REVIEW OF PARTICLE PROPERTIES

Particle Data Group

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This review of the properties of leptons, mesons, and baryons is an updating of Review of Particle Properties, Particle Data Group [Rev. Mod. Phys. 48 (1976) No. 2, Part II; and Supplement, Phys. Lett. 68B (1977) 1]. Data are evaluated, listed, averaged, and summarized in tables. Numerous tables, figures, and formulae of interest to particle physicists are also included. A data booklet is available.

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I. Introduction, credits, consultants

This review is an updating through December 1977 of our previous review of particle properties (Particle Data Group, 1976 and 1977). As in previous editions, we have attempted to make the text as complete and self-contained as possible.

As usual, the results of our compilation are presented in two sections, the Tables of Particle Properties and the Data Card Listings. The Tables summarize the properties of only those particles whose existence is in our judgment experimentally well founded and which have a large probability of standing the test of time. This is a conservative judgment, and surely some genuine resonances are (temporarily) omitted (see section V below).

The Data Card Listings give up-to-date information, with references, on all reported particles, whether considered well established or not. The Listings also contain mini-reviews on questions of interest.

A history of the Particle Data Group, with a discussion of procedures and problems, has been given by Rosenfeld (1975) and a short survey of the history of some of the constants we compile can be found in Appendix IV.

We have maintained in this review the new statistical procedure introduced in the previous one, i.e. we give simultaneously in the Listings the old (labeled "AVG") and new (labeled "STUDENT") average values and errors. Details may be found in section VII.

A pocket-sized data booklet, containing the Tables and a reprint of the figures and formulae from the first part of the review, is available on request. For North and South America, Australia, and the Far East, write to Technical Information Division, Lawrence Berkeley Laboratory, Berkeley, CA 94720, USA. For all other areas, write to CERN Scientific Information Service, CH-1211 Geneva 23, Switzerland.

As usual, we wish to emphasize that we compile the experimental results of others. It is inappropriate to give us the credit for their countless hours of effort. We urge that references be given directly to the original data, and we provide complete references in the Data Card Listings for that purpose.

The responsibilities for the various sections can be broken down as follows:

(1) *Stable particles*: N. Barash-Schmidt and T.G. Trippe.

(2) *Meson resonances*: D. Dionisi, M. Mazzucato, L. Montanet, and M. Roos.

(3) *Baryon resonances*: C. Bricman, R.L. Crawford, C.P. Horne, R.L. Kelly, and M.J. Losty.

(4) *General, including text*: All authors.

Consultants: To overcome unavoidable gaps in our coverage, both intellectual and geographical, we have solicited the help of consultants:
U. Amaldi (CERN),
V.E. Barnes (Purdue University),
K. Crowe (Lawrence Berkeley Laboratory),
J. Engler (CERN),
G. Feldman (SLAC),
F. Foster (University of Lancester),
G. Goldhaber (Lawrence Berkeley Laboratory),
R. Hagstrom (Lawrence Berkeley Laboratory),
F. Mönnig (CERN),
R.G. Moorhouse (University of Glasgow),
O.E. Overseth (University of Michigan),
S.I. Parker (Lawrence Berkeley Laboratory),
M. Perl (SLAC),
B.N. Taylor (U.S. National Bureau of Standards).

The usefulness of this compilation depends in large part on the interaction between the users and the authors and consultants. We appreciate comments, criticisms, and suggestions for improvements of all stages of data retrieval, processing, and presentation.

II. Selection of data

All particles are considered to fall into one of the three groups:

(1) Stable particles, immune to decay via the strong interaction, including the η and the photon and the leptons.

(2) Meson resonances.

(3) Baryon resonances.

The charmed, charmonium, and other new flavor particles have been merged into these groups.

These groups are maintained within the two main parts of the compilation:

(1) Tables of Particle Properties.

(2) Data Card Listings.

The Data Card Listings contain the original information (data, references, etc.), weighted averages, comments, and "mini-reviews". Immediately preceding the Data Card Listings is an illustrative key thereto. We attempt to give complete Data Card Listings up to our closing data (January 1, 1978) for all journals listed in the Illustrative Key. We also include preprints and unpublished conference reports that have come to our attention, but make no claim to completeness.

Roughly 40% of our encoded results, those set off in parentheses, are not used for averaging. The reasoning is then often given in a footnote below the data. If the reason is not given, it is one of the following:

The result was presented with no error stated.

The result comes from a preprint or conference report. It is our experience that such results (and particularly the errors) often change before final publication. Accordingly we keep these new results in parentheses until they are published (or explicitly verified to us by the authors).

It involves some assumptions that we do not wish to incorporate.

It is of poor quality, e.g. bad signal-to-noise ratio.

It is inconsistent with other results, e.g. because of different methods employed, rendering averaging meaningless.

It is not independent of other results, e.g. it is a result from one of several partial-wave analyses all using the same data, again rendering averaging meaningless.

When the data for a particle have received special treatment or present special problems, this is noted in a mini-review in the Data Card Listings.

The Tables of Particle Properties represent the output of weighted averages and some critical judgment. The extent to which "blind" averaging has been tempered with judgment is explained in footnotes to the Tables. In general, however, the footnotes are less complete than is the collection of notes and mini-reviews in the Data Card Listings. The reader is thus encouraged to familiarize himself with the Data Card Listings and, ultimately, with the original references.

III. Nomenclature

A. Quantum numbers

The symbols $I^G(J^P)C$ represent:
I = isospin,
G = G parity,
J = spin,
P = space parity,
C = charge conjugation parity.

1. Mesons. The charge conjugation operator C turns particle into antiparticle and has eigenvalues ±1 only for neutral states; so it is useful to define an extension G which has eigenvalues for charged states too. This is usually [‡1] defined by

$$G = C\exp(i\pi I_y) . \quad (1)$$

A neutral nonstrange, noncharmed state is an eigenstate of $\exp(i\pi I_y)$ with eigenvalue $(-1)^I$. Then we can write the eigenvalue equation for the whole multiplet as

$$G = C_n(-1)^I , \quad (2)$$

where C_n (n for neutral) is the eigenvalue C would have if applied to the neutral member of the multiplet. Thus, for a π^0, C has the eigenvalue +1, and since $I = 1$, $G = -1$. For a charged pion, there are no eigenvalues corresponding to C and to the isospin rotation, but eqs. (1) and (2) still give $G = -1$.

Consider a meson as a bound state of fermion–antifermion, e.g. $\bar{q}q$, with orbital angular momentum l, and with the two fermion spins coupling to give a spin S. Then one can show that the charge-conjugation eigenvalue (defined as in eq. (2)) is

$$C_n = (-1)^{l+S} . \quad (3)$$

Eqs. (2) and (3) combine to give

$$G = (-1)^{l+S+I} . \quad (4)$$

The parity is

$$P = -(-1)^l . \quad (5)$$

Eqs. (3) and (5) combine to give

$$C_nP = -(-1)^S , \quad (6)$$

so all singlets ($^1S_0$, $^1P_1$, ...) have $C_nP = -1$, and all triplets ($^3S_1$, ...) have $C_nP = +1$. For proofs of the above, see our 1969 text (Particle Data Group, 1969) and Appendix by C. Zemach.

If, instead of $\bar{q}q$, we consider the meson as a state of *boson–antiboson* (e.g. $A_2 \to \bar{K}K$), it turns out that some signs cancel, and eqs. (3) and (4) (not eq. (5)!) apply *unchanged*. Of course, the mesons are often spinless, so S is zero, but the equations are more general. Eqs. (3) and (4) can be considered as selection rules forbidding many decays.

We now use eqs. (3) and (4) to introduce the concept of "Abnormal-C" mesons, i.e. mesons that cannot be composed of $\bar{q}q$. For this, it is sufficient to consider the SU(3) subgroup of the full unitary group of flavors, containing the u, d, and s quarks in a $\{3\}$ representation.

This triplet of quarks is of course defined to have isospin and hypercharge properties such that $\bar{q}q$ can combine (according to the SU(3) relations $\{3\} \otimes \{3\} = \{8\} \oplus \{1\}$) so as to form only octets and singlets. The non-observation of "exotic" mesons (i.e., mesons in larger SU(3) representations, or mesons requiring at least a $q\bar{q}q\bar{q}$ structure) is of course a direct consequence of the naive quark model. States coupling directly to proton–antiproton channels (e.g., S,T,U, see Montanet (1977) and the Listings) are sometimes interpreted as "baryonium", requiring $q\bar{q}q\bar{q}$ structure, but this interpretation is model-dependent, and no manifestly exotic mesons have been found. It is slightly less obvious that even some *octets* are forbidden by the model, namely those with $(J^P)C_n = (0^\pm)-, (1^-)+, (2^+)-, \ldots$. Such states are not observed, and this is an additional success of the naive quark model classification scheme.

In what follows, do not confuse "Abnormal-C" with "Normal" or "Abnormal" J^P, both of which are allowed by the quark model. The series $J^P = 0^+, 1^-, 2^+, \ldots$ is called Normal because $P = (-1)^J$ as for normal spherical harmonics, and $J^P = 0^-, 1^+, \ldots$ is called Abnormal.

The top part of table 1 shows all the low angular momentum states that can be formed from $\bar{q}q$. Note that half of the J^P states can be formed by both a triplet and a singlet $\bar{q}q$ state, e.g. $^3P_1$, $^1P_1$ *or* $^3D_2$, $^1D_2$. Eq. (3) shows that $^3P_1$ and $^1P_1$ have opposite C_n, so the $\bar{q}q$ model allows both. But the states $^3P_0$ and $^3P_2$ have no ^1P counterparts. According to eq. (6) they have $C_nP = +1$, and with the $\bar{q}q$ model there is no way to form a state with a J^P of $^3P_{0,2}$ (i.e. J^P = Normal) and with $C_nP = -1$. As mentioned, such octets have not shown up. With the help of table 1 one can also see that the special state $^1S_0$, $C_nP = +1$, cannot be formed, so has Abnormal C.

2. General remarks. Well-established quantum numbers are underlined in the Tables of Particle Properties

[‡1] Most texts define it as in eq. (1); see e.g. Gasiorowicz (1966); however, sometimes the rotation is taken about I_x. The difference between the two conventions is mentioned in a footnote in Källen (1964).

Table 1. $I^G(J^P)C$ of mesons in the $\bar{q}q$ model. For the distinction between Abnormal J^P and Abnormal-C see text following eq. (6). Strange mesons share the same values of J^P as the $I = 0$ and 1 states shown, but are not eigenstates of G. The second column, which gathers together $(J^P)_{N \text{ or } A}$ CP, is a redundant intermediate step intended to make the table easier to read.

$\bar{q}q$ State CP −	$\bar{q}q$ State CP +	(J^P) CP Normal or abnormal	$I^G(J^P)C_n$	Examples	Strange partners ($I=\frac{1}{2}$)	Charmed partners ($I=\frac{1}{2}$)
		NORMAL-C STATES THAT CAN COME FROM $\bar{q}q$ MODEL				
Parity −	$^1S_0$	$(0^-)_A^-$	$0^+(0^-)+$	η,η'	K	D(1870)
			$1^-(0^-)+$	π		
	$^3S_1$	$(1^-)_N^+$	$0^-(1^-)-$	$\omega,\phi,J/\psi(3100),\psi(3685)$	$K^*(892)$	$D^*(2010)$
			$1^+(1^-)-$	ρ,ρ'		
Parity +	$^1P_1$	$(1^+)_A^-$	$0^-(1^+)-$			
			$1^+(1^+)-$	B		
	$^3P_0$	$(0^+)_N^+$	$0^+(0^+)+$	$\epsilon,S^*,\chi(3415)$	κ	
			$1^-(0^+)+$	δ		
	$^3P_1$	$(1^+)_A^+$	$0^+(1^+)+$	D	Q_1	
			$1^-(1^+)+$	A_1		
	$^3P_2$	$(2^+)_N^+$	$0^+(2^+)+$	f,f'	$K^*(1430)$	
			$1^-(2^+)+$	A_2		
Parity −	$^1D_2$	$(2^-)_A^-$	$0^+(2^-)+$			
			$1^-(2^-)+$	A_3		
	$^3D_1$	$(1^-)_N^+$	same as $^3S_1$	$\psi(3770)$		
	$^3D_2$	$(2^-)_A^+$	$0^-(2^-)-$	Regge recurrence of the		
			$1^+(2^-)-$	Abnormal-C state $(J^P)C_n = (0^-)-$		
	$^3D_3$	$(3^-)_N^+$	$0^-(3^-)-$	$\omega(1670)$	$K^*(1780)$	
			$1^+(3^-)-$	g,T		
Parity +	$^1F_3$	$(3^+)_A^-$	$0^-(3^+)-$			
			$1^+(3^+)-$			
	$^3F_2$	$(2^+)_N^+$	same as $^3P_2$			
	$^3F_3$	$(3^+)_A^+$	$0^+(3^+)+$			
			$1^-(3^+)+$			
	$^3F_4$	$(4^+)_N^+$	$0^+(4^+)+$	h,U		
			$1^-(4^+)+$			
		ABNORMAL-C STATES THAT CANNOT COME FROM $\bar{q}q$ MODEL				
Abnormal C states Have no $\bar{q}q$ model		$(0^-)_A^+$	$0^-(0^-)-$		All except $J^P = 0^-$ are J^P = normal, CP = −1	
			$1^+(0^-)-$			
		$(1^-)_N^-$	$0^+(1^-)+$			
			$1^-(1^-)+$			
		$(0^+)_N^-$	$0^-(0^+)-$			
			$1^+(0^+)-$			
		$(2^+)_N^-$	$0^-(2^+)-$			
			$1^+(2^+)-$			
		$(3^-)_N^-$	$0^+(3^-)+$			
			$1^-(3^-)+$			

(except for stable particles, where most of the quantum numbers are established). We have used flimsy evidence to guess many of the remaining ones, and we have indicated with "?" ones (in the Baryon Table) for which there is almost no evidence.

As is customary, we define antiparticles as the result of operating with *CPT* on particles, so both share the same spins, masses, and mean lives. Whenever there is a particularly interesting test of *CPT* invariance we include it in the Stable Particles Table.

B. Particle names

If a *meson* has a well-accepted colloquial name, we use it. If not, we name it by a single symbol which specifies its baryon number B (= 0 for mesons), its isospin I, its strangeness S and charm C, and, for a non-strange, non-charmed meson, its G parity.

The name conventions for mesons are given in the first part of table 2.

To crowd even more information onto the symbol, we sometimes add a subscript giving J^P. If J^P is not known, but must be "Normal" (0^+, 1^-, 2^+, ...), e.g. because $K\pi$ decays are seen, we use the subscript N. If such modes are *not* seen (and are not otherwise forbidden), we *guess* that it is because J^P is "Abnormal", and we use the subscript A.

For *some* pairs of *mesons* with supposedly identical quantum numbers, we also use primes; e.g. η, η'; f, f'.

For *baryons* no attempt has been made to attach a subscript about J and P. The name conventions are given in the second part of table 2. For stable baryons of each I and S we use the symbol standing alone; for resonances, the mass is in parentheses (i.e. N(1688), Λ(1405), Σ(1755), etc.). The J^P assignments are reported in the Baryon Table as $\frac{1}{2}+$, $\frac{3}{2}-$, $\frac{5}{2}+$, etc., and also by the symbols P_{11}, D_{13}, F_{15}, which refer to the πp or Kp partial-wave amplitude in which the resonant state occurs (the first subscript refers to the isospin state: $2 \times I$ for N and Δ and just I for Z, Λ, and Σ). When two or more baryons have identical quantum numbers we warn the reader by adding primes to the spectroscopic symbol as explained in footnote (a) of the Baryon Table.

Table 2
Particle name conventions.

Name	I	S	C	G
Mesons				
η	0	0	0	+
ω or ϕ [a]	0	0	0	−
ρ	1	0	0	+
π	1	0	0	−
K^+, K^0	1/2	+1	0	
K^-, $\bar{K}^0$	1/2	−1	0	
D^+, D^0	1/2	0	+1	
D^-, $\bar{D}^0$	1/2	0	−1	
F^+	0	+1	+1	
F^-	0	−1	−1	
Baryons				
N	1/2	0	0	
Δ	3/2	0	0	
Z_0, Z_1	0, 1	+1	0	
Λ	0	−1	0	
Σ	1	−1	0	
Ξ	1/2	−2	0	
Ω	0	−3	0	
Λ_c	0	0	1	
Σ_c	1	0	1	

[a] Since 1973, we have used the symbol ω for those $I^G = 0^-$ mesons that decay mainly into 3π [ω(783), ω(1670)]; we reserve the symbol ϕ for ϕ(1020) and possible future higher-mass $I^G = 0^-$ mesons that decay mainly into $K\bar{K}$.

IV. Conventions and parameters for strong interactions

A. Partial-wave amplitudes and resonance parameters

The vast majority of information concerning baryon resonances comes in the form of partial-wave analyses. In addition data concerning meson resonances ($\pi\pi$, $K\pi$, $\pi\pi\pi$) are, with increasing frequency, being subjected to partial-wave analyses. We thus find it natural to introduce the resonance parameters which we compile in terms of a Breit–Wigner approximation for the partial-wave amplitude.

In general the elastic amplitude for a given angular momentum l may be written as

$$T_{11} = \frac{\eta \exp(2i\delta) - 1}{2i}, \qquad (1)$$

where η is the absorption parameter ($0 \leqslant \eta \leqslant 1$) and δ, as the phase shift. The subscripts 11 on T denote scattering from channel 1 to channel 1 (e.g. $\pi\pi \to \pi\pi$ or $\bar{K}K \to \bar{K}K$).

In fig. 1 we show an Argand plot of the elastic partial wave amplitude T_{11}. It illustrates geometrically how the real parameters η and δ are related to the

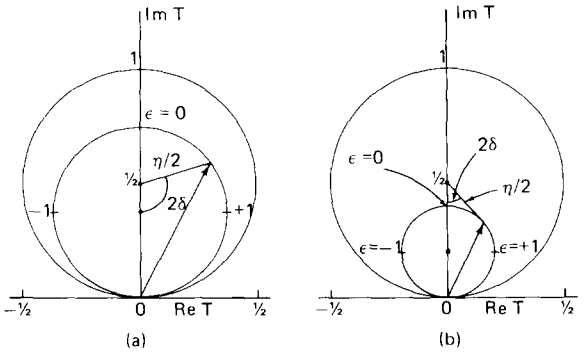

Fig. 1. Argand plots for the elastic partial wave amplitude T_{11}. The outer circles are the unitarity bound ($\eta = 1$). The inner circles correspond to the Breit–Wigner approximation of eq. (2) for (a) $x_1 = \Gamma_1/\Gamma = 0.75$ and (b) $x_1 = 0.4$. Note: $\epsilon = 2(M - E)/\Gamma$.

real and imaginary parts of T_{11}. Many examples of such Argand plots may be found in the Baryon Data Card Listings

Consider the so-called non-relativistic Breit–Wigner approximation for T_{11}:

$$T_{11} = \tfrac{1}{2}\Gamma_1/(M - E - \tfrac{1}{2}\mathrm{i}\Gamma) , \qquad (2)$$

where E is the c.m. energy of invariant mass, Γ_1 and Γ are the *elastic* and *total* widths, and M is the *resonance mass*. Eq. (2) is, of course, not the only possible description of a resonant amplitude; but it suffices to illustrate the properties of partial-wave amplitudes which we associate with resonance behavior in the absence of any background in the same partial wave (see, e.g., the πN D_{15} and F_{15} waves in the Baryon Data Card Listings). Usually the widths contain barrier-penetration factors which can vary rapidly with energy. Near threshold, $\Gamma_1(E)$ should start up as q^{2l+1} (also true for the inelastic width Γ_β). Various E dependences are then used for Γ_1, mostly of the form

$$\Gamma_1(E) \propto \frac{(qR)^{2l+1}}{\text{const} + \ldots + (qR)^{2l}} ; \qquad (3)$$

see Jackson (1964), Pišút and Roos (1968), and Barbaro-Galtieri (1968).

The BW approximation to the amplitude for an inelastic process leading from channel 1 to channel β ($\pi\pi \to \bar{\mathrm{K}}\mathrm{K}$ or $\mathrm{KN} \to \Sigma\pi$, for example) is

$$T_{1\beta} = \tfrac{1}{2}(\Gamma_1\Gamma_\beta)^{1/2}/(M - E - \tfrac{1}{2}\mathrm{i}\Gamma)$$
$$= (x_1 x_\beta)^{1/2}[\tfrac{1}{2}\Gamma/(M - E - \tfrac{1}{2}\mathrm{i}\Gamma)] , \qquad (4)$$

where

$$\Gamma = \sum_1^N \Gamma_\beta , \qquad x_\beta = \Gamma_\beta/\Gamma , \qquad (5)$$

and x_1 (called the elasticity) is often written x_e. (Note that in the Data Card Listings we use the symbol P_β to denote x_β.) The channel cross section $\sigma_{1\beta}$ for the reaction $1 \to \beta$, for spin 0–spin 1/2 scattering, is

$$\sigma_{1\beta} = 4\pi\lambda^2(J + \tfrac{1}{2})|T_{1\beta}|^2 , \qquad (6)$$

where $J = l \pm \frac{1}{2}$.

The important features of eq. (4) which characterize resonant behavior in the Argand diagram (Im $T_{1\beta}$ versus Re $T_{1\beta}$) are:

energy variation given by circles with diameter $(x_1 x_\beta)^{1/2}$ and maximum amplitude at $E = M$ of

$$T_{1\beta}^{\max} = \mathrm{i}(x_1 x_\beta)^{1/2} ; \qquad (7)$$

a maximum in the speed near resonance, given approximately by

$$\text{"Speed"(res)} = |\mathrm{d}T_{1\beta}/\mathrm{d}E|_{E=M} = \frac{2(x_1 x_\beta)^{1/2}}{\Gamma(E)} , \qquad (8)$$

for slowly varying $\Gamma(E)$. These features may be related to the η, δ representation of T_{11}. Thus when $E = M$, δ is either 90° ($x_1 > \frac{1}{2}$) or 0° ($x_1 < \frac{1}{2}$) and η dips to its minimum value.

These simple properties can be used to judge the presence or absence of resonance behavior in an Argand plot, but do not necessarily constitute the criteria we use (see section V). It must also be kept in mind that eqs. (2) and (4) are only approximations to the "true" amplitude. The simple picture given above can be distorted by various effects:

the presence of "background" in the same partial wave as the resonance,

two resonances in the same partial wave overlapping in energy,

the resonant energy M being close to an inelastic channel treshold, in which case a K-matrix-like parametrization is more appropriate,

the speed of the resonance being very slow so that the resonance is very broad, and the Breit–Wigner formula a bad approximation.

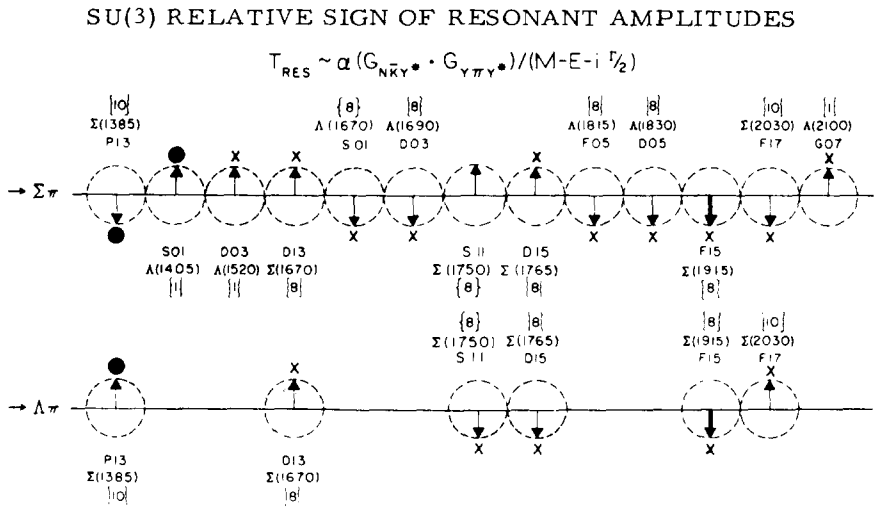

Fig. 2. Plot adapted from Levi-Setti (1969) showing the sign convention adopted here for the $\Sigma\pi$ and $\Lambda\pi$ amplitudes. Once the signs of one $I = 0$ and one $I = 1$ amplitude are fixed, the others can be measured relative to these two. Arrows here indicate signs predicted by SU(3); × marks indicate the observed phases; • indicates phase chosen according to sign convention described in text. The Σ(1915) predictions have been changed from Levi-Setti's original figure.

B. SU(3) sign conventions for Λ and Σ resonances

Consider the partial width Γ_β of a resonance decaying into the channel β. We can always define a coupling constant such that

$$\Gamma_\beta \propto G_\beta^2 .$$

In this case the inelastic amplitude in the Breit–Wigner approximation, eq. (4) will go as

$$T_{1\beta} \propto G_1 G_\beta/(M - E - \tfrac{1}{2}\mathrm{i}\Gamma) ,$$

where G_1 is the coupling constant for the elastic channel. In the context of exact SU(3) symmetry the relative signs of the product $G_1 G_\beta$ for different resonances are often useful as a consistency check on SU(3) assignment of Λ and Σ resonances. See appendix II for further details.

In the Data Card Listings for Λ and Σ resonances, we tabulate measured values for $(x_1 x_\beta)^{1/2} \propto G_1 G_\beta$. Whenever there is an explicit sign, it will be according to the convention advocated by Levi-Setti (1969) and used in the table of SU(3) Isoscalar Factors presented in this review. Thus the signs multiplying the Breit–Wigner amplitudes for $\bar{K}N \to \Sigma(1385) \to \Sigma\pi$, $\Lambda\pi$ and $\bar{K}N \to \Lambda(1405) \to \Sigma\pi$ are simply the product of the phases of the appropriate isoscalar factors. This convention is shown in fig. 2 from Levi-Setti (1969).

C. Types of partial-wave analyses

Partial-wave analyses (PWA) are classified into three categories in the Data Card Listings: energy-independent partial-wave analyses (IPWA), energy-dependent partial-wave analyses (DPWA), and model-dependent partial-wave analyses (MPWA), in increasing order of the number of explicit supplementary hypotheses that are used to extract the amplitudes from experimental data.

In an IPWA, data at different energies are analyzed separately. Usually each partial wave included in the fit is allowed to vary freely (subject to unitarity constraints) over some large region, and waves whose angular momenta are above some cutoff value are assumed to be negligible. The sharp cutoff in angular momentum resolves continuum ambiguities in the solution (such as the overall phase ambiguity), but there remains a finite number of indistinguishable "best" solutions (i.e., solutions corresponding to identical physical observables) which have been codified by Barrelet (1972). In addition, there are generally some nearby solutions (and their associated Barrelet ambiguities) which have chi-squared values close to the minimum one.

At the end of the analysis a choice is made among these many solutions, usually on the basis of energy

continuity. A popular criterion for making this choice is the shortest path technique in which the total "length" of the preferred solution is chosen to be a minimum. The definition of "length" used here is not universal but is usually closely related to the total geometrical length of the lines representing the various partial-wave amplitudes in Argand plots (see the Baryon section of the Data Card Listings for examples of Argand plots). Various other criteria which are also used in some analyses are, e.g., matching with known solutions at low energies, the presence of known resonances in the final results, and limited inelasticity in high partial waves.

In a DPWA, data at different energies are fit simultaneously by using an energy dependent parametrization of the partial-wave amplitudes. The parametrization is usually chosen to include both resonances and nonresonant background of some sort and an attempt is made to keep it as "model independent" as possible. Often the data are grouped into several energy bins which are fit separately rather than trying to fit the whole energy range under consideration simultaneously. One of the main advantages of DPWA over IPWA is that sparse data spread over many different energies can be analyzed, e.g., nearly all $S = -1$ analyses are DPWA. In addition, the built-in energy continuity helps to resolve the ambiguities that plague IPWA and eases the problems associated with resonance parameter extraction. The price one pays for these advantages lies in the danger of systematic error in the amplitudes and poor fits to the data if the parametrization is poorly chosen or insufficiently flexible.

An MPWA also uses an energy-dependent parametrization, but one based on explicit model-dependent theoretical assumptions such as Regge exchanges. This technique is usually applied to reactions where the data are incomplete. There is, of course, no sharp distinction between DPWA and MPWA, and a well chosen MPWA parametrization may actually be less biased than a model-independent but poorly chosen DPWA parametrization.

D. Production of resonances

Hereby, we mean the observation of statistically significant peaks in invariant mass plots or, loosely, in integrated cross sections. Many meson resonances are of this type. We expect most of these peaks to be associated with Breit–Wigner behavior in appropriate Argand plots; thus the ρ meson peak in $\pi\pi$ mass plots is firmly related to the $I = 1$, $l = 1$ $\pi\pi$ phase shift passing through 90°.

From mass plots we can determine M, Γ, and the approximate branching ratios

$$x_\alpha/x_\beta = \Gamma_\alpha/\Gamma_\beta \,. \tag{9}$$

In the case of total cross sections, the peak above background gives us, using the optical theorem, the product $(J + \frac{1}{2})x_e$:

$$\sigma^{tot}(E = M) = 4\pi\lambda\!\!\!^{-2}(J + \tfrac{1}{2})x_e \,. \tag{10}$$

V. Criteria for resonances

An experimentalist who sees indications of a resonance in some energy (or mass) region will of course want to know what has been seen in that region in the past; hence, we strive to have the Data Card Listings serve as an archive for all substantial claims for resonances.

For the Tables of Particle Properties, on the other hand, we wish to be more conservative and to include only those peaks or resonances which we feel have a large chance of survival. An arrow (→) at the left of the Tables of Particle Properties indicates that a questionable candidate has been omitted from the Table, but that it can be found in the corresponding part of the Data Card Listings. One's betting odds for survival are of course subjective; therefore no precise criteria can be defined. Very slow speeds (ϵ and κ) make it quite difficult to decide what is a resonance and what is not. For more detailed discussions, see the mini-reviews in the Listings. In what follows we shall attempt to specify some guide lines.

(a) When energy-independent partial-wave analyses are available (mostly for N*'s), approximate Breit–Wigner behavior of the amplitude appears to us to be the most satisfactory test for a resonance. We can check that the Argand plot follows roughly a left-hand circle, and that the "speed" of the amplitude also shows a maximum near the resonance energy; further, there should be data well above the resonance showing that the speed again decreases. Indeed proper behavior of the partial-wave amplitude could accredit a resonance even if its elasticity is too small to make a noticeable peak in the cross section.

Of course even if Argand plots are available, it may still be a matter of opinion as to what behavior constitutes a resonance. Such an example is the $Z_0(1780)$ state seen in KN total cross-section experiments and in partial-wave analysis. The recent partial-wave analyses of Giacomelli (1974) and Martin (1975) find preferred solutions which exhibit a resonance-like loop in the P_{01} wave near 1740 MeV. However, Giacomelli et al. and Martin point out that, despite the resonant-like *appearance* of the loop, the evidence for resonant *energy dependence* is inconclusive. Thus we omit the $Z_0(1780)$ from the Baryon Table. A similar quandary has existed for some time concerning the $Z_1(1900)$, and it too has been omitted from the Tables.

(b) When there are insufficient data to perform energy-independent analyses, one often resorts to energy-dependent partial-wave analyses (mostly for Y*'s). In this case Breit–Wigner behavior is an input. We therefore require that resonance solutions be found by several different analyses, preferably in different channels ($\bar{K}N \to \bar{K}N$, $\pi\Sigma$, etc.), before putting the claim in the table.

(c) Partial-wave analyses of three-body final states ($\pi N \to \pi\pi N$) are now available. While these analyses are based on the isobar model ($\pi N \to \rho N$, $\pi\Delta$, etc.) and are subject to theoretical objections of varying importance, they provide increasingly reliable information on inelastic decay modes of otherwise established resonances.

(d) Most mesons, Ξ^* peaks, and high mass N* and Y* peaks fall into a category for which no partial-wave analyses exist. In general we accept such peaks if they are experimentally reliable, of high statistical significance or if they are observed in several different production processes.

(e) A special category of "diffractive mesons" consists of statistically significant peaks like A_1, A_3 or Q, which are not far above the $\rho\pi$, $f\pi$, or $K^*\pi$ thresholds. The question of a resonance interpretation for these states is complicated, because the behavior near threshold in these channels may be described by the Deck effect. Modern partial-wave analyses can shed considerable light on these problems. Results are also becoming available from experiments designed to look for these mesons in channels where the Deck effect is minimized (baryon exchange processes, for example). See the mini-reviews for details.

Thus, we enter into the tables of Particle Properties only states for which there is experimentally convincing evidence, and we expect that most of these will be confirmed as resonances.

VI. Conventions and parameters for weak and electromagnetic decays

A. Muon-decay parameters

The μ-decay parameters describe the momentum spectrum (ρ and η), the asymmetry (ξ and δ), and the helicity (h) of the electron in the process $\mu^\pm \to e^\pm + \nu + \bar{\nu}$. Assuming a local and lepton-conserving interaction, the matrix element may be written as

$$\sum_i \langle \bar{e} | \Gamma_i | \mu \rangle \langle \bar{\nu} | \Gamma_i (C_i + C_i' \gamma_5) | \nu \rangle ,$$

where the summation is taken over i = S, V, T, A, P. Using the definitions and sign conventions of Kinoshita and Sirlin (1957), we have for the momentum parameters

$$\rho = [3g_A^2 + 3g_V^2 + 6g_T^2]/D ,$$

$$\eta = [g_S^2 - g_P^2 + 2g_A^2 - 2g_V^2]/D ,$$

for the asymmetry parameters:

$$\xi = \frac{6g_S g_P \cos\phi_{SP} - 8g_A g_V \cos\phi_{AV} + 14g_T^2 \cos\phi_{TT}}{D} ,$$

$$\delta = [-6g_A g_V \cos\phi_{AV} + 6g_T^2 \cos\phi_{TT}]/D\xi ,$$

and for the parameter describing the helicity of the electron:

$$h = \frac{2g_S g_P \cos\phi_{SP} - 8g_A g_V \cos\phi_{AV} - 6g_T^2 \cos\phi_{TT}}{D} .$$

Here

$$D = g_S^2 + g_P^2 + 4g_V^2 = 6g_T^2 + 4g_A^2 ,$$

$$g_i^2 = |C_i|^2 + |C_i'|^2 ,$$

and

$$\cos\phi_{ij} = \mathrm{Re}\,(C_i^* C_j' + C_i' C_j^*) .$$

The quantities g_i are defined to be real non-negative numbers, and the ϕ_{ij} are phase angles between the i-type and j-type interactions. Under the assumption of two-component neutrinos $C_i' = -C_i$ and $C_j' = -C_j$, the S, P, and T terms vanish, and ϕ_{AV} is the phase angle

between C_A and C_V in the complex plane.

By using the above equations and the experimental determinations of ρ, η, ξ, δ, and h, limits can be placed on g_S/g_V, g_A/g_V, g_T/g_V, g_P/g_V, and ϕ_{AV}. The results, given in the Data Card Listings assume neither two-component neutrinos nor time-reversal invariance. If, however, two-component neutrinos are assumed, then $\sin\phi_{AV}$ is the amplitude of time-reversal violation. Note that most experiments study only the upper end of the spectrum where ρ and η are highly correlated, so they can only report ρ for $\eta \equiv 0$ and η for $\rho \equiv \frac{3}{4}$. The values for ρ and η we use here were obtained by combining measurements of both upper and lower ends of the spectrum and turn out to be nearly uncorrelated.

Note also that the radiative corrections are unambiguous only when $g_S = g_T = g_P = 0$. The same limits on g_A/g_V and ϕ_{AV} are obtained, however, as when g_S, g_T, and g_P are left free.

Current values for the asymmetry parameters as well as $|g_A/g_V|$ and ϕ_{AV} are given in the Addendum to the Stable Particle Table. In addition, upper limits on $|g_S/g_V|$, $|g_T/g_V|$ and $|g_P/g_V|$ are given in the μ section of the Stable Particle Data Card Listings.

B. K-decay parameters

1. Dalitz plot for $K \to 3\pi$ decays. The small deviation from uniformity of the Dalitz plot for the 3π decay of the K meson is usually described by a "slope parameter" (Dalitz, 1956). For the τ and τ' decays of the charged K's, and the τ^0 decay mode of the K_L^0, we parametrize the Dalitz plot distribution by the expression

$$|M|^2 \propto 1 + g\frac{s_3 - s_0}{m_{\pi^+}^2} + h\left(\frac{s_3 - s_0}{m_{\pi^+}^2}\right)^2 + j\frac{s_2 - s_1}{m_{\pi^+}^2} + k\left(\frac{s_2 - s_1}{m_{\pi^+}^2}\right)^2 + \ldots , \quad (1)$$

where $m_{\pi^+}^2$ has been introduced so as to make the coefficients g, h, j, and k dimensionless, and

$$s_i = (P_K - P_i)^2 = (m_K - m_i)^2 - 2m_K T_i , \qquad i = 1, 2, 3,$$

$$s_0 = \tfrac{1}{3}\sum_i s_i = \tfrac{1}{3}(m_K^2 + m_1^2 + m_2^2 + m_3^2) .$$

Here the P_i are 4-vectors, m_i and T_i are the mass and kinetic energy of the ith pion, and the index 3 is used for the odd pion.

The coefficient g is a measure of the slope in the variable s_3 (or T_3) of the Dalitz plot, while h and k measure the quadratic dependence on s_3 and $(s_2 - s_1)$, respectively. The coefficient j is related to the asymmetry of the plot and must be zero if *CP* invariance holds. Note also that if *CP* is good, g must be the same for τ^+ and τ^-, and similarly for h and k.

At present there is no compelling experimental evidence for the h, k, or j term (for upper limits on the j term, see section B3(b) below). Thus we stop the above expansion at the first term and list only g. Since different experiments use different forms for $|M|^2$, in order to compare the experiments we have converted to g whatever coefficients have been measured. See the mini-review in the $K^\pm$ section of the Stable Particle Data Card Listings for details on this point. The results are given in the Addendum to the Stable Particle Table and in the $K^\pm$ and K_L^0 sections of the Stable Particle Data Card Listings.

Relations among $\tau^\pm$, $\tau'^\pm$, and τ^0 are predicted by the $\Delta I = \frac{1}{2}$ rule. See appendix I for these relations and a discussion of this rule.

2. Form factors in $K_{\ell 3}$ leptonic decays. Assuming that only the vector current contributes to these decays, we write the matrix element as

$$M \propto f_+(t)[(P_K + P_\pi)_\mu \bar{u}_\ell \gamma_\mu (1 + \gamma_5) u_\nu] + f_-(t)[m_\ell \bar{u}_\ell (1 + \gamma_5) u_\nu] , \quad (2)$$

where P_K and P_π are the four momenta of K and π mesons; m_ℓ is the lepton mass; f_+ and f_- are dimensionless form factors which can depend only on $t = (P_K - P_\pi)^2$, the square of the four-momentum transfer to the leptons. f_+ and f_- are relatively real if time reversal invariance holds for these decays. $K_{\mu 3}$ experiments measure f_+ and f_-, while K_{e3} experiments are sensitive only to f_+ because the presence of the lepton mass makes the f_- term negligible.

(a) $K_{\mu 3}$ experiments. Analyses of $K_{\mu 3}$ data frequently assume a linear dependence of f_+ and f_- on t, i.e.

$$f_\pm(t) = f_\pm(0)[1 + \lambda_\pm (t/m_\pi^2)] . \quad (3)$$

Most $K_{\mu 3}$ data are adequately described by eq. (3) for f_+ and a constant f_- (i.e. $\lambda_- = 0$). There are two

equivalent parametrizations commonly used in these analyses:

(1) λ_+, $\xi(0)$ *parametrization*. Analyses of $K_{\mu 3}$ data often introduce the ratio of the two form factors

$$\xi(t) = f_-(t)/f_+(t) .$$

The $K_{\mu 3}$ decay distribution is then described by the two parameters λ_+ and $\xi(0)$ (assuming time reversal invariance and $\lambda_- = 0$). These parameters can be determined by three different methods:

Method A. By studying the Dalitz plot or the pion spectrum of $K_{\mu 3}$ decay. The Dalitz plot density is (see, e.g. Chounet et al., 1972):

$$\rho(E_\pi, E_\mu) \propto f_+^2(t)[A + B\xi(t) + C\xi(t)^2] ,$$

where

$$A = m_K(2E_\mu E_\nu - m_K E'_\pi) + m_\mu^2(\tfrac{1}{4}E'_\pi - E_\nu) ,$$

$$B = m_\mu^2(E_\nu - \tfrac{1}{2}E'_\pi) ,$$

$$C = \tfrac{1}{4}m_\mu^2 E'_\pi ,$$

$$E'_\pi = E_\pi^{\max} - E_\pi = \frac{m_K^2 + m_\pi^2 - m_\mu^2}{2m_K} - E_\pi .$$

Here E_π, E_μ, and E_ν are respectively the pion, muon, and neutrino energies in the kaon center of mass. The density ρ is fit to the data to determine the values of λ_+, $\xi(0)$, and their correlation.

Method B. By measuring the $K_{\mu 3}/K_{e3}$ branching ratio and comparing it with the theoretical ratio (see, e.g., Fearing et al., 1970) as given in terms of λ^+ and $\xi(0)$, assuming μ–e universality:

$$\Gamma(K^\pm_{\mu 3})/\Gamma(K^\pm_{e3}) = 0.6457 + 1.4115\lambda_+ + 0.1264\xi(0) + 0.0192\xi(0)^2 + 0.0080\lambda_+\xi(0) ,$$

$$\Gamma(K^0_{\mu 3})/\Gamma(K^0_{e3}) = 0.6452 + 1.3162\lambda_+ + 0.1246\xi(0) + 0.0186\xi(0)^2 + 0.0064\lambda_+\xi(0) .$$

This cannot determine λ_+ and $\xi(0)$ simultaneously but simply fixes a relationship between them.

Method C. By measuring the muon polarization in $K_{\mu 3}$ decay. In the rest frame of the K, the μ is expected to be polarized in the direction $\boldsymbol{A}$ with $\boldsymbol{P} = \boldsymbol{A}/|\boldsymbol{A}|$, where $\boldsymbol{A}$ is given (Cabibbo and Maksymowicz, 1964) by

$$\boldsymbol{A} = a_1(\xi)\boldsymbol{p}_\mu - a_2(\xi)\left\{\frac{\boldsymbol{p}_\mu}{m_\mu}\left[m_K - E_\pi + \frac{\boldsymbol{p}_\pi \cdot \boldsymbol{p}_\mu}{|\boldsymbol{p}_\mu|^2}(E_\mu - m_\mu)\right] + \boldsymbol{p}_\pi\right\} + m_K \operatorname{Im}\xi(t)(\boldsymbol{p}_\pi \times \boldsymbol{p}_\mu) .$$

If time-reversal invariance holds, ξ is real, and thus there is no polarization perpendicular to the K-decay plane. Polarization experiments measure the weighted average of $\xi(t)$ over the t range of the experiment, where the weighting accounts for the variation with t of the sensitivity to $\xi(t)$.

(2) λ_+, λ_0 *parametrization*. Some of the more recent $K_{\mu 3}$ analyses have parametrized in terms of the form factors f_+ and f_0 which are associated with vector and scalar exchange respectively to the lepton pair. f_0 is related to f_+ and f_- by

$$f_0(t) = f_+(t) + [t/(m_K^2 - m_\pi^2)]f_-(t) .$$

Here $f_0(0)$ must equal $f_+(0)$ unless $f_-(t)$ diverges at $t = 0$. The earlier assumption that f_+ is linear in t and f_- is constant leads to f_0 linear in t:

$$f_0(t) = f_0(0)[1 + \lambda_0(t/m_\pi^2)] .$$

With the assumption that $f_0(0) = f_+(0)$, the two parametrizations, $(\lambda_+, \xi(0))$ and (λ_+, λ_0) are equivalent as long as correlation information is retained. (λ_+, λ_0) correlations tend to be less strong than $(\lambda_+, \xi(0))$ correlations.

The experimental results for $\xi(0)$ and its correlation with λ_+ are listed in the $K^\pm$ and K^0_L sections of the Stable Particle Data Card Listings in subsection XIA, XIB, or XIC depending on whether method A, B or C discussed above was used. The corresponding values of λ^+ are listed in subsection L + M.

Because current experiments tend to use the (λ_+, λ_0) parametrization, we have added a subsection L0 for λ_0 results. Wherever possible we have converted $\xi(0)$ results into λ_0 results and vice versa.

(b) K_{e3} experiments. Analysis of K_{e3} data is simpler than that of $K_{\mu 3}$ because the second term of the matrix element assuming a pure vector current (eq. (2) above) can be neglected. Here f_+ is usually assumed to be linear in t, and the linear coefficient λ_+ of eq. (3) is determined.

If we remove the assumption of a pure vector current, then the matrix element for the decay, in addition to the terms in eq. (2), would contain

$$+ 2m_K(f_S \bar{u}_\ell(1+\gamma_5)u_\nu$$

$$+ (2f_T/m_K)(P_K)_\lambda(P_\pi)_\mu \bar{u}_\ell \sigma_{\lambda\mu}(1+\gamma_5)u_\nu ,$$

where f_S is the scalar form factor, and f_T is the tensor form factor. In the case of the K_{e3} decays where the f_- term can be neglected, experiments have yielded limits on $|f_S/f_+|$ and $|f_T/f_+|$.

The K_{e3} results for λ_+, $|f_S/f_+|$ and $|f_T/f_+|$ are listed in the subsections L + M, FS, and FT respectively of the $K^\pm$ and K_L^0 sections of the Stable Particle Data Card Listings.

See also the Note on $K_{\ell 3}^\pm$ and $K_{\ell 3}^0$ Form Factors in the $K^\pm$ section of the Stable Particle Data Card Listings for additional discussion of the $K_{\mu 3}^0$ parameters, correlations, and conversion between parametrization and also for a comparison of the experimental results.

3. CP violation in K^0 decays. We list parameters for four different reactions in which *CP* can be tested (for details, see Okun and Rubbia (1967), Steinberger (1969), and Wolfenstein (1969)).

(a) $K_S \to \pi^+\pi^-\pi^0$. The quantity measured here is the ratio of amplitudes

$$A_S(K_S \to \pi^+\pi^-\pi^0)/A_L(K_L \to \pi^+\pi^-\pi^0) \equiv x + iy . \quad (4)$$

If *CPT* invariance holds and there is no $I = 3$ state present, then x can be neglected and *CP* violation would be observed as a nonzero y. We give the result for eq. (4) in the K_L^0 section of the Stable Particle Table and under Branching Ratio R4 in the K_S^0 section of the Stable Particle Data Card Listings. Our procedure is to assume that $x = 0$, and to list $(A_S/A_L)^2$ in the form of a branching ratio.

(b) *Charge asymmetry in $K_L \to 3\pi$ decays.* As mentioned above, the presence of a term in $(s_2 - s_1)$ in expression (1) describing the Dalitz plot distribution for $\tau^\pm$, τ^0 decays of K mesons would be an indication of *CP* violation. Rather than listing values of the $(s_2 - s_1)$ coefficient j in eq. (1), we choose to list $\sigma_\pm$ from the equivalent expression

$$|M|^2 \propto 1 + \sigma_\pm(2/\sqrt{3})(T_+ - T_-)/T_{\pm\,\max}$$

$$+ (CP \text{ nonviolating terms}) , \quad (5)$$

where $T_\pm$ are the kinetic energies of the charged pions. We have momentarily abandoned the form involving the Mandelstam variables s_i in favor of eq. (5) because the latter has been consistently used by experimenters searching for *CP* violation. We list $\sigma_\pm$ among the *CP*-violating parameters at the back of the K_L^0 section of the Stable Particle Data Card Listings. Note that only upper limits have been reported for this quantity.

(c) *Asymmetry in the $K_L \to \pi^\mp \ell^\pm \nu$ decays.* The quantity measured and compiled here is

$$\delta = \frac{\Gamma(K_L \to \pi^-\ell^+\nu) - \Gamma(K_L \to \pi^+\ell^-\nu)}{\Gamma(K_L \to \pi^-\ell^+\nu) + \Gamma(K_L \to \pi^+\ell^-\nu)} .$$

This asymmetry violates *CP* invariance. If *CPT* is good, for a pure K_L^0 beam, δ can be written as

$$\delta = 2[(1 - |x|^2)/(|1 - x|^2)] \operatorname{Re} \epsilon ,$$

where x is the $\Delta S = \Delta Q$-violating parameter defined in section B4, and ϵ is the parameter of the expansion

$$|K_L\rangle = [(1+\epsilon)|K\rangle - (1-\epsilon)|\bar{K}\rangle]/[2(1+|\epsilon|^2)]^{1/2}, \quad (6a)$$

$$|K_S\rangle = [(1+\epsilon)|K\rangle + (1-\epsilon)|\bar{K}\rangle]/[2(1+|\epsilon|^2)]^{1/2}. \quad (6b)$$

We give δ in the Addendum to the Stable Particle Table. In addition, in the K_L^0 *CP*-violation section of the Stable Particle Data Card Listings, we list δ separately for $K_L^0 \to \pi\mu\nu$ and $K_L^0 \to \pi e\nu$.

(d) *$K_L \to 2\pi$ decay.* The relevant parameters are

$$\eta_{+-} = A(K_L \to \pi^+\pi^-)/A(K_S \to \pi^+\pi^-)$$

$$= |\eta_{+-}| \exp(i\phi_{+-}) ,$$

$$\eta_{00} = A(K_L \to \pi^0\pi^0)/A(K_S \to \pi^0\pi^0)$$

$$= |\eta_{00}| \exp(i\phi_{00}) ,$$

ϵ, defined in eqs. (6) above, and

$$\epsilon' = \tfrac{1}{2} i\sqrt{2}[\exp i(\delta_2 - \delta_0)] \operatorname{Im}(A_2/A_0) .$$

Here, A_i and δ_i are the amplitude and phase of $\pi\pi$ scattering at the K mass, defined by

$$\langle I = 0|T|K\rangle = \exp(i\delta_0)A_0 ,$$

$$\langle I = 2|T|K\rangle = \exp(i\delta_2)A_2 .$$

Wu and Yang (1964) have derived the relationships

$$\eta_{+-} = \epsilon + \epsilon' , \qquad \eta_{00} = \epsilon - 2\epsilon' .$$

We give η_{+-}, η_{00}, ϕ_{+-}, and ϕ_{00} in the Addendum to the Stable Particle Table. The phases are measured directly, whereas the magnitudes η_{+-} and η_{00} are derived parameters. We use, as far as we can, the

directly measured quantities as input and calculate η_{+-} and η_{00} from the values given by our constrained fits. Therefore, if one looks at the Data Card Listings, most of the $|\eta|$ measurements appear in the form of branching ratios, with appropriate comments. We then give the values of η_{+-} and $|\eta_{00}|^2$ in a separate list at the end of the *CP*-violating parameters section of the K_L^0 section of the Stable Particle Data Card Listings.

4. $\Delta S = \Delta Q$ rule in K^0 decays. The relative amount of $\Delta S \neq \Delta Q$ component present is measured by the parameter x, defined as

$$x = A(\bar{K}^0 \to \pi^- \ell^+ \nu)/A(K^0 \to \pi^- \ell^+ \nu) .$$

We list $\mathrm{Re}\{x\}$ and $\mathrm{Im}\{x\}$ for both K_{e3} and $K_{\mu 3}$ at the end of the Stable Particle Data Card Listings and give values in the Addendum to the Stable Particle Table.

C. η-decay parameters

1. C-violation in η-decays. As a test of possible *C*-violation in electromagnetic interactions, a number of experiments have looked for possible charge asymmetries in the decays $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$. We list the following parameters.

(a) The left-right asymmetry

$$A = (N^+ - N^-)/(N^+ + N^-) ,$$

where $N^{(\pm)}$ means the number of events with the $\pi^{(\pm)}$ energy greater than the $\pi^{(\mp)}$ energy in the η rest frame.

(b) The sextant asymmetry

$$A_s = \frac{N_1 + N_3 + N_5 - N_2 - N_4 - N_6}{N_1 + N_2 + N_3 + N_4 + N_5 + N_6}$$

for the decay $\eta \to \pi^+\pi^-\pi^0$. The numbers refer to the sextants of the Dalitz plot (see, for example, Layter (1972)). A_s is sensitive to an $I = 0$ *C*-violating asymmetry.

(c) The quadrant asymmetry A_q, defined in a similar way as A_s, but with each sector of the Dalitz plot now containing $\pi/2$ rather than $\pi/3$ radians. A_q is sensitive to an $I = 2$ *C*-violating final state.

(d) The d-wave contribution to the *C*-violating amplitude in the decay $\eta \to \pi^+\pi^-\gamma$. The upper limit for this contribution is measured by the parameter β, defined by

$$dN/d|\cos\theta| \propto \sin^2\theta(1 + \beta\cos^2\theta) ,$$

where θ is the angle between the π^+ and the γ in the di-pion center of mass. A term proportional to $\cos^2\theta$ could also be due to p- and f-wave interference.

We list A for the decay modes $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$, A_s and A_q for the decay $\eta \to \pi^+\pi^-\pi^0$, and β for the decay $\eta \to \pi^+\pi^-\gamma$ in the η section of the Stable Particle Data Card Listings.

2. Dalitz plot for $\eta \to \pi^+\pi^-\pi^0$. The Dalitz plot for the decay $\eta \to \pi^+\pi^-\pi^0$ may be fit by the distribution

$$|M(x,y)|^2 \propto 1 + ay + by^2 + cx + dx^2 + exy .$$

Here,

$$x = \sqrt{3}(T_+ - T_-)/Q , \qquad y = (3T_0/Q) - 1 ,$$

T_+, T_-, T_0 are the kinetic energies of the π^+, π^-, and π^0 in the η rest system, and $Q = m_\eta - m_{\pi^+} - m_{\pi^-} - m_{\pi^0}$. The coefficient of the term linear in x is sensitive to *C*-violation due to an $I = 0$ or $I = 2$ final state. We list papers presenting determinations of the parameters a, b, c, and d in the η section of the Stable Particle Data Card Listings. However, we do not tabulate values of these parameters because the assumptions made by different authors are not compatible and do not allow comparison of the numerical values.

3. Dalitz plot for $\eta \to \pi^+\pi^-\gamma$. The Dalitz plot for the decay $\eta \to \pi^+\pi^-\gamma$ may be fit to the expression

$$|M|^2 \propto 1 + 2\alpha z ,$$

where

$$z = \frac{2}{3}\sum_{i=1}^{3}\left[\frac{3}{m_\eta - 3m_\pi}\left(E_i - \tfrac{1}{3}m_\eta\right)\right]^2 = \frac{\rho^2}{\rho^2_{\max}} .$$

Here E_i is the energy of the ith pion in the η rest frame, and ρ is the distance to the center of the Dalitz plot. We list the parameter α in the η section of the Stable Particle Data Card Listings.

D. Baryon-decay parameters

1. A/V ratio for baryon leptonic decays. Consider the decay

$$B_i \to B_f + \ell + \nu .$$

Assuming V, A theory, neglecting "induced" scalar, "induced" pseudoscalar, and axial weak-magnetism terms, and neglecting the q^2 dependence of the form

factors, the baryon part of the matrix element for these decays may be written (Goldberger and Treiman, 1958) as

$$\langle B_f|\gamma_\lambda(g_V - g_A\gamma_5) + (g_W/m_{B_i})\sigma^{\lambda\nu}q_\nu|B_i\rangle ,$$

where B_i and B_f represent initial and final baryons, g_A and g_V the axial and vector coupling constant, g_W the weak magnetism coupling constant, and q_ν the sum of the lepton momenta. Here the Pauli representation is used for the γ matrices. The ratio g_A/g_V may be written as

$$g_A/g_V = |g_A/g_V| \exp(i\phi) ,$$

where ϕ is $0 + n\pi$ if time reversal holds (see Jackson et al., 1957).

Experiments on the leptonic decays of baryons other than the neutron have generally assumed ϕ to be either 0 or π, and have thus measured the magnitude and sign of g_A/g_V. In studying neutron beta decay, however, experiments have been sensitive enough to measure ϕ more precisely, and we include the phase angle in our Listings for this case. It is consistent with time reversal invariance, and by using the above definition of the matrix element with the Pauli representations, the value of g_A/g_V in neutron beta decay is negative.

Due to statistical limitation the weak magnetism form factor g_W is usually assumed from CVC and SU(3), so only g_A and g_V are determined experimentally. This determination is accomplished in a variety of ways.

(a) The lepton-neutrino angular correlation provides a measure of the absolute value of g_A/g_V (for relevant formulas, see, e.g., Albright, 1959).

(b) The up–down asymmetry of the lepton from polarized baryon decays provides a measure of g_A/g_V with its sign (for relevant formulas, see, e.g. Albright, 1959).

(c) The lepton spectrum, given enough statistics, provides a measure of g_A/g_V with its sign (for relevant formulas, see, e.g., Bender, 1968).

(d) The polarization of the decay baryon, from polarized or unpolarized initial baryon, also provides g_A/g_V with its sign (for formulas, see, e.g., Willis and Thompson, 1968).

(e) The presence of a term proportional to

$$\boldsymbol{\sigma}_{B_i} \cdot (\boldsymbol{p}_e \times \boldsymbol{p}_\nu) ,$$

where the initial baryon is polarized or

$$\boldsymbol{\sigma}_{B_f} \cdot (\boldsymbol{p}_e \times \boldsymbol{p}_\nu) ,$$

where the polarization of the decay baryon is observed provides a measure of the deviation of ϕ from 0 or π, and is thus a test of time reversal invariance (see, e.g., Willis and Thompson, 1968).

We compile the ratio g_A/g_V with its sign, for those decays for which it has been measured.

All the coupling constants and decay rates for baryon leptonic decays are related by Cabibbo's theory (Cabibbo, 1964). A recent fit to this theory has been done by Roos (1974).

2. Asymmetry parameters in nonleptonic hyperon decays. The transition matrix for the hyperon decay may be written as

$$M = s + p(\boldsymbol{\sigma} \cdot \boldsymbol{q}) , \tag{7}$$

where s and p are the parity-changing and the parity conserving amplitudes, respectively; $\boldsymbol{\sigma}$ is the Pauli spin operator, and $\boldsymbol{q}$ is a unit vector along the direction of the decay baryon in the hyperon rest frame.

The asymmetry parameters are defined by the relations

$$\alpha = 2\,\mathrm{Re}(s^*p)/(|s|^2 + |p|^2) ,$$

$$\beta = 2\,\mathrm{Im}(s^*p)/(|s|^2 + |p|^2) ,$$

$$\gamma = (|s|^2 - |p|^2)/(|s|^2 + |p|^2) .$$

With the transition matrix (7), the angular distribution of the decay baryon, in the hyperon rest system, is of the form

$$I = 1 + \alpha \boldsymbol{P}_Y \cdot \boldsymbol{q} ,$$

where $\boldsymbol{P}_Y = \langle Y|\sigma|Y\rangle$ is the hyperon polarization.

In the notation of Lee and Yang (1957) the polarization $\boldsymbol{P}_B$ of the decay baryon is [‡2]

$$\boldsymbol{P}_B = \frac{(\alpha + \boldsymbol{P}_Y \cdot \boldsymbol{q})\boldsymbol{q} + \beta(\boldsymbol{P}_Y \times \boldsymbol{q}) + \gamma \boldsymbol{q} \times (\boldsymbol{P}_Y \times \boldsymbol{q})}{1 + \alpha \boldsymbol{P}_Y \cdot \boldsymbol{q}} ,$$

where $\boldsymbol{P}_B$ is defined in that rest system of the baryon obtained by a Lorentz transformation along $\boldsymbol{q}$ from

[‡2] Note that Lee and Yang (1957) contains a misprint. The minus sign in the definition of β should be replaced by a 2. In addition, our unit vector $\boldsymbol{q}$ is the direction of the baryon, whereas their unit vector $\boldsymbol{p}$ is the direction of the pion.

the hyperon rest system in which $\boldsymbol{q}$ and $\boldsymbol{P}_Y$ are defined. Note that α is the helicity of the decay baryon for unpolarized hyperons.

The three parameters α, β, and γ satisfy the relation

$$\alpha^2 + \beta^2 + \gamma^2 = 1 .$$

It is then convenient to describe hyperon nonleptonic decays in terms of the two independent parameters α and the angle ϕ defined by

$$\beta = (1 - \alpha^2)^{1/2} \sin\phi ,$$

$$\gamma = (1 - \alpha^2)^{1/2} \cos\phi ,$$

which has a more nearly gaussian distribution than β or γ. Evidently

$$-\tfrac{1}{2}\pi \leqslant \phi \leqslant \tfrac{1}{2}\pi \quad \text{for} \quad \gamma > 0 ,$$

$$+\tfrac{1}{2}\pi \leqslant \phi \leqslant \tfrac{3}{2}\pi \quad \text{for} \quad \gamma < 0 .$$

In discussing time-reversal invariance, the quantity of interest is Δ, defined by

$$\alpha = 2|s||p|\cos\Delta/(|s|^2 + |p|^2) ,$$

$$\beta = -2|s||p|\sin\Delta/(|s|^2 + |p|^2) ;$$

that is, Δ is the phase angle of s relative to p. Evidently

$$-\tfrac{1}{2}\pi \leqslant \Delta \leqslant \tfrac{1}{2}\pi \quad \text{for} \quad \alpha > 0 ,$$

$$+\tfrac{1}{2}\pi \leqslant \Delta \leqslant \tfrac{3}{2}\pi \quad \text{for} \quad \alpha < 0 .$$

Under the assumption of time-reversal invariance, the angle Δ must satisfy the relation

$$\Delta = \delta_s - \delta_p ,$$

modulo π, where δ_s and δ_p are the pion–baryon scattering phase shifts at the appropriate energy and for the appropriate isospin state. For Λ decay, assuming the validity of the $|\Delta I| = \frac{1}{2}$ rule,

$$\Delta = \delta_s - \delta_p = (7.0 \pm 1.0) \text{ deg.} \ ^{\ddagger 3}$$

In the Stable Particle Data Card Listings we give α and ϕ for each decay since they are the most closely related to the experiments and are essentially uncorrelated. Whenever necessary we have changed the signs of the reported values, so as to agree with our conventions.

In the Stable Particle Table we give α, ϕ, and Δ with errors; and for convenience we also give the central value of γ, without an error.

VII. Statistical procedures

We divide this discussion on obtaining averages and errors into two sections:
A. the unconstrained case, or "simple averaging", and
B. the constrained case.

In what follows, the term "error" means one standard deviation (1σ); that is, for central value $\bar{x}$ and error $\delta\bar{x}$, the range $\bar{x} \pm \delta\bar{x}$ constitutes a 68.3% confidence interval.

A. Unconstrained averaging

We first describe the standard procedure we have used for several years to determine averages and errors. We then discuss a second method, which we feel offers a less conservative, and possibly more accurate, estimate of errors.

1. Standard procedure – gaussian distribution with scale factor. We begin by assuming that measurements of a given quantity obey a gaussian distribution, and thus we calculate a weighted average and error

$$\bar{x} \pm \delta\bar{x} = \left(\sum_i w_i x_i \Big/ \sum_i w_i\right) \pm \left[1 \Big/ \left(\sum_i w_i\right)\right]^{-1/2} , \tag{1}$$

$$w_i = [1/(\delta x_i)^2] ,$$

where x_i and δx_i are the value and error, respectively, reported by the ith experiment, and the sums run over N experiments. We also calculate χ^2 and compare it with its expectation value of $N - 1$.

If $\chi^2/(N-1)$ is less than or equal to 1, and there are no known problems with the data, we accept the above results.

If $\chi^2/(N-1)$ is ridiculously large, or if there is prior knowledge of extremely large inconsistencies between experiments, we may choose not to average the data at all. Alternatively, we may quote the calculated average, but then give an educated guess as to the error; such a guess is generally a quite conservative estimate designed to take into account known problems with the data.

Finally, if $\chi^2/(N-1)$ is greater than 1, but not to

[‡3] This value for $\delta_S - \delta_P$ is derived from the phase-shift analyses by Ayed (1976). The error is our estimation of the uncertainty allowing for possible correlations.

such a large extent, we still average the data, but then try to make up for this fact in two ways:

(i) We plot an ideogram to guide the reader in deciding which data might be rejected before selected averages are made. An example of such an ideogram is given in fig. 3 below. Each experiment appearing in the plot is represented by a gaussian with central value x_i, error δx_i, and area proportional to $1/\delta x_i$. The choice of area is a somewhat arbitrary one; it is based on the assumption that an experimenter will work to reduce his (or her) systematic errors until they are slightly smaller (but seldom much smaller) than the statistical errors. Thus, as a bubble chamber physicist gets more events, he (or she) will use them both to reduce the statistical errors and to study the biases. Our confidence that a significant systematic error has not been made in a given experiment, as compared with other contradictory experiments, then tends to go up as $1/\delta x_i$.

But why not assign a weight $1/\delta x_i^2$, as is done when computing a weighted average? We feel that this is equivalent to assuming that large systematic errors are as infrequent as large statistical fluctuations, and that this is unrealistic.

We emphasize the difference between least-squares averaging (where the weighting factor is the inverse square of the error) and the ideograms prepared for visual display. The former arithmetic is of course best if one has statistically distributed input, and yields a narrow gaussian distribution centered at the weighted mean. The ideogram (often multipeaked and certainly not gaussian) is based on the opposite hypothesis that some of the input is systematically in error. The idea behind least-squares averaging is that experiments 1, 2, 3, etc., are *all* valid (so we should multiply their probabilities). Our *ideograms* are based on the assumption that 1 *or* 2 *or* 3, etc., is valid, "hedged" with $1/\delta x_i$ betting odds; we then add their probabilities. Both approaches cannot simultaneously be right; we leave it to the reader to choose. A glance at the ideogram will show, however, that the discrepancy is often not severe for reasonably distributed input.

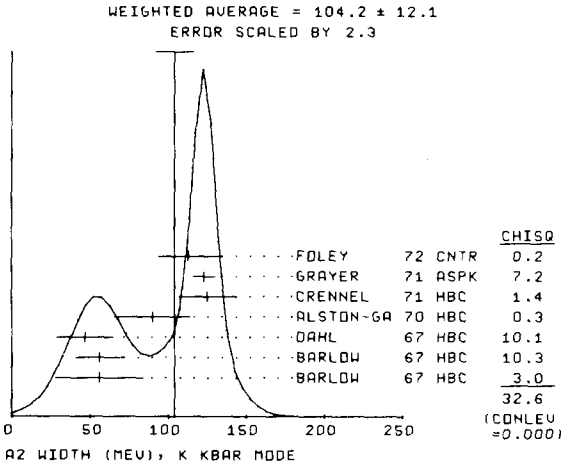

Fig. 3. Ideogram of measurements of the A_2 width, as determined from the $K\bar{K}$ mode. The vertical line indicates the position of the weighted average, while the horizontal bar atop the line gives the error in the average after scaling by the SCALE factor. Only those experiments indicated by + error flags were precise enough to be accepted in the calculation of the SCALE factor; the column on the far right gives the χ^2 contribution of each of these experiments. Occasionally, less precise experiments are included in the calculation of the weighted average, but not SCALE; they have ⊥ error flags.

(ii) The second way in which we try to take account of $\chi^2/(N-1)$ being greater than 1 is to scale up our quoted error $\delta\bar{x}$ in eq. (1) by a factor

$$\text{SCALE} = [\chi^2/(N-1)]^{1/2} . \qquad (2)$$

Our reasoning is as follows. Since we do not know which one or more of the experiments are wrong, we assume that all experimentalists underestimated their errors by the same scale factor (2). If we scale up all input errors by this factor, χ^2 returns to $N-1$, and of course the output error scales up by the same factor

If all the experiments have errors of about the same size, the above (straightforward) procedure for calculating SCALE is carried out. If, however, we are to combine experiments with widely varying errors, we must modify the procedure slightly. This is because it is the more precise experiments that most influence not only the average value $\bar{x}$, but also the error $\delta\bar{x}$. Now, on the average, the low-precision experiments each contribute about unity to *both* the numerator and the denominator of SCALE, hence the χ^2 contribution of the sensitive experiments is diluted, i.e., reduced. Therefore, we evaluate SCALE by using *only* experiments for which the errors are not much greater than those of the more precise experiments. Explicitly, to calculate SCALE we use only the most sensitive experiments, i.e., those with errors less than δ_0, where the ceiling δ_0 is (arbitrarily) chosen to be

$$\delta_0 = 3N^{1/2}\delta\bar{x} .$$

Here $\delta\bar{x}$ is the unscaled error of the mean of all the experiments. Note that if each experiment had the same error δx_i, then $\delta\bar{x}$ would be $\delta x_i/N^{1/2}$, so each individual experiment would be well under the ceiling on SCALE.

This scaling approach has the property that if there are two values with comparable errors separated by much more than their stated errors (with or without a number of other experiments of lower accuracy), the error on the mean value $\delta\bar{x}$ is increased so that it is approximately half the interval between the two discrepant values.

We wish to emphasize the fact that our scaling procedures for *errors* in no way affect central values. In addition, if one wishes to recover the unscaled error $\delta\bar{x}$, one need only divide the given error by the SCALE factor for that error.

2. A second procedure – Student's distribution. The second method of averaging data, described in detail in Roos et al. (1975), relies upon an empirical determination of the distribution of the residuals for the ensemble of data appearing in the Review. The residual for the ith measurement of a quantity with average value $\bar{x}$ is defined as

$$h_i = (x_i - \bar{x})/\delta x_i .$$

Roos et al. select several different subsamples of the data, and show that the residuals for *each* subsample have approximately the same properties; in particular, their first few even moments are similar. Since the distributions have longer tails than a gaussian, the authors choose to represent them by a distribution function having such a property, namely the Student distribution

$$S_n(h/c) = K\left[1 + \frac{(h/c)^2}{n}\right]^{-(n+1)/2} . \qquad (3)$$

Here K is a normalization constant, and n and c are parameters which the authors then fit to the combined sample of data. The resulting empirical distribution is

$$S_{10}(h/1.11) = 0.351\left[1 + \frac{(h/1.11)^2}{10}\right]^{-11/2} . \qquad (4)$$

Note that the shape of S_{10} is somewhere between that of a gaussian ($=S_\infty$) and that of a Breit–Wigner ($=S_1$).

The proposed method of averaging the data for a given quantity then consists of finding the value of $\bar{x}$ which maximizes the log-likelihood function

$$\log \mathcal{L}(\{x_i\}|\bar{x}) = \sum_i \log\left[S_{10}\left(\frac{x_i - \bar{x}}{1.11\,\delta x_i}\right)\right] ; \qquad (5)$$

the sum here is again taken over all N measurements of x. The error $\delta\bar{x}$ is determined by finding the variation in $\bar{x}$ needed to decrease the log-likelihood by 1/2:

$$\log \mathcal{L}(\{x_i\}|\bar{x}) - \log \mathcal{L}(\{x_i\}|\bar{x} \pm \delta\bar{x}) = \tfrac{1}{2} . \qquad (6)$$

3. Comparison of procedures. Both of the procedures described above adopt a partially empirical approach to the problem that measured values for the quantities tabulated in this Review do not exhibit the gaussian behavior naively expected. (This problem, it should be noted, persists even when careful attempts are made to resolve difficulties and inconsistencies in the data prior to averaging.)

The first approach operates on a quantity-by-quantity basis and adjusts the error in each case so that no scaled $\chi^2/(N-1)$ is greater than 1. This is obviously rather conservative, since even if the data obeyed a gaussian distribution, about half of the quantities would be expected to have $\chi^2/(N-1) > 1$.

The second approach, on the other hand, assumes that (provided we first eliminate quantities with obvious, known problems) all quantities have the same theoretical distribution function, namely the fairly long-tailed $S_{10}(h/1.11)$. With this supposition, if a *particular* quantity has a large χ^2, it is assumed to be just a happenstance, occasioned by a random fluctuation into the long tails, and no special scaling for this quantity is done. This procedure thus results in generally smaller, or less conservative, error estimates for quantities having $\chi^2/(N-1) > 1$. (However, it should be noted that, because of the overall scale of 1.11 appearing in the empirical Student's distribution, the errors for quantities with $\chi^2/(N-1) \leqslant 1$ are actually increased by about 10%.) Table 3 shows some comparisons of sample results from the two procedures, using data from the 1974 edition of the Review. Shifts in both $\bar{x}$ and $\delta\bar{x}$ can be observed, especially where SCALE > 1.

Since the new procedure is a significant departure from the past, we have repeated the previously adopted

Table 3
Comparison of procedures (data from 1974 edition).

Particle property	Pure gaussian $\bar{x} \pm \delta\bar{x}$	Standard method: gaussian + scale factor		Proposed method: Student's distribution $\bar{x} \pm \delta\bar{x}$
		$\bar{x} \pm \delta\bar{x}$	SCALE	
ρ^0 mass (MeV)	770.32 ± 0.65	770.32 ± 0.91	1.4	770.37 ± 0.82
η' mass (MeV)	957.59 ± 0.24	957.59 ± 0.24	1.0	957.58 ± 0.28
ϕ mass (MeV)	1019.69 ± 0.15	1019.69 ± 0.28	1.9	1019.83 ± 0.20
$K^*(1420)$ mass (MeV)	1421.3 ± 2.3	1421.3 ± 2.3	1.0	1421.3 ± 2.6
K_L^0 mean life (10^{-8} s)	5.158 ± 0.042	5.158 ± 0.042	1.0	5.158 ± 0.046
Σ^+ mean life (10^{-10} s)	0.8004 ± 0.0058	0.8004 ± 0.0058	1.0	0.8004 ± 0.0064
Σ^- mean life (10^{-10} s)	1.482 ± 0.011	1.482 ± 0.017	1.5	1.479 ± 0.013
$K^\pm \to \pi^\pm\pi^+\pi^-$ (%)	5.521 ± 0.075	5.521 ± 0.098	1.3	5.533 ± 0.089
$\Lambda \to p\pi^-$ (%)	63.99 ± 0.49	63.99 ± 0.49	1.0	63.98 ± 0.55

approach: in the Data Card Listings we give the average-and-error for each quantity calculated both ways; the standard way is labelled at the left with the code "AVG", while the second way is labelled "STUDENT". In the Tables of Particle Properties, we continue to use the standard procedure – gaussian with SCALE factor. As in the past, a SCALE factor greater than 1 is indicated by the appearance of "S = ..." next to the value and error.

We heartily invite your comments on the Student's distribution method. They will assist us in deciding on procedures for future editions.

B. Constrained fits

Except for trivial cases, all branching ratios and rate measurements are analyzed by the computer program AHR. This program makes a simultaneous least-squares fit to all the data, and outputs the partial-decay fractions $\bar{P}_i$, width Γ, partial widths Γ_i, and their error matrix.

The original version of AHR was written by J. Peter Berge. It is documented separately, and we wish here only to give the simplest nontrivial example that permits us to comment on the error matrix and the scale factor.

Assume that a state has only three partial-decay fractions, P_1, P_2, and P_3 ($\Sigma P_i = 1$), which have been measured in four different ratios, $R_1, \ldots, R_4$, where, e.g., $R_1 = P_1/P_2$, $R_2 = P_1/P_3$, etc.[‡4] Further assume that *each* ratio has been measured by N experiments (we designate each experiment with a subscript x, e.g., R_{1x}). Then AHR finds the best values of P_1, P_2, and P_3 by minimizing χ^2, namely

$$\chi^2 = \sum_{r=1}^{4}\left[\sum_{x=1}^{N}\left(\frac{R_{rx} - R_r(P_1,P_2,P_3)}{\delta R_{rx}}\right)^2\right]. \qquad (7)$$

In addition to the fitted values $\bar{P}_i$, the program calculates an error matrix $\langle\delta\bar{P}_i\delta\bar{P}_j\rangle$. We tabulate the diagonal elements $\delta\bar{P}_i = \langle\delta\bar{P}_i\delta\bar{P}_i\rangle^{1/2}$ (except that some errors are scaled according to eq. (2) as discussed below). In the listings we give the complete error matrix; we also calculate the fitted value of each ratio, for comparison with the input data, and list it below the relevant input, along with a simple unconstrained average of the same input.

Two further comments on the example above.

(1) There was no connection between measurements of the width and the branching ratios. But often we also have information on partial widths Γ_i as well as total width Γ. In this case AHR must introduce Γ as a parameter into the fit, along with the relations $\Gamma_i = \Gamma P_i$, $\Sigma\Gamma_i = \Gamma$. When appropriate, we tabulate the Γ_i along with the P_i, and give error matrices in the listings.

(2) Note that we do *not* allow for correlations between input data. We *do* try to pick those ratios and widths which are as independent and as close to the original data as possible.

In *asymmetric* errors, we use a continuous function of $\delta(P)^+$ and $\delta(P)^-$ in the fitting. When no errors are

[‡4] We can handle any R of the form $R = \Sigma\alpha_i P_i / \Sigma\beta_i P_i'$, where α_i and β_i are constants, usually 1 or 0.

reported, we merely list the data for inspection.

Hyperon-decay parameters. The program AHR handles any type of input, α, Φ, Δ, β, or γ, according to the definitions of section VI. If for a particular hyperon decay there are data for more than two of the decay parameters, they are analyzed by using the constraint

$$\alpha^2 + \beta^2 + \gamma^2 = 1 .$$

Inconsistent constrained data. According to our simple example, which led to eq. (7), the double sum for χ^2 is summed over experiments $x = 1$ to N, leaving a single sum over ratios

$$\chi^2 = \sum_r \chi_r^2 .$$

Even before fitting, some of the χ_r^2 may be too large. But if we scaled them before fitting, then the scaling would move the central value, contrary to our policy. So we do not scale until after the first fit; then, knowing the fitted χ_r^2 and its expectation value $\langle\chi_r^2\rangle$ we form SCALE factors (just as before), i.e.,

$$(\mathrm{SCALE})_r^2 = \chi_r^2/\langle\chi_r^2\rangle ,$$

and if any $(\mathrm{SCALE})_r$ is greater than 1, all N of the measurements of that particular ratio are equally penalized by having their errors increased by SCALE. Program AHR then recycles on all the data, those with errors unchanged as well as those with errors increased. We then get new values, $\delta\bar{P}_i'$ for the errors in the partial decay modes.

Because of the constraint ($\Sigma P_i = 1$) some SCALE factors may still be greater than 1 even after this second pass. If this is so, the whole procedure (i.e., increasing errors by the new SCALE factors and recycling through AHR) is repeated.

At the end of AHR's final pass we have *two* measures of the errors for the $\bar{P}_i$. One is, of course, the $\delta\bar{P}_i'$, i.e., the errors in the final fitted values $\bar{P}_i'$ which include the effects of scaling the input errors. The other measure of the errors is $(\bar{P}_i - \bar{P}_i')$, i.e., the *shift* in the central values of the ith mode between the first (unscaled) fit and the final (scaled) fit. In practice we find that on the average these two measures of the uncertainty are about equal. Rather than selecting just one or the other, our tabulated errors are given by the combination

$$(\delta\bar{P}_i)_{\mathrm{tab}} = [\delta\bar{P}_i'^2 + (\bar{P}_i - \bar{P}_i')^2]^{1/2} ,$$

where $\bar{P}_i$ is the fitted value of the ith partial-decay mode before scaling, $\bar{P}_i'$ is its value after scaling, and $\delta\bar{P}_i'$ is the error in $\bar{P}_i'$. The SCALE factors we finally list in such cases are defined by

$$(\mathrm{SCALE})_i = (\delta\bar{P}_i)_{\mathrm{tab}}/\delta\bar{P}_i .$$

However, in line with our policy of not letting SCALE affect the central values, we give the values of $\bar{P}_i$ obtained from the original (unscaled) fits. (The differences between the $\bar{P}_i$ calculated with either the scaled or the unscaled errors are, of course, always within the tabulated errors, $(\delta\bar{P}_i)_{\mathrm{tab}}$.)

Acknowledgments

We wish to make special note of the end of an era. Art Rosenfeld, co-founder of the Particle Data Group and its director for many years has resigned from the group to devote full time to his activities on behalf of energy research. It was 22 years ago that the first "wallet card" appeared. That small start has grown into a multi-national effort involving more than a score of physicists, and a product which is in constant use throughout the world. His foresight and guidance will be missed, and we wish him equal success in his new endeavors.

We thank all those who have assisted in the many phases of preparing this Review. In particular, we acknowledge the usefulness of feedback from the physics community, especially those who have made suggestions or pointed out errors. The European members of the Particle Data Group wish to acknowledge the generous support of CERN, in particular through Dr. A. Günther and his services.

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TABLES OF PARTICLE PROPERTIES

April 1978

N. Barash-Schmidt, A. Barbaro-Galtieri, C. Bricman, R. L. Crawford,
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M. J. Losty, M. Mazzucato, L. Montanet, A. Rittenberg,
M. Roos, T. G. Trippe, G. P. Yost

(Closing date for data: Jan. 1, 1978)

Stable Particle Table

For additional parameters, see Addendum to this table.

Quantities in italics have changed by more than one (old) standard deviation since April 1976.

Particle	$I^G(J^P)C_n$ [a]	Mass (MeV) Mass^2 (GeV)^2	Mean Life (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
γ	$0,1(1^-)-$	$0(<6\times10^{-22})$	stable	stable		
ν_e	$J=\frac{1}{2}$	$0(<0.00006)$	stable $(>3\times10^{8}\, m_{\nu_e}$(MeV))	stable		
e	$J=\frac{1}{2}$	$0.5110034 \pm .0000014$	stable $(>5\times10^{21}$y)	stable		
ν_μ	$J=\frac{1}{2}$	$0(<0.57)$	stable $(>1.3\times10^{4}\, m_{\nu_\mu}$(MeV))	stable		
μ	$J=\frac{1}{2}$	$105.65946 \pm .00024$ $m^2=0.01116392$ $m_\mu-m_{\pi^\pm}=-33.9074 \pm .0012$	$2.197134\times10^{-6} \pm .000077$ $c\tau=6.5868\times10^{4}$	$\mu^- \to e^- \bar{\nu}\nu$ $e^- \bar{\nu}\nu\gamma$ $e^-\gamma\gamma$ $e^-e^+e^-$ $e^-\gamma$ $e^-\nu_e\bar{\nu}_\mu$	$(98.6 \pm 1.4)\%$ [e] $(<4)\times10^{-6}$ $(<1.9)\times10^{-9}$ $(<3.6)\times10^{-9}$ $(<25)\%$	53 53 53 53 53 53
τ	$J=\frac{1}{2}$ [f]	1807 ± 20 $m^2=3.27$		$\tau^- \to \mu^- \bar{\nu}\nu$ $e^- \bar{\nu}\nu$	$(17.5 \pm 1.7)\%$ $(17.9 \pm 2.8)\%$	900 903
$\pi^\pm$	$1^-(0^-)$	$139.5669 \pm .0012$ $m^2=0.0194789$	$2.6030\times10^{-8} \pm .0023$ $c\tau=780.4$ $(\tau^+-\tau^-)/\bar{\tau}=(0.05\pm0.07)\%$ (test of CPT)	$\pi^+ \to \mu^+\nu$ $e^+\nu$ $\mu^+\nu\gamma$ $e^+\nu\pi^0$ $e^+\nu\gamma$ $e^+\nu e^+e^-$	$100\ \%$ $(1.267\pm0.023)\times10^{-4}$ $(1.24\pm0.25)\times10^{-4}$ [e] $(1.02\pm0.07)\times10^{-8}$ $(2.15\pm0.50)\times10^{-8}$ [e] $(<5)\times10^{-9}$	30 70 30 5 70 70
π^0	$1^-(0^-)+$	$134.9626 \pm .0039$ $m^2=0.0182149$ $m_{\pi^\pm}-m_{\pi^0}=4.6043 \pm .0037$	$0.828\times10^{-16} \pm .057$ S=1.8* $c\tau=2.5\times10^{-6}$	$\gamma\gamma$ γe^+e^- $\gamma\gamma\gamma$ $e^+e^-e^+e^-$ $\gamma\gamma\gamma\gamma$ e^+e^-	$(98.85\pm0.05)\%$ $(1.15\pm0.05)\%$ $(<5)\times10^{-6}$ $(3.32)\times10^{-5}$ [g] $(<6)\times10^{-5}$ $(<2)\times10^{-6}$	67 67 67 67 67 67
η	$0^+(0^-)+$	548.8 ± 0.6 S=1.4* $m^2=0.3012$	$\Gamma=(0.85\pm0.12)$keV [i] Neutral decays (71.0±0.7)% S=1.1* Charged decays (29.0±0.7)% S=1.1*	$\gamma\gamma$ $\pi^0\gamma\gamma$ [h] $3\pi^0$ $\pi^+\pi^-\pi^0$ $\pi^+\pi^-\gamma$ $e^+e^-\gamma$ $e^+e^-\pi^0$ $\pi^+\pi^-$ $e^+e^-\pi^+\pi^-$ $\pi^+\pi^-\pi^0\gamma$ $\pi^+\pi^-\gamma\gamma$ $\mu^+\mu^-$ $\mu^+\mu^-\pi^0$ e^+e^-	$(38.0\pm1.0)\%$ S=1.2* $(3.1\pm1.1)\%$ S=1.2* $(29.9\pm1.1)\%$ S=1.1* $(23.6\pm0.6)\%$ S=1.1* $(4.89\pm0.13)\%$ S=1.1* $(0.50\pm0.12)\%$ $(<4)\times10^{-5}$ $(<0.15)\%$ $(0.1\pm0.1)\%$ $(<6)\times10^{-4}$ $(<0.2)\%$ $(2.2\pm0.8)\times10^{-5}$ $(<5)\times10^{-4}$ $(<3)\times10^{-4}$	274 258 180 175 236 274 258 236 236 175 236 253 211 274

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C_n$ [d]	Mass (MeV) Mass^2 (GeV)^2	Mean life (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
				$K^+ \to$ [d]		
$K^\pm$	$\frac{1}{2}(0^-)$	*493.668* *±0.018* m^2= 0.24371	1.2371×10^{-8} ±.0026 S=1.9* $c\tau$=370.9 $(\tau^+-\tau^-)/\overline{\tau}$= (.11±.09)% (test of CPT) S=1.2*	$\mu^+\nu$	(63.50±0.16)%	236
				$\pi^+\pi^0$	(21.16±0.15)%	205
				$\pi^+\pi^+\pi^-$	(5.59±0.03)% S=1.1*	125
				$\pi^+\pi^0\pi^0$	(1.73±0.05)% S=1.3*	133
				$\mu^+\nu\pi^0$	(3.20±0.09)% S=1.7*	215
				$e^+\nu\pi^0$	(4.82±0.05)% S=1.1*	228
				$\mu^+\nu\gamma$	[e] (5.8 ±3.5)$\times10^{-3}$	336
				$e^+\nu\pi^0\pi^0$	(1.8 $^{+2.4}_{-0.6}$)$\times10^{-5}$	207
		$m_{K^\pm}-m_{K^0}$=-4.01 ±0.13 S=1.1*		$e^+\nu\pi^+\pi^-$	(3.90±0.15)$\times10^{-5}$	203
				$e^-\overline{\nu}\pi^+\pi^+$	(<5)$\times10^{-7}$	203
				$\mu^+\nu\pi^+\pi^-$	(0.9 ±0.4)$\times10^{-5}$	151
				$\mu^-\overline{\nu}\pi^+\pi^+$	(<3.0)$\times10^{-6}$	151
				$e^+\nu$	(1.54±0.09)$\times10^{-5}$	247
				$e^+\nu\gamma$	[e] (1.62±0.47)$\times10^{-5}$	247
				$\pi^+\pi^0\gamma$	[i,e] (2.75±0.16)$\times10^{-4}$	205
				$\pi^+\pi^+\pi^-\gamma$	[e] (1.0 ±0.4)$\times10^{-4}$	125
				$\mu^+\nu\pi^0\gamma$	[e] (<6)$\times10^{-5}$	215
				$e^+\nu\pi^0\gamma$	[e] (3.7 ±1.4)$\times10^{-4}$	228
				$e^+e^-\pi^+$	(2.6 ±0.5)$\times10^{-7}$	227
				$e^+e^+\pi^-$	(<1)$\times10^{8}$	227
				$\mu^+\mu^-\pi^+$	(<2.4)$\times10^{-6}$	172
				$\pi^+\gamma\gamma$	[e] (<3.5)$\times10^{-5}$	227
				$\pi^+\gamma\gamma\gamma$	[e] (<3.0)$\times10^{-4}$	227
				$\pi^+\nu\overline{\nu}$	(<0.6)$\times10^{-6}$	227
				$\pi^+\gamma$	(<4)$\times10^{-6}$	227
				$e^+\mu^\pm\pi^\mp$	(<7)$\times10^{-9}$	214
				$e^-\mu^+\pi^+$	(<5)$\times10^{-9}$	214
				$\mu^+\nu\overline{\nu}\overline{\nu}$	(<6)$\times10^{-6}$	236
				$\mu^+\nu e^+e^-$	(11 ±3)$\times10^{-7}$	236
				$\mu^-\nu e^+e^+$	(<2.0)$\times10^{-8}$	236
				$e^+\nu e^+e^-$	(2 $^{+2}_{-1}$)$\times10^{-7}$	247
K^0 $\overline{K}^0$	$\frac{1}{2}(0^-)$	497.67 ±0.13 S=1.1* m^2=0.24768	50% K_{Short}, 50% K_{Long}			
				$K^0_S \to$		
K^0_S	$\frac{1}{2}(0^-)$		0.8923×10^{-10} [j] ±.0022 $c\tau$=2.675	$\pi^+\pi^-$	(68.61±0.24)% S=1.1*	206
				$\pi^0\pi^0$	(31.39)%	209
				$\mu^+\mu^-$	(<3.2)$\times10^{-7}$	225
				e^+e^-	(<3.4)$\times10^{-4}$	249
				$\pi^+\pi^-\gamma$	[e] (1.85±0.10)$\times10^{-3}$	206
				$\gamma\gamma$	(<0.4)$\times10^{-3}$	249
				$K^0_L \to$		
K^0_L	$\frac{1}{2}(0^-)$		5.183×10^{-8} ±.040 $c\tau$=1554	$\pi^0\pi^0\pi^0$	(21.5 ±0.7)% S=1.3*	139
				$\pi^+\pi^-\pi^0$	(12.39±0.18)% S=1.2*	133
				$\pi^\pm\mu^\mp\nu$	(27.0 ±0.5)% S=1.1*	216
				$\pi^\pm e^\mp\nu$	[k] (38.8 ±0.5)% S=1.1*	229
				$\pi e\nu\gamma$	[k,e] (1.3 ±0.8)%	229
		$m_{K_L}-m_{K_S}$= $0.5349\times10^{10}\hbar$ sec^{-1} ±0.0022		$\pi^+\pi^-$	[j] (0.203±0.005)%	206
				$\pi^0\pi^0$	(0.094±0.018)% S=1.5*	209
				$\pi^+\pi^-\gamma$	[e] (6.0 ±2.0)$\times10^{-5}$	206
				$\pi^0\gamma\gamma$	(<2.4)$\times10^{-4}$	231
				$\gamma\gamma$	(4.9 ±0.5)$\times10^{-4}$	249
				$\epsilon\mu$	(<2.0)$\times10^{-9}$	238
				$\mu^+\mu^-$	(9.1 ±1.8)$\times10^{-9}$	225
				$\mu^+\mu^-\gamma$	(<7.8)$\times10^{-6}$	225
				$\mu^+\mu^-\pi^0$	(<5.7)$\times10^{-5}$	177
				e^+e^-	(<2.0)$\times10^{-9}$	249
				$e^+e^-\gamma$	(<2.8)$\times10^{-5}$	249
				$\pi^+\pi^-e^+e^-$	(<8.8)$\times10^{-6}$	206
				$\pi^0\pi^\pm e^\mp\nu$	(<2.2)$\times10^{-3}$	207
				$D^+ \to$ [d]		
$D^\pm$	$\frac{1}{2}(0^-)$[f]	1868.3[l] ±0.9 m^2= 3.491 $m_{D^\pm}-m_{D^0}$=5.0 ±0.8		$K^-\pi^+\pi^+$	(3.9 ±1.0)%	845
				$K^0\pi^+$	(1.5 ±0.6)%	862
				$e^\pm$anything [m]	(9.8 ±1.4)%	934
				$\pi^+\pi^+\pi^-$	(<0.31)%	908
				$\pi^+K^+K^-$	(<0.6)%	743
				$K^+\pi^+\pi^-$	(<0.20)%	845
				$D^0 \to$ [d]		
D^0 $\overline{D}^0$	$\frac{1}{2}(0^-)$[f]	1863.3[l] ±0.9 m^2= 3.472		$K^-\pi^+$	(1.8 ±0.5)%	860
				$K^-\pi^+\pi^0$	(12 ±6)%	843
				$K^-\pi^+\pi^+\pi^-$	(3.5 ±0.9)%	812
				$K^0\pi^0$	(<6)%	860
				$K^0\pi^+\pi^-$	(4.4 ±1.1)%	841
		$\frac{\Gamma(D^0\to\overline{D}^0\to K^+\pi^-)}{\Gamma(D^0\to K\pi)}$<0.16		$e^\pm$anything [m]	(9.8 ±1.4)%	932
				$\pi^+\pi^-$	(<0.13)%	921
				K^+K^-	(<0.13)%	790

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Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C_n$ [a]	Mass (MeV) $Mass^2$ $(GeV)^2$	Mean life (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction [b]	p or p_{max} [c] (MeV/c)
p	$\frac{1}{2}(\frac{1}{2}^+)$	938.2796 ±0.0027 m^2= 0.880369	stable (>2×10^{30}y)			
n	$\frac{1}{2}(\frac{1}{2}^+)$	939.5731 ±0.0027 m^2= 0.882798 m_p-m_n=-1.29343 ±0.00004	918±14 $c\tau=2.75\times10^{13}$	$pe^-\nu$	100 %	1
Λ	$0(\frac{1}{2}^+)$	1115.60 ±0.05 S=1.2* m^2= 1.2446 $m_\Lambda-m_{\Sigma^0}$= -76.87 ±0.08	*2.632×10^{-10}* *±.020* S=1.6* *$c\tau=7.89$*	$p\pi^-$ $n\pi^0$ $pe^-\nu$ $p\mu^-\nu$ $p\pi^-\gamma$	(64.2 ± 0.5)% (35.8 ± 0.5)% (8.07±0.28)$\times10^{-4}$ (1.57±0.35)$\times10^{-4}$ [e] (0.85±0.14)$\times10^{-3}$	100 104 163 131 100
Σ^+	$1(\frac{1}{2}^+)$	1189.37 ±0.06 S=1.8* m^2= 1.4146 $m_{\Sigma^+}-m_{\Sigma^-}$= -7.98 ±.08 S=1.2*	0.802×10^{-10} ±.005 $c\tau=2.40$ $\frac{\Gamma(\Sigma^+\to\ell^+n\nu)}{\Gamma(\Sigma^-\to\ell^-n\nu)}$<.04 ←	$p\pi^0$ $n\pi^+$ $p\gamma$ $n\pi^+\gamma$ $\Lambda e^+\nu$ $n\mu^+\nu$ $ne^+\nu$ pe^+e^-	(51.6 ±0.7)% (48.4 ±0.7)% (1.24±0.18)$\times10^{-3}$ S=1.4* [e] (0.93±0.10)$\times10^{-3}$ (2.02±0.47)$\times10^{-5}$ (<3.0)$\times10^{-5}$ (<0.5)$\times10^{-5}$ (<7)$\times10^{-6}$	189 185 225 185 71 202 224 225
Σ^0	$1(\frac{1}{2}^+)$	1192.47 ±0.08 m^2= 1.4220	5.8×10^{-20} ±1.3 $c\tau=1.7\times10^{-9}$	$\Lambda\gamma$ Λe^+e^- $\Lambda\gamma\gamma$	100 % [g] (5.45)$\times10^{-3}$ (<3)%	74 74 74
Σ^-	$1(\frac{1}{2}^+)$	1197.35 ±0.06 m^2= 1.4336 $m_{\Sigma^0}-m_{\Sigma^-}$= -4.88 ±.06	1.483×10^{-10} ±.015 S=1.4* $c\tau=4.45$	$n\pi^-$ $ne^-\nu$ $n\mu^-\nu$ $\Lambda e^-\nu$ $n\pi^-\gamma$	100 % (1.08±0.04)$\times10^{-3}$ (0.45±0.04)$\times10^{-3}$ (0.60±0.06)$\times10^{-4}$ [e] (4.6 ±0.6)$\times10^{-4}$	193 230 210 79 193
Ξ^0	$\frac{1}{2}(\frac{1}{2}^+)^n$	1314.9 ±0.6 m^2= 1.7290 $m_{\Xi^0}-m_{\Xi^-}$=-6.4 ±.6	2.90×10^{-10} ±.10 $c\tau=8.69$	$\Lambda\pi^0$ $\Lambda\gamma$ $\Sigma^0\gamma$ $p\pi^-$ $pe^-\nu$ $\Sigma^+e^-\nu$ $\Sigma^-e^+\nu$ $\Sigma^+\mu^-\nu$ $\Sigma^-\mu^+\nu$ $p\mu^-\nu$	100 % (0.5 ±0.5)% (<7)% (<3.6)$\times10^{-5}$ (<1.3)$\times10^{-3}$ (<1.1)$\times10^{-3}$ (<0.9)$\times10^{-3}$ (<1.1)$\times10^{-3}$ (<0.9)$\times10^{-3}$ (<1.3)$\times10^{-3}$	135 184 117 299 323 120 112 64 49 309
Ξ^-	$\frac{1}{2}(\frac{1}{2}^+)^n$	1321.32 ±0.13 m^2= 1.7459	1.654×10^{-10} ±.021 $c\tau=4.96$	$\Lambda\pi^-$ $\Lambda e^-\nu$ $\Sigma^0e^-\nu$ $\Lambda\mu^-\nu$ $\Sigma^0\mu^-\nu$ $n\pi^-$ $ne^-\nu$ $n\mu^-\nu$ $\Sigma^-\gamma$ $p\pi^-\pi^-$ $p\pi^-e^-\nu$ $p\pi^-\mu^-\nu$ $\Xi^0e^-\nu$	100 % [o] (0.69±0.18)$\times10^{-3}$ (<0.5)$\times10^{-3}$ (3.5 ±3.5)$\times10^{-4}$ (<0.8)$\times10^{-3}$ (<1.1)$\times10^{-3}$ (<3.2)$\times10^{-3}$ (<1.5)% (<1.2)$\times10^{-3}$ (<4)$\times10^{-4}$ (<4)$\times10^{-4}$ (<4)$\times10^{-4}$ (<2.3)$\times10^{-4}$	139 190 123 163 70 303 327 313 118 223 304 250 6
Ω^-	$0(\frac{3}{2}^+)^n$	1672.2 ±.4 m^2= 2.7963	$1.1^{+0.4}_{-0.3}\times10^{-10}$ [p] S=2.5* $c\tau=3$	$\Xi^0\pi^-$ $\Xi^-\pi^0$ ΛK^-	100%	293 290 211

→

ADDENDUM TO

Stable Particle Table

e

Magnetic moment

1.001 159 652 41 $\frac{e\hbar}{2m_e c}$
±.000 000 000 20

μ

1.001 165 922 $\frac{e\hbar}{2m_\mu c}$
±.000 000 009

μ Decay parameters [q]

ρ = 0.752±0.003 η = − 0.12 ±0.21
ξ = 0.972±0.013 δ = 0.755±0.009 h = 1.00±0.13
$|g_A/g_V| = 0.86^{+0.33}_{-0.11}$ ϕ = 180°±15°

η

Mode	Left-right asymmetry	Sextant asymmetry	Quadrant asymmetry
$\pi^+\pi^-\pi^0$	(0.12±.17)%	(0.19±0.16)%	(−0.17±0.17)%
$\pi^+\pi^-\gamma$	(0.88±.40)%		β=0.047±0.062

$K^\pm$

Mode	Partial rate (sec^{-1})	
$\mu\nu$	(51.33±0.17)×10^6	S=1.2*
$\pi\pi^0$	(17.10±0.13)×10^6	S=1.1*
$\pi\pi^+\pi^-$	(4.52±0.02)×10^6	S=1.1*
$\pi\pi^0\pi^0$	(1.40±0.04)×10^6	S=1.3*
$\mu\pi^0\nu$	(2.58±0.07)×10^6	S=1.7*
$e\pi^0\nu$	(3.90±0.04)×10^6	S=1.1*

Slope parameters for $K \to 3\pi$ [r]

$K^+\to\pi^+\pi^+\pi^-$ g=−0.215±.004 S=1.5*
$K^-\to\pi^-\pi^-\pi^+$ g=−0.214±.007 S=2.7*
$K^\pm\to\pi^0\pi^0\pi^\pm$ g= 0.561±.021 S=1.7*
$K^0_L\to\pi^+\pi^-\pi^0$ g= *0.670±.014* S=1.6*

See Data Card Listings for quadratic coefficients.

K^0_S

$\pi^+\pi^-$	[s] (0.7689±.0033)×10^10	
$\pi^0\pi^0$	[s] (0.3517±.0029)×10^10	S=1.1*

K^0_L

$\pi^0\pi^0\pi^0$	(4.14 ±0.15)×10^6	S=1.3*
$\pi^+\pi^-\pi^0$	(2.39 ±0.04)×10^6	S=1.2*
$\pi\mu\nu$	(5.21 ±0.10)×10^6	S=1.1*
$\pi e\nu$	(7.49 ±0.11)×10^6	S=1.1*
$\pi^+\pi^-$ [j,s]	(3.91 ±0.10)×10^4	
$\pi^0\pi^0$ [s]	(1.81 ±0.35)×10^4	S=1.5*

K^+_{l3}: λ^e_+= 0.029±.004; λ^μ_+= 0.026±.008 S=1.5*; λ^0_+= −0.003±.007 S=1.5*
K^0_{l3}: λ^e_+= 0.0300±.0018 S=1.2*; λ^μ_+= 0.034 ±.006 S=2.5*; λ^0_+= 0.020 ±.007 S=2.5*

See Data Card Listings for ξ, f_s, and f_t.

CP violation parameters [t,s,j]

$|\eta_{+-}|$=(2.274±.022)×10^−3 $|\eta_{00}|$=(2.32±.09)×10^−3 S=1.1*
ϕ_{+-}=(45.0±1.2)° ϕ_{00}=(48±13)°
$|\eta_{+-0}|^2$<0.12 $|\eta_{000}|^2$<0.28 δ=(0.330±.012)×10^−2

ΔS = −ΔQ

Re x=0.009±.020 S=1.4* Im x = −0.004±.026 S=1.1*

	Magnetic moment ($e\hbar/2m_pc$)	Decay parameters[u] Measured α	Measured φ(degree)	Derived γ	Derived Δ(degree)	g_A/g_V	g_V/g_A
p	2.7928456 ±.0000011						
n	−1.91304211 ±.00000088	$pe^-\nu$				−1.253±0.007	δ=(180.20±0.19)°
Λ	−0.606 ±.034	$p\pi^-$ 0.642±0.013 $n\pi^0$ 0.646±0.044 $pe\nu$	(−6.5±3.5)°	0.76	$(7.7^{+4.0}_{-4.1})°$	−0.62±0.05 S=1.2*	
Σ^+	2.83 ±.25	$p\pi^0$ −0.978±0.016 $n\pi^+$ +0.072±0.015 $p\gamma$ $-1.03^{+0.52}_{-0.42}$	(36±34)° (167±20)° S=1.1*	0.17 −0.97	(187±6)° $(-72^{+132}_{-11})°$		
Σ^-	−1.48 ±.37	$n\pi^-$ −0.069±0.008 $ne^-\nu$ $\Lambda e^-\nu$	(10±15)°	0.98	$(249^{+12}_{-115})°$	*±(0.385±0.070)* S=2.3* 0.24±0.23 S=1.3*	
Ξ^0		$\Lambda\pi^0$ −0.44±0.08 S=1.3*	(21±12)°	0.84	$(216^{+13}_{-19})°$		
Ξ^-	−1.85 ±.75	$\Lambda\pi^-$ −0.392±0.021	(2±6)° S=1.1*	0.92	(185±13)°		
Ω^-		ΛK^- $-0.66^{+0.36}_{-0.30}$					

Stable Particle Table *(cont'd)*

→ Indicates an entry in the Stable Particle Data Card Listings not entered in the Stable Particle Table. We do not regard these as established particles.

*S = Scale factor = $\sqrt{\chi^2/(N-1)}$, where N ≈ number of experiments. S should be ≈ 1. If S > 1, we have enlarged the error of the mean, $\delta\bar{x}$; i.e., $\delta\bar{x} \rightarrow S\delta\bar{x}$. This convention is still inadequate, since if S >> 1 the experiments are probably inconsistent, and therefore the real uncertainty is probably even greater than $S\delta x$. See text, and ideograms in Stable Particle Data Card Listings.

a. The baryon number B, strangeness S, and charm C of the hadrons which appear in the tables are as follows:

Mesons (B=0)	S	C	Baryons (B=1)	S	C
π,η	0	0	p,n	0	0
K^+,K^0	+1	0	Λ,Σ	−1	0
$K^-,\overline{K}^0$	−1	0	Ξ	−2	0
D^+,D^0	0	+1	Ω^-	−3	0
$D^-,\overline{D}^0$	0	−1			

b. Quoted upper limits correspond to a 90% confidence level.

c. In decays with more than two bodies, p_{max} is the maximum momentum that any particle can have.

d. For simplicity, decay mode charge states are written for the particle shown. For antiparticle modes all particles must be charge conjugated.

e. See Stable Particle Data Card Listings for energy limits used in this measurement.

f. Quantum numbers shown are favored but not yet established. See Data Card Listings.

g. Theoretical value; see also Stable Particle Data Card Listings.

h. See note in Stable Particle Data Card Listings.

i. The direct emission branching fraction is $(1.56\pm.35)\times10^{-5}$.

j. The $\tau(K_S^0)$ and $|\eta_{+-}|$ averages (and the related $K_L^0 \rightarrow \pi^+\pi^-$ branching fraction and rate averages) contain only post−1971 results. The pre−1971 averages were $|\eta_{+-}| = (1.95\pm0.03)\times10^{-3}$ and $\tau(K_S^0) = (0.862\pm0.006)\times10^{-10}$ sec. See notes on $|\eta_{+-}|$ and $\tau(K_S^0)$ discrepancies in Stable Particle Data Card Listings.

k. The branching fraction for $K_L^0 \rightarrow \pi e\nu$ includes the radiative events $K_L^0 \rightarrow \pi e\nu\gamma$.

l. Error does not include 0.13% uncertainty in the absolute SPEAR energy calibration. Assumes m_ψ=3095 MeV.

m. This is a weighted average of $D^\pm$ and D^0 branching fractions with undetermined weighting.

n. P for Ξ and J^P for Ω^- not yet measured. Values reported are SU(3) predictions.

o. Assumes rate for $\Xi^- \rightarrow \Sigma^0 e^-\nu$ small compared with $\Xi^- \rightarrow \Lambda e^-\nu$.

p. Warning. This is an average of two incompatible results: ABCLV collaboration $(1.41^{+0.15}_{-0.24})\times10^{-10}$ sec and ACNO collaboration $(0.75^{+0.14}_{-0.11})\times10^{-10}$ sec. See note in Data Card Listings.

q. $|g_A/g_V|$ defined by $g_A^2 = |C_A|^2+|C'_A|^2$, $g_V^2 = |C_V|^2+|C'_V|^2$, and $\Sigma\langle\overline{e}|\Gamma_i|\mu\rangle\langle\overline{\nu}|\Gamma_i(C_i+C'_i\gamma_5)|\nu\rangle$; ϕ defined by $\cos\phi = -\mathrm{Re}(C_A^*C'_V+C'_AC_V^*)/g_Ag_V$ [for more details, see text Section VI A].

r. The definition of the slope parameter of the Dalitz plot is as follows [see also text Section VI B.1]:

$$|M|^2 = 1 + g\left(\frac{s_3-s_0}{m_{\pi^+}^2}\right).$$

s. The $K_S^0 \rightarrow \pi\pi$ and $K_L^0 \rightarrow \pi\pi$ rates (and branching fractions) are from independent fits and do not include results of K_L^0–K_S^0 interference experiments. The $|\eta_{+-}|$ and $|\eta_{00}|$ values given in the addendum are these rates combined with the $|\eta_{+-}|$ and $|\eta_{00}|$ results from interference experiments.

t. The definition for the CP violation parameters is as follows [see also text Section VI B.3]:

$$\eta_{+-} = |\eta_{+-}|e^{i\phi+-} = \frac{A(K_L^0 \rightarrow \pi^+\pi^-)}{A(K_S^0 \rightarrow \pi^+\pi^-)} \qquad \eta_{00} \approx |\eta_{00}|e^{i\phi00} = \frac{A(K_L^0 \rightarrow \pi^0\pi^0)}{A(K_S^0 \rightarrow \pi^0\pi^0)}$$

$$\delta = \frac{\Gamma(K_L^0\rightarrow\ell^+)-\Gamma(K_L^0\rightarrow\ell^-)}{\Gamma(K_L^0\rightarrow\ell^+)+\Gamma(K_L^0\rightarrow\ell^-)}, \quad |\eta_{+-0}|^2 = \frac{\Gamma(K_S^0\rightarrow\pi^+\pi^-\pi^0)^{\text{CP viol.}}}{\Gamma(K_L^0\rightarrow\pi^+\pi^-\pi^0)}, \quad |\eta_{000}|^2 = \frac{\Gamma(K_S^0\rightarrow\pi^0\pi^0\pi^0)^{\text{CP viol.}}}{\Gamma(K_L^0\rightarrow\pi^0\pi^0\pi^0)}.$$

u. The definition of these quantites is as follows [for more details on sign convention, see text Section VI B]:

$$\alpha = \frac{2|s||p|\cos\Delta}{|s|^2+|p|^2} \qquad \beta = \sqrt{1-\alpha^2}\sin\phi \qquad g_A/g_V \text{ defined by } \langle B_f|\gamma_\lambda(g_V-g_A\gamma_5)|B_i\rangle$$

$$\beta = \frac{-2|s||p|\sin\Delta}{|s|^2+|p|^2} \qquad \gamma = \sqrt{1-\alpha^2}\cos\phi \qquad \delta \text{ defined by } g_A/g_V = |g_A/g_V|e^{i\delta}$$

Meson Table

April 1978

In addition to the entries in the Meson Table, the Meson Data Card Listings contain all substantial claims for meson resonances. See Contents of Meson Data Card Listings below.

Quantities in italics are new or have changed by more than one (old) standard deviation since April 1976.

Name	$I^G(J^P)C_n$ estab.	Mass M (MeV)	Full Width Γ (MeV)	$\pm\Gamma M^{2}$ [a] $(GeV)^2$	Partial decay mode: Mode	Fraction (%) [Upper limits are 1σ (%)]		p or p_{max} [b] (MeV/c)
$\pi^{\pm}$	$1^-(0^-)+$	139.57	0.0	0.019479	See Stable Particle Table			
π^0		134.96	7.95 eV ±.55 eV	0.018215				
η	$0^+(0^-)+$	548.8 ±0.6	0.85 keV ±.12 keV	0.301 ±.000	Neutral	71.0	See Stable	
					Charged	29.0	Particle Table	
ρ(770)	$1^+(1^-)-$	$776^{\P}_{\S}$ $\pm3^{\S}$	$155^{\P}_{\S}$ $\pm3^{\S}$	0.602 ±.120	ππ	≈100		362
					πγ	0.024 ±.007		375
					e^+e^-	0.0043±.0005 (d)		388
					$\mu^+\mu^-$	0.0067±.0012 (d)		373
					ηγ	*seen*¶		194
M and Γ from neutral mode.					For upper limits, see footnote (e)			
ω(783)	$0^-(1^-)-$	782.6 ±0.3 S=1.3*	10.1 ±.3	0.612 ±.008	$\pi^+\pi^-\pi^0$	89.9±0.6	S=1.2*	327
					$\pi^+\pi^-$	1.3±0.3	S=1.5*	366
					$\pi^0\gamma$	8.8±0.5		380
					e^+e^-	0.0076±.0017	S=1.9*	391
					ηγ	*seen*¶		199
					For upper limits, see footnote (f)			
η′(958)	$0^+(0^-)+$¶	957.6 ±0.3	< 1	0.917 <.001	ηππ	66.2±1.7		231
					$\rho^0\gamma$	29.8±1.7	S=1.1*	165
					ωγ	*2.1±0.4*		159
					γγ	2.0±0.3		479
					For upper limits, see footnote (g)			
δ(980)	$1^-(0^+)+$	$980^{(h)}_{\S}$ $\pm5^{\S}$	$50^{(h)}_{\S}$ $\pm10^{\S}$	0.960 ±.049	ηπ	seen		318
					KK̄	*seen*¶		
$S^*(980)$	$0^+(0^+)+$	∼ *980*$^{(c)\S}_{\S}$ *±10*§	$40^{(c)\S}_{\S}$ $\pm10^{\S}$	0.960 ±.039	KK̄	seen¶		
					ππ	seen		470
See note on ππ and KK̄ S wave¶.								
φ(1020)	$0^-(1^-)-$	1019.6 ±0.2 S=1.5*	4.1 ±.2	1.040 ±.004	K^+K^-	48.6±1.2	S=1.3*	128
					K_LK_S	35.1±1.2	S=1.5*	111
					$\pi^+\pi^-\pi^0$ (incl. ρπ)	*14.7±0.7*	S=1.2*	462
					ηγ	1.6±0.2		362
					$\pi^0\gamma$	0.14±0.05		501
					e^+e^-	.031±.001	S=1.1*	510
					$\mu^+\mu^-$	.025±.003		499
					For upper limits, see footnote (i)			
$A_1(1100)$	$1^-(1^+)+$	∼ 1100¶	∼ 300¶	1.21 ±.33	ρπ	∼ 100		249
B(1235)	$1^+(1^+)-$	$1231_{\S}$ $\pm10^{\S}$	$128_{\S}$ $\pm10^{\S}$	1.52 ±.16	ωπ	only mode seen		347
					[D/S amplitude ratio = .29±.05]			
					For upper limits, see footnote (j)			
f(1270)	$0^+(2^+)+$	$1271_{\S}$ $\pm5^{\S}$	$180_{\S}$ $\pm20^{\S}$	1.62 ±.23	ππ	80.3±0.3		620
					$2\pi^+2\pi^-$	2.8±0.3	S = 1.1*	557
					KK̄	3.1±0.4	S = 1.3*	395
					$\pi^+\pi^-2\pi^0$	seen		560
					For upper limits, see footnote (k)			
D(1285)	$0^+(1^+)+$	$1282_{\S}$ $\pm5^{\S}$	$25_{\S}$ $\pm10^{\S}$	1.64 ±.03	KK̄π	seen		301
					ηππ	seen		481
					†[δπ	seen]		238
					$2\pi^+2\pi^-$ (prob. $\rho^0\pi^+\pi^-$)	seen		563
ε(1300)	$0^+(0^+)+$	∼ *1300*	*200–400*		ππ	seen		
					KK̄	*seen*		
See note on ππ and KK̄ S wave¶.								

Meson Table *(cont'd)*

Name	$I^G(J^P)C_n$ ⟵ estab.	Mass M (MeV)	Full Width Γ (MeV)	M^2 $\pm\Gamma M$[a] $(GeV)^2$	Partial decay mode: Mode	Fraction (%) [Upper limits are 1σ (%)]	p or p_{max}[b] (MeV/c)
$A_2(1310)$	$1^-(2^+)+$	$1312^{\S}_{\S}$ $\pm5^{\S}$	$102_{\S}$ $\pm5^{\S}$	1.72 ±.13	ρπ	70.3±2.1	411
					ηπ	14.4±0.9	531
					ωππ	10.6±2.5	356
					$\bar{K}K$	4.7±0.5	430
					η′π	<1	281
					πγ	*0.45±0.11*	649
E(1420)	$0^+(A\ )+$	$1416_{\S}$ $\pm10^{\S}$	$60_{\S}$ $\pm20^{\S}$	2.01 ±.08	$K\bar{K}\pi$	seen	421
					†[$K^*\bar{K}$ + $\bar{K}^*K$	seen]	130
					ηππ	seen	564
					†[δπ	possibly seen]	349
Not a well established resonance.							
f′(1515)	$0^+(2^+)+$	$1516_{\S}$ $\pm10^{\S}$	$65_{\S}$ $\pm10^{\S}$	2.30 ±.10	$K\bar{K}$	dominant	572
					ππ	*seen*	745
					For upper limits, see footnote (k)		
ρ′(1600)	$1^+(1^-)-$	∼ 1600¶	∼ *300*¶	2.56 ±.48	4π	$75^{\S}_{\S}$ $\pm10^{\S}$	738
					†[ρπ$^+\pi^-$	seen with $\pi^+\pi^-$ in S-wave]	572
					ππ	$25^{\S}_{\S}$ $\pm10^{\S}$	788
$A_3(1640)$	$1^-(2^-)+$	∼ 1640	∼ 300	2.69 ±.49	fπ	dominant	304
Not a well established resonance.¶							
ω(1670)	$0^-(3^-)-$	$1668_{\S}$ $\pm10^{\S}$	$160_{\S}$ $\pm15^{\S}$	2.78 ±.27	ρπ	seen	645
					3π	possibly seen	806
					5π	possibly seen	740
					†[ωππ	possibly seen]	615
g(1680)¶	$1^+(3^-)-$	$1688_{\S}$ $\pm20^{\S}$	$180_{\S}$ $\pm30^{\S}$	2.85 ±.30	2π	$24\pm5^{\S}$	832
					4π (incl. ππρ,ρρ,A_2π,ωπ)	large	786
					$K\bar{K}$	small	682
J^P, M and Γ from the 2π mode.					$K\bar{K}\pi$ (incl. $K^*\bar{K}$)	small	623
S(1935)¶ J < 4		*1935*$_{\S}$ *±2*§	*9*$_{\S}$ *±4*§	3.74 ±.02	$N\bar{N}$	*dominant*	236
h(2040)	$0^+(4^+)+$	2040 ±20	193 ±50	4.16 ±.39	ππ	seen	1010
					$K\bar{K}$	seen	890
T(2190)¶	$1^+(3^-)-$	*2192*$_{\S}$ *±10*§	*150*$^{\S}_{\S}$ *±50*§	4.80 ±.33	$N\bar{N}$	*dominant*	564
					ππ	*seen*	1086
U(2350)¶	$0^+(4^+)+$	*2350*$^{\S}_{\S}$ *±25*§	∼ *200*§	5.52 ±.47	$N\bar{N}$	*dominant*	707
					ππ	*seen*	1167
ψ(3100) or J	$0^-(1^-)-$	3097±2	0.067±0.012	9.598 ±.000	e^+e^-	7±1	1549
					$\mu^+\mu^-$	7±1	1545
					hadrons	86±2	
					†[$2(\pi^+\pi^-)\pi^0$	*3.7±0.5*	1496
					$3(\pi^+\pi^-)\pi^0$	*2.9±0.7*	1433
					$\pi^+\pi^-\pi^0K^+K^-$	*1.2±0.3*	1369
					ρπ	*1.1±0.2*	1448
					$4(\pi^+\pi^-)\pi^0$	*0.9±0.3*	1345
					$K^{*0}(890)$ $\bar{K}^{*0}(1430)$	*0.67±0.26*	1007
					$K\bar{K}^*$	*0.61±0.08*	1373
					$p\bar{p}\pi^+\pi^-$	*0.41±0.08*	1108
					$2(\pi^+\pi^-)$	*0.4±0.1*	1517
					$3(\pi^+\pi^-)$	*0.4±0.2*	1466
					$p\bar{n}\pi^-$	*0.38±0.08*	1174
					$2(\pi^+\pi^-)K^+K^-$	*0.31±0.13*	1320
					$K^0K^+\pi^-$ +	*0.26±0.07*	1440
					$\phi\pi^+\pi^-$	*0.21±0.09*	1365
					$p\bar{p}$	*0.21±0.02*	1232
					$p\bar{p}\eta$	*0.19±0.04*	948
					$\phi K\bar{K}$	*0.18±0.08*	1176
					$\Lambda\bar{\Lambda}$	*0.16±0.08*	1075
					$p\bar{p}\pi^+\pi^-\pi^0$	*0.11±0.04*	1033
					$p\bar{p}\pi^0$	*0.10±0.02*	1175
					φη	*0.10±0.06*]	1320
					†[γη′	*0.25±0.06*	1401
					γf	*0.20±0.07*	1288
					$\gamma X(2830)\to3\gamma$	*0.14±0.04*]	256
					For smaller branching ratios, upper limits, and resonance subchannels of the above modes, see listing.¶		

Meson Table *(cont'd)*

Name	$I^G(J^P)C_n$ ⟵estab.	Mass M (MeV)	Full Width Γ (MeV)	$\pm\Gamma M^{2}$ [a] $(GeV)^2$	Partial decay mode: Mode	Fraction (%) [Upper limits are 1σ (%)]		p or p_{max} [b] (MeV/c)
$\chi(3415)$	$0^+(0^+)+$	3413±5		11.649	$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	*4.4±0.8*		1678
					$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	*3.7±1.0*		1579
					$\gamma J/\psi(3100)$	*3.3±1.0*		300
					$3(\pi^+\pi^-)$	*1.9±0.7*		1632
					$\pi^+\pi^-$	*1.0±0.3*		1701
					K^+K^-	*1.0±0.3*		1634
					$p\bar{p}\pi^+\pi^-$	*0.5±0.2*		1319
P_C or $\chi(3510)$	$0^+(A)+$	3508±4		12.306	$\gamma J/\psi(3100)$	*23.4±0.8*	S = *2.4* *	388
					$3(\pi^+\pi^-)$	*2.4±0.8*		1682
					$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	*1.5±0.6*		1727
					$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	*0.9±0.4*		1632
$J^P = 1^+$ preferred.					$\pi^+\pi^-p\bar{p}$	*0.14±0.11*		1381
$\chi(3555)$	$0^+(N)+$	3554±5		12.631	$\gamma J/\psi(3100)$	*16±3*	S = *1.8* *	427
					$\pi^+\pi^-K^+K^-$ (incl. $\pi K\bar{K}^*$)	*2.0±0.6*		1655
					$3(\pi^+\pi^-)$	*1.1±0.7*		1706
					$\pi^+\pi^-$ and K^+K^-	*0.29±0.15*		
					$\pi^+\pi^-p\bar{p}$	*0.29±0.14*		1408
$J^P = 2^+$ preferred.					$2(\pi^+\pi^-)$ (incl. $\pi\pi\rho$)	*0.23±0.06*		1750
$\psi(3685)$	$0^-(1^-)-$	3686±3	0.228±0.056	13.587 ±.001	e^+e^-	0.9±0.1		1842
					$\mu^+\mu^-$	0.8±0.2		1839
					hadrons	98.1±0.3		
					+[$J/\psi\ \pi^+\pi^-$	33±3]		474
	$m_{\psi(3685)} - m_{\psi(3100)} = 588.6\pm0.8$				+[$J/\psi\ \pi^0\pi^0$	17±2]		478
					+[$J/\psi\ \eta$	4.2±0.7]		189
					+[$2(\pi^+\pi^-)\pi^0$	*0.4±0.2*]		1798
					+[$\pi^+\pi^-K^+K^-$	*0.14±0.04*]		1725
					+[$2(\pi^+\pi^-)$	*0.08±0.02*]		1816
					+[$\gamma\ \chi(3415)$	7±2]		261
					+[$\gamma\ \chi(3510)$	7±2]		172
					+[$\gamma\ \chi(3555)$	7±2]		128
$\psi(3770)$	$(1^-)-$	*3772 ±6*	*28 ±5*	14.228 ±.106	e^+e^-	*0.0013±0.0002*		1885
					$D\bar{D}$	*dominant*		184
$\psi(4415)$	$(1^-)-$	4414±7	33±10	19.483 ±.146	e^+e^-	0.0013±0.0003		2207
					hadrons	dominant		
T(9500)	$(1^-)-$	*∼ 9500*		90.25	$\mu^+\mu^-$	*seen*		4750
					e^+e^-	*seen*		4750
Seen split into two peaks m_1 = 9410±13, m_2=10060±30. Additional structure may be present¶.								
K^+	$1/2(0^-)$	493.67		0.244	See Stable Particle Table			
K^0		497.67		0.248				
$K^*(892)$	$1/2(1^-)$	892.2 ±0.4	49.5 ±1.5	0.796 ±.044	$K\pi$	≈ 100		288
					$K\pi\pi$	< 0.2		216
					$K\gamma$	0.15±0.07		309
M and Γ from charged mode; $m^0 - m^\pm$ = 4.1±0.6 MeV.								
$Q_1(1280)$	$1/2(1^+)$	*∼ 1280*	*∼ 120*	1.64 ±.19	$K\pi\pi$	*dominant*		501
					+[$K\rho$	*large*]		62
					+[$K^*\pi$	*possibly seen*]		307
Existence of a second resonance, $Q_2(1400)$, decaying mainly into $K^*\pi$, not well established¶.					$K\omega$	*possibly seen*		
$\kappa(1400)$	$1/2(0^+)$	*1400-1450*	*200-300*		$K\pi$	seen		
See note on $K\pi$ S wave¶.								
$K^*(1430)$	$1/2(2^+)$	*1434* § *±5* §	100 § ±10 §	2.06 ±.14	$K\pi$	*49.1±1.6*		623
					$K^*\pi$	*27.0±2.2*		424
					$K^*\pi\pi$	*11.2±2.5*		374
					$K\rho$	6.6±1.5		327
					$K\omega$	3.7±1.6		320
					$K\eta$	2.5±2.5		492

Meson Table *(cont'd)*

Name (G \ I: 0, 1; − ω/φ π; + η ρ)	$I^G(J^P)C_n$ ⟼ estab.	Mass M (MeV)	Full Width Γ (MeV)	$M^2 \pm \Gamma M$[a] $(GeV)^2$	Partial decay mode: Mode	Fraction (%) [Upper limits are 1σ (%)]	p or p_{max}[b] (MeV/c)
L(1770)	1/2(A)	1765 ±10§	140 ±50§	3.11 ±.25	Kππ	dominant	788
					Kπππ	seen	757
					†[K*(1430)π and other subreactions¶]		
Not a well established resonance¶.							
K*(1780)¶	1/2(3⁻)	*1784 ±10*§	*135*§ *±40*§	3.19 ±.24	Kππ	*large*	798
					†[Kρ	*large*]	619
					†[K*π	*large*]	660
					Kπ	*19±5*§	817
D⁺	1/2(0⁻)	1868.3		3.491	See Stable Particle Table		
D⁰		1863.3		3.472			
D*⁺(2010)	1/2(1⁻)	2008.6 ±1.0	<2.0	4.034	$D^0\pi^+$	*60±15*	39
					$D^+\pi^0$	*40±15*	37
	$m_{D^{*+}} - m_{D^0}$ = 145.3 ± 0.5 MeV				$D^+\gamma$		135
D*⁰(2010)	1/2(1⁻)	2006 ±1.5	< 5	4.024	$D^0\pi^0$	*55±15*	45
					$D^0\gamma$	*45±15*	138

Contents of Meson Data Card Listings

Non-strange (S = 0, C = 0) entry	$I^G(J^P)C_n$	entry	$I^G(J^P)C_n$	entry	$I^G(J^P)C_n$	Strange (|S| = 1, C = 0) entry	I (J^P)
π	1⁻(0⁻)+	A_2(1310)	1⁻(2⁺)+	→ e^+e^-(1100-3100)		K	1/2(0⁻)
η	0⁺(0⁻)+	E (1420)	0⁺(A)+	→ X (2830)		K*(892)	1/2(1⁻)
ρ (770)	1⁺(1⁻)-	→ X (1410-1440)		ψ (3100) or J	0⁻(1⁻)-	Q_1(1280)	1/2(1⁺)
ω (783)	0⁻(1⁻)-	f′(1515)	0⁺(2⁺)+	χ (3415)	0⁺(0⁺)+	→ Q_2(1400)	1/2(1⁺)
→ M (940-953)		→ F_1(1540)	1 (A)	→ χ (3455)		→ K′(1400)	1/2(0⁻)
η′ (958)	0⁺(0⁻)+	ρ′(1600)	1⁺(1⁻)-	P_c or χ(3510)	0⁺(A)+	κ (1400)	1/2(0⁺)
δ (980)	1⁻(0⁺)+	A_3(1640)	1⁻(2⁻)+	χ (3555)	0⁺(N)+	K*(1430)	1/2(2⁺)
S* (980)	0⁺(0⁺)+	ω (1670)	0⁻(3⁻)-	ψ (3685)	0⁻(1⁻)-	→ K_N(1700)	1/2
→ H (990)		g (1680)	1⁺(3⁻)-	ψ (3770)	(1⁻)-	L (1770)	1/2(A)
φ (1020)	0⁻(1⁻)-	→ X (1690)		→ ψ (4030)	(1⁻)-	K*(1780)	1/2(3⁻)
→ M (1033-1040)		→ A_4(1900)	1⁻	ψ (4415)	(1⁻)-	→ K*(2200)	
→ η_N(1080)	0⁺(N)+	→ X (1900)	1⁻(4⁺)+	Υ (9500)	(1⁻)-	→ I (2600)	
A_1(1100)	1⁻(1⁺)+	S (1935)	1	→ Υ (10060)	(1⁻)-	Charmed (|C| = 1)	
→ M (1150-1170)		h (2040)	0⁺(4⁺)+				
B (1235)	1⁺(1⁺)-	T (2190)	1⁺(3⁻)-			D (1870)	1/2(0⁻)
→ ρ′(1250)	1⁺(1⁻)-	U (2350)	0⁺(4⁺)+			D*(2010)	1/2(1⁻)
f (1270)	0⁺(2⁺)+	→ $\bar{N}N$(2360)	1			→ F (2030)	
D (1285)	0⁺(A)+	→ $\bar{N}N$(1400-3600)				→ F*(2140)	
ε (1300)	0⁺(0⁺)+	→ X (1900-3600)				→ Exotics	

Meson Table *(cont'd)*

→ Indicates an entry in Meson Data Card Listings not entered in the Meson Table. We do not regard these as established resonances. All the entries in the Listings can be found in the Table of Contents of Meson Data Card Listings.

¶ See Meson Data Card Listings.

* Quoted error includes scale factor $S = \sqrt{\chi^2/(N-1)}$. See footnote to Stable Particle Table.

† Square brackets indicate a subreaction of the previous (unbracketed) decay mode(s).

§ This is only an educated guess; the error given is larger than the error of the average of the published values. (See Meson Data Card Listings for the latter.)

(a) ΓM is approximately the half-width of the resonance when plotted against M^2.

(b) For decay modes into ≥ 3 particles, p_{max} is the maximum momentum that any of the particles in the final state can have. The momenta have been calculated by using the averaged central mass values, without taking into account the widths of the resonances.

(c) From pole position $(M - i\Gamma/2)$.

(d) The e^+e^- branching ratio is from $e^+e^- \to \pi^+\pi^-$ experiments only. The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. See note in Meson Data Card Listings. The $\mu^+\mu^-$ branching ratio is compiled from 3 experiments; each possibly with substantial $\omega\rho$ interference. The error reflects this uncertainty; see notes in Meson Data Card Listings. If $e\mu$ universality holds, $\Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times 0.99785$.

(e) Empirical limits on fractions for other decay modes of $\rho(770)$ are $\pi^\pm\eta < 0.8\%$, $\pi^+\pi^+\pi^-\pi^- < 0.15\%$, $\pi^\pm\pi^+\pi^-\pi^0 < 0.2\%$.

(f) Empirical limits on fractions for other decay modes of $\omega(783)$ are $\pi^+\pi^-\gamma < 5\%$, $\pi^0\pi^0\gamma < 1\%$, η + neutral(s) < 1.5%, $\mu^+\mu^- < 0.02\%$, $\pi^0\mu^+\mu^- < 0.2\%$.

(g) Empirical limits on fractions for other decay modes of $\eta'(958)$: $\pi^+\pi^- < 2\%$, $\pi^+\pi^-\pi^0 < 5\%$, $\pi^+\pi^+\pi^-\pi^- < 1\%$, $\pi^+\pi^+\pi^-\pi^-\pi^0 < 1\%$, $6\pi < 1\%$, $\pi^+\pi^-e^+e^- < 0.6\%$, $\pi^0e^+e^- < 1.3\%$, $\eta e^+e^- < 1.1\%$, $\pi^0\rho^0 < 4\%$.

(h) The mass and width are from the $\eta\pi$ mode only. If the $K\bar{K}$ channel is strongly coupled, the width may be 300 MeV or more.

(i) Empirical limits on fractions for other decay modes of $\phi(1020)$ are $\pi^+\pi^- < 0.03\%$, $\pi^+\pi^-\gamma < 0.7\%$, $\omega\gamma < 5\%$, $\rho\gamma < 2\%$, $2\pi^+2\pi^-\pi^0 < 1\%$.

(j) Empirical limits on fractions for other decay modes of $B(1235)$: $\pi\pi < 15\%$, $K\bar{K} < 2\%$, $4\pi < 50\%$, $\phi\pi < 1.5\%$, $\eta\pi < 25\%$, $(\bar{K}K)^\pm\pi^0 < 8\%$, $K_SK_S\pi^\pm < 2\%$, $K_SK_L\pi^\pm < 6\%$.

(k) Empirical limits on fractions for other decay modes of $f'(1515)$ are $\eta\eta < 50\%$, $\eta\pi\pi < 30\%$, $K\bar{K}\pi + K^*\bar{K} < 35\%$, $2\pi^+2\pi^- < 32\%$.

(ℓ) Empirical limits on fractions for other decay modes of $f(1270)$ are $\eta\pi\pi < 1\%$, $K^0K^-\pi^+ + \text{c.c.} < 1\%$, $\eta\eta < 2\%$.

Established Nonets, and octet-singlet mixing angles from Appendix IIB, Eq. (2'). Of the two isosinglets, the "mainly octet" one is written first, followed by a semicolon.

$(J^P)C_n$	Nonet members	$\theta_{lin.}$	$\theta_{quadr.}$
$(0^-)+$	π, K, η; η'	-24 ± 1°	-11 ± 1°
$(1^-)-$	ρ, K^*, ϕ; ω	38 ± 1°	40 ± 1°
$(2^+)+$	A_2, $K^*(1430)$, f'; f	24 ± 2°	26 ± 2°

Baryon Table

April 1978

The following short list gives the status of all the Baryon States in the Data Card Listings. In addition to the status, the name, the nominal mass, and the quantum numbers (where known) are shown. States with three- or four-star status are included in the main Baryon Table; the others have been omitted because the evidence for the existence of the effect and/or for its interpretation as a resonance is open to considerable question.

N(939)	P11 ****	Δ(1232)	P33 ****	Λ(1115)	P01 ****	Σ(1193)	P11 ****	Ξ(1317)	P11 ****		
N(1470)	P11 ****	Δ(1550)	P31 *	Λ(1330)	Dead	Σ(1385)	P13 ****	Ξ(1530)	P13 ****		
N(1520)	D13 ****	Δ(1650)	S31 ****	Λ(1405)	S01 ****	Σ(1480)	*	Ξ(1630)	**		
N(1535)	S11 ****	Δ(1670)	D33 ***	Λ(1520)	D03 ****	Σ(1580)	D13 **	Ξ(1820)	13 ***		
N(1540)	P13 *	Δ(1690)	P33 ***	Λ(1600)	P01 **	Σ(1620)	S11 **	Ξ(1940)	**		
N(1670)	D15 ****	Δ(1890)	F35 ****	Λ(1670)	S01 ****	Σ(1660)	P11 ***	Ξ(2030)	1 ***		
N(1688)	F15 ****	Δ(1900)	S31 *	Λ(1690)	D03 ****	Σ(1670)	D13 ****	Ξ(2120)	*		
N(1700)	S11 ****	Δ(1910)	P31 ****	Λ(1800)	P01 **	Σ(1670)	**	Ξ(2250)	*		
N(1700)	D13 ***	Δ(1950)	F37 ****	Λ(1800)	G09 *	Σ(1690)	**	Ξ(2500)	**		
N(1780)	P11 ***	Δ(1960)	D35 ***	Λ(1815)	F05 ****	Σ(1750)	S11 ***				
N(1810)	P13 ***	Δ(2160)	***	Λ(1830)	D05 ****	Σ(1765)	D15 ****	Ω(1672)	P03 ****		
N(1990)	F17 **	Δ(2420)	H3 11 ***	Λ(1860)	P03 ***	Σ(1770)	P11 *				
N(2000)	F15 **	Δ(2850)	***	Λ(1870)	S01 ***	Σ(1840)	P13 *	Λ_c(2260)	*		
N(2040)	D13 **	Δ(3230)	***	Λ(2010)	**	Σ(1880)	P11 **				
N(2100)	S11 *			Λ(2020)	F07 *	Σ(1915)	F15 ****	Σ_c(2430)	*		
N(2100)	D15 **			Λ(2100)	G07 ****	Σ(1940)	D13 ***				
N(2190)	G17 ***	Z0(1780)	P01 *	Λ(2110)	F05 ***	Σ(2000)	S11 *	Dibaryons			
N(2200)	G19 ***	Z0(1865)	D03 *	Λ(2325)	D03 *	Σ(2030)	F17 ****	S = 0	*		
N(2220)	H19 ***	Z1(1900)	P13 *	Λ(2350)	****	Σ(2070)	F15 *	S = -1	*		
N(2650)	I1 11 ***	Z1(2150)	*	Λ(2585)	***	Σ(2080)	P13 **	S = -2	*		
N(3030)	***	Z1(2500)	*			Σ(2100)	G17 *				
N(3245)	*					Σ(2250)	****				
N(3690)	*					Σ(2455)	***				
N(3755)	*					Σ(2620)	***				
						Σ(3000)	**				

**** Good, clear, and unmistakable.
*** Good, but in need of clarification or not absolutely certain.
** Needs confirmation.
* Weak.

[See notes on N's and Δ's, Z*'s, Λ's and Σ's, Ξ*'s, and dibaryons at the beginning of those sections in the Baryon Data Card Listings; also see notes on individual resonances in the Baryon Data Card Listings.]

Particle[a]	I (J^P)[a] —— estab.	π or K beam[b] P_{beam} (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 $\pm\Gamma M$[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[c] %	p or p_{max}[d] (MeV/c)
p	1/2(1/2+)		938.3		0.880	See Stable Particle Table		
n	——		939.6		0.883			
N(1470)[g]	1/2(1/2+)P'_{11}	p = 0.66 σ = 27.8	1390 to 1470	180 to 240 (200)	2.16 ±0.29	Nπ	~60	420
						Nη	~18	d
						Nππ	~25	368
						[Nε	~ 7][e]	d
						[Δπ	~23][e]	177
						[Nρ	~ 7][e]	d
N(1520)[g]	1/2(3/2−)D'_{13}	p = 0.74 σ = 23.5	1510 to 1530	110 to 150 (125)	2.31 ±0.19	Nπ	~55	456
						Nππ	~45	410
						[Nε	< 5][e]	d
						[Nρ	~19][e]	d
						[Δπ	~23][e]	228
						Nη	< 1	d
N(1535)[g]	1/2(1/2−)S'_{11}	p = 0.76 σ = 22.5	1500 to 1545	50 to 150 (100)	2.36 ±0.15	Nπ	~30	467
						Nη	~65	182
						Nππ	~ 5	422
						[Nρ	~ 3][e]	d
						[Nε	~ 2][e]	d
						[Δπ	~ 1][e]	243

Baryon Table *(cont'd)*

Particle[a]	I (J^P)[a] — estab.	π or K beam[b] P_{beam} (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 $\pm\Gamma_M$[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[c] %	p or[d] P_{max} (MeV/c)
N(1670)[g]	1/2(5/2⁻)D'_{15}	p = 1.00 σ = 15.6	1650 to 1685	145 to 170 (155)	2.79 ±0.26	Nπ	~45	560
						Nππ	~55	525
						[Δπ	~47][e]	360
						[Nρ	~ 5][e]	*d*
						ΛK	< 0.3	200
						Nη	< 0.5	368
N(1688)[g]	1/2(5/2⁺)F'_{15}	p = 1.03 σ = 14.9	1670 to 1690	120 to 145 (140)	2.85 ±0.24	Nπ	~60	572
						Nππ	~40	538
						[Nε	~15][e]	340
						[Nρ	~13][e]	*d*
						[Δπ	~12][e]	375
						Nη	< 0.3	388
N(1700)[g]	1/2(1/2⁻)S''_{11}	p = 1.05 σ = 14.3	1660 to 1700	100 to 200 (150)	2.89 ±0.26	Nπ	~55	580
						Nππ	~30	547
						[Nε	<10][e]	355
						[Nρ	7-21][e]	*d*
						[Δπ	4-15][e]	385
						ΛK	~10	250
						ΣK	2-7	109
N(1700)[g]	1/2(3/2⁻)D''_{13}	p = 1.05 σ = 14.3	1660 to 1710	80 to[h] 120 (120)	2.89 ±0.20	Nπ	~10	580
						Nππ	~90	547
						[Nε	<40][e]	355
						[Nρ	< 5][e]	*d*
						[Δπ	15-40][e]	385
						ΛK	~ 1	250
N(1780)	1/2(1/2⁺)P''_{11}	p = 1.20 σ = 12.2	1650 to 1750	100 to 180 (160)	3.17 ±0.28	Nπ	~20	633
						Nππ	>50	603
						[Nε	15-40][e]	440
						[Nρ	40-65][e]	249
						[Δπ	10-20][e]	448
						ΛK	< 5	353
						ΣK	~10	267
						Nη	2-20[i]	476
N(1810)	1/2(3/2⁺)P''_{13}	p = 1.26 σ = 11.5	1650 to 1750	100 to 300 (200)	3.28 ±0.36	Nπ	~20	652
						Nππ	~70	624
						[Nε	~20][e]	468
						[Nρ	45-70][e]	297
						[Δπ	~20][e]	471
						ΛK	1-4	386
						ΣK	~ 2	307
						Nη	< 5	503
N(2190)	1/2(7/2⁻)G_{17}	p = 2.07 σ = 6.21	2140 to 2250	150 to 300 (250)	4.80 ±0.55	Nπ	15-35	888
N(2200)	1/2(9/2⁻)G_{19}	p = 2.10 σ = 6.12	2130 to 2270	200 to 300 (250)	4.84 ±0.55	Nπ	~10	894
N(2220)[g]	1/2(9/2⁺)H_{19}	p = 2.14 σ = 5.97	2200 to 2250	250 to 350 (300)	4.93 ±0.67	Nπ	~20	905
N(2650)	1/2(11/2⁻)$I_{1\,11}$[j]	p = 3.26 σ = 3.67	2580 to 2700	~400 (400)	7.02 ±1.06	Nπ	~5	1154
N(3030)	1/2(?)	p = 4.41 σ = 2.62	~3030	~400 (400)	9.18 ±1.21	Nπ	(J + 1/2)x <0.1[k]	1366

Baryon Table *(cont'd)*

Particle[a]	I (J^P)[a] — estab.	π or K beam[b] p_{beam} (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 $\pm\Gamma_M$[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[c] %	p or p_{max}[d] (MeV/c)
Δ(1232)[g]	3/2(3/2+)P'_{33}	p = 0.30 σ = 94.3	1230 to 1234	110 to 120 (115)	1.52 ±0.14	Nπ $N\pi^+\pi^-$	~99.4 ~ 0	227 80
	Δ(++) Pole position:[l] M - iΓ/2 = (1211.0 ± 0.8) - i(49.9 ± 0.6) Δ(0) Pole position:[l] M - iΓ/2 = (1210.9 ± 1.0) - i(53.1 ± 1.0)							
Δ(1650)[g]	3/2(1/2−)S'_{31}	p = 0.96 σ = 16.4	1600 to 1695	120 to 200 (140)	2.72 ±0.23	Nπ Nππ [Nρ [Δπ	~32 ~65 10-25][e] ~50][e]	547 511 d 344
Δ(1670)[g]	3/2(3/2−)D_{33}	p = 1.00 σ = 15.6	1620 to 1720	190 to 240 (200)	2.79 ±0.33	Nπ Nππ [Nρ [Δπ	~15 ~85 <40][e] 45-60][e]	560 525 d 361
Δ(1690)[g]	3/2(3/2+)P''_{33}	p = 1.03 σ = 14.9	1650 to 1900[m]	150 to 350 (250)	2.86 ±0.42	Nπ Nππ [Nρ [Δπ	10-20 ~80 10-20][e] >45][e]	573 540 d 377
Δ(1890)[g]	3/2(5/2+)F_{35}	p = 1.42 σ = 9.88	1860 to 1910	150 to 300 (250)	3.57 ±0.47	Nπ Nππ [Nρ [Δπ ΣK	~15 ~80 ~60][e] 10-30][e] < 3	704 677 403 531 400
Δ(1910)[g]	3/2(1/2+)P''_{31}	p = 1.46 σ = 9.54	1780 to 1960	200 to 280 (220)	3.65 ±0.42	Nπ Nππ [Nρ [Δπ ΣK	15-25 >40 ~40][e] small][e] 2-20	716 691 429 545 420
Δ(1950)[g]	3/2(7/2+)F_{37}	p = 1.54 σ = 8.90	1910 to 1950	200 to 280 (240)	3.80 ±0.47	Nπ Nππ [Nρ [Δπ ΣK	~40 >25 ~10][e] ~20][e] < 1	741 716 471 574 460
Δ(1960)[g]	3/2(5/2−)D_{35}	p = 1.56 σ = 8.75	1890 to 1950	100 to 300 (200)	3.84 ±0.39	Nπ ΣK	7-15 <10	748 469
Δ(2160)[n]	3/2(?−)	p = 2.00 σ = 6.46	2150 to 2240	160 to 440 (300)	4.67 ±0.65	Nπ	(J + 1/2)× =0.4 - 1.4[k]	870
Δ(2420)[g]	3/2(11/2+)$H_{3\,11}$	p = 2.64 σ = 4.68	2380 to 2450	300 to 500 (300)	5.86 ±0.73	Nπ	10-15	1023
Δ(2850)	3/2(?+)	p = 3.85 σ = 3.05	2800 to 2900	~400 (400)	8.12 ±1.14	Nπ	(J + 1/2)× ~0.25[k]	1266
Δ(3230)	3/2(?)	p = 5.08 σ = 2.25	3200 to 3350	~440 (440)	10.43 ±1.42	Nπ	(J + 1/2)× ~0.05[k]	1475

Z*

Evidence for states with strangeness +1 is inconclusive.
See the Baryon Data Card Listings for data and discussion.

Baryon Table *(cont'd)*

Particle[a]	I (J^P)[a] — estab.	π or K beam[b] P_{beam} (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 ±ΓM[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[e] %	p or[d] p_{max} (MeV/c)
Λ	$0(1/2^+)$		1115.6		1.245	See Stable Particle Table		
Λ(1405)	$0(1/2^-)S'_{01}$	Below K^-p threshold	1405 ±5 [o]	40 ± 10 [o] (40)	1.97 ±0.06	Σπ	100	142
Λ(1520)	$0(3/2^-)D'_{03}$	p = 0.389 σ = 84.5	1520 ±2 [o]	16 ± 2 [o] (16)	2.31 ±0.02	$N\bar{K}$ Σπ Λππ Σππ	46 ± 1 42 ± 1 10 ± 1 0.9 ± 0.1	234 258 250 140
Λ(1670)	$0(1/2^-)S''_{01}$	p = 0.74 σ = 28.5	1660 to 1680	20 to 60 (40)	2.79 ±0.07	$N\bar{K}$ Λη Σπ	15-25 15-35 20-60	410 64 393
Λ(1690)	$0(3/2^-)D''_{03}$	p = 0.78 σ = 26.1	1690 ±10 [o]	40 to 80 (60)	2.86 ±0.10	$N\bar{K}$ Σπ Λππ Σππ	20-30 20-40 ~25 ~20	429 409 415 352
Λ(1815)	$0(5/2^+)F'_{05}$	p = 1.05 σ = 16.7	1820 ±5 [o]	70 to 90 (80)	3.29 ±0.15	$N\bar{K}$ Σπ Σ(1385)π	55-65 5-15 5-10	542 508 362
Λ(1830)	$0(5/2^-)D_{05}$	p = 1.09 σ = 15.8	1810 to 1830	60 to 110 (95)	3.35 ±0.17	$N\bar{K}$ Σπ Σ(1385)π	<10 35-75 >15	554 519 375
Λ(1860)	$0(3/2^+)P'_{03}$	p = 1.14 σ = 14.7	1850 to 1920	60 to 200 (100)	3.46 ±0.19	$N\bar{K}$ Σπ	15-40 3-10	576 534
Λ(1870)	$0(1/2^-)S'''_{01}$	p = 1.16 σ = 14.2	1700 to 1850	200 to 400 (300)	3.50 ±0.56	$N\bar{K}$ Σπ	20-60 seen	582 542
Λ(2100)	$0(7/2^-)G_{07}$	p = 1.68 σ = 8.68	2080 to 2120	100 to 300 (250)	4.41 ±0.53	$N\bar{K}$ Σπ Λη ΞK Λω	~30 ~5 <3 <3 <8	748 699 617 483 443
Λ(2110)	$0(5/2^+)F''_{05}$	p = 1.70 σ = 8.48	2050 to 2150	150 to 300 (200)	4.45 ±0.42	$N\bar{K}$ Σπ	5-25 <40	756 709
Λ(2350)	$0(9/2^+)$	p = 2.29 σ = 5.85	2340 to 2420	100 to 250 (120)	5.52 ±0.28	$N\bar{K}$ Σπ	~12 ~10	913 865
Λ(2585)	0(?)	p = 2.91 σ = 4.37	~2585	~300 (300)	6.68 ±0.78	$N\bar{K}$	(J+1/2)x ~1.0 [k]	1058
Σ	$1(1/2^+)$		(+)1189.4 (0)1192.5 (-)1197.4		1.415 1.422 1.434	See Stable Particle Table		
Σ(1385)	$1(3/2^+)P'_{13}$	Below K^-p threshold	(+)1382.3±0.4 S = 1.6 [p] (-)1387.5±0.6 S = 1.0 [p] (0)1382.0±2.5 S = 1.6 [p]	(+)35±2 S = 2.2 [p] (-)40±2 S = 1.9 [p] (35)	1.92 ±0.05	Λπ Σπ	88 ± 2 12 ± 2	208 117

Baryon Table *(cont'd)*

Particle[a]	I (J^P)[a] — estab.	π or K beam[b] p_{beam} (GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass M[c] (MeV)	Full Width Γ[c] (MeV)	M^2 $\pm\Gamma_M$[b] (GeV^2)	Partial decay mode[f] Mode	Fraction[e] %	p or p_{max}[d] (MeV/c)
Σ(1660)[q]	1(1/2⁺)P'_{11}	p = 0.72 σ = 30.1	1580 to 1690	30 to 200 (100)	2.76 ±0.17	$N\bar{K}$ Σπ Λπ	<30 seen seen	402 383 440
Σ(1670)	1(3/2⁻)D''_{13}	p = 0.74 σ = 28.5	1675 ±10 ᵒ	35 to 70 (50)	2.79 ±0.08	$N\bar{K}$ Σπ Λπ	5-15 20-60 <20	410 387 447
Σ(1750)	1(1/2⁻)S''_{11}	p = 0.91 σ = 20.7	1730 to 1820	50 to 160 (75)	3.06 ±0.13	$N\bar{K}$ Λπ Σπ Ση	10-40 5-20 <8 15-55	483 507 450 54
Σ(1765)	1(5/2⁻)D_{15}	p = 0.94 σ = 19.6	1774 ±7 ᵒ	105 to 135 (120)	3.12 ±0.21	$N\bar{K}$ Λπ Λ(1520)π Σ(1385)π Σπ	~41 ~14 ~19 ~ 9 ~ 1	496 518 187 315 461
Σ(1915)[g]	1(5/2⁺)F'_{15}	p = 1.25 σ = 13.0	1905 to 1930	70 to 160 (100)	3.67 ±0.19	$N\bar{K}$ Λπ Σπ	5-15 10-20 seen	612 619 568
Σ(1940)[q]	1(3/2⁻)D'''_{13}	p = 1.32 σ = 12.0	1890 to 1960	100 to 300 (220)	3.76 ±0.43	$N\bar{K}$ Λπ Σπ Λ(1520)π	<20 seen seen seen	678 680 589 370
Σ(2030)[g]	1(7/2⁺)F_{17}	p = 1.52 σ = 9.93	2020 to 2040	120 to 200 (180)	4.12 ±0.37	$N\bar{K}$ Λπ Σπ ΞK Λ(1520)π Σ(1385)π	~20 ~20 5-10 <2 5-20 12	700 700 652 412 429 530
Σ(2250)[q]	1(?)[r]	p = 2.04 σ = 6.76	2200 to 2300	50 to 150 (100)	5.06 ±0.22	$N\bar{K}$ Λπ Σπ	<10 seen seen	849 841 801
Σ(2455)	1(?)	p = 2.57 σ = 5.09	~2455	~120 (120)	6.03 ±0.29	$N\bar{K}$	(J + 1/2)x ~0.2[k]	979
Σ(2620)	1(?)	p = 2.95 σ = 4.30	~2600	~200 (200)	6.86 ±0.52	$N\bar{K}$	(J + 1/2)x ~0.3[k]	1064
Ξ	1/2(1/2⁺)		(0)1314.9 (-)1321.3		1.729 1.746	See Stable Particle Table		
Ξ(1530)	1/2(3/2⁺)P_{13}		(0)1531.8±0.3 S = 1.3[p] (-)1535.0±0.6	(0)9.1±0.5 (-)10.1±1.9 (10)	2.34 ±0.02	Ξπ	100	144
Ξ(1820)	1/2(3/2)		1823 ±6 ᵒ	20^{+15}_{-10} ᵒ (20)	3.31 ±0.04	$\Lambda\bar{K}$ Ξ(1530)π $\Sigma\bar{K}$ Ξπ	~45 ~45 ~10 small	396 234 306 413
Ξ(2030)[s]	1/2(?)		2024 ±6 ᵒ	16^{+15}_{-5} ᵒ (16)	4.12 ±0.03	$\Sigma\bar{K}$ $\Lambda\bar{K}$ Ξπ Ξ(1530)π	~80 ~20 small small	524 587 573 418
Ω⁻	0(3/2⁺)		1672.2		2.796	See Stable Particle Table		

Baryon Table *(cont'd)*

→ For convenience all Baryon States for which information exists in the Baryon Data Card Listings are listed at the beginning of the Baryon Table. States with only a one or two star (*) rating in that list have been omitted from the main Baryon Table; each omitted state is indicated by an arrow in the left-hand margin of the Table. In the Listings there is an arrow under the name of each state omitted from the Table.

a. The names of the Baryon States in Col. 1 [such as N(1470)] contain a nominal mass which is primarily for purposes of identification. See Col. 4 for actual mass values. The convention for using primes in the spectroscopic notation for the quantun numbers in Col. 2 (such as P_{11}') is as follows: no prime is attached when the Data Card Listings include only one resonance in the given partial wave; when there is more than one resonance the first has been designated with a prime, the second with a double prime, etc. The name and the quantum numbers for each state are also given in large print at the beginning of the Data Card Listings for that state. See footnote a. of the Stable Particle Table for the strangeness quantum numbers of the baryons; in addition to the names listed there, we also use N and Δ for S = 0 baryons, and Z* for S = +1 baryons.

b. The numbers in Col. 3 and Col. 6 are calculated using the nominal mass (see *a.* above) for M and the nominal width (see *c.* below) for Γ.

c. For masses, widths, and branching fractions of most baryons we report here a range instead of an average. Averages are appropriate if each result is based on independent measurements, but inappropriate where the spread in parameters arises because different models or procedures have been applied to a common set of data. The ranges given in the Table are generally chosen to be *conservatively large*. See the Data Card Listings for the individual values obtained in specific analyses. A single value with an approximation sign (∼) indicates that there is not enough data to give a meaningful interval. A nominal width is included in parentheses in Col. 5; this nominal width is used to calculate the value of ΓM given in Col. 6.

d. For two-body decay modes we given the momentum, p, of the decay products in the decaying baryon rest frame. For decay modes into ⩾3 particles we give the maximum momentum, p_{max}, that any of the particles in the final state can have in this frame. The momenta are calculated using the nominal mass (see *a.* above) of the decaying baryon, and of any isobars in the final state. Some decays which would be energetically forbidden for the nominal masses actually occur because of the finite widths of the decaying baryon and/or isobars in the final state. In these cases, the decay momentum is omitted from Col. 9 and replaced with a reference to this footnote.

e. Square brackets around an isobar decay mode indicate that it is a sub-reaction of the previous unbracketed decay mode.

f. Many of the branching fractions in the Table are extracted from significantly more accurate results on $\sqrt{xx'}$ type couplings obtained in partial-wave analyses. The original $\sqrt{xx'}$ values are given in the Baryon Data Card Listings. For information on radiative decays of N's and Δ's, see the mini-review preceding the Baryon Data Card Listings.

g. Only information coming from partial-wave analyses has been used here. For the production experiment results see the Baryon Data Card Listings.

h. The range given here does not include the widths of several hundred MeV reported by LONGACRE 75 and LONGACRE 77.

i. The range given here does not include the branching ratio of approximately 80% reported by FELTESSE 75.

j. The existence of an $I_{1\,11}$ resonance at this mass has been confirmed, but the possibility remains that there are also other nearby I = 1/2 resonances. See the mini-review preceding the Baryon Data Card Listings.

k. This state has been seen only in an energy-dependent fit to total, channel, or fixed angle cross-section data. J is not known; x is Γ_{el}/Γ.

l. See note on determination of resonance parameters in the Baryon Data Card Listings. Values of mass and width are dependent upon resonance shape used to fit the data. The pole position is much less dependent upon the parametrization used. The pole positions given here are taken from results (in the Data Card Listings) of fits to the phase shifts of CARTER 73 without Coulomb corrections.

m. There may be more than one P_{33} resonance in or near this mass range.

n. There is probably more than one Δ resonance near 2160 MeV. The parameters in the Table correspond to the observations of REY 74. See the Baryon Data Card Listings for other possibilities.

o. The error given here is only an educated guess; it is larger than the error of the average of the published values (see the Baryon Data Card Listings for the latter).

p. Quoted error includes a S (scale) factor. See second footnote to Stable Particle Table.

q. Because the elastic branching fraction of this resonance is poorly determined, it is not possible to extract inelastic branching fractions from partial-wave couplings. See the Baryon Data Card Listings for the partial-wave couplings.

r. Recent partial-wave analyses of the College de France-Saclay group find evidence for a $5/2^-$ and a $9/2^-$ Σ resonance at this mass. See the Baryon Data Card Listings.

s. This state is now considered to be firmly established even though the quantum numbers and decay rates are not sufficiently well known.

PHYSICAL AND NUMERICAL CONSTANTS*

PHYSICAL CONSTANTS

		Uncert. (ppm)
N_A	$= 6.022\,045(31)\times10^{23}$ mole^{-1}	5.1
V_m	$= 22413.83(70)$ cm^3 mole^{-1} = molar volume of ideal gas at STP	31
c	$= 2.997\,924\,58(1.2)\times10^{10}$ cm sec^{-1}	0.004
e	$= 4.803\,242(14)\times10^{-10}$ esu $= 1.602\,189\,2(46)\times10^{-19}$ coulomb	2.9; 2.9
1 MeV	$= 1.602\,189\,2(46)\times10^{-6}$ erg	2.9
$\hbar=h/2\pi$	$= 6.582\,173(17)\times10^{-22}$ MeV sec $= 1.054\,588\,7(57)\times10^{-27}$ erg sec	2.6; 5.4
$\hbar c$	$= 1.973\,285\,8(51)\times10^{-11}$ MeV cm $= 197.32858(51)$ MeV fermi	2.6; 2.6
	$= 0.624\,007\,8(16)$ GeV mb$^{1/2}$	2.6
α	$= e^2/\hbar c = 1/137.03604(11)$	0.82
$k_{Boltzmann}$	$= 1.380\,662(44)\times10^{-16}$ erg °K^{-1}	32
	$= 8.61735(28)\times10^{-11}$ MeV °K^{-1} = 1 eV/11604.50(36) °K	32; 31
m_e	$= 0.511\,003\,4(14)$ MeV $= 9.109\,534(47)\times10^{-28}$ g	2.8; 5.1
m_p	$= 938.2796(27)$ MeV $= 1836.15152(70)\ m_e = 6.722\,776(65)\ m_{\pi^\pm}$	2.8; 0.38; 9.7
	$= 1.007\,276\,470(11)$ amu	0.011
1 amu	$= 1/12\ m_{C12} = 931.5016(26)$ MeV	2.8
m_d	$= 1875.6280(53)$ MeV	2.8
r_e	$= e^2/m_ec^2 = 2.817\,938\,0(70)$ fermi (1 fermi = 10^{-13} cm)	2.5
$\lambda\!\!\!^{-}_e$	$= \hbar/m_ec = r_e\alpha^{-1} = 3.861\,590\,5(64)\times10^{-11}$ cm	1.6
$a_{\infty Bohr}$	$= \hbar^2/m_ee^2 = r_e\alpha^{-2} = 0.529\,177\,06(44)$ Å (1 Å = 10^{-8} cm)	0.82
$\sigma_{Thomson}$	$= (8/3)\pi r_e^2 = 0.665\,244\,8(33)$barn (1 barn = 10^{-24} cm^2)	4.9
μ_{Bohr}	$= e\hbar/2m_ec = 0.578\,837\,85(95)\times10^{-14}$ MeV gauss^{-1}	1.6
μ_N	$= e\hbar/2m_pc = 3.152\,451\,5(53)\times10^{-18}$ MeV gauss^{-1}	1.7
μ_p/μ_{Bohr}	$= 0.001\,521\,032\,209(16)$	0.011
$1/2\omega^e_{cyclotron}$	$= e/2m_ec = 8.794\,024(25)\times10^6$ rad sec^{-1} gauss^{-1}	2.8
$1/2\omega^p_{cyclotron}$	$= e/2m_pc = 4.789\,378(14)\times10^3$ rad sec^{-1} gauss^{-1}	2.8

Hydrogen-like atom (nonrelativistic, μ = reduced mass):

$$\left(\frac{v}{c}\right)_{rms} = \frac{ze^2}{n\hbar c};\quad E_n = \frac{\mu}{2}v^2 = \frac{\mu z^2e^4}{2(n\hbar)^2};\quad a_n = \frac{n^2\hbar^2}{\mu ze^2}$$

$R_\infty = m_ee^4/2\hbar^2 = m_ec^2\alpha^2/2$	$= 13.605\,804(36)$ eV (Rydberg)	2.6
	$= m_ec\alpha^2/2h = 109\,737.3177(83)$ cm^{-1}	0.075

pc = 0.3 Hρ (MeV, kilogauss, cm)

1 year (sidereal)	$= 365.256$ days $= 3.1558\times10^7$ sec ($\approx\pi\times10^7$ sec)
density of dry air	$= 1.204$ mg cm^{-3} (at 20°C, 760 mm)
acceleration by gravity	$= 980.62$ cm sec^{-2} (sea level, 45°)
gravitational constant	$= 6.6720(41)\times10^{-8}$ cm^3 g^{-1} sec^{-2} — 615
1 calorie (thermochemical)	$= 4.184$ joules
1 atmosphere	$= 1.01325$ bar (1 bar = 10^6 dynes cm^{-2})
1 eV per particle	$= 11604.50(36)$ °K (from E = kT) — 31

NUMERICAL CONSTANTS

π	3.141 592 7	1 rad	57.295 779 5 deg	$\sqrt{\pi}$	1.772 453 85
e	2.718 281 8	1/e	0.367 879 4	$\sqrt{2}$	1.414 213 6
ln2	0.693 147 2	ln10	2.302 585 1	$\sqrt{3}$	1.732 050 8
$\log_{10}2$	0.301 030 0	$\log_{10}e$	0.434 294 5	$\sqrt{10}$	3.162 277 7

*Revised April 1978 by Barry N. Taylor. Originally prepared by Stanley J. Brodsky, based mainly on the "1973 Least-Squares Adjustment of the Fundamental Constants," by E. R. Cohen and B. N. Taylor, J. Phys. Chem. Ref. Data 2, 663 (1973). The figures in parentheses correspond to the one-standard-deviation uncertainty in the last digits of the main number. The equivalent uncertainty in parts per million (ppm) is given in the last column. Note that the uncertainties of the output values of a least-squares adjustment are in general correlated, and the general law of error propagation must be used in calculating additional quantities.

The set of constants resulting from the 1973 adjustment of Cohen and Taylor has been recommended for international use by CODATA (Committee on Data for Science and Technology), and is the most up-to-date, generally accepted set currently available. However, since the publication of the 1973 adjustment, a number of new experiments have been completed, yielding improved values for some of the constants: $N_A = 6.022\,097\,8(63)\times10^{23}$ mole^{-1} (1.04 ppm); $\alpha^{-1} = 137.035\,987(29)$ (0.21 ppm) [obtained using the Josephson effect]; and $R_\infty = 109\,737.3143(10)$ cm^{-1} (0.009 ppm). [See Atomic Masses and Fundamental Constants 5, Ed. by J. H. Sanders and A. H. Wapstra, Plenum Pub. Co., (1976).] But it must be realized that, since the output values of a least-squares adjustment are related in a complex way and a change in the measured value of one constant usually leads to corresponding changes in the adjusted values of others, one must be cautious in carrying out calculations using both the output values from the 1973 adjustment and the results of more recent experiments. A new adjustment is planned for completion in 1980.

CLEBSCH-GORDAN COEFFICIENTS, SPHERICAL HARMONICS, AND d FUNCTIONS

Note: A $\sqrt{\ }$ is to be understood over every coefficient; e.g., for -8/15 read $-\sqrt{8/15}$.

Notation:

J	J	...
M	M	...
m_1	m_2	
m_1	m_2	Coefficients
.	.	
.	.	
.	.	

$1/2 \times 1/2$

	+1	
+1/2 +1/2	1	1 0 0
+1/2 -1/2	1/2	1/2 1
-1/2 +1/2	1/2	1/2 -1
-1/2 -1/2	1	

$1 \times 1/2$

	3/2	
	+3/2	
+1 +1/2	1	3/2 1/2
+1 -1/2	1/3	2/3 3/2
0 +1/2	2/3	-1/3 1/2
0 -1/2	2/3	1/3 3/2
-1 +1/2	1/3	-2/3 -3/2
-1 -1/2	1	

2×1

	3		
	+3		
+2 +1	1	3 2	
		+2 +2	
+2 0	1/3	2/3	3 2 1
+1 +1	2/3	-1/3	+1 +1 +1
+2 -1	1/15	1/3	3/5
+1 0	8/15	1/6	-3/10
0 +1	6/15	-1/2	1/10

1×1

	2		
	+2		
+1 +1	1	2 1	
		+1 +1	
+1 0	1/2	1/2	2 1 0
0 +1	1/2	-1/2	0 0 0
+1 -1	1/6	1/2	1/3
0 0	2/3	0	-1/3
-1 +1	1/6	-1/2	1/3

+1 -1	1/5	1/2	3/10
0 0	3/5	0	-2/5
-1 +1	1/5	-1/2	3/10

0 -1	1/2	1/2	2
-1 0	1/2	-1/2	-2
-1 -1	1		

0 -1	6/15	1/2	1/10
-1 0	8/15	-1/6	-3/10
-2 +1	1/15	-1/3	3/5

-1 -1	2/3	1/3	3
-2 0	1/3	-2/3	-3
-2 -1	1		

$3/2 \times 1$

	5/2		
	+5/2		
+3/2 +1	1	5/2 3/2	
		+3/2 +3/2	
+3/2 0	2/5	3/5	5/2 3/2 1/2
+1/2 +1	3/5	-2/5	+1/2 +1/2 +1/2
+3/2 -1	1/10	2/5	1/2
+1/2 0	3/5	1/15	-1/3
-1/2 +1	3/10	-8/15	1/6

+1/2 -1	3/10	8/15	1/6
-1/2 0	3/5	-1/15	-1/3
-3/2 +1	1/10	-2/5	1/2

0 -1	6/15	1/2	1/10
-1 0	8/15	-1/6	-3/10
-2 +1	1/15	-1/3	3/5

-1 -1	2/3	1/3	3
-2 0	1/3	-2/3	-3
-2 -1	1		

$2 \times 1/2$

	5/2	
	+5/2	
+2 1/2	1	5/2 3/2
		+3/2 +3/2
+2 -1/2	1/5	4/5
+1 +1/2	4/5	-1/5

+1 -1/2	2/5	3/5	5/2 3/2
0 +1/2	3/5	-2/5	-1/2 -1/2
0 -1/2	3/5	2/5	5/2 3/2
-1 +1/2	2/5	-3/5	-3/2 -3/2

-1 -1/2	4/5	1/5	5/2
-2 +1/2	1/5	-4/5	-5/2
-2 -1/2	1		

$3/2 \times 1/2$

	2	
	+2	
+3/2 +1/2	1	2 1
		+1 +1
+3/2 -1/2	1/4	3/4
+1/2 +1/2	3/4	-1/4

+1/2 -1/2	1/2	1/2	2 1
-1/2 +1/2	1/2	-1/2	-1 -1
-1/2 -1/2	3/4	1/4	2
-3/2 +1/2	1/4	-3/4	-2
-3/2 -1/2	1		

2×2

	4		
	+4		
+2 +2	1	4 3	
		+3 +3	
+2 +1	1/2	1/2	4 3 2
+1 +2	1/2	-1/2	+2 +2 +2
+2 0	3/14	1/2	2/7
+1 1	4/7	0	-3/7
0 2	3/14	-1/2	2/7

		4	3	2 1
		+1	+1	+1 +1
+2 -1	1/14	3/10	3/7	1/5
+1 0	3/7	1/5	-1/14	-3/10
0 1	3/7	-1/5	-1/14	3/10
-1 2	1/14	-3/10	3/7	-1/5

			4	3	2 1 0
			0	0	0 0 0
+2 -2	1/70	1/10	2/7	2/5	1/5
+1 -1	8/35	2/5	1/14	-1/10	-1/5
0 0	18/35	0	-2/7	0	1/5
-1 1	8/35	-2/5	1/14	1/10	-1/5
-2 2	1/70	-1/10	2/7	-2/5	1/5

$2 \times 3/2$

	7/2		
	+7/2		
+2 3/2	1	7/2 5/2	
		+5/2 +5/2	
+2 +1/2	3/7	4/7	7/2 5/2 3/2
+1 +3/2	4/7	-3/7	+3/2 +3/2 +3/2
+2 -1/2	1/7	16/35	2/5
+1 1/2	4/7	1/35	-2/5
0 3/2	2/7	-18/35	1/5

		7/2	5/2	3/2 1/2
		+1/2	+1/2	+1/2 +1/2
+2 -3/2	1/35	6/35	2/5	2/5
+1 -1/2	12/35	5/14	0	-3/10
0 1/2	18/35	-3/35	-1/5	1/5
-1 3/2	4/35	-27/70	2/5	-1/10

			7/2	5/2	3/2 1/2
			-1/2	-1/2	-1/2 -1/2
+1 -3/2	4/35	27/70	2/5	1/10	
0 -1/2	18/35	3/35	-1/5	-1/5	
-1 1/2	12/35	-5/14	0	3/10	
-2 3/2	1/35	-6/35	2/5	-2/5	

$3/2 \times 3/2$

	3		
	+3		
+3/2 +3/2	1	3 2	
		+2 +2	
+3/2 +1/2	1/2	1/2	3 2 1
+1/2 +3/2	1/2	-1/2	+1 +1 +1
+3/2 -1/2	1/5	1/2	3/10
+1/2 +1/2	3/5	0	-2/5
-1/2 +3/2	1/5	-1/2	3/10

		3	2	1 0
		0	0	0 0
+3/2 -3/2	1/20	1/4	9/20	1/4
+1/2 -1/2	9/20	1/4	-1/20	-1/4
-1/2 +1/2	9/20	-1/4	-1/20	1/4
-3/2 +3/2	1/20	-1/4	9/20	-1/4

		3	2	1
		-1	-1	-1
+1/2 -3/2	1/5	1/2	3/10	
-1/2 -1/2	3/5	0	-2/5	
-3/2 +1/2	1/5	-1/2	3/10	

			3	2
			-2	-2
-1/2 -3/2	1/2	1/2	3	
-3/2 -1/2	1/2	-1/2	-3	
-3/2 -3/2	1			

		7/2	5/2	3/2
		-3/2	-3/2	-3/2
0 -3/2	2/7	18/35	1/5	
-1 -1/2	4/7	-1/35	-2/5	
-2 1/2	1/7	-16/35	2/5	

			7/2	5/2
			-5/2	-5/2
-1 -3/2	4/7	3/7	7/2	
-2 -1/2	3/7	-4/7	-7/2	
-2 -3/2	1			

				4	3 2 1
				-1	-1 -1 -1
+1 -2	1/14	3/10	3/7	1/5	
0 -1	3/7	1/5	-1/14	-3/10	
-1 0	3/7	-1/5	-1/14	3/10	
-2 1	1/14	-3/10	3/7	-1/5	

					4 3 2
					-2 -2 -2
0 -2	3/14	1/2	2/7		
-1 -1	4/7	0	-3/7		
-2 0	3/14	-1/2	2/7		

					4 3
					-3 -3
-1 -2	1/2	1/2	4		
-2 -1	1/2	-1/2	-4		
-2 -2	1				

$Y_1^0 = \sqrt{\frac{3}{4\pi}}\cos\theta$

$Y_1^1 = -\sqrt{\frac{3}{8\pi}}\sin\theta\, e^{i\phi}$

$Y_2^0 = \sqrt{\frac{5}{4\pi}}\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$

$Y_2^1 = -\sqrt{\frac{15}{8\pi}}\sin\theta\cos\theta\, e^{i\phi}$

$Y_2^2 = \frac{1}{4}\sqrt{\frac{15}{2\pi}}\sin^2\theta\, e^{2i\phi}$

$Y_\ell^{-m} = (-1)^m Y_\ell^{m*}$

$d^\ell_{m,0} = \sqrt{\frac{4\pi}{2\ell+1}}\, Y_\ell^m e^{-im\phi}$

$d^j_{m',m} = (-1)^{m-m'} d^j_{m,m'} = d^j_{-m,-m'}$

$d^{1/2}_{1/2,1/2} = \cos\frac{\theta}{2}$ $\quad d^{1/2}_{1/2,-1/2} = -\sin\frac{\theta}{2}$

$d^1_{1,1} = \frac{1+\cos\theta}{2}$ $\quad d^1_{1,0} = -\frac{\sin\theta}{\sqrt{2}}$ $\quad d^1_{1,-1} = \frac{1-\cos\theta}{2}$ $\quad d^1_{0,0} = \cos\theta$

$d^{3/2}_{3/2,3/2} = \frac{1+\cos\theta}{2}\cos\frac{\theta}{2}$

$d^{3/2}_{3/2,1/2} = -\sqrt{3}\,\frac{1+\cos\theta}{2}\sin\frac{\theta}{2}$ $\quad d^2_{2,2} = \left(\frac{1+\cos\theta}{2}\right)^2$

$d^{3/2}_{3/2,-1/2} = \sqrt{3}\,\frac{1-\cos\theta}{2}\cos\frac{\theta}{2}$ $\quad d^2_{2,1} = -\frac{1+\cos\theta}{2}\sin\theta$

$d^{3/2}_{3/2,-3/2} = -\frac{1-\cos\theta}{2}\sin\frac{\theta}{2}$ $\quad d^2_{2,0} = \frac{\sqrt{6}}{4}\sin^2\theta$ $\quad d^2_{1,1} = \frac{1+\cos\theta}{2}(2\cos\theta - 1)$

$d^{3/2}_{1/2,1/2} = \frac{3\cos\theta - 1}{2}\cos\frac{\theta}{2}$ $\quad d^2_{2,-1} = -\frac{1-\cos\theta}{2}\sin\theta$ $\quad d^2_{1,0} = -\sqrt{\frac{3}{2}}\sin\theta\cos\theta$

$d^{3/2}_{1/2,-1/2} = -\frac{3\cos\theta + 1}{2}\sin\frac{\theta}{2}$ $\quad d^2_{2,-2} = \left(\frac{1-\cos\theta}{2}\right)^2$ $\quad d^2_{1,-1} = \frac{1-\cos\theta}{2}(2\cos\theta + 1)$ $\quad d^2_{0,0} = \left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$

$\langle j_1 j_2 m_1 m_2 | j_1 j_2 J M\rangle = (-1)^{J - j_1 - j_2}\langle j_2 j_1 m_2 m_1 | j_2 j_1 J M\rangle$

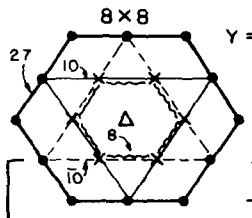
ign convention is that of Wigner (Group Theory, Academic Press, New York, 1959), also used by Condon and Shortley (The Theory of tomic Spectra, Cambridge Univ. Press, New York, 1953), Rose (Elementary Theory of Angular Momentum, Wiley, New York, 1957), nd Cohen (Tables of the Clebsch-Gordan Coefficients, North American Rockwell Science Center, Thousand Oaks, Calif., 1974). The igns and numbers in the current tables have been calculated by computer programs written independently by Cohen and at LBL. (Table xtended April 1974.)

SU(3) ISOSCALAR FACTORS

Adapted from J. J. de Swart, Rev. Mod. Phys. 35, 916 (1963)

The convention used here is: baryon first, meson second.

$\{8\} \otimes \{8\} = \{27\} \oplus \{10\} \oplus \{10^*\} \oplus \{8\}_1 \oplus \{8\}_2 \oplus \{1\}$.



Multiplicity of 27;

● = 1, × = 2, Δ = 3

* Five single-coefficient tables are omitted. The one involving a $\{10^*\}$ has a negative coefficient, i.e. $(NK|10^*) = -1$. The others, involving $\{27\}$ and $\{10\}$, are all +1

$Y = 1$ $I = 1/2$ N

ξ_1	27 (+)	8_D (+)	8_F (−)	10^* (−)
Nπ	$\sqrt{5}/10$	$3\sqrt{5}/10$	1/2	−1/2
ΣK	$-\sqrt{5}/10$	$-3\sqrt{5}/10$	1/2	−1/2
Nη	$3\sqrt{5}/10$	$-\sqrt{5}/10$	1/2	1/2
ΛK	$3\sqrt{5}/10$	$-\sqrt{5}/10$	−1/2	−1/2

$Y = 1$ $I = 3/2$ Δ

ξ_1	27 (+)	10 (−)
Nπ	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΣK	$\sqrt{2}/2$	$\sqrt{2}/2$

$Y = 0$ $I = 0$ Λ

ξ_1	27 (+)	8_D (+)	1 (+)	8_F (−)
NK̄	$\sqrt{15}/10$	$\sqrt{10}/10$	1/2	$\sqrt{2}/2$
ΞK	$-\sqrt{15}/10$	$-\sqrt{10}/10$	−1/2	$\sqrt{2}/2$
Σπ	$-\sqrt{10}/20$	$-\sqrt{15}/5$	$\sqrt{6}/4$	0
Λη	$3\sqrt{30}/20$	$-\sqrt{5}/5$	$-\sqrt{2}/4$	0

$Y = 0$ $I = 1$ Σ

ξ_1	27 (+)	8_D (+)	8_F (−)	10 (−)	10^* (−)
NK̄	$\sqrt{5}/5$	$-\sqrt{30}/10$	$\sqrt{6}/6$	$-\sqrt{6}/6$	$\sqrt{6}/6$
ΞK	$\sqrt{5}/5$	$-\sqrt{30}/10$	$-\sqrt{6}/6$	$\sqrt{6}/6$	$-\sqrt{6}/6$
Σπ	0	0	$\sqrt{6}/3$	$\sqrt{6}/6$	$-\sqrt{6}/6$
Ση	$\sqrt{30}/10$	$\sqrt{5}/5$	0	1/2	1/2
Λπ	$\sqrt{30}/10$	$\sqrt{5}/5$	0	−1/2	−1/2

$Y = -1$ $I = 1/2$ Ξ

ξ_1	27 (+)	8_D (+)	8_F (−)	10 (−)
Ξπ	$-\sqrt{5}/10$	$-3\sqrt{5}/10$	1/2	1/2
ΣK̄	$\sqrt{5}/10$	$3\sqrt{5}/10$	1/2	1/2
Ξη	$3\sqrt{5}/10$	$-\sqrt{5}/10$	−1/2	1/2
ΛK̄	$3\sqrt{5}/10$	$-\sqrt{5}/10$	1/2	−1/2

$Y = -1$ $I = 3/2$ Ξ

ξ_1	27 (+)	10^* (−)
Ξπ	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΣK̄	$\sqrt{2}/2$	$\sqrt{2}/2$

The phase factor $\xi_1 = \pm 1$, from de Swart's Table I, enters in his symmetry formula (14.3):

$$\langle \mu_1 \mu_2 | \mu \rangle = \xi_1 (-1)^{I_1 + I_2 - I} \langle \mu_2 \mu_1 | \mu \rangle .$$

This factor is irrelevant if you are doing your own self-consistent calculations; it enters when you try to check someone else who chose $\mu_2 \otimes \mu_1$ instead of $\mu_1 \otimes \mu_2$.

$\{10\} \otimes \{8\} = \{35\} \oplus \{27\} \oplus \{10\} \oplus \{8\}$.

* Four single coefficient tables are omitted; only the $\{27\}$ is −1; the three with $\{35\}$ are +1.

$Y = 1$ $I = 1/2$ N

ξ_1	27 (−)	8 (+)
Δπ	$-\sqrt{5}/5$	$-2\sqrt{5}/5$
ΣK	$-2\sqrt{5}/5$	$\sqrt{5}/5$

$Y = 1$ $I = 3/2$ Δ

ξ_1	35 (+)	27 (−)	10 (−)
Δπ	1/4	$-\sqrt{5}/4$	$\sqrt{10}/4$
Δη	$\sqrt{5}/4$	3/4	$\sqrt{2}/4$
ΣK	$\sqrt{10}/4$	$-\sqrt{2}/4$	−1/2

$Y = 0$ $I = 0$ Λ

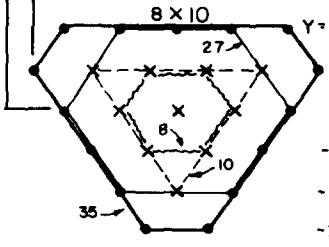
ξ_1	27 (−)	8 (+)
Σπ	$-\sqrt{10}/5$	$-\sqrt{15}/5$
ΞK	$-\sqrt{15}/5$	$\sqrt{10}/5$

$Y = 0$ $I = 1$ Σ

ξ_1	35 (+)	27 (−)	10 (−)	8 (+)
Σπ	$\sqrt{3}/6$	$-3\sqrt{5}/10$	$\sqrt{3}/3$	$-\sqrt{30}/15$
Ση	$\sqrt{2}/2$	$\sqrt{30}/10$	0	$-\sqrt{5}/5$
ΞK	$\sqrt{3}/3$	$-\sqrt{5}/5$	$-\sqrt{3}/3$	$\sqrt{30}/15$
ΔK̄	$\sqrt{3}/6$	$\sqrt{5}/10$	$\sqrt{3}/3$	$2\sqrt{30}/15$

$Y = 0$ $I = 2$

ξ_1	35 (+)	27 (−)
Σπ	$\sqrt{3}/2$	−1/2
ΔK̄	1/2	$\sqrt{3}/2$



Multiplicity of 35;

● = 1, × = 2

$Y = -1$ $I = 1/2$ Ξ

ξ_1	35 (+)	27 (−)	10 (−)	8 (+)
Ξπ	1/4	$-7\sqrt{5}/20$	$\sqrt{2}/4$	$-\sqrt{5}/5$
Ξη	3/4	$3\sqrt{5}/20$	$-\sqrt{2}/4$	$-\sqrt{5}/5$
ΩK	$\sqrt{2}/4$	$-3\sqrt{10}/20$	−1/2	$\sqrt{10}/5$
ΣK̄	1/2	$\sqrt{5}/10$	$\sqrt{2}/2$	$\sqrt{5}/5$

$Y = -1$ $I = 3/2$ Ξ

ξ_1	35 (+)	27 (−)
Ξπ	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΣK̄	$\sqrt{2}/2$	$\sqrt{2}/2$

$Y = -2$ $I = 0$ Ω^-

ξ_1	35 (+)	10 (−)
Ωη	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΞK̄	$\sqrt{2}/2$	$\sqrt{2}/2$

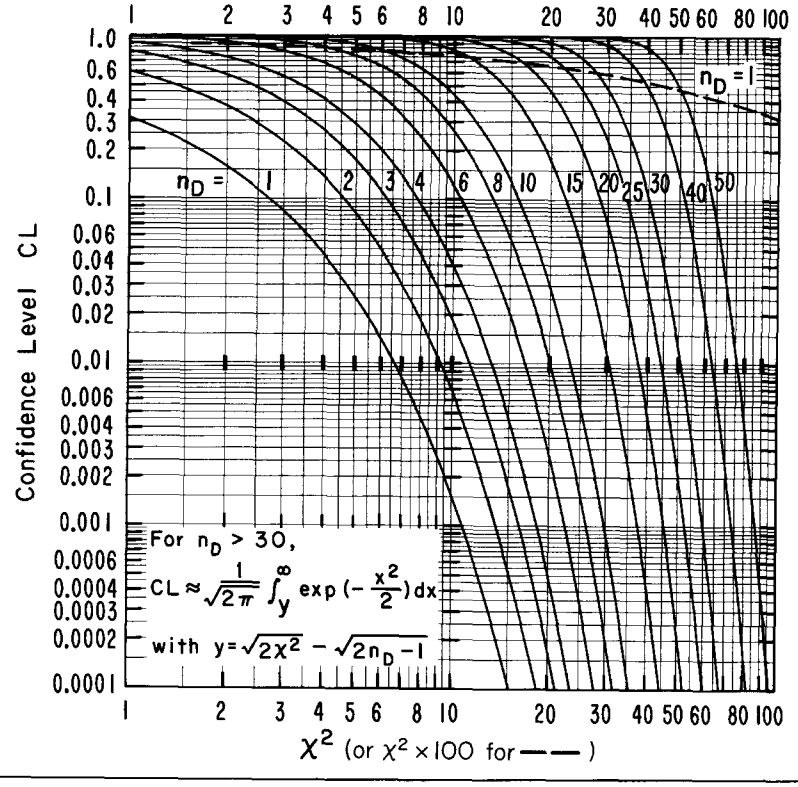
$Y = -2$ $I = 1$

ξ_1	35 (+)	27 (−)
Ωπ	1/2	$-\sqrt{3}/2$
ΞK̄	$\sqrt{3}/2$	1/2

PROBABILITY AND STATISTICS

A. PROBABILITY DISTRIBUTIONS AND CONFIDENCE LEVELS

We give here properties of the three probability distributions most commonly used in high energy physics: Normal (or Gaussian), Chi-squared, and Poisson. We warn the reader that there is no universal convention for the term "confidence level" as used by physicists; thus, explicit definitions are given for each distribution, and we have attempted to choose definitions that correspond to common usage. It is explained below how confidence levels for all three distributions can be extracted from the following figure.



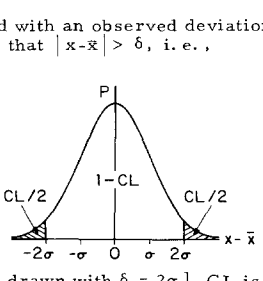
A.1. Normal Distribution

The normal distribution with mean $\bar{x}$ and standard deviation σ (variance σ^2) is:

$$P(x)dx = \frac{1}{\sqrt{2\pi}\sigma} e^{-(x-\bar{x})^2/2\sigma^2} dx. \qquad (1)$$

The confidence level associated with an observed deviation from the mean, δ, is the probability that $|x-\bar{x}| > \delta$, i.e.,

$$CL = 2\int_{\bar{x}+\delta}^{\infty} dx\, P(x) \qquad (2)$$



[The small figure in Eq. (2) is drawn with $\delta = 2\sigma$.] CL is given by the ordinate of the $n_D = 1$ curve in the figure at $\chi^2 = (\delta/\sigma)^2$. The confidence level for $\delta = 1\sigma$ is 31.7%; 2σ, 4.6%; 3σ, 0.3%. The central confidence interval, 1-CL, (which is also sometimes called confidence level) for $\delta = 1\sigma$ is 68.3%; 2σ, 95.4%; 3σ, 99.7%. The odds against exceeding δ, (1-CL)/CL, for $\delta = 1\sigma$ are 2.15:1; 2σ, 21:1; 3σ, 370:1; 4σ, 16,000:1; 5σ, 1,700,000:1. Relations between σ and other measures of the width: probable error (CL = 0.5 deviation) = 0.67σ; mean absolute deviation = 0.80σ; RMS deviation = σ; half width at half maximum = 1.18σ.

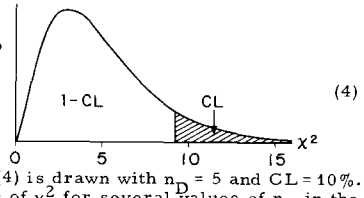
A.2. Chi-squared Distribution

The chi-squared distribution for n_D degrees of freedom is:

$$P_{n_D}(\chi^2)d\chi^2 = \frac{1}{2^h\Gamma(h)} (\chi^2)^{h-1} e^{-\chi^2/2} d\chi^2 \quad (\chi^2 \geq 0), \qquad (3)$$

where h (for "half") = $n_D/2$. The mean and variance are n_D and $2n_D$, respectively. In evaluating Eq. (3) one may use Stirling's approximation: $\Gamma(h) = (h-1)! \approx 2.507\, e^{-h}\, h^{(h-1/2)} \times (1 + 0.0833/h)$ which is accurate to ± 0.1% for all $h \geq 1/2$. The confidence level associated with a given value of n_D and an observed value of χ^2 is the probability of chi-squared exceeding the observed value, i.e.,

$$CL = \int_{\chi^2}^{\infty} d\chi^2\, P_{n_D}(\chi^2) \qquad (4)$$



[The small figure in Eq. (4) is drawn with $n_D = 5$ and CL = 10%.] CL is plotted as a function of χ^2 for several values of n_D in the above figure. For large n_D, χ^2 becomes normally distributed about n_D. Thus,

$$y_1 = (\chi^2 - n_D)/\sqrt{2n_D} \qquad (5)$$

becomes normally distributed with unit standard deviation. A better approximation, due to Fisher,[1] is that χ, not χ^2, becomes normally distributed, specifically

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \qquad (6)$$

approaches normality with unit standard deviation. For small CL's in particular, y_2 is much more accurate than y_1. Thus, for $n_D = 50$ and $\chi^2 = 80$, the true CL = 0.45%, but y_1 is 3.0 corresponding to a CL of 0.13%, while y_2 is 2.7 corresponding to a CL of 0.35%.

PROBABILITY AND STATISTICS (Cont'd)

A.3. Poisson Distribution

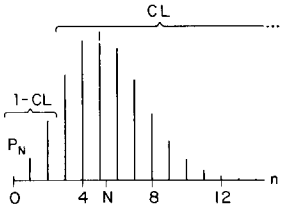
The Poisson distribution with mean $\bar{n}$ is:

$$P_{\bar{n}}(n) = \frac{e^{-(\bar{n})}(\bar{n})^n}{n!} \quad (n = 0, 1, 2, \cdots) . \tag{7}$$

The variance is equal to the mean. Confidence levels for Poisson distributions are usually defined in terms of quantities called "upper limits" as follows: The confidence level associated with a given upper limit N and an observed value n_0 of n is the probability that $n > n_0$ if $\bar{n} = N$, i.e.,

$$CL = \sum_{n=n_0+1}^{\infty} P_N(n)$$

$$= 1 - \sum_{n=0}^{n_0} P_N(n) \tag{8}$$



[The small figure in Eq. (8) is drawn with $n_0 = 2$ and CL = 90%.] A useful relation between Poisson and chi-squared confidence levels allows one to look up this quantity on the above figure. Specifically, the quantity 1-CL is given by the ordinate of the $n_D = 2(n_0+1)$ curve at $\chi^2 = 2N$. Thus, 90% confidence level upper limits for $n_0 = 0$, 1, and 2 are given by half the χ^2 value corresponding to an ordinate of 0.1 on the $n_D = 2, 4$, and 6 curves, respectively; the values are N = 2.3, 3.9, and 5.3.

- -

Tables of confidence levels for all three of these distributions, the relation between Poisson and chi-squared confidence levels, and numerous other useful tables and relations may be found in Ref. 2.

B. STATISTICS

We consider here the situation in which one is presented with N independent data, $y_n \pm \sigma_n$, and it is desired to make some inference about the "true" value of the quantity represented by these data. For this purpose we interpret each datum y_n as a single sample point drawn randomly (and independently of the other data) from a distribution having mean $\bar{y}_n$ (which we wish to estimate) and variance σ_n^2. (Identification of the true σ_n with the σ_n datum is an approximation which may become seriously inaccurate when σ_n is an appreciable fraction of y_n.) Some methods of estimation commonly used in high energy physics are given below; see Ref. 3 for numerous applications. Section B.1. deals with the case in which all $\bar{y}_n$ are the same, e.g., several different measurements of the same quantity; Sec. B.2. deals with the case in which $\bar{y}_n = \bar{y}(x_n)$, where x_n represents some set of independent variables, e.g., cross-section measurements at various values of energy and angle, $x_n = \{E_n, \theta_n\}$.

B.1. Single Mean and Variance Estimates

(1) If the y_n represent a set of values all supposedly drawn from a single distribution with mean $\bar{y}$ and variance σ^2 (i.e., the σ_n are all the same, but their common value is unknown) then

$$\bar{y}_e = \frac{1}{N} \sum_{\bar{n}} y_n \quad \text{and} \tag{9}$$

$$\sigma_e^2 = \frac{1}{N-1} \sum_{\bar{n}} (y_n - \bar{y}_e)^2 \tag{10}$$

are unbiased estimates of $\bar{y}$ and σ^2. The variance of $\bar{y}_e$ is σ^2/N. If the parent distribution is normal and N is large, the variance of σ_e^2 is $2\sigma^4/N$.

(2) If the $\bar{y}_n$ all have the common value $\bar{y}$ and the σ_n are known, then the weighted average

$$\bar{y}_e = \frac{1}{w} \sum_{\bar{n}} w_n y_n, \tag{11}$$

where $w_n = 1/\sigma_n^2$ and $w = \Sigma w_n$, is an appropriate unbiased estimate of $\bar{y}$. This choice of weighting factors in Eq. (11) minimizes the variance of the estimate; the variance is $1/w$.

B.2. Linear Least Squares Fit

A least squares fit of the function $y(x) = \Sigma_i a_i f_i(x)$ to independent data $y_n \pm \sigma_n$ at points x_n (e.g., a Legendre fit in which the f_i are Legendre polynomials and the a_i are Legendre coefficients) gives the following estimates of the parameters a_i:

$$a_{e,i} = \sum_{j,\bar{n}} V_{ij} f_j(x_n) y_n/\sigma_n^2 . \tag{12}$$

Here V is the covariance matrix of the fitted parameters

$$V_{ij} = \overline{(a_{e,i} - \bar{a}_{e,i})(a_{e,j} - \bar{a}_{e,j})} , \tag{13}$$

which is given by

$$(V^{-1})_{ij} = \sum_{\bar{n}} f_i(x_n) f_j(x_n)/\sigma_n^2 . \tag{14}$$

The variance of an interpolated or extrapolated value of y at point x, $y_e = \Sigma a_{e,i} f_i(x)$, is:

$$\overline{(y_e - \bar{y}_e)^2} = \sum_{ij} V_{ij} f_i(x) f_j(x) . \tag{15}$$

For the case of a straight line fit, $y(x) = a + bx$, one obtains the following estimates of a and b,

$$a_e = (S_y S_{xx} - S_x S_{xy})/D,$$
$$b_e = (S_1 S_{xy} - S_x S_y)/D, \tag{16}$$

where

$$S_1, S_x, S_y, S_{xx}, S_{xy} = \Sigma (1, x_n, y_n, x_n^2, x_n y_n)/\sigma_n^2, \tag{17}$$
$$D = S_1 S_{xx} - S_x^2 .$$

The covariance matrix of the fitted parameters is:

$$\begin{pmatrix} V_{aa} & V_{ab} \\ V_{ab} & V_{bb} \end{pmatrix} = \frac{1}{D} \begin{pmatrix} S_{xx} & -S_x \\ -S_x & S_1 \end{pmatrix} \tag{18}$$

The variance of an interpolated or extrapolated value of y at point x is:

$$\overline{(y_e - \bar{y}_e)^2} = \frac{1}{S_1} + \frac{S_1}{D} \left(x - \frac{S_x}{S_1} \right)^2 \tag{19}$$

C. ERROR PROPAGATION

We consider here the situation in which one wishes to calculate the value and error of a function of some other quantities with errors, e.g., in a Monte Carlo program. Let $\{y\}$ be a set of random variables with means $\{\bar{y}\}$ and covariance matrix V. Then the mean and variance of a function of these variables are approximately (to second order in $\{y-\bar{y}\}$):

$$\bar{f} \approx f(\{y\}) + \frac{1}{2} \sum_{m\bar{n}} V_{mn} \left(\frac{\partial^2 f}{\partial y_m \partial y_n} \right)_{\{y\} = \{\bar{y}\}} , \tag{20}$$

$$\overline{(f - \bar{f})^2} = \sum_{m\bar{n}} V_{mn} \left(\frac{\partial f}{\partial y_m} \right)_{\{y\} = \{\bar{y}\}} \left(\frac{\partial f}{\partial y_n} \right)_{\{y\} = \{\bar{y}\}} . \tag{21}$$

E.g., the mean and variance of a function of a single variable with mean $\bar{y}$ and variance σ^2 are:

$$\bar{f} \approx f(\bar{y}) + \frac{1}{2} \sigma^2 f''(\bar{y}), \tag{22}$$

$$\overline{(f - \bar{f})^2} = \sigma^2 f'(\bar{y})^2 . \tag{23}$$

Note that these equations will usually be applied by substituting some measured quantities, $\{\tilde{y}\}$ say, for the true means, $\{\bar{y}\}$. If, as is often the case, $\tilde{y}_n - \bar{y}_n$ is of order $\sqrt{V_{nn}}$, then there is no point in keeping the second order terms in Eq. (20) or (22) since the substitution itself introduces first order errors.

1. R. A. Fisher, Statistical Methods for Research Workers (Oliver and Boyd, Edinburgh and London, 1958).
2. M. Abramovitz and I. Stegun, eds., Handbook of Mathematical Functions (National Bureau of Standards, Applied Mathematics Series, Vol. 55, Washington, 1964).
3. W. T. Eadie, D. Drijard, F. E. James, M. Roos, and B. Sadoulet, Statistical Methods in Experimental Physics (North-Holland, Amsterdam and London, 1971).

Revised and expanded April 1974.

RELATIVISTIC KINEMATICS*

DEFINITIONS AND GENERAL FORMULAE | PARTICULAR CASES AND ASYMPTOTIC VALUES ($\simeq$)

I. NOTATION

We define any 4-vector p by its components:

$$p \equiv (p_0, \vec{P}) \quad \text{with} \quad \begin{cases} p_0 \equiv E \equiv \text{the energy} \\ \vec{P} \equiv (P_\parallel, \vec{P}_\perp) = \text{3-vector of magnitude P,} \end{cases} \tag{I-1}$$

where $\begin{cases} P_\parallel \equiv \text{the longitudinal momentum along a beam direction} \\ \vec{P}_\perp \equiv \text{the transverse momentum (2 components, along 2 axes perpendicular to the beam);} \end{cases}$

then
$$p^{lab} = (E^{lab}, P_\parallel^{lab}, \vec{P}_\perp^{lab}) \ , \tag{I-2}$$

$$p^{cm} = (E^{cm}, P_\parallel^{cm}, \vec{P}_\perp^{cm}) \quad . \tag{I-3}$$

The 4-vector scalar products are defined by

$$A \cdot B = A_0 B_0 - \vec{A} \cdot \vec{B} \ , \tag{I-4}$$

so that
$$p^{lab} \cdot p^{lab} = p^{cm} \cdot p^{cm} = m^2 \ . \tag{I-5}$$

II. GENERAL INVARIANT DEFINITIONS AND RELATED FORMULAE

For any 2 particles i and j, the most commonly used invariants are defined as follows:

A. *The invariant mass squared of the combination of particles i and j is*

$$s_{ij} \equiv m_{ij}^2 \equiv (p_i + p_j)^2 = m_i^2 + m_j^2 + 2(E_i E_j - \vec{P}_i \cdot \vec{P}_j) \ . \tag{II-1}$$

Using the function $\Delta(x,y,z)$ [also called $\lambda(x,y,z)$], defined by

$$\Delta(x,y,z) \equiv x^2 + y^2 + z^2 - 2xy - 2yz - 2zx$$
$$= [x - (\sqrt{y} + \sqrt{z})^2][x - (\sqrt{y} - \sqrt{z})^2] \ , \tag{II-2}$$

we have the relations:

A.1. *In the particle j rest frame* ($\vec{P}_j = 0$), the longitudinal axis being along $\vec{P}_i$,

$$p_i^{(j)} = \left(\frac{s_{ij} - m_i^2 - m_j^2}{2m_j} \ , \ \frac{\sqrt{\Delta(s_{ij}, m_i^2, m_j^2)}}{2m_j} \ , \ 0 \right) \ ; \tag{II-6}$$

A.2. *In the c.m. frame for particles (i and j)* ($\vec{P}_j = -\vec{P}_i$), the longitudinal axis being along $\vec{P}_i$,

$$p_i^{(ij)} = \left(\frac{s_{ij} + m_i^2 - m_j^2}{2\sqrt{s_{ij}}} \ , \ \frac{\sqrt{\Delta(s_{ij}, m_i^2, m_j^2)}}{2\sqrt{s_{ij}}} \ , \ 0 \right) \ ; \tag{II-11}$$

thus,
$$p_i^{(ij)} = \frac{m_j}{\sqrt{s_{ij}}} \, p_i^{(j)} \ . \tag{II-13}$$

A.3. *Applications: Useful relations involving* s_{ij}:

i) *In a Dalitz plot for the 3-body decay,* $X \to 1 + 2 + 3$,

$$\sum_{i<j} s_{ij} = \sum_i m_i^2 + m_{123}^2 = \text{const.} \ (i,j = 1,2,3) \tag{II-14}$$

with $m_{123}^2 = (p_1 + p_2 + p_3)^2 = m_X^2$.

ii) *In a triangle plot for the 4-body decay,* $X \to 1 + 2 + 3 + 4$,

$$\sum_{i<j} s_{ij} = 2\sum_i m_i^2 + m_{1234}^2 = \text{const.} \ (i,j = 1,2,3,4) \tag{II-15}$$

with $m_{1234}^2 = (p_1 + p_2 + p_3 + p_4)^2 = m_X^2$.

B. *The invariant momentum transfer squared* between particles i and k is

$$t_{ik} \equiv (p_i - p_k)^2 = m_i^2 + m_k^2 - 2(E_i E_k - \vec{P}_i \cdot \vec{P}_k) \ . \tag{II-16}$$

III. VERY HIGH ENERGY PHYSICS: ASYMPTOTIC FORMULAE

A. *Colliding beams*

$$s \simeq 2(E_a E_b - \vec{P}_a \cdot \vec{P}_b) \tag{III-1}$$

If θ is the *supplement* of the angle between the two beams, (and if we assume $E_i \sim P_i$), then:

$$s \simeq 4P_a P_b \cos^2 \frac{\theta}{2} \simeq 4P_a P_b \left(1 - \frac{\theta^2}{8} + \dots\right) \tag{III-2}$$

B. *Interaction of particle a with target b at rest*

B.1. *In the lab frame*

$$s = s_{ab} = m_a^2 + m_b^2 + 2m_b E_a^{lab} \simeq 2m_b E_a^{lab} \tag{III-3}$$

and
$$P_{inc} \simeq \frac{s}{2m_b} \ . \tag{III-4}$$

B.2. *In the center-of-mass frame*

$$s = s_{ab} = (E_a^{cm} + E_b^{cm})^2 \simeq 4(P_a^{cm})^2 \tag{III-5}$$

and
$$P_a^{cm} = P_b^{cm} \simeq \frac{\sqrt{s}}{2} \tag{III-6}$$

and
$$\begin{cases} p_a = \left(\dfrac{s + m_a^2 - m_b^2}{2\sqrt{s}} \ , \ \dfrac{m_b}{\sqrt{s}} P_{inc}, 0 \right) \\ p_b = \left(\dfrac{s + m_b^2 - m_a^2}{2\sqrt{s}} \ , \ \dfrac{-m_b}{\sqrt{s}} P_{inc}, 0 \right). \end{cases}$$

RELATIVISTIC KINEMATICS (Cont'd)

Application to the reaction a + b → c + d:

1. *General formulae in the* (ab) *c.m. system,*

$$t \equiv t_{ac} = t_{bd} = \left[t_{ac}^{min} - 4P_a P_c \sin^2\left(\frac{\theta_{ac}}{2}\right)\right]^{cm} ,$$

with $$t_{ac}^{min} = \left[(E_a - E_c)^2 - (P_a \mp P_c)^2\right]^{cm} \qquad \text{(II-20)}$$

(min/max refer to the minimum/maximum of $|t|$)

and $$t_{ac}^{max} = \left[\frac{m_a^2 - m_c^2 - m_b^2 + m_d^2}{2\sqrt{s}}\right]^2 - \left[\sqrt{\left(\frac{s+m_a^2-m_b^2}{2\sqrt{s}}\right)^2 - m_a^2} \mp \sqrt{\left(\frac{s+m_c^2-m_d^2}{2\sqrt{s}}\right)^2 - m_c^2}\right]^2 ,$$

which, after expansion in powers of (1/s), gives

$$t_{ac}^{min} = -\frac{(m_a^2 - m_c^2)(m_b^2 - m_d^2)}{s} - \frac{(m_a^2 + m_b^2 - m_c^2 - m_d^2)(m_a^2 m_b^2 - m_c^2 m_d^2)}{s^2} + O\left(\frac{1}{s^3}\right) \qquad \text{(II-22)}$$

In a similar way, defining $u_{ad} = (p_a - p_d)^2$, one finds

$$u \equiv u_{ad} \equiv t_{ad} = t_{bc} = \left[u_{ad}^{min} - 4P_a P_d \sin^2\left(\frac{\theta_{ad}}{2}\right)\right]^{cm} ,$$

with $$u_{ad}^{min} = t_{ad}^{min} .$$

A general relation between the invariants is

$$s + t + u = m_a^2 + m_b^2 + m_c^2 + m_d^2 .$$

IV. RELATIONS BETWEEN THE (j) PARTICLE AND (ij) PARTICLE REST FRAMES: LORENTZ TRANSFORMATION

The general Lorentz transformation has the matrix form

$$\begin{pmatrix} E \\ P_\parallel \\ \vec{P}_\perp \end{pmatrix}^{(ij)} = \begin{pmatrix} \gamma & -\eta & 0 \\ -\eta & \gamma & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} E \\ P_\parallel \\ \vec{P}_\perp \end{pmatrix}^{(j)} \qquad \text{(IV-1)}$$

If we define, in any frame, the quantity: $P_\pm = E \pm P_\parallel$,

$$\begin{pmatrix} P_+ \\ P_- \\ \vec{P}_\perp \end{pmatrix}^{(ij)} = \begin{pmatrix} (\gamma-\eta) & 0 & 0 \\ 0 & (\gamma+\eta) & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} P_+ \\ P_- \\ \vec{P}_\perp \end{pmatrix}^{(j)} , \qquad \text{(IV-3)}$$

$$\gamma \mp \eta = \frac{s_{ij} + m_j^2 - m_i^2 \mp \sqrt{\Delta(s_{ij}, m_i^2, m_j^2)}}{2m_j\sqrt{s_{ij}}} = e^{\mp \xi_{ij}} . \qquad \text{(IV-4)}$$

$$\left\{ \begin{aligned} |\vec{\beta}| &= \frac{|\vec{\eta}|}{\gamma} = \tanh \xi_{ij} = \frac{\sqrt{\Delta(s_{ij}, m_i^2, m_j^2)}}{s_{ij} + m_j^2 - m_i^2} = \frac{p_i^{(j)}}{E_i^{(j)} + m_j} && \text{(IV-5)} \\ \gamma &= \frac{1}{\sqrt{1-\beta^2}} = \cosh \xi_{ij} = \frac{s_{ij} + m_j^2 - m_i^2}{2m_j\sqrt{s_{ij}}} = \frac{E_i^{(j)} + m_j}{\sqrt{s_{ij}}} && \text{(IV-6)} \\ |\vec{\eta}| &= |\vec{\beta}|\gamma = \sinh \xi_{ij} = \frac{\sqrt{\Delta(s_{ij}, m_i^2, m_j^2)}}{2m_j\sqrt{s_{ij}}} = \frac{p_i^{(j)}}{\sqrt{s_{ij}}} && \text{(IV-7)} \end{aligned} \right.$$

The spatial part of the matrix in Eq. (IV-1) above can be written with the classical vector form

$$\vec{p}^{(ij)} = \vec{p}^{(j)} + \vec{\eta}\left(\frac{\vec{\eta} \cdot \vec{p}}{\gamma + 1} - E^{(j)}\right) \qquad \text{(IV-9)}$$

A convenient way to write the latter expression is

$$\vec{p}^{(ij)} = \vec{p}^{(j)} - \vec{\eta}\left[\frac{E^{(ij)} + E^{(j)}}{\gamma + 1}\right] \qquad \text{(IV-10)}$$

2. *Particular case*

In the c.m.: $dt = 2P_a P_c \, d(\cos\theta_{ac})$.

i) $m_a = m_c$, $m_b \neq m_d$:

$$t_{ac}^{min} \simeq -\frac{m_a^2 (m_b^2 - m_d^2)^2}{s^2} \qquad \text{(II-24)}$$

$$u_{ad}^{min} \simeq -\frac{(m_a^2 - m_d^2)(m_b^2 - m_c^2)}{s} \qquad \text{(II-25)}$$

ii) For elastic scattering (a + b → a' + b'),

$$t_{aa'}^{min} = 0,$$

and $$t_{aa'} = -4P_a^2 \sin^2\left(\frac{\theta_{aa'}}{2}\right) ,$$

$$dt_{aa'} = 2P_a^2 \, d(\cos\theta_{aa'}); \qquad \text{(II-26)}$$

also $$u_{ab'}^{min} = \frac{(m_a^2 - m_b^2)^2}{s} \qquad \text{(II-27)}$$

At high energy:

$$e^{\xi_{ij}} \simeq \frac{\sqrt{s_{ij}}}{m_j} \quad \text{and} \quad \xi_{ij} \simeq \ell n \frac{\sqrt{s_{ij}}}{m_j} .$$

ξ_{ij} is called the *boost parameter* of the Lorentz transformation that connects the particle ij rest frame to the particle j rest frame.

Application

1. *To reaction* a(beam) + b(target)

The transformation from the lab frame into the c.m. frame is given by:

$$\gamma = \frac{E_a^{lab} + m_b}{\sqrt{s}} \quad \text{and} \quad \eta = \frac{P_{inc}}{\sqrt{s}} ;$$

$$P_\pm^{cm} = e^{\mp \xi} P_+^{lab}$$

with

$$e^{\pm\xi} = \frac{s + m_b^2 - m_a^2 \mp \sqrt{\Delta(s, m_a^2, m_b^2)}}{2m_b\sqrt{s}} \qquad \text{(IV-11)}$$

2. *The Lorentz transform of any vector* $p_1 = (E_1, \vec{p}_1)$, *given in a frame containing another vector* $p_2 = (E_2, \vec{p}_2)$, *into the* p_2 *rest frame* — where $p_2 = (m_2, 0)$, and $p_1 = (E_1', \vec{p}_1')$ — may be calculated using:

$$\gamma = \frac{E_2}{m_2} \quad \text{and} \quad \vec{\eta} = \frac{\vec{p}_2}{m_2} ;$$

$$\left. \begin{aligned} E_1' &= \gamma E_1 - \vec{\eta} \cdot \vec{p}_1 = \frac{E_1 E_2 - \vec{p}_1 \cdot \vec{p}_2}{m_2} , \\ \vec{p}_1' &= \vec{p}_1 - \frac{\vec{p}_2}{m_2}\left(\frac{E_1 + E_1'}{\gamma + 1}\right) = \vec{p}_1 - \vec{p}_2\left(\frac{E_1 + E_1'}{E_2 + m_2}\right) \end{aligned} \right\} \qquad \text{(IV-12)}$$

RELATIVISTIC KINEMATICS (Cont'd)

V. RAPIDITY VARIABLE: DEFINITION AND KINEMATIC RELATIONS

Definition: in any system, for a particle of energy E and longitudinal momentum $P_\parallel$, the rapidity is defined by

$$y \equiv \tfrac{1}{2}\ln\left(\frac{E+P_\parallel}{E-P_\parallel}\right) = \tanh^{-1}\left(\frac{P_\parallel}{E}\right) = \tfrac{1}{2}\ln\left(\frac{P_+}{P_-}\right) = \ln\left(\frac{P_+}{m_\perp}\right) = -\ln\left(\frac{P_-}{m_\perp}\right) \quad , \tag{V-1}$$

with the transverse mass $m_\perp \equiv (m^2 + P_\perp^2)^{1/2}$.

From the last of the two equations above, one gets

$$P_+ = m_\perp e^{y} \quad , \tag{V-2}$$

$$P_- = m_\perp e^{-y} \quad , \tag{V-3}$$

so that

$$E = m_\perp \cosh y \quad , \tag{V-4}$$

$$P_\parallel = m_\perp \sinh y \quad . \tag{V-5}$$

A. *Relations between the rapidities of different frames:*

$$y^{(ij)} = y^{(j)} - \xi_{ij} \tag{V-7}$$

B. *Application to a reaction* a + b → c + d (or a + b → c + X):

In the lab frame,

$$\left.\begin{aligned} p_a^{lab} &= (m_a \cosh y_a^{lab},\ m_a \sinh y_a^{lab},\ 0) \\ p_b^{lab} &= (m_b,\ 0,\ 0) \\ p_c^{lab} &= (m_{\perp c} \cosh y_c^{lab},\ m_{\perp c} \sinh y_c^{lab},\ \vec{P}_{\perp c}) \end{aligned}\right\} \tag{V-8}$$

(and a similar formula for particle d or X).

In the c.m. frame,

$$\left.\begin{aligned} p_a^{cm} &= (m_a \cosh y_a^{cm},\ m_a \sinh y_a^{cm},\ 0) \\ p_b^{cm} &= (m_b \cosh y_b^{cm},\ m_b \sinh y_b^{cm},\ 0) \\ p_c^{cm} &= (m_{\perp c} \cosh y_c^{cm},\ m_{\perp c} \sinh y_c^{cm},\ \vec{P}_{\perp c}) \end{aligned}\right\} \tag{V-9}$$

(and a similar formula for particle d or X).

$$y_a^{lab} = \cosh^{-1}\left(\frac{s - m_a^2 - m_b^2}{2m_a m_b}\right) \xrightarrow{\text{at large } s} y_a^{lab} \simeq \ln\frac{s}{m_a m_b} \tag{V-10}$$

$$y_a^{cm} = \cosh^{-1}\left(\frac{s + m_a^2 - m_b^2}{2m_a\sqrt{s}}\right) \xrightarrow{\text{at large } s} y_a^{cm} \simeq \ln\frac{\sqrt{s}}{m_a} \tag{V-11}$$

$$y_b^{cm} = \cosh^{-1}\left(\frac{s + m_b^2 - m_a^2}{2m_b\sqrt{s}}\right) \xrightarrow{\text{at large } s} y_b^{cm} \simeq -\ln\frac{\sqrt{s}}{m_b} \tag{V-12}$$

$$y_c^{cm} = \cosh^{-1}\left(\frac{s + m_c^2 - m_d^2}{2m_{\perp c}\sqrt{s}}\right) \xrightarrow{\text{at large } s} y_c^{cm} \simeq \ln\frac{\sqrt{s}}{m_{\perp c}} \tag{V-13}$$

and m_d^2 (or m_X^2) $\ll s$

With $\xi \simeq \ln\frac{\sqrt{s}}{m_b}$, one gets, at large s:

$$y_c^{lab} \simeq \ln\frac{s}{m_b m_{\perp c}} \tag{V-14}$$

$$y^{lab} \simeq \tfrac{1}{2}\ln\left(\frac{p^{lab} + p_\parallel^{lab}}{p^{lab} - p_\parallel^{lab}}\right) \simeq -\ln(\tan\tfrac{\theta}{2}) \quad .$$

The *maximum rapidity gap* for the reaction a + b → c + d at large s is:

i) for the incoming particles (a,b):

$$y_{ab} = y_a^{lab} = y_a^{cm} - y_b^{cm} \simeq \ln\frac{s}{m_a m_b} \tag{V-15}$$

ii) for the outgoing particles (c,d):

$$y_{cd} = y_c^{lab} - y_d^{lab} = y_c^{cm} - y_d^{cm} \simeq \ln\frac{s}{m_{\perp c} m_{\perp d}} \tag{V-16}$$

Application to reaction a + b → 1 + 2 ... + N, with the N outgoing particles being ordered by increasing rapidity

1. *The maximum rapidity gap* between the outgoing particles has an approximate value

$$y_{1N} \simeq \ln\frac{s}{m_{\perp 1} m_{\perp N}} \tag{V-17}$$

2. *The rapidity gap* $(y_i - y_j)$ between the rapidities y_i and y_j of particles i and j, respectively, is related to the invariant mass squared of particles i and j

$$s_{ij} = m_i^2 + m_j^2 + 2m_{\perp i}\cdot m_{\perp j}\cosh(y_i - y_j) - 2\vec{P}_{\perp i}\cdot\vec{P}_{\perp j} \quad , \tag{V-18}$$

$$y_i - y_j = \cosh^{-1}\frac{s_{ij} - m_i^2 - m_j^2 + 2\vec{P}_{\perp i}\cdot\vec{P}_{\perp j}}{2m_{\perp i}m_{\perp j}} \tag{V-19}$$

3. *The rapidity gap between either of the extreme particles (1 or N) and its adjacent neighbor* [2 or (N - 1) respectively] is, on a statistical basis, and in first approximation

$$|y_1 - y_2| \simeq \ln\frac{s}{M_1^2} \quad , \tag{V-20}$$

and

$$|y_{N-1} - y_N| \simeq \ln\frac{s}{M_N^2} \quad , \tag{V-21}$$

M_1 (M_N) being the missing mass with respect to particle 1 (N) in the reaction a + b → 1 + M_1 (a + b → N + M_N).

4. The rapidity gap y_{a1} between the incoming particle a and the outgoing particle closest to a, 1, is related to the transverse momentum $t_{a1} = (p_a - p_1)^2$:

$$y_a - y_1 = \cosh^{-1}\left(\frac{t_{a1} - m_a^2 - m_1^2}{2m_a m_{\perp 1}}\right) \tag{V-23}$$

RELATIVISTIC KINEMATICS (Cont'd)

VI. INCLUSIVE REACTIONS AND SCALING VARIABLES: DEFINITIONS AND KINEMATIC RELATIONS

A. Scaling Variable: Definitions

- For the *inclusive reaction* $a + b \to c + X$

1) Feynman's definition:

$$x = p_{\parallel}^{cm}/p_{max}^{cm} \qquad \text{(VI-3)}$$

where
$$p_{max}^{cm} = \frac{\sqrt{\Delta(s, m_c^2, m_{X,min}^2)}}{2\sqrt{s}} \qquad \text{(VI-4)}$$

is the center-of-mass momentum of particle c and the lightest possible particle(s) $m_{X,min}$ which, consistent with conservation laws, could recoil against particle c.

A *relationship between x and* m_X^2 which becomes useful at high energy [see (VI-6)] derives from

$$m_X^2 = (p_a + p_b - p_c)^2 = s + m_c^2 - 2p_c \cdot (p_a + p_b)$$

2) An alternative definition:

$$x' = p_{\parallel}^{cm}/p_{\parallel max}^{cm} \qquad \text{(VI-7)}$$

with
$$p_{\parallel max}^{cm} = \sqrt{\left(p_{max}^{cm}\right)^2 - p_{\perp}^2} \ .$$

- For *electro- and photoproduction (off protons)*:

Bjorken's definition:

$$\omega = \frac{2m_p\nu}{-q^2} \ ,$$

where
- $\nu = e - e'$ = the difference between the incident and the outgoing energies
- m_p = proton mass
- q^2 = momentum transfer squared .

(NOTE: ω^{-1} is sometimes also called x.)

- For *neutrino interactions*:

For the inclusive reaction $\nu + b \to c + X$,

$$q^2 = (p_\nu - p_c)^2$$

$$\nu = p_b \cdot q/M_b \ .$$

If X is a system of hadrons,

$$W = \sqrt{p_X^2} \ .$$

Scaling variables:

$$x = -q^2/2M_b\nu \ , \qquad 0 \leq x \leq 1$$

$$y = M_b\nu/P_\nu \cdot p_b \ , \qquad 0 \leq y \leq 1$$

Note: ν is sometimes written

$\nu = p_b \cdot q$, leading to the replacement

$M_b\nu \to \nu$ throughout .

- *At high energy*,

$$p_{max}^{cm} \simeq \frac{\sqrt{s}}{2} \quad \text{and} \quad x \simeq \frac{2p_{\parallel}^{cm}}{\sqrt{s}} \ . \qquad \text{(VI-5)}$$

The relation between x and y is trivial:

$$x \simeq 2\frac{p_{\parallel}^{cm}}{\sqrt{s}} \simeq \frac{2m_{\perp}}{\sqrt{s}} \sinh y^{cm} \qquad \text{(VI-8)}$$

and, for y also large:

$$y^{cm} \simeq \ln \frac{x\sqrt{s}}{m_{\perp}} \qquad \text{(VI-9)}$$

$$x = 1 - \frac{m_X^2 - m_c^2}{s} \simeq 1 - \frac{m_X^2}{s} \qquad \text{(VI-6)}$$

$$(\text{for } m_X^2 >> m_c^2) \ .$$

For $p_\perp$ fixed as $s \to \infty$,

$$x' \simeq \frac{2p_{\parallel}^{cm}}{\sqrt{s}} \simeq x \ .$$

In the lab, with c a lepton of negligible mass, θ the neutrino $\to$ c scattering angle:

$$2M_b\nu \leq -q^2 \simeq 2E_\nu E_c \sin^2(\theta/2) \leq 2M_b E_\nu$$

$$\nu = E_\nu - E_c = E_X - M_b \leq E_\nu \ ;$$

$$W = \sqrt{-q^2 + 2M_b\nu + M_b^2}$$

$$x = \frac{2E_\nu E_c \sin^2(\theta/2)}{M_b(E_X - M_b)}$$

$$y = \frac{E_X - M_b}{E_\nu}$$

RELATIVISTIC KINEMATICS (Cont'd)

B. For the inclusive reaction $a + b \to c + X$, *the invariant differential cross section* $E(d^3\sigma/dp_c^3)$ may be written in the following forms using various expressions of the phase space volume d^3p_c/E_c (and omitting the subscript c):

Longitudinal variable of particle c	Transverse variable of particle c	Corresponding invariant (differential) cross section $E(d^3\sigma/dp^3)$	
p^{lab}	θ^{lab}	$\frac{E^{lab}}{(p^{lab})^2}\ \frac{d^3\sigma}{dp^{lab}d\Omega^{lab}}$	(VI-10)
$p_\parallel$	$p_\perp$	$\frac{E}{\pi}\ \frac{d^2\sigma}{dp_\parallel\, dp_\perp^2}$ (averaged over azimuth)	(VI-11)
x	$p_\perp$	$\frac{E^{cm}}{p^{cm}_{max}} \cdot \frac{1}{\pi}\ \frac{d^2\sigma}{dx dp_\perp^2} \approx \frac{2E^{cm}}{\pi\sqrt{s}}\ \frac{d^2\sigma}{dx dp_\perp^2}$ (averaged over azimuth)	(VI-12)
y	$p_\perp$ (or $m_\perp$)	$\frac{1}{\pi}\ \frac{d^2\sigma}{dy dp_\perp^2} = \frac{1}{\pi}\ \frac{d^2\sigma}{dy dm_\perp^2}$ (averaged over azimuth)	(VI-13)
$m_X^2 = (p_a + p_b - p_c)^2$	$t = (p_a - p_c)^2$	$\frac{\sqrt{\lambda(s,m_a^2,m_b^2)}}{\pi}\ \frac{d^2\sigma}{dm_X^2 dt}$ (averaged over azimuth)	(VI-14)

*See Denyse M. Chew, "Relativistic Kinematics," LBL-3815 (1975), for details and references.

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LORENTZ INVARIANT PHASE SPACE FORMULAE

For a system of n particles with overall four-momentum p and final four momenta $p_1, \cdots, p_n [p_i = (E_i, \vec{P}_i)]$, Lorentz Invariant Phase Space is given by

$$d\,LIPS(s;p_1,\cdots,p_n) = (2\pi)^4\,\delta^4\Big(p - \sum_i p_i\Big)\,\frac{1}{(2\pi)^{3n}}\prod_{i=1}^{n}\frac{d^3\vec{P}_i}{2E_i}\,. \tag{1}$$

$$\text{For 2-body: } d\,LIPS(s,p_1,p_2) = \frac{1}{(2\pi)^2}\,\delta^4(p-p_1-p_2)\,d^4p\,\frac{|\vec{P}_1^{cm}|}{4\sqrt{s}}\,d\Omega_1^{cm}\,. \tag{2}$$

$$\text{For 3-body: } d\,LIPS(s,p_1,p_2,p_3) = \frac{1}{(2\pi)^5}\,\delta^4(p-p_1-p_2-p_3)d^4p\,\frac{1}{32s}\,ds_{12}\,ds_{23}\,d\alpha d\cos\beta d\gamma, \tag{3}$$

where α, β, and γ are Euler angles.

For $a + b \to n$ particles or $X \to n$ particles, in general $|i\rangle \to |f\rangle$,

$$\sigma_{if} = \frac{1}{4F}\int |\mathcal{M}_{if}|^2\, d\,LIPS(s;p_1,\cdots,p_n), \tag{4}$$

or

$$\Gamma_{if} = \frac{1}{2m_X}\int |\mathcal{M}_{if}|^2\, d\,LIPS(m_X^2;\, p_1,\cdots,p_n), \tag{5}$$

where $\mathcal{M}_{if}$ is an invariant matrix element. F is Møller's invariant flux factor, $F^2 = (p_a \cdot p_b)^2 - m_a^2 m_b^2$. If a is beam, b, target ($\vec{P}_b^{lab} = 0$), then $F = |\vec{P}_a^{lab}|\, m_b = |\vec{P}_a^{cm}|\,\sqrt{s}$.

For elastic scattering in c.m., $|\vec{P}_a^{cm}| = |\vec{P}_1^{cm}|$, and (2) and (4) yield

$$\frac{d\sigma}{d\Omega} = \frac{|\mathcal{M}|^2}{(8\pi)^2 s} \quad \text{or} \quad \frac{d\sigma}{dt} = \frac{|\mathcal{M}|^2}{64\pi|\vec{P}_a^{cm}|^2 s}\,. \tag{6}$$

The normalization is such that the optical theorem reads

$$\text{Im}\ \mathcal{M}|_{t=0} = 2|\vec{P}_a^{cm}|\sqrt{s}\,\sigma_{tot}\,. \tag{7}$$

The choice of Eq. (1) implies a particular normalization of any spinors that may occur in $\mathcal{M}$. The advantage of this normalization is that it greatly simplifies the structure of $\mathcal{M}$ by putting factors such as $\frac{1}{(2\pi)^3}\ \frac{1}{2E}$ into the phase space where they really belong. In addition, the labels, i, f, refer to specific spin (helicity) states, so that the usual "average and sum" rule is implicit.

PARTICLE DETECTORS, ABSORBERS, AND RANGES*

A. DETECTOR PARAMETERS

In this section we give various parameters for common detectors. The quoted numbers represent at best an order of magnitude, and are useful only for preliminary design. A more detailed introduction to detectors can be found in "A Consumer's Guide to Particle Detectors," by D. J. Miller, Rutherford Lab Report RL-76-072, July 1976.

A.1 Scintillators: Photon yield ≈ 1γ/100 eV in plastic scintillator[1] and ≈ 1γ/25 eV in NaI.[1,2]

A.2 Čerenkov:[3] Half-angle θ_c of cone aperture in terms of velocity β and index of refraction n:

$$\theta_c = \arccos\left(\frac{1}{\beta n}\right) \sim \sqrt{2\left(1 - \frac{1}{\beta n}\right)} .$$

Threshold velocity: $\beta_t = 1/n$; $\gamma_t = 1/\sqrt{1-\beta_t^2}$.

Therefore, $\beta_t\gamma_t = 1/\sqrt{2\delta+\delta^2}$, where $\delta = n-1$. Values of δ for various commonly used gases are given as a function of pressure and wavelength in Ref. 4; for values at atmospheric pressure, see the Table of Atomic and Nuclear Properties following.

Number of photons N per cm:

$$N = \frac{\alpha}{c}\int\left(1 - \frac{1}{\beta^2 n^2}\right) 2\pi\, d\nu = \frac{\alpha}{c}\beta_t^2 \int\left(\frac{1}{\beta_t^2\gamma_t^2} - \frac{1}{\beta^2\gamma^2}\right) 2\pi\, d\nu$$

$$\approx 500 \sin^2\theta_c/\text{cm} \quad \text{(visible spectrum)} .$$

A.3 Photon Collection: In addition to the photon yield, one should take into account the light collection efficiency (≲ 10% for typical 1-cm-thick scintillator), attenuation length (≈1 to 4 m for typical scintillators[5]), and quantum efficiency of the photomultiplier cathode (≲ 25%).

A.4 Bubble, Streamer, Wire Chambers:

Chamber Type	Accuracy (rms)	Resolution Time	Dead Time
Bubble	± 75μ	≈ 1 ms	≈1/20 s[a]
Streamer	±300μ	≈ 2 μs	≈100 ms
Optical spark	±200μ[b]	≈ 2 μs	≈ 10 ms
Magnetostrictive Spark	±500μ	≈ 2 μs	≈ 10 ms
Proportional	⩾±300μ[c,d]	≈50 ns	≈200 ns
Drift	±50 to 300μ	≈ 2 ns[e]	≈100 ns

[a] Multiple pulsing time.
[b] 60μ for high pressure.
[c] 300μ is for 1 mm pitch.
[d] Delay line cathode readout can give ±150μ
[e] parallel to anode wire.
For two chambers.

A.5 Shower Detectors: Typical energy resolutions (FWHM) for incident electron in the 1 GeV range, E in GeV. For a fixed number of radiation lengths, FWHM in the last three detectors would be expected to be proportional to $\sqrt{t}$ for t (= plate thickness) ≥ 0.2 radiation lengths.[6]

NaI (20 rad. lengths):[7] $\frac{2\%}{E^{1/4}}$

Lead Glass (14 rad. lengths):[8] $\frac{10-12\%}{\sqrt{E}}$

Lead-Liquid Argon (15.75 rad. lengths):[6] $\frac{16\%}{\sqrt{E}}$
(42 cells: lead, 2 mm liquid argon, lead-G10, 2 mm liquid argon)

Lead-Scintillator Sandwich (14 rad. lengths):[9] $\frac{22\%}{\sqrt{E}}$
(35 cells: 2 mm lead, 12.7 mm scintillator)

Proportional Wire Shower Chamber (17 rad. lengths):[10] $\frac{40\%}{\sqrt{E}}$
(36 cells: 0.474 rad. length type-metal + Al, 9.5 mm 80% Ar - 20% CH_4 gas)

A.6 Proportional Chamber Wire Instability: The limit on the voltage V for a wire tension T is given by[11]

$$V \leqslant \frac{sT^{1/2}}{\ell C}$$

where s, ℓ, and C are the wire spacing, length, and capacitance per unit length. An approximation to C for chamber half-gap t and wire diameter d (good for s ≲ t) gives[12]

$$V \lesssim 59T^{1/2}\left[\frac{t}{\ell} + \frac{s}{\pi\ell}\ln\left(\frac{s}{\pi d}\right)\right] ,$$

where V is in kV, and T is in grams.

B. COSMIC RAY FLUXES

The fluxes of particles of different types depend on the latitude, their energy, and the conditions of measurement. Some typical sea-level values[13] are given below:

I_v flux per unit solid angle about vertical direction crossing unit horizontal area

J_1 perpendicular component of total flux crossing unit horizontal area from above

J_2 total flux crossing unit horizontal area

	Total Intensity	Hard Component	Soft Component
I_v	1.1×10^{-2}	0.8×10^{-2}	0.3×10^{-2} cm^{-2} sec^{-1} sterad^{-1}
J_1	1.8×10^{-2}	1.3×10^{-2}	0.5×10^{-2} cm^{-2} sec^{-1}
J_2	2.4×10^{-2}	1.7×10^{-2}	0.7×10^{-2} cm^{-2} sec^{-1}

Very approximately, about 75% of all particles at sea-level are penetrating, and are muons. The absolute flux of protons at sea-level, in a momentum range 700-1100 MeV/c, is 1.5×10^{-5} cm^{-2} sec^{-1} sterad^{-1}, or ~0.1% of all particles.

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

C. PASSAGE OF PARTICLES THROUGH MATTER

C.1 Energy Loss Rates for Heavy Charged Projectiles: A heavy projectile (much more massive than an electron) of charge $Z_{proj}e$, moving at speed βc ($\beta \gg 1/137$) through a slowing medium, dissipates energy principally via interactions with the electrons of the medium. The mean rate of such energy loss per unit path length x may be written as:[14]

$$\left(\frac{dE}{dx}\right)_{proj} = \frac{D\,\rho_{med}\,Z_{med}}{A_{med}}\left(\frac{Z_{proj}}{\beta}\right)^2 \times \left[\ln\left(\frac{2m_e\gamma^2\beta^2c^2}{I}\right) - \beta^2 - \frac{\delta}{2} - \frac{C}{Z_{med}}\right]\{1+\nu\},$$

where $D = 4\pi N_A r_e^2 m_e c^2 = 0.3070$ MeV cm^2/g (see Physical and Numerical Constants Table).

Here Z_{med} and A_{med} are the charge and mass numbers of the medium and ρ_{med} is the mass density of the medium; I, δ, C, and ν are phenomenological functions. Frequently, the values of δ, C, and ν are negligibly small; the parameter I characterizes the binding of the electrons of the medium. As a rule of thumb, we may estimate I for an idealized medium as $I \simeq 16\,(Z_{med})^{0.9}$ eV when $Z_{med} > 1$. For realistic media the value of I will vary at the 10% level from this estimate; for H_2, I = 20.0 eV. We may approximately treat media which are chemical mixtures or compounds by computing

$$\frac{dE}{dx} \approx \sum_{n=1}^{N}\left(\frac{dE}{dx}\right)_n ,$$

with $(dE/dx)_n$ appropriate to the nth chemical constituent (using $\rho_{med}^{(n)}$ as the partial density).[15]

The function δ represents the density effect upon the energy loss rate; it is non-negligible only for highly relativistic projectiles in dense media.[16] For ultra-relativistic projectiles, δ approaches $\ln\gamma^2$ + constant, where the value of the constant depends upon the density of the medium and its chemical composition.

The function C represents shell corrections to the energy loss rate.[14] These effects are non-negligible only for projectiles with speeds not much faster than the speeds of the fastest electrons bound in the medium.

The function ν represents corrections due to higher-order electrodynamics.[17] These effects become important when $|Z_{proj}/\beta|$ is comparable to 137. For relativistic unit-charge projectiles, $|\nu|$ is of the order of 1%; positively charged projectiles lose energy more rapidly than do their charge conjugates.[17,18]

$(dE/dx)_{proj}$ falls rapidly with β until reaching a minimum around $\beta = 0.96$ (almost independent of medium), followed by a slow rise. Because of the density effect, the quantity in square brackets approaches $\ln\gamma$ + constant for large γ.

The value $(dE/dx)_{proj}\delta x$ is the mean total energy loss via interactions with electrons of the medium in a layer of thickness δx. For any finite δx, Poisson fluctuations can cause the actual energy loss to deviate from the mean. For thin layers, the distribution is broad and skewed, being peaked below $(dE/dx)\delta x$, and having a long tail toward large energy losses.[19] Only for a very thick layer [$(dE/dx)\delta x \gg 2m_e\beta^2\gamma^2c^2$] will the distribution of energy losses become nearly Gaussian. The large fluctuations of the total energy loss rate from the mean are due to a small number of collisions with large energy transfers. The fluctuations are greatly reduced for the so-called restricted energy loss rate, described in section C.3.

C.2 Energetic Knock-On Electrons: For a spinless point-charge projectile, the production of high energy (kinetic energy $T \gg I$) electrons is given by (neglecting the spin of the electron):

$$\frac{dN}{dTdx} = \tfrac{1}{2}D\left(\frac{Z_{med}}{A_{med}}\right)\left(\frac{Z_{proj}}{\beta}\right)^2 \rho_{med}\,\frac{1}{T^2} ,$$

for $I \ll T \leq T_{max} = \dfrac{2m_e\beta^2\gamma^2c^2}{1 + 2\gamma\frac{m_e}{M_{proj}} + \left(\frac{m_e}{M_{proj}}\right)^2}$,

where M_{proj} is the mass of the projectile and all other quantities are as in section C.1. This formula does not differ significantly from the precise result, incorporating spin effects, for any projectile (including $e^{\pm}$) in the restricted range $I \ll T \ll T_{max}$; more accurate formulae are available for various projectiles.[20,21] Our formula is inaccurate for T close to I; for $2I \lesssim T \lesssim 10I$, the $1/T^2$ dependence above becomes $\simeq T^{-\eta}$ with $3 \lesssim \eta \lesssim 5$.[22]

C.3 Rates of Restricted Energy Loss for Charged Projectiles: The variability of energy loss for heavy projectiles is due primarily to the variability in the production of energetic knock-on electrons. Bremsstrahlung and pair production processes make this variability even greater for electrons than for heavy particles as projectiles (see, e.g., the figure "Fractional Energy Loss for e^+ and e^- in Lead"). If an instrument is capable of isolating these high-energy-loss interactions then it is appropriate to consider the rate of energy loss excluding them, i.e., a restricted energy loss rate. The mean energy loss rate via all collisions which have energy transfer T such that $T \leq E_{max} \ll T_{max}$ is:[14]

$$\left(\frac{dE}{dx}\right)_{\leq E_{max}} = \frac{D}{2}\,\frac{Z_{med}\,\rho_{med}}{A_{med}}\left(\frac{Z_{proj}}{\beta}\right)^2 \times \left[\ln\left(\frac{E_{max}\,T_{max}}{I^2}\right) - \beta^2 - \delta - \frac{2C}{Z_{med}}\right]$$

Notice the overall factor of 1/2.

The density effect causes the restricted energy loss rate to approach a constant, the Fermi plateau value, for the fastest projectiles.

C.4 Multiple Coulomb Scattering through Small Angles: As a charged particle traverses a medium it is deflected via many independent small-angle Coulomb scatterings. The bulk of this deflection is due to scattering from the nuclei in the medium. An estimate for the net deflection in the absence of large-angle scatters is:[23]

$$\theta_{plane}^{rms} = (1+\varepsilon)Z_{proj}\,\frac{15\ \text{MeV/c}}{p\beta}\sqrt{\frac{\delta x}{L_R}}\quad \text{(radians)},$$

where θ_{plane}^{rms} is the standard deviation of the distribution of net deflection angles projected onto any plane, p is the projectile momentum, βc is its speed, δx is the thickness of the medium, L_R is the radiation length for the medium (see the Table of Atomic and Nuclear Properties of Materials), and $|\varepsilon|$ is usually less than 0.1. This formula applies only when $\theta_{plane}^{rms} \ll 1$.

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

There is a definite possibility that some single large-angle scatter will deflect the projectile by much more than θ^{rms}_{plane}. These large-angle scatters are not included in the above estimate for θ^{rms}_{plane}; they lead to broad tails on the distribution of the actual deflection angles. The actual distribution is approximately a Gaussian with standard deviation θ^{rms}_{plane} for $\theta_{plane} \lesssim \theta^{rms}_{plane}$, while it falls as a power for $\theta_{plane} \gtrsim \theta^{rms}_{plane}$.

Other quantities are sometimes used to describe the amount of multiple Coulomb scattering. The non-projected scattering angle θ is distributed with:

$$\theta^{rms} = \sqrt{2}\ \theta^{rms}_{plane} ,$$

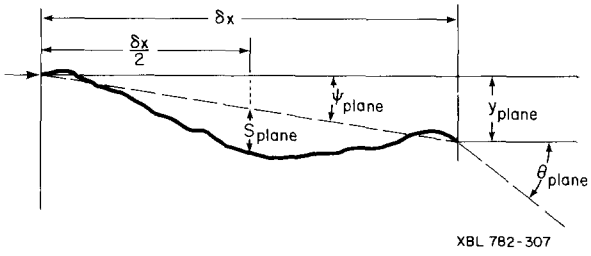
while auxiliary quantities ψ_{plane}, y_{plane}, and s_{plane} (see the figure) obey:

$$\psi^{rms}_{plane} = \frac{1}{\sqrt{3}}\ \theta^{rms}_{plane} ,$$

$$y^{rms}_{plane} = \frac{1}{\sqrt{3}}\ \delta x\ \theta^{rms}_{plane} ,$$

and

$$s^{rms}_{plane} = \frac{1}{\sqrt{12}}\ \delta x\ \theta^{rms}_{plane} .$$



All the quantitative estimates in this section apply only in the limit of small θ^{rms}_{plane} and in the absence of large-angle scatters.

C.5 Electron Range in Lead, Copper, Carbon, and Hydrogen: See figure following.

C.6 Fractional Energy Loss for Electrons and Positrons in Lead: See figure following.

C.7 Contributions to Photon Cross Section in Lead: See figure following.

C.8 Photon Mass Attenuation Coefficients, Energy Deposition: See figure following.

D. ATOMIC AND NUCLEAR PROPERTIES OF MATTER

See Table following.

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*Prepared April 1974 by Sherwood Parker and Bernard Sadoulet. Revised April 1978 by Sherwood Parker and Ray Hagstrom.

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17. For Z^3 calculations with Z = 1, see J. D. Jackson and R. L. McCarthy, Phys. Rev. B6, 4131 (1972).
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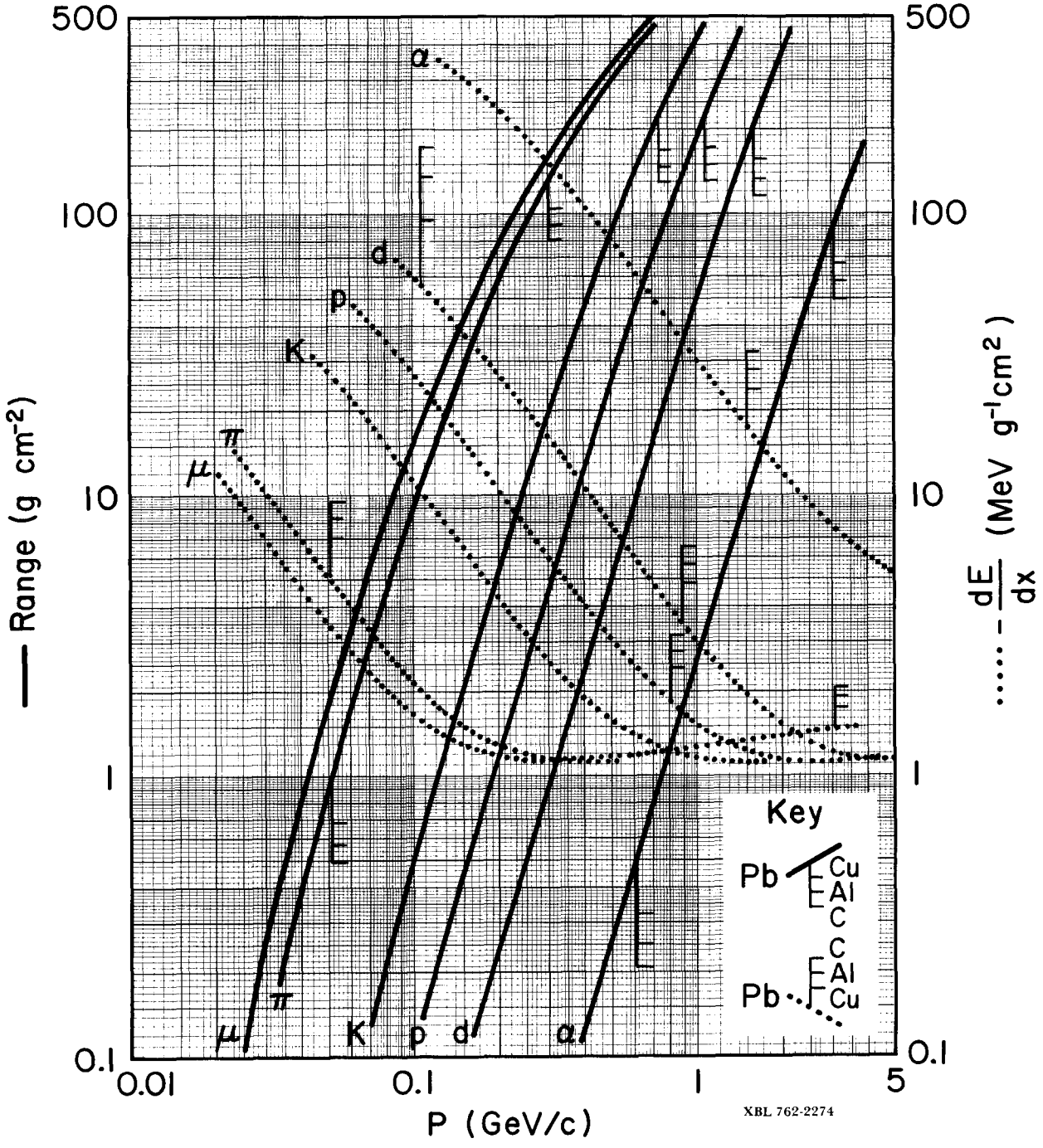
PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

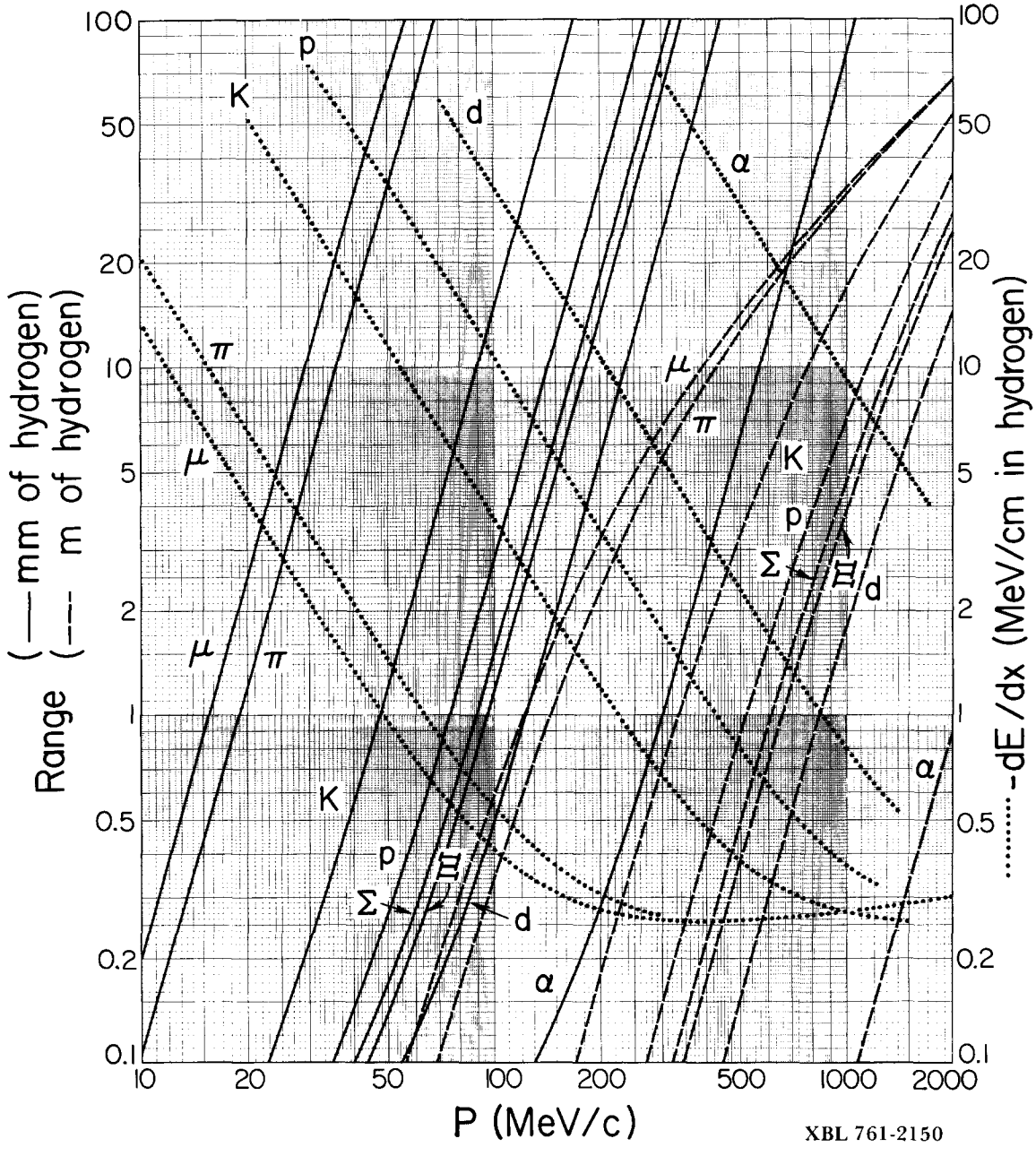
Mean Range and Energy Loss in Lead, Copper, Aluminum, and Carbon



Mean range and energy loss due to ionization for the indicated particles in Pb, with scaling to Cu, Al, and C indicated, using Bethe-Bloch equation (Section C.1 above) with corrections. Calculated using program of Hans Bichsel (UCRL-17538), with density correction added (Hans Bichsel, private communication). See also Joseph F. Janni [Air Force Weapons Laboratory Technical Report No. AFWL-TR-65-150 (1966)]. The average ionization potentials (I) assumed were: Pb (820 eV), Cu (320 eV), Al (166 eV), and C(77.5 eV). Figure indicates total path length; observed range may be smaller (by ~ 1% - 2% in heavy elements) due to multiple scattering, primarily from small energy-loss collisions with nuclei. The functional forms have not been experimentally verified to better than roughly ±1%. For higher energies refer to discussion by Cobb ["A Study of Some Electromagnetic Interactions of High Velocity Particles with Matter," University of Oxford Report HEP/T/55 (1973)] and by Turner ["Penetration of Charged Particles in Matter: A Symposium", National Academy of Sciences, Washington D.C. (1970), p. 48]. Scaling to other beam particles is, to a good approximation, described by the expression on the next page.

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Mean Range and Energy Loss in Liquid Hydrogen



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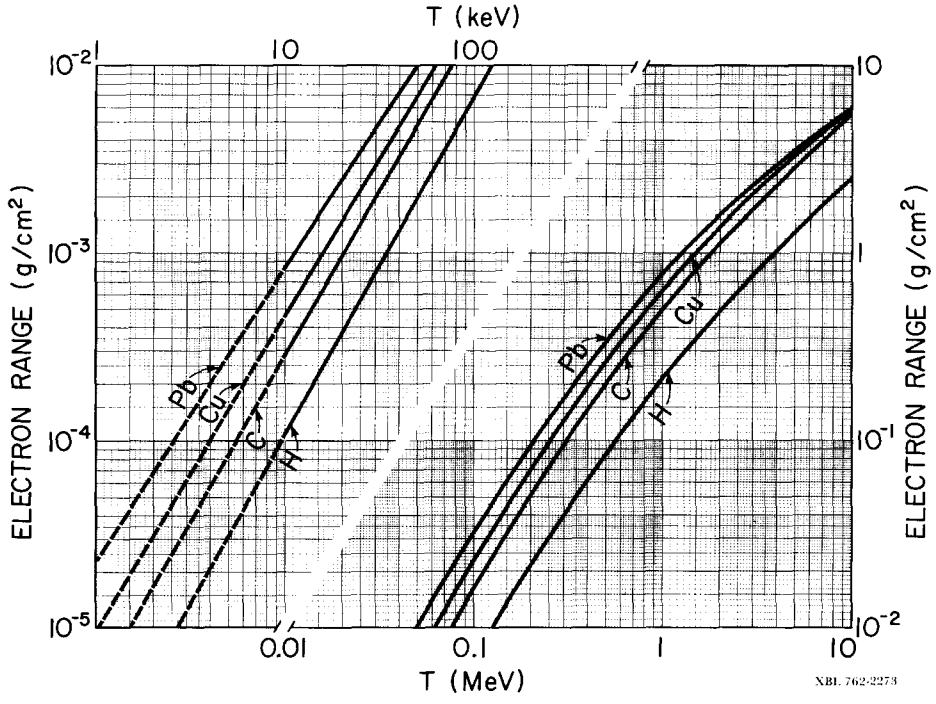
Range and energy loss in liquid hydrogen bubble chamber, based on Bethe-Bloch equation (Section C.1 above), using an average ionization potential for H_2 of I = 20.0 eV, which is an approximate average of the experimental result of Garbincius and Hyman [Phys. Rev. A2, 1834 (1970)] and the theoretical result of Ford and Browne [Phys. Rev. A7, 418 (1973)]. Bubble chamber conditions are chosen to be those of Garbincius and Hyman: parahydrogen of density = 0.0625 g/cm^3 (note: range $\propto$ 1/density), with vapor-pressure 60.8 lb/in^2 (absolute) and temperature 26.2°K. The functional dependence of the Bethe-Bloch equation is not experimentally verified to better than about ±1% over large momentum ranges. It should be noted that the number of bubbles per cm of a track in a bubble chamber is nearly proportional to $1/\beta^2$, not dE/dx. For the linear portions of the range curves, $R \propto p^{3.6}$. Scaling law for particles of other mass or charge (except electrons): for a given medium, the range R_b of any beam particle with mass M_b, charge z_b, and momentum p_b is given in terms of the range R_a of any other particle with mass M_a, charge z_a, and momentum $p_a = p_b M_a/M_b$ (i.e., having the same velocity) by the expression:

$$R_b(M_b, z_b, p_b) = \left[\frac{M_b/M_a}{z_b^2/z_a^2}\right] R_a(M_a, z_a, p_a = p_b M_a/M_b) \ .$$

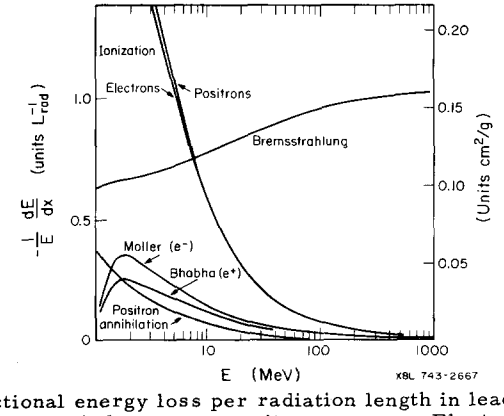
PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Mean Electron Range in Lead, Copper, Carbon, and Liquid Hydrogen



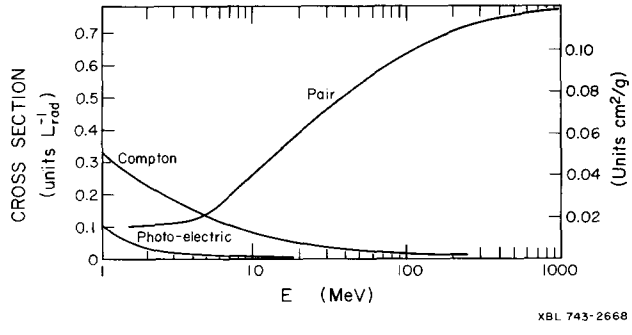
Mean range of electrons in the continuous-slowing-down approximation, taking into account energy loss by collisions with atomic electrons and by bremsstrahlung; strong fluctuations are to be expected for individual tracks. This range is the total path length; the practical range is shorter because of multiple Coulomb scattering, which becomes increasingly important as the electron slows down. E.g., for a fast electron the rms projected angle due to multiple Coulomb scattering reaches 1 radian by the time the electron has slowed to 0.4 MeV in hydrogen, 1.5 MeV in carbon, 9 MeV in copper, and 24 MeV (off scale) in lead. The "critical energy" (above which the energy loss due to bremsstrahlung exceeds that due to ionization, and showering becomes important) is 400 MeV for hydrogen, 100 MeV for carbon, 25 MeV for copper, and 10 MeV for lead. The mean positron range may differ from the mean electron range by several percent. See Berger and Seltzer, NASA SP-3012 (1964) and SP-3036, and P. Trower, UCRL-2426, Vol. III Rev. (1966). 1-10 keV range was obtained by linear extrapolation.

Fractional Energy Loss for e^+ and e^- in Lead



Fractional energy loss per radiation length in lead as a function of electron or positron energy. Electron (positron) scattering is considered as ionization when the energy loss per collision is below 0.255 MeV, and as Moller (Bhabha) scattering when it is above.

Contributions to Photon Cross Section in Lead

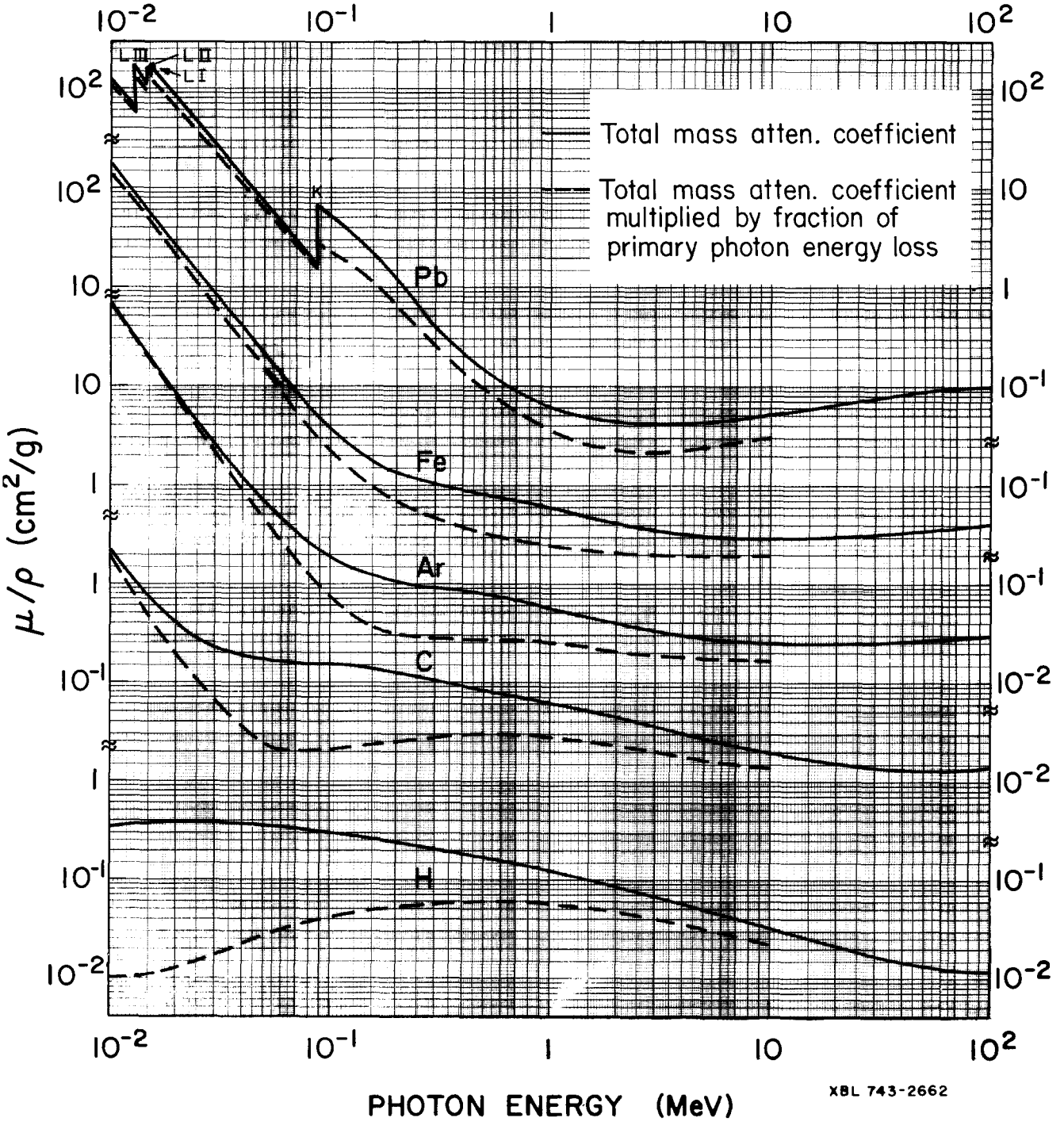


Photon cross section in lead in inverse radiation lengths as a function of photon energy. The intensity of photons can be expressed as $I = I_0 \exp(-\sigma x)$, where σ is read above and x is the path length in radiation lengths. See also figure following.

These figures are adapted from Fig. 3.2 and Fig. 3.3 from Messel and Crawford, Electron-Photon Shower Distribution Function Tables for Lead, Copper and Air Absorbers, Pergamon Press, 1970. Messel and Crawford use L_r (Pb) = 5.82 g/cm², but we have modified the figures to reflect the value given in the Table of Atomic and Nuclear Properties of Materials (following), namely L_r(Pb) = 6.4 g/cm². The development of electron-photon cascades is approximately independent of absorber when the results are expressed in terms of inverse radiation lengths (i.e., scales on left of plots).

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Photon Mass Attenuation Coefficients, Energy Deposition



The photon mass attenuation coefficient for various absorbers as a function of photon energy (solid curves). For a homogeneous medium of density ρ, the intensity I remaining after traversal of thickness t is given by $I = I_0 \exp(-\mu t)$. The accuracy is a few percent. Interpolation to other Z should be done in the cross section $\sigma = (\mu/\rho)\, M/N_A$ cm^2/atom, where M is the atomic weight of the absorber material and N_A is Avogadro's number. For a chemical compound or mixture, use $(\mu/\rho)_{eff} \cong \sum_i w_i (\mu/\rho)_i$, accurate to a few percent, where w_i is the proportion by weight of the ith constituent. The dashed curve is the mass energy-absorption coefficient, giving μ/ρ multiplied by the fraction of photon energy deposited in a small volume (assumed large enough to contain the ranges of most secondary electrons) about the interaction. This fraction is smaller than 1.0 because such processes as Compton scattering and electron bremsstrahlung imply radiation of some of the energy away from the immediate area. From J. H. Hubbell, NSRDS-NBS 29(1969).

PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Atomic and Nuclear Properties of Materials*

Material	Z	A	Nuclear cross section σ[a] [barns]	Nuclear collision length L_{coll}[b] [g/cm^2]	[cm]	Absorption length λ[b] [cm]	dE/dx min[c] [MeV/(g/cm^2)]	[MeV/cm]	Radiation length L_{rad}[d] [g/cm^2]	[cm]	Density[e] [g/cm^3] () is for gas [g/ℓ]	Refractive index n;[e] () is (n−1)×10^6 for gas
H_2	1	1.01	0.039	43.0	607	790	4.12	0.292	63.05	890	{0.0708 (0.090)	{1.112 (140)
D_2	1	2.01	0.074	45.1	273	342	2.07	0.342	126.1	764	0.163	1.128
He	2	4.00	0.134	49.6	397	478	1.94	0.243	94.32	755	{0.125 (0.178)	{1.024 (35)
Li	3	6.94	0.215	53.6	100.4	120.6	1.65	0.881	82.76	155	0.534	–
Be	4	9.01	0.270	55.4	30.0	36.7	1.61	2.97	65.19	35.3	1.848	–
C	6	12.01	0.340	58.7	≈37.8	49.9	1.78	≈2.76	42.70	≈27.5	≈1.55[f]	–
N_2	7	14.01	0.390	59.7	73.8	99.4	1.82	1.47	37.99	47.0	{0.808 (1.25)	{1.205 (300)
Ne	10	20.18	0.520	64.4	53.7	74.9	1.73	2.08	28.94	24.0	{1.207 (0.90)	{1.092 (67)
Al	13	26.98	0.650	68.9	25.5	37.2	1.62	4.37	24.01	8.9	2.70	–
Ar	18	39.95	0.890	74.5	53.2	80.9	1.51	2.11	19.55	14.0	{1.40 (1.78)	{1.233 (283)
Fe	26	55.85	1.160	79.9	10.2	17.1	1.48	11.6	13.84	1.76	7.87	–
Cu	29	63.54	1.270	83.1	9.3	14.8	1.44	12.9	12.86	1.43	8.96	–
Sn	50	118.69	2.040	96.6	13.2	22.8	1.28	9.4	8.82	1.21	7.31	–
W	74	183.85	2.810	108.6	5.6	10.3	1.17	22.6	6.76	0.35	19.3	–
Pb	82	207.19	3.080	111.7	9.8	18.5	1.13	12.8	6.37	0.56	11.35	–
U	92	238.03	3.380	116.9	≈6.2	12.0	1.09	≈20.7	6.00	≈0.32	≈18.95	–
Air				60.2	50000[g]	67500[g]	1.82	0.0022[g]	36.20	30050[g]	{0.001205[g] (1.29)	{1.000273[g] (293)
H_2O				58.3	58.3	78.8	2.03	2.03	36.08	36.1	1.00	1.33
H_2 (bubble chamber 26°K)[h]				43.0	≈683	887	4.12	≈0.26	63.05	≈1000	≈0.063[h]	1.112
D_2 (bubble chamber 31°K)[h]				45.1	≈322	403	2.07	≈0.29	126.1	≈900	≈0.140[h]	1.110
H–Ne mixture (50 mole percent)[i]				62.9	154.5	215	1.84	0.75	29.70	73.0	0.407	1.092
Propane (C_3H_8)[j]				55.0	134	176	2.28	0.98	45.38	111	{0.41[j] (2.0)	{1.25[j] (1005)
Freon 13B1 (CF_3Br)[j]				74.3	≈49.5	73.5	1.52	≈2.3	16.53	≈11	{≈1.50[j] (8.71)	{1.238[j] (750)
Ilford emulsion				88.1	23.1	36.7	1.44	5.49	11.02	2.94	3.815	–
NaI				91.9	25.0	41.3	1.32	4.84	9.49	2.59	3.67	1.775
LiF				61.1	23.1	30.7	1.69	4.46	39.25	14.9	2.64	1.394
Polyethylene (CH_2)				55.7	≈59.6	78.4	2.09	≈1.95	44.78	≈48	0.92–0.95	–
Mylar ($C_5H_4O_2$)				58.5	42.1	56.1	1.91	2.65	39.95	28.7	1.39	–
Polystyrene, scintillator (CH)[k]				57.0	55.2	68.5	1.97	2.03	43.8	42.9	1.032	1.581
Lucite, Plexiglas ($C_5H_8O_2$)				57.7	≈48.9	65.0	1.97	≈2.32	40.55	≈34.5	1.16–1.20	≈1.49
Spark or proportional chamber[ℓ]			0.05%		0.03%	–	0.073		2.7%		0.046	–
Shielding concrete[m]				65.5	26.2	36.8	1.70	4.25	26.7	10.7	2.5	–
CO_2[n]				60.4	33800	46000	1.82	0.0033	36.2	20210	(1.79)[n]	(410)[n]
Freon 12 (CCl_2F_2)[n]				68.1	13800	20200	1.64	0.0081	23.7	4810	(4.93)[n]	(1080)[n]
Freon 13 ($CClF_3$)[n]				66.0	15000	21400	1.70	0.0072	27.15	6380	(4.26)[n]	(720)[n]
Silica Aerogel[o]				62.3	≈311	430	1.82	≈0.36	30	≈150	0.1–0.3	1.0+0.25ρ

*) Table revised April 1978 by J. Engler and F. Mönnig. For details and references, see CERN NP Internal Report 74–1.

a) σ of neutrons (≈ σ of protons) at 20 GeV from Landolt–Bornstein, New Series I, Vol. 5. Energy dependence for all nuclei ≈ 1/2 percent/GeV (from 5–25 GeV).

b) $L_{coll} = A/(N.\sigma)$. In the absorption length the elastic scattering is subtracted.

c) For a minimum-ionizing, singly-charged particle in the material. From W.H. Barkas and M.J. Berger, Tables of Energy Losses and Ranges of Heavy Charged Particles, NASA-SP-3013 (1964).

d) From Y.S. Tsai, Rev. Mod. Phys. 46, 815 (1974).

e) Values for solids, or the liquid phase at boiling point, except where noted. Values in parentheses for gaseous phase STP (0°C, 1 atm.), except where noted.

f) Density variable.

g) Gas at 20°C.

h) Density may vary about ±3%, depending on operating conditions.

i) Values for typical working condition with H_2 target: 50 mole percent, 29°K, 7 atm.

j) Values for typical chamber working conditions: Propane ~ 57°C, 8–10 atm. Freon 13B1 ~ 28°C, 8–10 atm.

k) Typical scintillator; e.g. PILOT B and NE 102A have an atomic ratio H/C = 1.10.

ℓ) Values for typical construction: 2 layers 50 μm Cu/Be wires, 8 mm gap, 60% argon, 40% isobutane or CO_2; 2 layers 50 μm Mylar/Aclar foils.

m) Standard shielding blocks, typical composition O_2 52%, Si 32.5%, Ca 6%, Na 1.5%, Fe 2%, Al 4% plus reinforcing iron bars. Attenuation length ℓ = 115 ± 5 g/cm^2, also valid for earth (typical ρ = 2.15) from CERN–LRL–RHEL Shielding exp. UCRL 17841 (1968).

n) Used in Čerenkov counters, value at 26°C and 1 atm. Indices of refraction from E.R. Hayes, R.A. Schluter, and A. Tamosaitis, ANL-6916 (1964).

o) $n(SiO_2) + 2n(H_2O)$ used in Čerenkov counters, ρ = density in g/cm^3. From M. Cantin et al., Nucl. Instr. Meth. 118, 177 (1974).

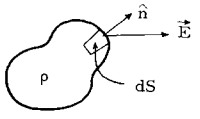
ELECTROMAGNETIC RELATIONS

Maxwell's Equations

Quantity	CGS (statcoul., statamp., sec cm^{-1})	MKSA (coul., amp., ohm)
Potentials:	$V = \sum_{\text{charges}} \frac{q}{r}$,	$V = \frac{1}{4\pi\epsilon_0} \sum_{\text{charges}} \frac{q}{r}$,
	$\vec{A} = \frac{1}{c} \sum_{\text{currents}} \frac{\vec{I}}{r}$;	$\vec{A} = \frac{\mu_0}{4\pi} \sum_{\text{currents}} \frac{\vec{I}}{r}$;
	c = speed of light in vacuum	$\epsilon_0 = \frac{1}{36\pi}\ 10^{-9}$ MKSA,
		$\mu_0 = 4\pi\ 10^{-7}$ MKSA
Fields:	$\vec{E} = -\vec{\nabla}V$, $\vec{B} = \vec{\nabla}\times\vec{A}$	$\vec{E} = -\vec{\nabla}V$, $\vec{B} = \vec{\nabla}\times\vec{A}$
Materials:	$\vec{D} = \epsilon\vec{E}$, $\vec{B} = \mu\vec{H}$	$\vec{D} = \epsilon\vec{E}$, $\vec{B} = \mu\vec{H}$
Force:	$\vec{F} = q(\vec{E} + \frac{\vec{v}}{c}\times\vec{B})$	$\vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$
Maxwell:	$\vec{\nabla}\cdot\vec{D} = 4\pi\rho$,	$\vec{\nabla}\cdot\vec{D} = \rho$,
	$\vec{\nabla}\times\vec{E} = -\frac{1}{c}\frac{\partial\vec{B}}{\partial t}$,	$\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$,
	$\vec{\nabla}\cdot\vec{B} = 0$,	$\vec{\nabla}\cdot\vec{B} = 0$,
	$\vec{\nabla}\times\vec{H} = \frac{4\pi\vec{j}}{c} + \frac{1}{c}\frac{\partial\vec{D}}{\partial t}$	$\vec{\nabla}\times\vec{H} = \vec{j} + \frac{\partial\vec{D}}{\partial t}$

Integral Forms (MKSA)

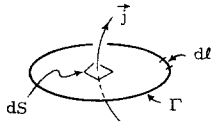
1. Gauss' theorem:



$$\int_{\text{surface}} \vec{E}\cdot\hat{n}\ dS = \int_{\text{volume}} \rho/\epsilon_0\ dV$$

(ρ = charge/volume)

2. Ampere's law:



$$\int_{\Gamma} \vec{H}\cdot d\vec{l} = \int_{\text{surface}} \vec{j}\cdot\hat{n}\ dS$$

($\vec{j}$ = surface current density)

Impedances: Alternating Currents (MKSA)

Ohm's law: $V = ZI$, $V = V_0 e^{i\omega t}$

1. Impedance of self-inductance of inductance L : $Z = i\omega L$
2. Impedance of a capacitor of capacitance C : $Z = \frac{1}{i\omega C}$
3. Impedance of a flat conductor of width w at high frequency:

$$Z = \frac{(1+i)\rho}{w\delta};$$

ρ = resistivity $\begin{cases} \sim 1.7\times10^{-8}\ \Omega\,\text{m for Cu} \\ \sim 2.8\times10^{-8}\ \Omega\,\text{m for Al} \end{cases}$

δ = effective skin depth

$$= \sqrt{\frac{\rho}{\pi\nu\mu}} \approx \frac{6.6\ \text{cm}}{\sqrt{\nu(\text{sec}^{-1})}} \quad \text{for Cu}$$

Capacitance C and Inductance L per Unit Length (MKSA)

1. For flat plates of width w, separated by $d \ll w$:

$$C = \frac{\epsilon w}{d}\ ;\quad L = \mu\frac{d}{w}\ .$$

2. For coax cable of interior and exterior radii r_1 and r_2:

$$C = \frac{2\pi\epsilon}{\ell n(r_2/r_1)}\ ;\quad L = \frac{\mu}{2\pi}\ \ell n(r_2/r_1);$$

ϵ = dielectric constant $\begin{cases} 2 \text{ to } 6 \text{ for plastics} \\ 4 \text{ to } 8 \text{ for porcelain, glasses} \end{cases}$

μ = magnetic susceptibility

Transmission Lines (No Loss) (MKSA)

Velocity $= 1/\sqrt{LC} = 1/\sqrt{\mu\epsilon}$

Impedance $= \sqrt{L/C}$

L, C are inductance and capacitance per unit length

Synchrotron Radiation (CGS)

Energy loss/revolution $= \frac{4\pi}{3}\frac{e^2}{\rho}\beta^3\gamma^4$, ρ = orbit radius.

For electrons ($\beta \approx 1$), $\frac{\Delta E(\text{MeV})}{\text{rev.}} = 0.0885\ [E(\text{GeV})]^4/\rho(\text{meter})$.

Critical frequency: $\omega_c = 3\gamma^3\ c/\rho$

See J. D. Jackson, Classical Electrodynamics, 2nd Ed., John Wiley & Sons, New York, 1975, for more formulae and details.
(Prepared April 1974; revised April 1976.)

RADIOACTIVITY AND RADIATION PROTECTION

Unit of activity = Curie:
1 Ci = 3.7×10^{10} disintegrations/sec
Unit of exposure dose for x and γ radiation = Roentgen:
1 R = 1 esu/cm^3 = 87.8 erg/g (5.49×10^7 MeV/g) of air
Unit of absorbed dose = rad:
1 rad = 100 erg/g (6.25×10^7 MeV/g) in any material
Unit of dose equivalent (for protection) = rem:
rems (Roentgen equivalents for man) = rads × QF,
where QF (quality factor) depends upon the type of radiation and other factors. For γ rays and HE protons, QF ≈ 1; for thermal neutrons, QF ≈ 3; for fast neutrons, QF ranges up to 10; and for α particles and heavy ions, QF ranges up to 20.
Maximum permissible occupational dose for the whole body:
5 rem/year (or ≈ 100 millirem/week)
Fluxes (per cm^2) to liberate 1 rad in carbon:
3.5×10^7 minimum ionizing singly charged particles
1.0×10^9 photons of 1 MeV energy
(These fluxes are correct to within a factor of 2 for all materials.)
Natural background: 120 to 130 millirem/year

cosmic radiation (charged particles + neutrons)	~25	mrem/yr
cosmic radiation (γ rays)	~25	mrem/yr
radiation from rocks and air (γ rays)	~73	mrem/yr

Cosmic ray background in counters: ~ 1/min/cm^2/ster

C.M. ENERGY AND MOMENTUM VS. BEAM MOMENTUM

$$E_{cm}dE_{cm} = m_p dT_{beam} = m_p v_{beam} dP_{beam} \approx m_p dP_{beam}$$

PBEAM (MEV/C)	C.M. ENERGY (MEV)				MOMENTUM IN C.M. (MEV/C)			
	γp ep	πp	Kp	pp	γp ep	πp	Kp	pp
0	939	1078	1432	1877	0	0	0	0
20	958	1079	1432	1877	20	17	13	10
40	977	1083	1433	1877	38	35	26	20
60	996	1089	1434	1877	56	52	39	30
80	1015	1096	1436	1878	74	68	52	40
		T(PI) = PBEAM - 59 MEV						
100	1033	1105	1439	1879	91	85	65	50
120	1051	1116	1441	1880	107	101	78	60
140	1069	1127	1445	1882	123	117	91	70
160	1087	1139	1449	1883	138	132	104	80
180	1104	1152	1453	1885	153	147	116	90
		T(PI) = PBEAM - 92 MEV						
200	1121	1165	1457	1887	167	161	129	99
220	1137	1178	1462	1889	182	175	141	109
240	1154	1192	1468	1892	195	189	153	119
260	1170	1206	1474	1894	209	202	166	129
280	1186	1219	1480	1897	222	215	178	138
		T(PI) = PBEAM - 107 MEV						
300	1201	1233	1486	1900	234	228	189	148
320	1217	1247	1493	1903	247	241	201	158
340	1232	1261	1500	1906	259	253	213	167
360	1247	1274	1507	1910	271	265	224	177
380	1262	1288	1514	1913	282	277	235	186
		T(PI) = PBEAM - 115 MEV						
400	1277	1302	1522	1917	294	288	247	196
420	1292	1315	1530	1921	305	300	258	205
440	1306	1329	1538	1925	316	311	268	214
460	1320	1342	1546	1929	327	322	279	224
480	1335	1356	1554	1933	337	332	290	233
		T(PI) = PBEAM - 120 MEV						
500	1349	1369	1563	1938	348	343	300	242
520	1362	1382	1572	1943	358	353	310	251
540	1376	1395	1580	1947	368	363	321	260
560	1390	1408	1589	1952	378	373	331	269
580	1403	1421	1598	1957	388	383	341	278
		T(PI) = PBEAM - 123 MEV						
600	1416	1434	1607	1962	397	393	350	287
620	1430	1446	1616	1967	407	402	360	296
640	1443	1459	1625	1973	416	412	370	304
660	1456	1472	1634	1978	425	421	379	313
680	1468	1484	1644	1984	434	430	388	322
		T(PI) = PBEAM - 125 MEV						
700	1481	1496	1653	1989	443	439	397	330
720	1494	1509	1662	1995	452	448	406	339
740	1506	1521	1671	2001	461	457	415	347
760	1519	1533	1681	2007	470	465	424	355
780	1531	1545	1690	2013	478	474	433	364
		T(PI) = PBEAM - 127 MEV						
800	1543	1557	1699	2019	486	482	442	372
820	1555	1569	1709	2025	495	490	450	380
840	1567	1580	1718	2031	503	499	459	388
860	1579	1592	1728	2037	511	507	467	396
880	1591	1604	1737	2043	519	515	475	404
		T(PI) = PBEAM - 129 MEV						
900	1603	1615	1747	2049	527	523	483	412
920	1615	1627	1756	2056	535	531	492	420
940	1626	1638	1765	2062	542	538	500	428
960	1638	1649	1775	2069	550	546	508	435
980	1649	1661	1784	2075	558	554	515	443
		T(PI) = PBEAM - 130 MEV						
1000	1660	1672	1794	2082	565	561	523	451
1020	1672	1683	1803	2088	573	569	531	458
1040	1683	1694	1812	2095	580	576	538	466
1060	1694	1705	1822	2102	587	583	546	473
1080	1705	1716	1831	2108	594	591	553	481
		T(PI) = PBEAM - 131 MEV						
1100	1716	1726	1840	2115	601	598	561	488
1120	1727	1737	1850	2122	609	605	568	495
1140	1738	1748	1859	2129	616	612	575	502
1160	1748	1758	1868	2135	622	619	583	510
1180	1759	1769	1877	2142	629	626	590	517
		T(PI) = PBEAM - 131 MEV						
1200	1770	1780	1887	2149	636	633	597	524
1220	1780	1790	1896	2156	643	639	604	531
1240	1791	1800	1905	2163	650	646	611	538
1260	1801	1811	1914	2170	656	653	618	545
1280	1812	1821	1923	2177	663	660	624	552
		T(PI) = PBEAM - 132 MEV						
1300	1822	1831	1932	2184	669	666	631	559
1320	1832	1841	1941	2191	676	673	638	565
1340	1843	1851	1950	2198	682	679	645	572
1360	1853	1862	1959	2205	689	685	651	579
1380	1863	1872	1968	2212	695	692	658	585
		T(PI) = PBEAM - 133 MEV						
1400	1873	1881	1977	2219	701	698	664	592
1420	1883	1891	1986	2226	708	704	671	599
1440	1893	1901	1995	2233	714	711	677	605
1460	1903	1911	2004	2240	720	717	684	612
1480	1912	1921	2013	2247	726	723	690	618
		T(PI) = PBEAM - 133 MEV						

PBEAM (MEV/C)	C.M. ENERGY (MEV)				MOMENTUM IN C.M. (MEV/C)			
	γp ep	πp	Kp	pp	γp ep	πp	Kp	pp
1500	1922	1930	2022	2254	732	729	696	624
1520	1932	1940	2031	2261	738	735	702	631
1540	1942	1950	2039	2268	744	741	709	637
1560	1951	1959	2048	2275	750	747	715	643
1580	1961	1969	2057	2282	756	753	721	650
		T(PI) = PBEAM - 133 MEV						
1600	1970	1978	2065	2289	762	759	727	656
1620	1980	1988	2074	2296	768	765	733	662
1640	1989	1997	2083	2304	773	770	739	668
1660	1999	2006	2091	2311	779	776	745	674
1680	2008	2016	2100	2318	785	782	751	680
		T(PI) = PBEAM - 134 MEV						
1700	2018	2025	2109	2325	791	788	756	686
1720	2027	2034	2117	2332	796	793	762	692
1740	2036	2043	2126	2339	802	799	768	698
1760	2045	2053	2134	2346	807	805	774	704
1780	2054	2062	2143	2353	813	810	779	710
		T(PI) = PBEAM - 134 MEV						
1800	2064	2071	2151	2360	818	816	785	716
1820	2073	2080	2159	2367	824	821	791	721
1840	2082	2089	2168	2374	829	827	796	727
1860	2091	2098	2176	2381	835	832	802	733
1880	2100	2107	2184	2388	840	837	808	739
		T(PI) = PBEAM - 134 MEV						
1900	2108	2115	2193	2395	845	843	813	744
1920	2117	2124	2201	2402	851	848	818	750
1940	2126	2133	2209	2409	856	853	824	756
1960	2135	2142	2217	2416	861	859	829	761
1980	2144	2150	2226	2423	867	864	835	767
		T(PI) = PBEAM - 135 MEV						
2000	2153	2159	2234	2430	872	869	840	772
2020	2161	2168	2242	2437	877	874	845	778
2040	2170	2176	2250	2444	882	879	851	783
2060	2179	2185	2258	2451	887	885	856	789
2080	2187	2194	2266	2458	892	890	861	794
		T(PI) = PBEAM - 135 MEV						
2100	2196	2202	2274	2465	897	895	866	799
2120	2204	2211	2282	2472	902	900	872	805
2140	2213	2219	2290	2479	907	905	877	810
2160	2221	2227	2298	2486	912	910	882	815
2180	2230	2236	2306	2493	917	915	887	821
		T(PI) = PBEAM - 135 MEV						
2200	2238	2244	2314	2500	922	920	892	826
2220	2246	2253	2322	2507	927	925	897	831
2240	2255	2261	2330	2514	932	930	902	836
2260	2263	2269	2338	2520	937	934	907	841
2280	2271	2277	2346	2527	942	939	912	846
		T(PI) = PBEAM - 135 MEV						
2300	2280	2286	2353	2534	947	944	917	852
2320	2288	2294	2361	2541	951	949	922	857
2340	2296	2302	2369	2548	956	954	927	862
2360	2304	2310	2377	2555	961	959	932	867
2380	2312	2318	2384	2561	966	963	937	872
		T(PI) = PBEAM - 135 MEV						
2400	2320	2326	2392	2568	970	968	941	877
2420	2328	2334	2400	2575	975	973	946	882
2440	2336	2342	2407	2582	980	977	951	887
2460	2344	2350	2415	2589	984	982	956	892
2480	2352	2358	2423	2595	989	987	960	897
		T(PI) = PBEAM - 136 MEV						
2500	2360	2366	2430	2602	994	991	965	901
2520	2368	2374	2438	2609	998	996	970	906
2540	2376	2382	2445	2616	1003	1001	975	911
2560	2384	2390	2453	2622	1007	1005	979	916
2580	2392	2398	2460	2629	1012	1010	984	921
		T(PI) = PBEAM - 136 MEV						
2600	2400	2405	2468	2636	1017	1014	988	926
2620	2408	2413	2475	2643	1021	1019	993	930
2640	2415	2421	2483	2649	1025	1023	998	935
2660	2423	2429	2490	2656	1030	1028	1002	940
2680	2431	2436	2498	2663	1034	1032	1007	944
		T(PI) = PBEAM - 136 MEV						
2700	2439	2444	2505	2669	1039	1037	1011	949
2720	2446	2452	2512	2676	1043	1041	1016	954
2740	2454	2459	2520	2682	1048	1045	1020	958
2760	2462	2467	2527	2689	1052	1050	1025	963
2780	2469	2474	2534	2696	1056	1054	1029	968
		T(PI) = PBEAM - 136 MEV						
2800	2477	2482	2542	2702	1061	1058	1034	972
2820	2484	2490	2549	2709	1065	1063	1038	977
2840	2492	2497	2556	2715	1069	1067	1042	981
2860	2499	2505	2563	2722	1074	1071	1047	986
2880	2507	2512	2570	2728	1078	1076	1051	990
		T(PI) = PBEAM - 136 MEV						
2900	2514	2520	2578	2735	1082	1080	1056	995
2920	2522	2527	2585	2742	1086	1084	1060	999
2940	2529	2534	2592	2748	1091	1088	1064	1004
2960	2537	2542	2599	2755	1095	1093	1069	1008
2980	2544	2549	2606	2761	1099	1097	1073	1013
		T(PI) = PBEAM - 136 MEV						

PBEAM (GEV/C)	C.M. ENERGY (GEV)			MOMENTUM IN C.M. (GEV/C)		
	γp ep πp	Kp	pp	γp ep πp	Kp	pp
3.0	2.56	2.61	2.77	1.10	1.08	1.02
3.2	2.63	2.68	2.83	1.14	1.12	1.06
3.4	2.70	2.75	2.89	1.18	1.16	1.10
3.6	2.77	2.82	2.96	1.22	1.20	1.14
3.8	2.83	2.88	3.02	1.26	1.24	1.18
		T(PI) = PBEAM - .137 GEV				
4.0	2.90	2.95	3.08	1.29	1.27	1.22
4.2	2.96	3.01	3.14	1.33	1.31	1.26
4.4	3.03	3.07	3.19	1.36	1.34	1.29
4.6	3.09	3.13	3.25	1.40	1.38	1.33
4.8	3.15	3.19	3.31	1.43	1.41	1.36
		T(PI) = PBEAM - .138 GEV				
5.0	3.21	3.25	3.36	1.46	1.44	1.40
5.5	3.35	3.39	3.50	1.54	1.52	1.48
6.0	3.49	3.52	3.63	1.61	1.60	1.55
6.5	3.62	3.65	3.75	1.69	1.67	1.63
7.0	3.75	3.78	3.87	1.75	1.74	1.70
		T(PI) = PBEAM - .138 GEV				
7.5	3.87	3.90	3.99	1.82	1.80	1.76
8.0	3.99	4.02	4.11	1.88	1.87	1.83
8.5	4.11	4.14	4.22	1.94	1.93	1.89
9.0	4.22	4.25	4.33	2.00	1.99	1.95
9.5	4.33	4.36	4.44	2.06	2.05	2.01
		T(PI) = PBEAM - .139 GEV				
10.0	4.43	4.46	4.54	2.12	2.10	2.07
11.0	4.64	4.67	4.74	2.22	2.21	2.18
12.0	4.84	4.86	4.93	2.33	2.31	2.28
13.0	5.03	5.05	5.12	2.43	2.41	2.38
14.0	5.21	5.24	5.30	2.52	2.51	2.48
		T(PI) = PBEAM - .139 GEV				
15.0	5.39	5.41	5.47	2.61	2.60	2.57
16.0	5.56	5.58	5.64	2.70	2.69	2.66
17.0	5.73	5.75	5.81	2.79	2.78	2.75
18.0	5.89	5.91	5.97	2.87	2.86	2.83
19.0	6.05	6.07	6.12	2.95	2.94	2.91
		T(PI) = PBEAM - .139 GEV				
20.0	6.20	6.22	6.27	3.03	3.02	2.99
22.0	6.49	6.51	6.56	3.18	3.17	3.14
24.0	6.78	6.79	6.84	3.32	3.31	3.29
26.0	7.05	7.07	7.11	3.46	3.45	3.43
28.0	7.31	7.33	7.37	3.59	3.59	3.56
		T(PI) = PBEAM - .139 GEV				
30.0	7.56	7.58	7.62	3.72	3.71	3.69
32.0	7.81	7.82	7.86	3.85	3.84	3.82
34.0	8.04	8.06	8.10	3.97	3.96	3.94
36.0	8.27	8.29	8.33	4.08	4.08	4.06
38.0	8.50	8.51	8.55	4.20	4.19	4.17
		T(PI) = PBEAM - .139 GEV				
40.0	8.72	8.73	8.77	4.31	4.30	4.28
42.0	8.93	8.94	8.98	4.41	4.41	4.39
44.0	9.14	9.15	9.18	4.52	4.51	4.50
46.0	9.34	9.35	9.39	4.62	4.62	4.60
48.0	9.54	9.55	9.58	4.72	4.72	4.70
		T(PI) = PBEAM - .139 GEV				
50.0	9.73	9.74	9.78	4.82	4.81	4.80
55.0	10.20	10.21	10.25	5.06	5.05	5.04
60.0	10.65	10.66	10.69	5.28	5.28	5.26
65.0	11.08	11.10	11.12	5.50	5.50	5.48
70.0	11.50	11.51	11.54	5.71	5.71	5.69
		T(PI) = PBEAM - .139 GEV				
75.0	11.90	11.91	11.94	5.91	5.91	5.89
80.0	12.29	12.30	12.32	6.11	6.10	6.09
85.0	12.67	12.67	12.70	6.30	6.29	6.28
90.0	13.03	13.04	13.06	6.48	6.48	6.46
95.0	13.39	13.39	13.42	6.66	6.65	6.64
		T(PI) = PBEAM - .139 GEV				
100.0	13.73	13.74	13.76	6.83	6.83	6.82
200.0	19.40	19.40	19.42	9.67	9.67	9.66
300.0	23.75	23.75	23.76	11.85	11.85	11.84
400.0	27.41	27.42	27.43	13.69	13.69	13.68
500.0	30.65	30.65	30.66	15.31	15.31	15.30
		T(PI) = PBEAM - .140 GEV				
600.0	33.57	33.57	33.58	16.77	16.77	16.76
700.0	36.26	36.26	36.27	18.12	18.11	18.11
800.0	38.76	38.76	38.77	19.37	19.37	19.36
900.0	41.11	41.11	41.12	20.54	20.54	20.54
1000.0	43.33	43.33	43.34	21.65	21.65	21.65
		T(PI) = PBEAM - .140 GEV				
1100.0	45.44	45.45	45.45	22.71	22.71	22.71
1200.0	47.46	47.47	47.47	23.72	23.72	23.72
1300.0	49.40	49.40	49.41	24.69	24.69	24.69
1400.0	51.26	51.27	51.27	25.62	25.62	25.62
1500.0	53.06	53.07	53.07	26.52	26.52	26.52
		T(PI) = PBEAM - .140 GEV				
1600.0	54.80	54.81	54.81	27.39	27.39	27.39
1700.0	56.49	56.49	56.50	28.24	28.24	28.23
1800.0	58.13	58.13	58.13	29.06	29.05	29.05
1900.0	59.72	59.72	59.73	29.85	29.85	29.85
2000.0	61.27	61.27	61.28	30.63	30.63	30.62
		T(PI) = PBEAM - .140 GEV				

PERIODIC TABLE OF THE ELEMENTS

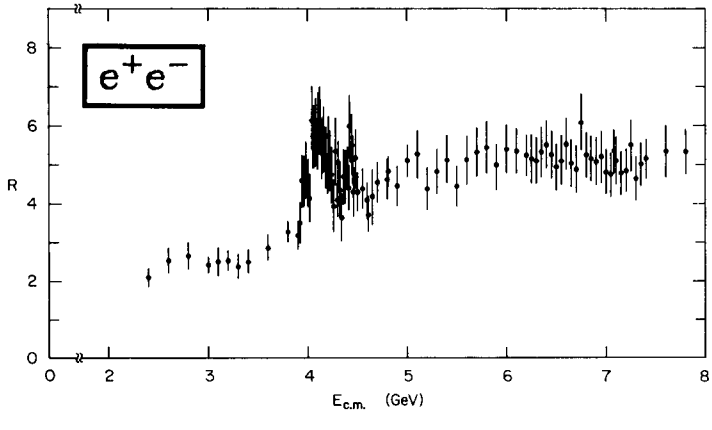
IA	IIA								1 H 1.008			IIIA	IVA	VA	VIA	VIIA	2 He 4.0026
3 Li 6.94	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.17
11 Na 22.9898	12 Mg 24.305	IIIB	IVB	VB	VIB	VIIB	— VIII —			IB	IIB	13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.10	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.941	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc 98.9062	44 Ru 101.07	45 Rh 102.906	46 Pd 106.4	47 Ag 107.868	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9045	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	57–71 Rare Earths	72 Hf 178.49	73 Ta 180.947	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.22	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.2	83 Bi 208.981	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89– Acti- nides	104 (261)	105 (262)	106 (263)												

57 La 138.91	58 Ce 140.12	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97	Rare earths (Lanthanide series)

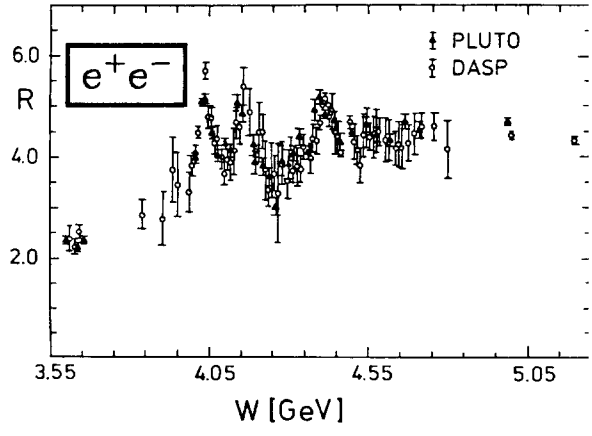
89 Ac (227)	90 Th 232.038	91 Pa 231.036	92 U 238.03	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)	Actinide series

Numbers in parentheses are mass numbers of most stable isotope of that element. Adapted from the *Handbook of Chemistry and Physics, 58th Ed., 1977-1978.* (Particle Data Group update, April 1978.)

CROSS SECTION PLOTS

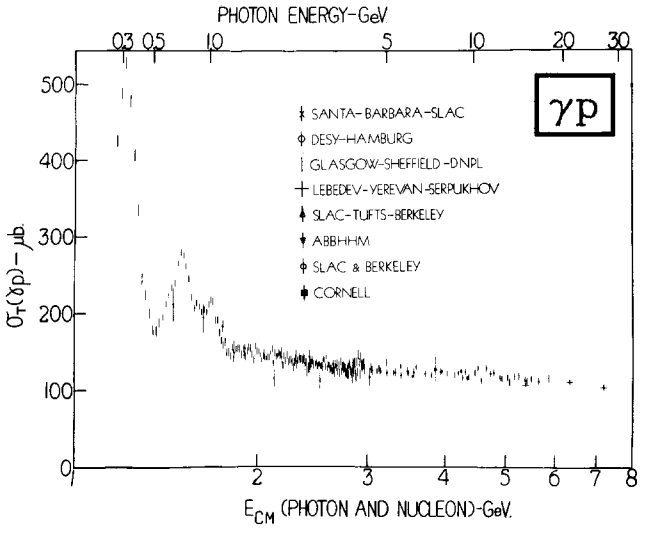


SPEAR data on the ratio R of the cross section for e^+e^- annihilation into hadrons to that for annihilation into muon pairs. Reproduced, with permission, from W. Chinowsky, Ann. Rev. Nucl. Sci. 27, 393 (1977).

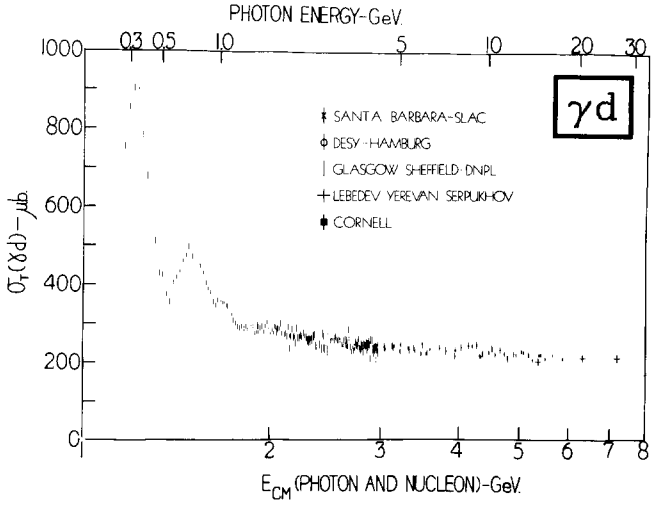


DESY measurements of the ratio R of the cross section for e^+e^- annihilation into hadrons to that for annihilation into muon pairs. From G. Knies, "Results from PLUTO," DESY 77/7 (1977).

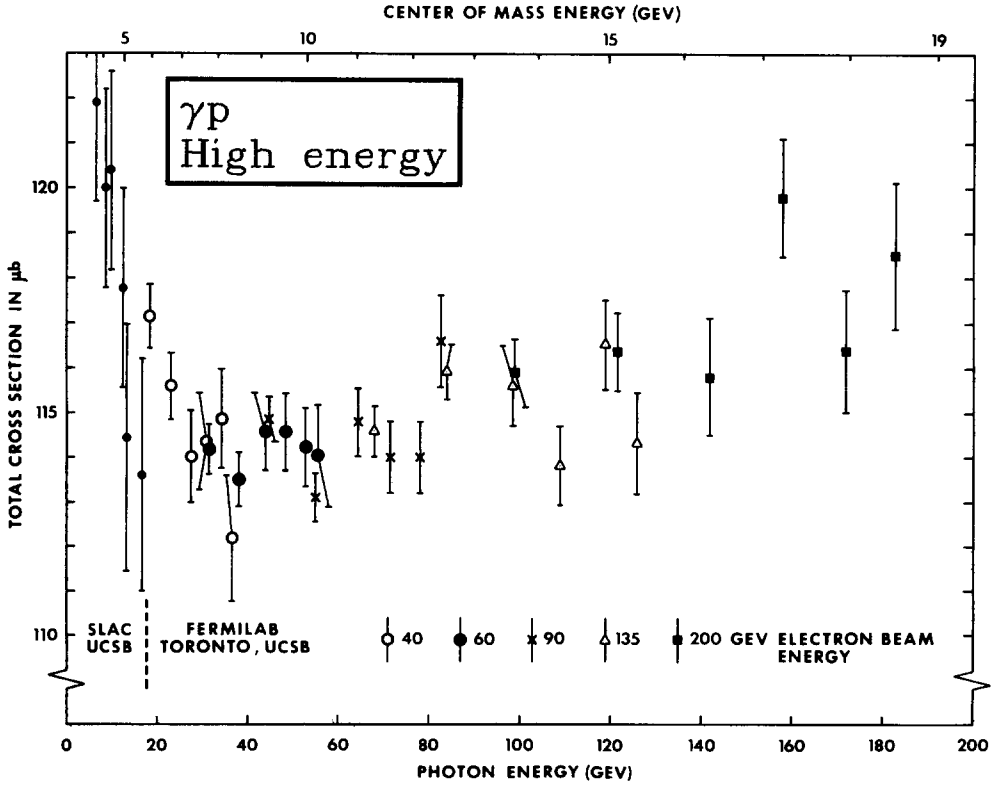
CROSS SECTION PLOTS (Cont'd)



γp total cross section versus photon energy (top scale) and photon-plus-nucleon total center-of-mass energy (lower scale). Courtesy Gething M. Lewis, Glasgow.

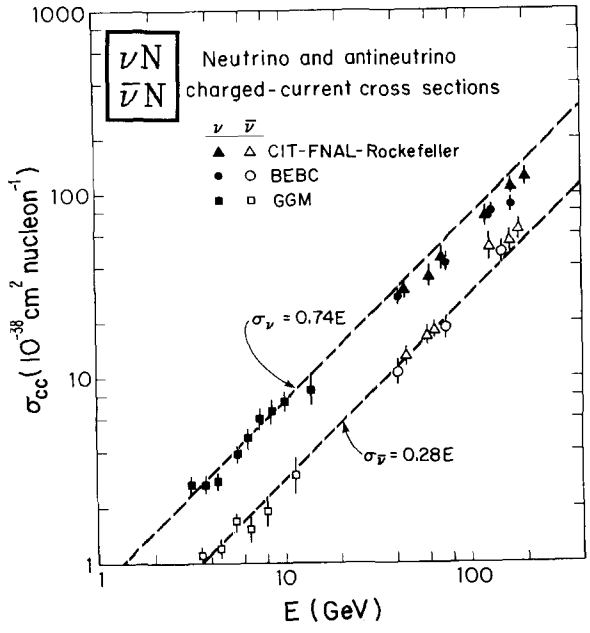


γd total cross section versus photon energy (top scale) and photon-plus-single-nucleon total center-of-mass energy (lower scale). Courtesy Gething M. Lewis, Glasgow.

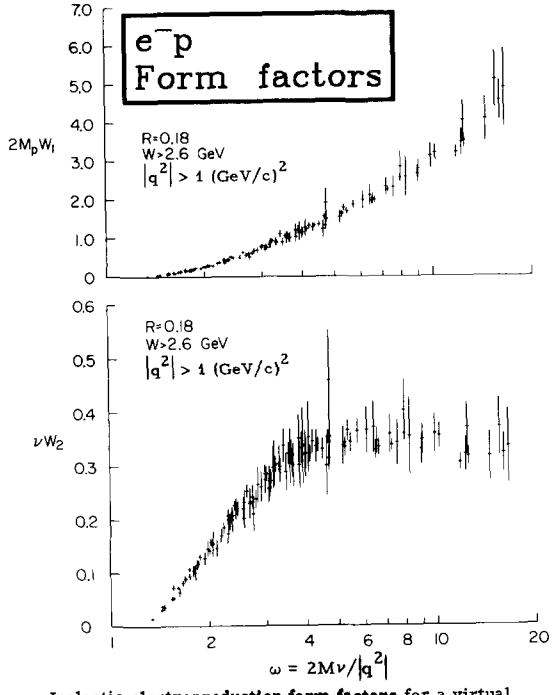


γp total cross section versus photon energy (lower scale) and total center-of-mass energy (upper scale). Courtesy Roland M. Egloff, Fermilab.

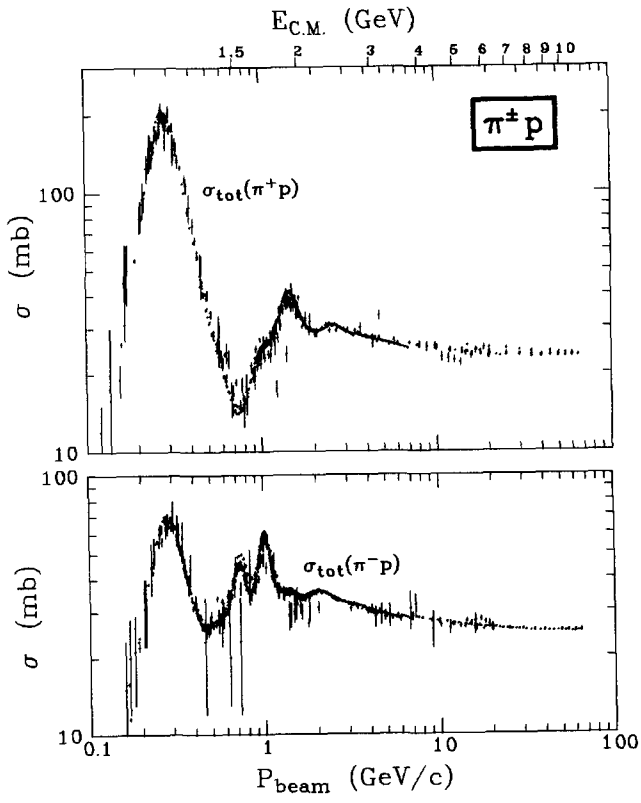
CROSS SECTION PLOTS (Cont'd)



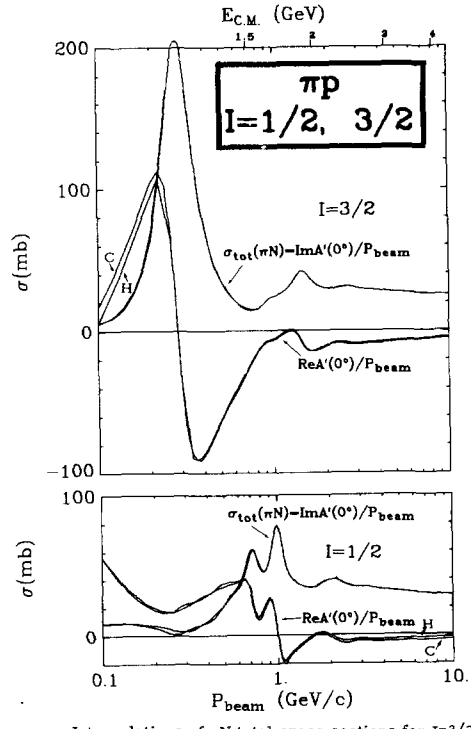
Muon neutrino and antineutrino charged-current cross section as a function of total energy, with linear fits to early Gargamelle data superimposed. Triangles from B. C. Barish et al., Phys. Rev. Lett. 39, 1595 (1977); circles from P. C. Bosetti et al., Phys. Lett. 70B, 273 (1977); squares from D. H. Perkins, Rep. Prog. Phys. 40, 409 (1977).



Inelastic **electroproduction form factors** for a virtual space-like photon scattering on a proton, from SLAC-MIT, Phys. Rev. D5, 528 (1972). $R = \sigma_S/\sigma_T$, the ratio of the longitudinal to transverse cross sections. See L. Hand, Phys. Rev. 129, 1834 (1963).

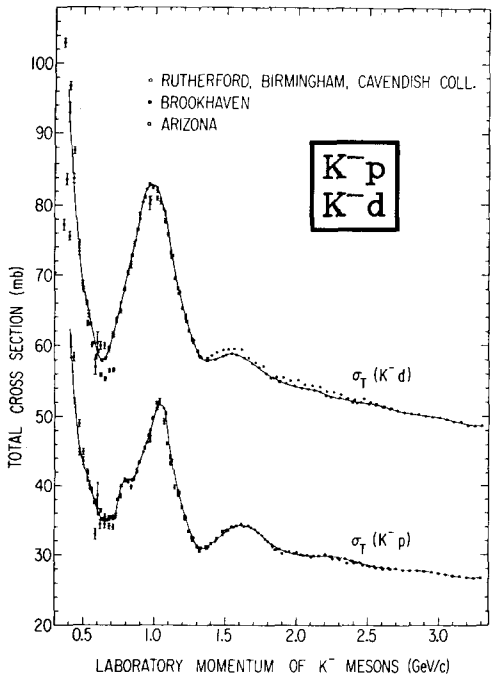


$\pi^{\pm}$ p total cross-section data from the Particle Data Group compilation "πN Two-Body Scattering Data," LBL-63 (1973).

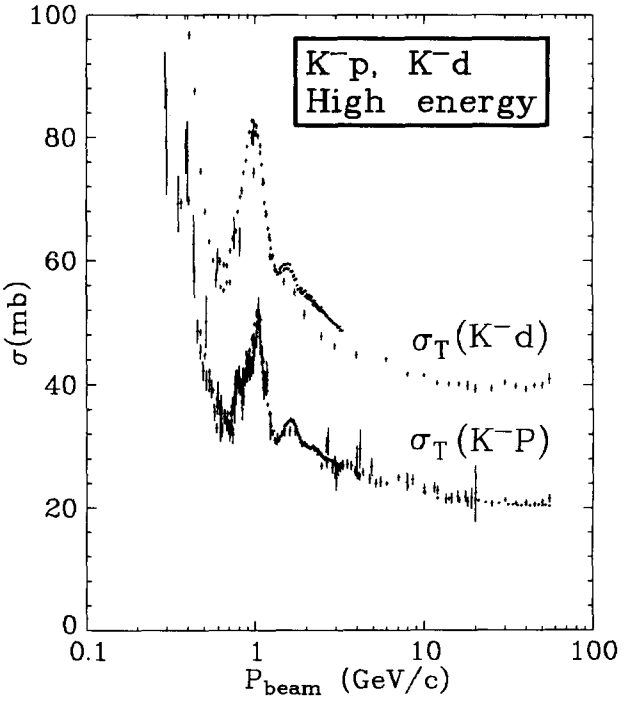


Interpolations of πN total cross sections for I=3/2 and 1/2, and the corresponding real parts of the forward amplitudes as calculated from dispersion relations by A. A. Carter and J. R. Carter (RHEL ppt. RL-73-024, 1973; labeled C above) and by G. Hohler and H. P. Jakob (priv. comm., 1972; labeled H above). The normalization of the curves for each value of I is such that the sum of their squares divided by 19.6 gives $d\sigma/dt$ at 0° in mb/(GeV/c)^2.

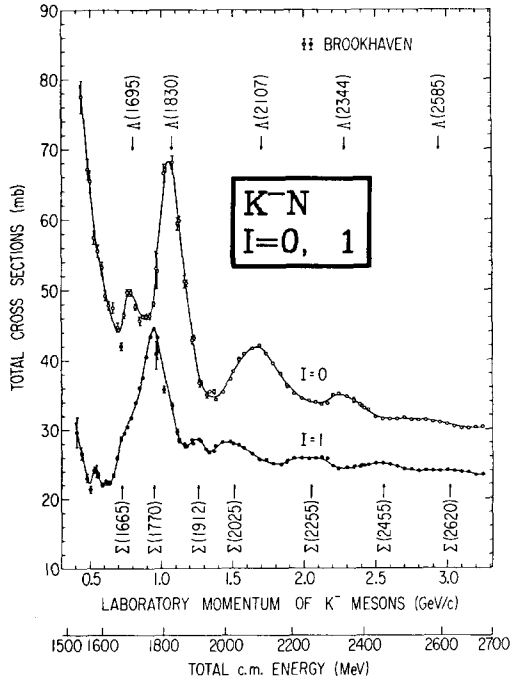
CROSS SECTION PLOTS (Cont'd)



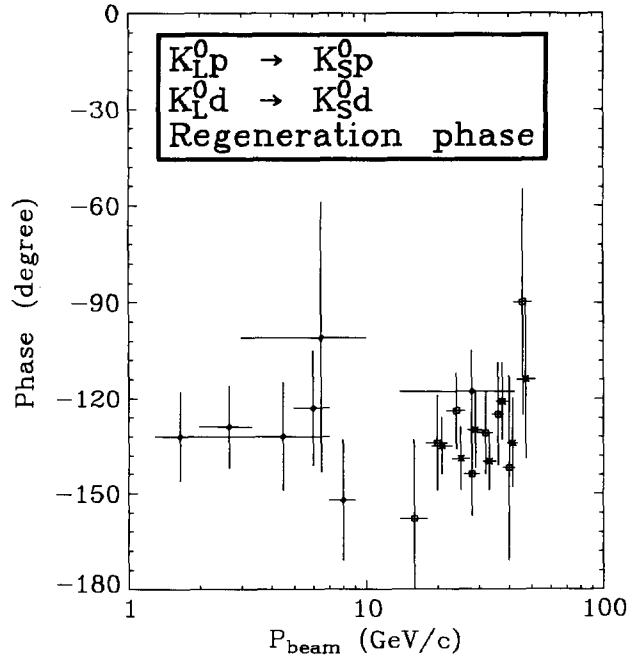
K⁻p and K⁻d total cross-section data compiled by Li et al., Proc. 1973 Purdue Conf. on Baryon Resonances. The solid curve passes through the Brookhaven data.



K⁻p and K⁻d total cross-section data. Compilation sources: E. Bracci et al., CERN/HERA 72-2, K⁻p; G.R. Lynch, K⁻d (< 3 GeV/c); Particle Data Group, K⁻d (>3 GeV/c). The new BNL data below 1 GeV/c are not included.

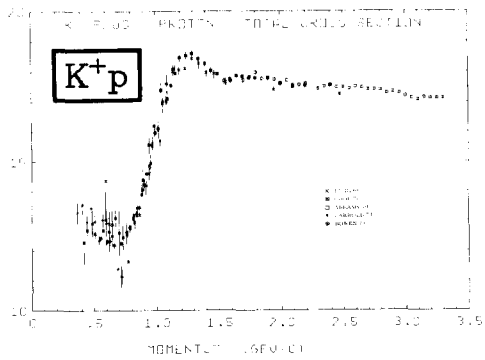


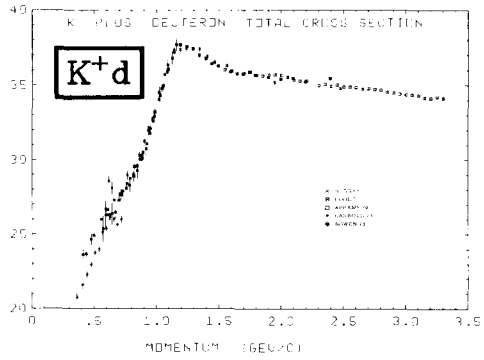
K⁻N total cross sections for I = 0 and I = 1 below 3.3 GeV/c. Compiled and unfolded by Li et al., Proc. 1973 Purdue Conf. on Baryon Resonances.



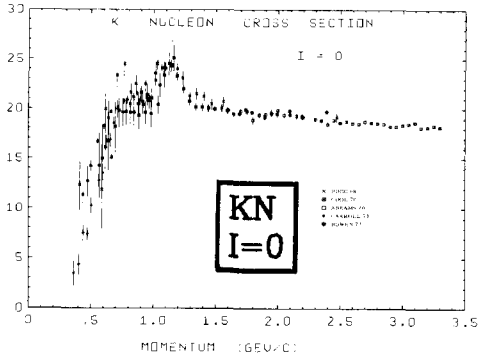
Phases of forward amplitudes for $K^0_L p \to K^0_S p$ (◇,□) and $K^0_L d \to K^0_S d$ (*). The deuterium data are shifted 1 GeV/c higher to avoid overlap with the proton data. ◇-p, compiled by Particle Data Group, LBL-55; □-p, V. Birnlev et al; JINR-E1-6851 (1972); *-d, K.-F. Albrecht et al., Phys. Lett. 48B, 257 (1974).

CROSS SECTION PLOTS (Cont'd)

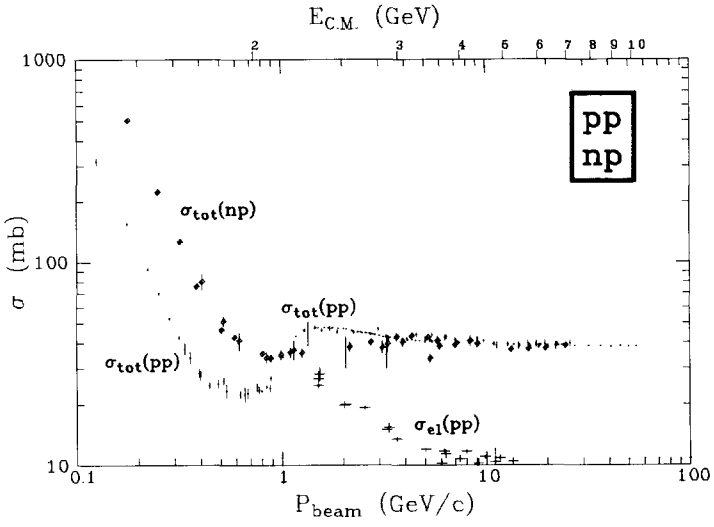




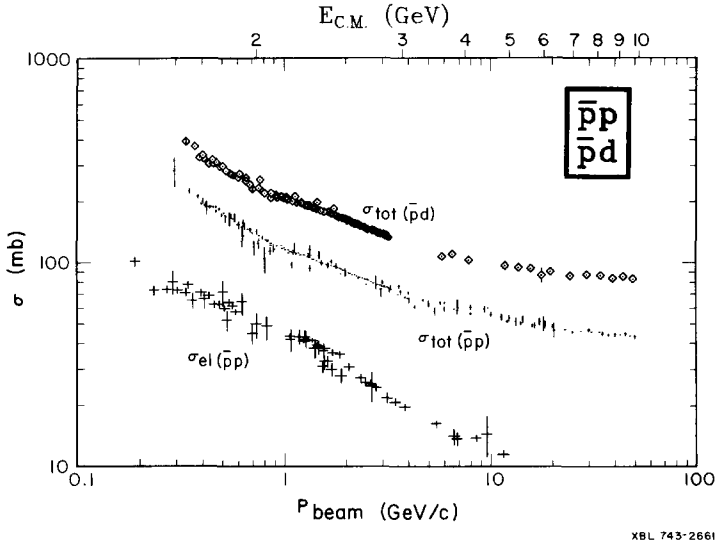
Compilation of recent K^+p and K^+d total cross-section measurements. References can be found in the Baryon Data Card Listings.



Total cross-section for isospin zero KN system. Unfolding of the BUGG 68 and BOWEN 70 and 73 data was done by G. R. Lynch (as in Proc. of 1970 Duke Conference). Tables of σ_0 were provided by the BNL authors. Lynch and BNL use the same method of unfolding; the BOWEN 73 unfolded distribution is obtained by a different method (see plot in Z^* mini-review in the Baryon Data Card Listings).

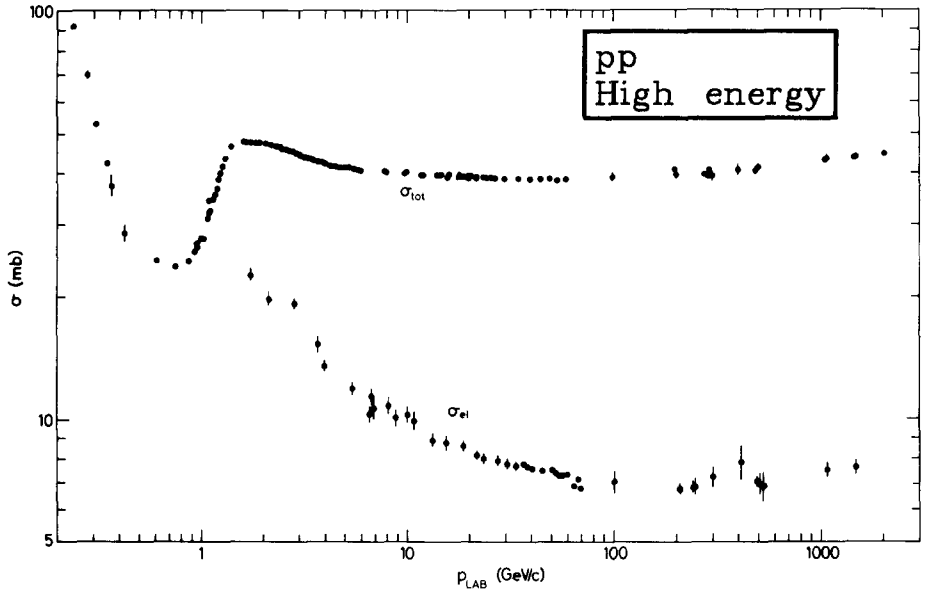


pp and np cross sections from Particle Data Group, "NN and ND Interactions -- A Compilation", UCRL-20 000 NN (August 1970); some points at higher energies added since original compilation.

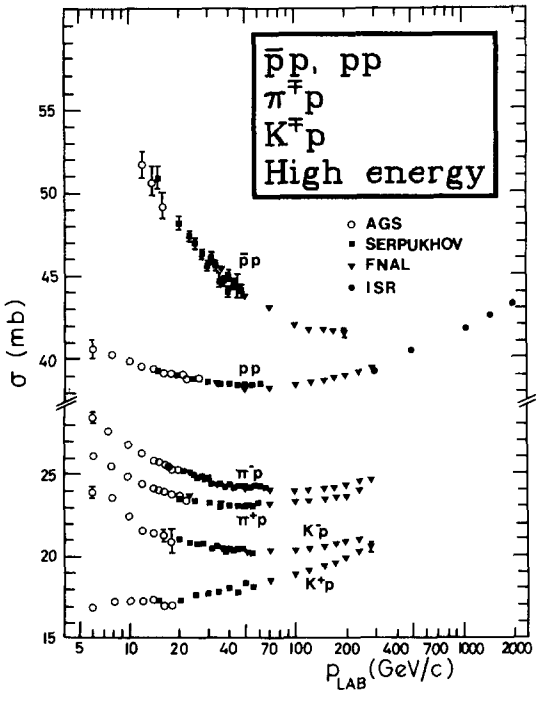


$\bar{p}p$ and $\bar{p}d$ cross sections from Particle Data Group, " A Compilation of NN and $\bar{N}D$ Reactions," LBL-58 (1972); some points added since original compilation.

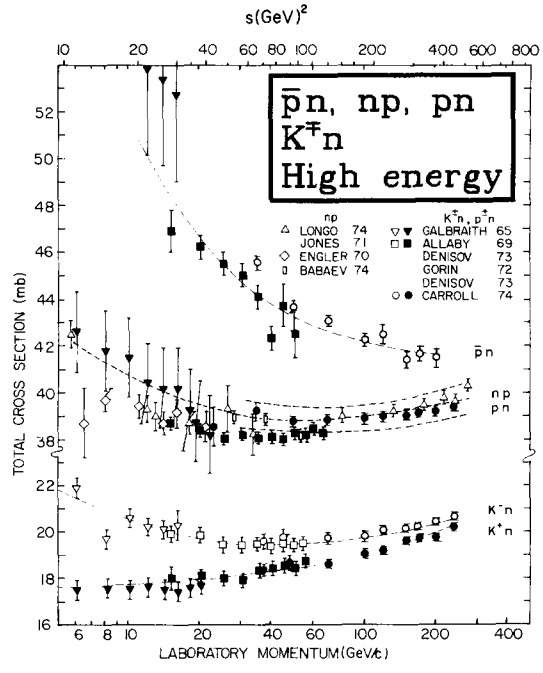
CROSS SECTION PLOTS (Cont'd)



Total and elastic pp cross-section data compiled by U. Amaldi, CERN.



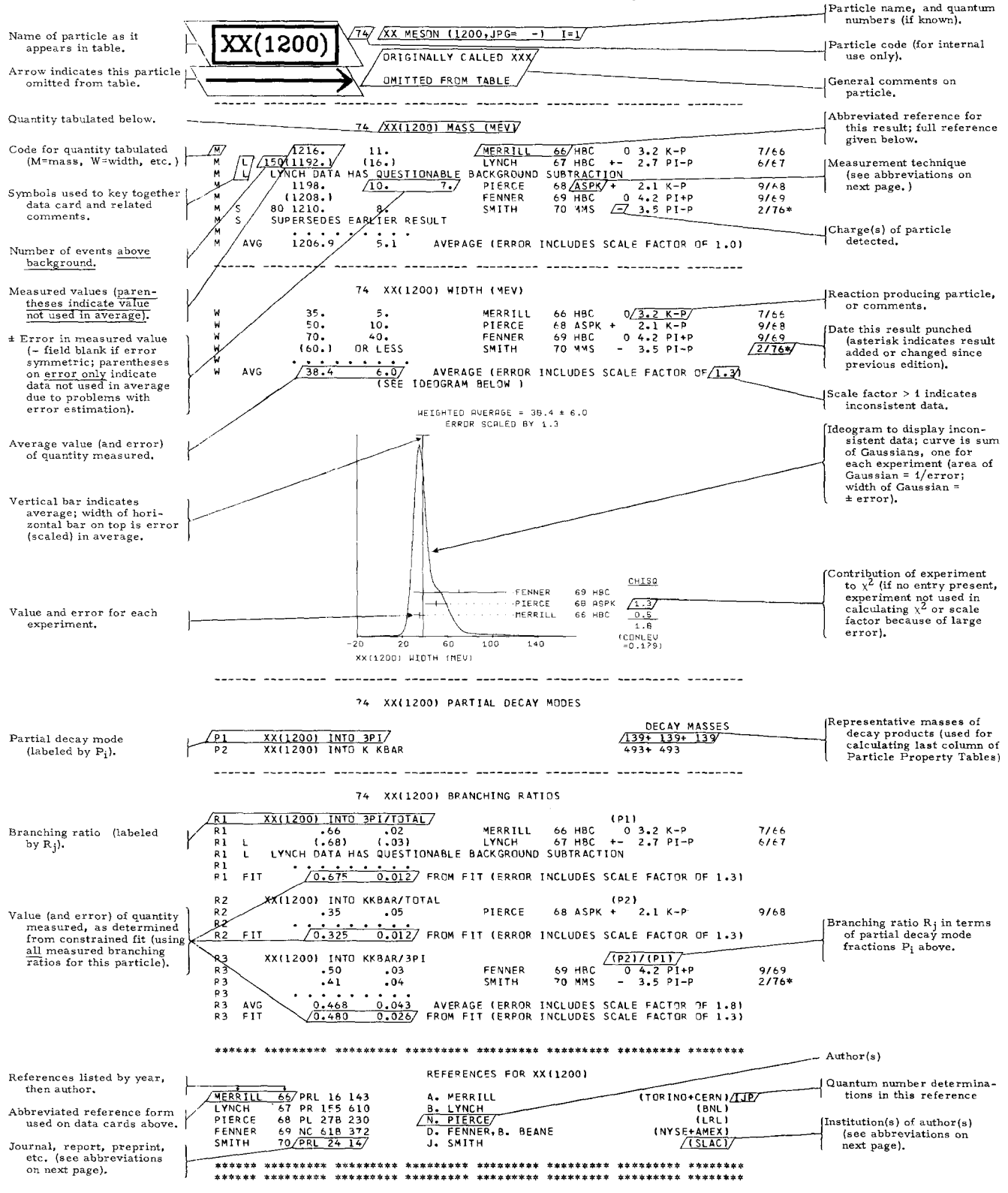
p̄p, pp, π^-p, π^+p, K^-p, and K^+p total cross sections versus $s(\approx 2m_p p_{lab})$, as compiled by U. Amaldi, CERN.



p̄n, np, pn, K^-n, and K^+n total cross sections versus $s(\approx 2m_p p_{lab})$, as compiled by G. Giacomelli, CERN.

DATA CARD LISTINGS

Illustrative Key



Illustrative Key *(cont'd)*

Abbreviations

Journals

APAH	Acta Phys. Acad. Hungarica
ADVP	Advances in Physics
ANP	Annals of Physics
ARNS	Annual Review of Nuclear Science
BAPS	Bulletin of the Amer. Phys. Soc.
CJP	Canadian Journal of Physics
JAP	Journal of Applied Physics
JETP	English Transl. of Soviet Physics JETP
JETPL	Letters of Soviet Physics JETP
JPA	Journal of Physics A
JPG	Journal of Physics G
JPSJ	Journal of the Phys. Soc. of Japan
LNC	Letters to Nuovo Cimento
NC	Nuovo Cimento
NIM	Nuclear Instruments and Methods
NP	Nuclear Physics
PL	Physics Letters
PN	Particles and Nuclei
PPSL	Proc. of the Phys. Soc. of London
PR	Physical Review
PRAM	Pramana
PRL	Physical Review Letters
PRSE	Proc. of the Royal Soc. of Edinburgh
PRSL	Proc. of the Royal Soc. of London
PTP	Progress of Theoretical Physics
RMP	Reviews of Modern Physics
RRP	Revue Romaine de Physique
SJNP	Soviet Journal of Nuclear Physics
SPU	Soviet Physics - Uspekhi
ZNAT	Zeitschrift für Naturforschung
ZPHY	Zeitschrift für Physik

Conferences

Conferences are referred to by the location in which they were held (e.g., DUBNA, BOULDER, LUND, etc.).

Measurement techniques

ASPK	Automatic spark chambers
CC	Cloud chamber
CNTR	Counters
DASP	DESY double-arm spectrometer
DBC	Deuterium bubble chamber
DPWA	Energy-dependent PWA
ELEC	Electronic combination
EMUL	Emulsions
FBC	Freon bubble chamber
FRAB	ADONE $B\bar{B}$ Group detector
FRAG	ADONE $\gamma\gamma$ Group detector
FRAM	ADONE MEA Group detector
HBC	Hydrogen bubble chamber
HEBC	Helium bubble chamber
HLBC	Heavy liquid bubble chamber
HYBR	Hybrid: BC + electronics
IPWA	Energy-independent PWA
MMS	Missing mass spectrometer
MPWA	Model-dependent PWA
NEUL	Neuland large-angle ν spectrometer
OMEG	CERN OMEGA spectrometer
OSPK	Optical spark chamber
PBC	Propane bubble chamber
PLAS	Plastic detector
PLUT	DESY PLUTO detector
PWA	Partial-wave analysis
RVUE	Review of previous data
SMAG	SPEAR magnetic detector
SPEC	Spectrometer
SPRK	Spark chamber
STRC	Streamer chamber
WIRE	Wire chamber
XEBC	Xenon bubble chamber

Institutions

AACH	TECHNISCHE UNIV. AACHEN	AACHEN, GERMANY
AARH	AARHUS UNIV.	AARHUS, DENMARK
ADEL	ADELPHI UNIV.	GARDEN CITY, N. Y., USA
AERE	ATOMIC ENERGY RES. ESTAB.	HARWELL, BERKS., ENGLAND
ALBA	STATE UNIV. OF NEW YORK AT ALBANY	ALBANY, N. Y., USA
ALBE	ALBERTA UNIV., NRC	EDMONTON, CANADA
AMST	UNIV. OF AMSTERDAM	AMSTERDAM, NETHERLANDS
ANKA	MIDDLE EAST TECHNICAL UNIV.	ANKARA, TURKEY
ANL	ARGONNE NATIONAL LAB.	ARGONNE, ILL., USA
ARIZ	UNIV. OF ARIZONA	TUCSON, ARIZ., USA
ATEN	NUCLEAR RES. CENTRE DEMOKRITOS	ATHENS, GREECE
ATHU	UNIV. OF ATHENS	ATHENS, GREECE
AUCK	UNIV. OF AUCKLAND	AUCKLAND, NEW ZEALAND
BARC	UNIV. DE BARCELONA	BARCELONA, SPAIN
BARI	UNIV. DI BARI	BARI, ITALY
BART	BARTOL RESEARCH FOUNDATION	SWARTHMORE, PA., USA
BELG	INST. INTERUNIV. DES SCI. NUC.	BRUXELLES, BELGIUM
BERG	UNIV. OF BERGEN	BERGEN, NORWAY
BERL	INST. HOCHENERGIEPHYS. DAW	ZEUTHEN/BERLIN, DDR
BERN	UNIV. BERN	BERN, SWITZERLAND
BGNA	UNIV. DI BOLOGNA	BOLOGNA, ITALY
BING	STATE UNIV. OF NEW YORK AT BINGHAMTON	BINGHAMTON, N. Y., USA
BIRM	BIRMINGHAM UNIV.	BIRMINGHAM, ENGLAND
BNL	BROOKHAVEN NATIONAL LAB.	UPTON, L.I., N. Y., USA
BOHR	NIELS BOHR INSTITUTE	COPENHAGEN, DENMARK
BOIS	BOISE STATE UNIV.	BOISE, IDAHO, USA
BONN	UNIV. BONN	BONN, GERMANY
BORD	UNIV. DE BORDEAUX	BORDEAUX, FRANCE
BOST	BOSTON UNIV.	BOSTON, MASS., USA
BRAN	BRANDEIS UNIV.	WALTHAM, MASS., USA
BRCO	UNIV. OF BRITISH COLUMBIA	VANCOUVER, CANADA
BRIS	H. H. WILLS PHYS. LAB., U. OF BRISTOL	BRISTOL, ENGLAND
BROW	BROWN UNIV.	PROVIDENCE, R. I., USA
BRUX	UNIV. LIBRE DE BRUXELLES	BRUXELLES, BELGIUM
BUCH	BUCHAREST STATE UNIV.	BUCHAREST, ROMANIA
BUDA	CENTRAL RESEARCH INSTITUTE OF PHYSICS	BUDAPEST, HUNGARY
BUFF	STATE UNIV. OF NEW YORK AT BUFFALO	BUFFALO, N. Y., USA
CAEN	LAB. DE PHYS. CORPUSCULAIRE	CAEN, FRANCE
CANB	AUSTRALIAN NATIONAL UNIV.	CANBERRA, AUSTRALIA
CARL	CARLETON UNIV.	OTTAWA, CANADA
CARN	CARNEGIE-MELLON UNIV.	PITTSBURGH, PA., USA
CASE	CASE WESTERN RESERVE UNIV.	CLEVELAND, OHIO, USA
CAVE	CAVENDISH LAB., CAMBRIDGE UNIV.	CAMBRIDGE, ENGLAND
CCAC	COMMUNITY COLLEGE OF ALLEGHENY COUNTY	PITTSBURGH, PENN., USA
CDEF	COLLEGE DE FRANCE	PARIS, FRANCE
CEA	CAMBRIDGE ELECTRON ACCEL.	CAMBRIDGE, MASS., USA
CENG	CEN. GRENOBLE	GRENOBLE, FRANCE
CERN	EUROPEAN ORG. FOR NUC. RES.	GENEVA, SWITZERLAND
CHIC	UNIV. OF CHICAGO	CHICAGO, ILL., USA
CINC	UNIV. OF CINCINNATI	CINCINNATI, OHIO, USA
CIT	CALIF. INSTITUTE OF TECHNOLOGY	PASADENA, CALIF., USA
CNRC	CANADIAN NATIONAL RESEARCH COUNCIL	OTTAWA, CANADA
COLO	UNIV. OF COLORADO	BOULDER, COLO., USA
COLU	COLUMBIA UNIV.	NEW YORK, N. Y., USA
CORN	CORNELL UNIV.	ITHACA, N. Y., USA
COSU	COLORADO STATE UNIV.	FORT COLLINS, COLO., USA
CRAC	INST. FOR NUCLEAR RESEARCH	CRACOW, POLAND
CUNY	CITY UNIV. OF NEW YORK	NEW YORK, N. Y., USA
CURI	LABORATOIRE JOLIOT-CURIE	PARIS, FRANCE
DARE	DARESBURY NUC. PHYS. LAB.	DARESBURY, ENGLAND
DART	DARTMOUTH COLLEGE	HANOVER, N. H., USA
DESY	DEUTSCHES ELEKTRONEN-SYNCH.	HAMBURG, GERMANY
DORT	UNIV. DORTMUND	DORTMUND, GERMANY
DUKE	DUKE UNIV.	DURHAM, N. C., USA
DURH	UNIV. OF DURHAM	DURHAM, ENGLAND
DUUC	UNIVERSITY COLLEGE	DUBLIN, IRELAND
EDIN	UNIV. OF EDINBURGH	EDINBURGH, SCOTLAND
EFI	ENRICO FERMI INST. FOR NUCL. STUDIES	CHICAGO, ILL., USA
EPOL	ECOLE POLYTECHNIQUE	PARIS, FRANCE
ETHZ	SWISS FEDERAL INST. OF TECHNOLOGY	ZURICH, SWITZERLAND
FIRZ	UNIV. DI FIRENZE	FIRENZE, ITALY
FISK	FISK UNIV.	NASHVILLE, TENN., USA
FLOR	UNIV. OF FLORIDA	GAINSVILLE, FLA., USA
FNAL	FERMI NATIONAL ACCELERATOR LAB.	BATAVIA, ILL., USA
FOM	FOUND. FOR FUNDAMENTAL RES. ON MATTER	UTRECHT, NETHERLANDS
FRAS	LAB. NAZIONALI DEL SINCROTRONE	FRASCATI, ITALY
FRAS	LAB. NAZIONALI DEL C.N.E.N.	FRASCATI, ITALY
FREI	UNIV. OF FREIBURG	FREIBURG, GERMANY
FSU	FLORIDA STATE UNIV.	TALLAHASSEE, FLA., USA
GENO	UNIV. DI GENOVA	GENOVA, ITALY
GESC	GENERAL ELECTRIC RES. AND DEV. CENTER	SCHENECTADY, N. Y., USA
GEVA	UNIV. DE GENEVE	GENEVA, SWITZERLAND
GLAS	UNIV. OF GLASGOW	GLASGOW, SCOTLAND
GRAZ	UNIV. GRAZ	GRAZ, AUSTRIA

Illustrative Key *(cont'd)*

Abbreviations *(cont'd)*

Institutions (cont'd)

GREN	INST. DES SCI. NUC., UNIV. DE GRENOBLE	GRENOBLE, FRANCE
GSCC	GEOLOGICAL SURVEY OF CANADA	OTTAWA, CANADA
HAIF	TECHNION - ISRAEL INST. OF TECHNOLOGY	HAIFA, ISRAEL
HAMB	UNIV. HAMBURG	HAMBURG, GERMANY
HARV	HARVARD UNIV.	CAMBRIDGE, MASS., USA
HAWA	UNIV. OF HAWAII	HONOLULU, HAWAII, USA
HEID	UNIV. HEIDELBERG	HEIDELBERG, GERMANY
HELS	HELSINGIN YLIOPISTO	HELSINKI, FINLAND
HOUS	UNIV. OF HOUSTON	HOUSTON, TEXAS, USA
IBM	INTERNATIONAL BUSINESS MACHINES	PALO ALTO, CALIF., USA
IIT	ILLINOIS INST. OF TECH.	CHICAGO, ILL., USA
ILL	UNIV. OF ILLINOIS	URBANA, ILL., USA
ILLC	UNIV. OF ILLINOIS AT CHICAGO	CHICAGO, ILL., USA
ILLG	INST. LAUE-LANGEVIN	GRENOBLE, FRANCE
IND	UNIV. OF INDIANA	BLOOMINGTON, IND., USA
INNS	PHYS. INST., UNIV. INNSBRUCK	INNSBRUCK, AUSTRIA
IOWA	UNIV. OF IOWA	IOWA CITY, IOWA, USA
IPN	INST. DE PHYS. NUCLEAIRE	ORSAY, FRANCE
IPNP	INSTITUT DE PHYSIQUE NUCLEAIRE	PARIS, FRANCE
IPPC	INST. FOR PARTICLE PHYSICS OF CANADA	MONTREAL, CANADA
IRAD	INSTITUTE DU RADIUM	PARIS, FRANCE
ISU	IOWA STATE UNIV.	AMES, IOWA, USA
ITEP	INST. FOR TEOR. AND EXP. PHYS.	MOSCOW, USSR
IUPU	INDIANA U. - PURDUE U. AT INDIANAPOLIS	INDIANAPOLIS, IND., USA
JAGL	JAGELLONIAN UNIV.	CRACOW, POLAND
JHU	JOHNS HOPKINS UNIV.	BALTIMORE, MD., USA
JINR	JOINT INST. FOR NUCL. RESEARCH	DUBNA, USSR
KANS	UNIV. OF KANSAS	LAWRENCE, KANSAS, USA
KARL	TECHNISCHE UNIV. KARLSRUHE	KARLSRUHE, GERMANY
KEK	NAT. LAB FOR HIGH ENERGY PHYS., JAPAN	TSUKUBA-GUN, JAPAN
KENT	KENT UNIV. AT CANTEBURY, KENT	CANTEBURY, ENGLAND
KIAE	KURCHATOV INST. OF ATOMIC ENERGY	MOSCOW, USSR
KIEV	PHYSICAL-TECHNICAL INST.	KIEV, USSR
KNTY	UNIV. OF KENTUCKY	LEXINGTON, KY., USA
KONA	KONAN UNIV.	KOBE, JAPAN
KONS	B. P. KONSTANTINOV INST. OF NUCL. PHYS.	USSR
LALC	LINEAR ACCELERATOR LAB, ORSAY	ORSAY, FRANCE
LANC	LANCASTER UNIV.	LANCASTER, ENGLAND
LASL	U. C. LOS ALAMOS SCIENTIFIC LAB.	LOS ALAMOS, N. M., USA
LAUS	UNIV. OF LAUSANNE	LAUSANNE, SWITZERLAND
LBL	U. C. LAWRENCE BERKELEY LAB.	BERKELEY, CALIF., USA
LCGT	LAB. DI COSMO-GEOFISICA DEL CNR	TORINO, ITALY
LEBD	LEBEDEV PHYSICS INST.	MOSCOW, USSR
LEED	UNIV. OF LEEDS	LEEDS, ENGLAND
LEHI	LEHIGH UNIV.	BETHLEHEM, PA., USA
LEID	INST. LORENTZ	LEIDEN, NETHERLANDS
LENI	INST. OF NUCL. PHYS., USSR ACAD. SCI.	LENINGRAD, USSR
LINZ	LINZ INSTITUT FUR PHYSIK, KEPLER HOCH.	LINZ, AUSTRIA
LIVP	LIVERPOOL UNIV.	LIVERPOOL, ENGLAND
LLL	LAWRENCE LIVERMORE LAB.	LIVERMORE, CALIF., USA
LOIC	IMPERIAL COL. OF SCI. AND TECH.	LONDON, ENGLAND
LOQM	QUEEN MARY COLLEGE	LONDON, ENGLAND
LOUC	UNIVERSITY COLLEGE	LONDON, ENGLAND
LOWC	WESTFIELD COLLEGE	LONDON, ENGLAND
LPNP	LAB. DE PHYS. NUCL. ET HAUTES ENERGIES	PARIS, FRANCE
LPTP	LAB. DE PHYS. THEOR. ET HAUTES ENERGIES	PARIS, FRANCE
LRL	U. C. LAWRENCE BERKELEY LAB.	BERKELEY, CALIF., USA
LSU	LOUISIANA STATE UNIV.	BATON ROUGE, LA., USA
LUND	UNIV. I LUND	LUND, SWEDEN
MADR	JUNTA DE ENERGIA NUCLEAR	MADRID, SPAIN
MADU	UNIV. AUTONOME DE MADRID	MADRID, SPAIN
MANH	MANHATTAN COLLEGE	NEW YORK, N. Y., USA
MANI	UNIV. OF MANITOBA	WINNIPEG, CANADA
MANZ	UNIV. MAINZ	MAINZ, GERMANY
MASA	UNIV. OF MASSACHUSETTS	AMHERST, MASS., USA
MASB	UNIV. OF MASSACHUSETTS	BOSTON, MASS., USA
MCGI	MCGILL UNIV.	MONTREAL, CANADA
MCHS	UNIV. MANCHESTER	MANCHESTER, ENGLAND
MELB	UNIV. OF MELBOURNE	PARKVILLE, AUSTRALIA
MHCO	MOUNT HOLYOKE COLL.	SOUTH HADLEY, MASS., USA
MICH	UNIV. OF MICHIGAN	ANN ARBOR, MICH., USA
MILA	UNIV. DI MILANO	MILANO, ITALY
MINN	UNIV. OF MINNESOTA	MINNEAPOLIS, MINN., USA
MIOH	MIAMI UNIV.	OXFORD, OHIO, USA
MIT	MASSACHUSETTS INST. OF TECHNOLOGY	CAMBRIDGE, MASS., USA
MODE	ISTITUTO DI FISICA DELLA UNIVERSITA	MODENA, ITALY
MONP	UNIV. DE MONTPELLIER	MONTPELLIER, FRANCE
MONS	UNIV. DE L'ETAT, MONS	MONS, BELGIUM
MONT	UNIV. DE MONTREAL	MONTREAL, CANADA
MOSU	MOSCOW STATE UNIV.	MOSCOW, USSR
MPEI	MOSCOW PHYS. ENG. INST.	MOSCOW, USSR
MPIH	MAX-PLANCK-INST. FUR PHYS.-ASTROPHYS.	HEIDELBERG, GERMANY
MPIM	MAX-PLANCK-INST. FUR PHYS.-ASTROPHYS.	MUNICH, GERMANY
MSNA	INS. DI FISICA DELL UNIV.	MESSINA, ITALY
MSU	MICHIGAN STATE UNIV.	EAST LANSING, MICH., USA
MTHO	MT. HOLYOKE COLLEGE	SOUTH HADLEY, MASS., USA
MULH	CENTRE UNIV. DU HAUT-RHIN	MULHOUSE, FRANCE
MUNC	UNIV. OF MUNICH	MUNICH, GERMANY
MURA	MIDWESTERN UNIV. RESEARCH ASSOC.	STROUGHTON, WISC., USA
NAGO	NAGOYA UNIV.	NAGOYA, JAPAN
NAPL	UNIV. DI NAPOLI	NAPOLI, ITALY
NASA	NASA, GODDARD SPACE FLIGHT CENTER	GREENBELT, MD., USA
NDAM	UNIV. OF NOTRE DAME	NOTRE DAME, IND., USA
NEAS	NORTHEASTERN UNIV.	BOSTON, MASS., USA
NEUC	UNIV. DE NEUCHATEL	NEUCHATEL, SWITZERLAND
NEVI	NEVIS LAB.	IRVINGTON-ON-HUDSON, N.Y., USA
NIJM	R. K. UNIV. NIJMEGEN	NIJMEGEN, NETHERLANDS
NIU	NORTHERN ILLINOIS UNIV.	DE KALB, ILL., USA
NORD	NORDISK INS. FOR TEOR. ATOMFYS.	COPENHAGEN, DENMARK
NOVO	INST. OF NUCL. PHYS.	NOVOSIBIRSK, USSR
NPOL	NORTHERN POLYTECHNIC	LONDON, ENGLAND
NRL	NAVAL RESEARCH LABORATORY	WASHINGTON, D.C., USA
NWES	NORTHWESTERN UNIV.	EVANSTON, ILL., USA
NYU	NEW YORK UNIV.	NEW YORK, N. Y., USA
OHIO	OHIO UNIV.	ATHENS, OHIO, USA
OREG	UNIV. OF OREGON	EUGENE, ORE., USA
ORNL	OAK RIDGE NATIONAL LAB.	OAK RIDGE, TENN., USA
ORSA	UNIV. DE PARIS, FAC. DES SCI.	ORSAY, FRANCE
OSAK	OSAKA UNIV.	OSAKA, JAPAN
OSKC	OSAKA CITY UNIV.	OSAKA, JAPAN
OSLO	OSLO UNIV.	OSLO, NORWAY
OSU	OHIO STATE UNIV.	COLUMBUS, OHIO, USA
OTTA	UNIV. OF OTTAWA	OTTAWA, CANADA
OXF	OXFORD UNIV.	OXFORD, ENGLAND
PADO	UNIV. DI PADOVA	PADOVA, ITALY
PATR	UNIV. OF PATRAS	PATRAS, GREECE
PAVI	UNIV. DI PAVIA	PAVIA, ITALY
PENN	UNIV. OF PENNSYLVANIA	PHILADELPHIA, PA., USA
PISA	UNIV. DI PISA	PISA, ITALY
PITT	UNIV. OF PITTSBURGH	PITTSBURGH, PA., USA
PPA	PRINCETON-PENN. PROTON ACCEL.	PRINCETON, N. J., USA
PRAG	INSTITUTE OF PHYSICS, CSAV	PRAGUE, CZECHOSLOVAKIA
PRIN	PRINCETON UNIV.	PRINCETON, N. J., USA
PURD	PURDUE UNIV.	LAFAYETTE, IND., USA
REHO	WEIZMANN INST. OF SCI.	REHOVOTH, ISRAEL
RHEL	RUTHERFORD HIGH ENERGY LAB.	CHILTON, DID., BERKS., ENGLAND
RISO	RESEARCH ESTAB. RISO	ROSKILDE, DENMARK
RMCS	ROYAL MILITARY COLLEGE OF SCIENCE	SHRIVENHAM, ENGLAND
ROCH	UNIV. OF ROCHESTER	ROCHESTER, N. Y., USA
ROCK	ROCKEFELLER UNIV.	NEW YORK, N. Y., USA
ROMA	UNIV. DI ROMA	ROMA, ITALY
ROSE	ROSE POLYTECHNIC INST.	TERRE HAUTE, IND., USA
RUTG	RUTGERS UNIV.	NEW BRUNSWICK, N. J., USA
SACL	CNTR. D'ETUDES NUC. SACLAY	GIF-SUR-YVETTE, FRANCE
SAGA	SAGA UNIV.	SAGA, JAPAN
SANI	IST. SUPERIORE DI SANITA	ROMA, ITALY
SBER	SAN BERNARDINO STATE COLLEGE	SAN BERNARDINO, CALIF., USA
SEAT	SEATTLE PACIFIC COLLEGE	SEATTLE, WASH., USA
SEIB	RESEARCH CENTER SEIBERSDORF	VIENNA, AUSTRIA
SERP	INST. OF HIGH EN. PHYS.	SERPUKOV, USSR
SETO	SETON HALL UNIV.	SOUTH ORANGE, N. J., USA
SFLA	UNIV. OF SOUTH FLORIDA	TAMPA, FLA., USA
SHEF	UNIV. OF SHEFFIELD	SHEFFIELD, ENGLAND
SHMP	UNIV. OF SOUTHAMPTON	SOUTHAMPTON, ENGLAND
SIEG	GESAMTHOCHSCHULE SIEGEN	HUTTENTAL, GERMANY
SLAC	STANFORD LINEAR ACCEL. CENTER	STANFORD, CALIF., USA
SMAS	SOUTHEASTERN MASSACHUSETTS UNIV.	NORTH DARTMOUTH, MASS., USA
SOFI	BULGARIAN ACAD. OF SCI.	SOFIA, BULGARIA
STAN	STANFORD UNIV.	STANFORD, CALIF., USA
STEV	STEVENS INST. OF TECH.	HOBOKEN, N. J., USA
STLO	ST. LOUIS UNIV.	ST. LOUIS, MO., USA
STOH	STOCKHOLM UNIV.	STOCKHOLM, SWEDEN
STON	STATE UNIV. OF NEW YORK AT STONYBROOK	STONYBROOK, L.I., N. Y., USA
STRB	CENTRE DES RES. NUCLEAIRES	STRASBOURG, FRANCE
SUSS	UNIV. OF SUSSEX	FALMER, BRIGHTON, ENGLAND
SYRA	SYRACUSE UNIV.	SYRACUSE, N. Y., USA
TATA	TATA INST. OF FUNDAMENTAL RESEARCH	BOMBAY, INDIA
TELA	UNIV. OF TEL-AVIV	TEL-AVIV, ISRAEL
TEMP	TEMPLE UNIV.	PHILADELPHIA, PA., USA
TENN	UNIV. OF TENNESSEE	KNOXVILLE, TENN., USA
TEXA	UNIV. OF TEXAS	AUSTIN, TEXAS, USA
TMSK	NUCL. PHYS. INST., TOMSK POLYTECH INST.	TOMSK, USSR
TNTO	UNIV. OF TORONTO	TORONTO, CANADA
TOHO	TOHOKU UNIV.	SENDAI, JAPAN
TOKY	UNIV. OF TOKYO	TOKYO, JAPAN
TORI	UNIV. DI TORINO	TORINO, ITALY
TRIU	TRIUMF, UNIV. OF BRITISH COLUMBIA	VANCOUVER, CANADA
TRST	UNIV. DI TRIESTE	TRIESTE, ITALY
TUFT	TUFTS UNIV.	MEDFORD, MASS., USA
TWAS	WASEDA UNIV.	TOKYO, JAPAN
UBEL	UNIV. OF BELGRADE	BELGRADE, YUGOSLAVIA
UCB	UNIV. OF CALIF. AT BERKELEY	BERKELEY, CALIF., USA
UCD	UNIV. OF CALIF. AT DAVIS	DAVIS, CALIF., USA
UCI	UNIV. OF CALIF. AT IRVINE	IRVINE, CALIF., USA
UCLA	UNIV. OF CALIF. AT LOS ANGELES	LOS ANGELES, CALIF., USA
UCND	UNION CARBIDE NUCLEAR DIVISION	OAK RIDGE, TENN., USA
UCR	UNIV. OF CALIF. AT RIVERSIDE	RIVERSIDE, CALIF., USA
UCSB	UNIV. OF CALIF. AT SANTA BARBARA	SANTA BARBARA, CALIF., USA
UCSC	UNIV. OF CALIF. AT SANTA CRUZ	SANTA CRUZ, CALIF., USA
UCSD	UNIV. OF CALIF. AT SAN DIEGO	LA JOLLA, CALIF., USA
UMD	UNIV. OF MARYLAND	COLLEGE PARK, MD., USA
UNCS	UNION COLL.	SCHENECTADY, N. Y., USA
UPNJ	UPSALA COLLEGE	EAST ORANGE, N. J., USA
UPPS	GUSTAF WERNER INSTITUTE	UPPSALA, SWEDEN
UTAH	UNIV. OF UTAH	SALT LAKE CITY, UTAH, USA
UTRE	UNIV. OF UTRECHT	UTRECHT, NETHERLANDS
VAND	VANDERBILT UNIV.	NASHVILLE, TENN., USA
VICT	UNIV. OF VICTORIA	VICTORIA, CANADA
VIEN	INST. FOR HIGH EN. PHYS., A. A. S.	VIENNA, AUSTRIA
VILL	SWISS INST. OF NUCLEAR RESEARCH	VILLIGEN, SWITZERLAND
VIRG	UNIV. OF VIRGINIA	CHARLOTTESVILLE, VA., USA
VPI	VIRGINIA POLYTECHNIC INST.	BLACKSBURG, VA., USA
WARS	UNIV. OF WARSAW	WARSAW, POLAND
WASH	UNIV. OF WASHINGTON	SEATTLE, WASH., USA
WIEN	UNIV. WIEN	WIEN, AUSTRIA
WILL	COLLEGE OF WILLIAM AND MARY	WILLIAMSBURG, VA., USA
WISC	UNIV. OF WISCONSIN	MADISON, WISC., USA
WOOD	WOODSTOCK COLLEGE	WOODSTOCK, MD., USA
WUPG	GESAMTHOCHSCHULE WUPPERTAL	WUPPERTAL GERMANY
WUPP	UNIV. WUPPERTAL	WUPPERTAL, GERMANY
WUSL	WASHINGTON UNIV.	ST. LOUIS, MO., USA
WYOM	UNIV. OF WYOMING	LARAMIE, WYOMING, USA
YALE	YALE UNIV.	NEW HAVEN, CONN., USA
ZEEM	ZEEMAN LAB., UNIV. OF AMSTERDAM	AMSTERDAM, NETHERLANDS
ZURI	UNIV. ZURICH	ZURICH, SWITZERLAND

Stable Particles

γ, ν_e, e, ν_μ

Data Card Listings

For notation, see key at front of Listings.

γ

0 GAMMA(0,J=1)

0 GAMMA MASS (IN UNITS OF 10**-21 MEV)

M	P	(6.)	OR LESS	PATEL	65	SATELLITE DATA	10/69	
M		6.	OR LESS	GINTSBURG	64	SATELLITE DATA	.10/69	
M		2.3	OR LESS	GOLDHABER	68	SATELLITE DATA	10/69	
M	F	(0.06)	OR LESS	FRANKEN	71	LOW FREQ RES CIR	3/72	
M		10.	OR LESS	WILLIAMS	71 CNTR	TESTS GAUSS LAW	3/71	
M		(4.E-13)MEV	OR LESS	LOWENTHAL	73	GENL RELATIVITY	8/77*	
M		0.73	OR LESS	HOLLWEG	74	ALFVEN WAVES	7/74	
M		0.6	OR LESS CL=.997	DAVIS	75	JUPITER MAGFIELD	1/78*	
M	F	INVALID MEASUREMENT. SEE CRITICISM IN KROLL 71 AND GOLDHABER 71.					3/78*	

REFERENCES FOR GAMMA

GINTSBUR 64 SOV. ASTR.AJ7 536	M. A. GINTSBURG	(ACAD SCI,USSR)	
PATEL 65 PL 14 105	V. L. PATEL	(DURHAM)	
GOLDHABE 68 PRL 21 567	A. GOLDHABER,M. NIETO	(STONY BROOK)	
FRANKEN 71 PRL 26 115	P A FRANKEN, G W AMPULSKI	(MICH)	
WILLIAMS 71 PRL 26 721	+FALLER,HILL	(WESLEYAN)	
LOWENTHA 73 PR D8 2349	D.D.LOWENTHAL	(UCI)	
HOLLWEG 74 PRL 32 961	J V HOLLWEG (NATL CENTER FOR ATMOS RESRCH)		
DAVIS 75 PRL 35 1402	+GOLDHABER,NIETO	(CIT+STON+LASL)	

PAPERS NOT REFERRED TO IN DATA CARDS

GOLDHABE 71 RMP 43 277	A S GOLDHABER, M M NIETO	(STON+BOHR+UCSB)
KROLL 71 PRL 26 1395	N M KROLL	(SLAC)
BYRNE 77 AST.SP.SCI.46 115	J.C.BYRNE	(LOIC)

ν_e

1 E-NEUTRINO(0,J=1/2)

1 E-NEUTRINO MASS (KEV)

M		(0.25)	OR LESS	LANGER	52 CNTR	ANTI-NEUT.(TRITIUM)		
M		(0.50)	OR LESS	HAMILTON	53 CNTR	ANTI-NEUT.(TRITIUM)	11/73	
M		(0.55) (0.28)		FRIEDMAN	58 CNTR	ANTI-NEUT.(TRITIUM)		
M		4.1	OR LESS CL=.67	BECK	68 CNTR	NEUTRINO(SODIUM 22)	11/73	
M	D	0.5	OR LESS CL=.90	DARIS	69 CNTR	ANTI-NEUT.(TRITIUM)	11/73	
M		0.32	OR LESS CL=.90	SALGO	69 CNTR	ANTI-NEUT.(TRITIUM)	11/73	
M		0.06	OR LESS CL=.90	BERGKVIS	72 CNT	ANTI-NEUT.(TRITIUM)	11/73	
M		(0.008)	OR LESS	COWSIK	72	THEOR.LIM.FROM COSMOLOGY	3/74	
M		0.086	OR LESS CL=.90	RODE	72 CNTR	ANTI-NEUT.(TRITIUM)	11/73	
M	D	DARIS 69 VALUE .075KEV(CL=.67) DISAGREES WITH FIG.6. WE USE FIG.6.					11/73	
M	C	450.	OR LESS CL=.90	CLARK	74 ASPK	KE3 DECAY	11/75	
M	C	LOWEST LIMIT FROM STRANGENESS CHANGING DECAY.					11/75	

1 (E-NEUTRINO) - (E-ANTINEUTRINO) MASS DIFF. (KEV)

DM		450.	OR LESS CL=.90	CLARK	74 ASPK	KE3 DECAY	11/75	

1 E-NEUTRINO MEAN LIFE/MASS (UNITS SEC/EV)

T	R	3. E 2	OR MORE	REINES	74 CNTR	ANTI-NEUTRINO	3/78*
T	R	REINES 74 LOOKED FOR E-ANTINEUTRINO OF NON-ZERO MASS DECAYING TO					3/78*
T	R	A NEUTRAL OF LESSER MASS + GAMMA. USED LIQUID SCINT. DETECTOR NEAR					3/78*
T	R	FISSION REACTOR. FINDS LAB LIFETIME 6.E7 SEC OR MORE. ABOVE VALUE					3/78*
T	R	OF MEAN LIFE/MASS ASSUMES AVG. EFFECTIVE NEUTRINO ENERGY OF 0.2MEV.					3/78*

REFERENCES FOR E-NEUTRINO

LANGER 52 PR 88 689	L M LANGER,R J D MOFFAT	(INDIANA)	
HAMILTON 53 PR 92 1521	D HAMILTON,W P ALFORD,L GROSS	(PRINCETON)	
FRIEDMAN 58 PR 109 2214	LEWIS FRIEDMAN,LINCOLN G SMITH	(BNL)	
BECK 68 ZPHY 216 229	E BECK,H DANIEL	(MPIH)	
DARIS 69 NP A138 545	R DARIS,C ST-PIERRE	(LAVAL-QUEBEC)	
SALGO 69 NP A138 417	R C SALGO,H H STAUB	(ZURICH)	
BERGKVIS 72 NP B39 317	KARL-ERIK BERGKVIST	(UNIV STOCKHOLM)	
COWSIK 72 PRL 29 669	R COWSIK,J MC CLELLAND	(UCB)	
RODE 72 LNC 5 139	B RODE,H DANIEL	(MUNICH+MPIH)	
CLARK 74 PR D9 533	+ELIOFF,FRISCH,JOHNSON,KERTH,SHEN+	(LBL)	
REINES 74 PRL 32 180	+SOBEL,GURR	(UCI)	
ALSC 78 PRIVATE COMM.	V. BARNES	(PURD)	

e

3 ELECTRON(0.5,J=1/2)

3 ELECTRON MASS (MEV)

M		(.511006)(.00002)		COHEN	65 RVUE			
M		(.5110041(.0000016)		TAYLOR	69 RVUE	USING NEW E/H	7/70	
M		.5110034 .0000014		COHEN	73 RVUE		3/74	

3 ELECTRON MEAN LIFE (UNITS 10**21 YR)

T		2.0	OR MORE	MOE	65 CNTR		6/66
T	S	5.3	OR MORE	STEINBERG	75 CNTR		2/76
T	S	STEINBERG 75 SENSITIVE TO ALL DECAY MODES IN WHICH DECAY PARTICLES					2/76
T	S	ESCAPE FROM DETECTOR WITHOUT DEPOSITING ENERGY. TEST OF CHARGE					2/76
T	S	CONSERVATION.					2/76

3 ELECTRON MAGNETIC MOMENT(E/2ME)

MM		SEE RICH 72 FOR A REVIEW OF THEORY AND EXPERIMENTS.						3/74
MM		(1.0011609)	+-(24)*10**-7	SCHUPP	61 CNTR	-		
MM		(1.001159622)	+-(27)*10**-9	WILKINSON	63 CNTR	-		8/66
MM		(1.001168)	+-(22)*10**-6	RICH	66 CNTR	+ POSITRON		8/66
MM	R	(1.001159557)	+-(30)*10**-9	RICH	68 CNTR	-		6/68
MM		(1.0011596389)	+-(31)*10**-10	TAYLOR	69 RVUE			2/71
MM		(1.001159644)	+-(7)* 10**-9	WESLEY	70 CNTR			6/70
MM		(1.0011596577)	+-(35)*10**-10	WESLEY	71 CNTR	-		2/72
MM		(1.0011603)	+-(12)*10**-7	GILLELAND	72 CNTR	+		2/72
MM		(1.0011596567)	+-(35)*10**-10	COGHEN	73 RVUE			3/74
MM		(1.001159667)	+-(24)*10**-9	WALLS	73 CNTR	- BOLOMETRIC TECHN		11/77*
MM		1.00115965241	+-(20)*10**-11	VANDYCK	77 CNTR	SINGLE ELECTRON		12/77*
MM	R	RICH 68 IS REEVALUATION OF WILKINSON 63.						
DMM		(E+ ANOMALOUS MAG MOM)- (E- ANOMALOUS MAG MOM)/AVG UNITS 10**-5						
DMM		1.0	OR LESS CL=.95	SEREDNYAK	77 CNTR			6/77*

REFERENCES FOR ELECTRON

SCHUPP 61 PR 121 1	A A SCHUPP,R W PIDD,H R CRANE	(MICH)	
WILKINSO 63 PR 130 852	D T WILKINSON,H R CRANE	(MICH)	
COHEN 65 RMP 37 537	COHEN,DUMOND (N.A.AVIATION SCI.CENTER+CIT)		
MOE 65 PR 140 B 992	M K MOE,F REINES	(CASE INST TECHNOLOGY)	
RICH 66 PRL 17 271	A RICH, H R CRANE	(MICH)	
RICH 68 PRL 20 967	A RICH	(MICH)	
TAYLOR 69 RMP 41 375	+PARKER,LANGENBERG	(PRIN+UCI+PENN)	
WESLEY 70 PRL 24 1320	J C WESLEY,A.RICH	(MICH)	
WESLEY 71 PR A4 1341	J C WESLEY,A RICH	(MICH)	
GILLELAN 72 PR A5 38	J GILLELAND,A RICH	(MICH)	
RICH 72 RMP 44 250	A RICH,J C WESLEY	(MICH)	
COHEN 73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR			
WALLS 73 PRL 31 975	F.L.WALLS,T.S.STEIN	(WASH)	
STEINBER 75 PR D12 2582	STEINBERG,KWIATKOWSKI,MAENHAUT,WALL	(UMD)	
SEREDNYA 77 PL 66B 102	SEREDNYAKOV,SIDOROV,SKRINSKY+	(NOVO)	
VANDYCK 77 PRL 38 310	+SCHWINBERG,DEHMELT	(WASH)	

ν_μ

2 MU-NEUTRINO(0,J=1/2)

2 MU-NEUTRINO MASS (MEV)

M		3.5	OR LESS	BARKAS	56 EMUL			
M		4.0	OR LESS	DUDZIAK	59 CNTR			
M		3.6	OR LESS	FEINBERG	63 RVUE			7/66
M		3.0	OR LESS	ALLCOCK	65 RVUE			7/66
M		2.5	OR LESS	BARDON	65 ASPK			
M		2.8	OR LESS CL=.90	SHAFER	65 CNTR			5/71
M		1.6	OR LESS CL=.90	BOOTH	67 CNTR			3/68
M		2.2	OR LESS CL=.90	HYMAN	67 HEBC	0. K- HE		11/67
M	B M	(1.2)	OR LESS CL=.90	BACKENSTO	71 CNTR	M**2=-1.28+-1.24		10/71
M	S	1.15	OR LESS CL=.90	SHRUM	71 CNTR	M**2=-1.55+-1.14		12/71
M		(8 EV)	OR LESS	COWSIK	72	THEOR.LIM.FROM COSMOLOGY		3/74
M	B M	1.15	OR LESS CL=.90	BACKENSTO	73 CNTR	M**2=-0.29+-0.90		1/73
M		0.65	OR LESS CL=.90	CLARK	74 ASPK	KMU3 DECAY		7/74
M	DM	(1.0)	OR LESS CL=. 0	DAUM	76 SPEC	M**2= 0.23+-0.54		1/76
M	D	0.57	OR LESS CL=.90	DAUM	78 SPEC	M**2= 0.13+-0.14		3/78*
M	M	WE CALCULATE UPPER LIMIT AT CL=.90 FROM M**2.						1/76
M	B	BACKENSTOSS 73 REPLACES BACKENSTOSS 71 AND USES THEIR NEW PI- MASS.						1/73
M	S	SHRUM 71 USES SHAFER 67 PI- MASS VALUE AND CRANE 71 MU MASS VALUE.						1/73
M	D	DAUM 78 REPLACES DAUM 76. EVALUATED USING M(PI)=139.5675+-0.0013						3/78*
M	D	AND M(MU)=105.65948+-0.00035. R. FROSCH, PRIVATE COMM.						3/78*

2 (MU-NEUTRINO) - (MU-ANTINEUTRINO) MASS DIFF. (MEV)

DM		0.45	OR LESS CL=.90	CLARK	74 ASPK	KMU3 DECAY		11/75

2 MU-NEUTRINO MEAN LIFE/MASS (UNITS SEC/EV)

T	B	0	3. E-3 OR MORE CL=.90	BELLOTTI	76 HLBC NEU, CERN GARGAMELL			1/78*
T	B	1	1.3E-2 OR MORE CL=.90	BELLOTTI	76 HLBC ANTINEU, CERN GARG			1/78*
T	B	0	2.2E-3 OR MORE CL=.90	BARNES	77 DBC NEU, ANL 12FT.			1/78*
T	C	(1. E17)	OR MORE	COWSIK	77 RVUE	ASTROPHYSICS		12/77*
T	B	THESE EXPERIMENTS LOOK FOR NEU(MU) --> NEU(E) GAMMA.						1/78*
T	C	COWSIK 77 REFERS TO RADIATIVE DECAY OF EITHER NEUE OR NEUMU.						12/77*

2 MU-NEUTRINO VELOCITY-C; ABS((V-C)/C) (UNITS 10**-4)
EXPECTED TO BE ZERO FOR MASSLESS NEUTRINO

V		77	2.0	OR LESS CL=.99	ALSPECTOR 76 SPEC >50GEV NEU, K DECAY			1/78*
V		26	4.0	OR LESS CL=.99	ALSPECTOR 76 SPEC <50GEV NEU, PI DCAY			1/78*

REFERENCES FOR MU-NEUTRINO

BARKAS 56 PR 101 778	W H BARKAS,W BIRNBAUM,F M SMITH	(LRL)	
DUDZIAK 59 PR 114 336	W F DUDZIAK,R SAGANE,J VEDDER	(LRL)	
FEINBERG 63 ARNS 13 431	G FEINBERG, L M LEDERMAN	(COLUMBIA)	
ALLCOCK 65 PPSL 85 875	G R ALLCOCK	(LIVERPOOL)	
BARDON 65 PRL 14 449	BARDON,NURTON,PEOPLES +	(COLU+STONY BROOK)	
SHAFER 65 PRL 14 923	R E SHAFER,CROWE,JENKINS	(LRL)	
BOOTH 67 PL 26B 39	BOOTH,JOHNSON,WILLIAMS,WORMALD	(LIVERPOOL)	
HYMAN 67 PL 25B 376	+LOKEN,PEWITT,MCKENZIE+	(ANL+CARN+NWES)	
BACKENST 71 PL 36B 403	BACKENSTOSS,DANIEL,KOCH+	(CERN,KARL,HEID)	
SHRUM 71 PL 37B 114	E V SHRUM,K O H ZIOCK	(UNIV OF VIRGINIA)	
COWSIK 72 PRL 29 669	R COWSIK,J MC CLELLAND	(UCB)	
BACKENST 73 PL 43B 539	BACKENSTOSS,DANIEL,KOCH+	(CERN+KARL+MUNICH)	
CLARK 74 PR D9 533	+ELIOFF,FRISCH,JOHNSON,KERTH,SHEN +	(LBL)	
ALSPECTO 76 PRL 36 837	ALSPECTOR +	(BNL+PURD+CIT+FNAL+ROCK)	
BELLOTTI 76 LNC 17 553	+CAVALLI,FIORINI,ROLLIER	(MILA)	
DAUM 76 PL 60B 380	+DUBAL,EATON,FROSCH,MCCULLOCH+	(VILL+ETHZ)	
BARNES 77 PRL 38 1049	+CARMONY,DAUWE,FERNANDEZ +	(PURD+ANL)	
COWSIK 77 PRL 39 784	R. COWSIK	(MPIM)	
DAUM 78 PL - TO BE PUBL.	+EATON,FROSCH,HIRSCHMANN,MC CULLOCH+	(VILL)	

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                  4  MUCN(106,J=1/2)
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                  4  MUON MASS (MEV)

M          (105.659)  (0.002)          FEINBERG  63 RVUE
M          (105.6599) (0.0014)         TAYLOR    69 RVUE    USING NEW E/H     7/70
M    C     (105.6597) (0.0005)         CRANE     71 CNTR INCLUDED IN COHEN73  1/73
M    D     (105.6594) (0.0004)         CROWE     72 CNTR INCLUDED IN COHEN73  2/72
M           105.65948  0.00035         COHEN     73 RVUE                      3/74
M    A      105.65945  0.00033         CASPERSON 77 CNTR +                   12/77*
M    C  CRANE 71 GIVES MU/ME=206.76878(85).  WE USE ME=.5110041(16)MEV.       1/73
M    D  CROWE 72 GIVES MU/ME=206.7682(5) AND USES ME=.5110041(16)MEV.         1/73
M    A  CASPERSON 77 GIVES MU/ME=206.76859(29).WE USE ME=.5110034(14)MEV.    12/77*
M              . . . . . . . . . .
M   AVG     105.65946  0.00024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT105.65946  0.00026  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT     105.65946  0.00024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*

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                  4  MUON MEAN LIFE (UNITS 10**-6)

T             2.198    0.001      0.001 FARLEY    62 CNTR
T             2.203    0.004            LUNDY     62 CNTR    CONLEV=.98      11/67
T             2.202    0.003      0.003 ECKHAUSE  63 CNTR
T             2.197    0.005      0.002 MEYER     63 CNTR +
T             2.198    0.002      0.002 MEYER     63 CNTR -                   7/66
T    W      (2.20026)(0.00081)          WILLIAMS  72 CNTR +                   2/76
T             2.1973   0.0003           DUCLOS    73 CNTR +                   1/76
T             2.19711  0.00008          BALANDIN  74 CNTR +                   1/76
T    W  WILLIAMS 72 MEAN LIFE MEASUREMENT WAS NOT THE PRIMARY PURPOSE OF      1/76
T    W  THEIR EXPERIMENT AND DISAGREES STRONGLY WITH LATER EXPTS. NOT AVGD.   1/76
T              . . . . . . . . . .
T   AVG      2.197134 0.000077 0.000077 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT 2.197133 0.000084 0.000084 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT

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                  4  MU+/MU- MEAN LIFE RATIO

DT              1.000    0.001          MEYER     63 CNTR  MEAN LIFE MU+/MU-   7/66

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                  4  MUON ANOMALOUS MAGN. MOMENT (10**-6*E/(2*MU MASS))

MM      SEE RICH 72 AND COMBLEY 74 FOR A REVIEW OF THEORY AND EXPERIMENTS.
MM         (1162.0)     (5.0)          CHARPAK   62 CNTR +
MM  B      (1165.75)    (0.71)         BAILEY    68 CNTR +  STOR. RINGS       5/69
MM  B      (1166.25)    (0.24)         BAILEY    68 CNTR  - STOR. RINGS       5/69
MM  B       ERRORS STATISTICAL. VALUES COMBINED TO GIVE MU+- VALUE BELOW      5/69
MM          1166.16      0.31          BAILEY    68 CNTR +- STOR. RINGS       5/69
MM          1060.       67.            HENRY     69 CNTR +                    1/77*
MM  A      (1165.895)   (0.027)        BAILEY    75 CNTR +  STORAGE RING     11/75
MM   A      1165.922     0.009         BAILEY    77 CNTR +- STORAGE RING     11/77*
MM   A  BAILEY 77 INCLUDES RESULTS OF BAILEY 75.                             11/77*
MM             . . . . . . . . . .
MM  AVG     1165.9222    0.0090  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
MM  STUDENT1165.9222    0.0097  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                  4  MUON TO PROTON MAGNETIC MOMENT RATIO

MMR     THIS RATIO IS USED TO OBTAIN PRECISE VALUES OF THE MUON MASS.         3/72
MMR     SEE CROWE 72.                                                         3/72
MMR       (3.1865)  (.0022)            COFFIN    58 CNTR +  SPIN RESONANCE    2/72
MMR       (3.1830)  (.0011)            LUNDY     58 CNTR +  PRECESSION STROB  2/72
MMR       (3.176)   (.013)             LUNDY     58 CNTR -  PRECESSION STROB  2/72
MMR       (3.1834)  (.0002)            GARWIN    60 CNTR +  PRECESSION PHASE  2/72
MMR       (3.18336) (.00007)           BINGHAM   63 CNTR +  PRECESSION STROB  2/72
MMR       (3.1808)  (.0004)            BINGHAM   63 CNTR -  PRECESSION STROB  2/72
MMR       (3.18338) (.00004)           HUTCHINS  63 CNTR +  PRECESSION PHASE  2/72
MMR D     (3.183351)(.000016)          EHRLICH   69 CNTR    HFS SPLITTING     2/72
MMR C     (3.183314)(.000034)          THOMPSON  69 CNTR    HFS SPLITTING     2/72
MMR       (3.183330)(.000044)          HUTCHINS  70 CNTR +  PRECESSION PHASE  2/72
MMR H     (3.183347)(.000009)          HAGUE     70 CNTR +  PRECESSION PHASE  2/72
MMR  C    (3.183336)(.000013)          CRANE     71 CNTR    HFS SPLITTING     2/72
MMR  D    (3.183349)(.000015)          DEVOE     71 CNTR    HFS SPLITTING     1/73
MMR F     (3.183326)(.000013)          FAVART    71 CNTR    HFS SPLITTING     2/72
MMR  H    (3.1833467(.0000082)         CROWE     72 CNTR +  PRECESSION PHASE  2/72
MMR  R  THE RESULTS THROUGH 1972 ARE INCLUDED IN COHEN 73.                    3/74
MMR  R     3.1833402 .0000072          COHEN     73 RVUE                      3/74
MMR        3.1833299 .0000025          CASPERSON 75 CNTR                      2/76
MMR        3.1833403 .0000044          CASPERSON 77 CNTR +  HFS SPLITTING    12/77*
MMR C   CRANE 71 SUPERSEDES THOMPSON 69. THIS IS NOT A DIRECT MEASUREMENT.    1/73
MMR H   CROWE 72 SUPERSEDES HAGUE 70.
MMR F   FAVART 71 ASSUMES A ZERO VALUE FOR THE PROTON POLARIZABILITY.         1/73
MMR  D  DEVOE 71 SUPERCEDES EHRLICH 69.  THIS IS NOT A DIRECT MEASUREMENT.    1/73
MMR  D  WE GIVE A NEW VALUE WHICH CONTAINS A THEORETICAL CORRECTION OF        1/73
MMR  D  -7.8+-2.3 PPM, AS DISCUSSED IN FOOTNOTE 35A OF CROWE 72.              1/73
MMR            . . . . . . . . . .
MMR AVG    3.18333310.0000034  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
MMR STUDENT3.18333300.0000027  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )

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                  4  MUON PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      MUON INTO E ANTI(E-NEU) (MU-NEU)                   .5+   0+   0
P2      MUON INTO E 2GAMMA                                 .5+   0+   0
P3      MUON INTO 3ELECTRONS                               .5+  .5+  .5
P4      MUON INTO E GAMMA                                  .5+   0
P5      MUON INTO E (E-NEU) ANTI(MU-NEU)                   .5+   0+   0
P6      MUON INTO E ANTI(E-NEU) (MU-NEU) GAMMA             .5+   0+   0+   0

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                  4  MUON BRANCHING RATIOS

R1      MUON INTO E+2GAMMA (IN UNITS OF 10**-5)             (P2)/(P1)
R1            1.6    OR LESS  CL=.90   FRANKEL1  63 OSPK +
R1 P          0.4    OR LESS  CL=.90   POUTISSOU 74 CNTR +                   12/75
R1 P    POUTISSOU 74 LIMIT APPLIES TO SUM OF ALL NEUTRINOLESS MU+ DECAYS.     1/76
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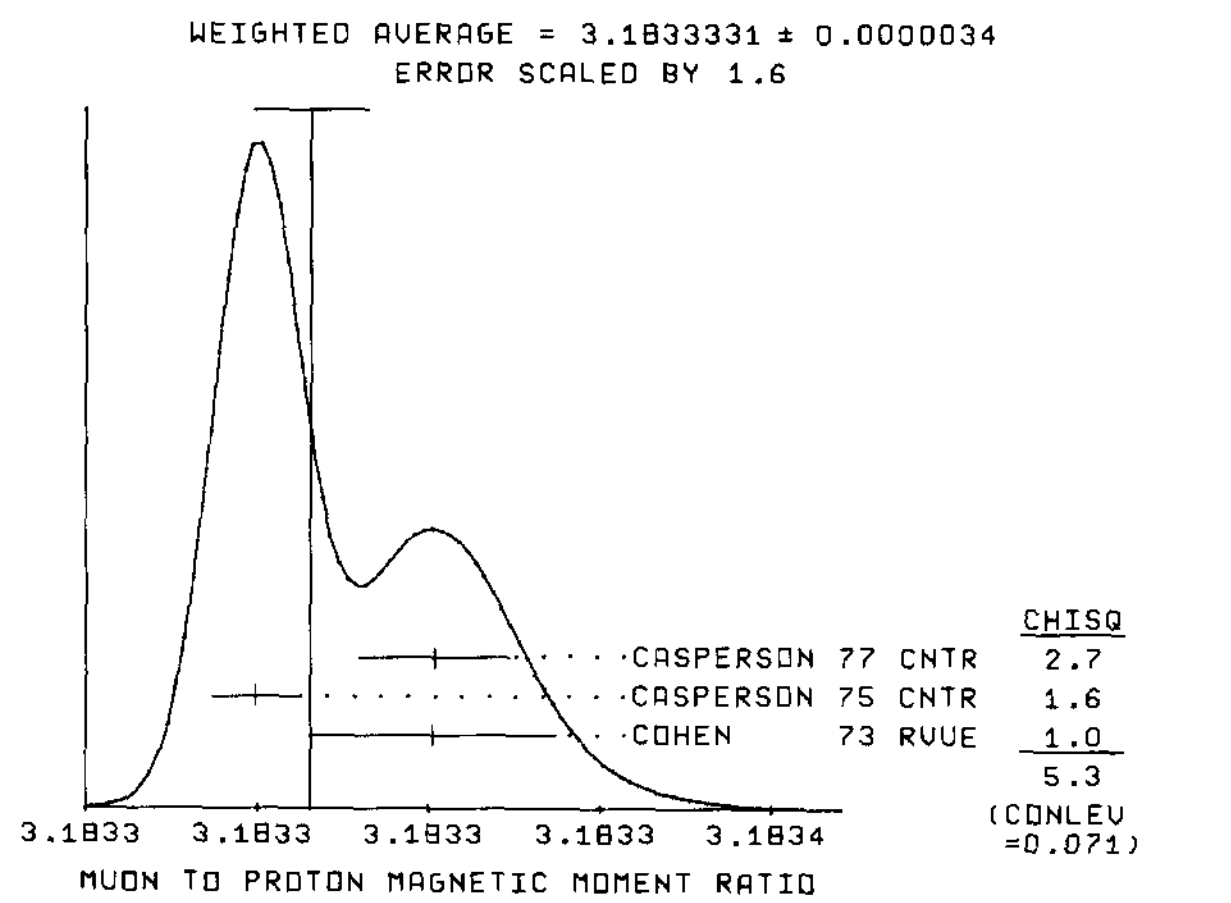


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R2      MUON INTO 3E (IN UNITS OF 10**-7)                    (P3)/(P1)
R2 F          5.0    OR LESS  CL=.90   PARKER    62 CNTR
R2 F          1.3    OR LESS  CL=.90   ALIKHANOV 62 OSPK
R2 F          1.5    OR LESS  CL=.90   FRANKEL2  63 CNTR
R2 F          1.2    OR LESS  CL=.90   BABAEV    63 OSPK
R2 K          0.062  OR LESS  CL=.90   KORENCH2  71 OSPK                      2/72
R2 K          0.019  OR LESS  CL=.90   KORENCHEN 76 SPEC +                    6/77*
R2 F    FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND
R2 F    ORDER V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED
R2 F    BY ASSUMING A CONSTANT MATRIX ELEMENT.
R2 K    THESE EXPERIMENTS ASSUME A CONSTANT MATRIX ELEMENT.                  10/77*

R3      MUON INTO E+GAMMA (IN UNITS OF 10**-8)               (P4)/(P1)
R3            4.3    OR LESS  CL=.90   FRANKEL1  63 OSPK
R3            2.2    OR LESS  CL=.90   PARKER    64 OSPK
R3            2.9    OR LESS  CL=.90   KORENCH1  71 OSPK +                   10/71
R3            0.36   OR LESS  CL=.90   DEPOMMIER 77 CNTR +                   12/77*

R4      MUON+ INTO (E+ (E-ANTINEU) (MU-NEU))                 (P5)/(P1)
R4       FORBIDDEN BY ADDITIVE CONSERVATIVATION LAW FOR MUON NUMBER.
R4       MULTIPLICATIVE LAW PREDICTS R4=0.5
R4            0.25   OR LESS  CL=.90   EICHTEN   73 HLBC +                   11/75

R5      MUON INTO E ANTI(E-NEU) (MU-NEU) GAMMA               (P6)/(P1)        1/78*
R5       27 EVENTS SEEN                ASHKIN    59 CNTR                      1/78*
R5            1.4E-2   0.4E-2          CRITTENDE 61 CNTR T(GAM) GT 10 MEV     1/78*
R5            3.3E-3   1.3E-3          CRITTENDE 61 CNTR T(GAM) GT 20 MEV     1/78*
R5      862 EVENTS SEEN                BOGART    67 CNTR T(GAM) GT 14.5 MEV   1/78*

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                  4  MUON DECAY PARAMETERS

        RELATED TEXT SECTION VI A


RHO     RHO PARAMETER                (V-A THEORY PREDICTS RHO=0.75)
RHO C         (0.741)  (0.027)         DUDZIAK   59 CNTR +  20-53 MEV E+     10/69
RHO  P9213     0.745    0.025          PLANO     60 HBC  +  WHOLE SPECTRUM   10/69
RHO  P  TWO PARAMETER FIT TO RHO AND ETA.
RHO C 2276    (0.751)  (0.034)         BLOCK     62 HEBC  - WHOLE SPECTRUM   10/69
RHO D         (0.64)   (0.04)          BARLOW    64 CNTR  - WHOLE SPECTRUM   10/69
RHO D         (0.661)  (0.016)         BARLOW    64 CNTR +  WHOLE SPECTRUM   10/69
RHO D         (0.867)  (0.035)         PONTECORV 64 CC    -                  10/69
RHO D   RESULTS IN DOUBT.                                                    10/69
RHO C 800K    (0.7503) (0.0026)        PEOPLES   66 ASPK +  20-53 MEV E+     10/69
RHO C 280K    (0.760)  (0.009)         SHERWOOD  67 ASPK +  25-53 MEV E+     10/69
RHO C 170K    (0.762)  (0.008)         FRYBERGER 68 ASPK +  25-53 MEV E+     10/69
RHO C   ETA CONSTRAINED =0. THESE VALUES INCORPORATED INTO A TWO PARAMETER
RHO C   FIT TO RHO AND ETA BY DERENZO 69.
RHO            0.7518   0.0026         DERENZO   69 RVUE                     10/69
RHO          . . . . . . . . . .
RHO AVG        0.7517   0.0026  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
RHO STUDENT    0.7517   0.0028  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

ETA     ETA PARAMETER                (V-A THEORY PREDICTS ETA=0)
ETA P 9213   (-2.0)    (0.9)           PLANO     60 HBC  +  WHOLE SPECTRUM   10/69
ETA P   TWO PARAMETER FIT TO RHO AND ETA- PLANO 60 DISCOUNTS VALUE FOR ETA   10/69
ETA C 800K    (0.05)   (0.5)           PEOPLES   66 ASPK +  20-53 MEV E+     10/69
ETA C 280K   (-0.7)    (0.6)           SHERWOOD  67 ASPK +  25-53 MEV E+     10/69
ETA C 170K   (-0.7)    (0.5)           FRYBERGER 68 ASPK +  25-53 MEV E+     10/69
ETA C   RHO CONSTRAINED =0.75.
ETA   6346    -0.12     0.21           DERENZO   69 HBC  +  1.6-6.8 MEV E+   10/69

XSI     XSI PARAMETER                (V-A THEORY PREDICTS XSI=1)
XSI     9K     0.97     0.05           BARDON    59 CNTR    BROMOFORM TARGET 10/69
XSI   8354     0.93     0.06           PLANO     60 HBC  +  8.8 KGAUSS       10/69
XSI A         (0.903)  (0.027)         ALI-ZADE  61 EMUL +  27 KGAUSS        10/69
XSI A   DEPOLARIZATION BY MEDIUM NOT KNOWN SUFFICIENTLY WELL.
XSI G  66K    (0.975)  (0.030)         GUREVICH  64 EMUL    140 KGAUSS       10/69
XSI            0.975    0.014          GUREVICH  67 EMUL                     10/69
XSI G   GUREVICH 67 SUPERSEDES GUREVICH 64                                   10/69
XSI          . . . . . . . . . .
XSI AVG        0.972    0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
XSI STUDENT    0.973    0.014   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

DEL     DELTA PARAMETER              (V-A THEORY PREDICTS DELTA=0.75)
DEL  8354      0.78     0.05           PLANO     60 HBC  +  WHOLE SPECTRUM   10/69
DEL            0.782    0.031          KRUGER    61                          10/69
DEL   490K     0.752    0.009          FRYBERGER 68 ASPK +  25-53 MEV E+     10/69
DEL     VOSSLER 69 HAS MEASURED THE ASYMMETRY BELOW 10 MEV                   11/69
DEL          . . . . . . . . . .
DEL AVG        0.7551   0.0085  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DEL STUDENT    0.7550   0.0094  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Stable Particles

μ, ν_τ, $\tau^\pm$

Data Card Listings

For notation, see key at front of Listings.

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HEL     HELICITY OF DECAY ELECTRON.
HEL      (V-A THEORY PREDICTS HELICITY=+-1 FOR E+-, RESPECTIVELY)
HEL      WE HAVE FLIPPED THE SIGN FOR E- SO OUR PROGRAMS CAN AVERAGE
HEL D          (0.28)    (0.16)          DICK      63 CNTR +  ANNIHILATION      10/69
HEL D    IN DOUBT- POSITRONS POSSIBLY DEPOLARIZED IN BE MODERATOR.
HEL             1.05      0.30           BUHLER    63 CNTR +  ANNIHILATION      10/69
HEL             0.94      0.38           BLOOM     64 CNTR +  BREMS TRANSMISS   10/69
HEL             1.04      0.18           DUCLOS    64 CNTR +  BHABHA SCATT      10/69
HEL     29K     0.89      0.28           SCHWARTZ  67 OSPK  - MOLLER SCATT      10/69
HEL              . . . . . .
HEL AVG         1.00      0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
HEL STUDENT     1.00      0.14    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

GS      SCALAR COUPLING CONSTANT IN MUON DECAY  (IN UNITS OF GV)
GS              0.33  OR LESS           DERENZO   69 RVUE                      10/69

GA      AXIAL VECTOR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV)
GA              0.86      0.33     0.11 DERENZO   69 RVUE                      10/69

FAV     PHASE BETWEEN VECTOR AND AXIAL VECTOR COUPLINGS  (DEGREES)
FAV           180.       15.           DERENZO   69 RVUE                      10/69

GT      TENSOR COUPLING CONSTANT IN MUON DECAY    (IN UNITS OF GV)
GT              0.28  OR LESS           DERENZO   69 RVUE                      10/69

GP      PSEUDOSCALAR COUPLING CONSTANT IN MUON DECAY  (IN UNITS OF GV)
GP              0.33  OR LESS           DERENZO   69 RVUE                      10/69

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REFERENCES FOR MUON

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COFFIN    58 PR 109 973        +GARWIN,PENMAN,LEDERMAN,SACHS      (COLUMBIA)
LUNDY     58 PRL 1 38          +SENS,SWANSON,TELEGDI,YOVANOVITCH  (CHICAGO)
ASHKIN    59 NC 14 1266        +FAZZINI,FIDECARO,LIPMAN,MERRISON +  (CERN)
BARDON    59 PRL   2   56      M BARDON, D BERLEY, L LEDERMAN     (COLUMBIA)
DUDZIAK   59 PR  114  336      W DUDZIAK,R SAGANE, J VEDDER           (LRL)
GARWIN    60 PR 118 271        GARWIN,HUTCHINSON,PENMAN,SHAPIRO   (COLUMBIA)
PLANO     60 PR  119 1400      R J PLANO                          (COLUMBIA)

ALI-ZADE  61 JETP  13  313     ALI-ZADE,GUREVICH,NIKOLSKI             (USSR)
CRITTEND  61 PR 121 1823       CRITTENDEN,WALKER,BALLAM           (MSU+MICH)
KRUGER    61 UCRL-9322 (UNPUB) H KRUGER                               (LRL)
ALIKHANO  62 CERN CONF 423     A I ALIKHANOV,A BABAEV +       (ITEP MOSCOW)
BLOCK     62 NC   23  1114     BLOCK,FIORINI,KIKUCHI+(DUKE,BOLOGNA,MILANO)
CHARPAK   62 NC    1   16      G CHARPAK,F J M FARLEY,R L GARWIN +   (CERN)
FARLEY    62 CERN CONF 415     FARLEY,MASSAM,MULLER,ZICHICHI          (CERN)

LUNDY     62 PR 125 1686       RICHARD A LUNDY                        (EFI)
PARKER    62 NC  23  485       S PARKER,S PENMAN                      (EFI)
BABAEV    63 JETP 16 1397      BABAEV,BALATS,KAFTANOV,LANDSBERG +   (ITEP)
BINGHAM   63 NC 27 1352        G.MCD.BINGHAM                          (LRL)
BUHLER    63 PL   7  368       +CABIBBO,FIDECARO,MASSAM,MULLER+       (CERN)
DICK      63 PL   7  150       DICK,FEUVRAIS,SPIGHEL                  (CERN)

ECKHAUSE  63 PR 132  422       M ECKHAUSE,T A FILIPPAS +          (CARNEGIE)
FEINBERG  63 ARNS 13 431       GERALD FEINBERG, L M LEDERMAN      (COLUMBIA)
FRANKEL1  63 NC  27  894       S FRANKEL,W FRATI,J HALPERN +          (PENN)
FRANKEL2  63 PR 130  351       S FRANKEL,W FRATI,J HALPERN +          (PENN)
HUTCHINS  63 PR 131 1351       HUTCHINSON,MENES,PATLACH,SHAPIRO   (COLUMBIA)
MEYER     63 PR  132  2693     S L MEYER,ANDERSON,BLESER,LEDERMAN+    (COLU)

BARLOW    64 PPS   84  239     +BOOTH,CARROL,COURT,DAVIES,EDWARDS+    (LIVP)
BLOOM     64 PL    8   87     +DICK,FEUVRAIS,HENRY,MACQ,SPIGHEL      (CERN)
DUCLOS    64 PL    9   62     +HEINTZE,DE ROUJULA,SOERGEL            (CERN)
GUREVICH  64 PL   11  185     GUREVICH,MAKARIYNA+          (KURCHATOV,MOSCOW)
PONTECOR  64 DUBNA CONF        PONTECORVO,SULYAEV                  (MOSCOW)
PARKER    64 PR 133B 768       S PARKER,H L ANDERSON,C REY            (EFI)

PEOPLES   66 NEVIS-147 (UNPUB) J PEOPLES                          (COLUMBIA)
BOGART    67 PR 156 1405       +DICAPUA,NEMETHY,STRELZOFF             (COLU)
GUREVICH  67   IAE 1297        GUREVICH,MAKARIYNA,MISHAKOVA+    (KURCHATOV)
SCHWARTZ  67 PR  162 1306      D M SCHWARTZ                           (EFI)
SHERWOOD  67 PR  156 1475      B A SHERWOOD                           (EFI)
BAILEY    68 PL   28B  287     +BARTL,VON BOCHMANN,BROWN,FARLEY+      (CERN)
    ALSO  72 NC 9A 369         +BARTL,VON BOCHMANN,BROWN,FARLEY+      (CERN)
FRYBERGE  68 PR  166 1379      D FRYBERGER                            (EFI)

DERENZO   69 PR  181 1854      S DERENZO                              (EFI)
EHRLICH   69 PRL 23 513        +HOFER,MAGNON,STOWELL,SWANSON+     (CHICAGO)
HENRY     69 NC 63A 995        +SCHRANK,SWANSON              (STAN+UCSB+UCSD)
TAYLOR    69 RMP 41 375        +PARKER,LANGENBERG             (PRIN+UCI+PENN)
THOMPSON  69 PRL 22 163        +AMATO,CRANE,HUGHES,MOBLEY+            (YALE)
HAGUE     70 PRL 25 628        +ROTHBERG,SCHENCK,WILLIAMS+       (WASH+LRL)
HUTCHINS  70 PRL 24 1254       HUTCHINSON,LARSON,SCHOEN,SOBER,+       (PPA)

CRANE     71 PRL 27 474        +CASPERSON,CRANE,EGAN,HUGHES+          (YALE)
DEVOE     71 PRL 25 1779(ER)   +MCINTGRE,MAGNON,STOWELL,SWANSON+    (CHICAGO)
    ALSO  71 PRL 26 213        DEVOE,MCINTGRE,MAGNON,STOWELL+     (CHICAGO)
FAVART    71 PRL 27 1336       +MCINTYRE,STOWELL,TELEGDI,DEVOE+   (CHICAGO)
KORENCH1  71 SJNP 13 190       KORENCHENKO,KOSTIN,MICELMACHER+        (JINR)
KORENCH2  71 SJNP 13 728       KORENCHENKO,KOSTIN,MICELMACHER+        (JINR)

CROWE     72 PR D5 2145        +HAGUE,ROTHBERG,SCHENCK+          (LBL+WASH)
WILLIAMS  72 PR D6 737         R W WILLIAMS,D L WILLIAMS      (WASHINGTON)
COHEN     73 J.PHYS,CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DUCLOS    73 PL 47B 491        +MAGNON,PICARD                         (SACL)
EICHTEN   73 PL 46B 281        +DEDEN+(AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)

BALANDIN  74 JETP 40 811       +GREBENYUK,ZINOV,KONIN,PONOMAREV       (JINR)
POUTISSO  74 NP B80 221        POUTISSOU,FELAWKA,INGRAM +       (MONT+BRCO)
BAILEY    75 PL 55B 420        +BORER+(CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM)
CASPERSO  75 PL 59B 397        CASPERSON,CRANE+ (YALE+LASL+HEID+BERN+WYOM)
KORENCHE  76 JETP 43 1         KORENCHENKO,KOSTIN,MITSELMAKHER+       (JINR)

BAILEY    77 PL 67B 225        +BORER+(CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM)
      OR  77 PL 68B 191        +BORER+/CERN+DARE+BERN+SHEF+MANZ+RMCS+BIRM
CASPERSO  77 PRL 38 956        CASPERSON,CRANE+ (BERN+HEID+LASL+WYOM+YALE)
DEPOMMIE  77 PRL 39 1113       DEPOMMIER,MARTIN+(MONT+BRCO+TRIU+VICT+MELB)
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PAPERS NOT REFERRED TO IN DATA CARDS

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FISHER    59 PRL  3  349       FISHER,LEONTIC,LUNDBY,MEUNIER,STROOT (CERN)
ASTBURY   60 ROCH CONF 60 542  ASTBURY,HATTERSLEY,HUSSAIN +     (LIVERPOOL)
DEVONS    60 PRL  5  330       DEVONS,GIDAL,LEDERMAN,SHAPIRO     (COLUMBIA)
LATHROP   60 NC   17 109       J LATHROP,R A LUNDY,V L TELEGDI +      (EFI)
LATHROP   60 NC   17 114       J LATHROP,R A LUNDY,S PENMAN +         (EFI)
REITER    60 PRL   5  22       REITER,ROMANOWSKI,SUTTON +         (CARNEGIE)
TELEGDI   60 ROCH CONF 60 713  V L TELEGDI                            (CERN)

CHARPAK   61 PRL   6 128       CHARPAK,FARLEY,GARWIN,MULLER,SENS +    (CERN)
HUTCHINS  61 PRL   7 129       D P HUTCHINSON,J MENES +           (COLUMBIA)
SHAPIRO   62 PR 125 1022       G SHAPIRO,L M LEDERMAN             (COLUMBIA)
FAIRLEY   66 NC 45A 281        FAIRLEY,BAILEY,BROWN,GIESCH +          (CERN)
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VOSSLER   69 NC 63A 423        C VOSSLER                              (EFI)
RICH      72 RMP 44 250        A RICH,J C WESLEY                     (MICH)
COMBLEY   74 PRPL 14 1         F.COMBLEY,E.PICASSO                    (CERN)

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$\tau^\pm(1800)$ Heavy Lepton

Since the discovery of anomalous $e\mu$ events (PERL 75) in e^+e^- collisions, the evidence for the existence of a new heavy lepton has steadily mounted. The evidence comes primarily from anomalous two-charged-prong leptonic events ($e^\pm\mu^\mp$, $e^\pm x^\mp$, $\mu^\pm x^\mp$) produced in e^+e^- annihilation. The production cross section and lepton momentum spectrum in these events is consistent with the hypothesis of pair production and leptonic decay of a charged lepton with mass around 1800 to 1900 MeV. The events cannot be explained by charm production, and no other viable hypothesis has been forthcoming. We refer the reader to the excellent reviews of FLUGGE 77 and PERL 77 (see $\tau^\pm$ reference section) for discussions of this evidence.

We now treat the $\tau^\pm$ as an established particle and enter it into the Stable Particle Table along with the e and μ.

In the Data Card Listings below we list the published measurements of $\tau^\pm$ properties as well as those of its associated neutrino ν_τ, assumed to exist if the τ is a sequential lepton.

For information about searches for heavy leptons of other types, see the Particle Searches section at the end of the Stable Particle Data Card Listings.

ν_τ →

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                        36  TAU NEUTRINO

                        NOT YET ESTABLISHED.
                        OMITTED FROM TABLE.

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                        36  TAU NEUTRINO MASS (MEV)

M       P 144   600.     OR LESS  CL=.95   PERL       77 SMAG E+E-3.8-7.8GEV ECM  12/77*
M           740.     OR LESS  CL=.90   BRANDELIK 78 DASP ASSUMES V-A DECAY     3/78*
M         (540.)     OR LESS  CL=.90   BRANDELIK 78 DASP ASSUMES V+A DECAY     3/78*
M     P  PERL 77 IS E+E- TO TAU+ TAU- EXPT. VALUE QUOTED ASSUMES V-A DECAY     12/77*
M     P  AND TAU MASS=1900 MEV.                                               12/77*

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REFERENCES FOR TAU NEUTRINO

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PERL      77 PL 70B 487        +FELDMAN,ABRAMS,ALAM,BOYARSKI+    (SLAC+LBL)
BRANDELI  78 PL 73B 109        BRANDELIK +         (AACH+DESY+HAMB+MPIM+TOKY)

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$\tau^\pm$

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                        35  TAU+-(1800,J=1/2)  HEAVY LEPTON

                        E+E- --> TAU+TAU- CROSS SECTION THRESHOLD BEHAVIOR
                        AND MAGNITUDE CONSISTENT WITH POINTLIKE SPIN 1/2
                        DIRAC PARTICLE.  BRANDELIK 78 RULES OUT POINTLIKE
                        SPIN 0 OR SPIN 1 PARTICLE.

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Data Card Listings

For notation, see key at front of Listings.


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                              35  TAU MASS (MEV)

M   P   64(1800.)   (200.)            PERL      75 SMAG    INCL. IN PERL 77   2/78*
M    B 220(1910.)    (30.)            BURMEST1  77 PLUT ASSUMES V-A DECAY    12/77*
M    B 220(1790.)    (70.)            BURMEST1  77 PLUT ASSUMES V+A DECAY    12/77*
M    P 144(1900.)   (100.)            PERL      77 SMAG E+E- 3.8-7.8GEV ECM  12/77*
M        1807.      20.               BRANDELIK 78 DASP E+E- 3.1-5.2GEV ECM  3/78*
M    B  BURMESTER 77 MASS VALUE ARE FROM EVENTS CONTAINING MU+- PLUS ONE      12/77*
M    B  OTHER PRONG, ORIGINATING FROM E+ E- --> TAU+ TAU-. THE MASS          12/77*
M    B  VALUES COME FROM A FIT TO THE SHAPE AND ECM DEPENDENCE OF THE        12/77*
M    B  MU+- SPECTRA, ASSUMING THAT THE TAU SPIN IS 1/2 AND ITS ASSOC        12/77*
M    B  NEUTRINO HAS M=0.                                                    12/77*
M    P  PERL 77 VALUE COMES FROM E+ E- TO E+- MU-+ AND NO OTHER DETECTED     12/77*
M    P  PARTICLES. ASSUMES V-A COUPLING AND ZERO MASS FOR ASSOC NEUTRINO.    12/77*

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                              35  TAU PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      TAU+- INTO MU+- NEU(MU) NEU(TAU)                      105+   0+    0
P2      TAU+- INTO E+- NEU(E) NEU(TAU)                         .5+   0+    0
P3      TAU+- INTO E+- GAMMA(S)                                .5+   0
P4      TAU+- INTO MU+- GAMMA(S)                              105+   0
P5      TAU+- INTO E+- CHARGED PARTICLES
P6      TAU+- INTO MU+- CHARGED PARTICLES
P7      TAU+- INTO HADRON+- NEUTRALS                          139+   0
P8      TAU+- INTO 3 HADRONS+- NEUTRALS                       139+ 139+ 139+    0
P9      TAU+- INTO NEU(TAU) RHOO PI+-                           0+ 776+ 139
P10     TAU+- INTO K+- NEUTRALS                               493+   0
P19     TAU+- INTO UNMEASURED MODES (1. - MEAS.MODES)

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

   The matrix below is derived from the error matrix for the fitted partial decay mode
branching fractions, P_i, as follows: The diagonal elements are P_i ± δP_i, where
δP_i = √⟨δP_i δP_i⟩, while the off-diagonal elements are the normalized correlation coeffi-
cients ⟨δP_i δP_j⟩/(δP_i · δP_j). For the definitions of the individual P_i, see the listings
above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and
are thus constrained to add to 1.

          P 1        P 2        P 7        P 8        P19
 P 1 .1754+-.0173
 P 2   -.0102  .1793+-.0284
 P 7    0.        0.        .3302+-.0952
 P 8    0.        0.        0.        .3500+-.1100
 P19   -.1142    -.1891    -.6381    -.7373  *.035+-.1492


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                              35  TAU BRANCHING RATIOS

R1      TAU+- INTO (MU+- NEU(MU) NEU(TAU))/TOTAL              (P1)
R1      220     0.15      0.03            BURMEST1  77 PLUT ASSUMES V-A DECAY    12/77*
R1      220     0.19)    (0.04)           BURMEST1  77 PLUT ASSUMES V+A DECAY    12/77*
R1              0.175     0.040           PERL      77 SMAG     E+E- TO MU+- X-+   12/77*
R1              0.22      0.10     0.07   CAVALLISF 77 SPEC     E+E- TO MU+- X-+   1/78*
R1            . . . . . . . . .
R1  AVG         0.164     0.023   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT     0.163     0.025   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT         0.175     0.017  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      TAU+- INTO (L+- NEU(L) NEU(TAU))/TOTAL          SQRT(P1*P2)
R2       WHERE L MEANS E OR MU.  EQUALITY OF E AND MU MODES IS ASSUMED.
R2   P 105     0.17      0.06     0.03  PERL      76 SMAG                      3/77*
R2   B 144     0.186     0.030           PERL      77 SMAG                      12/77*
R2   B  21     0.224     0.055           BARBARO-G 77 SMAG                      11/77*
R2   B  13     0.182     0.031           BRANDELIK 78 DASP ASSUMES V-A DECAY    3/78*
R2   B  13    (0.206)   (0.036)          BRANDELIK 78 DASP ASSUMES V+A DECAY    3/78*
R2   B  WE HAVE COMBINED STATISTICAL AND SYSTEMATIC ERRORS QUADRATICALLY.       3/78*
R2   P  ASSUMES V-A COUPLING, TAU MASS=1.8 GEV, TAU NEUTRINO MASS=0.
R2   B  ASSUMES V-A COUPLING, TAU MASS=1.9 GEV, TAU NEUTRINO MASS=0.
R2            . . . . . . . . .
R2  AVG         0.186     0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT     0.186     0.020   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT         0.177     0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      TAU+- INTO E+- NEU(E) NEU(TAU)/MU+- NEU(MU) NEU(TAU)(P2)/(P1)
R3       PREDICTED TO BE 1 FOR SEQUENTIAL LEPTON, 2 FOR PARAELECTRON,
R3       AND 1/2 FOR PARAMUON.
R3      21      0.92      0.37            BURMEST2  77 PLUT ASSUMES V-A DECAY    12/77*
R3      21     (0.67)    (0.28)           BURMEST2  77 PLUT ASSUMES V+A DECAY    12/77*
R3      18      0.92      0.32            BRANDELIK 78 DASP E+E- 3.1-5.2GEV ECM  3/78*
R3            . . . . . . . . .
R3  AVG         0.92      0.24    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT     0.92      0.26    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT         1.02      0.19   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4      TAU+- INTO(E+- GAMMA(S) + MU+- GAMMA(S))/TOTAL   (P3+P4)
R4   B          0.12  OR LESS  CL=.90   BURMEST2  77 PLUT E+E- 4-5 GEV ECM     12/77*
R4   B  ASSUMES SAME MU,E MOM. SPEC. AS (MU E + NOTHING DETECTED).              12/77*

R5      TAU+- INTO(E+- CHARGED PRONG + MU+- CHARGED PRONG)/TOTAL (P5+P6)
R5   B          0.04  OR LESS  CL=.90   BURMEST2  77 PLUT E+E- 4-5 GEV ECM     12/77*
R5   B  ASSUMES SAME MU,E MOM. SPEC. AS (MU E + NOTHING DETECTED).              12/77*

R6      TAU+- INTO (HADRON+- NEUTRALS)/(TOTAL)              (P7)               11/77*
R6       19     0.45      0.19            BARBARO-G 77 SMAG                    11/77*
R6              0.29      0.11            BRANDELIK 78 DASP ASSUMES V-A DECAY  3/78*
R6             (0.21)    (0.10)           BRANDELIK 78 DASP ASSUMES V+A DECAY  3/78*
R6            . . . . . . . . .
R6  AVG         0.330     0.095   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  STUDENT     0.33      0.10    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6  FIT         0.330     0.095  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R7      TAU+- INTO (K+- NEUTRALS)/TOTAL                     (P10)
R7   B   SMALL                         BRANDELIK 77 DASP   3.6-5.2ECM E+E-     1/78*
R7   B  BRANDELIK 77 FINDS 0.07+-0.06 K+- PER EVT IN E+E- --> E+- PRONG-+.     1/78*

R8      TAU+- INTO (3 HADRONS+- NEUTRALS)/TOTAL             (P8)
R8              0.35      0.11            BRANDELIK 78 DASP ASSUMES V-A DECAY  3/78*
R8             (0.38)    (0.11)           BRANDELIK 78 DASP ASSUMES V+A DECAY  3/78*
R8            . . . . . . . . .
R8  FIT         0.35      0.11   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9      TAU+- INTO (NEU RHOO PI+-)*(E+- NEU NEU)            (P9)*(P2)
R9   A          0.0083    0.0033          ALEXANDER 78 PLUT E+E- 4-5 GEV ECM   3/78*
R9   A  THIS IS AVG. OF TH3IR TWO VALUESITBL 11 WITH 30PCT SYST. ERR. INCL.

R10     TAU+- INTO ALL UNMEASURED MODES / TOTAL              (P19)
R10      THIS IS JUST = 1.-(SUM OF ALL MEASURED MODES) FROM FIT
R10           . . . . . . . . .
R10 FIT        -0.03     0.15   FROM FIT

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                              REFERENCES FOR TAU(1800) HEAVY LEPTON

PERL      75 PRL 35 1489        +ABRAMS,BOYARSKI,BREIDENBACH +   (LBL+SLAC)
PERL      76 PL 63B 466         +FELDMAN,ABRAMS,ALAM,BOYARSKI +  (SLAC+LBL)
BARBARO- 77 PRL 39 1058         BARBARO-GALTIERI+        (LBL+NWES+SLAC+HAWA)
BRANDELI 77 PL 70B 125          BRANDELIK +        (AACH+DESY+HAMB+MPIM+TOKY)
BURMEST1 77 PL 68B 297          BURMESTER,CRIEGEE +    (DESY+HAMB+SIEG+WUPG)
BURMEST2 77 PL 68B 301          BURMESTER,CRIEGEE +    (DESY+HAMB+SIEG+WUPG)
CAVALLIS 77 LNC 20 337          CAVALLI-SFORZA,GOGGI +       (PAVI+PRIN+UMD)
PERL      77 PRL 70B 487        +FELDMAN,ABRAMS,ALAM,BOYARSKI+   (SLAC+LBL)
ALEXANDE 78 PL 73B 99           ALEXANDER,CRIEGEE+     (DESY+AACH+SIEG+WUPG)
BRANDELI 78 PL 73B 109          BRANDELIK +        (AACH+DESY+HAMB+MPIM+TOKY)P

                              REVIEWS

PERL2     77 HAMBURG SYMP.      ALSO ISSUED AS SLAC-PUB-2022, M.PERL (SLAC)
FLUGGE    77 MESON CONF.BOSTON ALSO ISSUED AS DESY 77-35, G.FLUGGE (DESY)

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                              8  CHARGED PION(140,JPG=0--) I=1

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                              8  CHARGED PION MASS (MEV)

M           139.37      0.20            CROWE     54 CNTR  -
M           139.68      0.15            BARKAS    56 EMUL +
M     S    (139.577)   (0.013)          SHAFER    67 CNTR  - MESONIC ATOMS     6/68
M     B    (139.549)   (0.008)          BACKENSTO 71 CNTR  - MESONIC ATOMS     10/71
M     S     139.566     0.013           SHAFER    72 CNTR  - MESONIC ATOMS     1/73
M     B     139.569     0.008           BACKENSTO 73 CNTR  - MESONIC ATOMS     1/73
M           139.571     0.010           BRANDAGDO 76 CNTR  - MESONIC ATOMS     1/78*
M           139.5686    0.0020          CARTER    76 CNTR  - MESONIC ATOMS     6/77*
M     M     139.5667    0.0024          MARUSHENK 76 CNTR  - MESONIC ATOMS     12/77*
M     D    (139.5652) (0.0019)          DAUM      78 SPEC +  PI+ --> MU+ NEU   2/78*
M     S  SHAFER 72 UPDATES SHAFER67 WITH NEW ALPHA AND NEW CALIB. LINE ENER.   1/73
M     B  BACKENSTOSS 73 CORRECTS BACKENSTOSS 71 WITH NEW VACUUM POL. CALC.     1/73
M     M  THIS MARUSHENKG 76 VALUE USED AT AUTHORS REQUEST BECAUSE IT USES      3/78*
M     M  ACCEPTED SET OF CALIBRATION GAMMA ENERGIES.  ERROR INCREASED FROM     3/78*
M     M  .0017 TO INCLUDE QED CALC. ERROR OF .0017 (12 PPM).                   3/78*
M     D  DAUM 78 VALUE DEPENDS ON ASSUMED MU+ MASS M(MU)=105.65948+-.00035 .   2/78*
M     D  ENTERS OUR FIT VIA PI-MU MASS DIFF. BELOW WHICH IS INDEP. OF M(MU).   2/78*
M           . . . . . . . . .
M   AVG     139.5679    0.0015  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT 139.5679    0.0016  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT     139.5669    0.0012 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   2/78*

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                              8  (PI+) - (MU+) MASS DIFFERENCE (MEV)

D           34.00       0.076           BARKAS    56 EMUL
D           33.89       0.076           BARKAS    56 EMUL
D      145  33.881      0.035           HYMAN     67 HEBC  + K-HE              2/71
D           33.925      0.025           BOOTH     70 CNTR  + MAGNETIC SPECT.   2/71
D           33.9057     0.0019          DAUM      78 SPEC +  SEE NOTE D ABOVE   2/78*
D         . . . . . . . . .
D   AVG     33.9058     0.0019  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D   STUDENT 33.9058     0.0020  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D   FIT     33.9074     0.0012 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)   2/78*

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                              8  ((PI+) - (PI-))/AVG., MASS DIFFERENCE (PERCENT)

DM          0.02        0.05            AYRES     71 CNTR                      3/71

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                              8  CHARGED PION MEAN LIFE (UNITS 10**-9)

T           25.6        0.5     0.5     CROWE     57 RVUE
T           25.6        0.8     0.8     ANDERSON  60 CNTR
T      8000 25.46       0.32    0.32    ASHKIN    60 CNTR +
T           26.02       0.04            ECKHAUSE  65 CNTR +                    9/66
T           25.6        0.3             BARDON    66 CNTR                      6/66
T           25.9        0.3             DUNAITSEV 66 CNTR                      6/68
T     N    (26.40)     (0.08)           KINSEY    66 CNTR +                    6/66
T     N  SYSTEMATIC ERRORS IN CALIBR.IN THIS EXP.DISCUSSED BY NORDBERG 67       8/67
T           26.67       0.24            LOBKOWICZ 66 CNTR                      9/66
T           26.04       0.05            NORDBERG  67 CNTR +                    8/67
T           26.02       0.04            AYRES     71 CNTR +-                   3/71
T           26.09       0.08            DUNAITSEV 73 CNTR +                    3/74
T         . . . . . . . . .
T   AVG     26.030      0.023   0.023  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT 26.028      0.025   0.025  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT

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                              8  ((PI+) - (PI-))/AVG., MEAN LIFE DIFF. (PERCENT)

DT  N   THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT          0.23        0.40            LOBKOWICZ 66 CNTR     SEE NOTE L     9/66
DT  L   ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS                 9/66
DT          0.4         0.7             BARDON    66 CNTR                      7/66
DT         -0.14        0.29            PETRUKHIN 68 CNTR                      8/68
DT          0.055       0.071           AYRES     71 CNTR                      3/71
DT        . . . . . . . . .
DT  AVG     0.053       0.068   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DT  STUDENT 0.053       0.073   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                              8  CHARGED PION PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      CHAR. PION INTO MU (MU-NEU)                           105+   0
P2      CHAR. PION INTO E ( E-NEU)                             .5+   0
P3      CHAR. PION INTO MU (MU-NEU) GAMMA                     105+   0+    0
P4      CHAR. PION INTO PIO E (E-NEU)                         134+  .5+    0
P5      CHAR. PION INTO E NEU GAMMA                            .5+   0+    0
P6      CHAR. PION INTO E NEU E+ E-                            .5+   0+  .5+  .5

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Stable Particles

$\pi^{\pm}$, π^{0}

Data Card Listings

For notation, see key at front of Listings.

8 CHARGED PION BRANCHING RATIOS

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R1     CHAR. PION INTO MU NEU GAMMA (UNITS 10**-4)        (P3)/(P1)
R1      26    1.24     0.25          CASTAGNOL 58 EMUL    E(MU).LT.3.38 MV

R2     CHAR. PION INTO E NEU (UNITS 10**-4)               (P2)/(P1)
R2           1.21     0.07          ANDERSON  60 CNTR
R2  D       (1.247)  (0.028)        DI CAPUA  64 CNTR                        11/75
R2 D         1.274    0.024         BRYMAN    75 RVUE                        9/75
R2 D    BRYMAN 75 IS A RECALC. OF DICAPUA 64 EXPT USING LATEST PI LIFETIME.  9/75
R2                * * * * * * * * *
R2  AVG      1.267    0.023   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT  1.268    0.025   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R3     CHAR. PION INTO PIO E NEU (UNITS 10**-8)           (P4)/(P1)
R3  D   52   (1.15)   (.22)          DEPOMMI1  63 CNTR +                     2/72
R3    D 36    0.97     0.20         BARTLETT  64 OSPK +
R3    D 38    1.07     0.21         BACASTOW  65 OSPK +
R3    D       1.10     0.26         BERTRAM   65 OSPK +                     6/66
R3    D 43    1.1      0.2          DUNAITSEV 65 CNTR +                     7/66
R3     332    1.00     0.08    0.10 DEPOMMIER 68 CNTR +                     3/68
R3                * * * * * * * * *
R3  AVG      1.023    0.069   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT  1.023    0.074   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
    D   DEPOMMIER 68 STATES THAT THE RESULT OF DEPOMMIER 63 IS AT LEAST      2/72
    D   10 PERCENT TOO LARGE BECAUSE OF A SYSTEMATIC ERROR IN THE PIO        2/72
    D   DETECTION EFFICIENCY.  THIS MAY BE TRUE OF ALL THE PREVIOUS          2/72
    D   MEASUREMENTS ACCORDING TO DEPOMMIER 68 AND V.SOERGEL, PRIVATE        2/72
    D   COMMUNICATION, 1972.

R4     CHAR. PION INTO E NEU GAMMA (UNITS 10**-8)         (P5)/(P1)
R4  E 143    2.15     0.5           DEPOMMI2  63 CNTR + GAM KE 50-90 MEV  12/77*
R4  E   DEPOMMIER 63 VALUE IS CORRECTED FOR THE LATEST VALUE OF THE PIO     12/77*
R4  E   LIFETIME (0.828+-0.057 E-16). SEE FOOTNOTE 10 OF DEPOMMIER 77.      12/77*

R5     CHAR. PION INTO E NEU E+ E- (UNITS 10**-8)         (P6)/(P1)
R5           3.4   OR LESS  CL=.90   KORENCHEN 71 OSPK +                    10/71
R5           0.48  OR LESS  CL=.90   KORENCHEN 76 SPEC +                    1/78*
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REFERENCES FOR CHARGED PION

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CROWE     54 PR  96  470      K M CROWE,R H PHILLIPS                  (LRL)
BARKAS    56 PR 101  778      W H BARKAS,W BIRNBAUM,F M SMITH         (LRL)
CROWE     57 NC   5  541      K M CROWE                        (STANFORD HEPL)
CASTAGNO  58 PR 112 1779      C CASTAGNOLI,M MUCHNIK                 (ROMA)

ANDERSON  60 PR 119 2050      H L ANDERSON,T FUJII,R H MILLER +       (EFI)
ASHKIN    60 NC  16  490      ASHKIN,FAZZINI,FIDECARO,LIPMAN +       (CERN)
DEPOMMI1  63 PL  5  61        DEPOMMIER,HEINTZE,RUBBIA,SOERGEL       (CERN)
DEPOMMI2  63 PL  7  285       P DEPOMMIER,HEINTZE,RUBBIA,SOERGEL     (CERN)
    ALSO  77 PRL 39 1113      DEPOMMIER,MARTIN+(MONT+BRCO+TRIU+VICT+MELB)
BARTLETT  64 PR 136B 1452     BARTLETT,DEVONS,MEYER,ROSEN            (COLUMBIA)
DI CAPUA  64 PR 1338 1333     DI CAPUA,GARLAND,PONDROM,STRELZOFF      (COLU)

BACASTOW  65 PR 139 B407      +GHESQUIERE,WIEGAND,LARSEN              (LRL+SLAC)
BERTRAM   65 PR 139 B 617     BERTRAM,MEYER,CARRIGAN+          (MICH+CARNEGIE)
DUNAITSE  65 JETP 20 58       DUNAITSEV,PETRUKHIN,PROKOSHKIN +        (DUBNA)
ECKHAUSE  65 PL 19 348        ECKHAUSE,HARRIS,SHULER+  (WILLIAM AND MARY)

BARDON    66 PRL 16 775       BARDON,DORE,DORFAN,KRIEGER +           (COLUMBIA)
DUNAITSE  66 PL 23 283        +KUTYIN,PROKOSHKIN,RASUVAEV,SIMONOV     (DUBNA)
KINSEY    66 PR 144   1132    KINSEY,LOBKOWICZ,NORDBERG  (ROCHESTER UNIV)
LOBKOWIC  66 PRL  17  548     LOBKOWICZ,MELISSINOS,NAGASHIMA+  (ROCH+BNL)

HYMAN     67 PL 25B 376       +LOKEN,PEWITT,DERRICK +        (ANL+CARN+NWES)
NORDBERG  67 PL 24B  594      NORDBERG,LOBKOWICZ,BURMAN  (ROCHESTER UNIV)
SHAFER    67 PR 163 1451      ROBERT E. SHAFER                        (LRL)
    ALSO  65 PRL 14 923       SHAFER,CROWE,JENKINS                    (LRL)

DEPOMMIE  68 NP B4 189        DEPOMMIER,DUCLOS,HEINTZE,KLEINKNECHT+(CERN)
PETRUKHI  68 JINR-P1-3862     PETRUKHIN,RYKALIN,KHAZINS,CISEK         (DUBNA)
BOOTH     70 PL 32B 723       +JOHNSON,WILLIAMS,WORMALD               (LIVP)
AYRES     71 PR 3D 1051       +CORMACK,GREENBERG,KENNEY +       (LRL,UCSB)
    ALSO  67 PR  157  1288    AYRES,CALDWELL,GREENBERG,KENNEY,KURZ+   (LRL)
    ALSO  68 PRL 21 261       AYRES,CORMACK,GREENBERG,KENNEY+    (LRL,UCSB)
    ALSO  69 UCRL-18369       DAVID S AYRES (THESIS)                  (LRL)
    ALSO  69 PRL 23 1267      GREENBERG,AYRES,CORMACK,KENNEY+    (LRL,UCSB)

BACKENST  71 PL 36B 403       BACKENSTOSS,DANIEL,KOCH+     (CERN,KARL,HEID)
    ALSO  70 THESIS           C. VON DER MALSBURG                (HEIDELBERG)
KORENCHE  71 SJNP 13 189      KORENCHENKO,KOSTIN,MICELMACHER+          (JINR)
SHAFER    72 PRIVATE COMM.    R. SHAFER, 1972                         (FNAL)
BACKENST  73 PL 43B 539       BACKENSTOSS,DANIEL,KOCH+ (CERN+KARL+MUNICH)
    ALSO  73 SUBMITTED TO NP  L. TAUSCHER
DUNAITSE  73 SJNP 16 292      DUNAITSEV,PROKOSHKIN,RAZUVAEV+          (SERP)

BRYMAN    75 PR D11 1337      +PICCIOTTO                  (UNIV OF VICTORIA)
BRANDAOD  76 ZNAT 31A 1150    BRANDAO D'OLIVERA,DANIEL,VON EGIDY+      (MUNC)
CARTER    76 PRL 37 1380      +DIXIT,SUNDARESAN+       (CARL+CNRC+CHIC+CIT)
KORENCHE  76 JETP 44 35       KORENCHENKO,KOSTIN,MITSELMAKHER+         (JINR)
MARUSHEN  76 JETPL 23 72      MARUSHENKO,MEZENTSEV,PETRUNIN+           (LENI)
    ALSO  76  PRIVATE COMM.   R. SHAFER                               (FNAL)
    ALSO  78  PRIVATE COMM.   A. I. SMIRNOV                           (LENI)
DAUM      78 PL - TO BE PUBL. +EATON,FROSCH,HIRSCHMANN,MC CULLOCH+    (VILL)

                              PAPERS NOT REFERRED TO IN DATA CARDS

MERRISON  62 ADVP 11 1        A W MERRISON                          (LIVERPOOL)
SHAPIRO   62 PR 125 1022      G SHAPIRO,L M LEDERMAN                 (COLUMBIA)
CZIRR     63 PR 130  341      JOHN B CZIRR                            (LRL)
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9 NEUTRAL PION(135,JPG=0--) I=1

9 (PI+-) - (PIO) MASS DIFFERENCE (MEV)

```
D            (5.37)   (1.0)          PANOFSKY  51 CNTR  -
D             4.50    0.31           CHINOWSKY 54 CNTR  -
D             4.62    0.05           HADDOCK   59 CNTR  -
D             4.60    0.04           HILLMAN   59 CNTR
D             4.55    0.07           CASSELS   59 CNTR
D             4.69    0.07           SAMIOS    60 HBC                       2/72
D             4.6056  0.0055         CZIRR     63 CNTR
D             4.59    0.03           PETRUKHIN 63 CNTR  -
D             4.6034  0.0052         VASILEVSK 66 CNTR  -                  9/66
D                * * * * * * * * *
D  AVG        4.6043  0.0037  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D  STUDENT    4.6043  0.0040  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
```

9 NEUTRAL PION MEAN LIFE (UNITS 10**-16)

```
T   N   76   (1.9)    (0.5)   (0.5)  GLASSER   61 EMUL                    .
T   N   45   (2.3)    (1.1)   (1.0)  TIETGE    62 EMUL
T   N   88   (2.8)    (0.9)   (0.9)  KOLLER    63 EMUL    SEE STAMER 66
T                1.05     0.18    0.18  VON DARDE 63 CNTR
T   N   75   (1.7)    (0.5)          SHWE      64 EMUL
T                0.730    0.105        BELLETTIN 65 CNTR                    6/66
T   N   67   (1.6)    (0.6)   (0.5)  EVANS     65 EMUL                    6/66
T   K  232    1.0      0.5            STAMER    66 EMUL                    8/67
T                0.56     0.06         BELLETTIN 70 CNTR  PRIM.EFF. ON NUC  7/70
T                0.9      0.068        KRYSHKIN  70 CNTR  PRIMAKOFF EFFECT 12/70
T   B            0.82     0.04         BROWMAN   74 CNTR  PRIMAKOFF EFFECT  7/75
T   N   OLD EMULSION MEASUREMENTS NOT USED BECAUSE OF POSSIBLE SYSTEMATIC
T   N   SHIFT TO LARGER MEAN LIFE VALUES.
T   K   INCLUDES EVENTS OF KOLLER 63.                                       8/67
T   B   BROWMAN GIVES PIO WIDTH=8.02+-.42EV.  MEAN LIFE IS HBAR/WIDTH.     11/75
T                * * * * * * * * *
T  AVG        0.828    0.057    0.053  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.8)
T  STUDENT    0.835    0.038    0.035  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
                                       (SEE IDEOGRAM BELOW )
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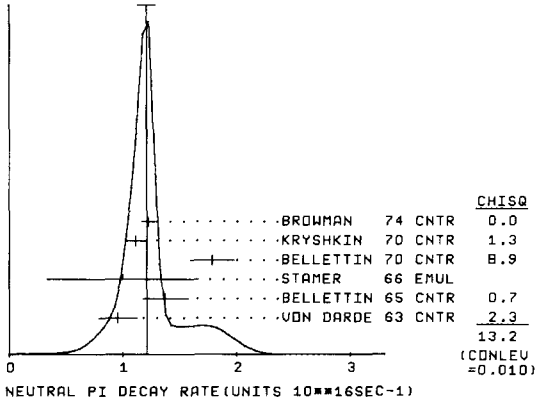

9 NEUTRAL PION PARTIAL DECAY MODES

```
                                                        DECAY MASSES
P1     PIO INTO 2GAMMA                                  0+   0
P2     PIO INTO E+ E- GAMMA                             .5+  .5+   0
P3     PIO INTO 4ELECTRONS                              .5+  .5+  .5+  .5
P4     PIO INTO 3 GAMMA                                 0+   0+   0
P5     PIO INTO 4 GAMMA                                 0+   0+   0+   0
P6     PIO INTO E+ E-                                   .5+  .5
```

9 NEUTRAL PION BRANCHING RATIOS

```
R1     PIO INTO (GAMMA E+ E-)/(2GAMMA) (PERCENT)          (P2)/(P1)
R1          (1.196)  THEORET. CALC.  JOSEPH    60          QUANTUM ELECT.   9/66
R1     27    1.17     0.15          BUDAGOV   60 HBC
R1  3071    1.166    0.047         SAMIOS    61 HBC      PI-P TO PIO N
R1  S   SAMIOS VALUE USES PANOFSKY RATIO = 1.62
R1                * * * * * * * * *
R1  AVG      1.166    0.045   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT  1.166    0.048   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2     PIO INTO (3 GAMMA)/(2 GAMMA) (UNITS 10**-6)        (P4)/(P1)
R2      0    5.0    OR LESS  CL=.90   DUCLOS    65 CNTR                    6/66
R2           5.0    OR LESS  CL=.90   KUTIN     65 CNTR                    3/68

R3     PIO INTO (E+E+E-E-)/(2 GAMMA) (UNITS 10**-5)       (P3)/(P1)
R3     146    3.18     0.30          SAMIOS    62 HBC      SEE NOTE N BELOW  6/66
R3            3.28     THEORET. CALC.  MIYAZAKI  73          QUANTUM ELECT.   2/76
R3  N   ABOVE VALUE USES PANOFSKY RATIO = 1.62

R4     PIO INTO (4 GAMMA)/(2 GAMMA)   (UNITS 10**-5)      (P5)/(P1)          8/73
R4      0    6.1    OR LESS  CL=.90   ABRAMS    73 ASPK                    8/73

R5     PIO INTO (E+ E-)/TOTAL  (UNITS 10**-6)            (P6)/(P1)          12/75
R5  D        2.0    OR LESS  CL=.90   DAVIES    74 RVUE                    12/75
R5  D   DAVIES 74 EXTRACTS THIS INFORMATION FROM BLOCH 75 K+ EXPERIMENT.    12/75
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REFERENCES FOR NEUTRAL PION

```
PANOFSKY  51 PR   81  565      W K H PANOFSKY,R L AAMODT,J HADLEY      (LRL)
CHINOWSK  54 PR   93  586      W CHINOWSKY,J STEINBERGER             (COLUMBIA)
CASSELS   59 PPS  74   92      CASSELS,JONES,MURPHY,O.NEILL        (LIVERPOOL)
HADDOCK   59 PRL   3  478      HADDOCK,ABASHIAN,CROWE,CZIRR            (LRL)
HILLMAN   59 NC   14  887      HILLMAN,MIDDELKOOP,YAMAGATA,ZAVATTINI(CERN)

BUDAGOV   60 JETP 11  755      BUDAGOV,VIKTOR,DZHELEPOV,ERMOLOV +      (JINR)
JOSEPH    60 NC 16 997         D W JOSEPH                              (EFI)
SAMIOS    60 NC 18 154         N P SAMIOS                           (COLUMBIA)
GLASSER   61 PR  123 1014      R G GLASSER,N SEEMAN,B STILLER           (NRL)
SAMIOS    61 PR  121  275      N P SAMIOS                    (COLUMBIA+BNL)
SAMIOS    62 PR 126 1844       SAMIOS,PLANO,PRODELL +       (COLUMBIA+BNL)
TIETGE    62 PR  127 1324      J TIETGE,W PUESCHEL          (MAX PLANCK INST)

CZIRR     63 PR  130  341      JOHN B CZIRR                            (LRL)
KOLLER    63 NC   27 1405     E L KOLLER,S TAYLOR,T HUETTER          (STEVENS)
    ALSO  66 STAMER
PETRUKHI  63 SIENA CONF 208    V I PETRUKHIN,YU D PROKOSHKIN           (JINR)
VON DARD  63 PL    4   51      VON DARDEL,DEKKERS,MERMOD,VAN PUTTEN+(CERN)

SHWE      64 PR  136B 1839     H SHWE,F M SMITH,W H BARKAS              (LRL)
BELLETTI  65 NC  40 A 1139     BELLETTINI,BEMPORAD,BRACCINI+(PISA+FIRENZE)
DUCLOS    65 PL  19  253       DUCLOS,FREYTAG,HEINTZE +  (CERN+HEIDELBERG)
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Data Card Listings

For notation, see key at front of Listings.


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EVANS     65 PR 139 B 982       D A EVANS                              (OXFORD)
KUTIN     65 JETP LETT 2 243    KUTIN,PETRUKHIN,PROKOSHKIN              (JINR)

STAMER    66 PR 151  1108       STAMER,TAYLOR,KOLLER,HUETTER+        (STEVENS)
VASILEVS  66 PL  23  281        VASILEVSKY,VISHNYAKOV,DUNAITSEV +      (DUBNA)
BELLETTI  70 NC 66A 243         BELLETTINI,BEMPORAD,LUBELSMEY+      (PISA+BONN)
KRYSHKIN  70 JETP 30 1037       +STERLIGOV,USOV          (TOMSK POLYTECH.INST.)

ABRAMS    73 PL 45B 66          +CARROLL,KYCIA,LI,MICHAEL,MOCKETT +      (BNL)
MIYAZAKI  73 PR D8 2051         T.MIYAZAKI,E.TAKASUGI                    (TOKY)
BROWMAN   74 PRL 33 1400        +DEWIRE,GITTELMAN,HANSON+             (CORN+BING)
DAVIES    74 NC 24A 324         +GUY,ZIA                    (BIRM+RHEL+SHMP)

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14 ETA(549,JPG=0-+) I=0

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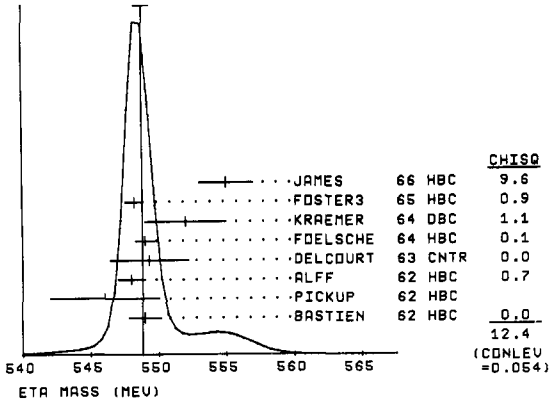
FOR C. BALTAY'S REVIEW OF THE ETA MESON, SEE PROC. UNIV. OF PENN. CONF. ON MESON SPECTROSCOPY (W.A.BENJAMIN, N.Y., 1968)

14 ETA MASS (MEV)

```
M        53  549.0      1.2          BASTIEN    62 HBC
M        35  546.0      4.0          PICKUP     62 HBC
M        91  548.0      1.0          ALFF       62 HBC
M            549.3      2.9          DELCOURT   63 CNTR
M       148  549.0      0.7          FOELSCHE   64 HBC
M       325  552.0      3.0          KRAEMER    64 DBC
M            548.2      0.65         FOSTER3    65 HBC                  7/66
M       250  555.0      2.0          JAMES      66 HBC                  6/66
M            . . . . . . . .
M   AVG      548.82     0.56    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M   STUDENT  548.72     0.44    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 548.82 ± 0.56
ERROR SCALED BY 1.4



14 ETA WIDTH

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W       ETA WIDTH DETERMINED FROM MASS SPECTRUM (UNITS MEV)
W        91  (10.0)  OR LESS          ALFF       62 HBC
W       148  (10.0)  OR LESS          FOELSCHE   64 HBC
W        31  (12.0)  OR LESS          JAMES      66 HBC                  6/66
W            (4.0)  OR LESS          BALTAY     66 DBC                  7/66
W            (.9)   OR LESS  CL=.95   JONES      66 CNTR                 8/67

W       ETA WIDTH DETERMINED FROM DECAY RATE (UNITS KEV)
W       THIS IS THE PARTIAL DECAY RATE (W1) FOR THE MODE (ETA INTO 2GAMMA)
W       DIVIDED BY THE FITTED BRANCHING FRACTION (P1) FOR THAT MODE.
W            . . . . . . . .
W   FIT      0.85      0.12   FROM FIT
```

14 ETA PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1      ETA INTO 2GAMMA                                   0+   0
P2      ETA INTO 3PIO                                     134+ 134+ 134
P3      ETA INTO PI+ PI- PIO                              139+ 139+ 134
P4      ETA INTO PI+ PI- GAMMA                            139+ 139+   0
P5      ETA INTO E+ E- PIO (VIOLATES C IN E.M.I.)         134+  .5+  .5
P6      ETA INTO E+ E- PI+ PI-                            139+ 139+  .5+  .5
P7      ETA INTO PIO 2GAMMA                               134+   0+   0
P8      ETA INTO E+ E- GAMMA                               .5+  .5+   0
P9      ETA INTO 2PIO GAMMA (VIOLATES C)                  134+ 134+   0
P10     ETA INTO PI+ PI- PIO GAMMA                        139+ 139+ 134+   0
P11     ETA INTO PI+ PI- 2GAMMA                           139+ 139+   0+   0
P12     ETA INTO MU+ MU-                                  105+ 105
P13     ETA INTO MU+ MU- GAMMA                            105+ 105+   0
P14     ETA INTO MU+ MU- PIO                              105+ 105+ 134
P15     ETA INTO PI+ PI-                                  139+ 139
P16     ETA INTO E+ E-                                     .5+  .5
```

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_j \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
          P 1        P 2        P 3        P 4        P 7        P 8
P 1  .3799+-.0098
P 2   -.2691   .2990+-.0106
P 3   -.3224    -.2353   .2358+-.0056
P 4   -.2866    -.2095    .8201   .0489+-.0013
P 7   -.4271    -.5781    -.0939    -.0801   .0314+-.0109
P 8   -.0434    -.0326    -.0494    -.0501    -.0036   .0050+-.0012
```

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

```
          G 1        G 2        G 3        G 4        G 7        G 8
G 1  .3240+-.0460
G 2    .9386   .2550+-.0385
G 3    .9689     .9513   .2011+-.0294
G 4    .9646     .9471   1.0097   .0417+-.0061
G 7    .3661     .3028    .4240     .4226   .0268+-.0104
G 8    .5178     .5082    .5233     .5199     .2318   .0043+-.0012
```

Note on Conflicting Results for $\eta \to \gamma\gamma$ Decay Rate

The BROWMAN 74 result for $\Gamma_{\gamma\gamma}$ is three standard deviations below the earlier BEMPORAD 67 result. This is because the BEMPORAD 67 analysis finds a negligible strong-production amplitude and attributes all of their observed η photoproduction cross section to Coulomb production. BROWMAN 74, on the other hand, find that the strong-production contribution to the cross section is significant, especially at lower energies, and that the Coulomb contribution is smaller, resulting in a smaller value of $\Gamma_{\gamma\gamma}$.

The η photoproduction data of BROWMAN 74 were taken at incident γ-ray energies of 5.8, 9.0, and 11.45 GeV on beryllium, aluminum, copper, silver, and uranium targets, while the BEMPORAD 67 data were taken at 4.0 and 5.5 GeV on lead, silver, and zinc. The higher energies, higher statistics, better angular resolution, and larger range of atomic weights of the BROWMAN 74 experiment result in a more reliable separation of the Coulomb amplitude from the strong-production amplitude. In addition, the bad approximation mentioned in BROWMAN 74 footnote 4 was present in the theoretical work utilized by BEMPORAD 67 and this may account for some of the discrepancy.

Browman et al. state that the BROWMAN 74 result is compatible with the BEMPORAD 67 data, although the agreement is not as good as that given by the

Stable Particles

η

Data Card Listings

For notation, see key at front of Listings.

BEMPORAD 67 fit to these data. On the other hand, the BEMPORAD 67 result appears to be incompatible with the 9 GeV data (especially uranium) shown in Fig. 2 of BROWMAN 74.

We quote the BROWMAN 74 result.

```
                    14  ETA DECAY RATES

W1      ETA INTO 2GAMMA (UNITS KEV)                                  (G1)
W1  B        (1.00)    (0.22)          BEMPORAD   67 CNTR     PRIMAKOFF EFFECT 11/75
W1           0.324     0.046           BROWMAN    74 CNTR     PRIMAKOFF EFFECT  7/74
W1  B   BEMPORAD 67 GIVES W1=1.21+-.26 KEV ASSUMING THAT W1/TOTAL=0.314.      11/75
W1  B   BEMPCRAD PRIVATE COMMUNICATION GIVES MORE GENERAL RESULT AS           11/75
W1  B   W1*W1/TOTAL=.380+-.083.  WE EVALUATE THIS USING W1/TOTAL=.38+-.01.   11/75
W1  B   NOT INCLUDED IN AVERAGE BECAUSE THE UNCERTIANTY RESULTING FROM THE     2/76
W1  B   SEPARATION OF THE COULOMB AND NUCLEAR AMPLITUDES HAS APPARENTLY        2/76
W1  B   BEEN UNDERESTIMATED.  SEE NOTE ON DISCREPANCY ABOVE.                  2/76
W1          . . . . . .
W1  FIT      0.324     0.046  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

------ -------- --------- --------- --------- --------- --------- --------- --------

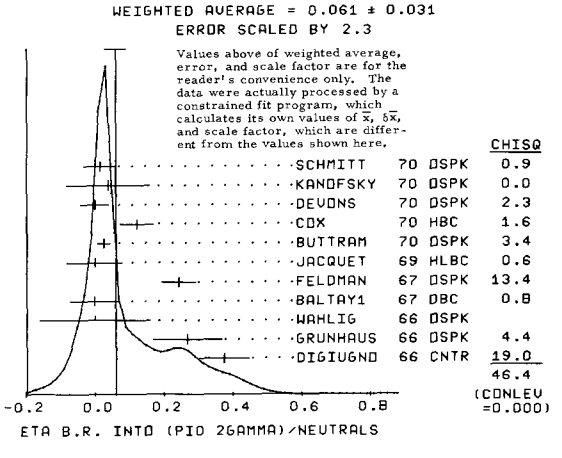
                    14  ETA BRANCHING RATIOS

R1      ETA INTO NEUTRALS/CHARGED                                (P1+P2+P7)/(P3+P4+P8)
R1  N   10   (2.5)    (1.0)          PICKUP     62 HBC
R1  N   53   (3.20)   (1.26)         BASTIEN    62 HBC
R1  N        (2.7)    (0.8)         SHAFER     62 HBC
R1           2.6       .9           BUSCHBECK  63 HBC                          7/66
R1  N  280   (4.5)    (1.0)          JAMES      66 HBC                          6/66
R1  N   THESE EXPERIMENTS HAVE NOT BEEN USED IN COMPUTING THE AVERAGES
R1  N   AS THEY WERE UNABLE TO SEPARATE CLEARLY PARTIAL MODES (3) AND (4)
R1  N   FROM EACH OTHER.  THE REPORTED VALUES THUS PROBABLY CONTAIN
R1  N   SOME (UNKNOWN) FRACTION OF MODE (4).
R1           2.64      0.23           BALTAY2    67 DBC                         11/67
R1          . . . . . .
R1  AVG      2.64      0.22    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT  2.64      0.24    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT      2.452     0.081  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2      ETA INTO 2GAMMA/CHARGED                                      (P1)/(P3+P4+P8)
R2           0.99      0.48           CRAWFORD   63 HBC
R2          . . . . . .
R2  FIT      1.311     0.053  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

Note on $\eta \to \pi^0\gamma\gamma$

The discrepancies between various measurements of branching ratios involving $\eta \to \pi^0\gamma\gamma$ are displayed in the ideogram below, in which all relevant experiments have been converted to a common ratio, $\pi^0\gamma\gamma$/neutrals. Our branching ratio fit does not include DIGIUGNO 66, FELDMAN 67, or the upper limit measurements. See page 43 of "Review of Particle Properties", Physics Letters 39B, No. 1 (1972) for more discussion.

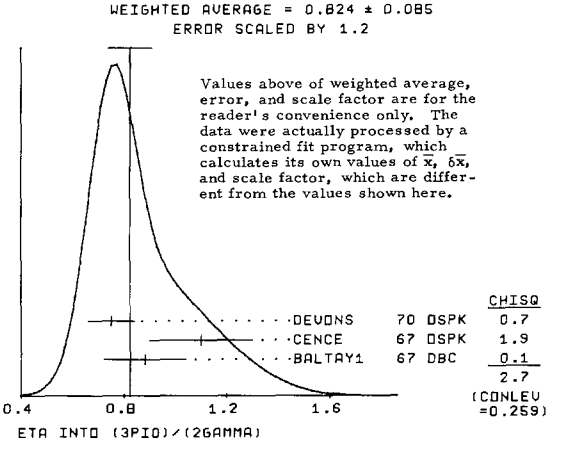



```
R3      ETA INTO (PIO 2GAMMA)/NEUTRALS                               (P7)/(P1+P2+P7)
R3  S        (0.375)  (0.072)          DIGIUGNO   66 CNTR     ERROR DOUBLED     6/66
R3      THE ERRORS OF DIGIUGNO+ 66 HAVE BEEN INCREASED BY A FACTOR
R3      OF TWO, TO TAKE INTO ACCOUNT POSSIBLE SYSTEMATIC ERRORS, AS
R3      SUGGESTED BY THE AUTHORS.
R3           .27       .10            GRUNHAUS   66 OSPK                        8/67
R3  R        (.028)    (.044)         BUNIATOV   67 OSPK                       11/67
R3  S        (.244)    (.05)          FELDMAN    67 OSPK                        8/67
R3  S   SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R3           .026      .019           BUTTRAM    70 OSPK                       12/70
R3           .122      .052     .044  COX        70 HBC                         6/70
R3           (.07) OR LESS  CL=.90     DEVONS     70 OSPK                       12/70
R3  R   16   .016      .047           SCHMITT    70 OSPK                       12/70
R3  R   SCHMITT 70 IS A REANALYSIS BUNIATOV 67
R3  E        (0.11)   (0.03)         STRUGALSK  71 HLBC                        5/71
R3  E   THIS MEASUREMENT HAS BEEN EXCLUDED BECAUSE THE ERROR APPEARS           2/71
R3  E   TO BE SERIOUSLY UNDERESTIMATED.                                       2/71
R3          . . . . . .
R3  AVG      0.042     0.023    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R3  STUDENT  0.039     0.019    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT      0.044     0.015   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R4      ETA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)                       (P4)/(P3)
R4           0.14      0.08           FOELSCHE   64 HBC
R4  M   24   (0.73)   (0.25)          PAULI      64 DBC
R4  M   THIS EXPERIMENT HAS NOT BEEN INCLUDED IN THE AVERAGES SINCE IT IS
R4  M   NOT CLEAR THAT THEIR CLASS B EVENTS ARE ACTUALLY FROM ETAS.
R4           0.30      0.06           CRAWFORD   66 HBC                         6/66
R4            .10       .10           KRAEMER    64 DBC                         7/66
R4            .196      .041          FOSTER3    65 HBC                         7/66
R4            .25       .035          LITCHFIEL  67 DBC                         8/67
R4           0.28      0.04           BALTAY2    67 DBC                        11/67
R4   7250    .201      .006           GORMLEY    70 ASPK                        6/70
R4    18K    0.209     0.004          THALER     73 ASPK                        6/73
R4          . . . . . .
R4  AVG      0.2074    0.0037   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R4  STUDENT  0.2074    0.0037   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4  FIT      0.2075    0.0033 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      ETA INTO (3PIO) + 2/3(PIO 2GAMMA)/ PI+PI-PIO      (P2+2/3P7)/P3
R5           0.83      0.32           CRAWFORD   63 HBC                         7/66
R5           2.0       1.0            FOELSCHE   64 HBC                         7/66
R5           0.90      0.24           FOSTER1    65 HBC                         7/66
R5          . . . . . .
R5  AVG      0.91      0.19    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  STUDENT  0.91      0.20    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5  FIT      1.357     0.057  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R6      ETA INTO 3PIO/2GAMMA                                         (P2)/(P1)
R6           (.90) OR MORE             CHRETIEN   62 PBC
R6           0.88      0.16           BALTAY1    67 DBC                        11/67
R6           1.1       0.2            CENCE      67 OSPK                        1/68
R6           0.75      0.09           DEVONS     70 OSPK                       12/70
R6          . . . . . .
R6  AVG      0.824     0.085    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R6  STUDENT  0.821     0.085    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6  FIT      0.787     0.039  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                              (SEE IDEOGRAM BELOW )
```




```
R7      ETA INTO 2GAMMA/(PI+ PI- PO)                                 (P1)/(P3)
R7           1.61      0.39           FOSTER1    65 HBC
R7   401     1.72       .25           BAGLIN     69 HLBC                        7/69
R7          . . . . . .
R7  AVG      1.69      0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7  STUDENT  1.69      0.23    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R7  FIT      1.611     0.065  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8      ETA INTO NEUTRAL/(PI+ PI- PIO)                               (P1+P2+P7)/(P3)
R8    50    3.6       0.8            KRAEMER    64 DBC
R8          3.8       1.1            PAULI      64 DBC                         7/66
R8          2.89      0.56           ALFF-STEI  66 HBC                         9/66
R8   244    3.6       0.6            FLATTE2    67 HBC                         1/68
R8    29    3.4       1.1            AGUILAR-B  72 HBC                        11/72
R8 B  70    2.83      0.80           BLOODWORT  72 HBC                        11/72
R8    74    2.54      1.89           KENDALL    74 OSPK                       12/75
R8 B   ERROR INCREASED FROM PUBLISHED VALUE 0.5 BY BLOODWORTH, PRIV. COMM.    1/73
R8          . . . . . .
R8  AVG      3.26      0.30    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  STUDENT  3.26      0.33    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R8  FIT      3.01      0.10   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R9      ETA INTO (E+E-PIO)/(PI+PI-PIO) (UNITS 10**-4)                (P5)/(P3)
R9         110.    OR LESS             PRICE      65 HBC
R9      0  77.     OR LESS             FOSTER2    65 HBC
R9         42.     OR LESS  CL=.90     BAGLIN1    67 HLBC                        8/67
R9      0  16.     OR LESS  CL=.90     BILLING    67 HLBC                       11/67
R9          1.9    OR LESS  CL=.90     JANE1      75 OSPK                       12/75
```

Data Card Listings

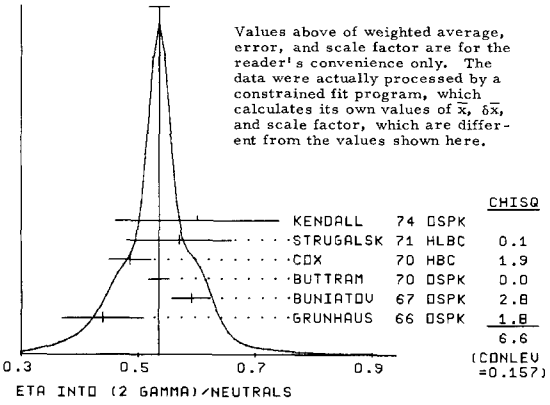
For notation, see key at front of Listings.


```
R10    ETA INTO (E+E-PI+PI-)/TOTAL (UNITS 10**-2)          (P6)
R10          (0.7)  OR LESS              RITTENBER 65 HBC                          6/66

R11    ETA INTO (E+E-PI+PI-)/(PI+PI-GAMMA)                 (P6)/(P4)
R11       1    0.026    0.026           GROSSMAN  66 HBC                          6/66

R12    ETA INTO 2 GAMMA/NEUTRALS                           (P1)/(P1+P2+P7)
R12 S        (0.416)  (0.044)           DIGIUGNO  66 CNTR    ERROR DOUBLED        6/66
R12             .44      .07           GRUNHAUS  66 OSPK                         8/67
R12 S        (.579)   (.052)           FELDMAN   67 OSPK                         8/67
R12 S   SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R12 T        (0.39)   (0.06)           JONES     66 CNTR                         8/67
R12 T   THIS RESULT FROM COMBINING CROSS SECTIONS FROM TWO DIFFERENT EXPTS.
R12             .59      .033          BUNIATOV  67 OSPK                        11/67
R12             .535     .018          BUTTRAM   70 OSPK                        12/70
R12             .486     .036          COX       70 HBC                         6/70
R12            0.57     0.09           STRUGALSK 71 HLBC                        5/71
R12     113    0.60     0.14           KENDALL   74 OSPK                        12/75
R12       . . . . . .
R12 AVG        0.535    0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R12 STUDENT    0.535    0.016   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R12 FIT        0.535    0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                               (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.535 ± 0.018
ERROR SCALED BY 1.3



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

```
R13    ETA INTO 3PIO/NEUTRALS                              (P2)/(P1+P2+P7)
R13 S        (0.209)  (0.054)           DIGIUGNO  66 CNTR    ERROR DOUBLED        6/66
R13 R           (.29)    (.10)          GRUNHAUS  66 OSPK                         8/67
R13 S        (.177)   (.035)           FELDMAN   67 OSPK                         8/67
R13 S   SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R13             .41      .033          BUNIATOV  67 OSPK                        11/67
R13 R   REDUNDANT INFORMATION FROM THIS EXPERIMENT.
R13 R        (.439)   (.024)           BUTTRAM   70 OSPK                        12/70
R13             .392     .042          COX       70 HBC                         6/70
R13            0.32     0.09           STRUGALSK 71 HLBC                        5/71
R13      75    0.40     0.14           KENDALL   74 OSPK                        12/75
R13       . . . . . .
R13 AVG        0.397    0.025   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R13 STUDENT    0.397    0.027   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R13 FIT        0.421    0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R14    ETA INTO PIO (2 GAMMA)/2GAMMA                       (P7)/(P1)
R14          (.5)  OR LESS  CL=.90     WAHLIG    66 SPRK                         7/66
R14            0.0      0.14          BALTAY1   67 DBC                         11/67
R14 P       (0.05)   (0.04)           BONAMY    67 SPRK  PRELIMINARY RESULT    11/67
R14       . . . . . .
R14 FIT        0.083    0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R15    ETA INTO (E+E-PIO)/TOTAL (UNITS 10**-2)             (P5)
R15            0.7   OR LESS           RITTENBER 65 HBC                          6/66
R15            0.084 OR LESS  CL=.90     BAZIN     68 DBC                         6/68
R15       0    0.016 OR LESS  CL=.90     MARTYNOV  76 HLBC                        6/77*

R16    ETA INTO 2GAMMA/(3PIO + PIO 2GAMMA)                 (P1)/(P2+P7)
R16            0.80     .25            BACCI     63 CNTR                        7/66
R16       . . . . . .
R16 FIT        1.150    0.060  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R17    ETA INTO (PI+PI-PIO GAMMA)/(PI+PI-PIO) (UNITS 10**-2)
R17                                                       (P10)/(P3)
R17            7.0   OR LESS           FLATTE    67 HBC                         8/67
R17            0.9   OR LESS           PRICE     67 HBC                         8/67
R17            1.6   OR LESS  CL=.95    BALTAY2   67 DBC                        11/67
R17            1.7   OR LESS  CL=.90    ARNOLD    68 HLBC                        9/68
R17   T    0   0.24  OR LESS  CL=.90    THALER    73 ASPK                        6/73
R17   T    0   0.0      0.15           LIMIT ABOVE RESTATED FOR AVERAGING        6/73

R18    ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PIO)                (P11)/(P3)
R18            .009 OR LESS              PRICE     67 HBC                         8/67
R18            .016 OR LESS  CL=.95      BALTAY2   67 DBC                        11/67

R19    ETA INTO 3PIO/(PI+ PI- PIO)                         (P2)/(P3)
R19            1.3      .4             BAGLIN2   67 HLBC                        8/67
R19            1.47     0.20     0.17  BULLOCK   68 HLBC                        9/68
R19     199    1.50     .15      .29   BAGLIN    69 HLBC                        7/69
R19       . . . . . .
R19 AVG        1.46     0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 STUDENT    1.46     0.14    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT        1.268    0.060  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R20    ETA INTO 2GAMMA/((3PIO)+2/3(PIO 2GAMMA))            (P1)/(P2+2/3P7)
R20            1.10     0.5            MULLER    63 DBC                         7/66
R20       . . . . . .
R20 FIT        1.187    0.058  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R21    ETA INTO NEUTRALS/TOTAL                             (P1+P2+P7)
R21            .79      .08            BUNIATOV  67 OSPK                        11/67
R21     16K    .705     .008           BASILE    71 CNTR MM SPECTROMETER        8/71
R21       . . . . . .
R21 AVG        0.7058   0.0080  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R21 STUDENT    0.7058   0.0086  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R21 FIT        0.7103   0.0068 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R22    ETA INTO (PIO 2GAMMA)/TOTAL                         (P7)
R22            .12  OR LESS  CL=.95    JACQUET   69 HLBC                         6/70
R22       . . . . . .
R22 FIT        0.031    0.011  FROM FIT

R23    ETA INTO MU+MU-/TOTAL (UNITS 10**-5)                (P12)
R23            0    2.    OR LESS  CL=.95   WEHMANN   68 OSPK                     4/68

R24    ETA INTO MU+MU-PIO/TOTAL (UNITS 10**-4)             (P14)
R24            5.    OR LESS             WEHMANN   68 OSPK                       4/68

R25    ETA INTO MU+MU-/2GAMMA (UNITS 10**-5)               (P12)/(P1)
R25            5.9      2.2            HYAMS     69 OSPK                        7/69

R26    ETA INTO (PIO 2GAMMA)/(3PIO + PIO 2GAMMA)           (P7)/(P2+P7)
R26 N          0.1      0.3            KANOFSKY  70 OSPK                        2/71
R26 N   WE HAVE CHANGED THE ERROR ON THIS EXPERIMENT FROM +0.3,-0.1              2/71
R26 N   TO THE ABOVE +0.3,-0.3 SINCE IT IS CLEAR FROM FIGURE 7 IN THE           2/71
R26 N   ARTICLE THAT A CENTRAL VALUE OF 0.0 IS ABOUT AS PROBABLE AS THE         2/71
R26 N   QUOTED VALUE OF 0.1.                                                    2/71
R26       . . . . . .
R26 FIT        0.095    0.032  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R27    ETA INTO (PI+ PI-)/TOTAL (UNITS 10**-2)             (P15)                6/73
R27            0    0.15  OR LESS            THALER    73 ASPK CON. LEV. NOT GIVEN 6/73

R28    ETA INTO (E+E-GAMMA)/(PI+PI-PIO) (UNITS 10**-2)  (P8)/(P3)
R28 J   80     2.1      0.5            JANE2     75 OSPK                        2/76
R28 J   VALUE CHANGED BY ERRATUM.                                               2/76
R28       . . . . . .
R28 FIT        2.11     0.50   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R29    ETA INTO (E+ E-)/TOTAL  (UNITS 10**-4)              (P16)
R29 D          3.    OR LESS  CL=.90   DAVIES    74 RVUE                        2/78*
R29 D   DAVIES 74 EXTRACTS THIS INFORMATION FROM ESTEN 67.                      2/78*
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14 ETA C-NONCONSERVING DECAY PARAMETERS

RELATED TEXT SECTION VI C.1

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A1     LEFT-RIGHT ASYMMETRY PARAMETER FOR PI+ PI- PIO  (UNITS 10**-2)
A1     1351     7.2      2.8            BALTAY    66 DBC                         8/66
A1     1300     5.8      3.4            CLPWY     66 HBC                         8/66
A1    10665    (0.3)    (1.0)           CNOPS     66 OSPK REPL BY MULLER 69      8/67
A1      705    -6.1      4.0            LARRIBE   66 HBC                         8/67
A1   G36800   (1.5)    (.5)            GORMLEY3  68 ASPK                        6/68
A1    10709     .3       1.1           MULLER    69 OSPK                        9/69
A1     1138    -1.4      3.            CARPENTR  70 HBC                         6/70
A1      349     3.2      5.4           DANBURG   70 DBC                         2/71
A1     220K    -0.05     0.22          LAYTER    72 ASPK                        8/72
A1     165K     0.28     0.26          JANE1     74 OSPK                        3/74
A1 G   GORMLEY3 68 ASYMMETRY PROBABLY DUE TO UNMEASURED (E X B) SPK. CH.        3/74
A1 G   EFFECTS.  NEW EXPTS. WITH (E X B) CONTROLS DONT OBSERVE ASYMMETRY.       3/74
A1        . . . . . .
A1 AVG         0.12     0.17    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A1 STUDENT     0.11     0.19    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

A2     LEFT-RIGHT ASYMMETRY PARAMETER FOR PI+ PI- GAMMA (UNITS 10**-2)
A2       33    -2.      17.            CRAWFORD  66 HBC                        11/66
A2            -4.       8.            LITCHFIEL 67 DBC                         8/67
A2 N    1620     1.5      2.5           MULLER    69 OSPK                        9/69
A2      7257     1.22     1.56          GORMLEY   70 ASPK                        6/70
A2       36K     0.5      0.6           THALER    72 ASPK                        8/72
A2       35K     1.2      0.6           JANE2     74 OSPK                        3/74
A2 N   MULLER 69 IS SENSITIVE ONLY TO UPPER .4 OF GAMMA-RAY SPECTRUM.
A2        . . . . . .
A2 AVG         0.88     0.40    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A2 STUDENT     0.88     0.45    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AS     SEXTANT ASYMMETRY PARAMETER FOR PI+ PI- PIO  (UNITS 10**-2)
AS     1300     6.8      3.3            CLPWY     66 HBC                        12/75
AS      705    -2.4      4.0            LARRIBE   66 HBC                        12/75
AS       37K     0.5      0.5           GORMLEY3  68 WIRE                       12/75
AS      220K     0.10     0.22          LAYTER    72 ASPK                       12/75
AS      165K     0.20     0.25          JANE1     74 OSPK                       12/75
AS        . . . . . .
AS AVG         0.19     0.16    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AS STUDENT     0.19     0.17    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AQ     QUADRANT ASYMMETRY PARAMETER FOR PI+ PI- PIO (UNITS 10**-2)
AQ      220K    -0.07     0.22          LAYTER    72 ASPK                       12/75
AQ      165K    -0.30     0.25          JANE1     74 OSPK                       12/75
AQ        . . . . . .
AQ AVG         -0.17     0.17    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AQ STUDENT     -0.17     0.18    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

BET    BETA FOR ETA TO PI+ PI- GAMMA. SENSITIVE TO D-WAVE CONTRIBUTION.
BET    DN/DCOS THETA = SIN**2 THETA * (1 + BETA * COS**2 THETA)          12/75
BET   7250    -0.060    0.065          GORMLEY   70 WIRE                       12/75
BET L            0.12     0.06          THALER    72 ASPK                       12/75
BET     35K     0.11     0.11          JANE2     74 OSPK                       12/75
BET L  AUTHORS DONT BELIEVE THIS TO INDICATE D-WAVE BECAUSE DEPENDENCE OF  12/75
BET L  BETA ON GAMMA ENERGY INCONSISTENT WITH THEOR. PREDICTION.           12/75
BET L  COS**2 DEPENDENCE MAY ALSO COME FROM P AND F-WAVE INTERFERENCE.     12/75
BET       . . . . . .
BET AVG        0.047    0.062   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
BET STUDENT    0.053    0.053   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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14 ENERGY DEPENDENCE OF ETA DALITZ PLOT

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DP     RELATED TEXT SECTION VI C.2
DP     THE FOLLOWING EXPTS FIT TO ONE OR MORE OF THE COEFFICIENTS
DP     A,B,C,D, OR E FOR ETA TO PI+ PI- PIO
DP     MATRIX ELEMENT**2=1 + A*Y + B*(Y**2) + C*X + D*(X**2) + E*X*Y
DP     1300 SEE TEXT SEC VI C.2          CLPWY     66 HBC                        12/75
DP      705 SEE TEXT SEC VI C.2          LARRIBE   66 HBC                        12/75
DP     7170 SEE TEXT SEC VI C.2          CNOPS     68 OSPK                       12/75
DP      37K SEE TEXT SEC VI C.2          GORMLEY3  68 WIRE                       12/75
DP      526 SEE TEXT SEC VI C.2          BAGLIN    69 HLBC                       12/75
DP     1138 SEE TEXT SEC VI C.2          CARPENTR  70 HBC                        12/75
DP      349 SEE TEXT SEC VI C.2          DANBURG   70 DBC                        12/75
DP     7250 SEE TEXT SEC VI C.2          GORMLEY   70 WIRE                       12/75
DP     220K SEE TEXT SEC VI C.2          LAYTER    72 ASPK                       12/75
DP      81K SEE TEXT SEC VI C.2          LAYTER    73 ASPK                       12/75

AO     ALPHA PARAMETER FOR ETA TO 3 PIO
AO     MATRIX ELEMENT **2 = 1 + 2*ALPHA*Z (SEE TEXT SEC VI C.3)          12/75
AO     192    -0.32     0.37           BAGLIN    70 HLBC                       12/75
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Stable Particles

η, $K^{\pm}$

Data Card Listings

For notation, see key at front of Listings.

REFERENCES FOR ETA

PEVSNER 61 PRL 7 421 PEVSNER,KRAEMER,NUSSBAUM,RICHARDSON + (JHU)

ALFF 62 PRL 9 322 ALFF,BERLEY,COLLEY,BRUGGER + (COLU+RUTGERS)
BASTIEN 62 PRL 8 114 BASTIEN,BERGE,DAHL,FERRO-LUZZI + (LRL)
CHRETIEN 62 PRL 9 127 CHRETIEN+ (BRAN+BROWN+HARVARD+MIT+PADOVA)
PICKUP 62 PRL 8 329 E PICKUP,ROBINSON,SALANT (CNRC+BNL)
SHAFER 62 CERN CONF 307 J SHAFER,FERRO-LUZZI,MURRAY + (UCB+LRL)

BACCI 63 PRL 11 37 BACCI,PENSO,SALVINI + (ROMA+FRAS)
BUSCHBEC 63 SIENA CONF 1 166 BUSCHBECK-CZAPP,COOPER + (VIENNA,CERN,AMST)
CRAWFORD 63 PRL 10 546 F S CRAWFORD,LLOYD,FOWLER (LRL+DUKE)
ALSO 66 PRL 16 907 F S CRAWFORD,L LLOYD,E FOWLER (LRL+DUKE)
DELCOURT 63 PL 7 215 DELCOURT,LEFRANCOIS,PEREZ Y JORBA+ (ORSAY)
MULLER 63 SIENA CONF 99 MULLER,PAULI + (SACL+ROMA)

FOELSCHE 64 PR 134 B 1138 H W FOELSCHE,H L KRAYBILL (YALE)
KRAEMER 64 PR 136 B 496 KRAEMER,MADANSKY,FIELDS + (JHU+NWES+WOOD)
PAULI 64 PL 13 351 E PAULI,A MULLER (SACLAY)

FOSTER1 65 PR 138 B 652 FOSTER,PETERS,MEER,LOEFFLER + (WISC+PURDUE)
FOSTER2 65 ATHENS FOSTER,GOOD,MEER (WISCONSIN)
FOSTER3 65 THESIS M.C.FOSTER (WISCONSIN)
PRICE 65 PRL 15 123 L.R.PRICE,F.S.CRAWFORD (LRL)
RITTENBE 65 PRL 15 556 RITTENBERG,KALBFLEISCH (LRL+BNL)

ALFF-STE 66 PR 145 1072 ALFF-STEINBERGER,BERLEY+ (COLUMBIA+RUTGERS)
BALTAY 66 PRL 16 1224 +FRANZINI,KIM,KIRSCH+(COLUMBIA+STONY BROOK)
CLPWY 66 PR 149 1044 COLUMBIA,LRL,PURDUE,WISCONSIN,YALE
CNOPS 66 PL 22 546 CNOPS,FINOCCHIARS.LASSALLE,(CERN,ETHZ,SACL)
CRAWFORD 66 PRL 16 333 F.S.CRAWFORD,L.R.PRICE (LRL)

DIGIUGNO 66 PRL 16 767 DIGIUGNO,GIORGI,SILVESTRI+ (NAPL,TRST,FRAS)
GROSSMAN 66 PR 146 993 R GROSSMAN,L PRICE,F CRAWFORD (LRL)
GRUNHAUS 66 THESIS J.GRUNHAUS (COLUMBIA)
JAMES 66 PR 142 896 F E JAMES,H L KRAYBILL (YALE+BNL)
JONES 66 PL 23 597 JONES,BINNIE,DUANE,HORSEY,MASON,(LOIC,RHEL)
LARRIBE 66 PL 23 600 LARRIBE,LEVEQUE,MULLER,PAULI,+ (SACL+RHEL)
WAHLIG 66 PRL 17 221 WAHLIG,SHIBATA,MANNELLI (MIT+PISA)

BAGLIN1 67 PL 24B 637 BAGLIN,BEZAGUET,DEGRANGE,+ (EPOL+UCB)
BAGLIN2 67 BAPS 12 567 BAGLIN,BEZAGUET,DEGRANGE,+ (EPOL+UCB)
BALTAY1 67 PRL 19 1495 BALTAY,FRANZINI,KIM,NEWMAN+ (COLU+BRAN)
BALTAY2 67 PRL 19 1498 BALTAY,FRANZINI,KIM,NEWMAN+ (COLU+STON)
BEMPORAD 67 PL 25B 380 BEMPORAD,BRACCINI,FOA,LUBELSMEY+(PISA,BONN)
ALSO PRIVATE COMMUNICATION

BILLING 67 PL 25B 435 BILLING,BULLOCK,ESTEN,GOVAN,+ (LOUC,OXF)
BONAMY 67 HEIDELBERG CONF. BONAMY,SONDEREGGER (SACLAY)
BOWEN 67 PL 24B 206 BOWEN,CNOPS ,FINOCCHIARO,+ (CERN+ETHZ+SACL)
BUNIATOV 67 PL 25B 560 BUNIATOV,ZAVATTINI,DEINET,+ (CERN+KARL)

CENCE 67 PRL 19 1393 CENCE,PETERSON,STENGER,CHIU+ (HAWAII+LRL)
FELDMAN 67 PRL 18 868 FELDMAN,FRATI,GLEESON,HALPERN,+ (PENN)
FLATTE 67 PRL 18 976 S.M.FLATTE (LRL)
FLATTE2 67 PR 163 1441 S.M.FLATTE AND C.G.WOHL (LRL)
LITCHFIE 67 PL 24B 486 LITCHFIELD,RANGAN,SEGAR,SMITH+(RHEL+SACLAY)
PRICE 67 PRL 18 1207 L.R.PRICE,F.S.CRAWFORD (LRL)

ARNOLD 68 PL 27B 466 +PATY,BAGLIN,BINGHAM+ (STRB+MADR+EPOL+UCB)
BAZIN 68 PRL 20 895 BAZIN,GOSHAW,ZACHER,+ (PRINCETON,QUEENS)
BULLOCK 68 PL 27B 402 +ESTEN,FLEMING,GOVAN,HENDERSON,OWEN+ (LOUC)
GORMLEY3 68 PRL 21 402 GORMLEY,HYMAN,LEE,NASH,PEOPLES+ (COLU+BNL)
WEHMANN 68 PRL 20 748 WEHMANN,ENGELS,+ (HARV+CASE+SLAC+CORN+MCGI)

BAGLIN 69 PL 29B 445 BAGLIN,BEZAGUET,+ (EPOL,UCB,MADR,STRB)
ALSO 70 NP B22 66 +BEZAGUET,DEGRANGE,MUSSET +(EPOL,MADR,STRB)
HYAMS 69 PL 29B 128 HYAMS,KOCH,POTTER,VON LINDERN,+ (CERN,MPIM)
JACQUET 69 NC 58 743 JACQUET,NGUYEN-KHAC,HAATUFT+ (EPOL,BERG)
MULLER 69 THESIS ARMAND MULLER (STRB)

BAGLIN 70 NP B22 66 +BEZAGUET,DEGRANGE,MUSSET+ (EPOL+MADR+STRB)
BUTTRAM 70 PRL 25 1358 +KREISLER,MISCHKE (PRIN)
CARPENTR 70 PR D1 1303 CARPENTER,BINKLEY,CHAPMAN,COX,DAGAN+ (DUKE)
COX 70 PRL 24 534 COX,FORTNEY,GOLSON (DUKE)

DANBURG 70 PR D2 2564 +ABOLINS,DAHL,DAVIES,HOGH,KIRZ,+ (LRL)
DEVONS 70 PR D1 1936 +GRUNHAUS,KOZLOWSKI,NEMETHY + (COLU,SYRA)
GORMLEY 70 PR D2 501 GORMLEY,HYMAN,LEE,NASH,PEOPLES+ (COLU+BNL)
ALSO 70 NEVIS 181(THESIS) MICHAEL GORMLEY (COLU)
KANOFSKY 70 NC 68 413 A. KANOFSKY (LEHI)
SCHMITT 70 PL 32B 638 +BUNIATOV,ZAVATTINI,DEINET+ (CERN,KARL)

BASILE 71 NC 3A 796 +BOLLINI,DALPIAZ,FRABETTI+ (CERN,BGNA,STRB)
STRUGALS 71 NP B27 429 +CHUVILO,GEMESY,IVANOVSKAYA+ (JINR)
AGUILAR- 72 PR D6 29 AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
BLOODWOR 72 NP B39 525 BLOODWORTH,JACKSON,PRENTICE,YOON (TORONTO)
LAYTER 72 PRL 29 316 +APPEL,KOTLEWSKI,LEE,STEIN,THALER (COLU)
THALER 72 PRL 29 313 +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN (COLU)

LAYTER 73 PR D7 2565 +APPEL,KOTLEWSKI,LEE,STEIN,THALER (COLU)
THALER 73 PR D7 2569 +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN (COLU)
BROWMAN 74 PRL 32 1067 +DEWIRE,GITTELMAN,HANSON,LOH + (CORN+BING)
DAVIES 74 NC 24A 324 +GUY,ZIA (BIRM+RHEL+SHMP)
ALSO 67 PL 24B 115 ESTEN,GOVAN,KNIGHT,MILLER,TOVEY+ (LOUC+OXF)
JANE1 74 PL 48B 260 +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
JANE2 74 PL 48B 265 +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
KENDALL 74 NC 21A 387 +LANOU,MASSIMO,SHAPIRO + (BROW+BARI+MIT)

JANE1 75 PL 59B 99 +GRANNIS,JONES,LIPMAN,OWEN + (RHEL+LOWC)
JANE2 75 PL 59B 103 +GRANNIS,JONES,LIPMAN,OWEN + (RHEL+LOWC)
ALSO 76 PL (TO BE PUBL.) ERRATUM, M.R.JANE, PRIVATE COMMUNICATION.
MARTYNOV 76 SJNP 23 48 +SALTYKOV,TARASOV,UZHINSKII (JINR)

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BASTIEN 62 PRL 8 114 BASTIEN,BERGE,DAHL,FERRO-LUZZI,MILLER+(LRL)
CARMONY 62 PRL 8 117 D CARMONY,A ROSENFELD,VAN DE WALLE (LRL)
ROSENFEL 62 PRL 8 293 A ROSENFELD,D CARMONY,VAN DE WALLE (LRL)

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$K^{\pm}$

10 CHARGED K(494,JP=0-) I=1/2

10 CHARGED K MASS (MEV)

M		493.9	0.2		COHEN	57 RVUE +		
M		493.7	0.3		BARKAS	63 EMUL -		
M		493.78	0.17		GREINER	65 EMUL + VIA TAU DECAY		7/66
M	A	(493.87)	(0.19)		KUNSELMAN	71 CNTR - KAONIC ATOMS		10/71
M		493.691	0.040		BACKENSTO	73 CNTR - KAONIC ATOMS		1/73
M	A	493.662	0.19		KUNSELMAN	74 CNTR - KAONIC ATOMS		3/74
M		493.657	0.020		CHENG	75 CNTR - KAONIC ATOMS		6/77*
M	A	KUNSELMAN 74 UPDATES KUNSELMAN 71 WITH IMPROVED KAONIC ATOM CALC.						3/74
M		. . . . .						
M	AVG	493.667	0.018	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
M	STUDENT	493.667	0.020	AVERAGE USING STUDENT1O(H/1.11) -- SEE MAIN TEXT				
M	FIT	493.668	0.018	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				2/78*

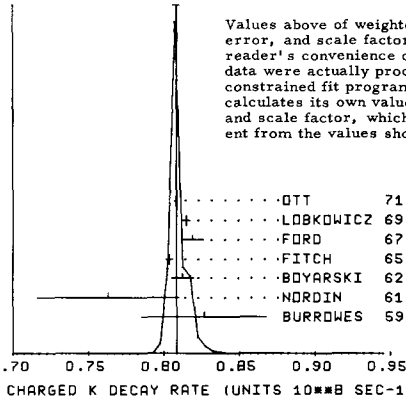
10 (K+) - (K-) MASS DIFFERENCE (MEV)

DM F	1.5M	-0.032	0.090		FORD	72 ASPK +-	4/72
DM F	FORD 72 USES M(PI+)-M(PI-) = +28+-70 KEV.						1/73

10 CHARGED K MEAN LIFE (UNITS 10**-8)

T		CHAR. K MEAN LIFE						
T	0	(0.95)	(0.36)	(0.25)	ILOFF	56 EMUL		
T	0 52	(1.60)	(0.3)	(0.3)	EISENBERG	58 EMUL		
T		1.21	0.06	0.06	BURROWES	59 CNTR		
T	0 33	(1.38)	(0.24)	(0.24)	FREDEN	60 EMUL		
T	0	(1.25)	(0.22)	(0.17)	BARKAS	61 EMUL		
T	0 51	(1.27)	(0.36)	(0.23)	BHOWMIK	61 EMUL		
T	293	1.31	0.08	0.08	NORDIN	61 HBC -		
T		(1.24)	(0.07)		NORDIN	61 RVUE -		
T		1.231	0.011	0.011	BOYARSKI	62 CNTR +		
T		1.2443	0.0038		FITCH	65 CNTR + K AT REST		6/66
T		1.221	0.011		FORD	67 CNTR +-		8/67
T		1.2272	0.0036		LOBKOWICZ	69 CNTR + K IN FLIGHT		9/66
T	3M	1.2380	0.0016		OTT	71 CNTR + STOPPING K		2/71
T	0	OLD EXPERIMENTS WITH LARGE ERRORS EXCLUDED FROM AVERAGING						2/71
T		. . . . .						
T	AVG	1.2370	0.0032	0.0032 AVERAGE (ERROR INCL. SCALE FACTOR OF 2.4)				
T	STUDENT	1.2374	0.0016	0.0016 AVG BY STUDENT1O(H/1.11) -- SEE MAIN TEXT				
T	FIT	1.2371	0.0026	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)				
				(SEE IDEOGRAM BELOW)				

WEIGHTED AVERAGE = 0.8084 ± 0.0021
ERROR SCALED BY 2.4



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

10 ((K+) - (K-))/AVG., MEAN LIFE DIFFERENCE (PERCENT)

DT N THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT	0.47	0.30		FORD	67 CNTR	8/67
DT	0.090	0.078		LOBKOWICZ	69 CNTR	12/70
DT	. . . . .					
DT AVG	0.114	0.093	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)			
DT STUDENT	0.112	0.083	AVERAGE USING STUDENT1O(H/1.11) -- SEE MAIN TEXT			

10 CHARGED K PARTIAL DECAY MODES

			DECAY MASSES		
P1	CHAR. K INTO MU NEU	K MU2	105+ 0		
P2	CHAR. K INTO PI PIO	K PI2	139+ 134		
P3	CHAR. K INTO PI PI+ PI-	TAU	139+ 139+ 139		
P4	CHAR. K INTO PI 2PIO	TAU PRIME	139+ 134+ 134		
P5	CHAR. K INTO MU PIO NEU	K MU3	105+ 134+ 0		
P6	CHAR. K INTO E PIO NEU	K E3	.5+ 134+ 0		
P7	K+ INTO PI+ PI- E+ NEU	K E+ 4	139+ 139+ .5+	0	
P8	K+ INTO PI+ PI+ E- NEU	K E- 4	139+ 139+ .5+	0	
P9	K+ INTO PI+ PI- MU+ NEU	K+MU+ 4	139+ 139+ 105+	0	
P10	K+ INTO PI+ PI+ MU- NEU	K+MU- 4	139+ 139+ 105+	0	
P11	CHAR. K INTO E NEU	K E2	.5+ 0		
P12	CHAR. K INTO MU NEU GAMMA	K MU RAD	105+ 0+ 0		
P13	CHAR. K INTO PI PIO GAMMA	K PI RAD	139+ 134+ 0		
P14	CHAR. K INTO PI PI+ PI- GAMMA	TAU RAD	139+ 139+ 139+	0	
P15	CHAR. K INTO PI E+ E-	PI E E	139+ .5+ .5		
P16	CHAR. K INTO PI MU+ MU-	PI MU MU	139+ 105+ 105		
P17	CHAR. K INTO PI GAMMA GAMMA	PI GAM GAM	139+ 0+ 0		
P18	CHAR. K INTO PIO E NEU GAMMA	PI E NEU GAM	134+ .5+ 0+	0	
P19	K+- INTO PI-+ E+- E+-	PI-+E+-E+-	139+ .5+ .5		
P20	CHAR. K INTO PI NEU NEU	PI NEU NEU	139+ 0+ 0		

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P21    CHAR. K INTO E NEU GAMMA              K E2 RAD          .5+   0+    0
P22    CHAR. K INTO PI GAMMA                 K PI GAM         139+   0
P23    CHAR. K INTO PI 3GAMMA                PI 3GAM          139+   0+    0+    0
P24    CHAR. K INTO PIO PIO E NEU            K E4 2PIO        134+ 134+   .5+    0
P25    K+ INTO PI- E+ MU+                    PI-E+MU+         139+  .5+  105
P26    K+ INTO PI+ E+ MU-                    PI+E+MU-         139+  .5+  105
P27    CHAR. K INTO MU NEU NEU NEUBAR        MU 3NEU          105+   0+    0+    0
P28    CHAR. K INTO PIO MU NEU GAMMA         PI MU NEU GAM    134+ 105+    0+    0
P29    K+ INTO PI+ MU+ E-                    PI+MU+E-         139+ 105+   .5
P30    CHAR. K INTO MU NEU E+ E-             MU NEU E+E-      105+   0+   .5+   .5
P31    K+- INTO MU-+ NEU E+- E+-             MU-+ NEU 2E+-    105+   0+   .5+   .5
P32    CHAR. K INTO NEU E E E                NEU 3E             0+  .5+   .5+   .5
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                CHARGED K CONSTRAINED FIT
           OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
           RATIOS USES 59 DATA POINTS TO DETERMINE SIX                     3/78*
           QUANTITIES.  OVERALL FIT HAS CHISQ=78.0.  MAIN                  3/78*
           CONTRIBUTION (13.2) COMES FROM R19 OF HAIDT                     3/78*
           71 (WE SEE NO REASON TO REJECT THIS EXPERIMENT
           AT THIS TIME)
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.6350+-.0016					
P 2	-.7381	.2116+-.0015				
P 3	-.1919	-.0353	.0559+-.0003			
P 4	-.1819	.0349	.2039	.0173+-.0005		
P 5	-.2725	-.2321	-.1179	-.3230	.0320+-.0009	
P 6	-.3388	-.1384	.1501	.0258	.2122	.0482+-.0005

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

	G 1	G 2	G 3	G 4	G 5	G 6
G 1	.5133+-.0017					
G 2	-.3275	.1710+-.0013				
G 3	-.0991	-.0024	.0452+-.0002			
G 4	-.1076	.0488	.2062	.0140+-.0004		
G 5	-.1623	-.1977	-.1229	-.3193	.0258+-.0007	
G 6	-.1551	-.0803	.1533	.0311	.2194	.0390+-.0004

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                  10  CHARGED K DECAY RATES

W1      CHAR. K INTO MU NEU (UNITS 10**6 SEC-1)            (G1)
W1             51.2      0.8           FORD       67 CNTR +-                   8/67
W1           . . . . . . . . .
W1   FIT       51.33     0.17   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

W2      CHAR. K INTO PI PI+ PI- (UNITS 10**6 SEC-1)        (G3)
W2   F        (4.496)  (0.030)         FORD       67 CNTR +- SEE NOTE F        8/67
W2   F 3.2M   (4.529)  (0.032)         FORD       70 ASPK    SEE NOTE F       11/70
W2             4.511    0.024          FORD       70 ASPK    SEE NOTE F       11/70
W2   F   THE LAST IS THE COMBINED RESULT OF FORD 67 AND FORD 70
W2           . . . . . . . . .
W2   FIT       4.517    0.023   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

W3      CHAR. K INTO (TAU) - (TAU PRIME) (UNITS 10**6 SEC-1)
W3                                                         (G3-G4)
W3       USED FOR DELTA I = 1/2 TEST.
W3           . . . . . . . . .
W3   FIT       3.117    0.039   FROM FIT

W4      CHAR. K INTO (MU PIO NEU) + (E PIO NEU) (UNITS 10**6 SEC-1)
W4                                                         (G5+G6)
W4       USED FOR DELTA I = 1/2 TEST.
W4           . . . . . . . . .
W4   FIT       6.484    0.089   FROM FIT

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            10  ((K+) - (K-))/AVG., DECAY RATE DIFFERENCE (PERCENT)

D1      DIFFERENCE IN K MU2 RATES    ((G1+)-(G1-))/G1        (PERCENT)
D1            -0.54     0.41           FORD       67 CNTR                      8/67

D2      DIFFERENCE IN TAU RATES      ((G3+)-(G3-))/G3        (PERCENT)
D2            -0.50     0.90           FLETCHER   67 OSPK                      8/67
D2   F       (-0.04)   (0.21)          FORD       67 CNTR    SEE NOTE F        8/67
D2   F 3.2M   (0.10)   (0.14)          FORD       70 ASPK    SEE NOTE F       11/70
D2 F           0.08     0.12           FORD       70 ASPK    SEE NOTE F       11/70
D2   S       (-0.02)   (0.16)          SMITH      73 ASPK +-                  11/73
D2   F   SECOND FORD 70 VALUE IS FIRST FORD 70 COMBINED WITH FORD 67.
D2   S   SMITH 73 VALUE OF D2 IS DERIVED FROM SMITH 73 VALUE OF D3.           11/73
D2           . . . . . . . . .
D2   AVG       0.07     0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D2   STUDENT   0.07     0.13    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

D3      DIFFERENCE IN TAU PRIME RATES ((G4+)-(G4-))/AVERAGE   (PERCENT)
D3    1802    -1.1      1.8            HERZO      69 OSPK                      5/70
D3             0.08     0.58           SMITH      73 ASPK +-                  11/73
D3           . . . . . . . . .
D3   AVG      -0.03     0.55    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D3   STUDENT  -0.03     0.60    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

D4      DIFFERENCE IN K PI2 RATES    ((G2+)-(G2-))/AVERAGE   (PERCENT)
D4             0.8      1.2            HERZO      69 OSPK                      5/70

D5      DIFFERENCE IN K PI RAD RATES  ((G13+)-(G13-))/AVERAGE (PERCENT)
D5      24     0.0      24.0           EDWARDS    72 OSPK    PI KE 58-90 MEV    8/72
D5    4000     1.0       4.0           ABRAMS     73 ASPK +- PI KE 51-100 MEV  3/74
D5    2461     0.8       5.8           SMITH      76 WIRE +- PI+-KE 55-90 MEV 11/76*
D5           . . . . . . . . .
D5   AVG       0.9       3.3    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D5   STUDENT   0.9       3.5    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                  10  CHARGED K BRANCHING RATIOS

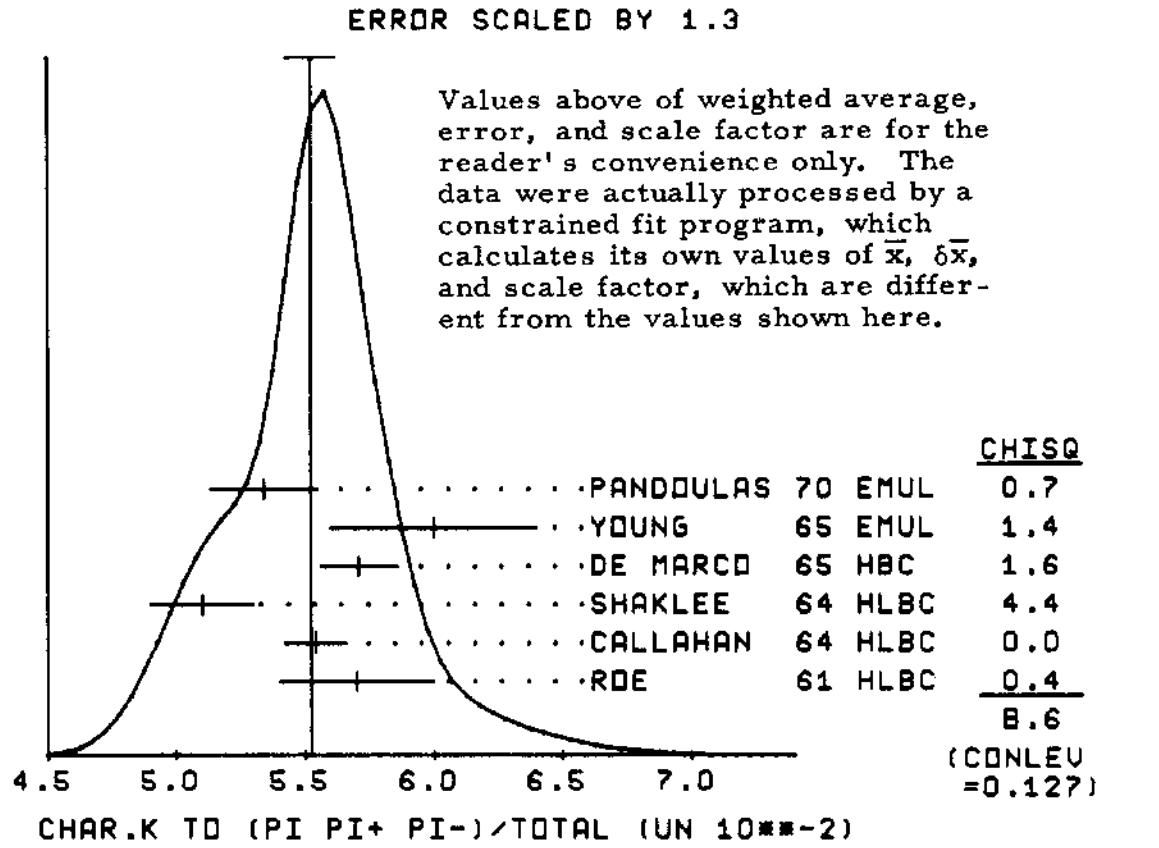
R    O      OLD DATA EXCLUDED

R1      CHAR. K INTO (MU NEU)/TOTAL (UNITS 10**-2)           (P1)
R1   O        (58.5)    (3.0)          BIRGE      56 EMUL +
R1   O        (56.9)    (2.6)          ALEXANDER 57 EMUL +
R1   O   OLD EXPERIMENTS NOT INCLUDED IN AVERAGING                             1/71
R1     62K     63.24     0.44          CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R1           . . . . . . . . .
R1   FIT       63.50     0.16   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      CHAR. K INTO (PI PIO)/TOTAL (UNITS 10**-2)           (P2)
R2   O        (27.7)    (2.7)          BIRGE      56 EMUL +
R2   O        (23.2)    (2.2)          ALEXANDER 57 EMUL +
R2   O   EARLIER EXPERIMENTS NOT AVERAGED
R2            (21.0)    (0.6)          CALLAHAN   65 HLBC    SEE R17
R2            (21.6)    (0.6)          TRILLING   65 RVUE                      6/66
R2     16K     21.18     0.28          CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R2           . . . . . . . . .
R2   FIT       21.16     0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      CHAR. K INTO (PI PI+ PI-)/TOTAL (UNITS 10**-2)    (P3)
R3   O        (5.6)     (0.4)          BIRGE      56 EMUL +
R3   O        (6.8)     (0.4)          ALEXANDER 57 EMUL +
R3   O        (5.2)     (0.3)          TAYLOR     59 EMUL +
R3   O   EARLIER EXPERIMENTS NOT AVERAGED
R3             5.7       0.3           ROE        61 HLBC +                    9/66
R3    2332     5.54      0.12          CALLAHAN   64 HLBC +
R3     540     5.1       0.2           SHAKLEE    64 HLBC +                    9/66
R3             5.71      0.15          DE MARCO   65 HBC                       6/66
R3      44     6.0       0.4           YOUNG      65 EMUL +                    6/66
R3 P   693     5.34      0.21          PANDOULAS 70 EMUL +                    10/70
R3   C 2330   (5.56)    (0.20)         CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R3   C   THIS VALUE IS NOT INDEPENDENT OF CHIANG 72 R1,R2,R4,R5, AND R6       9/72
R3 P     INCLUDES EVENTS OF TAYLOR 59.
R3           . . . . . . . . .
R3   AVG       5.521     0.098   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R3   STUDENT   5.533     0.089   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3   FIT       5.588     0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 5.521 ± 0.098
ERROR SCALED BY 1.3

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R4      CHAR. K INTO (PI 2PIO)/TOTAL (UNITS 10**-2)          (P4)
R4   O        (2.1)     (0.5)          BIRGE      56 EMUL +
R4   O        (2.2)     (0.4)          ALEXANDER 57 EMUL +
R4   O        (1.5)     (0.2)          TAYLOR     59 EMUL +
R4   O   EARLIER EXPERIMENTS NOT AVERAGED
R4             1.7       0.2           ROE        61 HLBC +                   11/67
R4     108     1.8       0.2           SHAKLEE    64 HLBC +                   11/67
R4 P   198     1.53      0.11          PANDOULAS 70 EMUL +                    10/70
R4    1307     1.84      0.06          CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R4 P     INCLUDES EVENTS OF TAYLOR 59.
R4           . . . . . . . . .
R4   AVG       1.767     0.071   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R4   STUDENT   1.778     0.063   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4   FIT       1.732     0.045  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW )

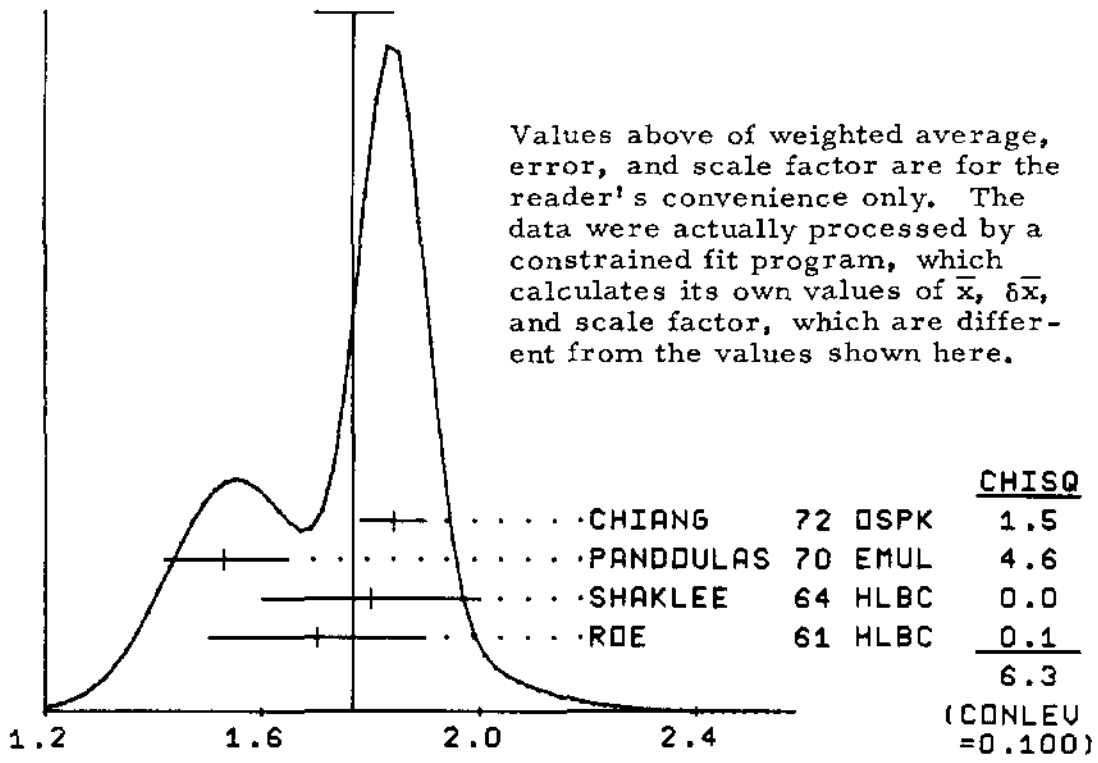
R5      CHAR. K INTO (MU PIO NEU)/TOTAL (UNITS 10**-2)    (P5)
R5   O        (2.8)     (1.0)          BIRGE      56 EMUL +
R5   O        (5.9)     (1.3)          ALEXANDER 57 EMUL +
R5   O        (2.8)     (0.4)          TAYLOR     59 EMUL +
R5   O   EARLIER EXPERIMENTS NOT AVERAGED
R5    2345     3.33      0.16          CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R5           . . . . . . . . .
R5   FIT       3.197     0.086  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R6      CHAR. K INTO (E PIO NEU)/TOTAL (UNITS 10**-2)     (P6)
R6   O        (3.2)     (1.3)          BIRGE      56 EMUL +
R6   O        (5.1)     (1.3)          ALEXANDER 57 EMUL +
R6   O   EARLIER EXPERIMENTS NOT AVERAGED
R6             5.0       0.5           ROE        61 HLBC +                   11/67
R6     429     4.7       0.3           SHAKLEE    64 HLBC +                   11/67
R6    3516     4.86      0.10          CHIANG     72 OSPK +  1.84 GEV/C K+     9/72
R6           . . . . . . . . .
R6   AVG       4.849     0.093   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6   STUDENT   4.85      0.10    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6   FIT       4.824     0.052  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

Stable Particles
K±

Data Card Listings
For notation, see key at front of Listings.

WEIGHTED AVERAGE = 1.767 ± 0.071
ERROR SCALED BY 1.4



CHAR. K INTO (PI 2PIO)/TOTAL (UN 10**-2)

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

```
R7      CHAR. K INTO (PI2 + MU3)/TOTAL (UNITS 10**-2)     (P2+P5)           11/67
R7       WE COMBINE THESE TWO MODES FOR EXPTS MEASURING THEM IN XENON BC
R7       BECAUSE OF DIFFICULTIES OF SEPARATING THEM THERE
R7           23.4       1.1             ROE         61 HLBC +                 11/67
R7      886  25.4       0.9             SHAKLEE     64 HLBC +                 11/67
R7           . . . . . . . . .
R7  AVG      24.60      0.98    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R7  STUDENT  24.61      0.83    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R7  FIT      24.36      0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8      K+ INTO (PI+ PI+ E- NEU)/TOTAL (UNITS 10**-7)     (P8)
R8           20.    OR LESS  CL=.95     BIRGE       65 FBC  +                  8/66
R8        0   6.9   OR LESS  CL=.95     ELY         69 HLBC +                 10/69
R8        0   9.0   OR LESS  CL=.95     SCHWEINBE 71 HLBC +                    9/71

R9      K+ INTO (PI+ PI- MU+ NEU)/TOTAL (UNITS 10**-5)    (P9)
R9        1   0.77      0.54      0.50  CLINE       65 FBC  +                  8/66

R10     K+ INTO (PI+ PI+ MU- NEU)/TOTAL (UNITS 10**-6)    (P10)
R10       0   3.0   OR LESS  CL=.95     BIRGE       65 FBC  +                  8/66

R11     CHAR. K INTO (E NEU)/TOTAL (UNITS 10**-5)         (P11)
R11          160.0  OR LESS  CL=.95     BORREANI    64 HBC  +                 11/67
R11       4   2.1       1.8       1.3   BOWEN       67 OSPK +                  8/67
R11      BOWEN RESULT SHOULD BE CORRECTED TO 1.9(+1.7,-1.2) BECAUSE OF
R11      K+ TO E+ NEU GAMMA DECAYS BEFORE COMPARING WITH BOTTERILL 67 R28

R12     CHAR. K INTO (PI GAMMA GAMMA)/TOTAL (UNITS 10**-4)
R12                                                       (P17)
R12      ALL VALUES GIVEN HERE ASSUME A PHASE SPACE PION ENERGY SPECTRUM     2/72
R12          -0.1       0.6             CHEN        68 OSPK +  T(PI) 60-90 MEV   9/73
R12       0   0.5   OR LESS  CL=.90     KLEMS       71 OSPK +  T(PI)GT 117 MEV   8/71
R12       0   0.35  OR LESS  CL=.90     LJUNG       73 HLBC +  6-102,114-127MEV  9/73
R12       0  -0.42      0.52            ABRAMS      77 SPEC +  T(PI)LT 92 MEV   12/77*

R13     CHAR. K INTO (PI PIO GAMMA)/TOTAL (UNITS 10**-4) (P13)
R13 O    18  (2.2)     (0.7)            CLINE       64 FBC  +  PI+ KE 55-80 MEV  8/66
R13       0   1.9   OR LESS  CL=.90     EMMERSON    69 OSPK    PI+ KE 55-80 MEV 10/69
R13  M    0   1.0   OR LESS             MALTSEV     70 HLBC +  PI+ KE LT 55 MEV 12/75
R13  A2100    2.71      0.19            ABRAMS      72 ASPK +- PI+ KE 55-90 MEV  1/73
R13 O    24  (2.4)     (0.8)            EDWARDS     72 OSPK    PI+ KE 58-90 MEV  8/72
R13 L        (1.5)     (1.1)     (0.6)  LJUNG       73 HLBC +  PI+ KE 55-80 MEV  9/73
R13 L        (2.6)     (1.5)     (1.1)  LJUNG       73 HLBC +  PI+ KE 55-90 MEV  9/73
R13 OL   17  (6.8)     (3.7)     (2.1)  LJUNG       73 HLBC +  PI+ KE 55-102MEV  9/73
R13    2461   2.87      0.32            SMITH       76 WIRE +- PI+-KE 55-90 MEV 11/76*
R13 O   ONLY HIGH STATISTICS EXPERIMENTS ARE AVERAGED.                          3/78*
R13  M  MALTSEV 70 SELECTS LOW PI+ ENERGY TO ENHANCE DIRECT EMISSION CONTR.   1/76
R13  L  THE LJUNG 73 VALUES ARE NOT INDEPENDENT.                                9/73
R13  A  ABRAMS 72 OBSERVES DIRECT EMISSION BR. RATIO OF (1.56+-0.35)*10**-5   1/73
R13  A  +-0.5*10**-5 ADDNL. SYST. ERROR  AND INNER BREMSSTRAHLUNG BR. RATIO   1/73
R13  A  OF (2.55+-0.18)*10**-4.  WE QUOTE THE SUM OF THESE BR. RATIOS.        1/73
R13          . . . . . . . . . .
R13 AVG       2.75      0.16    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R13 STUDENT   2.75      0.18    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R14     CHAR. K INTO (PI PI+ PI- GAMMA)/TOTAL (UNITS 10**-4)
R14                                                       (P14)
R14           1.0       0.4             STAMER      65 EMUL +  EGAM GT 11MEV     8/66

R15     CHAR. K INTO (PI E+ E-)/TOTAL (UNITS 10**-6)      (P15)
R15       1   2.45  OR LESS  CL=.90     CAMERINI    64 FBC  +                  8/66
R15           4.4   OR LESS  CL=.90     BISI        67 DBC  +                 11/67
R15  C       (0.4)  OR LESS             CLINE1      67 FBC  +                .11/67
R15  C        0.88  OR LESS  CL=.90     CLINE2      67 FBC  +                . 2/74
R15          32.0   OR LESS  CL=.90     BEIER       72 OSPK +-                 9/72
R15           1.7   OR LESS  CL=.90     CENCE       74 ASPK +  THREE TRACK EVTS 10/74
R15           0.27  OR LESS  CL=.90     CENCE       74 ASPK +  TWO TRACK EVENTS 10/74
R15  C  CLINE2 REPLACES CLINE1.  CLINE1 IS NOT FOR CL=.90 .                     2/74

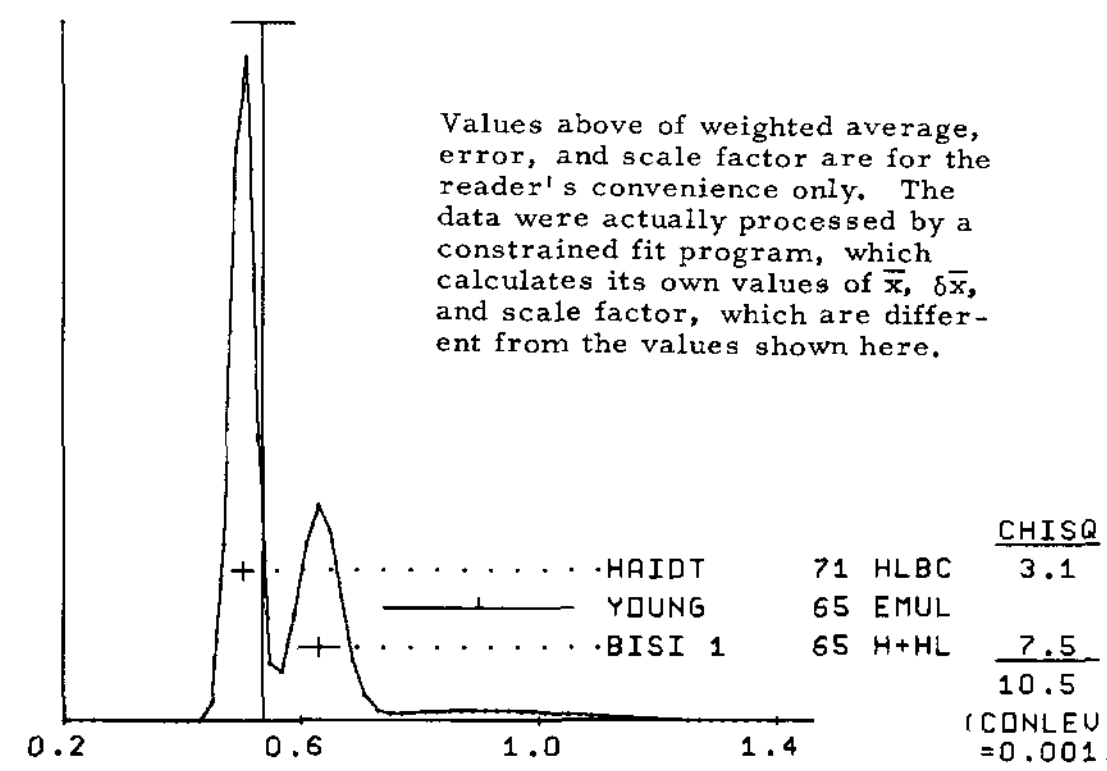
R16     CHAR. K INTO (PI MU+ MU-)/TOTAL (UNITS 10**-6)    (P16)
R16           3.0   OR LESS  CL=.90     CAMERINI    65 FBC  +                  8/66
R16           2.4   OR LESS  CL=.90     BISI        67 DBC  +                 11/67

R17     CHAR. K INTO (PI PIO)/TAU                         (P2)/(P3)
R17     134   3.24      0.34            YOUNG       65 EMUL +                . 8/66
R17    1045   3.96      0.15            CALLAHAN    66 FBC  +                  9/66
R17          . . . . . . . . . .
R17 AVG       3.84      0.27    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17 STUDENT   3.86      0.16    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R17 FIT       3.787     0.034  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R18     CHAR. K INTO (PI 2PIO)/TAU                        (P4)/(P3)
R18    2027   0.303     0.009           BISI        65 H+HL +                . 8/66
R18      17   0.393     0.099           YOUNG       65 EMUL +                  8/66
R18          . . . . . . . . . .
R18 AVG       0.3037    0.0090  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 STUDENT   0.3037    0.0097  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R18 FIT       0.3100    0.0079 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R19     CHAR. K INTO (MU PIO NEU)/TAU                     (P5)/(P3)
R19    2845   0.632     0.035           BISI 1      65 H+HL +                . 8/66
R19      38   0.90      0.16            YOUNG       65 EMUL +                  8/66
R19 H 1505   (0.510)   (0.017)          EICHTEN     68 HLBC +                 11/68
R19  H1505    0.503     0.019           HAIDT       71 HLBC +                 12/70
R19  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R19          . . . . . . . . . .
R19 AVG       0.536     0.054   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.2)
R19 STUDENT   0.527     0.025   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT       0.572     0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.536 ± 0.054
ERROR SCALED BY 3.2



CHARGED K INTO (MU PIO NEU)/TAU

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

```
R20     CHAR. K INTO (E PIO NEU)/TAU                      (P6)/(P3)
R20     230   0.90      0.06            BORREANI    64 HBC  +                . 8/66
R20      37   0.90      0.16            YOUNG       65 EMUL +                . 8/66
R20     854   0.94      0.09            BELLOTT2    67 HLBC                   11/67
R20 H 4385   (0.846)   (0.021)          EICHTEN     68 HLBC +                 11/68
R20  H4385    0.850     0.019           HAIDT       71 HLBC +                 12/70
R20    2827   0.856     0.040           BRAUN       75 HLBC +                 12/75
R20  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R20          . . . . . . . . . .
R20 AVG       0.858     0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R20 STUDENT   0.858     0.018   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R20 FIT       0.8633    0.0098 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R21     K+ INTO (PI+ PI- E+ NEU)/TAU (UNITS 10**-4)       (P7)/(P3)
R21      69   6.7       1.5             BIRGE       65 FBC  +                  8/66
R21     269   5.83      0.63            ELY         69 HLBC +                 11/68
R21     500   7.36      0.68            BOURQUIN    71 ASPK                   12/71
R21     106   7.0       0.9             SCHWEINBE 71 HLBC +                    9/71
R21     30K   7.21      0.32            ROSSELET    77 SPEC +                 11/77*
R21          . . . . . . . . . .
R21 AVG       6.98      0.26    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R21 STUDENT   7.02      0.29    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R22     K+ INTO (PI+ PI- MU+ NEU)/TAU (UNITS 10**-4)      (P9)/(P3)
R22       1  (2.5)  APPROX              GREINER     64 EMUL +                  8/66
R22       7   2.57      1.55            BISI        67 DBC  +                 11/67

R23     CHAR. K INTO (E PIO NEU)/(MU2+PI2) (UNITS 10**-2)(P6)/(P1+P2)
R23    1679   5.89      0.21            CESTER      66 OSPK +                  8/67
R23    5110   6.16      0.22            ESCHSTRUT 68 OSPK +                    3/68
R23  W        5.92      0.64            WEISSENBE 76 SPEC +                    1/78*
R23  W  VALUE CALCULATED FROM WEISSENBERG 76 KE3, KMU2, KPI2 VALUES            1/78*
R23  W  TO ELIMINATE DEPENDENCE ON OUR 1974 TAU AND TAU-PRIME FRACTIONS.       1/78*
R23          . . . . . . . . . .
R23 AVG       6.01      0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R23 STUDENT   6.01      0.17    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R23 FIT       5.698     0.067  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R24     CHAR. K INTO (PI PIO)/(MU NEU)                    (P2)/(P1)
R24  A4517    0.3277    0.0065          AUERBACH    67 OSPK +                  1/74
R24   1600    0.305     0.018           ZELLER      69 ASPK +                 10/69
R24 W  25K   (0.328)   (0.005)          WEISSENBE 74 STRC +                    7/74
R24  W        0.3355    0.0057          WEISSENBE 76 SPEC +                    1/78*
R24  A  AUERBACH 67 CHANGED FROM .3253+-.0065.  SEE COMMENT WITH RATIO R26.   1/74
R24  W  WEISSENBERG 76 REVISES WEISSENBERG 74.                                 1/78*
R24          . . . . . . . . . .
R24 AVG       0.3307    0.0051  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R24 STUDENT   0.3307    0.0048  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R24 FIT       0.3332    0.0030 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R25     CHAR. K INTO (E PIO NEU)/(MU NEU)                 (P6)/(P1)
R25  A 295    0.0791    0.0054          AUERBACH    67 OSPK +                  1/74
R25    960     .0775     .0033          BOTTERI1    68 ASPK +                  5/68
R25    561    0.069     0.006           GARLAND     68 OSPK +                  4/68
R25    350    0.069     0.006           ZELLER      69 ASPK +                 10/69
R25  A  AUERBACH 67 CHANGED FROM .0797+-.0054.  SEE COMMENT WITH RATIO R26.   1/74
R25  A  THE VALUE .0785+-.0025 GIVEN IN AUERBACH 67 IS AN AVERAGE OF          3/74
R25  A  AUERBACH 67 R25 AND CESTER 66 R23.                                     3/74
R25          . . . . . . . . . .
R25 AVG       0.0752    0.0024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R25 STUDENT   0.0753    0.0027  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R25 FIT       0.07597   0.00091 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R26     CHAR. K INTO (MU PIO NEU)/(MU NEU)                (P5)/(P1)
R26  A 307    0.0486    0.0040          AUERBACH    67 OSPK +                  1/74
R26  G 424    0.0480    0.0037          GARLAND     68 OSPK +                  1/74
R26    240    0.054     0.009           ZELLER      69 ASPK +                 10/69
R26  A  AUERBACH 67 CHANGED FROM .0602+-.0046 BY ERRATUM WHICH BRINGS THE     1/76
R26  A  MU-SPECTRUM CALCULATION INTO AGREEMENT WITH GAILLARD 70 APPENDIX B.   1/74
R26  G  GARLAND 68 CHANGED FROM .055+-.004 IN AGREEMENT WITH MU-SPECTRUM      1/74
R26  G  CALCULATION OF GAILLARD 70 APPENDIX B.  L.G.PONDROM, PRIV.COMM.(73)   1/74
R26          . . . . . . . . . .
R26 AVG       0.0488    0.0026  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R26 STUDENT   0.0487    0.0028  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R26 FIT       0.0503    0.0014 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)
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Data Card Listings

For notation, see key at front of Listings.


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R27    CHAR. K INTO (MU NEU)/TAU                                  (P1)/(P3)
R27 R  427  (10.38)   (0.82)          YOUNG     65 EMUL +                    9/66
R27 R   DELETED FROM OVERALL FIT BECAUSE YOUNG 65 CONSTRAINS HIS RESULTS.
R27 R   TO ADD UP TO 1.  ONLY YOUNG MEASURED MU2 DIRECTLY.
R27       . . . . . . . . . .
R27 FIT      11.364    0.072  FROM FIT

R28    CHAR. K INTO (E NEU)/(MU NEU) (UNITS 10**-5)       (P11)/(P1)
R28     10    1.9      0.7      0.5   BOTTERILL 67 ASPK +                  11/67
R28      8    1.8      0.8      0.6   MACEK     69 ASPK +                   4/69
R28    112    2.42     0.42           CLARK     72 OSPK +                   1/73
R28    534    2.37     0.17           HEARD2    75 SPEC +                  11/75
R28    404    2.51     0.15           HEINTZE   76 SPEC +                   2/76
R28       . . . . . . . . . .
R28 AVG      2.42     0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R28 STUDENT  2.42     0.12    AVERAGE USING STUDENT1O(H/1.11) -- SEE MAIN TEXT

R29    CHAR. K INTO (MU PIO NEU)/(E PIO NEU)                      (P5)/(P6)
R29  C1509    0.703    0.056          CALLAHAL  66 HLBC                     6/68
R29   5601    0.667    0.017          BOTTERI2  68 ASPK +                   6/68
R29 H 1398    (0.604)  (0.022)        EICHTEN   68 HLBC                     10/68
R29 H         (0.596)  (0.025)        HAIDT     71 HLBC +                   12/70
R29  D3480    0.698    0.025          CHIANG    72 OSPK +  1.84 GEV/C K+    9/72
R29  L 554    0.705    0.063          LUCAS2    73 HBC  -  DALITZ PRS ONLY  11/73
R29 B 1585    (0.608)  (0.014)        BRAUN     75 HLBC +                   1/76
R29           0.67     0.12           WEISSENBE 76 SPEC +                   1/78*
R29 E         (0.670)  (0.014)        HEINTZE   77 SPEC +                   12/77*
R29                  COMMENTS
R29  C  FROM CALLAHAN1 66 WE USE ONLY THE MU3/E3 RATIO AND DO NOT
R29  C  INCLUDE IN THE FIT THE RATIOS MU3/TAU AND E3/TAU, SINCE THEY SHOW
R29  C  LARGE DISAGREEMENTS WITH THE REST OF THE DATA.
R29  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R29  H  ONLY INDIVIDUAL RATIOS INCLUDED IN FIT (SEE R19 AND R20).          11/68
R29  D  CHIANG 72 R29 IS STATISTICALLY INDEPENDENT OF CHIANG 72 R5 AND R6.  9/72
R29  L  LUCAS 73 GIVES N(MU3)=554+-7.6PCT, N(E3)=786+-3.1PCT.  WE DIVIDE.   11/73
R29  B  BRAUN 75 VALUE IS FROM FORM FACTOR FIT.  ASSUMES MU-E UNIVERSALITY.  1/76
R29  E  HEINTZE 77 VALUE FROM FIT TO LAMBDA0.  ASSUMES MU-E UNIVERSALITY.   12/77*
R29       . . . . . . . . .
R29 AVG      0.679    0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R29 STUDENT  0.679    0.015   AVERAGE USING STUDENT1O(H/1.11) -- SEE MAIN TEXT
R29 FIT      0.663    0.018   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R30    CHAR. K INTO (PIO E NEU GAMMA)/(PIO E NEU) (UNITS 10**-2)
R30                                                        (P181)/(P6)
R30          1.2      0.8            BELLOTTI  67 HLBC +  EGAM GT 30MEV   11/67
R30  R 13    0.76     0.28           ROMANO    71 HLBC    EGAM GT 10MEV   10/71
R30 R        (0.53)   (0.22)         ROMANO    71 HLBC +  EGAM GT 30 MEV   9/73
R30  L 16    0.48     0.20           LJUNG     73 HLBC +  EGAM GT 30 MEV   9/73
R30 L        (0.22)   (0.15)  (0.10) LJUNG     73 HLBC +  EGAM GT 30 MEV   9/73
R30 L   FIRST LJUNG VALUE IS FOR COS(ELECT-GAMMA)L.T. 0.9, SECOND VALUE IS  9/73
R30 L   FOR COS(ELECT-GAMMA) BETW 0.6 AND 0.9 FOR COMPARISON WITH ROMANO.    9/73
R30 R   BOTH ROMANO VALUES ARE FOR COS(ELECT-GAMMA) BETW 0.6 AND 0.9.        9/73
R30 R   SECOND VALUE IS FOR COMPARISON WITH SECOND LJUNG VALUE.              9/73
R30 R   WE USE LOWEST EGAM CUT FOR TABLE VALUE. SEE ROMANO FOR EGAM DEPEND. 9/73
R30       . . . . . . . . . .
R30 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R31    K- INTO (PI+ E- E-)/TOTAL (UNITS 10**-5)                   (P19)
R31     TEST OF LEPTON NUMBER CONSERVATION.
R31          1.5   OR LESS          CHANG     68 HBC  -                    3/68

R32    CHAR. K INTO (PI NEU NEU)/TOTAL (UNITS 10**-6)             (P20)
R32 C        (1.4)  OR LESS  CL=.90   KLEMS     71 OSPK +  T(PI) 117-127MEV  3/74
R32 C        (0.94) OR LESS  CL=.90   CABLE     73 CNTR +  T(PI) 60-105 MEV  2/74
R32  C       0.56   OR LESS  CL=.90   CABLE     73 CNTR +  T(PI) 60-127 MEV  2/74
R32  L   0   57.0   OR LESS  CL=.90   LJUNG     73 HLBC +                    9/73
R32  C  KLEMS 71 AND CABLE 73 ASSUME PI SPECTRUM SAME AS KE3 DECAY.          3/74
R32  C  SECOND CABLE LIMIT COMBINES CABLE AND KLEMS DATA FOR VECTOR INT.     2/74
R32  L  LJUNG 73 ASSUMES VECTOR INTERACTION.                                9/73

R33    CHAR. K INTO (E NEU GAMMA)/TOTAL  (UNITS 10**-5)           (P21)
R33  M       7.1   OR LESS          MACEK     70 OSPK +  P(E) 234 TO 247   12/70
R33  M  ABOVE IS MEASUREMENT OF STRUCTURE-DEPENDENT DECAY ONLY.

R34    CHAR. K INTO (PI GAMMA)/TOTAL (UNITS 10**-6)               (P22)
R34          4.0   OR LESS  CL=.90   KLEMS     71 OSPK +                    8/71

R35    CHAR. K INTO (TAU)/(TAU PRIME)                             (P3/P4)
R35     USED FOR DELTA I=1/2 TEST.
R35       . . . . . . . . . .
R35 FIT      3.226    0.082  FROM FIT

R36    CHAR. K INTO (PI 3GAMMA)/TOTAL (UNITS 10**-4)              (P23)
R36          3.0   OR LESS  CL=.90   KLEMS     71 OSPK +  T(PI) GT 117MEV   8/71

R37    K+ INTO (PI+ PI+ E- NEU)/(PI+ PI- E+ NEU) (UNITS 10**-4)   (P8)/(P7)
R37     0  130.    OR LESS  CL=.95   BOURQUIN  71 ASPK                       8/76*
R37     3    3.6   OR LESS  CL=.95   BLOCH     76 SPEC                     8/76*

R38    CHAR. K INTO (PIO PIO E NEU)/KE3 (UNITS 10**-4)            (P24)/(P6)
R38     0   37.0   OR LESS  CL=.90   ROMANO    71 HLBC +                   12/71
R38     2    3.8       5.0      1.2  LJUNG     73 HLBC +                    9/73

R39    K+ INTO (PI- E+ MU+)/TOTAL (UNITS 10**-8)                  (P25)
R39    K- INTO (PI+ E- MU-)/TOTAL IS ALSO INCLUDED HERE
R39          2.8   OR LESS  CL=.90   BEIER     72 OSPK +-                   9/72

R40    K+ INTO (PI+ E+ MU-)/TOTAL (UNITS 10**-8)                  (P26)
R40    K- INTO (PI- E- MU+)/TOTAL IS ALSO INCLUDED HERE
R40          1.4   OR LESS  CL=.90   BEIER     72 OSPK +-                   9/72

R41    CHAR. K INTO (MU 3NEU)/TOTAL (UNITS 10**-6)                (P27)
R41  P   0    6.0   OR LESS  CL=.90   PANG      73 CNTR +                   11/73
R41  P  PANG 73 ASSUMES MU SPECTRUM FROM NEU-NEU INTERACTION OF PARDIN 70.   3/74

R42    CHAR. K INTO (PIO MU NEU GAM)/TOTAL(UNITS 10**-5)(P28)     9/73
R42     0    6.1   OR LESS  CL=.90   LJUNG     73 HLBC +  EGAM GT 30 MEV   9/73

R43    CHAR. K INTO (E PIO NEU)/(PI PIO)                          (P6)/(P2)
R43  L 786    0.221    0.012          LUCAS2    73 HBC  -  DALITZ PRS ONLY  11/73
R43  L  LUCAS 73 GIVES N(E3)=786+-3.1PCT, N(PI2)=3564+-3.1PCT.  WE DIVIDE.   11/73
R43       . . . . . . . . . .
R43 FIT      0.2280   0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R44    CHAR. K INTO (PI 2PIO)/(PI PIO)                            (P4)/(P2)
R44  L 574    0.081    0.005          LUCAS2    73 HBC  -  DALITZ PRS ONLY  11/73
R44  L  LUCAS 73 GIVES N(PI 2PIO)=574+-5.9 PCT, N(PI2)=3564+-3.1 PCT.       11/73
R44  L  WE QUOTE 0.5*N(PI 2PIO)/N(PI2) WHERE 0.5 IS BECAUSE ONLY DALITZ      11/73
R44  L  PAIR PIO'S WERE USED.                                               11/73
R44       . . . . . . . . . .
R44 FIT      0.0819   0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R45    CHAR. K INTO(MU NEU GAMMA)/TOTAL  (UNITS 10**-3) (P12)              7/74
R45     12    5.8      3.5            WEISSENBE 74 STRC +  E-GAMMA GT 9 MEV  7/74

R46    CHAR. K INTO (PI E+ E-)/(PI+ PI- E NEU) (UNITS 10**-3)  (P15)/(P7)
R46  B  41    7.0      1.3            BLOCH     75 SPEC +                   11/75
R46  B  BLOCH 75 QUOTES THIS RESULT MULTIPLIED BY OUR 1974 KE4 BR.FRAC.     11/75

R47    CHAR. K INTO (E NEU GAM)/(E NEU)                           (P21)/(P11)
R47  H  56    1.05     0.25     0.30  HEARD1    75 SPEC +  P(E) 236 TO 247  11/75
R47  H  ABOVE IS SENSITIVE ONLY TO STRUCTURE DECAY TERM.                     11/75

R48    K+ INTO (PI+-MU-+E+)/(PI+PI-E NEU) (UNITS 10**-4) (P25+P26)/(P7)     11/76*
R48  D   0    1.9   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76*
R48  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR. RATIO.        11/76*

R49    K+ INTO (PI+ MU+ E-)/(PI+PI- E NEU) (UNITS 10**-4)  (P29)/(P7)      11/76*
R49  D   0    1.3   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76*
R49  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76*

R50    CHAR. K INTO (MU NEU E+E-)/(PI+PI-ENEU) (UNITS 10**-3) (P30)/(P7)    11/76*
R50  D  14   (3.3)    (0.9)          DIAMANTBE 76 SPEC +  M(EE) GT 140      11/76*
R50  D  14   27.      8.             DIAMANTBE 76 SPEC +  EXTRAPOLATED BR   11/76*
R50  D  DIAMANTBE 76 QUOTES THESE RESULTS TIMES OUR 1975 KE4 BR RATIO.      11/76*
R50  D  THE SECOND DIAMANTBE 76 VALUE IS THE FIRST VALUE EXTRAPOLATED TO 0  11/76*
R50  D  TO INCLUDE LOW MASS E PAIRS.                                        11/76*

R51    K+- INTO(PI-+E+-E+-)/(PI+PI-E NEU)  UNITS(10**-4) (P19)/(P7)        11/76*
R51  D   0    2.5   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76*
R51  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 BR RATIO.            11/76*

R52    K+- INTO(MU-+ NEU E+- E+-)/(PI+PI-E NEU)(UNITS 10**-3) (P31)/(P7)    11/76*
R52  D   0    0.5   OR LESS  CL=.90   DIAMANTBE 76 SPEC +                    11/76*
R52  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76*

R53    K+ INTO (NEU E+ E+ E-)/(PI+PI- E NEU) (UNITS 10**-2) (P32)/(P7)     11/76*
R53     4   0.54     0.54     0.27  DIAMANTBE 76 SPEC +                    11/76*
R53  D  DIAMANTBE 76 QUOTES THIS RESULT TIMES OUR 1975 KE4 BR RATIO.         11/76*
```

Note on Slope Parameter for $K \to 3\pi$ Decays

As was discussed in Section VI B.1 of the text, for the 3π decays of the K mesons we list the slope parameter "g" which is defined, as in that section, by

$$|M|^2 \propto 1 + g\frac{(s_3 - s_0)}{m_{\pi^+}^2} + h\left(\frac{s_3 - s_0}{m_{\pi^+}^2}\right)^2 + j\frac{(s_2 - s_1)}{m_{\pi^+}^2} + k\left(\frac{s_2 - s_1}{m_{\pi^+}^2}\right)^2 + \ldots, \quad (1)$$

where

$$s_i = (p_K - p_i)^2 = (m_K - m_i)^2 - 2m_K T_i \quad (2)$$

$$s_0 = \frac{1}{3}\sum s_i = \frac{1}{3}(m_K^2 + m_1^2 + m_2^2 + m_3^2) \quad (3)$$

p_K, p_i are the four-vectors for the K and the ith pion, and the index 3 refers to the odd pion, i.e., the third pion in the decays listed below. (4)

We refer to the three possible charged decays as τ, τ', and τ^0:

$\tau^{\pm}$ $\quad K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$

$\tau'^{\pm}$ $\quad K^{\pm} \to \pi^0\pi^0\pi^{\pm}$

τ^0 $\quad K_L^0 \to \pi^+\pi^-\pi^0$

The measurements of g vary considerably beyond the authors' quoted errors as can be seen in the ideograms associated with the GT+, GT-, and GTP subsections of the $K^{\pm}$ Data Card Listings and the

Stable Particles
$K^{\pm}$

GTO subsection of the K_L^0 Listings. Appendix I discusses tests of the $\Delta I = 1/2$ rule utilizing these slopes.

There is no indication of a CP-violating asymmetry in K_L^0 decay as measured by the asymmetry parameter $\sigma_{\pm}$ (equivalent to j) given in subsection A of the K_L^0 Listings.

The high-statistics τ^0-decay experiment of MESSNER 74 finds significant non-zero quadratic coefficients h and k. CHO 77, a lower-statistics τ^0 experiment, obtains results in agreement with MESSNER 74 but can also obtain good fits with a linear term (g) only. The correlation between the linear and quadratic coefficients changes the CHO 77 g_{τ^0} from 0.629 ± 0.017 (linear fit) to 0.681 ± 0.024 (quadratic fit). Another recent experiment, PEACH 77, does not observe this correlation and is in agreement only with the linear fit of CHO 77.

Because the quadratic terms are required by MESSNER 74, we now include only those τ^0 experiments in the average for which we have quadratic (g,h,k) fit information.

There is some evidence for a non-zero k coefficient from $\tau^{\pm}$ experiments. FORD 72 (1.5M events) have studied $K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$ and find that the χ^2/DF goes from 1.38 to 1.20 for DF $\approx$ 150 when the second order and CP-violation terms are added. However, the authors state that since their Coulomb correction is larger than the experimental errors and is not well known, it is difficult to interpret these results. DEVAUX 77 also finds a non-zero k. However, these experiments do not find a strong correlation between g and the second order coefficients. We continue compiling the linear coefficient g.

Parametrizations

In the literature other definitions of slope parameters have appeared. We have converted to the definition of g in Eq. (1) whatever experimental quantity has been reported. We give the conversion to the definition (1) for the most widely used parametrizations and tabulate the conversion factors for the reader's convenience.

a) For analysis of charged K's the expression often used is:

$$|M|^2 = 1 + a_y Y$$

with

$$Y = \frac{3T_3 - Q}{Q} \quad , \qquad Q = m_K - \sum m_i \quad .$$

The relevant formulae are:

$$Y = -\frac{3}{2}\,\frac{s_3 - s_0}{m_K Q} + \Delta$$

with

$$\Delta = \frac{m_1 - m_3}{Q}\left(2 - \frac{m_3 + m_1}{m_K}\right)$$

and

$$\boxed{g = \frac{-c_y a_y}{1 + a_y \Delta}} \quad , \qquad \text{with} \quad c_y = \frac{3}{2}\,\frac{m_{\pi^+}^2}{m_K Q} \quad .$$

b) For the analysis of K^0 decay the expression often used is:

$$|M|^2 = 1 + 2a_t \frac{m_K}{m_{\pi^+}^2}(2T_3 - T_{3max})$$

with

$$T_{3max} = \frac{m_K^2 + m_3^2 - 4m_{12}^2}{2m_K} - m_3 \quad .$$

The relevant transformations are

$$T_3 = -\frac{s_3 - s_0}{2m_K} + \frac{Q}{3}(1 + \Delta)$$

and

$$\boxed{g = \frac{-2a_t}{1 + a_t c_t}} \quad ,$$

with

$$c_t = \frac{2m_K}{m_{\pi^+}^2}\left[\frac{2}{3}Q(1+\Delta) - T_{3max}\right] \quad .$$

c) Other K^0 authors use the same form of matrix element as given in b) above, but define

$$T_{3max} = \frac{2}{3}Q \quad .$$

Data Card Listings

For notation, see key at front of Listings.

The relevant transformation is then

$$\boxed{g = \frac{-2a_u}{1 + a_u c_u}} \text{ , with } c_u = \frac{4m_K}{3m_{\pi^+}^2} Q\Delta \ .$$

d) Older K^0 analyses were done using

$$|M|^2 = 1 + a_v \frac{T_3}{m_K} \ .$$

The relevant transformation is then

$$\boxed{g = \frac{-c_v a_v}{1 + d_v a_v}} \text{ , with } c_v = \frac{m_{\pi^+}^2}{2m_K^2}$$

and

$$d_v = \frac{Q}{3m_K}(1 + \Delta) \ .$$

For the reader's convenience we give a table of numerical values for Q, T_{3max}, Δ, c_y, and c_t, obtained using the masses from the current edition.

	$\tau^{\pm}$	$\tau'^{\pm}$	τ^0
Q	75.00	84.21	83.60
T_{3max}	48.10	53.22	53.91
Δ	0.0	-0.0789	0.0798
c_y	0.7891	0.7028	0.7023
c_t	0.0963	-0.0768	0.3204
c_u	0.0	-0.2247	0.2272
c_v	0.0400	0.0400	0.0393
d_v	0.0506	0.0524	0.0605

References

See the reference sections of the $K^{\pm}$ and K_L^0 Data Card Listings.

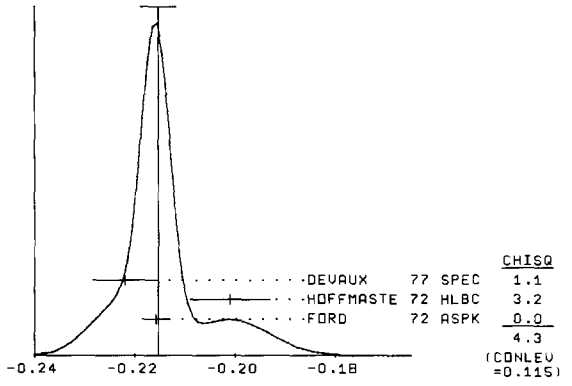
```
                10  CHARGED K ENERGY DEPENDENCE OF DALITZ PLOT

          RELATED TEXT SECTION VI B.1, APPENDIX I, AND MINI-REVIEW ABOVE

       MATRIX ELEMENT SQUARED =  1 + G (S3-S0)/(MPI+**2)

GT+  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  K+ INTO PI+ PI+ PI-
GT+      THESE EXPTS FIT M**2=1+AY*Y. WE LIST G IN THE MAIN LISTING AND
GT+      GIVE AY AT RIGHT. G=-1.5*AY*(MPI**2)/(MK*Q). SEE NOTE ABOVE.
GT+ZL 5428   (-0.22)   (0.024)          ZINCHENKO  67 HBC  +  AY=0.28+-.03      10/69
GT+ L 9994   (-0.218)  (0.016)          BUTLER     68 HBC  +  AY=0.277+-.020     10/69
GT+ G17898   (-0.196)  (0.012)          GRAUMAN    70 HLBC +  AY=0.228+-.030     8/70
GT+Q  750K    -0.2158   0.0028          FORD       72 ASPK +  AY=0.2734+-.0035   4/72
GT+  39819    -0.201    0.008           HOFFMASTE  72 HLBC +  INCLUDES GRAUMAN   1/71
GT+  225K     -0.222    0.0064          DEVAUX     77 SPEC +  AY=0.2822+-.0077 11/77*
GT+ L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.                   3/78*
GT+ Z   ALSO INCLUDES DBC EVENTS
GT+ G   EMULS. DATA ADDED - ALL EVENTS INCLUDED BY HOFFMASTER 72                 1/71
GT+ Q   THIS VALUE OF AY IS FROM A QUADRATIC FIT WITH Y**2 COEF=.030+-.010.     4/72
GT+ Q   A LINEAR FIT IS QUOTED ONLY FOR THEIR COMBINED K+ AND K- SAMPLE.        4/72
GT+ Q   IT GIVES AY=0.2737+-.0032 .  THE QUADRATIC FIT TO THE COMBINED          4/72
GT+ Q   SAMPLE GIVES AY=0.2752+-.0033 AND Y**2 COEFF=0.025+-.010 .              4/72
GT+ Q   (CHISQ/DF)=1.38 FOR LINEAR FIT AND 1.20 FOR QUADRATIC FIT.              1/73
GT+          .  .  .  .  .  .  .  .  .  .
GT+ AVG      -0.2153   0.0036  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
GT+ STUDENT  -0.2155   0.0027  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                               (SEE IDEOGRAM BELOW )
```

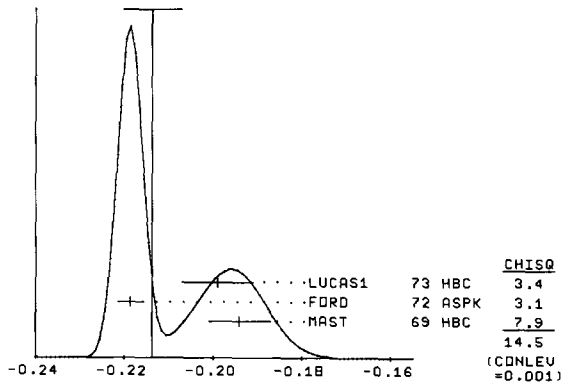
WEIGHTED AVERAGE = -0.2153 ± 0.0036
ERROR SCALED BY 1.5



LIN. ENERGY DEP. FOR K+ TO PI+ PI+ PI-

```
GT-  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  K- INTO PI- PI- PI+
GT-      FOR DEFINITION OF AY SEE NOTE IN ABOVE SECTION GT+.
GT- F 1347   (-0.220)  (0.035)          FERRO-LUZ  61 HBC   - AY=0.28+-.045     10/69
GT-ML 5778   (-0.190)  (0.023)          MOSCOSO    68 HBC   - AY=0.242+-.029     10/69
GT-  50919    -0.194    0.007           MAST       69 HBC   - AY=0.247+-.009     10/69
GT-Q  750K    -0.2187   0.0028          FORD       72 ASPK  - AY=0.2770+-.0035   4/72
GT-    81K    -0.199    0.008           LUCAS1     73 HBC   - AY=0.252+-.011     10/72
GT- F   NO RADIATIVE CORRECTIONS INCLUDED.
GT- L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.                   3/78*
GT- M   ALSO INCLUDES DBC EVENTS.
GT- Q   THIS VALUE OF AY IS FROM A QUADRATIC FIT WITH Y**2 COEF=.020+-.010.     4/72
GT- Q   SEE ALSO THE NOTE Q IN THE GT+ SECTION ABOVE.                           4/72
GT-          .  .  .  .  .  .  .  .  .  .
GT- AVG      -0.2137   0.0067  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
GT- STUDENT  -0.2147   0.0037  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                               (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = -0.2137 ± 0.0067
ERROR SCALED BY 2.7



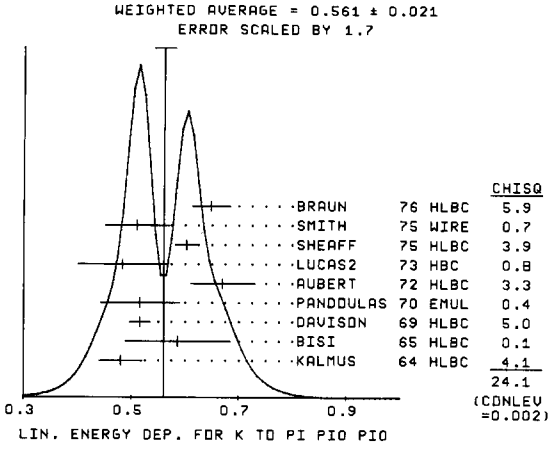
LIN. ENERGY DEP. FOR K- TO PI- PI- PI+

```
DG  ((GT+)-(GT-))/((GT+)+(GT-)) IN PERCENT
DG      A NON-ZERO VALUE FOR THIS QUANTITY INDICATES CP VIOLATION
DG    3.2M    -0.70     0.53          FORD       70 ASPK                        11/70

GTP  LINEAR ENERGY DEPENDENCE (G) FOR TAU PRIME DECAY CHA.K INTO PI PIOPIO
GTP   1792     0.48      0.04          KALMUS     64 HLBC +                      10/69
GTP   1874     0.586     0.098         BISI       65 HLBC +  ALSO HBC            10/69
GTP   4048     0.516     0.020         DAVISON    69 HLBC +  ALSO EMUL           10/69
GTP    198     0.516     0.074         PANOGOULAS 70 EMUL +                      10/70
GTP A1365      0.67      0.06          AUBERT     72 HLBC                        1/73
GTP    574     0.484     0.084         LUCAS2     73 HBC  -  DALITZ PRS ONLY     9/73
GTP   5635     0.602     0.021         SHEAFF     75 HLBC +                      2/76
GTP  S 27K     0.510     0.060         SMITH      75 WIRE +                      12/75
GTP  B3263     0.648     0.036         BRAUN      76 HLBC +                      11/77*
GTP LE4639    (0.806)   (0.220)        BERTRAND   76 EMUL                        12/77*
GTP  A  WE GIVE LINEAR TERM OF HIGHER ORDER FIT. EQ.1 OF APP.II,AUBERT 72.      1/73
GTP  S  SMITH 75 MEASURES QUADRATIC COEFFICIENT H=0.009+-0.040.                 12/75
GTP  B  BRAUN 76 GIVES C=.3244+-.018 FOR LINEAR MATX.ELEM. FIT. ABOVE G=2*C.    11/77*
GTP  E  WE GIVE LINEAR TERM OF HIGHER ORDER FIT.                                12/77*
GTP L   EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.                   3/78*
GTP          .  .  .  .  .  .  .  .  .  .
GTP AVG      -0.561    0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
GTP STUDENT  -0.559    0.020   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                               (SEE IDEOGRAM BELOW )
```

Stable Particles

$K^{\pm}$



Note on $K^{\pm}_{\ell 3}$ and $K^{0}_{\ell 3}$ Form Factors

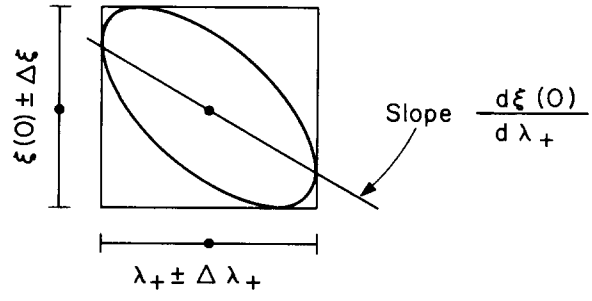
Definitions of the parameters λ_+, $\xi(0)$, λ_0, $|f_S/f_+|$ and $|f_T/f_+|$ and a general discussion of the methods of analysis are given in Section VI B.2 of the text.

This note describes the contents of the Data Card Listings for the two $K_{\mu 3}$ parametrizations, (λ_+, $\xi(0)$) and (λ_+, λ_0), which were discussed in the text. Problems related to our data entries for individual experiments are discussed and a comparison of results is given.

$K_{\mu 3}$ Experiments

The matrix element for $K_{\mu 3}$ decay, assuming a pure vector current, is given by Eq. (2) in Section VI B.2 of the text. Most experiments appear to be compatible with the assumption that f_+ depends linearly on t and that f_- is constant. Only DALLY 72 ($K^0_{\mu 3}$) appears to require $\lambda_- \neq 0$ (by about three standard deviations). A single data bin at low q^2 seems to be responsible. The effect is not observed in the high-statistics experiment of DONALDSON2 74 (also $K^0_{\mu 3}$).

λ_+, $\xi(0)$ Parametrization: λ_+ data from $K_{\mu 3}$ decay are entered into the $K^{\pm}$ and K^0_L sections of the Data Card Listings in subsection L+M. The corresponding $\xi(0)$ values are entered in subsection XIA, XIB, or XIC, depending on whether Method A, B, or C, discussed below and in the text, was used. The data cards contain the values, one-standard-deviation errors $\Delta\lambda_+$ and $\Delta\xi(0)$, as well as the correlation $d\xi(0)/d\lambda_+$, all indicated on the $e^{-1/2}$ likelihood contour below. The correlations are given on the right side of the $\xi(0)$ data cards.



λ_+, λ_0 Parametrization: This parametrization is used in recent $K_{\mu 3}$ analyses. To facilitate comparison between experiments, we convert earlier experiments from the (λ_+,$\xi(0)$) parametrization to (λ_+,λ_0) whenever possible (i.e., when λ_+ and $\xi(0)$ values, errors, and correlations are given). The transformation between these parametrizations is:

$$\lambda_0 = \lambda_+ + a\xi(0) \ ,$$

$$\Delta\lambda_0^2 = (1 + 2a\frac{d\xi(0)}{d\lambda_+})\Delta\lambda_+^2 + a^2\Delta\xi^2 \ ,$$

$$\frac{d\lambda_0}{d\lambda_+} = 1 + a\frac{d\xi(0)}{d\lambda_+} \ ,$$

where $a = m_\pi^2/(m_K^2 - m_\pi^2)$. The λ_0 value, the one-standard-deviation error $\Delta\lambda_0$, and the correlation $d\lambda_0/d\lambda_+$ are given in subsection L0 of the data cards.

We also convert (λ_+,λ_0) results into the (λ_+, $\xi(0)$) parametrization whenever possible so that subsection L0 is essentially equivalent to the three subsections XIA, XIB, and XIC.

Individual analyses have used a variety of parametrizations. Problems arise when trying to express their results in terms of the parametrizations used here. The discussion of these problems is divided into three sections corresponding to the three methods of analyses discussed in the text.

Method A: Dalitz plot analyses and pion spectrum analyses usually determine λ_+ and $\xi(0)$ (or λ_0) values, errors, and correlation. Such measurements are entered in the L+M, XIA, and L0 subsections. They give rise to the error ellipses

shown in Figs. 1 and 2. These are approximations to likelihood contours.

Some analyses of this type fix λ_+ and determine $\xi(0)$, e.g., CARPENTER 66 and PEACH 73 (both $K^0_{\mu 3}$). We enter $\xi(0)$ and $d\xi(0)/d\lambda_+$ in the XIA section and give the fixed λ_+ value in the data card footnote. The $\xi(0)$ error is parenthesized because it does not include the uncertainty in the value of λ_+. These results, transformed to λ_0 measurements, give rise to bands in Fig. 2. These bands are also approximations to the likelihood contours. The actual likelihood bands would not be straight.

In some cases, we alter an error from its published value in order to obtain an error ellipse with a width which matches the error in $\xi(0)$ for fixed λ_+. These adjustments are noted in the $\xi(0)$ data card footnotes, e.g., for CALLAHAN1 66 and HAIDT 71 (K^+ subsection XIA), where the published errors and correlation violate the constraint $|c_{\lambda\xi}| < 1$ on the normalized correlation coefficient $c_{\lambda\xi}$ given by

$$c_{\lambda\xi} = \frac{\Delta\lambda_+}{\Delta\xi}\,\frac{d\xi(0)}{d\lambda_+} \quad .$$

In some cases, e.g., BRAUN1 73, the parametrization used is λ_+, $\xi(0)$, $\xi(t^*)$, where t^* is the weighted average of t with weighting according to the sensitivity to ξ. In this case we do not use $\xi(0)$. It is a badly determined parameter comparable to λ_- or the slope of $\xi(t)$. Instead, we use

$$\xi(0) = \xi(t^*)(1 + \lambda_+ t^*) \quad ,$$

$$\frac{d\xi(0)}{d\lambda_+} = \frac{d\xi(t^*)}{d\lambda_+}(1 + \lambda_+ t^*) + \xi(t^*)t^* \quad .$$

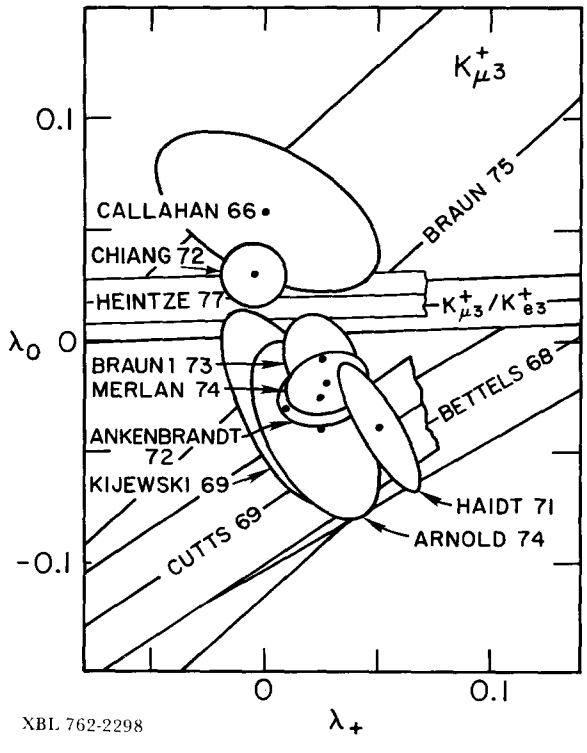


Fig. 1. One-standard-deviation ($e^{-1/2}$) likelihood contours in the (λ_+, λ_0) plane for $K^+_{\mu 3}$.

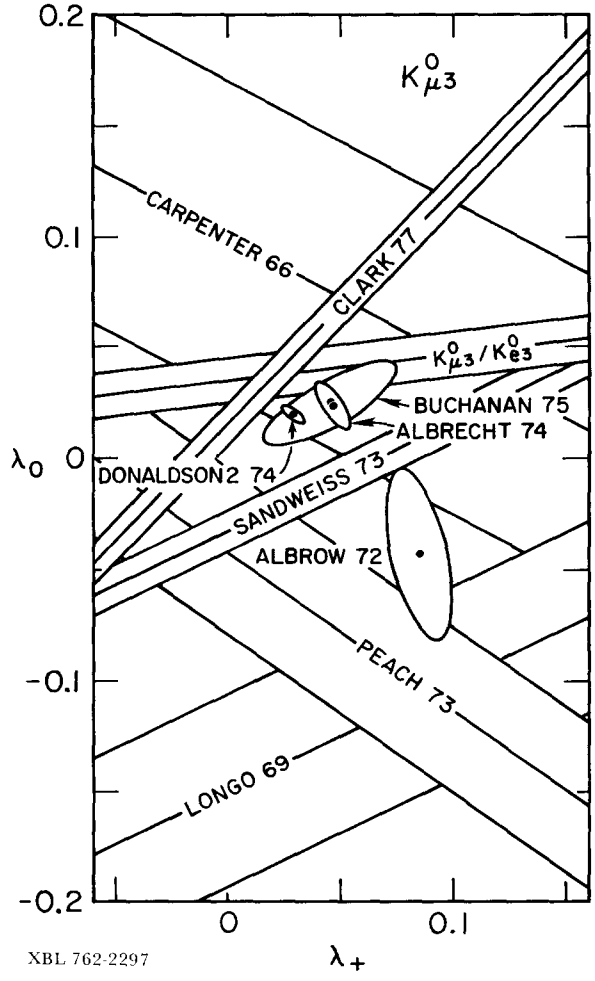


Fig. 2. One-standard-deviation ($e^{-1/2}$) likelihood contours in the (λ_+, λ_0) plane for $K^0_{\mu 3}$.

Stable Particles

$K^{\pm}$

Data Card Listings

For notation, see key at front of Listings.

With the BRAUN1 73 values, $\lambda_+ = 0.027$, $\xi(6.6) = -0.34 \pm 0.20$, and $d\xi(6.6)/d\lambda_+ = -14$, we obtain

$$\xi(0) = (-0.40 \pm 0.24) - 19(\lambda_+ - 0.027) ;$$

or for their fitted $\lambda_+ = 0.025 \pm 0.017$, we get $\xi(0) = -0.36 \pm 0.40$.

Method B: Branching ratio experiments cannot determine λ_+ and $\xi(0)$ simultaneously, but simply fix a relationship between them, given in Section VI B.2 of the text. Results are usually quoted as values of $\xi(0)$ at fixed λ_+. We list these results in subsection XIB, but we do not average them because the λ_+ values differ. Instead, we compute a combined result by using the relations in the text and our fitted values of $\Gamma(K^{\pm}_{\mu 3})/\Gamma(K^{\pm}_{e3})$ and $\Gamma(K^0_{\mu 3})/\Gamma(K^0_{e3})$, which include the branching ratios from these experiments. The branching ratios from our current edition and the results for $\xi(0)$ and λ_0 evaluated at $\lambda_+ = 0.030$ are

	$K^{\pm}$	K^0_L
$\Gamma(K_{\mu 3})/\Gamma(K_{e3})$	$0.663 \pm .018$ (S=1.7)	$0.695 \pm .017$
$\xi(0)$	$-0.20 \pm .15$ (S=1.7)	$+0.08 \pm .13$
$d\xi(0)/d\lambda_+$	-11.9	-10.3
λ_0	$+0.014 \pm .012$ (S=1.7)	$+0.037 \pm .011$
$d\lambda_0/d\lambda_+$	+0.04	+0.12

The scale factor S is the amount by which the error has been multiplied in order to compensate for discrepancies in the branching ratios. These λ_0 results give rise to the $K_{\mu 3}/K_{e3}$ bands in Figs. 1 and 2.

Method C: Polarization experiments measure $\langle \xi(t) \rangle$, the weighted average of $\xi(t)$ over the t range of the experiment, where the weighting accounts for the variation with t of the sensitivity to $\xi(t)$. Such measurements are entered in subsection XIC.

To reinterpret these results in the $(\lambda_+, \xi(0))$ parametrization, we recognize that $\lambda_+ = 0$ corresponds to $\xi(t)$ constant (always assuming $\lambda_- = 0$) so that

$$\xi(0)\big|_{\lambda_+=0} \equiv \langle \xi(t) \rangle .$$

The correlation with λ_+ is given by the following relations (valid for small λ_+):

$$\xi(0) \approx \langle \xi(t) \rangle \left(1 + \lambda_+ \left\langle \frac{t}{m_\pi^2} \right\rangle\right) ,$$

$$\frac{d\xi(0)}{d\lambda_+} \approx \langle \xi(t) \rangle \left\langle \frac{t}{m_\pi^2} \right\rangle ,$$

where $\langle t/m_\pi^2 \rangle$ is the average value of t weighted by the sensitivity to $\xi(t)$. These results, transformed to λ_0 and $d\lambda_0/d\lambda_+$ values, are entered in subsection L0 and give rise to bands in Figs. 1 and 2.

In Figs. 1 and 2, we disregard those polarization measurements for which $d\xi(0)/d\lambda_+$ is not obtainable. Also we disregard MERLAN 73 because the signs of $\xi(0)$ and $d\xi(0)/d\lambda_+$ are opposite, whereas the above equation requires them to be the same (since $t > 0$).

Comparison of $K_{\mu 3}$ Experiments: Figures 1 and 2 show the likelihood contours in the (λ_+, λ_0) plane for $K^+_{\mu 3}$ and $K^0_{\mu 3}$ respectively.

The $K^+_{\mu 3}$ Dalitz plot results (ellipses) shown are fairly consistent and appear to cluster between the $K_{\mu 3}/K_{e3}$ result and the polarization results of BETTELS 68 and CUTTS 69. The $K^0_{\mu 3}$ results are much less consistent with a small cluster appearing in the neighborhood of the DONALDSON2 74 result.

χ^2 fits to the results shown in Fig. 1 and Fig. 2 yield the following values for λ_+ and λ_0. The corresponding values of $\xi(0)$ are also given.

	$K^+_{\mu 3}$	$K^0_{\mu 3}$
λ_+	$+0.026 \pm .008$*	$+0.034 \pm .006$*
λ_0	$-0.003 \pm .007$*	$+0.020 \pm .007$*
$d\lambda_0/d\lambda_+$	-0.15	-0.24
χ^2/DF	40/19	72/12
S*	1.5	2.5
$\xi(0)$	$-0.35 \pm .14$*	$-0.16 \pm .11$*
$d\xi(0)/d\lambda_+$	-14.	-15.

*All errors have been increased by the scale factor $S = (\chi^2/DF)^{\frac{1}{2}}$ to take into account the discrepancies between measurements.

Data Card Listings

For notation, see key at front of Listings.

In view of the large χ^2/DF of these fits, especially $K^0_{\mu 3}$, the fit results should be taken with a grain of salt. The largest contributors to χ^2 in the $K^+_{\mu 3}$ case are CHIANG 72 with 8.1, and the polarization results, BETTELS 68 with 6.8 and CUTTS 69 with 5.5. In the $K^0_{\mu 3}$ case the largest contributors are the polarization results of SANDWEISS 73 with 17, LONGO 69 with 14, and CLARK 77 with 12, and the Dalitz plot results of ALBROW 72 with 11, ALBRECHT 74 with 7.3, and PEACH 73 with 5.3. All other χ^2 values were less than 4.

The DONALDSON2 74 result

$$\lambda_+ = 0.030 \pm 0.003$$

$$\lambda_0 = 0.019 \pm 0.004$$

clearly dominates the statistics in the $K^0_{\mu 3}$ case. The λ_+ value is consistent with the K_{e3} value of λ_+, and with the pole approximation

$$f_+(t) = f_+(0)\,\frac{m^2_{K^*}}{m^2_{K^*} - t}\ .$$

Their $f_0(t)$ extrapolates linearly to the Callan-Treiman point. It is less than two standard deviations from the $K_{\mu 3}/K_{e3}$ result.

K_{e3} Experiments

The f_- term of the matrix element [Eq. (2) text Section VI B.2] can be neglected for K_{e3} because it is proportional to the lepton mass. The f_+ term is usually assumed to be linear in $t = q^2 = (P_K - P_\pi)^2$, the square of the four-momentum transfer, i.e., the effective mass of the lepton pair. We quote the linear coefficient λ^e_+ (L+E on the data cards). There has been some suggestion of departure from linearity [CHIEN 71 (K^0_{e3}) and Chounet, Gaillard, and Gaillard[1] — Review] but no compelling evidence. The λ_+ results are fairly consistent and the average values are

$$K^+_{e3}: \quad \lambda_+ = 0.0285 \pm 0.0043$$

$$K^0_{e3}: \quad \lambda_+ = 0.0300 \pm 0.0018 \quad (S = 1.2)$$

where the K^0_{e3} error has been multiplied by the scale factor 1.2 to compensate for inconsistencies (see ideogram in K^0_L section L+E).

See also the excellent reviews of Gaillard and Chounet,[1] Chounet, Gaillard, and Gaillard,[2] and Pondrom.[3]

References

1. M. K. Gaillard and L. M. Chounet, "$K_{\ell 3}$ Form Factors," CERN 70-14 (May 1970), and Phys. Letters 32B, 505 (1970).
2. L. M. Chounet, J. M. Gaillard, and M. K. Gaillard, Physics Reports 4C, 199 (1972).
3. L. G. Pondrom, "Weak Decay Processes," Proc. Particles and Fields 1976, BNL, Oct. 6-8, 1976.

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                10  CHARGED K FORM FACTORS                                                    8/67

  RELATED TEXT SECTION VI B.2 AND MINI-REVIEW ABOVE.

  IN THE FORM FACTOR COMMENTS, THE FOLLOWING ABBREVIATIONS ARE USED.
  F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT.
  FS AND FT REFER TO THE SCALAR AND TENSOR TERM.
  F0 = (F+) + (F-)*T/(MK**2-MPI**2)
  L+, L- AND L0 ARE THE LINEAR EXPANSION COEFFS. OF F+, F- AND F0.
  L+ REFERS TO THE KMU3 VALUE EXCEPT IN THE KE3 SECTIONS.
  DXI/DL IS THE CORRELATION BETWEEN XI(0) AND L+ IN KMU3.
  DL0/DL+ IS THE CORRELATION BETWEEN L0 AND L+ IN KMU3.
  T  = MOMENTUM TRANSFER TO THE PI IN UNITS OF MPI**2.
  DP = DALITZ PLOT ANALYSIS
  PI = PI SPECTRUM ANALYSIS
  MU = MU SPECTRUM ANALYSIS
  POL= MU POLARIZATION ANALYSIS
  BR = KMU3/KE3 BRANCHING RATIO ANALYSIS
  E  = POSITRON OR ELECTRON SPECTRUM ANALYSIS
  RC = RADIATIVE CORRECTIONS

XIA    XIA = F-/F+ (DETERMINED FROM SPECTRA)  ------------------------------
XIA      76  (+1.81)    (0.6)            BROWN     62 XEBC +  DP+BR, L+=0          1/74
XIA      87  (+0.7)     (0.5)            GIACOMELL 64 ENUL +  MU+BR RVUE, L+=0     1/74
XIA J          (-0.08)   (0.7)            JENSEN    64 XEBC +  DP+BR(KMU3,KE3)     1/74
XIA    2648    (0.0)     (1.1)    (0.9)  CALLAHA1  66 FRBC +  MU, L+=0, T UNKN     1/74
XIA  C 444     +0.72      0.93            CALLAHA1  66 FRBC +  PI, DXI/DL=-.17      1/74
XIA      78  (-0.5)     (0.9)            EISLER    68 HLBC +  PI,L+=0,NO DX/DL     1/74
XIA  K2041     -0.5       0.8             KIJEWSKI  69 OSPK +  PI, DXI/DL=-.26      1/74
XIA  H3240     -1.1       0.56            HAIDT     71 HLBC +  DP, DXI/DL=-.29      1/74
XIA  A4025     -0.62      0.28            ANKENBRAN 72 ASPK +  PI, DXI/DL=-.12      1/74
XIA  B3480     +0.45      0.28            CHIANG    72 OSPK +  DP, DXI/DL=-.15      1/74
XIA  01897     -0.36      0.40            BRAUN1    73 HLBC +  DP, DXI/DL=-.19      3/74
XIA  N 490     -0.8       0.8             ARNOLD    74 HLBC +  DP, DXI/DL=-.20     11/75
XIA  M6527     -0.57      0.24            MERLAN    74 ASPK +  DP, DXI/DL= -9       3/74
XIA J   JENSEN 64 GIVES L+=L+E=-.020+-.027. DXI/DL UNKNOWN. INCLUDES               1/74
XIA J   SHAKLEE 64 XIB(KMU3/KE3).                                                  1/74
XIA  C  CALLAHAN 66 TABLE 1 (PI ANAL) GIVES DXI/DL=(.72-.05)/(0-.04)=-17,          1/74
XIA  C  ERROR RAISED FROM .80 TO AGREE WITH DXI0=.37 FOR FIXED L+.                 1/74
XIA  K  KIJEWSKI 69 FIG. 17 WAS USED TO OBTAIN DXI/DL AND ERRORS.                  1/74
XIA  H  HAIDT 71 TABLE 8 (DP ANAL) GIVES DXI/DL=(-1.1+0.5)/(.050-.029)=-29,        1/74
XIA  H  ERROR RAISED FROM .50 TO AGREE WITH DXI0=.20 FOR FIXED L+.                 1/74
XIA  A  ANKENBRANDT 72 FIG. 3 WAS USED TO OBTAIN DXI/DL.                           1/74
XIA  B  CHIANG 72 FIG. 10 WAS USED TO OBTAIN DXI/DL.                               1/74
XIA  B  FIT HAD L-=L+ BUT WOULD NOT CHANGE FOR L-=0.  L.PONDROM,PRIV.COM.74        1/74
XIA  D  BRAUN1 73 GIVES XI(T)=-.344+-.20, DXI(T)/DL+=-14 FOR L+=.027, T=6.6.       3/74
XIA  D  WE CALCULATE ABOVE XI(0) AND DXI(0)/DL+ FOR THEIR L+=.025+-.017 .          3/74
XIA  N  ARNOLD 74 FIG. 4 WAS USED TO OBTAIN XIA AND DXI/DL.                        11/75
XIA  M  MERLAN 74 FIG.5 WAS USED TO OBTAIN DXI/DL.                                 3/74
XIA     . . . . . .
XIA FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.

XIB    XIB = F-/F+ (DETERMINED FROM KMU3/KE3)  ------------------------------
XIB     THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN XI(0)            1/74
XIB     AND L+.  WE QUOTE THE AUTHORS XI(0) AND ASSOCIATED L+ BUT DO NOT           1/74
XIB     AVERAGE BECAUSE THE L+ VALUES DIFFER.  THE FIT RESULT AND SCALE            1/74
XIB     FACTOR GIVEN IN THE ABOVE NOTE ON KL3 FORM FACTORS ARE NOT OBTAINED        2/76
XIB     FROM THESE XIB VALUES.  INSTEAD THEY ARE OBTAINED DIRECTLY FROM THE        2/76
XIB     FITTED KMU3/KE3 RATIO (R29).                                               2/76
XIB            -0.17     0.75     0.99  SHAKLEE   64 XEBC +  BR, L+=0            1/74
XIB            +0.6      0.5             BISI 1    65 HBC  +  BR, L+=0            1/74
XIB     500    +0.8      0.6             CUTTS     65 OSPK +  BR, L+=0            1/74
XIB     636    +0.4      0.4             CALLAHA1  66 FRBC +  BR, L+=0            1/74
XIB     306    +0.75     0.50            AUERBACH  67 OSPK +  BR, L+=0            1/74
XIB B 5601  (-0.08)   (0.15)            BOTTERIL2 68 ASPK +  BR,L+=.023+-.008     1/74
XIB E 1398  (-0.60)   (0.20)            EICHTEN   68 HLBC +  BR, SEE NOTE E       1/74
XIB     986    +1.0      0.6             GARLAND   68 OSPK +  BR, L+=0            1/74
XIB            +0.91     0.82            ZELLER    69 ASPK +  BR, L+=.023         1/74
XIB  B         -0.35     0.22            BOTTERIL  70 OSPK +  BR,L+=.045+-.015    1/74
XIB  E1505     -0.81     0.27            HAIDT     71 HLBC +  BR,L+=.028,FIG.8    1/74
XIB   5825      0.0      0.15            CHIANG    72 OSPK +  BR,L+=.03,FIG.10    1/74
XIB  H 55K     -0.12     0.12            HEINTZE   77 CNTR +  BR,L+=.029          3/78*
XIB  B  BOTTERIL 70 IS REEVALUATION OF BOTTERIL 2 68 WITH DIFFERENT L+.            1/74
XIB  E  EICHTEN 68 HAS L+=.023+-.008, T=4, INDEP. OF L-. REPL. BY HAIDT 71.       1/74
XIB  H  CALCULATED BY US FROM L0 AND L+ GIVEN BELOW.                               3/78*
XIB     . . . . . .
XIB FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.

XIC    XIC = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)  -------------
XIC     THE MU POLARIZATION IS A MEASURE OF XI(T), NO ASSUMPTIONS ON L+-
XIC     NECESSARY, T (WEIGHTED BY SENSITIVITY TO XI0) SHOULD BE SPECIFIED.
XIC     IN L+,XI(0) PARAMETERIZATION THIS IS XI(0) FOR L+=0.  DXI/DL=XI*T.
XIC     FOR RAD. CORR. TO MUON POLARIZATION IN KMU3 SEE GINSBERG 71.
XIC T 2100  (+1.2)    (2.4)    (1.8)  BORREANI  65 HLBC +  POLARIZATION       8/67
XIC T  500 BTWN -4.0 AND +1.7          CUTTS     65 OSPK +  LONG. POL.          1/74
XIC T  397  (-1.4)    (1.8)            CALLAHA1  66 FRBC +  TOTAL POL.          8/67
XIC T 2950  (-0.7)    (0.9)    (3.3)  CALLAHA1  66 FRBC +  LONG. POL.          8/67
XIC  B6000    -1.0      0.3             BETTELS   68 HLBC +  TOTAL POL. T=4.9    1/74
XIC  C3133    -0.95     0.3             CUTTS     69 OSPK +  TOTAL POL. T=4.0    1/74
XIC M  40K  (-0.64)   (0.27)            MERLAN    74 ASPK +  POL.DXI/DL=+1.7     3/74
XIC  D1585    -0.25     1.20            BRAUN     75 HLBC +  POL. T=4.2          1/76
XIC T   T VALUE NOT GIVEN.
XIC  B  BETTELS 68 DXI/DL=XI*T=-1.0*4.9=-4.9 .
XIC  C  CUTTS 69 T=4.0 WAS CALCULATED FROM FIG.8. DXI/DL=XI*T=-.95*4=-3.8 .       1/74
XIC M   MERLAN 74 POLARIZATION RESULT (FIG.5) NOT POSSIBLE.  SEE DISCUSSION      1/76
XIC M   OF POLARIZATION EXPERIMENTS IN NOTE ON KL3 FORM FACTORS ABOVE.            1/76
XIC  D  BRAUN 75 DXI/DL=XI*T=-.25*4.2=-1.0 .                                      1/76
XIC     . . . . . .
XIC FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.
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IXI        IMAGINARY PART OF XI (TEST OF T REVERSAL)   ------------------
IXI   2648    0.0       1.0              CALLAHA1  66 FRBC +  MU                1/74
IXI    397   +1.6       1.3              CALLAHA1  66 FRBC +  TOTAL POL.        1/74
IXI   2950    0.5       1.4       0.5    CALLAHA1  66 FRBC +  LONG. POL.        1/74
IXI   6000   -0.1       0.3              BETTELS   68 HLBC +  TOTAL POL.        1/74
IXI   3133   -0.3       0.3       0.4    CUTTS     69 OSPK +  TOTAL POL. FIG.7  1/74
IXI           . . . . . . . . . .
IXI AVG      -0.09      0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
IXI STUDENT  -0.10      0.23    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)   ---------
L+M      SEE ALSO THE CORRESPONDING ENTRIES AND FOOTNOTES IN SECTIONS XIA,
L+M      XIC, AND LO.
L+M      FOR RAD.COR. OF KMU3 DP SEE GINSBURG 70 AND BECHERRAWY 70.             3/74
L+M    444     0.0       0.05            CALLAHA1  66 FRBC +  PI                1/74
L+M   2041     0.009     0.026           KIJEWSKI  69 OSPK +  PI                1/74
L+M   3240     0.050     0.018           HAIDT     71 HLBC +  DP                1/74
L+M  A4025     0.024     0.019           ANKENBRAN 72 ASPK +  PI                1/74
L+M   3480    -0.006     0.015           CHIANG    72 OSPK +  DP                1/74
L+M   1897     0.025     0.017           BRAUN1    73 HLBC +  DP                3/74
L+M    490     0.025     0.030           ARNOLD    74 HLBC +  DP                7/74
L+M   6527     0.027     0.019           MERLAN    74 ASPK +  DP                3/74
L+M  A  ANKENBRANDT 72 L+ FROM FIG.3 TO MATCH DXI/DL. TEXT GIVES .024+-.022     1/74
L+M           . . . . . . . . . .
L+M FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.

LO      LAMBDA 0 (LINEAR ENERGY DEPENDENCE OF F0 IN KMU3 DECAY)   ----------
LO       WHEREVER POSSIBLE, WE HAVE CONVERTED THE ABOVE VALUES OF XI(0) INTO
LO       VALUES OF LO USING THE ASSOCIATED L+M AND DXI/DL.
LO W   444    +0.058     0.036           CALLAHA1  66 FRBC +  PI,DLO/DL+=-0.37  1/74
LO L  6000    -0.063    (0.024)          BETTELS   68 HLBC +  POL,DLO/DL+=+.60  1/74
LO W  2041    -0.031     0.045           KIJEWSKI  69 OSPK +  PI,DLO/DL+=-1.10  1/74
LO L  3133    -0.056    (0.024)          CUTTS     69 OSPK +  POL,DLO/DL+=+.69  1/74
LO W  3240    -0.039     0.029           HAIDT     71 HLBC +  DP,DLO/DL+=-1.34  1/74
LO W  4025    -0.026     0.013           ANKENBRAN 72 ASPK +  PI,DLO/DL+=+0.03  1/74
LO W  3480    +0.030     0.014           CHIANG    72 OSPK +  DP,DLO/DL+=-0.21  1/74
LO    D1897   -0.008     0.020           BRAUN1    73 HLBC +  DP,DLO/DL+=-0.53  1/76
LO     490    -0.040     0.040           ARNOLD    74 HLBC +  DP,DLO/DL+=-0.62  7/74
LO  B        (-0.017)   (0.011)          BRAUN     74 HLBC +  KMU3/KE3 VS. T   11/75
LO M  6527    -0.019     0.015           MERLAN    74 ASPK +  DP,DLO/DL+=+0.27  3/74
LO L  1585    +0.008     0.097           BRAUN     75 HLBC +  POL,DLO/DL+=+.92  1/76
LO     H 55K  +0.019    (0.010)          HEINTZE   77 SPEC +  BR,DLO/DL+=+0.03 12/77*
LO W     LO CALCULATED BY US FROM XI0, L+M, AND DXI/DL.                         1/74
LO L     LO VALUE IS FOR L+=0.03  CALCULATED BY US FROM XI0 AND DXI/DL.         1/74
LO    D  THIS VALUE AND ERROR ARE TAKEN FROM BRAUN 75 BUT CORRESPOND TO THE     1/76
LO    D  BRAUN1 73 L+M RESULT.  DLO/DL+ IS FROM BRAUN1 73 DXI/DL IN XIA ABV.    1/76
LO    B  BRAUN 74 IS A COMBINED KMU3-KE3 RESULT.  IT IS NOT INDEPENDENT OF     11/75
LO    B  BRAUN1 73 (KMU3) AND BRAUN2 73 (KE3) FORM FACTOR RESULTS.             11/75
LO M     MERLAN 74 LO AND DLO/DL+ WERE CALCULATED BY US FROM XIA, L+M, AND      3/74
LO M     DXI/DL.  THEIR FIG.6 GIVES LO=-0.025+-0.012 AND NO DLO/DL+.            3/74
LO    H  HEINTZE 77 USES L+=0.029+-0.003.  DLO/DL+ ESTIMATED BY US.            12/77*
LO            . . . . . . . . . .
LO   FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS ABOVE.

L+E     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY)   ---------
L+E     FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.               3/74
L+E    217    +0.036     .045            BROWN     62 XEBC +  PI, NO RC
L+E    407    -0.010     .029            JENSEN    64 XEBC +  PI, NO RC         8/67
L+E    230    -0.04      .05             BORREANI  64 HBC  +  E+, NO RC         8/67
L+E    854     0.045     0.017     0.018 BELLOTT2  67 FBC  +  DP, USES RC      11/67
L+E   1393    +0.016     .016            IMLAY     67 OSPK +  DP, NO RC         8/67
L+E    515    +0.028     .013      .014  KALMUS    67 FBC  +  E+, PI, NO RC     8/67
L+E    960     .08       .04             BOTTERIL1 68 ASPK +  E+, USES RC     . 6/68
L+E     90    -0.02      0.08      0.12  EISLER    68 HLBC +  PI, USES RC       6/68
L+E   1458     .045      .015            BOTTERIL  70 OSPK    PI, USES RC      10/69
L+E   2707     0.027     0.010           STEINER   71 HLBC +  DP, USES RC      11/71
L+E   4017     0.029     0.011           CHIANG    72 OSPK +  DP, RC NEGLIGBLE  9/72
L+E  A         0.027     0.008           BRAUN2    73 HLBC +  DP, NO RC         3/74
L+E B         (0.025)   (0.007)          BRAUN     74 HLBC +  KMU3/KE3 VS. T   11/75
L+E  A  BRAUN2 73 STATES THAT RC OF GINSBERG 67 WOULD LOWER L+E BY .002 BUT     3/74
L+E  A  THAT RC OF BECHERRAWY DISAGREES AND WOULD RAISE L+E BY .005 .           1/76
L+E B   BRAUN 74 IS A COMBINED KMU3-KE3 RESULT.  IT IS NOT INDEPENDENT OF      11/75
L+E B   BRAUN1 73 (KMU3) AND BRAUN2 73 (KE3) FORM FACTOR RESULTS.              11/75
L+E           . . . . . . . . . .
L+E AVG        0.0285    0.0043  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
L+E STUDENT    0.0284    0.0047  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS              .18  OR LESS  CL=.90   BELLOTT2  67 HLBC                       10/69
FS              .30  OR LESS  CL=.95   KALMUS    67 HLBC +                     10/69
FS             0.23  OR LESS  CL=.90   BOTTERIL1 68 ASPK                        8/66
FS    2707     0.14      0.03      0.04  STEINER   71 HLBC +  L+,FS,FT,PHI FIT  2/72
FS    4017     0.13  OR LESS  CL=.90   CHIANG    72 OSPK +                      9/72
FS    2827     0.00      0.10            BRAUN     75 HLBC +                   12/75
FS            . . . . . . . . . .
FS  AVG        0.125     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
FS  STUDENT    0.126     0.037   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

FT      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FT              .58  OR LESS  CL=.90   BELLOTT2  67 HLBC                       10/69
FT             1.1   OR LESS  CL=.95   KALMUS    67 HLBC +                     10/69
FT             0.58  OR LESS  CL=.90   BOTTERIL1 68 ASPK                        8/66
FT    2707     0.24      0.16      0.14  STEINER   71 HLBC +  L+,FS,FT,PHI FIT  2/72
FT    4017     0.75  OR LESS  CL=.90   CHIANG    72 OSPK +                      9/72
FT    2827     0.07      0.37            BRAUN     75 HLBC +                   12/75
FT            . . . . . . . . . .
FT  AVG        0.22      0.14    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FT  STUDENT    0.22      0.15    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

FTM     FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KMU3 DECAY   ------------
FTM   1585     0.02      0.12            BRAUN     75 HLBC                      1/76

KE4     KE4 DECAY FORM FACTORS ARE GIVEN IN THE FOLLOWING PAPERS
KE4                                      BASILE    71 ASPK +                   11/75
KE4                                      BEIER     73 OSPK +-                  11/75

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REFERENCES FOR CHARGED K


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BIRGE     56 NC    4   834       BIRGE,PERKINS,PETERSON,STORK,WHITEHEA (LRL)
ILOFF     56 PR 102    927       ILOFF,GOLDHABER,LANNUTTI,GILBERT +     (LRL)
ALEXANDE 57 NC    6   478        ALEXANDER,JOHNSTON,OCEALLAIGH (DUBLIN INST)
COHEN     57 FUND.CONS.PHYS.     +CROWE,DUMOND         (ATOMICS INTER.+LRL+CIT)
EISENBER 58 NC    8   663        EISENBERG,KOCH,LOHRMANN,NIKOLIC +      (BERN)
BURROWES 59 PRL   2   117        BURROWES,CALDWELL,FRISCH,HILL +         (MIT)
TAYLOR    59 PR 114   359        S TAYLOR,HARRIS,OREAR,LEE,BAUMEL (COLUMBIA)

FREDEN    60 PR 118   564        S C FREDEN,F C GILBERT,R S WHITE        (LRL)
BARKAS    61 PR 124 1209         BARKAS,DYER,MASON,NORRIS,NICKOLS,SMIT (LRL)
BHOWMIK   61 NC   20   857       B BHOWMIK,P C JAIN,P C MATHUR  (DELHI UNIV)
FERRO-LU 61 NC    22  1087       FERRO-LUZZI,MILLER,MURRAY,ROSENFELD+  (LRL)
NORDIN    61 PR 123 2166         PAUL NORDIN JR                          (LRL)
ROE       61 PRL   7   346       ROE,SINCLAIR,BROWN,GLASER +        (MICH+LRL)
BOYARSKI 62 PR 128 2398          BOYARSKI,LOH,NIEMELA,RITSON             (MIT)

BROWN     62 PRL   8   450       BROWN,KADYK,TRILLING,ROE+          (LRL,MICH)
BARKAS    63 PRL 11    26        W H BARKAS,J N DYER,H H HECKMAN         (LRL)

BORREANI 64 PL    12 123         G BORREANI,G RINAUDO,A WERBROUCK      (TURIN)
CALLAHAN 64 PR   136 B 1463      A CALLAHAN,R MARCH,R STARK        (WISCONSIN)
CAMERINI 64 PRL   13 318         CAMERINI,CLINE,FRY,POWELL     (WISCONSIN+LRL)
CLINE     64 PRL  13 101         D CLINE, W F FRY                  (WISCONSIN)
GIACOMEL 64 NC 34  1134          GIACOMELLI,MONTI,QUARENI+  (BOLOGNA,MUNICH)
GREINER   64 PRL  13 284         D GREINER, W OSBORNE, W BARKAS          (LRL)
JENSEN    64 PR  136 B1431       JENSEN,SHAKLEE,ROE,SINCLAIR            (MICH)
KALMUS    64 PRL   13   99       +KERNAN,PU,POWELL,DOWD             (LRL,WISC)
SHAKLEE   64 PR  136 B 1423      SHAKLEE,JENSEN,ROE,SINCLAIR            (MICH)

BIRGE     65 PR 139 B 1600       BIRGE,ELY,GIDAL,CAMERINI,CLINE + (LRL+WISC)
BISI      65 NC    35  768       BISI,BORREANI,CESTER,FERRARO +       (TORINO)
BISI 1    65 PR 139 B 1068       BORREANI,MARZARI-CHIESA,RINAUDO+     (TORINO)
BORREANI 65 PR 140 B1686         BORREANI,GIDAL,RINAUDO,CAFORIO+ (BARI,TORI)
CALLAHAN 65 PRL   15  129        A CALLAHAN,D CLINE                (WISCONSIN)
CAMERINI 65 NC 37 1795           +CLINE,GIDAL,KALMUS,KERNAN         (WISC+LRL)
CLINE     65 PL    15  293       A CLINE,W F FRY                   (WISCONSIN)
CUTTS     65 PR 138 B969         CUTTS,ELIOFF,STIENING                   (LRL)

DE MARCO 65 PR 140 B 1430        DE MARCO,GROSSO,RINAUDO         (TORINO+CERN)
FITCH     65 PR 140 B 1088       FITCH,QUARLES,WILKINS(PRINCETON+MT HOLYOKE)
GREINER   65 ARNS  15  67        QUOTED BY BARKAS                        (LRL)
STAMER    65 PR  138 B 440       STAMER,HUETTER,KOLLER,TAYLOR,GRAUMAN (STEV)
TRILLING 65 UCRL 16473           GEORGE H TRILLING                       (LRL)
    UPDATED FROM 1965 ARGONNE CONF., PAGE 5.
YOUNG     65 UCRL 16362          POH-SHIEN YOUNG (THESIS,BERKELEY)       (LRL)
    ALSO 67 PR 156 1464          P-S YOUNG,W.Z.OSBORNE,W.H.BARKAS        (LRL)

CALLAHA1 66 PR 150 1153          CALLAHAN,CAMERINI+(WISC,LRL,RIVERSIDE,BARI)
CALLAHAN 66 NC   44A 90          A C CALLAHAN                      (WISCONSIN)
CESTER    66 PL 21 343           CESTER,ESCHSTRUTH,ONEILL+  (PRINCETON-PENN)
    ALSO 67 AUERBACH, FOOTNOTE 1.

AUERBACH 67 PR 155  1505         +DOBBS,MANN,MCFARLANE,WHITE+     (PENN,PRIN)
    ALSO 74 PR D9 3216           ERRATUM
BELLOTT1 67 HEIDELBERG CONF      BELLOTTI,PULLIA                       (MILAN)
BELLOTT2 67 NC 52A  1287         BELLOTTI,FIORINI,PULLIA               (MILAN)
    ALSO 66 PL   20  690         BELLOTTI,FIORINI,PULLIA+              (MILAN)
BISI      67 PL 25B  572         BISI,CESTER,CHIESA,VIGONE            (TORINO)

BOTTERIL 67 PRL  19  982         BOTTERILL,BROWN,CORBETT,CULLIGAN + (OXFORD)
    ALSO 68 BOTTERIL
BOWEN     67 PR 154 1314         BOWEN,MANN,MCFARLANE,HUGHES+(PENN-PRINCETO)
CLINE1    67 HEIDELBERG CONF     CLINE,HAGGERTY,SINGLETON,FRY+     (WISCONSIN)
CLINE2    67 HERCEG NOVI TBL.4 D.CLINE,PROC.INTL.SCH.ON ELEM.PART.PHYSICS

FLETCHER 67 PRL  19   98         FLETCHER,BEIER,EDWRADS,+          (ILLINOIS)
FORD      67 PRL 18 1214         +LEMONICK,NAUENBERG,PIROUE       (PRINCETON)
IMLAY     67 PR 160  1203        IMLAY,ESCHSTRUTH,FRANKLIN+       (PRINCETON)
KALMUS    67 PR  159  1187       KALMUS,KERNAN                           (LRL)
ZINCHENK 67 RUTGERS(THESIS)      ZINCHENKO                           (RUTGERS)

BETTELS   68 NC 56A 1106         AACHEN-BARI-BERGEN-CERN-EP-NIJMEGEN-ORSAY+
    ALSO 71 HAIDT
BOTTERIL 68 PR 171 1402          BOTTERILL,BROWN,CLEGG,CORBETT +    (OXFORD)
BOTTERI1 68 PR 174 1661          BOTTERILL,BROWN,CLEGG,CORBETT +    (OXFORD)
BOTTERI2 68 PRL 21 766           BOTTERILL,BROWN,CLEGG,CORBETT +    (OXFORD)
BUTLER    68 UCRL-18420          +BLAND,GOLDHABER,GOLDHABER,HIRATA+    (LRL)
CHANG     68 PRL 20  510         CHANG,YODH,EHRLICH,PLANO+(MARYLAND,RUTGERS)

CHEN      68 PRL 20 73           CHEN,CUTTS,KIJEWSKI,STIENING +    (LRL,MIT)
EICHTEN   68 PL 27B 586          AACHEN-BARI-CERN-EP-ORSAY-PADOVA-VALENCIA
EISLER    68 PR   169  1090      EISLER,FUNG,MARATECK,MEYER,PLANO  (RUTGERS)
ESCHSTRU 68 PR   165  1487       ESCHSTRUTH,FRANKLIN,HUGHES+(PRINCETON,PENN)
GARLAND   68 PR   167  1225      +TSIPIS,DEVONS,ROSEN+  (COLUMBIA,RUTG,WISC)
MOSCOSO   68  THESIS             M L MOSCOSO               (UNIV PARIS ORSAY)

CUTTS     69 PR 184 1380         +STIENING,WIEGAND,DEUTSCH         (LRL,MIT)
    ALSO 68 PRL 20 955           CUTTS,STIENING,WIEGAND,DEUTSCH    (LRL,MIT)
DAVISON   69 PR   180 1333       +BACASTOW,BARKAS,EVANS,FUNG,PORTER+   (UCR)
ELY       69 PR   180 1319       ELY,GIDAL,HAGOPIAN,KALMUS+  (LOUC+WISC+LRL)
EMMERSON 69 PRL 23 393           EMMERSON,QUIRK                       (OXFORD)

HERZO     69 PR 186 1403         +BANNER,BEIER,BERTRAM,EDWARDS +         (ILL)
KIJEWSKI 69 UCRL-18433 THESIS P K KIJEWSKI                               (LBL)
LOBKOWIC 69 PR 185 1676          +MELISSINOS,NAGASHIMA,TEWKSBURY+ (ROCH,BNL)
    ALSO 66 PRL 17 548           LOBKOWICZ,MELISSINOS,NAGASHIM+   (ROCH+BNL)
MACEK     69 PRL   22   32       MACEK,MANN,MC FARLANE,ROBERTS+(PENN,TEMPLE)
MAST      69 PR   183 1200       +GERSHWIN,ALSTON-GARNJOST,BANGERTER+  (LRL)
ZELLER    69 PR   182 1420       ZELLER,HADDOCK,HELLAND,PAHL+     (UCLA,LRL)

BOTTERIL 70 PL 31B 325           +BROWN,CLEGG,CORBETT,CULLIGAN+          (OXF)
FORD      70 PRL 25 1370         +PIROUE,REMMEL,SMITH,SOUDER            (PRIN)
GRAUMAN   70 PR D1 1277          +KOLLER,TAYLOR,PANDOULAS+  (STEV,SETO,LEHI)
    ALSO 69 PRL 23 737           +KOLLER,TAYLOR,PANDOULAS+  (STEV,SETO,LEHI)
MACEK     70 PR D1 1249          +MANN,MCFARLANE,ROBERTS                (PENN)
MALTSEV   70 SJNP 10 678         +PESTOVA,SOLODOVNIKOVA,FADEEV +        (JINR)
PANDOULA 70 PR D2 1205           +TAYLOR,KOLLER,GRAUMAN +          (STEV,SETO)

BASILE    71 PL 36B 619          +BREHIN,DIAMANT-BERGER,KUNZ+      (SACL+GEVA)
BOURQUIN 71 PL 36B 615           +BOYMOND,EXTERMANN,MARASCO+       (GEVA,SACL)
HAIDT     71 PR D3 10            AACHEN+BARI+CERN+EP+NIJMEGEN+ORSAY+PADOVA+
    ALSO 69 PL  29B 691          +(AACH,BARI,CERN,EPOL,NIJM,ORSAY,PADO,TORI)
KLEMS     71 PR D4 66            +HILDEBRAND,STIENING                (CHIC,LRL)
    ALSO 70 PRL 24 1086          KLEMS,HILDEBRAND,STIENING           (LRL,CHIC)
    ALSO 70 PRL 25 473           KLEMS,HILDEBRAND,STIENING           (LRL,CHIC)

KUNSELMA 71 PL 34B 485           R. KUNSELMAN                        (WYOMING)
OTT       71 PR D3 52            OTT,PRITCHARD                          (LOQM)
ROMANO    71 PL 36B 525          +RENTON,AUBERT,BURBAN-LUTZ (BARI,CERN,ORSA)
SCHWEINB 71 PL 36B 246           AACHEN+BELGIUM+CERN+NIJMEGEN+PADOVA COLLAB
STEINER   71 PL 36B 521          AACHEN+BARI+CERN+EPOL+ORSA+NIJM+PADO+TORIN

ABRAMS    72 PRL 29 1118         +CARROLL,KYCIA,LI,MENES,MICHAEL +       (BNL)
ANKENBRA 72 PRL 28 1472          ANKENBRANDT,LARSEN+    (BNL+LASL+FNAL+YALE)
AUBERT    72 NC 12A 509          +HEUSSE,PASCAUD,VIALLE+     (ORSA+BRUX+EPOL)
BEIER     72 PRL 29 678          +BUCHHOLZ,MANN,PARKER          (PENNSYLVANIA)
CHIANG    72 PR D6 1254          +ROSEN,SHAPIRO,HANDLER,OLSEN+     (ROCH+WISC)

CLARK     72 PRL 29 1274         +CORK,ELIOFF,KERTH,MCREYNOLDS,NEWTON+ (LBL)
EDWARDS   72 PR D5 2720          +BEIER,BERTRAM,HERZO,KOESTER +          (ILL)
FORD      72 PL 38B 335          +PIROUE,REMMEL,SMITH,SOUDER       (PRINCETON)
HOFFMAST 72 NP B36 1             HOFFMASTER,KOLLER,TAYLOR+  (STEV+SETO+LEHI)

ABRAMS    73 PRL 30 500          +CARROLL,KYCIA,LI,MENES,MICHAEL +       (BNL)
BACKENST 73 PL 43B 431           BACKENSTOSS,BAMBERGER+(CERN+KARL+HEID+STOH)
BEIER     73 PRL 30 399          +BUCHHOLZ,MANN,PARKER,ROBERTS          (PENN)
BRAUN1    73 PL 47B 182          AACHEN+BARI+BRUSSELS+CERN COLLABORATION
    ALSO 75 BRAUN
BRAUN2    73 PL 47B 185          AACHEN+BARI+BRUSSELS+CERN COLLABORATION
    ALSO 75 BRAUN
CABLE     73 PR D8 3807          +HILDEBRAND,PANG,STIENING           (EFI+LBL)
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LJUNG     73 PR D8 1307          D.LJUNG,D.CLINE                         (WISC)
   ALSO 72 PRL  28 523           D.LJUNG                                 (WISC)
   ALSC 72 PRL  28 1287          D.CLINE,D.LJUNG                         (WISC)
   ALSO 69 PRL  23 326           CAMERINI,LJUNG,SHEAFF,CLINE             (WISC)
LUCAS1    73 PR D8 719           LUCAS,TAFT,WILLIS                       (YALE)
LUCAS2    73 PR D8 727           LUCAS,TAFT,WILLIS                       (YALE)
PANG      73 PR D8 1989          +HILDEBRAND,CABLE,STIENING    (EFI+ARIZ+LBL)
   ALSO 72 PL  40B 699           CABLE,HILDEBRAND,PANG,STIENING    (EFI+LBL)
SMITH     73 NP B60 411          +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)

ARNOLD    74 PR D9 1221          C L ARNOLD,B P ROE,D SINCLAIR           (MICH)
BRAUN     74 PL 51B 393          +CORNELSSEN,MARTYN +  (AACH+BARI+BRUX+CERN)
CENCE     74 PR D10 776          +HARRIS,JONES,MORGADO +     (HAWA+LBL+WISC)
   ALSO 73 THESIS (UNPUBL.)      D B CLARKE                              (WISC)
KUNSELMA  74 PR C9 2469          R.KUNSELMAN                             (WYOM)
MERLAN    74 PR D9 107           +KASHA,WANDERER,ADAIR+      (YALE+BNL+LASL)
WEISSENB  74 PL 48B 474          WEISSENBERG,EGOROV,MINERVINA +  (ITEP+LEBD)

BLOCH     75 PL 56B 201          +BREHIN,BUNCE,DEVAUX+           (SACL+GEVA)
BRAUN     75 NP B89 210          +CORNELSSEN,MARTYN+   (AACH+BARI+BRUX+CERN)
CHENG     75 NP A254 381         +ASANO,CHEN,DUGAN,HU,WU,HUGHES+ (COLU+YALE)
HEARD1    75 PL 55B 324          +HEINTZE,HEINZELMANN+           (CERN+HEID)
HEARD2    75 PL 55B 327          +HEINTZE,HEINZELMANN+           (CERN+HEID)
SHEAFF    75 PR D12 2570         M. SHEAFF                               (WISC)
SMITH     75 NP B91 45           +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)

BERTRANC  76 NP B114 387         +SACTON +         (BRUX+UBEL+DUUC+LCUC+WARS)
BLOCH     76 PL 60B 393          +BUNCE,DEVAUX,DIAMANT-BERGER+   (GEVA+SACL)
BRAUN     76 LNC 17 521          +MARTYN,ERRIQUEZ +    (AACH+BARI+BELG+CERN)
DIAMANTB  76 PL 62B 485          DIAMANT-BERGER,BLOCH,DEVAUX +   (SACL+GEVA)
HEINTZE   76 PL 60B 302          +HEINZELMANN,IGO-KEMENES,MUNDHENKE+  (HEID)
SMITH     76 NP B109 173         +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)
WEISSENB  76 NP B115 55          WEISSENBERG,EGOROV,MINERVINA+   (ITEP+LEBD)

ABRAMS    77 PR D15 22           +CARROLL,KYCIA,LI,MICHAEL,MOCKETT +   (BNL)
DEVAUX    77 NP B126 11          +BLOCH,DIAMANT-BERGER,MAILLARD+ (SACL+GEVA)
HEINTZE   77 PL 70B 482          +HEINZELMANN,IGO-KEMENES,+      (HEID+CERN)
ROSSELET  77 PR D15 574          +EXTERMANN,FISCHER,GUISAN +     (GEVA+SACL)

     QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BLOCK     62 CERN CONF 371       BLOCK,LENDINARA,MONARI      (NWES+BOLOGNA)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

BRENE     61 NP 22 553           BRENE,EGARDT,QVIST                      (NORD)
BIRGE     63 PRL  11  35         BIRGE,ELY,GIDAL,CAMERINI +  (LRL+WISC+BARI)
ADAIR     64 PL 12  67           ADAIR,LEIPUNER                      (YALE,BNL)
CABIBBO   64 PL  9 352           CABIBBO,MAKSYMOWICZ                     (CERN)
   ALSO 64 PL 11 360             CABIBBO,MAKSYMOWICZ                     (CERN)
   ALSO 65 PL 14  72             CABIBBO,MAKSYMOWICZ                     (CERN)

CABIBBO   66 BERKELEY CONF 33    CABIBBO                                 (CERN)
GINSBERG  67 PR 162  1570        EDWARD S GINSBERG          (U. MASS BOSTON)
WILLIS    67 HEIDELBERG 273      W J WILLIS -RAPPORTEUR TALK             (YALE)
CRONIN    68 VIENNA CONF 241     RAPPORTEUR TALK                    (PRINCETON)
HAIDT 2   69 PL 29B 696          + (AACH,BARI,CERN,EPOL,NIJM,ORSA,PADO,TORI)

BARDIN    70 PL 32B 121          BARDIN,BILENKY,PONTECORVO               (JINR)
BECHERRA  70 PR D1 1452          T.BECHERRAWY                            (ROCH)
FEARING   70 PR D3 542           +FISCHBACK,SMITH                   (STON+BOHR)
GAILLARD  70 CERN 70-14          M K GAILLARD, L M CHOUNET          (CERN+ORSA)
GINSBERG  70 PR D1 229           E S GINSBERG                        (IIT HAIFA)

GINSBERG  71 PR D4 2893          E S GINSBERG                             (MIT)
CHOUNET   72 PL 4C 199           (PHYS. REPTS.)CHOUNET,2*GAILLARD(ORSA+CERN)
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K^0

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             11  NEUTRAL K(498,JP=0-) I=1/2
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             11  NEUTRAL K MASS (MEV)

M              498.1     0.4           CHRISTENS 64 OSPK
M       2223   497.44    0.33          KIM       65 HBC    KO FROM PBAR P    6/66
M       4500   498.9     0.5           BALTAY    66 HBC    KO FROM PBAR P    6/66
M              497.44    0.50          FITCH     67 OSPK                    11/67
M              . . . . . . . . . .
M   AVG        497.87    0.32    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
M   STUDENT    497.83    0.26    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT        497.67    0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/78*
                         (SEE IDEOGRAM BELOW )
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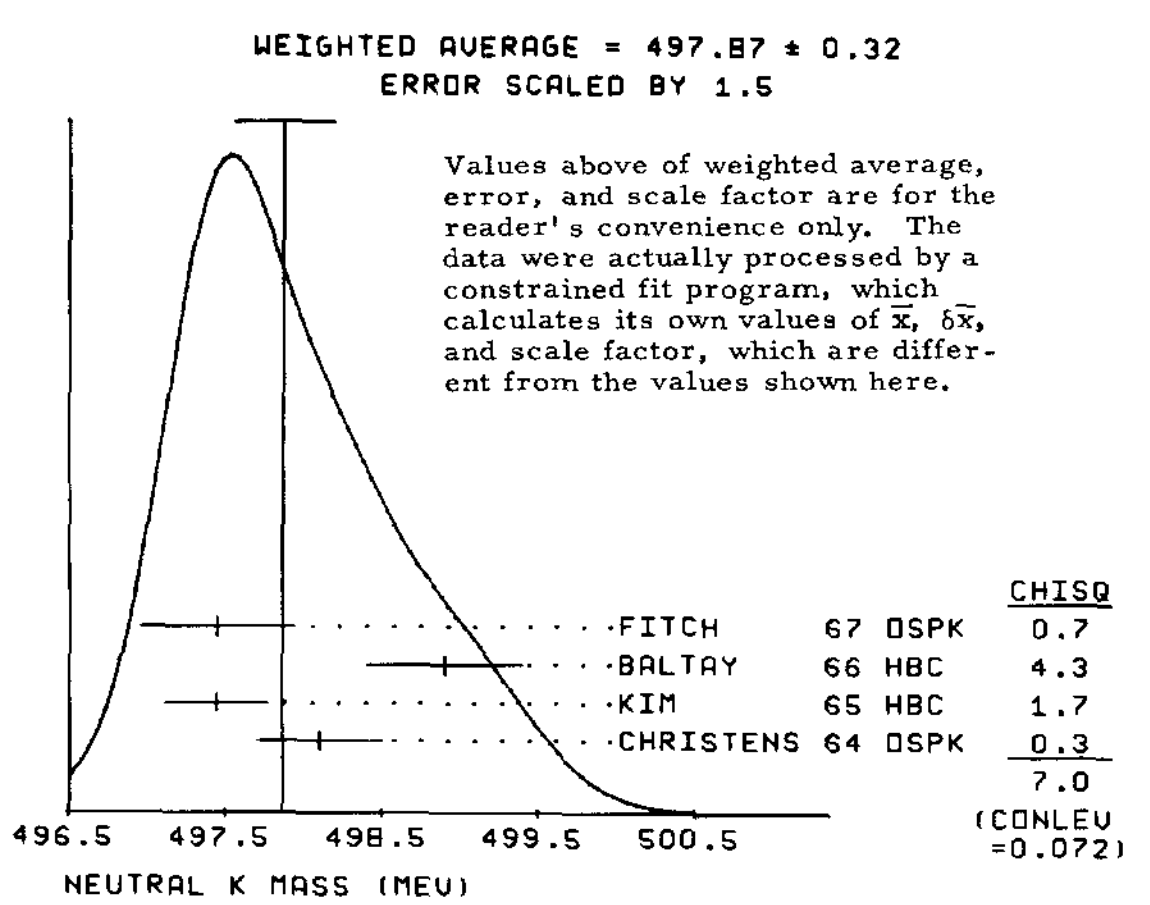


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             11  (KO) - (K+-) MASS DIFFERENCE (MEV)

D              3.9       0.6           ROSENFELD 59 HBC  -
D              5.4       1.1           CRAWFORD  59 HBC  +
D          9   3.90      0.25          BURNSTEIN 65 HBC  -
D          7   3.71      0.35          KIM       65 HBC  -  K- P TO KO N      6/68
D        417   3.95      0.21          HILL      68 DBC  +  K+D TO KOPP       3/68
D              . . . . . . . . . .
D   AVG        3.92      0.14    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D   STUDENT    3.91      0.15    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D   FIT        4.01      0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/78*

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                                REFERENCES FOR NEUTRAL K

CRAWFORD 59 PRL   2  112        CRAWFORD,CRESTI,GOOD,STEVENSON,TICHO  (LRL)
ROSENFEL 59 PRL   2  110        A H ROSENFELD,F SOLMITZ,R D TRIPP     (LRL)
CHRISTEN 64 PRL 13 138          CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
BURNSTEI 65 PR  138 B 895       R A BURNSTEIN,H A RUBIN          (MARYLAND)
KIM      65 PR 140 B 1334       J K KIM,L KIRSCH,D MILLER        (COLUMBIA)

BALTAY   66 PR 142   932        BALTAY,SANDWEISS,STONEHILL +     (YALE+BNL)
FITCH    67 PR 164  1711        FITCH,ROTH,RUSS,VERNON          (PRINCETON)
HILL     68 PR 168  1534        HILL,ROBINSON,SAKITT,CANTER  (BNL,CARNEGIE)
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K^0_S

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             12  SHORT-LIVED NEUTRAL K(498, JP=0-) I=1/2
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Note on the K^0_S Mean Life

From 1968 until 1972 our average value for the K^0_S mean life was $(0.862 \pm 0.006) \times 10^{-10}$ second. Since then several high-precision experiments have obtained results compatible with each other which average $(0.8923 \pm 0.0022) \times 10^{-10}$ second. This is about five standard deviations above the previous average. The origin of this discrepancy is not known. The discrepancy is displayed graphically in the ideogram below which contains all experiments, old and new.

Since the newer experiments are in principle superior — that is, they have higher statistics, better acceptance, and easier trigger conditions — we have chosen to average them separately from the older experiments as is seen in the Data Card Listings below. In the Stable Particle Table, we quote the new value, but give the old value in a warning footnote.

```
             12  KOS MEAN LIFE (UNITS 10**-10 SEC)

T      KOS MEAN LIFE (PRE-1971 EXPERIMENTS)
T   O   90   (1.07)   (0.13)   (0.13) BOLDT      58 CC
T      512    0.94     0.05     0.05  CRAWFORD   59 HBC
T   O   63   (1.09)   (0.18)   (0.15) BOWEN      60 CC
T   C   OLD EXPTS WITH LOW STATISTICS NOT INCLUDED IN AVERAGE.          6/68
T      378    0.94     0.05     0.05  BERTANZA   62 HBC
T      503    0.87     0.05           CHRETIEN   63 HLBC
T      545    0.86     0.04           KREISLER   64 OSPK
T             0.866    0.016          ALFF-STEI  66 OSPK                9/66
T      572    0.90     0.06     0.05  AUERBACH   66 OSPK                8/67
T     4500    0.92     0.04           BALTAY     66 HBC                 6/66
T   B        (0.904)  (0.024)         BOTT-BODE  66 OSPK                9/66
T     5000    0.843    0.013          KIRSCH     66 HBC                 6/66
T    19994    0.856    0.008          DONALD     68 HBC                 6/68
T  H 20000    0.872    0.009          HILL       68 DBC                11/72
T            . . . . . . . . . .
T   AVG       0.8641   0.0065   0.0065 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.3)
T   STUDENT   0.8642   0.0060   0.0059 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )

T      KOS MEAN LIFE (POST-1971 EXPERIMENTS)
T       THESE VALUES ARE USED TO DETERMINE THE STABLE PARTICLE TABLE
T       VALUES OF THE KOS MEAN LIFE AND RATES.
T  H   50K    0.8958   0.0045         SKJEGGEST 72 HBC                  1/73
T   F 2173   (0.867)  (0.024)         FACKLER   73 OSPK                11/73
T       6M    0.8937   0.0048         GEWENIGER 74 ASPK                 3/74
T  C          0.8913   0.0032         CARITHERS 75 SPEC                 7/75
T      26K    0.881    0.009          ARONSON   76 SPEC               11/76*
T            . . . . . . . . . .
T   AVG       0.8923   0.0022   0.0022 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT   0.8924   0.0025   0.0024 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
T   FIT       0.8923   0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
                       (SEE IDEOGRAM BELOW )
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Stable Particles

K^0_S

Data Card Listings

For notation, see key at front of Listings.

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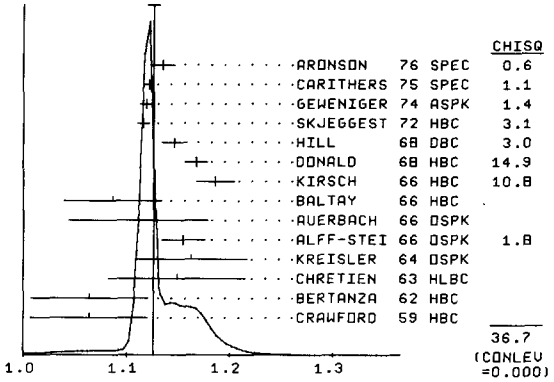
                              COMMENTS
T  H    HILL 68 HAS BEEN CHANGED BY THE AUTHORS FROM THE PUBLISHED VALUE     11/72
T  H    (0.865+-0.009) BECAUSE OF A CORRECTION IN THE SHIFT DUE TO ETA+-.    11/72
T  H    SKJEGGESTAD 72 AND HILL 68 GIVE DETAILED DISCUSSIONS OF SYSTEMATICS
T  H    ENCOUNTERED IN THIS TYPE OF EXPERIMENT.
T  B    KOS MEAN LIFE NOT THE PRIMARY QUANTITY MEASURED IN THIS EXPT.          6/68
T  F    FACKLER 73 DOES NOT INCLUDE SYSTEMATIC ERRORS.                       11/73
T  C    CARITHERS 75 VALUE IS FOR KOL-KOS MASS DIFFERENCE DM=.5348+-.0021.   11/75
T  C    THE DM DEPENDENCE OF THE TOTAL DECAY RATE (INVERSE MEAN LIFE) IS     11/75
T  C    GAMMA(KOS)=((1.122+-.004)+.16*(DM-.5348)/DM)*10**10 /SEC.            11/75
T  C    VALUE WOULD NOT CHANGE WITH OUR CURRENT DM=.5349+-.0022.              2/76
```

WEIGHTED AVERAGE = 1.1261 ± 0.0059
ERROR SCALED BY 2.3



KOS DECAY RATE (UNITS 10**10 SEC-1)

12 KOS PARTIAL DECAY MODES

		DECAY MASSES
P1	KOS INTO PI+ PI-	139+ 139
P2	KOS INTO PIO PIO	134+ 134
P3	KOS INTO MU+ MU-	105+ 105
P4	KOS INTO E+ E-	.5+ .5
P5	KOS INTO PI+ PI- GAMMA	139+ 139+ 0
P6	KOS INTO GAMMA GAMMA	0+ 0
P7	KOS INTO 3PIO	134+ 134+ 134

12 KOS BRANCHING RATIOS

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R1      KOS INTO (PI+ PI-)/TOTAL                              (P1)
R1            0.68      0.04          CRAWFORD  59 HBC
R1            0.70      0.08          COLUMBIA  60 HBC
R1  U       (0.740)   (0.024)         ANDERSON  62 HBC
R1  U 3447    0.670     0.010         DOYLE     69 HBC     PI- P TO LAM KO   1/76
R1  U   ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE          2/71
R1          . . . . . . . . .
R1  AVG       0.6710    0.0096  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT   0.671     0.010   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT       0.6861    0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2      KOS INTO (PIO PIO)/TOTAL                              (P2)
R2            0.27      0.11          CRAWFORD  59 HBC
R2            0.26      0.06          BAGLIN    60 HLBC
R2            0.30      0.035         BROWN     61 HLBC
R2    1066    0.335     0.014         BROWN     63 HLBC
R2     198    0.288     0.021         CHRETIEN  63 HLBC
R2          . . . . . . . . .
R2  AVG       0.316     0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2  STUDENT   0.316     0.014   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT       0.3139    0.0024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                              (SEE IDEOGRAM BELOW )
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WEIGHTED AVERAGE = 0.316 ± 0.014
ERROR SCALED BY 1.3

KOS INTO (PIO PIO)/TOTAL

```
R3      KOS INTO (PI+ PI-)/(PIO PIO)                          (P1)/(P2)
R3   N  267    (2.12)   (0.17)          BOZOKI    69 HLBC                    5/70
R3   G 3016    (2.285)  (0.055)         GOBBI     69 OSPK     K+N TO KOP     5/69
R3     3700     2.10     0.06           MORFIN    69 HLBC     K+N TO KOP    10/69
R3   G 7944     2.282    0.043          MOFFETT   70 OSPK     K+N TO KOP     2/72
R3   B 6150     2.222    0.095          BALTAY    71 HBC   K-P TO KO +NEUTRALS 12/71
R3   A 3068     2.22     0.10           ALITTI    72 HBC      K+P TO PI+ P KO   6/72
R3     6380     2.22     0.08           MORSE     72 DBC      K+N TO KOP        2/72
R3   N  701     2.10     0.11           NAGY      72 HLBC     K+N TO KOP        1/73
R3     4799     2.16     0.08           HILL      73 DBC      K+D TO KO P P     9/73
R3     16K      2.169    0.094          COWELL    74 OSPK     PI- P TO LAM KO   7/75
R3     1315     2.11     0.09           EVERHART  76 WIRE     PI- P TO LAM KO  11/76*
R3 N    NAGY 72 IS A FINAL RESULT WHICH INCLUDES BOZOKI 69.                    11/73
R3 G    MOFFETT 70 IS A FINAL RESULT WHICH INCLUDES GOBBI 69.                   2/72
R3 B    THE DIRECTLY MEASURED QUANTITY IS KS TO PI+PI-/ALL KOBAR=.345+-.005  12/71
R3 A    THE DIRECTLY MEASURED QUANTITY IS KOS TO PI+ PI-/ALL KO=.345+-.005    6/72
R3          . . . . . . . . .
R3  AVG       2.197    0.026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT   2.192    0.031   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT       2.186    0.025  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      (KOS INTO PI+ PI- PIO, CP VIOLATING)/(KOL INTO PI+ PI- PIO)
R4      TEST OF CP VIOLATION - SEE TEXT SECTION VI B.3A FOR DEFINITIONS
R4      CPT ASSUMED VALID - (I.E. RE(A)=0) - ONLY (IMA)**2 QUOTED HERE
R4       18    (3.8)  OR LESS  CL=.90   ANDERSON  65 HBC                     10/69
R4             0.45   OR LESS  CL=.90   BEHR      66 HLBC                     8/66
R4       53    (1.7)  OR LESS  CL=.90   WEBBER    70 HBC                      8/70
R4 C     71    0.8    OR LESS  CL=.90   WEBBER    70 HBC                      8/70
R4       99    1.2    OR LESS  CL=.90   CHO       71 DBC                      4/71
R4   J   98    (1.0)  OR LESS  CL=.90   JAMES     71 HBC                      6/71
R4   M   50    (1.2)  OR LESS  CL=.95   MEISNER   71 HBC      CL=.9 NOT AVAIL.  2/71
R4 J    180    0.66   OR LESS  CL=.90   JAMES     72 HBC                      1/73
R4       99    1.2    OR LESS  CL=.90   JONES     72 OSPK                    10/72
R4      384    0.12   OR LESS  CL=.90   METCALF   72 ASPK                     2/74
R4      148    0.71   OR LESS  CL=.90   MALLARY   73 OSPK     RE(A)=-.05+-.17   8/73
R4      192    1.2    OR LESS  CL=.90   BALDOCEOL 75 HLBC                     12/75
R4 C    THIS IS THE COMBINED RESULT OF ANDERSON 65 AND WEBBER 70
R4 J    JAMES 72 IS A FINAL RESULT WHICH INCLUDES JAMES 71.                    11/73
R4  M   THESE AUTHORS FIND REAL(A)= 2.75+-.65, ABOVE VALUE AT RE(A)=0           2/71

R5      KOS INTO (MU+ MU-)/CHARGED (UNITS 10**-5)             (P3)/(P1)
R5            10.0   OR LESS  CL=.90   BOTT-BODE 67 OSPK                      8/67
R5            20.0   OR LESS  CL=.90   BOHM      69 OSPK                      2/71
R5             1.07  OR LESS  CL=.90   HYAMS     69 OSPK                     10/69
R5   S        32.6   OR LESS  CL=.90   STUTZKE   69 OSPK                      5/69
R5             0.047 OR LESS  CL=.90   GJESDAL   73 ASPK                      7/73
R5   S  VALUE CALCULATED BY US, USING 2.3 INSTEAD OF 1 EVENT, 90 PERC.CL

R6      KOS INTO (PI+ PI- GAMMA)/(PI+ PI-) (UN.10**-3)   (P5)/(P1)
R6       27          NO RATIO GIVEN      BELLOTTI  66 HBC     PG GT 50 MEV/C   10/69
R6       10     3.3       1.2           WEBBER    70 HBC     PG GT 50 MEV/C   10/69
R6 B             2.8       0.6           BURGUN    73 HBC     PG GT 50 MEV/C   11/73
R6 C     29    (3.0)     (0.6)          BOBISUT   74 HLBC    PG GT 40 MEV/C   12/75
R6   T           2.68      0.15          TAUREG    76 SPEC    PG GT 50 MEV/C    6/77*
R6 B    BURGUN 73 ESTIMATES THAT DIRECT EMISSION CONTRIBUTION IS .3+-.6 .      11/73
R6 C    BOBISUT 74 NOT INCLUDED IN AVERAGE BECAUSE P(GAMMA) CUT DIFFERS.        1/76
R6 C    ESTIMATES DIRECT EMISSION CONTRIBUTION TO BE 0.5 OR LESS, CL=.95.      1/76
R6   T  TAUREG 76 FIND DIRECT EMISSION CONTRIB LT .06,CL=.90.                  6/77*
R6          . . . . . . . . .
R6  AVG       2.70      0.14    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  STUDENT   2.70      0.16    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R7      KOS INTO (E+ E-)/CHARGED (UNITS 10**-5)               (P4)/(P1)
R7            50.0   OR LESS  CL=.90   BOHM      69 OSPK                      2/71

R8      KOS INTO 2 GAMMA/TOTAL (UNITS 10**-3)                 (P6)
R8 R      0    21.0   OR LESS  CL=.90   BANNER    69 OSPK                     12/71
R8 R      0     2.2   OR LESS  CL=.90   REPELLIN  71 OSPK                     12/71
R8 R      0     0.71  OR LESS  CL=.90   BANNER    72 OSPK                      8/72
R8        0     2.0   OR LESS  CL=.90   MORSE     72 DBC                       2/72
R8        0     0.4   OR LESS  CL=.90   BAMIN2    73 HLBC                      2/74
R8 R    THESE LIMITS ARE FOR MAXIMUM INTERFERENCE IN KS-KL TO 2 GAMMAS        12/71

R9      (KOS INTO PI+ PI- PIO, CP CONSERVING)/(KOL INTO PI+ PI- PIO)
R9      384    0.42   OR LESS  CL=.90   METCALF   72 ASPK                     11/72

R10     (KOS INTO 3PIO,CP VIOLATING)/(KOL INTO 3PIO)
R10     SEE COMMENTS UNDER BRANCHING RATIO R4
R10      22    1.2    OR LESS  CL=.90   BARMIN1   73 HLBC                     11/73
R10  G          0.28   OR LESS  CL=.90   GJESDAL   74 SPEC                     11/75
R10  G  GJESDAL 74 USES K2PI, KMU3 AND KE3 DECAY RESULTS AND UNITARITY.       11/75
R10  G  CALCULATES ABS(ETA000)=.26+-.20.  WE CONVERT TO CL=.90 UPPER LIMIT.   11/75
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REFERENCES FOR KOS


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BOLDT     58 PRL   1  150      E BOLDT,D O CALDWELL,Y PAL                (MIT)
CRAWFORD  59 PRL   2  266      CRAWFORD,CRESTI,DOUGLASS,GOOD,TICHO + (LRL)

BAGLIN    60 NC   18 1043      BAGLIN,BLOCH,BRISSON,HENNESSY +        (EPOL)
BOWEN     60 PR  119 2030      BOWEN,HARDY,REYNOLDS,SUN,MOORE+   (PRIN+BNL)
COLUMBIA  60 ROCH CONF 727     M SCHWARTZ +                          (COLUMBIA)

BROWN     61 NC   19 1155      BROWN,BRYANT,BURNSTEIN,GLASER,KADYK+ (MICH)
ANDERSON  62 CERN CONF 836     J A ANDERSON,F S CRAWFORD +             (LRL)
BERTANZA  62  PREPRINT DIO5    BERTANZA,CONNOLLY,CULWICK,EISLER +      (BNL)
    UNPUBLISHED, BUT RECERTIFIED BY AUTHORS, AUGUST 66.

CHRETIEN  63 PR  131 2208      CHRETIEN+     (BRANDEIS+BROWN+HARVARD+ MIT)
BROWN     63 PR  130  769      BROWN,KADYK,TRILLING,ROE +          (LRL+MICH)
KREISLER  64 PR  136 B 1074    M KREISLER,O OVERSETH,J CRONIN  (PRINCETON)
ANDERSON  65 PRL 14  475       +CRAWFOR,GOLDEN,STERN,BINFORD +   (LRL+WISC)

ALFF-STE  66 PL  21  595       ALFF-STEINBERGER,HEUER,KLEINKNECHT + (CERN)
AUERBACH  66 PR  149 1052      AUERBACH,DOBBS,LANDE,MANN,SCIULLI+    (PENN)
    ALSO 65 AUERBACH
BALTAY    66 PR  142  932      BALTAY,SANDWEISS,STEINHILL +       (YALE+BNL)
BEHR      66 PL   22  540      BEHR,BRISSON,PETIAU+ (EPOL,MILA,PADO,ORSAY)
BELLOTTI  66 NC  45A 737       +PULLIA,BALDO-CEOLIN +          (MILAN+PADUA)
BOTT-BOD  66 PL   23 277       BOTT-BODENHAUSEN,DE BOUARD +          (CERN)
KIRSCH    66 PR  147  939      L KIRSCH,P SCHMIDT                 (COLUMBIA)

BOTT-BOD  67 PL  24B 194       BOTT-BODENHAUSEN,DE BOUARD,CASSEL+    (CERN)
DONALD    68 PL  27B  58       DONALD,EDWARDS,NISAR+ (LIVP,CERN,IPNP,CDEF)
HILL      68 PR 171 1418       HILL,ROBINSON,SAKITT +          (BNL,CARNEGIE)

BANNER    69 PR 188 2033       +CRONIN,LIU,PILCHER                (PRINCETON)
BOHM      69 THESIS            A. BOHM                               (AACH)
BOZOKI    69 PL  30B 498       +FENYVES,GOMBOSI,NAGY,SURANYI+      (BUDAPEST)
DOYLE     69 UCRL 18139-THESIS J.C. DOYLE                            (LRL)
GOBBI     69 PRL  22  682      GOBBI,GREEN,HAKEL,MOFFETT,ROSEN+(ROCHESTER)
HYAMS     69 PL   29B 521      +KOCH,POTTER,VON LINDERN,LORENZ+ CERN(MPIM)
MORFIN    69 PRL   23  660     MORFIN,SINCLAIR                        (MICH)
STUTZKE   69 PR   177 2009     +ABASHIAN,JONES,MANTSCH,ORR,SMITH(ILLINOIS)
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MOFFETT   70 BAPS 15 512         +GOBBI,GREEN,HAKEL,ROSEN          (ROCHESTER)
WEBBER    70 PR D1 1967          +SOLMITZ,CRAWFORD,ALSTON-GARNJOST       (LRL)
    ALSO 69 UCRL 19226 THESIS B R WEBBER                                  (LRL)

BALTAY    71 PRL 27 1678         +BRIDGEWATER,COOPER,GERSHWIN,HABIBI+ (COLU)
    ALSO 71 NEVIS-187 THESIS   WILLIAM A. COOPER                    (COLUMBIA)
CHO       71 PR D3 1557          +DRALLE,CANTER,ENGLER,FISK+ (CARN+BNL+CASE)
JAMES     71 PL 35B 265          +MONTANET,PAUL,PAULI+        (CERN+SACL+OSLO)
MEISNER   71 PR D3 59            +MANN,HERTZBACH,KOFLER +      (MASA+BNL+YALE)
REPELLIN  71 PL 36B 603          +WOLFF,CHOLLET,GAILLARD,JANE+    (ORSA+CERN)

ALITTI    72 PL 39B 568          J ALITTI,E LESQUOY,A MULLER          (SACLAY)
BANNER    72 PRL 29 237          +CRONIN,HOFFMAN,KNAPP,SHOCHET    (PRINCETON)
JAMES     72 NP B49 1            +MONTANET,PAUL,SAETRE+       (CERN+SACL+OSLO)
JONES     72 NC 9A 151           +ABASHIAN,GRAHAM,MANTSCH,ORR,SMITH+    (ILL)

METCALF   72 PL 40B 703          +NEUHOFER,NIEBERGALL+         (CERN+IPN+WIEN)
MORSE     72 PRL 28 388          +NAUENBERG,BIERMAN,SAGER+    (COLO+PRIN+UMD)
NAGY      72 NP B47 94           +TELBISZ,VESZTERGOMBI              (BUDAPEST)
    ALSO 69 PL 30B 498           BOZOKI,FENYVES,GOMBOSI,NAGY+       (BUDAPEST)
SKJEGGES 72 NP B48 343           SKJEGGESTAD,JAMES,MONTANET+(OSLO+CERN+SACL)

BARMIN1   73 PL 46B 465          +BARYLOV,CAVIDENKO,DEMIDOV+             (ITEP)
BARMIN2   73 PL 47B 463          +BARYLOV,DAVIDENKO,DEMIDOV+             (ITEP)
BURGUN    73 PL 46B 481          +BERTRANET,LESQUOY,MULLER,PAULI+(SACL+CERN)
FACKLER   73 PRL 31 847          +FRISCH,MARTIN,SMOOT,SOMPAYRAC           (MIT)
GJESDAL   73 PL 44B 217          +PRESSER,STEFFEN,STEINBERGER+    (CERN+HEID)
HILL      73 PR D8 1290          +SAKITT,SAMIOS,BURRIS,ENGLER+      (BNL+CARN)
MALLARY   73 PR D7 1953          +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI+  (CIT)

BOBISUT   74 LNC 11 646          +HUZITA,MATTIOLI,PUGLIERIN              (PADO)
COWELL    74 PR D10 2083         +LEE-FRANZINI,ORCUTT,FRANZINI + (STON+COLU)
GEWENIGE 74 PL 48B 487           GEWENIGER,GJESDAL,PRESSER+       (CERN+HEID)
GJESDAL   74 PL 52B 119          +PRESSER,STEFFEN,STEINBERGER +   (CERN+HEID)

BALDOCEO 75 NC 25A 688           BALDO-CEOLIN,BOBISUT,CALIMANI+   (PADO+WISC)
CARITHER 75 PRL 34 1244          CARITHERS,MODIS,NYGREN,PUN +       (COLU+NYU)
ARONSON   76 NC 32A 236          +MCINTYRE,ROEHRIG +       (WISC+EFI+UCSD+ILLC)
EVERHART 76 PR D14 661           +KRAUS,LANDE,LONG,LOWENSTEIN +          (PENN)
TAUREG    76 PL 65B 92           +ZECH,DYDAK,NAVARRIA+         (HEID+CERN+DORT)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

BIRGE     60 ROCH CONF 601       R W BIRGE,P P ELY +            (LRL+WISCONSIN)
MULLER    60 PRL    4  418       MULLER,BIRGE,FOWLER,GOOD,PICCIONI+(LRL+BNL)
FITCH     61 NC    22 1160       V FITCH,P PIROUE,R PERKINS        (PRIN+LASL)
GOOD      61 PR   124 1223       GOOD,MATSEN,MULLER,PICCIONI +            (LRL)

CRAWFORD 62 CERN CONF 827        F S CRAWFORD                             (LRL)
AUERBACH 65 PRL 14 192           AUERBACH,LANDE,MANN,SCIULLI,UTO +       (PENN)
TRILLING 65 UCRL 16473           GEORGE H TRILLING                        (LRL)
    UPDATED FROM 1965 ARGONNE CONF., PAGE 115.

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K^0_L

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              13  LONG-LIVED NEUTRAL K(498, JP=0-) I=1/2
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                  13  (KOL) - (KOS) MASS DIFFERENCE
      WE GIVE (KOL-KOS MASS DIFFERENCE / HBAR) IN UNITS OF 10**10 SEC-1

D  TX       (2.20)   (0.35)           FITCH     61 CNTR
D   X       (0.84)   (0.29)     (0.22)GOOD      61 HLBC
D  TXC      (1.02)   (0.23)           CAMERINI  62 HLBC                     8/67
D  TX       (0.55)   (0.24)           AUBERT    65 HLBC                     6/66
D   X       (0.26)   (0.36)     (0.26)BALDO-CEO 65 HLBC   ASSUMES CP CONS.
D  TXA      (0.64)   (0.12)           CHRISTENS 65 OSPK                     6/66
D  TX       (0.70) OR LESS            FITCH     65 OSPK   CF. MEISNER 66    7/66
D   V  130  (0.89)   (0.15)           VISHNEVSK 65 OSPK   CU AND AL REGEN   8/67
D   X       (0.514)  (0.039)          ALFF-STEI 66 OSPK                     6/66
D   X   84  (0.42)   (0.24)    (0.36) BALDO-CEO 66 HLBC   KO+N INTO HYPER.  8/67
D   B       (0.531)  (0.027)          BOTT-BODE 66 OSPK   C REGEN           9/66
D  TX   77  (0.58)   (0.17)           CAMERINI  66 HBC, DBC KO+N INTO HYPER 8/67
D   N   72  (+0.64)  (0.18)           CANTER    66 DBC    KO SCATTER IN D2 11/66
D   X   95  (0.62)   (0.10)    (0.16) CHANG     66 HBC    KO+P INTO HYPER.  8/67
D   X       (0.81)   (0.17)           FUJII     66 OSPK   IRON REGENERATOR  9/66
D   X   59  (0.74)   (0.34)           MEISNER1  66 HBC                      6/66
D         + SIGN FAVORED              MEISNER2  66 HBC                      9/66
D   X       (0.38)   (0.16)           JOVANOVIC 66 OSPK   C+URANIUM REGEN. 11/66
D  TX  136  (+0.64)  (0.19)           CANTER    67 DBC    KO+D INTO HYPER. 11/67
D   X       (0.65)   (0.11)           MISCHKE   67 OSPK                   .11/67
D   X  590  (0.59)   (0.13)           BALATZ    68 OSPK   AL REGENERATOR    3/68
D   X       (0.520)  (0.044)          CARNEGIE  68 HBC    GAP METHOD        3/68
D  TX       (+0.487) (0.046)          MELHOP    68 OSPK   ST.STEEL REGEN    6/68
D  BX       (0.547)  (0.024)          BOTT-BODE 69 OSPK   C REGEN           1/71
D  FX       (0.555)  (0.020)          FAISSNER  69 ASPK   REGEN IN CU      10/69
D            0.542    0.006           CULLEN    70 CNTR                     1/71
D   R       (0.542)  (0.006)          ARONSON   70 ASPK   GAP METHOD        1/71
D   X       (0.481)  (0.052)   (0.075)BALATS    71 OSPK                     9/71
D   R       (0.534)  (0.007)          CARNEGIE  71 ASPK   GAP METHOD        8/71
D  TH  119  (+0.67)  (0.14)           HILL      71 DBC                     10/71
D   S 1757  (0.557)  (0.038)          FACKLER   73 OSPK                    11/73
D            0.5340   0.0030          GEWENIG3  74 SPEC   GAP METHOD       11/75
D            0.5334   0.0040          GJESDAL   74 SPEC   CHG ASYMMETRY    11/75
D           . . . . . . . . . .
D  AVG      0.5349   0.0022  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D  STUDENT  0.5348   0.0025  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                    COMMENTS
D   X   NO ATTEMPT HAS BEEN MADE TO CORRECT OLDER EXPERIMENTS WITH LARGE   11/75
D   X   ERRORS FOR THE SUBSEQUENT CHANGES IN THE KOS MEAN LIFE OR IN ETA+-. 2/76
D  T    A KOS MEAN LIFE OF 0.862 10**-10 SEC WAS USED IN CONVERTING THE     1/71
D  T    MASS DIFFERENCE FROM UNITS OF INVERSE KOS MEAN LIVES TO ABSOLUTE    1/71
D  T    UNITS. VALUES NOT BEARING THIS FOOTNOTE EITHER WERE GIVEN IN        1/71
D  T    ABSOLUTE UNITS OR WERE CONVERTED USING THE AUTHORS' VALUE OF THE    1/71
D  T    KOS MEAN LIFE.                                                      1/71
D    C  CAMERINI 62 VALUE CHANGED FROM 1.7 (SEE TABLE 1 OF CAMERINI 66)     8/67
D    A  CHRISTENSON 65 CORRECTED FOR INTERFERENCE BY FITCH 65 FOOTNOTE.     1/71
D   V   VISHNEVSKY 65 NOT CORRECTED FOR INTERFERENCE EFFECTS.               3/68
D   N   CANTER 66 ERROR IGNORES UNCERTAINTY OF PHASE SHIFTS.  THESE EVENTS 10/71
D   N   ARE USED IN HILL 71.                                               10/71
D  B    BOTT-BODENHAUSEN 69 IS A REEVALUATION OF BOTT-BODENHAUSEN 66.       1/71
D  F    FAISSNER 69 HAS ADDNL. SYSTEMATIC ERROR LESS THAN TWO PERCENT.      1/71
D   R   ARONSON 70 AND CARNEGIE 71 USE KOS MEAN LIFE=.862+-.006 E-10 SEC.  11/75
D   R   WE HAVE NOT ATTEMPTED TO ADJUST THESE VALUES FOR THE SUBSEQUENT     2/76
D   R   CHANGE IN THE KOS MEAN LIFE OR IN ETA+-.                            2/76
D   H   HILL 71 PRIMARY RESULT IS THAT DM IS POSITIVE.                     10/71
D   H   THE MAGNITUDE MAY HAVE AN ADDITIONAL SYSTEMATIC ERROR OF ABOUT 0.12 10/71
D   S   NOT AVERAGED BECAUSE ERROR IS LARGE AND SYSTEMATICS NOT DISCUSSED.  2/76

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                  13  KOL MEAN LIFE (UNITS 10**-8 SEC)

T        KOL MEAN LIFE
T       34    8.1      3.2      2.4   BARDON    58 CNTR
T       ASSUMED DS=DQ AND DELTA I=1/2 CRAWFORD  59 HBC
T       15    5.1      2.4      1.3   DARMON    62 FBC
T             5.3      0.6            FUJII     64 OSPK
T     1700    6.1      1.5      1.2   ASTBURY3  65 CNTR
T             5.15     0.14           DEVLIN    67 CNTR
T   L        (5.0)    (0.5)           LOWYS     67 HLBC
T      .4M    5.154    0.044          VOSBURGH  72 CNTR                     2/71
T   L   SUM OF PARTIAL DECAY RATES.
T           . . . . . . . . . .
T   AVG       5.158    0.042    0.042  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT   5.158    0.046    0.045  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
T   FIT       5.183    0.040  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  13  KOL PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      KOL INTO 3PIO                        TAU O PRIME    134+ 134+ 134
P2      KOL INTO PI+ PI- PIO                 TAU O          139+ 139+ 134
P3      KOL INTO PI MU NEUTRINO              KL MU3         139+ 105+   0
P4      KOL INTO PI E NEUTRINO               KL E3          139+  .5+   0
P5      KOL INTO PI+ PI-                     KL PI+ PI-     139+ 139
P6      KOL INTO MU+ MU-                     KL 2MU         105+ 105
P7      KOL INTO E+ E-                       KL 2E           .5+  .5
P8      KOL INTO E MU                        KL EMU          .5+ 105
P9      KOL INTO TWO GAMMAS                  KL 2GAMMA        0+   0
P10     KOL INTO PI+ PI- GAMMA               KL PI+-G       139+ 139+   0
P11     KOL INTO PIO PIO                     KL 2PIO        134+ 134
P12     KOL INTO PI E NEU GAMMA              KL E3GAM       139+  .5+   0+   0
P13     KOL INTO PIO TWO GAMMAS              KL PI2GAMMA    134+   0+   0
P14     KOL INTO E+ E- GAMMA                 KL 2EGAM        .5+  .5+   0
P15     KOL INTO MU+ MU- GAMMA               KL 2MUGAM      105+ 105+   0
P16     KOL INTO MU+ MU- PIO                 KL 2MUPIO      105+ 105+ 134
P17     KOL INTO PI+ PI- E+ E-               KL 2PI2E       139+ 139+  .5+  .5
P18     KOL INTO PIO PI+- E-+ NEU            KL 2PIENEU     134+ 139+  .5+   0
P19     KOL INTO (PI MU ATOM) NEU            KL (PIMU)NEU

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                  NEUTRAL K CONSTRAINED FIT
          OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
          RATIOS USES 64 DATA POINTS TO DETERMINE SIX                     3/78*
          QUANTITIES.  OVERALL FIT HAS CHI-SQUARED=69.8                   3/78*

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P11
P 1	.2147+-.0073					
P 2	-.5340	.1239+-.0018				
P 3	-.5709	.1869	.2701+-.0048			
P 4	-.6711	.2212	-.1788	.3884+-.0054		
P 5	-.3361	.4867	.1379	.1627	.0020+-.0001	
P11	.1719	-.1061	-.1115	-.1312	-.0665	.0009+-.0002

FITTED PARTIAL DECAY MODE RATES

The matrix below is the branching fraction matrix above, transformed into rate space; i.e., $G_i \equiv \Gamma_i = \Gamma_{total} P_i$, in appropriate units. In analogy to the matrix above, the diagonal elements are $G_i \pm \delta G_i$, where $\delta G_i = \sqrt{\langle \delta G_i \delta G_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta G_i \delta G_j \rangle / (\delta G_i \cdot \delta G_j)$. Note that, because of the error in Γ_{total}, the errors and correlations here are not directly derivable from those above.

	G 1	G 2	G 3	G 4	G 5	G11
G 1	.0414+-.0015					
G 2	-.3285	.0239+-.0004				
G 3	-.3816	.2970	.0521+-.0010			
G 4	-.4277	.3439	-.0028	.0749+-.0011		
G 5	-.2206	.5284	.2112	.2440	.0004+-.0000	
G11	.1814	-.0706	-.0798	-.0896	-.0471	.0002+-.0000

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                  13  KOL DECAY RATES

W1      KOL INTO PIO PIO PIO (UNITS 10**6 SEC-1)          (G1)
W1       54    5.22     1.03      0.84  BEHR      66 HLBC    ASSUMES CP      8/66
W1           . . . . . . . . . .
W1   FIT       4.14     0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

W2      KOL INTO PI+ PI- PO (UNITS 10**6 SEC-1)           (G2)
W2       18    3.26     0.77            ANDERSON  65 HBC                     8/66
W2       14    1.4      0.4             FRANZINI  65 HBC                     6/66
W2      136    2.62     0.28      0.27  BEHR      66 HLBC    ASSUMES CP      8/66
W2       53    2.20     0.35            WEBBER    70 HBC     ASSUMES CP     10/71
W2       99    2.71     0.28            CHO       71 DBC     ASSUMES CP    . 4/71
W2   J   98   (2.5)    (0.3)            JAMES     71 HBC     ASSUMES CP      6/71
W2       50    2.12     0.33            MEISNER   71 HBC     ASSUMES CP     10/71
W2 J    180    2.35     0.20            JAMES     72 HBC     ASSUMES CP      1/73
W2      192    2.32     0.13      0.15  BALDOCEOL 75 HLBC    ASSUMES CP      1/76
W2        IN THE OVERALL FIT THIS RATE IS WELL DETERMINED BY THE MEAN LIFE AN
W2        THE BRANCHING RATIO R2. FOR THIS REASON THE DISCREPANCY BETWEEN THE
W2        W2 MEASUREMENTS DOES NOT AFFECT THE SCALE FACTOR OF THE OVERALL FIT
W2 J      JAMES 72 IS A FINAL MEASUREMENT AND INCLUDES JAMES 71.            11/73
W2           . . . . . . . . . .
W2   AVG       2.34     0.11      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
W2   STUDENT   2.35     0.10      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
W2   FIT       2.391    0.038  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                        (SEE IDEOGRAM BELOW )
```

Stable Particles

K_L^0

Data Card Listings

For notation, see key at front of Listings.

```
                WEIGHTED AVERAGE = 2.34 ± 0.11
                  ERROR SCALED BY 1.2
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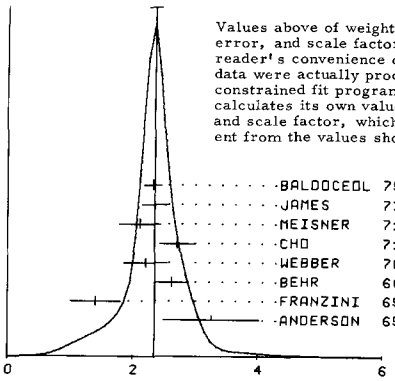


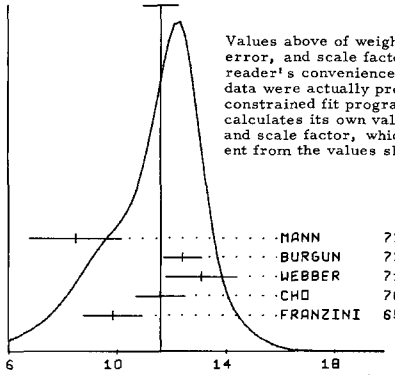
Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

```
W3     KOL INTO PI E NEUTRINO (UNITS 10**6 SEC-1)          (G4)
W3          7.52      0.85      0.72  AUBERT     65 HLBC    DS=DQ+CP ASSUMED   8/67
W3     620  7.81      0.56            CHAN       71 HBC                        2/72
W3          . . . . . . . . . .
W3  AVG     7.71      0.46     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W3  STUDENT 7.71      0.49     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
W3  FIT     7.49      0.11   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

W4     KOL INTO CHARGED (3-BODY) (UNITS 10**6 SEC-1)    (G2+G3+G4)
W4      98  15.1      1.9             AUERBACH   66 OSPK                       8/67
W4          . . . . . . . . . .
W4  FIT     15.09     0.17   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

W5     KOL INTO LEPTONIC (KMU3+KE3) (UNITS 10**6 SEC-1) (G3+G4)
W5   D 109    9.85     1.15     1.05  FRANZINI   65 HBC                        2/72
W5 C 335 (10.3)  (0.8)             HILL       67 DBC    K+N TO KO P            8/67
W5   D 393   11.6      0.9             CHO        70 DBC    K+N TO KOP          10/70
W5   D 252   13.1      1.3             WEBBER     71 HBC    K- P TO KOBAR N      2/72
W5   D 410   12.4      0.7             BURGUN     72 HBC    K+P TO KOPPI+        1/73
W5   D 126   8.47     1.69             MANN       72 HBC    K- P TO KOBAR N      9/72
W5 C  CHO 70 INCLUDES EVENTS OF HILL 67
W5   D  ASSUMES DS=DQ RULE
W5          . . . . . . . . . .
W5  AVG    11.60     0.65     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
W5  STUDENT 11.66    0.54     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
W5  FIT     12.70    0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                             (SEE IDEOGRAM BELOW )
```

```
                WEIGHTED AVERAGE = 11.60 ± 0.65
                  ERROR SCALED BY 1.5
```



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

```
W6     KOL INTO PI MU NEUTRINO UNITS 10**6 SEC-1)          (G3)
W6      19   4.54     1.24     1.08  LOWYS      67 HLBC                       8/67
W6          . . . . . . . . . .
W6  FIT     5.211    0.100   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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13 KOL BRANCHING RATIOS

```
R1     KOL INTO (PIO PIO PIO)/CHARGED                      (P1)/(P2+P3+P4)
R1      24    0.24     0.08            ANIKINA    64 CC                         6/66
R1     549    0.251    0.014           BUDAGOV    68 HLBC    ORSAY MEASUR.      10/68
R1     444    0.277    0.021           BUDAGOV    68 HLBC    EC. POLYTEC.MEAS   10/68
R1      29    0.31     0.07     0.06   KULYUKINA  68 CC                         2/71
R1          . . . . . . . . . .
R1  AVG     0.260    0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT 0.260    0.013   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT     0.274    0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2     KOL INTO (PI+ PI- PIO)/CHARGED                      (P2)/(P2+P3+P4)
R2      59    0.185    0.038           ASTIER     61 CC                         8/66
R2      79    0.151    0.020           ADAIR      64 HBC                        8/66
R2      75    0.157    0.03     0.04   LUERS      64 HBC                        8/66
R2      66    0.15     0.03     0.04   ASTBURY1   65 CC                         8/66
R2     326    0.159    0.015           ASTBURY2   65 CC                         6/66
R2     566    0.178    0.017           GUIDONI    65 HBC                        6/66
R2    1729   (0.144)  (0.004)          HOPKINS    65 HBC     SEE HOPKINS 67     6/66
R2     126    0.162    0.015           HAWKINS    66 HBC                        6/66
R2            0.161    0.005           HOPKINS    67 HBC                        8/67
R2    1402    0.167    0.016           KULYUKINA  68 CC                         2/71
R2    1590    0.1605   0.0038          ALEXANDER  73 HBC                        1/74
R2    3200    0.146    0.004           BRANDENBU  73 HBC                        1/74
R2     558    0.159    0.010           EVANS      73 HLBC                       1/73
R2    6499    0.163    0.003           CHO        77 HBC                       11/77*
R2          . . . . . . . . . .
R2  AVG     0.1587   0.0024  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2  STUDENT 0.1600   0.0022  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT     0.1584   0.0020 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                     (SEE IDEOGRAM BELOW )
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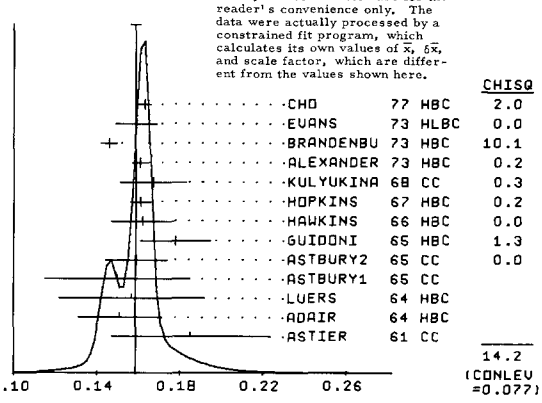
                WEIGHTED AVERAGE = 0.1587 ± 0.0024
                  ERROR SCALED BY 1.3
```



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

```
R3     KOL INTO (PI MU NEUTRINO)/CHARGED                   (P3)/(P2+P3+P4)
R3  C  251   (0.356)  (0.07)          LUERS      64 HBC
R3  C  172   (0.39)   (0.08)   (0.10) ASTBURY1   65 CC                         7/66
R3  C  330   (0.335)  (0.055)         KULYUKINA  68 CC                         2/71
R3  C THIS MODE NOT MEASURED INDEPENDENTLY FROM R2 AND R4
R3          . . . . . . . . . .
R3  FIT     0.3452   0.0051 FROM FIT

R4     KOL INTO (PI E NEUTRINO)/CHARGED                    (P4)/(P2+P3+P4)
R4      24    0.46     0.11            NEAGU      61 CC                         2/76
R4     153    0.487    0.05            LUERS      64 HBC
R4     202    0.46     0.08     0.10   ASTBURY1   65 CC                         7/66
R4     500    0.498    0.052           KULYUKINA  68 CC                         2/71
R4          . . . . . . . . . .
R4  AVG     0.485    0.032   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  STUDENT 0.485    0.034   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4  FIT     0.4964   0.0051 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5     KOL INTO (PI E NEU)/((PI E NEU)+(PI MU NEU))        (P4)/(P3+P4)
R5      320   0.415    0.120           ASTIER     61 CC
R5          . . . . . . . . . .
R5  FIT     0.5898   0.0059 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6     KOL INTO (PI+ PI- PIO)/TOTAL                        (P2)
R6
R6          . . . . . . . . . .
R6  FIT     0.1239   0.0018 FROM FIT

R7     KOL INTO (LEPTON PI NEUTRINO)/TOTAL                 (P3+P4)
R7
R7          . . . . . . . . . .
R7  FIT     0.6584   0.0066 FROM FIT

R8     KOL INTO (2 GAMMA)/TOTAL (UN. 10**-4)               (P9)
R8  C         (1.3)    (0.6)           CRIEGEE    66 OSPK                       8/66
R8       32    6.7      2.2             TODOROFF   67 OSPK    REPL. CRIEGEE66    11/68
R8  K    33   (7.4)    (1.6)            CRONIN 1   67 OSPK                       11/67
R8       99    5.5      1.1             KUNZ       68 OSPK    NORM.TO 3PI(C+N)   2/71
R8       23    4.5      1.0             ENSTROM    71 OSPK    KOL 1.5-9 GEV/C    2/72
R8 R          5.0     (1.0)            REPELLIN   71 OSPK                       11/71
R8 B          4.54     0.84            BANNER2    72 OSPK                       8/72
R8 B   THIS VALUE USES (E00/E+-)**2=1.05+-0.14. IN GENERAL, S13R8 =             8/72
R8 B   (4.32+-0.55)*(10**-4)*((E00/E+-)**2).                                    8/72
R8 R   ASSUMES REGEN AMPL IN COPPER AT 2GEV IS 22  MB. TO EVALUATE             11/71
R8 R   FOR A GIVEN REGEN AMPL AND ERROR, MULTIPLY BY (REGEN AMPL/22MB)**2      11/71
R8 C      CRIEGEE 66 REPLACED BY TODOROFF 67                                   11/68
R8 K      CRONIN1 67 REPLACED BY KUNZ 68.                                      2/71
R8          . . . . . . . . . .
R8  AVG     4.89     0.54    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  STUDENT 4.88     0.59    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9     KOL INTO (PI+ PI-)/CHARGED (UNIT 10**-3)            (P5)/(P2+P3+P4)
R9  O   45   (2.0)    (0.4)           CHRISTENS  64 OSPK ETA +- = 1.95+-0.20  2/76
R9  O   54   (2.08)   (0.35)          GALBRAITH  65 OSPK ETA +- = 1.99+-0.16  2/76
R9  O        (1.93)   (0.26)          BASILE     66 OSPK ETA +- = 1.92+-0.13. 2/76
R9  O        (1.993)  (0.080)         BOTT-BODE  66 OSPK ETA +- = 1.95+-0.04  2/76
R9  M 4200   (2.60)   (0.07)          MESSNER    73 ASPK ETA +- = 2.23+-0.05  6/73
R9  O  OLD EXPERIMENTS EXCLUDED FROM FIT.  SEE SUBSECTION E+- BELOW FOR        2/76
R9  O  AVERAGE ETA+- OF THESE EXPERIMENTS AND FOR NOTE ON DISCREPANCY.         2/76
R9  M  FROM SAME DATA AS R27 MESSNER 73,BUT WITH DIFFERENT NORMALIZATION.      6/73
R9          . . . . . . . . . .
R9  FIT     2.589    0.060   FROM FIT
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Data Card Listings

For notation, see key at front of Listings.


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R10    KOL INTO (PI MU NEU)/(PI E NEU)                          (P3)/(P4)
R10          0.81      0.19          ADAIR     64 HBC                        6/66
R10          0.82      0.10          DEBOUARD  67 OSPK                      11/67
R10    273   0.7       0.2           HAWKINS   67 HBC                        8/67
R10          0.81      0.08          HOPKINS   67 HBC                        8/67
R10    770   0.71      0.05          BUDAGOV   68 HLBC                      10/68
R10 K       (0.67)    (0.13)         KULYUKINA 68 CC                      . 3/74
R10 B  569  (0.71)    (0.04)         BEILLIERE 69 HLBC                      10/69
R10   1309  (0.648)   (0.030)        EVANS     69 HLBC REPL. BY EVANS 73    1/73
R10   3548    0.68      0.08         BASILE    70 OSPK                      10/70
R10   6700    0.741     0.044        BRANDENBU 73 HBC                        1/74
R10   1309    0.662     0.030        EVANS     73 HLBC                       1/73
R10    10K    0.662     0.037        WILLIAMS  74 ASPK                      10/74
R10 K   KULYUKINA 68 R10 IS NOT MEASURED INDEPENDENTLY FROM R2 AND R4.       1/74
R10 B  BEILLIERE 69 IS A SCANNING EXPT USING SAME EXPOSURE AS BUDAGOV 68
R10          * * * * * * * * *
R10 AVG      0.695     0.019    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R10 STUDENT  0.695     0.021    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R10 FIT      0.695     0.017  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11    KOL INTO (MU+MU-)/CHARGED (UNITS 10**-6)                 (P6)/(P2+P3+P4)
R11         100.0    OR LESS              ANIKINA   65 CC                      6/66
R11         250.0    OR LESS  CL=.90      ALFF-STEI 66 OSPK                    9/66
R11           2.0    OR LESS  CL=.90      BOTT-BODE 67 OSPK                    8/67
R11          35.0    OR LESS  CL=.90      FITCH     67 OSPK                    3/68

R12    KOL INTO (PI+ PI- GAMMA)/TOTAL (UNITS 10**-3)            (P10)
R12          15.0    OR LESS              ANIKINA   65 CC                      6/66
R12     0     5.0    OR LESS              BELLOTTI  66 HLBC    GAM KE 40-130 MV 8/67
R12     1     3.0    OR LESS              NEFKENS   66 OSPK    GAM KE 120 MEV   6/66
R12           0.4    OR LESS  CL=.90      THATCHER  68 OSPK    GAM KE 20-170 MV 2/71
R12           3.2    OR LESS  CL=.90      BOBISUT   74 HLBC    GAM KE GT 40 MEV 12/75
R12  D  24    0.062     0.021             DONALDS1  74 SPEC                    10/74
R12           0.46   OR LESS  CL=.90      WOO       74 SPEC                    12/75
R12  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                          10/74

R13    KOL INTO (E+ E-)/CHARGED (UNITS 10**-6)                  (P7)/(P2+P3+P4)
R13        1000.0    OR LESS              ANIKINA   65 CC                      6/66
R13         200.0    OR LESS  CL=.90      ALFF-STEI 66 OSPK                    6/66
R13          23.0    OR LESS  CL=.90      BOTT-BODE 67 OSPK                    8/67

R14    KOL INTO (E MU)/CHARGED (UNITS 10**-4)                   (P8)/(P2+P3+P4)
R14          10.0    OR LESS              ANIKINA   65 CC                      6/66
R14           1.0    OR LESS  CL=.90      CARPENTER 66 OSPK                    8/66
R14           0.1    OR LESS  CL=.90      BOTT-BODE 67 OSPK                    8/67
R14           0.08   OR LESS  CL=.90      FITCH     67 OSPK                    3/68

R15    KOL INTO (E+ PI- NEU)/(E- PI+ NEU)
R15 O   97  (0.90)   (0.18)              NEAGU     61 CC
R15 O       (1.01)   (0.16)              LUERS     64 HBC                     8/66
R15 O  894  (0.99)   (0.023)             KULYUKINA 66 CC                      9/66
R15 O 1539  (1.06)   (0.05)              VERHEY    66 OSPK                    8/67
R15 O   LOW PRECISION EXPTS NOT AVERAGED.  FOR MORE PRECISE VALUE,
R15 O   SEE S13A2 (BENNETT 70, MARX 70)

R16    KOL INTO (MU+ PI- NEU)/(MU- PI+ NEU)
R16     1M   1.0081    0.0027            DORFAN    67 OSPK                    11/67
R16     SEE ALSO S13A2 AND S13AL IN THE CP VIOLATION SECTION                   2/71

R17    KOL INTO (PIO PIO)/TOTAL (UNITS 10**-3)                  (P11)
R17 C    7   (1.2)    (1.5)    (1.2)  CRIEGEE   66 OSPK                      7/66
R17 C   CRIEGEE EXPT NOT DESIGNED TO MEASURE 2 PIO DECAY MODE
R17 G  189   (2.5)    (0.8)            GAILLARD  69 OSPK    E00=3.6+-0.6      5/69
R17 G   LATEST RESULT OF THIS EXPERIMENT GIVEN BY FAISSNER 70 R19              1/71
R17          * * * * * * * * *
R17 FIT      0.94      0.18   FROM FIT

R18    KOL INTO (3PIO)/(PI+PI-PIO)                              (P11)/(P2)
R18    188    2.0       0.6             ALEKSANYA 64 FBC                     9/66
R18   1010    1.80      0.13            BUDAGOV   68 HLBC                    10/68
R18    883   (1.65)   (0.07)           BARMIN2   72 HLBC    ERROR STAT. ONLY  3/74
R18          * * * * * * * * *
R18 AVG      1.81      0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 STUDENT  1.81      0.14    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R18 FIT      1.733     0.076  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R19    KOL INTO (2PIO)/(3PIO) (UNITS 10**-2)                    (P11)/(P1)
R19 C  109   (1.89)   (0.31)            CRONIN 1  67 OSPK    ETA00=4.9+-0.5     8/67
R19 C        (1.36)   (0.18)            CRONIN 2  67 OSPK    ETA00=3.92+-0.3    11/67
R19 C      CRONIN2 IS FURTHER ANALYSIS OF CRONIN1 ,NOW BOTH WITHDRAWN           11/68
R19     NO EVENTS SEEN                  BARTLETT  68 OSPK    SEE E00 BELOW      11/68
R19     57    0.46      0.11            BANNER    69 OSPK    ETA00=2.2+-0.3     2/72
R19 R  133   (1.31)   (0.31)           CENCE     69 OSPK    ETA00=3.7+-0.5     10/69
R19     29    0.37      0.08            BARMIN    70 HLBC    ETA00=2.02+-0.23   12/70
R19     30    0.32      0.15            BUDAGOV   70 HLBC    ETA00=1.9+-0.5     10/70
R19  F 172    0.90      0.30            FAISSNER  70 OSPK    ETA00=3.2+-0.5     12/70
R19  R 150    1.21      0.30            REY       76 OSPK    ETA00=3.8+-0.5     8/76*
R19  F FAISSNER 70 CONTAINS SAME 2PIO EVENTS AS GAILLARD 69 R17
R19  R  CENCE 69 EVENTS ARE INCLUDED IN REY 76.                               1/77*
R19          * * * * * * * * *
R19 AVG      0.437     0.092    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R19 STUDENT  0.425     0.065    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT      0.437     0.083  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)
                              (SEE IDEOGRAM BELOW )

R20    KOL INTO (PI+ PI-)/(KE3 + KMU3) (UNITS 10**-3)   (P5)/(P3+P4)
R20 O  309   (2.51)   (0.23)            DEBOUARD  67 OSPK    ETA+-=2.00+-0.09   2/76
R20 O  525   (2.35)   (0.19)            FITCH     67 OSPK    ETA+-=1.94+-0.08   2/76
R20   2703    3.04      0.14            DEVOE     77 SPEC    ETA+-=2.25+-0.05   11/77*
R20 O   OLD EXPERIMENTS EXCLUDED FROM FIT.  SEE SUBSECTION E+- BELOW FOR       2/76
R20 O   AVERAGE ETA+- OF THESE EXPERIMENTS AND FOR NOTE ON DISCREPANCY.        2/76
R20          * * * * * * * * *
R20 FIT      3.076     0.075  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R21    KOL INTO (2GAMMA)/(3 PIO) (UNITS 10**-3)                 (P9)/(P1)
R21     16    2.5       0.7             ARNOLD    68 HLBC    VACUUM DECAY      11/68
R21  $  BANNER 69 IS NEW EXPT. NOT TO BE CONF WITH R8 OF CRONIN1 67             2/72
R21    115    2.24      0.28            BANNER    69 OSPK                      11/68
R21     28    2.13      0.43            BARMIN    71 HLBC                      8/71
R21          * * * * * * * * *
R21 AVG      2.24      0.22    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R21 STUDENT  2.24      0.24    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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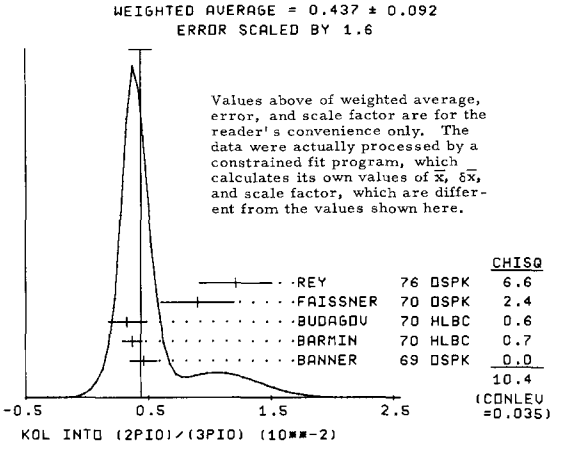


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R22    KOL INTO (MU+MU-)/(PI+PI-) (UNITS 10**-6)                (P6)/(P5)
R22      0  140.    OR LESS  CL=.90   FOETH     69 SPEC EFF.DENOM.=  16000   5/70
R22      0   18.    OR LESS  CL=.90   DARRIULAT 70 SPEC EFF.DENOM.= 125000   11/70
R22 A    0  (1.53) OR LESS  CL=.90   CLARK     71 SPEC EFF.DENOM.(1500000)   2/76
R22 C    6   6.7      6.1      3.1   CARITHE1  73 SPEC EFF.DENOM.= 893000    2/76
R22 C    3   4.5      6.       3.    CARITHE2  73 SPEC EFF.DENOM.= 667000    2/76
R22 C    9  (5.8)    (4.)     (2.)   CARITHE2  73 SPEC EFF.DENOM.(1560000)   2/76
R22  F   3   4.2      5.1      2.6   FUKUSHIMA 76 SPEC EFF.DENOM.= 719000    2/76
R22     16   4.2      1.4      0.9   SHOCHET   77 SPEC EFF.DENOM.=3820000    8/77*
R22 A   CLARK 71 LIMIT RAISED FROM 1.2 E-06 BY FIELD 74 REANALYSIS.           2/76
R22 A   NOT IN AGREEMENT WITH THREE SUBSEQUENT EXPTS. SO NOT AVERAGED.        2/76
R22  C  CARITHERS ERRORS ARE AT CL=90 PERCENT.  SECOND CARITHERS2 VALUE IS    2/76
R22  C  AVERAGE OF CARITHERS1 73 VALUE AND FIRST CARITHERS2 73 VALUE.         2/76
R22  F  FUKUSHIMA 76 ERRORS ARE AT CL=90 PERCENT.                             2/76
R22                                                                           8/77*
R22     THE COMBINED RESULT BELOW IS THE OBSERVED NUMBER OF EVENTS            8/77*
R22     (28+-5.3) DIVIDED BY THE SUM OF THE EFFECTIVE DENOMINATORS FOR        8/77*
R22     EACH OF THE UNPARENTHESIZED RESULTS ABOVE.  INDIVIDUAL EFFECTIVE      8/77*
R22     DENOMINATORS ABOVE INCLUDE THE PI+PI-/MU+MU- RELATIVE ACCEPTANCES.    8/77*
R22          * * * * * * * * *
R22     28    4.5      0.9          COMBINED (CL=.68) EFF.DENOM.=6240000     8/77*

R23    KOL INTO (E+ E- )/(PI+PI-) (UNITS 10**-5)                (P7)/(P5)
R23      0   10.0    OR LESS  CL=.90   FOETH     69 ASPK                      5/70
R23          0.10    OR LESS  CL=.90   CLARK     71 ASPK                      6/71

R24    KOL INTO (E MU)/(PI+PI-) (UNITS 10**-5)                  (P8)/(P5)
R24          0.10    OR LESS  CL=.90   CLARK     71 ASPK                      6/71

R25    KOL INTO (PI E NEU GAM)/(KL E3) (UNITS 10**-2)   (P12)/(P3)
R25     10   3.3       2.0          PEACH     71 HLBC GAM KE GT 15 MEV      6/71

R26    KOL INTO (PIO TWO GAMMAS)/(3PIO) (UNITS 10**-3)  (P13)/(P1)
R26      0   1.1     OR LESS  CL=.90   BANNER    69 OSPK                      2/72

R27    KOL INTO (PI+ PI-)/TAU (UNITS 10**-2)                    (P5)/(P2)     6/73
R27  4200   1.64      0.04          MESSNER   73 ASPK    ETA +- = 2.23        6/73
R27          * * * * * * * * *
R27 FIT      1.635     0.036  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R28    KOL INTO (E+ E- GAMMA)/(3PIO) (UNITS 10**-4)     (P14)/(P1)
R28      0   1.3     OR LESS  CL=.90   BARMIN1   72 HLBC                      3/74

R29    KOL INTO (MU+ MU- GAMMA)/TOTAL (UNITS 10**-6)    (P15)                 12/75
R29  D       7.81    OR LESS  CL=.90   DONALDS3  74 SPEC                      6/77*
R29  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                          6/77*

R30    KOL INTO (MU+ MU- PIO)/TOTAL   (UNITS 10**-5)    (P16)                 12/75
R30  D       5.66    OR LESS  CL=.90   DONALDS3  74 SPEC                      6/77*
R30  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                          6/77*

R31    KOL INTO (PI+PI-E+E-) /TOTAL   (UNITS 10**-6)    (P17)                 12/75
R31         30.    OR LESS           ANIKINA   73 STRC                      3/78*
R31          8.81  OR LESS  CL=.90   DONALDSON 76 SPEC                      6/77*
R31  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                          6/77*

R32    KOL INTO (PIO PI+- E-+ NEU)/TOTAL (UNITS 10**-3) (P18)                 12/75
R32  D       2.2     OR LESS  CL=.90   DONALDS3  74 SPEC                      6/77*
R32  D  USES KOL TO PI+PI-PIO/ALL KOL DECAYS = 0.126                          6/77*

R33    KOL INTO (PI MU ATOM) NEU/TOTAL (UNITS 10**-7)  (P19)                  6/77*
R33     18  SEEN                      COOMBES   76 WIRE                      6/77*
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             13  KOL ENERGY DEPENDENCE OF DALITZ PLOT

      RELATED TEXT SECTION VI B.1, APPENDIX I, AND MINI-REVIEW ON SLOPE
      PARAMETERS IN THE CHARGED K SECTION OF THE DATA CARD LISTINGS ABOVE

      MATRIV ELEMENT SQUARED = 1 + G*U + H*U**2 + K*V**2
      WHERE U=(S3-S0)/(MPI**2) AND V=(S1-S2)/(MPI+**2)

GTO     LINEAR COEFFICIENT G FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
GTO Q   79    (0.55)    (0.23)          ADAIR     64 HBC  AV=-7.6 +- 1.7        3/71
GTO Q   77    (0.51)    (0.20)          LUERS     64 HBC  AV=-7.3 +- 1.6        3/71
GTO Q   66    (0.32)    (0.13)          ASTBURY1  65 CC   AV=-5.5 +- 1.5        3/71
GTO Q  310    (0.51)    (0.09)          ASTBURY2  65 CC   AV=-(7.3 +.6 -.8)     3/71
GTO Q  280    (0.64)    (0.17)          ANIKINA   66 CC   AV=-(8.2 +.9 -1.3)    3/71
GTO Q  126    (0.70)    (0.12)          HAWKINS   66 HBC  AV=-8.6 +- 0.7        3/71
GTO Q 1350    (0.649)   (0.044)         HOPKINS   67 HBC  AT=-0.294 +- .018    10/69
GTO Q 1198    (0.428)   (0.055)         NEFKENS   67 OSPK AU=-0.204 +- .025     3/71
GTO Q 2446    (0.400)   (0.045)         BASILE2   68 OSPK AT=-0.188 +- .020     3/71
GTO Q29000    (0.651)   (0.012)         ALBROW    70 ASPK AY=-0.862 +- .015     1/71
GTO QB 36K    (0.593)   (0.022)         BUCHANAN  70 SPEC AU=-0.278 +- .010     2/76
GTO Q 4400    (0.656)   (0.058)         SMITH     70 OSPK AT=-0.297 +- .024     3/71
GTO Q  180    (0.50)    (0.11)          JAMES     72 HBC                        1/73
GTO Q 1486    (0.608)   (0.043)         KRENZ     72 HLBC AT=-0.277 +- .018    11/72
GTO Q  384    (0.688)   (0.074)         METCALF   72 ASPK AT=-0.31  +- .03     11/72
GTO Q         (0.612)   (0.032)         ALEXANDER 73 HBC                        2/76
GTO Q 3200    (0.73)    (0.04)          BRANDENBU 73 HBC                        1/74
GTO QC 20K    (0.619)   (0.027)         BISI      74 ASPK AT=-0.282 +- .011    10/74
GTO Q         (0.645)   (0.026)         HILL      74 STRC    PRELIMINARY        3/78*
GTO    509K    0.677     0.010          MESSNER   74 ASPK AY=-0.917+-.013       7/75
GTO Q  192    (0.69)    (0.07)          BALDOCEOL 75 HLBC                      12/75
GTO Q  56K    (0.590)   (0.022)         BUCHANAN  75 SPEC AU=-0.277 +- .010     7/75
GTO  H6499     0.681     0.024          CHO       77 HBC                       11/77*
GTO   4709     0.620     0.023          PEACH     77 HBC                       11/77*
GTO Q   QUADRATIC DEPENDECE REQUIRED BY RECENT EXPERIMENTS (SEE SECTIONS
GTO Q   HTO AND KTO BELOW.  CORRELATIONS PREVENT US FROM AVERAGING RESULTS
GTO Q   OF FITS NOT INCLUDING G, H, AND K TERMS.
GTO  B  BUCHANAN 70 RESULT REVISED BY BUCHANAN 75 TO INCLUDE RADIATIVE COR.  2/76
GTO  B  AND TC USE MORE RELIABLE KL MOM.SPECT. OF 2ND EXPT.(HAD SAME BEAM).  2/76
GTO  C  BISI 74 VALUE COMES FROM QUADRATIC FIT WITH QUAD. TERM CONSISTENT   11/75
GTO  C  WITH ZERO.  GTO ERROR IS THUS LARGER THAN IF LINEAR FIT WERE USED.  11/75
GTO          . . . . . . . . .
GTO AVG        0.670     0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
GTO STUDENT    0.6716    0.0100  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )
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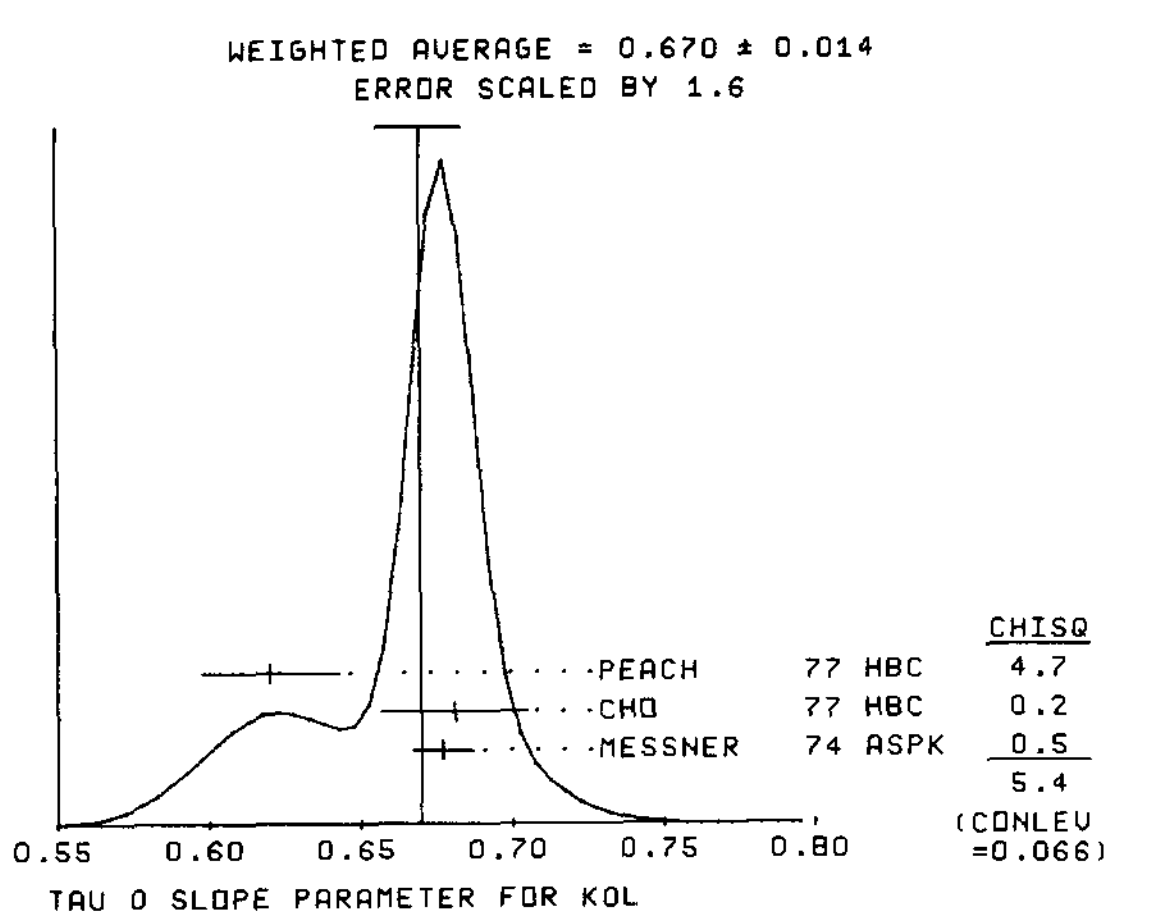


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HTO     QUADRATIC COEFF. H FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
HTO    509K     0.079      0.007          MESSNER   74 ASPK                3/78*
HTO    6499     0.095      0.032          CHO       77 HBC                 3/78*
HTO    4709     0.048      0.036          PEACH     77 HBC                 3/78*
HTO          . . . . . . . . . .
HTO AVG         0.0786     0.0067  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
HTO STUDENT     0.0787     0.0073  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

KTO     QUADRATIC COEFF. K FOR KL --> PI+ PI- PIO MATRIX ELEMENT SQUARED
KTO    509K     0.0097     0.0018         MESSNER   74 ASPK                3/78*
KTO    6499     0.024      0.010          CHO       77 HBC                 3/78*
KTO    4709    -0.008      0.012          PEACH     77 HBC                 3/78*
KTO          . . . . . . . . . .
KTO AVG         0.0098     0.0018  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
KTO STUDENT     0.0098     0.0019  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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             13  KOL FORM FACTORS

      RELATED TEXT SECTION VI B.2 AND MINI-REVIEW ON FORM FACTORS
      IN THE CHARGED K SECTION OF THE DATA CARD LISTINGS ABOVE.

      IN THE FORM FACTOR COMMENTS, THE FOLLOWING ABBREVIATIONS ARE USED.
      F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT.
      FS AND FT REFER TO THE SCALAR AND TENSOR TERM.
      FO = (F+) + (F-)*T/(MK**2-MPI**2)
      L+, L- AND LO ARE THE LINEAR EXPANSION COEFFS. OF F+, F- AND FO.
      L+ REFERS TO THE KMU3 VALUE EXCEPT IN THE KE3 SECTIONS.
      DXI/DL IS THE CORRELATION BETWEEN XI(O) AND L+ IN KMU3.
      DLO/DL+ IS THE CORRELATION BETWEEN LO AND L+ IN KMU3.
      T  = MOMENTUM TRANSFER TO THE PI IN UNITS OF MPI**2.
      DP = DALITZ PLOT ANALYSIS
      PI = PI SPECTRUM ANALYSIS
      MU = MU SPECTRUM ANALYSIS
      POL= MU POLARIZATION ANALYSIS
      BR = KMU3/KE3 BRANCHING RATIO ANALYSIS
      E  = POSITRON OR ELECTRON SPECTRUM ANALYSIS
      RC = RADIATIVE CORRECTIONS
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```
XIA     XIA = F-/F+ (DETERMINED FROM SPECTRA)  ---------------------------
XIA  L1341   +1.2      (0.8)               CARPENTER 66 OSPK    DP, DXI/DL=-18      1/74
XIA B 3140  (-3.9)     (0.4)               BASILE    70 OSPK    DP, INDEP OF L+     1/74
XIA C  16K  (-0.68)    (0.12)     (0.20)   CHIEN     70 ASPK    DP, DXI/DL=-26      1/74
XIA  A9086   -1.5       0.7                ALBROW    72 ASPK    DP, DXI/DL=-28      1/74
XIA C  16K  (+0.50)    (0.61)              DALLY     72 ASPK    DP, DXI/DL UNKN.    1/74
XIA  P1385   -1.00     (0.45)              PEACH     73 HLBC    DP, DXI/DL=-20      1/74
XIA  D 82K   -0.26      0.21               ALBRECHT  74 WIRE    DP, DXI/DL=-24     11/75
XIA D  82K  (-2.41)    (0.17)              ALBRECHT  74 WIRE    DP, DXI/DL=-9.4    11/75
XIA  E1.6M   -0.11      0.07               DONALDS2  74 SPEC    DP, DXI/DL=-17     11/75
XIA  F 32K   -0.25      0.22               BUCHANAN  75 SPEC    DP, DXI/DL=-5.9     2/76
XIA  L  CARPENTER 66 XI(O) IS FOR L+=0.  DXI/DL IS FROM FIG. 9.                     1/74
XIA B   BASILE 70 IS INCOMPATIBLE WITH ALL OTHER RESULTS.  AUTHORS SUGGEST          1/74
XIA B   THAT EFFICIENCY ESTIMATES MIGHT BE RESPONSIBLE.                             1/74
XIA  A  ALBROW 72 FIT HAS L- FREE, GETS L-=-.030+-.060 OR LAM=+.15+.17-.11.         1/74
XIA C   CHIEN 70 ERRORS ARE STATISTICAL ONLY.  DXI/DL FROM FIG.4.                   1/74
XIA  C  DALLY 72 IS A REANALYSIS OF CHIEN 70.  THE DALLY 72 RESULT IS               1/74
XIA  C  NOT COMPATIBLE WITH ASSUMPTION L-=0 SO NOT INCLUDED IN OUR FIT.             2/76
XIA  C  THE NON-ZERO L- VALUE AND THE RELATIVELY LARGE L+ VALUE FOUND BY            1/74
XIA  C  DALLY 72 COME MAINLY FROM A SINGLE LOW T BIN (FIGS.1,2).                    1/74
XIA  C  THE (F+,XI) CORRELATION WAS IGNORED.                                        1/74
XIA  C  WE ESTIMATE FROM FIG. 2 THAT FIXING L-=0 WOULD GIVE XI(0)=-1.4+-0.3         1/74
XIA  C  AND WOULD ADD 10 TO CHI SQUARED.  DXI/DL IS NOT GIVEN.                      1/74
XIA  D  ALBRECHT 74 IS CALCULATED BY US FROM LO, L+ AND DLO/DL+.  THEY FIND        11/75
XIA  D  TWO SOLUTIONS.  THE FIRST HAS L+=.046+-.008 IN AGREEMENT WITH KE3.          3/74
XIA  P  PEACH 73 GIVES XIO=-.95+-.45 FOR L+=L-=.025 .  THE ABOVE VALUE IS           1/74
XIA  P  FOR L-=0.  K.PEACH, PRIVATE COMMUNICATION(1974).                            1/74
XIA  E  DONALDSON2 74 GIVES XI=-.11+-.02 NOT INCLUDING SYSTEMATICS.  ABOVE         11/75
XIA  E  ERROR AND DXI/DL WERE CALCULATED BY US FROM LO AND L+ ERRORS (WHICH        11/75
XIA  E  INCLUDE SYSTEMATICS) AND DLO/DL+.                                          11/75
XIA  F  BUCHANAN 75 IS CALCULATED BY US FROM LO, L+ AND DLO/DL+ BECAUSE             2/76
XIA  F  THEIR APPENDIX A VALUE -.20+-22 ASSUMES XI(T) CONSTANT, I.E. L-=L+.         2/76
XIA         . . . . . . . . .
XIA FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

XIB     XIB = F-/F+ (DETERMINED FROM KMU3/KE3)  --------------------------
XIB      THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BE WEEN XI(O)            1/74
XIB      AND L+.  WE QUOTE THE AUTHORS XI(O) AND ASSOCIATED L+ BUT DO NOT           1/74
XIB      AVERAGE BECAUSE THE L+ VALUES DIFFER.  THE FIT RESULT AND SCALE            1/74
XIB      FACTOR GIVEN IN THE NOTE ON KL3 FORM FACTORS IN THE K+- SECTION OF         2/76
XIB      THE DATA CARDS ARE NOT OBTAINED FROM THESE XIB VALUES.  INSTEAD            2/76
XIB      THEY ARE OBTAINED DIRECTLY FROM THE FITTED KMU3/KE3 RATIO (R10).           2/76
XIB    389   +1.1       1.1                ADAIR     64 HBC     BR, L+=0            1/74
XIB          +0.66      0.9        1.3     LUERS     64 HBC     BR, L+=0            1/74
XIB          +0.2       0.8        1.2     KULYUKINA 68 CC      BR, L+=0          . 1/74
XIB    569   +0.45      0.28               BEILLIERE 69 HLBC    BR, L+=0            1/74
XIB E 1309  (-0.22)    (0.30)              EVANS     69 HLBC    BR, L+=.02+-.015    1/74
XIB   3548   -0.5       0.5                BASILE    70 OSPK    BR, L+=.02          1/74
XIB   6700    0.5       0.4                BRANDENBU 73 HBC     BR,L+=.019+-.013    1/74
XIB  E1309   -0.08      0.25               EVANS     73 HLBC    BR, L+=.02          1/74
XIB  E  EVANS 73 REPLACES EVANS 69.                                                 1/74
XIB         . . . . . . . . .
XIB FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

XIC     XIC = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)  -----------
XIC     THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIC     NECESSARY, T (WEIGHTED BY SENSITIVITY TO XIO) SHOULD BE SPECIFIED.
XIC     IN L+,XI(O) PARAMETERIZATION THIS IS XI(O) FOR L+=0.  DXI/DL=XI*T.
XIC      FOR RAD. CORR. TO MUON POLARIZATION IN KMU3, SEE GINSBERG 73.              2/72
XIC T 2608  (-1.2)     (0.5)               AUERBACH  66 OSPK    POLARIZATION        8/67
XIC T  638  (-1.6)     (0.5)               ABRAMS    68 OSPK    POLARIZATION        5/69
XIC  L       -1.81      0.50       0.26    LONGO     69 CNTR    POL. T=3.3          1/74
XIC  S2.2M   -0.385     0.105              SANDWEISS 73 CNTR    POL,DXI/DL=-6       1/74
XIC  H207K   +0.178     0.105              CLARK     77 SPEC    POL,DXI/DL=+.68    11/77*
XIC T   T VALUE NOT GIVEN.                                                          1/74
XIC  L  LONGO 69 T=3.3 CALC. FROM DXI/DL=-6.0 (TABLE 1) DIVIDED BY XI=-1.81         1/74
XIC  S  SANDWEISS 73 IS FOR L+=0 AND T=0.                                           1/74
XIC  H  CLARK 77 T=+3.80, DXI/DL=XI(T)*T=.178*3.80=+.68 .                          11/77*
XIC         . . . . . . . . .
XIC FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

IXI        IMAGINARY PART OF XI  (TEST OF T REVERSAL)  ------------------
IXI          -0.2       0.6                ABRAMS    68 OSPK    POLARIZATION       10/69
IXI          -0.02      0.08               LONGO     69 CNTR    POL. T=3.3         11/69
IXI   2.2M   -0.060     0.045              SANDWEISS 73 CNTR    POL, T=0            1/74
IXI  C207K    0.35      0.30               CLARK     77 SPEC    POL, T=0           11/77*
IXI  C  CLARK 77 VALUE HAS ADDITIONAL XIO DEPENDENCE +0.21*RE(XIO).                11/77*
IXI         . . . . . . . . .
IXI AVG      -0.044     0.039    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
IXI STUDENT  -0.045     0.042    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)  ---------
L+M      SEE ALSO THE CORRESPONDING ENTRIES AND NOTES IN SECTION XIA AND LO.
L+M      FOR RAD.COR. OF KMU3 DP SEE GINSBURG 70 AND BECHERRAWY 70.                 3/74
L+M C  16K   (0.07)    (0.02)              CHIEN     70 ASPK    DP                  1/74
L+M  A9086    0.085     0.015              ALBROW    72 ASPK    DP                  1/74
L+M C  16K   (0.11)    (0.04)              DALLY     72 ASPK    DP                  1/74
L+M  D 82K    0.046     0.008              ALBRECHT  74 WIRE    DP                 11/75
L+M D  82K   (0.076)   (0.004)             ALBRECHT  74 WIRE    DP                 11/75
L+M   1.6M    0.030     0.003              DONALDS2  74 SPEC    DP                 10/74
L+M    32K    0.046     0.030              BUCHANAN  75 SPEC    DP                  9/75
L+M C   CHIEN 70 VALUE AND ERROR HAVE BEEN CHANGED FROM 0.08 +- 0.01 TO             3/71
L+M C   INCLUDE SYSTEMATIC EFFECTS. DALLY 72 IS A REANALYSIS OF CHIEN 70.           3/71
L+M C   SEE NOTE IN SECTION XIA.                                                    1/74
L+M  D  ALBRECHT 74 FINDS TWO SOLUTIONS.  THE FIRST AGREES WITH KE3.               11/75
L+M         . . . . . . . . .
L+M FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

LO      LAMBDA O (LINEAR ENERGY DEPENDENCE OF FO IN KMU3 DECAY)  ----------
LO       WHEREVER POSSIBLE, WE HAVE CONVERTED THE ABOVE VALUES OF XI(O) INTO
LO       VALUES OF LO USING THE ASSOCIATED L+M AND DXI/DL.
LO L  1371   +0.08     (0.07)              CARPENTER 66 OSPK    DP,DLO/DL+=-0.54    1/74
LO L         -0.140    (0.043)   (0.022)   LONGO     69 CNTR    POL,DLO/DL+=+.49    1/74
LO  B 3140  (-0.333)   (0.034)             BASILE    70 OSPK    DP,DLO/DL+=+1.      1/74
LO A  9086   -0.043     0.052              ALBROW    72 ASPK    DP,DLO/DL+=-1.39    1/74
LO  C  16K  (-0.067)   (0.227)             DALLY     72 ASPK    DP,DLO/DL+ UNKN.    1/74
LO  R 6700  (+0.06)    (0.03)              BRANDENBU 73 HBC     BR,L+=.019+-.013    1/74
LO P  1385   -0.060    (0.038)             PEACH     73 HLBC    DP,DLO/DL+=-0.71    1/74
LO L  2.2M   -0.018    (0.009)             SANDWEISS 73 CNTR    POL,DLO/DL+=+.49    1/74
LO    D 82K  +0.024     0.011              ALBRECHT  74 WIRE    DP,DLO/DL+=-1.06   11/75
LO  D  82K  (-0.130)   (0.014)             ALBRECHT  74 WIRE    DP,DLO/DL+=+0.20   11/75
LO E  1.6M   +0.019     0.004              DONALDS2  74 SPEC    DP,DLO/DL+=-0.47   10/74
LO    F 32K  +0.025     0.019              BUCHANAN  75 SPEC    DP,DLO/DL+=+0.5     2/76
LO L  207K   +0.047    (0.009)             CLARK     77 SPEC    POL,DLO/DL+=1.06   11/77*
LO L    LO VALUE IS FOR L+=0.03  CALCULATED BY US FROM XIO AND DXI/DL.              1/74
LO  B   BASILE 70 LO IS FOR L+=0.  CALCULATED BY US FROM XIA WITH DXI/DL=0.         1/74
LO  B   BASILE 70 IS INCOMPATIBLE WITH ALL OTHER RESULTS.  AUTHORS SUGGEST          1/74
LO  B   THAT EFFICIENCY ESTIMATES MIGHT BE RESPONSIBLE.                             1/74
LO A    ALBROW 72 LO IS CALCULATED BY US FROM XIA,L+ AND DXI/DL.  THEY GIVE         1/74
LO A    LO=-.043+-.039 FOR L-=0.  WE USE OUR LARGER CALCULATED ERROR.               1/74
LO  C   DALLY 72 GIVES FO=1.20+-.35, LO=-.080+-.272, LOPRIME=-.006+-.045,           1/74
LO  C   BUT WITH A DIFFERENT DEFINITION OF LO.  OUR QUOTED LO IS HIS LO/FO.         1/74
LO  C   WE CANNOT CALCULATE TRUE LO ERROR WITHOUT HIS (LO,FO) CORRELATIONS.         1/74
LO  C   SEE ALSO NOTE C IN SECTION XIA.                                             1/74
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Data Card Listings

For notation, see key at front of Listings.


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L0 P    PEACH 73 ASSUMES L+=0.025.  CALCULATED BY US FROM X10 AND DX10/DL+.  1/74
L0  R   FIT FOR L0 DOES NOT INCLUDE THIS VALUE BUT INSTEAD INCLUDES THE      2/76
L0  R   KMU3/KE3 RESULT FROM THIS EXPERIMENT.                                2/76
L0   D  ALBRECHT 74 FINDS TWO SOLUTIONS.  THE FIRST HAS L+=.046+-.008 IN     11/75
L0   D  AGREEMENT WITH KE3.  DL0/DL+ OBTAINED FROM FIG.2C.                   11/75
L0 E    DONALDSON2 74 DL0/DL+ OBTAINED FROM FIG. 18.                         11/75
L0   F  BUCHANAN 75 VALUE IS FROM THEIR APPENDIX A AND USES ONLY KMU3 DATA.  2/76
L0   F  DL0/DL+ WAS OBTAINED BY PRIVATE COMMUNICATION, C.BUCHANAN, 1976.     2/76
L0
L0  FIT DISCUSSED IN NOTE ON KL3 FORM FACTORS IN K+- SECTION OF DATA CARDS.

L+E     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN K0 E3 DECAY)    ------
L+E     FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.            3/74
L+E   153   +0.07      .06          LUERS     64 HBC     DP, NO RC
L+E   577   +0.15      .08          FISHER    65 OSPK    DP, NO RC           8/67
L+E   762   -0.01      .02          FIRESTONE 67 HBC     DP, NO RC           8/67
L+E   531   +0.01      .015         KADYK     67 HBC     E,PI, NO RC         8/67
L+E   240   +0.08      .10     .08  LOWYS     67 FBC     PI, USES RC         8/67
L+E  1000     0.02     0.013        ARONSON   68 OSPK    PI                  5/69
L+E  4800   +0.023     0.012        BASILE    68 OSPK    DP, NO RC           3/68
L+E   42K     0.023    0.005        BISI      71 ASPK    DP, USES RC        12/71
L+E   16K     0.05     0.01         CHIEN     71 ASPK    DP, NO RC           6/71
L+E  1910     0.022    0.014        NEUHOFER  72 ASPK    PI, USES RC         1/73
L+E  5600     0.045    0.014        ALBROW    73 ASPK    DP, USES RC         9/73
L+E  1871     0.019    0.013        BRANDENBU 73 HBC     PI TRANSV., RC      1/74
L+E  2171     0.040    0.012        WANG      74 OSPK    DP, USES RC         7/74
L+E   25K     0.0270   0.0028       BLUMENTHA 75 SPEC    DP                  7/75
L+E   24K     0.044    0.006        BUCHANAN  75 SPEC    DP, USES RC         7/75
L+E   48K     0.032    0.0042       BIRULEV   76 SPEC    DP, USES RC         1/78*
L+E  500K     0.0312   0.0025       GJESDAL   76 SPEC    DP, USES RC         1/77*
L+E
L+E AVG         0.0300   0.0018  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
L+E STUDENT     0.0298   0.0017  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )
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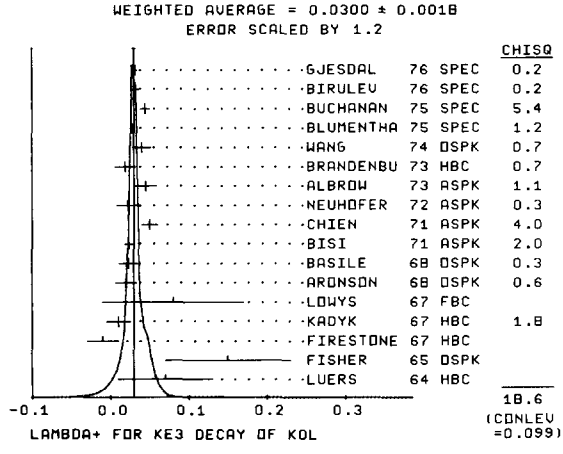


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FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS             0.15  OR LESS  CL=.68   KULYUKINA 67 CC                      10/69
FS      5600   0.19  OR LESS  CL=.95   ALBROW    73 ASPK                    9/73
FS       25K   0.04  OR LESS  CL=.68   BLUMENTHA 75 SPEC                    7/75
FS       48K   0.07  OR LESS           BIRULEV   76 SPEC    CL NOT GIVEN     1/78*

FT      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FT             1.0   OR LESS  CL=.68   KULYUKINA 67 CC                      10/69
FT      5600   1.0   OR LESS  CL=.95   ALBROW    73 ASPK                    9/73
FT       25K   0.23  OR LESS  CL=.68   BLUMENTHA 75 SPEC                    7/75
FT       48K   0.34  OR LESS           BIRULEV   76 SPEC    CL NOT GIVEN     1/78*

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                    13  CP VIOLATION PARAMETERS IN KOL DECAYS

          RELATED TEXT SECTION VI B.3 AND MINI-REVIEW BELOW

--------------------13 CHARGE ASYMMETRY IN TAU DECAYS----------------------
TEXT SECTION VI B.3 B

     SEE SCRIBANO 70 FOR DEFINITION (HIS SIGMA+-). A=1 FOR MAX ASYMMETRY
     (M)**2 = 1+ SIG+- (2/SQRT(3) *((T+)-(T-))/ TMAX)  AS SCRIBANO 70

A     DECAY ASYMMETRY PARAMETER FOR PI+ PI- PI0   (UNITS 10**-2)
A      .3M     0.2      0.95          BLANPIED  68 CNTR                    . 4/70
A       3M     0.27     0.2           SCRIBANO  70 CNTR                   .12/70
A     4400     0.000    0.050         SMITH     70 OSPK                   .10/70
A
A   AVG         0.016    0.063   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
A   STUDENT     0.015    0.053   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )

--------------------13  CHARGE ASYMMETRY IN LEPTONIC DECAYS (PERCENT)------
TEXT SECTION VI B.3 C

     SUCH ASYMMETRY VIOLATES CP . IT IS RELATED TO REAL(EPSILON).

A1     KOL INTO (MU+PI-NU)-(MU-PI+NU)/(MU+PI-NU)+(MU-PI+NU)     (PERCENT)
A1  D   1M   (0.403)  (0.134)        DORFAN    67 OSPK    DERIVED FROM R16 11/67
A1  D   1M     0.57     0.17         PACIOTTI  69 OSPK                     1/73
A1     7.7M    0.278    0.051        PICCIONI  72 ASPK                     1/73
A1     4.1M    0.60     0.14         MCCARTHY  73 CNTR                     6/73
A1      15M    0.313    0.029        GEWENIG1  74 ASPK                     7/74
A1  D   PACIOTTI 69 IS A REANALYSIS OF DORFAN 67 AND IS CORRECTED FOR       1/73
A1  D   MU+ MU- RANGE DIFFERENCE IN MC CARTHY 72.                          1/73
A1
A1  AVG         0.319    0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
A1  STUDENT     0.316    0.027   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )
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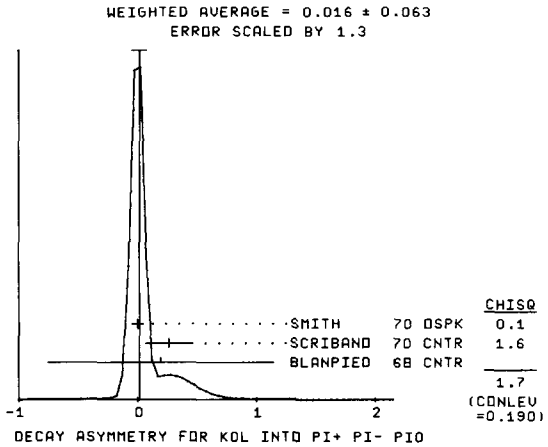

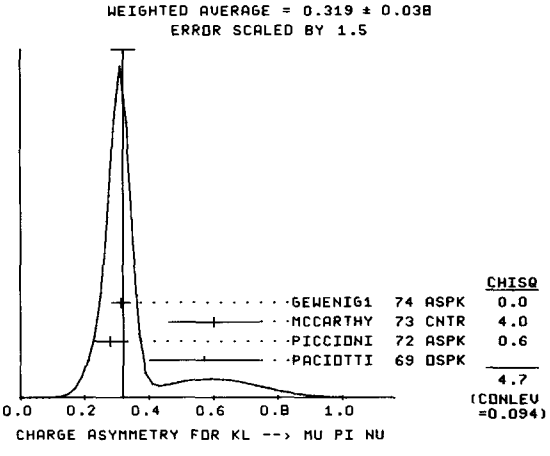


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A2     KOL INTO (E+PI-NU)-(E-PI+NU)/(E+PI-NU)+(E-PI+NU)          (PERCENT)
A2  B   10M    (0.224)  (0.036)        BENNETT   67 CNTR                    11/67
A2 B    10M     0.246    0.059         SAAL      69 CNTR                    10/70
A2      10M     0.346    0.033         MARX      70 CNTR                    10/70
A2     600K     0.36     0.18          ASHFORD   72 ASPK                     2/72
A2      40M     0.318    0.038         FITCH     73 ASPK                    12/73
A2      34M     0.341    0.018         GEWENIG1  74 ASPK                     7/74
A2  B SAAL 69 IS A REANALYSIS OF BENNETT 67
A2
A2  AVG         0.333    0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A2  STUDENT     0.334    0.016   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AL     KOL INTO ((L+)-(L-))/((L+)+(L-))  (COMBINED A1 AND A2) (PERCENT)
AL  B   10M     0.246    0.059         SAAL      69 CNTR    KE3              2/71
AL  D    1M     0.57     0.17          PACIOTTI  69 OSPK    KMU3             1/73
AL      10M     0.346    0.033         MARX      70 CNTR    KE3              2/71
AL     600K     0.36     0.18          ASHFORD   72 ASPK    KE3              2/72
AL     7.7M     0.278    0.051         PICCIONI  72 ASPK    KMU3             1/73
AL      40M     0.318    0.038         FITCH     73 ASPK    KE3             12/73
AL     4.1M     0.60     0.14          MCCARTHY  73 CNTR    KMU3             6/73
AL      33M     0.333    0.050         WILLIAMS  73 ASPK    KMU3+KE3        12/73
AL      15M     0.313    0.029         GEWENIG1  74 ASPK    KMU3             7/74
AL      34M     0.341    0.018         GEWENIG1  74 ASPK    KE3              7/74
AL       SEE FOOTNOTES IN SECTIONS A1 AND A2 ABOVE.                          1/73
AL
AL  AVG         0.330    0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AL  STUDENT     0.330    0.013   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

--------------------13  PARAMETERS FOR KOL INTO 2PI DECAY-----------------
TEXT SECTION VI B.3 D

     ETA+- = A(KL TO PI+PI-)/A(KS TO PI+PI-)
     ETA00 = A(KL TO PI0PI0)/A(KS TO PI0PI0)
```

Note on $|\eta_{+-}|$

There is a very large discrepancy between old and new results for $|\eta_{+-}|$, the ratio of amplitudes $A(K^0_L \to \pi^+\pi^-)/A(K^0_S \to \pi^+\pi^-)$. The average of the older $|\eta_{+-}|$ results of CHRISTENSON 64, GALBRAITH 65, BASILE 66, BOTT-BODENHAUSEN 66, DE BOUARD 67, and

Stable Particles

K_L^0

FITCH 67 (see subsections R9, R20, R27, and E+- of the K_L^0 Data Card Listings) is

$$|\eta_{+-}| = (1.95 \pm 0.03) \times 10^{-3}$$

with very good consistency.

The more recent results of MESSNER 73, GEWENIGER2 74, and DEVOE 77 are in good agreement with each other but do not agree with the average of the older results. The three recent results, when adjusted for the current values of the K_S^0 and K_L^0 mean lives and current normalizing branching fractions, give an average value of

$$|\eta_{+-}| = (2.273 \pm 0.023) \times 10^{-3} ,$$

which is eleven standard deviations above the previous average.

The origin of the discrepancy between old and new results is not known. The effect of the change in the K_S^0 mean life value (see note in K_S^0 section of the Stable Particle Data Card Listings) is insufficient to explain it, raising $|\eta_{+-}|$ by only about 2%.

Since the newer experiments are in principle superior (higher statistics, better acceptance, easier trigger conditions), we have chosen to average them separately from the earlier experiments as is seen in the E+- subsection of the Data Card Listings below.

The entry referenced as GKL/GKS 71 is the average of all seven experiments before 1971. This average is determined from the branching ratios quoted for these experiments in subsections R9 and R20 above. It was quoted by us as the $|\eta_{+-}|$ value in our 1971 edition. The average and fit values at the end of the E+- subsection below do not include the pre-1971 $|\eta_{+-}|$ results.

The fitted values in the EOS, E+-, and ER subsections below are the result of a fit to the unparenthesized values of $|\eta_{00}|$, $|\eta_{+-}|$, and $|\eta_{00}/\eta_{+-}|$ in these subsections. We quote the fitted values of $|\eta_{+-}|$ and $|\eta_{00}|$ in the Addendum to the Stable Particle Table but warn in a footnote that they exclude pre-1971 $|\eta_{+-}|$ results.

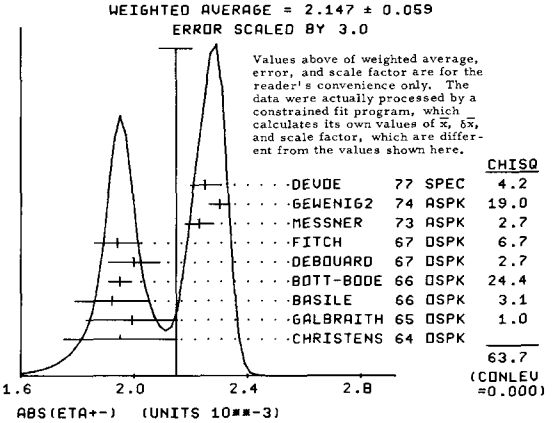
THE FITTED VALUES OF ETA+- AND ETA00 GIVEN BELOW ARE THE RESULTS OF A FIT TO ETA+-, ETA00 AND ETA00/ETA+- RESULTS. THE VALUES LISTED BELOW WHICH ARE NOT PARENTHESIZED ENTER THE FIT AS SHOWN. THE VALUES WHICH ARE PARENTHESIZED AND BEAR THE FOOTNOTE X DO NOT ENTER THE FIT AS SHOWN. THESE EXPERIMENTS GIVE BRANCHING RATIOS AND ENTER THE FIT VIA THE QUANTITY ACTUALLY MEASURED -- BRANCHING RATIOS R9, R20 AND R27 (ETA+-) AND R17 AND R19 (ETA00). THESE BRANCHING RATIOS ARE COMBINED WITH CURRENT NORMALIZATIONS AND CURRENT KL AND KS MEAN LIVES TO OBTAIN PI PI RATES. THE ETA+- AND ETA00 VALUES OBTAINED FROM THESE RATES ARE ENTERED BELOW WITH THE NAME 'GKL/GKS'.

Data Card Listings

For notation, see key at front of Listings.

```
EOS     (ETA00)**2 = A(KL TO 2PI0)/A(KS TO 2PI0)**2  (UNITS 10**-6)   ---
EOS X     0  (-2.)      (7.0)          BARTLETT   68 OSPK                        10/69
EOS X    57   (4.9)     (1.2)          BANNER     69 OSPK                         2/72
EOS XR 133  (14.1)     (3.4)          CENCE      69 OSPK                        10/69
EOS XF 180  (13.)      (4.)           GAILLARD   69 OSPK                        10/69
EOS X     29   (4.08)    (0.9)          BARMIN     70 HLBC                        12/70
EOS X     30   (3.61)    (1.9)          BUDAGOV    70 HLBC                        10/70
EOS  C     8.7           3.7           CHOLLET    70 OSPK    CU REG.,4 GAMMAS    2/72
EOS XF 172   (9.9)     (3.4)          FAISSNER   70 OSPK                        12/70
EOS  C    56   7.4       2.0           WOLFF      71 OSPK    CU REG.,4GAMMAS     12/71
EOS XR 150  (14.1)     (3.4)          REY        76 OSPK                         8/76*
EOS  X      5.1           1.0          GKL/GKS    78 RVUE  BR SCALE FACTOR=1.5   2/78*
EOS X   SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
EOS  R  CENCE 69 EVENTS ARE INCLUDED IN REY 76.                                  1/77*
EOS  F  FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69
EOS  C  CHOLLET 70 GIVES ETA00=(1.23+-0.24)*(REGEN AMPL,2GEV/C CU)/10000MB       2/72
EOS  C  WOLFF 71   GIVES ETA00=(1.13+-0.12)*(REGEN AMPL,2GEV/C CU)/10000MB       2/72
EOS  C  WE COMPUTE BOTH ETA00**2 VALUES FOR (REGEN AMPL,2GEV/C CU)=24+-2MB.      2/72
EOS  C  THIS REGEN AMPL RESULTS FROM AVERAGING OVER FAISSNER 69,                 2/72
EOS  C  EXTRAPOLATED USING OPTICAL MODEL CALCULTIONS OF BOHM ET AL.              2/72
EOS  C  PL 27B 594 (1968) AND THE DATA OF BALATS 71. (FROM H. FAISSNER,          2/72
EOS  C  PRIVATE COMMUNICATION)                                                   2/72
EOS  F  FAISSNER 70 CONTAINS SAME 2PI0 EVENTS AS GAILLARD 69
EOS     . . . . . .
EOS AVG       5.73      0.87    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
EOS STUDENT   5.72      0.99    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
EOS FIT       5.40      0.43   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/78*
EOO THIS FIT VALUE CORRESPONDS TO ETA00=2.324+-0.092                           2/78*

E+-    ETA+-  = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3  ------------
E+- X   45   (1.95)    (0.20)          CHRISTENS 64 OSPK                       2/76
E+- X   54   (1.99)    (0.16)          GALBRAITH 65 OSPK                       2/76
E+- X        (1.92)    (0.13)          BASILE     66 OSPK                      2/76
E+- X        (1.95)    (0.04)          BOTT-BODE 66 OSPK                       2/76
E+- X        (2.00)    (0.09)          DEBOUARD   67 OSPK                      2/76
E+- X        (1.94)    (0.08)          FITCH      67 OSPK                      2/76
E+- AX       (1.95)    (0.03)          GKL/GKS    71 RVUE    EXPTS. BEFORE 71  2/76
E+- A   AVERAGE OF ABOVE EXPTS.  EXCLUDED FROM FIT.  SEE TYPED NOTE ABOVE.     2/76
E+- X 4200   (2.23)    (0.05)          MESSNER    73 ASPK                      11/75
E+-          2.30      0.035           GEWENIG2   74 ASPK                       3/74
E+- X 2703   (2.25)    (0.05)          DEVOE      77 SPEC                      11/77*
E+-  X       2.254     0.029           GKL/GKS    78 RVUE    BR EXP. AFTER 71   2/78*
E+- X   SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
E+-     . . . . . .
E+- AVG       2.273     0.023    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
E+- STUDENT   2.273     0.025    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
E+- FIT       2.274     0.022  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*
                       (SEE IDEOGRAM BELOW )
```

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ER     RATIO OF ETA00 OVER ETA+-
ER      124    1.03     0.07          BANNER1    72 OSPK                       8/72
ER      167    1.00     0.06          HOLDER     72 ASPK                       8/72
ER      . . . . . .
ER  AVG       1.013     0.046   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
ER  STUDENT   1.013     0.049   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
ER  FIT       1.022     0.040  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/78*

F+-    PHASE OF ETA +-          (DEGREES)  ----------------------------
F+-     THE DEPENDENCE OF THE PHASE ON THE KOL-KOS MASS DIFFERENCE
F+-     IS GIVEN FOR EACH EXPERIMENT IN THE COMMENTS BELOW, WHERE DM IS
F+-     (MASS DIFF./HBAR) IN UNITS 10**10 SEC-1.  WE HAVE EVALUATED THESE
F+-     MASS DEPENDENCES USING OUR APRIL 1978 VALUE, DM=0.5349+-0.0022
F+-     TO OBTAIN THE VALUES AND AVERAGE QUOTED BELOW. WE ALSO GIVE THE
F+-     REGENERATOR PHASE FR IN THE COMMENTS BELOW.
F+- O       (45.0)   (50.0)          FITCH      65 OSPK    BE REGEN           11/67
F+- O       (30.0)   (45.0)          FIRESTONE  66 HBC                        11/67
F+- O       (70.0)   (21.0)          BOTT-BODE  67 OSPK    C REGEN            11/67
F+- O       (25.0)   (35.0)          MISCHKE    67 OSPK    CU REGEN            7/68
F+- O   OLD EXPERIMENTS WITH LARGE ERRORS NOT INCLUDED IN AVERAGE.              2/76
F+- N       (51.0)   (11.0)          BENNETT2   68 CNTR    CU REG. USES        8/68
F+- C        34.2      10.0          BENNETT    69 CNTR    CU REGEN            2/71
F+- B        45.3      12.0          BOHM       69 OSPK    VACUUM REGEN        2/71
F+- F        45.2       7.4          FAISSNER   69 ASPK    CU REGEN            2/71
F+- J        40.6       4.2          JENSEN     70 ASPK    VACUUM REGEN        2/71
F+- D        37.2      12.0          BALATS     71 OSPK    CU REGEN            9/71
F+- P        36.2       6.1          CARNEGIE   72 ASPK    CU REGEN            1/73
F+- G        46.5       1.6          GEWENIG2   74 ASPK    VACUUM REGEN        3/74
F+- H        45.5       2.8          CARITHERS  75 SPEC    C REGEN             7/75
F+-     . . . . . .
F+- AVG      45.0       1.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F+- STUDENT  45.1       1.4     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
F+- FIT      45.0       1.2   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*
                      COMMENTS
F+-  N  BENNETT 69 IS A REEVALUATION OF BENNETT2 68.                           11/69
F+-  C  BENNETT 69 USES MEASUREMENT OF (F+-)-(PHIF) OF ALFF-STEINBERGER 66.    2/71
F+-  C  BENNETT 69   F+-=(34.9+-10.0)+ 69*(DM-.545) DEG.  FR=-49.9+-5.4 DEG.   2/71
F+-  B  BOHM 69      F+-=(41.0+-12.0)+479*(DM-.526) DEG.                       2/71
F+-  F  FAISSNER 69 ERROR ENLARGED TO INCLUDE ERROR IN REGENERATOR PHASE.      11/69
F+-  F  FAISSNER 69 F+-=(49.3+-7.4)+205*(DM-.555) DEG.   FR=-42.7+-5.0 DEG.    2/71
F+-  J  JENSEN 70   F+-=(42.4+-4.0)+576*(DM-.538) DEG.                         2/71
F+-  D  BALATS 71   F+-=(39.0+-12.0)+198*(DM-.544) DEG.  FR=-43.0+-4.0 DEG.    9/71
F+-  P  CARNEGIE 72 F+- IS INSENSITIVE TO DM.           FR=-56.2+-5.2 DEG.    1/73
F+-  G  GEWENIG2 74 F+-=(49.4+-1.0)+565*(DM-.540) DEG.                         3/74
F+-  H  CARITHER 75 F+-=(45.5+-2.8)+224*(DM-.5348) DEG.  FR=-40.9+-2.6 DEG.   11/75
```

Data Card Listings

For notation, see key at front of Listings.


```
FOO    PHASE OF ETA 00    (DEGREES)    ------------------------------------
FOO        FIRST QUADRANT PREFERRED   GOBBI     69 OSPK                      11/69
FOO  C       51.0      30.0          CHOLLET   70 OSPK    CU REG.,4 GAMMAS 10/70
FOO  W  56   38.0      25.0          WOLFF     71 OSPK    CU REG.,4 GAMMAS 12/71
FOO  C  CHOLLET 70 USES REGENERATOR PHASE FR=-46.5+-4.4 DEG.                 1/73
FOO  W  WOLFF 71   USES REGENERATOR PHASE FR=-48.2+-3.5 DEG.                 1/73
FOO          . . . . . . . . . .
FOO AVG      43.3      19.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FOO STUDENT  43.3      20.7      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
FOO FIT      48.3      13.2    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*

DF     PHASE DIFFERENCE FOO - F+-     (DEGREES)-----------------------------
DF B          7.6      18.0          BARBIELLI 73 ASPK                        7/73
DF B    INDEPENDENT OF REGENERATOR MECHANISM,DM,AND LIFETIMES.                 7/73
DF           . . . . . . . . . .
DF  FIT      3.3      13.1    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*
```

Superweak Model Predictions for $\phi_{\eta_{+-}}$ and $Re\varepsilon$

The superweak model of Wolfenstein, Phys. Letters 13, 562 (1964) predicts that

$$\phi_{+-} = \phi_{00} = \tan^{-1}\left(\frac{2\Delta m \tau_S}{\hbar}\right)$$

and

$$Re\varepsilon = |\eta_{+-}| \left[1 + \left(\frac{2\Delta m \tau_S}{\hbar}\right)^2\right]^{-1/2} .$$

These expressions and the values of the $K_L^0 - K_S^0$ mass difference $\Delta M = (0.5349 \pm 0.0022) \times 10^{10} \hbar\ \text{sec}^{-1}$, the K_S^0 mean life $\tau_S = (0.8923 \pm 0.0022) \times 10^{-10}$ sec, and the magnitude of the $K_L^0 \to \pi^+\pi^-/K_S^0 \to \pi^+\pi^-$ amplitude ratio $|\eta_{+-}| = (2.274 \pm 0.022) \times 10^{-3}$, all from the current edition, result in the predictions that

$$\phi_{+-} = \phi_{00} = (43.67 \pm 0.14)^\circ$$

and

$$Re\varepsilon = (1.645 \pm 0.016) \times 10^{-3} .$$

These can be compared with the experimental values

$$\phi_{+-} = (45.0 \pm 1.2)^\circ$$

$$\phi_{00} = (48.3 \pm 13.2)^\circ$$

$$Re\varepsilon = (1.621 \pm 0.088) \times 10^{-3} ,$$

where $Re\varepsilon$ has been computed using the relation

$$Re\varepsilon = \frac{\delta}{2}\left(\frac{|1-x|^2}{1-|x|^2}\right) ,$$

and our current values of the charge asymmetry parameter for leptonic K_L^0 decay $\delta = (0.330 \pm 0.012)\%$ and the $\Delta S = -\Delta Q$ amplitude (Rex, Imx) = $(0.009 \pm 0.020, -0.004 \pm 0.026)$.

The superweak predictions are in good agreement with the data.

The values of τ_S and $|\eta_{+-}|$ have undergone major revision in the past few years (see notes on these parameters in the K_S^0 and K_L^0 sections of the Data Card Listings). We have utilized only the post-1971 experimental values of these parameters and have made necessary changes in the related parameters ΔM and ϕ_{+-} (see footnotes in the related data card subsections D and F+- above).

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                    13  X = (DS=-DQ AMPLITUDE)/(DS=+DQ AMPLITUDE)

          RELATED TEXT SECTION VI B.4

REX        REAL PART OF X
REX   C 152      0.06      0.18      0.44  BALDO-CE   65 HLBC    K+ CHARGE EXCHNG 11/67
REX     196      0.035     0.11      0.13  AUBERT     65 HLBC    K+ CHARGE EXCHNG 11/67
REX   F 109     -0.08      0.16      0.28  FRANZINI   65 HBC     PBAR P           11/67
REX     116      0.17      0.16      0.35  FELDMAN    67 OSPK    PI-P TO KO LMBDA 11/67
REX N 335       (0.17)    (0.10)          HILL       67 DBC     K+D YIELDS KOPP  11/67
REX B           (0.03)    (0.03)          BENNETT1   68 CNTR                     7/68
REX     121      0.09      0.07      0.09  JAMES      68 HBC     PBAR P           5/69
REX   B         -0.020     0.025           BENNETT    69 CNTR    CHAR ASYM+ CU RE 10/69
REX     686      0.09      0.14      0.16  LITTENBER  69 OSPK    K+N TO KOP       4/69
REX   N 215      0.12      0.09            CHO        70 DBC     K+D TO KOPP      10/70
REX U   222      (0.04)    (0.07)    (0.08) BURGUN     71 HBC     K+P TO KOPPI+    2/72
REX     252      0.25       .07       .09  WEBBER     71 HBC     K-P TO KBAR N    10/69
REX U 410        0.03      0.06      0.06  BURGUN     72 HBC     K+P TO KOPPI+    1/73
REX     126      0.26      0.10      0.14  MANN       72 HBC     K-P TO KOBAR N   9/72
REX G 342       (-0.13)   (0.11)          MANTSCH    72 OSPK    KE3  FROM KO LMB 2/72
REX G 100       (0.04)    (0.10)    (0.13) GRAHAM     72 OSPK    KMU3 FROM KO LMB 2/72
REX   G 442     -0.05      0.09            GRAHAM     72 OSPK    PI-P TO KO LMBDA 2/72
REX    1757     -0.008     0.044           FACKLER    73 OSPK    KE3 FROM KO      9/73
REX    1367     -0.03      0.07            HART       73 OSPK    KE3 FROM KO LMB  2/74
REX    1079     -0.070     0.036           MALLARY    73 OSPK    KE3 FROM KO LM + 6/73
REX    4724      0.04      0.03            NIEBERGA   74 ASPK    K+P TO KOPPI+    7/74
REX      79      0.10      0.18      0.19  SMITH      75 WIRE    PI-P TO KO LMBDA 8/76*
REX   C  BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX.          11/67
REX   F  FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67.         11/67
REX N    CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67.     10/70
REX U    BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71.                 11/73
REX B    BENNETT 69 IS A REANALYSIS OF BENNETT1 68.                            10/69
REX G    SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH          2/72
REX G    MANTSCH 72.                                                            2/72
REX            . . . . . . . . . .
REX AVG       0.009     0.020    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
REX STUDENT   0.008     0.017    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                  (SEE IDEOGRAM BELOW )
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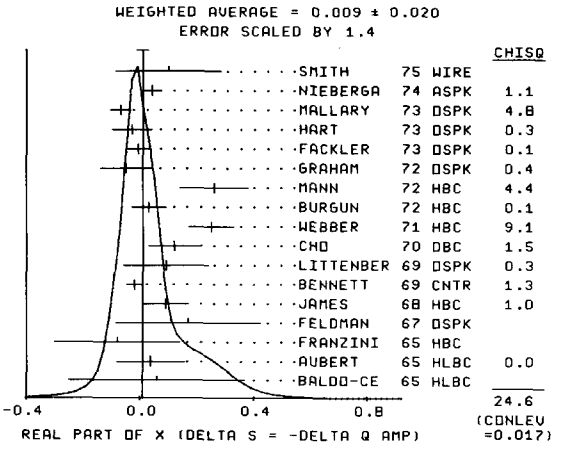


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IMX        IMAGINARY PART OF X (ASSUMES M(KL)-M(KS) POSITIVE -- SEE S13D)
IMX   C 152     -0.44      0.32      0.19  BALDO-CE   65 HLBC    K+ CHARGE EXCHNG  3/68
IMX     196     -0.21      0.11      0.15  AUBERT     65 HLBC    K+ CHARGE EXCHNG  3/68
IMX   F 109     +0.24      0.40      0.30  FRANZINI   65 HBC     PBAR P            3/68
IMX     116      0.0       0.25            FELDMAN    67 OSPK    PI-P TO KO LMBDA 11/67
IMX N 335       (-0.20)   (0.10)          HILL       67 DBC     K+D YIELDS KOPP  11/67
IMX     121     +0.22      0.37      0.29  JAMES      68 HBC     PBAR P           5/69
IMX     686     -0.11      0.10      0.11  LITTENBER  69 OSPK    K+N TO KOP       4/69
IMX   N 215     -0.08      0.07            CHO        70 DBC     K+D TO KOPP      10/70
IMX U   222      0.12      (0.08)    (0.09) BURGUN     71 HBC     K+P TO KOPPI+    2/72
IMX     252      0.0        .08            WEBBER     71 HBC     K-P TO KBAR N    10/69
IMX   U 410      0.07      0.06      0.07  BURGUN     72 HBC     K+P TO KOPPI+    1/73
IMX     126      0.21      0.15      0.12  MANN       72 HBC     K-P TO KOBAR N   9/72
IMX G   342     (-0.04)   (0.16)          MANTSCH    72 OSPK    KE3  FROM KO LMB  2/72
IMX G   100     (0.12)    (0.17)    (0.16) GRAHAM     72 OSPK    KMU3 FROM KO LMB  2/72
IMX   G 442      0.05      0.13            GRAHAM     72 OSPK    PI-P TO KO LMBDA  2/72
IMX    1757     -0.017     0.060           FACKLER    73 OSPK    KE3 FROM KO       9/73
IMX    1367      0.09      0.07            HART       73 OSPK    KE3 FROM KO LMB   2/74
IMX    1079      0.107     0.092     0.074 MALLARY    73 OSPK    KE3 FROM KO LM +  6/73
IMX    4724     -0.06      0.05            NIEBERGA   74 ASPK    K+P TO KOPPI+     7/74
IMX      79     -0.10      0.16      0.19  SMITH      75 WIRE    PI-P TO KO LMBDA  8/76*
IMX   C  BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX.          11/67
IMX   F  FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67.         11/67
IMX N    FTNOTE 10 OF HILL 67 SHOULD READ +0.58, NOT -0.58 (PRIV.COMM.).       3/68
IMX N    CHO 70 IS ANALYSIS OF UNAMBIGUOUS EVENTS IN NEW DATA AND HILL 67.     10/70
IMX U    BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71.                 11/73
IMX G    SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH          2/72
IMX G    MANTSCH 72.                                                            2/72
IMX            . . . . . . . . . .
IMX AVG      -0.004     0.026    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
IMX STUDENT  -0.005     0.027    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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Stable Particles

K_L^0

Data Card Listings

For notation, see key at front of Listings.

REFERENCES FOR K0L

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BARDON   58 ANP 5 156          M BARDON,K LANDE,L LEDERMAN  (COLUMBIA+BNL)
CRAWFORD 59 PRL 2 361          CRAWFORD,CRESTI,DOUGLASS,GOOD +          (LRL)
ASTIER   61 AIX CONF 1 227     ASTIER,BLASKOVIC,RIVET,SIAUD +           (EPOL)
FITCH    61 NC  22 1160        V FITCH,P PIROUE,R PERKINS       (PRINCETON)
GOOD     61 PR 124 1223        GOOD,MATSEN,MULLER,PICCIONI,POWELL +     (LRL)
NEAGU    61 PRL  6  552        NEAGU,OKONOV,PETROV,ROSANOVA,RUSAKOV  (JINR)
    ALSO 61 JETP 13 1138       NYAGU,OKONOV,PETROV,ROZANOVA,RUSAKOV  (JINR)

CAMERINI 62 PR 128 362         CAMERINI,FRY,GAIDOS,BIRGE,ELY +  (WISC+LRL)
DARMON   62 PL 3 57            J DARMON,A ROUSSET,J SIX                 (EPOL)

ADAIR    64 PL 12 67           R K ADAIR,L B LEIPUNER           (YALE+BNL)
ALEKSANY 64 DUBNA 2 102        ALEKSANYAN,ALIKHANYAN,VARTAZARYAN+  (EREVAN)
    ALSC 64 JETP 19 1019       ALEKSANYAN+   (LEBEDEV+MOS ENG PHYS+EREVAN)
ANIKINA  64 JETP 19 42         ANIKINA,ZHURAVLEVA+ (GEORG ACAD SCI+ DUBNA)
CHRISTEN 64 PRL 13 138         CHRISTENSON,CRONIN,FITCH,TURLAY  (PRINCETON)
FUJII    64 DUBNA 2 146        FUJII,JOVANOVICH,TURKOT+ (BNL,MARYLAND,MIT)
LUERS    64 PR 133 B 1276      LUERS,MITTRA,WILLIS,YAMAMOTO             (BNL)

ANIKINA  65 JINR P 2488        ANIKINA,VARDENGA,ZHURAVLEVA,KOTLYA+ (DUBNA)
ANDERSON 65 PRL 14 475         ANDERSON,CRAWFORD,GOLDEN,STERN + (LRL+WISC)
ASTBURY1 65 PL 16 80           ASTBURY,FINOCCHIARO,BEUSCH +  (CERN+ZURICH)
    ALSO 65 HELV.PH.AC.39 523 M PEPIN
ASTBURY2 65 PL 18 175          ASTBURY,MICHELINI,BEUSCH +    (CERN+ZURICH)
ASTBURY3 65 PL 18 178          ASTBURY,MICHELINI,BEUSCH +    (CERN+ZURICH)

AUBERT   65 PL 17 59           AUBERT,BEHR,CANAVAN,CHOUNET+   (EPOL+ORSAY)
    ALSO 67 LOWYS
BALDO-CE 65 NC 38 684          BALDO-CEOLIN,CALIMANI,CIAMPOLILLO +  (PADO)
CHRISTEN 65 PR 140 B 74        CHRISTENSEN,CRONIN,FITCH,TURLAY  (PRINCETON)
FISHER   65 ANL 7130 83        FISHER,ABASHIAN,ABRAMS,CARPENTER+        (ILL)
FITCH    65 PRL 15 73          FITCH,ROTH,RUSS,VERNON           (PRINCETON)

FRANZINI 65 PR 140 B 127       FRANZINI,KIRSCH,PLANO +  (COLUMBIA+RUTGERS)
GALBRAIT 65 PRL 14 383         GALBRAITH,MANNING,JONES +  (AERE+BRIS+RHEL)
GUIDONI  65 ARGONNE CONF 49    +BARNES,FOELSCHE,FERBEL,FIRESTO+ (BNL+YALE)
HOPKINS  65 ARGONNE CONF 67    H W K HOPKINS,BACON,EISLER   (VAND+RUTGERS)
VISHNEVS 65 PL  18   339       VISHNEVSKY,GALANINA,SEMENOV +        (ITEP)

ALFF-STE 66 PL 21 595          ALFF-STEINBERGER,HEUER,RUBBIA +          (CERN)
ANIKINA  66 SJNP 2 339         ANIKINA, VARDENGA, ZHURAVLEVA+           (JINR)
AUERBACH 66 PRL  17  980       AUERBACH,MANN,MCFARLANE,SCIULLI          (PENN)
AUERBACH 66 PR  149 1052       AUERBACH,DOBBS,LANDE,MANN,SCIULLI+       (PENN)
    ALSO 65 PRL  14  192       +LANDE,MANN,SCIULLI,UTO,WHITE,YOUNG      (PENN)
BALDO-CE 66 NC  45A  733       BALDO-CEOLIN,CALIMANI,CIAMPOLILLO+  (PADUA)
BASILE   66  BALATCN CONF      BASILE,CRONIN,THEVENET +                 (SACLAY)

BEHR     66 PL  22 540         +BRISSON,BALDO-CEOLIN,AUBERT+    (PADO,EPOL)
BELLOTTI 66 NC  45A  737       BELLOTTI,PULLIA,BALDO-CEOLIN+ (MILAN,PADUA)
BOTT-BOD 66 PL  23  277        BOTT-BODENHAUSEN,DE BOUARD,CASSEL+       (CERN)
CAMERINI 66 PR  150 1148       CAMERINI,CLINE,ENGLISH,FISCHBEIN+WISCONSIN
CANTER   66 PRL 17 942         +CHO,ENGLER,FISK,HILL +       (CARNEGIE+BNL)
CARPENTE 66 PR  142  871       CARPENTER,ABASHAN,ABRAMS,FISHER  (ILLINOIS)
CHANG    66 PL  23  702        CHANG,BASSANO,KIKUCHI,DODO+  (SYRACUSE,BNL)

CRIEGEE  66 PRL 17 150         +FOX,FRAUENFELDER,HANSON,MOSCAT+ (ILLINOIS)
FIRESTON 66 PRL 16 556         FIRESTONE,KIM,LACH,SANDWEISS+     (YALE,BNL)
FIRESTON 66 PRL 17 116         FIRESTONE,KIM,LACH,SANDWEISS+     (YALE,BNL)
FUJII    66 PRL 13 253         FUJII,JOVANOVICH,TURKOT,ZORN (BNL+MARYLAND)
    FUJII 66 IS THE CORRECTED VALUE GIVEN BY JOVANOVICH+ 66
HAWKINS  66 PL 21 238          C J B HAWKINS                            (YALE)
    ALSO 67 PR  156  1444      C J B HAWKINS                            (YALE)

JOVANOVI 66 PRL 17 1075        JOVANOVICH,FUJII,TURKOT,ZORN +(BNL+UMD+MIT)
KULYUKIN 66   BERKELEY 28     KULYUKINA,MESTVIRISHVILI,NEAGU,PETR+  (JINR)
MEISNER1 66 PRL 16 278         G W MEISNER,B B CRAWFORD,F CRAWFORD       (LRL)
MEISNER2 66 PRL  17  492       G MEISNER,B CRAWFORD,F CRAWFORD           (LRL)
NEFKENS  66 PL 19 706          NEFKENS,ABASHIAN,ABRAMS,CARPENTER+       (ILL)
VERHEY   66 PRL 17 669         VERHEY,NEFKENS,ABASHIAN+                 (ILL)

BENNETT  67 PRL  19  993       BENNETT,NYGREN,SAAL,STEINBERGER +(COLUMBIA)
BOTT-BOD 67 PL  24B  194       BOTT-BODENHAUSEN,DEBOUARD,CASSEL +       (CERN)
BOTT-BOD 67 PL  24B  438       BOTT-BODENHAUSEN,DEBOUARD,DEKKERS+       (CERN)
    ALSO 66 PL  20  212        BOTT-BODENHAUSEN,DEBOUARD,CASSEL+        (CERN)
    ALSO 66 PL  23  277        BOTT-BODENHAUSEN,DEBOUARD,CASSEL         (CERN)
CANTER   67 THESIS             J.M. CANTER                      (CARNEGIE)

CRONIN 1 67 PRL 18 25          +KUNZ,RISK,WHEELER               (PRINCETON)
CRONIN 2 67 PRINC CONF(11/67) +KUNZ,RISK,WHEELER                (PRINCETON)
DEBOUARD 67 NC  52A  662       DEBOUARD,DEKKERS,JORDAN,MERMOD +         (CERN)
    ALSC 65 PL  15  58         DE BOUARD,DEKKERS,SCHARFF+ (CERN+ORSA+NPIM)
DEVLIN   67 PRL 18 54          DEVLIN,SOLOMON,SHEPARD,BEALL+     (PRIN+UMD)
    ALSO 68 PR 169 1045        SAYER,BEALL,DEVLIN,SHEPHARD+ (UMD+PPA+PRIN)

DORFAN   67 PRL  19  987       DORFAN,ENSTROM,RAYMOND,SCHWARTZ +(SLAC+LRL)
FELDMAN  67 PR  155  1611      FELDMAN,FRANKEL,HIGHLAND,SLOAN           (PENN)
FIRESTON 67 PRL 18  176        FIRESTONE,KIM,LACH,SANDWEISS,+    (YALE,BNL)
FITCH    67 PR 164  1711       FITCH,ROTH,RUSS,VERNON           (PRINCETON)
HAWKINS  67 PR  156  1444      C J B HAWKINS                            (YALE)
HILL     67 PRL  19  668       HILL,LUERS,ROBINSON,CANTER+  (BNL,CARNEGIE)

HOPKINS  67 PRL 19  185        HOPKINS,BACON,EISLER                     (BNL)
KADYK    67 PRL 19  597        KADYK,CHAN,DRIJARD,OREN,SHELDON          (LRL)
KULYUKIN 67  PREPRINT          KULYUKINA+MESTVIRISHVILI+NEAGU +         (JINR)
LOWYS    67 PL  24B  75        LOWYS,AUBERT,CHOUNET,PASCAUD+   (EPOL,ORSA)
MISCHKE  67 PRL 18  138        MISCHKE,ABASHIAN,ABRAMS+         (ILLINOIS)
NEFKENS  67 PR  157  1233      +ABASHIAN,ABRAMS,CARPENTER,FISHER+       (ILL)
TODOROFF 67  THESIS            JOHN A TODOROFF                  (ILLINOIS)

ABRAMS   68 PR   176  1603     +ABASHIAN,MISCHKE,NEFKENS,SMITH+ (ILLINOIS)
ARNOLD   68 PL 28B 56          ARNOLD,BUDAGOV,CUNDY,AUBERT+   (CERN+ORSAY)
ARONSON  68 PRL 20 287         S.H.ARONSON, K.W.CHEN                (PRINCETON)
    ALSO 69 PR  175 1708       S H ARONSON, K W CHEN                (PRINCETON)
BALATZ   68 PL 26B  320        BALATZ,BEREZIN,VISHNEVSKY,GALANINA+  (ITEP)
BARTLETT 68 PRL 21 558         BARTLETT,CARNEGIE,FITCH+         (PRINCETON)

BASILE   68 PL 26B  542        BASILE,CRONIN,THEVENET,TURLAY+           (SACLAY)
BASILE2  68 PL 28B  58         +CRONIN,THEVENET,TURLAY,ZYLBERAJCH+(SACLAY)
BENNETT1 68 PL 27B 244         BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BENNETT2 68 PL 27B 248         BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BLANPIED 68 PRL 21 1650        BLANPIED,LEVIT,ENGELS+     (CASE+HARV+MCGI)
BUDAGOV  68 NC  57A 182        BUDAGOV,BURMEISTER,CUNDY+  (CERN,ORSA,IPNP)
    ALSO 68 PL  28B 215        +CUNDY,MYATT,NEZRICK+          (CERN,ORSA,EPOL)

CARNEGIE 68 PRINC TR44 THESIS R.K.CARNEGIE                      (PRINCETON)
JAMES    68 NP  B8 365         F JAMES, H BRIAND                 (IPNP,CERN)
    ALSO 68 PRL 21 257         HELLAND,LONGO,YOUNG              (UCLA,MICH)
KULYUKIN 68 JETP 26 20         KULYUKINA,MESTVIRISHVILI,NEAGU+       (JINR)
KUNZ     68 THESIS (PU 46)     P F KUNZ                         (PRINCETON)
MELHOP   68 PR 172 1613        MELHOP MURTY BOWLES,BURNETT+      (LA JOLLA)
THATCHER 68 PR 174 1674        THATCHER,ABASHIAN,ABRAMS,CARPENTER +     (ILL)

BANNER   69 PR 188 2033        +CRONIN,LIU,PILCHER              (PRINCETON)
    ALSO 68 PRL 21 1103        BANNER,CRONIN,LIU,PILCHER        (PRINCETON)
    ALSO 68 PRL 21 1107        BANNER CRONIN,LIU,PILCHER        (PRINCETON)

BEILLIER 69 PL  30B 202        BEILLIERE,BOUTANG,LIMON                  (EPOL)
BENNETT  69 PL  29B 317        +NYGREN,SAAL,STEINBERGER+        (COLU,BNL)
BOHM     69 NP  B9 605         +DARRIULAT,GROSSO,KAFTANOV+              (CERN)
    ALSO 68 PL 27B 321         BOHM,DARRIULAT,GROSSO,KAFTANOV           (CERN)

BOTT-BOD 69 CERN 69-7 329      BOTT-BODENHAUSEN,DE BOUARD,CASSEL+       (CERN)
CENCE    69 PRL 22 1210        CENCE,JONES,PETERSON,STENGER+  (HAWAII,LRL)
EVANS    69 PRL 23 427         EVANS,GOLDEN,MUIR,PEACH+     (EDINBURGH,CERN)
FAISSNER 69 PL  30B 204        +FOETH,STAUDE,TITTEL+          (AACH,CERN,TORI)
FOETH    69 PL 30B 282         +HOLDER,RADERMACHER +  (AACHEN,CERN,TORINO)

GAILLARD 69 NC  59A 453        +GALBRAITH,HUSSRI,JANE+   (CERN,RHEL,AACHEN)
    ALSO 67 PRL 18 20          +KRIENEN,GALBRAITH,HUSSRI+ (CERN+RHEL+AACH)
GOBBI    69 PRL 22 685         +GREEN,HAKEL,MOFFETT,ROSEN,GOZ+ (ROCH+RUTG)
LITTENBE 69 PRL 22 654         LITTENBERG,FIELD,PICCIONI,MEHLHOP+    (UCSD)
LONGO    69 PR 181  1808       M J LONGO,K K YOUNG,J A HELLAND (MICH,UCLA)
PACIOTTI 69 THESIS,UCRL 19446 M A PACIOTTI                       (LRL)
SAAL     69 THESIS             H J SAAL                         (COLUMBIA)

ALBROW   70 PL 33B 516         +ASTON,BARBER,BIRD,ELLISON +     (MCHS+DARE)
ARONSON  70 PRL 25 1057        +EHRLICH,HOFER,JENSEN+          (EFI,ILLC,SLAC)
BARMIN   70 PL 33B 377         +BARYLOV,BORISOV,BYSHEVA+            (ITEP,JINR)
BASILE   70 PR D2 78           +CRONIN,THEVENT,TURLAY,ZYLBERAJCH +  (SACL)
BUCHANAN 70 PL 33B 623         +DRICKEY,RUDNICK,SHEPARD+    (SLAC,JHU,UCLA)
    ALSO PRIVATE COMMUNICATION, B. COX, FEB. 71

BUDAGOV  70 PR D2 815          +CUNDY,MYATT,NEZRICK+       (CERN, ORSA,EPOL)
    ALSC 68 PL  28B 215        +CUNDY,MYATT,NEZRICK+       (CERN,ORSA,EPOL)
CHIEN    70 PL 33B 627         C-Y.CHIEN,COX,ETTLINGER +    (JHU+SLAC+UCLA)
    ALSO PRIVATE COMMUNICATION, B. COX, FEB. 71.
CHO      70 PR D1 3031         +DRALLE,CANTER,ENGLER,FISK+ (CARN,BNL,CASE)
    ALSO 67 PRL 19 668         HILL,LUERS,ROBINSON,SAKITT +     (BNL,CARN)

CHOLLET  70 PL 31B 658         +GAILLARD,JANE,RATCLIFFE,REPELLIN +      (CERN)
CULLEN   70 PL 32B 523         +DARRIULAT,DEUTSCH,FOETH + (AACH,CERN,TORI)
DARRIULA 70 PL 33B 249         +FERRERO,GROSSO,HOLDER +   (AACH,CERN,TORI)
FAISSNER 70 NC 70A 57          +REITHLER,THOME,GAILLARD+  (AACH,CERN,RHEL)
JENSEN   70 THESIS             O.A. JENSEN                          (EFI)
    ALSO 69 PRL 23 615         JENSEN,ARONSON,EHRLICH,FRYBERGER+ (EFI,ILL)

MARX     70 PL 32B 219         +NYGREN,PEOPLES,STEINBERGE+(COLU,HARV,CERN)
    ALSO 70 THESIS,NEVIS 179   JAY MARX                         (COLUMBIA)
SCRIBANO 70 PL 32B 224         +MANNELLI,PIERAZZINI,MARX+ (PISA,COLU,HARV)
SMITH    70 PL 32B 133         +WANG,WHATLEY,ZORN,HORNBOSTEL      (UMD,BNL)
WEBBER   70 PR D1 1967         +SOLMITZ,CRAWFORD,ALSTON-GARNJOST        (LRL)
    ALSO 69 UCRL 19226 THESIS B R WEBBER                            (LRL)

BALATS   71 SJNP 13 53         +BEREZIN,VISHNEVSKII,GALANINA+           (ITEP)
BARMIN   71 PL 35B 604         +BARYLOV,VESELOVSKY,DAVIDENKO+           (ITEP)
BISI     71 PL 36B 533         +DARRIULAT,FERRERO,RUBBIA+ (AACH,CERN,TORI)
BURGUN   71 LNC 2 1169         +LESQUOY,MULLER,PAULI+      (SACL+CERN+OSLO)
CARNEGIE 71 PR D4 1            +CESTER,FITCH,STROVINK,SULAK             (PRIN)
CHAN     71 LBL-350  THESIS    J.HIONG-SING CHAN                        (LBL)

CHIEN    71 PL 35B 261         +COX,ETTLINGER,RESVANIS+     (JHU,SLAC,UCLA)
    ALSO 72 CALLY
CHO      71 PR D3 1557         +DRALLE,CANTER,ENGLER,FISK+ (CARN,BNL,CASE)
CLARK    71 PRL 26 1667        +ELIOFF,FIELD,FRISCH,JOHNSON,KERTH+      (LRL)
    ALSC 70 UCRL 19709-THESIS ROLLAND JOHNSON                       (LRL)
    ALSO 71 UCRL 20264-THESIS HENRY FRISCH                          (LRL)
    ALSO 74 SLAC-PUB-1498     R.C.FIELD                             (SLAC)

ENSTROM  71 PR D4 2629         +AKAVIA,COOMBES,DORFAN+          (SLAC,STAN)
    ALSO 70 THESIS (SLAC 125) J E ENSTROM                      (STANFORD)
HILL     71 PR D4 7            +SAKITT,SKJEGGESTAD,CANTER+ (BNL,CARN,CASE)
JAMES    71 PL 35B 265         +MONTANET,PAUL,PAULI+      (CERN+SACL+OSLO)
MEISNER  71 PR D3 59           +MANN,HERTZBACH,KOFLER +    (MASA+BNL+YALE)
PEACH    71 PL 35B 351         +EVANS,MUIR,BUDAGOV,HOPKINS+      (EDIN,CERN)

REPELLIN 71 PL 36B 603         +WOLFF,CHOLLET,GAILLARD,JANE+    (ORSA,CERN)
WEBBER   71 PR D3 64           +SOLMITZ,CRAWFORD,ALSTON-GARNJOST        (LRL)
    ALSO 68 PRL 21 498         WEBBER,SOLMITZ,CRAWFORD,ALSTONGARNJOST(LRL)
    ALSO 69 UCRL 19266-THESIS B R WEBBER                            (LRL)
WOLFF    71 PL 36B 517         +CHOLLET,REPELLIN,GAILLARD+      (ORSA,CERN)

ALBROW   72 NP B44 1           +ASTON,BARBER,BIRD,ELLISON+      (MCHS+DARE)
ASHFORD  72 PL 38B 47          +BROWN,MASEK,MAUNG,MILLER,RUDERMAN+  (UCSD)
BANNER1  72 PRL 28 1597        +CRONIN,HOFFMAN,KNAPP,SHOCHET    (PRINCETON)
BANNER2  72 PRL 29 237         +CRONIN,HOFFMAN,KNAPP,SHOCHET    (PRINCETON)
BARMIN1  72 SJNP 15 636        +DAVIDENKO,DEMIDOV,DOLGOLENKO+           (ITEP)
BARMIN2  72 SJNP 15 638        +BARYLOV,DAVIDENKO,DEMIDOV+              (ITEP)
BURGUN   72 NP B50 194         +LESQUOY,MULLER,PAULI,+      (SACL+CERN+OSLO)
CARNEGIE 72 PR D6 2335         +CESTER,FITCH,STROVINK,SULAK     (PRINCETON)

DALLY    72 PL 41B 647         +INNOCENTI,SEPPI,CHIEN,COX+ (SLAC+JHU+UCLA)
    ALSO 70 CHIEN
    ALSC 71 CHIEN
GRAHAM   72 NC 9A 166          +ABASHIAN,JONES,MANTSCH,ORR+      (ILL+NEAS)
HOLDER   72 PL 40B 141         +RADERMACHER,STAUDE+         (AACH+CERN+TORI)
JAMES    72 NP B49 1           +MONTANET,PAUL,SAEFRE+      (CERN+SACL+OSLO)
KRENZ    72 LNC 4 213          +HOPKINS,EVANS,MUIR,PEACH  (AACH+CERN+EDIN)

MANN     72 PR D6 137          +KOFLER,MEISNER,HERTZBACH+  (MASA+BNL+YALE)
MANTSCH  72 NC 9A 160          +ABASHIAN,GRAHAM,JONES,ORR+       (ILL+NEAS)
METCALF  72 PL 40B 703         +NEUHOFER,NIEBERGALL+       (CERN+IPN+WIEN)
NEUHOFER 72 PL 41B 642         +NIEBERGALL,REGLER,STIER+  (CERN+ORSA+VIEN)
PICCIONI 72 PRL 29 1412        +COOMBES,DONALDSON,DORFAN,FRYBERGER+ (SLAC)
    ALSO 74 PR D9 2939         PICCIONI,DONALDSON +        (SLAC+UCSC+COLO)
VOSBURGH 72 PR D6 1834         +DEVLIN,ESTERLING,GOZ,BRYMAN +   (RUTG,MASA)
    ALSO 71 PRL 26 866         VOSBURGH,DEVLIN,ESTERLING,GOZ + (RUTG,MASA)

ALBROW   73 NP B58 22          +ASTON,BARBER,BIRD,ELLISON+      (MCHS+DARE)
ALEXANDE 73 NP B65 301         ALEXANDER,BENARY,BOROWITZ,LANDE+ (TELA+HEID)
ANIKINA  73  P1-7539 COM.JINR +BALASHOV,BANNIK +                  (JINR)
BARBIELL 73 PL 43B 529         BARBIELLINI,DARRIULAT,FAINBERG+          (CERN)
BRANDENB 73 PR D8 1978         BRANDENBURG,JOHNSON,LEITH,LOOS+          (SLAC)
CARITHE1 73 PRL 30 1336        +MODIS,NYGREN,PUN,SCHWARTZ+ (COLU+CERN+NYU)
CARITHE2 73 PRL 31 1025        CARITHERS,NYGREN,GORDON+     (COLU+BNL+CERN)
EVANS    73 PR D7 36           +MUIR,PEACH,BUDAGOV+        (EDINBURGH+CERN)
    ALSO 69 PRL 23 427         EVANS,GOLDEN,MUIR,PEACH+    (EDINBURGH+CERN)

FACKLER  73 PRL 31 847         +FRISCH,MARTIN,SMOOT,SOMPAYRAC           (MIT)
FITCH    73 PRL 31 1524        +HEPP,JENSEN,STROVINK,WEBB       (PRINCETON)
    ALSO 72 COO-3072-13        R.C.WEBB (THESIS)                (PRINCETON)
HART     73 NP B66 317         +HUTTON,FIELD,SHARP,BLACKMORE+  (CAVE+RHEL)
MALLARY  73 PR D7 1953         +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI + (CIT)
    ALSO 70 PRL 25 1214        SCIULLI,GALLIVAN,BINNIE,GOMEZ +          (CIT)

MCCARTHY 73 PR D7 687          +BREWER,BUDNITZ,ENTIS,GRAVEN,MILLER+     (LBL)
    ALSO 72 PL 42B 291         MCCARTHY,BREWER,BUDNITZ,ENTIS,GRAVEN+    (LBL)
    ALSO 71 THESIS LBL-550     R.L.MCCARTHY                             (LBL)
MESSNER  73 PRL 30 876         +MORSE,NAUENBERG,HITLIN +  (COLD+SLAC+UCSC)
PEACH    73 PL 43B 441         +EVANS,MUIR,HOPKINS,KRENZ  (EDIN+CERN+AACH)
SANDWEIS 73 PRL 30 1002        +SUNDERLAND,TURNER,WILLIS,KELLER (YALE+ANL)
WILLIAMS 73 PRL 31 1521        +LARSEN,LEIPUNER,SAPP,SESSOMS+   (BNL+YALE)

ALBRECHT 74 PL 48B 393         DUBNA+BERLIN+BUDAPEST+PRAGUE+SERPUKH+SOFIA
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Data Card Listings

For notation, see key at front of Listings.


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BISI     74 PL 50B 504          BISI,FERRERO                          (TORI)
BOBISUT  74 LNC 11 646          +HUZITA,MATTIOLI,PUGLIERIN            (PADO)
DONALDS1 74 PRL 33 554          DONALDSON,HITLIN,KENNELLY,KIRKBY +    (SLAC)
    ALSO 74 DONALDSON 3
    ALSO 76 DONALDSON
DONALDS2 74 PR D9 2960          DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
    ALSO 73 PRL 31 337          DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
DONALDS3 74 SLAC 184-THESIS     GREGORY J. DONALDSON                  (SLAC)
    ALSO 76 DONALDSON

GEWENIG1 74 PL 48B 483          GEWENIGER,GJESDAL,KAMAE,PRESSER+(CERN+HEID)
    ALSO 74 CERN INT. REPT.     VERA LUTH (THESIS-INT. REPT. 74-4)    (HEID)
GEWENIG2 74 PL 48B 487          GEWENIGER,GJESDAL,PRESSER +       (CERN+HEID)
    ALSO 74 PL 52B 119          GJESDAL,PRESSER,STEFFEN +         (CERN+HEID)
GEWENIG3 74 PL 52B 108          GEWENIGER,GJESDAL,PRESSER +       (CERN+HEID)
GJESDAL  74 PL 52B 113          +PRESSER,KAMAE,STEFFEN+           (CERN+HEID)

HILL     74 17TH INT.CONF.HEP   +SAKITT,SNAPE,STEVENS,PARK+ (BNL+SLAC+SBER)
MESSNER  74 PRL 33 1458         +FRANKLIN,MORSE,NAUENBERG+ (COLO+SLAC+UCSC)
NIEBERGA 74 PL 49B 103          NIEBERGALL,REGLER,STIER +  (CERN+ORSA+VIEN)
WANG     74 PR D9 540           +SMITH,WHATLEY,ZORN,HORNBOSTEL      (UMD+BNL)
WILLIAMS 74 PRL 33 240          +LARSEN,LEIPUNER,SAPP,SESSOMS +   (BNL+YALE)
WOO      74 LNC 10 38           +BUCHANAN,PEPPER                      (UCLA)

BALDOCEO 75 NC 25A 688          BALDO-CEOLIN,BOBISUT,CALIMANI+  (PADO+WISC)
BLUMENTH 75 PRL 34 164          BLUMENTHAL,FRANKEL,NAGY +   (PENN+CHIC+TEMP)
BUCHANAN 75 PR D11 457          +DRICKEY,PEPPER,RUDNICK +     (UCLA+SLAC+JHU)
CARITHER 75 PRL 34 1244         CARITHERS,MODIS,NYGREN,PUN +      (COLO+NYU)
SMITH    75 UCSD THESIS-UNPUB   JAMES G. SMITH                        (UCSD)

BIRULEV  76 SJNP 24, 178        +VESTERGOMBI,VOVENKO,VOTRUBA,GENCHEV+(JINR)
COOMBES  76 PRL 37 249          +FLEXER,HALL,KENNELLY,KIRKBY +      (STAN+NYU)
DONALDSO 76 PR D14 2839         DONALDSON,HITLIN,KENNELLY,KIRKBY,LIU+(SLAC)
    ALSO 74 SLAC 184-THESIS     GREGORY J. DONALDSON                  (SLAC)
FUKUSHIM 76 PRL 36 348          FUKUSHIMA,JENSEN,SURKO,THALER+   (PRIN+MASA)
GJESDAL  76 NP B109 118         +KAMAE,PRESSER,STEFFEN +          (CERN+HEID)
REY      76 PR D13 1161         +CENCE,JONES,PARKER +         (NDAM+HAWA+LBL)
    ALSO 69 CENCE

CHO      77 PR D15 587          +DERRICK,LISSAUER,MILLER,ENGLER+ (ANL+CARN)
CLARK    77 PR D15 553          +FIELD,HOLLEY,JOHNSON,KERTH,SAH,SHEN  (LBL)
    ALSO 75 LBL-4275 THESIS     GILBERT SHEN                          (LBL)
DEVOE    77 PR D16 565          +CRONIN,FRISCH,GROSSO-PILCHER+     (EFI+ANL)
PEACH    77 NP B127 399         +CAMERON +          (BGNA+EDIN+GLAS+PISA+RHEL)
SHOCHET  77 PRL 39 59           +LINSAY,GROSSO-PILCHER,FRISCH +    (EFI+ANL)

                                PAPERS NOT REFERRED TO IN DATA CARDS

ALEXANDE 62 PRL 9 69            G ALEXANDER,S ALMEIDA,F CRAWFORD       (LRL)
JOVANOVI 63 BNL CONF 42         JOVANOVIC,FISCHER,BURRIS +    (BNL+MARYLAND)
STERN    64 PRL 12 459          STERN,BINFORD,LIND,ANDERSON +     (WISC+LRL)
BEHR     65 ARGONNE CONF 59     BEHR,BRISSON,BELLOTTI+       (EPOL,MILA,PADO)
MESTVIRI 65 JINR P 2449         MESTVIRISHVILI,NYAGU,PETROV,RUSAKOV+ (JINR)
TRILLING 65 UCRL 16473          GEORGE H TRILLING                      (LRL)
    UPDATED FROM 1965 ARGONNE CONF., PAGE 115.

GINSBERG 67 PR 162  1570        EDWARD S GINSBERG          (U. MASS BOSTON)
RUBBIA   67 PL  24B  531        C.RUBBIA,J.STEINBERGER            (CERN+COLU)
  ALSO 1 66 PL  20  207         ALFF-STEINBERGER,HEUER,KLEINKNECHT+  (CERN)
  ALSO 2 66 PL  21  595         ALFF-STEINBERGER,HEUER,KLEINKNECHT+  (CERN)
  ALSO 3 66 PL  23  167         C.RUBBIA,J.STEINBERGER            (CERN+COLU)
SCHMIDT  67 NEVIS 160(THESIS)   P. SCHMIDT                        (COLUMBIA)

CRONIN   68 VIENNA CONF P.281   CRONIN,RAPPORTEURS TALK           (PRINCETON)
BECHERRA 70 PR D1 1452          T BECHERRAWY                          (ROCH)
GINSBERG 70 PR D1 229           E S GINSBERG                      (IIT HAIFA)
HEUSSE   70 LNC  3 449          +AUBERT,PASCAUD,VIALLE                (ORSAY)
GINSBERG 73 PR D8 3887          E S GINSBERG, J SMITH             (MIT+STON)
KLEINKNE 76 ARNS 26 1           K. KLEINKNECHT                        (DORT)

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Charmed Particles

Since this is the first full edition of the Review to contain charmed particles, we need to describe the placement of the charmed particle information within the Data Card Listings. As always, the Listings are divided into three groups according to particle type:

1) Stable Particles, immune to decay via the strong interaction;

2) Meson Resonances;

3) Baryon Resonances.

The charmed particle listings are fit into this scheme as follows:

D,F → Stable Particles following K

Λ_c^+ → Stable Particles following Ω^-

Charm Searches → Stable Particles at end

D^*, F^* → Mesons following strange mesons

Σ_c → Baryons following strange baryons .

In the Charm Searches section we give negative search results, as well as positive results such as emulsion tracks which can be interpreted as charm but cannot be classified as one of the particles named above.

There are many excellent reviews of charm. A few which give a theoretical overview are listed in references 1 and 2. Reference 3 is a thorough recent experimental review. Others, related to specific particles or searches, are listed in the appropriate reference sections below.

Charm is described by the standard GIM model[4] with four spin-1/2, fractionally-charged, baryon number B = 1/3 quarks with quantum number assignments as follows:

Quark	Q	I_3	S	C
u	2/3	1/2	0	0
d	-1/3	-1/2	0	0
s	-1/3	0	-1	0
c	2/3	0	0	1

where the charge is related to the third component of the isospin, baryon number, strangeness, and charm by

$$Q = I_3 + \tfrac{1}{2}(B + S + C) \quad .$$

The conventional model for describing the weak interactions involving these quarks and leptons is a Weinberg-Salam theory[5] with left-handed weak isodoublets

$$\begin{pmatrix} \nu_e \\ e^- \end{pmatrix} \quad \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix} \quad \begin{pmatrix} u \\ d' \end{pmatrix} \quad \begin{pmatrix} c \\ s' \end{pmatrix}$$

and right-handed weak isosinglets. Here

$$d' = d\cos\theta + s\sin\theta$$

$$s' = s\cos\theta - d\sin\theta \quad ,$$

where θ is the Cabibbo mixing angle ($\sin^2\theta \cong 0.055$). Then, following Jackson's (Ref. 1) shorthand notation, the weak interaction has a current-current structure

$$H_w = \frac{G}{\sqrt{2}} J J^\dagger \quad \text{with } J = J_C + J_N \ ,$$

where the charged and neutral currents are

$$J_C = \bar{\nu}_e e + \bar{\nu}_\mu \mu + \bar{u}\,(d\cos\theta + s\sin\theta) + \bar{c}\,(s\cos\theta - d\sin\theta)$$

Stable Particles

CHARMED PARTICLES, CHARMED D's

$$J_N = \bar{\nu}_e\nu_e + \bar{\nu}_\mu\nu_\mu - \bar{e}e - \bar{\mu}\mu + \bar{u}u + \bar{c}c - \bar{d}d - \bar{s}s$$

ignoring the Lorentz group structure. Thus only the charged current has terms which change charm, and the Cabibbo-favored transition is to a strange quark ($c \to s$), giving $\Delta C = \Delta S$.

The particles entering the charmed particle listings are believed to have the following quark composition:

$$D^+, D^{*+} \to c\bar{d}$$

$$D^0, D^{*0} \to c\bar{u}$$

$$F^+, F^{*+} \to c\bar{s}$$

$$\Lambda_c^+, \Sigma_c \to cud \ .$$

The lowest lying states, D, F, and Λ_c, should decay weakly. The Cabibbo-favored transition ($c \to s$) then leads to the expectation that D final states contain $\bar{K}$, that F final states contain $\bar{K}K$ or are non-strange, and that Λ_c^+ final states contain Λ, Σ, or $p\bar{K}$.

References

1. Proceedings of Summer Institute on Particle Physics, Aug. 2-13, 1976, Report No. SLAC-198 (November 1976): J. D. Bjorken, p.1; J. D. Jackson, p.147 (also available separately as LBL-5500); S. L. Glashow, p.473; A. De Rujula (a pictorial review), p.483; also F. J. Gilman, 1976 Particles and Fields Conference at Brookhaven National Lab, SLAC-PUB-1833, November 1976.
2. M. K. Gaillard, B. W. Lee, and J. L. Rosner, Rev. Mod. Phys. 47, 277 (1975).
3. G. J. Feldman, Charmed Particle Spectroscopy, Lectures given at the Banff Summer Institute on Particles and Fields, Banff, Alberta, Canada, Aug 26-Sept. 3, 1977; SLAC-PUB-2068 (December 1977).
4. S. L. Glashow, J. Iliopoulos, and L. Maiani, Phys. Rev. D2, 1285 (1970); also B. J. Bjorken and S. L. Glashow, Phys. Lett. 11, 255 (1964).
5. S. Weinberg, Phys. Rev. Lett. 19, 1264 (1967) and A. Salam, in Elementary Particle Theory, edited by N. Svartholm (Almqvist and Wiksell, Stockholm, 1968), p.367.

$D^{\pm}(1863)$, $D^0(1868)$, and $D^*(2010)$

Note that D and D^* are used throughout this review to mean the apparently charmed states at ~1865 MeV and ~2010 MeV, respectively, and should not be confused with the uncharmed D(1285) meson.

There is very strong evidence for the charm interpretation of the narrow $K\pi$, $K2\pi$, $K3\pi$ states observed in e^+e^- collisions at SPEAR. In agreement with the expectations for charmed mesons,[1-3] the following are observed (see data cards and references in the D and D^* Data Card Listings):

a) The D state appears to be produced only in association with equal (~1870 MeV) or higher mass states. Electromagnetic production of charm via a massive virtual photon would produce charm-anticharm pairs.

b) The D^+ decays via the exotic charge mode $K^-\pi^+\pi^+$ and not $K^+\pi^+\pi^-$. A charmed charge-plus ($c\bar{d}$) meson decays weakly to an uncharmed negative strangeness state as expected for $\Delta C = \Delta S$.

c) The observed decay modes of the D are Cabibbo-favored (strange). The Cabibbo-suppressed modes ($c \to d$, $\Delta S = 0$) are not observed within present statistics.

d) An excited state appears at ~2010 MeV in agreement with mass predictions.[4]

e) The masses suggest that the D states and D^* states are isospin multiplets. There are two distinct neutral states as is known from the D^0-$\bar{D}^0$ mixing studies (see D^0 branching ratio R9 section), suggesting the isodoublet structure (D^+, D^0) and $(D^-, \bar{D}^0)$ as expected for charmed nonstrange mesons ($c\bar{d}$, $c\bar{u}$) and ($\bar{c}d$, $\bar{c}u$).

f) Parity violation indicates that the ground state decays weakly. Charm conservation prevents strong decay.

g) Semileptonic decay modes are observed as would be expected from elementary processes such as $c \to se^+\nu_e$.

The published data and references are listed in the $D^{\pm}$ and D^0 sections below and in the $D^*(2010)$ sections of the Meson Data Card Listings. These data are summarized in the Tables at the beginning

of this report. For a thorough recent review of the data see reference 5.

References

1. M. K. Gaillard, B. W. Lee, and J. L. Rosner, Rev. Mod. Phys. 47, 277 (1975).
2. M. B. Einhorn and C. Quigg, Phys. Rev. D12, 2015 (1975).
3. A. De Rujula, H. Georgi, and S. L. Glashow, Phys. Rev. Lett. 37, 398 (1976).
4. A. De Rujula, H. Georgi, and S. L. Glashow, Phys. Rev. D12, 147 (1975).
5. G. J. Feldman, Properties of the D Mesons, Proceedings of Summer Institute on Particle Physics, July 11-22, 1977, SLAC-204, p.241. Also available individually as SLAC-PUB-2000.

$D^{\pm}$

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                   31  CHARGED D(1868,JP=0-)  I=1/2
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                   31  CHARGED D MASS (MEV)

M   L   50(1876.)    (15.)          PERUZZI   76 SMAG +-  K+-PI+-PI+-       1/77*
M   L     (1874.)     (5.)          GOLDHABER 77 SMAG +- DO,D+ RECOIL SPC 12/77*
M    P     1868.3      0.9          PERUZZI   77 SMAG +- E+E- 3.77GEV ECM 12/77*
M   L     (1874.)    (11.)          PICCOLO   77 SMAG +- E+E-4.03,4.41ECM  1/78*
M   L   VALUES WITH LARGE ERRORS NOT AVERAGED.
M    P  ERROR DOES NOT INCLUDE 0.13 PERCENT UNCERTIANTY IN THE ABSOLUTE     3/78*
M    P  SPEAR ENERGY CALIBRATION.  USES M(PSI)=3095 MEV.                    3/78*

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                   31  (D+-) - (DO) MASS DIFFERENCE (MEV)

DM   P         5.0      0.8         PERUZZI   77 SMAG +- E+E- 3.77GEV ECM  3/78*
DM   P  NOT INDEPENDENT OF PERUZZI 77 D+- AND DO MASSES.                    3/78*

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                   31  CHARGED D WIDTH FROM MASS SPECTRUM (MEV)

W    P  50   40.     OR LESS  CL=.90  PERUZZI   76 SMAG +- K-+PI+-PI+-      1/77*
W    P         7.    OR LESS          PERUZZI   77 SMAG +- E+E- 3.77GEV ECM 3/78*
W    P  PERUZZI WIDTHS ARE CONSISTENT WITH THEIR EXPERIMENTAL RESOLUTION.   1/77*

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                   31  EVIDENCE FOR WEAK DECAY OF D

WK      70                          WISS      76                            1/77*
WK      WISS 76, USING A SAMPLE OF ABOUT 70 D+- --> K-+ PI+- PI+-           1/77*
WK      EVENTS WHICH INCLUDE THE PERUZZI 76 EVENTS, FINDS THAT THIS FINAL   1/77*
WK      STATE IS INCOMPATIBLE WITH NATURAL SPIN AND PARITY.  THE NATURAL    1/77*
WK      SPIN PARITY FINAL STATE IN DO --> K- PI+ (GOLDHABER 76) INDICATES   1/77*
WK      PARITY VIOLATION IN THE D+- AND DO DECAYS IF BOTH ARE MEMBERS OF    1/77*
WK      THE SAME ISOMULTIPLET AS SUGGESTED BY THEIR SIMILAR MASSES.         1/77*
WK      THIS SUGGESTS A WEAK DECAY AND CONSEQUENTLY A NARROW WIDTH OF ORDER 1/77*
WK      10**13 SEC-1 OR 10**-8 MEV.                                         1/77*

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                   31  CHARGED D  PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      D+- INTO K-+ PI+- PI+-                          493+ 139+ 139
P2      D+- INTO KO PI+-                                497+ 139
P3      D+- INTO PI+- PI+ PI-                           139+ 139+ 139
P4      D+- INTO PI+- K+ K-                             139+ 493+ 493
P5      D+- INTO K+- PI+ PI-                            493+ 139+ 139
P6      D+- INTO E+- NUE                                 .5+   0
P7      D+- INTO E+- ANYTHING                            .5+   0

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                   31  CHARGED D BRANCHING RATIOS

R1      D+- INTO (K-+ PI+- PI+-)/TOTAL                    (P1)
R1       85    0.039    0.010        PERUZZI   77 SMAG   E+E- 3.77GEV ECM 12/77*

R2      D+- INTO (KO PI+-)/TOTAL                          (P2)
R2       17    0.015    0.006        PERUZZI   77 SMAG   E+E- 3.77GEV ECM 12/77*

R3      D+- INTO (KO PI+-)/(K-+ PI+- PI+-)                (P2)/(P1)
R3   P          .45  OR LESS  CL=.90  PICCOLO  77 SMAG +- E+E- 4.03GEV ECM 12/77*
R3   P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                           12/77*

R4      D+- INTO (PI+- PI+ PI-)/(K-+ PI+-PI+-)            (P3)/(P1)
R4   P          .08  OR LESS  CL=.90  PICCOLO  77 SMAG +- E+E- 4.03GEV ECM 12/77*
R4   P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                           12/77*

R5      D+- INTO (PI+- K+ K-)/(K-+ PI+- PI+-)             (P4)/(P1)
R5   P          .15  OR LESS  CL=.90  PICCOLO  77 SMAG +- E+E- 4.03GEV ECM 12/77*
R5   P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                           12/77*

R6      D+- INTO (K+- PI+ PI-)/(K-+ PI+- PI+-)            (P5)/(P1)
R6   P          .05  OR LESS  CL=.90  PICCOLO  77 SMAG +- E+E- 4.03GEV ECM 12/77*
R6   P  OBTAINED FROM SIGMA*BR VALUES OF TABLE I.                           12/77*

R7      (D+- INTO E+- NUE)/(D+- TO E+- ANYTHING + DO TO E+- ANYTHING)       12/77*
R7             0.10  OR LESS  CL=.90   BRANDELIK 77 DASP E+E- 3.99-4.08 GEV 12/77*

R8      D+- AND DO INTO (E+- ANYTHING)/(TOTAL D+- AND DO)(P7)                1/78*
R8             0.10      0.03          BRANDELIK 77 DASP E+E- 3.99-4.08 GEV  1/78*
R8             0.072     0.028         FELLER    78 SMAG E+E- 3.772 GEV ECM  2/78*
R8             0.11      0.02          BACINO    78 SPEC E+E- 3.772 GEV ECM  3/78*
R8          . . . . . . . . . .
R8   AVG       0.098     0.014    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   STUDENT   0.098     0.016    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                         REFERENCES FOR CHARGED D

GOLDHABE 76 PRL 37 255        GOLDHABER,PIERRE,ABRAMS,ALAM+     (LBL+SLAC)
PERUZZI  76 PRL 37 569        +PICCOLO,FELDMAN,NGUYEN,WISS+     (SLAC+LBL)
WISS     76 PRL 37 1531       +GOLDHABER,ABRAMS,ALAM,BOYARSKI+ (LBL+SLAC)
BRANDELI 77 PL 70B 387        BRANDELIK +        (AACH+DESY+HAMB+MPIM+TOKY)
GOLDHABE 77 PL 69B 503        GOLDHABER,WISS,ABRAMS,ALAM +      (LBL+SLAC)
PERUZZI  77 PRL 39 1301       +PICCOLO,FELDMAN+        (SLAC+LBL+NWES+HAWA)
PICCOLO  77 PL 70B 260        +PERUZZI,LUTH,NGUYEN,WISS,ABRAMS+(SLAC+LBL)
BACINO   78 PRL 40 671        +BAUMGARTEN,BIRKWOOD +       (SLAC+UCLA+UCI)
FELLER   78 PRL 40 274        +LITKE,MADARAS,RONAN+  (LBL+SLAC+NWES+HAWA)

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D^0

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                   32  NEUTRAL D(1863,JP=0-)  I=1/2
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                   32  NEUTRAL D MASS (MEV)

M   L  234(1865.)    (15.)           GOLDHABER 76 SMAG CHGD K PI AND K 3PI  1/77*
M          1863.      3.             GOLDHABER 77 SMAG    DO,D+ RECOIL SPC 12/77*
M    P     1863.3     0.9            PERUZZI   77 SMAG    E+E- 3.77GEV ECM 12/77*
M   L     (1868.)    (11.)           PICCOLO   77 SMAG +- E+E-4.03,4.41ECM  1/78*
M   L  VALUES WITH LARGE ERRORS NOT AVERAGED.
M    P ERROR DOES NOT INCLUDE 0.13 PERCENT UNCERTIANTY IN THE ABSOLUTE      3/78*
M    P SPEAR ENERGY CALIBRATION.  USES M(PSI)=3095 MEV.                     3/78*
M          . . . . . . . . . .
M   AVG    1863.28     0.86     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1863.28     0.93     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                   32  NEUTRAL D WIDTH FROM MASS SPECTRUM (MEV)

W       234   40.    OR LESS         GOLDHABER 76 SMAG CHGD K PI AND K 3PI  1/77*
W        30   2.0    OR LESS  CL=.90 FELDMAN   77 SMAG D*+ TO DO PI+        8/77*
W       WIDTHS ARE CONSISTENT WITH EXPERIMENTAL RESOLUTION. SEE NOTE ON     3/77*
W       WEAK DECAY IN CHARGED D SECTION ABOVE.                              3/77*

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                   32  NEUTRAL D PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      DO INTO K- PI+                                  493+ 139
P2      DO INTO K- PI+ PI+ PI-                          493+ 139+ 139+ 139
P3      DO INTO KO PI+ PI-                              497+ 139+ 139
P4      DO INTO KO PI+ PI- PI+ PI-                      497+ 139+ 139+ 139+
P5      DO INTO PI- PI+                                 139+ 139
P6      DO INTO K+ PI- (VIA DOBAR)                      493+ 139
P7      DO INTO K+ K-                                   493+ 493
P8      DO INTO K- PI+ PIO                              493+ 139+ 134
P9      DO INTO KO PIO                                  497+ 134
P10     DO INTO E+- ANYTHING                             .5+  .5
P19     DO INTO UNMEASURED MODES (1. - MEAS.MODES)

        DOBAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

```
         P 1         P 2         P 3         P 8        P19
 P 1 .0184+-.0049
 P 2   .3052  .0350+-.0092
 P 3   .2891      .0883  .0438+-.0111
 P 8  0.          0.          0.         .1200+-.0600
 P19  -.1741      -.1873      -.2128      -.9597  .7828+-.0625
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                   32  NEUTRAL D BRANCHING RATIOS

R1      DO INTO (K- PI+)/TOTAL                            (P1)
R1      130    0.022    0.006         PERUZZI   77 SMAG   E+E- 3.77GEV ECM 12/77*
R1          . . . . . . . . . .
R1   FIT       0.0184   0.0049 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      DO INTO (K- PI+ PI+ PI-)/TOTAL                    (P2)
R2       44    0.032    0.011         PERUZZI   77 SMAG   E+E- 3.77GEV ECM 12/77*
R2          . . . . . . . . . .
R2   FIT       0.0350   0.0092 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      DO INTO (KO PI+ PI-)/TOTAL                        (P3)
R3       28    0.040    0.013         PERUZZI   77 SMAG   E+E- 3.77GEV ECM 12/77*
R3          . . . . . . . . . .
R3   FIT       0.044    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4      DO INTO (K- PI+ PI+ PI-)/(K- PI+)                 (P2)/(P1)
R4    P 214    2.2      0.8           PICCOLO   77 SMAG   E+E-4.03,4.41ECM 12/77*
R4    P THIS CHANNEL DOMINATED BY K- PI+ RHOO (85+-15 PERCENT).            12/77*
R4    P K* PI+ PI- AND K- A2+ CONSISTENT WITH O, K* RHOO FRAC IS 0.1+-0.1 . 12/77*
R4          . . . . . . . . . .
R4   FIT       1.91     0.59   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      DO INTO (KO PI+ PI-)/(K- PI+)                     (P3)/(P1)
R5      116    2.8      1.0           PICCOLO   77 SMAG   E+E-4.03,4.41ECM 12/77*
R5          . . . . . . . . . .
R5   FIT       2.39     0.74   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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R6      DO INTC  (PI- PI+)/(K- PI+)                              (P5)/(P1)
R6              0.07  OR LESS  CL=.90   PICCOLO    77 SMAG    E+E- 4.03 GEVECM 12/77*

R7      DO INTO (K+ K-)/(K- PI+)                                 (P7)/(P1)
R7              0.07  OR LESS  CL=.90   PICCOLO    77 SMAG    E+E- 4.03GEV ECM 12/77*

R8      DO INTC (KO PI+ PI- PI+ PI-)/TOTAL                       (P4)
R8          POSSIBLY SEEN               KNAPP      76 SPEC    PHOTOPRODUCTION   3/77*

R9      DO INTO (K+ PI- VIA DOBAR)/(K PI)                        (P5)/(P1+P5)
R9       THIS IS THE DO-DOBAR MIXING LIMIT
R9              0.16  OR LESS  CL=.90   FELDMAN    77 SMAG    D*+ TO DO PI+     3/77*
R9              0.18  OR LESS  CL=.90   GOLDHABER  77 SMAG                     12/77*

R10     DO INTO (K- PI+ PIO)/TOTAL                               (P8)
R10       7     0.12       0.06         SCHARRE    78 SMAG    E+E- 3.77 GEV     1/78*
R10             . . . . . . . . .
R10 FIT         0.120      0.060  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11     DO INTO (KO PIO)/TOTAL                                   (P9)
R11             0.06  OR LESS  CL=.90   SCHARRE    78 SMAG    E+E- 3.77 GEV     1/78*

R12     DO INTO ALL UNMEASURED MODES / TOTAL                     (P19)
R12      THIS IS JUST 1.-(SUM OF ALL MEASURED MODES) FROM FIT
R12             . . . . . . . . .
R12 FIT         0.783      0.063  FROM FIT

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REFERENCES FOR NEUTRAL D


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GOLCHABE 76 PRL 37 255        GOLDHABER,PIERRE,ABRAMS,ALAM+      (LBL+SLAC)
KNAPP    76 BNL CONF.         B.KNAPP                                (COLU)
FELDMAN  77 PRL 38 1313       +PERUZZI,PICCOLO,ABRAMS,ALAM +     (SLAC+LBL)
GOLCHABE 77 PL 69B 503        GOLDHABER,WISS,ABRAMS,ALAM +       (LBL+SLAC)
PERUZZI  77 PRL 39 1301       +PICCOLO,FELDMAN+         (SLAC+LBL+NWES+HAWA)
PICCOLO  77 PL 70B 260        +PERUZZI,LUTH,NGUYEN,WISS,ABRAMS+(SLAC+LBL)
SCHARRE  78 PRL 40 74         +BARBARO-GALTIERI +       (SLAC+LBL+NWES+HAWA)
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QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

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NGUYEN   77 PRL 39 262        +WISS,ABRAMS,ALAM,BOYARSKI+       (LBL+SLAC)J
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$F^\pm(2030)$ and $F^{*\pm}(2140)$

The only published evidence for the existence of the charmed-strange F meson states comes from BRANDELIK 77. They observe events in e^+e^- collisions at 4.4 GeV each having a low energy photon, two other photons with a $\gamma\gamma$ mass in the η region, and a charged pion. They find four events with negligible background which fit the hypothesis $e^+e^- \rightarrow F\bar{F}^*$ or $e^+e^- \rightarrow F^*\bar{F}^*$, $F^* \rightarrow F\gamma$, $F \rightarrow \eta\pi$, and $\eta \rightarrow \gamma\gamma$ with consistent F and F^* masses. These data are entered into the Data Card Listings below and in the $F^{*\pm}(2140)$ section of the Meson Data Card Listings, but await confirmation before entry into the Tables.

$F^\pm$ →

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                  34  F+-(2030,JP= )

                  NEEDS CONFIRMATION.
                  OMITTED FROM TABLE.
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                  34  F+-(2030) MASS (MEV)

M        4 2030.     60.          BRANDELIK 77 DASP +- E+E- ECM=4GEV    12/77*
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                  34  F+-(2030) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      F+- INTO PI+- ETA                              139+ 548

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REFERENCES FOR F+-(2030)


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BRANDELI 77 PL 70B 132        BRANDELIK +       (AACH+DESY+HAMB+MPIM+TOKY)
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                  16  PROTON(938,J=1/2) I=1/2
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                  16  PROTON MASS (MEV)

M          (938.256)  (0.005)      COHEN     65 RVUE                   7/66
M          (938.2592) (0.0052)     TAYLOR    69 RVUE   USING NEW E/H   7/70
M           938.2796   0.0027      COHEN     73 RVUE                   3/74
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                  16  PROTON MEAN LIFE (UNITS 10**26 YR)

T           (.000001)OR MORE         GOLDHABE  54 TH 232 FISS.MODE INDEPEN
T             (0.002)OR MORE         FLEROV    57 TH 232 FISS.MODE INDEPEN
T    B         (1.5)  OR MORE        BACKENSTO 60 CNTR
T    B        (60.0)  OR MORE        KROPP     65 CNTR
T            (200.0)  OR MORE        GURR      67 CNTR DEP. ON DECAY MODE
T           (1300.0)  OR MORE        BERGAMASC 74 CNTR                    12/75
T     R      20000.0  OR MORE        REINES    74 CNTR                    12/75
T    B   KROPP AND BACKENSTOSS SENSITIVE TO PARTICULAR DECAY MODES OF PROTON
T     R  REINES 74 LOOKS AT DECAY CHAINS ENDING IN MUON DECAY.            12/75
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                  16  PROTON MAGNET. MOMENT(E/2MP)

MM         (2.79276) (.00002)        COHEN     65 RVUE
MM         (2.792782)(.000017)       TAYLOR    69 RVUE   USING NEW E/H   7/70
MM          2.7928456 .0000011       COHEN     73 RVUE                   3/74
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                  16  ANTIPROTON MAGNETIC MOMENT (E/2MP)

MM1 O       (-1.8)     (1.2)         BUTTON    62 CNTR
MM1 R       (-2.83)    (0.10)        FOX       72 CNTR                   11/75
MM1  R       -2.819     0.056        ROBERTS   74 CNTR                    7/75
MM1 O   OLD EXPERIMENT WITH LARGE ERROR.  NOT AVERAGED.
MM1  R  ROBERTS 74 IS REANALYSIS OF FOX 72 DATA.  REPLACES OLD FOX VALUE.  7/75
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                  16  PROTON ELECTRIC DIPOLE MOMENT (UNITS 10**-23 E CM)
            NONZERO VALUE IMPLIES VIOLATION OF T AND P IN EM INTERACTION

EDM     1G   700.       900.         HARRISON  69 MBR                    10/69
EDM        55000.    OR LESS         KHRIPLOVI 76                         1/78*

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REFERENCES FOR PROTON


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GOLDHABE 54 PR 96 1157 FNOTE2 GOLDHABER,F REINES+        (LOS ALAMOS,BNL)
FLEROV   57 SOV PHYS DOK 3 79 FLEROV,KLOCHKOV,SKOBKIN,TERENTEV       (USSR)
BACKENST 60 NC   16  749      BACKENSTOSS,FRAUENFELDER,HYAMS +       (CERN)
BUTTCN   62 PR 127 1297       J BUTTON,B MAGLIC                       (LBL)
COHEN    65 RMP 37 537        +DUMOND (N.AMER.AVIATION SCIENCE CENT.,CIT)
KROPP    65 PR 137 B 740      W R KROPP,F REINES   (CASE INST TECHNOLOGY)
GURR     67 PR  158  1321     GURR,KROPP,REINES,MEYER (CASE,JOHANNESBURG)

HARRISON 69 PRL   22  1263    HARRISON,SANDARS,WRIGHT  (CLARENDON OXFORD)
TAYLOR   69 RMP 41 375        +PARKER,LANGENBERG             (PRIN+UCI+PENN)
FOX      72 PRL 29 193        +BARNES,EISENSTEIN+(BNL+CARN+VPI+WILL+WYOM)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR

BERGAMAS 74 LNC 11 636        BERGAMASCO,PICCHI                 (TORI+FRAS)
REINES   74 PRL 32 493        +CROUCH                           (UCI+CASE)
ROBERTS  74 PRL 33 1181       +COX,ECKHAUSE+ (WILL+VPI+CARN+WYOM+CIT+BNL)
   ALSO  75 PR D12 1232       ROBERTS,COX +  (WILL+VPI+CARN+WYOM+CIT+BNL)
KHRIPLOV 76 JETP 44 25        I.B.KHRIPLOVICH     (NUC.PHYS.INST.,SIBERIA)
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QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

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KALOGERO 76 PRL 37 1037       KALOGEROPOULOS,CHIU,SUDARSHAN   (SYRA+TEXA)P
FRANKLIN 77 PR D16 910        JERROLD FRANKLIN                      (HAIF)P
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                  17  NEUTRON(939,J=1/2) I=1/2
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                  17  NEUTRON MASS (MEV)

M   T       (939.5527) (0.0052)      TAYLOR    69 RVUE   USING NEW E/H   7/70
M  T         939.5731   0.0027       COHEN     73 RVUE                   3/74
M  T    THESE DETERMINATIONS OF NEUTRON MASS NOT INDEPENDENT OF          7/70
M  T    NEUTRON-PROTON MASS DIFFERENCE MEASUREMENTS BELOW.               7/70
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                  17  (NEUTRON) - (PROTON) MASS DIFFERENCE (MEV)

D  M        (1.29344)(0.00007)       MATTAUCH  65 RVUE                   3/71
D            1.293429 0.000036       COHEN     73 RVUE                   3/74
D  M    WE HAVE CONVERTED MATTAUCH NEUTRON-HYDROGEN MASS DIFFERENCE TO   3/71
D  M    NEUTRON-PROTON MASS DIFFERENCE USING CURRENT VALUE OF ELECTRON MASS 3/71
D  M    AND A HYDROGEN BINDING ENERGY OF 13.6 EV.                        3/71
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                  17  NEUTRON MAGNETIC MOMENT (MAGNETONS,938.2 MEV)

MM      (-1.913148   0.000066)       COHEN     56 RVUE                   7/66
MM       -1.91304211 0.00000088      GREENE    77                        3/78*
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                  17  NEUTRON ELECTRIC DIPOLE MOMENT (UNITS 10**-23 E CM)
               TEST OF CP OR T VIOLATION IN THE EM INTERACTION

EDM M       (-20.)     (30.)         MILLER    67 MRS                    1/78*
EDM          +24.       39.          SHULL     67 CNTR                   1/78*
EDM   M      (30.)    OR LESS        DRESS     68 MRS  ABSOLUTE VALUE    1/78*
EDM           (5.)    OR LESS        BAIRD     69 MRS  INCLUDED IN DRESS73 10/69
EDM          - 2.       39.          APOSTOLES 70 MRS                    1/78*
EDM            0.32      0.75        DRESS     73 MRS  .LT.10**-23 CL=.80  6/73
EDM   D        0.04      0.15        DRESS     77 MRS                    6/77*
EDM   M  DRESS 68 INCLUDES DATA OF MILLER 67.                            1/78*
EDM   D  THE DRESS 77 RESULT IS EQUIV TO EDM < 3 E-24 (CL=.90)           6/77*
EDM           . . . . . . . . .
EDM AVG        0.05      0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
EDM STUDENT    0.05      0.16    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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Data Card Listings

For notation, see key at front of Listings.


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                    17  NEUTRON MEAN LIFE (UNITS 10**3 SEC)

          THE MEASUREMENT OF THE NEUTRON MEAN LIFE BY SOSNOVSKII 59 HAS
          BEEN DISCARDED SINCE 1.  IT DISAGREES WITH THE BETTER AND MORE
          RECENT RESULT OF CHRISTENSEN 67.  2.  THE VALUE OF GA/GV DE-
          RIVED FROM THE NEW VALUE OF THE MEAN LIFE AGREES WELL WITH THE
          GA/GV VALUE OBTAINED FROM THE FREE NEUTRON DATA.

T            (1.012)  (0.021)          SOSNOVSKI 59 PILE      SEE NOTE E        7/68
T            (0.935)  (0.014)          CHRISTENS 67 PILE REPL BY CHRISTENS72   3/68
T             0.918    0.014           CHRISTENS 72 PILE                        6/72
    E   ERROR CHANGED BECAUSE ERROR IN CROSS SECTION FOR NEUTRON ABSORPTION
    E   IN GOLD HAS BEEN REDUCED.

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                    17  NEUTRON BETA DECAY PARAMETERS

          RELATED TEXT SECTION VI D.1

AV        GA/GV  (SEE TEXT FOR SIGN CONVENTION)
AV  C       (-1.250)  (0.044)          CONFORTO  67 RVUE  SEE NOTE C BELOW
AV EP       (-1.23)   (0.01)           CHRISTENS 67 CNTR  N DECAY FT VALUE    11/68
AV  P       (-1.22)   (0.08)           GRIGOREV  68 CNTR E-NEU ANG CORREL     10/71
AV  P       (-1.26)   (0.02)           CHRISTENS 70 CNTR PE,NEUT SPIN CORREL 10/71
AV EP       (-1.27)   (0.025)          EROZOLIMS 71 CNTR PE,NEUT SPIN CORREL 10/71
AV EP       (-1.239)  (0.011)          CHRISTENS 72 CNTR    N DEC.+ FT VALUE  1/73
AV  P       (-1.263)  (0.016)          KROPF     73 RVUE    N DECAY ALONE     1/73
AV  P        -1.250    0.009           KROPF     73 RVUE    N DEC.+ FT VALUE  1/73
AV E         -1.250    0.036           DOBROZEMS 75 CNTR E-NEU ANG CORREL.    12/75
AV  K        -1.253    0.021           KROHN     75 CNTR PE,NEUT SPIN CORREL 1/77*
AV           -1.263    0.015           EROZOLIMS 77 CNTR PE,NEUT SPIN CORREL 1/78*
AV  C   CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPF 73.   1/73
AV E    THESE EXPERIMENTS MEASURE THE ABSOLUTE VALUE OF GA/GV ONLY            10/71
AV  P   KROPF 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972.             1/73
AV  K   KROHN 75 PAPER GIVES -1.258+-.015 INCLUDING EVENTS OF CHRISTENS 70.   1/78*
AV  K   THE VALUE QUOTED ABOVE IS DERIVED FROM HIS A,BASED ON NEW EXPT ONLY   1/77*
AV           . . . . . . . . .
AV  AVG      -1.2533   0.0071  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AV  STUDENT  -1.2532   0.0077  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

F         PHASE ANGLE OF GA RELATIVE TO GV  (DEGREES)
F   P       (175.)    (10.)           BURGY     60 CNTR    POLAR. NEUTRONS    6/77*
F   P       (198.)    (27.)           CLARK     60 CNTR    POLAR. NEUTRONS    6/77*
F   C       (176.1)   (6.4)           CONFORTO  67 RVUE                       11/68
F   P       (181.3)   (1.3)           EROZOLIMS 70 CNTR    POLAR. NEUTRON     10/69
F    P       181.1     1.3            KROPF     73 RVUE    N DECAY            1/73
F            180.35    0.43           EROZOLIMS 74 CNTR    POLAR. NEUTRONS    6/77*
F            180.14    0.22           STEINBERG 74 CNTR    POLAR. NEUTRONS    6/77*
F   C   CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPF 73.   1/73
F    P  KROPF 73 VALUE OBTAINED BY FITTING ALL DATA THROUGH 1972.             1/73
F           . . . . . . . . .
F   AVG      180.20    0.19    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F   STUDENT  180.20    0.21    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

D1        THREE-VECTOR CORRELATION COEFFICIENT                               7/76*
D1        D1 MEASURES COMPONENT OF NEUTRON SPIN PERPENDICULAR TO THE DECAY    7/76*
D1        PLANE IN BETA DECAY. SHOULD BE ZERO IF T-INVARIANCE NOT            7/76*
D1        VIOLATED.  SEE TEXT SEC VI D.                                      7/76*
D1             -0.01     .01          EROZOLIMS 70 CNTR    POLAR. NEUTRONS    7/76*
D1             -0.0027   .0033        EROZOLIMS 74 CNTR    POLAR. NEUTRONS    7/76*
D1             -0.0011   .0017        STEINBERG 74 CNTR    POLAR. NEUTRONS    7/76*
D1           . . . . . . . . .
D1  AVG      -0.0016   0.0015  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D1  STUDENT  -0.0016   0.0016  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                              REFERENCES FOR NEUTRON

COHEN     56 PR 104 283       V W COHEN, CORNGOLD, RAMSEY    (BNL+HARVARD)
SOSNOVSK  59 JETP  9  717     SOSNOVSKII,SPIVAK,PROKOFEV +    (IAE MOSCOW)
BURGY     60 PR 120 1829      +KROHN,NOVEY,RINGO                (ANL+CHIC)
CLARK     60 CJP 38 693       +ROBSON

MATTAUCH  65 NP 67 1          +THIELE,WAPSTRA      (MAX PLANCK INST.CHEM.)
CHRISTEN  67 PL 26B 11        CHRISTENSEN,NIELSON,BAHNSEN,BROWN+    (RISO)
CONFORTO  67 APAH 22 15       G. CONFORTO                           (CERN)
MILLER    67 PRL 19 381       +DRESS,BAIRD,RAMSEY                (ORNL+HARV)
SHULL     67 PRL 19 384       C.G.SHULL, R.NATHANS                (MIT+BNL)
DRESS     68 PR 170 1200      +BAIRD,MILLER,RAMSEY               (ORNL+HARV)
GRIGOREV  68 SJNP 6 239       +GRISHIN,VLADIMIRSKII,NIKOLAEVSKII + (ITEP)

BAIRD     69 PR  179  1285    +MILLER,DRESS,RAMSEY               (ORNL,HARV)
TAYLOR    69 RMP 41 375       +PARKER,LANGENBERG            (PRIN+UCI+PENN)
APOSTOLE  70 RRP 15 343       APOSTOLESCU,IONESCU,IONESCU-BUJOR +   (BUCH)
CHRISTEN  70 PR C1 1693       CHRISTENSEN,KROHN,RINGO                (ANL)
EROZOLIM  70 SJNP 11 583      EROZOLIMSKI,BONDARENKO,  +        (KURC MOSCOW)
    ALSO      PL 27B 557      EROZOLIMSKY,BONDARENKO  +  (KURC IN MOSCOW)

EROZOLIM  71 JETPL 13 252     EROZOLIMSKII,BONDARENKO +         (KURC MOSCOW)
CHRISTEN  72 PR D5 1628       CHRISTENSEN,NIELSON,BAHNSEN,BROWN+    (RISO)
COHEN     73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR
DRESS     73 PR D7 3147       DRESS,MILLER,RAMSEY                (ORNL+HARV)
KROPF     73 ZPHY TO BE PUBL.  A KROPF,H PAUL                       (LINZ)
    ALSO  70 NP A154 160      H PAUL                                (VIEN)

EROZOLIM  74 JETPL 20 345     EROZOLIMSKII,MOSTOVOI,FEDUNIN,FRANK+
STEINBER  74 PRL 33 41        STEINBERG,LIAUD,VIGNON,HUGHES    (YALE+GREN)
    ALSO  76 PR D13 2469      STEINBERG,LIAUD,VIGNON,HUGHES    (YALE+GREN)
DOBROZEM  75 PR D11 510       DOBROZEMSKY,KERSCHBAUM,MORAW,PAUL +   (SEIB)
KROHN     75 PL 58B 175       KROHN,RINGO                            (ANL)
DRESS     77 PR D15 9         +MILLER,PENDLEBURY,PERRIN+ (ORNL+GREN+HARV)
EROZOLIM  77 JETPL 23 663     EROZOLIMSKII,FRANK,MOSTOVOI+   (KURC MOSCOW)
GREENE    77 PL 71B 297       +RAMSEY,MAMPE+    (CENG+ILLG+SUSS+ORNL+CENG)

                              PAPERS NOT REFERRED TO IN DATA CARDS

JACKSON   57 PR 106 517       JACKSON,TREIMAN,WYLD              (PRINCETON)
COHEN     65 RMP 37 537       +DUMOND (N.AMER.AVIATION SCIENCE CENT.,CIT)
BHALLA    66 PL 19  691       C P BHALLA                           (ALABAMA)

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                    18  LAMBDA(1115,JP=1/2+)  I=0

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                    18  LAMBDA MASS (MEV)

M   N   SINCE OUR FINAL VALUES FOR THE SIGMA AND LAMBDA MASSES COME FROM
M   N   DOING AN OVERALL FIT TO ALL MEASURED MASSES AND MASS DIFFERENCES,
M   N   WE HAVE USED THE UNCORRELATED MEASUREMENTS FROM SCHMIDT 65 RATHER
M   N   THAN THE ONES COMING FROM THE OVERALL FIT REPORTED IN THAT PAPER.
M   N   SINCE THERE SEEMS TO BE NO CONVINCING ARGUMENT AS TO WHY ONE SHOULD
M   N   IGNORE DATA USING RANGE MEASUREMENTS, WE HAVE INCLUDED HERE VALUES
M   N   DEPENDING ON PROTON AND PION RANGES.  THE SCHMIDT 65 MASSES HAVE
M   N   BEEN REEVALUATED USING OUR APRIL 1973 PROTON AND CHARGED K AND PI
M   N   MASSES.  P. SCHMIDT, PRIVATE COMMUNICATION, (1974).

M         1115.44     0.12          BHOWMIK   63 RVUE +  SEE NOTE L BELOW
M   L   ABOVE LAMBDA MASS HAS BEEN RAISED 35 KEV TO ACCOUNT FOR 46 KEV
M   L   INCREASE IN PROTON MASS AND 11 KEV DECREASE IN CHARGED PION MASS.
M   S  635(1115.86)   (0.09)         BALTAY    65 HBC    ERROR IS STATIS.   6/66
M    488 1115.65      0.07          SCHMIDT   65 HBC   SEE NOTE N          3/74
M   S 1147(1115.74)   (0.04)         CHIEN     66 HBC      6.9 PBAR P       9/67
M   S  972(1115.69)   (0.05)         CHIEN     66 HBC      6.9 PBAR PANTIL  9/67
M        1115.6       0.4           LONDON    66 HBC                       6/66
M         (1116.0)    (0.2)         BADIER    67 HBC    2.4 PBAR P,LLBAR   8/67
M    195 1115.39      0.12          MAYEUR    67 EMUL                      11/67
M   B 1524(1115.52)   (0.03)         BOHM      70 EMUL                      3/72
M    935 1115.59      0.08          HYMAN     72 HEBC                      11/71
M   B   AVERAGE OF VERY INCONSISTENT DATA. ERROR STATISTICAL ONLY. AUTHORS   3/72
M   B   DETECT SYSTEMATIC EFFECT OF ABOUT .15 MEV, WHICH THEY ATTRIBUTE     3/72
M   B   TO ERROR IN RANGE-ENERGY RELATIONS. IN REGION BETA=0.6-0.7.         3/72
M   B   THIS EFFECT, IF CONFIRMED, WOULD AFFECT VERY LITTLE THE VALUES OF   3/72
M   B   BHOWMICK 63 AND MAYEUR 67.
M   S   ERROR PURELY STATISTICAL.
M         . . . . . . . . .
M   AVG      1115.566    0.056   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
M   STUDENT1115.568      0.053   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT      1115.600    0.048  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  2/78*
                        (SEE IDEOGRAM BELOW )
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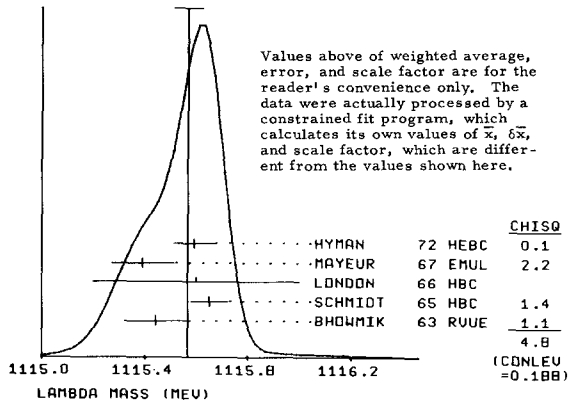


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                    18  LAMDA - ANTILAMBDA MASS DIFFERENCE (MEV)
DM           0.05     0.06          CHIEN     66 HBC      6.9 PBAR P       9/67
DM           0.29     0.15          BADIER    67 HBC    2.4 PBAR P         8/67
DM         . . . . . . . . .
DM  AVG      0.083    0.083   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
DM  STUDENT  0.080    0.063   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    18  LAMBDA MEAN LIFE (UNITS 10**-10)

T   O  188   (2.63)   (0.21)   (0.21) BOLDT     58 CC
T   O  825   (2.72)   (0.16)   (0.16) CRAWFORD  59 HBC
T   O  140   (2.72)   (0.29)   (0.27) BOWEN     60 CC
T   O  186   (2.60)   (0.28)   (0.20) CHANG     62 HBC
T   C  799   (2.69)   (0.11)   (0.11) HUMPHREY  62 HBC
T   O 2239   (2.36)   (0.06)   (0.06) BLOCK     63 HEBC
T   O  706   (2.76)   (0.20)          CHRETIEN  63 HLBC
T   O  794   (2.59)   (0.09)          HUBBARD   64 HBC
T   O 2260   (2.31)   (0.10)          KREISLER  64 OSPK
T   O 1378   (2.59)   (0.07)          SCHWARTZ  64 HBC
T   O  635   (2.51)   (0.16)          BALTAY    65 HBC                       6/66
T   O 2534   (2.6)    (0.1)           HILL      65 OSPK
T   O  916   (2.35)   (0.09)          BURAN     66 HLBC                      6/66
T   S 1147   (2.50)   (0.14)          CHIEN     66 HBC      6.9 PBAR P       9/67
T   S  972   (2.70)   (0.20)          CHIEN     66 HBC      6.9 PBAR P,ANTI  9/67
T   O 2213   (2.452)  (0.056)  (0.054)ENGELMANN 66 HBC                      9/66
T   O  585   (2.68)   (0.13)   (0.11) AVERBACH  67 OSPK                     8/67
T   O        (2.44)   (0.15)          BADIER    67 HBC    2.4 PBAR P       6/68
T   O        (2.55)   (0.15)          BADIER    67 HBC    2.4 PBAR P,ANTIL 6/68
T   O 8342   (2.535)  (0.035)         GRIMM     68 HBC                     6/68
T   O 2600   (2.47)   (0.08)          HEPP      68 HBC                     8/68
T   O 1059   (2.39)   (0.10)          DEMIDOV   70 HLBC PI-P, 3.86 GEV/C   12/70
T   O 4572   (2.54)   (0.04)          BALTAY    71 HBC    K-P AT REST      6/71
T   O 6582   (2.69)   (0.05)          ALTHOFF2  73 OSPK   PI+N TO K+LAMBDA 2/74
T        36K   2.626    0.020         POULARD   73 HBC    K-P,KMOM .4TO2.3 9/73
T        34K   2.611    0.020         CLAYTON   75 HBC    K-P,KMOM .96-1.4 1/77*
T        53K   2.69     0.03          ZECH      77 SPEC NEUTRAL HYP. BEAM  12/77*
T   O   OLD LOWER STATISTICS EXPERIMENTS NOT INCLUDED IN AVERAGE.            1/78*
T   S   ERROR PURELY STATISTICAL.
T         . . . . . . . . .
T   AVG      2.632    0.020    0.020  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.6)
T   STUDENT  2.630    0.015    0.015  AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
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Stable Particles

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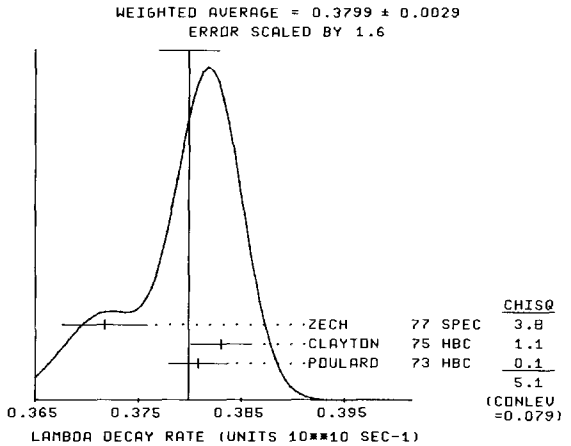

18 (LAMBDA - ANTILAMBDA)/AVG., MEAN LIFE DIFFERENCE

DT		0.044	0.085	BADIER	67 HBC	2.4 PEAR P		8/67

18 LAMBDA MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM		-1.5	0.5	COOL	62 OSPK			
MM		0.0	0.6	KERNAN	63 CC			
MM	8553	-1.39	0.72	ANDERSON	64 HBC			
MM	151	-0.5	0.28	CHARRIERE	65 EMUL			
MM	49	(-0.67)	(0.31) (0.37)	BARKOV	71 EMUL	PRELIM. RESULT		2/72
MM	1300	-0.66	0.07	DAHLJENSE	71 EMUL	MAG FIELD=200KG		6/71
MM	3868	-0.73	0.18	HILL	71 OSPK			10/71
MM	57	-0.65	0.28	BARKOV	72 EMUL	INCLUDES BARKOV 71		3/78*
MM	1.2M	-0.57	0.05	BUNCE	76 SPEC			1/78*
MM	350K	-0.59	0.07	HELLER	77 SPEC			1/78*
MM								
MM	AVG	-0.606	0.034	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
MM	STUDENT	-0.605	0.038	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

18 LAMBDA ELECTRIC DIPOLE MOMENT (UNITS 10**-14 E CM)
NONZERO VALUE IMPLIES VIOLATION OF T AND P

EDM		5.0	OR LESS CL=.95	GIBSON	66 EMUL			2/72
EDM	B	1.0	OR LESS CL=.95	BARONI	71 EMUL			2/72
EDM	B	BARONI MEASURES (-5.9+-2.9)*10**-15 E CM						2/72

18 LAMBDA PARTIAL DECAY MODES

		DECAY MASSES		
P1	LAMBDA INTO PROTON PI-	938+ 139		
P2	LAMBDA INTO NEUTRON PIO	939+ 134		
P3	LAMBDA INTO PROTON MU- NEUTRINO	938+ 105+	0	
P4	LAMBDA INTO PROTON E- NEUTRINO	938+ .5+	0	
P5	LAMBDA INTO PROTON PI- GAMMA	938+ 139+	0	

18 LAMBDA BRANCHING RATIOS

R1	LAMBDA INTO (P PI-)/((P PI-)+(N PIO))				(P1)/(P1+P2)			
R1		0.627	0.031	CRAWFORD	59 HBC			
R1		0.65	0.05	COLUMBIA	60 HBC			
R1	U	(0.685)	(0.017)	ANDERSON	62 HBC			
R1	903	0.643	0.016	HUMPHREY	62 HBC			
R1	U 6736	0.635	0.007	DOYLE	69 HBC	PI-P TO LAM. KO		2/71
R1	4572	0.646	0.008	BALTAY	71 HBC	K-P AT REST		6/71
R1	U ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE.							2/71
R1								
R1	AVG	0.6399	0.0049	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R1	STUDENT	0.6398	0.0055	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R1	FIT	0.6419	0.0049	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R2	LAMBDA INTO (N PIO)/((P PI-)+(N PIO))				(P2)/(P1+P2)			
R2		0.23	0.09	EISLER	57 HLBC			
R2		0.43	0.14	CRAWFORD	59 HBC			
R2		0.28	0.08	BAGLIN	60 HLBC			
R2		0.35	0.05	BROWN	63 HLBC			
R2	75	0.291	0.034	CHRETIEN	63 HLBC			
R2								
R2	AVG	0.304	0.025	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R2	STUDENT	0.306	0.028	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R2	FIT	0.3581	0.0049	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R3	LAMBDA INTO (P E- NEU)/TOTAL (UNITS 10**-3)				(P4)/(P1+P2)			
R3	O 15	(2.0)	(0.5)	HUMPHREY	61 RVUE			
R3	O 8	(2.9)	(1.5) (1.2)	AUBERT	62 FBC			
R3	N 150	(0.82)	(0.12)	ELY	63 FBC	K- AT REST		
R3	N 102	(0.78)	(0.12) (0.13)	BAGLIN	64 FBC	K- AT 1.45 GEV/C		
R3	O 20	(1.55)	(0.34)	LIND	64 HBC			
R3	N 143	(0.80)	(0.08)	MALONEY	69 HBC			10/69
R3	N 86	(0.78)	(0.09)	CANTER	71 HBC	K-P AT REST		4/71
R3	N 218	(0.88)	(0.10)	LINDQUIST	71 OSPK	PI- P TO K0 LAM		2/72
R3	N THESE VALUES HAVE BEEN CHANGED BY US INTO RATIOS TO PROTON PI-.							3/72
R3	N BECAUSE THAT IS THE DIRECTLY MEASURED QUANTITY. SEE R5 BELOW							3/72
R3	O LOW STATISTICS EXPERIMENTS. NOT AVERAGED							7/70
R4	LAMBDA INTO (P MU- NEU)/TOTAL (UNITS 10**-4)				(P3)/(P1+P2)			
R4	1	(0.2) OR MORE		GOOD	62 HBC			
R4	1	(1.0) OR LESS		ALSTON	63 HBC			
R4	2	(1.0) OR LESS		KERNAN	64 FBC			
R4	BETWEEN 1.3 AND 6.0			LIND	64 HBC			
R4	3	1.3	0.7	LIND	64 RVUE			7/66
R4	2	1.5	1.2	RONNE	64 FBC			
R4	9	2.4	0.8	CANTER1	71 HBC	STOPPED K-P		7/71
R4	14	1.4	0.5	BAGGETT2	72 HBC	STOP K-		8/72
R4								
R4	AVG	1.57	0.35	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R4	STUDENT	1.56	0.38	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R5	LAMBDA INTO (P E- NEU)/(P PI-) (UNITS 10**-3)				(P4)/(P1)			
R5	150	1.23	0.20	ELY	63 FBC			2/72
R5	120	1.17	0.18	BAGLIN	64 FBC			2/72
R5	143	1.20	0.12	MALONEY	69 HBC			2/72
R5	1078	1.31	0.06	ALTHOFF1	71 OSPK			2/72
R5	C 86	1.17	0.13	CANTER	71 HBC	K-P AT REST		3/72
R5	LC 218	(1.32)	(0.15)	LINDQUIST	71 OSPK	PI-P TO K0 LAM		3/72
R5	L 544	1.23	0.11	LINDQUIST	77 SPEC	PI-P TO K0 LAM		12/77*
R5	C CALCULATED BY US FROM R3 ASSUMING THE AUTHORS USED (P PI-)/TOT=2/3							3/72
R5	L LINDQUIST 77 INCLUDES DATA OF LINDQUIST 71.							12/77*
R5								
R5	AVG	1.257	0.043	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R5	STUDENT	1.256	0.048	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R6	LAMBDA INTO (P PI- GAMMA)/(P PI-) (UNITS 10**-3) (P5)/(P1)							1/73
R6	72	1.32	0.22	BAGGETT3	72 HBC	PI- MOM LT 95 MEV/C		1/73

18 LAMBDA DECAY PARAMETERS

RELATED TEXT SECTION VI D AND APPENDIX III

A-	ALPHA LAMBDA- (LAMBDA INTO PI- PROTON)							
A-	1156	0.62	0.07	CRONIN	63 CNTR	LAMBDA FROM PI-P		8/67
A-		(0.663)	(0.022)	BERGE	66 RVUE	INCLUDES ABOVE		9/66
A-	10130	0.645	0.017	OVERSETH	67 OSPK	LAMBDA FROM PI-P		8/67
A-	M 2529	(0.747)	(0.086)	MERRILL	68 HBC	REPL BY DAUBER 68		6/68
A-	3520	0.67	0.06	DAUBER	69 HBC	FROM XI DECAY		6/68
A-	10325	0.649	0.023	CLELAND	72 OSPK	LAMBDA FROM PI-P		5/72
A-	8500	0.584	0.046	ASTBURY	75 SPEC	LAMBDA FROM PI-P		2/78*
A-								
A-	AVG	0.642	0.013	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
A-	STUDENT	0.642	0.014	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
A0	ALPHAO /ALPHA- FOR LAMBDA (L INTO PIO N/L INTO PI- P)							
A0		1.10	0.27	CORK	60 CNTR			
A0	O 4760	1.000	0.068	OLSEN	70 OSPK	PI*N TO K+ LAMBDA		5/70
A0								
A0	AVG	1.006	0.066	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
A0	STUDENT	1.006	0.071	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
A0	O DONE BY COMPARING PROTON DISTR.WITH N DISTR. FROM LAMBDA DECAY.							
F-	PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)							
F-	1156	13.0	17.0	CRONIN	63 OSPK	LAMBDA FROM PI-P		11/67
F-	10130	-8.0	6.0	OVERSETH	67 OSPK	LAMBDA FROM PI-P		11/67
F-	7377	(-9.2)	(5.2)	CLELAND	67 OSPK	REPL BY CLELAND 72		5/72
F-	10325	-7.0	4.5	CLELAND	72 OSPK	LAMBDA FROM PI-P		5/72
F-								
F-	AVG	-6.5	3.5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
F-	STUDENT	-6.6	3.8	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
AV	GA/GV FOR LAMBDA BETA DECAY (SEE TEXT SEC. VI D.1 FOR SIGN CONV.)							
AV	C 22	(-1.03)		LIND	64 HBC			6/68
AV	C 102	(0.6) OR MORE		BAGLIN	65 HLBC	NO SIGN GIVEN		1/71
AV	C BETW 0. AND -1.1			BARLOW	65 OSPK			6/68
AV	C 102	(0.7) OR MORE CL=.95		ELY	65 HLBC	ABS. VALUE		1/71
AV	C EXPERIMENTS INCLUDED IN CONFORTO 65, RVUE							6/68
AV		-1.14	0.23 0.33	CONFORTO	65 RVUE			11/67
AV	M 148	-0.72	0.14 0.19	MALONEY	69 HBC			10/69
AV	A 1078	(-0.62)	(0.08) (0.09)	ALTHOFF2	71 OSPK	POLARIZED LAMBDA		7/73
AV	M 141	-0.75	0.15 0.18	CANTER	71 HBC			4/71
AV	L 173	(-0.40)	(0.13) (0.17)	LINDQUIST	71 OSPK	E-NEU AND UP-DOWN		9/71
AV	M 352	-0.74	0.09 0.12	BAGGETT1	72 HBC	STOP.K-		2/72
AV	A 817	-0.63	0.06	ALTHOFF1	73 OSPK	POLARIZED LAMBDA		7/73
AV	405	-0.47	0.09	BURNETT	76 SPEC	E-NEU AND SPIN		2/78*
AV	L 441	-0.53	0.09 0.11	LINDQUIST	77 SPEC	POL LAMBDA, 3 ASYMM		12/77*
AV	A ALTHOFF1 73 INCLUDES DATA OF ALTHOFF2 71. USES PROT SPECTRUM AND							7/73
AV	A THREE SPIN ASYMMETRIES.							7/73
AV	M EXPT MEASURES ONLY THE ABSOLUTE VALUE OF A/V							7/73
AV	L LINDQUIST 77 INCLUDES DATA OF LINDQUIST 71.							12/77*
AV								
AV	AVG	-0.622	0.048	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)				
AV	STUDENT	-0.624	0.045	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT (SEE IDEOGRAM BELOW)				

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REFERENCES FOR LAMBDA

EISLER 57 NC 5 1700 — EISLER,PLANO,SAMIOS,SCHWARTZ + (COLU+BNL)
BOLDT 58 PRL 1 148 — E BOLDT,D O CALDWELL,Y PAL (MIT)
CRAWFORD 59 PRL 2 266 — CRAWFORD,CRESTI,DOUGLASS,GOOD + (LRL)

BAGLIN 60 NC 18 1043 — BAGLIN,BLOCH,BRISSON,HENNESSY + (EPOL)
BOWEN 60 PR 119 2030 — BOWEN,HARDY,REYNOLDS,SUN + (PRINCETON)
CORK 60 PR 120 1000 — CORK,KERTH,WENZEL,CRONIN+ (LRL+PRIN+BNL)
COLUMBIA 60 ROCH CONF 726 — M SCHWARTZ + (COLUMBIA)
HUMPHREY 61 PRL 6 478 — HUMPHREY,KIRZ,ROSENFELD,RHEE + (LRL+SYRA)

ANDERSON 62 CERN CONF 832 — ANDERSON,CRAWFORD,GOLDEN,LLOYD + (LRL)
AUBERT 62 NC 25 479 — AUBERT,BRISSON,HENNESSY,SIX + (EPOL)
CHANG 62 THESIS DUKE — CHUEN CHUEN CHANG (DUKE)
COOL 62 PR 127 2223 — COOL,HILL,MARSHALL + (BNL+MIT+NYU+ANL)
GOOD 62 PRL 9 518 — M L GOOD,V G LIND (WISCONSIN)
HUMPHREY 62 PR 127 1305 — W E HUMPHREY,R R ROSS (LRL)

ALSTON 63 UCRL 10926 — ALSTON,KIRZ,NEUFELD,SOLMITZ,WOHLMUT (LRL)
BHOWMIK 63 NC 28 1494 — B BHOWMIK,D P GOYAL (DELHI)
BLOCK 63 PR 130 766 — BLOCK,GESSAROLI,RATTI+(NWES+BGNA+SYRA+ORNL)
BROWN 63 PR 130 769 — BROWN,KADYK,TRILLING,ROE + (LRL+MICH)
CHRETIEN 63 PR 131 2208 — CHRETIEN,CROUCH+ (BRAN+BROWN+HARVARD+MIT)
CRONIN 63 PR 129 1795 — J W CRONIN,O E OVERSETH (PRINCETON)
ELY 63 PR 131 868 — ELY,GIDAL,KALMUS,OSWALD,POWELL + (LRL)
KERNAN 63 PR 129 870 — KERNAN,NOVEY,WARSHAW,WATTENBERG (ANL+ILL)

ANDERSON 64 PRL 13 167 — J A ANDERSON,F S CRAWFORD (LRL)
BAGLIN 64 NC 35 977 — BAGLIN,BINGHAM+ (EPOL+CERN+LOUC+RHEL+BERG)
HUBBARD 64 PR 135 B 183 — HUBBARD,BERGE,KALBFLEISCH,SHAFER + (LRL)
KERNAN 64 PR 133 B 1271 — KERNAN,POWELL,SANDLER + (LRL+LOUC)
KREISLER 64 PR 136 B 1074 — M N KREISLER,O OVERSETH,J CRONIN (PRIN)
LIND 64 PR 135 B 1483 — LIND,BINFORD,GOOD,STERN (WISCONSIN)
RONNE 64 PL 11 357 — PONNE+ (CERN+EPOL+LOUC++UNIV.BERGEN)
SCHWARTZ 64 UCRL 11360 THESIS — JOSEPH ADAM SCHWARTZ (LRL)

BAGLIN 65 NC 35 977 — BAGLIN + (EPOL,CERN,LOUC,RHEL,BERGEN)
BALTAY 65 PR 140 B 1027 — BALTAY,SANDWEISS,CULWICK,KOPP + (YALE+BNL)
BARLOW 65 PL 18 64 — J BARLOW,BLAIR,CONFORTO+ (CERN+RHEL+PENN)
CHARRIER 65 PL 15 66 — CHARRIERE,GIBSON+ (EPOL+BRIS+CERN+MPIM)
ALSO 66 NC 46A 205 — CHARRIERE,GIBSON + (EPOL,BRIS,CERN,MPIM)
CONFORTO 65 EC INT HERZEGNOVI — G CONFORTO (CERN)
ELY 65 PR 137 B1302 — ELY,GIDAL,KALMUS,POWELL + (LRL,LOUC)
HILL 65 PRL 15 85 — HILL,LI,JENKINS,KYCIA,RUDERMAN (MIT,BNL)
SCHMIDT 65 PR 140 B 1328 — P SCHMIDT (COLUMBIA)

BERGE 66 BERKELEY 46 — BERGE,CABIBBO ((RVUE) LRL,CERN)
BURAN 66 PL 20 318 — BURAN,EIVINDSON,SKJEGGESTAD,TOFTE + (OSLO)
CHIEN 66 PR 152 1171 — +LACH,SANDWEISS,TAFT,YEH,OREN + (YALE+BNL)
ENGELMAN 66 NC 45A 1038 — ENGELMANN,FILTHUTH,ALEXANDER+ (HEID,REHO)
GIBSON 66 NC 45A 882 — W M GIBSON,K GREEN (BRIS)
LONDON 66 PR 143 1034 — LONDON,RAU,GOLDBERG,LICHTMAN+ (BNL,SYRA)

AUERBACH 67 NC 47A 19 — AUERBACH,BOWEN,DOBBS,LANDE,MANN+ (PENN)
BADIER 67 PL 25B 152 — +BONNET,BRIANDET,SADOULET (EPOL)
CLELAND 67 PL 26B 45 — CLELAND,BIENLEIN,CONFORTO+ (CERN+GEVA+LUND)
MAYEUR 67 U.LIBR.BRUX.BUL32 — C.MAYEUR,E.TOMPA,J.WICKENS (BELG,LOUC)
OVERSETH 67 PRL 19 391 — O E OVERSETH, R F ROTH (MICH+PRIN)
GRIMM 68 NC 54A 187 — H.-J.GRIMM (HEIDELBERG)
HEPP 68 ZPHYS 214 71 — V.HEPP,H. SCHLEICH (HEIDELBERG)
MERRILL 68 PR 167 1202 — MERRILL,SHAFER (LRL)

DAUBER 69 PR 179 1262 — +BERGE,HUBBARD,MERRILL,MILLER (LRL)
DOYLE 69 UCRL 18139-THESIS — J.C. DOYLE (LRL)
MALONEY 69 PRL 23 425 — MALONEY,SECHI-ZORN (UNIV MARYLAND)
BOHM 70 NC 70A 384 — + KRECKER + (BERL+BRUX+DUUC+LOUC+LOWC+WARS)
DEMIDOV 70 SJNP 10 681 — +KIRILLOV-UGRYUMOV,PONOSOV,PROTASOV+ (ITEP)
OLSEN 70 PRL 24 843 — +PONDROM,HANDLER,LIMON,SMITH + (WISC,MICH)

ALTHOFF1 71 PL 37B 531 — +BROWN,FREYTAG,HEARD,HEINTZE + (CERN,HEID)
ALTHOFF2 71 PL 37B 535 — +BROWN,FREYTAG,HEARD,HEINTZE + (CERN,HEID)
BALTAY 71 PR D4 670 — +BRIDGEWATER,COOPER,HABIBI+ (COLU+BING)
BARKOV 71 JETPL 14 60 — +GUREVICH,MAKARINA,MARTEMYANOV+ (ITEP)
BARONI 71 LNC 2 1256 — G BARONI,S PETRERA,G ROMANO (ROMA)
CANTER 71 PRL 26 868 — +COLE,LEE-FRANZINI,LOVELESS + (STON+COLU)

CANTER1 71 PRL 27 59 — +COLE,LEE-FRANZINI,LOVELESS+ (STON+COLU)
DAHLJENS 71 NC 3A 1 — DAHL-JENSEN + (CERN+ANKA+LAUS+MPIM+ROMA)
HILL 71 PR D4 1979 — +LI,JENKINS,KYCIA,RUDERMAN (MIT,BNL)
ALSO 65 PRL 15 85 — HILL,LI,JENKINS,KYCIA,RUDERMAN (MIT,BNL)
LINDQUIS 71 PRL 27 612 — LINDQUIST,SUMNER+ (EFI,WUSL,OSU,ANL)

BAGGETT1 72 ZPHY 249 279 — +BAGGETT,EISELE,FILTHUTH,FREHSE+ (HEID)
BAGGETT2 72 ZPHY 252 362 — +BAGGETT,EISELE,FILTHUTH,FREHSE+ (HEID)
BAGGETT3 72 PL 42B 379 — +BAGGETT,EISELE,FILTHUTH,FREHSE,HEPP+(HEID)
BARKOV 72 JETPL 16 104 — +GUREVICH,MAKARINA,MARTEMYANOV + (ITEP)
CLELAND 72 NP B40 221 — +CONFORTO,EATON,GERBER+ (CERN+GEVA+LUND)
HYMAN 72 PR D5 1063 — +BUNNELL,DERRICK,FIELDS,KATZ+ (ANL+CARN)

ALTHOFF1 73 PL 43B 237 — +BROWN,FREYTAG,HEARD,HEINTZE+ (CERN+HEID)
ALTHOFF2 73 NP B66 29 — +BROWN,FREYTAG,HEARD,HEINTZE+ (CERN+HEID)
POULARD 73 PL 46B 135 — +GIVERNAUD,BORG (SACL)

ASTBURY 75 NP B99 30 — +GALLIVAN,JAFAR + (LOIC+CERN+ETHZ+SACL)
CLAYTON 75 NP B95 130 — +BACON,BUTTERWORTH,WATERS + (LOIC+RHEL)
BUNCE 76 PRL 36 1113 — +HANDLER,MARCH,MARTIN + (WISC+MICH+RUTG)
BURNETT 76 NC 34A 14 — +INNES,MASEK,MAUNG,MILLER,RUDERMAN+ (UCSC)
HELLER 77 PL 68B 480 — +OVERSETH,BUNCE,DYDAK + (MICH+WISC+HEID)
LINDQUIS 77 PR D16 2104 — LINDQUIST,SWALLOW,SUMNER + (EFI+OSU+ANL)
ALSO 76 JPG 2 L211 — LINDQUIST,SWALLOW,SUMNER+(EFI+WUSL+OSU+ANL)
ZECH 77 NP B124 413 — +DYDAK,NAVARRIA+ (SIEG+CERN+DORT+HEID)

PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 62 CERN CONF 236 — ARMENTEROS+ (CERN+EPOL+LOIC+BIRM+CEN-SACLAY)
BALTAY 62 CERN CONF 233 — BALTAY,FOWLER,SANDWEISS,CULWICK+ (YALE+BNL)
BERGE 63 THESIS (BERKELEY) — J PETER BERGE (LRL)

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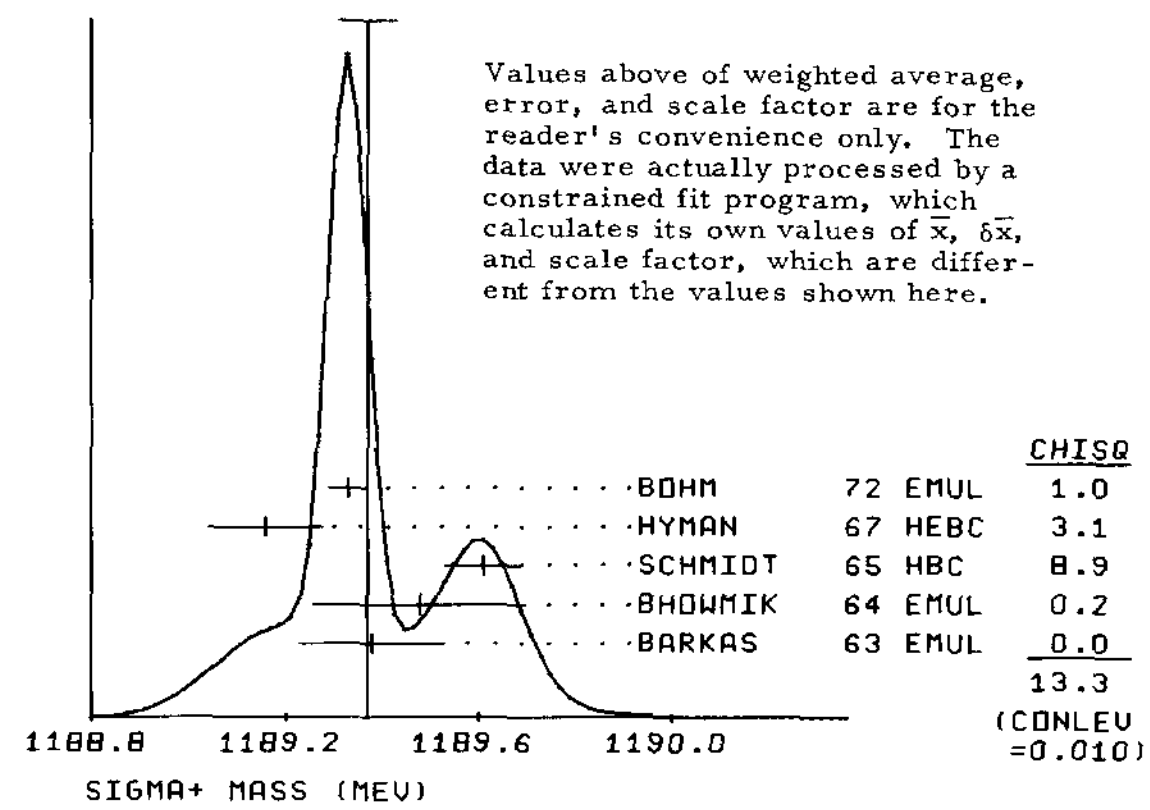
19 SIGMA+(1189,JP=1/2+) I=1

19 SIGMA+ MASS (MEV)

M N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M	144 1189.38	0.15	BARKAS	63 EMUL	+ SEE NOTE S BELOW	
M	58 1189.48	0.22	BHOWMIK	64 EMUL	+ SEE NOTE S BELOW	
M	S ABOVE SIGMA+ MASSES HAVE BEEN RAISED 30 KEV TO ACCOUNT FOR 46 KEV					
M	S INCREASE IN PROTON MASS AND 21 KEV DECREASE IN PION MASS					
M	4205 1189.61	0.08	SCHMIDT	65 HBC	SEE NOTE N	3/74
M	1189.16	0.12	HYMAN	67 HEBC		6/68
M	B 607 1189.33	0.04	BOHM	72 EMUL		12/73
M	B BOHM 72 UPDATED WITH PDG APR. 73 K-, PI- AND PIO MASSES.					12/73
M	. . . .					
M	AVG 1189.371	0.060	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)			
M	STUDENT 1189.354	0.041	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			
M	FIT 1189.366	0.057	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8) (SEE IDEOGRAM BELOW)			2/78*

WEIGHTED AVERAGE = 1189.371 ± 0.060
ERROR SCALED BY 1.8



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

19 SIGMA+ MEAN LIFE (UNITS 10**-10)

T					GLASER	58 RVUE			
T	127	0.98	0.16	0.12	PUSCHEL	60 EMUL			
T	41	0.82	0.34	0.20	EVANS	60 EMUL			
T	117	0.85	0.14	0.11	FREDEN	60 EMUL			
T	54	0.80	0.10	0.067	KAPLON	60 EMUL			
T	23	0.76	0.22	0.14	CHIESA	61 EMUL			
T	49	0.75	0.13	0.09	BERTHELOT	61 HLBC			
T	140	0.82	0.10	0.08	BARKAS	61 EMUL			
T	192	0.749	0.056	0.052	GRARD	62 HBC			
T	456	0.765	0.04	0.04	HUMPHREY	62 HBC			
T	203	0.84	0.12	0.08	BHOWMIK	64 EMUL			
T	181	0.84	0.09		BALTAY	65 HBC			6/66
T	900	0.76	0.03		CARAYAN	65 HBC			6/66
T	C 1300	0.83	0.032		CHANG	66 HBC			6/66
T	S 125	(0.86)	(0.15)		CHIEN	66 HBC	+	6.9 PBAR P	9/67
T	S 117	(1.10)	(0.24)		CHIEN	66 HBC	-	6.9 PBAR P,ANTI	9/67
T	381	0.80	0.07		COOK	66 OSPK			7/66
T	10664	0.803	0.008		BARLOUTAU	69 HBC		K-P .4-1.2 GEV/C	11/69
T	20K	0.795	0.010		EISELE	70 HBC		K-P AT REST	2/71
T	526	0.83	0.04		BAKKER	71 DBC	-	K-N TO SIG+ 2PI-	10/71
T	5719	0.807	0.013		CONFORTO	76 HBC		K-P 1-1.4 GEV/C	11/77*
T	C CHANG ERROR 0.018 RAISED BY US. SEE 1970 EDITION, RMP 42,123(1970)								1/73
T	S ERROR PURELY STATISTICAL								
T	. . . .								
T	AVG	0.8015	0.0053	0.0052	AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)				
T	STUDENT	0.8015	0.0058	0.0057	AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT				

19 SIGMA+ MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM	381	1.5	1.1	COOK	66 OSPK		7/66
MM	52	3.5	1.5	KOTELCHUC	67 EMUL	K-P AT 1.15BEV/C	8/67
MM	51	3.0	1.2	SULLIVAN	67 EMUL	PHOTOPRODUCTION	8/67
MM	69	3.5	1.2	COMBE	68 EMUL		10/68
MM	29333	2.1	1.0	MAST	68 HBC	K-P AT .4 GEV/C	6/68
MM	955	2.67	0.97	ALLEY	71 OSPK	1.28 GEV/C PI+P	10/70
MM	2651	2.7	0.9	SAHA	73 HLBC	K-P.25TO.55GEV/C	6/73
MM	8503	2.95	0.31	DOBLE	77 HBC	K-P .46 GEV/C	12/77*
MM	. . . .						
MM	AVG	2.83	0.25	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
MM	STUDENT	2.84	0.27	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

19 SIGMA+ PARTIAL DECAY MODES

		DECAY MASSES
P1	SIGMA+ INTO PROTON PIO	938+ 134
P2	SIGMA+ INTO NEUTRON PI+	939+ 139
P3	SIGMA+ INTO NEUTRON PI+ GAMMA	939+ 139+ 0
P4	SIGMA+ INTO LAMBDA E+ NEU	1115+ .5+ 0
P5	SIGMA+ INTO PROTON GAMMA	938+ 0
P6	SIGMA+ INTO NEUTRON MU+ NEUTRINO	939+ 105+ 0
P7	SIGMA+ INTO NEUTRON E+ NEUTRINO	939+ .5+ 0
P8	SIGMA+ INTO PROTON E+ E-	938+ .5+ .5

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                    19  SIGMA+ BRANCHING RATIOS

R1      SIGMA+ INTO (NEUTRON PI+)/(NUCLEON PI)              (P2)/(P1+P2)
R1      308     0.490     0.024          HUMPHREY  62 HBC
R1      534     0.46      0.02           CHANG     66 HBC                        6/66
R1     1331     0.488     0.010          BARLOUTAU 69 HBC     K-P .4-1.2 GEV/C 11/69
R1      537     0.484     0.015          TOVEE     71 EMUL                      12/71
R1           . . . . . . . . . .
R1   AVG        0.4835    0.0073   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   STUDENT    0.4838    0.0081   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2      SIGMA+ INTO (NEUT PI+ GAM)/(PI+N) (UNITS 10**-3) (P3)/P2)
R2             (1.8)      ABOUT          BAZIN2    65 HBC     PI+ LT 116 MEV/C  8/67
R2       29     0.27      0.05           ANG       69 HBC     PI+ LT 110 MEV/C 11/68
R2      180     0.93      0.10           EBENHOH   73 HBC     PI+ LT 150 MEV/C  3/74

R3      SIGMA+ INTO (LAMBCA E+ NEU)/TOTAL (UNITS 10**-5) (P4)
R3   W    4    (3.3)      (1.7)          WILLIS    64 HBC     STOP. K-           9/66
R3   W                    EVENTS FROM THIS EXPERIMENT,INCLUDED IN EISELE1 69    11/69
R3        6     2.0       0.8            BARASH    67 HBC     STOP K-            8/67
R3        5     1.6       0.7            BALTAY    69 HBC     STOP K-           11/69
R3       10     2.9       1.0            EISELE1   69 HBC     STOP K-           10/69
R3           . . . . . . . . . .
R3   AVG        2.02      0.47     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3   STUDENT    2.01      0.52     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R4      SIGMA+ INTO (P GAMMA)/(P PIO) (UNITS 10**-2)      (P5)/(P1)
R4        1    (0.068)OR LESS            CARRARA   64 HBC
R4       24     0.37      0.08           BAZIN     65 HBC
R4        4    (0.17)                    QUARENI   65 EMUL                       6/66
R4       45     0.21      0.03           ANG       69 HBC     STOP K-           10/69
R4       31     0.276     0.051          GERSHWIN  69 HBC                       10/69
R4           . . . . . . . . . .
R4   AVG        0.240     0.035    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R4   STUDENT    0.239     0.030    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                          (SEE IDEOGRAM BELOW )
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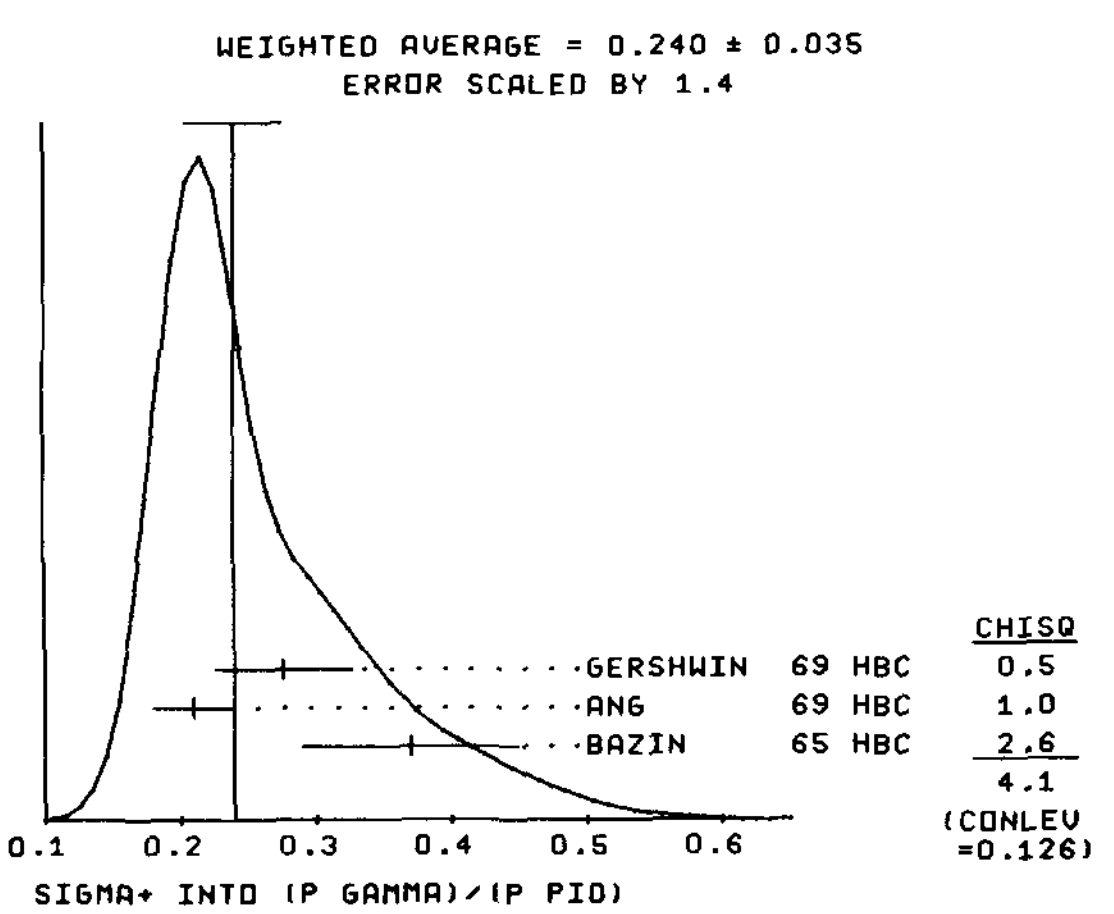


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R5      SIGMA+ INTO (N E+ NEU)/(N PI+) (UNITS 10**-5)     (P7)/(P2)
R5 EO     0     (16220)EFFECTIVE DENOM.  COURANT   64 HBC     SEE NOTE E        11/67
R5 EO     0      (2720)EFFECTIVE DENOM.  MURPHY    64 HBC     SEE NOTE E        11/67
R5 EO     1      (9690)EFFECTIVE DENOM.  NAUENBERG 64 HBC     SEE NOTE E         6/68
R5  O     0     (32406)EFFECTIVE DENOM.  BIERMAN   68 HBC                        6/68
R5 UA     0     (80400)EFFECTIVE DENOM.  EISELE2   69 HBC  +  STOP K-            6/68
R5 UO     1     (30000)EFFECTIVE DENOM.  NORTON    69 HBC                       11/69
R5  O   OLDER LOWER STATISTICS EXPTS.  NOT INCLUDED IN AVERAGE.                  2/76
R5 U      0    105000 EFFECTIVE DENOM.   SECHIZORN 73 HBC     STOP K-            2/76
R5 U A    0    111000 EFFECTIVE DENOM.   EBENHOH   74 HBC     STOP K-            1/76
R5 U                  EFFECTIVE DENOM.   CALCULATED BY US
R5 E                  EFFECTIVE DENOM.   TAKEN FROM EISELE 67                   11/67
R5    A  EISELE2 69 REPLACED BY BY EBENHOH 74.                                   1/76
R5           . . . . . . . . . .
R5              1.1    OR LESS  CL=.90   OUR AVERAGE (2.3 EVTS)/(EFF.DNOM.SUM)  2/76
R5       NUMBER OF EVENTS INCREASED TO 2.3 FOR 90PC CONFIDENCE LEVEL             2/76

R6      SIGMA+ INTO (N MU+ NEU)/(PI+N) (UNITS 10**-5)     (P6)/(P2)
R6        1      (120)ANALYSED EVENTS    GALTIERI  62 EMUL    NO RATIO QUOTED  11/67
R6 E      0     10150 EFFECTIVE DENOM.   COURANT   64 HBC     SEE NOTE E        11/67
R6 E      0      1710 EFFECTIVE DENOM.   NAUENBERG 64 HBC     SEE NOTE E        11/67
R6 U      2     62000 EFFECTIVE DENOM.   EISELE2   69 HBC                        6/68
R6        0     33800 EFFECTIVE DENOM.   BAGGETT   69 HBC                       11/68
R6 E                  EFFECTIVE DENOM.   TAKEN FROM EISELE 67                   11/67
R6 U                  EFFECTIVE DENOM.   CALCULATED BY US
R6           . . . . . . . . . .
R6              6.2    OR LESS  CL=.90   OUR AVERAGE (6.7 EVTS)/(EFF.DNOM.SUM)  2/76
R6       NUMBER OF EVENTS INCREASED TO 6.7 FOR 90PC CONFIDENCE LEVEL             2/76

R7      (SIGMA+ INTO LEPTONS)/(SIGMA- INTO LEPTONS)
R7        0     0.034 OR LESS            BAGGETT   67 HBC                        6/68
R7        1     0.08  OR LESS            NORTON    69 HBC                       10/69
R7           . . . . . . . . . .
R7              0.043 OR LESS   CL=.90   OUR AVERAGE  USING R5 AND R6            2/76

R8      SIGMA+ INTO (PROTON E+ E-)/TOTAL (UNITS 10**-6)  (P8)
R8              7.0    OR LESS           ANG       69 HBC     STOP K-           10/69
R8    A   ANG 69 FOUND 3 E+E- EVENTS IN AGREEMENT WITH GAMMA CONVERSION OF
R8    A   PROTON GAMMA DECAY -LIMIT GIVEN HERE IS FOR NEUTRAL CURRENT

R9      (SIGMA+ INTO N MU+ NEU)/(SIGMA- INTO N MU- NEU)
R9       2  0.06       0.045     0.03    EISELE2   69 HBC  +-   STOP K-         10/69
R9           . . . . . . . . . .
R9              0.12   OR LESS  CL=.90   OUR AVERAGE  USING R6                   2/71

R10     (SIGMA+ INTO N E+ NEU)/(SIGMA- INTO N E- NEU)
R10 E     0    (0.03) OR LESS   CL=.90   EISELE2   69 HBC  +- STOP K-           10/69
R10 O     0    (0.12) OR LESS   CL=.95   COLE      71 HBC     STOP K-           10/71
R10 C   LOWER STATISTICS EXPERIMENT NOT INCLUDED IN AVERAGE                      2/76
R10       0     0.018 OR LESS   CL=.90   SECHIZORN 73 HBC     STOP K-,POISSON    8/73
R10  E    0     0.019 OR LESS   CL=.90   EBENHOH   74 HBC  +- STOP K-           12/75
R10  E  EISELE2 69 REPLACED BY EBENHOH 74.                                      12/75
R10          . . . . . . . . . .
R10             0.009 OR LESS   CL=.90   OUR AVERAGE  USING R5                   2/76

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                    19  SIGMA+ DECAY PARAMETERS

        RELATED TEXT SECTION VI D AND APPENDIX III

A+0     ALPHA+/ALPHAO FOR SIGMA+ (SIG+ TO PI+ N)/(SIG+ TO PIO P)
A+0            +0.04      0.11           CORK      60 CNTR    SIG+ FROM PI+P
A+0           (+0.20)    (0.24)          TRIPP     62 HBC  +  REPLAC.BY BANGER
A+0 O 3500    (-.014)    (0.052)         BANGERTER 66 HBC  +  SIG+ FROM K-P      9/66
A+0 O 2600    (-.047)    (.07)           BERLEY    66 HBC  +  SIG+ FROM K-P      9/66
A+0    20K     -0.104     0.028          REUCROFT  77 HBC                        6/77*
A+0 O       OLD RESULTS, HAVE BEEN REPLACED. SEE BELOW -
A+0          . . . . . . . . . .
A+0 AVG        -0.095     0.034    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
A+0 STUDENT    -0.096     0.030    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
A+0 FIT        -0.074     0.015  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/78*

A+      ALPHA+ FOR SIGMA+ (SIG+ TO PI+ N)
A+    35000     0.069     0.017          BANGERTER 69 HBC     K-P AT 400 MEV/C 11/69
A+     4101     0.037     0.049          BERLEY    70 HBC                       12/70
A+           . . . . . . . . . .
A+  AVG         0.066     0.016    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A+  STUDENT     0.066     0.017    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
A+  FIT         0.072     0.015  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/78*

AO      ALPHAO FOR SIGMA+ (SIG+ INTO PIO PROTON)
AO             -0.80      0.16           BEALL     62 CNTR
AO            (-0.90)    (0.25)          TRIPP     62 HBC     REPLAC. BY BANGE
AO  O 5200    (-0.986)   (0.072)         BANGERTER 66 HBC     K-P TO SIG+ PI-    7/66
AO   32000     -0.999     0.022          BANGERTER 69 HBC                       10/69
AO H  1335     -0.98      0.05     0.02  HARRIS    70 OSPK    PI+P TO SIG+ K+    5/70
AO     16K     -0.940     0.045          BELLAMY   72 ASPK    PI+P TO SIG+ K+   11/72
AO L  1259     -0.945     0.055   0.042  LIPMAN    73 OSPK    PI+P TO SIG +      7/73
AO L    DECAY PROTONS SCATTERED OFF ALUMINUM.                                    7/73
AO H    DECAY PROTONS SCATTERED OFF CARBON.
AO           . . . . . . . . . .
AO  AVG        -0.979     0.016    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AO  STUDENT    -0.979     0.018    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
AO  FIT        -0.978     0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/78*

F+      PHI+ ANGLE (SIG+ INTO N PI)  SIN(PHI)/COS(PHI)=BETA/GAMMA  (DEGREE)
F+  O  370 (180.)    (30.)               BERLEY    66 HBC  +  NEUTRON RESCATT.  9/66
F+     560  143.      29.                BANGERT1  69 HBC                       10/69
F+   C1054  184.      24.                BERLEY    70 HBC     K-P AT 400 MEV/C 11/69
F+   C  CHANGED FROM 176 TO 184 TO AGREE WITH SIGN CONVENTION.
F+           . . . . . . . . . .
F+  AVG       167.3       20.1         AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
F+  STUDENT   167.5       21.2         AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AG      ALPHAG FOR SIGMA+ (SIG+ INTO PROTON GAMMA)
AG      61   -1.03       0.52      0.42  GERSHWIN  69 HBC     K-P TO SIG PI     11/69

FO      PHIO ANGLE (SIG+ INTO PIO PROTON) SIN(PHI)/COS(PHI)=BETA/GAMMA (DEG)
FO H          22.0       90.0            HARRIS    70 OSPK PI+P TO SIG+ K+       5/70
FO L  1259    38.1       35.7      37.1  LIPMAN    73 OSPK    PI+P TO SIG+K+     7/73
FO L    DECAY PROTON SCATTERED OFF ALUMINUM.                                     7/73
FO H    DECAY PROTONS SCATTERED OFF CARBON.
FO           . . . . . . . . . .
FO  AVG       35.8       33.7          AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FO  STUDENT   35.8       36.3          AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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REFERENCES FOR SIGMA+


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CORK      60 PR 120 1000         CORK,KERTH,WENZEL,CRONIN,COOL(LRL+PRIN+BNL)
EVANS     60 NC 15 873           BRIST+BRUSS+IAS-U.COL-DUBLIN+LON+MILAN+PAD
FREDEN    60 NC 16 611           S FREDEN,H KORNBLUM,R WHITE             (LRL)
KAPLON    60 ANP 9 139           M KAPLON,A MELISSINOS,YAMANOUCHI       (ROCH)
PUSCHEL   60 NP 20 254           W PUSCHEL                   (MAX PLANCK INST)

BARKAS    61 PR 124 1209         BARKAS,DYER,MASON,NICHOLS,SMITH         (LRL)
BERTHELO  61 NC 21 693           BERTHELOT,DAUDIN,GOUSSU +      (SACLAY+ORSAY)
CHIESA    61 NC 19 1171          CHIESA,QUASSIATI,RINAUDO        (INFN-TURIN)

BEALL     62 PRL 8 75            BEALL,CORK,KEEFE,MURPHY,WENZEL          (LRL)
GRARD     62 PR 127 607          F GRARD,G A SMITH                       (LRL)
GALTIERI  62 PRL 9 26            GALTIERI,BARKAS,HECKMAN,PATRICK,SMITH (LRL)
HUMPHREY  62 PR 127 1305         W E HUMPHREY,R R ROSS                   (LRL)
TRIPP     62 PRL 9 66            R D TRIPP,M B WATSON,M FERRO-LUZZI      (LRL)

BARKAS    63 PRL 11 26           W H BARKAS,J N DYER,H H HECKMANN        (LRL)
    ALSO  61 UCRL 9450           JOHN DYER (THESIS, BERKELEY)            (LRL)

BHOWMIK   64 NP 53 22            B BHOWMIK,P JAIN,P MATHUR,LAKSHMI     (DELHI)
CARRARA   64 PL 12 72            CARRARA,CRESTI,GRIGOLETTO,PERUZZO+ (PADOVA)
COURANT   64 PR 136 B 1791       COURANT,FILTHUTH+    (CERN+HEID+UMD+NRL+BNL)
MURPHY    64 PR 134 B 188        C THORNTON MURPHY                 (WISCONSIN)
NAUENBER  64 PRL 12 679          NAUENBERG,MARATECK,+          (COLU+RUTG+PRIN)
WILLIS    64 PRL 13 291          WILLIS,COURANT,ENGELMAN+(BNL,CERN,HEID,UMD)

BALTAY    65 PR 140 B 1027       BALTAY,SANDWEISS,CULWICK,KOPP +  (YALE+BNL)
BAZIN     65 PRL 14 154          BAZIN,BLUMENFELD,NAUENBERG +     (PRIN+COLU)
BAZIN2    65 PR 140  B1358       BAZIN,PLANO,SCHMIDT+           (PRIN,RUTG,COLU)
CARAYAN   65 PR 138 B 433        CARAYANNOPOULOS,TAUTFEST,WILLMANN  (PURDUE)
QUARENI   65 NC 40 A 928         QUARENI,CARTACCI +    (BGNA,FIRZ,GENO,PARMA)
SCHMIDT   65 PR 140 B 1328       P SCHMIDT                          (COLUMBIA)

BANGERTE  66 PRL  17  495        BANGERTER,GALTIERI,BERGE,MURRAY+        (LRL)
BERLEY    66 PRL 17 1071         +HERZBACH,KOFLER,YAMAMOTO + (BNL+MASA+YALE)
CHANG     66 PR  151  1081       CHUNG YUN CHANG                    (COLUMBIA)
    ALSO  65 NEVIS 145  THESIS   CHUNG YUN CHANG                    (COLUMBIA)
CHIEN     66 PR  152  1171       +LACH,SANDWEISS,TAFT,YEH,OREN +   (YALE+BNL)
COOK      66 PRL  17  223        V COOK,EWART,MASEK,ORR,PLATNER (WASHINGTON)

BAGGETT   67 PRL 19 1458         BAGGETT,DAY,GLASSER,KEHOE,KNOP+  (MARYLAND)
    ALSO  68 VIENNA ABS. 374     BAGGETT,KEHOE                      (MARYLAND)
    ALSO  68 PRIVATE COMM.       N. BAGGETT                         (MARYLAND)

BARASH    67 PRL 19  181         BARASH,DAY,GLASSER,KEHOE,KNOP +  (MARYLAND)
EISELE    67 ZPHYS 205 409       +ENGELMANN,FILTHUTH,FOLISH,HEPP+       (HEID)
HYMAN     67 PL 25 B 376         +LOKEN,PEWITT,MCKENZIE,+       (ANL+CARN+NWES)
KOTELCHU  67 PRL 18 1166         KOTELCHUCK,GOZA,SULLIVAN,ROSS  (VANDERBILT)
SULLIVAN  67 PRL 18 1163         SULLIVAN,MCINTURFF,KOTELCHUCH  (VANDERBILT)
    ALSO  64 PRL 13 246          A D MCINTURFF,C E ROOS         (VANDERBILT)
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BIERMAN 68 PRL 20 1459 BIERMAN,KOUNOSU,NAUENBERG + (PRINCETON)
COMBE 68 NC 57A 54 CERN-BRISTOL-LAUSANNE-MUNICH-ROME-COLLABOR
MAST 68 PRL 20 1312 MAST,GERSHWIN,ALSTON-GARNJOST + (LRL)

ANG 69 ZPHYS 228 151 +EBENHOH,EISELE,ENGELMANN,FILTHUTH+ (HEID)
BAGGETT 69 MDDP-TR-973 N V BAGGETT (THESIS) (UMD)
BALTAY 69 PRL 22 615 BALTAY,FRANZINI,NEWMAN,NORTON+ (COLU,STON)
BANGERTE 69 UCRL-19244 ROGER ODELL BANGERTER (THESIS) (LRL)
BANGERT1 69 PR 187 1821 BANGERTER,GARNJOST,GALTIERI,GERSHWIN+ (LRL)

BARLOUTA 69 NP B14 153 BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
EISELE1 69 ZPHYS 221 1 +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+ (HEID)
EISELE2 69 ZPHYS 221 401 +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+ (HEID)
GERSHWIN 69 PR 188 2077 +ALSTON-GARNJOST,BANGERTER + (LRL)
ALSO UCRL 19246 THESIS LAWRENCE K GERSHWIN (LRL)
NORTON 69 NEVIS 175 (THESIS) HERBERT NORTON (COLUMBIA)

BERLEY 70 PR D1 2015 +YAMIN,HERTZBACH,KOFLER + (BNL,MASA,YALE)
EISELE 70 ZPHY 238 372 +FILTHUTH,HEPP,PRESSER,ZECH (HEIDELBERG)
HARRIS 70 PRL 24 165 +OVERSETH,PONDROM,DETTMANN (MICH,WISC)

ALLEY 71 PR D3 75 +BENBROOK,COOK,GLASS,GREEN,HAGUE + (WASH)
BAKKER 71 LNC 1 37 +,SABRE COLLAB. (ZEEM+SACL+BGNA+REHO+EPOL)
COLE 71 PR D4 631 +LEE-FRANZINI,LOVELESS,BALTAY+ (STON,COLU)
TOVEE 71 NP B33 493 LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB
BELLAMY 72 PL 39B 299 +ANDERSON,CRAWFORD,OSMON+ (LOWC+RHEL+SUSS)
BOHM 72 NP B48 1 BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAW
ALSO 73 IIHE-73.2 NOV BRUSSELS BULLETIN, SAME COLLABORATION

EBENHOH 73 ZPHY 264 413 +EISELE,FILTHUTH,HEPP,LEITNER,THOUW+ (HEID)
LIPMAN 73 PL 43B 89 +UTO,WALKER,MONTGOMERY+ (RHEL+SUSS+LOWC)
SAHA 73 PR D7 3295 +FETKOVICH,HEINTZELMAN,MELTZER + (CARN)
SECHIZOR 73 PR D8 12 B.SECHI-ZORN,G.SNOW (UMD)

EBENHOH 74 ZPHY 266 367 +EISELE,ENGELMANN,FILTHUTH,HEPP + (HEID)
CONFORTO 76 NP B105 189 +GOPAL,KALMUS,LITCHFIELD,ROSS + (RHEL+LOIC)
DOBLE 77 PL 67B 483 +GOTTSTEIN,HANSL,HERYNEK+ (MPIM+BOHR+VAND)
REUCROFT 77 PR D15 5 +ROOS,WATERS,WEBSTER,HANSL + (VAND+MPIM)

PAPERS NOT REFERRED TO IN DATA CARDS

GLASER 58 CERN CONF 270 GLASER,GOOD,MORRISON (MICH+LRL)

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

TRIPP 62 PRL 8 175 R TRIPP,M WATSON,M FERRO-LUZZI (LRL) P
ALFF 63 SIENA CONF 1 205 ALFF,NAUENBERG,KIRSCH,+ (COLU+RUTG+BNL)
ALSO 65 PR 137 B 1105 ALFF,GELFAND,BRUGGER,BERLEY+(COLU+RUTG+BNL)
COURANT 63 SIENA CONF 1 73 COURANT,FILTHUTH,BURNSTEIN,DAY+ (CERN+UMD)

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20 SIGMA-(1198,JP=1/2+) I=1

20 SIGMA- MASS (MEV)

M N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M	3000	1197.43	0.08	SCHMIDT 65 HBC	SEE NOTE N	3/74
M		. . . .				
M	FIT	1197.35	0.06	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)		2/78*

20 (SIGMA-) - (SIGMA+) MASS DIFFERENCE (MEV)

D	87	8.25	0.40	BARKAS 63 EMUL	-	
D	2500	8.25	0.25	DOSCH 65 HBC		
D	86	7.91	0.23	BOHM 72 EMUL		1/73
D		. . . .				
D	AVG	8.09	0.16	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		
D	STUDENT	8.10	0.18	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT		
D	FIT	7.98	0.08	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)		2/78*

20 (SIGMA-) - (LAMBDA) MASS DIFFERENCE (MEV)

DL N SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

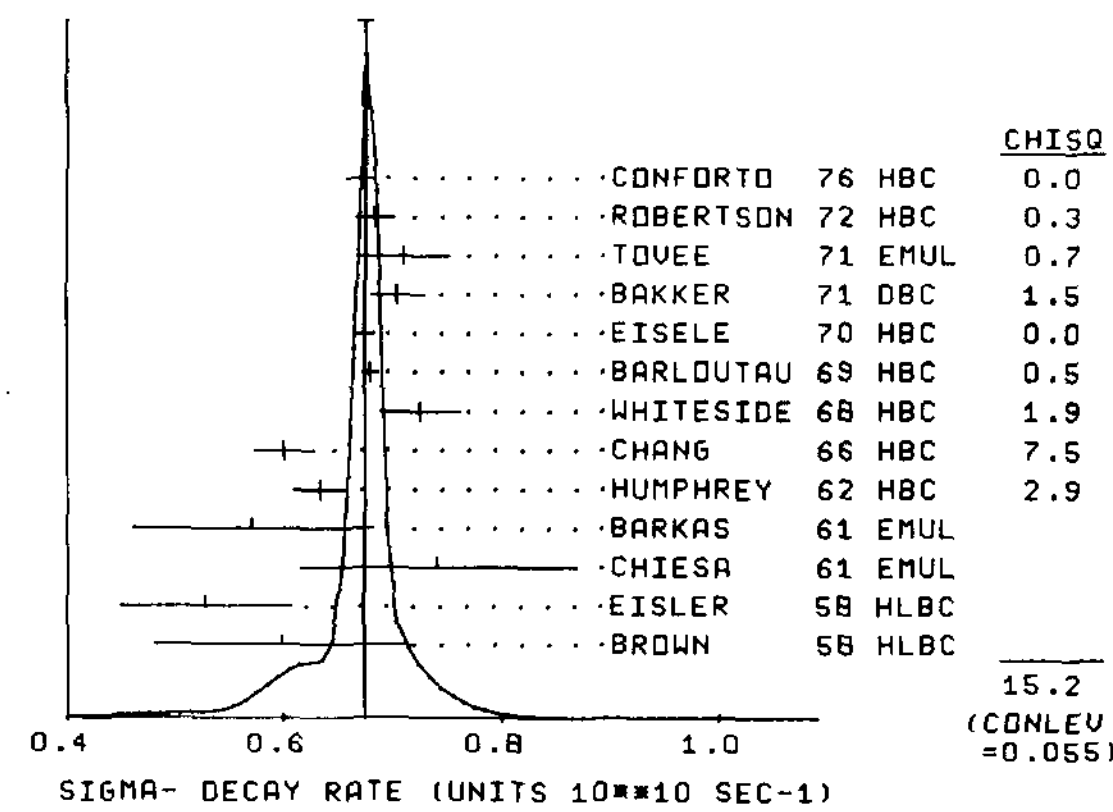
DL		81.70	0.19	BURNSTEIN 64 HBC		9/66
DL	85	81.80	0.13	SCHMIDT 65 HBC	SEE NOTE N	3/74
DL	2279	81.64	0.09	HEPP 68 HBC		8/68
DL		. . . .				
DL	AVG	81.693	0.069	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		
DL	STUDENT	81.692	0.077	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT		
DL	FIT	81.750	0.054	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)		2/78*

20 SIGMA- MEAN LIFE (UNITS 10**-10)

T		1.67	0.40	0.28	BROWN 58 HLBC			
T		1.89	0.33	0.25	EISLER 58 HLBC			
T	45	1.35	0.32	0.17	CHIESA 61 EMUL			
T	41	1.75	0.39	0.30	BARKAS 61 EMUL			
T	1208	1.58	0.06	0.06	HUMPHREY 62 HBC		STOP. K-	
T	C 3267	1.666	0.075		CHANG 66 HBC		STOP. K-	6/66
T	S 61	(2.08)	(0.22)		CHIEN 66 HBC	-	6.9 PBAR P	9/67
T	S 64	(1.46)	(0.31)		CHIEN 66 HBC	+	6.9 PBAR P,ANTI	9/67
T	506	1.38	0.07		WHITESIDE 68 HBC		STOP. K-	6/68
T	10253	1.472	0.016		BARLOUTAU 69 HBC		K-P .4-1.2 GEV/C	11/69
T	.1M	1.485	0.022		EISELE 70 HBC		K-P AT REST	2/71
T	1383	1.42	0.05		BAKKER 71 DBC	-	K-N TO SIG- 2PI	10/71
T		1.41	0.09	0.08	TOVEE 71 EMUL			12/71
T	2400	1.463	0.039		ROBERTSON 72 HBC		K-P .25 GEV/C	3/74
T	8437	1.49	0.03		CONFORTO 76 HBC		K-P 1-1.4 GEV/C	11/77*

T C CHANG ERROR 0.018 RAISED BY US. SEE 1970 EDITION, RMP 42,123(1970) 1/73
T S ERROR PURELY STATISTICAL.
T . . . .
T AVG 1.483 0.015 0.014 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.4)
T STUDENT 1.481 0.012 0.012 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 0.6742 ± 0.0066
ERROR SCALED BY 1.4



20 SIGMA- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM R BTWN -1.6 AND +0.8 FOX 73 CNTR SIG-ATOM FINE ST 3/74
MM R -1.48 0.37 ROBERTS 74 CNTR SIG-ATOM FINE ST 12/75
MM R ROBERTS 74 INCLUDES DATA FROM FOX 73. 12/75

20 SIGMA- PARTIAL DECAY MODES

		DECAY MASSES
P1	SIGMA- INTO NEUTRON PI-	939+ 139
P2	SIGMA- INTO NEUTRON PI- GAMMA	939+ 139+ 0
P3	SIGMA- INTO NEUTRON MU- NEUTRINO	939+ 105+ 0
P4	SIGMA- INTO NEUTRON E- NEUTRINO	939+ .5+ 0
P5	SIGMA- INTO LAMBDA E- NEUTRINO	1115+ .5+ 0

20 SIGMA- BRANCHING RATIOS

R1 SIGMA- INTO (N MU- NEU)/(N PI-) (UNITS 10**-3) (P3)/(P1)

R1	22	0.66	0.15		COURANT 64 HBC		
R1	11	0.56	0.20		BAZIN 65 HBC	FROM STOP. K-	6/66
R1	56	0.43	0.09		BAGGETT 69 HBC	STOP. K-	10/69
R1	72	0.43	0.06		ANG 1 69 HBC	STOP K-	10/69
R1	13	0.38	0.11		COLE 71 HBC	STOP K-	10/71
R1		. . . .					
R1	AVG	0.447	0.043	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R1	STUDENT	0.445	0.047	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

R2 SIGMA- INTO (N E- NEU)/(N PI-) (UNITS 10**-3) (P4)/(P1)

R2	9	1.0	0.4	0.3	MURPHY 64 HLBC		
R2	16	1.37	0.34		NAUENBERG 64 HBC		
R2	16	1.15	0.4		MILLER 64 FBC		
R2	31	1.4	0.3		COURANT 64 HBC		
R2	180	1.11	0.09		BIERMAN 68 HBC		6/68
R2	A 331	(1.02)	(0.08)		ANG 1 69 HBC	- STOP K-	10/69
R2	57	0.97	0.15		COLE 71 HBC	STOP K-	10/71
R2	455	1.05	0.07		SECHIZORN 73 HBC	STOP K-	8/73
R2	A 601	1.09	0.06		EBENHOH 74 HBC	STOP K-	1/76

R2 A ANG 1 69 REPLACED BY EBENHOH 74. 1/76
R2 . . . .
R2 AVG 1.082 0.038 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2 STUDENT 1.082 0.041 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R3 SIGMA- INTO (LAMBDA E- NEU)/(N PI-) (UNITS 10**-4)
R3 (P5)/(P1)

R3	11	0.75	0.28	COURANT 64 HBC	STOP. K-	
R3	35	0.64	0.12	BARASH 67 HBC	STOP K-	8/67
R3	31	0.69	0.12	EISELE1 69 HBC	STOP K-	10/69
R3	31	0.52	0.09	BALTAY 69 HBC	STOP K-	4/69
R3		. . . .				
R3	AVG	0.604	0.060	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		
R3	STUDENT	0.605	0.069	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT		

R4 SIGMA- INTO (N PI- GAMMA)/(N PI-) (UNITS 10**-3) (P2)/(P1)

R4		(1.1)APPROXIM.		BAZIN 65 HBC	PI- LT 166 MEV/C	8/67
R4	23	0.10	.02	ANG 2 69 HBC	PI- LT 110 MEV/C	10/69
R4	292	0.46	0.06	EBENHOH 73 HBC	PI+ LT 150 MEV/C	3/74

20 SIGMA- DECAY PARAMETERS

RELATED TEXT SECTION VI D AND APPENDIX III

A- ALPHA SIGMA-

A-		(-0.16)	(0.21)	TRIPP 62 HBC	REPL.BY BANGERTE	
A-	O 6500	(-0.010)	(0.043)	BANGERTER 66 HBC	K-P TO SIG- PI+	7/66
A-	O 6068	(-0.104)	(0.04)	BERLEY 67 HBC	K-P TO SIG- PI+	11/67
A-	51000	-0.071	0.012	BANGERTER 69 HBC		10/69
A-	B 5978	(-0.134)	(0.034)	BERLEY 70 HBC	K-P AT 400 MEV/C	2/71
A-	60000	-0.067	0.011	BOGERT 70 HBC	K-P AT 400 MEV/C	12/70

A- O OLD RESULTS. HAVE BEEN REPLACED.
A- B BERLEY 70 REPLACED BY BOGERT 70 2/71
A- . . . .
A- AVG -0.0688 0.0081 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A- STUDENT -0.0688 0.0087 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

F- PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)

F-	O 1006	(+22.)	(30.)	BERLEY 67 HBC	K-P TO SIG- PI+	11/67
F-	1385	14.	19.	BANGERT1 69 HBC		10/69
F-	C1092	+ 5.	23.	BERLEY 70 HBC	NEUTRON RESCATT.	11/69

F- C CHANGED FROM -5 TO +5 TO AGREE WITH SIGN CONVENTION
F- . . . .
F- AVG 10.3 14.6 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F- STUDENT 10.4 15.8 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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AV      GV/GA FOR SIGMA TO LAMBDA BETA DECAY (TEXT SEC VI D.1 FOR SIGN CONV)
AV       PREDICTED TO BE ZERO BY CONSERVED VECTOR CURRENT THEORY
AV  FB  45   (0.31)   (0.30)           BARASH    67 HBC                      11/67
AV  FS  51   (0.7)    (0.4)            BALTAY    69 HBC      USING SIG+-      4/69
AV  FS  81  (+0.22)   (0.28)           EISELE1   69 HBC                      10/68
AV F S 186    0.37     0.20            FRANZINI  72 HBC      USING SIG+-      1/73
AV   T  55   -0.17     0.35            TANENBAUM 75 SPEC                     12/75
AV   B  BARASH 67 MEASURED ABSOLUTE VALUE.
AV   S  SIGN CHANGED TO AGREE WITH OUR CONVENTION.
AV F    FRANZINI 72 INCLUDES EVENTS OF BARASH 67, EISELE1 69, BALTAY 69.      1/73
AV   T  WE QUOTE TANENBAUM 75 WHICH ASSUMES CVC WK MAG TERM.                   1/76
AV           . . . . . . . . . .
AV  AVG        0.24     0.23    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
AV  STUDENT    0.24     0.20    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AV1     GA/GV FOR SIGMA TO NEUTRON BETA DECAY(TEXT SEC VI D.1 FOR SIGN CONV)
AV1     57   (0.05)   (0.23)   (0.32) GERSHWIN   68 HBC  REPLACED BY GER.69   6/68
AV1     61   +0.19     0.20     0.17  GERSHWIN   69 HBC  POLARIZED SIGMAS    10/69
AV1     63   -0.33     0.30     0.85  BOGERT     70 HBC  K-P AT 400 MEV/C    10/70
AV1     43   -0.4      0.52     1.5   ELLIS      72 ASPK    POLARIZED SIGMAS 10/71
AV1 E       (+0.10)   (0.11)          ELLIS      72 RVUE    SUM LIKEL.(+SOL) 10/71
AV1 E       (-0.27)   (0.13)   (0.17) ELLIS      72 RVUE    SUM LIKEL.(-SOL) 10/71
AV1 E   ELLIS 72 HAS COMBINED THE MAXIMUM LIKELIHOODS OF COLLERAINE 69,        3/72
AV1 E   EISELE2 69, GERSHWIN 69, ELLIS 72, AND GETS TWO POSSIBLE VALUES.       3/72
AV1          . . . . . . . . . .
AV1 AVG        0.13     0.17    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AV1 STUDENT    0.13     0.19    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

AV2     ABSOLUTE VALUE OF GA/GV FOR SIGMA TO NEUTRON BETA DECAY
AV2     49     0.23     0.16          COLLERAIN 69 HBC      NEUTRON SCATTER  10/69
AV2     33     0.37     0.26    0.19  EISELE2   69 HBC      NEUTRON SCATTER .10/69
AV2     36     0.29     0.28    0.29  BALTAY    72 HBC      NEUTRON SCATTER   6/72
AV2   3507     0.435    0.035         TANENBAU  74 ASPK                      10/74
AV2    519     0.17     0.07    0.09  DECAMP    77 ELEC     H.E.HYPERON BEAM 11/77*
AV2          . . . . . . . . . .
AV2 AVG        0.385    0.070   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
AV2 STUDENT    0.396    0.041   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                (SEE IDEOGRAM BELOW )
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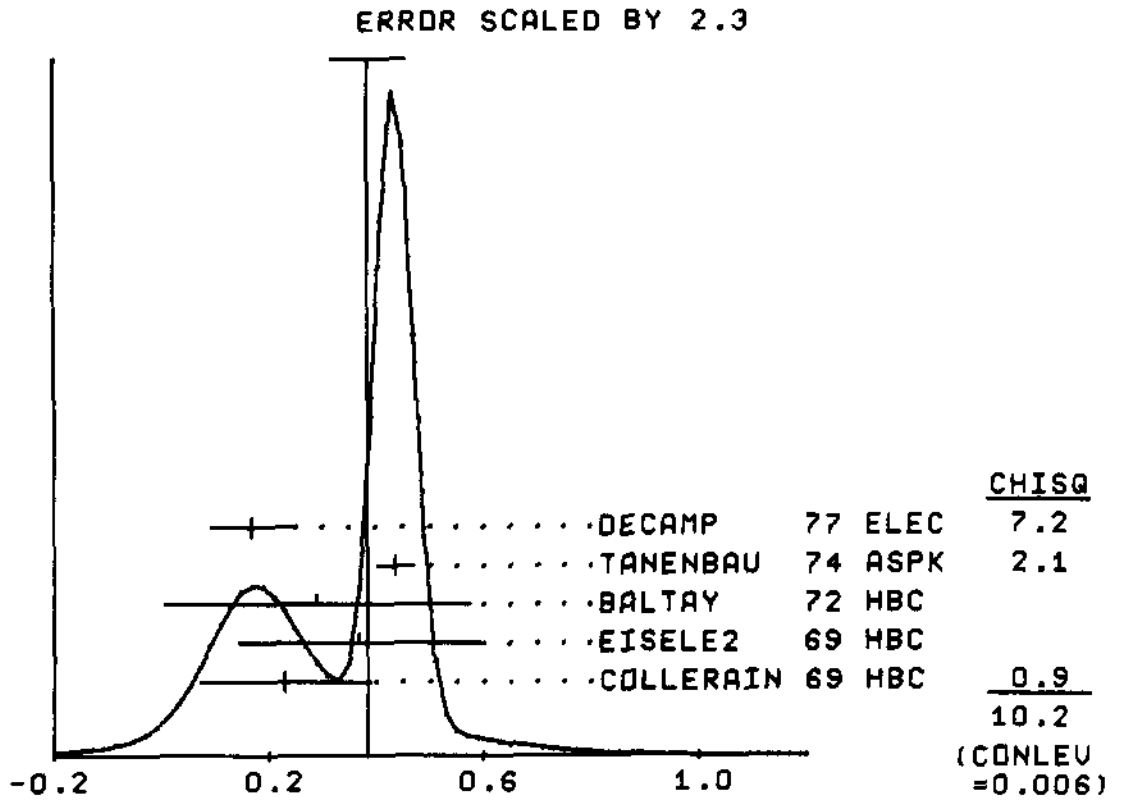
WEIGHTED AVERAGE = 0.385 ± 0.070
ERROR SCALED BY 2.3



ABS(GA/GV) FOR SIGMA TO N BETA DECAY

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REFERENCES FOR SIGMA-


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BROWN     58 CERN CONF 270       BROWN,GLASER,GRAVES,PERL,CRONIN +      (MICH)
EISLER    58 NC SER10 10 150     EISLER,BASSI,CONVERSI+ (COLU,BNL,BGNA,PISA)

BARKAS    61 PR 124 1209         BARKAS,DYER,MASON,NICKOLS,SMITH         (LRL)
CHIESA    61 NC 19 1171          A M CHIESA,B QUASSIATI,G RINAUDO      (TURIN)
HUMPHREY  62 PR 127 1305         W E HUMPHREY,R R ROSS                   (LRL)
TRIPP     62 PRL 9 66            R D TRIPP,M WATSON,M FERRO-LUZZI        (LRL)

BARKAS    63 PRL 11 26           W H BARKAS,J N DYER,H H HECKMAN         (LRL)
BURNSTEI  64 PRL 13 66           BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW     (UMD)
COURANT   64 PR 136 B 1791       COURANT,FILTHUTH+    (CERN+HEID+UMD+NRL+BNL)
MILLER    64 PL 11 262           MILLER,STANNARD,BEZAGUET+  (LOUC,EPOL+BERG)
MURPHY    64 PR 134 B 188        C THORNTON MURPHY                 (WISCONSIN)
NAUENBER  64 PRL 12 679          NAUENBERG,SCHMIDT,MARATECK+(COLU+RUTG+PRIN)

BAZIN     65 PR 140 B 1358       BAZIN,PLANO,SCHMIDT +        (PRIN+RUTG+COLU)
DOSCH     65 PL 14 239           DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
   ALSO   66 PR  151  1081       CHUNG YUN CHANG                    (COLUMBIA)
SCHMIDT   65 PR 140 B 1328       P SCHMIDT                          (COLUMBIA)
BANGERTE  66 PRL  17  495        BANGERTER,GALTIERI,BERGE,MURRAY+        (LRL)
CHANG     66 PR   151 1081       CHUNG YUN CHANG                    (COLUMBIA)
CHIEN     66 PR   152  1171      +LACH,SANDWEISS,TAFT,YEH,OREN +   (YALE+BNL)

BARASH    67 PRL 19  181         BARASH,DAY,GLASSER,KEHOE,KNOP +  (MARYLAND)
BERLEY    67 PRL  19  979        BERLEY,HERTZBACH,KOFLER +    (BNL,MASA,YALE)
BIERMAN   68 PRL 20 1459         BIERMAN,KOUNOSU,NAUENBERG +     (PRINCETON)
GERSHWIN  68 PRL 20 1270         GERSHWIN,ALSTON-GARNJOST,BANGERTER+    (LRL)
HEPP      68 ZPHY         214 71 V.HEPP,H. SCHLEICH                (HEIDELBERG)
WHITESID  68 NC   54A  537       H. WHITESIDE,J. GOLLUB              (OBERLIN)

ANG 1     69 ZPHY 223 103        ANG,EISELE,ENGELMANN,FILTHUTH +        (HEID)
ANG 2     69 ZPHY 228 151        +EBENHOR,EISELE,ENGELMANN,FILTHUTH+   (HEID)
BAGGETT   69 PRL 23 249          BAGGETT,KEHOE,SNOW           (UNIV MARYLAND)
BALTAY    69 PRL 22 615          BALTAY,FRANZINI,NEWMAN,NORTON+  (COLU,STON)
BANGERTE  69 UCRL-19244          ROGER ODELL BANGERTER (THESIS)          (LRL)
BANGERT1  69 PR 187 1821         BANGERTER,GARNJOST,GALTIERI,GERSHWIN+ (LRL)

BARLOUTA  69 NP B14 153          BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
COLLERAI  69 PRL 23 198          COLLERAINE,DAY,GLASSER,KNOP+(UNIV MARYLAND)
EISELE1   69 ZPHY 221 1          +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+     (HEID)
EISELE2   69 ZPHY 223 487        EISELE,ENGELMANN,FILTHUTH,FOHLISCH+    (HEID)
GERSHWIN  69 UCRL-19246          LAWRENCE KENNETH GERSHWIN (THESIS)     (LRL)

BERLEY    70 PR D1 2015          +YAMIN,HERTZBACH,KOFLER +    (BNL,MASA,YALE)
BOGERT    70 PR D2 6             +LUCAS,TAFT,WILLIS,BERLEY + (BNL,MASA,YALE)
EISELE    70 ZPHY 238 372        +FILTHUTH,HEPP,PRESSER,ZECH     (HEIDELBERG)
BAKKER    71 LNC 1 37            +,SABRE COLLAB.  (ZEEM+SACL+BGNA+REHO+EPOL)
COLE      71 PR D4 631           +LEE-FRANZINI,LOVELESS,BALTAY+  (STON,COLU)
   ALSO   69 NEVIS-175 THESIS    HERBERT NORTON                     (COLUMBIA)
TOVEE     71 NP B33 493          LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB

BALTAY    72 PR D5 1569          +FEINMAN,FRANZINI,NEWMAN,YEH+    (COLU+STON)
BOHM      72 NP B48 1            BERLIN+BELGRADE+BRUX+DUBLIN+LOUC+WARSAW
ELLIS     72 NP B39 77           OXF+AERE+RHEL+LOQM+LYON+NWES+ITEP COLLABOR
FRANZINI  72 PR D6 2417          COLUMBIA+HEIDELBERG+MARYLAND+STONY BROOK
ROBERTSC  72 THESIS              R.M.ROBERTSON                           (IIT)

EBENHOH   73 ZPHY 264 413        +EISELE,FILTHUTH,HEPP,LEITNER,THOUW+ (HEID)
FOX       73 PRL 31 1084         +LAM,BARNES,EISENSTEIN+ (BNL+VPI+WILL+WYOM)
SECHIZOR  73 PR D8 12            B.SECHI-ZORN,G.SNOW                     (UMD)
EBENHOH   74 ZPHY 266 367        +EISELE,ENGELMANN,FILTHUTH,HEPP +     (HEID)
ROBERTS   74 PRL 32 1265         WILL+VPI+CARN+WYOM+CIT COLLABORATION
   ALSO   74 PRL 33 122          ERRATUM TO ROBERTS 74
   ALSO   75 PR D12 1232         ROBERTS,COX +  (WILL+VPI+CARN+WYOM+CIT+BNL)
TANENBAU  74 PRL 33 175          TANENBAUM,HUNGERBUEHLER +    (YALE+FNAL+BNL)
   ALSO   75 TANENBAUM

TANENBAU  75 PR D12 1871         TANENBAUM,HUNGERBUEHLER +    (YALE+FNAL+BNL)
CONFORTO  76 NP B105 189         +GOPAL,KALMUS,LITCHFIELD,ROSS + (RHEL+LOIC)
DECAMP    77 PL 66B 295          +BADIER,BLAND,CHOLLET,GAILLARD+ (LALO+EPOL)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

BROWN     57 PR 108 1036         J BROWN, D GLASER, M PERL          (MICH+BNL)
NIETC     68 RMP 40 140          M NIETO                                (STON)
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21 SIGMA0(1193,JP=1/2+) I=1

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                    21  (SIGMA-) - (SIGMA0) MASS DIFFERENCE (MEV)
D1   N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

D1       18    4.75      0.1            BURNSTEIN 64 HBC
D1       37    4.87      0.12           DOSCH     65 HBC
D1       12    5.01      0.12           SCHMIDT   65 HBC   SEE NOTE N          3/74
D1           . . . . . . . . . .
D1   AVG       4.860     0.076   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
D1   STUDENT   4.860     0.077   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D1   FIT       4.882     0.063  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*
                         (SEE IDEOGRAM BELOW )
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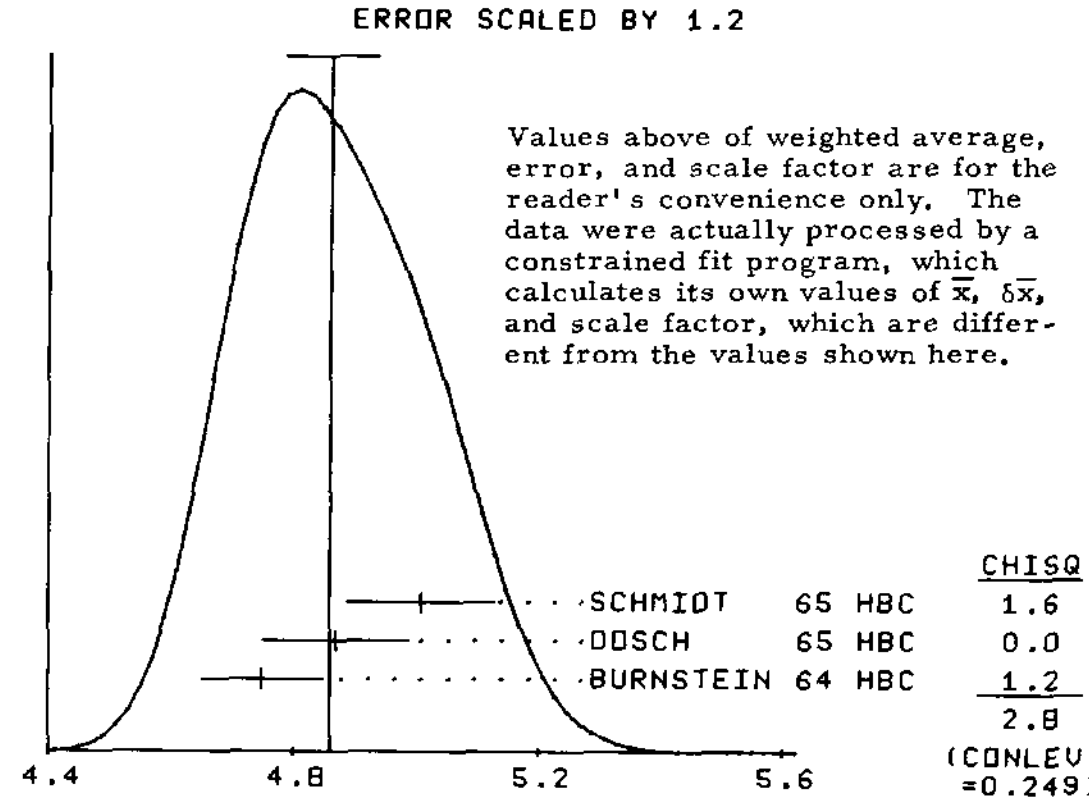
WEIGHTED AVERAGE = 4.860 ± 0.076
ERROR SCALED BY 1.2



(SIGMA-)-(SIGMA0) MASS DIFFERENCE

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                    21  (SIGMA0) - (LAMBDA) MASS DIFFERENCE (MEV)

DL   N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

DL      208    76.63     0.28           SCHMIDT   65 HBC   SEE NOTE N          6/68
DL      109    76.23     0.55           COLAS     75 HLBC    LAMBDA-GAMMA DEC 12/75
DL           . . . . . . . . . .
DL   AVG       76.55     0.25    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DL   STUDENT   76.55     0.27    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
DL   FIT       76.87     0.08   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*

                    21  SIGMA0 MEAN LIFE (UNITS 10**-19)                       6/77*

T             (E-14 OR LESS)            DAVIS     62 EMUL                      6/77*
T              0.58      0.13           DYDAK     77 SPEC PRIMAKOFF EFFECT     6/77*

                    21  SIGMA0 PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      SIGMA0 INTO LAMBDA GAMMA                              1115+   0
P2      SIGMA0 INTO LAMBDA E+ E-                              1115+  .5+  .5
P3      SIGMA0 INTO LAMBDA GAMMA GAMMA                        1115+   0+   0

                    21  SIGMA0 BRANCHING RATIOS

R1      SIGMA0 INTO(LAMBDA E+ E-)/TOTAL                     (P2)/(P1+P2)
R1           (0.00545)   THEORET. CAL. FEINBERG  58           QUANTUM ELECT.   9/66

R2      SIGMA0 INTO (LAMBDA GAMMA GAMMA)/(LAMBDA GAMMA)  (P3)/(P1)            12/75
R2           0.03  OR LESS  CL=.90   COLAS     75 HLBC                        12/75
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                            REFERENCES FOR SIGMAO

FEINBERG 58 PR 109 1019       G.FEINBERG                             (BNL)
DAVIS    62 PR 127 605        D DAVIS,R SETTI,M RAYMOND,G TOMASIN    (EFI)
BURNSTEI 64 PRL 13 66         BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW    (UMD)
DOSCH    65 PL 14 239         DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
SCHMIDT  65 PR 140 B 1328     P SCHMIDT                         (COLUMBIA)

COLAS    75 NP B91 253        +FARWELL,FERRER,SIX                   (ORSA)
DYDAK    77 NP B118 1         +NAVARRIA,OVERSETH,STEFFEN+(CERN+DORT+HEID)

                              PAPERS NOT REFERRED TO IN DATA CARDS.

COURANT  63 PRL 10 409        COURANT,FILTHUTH,FRANZINI+   (CERN+UMD+NRL)

      QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

ALFF     65 PR 137 B1105      ALFF,GELFAND,NAUENBERG+ (COLUMBIA+RUTG+BNL)P

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                  22  XI-(1321,JP=1/2 ) I=1/2

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                  22  XI- MASS (MEV)

M   H   11(1317.0)     (2.2)           WANG      61 HLBC
M   H   18(1317.9)     (1.9)           FOWLER    61 HLBC
M   H   (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
M      517 1321.4       0.4            JAUNEAU   63 FBC
M       62 1321.1       0.65           SCHNEIDER 63 HBC
M      241 1321.1       0.3            BADIER1   64 HBC
M       ALL MASSES ABOVE WERE RAISED 0.09 MEV BECAUSE LAMBDA MASS RAISED
M      149 1321.3       0.4            PJERROU   65 HBC                11/67
M        6 1321.67      0.52           CHIEN     66 HBC  -  6.9 PBAR P   9/67
M      299 1321.4       1.1            LONDON    66 HBC                 6/66
M  G   195 1321.87      0.51           GOLDWASSE 70 HBC     5.5 K-P     8/70
M  G    USES LAMBDA MASS OF 1115.58-M(XI) IS 1322.18 IF M(LAMBDA)=1115.84  8/70
M      268 1321.12      0.41           WILQUET   72 HLBC                1/73
M      632 1321.46      0.34           DIBIANCA  75 DBC     4.9 GEV/C K-D  1/77*
M              . . . . . . . . . .
M   AVG    1321.34      0.14    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1321.34      0.16    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT    1321.32      0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*
        THE FIT ASSUMES XI AND ANTI-XI MASSES EQUAL.

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                  22  ANTI-XI+ MASS (MEV)

M1        1(1322.0)     (1.3)          BROWN     62 HBC     ANTI-XI-      7/66
M1        5 1320.69      0.93          CHIEN     66 HBC  +  6.9 PBAR P,ANTI  9/67
M1  S    12(1321.7)     (0.6)          SHEN      67 HBC     ANTI-XI-     10/67
M1       34 1321.2       0.4           STONE     70 HBC                  10/70
M1       35 1321.6       0.8           VOTRUBA   72 HBC     10 GEV/C K+ P  11/72
M1  S   THE ERROR IS STATISTICAL ONLY
M1             . . . . . . . . . .
M1  AVG    1321.20      0.33    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M1  STUDENT1321.20      0.36    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M1  FIT    1321.32      0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*
        THE FIT ASSUMES XI AND ANTI-XI MASSES EQUAL.

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                  22  (XI-) - (ANTI-XI+) MASS DIFFERENCE (MEV)

DM            1.0       1.1            CHIEN     66 HBC     6.9 PBAR P    9/67

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                  22  XI- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM    2724   -0.1       2.1            BINGHAM   70 OSPK  - 1.8 GEV/C K-P   2/71
MM    2436   -2.1       0.8            COOL      74 OSPK -  1.8 GEV/C K-P  10/74
MM             . . . . . . . . . .
MM  AVG      -1.85      0.75    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
MM  STUDENT  -1.86      0.82    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                  22  XI- MEAN LIFE (UNITS 10**-10)

T   H   11   (3.5)     (3.4)     (1.23) WANG      61 HLBC
T   H   18   (1.28)    (0.41)    (0.25) FOWLER    61 HLBC
T   H   (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
T      517    1.86      0.15      0.14  JAUNEAU   63 FBC
T       62    1.55      0.31      0.31  SCHNEIDER 63 HBC
T      356   (1.77)    (0.12)           CARMONY   64 HBC    REP BY PJERROU 65
T      794    1.69      0.07            HUBBARD   64 HBC
T      246    1.70      0.12            PJERROU   65 HBC                 11/67
T   S    6   (1.37)    (0.51)           CHIEN     66 HBC  -  6.9 PBAR P    9/67
T      299    1.80      0.16            LONDON    66 HBC                  6/66
T   S        (1.67)    (0.07)           BURGUN    68 HBC    K-P AT 1.3-1.8   2/71
T     2610    1.61      0.04            DAUBER    69 HBC                  6/68
T      680    1.73      0.08      0.07  MAYEUR    72 HLBC   2.1 GEV/C K-    1/73
T     4303    1.63      0.03            BALTAY    74 HBC    1.75 GEV/C K-   3/74
T   S 2436   (1.637)   (0.050)          COOL      74 OSPK - 1.8 GEV/C K-P  10/74
T             1.67      0.08            DIBIANCA  75 DBC    4.9 GEV/C K-D   1/77*
T   S   THE ERROR IS STATISTICAL ONLY
T              . . . . . . . . . .
T   AVG       1.654     0.021     0.020 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T   STUDENT   1.653     0.024     0.023 AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT

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                  22  ANTI-XI+ MEAN LIFE (UNITS 10**-10)

T1  S    5   (1.51)    (0.55)           CHIEN     66 HBC  +  6.9 PBAR P,ANTI  9/67
T1  S   12   (1.9)     (0.7)     (0.5)  SHEN      67 HBC     ANTI-XI-     10/67
T1      34    1.6       0.3             STONE     70 HBC                  10/70
T1  S   35   (1.55)    (0.35)    (0.20) VOTRUBA   72 HBC     10 GEV/C K+ P  11/72
T1  S   THE ERROR IS STATISTICAL ONLY

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                  22  XI- PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI- INTO LAMBDA PI-                            1115+ 139
P2      XI- INTO LAMBDA E- NEUTRINO                    1115+  .5+   0
P3      XI- INTO NEUTRON PI-                            939+ 139
P4      XI- INTO LAMBDA MU- NEUTRINO                   1115+ 105+   0
P5      XI- INTO SIGMAO E- NEUTRINO                    1192+  .5+   0
P6      XI- INTO SIGMAO MU- NEUTRINO                   1192+ 105+   0
P7      XI- INTO NEUTRON E- NEUTRINO                    939+  .5+   0
P8      XI- INTO NEUTRCN MU- NEUTRINO                   939+ 105+   0
P9      XI- INTO SIGMA- GAMMA                          1197+   0
P10     XI- INTO PROTON PI- PI-                         938+ 139+ 139
P11     XI- INTO PROTON PI- E- NEUTRINO                 938+ 139+  .5+   0
P12     XI- INTO PROTON PI- MU- NEUTRINO                938+ 139+ 105+   0
P13     XI- INTO XIO E- NEUTRINO                       1314+  .5+   0

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                  22  XI- BRANCHING RATIOS

R1      XI- INTO (LAMBDA E- NEU)/(LAMBDA PI-) (UNITS 10**-3)
R1                                                    (P2)/(P1)
R1        1       155 EFFECTIVE DENOM.  CARMONY   63 HBC                 11/67
R1        0       260 EFFECTIVE DENOM.  JAUNEAU   63 HBC                 11/67
R1        0       220 EFFECTIVE DENOM.  BERGE     66 HBC                 11/67
R1        1       155 EFFECTIVE DENOM.  LONDON    66 HBC                 11/67
R1        0       717 EFFECTIVE DENOM.  TRIPPE    67 HBC                 11/67
R1        2      1976 EFFECTIVE DENOM.  HUBBARD   68 HBC                  6/68
R1   H    4   (1.15)    (0.90)    (0.55) HUBBARD  68 RVUE                 6/68
R1   H   HUBBARD 68 (RVUE) INCLUDES ALL ABOVE EVENTS                      6/68
R1        1      4150 EFFECTIVE DENOM.  YEH       74 HBC                  7/75
R1            . . . . . . . . . .
R1   AVG       0.7       0.3       OUR AVERAGE USING ALL THE ABOVE        2/76

R2      XI- INTO (NEUTRON PI-)/(LAMBDA PI-) (UNITS 10**-3)
R2                                                    (P3)/(P1)
R2              5.0    OR LESS             FERRO-LUZ 63 HBC                6/68
R2              1.1    OR LESS             DAUBER    69 HBC                6/68
R2        0     3.0    OR LESS  CL=.90     YEH       74 HBC      760 EFF.DENOM.  7/75

R3      XI- INTO (LAMBDA MU- NEUTRINO)/TOTAL (UNITS 10**-3)
R3                                                    (P4)
R3             12.0    OR LESS             BERGE     66 HBC                6/68
R3              1.3    OR LESS             DAUBER    69 HBC                6/68
R3        1     0.35      0.35             YEH       74 HBC     2859 EFF.DENOM.  7/75

R4      XI- INTO (SIGMAO E- NEUTRINO)/TOTAL (UNITS 10**-3)
R4                                                    (P5)
R4              3.0    OR LESS             BERGE     66 HBC                6/68
R4              0.5    OR LESS             DAUBER    69 HBC                6/68
R4        0     0.53   OR LESS  CL=.90     YEH       74 HBC     4363 EFF.DENOM.  7/75

R5      XI- INTO (SIGO MU- NEU)/(LAM PI-) (UNITS 10**-3) (P6)/(P1)
R5              5.0    OR LESS             BERGE     66 HBC                7/66
R5        0     0.76   OR LESS  CL=.90     YEH       74 HBC     3026 EFF.DENOM.  7/75

R6      XI- INTO (N E- NEU)/(LAMBDA PI-) (UNITS 10**-3)  (P7)/(P1)
R6             10.0    OR LESS  CL=.90     BINGHAM   65 RVUE               9/66
R6        0     3.2    OR LESS  CL=.90     YEH       74 HBC      715 EFF.DENOM.  7/75

R7      XI- INTO (SIGMAO E- NEU + LAMBDA E- NEU)/TOTAL (10**-3)
R7                                                    (P2+P5)
R7       17     0.68      0.22             DUCLOS    71 OSPK    SEE NOTE D     10/71
R7   D   THIS EXPERIMENT CANNOT DISTINGUISH SIGMAO FROM LAMBDA. THE CABIBBO
R7   D   THEORY PREDICTS SIGMAO RATE ABOUT A FACTOR 6 SMALLER THAN THE
R7   D   LAMBDA.  TO GET A VALUE FOR THE TABLE R7 HAS BEEN AVERAGED WITH R1.

R8      XI- INTO (N MU- NEU)/(LAMBDA PI-) (UNITS 10**-3) (P8)/(P1)
R8        0    15.3    OR LESS  CL=.90     YEH       74 HBC      150 EFF.DENOM. 11/75

R9      XI- INTO (SIGMA- GAMMA)/(LAM PI-) (UNITS 10**-4) (P9)/(P1)
R9        0    11.5    OR LESS  CL=.90     YEH       74 HBC     2000 EFF.DENOM. 11/75

R10     XI- INTO (P PI- PI-)/(LAMBDA PI-) (UNITS 10**-4) (P10)/(P1)
R10       0     3.7    OR LESS  CL=.90     YEH       74 HBC     6200 EFF.DENOM. 11/75

R11     XI- INTO (P PI- E- NEU)/(LAM PI-) (UNITS 10**-4) (P11)/(P1)
R11       0     3.7    OR LESS  CL=.90     YEH       74 HBC     6200 EFF.DENOM. 11/75

R12     XI- INTO (P PI- MU- NEU)/(LAM PI-) (UNITS 10**-4) (P12)/(P1)
R12       0     3.7    OR LESS  CL=.90     YEH       74 HBC     6200 EFF.DENOM. 11/75

R13     XI- INTO (XIO E- NEU)/(LAM PI-) (UNITS 10**-3)   (P13)/(P1)
R13       0     2.3    OR LESS  CL=.90     YEH       74 HBC     1000 EFF.DENOM. 11/75

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                  22  XI- DECAY PARAMETERS

       RELATED TEXT SECTION VI D AND APPENDIX III

A       ALPHA XI-
A   O         (-0.44)    (0.12)          JAUNEAU   63 FBC     SEE NOTE D BELOW  6/68
A   O    62   (-0.73)    (0.23)          SCHNEIDER 63 HBC     SEE NOTE D BELOW  6/68
A       240    -0.5       0.38           BADIER1   64 HBC     SEE NOTE D BELOW  6/68
A       356    -0.62      0.13           CARMONY   64 HBC     SEE NOTE D BELOW  6/68
A      1004    -0.365     0.068          BERGE     66 HBC     SEE NOTE D BELOW  6/68
A   L   364    -0.47      0.13           LONDON    66 HBC     SEE NOTE D BELOW  6/68
A             (-0.391)   (0.032)         BERGE 2   66 RVUE  INCLUDES ALL ABOVE  9/66
A    M 2529   (-0.375)   (0.051)         MERRILL   68 HBC                       6/68
A      2781    -0.391     0.045          DAUBER    69 HBC     SEE NOTE A BELOW
A      2724    -0.383     0.065          BINGHAM   70 OSPK                     10/70
A       820    -0.42      0.11           MAYEUR    72 HLBC    2.1 GEV/C K-      1/73
A      4303    -0.376     0.038          BALTAY    74 HBC     1.75 GEV/C K-     3/74
A      2436    -0.39      0.05           COOL      74 OSPK -  1.8 GEV/C K-P    10/74
A     B 414    -0.40      0.19           DIBIANCA  75 DBC     4.9 GEV/C K-D     1/77*
A   O   OLD DATA NOT INCLUDED IN AVERAGE.
A   D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A   D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)               6/68
A  L    LONDON 66 USES ALPHA-LAMBDA = 0.62
A    M  DATA OF MERRILL 68 INCLUDED IN DAUBER 68.
A    A  USED ALPHA LAMBDA = 0.647 +- 0.020.
A     B DIBIANCA 75 USES ALPHA LAMBDA = 0.647.                              1/77*
A            . . . . . . . . . .
A    AVG      -0.392     0.021    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A    STUDENT  -0.391     0.023    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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F        PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)
F   D        (-16.0)    (45.0)            JAUNEAU    63 FBC     SEE NOTE D BELOW  6/68
F   D    62  (45.0)     (36.0)            SCHNEIDER 63 HBC      SEE NOTE D BELOW  6/68
F       356   54.0       30.0             CARMONY    64 HBC     SEE NOTE D BELOW  6/68
F      1004    0.        12.              BERGE      66 HBC     SEE NOTE D BELOW  6/68
F   L   364    0.0       20.4             LONDON     66 HBC     SEE NOTE D BELOW  6/68
F    M 2529   (9.8)     (11.6)            MERRILL    68 HBC                       6/68
F      2781  -14.        11.              DAUBER     69 HBC     SEE NOTE A BELOW
F      2724  -26.0       30.0             BINGHAM    70 OSPK                     10/70
F      4303   11.0        9.0             BALTAY     74 HBC     1.75 GEV/C K-     3/74
F      2436    5.0       16.0             COOL       74 OSPK -  1.8 GEV/C K-P    10/74
F   D    OLD DATA NOT INCLUDED IN AVERAGE.
F   D    ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F   D    POLARIZATION. (SEE DAUBER 68 FOR DETAILED DISCUSSION)
F   L    LONDON 66 USES ALPHA-LAMBDA = 0.62
F    M   DATA OF MERRILL 68 INCLUDED IN DAUBER 68.
F    A   USED ALPHA LAMBDA = 0.647 +- 0.020.
F             . . . . . . . . .
F    AVG        2.0        5.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
F    STUDENT    2.0        6.2      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                    (SEE IDEOGRAM BELOW )
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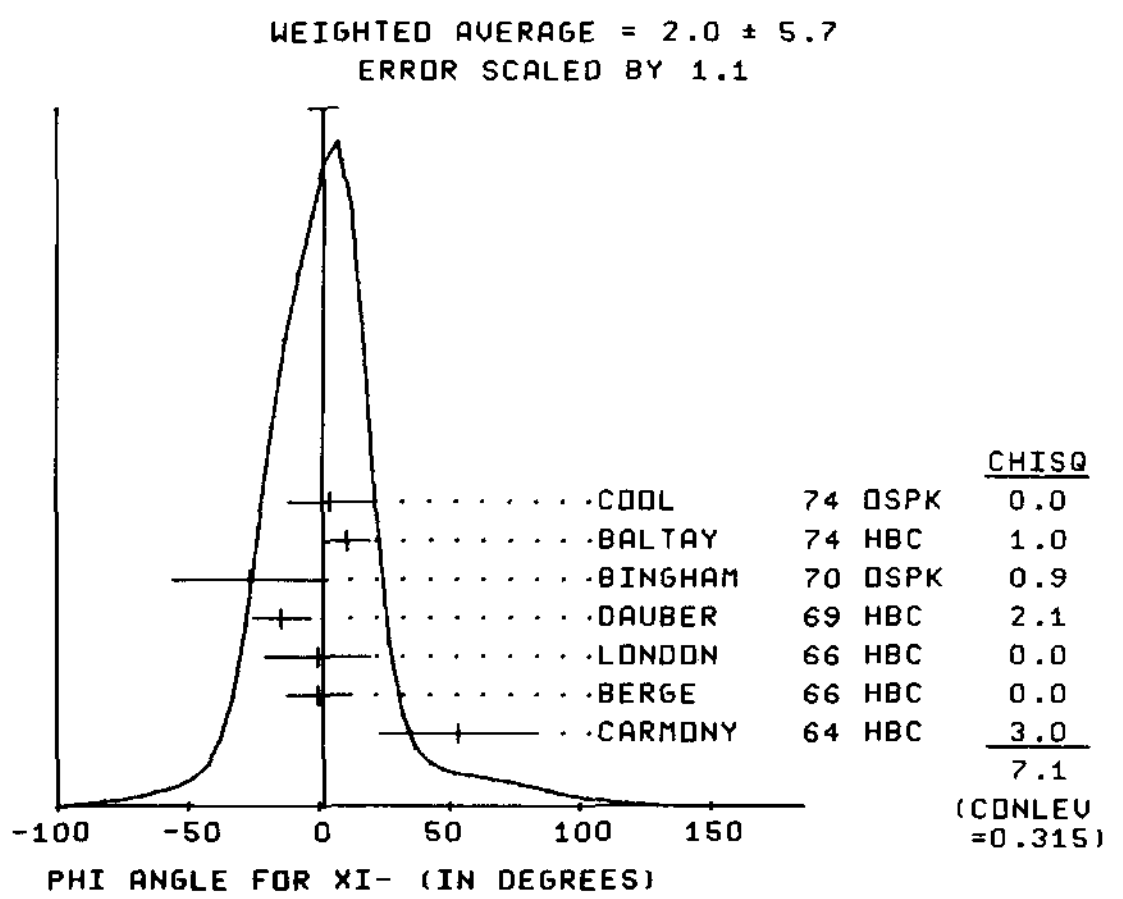

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REFERENCES FOR XI-


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FOWLER    61 PRL 6 134            FOWLER,BIRGE,EBERHARD,ELY,GOOD,POWELL+(LRL)
WANG      61 JETP 13 512          K WANG,T WANG,VIRYASOV,TING,SOLOVEV+ (JINR)
BROWN     62 PRL 8 255            BROWN,CULWICK,FOWLER,GAILLOUD +  (BNL+YALE)

CARMONY   63 PRL  10  381         CARMONY,PJERROU                      (UCLA)
FERRO-LU  63 PR 130 1568          FERRO-LUZZI,ALSTON,ROSENFELD,WOJCICKI (LRL)
JAUNEAU   63 SIENA CONF 4         JAUNEAU+        (EPOL+CERN+LOUC+RHEL+BERGEN)
    ALSO  63 PL  5  261           JAUNEAU,+       (EPOL,CERN,LOUC,RHEL,BERGEN)
SCHNEIDE  63 PL 4 360             H SCHNEIDER                          (CERN)

CARMONY   64 PRL 12 482           CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA) J
BADIERI   64 DUBNA CONF I 593     BADIER,DEMOULIN,BARLOUTAUD+(EPOL,SACL,ZEEM)
HUBBARD   64 PR 135 B 183         HUBBARD,BERGE,KALBFLEISCH,SHAFER +    (LRL)
BINGHAM   65 PRSL  285  202       H H BINGHAM                          (CERN)
PJERROU   65 PRL 14 275           + SCHLEIN,SLATER,SMITH,STORK,TICHO   (UCLA)
PJERROU   65 THESIS               G M PJERROU                          (UCLA)

BERGE     66 PR  147  945         BERGE,EBERHARD,HUBBARD,MERRILL +      (LRL)
BERGE 2   66 BERKELEY CONF 46     BERGE,CABIBBO               (LRL,CERN(RVUE))
LONDON    66 PR 143 1034          LONDON,RAU,GOLDBERG,LICHTMAN+(BNL+SYRACUSE)
CHIEN     66 PR  152  1171        +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
SHEN      67 PL 25 B 443          B.C.SHEN,A.FIRESTONE,G.GOLDHABER  (UCB+LRL)
TRIPPE    67 PRIV. COMM.          T. TRIPPE                            (UCLA)

BURGUN    68 NP B8 447            +MEYER,PAULI,TALLINI, +     (SACL+CDEF+RHEL)
HUBBARD   68 PRL 20 465           HUBBARD,BERGE,DAUBER                  (LRL)
MERRILL   68 PR 167 1202          MERRILL,SHAFER                        (LRL)J

DAUBER    69 PR  179 1272         +BERGE,HUBBARD,MERRILL,MILLER         (LRL)J
BINGHAM   70 PR D1 3010           +COOK,HUMPHREY,SANDER,WILLIAMS+ (UCSD,WASH)
GOLDWASS  70 PR D1 1960           GOLDWASSER, SCHULTZ                   (ILL)
STONE     70 PL 32B 515           +BERLINGHIERI,BROMBERG,COHEN,FERBEL +(ROCH)

DUCLOS    71 NP B32 493           +FREYTAG,HEINTZE,HEINZELMAN,JONES+   (CERN)
MAYEUR    72 NP B47 333           +VAN BINST,WILQUET+   (BRUX+CERN+TUFT+LOUC)
VOTRUBA   72 NP B45 77            VOTRUBA,SAFDER,RATCLIFFE        (BIRM+EDIN)
WILQUET   72 PL 42B 372           +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)

BALTAY    74 PR D9 49             +BRIDGEWATER,COOPER,GERSHWIN+   (COLU+BING)J
COOL      74 PR D10 792           +GIACOMELLI,JENKINS,KYCIA,LEONTIC,LI+ (BNL)
    ALSO  72 PRL 29 1630          COOL,GIACOMELLI,JENKINS,KYCIA,LEONTIC+(BNL)
YEH       74 PR D10 3545          +GAIGALAS,SMITH,ZENOLE,BALTAY + (BING+COLU)
DIBIANCA  75 NP B98 137           F.A.DIBIANCA, R.J.ENDORF             (CARN)
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23 XI0(1314,JP=1/2) I=1/2

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                  23  XI0 MASS (MEV)

M         1 1313.4       1.8           PALMER     68 HBC                   3/68
M        49 1315.2       0.92          WILQUET    72 HLBC                  1/73
M            . . . . . . . . . .
M    AVG     1314.83     0.82    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT1314.84      0.91    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M    FIT     1314.91     0.55   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*
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                  23  (XI-) - (XI0) MASS DIFFERENCE (MEV)

D        23    6.8       1.6            JAUNEAU   63 FBC
D        45   (6.1)     (1.6)           CARMONY   64 HBC    REP BY PJERROU 65
D        88    6.1       0.9            PJERROU   65 HBC                      11/67
D        29    6.9       2.2            LONDON    66 HBC                       6/66
D          . . . . . . . . . .
D    AVG       6.34      0.74   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    STUDENT   6.34      0.80   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
D    FIT       6.41      0.55  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/78*
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                  23  XI0 MEAN LIFE (UNITS 10**-10)

T         24    3.9       1.4       0.80  JAUNEAU   63 FBC
T         45   (3.5)     (1.0)     (0.8)  CARMONY   64 HBC     REP BY PJERROU 65
T        101    2.5       0.4       0.3   HUBBARD   64 HBC
T         80    3.0       0.5             PJERROU   65 HBC                      11/67
T        340    3.07      0.22      0.20  DAUBER    69 HBC                       6/68
T    B   469   (2.85)    (0.20)    (0.18) BRIDGEWAT 72 HBC     1.75 GEV/C K-P    1/73
T   M    157    2.90      0.32      0.27  MAYEUR    72 HLBC    2.1 GEV/C K-      1/74
T   B    652    2.88      0.21      0.19  BALTAY    74 HBC     1.75 GEV/C K-     3/74
T   Z   6300    2.77      0.16            ZECH      77 SPEC NEUTRAL HYP. BEAM   12/77*
T   M    MAYEUR 72 VALUE MODIFIED BY ERRATUM.                                    1/74
T   B    BALTAY 74 INCLUDES BRIDGEWATER 72.                                      3/74
T   Z    ZECH 77 VALUE IS FOR LAMBDA LIFETIME=2.69E-10. FOR LAM LIFETIME        12/77*
T   Z    DIFFERENT FROM THIS, TAUXI0=(2.77-(TAULAMBDA-2.69))E-10.                12/77*
T          . . . . . . . . .
T    AVG        2.903     0.099     0.093  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)
T    STUDENT    2.90      0.11      0.10   AVG BY STUDENT10(H/1.11) -- SEE MAIN TEXT
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                  23  XI0 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI0 INTO LAMBDA PI0                              1115+ 134
P2      XI0 INTO PROTON PI-                               938+ 139
P3      XI0 INTO PROTON E- NEU                            938+  .5+   0
P4      XI0 INTO SIGMA+ E- NEU                           1189+  .5+   0
P5      XI0 INTO SIGMA- E+ NEU                           1197+  .5+   0
P6      XI0 INTO SIGMA+ MU- NEUTRINO                     1189+ 105+   0
P7      XI0 INTO SIGMA- MU+ NEUTRINO                     1197+ 105+   0
P8      XI0 INTO PROTON MU- NEUTRINO                      938+ 105+   0
P9      XI0 INTO LAMBDA GAMMA                            1115+   0
P10     XI0 INTO SIGMA0 GAMMA                            1192+   0
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                  23  XI0 BRANCHING RATIOS

R1      XI0 INTO (PROTON PI-)/(LAMBDA PI0)  (UNITS 10**-5) (P2)/(P1)
R1          2700.    OR LESS              TICHO      63 HBC                    6/68
R1           500.    OR LESS              HUBBARD    66 HBC                    6/68
R1            90.    OR LESS              DAUBER     69 HBC                    6/68
R1        0  180.    OR LESS  CL=.90      YEH        74 HBC     1300 EFF.DENOM. 11/75
R1            3.6    OR LESS  CL=.90      GEWENIGER 75 SPEC                    11/75

R2      XI0 INTO (PROTON E- NEU)/(LAMBDA PI0) (UNITS 10**-3)
R2                                                       (P3)/(P1)
R2           27.0    OR LESS              TICHO      63 HBC                    6/68
R2            6.0    OR LESS              HUBBARD    66 HBC                    6/68
R2            1.3    OR LESS              DAUBER     69 HBC                    6/68
R2        0   3.4    OR LESS  CL=.90      YEH        74 HBC      670 EFF.DENOM. 11/75

R3      XI0 INTO (SIGMA+ E- NEU)/(LAMBDA PI0) (UNITS 10**-3)
R3                                                       (P4)/(P1)
R3           13.0    OR LESS              TICHO      63 HBC                    6/68
R3            7.0    OR LESS              HUBBARD    66 HBC                    6/68
R3            1.5    OR LESS              DAUBER     69 HBC                    6/68
R3        0   1.1    OR LESS  CL=.90      YEH        74 HBC     2100 EFF.DENOM. 11/75

R4      XI0 INTO (SIGMA- E+ NEU)/(LAMBDA PI0) (UNITS 10**-3)
R4                                                       (P5)/(P1)
R4            6.0    OR LESS              HUBBARD    66 HBC                    6/68
R4            1.5    OR LESS              DAUBER     69 HBC                    6/68
R4        0   0.9    OR LESS  CL=.90      YEH        74 HBC     2500 EFF.DENOM. 11/75

R5      XI0 INTO (SIGMA+ MU- NEU)/TOTAL (UNITS 10**-3)   (P6)
R5            7.0    OR LESS              HUBBARD    66 HBC                    6/68
R5            1.5    OR LESS              DAUBER     69 HBC                    6/68
R5        0   1.1    OR LESS  CL=.90      YEH        74 HBC     2100 EFF.DENOM. 11/75

R6      XI0 INTO (SIGMA- MU+ NEU)/TOTAL (UNITS 10**-3)   (P7)
R6            6.0    OR LESS              HUBBARD    66 HBC                    6/68
R6            1.5    OR LESS              DAUBER     69 HBC                    6/68
R6        0   0.9    OR LESS  CL=.90      YEH        74 HBC     2500 EFF.DENOM. 11/75

R7      XI0 INTO (PROTON MU- NEU)/TOTAL (UNITS 10**-3)   (P8)
R7            6.0    OR LESS              HUBBARD    66 HBC                    6/68
R7            1.3    OR LESS              DAUBER     69 HBC                    6/68
R7        0   3.5    OR LESS  CL=.90      YEH        74 HBC      664 EFF.DENOM. 11/75

R8      XI0 INTO (LAMBDA GAMMA)/(LAM PI0) (UNITS 10**-3) (P9)/(P1)
R8        1    5.         5.              YEH        74 HBC      200 EFF.DENOM. 11/75

R9      XI0 INTO (SIGMA0 GAMMA)/(LAM PI0) (UNITS 10**-2) (P10)/(P1)
R9      0-1    6.5   OR LESS  CL=.90      YEH        74 HBC       60 EFF.DENOM. 11/75
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                  23  XI0 DECAY PARAMETER

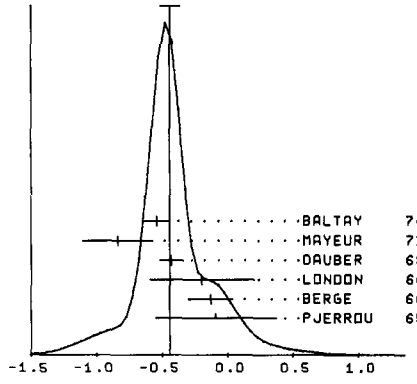
        RELATED TEXT SECTION VI D AND APPENDIX III

A       ALPHA XI 0
A              -0.09      0.46            PJERROU   65 HBC     SEE NOTE D BELOW  6/68
A        146   -0.13      0.17            BERGE     66 HBC     SEE NOTE D BELOW  6/68
A   L     46   -0.2       0.4             LONDON    66 HBC     SEE NOTE D BELOW  6/68
A    M   490  (-0.33)    (0.11)           MERRILL   66 HBC     SEE NOTE D BELOW  6/68
A   A    739   -0.43      0.09            DAUBER    69         SEE NOTE A BELOW
A    B   440  (-0.52)    (0.09)           BRIDGEWAT 72 HBC     1.75 GEV/C K-P    1/73
A        130   -0.84      0.27            MAYEUR    72 HLBC    2.1 GEV/C K-      1/73
A   B    652   -0.54      0.10            BALTAY    74 HBC     1.75 GEV/C K-     3/74
A    A   USED ALPHA LAMBDA = 0.647 +- 0.020.
A    D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A    D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
A   L    LONDON 66 USES ALPHA-LAMBDA = 0.62
A    M   MERRILL 66 REPLACED BY DAUBER 69
A    B   BRIDGEWATER 72 ERROR PURELY STATISTICAL.                                1/73
A   B    BALTAY 74 INCLUDES BRIDGEWATER 72.                                      3/74
A          . . . . . . . . .
A    AVG      -0.441     0.078   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
A    STUDENT  -0.445     0.069   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                 (SEE IDEOGRAM BELOW )
```

Data Card Listings

For notation, see key at front of Listings.


```
                WEIGHTED AVERAGE = -0.441 ± 0.078
                    ERROR SCALED BY 1.3
```

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F      PHI ANGLE  (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGREES)
F      146   -8.      30.          BERGE     66 HBC     SEE NOTE D BELOW  6/68
F   M  490 (107.0)   (46.0)        MERRILL   66 HBC     SEE NOTE D BELOW  6/68
F   A  739   38.      19.          DAUBER    69 HBC     SEE NOTE A BELOW
F   B  440  (11.2)   (14.4)        BRIDGEWAT 72 HBC     1.75 GEV/C K-P    1/73
F   B  652   16.0     17.0         BALTAY    74 HBC     1.75 GEV/C K-     3/74
F    A   USED ALPHA LAMBDA = 0.647 +- 0.020.
F    D   ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F    D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
F    M   MERRILL 66 REPLACED BY DAUBER 69
F    B   BRIDGEWATER 72 ERROR PURELY STATISTICAL.                          1/73
F    B   BALTAY 74 INCLUDES BRIDGEWATER 72.                               3/74
F        . . . . . . . . .
F    AVG     20.7     11.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
F    STUDENT 20.6     13.2     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                              REFERENCES FOR XI0

ALVAREZ   59 PRL 2 215        ALVAREZ,EBERHARD,GOOD,GRAZIANO,TICHO+ (LRL)
JAUNEAU   63 SIENA CONF 1 1   JAUNEAU+       (EPOL+CERN+LOUC+RHEL+BERGEN)
    ALSO  63 PL 4 49          JAUNEAU+       (EPOL+CERN+LOUC+RHEL+BERGEN)
TICHO     63 BNL CONF 410     HAROLD K TICHO                    (UCLA)

CARMONY   64 PRL 12 482       CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA)
HUBBARD   64 PR 135 B 183     HUBBARD,BERGE,KALBFLEISCH,SHAFER +   (LRL)
PJERROU   65 PRL 14 275       + SCHLEIN,SLATER,SMITH,STORK,TICHO   (UCLA)
PJERROU   65 THESIS           G M PJERROU                          (UCLA)

BERGE     66 PR  147  945     BERGE,EBERHARD,HUBBARD,MERRILL +      (LRL)
HUBBARD   66 UCRL 11510       J RICHARD HUBBARD (THESIS,BERKELEY)  (LRL)
LONDON    66 PR 143 1034      LONDON,RAU,GOLDBERG,LICHTMAN+(BNL+SYRACUSE)
MERRILL   66  BERKELEY CONF   MERRILL,SHAFER,BERGE                 (LRL)
    ALSO  66 UCRL 16455       DEANE MERRILL (THESIS, BERKELEY)     (LRL)

PALMER    68 PL 268  323      PALMER,RADOJICIC,RAU,RICHARDSON+ (BNL,SYRA)
DAUBER    69 PR  179 1262     +BERGE,HUBBARD,MERRILL,MILLER        (LRL)

BRIDGEWA  72 NEVIS 195(THESIS) ALBERT BRIDGEWATER                (COLUMBIA)
MAYEUR    72 NP B47 333       +VAN BINST,WILQUET+    (BRUX+CERN+TUFT+LOUC)
    ALSO  73 NP B53 268       ERRATUM TO MAYEUR 72
WILQUET   72 PL 42B 372       +FLIAGINE,GUY,KNIGHT+ (BRUX+CERN+TUFT+LOUC)

BALTAY    74 PR D9 49         +BRIDGEWATER,COOPER,GERSHWIN+   (COLU+BING)J
YEH       74 PR D10 3545      +GAIGALAS,SMITH,ZENDLE,BALTAY + (BING+COLU)
GEWENIGE  75 PL 57B 193       GEWENIGER,GJESDAL,PRESSER +     (CERN+HEID)
ZECH      77 NP B124 413      +DYDAK,NAVARRIA+       (SIEG+CERN+DORT+HEID)

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Ω^-

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        24  OMEGA-(1675,JP=3/2+) I=0
      QUANTUM NUMBERS ASSIGNED FROM SU3
      SPIN 1/2 EXCLUDED BY DEUTSCHMANN 77

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                    24  OMEGA- MASS (MEV)

M   E    1(1615.)                 EISENBERG 54 EMUL                        9/73
M    F   1 1672.1      1.         FRY1      55 EMUL                        9/73
M    F   1 1670.6     (1.)        FRY2      55 EMUL                        9/73
M        1 1675.0      8.0        ABRAMS    64 HBC     INTO XI- PIO
M        3 1673.3      1.0        PALMER    68 HBC     K-P 4.6,5. GEV/C  11/69
M        3 1671.8      0.8        SCHULTZ   68 HBC     K-P 5.5 GEV/C     11/69
M        5 1674.2      1.6        SCOTTER   68 HBC     K-P 6.  GEV/C     11/69
M   B    6(1671.9)    (1.2)       SPETH     69 HBC     K-P 10. GEV/C     11/69
M    B  13 1671.43     0.78       ABCLV     73 HBC     K-P 10. GEV/C     12/73
M    D   4 1673.4      1.7        DIBIANCA  75 DBC     4.9 GEV/C K-D     1/77*
M   E   EISENBERG 54 MASS CALCULATED FOR DECAY IN FLIGHT. ALVAREZ 73 HAS  9/73
M   E   SHOWN THAT THE OMEGA INTERACTED WITH AG NUCLEUS TO GIVE K- XI AG.  9/73
M    F  BOTH FRY EVENTS IDENTIFIED AS OMEGA- BY ALVAREZ 73.               9/73
M    F  FRY MASSES ASSUME DECAY TO LAMBDA K- AT REST.  DECAY FROM ATOMIC  3/74
M    F  ORBIT COULD DOPPLER SHIFT THE K- ENERGY AND RESULTING OMEGA- MASS 3/74
M    F  BY SEVERAL MEV FOR FRY 2.  THIS SHIFT IS NEGLIGIBLE FOR FRY 1    3/74
M    F  BECAUSE THE OMEGA DECAY IS APPROXIMATELY PERPENDICULAR TO ITS     3/74
M    F  ORBITAL VELOCITY, AS IS KNOWN BECAUSE THE LAMBDA STRIKES THE      3/74
M    F  NUCLEUS (L.ALVAREZ, PRIVATE COMM. 1973).  WE HAVE CALCULATED THE  3/74
M    F  ERROR ASSUMING THAT ORBITAL N IS 4 OR LARGER.                     3/74
M    B  ABCLV VALUE INCLUDES THE SPETH 69 EVENTS.                        12/73
M    D  DIBIANCA 75 GIVES MASS FOR EACH EVENT.  WE QUOTE AVERAGE.        1/77*
M        . . . . . . . . .
M   AVG    1672.25     0.41     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1672.24     0.47     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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        24  ANTI-OMEGA+ MASS (MEV)

MB       1 1673.1     1.0            FIRESTONE 71 HBC     12 GEV/C K+D      3/71

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Ω^- Mean Life

There are now two large-statistics measurements of the Ω^- mean life:

$$\tau_{\Omega^-} = \left(1.41\ {}^{+0.15}_{-0.24}\right) \times 10^{-10} \text{ sec (DEUTSCHMANN 77)}$$

$$\tau_{\Omega^-} = \left(0.75\ {}^{+0.14}_{-0.11}\right) \times 10^{-10} \text{ sec (ACNO 78)} .$$

Neither result is published as of this writing, but both are considered final by their authors. The DEUTSCHMANN 77 (ABCLV collaboration) result is from 101 events of the inclusive reaction $K^-p \to \Omega^- +$ anything at 10 and 16 GeV/c, where the Ω^- decays into ΛK^-, $\Xi^0\pi^-$, or $\Xi^-\pi^0$. The ACNO 78 result is from 39 events of the exclusive reactions $K^-p \to \Omega^-K^+K^0$ and $K^-p \to \Omega^-K^+K^+\pi^-$ at 4.2 GeV/c, where the Ω^- is observed in the same decay channels.

The ACNO 78 value is only about half as large as (i.e., about two and a half standard deviations below) the DEUTSCHMANN 77 value. The explanation of this discrepancy is not known. Contamination from Ξ^- decays would increase τ_{Ω^-} and would pose more of a problem for the inclusive events of DEUTSCHMANN 77 than for the exclusive-production, constrained events of ACNO 78. DEUTSCHMANN 77 include an additional ~8% systematic error in their negative error to account for possible Σ^- and/or Ξ^- contamination.

Our 1976 average was based on the lifetimes of individual events listed below and on 16 ABCLV 73 events. We now exclude the individual events from our average because of possible systematic errors. The ABCLV 73 events are included in the DEUTSCHMANN 77 result. We then average the DEUTSCHMANN 77 and ACNO 78 values and multiply the errors by a scale factor S = 2.5 to account for the discrepancy. In the Tables we quote the average value

$$\tau_{\Omega^-} = \left(1.1\ {}^{+0.4}_{-0.3}\right) \times 10^{-10} \text{ sec} \qquad S = 2.5$$

and warn of the discrepancy in a footnote.

Stable Particles

Ω^-, CHARMED BARYONS

Data Card Listings

For notation, see key at front of Listings.

24 OMEGA- MEAN LIFE (UNITS 10**-10 SEC)

T		1	(1.63)			ABRAMS	64 HBC		7/66
T		1	(0.7)			BARNES 1	64 HBC		7/66
T		1	(1.4)			BARNES 2	64 HBC		7/66
T		1	(1.85)			COLLEY	65 HBC		7/66
T		1	(1.5)			RICHARDSO	65 HBC		7/66
T		1	(1.20)			SCHULTZ	68 HBC		11/67
T		1	(0.06)			SCHULTZ	68 HBC		11/67
T		1	(0.63)			SCHULTZ	68 HBC		11/67
T		1	(0.25)			SCOTTER	68 HBC		6/68
T		1	(0.30)			SCOTTER	68 HBC		6/68
T		1	(0.71)			SCOTTER	68 HBC		6/68
T		1	(0.08)			SCOTTER	68 HBC		6/68
T		1	(1.04)			SCOTTER	68 HBC		6/68
T		1	(2.38)			SCOTTER	68 HBC		6/68
T	D	16	(1.39)	(0.45)	(0.31)	ABCLV	73 HBC	K-P 10. GEV/C	12/73
T		1	(0.135)			DIBIANCA	75 DBC	4.9 GEV/C K-D	1/77*
T		1	(0.482)			DIBIANCA	75 DBC	4.9 GEV/C K-D	1/77*
T		1	(0.702)			DIBIANCA	75 DBC	4.9 GEV/C K-D	1/77*
T		1	(0.228)			DIBIANCA	75 DBC	4.9 GEV/C K-D	1/77*
T	D	101	1.41	0.15	0.24	DEUTSCHMA	77 HBC	10,16 GEV/C K- P	2/78*
T		39	0.75	0.14	0.11	ACNO	78 HBC	4.2 GEV/C K- P	2/78*
T	D	DEUTSCHMAN 77 INCLUDES EVENTS OF ABCLV 73.							2/78*
T		* * * * * * * * *							
T	AVG		1.1	0.4	0.3	AVG (ERROR INCL. SCALE FACTOR OF 2.5)			2/78*

24 OMEGA- PARTIAL DECAY MODES

		DECAY MASSES
P1	OMEGA- INTO LAMBDA K-	1115+ 493
P2	OMEGA- INTO XIO PI-	1314+ 139
P3	OMEGA- INTO XI- PIO	1321+ 134

24 OMEGA- BRANCHING RATIOS

R1		OMEGA- INTO LAMBDA K-			(P1)			
R1	F	1	EVENT		FRY1	55 EMUL		11/73
R1	F	1	EVENT		FRY2	55 EMUL		11/73
R1	F	BOTH FRY EVENTS IDENTIFIED BY ALVAREZ 73.						11/73
R1		2	EVENTS		PALMER	68 HBC		11/69
R1		3	EVENTS		SCHULTZ	68 HBC		11/69
R1		5	EVENTS 1 XI PI DECAY AMB.		SCOTTER	68 HBC		11/69
R1		13	EVENTS +2 AMBIG. WITH XI-		ABCLV	73 HBC	K-P 10. GEV/C	12/73
R1		2	EVENTS		DIBIANCA	75 DBC	4.9 GEV/C K-D	1/77*
R2		OMEGA- INTO XIO PI-			(P2)			
R2		5	EVENTS		PALMER	68 HBC		11/69
R2		3	EVENTS		SCOTTER	68 HBC		11/69
R2		3	EVENTS +1 AMBIG. WITH SIG-		ABCLV	73 HBC	K-P 10. GEV/C	12/73
R2		2	EVENTS		DIBIANCA	75 DBC	4.9 GEV/C K-D	1/77*
R3		OMEGA- INTO XI- PIO			(P3)			
R3		1	EVENT		ABRAMS	64 HBC		11/69
R3		1	EVENT		PALMER	68 HBC		11/69
R3		1	EVENT		SCOTTER	68 HBC		11/69
R3		1	EVENT		ABCLV	73 HBC	K-P 10. GEV/C	12/73

24 OMEGA- DECAY PARAMETERS

RELATED SECTION VI D IN TEXT

AL	ALPHA FOR OMEGA- TO K- LAMBDA					
AL	15	-0.66	0.36	0.30	KOCHER 74	10/74

REFERENCES FOR OMEGA-

EISENBER	54 PR 96 541	Y EISENBERG	(CORNELL)
FRY1	55 PR 97 1189	*FRY, SCHNEPS, SWAMI*	(WISC)
FRY2	55 NC 2 346	FRY, SCHNEPS, SWAMI	(WISC)
ABRAMS	64 PRL 13 670	+ BURNSTEIN, GLASSER +	(UMD+NRL)
BARNES 1	64 PRL 12 204	V E BARNES, CONNOLLY, CRENNELL, CULWICK+	(BNL)
BARNES 2	64 PL 12 134	V E BARNES, CONNOLLY, CRENNELL, CULWICK+	(BNL)
COLLEY	65 PL 19 152	COLLEY, DODD +(BIRM+GLAS+LOIC+MPIM+OXF+RHEL)	
RICHARDS	65 BAPS 10 115	RICHARDSON, BARNES, CRENNEL+	(BNL+SYRACUSE)
SAMIOS	65 ARGONNE CONF 189	N P SAMIOS	((RVUE) BNL)
PALMER	68 PL 26B 323	PALMER, RADOJICIC, RAU, RICHARDSON+	(BNL, SYRA)
SCHULTZ	68 PR 168 1509	SCHULTZ+	(ILL, ARGONNE, NORTHWESTERN, WISC)
SCOTTER	68 PL 26B 474	SCOTTER+	(BIRM, GLASGOW, LOIC, MUNICH, OXF)
SPETH	69 PL 29B 252	SPETH+	(AACHEN, BERLIN, CERN, LOIC, VIEN)
FIRESTON	71 PRL 26 410	+GOLDHABER, LISSAUER, SHELDON, TRILLING	(LRL)
ABCLV	73 NP B61 102	AACHEN+BERLIN+CERN+LONDON+VIENNA COLLABOR.	
ALVAREZ	73 PR D8 702	LUIS W. ALVAREZ	(LBL)
KOCHER	74 PL 51B 193	KOCHER, WERNHARD	(INNS+VIEN)
DIBIANCA	*75 NP B98 137*	*F.A.DIBIANCA, R.J.ENDORF*	(CARN)
DEUTSCHM	77 CERN/EP/PH772GREV	DEUTSCHMANN+(AACH+BERL+CERN+INNS+LOIC+VIEN)	
ACNO	78 PRIVATE COMM.	B.JONGEJANS	(CERN+ZEEM+NIJM+OXF COLLAB.)

$\Lambda_c^+(2260)$ and $\Sigma_c(2430)$

There is some evidence for the existence of these charmed baryons, although the evidence is weak compared with that for the charmed D states. The data on the Λ_c^+ are summarized in the section below while the data on the $\Sigma_c(2430)$ are summarized in the Baryon Data Card Listings.

The evidence is quite consistent with the charmed baryon picture.[1,2] A single event, identified with high probability as $\nu p \to \mu^- \Lambda \pi^+ \pi^+ \pi^+ \pi^-$ observed at BNL (CAZZOLI 75) has $\Delta S = -1$ and $\Delta Q = +1$ for the hadrons. For this event, rate arguments indicate a $\Delta S = -\Delta Q$ strength comparable to $\Delta S = \Delta Q$. For noncharmed particles, no $\Delta S = -\Delta Q$ semileptonic processes have been observed, and limits on such rates are a few percent of $\Delta S = \Delta Q$ rates. With charm, such events are expected at rates comparable to $\Delta S = \Delta Q$ rates. Production can occur via the Cabibbo-suppressed transition $\nu d \to \mu^- c$ ($\Delta Q = +1$, $\Delta S = 0$), while the Cabibbo-favored nonleptonic decay involves the transition $c \to s\bar{u}d$ ($\Delta Q = 0$, $\Delta S = -1$) resulting in $\Delta Q = +1$, $\Delta S = -1$ as observed. Thus charm provides a natural explanation for this event. The $(\Lambda 4\pi)^{++}$ mass and one of the $(\Lambda 3\pi)^+$ mass combinations are in good agreement with charm predictions[3] for the lowest lying charmed baryon states with charge +2 and +1 and $J^P = 1/2^+$, the $\Sigma_c^{++}(2430)$ and the $\Lambda_c^+(2260)$.

CAZZOLI 75 state that the most likely alternative to charm for this event is associated production of a missing K_L^0 with a probability of $\simeq 3 \times 10^{-5}$.

We adopt the names Λ_c and Σ_c used by CAZZOLI 75. The name Λ or Σ indicates the isospin (u,d quark) structure, while the subscript c indicates that the strange quark in an uncharmed Λ or Σ has been replaced by a charmed quark giving $c(ud)_{I=0}$ for Λ_c^+ and $c(ud)_{I=1}$ for Σ_c. Alternative names to Λ_c and Σ_c are C_0 and C_1, used e.g. in Ref. 1 and Ref. 2.

Additional charmed baryon evidence comes from Fermilab photoproduction data (KNAPP 76) on the reaction

$$\gamma + \text{Be} \to \bar{\Lambda} + \text{pions} \quad .$$

A narrow peak is observed in $\bar{\Lambda}\pi^-\pi^-\pi^+$ at 2.26 GeV and not in $\bar{\Lambda}\pi^+\pi^+\pi^-$. A higher mass (~2.5 GeV) peak in $(\bar{\Lambda}4\pi)^0$ is seen to cascade into this state. Their results are consistent with being

$$\left.\begin{matrix} \bar{\Sigma}_c^0(2430,\ J^P = 1/2^+) \\ \bar{\Sigma}_c^0(2480,\ J^P = 3/2^+) \end{matrix}\right\} \longrightarrow \bar{\Lambda}_c^-(2260)\pi^+ \longrightarrow \bar{\Lambda}\pi^-\pi^-\pi^+$$

in striking agreement with the CAZZOLI 75 event.

Data Card Listings

For notation, see key at front of Listings.

Uncharmed Σ states are known to exist[4] in the neighborhood of the observed states. However, the narrow width of the $\bar{\Lambda}\pi^-\pi^-\pi^+$ peak and the absence of the opposite-charge state tend to favor the charm interpretation. One disturbing feature of the KNAPP 76 data which is contrary to charm expectations is the absence of a signal in the $\Lambda\pi^+\pi^+\pi^-$ state.

BARISH 77 in an ANL deuterium exposure find one neutrino dilepton candidate, which they identify as

$$\nu_\mu d \rightarrow \mu^- p\pi^+\pi^-\pi^0 e^+\nu_e (n_s) \quad ,$$

where the π^0 is inferred from the observation of a single converted photon, and the neutrino and spectator neutron are not seen. This event has a possible, but highly speculative, interpretation as a semileptonic decay of a charmed baryon:

$$\nu_\mu d \rightarrow \mu^- \Sigma_c^{++}(2430)(n_s)$$

$$\Sigma_c^{++}(2430) \rightarrow p\pi^+\pi^-\pi^0 e^+\nu_e$$

or

$$\Sigma_c^{++}(2430) \rightarrow p\pi^+\pi^-\pi^0\bar{K}^0 e^+\nu_e \quad ,$$

where the $\bar{K}^0$ escaped detection. With the second interpretation and the charm expectation that $\Sigma_c^{++}(2430) \rightarrow \Lambda_c^+\pi^+$, they speculate that they may have observed the semileptonic decay

$$\Lambda_c^+ \rightarrow p\pi^-\pi^0\bar{K}^0 e^+\nu_e \quad .$$

This interpretation would require that mass$(\Sigma_c^{++}) > 2439$ MeV and mass$(\Lambda_c^+) > 2248$ MeV, limits consistent within errors with the CAZZOLI 75 mass values. It would also require a fairly unlikely spectator neutron momentum of 260 MeV. Other interpretations exist for this event including a lighter mass, ~2 GeV charmed baryon or a background non-dilepton event.

References

1. M. K. Gaillard, B. W. Lee, and J. L. Rosner, Rev. Mod. Phys. 47, 277 (1975).
2. B. W. Lee, C. Quigg, and J. L. Rosner, Phys. Rev. D15, 157 (1977).
3. A. De Rujula, H. Georgi, and S. L. Glashow, Phys. Rev. D12, 147 (1975).
4. A. de Bellefon *et al.*, Nuovo Cimento 42A, 403 (1977). See also the $\Sigma(2250)$ and $\Sigma(2455)$ sections of the Baryon Data Card Listings.

See also the reference section in the $\Lambda_c^+(2260)$ Data Card Listings below.

Λ_c^+ →

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                33  LAMBDA/C+(2260,JP= )

                NEEDS CONFIRMATION.
                OMITTED FROM TABLE.
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                33  LAMBDA/C+ MASS (MEV)

M    C   1 2260.      20.            CAZZOLI   75 HBC  +  LAMBDA 2PI+ PI-   3/77*
M    S   1(2360.)   (590.)           SUGIMOTO  75 EMUL     INTO SIGMA PIO    3/77*
M    S   1(2230.)   (560.)           SUGIMOTO  75 EMUL     INTO SIGMA ETAO   3/77*
M    K  60 2260.     (10.)           KNAPP     76 SPEC -   ANTILAM 2PI- PI+  3/77*
M    B   1(2248.)   OR MORE          BARISH    77 DBC      MODE P4 BELOW     3/77*
M    C  CAZZOLI 75 IS BNL EXPT.  SEES (NEUTRINO P --> MU- LAMBDA 3PI+ PI-)  3/77*
M    C  EVENT WITH M(LAMBDA 4PI)=2426+-12MEV.  LARGE DS=-DQ RATE (SAME AS   3/77*
M    C  DS=DQ) SUGGESTS CHARM.  DERUJULA 75 PREDICTS 2 STATES NEAR THIS     3/77*
M    C  MASS WHICH DECAY STRONGLY BY PI+ EMISSION (MASS DIFF 160 AND 220MEV 3/77*
M    C  FOR THE TWO STATES) TO THE LOWEST MASS CHARMED BARYON.  THE THREE   3/77*
M    C  POSSIBLE PI+ EMISSION MASS DIFFS FOR THIS EVT ARE 338+-12, 327+-12  3/77*
M    C  AND 166+-15MEV.  WE USE THE LATTER FOR THE ABOVE QUOTED MASS.       3/77*
M    S  SUGIMOTO 75 VALUES ASSUME DECAY TRACK IDENTIFICATION AS SIGMA+-.    3/77*
M    S  VALUES TAKEN FROM GAISSER 76 TABLE 3. VERY SPECULATIVE INTERP.      3/77*
M    K  KNAPP 76 IS FNAL WIDE BAND PHOTON BEAM ON BE TARG. THEY SEE PEAK IN 3/77*
M    K  ANTILAM 2PI- PI+ BUT NOT IN ANTILAM 2PI+ PI-.  THEY ALSO SEE AN     3/77*
M    K  ANTILAM  2PI+ 2PI- STATE AT 2.5GEV CASCADING VIA PI- EMISSION TO    3/77*
M    K  THE 2.26 GEV STATE.                                                 3/77*
M    B  BARISH 77 IS ANL EXPT.  SEES ONE DILEPTON EVENT WHICH IS CONSISTENT 3/77*
M    B  WITH NEU P --> MU- SIGMA/C++, SIGMA/C++ --> LAMBDA/C+ PI+  AND      3/77*
M    B  LAMBDA/C+ --> P PI- PIO KOBAR E+ NEU.  THIS INTERPRETATION GIVES    3/77*
M    B  ABOVE MASS LIMIT. IT IS A VERY SPECULATIVE INTERPRETATION.          3/77*

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                33  LAMBDA/C+ MEAN LIFE (UNITS 10**-12 SEC)

T    S   1   (4.5)                  SUGIMOTO  75 EMUL     INTO SIGMA PIO    3/77*
T    S   1   (0.68)                 SUGIMOTO  75 EMUL     INTO SIGMA ETAO   3/77*
T    S  SUGIMOTO 75 VALUES ASSUME DECAY TRACK IDENTIFICATION AS SIGMA+-.     3/77*
T    S  VALUES TAKEN FROM GAISSER 76 TABLE 3.  VERY SPECULATIVE.            3/77*

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                33  LAMBDA/C+ WIDTH FROM MASS SPECTRUM

W    C  60   75.    OR LESS          KNAPP     76 SPEC -   ANTILAM 2PI- PI+  3/77*
W    C  KNAPP 76 MEASURES WIDTH 40+-20MEV CONSISTENT WITH THEIR EXPT         3/77*
W    C  RESOLUTION (30MEV) FOR A ZERO WIDTH STATE.                          3/77*

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                33  LAMBDA/C+ PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     LAMBDA/C+ INTO LAMBDA PI+ PI+ PI-                      1115+ 139+ 139+ 139
P2     LAMBDA/C+ INTO SIGMA+ PIO                              1189+ 134
P3     LAMBDA/C+ INTO SIGMA+ ETA                              1189+ 548
P4     LAMBDA/C+ INTO P PI- PIO KO E+ NEU

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N      NOTE ON VERY TENTATIVE MODES P2, P3, AND P4                      3/77*
N       THESE MODES ARE VERY TENTATIVE.  P2 AND P3 ARE FROM SUGIMOTO 75 3/77*
N       (SEE GAISSER 76 REVIEW) AND P4 IS FROM BARISH 77.  EACH IS FROM A 3/77*
N       SINGLE EVENT.  SEE DETAILS IN TYPED REVIEW ABOVE.                3/77*

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                        REFERENCES FOR LAMBDA/C+

CAZZOLI  75 PRL 34 1125      +CNOPS,CONNOLY,LOUTTIT,MURTAGH+          (BNL)
SUGIMOTO 75 PTP 53 1540      +SATO,SAITO                          (TWAS+TOKY)
KNAPP    76 PRL 37 882       +LEE,LEUNG,SMITH +      (COLU+HAWA+ILL+FNAL)
BARISH   77 PR D15 1         +DERRICK,DOMBECK,MUSGRAVE +          (ANL+PURD)

                        THEORY AND REVIEW

DERUJULA 75 PR D12 147       +GEORGI,GLASHOW                          (HARV)
GAISSER  76 PR D14 3153      T.K.GAISSER,F.HALZEN                 (BART+WISC)
LEE      77 PR D15 157       +QUIGG,ROSNER                            (FNAL)

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HEAVY LEPTON SEARCHES

Data on the $\tau^{\pm}(1800)$ heavy lepton are listed in a separate section above, following the e and μ listings.

The following section contains information on searches for heavy leptons of other types and searches for the $\tau^{\pm}$ in collisions other than e^+e^-.

Several types of heavy leptons (that is, non-strongly-interacting fermions other than e and μ) have been proposed. In the Data Card Listings we distinguish four types.[1,2] Each has a corresponding antiparticle with opposite charge and lepton number. For convenience we omit writing the antiparticles in the following descriptions. The four types are:

Sequential Leptons (L^-,ν_L). Such a pair is assumed to have its own separately strictly conserved lepton number $n_L = +1$. This means that the radiative decays

$$\left.\begin{aligned} L^- &\to e^-\gamma \\ L^- &\to \mu^-\gamma \end{aligned}\right\} \quad \text{are forbidden ,}$$

while the weak decays (assuming m_{L^-} sufficiently massive)

$$\left.\begin{aligned} L^- &\to \nu_L\, e^-\bar{\nu}_e \\ L^- &\to \nu_L\, \mu^-\bar{\nu}_\mu \\ L^- &\to \nu_L \text{ hadrons} \end{aligned}\right\} \quad \text{are allowed .}$$

There could be an increasing mass sequence of such pairs. It is frequently assumed that the neutrinos are massless.

Decay rates are assumed calculable from conventional weak interactions theory. For L^- mass between 1 and 3 GeV, the branching fraction to each of the two leptonic modes should be roughly 10% to 20%. For L^- mass above 1 GeV, the mean life should be $\lesssim 10^{-12}$ sec, too short to be observed in a track chamber.[1]

Paraleptons (E^+,E^0) and (M^+,M^0). These pairs have the same lepton numbers as the opposite-charge ordinary leptons, i.e., e^- and μ^-, respectively. Radiative decays are again forbidden and decays similar to those allowed for L^- are allowed here; e.g.,

$$M^+ \to \nu_\mu\, e^+\nu_e$$

or

$$M^+ \to \nu_\mu\, \mu^+\nu_\mu \ .$$

However, the lightest member is not stable as is the case for sequential leptons, so that bizarre decay schemes such as (assuming $m_{E^0} < m_{E^+}$)

$$E^+ \to E^0\, \mu^+\nu_\mu \quad (E^0 \to e^-e^+\nu_e)$$

are allowed.

Heavy leptons of this type (and/or a neutral intermediate boson Z^0) are desired in unified gauge theories of weak and electromagnetic interactions to cancel unphysical high energy behavior in such processes as $e^+e^- \to W^+W^-$.[3]

Ortholeptons $(F^-$ and $N^-)$. These have the same lepton numbers as e^- and μ^-, respectively. They may or may not have associated neutral leptons. Radiative decays are allowed in addition to weak modes similar to those of sequential leptons. The radiative mode can dominate or can be relatively unimportant depending on the model.[4] Decays such as

$$F^- \to e^- + \text{hadrons}$$

are also allowed.

Long-Lived Penetrating Particles. Heavy leptons could have long mean lives under certain circumstances. For example, if $m_{\nu_L} > m_{L^-}$, then L^-, the sequential lepton, is completely stable since its lepton number is conserved.

Experimental Results. The results are summarized in the Data Card Listings below. Mass limits for all types are listed together in subsection M. Mass information on the $\tau^{\pm}(1800)$ is no longer included here but has been moved into the new $\tau^{\pm}(1800)$ section.

The Listings also contain cross-section upper limits reported as results of unsuccessful searches. We no longer list cross sections for anomalous eμ events in e^+e^- collisions. These cross sections are consistent with coming from $e^+e^- \to \tau^+\tau^-$ where the $\tau^{\pm}(1800)$ is assumed to be a spin-1/2 Dirac point particle with a mass about 1800 MeV.

Data Card Listings

For notation, see key at front of Listings.

References

1. M. L. Perl and P. Rapidis, SLAC-PUB-1496 (October 1974).
2. C. H. Llewellyn Smith, Invited paper presented at the Royal Society Meeting on New Particles and New Quantum Numbers, 11 March 1976, Oxford Ref. 33/76.
3. J. D. Bjorken and C. H. Llewellyn Smith, Phys. Rev. D7, 887 (1973).
4. F. Wilczek and A. Zee, Nucl. Phys. B106, 461 (1976).


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      PROPERTIES OF THE TAU+-(1800) HEAVY LEPTON AND ITS ASSOCIATED
      NEUTRINO ARE LISTED SEPARATELY ABOVE FOLLOWING THE E AND MU
      LISTINGS.  THE FOLLOWING SECTION CONTAINS INFORMATION ON SEARCHES
      FOR HEAVY LEPTONS OF OTHER TYPES AND SEARCHES FOR TAU+- IN
      COLLISIONS OTHER THAN E+E-.  WE LIST MASS LIMITS AND CROSS SECTION
      UPPER LIMITS REPORTED AS NEGATIVE SEARCH RESULTS.  WE NO LONGER
      LIST CROSS SECTIONS FOR THE ESTABLISHED PROCESS E+ E- --> TAU+ TAU-
      AS WAS DONE IN OUR 1977 SUPPLEMENT.

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M     HEAVY LEPTON MASS LIMITS (GEV)
M     H   0     1.0    OR MORE          BEHREND    65 SPEC -  ORTHOELECTRON(F)  6/77*
M     T   NONE BETWEEN .12   AND  .57    BETOURNE   65 SPEC -  ORTHOELECTRON(F)  6/77*
M     U   NONE BETWEEN .3    AND  .7     BUDNITZ    66 SPEC -  ORTHOELECTRON(F)  6/77*
M     R   NONE BETWEEN .2    AND  .92    BARNA      68 CNTR -  LONG-LIVED        6/77*
M     R   NONE BETWEEN .97   AND 1.03    BARNA      68 CNTR -  LONG-LIVED        6/77*
M     Y   NONE BETWEEN .1    AND 1.3     BOLEY      68 SPEC -  ORTHOELECTRON(F)  6/77*
M     L   NONE BETWEEN .2    AND  .6     LIBERMAN   69 OSPK -  ORTHOMUON(N)     6/77*
M     W         .490 OR MORE             ROTHE      69 RVUE                      6/77*
M     I   NONE BETWEEN .26   AND 1.32    LICHTENST  70 SPEC -  ORTHOELECTRON(F)  6/77*
M     M   20    (.424)   (.013)   (.002)RAMM       70 HLBC 0  ORTHOMUON(N)     6/77*
M     M   22    (.431)   (.004)         RAMM       71 HLBC -  ORTHOMUON(N)     6/77*
M     S   0     0.1    OR MORE          ANSORGE    73 HBC  -  LONG-LIVED        6/77*
M     B   0     0.6    OR MORE          BACCI      73 ELEC +- ORTHOELECTRON(F)  1/76
M     B   0     2.2    OR MORE          BACCI      73 ELEC +- ORTHOELECTRON(F)  1/76
M     C   0     2.0    OR MORE  CL=.90  BARISH     73 ASPK +  PARAMUON (M)      2/74
M     D   0     1.4    OR MORE  CL=.95  BERNARDIN  73 ASPK +- ANY NON-RAD TYPE  2/74
M     D   0     1.0    OR MORE  CL=.95  BERNARDIN  73 ASPK +- ANY NON-RAD TYPE  2/74
M     N   NONE BETWEEN 0.55 AND 4.5      BUSHNIN    73 CNTR -  LONG-LIVED        2/74
M     E   0     2.4    OR MORE  CL=.90  EICHTEN    73 HLBC +  PARAMUON (M)      3/74
M     J         7.8    OR MORE  CL=.95  HANSON     73 WIRE    ORTHOELECTRON(F)  6/77*
M     A         1.8    OR MORE  CL=.90  ASRATYAN   74 HLBC +- ORTHOMUON (N)    11/75
M     F         8.4    OR MORE  CL=.90  BARISH     74 SPEC +  PARAMUON (M)      7/74
M     G   NONE BETWEEN 0 AND 2.0         GITTLESON  74 SPEC     ORTHOMUON (N)  12/77*
M     O   0     1.15   OR MORE  CL=.95  ORITO      74 ASPK +- ANY NON-RAD TYPE 11/75
M     K   NONE BETWEEN 0.25 AND 2.3      BACCI      77 SPEC +- ORTHOELECTRON(F) 12/77*
M     P         1.2    OR MORE          MEYER      77 SMAG 0  NEUTRAL           12/77*
M
M                                  COMMENTS                                    3/77*
M       LIMITS APPLY ONLY TO HEAVY LEPTON TYPE GIVEN IN COMMENT AT RIGHT ON    3/77*
M       DATA CARD.  SEE REVIEW ABOVE FOR DESCRIPTION OF TYPES.                 3/77*
M       IN COMMENTS BELOW: ALL BEAMS ARE MU TYPE NEUTRINO OR ANTINEUTRINO.     3/77*
M       L,E,M,F,N STAND FOR SEQUENTIAL LEPTON,PARA-ELECTRON,PARA-MUON,         3/77*
M       ORTHO-ELECTRON,ORTHO-MUON RESPECTIVLY.                                 3/77*
M
M     H  BEHREND 65 IS DESY EXPT. LOOKS FOR E P-->F P, F--> E GAMMA.           6/77*
M     H  THIS MASS LIMIT CORRESPONDS TO A LIMIT ON LAMBDA**2 OF 6.25*10**-4.   6/77*
M     T  BETOURNE 65 IS ORSAY EXPT. LOOKS FOR E P -->F P. MASS OF .12          6/77*
M     T  CORRESPONDS TO COUPLING CONSTANT LAMBDA**2 GT .0016, MASS OF .57      6/77*
M     T  TO LAMBDA**2 GT .22.                                                  6/77*
M     U  BUDNITZ 66 IS CEA EXPT. LOOKS FOR E P-->F P.                          6/77*
M     R  BARNA 68 IS SLAC PHOTOPRODUCTION EXPT.                                6/77*
M     Y  BOLEY 68 IS CEA EXPT. LOOKS FOR E P-->F P. MASS OF .1 CORRESPONDS     6/77*
M     Y  TO COUPLING CONSTANT LAMBDA**2 GT 3*10**-4, MASS LIMIT OF 1.3 TO      6/77*
M     Y  LAMBDA**2 GT .01.                                                     6/77*
M     L  LIBERMAN 69 IS A BNL EXPT MEASURING MUON BREMSSTRAHLUNG.              6/77*
M     W  ROTHE 69 EXAMINES PREVIOUS DATA ON MU PAIR PROD AND PI AND K DECAYS   6/77*
M     I  LICHTENSTEIN 70 IS CORNELL EXPT MEASURING E BREMSSTRAHLUNG.           6/77*
M     I  MASS LIMIT DEPENDS ON COUPLING CONSTANT. FIRST VALUE ABOVE IS FOR     6/77*
M     I  LAMBDA**2 GT .17, SECOND IS FOR LAMBDA**2 GT .42.                     6/77*
M     M  RAMM 70 FINDS PEAK IN MU PI COMBINED MASS PRODUCED BY NEUTRINO        6/77*
M     M  INTERACTIONS. HE ALSO CLAIMS EVIDENCE FOR THIS IN KOMU3 DECAYS IN     6/77*
M     M  HBC WHERE PI MU COMBINED MASS PEAKS IN SAME REGION. CLARK 72 FINDS    6/77*
M     M  NO EVIDENCE FOR PI MU PEAK IN HIGH STATISTICS KOL3 EXPT.              6/77*
M     M  RAMM 71 SEES PEAK IN MU GAMMA COMBINED MASS PRODUCED BY NEUTRINOS.    6/77*
M     S  ANSORGE 73 LOOKS FOR ELECTRON PAIR PROD AND ELECTRON-LIKE BREMSS.     6/77*
M     B  BACCI 73 IS FRASCATI E+E- EXPT. LOOKS FOR F --> E GAMMA.              1/76
M     B  MASS LIMIT DEPENDS ON COUPLING CONSTANT LAMBDA FOR THIS DECAY.        1/76
M     B  FIRST VALUE ABOVE IS FOR LAMBDA**2 GT 9*10**-5, 2ND IS FOR            1/76
M     B  LAMBDA**2 GT 10**-3.                                                  1/76
M     C  BARISH 73 IS FNAL 50,145 GEV NEU EXPT.  LOOKS FOR (NEU NUCLEON -->   3/77*
M     C  M+ ANYTHING). ASSUMES (M+ --> MU+ NEU NEU) WITH BR=.3.                3/77*
M     D  BERNARDINI 73 IS FRASCATI E+E- EXPT. FIRST VALUE ASSUMES UNIVERSAL    2/74
M     D  COUPLING TO ORDINARY LEPTONS.  SECOND VALUE ALSO ASSUMES COUPLING     2/74
M     D  TO HADRONS.                                                           2/74
M     N  BUSHNIN 73 IS SERPUKOV 70 GEV P EXPT. MASSES ASSUME MEAN LIFE ABOVE   2/74
M     N  7E-10 AND 3E-8 RESPECTIVELY. CALCULATED FROM CROSS SEC(DOC BELOW)     2/74
M     N  AND 30 GEV MUON PAIR PRODUCTION DATA.                                 2/74
M     E  EICHTEN 73 IS CERN 1-10GEV NEU EXPT. LOOKS FOR M+ PRODUCED IN         2/76
M     E  NEU NUCL --> M+ HADRONS ASSUMING 15 PERCENT DECAY TO E+ NEU NEU.      2/76
M     J  HANSON 73 LOOK FOR DEVIATIONS FROM QED IN E+ E- -->2 GAMMA. THEY      6/77*
M     J  MEASURE THE PRODUCT OF THE F MASS * THE COUPLING CONSTANT LAMBDA,     6/77*
M     J  WHICH IS THE VALUE QUOTED ABOVE.                                      6/77*
M     A  ASRATYAN 74 USES EICHTEN 73 DATA ON NEU NUCL --> E- HADRONS AND       2/76
M     A  ANTINEU NUCL --> E+ HADRONS TO SET LIMITS ON ORTHOMUON PRODUCTION.    2/76
M     F  BARISH 74 IS FNAL 50,135 GEV NEU EXPT.  LOOKS FOR (NEU NUCLEON -->   7/74
M     F  M+ ANYTHING).  ASSUMES (M+ -->MU+ NEU NEU) WITH BR=.3.                7/74
M     G  GITTLESON 74 IS MU P --> P ORTHOMUON SEARCH. COUPLING CONSTANT        12/77*
M     G  LAMBDA**2 IS <.01 FOR MASS UP TO .7 GEV, LIMIT ON LAMBDA**2 RISES     12/77*
M     G  TO <.1 FOR MASS OF 2.0 GEV.                                           12/77*
M     O  ORITO 74 LOOKED FOR H+H- PAIRS GIVING MU-E PAIRS. MASS LIMIT REFERS   3/74
M     G  TO ANY NON-RADIATIVE TYPE HEAVY LEPTON: L, E, M, F, N.                3/74
M     O  COUPLING TO HADRON ASSUMED FROM THEORETICAL MODELS.                   3/74

M     K  BACCI 77 IS SAME TYPE AS BACCI 73. LOWER MASS LIMIT CORRESPONDS TO    12/77*
M     K  LAMBDA**2 LIMIT OF 4*10**-5, UPPER VALUE IS FOR LAMBDA**2 LIMIT OF    12/77*
M     K  1.5*10**-3.                                                           12/77*
M     P  MEYER 77 LOOKS FOR NARROW NEUTRAL RESONANCE IN(E PI)AND(MU PI)         12/77*
M     P  CHANNELS PRODUCED BY E+E- AT 6.8 GEV (ECM). ASSUMED TO BE DECAY       12/77*
M     P  PRODUCT OF THE TAU. SEE SECTION NE BELOW.

NEU     HEAVY LEPTON EVIDENCE (NEUTRINO NUCLEON)
NEU     SEE ALSO SECTION 'Y' IN 'CHARMED HADRON SEARCHES' AND
NEU     SECTION 'T' IN 'OTHER NEW PARTICLE SEARCHES'.
NEU  B   6 TRIMUON EVENTS                BENVENU1  77 NEUL    5/6NEU,1/6NEUBAR  1/78*
NEU  B  10 MU+ MU-, 3 MU- MU- EVENTS     BENVENU2  77 NEUL                       1/78*
NEU  B  BENVENUT1 77 IS FNAL EXPT. TRIMUON EVENTS CAN BE EXPLAINED BY PROD      7/77*
NEU  B  OF A NEW HEAVY LEPTON -->MU- NEUBAR NEW LIGHTER LEPTON --> MU+ MU-      7/77*
NEU  B  NEUTRINO. SEE ALSO BENVENUT2 77, ALBRIGHT 77 AND BARGER 77 FOR         7/77*
NEU  B  FURTHER ANALYSIS. HEAVIER LEPTON HAS M=7 (+3,-1) GEV, LIGHTER HAS      7/77*
NEU  B  M=3.5(+1.5,-.4) GEV.                                                   7/77*
NEU  E  BENVENUT2 77 IS FNAL EXPT WHICH ANALYSES THE DIMUON EVENTS THAT ARE    7/77*
NEU  E  UNLIKELY TO COME FROM CHARM PRODUCTION BECAUSE OF MUON MOMENTA.        7/77*
NEU  E  THEY MAY BE EXPLAINED BY SAME CASCADE DECAY PROCESS AS TRIMUON         7/77*
NEU  E  EVENTS.                                                                7/77*

DC      HEAVY LEPTON PRODUCTION DIFF. CROSS SEC. (P NUCLEON) (CM**2/SR-GEV)
DC   G   0  1.6E-37 OR LESS  CL=.90   GOLOVKIN  72 CNTR- 70GEV P, SERPUKHOV   1/76
DC B     0  4. E-38 OR LESS  CL=.90   BUSHNIN   73 CNTR- 70GEV P, SERPUKHOV   2/74
DC   G  MASS RANGE 1 TO 4.5 GEV,THETA=0,P=25 GEV/C.                            1/76
DC B    BUSHNIN 74 HEAVY LEPTON PATH TRAVERSES 6800 GM/CM**2 ABSORBER.         2/74
DC B    DIFFERENTIAL CROSS-SECTION MEASURED AT P=30 GEV/C THETA= 2 MRAD.       3/74

IC      INVARIANT HEAVY LEPTON PROD. CROSS SEC. (P NUCLEON) (CM**2/GEV**2)
IC   S   0  5.4E-39 OR LESS  CL=.90   CRONIN    74 SPEC -  M=1-6.8 GEV         1/76
IC   B   0  6.4E-35 OR LESS  CL=.90   BINTINGER 75 SPEC +- M=1-5 GEV           2/76
IC   S  CRONIN 74 IS AN FNAL 300 GEV P CU EXPT.  LOOKED FOR LONG LIVED         2/76
IC   S  PENETRATING PARTICLES.  ABOVE LIMIT ASSUMES STABLE.  MULTIPLY IT BY    2/76
IC   S  EXP(1.22E-8*M/TAU) FOR MASS M(GEV) AND LIFETIME TAU(SEC). LIMIT        2/76
IC   S  OBTAINED AT THETA(LAB) = 77 MRAD, PT = 2.38 GEV/C.                     4/77*
IC   B  BINTINGER 75 IS A 30-300 GEV P C EXPT.  LOOKED FOR LONG LIVED          2/76
IC   B  PENETRATING PARTICLES.  ABOVE LIMIT ASSUMES STABLE.  MULTIPLY IT BY    2/76
IC   B  EXP(3.5E-8*M/TAU/P) FOR MASS M(GEV), LIFETIME TAU(SEC), MOM.P(GEV).    2/76
IC   B  OBTAINED AT THETA(LAB) = 91 MRAD, PT = 1~2.25 GEV/C.                   4/77*

CN      NEUTRAL HEAVY LEPTON PRODUCTION CROSS SECTION (CM**2)
CN   K   5 (1. E-37 OR MORE)            KRISHNASW 75 CNTR +0-  M=2-5 GEV       2/76
CN   B   0                              BENVENUTI 75 SPEC  0                   2/76
CN   K  KRISHNASWAMY 75 IS KOLAR GOLD MINE COSMIC RAY EXPT.  TYPICAL EVENT     2/76
CN   K  HAS VERTEX IN AIR 70 CM FROM WALL WITH THREE OBSERVED CHARGED          2/76
CN   K  TRACKS.  AUTHORS SUGGEST NEU+ROCK GIVES NEW PARTICLE WITH MEAN LIFE    2/76
CN   K  10E-9 SEC OR LONGER.  DE RUJULA 75 GIVES ANOTHER INTERPRETATION.       2/76
CN   K  SEE ALSO RAJASEKARAN 75.                                               8/76*
CN   B  BENVENUTI 75 IS AN FNAL EXPERIMENT WHICH ROUGHLY SIMULATES THE         2/76
CN   B  KRISHNASWAMY 75 EXPT. BUT APPARENTLY CONTRADICTS IT, FINDING NO        2/76
CN   B  EVENTS. SENSITIVE TO DECAYS OF NEUTRAL PENETRATING PARTICLES           3/77*
CN   B  PRODUCED BY THE PRIMARY PROTONS OR BY SECONDARY NEUTRINO               3/77*
CN   B  INTERACTIONS IN THE 1 KM. NEUTRINO BEAM EARTH SHIELD.                  3/77*

N       EVIDENCE FOR NEUTRAL HEAVY LEPTON PRODUCED IN NEUTRINO INTERATIONS     12/77*
N    B   1 SEEN                          BARANOV   77 HLBC   0 SERPUKHOV      12/77*
N    B  BARANOV EVENT INTERPRETED AS NEU N --> P 2PI0 NEUTRAL M,LEPTON WITH    12/77*
N    B  M,LEPTON --> MU- E+ NEU. MASS=1.4-2.5 GEV, TAU=6*10**-12 SEC.          12/77*
N    B  EVENT ALSO HAS A POSSIBLE CHARMED PARTICLE INTERPRETATION.             12/77*

MM      UNEXPLAINED MISSING NEUTRAL (HEAVY LEPTON?) MOMENTUM /TOTAL MOMENTUM
MM   E      0.05     0.03              ELLIOT    77 CALO                      1/78*
MM   E  ELLIOT 77 IS SLAC 10.5 GEV PI+ P --> P NPI+- NEUTRALS.  FINDS THAT    1/78*
MM   E  NEUTRAL SPECTRUM CAN BE EXPLAINED BY GAMMA, K0, LAMBDA, NEUTRON.       1/78*

CP      NEUTRAL HEAVY LEPTON PROD. CROSS SEC. (PROTON NUCLEON) (CM**2)
CP   F   0  1. E-29 OR LESS              FAISSNER  76 HLBC 0                    1/77*
CP   F  FAISSNER 76 LIMIT ASSUMES STABLE NEUTRAL WEAKLY INTERACTING LEPTON.    1/77*
CP   F  ALSO RULES OUT DE RUJULA 75 INTERP. OF 5 KRISHNASWAMY 75 EVENTS AS     1/77*
CP   F  (P NUCLEON --> L+ X, L+ --> LO X) UNLESS L+ MASS IS ABOVE 3 GEV.       1/77*

NE      NEUTRAL HEAVY LEPTON PROD. CROSS SECTION (E+ E-)  (CM**2)              12/77*
NE   M      4.5E-36 OR LESS  CL=.90   MEYER     77 SMAG E+E- 6.8 GEV (ECM)    12/77*
NE   M  MEYER 77 EXPT LOOKS FOR NARROW NEUTRAL RESONANCE IN E-PI AND MU-PI     12/77*
NE   M  CHANNELS. VALUE GIVEN IS FOR MASS OF .5 GEV, AND IS PRODUCT OF CS*    12/77*
NE   M  BRITAU--> NEW NEUTRAL LEPTON)*BR(NEUTRAL LEPTON--> E OR MU PI). IF    12/77*
NE   M  MASS OF NEUTRAL LEPTON IS 1.5 GEV, LIMIT BECOMES 2.5E-36. SEE S25M.   12/77*

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                              REFERENCES FOR HEAVY LEPTON SEARCHES

BEHREND   65 PRL 15 900          +BRASSE,ENGLER,GANSSAUGE+          (DESY+KARL)
BETOURNE  65 PL 17 70            +NGUYEN NGOC,PEREZ Y JORBA+              (ORSA)
BUDNITZ   66 PR 141 1313         +DUNNING,GOITEIN,RAMSEY,WALKER,WILSON(HARV)
BARNA     68 PR 173 1391         +COX,MARTIN,PERL,TAN,TONER,ZIPF+(SLAC+STAN)
BOLEY     68 PR 167 1275         +ELIAS,FRIEDMAN,HARTMANN,KENDALL+ (MIT+CEA)

BERNARDI  69 NCL 1 15            BERNARDINI,FELICETTI+      (FRAS+NAPL+ROMA)
LIBERMAN  69 PRL 22 663          +HOFFMAN,ENGELS,IMRIE+(HARV+CASE+MCGI+SLAC)
ROTHE     69 NP B10 241            K.W.ROTHE,A.M.WOLSKY                 (PENN)
LICHTENS  70 PR D1 825           LICHTENSTEIN,ASH,BERKELMAN,HARTILL+    (CORN)
RAMM      70 NATURE 227 1323     C.A.RAMM                               (CERN)
    ALSO  72 NATURE 237 388      CLARK,ELIOFF,FIELD,FRISCH,JOHNSON+     (LBL)

RAMM      71 NAT.PH.SC.230 145 C.A.RAMM                                 (CERN)
GOLOVKIN  72 PL 42B 136          +GRACHEV,KHODYREV,KUBAROVSKY+          (SERP)
ANSORGE   73 PR D7 26            +BAKER,KRZESINSKI,NEALE,RUSHBROOKE+    (CAVE)
BACCI     73 PL 44B 530          +PARISI,PENSO,SALVINI,STELLA+    (ROMA+FRAS)
BARISH    73 PRL 31 410          +BARTLETT,BUCHHOLZ,HUMPHREY+           (CIT+FNAL)

BERNARDI  73 NC 17A 383          BERNARDINI,BOLLINI,BRUNINI+(CERN+BGNA+FRAS)
    ALSO  70 LNC 4 1156          ALLES-BORELLI,BERNARDINI,BOLLINI+      (CERN)
BUSHNIN   73 NP B58 476          +DUNAYTZEV,GOLOVKIN,KUBAROVSKY +       (SERP)
    ALSO  72 PL 42B 136          GOLOVKIN,GRACHEV,SHODYREV +            (SERP)
EICHTEN   73 PL 46B 281          +DEDEN+(AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)
HANSON    73 NCL 7 587           +LEONG,NEWMAN,LAW,LITKE+(MIT+HARV+CEA+HAIF)

ASRATYAN  74 PL 49B 488          +GERSHTEIN,KAFTANOV,KUBANTZEV,LAPIN+ (SERP)
BARISH    74 PRL 32 1387         +BARTLETT,BUCHHOLZ,MERRITT +           (CIT+FNAL)
CRONIN    74 PR D10 3093         +FRISCH,SHOCHET,BOYMOND,MERMOD + (EFI+PRIN)
GITTLESO  74 PR D10 1379         GITTLESON,KIRK+          (HARV+ROCH+COLU+FNAL)
ORITO     74 PL 48B 165          +VISENTIN,CERADINI,CONVERSI +    (FRAS+ROMA)

BENVENUT  75 PRL 35 1486         BENVENUTI,CLINE,FORD+ (HARV+PENN+WISC+FNAL)
BINTINGE  75 PRL 34 982          BINTINGER,CURRY+          (EFI+HARV+PENN+WISC)
BACCI     77 PL 71B 227          +DEZORZI,PENSO,STELLA+          (ROMA+FRAS)
KRISHNAS  75 PL 57B 105          KRISHNASWAMY,MENON+           (BOMBAY+OSAKA)
    ALSO  75 PRL 35 628          DE RUJULA,GEORGI,GLASHOW                (HARV)
    ALSO  75 PRAMANA 5 78        RAJASEKARAN,SARMA                       (TATA)

FAISSNER  76 PL 60B 401          +HASERT+(AACH+BELG+CERN+EPOL+MILA+OXF+LOUC)
BARANOV   77 PL 70B 269          +VOLKOV,GERSHTEIN,IVANILOV +             (SERP)
BENVENU1  77 PRL 38 1110         BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)
    ALSO  77 PRL 38 1187         ALBRIGHT,SMITH,VERMASEREN          (FNAL+STON)
    ALSO  77 PRL 38 1190         BARGER,GOTTSCHALK+          (WISC+ZARAGOZA+RHEL)
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BENVENU2 77 PRL 38 1183        BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)

CAVALLIS 77 LNC 20 337         CAVALLI-SFORZA,GOGGI +       (PAVI+PRIN+UMD)
ELLIOT   77 PR D15 1851        +FORTNEY,GOSHAW,LAMSA,LOOS+      (DUKE+ALBA)
MEYER    77 PL 70B 469         +NGUYEN,ABRAMS,ALAM+    (SLAC+LBL+NWES+HAWA)

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INTERMEDIATE BOSON SEARCHES

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M      W BOSON MASS LIMITS (GEV)
M    B   0     1.7    OR MORE  CL=.99   BERNARDIN 65 HYBR +  NEU N, CERN        2/74
M    B   0     2.0    OR MORE  CL=.90   BURNS     65 OSPK +  NEU N, BNL         2/74
M    C   0     3.8    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TO LEP+NEU=.2   2/74
M    C   0     4.5    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TC LEP+NEU=.5   2/74
M    C   0     4.7    OR MORE  CL=.90   BARISH    73 ASPK +  W+ TC LEP+NEU=.8   2/74
M    E   0     5.0    OR MORE  CL=.95   BERGESON  73 ELEC                        1/76
M    U   0 NONE WITH MASS 10-20 GEV     BUSSER    74 WIRE +-0 P-P,52.7 GEV CM   8/76*
M    A   0 NONE WITH MASS 5.5-8.5 GEV ABRAMOV     77 CNTR +-                   12/77*
M    A   ABRAMOV 77 IS 70 GEV P-CU EXPT AT SERP LOOKING AT DIRECT MUONS OF     12/77*
M    A   HIGH TRANSVERSE MOM. RESULT IS MODEL DEPENDENT.                       12/77*
M    B   LOOKED FOR (NEU N) TO (W+ MU- N), W+ TO (MU+ NEU, E+ NEU, OR HORNS)   2/74
M    C   BARISH 73 LOOKED FOR (NEU N) TO (W+ MU- N), W+ TO (MU+ NEU) AT NAL.   2/74
M    C   RESULT GIVEN FOR THREE ASSUMED BR.FRACS. W+ TO (LEPTON NEU)/ALL.      2/74
M    E   BERGESON 73 LOOKED AT ENERGY DISTR OF NEU-INDUCED MUON FLUX UNDER-    1/76
M    E   GROUND. SCALE INVARIANCE OF THE INELASTIC STRUCT FN ASSUMED.          1/76
M    U   BUSSER 74 IS CERN ISR EXPT. LOOKED FOR ELECTRONS OF LARGE             8/76*
M    U   TRANSVERSE MOMENTUM. RESULT QUOTED ABOVE IS MODEL DEPENDENT.          8/76*

C      W BOSON PRODUCTION CROSS SECTION (10**-36 CM**2)
C    A   0     6.0    OR LESS           ANKENBRAN 71 CNTR +- W TO(MU NEU)=1.0   2/74
C    A   ANKENBRANDT 71 LOOKED FOR (P N)TO(W HADRONS), W TO (MU NEU) AT BNL.   2/74
C    A   THIS ASSUMES BR OF W TO MU NEU IS 1.  IN GENERAL THIS VALUE IS        2/74
C    A   6.0/BR, WHERE BR=(W TO MU NEU)/(W TO ALL).                            2/74

S      SCALAR BOSON MASS LIMITS (GEV)
S    C   0    10.0    OR MORE  CL=.90   CONVERSI  73 ASPK  0 E+E- FRASCATI       3/74
S    C   CONVERSI 73 LOOKED FOR QED VIOLATION IN E+E- SCATTERING AT 2.8 GEV    3/74
S    C   AND ASSUMED W BOSON MASS=10 GEV.  FOR MW=15 GEV, MS LIMIT= 6.5 GEV    3/74

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                               REFERENCES FOR INTERMEDIATE BOSON SEARCHES
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BERNARDI 65 NC 38 608          BERNARDINI,BIENLEIN,BOHM,DARDEL,+     (CERN)
BURNS    65 PRL 15 42          +GOULIANOS,HYMAN,LEDERMAN,LEE +  (COLU+BNL)
ANKENBRA 71 PR D3 2582         ANKENBRANDT,LARSEN,LEIPUNER+     (BNL+YALE)

BARISH   73 PRL 31 180         +BARTLETT,BUCHHOLZ,HUMPHREY+     (CIT+FNAL)
BERGESON 73 PRL 31 66          +CASSIDAY,HENDRICKS                  (UTAH)
CONVERSI 73 PL 46B 269         +D'ANGELO,GATTO,PAOLUZI              (ROMA)
BUSSER   74 PL 48B 371         +CAMILLERI,DI LELLA +      (CERN+COLU+ROCK)
ABRAMOV  77 SJNP 25 41         +ANISIMOVA,BONDARENKO,GRIDASOV +     (SERP)
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QUARK SEARCHES

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SEARCHES FOR INTEGRALLY CHARGED QUARKS APPEAR ALONG WITH OTHER
SIMILAR SEARCHES IN 'OTHER NEW PARTICLE SEARCHES' SECTION BELOW.
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Since the last edition, there has been a claim (LARUE 77) that charges of ±1/3 were detected on niobium beads heat-treated on a tungsten substrate using a magnetic levitometer. No non-integral charges were found on niobium beads heat-treated on a niobium substrate. Using a Millikan apparatus, BLAND 77 found no non-integral charges on tungsten particles, but the sensitivity of LARUE 77 is so much greater than BLAND 77 that these experiments may not be inconsistent. Thus, there is still no confirmed evidence for the existence of free quarks.

The best searches for quarks in cosmic rays yield upper limits on the flux of quarks of about 10^{-11} cm^{-2} $ster^{-1}$ sec^{-1}. Cross-section upper limits established from proton accelerator experiments and calculations based on production models[1] imply that free quarks have a mass greater than about 5 GeV. Mass limits from photon and electron beam searches are slightly lower, but more reliable, depending only on the QED calculations for quark pair production. Limits on free quark concentrations in stable matter vary enormously depending on the source of matter and the technique.

We group quark searches by experimental technique — proton accelerators, electron accelerators, cosmic rays, and stable matter. Proton accelerator experiments generally measure quark production cross sections (we quote these in section C), differential cross-section ratios (section AF), or differential cross sections (sections IC and D). Searches with photon or electron beams may measure differential cross sections (section G) and set limits on the quark mass (section M). Cosmic ray experiments measure quark flux (section F), and searches in stable matter measure quark concentration (section RHO). Most of the accelerator and cosmic ray experiments have searched for fractionally charged particles, but some have searched for massive stable particles which would have low velocity. The latter searches are usually sensitive to a range of charges and may appear in the section below on Other New Particle Searches.

We have relied heavily on the recent review of L. W. Jones[2] for data prior to April 1977.

References

1. T. K. Gaisser and F. Halzen, Phys. Rev. D11, 3157 (1975).

2. L. W. Jones, Rev. Mod. Phys. 69, 717 (1977).


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C      QUARK PRODUCTION CROSS SECT. FROM PROTON ACCELERATOR EXPTS. (CM**2)
C        0  2.0E-34 OR LESS  CL=.90   BINGHAM   64  HBC Q= -1/3 M=.5-2.0GEV   3/77*
C        0  1.0E-34 OR LESS  CL=.90   BINGHAM   64 HLBC Q= -2/3 M=.5-2.5GEV   3/77*
C        0  2.0E-35 OR LESS           BLUM      64  HBC Q= -1/3 M=0-2.5GEV    3/77*
C    Z   0  9.5E-36 OR LESS           HAGOPIAN  64  HBC Q= +1/3 M=.5-2.5GEV   3/77*
C        0  1.0E-34 OR LESS           LEIPUNER  64 CNTR Q= -1/3 M=0-2.0GEV    3/77*
C        0  4.0E-34 OR LESS           MORRISON  64  HBC Q= -1/3 M=.5-2.5GEV   3/77*
C        0  1.0E-33 OR LESS           MORRISON  64  HBC Q= -2/3 M=.5-2.5GEV   3/77*
C    W   0  2.0E-35 OR LESS           FRANZINI  65 CNTR Q= -2/3 M=0-2.5GEV    3/77*
C    Y   0  3.2E-39 OR LESS  CL=.90   ALLABY    69 CNTR Q= -1/3 M=2GEV        1/76
C    Y   0  5.5E-38 OR LESS  CL=.90   ALLABY    69 CNTR Q= -2/3 M=2GEV        1/76
C    Y   0  1.8E-35 OR LESS  CL=.90   ALLABY    69 CNTR Q= +1/3 M=2GEV        1/76
C    Y   0  1.0E-35 OR LESS  CL=.90   ALLABY    69 CNTR Q= +2/3 M=2GEV        1/76
C    A   0  4.0E-37 OR LESS  CL=.90   ANTIPOV1  69 CNTR Q= -2/3 M=0-5GEV      2/74
C    A   0  3.0E-39 OR LESS  CL=.90   ANTIPOV2  69 CNTR Q= -1/3 M=4.5-5GEV    1/76
C    A   0  3.0E-37 OR LESS  CL=.90   ANTIPOV2  69 CNTR Q= -2/3 M=2-5GEV      1/76
C    V   0  1.0E-36 OR LESS  CL=.90   ANTIPOV   71 CNTR Q= -4/3 M=4GEV        1/76
C    B   0  3.0E-34 OR LESS           BOTT-BODE 72 CNTR Q=+-1/3 M=0-22GEV     2/74
C    B   0  6.0E-34 OR LESS           BOTT-BODE 72 CNTR Q=+-2/3 M=0-13GEV     2/74
C    P   0  1.0E-32 OR LESS  CL=.90   ALPER     73 SPEC Q=  2/3 M=4-24 GEV    1/76
C    P   0  1.0E-32 OR LESS  CL=.90   ALPER     73 SPEC Q=  4/3 M=4-24 GEV    1/76
C    L   0  1.0E-35 OR LESS           LEIPUNER  73 CNTR Q=  1/3 M=0-12GEV     2/74
C    L   0  1.0E-35 OR LESS           LEIPUNER  73 CNTR Q=  2/3 M=0-12GEV     2/74
C    L   0  5.0E-31 OR LESS           LEIPUNER  73 CNTR Q=  4/3 M=0-12GEV     2/74
C    N   0  5.0E-39 OR LESS  CL=.90   NASH      74 CNTR Q= -1/3 M=4- 9GEV     2/77*
C    N   0  5.0E-38 OR LESS  CL=.90   NASH      74 CNTR Q= -2/3 M=4-11GEV     2/77*
C    F   0  4.0E-35 OR LESS  CL=.90   FABJAN    75 CNTR Q=  1/3 M=0-20 GEV    1/77*
C    F   0  8.0E-35 OR LESS  CL=.90   FABJAN    75 CNTR Q=  2/3 M=0-20 GEV    1/77*
C    Z   HAGOPIAN 64 CROSS SECTION INFERRED FROM FLUX DATA.                   3/77*
C    W   FRANZINI 65 CROSS SECTION INFERRED FROM FLUX DATA.                   3/77*
C    Y   ALLABY 69 IS A CERN 27 GEV P+BE EXPT.  STUDIES MASSES 0-2.7GEV       1/76
C    Y   ASSUMING NN=NNQQ.  CROSS SECTIONS ASSUME ISOTROPIC PROD. IN CM.      1/76
C    Y   CROSS SECTIONS AT 2GEV ARE GIVEN HERE.  SEE FIG.9 FOR MASS DEPEN.    1/76
C    A   ANTIPOV1 69 IS A SERPUKHOV 70 GEV P EXPT.  MASS LIMIT FROM NN=NNQQ.  2/74
C    A   ANTIPOV1 69 AND ANTIPOV2 69 ARE SERPUKHOV 70GEV P EXPTS.  ANTIPOV2   1/76
C    A   GIVES RESULTS FOR M=2-5GEV ASSUMING NN-->NNQQ, HADRONIC OR LEPTONIC  1/76
C    A   QUARKS.  WE QUOTE TYPICAL VALUES.                                    1/76
C    V   ANTIPOV 71 IS A SERPUKHOV 70 GEV P+AL EXPT.  STUDIES DIQUARK MASSES  1/76
C    V   1.9-4.4GEV.  WE SHOW 4GEV VALUE.  SEE THEIR FIG.2 FOR MASS DEPEN.    1/76
C    B   BOTT-BODENHAUSEN 72 IS A CERN ISR 26+26 GEV P+P EXPERIMENT.          2/74
C    P   ALPER 73 IS CERN ISR 26+26 GEV P+P EXPT. ASSUMES ISOTROPIC C.M.      1/76
C    P   PRODUCTION.  SENSITIVE TO ANY Q>2/3.                                 1/76
C    L   LEIPUNER 73 IS AN NAL 300 GEV P EXPERIMENT.                          2/74
C    N   NASH 74 IS FNAL EXPT USING 200 AND 300 GEV PROTONS. SEE FIG 2,PG861  2/77*
C    N   FOR OTHER MASS VALUES AND VARIOUS PRODUCTION MECHANISMS.             2/77*
C    F   FABJAN 75 IS CERN ISR P+P EXPT AT ECM=53 GEV. INCLUDES RESULTS       1/77*
C    F   OF BOTT-BODE 72 EXPT.                                                1/77*
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Data Card Listings

For notation, see key at front of Listings.

Stable Particles

QUARK SEARCHES

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AF       QUARK PRODUCTION FLUX (FLUX QUARKS / FLUX CHARGED PARTICLES)
AF F      0     0.0     6.0E-10            FABJAN     75 CNTR    M=0-20 GEV        2/78*
AF    B   0  1.78E-9 OR LESS  CL=.90   BASILE     77 SPEC Q= +1/3 M=0-26GEV     1/78*
AF    B   0  1.05E-9 OR LESS  CL=.90   BASILE     77 SPEC Q= -1/3 M=0-26GEV     1/78*
AF F     FABJAN 75 REPORTS BOTH FLUX AND CROSS SECTION (ABOVE)
AF    B  BASILE 77 IS A CERN-ISR EXP AT ECM=62.2 GEV COVERING PT UP TO 1 GEV  2/78*
AF    B  BASILE 77 FIND ONE QUARK CANDIDATE WITH M .LT. .169 GEV.             2/78*
AF    B  THEY DO NOT CLAIM THIS AS A QUARK.                                   2/78*

IC       QUARK INVARIANT PROD. CROSS SECT. FROM PROTON ACCEL. (CM**2/GEV**2)
IC    T   0  5.1E-39 OR LESS  CL=.90   ANTREASYA 77 SPEC Q= +1/3 M=0-6.3 GEV 11/77*
IC    T   0  8.8E-39 OR LESS  CL=.90   ANTREASYA 77 SPEC Q= -1/3 M=0-6.3 GEV 11/77*
IC    T   0  1.3E-39 OR LESS  CL=.90   ANTREASYA 77 SPEC Q= +2/3 M=0-8   GEV 11/77*
IC    T   0  2.2E-39 OR LESS  CL=.90   ANTREASYA 77 SPEC Q= -2/3 M=0-8   GEV 11/77*
IC    T  ANTREASYAN 77 LOOKS FOR HIGH TRANSVERSE MOM QUARKS IN 400 GEV P-CU  11/77*
IC    T  INTERACTIONS AT FNAL.                                              11/77*

D        QUARK PROD. DIFF. CROSS SEC. FROM PROTON ACCL. EXPTS. (CM**2/SR-GEV)
D     D   0  1.5E-36 OR LESS              DORFAN     65 CNTR BE TARG  M=3-7GEV    2/74
D     D   0  3.0E-36 OR LESS              DORFAN     65 CNTR FE TARG  M=3-7GEV    2/74
D     Y   0  7.2E-39 OR LESS  CL=.90   ALLABY     69 CNTR Q=-1/3  THETA= 0 MR   1/76
D     Y   0  5.2E-38 OR LESS  CL=.90   ALLABY     69 CNTR Q=-2/3  THETA=6.5MR   1/76
D     Y   0  2.6E-35 OR LESS  CL=.90   ALLABY     69 CNTR Q=+1/3  THETA=44 MR   1/76
D     Y   0  1.3E-35 OR LESS  CL=.90   ALLABY     69 CNTR Q=+2/3  THETA=44 MR   1/76
D     A   0  7.0E-38 OR LESS  CL=.90   ANTIPOV2   69 CNTR Q=-1/3   M=0-5GEV     1/76
D     A   0  4.0E-38 OR LESS  CL=.90   ANTIPOV2   69 CNTR Q=-2/3   M=0-2.5GEV   1/76
D     V   0  1.6E-36 OR LESS  CL=.90   ANTIPOV    71 CNTR Q=-4/3  THETA=47 MR   1/76
D     V   0  3.8E-36 OR LESS  CL=.90   ANTIPOV    71 CNTR Q=-4/3  THETA=47 MR   1/76
D     N   0  5.6E-36 OR LESS  CL=.90   NASH       74 CNTR Q=-1/3                2/77*
D     N   0  5.0E-35 OR LESS  CL=.90   NASH       74 CNTR Q=-2/3   M GT 1.76    2/77*
D     N   0  8.5E-35 OR LESS  CL=.90   NASH       74 CNTR Q=-2/3   M LT 1.76    2/77*
D     L   0  1.6E-33 OR LESS  CL=.90   ALBROW     75 SPEC Q=+-4/3  M=5-20 GEV   1/77*
D     J   0  5.0E-34 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=1/3  M=7-15 GEV     2/76
D     J   0  2.0E-34 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=1/3  M=15-26 GEV   11/75
D     J   0  1.3E-34 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=2/3  M=10-26 GEV   11/75
D     J   0  8.0E-35 OR LESS  CL=.90   JOVANOVIC 75 CNTR Q=4/3  M=10-26 GEV   11/75
D     B   0  3.9E-36 OR LESS  CL=.90   BALDIN     76 CNTR Q=-2/3  M=1.4-6 GEV   1/77*
D     B   0  2.0E-36 OR LESS  CL=.90   BALDIN     76 CNTR Q=-4/3  M=2.7-12GEV   1/77*
D     D  DORFAN 65 IS A 30 GEV/C P EXPERIMENT AT BNL.   V=.18-.995              2/74
D     Y  SEE FOOTNOTE Y IN SUBSECTION C ABOVE.                                  2/76
D     A  SEE FOOTNOTE A IN SUBSECTION C ABOVE.                                  2/76
D     V  FIRST ANTIPOV 71 VALUE IS FOR M=1.9-2.3,2.7-4.4GEV, SECOND IS FOR      1/76
D     V  M=2.3-2.7GEV.  SEE ALSO NOTE V IN SECTION C ABOVE.                     1/76
D     N  NASH 74 IS FNAL EXPT USING 200 AND 300 GEV PROTONS.  VALUES ARE FOR   2/77*
D     N  A 1MRAD LAB PROD. ANGLE AND OUTGOING MOMENTUM AT MAX OF FOUR BODY     2/77*
D     N  PHASE SPACE FOR QUARK-PAIR PROD.  SEE TABLE I PG. 860 FOR OTHER       2/77*
D     N  LIMITS.                                                               2/77*
D     L  ALBROW 75 IS A CERN ISR EXPT WITH ECM=53 GEV. THETA=40 MR. SEE        1/77*
D     L  FIG. 5 FOR MASS RANGES UP TO 25 GEV.                                  1/77*
D     J  JOVANOVICH 75 FIG.4 COVERS RANGES Q=1/3 TO 2 AND M=3 TO 26 GEV.     11/75
D     J  THIS IS A CERN ISR 26+26, 22+22 GEV P+P EXPERIMENT.                    2/76
D     B  BALDIN 76 IS A 70 GEV SERP EXP.  VALUES ARE PER AL NUCLEUS AT         1/77*
D     B  THETA=0.  ASSUMES STABLE PARTICLE INTERACTING WITH MATTER IN SAME     1/77*
D     B  MANNER AS ANTIPROTON.                                                 1/77*

DG       QUARK PROD. DIFF. CROSS SEC. FROM PHOTOPROD. (CM**2/SR-EQUIV.QUANTA)
DG    G       5.0E-35 OR LESS  CL=.90   GALIK      74 CNTR     THETA=1.2,7 DEG. 11/76*
DG    G  GALIK 74 IS 20 GEV(MAX) GAMMA CU EXPT. USING SLAC 20 GEV SPTRMETER. 11/76*

M        LIMIT ON QUARK MASS FROM ELECTRON ACCELERATORS (GEV/C**2)
M         *LEP QUARK  INDICATES LEPTONIC QUARK
M         *STR QUARK  INDICATES STRONG QUARK
M                .85   OR MORE  CL=.99   BATHOW     67 CNTR Q=1/3   *LEP QUARK   3/77*
M                .90   OR MORE  CL=.99   BATHOW     67 CNTR Q=2/3   *LEP QUARK   3/77*
M                .70   OR MORE  CL=.90   FOSS       67 CNTR Q=1/3   *LEP QUARK   3/77*
M                .84   OR MORE  CL=.90   FOSS       67 CNTR Q=2/3   *LEP QUARK   3/77*
M               1.0    OR MORE           BELLAMY    68 CNTR Q=1/3   *LEP QUARK   3/77*
M               1.5    OR MORE           BELLAMY    68 CNTR Q=2/3   *LEP QUARK   3/77*
M               0.5    OR MORE           BELLAMY    68 CNTR Q=1/3   *STR QUARK   3/77*
M                .75   OR MORE           BELLAMY    68 CNTR Q=2/3   *STR QUARK   3/77*
M     G         3.6    OR MORE  CL=.90   GALIK      74 CNTR Q=1/3   *STR QUARK   7/76*
M     G         4.5    OR MORE  CL=.90   GALIK      74 CNTR Q=2/3   *STR QUARK   7/76*
M     G         1.4    OR MORE  CL=.90   GALIK      74 CNTR Q=1/3   *LEP QUARK   7/76*
M     G         1.8    OR MORE  CL=.90   GALIK      74 CNTR Q=2/3   *LEP QUARK   7/76*
M     G  FIRST TWO MASS LIMITS ARE FOR STRONGLY INTERACTING QUARKS,INFERRED    7/76*
M     G  FROM CROSS-SEC LIMITS USING DRELL MODEL. LAST TWO ARE FOR LEPTONIC    7/76*
M     G  QUARKS. EXPT USES PHOTOPRODUCTION ON COPPER.                          7/76*

F        QUARK FLUX FROM COSMIC RAY EXPERIMENTS  (NUMBER/CM**2-SR-SEC)
F         *TD IN THE RIGHT HAND COLUMNS INDICATES A SEARCH FOR MASSIVE
F            QUARKS USING TIME DELAY AFTER AIR SHOWERS, SENSITIVE TO A RANGE
F            OF CHARGES
F         *AS IN THE RIGHT HAND COLUMNS INDICATES A SEARCH IN AIR SHOWERS
F         ALL SEARCHES ARE AT SEA LEVEL UNLESS OTHERWISE INDICATED
F           0 1.6E-8    OR LESS  CL=.90   BOWEN      64 CNTR Q=-1/3  ALT=2750M    3/77*
F           0 2.0E-7    OR LESS  CL=.90   SUNYAR     64 CNTR Q=1/3                3/77*
F           0 8.7E-9    OR LESS  CL=.90   DELISE     65 CNTR Q=1/3   ALT=2750M    3/77*
F           0 1.8E-8    OR LESS  CL=.90   DELISE     65 CNTR Q=2/3   ALT=2750M    3/77*
F           0 5.0E-8    OR LESS  CL=.90   MASSAM     65 CNTR Q=2/3                3/77*
F     V     0 1.4E-10   OR LESS           BARTON     66 CNTR Q=2/3                3/77*
F           0 1.5E-9    OR LESS  CL=.90   BUHLER-BR 66 CNTR Q=1/3   ALT= 450M    3/77*
F           0 1.4E-9    OR LESS  CL=.90   BUHLER-BR 66 CNTR Q=2/3   ALT= 450M    3/77*
F           0 2.6E-9    OR LESS           KASHA      66 CNTR Q=1/3                3/77*
F           0 2.1E-9    OR LESS           KASHA      66 CNTR Q=2/3                3/77*
F           0 4.5E-10   OR LESS  CL=.90   LAMB       66 CNTR Q=1/3                3/77*
F           0 1.6E-9    OR LESS  CL=.90   LAMB       66 CNTR Q=2/3                3/77*
F     W     0 1.4E-10   OR LESS           BARTON     67 CNTR Q=2/3                3/77*
F     Q     0 1.6E-7    OR LESS           BUHLER-1   67 CNTR Q=4/3   ALT= 450M    3/77*
F     Q     0 4.5E-10   OR LESS  CL=.90   BUHLER-2   67 CNTR Q=1/3   ALT= 450M    3/77*
F     Q     0 1.7E-10   OR LESS           BUHLER-2   67 CNTR Q=2/3   ALT= 450M    3/77*
F           0 1.7E-10   OR LESS  CL=.90   GOMEZ      67 CNTR Q=1/3                3/77*
F           0 3.4E-10   OR LESS  CL=.90   GOMEZ      67 CNTR Q=2/3                3/77*
F           0 2.0E-9    OR LESS  CL=.90   KASHA      67 CNTR Q=2/3                3/77*
F     C     0 3.0E-10   OR LESS           BJORNBOE   68 CNTR M=5GEV OR MORE *TD   2/74
F     R     0 1.8E-10   OR LESS  CL=.90   BRIATORE   68 CNTR Q=1/3                5/76*
F     R     0 1.8E-10   OR LESS  CL=.90   BRIATORE   68 CNTR Q=2/3                5/76*
F     R     0 3.7E-8    OR LESS  CL=.90   BRIATORE   68 CNTR Q=4/3                5/76*
F     Y     0 2.2E-8    OR LESS           FRANZINI   68 CNTR V=.5-.9C  M=2GEV UP  2/74
F           0 6.6E-11   OR LESS  CL=.95   GARMIRE    68 CNTR Q=1/3                3/77*
F           0 8.8E-11   OR LESS  CL=.95   GARMIRE    68 CNTR Q=2/3                3/77*
F           0 3.1E-10   OR LESS  CL=.90   HANAYAMA   68 CNTR Q=1/3                3/77*
F           0 2.4E-8    OR LESS  CL=.95   KASHA1     68 OSPK V=.5-.75C M=5-15GEV  2/74
F           0 1.2E-10   OR LESS  CL=.90   KASHA2     68 CNTR Q=2/3                3/77*
F           0 1.3E-10   OR LESS  CL=.90   KASHA3     68 CNTR Q=4/3                3/77*
F     Z     0 5.0E-11   OR LESS           CAIRNS     69 CC   Q=2/3                3/77*
F     F     0 5.0E-11   OR LESS  CL=.90   FUKUSHIMA 69 CNTR Q=1/3                2/74
F     F     0 7.5E-10   OR LESS  CL=.90   FUKUSHIMA 69 CNTR Q=2/3                2/74
F    M      1  EVENT CLAIMED              MCCUSKER   69 CC   Q=2/3         *AS    2/74
F           0 5.0E-10   OR LESS           BOSIA      70 CNTR Q=1/3   ALT=3500M    1/78*
F           0 2.5E-10   OR LESS           BOSIA      70 CNTR Q=2/3   ALT=3500M    1/78*
F    U      1  EVENT CLAIMED              CHU        70 HLBC               *AS    5/76*
F           0 1.9E-9    OR LESS  CL=.90   FAISSNER   70 CNTR Q=1/3                3/77*
F           0 9.8E-11   OR LESS  CL=.90   KRIDER     70 CNTR Q=1/3   ALT=750M     3/77*
F           0 1.6E-10   OR LESS  CL=.90   KRIDER     70 CNTR Q=2/3   ALT=750M     3/77*
F           0 1.3E-10   OR LESS  CL=.90   CHIN       71 CNTR Q=1/3                3/77*
F           0 5.7E-11   OR LESS  CL=.90   CHIN       71 CNTR Q=1/3   ALT=2770M    3/77*
F           0 3.0E-10   OR LESS  CL=.90   CLARK      71 CC   Q=1/3         *AS    3/77*
F           0 3.0E-11   OR LESS  CL=.90   CLARK      71 CC   Q=2/3         *AS    3/77*
F           0 1.0E-10   OR LESS  CL=.90   HAZEN      71 CC   Q=1/3,2/3     *AS    2/77*
F           0 4.1E-10   OR LESS           BEUCHAMP   72 CNTR Q=4/3   ALT=2750M    3/77*
F           0 1.0E-10   OR LESS  CL=.90   BOHM       72 CNTR Q=1/3         *AS    2/74
F           0 1.0E-10   OR LESS  CL=.90   BOHM       72 CNTR Q=2/3         *AS    2/74
F           0 8.3E-11   OR LESS  CL=.90   COX        72 ELEC Q=1/3   ALT=2750M    3/77*
F           0 9.6E-11   OR LESS  CL=.90   COX        72 ELEC Q=2/3   ALT=2750M    3/77*
F           0 2.2E-10   OR LESS  CL=.90   CROUCH     72 CNTR Q=2/3                3/77*
F     X     0 3.0E-8    OR LESS           DARDO      72                    *TD    3/77*
F           0 4.0E-9    OR LESS  CL=.95   EVANS      72 CC   Q=1/3         *AS    1/77*
F           0 1.5E-9    OR LESS           TONWAR     72 CNTR M.GT.10GEV    *TD    3/77*
F           0 8.0E-11   OR LESS           ASHTON     73 CNTR Q=1/3         *AS    3/77*
F     H     0 1.7E-8    OR LESS  CL=.90   HICKS      73 CNTR Q=1/3                1/76
F     H     0 1.7E-8    OR LESS  CL=.90   HICKS      73 CNTR Q=2/3                1/76
F           0 1.0E-7    OR LESS  CL=.90   CLARK      74 CC   Q=1/6         *AS    1/77*
F           0 7.0E-10   OR LESS  CL=.90   CLARK      74 CC   Q=1/4         *AS    1/77*
F           0 8.0E-11   OR LESS  CL=.90   CLARK      74 CC   Q=1/3         *AS    1/77*
F           0 2.0E-11   OR LESS  CL=.90   CLARK      74 CC   Q=2/3         *AS    1/77*
F     K     0 3.0E-10   OR LESS  CL=.95   KIFUNE     74 CNTR Q=1/3                7/76*
F           0 1.2E-11   OR LESS  CL=.90   HAZEN      75 CC   Q=1/3         *AS    7/76*
F           0 7.0E-11   OR LESS  CL=.90   KRISOR     75 CNTR Q=1/3                3/77*
F           0 5.0E-11   OR LESS  CL=.90   KRISOR     75 CNTR Q=2/3  GAMMA = 10    3/77*
F           0 1.5E-10   OR LESS  CL=.90   KRISOR     75 CNTR Q=2/3  GAMMA GT1000  3/77*
F           0 1.0E-9    OR LESS           BRIATORE   76 ELEC               *TD    1/77*
F     V  BARTON 66 HAD 220000 G/CM**2 EXTRA SHIELDING                          3/77*
F     W  BARTON 67 HAD 6000 G/CM**2 EXTRA SHIELDING                            3/77*
F     Q  BUHLER-1 67 AND BUHLER-2 67 HAD 760 G/CM**2 EXTRA SHIELDING           3/77*
F     C  BJORNBOE 68 -TWO EXPERIMENTS HAVING 1650 AND 3600 G/CM**2 SHIELDING   3/77*
F     R  BRIATORE 68 SEARCHES FOR LEPTONIC QUARKS WITH 6300 G/CM2 SHIELDING    3/77*
F     R  BRIATORE 68 GIVES (1.1+-1.8)E-10 FOR Q=4/3  . WE CONV. TO CL=.90      3/77*
F    Z   CAIRNS 69 OBSERVED 4 POSSIBLE QUARK CANDIDATES                        3/77*
F     Y  FRANZINI 68 MEASURES VELOCITY DIRECTLY BY TOF                         3/77*
F     F  FUKUSHIMA 69 DOES NOT RULE OUT QUARKS HEAVIER THAN 10 GEV.            7/76*
F    M   MC CUSKER 69 CLAIMS 1 CANDIDATE.   LATER SIMILAR EXPTS. SEE NONE.     2/74
F    U   Q=2/3 IF MASS LT 6.5 GEV, Q=1/3 IF MASS = 8 GEV.                      5/76*
F    U   COULD BE AN EARLY-TIME NORMALLY CHARGED COSMIC RAY. SEE ALLISON 70.   2/77*
F     X  DARDO 72 HAD 7000 G/CM**2 EXTRA SHIELDING                             3/77*
F     H  HICKS 73 LOOKED AT LARGE ZENITH ANGLES, THUS USING THE ATMOSPHERE     1/76
F     H  AS AN EXTENDED FILTER FOR HADRONIC QUARKS. THEIR SEARCH PUTS AN       1/76
F     H  UPPER LIMIT ON LEPTONIC QUARK FLUX IN COSMIC RAYS.                    1/76
F     K  KIFUNE 74 LOOKED AT LARGE ZENITH ANGLES. FROM THEIR FLUX LIMIT,THEY   7/76*
F     K  GET A LOWER LIMIT ON QUARK MASS OF 20 GEV.                            7/76*

RHO      QUARK CONCENTRATION IN MATTER (QUARKS PER NUCLEON)
RHO  S    0 1.0E-22  OR LESS              HILLAS     59                         3/77*
RHO  R    0 1.0E-10  OR LESS              BENNETT    66 SOLAR SPECTRUM          3/77*
RHO       0 1.0E-17  OR LESS              CHUPKA     66 METORITES               3/77*
RHO       0 1.0E-16  OR LESS              GALLINARO 66   GRAPHITE LEVITOMETER  . 3/77*
RHO       0 4.0E-19  OR LESS              STOVER     67 IRON LEVITOMETER        2/74
RHO       0 1.0E-17  OR LESS              BRAGINSKI 68 GRAPHITE LEVITOMETER    3/77*
RHO       0 1.0E-20  OR LESS              RANK       68 OIL DROPS               3/77*
RHO  T    0 1.0E-18  OR LESS              RANK       68 SEA WATER               3/77*
RHO  T    0 1.0E-17  OR LESS              RANK       68 SEA SALT, ETC.          3/77*
RHO  T    0 1.0E-18  OR LESS              RANK       68 LAKE WATER              3/77*
RHO  V    0 1.0E-24  OR LESS              COOK       69  SEAWATER               2/74
RHO  V    0 1.0E-23  OR LESS              COOK       69  ROCK SAMPLES           2/74
RHO  V    0 1.0E-23  OR LESS              COOK       69 LAVA                    3/77*
RHO  V    0 5.0E-23  OR LESS              COOK       69 LIMESTONE               3/77*
RHO       0 1.0E-15  OR LESS              ELBERT     70 ION SPECTROMETER        3/77*
RHO       0 5.0E-19  OR LESS              MORPURGO   70 GRAPHITE LEVITOMETER    3/77*
RHO  Z    0 1.0E-21  OR LESS              STEVENS    76 DEEP OCEAN SEDIMENT     3/77*
RHO  Z    0 1.0E-22  OR LESS              STEVENS    76 LUNAR SOIL              3/77*
RHO  B    0 3.0E-18  OR LESS              BLAND      77 TUNGSTEN BEADS          8/77*
RHO       0 3.0E-21  OR LESS              GALLINARO 77 IRON LEVITOMETER        7/77*
RHO  L    1 EVENT  Q=+0.337+-.009         LARUE      77 NIOBIUM-TUNGSTEN LEVITOM 7/77*
RHO  L    1 EVENT  Q=-0.331+-.070         LARUE      77 NIOBIUM-TUNGSTEN LEVITOM 7/77*
RHO  S   HILLAS 59 WAS INSENSITIVE TO QUARKS ACCORDING TO SUNYAR 64.           3/77*
RHO  R   BENNETT 66 LIMIT INFERRED BY JONES 76.                                3/77*
RHO  T   RANK 68 USES U.V. SPECTROSCOPY.                                       3/77*
RHO  V   COOK 69 USES MOLECULAR BEAMS.                                         3/77*
RHO  Z   STEVENS 76 USES AN ION SPECTROMETER.                                  3/77*
RHO  B   BLAND 77 IS A MILLIKAN OIL-DROP TYPE EXPT USING TUNSTEN PARTICLES.    8/77*
RHO  B   NO FRACTIONAL CHARGE WAS FOUND ON A TOTAL SAMPLE OF 3.07E-7 GRAMS     8/77*
RHO  L   LARUE 77 SEES RESIDUAL CHARGE LISTED ABOVE TRANSFERRED TO A           7/77*
RHO  L   NIOBIUM BALL FROM A TUNGSTEN SUBSTRATE, CORRESPONDING TO A DENSITY
RHO  L   OF 1.E-23.

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REFERENCES FOR QUARK SEARCHES


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HILLAS    59 NATURE 184 892     HILLAS,CRANSHAW                             (AERE)

BINGHAM   64 PL 9 201           +DICKINSON,DIEBOLD,KOCH,LEITH+   (CERN+EPOL)
BLUM      64 PRL 13 353A        +BRANDT,COCCONI,CZYZEWSKI,DANYSZ+      (CERN)
BOWEN     64 PRL 13 728         BOWEN,DELISE,KALBACH,MORTARA           (ARIZ)
HAGOPIAN  64 PRL 13 280         +SELOVE,EHRLICH,LEBOY,LANZA,RAHM+(PENN+BNL)
LEIPUNER  64 PRL 12 423         LEIPUNER,CHU,LARSEN,ADAIR          (BNL+YALE)
MORRISON  64 PL 9 199           MORRISON                               (CERN)
SUNYAR    64 PR 136B 1157       SUNYAR,SCHWARZSCHILD,CONNORS            (BNL)

DELISE    65 PR 140B 458        DELISE,BOWEN                           (ARIZ)
DORFAN    65 PRL 14 999         +EADES,LEDERMAN,LEE,TING               (COLU)
FRANZINI  65 PRL 14 196         +LEONTIC,RAHM,SAMIOS,SCHWARTZ      (BNL+COLU)
MASSAM    65 NC 40A 589         MASSAM,MULLER,ZICHICHI                 (CERN)

BARTON    66 PL 21 360          BARTON,STOCKEL                         (NPOL)
BENNETT   66 PRL 17 1196        W.R.BENNETT                            (YALE)
BUHLER-B  66 NC 45A 520         BUHLER-BROGLIN,FORTUNATO,MASSAM+       (CERN)
CHUPKA    66 PRL 17 60          CHUPKA,SCHIFFER,STEVENS                 (ANL)
GALLINAR  66 PL 23 609          GALLINARO,MORPURGO                     (GENO)
KASHA     66 PR 150 1140        KASHA,LEIPUNER,ADAIR               (BNL+YALE)
LAMB      66 PRL 17 1068        LAMB,LUNDY,NOVEY,YOVANOVITCH            (ANL)

BARTON    67 PRSL 90 87         BARTON                                 (NPOL)
BATHOW    67 PL 25B 163         BATHOW,FREYTAG,SCHULZ,TESCH            (DESY)
BUHLER-1  67 NC 49A 209         BUHLER-BROGLIN,FORTUNATO,MASSAM+       (CERN)
BUHLER-2  67 NC 51A 837         BUHLER-BROGLIN,DALPIAZ,MASSAM,ZICHICH(CERN)
FOSS      67 PL 25B 166         +GARELICK,HOMMA,LOBAR,OSBORNE,UGLUM     (MIT)
GOMEZ     67 PRL 18 1022        +KOBRAK,MOLINE,MULLINS,ORTH,VANPUTTEN+(CIT)
KASHA     67 PR 154 1263        +LEIPUNER,WANGLER,ALSPECTOR,ADAIR(BNL+YALE)
STOVER    67 PR 164 1599        +MORAN,TRISCHKA                        (SYRA)

BELLAMY   68 PR 166 1391        +HOFSTADTER,LAKIN,PERL,TONER     (STAN+SLAC)
BJORNBOE  68 NC B53 241         +DAMGARD,HANSEN,CHATTERJEE+      (BOHR+BERN)
BRAGINSK  68 JETP 27 51         BRAGINSKII,ZELDOVICH,MARTYNOV          (MOSU)
BRIATORE  68 NC 57A 850         +CASTAGNOLI,BOLLINI,MASSAM+      (TORI+CERN)
FRANZINI  68 PRL 21 1013        FRANZINI,SHULMAN                       (COLU)
GARMIRE   68 PR 166 1280        GARMIRE,LEONG,SREEKANTAN                (MIT)

HANAYAMA  68 CJP 46 S734        +HARA,HIGASHI,KITAMURA,MIONO+          (OSAK)
KASHA1    68 PR 172 1297        +STEFANSKI                         (BNL+YALE)
KASHA2    68 PRL 20 217         KASHA,LARSEN,LEIPUNER,ADAIR        (BNL+YALE)
KASHA3    68 CJP 46 S730        KASHA,LARSEN,LEIPUNER,ADAIR        (BNL+YALE)
RANK      68 PR 176 1635        D.M.RANK                               (MICH)
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Stable Particles

MAGNETIC MONOPOLE, CHARM SEARCHES

Data Card Listings

For notation, see key at front of Listings.

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ALLABY   69 NC 64A 75          +BIANCHINI,DIDDENS,DOBINSON,HARTUNG+ (CERN)
ANTIPOV1 69 PL 298 245         +KARPOV,KHRGMOV,LANDSBERG,LAPSHIN+   (SERP)
ANTIPOV2 69 PL 308 576         +BOLDTOV,DEVISHEV,DEVISHEVA,ISAKOV+  (SERP)
CAIRNS   69 PR 186 1394        +MCCKUSKER,PEAK,WOOLCOTT                (SYDNEY)
COOK     69 PR 188 2092        +DEPASQUALI,FRAUENFELDER,PEACOCK +      (ILL)
FUKUSHIM 69 PR 178 2058        FUKUSHIMA,KIFUNE,KONDO,KOSHIBA+         (TOKY)
MCCUSKER 69 PRL 23 658         MCCUSKER,CAIRNS                         (SYDNEY)

BOSIA    70 NC 66A 167         G.BOSIA,L.BRIATORE                      (TORI)
CHU      70 PRL 24 917         CHU,KIM,BEAM,KWAK                (OSU+ROSE+KANS)
  ALSO   70 PRL 25 550         ALLISON,DERRICK,HUNT,SIMPSON,VOYVODIC (ANL)
ELBERT   70 NP 820 217         +ERWIN,HERB,NIELSEN,PETRILAK,WEINBERG(WISC)
FAISSNER 70 PRL 24 1357        +HOLDER,KRISOR,MASON,SAWAF,UMBACH       (AACH)
KRIDER   70 PR D1 835          KRIDER,BOWEN,KALBACH                    (ARIZ)
MORPURGO 70 NIM 79 95          MORPURGO,GALLINARO,PALMIERI             (GENO)

ANTIPOV  71 NP B27 374         +KACHANOV,KUTJIN,LANDSBERG,LEBEDEV + (SERP)
CHIN     71 NC 2A 419          CHIN,HANAYAMA,HARA,HIGASHI,TSUJI        (OSAK)
CLARK    71 PRL 27 51          +ERNST,FINN,GRIFFIN,HANSEN,SMITH+ (LLL+LBL)
HAZEN    71 PRL 26 582         W.E.HAZEN                               (MICH)

BEUCHAMP 72 PR D6 1211         BEUCHAMP,BOWEN,COX,KALBACH              (ARIZ)
BOHM     72 PRL 28 326         +DIEMONT,FAISSNER,FASOLO,KRISOR+        (AACH)
BOTT-BOD 72 PL 40B 693         BOTT-BODENHAUSEN,CALDWELL+       (CERN+MPIM)
COX      72 PR D6 1203         COX,BEUCHAMP,BOWEN,KALBACH              (ARIZ)
CROUCH   72 PR D5 2667         CROUCH,MORI,SMITH                       (CASE)
DARDO    72 NC 9A 319          DARDO,NAVARRA,PENENGO,SITTE             (TORI)
EVANS    72 PRSE A70 143       +FANCEY,MUIR,WATSON                (EDIN+LEED)
TONWAR   72 JPA 5 569          TONWAR,NARANAN,SREEKANTAN               (TATA)

ALPER    73 PL 46B 265           (CERN+LIVP+LUND+BOHR+RHEL+STOH+BERG+LOUC)
ASHTON   73 JPA 6 577          ASHTON,COOPER,PARVARESH,SALEH           (DURH)
HICKS    73 NC 14A 65          +FLINT,STANDIL                          (MANI)
LEIPUNER 73 PRL 31 1226        +LARSEN,SESSOMS,SMITH,WILLIAMS+  (BNL+YALE)

CLARK    74 PR D10 2721        +FINN,HANSEN,SMITH                      (LLL)
GALIK    74 PR D9 1856         +JORDAN,RICHTER,SEPPI,SIEMANN + (SLAC+FNAL)
KIFUNE   74 JPSJ 36 629        +HIEDA,KUROKAWA,TSUNEMOTO,KIMURA+(TOKY+KEK)
NASH     74 PRL 32 858         +YAMANOUCHI,NEASE,SCULLI     (FNAL+CORN+NYU)

ALBROW   75 NP B97 189         +BARBER,BENZ+(CERN+DARE+FOM+LANC+MCHS+UTRE)
FABJAN   75 NP B101 349        +GRUHN,PEAK,SAULI,CALDWELL+      (CERN+MPIM)
HAZEN    75 NP B95 189         +HODSON,WINTERSTEIN,GREEN,KASS+ (MICH+LEED)
JOVANOVI 75 PL 56B 105         JOVANOVICH+ (MANI+AACH+CERN+GENO+HARV+TORI)
KRISOR   75 NC 27A 132         KRISOR                                  (AACH)

BALDIN   76 SJNP 22 264        +VERTOGRADOV,VISHNEVSKII,GRISHKEVICH+(JINR)
BRIATORE 76 NC 31A 553         +DARDO,PIAZZOLI,MANNOCCHI+ (LCGT+FRAS+FREI)
STEVENS  76 PR D14 716         +SCHIFFER, CHUPKA                       (ANL)

ANTREASY 77 PRL 39 513         ANTREASYAN,COCCONI,CRONIN,FRISCH+(EFI+PRIN)
BASILE   77 NC 40A 41          +CARA ROMEO,CIFARELLI,GIUSTI+    (CERN+BGNA)
BLAND    77 PRL 39 369         +BOCOBO,EUBANK,ROYER          (SAN FRAN STATE)
GALLINAR 77 PRL 38 1255        GALLINARO,MARINELLI,MORPURGO            (GENO)
LARUE    77 PRL 38 1011        +FAIRBANK,HEBARD                        (STAN)

                                 REVIEW ARTICLES

ZAITSEV  72 SJNP 15 656        +LANDSBERG                              (SERP)
JONES    76 RMP 69 717         L.W.JONES                               (MICH)
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MAGNETIC MONOPOLE SEARCHES

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C      MONOPOLE PROD. CROSS SECTION - ACCELERATOR EXP.      (CM**2)/NUCLEON
C   A   0   1 E-40 OR LESS  CL=.95   AMALDI     63 EMUL   M=0 TO 3 GEV      12/75
C   A   0   5 E-41 OR LESS  CL=.95   AMALDI     63 EMUL   M=0 TO 3.4 GEV    12/75
C   P   0   2 E-40 OR LESS           PURCELL     63 CNTR   M=0 TO 3 GEV      12/75
C   G   0   4 E-43 OR LESS  CL=.95   GUREVICH    72 EMUL   M=0-5 GEV         3/74
C   C   0   6 E-42 OR LESS  CL=.95   CARRIGAN    73 CNTR Q=1/6-24 DIRAC CHAR  3/74
C   M   0   5 E-42 OR LESS  CL=.95   CARRIGAN    74 CNTR   Q=1/30 TO 24      12/75
C   B   0  2.7E-30 OR LESS           BURKE       75 ASPK                      1/78*
C   N   0   1 E-39 OR LESS  CL=.95   CARRIGAN    75 HLBC   NEU ENERGY=1.0     1/76
C   N   0   4 E-38 OR LESS  CL=.95   CARRIGAN    75 HLBC   NEU ENERGY=5.0     1/76
C   N   0   1 E-37 OR LESS  CL=.95   CARRIGAN    75 HLBC   NEU ENERGY=8.0     1/76
C   E   0   5 E-44 OR LESS  CL=.95   EBERHARD    75 CNTR   M=0 TO 12 GEV      11/75
C   I   0   2 E-36 OR LESS  CL=.95   GIACOMELL   75 PLAS   M=0 TO 20 GEV      2/76
C   A  AMALDI 63 USES 28 GEV PROT BEAM AT CERN PS. FIRST RESULT IS FOR       12/75
C   A  PROTON TARGET, SECOND IS FOR NUCLEON TARGET INSIDE NUCLEUS.           12/75
C   P  PURCELL 63 LOOKS FOR MONOPOLES PRODUCED BY 30 GEV PROT AT THE AGS.    12/75
C   G  GUREVICH 72 IS A SERPUKHOV 70 GEV/C P EXP. MASS LIMIT FROM PP=PPMM    3/74
C   C  CARRIGAN 73 IS NAL 300 GEV P EXP. MASS LIMIT 0-12 GEV FROM PP=PPMM    3/74
C   M  CARRIGAN 74 IS NAL 400 GEV EXP.  MASS LIMIT 0-13.7 GEV/MONOPOLE.      12/75
C   N  CARRIGAN 75 REEXAMINES OLD CERN NEUTRINO EXPTS IN HLBC. NEU ENERGY    1/76
C   N  GIVEN AT RIGHT REPRESENTS NEUTRINO THRESHOLD ENERGY.                  1/76
C   N  THESE VALUES ARE IN UNITS CM**2/NUCLEUS.                              1/76
C   E  EBERHARD 75 USED NAL TARGETS - 300 GEV AND 400 GEV P ON ALUMINUM.     2/76
C   E  Q=1-7 DIRAC CHGS.  USED SAME TYPE OF DETECTOR AS ROSS 73.             2/76
C   I  GIACOMELLI 75 IS CERN ISR EXP., M=0-30 GEV, Q=0.4-2.5 DIRAC CHGS.     2/76
C   B  BURKE 75 EXPT LOOKS FOR MULTIPHOTON EVENTS FROM ANNIHILATION OF       1/78*
C   B  MONOPOLE PAIR. 300 GEV NEUTRON BEAM AT FNAL.                          1/78*

CS     MONOPOLE PROD. CROSS SECTION - SEARCH IN MATTER      (CM**2)/NUCLEON
CS  G   0   5 E-38 OR LESS           GOTO        63 EMUL   M=1 GEV          12/75
CS  G   0   5 E-36 OR LESS           GOTO        63 EMUL   M=10 GEV         12/75
CS  G   0   5 E-33 OR LESS           GOTO        63 EMUL   M=100 GEV        12/75
CS      0   3 E-40 OR LESS  CL=.95   PETUKHOV    63 CNTR   METEORITE        12/75
CS  C   0   1 E-38 OR LESS  CL=.90   CARITHERS   66 ELEC   M=2 GEV          12/75
CS  C   0   7 E-37 OR LESS  CL=.90   CARITHERS   66 ELEC   M=10 GEV         12/75
CS  C   0   1 E-35 OR LESS  CL=.90   CARITHERS   66 ELEC   M=25 GEV         12/75
CS  F   0   5 E-43 OR LESS  CL=.90   FLEISCH1    69 CNTR   M=1 GEV          2/76
CS  F   0   2 E-40 OR LESS  CL=.90   FLEISCH1    69 CNTR   M=10 GEV         2/76
CS  F   0   3 E-37 OR LESS  CL=.90   FLEISCH1    69 CNTR   M=100 GEV        2/76
CS  F   0   5 E-34 OR LESS  CL=.90   FLEISCH1    69 CNTR   M=1000 GEV       2/76
CS  F   0   1 E-29 OR LESS  CL=.90   FLEISCH1    69 CNTR   M=10000 GEV      2/76
CS  K   0   1 E-42 OR LESS  CL=.95   KOLM        71 CNTR   M=1.5 GEV        3/74
CS  K   0   1 E-42 OR LESS  CL=.95   KOLM        71 CNTR   M=10 GEV         3/74
CS  K   0   1 E-37 OR LESS  CL=.95   KOLM        71 CNTR   M=100 GEV        3/74
CS  K   0   1 E-34 OR LESS  CL=.95   KOLM        71 CNTR   M=1000 GEV       3/74
CS  K   0   1 E-31 OR LESS  CL=.95   KOLM        71 CNTR   M=1500 GEV       3/74
CS  R   0   1 E-43 OR LESS  CL=.95   ROSS        73 ELEC   M=2 GEV          3/74
CS  R   0   5 E-41 OR LESS  CL=.95   ROSS        73 ELEC   M=10 GEV         3/74
CS  R   0   5 E-38 OR LESS  CL=.95   ROSS        73 ELEC   M=100 GEV        3/74
CS  G  GOTO 63 EXAMINES MAGNETITE ROCK IN THE ADIRONDACK MOUNTAINS.          12/75
CS  C  CARITHERS 66 LIMITS ABOVE ARE FOR NUCLEON-NUCLEON INTERACTIONS.       12/75
CS  C  LIMITS FOR PHOTONUCLEON PRODUCTION ARE 10**3 TIMES LARGER.            12/75
CS  F  FLEISCHER 69 LOOKED FOR MONOPOLES IN SEDIMENTS AT BOTTOM OF OCEAN     3/74
CS  F  DEPOSITED DURING THE LAST 16 MILLION YEARS. Q=60 DIRAC CHAR.OR LESS   3/74
CS  K  KOLM 71 TRIED TO DETECT MONOP. IN DEEP SEAWATER Q=.2-27 DIRAC CHAR.   2/76
CS  R  ROSS 73 TRIED TO DETECT MONOP. IN LUNAR DUST    Q=.4-36 DIRAC CHAR    2/76
CS  R  OR LARGER CHARGES EXCEPT FOR G= N*36*GO, WITH N INTEGER.  THEY ALSO   3/74
CS  R  REPORT LIMIT OF DENSITY IN LUNAR MATERIAL AS 1.7*10**-4 MONOP./GM.    2/76

F      MONOPOLE FLUX IN COSMIC RAYS (NUMBER/CM**2-SEC-SR)
F       0   1 E-13 OR LESS           GOTO        63 EMUL   KE TO 10**4 GEV  12/75
F       0   5 E-15 OR LESS  CL=.90   CARITHERS   66 ELEC                    12/75
F   F   0   3 E-19 OR LESS  CL=.90   FLEISCH2    69 SCAN   KE TO 10**10 GEV 12/75
F       0   2 E-18 OR LESS           KOLM        71 CNTR   KE TO 10**5 GEV  12/75
F   R   0   5 E-19 OR LESS  CL=.95   ROSS        73 ELEC   KE TO 10**4 GEV  12/75
F   P   1  (1 E-13)                  PRICE       75 EMUL   M GT 200 GEV     12/75
F   F  FLEISCHER 2 69 LOOKED FOR MONOPOLE TRACKS LEFT IN OBSIDIAN AND MICA  12/75
F   F  OVER GEOLOGICAL TIMES.                                                12/75
F   R  ROSS 73 INCLUDES DATA OF EBERHARD 71 PAPER.                           12/75
F   P  THE PRICE 75 EVENT COULD BE EXPLAINED AS DUE TO A FRAGMENTING HEAVY   11/76*
F   P  NUCLEUS.  SEE ALVAREZ 75, FLEISCHER 75, FRIEDLANDER 75,AND ROSS 76.   11/76*
F   P  SEE EBERHARD 75 FOR DISCUSSION OF CONFLICT WITH OTHER EXPERIMENTS.    12/75
F   P  NOT CONSIDERED CONVINCING EVIDENCE FOR THE EXISTENCE OF MONOPOLES.    12/75
F   P  HAGSTROM 77 GIVES A REINTERPRETATION AS A HEAVY ANTINUCLEUS.          3/77*

D      MONOPOLE DENSITY IN MATTER     (NUMBER/LITER)
D   S   0  1.6E-4  OR LESS           SCHATTEN    70 ELEC   MOON             4/77*
D   C   0   4.4E-5  OR LESS  CL=.95   CARRIGAN    76 CNTR   AIR              1/77*
D   C   0   1.8E-3  OR LESS  CL=.95   CARRIGAN    76 CNTR   SEA WATER        1/77*
D   S  SCHATTEN 70 EXAMINED SATELITE DATA FOR PERTURBATIONS IN THE LUNAR      4/77*
D   S  MAGNETIC WAKE. LIMIT IS FOR THE DIFFERENCE IN NUMBERS OF NORTH AND    4/77*
D   S  SOUTH MONOPOLES.                                                      4/77*
D   C  CARRIGAN 76 IS SENSITIVE TO MONOPOLES WITH DIRAC CHARGE Q=1/6 TO 24   1/77*
D   C  AND MASS AS LARGE AS (7500 GEV)*Q.                                    1/77*
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REFERENCES FOR MAGNETIC MONOPOLE SEARCHES

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AMALDI   63 NC 28 773          +BARONI,MANFREDINI,BRADNER+(ROMA+UCSD+CERN)
GOTO     63 PR 132 387         +KOLM,FORD                        (TOKY+MIT+BRAN)
PETUKHOV 63 NP 49 87           +YAKIMENKO                              (LEBD)
PURCELL  63 PR 129 2326        +COLLINS,FUJII,HORNBOSTEL,TURKOT (HARV+BNL)
CARITHER 66 PR 149 1070        CARITHERS,STEFANSKI,ADAIR               (YALE)

FLEISCH1 69 PR 184 1393        FLEISCHER,HART,JACOBS+      (GESC+UNCS+GSCO)
   ALSO  70 JAP 41 958         FLEISCHER,HART,JACOBS,PRICE,SCHWARTZ+(GESC)
FLEISCH2 69 PR 184 1398        FLEISCHER,PRICE,WOODS                   (GESC)
   ALSO  70 JAP 41 958         FLEISCHER,HART,JACOBS,PRICE,SCHWARTZ+(GESC)
SCHATTEN 70 PR D1 2245         SCHATTEN                                (NASA)
KOLM     71 PR D4 1285         +VILLA,ODIAN                       (MIT+SLAC)

GUREVICH 72 PL 38B 549         +KHAKIMOV,MARTEMIANOV+      (KIAE+NOVO+SERP)
   ALSO  70 PL 31B 394         GUREVICH,KHAKIMOV +         (KIAE+NOVO+SERP)
   ALSO  72 JETP 34 917        BARKOV, GUREVICH,           (KIAE+NOVO+SERP)
CARRIGAN 73 PR D8 3717         +NEZRICK,STRAUSS                        (FNAL)
ROSS     73 PR D8 698          +EBERHARD,ALVAREZ,WATT             (LBL+SLAC)
   ALSO  71 PR D4 3260         EBERHARD,ROSS,ALVAREZ,WATT         (LBL+SLAC)
CARRIGAN 74 PR D10 3867        +NEZRICK,STRAUSS                        (FNAL)

BURKE    75 PL 60B 113         +GUSTAFSON,JONES,LONGO                  (MICH)
CARRIGAN 75 NP B91 279         +NEZRICK                                (FNAL)
   ALSO  71 PR D3 56           CARRIGAN,NEZRICK                        (FNAL)
EBERHARD 75 PR D11 3099        +ROSS,TAYLOR,ALVAREZ,OBERLACK      (LBL+MPIM)
GIACOMEL 75 NC 28A 21          GIACOMELLI,ROSSI+       (BGNA+CERN+SACL+ROMA)

PRICE    75 PRL 35 487         +SHIRK,OSBORNE,PINSKY          (UCB+HOUSTON)
   ALSO  75 LBL-4260           LUIS ALVAREZ                            (LBL)
   ALSO  75 LBL-4289           PHILIPPE EBERHARD                       (LBL)
   ALSO  75 PRL 35 1412        R.L. FLEISCHER,R.M.WALKER       (GESC+WUSL)
   ALSO  75 PRL 35 1167        M.W. FRIEDLANDER                        (WUSL)
   ALSO  76 LBL-4665           RONALD ROSS                             (LBL)
   ALSO  77 PRL 38 729         RAY HAGSTROM                            (LBL)

CARRIGAN 76 PR D13 1823        +NEZRICK,STRAUSS                        (FNAL)
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CHARM SEARCHES

Data on specific charmed states are listed in separate sections in the appropriate places in the Data Card Listings: D, F, and Λ_c — Stable Particles; D*, F* — Mesons; Σ_c — Baryons.

Evidence for charm not directly relatable to a given state is listed in this section. Neutrino-induced dilepton events are summarized. Short-lived tracks in emulsions are also dealt with, as are cross-section upper limits for charm searches.

Direct lepton production in pN collisions is summarized in the Other New Particle Searches section below rather than in this section, because recent results favor other interpretations than charm. Tri-muon production in neutrino interactions is also summarized in that section.

Neutrino-induced Dilepton Events

Many neutrino experiments have now observed dilepton events. These data are summarized in subsections Y and V0. Bubble chamber experiments have

Data Card Listings

For notation, see key at front of Listings.

Stable Particles

CHARM SEARCHES

observed neutrino-induced $\mu^- e^+$ events associated with strange particle production in the reaction

$$\nu N \rightarrow \mu^- e^+ K^0 (\text{or } \Lambda) + \text{anything} \ .$$

Dilepton events have no conventional explanation. Production of charmed hadrons, heavy leptons, and intermediate bosons have been proposed as potential explanations. Production of charmed particles (C) in neutrino interactions would be expected to give rise to such events via the mechanism

$$\nu_\mu N \rightarrow \mu^- C + \text{hadrons}$$
$$\qquad\qquad\quad \downarrow$$
$$\qquad\qquad\quad \ell^+ \nu_\ell + \text{hadrons} \ ,$$

where the Cabibbo-favored transition would predict a strange particle among the hadrons. Thus the appearance of neutrino-induced dimuon events, $\mu^- e^+$ events, and associated strange particles can be understood via the charm mechanism.

Short-lived Tracks in Emulsions

The mean life of a weakly decaying charmed meson or baryon of mass M (in GeV) is expected to be in the range[1]

$$\tau = (10^{-11} \text{ to } 10^{-13} \text{ sec}) \times 1/M^5$$

with a corresponding mean path length for lab momentum p (in GeV/c) of

$$\ell = \frac{pc\tau}{M} = (1\mu \text{ to } 100\mu) \times p \ .$$

Thus even at Fermilab energies, these would be hard to see as tracks in bubble chambers, so emulsion is used. We list data for these experiments in subsections CC and EM below.

Charm Searches

We list cross-section upper limits for the many unsuccessful charm searches. In cases where limits are given for many channels and mass ranges, we list only a range or a few likely channels and indicate in the comments cards the extent and location of the tables of data included in the paper.

References

1. M. K. Gaillard, B. W. Lee, and J. L. Rosner, Rev. Mod. Phys. 47, 277 (1975).


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      PROPERTIES OF THE CHARMED D, D*, F, F*, LAMBDA/C+, AND SIGMA/C+
      STATES ARE LISTED IN SEPARATE SECTIONS.
      THE FOLLOWING SECTION CONTAINS INFORMATION ON SEARCHES FOR
      OTHER CHARMED PARTICLE STATES AND SEARCHES FOR THE ABOVE STATES
      IN NEW COLLISION PROCESSES.  THESE SEARCH RESULTS ARE USUALLY
      LISTED AS CROSS SECTION UPPER LIMITS.  WE NO LONGER LIST CROSS
      SECTIONS FOR ESTABLISHED PROCESSES LIKE E+ E- --> D DBAR AS WAS
      DONE IN OUR 1977 SUPPLEMENT.

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CE     CHARMED BARYON PRODUCTION IN (E+ E-) COLLISIONS
CE   I                                  PICCOLO    77 SMAG                    1/78*
CE   I  PICCOLO 77 LOOK AT INCLUSIVE PBAR AND LAMBDA PROD IN 3.7-7.6 GEVECM   1/78*
CE   I  E+E- AT SLAC. FINDS SHARP RISE IN CS BETW 4.4 AND 5 GEV. EVIDENCE     1/78*
CE   I  FOR PROD OF CHARMED BARYON IN THAT REGION.                            1/78*

CG     CHARMED HADRON PRODUCTION CROSS SEC (GAMMA NUCLEON)  (CM**2)
CG   K  60 EVENTS                       KNAPP     76 SPEC LAMBDABAR PI-PI-PI+ 2/77*
CG   Q   0  1.1E-31 OR LESS  CL=.95     QUINN     76 HBC     B++ M-           9/77*
CG   Q   0  1.2E-31 OR LESS  CL=.95     QUINN     76 HBC     B+ M0            9/77*
CG   K  KNAPP 76 SEES A PEAK AT M=2.26+-0.01 GEV/C**2. WIDTH IS 40+-20 MEV,  2/77*
CG   K  CONSISTENT WITH ZERO WIDTH STATE (RESOLUTION=30 MEV). NO PEAK SEEN    2/77*
CG   K  IN LAMBDABAR PI+ PI+ PI-. THEY ALSO SEE A LAMBDABAR (4PI)0 PEAK AT   2/77*
CG   K  2.5 GEV CASCADING DOWN TO THE PEAK AT 2.26. EXPT USED WIDE-BAND      2/77*
CG   K  PHOTON BEAM AT FNAL.                                                 2/77*
CG   Q  QUINN 76 USED A 9.3 GEV PHOTON BEAM AT SLAC. SEE TABLES 1 AND 3 FOR  2/77*
CG   Q  INDIVIDUAL CHANNELS. ABOVE LIMITS ARE FOR ALL CHANNELS WITH ONE OR   2/77*
CG   Q  NO MISSING NEUTRALS.                                                 2/77*

CPI    CHARMED HADRON PRODUCTION CROSS SECTION (PI NUCLEON)   (CM**2)
CPI  B   0 1.5 TO 3.7 E-30 OR LESS     BALTAY    75 HBC      15 GEV PI+P       7/76*
CPI  B   0 0.2 TO 35  E-30 OR LESS     BALTAY    75 HBC      15 GEV PI+P       7/76*
CPI  P      8. E-33 OR LESS  CL=.90    APEL      76 ASPK     40 GEV/C PI-      1/78*
CPI  U   0 0.5 TO 15 E-30 OR LESS      BUNNELL   76 STRC     CL=.97            1/77*
CPI  C   0  1. TO 8. E-31  OR LESS     CESTER    76 SPEC     15 GEV/C PI-      2/77*
CPI  G   0  4. TO 8. E-32  OR LESS     GHIDINI   76 SPEC     19 GEV/C PI P     2/77*
CPI  H   0  4. E-30 OR LESS  CL=.95    HAGOPIAN  76 DBC  SHORT LIVED 2-5GEV    2/76
CPI  H   1  7. E-31 OR LESS  CL=.95    HAGOPIAN  76 DBC  LONG LIVED 1.9-2GEV   2/76
CPI  H   0  3. E-31 OR LESS  CL=.95    HAGOPIAN  76 DBC  LONG LIVED1-1.9,2-5   2/76
CPI  A   0  3.8E-31 OR LESS  CL=.95    BLANAR    77 SPEC    200 GEV/C PI+     4/77*
CPI  S         .028 OR LESS  CL=.90    BRANSON   77 SPEC PI+ SEE NOTE S       7/77*
CPI  S         .041 OR LESS  CL=.90    BRANSON   77 SPEC PI- SEE NOTE S       7/77*
CPI  D      2.6E-30 OR LESS  CL=.95    GODDARD   77 HBC   D0BAR C++           1/78*
CPI  J   0  5.7E-34 OR LESS            JONCKHEER 77 STRC    225 GEV/C PI-     1/78*
CPI  E      7.E-30 +-20.E-30           CESTER    78 SPEC 10.5 GEV/C PI- N      1/78*
CPI  B  BALTAY 75 SENSITIVE TO CHARMED PARTICLES WITH M=1.5 TO 4.0 GEV AND    7/76*
CPI  B  TAU LT 10**-11 WHICH THEN DECAY INTO STRANGE PARTICLES.               7/76*
CPI  B  THE FIRST VALUE ABOVE IS FOR ASSOC PROD OF CHARMED PARTICLES.         7/76*
CPI  B  SEE HIS TABLE 1 FOR SPECIFIC DECAY MODES.  THE SECOND RANGE OF       7/76*
CPI  B  VALUES IS FOR INCLUSIVE PROD OF CHARMED MESONS AND BARYONS WITH      7/76*
CPI  B  CHARGES -2 TO +2. SEE HIS TABLE 2 FOR SPECIFIC DECAY MODES.          7/76*
CPI  P  APEL 76 IS SERP EXPT. LOOKS FOR PI- P --> D0 ADD N, D0 --> K0 PI0.   1/78*
CPI  U  BUNNELL 76 IS A SLAC 15.5 PI+P EXPT. ALL POSSIBLE 2 TO 5-BODY MASS   1/77*
CPI  U  COMBINATIONS WERE STUDIED FOR NARROW RESONANCES PRODUCED IN COINC     1/77*
CPI  U  WITH SINGLE MUONS. MASS RANGE STUDIED WAS UP TO 3.1 GEV. SEE TABLE   1/77*
CPI  U  1 ON PG 87 FOR DETAILED RESULTS OF INDIVIDUAL CHANNELS.              1/77*
CPI  C  CESTER 76 LOOKS AT MASS RANGE 1.8 TO 2.5 GEV. SEE TABLE 1 FOR        2/77*
CPI  C  INDIVIDUAL CHANNELS. VALUES GIVEN ARE CROSS-SEC/NUCLEON ON CARBON.   2/77*
CPI  G  GHIDINI 76 LOOKED FOR CHARMED MESONS OF MASS GT 1.5 GEV AND BARYONS  2/77*
CPI  G  OF MASS GT 2.0 GEV. LIMITS ARE CL=.95. LIMITS FOR MOST CHANNELS LIE  2/77*
CPI  G  IN THE ABOVE RANGE.  SEE TABLE 2 FOR INDIVIDUAL CHANNELS.            2/77*
CPI  H  HAGOPIAN 76 IS A SLAC 15GEV PI+ D EXPT.  ALL POSSIBLE TWO AND THREE  2/76
CPI  H  BODY MASS COMBINATIONS WERE STUDIED FOR NARROW RESONANCES WITH MASS   2/76
CPI  H  1.5-5GEV FOR MESONS AND 2-5GEV FOR BARYONS.  INDIVIDUAL LIMITS FOR   2/76
CPI  H  TWO AND THREE BODY DECAY FROM MANY REACTIONS ARE GIVEN.               2/76
CPI  H  VEES WERE STUDIED FOR THE POSSIBILITY OF A NEW LONG LIVED (MEAN      2/76
CPI  H  LIFE 1E-11 SEC. OR MORE) NEUTRAL PARTICLE.  ONE CANDIDATE WITH MASS  2/76
CPI  H  1.9-2 GEV WAS FOUND.  SECOND LONG LIVED LIMIT FOR M=1-1.9, 2-5 GEV.  2/76
CPI  A  BLANAR 77 IS FNAL EXPT.  LIMIT IS FOR CS*BR TO MUONS.  ASSUMES       4/77*
CPI  A  DIFFRACTIVE CHARMED 2GEV MESON PAIR PRODUCTION.  OTHER LIMITS FOR    4/77*
CPI  A  PI AND P BEAMS GIVEN IN TABLE 1.                                     4/77*
CPI  S  BRANSON 77 MEASURES (PI NUC -->J C CBAR)/(PI NUC -->J ANYTHING)      7/77*
CPI  S  WITH J,C, AND CBAR ALL DECAYING TO MUONS. FNAL EXPT. FIRST VALUE     7/77*
CPI  S  ABOVE IS FOR 225 GEV/C PI+ BEAM, SECOND IS FOR 225 GEV/C PI- BEAM.   7/77*
CPI  D  GODDARD 77 IS A SLAC PI+ P EXPT AT 4.51 GEV ECM.                     1/78*
CPI  J  JONCKHEERE 77 LOOKS FOR CORRELATION BETW VOS AND PROMPT MUONS TO     1/78*
CPI  J  SIGNAL DECAY OF CHARMED PARTICLE.                                    1/78*
CPI  E  CESTER 78 IS BNL EXPT, LOOKS FOR PI- N-->D*- X, D*- --> D0BAR PI ,   1/78*
CPI     D0BAR-->K+ PI-.                                                      1/78*

CP     CHARMED HADRON PRODUCTION CROSS SECTION (P NUCLEON)   (CM**2)
CP   A   0  1. E-33 OR LESS            AUBERT    75 SPEC    PI+ K-            2/76
CP   A   0  4. E-33 OR LESS            AUBERT    75 SPEC    K+ PI-            2/76
CP   A   0  1. E-33 OR LESS            AUBERT    75 SPEC    K+ K-             2/76
CP   A   0  8. E-33 OR LESS            AUBERT    75 SPEC    PI+ PI-           2/76
CP   A   0  7. E-33 OR LESS            AUBERT    75 SPEC    P K-              2/76
CP   A   0  2. E-33 OR LESS            AUBERT    75 SPEC    K+ PBAR           2/76
CP   A   0  4. E-32 OR LESS            AUBERT    75 SPEC    P PI-             2/76
CP   A   0  2. E-33 OR LESS            AUBERT    75 SPEC    PI+ PBAR          2/76
CP   H   0  5. TO 20. E-30   OR LESS   AAHLIN    76 HBC     BARYON,M LT 2GEV  2/77*
CP   H   0 15. TO 100.E-30   OR LESS   AAHLIN    76 HBC     BARYON,M 2-3 GEV  2/77*
CP   H   0 10. TO 35. E-30   OR LESS   AAHLIN    76 HBC     MESON, M 1-2 GEV  2/77*
CP   L      0.05 TO 1.35E-27           ALBROW    76 SPEC                      1/78*
CP   B   0  2. E-30 OR LESS            BINTINGER 76 SPEC    M=2 GEV/C**2      1/77*
CP   B   0  5. E-32 OR LESS            BINTINGER 76 SPEC    M=4 GEV/C**2      1/77*
CP   C   0  9. E-30 OR LESS  CL=.95    ALDER     77 SPEC    D0 --> K- PI+     12/77*
CP   C   0  8. E-30 OR LESS  CL=.95    ALDER     77 SPEC    D0BAR--> K+ PI-   12/77*
CP   S         .04  OR LESS  CL=.90    BRANSON   77 SPEC    SEE NOTE S BELOW  7/77*
CP   D   0 3.6E-31 OR LESS  CL=.95     DITZLER   77 SPEC    D0 --> K- PI+     1/78*
CP   D   0 2.9E-31 OR LESS  CL=.95     DITZLER   77 SPEC    D0BAR --> K+ PI-  1/78*
CP   A  AUBERT 75 IS A BNL 30 GEV EXPT.  LOOKS FOR P BE --> JPRIME ANYTHING  2/76
CP   A  WHERE JPRIME DECAYED VIA THE CHANNEL SHOWN.  ABOVE VALUES ARE        2/76
CP   A  FOR M=2.25GEV AND ASSUME A WIDTH SMALL COMPARED TO THE RESOLUTION.   2/76
CP   A  UPPER LIMITS ARE ALSO GIVEN FOR THE ABOVE CHANNELS AND P PBAR FOR    2/76
CP   A  M=3.1 AND 3.7 GEV.  THOSE LIMITS RANGE FROM 7E-36 TO 4E-33.          2/76
CP   A  NA 77 SAYS AUBERT 75 LIMITS SHOULD BE AN ORDER OF MAG. LARGER.       2/77*
CP   H  AAHLIN 76 IS A 19 GEV/C P-P EXPT AT CERN. VALUES GIVEN ARE CL=.975.  2/77*
CP   H  SEE TABLE 2B, PG 479 FOR INDIVIDUAL LAMBDA (OR KS) +PIONS CHANNELS.  2/77*
CP   L  ALBROW 76 IS ISR EXPT, ECM=53GEV. SEE THEIR TABLE 2B,PG 377 FOR      1/78*
CP   L  INDIVIDUAL MESON AND BARYON CHANNELS. EXAMINES MASS RANGE 2-4 GEV.    1/78*
CP   B  BINTINGER 76 IS CROSS-SEC TIMES BR INTO K- PI+.  WE SHOW TWO VALUES  1/77*
CP   B  FROM THEIR FIG.4 WHICH COVERS MASS RANGE 1.7-4 GEV.  SIMILAR LIMITS  1/77*
CP   B  ARE GIVEN FOR K+ PI- AND PI+ PI- CHANNELS.  LIMITS ARE PROPORTIONAL  1/77*
CP   B  TO CS*BR FOR J/PSI INTO MU+ MU-, TAKEN=10NB FOR ABOVE VALUES.        1/77*
CP   C  ALDER 77 IS CERN-ISR EXPT AT ECM=53 GEV.                            12/77*
CP   S  BRANSON 77 MEASURES (P NUC -->J C CBAR)/(P NUC -->J ANYTHING) WITH   7/77*
CP   S  J,C, AND CBAR ALL DECAYING TO MUONS.FNAL EXPT USING 225 GEV/C BEAM.  7/77*
CP   D  DITZLER 77 IS FNAL 400GEV P EXPT.  ABOVE LIMITS ARE FOR              1/78*
CP   D  BR(K PI)*DSIGMA/DY AT Y(CM)=-0.4.                                    1/78*
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Stable Particles

CHARM SEARCHES

Data Card Listings

For notation, see key at front of Listings.

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CN     CHARMED HADRON PRODUCTION CROSS SECTION (N NUCLEON)  (CM**2)
CN   B   0  1.9E-31 OR LESS              BLESER     75 SPEC K+PI-, M=1.8 GEV     2/77*
CN   B   0  1.0E-31 OR LESS              BLESER     75 SPEC K+PI-, M=2.5 GEV     2/77*
CN   B   0  1.0E-31 OR LESS              BLESER     75 SPEC K- P , M=2.5 GEV     2/77*
CN   W   0  2.5E-29 OR LESS  CL=.975     WARD       75 HBC     K$ PI+ PI-        1/77*
CN   A   0  6. E-32 OR LESS              ABOLINS    76 SPEC    PI+ PI-           1/77*
CN   A   0  7. E-32 OR LESS              ABOLINS    76 SPEC    PBAR P            1/77*
CN   A   0  4. E-32 OR LESS              ABOLINS    76 SPEC    K- PI+            1/77*
CN   A   0  6. E-32 OR LESS              ABOLINS    76 SPEC    K- P              1/77*
CN   G 0-2 SEE COMMENT G BELOW           BINKLEY    76 SPEC                      1/77*
CN   B  BLESER 75 USES NEUTRONS UP TO 300 GEV/C, BE TARGET. EXAMINES MASS       2/77*
CN   B  RANGE UP TO 3.5 FOR KPI, UP TO 4.0 FOR KP. VALUES ARE CROSS-SEC/NUC    2/77*
CN   W  WARD 75 IS N-P EXPT WITH MOM UP TO 24 GEV/C. THIS VALUE IS FOR MASS    1/77*
CN   W  RANGE 1.5-2.5 GEV.  SEE TABLE 1 PG 31 FOR UPPER LIMITS ON C++,C+,     1/77*
CN   W  CO,D+,D0,D- DECAYS INTO VARIOUS FINALSTATES IN MASS RANGE 1.5-5GEV.    1/77*
CN   W  UPPER LIMIT FOR SEEING DECAY OF CHGD CHARMED PARTICLE INTO V0 FOR      1/77*
CN   W  TAU GT 10**-11 SEC GIVEN AS 1.5*EXP(T) FOR V0 =LAMBDA OR SIGMA, AND   1/77*
CN   W  3.0*EXP(T) FOR V0=K0. HERE, T=10*-11/TAU, CS GIVEN IN MICROBARNS.     1/77*
CN   A  ABOLINS 76 IS FNAL EXPT. USES NEUTRONS UP TO 300 GEV/C ON BE TARG.    1/77*
CN   A  TYPICAL VALUES ABOVE ARE FOR M=3.0 GEV. SEE FIG 4 FOR MASS RANGE      1/77*
CN   A  2-4 GEV. OBSERVES POSSIBLE K- PI+ ENHANCEMENT AT 2.29+-.03 GEV.       1/77*
CN   G  BINKLEY 76 MEASURES BR(C TO MU + OTHERS)*R WHERE R IS THE RATIO OF     1/77*
CN   G  THE CROSS-SEC FOR PRODUCING THE J/PSI TOGETHER WITH A C-CBAR PAIR      1/77*
CN   G  TO THE TOTAL CROSS-SEC FOR PRODUCING THE J/PSI AT THIS ENERGY. THE     1/77*
CN   G  EXPT WAS A 300 GEV/C FNAL RUN, AND SAW 2 TRI-MUON EVENTS. THIS GAVE    1/77*
CN   G  A .90 CL UPPER LIMIT OF .003 FOR THE MEASURED QUANTITY DESCRIBED       1/77*
CN   G  ABOVE.                                                                 1/77*

CAP    CHARMED HADRON PRODUCTION CROSS SECTION (PBAR NUCLEON)  (CM**2)
CAP  C   0  5. E-29 OR LESS  CL=.95      CARLSSON   75 HBC     PBAR P ANYTHING    2/77*
CAP  C   0  3. E-29 OR LESS  CL=.95      CARLSSON   75 HBC     PBAR P PI+ PI-     2/77*
CAP  E   0  .8 TO 4.4 E-30   OR LESS     CESTER     76 SPEC    12.4 TO 15 GEV/C   2/77*
CAP  C  CARLSSON 75 IS A 9GEV PBAR P CERN EXPT.  LIMITS ARE FOR P PBAR PEAK    2/77*
CAP  C  IN CHANNELS INDICATED. K KBAR CHANNELS CHECKED BUT NO LIMITS GIVEN.    2/77*
CAP  E  CESTER 76 LOOKS AT MASS RANGE 1.8 TO 2.5 GEV. SEE TABLE 1 FOR          2/77*
CAP  E  INDIVIDUAL CHANNELS. VALUES GIVEN ARE CROSS-SEC/NUCLEON ON CARBON.     2/77*

Y      CHARMED HADRON EVIDENCE IN NEUTRINO NUCLEON --> 2 LEPTONS ANYTHING
Y      SEE ALSO SECTION 'NEU' IN 'HEAVY LEPTON SEARCHES' AND
Y      SECTION 'T' IN 'OTHER NEW PARTICLE SEARCHES'.
Y    B  14MU+MU-  0MU-MU-  0MU+MU+     BENVENU1   75 SPEC    PREDOM. NEU BEAM   2/76
Y    B  51MU+MU-  7MU-MU-  3MU+MU+     BENVENU3   75 SPEC    6/7 NEU BEAM       2/76
Y    B   5MU+MU-  0MU-MU-  2MU+MU+     BENVENU5   75 SPEC    9/10ANTINEU BEAM   2/76
Y        4MU+MU-  4 OTHER MU PAIRS     BARISH     76 SPEC    NEU BEAM           3/76*
Y    S  32 DIMUON EVENTS               ASRATYAN   77 SPEC    NEU BEAM           1/78*
Y    A  4MU+E-  6MU-E+                 BALLAGH    77 HLBC .55 NEUBAR,.45 NEU    12/77*
Y    L  81 EVENTS MU-E+                BALTAY     77 HLBC    PREDOM. NEU BEAM   8/77*
Y    K   1 EVENT  MU-E+                BARISH     77 DBC     NEU BEAM           3/77*
Y    R  67 MU MU                       BARISH2    77 SPEC FNAL 45-205GEV NEU    1/78*
Y    R  28 MU MU                       BARISH2    77 SPEC FNAL 45-205 ANTINEU   1/78*
Y    L                                 BLETZACKE  77 RVUE                       1/78*
Y    O  17 EVENTS MU-E+                BOSETTI    77 HYBR                       7/77*
Y    O  11 MU-E+                       DEDEN      77 HLBC                      12/77*
Y    H  15 MU-E+                       HAIDT      77 HLBC                       1/78*
Y    H 257MU+MU-                       HOLDER     77 SPEC    INCIDENT NEU       12/77*
Y    H  58MU+MU-                       HOLDER     77 SPEC    INCIDENT ANEU      12/77*
Y    H  49 MU-MU-                      HOLDER2    77 SPEC    NEU BEAM           12/77*
Y    H   9 MU+MU+                      HOLDER2    77 SPEC    NEUBAR BEAM        12/77*
Y    B  BENVENUTI 75 ARE FNAL NEUTRINO NUCLEON EXPERIMENTS WHICH LOOKED FOR     2/76
Y    B  TWO OR MORE MUONS IN THE FINAL STATE.  NO TRIMUON EVENTS WERE SEEN.     2/76
Y    B  AUTHORS STATE THAT THESE DIMUON EVENTS REQUIRE THE EXISTENCE OF ONE     2/76
Y    B  OR MORE NEW PARTICLES WITH M=2-4GEV AND TAU=10**-10SEC. OR LESS.        2/76
Y    B  BENVENUTI4 75 SHOW THAT THE OBSERVED PROPERTIES OF THESE EVENTS         2/76
Y    B  DO NOT AGREE WITH HYPOTHESES OF HEAVY LEPTON OR INTERMEDIATE VECTOR     2/76
Y    B  BOSON.  THEY SUGGEST A HADRON (Y) WITH A NEW QUANTUM NUMBER.           2/76
Y    S  ASRATYAN 77 IS SERPUKHOV EXPT. FINDS R=(DIMUONS/SINGLE MUON EVENTS)    1/78*
Y    S  GT (6.2+-1.7)E-3 FOR NEU BEAM AND LT .011 FOR NEUBAR BEAM.             1/78*
Y    A  BALLAGH 77 IS AN FNAL EXPT. MEASURES (NEUMU N-->MU- E+ X)/(ALL NUMU    12/77*
Y    A  C.C.)=(.34+.23-.13)*10**-2 AND (NEUMUBAR N-->MU+ E- X)/(ALL NUMUBAR    12/77*
Y    A  C.C.)=(.15+.14-.08)*10**-2. RATIO OF ANTINEU TO NEU FRACTIONS IS        12/77*
Y    A  (0.45+0.6-0.3).
Y    L  BALTAY 77 IS FNAL EXPT IN NEON-H2 MIXTURE. THEY SEE 15 ASSOCIATED       8/77*
Y    L  VEES, GIVING (.6+-.2) NEUTRAL STRANGE PARTICLES PER EVENT.              8/77*
Y    K  BARISH 77 EVENT COULD BE NEU P TO MU+ B++. SEE CHARMED BARYON NOTE      3/77*
Y    K  AND LAMBDA/C+ SECTION ABOVE.                                            3/77*
Y    R  BARISH2 77 FINDS DIMUON TO SINGLE MUON RATE CONSISTENT WITH CHARM.      1/78*
Y    L  BLETZACKER 77 EXPLAINS TRIMUON AND LIKE SIGN DIMUON PROD AS ASSOC       12/77*
Y    L  PROD OF CHARM.                                                          12/77*
Y    O  BOSETTI 77 IS FNAL 15-FT CHAMBER EXPT. SEES 11 VEES ASSOC WITH          7/77*
Y    O  THESE EVENTS. KO MULTIPLICITY IS 1.84 (+-.63,-.53) PER EVENT.           7/77*
Y    D  DEDEN 77 IS CERN WIDE BAND EXPT, EMAX=2 GEV.11+-5 EVENTS ABOVE A        12/77*
Y    D  BACKGROUND OF 6 EVENTS.                                                 12/77*
Y    H  HAIDT 77 IS SAME EXPT AS VONKROGH 76 LISTED UNDER S29V0. MEASURES       1/78*
Y    H  (NEUMU N-->MU-E+X)/(NEUMU N-->MU-X)=(.63+-.21)E-2 FOR TIE+)>.8 GEV.     1/78*
Y    H  THESE EVENTS HAVE AN AVERAGE OF 2.0+-0.6 KO PER EVENT.                  1/78*
Y    H  HOLDER 77 IS CERN NARROW-BAND BEAM EXPT IN WHICH ALL MOMENTA ARE        12/77*
Y    H  MEASURED.ENERGY SPECTRA,ANG.CORRELATIONS,PT DISTRIBUTIONS ALL IN        12/77*
Y    H  AGREEMENT WITH PROD AND DECAY OF CHARMED PARTICLE.                      12/77*
Y    H  HOLDER2 77 IS 200GEV NARROW BAND EXPT. AFTER BACKGROUND SUBTRACTION     12/77*
Y    H  THE RATE OF LIKE-SIGN DIMUON EVENTS TO CHARGED CURRENT EVENTS IS        12/77*
Y    H  (3+-2)*10**-4. MAY COME FROM ASSOC PROD OF CHARM-ANTICHARM PAIR.        12/77*

VO     CHARMED HADRON EVIDENCE IN NEUTRINO NUCLEON --> MU- E+ V0 ANYTHING
VO     WHERE THE V0 IS A KOS OR A LAMBDA
VO   B   1 EVENT                         DEDEN      75 HLBC                      2/76
VO   B   1 EVENT                         BLIETSCHA  76 HLBC                      2/76
VO   V   4 EVENTS                        VONKROGH   76 HLBC                      2/76
VO   E   0 EVENTS                        BERGSN     77 HLBC    ANTINEU BEAM      3/77*
VO   D   3 EVENTS                        DEDEN      77 HLBC                      12/77*
VO   B  THE DEDEN 75 AND BLIETSCHAU 76 EVENTS ARE FROM CERN                      2/76
VO   B  GARGAMELLE NEUTRINO EXPOSURES.  THE MASSES OF THE E+ V0 SYSTEM FOR      2/76
VO   B  THE TWO EVENTS ARE 1.24, 1.91 GEV FOR LAMBDA OR 0.65, 1.57 FOR K0.      2/76
VO   V  THE VON KROGH 76 EVENTS ARE FROM AN FNAL 15 FT NEON BUBBLE CHAMBER      2/76
VO   V  EXPOSURE.  ALL FOUR E+ EVENTS FOUND HAVE ASSOCIATED K0S.                2/76
VO   E  BERGE 77 USED FNAL 15 FT CHAMBER FILLED WITH H-NEON. SAW TWO            3/77*
VO   E  POSSIBLE MU E EVENTS, COMMENSURATE WITH PREDICTED BACKGROUND,           3/77*
VO   E  NEITHER WITH ASSOCIATED V0.                                            3/77*
VO   D  DEDEN 77 EVENTS INCLUDE THOSE OF DEDEN 75 AND BLEITSCHAU 76.           12/77*

R1     CHARMED HADRON BRANCHING RATIO INTO (MU NEU ANYTHING)/TOTAL
R1   B   8    A FEW PERCENT              BENVENU2   75 SPEC    FNAL NEUTRINO NU   2/76
R1   H 315 APPROX 0.15                   HOLDER     77 SPEC                       12/77*
R1   A       0.19  OR LESS              BAUM       77                            12/77*
R1   D   3     .15      .18      .07     DEDEN      77 HLBC                       1/78*
R1   B  BENVENUTI2 75 LOOKS AT ANTINEUTRINO NUCLEON --> MUON HADRONS.  SEES     2/76
R1   B  EXCESS EVENTS ABOVE INCIDENT ENERGY 30 GEV.  COMPARES BENVENUTI1 75     2/76
R1   B  DIMUON EVENTS WITH EXCESS EVENTS TO GET BRANCHING RATIO.                2/76
R1   H  HOLDER 77 VALUE IS FROM NEU AND ANEU INDUCED DIMUON EVENTS OF           12/77*
R1   H  OPPOSITE SIGN. SEE SEC. Y LISTING ABOVE. BR CALCULATED USING EFF       12/77*
R1   H  BASED ON DECAY OF D+(1850) TO K0 MU+ NEU.                              12/77*
R1   A  BAUM 77 PUTS UPPER LIMIT ON E+- MU-+ PROD AT ISR. INFERS BR ABOVE      12/77*
R1   A  FROM THIS, ASSUMING THAT ALL DIRECT ELECTRONS COME FROM THE D.         12/77*
R1   D  DEDEN 77 IS FOR CHARMED BARYON --> LAMBDA LEPTON+ NEU ANYTHING.        1/78*
R1   D  SEES 3 NEU N --> MU- E+ V0 X EVENTS AND EXCESS OF 42+-20 NEU N -->     1/78*
R1   D  MU- LAMBDA X EVENTS OVER EXPECTED ASSOC. PROD..  SUGGESTS CHRM.BAR.    1/78*

R2     CHARMED HADRON (ASSOC. V0) BRANCHING RATIO INTO SEMILEPTONICS/ALL
R2   B   2    0.1   OR MORE             BLIETSCHA 76 HLBC    M=2.5-4 GEV       2/76
R2   B  THIS BR.RATIO AND MASS ARE REQD. BY OBSERVED RATE AND CHARM SCHEME.     2/76

R3     CHARMED HADRON BRANCHING RATIO INTO (E NEU ANYTHING)                    12/77*
R3   B        0.11     0.03             BRANDEL2   77 SPEC E+E- 4-5.2 GEV(ECM) 12/77*
R3   B        0.16     0.06             BRANDEL2   77 SPEC E+E- 4-5.2 GEV(ECM) 12/77*
R3   B  FIRST BRANDELIK 77 VALUE USES INCLUSIVE ELECTRON EVENTS. SECOND         12/77*
R3   B  VALUE(ERROR STAT ONLY) USES EVENTS WITH A SECOND ELECTRON.              12/77*

CC     CHARMED HADRON EVIDENCE IN COSMIC RAYS
CC   N   1 EVENT                         NIU        71 EMUL                      9/76*
CC   N  NIU 71 DETECTS CHGD PARTICLE DECAYING INTO HADRON+PIO. MASS=1.78GEV     9/76*
CC   N  AND TAU=2.2 E-14 IF SECONDARY IS PION. MASS=2.95 GEV AND TAU=3.6        9/76*
CC   N  E-14 IF IT IS PROTEN. POSSIBLE EVIDENCE OF PAIR PRODUCTION.            9/76*
CC   T   8 EVENTS                        TASAKA     73 EMUL                      9/76*
CC   T  SAME TYPE AS NIU EVENT. TAU BETW 1.5 AND 175 E-13.                     9/76*
CC   S   1 EVENT                         SUGIMOTO   75 EMUL                      1/77*
CC   S  SAME TYPE AS NIU EVENT. TWO SUCH PARTICLES PRODUCED TOGETHER.          1/77*
CC   S  TAU1=6.E-13, DECAYS TO CHARGED PRONG + ETA. TAU2=4.E-12, DECAYS TO     1/77*
CC   S  CHARGED PRONG + PIO. MASSES OF BOTH PARTICLES ARE ABOUT 2.0 GEV IF     1/77*
CC   S  DECAY PRONG IS PROTON, 1.7 IF DECAY PRONG IS KAON, AND 1.55 IF         1/77*
CC   S  DECAY PRONG IS PI. COMBINED MASS OF THE TWO NEW PARTICLES = 4.1 GEV    1/77*
CC   S  OR 3.8 GEV ASSUMING THE DECAY PRONGS TO BE KAONS OR PIONS              1/77*
CC   S  RESPECTIVELY. CONSISTENT WITH LAMBDA/C+ LAMBDABAR/C-.SEE GAISSER 76    1/77*

EM     CHARMED HADRON CROSS SEC. IN MISC. EMUL. EXPTS, WHERE LIFETIME SEEN     3/77*
EM   J   1 EVENT                         JAIN       75 EMUL TAU APROX. 10E-13  2/77*
EM   K   2 EVENTS                        KOMAR      75 EMUL    TAU .LT. E-15   4/77*
EM   B   1 EVENT                         BURHOP     76 EMUL    TAU APPROX E-13 3/77*
EM   C   0  1.5E-30 OR LESS  CL=.90      COREMANS   76 EMUL    TAU E-12 TO E-14 3/77*
EM   Z   0   7.E-30 OR LESS  CL=.90      BOZZOLI    77      300,400 GEV P-NUCL  1/78*
EM   M   0  0.0018 OR LESS   CL=.90      MUNDRA     77 EMUL +- TAU E-12 TO E-14 1/78*
EM   J  JAIN 75 IS A FNAL 300 GEV PROTON EXPT. EVENT SHOWS DECAY OF NEUTRAL    2/77*
EM   J  INTO HADRON-E-NEU, TAKING PLACE .019 CM FROM THE PROD VERTEX. MAY      2/77*
EM   J  BE LEPTONIC DECAY OF CHARMED PARTICLE.                                 2/77*
EM   K  KOMAR 75 IS FNAL 200 GEV/C PROTON EXPT.  SEE 2 EVENTS WITH SINGLE     4/77*
EM   K  ELECTRON EMITTED FROM NEAR INTERACTION.                                4/77*
EM   B  BURHOP 76 EXPT DONE AT FERMILAB HIGH ENERGY NEUTRINO BEAM. USED A     3/77*
EM   B  COMBINATION OF EMULSION AND SPARK CHAMBERS. THEY SEE A PARTICLE        3/77*
EM   B  WITH TAU=ABOUT 6 E-13 SEC DECAYING TO V0 + 3 CHGD TRACKS.  DECAY       3/77*
EM   B  MODE APPEARS DIFFERENT FROM PREVIOUSLY OBSERVED MODES OF CHARMED       3/77*
EM   B  HADRON DECAYS.                                                         3/77*
EM   C  COREMANS 76 USED 300 GEV/C PROTONS, AND LOOKED FOR ABOVE LIFETIMES.    3/77*
EM   Z  BOZZOLI 77 IS FNAL EXPT LOOKING FOR ASSOC PROD OF CHARMED PARTICLES    1/78*
EM   Z  WITH TAU=3E-15 TO 3E-13 SECONDS AND MASS LT 4.5 GEV.                   1/78*
EM   M  MUNDRA 77 IS FNAL 400GEV P EXPT. ABOVE VALUE IS RATIO TO PI+- PROD.    1/78*

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REFERENCES FOR CHARMED HADRON SEARCHES


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NIU       71 PTP 46 1644      +MIKUMO,MAEDA                    (TOKY+YOKOHAMA)
TASAKA    73 PTP 50 1879      +YAMAMOTO                        (KONA)

AUBERT    75 PRL 35 416       +BECKER,BIGGS,BURGER,CHEN+       (MIT+BNL)
   ALSO   77 PRL 38 172       Z. MING MA, B. Y. OH             (MSU)
BALTAY    75 PRL 34 1118      +CAUTIS,COHEN,CSORNA,KALELKAR + (COLU+BING)
BENVENU1  75 PRL 34 419       BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
BENVENU2  75 PRL 34 597       BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
   ALSO   74 PRL 33 984       AUBERT,BENVENUTI+     (HARV,PENN,WISC,FNAL)

BENVENU3  75 PRL 35 1199      BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
BENVENU4  75 PRL 35 1203      BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
BENVENU5  75 PRL 35 1249      BENVENUTI,CLINE,FORD+ (HARV,PENN,WISC,FNAL)
BLESER    75 PRL 35 76        +GOBBI,KENAH,KEREN+   (FNAL+NWES+ROCH+SLAC)
CARLSSON  75 NP B99 451       +EKSPONG,HOLMGREN,NILSSON+       (STOH+LIVP)
DEDEN     75 PL 58B 361               (AACH+BRUX+CERN+EPOL+MILA+ORSA+LOUC)

JAIN      75 PRL 34 1238      P. L. JAIN, B. GIRARD                (BUFF)
KOMAR     75 JETPL 21 239     +ORLOVA,TRETYAKOVA,CHERNYAYSKII      (LEBD)
   ALSC   76 SJNP 24 275      KOMAR,ORLOVA,TRETYAKOVA,CHERNYAVSKII (LEBD)
SUGIMOTO  75 PTP 53 1540      +SATO,SAITO                      (TWAS+TOKY)
WARD      75 NP B101 29       +ANSORGE,CARTER,MOUNT,NEALE+         (CAVE)

AAHLIN    76 NP B107 476      +ALPGARD,ANDERSEN,BERGVATN+(OSLO+STOH+HELS)
ABOLINS   76 PRL 37 417       +CARDIMONA,MATTHEWS,SIDWELL+ (MSU+OSU+CARL)
ALBROW    76 NP B114 365      CERN+DARE+FOM+LANC+LIVP+MCHS+RHEL+UTR+LUND
APEL      76 SJNP 24 507      +BERTOLUCCI,VIKTOROV,VINCELLI+   (SERP+CERN)
BARISH    76 PRL 36 939       +BARTLETT,BODEK,BROWN,BUCHHOLZ + (CIT+FNAL)
BINKLEY   76 PRL 37 578       +GAINES,PEOPLES,KNAPP+ (FNAL+COLU+HAWA+ILL)

BINTINGE  76 PRL 37 732       BINTINGER,LUNDY,AKERLOF+    (FNAL+MICH+PURD)
BLIETSCH  76 PL 60B 207             (AACH+BRUX+CERN+EPOL+MILA+ORSA+LOUC)
BUNNELL   76 PRL 37 85        +CHENG,DELPAPA,DORFAN,DOUNGVAN+ (UCSC+SLAC)
BURHOP    76 PL 65B 299        (LOUC+FNAL+BELG+DUUC+CERN+LOIC+ROMA+STR8+)
CESTER    76 PRL 37 1178      +FITCH,KADEL,WEBB,WHITTAKER +      (PRIN+BNL)

COREMANS  76 PL 65B 480       +SACTON+    (BELG+DUUC+LOUC+ROMA+STR8+WARS)
GHIDINI   76 NP B111 189      +NAVACH,DOWELL,KENYON+       (OMEGA GROUPS)
HAGOPIAN  76 PRL 36 296       +WILKINS,WIND,HAGOPIAN,ALBRIGHT+ (FSU+BRAN)
KNAPP     76 PRL 37 882       +LEE,LEUNG,SMITH +       (COLU+HAWA+ILL+FNAL)
QUINN     76 PR D14 2857      D. J. QUINN, R. H. MILBURN           (TUFTS)
VONKROGH  76 PRL 36 710       +FRY,CAMERINI,CLINE+    (WISC+LBL+CERN+HAWA)

ALDER     77 PL 66B 401       +BLOCK+ (AACH+UCR+CERN+HARV+LAUS+MUNC+NWES)
ASRATYAN  77 PL 71B 439       +EPSTEIN,GRIGORIEV,KALGANOV +    (ITEP+SERP)
BALLAGH   77 PRL 39 1650      +BINGHAM,BOSETTI,FRETTER+    (LBL+HAWA+WASH)
BALTAY    77 PRL 39 62        +HIBBS,HYLTON,KALELKAR,DRANCE +  (COLU+BNL)
BARISH    77 PR D15 1         +DERRICK,DOMBECK,MUSGRAVE +      (ANL+PURD)
BARISH2   77 PRL 39 981       +BARTLETT,BODEK,BROWN +     (CIT+FNAL+ROCK)
BAUM      77 PL 68B 279       +BLOCK,BOHM+ (AACH+UCR+CERN+HARV+MUNC+NWES)

BERGE     77 PRL 38 266       +DIBIANCA,EMANS +      (FNAL+SERP+ITEP+MICH)
BLANAR    77 PRL 38 192       +BOYER,FAISSLER,GARELICK,GETTNER +   (NEAS)
BLETZACK  77 PRL 38 1241      BLETZACKER,NIEH,SONI             (STON+UCSB)
BOSETTI   77 PRL 38 1248      +GALTIERI,LYNCH +      (LBL+CERN+HAWA+WISC)
BOZZOLI   77 LNC 19 32        +CAMPANINI,CAPILUPPI,GESSAROLI+ (BGNA+FIRZ)
BRANDEL2  77 PL 70B 387       BRANDELIK +       (AACH+DESY+HAMB+MPIM+TOKY)

BRANSON   77 PRL 38 580       +SANDERS,SMITH,THALER,ANDERSON+  (PRIN+EFI)
DEDEN     77 PL 67B 474       +      (AACH+BELG+CERN+EPOL+MILA+LALO+LOUC)
DITZLER   77 PL 71B 451       +FINLEY,JOHNSON,LOEFFLER + (PURD+MICH+FNAL)
GODDARD   77 PR D16 2730      +GILBERT,KEY,GORDON,LAI          (TNTO+BNL)
HAIDT     77 JPG 3 1                    (BERKELEY+CERN+HAWAII+WISCONSIN)

HOLDER    77 PL 69B 377       +KNOBLOCH,MAY+    (CERN+DORT+HEID+SACL+BGNA)
HOLDER2   77 PL 70B 396       +KNOBLOCH,MAY+    (CERN+DORT+HEID+SACL+BGNA)
JONGKHEE  77 PR D16 2073      JONGKHEERE,COOK,CSORNA +     (WASH+LALO+UCD)
   ALSO   76 PL 64B 221       COOK,CSORNA,HOLMGREN+            (WASH+LALO+UCD)
MUNDRA    77 LNC 18 554       +PUTT,STUTELEY,YOCK                  (AUCK)
PICCOLO   77 PRL 39 1503      +PERUZZI,LUKE,LUTH+      (SLAC+LBL+NWES+HAWA)
CESTER    78 PRL 40 139       +FITCH,KADEL,WEBB,WHITTAKER +      (PRIN+BNL)
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Data Card Listings

For notation, see key at front of Listings.


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                                REVIEWS REFERRED TO IN DATA CARDS

GAISSER  76 PR D14 3153          T.K.GAISSER,F.HALZEN                (BART+WISC)

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OTHER STABLE PARTICLE SEARCHES

We collect here those searches which do not fit neatly into one of the above search categories.

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T       TRIMUON PRODUCTION IN NEUTRINO NUCLEON INTERACTIONS
T        SEE ALSO SECTION 'NEU' IN 'HEAVY LEPTON SEARCHES' AND
T        SECTION 'Y' IN 'CHARMED HADRON SEARCHES'.
T     R   2 EVENTS MU- MU MU              BARISH    77 SPEC    NEU BEAM          7/77*
T     R  BARISH 77 EVENTS CONTAIN FAST MU- AND 2 ADDITIONAL MUONS WITH LOW       7/77*
T     R  ENGERY IN DIMUON REST FRAME. SLOW MUONS COULD COME FROM EITHER          7/77*
T     R  VIRTUAL PHOTON OR VECTOR MESON OR FROM ASSOC PROD OF CHARMED            7/77*
T     R  PARTICLES WHICH DECAY LEPTONICALLY.                                     7/77*
T     E    6 SEEN                         BENVENUTI 77 NEUL    5/6NEU,1/6NEUBAR 12/77*
T     E  BENVENUTI 77 IS FNAL EXPT. CAN BE EXPLAINED BY PROD OF NEW HEAVY        12/77*
T     E  LEPTON --> MU- NEUBAR NEW LIGHTER LEPTON --> MU- MU- NEU.               12/77*
T     L                                  BLETZACKE 77 RVUE                     12/77*
T     L  BLETZACKER 77 EXPLAINS TRIMUON AND LIKE SIGN DIMUON PROD AS ASSOC      12/77*
T     L  PROD OF CHARM.                                                         12/77*
T     H    3 SEEN                        HOLDER    77 SPEC                     12/77*
T     H  HOLDER 77 EVENTS ARE MU-MU-M+ AND MU-MU+MU+ WITH NEU BEAM, AND         12/77*
T     H  MU+MU-MU- WITH NEUBAR BEAM. RATE RELATIVE TO CHARGED CURRENT EVENTS    12/77*
T     H  IS 4*10**-5.                                                           12/77*

MU      DI- AND TRI-MUON PRODUCTION IN MU NUCLEON INTERACTIONS
MU    C 11 TRIMUON EVENTS                 CHANG     77 SPEC                    12/77*
MU    C 32 DIMUON EVENTS                  CHANG     77 SPEC                    12/77*
MU    C  CHANG 77 DIMUON RATE IS GT 5*10**-4 THAT OF INCLUSIVE MUON RATE.       12/77*
MU    C  CROSS SECTION UNCORRECTED FOR ACCEPTANCE IS 5*10**-36 CM**2/NUCLEON    12/77*

LEP     DIRECT LEPTON PRODUCTION IN PROTON NUCLEON INTERACTIONS
LEP      THESE LEPTONS DO NOT RESULT FROM PIO, ETA OR KNOWN WEAK DECAYS.
LEP      CANDIDATES FOR PARENTS OF DIRECT LEPTONS INCLUDE VIRTUAL MASSIVE
LEP      PHOTONS, HIGH PT VECTOR MESONS, INTERMEDIATE BOSONS, CHARMED
LEP      PARTICLES AND HEAVY LEPTONS.
LEP  A                                  APPEL2    74 SPEC FNAL 300GEV P+BE   3/77*
LEP  A  APPEL2 74 OBSERVE DIRECT ELECTRON AND MUON SIGNALS 10**-4 TIMES THE    3/77*
LEP  A  PIO YIELD FOR PPERP RANGE 1.9-4 GEV.  ELECTRON SOURCE LIFETIME LESS    3/77*
LEP  A  THAN (10**-9 SEC)*(PARENT MASS/GEV).  SUGGESTS LIGHT VEC.MES.(PHI).    3/77*
LEP  B                                  BOYMOND   74 SPEC FNAL 300GEV P+CU,W   3/77*
LEP  B  BOYMOND 74 SEE DIRECT MUON SIGNAL OF 8E-4 TIMES THE PION YIELD FOR     3/77*
LEP  B  PT RANGE 1.5-5.4GEV.  SUGGEST STRONGLY INTERACTING, SHORT LIFETIME     3/77*
LEP  B  SOURCE.  RHO AND PHI ARE POSSIBLE SOURCES.                             3/77*
LEP  U                                  BUSSER    74 SPEC CERNISR 26+26GEV PP  3/77*
LEP  U  BUSSER 74 SEE DIRECT ELECTRON SIGNAL 10**-4 TIMES PION YIELD FOR       3/77*
LEP  U  PT RANGE 1.6-4.7GEV.  CANT BE PHI ALONE SINCE PHI TO K+K- NOT SEEN.    3/77*
LEP  L                                  LEDERMAN  75 RVUE                    3/77*
LEP  L  LEDERMAN 75 DISCUSSES ABOVE EXPTS AND RECENT UNPUBLISHED RESULTS.      3/77*
LEP  L  SUGGESTS NEW LIGHT(1-5 PION MASSES) VECTOR MESON WEAKLY DECAYING.      3/77*
LEP  R                                  ABRAMOV   76 CNTR 35-70 GEV P+BE,CU  3/77*
LEP  R  ABRAMOV 76 SEE DIRECT MUON SIGNAL (6.7+-.9)E-5 TIMES PION YIELD FOR    3/77*
LEP  R  PT RANGE 1.9-3.1 GEV. RATIO MU+/MU- = 1.2. RATIO MU+/PI+ INCREASES    3/77*
LEP  R  WITH INCREASING PROTON ENERGY, INDICATING DECAY OF HEAVY PARTICLE      3/77*
LEP  R  WITH TAU LT 10**-11 SEC.                                               3/77*
LEP  N                                  ANISIMOVA 76 ELEC 70 GEV PROT ON CU  3/77*
LEP  N  ANISIMOVA 76 MEASURES LONG. POLARIZ. OF DIRECT MUONS WITH PT=2 -2.8    3/77*
LEP  N  GEV/C. FIND POL.=-0.85+-0.36. THIS WOULD INDICATE THAT MUONS COME      3/77*
LEP  N  FROM PARTICLE DECAYING VIA WK INTERACTIONS. OPPOSITE RESULT IS         3/77*
LEP  N  SEEN AT 400 GEV (LAUTERBACH 76, LEIPUNER 76) AND 28GEV(GRANNAN 77).    1/78*
LEP  M                                  ABRAMOV2  76 CNTR  70 GEV P-CU       1/68
LEP  M  ABRAMOV2 76 FINDS POLARIZ.OF PROMPT MUONS TO BE CLOSE TO THAT OF       1/78*
LEP  M  MUONS FROM DECAY OF PIONS AND KAONS.                                   1/78*
LEP  K                                  KASHA     76 CNTR FNAL 400GEV P+NUCL   3/77*
LEP  K  KASHA 76 FIND THAT MUON PAIR PRODUCTION CAN ACCOUNT FOR MOST OF THE    3/77*
LEP  K  DIRECT MUONS INDICATING ELECTROMAGNETIC PRODUCTION MECHANISM.          3/77*
LEP  T                                  LAUTERBAC 76 CNTR FNAL 400GEV P+CU   3/77*
LEP  T  LAUTERBACH 76 MEASURES LONG. POLARIZ. OF HIGH PT DIRECT MUONS TO BE    3/77*
LEP  T  P=-0.06+-0.16 (RESULT GIVEN IN GRANNAN 77) AS EXPECTED FOR             1/78*
LEP  T  ELECTROMAGNETIC PROCESS, NOT WEAK DECAY.                               1/78*
LEP  E                                  LEIPUNER  76                         3/77*
LEP  E  LEIPUNER 76 MEASURES LONG. POLARIZ. OF FORWARD DIRECT MUONS TO BE      3/77*
LEP  E  P=-0.00+-0.10 AS EXPECTED FOR ELECTROMAGNETIC PROCESS, NOT WK. DEC.    3/77*
LEP  S                                  BRANSON   77 SPEC 200 GEV/C PROT + FE 3/77*
LEP  S  BRANSON 77 FINDS MU/PI RATIO= 3.E-5 FOR PT LESS THAN 1 GEV/C.          3/77*
LEP  S  ALSO FINDS THAT 0.7+-0.2 OF ALL PROMPT MUS ARE PRODUCED IN PAIRS.      3/77*
LEP  M                                  BAUM      77 SPEC                    12/77*
LEP  M  BAUM 77 MEASURES RATIO OF DIRECT (E MU) EVENTS TO DIRECT E EVENTS.     12/77*
LEP  M  FINDS NO E+- MU+ SIGNAL AFTER BACKGROUND SUBTRACTION. IF ALL           12/77*
LEP  M  DIRECT ELECTRONS COME FROM D DECAY, THEN THIS LEADS TO UPPER LIMIT     12/77*
LEP  M  OF .19 FOR D--> K MU NEU BRANCHING RATIO.                              12/77*
LEP  G                                  GRANNAN   77 CNTR BNL 28.5 GEV PROT  12/77*
LEP  G  GRANNAN 77 MEASURES LONG. POLARIZ. OF HIGH PT DIRECT MUONS TO BE       12/77*
LEP  G  P=-0.15+-0.18 AS EXPECTED FOR ELECTROMAGNETIC  PROCESS,NOT WK.DEC.     12/77*
LEP  G  TRANSV. POLARIZ. MEASURED TO BE 0.05+-0.05.                            12/77*

LPI     ANOMOLOUS DIRECT LEPTON PROD IN PI P INTERATIONS
LPI                                     BUNNELL   78 STRC 16 GEV PI+,PI- P    1/78*
LPI      BUNNELL 78 IS SLAC EXPT. SEES EXCESS OF DIMUON EVENTS IN MASS         1/78*
LPI      REGION 400-600 MEV NOT EXPLAINABLE BY ORDINARY MEANS.                 1/78*

ICL     CHARMONIUM-LIKE STATES - INTEG. CROSS SECTION * B.R. (CM**2-MEV)
ICL  B    0  1.3E-30 OR LESS  CL=.90    BOYARSKI  75 SMAG                     4/77*
ICL  A    0  9.0E-31 OR LESS            BARBIELLI 76 CNTR M=2.5-3 GEV         4/77*
ICL  C    0  5.5E-31 OR LESS  CL=.90    BACCI     76 CNTR M=2.5-3 GEV         4/77*
ICL  E    0  9.0E-31 OR LESS            ESPOSITO  76 CNTR M=2.5-3 GEV         4/77*
ICL  N       18.E-30 OR LESS  CL=.90    BENSINGER 77 SPEC    LAMBDA LAMBDABAR 1/78*
ICL  N       18.E-30 OR LESS  CL=.90    BENSINGER 77 SPEC    KO K*(890)O      1/78*
ICL  N        2.E-30 OR LESS  CL=.90    BENSINGER 77 SPEC    KS KL            1/78*
ICL  B  BOYARSKI 75 IS A SPEAR EXPT. LIMIT IS FOR ECM=3.2-5.9 GEV,            4/77*
ICL  B  EXCLUSIVE OF THE PSI(3700). LIMIT RANGES FROM 1.1 TO 1.7 E-30.        4/77*
ICL  B  FOR A WIDTH OF 10 MEV, FROM  E+E- HADRONS.                            4/77*
ICL  A  BARBIELLINI 76 IS AN ADONE E+ E- EXPT. CROSS SECT. CONVERTED FROM     4/77*
ICL  A  RATIO TO E+E- --> J/PSI CROSS SECT.                                   4/77*
ICL  C  BACCI 76 IS AN ADONE E+ E- EXPT.                                      4/77*
ICL  E  ESPOSITO 76 IS AN ADONE E+ E- EXPT. CROSS SECT. CONVERTED FROM        4/77*
ICL  E  RATIO TO E+E- --> J/PSI CROSS SECT.                                   4/77*
ICL  N  BENSINGER 77 IS A PBAR P FORMATION EXPT COVERING ECM=2.99-3.14 GEV.   1/78*

CL      CHARMONIUM-LIKE STATES   CROSS-SECTION * B.R. (CM**2)
CL  A    0  1.0E-34   CL LESS              APEL      75 CNTR  M=2-5 GEV        4/77*
CL  E                                     EARTLY    76 CNTR  SHOULDER AT 6 GEV  4/77*
CL  H  12  5.2E-36     (2.0E-16            HOM1      76 CNTR    PEAK AT 6 GEV   4/77*
CL  H   0  2.0E-36   OR LESS               HOM2      76 CNTR                    4/77*
CL  T   0  2.0E-33   OR LESS               THEODOSIO 76 CNTR    M=1.2-3.5 GEV   4/77*
CL  S   0                                  ASCHMAN   77 CNTR    E+E- 6GEV REGION 1/78*
CL  A  APEL 75 IS A 40 GEV PI- P EXP. SENSITIVE TO MULTI-GAMMAS. DOES NOT      4/77*
CL  A  SEE J/PSI OR PSI(3700).                                                 4/77*
CL  E  EARTLEY 76 IS A 300 GEV P NUCLEUS EXPT.  STRUCTURE AT 6 GEV IS AT       4/77*
CL  E  MOST 5 PER CENT OF THE J/PSI CROSS SECT. DOESN*T SEE THE PSI(3700).     4/77*
CL  H  HGM1 76 AND HOM2 76 ARE FROM A 400 GEV P NUCLEUS EXPT. CROSS SECTS.     4/77*
CL  H  ARE FOR THE 6 GEV MASS REGION, WHERE AN ENHANCEMENT IS REPORTED IN      4/77*
CL  H  E+E-(HGM1 76) BUT NOT IN MU+MU-(HOM2 76). E+E- BUMP MAY BE A            4/77*
CL  H  STATISTICAL FLUCTUATION.                                                4/77*
CL  T  THEODOSIOU 76 IS A CORNELL GAMMA BE EXPT., WITH MAX. ENERGY OF         4/77*
CL  T  11 GEV, LOOKING FOR ELECTRONS AND/OR GAMMAS. CROSS SECTION IS          4/77*
CL  T  CONVERTED FROM DIFF. C.S. GIVEN AS 130EXP(3T) NB/GEV2 EXPECTED FOR     4/77*
CL  T  THE O- CHARM-ANTICHARM STATE                                            4/77*
CL  S  ASCHMAN 77 IS SLAC SPEAR EXPT.  LOOKS FOR PEAKS IN E+E- --> HADRONS     1/78*
CL  S  AND --> E+E- NEAR 6GEV. FINDS GAMMA<200EV FOR HADRON OR E+E- DECAY.     1/78*

CH      HEAVY PARTICLE PRODUCTION CROSS SECTION (CM**2)
CH  L    0  1. E-31 OR LESS                LEIPUNER  73 CNTR +- M=3-11 GEV     5/76*
CH  L  LEIPUNER 73 IS AN NAL 300 GEV P EXPT. WOULD HAVE DETECTED PARTICLES     4/76*
CH  L  WITH LIFETIME GREATER THAN 200 NSEC.                                    4/76*

CS      HEAVY PARTICLE PRODUCTION CROSS-SECTION (CM**2/NUCLEON)
CS  G    0  2.5E-35 OR LESS                GUSTAFSON 76 CNTR 0  TAU GT 10**-7   1/77*
CS  G  GUSTAFSON 76 IS A 300 GEV FNAL EXPT LOOKING FOR HEAVY (M GT 2 GEV)      1/77*
CS  G  LONGLIVED NEUTRAL HADRONS IN THE M4 NEUTRAL BEAM. THE ABOVE TYPICAL     1/77*
CS  G  VALUE IS FOR M=3 GEV AND ASSUMES AN INTERACTION CROSS SECTION OF        1/77*
CS  G  1 MB.  VALUES AS A FUNCTION OF MASS AND INTERACTION CROSS SECTION       1/77*
CS  G  ARE GIVEN IN FIG. 2.

D       HEAVY PARTICLE PRODUCTION DIFFERENTIAL CROSS SECTION (CM**2/SR-GEV)
D   D    0  1.5E-36 OR LESS                DORFAN    65 CNTR BE TARGET  M=3-7GEV  5/76*
D   D    0  3.0E-36 OR LESS                DORFAN    65 CNTR FE TARGET  M=3-7GEV  5/76*
D        0  2.4E-35 OR LESS  CL=.90        BINON     69 CNTR Q=- M=1-1.8 GEV      3/77*
D   S    0  2.4E-35 OR LESS  CL=.90        ANTIPOV1  71 CNTR Q=- M=1.2-1.7,2.1-4  3/77*
D   T    0  1.2E-35 OR LESS  CL=.90        ANTIPOV2  71 CNTR Q=- M=2.2-2.8        3/77*
D   L    0  5.8E-34 OR LESS  CL=.90        ALPER     73 SPEC +- M=1.5-24 GEV      5/76*
D   A    0  1. E-31 OR LESS  CL=.90        APPEL1    74 CNTR +- M=3.2-7.2 GEV    2/76
D   W    0  2.2E-33 OR LESS  CL=.90        ALBROW    75 SPEC Q=+-1  M=4-15 GEV    1/77*
D   W    0  1.1E-33 OR LESS  CL=.90        ALBROW    75 SPEC Q=+-2  M=6-27 GEV    1/77*
D   J    0  8. E-35 OR LESS  CL=.90        JOVANOVIC 75 CNTR +- M=15-26 GEV       2/76
D   J    0  1.5E-34 OR LESS  CL=.90        JOVANOVIC 75 CNTR Q=+-2, M=3-10 GEV    2/76
D   J    0  6. E-35 OR LESS  CL=.90        JOVANOVIC 75 CNTR Q=+-2, M=10-26 GEV   2/76
D   B    0  2.6E-36 OR LESS  CL=.90        BALDIN    76 CNTR Q=-1, M=2.1-9.4 GEV  1/77*
D   D  DORFAN 65 IS A 30 GEV/C P EXPT AT BNL.  UNITS ARE PER GEV MOMENTUM      5/76*
D   D  PER NUCLEUS.                                                            5/76*
D   S  ANTIPOV1 71 LIMIT INFERRED FROM FLUX RATIO. 70 GEV P EXPERIMENT.        3/77*
D   T  ANTIPOV2 71 IS FROM SAME 70 GEV P EXP. AS ANTIPOV1 71 AND BINON 69.     3/77*
D   L  ALPER 73 IS CERN ISR 26+26 GEV P+P EXPT.  P>.9 GEV, .2< BETA <.65.      5/76*
D   A  APPEL1 74 IS NAL 300 GEV P+W EXPERIMENT. STUDIES FORWARD PRODUCTION      2/76
D   A  OF HEAVY (UP TO 24 GEV) CHARGED PARTICLES WITH MOMENTA 24-200GEV(-)      2/76
D   A  AND 40-150GEV (ACHD).  ABOVE TYPICAL VALUE IS FOR 75 GEV AND IS          5/76*
D   A  PER GEV MOMENTUM PER NUCLEON.                                           5/76*
D   W  ALBROW 75 IS A CERN ISR EXPT WITH ECM=53 GEV. THETA=40 MR. SEE          1/77*
D   W  FIG. 5 FOR MASS RANGES UP TO 35 GEV.                                    1/77*
D   J  JOVANOVICH 75 IS A CERN ISR 26+26 AND 15+15 GEV P+P EXPERIMENT.         2/76
D   J  FIG.4 COVERS RANGES Q=1/3 TO 2 AND M=3 TO 26 GEV.                       2/76
D   J  VALUE IS PER GEV MOMENTUM.                                             5/76*
D   B  BALDIN 76 IS A 70 GEV SERP EXP.  VALUE IS PER AL NUCLEUS AT            1/77*
D   B  THETA=0.  FOR OTHER CHARGES IN RANGE -0.5 TO -3.0, CL=.90 LIMIT IS     1/77*
D   B  (2.6E-36)/ABS(CHARGE) FOR MASS RANGE (2.1 TO 9.4GEV)*ABS(CHARGE).      1/77*
D   B  ASSUMES STABLE PARTICLE INTERACTING WITH MATTER AS DO ANTIPROTONS.      1/77*

CA      CROSS-SEC FOR PROD AND CAPT OF LONG-LIVED MASSIVE PARTICLES (CM**2)
CA  F    0   .1-9E-36 OR LESS              FRANKEL   74 CNTR TAU=1 TO 1000 HRS  7/76*
CA  R    0  1.4-9E-36 OR LESS              FRANKEL   75 CNTR TAU=50 MS TO 10 HRS 2/77*
CA  A    0  2-20E-34 OR LESS               ALEKSEE1  76 ELEC TAU=100 MS TO 1 DAY 3/77*
CA  A    0  2-8E-34 OR LESS                ALEKSEE2  76 ELEC TAU=5 MS TO 1 DAY  3/77*
CA  F  FRANKEL 74 LOOKS FOR PARTICLES PRODUCED IN THICK AL TARGETS BY          7/76*
CA  F  300-400 GEV/C PROTONS.                                                  7/76*
CA  R  FRANKEL 75 IS EXTENSION OF FRANKEL 74.                                  2/77*
CA  A  ALEKSEEV(1,2) 76 ARE 61-70 GEV P SERP EXPT. CS IS PER PB NUCLEUS.       3/77*

F       HEAVY PARTICLE FLUX IN COSMIC RAYS (NUMBER/CM**2-SEC-SR)
F        0  3.0E-10 OR LESS               BJORNBOE  68 CNTR    M ABOVE 5 GEV   4/77*
F        0  5.0E-11 OR LESS  CL=.90       JONES     67 ELEC    M=5 TO 15 GEV   3/77*
F        0  3.0E-8  OR LESS               DARDO     72 CNTR                    4/77*
F        0  1.5E-9  OR LESS               TONWAR    72 CNTR    M GT 10 GEV     4/77*
F   Y    5  6. E-9  OR MORE               YOCK      74 CNTR    M GT 6 GEV      1/76
F        0  7. E-10 OR LESS  CL=.90       YOCK      75 ELEC +- Q GT 7 OR LT -7E  9/76*
F        0  1.0E-9  OR LESS               BRIATORE  76 ELEC                    4/77*
F   Y  YOCK 74 EVENTS COULD BE TRITONS.                                        1/76

C       LIGHT (BETWEEN MU AND E MASSES) PARTICLE MASS(UNITS-ELECTRON MASSES)
C        0   NONE BETWEEN 6 AND 25        BELOUSOV  60 CNTR  SPINOR,TAU>1 E-8   5/76*
C        0   NONE BETWEEN 2 AND 25        GORBUNOV  60 CC    SPINOR,TAU>1 E-9   5/76*
C        0   NONE BETWEEN 5 AND 175       COWARD    63 CNTR  SPINOR,TAU>22 E-10 5/76*
C        0   NONE BETWEEN 5 AND 175       COWARD    63 CNTR  SCALAR,TAU>68 E-10 5/76*
C   D    0   NONE BETWEEN 2 AND 13        BLAGOV    75 CNTR SPINOR,TAU>2E-10SEC 2/76
C   D    0   NONE BETWEEN 2 AND 10.6      BLAGOV    75 CNTR SCALAR,TAU>2E-10SEC 2/76
C   D  BLAGOV 75 BOUNDS ON LIFETIME DEPEND ON MASS AND IMPROVE AS MASS          4/77*
C   D  DECREASES.  AT 2 GEV THE EXPERIMENT IS SENSITIVE TO TAU>3E-11 SEC        4/77*
C   D  FOR SPINOR, TAU>5E-11 SEC FOR SCALAR.                                   4/77*

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REFERENCES FOR OTHER NEW PARTICLE SEARCHES


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BELOUSOV 60 JETP 11 1143        +RUSAKOV,TAMM,CERENKOV                  (LEBD)
GORBUNOV 60 JETP 11 51          +SPIRIDONOV,CERENKOV                    (LEBD)
COWARD   63 PR 131 1782         +GITTELMAN,LYNCH,RITSON                 (STAN)
DORFAN   65 PRL 14 999          +EADES,LEDERMAN,LEE,TING                (COLU)
JONES    67 PR 164 1584           (MICH+WISC+LBL+UCLA+MINN+COSU+COLO+MURA)

BJORNBOE 68 NC B53 241          +DAMGARD,HANSEN,CHATTERGEE+     (BOHR+BERN)
BINON    69 PL 30B 510          DUTEIL,KACHANOV,KHROMOV,KUTYIN+         (SERP)

ANTIPOV1 71 PL 34B 164          +DENISOV,DONSKOV,GORIN,KACHANOV+         (SERP)
ANTIPOV2 71 NP B31 235          +DENISOV,DONSKOV,GORIN,KACHANOV+         (SERP)
DARDO    72 NC 9A 319           DARDO,NAVARRA,PENENGO,SITTE              (TORI)
TONWAR   72 JPA 5 569           TONWAR,NARANAN,SREEKANTAN                (TATA)
ALPER    73 PL 46B 265            (CERN+LIVP+LUND+BOHR+RHEL+STOH+BERG+LOUC)
LEIPUNER 73 PRL 31 1226         +LARSEN,SESSOMS,SMITH,WILLIAMS+  (BNL+YALE)

APPEL1   74 PRL 32 428          +BOURQUIN,GAINES,LEDERMAN,PAAR+ (COLU+FNAL)
APPEL2   74 PRL 33 722          +BOURQUIN,GAINES,HOM,LEDERMAN+  (COLU+FNAL)
BOYMOND  74 PRL 33 112          +MERMOD,PIROUE,SUMNER,CRONIN+       (PRIN+EFI)
BUSSER   74 PL 53B 212          +CAMILLERI,DILELLA+   (CERN+COLU+ROCK+SACL)
FRANKEL  74 PR D9 1932          +FRATI,RESVANIS,YANG,NEZRICK     (PENN+FNAL)
YOCK     74 NP B76 175          P.C.M.YOCK                  (UNIV OF AUCKLAND)
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Stable Particles

OTHER STABLE PARTICLE SEARCHES


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ALBROW    75 NP B97 189          +BARBER,BENZ+(CERN+DARE+FOM+LANC+MCHS+UTRE)
APEL      75 PL 56B 190          +AUGENSTEIN,BERTOLUCCI,DONSKOV,+(SERP+CERN)
BOYARSKI  75 PRL 34 762          +BREIDENBACH,BULOS,FELDMAN+       (SLAC+LBL)
BLAGOV    75 YAD.FIZ. 21,300     +KOMAR,MURASHOVA,SYREISHCHIKOVA+      (LEBD)
FRANKEL   75 PR D12 2561         +FRATI,RESVANIS,YANG,NEZRICK     (PENN+FNAL)
JOVANOVI  75 PL 56B 105          JOVANOVICH+ (MANI+AACH+CERN+GENO+HARV+TORI)
LEDERMAN  75 PRL 35 1543         +WHITE                                (COLU)
YOCK      75 NP B86 216          P.C.M. YOCK          (UNIV OF AUCKLAND+SLAC)

ABRAMOV   76 PL 64B 365          +SULYAEV,BONDARENKO,DOBRETSOV + (SERP+MPEI)
ABRAMOV2  76 SJNP 24 511         +ALEEV,ANISIMOVA,BONDARENKO +         (SERP)
ALEKSEE1  76 SJNP 22 531         ALEKSEEV,ZAITSEV,KALININA,KRUGLOV+    (JINR)
ALEKSEE2  76 SJNP 23 633         ALEKSEEV,ZAITSEV,KALININA,KRUGLOV+    (JINR)
ANISIMOV  76 PL 65B 85           ANISIMOVA,BONDARENKO,GOVOROV +  (SERP+MPEI)
BACCI     76 PL 56B 190          +BIDOLI,PENSO,STELLA,+                (ROMA+FRAS)

BALDIN    76 SJNP 22 264         +VERTOGRADOV,VISHNEVSKII,GRISHKEVICH+(JINR)
BARBIELL  76 PL 64B 359          BARBIELLINI,NICOLETTI+(FRAS+NAPL+PISA+ROMA)
BRIATORE  76 NC 31A 553          +DARDO,PIAZZOLI,MANNOCCHI+ (LCGT+FRAS+FREI)
EARTLY    76 PRL 36 1355         +GIACOMELLI,PRETZL              (FNAL+BGNA+MPIM)
ESPOSITO  76 PL 64B 362          +FELICETTI,MARINI,+    (FRAS+ROMA+PADO+NAPL)
GUSTAFSO  76 PRL 37 474          GUSTAFSON,AYRE,JONES,LONGO,MURTHY     (MICH)

HOM1      76 PRL 36 1236         +LEDERMAN,PAAR,SNYDER+       (COLU+FNAL+STON)
HOM2      76 PRL 37 1374         +LEDERMAN,PAAR,SNYDER,+      (COLU+FNAL+STON)
KASHA     76 PRL 36 1007         +KELLOGG,LAUTERBACH,ADAIR+  (YALE+BNL+FNAL)
LAUTERBA  76 PRL 37 1436         LAUTERBACH,ADAIR,CARTER,GRANNAN+ (YALE+BNL)
LEIPUNER  76 PRL 36 1011         +LARSEN,ADAIR,CARTER+             (BNL+YALE+FNAL)
THEODOSI  76 PRL 37 126          THEODOSIOU,GITTELMAN,HANSON,LARSON+   (CORN)

ASCHMAN   77 PRL 39 124          +COYNE,GROOM+       (PRIN+PAVI+UMD+UCSD+SLAC)
BARISH2   77 PRL 38 577          +BARTLETT,BODEK,BROWN +       (CIT+FNAL+ROCK)
BAUM      77 PL 68B 279          +BLOCK,BOHM+ (AACH+UCR+CERN+HARV+MUNC+NWES)
BENVENUT  77 PRL 38 1110         BENVENUTI,CLINE+ (FNAL+HARV+PENN+RUTG+WISC)
BLETZACK  77 PRL 38 1241         BLETZACKER,NIEH,SONI                (STON+UCSB)
BENSINGE  77 NP B119 77           (BRAN+BNL+CARN+CINC+CUNY+MASA+PENN+SMAS +)

BRANSON   77 PRL 38 457          +SANDERS,SMITH,THALER,ANDERSON+   (PRIN+EFI)
CHANG     77 PRL 519             +CHEN,VAN GINNEKEN                   (MSU+FNAL)
GRANNAN   77 PL 69B 125          +ADAIR,KASHA,KELLOGG,LAUTERBACH+ (YALE+BNL)
HOLDER    77 PL 70B 393          +KNOBLOCH,MAY+    (CERN+DORT+HEID+SACL+BGNA)
BUNNELL   78 PRL 40 136          +DUONG-VAN,KOGAN +       (SLAC+VAND+UCSC+MIT)

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Data Card Listings

For notation, see key at front of Listings.

Mesons

$\pi^{\pm}$, π^{0}, η, $\rho(770)$

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S=0, C=0 MESON STATES

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$\boxed{\pi^{\pm}}$

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8  CHARGED PION(140,JPG=0--) I=1
SEE STABLE PARTICLE DATA CARD LISTINGS
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$\boxed{\pi^{0}}$

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9  NEUTRAL PION(135,JPG=0--) I=1
SEE STABLE PARTICLE DATA CARD LISTINGS
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$\boxed{\eta}$

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14  ETA(549,JPG=0-+) I=0
SEE STABLE PARTICLE DATA CARD LISTINGS
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$\boxed{\rho(770)}$

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9  RHO(770,JPG = 1-+) I=1
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Note on the ρ^0 Mass and Width

Because of the large width of the ρ meson, determinations of the resonance parameters are beset with many difficulties. In physical-region fits, it is well known that the ρ line shape does not correspond to a relativistic Breit-Wigner function with a P-wave width, but it requires one further shape parameter (PISUT 68). The same remark applies to the energy dependence of the phase shift δ_1^1. Different ways of introducing the shape parameter lead to systematic differences, in addition to the systematic errors due to different ways of accounting for the background in physical-region fits, or due to different ways of projecting out the partial waves for phase-shift analysis.

We consider phase-shift analyses more reliable than physical-region fits. In the table below we have collected the most reliable information on the ρ^0 mass and width. The spread of values essentially reflects the order of magnitude of the systematic errors. We choose to recommend only a central value and a spread.

$M(\rho^0)$ (MeV)	$\Gamma(\rho^0)$ (MeV)	References
773 ± 1.7	not reliable	JACOBS 72 analysis of BATON 70 phase shifts
778 ± 2	152 ± 2	HYAMS 73 phase shifts
775 ± 4	160 ± 10	PROTOPOPESCU 73 phase shifts
770 ± 9	143 ± 13	ESTABROOKS 74 analysis of HYAMS 73 phase shifts
776.3 ± 0.4	154.5 ± 1.0	ROOS 75 analysis of BATON 70, HYAMS 73, and PROTOPOPESCU 73 phase shifts
770.2 ± 0.9	150.3 ± 2.7	Weighted mean of good physical-region fits
776 ± 3	155 ± 3	"Educated guess"

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                    9  RHO MASS (MEV)

M       WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
M       COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.
M       SEE ALSO THE MINI-REVIEW ABOVE.

M   MIXED CHARGES
M      240 (752.0)                    ALITTI    63 HBC   -0 1.6 PI-P
M      290 (755.0)                    CHADWICK  63 HBC  +-0 0.0 PBAR P

M   CHARGED CNLY
M          (748.0)                    KENNEY    62 HBC   -  1.2 PI-P
M      130 (775.0)                    GUIRAGOSS 63 HBC   -  3.3 PI-P
M   R      (760.0)    (9.0)           CARMONY   64 HBC  +   3.5 PI+P,TCUT 4
M   R      (768.0)    (5.0)           BLIEDEN   65 MMSP  -  3-5 PI- P          6/66
M   R      (765.0)    (5.0)           ALFF-STEI 66 HBC  +   2-3 PI+ P          6/66
M   R      (760.0)    (5.0)           HAGOPIAN1 66 HBC   -  3.0 PI- P          6/66
M   R      (765.0)    (5.0)           HAGOPIAN2 66 HBC   -  2.14 PI-,TCUT12    9/67
M   R 2775 (753.5)   (10.5)           JACOBS    66 HBC   -  2-3PI-,T CUT 20    6/68
M   R      (758.0)   (10.0)           JAMES     66 HBC  +   2.1 PI+,TCUT2.5    8/66
M   R      (749.0)    (3.0)           WEST      66 HBC   -  2.1 PI- P         10/66
M  Z   900  767.       6.             EISNER    67 HBC   -  4.2 PI-,T CUT10    1/73
M   R      (768.0)    (5.0)           MILLER    67 HBC   -  2.7 PI-,T CUT20    9/66
M   R      (773.0)    (2.0)           BATON     68 HBC   -  2.8 PI-,T CUT13    7/69
M     1700 (782.1     (5.)            FOSTER    68 HBC  +-  PBAR P AT REST     1/73
M     9650  764.3      1.9      1.8   PISUT     68 RVUE  -  1.7-3.2PI-,CT10    6/68
M   A 9650 (764.3)   (19.2)    (3.3)  PISUT     68 RVUE  -  1.7-3.2PI-,CT10    6/68
M   A   ERRORS ARE 2 STD AND INCLUDE SYSTEMATIC UNCERTAINTIES FROM THEORY
M  X  1300  777.0      5.0            REYNOLDS  69 HBC   -  2.26 PI- P         1/73
M  X  6500  766.       7.             BYERLY    73 OSPK  -  5. PI- P           2/74
M          . . . . . . . . . .
M   AVG     765.9      2.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M   STUDENT 765.6      1.9      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                       (SEE IDEOGRAM BELOW )
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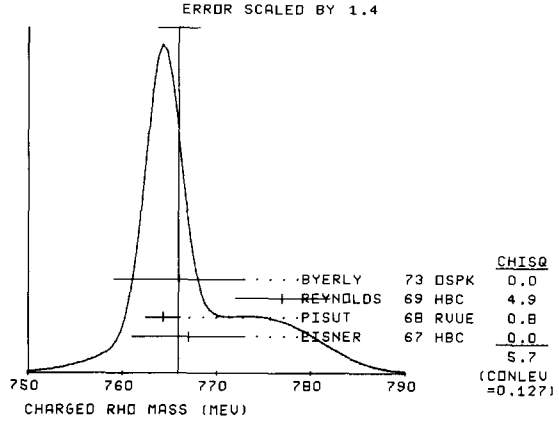
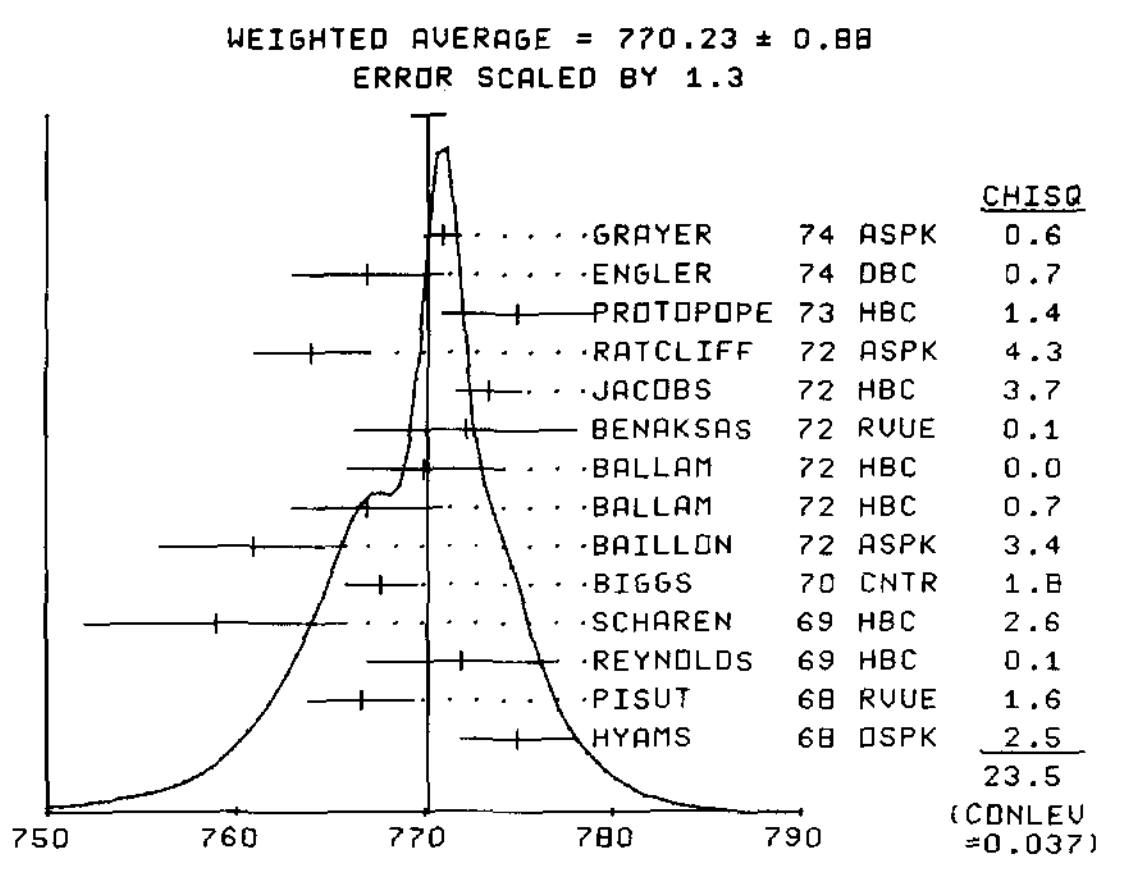
WEIGHTED AVERAGE = 765.9 ± 2.2
ERROR SCALED BY 1.4



MO NEUTRAL ONLY

MO		190	(750.0)	(20.0)	SAMIOS	62	HBC	0 4.7 PI-P	
MO	R	300	(760.0)	(10.0)	ABOLINS	63	HBC	0 3.5 PI+P	
MO		160	(775.0)		GUIRAGOSS	63	HBC	0 3.3 PI-P	
MO	R	500	(770.0)	(10.0)	GOLDHABER	64	HBC	0 3.7 PI+P	
MO	R		(750.0)	(5.0)	ALFF-STEI	66	HBC	0 2-3 PI+ P	6/66
MO	R		(775.0)	(5.0)	HAGOPIAN1	66	HBC	0 3.0 PI- P	6/66
MO	R		(770.)	(5.)	HAGOPIAN2	66	HBC	0 2.1 PI-,TCUT 12	2/67
MO	R	4207	(758.0)	(7.5)	JACOBS	66	HBC	0 2-3PI-,T CUT 20	6/68
MO	R		(765.0)	(8.0)	JAMES	66	HBC	0 2.1 PI+ P	6/66
MO	R		(760.0)	(3.0)	WEST	66	HBC	0 2.1 PI- P	10/66
MO	P	4000	(765.)	(5.0)	ASBURY 2	67	CNTR	0 GAMMA + PB	1/73
MO	R		(768.0)	(2.0)	BACON	67	HBC	0 1.7 PI-P	9/67
MO	R		(761.)	(3.)	HUWE	67	HBC	0 2.4 PI- P	7/67
MO	R		(770.0)	(4.0)	MILLER	67	HBC	0 2.7 PI-,T CUT20	9/66
MO	R		(775.0)	(2.0)	ARMENISE	68	DBC	0 5.1 PI+D	6/68
MO		1900	(776.)	(5.)	FOSTER	68	HBC	0 PBAR P AT REST	1/73
MO		2250	775.0	3.0	HYAMS	68	OSPK	011.2 PI- P .	9/68
MO		13300	766.7	2.8	PISUT	68	RVUE	0 1.7-3.2PI-,CT10	1/73
MO	B		(754.0)	(9.0)	AUSLENDER	69	OSPK	0 E+E- COLL.BEAMS	2/74
MO	R		(768.4)	(2.4)	MALAMUD	69	RVUE	0 2-4 PI-P	1/73
MO	X	1700	772.0	5.0	REYNOLDS	69	HBC	0 2.26 PI- P	1/73
MO	C		759.0	7.0	SCHAREN	69	HBC	0 2-4 PI- P	1/73
MO	P		(765.0)	(10.0)	ALVENSLEB	70	CNTR	0 GAMMA A,TCUT.01	1/73
MO	C	12630	(760.0)		BATON	70	HBC	0 2.8 PI- P	1/71
MO		140K	767.7	1.9	BIGGS	70	CNTR	0PHOTOPRODUCTION	1/73
MO	C		761.0	5.0	BAILLON	72	ASPK	0 15. PI- P	1/73
MO		1930	767.0	4.0	BALLAM	72	HBC	0 2.8 GAMMA P	1/73
MO		2430	770.0	4.0	BALLAM	72	HBC	0 4.7 GAMMA P	1/73
MO	B		(775.4)	(7.3)	BENAKSAS	72	OSPK	0 E+E- COLL.BEAMS	2/74
MO			772.3	5.9	BENAKSAS	72	RVUE	0 E+E- COLL.BEAMS	2/74
MO	Z	11200	773.5	1.7	JACOBS	72	HBC	0 2.8 PI- P	1/73
MO		6800	764.0	3.0	RATCLIFF	72	ASPK	0 15. PI-P,TCUT.3.	2/74
MO	P		(775.)	(5.)	GLADDING	73	CNTR	0 2.9-4.7 GAMMA P	2/74
MO	H		(778.)	(2.)	HYAMS	73	ASPK	017 PI-P,N PI+PI-	1/74
MO	C	32000	775.0	4.0	PROTOPOPE	73	HBC	0 7.1 PI+P,TCUT.4	2/74
MO		4100	767.	4.	ENGLER	74	DBC	0 6. PI+N,PI+PI-P	12/75
MO	H		(770.)	(9.)	ESTABROOK	74	RVUE	0 17 PI-P,PI+PI-N	12/75
MO			771.	1.	GRAYER	74	ASPK	017 PI-P,N PI+PI-	2/74
MO	D		(776.3)	(0.4)	ROOS	75	RVUE	OPHASE SHIFTS	12/75
MO			(767.6)	(3.0)	BARTALUCC	77	CNTR	OBREMS,E+E-P	12/77*
MO	X		(769.0)	(3.0)	WICKLUND	77	ASPK	03,4,6 PI+-PN	12/77*

MO . . . .
MO AVG 770.23 0.88 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
MO STUDENT 770.25 0.82 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
(SEE IDEOGRAM BELOW)



M ----------NOTES----------

M B INCLUDED IN BENAKSAS 72 REVUE VALUE
M C FROM POLE EXTRAPOLATION
M D INCLUDES BATON 70,HYAMS 73,PROTOPOPESCU 73
M H FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
M P FROM PHOTOPRODUCTION, MODEL DEPENDENT.
M R INCLUDED IN PISUT 68 RVUE
M X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
M Z MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE

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9 (RHO0) - (RHO+-) MASS DIFFERENCE (MEV)

D 2.4 2.1 PISUT 68 RVUE PI N TO RHO N 6/68

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9 RHO WIDTH (MEV)

W WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
W COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.
W SEE FURTHER MINI-REVIEW ABOVE.

W MIXED CHARGES
W 290 (110.0) CHADWICK 63 HBC +-0 0.0 PBAR P

W CHARGED ONLY

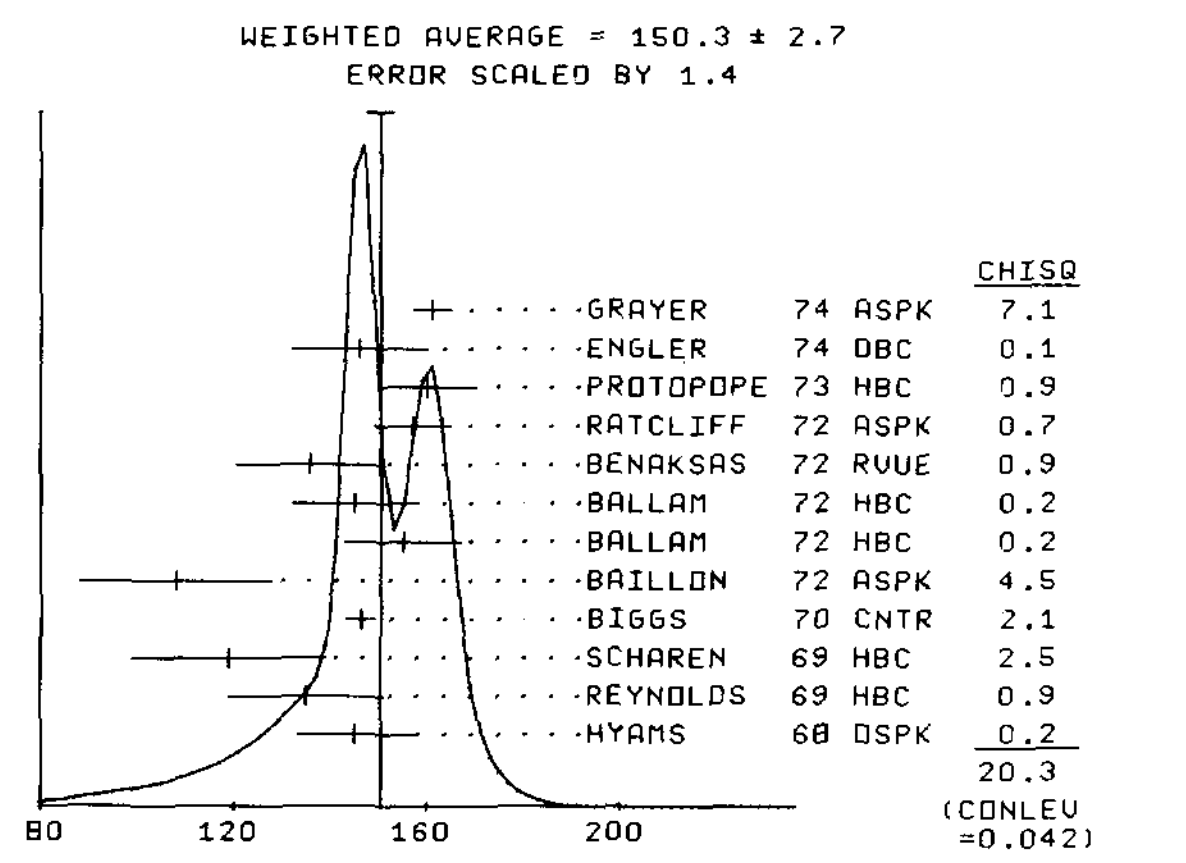
W		130	(125.0)			GUIRAGOSS	63	HBC	-	3.3 PI-P	
W			(90.0)	(10.0)		SACLAY	63	HBC	+	2.8 PI+P	
W		98	(180.0)			BONDAR	64	HBC	-	4.1 PI-P	
W	R		(77.0)	(20.0)		CARMONY	64	HBC	+	3.5 PI+P,TCUT 4	
W	R		(100.0)			ALFF-STEI	66	HBC	+	2-3 PI+ P	6/66
W	R		(127.0)	(5.0)		BLIEDEN	66	MMSP	-	3-5 PI- P	6/66
W	R		(150.0)	(20.0)		HAGOPIAN1	66	HBC	-	3.0 PI- P	6/66
W	R		(135.0)	(20.0)		HAGOPIAN2	66	HBC	-	2.14 PI-,TCUT12	9/67
W	R	2775	(137.1)	(20.0)		JACOBS	66	HBC	-	2-3PI-,T CUT 20	6/68
W	R		(147.0)	(19.0)		JAMES	66	HBC	+	2.1 PI+,TCUT2.5	8/66
W	R		(149.0)	(13.0)		WEST	66	HBC	-	2.1 PI- P	10/66
W		900	146.	13.		EISNER	67	HBC	-	4.2 PI-,T CUT10	9/67
W	R		(153.0)	(13.0)		MILLER	67	HBC	-	2.7 PI-,T CUT20	9/66
W	R		(150.0)	(5.0)		BATON	68	HBC	-	2.8 PI- P	7/69
W		1700	(145.0)	(10.0)		FOSTER	68	HBC	+-	PBAR P AT REST	1/73
W		9650	147.3	4.0	3.9	PISUT	68	RVUE	-	1.7-3.2PI-,CT10	6/68
W	X	1300	154.0	13.0		REYNOLDS	69	HBC	-	2.26 PI- P	1/73
W	X	6500	146.	12.		BYERLY	73	OSPK	-	5. PI- P	2/74

W . . . .
W AVG 147.6 3.5 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W STUDENT 147.6 3.7 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

WO NEUTRAL ONLY

WO		190	(150.0)	(20.0)	SAMIOS	62	HBC	0 4.7 PI-P	
WO	R	300	(90.0)	(10.0)	ABOLINS	63	HBC	0 3.5 PI+P	
WO		160	(175.0)		GUIRAGOSS	63	HBC	0 3.3 PI-P	
WO	R	500	(130.0)		GOLDHABER	64	HBC	0 3.7 PI+P	
WO	R		(100.0)		ALFF-STEI	66	HBC	0 2-3 PI+ P	6/66
WO	R		(120.0)	(10.0)	HAGOPIAN1	66	HBC	0 3.0 PI- P	6/66
WO	R		(135.0)	(20.0)	HAGOPIAN2	66	HBC	0 2.14 PI-P,LOW T	9/67
WO	R	4207	(122.2)	(15.0)	JACOBS	66	HBC	0 2-3PI-,T CUT 20	6/68
WO	R		(103.0)	(13.0)	JAMES	66	HBC	0 2.1 PI+ P	6/66
WO	R		(173.0)	(13.0)	WEST	66	HBC	0 2.1 PI- P	10/66
WO	P	4000	(130.)	(5.)	ASBURY 2	67	CNTR	0 GAMMA + PB	1/73
WO	R		(148.0)	(8.0)	BACON	67	HBC	0 1.7 PI-P	9/67
WO	R		(152.)	(15.)	HUWE	67	HBC	0 2.4 PI- P	7/67
WO	R		(160.0)	(15.0)	MILLER	67	HBC	0 2.7 PI-,T CUT20	9/66
WO	R		(167.0)	(6.0)	ARMENISE	68	DBC	0 5.1 PI+D	6/68
WO		1900	(132.)	(10.)	FOSTER	68	HBC	0 PBAR P AT REST	1/73
WO	Z	2250	145.0	12.0	HYAMS	68	OSPK	011.2 PI- P .	1/73
WO	P		(160.0)	(10.0)	LANZEROTT	68	CNTR	0 GAMMA P	1/73
WO	B		(105.0)	(20.0)	AUSLENDER	69	OSPK	0 E+E- COLL.BEAMS	2/74
WO	R		(132.0)	(13.0)	MALAMUD	69	RVUE	0 2-4 PI-P	1/73
WO	X	1700	135.0	16.0	REYNOLDS	69	HBC	0 2.26 PI- P	1/73
WO	C		119.0	20.0	SCHAREN	69	HBC	0 2-4 PI- P	1/73
WO	P		(140.0)	(5.0)	ALVENSLEB	70	CNTR	0 GAMMA A,TCUT.01	1/73
WO	C	12630	(131.0)		BATON	70	HBC	0 2.8 PI- P	1/71
WO		140K	146.1	2.9	BIGGS	70	CNTR	0PHOTOPRODUCTION	1/73
WO	C		108.0	20.0	BAILLON	72	ASPK	0 15. PI- P	1/73
WO	Z	2430	155.0	12.0	BALLAM	72	HBC	0 4.7 GAMMA P	1/73
WO	Z	1930	145.0	13.0	BALLAM	72	HBC	0 2.8 GAMMA P	1/73
WO	B		(149.6)	(23.2)	BENAKSAS	72	OSPK	0 E+E- COLL.BEAMS	2/74
WO			135.8	15.1	BENAKSAS	72	RVUE	0 E+E- COLL.BEAMS	2/74
WO		11200	(178.35)	(2.5)	JACOBS	72	HBC	0 2.8 PI- P	1/73
WO		6800	157.0	8.0	RATCLIFF	72	ASPK	0 15. PI-P,TCUT.3.	2/74
WO	P		(147.)	(11.)	GLADDING	73	CNTR	02.9-4.7 GAMMA P	2/74
WO	H		(152.)	(2.)	HYAMS	73	ASPK	017 PI-P,N PI+PI-	1/74
WO	C	32000	160.0	10.0	PROTOPOPE	73	HBC	0 7.1 PI+P,TCUT.4	2/74
WO		4100	146.	14.	ENGLER	74	DBC	0 6. PI+N,PI+PI-P	12/75
WO	H		(143.)	(13.)	ESTABROOK	74	RVUE	0 17 PI-P,PI+PI-N	12/75
WO			161.	4.	GRAYER	74	ASPK	017 PI-P,N PI+PI-	2/74
WO	D		(154.5)	(1.0)	ROOS	75	RVUE	OPHASE SHIFTS	12/75
WO			(150.9)	(3.0)	BARTALUCC	77	CNTR	OBREMS,E+E-P	12/77*
WO	X		(152.0)	(9.0)	WICKLUND	77	ASPK	03,4,6 PI+-PN	12/77*

WO . . . .
WO AVG 150.3 2.7 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
WO STUDENT 149.4 2.8 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
(SEE IDEOGRAM BELOW)



W ----------NOTES----------

W B INCLUDED IN BENAKSAS 72 REVUE VALUE
W C FROM POLE EXTRAPOLATION
W D INCLUDES BATON 70,HYAMS 73,PROTOPOPESCU 73
W H FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
W P FROM PHOTOPRODUCTION, MODEL DEPENDENT.
W R INCLUDED IN PISUT 68 RVUE
W X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
W Z WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE

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Data Card Listings

For notation, see key at front of Listings.


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                    9  RHO PARTIAL DECAY MODES

                                                                    DECAY MASSES
P1      RHO INTO 2PI                                                139+ 139
P2      RHO INTO 4PI                                                139+ 139+ 139+ 139
P3      RHO INTO PI GAMMA                                           139+   0
P4      RHO INTO E+ E-                                               .5+  .5
P5      RHO INTO PI ETA (VIOLATES G)                                139+ 548
P6      RHO INTO MU+ MU-                                            105+ 105
P7      RHO INTO PI+ PI- PIO (VIOLATES G)                           139+ 139+ 134
P8      RHO INTO ETA GAMMA                                          548+   0
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                    9  RHO BRANCHING RATIOS

R1      RHO INTO 4PI/2PI                                    (P2)/(P1)

R1      RHO+- INTO (PI+- PI+ PI- PIO) / (PI+- PIO)
R1            (0.026)OR LESS          BLIEDEN   66 MMSP  -  3-5 PI- P          6/66
R1            (0.01) OR LESS          DEUTSCHMA 66 HBC   +   8.0 PI+ P          6/66
R1            (0.002)OR LESS          FERBEL    66 HBC   +- PI+- P ABOVE 2.5 10/66
R1             0.0035   0.004         JAMES     66 HBC   +   2.1 PI+P          11/66

R1      RHOO INTO (PI+ PI- PI+ PI-) / (PI+ PI-)
R1            (0.008)OR LESS          JAMES     66 HBC     0 2.1 PI+P          6/66
R1            (0.002)OR LESS          CHUNG     68 HBC     0 3.2,4.2 PI-P      7/67
R1            (0.002)OR LESS  CL=.90  HUSON     68 HLBC    0 16.0 PI- P        1/71
R1            (0.0015)OR LESS CL=.90  GERMAN CO 69 HBC     0 2.5-5.8 GAMMA P 10/67

R2      RHO INTO PI GAMMA/2PI  (UNITS 10**-3)               (P3)/(P1)
R2  M         (20.)   OR LESS        LANZEROTT 65 CNTR    GAMMA P(BREMS)  11/66
R2            (5.)    OR LESS  CL=.97 FIDECARO  66 OSPK  -                 10/66
R2            (7.)    OR LESS        HUSON     66 HLBC  -  15 PI-PB          6/66
R2  M         (2.)    OR LESS  CL=.90 GERMAN CO 69 HBC
R2  C          0.24     0.07          GOBBI     74 OSPK  - 23. PI-A,PI-PIOA 12/75
R2  C  GOBBI 74 QUOTES THE PARTIAL WIDTH FOR RHO- INTO PI- GAMMA
R2  C  AS (35 +- 10) KEV
R2  M          ONE PION EXCHANGE MODEL USED IN THIS ESTIMATION
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Note on the e^+e^- and $\mu^+\mu^-$ Decays

Extraction of a ratio for $\rho^0 \to e^+e^-$ is complicated by interference with ω decay. In photoproduction, $\gamma A \to e^+e^- A$, there is substantial interference between the allowed $(\rho^0,\omega) \to e^+e^-$ decays. The interference in the colliding-beam reaction $e^+e^- \to \pi^+\pi^-$ is due to G-parity-violating mixing of the overlapping ρ^0 and ω resonances; it alters the results for the rate $\Gamma(\rho^0 \to e^+e^-)$ only by a small amount. Therefore at present we average only the values from the $e^+e^- \to \pi^+\pi^-$ experiments.

The same comment applies to the decay $\rho^0 \to \mu^+\mu^-$.

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R3      RHO INTO(E+ E-)/(PI+PI-) (UNITS 10**-4)             (P4)/(P1)
R3
R3       SEE MINI-REVIEW ABOVE.
R3
R3  P   94   (0.65)   (0.14)          ASBURY 1  67 CNTR     PHOTOPRODUCTION  9/67
R3  P         POSSIBLY LARGE RHO-OMEGA INTERFERENCE
R3  H        (0.65)   (1.1)    (0.5)  HERTZBACH 67 OSPK ASSUME SU(3)+MIXING.10/66
R3  H         NOT SEPARATED FROM OMEGA DECAY.
R3  A   33   (0.53)   (0.11)          ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R3  A         NOT SEPARATED FROM OMEGA DECAY. ERROR STATISTICAL ONLY.
R3             0.50     0.10          AUSLENDER 69 OSPK    E+E- COLLID.BEAM  9/68
R3  F        (0.49)   (0.12)   (0.15) BIGGS     70 CNTR    PHOTOPRODUCTION   6/70
R3  F         ASSUMING RHO WIDTH 140 MEV. ERROR STATISTICAL ONLY.
R3             0.41     0.05          BENAKSAS  72 OSPK    E+E- COLL.BEAMS 12/72
R3          * * * * * * * * *
R3  AVG        0.428    0.045   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT    0.428    0.049   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R4      RHO INTO (PI ETA)/(2PI)                             (P5)/(P1)
R4            (0.03) OR LESS            DEUTSCHMA 66 HBC   +   8.0 PI+ P       6/66
R4            (0.008)OR LESS            FERBEL    66 HBC   +- PI+- P ABOVE 2.5 11/66

R5      RHO INTO (MU+ MU-)/(PI+ PI-) (UNITS 10**-4)         (P6)/(P1)
R5
R5       SEE MINI-REVIEW ABOVE.
R5
R5  H         0.97     0.31     0.33  HYAMS     67 OSPK    11 PI- LI H       6/67
R5  H         HYAMS MASS RESOL. IS 20 MEV. THE OMEGA REGION WAS EXCLUDED.
R5  R        0.82     0.16     0.36  ROTHWELL  69 CNTR    PHOTOPRODUCTION . 4/70
R5  R         POSSIBLY LARGE RHO-OMEGA INTERFERENCE LEADS US TO INCREASE
R5  R         THE MINUS ERROR
R5             0.56     0.15          WEHMANN   69 OSPK    12 PI- ON C,FE    7/69
R5  W         RESULT CONTAINS (11 +- 11) PER CENT CORRECTION USING SU(3)
R5  W         FOR CENTRAL VALUE. THE ERROR ON THE CORRECTION TAKES ACCOUNT
R5  W         OF POSSIBLE RHO-OMEGA INTERFERENCE AND THE UPPER LIMIT AGREES
R5  W         WITH THE UPPER LIMIT OF (OMEGA INTO MU+ MU-) FROM THIS EXPT.
R5          * * * * * * * * *
R5  AVG        0.67     0.12   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  STUDENT    0.67     0.14   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R6      RHO  INTO (PI+ PI- PIO)/(PI+ PI-)                   (P7)/(P1)
R6  G        (0.01) OR LESS  CL=.84   ABRAMS    71 HBC     0 3.7 PI+ P       11/71
R6  G       MODEL DEPENDENT,ASSUMES I = 1,2,OR 3 FOR THE 3PI SYSTEM          11/71

R7      RHO INTO (ETA GAMMA)/TOTAL (UNITS 10**-4)           (P8)
R7  A        (3.6)    (0.9)          ANDREWS   77 CNTR    0 6.7-10 GAMMA CU 12/77*
R7  A   SOLUTION CORRESPONDING TO CONSTRUCTIVE OMEGA-RHO INTERFERENCE
R7  A   THE QUARK MODEL PREDICTS A RELATIVE DECAY PHASE OF ZERO.
R7  B        (5.4)    (1.1)          ANDREWS   77 CNTR    0 6.7-10 GAMMA CU 12/77*
R7  B   SOLUTION CORRESPONDING TO DESTRUCTIVE OMEGA-RHO INTERFERENCE

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                    REFERENCES FOR RHO

ANDERSON 61 PRL  6 365          ANDERSON,BANG,BURKE,CARMONY,SCHMITZ    (LRL)
ERWIN    61 PRL  6 628          A.R.,R.MARCH,W.D.WALKER,E.WEST         (WISC)
KENNEY   62 PR  126 736         V P KENNEY,W D SHEPHARD,C D GALL (KENTUCKY)
SAMIOS   62 PRL  9 139          SAMIOS,BACHMAN,LEA+     (BNL+CUNY+COLU+KNTY)
XUONG    62 PR  128 1849        NGUYEN HUU XUONG,GERALD R LYNCH        (LRL)

ABOLINS  63 PRL 11 381          ABOLINS,LANDER,MEHLHOP,NGUYEN,YAGER    (UCSD)
ALITTI   63 NC  29 515          ALITTI,BATON,ARMENISE+(SACL+ORSA+BARI+BGNA)
CHADWICK 63 PRL 10 62           CHADWICK,DAVIES,DERRICK,CRESTI + (DXF+PADC)
GUIRAGOS 63 PRL 11 85           ZAVEN GUIRAGOSSIAN                     (LRL)
SACLAY   63 SIENA CONF 1 239    SACLAY+ORSAY+BARI + BOLOGNA- COLLABORATION

BONDAR   64 NC  31 729          BONDAR+    (AACHEN+BIRM+BONN+DESY+LOIC+MPIM)
CARMONY  64 DUBNA CONF 1 486    CARMONY,HOA,LANDER,NG.H.XUONG,YAGER    (UCSD)
GOLDHABE 64 PRL 12 336          GOLDHABER,BROWN,KADYK,SHEN+            (LRL+UCB)

ALYEA    65 PL  15 82           ALYEA,CRITTENDEN,MARTIN,RHODE +    (INDIANA)
ARMENISE 65 NC  37 361          SACLAY+ORSAY+BARI+BOLOGNA    COLLABORATION
BLIEDEN  65 PL  19 444          CERN MISSING MASS SPECTROMETER GROUP (CERN)
CLARK    65 PR  139 B 1556      A CLARK,CHRISTENSON,CRONIN,TURLAY(PRINCETO)
GUTAY    65 NC  39 381          GUTAY,LANNUTTI,TULI                    (FSU)
LANZEROT 65 PRL 15 210          LANZEROTTI,BLUMENTHAL,EHN,FAISSLER + (HARV)
ZDANIS   65 PRL 14 721          ZDANIS,MADANSKY,KRAEMER +          (JHU+BNL)

ACCENSI  66 PL  20 557          ACCENSI,ALLES-BORELLI,FRENCH,FRISK+    (CERN)
ALFF-STE 66 PR  145 1072        ALFF-STEINBERGER,BERLEY,BRUGGER+(COLU+RUTG)
BALTAY   66 PR  145 1103        +FRANZINI,LUTJENS,SEVERINS,TYCKO+(COLUMBIA)
BLIEDEN  66 NC  43 71           CERN MISSING MASS SPECTROMETER GROUP (CERN)
CAMBRIDG 66 PR  146  994        CAMBRIDGE BUBBLE CHAMBER GROUP  (MIT+HARV+)
CASON    66 PP  148  1282       N M CASON                        (WISCONSIN)
DEUTSCHM 66 PL  20 82           DEUTSCHMANN,STEINBERG + (AACH+BERLIN+ CERN)
FERBEL   66 PL  21 111          FERBEL                          (ROCHESTER)
FIDECARO 66 PL  23  163         G+M FIDECARO,J POIRIER,P SCHIAVON       (CERN)
HAGOPIAN166 PR  145 1128        HAGOPIAN,SELOVE,ALITTI,BATON+ (PENN+SACLAY)
HAGOPIAN266 PR  152  1183       HAGOPIAN;PAN    (PENNSYLVANIA,LRL-BERKELEY)
HUSON    66 PL  20 91           HUSON,ALLARD,DRIJARD,HENNESSY+ (ORSAY+EPOL)
JACOBS   66 UCRL-16877          L.D.JACOBS                             (LRL)
JAMES    66 PR  142 896         F E JAMES,KRAYBILL          (YALE+BROOKHAVEN)
WEST     66 PR  149 1089        WEST,BOYD,ERWIN,WALKER                 (WISCONSIN)

ALLES-BO 67 NC  50 A 776        ALLES-BORELLI,FRENCH,FRISK,+       (CERN+BONN)
ASBURY 1 67 PRL 19 869          +BECKER+BERTRAM+JOOS+JORDAN+       (DESY+COLU)
ASBURY 2 67 PRL 19 865          +BECKER+BERTRAM+JOOS+JORDAN+       (DESY+COLU)
BACON    67 PR  157 1263        +FICKINGER,HILL,HOPKINS,ROBINSON+        (BNL)
BANNER   67 PL  25 B  300       +FAYOUX,HAMEL,ZSEMBERY,CHEZE+  (SACLAY+CAEN)
BARLOW   67 NC  50A 701         +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BATON    67 PL  25 B 419        J.BATON,G.LAURENS,J.REIGNIER           (SACLAY)
    ALSO 67 NP B 3  349         J.BATON,G.LAURENS,J.REIGNIER           (SACLAY)
CLEAR    67 NC  49A 399         +JOHNSTON+COOPER+MANNER+     (TNTO+ANL+WISC)
DANYSZ   67 NC  51 A 801        DANYSZ+FRENCH+SIMAK                    (CERN)
EISNER   67 PR  164 1699        +JOHNSON+KLEIN+PETERS+SAHNI+YEN+   (PURDUE)
FRENCH   67 NC  52A 442         +KINSON+MCDONALD+RIDDIFORD+      (CERN+BIRM)
HERTZBAC 67 PR  155  1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
    ALSO 65 ZDANIS
HUWE     67 PL  24B 252         +MARQUIT+OPPENHEIMER+SCHULTZ+WILSON   (COLU)
HYAMS    67 PL  24B 634         +KOCH+PELLETT+POTTER+VONLINDERN+(CERN+MPIM)
MILLER   67 PR  153 1423        MILLER,GUTAY,JOHNSON,LOEFFLER +    (PURDUE)
POIRIER  67 PR  163 1462        +BISWAS,CASON,DERADO,KENNEY+     (NDAM+PENN)

ABC COLL 68 NP B4 501                    AACHEN+BERLIN+CERN COLLABORATION+
ARMENISE 68 NC  54A 999         +GHIDINI,FORINO+      (BARI+BGNA+FIRZ+ORSAY)
ASTVACAT 68 PL  27 B  45        ASTVACATUROV,AZIMOV,BALDIN+    (JINR+MOSCOW)
BATON    68 PR  176 1574        J.P. BATON, G. LAURENS                 (SACLAY)
BLECHSCH 68 NC   53 A  1045     BLECHSCHMIDT,DOWD,ELSNER,+       (DESY+MCHS)
    ALSO 67 NC   52 A  1348
CHUNG    68 PR  165 1491        S.U.CHUNG,O.I.DAHL,J.KIRZ,D.H.MILLER   (LRL)
DONALD   68 NP B 6  174         +EDWARDS,FRODESEN,BETTINI+ (LIVP+OSLO+PADO)
FOSTER   68 NP B 6  107         +GAVILLET+LABROSSE+MONTANET+     (CERN+CDEF)
HUSON    68 PL  28B 208         +LUBATTI,SIX,VEILLET,+       (ORSA+MILA+UCLA)
HYAMS    68 NP B 7  1           +KOCH,POTTER,WILSON,VON LINDERN+(CERN+MPIM)
JONES    68 PR  166 1405        +BLEULER,CALDWELL,ELSNER,HARTING+      (CERN)
JOHNSON  68 PR  176 1651        +POIRIER,BISWAS,GUTAY+       (NDAM+PURD+SLAC)
KEY      68 PR  166 1430        +PRENTICE+COOPER+MANNER+     (TNTO+ANL+WISC)
LAMSA    68 PR  166 1395        +CASON+BISWAS+DERADO+GROVES+      (NOTREDAME)
LANZEROT 68 PR  166 1365        LANZEROTTI,BLUMENTHAL,EHN,FAISSLER + (HARV)
MARATECK 68 PRL 21 1613         +HAGOPIAN,+  (PENN+LRL+COLO+PURD+TNTO+WISC)
PISUT    68 NP B 6  325         J.PISUT,M.ROOS                         (CERN)

AUGUSTI1 69 PL  28 B 508        +BIZOT+BUON+HAISSINSKI+LALANNE+        (ORSAY)
AUGUSTI2 69 LNC 2  214          +LEFRANCOIS,LEHMANN,MARIN,+            (ORSAY)
AUSLENDE 69 SJNP 9  69          AUSLENDER,BUDKER,PANTUSOVA,PESTOV+     (NOVO)
GERMAN C 69 PR  188  2060       GERMAN BUBBLE CHAMBER COLL.            (DESY)
HAISSINS 69 ARGONNE CONF. 373   J.HAISSINSKI                           (ORSAY)
JUHALA   69 PR  184  1461       +LEACOCK,RHODE,KCPELMAN,LIBBY,+  (ISU+COLO)
MALAMUD  69 ARGONNE CONF.P.93   E.MALAMUD, P.SCHLEIN                   (UCLA)
MILLER   69 PR  178 2061        R.MILLER,LICHTMAN,WILLMANN             (PURDUE)
MOTT     69 PR  177 1966        +AMMAR,DAVIS,KROPAC,SLATE,DAGAN+  (NWES+ANL)
REYNOLDS 69 PR  184 1424        +ALBRIGHT,BRADLEY,BRUCKER,HARMS+       (FSU)
ROOS     69 NP B 10 563         M.ROOS,J.PISUT              (CERN+BRATISLAVA)
ROTHWELL 69 PR  23  1521        +CHASE,EARLES,GETTNER,GLASS,WEINSTEI+(NEAS)
SCHAREN  69 ARGONNE CONF.306    SCHARENGUIVEL                          (PURDUE)
WEHMANN  69 PR  178  2095       +ENGELS,WILSON,+ (HARV+CASE+SLAC+CORN+MCGI)

ALVENSLE 70 PRL 24 786          ALVENSLEBEN,BECKER,BERTRAM,CHEN,COHEN(DESY)
BATON    70 PL  33 B 528        +LAURENS,REIGNIER                      (SACLAY)
BIGGS    70 PRL 24 1197         +BRABEN,CLIFFT,GABATHULER,KITCHING+    (DARE)
BINGHAM  70 PRL 24 955          +FRETTER,MOFFEIT,BALLAM+     (LRL+SLAC+TUFT)
GALLOWAY 70 PR  D 1 3077        +MOTT,ALYA,LEE,MARTIN,PRICKETT           (IND)

ABRAMS   71 PR  D 4 653         +BARNHAM,BUTLER,COYNE,GOLDHABER,HALL,+(LBL)
BLOODWOR 71 NP B 35 133         BLOODWORTH,JACKSON,PRENTICE,YOON   (TORONTO)
DEERY    71 PR  D 3 635         +BISWAS,CASON,GROVES,JOHNSON,+ (NOTRE DAME)

BAILLON  72 PL  38 B 555        +CARNEGIE,KLUGE,LEITH,LYNCH,RATCLIFF+(SLAC)
BALLAM   72 PR  D 5  545        +CHADWICK,BINGHAM,MILBURN,+ (SLAC+LBL+TUFT)
BASDEVAN 72 PL  41 B 178        BASDEVANT,FROGGATT,PETERSEN            (CERN)
BENAKSAS 72 PL  39 B 289        +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE,+(ORSA)
DRIVER   72 NP B 38 1           +HEINLOTH,HOHNE,HOFMANN,RATHJE,+(DESY+HAMB)
EISENBER 72 PR  D 5  15         EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
GRAYER   72 PHIL.CONF.PROC. 5   +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
GRAYER   72 NP B 50 29          +HYAMS,JONES,WEILHAMMER,BLUM,+  (CERN+MPIM)
JACOBS   72 PR  D 6  1291       L.D.JACOBS                             (SACLAY)
RATCLIFF 72 PL  38 B 345        +BULOS,CARNEGIE,KLUGE,LEITH,LYNCH,+    (SLAC)
TAKAHASH 72 PR  D 6  1266       TAKAHASHI,BARISH,+      (TOHO+PENN+NDAM+ANL)

BYERLY   73 PR  D 7  637        +ANTHONY,COFFIN,MEANLEY,MEYER,RICE,+   (MICH)
CHARLESW 73 NP B 65 253         CHARLESWORTH,EMMS,BELL,+    (RHEL+BIRM+DURH)
GLADDING 73 PR  D 8  3721       +RUSSEL,TANNENBAUM,WEISS,THOMSON         (HARV)
HYAMS    73 NP B 64 134         +JONES,WEILHAMMER,BLUM,DIETL,+  (CERN+MPIM)
PROTOPOP 73 PR  D 7  1280       PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)

CARROLL  74 PR  D 10 1430       +MATTHEWS,WALKER+      (SLAC+DUKE+WISC+TNTO)
ENGLER   74 PR  D 10 2070       +KRAEMER,TOAFF,WEISSER,DIAZ+     (CARN+CASE)
ESTABROO 74 NP B 79 301         P.ESTABROOKS,A.D.MARTIN                (DURH)
GOBBI    74 PRL 33 1450         +ROSEN,SCOTT,SHAPIRO+        (NWES+ROCH+CARN)
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Mesons

$\rho(770)$, $\omega(783)$

Data Card Listings

For notation, see key at front of Listings.

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GRAYER    74 NP B 75 189        G.GRAYER,HYAMS,BLUM,DIETL,+      (CERN+MPIM)
HABER     74 PR D10 1387        +HODOUS,HULSIZER,KISTIAKOWSKY,LEVY+   (MIT)
NORDBERG  74 PL 51 8 106        +ABRAMSON,ANDREWS,HARVEY,+       (CORN+ROCH)
SPITAL    74 PR D 9 126         R.SPITAL,D.R.YENNIE                (CORN)

ROOS      75 NP B 97 165        M.ROOS                             (HELS)

ANDREWS   77 PRL 38 198         +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+    (ROCH)
BARTALUC  77  DESY 77/56        BARTALUCCI,BERTOLUCCI,+          (DESY+FRAS)
WICKLUND  77  ANL-HEP-PR-77-58  +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

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$\omega(783)$

1 OMEGA(783,JPC=1--) I=0

1 OMEGA MASS (MEV)

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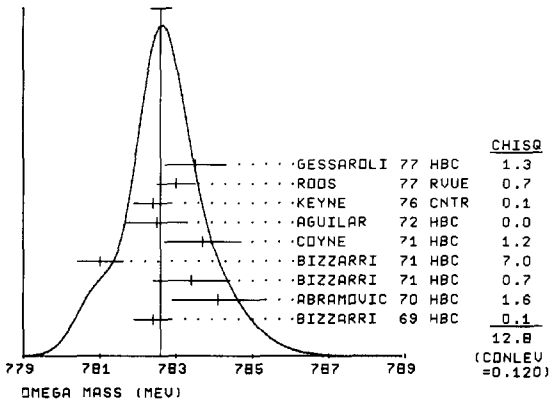
M        64 (779.4)    (1.4)          ARMENTERO 62 HBC      0.0 PBAR P K1K1. 2/74
M       800 (782.0)    (1.0)          ALFF      62 HBC      2.3-2.9 PI+P     . 2/74
M        34 (784.0)    (1.0)          ARMENTERO 63 HBC      0.0 PBAR P       . 2/74
M       220 (781.0)    (2.0)          KRAEMER   64 DBC      1.2 PI+D         . 2/74
M       170 (785.6)    (1.2)          MILLER D  65 HBC      SEEN WITH K+K-   . 2/74
M       666 (786.0)    (1.0)          JAMES     66 HBC      2.1 PI+P         . 2/74
M   R 2198 (783.4)    (0.7)          BALTAY    67 HBC      0.0 PBAR P         2/74
M       155 (779.5)    (1.5)          BARASH    67 HBC      0.0 PBAR P K1K1. 2/74
M         (784.8)    (1.1)          KEY       68 HBC      3 PI-P           . 2/74
M      2400  782.4     0.5           BIZZARRI  69 HBC      0 PBAR P         9/69
M       750  784.1     1.2           ABRAMOVIC 70 HBC      3.9 PI- P        2/74
M   R           (784.0)    (0.7)     ATHERTON  70 HBC      3.6 PBAR P, 7 PI. 2/74
M   F           (783.2)    (1.6)     BIGGS     70 CNTR     PHOTOPRODUCTION    2/74
M   F    FROM OMEGA-RHO INTERFERENCE IN THE PI+PI- MASS SPECTRUM
M   F    ASSUMING OMEGA WIDTH 12.6 MEV.
M       260 (781.0)    (2.0)          CASON     70 HBC      8.0 PI-P,4PI     . 2/74
M       250 (784.)     (1.)           DANBURG   70 DBC      1.2 PI+ D        . 2/74
M       500 (786.)     (1.)           DANBURG   70 DBC      1.4 PI+ D        . 2/74
M       600 (784.)     (1.)           DANBURG   70 DBC      1.7 PI+ D        . 2/74
M       500 (786.)     (1.)           DANBURG   70 DBC      1.9 PI+ D        . 2/74
M       400 (785.)     (1.)           DANBURG   70 DBC      2.1 PI+ D        . 2/74
M       200 (785.)     (2.)           DANBURG   70 DBC      2.3 PI+ D        . 2/74
M       248  783.4     1.0           BIZZARRI  71 HBC      0.0 P PBAR K+K-  11/71
M       510  781.0     0.6           BIZZARRI  71 HBC      0.0 P PBAR K1K1  11/71
M   C 4270 (784.1)    (0.3)          COYNE     71 HBC      3.7 PI+ P          11/71
M   C    FROM TOTAL SAMPLE OF COYNE 71.  THEY OBSERVE AN IMPORTANT
M   C    CORRELATION BETWEEN SIGMA OF EXP. RESOLUTION AND THE MEAS. MASS.
M D           783.7     1.0           COYNE     71 HBC      3.7 PI+ P        11/71
M D    FROM BEST-RESOLUTION SAMPLE OF COYNE 71                              11/71
M       369 (784.0)    (1.4)          MATTHEWS  71 DBC      6.95 PI+ D       . 2/74
M       418  782.5     0.8           AGUILAR   72 HBC      3.9,4.6 K- P     12/72
M SR 4800 (782.0)    (0.8)          OREN      74 HBC      2.3 PBAR P,5PI   12/75
M S    ERROR INCLUDES 0.5 MEV MASS SCALE ERROR
M B 7000  782.4     0.5           KEYNE     76 CNTR     PI-P, OMEGA N    12/75
M   33260  783.0     0.5           ROOS      77 RVUE     0-3.6 PBAR P     12/75
M B    OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM
M R    INCLUDED IN ROOS 77 RVUE.
M      2100  783.5     0.8           GESSAROLI 77 HBC      11 PI-P,OMEGA PI 12/77*
M
M          . . . . . .
M AVG      782.59     0.28    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
M STUDENT  782.66     0.26    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                              (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 782.59 ± 0.28
ERROR SCALED BY 1.3



			CHISQ
GESSAROLI	77	HBC	1.3
ROOS	77	RVUE	0.7
KEYNE	76	CNTR	0.1
AGUILAR	72	HBC	0.0
COYNE	71	HBC	1.2
BIZZARRI	71	HBC	7.0
BIZZARRI	71	HBC	0.7
ABRAMOVIC	70	HBC	1.6
BIZZARRI	69	HBC	0.1
			12.8

(CONLEV =0.120)

1 OMEGA FULL WIDTH (MEV)

```
W        34     9.0      3.0          ARMENTERO 63 HBC      0.0 PBAR P
W              13.4      3.0          MILLER D  65 HBC      SEEN WITH K+ K-
W       155  (12.3)     (2.0)         BARASH    67 HBC      SEEN WITH K1 K1  . 6/66
W   B   171   (5.8)     (2.8)         BARASH    67 HBC      0.0 PBAR P,K1 K1 11/71
W   B          UNFOLDED BY COYNE 71                                          11/71
W       750     8.8      3.0          ABRAMOVIC 70 HBC      3.9 PI- P        6/70
W              11.2      2.7          ATHERTON  70 HBC      3.6 PBAR P, 7 PI  5/70
W       510     10.3     1.4          BIZZARRI  71 HBC      0.0 P PBAR K1K1 11/71
W       248     12.8     3.0          BIZZARRI  71 HBC      0.0 P PBAR K+K- 11/71
W      4270     9.5      1.0          COYNE     71 HBC      3.7 PI+ P        11/71
W       418     13.3     2.           AGUILAR   72 HBC      3.9,4.6 K- P     12/72
W               9.1      0.8          BENAKSAS1 72 OSPK     E+E- COLL.BEAMS   2/73
W              10.5      1.5          BORENSTEI 72 HBC      2.18 K-P         7/77*
W   E   940     7.70     1.65         BROWN     72 MMS      2.5 PI- P,N MMS  12/72
W   E    ERROR TAKES ACCOUNT OF SYSTEMATICS ADDED LINEARLY
W   B 20000    10.22     0.43         KEYNE     76 CNTR     PI-P, OMEGA N    12/75
W   B    OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM
W      2100     9.4      2.5          GESSAROLI 77 HBC      11 PI-P,OMEGA PI 12/77*
W          . . . . . .
W AVG        10.06     0.31    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W STUDENT    10.06     0.35    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
```

1 OMEGA PARTIAL DECAY MODES

		DECAY MASSES
P1	OMEGA INTO PI+ PI- PIO	139+ 139+ 134
P2	OMEGA INTO PI+ PI- (VIOLATES G)	139+ 139
P3	OMEGA INTO PIO GAMMA	134+ 0
P4	OMEGA INTO PI+ PI- GAMMA	139+ 139+ 0
P5	OMEGA INTO 2PIO GAMMA	134+ 134+ 0
P6	OMEGA INTO ETA GAMMA	548+ 0
P7	OMEGA INTO E+ E-	.5+ .5
P8	OMEGA INTO MU+ MU-	105+ 105
P9	OMEGA INTO ETA PIO (VIOLATES C)	548+ 134
P10	OMEGA INTO 3 GAMMA	0+ 0+ 0
P11	OMEGA INTO PIO MU+ MU-	134+ 105+ 105

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{(\delta P_i \delta P_j)}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3
P 1	.8987+-.0056		
P 2	-.5582	.0130+-.0027	
P 3	-.8728	.0824	.0884+-.0046

1 OMEGA BRANCHING RATIOS

```
R1     OMEGA INTO NEUTRAL/(PI+ PI- PIO)                        (P3+...)/(P1)
R1          0.17      0.04          ARMENTERO 63 HBC      0.0 PBAR P
R1    20    0.11      0.02          BUSCHBECK 63 HBC      1.5 K-P
R1    35    0.08      0.03          KRAEMER   64 DBC      1.2 PI+D
R1    65    0.10      0.04          ALFF-STEI 66 HBC CORR.BY SCHULTZ(COL)   9/66
R1   850    0.134     0.026         DIGIUGNO  66 CNTR     1.4 PI-P         9/66
R1   348    0.097     0.016         FLATTE    66 HBC      1.8 K-P          9/66
R1          0.06      0.05     0.02 JAMES     66 HBC      2.1 PI+P         6/66
R1    19    0.10      0.03          BARASH    67 HBC      0.0 PBAR P       7/67
R1    46    0.15      0.04          AGUILAR   72 HBC      3.9,4.6 K- P     12/72
R1          . . . . . .
R1  AVG     0.1065    0.0088  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  STUDENT 0.106     0.010   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT     0.0983    0.0057 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2     OMEGA INTO (PI+ PI-)/(PI+ PI- PIO). SEE ALSO R15 (P2)/(P1)
R2 R        (0.011)OR MORE  CL=.95  ABRAMOVIC 70 HBC      3.9 PI- P        . 6/70
R2 R        (0.035)OR LESS  CL=.95  BIZZARRI  70 DBC      PBAR N AT REST  11/71
R2          (0.019)OR MORE  CL=.95  CHAPMAN   70 HBC      1.6-2.2 P PBAR   6/70
R2 F        (.002)OR MORE  CL=.90   FLATTE    70 HBC      1.5    K- P      8/69
R2 F        FLATTE 70 SEES NO SIGNAL AT 1.7, 2.1, 2.6 GEV/C.
R2          (0.0026)OR MORE CL=.84  HAGOPIAN  70 HBC      2.3 PI- P        1/71
R2          (0.040)OR LESS  CL=.84  HAGOPIAN  70 HBC      2.3 PI- P        1/71
R2 R        0.022     0.009    0.01 ROOS     70 RVUE                      6/70
R2 R        ROOS 70 COMBINES ABRAMOVICH 70 AND BIZZARRI 70
R2          0.028     0.006         BEHREND   71 ASPK     PHOTOPRODUCTION  11/71
R2 S        0.021     0.028    0.009 RATCLIFF 72 ASPK     15.PI- P,N 2PI   12/72
R2 S  SIGNIFICANT INTERFERENCE EFFECT OBSERVED.NB OF OMEGA INTO 3PI         12/72
R2 S  COMES FROM AN EXTRAPOLATION.                                         12/72
R2          (0.0115)OR MORE         BURNS     73 HBC      .6-1.1 PBAR P    12/75
R2          (0.024)OR MORE  CL=0.95 LYONS     77 HBC      3-4 K-P,LAM OMEG 12/77*
R2          . . . . . .
R2  AVG     0.0259    0.0049  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT 0.0259    0.0053  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT     0.0144    0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R3     OMEGA INTO (PIO GAMMA) / (PI+ PI- PIO)                  (P3)/(P1)
R3          (0.125)  (0.025)OR GRTR. BARMIN     64 PXBC      2.8 PI-P
R3          0.13      0.04          JACQUET   69 HLBC                     10/67
R3          0.081     0.020         BALDIN    71 HLBC      2.9 PI+ P       11/71
R3          0.109     0.025         BENAKSAS2 72 OSPK     E+E- COLL.BEAMS   2/73
R3          0.084     0.013         KEYNE     76 CNTR     PI-P, OMEGA N    12/75
R3          . . . . . .
R3  AVG     0.0898    0.0097  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT 0.090     0.011   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT     0.0983    0.0057 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4     OMEGA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)                (P4)/(P1)
R4          (0.05) OR LESS  CL=.90  FLATTE    66 HBC      1.8 K-P          9/66
R4          (.066)OR LESS   CL=.90  KALBFLEI  75 HBC      2.2 K- P,GAMMA + 12/75

R6     OMEGA INTO (MU+ MU-)/(PI+ PI- PIO)(UNITS 10**-3)        (P8)/(P1)
R6          (1.2)  OR LESS          GALTIERI  65 HBC      2.7 K-P
R6          (1.7)  OR LESS  CL=.74  FLATTE    66 HBC      1.8 K-P          9/66
R6          (0.2)  OR LESS          WILSON    69 OSPK     12 PI- ON C,FE   9/69

R7     OMEGA INTO (2PIO GAMM)/(PIO GAMMA)                      (P5)/(P3)
R7          (0.1)  OR LESS          BARMIN    64 PXBC      1.3-2.8 PI-P
R7          (0.45)   (0.33)        STRUGALSK 69 HLBC      2.34 PI+ N       8/69
R7          (0.14) OR LESS          BALDIN    71 HLBC      2.9 PI+ P       11/71
R7          (0.15) OR LESS  CL=.90  BENAKSAS2 72 OSPK     E+E- COLL. BEAMS  2/73
R7          (0.18) OR LESS  CL=0.95 KEYNE     76 CNTR     PI-P,OMEGA N     7/77*

R8     OMEGA INTO (ETA PIO + ETA GAMMA)/(PI+ PI- PIO)  (P9+P6)/(P1)
R8          (0.017)OR LESS  CL=.90  FLATTE    66 HBC      1.8 K-P          9/66
R8          (0.045)OR LESS  CL=.95  JACQUET   69 HLBC                     4/70

R9     OMEGA INTO (NEUTRALS) / (CHARGED)                       (P3+...)/(P1+P2...)
R9          0.124     0.021         FELDMAN   67 OSPK     1.2 PI- P        3/67
R9          . . . . . .
R9  FIT     0.0969    0.0056 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R10    OMEGA INTO (2PIO GAMMA)/(PI+PI-PIO)                     (P5)/(P1)
R10         (0.08) OR LESS  CL=.95  JACQUET   69 HLBC                     4/70

R11    OMEGA INTO (ETA GAMMA)/(PIO GAMMA)                      (P6)/(P3)
R11         (0.58)   (0.30)        STRUGALSK 69 HLBC      2.34 PI+ N       8/69
R11         (0.40) OR LESS          BALDIN    71 HLBC      2.9 PI+ P       11/71
R11         0.010     0.045         APEL      72 OSPK     4-8 PI- P,N 3GAM  2/73
R11         (0.27) OR LESS  CL=.90  BENAKSAS2 72 OSPK     E+E- COLL. BEAMS  2/73

R12    OMEGA INTO (PIO MU+ MU-) / TOTAL (UNITS 10**-3)  (P11)
R12         (2.)   OR LESS          WEHMANN   68 OSPK     12 PI- FE        6/68
```

R13 OMEGA INTO (E+ E-)/TOTAL (UNITS 10**-4) (P7)
R13 3 2. 1.2 BINNIE 65 OSPK PI-P NEAR THLD. 6/66
R13 B MASS RESOLUTION OF BINNIE 65 IS ABOUT 15 MEV.
R13 H (1.0) (1.7) (0.75) HERTZBACH 67 OSPK ASSUME SU(3)+MIXING.10/66
R13 H NOT RESOLVED FROM RHO DECAY.
R13 A 33 (0.65) (0.13) ASTVACATU 68 OSPK ASSUME SU(3)+MIXING 6/68
R13 A NOT RESOLVED FROM RHO DECAY. ERROR STATISTICAL ONLY.
R13 0.40 0.21 BOLLINI1 68 CNTR 1.7PI-P,NOTE Z 9/68
R13 Z MASS RESOLUTION OF BOLLINI 1 IS +-10 MEV.HIS ERROR IS +-.15
R13 Z WITHOUT RHO-OMEGA INTERFERENCE. COMPLETE INTERFERENCE WOULD
R13 Z CHANGE VALUE BY +-35 PER CENT. THEREFORE WE INCREASED ERROR.
R13 E (0.76) (0.14) AUGUSTI1 69 OSPK SEE NOTE E 2/72
R13 E FROM E+ E- COLLIDING BEAMS, ASSUMING OMEGA WIDTH 12.2+-1.3 MEV 4/69
R13 0.83 0.10 BENAKSAS1 72 OSPK E+E- COLL.BEAMS 2/73
R13 . . . .
R13 AVG 0.76 0.17 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R13 STUDENT 0.77 0.11 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R14 OMEGA INTO NEUTRALS / TOTAL (P3+...)
R14 0.084 0.015 BOLLINI 68 CNTR 2.1 PI- P 6/68
R14 0.079 0.019 DEINET 69 OSPK 1.5 PI- P 9/69
R14 0.075 0.025 BIZZARRI 71 HBC 0.0 P PBAR 11/71
R14 42 0.073 0.018 BASILE 72 CNTR 1.67 PI- P 2/73
R14 . . . .
R14 AVG 0.0788 0.0092 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R14 STUDENT 0.0788 0.0098 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R14 FIT 0.0884 0.0046 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R15 OMEGA INTO (PI PI)/(TOTAL). SEE ALSO R2 (P2)
R15 0.032 0.028 0.019 AUGUSTI2 69 OSPK E+E- COLL.BEAMS 8/69
R15 (0.003)OR MORE CL=.95 GOLDHABER 69 HBC 3.7-4.0 PI+P 11/69
R15 (0.014)OR MORE CL=.95 ALLISON 70 HBC 1.3-1.7 PBAR P . 6/70
R15 0.0080 0.0028 0.0022BIGGS 70 CNTR PHOTOPRODUCTION 6/70
R15 0.0122 0.0030 ALVENSLEB 71 CNTR PHOTOPRODUCTION 11/71
R15 0.013 0.012 0.009 MOFFEIT 71 HBC 2.8,4.7 GAMMA P 11/71
R15 0.036 0.024 0.018 BENAKSAS 72 OSPK E+E- COLL.BEAMS 12/72
R15 (0.005)OR MORE CL=0.95 BRANDENBU 76 ASPK 13.K-P,PI+PI- 7/77*
R15 (0.009)OR MORE CL=0.95 HOLMGREN 77 HBC 4.2 K-P,PI+PI- 7/77*
R15 (0.008)OR MORE CL=0.95 WICKLUND 77 ASPK 3,4,6 PI+-PN 12/77*
R15 . . . .
R15 AVG 0.0102 0.0019 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R15 STUDENT 0.0102 0.0022 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R15 FIT 0.0130 0.0027 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R16 OMEGA INTO (ETA GAMMA) / (ALL NEUTRALS) (P6)/(P3+...)
R16 (0.24) OR LESS CL=.90 DEINET 69 OSPK 9/69
R16 (0.36) OR LESS CL=.90 DAKIN 72 OSPK 1.4 PI- P,N MMO 12/72

R17 OMEGA INTO (2 PI0 GAMMA) / (ALL NEUTRALS) (P5)/(P3+...)
R17 (0.19) OR LESS CL=.90 DEINET 69 OSPK 9/69
R17 D (0.22) (0.07) DAKIN 72 OSPK 1.4 PI- P,N MMO 12/72
R17 D SEE R18

R18 OMEGA INTO (PI0 GAMMA) / (ALL NEUTRALS) (P3)/(P3+...)
R18 (0.81) OR MORE CL=.90 DEINET 69 OSPK 9/69
R18 D (0.78) (0.07) DAKIN 72 OSPK 1.4 PI- P,N MMO 12/72
R18 D ERROR STATISTICAL ONLY.AUTHORS OBTAIN GOOD FIT ALSO ASSUMING 11/71
R18 D PI0 GAMMA AS THE ONLY NEUTRAL DECAY. 11/71

R19 OMEGA INTO (ETA GAMMA)/TOTAL (UNITS 10**-4) (P6)
R19 A (3.0) (2.5) (1.8) ANDREWS 77 CNTR 0 6.7-10 GAMMA CU 12/77*
R19 A SOLUTION CORRESPONDING TO CONSTRUCTIVE OMEGA-RHO INTERFERENCE
R19 A THE QUARK MODEL PREDICTS A RELATIVE DECAY PHASE OF ZERO
R19 B (29.0) (7.0) ANDREWS 77 CNTR 0 6.7-10 GAMMA CU 12/77*
R19 B SOLUTION CORRESPONDING TO DESTRUCTIVE OMEGA-RHO INTERFERENCE

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REFERENCES FOR OMEGA

MAGLIC 61 PRL 7 178 B MAGLIC,ALVAREZ,ROSENFELD,STEVENSON (LRL)
PEVSNER 61 PRL 7 421 PEVSNER,KRAEMER,NUSSBAUM,RICHARD+(JHU+NWES)
XUONG 61 PRL 7 327 NGUYEN HUU XUONG,GERALD R LYNCH (LRL)

ALFF 62 PRL 9 325 ALFF,BERLEY,COLLEY,GELFAND + (COLU+RUTGERS)
ARMENTER 62 CERN CONF 90 R ARMENTEROS,R BUDDE + (CERN+CDEF+EPOL)
STEVENSO 62 PR 125 687 STEVENSON,ALVAREZ,MAGLIC,ROSENFELD (LRL)

ARMENTER 63 SIENA CONF 1 296 ARMENTEROS,EDWARDS,JACOBSEN+ (CERN+CDEF)
BARMIN 63 SIENA CONF 1 207 BARMIN,DOLGOLENKO,KRESTNIKOV+ (ITEP)
BUSCHBEC 63 SIENA CONF 1 166 BUSCHBECK,CZAPP+ (VIENNA+CERN+AMSTERDAM)
GELFAND 63 PRL 11 436 GELFAND,MILLER,NUSSBAUM,RATAU+ (COLU+RUTG)
MURRAY 63 PL 7 358 MURRAY,FERROLUZZI,HUWE,SHAFER,SOLMITZ+(LRL)

BARMIN 64 JETP 18 1289 BARMIN,DOLGOLENKO,KRESTNIKOV + (ITEP)
KRAEMER 64 PR 136 B 496 KRAEMER,MADANSKY,MEER+ (JHU+NWES+WOOD)

BINNIE 65 PL 18 348 BINNIE,DUANE,JANE,W JONES+ (LOIC+MCHS)
GALTIERI 65 PRL 14 279 A BARBARO GALTIERI,R D TRIPP (LRL)
MILLER D 65 CU-237(NEVIS 131) DAVID C MILLER (THESIS) (COLUMBIA)
INCLUDES DATA OF GELFAND 63 ABOVE
ALFF-STE 66 PR 145 1072 ALFF-STEINBERGER,BERLEY,BRUGGER+(COLU+RUTG)
ZDANIS 65 PRL 14 721 ZDANIS,MADANSKY,KRAEMER,HERTZBACH+(JHU+BNL)

DIGIUGNO 66 NC 44A 1272 DI GIUGNO,PERUZZI,TROISE+ (NAPL+FRAS+TRST)
FLATTE 66 PR 145 1050 +HUWE,MURRAY,BUTTON-SHAFER,SOLMITZ+ (LRL)
JAMES 66 PR 142 896 F E JAMES,KRAYBILL (YALE+BROOKHAVEN)

BALTAY 67 PRL 18 93 +FRANZINI,SEVERIENS,YEH,ZANELLO (COLUMBIA)
BARASH 67 PR 156 1399 BARASH,KIRSCH,MILLER,TAN (COLUMBIA)
FELDMAN 67 PR 159 1219 +FRATI,GLEESON,HALPERN,NUSSBAUM+ (PENN)
HERTZBAC 67 PR 155, 1461 HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
ALSO 65 ZDANIS

ASTVACAT 68 PL 27 B 45 ASTVACATUROV,AZIMOV,BALDIN+ (JINR+MOSCOW)
BOLLINI 68 NC 56 A 531 +BUHLER,DALPIAZ,MASSAM+ (CERN+BGNA+STRB)
BOLLINI1 68 NC 57 A 404 +BUHLER,DALPIAZ,MASSAM+ (CERN+BGNA+STRB)
KEY 68 PR 166 1430 +PRENTICE+COOPER+MANNER (TNTO+ANL+WISC)
PISUT 68 NP B 6 325 J.PISUT,M.ROOS (CERN)
WEHMANN 68 PRL 20 748 +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)

AUGUSTI1 69 PL 28 B 513 +BENAKSAS,BUON,GRACCO,HAISSINSKI,+ (ORSAY)
AUGUSTI2 69 LNC 2 214 +LEFRANCOIS,LEHMANN,MARIN,+ (ORSAY)
BIZZARRI 69 NP B 14 169 +FOSTER,GAVILLET,MONTANET,+ (CERN+CDEF)
DANBURG 69 UCRL-19275 JEROME S. DANBURG, THESIS (LRL)
ALSO DANBURG 70
DEINET 69 PL 30 B 426 +MENZIONE,MULLER,BUNIATOV+ (KARL+CERN)
ERWIN 69 NP B 9 364 +WALKER,GOSHAW,WEINBERG (WISC+PRIN+VAND)
GOLDHABE 69 PRL 23,1351 +BUTLER,COYNE,HALL,MACNAUGHTON,TRILING(LRL)
JACQUET 69 NC 63 A 743 +NGUYEN-KHAC,HAATUFT,HALSTEINSLI(EPOL+BERG)
MILLER 69 PR 178 2061 R.MILLER,LICHTMAN,WILLMANN (PURDUE)
STRUGALS 69 PL 29 B 532 +CHUVILO,FENYVES,+ (WARS+JINR+BUDA)
WILSON 69 PRIVATE COMM. RICHARD WILSON (SEE ALSO PR 178 2095)(HARV)

ABRAMOVI 70 NP B 20 209 ABRAMOVICH,BLUMENFELD,BRUYANT,+ (CERN)
BIZZARRI 70 PRL 25 1385 +CIAPETTI,DORE,GASPERO,GUIDONI,+(ROMA+SYRA)
ALLISON 70 PRL 24 618 +COOPER,FIELDS,RHINES (ANL)
ATHERTON 70 NP B 18 221 +BLAIR,CELNIKER,DOMINGO,FRENCH+ (CERN+IPN)
BIGGS 70 PRL 24 1201 +CLIFFT,GABATHULER,KITCHING,RAND (DARE)
CASON 70 PR D 1 851 +ANDREWS,BISWAS,GROVES,HARRINGTON,+ (NDAM)
CHAPMAN 70 NP B 24 445 +DAVIDSON,GREEN,LYS,ROE,VANDER VELDE (MICH)
DANBURG 70 PR D 2 2564 +ABOLINS,DAHL,DAVIES,HOCH,KIRZ,MILLER+(LRL)
FLATTE 70 PR D 1 1 STANLEY M. FLATTE (LRL)
GOLDHABE 70 PHILA.CONF.P.59 GERSON GOLDHABER,REVIEW (LRL)
HAGOPIAN 70 PRL 25 1050 S. AND V.HAGOPIAN,BOGART,SELOVE (FSU+PENN)
ROOS 70 DNPL/R7 P.173 PROC. DARESBURY STUDY WEEKEND NO 1. (CERN)

ABRAMS 71 PR D 4 653 +BARNHAM,BUTLER,COYNE,GOLDHABER,HALL,+(LBL)
ALVENSLE 71 PRL 27 888 ALVENSLEBEN,BECKER,BUSZA,CHEN,COHEN,+(DESY)
ANGELOW 71 SJNP 12 427 +GRAMENITSKY,KANASIRSKY,KERATSCHEW,+ (JINR)
BALDIN 71 SJNP 13 758 +YERGAKOV,TREBUKHOVSKY,SHISHOV (ITEP)
BARDADIN 71 PR D4 2711 BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BEHREND 71 PRL 27 61 +LEE,NORDBERG,WEHMAN,+ (ROCH+CORN+FNAL)
BIZZARRI 71 NP B 27 140 +MONTANET,NILSSON,D-ANDLAU,+ (CERN+CDEF)
BLOODWOR 71 NP B 35 133 BLOODWORTH,JACKSON,PRENTICE,YOON (TORONTO)
CHAPMAN 71 PR D 3 38 +FORTNEY,FOWLER (DUKE)
COYNE 71 NP B 32 333 +BUTLER,FANG-LANDAU,MACNAUGHTON (LRL)
FIELDS 71 PRL 27 1749 +COOPER,RHINES,ALLISON (ANL+OXF)
MATTHEWS 71 PRL 26 400 +PRENTICE,YOON,CARROLL,WALKER,+ (TNTO+WISC)
MOFFEIT 71 NP B 29 349 +BINGHAM,FRETTER,BALLAM+(LRL+UCB+SLAC+TUFT)

AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
APEL 72 PL 41 B 234 +AUSLANDER,MULLER,BERTOLUCCI,+ (KARL+PISA)
BASILE 72 PHIL.CONF.PROC153 +BOLLINI,BROGLIN,DALPIAZ,FRABETTI,+ (CERN)
BENAKSAS 72 PL 39 B 289 +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE,+(ORSA)
BENAKSAS172 PL 42 B 507 +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BENAKSAS272 PL 42 B 511 +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
BROWN 72 PL 42 B 117 +DOWNING,HOLLOWAY,HULD,BERNSTEIN+(ILL+ILLC)
DAKIN 72 PR D 6 2321 +HAUSER,KREISLER,MISCHKE (PRINCETON)
EISENBER 72 PR D 5 15 EISENBERG,BALLAM,DAGAN,+ (REHO+SLAC+TELA)
RATCLIFF 72 PL 38 B 345 +BULOS,CARNEGIE,KLUGE,LEITH,LYNCH,+ (SLAC)
BORENSTE 72 PR D 5 1559 BORENSTEIN,DANBURG,KALBFLEISCH,+ (BNL+MICH)

BINNIE 73 PR D 8 2789 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)
BURNS 73 PR D 7 1310 +CONDON,KIM,MANDELKERN,PRICE,SCHULTZ (UCI)

ESTABROO 74 NP B 81 70 ESTABROOKS,HYAMS,JONES,BLUM, (CERN+MPIM)
GREGORIO 74 NC 20 A 437 M.A.GREGORIO (ICTP-TRIESTE)
KRAMER 74 PRL 33 505 +AYRES,DIEBOLD,GREENE,PAWLICKI+ (ANL)
OREN 74 NP B 71 189 +COOPER,FIELDS,RHINES,ALLISON+ (ANL+OXF)

EMMS 75 NP B98 1 +KINSON,STACEY,BELL,DALE+ (BIRM+DURH+RHEL)
KALBFLEI 75 PR D 11 987 KALBFLEISCH,STRAND,CHAPMAN (BNL+MICH)
ROOS 75 NP B 97 165 M.ROOS (HELS)

KEYNE 76 PR D 14 28 +BINNIE,CARR,DEBENHAM,GARBUTT,+ (LOIC+SHMP)
ALSO 73 BINNIE
BRANDENB 76 NP B 104 413 BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)

ANDREWS 77 PRL 38 198 +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+ (ROCH)
GESSAROL 77 NP B 126 382 GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
HOLMGREN 77 PL 66 B 191 +JONGEJANS,ENGELEN,+ (CERN+AMST+NIJM+OXF)
LYONS 77 NP B 125 207 +COOPER,CLARK (OXF)
ROOS 77 LNC 19 419 M.ROOS (HELSINKI)
WICKLUND 77 ANL-HEP-PR-77-58 +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)

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M(940−953)

66 M(940-953)

→ THE CLAIM FOR A NARROW RESONANCE AT 940 MEV BY CHESHIRE 72 HAS NOT BEEN CONFIRMED BY BINNIE 72, 74, GRAYER 74, BUTTRAM 75. OMITTED FROM TABLE. THE CLAIM FOR A RESONANCE M(953) IN THE PI+ PI- GAMMA CHANNEL (AGUILAR 70) HAS NOT BEEN CONFIRMED. OMITTED FROM TABLE.

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REFERENCES FOR M(940-953)

AGUILAR 70 PRL 25 1635 AGUILAR-BENITEZ,BASSANO,SAMIOS,BARNES+(BNL)
MAGLICH 71 PRL 27 1479 +OOSTENS,BRODY,CVIJANOVICH (RUTG+PENN+UPNJ)
ROSNER 71 PRL 26 933 J.L.ROSNER,E.W.COLGLAZIER (MINN+CIT)
AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
CHESHIRE 72 PRL 28 520 +HOFFMAN,GARFINKEL,+ (IOWA+ANL+PURD)
BINNIE 72 PL 39 B 275 +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
BINNIE 74 PRL 32 392 +CAMILLERI,CARR,DEBENHAM,+ (LOIC+SHMP)
BUTTRAM 75 PRL 35 970 +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON (ISU)
GRIGORIA 75 NP B91 232 GRIGORIAN,LADAGE,MELLEMA,RUDNICK,+ (UCLA)

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η'(958)

2 ETA PRIME(958,JPG=0-+) I=0

Note on the J^P Assignment of $\eta'(958)$

From the Dalitz plot analyses of the $\eta' \to \pi\pi\eta$ and $\eta' \to \pi^+\pi^-\gamma$ decays and from the observation of an $\eta' \to \gamma\gamma$ decay mode, all assignments except $J^{PC} = 0^{-+}$ and 2^{-+} are excluded. The Dalitz plot analyses favor spin 0, but cannot rule out spin 2. The indication of anisotropy in the decay of very forward-produced η' (KALBFLEISCH 73) has not been confirmed by BALTAY 74 or CERRADA 77, thus again favoring spin 0, but still not ruling out spin 2 (LEDNICKY 77).

Mesons
$\eta'(958)$

Data Card Listings
For notation, see key at front of Listings.

Two recent analyses, however, seem to have finally established the spin 0 assignment of the η'.

CERRADA 77 perform a partial-wave analysis of the $\eta\pi\pi$ system produced in the reaction $K^-p \to \eta'\Lambda$, taking into account the η' and Λ joint decay angular correlations. They conclude that J^P is unambiguously 0^- (see also DELAGUILA 77).

ROUSSARIE 77 analyze a large sample of events from the reaction $\pi^-p \to \eta'n$ at beam momenta just above threshold. They verify that the η' is produced in a relative S-wave state, and thus the Adair condition is satisfied by their total sample of some 1800 events. The decay angular distribution of the η' is consistent with isotropy, and thus ROUSSARIE 77 conclude that the spin cannot be 2.

2 ETA PRIME MASS (MEV)

M	C	ONLY EXPERIMENTS GIVING ERROR LESS THAN 2 MEV KEPT FOR AVERAGING						12/75
M		85	(957.0)			DAUBER	64 HBC	1.95 K-P	
M	K		(958.0)	(1.0)		KALBFLEISCH 64 HBC	2.7 K-P	6/66
M	K	KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69						
M	C		(957.0)	(3.0)		BADIER	65 HBC	3.0 K-P	
M	C	8	(960.0)	(2.0)		TRILLING	65 HBC	3.65 PI+ P	12/75
M	C	7	(955.0)	(10.0)		COHN	66 OBC	3.3 PI+D	6/66
M	D		(959.0)	(3.0)		LONDON	66 HBC	2.2 K-P	6/66
M	C		(960.0)	(5.0)		MOTT	69 HBC	4.1-5.5 K- P	7/69
M			957.	1.		RITTENBER	69 HBC	1.7-2.7 K- P	9/69
M	D		(956.0)	(2.0)		AGUILAR	70 HBC	3.9-4.6K-P	12/75
M		3415	956.1	1.1		BASILE1	71 CNTR	1.6 PI- P,N XO	11/71
M		535	957.4	1.4		BASILE1	71 CNTR	1.6 PI- P,N XO	11/71
M		1414	958.2	0.5		DANBURG	73 HBC	2.2 K-P,LAM XO	2/74
M		400	958.	1.		JACOBS	73 HBC	2.9 K-P,LAM XO	1/74
M			957.46	0.33		DUANE	74 MMS	PI- P,N MM	1/74
M									
M	AVG		957.57	0.25	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
M	STUDENT		957.57	0.28	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

2 ETA PRIME WIDTH (MEV)

W	85	(4.0)	OR LESS		DAUBER	64 HBC	1.95 K-P	
W	3415	(8.)	OR LESS	CL=.90	BASILE1	71 CNTR	1.6 PI- P,N XO	11/71
W	514	(4.7)	OR LESS	CL=.95	DANBURG	73 HBC	2.2 K-P,LAM XO	2/74
W		(0.8)	OR LESS	CL=.95	DUANE	74 MMS	PI- P,N MM	1/74

2 ETA PRIME PARTIAL DECAY MODES

		DECAY MASSES
P1	ETA PRIME INTO PI+ PI- ETA P1(N) ETAS DECAY INTO ALL NEUTRALS P1(C) ETAS DECAY CHARGED	139+ 139+ 548
P2	ETA PRIME INTO PI0 PI0 ETA P2(N) ETAS DECAY INTO ALL NEUTRALS P2(C) ETAS DECAY CHARGED	134+ 134+ 548
P3	ETA PRIME INTO PI+ PI- GAMMA (INCLUDING RHO GAMMA)	139+ 139+ 0
P4	ETA PRIME INTO GAMMA GAMMA	0+ 0
P5	ETA PRIME INTO OMEGA GAMMA	0+ 783
P6	ETA PRIME INTO RHO0 GAMMA	0+ 776
P10	ETA PRIME INTO PI+ PI- E+ E-	139+ 139+ .5+ .5
P11	ETA PRIME INTO 2 PI	139+ 139
P12	ETA PRIME INTO 3 PI	139+ 139+ 134
P13	ETA PRIME INTO 4 PI	139+ 139+ 139+ 139
P14	ETA PRIME INTO 5 PI	
P15	ETA PRIME INTO 6 PI	
P16	ETA PRIME INTO PI0 E+ E- (VIOLATES C IN BORN APPROX.)	134+ .5+ .5
P17	ETA PRIME INTO ETA E+ E- (VIOLATES C IN BORN APPROX.)	548+ .5+ .5
P18	ETA PRIME INTO PI0 RHO 0 (VIOLATES C)	134+ 776
P19	ETA PRIME INTO PI0 OMEGA (VIOLATES C)	134+ 783

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5
P 1	.4262+-.0168				
P 2	-.5825	.2358+-.0195			
P 3	-.3544	-.5209	.2976+-.0167		
P 4	.0276	-.1387	-.0162	.0197+-.0026	
P 5	.1085	-.1676	-.1440	-.0235	.0206+-.0039

2 ETA PRIME BRANCHING RATIOS

Note on $\eta'(958)$ Branching Fractions

In our calculation of the branching fractions of the $\eta'(958)$, we use the decay modes $\eta\pi\pi$ (including $\eta\pi^0\pi^0$), $\rho^0\gamma$, and $\gamma\gamma$. It is assumed that the rate $\eta \to$ neutrals is 71.1%.

In the fit we do not use the constraint

$$R = \Gamma(\eta' \to \eta\pi^+\pi^-) / \Gamma(\eta' \to \eta\pi^0\pi^0) = 2$$

from I-spin conservation. The result of the fit is in agreement with it: $R = 1.8 \pm 0.2$.

R1		ETA PRIME INTO (PI+ PI-ETA (NEUTRAL DEC.))/TOTAL (P1N)							
R1	K	68	(0.36)	(0.05)		KALBFLE2	64 HBC	2.7 K-P	10/66
R1	K		KALBFLE2 64 SUPERSEDED BY RITTENBERG 69						
R1		281	0.314	0.026		RITTENBER	69 HBC	1.7-2.7 K-P	9/69
R1			• • • • • • • • •						
R1	FIT		0.309	0.012	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R2		ETA PRIME INTO (PI+ PI- NEUTRALS) / TOTAL (P1N+P2C)							
R2		33	0.35	0.06		BADIER	65 HBC	3.0 K-P	10/66
R2		39	0.4	0.1		LONDON	66 HBC	2.2 K-P	10/66
R2			• • • • • • • • •						
R2	AVG		0.363	0.051	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R2	STUDENT		0.363	0.056	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R2	FIT		0.379	0.010	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R3		ETA PRIME INTO (PI+ PI- ETA (CHRGD.DECAY))/TOTAL (P1C)							
R3	K	44	(0.12)	(0.02)		KALBFLE2	64 HBC	2.7 K-P	10/66
R3	K		KALBFLE2 64 SUPERSEDED BY RITTENBERG 69						
R3		7	0.07	0.04		BADIER	65 HBC	3.0 K-P	10/66
R3		10	0.1	0.04		LONDON	66 HBC	2.2 K-P	10/66
R3		107	0.123	0.014		RITTENBER	69 HBC	1.7-2.7 K-P	9/69
R3			• • • • • • • • •						
R3	AVG		0.116	0.013	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R3	STUDENT		0.116	0.014	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R3	FIT		0.1258	0.0050	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R4		ETA PRIME INTO (PI+ PI- NEUTRALS (EXCLUDING PI+ PI- ETA (NEUTR.DEC.))) / TOTAL (P2C)							
R4	K	10	(0.05)	(0.04)		KALBFLE2	64 HBC	2.7 K-P	10/66
R4	K		KALBFLE2 64 SUPERSEDED BY RITTENBERG 69						
R4		42	0.045	0.029		RITTENBER	69 HBC	1.7-2.7 K-P	9/69
R4			• • • • • • • • •						
R4	FIT		0.0696	0.0057	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R5		ETA PRIME INTO (NEUTRALS) / TOTAL (P2N+P4)							
R5	K	54	(0.25)	(0.05)		KALBFLE2	64 HBC	2.7 K-P	10/66
R5	K		KALBFLE2 64 SUPERSEDED BY RITTENBERG 69						
R5		16	0.24	0.17		BADIER	65 HBC	3.0 K-P	10/66
R5		32	0.3	0.1		LONDON	66 HBC	2.2 K-P	10/66
R5		123	0.189	0.026		RITTENBER	69 HBC	1.7-2.7 K-P	9/69
R5		535	0.185	0.022		BASILE1	71 CNTR	1.6 PI- P,N XO	11/71
R5			• • • • • • • • •						
R5	AVG		0.190	0.016	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R5	STUDENT		0.190	0.018	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R5	FIT		0.191	0.014	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R6		ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL (P3)							
R6	K	42	(0.22)	(0.04)		KALBFLE2	64 HBC	2.7 K-P	10/66
R6	K		KALBFLE2 64 SUPERSEDED BY RITTENBERG 69						
R6		35	(0.34)	(0.09)		BADIER	65 HBC	3.0 K-P	.10/66
R6		20	0.2	0.1		LONDON	66 HBC	2.2 K-P	10/66
R6		298	0.329	0.033		RITTENBER	69 HBC	1.7-2.7 K-P	9/69
R6			• • • • • • • • •						
R6	AVG		0.316	0.038	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)				
R6	STUDENT		0.317	0.035	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R6	FIT		0.304	0.017	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)				
R7		ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/(PI PI ETA) (P3)/(P1+P2)							
R7		0.25	0.14		DAUBER	64 HBC	1.95 K-P	10/66
R7		0.31	0.15		DAVIS	68 HBC	5.5 K- P	9/68
R7			• • • • • • • • •						
R7	AVG		0.28	0.10	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R7	STUDENT		0.28	0.11	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R7	FIT		0.450	0.036	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)				
R8		ETA PRIME INTO (PI0 E+ E-)/TOTAL (P16)							
R8		(0.013)OR LESS				RITTENBER	65 HBC	2.7 K-P	10/66
R9		ETA PRIME INTO (ETA E+ E-)/TOTAL (P17)							
R9		(0.011)OR LESS				RITTENBER	65 HBC	2.7 K-P	10/66
R10		ETA PRIME INTO (PI0 RHO0)/TOTAL (P18)							
R10		(0.04) OR LESS				RITTENBER	65 HBC	2.7 K-P	10/66
R11		ETA PRIME INTO(GAMMA OMEGA)/TOTAL (P5)							
R11 R		(0.08) OR LESS				RITTENBER	65 HBC	2.7 K-P	10/66
R11 R		INCLUDES PI0 OMEGA							
R11		(.05) OR LESS	CL=.90			KALBFLE1	75 HBC	2.2 K- P,GAMMA +	12/75
R12		ETA PRIME INTO (PI+ PI- E+ E-)/TOTAL (P10)							
R12		(0.006)OR LESS				RITTENBER	65 HBC	2.7 K-P	10/66
R13		ETA PRIME INTO (2 PI)/TOTAL (P11)							
R13		(0.07) OR LESS				LONDON	66 HBC	COMPILATION	10/66
R14		ETA PRIME INTO (3 PI)/TOTAL (P12)							
R14		(0.07) OR LESS				LONDON	66 HBC	COMPILATION	10/66
R15		ETA PRIME INTO (4 PI)/TOTAL (P13)							
R15		(0.01) OR LESS				LONDON	66 HBC	COMPILATION	10/66

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R16    ETA PRIME INTO (6 PI)/TOTAL                            (P15)
R16          (0.01) OR LESS             LONDON     66 HBC       COMPILATION        10/66

R17    ETA PRIME INTO (OMEGA GAMMA)/(PI+PI-ETA NEUTRALS)(P5)/(PIN)
R17     68     0.068     0.013          ZANFINO    77 ASPK     8.4 PI-P            12/77*
R17           . . . . . . . . . .
R17 FIT        0.068     0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R19    ETA PRIME INTO (2 GAMMA)/TOTAL                          (P4)
R19      5     0.055     0.036    0.030 BOLLINI    68 CNTR     1.9 PI- P           12/72
R19      7     0.126     0.075          BENSINGER 70 DBC       2.2 PI+ D           12/72
R19     31     0.020     0.008    0.006 HARVEY     71 OSPK     3.65 PI- P,N XO     11/71
R19     68     0.0171    0.0033         DALPIAZ    72 CNTR     1.6 PI- P,N XO      12/72
R19             .025      .007          DUANE      74 MMS      PI-P,N MM           12/75
R19           . . . . . . . . . .
R19 AVG        0.0192    0.0027  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 STUDENT    0.0191    0.0031  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT        0.0202    0.0027 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R20    ETA PRIME INTO (PI+PI-)/TOTAL                           (P11)
R20          (0.02) OR LESS             RITTENBER 69 HBC       1.7-2.7 K-P          9/69
R20          (0.08) OR LESS  CL=.95     DANBURG    73 HBC      2.2 K-P,LAM XO       2/74

R21    ETA PRIME INTO (PI+PI-PI0)/TOTAL                        (P12)
R21          (0.05) OR LESS             RITTENBER 69 HBC       1.7-2.7 K-P          9/69
R21          (0.09) OR LESS  CL=.95     DANBURG    73 HBC      2.2 K-P,LAM XO       2/74

R22    ETA PRIME INTO (PI+PI+PI-PI-)/TOTAL                     (P13)
R22          (0.01) OR LESS             RITTENBER 69 HBC       1.7-2.7 K-P          9/69
R22          (0.01) OR LESS  CL=.95     DANBURG    73 HBC      2.2 K-P,LAM XO       2/74

R23    ETA PRIME INTO (PI+PI+PI-PI-PI0)/TOTAL                  (P14)
R23          (0.01) OR LESS             RITTENBER 69 HBC       1.7-2.7 K-P

R24    ETA PRIME INTO (PI+PI+PI-PI- NEUTRALS)/TOTAL            (P15+...)
R24          (0.01) OR LESS             RITTENBER 69 HBC       1.7-2.7 K-P          9/69

R25    ETA PRIME INTO (RHO0 GAMMA)/(ALL PI+ PI- GAMMA)    (P6)/(P3)
R25            0.94      0.20           AGUILAR    70 HBC      3.9-4.6K-P           1/71
R25  E 473     1.15      0.10           DANBURG    73 HBC      2.2 K-P,LAM XO       2/74
R25  E 473    (0.95) OR MORE  CL=.95    DANBURG    73 HBC      2.2 K-P,LAM XO       2/74
R25  E  EQUIVALENT STATEMENTS
R25    137     1.01      0.15           JACOBS     73 HBC      2.9 K-P,LAM XO       1/74
R25    615    (1.)                      ROUSSARIE 77 OSPK      1.4 PI-P ETAPR N     1/78*
R25           . . . . . . . . . .
R25 AVG        1.082     0.077   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R25 STUDENT    1.082     0.086   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R26    ETA PRIME INTO (PI0 PI0 ETA INTO 3 PI0)/TOTAL       (P2N(3PI0))
R26      4     0.11      0.06           BENSINGER 70 DBC       2.2 PI+ D            1/71
R26           . . . . . . . . . .
R26 FIT        0.0722    0.0059 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R27    ETA PRIME INTO (PI+ PI- GAMMA)/(PI+ PI- ETA(NEUTRAL DEC.))
R27                                                        (P3)/(PIN)
R27 K         (0.54)    (0.10)          AGUILAR    72 HBC      3.9,4.6 K- P        12/72
R27 K   NOT AVERAGED DUE TO COMPLICATION WITH M(953).SEE KALBFLEI 74.
R27    473     0.92      0.14           DANBURG    73 HBC      2.2 K-P,LAM XO       2/74
R27    192     1.11      0.18           JACOBS     73 HBC      2.9 K-P,LAM XO       1/74
R27 P 2603    (1.18)    (0.20)          ROUSSARIE 77 OSPK      1.4 PI-P,ETAPR N 12/77*
R27 P   PRELIMINARY RESULT
R27           . . . . . . . . . .
R27 AVG        0.99      0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R27 STUDENT    0.99      0.12    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R27 FIT        0.982     0.078   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R28    ETA PRIME INTO (2 GAMMA)/(PI0 PI0 ETA(NEUTRAL DEC.))
R28                                                        (P4)/(P2(N))
R28     16     0.188     0.058          APEL       72 OSPK     3.8 PI- P,N XO       1/73
R28           . . . . . . . . . .
R28 FIT        0.118     0.019   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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 2  ETA PRIME C-NONCONSERVING DECAY PARAMETER

     RELATED TEXT SECTION  VI C

A   DECAY ASYMMETRY PARAMETER FOR PI+ PI- GAMMA
A      152      .07       .08           RITTENBE  65 HBC      2.1-2.7 K-P         12/75
A      103      .00       .10           KALBFLEI  75 HBC      2.2 K-P             12/75
A      295     -.069      .078          GRIGORIA  75 STRC     2.1 PI-P            12/75
A  SP  615    (-.008)    (.053)         ROUSSARIE 77 OSPK     1.4 PI-P ETAPR N   1/78*
A  S     SIGN OF ASYMMETRY PARAMETER CHANGED BY US TO CONFORM WITH
A  S     DEFINITION IN TEXT SECTION VI C
A   P    PRELIMINARY RESULT
A             . . . . . . . . . .
A   AVG       -0.001     0.049   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
A   STUDENT   -0.001     0.056   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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REFERENCES FOR ETA PRIME


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DAUBER    64 PRL 13 449          DAUBER,SLATER,SMITH,STORK,TICHO       (UCLA)JP
    ALSO  64 DUBNA CONF 1 418    DAUBER,SLATER,L T SMITH,STORK,TICHO  (UCLA)
GOLDBERG  64 PRL 12 546          +GUNDZIK,LICHTMAN,CONNOLLY,HART,+(SYRA+BNL)
GOLDBERG  64 PRL 13 249          +GUNDZIK,LEITNER,CONNOLLY,HART,+ (SYRA+BNL)
KALBFLE1  64 PRL 12 527          KALBFLEISCH,ALVAREZ,BARBARO-GALTIERI,+(LRL)JP
KALBFLE2  64 PRL 13 349          G.R.KALBFLEISCH,O.DAHL,A.RITTENBERG    (LRL)JP

BADIER    65 PL 17 337           BADIER,DEMOULIN,BARLOUTAUD+(EPOL+SACL+AMST)
KIENZLE   65 PL 19 438           KIENZLE,MAGLIC,LEVRAT,LEFEBVRES +     (CERN)
RITTENBE  65 PRL 15 556          RITTENBERG,KALBFLEISCH              (LRL+BNL)
TRILLING  65 PL 19 427           +BROWN,GOLDHABERS,KADYK,SCANIO           (LRL)

COHN      66 PL 21 347           COHN,MCCULLOCH,BUGG,CONDO  (ORNL+TENN+UCND)
LONDON    66 PR 143 1034         LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)IJP
MARTIN    66 PL 22,352           MARTIN,CRITTENDEN,SCHROEDER      (INDIANA U)I

BARBARO-  68 PRL 20 349          BARBARO-GALTIERI,MATISON,RITTENBERG+  (LRL)I=0
BARLOUTA  68 PL 26 B  674        BARLOUTAUD+     (SACLAY+AMST+BGNA+REHO+EPOL)I=0
BOLLINI   68 NC 58 A  289        +BUHLER,DALPIAZ,MASSAM+      (CERN+BGNA+STRB)
DAVIS     68 PL 27 B 532         +AMMAR,MOTT,DAGAN,DERRICK,FIELDS (NWES+ANL)

DUFEY     69 PL 29 B 605         +GOBBI,POUCHON,CNOPS,+       (ETHZ+CERN+SACL)IJP
MOTT      69 PR 177 1966         +AMMAR,DAVIS,KROPAC,SLATE,DAGAN+ (NWES+ANL)
RITTENBE  69  UCRL-18863         ALAN RITTENBERG (THESIS)              (LRL)I=0

AGUILAR   70 PRL 25 1635         AGUILAR-BENITEZ,BASSANO,SAMIOS,BARNES+(BNL)
BENSINGE  70 PL 33 B 505         BENSINGER,ERWIN,THOMPSON,W.D.WALKER  (WISC)

BARDADIN  71 PR D4 2711          BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BASILE1   71 NC 3 A 371          +BOLLINI,DALPIAZ,FRABETTI,+(CERN+BGNA+STRB)
BASILE2   71 NP B 33 29          +BOLLINI,DALPIAZ,FRABETTI,+(CERN+BGNA+STRB)
HARVEY    71 PRL 27 885          +MARQUIT,PETERSON,RHOADES,+       (MINN+MICH)
OGIEVETS  71 PL 35 B 69          OGIEVETSKY,TYBOR,ZASLAVSKY            (DUBNA)

AGUILAR   72 PR D 6 29           AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
APEL      72 PL 40 B 680         +AUSLANDER,MULLER,BERTOLUCCI,+  (KARL+PISA)
BINNIE    72 PL 39 B 275         +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
BLOODWOR  72 NP B 39 525         BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
DALPIAZ   72 PL 42 B 377         +FRABETTI,MASSAM,NAVARRIA,ZICHICHI   (CERN)
RADER     72 PR D 6 3059         +ABOLINS,DAHL,DANBURG,DAVIES,HOCH,+   (LBL)

DANBURG   73 PR D 8 3744         +KALBFLEISCH,BORENSTEIN,CHAPMAN,+(BNL+MICH)  JP
JACOBS    73 PR D 8 18           +CHANG,GAUTHIER,+      (BRAN+UMD+SYRA+TUFT)  JP
KALBFLEI  73 PRL 31 333          KALBFLEISCH,CHAPMAN,+          (BNL+MICH+LBL)  JP

BALTAY    74 PR D9 2999          +COHEN,CSORNA,HABIBI,KALELKAR,+ (COLU+BING)  JP
DUANE     74 PRL 32 425          +BINNIE,CAMILLERI,CARR,DEBENHAM+(LOIC+SHMP)
GAULT     74 NC 24 A 259         +JONES,SCADRON,THEWS         (DURH+LOIC+ARIZ)
KALBFLEI  74 PR D10 916          G.R.KALBFLEISCH                         (BNL)

GRIGORIA  75 NP B91 232          GRIGORIAN,LADAGE,MELLEMA,RUDNICK,+    (UCLA)
KALBFLEI  75 PR D11 987          KALBFLEISCH,STRAND,CHAPMAN         (BNL+MICH)

CERRADA   77 NP B 126 189        +WAGNER,BLOCKZIJL,+      (CERN+AMST+NIJM+OXF)  JP
DELAGUIL  77 PR D16 2833         F.DEL AGUILA AND M.G.DONCEL       (BARCELONA)  JP
GESSAROL  77 NP B 126 382        GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)
LEDNICKY  77  E2-10521,22,23     R.LEDNICKY                             (JINR)  JP
ROUSSARI  77  PREPRINT           +ERNWEIN,FELTESSE,BORGEAUD,ROUSSARIE+(SACL)  JP
    ALSO  77 BUDAPEST CONF.      HEMINGWAY REVIEW TALK                  (CERN)
ZANFINO   77 PRL 38 930          +BROCKMAN,DANKOWYCH,+ (CARL+MCGI+OHIO+TNTO)
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$\delta(980)$

36 DELTA(980,JPG=0+-) I=1

Observations of missing mass peaks in the 960 MeV mass region are mostly controversial and are therefore not listed here. Under this entry, we list two types of I = 1 peaks near the $K\bar{K}$ threshold:

1) $\eta\pi$ decays, peaking slightly below the $K\bar{K}$ threshold. This defines $I^G = 1^-$ and J^P = normal.

2) A $K\bar{K}$ threshold enhancement with I = 1.

This association is justified by the remark (ASTIER 67) that the $K\bar{K}$ threshold enhancement may be due to a virtual bound state also coupled to the $\eta\pi$ system. In a coupled-channel analysis of the most significant data, MORGAN 75 and FLATTE 77 show that the resonance width of the $\delta(980)$ may be much larger than the apparent width observed in the $\eta\pi$ channel (see, however, IRVING 77).

The low Q-value of the $K\bar{K}$ threshold enhancement and the decay distributions of the $\eta\pi$ system favor $J^P = 0^+$. Additional argument (LIPKIN 69) comes from the absence of a $\rho\pi$ decay mode (GRASSLER 77).

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              36  DELTA(980) MASS  (MEV)

M  ETA PI FINAL STATE ONLY.
M  S    30  980.0      10.0            AMMAR      68 HBC  +-     ,5.5K-,ETA PI   2/73
M  S    SEE ALSO AMMAR 70.
M       10 (960.)      APPROX.         CHUNG S    68 HBC   -   3.2 PI-P           5/70
M       80 (975.0)                     DEFOIX     68 HBC  +-   1.2 PB P,ETA PI  11/77*
M       20  970.0      15.0            BARNES     69 HBC   -   4-5 K-P,PI-ETA     9/69
M           980.       10.             CAMPBELL   69 DBC  +- 2.7 PI+ D            1/73
M       15 (980.0)    (10.0)           MILLER     69 HBC   -   4.5 K-N,ETA PI     7/69
M       21 (948.0)     (7.0)           BARDADIN   71 HBC  +- 8 PI+P,P D0 PI     11/77*
M      150  972.       10.             DEFOIX     72 HBC  +- 0.7 PBAR P,7 PI      1/73
M       47 (980.)                      CONFORTO   73 OSPK -  4.5 PI-P,P X-        1/74
M  C    70  989.0      10.0            WELLS      75 HBC   - 3.1-6 K-P,ETA PI  11/77*
M  CW   20 (988.0)     (9.0)           WELLS      75 HBC  +  3.1-6 K-P,ETA PI  11/77*
M  C    SYSTEMATIC ERROR 6 MEV DUE TO ENERGY CALIBRATION ADDED
M   W   WEAK EVIDENCE ONLY FOR DELTA+ PRODUCTION
M       80  981.0       6.0            GAY        76 HBC   - 4.2 K-P,ETA PI     11/77*
M   J   80 (974.0)     (9.0)           GAY        76 HBC   - 4.2 K-P,ETA PI     11/77*
M   J   USING A TWO CHANNEL RESONANCE PARAMETRIZATION, WITH THE COUPLING
M   J   CONSTANT RATIO (ETA PI)/(K KBAR) FIXED AT SU(3) VALUE OF 2/3.
M           977.0       7.0            GRASSLER   77 HBC   - 16 PI-+P,ETA PI    11/77*
M           . . . . . . . . . .
M   AVG     979.3       3.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT 979.2       3.6     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M  K KBAR ONLY, SEE THE TYPED NOTE ABOVE
M      143(1003.3)     7.0+SYSTEMATIC ROSENFELD 65 RVUE +-                    . 8/66
M      100(1016.)     (10.)            ASTIER     67 HBC  +-  0 PBAR P          12/77*
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36 DELTA(980) WIDTH (MEV)

W ETA PI FINAL STATE ONLY
W 30 80.0 30.0 AMMAR 68 HBC +- ,5.5K-,ETA PI 2/73
W 80 (25.0) DEFOIX 68 HBC +- 1.2 PB P,ETA PI 11/77*
W 20 (50.0) OR LESS BARNES 69 HBC - 4-5 K-P,PI-ETA 11/77*
W 40. 15. CAMPBELL 69 DBC +- 2.7 PI+ D 1/73
W 15 60.0 30.0 MILLER 69 HBC - 4.5 K-N,ETA PI 2/74
W 21 31.0 28.0 BARDADIN 71 HBC +- 8 PI+P,P DO PI . 2/74
W 150 (30.) (5.) DEFOIX 72 HBC +- 0.7 PBAR P,7 PI . 2/74
W 47 (60.) (50.) (30.) CONFORTO 73 OSPK - 4.5 PI-P,P X- 1/74
W 70 (16.0) (25.0) (16.0) WELLS 75 HBC - 3.1-6 K-P,ETA PI
W W 20 (5.0) (11.0) (5.0) WELLS 75 HBC + 3.1-6 K-P,ETA PI
W W WEAK EVIDENCE ONLY FOR DELTA+ PRODUCTION.
W F 80 TO 300 FLATTE 76 RVUE - 4.2 K-P,ETA PI 11/77*
W F USING A TWO CHANNEL RESONANCE PARAMETRIZATION OF GAY 76 DATA.
W N 55.0 15.0 GAY 76 HBC - 4.2 K-P ETA PI 11/77*
W N THE ERROR IN THE PAPER IS WRONGLY QUOTED AT ONE POINT
W J (72.0) (51.0) GAY 76 HBC - 4.2 K-P ETA PI 11/77*
W J SEE NOTE J ABOVE .
W 44.0 22.0 GRASSLER 77 HBC - 16 PI-+P,ETA PI 11/77*
W . . . .
W AVG 49.0 8.3 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W STUDENT 48.9 9.2 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W K KBAR ONLY, SEE THE TYPED NOTE ABOVE
W 143 (57.0) 13.0+SYSTEMATIC ROSENFELD 65 RVUE +- 8/66
W 100 (25.) APPROX. ASTIER 67 HBC +- SEE NOTE A ABOVE 9/67
W M (120.) APPROX. MORGAN 75 RVUE 1.2 PBAR P 12/75
W M FROM COUPLED CHANNEL FIT TO DUBOC 72 DATA

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36 DELTA(980) PARTIAL DECAY MODES

DECAY MASSES
P1 DELTA(980) INTO ETA PI 548+ 134
P2 DELTA(980) INTO RHO PI 776+ 134
P3 DELTA(980) INTO K KBAR 497+ 497

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36 DELTA(980) BRANCHING RATIOS

R1 DELTA(980) INTO (RHO PI)/(ETA PI) (P2)/(P1)
R1 (0.25) OR LESS CL=.70 AMMAR 70 HBC +- 4.1,5.5K-,ETA PI. 5/70

R2 DELTA(980) INTO (K KBAR)/(ETA PI) (P3)/(P1)
R2 L (0.25) (0.08) DEFOIX 72 HBC +- 0.7 PBAR P 11/77*
R2 L FROM THE DECAY OF D(1285).
R2 SEEN GAY 76 HBC - 4.2 K-P ETA PI 11/77*

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REFERENCES FOR DELTA(980)

TURKOT 63 SIENNA CONF 1 661 +COLLINS,FUJII,KEMP+ (BNL+PITTSBURGH)

ARMENTER 65 PL 17 344 ARMENTEROS,EDWARDS, JACOBSEN + (CERN+CDEF)
BARASH 65 PR 139 B 1659 +FRANZINI,KIRSCH,MILLER,STEINBERGER+ (COLU)
KIENZLE 65 PL 19 438 + MAGLIC,LEVRAT,LEFEBVRES + (CERN)
ROSENFEL 65 OXFORD CONF 58 A H ROSENFELD (LRL--RVUE)

ALLEN D 66 PL 22 543 +GP FISHER,G GODDEN,L MARSHALL,SEARS (COLO)G=+
BALTAY 66 PR 142 B 932 +LACH,SANDWEISS,TAFT,YEH,STONEHILL+ (YALE)
FOCACCI 66 PRL 17 890 + KIENZLE,LEVRAT,MAGLIC,MARTIN (CERN)
OOSTENS 66 PL 22 708 +CHAVANON,CROZON,TOCQUEVILLE (SACLAY,CDEF)I=1

ALLISON 67 PL 25B 619 +CRUZ+ (OXF+MPIM+BIRM+RHEL+GLAS+LOIC)
ASTIER 67 PL 25 B 294 +MONTANET,BAUBILLIER,DUBOC+(CDEF+CERN+IRAD)
ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.
BAILLON 67 NC 50A 393 +EDWARDS+D-ANDLAU+ASTIER+ (CERN+CDEF+IRAD)
BANNER 1 67 PL 25 B 300 +FAYOUX,HAMEL,ZSEMBERY,CHEZE+ (SACLAY+CAEN)
BANNER 2 67 PL 25 B 569 +CHEZE,HAMEL,MAREL,TEIGER+ (CDEF+SACL)
BARLOW 67 NC 50 A 701 +MONTANET,D-ANDLAU+ (CERN+CDEF+IRAD+LIVP)
CONFORTO 67 NP B3 469 CONFORTO,MARECHAL+ (CERN+CDEF+IPNP+LIVP)

AMMAR 68 PRL 21 1832 +DAVIS,KROPAC,DERRICK,FIELDS,+ (NWES+ANL)
CHUNG S 68 PR 165 1491 +O.DAHL, J. KIRZ, D.H.MILLER (LRL)
DEFOIX 68 PL 28 B 253 +RIVET,SIAUD,CONFORTO+ (CDEF+IPNP+CERN)
GALTIERI 68 PRL 20 349 BARBARO-GALTIERI,MATISON,RITTENBERG+ (LRL)
JUHALA 68 PL 27 B 257 +LEACOCK,RHODE,KOPELMAN,LIBBY+ (IOWA+COLO)
SABRE CO 68 PL 26 B 674 BARLOUTAUD+ (SACL+AMST+BGNA+REHO+EPOL)

BARNES 69 PRL 23 610 +CHUNG,EISNER,BASSANO,GOLDBERG+ (BNL+SYRA)
CAMPBELL 69 PRL 22 1204 J.H.CAMPBELL,LICHTMAN,LOEFFLER,+ (PURDUE)
CRENNELL 69 PRL 22 1398 +KARSHON,KWAN WU LAI,+ (BNL+NYU)
JUHALA 69 PR 184 1461 +LEACOCK,RHODE,KOPELMAN,LIBBY,+ (ISU+COLO)
KRUSE 69 PR 177 1951 KRUSE,LOOS,GOLDWASSER (ILLINOIS)
MILLER 69 PL 29 B 255 D.H.MILLER,S.L.KRAMER,D.D.CARMONY,+(PURDUE)
ALSO 69 PR 188 2011 YEN,AMMANN,CARMONY,ELSNER,+ (PURDUE)
SCHROEDE 69 PR 188 2081 SCHROEDER,KERNAN,FISHER,LIBBY,+ (ISU+COLO)

ABOLINS 70 PRL 25 469 +GRAVEN,MCCARTHY,G.SMITH,L.SMITH+ (LRL+UCD)
AMMAR 70 PR D 2 430 +KROPAC,DAVIS,DERRICK+ (KANS+NWES+ANL+WISC)
COOPER 70 NP B 23 605 +HANNER,MUSGRAVE,POLLARD,VOYVODIC (ANL)
YIOU 70 THESIS, A 646 TCHIU-PUNG YIOU (ORSAY)

ANDERSON 71 PRL 26 108 +DIXIT,+ (CHIC+ANL+CARL+LASL+CNRC+NAGOYA)
BARDADIN 71 PR D4 2711 BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)

BINNIE 72 PL 39 B 275 +CAMILLERI,DUANE,GARBUTT,BURTON+(LOIC+SHMP)
CHESHIRE 72 PRL 28 520 +HOFFMAN,GARFINKEL,+ (IOWA+ANL+PURD)
DEFOIX 72 NP B 44 125 +NASCIMENTO,BIZZARRI,+ (CDEF+CERN)
DUBOC 72 NP B 46 429 +GOLDBERG,MAKOWSKI,DONALD,+ (LPNP+LIVP)
HOLLOWAY 72 PHIL.CONF.PROC.133+HULD,KOETZ,KRUSE,BERNSTEIN,+ (ILL+ILLC)

ATHERTON 73 PL 43 B 249 +FRANEK,FRENCH,GHIDINI,HILPERT,+ (CERN)
CONFORTO 73 AIX CONF. BUTTERWORTH RAPPORTEUR TALK C1-195,FIG.39

BINNIE 74 PRL 32 392 +CAMILLERI,CARR,DEBENHAM,+ (LOIC+SHMP)
KALBFLEI 74 NP B69 279 KALBFLEISCH,VANDERBURG,+ (BNL+RUTG+IND)
MORGAN 74 PL 51B 71 D.MORGAN (RHEL)

BUTTRAM 75 PRL 35 970 +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON (ISU)
MORGAN 75 ARGONNE CONF. 45 D.MORGAN (RHEL)
WELLS 75 NP B 101 333 +RADOJICIC,ROSCOE,LYONS (OXF)

GAY 76 PL 63 B 220 +CHALOUPKA,BLOKZIJL,HEINEN+(CERN+AMST+NIJM) JP
FLATTE 76 PL 63 B 224 S.M.FLATTE (CERN)

GRASSLER 77 NP B 121 189 + (AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
IRVING 77 PL 70 B 217 A.C.IRVING (LIVERPOOL)
MAY 77 PR D 16 1983 +ABRAMSON,ANDREWS,BUSNELLO,+ (ROCH+CORN)
MINNAERT 77 PREPRINT MINNAERT (BORDEAUX) J

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$S^*(980)$

3 S*(980,JPG=0++) I=0

UNDER THIS ENTRY WE LIST PARAMETERS OF THE POLE IN THE ISOSCALAR S WAVE. FOR A MINI-REVIEW SEE UNDER EPSILON. POSSIBLE EVIDENCE OF D-WAVE PI PI INTERACTIONS IN THIS REGION IS LISTED SEPARATELY UNDER ETA N(1080).

FOR EARLY WORK USING BREIT-WIGNER OR SCATTERING LENGTH PARAMETRIZATION IN FITS TO THE K KBAR MASS SPECTRUM, SEE REFERENCE SECTION AND OUR 1972 EDITION.

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3 REAL PART OF THE S* POLE POSITION (MEV)

M R (997.) (6.) PROTOPOPE 73 HBC PI+ P 12/77*
M 987. 7. BINNIE 73 CNTR PI- P,S* N 12/77*
M (997.) ESTABROOK 73 ASPK 17 PI-P,PI+PI-N 12/75
M R (1012.) (6.) GRAYER 73 ASPK 17 PI-P,PI+PI-N 12/77*
M R (1007.) (20.) HYAMS 73 ASPK 0 17 PI-P,N PI+PI- 12/77*
M A (986.) (5.) FUJII 75 RVUE 17 PI-P,PI+PI-N 12/75
M N C 986. 10. AGUILAR 77 HBC .7 PBAR P, KS KS 12/77*
M 969.0 5.0 LEEPER 77 ASPK 2-2.4 PI-P 12/77*
M . . . .
M AVG 976.6 6.2 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
M STUDENT 976.9 5.1 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M A FROM SINGLE CHANNEL FIT TO HYAMS 73 DATA.
M C WITH A SIMULTANEOUS FIT TO THE PI PI PHASE-SHIFTS,
M C INELASTICITY AND TO THE KS KS INVARIANT MASS.
M N FROM COUPLED CHANNEL FIT TO HYAMS 73 AND PROTOPOPESCU 73 DATA.
M R INCLUDED IN AGUILAR 77 FIT

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3 NEGATIVE IMAG. PART OF THE S* POLE POSITION (MEV)
CORRESPONDS TO HALF-WIDTH, NOT FULL WIDTH.

W R (27.) (8.) PROTOPOPE 73 HBC 7. PI+ P 12/77*
W 24. 7. BINNIE 73 CNTR PI- P,S* N 12/77*
W (5.) ESTABROOK 73 ASPK 17 PI-P,PI+PI-N 12/75
W R (16.) (5.) GRAYER 73 ASPK 17 PI-P,PI+PI-N 12/77*
W R (15.) (5.) HYAMS 73 ASPK 0 17 PI-P,N PI+PI- 12/77*
W A (19.) (3.) FUJII 75 RVUE 17 PI-P,PI+PI-N 12/75
W A FROM SINGLE CHANNEL FIT TO HYAMS 73 12/77*
W N C 50. 40. AGUILAR 77 HBC .7 PBAR P, KS KS 12/77*
W 15.0 4.0 LEEPER 77 ASPK 2-2.4 PI-P 12/77*
W . . . .
W AVG 17.5 3.9 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
W STUDENT 17.4 3.9 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W A FROM SINGLE CHANNEL FIT TO HYAMS 73 DATA.
W C WITH A SIMULTANEOUS FIT TO THE PI PI PHASE-SHIFTS,
W C INELASTICITY AND TO THE KS KS INVARIANT MASS.
W N FROM COUPLED CHANNEL FIT TO HYAMS 73 AND PROTOPOPESCU 73 DATA.
W R INCLUDED IN AGUILAR 77 FIT

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3 S*(980) PARTIAL DECAY MODES

DECAY MASSES
P1 S*(980) INTO K KBAR 497+ 497
P2 S*(980) INTO PI PI 139+ 139

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REFERENCES FOR S*

WANG 61 JETP 13 323 WANG TSU-TSENG,VEKSLER,VRANA,+ (JINR)

BIGI 62 CERN CONF 247 A BIGI,S BRANDT, R CARRARA + (CERN)
BINGHAM 62 CERN CONF 240 H H BINGHAM,M BLOCH + (EPOL+CERN)
ERWIN 62 PRL 9 34 ERWIN,HOYER,MARCH,WALKER,WANGLER (WISC+BNL)

BALTAY 64 DUBNA CONF 1 409 BALTAY,LACH,CRENNELL,OREN,STUMP +(YALE+BNL)
BARMIN 64 DUBNA CONF 1 433 BARMIN,DOLGOLENKO,YEROFEEV,KRESTNI+ (ITEP)

CRENNELL 66 PRL 16 1025 CRENNELL,KALBFLEISCH,LAI,SCARR,SCHU+ (BNL)
HESS 66 PRL 17 1109 +DAHL+HARDY+KIRZ+MILLER (LRL)

BARLOW 67 NC 50A 701 +LILLESTOL+MONTANET+ (CERN+CDEF+IRAD+LIVP)
BEUSCH 67 PL 25 B 357 +FISCHER,GOBBI,ASTBURY+ (ETHZ+CERN)
DAHL 67 PR 163 1377 +HARDY+HESS+KIRZ+MILLER (LRL)

ALITTI 68 PRL 21 1705 +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+ (BNL)
LAI 68 PHILAD.CONF.P.303 KWAN WU LAI (BNL)
PHELAN 68 THESIS JAMES J. PHELAN (ANL+ST.LOUIS UNIV)
ALSO 68 PRL 21 316 HOANG,EARTLY,PHELAN,ROBERTS+(ANL+CHIC+NDAM)

AGUILAR- 69 PL 29 B 241 M.AGUILAR-BENITEZ,J.BARLOW,+ (CERN+CDEF)
ALSO 67 BARLOW
ALSO 69 NP B 14 195 M.AGUILAR-BENITEZ,J.BARLOW,+ (CERN+CDEF)
HOANG 69 NC 61 A 325 T.F.HOANG (ANL)
HOANG 69 PR 184 1363 +EARTLY,PHELAN,ROBERTS,+ (ANL+ILLC)

BADIER 70 NP B 22 512 +BONNET,DREVILLON,BAUBILLIER,+ (EPOL+IPNP)
BATON 70 PL 33 B 528 +LAURENS,REIGNIER (SACLAY)
BEUSCH 70 PHILA.CONF.P.185 W.BEUSCH (ETHZ+CERN)
HYAMS 70 PHILA.CONF.P.41 +KOCH,BEUSCH,+ (CERN+MPIM+ETHZ+LOIC+HAWA)
ALSO 70 NP B 22 189 HYAMS,KOCH,POTTER,VON LINDERN,+ (CERN+MPIM)
OH 70 PR D 1 2494 +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)

ALSTON-G 71 PL 36 B 152 ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)

BASDEVAN 72 PL 41 B 178 BASDEVANT,FROGGATT,PETERSEN (CERN)
DAMERI 72 NC 9 A 1 +BORZATTA,GOUSSU,+ (GENO+MILA+SACL)
DUBOC 72 NP B 46 429 +GOLDBERG,MAKOWSKI,DONALD,+ (LPNP+LIVP)
FLATTE 72 PL 38 B 232 +ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)
GRAYER 72 PHIL.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
WILLIAMS 72 PR D 6 3178 P.K.WILLIAMS (FSU)

BINNIE 73 PRL 31 1534 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)
DIAMOND 73 PR D 7 1977 +BINKLEY,+ (WISC+DUKE+COLO+TNTO+OHIO)
ESTABROO 73 TALLAHASSEE ESTABROOKS,MARTIN,GRAYER,HYAMS+ (CERN+MPIM)
FUJII 73 NC 13 A 311 Y.FUJII,M.KATO (TOKYO)
GRAYER 73 TALLAHASSEE +HYAMS,JONES,BLUM,DIETL,KOCH+ (CERN+MPIM)
HYAMS 73 NP B 64 134 +JONES,WEILHAMMER,BLUM,DIETL,+ (CERN+MPIM)
OCHS 73 THESIS W.OCHS (MPIM)
PROTOPOP 73 PR D 7 1280 PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)

GRAYER 74 NP B 75 189 +HYAMS,JONES,BLUM,DIETL,KOCH+ (CERN+MPIM)
GRAYER 74 NP B 76 375 +HYAMS,JONES,BLUM,DIETL (CERN+MPIM)
MORGAN 74 PL 51B 71 D.MORGAN (RHEL)

FUJII 75 NP B85 179 Y.FUJII,M.FUKUGITA (TOKY)
MORGAN 75 ARGONNE CONF. 45 D. MORGAN (RHEL)
PAWLICKI 75 PR D12 631 +AYRES,DIEBOLD,GREENE,KRAMER,WICKLUND (ANL)

BRANDEB 76 NP B 104 413 +CARNEGIE,CASHMORE,DAVIER,LASINSKI,+ (SLAC)
BUTTRAM 76 PR D 13 1153 +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON (ISU)
CERRADA 76 PL 62 B 353 +GONZALEZ-ARROYO,RUBIO,YNDURAIN (CERN+MADR)
FLATTE 76 PL 63 B 228 S.M.FLATTE (CERN)
WILKINS 76 PR D 13 1831 +ALBRIGHT,S+V HAGOPIAN,LANNUTTI (FSU)

AGUILAR 77 PREPRINT +CERRADA,+ (MADRID+BOMBAY+CERN+PARIS)
FROGATT 77 NP B 129 89 +PETERSEN (GLASGOW+COPENHAGEN)
LEEPER 77 PR D 16 2054 +BUTTRAM,CRAWLEY,DUKE,LAMB,PETERSON (ISU)
MARTIN 77 NP B 121 514 +OZMUTLU,SQUIRES (DURHAM)
PAWLICKI 77 PR D 15 3196 +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND (ANL)I J

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H(990)

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35 H(990,JPG=A -) I=0

THE EVIDENCE OF BENSON 66 HAS DISAPPEARED AFTER
RE-ANALYSIS (CHAUDHARY 70). NO SIGNIFICANT
OTHER EVIDENCE HAS BEEN PUBLISHED.
OMITTED FROM TABLE.

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REFERENCES FOR H

BARTSCH 64 PL 11 167 AACHEN-ZEUTHEN-BIRM-BONN-HAMB-MUNCHEN COLL
GOLDHABE 65 CORAL GABLES P.76 G. GOLDHABER (LRL)
BENSON 66 PRL 17 1234 +MARQUIT,ROE,SINCLAIR,VANDER VELDE (MICH)IJP
COHN 67 NP B1 57 +MC CULLOCH,BUGG,CONDO (ORNL+UNIV.TENN)
ROSENFEL 67 RMP 39 1,APPENDIX ROSENFELD,BARBARO-GALTIERI+(LRL+CERN+YALE)
ARMENISE 68 PL 26B 336 +GHIDINI,FORINO+ (BARI+BGNA+FIRZ+ORSAY)
BARBARO- 68 PHILAD.CONF.P.137 A.BARBARO-GALTIERI,P.SODING (LRL)
FUNG 68 PRL 21 47 +JACKSON+PU+BROWN+GIDAL (U.C.RIVERS+LRL)
GOLDHABE 69 LUND CONF.P.271 G.GOLDHABER QUOTED BY B.MAGLIC (LRL)
CHAUDHAR 70 PR D 2 2110 B.CHAUDHARY,E.MARQUIT (MINNESOTA)
GORDON 70 COO 1195 179 THESIS,ILLINOIS (ILL)
MICHAEL 72 PRL 28 1475 W.MICHAEL,G.GIDAL (LBL)

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φ(1020)

4 PHI(1020,JPG=1--) I=0

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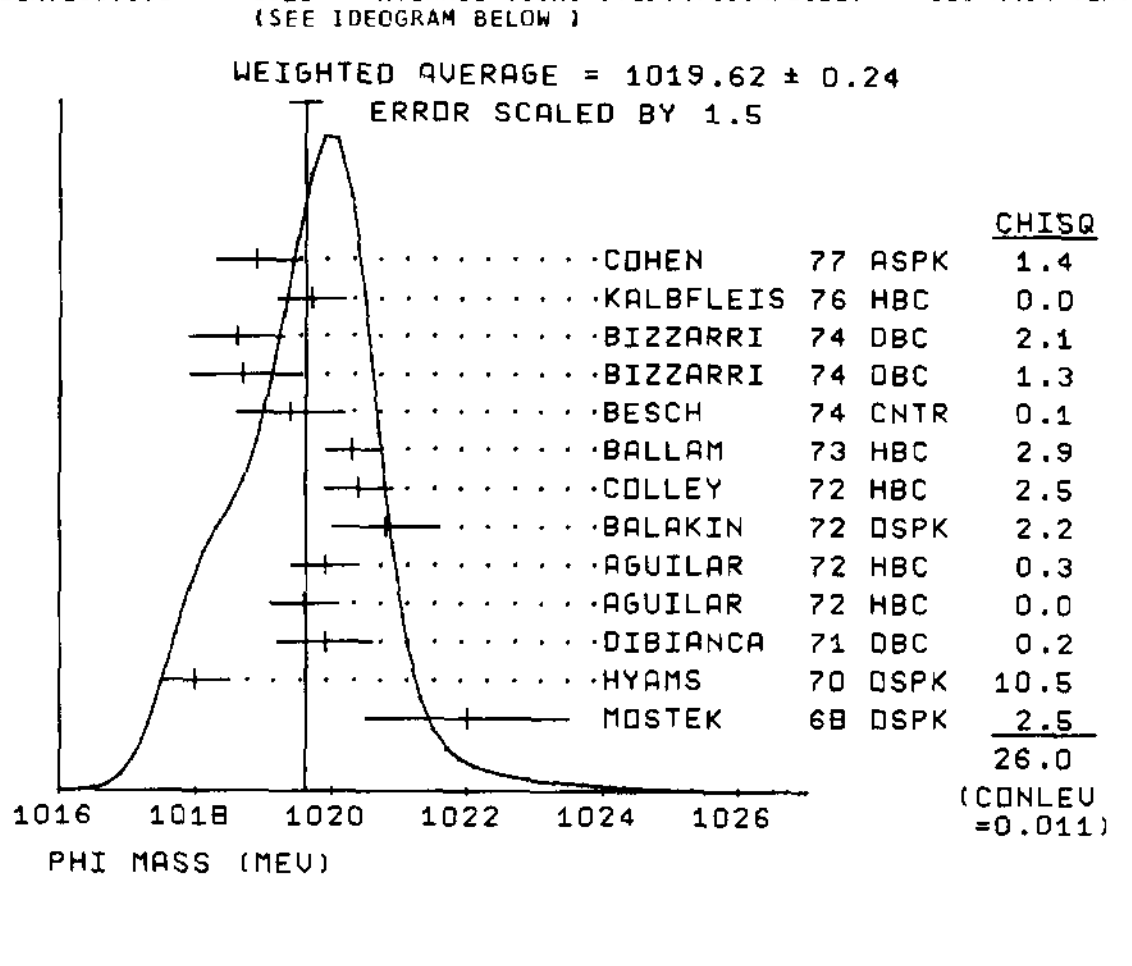
4 PHI MASS (MEV)

M WE ONLY AVERAGE MASS AND WIDTH VALUES WHEN THE
M SYSTEMATIC ERRORS HAVE BEEN EVALUATED.

M	S	18(1019.0)	(2.0)	SCHLEIN	63	HBC	2.0 K- P	.12/75
M	S	20(1018.6)	(0.5)	MILLER D	65	HBC	0.0 PBAR P	12/75
M	S	41(1020.0)	(2.0)	LONDON	66	HBC	2.2 K-P	12/75
M	S	46(1021.5)	(0.8)	ABRAMS	67	HBC	4.2 K- P	12/75
M	S	15(1019.)	(3.)	BARLOW	67	HBC	1.2 PBAR P	12/75
M	S	32(1021.0)	(4.0)	DAHL	67	HBC	1-4 PI- P	12/75
M		165 1022.	1.5	MOSTEK	68	OSPK	1.8 GAMMA + C	6/68
M		136 1018.	0.5	HYAMS	70	OSPK	11. PI- P	12/77*
M	A	107(1021.0)	(1.5)	ALVENSLE	71	OSPK	GAMMA+C	12/77*
M	D	70 1019.9	0.7	DIBIANCA	71	DBC	4.93 K- N	12/75
M		410(1019.9)	(0.3)	STOTTLEMY	71	HBC	2.9 K-P,Y K KBAR	11/71
M	D	120 1019.6	0.5	AGUILAR	72	HBC	3.9,4.6 K- P	12/75
M	D	100 1019.9	0.5	AGUILAR	72	HBC	3.9,4.6 K- P	12/75
M		87 1020.8	0.8	BALAKIN	72	OSPK	E+ E- COLL.BEAMS	12/72
M		131 1020.4	0.5	COLLEY	72	HBC	10.K+ P,K+ P PHI	12/72
M		100 1020.3	0.4	BALLAM	73	HBC	2.8 - 9.3 G P	1/74
M	A	500(1019.5)	(0.6)	AYRES	74	ASPK	3-6PI/K-P,K+K-	12/77*
M		984 1019.4	0.8	BESCH	74	CNTR	2 GAMMA P,PK+K-	12/75
M		54 1018.7	0.8	BIZZARRI	74	DBC	0 PBAR N,K+K- PI.	12/75
M		71 1018.6	.7	BIZZARRI	74	DBC	0 PBAR N,KLKS PI	12/75
M	A	170(1020.3)	(0.4)	DE GROOT	74	HBC	4.2 K-P,L K+K-	12/77*
M		(1019.4)	(0.3)	BUKIN	75	ELEC	E+E- COLL.BEAMS	12/77*
M		454 1019.7	0.5	KALBFLEIS	76	HBC	2.18 K-P,K KBAR	7/77*
M		800 1018.9	0.6	COHEN	77	ASPK	6 PI- PN,K+K-PN	12/77*
M	A	905(1020.4)	(0.3)	BALDI	77	CNTR	10 K-P,K-PHI P	12/77*
M	A	383(1020.0)	(1.0)	BALDI	77	CNTR	10 PI-P,PI-PHI P	12/77*
M	A	2504(1020.0)	(0.2)	BALDI	77	CNTR	10 K+P,K+PHI P	12/77*
M	A	721(1022.0)	(1.0)	BALDI	77	CNTR	10 P P,P PHI P	12/77*
M	A	1300(1019.7)	(0.2)	AKERLOF	77	SPEC	400 P+A,K+K-	12/77*

M . . . .
M AVG 1019.62 0.24 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
M STUDENT1019.68 0.21 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
(SEE IDEOGRAM BELOW)



M A SYSTEMATIC ERRORS NOT EVALUATED.
M S INSIGNIFICANT DATA WITH SMALL STATISTICS NO LONGER AVERAGED
M D MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE

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4 PHI WIDTH (MEV)

W WE ONLY AVERAGE MASS AND WIDTH VALUES WHEN THE
W SYSTEMATIC ERRORS HAVE BEEN EVALUATED.

W	S	20	(3.5)	(1.0)		MILLER D	65	HBC	0.0 PBAR P	.12/75
W	S	41	(6.0)	(4.0)		LONDON	66	HBC	2.2 K-P	12/75
W	S	46	(1.8)	(3.0)	(1.5)	ABRAMS	67	HBC	4.2 K- P	12/75
W		165	(4.5)	(3.0)	(2.0)	MOSTEK	68	OSPK	1.8 GAMMA + C	6/68
W		150	4.2	0.9		AUGUSTIN	69	OSPK	E+ E- COLL.BEAMS.	12/72
W			4.09	0.29		BIZOT	70	OSPK	E+ E- COLL.BEAMS	12/72
W		136	3.3	1.5		HYAMS	70	OSPK	11. PI- P	6/70
W	D	87	4.67	2.02		BALAKIN	71	OSPK	E+ E- COLL.BEAM	12/75
W	D	70	5.5	2.6		DIBIANCA	71	DBC	4.93 K- N	12/75
W		110	(4.5)	(3.0)	(4.0)	STOTTLEMY	71	HBC	2.9 K-P,Y K KBAR	11/71
W	D	120	4.6	1.7		AGUILAR	72	HBC	3.9,4.6 K- P	12/75
W	D	100	4.7	1.9		AGUILAR	72	HBC	3.9,4.6 K- P	12/75
W	D	131	5.0	1.8		COLLEY	72	HBC	10.K+ P,K+ P PHI	12/75
W	D	454	3.8	0.7		BORENSTEI	72	HBC	2.18 K-P,K KBAR	7/77*
W	D	100	3.8	1.5		BALLAM	73	HBC	2.8 - 9.3 G P	12/75
W	AD	500	(4.5)	(0.8)		AYRES	74	ASPK	3-6PI/K-P,K+K-	12/75
W	D	984	4.4	0.6		BESCH	74	CNTR	2 GAMMA P,PK+K-	12/75
W	S	54	(6.8)	(3.1)	(2.5)	BIZZARRI	74	DBC	0 PBAR N,K+K- PI	12/75
W	S	71	(4.1)	(3.8)	(3.6)	BIZZARRI	74	DBC	0 PBAR N,KLKS PI	12/75
W			3.81	0.37		COSME 2	74	OSPK	E+E- COLL.BEAMS	2/74
W	AD	170	(4.2)	(1.3)		DE GROOT	74	HBC	4.2 K-P,L K+K-	12/75
W	A	1300	4.5	0.42		AKERLOF	77	SPEC	400 P+A,K+K-	12/77*

W . . . .
W AVG 4.13 0.17 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W STUDENT 4.13 0.19 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W A SYSTEMATIC ERRORS NOT EVALUATED.
W S INSIGNIFICANT DATA WITH SMALL STATISTICS NO LONGER AVERAGED
W D WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N), SEE K* TYPED NOTE

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4 PHI PARTIAL DECAY MODES

		DECAY MASSES
P1	PHI INTO K+ K-	493+ 493
P2	PHI INTO KL KS	497+ 497
P3	PHI INTO PI+ PI- PIO (INCLUDING RHO PI)	139+ 139+ 134
P4	PHI INTO ETA GAMMA	548+ 0
P5	PHI INTO E+ E-	.5+ .5
P6	PHI INTO MU+ MU-	105+ 105
P7	PHI INTO PIO GAMMA	134+ 0
P8	PHI INTO PI+ PI- (VIOLATES G)	139+ 139
P9	PHI INTO PI+PI-GAMMA	139+ 139+ 0
P10	PHI INTO OMEGA GAMMA (VIOLATES C)	783+ 0
P11	PHI INTO ETA PIO (VIOLATES C)	548+ 134
P12	PHI INTO RHO GAMMA (VIOLATES C)	776+ 0
P13	PHI INTO ETA NEUTRALS	
P14	PHI INTO 5PI	139+ 139+ 139+ 139+

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4
P 1	.4856+-.0116			
P 2	-.8019	.3514+-.0123		
P 3	-.2146	-.3846	.1469+-.0072	
P 4	-.0999	-.0842	-.0019	.0161+-.0022

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4 PHI BRANCHING RATIOS

R1 PHI INTO (K+ K-)/(K KBAR + PI+ PI- PIO) (P1)/(P1+P2+P3)

R1	B	27	(0.26)	(0.06)	BADIER	65	HBC		10/66
R1		252	0.48	0.04	LINDSEY	66	HBC	2.7 K-P	10/66
R1			0.540	0.034	BALAKIN	71	OSPK	E+ E- COLL.BEAM	11/71
R1			0.486	0.044	CHATELUS	71	OSPK	E+ E- COLL.BEAMS	11/71
R1		270	0.49	0.06	DE GROOT	74	HBC	4.2 K-P,L PHI	12/75
R1		321	0.45	0.05	KALBFLEIS	76	HBC	2.18 K-P	7/77*

R1 . . . .
R1 AVG 0.497 0.019 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1 STUDENT 0.496 0.022 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1 FIT 0.494 0.012 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2 PHI INTO (KL KS)/(K KBAR + PI+ PI- PIO) (P2)/(P1+P2+P3)

R2	B	25	(0.23)	(0.06)	BADIER	65	HBC		10/66
R2		167	0.40	0.04	LINDSEY	66	HBC	2.7 K-P	10/66
R2			0.257	0.038	BALAKIN	71	OSPK	E+ E- COLL.BEAMS.	1/73
R2		133	0.27	0.03	KALBFLEIS	76	HBC	2.18 K-P	7/77*
R2	A	270	(0.37)	(0.05)	DE GROOT	74	HBC	4.2 K-P,L PHI	12/77*

R2 A SUPERSEDED BY LOSTY 77 UNDER R19.
R2 . . . .
R2 AVG 0.300 0.042 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
R2 STUDENT 0.290 0.026 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2 FIT 0.357 0.012 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R3 PHI INTO (PI+ PI- PIO (INCL.RHO PI))/TOTAL (P3)
R3 E 0.139 0.007 PARROUR2 76 OSPK E+E- COLL.BEAMS . 7/77*
R3 E USING TOTAL WIDTH 4.1 MEV. THE 3 PI MODE IS MORE THAN 80 PER CENT
R3 E RHO PI AT THE 90 PER CENT C.L.
R3 . . . .
R3 FIT 0.1469 0.0072 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R5 PHI INTO (KL KS)/(K KBAR) (P2)/(P1+P2)

R5	10	0.40	0.10	SCHLEIN	63	HBC	2.0 K-P	10/66
R5	52	0.48	0.07	BADIER	65	HBC	3.0 K-P	11/67
R5		0.44	0.07	LONDON	66	HBC	2.2 K-P	.10/66

R5 . . . .
R5 AVG 0.448 0.044 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5 STUDENT 0.448 0.048 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5 FIT 0.420 0.014 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

Mesons

ϕ(1020), M(1033−1040)


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R6      PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(K KBAR)     (P3)/(P1+P2)
R6             0.30      0.15              LONDON     66 HBC      2.2 K-P          10/66
R6             0.237     0.039             CERRADA    77 HBC      4.2 K-P,LAM 3PI  12/77*
R6             . . . . . . . . . .
R6  AVG        0.241     0.038    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  STUDENT    0.241     0.041    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6  FIT        0.175     0.010   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R7      PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(KL KS)      (P3)/(P2)
R7           (0.3)  OR LESS                BERLEY     65 HBC      2.9 PI+P         10/66
R7             0.47      0.06              COSME 1    74 OSPK    E+E- COLL.BEAMS   2/74
R7             . . . . . . . . . .
R7  FIT        0.418     0.029   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R8      PHI INTO (PI+ PI-)/(K KBAR) (SEE ALSO R18)         (P8)/(P1+P2)
R8           (0.2)  OR LESS                LONDON     66 HBC      2.2 K-P          10/66

R9      PHI INTO (E+ E-)/(K+ K-) (UNITS 10**-4)            (P5)/(P1)
R9       (SEE ALSO R16)
R9       40    6.1       1.7               BECKER     68 CNTR          GAMMA C      9/68

R10     PHI INTO (MU+ MU-)/TOTAL (UNITS 10**-4)           (P6)
R10            3.5       3.5      1.8    WEHMANN    68 OSPK    12 K- C           6/68
R10            2.34      1.01              MOY        69 CNTR     PHOTOPROD.      11/70
R10            2.17      0.60              EARLES     70 CNTR     6.0 BREMSSTR.   11/70
R10            2.69      0.46              HAYES      71 CNTR    PHOTOPROD.       .11/71
R10            . . . . . . . . . .
R10 AVG        2.50      0.34     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R10 STUDENT    2.50      0.37     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R11     PHI INTO (ETA GAMMA)/TOTAL                         (P4)
R11      27    0.073     0.019             BASILE     72 CNTR    1.8 PI- P         12/72
R11A     25    0.026     0.007             BENAKSAS   72 OSPK    E+E- COLL.BEAMS . 2/73
R11A     54    0.015     0.004             COSME      76 OSPK    E+E- COLL.BEAMS  12/75
R11A     FROM 2 GAMMA    DECAY MODE OF ETA                                          7/77*
R11B         (0.024)OR LESS  CL=0.95  COSME       76 OSPK    E+E- COLL.BEAMS    7/77*
R11B     FROM PI+PI-PIO DECAY MODE OF ETA                                            7/77*
R11            0.0135    0.0029            ANDREWS    77 CNTR    6.7-10 GAMMA CU  12/77*
R11            . . . . . . . . . .
R11 AVG        0.0160    0.0026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R11 STUDENT    0.0156    0.0025   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R11 FIT        0.0161    0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R12     PHI INTO (PI+ PI- GAMMA)/TOTAL                     (P9)
R12          (0.04) OR LESS                LINDSEY    65 HBC      2.7 K-P           2/74
R12          (0.007)OR LESS   CL=.90      COSME 1    74 OSPK    E+E- COLL.BEAMS    2/74
R12           (.06) OR LESS   CL=.90      KALBFLEI   75 HBC     2.2 K- P,GAMMA + 12/75

R13     PHI INTO (ETA NEUTRALS)/(K KBAR)                   (P13)/(P1+P2)
R13          (0.15) OR LESS                LINDSEY    66 HBC      2.7 K-P          10/66

R14     PHI INTO (OMEGA GAMMA) / TOTAL                     (P10)
R14          (0.05) OR LESS                LINDSEY    66 HBC      2.7 K-P          10/66

R15     PHI INTO (RHO GAMMA) / TOTAL                       (P12)
R15          (0.02) OR LESS                LINDSEY    66 HBC      2.7 K-P          10/66

R16     PHI INTO (E+ E-)/TOTAL (UNITS 10**-4)              (P5)
R16      (SEE ALSO R9)
R16 A     5   (6.6)     (4.4)     (2.8)  ASTVACATU 68 OSPK    4 PI- P           6/68
R16 A    ERROR OF ASTVACATUROV 68 DOES NOT INCLUDE SIGMA(PHI) UNCERTAINTY.    6/68
R16      27   (7.2)     (3.9)             BINNIE     68 OSPK    1.6 PI- P       . 6/68
R16       9   (6.1)     (2.6)             BOLLINI    68 CNTR    1.9 PI- P         9/68
R16            2.81      0.25              BALAKIN    71 OSPK    E+ E- COLL.BEAMS 11/71
R16            3.50      0.27              CHATELUS   71 OSPK    E+ E- COLL.BEAMS 11/71
R16            3.3       0.3               COSME 1    74 OSPK    E+ E- COLL.BEAMS  2/74
R16  E         3.10      0.14              PARROUR1   76 OSPK    E+ E- COLL.BEAMS  7/77*
R16  E    USING TOTAL WIDTH 4.2 MEV. THEY DETECT 3 PI MODE AND OBSERVE
R16  E    SIGNIFICANT INTERFERENCE WITH OMEGA TAIL. THIS IS ACCOUNTED FOR
R16  E    IN THE RESULT QUOTED ABOVE
R16            . . . . . . . . . .
R16 AVG        3.13      0.12     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R16 STUDENT    3.13      0.12     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R17     PHI INTO (PIO GAMMA)/(TOTAL)                       (P7)
R17       7   (0.0025) (0.0012)            BENAKSAS   72 OSPK    E+E- COLL. BEAMS  2/73
R17      32    0.0014    0.0005            COSME      76 OSPK    E+ E- COLL.BEAMS 12/77*

R18     PHI INTO (PI+ PI-)/(TOTAL) (UNITS 10**-4)         (P8)
R18      (SEE ALSO R8)
R18          (50.)    OR LESS  CL=.95     BIZOT2     70 OSPK    E+ E- COLL.BEAMS 11/71
R18          (80.)    OR LESS  CL=.95     BALAKIN    71 OSPK    E+ E- COLL.BEAMS  1/71
R18           (2.7)   OR LESS  CL=.95     ALVENSLE   72 OSPK    GAMMA+C           1/72

R19     PHI INTO (KL KS)/(K+ K-)                           (P2)/(P1)
R19     144    0.89      0.10              AGUILAR    72 HBC     3.9,4.6 K- P      12/72
R19     125    1.15      0.15              COLLEY     72 HBC     10.K+ P,K+ P PHI 12/72
R19            0.71      0.05              LAVEN      77 HBC     10 K-P,K+K-LAMBD 12/77*
R19            0.82      0.08              LOSTY      77 HBC     4.2 K-P,PHI HYP  12/77*
R19            0.71      0.08              LYONS      77 HBC     3-4 K-P,LAMB PHI 12/77*
R19            . . . . . . . . . .
R19 AVG        0.774     0.055    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
R19 STUDENT    0.768     0.042    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R19 FIT        0.724     0.041   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)
                         (SEE IDEOGRAM BELOW )
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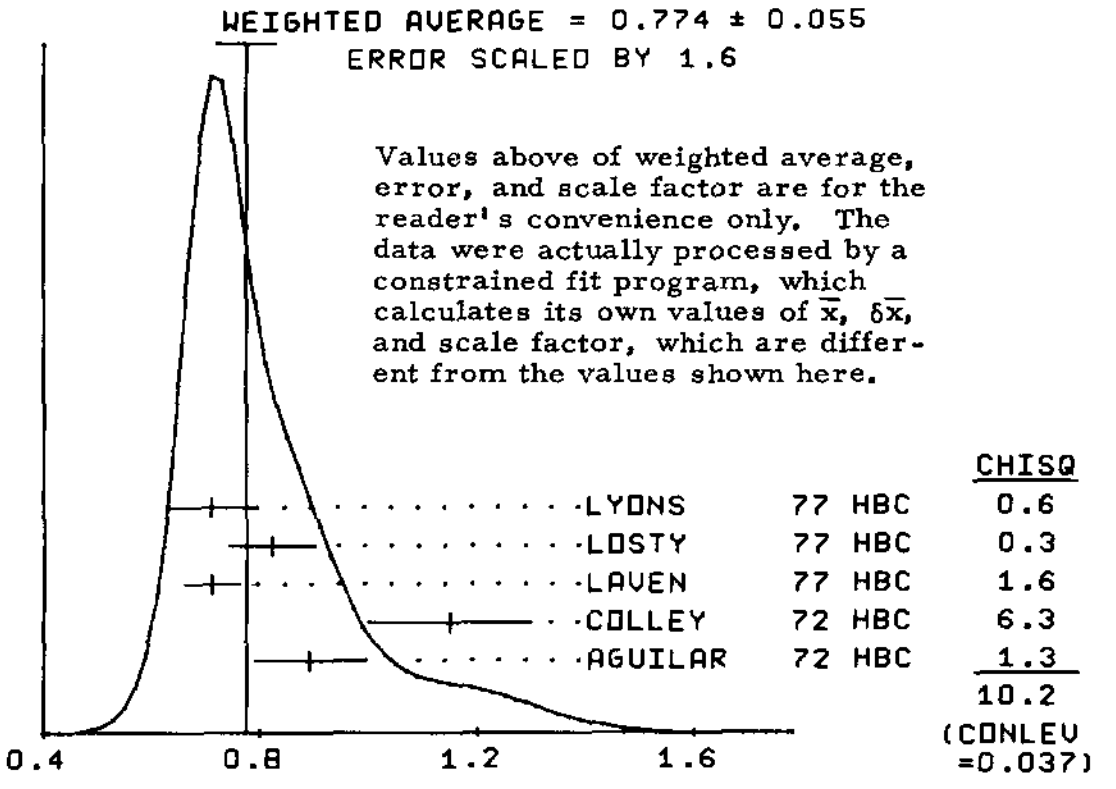


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R20     PHI INTO (PI+ PI- PIO(INCL.RHO PI)/(K+ K-)        (P3)/(P1)
R20      34    0.28      0.09              AGUILAR    72 HBC     3.9,4.6 K- P     12/72
R20            . . . . . . . . . .
R20 FIT        0.302     0.018   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R21     PHI INTO (2PI+ 2PI- PIO)/(K+ K-)                   (P14)/(P1)
R21           (0.02) OR LESS  CL=0.95  AGUILAR    72 HBC     3.9,4.6 K- P    .12/72

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REFERENCES FOR PHI


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BERTANZA 62 PRL 9 180          BERTANZA,BRISSON,CONNOLLY,HART + (BNL+SYRA)
GELFAND  63 PRL 11 438         GELFAND,MILLER,NUSSBAUM,KIRSCH+ (COLU+RUTG)
   GELFAND 63 DATA INCLUDED IN MILLER 65 BELOW
SCHLEIN  63 PRL 10 368         SCHLEIN,SLATER,SMITH,STORK,TICHO      (UCLA)

BADIER   65 PL 17 337          BADIER,DEMOULIN,BARLOUTAUD+      (SACL+AMST)
BERLEY   65 PR 139 B 1097      D BERLEY,N GELFAND            (BNL+COLUMBIA)
GALTIERI 65 PRL 14 279         A BARBARO GALTIERI,R D TRIPP            (LRL)
LINDSEY  65 PRL 15 221         JAMES S LINDSEY,GERALD A SMITH          (LRL)
   LINDSEY 65 DATA INCLUDED IN LINDSEY 66 BELOW
MILLER D 65 CU-237(NEVIS 131) DAVID C MILLER  (THESIS)          (COLUMBIA)

GRAY, L  66 PRL  17  501       +HAGERTY,BIZZARRI,CIAPETTI +    (SYRA+ROMA)JPG
LINDSEY  66 PR  147  913       JAMES S LINDSEY, GERALD A SMITH         (LRL)
LINDSEY1 66 PL 20 93           J.S.LINDSEY, G.A.SMITH                  (LRL)
   LINDSEY 1 66 DATA INCLUDED  IN LINDSEY 66 ABOVE
LONDON   66 PR 143 1034        LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)

ABRAMS   67 MD TECH REP 720    GERALD ABRAMS , THESIS            (MARYLAND)
BARLOW   67 NC 50A 701         +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
CHASE    67 PRL 18 710         R.C.CHASE,P.ROTHWELL,R.WEINSTEIN (CEA+NEAS)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                 (LRL)
HERTZBAC 67 PR 155  1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
KHACHATU 67 PL 24B 349         KHACHATURYAN+AZIMOV+BALDIN+BELOUSOV+(DUBNA)

ABRAMS   68 PR 175 1697        +GLASSER,KEHOE,SECHI-ZORN,WOLSKY (MARYLAND)
ASTVACAT 68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+    (JINR+MOSCOW)
    ALSO 67 PRL 19 869         ASBURY,BECKER,BERTRAM,TING+ (DESY+COLUMBIA)
BECKER   68 PRL 21 1504        +BERTRAM,BINKLEY,JORDAN,KNASEL+  (DESY+MIT)
BINNIE   68 PL 27B 106         +DUANE+FARUQI+HORSEY+             (LOIC+RHEL)
BOLLINI  68 NC 56 A 1171       +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
MOSTEK   68 PRL 20 1057        +EISENHANDLER,MCCLELLAN,MISTRY+   (CORNELL)
WEHMANN  68 PRL 20 748         +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)

AUGUSTIN 69 PL 28 B 517        +BIZOT,BUON,DELCOURT,HAISSINSKI,+   (ORSAY)
MOY      69  THESIS            KEN MIN MOY      (NORTHEASTERN UNIVERSITY)
SCOTTER  69 NC 62 A 1057       +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)

BIZOT    70 PL 32 416          +BUON,CHATELUS,JEANJEAN,LALANNE,+     (ORSA)
    ALSO 69 PEREZ-Y-JORBA, LIVERPOOL SYMP.69
BIZOT2   70 LNC 4 1273         +DELCOURT,JEANJEAN,LALANNE,+         (ORSAY)
EARLES   70 PRL 25 1312        +FAISSLER,GETTNER,LUTZ,MOY,TANG,+     (NEAS)
HYAMS    70 NP B 22 189        +KOCH,POTTER,V.LINDERN,LORENZ,LUTJENS(CERN)

ALVENSLE 71 PRL 27 441         ALVENSLEBEN,BECKER,BUSZA,CHEN,+  (MIT+DESY)
BALAKIN  71 PL 34 B 328        +BUDKER,PAKHTUSOVA,SIDOROV,SKRINSKY,+(NOVO)
DIBIANCA 71 NP B 35 13         +EINSCHLAG,ENDORF,ENGLER,FISK,+       (CORN)
CHATELUS 71  LAL 1247(THESIS) Y.CHATELUS                     (STRASBOURG)
    ALSO 70 BIZOT
HAYES    71 PR D 4 899         +IMLAY,JOSEPH,KEIZER,STEIN            (CORN)
STOTTLEM 71  ORO 2504 170      A.R.STOTTLEMYER,THESIS            (MARYLAND)

AGUILAR  72 PR D 6 29          AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS   (BNL)
ALVENSLE 72 PRL 28 66          ALVENSLEBEN,BECKER,BIGGS,BINKLEY+(MIT+DESY)
BALAKIN  72 PL 40 B 431        +BOKIN,PAKHTUSOVA,SIDOROV,+    (NOVOSIBIRSK)
BASILE   72 NP B 44 605        +DALPIAZ,FRABETTI,ZICHICHI+(CERN+BGNA+STRB)
BENAKSAS 72 PL 42 B 511        +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
COLLEY   72 NP B 50 1          +JOBES,RIDDIFORD,GRIFFITHS,+     (BIRM+GLAS)
BORENSTE 72 PR D 5 1559        BORENSTEIN,DANBURG,KALBFLEISCH,+ (BNL+MICH)

BALLAM   73 PR D 7 3150        +CHADWICK,EISENBERG,BINGHAM,+     (SLAC+LBL)

AYRES    74 PRL 32 1463        +DIEBOLD,GREENE,KRAMER,LEVINE,+        (ANL)
BESCH    74 NP B70 257         +HARTMANN,KOSE,KRAUTSCHNEIDER,PAUL,+ (BONN)
BIZZARRI 74 NC 20A 393         +CIAPETTI,DIONISI,DORE,GASPERO+       (ROMA)
COSME 1  74 PL 48 B 155        +JEAN-MARIE,JULLIAN,LAPLANCHE,+      (ORSAY)
COSME 2  74 PL 48 B 159        +JEAN-MARIE,JULLIAN,LAPLANCHE,+      (ORSAY)
DE GROOT 74 NP B74 77          +HOOGLAND,JONGEJANS,METZGER+    (AMST+NIJM)

BUKIN    75  IYAF 75-64        +DERBENEV,KONDRATENKO,KURDADZE,+      (NOVO)
KALBFLEI 75 PR D11 987         KALBFLEISCH,STRAND,CHAPMAN        (BNL+MICH)

COSME    76 PL 63 B 352        +COURAU,DUDELZAK,GRELAUD,JEAN-MARIE+(ORSAY)
PARROUR1 76 PL 63 B 357        +GRELAUD,COSME,COURAU,DUDELZAK,+     (ORSAY)
PARROUR2 76 PL 63 B 362        +GRELAUD,COSME,COURAU,DUDELZAK,+     (ORSAY)
KALBFLEI 76 PR D 13 22         KALBFLEISCH,STRAND,CHAPMAN        (BNL+MICH)

ANDREWS  77 PRL 38 198         +FUKUSHIMA,HARVEY,LOBKOWICZ,MAY,+     (ROCH)
AKERLOF  77 PRL 39 861         +ALLEY,BINTINGER,DITZLER,+ (FNAL+MICH+PURD)
BALDI    77 PL 68 B 381        +BOHRINGER,DORSAZ,HUNGERBUHLER,+   (GENEVA)
BARTALUC 77  DESY 77/56        BARTALUCCI,BERTOLUCCI,+          (DESY+FRAS)
CERRADA  77 NP B 126 241       +BLOCKZIJL,HEINEN,+     (AMST+CERN+NIJM+OXF)
COHEN    77 PRL 38 269        +AYRES,DIEBOLD,KRAMER,PAWLICKI,WICKLUND(ANL)
COURANT  77 PR D 16 1          +MAKDISI,MARSHAK,PETERSON,RUDDICK,+  (MINN)
EVANGEL  77 NP B 127 384       EVANGELISTA,+   (BARI+BONN+CERN+DARE+GLAS+)
LAVEN    77 NP B 127 43        +OTTER,KLEIN,+   (AACH+BERL+CERN+LOIC+WIEN)
LOSTY    77  CERN/EP/PHYS77    +HOLMGREN,BLOKZIJL,+    (CERN+AMST+NIJM+OXF)
LYONS    77 NP B 125 207       +COOPER,CLARK                          (OXF)
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M(1033−1040)

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67  M(1033-1040)

THE CLAIM FOR A NARROW RESONANCE AT 1033 MEV
BY GARFINKEL 72 HAS NOT BEEN CONFIRMED BY
BINNIE 74, GRAYER 74, BUTTRAM 75. OMITTED
FROM TABLE.
THE CLAIM FOR AN OMEGA PI RESONANCE AT 1040
MEV BY DEFOIX 73 HAS NOT BEEN CONFIRMED BY
DIAZ 74. OMITTED FROM TABLE.

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REFERENCES FOR M(1033-1040)


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GARFINKE 72 PRL 29 1477        GARFINKEL,HOFFMAN,JACOBEL,+ (PURD+ANL+IOWA)
DEFOIX   73 PL 43 B 141        +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+      (CDEF)
BINNIE   74 PRL 32 392         +CAMILLERI,CARR,DEBENHAM,+       (LOIC+SHMP)
DIAZ     74 PRL 32 260         +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)
GRAYER   74 NP B 75 189        +HYAMS,JONES,BLUM,DIETL,KOCH+   (CERN+MPIM)
BUTTRAM  75 PRL 35 970         +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON    (ISU)
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Data Card Listings

For notation, see key at front of Listings.

$\eta_N(1080)$

30 ETA N(1080,JPG=N +) I=0 J GREATER THAN 1

SOME EXPERIMENTS SUGGEST J=2. NOT CONFIRMED BY GRAYER 74, FROGGATT 77. OMITTED FROM TABLE.

30 ETA N MASS (MEV)

M		1060.0	15.0		MILLER	68 HBC	4.0 PI- P		9/68
M	70	1085.0	10.0		WHITEHEAD	68 ASPK	3.1-3.6 PI-P		10/67
M		1120.0	100.0	40.0	OH	69 HBC	7.PI- P,PI+ D		9/69
M		1112.0	16.0		CLAYTON	70 HBC	2.5 PBAR P,4 PI		1/71
M		(1080.0)			DIAZ	70 HBC	0. PBAR P, 4 PI		5/70
M		1070.0	20.0		REYNOLDS	70 HBC	2.26-2.36 PI- P		1/71
M		. . . . .							
M	AVG	1083.3	9.8		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)				
M	STUDENT	1083.0	8.3		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

30 ETA N WIDTH (MEV)

W		(70.0)	OR LESS		MILLER	68 HBC	4.0 PI- P		9/68
W		(25.0)	OR LESS		WHITEHEAD	68 ASPK	3.1-3.6 PI-P		10/67
W		150.0	100.0	40.0	OH	69 HBC	7.PI- P,PI+ D		9/69
W		(80.0)			CLAYTON	70 HBC	2.5 PBAR P,4 PI		1/71
W		(80.0)			DIAZ	70 HBC	0. PBAR P, 4 PI		5/70
W		85.0	35.0		REYNOLDS	70 HBC	2.26-2.36 PI- P		1/71
W		. . . . .							
W	AVG	98.0	31.3		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
W	STUDENT	97.7	34.5		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

REFERENCES FOR ETA N

MILLER	68	PRL 21 1489	+GUTAY,JOHNSON,KENNEY+	(PURDUE+NDAM+SLAC)
WHITEHEA	68	NC 53 A 817	C.WHITEHEAD +	(AERE+SHMP+LOIC)
OH	69	PRL 23 331	+WALKER,CARROLL,FIREBAUGH,+	(WISC+TNTO)
CLAYTON	70	NP B 22 85	+MASON,MUIRHEAD,RIGOPOULOS,+	(LIVP+ATEN)
DIAZ	70	NP B 16 239	+GAVILLET,LABROSSE,MONTANET,+	(CERN+CDEF)
REYNOLDS	70	NP B 21 77	+ALBRIGHT,BRADLEY,+	(OHIO+FSU+MINN+COLO)
WHITEHEA	72	NP B 48 365	WHITEHEAD,AULD,+	(AERE+RHEL+SHMP+LOUC)
DIAMOND	73	PR D 7 1977	+BINKLEY,+	(WISC+DUKE+COLO+TNTO+OHIO)
GRAYER	74	NP B 75 189	+HYAMS,JONES,BLUM,DIETL,KOCH+	(CERN+MPIM)
FROGATT	77	NP B 129 89	+PETERSEN	GLASGOW+COPENHAGEN

$A_1(1100)$

10 A1(1100,JPG=1+-) I=1

The peak in the $(3\pi)^{\pm}$ mass distribution near the $\rho\pi$ threshold was discovered by BELLINI 63 in very forward π^- scattering on carbon without nuclear break-up, thus coherent diffractive $\rho\pi$ production.

Until 1977, all the significant observations of a $\rho^0\pi^{\pm}$ peak near 1100 MeV were made in the reaction $\pi^{\pm}N \to (\pi\pi\pi)^{\pm}N$. At small momentum transfer, the diffraction-like mechanism without quantum number exchange in the t channel contributes to this reaction. The dominant effect is a broad $J^P = 1^+$ enhancement in the S-wave $\rho\pi$ system, its maximum intensity occurring at ~1100 MeV and its width being ~300 MeV (ANTIPOV1 73, KRUSE 74, OTTER 74, TABAK 74, THOMPSON 74, EMMS1 75, BALTAY 77, PERNEGR 77).

All of these experiments have been partial-wave analyzed by the method of ASCOLI 70, TABAK 74, CAUTIS 77. Assuming that, for a given momentum transfer t, the 3π vertex is independent of the NN vertex, the 3π system is composed, in the spirit of the non-unitary isobar model, of quasi-two-body $\pi\rho$ and $\pi\varepsilon$ amplitudes. The waves contributing to the 3π final state are (at most) the 0^-P, 1^+S, 1^+D, 2^-P, 3^+D, 1^-P, and 2^+D $\rho\pi$ waves and the 0^-S, 1^+P, and 2^-D $\varepsilon\pi$ waves. Here ε stands for a pole in the $J^P = 0^+$ $\pi\pi$ system, the location of which is not well established [see the review of S-wave $\pi\pi$ interactions under $\varepsilon(1300)$].

The results of these analyses have shown that the phase of the 1^+S wave displays little variation relative to the $0^-S(\varepsilon\pi)$, $1^+P(\varepsilon\pi)$, and $2^-P(\rho\pi)$ waves (ANTIPOV1 73, OTTER 74, TABAK 74, THOMPSON 74, BALTAY 77). As the 2^+D wave exhibits a clear Breit-Wigner-like phase change in the A_2 region (ASCOLI 70, ANTIPOV1 73, OTTER 74, TABAK 74, THOMPSON 74, BALTAY 77), the above results have been interpreted to imply that no resonant A_1 is needed. Unitarity corrections to the isobar model do not change this conclusion (ASCOLI 75, AITCHISON 75).

This conclusion has been, however, reversed by several new analyses. BOWLER 75 demonstrated that the small variation in the 1^+S phase could be due to a phase difference between the Deck amplitude and the direct A_1 resonance-production amplitude. Another cause could be inelasticity due to the coupling of the $\rho\pi$, $\varepsilon\pi$, and $K^*\bar{K}$ channels, and rescattering (BRAYSHAW 76, LONGACRE 76,77). Finally, SCHULT 77 re-analyzed the ANTIPOV1 73 data using three-pion-state amplitudes which satisfy both unitarity and analyticity, and found a solution with considerably more phase variation than originally had been found.

BASDEVANT 77 performed an analysis of the $\rho\pi$ waves exclusively, ignoring the $\varepsilon\pi$ waves as being meaningless in an isobar analysis, since the ε could not be considered a bona fide particle. Their full amplitude is properly analytic and unitary, and it includes: the Deck amplitude, resonant as well as background elastic $\rho\pi \to \rho\pi$ scattering, rescattering corrections, inelasticity due to the $K^*\bar{K}$ channel, and direct diffractive A_1 production. They take the 1^+S phase from the difference of the known A_2 phase and the observed $2^+D - 1^+S$ phase difference (ANTIPOV1 73). BASDEVANT 77 show that the ANTIPOV1 73 data are consistent with a resonance at $M = 1300 \pm 150$ MeV, $\Gamma = 400 \pm 100$

Mesons
$A_1(1100)$

MeV, and that the data are rather inconsistent with the hypothesis of no resonance.

Recently, new light has been shed on the existence of the A_1 by the PERNEGR 77 data on coherent π scattering on nuclei. For the first time these data contain information on the $1^+S - 0^-P$ phase difference. Although this phase-shift analysis is ambiguous between two solutions, interestingly enough one solution exhibits a conspicuous phase variation near $M \sim 1100$ MeV, $\Gamma \sim 300$ MeV. The energy dependence of the $1^+S - 0^-P$ phase difference is in fact exactly as predicted by BASDEVANT 77 on the basis of the ANTIPOV1 73 data.

A long-standing problem of the A_1 has been its non-observation in non-diffractive processes (for a recent review of the situation up to 1976, see HABER 77). Here also the situation is completely changed due to new observations.

GAVILLET 77 select backwardly produced 3π events in the reaction $K^-p \to \Sigma^-\pi^+\pi^+\pi^-$ in sufficient number to project out the different partial waves. An A_1 peak is seen not only in the total 3π mass distribution, but most clearly in the 1^+S partial wave. The Breit-Wigner parameters of the peak are: mass 1041 ± 13 MeV, width 230 ± 50 MeV.

A possible confirmation of backward A_1 production by pions has been obtained by FERRER 77 in a very large-statistics experiment. The observed peak has the resonance parameters, $M \simeq 1050$ MeV and $\Gamma \simeq 200 \pm 50$ MeV, but nothing is known about the partial-wave composition. The production cross sections at two different beam momenta of 9 and 12 GeV/c agree with limits set by earlier, less significant experiments (ANDERSON 69, ABASHIAN 75).

On the other hand, no evidence for the A_1 has been found in the charge-exchange reactions $\pi^+n \to \pi^+\pi^-\pi^0p$ (EMMS2 75), $\pi^+p \to \pi^+\pi^-\pi^0\Delta^{++}$ (WAGNER 75, BALTAY 77), or $K^-p \to \pi^+\pi^-\pi^0\Lambda$ (CERRADA 77). However, the number of partial waves is greater in charge exchange due to the two possible values of isospin, and thus the analysis is more complicated.

Other non-diffractive channels, such as $\bar{p}p$ annihilation, have not produced consistent results of any statistical significance.

Finally, the semileptonic decay $\tau^\pm \to A_1^\pm\nu$ seems to have been discovered at PLUTO (ALEXANDER 77). The $\pi^+\pi^-\pi^\pm$ mass distribution with a $\rho^0\pi^\pm$ selection shows a peak centered at $M \sim 1150$ MeV, $\Gamma \sim 250 \pm 50$ MeV, very unlike phase space. The Dalitz plot distribution is consistent with 1^+S. However, with only 23 events in the plot it is not impossible to rule out all other possible waves. It is amusing to notice that this peak looks very much like the first A_1 (BELLINI 63), which contained only 47 events!

BASDEVANT 78 use the data of ALEXANDER 77 and preliminary unpublished SLAC-LBL data to restrict the range of solutions for the A_1 resonance parameters obtained in their analysis of diffractive A_1 production (BASDEVANT 77). The parameters they obtain, when expressed as second sheet pole values rather than as simple Breit-Wigner parameters, are: $M = 1180 \pm 50$ MeV, $\Gamma = 400 \pm 50$ MeV. This is not in contradiction with the results of the physical-region fits of FERRER 77 and GAVILLET 77 quoted above.

Thus we may finally be arriving at a consistent picture of the A_1 as a meson resonance. The quantitative details, however, are a long way from being determined exactly.

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                  10  A1 MASS (MEV)

M   PRODUCED BY PI +
M        (1080.0)                    ADERHOLZ  64 HBC      4.0 PI+P
M        (1080.)    APPROX.          BOESEBECK 68 HBC  +   8 PI+ P              6/68
M        (1040.0)                    ARMENISE  70 HBC    0 9 PI+ N -- A1 P      1/71
M F      (1128.)      (8.)           THOMPSON  74 HBC  +  13 PI+P,PI3PI+        12/75
M
M   PRODUCED BY PI -
M        (1060.)                     ASCOLI    68 HBC   -0 5 PI-P               6/68
M        (1089.0)    (12.0)          BALLAM    68 HBC   - 16.0 PI- P            9/68
M        (1090.)   APPROX.           CHUNG     68 HBC   -  3.2,4.2 PI-P         2/67
M        (1055.0)     (6.0)          JUNKMANN  68 HBC   -  16. PI- P, 5PI       9/69
M   S    (1119.)    (30.)            KEY       68 HBC   -  3 PI-P               9/68
M   S     SHOULDER ON A2 ONLY
M        (1069.0)     (7.0)          CASO      70 HBC   - 11.2PI-P              5/70
M        (1120.0)                    CRENNELL  70 HBC   -  6. PI- P,F PI        5/70
M F T    (1150.)                     ANTIPOVI  73 CNTR  -  25.,40. PI- P        1/74
M  T  MASS AND WIDTH SEEN TO DEPEND ON T, UNIQUE DET. IMPOSSIBLE                 1/74
M        (1152.0)     (9.0)          BALTAY    77 HBC   0 15 PI- P,P 3PI        12/77*
M   P    (1100.0)                    PERNEGR   77 CNTR  - 9+13+15 PI- NUC.     12/77*
M   P PHASE VARIATION OBSERVED BETWEEN (1+S) AND (0-P) WAVES
M
M   PRODUCED BY PIONS,BACKWARDS SCATT.
M        (1115.0)    (20.0)          ANDERSON  69 MMS   -  16 PI- P,BACKW9       8/69
M   J    (1050.0)    (11.0)          FERRER    77 OMEG  - 9+12 PI- P,P 3PI.12/77*
M   J NO JP DETERMINATION ATTEMPTED
M
M   PRODUCED BY PBARS.
M        (1054.)      (7.)           DANYSZ    67 HBC  +-  3.3.6 PBAR P       7/67
M        (1042.)     (21.)           FRIDMAN   68 HBC  +-  5.7 PBAR P          6/68
M   A    (1076.)      (5.)           ATHERTON  73 HBC  +- 5.7 PBAR P           1/74
M   A   JP ANALYSIS GIVES SOME EVIDENCE FOR RHO PI D-WAVE                       1/73
M
M   PRODUCED BY K-.
M        (1111.)     (10.)           ALLISON   67 HBC   +   6 K-P,LAM +5 PI    1/68
M        (1117.)     (30.)           ALLISON   67 HBC   +   6 K-P,LAM +4 PI    1/68
M        (1060.)     (15.)           JUHALA    67 HBC     0 4.6-5 K-P,5BODY    1/68
M
M   PRODUCED BY K+.
M   K+   (1060.0)    (20.0)          ALEXANDER 69 HBC   +   9 K+P               9/69
M   K+   (1030.0)    (20.0)          BERLINGHI 69 HBC   + 0 12.7 K+ P           9/69
M   K+ FOR CONTRADICTORY EVIDENCE SEE RABIN 70 .
M
M   PRODUCED BY K-,BACKWARDS SCATTERING
M   F    (1041.0)    (13.0)          GAVILLET  77 HBC   +  4.2 K- P,S 3PI      12/77*
M   F   FROM A FIT TO JP=1+ RHO PI PARTIAL WAVE
M
M   AVERAGING NOT MEANINGFUL

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                  10  A1 WIDTH (MEV)

W   PRODUCED BY PI +
W          (80.0)                    ADERHOLZ  64 HBC      4.0 PI+P
W         (130.)   APPROX.           BOESEBECK 68 HBC  +   8 PI+ P          6/68
W          (50.0)  OR LESS           ARMENISE  70 HBC    0 9 PI+ N -- A1 P  1/71
W  F      (300.)   APPROX.           RINAUDO   71 HBC  +  5. PI+P,P (3PI)+ 11/71
W  F      (367.)    (30.)            THOMPSO1  74 HBC  +  13 PI+P,P(3PI)+  12/75
W
W   PRODUCED BY PI -
W         (140.0)   (31.0)           BALLAM    68 HBC   - 16.0 PI- P        9/68
W         (125.)   APPROX.           CHUNG     68 HBC   -  3.2,4.2 PI-P     2/67
W          (77.0)   (17.0)           JUNKMANN  68 HBC   -  16. PI- P, 5PI   9/69
W   K      (76.)    (46.)            KEY       68 HBC   - 3.0 PI- P        11/67
W   K      SHOULDER ON A2 ONLY
W          (99.0)   (15.0)           CASO      70 HBC   - 11.2PI-P          5/70
W  F T    (300.)                     ANTIPOV1  73 CNTR -  25.,40. PI- P     1/74
W    T  MASS AND WIDTH SEEN TO DEPEND ON T, UNIQUE DET. IMPOSSIBLE          1/74
W         (264.0)   (11.0)           BALTAY    77 HBC   0 15 PI+ P,P 3PI   12/77*
W   P     (300.0)                    PERNEGR   77 CNTR  - 9+13+15 PI- NUC. 12/77*
    P PHASE VARIATION OBSERVED BETWEEN (1+S) AND (0-P) WAVES
W
W   PRODUCED BY PIONS,BACKWARDS SCATT.
W          (98.0)   (45.0)   (20.0)  ANDERSON  69 MMS   -  16 PI- P,BACKW9  8/69
W   J     (195.0)   (32.0)           FERRER    77 OMEG  - 9+12 PI- P,P 3PI 12/77*
    J NO JP DETERMINATION ATTEMPTED
W
W   PRODUCED BY PBARS.
W          (33.)    (19.)            DANYSZ    67 HBC  +-  3,3.6 PBAR P     7/67
W         (130.)   APPROX.           FRIDMAN   68 HBC  +-  5.7 PBAR P       6/68
W   A      (36.)    (20.)    (15.)   ATHERTON  73 HBC  +- 5.7 PBAR P        1/74
W   A   JP ANALYSIS GIVES SOME EVIDENCE FOR RHO PI D-WAVE                   1/73
W
W   PRODUCED BY K-.
W          (50.)    (50.)            ALLISON   67 HBC  +   6 K-P,LAM +4 PI  1/68
W          (50.)    (25.)            ALLISON   67 HBC  +   6 K-P,LAM +5 PI  1/68
W         (120.)    (15.)            JUHALA    67 HBC    0 4.6-5 K-P,5BODY  1/68
W
W   PRODUCED BY K+.
W         (160.0)   (20.0)           ALEXANDER 69 HBC  +     9 K+P          9/69
W   B     (120.0)   (30.0)           BERLINGHI 69 HBC      12.7 K+ P        8/69
W   K+ FOR CONTRADICTORY EVIDENCE SEE RABIN 70 .
W         (130.0)   (20.0)           BERLINGHI 69 HBC  + 0 12.7 K+ P        9/69
W
W   PRODUCED BY K-,BACKWARDS SCATTERING.
W   F     (230.0)   (50.0)           GAVILLET  77 HBC  +  4.2 K- P,S 3PI   12/77*
W   F   FROM A FIT TO JP=1+ RHO PI PARTIAL WAVE
W
W   AVERAGING NOT MEANINGFUL

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                  10  A1 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      A1 INTO RHO PI                                    776+ 139
P2      A1 INTO KBAR K                                    493+ 497

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                  10  A1 BRANCHING RATIOS

R1      A1 INTO (KBAR K)/(RHO PI)                         (P2)/(P1)
R1          (0.0025)OR LESS          DAHL      67 HBC   -  4.0 PI- P     .10/66

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                              REFERENCES FOR A1

BELLINI  63 NC 29 896           BELLINI,FIORINI,HERZ,NEGRI,RATTI     (MILAN)

ADERHOLZ 64 PL 10 226           AACH+BERL+BIRM+BONN+DESY+HAMBURG+LOIC+MPIM
GOLDHABE 64 PRL 12 336          GOLDHABER,BROWN,KADYK,SHEN+        (LRL+UCB)
LANDER   64 PRL 13 346 A        LANDER,ABOLINS,CARMONY,HENDRICKS +    (UCSD)  JP

ABOLINS  65 ATHENS(OHIO)CONF.  +CARMONY,LANDER,XUONG,YAGER        (LA JOLLA)I=1
ALITTI   65 PL 15 69            ALITTI,BATON,DELER,CRUSSARD+       (SACL+BGNA)

ALLARD   66 NC 46A 737          +DRIJARD+HENNESSY+    (ORSAY+MILAN+SACL+UCB)
DEUTSCHM 66 PL 20 82            DEUTSCHMANN,STEINBERG +   (AACH+BERLIN+CERN)
HESS     66 UCRL-16832          R I HESS (THESIS, BERKELEY)               (LRL)

ALLISON  67 PL 25B 619          +CRUZ+        (OXF+MPIM+BIRM+RHEL+GLAS+LOIC)
DAHL     67 PR 163 1377         +HARDY+HESS+KIRZ+MILLER                   (LRL)
DANYSZ   67 NC 51 A 801         DANYSZ+FRENCH+SIMAK                      (CERN)
JUHALA   67 PRL 19 1355         +LEACOCK+RHODE+KOPELMAN+            (IOWA+COLO)
SLATTERY 67 NC 50A 377          +KRAYBILL+FORMAN+FERBEL             (YALE+ROCH)  JP

ARMENISE 68 PL 26 B  336        +FORINO+CARTACCI+      (BARI+BGNA+FIRZ+ORSAY)
ASCOLI   68 PRL 21 113          +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINOIS)
BALLAM   68 PRL 21 934          +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)JP
BOESEBEC 68 NP B 4 501          BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983         +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
CHUNG    68 PR 165 1491         S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER        (LRL)
CNOPS    68 PRL 21 1609         +HOUGH,COHN,BUGG+ (BNL+ORNL+UCND+TENN+PENN)
FRIDMAN  68 PR 167 1268         +MAURER,MICHALON,OUDET+    (HEID+STRASBOURG)
JUNKMANN 68 NP B8 471           +COCCONI+          (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430         +PRENTICE+COOPER+MANNER+      (TNTO+ANL+WISC)

ALEXANDE 69 PR 183 1168         G.ALEXANDER,A.FIRESTONE,G.GOLDHABER       (LRL)
ALLABY   69 PL 29B 198          +BINON+DIDDENS+DUTEIL+KLOVNING+...       (CERN)
ANDERSON 69 PRL 22 1390         +COLLINS,+                          (BNL+CARN)
BERLINGH 69 PRL 23 42           BERLINGHIERI,FARBER,+                    (ROCH)
DONALD   69 NP B 11 551         +EDWARDS,BURAN,BETTINI,+    (LIVP+OSLO+PADO)
FAYOLLE  69 NP B 13 40          +DE MONTAIGNAC,MORAND,STRACHMAN+       (PARIS)
JUHALA   69 PR 184  1461        +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+COLO)
KENYON   69 PRL 23 146          +KINSON,SCARR,+                (BNL+UCND+ORNL)

ARMENISE 70 LNC 4  199          +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
ASCOLI   70 PRL 25 962          +BROCKWAY,CRAWLEY,EISENSTEIN,HANFT,+  (ILL)  JP
BRANDENB 70 NP B16 369          +BRENNER,IOFFREDO,JOHNSON,KIM+      (HARVARD)
CASO     70 LNC 3  707          +CORDS,COSTA+      (GENO+DESY+HAMB+MILA+SACL)
CRENNELL 70 PRL 24 781          +KARSHON,LAI,SCARR,SIMS                   (BNL)
GARELICK 70 PHILAD.CONF.P.205 D.A.GARELICK,REVIEW              (NORTHEASTERN)
RABIN    70 PRL 24 925          +GALTIERI,DERENZO,FLATTE,FRIEDMAN+        (LRL)

ASCOLI   71 PRL 26 929          ILLINOIS+GENO+HAMB+MIL+SACL+HARV+TNTO+WISC
BEMPORAD 71 NP B 33 397         +BEUSCH,MELISSINOS,+  (CERN+ETHZ+LOIC+MILA)
BERGER   71 PHENOMENOLOGY  IN PARTICLE PHYSICS, CALTECH 1971              (LRL)
RINAUDO  71 NC 5 A 239          +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

BERENYI  72 NP B 37 621         +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
BLOODWOR 72 NP B 46 402         BLOODWORTH,JACKSON,PRENTICE,YOON  (TORONTO)
DIEBOLD  72 BATAV.CONF.3P.17 R.DIEBOLD  RAPPORTEUR TALK                  (ANL)
LAMSA    72 NP B 41 388         +EZELL,GAIDOS,WILLMANN                 (PURDUE)
MORSE    72 NP B 43 77          +OH,WALKER,JOHNSTON,YOON              (WISC+TNTO)

ANTIPOV1 73 NP B 63 153         +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ANTIPOV2 73 NP B 63 141         +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ARNOLD   73 NC 17 A 393         +ENGEL,ESCOUBES,GEMESY,JANOSSY,+(STRB+BUDA)
ASCOLI 1 73 PR D 8 3894         +JONES,WEINSTEIN,WYLD                     (ILL)
ASCOLI 2 73 PRL 31 795          +CHAPIN,CUTLER,HOLLOWAY,KOESTER,KRUSE+(ILL)  JP
ATHERTON 73 PL 43 B 249         +FRANEK,FRENCH,GHIDINI,HILPERT,+         (CERN)
READ     73 NP B 64 511         B.J.READ                                 (DESY)

BOWLER   74 NP B74 493          +DAINTON,KADDOURA,AITCHISON               (OXF)
ASCOLI   74 PR D9 1963          +CUTLER,JONES,KRUSE,ROBERTS,WEINSTEIN+(ILL)
KRUSE    74 PRL 32 1328         +ROBERTS,EDELSTEIN+      (ILL+CARN+NWES+ROCH)  JP
LICHTMAN 74 NP B81 31           +BISWAS,CASON,KENNEY,MCGAHAN,+          (NDAM)  JP
OTTER    74 NP B80 1            +RUDOLPH+          (AACH+BERL+BONN+CERN+HEID)  JP
TABAK    74 BOSTON CONF. P.46 +RONAT,ROSENFELD,LASINSKI+         (LBL+SLAC)  JP
THOMPSO1 74 PR D9 560           THOMPSON,GAIDOS,MCILWAIN,WILLMANN      (PURD)  JP
THOMPSO2 74 NP B69 381          THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+      (PURD)  JP

ABASHIAN 75 PRL 34 691          +BEAMER,BROSS,EISENSTEIN,+      (ILL+ANL+ISU)
AITCHISO 75 PL 59 B 288         I.J.R.AITCHISON, R.J.GOLDING            (OXFORD)
ASCOLI   75 PR D 12 43          G.ASCOLI, H.W.WYLD                    (ILLINOIS)
BEUSCH   75 PL 55B 97           +POLGAR,FREUDENREICH+ (CERN+ETHZ+LOIC+MILA)
BOSETTI  75 NP B 101 304        +OTTER+(AACH+BERL+BONN+CERN+HEID+LOIC+WIEN)
BOWLER   75 NP B97 227          +GAME,AITCHISON,DAINTON             (OXF+DARE)
DIAZ     75 PR 12 D 1272        +DIBIANCA,FICKINGER,DADO,ENGLER+(CASE+CARN)  JP
EMMS 1   75 NP B93 1            +JONES,KINSON,BELL,DALE+    (BIRM+DURH+RHEL)  JP
EMMS 2   75 PL 60 B 109         +JONES,KINSON,BELL,DALE+    (BIRM+DURH+RHEL)  JP
HORNE    75 PR D11 996          +S.HAGOPIAN,V.HAGOPIAN,BENSINGER+(FSU+BRAN)
KANE     75  TENTH RENCONTRE DE MORIOND                                 (MICH)
WAGNER   75 PL 58B 201          +TABAK,CHEW                               (LBL)  JP
ASCOLI   75 PR D 12 43          G.ASCOLI,H.W.WYLD                     (ILLINOIS)
AITCHISO 75 PL 59 B 288         I.J.R.AITCHISON,R.J.GOLDING             (OXFORD)
BOSETTI  75 NP B 101 304        HOTTER+(AACH+BERL+BONN+CERN+HEID+LOIC+WIEN)

BAUBILLI 76 NP B 115 237        BAUBILLIER,RIVOAL,ARMENISE +      (BARI+LPNP)  JP
BENZ     76 NP B 115 385        +BRAUN +(AACHEN+BONN+HAMBURG+HEIDBERG+MPIM)
BRAYSHAW 76 PRL 36 73           D.BRAYSHAW                               (SLAC)

ALEXANDE 77  DESY 77/78         ALEXANDER,KNIES,+(DESY+AACH+HAMB+SIEG+WUPP)
BALTAY   77 PRL 39 591          +CAUTIS,KALELKAR                     (COLUMBIA)  JP
BASDEVAN 77 PR D 16 657         BASDEVANT,BERGER                     (FNAL+ANL)  JP
CAUTIS   77  THESIS NEVIS 221 C.V.CAUTIS                           (COLUMBIA)  JP
CERRADA  77 NP B 126 241        +BLOCKZIJL,HEINEN+      (AMST+CERN+NIJM+OXF)  JP
FERRER   77  BUDAPEST CONF.     +TREILLE,RIVET +     (ORSAY+CERN+CDEF+LPNP)
    ALSO 77  THESIS,LAL 1295    A.FERRER SORIA                          (ORSAY)
GAVILLET 77 PL 69 B 119         +BLOCKZIJL,ENGELEN+     (AMST+CERN+NIJM+OXF)  JP
HABER    77 NP B 129 429        H.E.HABER,G.L.KANE         (UNIV. OF MICHIGAN)
KNIES    77  HAMBURG CONF.      PLUTO DETECTOR                           (DESY)
LONGACRE 77 PRL 38 1509         +AARON                  (NORTHEASTERN,BOSTON)  JP
PERNEGR  77  BUDAPEST CONF.     +BEUSCH,ASTBURY+        (ETHZ+CERN+LOIC+MILA)  JP
SCHULT   77 PR D 16 62          + WYLD                               (ILLINOIS)  JP
BASDEVAN 78  ANL-HEP-PR-78-01 BASDEVANT+BERGER                     (LPTP+ANL)  JP

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M(1150–1170)

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68  M(1150-1170)

THIS ENTRY LISTS REFERENCES TO PEAKS OF LOW
STATISTICAL SIGNIFICANCE IN THE 3 PI SYSTEM
BETWEEN THE A1 AND THE A2, AS WELL AS A CLAIM
FOR A NARROW RESONANCE AT 1150 MEV BY JACOBEL
72, NOT CONFIRMED BY BUTTRAM 75. OMITTED FROM
TABLE.

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                      REFERENCES FOR M(1150-1170)

BUTTERWO 67 HEIDELB.CONF.P.28 REVIEW TALK ON MESONS  AT HEIDELBERG CONF.
CASON    67 PRL 18  880         +LAMSA,BISWAS,DERADO,GROVES,+   (NOTREDAME)
ASCOLI   68 PRL 21 113          +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINOIS)
DONALD   68 PL 26 B  327        +FRODESEN,BETTINI,+  (LIVERPOOL,OSLO,PADUA)
VON KROG 68 PL 27B 253          +MIYASHITA,KOPELMAN,MARSHALL LIBBY    (COLO)
JUNKMANN 68 NP B8 471           +COCCONI+          (AACH+BERL+BONN+CERN+WARS)
ARMENISE 69 LNC 2 501           +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
GALLOWAY 70 PR D 1 3077         +MOTT,ALYEA,LEE,MARTIN,PRICKETT           (IND)
JACOBEL  72 PRL 29 671          +GARFINKEL,HOFFMAN,+          (IOWA+PURD+ANL)
MORSE    72 NP B 43 77          +OH,WALKER,JOHNSTON,YOON           (WISC+TNTO)
BUTTRAM  75 PRL 35 970          +CRAWLEY,DUKE,LAMB,LEEPER,PETERSON       (ISU)

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B(1235)

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11  B(1235,JPG=1++) I=1

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                  11  B MASS (MEV)

M        60(1220.0)                  ABOLINS   63 HBC  +   3.5 PI+P
M          (1220.0)                  GOLDHABER 65 HBC      3.7 PI+,PI-P
M       376 1200.       20.          BALTAY    67 HBC  +- 0.0 PBAR P        2/67
M           1259.0      27.0         BOESEBECK 68 HBC  +   8.0 PI+ P       10/67
M           1220.       20.          CHUNG     68 HBC   - 3.2,4.2 PI- P     9/67
M           1240.0      20.0         ANDERSON  70 CNTR   0 5-18 GAMMA P   11/70
M         (1272.0)     (15.0)        CASON     70 HBC   -  8.0 PI-P,4PI
M           1200.0     (10.0)        EROFEEV   70 HBC   -  3.25 PI- P       1/71
M           1225.0      22.0         HONES     70 HBC  +  18.5 PI+ P       11/70
M           1236.0      15.0         HOOGLAND  70 DBC   -  3.0 K- D         2/71
M           1200.0      15.0         MIYASHITA 70 HBC   -  6.7 PI-P,4PI
M   P     (1230.)      (10.)         POLS      70 HBC  +  5. PI+ P         11/71
M   P     HANDDRAWN BACKGROUND.ERRORS STATISTICAL ONLY.                    11/71
M   W     (1228.)      (5.)          FRENKIEL  72 HBC  +- 0. PBAR PI,5 PI  12/72
M   W     FIT REQUIRES AN ADDITIONAL JP=1- RESONANCE
M   W     AT 1256 MEV, WIDTH 129 MEV.
M  O  1163 1243.         6.          OTT       72 HBC  +  7.1 PI+ P,P B+    2/73
M  O      FROM FIT OF THE MASS SPECTRUM
M   A     (1252.)      (6.)          OTT       72 HBC  +  7.1 PI+ P,P B+    2/73
M   A     FROM FIT OF MASS SPECTRUM AND MOMENTS DISTRIBUTION WITH A STRONG
M   A     INTERFERENCE WITH THE BACKGROUND.
M           1235.       15.          AFZAL     73 HBC  +  11.7 PI+ P        2/73
M           1268.       16.          AFZAL     73 HBC  -  11.2 PI- P        2/73
M      1400 1222.        4.          CHALOUPKA 74 HBC   - 3.9 PI-P,P B-    12/75
M       600 1220.        7.          KARSHON   74 HBC  +  4.9 PI+P,P B+    12/75
M       890 1245.0      11.0         FLATTE    76 HBC   - 4.2 K-P,PI-OMEGA  7/77*
M       450 1251.0       8.0         GESSAROLI 77 HBC   - 11 PI-P,PI- OME  12/77*
M              . . . . . . . . . .
M   AVG     1230.8       4.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
M   STUDENT1230.5        3.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                        (SEE IDEOGRAM BELOW )
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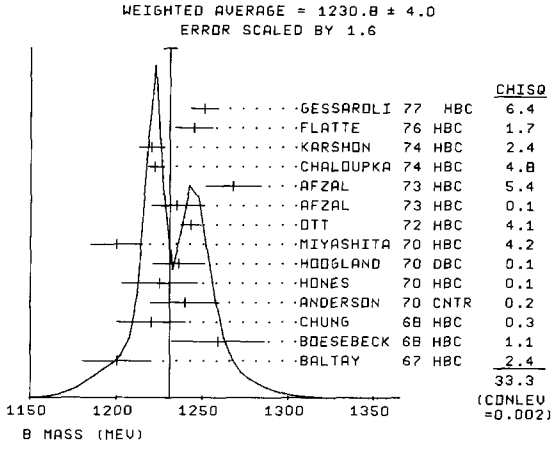
Mesons

B(1235), $\rho'(1250)$

Data Card Listings

For notation, see key at front of Listings.



11 B WIDTH (MEV)

W		60 100.0	20.0		ABOLINS	63 HBC	+	3.5 PI+P		
W		(80.0)			GOLDHABER	65 HBC		3.7 PI+,PI-P		
W		376 100.	30.		BALTAY	67 HBC	+-	0.0 PBAR P		2/67
W		25 (100.)	ESTIMATED		LEE	67 HBC	-	3.6 PI- P		1/68
W		203.	75.		BOESEBECK	68 HBC	+	8. PI+ P		11/67
W		150.	20.		CHUNG	68 HBC	-	3.2,4.2 PI- P		9/67
W	B	300 (83.)	(12.)		BIZZARRI	69 HBC	+-	0 PBAR P		12/72
W	B	SUPERSEDED BY FRENKIEL 72								
W		(100.0)	APPROX.		ANDERSON	70 CNTR		0.5-18+GAMMA P		11/70
W	C	(150.0)			CASO	70 HBC	-	11.2PI-P		2/73
W	C	SUPERSEDED BY AFZAL 73								
W		(122.0)	(38.0)	(28.0)	CASON	70 HBC	-	8.0 PI-P,+PI		
W		100.0	20.0		EROFEEV	70 HBC	-	3.25 PI- P		1/71
W		78.0	14.0	46.0	HONES	70 HBC	+	18.5 PI+ P		11/70
W		132.0	20.0		HODGLAND	70 DBC	-	3.0 K- D		2/71
W		113.0	44.0		MIYASHITA	70 HBC	-	6.7 PI-P,+PI		
W	P	(120.)	(20.)		POLS	70 HBC	+	5. PI+ P		11/71
W	P	HANDDRAWN BACKGROUND.ERRORS STATISTICAL ONLY.								11/71
W	W	(126.)	(10.)		FRENKIEL	72 HBC	+-	0. PBAR PI,5 PI		12/72
W	W	SEE NOTE UNDER THE MASS ABOVE.								
W	O	1163 134.	23.	26.	OTT	72 HBC	+	7.1 PI+ P,P B+		2/73
W	O	FROM FIT OF THE MASS SPECTRUM								
W	A	(156.)	(21.)	(18.)	OTT	72 HBC	+	7.1 PI+ P,P B+		2/73
W	A	SEE NOTE UNDER THE MASS ABOVE.								
W		120.	50.		AFZAL	73 HBC	+	11.7 PI+ P		2/73
W		130.	50.		AFZAL	73 HBC	-	11.2 PI- P		2/73
W		1400 135.	20.		CHALOUPKA	74 HBC	-	3.9 PI-P,P B-		12/75
W		600 156.	22.		KARSHON	74 HBC	+	4.9 PI+P,P B+		12/75
W		890 182.0	45.0		FLATTE	76 HBC	-	4.2 K-P,PI-OMEGA		7/77*
W		450 155.0	32.0		GESSAROLI	77 HBC	-	11 PI-P,PI- OME		12/77*
W		* * * * * * * * *								
W	AVG	127.1	6.8		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
W	STUDENT	127.7	8.1		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

11 B PARTIAL DECAY MODES

		DECAY MASSES
P1	B INTO OMEGA+PI	783+ 139
P2	B INTO 2PI+ 2PI-	139+ 139+ 139+ 139
P3	B INTO K KBAR	493+ 493
P4	B INTO PI PI	139+ 139
P5	B INTO PI PHI	134+1020
P6	B INTO ETA PI (FORBIDDEN BY G)	548+ 139
P7	B INTO K KBAR PI	493+ 493+ 139

11 B BRANCHING RATIOS

R10	D/S RATIO FOR B(1235) INTO OMEGA PI									
R10										
R10		0.3	0.1		CHALOUPKA	74 HBC	-	3.9-7.5 PI-P		1/74
R10	600	0.35	0.25		KARSHON	74 HBC	+	4.9 PI+P,P B+		12/75
R10		0.21	0.08		CHUNG	75 HBC	+	7.1 PI+P		12/75
R10		0.4	0.1	0.1	GESSAROLI	77 HBC	-	11 PI-P,PI- OME		12/77*
R10		* * * * * * * * *								
R10	AVG	0.291	0.052		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
R10	STUDENT	0.291	0.060		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
R1	B INTO (4PI)/(OMEGA PI)							(P2)/(P1)		
R1		(0.5) OR LESS			ABOLINS	63 HBC	+	3.5 PI+P		
R2	B INTO (K KBAR)/(OMEGA PI)							(P3)/(P1)		
R2		(0.02) OR LESS			DAHL	67 HBC	-	1.6-4.2 PI- P		10/66
R2		(0.10) OR LESS	CL=.90		BALTAY	67 HBC	+-	0.0 PBAR P		2/67
R2		(0.08) OR LESS	CL=.95		BIZZARRI	69 HBC	+-	0 PBAR P		9/69
R3	B INTO (PI PI)/(PI OMEGA)							(P4)/(P1)		
R3		(0.3) OR LESS			ADERHOLZ	64 HBC		4.0 PI+P		7/66
R3		(0.15) OR LESS	CL=.90		OTT	72 HBC	+	7.1 PI+ P		12/72
R4	B INTO (PI PHI) / (PI OMEGA)							(P5)/(P1)		
R4		(0.015)OR LESS			DAHL	67 HBC		1.6-4.2 PI- P		10/66
R4		(0.04) OR LESS	CL=.95		BIZZARRI	69 HBC	+-	0 PBAR P		9/69
R5	B INTO (ETA PI) / (PI OMEGA)							(P6)/(P1)		
R5		(0.25) OR LESS	CL=.90		BALTAY	67 HBC	+-	0.0 PBAR P		2/67
R6	B+- INTO ((K KBAR)+- PI0) / (PI OMEGA)									
R6		(0.08) OR LESS	CL=.90		BALTAY	67 HBC	+-	0.0 PBAR P		2/67
R6	B+- INTO (KS KS PI+-) / (PI OMEGA)									
R6		(0.02) OR LESS	CL=.90		BALTAY	67 HBC	+-	0.0 PBA- P		2/67
R6	B+- INTO (KS KL PI+-) / (PI OMEGA)									
R6		(0.06) OR LESS	CL=.90		BALTAY	67 HBC	+-	0.0 PBAR P		2/67

REFERENCES FOR B(1235)

ABOLINS	63 PRL 11 381	ABOLINS,LANDER,MEHLHOP,XUONG,YAGER	(UCSD)
BONDAR	63 PL 5 209	BONDAR,DODD+ (AACHEN+BIRM+HAMB+LOIC+MPIM)	
ADERHOLZ	64 PL 10 240	AACHEN+BERLIN+BIRM + BONN+HAMBUR+LOIC+MPIM	
CARMONY	64 PRL 12 254	CARMONY,LANDER,RINDFLEISCH,XUONG,YAGER(UCB)	JP
GOLDHABE	65 PRL 15 118	G GOLDHABER,S GOLDHABER,KADYK,SHEN	(LRL)
BALTAY	67 PRL 18 93	+SEVERIENS+YEH+ZANELLO	(COLU+BNL)
DAHL	67 PR 163 1377	+HARDY+HESS+KIRZ+MILLER	(LRL)
LEE	67 PR 159 1156	+MOEBS,ROE,SINCLAIR,VANDERVELDE	(MICH)
SLATTERY	67 NC 50A 377	+KRAYBILL+FORMAN+FERBEL	(YALE+ROCH)
ASCOLI	68 PRL 20 1411	+CRAWLEY,MORTARA,SHAPIRO	(ILL) JP
BOESEBEC	68 NP B 4 501	BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)	
CASO	68 NC 54 A 983	+CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILA+SACL)	
CHUNG	68 PR 165 1491	S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER	(LRL)
BIZZARRI	69 NP B 14 169	+FOSTER,GAVILLET,MONTANET,+	(CERN+CDEF)
ANDERSON	70 PR D 1 27	+GUSTAVSON,JOHNSON,+ (SLAC+CIT+UCSB+NEAS)	
CASO	70 LNC 3 707	+CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)	
CASON	70 PR D 1 851	+ANDREWS,BISWAS,GROVES,HARRINGTON,+	(NDAM)
EROFEEV	70 SJNP 11 450	+VETLITSKY,WLADIMIRSKY,GRIGOREV,+	(ITEP)
HONES	70 PR D 2 827	+CASON,BISWAS,HELLAND,KENNEY,MCGAHAN+(NDAM)	
HODGLAND	70 PL 33 B 631	SABRE COLLABOR. (AMST+SACL+BGNA+REHO+EPOL)	
MIYASHIT	70 PR D 1 771	MIYASHITA,VON KROGH,KOPELMAN,LIBBY	(COLO)
POLS	70 NP B 25 109	+BOECKMANN,CIRBA,+ (BONN+DURH+EPOL+TORI)	
WERBROUC	70 LNC 4 1267	WERBROUCK,RINAUDO,+ (TORI+NIJM+BONN+LBL)	JP
DEVONS	71 PRL 27 1614	+KOZLOWSKI,HORWITZ,+	(COLU+SYRA)
FRENKIEL	72 NP B 47 61	+GHESQUIERE,LILLESTOL,CHUNG,+ (CDEF+CERN)	JP
OTT	72 LBL-1547	R.L.OTT THESIS	(LBL) JP
SISTERSO	72 NP B 48 493	SISTERSON,HARRISON,HEYDA,JOHNSON,+(HARVARD)	
AFZAL	73 NCL 15 A 61	+BASSLER,+ (DURH+GENO+DESY+MILA+SACL)	JP
ARMENISE	73 NC 17 A 707	+FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)	
ARMENISE	73 LNC 8 425	+FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)	
ARNOLD	73 LNC 6 707	+ENGEL,ESCOUBES,KURTZ,LLORET,PATY,+ (STRB)	
CASON	73 PR D 7 1971	+BISWAS,KENNEY,MADDEN,SANDER,SHEPHARD(NDAM)	
CASON 1	73 NP B 64 14	+MADDEN,BISHOP,BISWAS,KENNEY,+ (NDAM)	
COHEN	73 PR D 8 23	+FERBEL,SLATTERY (ROCHESTER)	
BALLAM	74 NP B76 375	+CHADWICK,BINGHAM,FRETTER+ (SLAC+LBL+MPIM)	
CHALOUPK	74 PL 51B 407	CHALOUPKA,FERRANDO,LOSTY,MONTANET (CERN)	JP
KARSHON	74 PR D10 3608	+MIKENBERG,EISENBERG,PITLUCK,RONAT+ (REHO)	JP
CHUNG	75 PR D11 2426	+PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)	JP
ALSO	73 PL 47 B 526	+PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)	JP
DUBOVIKO	75 SJNP 20 229	M.S.DUBOVIKOV,I.A.EROFEEV (ITEP)	JP
FLATTE	76 PL 64 B 225	+GAY,BLOKZIJL,METZGER,+(CERN+AMST+NIJM+OXF)	JP
GESSAROL	77 NP B 126 382	GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)	JP

$\rho'(1250)$

69 RHO PRIME(1250,JPG=1-+) I=1

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
SEE ALSO THE RHO PRIME(1600) MINI-REVIEW.

69 RHO PRIME(1250) MASS (MEV)

M	A	1256.	10.		FRENKIEL	72 HBC	+-	0.PBARP,OMEGA2PI	12/77*
M	A	SEE ALSO RHO PRIME(1600) MINI REVIEW							12/77*

69 RHO PRIME(1250) WIDTH (MEV)

W	A	130.	20.		FRENKIEL	72 HBC	+-	0.PBARP,OMEGA2PI	12/77*
W	A	SEE ALSO RHO PRIME(1600) MINI REVIEW							12/77*

REFERENCES FOR RHO PRIME(1250)

ANDERSON	70 PR D 1 27	+GUSTAVSON,JOHNSON,+ (SLAC+CIT+UCSB+NEAS)	
PODOLSKY	71 UCRL 20128	W.J.PODOLSKY,PH.D. THESIS	(LBL)
FRENKIEL	72 NP B 47 61	+GHESQUIERE,LILLESTOL,CHUNG,+ (CDEF+CERN)	JP
WOLF	72 ITHACA N.Y. CONF.	G.WOLF,P.213	(SLAC)
CHUNG	73 PL 47 B 526	+PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)	
BRAMON	73 LNC 8 659	A.BRAMON	(FRASCATI)
BALLAM	74 NP B76 375	+CHADWICK,BINGHAM,FRETTER+ (SLAC+LBL+MPIM)	
CHALOUPK	74 PL 51B 407	CHALOUPKA,FERRANDO,LOSTY,MONTANET (CERN)	
CONVERSI	74 PL 52B 493	+PAOLUZI,CERADINI,GRILLI+	(ROMA+FRAS)
ESTABROO	74 NP B79 301	P.ESTABROOKS,A.D.MARTIN	(DURH)
KARSHON	74 PR D10 3608	+MIKENBERG,EISENBERG,PITLUCK,RONAT+ (REHO)	JP
ALLES	75 NC 30A 136	ALLES-BORELLI,BERNARDINI+ (CERN+BGNA+FRAS)	
CHUNG	75 PR D11 2426	+PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)	
ESTABROO	75 NP B95 322	P.ESTABROOKS,A.D.MARTIN	(DURH)
FROGGATT	75 NP B91 454	C.D.FROGGATT,J.L.PETERSEN	(GLAS+NORD)
HYAMS	75 NP B100 205	+JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)	
BASSOMPI	76 PL 65 B 397	BASSOMPIERRE,BINDER,+ (MULH+STRB+TORI)	
BARTALUC	77 PREP. DESY 77-59	BARTALUCCI,BERTOLUCCI,BIENLEIN+ (DESY+FRAS)	
BUDNEV	77 PL 70 B 365	N.M.BUDNEV,V.M.BUDNEV,V.V.SEREBRYAKOV(NOVO)	
COSTA	77 PL 67 B 213	COSTA DE BEAUREGARD,PHAM,PIRE,TRUONG (EPOL)	
GESSAROL	77 NP B 126 382	GESSAROLI,+ (BGNA+FIRZ+GENO+MILA+OXF+PAVI)	

Data Card Listings

For notation, see key at front of Listings.

f(1270)

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5  F(1270,JPG=2++) I=0

WE NO LONGER LIST EVERY PUBLISHED VALUE.                              1/73
WE AVERAGE ONLY THE MOST SIGNIFICANT                                  1/73
DETERMINATIONS OF MASS AND WIDTH.                                     1/73
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5 F MASS (MEV)

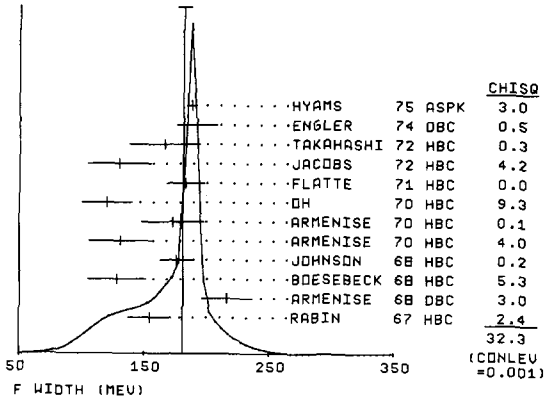
M		(1250.0)	(25.0)	SELOVE	62 HBC	3.0 PI- P		1/73
M		1416(1267.0)	(10.0)	JACOBS	66 HBC	2-3 PI-P,T CUT20		10/67
M		1276.	11.	RABIN	67 HBC	8.5 PI+ P		9/67
M	T	1960 1261.	5.	ARMENISE	68 DBC	5.1 PI+N,P PI+ -		1/73
M	T	360 1270.	10.	ARMENISE	68 DBC	5.1 PI+N,P PI0 0		1/73
M		1265.	8.	BOESEBECK	68 HBC	8 PI+ P		6/68
M	J	1268.0	6.0	JOHNSON	68 HBC	3.7-4.2 PI- P		7/69
M	J	JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.						
M		1275.0	13.0	ARMENISE	70 HBC	9 PI+ N -- F P		1/71
M		1273.0	7.0	ARMENISE	70 HBC	9 PI+ N -- MM P		1/71
M		600 1275.0	10.0	OH	70 HBC	1.26 PI- P,P F		1/71
M	E	(1273.0)	(6.0)	STUNTEBEC	70 HBC	8.PI-P,5.4 PI+0		11/71
M		5300 1277.0	4.0	FLATTE	71 HBC	7.0 PI+ P		6/71
M	E	300(1272.)		KEMP	72 DBC	11.7 PI+ N		12/72
M		2000 1261.0	10.0	JACOBS	72 HBC	2.8 PI- P		1/73
M		600 1258.0	10.0	TAKAHASHI	72 HBC	8. PI- P,N 2PI		1/73
M		1200 1274.	12.	WHITEHEAD	72 ASPK	3.1-3.6 PI- P	.	2/73
M		4600 1272.	4.	ENGLER	74 DBC	0 6. PI+N,PI+PI-P		12/75
M	IH	(1269.)	(4.)	ESTABROOK	75 RVUE	17 PI-P,PI+PI-N		12/75
M	I	1275.	4.	HYAMS	75 ASPK	17 PI-P,PI+PI-N		12/75
M		. . . . .						
M	AVG	1271.1	1.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
M	STUDENT	1271.3	2.0	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

```
M  I    ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
M  E    EVIDENCE FOR A STRUCTURE CLAIMED
M  T    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE
M  H    USES SAME DATA AS HYAMS 75
```

5 F WIDTH (MEV)

W		(100.0)	(25.0)	SELOVE	62 HBC	3.0 PI-P		
W		1416 (99.0)	(10.0)	JACOBS	66 HBC	2-3 PI-P,T CUT20		10/67
W		155.	17.	RABIN	67 HBC	8.5 PI+ P		9/67
W	T	1960 216.	20.	ARMENISE	68 DBC	5.1 PI+N,P PI+ -		1/73
W	T	360 (188.)	(40.)	ARMENISE	68 DBC	5.1 PI+N,P PI0 0		1/73
W		128.	23.	BOESEBECK	68 HBC	8 PI+ P		6/68
W	J	176.0	13.0	JOHNSON	68 HBC	3.7-4.2 PI- P		7/69
W	J	JOHNSON 68 INCLUDES BONDAR 63, LEE 64, DERADO 65, EISNER 67.						
W		131.0	25.0	ARMENISE	70 HBC	9 PI+ N -- MM P		1/71
W	T	173.0	25.0	ARMENISE	70 HBC	9 PI+ N -- F P		2/74
W	T	600 120.0	20.0	OH	70 HBC	1.26 PI- P,P F		2/74
W	E	(196.0)	(18.0)	STUNTEBEC	70 HBC	8.PI-P,5.4 PI+0		11/71
W		5300 183.0	15.0	FLATTE	71 HBC	7.PI+P,DELTA++F		1/71
W	E	300 (143.)		KEMP	72 DBC	11.7 PI+ N		12/72
W		2000 130.0	25.0	JACOBS	72 HBC	2.8 PI- P		1/73
W	T	600 166.0	28.0	TAKAHASHI	72 HBC	8. PI- P,N 2PI		1/73
W		1200 (217.)	(24.)	WHITEHEAD	72 ASPK	3.1-3.6 PI- P	.	2/73
W		4600 192.	16.	ENGLER	74 DBC	0 6. PI+N,PI+PI-P		12/75
W	IH	(209.)	(10.)	ESTABROOK	75 RVUE	17 PI-P,PI+PI-N		12/75
W	I	188.	4.	HYAMS	75 ASPK	17 PI-P,PI+PI-N		12/75
W		. . . . .						
W	AVG	181.1	5.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)				
W	STUDENT	182.0	4.5	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT (SEE IDEOGRAM BELOW)				

WEIGHTED AVERAGE = 181.1 ± 5.6
ERROR SCALED BY 1.7

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W  I    ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
W  E    EVIDENCE FOR A STRUCTURE CLAIMED
W  T    WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
W  H    USES SAME DATA AS HYAMS 75
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5 F PARTIAL DECAY MODES

		DECAY MASSES
P1	F INTO PI PI	139+ 139
P2	F INTO 2PI+ 2PI-	139+ 139+ 139+ 139
P3	F INTO PI+ PI- 2PI0	139+ 139+ 134+ 134
P4	F INTO K KBAR	497+ 497
P5	F INTO K KBAR PI	497+ 497+ 139
P6	F INTO ETA PI PI	548+ 139+ 139
P7	F INTO ETA ETA	548+ 548

5 F BRANCHING RATIOS

R1 F INTO (2PI+ 2PI-)/(PI PI) (P2)/(P1)

R1 ASCOLI 68 SUGGEST DECAY IS MAINLY RHO-RHO,1/3 OF WHICH YIELD 2PI+ 2PI-

R1		0.08	0.06	BONDAR	63 HBC	4.0 PI-P		
R1	D	0.04	0.05	CHUNG	65 HBC	3.2 PI-P		11/71
R1	D	CORRECTED BY D.DAHL						11/71
R1	50	0.07	0.04	ASCOLI	68 HBC	5 PI- P		6/68
R1		0.022	0.045	0.022 BARDADIN	71 HBC	8. PI+ P		2/72
R1		0.047	0.013	OH	70 HBC	1.26 PI- P,P F		2/73
R1	154	0.037	0.007	ANDERSON	73 DBC	6. PI+N,P F0		1/74
R1		(0.033)CR LESS	C.L.=.90	BUGG	73 DBC	8. PI+N,P F0		1/74
R1	70	.051	.025	EISENBERG	74 HBC	4.9 PI+P,DEL++F0		11/75
R1	285	.043	.007	.011 LOUIE	74 HBC	3.9 PI- P,N F0		.11/75
R1	160	.024	.006	EMMS	75 DBC	4. PI+N,P F0		11/75
R1		. . . . .						
R1	AVG	0.0344	0.0040	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)				
R1	STUDENT	0.0351	0.0047	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

R2 F INTO (PI+ PI- 2PI0)/(PI PI) (P3)/(P1)

R2 SHOULD BE TWICE R1 IF DECAY IS RHO-RHO (SEE ASCOLI 68)

R2	600	.15	.06	EISENBERG	74 HBC	4.9 PI+P,DEL++F0	11/75
R2		(.07)		EMMS	75 DBC	4. PI+N,P F0	11/75

R3 F INTO (K KBAR)/(PI PI) (P4)/(P1)

```
R3       WE ONLY AVERAGE EXPERIMENTS WHICH EITHER TAKE INTO ACCOUNT F-A2
R3       INTERFERENCE EXPLICITLY OR DEMONSTRATE THAT A2 PRODUCTION IS
R3       NEGLIGIBLE.
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R3		(0.047)	(0.012)+ SYST.	BEUSCH	67 OSPK	5,7,12 PI-P		9/67
R3	D	0.05	0.05	DAHL	67 HBC	1.6-4.2 PI- P		10/66
R3	D	CORRECTED BY D.DAHL						11/71
R3	20	0.031	0.012	ADERHOLZ	69 HBC	8 PI+ P,K+K-PI-		12/75
R3 L		(0.07) OR LESS	CL=.95	AGUILAR	72 HBC	3.9,4.6 K- P		12/72
R3 L	LIMIT ABOVE RESTATED FOR AVERAGING BELOW.							12/72
R3 L		0.0	0.04	AGUILAR	72 HBC	3.9,4.6 K- P		12/72
R3		0.13	0.05	BISWAS	72 HBC	18.5 PI+- P		1/73
R3		(0.02) OR LESS	CL=.85	WHITEHEAD	72 ASPK	3.1-3.6 PI- P		12/72
R3		0.03	0.02	TOET	73 HBC	5 PI+P,P PI+ F0		1/74
R3		.025	.015	EMMS	75 DBC	4. PI+N,P F0		11/75
R3		.029	.006	WETZEL	76 OSPK	8.9 PI-P,KS KS		7/77*
R3	C	0.047	0.005	PAWLICKI	77 SPEC	6. PI N,K+ K- N		12/77*

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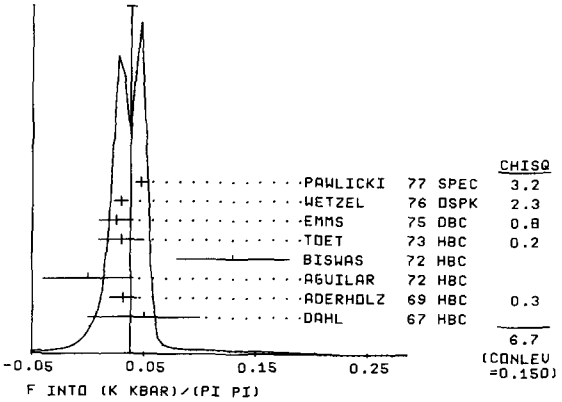
R3  C  THIS DETERMINATION HAS QUANTITATIVELY ACCOUNTED FOR BOTH F-PRIME
R3  C  AND A2 INTERFERENCE EFFECTS.
```

R3		. . . . .						
R3	AVG	0.0380	0.0045	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)				
R3	STUDENT	0.0372	0.0048	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT (SEE IDEOGRAM BELOW)				

WEIGHTED AVERAGE = 0.0380 ± 0.0045
ERROR SCALED BY 1.3



R4	F INTO (K0 K- PI+ AND C.C.)/(PI PI)					(P5)/(P1)		
R4		(0.07) OR LESS	CL=.95	AGUILAR	72 HBC	3.9,4.6 K- P		12/72
R4		(.004)OR LESS	CL=.95	EMMS	75 DBC	4. PI+N,P F0		11/75
R5	F INTO (ETA PI PI)/(PI PI)					(P6)/(P1)		
R5		(0.19) OR LESS	CL=.95	AGUILAR	72 HBC	3.9,4.6 K- P		12/72
R5		(.010)OR LESS	CL=.95	EMMS	75 DBC	4. PI+N,P F0		11/75
R6	F INTO (ETA ETA)/(PI PI)					(P7)/(P1)		
R6		(.09) OR LESS	CL=.95	EISENBERG	74 HBC	4.9 PI+P,DEL++F0		11/75
R6		(.016)OR LESS	CL=.95	EMMS	75 DBC	4. PI+N,P F0		11/75
R10	F INTO (PI PI)/TOTAL					(P1)		
R10	600	0.8	0.04	OH	70 HBC	01.26 PI- P,P F		1/71
R10	250	0.85	0.05	BEAUPRE	71 HBC	08 PI+ P,DELTA++F		1/71
R10IH		(.82)	(.01)	ESTABROOK	75 RVUE	17 PI-P,PI+PI-N		12/75
R10 H	USES SAME DATA AS HYAMS 75							
R10I		.803	.003	HYAMS	75 ASPK	17 PI-P,PI+PI-N		12/75
R10I	ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS							
R10		. . . . .						
R10 AVG		0.8032	0.0030	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R10 STUDENT		0.8031	0.0032	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

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REFERENCES FOR F

SELOVE	62 PRL 9 272	SELOVE,HAGOPIAN,BRODY,BAKER,LEBOY	(PENN)
BONDAR	63 PL 5 153	BONDAR+ (AACHEN+BIRM+BONN+DESY+LOIC+MPIM)	
GUIRAGOS	63 PRL 11 85	Z.G.T. GUIRAGOSSIAN	(LRL)
HAGOPIAN	63 PRL 10 533	V HAGOPIAN,W SELOVE	(PENN)
VEILLET	63 PRL 10 29	VEILLET,HENNESSY,BINGHAM,BLOCH+(EPOL+MILAN)	
ADERHOLZ	64 PL 10 240	AACHEN¬BERLIN¬BERLIN¬BONN¬HAMBURG¬LOIC¬MPI	IJ
BRUYANT	64 PL 10 232	BRUYANT,GOLDBERG,HOLDER,FLEURY+ (CERN+EPOL)	I
LEE	64 PRL 12 342	LEE,ROE,SINCLAIR,VANDERVELDE	(MICH)
SODICKSO	64 PRL 12 485	SODICKSON,WAHLIG,MANNELLI,FRISCH+	(MIT) I
BARMIN	65 SJNP 1 230	+DOLGOLENKO,ELENSKY,EROFEEV+ (ITEP MOSCOW)	JP
BARMIN	65 SJNP 1 623	+DOLGOLENKO+EROFEEV+KRESTNIKOV+ (ITEP MOSC)	
CHUNG	65 PRL 15 325	CHUNG,DAHL,HARDY,HESS,JACOBS,KIRZ	(LRL)
DERADO	65 PRL 14 872	DERADO,KENNEY,POIRIER,SHEPHARD (NOTRE DAME)	
GUIRAGOS	65 PRL 11 85	Z G T GUIRAGOSSIAN	(LRL)
WANGLER	65 PR 137 B 414	T P WANGLER,A R ERWIN,W WALKER	(WISCONSIN)

ACCENSI 66 PL 20 557 ACCENSI,ALLES-BORELLI,FRENCH,FRISK+ (CERN)
JACOBS 66 UCRL-16877 L.D.JACOBS,THESIS (LRL)
WAHLIG 66 PR 147 941 +SHIBATA,GORDON,FRISCH,MANNELLI (MIT+PISA) J

BARLOW 67 NC 50A 701 +LILLESTOL+MONTANET+ (CERN+CDEF+IRAD+LIVP)
BEUSCH 67 PL 25 B 357 +FISCHER,GOBBI,ASTBURY+ (ETHZ+CERN)
DAHL 67 PR 163 1377 +HARDY+HESS+KIRZ+MILLER (LRL)
EISNER 67 PR 164 1699 +JOHNSON+KLEIN+PETERS+SAHNI+YEN+ (PURDUE)
POIRIER 67 PR 163 1462 +BISWAS,CASON,DERADO,KENNEY+ (NDAM+PENN)
RABIN 67 THESIS M. RABIN (RUTGERS)

ARMENISE 68 NC 54 A 999 +FORINO+CARTACCI+ (BARI+BGNA+FIRENZE+ORSAY)
ASCOLI 68 PRL 21 1712 G.ASCOLI,H.B.CRAWLEY,D.W.MORTARA,+ (ILL)
BOESEBEC 68 NP B 4 501 BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
FOSTER 68 NP B 6 107 +GAVILLET+LABROSSE+MONTANET+ (CERN+CDEF)
JOHNSON 68 PR 176 1651 +POIRIER,BISWAS,GUTAY+ (NDAM+PURD+SLAC)
LAMSA 68 PR 166 1395 +CASON+BISWAS+DERADO+GROVES+ (NOTREDAME)
WHITEHEA 68 NC 53A 817 +MCEWEN,OTT,AITKEN+ (AERE+SHMP+LOUC)

ADERHOLZ 69 NP B 11 259 +BARTSCH,+ (AACH+BERL+CERN+JAGL+WARS)
AGUILAR- 69 PL 29 B 241 M.AGUILAR-BENITEZ,J.BARLOW,+ (CERN+CDEF)
ARMENISE 69 LNC 2 501 +GHIDINI,FORINO,CARTACCI+ (BARI+BGNA+FIRZ)
CASO 69 NC 62 A 755 +CONTE,BENZ,+ (GENO+DESY+HAMB+MILA+SACL)
DONALD 69 NP B 11 551 +EDWARDS,BURAN,BETTINI,+ (LIVP+OSLO+PADO)

AGUILAR 70 PRL 25 58 AGUILAR-BENITEZ,BARNES,BASSANO,+ (BNL+SYRA)
ARMENISE 70 LNC 4 199 +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
BADIER 70 NP B 22 512 +BONNET,DREVILLON,BAUBILLIER,+ (EPOL+IPNP)
OH 70 PR D 1 2494 +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTOJ)
STUNTEBE 70 PL 32 B 391 STUNTEBECK,KENNEY,DEERY,BISWAS,CASON+(NDAM)

BARDADIN 71 PR D4 2711 BARDANIN-OTWINOWSKA,HOFMOKL,+ (WARS)
BEAUPRE 71 NP B 28 77 +DEUTSCHMANN,GRAESSLER,+ (AACH+BERL+CERN)
FARBER 71 NP B 29 237 +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
FLATTE 71 PL 34 B 551 +ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)

AGUILAR 72 PR D 6 29 AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS (BNL)
BISWAS 72 PR D 5 1564 +CASON,HARRINGTON,KENNEY,SHEPHARD (NDAM)
FOGLI 72 NC 8 A 670 FOGLI-MUCIACCIA,PICCIARELLI (BARI)
GRAYER 72 PHIL.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
JACOBS 72 PR D 6 1291 L.D.JACOBS (SACLAY)
KEMP 72 NC 8 A 611 +MAJOR,CONTRI,+ (DURH+GENO+MILA+EPOL+LPNP)
SCARROTT 72 LNC 3 271 SCARROTT,KEMP (DURHAM)
TAKAHASH 72 PR D 6 1266 TAKAHASHI,BARISH,+ (TOHO+PENN+NDAM+ANL)
WHITEHEA 72 NP B 48 365 WHITEHEAD,AULD,+ (AERE+RHEL+SHMP+LOUC)

ANDERSON 73 PRL 31 562 +ENGLER,KRAEMER,TOAF,DIAZ,+ (CARN+CASE)
BUGG 73 PR D 7 3264 +CONDO,HART,COHN,ENDORF,+ (TENN+ORNL+CINC)
CHARLESW 73 NP B 65 253 CHARLESWORTH,EMMS,BELL,+ (RHEL+BIRM+DURH)
HYAMS 73 NP B 64 134 +JONES,WEILHAMMER,BLUM,DIETL,+ (CERN+MPIM)
TOET 73 NP B 63 248 +THUAN,MAJOR,RINAUDO,+(NIJM+BONN+DURH+TORI)

EISENBER 74 PL 52B 239 EISENBERG,ENGLER,HABER,KARSHON+ (REHO)
ENGLER 74 PR D10 2070 +KRAEMER,TOAFF,WEISSER,DIAZ+ (CARN+CASE)
GRAYER 74 NP B 75 189 G.GRAYER,HYAMS,BLUM,DIETL,+ (CERN+MPIM)
HOLLOWAY 74 PR D9 1161 +HULD,JORDAN,KOETZ,BERNSTEIN+ (ILL+ILLC)
LOUIE 74 PL 48B 385 +ALITTI,GANDOIS,CHALOUPKA+ (SACL+CERN)

EMMS 75 NP B96 155 +KINSON,STACEY,VOTRUBA+ (BIRM+DURH+RHEL)
ESTABROO 75 NP B95 322 P.ESTABROOKS,A.D.MARTIN (DURH)
HYAMS 75 NP B100 205 +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)
PAWLICKI 75 PR D12 631 +AYRES,DIEBOLD,GREENE,KRAMER,WICKLUND (ANL)

WETZEL 76 NP B 115 208 +FREUDENREICH,BEUSCH,+ (ETHZ+CERN+LOIC)

ANTIPOV 77 NP B 119 45 +BUSNELLO,DAMGAARD,KIENZLE,+ (SERP+GEVA)
PAWLICKI 77 PR D 15 3196 +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND (ANL)

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D(1285)

8 D(1285,JPG=1++) I=0

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8 D MASS (MEV)

M		(1290.)	APPROX.	BARLOW	67	HBC	1.2 PBAR P, 4PFS	5/67
M		1283.0	5.0	DAHL	67	HBC	1.6-4.2 PI- P	10/66
M		1290.	7.	D-ANDLAU	68	HBC	1.2 PBAR P, 5-6 PFS	6/68
M		(1310.0)		DEFOIX	68	HBC	1.2 PB P,7 PI	3/69
M		1270.0	10.0	CAMPBELL	69	DBC	2.7 PI+ D	8/69
M		1285.	7.	LORSTAD	69	HBC	0.7 PB P, 4,5-BODY	9/69
M		1303.0	8.0	BARDADIN	71	HBC	8 PI+ P, P+6PI	9/69
M		1283.0	6.0	BOESEBECK	71	HBC	16.0 PI P,5 PI	6/71
M		150 1292.	10.	DEFOIX	72	HBC	0.7 PBAR P,7 PI	1/73
M		180 1286.	3.	DUBOC	72	HBC	1.2 PBAR P,2K4PI	12/72
M	S	500(1280.)	(3.)	THUN	72	MMS	13.4 PI- P	12/72
M	S	SEEN IN THE MISSING MASS SPECTRUM						12/72
M		210 1279.0	5.0	GRASSLER	77	HBC	0 16. PI-+ P	11/77*
M		365 1276.0	3.0	EDWARDS	77	SPEC	0 8.5 PI- P	12/77*
M		320 1282.0	2.0	NACASCH	77	HBC	0 .7+.76 PB P,KKBP	12/77*
M		. . . .						
M	AVG	1282.4	1.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)				
M	STUDENT	1282.5	1.5	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
				(SEE IDEOGRAM BELOW)				

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8 D WIDTH (MEV)

W	R		(35.0)	(10.0)	DAHL	67	HBC	1.6-4.2 PI- P	11/71
W	U		46.	20.	D-ANDLAU	68	HBC	1.2 PBAR P, 5-6 PFS	2/72
W	U	UNFOLDED BY DOBRZYNSKI 71							
W	R		(40.0)		DEFOIX	68	HBC	1.2 PB P,7 PI	11/71
W			30.0	15.0	CAMPBELL	69	DBC	2.7 PI+ D	8/69
W	R		(60.)	(15.)	LORSTAD	69	HBC	0.7 PB P, 4,5-BODY	11/71
W	R		(44.0)	(24.0)	BARDADIN	71	HBC	8 PI+ P, P+6PI	11/71
W			10.0	10.0	BOESEBECK	71	HBC	16.0 PI P,5 PI	6/71
W	R	150	(28.)	(5.)	DEFOIX	72	HBC	0.7 PBAR P,7 P9	1/73
W	R	180	(46.)	(9.)	DUBOC	72	HBC	1.2 PBAR P,2K4PI	12/72
W	S	500	(37.)	(5.)	THUN	72	MMS	13.4 PI- P	12/72
W	S	SEEN IN THE MISSING MASS SPECTRUM							12/72
W	R	RESOLUTION NOT UNFOLDED							11/71
W		210	24.0	18.0	GRASSLER	77	HBC	0 16. PI-+ P	12/77*
W		320	28.3	6.7	NACASCH	77	HBC	0 .7+.76 PB P,KKBP	12/77*
W			. . . .						
W	AVG		24.9	4.9	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
W	STUDENT		25.3	5.6	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

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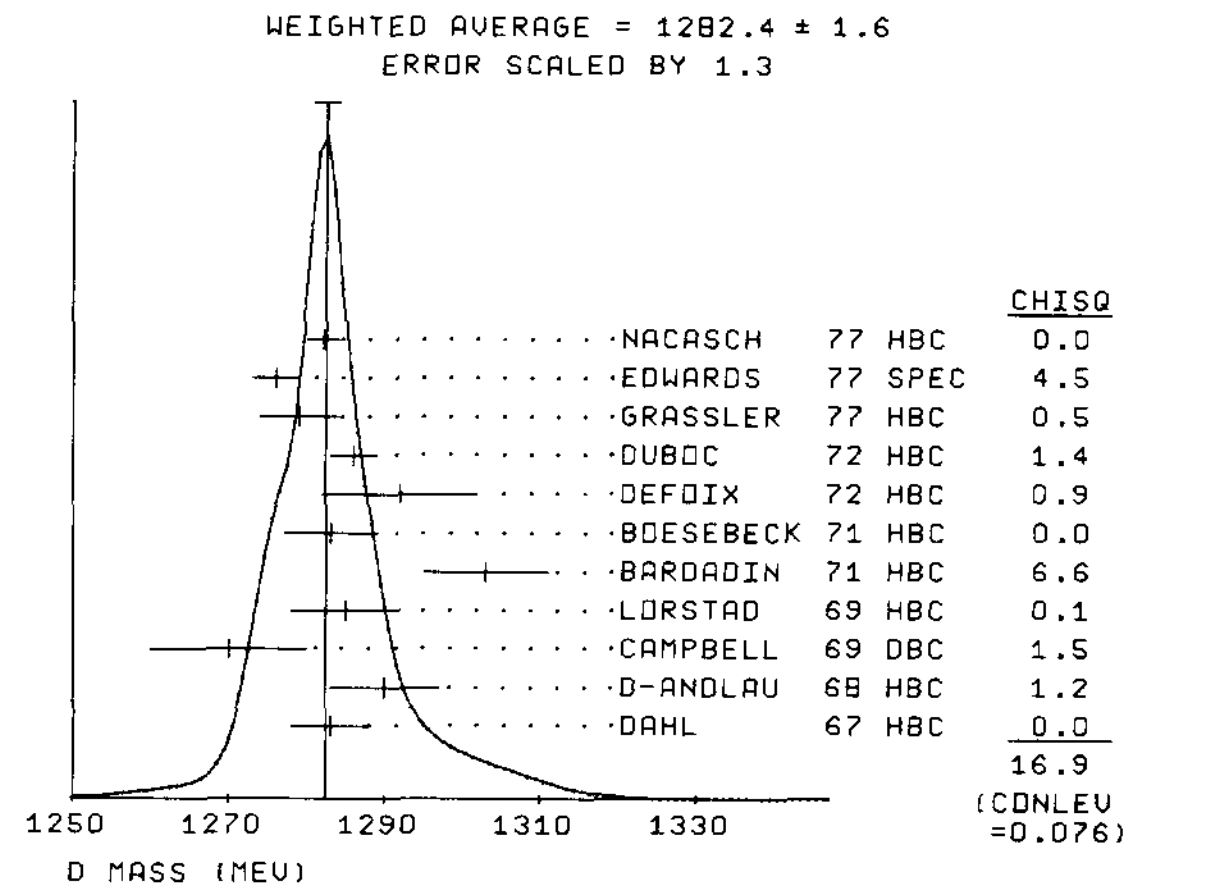

8 D PARTIAL DECAY MODES

		DECAY MASSES
P1	D INTO K KBAR PI	497+ 497+ 134
P2	D INTO PI PI RHO	134+ 134+ 776
P3	D INTO ETA PI PI	548+ 134+ 134
P4	D INTO DELTA PI	980+ 134
P5	D INTO 2PI+ 2PI-	139+ 139+ 139+ 139
P6	D INTO K* KBAR	892+ 497

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8 D BRANCHING RATIOS

R1		D INTO (PI PI RHO) / (K KBAR PI)					(P2)/(P1)	
R1		(2.0)	OR LESS	DAHL	67	HBC	CHARGED PI ONLY	10/66
R1	D	(4.0)	OR LESS	DONALD	69	HBC	1.2 PBAR P,5P+ .	
R1	D	THIS IS FOR (RHOO PI+ PI-)/(K KBAR PIO)						
R2		D INTO (K KBAR PI)/(ETA PI PI)					(P1)/(P3)	
R2	K R	0.166	0.055	DEFOIX	68	HBC	1.2 PBAR P	1/73
R2	R	REVISED BY DEFOIX 72						
R2		0.16	0.08	CAMPBELL	69	DBC	2.7 PI+ D	1/73
R2	K	0.20	0.08	DEFOIX	72	HBC	0.7 PBAR P,7 PI	1/73
R2	K	K KBAR SYSTEM CHARACTERIZED BY THE I=1 THRESHOLD						
R2	K	ENHANCEMENT (SEE UNDER DELTA(980)).						
R2		. . . .						
R2	AVG	0.173	0.039	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R2	STUDENT	0.173	0.042	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R3		D INTO (DELTA PI)/(ETA PI PI)					(P4)/(P3)	
R3		POSSIBLY SEEN		AMMAR	70	HBC	4.1,5.5K-,ETA	5/70
R3		POSSIBLY SEEN		OTWINOWSK	70	HBC	8 PI+ P, P+6PI	9/69
R3		(0.8)	(0.2)	DEFOIX	72	HBC	0.7 PBAR P,7 PI .	1/73
R3		1.0	0.3	GRASSLER	77	HBC	0 16. PI-+ P	11/77*
R4		D INTO (2PI+ 2PI- (INCL. RHO PI PI))/(ETA PI+ PI-)						
R4							(P5)/(2/3P3)	
R4	50	(0.55)	OR MORE	BOESEBECK	71	HBC	16. PI+- P,P 5PI	11/71
R4		0.46	0.15	GRASSLER	77	HBC	0 16. PI-+ P	11/77*
R5		D INTO (K* KBAR)/TOTAL					(P6)	
R5		NOT SEEN		NACASH	77	HBC	.7+.76 PB P,KKBP	12/77*

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REFERENCES FOR D

D-ANDLAU 65 PL 17 347 +BARLOW,ADAMSON,+ (CDEF+CERN+IRAD+LIVP)
MILLER 65 PRL 14 1074 +CHUNG,DAHL,HESS,HARDY,KIRZ,+ (LRL+UCB)
BARLOW 67 NC 50 A 701 +MONTANET,D-ANDLAU+ (CERN+CDEF+IRAD+LIVP)
DAHL 67 PR 163 1377 +HARDY+HESS+KIRZ+MILLER (LRL)I JP
D-ANDLAU 68 NP B 5 693 +ASTIER,BARLOW+ (CDEF+CERN+IRAD+LIVP)I JP
DEFOIX 68 PL 28 B 353 +RIVET,SIAUD,CONFORTO+ (CDEF+IPNP+CERN)

CAMPBELL 69 PRL 22 1204 +LICHTMAN,+ (PURD)
DONALD 69 NP B 11 551 +EDWARDS,BURAN,BETTINI,+ (LIVP+OSLO+PADO)
LORSTAD 69 NP B 14 63 B.LORSTAD,D-ANDLAU,ASTIER,+ (CDEF+CERN) JP
OTWINOWS 69 PL 29 B 529 S.OTWINOWSKI (WARSAW)

AMMAR 70 PR D2 430 +KROPAC,DAVIS,DERRICK+ (KANS+NWES+ANL+WISC)

BARDADIN 71 PR D4 2711 BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
BOESEBEC 71 PL 34 B 659 (AACH+BERL+BONN+CERN+CRAC+HEID+WARS)
GOLDBERG 71 LNC 1 627 +MAKOWSKI,TOUCHARD,DONALD,+ (IPN+LIVP) JP

BERENYI 72 NP B 37 621 +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
CHAPMAN 72 NP B 42 1 +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DEFOIX 72 NP B 44 125 +NASCIMENTO,BIZZARRI,+ (CDEF+CERN)
DUBOC 72 NP B 46 429 +GOLDBERG,MAKOWSKI,DONALD,+ (LPNP+LIVP)
THUN 72 PRL 28 1733 +BLIEDEN,FINOCCHIARO,BOWEN,+ (STON+NEAS)

VUILLEMI 75 LNC 14 165 VUILLEMIN,+ (LAUS+NEUC+LPNP+LIVP+GLAS) JP
WELLS 75 NP B 101 333 +RADOJICIC,ROSCOE,LYONS,+ (OXF)

HANDLER 76 NP B 110 173 +PLANO,BRUCKER,KOLLER+ (RUTG+STEV+SETO)
VUILLEMI 76 NC 33A 133 VUILLEMIN+ (LAUS+NEUC+LPNP+LIVP+GLAS)

EDWARDS 77 PREPRINT +LEGACEY+(OTTAWA+MONTREAL+COLUMBUS+TORONTO)
GRASSLER 77 NP B 121 189 +(AACHEN+BERLIN+BONN+CERN+CRACOW+HEID+WARS)
NACASCH 77 PREPRINT +DEFOIX,DOBRZYNSKI+(PARIS+MADRID+CERN+TATA) JP

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ϵ(1300) 14 EPSILON(1300,JPG=0++) I=0

S-Wave ππ and $K\bar{K}$ Interactions

In this note, we discuss information on the non-strange $I^GJ^{PC} = 0^+0^{++}$ partial wave, coupled to the ππ and $K\bar{K}$ systems.

The threshold behavior of elastic $\pi^+\pi^-$ scattering involves S and P waves which can be sufficiently well described by the scattering lengths a_0^0, a_1^1, and a_0^2. In spite of many attempts (see PILKUHN 73, BONNIER 74, PASCUAL 74, RIESTER 75, SRINIVASAN 75, GRIVAZ 76), the determination of these parameters still meets with great difficulties (BASDEVANT 73, 75). The parameters a_0^0 and a_0^2 are strongly correlated and must lie in a narrow band in the (a_0^0, a_0^2)-plane (MORGAN2 70). Thus if a_0^0 is fixed, a_0^2 and a_1^1 are determined within small uncertainties (BASDEVANT 72,75).

The best value of a_0^0 comes from combining the K_{e4} data of ROSSELET 77 with the Roy-equation fits to δ_0^0 above 600 MeV, yielding $a_0^0 = (0.26 \pm 0.05)\mu^{-1}$ (FROGGATT 77).

Near threshold the S wave shows no resonant behavior. The so-called ABC and DEF effects (BOOTH 63, HALL 69, BRODY 70,72, BANAIGS 71,73) occur only on nuclear targets (d, H^3, He^3) and move when kinematical conditions change. Thus they must be kinematical effects (DUBAL 71, BRODY 72, RISSER 73, BAR-NIR 75, BARRY 75).

The region of elastic ππ scattering is known to extend from threshold to about 990 MeV, near the $K\bar{K}$ threshold (BATON 70, CARROLL 72, PROTOPOPESCU 73, HYAMS 73, OCHS 73).

Up to the ρ-meson mass region, the phase shift δ_0^0 is (qualitatively) uniquely determined; it rises monotonically and reaches a value of 60° to 70° near 700 MeV (SONDEREGGER 69, BATON 70, BAILLON 72, CARROLL 72, FRENKIEL 72, GAIDOS 72, PROTOPOPESCU 73, HYAMS 73, OCHS 73, ENGLER 74, ESTABROOKS 74,75, GRAYER 74); see Fig. 1.

In the mass region of 700 to 900 MeV, all energy-*independent* phase-shift analyses using the constraint $\eta_0^0 = 1$ find two solutions ("up-down ambiguity"). This ambiguity was resolved in favor of the "down" solution (see Fig. 2) by the observation of a very rapid decrease in the S-wave

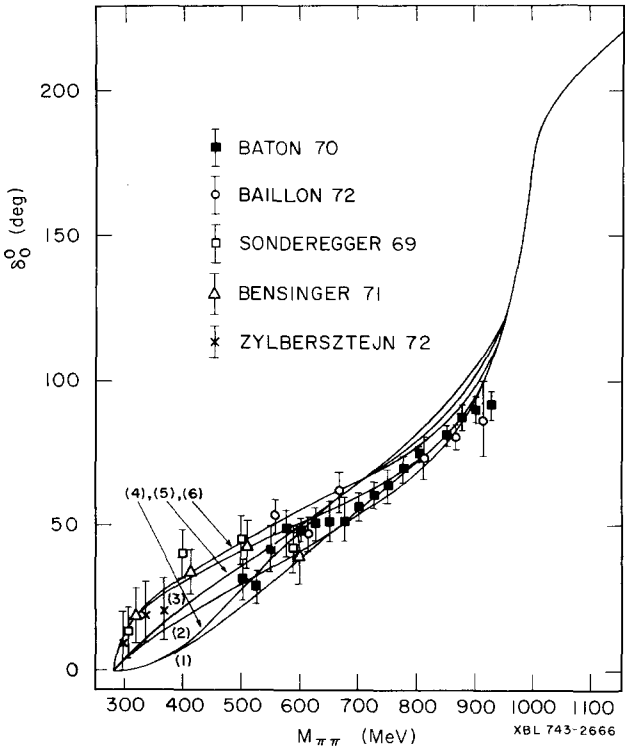

Fig. 1. The S-wave, I = 0 ππ phase shift, as determined by several experiments. The curves are from BASDEVANT 73; solutions (1 - 3) were obtained by fitting the data of BATON 70, while (4 - 6) are from fits to the data of PROTOPOPESCU 73.

amplitude between 950 and 980 MeV (FLATTE 72, GAIDOS 72, HYAMS 73, BINNIE 73, ENGLER 74). The size of the observed drop corresponds to a change from nearly the unitarity limit to zero.

Independent evidence for the correctness of this "down" solution comes from studies of the $\pi^0\pi^0$ system (APEL 72, BRAUN 73, SKUJA 73, RIESTER 75). They observe a wide $\pi^0\pi^0$ enhancement of ~800 MeV which is much better described by the "down" solution than the "up" solution. However, this conclusion is not confirmed by DAVID 77. Indirect information from elastic ππ scattering in the crossed channel (ELVEKJAER 72, NIELSEN 70,72) is compatible with the "down", but not with the "up" solution.

The ambiguities of the phase-shift solutions stem from the fact that there are more helicity amplitudes than observables. Thus in the absence of polarization measurements one is obliged to make

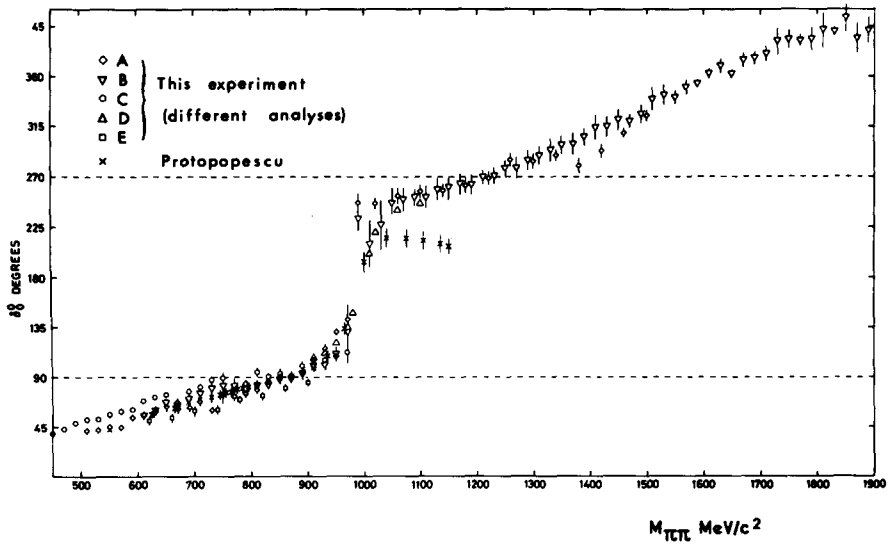

Fig. 2. The S-wave, I = 0 $\pi\pi$ phase shift, as determined by various analyses of the data of GRAYER 74, compared with the previous results of PROTOPOPESCU 73. (Figure from GRAYER 74.)

some supplementary assumptions (see, e.g., DONOHUE 75). Analyzing the same data (GRAYER 74) by different methods, HYAMS 75 find four solutions in the region 1.0 - 1.8 GeV, while ESTABROOKS 75 find four solutions denoted A,B,C,D below 1.2 GeV which become eight solutions above 1.2 GeV (see Fig. 3). COMMON 76 rules out solutions B and D, which are distinguished by containing the $\rho'(1600)$ in the P wave. JOHNSON 76 rule out solutions A and C, and FROGGATT 75,77 favor only solution B unambiguously. MARTIN2 77 favor solution B and a variant of the A solution which, however, has a much larger backward, high energy (exotic I = 2 exchange) cross section than solution B, and which in addition has a D-wave $\pi\pi$ resonance at 1600 MeV instead of the P-wave $\rho'(1600)$. What emerges from these analyses of the uncoupled $\pi\pi$ system is a second sheet pole ϵ, located at about 1.3 GeV, rather far from the real axis (FROGGATT 77, MARTIN2 77).

In spite of the apparent $\pi^0\pi^0$ peaking in the 600 - 800 MeV region, it has been made plausible (MORGAN 75) that all available $\pi\pi \to \pi\pi$ and $\pi\pi \to K\bar{K}$ data are compatible with the existence of just two poles: the S^* connected with the rapid variation of δ_0^0 near the $K\bar{K}$ threshold, and the ϵ. The narrow S^* resonance would also be responsible for the large $K\bar{K}$ I = 0 S-wave scattering lengths.

In quark model language, the S^* would be mainly an $s\bar{s}$ state and the ϵ mainly a $u\bar{u}$ and $d\bar{d}$ state. Some recent coupled-channel analyses indicate, however, that these states mix unexpectedly and appreciably. It was first demonstrated (FLATTE 76) that the $\pi\pi \to \pi\pi$ and $\pi\pi \to K\bar{K}$ data near the $K\bar{K}$ threshold are consistent also with a broad S^* with an appreciable coupling to $\pi\pi$. In contrast to this, MARTIN1 77 show that the data prefer interpreting only the S^* as a quark-antiquark system, the ϵ being a molecular $\pi\pi$-compound with no significant force in the $K\bar{K}$ channel.

Recently new data on $\pi^- p \to K_S^0 K_S^0 n$ (CASON 76) showed that the phase difference $|\phi_D - \phi_S|$ under the well known f meson indeed showed a resonance-like behavior: one of their solutions has a rapid phase variation near 1255 MeV, whereas the other looks very much like the ϵ in the $\pi\pi$ data. In a very-large-statistics experiment on $\pi^- p \to K^- K^+ n$ and $\pi^+ n \to K^- K^+ p$, PAWLICKI 77 confirm unambiguously that the $\epsilon(1300)$ indeed couples strongly to the K^+K^- system, quite in agreement with the slow-rise solution of CASON 76.

Finally, a yet uncompleted analysis of $\pi\pi \to \pi\pi$ and $\pi\pi \to K\bar{K}$ data with some additional information from a $\bar{p}p \to K_S^0 K_S^0 \pi^+\pi^-$ experiment concludes that both the S^* and the ϵ are very broad and strongly coupled to both the $\pi\pi$ and the $K\bar{K}$ systems (CERRADA 76, AGUILAR 77).

Data Card Listings

For notation, see key at front of Listings.

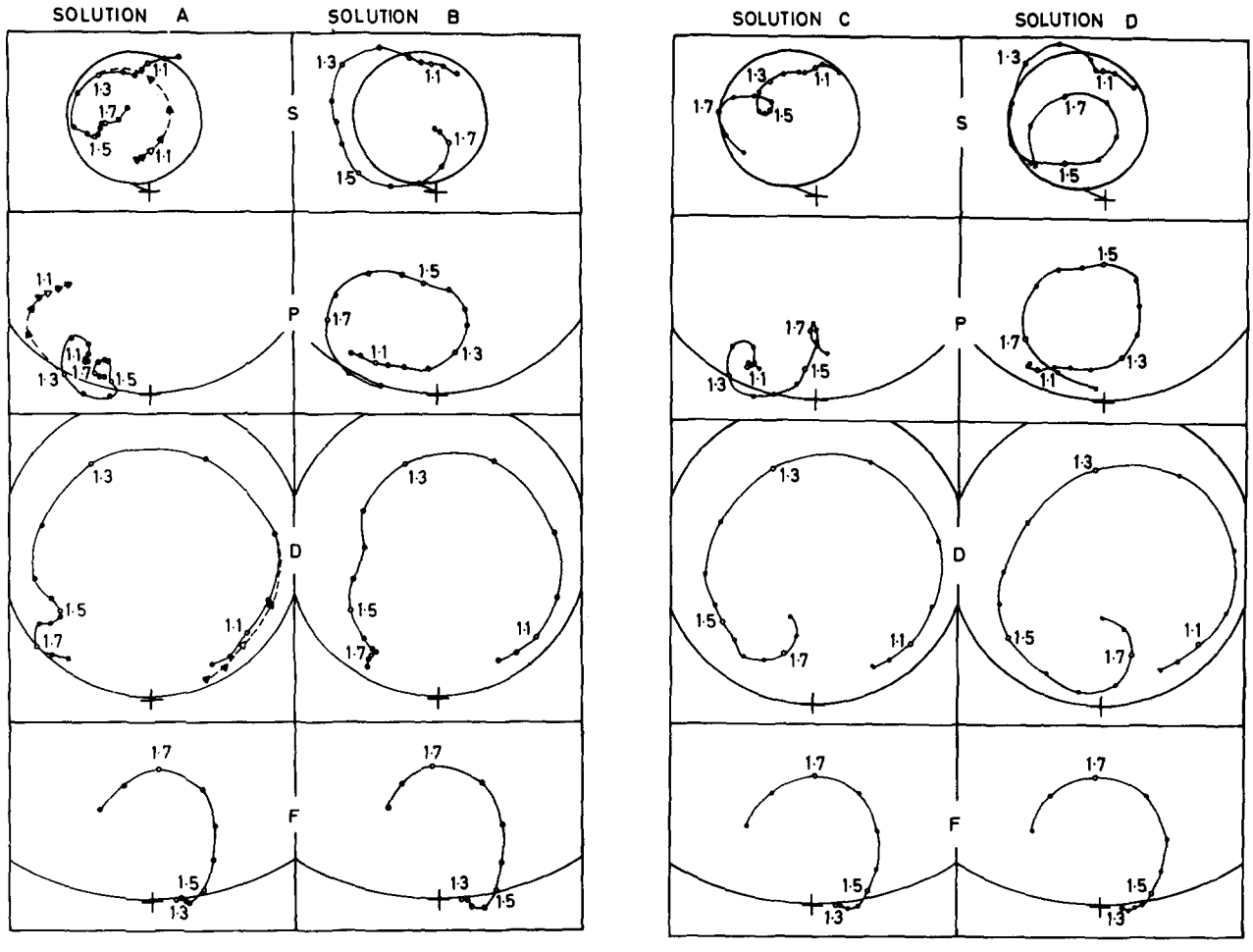

Fig. 3. Argand plots for ππ S, P, D, and F partial-wave amplitudes. Shown are solutions A-D of ESTABROOKS 75, obtained with the data of GRAYER 74. The points on the curves are at 50 MeV intervals. The diameters of the S-, P-, D-, and F-wave unitarity circles shown are given by 2/3, $\sqrt{3}$, $(2/3)\sqrt{5}$, and $\sqrt{7}$, respectively. An elastic I = 2 S-wave phase shift of 25° independent of $M_{\pi\pi}$ has been assumed. (Figure from ESTABROOKS 75.)

14 EPSILON MASS (MEV)

M		(1255.) (5.)	CASON	76 STRC	7. PI-P,KS KS		12/77*
M	F	(1256.0)	FROGGATT	77 RVUE	PI+PI- CHANNEL		12/77*
M	N	(1100.)	MARTIN 1	77 RVUE	PI+PI-/K+K-		12/77*
M	M	(1270.) APPROX.	MARTIN 2	77 RVUE	PI+PI- CHANNEL		12/77*
M		(1300.)	PAWLICKI	77 SPEC	6. PI N,K+ K- N		12/77*
M	F	THIS SOLUTION IS UNIQUE, ELASTICITY 0.69, RHO PRIME IN P-WAVE.					12/77*
M	M	VERY ELASTIC SOLUTION, HAS RHO PRIME IN P WAVE, AMBIGUOUS TO MAINLY					12/77*
M	M	INELASTIC SOLUTION WHICH IS BACKWARD EXOTIC AND HAS NO RHO PRIME.					12/77*
M	N	BROAD ELASTIC SOLUTION					12/77*

14 EPSILON WIDTH (MEV)

W	C	(79.) (10.)	CASON	76 STRC	7. PI-P,KS KS		12/77*
W	C	CASON 77 CANNOT RULE OUT A SECOND SOLUTION WITH LARGE WIDTH.					12/77*
W	E	(400.) APPROX.	FROGGATT	77 RVUE	PI+PI- CHANNEL		12/77*
W	E	WIDTH DEFINED AS DISTANCE BETWEEN 45 AND 135 DEGREES PHASE SHIFT.					12/77*
W		(150.) APPROX.	PAWLICKI	77 SPEC	6. PI N,K+ K- N		12/77*

REFERENCES FOR EPSILON

SAMIOS	62 PRL 9 139	+BACHMAN,LEA+	(BNL+CUNY+COLU+KNTY)
BLOKHINT	63 JETP 17 80	BLOKHINTSEVA,GREIBINNIK,ZHUKOV +	(DUBNA)
BOOTH	63 PR 132 2314	+ ABASHIAN	(LRL)
KIRZ	63 *PR 130 2481*	*+SCHWARTZ + YRIPP*	(LRL)
BARISH	64 PR 135 B 416	BARISH,KURZ,PEREZ-MENDEZ,SOLOMON	(LRL)
CRAWFORD	64 *PRL 13 421*	*+GROSSMAN,LLOYD,PRICE,FOWLER*	(LRL)
DEL FABR	64 PRL 12 674	DEL FABRO,DE PRETIS,JONES+	(FRASCATI)
KALMUS	64 PRL 13 99	+KERNAN,PU,POWELL,DOWD	(LRL+WISCONSIN)
BATON	65 NC 36 1149	J.P.BATON, J.REGNIER	(SACLAY)
BIRGE	65 PR 139 B 1600	+ELY+GIDAL+KALMUS+CAMERINI+	(LRL+WISC)
BROWN	65 CORAL GABLES 219	BROWN+FAIER	(NORTHWESTERN)
DURAND	65 PRL 14 329	L. DURAND AND Y.T. CHIU	(YALE)
JACOBS	66 PRL 16 669	+SELOVE	(LRL)
KOPELMAN	66 PL 22 118	+ALLEN,GODDEN,MARSHALL +	(COLORADO+IOWA)
LOVELACE	66 PL 22 332	LOVELACE,HEINZ,DONNACHIE	(CERN)
ANDERSON	67 PRL 18 89	+FUKUI+KESSLER+ (CHIC+ANL+CNRC+MCGILL+LOQM)	
CLEGG	67 *PR 163 1664*	A.B.CLEGG	(LANCASTER)
CORBETT	67 PR 156 1451	+DAMERELL+MIDDLEMAS+NEWTON	(OXF+RHEL)
GUTAY	67 PRL 18 142	+JOHNSON+LOEFFLER+MCILWAIN+	(PURDUE+LRL)
JOHNSON	67 PR 163 1497	+GUTAY,EISNER,KLEIN,PETERS,SAHNI,YEN+(PURD)	
MALAMUD	67 PRL 19 1056	E.MALAMUD + P.E.SCHLEIN	(UCLA)
WALKER	67 *RMP 39 695*	W.D.WALKER	(*WISCONSIN*)
WALKER	67 PRL 18 630	+CARROLL,GARFINKEL,OH	(WISCONSIN)
BANDER	68 PR 168 1679	+SHAW,FULCO (UC IRVINE+S.BARBARA)	
BISWAS	68 PL 27 B 513	+CASON,JOHNSON,KENNEY,POIRIER+	(NDAM)
BRAUN	68 PRL 21 1275	BRAUN,CLINE,SCHERER	(WISCONSIN)
DUTTA-RO	68 PR 169 1357	B. DUTTA-ROY, I.R. LAPIDUS	(STEV)
EISENHAN	68 PRL 20 758	EISENHANDLER,MISTRY,MOSTEK +	(CORNELL)
FOSTER	68 NP B 6 107	+GAVILLET+LABROSSE+MONTANET+	(CERN+CDEF)
HYAMS	68 NP B7 1	+KOCH,POTTER,..VON LINDERN,LOREN(CERN+MPIM)	
JONES	68 PR 166 1405	+CALDWELL+ZACHAROV+HARTING+BLEULER+	(CERN)
JOHNSON	68 PR 176 1651	+POIRIER,BISWAS,GUTAY+	(NDAM+PURD+SLAC)
LOVELACE	68 PL 28 B 264	C.LOVELACE	(CERN)
MARATECK	68 PRL 21 1613	+HAGOPIAN,+ (PENN+LRL+COLO+PURD+TNTO+WISC)	

BIZZARRI 69 NP B14 169(SEE P.190)+FOSTER,GAVILLET,GHESQUIERE+ (CERN+CDEF)
DAVISON 69 PR 180 1333 +BACASTOW,BARKAS,+ (UCR+UCB)
DEINET 69 PL 30 B 359 +MENZIONE,MULLER,STAUDENMAIER,+ (KARL+CERN)
ELY 69 PR 180 1319 +GIDAL,HAGOPIAN,+ (UCB+LOUC+WISC)
FELDMAN 69 PRL 22 316 +FRATI,GLEESON,HALPERN,NUSSBAUM,+ (PENN)
GUTAY 69 NP B 12 31 +CARMONY,CSONKA,LOEFFLER,MEIERE (PURDUE)
HALL 69 NP B 12 573 +MURRAY,RIDDIFORD (BIRMINGHAM)
HOPKINSO 69 NC 59 A 181 J.HOPKINSON,R.G.ROBERTS (CERN)
MALAMUD 69 ARGONNE CONF.P.93 E.MALAMUD, P.SCHLEIN (UCLA)
MORGAN 69 NP B 10 261 D.MORGAN,G.SHAW (RHEL)
ROBERTS 69 PL 29 B 368 R.G. ROBERTS, F. WAGNER (CERN)
SCHAREN1 69 ARGONNE CONF.306 SCHARENGUIVEL (PURDUE)
SCHAREN2 69 PR 186 1387 SCHARENGUIVEL(PURD+LRL+CERN+COLO+PENN+TNTO)
SMITH 69 PRL 23 335 G.A.SMITH, R.J.MANNING (MSU+LRL)
SONDEREG 69 SEE BASDEVANT 72 SONDEREGGER,BONAMY (SACL)
STRUGALS 69 PL 29 B 518 +CHUVILO,FENYVES,+ (WARS+JINR+BUDA)
ALSO 70 NP B 24 358 STRUGALSKI,CHUVILO,FENYVES,GEMESY,+ (DUBNA)
WAGNER 69 NC 64 A 189 F.WAGNER (CERN)

BARTSCH 70 NP B 22 1 +KEPPEL,GENSCH,MORRISON,+ (AACH+BERL+CERN)
BATON 70 PL 33 B 528 +LAURENS,REIGNIER (SACLAY)
BRODY 70 PRL 24 948 +GROVES,VANBERG,MAGLIC+(PENN+RUTG+UPNJ+ANL)
DIAZ 70 NP B 16 239 +GAVILLET,LABROSSE,MONTANET+ (CERN+CDEF)
HYAMS 70 PHILAD.CONF.P.41 +SCHLEIN,BEUSCH,+(CERN+MPIM+ETHZ+LOIC+HAWA)
MAUNG 70 PL 33 B 521 +MASEK,MILLER,RUDERMAN,VERNON,+ (UCSD+LRL)
MORGAN1 70 SPRINGER TRACTS MOD.PHYS.,VOL.55,P.1. MORGAN,PISUT(RHEL+CERN)
MORGAN 2 70 PR D 2 520 D.MORGAN,G.SHAW (RHEL)
NIELSEN 70 NP B 22 525 +LYNG-PETERSEN,PIETARINEN (NORDITA)
SCHARENG 70 NP B 22 16 SCHARENGUIVEL,GUTAY,MILLER,+ (PURD+PENN)
OH 70 PR D 1 2494 +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)
SHIBATA 70 PRL 25 1227 +FRISCH,WAHLIG (MIT)

ALSTON-G 71 PL 36 B 152 ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)
BANAIGS 71 NP B 28 509 +BERGER,DUFLO,GOLDZAHL,COTTEREA+(SACL+CAEN)
BEAUPRE 71 NP B 28 77 +DEUTSCHMANN,GRAESSLER,+ (AACH+BERL+CERN)
BENSINGE 71 PL 36 B 134 BENSINGER,ERWIN,THOMPSON,W.D.WALKER (WISC)
DUBAL 71 NP B 32 535 L.DUBAL,D.J.BROWN (CNRC+CARL)
GUILLOU 71 NC 5 A 659 LE GUILLOU,MOREL,NAVELET (CERN)
GUTAY 71 NP B 27 486 +SCHARENGUIVEL,FUCHS,GAIDOS,MILLER,+ (PURD)
HAMILTON 71 SPRINGER TRACTS MOD.PHYS.,VOL. 57,P.41 J.HAMILTON (NORDITA)
KIM 71 PR D 4 265 +BANDER (UCI)
LYNG PET 71 PHYS.REPRTS 2 155 J.LYNG PETERSEN (REVIEW) (CERN)

APEL 72 PL 41 B 542 +AUSLANDER,MULLER,BERTOLUCCI,+ (KARL+PISA)
BAILLON 72 PL 38 B 555 +CARNEGIE,KLUGE,LEITH,LYNCH,RATCLIFF+(SLAC)
BASDEVAN 72 PL 41 B 178 BASDEVANT,FROGGATT,PETERSEN (CERN)
BRODY 1 72 PRL 28 1215 +GROVES,MAGLICH,NOREM,+ (PENN+RUTG+UPNJ)
BRODY 2 72 PRL 28 1217 H.BRODY (PENNSYLVANIA)
CARROLL 72 PRL 28 318 +DIAMOND,FIREBAUGH,MATTHEWS,+ (WISC+TNTO)
ELVEKJAE 72 NP B 43 445 F.ELVEKJAER (AARHUS)
FLATTE 72 PL 38 B 232 +ALSTON-GARNJOST,BARBARO-GALTIERI, (LBL)
FRENKIEL 72 NP B 47 61 +GHESQUIERE,LILLESTOL,CHUNG,+ (CDEF+CERN)
GAIDOS 72 NP B 46 449 +MCILWAIN,THOMPSON,WILLMANN (PURDUE)
PRASAD 72 PR D 6 3216 +BREHM (UNIV.OF MASSACHUSETTS)
NIELSEN 72 NP B 49 586 H.NIELSEN,G.OADES (NORD+AARHUS)
WHITEHEA 72 NP B 48 365 WHITEHEAD,AULD,+ (AERE+RHEL+SHMP+LOUC)
WILLIAMS 72 PR D 6 3178 P.K.WILLIAMS (FSU)
ZYLBERSZ 72 PL 38 B 457 ZYLBERSZTEJN,BASILE,BOURQUIN,+ (GEVA+SACL)

ANJOS 73 NP B 67 37 +D.LEVY,A.SANTORO (SACLAY)
BANAIGS1 73 PL 43 B 535 +COTTEREAU,FABBRI,+ (SACL+CAEN+FRAS)
BANAIGS2 73 NP B 67 1 +BERGER,GOLDZAHL,COTTEREAU,+ (SACL+CAEN)
BASDEVAN 73 AIX CONF.P.220 J.L.BASDEVANT RAPPORTEUR TALK (PARIS VI)
BEIER 73 PRL 30 399 +BUCHHOLZ,MANN,PARKER,ROBERTS (PENN)
BINNIE 73 PRL 31 1534 +CARR,DEBENHAM,DUANE,GARBUTT,+ (LOIC+SHMP)
BRAUN 73 PR D 8 3794 +D.CLINE (WISC)
HYAMS 73 NP B 64 134 +JONES,WEILHAMMER,BLUM,DIETL,+ (CERN+MPIM)
FOR OTHER RESULTS ON SAME EXPERIMENT SEE GRAYER 74
OCHS 73 THESIS THESIS (MPIM)
PILKUHN 73 NP B 65 460 +SCHMIDT,MARTIN,+ (KARL+CERN+LOUC+NIJM)
PROTOPOP 73 PR D 7 1280 PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)
RISSER 73 PL 43 B 68 T.RISSER,M.D.SHUSTER (SACL)
SKUJA 73 PRL 31 653 +WAHLIG,RISSER,PRIPSTEIN,NELSON,+ (LBL)

BASDEVAN 74 NP B 72 413 BASDEVANT,FROGGATT,PETERSEN (LPTP+NORD)
BONNIER 74 NP B 83 440 B.BONNIER,N.JOHANNESSON (CERN)
CARROLL 74 PR D 10 1430 +MATTHEWS,WALKER+ (SLAC+DUKE+WISC+TNTO)
ENGLER 74 PR D 10 2070 +KRAEMER,TOAFF,WEISSER,DIAZ+ (CARN+CASE)
ESTABROO 74 NP B 79 301 P.ESTABROOKS,A.D.MARTIN (DURH)
GRAYER 74 NP B 76 375 +HYAMS,JONES,BLUM,DIETL (CERN+MPIM)
JONES 74 NP B 83 93 +ALLISON,SAXON (OXF)
MORGAN 74 PL 51 B 71 D.MORGAN (RHEL)
ORITO 74 PL 48 B 380 +FERRER,PAOLUZI,SANTONICO (FRAS+ROMA)
PASCUAL 74 NP B 83 362 P.PASCUAL,F.J.YNDURAIN (BARC+MADU)

BAR-NIR 75 NP B 87 109 +RISSER,SHUSTER (CERN+UCSB+TELA)
BARRY 75 NP B 85 239 G.W.BARRY (PURD)
BASDEVAN 75 NP B 98 285 BASDEVANT,CHAPELLE,LOPEZ,SIGELLE (LPTP)
DONOHUE 75 NC 25 A 409 J.T.DONOHUE,Y.LEROYER (BORD)
ESTABROO 75 NP B 95 322 P.ESTABROOKS,A.D.MARTIN (DURH)
FROGGATT 75 NP B 91 454 C.D.FROGGATT,J.L.PETERSEN (GLAS+NORD)
FUJII 75 NP B 85 179 Y.FUJII,M.FUKUGITA (TOKY)
HYAMS 75 NP B 100 205 +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)
MORGAN 75 ARGONNE CONF. 45 D.MORGAN (RHEL)
RIESTER 75 NP B 96 407 +ARNOLD,ENGEL,PATY (STRB)
SHIMADA 75 NP B 100 225 T.SHIMADA (TOKY)
SRINIVAS 75 PR D 12 681 SRINIVASAN,HELLAND,LENNOX,KLEM+ (NDAM+ANL)

BANAIGS 76 NP B 105 52 +BERGER,GOLDZAHL,COTTEREAU+(SACL+CAEN+FRAS)I,JP
CASON 76 PRL 36 1485 +POLYCHRONAKOS,BISHOP,BISWAS,+ (NDAM+ANL)I J
CERRADA 76 PL 62 B 353 +GONZALEZ-ARROYO,RUBIO,YNDURAIN (CERN+MADR)
COMMON 76 NP B 103 109 A.K.COMMON (KENT) JP
FLATTE 76 PL 63 B 228 S.M.FLATTE (CERN)
GRIVAZ 76 PL 61 B 400 +DAVIS,HALSTEINSLID,IRWIN,+(LALO+BERG+EPOL)
JOHNSON 76 PL 63 B 95 +MARTIN,PENNINGTON (DURH+CERN) JP
WETZEL 76 NP B 115 208 +FREUDENREICH,BEUSCH,+ (ETHZ+CERN+LOIC)

AGUILAR 77 NP B +CERRADA,+ (MADRID+BOMBAY+CERN+PARIS)
FROGGATT 77 NP B 129 89 +PETERSEN (GLASGOW+COPENHAGEN)
DAVID 77 PR D 16 2027 +VILLET,AYED,BAREYRE,BORGEAUD,+ (SACL)
MAY 77 PR D 16 1583 +ABRAMSON,ANDREWS,BUSNELLO,+ (ROCH+CORN)
MARTIN 1 77 NP B 121 514 +OZMUTLU,SQUIRES (DURHAM)
MARTIN 2 77 PREPRINT TH.2353 A.D.MARTIN,M.R.PENNINGTON (CERN)
PAWLICKI 77 PR D 15 3196 +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND (ANL)I J
ROSSELET 77 PR D 15 574 +EXTERMANN,FISHER,BERGER,BLOCH,+(GEVA+SACL)

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$A_2(1310)$

12 A2(1310,JPG=2+-) I=1

WE LIST THE A2 AS AN ORDINARY BREIT-WIGNER RESONANCE. FOR DISCUSSION OF THE REPORTED SPLITTING, SEE OUR APRIL 72 AND APRIL 73 EDITION.

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12 A2 MASS (MEV), 3PI MODE

M			(1320.0)		ADERHOLZ	64	HBC	4.0 PI+P	
M			(1335.0)	(10.0)	GOLDHABER	64	HBC	+- 3.7 PI+- P	12/75
M		1425	1290.0	(5.0)	LEFEBVRES	65	MMSP	- 5.6,6.0 PI-P	1/73
M			(1290.0)	(10.0)	BARNES	66	HBC	- 6.0 PI-P	2/73
M			(1310.0)	(10.0)	BENSON	66	DBC	0 3.65 PI+D	12/75
M		1060	1286.	(8.)	LEVRAT	66	MMS	- 6-7 PI- P	1/73
M	O	4000	(1307.)	(16.)	CHIKOVANI	67	MMS	- 7 PI- P	12/75
M		260	1311.0	6.0	ARMENISE	68	DBC	0 5.1 PI+D	9/67
M		120	1320.	10.	BOESEBECK	68	HBC	0 8 PI+ P	6/68
M	O		(1310.)	(20.)	CHUNG	68	HBC	- 2.7-4.5 PI- P	5/68
M			(1301.0)	(8.0)	VON KROGH	68	HBC	- 6.7 PI- P	9/68
M	A		(1300.0)	(4.0)	JUNKMANN	68	HBC	- 16. PI- P, 5PI	1/73
M	A		(1299.)	(14.)	LAMSA	68	HBC	- 8 PI- P	1/71
M	O		(1295.0)	(20.0)	ANDERSON	69	MMS	- 16 PI- P,BACKW9	8/69
M	A	241	(1299.0)	(12.0)	ARMENISE	69	DBC	+ 5.1 PI+D,3PI++-	5/70
M			1310.0	14.0	EISENBERG	69	HBC	+ 4.3,5.3 GAMMA P	12/69
M			1305.	(3.)	ASCOLI	70	HBC	- 5 - 7.5 PI- P	1/71
M		941	1306.0	4.0	ALSTON	70	HBC	+ 7.0 PI+P,3PI P	1/71
M		280	1313.0	7.0	BOCKMANN	70	HBC	05. PI+P	5/70
M	A	581	(1288.0)	(10.0)	CASO	70	HBC	- 11.2PI-P,PI RHO	1/73
M	O		(1335.0)	(15.0)	DIAZ	70	HBC	+- 0. PBAR P, 4 PI	12/75
M	O		(1330.0)	(15.0)	GARFINKEL	70	DBC	- 4.5 K-D,LAMBDA	12/75
M			(1274.0)	(22.0)	GORDON	70	DBC	0 4.2 PI+ D .	1/71
M		360	1304.0	4.5	BARNHAM	71	HBC	+ 3.7 PI+ P,(3PI)+	11/71
M		10000	1307.	5.	BINNIE1	71	MMS	- PI-P NEAR A2 THR	11/71
M		5000	1309.	5.	BINNIE1	71	MMS	- PI-P NEAR A2 THR	11/71
M		28000	1299.0	6.0	BOWEN	71	MMS	- 5. PI- P	11/71
M		24000	1300.	6.0	BOWEN	71	MMS	+ 5. PI+ P	11/71
M		17000	1309.0	4.0	BOWEN	71	MMS	- 7. PI- P	11/71
M		160	1307.	7.	BLOODWORT	72	HBC	+ 5.45 PI+ P,P 3PI	1/73
M	P		1315.	5.	ANTIPOV1	73	CNTR	- 25.,40. PI- P	1/74
M		1580	1306.	9.	CHALOUPKA	73	HBC	- 3.9 PI- P,P A2	2/73
M	P	1600	1318.	7.	EMMS	75	DBC	04. PI+N,P A20	11/75
M	P	1200	1298.	8.	WAGNER	75	HBC	07. PI+P,DEL++A2	11/75
M	P	3000	(1318.0)	(2.0)	GHIDINI	77	OMEG	-12 PI-P,P 3PI	12/77*
M			. . . . . .	. . . .					
M	AVG		1307.7	1.4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
M	STUDENT		1307.7	1.7	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

M O ONLY EXPERIMENTS GIVING ERROR LESS THAN 15 MEV KEPT FOR AVERAGING
M A ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AND/OR A1
M P FROM A FIT TO JP=2+ RHO PI PARTIAL WAVE

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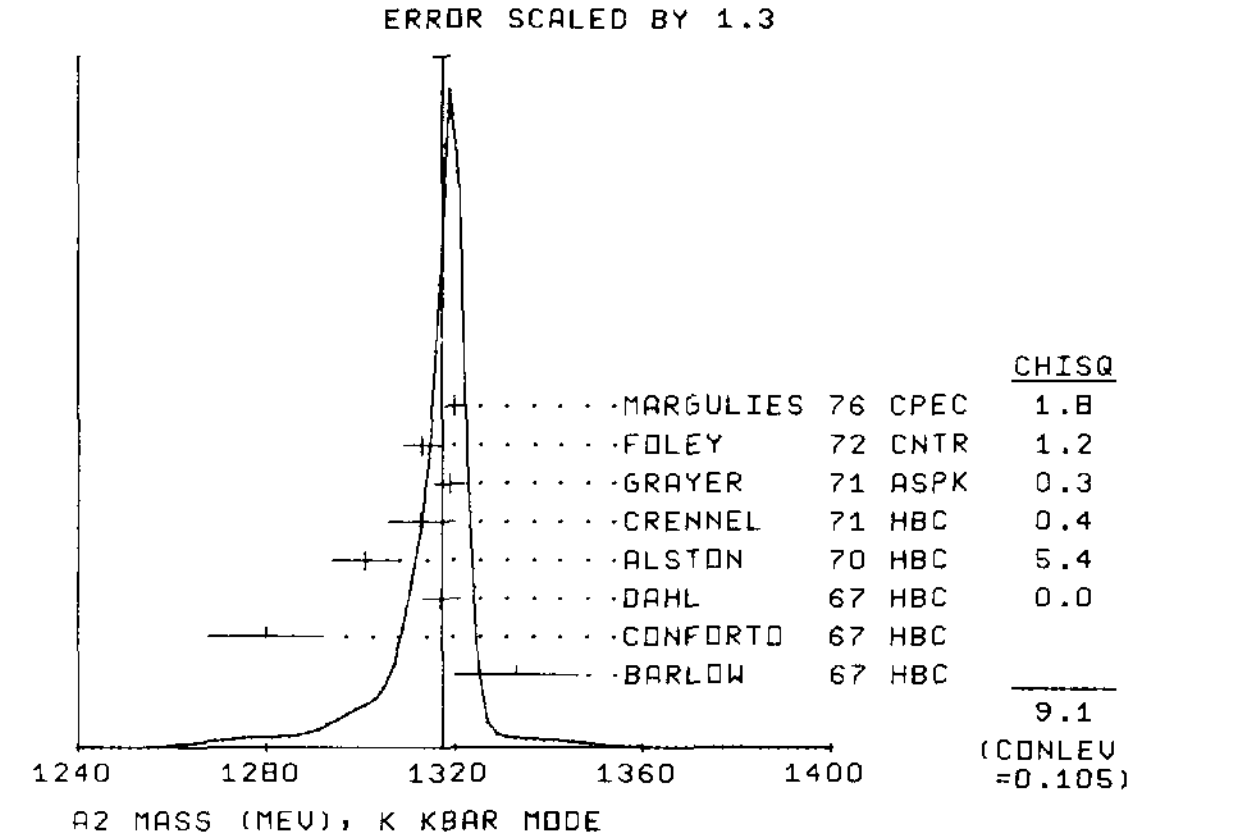
12 A2 MASS (MEV), K KBAR MODE

MK		80	(1317.0)	(3.0)		BARLOW	67	HBC	+- 1.2 PBAR P, KK .	2/72
MK		60	1333.0	13.0		BARLOW	67	HBC	+- 1.2 PBAR P, KK	9/67
MK	N		(1344.0)	(7.)	(6.)	BEUSCH	67	OSPK	0 5-12 PI-P,K1K1	11/71
MK		130	1280.0	12.0		CONFORTO	67	HBC	+- 0. PBAR P IN KK.	9/67
MK			1317.2	4.0		DAHL	67	HBC	- 2.7-4.5 PI- P	8/67
MK	N		(1315.7)	(10.8)		DAHL	67	HBC	0 2.7-4.5 PI- P	11/71
MK	N		(1311.0)	(5.0)		CRENNELL	68	HBC	0 6.0 PI-P,K1K1	11/71
MK		132	1301.0	7.0		ALSTON	70	HBC	+ 7.0 PI+P,K+KS P	1/71
MK		190	1313.0	7.0		CRENNEL	71	HBC	- 4.5 PI- P,KSK-P	11/71
MK	S	1500	1319.0	3.0		GRAYER	71	ASPK	- 17.2 PI-P,K-KS P	2/72
MK		730	1313.0	4.0		FOLEY	72	CNTR	- 20.3 PI- P,K- KS	12/72
MK		2724	1320.0	2.0		MARGULIES	76	SPEC	- 23.PI-P,K-KS	12/77*
MK	P		(1318.)	(1.)		MARTIN	77	SPEC	-10 PI P,KS K- P	12/77*
MK			. . . . . .	. . . .						
MK	AVG		1317.3	1.8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)					
MK	STUDENT		1317.6	1.6	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 1317.3 ± 1.8
ERROR SCALED BY 1.3



MK N THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
MK S SYSTEMATIC ERROR IN MASS SCALE SUBTRACTED
MK P FROM A FIT TO JP=2+ PARTIAL

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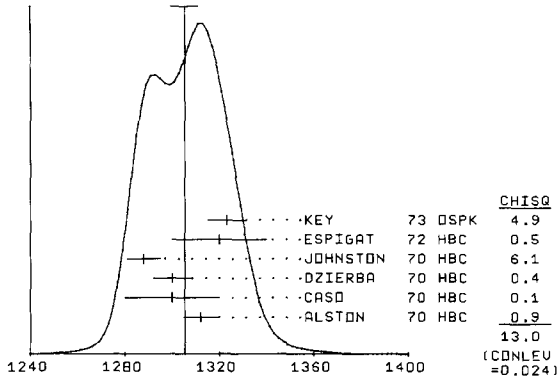
Data Card Listings

For notation, see key at front of Listings.

12 A2 MASS (MEV), ETA PI MODE

M	189	1312.0	7.0		ALSTON	70	HBC	+ 7.0 PI+P,PI ETA	1/71
M		1300.0	20.0		CASO	70	HBC	- 11.2PI-P,PI ETA	5/70
M	32	1300.0	8.		DZIERBA	70	HBC	- 8. PI- P,PI ETA	1/73
M	30	1268.	7.		JOHNSTON	70	HBC	- 7.PI-P,PI-ETA P	1/71
M		1320.	20.		ESPIGAT	72	HBC	+- 0.PBAR P,ETA 2PI	11/71
M	E 1000	1323.	8.		KEY	73	OSPK	- 6.PI-P,P PI-ETA	1/74
M	EM 6200	(1324.)	(8.)		CONFORTO	73	OSPK	- 6.PI-P,P MMS-	1/74
M									
M	AVG	1305.3	5.8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)					
M	STUDENT	1306.0	5.0	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT (SEE IDEOGRAM BELOW)					

WEIGHTED AVERAGE = 1305.3 ± 5.8
ERROR SCALED BY 1.6



A2 MASS (MEV) , ETA PI MODE

M E ERROR INCLUDES 5 MEV SYSTEMATIC MASS-SCALE ERROR
M M MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA

12 A2 WIDTH (MEV), 3PI MODE

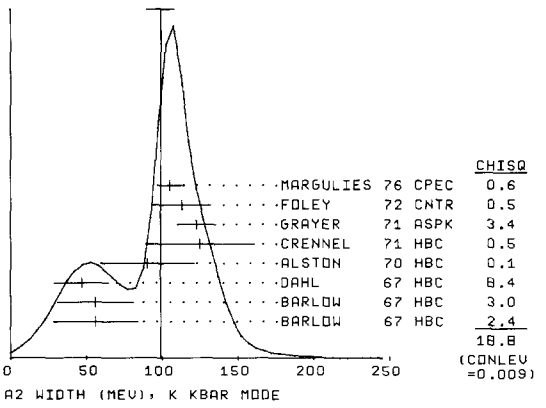
W		(100.0)			ADERHOLZ	64	HBC	4.0 PI+P	
W		(90.0)	(10.0)		GOLDHABER	64	HBC	+- 3.7 PI+- P	12/75
W	1425	59.0	(15.0)		LEFEBVRES	65	MMSP	- 6.0 PI-P	1/73
W		(70.0)	(10.0)		BARNES	66	HBC	- 6.0 PI-P	2/73
W		(100.)	(15.)		BENSON	66	DBC	0 3.65 PI+D	12/75
W	1060	98.	(5.)		LEVRAT	66	MMS	- 6.7 PI- P	1/73
W	0 4000	(90.)	(15.)		CHIKOVANI	67	MMS	- 7 PI- P	12/75
W	260	96.0	16.0		ARMENISE	68	DBC	0 5.1 PI+D	9/67
W	0 120	(56.)	(21.)		BOESEBECK	68	HBC	0 8 PI+ P	1/73
W	0	(80.)	(20.)		CHUNG	68	HBC	- 2.7-4.5 PI- P	5/68
W		(40.0)	(25.0)		VON KROGH	68	HBC	- 6.7 PI- P	9/68
W	A	(52.0)	(16.0)		JUNKMANN	68	HBC	- 16. PI- P, 5PI	1/73
W	0	(90.0)	(10.0)	(50.0)	ANDERSON	69	MMS	- 16 PI- P,BACKW9	12/75
W	AE 241	(164.0)	(20.0)		ARMENISE	69	DBC	+ 5.1 PI+D,3PI++-	5/70
W	0	(80.0)	(30.0)		EISENBERG	69	HBC	+ 4.3,5.3 GAMMA P	12/69
W	941	79.0	12.0		ALSTON	70	HBC	+ 7.0 PI+P,3PI P	1/71
W	0 280	(70.0)	(29.0)		BOCKMANN	70	HBC	05. PI+P	5/70
W	A 581	(135.0)	(26.0)		CASO	70	HBC	- 11.2PI-P,PI RHO	1/73
W	0	(90.0)	(20.0)		DIAZ	70	HBC	+- 0. PBAR P, 4 PI	5/70
W	D	(35.0)	(35.0)		GARFINKEL	70	DBC	- 4.5 K-D,LAMBDA	1/71
W		(215.0)	(22.0)		GORDON	70	DBC	0 4.2 PI+ D	1/71
W	360	111.4	18.0		BARNHAM	71	HBC	+ 3.7 PI+ P,(3PI)+	11/71
W	10000	(100.)			BINNIE1	71	MMS	- PI-P NEAR A2 THR	11/71
W	5000	72.	16.		BINNIE1	71	MMS	- PI-P NEAR A2 THR	11/71
W	28000	105.0	5.0		BOWEN	71	MMS	- 5. PI- P	11/71
W	24000	99.0	5.0		BOWEN	71	MMS	+ 5. PI+ P	11/71
W	17000	103.0	5.0		BOWEN	71	MMS	- 7. PI- P	11/71
W	0 160	(72.)	(25.)		BLOODWORT	72	HBC	+ 5.45 PI+ P,P 3PI	12/72
W	P	115.	15.		ANTIPOV1	73	CNTR	- 25.,40. PI- P	1/74
W	1580	99.	15.		CHALOUPKA	73	HBC	- 3.9 PI- P,P A2	2/73
W	P 1600	112.	18.		EMMS	75	DBC	04. PI+N,P A20	11/75
W	P S1200	122.	14.		WAGNER	75	HBC	07. PI+P,DEL++A2	11/75
W	P 3000	(130.0)	(7.0)		GHIDINI	77	OMEG	-12 PI-P,P 3PI	12/77*
W									
W	AVG	101.7	2.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)					
W	STUDENT	101.9	2.9	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

W O ONLY EXPERIMENTS GIVING MASS ERROR LT. 15 MEV KEPT FOR AVERAGING
W E BACKGROUND SUBTRACTION MODEL-DEPENDENT.
W D MAY BE DIFFERENT OBJECT, ALTHOUGH JPC=2++. COMPARE CRENNELL 69.
W A ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AND/OR A1
W S WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
W P FROM A FIT TO JP=2+ RHO PI PARTIAL WAVE

12 A2 WIDTH (MEV), K KBAR MODE

WK	60	56.0	28.0		BARLOW	67	HBC	+- 1.2 PBAR P, KK	9/67
WK	S 80	56.0	25.0		BARLOW	67	HBC	+- 1.2 PBAR P, KK	9/67
WK	N	(88.)	(23.)	(22.)	BEUSCH	67	OSPK	0 5-12 PI-P,K1K1	11/71
WK	130	(90.0)			CONFORTO	67	HBC	+- 0. PBAR P IN KK	9/67
WK		47.	18.		DAHL	67	HBC	- 2.7-4.5 PI- P	8/67
WK	N	(80.5)	(36.5)		DAHL	67	HBC	0 2.7-4.5 PI- P	11/71
WK	N	(21.0)	(10.0)	(6.0)	CRENNELL	68	HBC	0 6.0 PI-P,K1K1	11/71
WK	S 132	90.0	31.0		ALSTON	70	HBC	+ 7.0 PI+P,K+KS P	1/71
WK	S 190	125.0	36.0		CRENNEL	71	HBC	- 4.5 PI- P,KSK-P	11/71
WK	S1500	123.0	13.0		GRAYER	71	ASPK	- 17.2 PI-P,K-KS P	11/71
WK	730	113.0	19.0		FOLEY	72	CNTR	- 20.3 PI- P,K- KS	12/72
WK	S2724	105.0	8.0		MARGULIES	76	CPEC	- 23.PI-P,K-KS	12/77*
WK	PS	(113.)	(4.)		MARTIN	77	SPEC	-10 PI P,KS K- P	12/77*
WK									
WK	AVG	99.0	9.1	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)					
WK	STUDENT	101.2	6.9	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT (SEE IDEOGRAM BELOW)					

WEIGHTED AVERAGE = 99.0 ± 9.1
ERROR SCALED BY 1.6



A2 WIDTH (MEV), K KBAR MODE

WK P FROM A FIT TO JP=2+ PARTIAL WAVE.
WK N THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
WK S WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE

12 A2 WIDTH (MEV), ETA PI MODE

W	189	103.0	20.0		ALSTON	70	HBC	+ 7.0 PI+P,PI ETA	1/71
W		(120.0)			CASO	70	HBC	- 11.2PI-P,PI ETA	5/70
W	32	(41.0)	(20.0)	(16.0)	DZIERBA	70	HBC	- 8. PI- P,PI ETA	11/70
W	T 30	(38.0)	(30.0)		JOHNSTON	70	HBC	- 7.PI-P,PI-ETA P	1/73
W		120.	30.		ESPIGAT	72	HBC	+- 0.PBAR P,ETA 2PI	11/71
W	1000	108.	9.		KEY	73	OSPK	- 6.PI-P,P PI-ETA	1/74
W	M 6200	(104.)	(9.)		CONFORTO	73	OSPK	- 6.PI-P,P MMS-	1/74
W									
W	AVG	108.1	7.9	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
W	STUDENT	108.0	8.5	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

W M MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA
W T WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE

12 A2 PARTIAL DECAY MODES

		DECAY MASSES
P1	A2 INTO RHO PI	776+ 139
P2	A2 INTO K KBAR	493+ 497
P3	A2 INTO ETA PI	548+ 139
P4	A2 INTO OMEGA PI PI	139+ 139+ 783
P5 S	A2 INTO PI+ PI- PIO EXCL.RHO PI	139+ 139+ 134
P6 S	A2 INTO PI+ PI- PI- EXCL.RHO PI	139+ 139+ 139
P7 S	A2 INTO PI GAMMA	139+ 0
P8 S	A2 INTO ETA PRIME PI	958+ 139

P S SMALL, NOT USED IN THE FIT

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{(\delta P_i \delta P_i)}$, while the off-diagonal elements are the normalized correlation coefficients $(\delta P_i \delta P_j)/(\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4
P 1	.7033+-.0211			
P 2	.0623	.0466+-.0054		
P 3	.1515	-.0186	.1438+-.0090	
P 4	-.9124	-.2618	-.4821	.1063+-.0250

12 A2 BRANCHING RATIOS

R1	A2 (CHARGED ONLY) INTO (K KBAR)/(RHO PI)							(P2)/(P1)	
R1	N	(0.13)	(0.03)		BEUSCH	67	OSPK	0 5,7,12 PI-+	9/67
R1	N THE NEUTRAL MODE CAN INTERFERE WITH F.								
R1	11	0.09	0.06	0.09	ASCOLI	68	HBC	- 5 PI-P	6/68
R1		0.054	0.022		CHUNG	68	HBC	- 3.2 PI-P	. 1/67
R1		(0.03)	(0.012)		DONALD	68	HBC	+- 1.2 PBAR P	. 2/72
R1		0.06	0.03		ABRAMOVIC	70	HBC	- 3.93 PI- P	1/71
R1		0.07	0.03		NEF	70	MMS	- 7.0 PI- P	6/70
R1	113	0.097	0.018		ALSTON	71	HBC	+ 7.0 PI+ P	1/71
R1	50	0.056	0.014		CHALOUPKA	73	HBC	- 3.9 PI- P,P A2	2/73
R1									
R1	AVG	0.0677	0.0089	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
R1	STUDENT	0.067	0.010	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
R1	FIT	0.0663	0.0078	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)					
R2	A2 INTO (ETA PI)/(RHO PI + K KBAR + ETA PI)							(P3)/(P1+P2+P3)	
R2	34	0.15	0.04		BARNHAM	71	HBC	+ 3.7 PI+ P	11/71
R2		0.13	0.04		ESPIGAT	72	HBC	+- 0.PBAR P,	11/71
R2									
R2	AVG	0.140	0.028	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
R2	STUDENT	0.140	0.030	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
R2	FIT	0.1609	0.0088	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)					

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R3     A2 INTO (ETA PI) / (RHO PI)                                    (P3)/(P1)
R3           0.3       0.2                 ADERHOLZ  64 HBC     4.0 PI+P
R3           0.22      0.09                CONTE     67 HBC  -  11.0 PI-P         8/67
R3      22   0.23      0.08                ASCOLI    68 HBC  -  5 PI-P            6/68
R3           0.12      0.08                CHUNG     68 HBC  -  3.2 PI-P         12/66
R3           0.16      0.10                KEY       68 HBC  -  3 PI-P          .11/67
R3  D        (0.18)    (0.06)              VETLITSKY 69 HBC  -  3.3 PI- P         9/68
R3           0.3       0.13                ABRAMOVIC 70 HBC  -  3.93 PI- P      . 1/71
R3      15   0.25      0.09                BOCKMANN  70 HBC  +  5.0 PI+P          9/69
R3           0.34      0.17      0.34      BOCKMANN  70 HBC   0 5.0 PI+ P         9/69
R3  D   39   (0.18)    (0.07)              DZIERBA   70 HBC  -  8. PI- P         11/71
R3     167   0.246     0.042               ALSTON    71 HBC  +  7.0 PI+ P         1/71
R3     149   0.211     0.044               CHALOUPKA 73 HBC  - 3.9 PI- P,P A2     2/73
R3      52   0.22      0.05                ANTIPOV   73 CNTR - 40. PI-P,P A2-     1/74
R3           0.18      0.05                FORINO    76 HBC    11 PI- P,ETA PI  12/77*
R3           0.2       0.02                GHIDINI   77 OMEG   -12 PI-P,P 3PI   12/77*
R3           . . . . . . . . . .
R3  AVG      0.208     0.014    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  STUDENT  0.208     0.015    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT      0.204     0.013   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4     A2 INTO (ETA PRIME PI) / TOTAL                                 (P8)
R4           (0.1)  OR LESS                CHUNG     65 HBC  -  3.2 PI-P
R4           (0.02) OR LESS  CL=.97        BARNHAM   71 HBC  +  3.7 PI+ P       . 2/72

R5     A2 INTO (ETA PRIME PI)/(RHO PI)                                (P8)/(P1)
R5           0.04      0.03      0.04      BOCKMANN  70 HBC   0 5.0 PI+ P         9/69
R5  D    8   (0.15)    (0.09)              DZIERBA   70 HBC  -  8. PI- P         11/71
R5  D      STRONGLY DEPENDENT ON BACKGROUND SUBTRACTION                          11/71
R5           (0.04) OR LESS                ALSTON    71 HBC  +  7.0 PI+ P         1/71
R5           (0.011)OR LESS  CL=.90        EISENSTEI 73 HBC  -  5.PI- P,P 6PI     1/74

R6     A2 INTO (PI+ PI- PI0) / (RHO PI)                               (P5)/(P1)
R6           (0.17) OR LESS                BENSON    66 DBC   0 3.7 PI+D

R7     A2 INTO (ETA PI)/(K KBAR)                                      (P3)/(P2)
R7  E        (3.0)  OR LESS                FOSTER    68 HBC  -  PBAR P,PBA REST 11/71
R7  E SUPERSEDED BY ESPIGAT 72 (SEE UNDER R2 AND R8)                             11/71
R7           . . . . . . . . . .
R7  FIT      3.08      0.41    FROM FIT

R8     A2 INTO (K KBAR)/(RHO PI + K KBAR + ETA PI)          (P2)/(P1+P2+P3)
R8      17   0.06      0.03                BARNHAM   71 HBC  + 3.7 PI+ P,KSK+P  11/71
R8  A        (0.020)   (0.004)             ESPIGAT   72 HBC  +- 0.PBAR P,         2/72
R8  A   NOT AVERAGED BECAUSE OF DISCREPANCY BETWEEN MASSES                     .
R8  A   FROM  (K KBAR)  AND  (RHO PI)  MODES
R8       8   0.03      0.02                DAMERI    72 HBC  -  11. PI- P        12/72
R8           0.05      0.02                TOET      73 HBC  + 5. PI+ P,P K+ K0 12/75
R8           0.09      0.04                TOET      73 HBC   0 5.PI+P,PI+P K KB 12/75
R8           . . . . . . . . . .
R8  AVG      0.048     0.012    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  STUDENT  0.048     0.014    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R8  FIT      0.0522    0.0058 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9     A2 INTO (PI+ PI- PI-)/(RHO0 PI-)                               (P6C)/(P1C)
R9           (0.23) OR LESS  CL=.90        ABRAMOVIC 70 HBC  -  3.93 PI- P        1/71

R11    A2 INTO (PI GAMMA)/TOTAL                                       (P7)
R11 R        (0.005)   (0.005)   (0.003)EISENBERG 72 HBC      PHOTOPRODUCTION   11/71
R11R M       0.0045    0.0011              MAY       77 SPEC +- 9.7 GAM N,A2 X   12/77*
R11 R   PION EXCHANGE MODEL USED IN THIS ESTIMATION
R11  M  MAY 77 GIVE PARTIAL WIDTH 460+/-110 KEV.

R12    A2 INTO (OMEGA PI PI)/(RHO PI)                                 (P4)/(P1)
R12          (0.19)    (0.08)              DEFOIX    73 HBC   0 0.7 PBAR P,7 PI  12/77*
R12    279   0.10      0.05                CHALOUPKA 73 HBC  - 3.9 PI- P,P A2   . 2/73
R12     60   0.28      0.09                DIAZ      74 DBC   0 6.PI+N,P(5PI)0    1/74
R12  K 140   (0.29)    (0.08)              KARSHON   74 HBC   0 4.9 PI+P,DEL++A2 12/77*
R12  K  60   (.10)     (.04)               KARSHON   74 HBC  + 4.9 PI+P,P A2+    12/77*
R12  K       0.18      0.08                KARSHON   74 HBC   AVG OF ABOVE TWO   12/77*
R12  K  KARSHON 74 SUGGEST AN ADDITIONAL I=0 STATE, STRONGLY COUPLED
R12  K  TO OMEGA PI PI  COULD EXPLAIN DISCREPANCIES IN BRANCHING RATIOS
R12  K  AND MASSES. WE USE A CENTRAL VALUE AND A SYST. SPREAD.
R12          . . . . . . . . . .
R12 AVG      0.151     0.049    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R12 STUDENT  0.150     0.046    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R12 FIT      0.151     0.040   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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REFERENCES FOR A2


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ADERHOLZ 64 PL 10 248            (AACHEN+BERLIN+BIRM+BONN+HAMBURG+LOIC+MPIM)
CHUNG    64 PRL 12 621           +DAHL,HARDY,HESS,KALBFLEISCH,KIRZ         (LRL)
GOLDHABE 64 DUBNA CONF  1 480 G GOLDHABER,S GOLDHABER,OHALLORAN,SHEN(LRL)
LANDER   64 PRL 13 346           +ABOLINS,CARMONY,HENDRIKS,XUONG+ (LA JOLLA)

ABOLINS  65 ATHENS(OHIO)CONF. +CARMONY,LANDER,XUONG,YAGER        (LA JOLLA)I=1
ADERHOLZ 65 PR 138 B 897            (AACHEN+BERL+BIRM+BONN+HAMB+LOIC+MPIM)
ALITTI   65 PL 15 69             ALITTI,BATON,DELER,CRUSSARD+  (SACLAY+BGNA)  JP
CHUNG    65 PRL  15  325         +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER    (LRL)
FORINO   65 PL 19 68             +GESSAROLI+        (BGNA+BARI+FIRZ+ORSA+SACL)
LEFEBVRE 65 PL 19 434            CERN MISSING MASS SPECTROMETER GROUP (CERN)
SEIDLITZ 65 PRL 15 217           L SEIDLITZ,O I DAHL,D H MILLER         (LRL)

BARNES   66 PRL 16 41            BARNES,FOWLER,LAI,ORENSTEIN +     (BNL+CUNY)
BENSON   66 MICH COO-1112-4      G.C.BENSON, THESIS                    (MICH)
   ALSO  66 PRL 16 1177          G BENSON,LOVELL,MARQUIT,ROE  +        (MICH)
EHRLICH  66 PR 152 1194          R. EHRLICH,W.SELOVE,H.YUTA            (PENN)
FERBEL   66 PL 21 111            FERBEL                           (ROCHESTER)
LEVRAT   66 PL   22  714         CERN MISSING MASS SPECTROMETER GROUP (CERN)

ARMENISE 67 PL 25B 53            ARMENISE,FORINO,+    (BARI+BGNA+FIRZ+ORSAY)
BALTAY   67 PL 25B 160           +KIRSCH+KUNG+YEH+RABIN   (COLU+BNL+RUTGERS)
BARLOW   67 NC 50A 701           +LILLESTOL+MONTANET+  (CERN+CDEF+IRAD+LIVP)
BARTSCH  67 PL 25B 48            +DEUTSCHMANN+GROTE+COCCONI+(AACH+BERL+CERN)
BEUSCH   67 PL 25 B 357          +FISCHER,GOBBI,ASTBURY+           (ETHZ+CERN)
CASON    67 PRL 18 880           +LAMSA,BISWAS,DERADO,GROVES,+   (NOTREDAME)
CHIKOVAN 67 PL 25B 44            CERN MISSING MASS SPECTROMETER GROUP (CERN)
CHUNG    67 PRL 18 100           +DAHL,HARDY,HESS,KIRZ,MILLER           (LRL)
   ALSO  66 UCRL-16832           RICHARD I HESS--THESIS,BERKELEY        (LRL)
COHN     67 NP B1 57             +MCCULLOCH+BUGG+CONDO      (ORNL+UNIV.TENN.)
CONFORTO 67 NP B3 469            +MARECHAL,MONTANET+     (CERN+CDEF+IPN+LIVP)
CONTE    67 NC  51 A  175        +TOMASINI,CORDS+(GENOVA+HAMB+MILANO+SACLAY)
DAHL     67 PR 163 1377          +HARDY+HESS+KIRZ+MILLER                (LRL)
DANYSZ   67 NC 51 A 801          DANYSZ+FRENCH+SIMAK                   (CERN)
SLATTERY 67 NC 50A 377           +KRAYBILL+FORMAN+FERBEL         (YALE+ROCH)  JP

ARMENISE 68 PL 26B 336           ARMENISE,FORINO,+    (BARI+BGNA+FIRZ+ORSAY)
ASCOLI   68 PRL 20  1321         +CRAWLEY,MORTARA,SHAPIRO,BRIDGES+(ILLINOIS)  JP
BALLAM   68 PRL 21 934           +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)
BENZ     68 PL 28 B 233          CERN MISSING MASS SPECTROMETER GROUP (CERN)
BOESEBEC 68 NP B 4 501           BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983          +CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILAN+SACL)
CHUNG    68 PR 165 1491          S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER     (LRL)
CRENNELL 68 PRL 20 1318          +KARSHON+KWAN LAI,SCARR,SKILLICORN     (BNL)
DONALD   68 PL 26 B  327         +FRODESEN+BETTINI+   (LIVERPOOL+OSLO+PADUA)
FOSTER   68 NP B 8 174           +GAVILLET,LABROSSE,MONTANET,+    (CERN+CDEF)
FRIDMAN  68 PR 167 1268          +MAURER,MICHALON,OUDET+(HEID   +STRASBOURG)
JUNKMANN 68 NP B8 471            +COCCONI,+         (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430          +PRENTICE+COOPER+MANNER+     (TNTO+ANL+WISC)
LAMSA    68 PR 166 1395          +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
VON KROG 68 PL 27 B 253          +MIYASHITA,KOPELMAN,MARSHALL LIBBY   (COLO)

ADERHOLZ 69 NP B 11 259          +BARTSCH,+         (AACH+BERL+CERN+JAGL+WARS)
AGUILAR 169 PL 29 B  62          +EARLOW,JACOBS,DELLA NEGRA+(CERN+CDEF+LIVP)
AGUILAR 269 PL 29 B  241         M.AGUILAR-BENITEZ,J.BARLOW,+     (CERN+CDEF)
ANDERSON 69 PRL 22 1390          +COLLINS,+                        (BNL+CARN)
ARMENISE 69 LNC 2 501            +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
CHIKOVAN 69 PL 28 B  526         CERN MISSING MASS SPECTROMETER GROUP (CERN) JP
CRENNELL 69 PRL 22 1327          +KARSHON,KWAN WU LAI,+                (BNL)IJP
DONALD   69 NP B 12 325          +EDWARDS,FOSTER,MOORE             (LIVERPOOL)
EISENBER 69 PRL 23 1322          EISENBERG,HABER,BALLAM,CHADWICK+(REHO+SLAC)
VETLITSK 69 SJNP 9 596           VETLITSKY,GRIGOREYEV,GRISHIN,+        (ITEP)

ABRAMOVI 70 NP B 29 466          ABRAMOVICH,BLUMENFELD,BRUYANT,+       (CERN)  JP
ALSTON   70 PL 33 B 607          +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
ASCOLI   70 PRL 25 962           +BROCKWAY,CRAWLEY,EISENSTEIN,HANFT,+  (ILL)  JP
BASILE   70 LNC 4 838            +DALPIAZ,FRABETTI,MASSAM,+ (CERN+BGNA+STRB)
BAUD1    70 PL 31B  397          CERN BOSON SPECTROMETER GROUP         (CERN)
BAUD2    70 PHILAD.CONF.P.311 CERN BOSON SPECTROMETER GROUP            (CERN)
BAUD3    70 PL 31 B 401          CERN BOSON SPECTROMETER GROUP         (CERN)
BOCKMANN 70 NP B 16 221          +MAJOR,POLS,+    (BONN+DURH+NIJM+EPOL+TORI)
BUTLER   70  UCRL 19845          THESIS                                 (LRL)
CAROLL   70 PRL 25 1393          +FIREBAUGH,GARFINKEL,MORSE,OH,+ (WISC+TNTO)
CASO     70 LNC 3 707            +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
DIAZ     70 NP B 16 239          +GAVILLET,LABROSSE,MONTANET+     (CERN+CDEF)JP
DZIERBA  70 PR D 2 2544          +SHEPHARD,BISWAS,CASON,JOHNSON,KENNEY(NDAM)
   ALSO  68 LAMSA
GARFINKE 70 PL 33 B 536          GARFINKEL,AMMANN,CARMONY,YEN          (PURD)JPC
GORDON   70  COO 1195 179        THESIS,ILLINOIS                        (ILL)
JOHNSTON 70 NP B 24 253          +KEY,PRENTICE,YOON,GARFINKEL,+  (TNTO+WISC)
KRUSE    70 PHILAD.CONF.P.359 U.KRUSE, PARTIAL WAVE ANALYSIS           (ILL)  JP
NEF      70  THESIS+PRIV.COMM.CERN BOSON SPECTROMETER GROUP            (CERN)
SUTHERLA 70 PHILAD.CONF.P.369 G.SUTHERLAND,INTERFERING RESONANCE(GLASGOW)

AGUILAR  71 PR D 4 2583          AGUILAR-BENITEZ,EISNER,KINSON          (BNL)
ALSTON   71 PL 34 B 156          +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
BARNHAM  71 PRL 26 1494          +ABRAMS,BUTLER,COYNE,GOLDHABER,HALL,+ (LBL)
BEKETOV  71 SJNP 4 765           +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+ (ITEP)  JP
BINNIE1  71 PL 36 B 257          +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHMP)
BINNIE2  71 PL 36 B 537          +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHMP)
BOWEN    71 PRL 26 1663          +FARLES,FAISSLER,BLIEDEN,+       (NEAS+STON)
CRENNEL  71 PL 35 B 185          +GORDON,KWAN-WU LAI,SCARR              (BNL)
FARBER   71 NP B 29 237          +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
FOLEY    71 PRL 26 413           +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
GRAYER   71 PL 34 B 333          +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
LYNCH    71 UCRL 20022 AND 71 AMSTERDAM CONF.  G.LYNCH                 (LBL)
RINAUDO  71 NC 5 A 239           +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

ANKENBRA 72 PRL 29 1688          ANKENBRANDT,BRABSON,CRITTENDEN,HEINZ,+(IND)
BERENYI  72 NP B 37 621          +PRENTICE,STEENBERG,YOON,WALKER (TNTO+WISC)
BLOODWOR 72 NP B 37 203          BLOODWORTH,JACKSON,PRENTICE,YOON      (TNTO)
DAMERI   72 NC 9 A 1             +BORZATTA,GOUSSU,+          (GENO+MILA+SACL)
DIEBOLD  72  BATAV.CONF.         R.DIEBOLD  RAPPORTEUR TALK             (ANL)
EISENBER 72 PR D 5 15            EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
ESPIGAT  72 NP B 36 93           +GHESQUIERE,LILLESTOL,MONTANET  (CERN+CDEF)
FOLEY    72 PR D 6 747           +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
LASSILA  72 PRL 28 1491          LASSILA,YOUNG                         (IOWA)
MORSE    72 NP B 43 77           +OH,WALKER,JOHNSTON,YOON         (WISC+TNTO)

AMMANN   73 PR D 7 1345          +CARMONY,GARFINKEL,GUTAY,MILLER+(PURD+IUPU)
ANKEBRAN 73 PR D 8 2785          ANKEBRANDT,BRABSON,CRITTENDEN,HEINZ,+ (IND)
ANTIPOV  73 NP B 63 175          +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ANTIPOV1 73 NP B 63 153          +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ANTIPOV2 73 NP B 63 141          +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
CASON    73 NP B 64 14           +MADDEN,BISHOP,BISWAS,KENNEY,+        (NDAM)
CHALOUPK 73 PL 44 B 211          CHALOUPKA,DOBRZYNSKI,FERRANDO,LOSTY,+(CERN)
CONFORTO 73 PL 45 B 154          +MOBLEY,KEY,PERPOST,+  (EFI+FNAL+TNTO+WISC)
DEFOIX   73 PL 43 B 141          +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+      (CDEF)
EISENSTE 73 PR D 7 278           EISENSTEIN,SCHULTZ,ASCOLI,IOFFREDO,+  (ILL)
KEY      73 PRL 30 503           +CONFORTO,MOBLEY,+      (TNTO+EFI+FNAL+WISC)
TOET     73 NP B 63 248          +THUAN,MAJOR,RINAUDO,+(NIJM+BONN+DURH+TORI)

DIAZ     74 PRL 32 260           +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)
KARSHON  74 PRL 32 852           +MIKENBERG,PITLUCK,EISENBERG,RONAT+  (REHO)
OTTER    74 NP B80 1             +RUDOLPH+         (AACH+BERL+BONN+CERN+HEID)  JP
TABAK    74  BOSTON P. 46        +RONAT,ROSENFELD,LASINSKI+       (LBL+SLAC)  JP
THOMPSO1 74 PR D9 560            THOMPSON,GAIDOS,MCILWAIN,WILLMANN    (PURD)  JP
THOMPSO2 74 NP B69 381           THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+   (PURD)  JP

ABASHIAN 75 PRL 34 691           +BEAMER,BROSS,EISENSTEIN,+     (ILL+ANL+ISU)
EMMS     75 PL 58B 117           +JONES,KINSON,STACEY,BELL+ (BIRM+DURH+RHEL)  JP
LOSTY    75 PL 56B 96            +CHALOUPKA,MONTANET,GANDOIS+    (CERN+SACL)  JP
UNDERWOO 75 PR D11 2345          UNDERWOOD,CONFORTO,KEY+(EFI+FNAL+TNTO+WISC)
   ALSO  73 CONFORTO, 73 KEY
WAGNER   75 PL 58B 201           +TABAK,CHEW                            (LBL)  JP

FORINO   76 NC A 35 465          +GESSAROLI,+  BGNA+FIRZ+GENO+MILA+OXF+PAV
HANDLER  76 NP B 110 173         +PLANO,BRUCKNER,KOLLER,,+  (RUTG,STEV,SETO)
MARGULIE 76 PR D 14 667          +KRAMER,FOLEY,LOVE,LINDENBAUM,+  (BNL+CUNY)

CERRADA  77 NP B 126 241         +BLOCKZIJL,HEINEN,+     (AMST+CERN+NIJM+OXF)
CORDEN   77  RL-77-097/A         +DOWELL,GARVEY,JOBES+ (BIRM+RHEL+TELA+LOWC)  JP
GHIDINI  77  PREPRINT            +              (BARI+BONN+CERN+DARE+LIVP+MILA)  JP
MAY      77 PR D 16 1983         +ABRAMSON,ANDREWS,BUSNELLO,+    (ROCH+CORN)
PAWLICKI 77 PR D 15 3196         +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)I J

MARTIN   78  PREPRINT CERN       +OZMUTLU,BALDI,+             (DURH+GEVA+CERN)  JP
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E(1420)

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 6  E(1420,JPG=A +) I=0

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        6  E MASS (MEV)

M          1425.        7.             BAILLON   67 HBC     0. PBAR P         11/66
M          1420.       20.             DAHL      67 HBC     1.6-4.2 PI- P      9/66
M          1423.0      10.0            FRENCH    67 HBC       3-4 PBAR P       6/67
M       310 1420.       7.             LORSTAD   69 HBC   0.7 PB P, 4,5-BODY   9/69
M       170 1398.      10.             DEFOIX    72 HBC     0.7 PBAR P,7 PI    1/73
M       280 1406.       7.             DUBOC     72 HBC     1.2 PBAR P,2K4PI  12/72
M         (1417.5)     (4.)            NACASCH   77 HBC   0  .7,.76 PBAR P    12/77*
M            . . . . . . . . . .
M   AVG     1415.5      4.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
M   STUDENT1416.0       4.3     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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Data Card Listings

For notation, see key at front of Listings.

Mesons

E(1420), X(1410–1440), f'(1515)

6 E WIDTH (MEV)

W		80.	10.		BAILLON	67 HBC	0. PBAR P	11/66
W		60.0	20.0		DAHL	67 HBC	1.6-4.2 PI- P	10/66
W		45.	20.		FRENCH	67 HBC	3-4 PBAR P	6/67
W	310	60.	20.		LORSTAD	69 HBC	0.7 PB P, 4,5-BODY	9/69
W	170	50.	10.		DEFOIX	72 HBC	0.7 PBAR P,7 PI	1/73
W	280	50.	12.		DUBOC	72 HBC	1.2 PBAR P,2K4PI	12/72
W		(53.)	(20.0)		NACASCH	77 HBC	0 .7,.76 PBAR P	12/77*
W		. . . . .						
W	AVG	59.8	6.0		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)			
W	STUDENT	58.3	6.7		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

6 E PARTIAL DECAY MODES

		DECAY MASSES
P1	E INTO K K*(892)	497+ 892
P2	E INTO K KBAR PI	497+ 497+ 139
P3	E INTO PI PI RHO	134+ 134+ 776
P4	E INTO DELTA PI	980+ 139
P5	E INTO ETA PI PI	548+ 139+ 139

6 E BRANCHING RATIOS

R1	E INTO (KBAR K*(892) + C.C.)/(K KBAR PI)			(P1)/(P2)		
R1	.50 .10		BAILLON	67 HBC	0.0 PBAR P	11/66
R2	E INTO (PI PI RHO) / (K KBAR PI)			(P3)/(P2)		
R2	(2.0) OR LESS		DAHL	67 HBC	0 1.6-4.2 PI- P	.10/66
R3	E INTO (ETA 2 PI)/(K KBAR PI)			(P5)/(P2)		
R3	(1.5) OR LESS CL=.95		FOSTER	68 HBC	- 0.0 PBAR P	9/69
R3	1.5 0.8		DEFOIX	72 HBC	0.7 PBAR P	1/73
R4	E INTO (DELTA PI)/(ETA PI PI)			(P4)/(P5)		
R4	0.4 0.2		DEFOIX	72 HBC	0.7 PBAR P,7 PI	1/73

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REFERENCES FOR E

BAILLON 67 NC 50A 393	+EDWARDS+D-ANDLAU+ASTIER+	(CERN+CDEF+IRAD)
BARASH 67 PR 156 1399	BARASH,KIRSCH,MILLER,TAN	(COLUMBIA)
DAHL 67 PR 163 1377	+HARDY+HESS+KIRZ+MILLER	(LRL)I JP
ALSO 65 PRL 14 1074	MILLER,CHUNG,DAHL,HESS,HARDY,KIRZ+(LRL+UCB)	
FRENCH 67 NC 52A 438	+KINSON+MCDONALD+RIDDIFORD+	(CERN+BIRM)
FOSTER 68 NP B 8 174	+GAVILLET,LABROSSE,MONTANET,+	(CERN+CDEF)
BETTINI 69 NC 62 A 1038	+CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)IC	
LORSTAD 69 NP B 14 63	B.LORSTAD,D-ANDLAU,ASTIER,+	(CDEF+CERN) JP
DEVONS 71 PRL 27 1614	+KOZLOWSKI,HORWITZ,+	(COLU+SYRA)
CHAPMAN 72 NP B 42 1	+CHURCH,LYS,MURPHY,RING,VANDER VELDE	(MICH)
DEFOIX 72 NP B 44 125	+NASCIMENTO,BIZZARRI,+	(CDEF+CERN)
DUBOC 72 NP B 46 429	+GOLDBERG,MAKOWSKI,DONALD,+	(LPNP+LIVP)
VUILLEMI 75 LNC 14 165	VUILLEMIN,+	(LAUS+NEUC+LPNP+LIVP+GLAS) JP
HANDLER 76 NP B 110 173	+PLANO,BRUCKER,KOLLER+	(RUTG+STEV+SETO)
VUILLEMI 76 NC 33A 133	+VUILLEMIN,+	(LAUS+NEUC+LPNP+LIVP+GLAS)
EDWARDS 77 PREPRINT	+LEGACEY+(OTTAWA+MONTREAL+COLUMBUS+TORONTO)	
GRASSLER 77 NP B 121 189	+(AACHEN+BERLIN+BONN+CERN+CRACOW+HEID+WARS)	
NACASCH 77 PREPRINT	+DEFOIX,DOBRZYNSKI+	(CDEF+MADR+CERN+TATA)

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X(1410–1440)

38 X(1410-1440)

THIS ENTRY LIST PEAKS OF LOW STATISTICAL SIGNIFICANCE, SEEN IN RHOO RHOO OR K KBAR. OMITTED FROM TABLE.

38 X(1410-1440) MASS (MEV)

M	-------RHOO RHOO MODE--------							
M	(1410.0)				BETTINI	66 DBC	0 0. PBAR N,5 PI	2/74
M	-------KS KS MODE ----------							
M	B POSSIBLY SEEN				ABRAMS	67 HBC	4.25 K- P	5/67
M	B THE AUTHORS ASSOCIATE THE PEAK WITH THE F PRIME, BUT BACKGROUND							
M	B ESTIMATION IS DIFFICULT							
M	1412.	23.			BARLOW	67 HBC	1.2 PBAR P	5/67
M	1439.0	5.0	6.0		BEUSCH	67 OSPK	5,7,12 PI-P	9/67
M	(1425.0)				FOLEY	71 CNTR	- 20.3 PI- P,K- KS	2/71
M	(1405.)				DEFOIX	73 HBC	0 0.7 PBAR P,7 PI	1/74
M	. . . . .							
M	AVG 1437.5	5.3			AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
M	STUDENT1437.7	5.9			AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

38 X(1410-1440) WIDTH (MEV)

W	-------RHOO RHOO MODE--------							
W	(90.0)				BETTINI	66 DBC	0 0. PBAR N,5 PI	2/74
W	-------KS KS MODE ----------							
W	100.	70.			BARLOW	67 HBC	1.2 PBAR P	5/67
W	43.0	17.0	18.0		BEUSCH	67 OSPK	5,7,12 PI-P	9/67
W	(20.0) OR LESS				FOLEY	71 CNTR	- 20.3 PI- P,K- KS	2/71
W	(40.)				DEFOIX	73 HBC	0 0.7 PBAR P,7 PI	1/74
W	. . . . .							
W	AVG 46.4	17.0			AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
W	STUDENT 46.2	18.5			AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

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REFERENCES FOR X(1410-1440)

BETTINI 66 NC 42A 695	+CRESTI,LIMENTANI,LORIA,PERUZZO+(PADO+PISA)	
ABRAMS 67 PRL 18 620	+KEHOE,GLASSER,SECHI-ZORN,WOLSKY	(MARYLAND)
BARLOW 67 NC 50 A 701	+MONTANET,D-ANDLAU+	(CERN+CDEF+IRAD+LIVP)
BEUSCH 67 PL 25 B 357	+FISCHER,GOBBI,ASTBURY+	(ETHZ+CERN)
DONALD 69 NP B 11 551	+EDWARDS,BURAN,BETTINI,+	(LIVP+OSLO+PADO)
FOLEY 71 PRL 26 413	+LOVE,OZAKI,PLATNER,LINDENBAUM,+	(BNL+CUNY)
DEFOIX 73 PL 43 B 141	+DOBRZYNSKI,ESPIGAT,NASCIMENTO,+	(CDEF)

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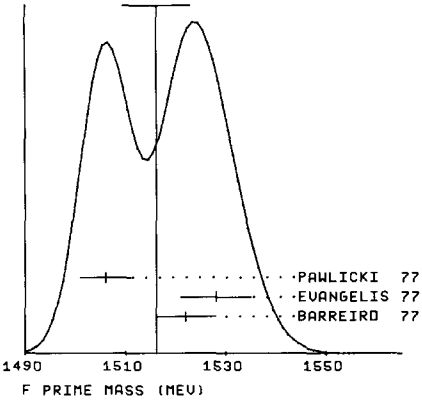
f'(1515)

13 F PRIME(1515,JPG=2++) I=0

13 F PRIME MASS (MEV)

M	P	14(1480.0)			CRENNELL	66 HBC	6.0 PI- P	8/66
M	B	5(1460.)	(10.)		ABRAMS	67 HBC	4.25 K- P,KS KS	5/67
M	B	BACKGROUND ESTIMATION DIFFICULT.						5/67
M	P	(1515.0)	(7.0)		AMMAR	67 HBC	5.5 K-P,K KBAR	9/67
M	P	100(1519.)	(7.)		AGUILAR	72 HBC	3.9,4.6 K-,K KB	12/72
M	P	46(1514.)	(4.)		COLLEY	72 HBC	10.K+ P,K+ K-	12/72
M	P	47(1521.)	(7.)		VIDEAU	72 HBC	4.K- P,K KBAR	12/72
M	EP	120(1527.0)	(6.0)		BRANDENBU	76 ASPK	13.K-P,K+K-	7/77*
M		123 1522.0	6.0		BARREIRO	77 HBC	4.15 K-P,KS KS	7/77*
M		166 1528.	7.		EVANGELIS	77 OMEG	10 K- P	12/77*
M	C	1506.0	5.0		PAWLICKI	77 SPEC	6.PI N,K+K-	12/77*
M		. . . . .						
M	AVG	1516.1	6.7		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)			
M	STUDENT	1517.1	4.9		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT (SEE IDEOGRAM BELOW)			

WEIGHTED AVERAGE = 1516.1 ± 6.7
ERROR SCALED BY 2.0



M	C	WITH A PHASE SHIFT ANALYSIS
M	E	MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE.
M	P	F-A2-F PRIME INTERFERENCE IN K+K- FINAL STATE NOT ACCOUNTED FOR.

13 F PRIME WIDTH (MEV)

W	B	5 (53.)	(18.)		ABRAMS	67 HBC	4.25 K- P,KS KS	5/67
W	B	BACKGROUND ESTIMATION DIFFICULT.						5/67
W	P	(35.0)	(25.0)		AMMAR	67 HBC	5.5 K-P, K KBAR	9/67
W	P	100 (69.)	(22.)		AGUILAR	72 HBC	3.9,4.6 K-P,K KB	12/72
W	P	46 (28.)	(15.)		COLLEY	72 HBC	10.K+ P,K+ K-	12/72
W	EP	47 (40.)	(20.)		VIDEAU	72 HBC	4.K- P,K KBAR	12/72
W	EP	120 (61.0)	(22.0)		BRANDENBU	76 ASPK	13.K-P,K+K-	7/77*
W		123 62.0	19.0	14.0	BARREIRO	77 HBC	4.15 K-P,KS KS	7/77*
W		166 72.0	25.0		EVANGELIS	77 OMEG	10 K- P	12/77*
W	C	66.0	10.0		PAWLICKI	77 SPEC	6.PI N,K+K-	12/77*
W		. . . . .						
W	AVG	65.7	8.1		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
W	STUDENT	65.7	8.7		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

W	C	WITH A PHASE SHIFT ANALYSIS
W	E	WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE.
W	P	F-A2-F PRIME INTERFERENCE IN K+K- FINAL STATE NOT ACCOUNTED FOR.

13 F PRIME PARTIAL DECAY MODES

		DECAY MASSES
P1	F PRIME INTO PI+ PI-	139+ 139
P2	F PRIME INTO K KBAR	497+ 497
P3	F PRIME INTO K K*(892)	493+ 892
P4	F PRIME INTO ETA ETA	548+ 548
P5	F PRIME INTO PI PI ETA	139+ 139+ 548
P6	F PRIME INTO PI K KBAR	139+ 497+ 497
P7	F PRIME INTO PI+ PI+ PI- PI-	139+ 139+ 139+ 139

13 F PRIME BRANCHING RATIOS

R1	F PRIME INTO (PI+ PI-)/(K KBAR)			(P1)/(P2)		
R1	(.01) OR LESS		BEUSCH	75 OSPK	8.9 PI-P,KO KO N	12/77*
R1	(0.06) OR LESS CL=0.90		BRANDENBU	76 ASPK	13.K-P,K+K-	7/77*
R1	(0.043)OR LESS CL=0.95		BARREIRO	77 HBC	4.15 K-P,KS KS	7/77*
R1 C	0.011	0.003	PAWLICKI	77 SPEC	6.PI N,K+K-	12/77*
R1 C	THEY GIVE (PI PI)/TOTAL = (1.2+-0.4) PER CENT. THE F- F PRIME					
R1 C	INTERFERENCE TERM CAN BE SEPARATED FROM THE F PRIME-A2 TERM.					
R3	F PRIME INTO (ETA ETA)/(K KBAR)			(P4)/(P2)		
R3	(0.50) OR LESS		BARNES	67 HBC	4.6, 5.0 K- P	10/67
R4	F PRIME INTO (PI PI ETA)/(K KBAR)			(P5)/(P2)		
R4	(0.3) OR LESS CL=.67		AMMAR	67 HBC		10/67
R4 A	(0.25) (0.13)		BARNES	67 HBC	4.6, 5.0 K- P	10/67
R4 A	SUPERSEDED BY AGUILAR 72					
R4	(0.41) OR LESS CL=.95		AGUILAR	72 HBC	3.9,4.6 K- P	12/72
R5	F PRIME INTO (PI K KBAR + K K*(892))/(K KBAR)			(P6+P3)/(P2)		
R5	(0.4) OR LESS CL=.67		AMMAR	67 HBC		10/67
R5	(0.35) OR LESS CL=.95		AGUILAR	72 HBC	3.9,4.6 K- P	12/72
R6	F PRIME INTO (PI+ PI+ PI- PI-)/(K KBAR)			(P7)/(P2)		
R6	(0.32) OR LESS CL=.95		AGUILAR	72 HBC	3.9,4.6 K- P	12/72

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Mesons

f'(1515), $F_1(1540)$, $\rho'(1600)$


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                              REFERENCES FOR F PRIME

BARNES    65 PRL 15 322       +CULWICK,GUIDONI,KALBFLEISCH,GOZ+(BNL+SYRA)

CRENNELL 66 PRL  16  1025     + KALBFLEISCH,LAI,SCARR,SCHUMANN +    (BNL)I

ABRAMS    67 PRL 18 620       +KEHOE,GLASSER,SECHI-ZORN,WOLSKY (MARYLAND)
AMMAR     67 PRL  19  1071    +DAVIS,HWANG,DAGAN,DERRICK +      (NWES+ANL)  JP
BARNES    67 PRL  19  964     +DORNAN,GOLDBERG,LEITNER +    (BNL+SYRACUSE)ICJP
ALITTI    68 PRL 21 1705      +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+  (BNL)

LORSTAD   69 NP B 14 63       B.LORSTAD,D-ANDLAU,ASTIER,+       (CDEF+CERN)
SCOTTER   69 NC 62 A 1057     +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)

AGUILAR   72 PR D 6 29        AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS    (BNL)
COLLEY    72 NP B 50 1        +JOBES,RIDDIFORD,GRIFFITHS,+      (BIRM+GLAS)
VIDEAU    72 PL 41 B 213      +VIDEAU,ROUGE,BARRELET,DEBRION,+(EPOL+SACL)

BEUSCH    75 PL 60 B 101      +BIRMAN,WEBSDALE,WETZEL           (CERN+ETHZ)

BRANDENB 76 NP B 104 413      BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)

BARREIRO 77 NP B 121 237      +DIAZ,GAY,HEMINGWAY,+  (CERN+AMST+NIJM+OXF)
EVANGELI 77 NP B 127 384      EVANGELISTA,+    (BARI+BONN+CERN+DARE+GLAS+)
LAVEN     77 NP B 127 43      +OTTER,KLEIN,+     (AACH+BERL+CERN+LCIC+WIEN)
PAWLICKI 77 PR D 15 3196      +AYRES,COHEN,DIEBOLD,KRAMER,WICKLUND  (ANL)I JP

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$F_1(1540)$ 47 F1(1540,JPG=) I=1

→ JP = 2-,1+ FAVORED.
A NEW EXPERIMENT (CERRADA 77, MONTANET 77)
WITH 5 TIMES THE STATISTICS OF AGUILAR 69 DOES
NOT CONFIRM THE F1. OMITTED FROM TABLE.

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                              47  F1 MASS (MEV)

M        10(1490.0)   (20.0)           ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI.11/69
M       142 1540.0     5.0            AGUILAR   69 HBC     0.7PBARP,KKBARPI 11/69
M        25(1543.0)   (3.0)           DUBOC     71 HBC     0 1.1-1.2 PBAR P . 2/72
M   B    70(1557.)    (10.)           BAKKEN    75 HBC  +  19 PP,PN3PI       12/75
M   B    DUBIOUS BACKGROUND SUBTRACTION

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                              47  F1 WIDTH (MEV)

W        10   (85.0)   (39.0)           ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI 11/69
W       142    40.0     15.0            AGUILAR   69 HBC     0.7PBARP,KKBARPI 11/69
W        25   (16.0)   (10.0)           DUBOC     71 HBC     0 1.1-1.2 PBAR P   2/72
W   B    70   (40.)    (10.)            BAKKEN    75 HBC  +  19 PP,PN3PI       12/75
W   B    DUBIOUS BACKGROUND SUBTRACTION

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                              47  F1 PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1      F1 INTO K KBAR PI                                       134+ 497+ 497
P2      F1 INTO K*(892) KBAR                                    892+ 497
P3      F1 INTO 3 PI                                            139+ 139+ 139

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                              REFERENCES FOR F1

ADERHOLZ 69 NP B 11 259       +BARTSCH,+        (AACH+BERL+CERN+CRAC+WARS)
AGUILAR  69 PL 29 B 379       +BARLOW,JACOBS,D-ANDLAU,ASTIER+ (CERN+CDEF)
AGUILAR  69 NP B 14 195       +BARLOW,JACOBS,D-ANDLAU,ASTIER+ (CERN+CDEF)

DUBOC     71 PL 34 B 343      +GOLDBERG,MAKOWSKI,TOUCHARD,+   (IPNP+LIVP)

CHAPMAN  72 NP B 42 1         +CHURCH,LYS,MURPHY,RING,VANDER VELDE (MICH)
DUBOC     72 NP B 46 429      +GOLDBERG,MAKOWSKI,DONALD,+       (LPNP+LIVP)

BAKKEN    75 NP B90 227       +JACOBSEN,OLSSON,SKJEVLING              (OSLO)G=-

CERRADA   77  PREPR.BUDAPEST C +DIAZ,FERRANDO,GARZON+(MADR+TATA+CERN+CDEF)
MINNAERT 77  PREPRINT         +BILLY,+     (BORD+LPNP+LAUS+NEUC+LIVP+GLAS)  JP
MONTANET 77  PRIVATE COMMUN.  L. MONTANET                        (CERN)

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$\rho'(1600)$ 65 RHO PRIME(1600,JPG=1-+) I=1

The $\rho'(1600)$ was first seen in

$$\gamma \text{ (real or virtual)} \rightarrow \rho'^0 \rightarrow \rho^0\pi^+\pi^-$$

with the $\pi^+\pi^-$ pair apparently in an S wave (BINGHAM 72, DAVIER 73, SCHACHT 74, ALEXANDER 75, LEE 75). A peak seen in the cross section of the reaction $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-$ has also been claimed as evidence for the ρ' (BARBARINO 72, CONVERSI 74); however, exchange mechanisms can be invoked that reproduce these results without any ρ' (HIRSCHFELD 74).

Evidence for a 2π decay has been looked for in several phase-shift analyses of one $\pi^-p \rightarrow \pi^-\pi^+n$ experiment (GRAYER 74). The first phase-shift solution found yielded clear evidence for $\rho' \rightarrow \pi^+\pi^-$ (HYAMS 73, OCHS 73). Since then, however, it has been recognized that at least four distinct solutions fit the data above 1.2 GeV (ESTABROOKS 75, HYAMS 75). The solutions denoted B,D by ESTABROOKS 75 exhibit the $\rho'(1600)$ whereas the solutions A,C do not. In several attempts to constrain the solutions further, COMMON 76 rules out solutions B and D, but does still find a ρ', JOHNSON 76 rule out A and C, FROGGATT 75,77 unambiguously prefer solution B and give $\rho'(1600)$ parameter values, and MARTIN 77 has a D-wave $\pi\pi$ resonance at 1600 MeV instead of the $\rho'(1600)$. This latter solution could be suspect because it corresponds to an exotic I = 2 exchange ($\pi^+\pi^- \rightarrow \pi^-\pi^+$). Note that none of the solutions has any evidence for a $\rho'(1250)$, claimed mainly by vector dominance arguments to explain the nucleon form factors. There is no clear evidence for a localized $\rho'(1250)$ peak in $e^+e^- \rightarrow \pi^+\pi^-$ nor in $e^+e^- \rightarrow 4\pi$ (BUDNEV 77); the enhancement above the $\rho(770)$ tail seen over a wide range of energies can be explained as an effect of inelasticity, due mainly to the opening of the $\omega\pi$ channel (ROOS 75, COSTA1 77). The $J^P = 1^-$ partial wave of the $\omega\pi$ system is strong in the 1250 MeV region, but does not exhibit a resonance behavior (CHALOUPKA 74, CHUNG 73,75, GESSAROLI 77).

The mass and width values listed below are only indicative, because for such a broad peak they are extremely dependent on the parametrization chosen (SMADJA 72). Note also that the mass dependence of the width will be strongly affected by the inelastic channels with their rather high thresholds. For the photoproduction data, possible diffractive background could explain the observed energy dependence of the width (SCHACHT 74).

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                              65  RHO PRIME MASS (MEV)

M       400 1430.      50.            BINGHAM    72 HBC     9.3 GAM P,P 4PI  12/72
M           1590.      20.            HYAMS      73 ASPK    17 PI-P,N PI+PI-  1/74
M           1550.      60.            CONVERSI   74 OSPK    E+ E- TO 4PI      12/75
M       160 1550.      50.            SCHACHT    74 STRC    5.5-9 G P,P 4PI   12/75
M       340 1450.     100.            SCHACHT    74 STRC    9-18 G P,P 4PI    12/75
M        65 1570.      60.            ALEXANDER  75 HBC     7.5 GAM P,P 4PI   12/75
M   P     1610.      30.              FROGGATT   77 RVUE    17 PI-P,PI+PI-N   12/77*
M   P    (1575.)                      MARTIN     77 RVUE    17 PI-P,PI+PI-N   12/77*
M        (1540.)    (30.)            LAPLANCHE  77 OSPK    E+E- TO 4PI,6PI    1/78*
M             . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

M   P    FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA

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Data Card Listings

For notation, see key at front of Listings.


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                    65  RHO PRIME WIDTH (MEV)

W      400  650.      100.          BINGHAM   72 HBC     9.3 GAM P,P 4PI   12/72
W           180.       50.          HYAMS     73 ASPK    17 PI-P,N PI+PI-  12/75
W           360.      100.          CONVERSI  74 OSPK    E+ E- TO 4PI      12/75
W  E   160  400.      120.          SCHACHT   74 STRC    5.5-9 G P,P 4PI   12/75
W  E   340  850.      200.          SCHACHT   74 STRC    9-18 G P,P 4PI    12/75
W  E    65  340.      160.          ALEXANDER 75 HBC     7.5 GAM P,P 4PI   12/75
W  P        300.      100.          FROGGATT  77 RVUE    17 PI-P,PI+PI-N   12/77*
W  P       (340.)                   MARTIN    77 RVUE    17 PI-P,PI+PI-N   12/77*
W          (220.)     (70.)         LAPLANCHE 77 OSPK    E+E- TO 4PI,6PI   1/78*
W           . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.1)

W  P    FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
W  E    WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE

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                    65  RHO PRIME PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     RHO PRIME INTO RHO PI PI                               139+ 139+ 776
P2     NEUTRAL RHO PRIME INTO ALL 4 CHARGED PI MODES          139+ 139+ 139+ 139
P3     RHO PRIME INTO RHO RHO                                 776+ 776
P4     RHO PRIME INTO PI PI                                   139+ 139
P5     RHO PRIME INTO KBAR K                                  493+ 493
P6     RHO PRIME INTO PI OMEGA                                139+ 783
P7     RHO PRIME INTO PI+ PI- PIO PIO                         139+ 139+ 134+ 134

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                    65  RHO PRIME BRANCHING RATIOS

R1     RHO PRIME INTO (RHO PI+ PI-)/(4 PI, ALL CHARGED) (P1)/(P2)
R1 S       DOMINANT                  BARBARINO 72 OSPK    E+E- TO 4 PI      1/73
R1 S         (.80)                   BINGHAM   72  HBC    9.3 GAM P,P 4PI   1/73
R1     500   0.7      0.1           SCHACHT   74 STRC    5.5-18 G P,P 4PI  12/75
R1 S    THE PI PI SYSTEM IS IN S WAVE                                       1/73

R2     RHO PRIME INTO (RHO 0 RHO 0)/(RHO 0 PI+ PI-)      (P3)/(P1)
R2           NONE    (FORBIDDEN BY I=1)BINGHAM   72  HBC    9.3 GAM P,P 4PI   1/73

R3     RHO PRIME INTO (PI+ PI-)/(4 PI, ALL CHARGED)      (P4)/(P2)
R3           (.2)  OR LESS  2 SIGMA  BINGHAM   72  HBC    0 9.3 GAM P,P 2PI   1/73
R3         (0.14) OR LESS  ESTIMATE DAVIER     73 STRC    0 6-18 G P,P 4PI    1/74

R4     RHO PRIME INTO (KBAR K)/(4 PI, ALL CHARGED)       (P5)/(P2)
R4           (.04) OR LESS  2 SIGMA  BINGHAM   72  HBC    0 9.3 GAM P         . 1/73

R5     RHO PRIME INTO (PI+PI-)/TOTAL                     (P4)
R5  E        (0.15) OR LESS            EISENBERG 73 HBC     5 PI+ P,DEL++2PI  1/74
R5  E   ESTIMATED USING CPE MODEL.
R5           0.25      0.05           HYAMS     73 ASPK    17 PI-P,N PI+PI-  1/74
R5           0.20      0.05           MONTANET  73 HBC     PBAR P AT REST    12/77*
R5 C       (0.20) OR LESS              COSTA 2   77 RVUE    E+E-,2 PI + 4 PI  12/77*
R5 C    ESTIMATE USING UNITARITY,TIME REVERSAL INVARIANCE,BREIT WIGNER       12/77*
R5 P          .30       .05           FROGGATT  77 RVUE    17 PI-P,PI+PI-N   12/77*
R5 P   BETWEEN 0.15 AND  0.30         MARTIN    77 RVUE    17 PI-P,PI+PI-N   12/77*
R5 P    FROM PHASE SHIFT ANALYSIS OF HYAMS 73 DATA
R5           . . . . . .
R5 AVG       0.250     0.029   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5 STUDENT   0.250     0.033   AVERAGE USING STUDENT10(N/1.11) -- SEE MAIN TEXT

R6     RHO PRIME INTO (PI+ PI- PIO PIO)/(4PI, ALL CHARGED)
R6                                                       (P7)/(P2)
R6           (1.)   OR LESS  ESTIMATE DAVIER     73 STRC    6-18 G P,P 4PI    1/74

R7     RHO PRIME INTO (PI+ PI- + NEUTRALS)/(4PI,ALL CHARGED)
R7                                                       (P7+....)/(P2)
R7  U        (2.6)    (0.4)           BALLAM    74 HBC     9.3 GAMMA P       12/75
R7  U   UPPER LIMIT. BACKGROUND NOT SUBTRACTED

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                          REFERENCES FOR RHO PRIME

ALVENSLE 71 PRL 26 273          ALVENSLEBEN,BECKER,BERTRAM,CHEN,+(DESY+MIT) G
BRAUN    71 NP B30 213          +FRIDMAN, GERBER, GIVERNAUD,+  (STRASBOURG) G
BULOS    71 PRL 26 149          +BUSZA,KEHOE,BENISTON,+  (SLAC+UMD+IBM+LBL) G

BACCI    72 PL 38B 551          +PENSO,SALVINI,STELLA,BALDINI-CE(ROMA+FRAS) JPC
BARBARIN 72 LNC 3 689           BARBARINO,CERADINI,+   (FRAS+ROMA+PADO+UMD)IGJP
BARTOLI  72 PR D 6 2374         +FELICETTI,OGREN,+              (FRAS+ROMA+NAPL)IGJP
BINGHAM  72 PL 41B 635          +RABIN,ROSENFELD,SMADJA,YOST+(LBL,UCB,SLAC)IGJP
BRAMON   72 LNC 3 693           +GRECO (THEORETICAL PAPER)          (FRASCATI)
DIEBOLD  72  BATAV.CONF.        R.DIEBOLD  RAPPORTEUR TALK                (ANL)
EISENBER 72 PR D 5 15           EISENBERG,BALLAM,DAGAN,+   (REHO+SLAC+TELA)
LAYSSAC  72 NC 10A 407          J.LAYSSAC,F.M.RENARD                     (MONP)
SMADJA   72 PHIL.CONF.PROC349 +BINGHAM,FRETTER,BALLAM,CHADWICK+(LBL+SLAC)

CERADINI 73 PL 43 B 341         +CONVERSI,EKSTRAND,GRILLI,+(ROMA+FRAS+PADO)IGJP
DAVIER   73 NP B 58 31          +DERADO,FRIES,LIU,MOZLEY,ODIAN,PARK,+(SLAC)
EISENBER 73 PL 43 B 149         EISENBERG,KARSHON,MIKENBERG,PITLUCK,+(REHO)
HYAMS    73 NP B 64 134         +JONES,WEILHAMMER,BLUM,DIETL,+   (CERN+MPIM)
KREUZER  73 PR D 8 1431         H.J.KREUZER,A.N.KAMAL    (UNIV. OF ALBERTA)
MONTANET 73 ERICE SCHOOL 518    L.MONTANET                               (CERN)
OCHS     73 THESIS              THESIS                                   (MPIM)
PARK     73 NP B 58 45          J.C.H.PARK                               (MPIM)  JP

BALLAM   74 NP B76 375          +CHADWICK,BINGHAM,FRETTER+  (SLAC+LBL+MPIM)
BERNABEI 74 LNC 11 261          +D.ANGELO,SPILLANTINI,VALENTE    (ROMA+FRAS)
CONVERSI 74 PL 52B 493          +PAOLUZI,CERADINI,GRILLI+        (ROMA+FRAS)
ESTABROO 74 NP B79 301          P.ESTABROOKS,A.D.MARTIN                  (DURH)
FERBEL   74 PR D9 824           T.FERBEL AND P.SLATTERY                  (ROCH)
GRAYER   74 NP B 75 189         G.GRAYER,HYAMS,BLUM,DIETL,+      (CERN+MPIM)
HIRSHFEL 74 NP B74 211          A.C.HIRSHFELD,G.KRAMER                   (HAMB)
SCHACHT  74 NP B81 205          +DERADO,FRIES,PARK,YOUNT                 (MPIM)

ALEXANDE 75 PL 57B 487          ALEXANDER,BENARY,GANDSMAN,LISSAUER+  (TELA)
ALLES    75 NC 30A 136          ALLES-BORELLI,BERNARDINI+  (CERN+BGNA+FRAS)
ESTABROO 75 NP B95 322          P.ESTABROOKS,A.D.MARTIN                  (DURH)
FROGGATT 75 NP B91 454          C.D.FROGGATT,J.L.PETERSEN        (GLAS+NORD)
HYAMS    75 NP B100 205         +JONES,WEILHAMMER,BLUM,DIETL+    (CERN+MPIM)
LANG     75 PL 58B 450          C.B.LANG,I.S.STEFANESCU                  (KARL)
LANGACKE 75 PR D 13 697         P.LANGACKER,G.SEGRE                      (PENN)
LEE      75 STANFORD CONF.213   WONYONG LEE                              (COLU)
ROOS     75 NP B 97 165         M.ROOS                                   (HELS)

BASSOMPI 76 PL 65 B 397         BASSOMPIERRE,BINDER,+        (MULH+STRB+TORI)
COMMON   76 NP B 103 109        A.K.COMMON                               (KENT)  JP
JOHNSON  76 PL 63 B 95          +MARTIN,PENNINGTON                (DURH+CERN)  JP

BUDNEV   77 PL 70 B 365         N.M.BUDNEV,V.M.BUDNEV,V.V.SEREBRYAKOV(NOVO)
COSTA 1  77 PL 67 B 213         COSTA DE BEAUREGARD,PHAM,PIRE,TRUONG  (EPOL)
COSTA 2  77 PL 71 B 345         COSTA DE BEAUREGARD,PIRE,T.N.TRUONG   (EPOL)
FROGGATT 77 NP B 129 89         C.D.FROGGATT,J.L.PETERSEN          (GLAS+BOHR)
LAPLANCH 77  HAMBURG CONF.      F. LAPLANCHE                             (ORSA)
MARTIN   77  PREPRINT TH.2353 A.D.MARTIN,M.R.PENNINGTON                (CERN)

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$A_3(1640)$

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34  A3(1640,JPG=2-+) I = 1
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The $A_3(1640)$ is seen as a bump in the diffractive-like process $\pi N \to (\pi\pi\pi)N$. The dominant effect is a ~300 MeV-wide enhancement in the $J^P = 2^-$ $f\pi$ S-wave system, starting from $f\pi$ threshold. Neither additional (narrower) structure in the 3π mass distribution, nor other decay modes, have been clearly established. The situation would appear to be similar to that of the A_1, but there are certain additional complications.

(a) Some experiments with incident π^- observe little variation of the $J^P = 2^-$ $f\pi$ phase in the A_3 mass region (ANTIPOV1 73, ASCOLI1 73). This is confirmed by GHIDINI 77 with a large-statistics experiment at 12 GeV/c using the OMEGA spectrometer. Even though there is a peak compatible with a Breit-Wigner shape, the phase of the 2^-S wave with respect to the 0^-S does not show any clear resonant behavior. On the other hand, PERNEGR 77 perform a PWA of the reaction $\pi^- A \to (\pi^+\pi^-\pi^-)A$ on nine different nuclear targets at 8.9, 12.9, and 15.1 GeV/c, and obtain evidence for resonance-like phase variations of the 2^-S and 2^-P waves relative to 1^+S and 1^+P. Thus they propose two decay modes: $f\pi$ via S wave and $\rho\pi$ via P wave.

(b) Experiments with incident π^+ have shown evidence for variations consistent with a resonance interpretation (OTTER 74, THOMPSON 74). This is not confirmed by BALTAY 77 (see also CAUTIS 77) with a PWA of $\pi^+ p \to (\pi^+\pi^+\pi^-)p$ at 15 GeV/c.

(c) In the non-diffractive charge-exchange reaction $\pi^+ p \to \pi^+\pi^-\pi^0\Delta^{++}$ at 7 GeV/c (WAGNER 75) and at 15 GeV/c (BALTAY 77 or CAUTIS 77), and in the hypercharge-exchange reaction $K^- p \to \pi^+\pi^-\pi^0\Lambda$ at 4.2 GeV/c (CERRADA 77), there is no evidence for A_3 production.

Mesons
$A_3(1640)$

Data Card Listings
For notation, see key at front of Listings.

(d) The A_3 region is not well described by the Deck-like model of Ascoli et al., although the agreement could probably be improved by a series of more or less well motivated adjustments to the model (ASCOLI2 73, ASCOLI 74). Nevertheless, relative phase variations of ~40° through the A_3 mass region are predicted for the 2^- fπ wave.

(e) Other partial waves contribute strongly in the A_3 region. The 2^- ρπ P wave may exhibit a broad enhancement; no phase variation relative to 2^- fπ is observed (ANTIPOV1 73, ASCOLI1 73, OTTER 74, THOMPSON 74, PERNEGR 77). ANTIPOV1 73 show some evidence for an enhancement in the 2^+ fπ P wave with M ~ 1750 MeV, Γ ~ 200 MeV. The relative phases are not inconsistent with a resonance interpretation. The 1^+D ρπ wave of PERNEGR 77 shows features of a resonance-like behavior with a mass ~1650 MeV and a width ~400 MeV.

Thus, while for the A_1 evidence for a resonance interpretation seems to be emerging, the new results for the A_3 are still contradictory and must await further clarification.

34 A3 MASS (MEV)

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M       30(1600.0)                      FORINO    65 DBC    04.5 PI+ D          10/66
M       20(1630.0)   (30.0)             VETLITSKY 66 HBC  -  4.7 PI- P          12/75
M         (1630.)    (10.)              BALTAY    68 HBC  +  7, 8.5 PI+ P       12/75
M         (1660.0)   (16.0)             BARTSCH   68 HBC  +  8. PI+ P,3PI P     12/75
M         (1610.)    (19.)              LAMSA     68 HBC  -  8.0 PI-P, PI-F     12/75
M       297(1673.0)  (40.0)             ARMENISE  69 DBC  +  5.1 PI+D,3PI++-     12/75
M         (1680.)    (20.0)             CASO      69 HBC  -  11 PI- P           5/70
M         (1660.0)   (20.0)             CASO      69 HBC  -  11 PI-P, PI-F      12/75
M         (1645.0)   (10.0)             CRENNELL  70 HBC  -  6. PI- P,F PI      12/75
M   M     (1633.0)   (12.0)             MIYASHITA 70 HBC  -  6.7 PI-P,PI-F      1/71
M   M   BACKGROUND SUBTRACTION DIFFICULT.
M         (1672.0)                      BEKETOV   71 HBC  -  4.45 PI- P         11/71
M         (1600.)    (50.)              PALER     71 DBC  +  13.PI+ D,D(3PI)+-.12/75
M       260(1660.)   (25.)              CASO      72 HBC  +  11.7 PI+ P         12/75
M   F     (1658.)    (8.)               HARRISON  72 HBC  -  13.,20. PI- P      12/72
M   F   FIT ASSUMES AN ADDITIONAL PEAK AT 1830 MEV.                              12/72
M   F   EVIDENCE FOR A SUBSTANTIAL DECAY INTO 3PI CLAIMED
M P       (1650.)    (30.)              ANTIPOV1  73 CNTR  -  25.,40. PI- P      12/75
M P       (1660.)    (10.)              ASCOLI 1  73 HBC  -  5.-25.PI- P,P A3    12/75
M P E     (1600.)    (10.)              THOMPSON  74 HBC  +  13. PI+ P,P A3+     12/75
M     E   EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
M     575(1640.)     (10.)              KALELKAR  75 HBC  +  15 PI+P,P PI+F     12/75
M   P 2000(1662.0)   (10.0)             BALTAY    77 HBC    0 15 PI+ P,P 3PI    12/77*
M   P 2000(1680.0)    (8.0)             GHIDINI   77 OMEG   -12 PI-P,P 3PI      12/77*
M     R     (1650.0)                    PERNEGR   77 CNTR  -  9+13+15,PI- NUC.  12/77*
M     R   CLEAR PHASE ROTATION SEEN IN (2-S) AND (2-P) WAVES
M   P     FROM A FIT TO JP=2- F PI PARTIAL WAVE
M
M   AVERAGING NOT MEANINGFUL
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34 A3 WIDTH (MEV)

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W       20 (100.)                       VETLITSKY 66 HBC  -  4.7 PI-P          6/66
W   M       (70.)    (40.)              BALTAY    68 HBC  +  7, 8.5 PI+ P      6/68
W         (115.0)    (45.0)             BARTSCH   68 HBC  +  8. PI+ P,3PI P    12/75
W   M     (100.)     (50.)    (30.)     LAMSA     68 HBC  -  8.0 PI-P  PI-F    11/67
W   A   297 (240.0)  (50.0)             ARMENISE  69 DBC  +  5.1 PI+D,3PI++-    5/70
W   A   BACKGROUND SUBTRACTION MODEL-DEPENDENT.                                 5/70
W         (130.)                        CASO      69 HBC  -  11 PI- P          6/68
W         (150.0)                       CASO      69 HBC  - 11.0 PI-P,PI- F    6/68
W         (130.0)    (30.0)             CRENNELL  70 HBC  -  6. PI- P,F PI  . 5/70
W   M     (37.0)     (24.0)             MIYASHITA 70 HBC  -  6.7 PI-P,PI-F     1/71
W   M   BACKGROUND SUBTRACTION DIFFICULT.
W         (128.0)                       BEKETOV   71 HBC  -  4.45 PI- P        11/71
W         (220.)     (80.)              PALER     71 DBC  +  13.PI+ D,D(3PI)+-.12/75
W P       200. TO 400.                  CASO      72 HBC  +  11.7 PI+ P        1/72
W       260 (190.)   (100.)             CASO      72 HBC  +  11.7 PI+ P        12/75
W   F     (53.)      (20.)    (16.)     HARRISON  72 HBC  -  13.,20. PI- P      12/72
W   F   FIT ASSUMES AN ADDITIONAL PEAK AT 1830 MEV.                             12/72
W   F   EVIDENCE FOR A SUBSTANTIAL DECAY INTO 3PI CLAIMED
W P       (300.)     (50.)              ANTIPOV1  73 CNTR  -  25.,40. PI- P     12/75
W P       (270.)     (60.)              ASCOLI 1  73 HBC  -  5.-25.PI- P,P A3  12/75
W   F E     (310.)     (40.)            THOMPSON  74 HBC  +  13. PI+ P,P A3+   12/75
W     E   EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
W     575 (240.)     (30.)              KALELKAR  75 HBC  +  15 PI+P,P PI+F     12/75
W   P 2000 (285.0)   (60.0)             BALTAY    77 HBC    0 15 PI+ P,P 3PI    12/77*
W   P 2000 (220.0)   (30.0)             GHIDINI   77 OMEG   -12 PI-P,P 3PI      12/77*
W     R     (400.0)                     PERNEGR   77 CNTR  -  9+13+15,PI- NUC.  12/77*
W     R   CLEAR PHASE ROTATION SEEN IN (2-S) AND (2-P) WAVES
W   P     FROM A FIT TO JP=2- F PI PARTIAL WAVE
W
W   AVERAGING NOT MEANINGFUL
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34 A3 PARTIAL DECAY MODES

		DECAY MASSES
P1	A3 INTO 3 PI	134+ 134+ 134
P2	A3 INTO RHO PI	134+ 776
P3	A3 INTO ETA PI	134+ 548
P4	A3 INTO 5 PI	139+ 139+ 139+ 139+
P5	A3 INTO K K*(892)	497+ 892
P6	A3 INTO K KBAR PI	497+ 497+ 134
P7	A3 INTO K KBAR	497+ 497
P8	A3 INTO F PI	1271+ 134
P9	A3 INTO OMEGA PI PI	783+ 134+ 134

34 A3 BRANCHING RATIOS

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R2     A3+- INTO (PI+- RHO0)/(ALL PI+- PI+ PI-)          (P2C)/(P1C)
R2           (0.3)  OR LESS            BARTSCH   68 HBC  +  8. PI+ P,3PI P   8/69
R2           (0.4)  OR LESS            FERBEL    68 RVUE +-                  . 9/68
R2           (.18) OR LESS  CL=.95     PALER     71 DBC  +  13.P++ D,D(3P+)+ 11/71

R3     A3+- INTO (PI+- F)/(ALL PI+- PI+ PI-)             (P8)/(P1C)
R3                (WITH F INTO PI+ PI-)
R3            INDICATION SEEN           LUBATTI   66 HLBC     16 PI-          11/66
R3           (0.59)FOR JP=2-            BARTSCH   68 HBC  +  8. PI+ P,3PI P   8/69
R3           (0.51)FOR JP=1+            BARTSCH   68 HBC  +  8. PI+ P,3PI P   8/69
R3           (0.20)FOR JP=0-            BARTSCH   68 HBC  +  8. PI+ P,3PI P   8/69
R3           (0.35)    (0.20)           BALTAY    68 HBC  +  7-8.5 PI+P       . 5/68
R3            CONSISTENT WITH 1.0       CASO      68 HBC  -  11 PI- P          6/68
R3           (0.76)    (0.24)   (0.34) ARMENISE  69 DBC  +  5.1 PI+D,3PI++-   5/70
R3            CONSISTENT WITH 1.0       CRENNELL  70 HBC  -  6. PI- P,F PI  . 5/70
R3            (.85) OR MORE  CL=.95     PALER     71 DBC  +  13.P++ D,D(3P+)+ 11/71
R3            CONSISTENT WITH 1.0       LICHTMAN  74 HBC  +- 18.5 PI+-P,P 3PI 12/75
R3            CONSISTENT WITH 1.0       KALELKAR  75 HBC  +  15 PI+P,P 3PI    12/75

R5     A3+- INTO (PI+- ETA)/(ALL PI+- PI+ PI-)           (P3)/(P1C)
R5                (ALL ETA DECAYS)
R5           (0.09) OR LESS            BALTAY    68 HBC  +  7-8.5 PI+P         5/68
R5           (0.10) OR LESS            CRENNELL  70 HBC  -  6. PI- P,F PI      5/70

R6     A3+- INTO (PI+- 2PI+ 2PI-)/(ALL PI+- PI+ PI-)     (P4C)/(P1C)
R6           (0.1)  OR LESS            BALTAY    68 HBC  +  7,8.5 PI+ P        6/68
R6           (0.10) OR LESS            CRENNELL  70 HBC  -  6. P+- P,F P+      5/70

R8     A3+- INTO (RHO PI)/(F PI)                         (P2)/(P8)
R8           (0.03)   (0.37)   (0.03) CASO      69 HBC  -  11 PI- P          12/75

R9     A3+- INTO (PI+- PI+ PI-)/(F PI)                   (P1C-P8)/(P8)
R9           (0.06)   (0.47)   (0.06) CASO      69 HBC  -  11 PI- P          12/75
R9         POSSIBLY SEEN               HARRISON  72 HBC  -  13.,20. PI- P     12/72

R10    A3+- INTO (UNCORREL.PI+- PI+ PI-)/(ALL PI+- PI+ PI-)
R10 M        (.05) OR LESS  CL=.95     PALER     71 DBC  +  13. PI+D,D(3PI)+ 11/71
R10 M  MODEL DEPENDENT FIT
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REFERENCES FOR A3

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FORINO    65 PL 19 68          +GESSAROLI+      (BGNA+BARI+FIRZ+ORSA+SACL)
FOCACCI   66 PRL  17  890      CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT    66 PL   22  714      CERN MISSING MASS SPECTROMETER GROUP (CERN)
LUBATTI   66 THESIS BERKELEY   H.J.LUBATTI                          (LRL)1-2-
VETLITSK 66 PL   21  579       VETLITSKY,GUSZAVIN,KLIGER,ZOLGANOV+  (ITEP)
DANYSZ    67 NC 51 A 801       DANYSZ+FRENCH+SIMAK                  (CERN)
DUBAL     67 NP B3 435         CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO   68 THESIS 1456       L.DUBAL                              (GENEVE)

BALTAY    68 PRL 20 887        +KUNG+YEH+FERBEL+     (COLU+ROCH+RUTG+YALE) I=1
BARTSCH   68 NP B 7 345        +KEPPEL,KRAUS,+              (AACH+BERL+CERN) JP
CASO      68 NC 54 A 983       +CONTE+CORDS+DIAZ+  (GENOVA+HAMB+MILA+SACL)
FERBEL    68 PHILA.CONF.335    T.FERBEL                          (ROCHESTER)
IOFFREDO  68 PRL 21 1212       +BRANDENBURG,BRENNER,EISENSTEIN+  (HARVARD)
LAMSA     68 PR 166 1395       +CASON+BISWAS+DERADO+GROVES+      (NDTREDAME)

ARMENISE 69 LNC 2 501          +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
BARNES    69 PRL 23 142        +CHUNG,EISNER,FLAMINIO,+                (BNL)
CASO      69 LNC 2 437         +CONTE,TOMASINI,CANTORE+   (GENO+MILA+SACL)
   ALSO   68 CASO

BRANDENB 70 NP B16 369         +BRENNER,IOFFREDO,JOHNSON,KIM+     (HARVARD)
CRENNELL 70 PRL 24 781         +KARSHON,LAI,SCARR,SIMS                 (BNL)
CHIEN     70 PHILAD.CONF.P.275 C.Y.CHIEN; REVIEW                (JOHNS HOPKINS)
MIYASHIT 70 PR D 1 771         MIYASHITA,VON KROGH,KOPELMAN,LIBBY   (COLO)

BEKETOV   71 SJNP 4 765        +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+  (ITEP)  JP
PALER     71 PRL 26 1675       +BADEWITZ,BARTON,MILLER,PALFREY,TEBES(PURD)

ALEXANDE 72 NP B 45 29         ALEXANDER,BAR-NIR,BENARY,DAGAN,+       (TELA)
ARMENISE 72 LNC 4 201          +FORINO,CARTACCI,+           (BARI+BGNA+FIRZ)
CASO      72 NP B 36 349       +MADDOCK,BASSLER+(DURH+GENO+DESY+MILA+SACL)
HARRISON 72 PRL 28 775         +HEYDA,JOHNSON,KIM,LAW,MUELLER,+       (HARV)
SALZBERG 72 NP B 41 397        +HARRISON,HEYDA,JOHNSON,KIM,LAW,+      (HARV)

ANTIPOV1 73 NP B 63 153        +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ANTIPOV2 73 NP B 63 141        +ASCOLI,BUSNELLO,FOCACCI,+       (CERN+SERP)  JP
ASCOLI 1 73 PR D 7 669         INTERNAT. COLLABORATION                (ILL+)  JP
ASCOLI 2 73 PR D 8 3894        +JONES,WEINSTEIN,WYLD                  (ILL)   JP

ASCOLI    74 PR D9 1963        +CUTLER,JONES,KRUSE,ROBERTS,WEINSTEIN+ (ILL)
LICHTMAN  74 NP B81 31         +BISWAS,CASON,KENNEY,MCGAHAN,+         (NDAM)
OTTER     74 NP B80 1          +RUDOLPH+          (AACH+BERL+BONN+CERN+HEID)  JP
TABAK     74  BOSTON           +RONAT,ROSENFELD,LASINSKI+       (LBL+SLAC)  JP
THOMPSON  74 PRL 32 331        +BADEWITZ,GAIDOS,MCILWAIN,PALER,+    (PURD)  JP
   ALSO   74 NP B69 381        THOMPSON,BADEWITZ,GAIDOS,MCILWAIN+   (PURD)  JP

BEKETOV   75 SJNP 20 379       +ZOMBKOVSKII,KAIDALON,KONOVALOV+       (ITEP)
EMMS      75 PL 60 B 109       +JONES,KINSON,BELL,DALE+   (BIRM+DURH+RHEL)  JP
HORNE     75 PR D11 996        +S.HAGOPIAN,V.HAGOPIAN,BENSINGER+(FSU+BRAN)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                           (COLU)
WAGNER    75 PL 58B 201        +TABAK,CHEW                            (LBL)   JP
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BALTAY   77 PRL 39 591        +CAUTIS,KALELKAR                 (COLUMBIA)  JP
CAUTIS   77  THESIS NEVIS 221 C.V.CAUTIS                       (COLUMBIA)  JP
CERRADA  77 NP B 126 241      +BLOCKZIJL,HEINEN,+    (AMST+CERN+NIJM+OXF)  JP
GHIDINI  77  PREPRINT         +            (BARI+BONN+CERN+DARE+LIVP+MILA)  JP
PERNEGR  77  BUDAPEST CONF.   +BEUSCH,ASTBURY+       (ETHZ+CERN+LOIC+MILA)  JP
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ω(1670)

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45  OMEGA(1670,JPG=3--) I=0.

THIS RESCNANCE OVERLAPS IN ITS 3PI MODE WITH THE A3,
BUT IN SCME EXPERIMENTS CNE CAN ESTABLISH THE DECAY
MODE RHOO PIO, THUS I=0. WAGNER 75 FIND JP=3- UNIQUELY.
CERRADA 77 SEE CLEAR PHASE ROTATICN RESPECT TO FOUR
DIFFERENT REFERENCE WAVES. CONFIRMED BY CAUTIS 77.
THE DECAYS INTO 5PI AND OMEGA PI+ PI- NEED FURTHER
CONFIRMATION (SEE ALSO X(1690)).

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                 45  OMEGA(1670) MASS (MEV)

M            1636.      20.           ARMENISE  68 DBC    5.1 PI+N,P(3PI)O  9/68
M            1670.      20.           KENYON    69 DBC    8.  PI+N,P(3PI)O  8/69
M        200 1679.      17.           MATTHEWS  71 DBC    7.0 PI+N,P(3PI)O. 1/71
M        500 1678.      14.           DIAZ      74 DBC    6.  PI+N,P(3PI)O  1/74
M      Q 200 1660.      13.           DIAZ      74 DBC    6.  PI+N,P(5PI)O  1/74
M   P    600 1669.      11.           WAGNER    75 HBC    7. PI+P,DEL++3PI 11/75
M   P E      1673.0     12.0          CAUTIS    77 HBC    15 PI+P,DEL 3PI  12/77*
M     E 110(1700.0)   APPROX.         CERRADA   77 HBC    4.2 K-P,LAM 3PI  12/77*
M            . . . . . . . . . .
M    AVG     1668.3      5.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    STUDENT1668.7       6.0     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M     E  PHASE ROTATION SEEN FOR JP 3- (RHO PI) WAVE.
M   P    FROM A FIT TO I=0, JP=3- RHO PI PARTIAL WAVE
M     Q  FROM (OMEGA PI PI) MODE

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                 45  OMEGA(1670) WIDTH (MEV)

W            112.       60.           ARMENISE  68 DBC    5.1 PI+N,P(3PI)O  9/68
W            100.       40.           KENYON    69 DBC    8.  PI+N,P(3PI)O  8/69
W      S 200 155.       40.           MATTHEWS  71 DBC    7.0 PI+N,P(3PI)O 11/75
W        500 167.       40.           DIAZ      74 DBC    6.  PI+N,P(3PI)O  1/74
W      Q 200 122.       39.           DIAZ      74 DBC    6.  PI+N,P(5PI)O  1/74
W   P S  600 173.       28.           WAGNER    75 HBC    7. PI+P,DEL++3PI 11/75
W   P E      173.0      16.0          CAUTIS    77 HBC    15 PI+P,DEL 3PI  12/77*
W            . . . . . . . . . .
W    AVG     159.1      11.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W    STUDENT 159.7      12.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W     E  PHASE ROTATION SEEN FOR JP 3- (RHO PI) WAVE.
W   P    FROM A FIT TO I=0, JP=3- RHO PI PARTIAL WAVE
W     S  WIDTH ERRORS ENLARGED BY US TO 4*WIDTH/SQRT(N),SEE K* TYPED NOTE
W     Q  FROM (CMEGA PI PI ) MODE

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                 45  OMEGA(1670) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      OMEGA(1670) INTO 3 PI (INCL. RHO PI)           134+ 134+ 134
P2      OMEGA(1670) INTO 5 PI (INCL. OMEGA PI+PI-)     134+ 134+ 134+ 134+
P3      OMEGA(1670) INTO RHO PI                        776+ 134
P4      OMEGA(1670) INTO OMEGA PI+ PI-                 783+ 134+ 134
P5      OMEGA(1670) INTO B(1235) PI                   1231+ 134

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                 45  OMEGA(1670) BRANCHING RATIOS

R1      CMEGA(1670) INTO (5 PI)/(3 PI)                (P2)/(P1)
R1            (0.10)    (0.10)        KENYON    69 DBC    8.  PI+N,P(3PI)O. 8/69
R1      200     0.97      0.28        DIAZ      74 DBC    6.  PI+N,P(5PI)O  1/74

R2      CMEGA(1670) INTO (RHO PI)/(3 PI)              (P3)/(P1)
R2      200   (0.70) OR MORE          MATTHEWS  71 DBC    7.0 PI+N,P(3PI)O 11/71

R3      OMEGA(1670) INTO (CMEGA PI+ PI-)/(RHO PI)     (P4)/(P3)
R3      100     0.47      0.18        DIAZ      74 DBC    6.  PI+N,P(5PI)O  1/74

R4      OMEGA(1670) INTO (B(1235) PI)/(RHO PI)        (P5)/(P3)
R4           POSSIBLY SEEN            DIAZ      74 DBC    6.  PI+N,P(5PI)O  1/74

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                        REFERENCES FOR CMEGA(1670)

ARMENISE 68 PL 26B 336        +GHIDINI,FORINO+ (BARI+BGNA  +FIRZ  +ORSAY)

KENYON   69 PRL 23 146        +KINSON,SCARR,+               (BNL+UCND+ORNL)

ARMENISE 70 LNC 4 199         +GHIDINI,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)

MATTHEWS 71 PR D 3 2561       +PRENTICE,YOON,CARROLL,+          (TNTO+WISC)
MATTHEW1 71 LNC 1 361         +PRENTICE,YOON,CARROLL,+          (TNTO+WISC)

DIAZ     74 PRL 32 260        +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)

WAGNER   75 PL 58B 201        +TABAK,CHEW                            (LBL)  JP

BALTAY   77  PREPRINT         +CAUTIS,KALELKAR                      (COLU)  JP
CAUTIS   77  THESIS NEVIS 221 C.V.CAUTIS                        (COLUMBIA)  JP
CERRADA  77 NP B 126 241      +BLOCKZIJL,HEINEN,+     (AMST+CERN+NIJM+OXF)  JP
CORDEN   77  PREP. RL 77 097A CORDEN,CORBETT+        (BIRM+RHEL+TELA+LOWC)  JP
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g(1680)

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15  G(1680,JPG = 3-+) I=1
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This entry contains the 2π, 4π, ωπ, $K\bar{K}$, and $K\bar{K}\pi$ peaks in the region of 1700 MeV. The spin-parity determination and the mass and width in the Meson Table come from the 2π mode. An elasticity of 24% is found at resonance in the ππ elastic partial-wave analysis (HYAMS 75). This is consistent with the assumption that at least some of the effects listed are due to g decay into various channels. On the other hand, some discrepancies in masses, widths, and branching ratios indicate that there may be more than one $I^G = 1^+$ meson in this region (BARNHAM 70, HOLMES 72, THOMPSON 74). Although we have collected all the data here under a common entry, we do not imply that they are necessarily all related.

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                 15  G MASS (MEV)

M     PI+ PI- MODE
M
M         (1700.0)  (100.0)          BELLINI   65 HLBC   O 6.1 PI-P          12/75
M         (1640.0)                   FORINO    65 DBC    O 4.5 PI+D           6/66
M          1670.0     30.0           GOLDBERG  65 HBC    O 6 PI+D, 8 PI-P
M         (1683.)    (13.)           ARMENISE  68 DBC    O 5.1 PI+ D        . 6/68
M          1720.0     20.0           CRENNELL  68 HBC    O 6.0 PI- P         12/68
M         (1655.0)   (10.0)          JOHNSTON  68 HBC    O 7.0 PI- P        . 6/68
M          1737.0     23.0           ARMENISE  70 DBC    O 9 PI+ N            1/71
M          1687.      21.            STUNTEBEC 70 HDBC  O 8. PI-P,5.4 PI+D   2/72
M          1678.      12.            MATTHEWS  71 DBC   O  7. PI+ N           2/72
M          1652.      13.            MATTHEWS  71 HBC   O  7. PI- P           2/72
M  E   600 1690.       7.            ENGLER    74 DBC    O 6. PI+N,PI+PI-P  12/75
M  G       1693.       8.            GRAYER    74 ASPK   O 17 PI-P,PI+PI-N   2/74
M  GI     (1692.)    (12.)           ESTABROOK 75 RVUE     17 PI-P,PI+PI-N  12/75
M   I     (1722.)     (3.)           HYAMS     75 ASPK   O 17 PI-P,PI+PI-N  12/75
M          . . . . . . . . . .
M   AVG    1687.8      6.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
M   STUDENT1688.7      4.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                             (SEE IDEOGRAM BELOW )

M  E    MASS ERRORS ENLARGED BY US TO WIDTH/SQRT(N),SEE K* TYPED NOTE
M   I   FROM PHASE-SHIFT ANALYSIS
M       ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
M  G    USES SAME DATA AS HYAMS 75

M     (2PI)+- MODE
M
M          1640.0     25.0           CRENNELL  68 HBC    -  6.0 PI- P        12/68
M      122 1650.0     35.0           BARTSCH   70 HBC    +  8 PI+ P,2 PI      5/70
M         (1632.)     (5.)           THOMPSON  74 HBC    +  13 PI+ P         12/75
M          . . . . . . . . . .
M   AVG    1643.4     20.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1643.4     21.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M     K KBAR + K KBAR PI MODE
M
M         (1675.)                    EHRLICH   66 HBC   +-  7.9 PI-P,K KBAR  2/72
M   K     (1700.)                    FRENCH    67 HBC     O 3,3.6 PBAR P     7/67
M   K   OBSERVED IN NEUTRAL(K* KBAR) MODE  (G-PARITY UNKNOWN)
M   F     (1740.)                    FRENCH    67 HBC   (KO K+-) 3-4 PBAR P  7/67
M   F      SEE FIG. 9 OF FRENCH 67
M          1640.0     20.0     25.0  CRENNELL  68 HBC   +-  6.0 PI-P,KBAR K 12/68
M          1690.0     16.0           ADERHOLZ  69 HBC   +   8 PI+ P,KKBARPI  8/69
M          1692.       6.            BLUM      75 ASPK   O18.4 PI-P,N K+K- 11/75
M  P  6000 1698.      12.            MARTIN    77 SPEC    10 PI P,KS K- P  12/77*
M  P       FROM A FIT TO JP=3- PARTIAL WAVE.
M          . . . . . . . . . .
M   AVG    1690.3      6.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M   STUDENT1691.0      5.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                             (SEE IDEOGRAM BELOW )

M     (4PI)+- MODE
M
M          1720.      15.            BALTAY    68 HBC   +   7, 8.5 PI+ P     6/68
M   J     (1675.0)   (10.0)          JOHNSTON  68 HBC    -  7.0 PI- P        6/68
M      144 1680.0     40.0           BARTSCH   70 HBC   +  8 PI+ P,4 PI      4/71
M       90(1640.0)   (20.0)          BARTSCH   70 HBC   +  8 PI+ P,A2 PI     4/71
M   F  102(1689.0)   (20.0)          BARTSCH   70 HBC   +  8 PI+ P,2 RHO     4/71
M          1705.0     21.0           CASO      70 HBC    - 11.2PI-P,RHO 2PI  5/70
M      300(1710.)                    ARMENISE  72 HBC   -  9.1 PI- P,P 4PI  12/72
M          1630.      15.            HOLMES    72 HBC   +  10.-12. K+ P      1/73
M          1687.      20.            CASON     73 HBC   -  8.,18.5 PI- P     1/74
M   F     (1685.)    (14.)           CASON     73 HBC   -  8.,18.5 PI- P     1/74
M   F   66(1733.)     (9.)           KLIGER    74 HBC    - 4.5 PI-P,P 4PI   12/75
M          1670.      10.            THOMPSON  74 HBC   +  13 PI+ P         12/75
M          . . . . . . . . . .
M   AVG    1677.1     13.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
M   STUDENT1677.9      9.0     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                             (SEE IDEOGRAM BELOW )

M   F   FROM (RHO+- RHOO) MODE

M     RHOO RHOO MODE
M
M         (1700.0)                   MAURER    70 HBC     O5.7 PBAR P,7 PI . 2/71
M         (1700.0)                   BRAUN     71 HBC     O5.7 PBAR P,7 PI  11/71

M     CMEGA PI  MODE
M
M          1654.      24.            BARNHAM   70 HBC   +  10 K+ P,OMEGA PI  6/70
M          1630.0     11.0           CASO      70 HBC    - 11.2PI-P,PI OMEG  5/70
M         (1666.)    (50.)           CASON     73 HBC   -  8.,18.5 PI- P     1/74
M          1686.       9.            THOMPSON  74 HBC   +  13 PI+ P         12/75
M          1666.0     14.0           GESSAROLI 77 HBC      11 PI-P,OMEGA PI 12/77*
M          . . . . . . . . . .
M   AVG    1663.4     13.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
M   STUDENT1665.7     10.2     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                             (SEE IDEOGRAM BELOW )
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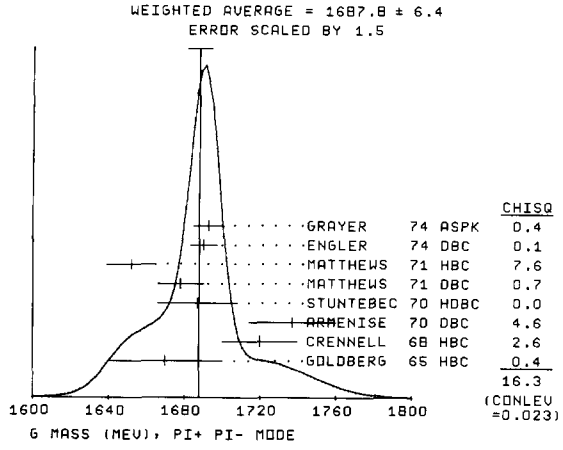
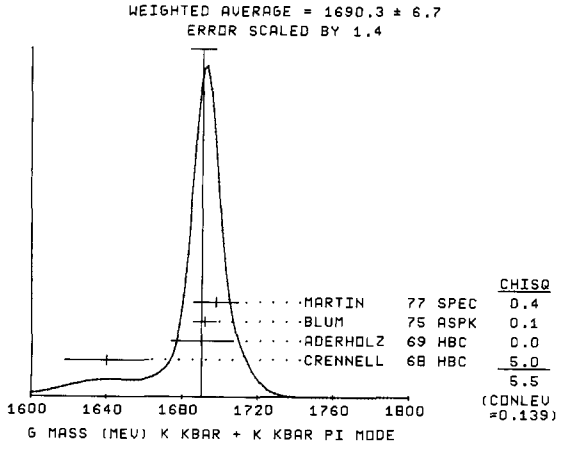
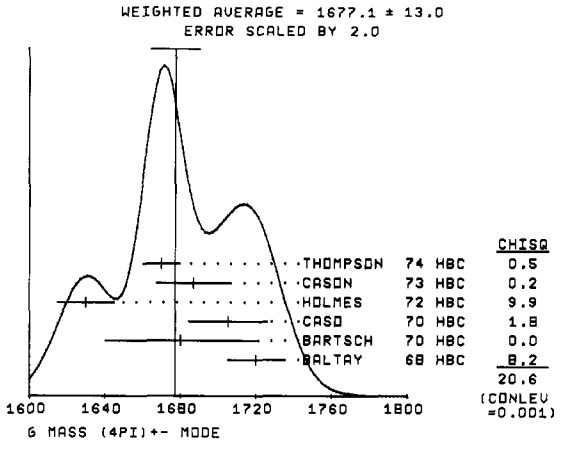
# Mesons
g(1680)

Data Card Listings
For notation, see key at front of Listings.





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M       R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPTS. SEE
M                          THE A2 MINI-REVIEW IN THE 1973 EDITION)
M
M  NR1     (1632.)     (15.)          FOCACCI   66 MMS  -  7-12 PI-P,P MMS 12/72
M  NR2     (1700.)     (15.)          FOCACCI   66 MMS  -  7-12 PI-P,P MMS 12/72
M  NR3     (1748.)     (15.)          FOCACCI   66 MMS  -  7-12 PI-P,P MMS 12/72
M  N     NOT SEEN BY BOWEN 72
M   R      (1700.0)    (47.0)         ANDERSON  69 MMS  -  16 PI- P,BACKW   8/69
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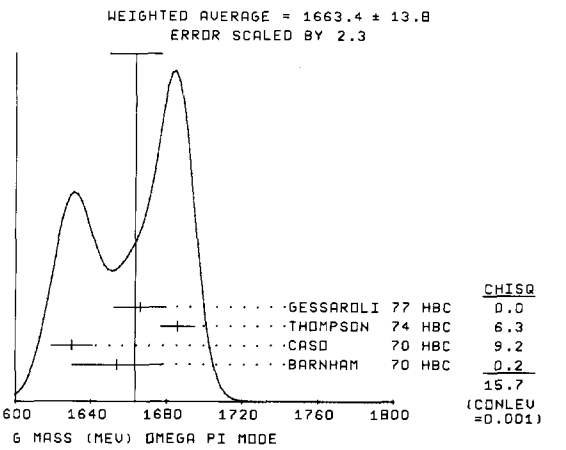


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                        15  G WIDTH (MEV)

W     PI+ PI- MODE
W
W           (40.0)                          FORINO    65 DBC    0 4.5 PI+D          6/66
W           180.0      40.0                 GOLDBERG  65 HBC    0 6 PI+D, 8 PI-P
W           188.       49.                  ARMENISE  68 DBC    0 5.1 PI+ D         6/68
W           200.0      100.0                CRENNELL  68 HBC    0 6.0 PI- P        12/68
W           (80.0)     (20.0)               JOHNSTON  68 HBC    0 7.0 PI- P       . 6/68
W           171.0      65.0                 ARMENISE  70 DBC    0 9 PI+ D           1/71
W          267.        72.        46.       STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D   2/72
W           156.       36.                  MATTHEWS  71 DBC    0  7. PI+ N        2/72
W           73.        36.                  MATTHEWS  71 HBC    0  7. PI- P        2/72
W      600  167.       40.                  ENGLER    74 DBC    0 6. PI+N,PI+PI-P  12/75
W  G        200.       18.                  GRAYER    74 ASPK   0 17 PI-P,PI+PI-N   2/74
W  GI      (240.)     (30.)                 ESTABROOK 75 RVUE    17 PI-P,PI+PI-N  12/75
W   I      (267.)     (30.)                 HYAMS     75 ASPK   0 17 PI-P,PI+PI-N 12/75
W           . . . . . . . . .
W  AVG      177.2      15.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
W  STUDENT  181.2      14.6      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                   (SEE IDEOGRAM BELOW )
W
W   I   FROM PHASE-SHIFT ANALYSIS
W       ERROR TAKES ACCOUNT OF SPREAD OF DIFFERENT PHASE-SHIFT SOLUTIONS
W   G   USES SAME DATA AS HYAMS 75

W     (2PI)+- MODE
W
W           200.0      100.0                CRENNELL  68 HBC   -  6.0 PI- P        12/68
W      122  180.0      30.0                 BARTSCH   70 HBC   +  8 PI+ P,2 PI      5/70
W           (42.)      (20.)                THOMPSON  74 HBC   +  13 PI+ P         12/75
W           . . . . . . . . .
W  AVG      181.7      28.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W  STUDENT  181.6      31.0      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W     K KBAR + K KBAR PI MODE
W
W  F       (120.)    APPROX.              FRENCH    67 HBC  (KO K+-) 3-4 PBAR P 11/69
W  F        ABOVE VALUE ESTIMATED FROM FIG. 9 OF FRENCH 67
W           79.0       70.0       25.0     CRENNELL  68 HBC  +-  6.0 PI-P,KBAR K  12/68
W           112.0      60.0                ADERHOLZ  69 HBC  +  8 PI+ P,KKBARPI   8/69
W           205.       20.                 BLUM      75 ASPK   018.4 PI-P,N K+K-  11/75
W  P  6000  199.       40.                 MARTIN    77 SPEC    10 PI P,KS K- P   12/77*
W  P       FORM A FIT TO JP=3- PARTIAL WAVE.
W           . . . . . . . . .
W  AVG      182.8      25.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
W  STUDENT  186.1      19.7      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                   (SEE IDEOGRAM BELOW )

W     (4PI)+- MODE
W
W           100.       35.                  BALTAY    68 HBC  +   7, 8.5 PI+ P      6/68
W  J       (90.0)     (20.0)               JOHNSTON  68 HBC  -  7.0 PI- P         6/68
W  J      NOT SEPARATED FROM 2 PI DECAY
W      144  135.0      30.0                 BARTSCH   70 HBC  +  8 PI+ P,4 PI      4/71
W       90 (180.0)    (30.0)               BARTSCH   70 HBC  +  8 PI+ P,A2 PI     4/71
W  F   102 (160.0)    (30.0)               BARTSCH   70 HBC  +  8 PI+ P,2 RHO
W          (160.0)                         CASO      70 HBC  - 11.2PI-P,RHO 2PI   5/70
W       300 (200.)                         ARMENISE  72 HBC  -  9.1 PI- P,P 4PI  12/72
W           130.       30.                  HOLMES    72 HBC  +  10.-12. K+ P      1/73
W           169.       70.        48.       CASON     73 HBC  -  8.,18.5 PI- P      1/74
W  F       (125.)     (83.)      (35.)     CASON     73 HBC  -  8.,18.5 PI- P      1/74
W  F    66 (150.)                          KLIGER    74 HBC  -  4.5 PI-P,P 4PI    12/75
W           106.       25.                  THOMPSON  74 HBC  +  13 PI+ P         12/75
W           . . . . . . . . .
W  AVG      120.6      16.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W  STUDENT  120.6      15.7      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W   F   FROM (RHO+- RHO0) MODE

W     OMEGA PI  MODE
W
W           130.       73.        43.      BARNHAM   70 HBC  +  10 K+ P,OMEGA PI  6/70
W           (60.0)                         CASO      70 HBC  -  11.2PI-P,PI OMEG  5/70
W          (194.)     (94.)      (60.)     CASON     73 HBC  -  8.,18.5 PI- P      1/74
W           89.        25.                  THOMPSON  74 HBC  +  13 PI+ P         12/75
W           160.0      56.0                 GESSAROLI 77 HBC     11 PI-P,OMEGA PI 12/77*
W           . . . . . . . . .
W  AVG      104.7      21.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W  STUDENT  104.4      24.0      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W       R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPTS. SEE
W                          THE A2 MINI-REVIEW IN THE 1973 EDITION)
W
W  NR1      (21.)   OR LESS            FOCACCI   66 MMS  -  7-12 PI-P,P MMS 12/72
W  NR2      (30.)   OR LESS            FOCACCI   66 MMS  -  7-12 PI-P,P MMS 12/72
W  NR3      (38.)   OR LESS            FOCACCI   66 MMS  -  7-12 PI-P,P MMS 12/72
W  N     NOT SEEN BY BOWEN 72
W   R      (195.0)                      ANDERSON  69 MMS  -  16 PI- P,BACKW   8/69
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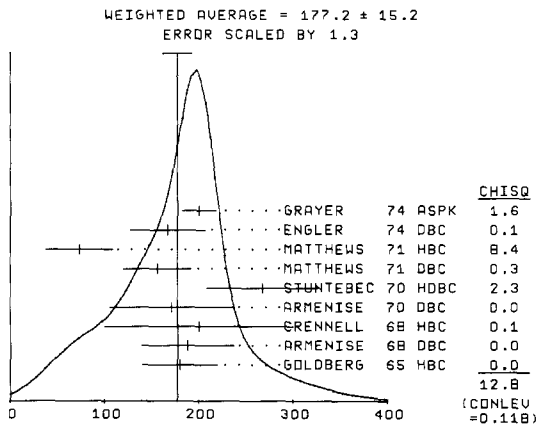
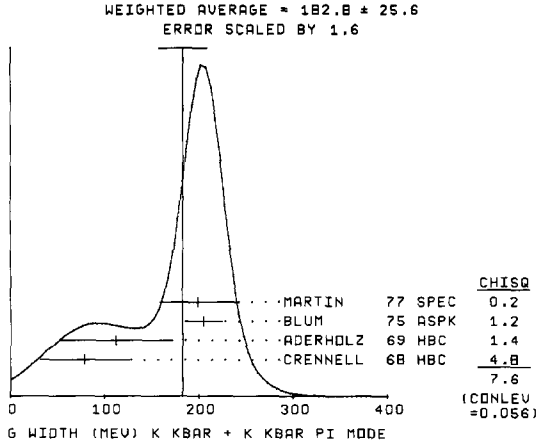
Data Card Listings

For notation, see key at front of Listings.





15 G PARTIAL DECAY MODES

		DECAY MASSES
P1	G INTO PI PI	139+ 139
P2	G INTO 4PI	139+ 139+ 139+ 139
P3	G INTO 2 RHO	776+ 776
P4	G INTO PI PI RHO	139+ 139+ 776
P5	G INTO A2 PI	1312+ 139
P6	G INTO K KBAR	497+ 497
P7	G INTO OMEGA PI	139+ 783
P8	G INTO K KBAR PI	497+ 497+ 139
P9	G INTO PHI PI	1020+ 139
P10	G INTO ETA PI	548+ 139

15 G BRANCHING RATIOS

R1 G INTO (2PI)/TOTAL (P1)
R1 P (0.4) BARTSCH 70 HBC + 8. PI+ P 2/72
R1 P (0.22) (0.04) MATTHEWS 71 HDBC 0 7. PI+N,PI-P 2/72
R1 P OPE MODEL USED IN THIS ESTIMATION
R1 G (.245) (.006) ESTABROOK 75 RVUE 17 PI-P,PI+PI-N 12/75
R1 G FROM PHASE-SHIFT ANALYSIS OF HYAMS 75 DATA
R1 S .24 .01 HYAMS 75 ASPK 0 17 PI-P,PI+PI-N 12/75
R1 S ERROR TAKES ACCOUNT OF SPREAD OF 4 DIFFERENT PHASE-SHIFT SOLUTIONS

R2 G INTO (PI+- PI0) / (ALL PI+- PI+ PI- PI0) (P1)/(P2C)
R2 D (0.08) OR LESS BALTAY 68 HBC + 7-8.5 PI+ P 6/68
R2 D USING DATA OF DEUTSCHMANN 65 ON PI+P TO PI+ PI0 P 6/68
R2 0.8 0.2 JOHNSTON 68 HBC - 7. PI- P 2/72
R2 0.8 0.15 BARTSCH 70 HBC + 8. PI+ P 2/72
R2 (0.12) OR LESS BALLAM 71 HBC - 16. PI- P 2/72
R2 (0.2) OR LESS HOLMES 72 HBC + 10.-12. K+ P 1/73
R2 0.35 0.11 CASON 73 HBC - 8.,18.5 PI- P 1/74
R2 . . . . . .
R2 AVG 0.56 0.16 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
R2 STUDENT 0.57 0.12 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R3 G+- INTO (2PI)/(2RHO) (P1)/(P3)
R3 S (0.48) OR LESS BISWAS 68 HBC - 8. PI- P 2/72
R3 S SUPERSEDED BY CASON 73 1/74

R4 G+- INTO (K KBAR)/(2PI) (P6)/(P1)
R4 0.08 0.08 0.03 CRENNELL 68 HBC 6.0 PI- P 12/68
R4 0.08 0.03 BARTSCH 70 HBC + 8. PI+ P 1/71
R4 . . . . . .
R4 AVG 0.080 0.026 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4 STUDENT 0.080 0.028 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R5 G+- INTO (K KBAR PI)/(2PI) (P8)/(P1)
R5 0.10 0.03 BARTSCH 70 HBC + 8. PI+ P 2/72

R6 G+- INTO (RHO 2PI)/(ALL 4PI) (P4)/(P2)
R6 CONSISTENT WITH 1. CASO 68 HBC - 11 PI- P 6/68
R6 1. 0.15 BARTSCH 70 HBC + 8. PI+ P 2/72
R6 0.88 0.15 BALLAM 71 HBC - 16. PI- P 2/72
R6 . . . . . .
R6 AVG 0.94 0.11 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6 STUDENT 0.94 0.12 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R7 G+- INTO (2RHO)/(ALL 4PI) (P3)/(P2)
R7 0.7 0.15 BARTSCH 70 HBC + 8. PI+ P 2/72
R7 (0.92) ARMENISE 72 HBC - 9.1 PI- P,P 4PI 12/72
R7 A (0.78) (0.33) CASON 73 HBC - 8.,18.5 PI- P 1/74
R7 A ASSUMING (ALL 4PI)=(RHO RHO) + (OMEGA PI)
R7 66 (.56) KLIGER 74 HBC - 4.5 PI-P,P 4PI 12/75
R7 T (0.13) (0.09) THOMPSON 74 HBC + 13 PI+ P 12/75
R7 T RHO RHO AND A2 PI MODES ARE INDISTINGUISHABLE

R8 G+- INTO (2 RHO)/(ALL RHO 2PI) (P3)/(P4)
R8 0.48 0.16 CASO 68 HBC - 11 PI- P 6/68
R8 (0.75) OR MORE BISWAS 68 HBC - 8. PI- P 2/72

R9 G+- INTO (PI+- A2O)/(ALL 4PI)
R9 (WITH A2O INTO (PI+ PI- PIO))
R9 0.40 0.20 BALTAY 68 HBC + 7,8.5 PI+P 6/68
R9 NOT SEEN JOHNSTON 68 HBC - 7 PI- P 6/68
R9 (0.61) (0.15) BARTSCH 70 HBC + 8. PI+ P 2/72
R9 NOT SEEN CASON 73 HBC - 8.,18.5 PI- P 1/74

R10 G+- INTO (PI OMEGA)/(ALL 4PI) (P7)/(P2)
R10 (WITH OMEGA INTO(PI+ PI- PIO))
R10 0.25 0.10 BALTAY 68 HBC + 7-8.5 PI+P 5/68
R10 .25 0.10 JOHNSTON 68 HBC - 7.0 PI- P 6/68
R10 0.12 0.07 BALLAM 71 HBC - 16. PI- P 2/72
R10 A (0.22) (0.08) CASON 73 HBC - 8.,18.5 PI- P 1/74
R10 A ASSUMING (ALL 4PI)=(RHO RHO) + (OMEGA PI)
R10 (.09) OR LESS KLIGER 74 HBC - 4.5 PI-P,P 4PI 12/75
R10 0.33 0.07 THOMPSON 74 HBC + 13 PI+ P 12/75
R10 . . . . . .
R10 AVG 0.233 0.050 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R10 STUDENT 0.236 0.051 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R11 G+- INTO (PI PHI)/(ALL 4PI) (P9)/(P2)
R11 (0.11) OR LESS BALTAY 68 HBC + 7,8.5 PI+P 6/68

R12 G+- INTO (PI+- 2PI+ 2PI- PIO)/(ALL PI+- PI+ PI- PIO)
R12 (0.15) OR LESS BALTAY 68 HBC + 7,8.5 PI+ P 6/68

R13 G+- INTO (PI ETA)/(ALL 4PI) (P10)/(P2)
R13 (0.02) OR LESS THOMPSON 74 HBC + 13 PI+ P 12/75

R14 GO INTO (2PI+ 2PI-)/(2PI) (P2C)/(P1)
R14 GO INTO (2PI+ 2PI-) FORBIDDEN IF 4PI MODE IS (RHO RHO)
R14 0.44 0.20 KALELKAR 75 HBC 015 PI+P 12/75

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REFERENCES FOR G

BELLINI 65 NC 40 A 948 BELLINI,DI CORATO,DUIMIO,FIORINI (MILANO)
DEUTSCHM 65 PL 18 351 M.DEUTSCHMANN ET AL (AACHEN+BERLIN+CERN)
FORINO 65 PL 19 65 FORINO,GESSAROLI + (BOLOGNA+ORSAY+SACLAY)
GOLDBERG 65 PL 17 354 GOLDBERG+ (CERN+EPOL+ORSAY+MILANO+CEA-SACL)

EHRLICH 66 PR 152 1194 R. EHRLICH,W.SELOVE,H.YUTA (PENNSYLVANIA)
FOCACCI 66 PRL 17 890 CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT 66 PL 22 714 CERN MISSING MASS SPECTROMETER GROUP (CERN)
SEGUINOT 66 PL 19 712 CERN MISSING MASS SPECTROMETER GROUP (CERN)

ABRAMS 67 PRL 18 620 +KEHOE+GLASSER+SECHI-ZORN+WOLSKY (MARYLAND)
DANYSZ 67 PL 24B 309 +FRENCH+KINSON+SIMAK+ (CERN+LIVERPOOL)
DUBAL 67 NP B3 435 +FOCACCI+KIENZLE+LECHANDINE+LEVRAT+ (CERN)
ALSO 68 THESIS 1456 L.DUBAL (GENEVE)
FRENCH 67 NC 52A 442 +KINSON+MCDONALD+RIDDIFORD+ (CERN+BIRM)

ARMENISE 68 NC 54 A 999 +FORINO+CARTACCI+(BARI+BGNA +FIRENZE+ORSAY)I
BALTAY 68 PRL 20 887 +KUNG+YEH+FERBEL+ (COLU+ROCH+RUTG+YALE)I=1
BISWAS 68 PRL 21 50 +CASON,DZIERBA,GROVES,KENNEY,+ (NDAM)
BOESEBEC 68 NP B 4 501 BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO 68 NC 54 A 983 +CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILA+SACL)
CRENNELL 68 PL 28 B 136 +KARSHON,LAI,SCARR,SKILLICORN (BNL)
JOHNSTON 68 PRL 20 1414 +PRENTICE,STEENBERG,YOON (TORONTO+WISC)IJP

ADERHOLZ 69 NP B 11 259 +BARTSCH,+ (AACH+BERL+CERN+JAGL+WARS)
ANDERSON 69 PRL 22 1390 +COLLINS,BLIEDEN+ (BNL+CARN)
BARISH 69 PR 184 1375 +SELOVE,BISWAS,CASON,+ (PENN+NDAM+ROCH)
CASO 69 NC 62 A 755 +CONTE,BENZ,+ (GENO+DESY+HAMB+MILA+SACL)
VETLITSK 69 SJNP 9 461 +GUZHAVIN,KLIGER,KOLGANOV,LEBEDEV+ (ITEP)

ARMENISE 70 LNC 4 199 +GHIDINI,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
BARNHAM 70 PRL 24 1083 +COLLEY,JOBES,KENYON,PATHAK,RIDDIFORD(BIRM)
BARTSCH 70 NP B 22 109 +KRAUS,TSANOS,GROTE,KOTZAN+(AACH+BERL+CERN)
CASO 70 LNC 3 707 +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
KRAMER 70 PRL 25 396 +BARTON,GUTAY,LICHTMAN,MILLER,+ (PURDUE)
MAURER 70 THESIS NO.588 G.MAURER (STRASBOURG)
STUNTEBE 70 PL 32 B 391 STUNTEBECK,KENNEY,DEERY,BISWAS,CASON+(NDAM)

BALLAM 71 PR D 3 2606 +CHADWICK,GUIRAGOSSIAN,JOHNSON,+ (SLAC)
BRAUN 71 NP B 30 213 +FRIDMAN,GERBER,GIVERNAUD,KAHN,+ (STRB)
GRAYER 71 PL 35 B 610 +HYAMS,JONES,SCHLEIN,BLUM,+ (CERN+MPIM)JP3-
MATTHEWS 71 NP B 331 +PRENTICE,YOON,CARROLL,+ (TNTO+WISC)JP3-

ARMENISE 72 LNC 4 205 +FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
ALSO 75 LNC 14 177 +FOGLI-MUCIACCIA,FORINO+ (BARI+BGNA+FIRZ) JP
BOWEN 72 PRL 29 890 +EARLES,FAISSLER,BLIEDEN,+ (NEAS+STON)
CLAYTON 72 NP B 47 81 +MASON,MUIRHEAD,RIGOPOULOS,+ (LIVP+PATR)
GRAYER 72 PHIL.CONF.PROC. 5 +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)
HOLMES 72 PR D 6 3336 +FERBEL,SLATTERY,WERNER (ROCH)

ARNOLD 73 LNC 6 707 +ENGEL,ESCOUBES,KURTZ,LLORET,PATY,+ (STRB)
CASON 73 PR D 7 1971 +BISWAS,KENNEY,MADDEN,SANDER,SHEPHARD(NDAM)
CASON 1 73 NP B 64 14 +MADDEN,BISHOP,BISWAS,KENNEY,+ (NDAM)
HYAMS 73 NP B 64 134 +JONES,WEILHAMMER,BLUM,DIETL,+ (CERN+MPIM)
ROBERTSO 73 PR D 7 2554 ROBERTSON,WALKER,DAVIS (DUKE+WISC)

DUBOVIKO 74 SJNP 19 568 DUBOVIKOV,MATSYUK,NILOV,SOKOLOV (ITEP)
ENGLER 74 PR D10 2070 +KRAEMER,TOAFF,WEISSER,DIAZ+ (CARN+CASE)
GRAYER 74 NP B 75 189 G.GRAYER,HYAMS,BLUM,DIETL,+ (CERN+MPIM)
KLIGER 74 SJNP 19 428 +BEKETOV,GRECHKO,GUZHAVIN,DUBOVIKOV+ (ITEP)
OREN 74 NP B71 189 +COOPER,FIELDS,RHINES,WHITMORE,+ (ANL+OXF)
THOMPSON 74 NP B69 220 +GAIDOS,MCILWAIN,MILLER,MULERA,+ (PURD)

BLUM 75 PL 57B 403 +CHABAUD,DIETL,GARELICK,GRAYER+ (CERN+MPIM) JP
ESTABROO 75 NP B95 322 P.ESTABROOKS,A.D.MARTIN (DURH)
HYAMS 75 NP B100 205 +JONES,WEILHAMMER,BLUM,DIETL+ (CERN+MPIM)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR (COLU)I=1

Mesons

g(1680), X(1690), A_4(1900), X(1900), S(1935)

For notation, see key at front of Listings.

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ANTIPOV  77 NP B 119 45       +BUSNELLO,DAMGAARD,KIENZLE+     (CERN+SERP)
GESSAROL 77 NP B 126 382      GESSAROLI,+  (BGNA+FIRZ+GENO+MILA+OXF+PAVI)

MARTIN   78  PREPRINT CERN    +OZMUTLU+BALDI,+                (DURH+GEVA+CERN)

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X(1690)

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64  X(1690)

THIS ENTRY CONTAINS OMEGA PI PI PEAKS AROUND
1690 MEV. EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
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                    64  X(1690) MASS (MEV)

M   N     (1689.)     (10.)          DANYSZ    67 HBC     0 3,3.6 PBAR P     2/74
M   N   NOT SEEN IN HIGH STATISTICS EXP. OF OREN 74
M         1670.0      18.0           YOST      68 HBC     04.3 K-P,LMBD.5PI. 2/74
M         1695.0      20.0           BARNES    69 HBC     0 4.6 K-P,OMEG2PI  2/74
M          . . . . . .
M   AVG   1681.2      13.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1681.1     15.1     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

                    64  X(1690) WIDTH (MEV)

W   N       (38.)     (18.)          DANYSZ    67 HBC     0 3,3.6 PBAR P     1/73
W   N   NOT SEEN IN HIGH STATISTICS EXP. OF OREN 74
W         50.0        15.0           YOST      68 HBC     04.3 K-P,LMBD.5PI. 1/73
W         90.         20.            BARNES    69 HBC     0 4.6 K-P,OMEG2PI  1/73
W          . . . . . .
W   AVG   64.4        19.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
W   STUDENT  63.8     14.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    REFERENCES FOR X(1690)

DANYSZ   67 NC 51 A 801       DANYSZ+FRENCH+SIMAK                    (CERN)
YOST     68  UMD  T.REPORT849 +YCOH,EINSCHLAG,DAY,GLASSER            (UMD)
BARNES   69 PRL 23 142        +CHUNG,EISNER,FLAMINIO,+               (BNL)
OREN     74 NP B71 189        +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)

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A_4(1900)

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43  A4(1900,JPG=  -)  I=1

THIS ENTRY CONTAINS THE DIFFRACTIVE-LIKE 3PI AND 5PI
BUMPS IN THE REGION OF 1900 MEV, AS WELL AS VARIOUS
PEAKS NEARBY. NOTE THAT THE EXISTENCE OF AN S-WAVE
GPI THRESHOLD BUMP (IN ANALOGY TO A1 AND A3)
IS NOT UNEXPECTED. OMITTED FROM TABLE.
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                    43  A4 MASS  (MEV)

M         (1900.)                  HUSON     68 HLBC -  16.PI-A,A 5PI     2/74
M         (1830.)                  SALZBERG  72 HBC  -  13,20 PI-P,P 3PI  2/74
M    B  40(1960.)    (30.)         BASTIEN   73 OBC  -  15.PI-D,D 3PI     2/74
M    B  MARGINAL STATISTICAL SIGNIFICANCE.
M         (1800.)                  DEUTSCHM  75 HBC  +  16 PI+P,P 3PI     12/75
M      208(2080.)    (40.)         KALELKAR  75 HBC  +  15 PI+P,P PI+G     12/75
M         (2100.)    APPROX        ANTIPOV   77 CIBS -  25PI-P,P 3PI      12/77*
M         (2214.)    (15.)         BALTAY    77 HBC   0 15PI-P,DEL++3PI   12/77*

M       VARICUS PEAKS
M    K    (1820.)    (12.)         FRENCH    67 HBC     0 3,3.6 PBAR P     7/67
M    K  OBSERVED IN (KS KO PIO...) MODE  (G-PARITY UNKNOWN)

                    A4  WIDTH  (MEV)

W         (130.)                   SALZBERG  72 HBC  -  13,20 PI-P,P 3PI  2/74
W    B  40 (200.)                  BASTIEN   73 OBC  -  15.PI-D,D 3PI     2/74
W    B  MARGINAL STATISTICAL SIGNIFICANCE.
W      208 (340.)    (80.)         KALELKAR  75 HBC  +  15 PI+P,P PI+G     12/75
W         (500.)    APPROX.       ANTIPOV   77 CIBS -  25PI-P,P 3PI      12/77*
M         (355.)    (21.)         BALTAY    77 HBC   0 15PI-P,DEL++3PI   12/77*

W       VARIOUS PEAKS
W    K    (50.)     (20.)         FRENCH    67 HBC     0 3-4 PBAR P       7/67
W    K  SEE NOTE K ABOVE

                    43  A4 PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      A4 INTO 3PI                                          139+ 139+ 139
P2      A4 INTO RHO PI                                       776+ 139
P3      A4 INTO F PI                                        1271+ 139
P4      A4 INTO G PI                                        1688+ 139

                    43  A4 BRANCHING RATIOS

R1      A4 INTO (G PI)/(ALL 3PI)                          (P4)/(P1)
R1         DOMINANT                  KALELKAR  75 HBC  +  15 PI+P,P 3PI     12/75

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                    REFERENCES FOR A4

DANYSZ   67 NC 51A 801        DANYSZ+FRENCH+SIMAK                    (CERN)
FRENCH   67 NC 52A 442        +KINSON+MCDONALD+REDDIFORD+       (CERN+BIRM)

HUSON    68 PL 28 B 208       +LUBATTI,BELLINI,BINGHAM,+   (ORSA+MILA+LBL)

BEMPERAD 71 NP B 33 397       +DUFEY,CODLING,+        (CERN+ETHZ+LOIC+MILA)

CLAYTON  72 NP B 47 81        +MASON,MUIRHEAD,RIGOPOULOS,+      (LIVP+PATR)
HARRISON 72 PRL 28 775        +HEYDA,JOHNSON,KIM,LAW,MUELLER,+       (HARV)
SALZBERG 72 NP B 41 397       +HARRISON,HEYDA,JOHNSON,KIM,LAW,+      (HARV)

BASTIEN  73 UPPSALA CONF. 73  +DUNN,HARRIS,LUBATTI,BINGHAM,+    (SEAT+UCB)

OREN     74 NP B71 189        +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)
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DEUTSCHM 75 NP B99 397        DEUTSCHMANN,+          (ABBCCHW COLLABORATION)
KALELKAR 75 THESIS(NEVIS 207) M.S.KALELKAR                          (COLU)

ANTIPOV  77 NP B 119 45       +BUSNELLO,DAMGAARD,KIENZLE+      (CERN+SERP)
BALTAY   77 PRL 39 591        +CAUTIS,KALELKAR                  (COLUMBIA)  JP
CAUTIS   77  THESIS NEVIS 221 C.V.CAUTIS                        (COLUMBIA)  JP

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X(1900)

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17  X(1900,JPG=4+-)  I=1

THIS ENTRY CONTAINS THE STRUCTURE FOUND WITH A
MOMENTS ANALYSIS OF THE KS K- SYSTEM.
WAIT CONFIRMATION. OMITTED FROM TABLE.
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                    17  X(1900) MASS (MEV)

M  Y      1903.0      10.0           BALDI     78 SPEC -  10 PI-P,P KS K-   12/77*
M  Y      FROM A FIT TO THE Y(8,0) MOMENT.
M

                    17  X(1900) WIDTH (MEV)

W  Y       166.0      43.0           BALDI     78 SPEC -  10PI-P,P KS K-   12/77*
W  Y      FROM A FIT TO THE Y(8,0) MOMENT.
W

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                    REFERENCES FOR X(1900)

BALDI    78 PL B              +BOHRINGER,DORSAZ,HUNGERBULER,+    (GENEVA)  JP

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S(1935)

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31  S(1935,JPG=  )
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Three enhancements have been observed in anti-proton-proton cross sections, called S(1935), T(2190), U(2350).

The S(1935) has a narrow width, 9 ± 4 MeV, whereas the T(2190) and the U(2350) have widths of 150 ± 50 and ~200 MeV, respectively. Three independent experiments (CARROLL 74, CHALOUPKA 76, BRUCKNER 77) are in fair agreement on the characteristics of the S(1935). However, its isospin is not yet well established (CARROLL 74, CHALOUPKA 76). Although the S(1935) couples strongly to the elastic channel, it is not seen in $\bar{p}p$ charge exchange (GARNJOST 75, CHALOUPKA 76). KELLY 76 has proposed an explanation in terms of an interfering background wave of the same spin-parity, and favors J = 1 or 2. Other explanations, requiring two resonances nearly degenerate in mass, but of different isospin (DOVER 76), are not supported by the data (KELLY 76, MONTANET 77). Analyzing backward $\bar{p}p$ elastic scattering data, CARTER 77 has given arguments for $J^{PC} = 2^{++}$.

The observation of broad enhancements at 2190 and 2350 MeV comes from total cross-section measurements (ABRAMS 67), $\bar{p}p$ annihilation measurements (ALSPECTOR 73), $\bar{p}p$ elastic cross-section measurements (COUPLAND 77), and from an amplitude analysis of $\bar{p}p$ annihilations into $\pi\pi$ (CARTER 77). Comparison of $\bar{p}p$ and $\bar{p}d$ total cross sections (ABRAMS 67)

suggests I = 1 for T(2190), whereas I = 0 and I = 1 are both present in the U(2350) bump. CARTER 77 succeeds in assigning $I^GJ^P = 1^+3^-$ to T(2190) and $I^GJ^P = 0^+4^+$ to U(2350), and finds in addition evidence for an $I^GJ^P = 1^+5^-$ resonance at 2480 MeV. The $I^GJ^P = 0^+4^+$ resonance may also be observed in $\bar{p}p \to \pi^0\pi^0$ annihilations (DEMARZO 77).

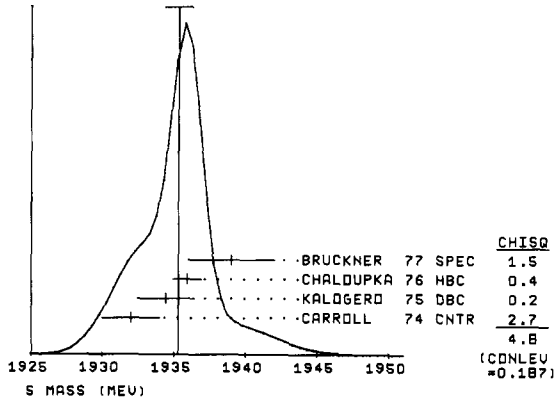
For other objects coupled to $\bar{p}p$, see the entry $\bar{N}N(1700\text{-}3600)$.

31 S MASS (MEV)

		S CHANNEL NBAR N							
M	C	(1940.)	(8.)		CLINE	70 HBC	0 .25-.74 PBAR P	2/72	
M	B	(1968.)			BENVENUTI	71 HBC	0 .1 - .8 PBAR P	2/72	
M	S	1932.	2.		CARROLL	74 CNTR	S CHAN.PBAR P,D	12/75	
M	C	(1942.)	(5.)		D-ANDLAU	75 HBC	0 .175-.750 PBAR P	12/75	
M		1934.4	2.6	1.4	KALOGERO	75 DBC	- PBAR N ANNIH	12/75	
M	A	(1940.)			DEFOIX	75 HBC	OPBAR P,5PI	12/75	
M	S	1935.9	1.0		CHALOUPKA	76 HBC	OPBAR P TOT,ELAS	12/75	
M		1939.0	3.0		BRUCKNER	77 SPEC	.4-.85 PBAR P	7/77*	
M		. . . . .							
M	AVG	1935.28	1.00	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)					
M	STUDENT	1935.34	0.91	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 1935.28 ± 1.00
ERROR SCALED BY 1.3



M A FROM ENERGY DEPENDENCE OF 5PI CROSS-SECTION.
M B SEEN AS A BUMP IN THE PBAR P - KS KL CROSS SECTION WITH JPC=1--.
M NOT SEEN BY CARSON 72 WITH EQUAL STATISTICS.
M C FROM ENERGY DEPENDENCE OF FAR BACKWARD ELASTIC SCATTERING.
M SOME INDICATION OF ADDITIONAL STRUCTURE.
M N SEEN IN 3 CHARGED MODE. NOT SEEN BY BOWEN 73 WITH 6X STATISTICS.
M S NARROW BUMP SEEN IN TOTAL PBAR P,D CROSS-SECTIONS.ISOSPIN UNCERTAIN
M NOT SEEN IN PBAR P CEX BY GARNJOST 75,CHALOUPKA 76. INTEGRATED
M CROSS-SECTION 3X LARGER THAN BRUCKNER 77.

31 S WIDTH (MEV)

		S CHANNEL NBAR N							
W	C	(49.)	(9.)		CLINE	70 HBC	0 .25-.74 PBAR P	2/72	
W	B	(35.)			BENVENUTI	71 HBC	0 .1 - .8 PBAR P	2/72	
W	S	9.	4.	3.	CARROLL	74 CNTR	S CHAN.PBAR P,D	12/75	
W	C	(57.5)	(5.)		D-ANDLAU	75 HBC	0 .175-.750 PBAR P	12/75	
W		11.	11.	4.	KALOGERO	75 DBC	- PBAR N ANNIH	12/75	
W	A	(60.)			DEFOIX	75 HBC	OPBAR P,5PI	12/75	
W	S	8.8	4.3	3.2	CHALOUPKA	76 HBC	OPBAR P TOT,ELAS	12/75	
W		(4.0) OR LESS			BRUCKNER	77 SPEC	.4-.85 PBAR P	7/77*	
W		. . . . .							
W	AVG	9.1	2.4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
W	STUDENT	9.1	2.6	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

W SEE FOOTNOTES UNDER S MASS ABOVE

31 S PARTIAL DECAY MODES

		DECAY MASSES
P1	S INTO PBAR P	938+ 938

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REFERENCES FOR S

CLINE	68 PRL 21 1268	+ENGLISH,REEDER,TERRELL,TWITTY	(WISCONSIN)
CLINE	70 PREPRINT	D.CLINE,J.ENGLISH,D.D.REEDER	(WISC)J
ALSO	70 KIEV CONF.	ASTIER RAPPORTEUR TALK	
BENVENUT	71 PRL 27 283	BENVENUTI,CLINE,RUTZ,REEDER,SCHERER	(WISC)
CLINE	71 REVIEW	D.CLINE,TALK AT ANL WORKSHOP JULY 71	(WISC)
PINSKI	71 PRL 27 1548	STEPHEN S. PINSKY	(UTAH+ARGONNE)
BIZZARRI	72 PR D 6 160	+GUIDONI,MARZANO,CASTELLI,+	(ROMA+TRST)
BOWEN 1	72 PRL 29 890	+EARLES,FAISSLER,BLIEDEN,+	(NEAS+STON)
DIEBOLD	72 EATAV.CONF.V3 17	R.DIEBOLD RAPPORTEUR TALK	(ANL)
BOWEN	73 PRL 30 332	+EARLES,FAISSLER,BLIEDEN,+	(NEAS+STON)
BURNS	73 PR D 8 1286	+CONDON,DONAHUE,MANDELKERN,PRICE,+	(UCI)
KIENZLE	73 PR D 7 3520	W.KIENZLE	(CERN)
ASTBURY	74 CERN 74-18	A.ASTBURY REVIEW AT PRAGUE 74	(RHEL)
BURNS	74 NC 20A 463	+CONDON,MANDELKERN,PRICE,SCHULTZ	(UCI)
CARROLL	74 PRL 32 247	+CHIANG,KYCIA,LI,MAZUR,MICHAEL,+	(BNL)
KALOGERO	74 BOSTON 74	T.E.KALOGEROPOULOS (REVIEW) PG.97	
ABASHIAN	75 PRL 34 691	+BEAMER,BROSS,EISENSTEIN,+	(ILL+ANL+ISU)
D-ANDLAU	75 PL 58B 223	+COHEN-GANOUNA,LALOUM,LUTZ,PETRI	(CDEF+PISA) JP
DEFOIX	75 PALERMO CONF.	B.FRENCH, RAPPORTEURS TALK	(CDEF)
DONNACHI	75 NC 26 A 317	A.DONNACHIE,P.R.THOMAS	(MANCHSTER)
GARNJOST	75 PRL 35 1685	+KENNEY,POLLARD,ROSS,TRIPP,+	(LBL+MHCO)
KALOGERO	75 PRL 34 1047	KALOGEROPOULOS,TZANAKOS	(SYRA)
WEINGART	75 PRL 34 1201	WEINGARTEN,OKUBO	(ROCH)
ABASHIAN	76 PR D 13 5	+WATSON,GELFAND,BUTTRAM,+	(ILL+ANL+CHIC+ISU)
DEFOIX1	76 STOCK.SYMP.NBAR-N	+LADRON DE GUEVARA,ANGELINI,+	(CDEF+PISA)
DEFOIX2	76 STOCK.SYMP.NBAR-N	+LADRON DE GUEVARA,ANGELINI,+	(CDEF+PISA)
DOVER	76 PL 62 B 293	+KAHANA	(BNL)
CHALOUPK	76 PL 61 B 487	CHALOUPKA,+ (CERN+LIVP+MONS+PADO+ROMA+TRST)	
EISENHAN	76 STOCK.SYMP.NBAR-N	E.EISENHANDLER	(LOQM)
KELLY	76 PREP. RL 76 053	R.L.KELLY,R.J.PHILLIPS	(LBL+RHEL)
BENKHEIR	77 PL B 68 483	BENKHEIRI,BOUCROT,+ (CERN+CDEF+EPOL+LALO)	
BRUCKNER	77 PL 67 B 222	+GRANZ,INGHAM,KILIAN,LYNEN+(MPIH+HEID+CERN)	
CARTER	77 PREP. RL 77-035A	A.A.CARTER	(LOQM) JP
MONTANET	77 BOSTON CONF.	L.MONTANET	(CERN)
ROSSI	77 PL 70 B 255	G.C.ROSSI,G.VENEZIANO	(CERN)

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h(2040)

16 H(2040,JPG=4++) I=0

APEL 75 AND BLUM 75 ESTABLISH JP AS 4+ AND I=0. ADDITIONAL EVIDENCE FOR THE H MESON IS REPORTED IN WAGNER 74.

16 H MASS (MEV)

M		700 2030.	30.		APEL	75 CNTR	40. PI-P,N 2PIO	11/75	
M		2050.	25.		BLUM	75 ASPK	18.4 PI-P,N K+K-	11/75	
M		. . . . .							
M	AVG	2041.8	19.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
M	STUDENT	2041.8	20.9	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

16 H WIDTH (MEV)

W		700 180.	60.		APEL	75 CNTR	40. PI-P,N 2PIO	11/75	
W		225.	120.	70.	BLUM	75 ASPK	18.4 PI-P,N K+K-	11/75	
W		. . . . .							
W	AVG	192.8	50.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
W	STUDENT	192.8	54.8	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

16 H PARTIAL DECAY MODES

		DECAY MASSES
P1	H INTO PI PI	139+ 139
P2	H INTO K KBAR	497+ 497

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REFERENCES FOR H

WAGNER	74 LONDON CONF.	F. WAGNER, RAPPORTEURS TALK	(MPIM)
APEL	75 PL 57B 398	+AUGENSTEIN+ (KARL+PISA+SERP+WIEN+CERN)	JP
BLUM	75 PL 57B 403	+CHABAUD,DIETL,GARELICK,GRAYER+ (CERN+MPIM)	JP

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T(2190)

32 T(2190,JPG=3-+) I=1.

THIS ENTRY CONTAINS THE BUMP OBSERVED IN S-CHANNEL NBAR N AND THE STRUCTURE FOUND BY AMPLITUDE ANALYSIS OF PBAR P INTO PI PI. FOR A REVIEW SEE ASTBURY 74, EISENHANDLER 76, AND MONTANET 77. SEE ALSO S MINI-REVIEW.

32 T MASS (MEV)

		S CHANNEL NBAR N							
M	B	2190.	10.		ABRAMS	70 CNTR	S CHANNEL PBAR N	1/73	
M	B	SEEN AS BUMP IN I=1 STATE. SEE ALSO COOPER 68.							
M	B	PEASLEE 75 CONFIRM PBAR P RESULTS OF ABRAMS 70,NC NARROW STRUCTURE							
M		2193.	2.		ALSPECTOR	73 CNTR	S CHANNEL PBAR P	1/74	
M	E	2155.0	15.0		COUPLAND	77 CNTR	0 .7-2.4PB-P,PB-P	12/77*	
M	E	FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.							
M		. . . . .							
M	AVG	2192.2	1.9	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
M	STUDENT	2192.5	2.1	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

		PBAR P INTO PI+ PI-							
M	J	(2150.0)			CARTER1	77 CNTR	0 .7-2.4PB P,PIPI	12/77*	
M	J	I=1,JP=3- FROM AMPLITUDE ANALYSIS.							

32 T WIDTH (MEV)

		S CHANNEL NBAR N							
W	B	(85.)			ABRAMS	67 CNTR	S CHANNEL PBAR N	7/67	
W	B	SEE NOTE B ABOVE.							
W		98.	8.		ALSPECTOR	73 CNTR	S CHANNEL PBAR P	1/74	
W	E	135.0	75.0		COUPLAND	77 CNTR	0 .7-2.4PB-P,PB-P	12/77*	
W	E	FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.							
W		. . . . .							
W	AVG	98.4	8.0	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
W	STUDENT	98.4	8.6	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					

Mesons

T(2190), U(2350), $\bar{N}N$(2360)

Data Card Listings

For notation, see key at front of Listings.

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W       PBAR P INTO PI+ PI-
W  J      (200.0)                    CARTER1   77 CNTR  0 .7-2.4PB P,PIPI  12/77*
W  J    I=1,JP=3- FROM AMPLITUDE ANALYSIS.
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                        32  SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS A          (5.5)                    ABRAMS    70 CNTR    S CHANNEL PBAR N  1/71
CS A    FOR I=1 NBAR N
CS            2.3       0.13      0.08  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
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                        32  T PARTIAL DECAY MODES

                                                                   DECAY MASSES
P1      T INTO PBAR P                                            938+ 938
P2      T INTO PI PI                                             139+ 139
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                        REFERENCES FOR T

ABRAMS    67 PRL 18 1209        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)

COOPER    68 PRL 20 1059        +HYMAN,MANNER,MUSGRAVE,VDYVODIC        (ANL)

BRICMAN   69 PL 29 B 451        +FERRO-LUZZI,BIZARD,+          (CERN+CAEN+SACL)
MONTANET  69 LUND CONF.P.189    L.MONTANET, RAPPORTEUR                 (CERN)

ABRAMS    70 PR D 1 1917        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)

BACON     71 NP B 32 66         +BUTTERWORTH,MILLER,PHELAN,+       (RHEL+LIVP)
FIELDS    71 PRL 27 1749        +COOPER,RHINES,ALLISON               (ANL+OXF)
YOH       71 PRL 26 922         +BARISH,CAROLL,LOBKOVICZ+      (CIT+BNL+ROCH)

ALEXANDE  72 NP B 45 29         ALEXANDER,BAR-NIR,BEVARY,DAGAN,+       (TELA)
BERTANZA  72  CHEXBRES (CERN 72-10)  L.BERTANZA, REVIEW TALK           (PISA)
BUGG      72 PR D 6 3047        +CONDO,HART,COHN,ENDORF,+  (TENN+ORNL+CINC)
CLAYTON   72 NP B 47 81         +MASON,MUIRHEAD,RIGOPOULOS,+       (LIVP+PATR)
DIEBOLD   72 BATAV.CONF.        R.DIEBOLD  RAPPORTEUR TALK               (ANL)
DONALD    72 PL 40 B 586        +GALLETLY,EDWARDS,DE BILLY,+       (LIVP+LPNP)

ALSPECTO  73 PRL 30 511         ALSPECTOR,COHEN,CVIJANOVICH,+    (RUTG+UPNJ)
BACON     73 PR D  7 577        +BUTTERWORTH,                      (RHEL+LIVP)
BETTINI   73 NC 15 A 563        +GARNJOST,BIGI,+          (PADO+LBL+PISA+TORI)
BOWEN     73 PRL 30 332         +EARLES,FAISSLER,BLIEDEN,+         (NEAS+STON)
MING MA   73 NP B 51 77         +EASTMAN,OH,PARKER,SMITH,SPRAFKA       (MSU)
NICHOLSO  73 PR D 7 2572        NICHOLSON,DELORME,CARROLL,+    (CIT+ROCH+BNL)

ASTBURY   74  CERN 74-18        A.ASTBURY REVIEW AT PRAGUE 74          (RHEL)
BERTANZA  74 NC 23A 209         +BIGI,CASALI,LARICCIA,+      (PISA+PADO+TORI)
HYAMS     74 NP B 73 202        +JONES,WEILHAMMER,BLUM,+           (CERN+MPIM)

DONNACHI  75 NC 26 A 317        A.DONNACHIE,P.R.THOMAS             (MANCHESTER)
EISENHAN  75 NP B 96 109        EISENHANDLER,GIBSON,+  (LOQM+LIVP+DARE+RHEL)
HANDLER   75 NP B101 35         +JACQUES,JONES,PANDOULAS,+     (RUTG+STEV+ALBA)
HUESMAN   75 NC 25A  91         +GARNJOST,ROSS,+          (LBL+PADO+PISA+TORI)
PEASLEE   75 PL 57B 189         +DEMARZO,GUERRIERO,+       (CANB+BARI+BROW+MIT)

GAY       76 NC 31 A 593        +JEANNERET,BOGDANSKI,+(NEUC+LAUS+LIVP+LPNP)
EISENHAN  76 STOCK.SYMP.NBAR-N  E.EISENHANDLER                         (LOQM)
ZEMANY    76 NP B 103 537       +MING MA,MOUNTZ,SMITH                    (MSU)

CARTER1   77 PL 67 B 117        +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER2   77 PL 67 B 122        A.A.CARTER                             (LOQM)  JP
CARTER3   77  PREP. RL 77 045A  A.A.CARTER                             (LOQM)  JP
COUPLAND  77 PL 71 B 460        +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
JONES     77 NP B 119 476       M.D.JONES,R.J.PLAND                    (RUTG)
MONTANET  77  BOSTON CONF.      L.MONTANET                             (CERN)
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U(2350)

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        41  U(2350,JPG=4++) I=0

        FOR A REVIEW SEE ASTBURY 74, EISENHANDLER 76,
        AND MONTANET 77.  SEE ALSO S MINI-REVIEW.
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                        41  U(2350) MASS

M         2375.       10.            ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
M   I     (2359.)     (2.)           ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  EI     (2345)      (15.0)         COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77*
M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M   I   ISOSPINS 0 AND 1 NOT SEPARATED

M       PBAR P INTO PI+ PI-
M  J      (2310.0)                   CARTER1   77 CNTR  0 .7-2.4PB P,PIPI  12/77*
M  J    I=0,JP=4+ FROM AMPLITUDE ANALYSIS.
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                        41  U(2350) WIDTH

W         (190.)                     ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
W   I     (165.)      (18.)     (8.) ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  EI     (135.0)   (150.0)   (65.0) COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77*
W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W   I   ISOSPINS 0 AND 1 NOT SEPARATED

W       PBAR P INTO PI+ PI-
W  J      (210.0)                    CARTER1   77 CNTR  0 .7-2.4PB P,PIPI  12/77*
W  J    I=0,JP=4+ FROM AMPLITUDE ANALYSIS.
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                        41  U(2350) SIGMA (MB) FOR FORMATION EXPERIMENTS

CS          (2.5)                    ABRAMS    70 CNTR                       1/71
CS  I       (2.1)     (0.2)     (0.1) ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
CS  I   ISOSPINS 0 AND 1 NOT SEPARATED
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                        41  U PARTIAL DECAY MODES

                                                                   DECAY MASSES
P1      U INTO PBAR P                                            938+ 938
P2      U INTO PI PI                                             139+ 139
****** ********* ********* ********* ********* ********* ********* ********

                        REFERENCES FOR U(2350)

BRICMAN   69 PL 29 B 451        +FERRO-LUZZI,BIZARD,+          (CERN+CAEN+SACL)
ABRAMS    70 PR D 1 1917        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
EASTMAN   72 NP B 51 29         +MING MA,OH,PARKER,SMITH,SPRAFKA       (MSU)
MING MA   72 NP B 51 77         +EASTMAN,OH,PARKER,SMITH,SPRAFKA       (MSU)
ALSPECTO  73 PRL 30 511         ALSPECTOR,COHEN,CVIJANOVICH,+    (RUTG+UPNJ)
NICHOLSO  73 PR D 7 2572        NICHOLSON,DELORME,CARROLL,+    (CIT+ROCH+BNL)

ASTBURY   74  CERN 74-18        A.ASTBURY REVIEW AT PRAGUE 74          (RHEL)
HYAMS     74 NP B 73 202        +JONES,WEILHAMMER,BLUM,+           (CERN+MPIM)
MING MA   74 NP B68 214         +MOUNTZ,ZEMANY,SMITH                     (MICH)

DONNACHI  75 NC 26 A 317        A.DONNACHIE,P.R.THOMAS             (MANCHESTER)
EISENHAN  75 NP B 96 109        EISENHANDLER,GIBSON,+  (LOQM+LIVP+DARE+RHEL)

EISENHAN  76 STOCK.SYMP.NBAR-N  E.EISENHANDLER                         (LOQM)

CARTER1   77 PL 67 B 117        +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER2   77 PL 67 B 122        A.A.CARTER                             (LOQM)  JP
CARTER3   77  PREP. RL 77 045A  A.A.CARTER                             (LOQM)  JP
COUPLAND  77 PL 71 B 460        +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
DE MARZO  77  PRIVATE COMM.     +                          (BARI+BROWN+MIT)  JP
MONTANET  77  BOSTON CONF.      L.MONTANET                             (CERN)
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$\bar{N}N$(2360)

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        33  NBAR N(2360,JPG=   ) I=1

        THIS ENTRY CONTAINS THE BROAD BUMP OBSERVED
        IN THE S-CHANNEL NBAR N AND THE STRUCTURE FOUND
        BY AMPLITUDE ANALYSIS OF PBAR P INTO PI PI.
        OMITTED FROM TABLE.
        FOR A REVIEW SEE ASTBURY 74, EISENHANDLER 76,
        AND MONTANET 77.  SEE ALSO S MINI-REVIEW.
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                        33  NBAR N(2360)  MASS (MEV)

M       S CHANNEL NBAR N
M  A      2350.       10.            ABRAMS    70 CNTR    S CHANNEL NBAR N  1/73
M  A    FOR I=1 NBAR N
M  N      (2360.0)    (25.0)         OH        70 HDBC  -OPBAR(P,N),K*K2PI  1/73
M  N    NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71
M  N    NARROW STATE NOT CONFIRMED BY OH 73 WITH MORE DATA.
M  I      (2359.)     (2.)           ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
M  EI     (2345.0)    (15.0)         COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77*
M  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
M  I    ISOSPINS 0 AND 1 NOT SEPARATED
M
M       PBAR P INTO PI+ PI-
M  J      (2480.0)                   CARTER1   77 CNTR  0 .7-2.4PB P,PIPI  12/77*
M  J    I=1,JP=5- FROM AMPLITUDE ANALYSIS.
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                        33  NBAR N(2360)  WIDTH (MEV)

W       S CHANNEL NBAR N
W         (140.)                     ABRAMS    67 CNTR    S CHANNEL PBAR N  1/73
W  N      (60.0)  OR LESS            OH        70 HDBC  -OPBAR(P,N),K*K2PI 11/71
W  N    NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71
W  N    NARROW STATE NOT CONFIRMED BY OH 73 WITH MORE DATA.
W  I      (165.)    (18.)     (8.)  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
W  EI     (135.0)   (150.0)   (65.0) COUPLAND  77 CNTR  0 .7-2.4PB-P,PB-P  12/77*
W  E    FROM A FIT TO THE TOTAL ELASTIC CROSS SECTION.
W  I    ISOSPINS 0 AND 1 NOT SEPARATED
W
W       PBAR P INTO PI+ PI-
W  J      (210.0)                    CARTER1   77 CNTR  0 .7-2.4PB P,PIPI  12/77*
W  J    I=1,JP=5- FROM AMPLITUDE ANALYSIS.
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                        33  SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS  A       (3.2)                    ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
CS  A   FOR I=1 NBAR N
CS  I       (2.1)     (0.2)     (0.1) ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74
CS  I   ISOSPINS 0 AND 1 NOT SEPARATED

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                        REFERENCES FOR NBAR N(2360)

ABRAMS    67 PRL 18 1209        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)

BRICMAN   69 PL 29 B 451        +FERRO-LUZZI,BIZARD,+          (CERN+CAEN+SACL)
CASO      69 LNC 3 707          +CONTE,BENZ,+          (GENO+DESY+HAMB+MILA+SACL)

ABRAMS    70 PR D 1 1917        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+    (BNL)
OH        70 PRL 24 1257        +PARKER,EASTMAN,SMITH,SPRAFKA,MA         (MSU)

CHAPMAN   71 PR D4 1275         +GREEN,LYS,MURPHY,RING,+                 (MICH)
FIELDS    71 PRL 27 1749        +COOPER,RHINES,ALLISON               (ANL+OXF)
YOH       71 PRL 26 922         +BARISH,CAROLL,LOBKOVICZ+      (CIT+BNL+ROCH)

ASTBURY   72  CERN 72-10        A.ASTBURY REVIEW AT CHEXBRES 72        (RHEL)
DIEBOLD   72 BATAV.CONF.V3 17   R.DIEBOLD  RAPPORTEUR TALK               (ANL)
EASTMAN   72 NP B 51 29         +MING MA,OH,PARKER,SMITH,SPRAFKA       (MSU)
MING MA   72 NP B 51 77         +EASTMAN,OH,PARKER,SMITH,SPRAFKA       (MSU)

ALSPECTO  73 PRL 30 511         ALSPECTOR,COHEN,CVIJANOVICH,+    (RUTG+UPNJ)
BOWEN     73 PRL 30 332         +EARLES,FAISSLER,BLIEDEN,+         (NEAS+STON)
DONNACHI  73 LNC 7 285          A.DONNACHIE,P.R.THOMAS             (MANCHESTER)
OH        73 NP B 51 57         +EASTMAN,MING MA,PARKER,SMITH,+        (MSU)
NICHOLSO  73 PR D 7 2572        NICHOLSON,DELORME,CARROLL,+    (CIT+ROCH+BNL)

ASTBURY   74  CERN 74-18        A.ASTBURY REVIEW AT PRAGUE 74          (RHEL)
HYAMS     74 NP B 73 202        +JONES,WEILHAMMER,BLUM,+           (CERN+MPIM)
MING MA   74 NP B68 214         +MOUNTZ,ZEMANY,SMITH                     (MICH)

DONNACHI  75 NC 26 A 317        A.DONNACHIE,P.R.THOMAS             (MANCHESTER)
EISENHAN  75 NP B 96 109        EISENHANDLER,GIBSON,+  (LOQM+LIVP+DARE+RHEL)

EISENHAN  76 STOCK.SYMP.NBAR-N  E.EISENHANDLER                         (LOQM)

CARTER1   77 PL 67 B 117        +COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)  JP
CARTER2   77 PL 67 B 122        A.A.CARTER                             (LOQM)  JP
CARTER3   77  PREP. RL 77 045A  A.A.CARTER                             (LOQM)  JP
COUPLAND  77 PL 71 B 460        +EISENHANDLER,GIBSON,ASTBURY,+  (LOQM+RHEL)
MONTANET  77  BOSTON CONF.      L.MONTANET                             (CERN)
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Data Card Listings

For notation, see key at front of Listings.

$\bar{N}N(1400-3600)$

51 NBAR N(1400-3600)

THIS ENTRY CONTAINS VARIOUS HIGH-MASS NON-STRANGE PEAKS COUPLED TO THE NBAR N SYSTEM, AS WELL AS QUASI NUCLEAR BOUND STATES BELOW THRESHOLD. SEE ALSO THE S, T, U DATA CARD LISTINGS AND MINI-REVIEW. OMITTED FROM TABLE.

51 NBAR N(1400-3600) MASSES AND WIDTHS (MEV)

M	W G	(1395.)			PAVLOPOUL 78 CNTR		STOPPED PBARS			1/78*
M	W G	(1646.)			PAVLOPOUL 78 CNTR		STOPPED PBARS			1/78*
M	W G	(1684.)			PAVLOPOUL 78 CNTR		STOPPED PBARS			1/78*
	W	OBSERVED WIDTHS CONSISTENT WITH EXPERIMENTAL RESOLUTION.								
	G	THEY LOOKED FOR RADIATIVE TRANSITIONS TO BOUND P PBAR STATES,								
	G	MONO-ENERGETIC GAMMA RAYS DETECTED.								
M	D	1794.5	1.4		GRAY	71 DBC	-	0.PBAR D		1/72
W	D	(8.)	OR LESS CL=.95		GRAY	71 DBC	-	0.PBAR D		1/72
	D	DECAYS TO FOUR OR MORE PIONS,I=1.								
M		(1897.)	(1.)		KALOGERO 75 DBC	-	PBAR N ANNIH			12/75
W		(25.)	(6.)		KALOGERO 75 DBC	-	PBAR N ANNIH			12/75
M	B	1897.0	17.0		ABASHIAN 76 STRC		8PI-P,P 3PI			12/77*
W	B	110.0	82.0		ABASHIAN 76 STRC		8PI-P,P 3PI			12/77*
	B	PRODUCED BACKWARDS.								
M		(1930.)			SEE S(1935) ABOVE.					
W		(9.)			SEE S(1935) ABOVE.					
M		153 2020.0	3.0		BENKHEIRI 77 OMEG	-	9,12PI-P,PPPBPI-			12/77*
W		153 24.0	12.0		BENKHEIRI 77 OMEG	-	9,12PI-P,PPPBPI-			12/77*
M	K	(2190.0)			KALBFLEIS 69 HBC		0 S-CHANNEL PBARP			7/69
W	K	BETWEEN 20 AND 80 MEV			KALBFLEIS 69 HBC		0 S-CHANNEL PBARP			7/69
	K	SEEN IN PBAR P TO RHOO RHOO PIO. IG=1-.								
	K	NOT SEEN BY BACON 73,NOR BY ZEMAN 76								
M		(2200.)			SEE T (2200) ABOVE.					
W		(150.)			SEE T (2200) ABOVE.					
M		58 2204.0	5.0		BENKHEIRI 77 OMEG	-	9,12PI-P,PPPBPI-			12/77*
W		58 (16.)	OR LESS		BENKHEIRI 77 OMEG	-	9,12PI-P,PPPBPI-			12/77*
M	A	(2207.)	(13.)		ALLES-BOR 67 HBC		0 5.7 PBAR P			12/66
W	A	(62.)	(52.)		ALLES-BOR 67 HBC		0 5.7 PBAR P			12/66
	A	ALLES-BORELLI 67 SEE NEUTRAL MODE ONLY (PI+PI-PIO)								
M	S	(2141.)			DONALD 73 HBC		0 S CHANNEL PBAR P			1/74
W	S	(14.)			DONALD 73 HBC		0 S CHANNEL PBAR P			1/74
	S	SEEN IN FINAL STATE (OMEGA PI+ PI-)								
M		(2360.)			SEE NBAR N (2360) ABOVE.					
M		(2375.)			SEE U(2350) ABOVE.					
W		(200.)			SEE U(2350) ABOVE.					
M	J	2480.0	30.0		CARTERI 77 CNTR	0	.7-2.4PB P,PIPI			12/77*
W	J	210.0	25.0		CARTERI 77 CNTR	0	.7-2.4PB P,PIPI			12/77*
	J	I=1,JP=5- FROM AMPLITUDE ANALYSIS OF PABAR P INTO PI PI.								
M	V	2850.0	5.0		BRAUN 76 DBC	-	5.5PBAR D,N NBP+			12/77*
W	V	(39.)	OR LESS		BRAUN 76 DBC	-	5.5PBAR D,N NBP+			12/77*
	V	DECAYS TO NBAR N AND NBAR N PI								
M		150 2950.0	10.0		EVANGELIS 77 OMEG	-	16PI-P,PPBARPI-S			12/77*
W		150 (32.0)	OR LESS CL=.99		EVANGELIS 77 OMEG	-	16PI-P,PPBARPI-S			12/77*
M	W	3080.	20.		ALEXANDER 72 HBC		0 6.94 PBAR P			1/73
W	W	220.	70.		ALEXANDER 72 HBC		0 6.94 PBAR P			1/73
	W	DECAYS TO 3PI+ 3PI-								
	W	NOT SEEN BY KALELKAR 75 WITH 1.5 TIMES MORE DATA								
M	X	3370.	10.		ALEXANDER 72 HBC		0 6.94 PBAR P			1/73
W	X	150.	40.		ALEXANDER 72 HBC		0 6.94 PBAR P			1/73
	X	DECAYS TO 4PI+ 4PI-								
M	Y	3390.	20.		ALEXANDER 72 HBC		0 6.94 PBAR P			1/73
W	Y	220.	100.		ALEXANDER 72 HBC		0 6.94 PBAR P			1/73
	Y	DECAYS TO 3PI+ 3PI-								
	Y	NOT SEEN BY KALELKAR 75 WITH 1.5 TIMES MORE DATA								
M	Z	3600.	20.		ALEXANDER 72 HBC		0 6.94 PBAR P			1/73
W	Z	140.	20.		ALEXANDER 72 HBC		0 6.94 PBAR P			1/73
	Z	DECAYS TO 4PI+ 4PI-								

REFERENCES FOR NBAR N(1400-3600)

ALLES-BO 67 NC 50 A 776	ALLES-BORELLI,FRENCH,FRISK,+	(CERN+BONN)G=-
KALBFLEI 69 PL 29 B 259	G.KALBFLEISCH,R.STRAND,V.VANDERBURG	(BNL)
KALBFLEI 70 PHILAD.CONF.P.409	G.KALBFLEISCH AND D.MILLER REVUES	(BNL)
ALEXANDE 70 PRL 25 63	+BAR-NIR,DAGAN,GIDAL,GRUNHAUS+	(TEL-AVIV)
GRAY 71 PRL 26 1491	+HAGERT,KALOGEROPOULOS	(SYRA)
ALEXANDE 72 NP B 45 29	ALEXANDER,BAR-NIR,BEVARY,DAGAN,+	(TELA)
BOGDANOV 72 PRL 28 1418	BOGDANOVA,DALKAROV,SHAPIRO	(ITEP)
DONALD 73 NP B 61 333	+EDWARDS,GIBBINS,BRIAND,DUBOC,+	(LIVP+LPNP)
GRAY 73 PRL 30 1091	+PAPADOPOULOU,KARAGEOPOULOS,+	(ATEN+SYRA)
NICHOLSO 73 PR D 7 2572	NICHOLSON,DELORME,CARROLL,+	(CIT+ROCH+BNL)
HYAMS 74 NP B 73 202	+JONES,WEILHAMMER,BLUM,+	(CERN+MPIM)
DONNACHI 75 NC 26 A 317	A.DONNACHIE,P.R.THOMAS	(MANCHESTER)
EISENHAN 75 NP B 96 109	EISENHANDLER,GIBSON,+ (LOQM+LIVP+DARE+RHEL)	
KALELKAR 75 THESIS(NEVIS 207)	M.S.KALELKAR	(COLU)
KALOGERO 75 PRL 34 1047	KALOGEROPOULOS,TZANAKOS	(SYRA)
ABASHIAN 76 PR D 13 5	+WATSON,GELFAND,BUTTRAM+(ILL+ANL+CHIC+IOWA)	
BRAUN 76 PL B 60 481	+BRICK,FRIDMAN,GERBER,JUILLOT,MAURER+(STRB)	
BENKHEIR 77 PL B 68 483	BENKHEIRI,BOUCROT,+ (CERN+DEF+EPOL+LALO)	
CARTERI 77 PL 67 B 117	+COUPLAND,EISENHANDLER,ASTBURY,+(LOQM+RHEL)	JP
EVANGELI 77 PL B 72 139	EVANGELISTA+ (BARI+BONN+CERN+DARE+GLAS+)	
PAVLOPOU 78 PL 72 B 415	PAVLOPOULOS+ (KARL+BASEL+CERN+STOH+STRB)	

X(1900–3600)

46 X(1900-3600)

THIS ENTRY CONTAINS VARICUS HIGH-MASS NON-STRANGE PEAKS. OMITTED FROM TABLE.

The high mass region is covered nearly continuously by evidence for peaks of various widths and decay modes. As a satisfactory grouping into particles is not yet possible, we list together all the Y = 0 bumps coupled neither to $\bar{N}N$ nor to e^+e^- and having M > 1900 MeV, ordered by increasing mass. Note that ANTIPOV 72 ($\pi^- p \to p M M^-$ at 25 and 40 GeV/c) see no narrow bumps.

46 X(1900-3600) MASSES AND WIDTHS (MEV)

M		100 1898.	18.		THOMPSON 74 HBC	+	13 PI+ P,2RHO			12/75
W		100 108.	41.	27.	THOMPSON 74 HBC	+	13 PI+ P,2RHO			12/75
M		100 1900.	40.		BOESEBECK 68 HBC	+	8 PI+ P,PI+ PIO			12/75
W		100 216.	105.		BOESEBECK 68 HBC	+	8 PI+ P,PI+ PIO			12/75
M		30 1973.0	15.0		CASO 70 HBC	-	11.2PI-P,RHO 2PI			12/75
W		30 (80.0)			CASO 70 HBC	-	11.2PI-P,RHO 2PI			12/75
M	K	40(1975.0)	(12.0)		KRAMER 70 HBC	+	13.1 PI+ P,2PI			11/70
W	K	40 (52.0)	OR LESS CL=.90		KRAMER 70 HBC	+	13.1 PI+ P,2PI			12/75
	K	2PI PEAK OF KRAMER NOT SEEN IN SAME EXP WITH MORE DATA(THOMPSON 74)								
M		50(2070.)			TAKAHASHI 72 HBC		8. PI-P,N 2PI			12/75
W		50 (160.)			TAKAHASHI 72 HBC		8. PI-P,N 2PI			12/75
M	E	2157.0	10.0		KRAMER 70 HBC	+	13.1 PI+ P,2PI			11/70
W	E	68.0	22.0		KRAMER 70 HBC	+	13.1 PI+ P,2PI			11/70
	E	EVIDENCE OF KRAMER 70 DISAPPEARED WITH MORE STATISTICS(THOMPSON 74)								
M		2190.0	10.0		CLAYTON 67 HBC	+-	2.5PBAR,A2+OMEGA			10/67
M	C	(2207.0)	(22.0)		CASO 70 HBC	-	11.2PI- P,NOTE C			5/70
W	C	(130.0)			CASO 70 HBC	-	11.2PI- P,NOTE C			5/70
	C	SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)								
M	B	126 2340.	20.		BALTAY 75 HBC	+	15 PI+P,P5PI			12/75
W	B	126 180.	60.		BALTAY 75 HBC	+	15 PI+P,P5PI			12/75
	B	DOMINANT DECAY INTO RHO RHO PI								
M		2500.0	32.0		ANDERSON 69 MMS	-	16 PI- P,BACKW9			8/69
W		(87.0)			ANDERSON 69 MMS	-	16 PI- P,BACKW9			8/69
M		550 2620.	20.		BAUD 69 MMS	-	8.-10. PI- P			9/69
W		550 85.	30.		BAUD 69 MMS	-	8.-10. PI- P			9/69
M		2676.0	27.0		CASO 70 HBC	-	11.2PI- P,NOTE C			5/70
W		(150.0)			CASO 70 HBC	-	11.2PI- P,NOTE C			5/70
	C	SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM)								
M		640 2800.	20.		BAUD 69 MMS	-	8.-10. PI- P			9/69
W		640 46.	10.		BAUD 69 MMS	-	8.-10. PI- P			9/69
M	C	15 2820.	10.		SABAU 71 HBC	+	8. PI+ P			11/71
W	C	15 50.	10.		SABAU 71 HBC	+	8. PI+ P			11/71
	C	SEEN IN (K KBAR PI PI)+ MASS DISTRIBUTION								
M		230 2880.	20.		BAUD 69 MMS	-	8.-10. PI- P			9/69
W		230 (15.)	OR LESS		BAUD 69 MMS	-	8.-10. PI- P			9/69
M	Y	43 3013.	5.		YOST 71 HBC	+	11.PI+ P,P(8PI)+			11/71
W	Y	43 (40.)	OR LESS		YOST 71 HBC	+	11.PI+ P,P(8GI)			5/71
	Y	4.3 S.D. EFFECT . DECAY TO 7 PIONS								
	Y	NOT SEEN BY KALELKAR 75 WITH 5 TIMES MORE DATA								
M		3025.0	20.0		BAUD 70 MMS	-	10.5-13 PI- P			5/70
W		(25.0)	APPROX.		BAUD 70 MMS	-	10.5-13 PI- P			5/70
M		3075.0	20.0		BAUD 70 MMS	-	10.5-13 PI- P			5/70
W		(25.0)	APPROX.		BAUD 70 MMS	-	10.5-13 PI- P			5/70
M		3145.0	20.0		BAUD 70 MMS	-	10.5-15 PI- P			5/70
W		(10.0)	OR LESS		BAUD 70 MMS	-	10.5-15 PI- P			5/70
M		3475.0	20.0		BAUD 70 MMS	-	14-15.5 PI- P			5/70
W		(30.0)	APPROX.		BAUD 70 MMS	-	14-15.5 PI- P			5/70
M		3535.0	20.0		BAUD 70 MMS	-	14-15.5 PI- P			5/70
W		(30.0)	APPROX.		BAUD 70 MMS	-	14-15.5 PI- P			5/70

REFERENCES FOR X(1900-3600)

CLAYTON 67 HEIDBG.CONF.P.57	+MASON,MUIRHEAD,FILIPPAS+(LIVERPOOL+ATHENS)	
BOESEBEC 68 NP B 4 501	BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)	
ANDERSON 69 PRL 22 1390	+COLLINS,+	(BNL+CARN)
BAUD 69 PL 30B 129	CERN BOSON SPECTROMETER GROUP	(CERN)
BAUD 70 PL 31 B 549	CERN BOSON SPECTROMETER GROUP	(CERN)
CASO 70 LNC 3 707	+CONTE,TOMASINI,COROS+(GENO+HAMB+MILA+SACL)	
KRAMER 70 PRL 25 396	+BARTON,GUTAY,LICHTMAN,MILLER,+	(PURDUE)
SABAU 71 LNC 1 514	+URETSKY	(BUCH+ANL)
YOST 71 PR D 3 642	+MORRIS,ALBRIGHT,BRUCKER,LANNUTTI	(FSU)
TAKAHASH 72 PR D 6 1266	TAKAHASHI,BARISH,+ (TOHO+PENN+NDAM+ANL)	
THOMPSON 74 NP B69 220	+GAIDOS,MCILWAIN,MILLER,MULERA,+	(PURD)
BALTAY 75 PRL 35 891	+CAUTIS,COHEN,KALELKAR,PISELLO,+(COLU+BING)	
KALELKAR 75 THESIS(NEVIS 207)	M.S.KALELKAR	(COLU)
KEMP 75 NC 27 A 155	+LOTTS,CONTRI,TEDDORO+(DURH+GENO+MILA+LPNP)	

Mesons

e^+e^-(1100–3100), X(2830), J/ψ(3100)

e^+e^-(1100–3100)

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7  E+ E-(1100-3100,JPG=1- ) I=

THIS ENTRY CONTAINS NON-STRANGE
VECTOR MESONS COUPLED TO E+ E-
BETWEEN PHI AND J/PSI MASS REGION.
SEE ALSO RHO PRIME(1250) AND RHO
PRIME(1600) MINI-REVIEW.
OMITTED FROM TABLE.
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7 E+ E-(1100-3100) MASSES AND WIDTHS (MEV)

M		400 1097.	19.		BARTALUC 77 MASP	7 GAM P, E+E- P		12/77*
W		400 31.	24.		BARTALUC 77 MASP	7 GAM P, E+E- P		12/77*
M		1256.	10.		SEE RHO PRIME (1250)			12/77*
W		130.	20.		SEE RHO PRIME (1250)			12/77*
M	A	(1499.0)	(0.5) (0.7)		BEMPORAD 77 BBAR	E+ E-		1/78*
W	A	(2.3)	(0.5) (0.3)		BEMPORAD 77 BBAR	E+ E-		1/78*
	A	SEEN ALSO BY THE GAMMA GAMMA 2 GROUP (BEMPORAD 77).						
M		(1600.)	APPROX.		SEE RHO PRIME (1600)			12/77*
W		300 TO 800			SEE RHO PRIME (1600)			12/77*
M	C	(1662.)	(5.)		LAPLANCHE 77 OSPK	E+ E-		1/78*
W	C	(25.)	(13.)		LAPLANCHE 77 OSPK	E+ E-		1/78*
	C	COUPLES TO BOTH 3 PI AND 5 PI						
M	R	(1700.)	(20.)		LAPLANCHE 77 OSPK	E+E- TO 4PI,6PI		1/78*
W	R	(150.)	(60.)		LAPLANCHE 77 OSPK	E+E- TO 4PI,6PI		1/78*
	R	G=+, BUT BRANCHING TO 4PI+- IS SMALL. THEY ALSO OBSERVE A						
	R	STATE AT 1540 MEV WITH LARGER 4PI+- DECAY (SEE RHO PRIME (1600)).						
M	I	1765 TO 1792			BARBIELLI 77 BBAR	E+ E-		12/77*
W	I	47 TO 79			BARBIELLI 77 BBAR	E+ E-		12/77*
M	D	(1769.)	(8.)		LAPLANCHE 77 OSPK	E+ E-		1/78*
W	D	(53.)	(30.)		LAPLANCHE 77 OSPK	E+ E-		1/78*
	D	COUPLES MAINLY TO 5 PI.						
M	I	1812 TO 1836			BARBIELLI 77 BBAR	E+ E-		12/77*
W	I	13 TO 34			BARBIELLI 77 BBAR	E+ E-		12/77*
M	S	58 1819.	7.		BACCI 77 GG2	E+ E-		12/77*
W	S	58 24.	9.		BACCI 77 GG2	E+ E-		12/77*
M	S	1821.	18.		ESPOSITO 77 MEA	E+ E-		12/77*
W	S	31.	25.		ESPOSITO 77 MEA	E+ E-		12/77*
M		(2130.)	APPROX.		BEMPORAD 77 MEA	E+E-,K*(892)+...		1/78*
W		(30.)	APPROX.		BEMPORAD 77 MEA	E+E-,K*(892)+...		1/78*
	I	SPREAD TAKES ACCOUNT OF POSSIBLE INTERFERENCE BETWEEN THE						
	I	TWO STRUCTURES.						
	S	SYSTEMATIC ERROR ADDED LINEARLY.						

REFERENCES FOR E+ E-(1100-3100)

BACCI	77 PL B 68 393	+DE ZORZI,PENSO,STELLA,BALDINI,+(ROMA+FRAS)
BARBIELL	77 PL B 68 397	BARBIELLINI,BARLETTA,+(FRAS+NAPL+PISA+SANI)
BARTALUC	77 NC A 39 374	BARTALUCCI BERTOLUCCI,BRADASCHIA(DESY+FRAS)
ALSC	77 PREP. DESY 77-59	
BEMPORAD	77 HAMBURG CONF.	C. BEMPORAD (PISA)
ESPOSITO	77 PL B 68 389	+FELICETTI,MARINI,+ (FRAS+NAPL+PADO+ROMA)
LAPLANCH	77 HAMBURG CONF.	F. LAPLANCHE (ORSA)
ALSO	77 PL B 67 231	COSME,DUDELZAK,GRELAUD,JEAN-MARIE+ (ORSA)

X(2830)

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54  X(2830,JPG=   1 I=

OBSERVED IN THE SEQUENTIAL RADIATIVE DECAY OF THE
J/PSI(3100) INTO X(2830) GAMMA, X(2830) INTO GAMMA
GAMMA. THIS SUGGESTS QUANTUM NUMBER ASSIGNMENTS C=+,
IG=0+ OR 1-. POSSIBLY ALSO SEEN IN THE REACTION PI- P
INTO NEUTRON 2 GAMMA.
NEEDS CONFIRMATION. OMITTED FROM TABLE.
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54 X(2830) MASS (MEV)

M	B	8(2700.0)			BARTEL 76 CNTR	E+E-,3 GAMMA		1/76
M	B	SIGNAL IS ONLY 2 STD EFFECT IN BARTEL 76.						3/77*
M		19 2820.0	14.0		YAMADA 77 DASP	E+ E-,3 GAMMA		12/77*
M		11 2880.0	90.0		APEL 78 SPEC	40 PI-P,N 2GAMMA		1/78*
M		. . . . .						
M	AVG	2821.4	13.8		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
M	STUDENT	2821.4	15.0		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

54 X(2830) PARTIAL DECAY MODES

		DECAY MASSES
P1	X(2830) INTO GAMMA GAMMA	0+ 0
P2	X(2830) INTO PBAR P	938+ 938

54 X(2830) BRANCHING RATIOS

R		SEE BRANCHING RATIOS R70,R76,R77,R79 OF J/PSI(3100)						
R		SEE BRANCHING RATIOS R30,R54 OF PSI(3685)						
R1		X(2830) INTO (PBAR P)/TOTAL			(P2)			
R1		2 POSSIBLY SEEN			WIIK 75 DASP	E+E-		1/76
R2		X(2830) INTO (GAMMA GAMMA)/TOTAL			(P1)			
R2		SEEN			YAMADA 77 DASP	E+ E-,3 GAMMA		12/77*
R2		SEEN			APEL 78 SPEC	40 PI-P,N 2GAMMA		1/78*

REFERENCES FOR X(2830)

WIIK	75 STANFORD SYMP.69	B.H.WIIK (DESY)
BARTEL	76 TBILISI CONF.N56	+QUINKER,OLSSON,HEINTZE,+ (DESY+HEID)
WIIK	76 TBILISI CONF.N 75	B.H.WIIK RAPPORTEUR (DESY)
AMALDI	77 LNC 20 409	+BENEVENTANO,DELL,DCOHER+(ROMA+BNL+ADELPHI)
APEL	77 PL	+AUGENSTEIN,+ (KARL+PISA+SERP+WIEN+CERN)
BRAUNSCH	77 PL 67 B 243	BRAUNSCHWEIG,+ (AACH+DESY+HAMB+MPIM+TOKY)
YAMADA	77 HAMB. CONF. P. 69	YAMADA (AACH+HAMB+DESY+MUNC+TOKY)
WIIK	77 DESY 77/01	+WOLF (DESY)

J/ψ(3100)

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70  J/PSI(3100,JPG=1--) I=0
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70 J/PSI(3100) MASS (MEV)

WE USE INDEPENDENT MEASUREMENTS OF THE J/PSI(3100) MASS, THE PSI(3685) MASS AND THE MASS DIFFERENCE TO PERFORM A CONSTRAINED FIT.

M		(3100.)			AUBERT 74 SPEC	28. PP(E+E-)		2/75
M	L	(3105.)	(3.)		AUGUSTIN 74 SMAG	E+E-		2/75
M	O	3095.	4.		BOYARSKI 75 SMAG	E+E-		3/75
M	S	3089.5	31.		CRIEGEE1 75 PLUT	E+E-		2/75
M		3098.	6.		PREPOST 75 SPEC	13.-21.GAMMA D		1/76
M		3103.	6.		BEMPORAD 75 FRAB	E+E-		1/76
M		3096.0	30.0		SNYDER 76 SPEC	400 P BE,E+E-		1/77*
M	L	BOYARSKI 75 IS A REEVALUATION OF AUGUSTIN 74 BASED						
M	L	ON A RECALIBRATION OF THE SPEAR BEAM ENERGY.						
M								
M	O	MASS, WIDTH, PARTIAL WIDTHS, AND BRANCHING RATIOS ALL OBTAINED						
M	O	FROM ONE OVERALL FIT TO DATA OF THIS EXPERIMENT.						
M								
M	S	ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF						
M	S	THE BEAM ENERGY.						
M		. . . . .						
M	AVG	3097.5	2.9		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
M	STUDENT	3097.5	3.2		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			
M	FIT	3096.8	2.4		FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)			

70 J/PSI(3100) WIDTH (KEV)

W		69.	15.		BOYARSKI 75 SMAG	E+E-		3/75
W		68.	26.		BALDINI1 75 FRAG	E+E-		1/76
W		60.	25.		ESPOSITO 75 FRAM	E+E-		1/76
W		. . . . .						
W	AVG	66.9	11.5		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
W	STUDENT	66.9	12.4		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

70 J/PSI(3100) PARTIAL DECAY MODES

		DECAY MASSES
P1	J/PSI(3100) INTO E+ E-	.5+ .5
P2	J/PSI(3100) INTO MU+ MU-	105+ 105
P3	J/PSI(3100) INTO HADRONS	
P4	J/PSI(3100) INTO VIRTUAL GAMMA INTO HADRONS	
P	HADRONIC DECAYS	
P11	J/PSI(3100) INTO PI+ PI-	139+ 139
P12	J/PSI(3100) INTO PI+ PI- PI0	139+ 139+ 134
P13	J/PSI(3100) INTO 2(PI+ PI-)	139+ 139+ 139+ 139
P14	J/PSI(3100) INTO 2(PI+ PI-) PI0	
P15	J/PSI(3100) INTO 3(PI+ PI-)	
P16	J/PSI(3100) INTO 3(PI+ PI-) PI0	
P17	J/PSI(3100) INTO 4(PI+ PI-)	
P18	J/PSI(3100) INTO 4(PI+ PI-) PI0	
P19	J/PSI(3100) INTO K KBAR	497+ 497
P20	J/PSI(3100) INTO K KBAR PI	497+ 497+ 139
P21	J/PSI(3100) INTO PI+ PI- K+ K-	139+ 139+ 497+ 497
P22	J/PSI(3100) INTO 2(PI+ PI-) K+ K-	
P23	J/PSI(3100) INTO PI+ PI- PI0 K+ K-	
P24	J/PSI(3100) INTO RHO PI	776+ 139
P25	J/PSI(3100) INTO RHO PI PI PI	776+ 139+ 139+ 139
P26	J/PSI(3100) INTO OMEGA PI PI	783+ 139+ 139
P27	J/PSI(3100) INTO OMEGA 4PI	783+ 139+ 139+ 139+
P28	J/PSI(3100) INTO OMEGA K KBAR	783+ 497+ 497
P29	J/PSI(3100) INTO OMEGA F	783+1271
P30	J/PSI(3100) INTO OMEGA F PRIME	783+1516
P31	J/PSI(3100) INTO PHI PI PI	1020+ 139+ 139
P32	J/PSI(3100) INTO PHI 2(PI+ PI-)	
P33	J/PSI(3100) INTO PHI K KBAR	1020+ 497+ 497
P34	J/PSI(3100) INTO PHI ETA	1020+ 548
P35	J/PSI(3100) INTO PHI ETA PRIME	1020+ 958
P36	J/PSI(3100) INTO PHI F	1020+1271
P37	J/PSI(3100) INTO PHI F PRIME	1020+1516
P38	J/PSI(3100) INTO A2 PI	1312+ 139
P39	J/PSI(3100) INTO A2 RHO	1312+ 776
P40	J/PSI(3100) INTO K K*(892)	497+ 892
P41	J/PSI(3100) INTO K K*(1430)	497+1434
P42	J/PSI(3100) INTO K*(892) K*(892)	892+ 892
P43	J/PSI(3100) INTO K*(1430) K*(1430)	1434+1434
P44	J/PSI(3100) INTO K*(892) K*(1430)	892+1434
P45	J/PSI(3100) INTO P PBAR	938+ 938
P46	J/PSI(3100) INTO P PBAR PI	938+ 938+ 139
P47	J/PSI(3100) INTO P NBAR PI	938+ 939+ 139
P48	J/PSI(3100) INTO P PBAR PI+ PI-	938+ 938+ 139+ 139
P49	J/PSI(3100) INTO P PBAR PI+ PI- PI0	
P50	J/PSI(3100) INTO P PBAR ETA	938+ 938+ 548
P51	J/PSI(3100) INTO P PBAR OMEGA	938+ 938+ 783
P52	J/PSI(3100) INTO LAMBDA ANTILAMBDA	1115+1115
P53	J/PSI(3100) INTO LAMBDA ANTISIGMA	1115+1192
P54	J/PSI(3100) INTO XI ANTIXI	1314+1314
P55	J/PSI(3100) INTO PI 8	139+1231
P	RADIATIVE DECAYS	
P70	J/PSI(3100) INTO GAMMA GAMMA	0+ 0
P71	J/PSI(3100) INTO 3 GAMMA	0+ 0+ 0
P72	J/PSI(3100) INTO PI0 GAMMA	134+ 0
P73	J/PSI(3100) INTO ETA GAMMA	548+ 0
P74	J/PSI(3100) INTO ETA PRIME GAMMA	958+ 0
P75	J/PSI(3100) INTO X(2830) GAMMA	2830+ 0
P76	J/PSI(3100) INTO F GAMMA	1271+ 0

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                         70  J/PSI(3100) PARTIAL WIDTHS (KEV)

W1       J/PSI(3100) INTO E+ E-                                  (G1)                  2/75
W1               4.8         0.6              BOYARSKI  75 SMAG          E+E-           3/75
W1   B          (4.6)       (.8)              BALDINI1  75 FRAG          E+E-           1/76
W1               4.6         1.0              ESPOSITO  75 FRAM          E+E-           1/76
W1   B    ASSUMING EQUAL PARTIAL WIDTHS FOR (E+E-) AND (MU+MU-)
W1              . . . . . . . . .
W1   AVG         4.75        0.51     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W1   STUDENT     4.75        0.55     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W2       J/PSI(3100) INTO MU+ MU-                                (G2)                  2/75
W2               4.8         0.6              BOYARSKI  75 SMAG          E+E-           3/75
W2               5.0         1.0              ESPOSITO  75 FRAM          E+E-           1/76
W2              . . . . . . . . .
W2   AVG         4.85        0.51     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W2   STUDENT     4.85        0.55     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W3       J/PSI(3100) INTO HADRONS                                (G3)                  2/75
W3               59.        14.               BOYARSKI  75 SMAG          E+E-           3/75
W3               59.        24.               BALDINI1  75 FRAG          E+E-           1/76
W3               50.        25.               ESPOSITO  75 FRAM          E+E-           1/76
W3              . . . . . . . . .
W3   AVG         57.3       10.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W3   STUDENT     57.3       11.7      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W4       J/PSI(3100) INTO GAMMA INTO HADRONS
W4 C             12.         2.               BOYARSKI  75 SMAG          E+E-           1/76
W4 C      INCLUDED IN W3

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                         70  J/PSI(3100) BRANCHING RATIOS

          FOR THE BRANCHING RATIOS R1 - R4, SEE ALSO THE PARTIAL
          WIDTHS ABOVE, AND (PARTIAL WIDTHS)*R1 BELOW.

R1       J/PSI(3100) INTO (E+ E-)/TOTAL                          (P1)                  3/75
R1              0.069       0.009             BOYARSKI  75 SMAG          E+E-           3/75

R2       J/PSI(3100) INTO (MU+ MU-)/TOTAL                        (P2)                  3/75
R2              0.069       0.009             BOYARSKI  75 SMAG          E+E-           3/75

R3       J/PSI(3100) INTO (HADRONS)/TOTAL                        (P3)                  3/75
R3              0.86        0.02              BOYARSKI  75 SMAG          E+E-           3/75

R4       J/PSI(3100) INTO (E+ E-)/(MU+ MU-)                      (P1)/(P2)             2/75
R4              1.00        0.05              BOYARSKI  75 SMAG          E+E-           3/75
R4              0.93        0.10              FORD      75 SPEC          E+E-           2/75
R4               .91         .15              ESPOSITO  75 FRAM          E+E-           1/76
R4              . . . . . . . . .
R4   AVG        0.980       0.043     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4   STUDENT    0.980       0.047     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R5       J/PSI(3100) INTO (GAMMA INTO HADRONS)/TOTAL
R5 C             .17         .02              BOYARSKI  75 SMAG          E+E-           1/76
R5 C      INCLUDED IN R3


R        HADRONIC DECAYS
R        ---------------

R8       J/PSI(3100) INTO (PI+ PI-)/TOTAL          (UNITS 10**-4)
R8        2     1.0         0.7               BRAUNSCHW 76 DASP          E+E-           1/77*
R8        1     1.6         1.6               VANNUCCI  77 SMAG          E+E-           1/77*
R8              . . . . . . . . .
R8   AVG        1.10        0.64      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   STUDENT    1.10        0.69      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9       J/PSI(3100) INTO (2(PI+ PI-))/TOTAL
R9       76     .004        .001              JEAN-MARI 76 SMAG          E+E-           1/76

R10      J/PSI(3100) INTO (2(PI+ PI-) PI0)/TOTAL
R10     675     .04         .01               JEAN-MARI 76 SMAG          E+E-           1/76
R10    1500     0.0364      0.0052            BURMESTER 77 PLUT          E+E-          12/77*
R10             . . . . . . . . .
R10 AVG         0.0372      0.0046    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R10 STUDENT     0.0372      0.0050    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R11      J/PSI(3100) INTO (3(PI+ PI-)/TOTAL
R11      32     .004        .002              JEAN-MARI 76 SMAG          E+E-           1/76

R12      J/PSI(3100) INTO (3(PI+ PI-) PI0)/TOTAL
R12     181     .029        .007              JEAN-MARI 76 SMAG          E+E-           1/76

R13      J/PSI(3100) INTO (4(PI+ PI-) PI0)/TOTAL
R13      13     .009        .003              JEAN-MARI 76 SMAG          E+E-           1/76

R14      J/PSI(3100) INTO (PI+ PI- K+ K-)/TOTAL
R14     205     0.0072      0.0023            VANNUCCI  77 SMAG          E+E-           1/77*

R15      J/PSI(3100) INTO (2(PI+ PI-) K+ K-)/TOTAL
R15      30     0.0031      0.0013            VANNUCCI  77 SMAG          E+E-           1/77*

R16      J/PSI(3100) INTO (RHO PI)/(PI+ PI- PI0)
R16             (.7)  OR MORE  CL=0.90  JEAN-MARI 76 SMAG          E+E-           1/76

R17      J/PSI(3100) INTO (RHO0 PI0)/(RHO+- PI-+)
R17             0.63        0.22              BARTEL 1  76 CNTR          E+E-           1/77*
R17              .59         .17              JEAN-MARI 76 SMAG          E+E-           1/76
R17            (0.53)      (0.15)             ALEXANDER 77 PLUT          E+E-          12/77*
R17             . . . . . . . . .
R17 AVG         0.60        0.13      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R17 STUDENT     0.60        0.14      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R18      J/PSI(3100) INTO (RHO PI)/TOTAL
R18     543     0.010       0.002             BARTEL 1  76 CNTR          E+E-           1/77*
R18      99     0.012       0.003             BRAUNSCHW 76 DASP          E+E-           1/77*
R18     153      .013        .003             JEAN-MARI 76 SMAG          E+E-           1/76
R18     183    (0.016)     (0.004)            ALEXANDER 77 PLUT          E+E-          12/77*
R18             . . . . . . . . .
R18 AVG         0.0112      0.0015    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 STUDENT     0.0112      0.0016    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R19      J/PSI(3100) INTO (OMEGA PI PI)/(2(PI+ PI-) PI0)
R19  J          (.2)                          JEAN-MARI 76 SMAG          E+E-           1/76

R20      J/PSI(3100) INTO (RHO PI PI PI)/(2 (PI+ PI-) PI0)
R20  J          (.3)                          JEAN-MARI 76 SMAG          E+E-           1/76

R21      J/PSI(3100) INTO (PHI PI+ PI-)/TOTAL
R21      23     0.0021      0.0009            FELDMAN   77 SMAG          E+E-          12/77*

R22      J/PSI(3100) INTO (K0S K0L)/TOTAL  (UNITS 10**-4)
R22             (0.89) OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-           1/77*
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R23      J/PSI(3100) INTO (K+ K-)/TOTAL      (UNITS 10**-4)
R23       1     1.4         1.4               BRAUNSCHW 76 DASP          E+E-           1/77*
R23       2     2.0         1.6               VANNUCCI  77 SMAG          E+E-           1/77*
R23             . . . . . . . . .
R23 AVG         1.7         1.1       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R23 STUDENT     1.7         1.1       AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R24      J/PSI(3100) INTO (K0 K*(892)0)/TOTAL
R24      45     0.0027      0.0006            VANNUCCI  77 SMAG          E+E-           1/77*

R25      J/PSI(3100) INTO (K+- K*(892)-+)/TOTAL
R25      39     0.0041      0.0012            BRAUNSCHW 76 DASP          E+E-           1/77*
R25      48     0.0032      0.0006            VANNUCCI  77 SMAG          E+E-           1/77*
R25             . . . . . . . . .
R25 AVG         0.00338     0.00054   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R25 STUDENT     0.00338     0.00059   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R26      J/PSI(3100) INTO (K0 K*(1430)0)/TOTAL
R26             (0.002) OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-           1/77*

R27      J/PSI(3100) INTO (K+- K*(1420-+)/TOTAL
R27             (0.0033)OR LESS  CL=0.90  BRAUNSCHW 76 DASP          E+E-           1/77*
R27             (0.0015)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-           1/77*

R28      J/PSI(3100) INTO (K*(892)0 K*(892)0)/TOTAL
R28             (0.0005)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-           1/77*

R29      J/PSI(3100) INTO (K*(1430)0 K*(1430)0)/TOTAL
R29             (0.0029)OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-           1/77*

R30      J/PSI(3100) INTO (K*(892)0 K*(1430)0)/TOTAL
R30      40     0.0067      0.0026            VANNUCCI  77 SMAG          E+E-           1/77*


R31      J/PSI(3100) INTO (PBAR P)/TOTAL     (UNITS 10**-3)
R31  A  70      2.3         0.3               BRAUNSCHW 76 DASP          E+E-           1/77*
R31  A 300      2.0         0.15              GOLDHABER 76 SMAG          E+E-          12/77*
R31             2.0         0.5               TONUTTI   77CNTR           E+E-          12/77*
R31             . . . . . . . . .
R31 AVG         2.06        0.13      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R31 STUDENT     2.05        0.14      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R32      J/PSI(3100) INTO (PBAR P)/(MU+ MU-)
R32  A  20      (.051)      (.02)             CRIEGEE2  75 PLUT          E+E-           1/76

R33      J/PSI(3100) INTO (LAMBDA ANTILAMBDA)/TOTAL
R33      19      .0016       .0008            ABRAMS    75 SMAG          E+E-           1/76

R34      J/PSI(3100) INTO (P PBAR PI0)/TOTAL
R34             0.0010      0.0002            FELDMAN   77 SMAG          E+E-          12/77*

R35      J/PSI(3100) INTO (P PBAR PI+PI-)/TOTAL
R35             0.0041      0.0008            FELDMAN   77 SMAG          E+E-          12/77*

R36      J/PSI(3100) INTO (P PBAR PI+ PI- PI0)/TOTAL
R36             0.0011      0.0004            FELDMAN   77 SMAG          E+E-          12/77*

R37      J/PSI(3100) INTO (LAMBDA ANTISIGMA)/TOTAL
R37             (.0004)OR LESS CL=0.90  FELDMAN   77 SMAG          E+E-          12/77*

R38      J/PSI(3100) INTO (PI+- A2)/TOTAL
R38             (0.0043)OR LESS  CL=0.90 BRAUNSCHW 76 DASP          E+E-           1/77*

R39      J/PSI(3100) INTO (OMEGA PI PI)/TOTAL
R39     215     0.0078      0.00216           BURMESTER 77 PLUT          E+E-          12/77*
R39     348     0.0068      0.0019            VANNUCCI  77 SMAG          E+E-           1/77*
R39             . . . . . . . . .
R39 AVG         0.0068      0.0019    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R39 STUDENT     0.0068      0.0021    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R40      J/PSI(3100) INTO 2(K+ K-)/TOTAL
R40             0.0007      0.0003            VANNUCCI  77 SMAG          E+E-           1/77*

R41      J/PSI(3100) INTO (OMEGA K KBAR)/TOTAL
R41      22     0.0016      0.0010            FELDMAN   77 SMAG          E+E-          12/77*

R42      J/PSI(3100) INTO (PHI K KBAR)/TOTAL
R42      14     0.0018      0.0008            FELDMAN   77 SMAG          E+E-          12/77*

R43      J/PSI(3100) INTO (PHI ETA)/TOTAL
R43       5     0.0010      0.0006            VANNUCCI  77 SMAG          E+E-           1/77*

R44      J/PSI(3100) INTO (PHI ETA PRIME)/TOTAL
R44             (0.0013)OR LESS  CL=0.90 VANNUCCI  77 SMAG          E+E-           1/77*

R45      J/PSI(3100) INTO (PHI F PRIME)/TOTAL
R45       6     0.0008      0.0005            VANNUCCI  77 SMAG          E+E-           1/77*

R46      J/PSI(3100) INTO (P NBAR PI-)/TOTAL
R46             0.0038      0.0008            FELDMAN   77 SMAG          E+E-          12/77*

R47      J/PSI(3100) INTO (P PBAR ETA)/TOTAL
R47             0.0019      0.0004            FELDMAN   77 SMAG          E+E-          12/77*

R48      J/PSI(3100) INTO (P PBAR OMEGA)/TOTAL
R48             0.0005      0.0001            FELDMAN   77 SMAG          E+E-          12/77*

R49      J/PSI(3100) INTO (K0S K+- PI-+)/TOTAL
R49     126     0.0026      0.0007            VANNUCCI  77 SMAG          E+E-           1/77*

R50      J/PSI(3100) INTO (PHI F)/TOTAL     (UNITS 10**-4)
R50             (3.7)  OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-           1/77*

R51      J/PSI(3100) INTO (PHI 2(PI+PI-))/TOTAL
R51             (0.0015)OR LESS  CL=0.90 VANNUCCI  77 SMAG          E+E-           1/77*

R52      J/PSI(3100) INTO (OMEGA F)/TOTAL
R52      81     0.0019      0.0008            VANNUCCI  77 SMAG          E+E-           1/77*
R52      70     0.0040      0.0016            BURMESTER 77 PLUT          E+E-          12/77*
R52             . . . . . . . . .
R52 AVG         0.00232     0.00084   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R52 STUDENT     0.00230     0.00081   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R53      J/PSI(3100) INTO (OMEGA F PRIME)/TOTAL  (UNITS 10**-4)
R53             (1.6)  OR LESS  CL=0.90  VANNUCCI  77 SMAG          E+E-           1/77*

R54      J/PSI(3100) INTO (PI+PI-PI0 K+K-)/TOTAL
R54     309     0.012       0.003             VANNUCCI  77 SMAG          E+E-           1/77*

R55      J/PSI(3100) INTO (RHO A2)/TOTAL
R55      36     0.0084      0.0045            VANNUCCI  77 SMAG          E+E-           1/77*

R56      J/PSI(3100) INTO (OMEGA 2PI+ 2PI-)/TOTAL
R56     140     0.0085      0.0034            VANNUCCI  77 SMAG          E+E-           1/77*

R57      J/PSI(3100) INTO (XI- ANTIXI-)/TOTAL
R57       4     (0.0004)APPROX.               FELDMAN   77 SMAG          E+E-          12/77*
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Mesons

$J/\psi(3100)$, $\chi(3415)$

Data Card Listings

For notation, see key at front of Listings.

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R58    J/PSI(3100) INTO (RHO+- PI-+)/(K*(892)+- K-+)
R58          (0.26)   (0.09)          PIERRE    76 SMAG          E+E-          4/77*

R69    J/PSI(3100) INTO (B+- PI-+)/TOTAL
R69     87    0.0029   0.0007         BURMESTER 77 PLUT          E+E-          12/77*

R60    J/PSI(3100) INTO (N NBAR)/TOTAL (UNITS 10**-2)
R60          0.18     0.09           YAMADA    77 DASP    E+ E-,3 GAMMA     12/77*

R    J  FINAL STATE  2(PI+PI-)PIO
R    A  ASSUMING ANGULAR DISTRIBUTION (1.+COS(THETA)**2)



R      RADIATIVE DECAYS
R      ----------------

R70    J/PSI(3100) INTO (X(2830) GAMMA)/TOTAL  (UNITS 10**-3)
R70          (39.)   OR LESS  CL=0.90  WHITAKER  76 SMAG          E+E-          4/77*
R70          (17.)   OR LESS  CL=0.90  BIDDICK   77 CNTR          E+E-          3/77*

R71    J/PSI(3100) INTO (2 GAMMA)/TOTAL  (UNITS 10**-3) (P4)
R71          (3.)    OR LESS  CL=0.90  WIIK      75 DASP          E+E-          1/77*
R71          (0.5)   OR LESS  CL=0.90  BARTELI   77 CNTR          E+E-          4/77*

R72    J/PSI(3100) INTO (PIO GAMMA)/TOTAL (UNITS 10**-3)                       2/75
R72  U   9   (0.075) (0.048)           BRAUNSCHW 77 DASP    E+E-,3 GAMMA      1/77*

R73    J/PSI(3100) INTO (ETA GAMMA)/TOTAL (UNITS 10**-3)
R73     21    1.3      0.4            BARTELI   77 CNTR    E+E-,3 GAMMA      1/77*
R73     60    0.8      0.1            YAMADA    77 DASP    E+E-,3 GAMMA      12/77*
R73      . . . . . .
R73 AVG       0.83     0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R73 STUDENT   0.83     0.11    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R74    J/PSI(3100) INTO (ETA PRIME GAMMA)/TOTAL  (UNITS 10**-3)
R74          (3.3)   OR LESS  CL=.90   BACCI     76 FRAG          E+E-          4/77*
R74     57   2.4      0.7            BARTEL 1  76 CNTR    E+E-,2 GAMMA RHO  1/77*
R74      6   2.9      1.1            YAMADA    77 DASP    E+E-,3 GAMMA      12/77*
R74      . . . . . .
R74 AVG       2.54     0.59    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R74 STUDENT   2.54     0.64    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R75    J/PSI(3100) INTO (ETA PRIME GAMMA)/(ETA GAMMA)
R75          1.8      0.8            BARTELI   77 CNTR    E+E-,3 GAMMA      3/77*

R76    J/PSI(3100) INTO (X(2830) GAMMA)/TOTAL,X TO 2 GAMMA (UNITS 10**-3)
R76  X       (0.14)   (0.08)         BARTEL 2  76 CNTR    E+E-,3 GAMMA      1/77*
R76  X  EXISTENCE OF X(2830) IN BARTEL 2 76 DATA IS ONLY 2 STD EFFECT        3/77*
R76          (0.32) OR LESS  CL=0.90  BARTELI   77 CNTR    E+E-,3 GAMMA      12/77*
R76     19   0.14     0.04           YAMADA    77 DASP    E+E-,3 GAMMA      12/77*

R77    J/PSI(3100) INTO (X(2830) GAMMA)/TOTAL,X TO P PBAR GAM (UNITS 10**-3
R77          (0.04) OR LESS  CL=0.90  GOLDHABER 76 SMAG          E+E-          1/77*
R77          (0.2)  OR LESS  CL=0.90  WIIK      76 DASP          E+E-          1/77*

R78    J/PSI(3100) INTO (3 GAMMA)/TOTAL  (UNITS 10**-3)
R78  U       (0.08) OR LESS  CL=0.90  BRAUNSCHW 77 DASP    E+E-,3 GAMMA      1/77*

R79    J/PSI(3100) INTO (X(2830) GAMMA)/TOTAL,X TO RHO GAMMA (UNITS 10**-3)
R79          (0.3)  OR LESS  CL=0.90  BARTEL 2  76 CNTR    E+E-,2 GAMMA RHO  1/77*

R80    J/PSI(3100) INTO (GAMMA + 2 OR MORE NEUTRALS)/TOTAL   (UNITS 10**-3)
R80          7.0      2.0            BARTELI   77 CNTR          E+E-          1/77*

R81    J/PSI(3100) INTO (F GAMMA)/TOTAL
R81     35   (0.0020) (0.0007)       ALEXANDER 77 PLUT  0 E+E-                12/77*
R
R    U   RE-STATED BY US USING TOTAL WIDTH 67 KEV.

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                    70  J/PSI(3100)   G(I)*G(E+E-)/G(TOTAL)  (KEV)

        THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH
        INTO E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
        CROSS-SECTION INTO CHANNEL(I) IN THE E+E- ANNIHILATION.
        WE ONLY LIST DATA NOT HAVING BEEN USED TO DETERMINE THE PARTIAL
        WIDTH G(I) OR THE BRANCHING RATIO G(I)/TOTAL.

G1     G(E+E-)*G(E+E-)/G(TOTAL)
G1   S       (.32)    (.07)          BALDINI1  75 FRAG          E+E-          1/76
G1           .34      .14            BEMPORAD  75 FRAB          E+E-          1/76
G1           .41      .06            DASP1     75 DASP          E+E-          1/76
G1   S   (.34)    (.09)          ESPOSITO  75 FRAM          E+E-          1/76
G1   S   (.36)    (.10)          FORD      75 SPEC          E+E-
G1      . . . . . .
G1 AVG       0.399    0.055   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
G1 STUDENT   0.399    0.060   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

G2     G(MU+MU-)*G(E+E-)/G(TOTAL)
G2           .31      .09            BEMPORAD  75 FRAB          E+E-          1/76
G2       (.32)    (.08)          CRIEGEE2  75 PLUT          E+E-          1/76
G2           .51      .09            DASP1     75 DASP          E+E-          1/76
G2   S   (.38)    (.05)          ESPOSITO  75 FRAM          E+E-          1/76
G2   S   (.46)    (.10)          LIBERMAN  75 SPEC          E+E-          1/76
G2      . . . . . .
G2 AVG       0.41     0.10    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
G2 STUDENT   0.410    0.079   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

G3     G(HADRONIC)*G(E+E-)/G(TOTAL)
G3   S       (4.)     (.8)           BALDINI1  75 FRAG          E+E-          1/76
G3   S       (3.9)    (.8)           ESPOSITO  75 FRAM          E+E-          1/76

G    S   SEE THE BRANCHING RATIOS AND PARTIAL WIDTHS ABOVE.

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                          REFERENCES FOR J/PSI(3100)

CHRISTEN 70 PRL 25 1523       CHRISTENSON,HICKS,LEDERMAN+ (COLU+BNL+CERN)

ABRAMS   74 PRL 33 1453       +BRIGGS,AUGUSTIN,BOYARSKI+        (LBL+SLAC)
ASH      74 NCL 11 705        +ZORN,BARTOLI+      (FRAS+UMD+NAPL+PADO+ROMA)
AUBERT   74 PRL 33 1404       +BECKER,BIGGS,BURGER,CHEN,EVERHART(MIT+BNL)
AUGUSTIN 74 PRL 33 1406       +BOYARSKI,ABRAMS,BRIGGS+          (SLAC+LBL)
BACCI    74 PRL 33 1408       +BARTOLI,BARBARINO,BARBIELLINI+   (FRASCATI)
   ALSO  74 PRL 33 1649       FOR ERRATA
BALDINI- 74 NCL 11 711        BALDINI-CELIO,BACCI+          (FRASCATI+ROMA)
BARBIELL 74 NCL 11 718        BARBIELLINI,BEMPORAD+ (FRAS+NAPL+PISA+ROMA)
BRAUNSCH 74 PL 53B 393        BRAUNSCHWEIG+     (AACHEN+HAMB+MUNICH+TOKYO)
ABRAMS   75 STANFORD SYMP.25  G.S.ABRAMS                                (LBL)
ANDREWS  75 PRL 34 231        +HARVEY,LOBKOWICZ,MAY,NORDBERG  (RCCH+CORN)
AUBERT   75 NP B 89 1         +BECKER,BIGGS,BURGER,GLENN,+        (MIT+BNL)
BACCI    75 NCL 12 269        +PENSO,STELLA,BALDINI-CELIO,+       (ROMA+FRAS)
BALDINI1 75 PL 58B 471        BALDINI-CELIO,BOZZO,CAPON,BACCI+(FRAS+ROMA)
BALDINI2 75 PL 58B 475        BALDINI-CELIO,CAPON,DEL FABBRO+  (FRAS+ROMA)
BEMPORAD 75 STANFORD SYMP.113 C.BEMPORAD                        (PISA+FRASCATI)
BLANAR   75 PRL 35 346        +BOYER,FAISSLER,GARELICK,GETTNER,+      (NEAS)
BOYARSKI 75 PRL 34 1357       +BREIDENBACH,BULOS,FELDMAN,+      (SLAC+LBL)JPC
BRAUNSCH 75 PL 53B 491        BRAUNSCHWEIG+     (AACHEN+HAMB+MUNICH+TOKYO)
BUSSER   75 PL 56 B 482       +BLUMENFELD,BANNER,+  (CERN+COLU+ROCK+SACL)
CAMERINI 75 PRL 35 483        +LEARNED,PREPOST,ASH,ANDERSON,+ (WISC+SLAC)
CRIEGEE1 75 PL 53B 489        +DEHNE,FRANKE,HORLITZ,KRECHLOCK+      (DESY)
CRIEGEE2 75  DESY PREP.75/32  +DEHNE,FOX,FRANKE,HORLITZ,KNIES,+     (DESY)
DAKIN    75 PL 56 B 405       +KREISLER,BOLON,HEILE+          (MASA+MIT+SLAC)
DASP1    75 PL 56B 491        BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
DASP2    75 PL 57B 297        BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
ESPOSITO 75 NCL 14 73         +BARTOLI,BISELLO,+      (FRAS+NAPL+PADO+ROMA)
FORD     75 PRL 34 604        +BERON,HILGER,HOFSTADTER+         (SLAC+PENN)
GITTELMA 75 PRL 35 1616       GITTELMAN+HANSON+LARSON+LOH+             (CORN)
GRECO    75 PL 56B 367        +PANCHERI-SRIVASTAVA,SRIVASTAVA          (FRAS)
HEINTZE  75 STANFORD SYMP.97  J.HEINTZE                       (HEIDELBERG)
JACKSON  75 NIM 128 13        J.D.JACKSON,D.SCHARRE                    (LBL)
KNAPP1   75 PRL 34 1040       +LEE,BRONSTEIN+   (COLU+HAWA+CORN+ILL+FNAL)
KNAPP2   75 PRL 34 1044       +LEE,BRONSTEIN+   (COLU+HAWA+CORN+ILL+FNAL)
LIBERMAN 75 STANFORD SYMP.55  A.D.LIBERMAN                    (STANFORD)
MARTIN   75 PRL 34 288        +BOLON,DAKIN,FELDMAN,HANSON+(MIT+MASA+SLAC)
PREPOST  75 STANFORD SYMP.241 R.PREPOST                       (WISCONSIN)
SIMPSON  75 PRL 35 699        +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
WIIK     75 STANFORD SYMP.69  B.H.WIIK                            (DESY)
YENNIE   75 PRL 34 239        D.R.YENNIE                              (CORNELL)

ANTIPOV  76 TBILISI CONF.N 8  +BESSUBOV,BUDANOV,BUSHNIN,DENISOV,+  (SERP)
BACCI    76  LNF-76/60(P)     +BALDINI-CELIO,CAPON+       (FRAS+ROMA+GENO)
BARTEL 1 76 PL 64 B 483       +DUINKER,OLSSON,STEFFEN,HEINTZE+(DESY+HEID)
BARTEL 2 76 TBILISI CONF.N56  +DUINKER,OLSSON,HEINTZE,+       (DESY+HEID)
BRAUNSCH 76 PL 63 B 487       BRAUNSCHWEIG,+    (AACH+DESY+HAMB+MPIM+TOKY)
BUSSER   76 NP B 113 189      +BLUMENFELD,BANNER,+  (CERN+COLU+ROCK+SACL)
GOLDHABE 76 WISCONSIN CONF.40 G.GOLDHABER                     (SLAC+LBL)
JEAN-MAR 76 PRL 36 291        +ABRAMS,BOYARSKI,BREIDENBACH,+    (SLAC+LBL)IG
PIERRE   76 SACLAY-DPHPE76-21 F.PIERRE                        (SLAC+LBL)
SNYDER   76 PRL 36 1415       +HOM,LEDERMAN,APPEL,KAPLAN+(COLU+FNAL+STON)
VANNUCCI 76  SLAC-PUB-1724    +ABRAMS,BOYARSKI,BREIDENBACH,+    (SLAC+LBL)
WHITAKER 76 PRL 37 1596       +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)
WIIK     76 TBILISI CONF.N75  B.H.WIIK RAPPORTEUR                    (DESY)

ALEXANDE 77  DESY 77/72       ALEXANDER,CRIEGEE,+   (DESY+HAMB+SIEG+WUPP)
BARTEL1  77 PL 66 B 489       +DUINKER,OLSSON,HEINTZE,+         (DESY+HEID)
BARTEL 2 77  DESY 77/70       +DITTMANN,FRITSCHER,HEINTZE,+     (DESY+HEID)
BIDDICK  77 PRL 38 1324       +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH 77  DESY 77/02       BRAUNSCHWEIG,+    (AACH+DESY+HAMB+MPIM+TOKY)
BURMESTE 77 PL 72 B 135       BURMESTER,CRIEGEE,+   (DESY+HAMB+SIEG+WUPP)
CORDEN   77 PL 68 B 96        +DOWELL,+    (BIRM+CERN+MPIM+NEUC+EPOL+RHEL)
FELDMAN  77 PL 33 C 285       +PERL                          (LBL+SLAC)
KNIES    77  DESY 77/74        G.KNIES HAMBURG TALK ON PLUTO COLLAB.(DESY)
TONUTTI  77 HAMB. CONF. P. 145+BESCH,KOVALSKI                (BONN+DESY+MAINZ)
VANNUCCI 77 PR D 15 1814      +ABRAMS,ALAM,BOYARSKI,+           (SLAC+LBL)
YAMADA   77 HAMB. CONF. P) 69 YAMADA                         (DESY+TOKY)
WIIK     77  DESY 77/01       +WOLF                                (DESY)

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$\chi(3415)$

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                56  CHI(3415,JPG=0++)  I=0

        OBSERVED IN THE RADIATIVE DECAY OF PSI(3685) INTO
      CHI(3415) GAMMA. THEREFORE C=+. THE OBSERVED DECAY INTO PI+ PI-
      OR K+ K- IMPLIES G=+, JP=0+,2+.... . THE ANGULAR DISTRIBUTION
      IS CONSISTENT WITH J=0. JP ABNORMAL EXCLUDED BY PI+ PI- AND
      K+ K- DECAYS. JP=0+ PREFERRED (FELDMAN 77) .

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                56  CHI(3415) MASS (MEV)

M    W   2 3412.0      8.0            WIIK      75 DASP    E+E-,J/PSI 2 GAM  1/77*
M        1 3413.0     10.0            WHITAKER  76 SMAG    E+E-,J/PSI 2 GAM  12/77*
M           3415.0     10.0            TRILLING  76 SMAG    E+E-,HADRONS GAM  1/77*
M           3413.0     11.0            WHITAKER  76 SMAG    E+E-,MONOCHR.GAM  1/77*
M           3413.0      9.0            BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77*
M    W  INCREASED 4 MEV BY FELDMAN 77 TO CORRECT FOR ENERGY CALIBRATION.
M       . . . . . .
M  AVG    3413.1      4.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M  STUDENT3413.1      4.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                56  CHI(3415) PARTIAL DECAY MODES

                                                                 DECAY MASSES
P1     CHI(3415) INTO PI+ PI-                                    139+ 139
P2     CHI(3415) INTO K+ K-                                      493+ 493
P3     CHI(3415) INTO 2(PI+ PI-)                                 139+ 139+ 139+ 139
P4     CHI(3415) INTO 3(PI+ PI-)
P5     CHI(3415) INTO PI+ PI- K+ K-                              139+ 139+ 493+ 493
P6     CHI(3415) INTO J/PSI(3100) GAMMA                         3098+   0
P7     CHI(3415) INTO 2 GAMMA
P8     CHI(3415) INTO PI+ PI- P PBAR                             139+ 139+ 938+ 938
P9     CHI(3415) INTO RHO0 PI+ PI-                               776+ 139+ 139
P10    CHI(3415) INTO K*(892)0 K+/- PI-/+                        892+ 493+ 139

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                56  CHI(3415) BRANCHING RATIOS

R1     CHI(3415) INTO (2 GAMMA)/TOTAL
R1 T          (0.0019)OR LESS  CL=0.90 YAMADA     77 DASP    E+ E-,3 GAMMA     12/77*

R2     CHI(3415) INTO 2(PI+ PI-)/TOTAL
R2 T          .044     .008           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R3     CHI(3415) INTO (PI+ PI- K+ K-)/TOTAL
R3 T          .037     .010           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R4     CHI(3415) INTO 3(PI+ PI-)/TOTAL
R4 T          .019     .007           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R5     CHI(3415) INTO (PI+ PI-)/TOTAL
R5 T          .01      .003           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R6     CHI(3415) INTO (K+ K-)/TOTAL
R6 T          .01      .003           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*
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Data Card Listings

For notation, see key at front of Listings.

Mesons

$\chi(3415)$, $\chi(3455)$, P_c or $\chi(3510)$, $\chi(3555)$

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R7     CHI(3415) INTO (PI+ PI- P PBAR)/TOTAL
R7 T          .005     .002          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R8     CHI(3415) INTO (J/PSI(3100) GAMMA)/TOTAL
R8 T          0.027    0.013         BARTEL    77 CNTR PSI(3685)TO GAM CHI 12/77*
R8 T          0.045    0.023         BIDDICK   77 CNTR PSI(3685)TO GAM CHI 12/77*
R8 T           .03      .03          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*
R8 T          0.047    0.027         YAMADA    77 DASP    E+ E-,3 GAMMA    12/77*
R8          * * * * * * * * *
R8  AVG       0.0333   0.0095  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  STUDENT   0.033    0.011   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9     CHI(3415) INTO (RHO0 PI+ PI-)/TOTAL
R9 T          .017     .006          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R10    CHI(3415) INTO (K*(892)0 K+ - PI- +)/TOTAL
R10T          .023     .008          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R  T    CALCULATED USING PSI(3685) TO (GAMMA CHI(3415))/TOTAL=.07          12/77*
R  T    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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                          REFERENCES FOR CHI(3415)

FELDMAN  75 PRL 35 821        +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
    ALSO 75 PRL 35 1189  (ERRATA)
TANENBAU 75 PRL 35 1323       TANENBAUM,WHITAKER,ABRAMS,+      (LBL+SLAC)
WIIK     75 STANFORD SYMP.69  B.H.WIIK                          (DESY)

PIERRE   76  LBL-5324         F.PIERRE                         (SLAC+LBL)
TRILLING 76 STANFORD SYMP.437 G. H. TRILLING                      (LBL)
VERNON   76 TBILISI CONF.N63  W.VERNON      (UMD+PAVI+PRIN+UCSD+SLAC+STAN)
WHITAKER 76 PRL 37 1596       +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)
WIIK     76 TBILISI CONF.N75  B.H.WIIK RAPPORTEUR                 (DESY)

BARTEL   77  DESY 77/70       +DITTMANN(FRITSCHER,HEINTZE,+   (DESY+HEID)
BIDDICK  77 PRL 38 1324       +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH 77  DESY 77/03       BRAUNSCHWEIG,+    (AACH+DESY+HAMB+MPIM+TOKY)
FELDMAN  77 PL 33 C 285       +PERL                            (LBL+SLAC)
YAMADA   77 HAMB. CONF. P) 69 YAMADA                         (DESY+TOKY)
WIIK     77  DESY 77/01       +WOLF                            (DESY)

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$\chi(3455)$

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                58  CHI(3455,JPG=   ) I=

                OBSERVED IN THE CASCADE RADIATIVE DECAY OF PSI(3685)
                INTO CHI(3455) GAMMA, CHI(3455) INTO J/PSI(3100) GAMMA
                (WHITAKER 76), THEREFORE C=+.  NOT SEEN IN HADRONIC
        MODES. NOT SEEN IN OTHER EXPERIMENTS LOOKING ONLY FOR MONOCHROMATIC
        PHOTONS.  AMBIGUOUS, WITH A (BROADER) STATE AT ABOUT 3340 NOT
        EXCLUDED.  NEEDS CONFIRMATION. JP=0- PREFERRED (FELDMAN 77).
        OMITTED FROM TABLE.

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                58  CHI(3455) MASS (MEV)

M        4 3454.0     10.0          WHITAKER  76 SMAG    E+E-,J/PSI 2 GAM  1/77*

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                58  CHI(3455) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     CHI(3455) INTO J/PSI(3100) GAMMA                   3098+   0

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                58  CHI(3455) BRANCHING RATIOS

R       SEE BRANCHING RATIOS R62 OF PSI(3685)

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                          REFERENCES FOR CHI(3455)

WHITAKER 76 PRL 37 1596       +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)
WIIK     76 TBILISI CONF.N75  B.H.WIIK RAPPORTEUR                 (DESY)

WIIK     77  DESY 77/01       +WOLF                            (DESY)

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P_c or $\chi(3510)$

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                55  PC OR CHI(3510,JPG=  +) I=0

                OBSERVED IN THE RADIATIVE SEQUENTIAL DECAY
                OF THE PSI(3685) INTO PC GAMMA, PC INTO
                J/PSI(3100) GAMMA. THEREFORE, C=+.
        THE LACK OF DECAYS INTO PI+ PI- OR K+ K- IS SUGGESTIVE OF
        JP = ABNORMAL. THE DECAYS INTO 4PI AND 6PI IMPLY G=+, THUS I=0.
        J=0 IS EXCLUDED BY THE ANGULAR DISTRIBUTION IN THE (GAMMA J/PSI)
        DECAY. JP=1+ PREFERRED (FELDMAN 77) .

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                55  PC MASS (MEV)

M       40 3500.      10.           TANENBAUM 75 SMAG          HADRONS GAM 12/77*
M    W   7 3512.0      7.0          WIIK      75 DASP    E+E-,J/PSI 2 GAM  1/77*
M        3510.0     20.0           BARTEL    76 CNTR    E+E-,J/PSI 2 GAM  1/77*
M       12 3504.0     10.0          WHITAKER  76 SMAG    E+E-,J/PSI 2 GAM  1/77*
M        3511.0      7.0          BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77*
M    W  INCREASED 4 MEV BY FELDMAN 76 TO CORRECT FOR ENERGY CALIBRATION.
M          * * * * * * * * *
M   AVG    3508.4      4.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT3508.5      4.4     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                55  PC PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     PC INTO J/PSI(3100) GAMMA                          3098+   0
P2     PC INTO PI+ PI-                                     139+ 139
P3     PC INTO K+ K-                                       493+ 493
P4     PC INTO GAMMA GAMMA
P5     PC INTO 2(PI+ PI-)                                  139+ 139+ 139+ 139
P6     PC INTO 3(PI+ PI-)
P7     PC INTO PI+ PI- K+ K-                               139+ 139+ 493+ 493
P8     PC INTO PI+ PI- P PBAR                              139+ 139+ 938+ 938
P9     PC INTO RHO0 PI+ PI-                                776+ 139+ 139
P10    PC INTO K*(892)0 K+/- PI-/+                         892+ 493+ 139
P11    PC INTO PI+ PI- X(2830)

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                55  PC BRANCHING RATIOS

R1     PC INTO (J/PSI(3100) GAMMA)/TOTAL
R1 T          0.46     0.11          BARTEL    77 CNTR PSI(3685) TO GAM PC 12/77*
R1 T          0.70     0.21          BIDDICK   77 CNTR PSI(3685)TO GAM  PC  12/77*
R1  F          .35      .07          FELDMAN   77 RVUE PSI(3685)TO GAM PC  12/77*
R1  F  INCLUDES WHITAKER 76 WIIK 76,BIDDICK 77.
R1 T          0.15     0.04          YAMADA    77 DASP    E+ E-,3 GAMMA    12/77*
R1          * * * * * * * * *
R1  AVG       0.234    0.078   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.4)
R1  STUDENT   0.240    0.058   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2     PC INTO (PI+PI- AND K+K-)/TOTAL
R2 T        LESS THAN .0021               FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77*

R3     PC INTO (GAMMA GAMMA)/TOTAL
R3 T        (0.0019)OR LESS CL=0.90  YAMADA    77 DASP    E+ E-,3 GAMMA    12/77*

R4     PC INTO 2(PI+ PI-)/TOTAL
R4 T          .015     .006          FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77*

R5     PC INTO (PI+ PI- K+ K-)/TOTAL
R5 T          .0085    .0042         FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77*

R6     PC INTO 3(PI+ PI-)/TOTAL
R6 T          .024     .008          FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77*

R7     PC INTO (PI+ PI- P PBAR)/TOTAL
R7 T          .0014    .0011         FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77*

R8     PC INTO (RHO0 PI+ PI-)/TOTAL
R8 T          .0037    .0031         FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77*

R9     PC INTO (K*(892)0 K+ - PI- +)/TOTAL
R9 T          .0044    .0031         FELDMAN   77 SMAG PSI(3685) TO GAM PC 12/77*

R10    PC INTO (PI+ PI- X(2830))/TOTAL,X TO 2 GAMMA (UNITS 10**-4)
R10C          (8.3)  OR LESS  CL=0.90  BARTEL   77 CNTR    E+ E-          12/77*

R  C    THE VALUE IS NORMALIZED TO THE BRANCHI. RATIO O PSI(3685)
R  C    INTO (J/PSI(3100) ETA)/TOTAL.
R  T    ESTIMATED USING PSI(3685) TO (GAMMA PC)/TOTAL=.071                 12/77*
R  T    THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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                          REFERENCES FOR PC

DASP     75 PL 57B 407        BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
FELDMAN  75 STANFORD SYMP.39  G.J.FELDMAN                          (SLAC)
HEINTZE  75 STANFORD SYMP.97  J.HEINTZE                       (HEIDELBERG)
SIMPSON  75 PRL 35 699        +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
TANENBAU 75 PRL 35 1323       TANENBAUM,WHITAKER,ABRAMS,+      (LBL+SLAC)
WIIK     75 STANFORD SYMP.69  B.H.WIIK                          (DESY)

BARTEL   76 TBILISI CONF.N56  +DUINKER,OLSSON,HEINTZE,+        (DESY+HEID)
WHITAKER 76 PRL 37 1596       +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)
WIIK     76 TBILISI CONF.N75  B.H.WIIK RAPPORTEUR                 (DESY)

BARTEL   77  DESY 77/70       +DITTMANN(FRITSCHER,HEINTZE,+   (DESY+HEID)
BIDDICK  77 PRL 38 1324       +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH 77  DESY 77/03       BRAUNSCHWEIG,+    (AACH+DESY+HAMB+MPIM+TOKY)
FELDMAN  77 PL 33 C 285       +PERL                            (LBL+SLAC)
YAMADA   77 HAMB. CONF. P. 69 YAMADA                         (DESY+TOKY)
WIIK     77  DESY 77/01       +WOLF                            (DESY)

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$\chi(3555)$

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                57  CHI(3555,JPG=  +) I=0

                OBSERVED IN RADIATIVE DECAY OF PSI(3685) INTO
        CHI(3555) GAMMA. THEREFORE C=+. THE OBSERVED DECAY INTO 4PI
        AND 6PI IMPLY G=+, THUS I=0.
        J=0 IS EXCLUDED BY THE ANGULAR DISTRIBUTION IN THE HADRONIC
        DECAYS. JP ABNORMAL EXCLUDED BY PI+ PI- AND K+ K- DECAYS.
        JP=2+ PREFERRED (FELDMAN 77) .

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                57  CHI(3555) MASS (MEV)

M         3550.0     10.0          TRILLING  76 SMAG    E+E-,HADRONS GAM  1/77*
M       4 3543.0     10.0          WHITAKER  76 SMAG    E+E-,J/PSI 2 GAM  1/77*
M         3561.0      7.0          BIDDICK   77 CNTR    E+E-,MONOCHR.GAM  3/77*
M          * * * * * * * * *
M   AVG    3553.8      5.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
M   STUDENT3553.8      5.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                57  CHI(3555) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     CHI(3555) INTO PI+ PI-                             139+ 139
P2     CHI(3555) INTO K+ K-                               493+ 493
P3     CHI(3555) INTO 2(PI+ PI-)                          139+ 139+ 139+ 139
P4     CHI(3555) INTO 3(PI+ PI-)
P5     CHI(3555) INTO PI+ PI- K+ K-                       139+ 139+ 493+ 493
P6     CHI(3555) INTO J/PSI(3100) GAMMA                   3098+   0
P7     CHI(3555) INTO 2 GAMMA                               0+    0
P8     CHI(3555) INTO PI+ PI- P PBAR                      139+ 139+ 938+ 938
P9     CHI(3555) INTO RHO0 PI+ PI-                        776+ 139+ 139
P10    CHI(3555) INTO K*(892)0 K+/- PI-/+                 892+ 493+ 139

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                57  CHI(3555) BRANCHING RATIOS

R1     CHI(3555) INTO (2 GAMMA)/TOTAL
R1 T        (0.0006)OR LESS  CL=0.90 YAMADA    77 DASP    E+ E-,3 GAMMA    12/77*

R2     CHI(3555) INTO 2(PI+ PI-)/TOTAL
R2 T          .0023    .006          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*
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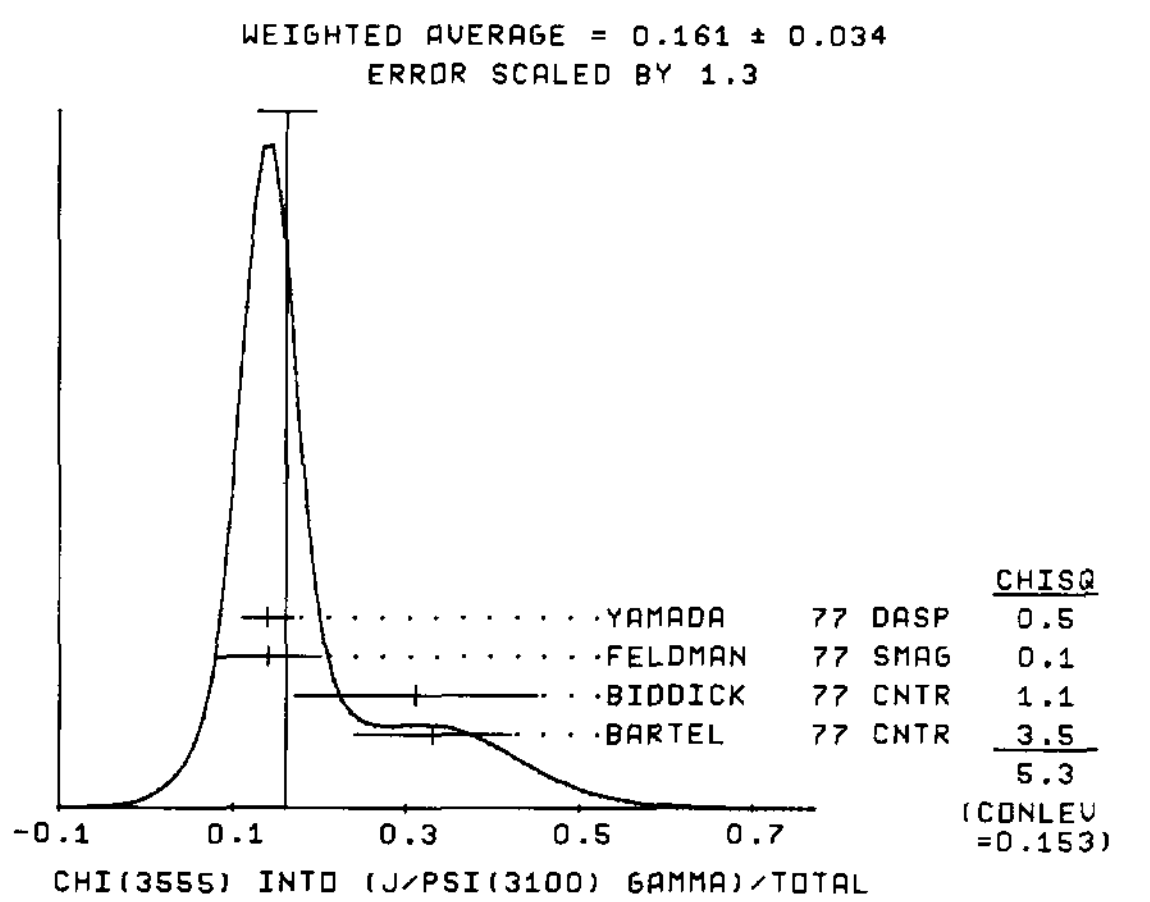
R3       CHI(3555) INTO (PI+ PI- K+ K-)/TOTAL
R3 T            .020      .006           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R4       CHI(3555) INTO 3(PI+ PI-)/TOTAL
R4 T            .011      .007           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R5       CHI(3555) INTO (PI+ PI- AND K+ K-)/TOTAL
R5 T            .0029     .0014          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R6       CHI(3555) INTO (PI+ PI- P PBAR)/TOTAL
R6 T            .0029     .0014          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R7       CHI(3555) INTO (J/PSI(3100) GAMMA)/TOTAL
R7 T            0.33      0.09           BARTEL    77 CNTR PSI(3685)TO GAM CHI 12/77*
R7 T            0.31      0.14           BIDDICK   77 CNTR PSI(3685)TO GAM CHI 12/77*
R7 T             .14       .06           FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*
R7 T            0.14      0.03           YAMADA    77 DASP    E+ E-,3 GAMMA    12/77*
R7              . . . . . . . . . .
R7  AVG         0.161     0.034   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R7  STUDENT     0.157     0.029   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                          (SEE IDEOGRAM BELOW )
```

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R8       CHI(3555) INTO (RHOO PI+ PI-)/TOTAL
R8 T            .0071     .0043          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R9       CHI(3555) INTO (K*(892)0 K+ - PI- +)/TOTAL
R9 T            .0074     .0044          FELDMAN   77 SMAG PSI(3685)TO GAM CHI 12/77*

R  T     ESTIMATED USING PSI(3685) TO (GAMMA CHI(3555))/TOTAL=.07
R  T     THE ERRORS DO NOT CONTAIN THE UNCERTAINTY IN THE PSI(3685) DECAY.

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REFERENCES FOR CHI(3555)


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FELDMAN  75 PRL 35 821          +JEAN-MARIE,SADOULET,VANNUCCI,+  (LBL+SLAC)
    ALSO 75 PRL 35 1189  (ERRATA)
TANENBAU 75 PRL 35 1323         TANENBAUM,WHITAKER,ABRAMS,+      (LBL+SLAC)

TRILLING 76 STANFORD SYMP.437 G. H. TRILLING                          (LBL)
WHITAKER 76 PRL 37 1596         +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)
WIIK     76 TBILISI CONF.N75   B.H.WIIK RAPPORTEUR                   (DESY)

BARTEL   77  DESY 77/70         +DITTMANN(FRITSCHER,HEINTZE,+   (DESY+HEID)
BIDDICK  77 PRL 38 1324         +BURNETT+     (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH 77  DESY 77/03         BRAUNSCHWEIG,+   (AACH+DESY+HAMB+MPIM+TOKY)
FELDMAN  77 PL 33 C 285         +PERL                            (LBL+SLAC)
YAMADA   77 HAMB. CONF. P. 69 YAMADA                            (DESY+TOKY)
WIIK     77  DESY 77/01         +WOLF                                (DESY)
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ψ(3685)

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         71  PSI(3685,JPG=1--) I=0
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71 PSI(3685) MASS (MEV)

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                      WE USE INDEPENDENT MEASUREMENTS OF THE J/PSI(3100)
                      MASS, THE PSI(3685) MASS, AND THE MASS DIFFERENCE TO
                      PERFORM A CONSTRAINED FIT.

M  S          3680.3     37.               CRIEGEE   75 PLUT        E+E-         2/75
M             3684.       5.               LUTH      75 SMAG        E+E-         1/76
M             3684.       9.               PREPOST   75 SPEC    21. GAMMA D      1/76
M             . . . . . . . . . .
M   AVG       3683.9      4.3    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT3683.9         4.7    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
M   FIT       3685.5      2.5   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

M   S   ERROR OF ABOUT 1 PER CENT FROM THE UNCERTAINTY IN CALIBRATION OF
M   S   THE BEAM ENERGY.

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71 PSI(3685) - J/PSI(3100) MASS DIFFERENCE (MEV)

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DM            588.7       .8               LUTH      75 SMAG
DM            . . . . . . . . . .
DM  FIT       588.6       0.8   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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71 PSI(3685) WIDTH (KEV)

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W             228.       56.               LUTH      75 SMAG

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71 PSI(3685) PARTIAL DECAY MODES

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                                                              DECAY MASSES
P1       PSI(3685) INTO E+ E-                                .5+  .5
P2       PSI(3685) INTO MU+ MU-                             105+ 105
P3       PSI(3685) INTO HADRONS
P4       PSI(3685) INTO VIRTUAL GAMMA INTO HADRONS

P        DECAYS INTO J/PSI(3100) + ANYTHING
P        ------------------------------
P11      PSI(3685) INTO J/PSI(3100) + ANYTHING
P12      PSI(3685) INTO J/PSI(3100) + NEUTRALS
P13      PSI(3685) INTO J/PSI(3100) PI+ PI-                3098+ 139+ 139
P14      PSI(3685) INTO J/PSI(3100) PIO PIO                3098+ 134+ 134
P15      PSI(3685) INTO J/PSI(3100) ETA                    3098+ 548
P16      PSI(3685) INTO J/PSI(3100) GAMMA GAMMA

P        HADRONIC DECAYS
P        --------------
P21      PSI(3685) INTO PI+ PI-                             139+ 139
P22      PSI(3685) INTO RHO PI                              776+ 139
P23      PSI(3685) INTO K+ K-                               493+ 493
P24      PSI(3685) INTO 2(PI+ PI-)                          139+ 139+ 139+ 139
P25      PSI(3685) INTO 2(PI+ PI-) PIO                      139+ 139+ 139+ 139+
P26      PSI(3685) INTO PI+ PI- K+ K-                       139+ 139+ 493+ 493
P27      PSI(3685) INTO PBAR P                              938+ 938
P28      PSI(3685) INTO LAMBDA ANTILAMBDA                  1115+1115
P29      PSI(3685) INTO XI ANTIXI                          1321+1321
P30      PSI(3685) INTO OMEGA X(2830)                       783+2830

P        RADIATIVE DECAYS
P        ---------------
P51      PSI(3685) INTO GAMMA GAMMA
P52      PSI(3685) INTO PIO GAMMA
P53      PSI(3685) INTO ETA GAMMA
P54      PSI(3685) INTO ETA PRIME GAMMA
P55      PSI(3685) INTO X(2830) GAMMA                      2830+   0
P56      PSI(3685) INTO CHI(3415) GAMMA                    3413+   0
P57      PSI(3685) INTO CHI(3455) GAMMA                    3454+   0
P58      PSI(3685) INTO PC(3510) GAMMA                     3508+   0
P59      PSI(3685) INTO CHI(3555) GAMMA                    3554+   0
P60      PSI(3685) INTO PC(3510) + ANYTHING

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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	$J/\psi\ \pi^+\pi^-$	$J/\psi\ \pi^o\pi^o$	$J/\psi\ \eta$	J/ψ+OTHER	NON-J/ψ
$J/\psi\ \pi^+\pi^-$	.3289+-.0251				
$J/\psi\ \pi^o\pi^o$	.4707	.1734+-.0178			
$J/\psi\ \eta$	-.0216	-.0102	.0416+-.0071		
J/ψ+OTHER	.2593	-.4156	-.1526	.0334+-.0258	
NON-J/ψ	-.9014	-.4243	-.0537	-.5365	.4227+-.0445

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71 PSI(3685) PARTIAL WIDTHS (KEV)

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W1       PSI(3685) INTO E+ E-                               (G1)                 2/75
W1            2.1        .3           LUTH       75 SMAG            E+E-         1/76

W3       PSI(3685) INTO HADRONS                              (G3)
W3            224.       56.          LUTH       75 SMAG            E+E-         1/76

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71 PSI(3685) BRANCHING RATIOS

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R1       PSI(3685) INTO (E+ E-)/TOTAL
R1 L           .0088      .0013       FELDMAN    77 RVUE            E+E-        12/77*
R1 L      FROM AN OVERALL FIT ASSUMING EQUAL PARTIAL WIDTHS FOR (E+E-)
R1 L      AND (MU+MU-). FOR A MEASUREMENT OF THE RATIO SEE THE ENTRY R4 BELOW
R1 L      INCLUDES LUTH 75,HILGER 75,BURMESTER 77

R2       PSI(3685) INTO (MU+ MU-)/TOTAL
R2 H           .0077      .0017       HILGER     75 SPEC            E+E-         1/76
R2 H      RE-STATED BY US USING (J/PSI(3100)+ANYTHING)/TOTAL =0.55

R3       PSI(3685) INTO (HADRONS)/TOTAL
R3    P        .981       .003        LUTH       75 SMAG            E+E-         1/76
R3    P   INCLUDES CASCADE DECAY INTO J/PSI(3100)                                4/77*

R4       PSI(3685) INTO (MU+ MU-)/(E+ E-)
R4             .89        .16         BOYARSKI   75 SMAG            E+E-        12/77*

R5       PSI(3685) INTO (GAMMA INTO HADRONS)/TOTAL
R5 C           .029       .004        LUTH       75 SMAG            E+E-         1/76
R5 C      INCLUDED IN R3


R        DECAYS INTO J/PSI(3100) + ANYTHING
R        ------------------------------

R10      PSI(3685) INTO (J/PSI(3100) + ANYTHING)/TOTAL
R10            .57        .08         ABRAMS     75 SMAG            E+E-         1/76
R10        . . . . . . . . . .
R10 FIT        0.577      0.044   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11      PSI(3685) INTO (J/PSI(3100) + NEUTRALS)/(J/PSI(3100) + ANYTHING)
R11            .41        .02         TANENBAUM 76 SMAG             E+E-         2/76
R11        . . . . . . . . . .
R11 FIT        0.410      0.020   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R12      PSI(3685) INTO (J/PSI(3100) PI+ PI-)/TOTAL
R12            .32        .04         ABRAMS1    75 SMAG            E+E-         1/76
R12            .36        .06         WIIK       75 DASP            E+E-         1/76
R12        . . . . . . . . . .
R12 AVG        0.332      0.033    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R12 STUDENT    0.332      0.036    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R12 FIT        0.329      0.025   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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Data Card Listings

For notation, see key at front of Listings.

Mesons

$\psi(3685)$, $\psi(3770)$

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R13    PSI(3685) INTO (J/PSI(3100) PIO PIO)/TOTAL
R13          0.17     0.029          ABRAMS1   75 SMAG          E+E-          1/77*
R13           .18      .06           WIIK      75 DASP          E+E-          1/76
R13      . . . . . . . . .
R13 AVG      0.172    0.026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R13 STUDENT  0.172    0.028   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R13 FIT      0.173    0.018  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R14    PSI(3685) INTO (J/PSI(3100) PIO PIO)/(J/PSI(3100) PI+ PI-)
R14 H         (.64)    (.15)          HILGER    75 SPEC          E+E-          1/76
R14           0.53     0.06           TANENBAUM 76 SMAG          E+E-          1/77*
R14 H   IGNORING THE (J/PSI ETA) AND (J/PSI GAMMA GAMMA) DECAYS
R14      . . . . . . . . .
R14 FIT      0.527    0.050  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R15    PSI(3685) INTO (J/PSI(3100) ETA)/TOTAL
R15           .043     .008           TANENBAUM 76 SMAG          E+E-          1/76
R15           .037     .015           WIIK      75 DASP          E+E-          1/76
R15      . . . . . . . . .
R15 AVG      0.0417   0.0071  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R15 STUDENT  0.0417   0.0076  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R15 FIT      0.0416   0.0071 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R16    PSI(3685) INTO (J/PSI(3100) GAMMA OR J/PSI(3100) PIO)/TOTAL
R16          (.0015)OR LESS CL=.90   TANENBAUM 76 SMAG          E+E-          2/76


R      HADRONIC DECAYS
R      ---------------

R20    PSI(3685) INTO (PI+ PI-)/TOTAL  (UNITS 10**-4)
R20          (3.7)  OR LESS  CL=0.90  BRAUNSCHW 76 DASP          E+E-          1/77*
R20          (0.5)  OR LESS  CL=0.90  FELDMAN   77 SMAG          E+E-         12/77*

R21    PSI(3685) INTO (RHOO PIO)/TOTAL
R21          (.001)OR LESS  CL=.90    ABRAMS    75 SMAG          E+E-          1/76

R22    PSI(3685) INTO (2(PI+ PI-) PIO)/TOTAL
R22           .0035    .0015          ABRAMS    75 SMAG          E+E-          1/76

R23    PSI(3685) INTO (K+ K-)/TOTAL  (UNITS 10**-4)
R23      2  (14.)    OR LESS  CL=0.90  BRAUNSCHW 76 DASP          E+E-          1/77*
R23          (0.5)  OR LESS  CL=0.90  FELDMAN   77 SMAG          E+E-         12/77*

R24    PSI(3685) INTO (PI+ PI- K+ K-)/TOTAL
R24          0.0014   0.0004         FELDMAN   77 SMAG          E+E-         12/77*

R25    PSI(3685) INTO (PBAR P)/TOTAL  (UNITS 10**-4)
R25          (4.7)  OR LESS  CL=0.90  BRAUNSCHW 76 DASP          E+E-          1/77*
R25           2.3     0.7           FELDMAN   77 SMAG          E+E-         12/77*

R26    PSI(3685) INTO (RHO PI)/TOTAL
R26          (0.001)OR LESS  CL=0.90  BARTEL 1  76 CNTR          E+E-          1/77*

R27    PSI(3685) INTO 2(PI+PI-)/TOTAL
R27           0.0008   0.0002         FELDMAN   77 SMAG          E+E-         12/77*

R28    PSI(3685) INTO (LAMBDA ANTILAMBDA)/TOTAL
R28          (0.0004)OR LESS  CL=0.90 FELDMAN   77 SMAG          E+E-         12/77*

R29    PSI(3685) INTO (XI- ANTIXI-)/TOTAL
R29          (0.0002)                 FELDMAN   77 SMAG          E+E-         12/77*

R30    PSI(3685) INTO (OMEGA X(2830))/TOTAL,X TO 2 GAMMA (UNITS 10**-2)
R30          (0.023)OR LESS  CL=0.90  BARTEL    77 CNTR    E+E-               12/77*


R      RADIATIVE DECAYS
R      ----------------

R41    PSI(3685) INTO (GAMMA GAMMA)/TOTAL
R41  U        (.005)OR LESS  CL=.95   HUGHES    75 SPEC          E+E-          1/76
R41           (.008)OR LESS  CL=.90   WIIK      75 DASP          E+E-          1/76

R42    PSI(3685) INTO (PIO GAMMA)/TOTAL
R42  U        (.007)OR LESS  CL=.95   HUGHES    75 SPEC          E+E-          1/76
R42           (.01) OR LESS  CL=.90   WIIK      75 DASP          E+E-          1/76

R43    PSI(3685) INTO (ETA GAMMA)/TOTAL (UNITS 10**-2)
R43  U        (1.8)  OR LESS  CL=.95   HUGHES    75 SPEC          E+E-          1/76
R43           (0.02)OR LESS  CL=0.90   YAMADA    77 DASP    E+ E-,3 GAMMA      12/77*

R44    PSI(3685) INTO (ETA PRIME GAMMA)/TOTAL (UNITS 10**-2)
R44C          (0.023)OR LESS  CL=0.90  BARTEL 2  76 CNTR          E+E-         12/77*
R44  R        (0.6)  OR LESS  CL=0.90  BRAUNSCHW 77 DASP          E+E-         12/77*

R53    PSI(3685) INTO (X(2830) GAMMA)/TOTAL (UNITS 10**-2)
R53           (1.1)  OR LESS  CL=0.90  WHITAKER  76 SMAG          E+E-          4/77*
R53           (1.0)  OR LESS  CL=0.90  BIDDICK   77 CNTR          E+E-          3/77*

R54    PSI(3685) INTO (X(2830) GAMMA)/TOTAL (UNITS 10**-2)
R54                   X(2830) INTO CHANNEL SPECIFIED IN COMMENTS
R54           (0.3)  OR LESS  CL=0.95  HUGHES    75 SPEC    X TO (2 GAMMA)     12/77*
R54           (0.014)OR LESS  CL=0.90  YAMADA    77 DASP    E+ E-,3 GAMMA      12/77*
R54           (0.05) OR LESS  CL=0.90  BARTEL    77 CNTR    X TO (2 GAMMA)     12/77*
R54C          (0.018)OR LESS  CL=0.90  BARTEL 2  77 CNTR    X TO (RHO GAMMA)   12/77*

R55    PSI(3685) INTO (CHI(3415) GAMMA)/TOTAL  (UNITS 10**-2)
R55  A        7.5      2.6            WHITAKER  76 SMAG          E+E-          1/77*
R55  A        7.2      2.3            BIDDICK   77 CNTR    E+E-,MONOCHR.GAM    3/77*
R55      . . . . . . . . .
R55 AVG       7.3      1.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R55 STUDENT   7.3      1.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT


R57    PSI(3685) INTO (CHI(3555) GAMMA)/TOTAL  (UNITS 10**-2)
R57  B        7.0      2.0            BIDDICK   77 CNTR    E+E-,MONOCHR.GAM    3/77*


R59    PSI(3685) INTO (PC(3510) GAMMA)/TOTAL  (UNITS 10**-2)
R59  B        7.1      1.9            BIDDICK   77 CNTR    E+E-,MONOCHR.GAM    3/77*

R61    PSI(3685) INTO (CHI(3455) GAMMA)/TOTAL  (UNITS 10**-2)
R61  B        (2.5)  OR LESS  CL=0.90  BIDDICK   77 CNTR          E+E-          3/77*

R62    PSI(3685) INTO (CHI(3455) GAMMA)/TOTAL  (UNITS 10**-2)
R62                   CHI(3455) INTO CHANNEL SPECIFIED IN COMMENTS
R62      4    (0.8)    (0.4)          TRILLING  76 SMAG CHI TO(J/PSI GAMMA)   1/77*
R62           (0.007)OR LESS  CL=0.90  YAMADA    77 DASP    E+ E-,3 GAMMA      12/77*
R62           (0.6)  OR LESS  CL=0.90  BARTEL    77 CNTR CHI TO(J/PSI GAMMA)  12/77*
R62F           0.6      0.4           FELDMAN   77 RVUE CHI TO(J/PSI GAMMA)  12/77*
R62F      INCLUDES WHITAKER 76 WIIK 76.                                       12/77*

R    A  ANGULAR DISTRIBUTION (1+COS**2) ASSUMED
R    B  VALID FOR ISOTROPIC DISTRIBUTION OF THE PHOTON
R  C    THE VALUE IS NORMALIZED TO THE BRANCHI. OBTAINED FROM PSI(3685)
R  C    INTO (J/PSI(3100) ETA)/TOTAL.
R    U  RE-STATED BY US USING (MU+MU-)/TOTAL = .0077
R    R  RE-STATED BY US USING TOTAL DECAY WIDTH 228 KEV.


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                    71  PSI(3685)     G(I)*G(E+E-)/G(TOTAL)  (KEV)

       THIS COMBINATION OF A PARTIAL WIDTH WITH THE PARTIAL WIDTH
       INTO E+E- AND WITH THE TOTAL WIDTH IS OBTAINED FROM THE INTEGRATED
       CROSS-SECTION INTO CHANNEL(I) IN THE E+E- ANNIHILATION.
       WE ONLY LIST DATA NOT HAVING BEEN USED TO DETERMINE THE PARTIAL
       WIDTH G(I) OR THE BRANCHING RATIO G(I)/TOTAL.


G3     G(HADRONIC)*G(E+E-)/G(TOTAL)
G3            2.2      .4            ABRAMS    75 SMAG          E+E-          1/76


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                              REFERENCES FOR PSI(3685)

ABRAMS    74 PRL 33 1453       +BRIGGS,AUGUSTIN,BOYARSKI+        (LBL+SLAC)

ABRAMS    75 STANFORD SYMP.25  G.S.ABRAMS                          (LBL)
ABRAMS1   75 PRL 34 1181       +BRIGGS,CHINOWSKY,FRIEDBERG,+     (LBL+SLAC)
AUBERT    75 PRL 33 1624       +BECKER,BIGGS,BURGER,GLENN+        (MIT+BNL)
BOYARSKI  75 PALERMO CONF. 54  +BREIDENBACH,BULOS,ABRAMS,BRIGGS+(SLAC+LBL)
CAMERINI  75 PRL 35 483        +LEARNED,PREPOST,ASH,ANDERSON,+ (WISC+SLAC)
CRIEGEE   75 PL 53B 489        +DEHNE,FRANKE,HORLITZ,KRECHLOCK+     (DESY)
DASP3     75 PL 57B 407        BRAUNSCHWEIG,KONIGS,+ (AACH+DESY+MPIM+TOKY)
FELDMAN   75 PRL 35 821        +JEAN-MARIE,SADOULET,VANNUCCI,+   (LBL+SLAC)
FELDMAN1  75 STANFORD SYMP.39  G.J.FELDMAN                        (SLAC)
GRECO     75 PL 56B 367        +PANCHERI-SRIVASTAVA,SRIVASTAVA     (FRAS)
HEINTZE   75 STANFORD SYMP.97  J.HEINTZE                      (HEIDELBERG)
JACKSON   75 NIM 128 13        J.D.JACKSON,D.SCHARRE               (LBL)
MILGER    75 PRL 35 625        +BERON,FORD,HOFSTADTER,HOWELL,+ (STAN+PENN)
HUGHES    75  PREP.HEPL 765    +BERON,CARRINGTON,FORD,HILGER,+ (STAN+PENN)
LUTH      75 PRL 35 1124       +BOYARSKI,LYNCH,BREIDENBACH,+    (SLAC+LBL)JPC
LIBERMAN  75 STANFORD SYMP.55  A.D.LIBERMAN                      (STANFORD)
PREPOST   75 STANFORD SYMP.241 R.PREPOST                       (WISCONSIN)
SIMPSON   75 PRL 35 699        +BERON,FORD,HILGER,HOFSTADTER,+ (STAN+PENN)
TANENBAU  75 PRL 35 1323       TANENBAUM,WHITAKER,ABRAMS,+       (LBL+SLAC)
WIIK      75 STANFORD SYMP.69  B.H.WIIK                          (DESY)

BADTKE    76  PREPRINT         +BARNETT,+   (UMD+PAVI+PRIN+UCSD+SLAC+STAN)
BARTEL 1  76 PL 64 B 483       +DUINKER,OLSSON,STEFFEN,HEINTZE+(DESY+HEID)
BARTEL 2  76 TBILISI CONF.N56  +DUINKER,OLSSON,HEINTZE,+        (DESY+HEID)
BRAUNSCH  76 PL 63 B 487       BRAUNSCHWEIG,+    (AACH+DESY+HAMB+MPIM+TOKY)
SNYDER    76 PRL 36 1415       +HOM,LEDERMAN,APPEL,KAPLAN+(COLU+FNAL+STON)
TANENBAU  76 PRL 36 402        TANENBAUM,ABRAMS,BOYARSKI,BULOS,+(SLAC+LBL)IG
TRILLING  76 STANFORD SYMP.437 G. H. TRILLING                     (LBL)
VERNON    76 TBILISI CONF.N63  W.VERNON      (UMD+PAVI+PRIN+UCSD+SLAC+STAN)
WHITAKER  76 PRL 37 1596       +TANENBAUM,ABRAMS,ALAM,BOYARSKI,+(SLAC+LBL)
WIIK      76 TBILISI CONF.N75  B.H.WIIK RAPPORTEUR                 (DESY)

BARTEL    77  DESY 77/70       +DITTMANN(FRITSCHER,HEINTZE,+   (DESY+HEID)
BARTEL 2  77 HAM. CON. P. 117  +DITTMANN,FRITSCHER,HEINTZE,+   (DESY+HEID)
BIDDICK   77 PRL 38 1324       +BURNETT+    (UCSD+UMD+PAVI+PRIN+SLAC+STAN)
BRAUNSCH  77 PL 67 B 249       BRAUNSCHWEIG,+    (AACH+DESY+HAMB+MPIM+TOKY)
BURMESTE  77 PL 66 B 395       BURMESTER,CRIEGEE,+   (DESY+HAMB+SIEG+WUPP)
FELDMAN   77 PL 33 C 285       +PERL                          (LBL+SLAC)
YAMADA    77 HAMB. CONF. P. 69 YAMADA                        (DESY+TOKY)
WIIK      77  DESY 77/01       +WGLF                             (DESY)

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## $\psi(3770)$

53  PSI(3770,JPG=1- ) I=

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                    53  PSI(3770) MASS (MEV)

M          (3770.)      (6.0)          BACIND    77 SPEC  0 E+E- (DELCO)      12/77*
M           3772.0       6.0           RAPIDIS   77 SMAG  0 E+E-              12/77*

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DM                  53  PSI(3770)-PSI(3685) MASS DIFFERENCE (MEV)
DM            88.0       3.0           RAPIDIS   77 SMAG    E+E-              12/77*

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                    53  PSI(3770) WIDTH (MEV)

W           (24.0)     (5.0)          BACIND    77 SPEC  0 E+E- (DELCO)      12/77*
W            28.0       5.0           RAPIDIS   77 SMAG  0 E+E-              12/77*

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                    53  PSI(3770) PARTIAL WIDTHS (KEV)

W1     PSI(3770) INTO E+E-
W1            (0.18)   (0.06)         BACIND    77 SPEC  0 E+E- (DELCO)      12/77*
W1 R          0.37     0.09           RAPIDIS   77 SMAG  0 E+E-              12/77*
W1 R    SEE ALSO R2 BELOW

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                    53  PSI(3770) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     PSI(3770) INTO E+ E-                                        .5+  .5
P2     PSI(3770) INTO D DBAR                                      1876+1876

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                    53  PSI(3770) BRANCHING RATIOS

R1     PSI(3770) INTO (D DBAR)/TOTAL                        (P2)
R1          DOMINANT                 PERUZZI   77 SMAG    E+E-,D DBAR         12/77*

R2     PSI(3770) INTO (E+ E-)/TOTAL (UNITS 10**-5)        (P1)
R2            1.3      0.2           RAPIDIS   77 SMAG  0 E+E-              12/77*

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Mesons

$\psi(4030)$, $\psi(4415)$, $\Upsilon_1(9410)$, $\Upsilon_2(10060)$, $K^{\pm}$, K^0

Data Card Listings

For notation, see key at front of Listings.

REFERENCES FOR PSI(3770)

BACINO	77 SLAC-PUB-2030	+BAUMGARTEN,BIRKWOOD,+	(SLAC+STAN+UCLA+UCI)
PERUZZI	77 PRL 39 1301	+PICCOLO,FELDMAN,PERL,+	(SLAC,LBL,NWES+HAWA)
RAPIDIS	77 PRL 39 526	+GOBBI,LUKE,PERL,+	(STAN+SLAC+LBL+NWES+HAWA)

$\psi(4030)$

72 PSI(4030,JPG=1-) I=

OMITTED FROM TABLE.

72 PSI(4030) MASS (MEV)

M	4028.0	2.5	GOLDHABER 77 SMAG	E+E-		12/77*

72 PSI(4030) PARTIAL DECAY MODES

		DECAY MASSES
P1	PSI(4030) INTO D DBAR	
P2	PSI(4030) INTO D* DBAR AND D*BAR D	
P3	PSI(4030) INTO D* D*BAR	
P4	PSI(4030) INTO J/PSI(3100) HADRONS	
P5	PSI(4030) INTO E+ E-	
P6	PSI(4030) INTO MU+ MU-	

72 PSI(4030) BRANCHING RATIOS

R1	PSI(4030) INTO (D DBAR)/(D* DBAR+D*BAR D)			(P1)/(P2)		
R1	0.05	0.03	GOLDHABER 77 SMAG	0 E+ E-		12/77*
R2	PSI(4030) INTO J/PSI(3100) HADRONS			(P4)		
R2	LOOKED FOR		BURMESTER 77 PLUT	E+E-		4/77*
R3	PSI(4030) INTO (D* D*BAR)/(D* DBAR+D*BAR D)			(P3)/(P2)		
R3	32.0	12.0	GOLDHABER 77 SMAG	0 E+ E-		12/77*
R4	PSI(4030) INTO (E+ E-)/TOTAL	(UNITS 10**-5)		(P5)		
R4	(1.0) APPROX.		FELDMAN 77 SMAG	E+ E-		12/77*

REFERENCES FOR PSI(4030)

AUGUSTIN	75 PRL 34 764	+BOYARSKI,ABRAMS,BRIGGS+	(SLAC+LBL)
BACCI	75 PL 58B 481	+BIDOLI,PENSO,STELLA,+	(ROMA+FRAS)
BOYARSKI	75 PRL 34 762	+BREIDENBACH,ABRAMS,BRIGGS,+	(SLAC+LBL)
ESPOSITO	75 PL 58B 478	+FELICETTI,PERUZZI,+	(FRAS+NAPL+PADO+ROMA)
SCHWITTE	75 STANFORD SYMP.5	R.F.SCHWITTERS	(SLAC)
PERUZZI	76 PRL 37 569	+PICCOLO,FELDMAN,NGUYEN,WISS,+	(SLAC+LBL)
BURMESTE	77 DESY 77/19	+CRIEGEE,DEHNE+	(DESY+HAMB+SIEG+WUPP)
GOLDHABE	77 PL 69 B 503	GOLDHABER,WISS,ABRAMS,ALAM,LUTH,+	(LBL+SLAC)
FELDMAN	77 PL 33 C 285	+PERL	(LBL+SLAC)
LUTH	77 PL 70 B 120	+PIERRE,ABRAMS,ALAM,BOYARSKI,+	(LBL+SLAC)
WIIK	77 DESY 77/01	+WOLF	(DESY)

$\psi(4415)$

73 PSI(4415,JPG=1-) I=

RESONANCE-SHAPED STRUCTURE IN E+E- INTO HADRONS.
NUMBER OF STATES IN THIS REGION, AND SPECIFIC DECAY MODES, UNKNOWN.

73 PSI(4415) MASS (MEV)

M	4414.	7.	SIEGRIST 76 SMAG	E+E-		2/76
M	(4400.)	APPROX.	KNIES 77 PLUT	0 E+E-,MU+ MU-		12/77*

73 PSI(4415) WIDTH (MEV)

W	33.	10.	SIEGRIST 76 SMAG	E+E-		2/76

73 PSI(4415) PARTIAL DECAY MODES

		DECAY MASSES
P1	PSI(4415) INTO E+ E-	.5+ .5

73 PSI(4415) BRANCHING RATIOS

R1	PSI(4415) INTO (E+ E-)/TOTAL	(UNITS 10**-5)				
R1	1.3	.3	SIEGRIST 76 SMAG	E+E-		2/76
R2	PSI(4415) INTO HADRONS/TOTAL					
R2	DOMINANT		SIEGRIST 76 SMAG	E+E-		1/77*

REFERENCES FOR PSI(4415)

SCHWITTE	75 STANFORD SYMP.5	R.F.SCHWITTERS	(SLAC)
SIEGRIST	76 PRL 36 700	+ABRAMS,BOYARSKI,BREIDENBACH,+	(LBL+SLAC)
KNIES	77 DESY 77/74	G.KNIES HAMBURG TALK ON PLUTO COLLAB.(DESY)	
LUTH	77 PL 70 B 120	+PIERRE,ABRAMS,ALAM,BOYARSKI,+	(LBL+SLAC)
WIIK	77 DESY 77/01	+WOLF	(DESY)

$\Upsilon_1(9410)$

49 UPSILON1(9410,JPG=1-) I=

49 UPSILON1 MASS (MEV)

M I	9410.	13.	INNES	77 SPEC	0 400 P+A,MU+MU-		12/77*
M I	FROM 2-PEAK FIT						12/77*

49 UPSILON1 WIDTH (GEV)

W A	(100.)	OR LESS	INNES	77 SPEC	0 400 P+A,MU+MU-		12/77*
W A	FROM QUOTED RESOLUTION						

49 UPSILON1 PARTIAL DECAY MODES

		DECAY MASSES
P1	UPSILON1 INTO MU+ MU-	105+ 105
P2	UPSILON1 INTO E+ E-	.5+ .5

49 UPSILON1 BRANCHING RATIOS

R1	UPSILON1 INTO MU+ MU-			(P1)		
R1	SEEN		HERB 77			12/77*
R2	UPSILON1 INTO E+ E-			(P2)		
R2	SEEN		COBB 77			12/77*

REFERENCES FOR UPSILON1(9410)

COBB	77 PL	+IWATA,FABJAN,GOLDBERG+	(BNL+CERN+SYRA+YALE)
HERB	77 PRL 39 252	+HOM,LEDERMAN,APPEL,ITO,+	(COLU+FNAL+STON)
INNES	77 PRL 39 1240	+APPEL,BROWN,HERB,HOM,FISK+	(COLU+FNAL+STON)

$\Upsilon_2(10060)$

52 UPSILON2(10060,JPG=1-) I=

SPLITTING OF UPSILON SEEN IN ONE EXPERIMENT
ONLY. WAIT CONFIRMATION. OMITTED FROM TABLE.

52 UPSILON2 MASS (MEV)

M I	10060.	30.	INNES	77 SPEC	0 400 P+A,MU+MU-		12/77*
M I	FROM 2-PEAK FIT						12/77*

52 UPSILON2 WIDTH (GEV)

W A	(106.)	OR LESS	INNES	77 SPEC	0 400 P+A,MU+MU-		12/77*
W A	FROM QUOTED RESOLUTION						

52 UPSILON2 PARTIAL DECAY MODES

		DECAY MASSES
P1	UPSILON2 INTO MU+ MU-	105+ 105
P2	UPSILON2 INTO E+ E-	.5+ .5

52 UPSILON2 BRANCHING RATIOS

R1	UPSILON2 INTO MU+ MU-			(P1)		
R1	SEEN		HERB 77			12/77*
R2	UPSILON2 INTO E+ E-			(P2)		
R2	SEEN		COBB 77			12/77*

REFERENCES FOR UPSILON2(10060)

COBB	77 PL	+IWATA,FABJAN,GOLDBERG+	(BNL+CERN+SYRA+YALE)
HERB	77 PRL 39 252	+HOM,LEDERMAN,APPEL,ITO,+	(COLU+FNAL+STON)
INNES	77 PRL 39 1240	+APPEL,BROWN,HERB,HOM,FISK+	(COLU+FNAL+STON)

S=±1, C=0 MESON STATES

$K^{\pm}$

10 CHARGED K(494,JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

K^0

11 NEUTRAL K(498,JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

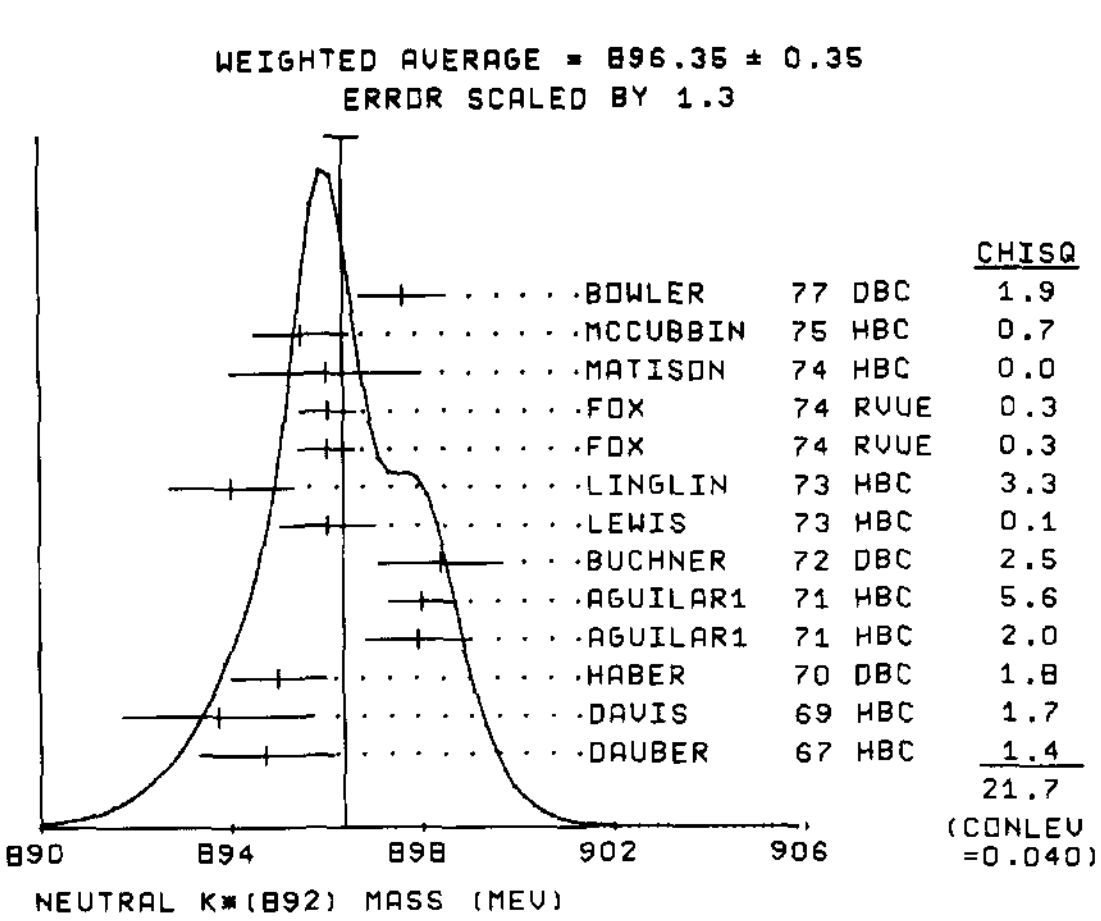
$K^*(892)$

18 K*(892,JP=1-) I=1/2

18 K*(892) MASS (MEV)

M	CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE						
M	S 100	(898.0)	(5.0)	CHADWICK	63 HBC	+ 1.5 K+P(K PI)	12/75
M	W 1700	891.0	1.2	WOJCICKI	64 HBC	- 1.7 K-P(KO PI-)	12/75
M	SD 200	(889.5)	(3.6)	ADELMAN	65 HBC	- 1.5 K-P	12/75
M	S 300	(891.0)	(3.0)	FERRO-LUZ	65 HBC	+ K+P	12/75
M	S 300	(895.0)	(3.0)	GELSEMA	65 HBC	- 1.5 K-P(KO PI-)	12/75
M	SD 190	(895.)	(3.6)	BOMSE	67 HBC	+ 2.3 K+P (KO PI+)	12/75
M	D 620	891.	2.3	DE BAERE	67 HBC	+ 3.5 K+P (KO PI+)	12/75
M	SD 260	(892.5)	(3.3)	DE BAERE	67 HBC	+ 3.5 K+P (K+ PI0)	12/75
M	SD 70	(898.)	(9.0)	SALLSTROM	67 HBC	+ 3. K+ P (KO PI+)	12/75
M	SD 50	(883.)	(7.0)	SALLSTROM	67 HBC	+ 3. K+ P (K+ PI0)	12/75
M	720	890.	3.0	BARLOW	67 HBC	+- 1.2 PBARP(KO PI)	12/75
M	600	889.	3.0	BARLOW	67 HBC	+- 1.2 PBARP(K PI)	12/75
M	S 300	(896.0)	(5.0)	CONFORTO	67 HBC	+- 0. PBARP(KO PI)	12/75
M	S 430	(893.)	(3.0)	DE WIT	68 DBC	- 3.0 K-P(KOPI-)	12/75
M	D 540	888.	2.5	DE WIT	68 HBC	- 3.0 K-P	12/75
M	S	(891.)	(4.0)	FICENEC1	68 HBC	- 1.3 K-P (K-PI0)	12/75
M	S	(887.)	(3.0)	FICENEC1	68 HBC	- 1.3 K-P (KOPI-)	12/75
M	S	(890.0)	(5.0)	FICENEC2	68 HBC	- 2.7 K- P(K-PI0)	12/75
M	S	(892.0)	(3.0)	FICENEC2	68 HBC	- 2.7 K- P(KOPI-)	12/75
M	S 115	(896.0)	(4.0)	SCHWEINGR	68 HBC	- 4.1 K-P(KO PI-)	12/75
M	D 341	892.0	2.6	SCHWEINGR	68 HBC	- 5.5 K-P(KO PI-)	12/75
M	S 175	(884.0)	(5.0)	KANG	68 HBC	- 4.6 K-P(K PI)	12/75
M	1000	891.0	2.0	CRENNELL	69 DBC	- 3.9 K-N (KOPI-)	12/75
M	2886	894.	1.0	FRIEDMAN	69 HBC	- 2.1 K-P(KO PI-)	12/75
M	728	892.	2.	FRIEDMAN	69 HBC	- 2.45 K-P(KO PI-)	12/75
M	3229	892.	1.0	FRIEDMAN	69 HBC	- 2.6 K-P(KO PI-)	12/75
M	D1027	892.	1.6	FRIEDMAN	69 HBC	- 2.7 K-P(KO PI-)	12/75
M	SD 127	(895.)	(4.5)	LIND	69 HBC	+ 9. K+ P	12/75
M	4404	892.2	1.5	AGUILAR1	71 HBC	- 3.9,4.6 K- P	11/71
M	D 765	894.2	2.0	CLARK	73 HBC	- 3.13 K-P(KO PI-)	12/75
M	W D1150	894.3	1.5	CLARK	73 HBC	- 3.3 K-P,P PI- KO	12/75
M	I 9000	(891.9)	(0.7)	PALER	75 HBC	- 14.3 K-P,K*- X+	12/75
M		. . . .	. . . .				
M	AVG	892.24	0.43	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
M	STUDENT	892.19	0.51	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

M	NEUTRAL ONLY.						
M	S 70	(897.0)	(10.0)	COLLEY	62 HBC	0 2.0 PI-P	12/75
M	S 120	(899.)	(4.0)	BARLOW	67 HBC	0 1.2 PBAR P	12/75
M	S 310	(897.)	(4.0)	BARLOW	67 HBC	0 1.2 PBAR P	12/75
M	S	(889.0)	(5.0)	CONFORTO	67 HBC	0 0. PBAR P	12/75
M	D1040	894.7	1.4	DAUBER	67 HBC	02.0 K-P(K-PI+)	12/75
M	AS 490	(892.0)	(4.0)	GEORGE	67 HBC	0 5.0 K+ P	12/75
M	SD	(895.)	(4.0)	FICENEC1	68 HBC	0 1.3 K-P (K-PI+)	12/75
M	SD	(901.)	(4.0)	FICENEC2	68 HBC	0 2.7 K-P (K-PI+)	12/75
M	SD 150	(896.0)	(4.5)	SCHWEINGR	68 HBC	0 4.1 K-P(K-PI+)	12/75
M	SD120	(903.0)	(5.0)	SCHWEINGR	68 HBC	0 5.5 K-P(K-PI+)	12/75
M	S 200	(899.0)	(5.0)	KANG	68 HBC	0 4.6 K-P(K-PI+)	12/75
M	10K	893.7	2.0	DAVIS	69 HBC	0 12. K+P(K+PI-)	12/75
M	WAD2200	(890.0)	(1.3)	DE BAERE	69 HBC	0 5.0 K+P(K+PI-)	12/75
M	W 4300	895.0	1.0	HABER	70 DBC	0 3. K-N (K-PI+)	12/75
M	D2934	897.9	1.1	AGUILAR1	71 HBC	0 3.9,4.6 K- P	12/75
M	D5362	898.0	0.7	AGUILAR1	71 HBC	0 3.9,4.6 K- P	12/75
M	D1700	898.4	1.3	BUCHNER	72 DBC	04.6 K+ N,K+ PI-	12/72
M	3186	896.0	1.0	LEWIS	73 HBC	02.1-2.7 K+P	2/74
M	C	894.0	1.3	LINGLIN	73 HBC	02-13 K+P,K+PI-	12/75
M	10K	896.0	0.6	FOX	74 RVUE	0 2 K-P,K-PI+N	12/75
M		896.0	0.6	FOX	74 RVUE	0 2 K+N,K+PI-P	12/75
M	C	896.	2.	MATISON	74 HBC	012 K+P,K+PI-	12/75
M	3600	895.5	1.0	MCCUBBIN	75 HBC	0 3.6 K-P,K-PI+N	12/75
M	I 22K	(897.1)	(0.7)	PALER	75 HBC	014.3 K-P,K*0 X0	12/75
M		897.6	0.9	BOWLER	77 DBC	05.4 K+D,K+PI-P P	12/77*
M	P	(895.7)	(0.3)	ESTABROOK	77 SPEC	013 K+-P,K+-PI+-	12/77*
M	P FROM PHASE SHIFT ANALYSIS OF 155000 EVENTS.						
M		(894.9)	(1.6)	WICKLUND	77 ASPK	0 3,4,6 PI+-PN	12/77*
M		. . . .	. . . .				
M	AVG	896.35	0.35	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)			
M	STUDENT	896.26	0.32	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			
				(SEE IDEOGRAM BELOW)			



M A INCLUDED IN LINGLIN 73 WORLD K+P DST
M C FROM POLE EXTRAPOLATION.
M D MASS ERRORS ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE.
M I INCLUSIVE REACTION. COMPLICATED BACKGROUND AND PHASE-SPACE EFFECTS
M S DATA WITH MASS ERROR OF 3 MEV OR MORE NOT AVERAGED
M W NUMBER OF EVENTS IN PEAK REEVALUATED BY US

Note on K^*(892) Masses and Mass Differences

Unrealistically small errors are reported by some experiments. We use simple "realistic" tests for the minimum errors on the determination of mass and width from a sample of N events:

$$\delta_{min}(m) = \frac{\Gamma}{\sqrt{N}} , \quad \delta_{min}(\Gamma) = 4 \frac{\Gamma}{\sqrt{N}} .$$

(For detailed discussion see the April 1971 edition of this note.) We consistently increase unrealistic errors before averaging.

Although in the past we have argued against taking the mass difference $m(K^{*0}) - m(K^{*\pm})$ from the separate averages of $m(K^{*0})$ and $m(K^{*\pm})$, we no longer see any reason for such caution. In fact, the difference between the separate averages agrees with direct measurements of the mass difference, and it has a smaller statistical error.

18 K*(0) - K*(+-) MASS DIFF. (MEV)

	D	W 283	6.3	4.1	BARASH	67 HBC	0 PBAR P	12/75
*	D	SD1400	(6.5)	(5.0)	FICENEC1	68 HBC	1.3 K- P	12/75
*	D	SD1600	(9.5)	(5.0)	FICENEC2	68 HBC	2.7 K- P	12/75
	D	7338	5.7	1.7	AGUILAR1	71 HBC	-0 3.9,4.6 K- P	11/71
*	D		. . . .	. . . .				
	D	AVG	5.8	1.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
	D	STUDENT	5.8	1.7	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

D MASS ERRORS ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE.
S DATA WITH MASS ERROR OF 3 MEV OR MORE NOT AVERAGED
W NUMBER OF EVENTS IN PEAK REEVALUATED BY US

18 K*(892) WIDTH (MEV)

W	CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE						
W	S 100	(46.0)	(8.0)	CHADWICK	63 HBC	+ 1.5 K+P(K PI)	12/75
W	W D1700	46.0	5.0	WOJCICKI	64 HBC	- 1.7 K-P(KO PI-)	12/75
W	SD 200	(51.0)	(15.0)	ADELMAN	65 HBC	- 1.5 K-P	12/75
W	SD 300	(47.0)	(11.0)	FERRO-LUZ	65 HBC	+ 3.0 K+P	12/75
W	SD 300	(50.0)	(12.0)	GELSEMA	65 HBC	- 1.5 K-P(KO PI-)	12/75
W	SD 190	(50.)	(15.0)	BOMSE	67 HBC	+ 2.3 K+P(KO PI+)	12/75
W	D 620	56.0	9.0	DE BAERE	67 HBC	+ 3.5 K+P(KO PI+)	12/75
W	SD 260	(53.)	(13.0)	DE BAERE	67 HBC	+ 3.5 K+P (K+ PI0)	12/75
W	SD 70	(68.)	(33.0)	SALLSTROM	67 HBC	+ 3. K+ P (KO PI+)	12/75
W	SD 50	(47.)	(27.0)	SALLSTROM	67 HBC	+ 3. K+ P (K+ PI0)	12/75
W	SD 210	(44.)	(12.0)	BARLOW	67 HBC	+- 1.2 PBAR P	12/75
W	720	43.	9.0	BARLOW	67 HBC	+- 1.2 PBARP(KO PI)	12/75
W	D 600	53.	9.0	BARLOW	67 HBC	+- 1.2 PBARP(K PI)	12/75
W	SD 430	(58.)	(12.0)	DE WIT	68 DBC	- 3. K- D	12/75
W	D 540	44.0	8.0	DE WIT	68 DBC	- 3. K- D	12/75
W	S	(58.)	(16.0)	FICENEC1	68 HBC	- 1.3 K-P (K-PI0)	12/75
W	S	(44.)	(13.0)	FICENEC1	68 HBC	- 1.3 K-P (KOPI-)	12/75
W	SD 115	(41.0)	(16.0)	SCHWEINGR	68 HBC	- 4.1 K-P(KO PI-)	12/75
W	SD 341	(47.0)	(10.0)	SCHWEINGR	68 HBC	- 5.5 K-P(KO PI-)	12/75
W	S	(57.0)	(13.0)	FICENEC2	68 HBC	- 2.7 K- P(K-PI0)	12/75
W	S	(48.0)	(9.0)	FICENEC2	68 HBC	- 2.7 K- P(KOPI-)	12/75
W	SD 175	(52.0)	(16.0)	KANG	68 HBC	- 4.6 K- P	12/75
W	D2886	53.	4.0	FRIEDMAN	69 HBC	- 2.1 K-P(KO PI-)	12/75
W	D 728	49.	7.3	FRIEDMAN	69 HBC	- 2.45K-P(KO PI-)	12/75
W	D3229	46.	3.2	FRIEDMAN	69 HBC	- 2.6 K-P(KO PI-)	12/75
W	D1027	49.	6.1	FRIEDMAN	69 HBC	- 2.7 K-P(KO PI-)	12/75
W	SD 127	(50.)	(18.0)	LIND	69 HBC	+ 9. K+ P	12/75
W	D4404	54.3	3.3	AGUILAR1	71 HBC	- 3.9,4.6 K- P	12/75
W	D 765	46.3	6.7	CLARK	73 HBC	- 3.13K-P,P PI- KO	12/75
W	W D1150	48.2	5.7	CLARK	73 HBC	- 3.3 K-P,P PI- KO	12/75
W	I 9000	(52.1)	(2.2)	PALER	75 HBC	- 14.3 K-P,K*- X+	12/75
W		. . . .	. . . .				
W	AVG	49.5	1.5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
W	STUDENT	49.4	1.8	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

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W  NEUTRAL ONLY.
W   SD  70  (60.0)   (29.0)          COLLEY     62 HBC    0 2.0 PI-P         12/75
W   S  310  (53.)    (13.0)          BARLOW     67 HBC    0 1.2 PBAR P       12/75
W   SD 120  (34.)    (12.5)          BARLOW     67 HBC    0 1.2 PBAR P       12/75
W    D1040   44.       5.5           DAUBER     67 HBC    0  2.0 K- P        12/75
W   S       (52.)    (12.0)          FICENEC1   68 HBC    0 1.3 K-P (K-PI+)  12/75
W   S       (50.0)    (8.0)          FICENEC2   68 HBC    0 2.7 K- P(K-PI+)  12/75
W   SD 200  (48.0)   (16.0)          KANG       68 HBC    0 4.6 K-P(K-PI+)   12/75
W   SD 120  (51.0)   (19.0)          SCHWEINGR  68 HBC    0 5.5 K-P(K-PI+)   12/75
W   SD 150  (53.0)   (17.5)          SCHWEINGR  68 HBC    0 4.1 K-P(K-PI+)   12/75
W    D 10K   53.2      2.1           DAVIS      69 HBC    0 12. K+P(K+PI-)   12/75
W  WAD2200  (58.0)    (5.0)          DE BAERE   69 HBC    0 5.0 K+P(K+PI-)   12/75
W  W D4300   54.0      3.3           HABER      70 DBC    0 3. K-N (K-PI+)   12/75
W     2934   55.8      4.2     3.4   AGUILAR1   71 HBC    0 3.9,4.6 K- P     11/71
W    D5362   48.5      2.7           AGUILAR1   71 HBC    0 3.9,4.6 K- P     12/75
W    D1700   51.4      5.0           BUCHNER    72 DBC    04.6 K+ N,K+ PI-P  12/72
W    D3186   46.0      3.3           LEWIS      73 HBC    02.1-2.7 K+P       12/75
W   C       (46.5)    (1.5)          LINGLIN    73 HBC    02-13 K+P,K+PI-     1/74
W      10K   47.       2.            FOX        74 RVUE   0 2 K-P,K-PI+N     12/75
W            51.       2.            FOX        74 RVUE   0 2 K+N,K+PI-P     12/75
W   C       (47.)     (3.)           MATISON    74 HBC    012 K+P,K+PI-      12/75
W     3600   48.       3.      2.    MCCUBBIN   75 HBC    0 3.6 K-P,K-PI+N   12/75
W   I  22K  (50.6)    (2.5)          PALER      75 HBC    014.3 K-P,K*0 X0   12/75
W            48.9      2.5           BOWLER     77 DBC    05.4 K+D,K+PI-P P  12/77*
W  P        (52.9)    (0.4)          ESTABROOK  77 SPEC   013 K+-P,K+-PI+-   12/77*
W  P   FROM PHASE SHIFT ANALYSIS OF 155000 EVENTS.
W           (51.2)    (1.7)          WICKLUND   77 ASPK   03,4,6 PI+-PN      12/77*
W           . . . . . . . . . .
W   AVG      49.86     0.91    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
W   STUDENT  49.79     0.98    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W   A   INCLUDED IN LINGLIN 73 WORLD K+P DST
W    C  FROM POLE EXTRAPOLATION.
W    D  WIDTH ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE.
W   I   INCLUSIVE REACTION. COMPLICATED BACKGROUND AND PHASE-SPACE EFFECTS
W   S   DATA WITH MASS ERROR OF 3 MEV OR MORE NOT AVERAGED
W  W    NUMBER OF EVENTS IN PEAK REEVALUATED BY US
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                  18  K*(892) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      K*(892) INTO K PI                               493+ 139
P2      K*(892) INTO K PI PI                            493+ 139+ 139
P3      K*(892) INTO K GAMMA                            493+   0
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                  18  K*(892) BRANCHING RATIOS

R1      K*(892) INTO (K PI PI)/(K PI)                   (P2)/(P1)
R1        0   (0.002)OR LESS           WOJCICKI2 64 HBC   ~ 1.7 K-P

R2      K*(892)  INTO (K  GAMMA)/TOTAL  (UNITS 10**-3)  (P3)
R2            (1.6)  OR LESS  CL=.95   BEMPORAD  72 CNTR +  10.-16. K+A,COUL  1/73
R2             1.5        0.7          CARITHERS 75 CNTR  0 8-16K0BAR A,COUL 12/75

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REFERENCES FOR K*(892)


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ALSTON    61 PRL 6 300          ALSTON,ALVAREZ,EBERHARD,GOOD,GRAZIANO+(LRL)
ALEXANDE  62 PRL 8 447          ALEXANDER,KALBFLEISCH,MILLER,G SMITH  (LRL)
COLLEY    62 CERN CONF 315      D COLLEY,N GELFAND +     (COLUMBIA+RUTGERS)

CHADWICK  63 PL 6 309           CHADWICK,CRENNELL,DAVIES,BETTINI+(OXF+PADO)
GOLDHABE  63 ATHENS CONF 92     SULAMITH GOLDHABER                    (LRL)

WOJCICKI  64 PR 135 B 484       STANLEY G WOJCICKI                    (LRL)

ADELMAN   65 ATHENS 527         STUART LEE ADELMAN              (CAVENDISH)
FERRO-LU  65 NC 36 1101         FERRO-LUZZI,GEORGE,HENRI,JONGEJANS   (CERN)
FERRO-LU  65 NC 39 417          FERRO-LUZZI,GEORGE,GOLDSCHMIDT-CLER+ (CERN)
GELSEMA   65 THESIS             E.S.GELSEMA (SEE ALSO PL 10 341)(AMSTERDAM)
WANGLER   65 PR 137 B 414       WANGLER,ERWIN,WALKER            (WISCONSIN)

BARASH    67 PR  156  1399      BARASH,KIRSCH,MILLER,TAN         (COLUMBIA)
BARLOW    67 NC  50 A  701      +MONTANET,D-ANDLAU+   (CERN+CDEF+IRAD+LIVP)
BOMSE     67 PR 158 1298        +BORENSTEIN+COLE+GILLESPIE+  (JOHN HOPKINS)
CONFORTO  67 NP B3 469          +MARECHAL,MONTANET+CERN+CDEF+IPN+LIVERPOOL
DAUBER    67 PR 153 1403        +SCHLEIN,SLATER,TICHO                (UCLA)
DE BAERE  67 NC 51 A 401        +GOLDSCHMIDT-CLERMONT,HENRI+    (BRUX+CERN)
FRENCH    67 NC 42A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)
GEORGE    67 NC 49A 9           +GOLDSCHMIDT-CLERMONT+HENRI+    (CERN+BRUX)
SALLSTRO  67 NC 49A 348         SALLSTROM+OTTER+EKSPONG         (STOCKHOLM)

DE WIT    68  THESIS            S. DE WIT                       (AMSTERDAM)
FICENEC1  68 PR 169 1034        +HULSIZER+SWANSON+TROWER              (ILL)
FICENEC2  68 PR 175 1725        FICENEC, GORDON, TROWER          (ILLINOIS)
KANG      68 PR 176 1587        Y.W.KANG                             (IOWA)
SCHWEING  68 PR 166 1317        SCHWEINGRUBER,DERRICK,FIELDS+    (ANL+NWES)

CRENNELL  69 PRL 22  487        +KARSHON,LAI,ONEALL,SCARR             (BNL)
DAVIS     69 PRL 23 1071        +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ  (LRL)
DE BAERE  69 NC 61 A 397        +GOLDSCHMIDT-CLERMONT,HENRI,+   (BELG+CERN)
FRIEDMAN  69  UCRL-18860        J.FRIEDMAN,PH.D. THESIS               (LRL)
JUHALA    69 PR 184  1461       +LEACOCK,RHODE,KOPELMAN,LIBBY,+  (ISU+COLO)
LIND      69 NP B 14 1          +ALEXANDER,FIRESTONE,FU,GOLDHABER     (LRL) JP

ATHERTON  70 NP B 16 416        +FRANEK,FRENCH,FRISK,BEDNAR+    (CERN+PRAG)
HABER     70 NP B 17 289        +SHAPIRA,ALEXANDER+   (REHO+SACL+BGNA+EPOL)

AGUILAR   71 PRL 26 466         +BARNES,BASSANO,EISNER,KINSON,SAMIOS  (BNL)
AGUILAR1  71 PR D 4 2583        +EISNER,KINSON                        (BNL)
BARNHAM   71 NP B 28 171        +COLLEY,JOBES,GRIFFITHS,HUGHES,+(BIRM+GLAS)
BUCHNER   71 NP B 29 381        +DEHM,GOEBEL,GOLDSCHMIDT,+ (MPIM+CERN+BELG)
CORDS     71 PR D 4 1974        +CARMONY,ERWIN,MEIERE,+     (PURD+UCD+IUPU)
MERCER    71 NP B32 381         +ANTICH,CALLAHAN,CHIEN,COX,+ (JOHN HOPKINS)
YUTA      71 PRL 26 1502        +DERRICK,ENGELMANN,MUSGRAVE       (ANL+EFI)

ABRAMOVI  72 NP B 39 189        ABRAMOVICH,CHALOUPKA,CHUNG,HILPERT,+ (CERN)
BINGHAM   72 NP B 41 1          +          (INTERNATIONAL K+ COLLABORATION)
BEMPORAD  72 NP B 51 1          +BEUSCH,FREUDENREICH,+     (CERN+ETHZ+LOIC)
BRUNET    72 NP B 37 114        +DANYSZ,GOLDSACK,+    (CDEF+SACL+LOIC+LOWC)
BUCHNER   72 NP B 45 333        +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CRENNELL  72 PR D 6 1220        +GORDON,KWAN-WU LAI,SCARR             (BNL)
DEUTSCHM  72 NP B 36 373        DEUTSCHMANN,+         (ABCLV COLLABORATION)
ENGELMAN  72 PR D 5 2162        ENGELMANN,MUSGRAVE,FORMAN,+       (ANL+EFI)
ROUGE     72 NP B 46 29         +VIDEAU,VOLTE,DE BRION,+        (EPOL+SACL)
TIECKE    72 NP B 39 596        +GRIJNS,HEINEN,DE GROOT,+       (NIJM+AMST)

BERTHON   73 NP B 63 54         +MONTANET,PAUL,BERTRANET,+      (CERN+SACL)
CHARRIER  73 NP B 51 317        CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
CLARK     73 NP B 54 432        +LYONS,RADOJICIC                   (OXFORD)
LEWIS     73 NP B 60 283        +ALLEN,JACOBS,DANYSZ,BORG,+(LOWC+LOIC+CDEF)
LINGLIN   73 NP B 55 408        D.LINGLIN                            (CERN)
WALUCH    73 PR D 8 2837        +FLATTE,FRIEDMAN                      (LBL)

FOX       74 NP B80 403         G.C.FOX,M.L.GRISS                     (CIT)
MATISON   74 PR D9 1872         +GALTIERI,GARNJOST,FLATTE,FRIEDMAN,+  (LBL)

BRANDENB  75 PL 59 B 405        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)
CARITHER  75 PRL 35 349         CARITHERS,MUHLEMANN,UNDERWOOD,+ (ROCH+MCGI)
MCCUBBIN  75 NP B86 13          N.A.MCCUBBIN,L.LYONS                  (OXF)
PALER     75 NP B96 1           +TOVEY,SHAH,SPIRO,CHAURAND+(RHEL+SACL+EPOL)

BOWLER    77 NP B 126 31        +DAINTON,DRAKE,WILLIAMS            (OXFORD)
ESTABROO  77  SLAC PUB 2004     ESTABROOKS,CARNEGIE+(MONT+CARL+DURHAM+SLAC)
WICKLUND  77  ANL-HEP-PR-77-58 +AYRES,DIEBOLD,GREENE,KRAMER,PAWLICKI (ANL)
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Q REGION, $K\pi\pi$(1240–1400)

28 Q REGION (1200-1400) I=1/2

The main effect in the Q region is a broad bump in the $K\pi\pi$ spectrum between 1200 and 1400 MeV (not far above the $K^*(892)\pi$ threshold), produced by K beams without charge exchange. In particular, it has been observed in coherent K^+d interactions (FIRESTONE 72) and in coherent interactions on heavy nuclei (BINGHAM 73). Throughout the entire region, $J^P = 1^+$ and $I = 1/2$. FIRESTONE1 72 observe a bump in the backward direction with a shape similar to that of the Q. The broad Q peak does not have a simple Breit-Wigner shape. It can be fitted at all energies by a superposition of two Breit-Wigner amplitudes. Dalitz plot analyses of the interference between the $K^*\pi$ and $K\rho$ modes show the relative magnitude and relative phase of the two decay amplitudes varying with $K\pi\pi$ mass. The $K\rho$ mode has a maximum intensity below that of $K^*\pi$.

Partial-wave analyses have confirmed the rather complex situation of the Q region (DEUTSCHMANN 74, ANTIPOV 75, OTTER 75,76, TOVEY 75, BRANDENBURG 76). The dominant states are $1^+S(K^*\pi)$ and $1^+S(K\rho)$. Other important states are $J^P = 0^-$ and $J^P = 2^+$. The $K^*\pi$ and $K\rho$ modes are not produced coherently and have different polarization properties (BRANDENBURG 76, OTTER 76). Whereas the $K\rho$ mode approximately conserves s-channel helicity, the $K^*\pi$ mode is approximately t-channel-helicity conserving.

Most recent partial-wave analyses of the Q bump support the existence of a $J^P = 1^+$ $K\pi\pi$ resonance, the Q_1, with a mass around 1280 MeV, a width of the order of 150 MeV, and mainly coupled to the $K\rho$ channel (BRANDENBURG 76, OTTER 76, BOWLER 76,

Data Card Listings

For notation, see key at front of Listings.

CARNEGIE 77). The status of the $K^*\pi$ channel is less transparent, a large $K^*\pi$ background (Deck effect) impeding its interpretation. Experimentally, those data with sufficient statistics show the presence of a two-peak structure (OTTER 75, BRANDENBURG 76). BRANDENBURG 76 claim to observe sufficient phase variation to warrant proposing the existence of a $J^P = 1^+$ $K\pi\pi$ resonance, the Q_2, with a mass around 1400 MeV, a width of the order of 150 MeV, and mainly coupled to the S-wave $K^*\pi$ channel. This is supported by BOWLER 77, but questioned by BASDEVANT 76, who show that the data can be explained (at least qualitatively) by a single resonance interfering with a proper Deck background.

AACHEN 76 and WOHL 77 have shown some evidence for a $K\omega$ decay of the Q_1 in diffraction-like processes.

The $(K\pi\pi)^0$ system produced in the charge-exchange reaction appears to have an important $J^P = 1^+$ contribution (OTTER1 75, VERGEEST 76). The $1^+(K^*\pi)$ and $1^+(K\rho)$ waves cannot be explained as decay products of a single resonance, and the $K^*\pi$ wave behavior suggests a resonance contribution around 1400 MeV (VERGEEST 76).

There are a number of claims for the observation of $K\pi\pi$ resonances in the Q mass region in other non-diffractive processes (ARMENTEROS 64, CRENNEL 67,72, ASTIER 69, DAVIDSON 74, DORE 75). These data can be described in terms of a single resonance of characteristics consistent with those of Q_1 (CONFORTO 77). The most recent result comes from a hyperon-exchange reaction (GAVILLET 77), which shows again the production of a $J^P = 1^+$ $K\rho$ enhancement with mass and width close to those of the Q_1. However, neither ARMENTEROS 64 (or a later analysis by ASTIER 69) nor GAVILLET 77 observe a $K^*\pi$ resonance compatible with the Q_2.

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                    28  Q REGION MASS  (MEV)

M   PRODUCED BY BEAMS OTHER THAN K MESONS
M  A      1242.0      9.0     10.0   ASTIER     69 HBC     0 PBAR P          . 9/69
M  A   THIS IS THE C MESON.
M       45(1300.)                    CRENNELL   67 HBC     0 6 PI- P,LK2PI     7/67
M       40(1300.)                    CRENNELL   72 HBC     0 4.5PI-P,LK2PI    12/72
M       40(1278.)     (5.)           DAVIDSON   74 HBC  +- 1.6-2.2 PBAR P     12/75
M       43(1235.)    (10.)           DORE       75 OSPK    06.2 PI-P,L MM     12/75

M   PRODUCED BY K-, BACKWARDS SCATTERING, HYPERON EXCHANGE
M  C    700 1279.0      5.0          GAVILLET   77 HBC   +  4.2 K-P,XI-KPIPI 12/77*
M  C       COUPLES MAINLY TO RHO K.
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M   PRODUCED BY K BEAMS
M       12(1320.0)    (25.0)         ALMEIDA    65 HBC   +    3-5 K+  P         12/72
M  C      (1230.0)    (15.0)         BASSOMPIE  67 HBC   +    5. K+ P           11/67
M  C    35(1280.0)    (10.0)         BASSOMPIE  67 HBC   +    5. K+ P           11/67
M  C      (1320.0)    (15.0)         BASSOMPIE  67 HBC   +    5. K+ P           11/67
M  C   SPLIT THE Q REGION INTO 3 BUMPS
M         (1270.)    APPROX.         DE BAERE   67 HBC   +    3.5 K+ P            7/67
M         (1335.0)     (6.0)         BARTSCH    68 HBC        10. K-P,K NPI    .12/75
M         (1300.)    APPROX.         BARBARO    69 HBC   +    12.K+ P (K 2PI)   9/69
M       45(1301.0)    (10.0)         BISHOP     69 HBC   +    3.5 K+P(K* PI)    12/75
M       21(1300.0)    (10.0)         ERWIN      69 HBC     0 3.5 K+P(K* PI)    12/75
M         (1281.)     (7.)           FRIEDMAN   69 HBC   -    2.6,2.7 K- P      12/75
M         (1300.0)    (10.0)         ABRAMS     70 HBC   +    2.5-3.2 K+ P      12/75
M         (1260.)     (20.)          FARBER     70 HBC   +    12.7 K+ P       .12/75
M         (1325.0)                   DENEGRI    71 DBC    - 12.6 K-D,K 2PI D  12/75
M         (1296.)      (5.)          BARLOUTAU  73 HBC   -    14.3 K-P,P K-2PI  12/75
M         (1283.)      (6.)          BARLOUTAU  73 HBC   -    14.3 K-P,P KO2PI  12/75
M         (1315.)      (7.)          BINGHAM    73 HLBC  -    5.5-12.7 COH K-A  12/75
M         (1260.)     (10.)          LEWIS      73 HBC   +    2.1-2.7 K+ P      12/75
M         (1260.)      (5.)          LEWIS      73 HBC   +    2.1-2.7 K+ P      12/75

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                    28  Q LOW (QA)  MASS  (MEV)

ML F    FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
ML
ML        (1280.)                    SHEN       66 HBC   + 0 4.6 K+P,5 BODY  12/72
ML        (1260.0)    (10.0)         ALEXANDER  69 HBC       9.0 K+ P          12/75
ML        (1240.0)     (5.0)         BARNHAM    71 HBC   +  10.0 K+P,K 2PI    12/75
ML        (1243.)      (8.)          GARFINKEL  71 DBC   +  9. K+ D           12/75
ML        (1228.)     (14.)          ANDERSON   72 DBC   -  7.3 K- D          12/75
ML        (1260.)                    DAVIS      72 HBC   +  12. K+ P          12/72
ML        (1234.)     (12.)          FIRESTONE  72 DBC   +  12. K+ D            2/73
ML C      (1300.)    APPROX.         BRANDENB   76 ASPK  +- 13 K+-P,(KPIPI)P  12/75
ML C    COUPLES MAINLY TO RHO K
ML  E     (1289.0)    (25.0)         CARNEGIE1  77 ASPK  +- 13 K+-P,P KPIPI   12/77*
    E     FROM A MODEL DEPENDENT FIT WITH GAUSSIAN BACKGROUND TO
    E     BRANDENBURG 76 DATA.
ML        (1270.0)   APPROX.         OTTER      76 HBC   -  10-14-16K-P        12/77*
ML
ML  AVERAGING NOT MEANINGFUL

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                    28  Q HIGH (QB)  MASS  (MEV)

MH F    FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
MH
MH      70(1320.0)    (10.0)         SHEN       66 HBC   +    4.6 K+  P        12/75
MH        (1380.0)    (20.0)         ALEXANDER  69 HBC        9.0 K+ P          12/75
MH        (1420.0)     (5.0)         BARNHAM    71 HBC   +  10.0 K+P,K 2PI     12/75
MH        (1344.)      (8.)          GARFINKEL  71 DBC   +  9. K+ D            12/75
MH        (1414.)     (15.)          ANDERSON   72 DBC   -  7.3 K- D           12/75
MH        (1420.)                    DAVIS      72 HBC   +  12. K+ P           12/72
MH        (1368.)     (18.)          FIRESTONE  72 DBC   +  12. K+ D           12/77*
MH D      (1400.)    APPROX.         BRANDENB   76 ASPK  +- 13 K+-P,(KPIPI)P  12/75
MH D    COUPLES MAINLY TO K* PI
MH  E     (1404.0)    (10.0)         CARNEGIE1  77 ASPK  +- 13 K+-P,P KPIPI   12/77*
    E  SEE NOTE E ABOVE.
MH
MH  AVERAGING NOT MEANINGFUL

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                    28  Q REGION WIDTH  (MEV)

W   PRODUCED BY BEAMS OTHER THAN K MESONS
W          127.0       7.0      25.0   ASTIER     69 HBC     0 PBAR P          . 9/69
W       45  (60.)                     CRENNELL   67 HBC     0 6 PI- P           7/67
W       40  (60.)                     CRENNELL   72 HBC     0 4.5PI-P,LK2PI    12/72
W D     40  (25.)     (15.)           DAVIDSON   74 HBC  +- 1.6-2.2 PBAR P     12/75
W D   ERROR INCREASED BY US. SEE K* TYPED NOTE.
W       43  (30.)     (25.)    (18.)  DORE       75 OSPK    06.2 PI-P,L MM     12/75

W   PRODUCED BY K-, BACKWARDS SCATTERING, HYPERON EXCHANGE
W  C    700   78.0      15.0          GAVILLET   77 HBC   +  4.2 K-P,XI-KPIPI 12/77*
W  C       COUPLES MAINLY TO RHO K.

W   PRODUCED BY K BEAMS
W       12  (60.0)    (20.0)         ALMEIDA    65 HBC   +    3-5 K+P           12/72
W  C      (60.0)    (20.0)           BASSOMPIE  67 HBC   +    5. K+ P           11/67
W  C    35  (80.0)    (20.0)         BASSOMPIE  67 HBC   +    5. K+ P           11/67
W  C      (60.0)    (20.0)           BASSOMPIE  67 HBC   +    5. K+ P           11/67
W  C   SPLIT THE Q REGION INTO 3 BUMPS
W         (200.)    APPROX.          DE BAERE   67 HBC   +  3.5 K+ P            7/67
W         (196.0)    (16.0)         BARTSCH    68 HBC        10. K- P,K NPI   .12/75
W  B       250. APPROX.              BARBARO    69 HBC   +    12.K+ P (K 2PI)   9/69
W  B    NO BACKGROUND SUBTRACTION.
W       45  (40.0)    (10.0)         BISHOP     69 HBC   +  3.5 K+P(K* PI)    12/75
W       21  (40.0)    (15.0)         ERWIN      69 HBC     0 3.5 K+P(K* PI)    12/75
W         (51.)      (22.)          FRIEDMAN   69 HBC   -    2.6,2.7 K- P      12/75
W         (80.0)     (20.0)         ABRAMS     70 HBC   +    2.5-3.2 K+ P      12/75
W         (180.)     (28.)          FARBER     70 HBC   +    12.7 K+ P       .12/75
W         (180.0)                   DENEGRI    71 DBC    - 12.6 K-D,K 2PI D   5/71
W         (326.)     (17.)          BARLOUTAU  73 HBC   -    14.3 K-P,P K-2PI  12/75
W         (266.)     (21.)          BARLOUTAU  73 HBC   -    14.3 K-P,P KO2PI  12/75
W         (150.)     (70.)          LEWIS      73 HBC   +    2.1-2.7 K+ P      12/75
W         (47.)      (18.)          LEWIS      73 HBC   +    2.1-2.7 K+ P      12/75

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                    28  Q LOW (QA)  WIDTH  (MEV)

WL F    FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
WL
WL        (100.0)    (20.0)         SHEN       66 HBC   + 0 4.6 K+P,5 BODY  12/75
WL         (40.0)    (10.0)         ALEXANDER  69 HBC       9.0 K+ P          12/75
WL        (110.0)    (15.0)         BARNHAM    71 HBC   +  10.0 K+P,K 2PI    12/75
WL         (70.)     (26.)    (18.) GARFINKEL  71 DBC   +  9. K+ D           12/75
WL        (111.)     (33.)          ANDERSON   72 DBC   -  7.3 K- D          12/75
WL        (120.)                    DAVIS      72 HBC   +  12. K+ P          12/72
WL        (188.)     (21.)          FIRESTONE  72 DBC   +  12. K+ D           12/75
WL C      (200.)    APPROX.         BRANDENB   76 ASPK  +- 13 K+-P,(KPIPI)P  12/75
WL C    COUPLES MAINLY TO RHO K
WL  E     (150.00)   (71.0)         CARNEGIE1  77 ASPK  +- 13 K+-P,P KPIPI   12/77*
    E  SEE NOTE E ABOVE.
WL
WL  AVERAGING NOT MEANINGFUL

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Mesons

Q, K'(1400)

Data Card Listings

For notation, see key at front of Listings.

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                    28  Q HIGH (QB)  WIDTH  (MEV)

WH F    FROM EXPERIMENTS SPLITTING Q REGION INTO TWO PEAKS
WH
WH       70  (80.0)   (20.0)          SHEN      66 HBC  +   4.6 K+P          12/75
WH          (120.0)   (20.0)          ALEXANDER 69 HBC      9.0 K+ P         12/75
WH          (120.0)   (15.0)          BARNHAM   71 HBC  +  10.0 K+P,K 2PI    12/75
WH           (60.)   OR LESS         GARFINKEL 71 DBC  +  9. K+ D            12/72
WH           (89.)    (24.)          ANDERSON  72 DBC  -  7.3 K- D            12/75
WH           (80.)                   DAVIS     72 HBC  +  12. K+ P           12/72
WH          (241.)    (30.)          FIRESTONE 72 DBC  +  12. K+ D           12/75
WH D        (160.)   APPROX.         BRANDENB  76 ASPK +- 13 K+-P,(KPIPI)P    12/75
WH D    COUPLES MAINLY TO K* PI
WH  E       (142.0)   (16.0)          CARNEGIE1 77 ASPK +- 13 K+-P,P KPIPI   12/77*
    E SEE NOTE E ABOVE.
WH
WH  AVERAGING NOT MEANINGFUL

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                    28  Q REGION PARTIAL DECAY MODES

                                                                DECAY MASSES
P1      Q REGION INTO K*(892) PI                                892+ 139
P2      Q REGION INTO K RHO                                     497+ 776
P3      Q REGION INTO K PI                                      497+ 139
P4      Q REGION INTO K ETA                                     497+ 548
P5      Q REGION INTO K OMEGA                                   497+ 783
P6      Q REGION INTO K PI PI                                   497+ 139+ 139

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                    28  Q REGION BRANCHING RATIOS

    PRODUCED BY BEAMS OTHER THAN K MESONS
R1      Q REGION INTO (K RHO)/TOTAL (UNITS OF 10**-2)     (P2)
R1           75.0     10.0          ARMENTERO 64 HBC       0.0 PBAR P        6/66
R1         DOMINANT                 CRENNELL  72 HBC       0 4.5PI-P,LK2PI   12/72

R2      Q REGION INTO (K* PI)/TOTAL (UNITS OF 10**-2)     (P1)
R2           25.0     10.0          ARMENTERO 64 HBC       0.0 PBAR P        6/66

R3      Q REGION INTO (K+ PI-) / (K+O PIO+ PI-)
R3           (0.2)  OR LESS  CL=.90  CRENNELL  67 HBC       0 6.0 PI-P        7/67

R4      Q REGION INTO (KO PI+ PI- PIO) / (K+O PIO+ PI-)
R4           (0.1)  OR LESS  CL=.90  CRENNELL  67 HBC       0 6.0 PI-P        7/67

    PRODUCED BY K BEAMS
R10     Q REGION INTO (K PI) / (K*(892) PI)               (P3)/(P1)
R10          (0.8)  OR LESS          SHEN      66 HBC      4.6 K+P, 5 BODY   11/67
R10       Q REGION       INTO K*(892) PI AND K RHO (OVERLAPPING BANDS)(P1+P
R10     70   (1.0)                   SHEN      66 HBC  +   4.6 K+P           8/66

R11     Q REGION INTO (K OMEGA)/(K*(892) PI)              (P5)/(P1)
R11          (0.1)  OR LESS          SHEN      66 HBC  +   4.6 K+P           10/66

R12     Q REGION INTO (K PI) / (K*(892) PI)               (P3)/(P1)
R12          (0.30) OR LESS          SHEN      66 HBC  +   4.6 K+P           10/66

R13     Q REGION INTO K*(892) PI AND K RHO (OVERLAPPING BANDS)
R13                                                       (P1+P2)
R13      200   (1.0)                 BERLINGHI 67 HBC  +   12.7 K+ P         7/67

R14     Q REGION INTO (K PI) / TOTAL                      (P3)
R14          (0.02) OR LESS          BERLINGHI 67 HBC  +   12.7 K+ P         11/67
R14          (0.02) OR LESS  CL=.95  BARTSCH   68 HBC    - 10.0 K- P

R15     Q REGION INTO (K ETA) / TOTAL                     (P4)
R15          (0.02) OR LESS          BERLINGHI 67 HBC  +   12.7 K+ P         11/67

R16     Q REGION INTO (K OMEGA) / TOTAL                   (P5)
R16          (0.02) OR LESS          BERLINGHI 67 HBC  +   12.7 K+ P         11/67
R16     12   0.01     0.005         BARTSCH   68 HBC    - 10.0 K- P         9/68

R17     Q REGION INTO (K RHO) / (K*(892) PI)              (P2)/(P1)
R17          0.91     0.25          BERLINGHI 67 HBC  +   12.7 K+ P         11/67
R17      701  0.4      0.1          BARTSCH   68 HBC    - 10.0 K- P         9/68
R17          . . . . . .
R17 AVG      0.47     0.18    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17 STUDENT  0.46     0.11    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R18     Q REGION INTO (K PI) / (K*(892) PI)               (P3)/(P1)
R18          (0.21) OR LESS          DE BAERE  67 HBC  +   3.5 K+ P         11/66

R19     Q REGION INTO (K PI PI) / TOTAL                   (P6)
R19      201   0.22     0.08          BARTSCH   68 HBC    - 10.0 K- P         9/68
R19  S      POSSIBLY SEEN             ALEXANDER 69 HBC      9.0 K+ P         2/73
R19  S      POSSIBLY SEEN             DAVIS     72 HBC  +   12. K+ P         1/73
R19  S  WITH THE (PI PI) SYSTEM IN S-WAVE                                    1/73

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                    REFERENCES FOR Q REGION

        PRODUCED BY BEAMS OTHER THAN K MESONS

ARMENTER 64 DUBNA CONF 1 577  ARMENTEROS,EDWARDS,D-ANDLAU +    (CERN+CDEF)
    ALSO 64 DUBNA CONF 1 617  R ARMENTEROS (RAPPORTEUR)
ARMENTER 64 PL 9 207          ARMENTEROS,EDWARDS,D-ANDLAU,+    (CERN+CDEF)
    ALSO 66 PR  145  1095     BARASH,KIRSCH+MILLER,TAN          (COLUMBIA)
CRENNELL 67 PRL 19  44        +KALBFLEISCH,LAI,SCARR,SCHUMANN       (BNL)I
ASTIER   69 NP B 10 65        +MARECHAL,MONTANET,+  (CDEF+CERN+IPNP+LIVP)IJP
BETTINI  69 NC 62 A 1038      +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)I
CRENNELL 72 PR D 6 1220       +GORDON,KWAN-WU LAI,SCARR                 (BNL)
DAVIDSON 74 PR D9 77          +CHAPMAN,GREEN,LYS,ROE                    (MICH)
DORE     75 LNC 13 265        +GUIDONI,LAAKSO,MARINI,CONFORTO+(ROMA+RHEL)

        PRODUCED BY K BEAMS

ALMEIDA  65 PL 16 184         ALMEIDA,ATHERTON,BYER,DORNAN,FORSON+ (CAVE)

SHEN     66 PRL  17  726      +BUTTERWORTH,FU,GOLDHABERS,TRILLING    (LRL)
    ALSO 66  (PRIVATE COMMUN)GERSON GOLDHABER                        (LRL)

BASSOMPI 67 PL 26B 30         BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
BERLINGH 67 PRL 18 1087       BERLINGHIERI+FARBER+FERBEL+FORMAN     (RGCH)IJP
DE BAERE 67 NC 49A 374        +DEBAISIEUX+FAST+FILIPPAS+          (CERN+BRUX)
    ALSO  PRIVATE COMMUNICATION BY B. JONGEJANS
GOLDHABE 67 PRL 19 976        G.GOLDHABER                               (LBL)

BARTSCH  68 NP B8 9           +COCCONI,+          (AACH+BERL+CERN+LCIC+VIEN)
BOMSE    68 PRL 20 1519       +BORENSTEIN,CALLAHAN,COLE,COX,+  (JOHNHOPK)  1+
DENEGRI  68 PRL 20 1194       +CALLAHAN+ETTLINGER+GILLESPIE+   (JOHNHOPK)  1+
    ALSO 70 ANTICH

ALEXANDE 69 NP B 13 503       G.ALEXANDER,FIRESTONE,GOLDHABER,+         (LRL)
ANDREWS  69 PRL 22 731        +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
BARBARO  69 PRL 22 1207       BARBARO-GALTIERI,DAVIS,FLATTE,+           (LRL)
BISHOP   69 NP B 9 403        +GOSHAW,ERWIN,WALKER                      (WISC)
CHIEN    69 PL 29B 433        +MALAMUD,NELLEMA,RUDNICK,SCHLEIN+        (UCLA)
CHUNG    69 PR 182 1443       +EISNER+BALI+LUERS                        (BNL)
COLLEY   69 NC A 59 519       +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+CXF+RHEL)
ERWIN    69 NP B 9 364        +WALKER,GOSHAW,WEINBERG     (WISC+PRIN+VAND)
FRIEDMAN 69  UCRL-18860       J.FRIEDMAN,PH.D. THESIS                   (LRL)
WERNER   69 PR 188 2023       +AMMAR,DAVIS,KROPAC,YARGER,CHO,+ (NWES+ANL) 1+

ABRAMS   70 PR D 1 2433       +EISENSTEIN,KIM,MARSHALL,O-HALLORAN,+ (ILL)
ANTICH   70 NP B 20 201       +CARSON,CHIEN,COX,DENEGRI,ETTLINGER,+ (JHU)  1+
BOWLER   70 PL 31 B 318       M.G.BOWLER                              (OXFORD)
FARBER   70 PR D 1 78         +FERBEL,SLATTERY,YUTA                     (ROCH)  1+
FIRESTON 70 PHILAD.CONF.P.229 A. FIRESTONE REVIEW                       (LRL)

BARNHAM  71 NP B25 49         +COLLEY,GRIFFITHS,ALPER, +  (BIRM+GLAS+OXF)
BOWLER   71 BOLOGNA CONF.PROC M.G.BOWLER  INTRODUCTORY TALK          (OXFORD)
DENEGRI  71 NP B 28 13        +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+    (JHU)  1+
FORMAN   71 PR D 3 2610       +GELFAND,LEARY,MOSER,SEIDL,WOLFSON       (EFI)
GARFINKE 71 PRL 26 1505       GARFINKEL,HOLLAND,CARMONY,LANDER+(PURD+UCD)  1+

ANDERSON 72 PR D 6 1823       +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BINGHAM  72 NP B 48 589       +EISENSTEIN,GPARD,HERQUET,+      (CERN+BRUX)
BRANDENB 72 NP B 45 397       BRANDENBURG,BRODY,JOHNSON,LEITH,LOOS+(SLAC)
BRANDENB 72 PRL 28 932        BRANDENBURG,JOHNSON,LEITH,LOOS,LUSTE+(SLAC)
DAVIS    72 PR D 5 2688       +ALSTON,BARBARO,FLATTE,FRIEDMAN,LYNCH+(LBL)
FIRESTON172 NP B 47 348       A.FIRESTONE                               (CIT)
FIRESTON 72 PR D 5 505        FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
FRATI    72 PR D 6 2361       +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
HAATUFT  72 NP B 48 78        +ARNOLD,HAGUENAUER,+  (BERG+STRB+EPOL+MADR)

BARLOUTA 73 NP B 59 374       +DREVILLON,SHAH,+           (SACL+EPOL+RHEL)  JP
BINGHAM  73 NP B 52 31        +FARWELL,+          (LBL+ORSAY+BNL+SACLAY+MILAN)  JP
DE JONGH 73 NP B 58 110       +CORNET,CHARRIERE,+   (BRUX+MONS+CERN+MPIM)
JONES    73 NP B 52 383       G.T.JONES                                 (CERN)  JP
LEWIS    73 NP B 60 283       +ALLEN,JACOBS,DANYSZ,BORG,+(LONG+LOIC+COEF)
WERNER   73 PR D 7 1275       +SLATTERY,FERBEL                      (ROCHESTER)

ANGELOPC 74 NC 20A 49         ANGELOPOULOS,FILIPPAS+(ATHU+ATEN+LIVP+VIEN)  JP
BOWLER   74 NP B74 493        +DAINTON,KADDOURA,AITCHISON               (OXF)
DEUTSCHM 74 PL 49B 388        DEUTSCHMANN,+     (AACH+BERL+CERN+LOIC+VIEN)  JP

ANTIPOV  75 NP B86 381        +ASCOLI,BUSNELLO,KIENZLE+    (SERP+CERN+ILL)  JP
BOWLER   75 NP B97 227        +GAME,AITCHISON,DAINTON          (OXF+DARE)
DREVILLO 75 PL 55 B 245       DREVILLON,BORENSTEIN+       (EPOL+BOHR+CDEF)  JP
DUNWOODI 75 NP B91 189        DUNWOODIE,GRANT+        (CERN+BELG+MONS+MPIM)  JP
OTTER1   75 NP B84 333        + (AACH+BERL+CERN+LCIC+VIEN+ATHU+ATEN+LIVP)  JP
OTTER2   75 NP B93 365        +RUDOLPH,RUMPF+  (AACH+BERL+CERN+LOIC+VIEN)  JP
OTTER3   75 NP B96 29         +RUDOLPH,SEYFERT+(AACH+BERL+CERN+LOIC+VIEN)I,JP
TOVEY    75 NP B95 109        +HANSEN,BORENSTEIN,BORG+    (RHEL+EPOL+SACL)I,JP

AACHEN   76  PREPRINT         +BERL+CERN+LOIC+VIEN+BIRM+BRUX+CERN+MONS++
BASDEVAN 76 PRL 37 977        BASDEVANT,BERGER                       (FNAL+ANL)
BOAL     76 PR D 14 2998      +EDWARDS,KAMAL,TORGESON                 (ALBERTA)
BOWLER   76 PHYS. L. G3 775   M.G.BOWLER                              (OXFORD)
BRANDENB 76 PRL 26 703        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
OTTER    76 NP B 106 77       + (AACH+BERL+CERN+LOIC+VIEN+LPNP+RHEL+SACL)  JP
VERGEEST 76 PL 62 B 471       +ENGELEN,JONGEJANS,+    (AMST+CERN+NIJM+OXF)  JP

CARNEGIE177 NP B 127 509      +CASHMORE,DAVIER,DUNWOODIE,LASINSKI+ (SLAC)
CARNEGIE277  SLAC PUB 1887    +CASHMORE,DUNWOODIE,LASINSKI,LEITH    (SLAC)
CHEN     77  ANL HEP PR 77 22 +FIELDS,RHINES                          (ANL)
CONFORTO 77 RL-77-024/A       B.CONFORTO,G.CONFORTO              (ROMA+RHEL)
DHEM     77  MPI-PAE E1 60    +GEIST,GOBEL,KULWEIN,WITTEK,WOLF     (MUNICH)
GAVILLET 77  PREP. CERN       +DIAZ,DIONISI,+          (AMST+CERN+NIJM+OXF)  JP
WOHL     78 NP B              +PALER,CHAURAND,+          (LPNP+RHEL+SACLAY)

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K'(1400)

21  K PRIME(1400,JP=0-)  I=1/2

OBSERVED IN K PI PI PARTIAL-WAVE ANALYSIS.
WAIT CONFIRMATION.  OMITTED FROM TABLE.

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                    21  K PRIME MASS (MEV)

M  A      1100.       APPROX.           BRANDENBU 76 ASPK +- 13 K+-P,KPIPI    12/77*
M  A       COUPLED MAINLY TO K EPSILON.  DECAY INTO K*(890) PI SEEN.
M

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                    21  K PRIME WIDTH (MEV)

W  A       (250.)    APPROX.           BRANDENBU 76 ASPK +- 13 K+-P,KPIPI    12/77*
W  A       COUPLED MAINLY TO K EPSILON.  DECAY INTO K*(890) PI SEEN.
W

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                    REFERENCES FOR K PRIME

BRANDENB 76 PRL 36 1239       BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
AACHEN   77  PREP. AACHEN 41  +          (AACHEN+BERLIN+CERN+LOIC+VIENNA)  JP

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Data Card Listings

For notation, see key at front of Listings.

κ(1400)

19 KAPPA(1400,JP=0+) I=1/2

S-Wave Kπ Interactions

The Kπ interactions are reminiscent of the ππ interactions, apart from the inelastic thresholds, both for the leading $J^P = 1^-$, 2^+, 3^- resonances and for the S wave. The first inelastic S-wave thresholds are Kπππ and Kη, neither of these channels being known to be important below 1400 MeV.

From the Kπ threshold (~630 MeV) up to this energy, the phase shift δ_0^1 of the $I(J^P) = 1/2\ (0^+)$ wave is determined uniquely by the requirements of elastic unitarity. It grows monotonically, reaching 40° at about 900 MeV, and 90° at about 1350 MeV, being everywhere well described by an effective-range formalism (MERCER 71, BINGHAM 72, FIRESTONE 71,72, MATISON 72,74, GALTIERI 73, YUTA 73, FOX 74, BAKER 75, LAUSCHER 75, BOWLER 77, ESTABROOKS 77); see Fig. 1. The ambiguous "up" solution in the region of the $K^*(892)$ has by now been ruled out conclusively (MATISON 72,74, GALTIERI 73, BOWLER 77, ESTABROOKS 77).

In the 1400 MeV region the analysis becomes complicated due to the largeness of δ_0^1, to the nearness of the $K^*(1430)$ and the resulting strong S-D interference, and to the opening of inelastic channels. Several groups have interpreted the slow passage of δ_0^1 through 90° as evidence for a resonance (FIRESTONE 71,72, FRATI 72, ROUGE 72, CORDS 73, LAUSCHER 75, MORGAN 75), while others contended that δ_0^1 was large but non-resonant (AGUILAR 72, BUCHNER 72, CRENNELL 72, ENGELMANN 72, BAKER 75).

New features emerge as the phase-shift analysis is continued up to 1900 MeV from a large-statistics experiment (ESTABROOKS 77). In the inelastic region where the ambiguities cannot be resolved, ESTABROOKS 77 find four solutions for the S wave, all of which exhibit a rapid drop in the modulus of the amplitude near 1450 MeV (see Fig. 2). This behavior is confirmed with less statistics by BOWLER 77 and MARTIN 77, and a clear circular motion is seen in the Argand plot with a maximum speed in the region 1400-1500 MeV. This behavior in all four solutions is interpreted as evidence for an S-wave 0^+ Kπ resonance with a mass of 1400 to 1500 MeV, a width of 200 to 300 MeV, and an elasticity

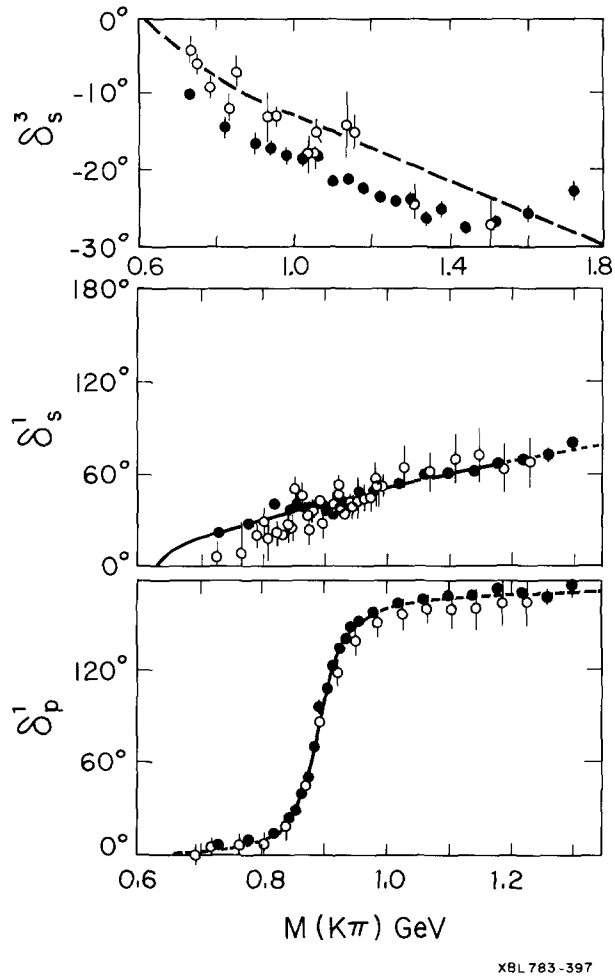

Fig. 1. The solid points are the Kπ phase shifts calculated in a simultaneous analysis of the SLAC 13 GeV/c neutron and Δ recoil reactions. The curves represent the effective range or resonance fits of ESTABROOKS 77, except for the dashed curve on the δ_s^3 plot which represents a constant cross section of 1.8 mb. The open circles are from MERCER 71, BINGHAM 72, LINGLIN 73, MATISON 74, BAKER 75.

greater than 0.8 (for all but one solution). We call this resonance κ(1400), and enter it into the Table.

In addition, ESTABROOKS 77 see the slow passage of δ_0^1 through 90°, already referred to, at about 1350 MeV. Whether an additional pole would be required for its explanation, has not been studied by anyone. We note that the situation is reminiscent of the ππ system, where δ_0^0 goes slowly through 90° at about 850 MeV, yet no pole is needed at that mass (MORGAN 75). The half-width, as measured by the distance between phase shifts of

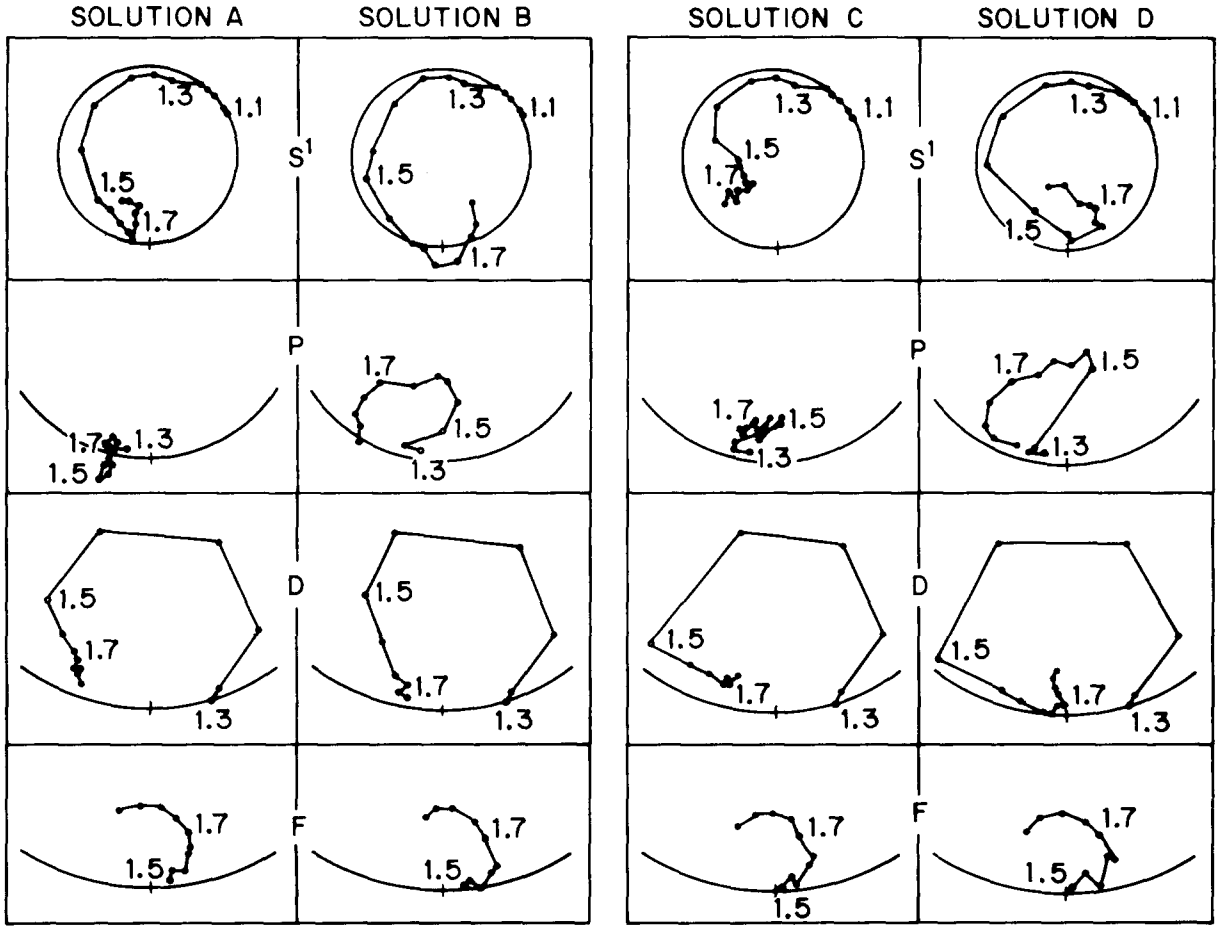

Fig. 2. Argand diagrams for the Kπ partial waves of ESTABROOKS 77.

45° and 90°, is about 400 MeV in the $\pi\pi$ case, and about 450 MeV in the Kπ case.

The present 0^+ nonet looks rather different from the one considered by MORGAN 75. The ε and κ are both heavier and narrower than before, and the ε in addition couples strongly to $K\bar{K}$. The question of whether the δ and the S^* are narrow or wide is still unsettled.

Finally, we remark that two of the four solutions of ESTABROOKS 77 provide evidence for a second P-wave resonance with mass ~1650 MeV, width ~250 MeV, and elasticity ~0.25. This new state, $K^{*\prime}(1650)$, would, if confirmed, most probably be assigned in the quark model as a radial excitation, similarly to $\rho'(1600)$.

19 KAPPA MASS (MEV)

M	C	1425. ABOUT	ESTABROOK 77 SPEC	13 K+- P	12/77*
M	C	FROM ELASTIC K PI PARTIAL WAVE ANALYSIS (SEE KAPPA MINI-REVIEW)			12/77*

19 KAPPA WIDTH (MEV)

W	C	200-300 ABOUT	ESTABROOK 77 SPEC	13 K+- P	12/77*
W	C	FROM ELASTIC K PI PARTIAL WAVE ANALYSIS (SEE KAPPA MINI-REVIEW)			12/77*

REFERENCES FOR KAPPA

TRIPPE	68	PL 28 B 203	+CHIEN,MALAMUD,MELLEMA,SCHLEIN,+	(UCLA)
CRENNELL	69	PRL 22 487	+KARSHON,LAI,D.NEALL,SCARR	(BNL)
DODD	69	PR 177 1994	+JOLDERSMA,PALMER,SAMIOS	(BNL)
GOLDBERG	69	PL 30 B 434	SABRE COLLABOR. (SACL+AMST+BGNA+REHO+EPOL)	
SCHLEIN	69	ARGONNE CONF. 446	P.SCHLEIN	(UCLA)
FIRESTON	71	PRL 26 1460	A.FIRESTONE,G.GOLDHABER,D.LISSAUER	(LRL)
MERCER	71	NP B32 381	+ANTICH,CALLAHAN,CHIEN,COX,+ (JOHN HOPKINS)	
YUTA	71	PRL 26 1502	+DERRICK,ENGELMANN,MUSGRAVE	(ANL+EFI)
AGUILAR	72	PR D 6 11	AGUILAR-BENITEZ,CHUNG,EISNER	(BNL)
BINGHAM	72	NP B 41 1	+ (INTERNATIONAL K+ COLLABORATION)	
BUCHNER	72	NP B 45 333	+DEHM,CHARRIERE,CORNET,+ (MPIM+CERN+BRUX)	
CHUNG	72	PRL 29 1570	+EISNER,AGUILAR-BENITEZ	(BNL)
DIEBOLD	72	BATAV.CONF. V.3 17	R.DIEBOLD RAPPORTEUR TALK	(ANL)
CRENNELL	72	PR D 6 1220	+GORDON,KWAN-WU LAI,SCARR	(BNL)
ENGELMAN	72	PR D 5 2162	ENGELMANN,MUSGRAVE,FORMAN,+	(ANL+EFI)
FIRESTON	72	PR D 5 2188	+GOLDHABER, LISSAUER, TRILLING	(LBL)PWA
FRATI	72	PR D 6 2361	+HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)	
MATISON	72	LBL 1537 (THESIS)	REVISED VERSION WILL GO TO PHYS.REV. LBL	
ROUGE	72	NP B 46 29	+VIDEAU,VOLTE,DE BRION,+	(EPOL+SACL)
CORDS	73	NP B 54 109	+CARMONY,LANDER,MEIERE,+ (PURD+UCD+IUPU)	
LINGLIN	73	NP B 55 408	D.LINGLIN	(CERN)
YUTA	73	NP B 52 70	+ENGELMANN,MUSGRAVE,FORMAN,+	(ANL+EFI)

Data Card Listings

For notation, see key at front of Listings.


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FOX       74 NP B80 403        G.C.FOX,M.L.GRISS                        (CIT)
MATISON   74 PR D9 1872        +GALTIERI,GARNJOST,FLATTE,FRIEDMAN,+     (LBL)
MORGAN    74 PL 51B 71         D.MORGAN                                 (RHEL)

BAKER     75 NP B99 211        +BANERJEE,CAMPBELL,ALLEN,MARCH+ (LOIC+LOWC)
LAUSCHER  75 NP B86 189        +OTTER,WIECZOREK,+      (ABCLV COLLABORATION)
MORGAN    75 ARGONNE CONF. 45  D.MORGAN                                 (RHEL)

CHIEN     76 NP B 106 355      +FEIOCK,LUCAS,PEVSNER,ZGANIS             (BALTIMORE)

BALDI     77 NP B              +BOHRINGER,DORSAZ,+                      (GENEVE+CERN)
BOWLER    77 NP B 126  31      +DAINTON,DRAKE,WILLIAMS                  (OXFORD)
ESTABROO  77  SLAC PUB 2004    ESTABROOKS,CARNEGIE+(MONT+CARL+DURHAM+SLAC)
MARTIN    77 NP B              +SHIMADA,BALDI,+                         (DURHAM+GENEVA)
SPIRO     77 NP B 125 162      +BARLOUTAUD,COMBER,PALER,+  (SACL+RHEL+EPOL)

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K*(1430)

22 K*(1430,JP=2+) I=1/2

WE CONSIDER THAT PHASE-SHIFT ANALYSES PROVIDE MORE RELIABLE DETERMINATIONS OF THE MASS AND WIDTH. SEE RHO(770) MINI-REVIEW.

22 K*(1430) MASS (MEV)

```
M   CHARGED ONLY, WITH FINAL STATE K PI
M     D  39 1423.      11.0              BASSANO   67 HBC   - 4.6-5.0K-P,KOPI- 12/75
M     S   25(1440.)    (24.0)   (40.)    DE BAERE  67 HBC  +  3.5 K+P (K+ PI0) 12/75
M    SD  13(1401.0)    (25.0)             SCHWEINGR 68 HBC   -  4.1 K- P (K PI) 12/75
M     D  63 1427.0      12.0              SCHWEINGR 68 HBC   -  5.5 K- P (K PI) 12/77*
M     S  136(1420.0)    (20.0)            BISHOP    69 HBC  +  3.5 K+P(K0 PI+) 12/77*
M        220 1416.0      10.0             CRENNELL  69 DBC   -  3.9 K-N (KOPI-)  7/69
M     D   60 1414.       13.0             LIND      69 HBC  +  9. K+ P(K0 PI+) 12/77*
M      1400 1420.0        3.1             AGUILAR1  71 HBC   -  3.9,4.6 K- P     11/71
M  W D 225 1425.          8.0             BARNHAM   71 HBC  +  K+ P,K0 PI+ P     12/75
M      130(1418.)        (6.)             CLARK     73 HBC   -  3.3 K-P,P PI- K0 12/77*
M                . . . . . . . . .
M   AVG    1420.5         2.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1420.5         2.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M   CHARGED ONLY, WITH OTHER FINAL STATES
M      130(1400.0)    (20.0)             BADIER    65 HBC   -  3.  K- P (K*PI) 12/75
M       20(1440.0)    (20.0)             DUBAL     68 MMS   -  11.5 K- P       12/75
M  W D 240(1396.)      (6.)              BASSOMPIE 69 HBC  +  5 K+P (K 2PI)    12/75
M          (1411.)     (7.)              FRIEDMAN  69 HBC   -  2.7 K-P (K 2PI)  2/72

M   CHARGED AND NEUTRAL
M      134(1404.0)    (15.0)             FOCARDI   65 HBC  -0 3.  K- P (K PI) 12/75
M     D  55(1423.)    (24.0)             ADERHOLZ  68 HBC  -0 10 K- P (K PI)  12/75

M   NEUTRAL ONLY
M     D  46(1446.0)    (9.0)             DAHL      67 HBC   0 4.PI- P (KPI)   12/77*
M     S  160(1425.0)   (15.0)            KANG      68 HBC   0 4.6 K- P        12/75
M    SD  81(1405.0)    (22.0)            SCHWEINGR 68 HBC   0 4.1 K- P (K PI)  12/75
M     S   97(1397.0)   (19.0)            SCHWEINGR 68 HBC   0 5.5 K- P (K PI)  12/75
M  WAD 210(1422.)      (8.0)             BASSOMPIE 69 HBC   0 5 K+P (K PI)    12/75
M     2200 1421.1        2.6             DAVIS     69 HBC   0 12. K+ P(K+PI-)  9/69
M     1800 1419.1        3.7             AGUILAR1  71 HBC   0 3.9,4.6 K- P     11/71
M      600 1416.         6.              CORDS     71 DBC  0 9. K+ N,K+ PI- P  2/72
M     1100 1427.         3.              BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P 12/72
M      C   1420.1        4.3             LINGLIN   73 HBC   0 2-13 K+P,K+PI-   12/75
M      800 1421.6        4.2             MCCUBBIN  75 HBC   0 3.6 K-P,K-PI+N   12/75
M          1423.0        3.0             ETKIN     76 SPEC   06.K-P,K0 PI+PI-   7/77*
M      300 1420.0        7.0             HENDRICKX 76 DBC     8.25 K+N,K+PI     7/77*
M  P       1440.0       10.0             BOWLER    77 DBC  0 5.5 K+D,K PI P P 12/77*
M  P       1434.0        2.0             ESTABROOK 77 ASPK  0 13K+-P,P K PI    12/77*
M                . . . . . . . . .
M   AVG    1425.7         2.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
M   STUDENT1423.7         1.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                   (SEE IDEOGRAM BELOW )
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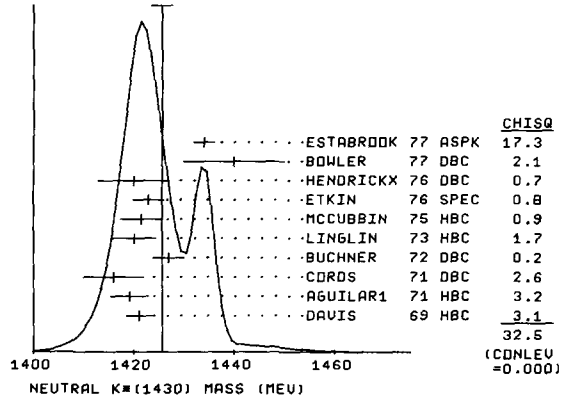
WEIGHTED AVERAGE = 1425.7 ± 2.0
ERROR SCALED BY 1.9

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M   A   INCLUDED IN LINGLIN 73 WORLD K+P DST
M   C   FROM POLE EXTRAPOLATION, USING WORLD K+P DST
M   D   ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE ON K*
M   P   FROM PHASE SHIFT ANALYSIS.
M   S   DATA WITH MASS ERROR OF 15 MEV OR MORE NOT AVERAGED
M   W   NUMBER OF EVENTS IN PEAK REEAVALUATED BY US
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22 K*(1430) WIDTH (MEV)

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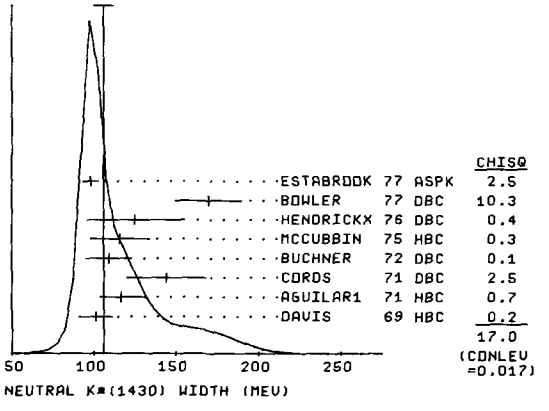
W   CHARGED ONLY, WITH FINAL STATE K PI
W     D  63   89.       45.              SCHWEINGR 68 HBC   - 5.5 K-P(K0 PI-)  12/75
W    SD 136 (110.0)    (42.0)            BISHOP    69 HBC  +   3.5 K+ P         12/75
W     D  60   96.       50.0             LIND      69 HBC  +   9. K+ P          12/77*
W      1400   94.7      15.1      12.5   AGUILAR1  71 HBC   -  3.9,4.6 K- P     11/71
W  W D 225   115.       31.0             BARNHAM   71 HBC  +  K+ P,K0 PI+ P     12/75
W      130   (42.)     (12.)             CLARK     73 HBC   -  3.3 K-P,P PI- K0 12/77*
W                . . . . . . . . .
W   AVG      97.3       11.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT  97.3       12.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W   CHARGED ONLY, WITH OTHER FINAL STATES
W     D 130 (105.0)    (37.0)            BADIER    65 HBC   -  3.0 K-P          12/75
W   CHARGED ONLY, WITH OTHER FINAL STATES
W     D 130 (105.0)    (37.0)            BADIER    65 HBC   -  3.0 K-P          12/75
W     D 120 (110.)     (40.0)            BASSOMPIE 69 HBC  +   5 K+P (K 2PI)    12/75
W              (43.)    (13.)            FRIEDMAN  69 HBC   -  2.7 K-P (K 2PI)  2/72

W   CHARGED AND NEUTRAL
W      134   (92.0)    (32.0)            FOCARDI   65 HBC  -0 3.0 K- P (K PI) 12/75
W     D  55  (175.)     (94.0)            ADERHOLZ  68 HBC  -0 10 K- P (K PI)  12/75

W   NEUTRAL ONLY
W     D  46   (61.0)    (36.0)            DAHL      67 HBC   0 3.8-4.2 PI- P   12/77*
W    SD 160 (116.0)    (37.0)            KANG      68 HBC   0 4.6 K- P        12/75
W  WAD 210  (110.)     (30.0)            BASSOMPIE 69 HBC   0 5 K+P (K PI)    12/75
W     2200   101.       10.              DAVIS     69 HBC   0 12. K+ P (K PI) 9/69
W     1800   116.6      10.3      15.5   AGUILAR1  71 HBC   0 3.9,4.6 K- P    11/71
W     D 600  144.       24.0             CORDS     71 DBC  0 9. K+ N,K+ PI- P 12/75
W     D1100  109.       14.0             BUCHNER   72 DBC  0 4.6 K+ N,K+ PI-P 12/75
W     C      (61.0)     (14.0)           LINGLIN   73 HBC  0 2-13 K+P,K+PI-   1/74
W        800  116.      18.              MCCUBBIN  75 HBC   0 3.6 K-P,K-PI+N   12/75
W     D 300  125.0       29.0            HENDRICKX 76 DBC     8.25 K+N,K+PI     7/77*
W  P         170.0      20.0             BOWLER    77 DBC  0 5.5 K+D,K PI P P 12/77*
W  P          98.0       5.0             ESTABROOK 77 ASPK  0 13K+-P,P K PI    12/77*
W                . . . . . . . . .
W   AVG     105.8        5.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
W   STUDENT 105.1        4.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                                   (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 105.8 ± 5.9
ERROR SCALED BY 1.6




```
W   A   INCLUDED IN LINGLIN 73 WORLD K+P DST
W   C   FROM POLE EXTRAPOLATION, USING WORLD K+P DST
W   D   ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K* TYPED NOTE.
W   P   FROM PHASE SHIFT ANALYSIS.
W   S   DATA WITH MASS ERROR OF 15 MEV OR MORE NOT AVERAGED
W   W   NUMBER OF EVENTS IN PEAK REEAVALUATED BY US
```

22 K*(1430) PARTIAL DECAY MODES

		DECAY MASSES
P1	K*(1430) INTO K PI	493+ 139
P2	K*(1430) INTO K*(892) PI	892+ 139
P3	K*(1430) INTO K RHO	493+ 776
P4	K*(1430) INTO K OMEGA	493+ 783
P5	K*(1430) INTO K ETA	493+ 548
P6	K*(1430) INTO K*(892) PI PI	892+ 139+ 139

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4907+-.0163					
P 2	.0641	.2703+-.0215				
P 3	-.0836	-.0010	.0657+-.0145			
P 4	-.1081	-.2010	-.1212	.0369+-.0159		
P 5	-.3209	-.3905	-.2214	-.1600	.0248+-.0261	
P 6	-.2544	-.3690	-.2154	-.1581	-.2722	.1116+-.0248

```
                   22  K*(1430) BRANCHING RATIOS

R1      K*(1430) INTO (K PI)/TOTAL                          (P1)
R1 P           0.49      0.02         ESTABROOK 77 ASPK +- 13K+-P,P K PI     12/77*
R1 P     FROM PHASE SHIFTS ANALYSIS.
R1             . . . . . . . . . .
R1  FIT        0.491     0.016   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      K*(1430) INTO (K*(892) PI)/(K PI + K PI PI)          (P2)/(P1+P2+P3)
R2  QR         (.45)     (0.13)       BADIER     65 HBC   -  3.0 K-P          1/78*
R2  C          (0.47)    (0.10)       BASSANO    67 HBC   -0 4.6, 5.0 K- P   10/67
R2             . . . . . . . . . .
R2  FIT        0.327     0.019   FROM FIT

R3      K*(1430) INTO (K RHO)/(K PI + K PI PI)              (P3)/(P1+P2+P3)
R3  QR         (0.14)    (0.07)       BADIER     65 HBC   -  3.0 K-P          1/78*
R3  Q          (0.14)    (0.10)       BASSANO    67 HBC   -0 4.6, 5.0 K- P   10/67
R3             . . . . . . . . . .
R3  FIT        0.079     0.016   FROM FIT

R4      K*(1430) INTO (K*(892) PI) / (K PI)                  (P2)/(P1)
R4        6    0.33      0.33         CHUNG      65 HBC   + 0  3.9-4.2 PI- P   8/66
R4             0.65      0.20         SHEN       66 HBC     0  N* PRODUCED    10/66
R4  C          (0.63)    (0.20)       SHEN       66 HBC   +    NO N* PRODUCED 10/66
R4             0.52      0.12         SCHWEINGR 68 HBC     0 4.1+5.5 K- P    10/67
R4  Q          (1.06)    (0.30)       BASSOMPIE 69 HBC    +    5.0 K+P         1/78*
R4             0.80      0.30         BASSOMPIE 69 HBC    0    5.0 K+P         1/78*
R4  Q    84    (0.93)    (0.11)       BISHOP     69 HBC        3.5 K+ P        9/69
R4             0.47      0.08         AGUILAR1   71 HBC        3.9,4.6 K- P   11/71
R4   G         0.91      0.20         CHARRIERE 73 HBC    0 5. K+ P,K P 3PI   1/73
R4   G  REVISED BY GOLDSCHMIDT 75
R4 AC  150     (0.65)    (0.25)       ANTIPOV    75 ASPK  - 40 K-P,K*- P     .12/75
R4 A     K* PI SIGNAL FROM PARTIAL WAVE ANALYSIS OF (K-PI+PI-) SYSTEM
R4             0.54      0.16         DEHM       74 DBC    0 4.6 K+ N        12/75
R4             0.62      0.19         LAUSCHER   75 HBC     010,16 K-P,K-PI+N 12/75
R4             . . . . . . . . . .
R4  AVG        0.548     0.053   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  STUDENT    0.544     0.060   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R4  FIT        0.551     0.046   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      K*(1430) INTO (K OMEGA) / K PI                       (P4)/(P1)
R5   R         0.19      0.16         BADIER     65 HBC   -  3.0 K-P          1/78*
R5             (0.08) OR LESS         SHEN       66 HBC      4.6 K+P          8/66
R5             (0.2)  OR LESS         BASSOMPIE 69 HBC   +   5 K+ P           9/69
R5             0.13      0.07         BASSOMPIE 69 HBC    0 5 K+ P            9/69
R5             0.05      0.04         AGUILAR1   71 HBC      3.9-4.6 K- P    11/71
R5             (0.2)  OR LESS  CL=.95 CHUNG      74 HBC   - 7.3 K-P,K*- P    12/75
R5             . . . . . . . . . .
R5  AVG        0.075     0.034   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  STUDENT    0.075     0.038   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R5  FIT        0.075     0.033   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6      K*(1430) INTO (K RHO) / (K PI)                       (P3)/(P1)
R6             (0.09) OR LESS         CHUNG      65 HBC   + 0  3.9-4.2 PI- P   8/66
R6             0.26      0.16         SCHWEINGR 68 HBC     0 4.1+5.5 K- P    10/67
R6             (0.2)  OR LESS         BASSOMPIE 69 HBC   +   5 K+ P           9/69
R6             (0.3)  OR LESS         BASSOMPIE 69 HBC    0 5 K+ P            9/69
R6  Q    15    (0.11)    (0.06)       BISHOP     69 HBC      3.5 K+ P         9/69
R6             0.16      0.05         AGUILAR1   71 HBC      3.9,4.6 K- P    11/71
R6             0.02      0.10      0.02 DEHM     74 DBC    0 4.6 K+ N        12/75
R6  S          (0.24)    (0.14)       LAUSCHER   75 HBC     010,16 K-P,K-PI+N 12/75
R6  S    USES RESULTS OF OTTER 75 (SEE R7 BELOW). WE DO NOT AVERAGE THIS
R6  S    STATISTICALLY REDUNDANT RATIO, BUT KEEP THE LAUSCHER 75 RESULT
R6  S    FOR R4 ABOVE.
R6             . . . . . . . . . .
R6  AVG        0.111     0.054   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R6  STUDENT    0.116     0.047   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R6  FIT        0.134     0.030   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R7      K*(1430) INTO (K RHO) / (K*(892) PI)                 (P3)/(P2)
R7             (0.39) OR LESS         BASSOMPIE 67 HBC   +  5. K+ P           9/67
R7             (0.40) OR LESS  CL=.90 FIELD      67 HBC   - 3.8 K- P          6/67
R7 P   130     .13       .09          OTTER      75 HBC     08,10,16 K-P,K* N 12/75
R7 AN          (0.03)    (0.03)       ANTIPOV    75 ASPK  - 40 K-P,K*- P     12/75
R7  N    K RHO MODE NOT OBSERVED
R7 A     FROM PARTIAL WAVE ANALYSIS OF (K-PI+PI-) SYSTEM
R7 P           0.36      0.10         VERGEEST  76 HBC    0 4.2 K-P,P KOPIPI 12/77*
R7 P     FROM PARTIAL WAVE ANALYSIS OF (KO PI+ PI-) SYSTEM
R7             . . . . . . . . . .
R7  AVG        0.23      0.11    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R7  STUDENT    0.231     0.085   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R7  FIT        0.243     0.057   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8      K*(1430) INTO (K OMEGA) / (K*(892) PI)               (P4)/(P2)
R8  Q          (0.10)    (0.04)       FIELD      67 HBC   - 3.8 K- P          6/67
R8             . . . . . . . . . .
R8  FIT        0.137     0.062   FROM FIT

R9      K*(1430) INTO (K ETA) / (K*(892) PI)                 (P5)/(P2)
R9  Q          (0.07)    (0.04)       FIELD      67 HBC   - 3.8 K- P          6/67
R9             . . . . . . . . . .
R9  FIT        0.092     0.100   FROM FIT

R10     K*(1430) INTO (K ETA) / (K PI)                       (P5)/(P1)
R10  R         0.05      0.06         BADIER     65 HBC   -  3.0 K-P          1/78*
R10  R         (0.065)OR LESS         BASSOMPIE 69 HBC       5.0 K+P          1/78*
R10            (0.02) OR LESS         BISHOP     69 HBC      3.5 K+ P         9/69
R10            (0.04) OR LESS  CL=.95 AGUILAR1   71 HBC      3.9-4.6 K- P    11/71
R10            . . . . . . . . . .
R10 FIT        0.050     0.054   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11     K*(1430) INTO (K*(892) PI PI)/TOTAL                  (P6)
R11T           0.12      0.04         GOLDBERG   76 HBC   - 3 K-P,P KOPIPIPI 12/77*
R11            . . . . . . . . . .
R11 FIT        0.112     0.025   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R12     K*(1430) INTO (K*(892) PI PI)/(K PI)                 (P6)/(P1)
R12T R         0.21      0.08         JONGEJANS 77 HBC   - 4 K-P,P KOPIPIPI 12/77*
R12            . . . . . . . . . .
R12 FIT        0.227     0.053   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R   Q   FOLLOWING SUGGESTION BY AGUILAR 70, WE DO NOT MAKE USE OF MEASURE-
R   Q   MENTS WHERE THE (K PI PI) BACKGROUND SUBTRACTION IS DIFFICULT DUE
R   Q   TO THE NEARBY Q REGION.
R    R  RESTATED BY US.
R  T    ASSUMING PI PI SYSTEM HAS ISO-SPIN 1, WHICH IS SUPPORTED BY
R  T    THE DATA

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                         REFERENCES FOR K*(1430)
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BADIER    65 PL 19 612          BADIER,DEMOULIN,GOLDBERG+  (EPOL+SACL+AMST)
CHUNG     65 PRL  15  325       +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FOCARDI   65 PL 16 351          FOCARDI,MINGUZZI RANZI,SERRA+(BOLOGNA+SACL)

SHEN      66 PRL  17  726       +BUTTERWORTH,FU,GOLDHABERS,TRILLING   (LRL)
    ALSO 66  (PRIVATE COMMUN)GERSON GOLDHABER                         (LRL)

BASSANO   67 PRL  19  968       +GOLDBERG,GOZ,BARNES,LEITNER+(BNL+SYRACUSE)
BASSOMPI 67 PL 26B 30           BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
CRENNELL 67 PRL 19  44          +KALBFLEISCH,LAI,SCARR,SCHUMANN       (BNL)
DAHL      67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER               (LRL)
    ALSO 65 PRL 14 401          HARDY,CHUNG,DAHL,HESS,KIRZ,MILLER     (LRL)
DE BAERE 67 NC 51 A 401         +GOLDSCHMIDT-CLERMONT,HENRI+     (BRUX+CERN)
FIELD     67 PL 24B 638         +HENDRICKS+PICCIONI+YAGER         (LAJOLLA)
GOLDHABE 67 PRL 19  972         G.GOLDHABER,FIRESTONE,SHEN            (LRL)

ADERHOLZ 68 NP B 5  567         +DEUTSCHMANN+  (AACH+BERL+CERN+LOIC+VIENNA)
    ALSO 66 PL 22 357           BARTSCH,DEUTSCHMANN,MORRISON+    (ABCL(IC)V)
ANTICH    68 PRL 21 1842       +CALLAHAN,CARSON,COX,DENEGRI,+        (JHU)
DUBAL     68 THESIS    1456     L.DUBAL                            (GENEVE)
KANG      68 PR 176 1587        Y.W.KANG                             (IOWA)
SCHWEING 68 PR 166 1317         SCHWEINGRUBER,DERRICK,FIELDS+    (ANL+NWES)
   ALSO  67  THESIS             F.L.SCHWEINGRUBER   (NORTHWESTERN,EVANSTON)

BASSOMPI 69 NP  B13 189         BASSOMPIERE,GOLDSCHMIDT-CLERM.+ (CERN+BRUX) JP
BISHOP    69 NP B 9 403         +GOSHAW,ERWIN,WALKER                 (WISC)
CRENNELL 69 PRL 22  487         +KARSHON,LAI,ONEALL,SCARR             (BNL)
DAVIS     69 PRL 23 1071        +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ  (LRL)
DE BAERE 69 NC 61 A 397         +GOLDSCHMIDT-CLERMONT,HENRI,+    (BELG+CERN)
FRIEDMAN 69  UCRL-18860         J.FRIEDMAN,PH.D. THESIS               (LRL)
LIND      69 NP B 14 1          +ALEXANDER,FIRESTONE,FU,GOLDHABER     (LRL) JP

ABRAMS    70 PR D 1 2433        +EISENSTEIN,KIM,MARSHALL,O.HALLORAN,+ (ILL)
AGUILAR   70 PRL 25 1362        AGUILAR-BENITEZ,BASSANO,EISNER,+ (BNL+PURD)
BIRMINGH 70  KIEV CONF.         ASTIER RAPPORTEURS TALK     (BIRM+GLAS+OXF)

AGUILAR1 71 PR D 4 2583         +EISNER,KINSON                        (BNL)
BARNHAM   71 NP B 28 171        +COLLEY,JOBES,GRIFFITHS,HUGHES,+(BIRM+GLAS)
CORDS     71 PR D 4 1974        +CARMONY,ERWIN,MEIERE,+      (PURD+UCD+IUPU)

BUCHNER   72 NP B 45 333        +DEHM,CHARRIERE,CORNET,+   (MPIM+CERN+BRUX)
CRENNELL 72 PR D 6 1220         +GORDON,KWAN-WU LAI,SCARR             (BNL)
DEUTSCHM 72 NP B 36 373         DEUTSCHMANN,+          (ABCLV COLLABORATION)
ENGELMAN 72 PR D 5 2162         ENGELMANN,MUSGRAVE,FORMAN,+        (ANL+EFI)
FRATI     72 PR D 6 2361        +HALPERN,HARGIS,SNAPE,CARNAHAN,+(PENN+CINC)
ROUGE     72 NP B 46 29         +VIDEAU,VOLTE,DE BRION,+         (EPOL+SACL)
TIECKE    72 NP B 39 596        +GRIJNS,HEINEN,DE GROOT,+        (NIJM+AMST)

CHARRIER 73 NP B 51 317         CHARRIERE,DRIJARD,DE BAERE,+     (CERN+BELG)
    ALSO 75  (PRIVATE COMMUNICATION) GOLDSCHMIDT-CLERMONT             (CERN)
CLARK     73 NP B 54 432        +LYONS,RADOJICIC                    (OXFORD)
DE JONGH 73 NP B 58 110         +CORNET,CHARRIERE,+   (BRUX+MONS+CERN+MPIM)
LINGLIN   73 NP B 55 408        D.LINGLIN                             (CERN)
WALUCH    73 PR D 8 2837        +FLATTE,FRIEDMAN                       (LBL)

DEHM      74 NP B75 47          +GOEBEL,WITTEK,WOLF,+ (MPIM+BRUX+MONS+CERN)
CHUNG     74 PL 51B 413         +EISNER,PROTOPOPESCU,SAMIOS,STRAND    (BNL)

ANTIPOV   75 NP B86 381         +ASCOLI,BUSNELLO,KIENZLE+   (SERP+CERN+ILL)
LAUSCHER 75 NP B86 189          +OTTER,WIECZOREK,+     (ABCLV COLLABORATION)  JP
MCCUBBIN 75 NP B86 13           N.A.MCCUBBIN,L.LYONS                  (OXF)
OTTER     75 NP B84 333         + (AACH+BERL+CERN+LOIC+VIEN+ATHU+ATEN+LIVP)

ETKIN     76 PRL 36 1482        +FOLEY,GOLDMAN,LINDENBAUM,KIM,+  (BNL+CUNY)
GOLDBERG 76 LNC 17 253          J.GOLDBERG                          (HAIFA)
HENDRICK 76 NP B 112 189        +VIGNAUD,BURLAUD,+      (MONS+SACL+LPNP+BELG)
VERGEEST 76 PL 62 B 471         +ENGELEN,JONGEJANS,+    (AMST+CERN+NIJM+OXF)  JP

BOWLER    77 NP B 126  31       +DAINTON,DRAKE,WILLIAMS             (OXFORD)
ESTABROO 77  SLAC PUB 2004      ESTABROOKS,CARNEGIE+(MONT+CARL+DURHAM+SLAC)
JONGEJAN 77  PREPRINT (ZEEM)    JONGEJANS,CERRADA,+     (AMST+CERN+NIJM+OXF)
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$K_N(1700)$

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27  KN(1700,JP=  ) I = 1/2

     THIS ENTRY CONTAINS VARIOUS PEAKS IN STRANGE MESON
     SYSTEMS REPORTED IN THE 1700 MEV REGION.
     EVIDENCE NOT COMPELLING, OMITTED FROM TABLE.

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                  27  KN(1700) MASS (MEV)

M          (1660.0)                 CARMONY    67 HBC   -  3.8 K-P,OMEGA K 11/67
M  J       (1660.0)   (10.0)        JOBES      67 HBC  +   5. K+ P          12/75
M  J        CLAIMED BY JOBES IN (K PI), (K*(892) PI), AND (K*(1430) PI)
M  J        MODES. K PI BUMP INTERFERES MOSTLY WITH DELTA(1236).
M          (1660.)                  CHARRIERE 73 HBC   0 5. K+ P,K P 3PI   1/73
M       60(1710.)     (15.)         CHUNG      74 HBC   - 7.3K-P,K-OMEGA P 12/75
M    E 137(1692.0)     (6.0)        ETKIN      76 SPEC   06.K-P,KO PI+PI-   7/77*
M    E NOT SEEN BY JONGEJANS 77 WITH LARGER STATISTICS.

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                  27  KN(1700) WIDTH (MEV)

W  J          (60.0)   (20.0)       JOBES      67 HBC  +   5. K+ P          12/75
W  J     SEE NOTE J ABOVE
W             (60.)                 CHARRIERE 73 HBC   0 5. K+ P,K P 3PI   1/73
W       60 (110.)     (50.)         CHUNG      74 HBC   - 7.3K-P,K-OMEGA P 12/75
W    E 137  (26.0)    (24.0)   (17.0) ETKIN    76 SPEC   06.K-P,KO PI+PI-   7/77*
W    E NOT SEEN BY JONGEJANS 77 WITH LARGER STATISTICS.

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                  27  KN(1700) PARTIAL DECAY MODES

                                                     DECAY MASSES
P1      KN(1700) INTO K PI                          493+ 139
P2      KN(1700) INTO K PI PI                       493+ 139+ 139
P3      KN(1700) INTO K*(892) PI                    892+ 139
P4      KN(1700) INTO K RHO                         493+ 776
P5      KN(1700) INTO K*(1430) PI                  1434+ 139
P6      KN(1700) INTO K OMEGA                       493+ 783

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                  27  KN(1700) BRANCHING RATIOS

R1      KN(1700) INTO (K PI)/(K OMEGA)                  (P1)/(P6)
R1 N          (0.5)     (0.5)       CHUNG      74 HBC   - 7.3 K-P,KN- P     12/75
R1 N     NO K PI SIGNAL SEEN IN THIS EXPERIMENT

R2      KN(1700) INTO (K*(892) PI)/(TOTAL K PI PI)      (P3)/(P2)+(P3)
R2            (0.5)                 ETKIN      76 SPEC   06.K-P,KO PI+PI-   7/77*

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Data Card Listings

For notation, see key at front of Listings.


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                        REFERENCES FOR KN(1700)

CARMONY  67 PRL  18  615        D.CARMONY,T.HENDRICKS,L.LANDER   (LA JOLLA)
JOBES    67 PL 26B 49           +BASSOMPIERRE,DE BAERE +   (BIRM+CERN+BRUX)
CHARRIER 73 NP B 51 317         CHARRIERE,DRIJARD,DE BAERE,+     (CERN+BELG)
CHUNG    74 PL 51B 412          +EISNER,PROTOPOPESCU,SAMIOS,STRAND    (BNL)
ETKIN    76 PRL 36 1482         +FOLEY,GOLDMAN,LINDENBAUM,KIM,+  (BNL+CUNY)
JONGEJAN 77  PREPRINT (ZEEM)    JONGEJANS,CERRADA,+     (AMST+CERN+NIJM+OXF)

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L(1770)

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23  L(1770, JP=  ) I = 1/2
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The L(1770) is seen as a bump in the diffractive-like process $KN \to (K\pi\pi)N$. BARBARO 69 and FIRESTONE 72 find the decay is consistent with being entirely $K^*(1430)\pi$, whereas AGUILAR 70, BARTSCH 70, COLLEY 71, and DENEGRI 71 present evidence for alternate decay modes. For a review see EISNER 74.

Partial-wave analyses (DEUTSCHMANN 74, ANTIPOV 75, OTTER 75) have shown that the situation in the L region is complicated, with many waves contributing. The 2^- $K^*(1430)\pi$ S wave is important, but cannot explain the whole L enhancement (DEUTSCHMANN 74).

On the other hand, a recent paper repeating the PWA of OTTER 75 on an enlarged sample (AACHEN 77) proposes the existence of a 2^- resonance to explain the sharp rise of the 2^- $K^*(1430)\pi$ channel, the peak in the 2^- $K^*(892)\pi$ partial wave, and the observed phase variation. Further confirmation is, however, needed before considering this an established resonance.

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                        23  L MASS (MEV)

M       2011780.)                       BERLINGHI 67 HBC  +   12.7 K+P          7/67
M         (1760.0)    (15.0)            JOBES     67 HBC  +   5. K+ P           1/73
M          1745.0      20.0             AGUILAR   70 HBC  -   4.6 K- P          6/70
M          1780.0      15.0             BARTSCH   70 HBC  -   10.1 K- P         1/71
M         (1760.0)    (15.0)            LUDLAM    70 HBC  -   12.6 K- P         1/73
M  X       1765.0      40.0             COLLEY    71 HBC  +  10.K+P,K 2PI       1/73
M  X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
M         (1740.0)                      DENEGRI   71 DBC  - 12.6 K-D,K 2PI D   5/71
M          1767.       6.               BLIEDEN   72 MMS  -  11.-16. K- P     12/72
M  P   306 1730.      20.               FIRESTONE 72 DBC  +  12. K+ D           1/73
M  P    PRODUCED IN CONJUNCTION WITH D*
M          . . . . . . . . .
M   AVG    1764.6      6.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
M   STUDENT1765.0      5.8     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

                        23  L WIDTH (MEV)

W        20  (80.)                      BERLINGHI 67 HBC  +   12.7 K+P          7/67
W          (60.0)    (20.0)            JOBES     67 HBC  +   5. K+ P           1/73
W          100.0      50.0             AGUILAR   70 HBC  -   4.6 K- P          6/70
W          138.0      40.0             BARTSCH   70 HBC  -   10.1 K- P         1/71
W          (50.0)    (40.0)   (20.0)   LUDLAM    70 HBC  -   12.6 K- P         1/73
W  X        90.       70.              COLLEY    71 HBC  +  10.K+P,K 2PI       1/73
W  X    SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
W          (130.0)                      DENEGRI   71 DBC  - 12.6 K-D,K 2PI D   5/71
W          100.       26.              BLIEDEN   72 MMS  -  11.-16. K- P     12/72
W  P   306  210.      30.               FIRESTONE 72 DBC  +  12. K+ D           12/72
W  P    PRODUCED IN CONJUNCTION WITH D*
W          . . . . . . . . .
W   AVG    137.7      24.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
W   STUDENT 130.7      21.5     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

                        23  L PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     L INTO K PI PI                                          497+ 134+ 134
P2     L INTO K*(1430) PI                                      134+1434
P3     L INTO K PI PI PI                                       497+ 134+ 134+ 134
P4     L INTO K*(892) PI                                       892+ 134
P5     L INTO K*(892) RHO                                      892+ 776
P6     L INTO K*(892) OMEGA                                    892+ 783
P7     L INTO K*(892) PI PI                                    892+ 134+ 134
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                        23  L BRANCHING RATIOS

R1     L INTO (K*(1430) PI) / (K PI PI )                              (P2)/(P1)
R1        LARGE                        DENEGRI   68 DBC  -  12.6 K- D          1/71
R1          (1.0)                      BARBARO   69 HBC  +  12.0 K+ P          1/71
R1           0.2      0.2             AGUILAR   70 HBC  -  4.6 K- P           1/71
R1        LESS THAN   1.0             BARTSCH   70 HBC  -  10.1 K- P          1/71
R1        LESS THAN   1.0             COLLEY    71 HBC     10. K+ P            11/71
R1  P     CONSISTENT WITH 1.          FIRESTONE 72 DBC  +  12. K+ D            12/72
R1  P  PRODUCED IN CONJUNCTION WITH D*                                         12/72
R1   R  LESS THAN 1.0 SEEMS TO BE ESTABLISHED.
R1   R  FOR DISCUSSION OF THE EXPERIMENTAL EVIDENCE ON OTHER DECAY             11/71
R1   R  MODES SEE HUGHES 71,SLATTERY 71,EISNER 74.

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                        REFERENCES FOR L(1770)

BARTSCH  66 PL 22 357           +DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)

BERLINGHIERI 67 PRL 18 1087     BERLINGHIERI+FARBER+FERBEL+FORMAN+   (ROCH)I
JOBES    67 PL 26B 49           +BASSOMPIERRE,DE BAERE +   (BIRM+CERN+BRUX)

DENEGRI  68 PRL 20 1194         +CALLAHAN+ETTLINGER+GILLESPIE+          (JHU)
BARTSCH  68 NP B8 9             +COCCONI,+        (AACH+BERL+CERN+LOIC+VIEN)

ANDREWS  69 PRL 22 731          +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
BARBARO  69 PRL 22 1207         BARBARO-GALTIERI,DAVIS,FLATTE,+          (LRL)
COLLEY   69 NC A 59 519         +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)

AGUILAR  70 PRL 25 54           AGUILAR-BENITEZ,BARNES,BASSANO,CHUNG,+(BNL)
BARTSCH  70 PL 33 B 186         +DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)
LUDLAM   70 PR D 2 1234         +SANDWEISS,SLAUGHTER                    (YALE)

COLLEY   71 NP B 26 71          +JOBES,KENYON,PATHAK,HUGHES,+   (BIRM+GLAS)
DENEGRI  71 NP B 28 13          +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+    (JHU)  JP
HUGHES   71 BOLOGNA CONF.PROC   I.S.HUGHES,TALK AT BOLOGNA CONF.  (GLASGOW)

ANDERSON 72 PR D 6 1823         +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN   (COLO)
BLIEDEN  72 PL 39 B 668         +FINOCCHIARO,BOWEN,EARLES,+      (STON+NEAS)
FIRESTON 72 PR D 5 505          FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)

BARLOUTA 73 NP B 59 374         +DREVILLON,SHAH,+            (SACL+EPOL+RHEL)
BINGHAM  73 NP B 52 31          +FARWELL,+       (LBL+ORSAY+BNL+SACLAY+MILAN)
CHARRIER 73 NP B 51 317         CHARRIERE,DRIJARD,DE BAERE,+     (CERN+BELG)

DEUTSCHM 74 PL 49B 388          DEUTSCHMANN,+     (AACH+BERL+CERN+LOIC+VIEN)  JP
EISNER   74  BOSTON             R.L.EISNER  REVIEW TALK                 (BNL)

ANTIPOV  75 NP B86 381          +ASCOLI,BUSNELLO,KIENZLE+    (SERP+CERN+ILL)  JP
OTTER    75 NP B93 365          +RUOQLPH,RUMPF+  (AACH+BERL+CERN+LOIC+VIEN)  JP
    ALSO 77  PREP. AACHEN 41             /AACHEN+BERLIN+CERN+LOIC+VIENNA     JP

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K*(1780)

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60  K*(1780,JP=3-)
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Evidence for $K^*(1780)$ has been reported by a number of experiments which observe peaks of low statistical significance around 1800 MeV in the mass spectra of $K\pi$ and $K\pi\pi$ systems produced both with charge exchange (CARMONY 71, AGUILAR 73, SPIRO 76, CARMONY 77, GRASSLER 77) and without charge exchange (SPIRO 76). The large variation in the measured values of the mass (see the Data Card Listings) leads GRASSLER 77 to suggest that there may be further structure at higher mass (around 1850 MeV).

Additional evidence for the $K^*(1780)$ has come from observations of structure in the charge-exchange $K\pi$ angular distribution at ~1800 MeV (FIRESTONE 71, BRANDENBURG 76), which can be explained by a rapid rise of the F-wave amplitude interfering strongly with other waves. This behavior has been interpreted by BRANDENBURG 76 as implying the existence of a resonance with $J^P = 3^-$, $M \sim 1780$ MeV, and $\Gamma \sim 270$ MeV. The existence of such a resonance has been confirmed by BALDI 76 and CHUNG 78. BALDI 76 analyze non-charge-exchange data and find significant signals at ~1780 MeV in all moments up to $L = 6$. A clear, statistically

significant peak at ~1786 MeV is observed by CHUNG 78 in their charge-exchange Kπ mass spectrum. Both of these experiments obtain narrower widths than BRANDENBURG 76. BALDI 76 finds a width of 135 ± 22 MeV and CHUNG 78 a width of 95 ± 31 MeV.

There have been two recent phase-shift analyses of the Kπ system in this energy region. The energy-dependent analysis of BOWLER 77 supports the existence of a broad $J^P = 3^-$ resonance at ~1760 MeV with a width ~300 MeV. The problem of the width has been partly resolved by the ESTABROOKS 77 analysis of the high-statistics spectrometer data of BRANDENBURG 76. ESTABROOKS 77 find four solutions (see the Kπ S-wave mini-review), all of which are compatible with the existence of an F-wave resonance at ~1780 MeV with a width ~175 MeV and elasticity ~0.2. The Kππ decay mode has been confirmed by KONIGS 77 with good statistics and can be considered established.

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                   60  K*(1780) MASS (MEV)

M   C   76(1753.)    (12.)          CARMONY   71 DBC    09 K+N,K+PI-P      11/71
M   C  PRESENCE OF RESCNANCE ONLY INDICATED BY HOLE AT 1600 MEV,FIT
M   C  DFFICULT.SEE ALSO CARMONY 77.
M   I     (1850.)   APPROX.         FIRESTONE 71 DBC    0 12.K+ N,K+ PI-P 11/71
M   I        APPARENT INTERFERENCE WITH OTHER AMPLITUDES PRECLUDES       11/71
M   I        PRECISE DETERMINATION .                                    11/71
M       65(1760.)                   AGUILAR   73 HBC    07.3 K-P,K-PI+N    1/74
M    M     1779.0      11.0         BALDI     76 SPEC +  10 K+P,KO PI+P   12/77*
M    M  FROM A FIT TO Y(6,2) MOMENT. JP=3- FOUND.
M    A     1776.       26.          BRANDENB  76 ASPK   013 K+-P,K+-PI-+  12/75
M    A  CONFIRMED BY PHASE SHIFT ANALYSIS OF ESTABROOKS 77,YIELDS JP=3-
M       40(1780.)    (30.)          SPIRO     76 HBC   - 14.3 K-P,KOPI-P  12/75
M   G   80(1840.)    (30.)          SPIRO     76 HBC    014.3 K-P,K-PI+N  12/75
M    B    (1760.0)  APPROX.         BOWLER    77 DBC   0 5.4 K+D,K+PI-P P 12/77*
M    B  PHASE SHIFT ANALYSIS,YIELDS JP=3-.
M     127 1789.0      18.0          CARMONY   77 DBC   0 9 K+N,KO PI+PI-P 12/77*
M   G      (1871.0)   (10.0)        GRASSLER  77 HBC   0 10-16 K-P,K-PI+N 12/77*
M          (1812.0)   (28.0)        KONIGS    77 OMEG  0 10K-P,KO PI+PI-N 12/77*
M           1786.0      8.0         CHUNG     78 MPS   0 K-P,K-PI+N 6 GEV  1/78*
M           . . . . . . . . . .
M   AVG    1783.8      5.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1783.8      6.4     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M   G     GRASSLER 77 PROPOSE THE EXISTENCE OF ANOTHER OBJECT.
M   G     NOT AVERAGED
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                   60  K*(1780) WIDTH (MEV)

W   C   76  (60.)     (20.)          CARMONY   71 DBC    09 K+N,K+PI-P      11/71
W   C  SEE NOTE C ABOVE
W   I      (300.)    APPROX.         FIRESTONE 71 DBC    0 12.K+ N,K+ PI-P 11/71
W   I    SEE NOTE I ABOVE
W       65  (80.)    OR LESS         AGUILAR   73 HBC    07.3 K-P,K-PI+N    1/74
W    M      135.0      22.0          BALDI     76 SPEC +  10 K+P,KO PI+P   12/77*
W    M  FROM A FIT TO Y(6,2) MOMENT. JP=3- FOUND.
W   E      (270.)     (70.)          BRANDENB  76 ASPK   013 K+-P,K+-PI-+  12/75
W   E     ESTABROOKS 77 FIND THAT BRANDENBURG 76 DATA ARE CONSISTENT
W   E     WITH 175 MEV WIDTH.NOT AVERAGED.
W   D   40 (120.)     (75.)          SPIRO     76 HBC   - 14.3 K-P,KOPI-P  12/77*
W  GD   80 (100.)     (45.)          SPIRO     76 HBC    014.3 K-P,K-PI+N  12/77*
W    B     (300.0)  APPROX.          BOWLER    77 DBC   0 5.4 K+D,K+PI-P P 12/77*
W    B SEE NOTE ABOVE
W      127    85.0      50.0         CARMONY   77 DBC   0 9 K+N,KO PI+PI-P 12/77*
W   G      (285.0)   (40.0)          GRASSLER  77 HBC   0 10-16 K-P,K-PI+N 12/77*
W    D     (181.0)   (44.0)          KONIGS    77 OMEG  0 10K-P,KO PI+PI-N 12/77*
W           96.0      31.0           CHUNG     78 MPS   0 K-P,K-PI+N 6 GEV  1/78*
W          . . . . . . . . . .
W   AVG     117.7      16.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W   STUDENT 117.6      19.3     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W    D  ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K* TYPED NOTE.
W   G   SEE NOTE ABOVE.

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                   60  K*(1780) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      K*(1780) INTO K PI                                493+ 139
P2      K*(1780) INTO K*(892) PI                          892+ 139
P3      K*(1780) INTO K RHO                               493+ 776
P4      K*(1780) INTO K*(1430) PI                        1434+ 139
P5      K*(1780) INTO K PI PI                             493+ 139+ 139
P6      K*(1780) INTO K*(890) RHO                        1100+ 776

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                   60  K*(1780) BRANCHING RATICS

R1      K*(1780) INTO (K*(892) PI + K RHO)/(K PI)          (P2+P3)/P1
R1            0.9        0.4          AGUILAR   73 HBC      7.3 K-P,K-PI+N   12/77*
R1            0.4        0.6          SPIRO     76 HBC     14.3 P-P,KO-PI+-  12/77*
R1            1.59       0.44         CARMONY   77 DBC   0 9 K+N,KO PI+PI-P 12/77*
R1          . . . . . . . . . .
R1  AVG       1.05       0.32     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R1  STUDENT   1.04       0.31     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2      K*(1780) INTO (K*(892) PI)/(K PI PI)               (P2)/(P5)
R2            0.33       0.12         CARMONY   77 DBC    0 9. K+ N          12/77*

R3      K*(1780) INTO (K RHO)/(K PI PI)                    (P3)/(P5)
R3            0.48       0.14         CARMONY   77 DBC    0 9. K+ N          12/77*

R4      K*(1780) INTO (K PI )/TOTAL                        (P1)
R4   B       (0.3)  OR LESS           BOWLER    77 DBC   0 5.4 K+D,K+PI-P P 12/77*
R4   B        0.19       0.02         ESTABROO  77 ASPK  0 13 K+-P,K PI     12/77*
R4   B  SEE NCTE ABOVE.

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                            REFERENCES FOR K*(1780)

CARMONY  71 PRL 27 1160        +CORDS,CLOPP,ERWIN,MEIERE,+ (PURD+UCD+IUPU)
FIRESTCN 71 PL 36 B 513        FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
AGUILAR  73 PRL 30 672         +CHUNG,EISNER,PROTOPOPESCU,SAMIOS,+   (BNL)
WALUCH   73 PR D 8 2837        +FLATTE,FRIEDMAN                       (LBL)

BALDI    76 PL 63 B 344        +BOEHRINGER,DORSAZ,HUNGERBUHLER,+  (GENEVA)  JP
BRANDENB 76 PL 60 B 478        BRANDENBURG,CARNEGIE,CASHMORE,DAVIER+(SLAC)  JP
SPIRC    76 PL 60 B 389        +BARLOUTAUD,PALER,CHAURAND+(SACL+RHEL+EPOL)  JP

BOWLER   77 NP B 126 31        +DAINTON,DRAKE,WILLIAMS             (OXFORD)  JP
CARMONY  77 PRD 16 1251        +CLOPP,LANDER,MEIERE,YEN,+  (PURD+UCD+IUPU)
ESTABROO 77  SLAC PUB 2004     ESTABROOKS,CARNEGIE+(MONT+CARL+DURHAM+SLAC)  JP
GRASSLER 77 NP B 125 189       +KLUGOW,+  (AACHEN+BERLIN+CERN+LOIC+VIENNA)
KONIGS   77  BUDAPEST CONF.    +OTTER,BEUSH,BIRMAN,+      (AACHEN+CERN+ETHZ)
CHUNG    78 PRL 40 355         +ETKIN,FLAMINO+    (BNL+BRAN+CUNY+MASA+PENN)  JP

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K*(2200)

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                   40  K*(2200,JP=  )

--->               ENHANCEMENT SEEN IN (ANTIHYPERON NUCLEON) MASS
                   NEAR THRESHOLD. INTERPRETATION UNCERTAIN.
                   OMITTED FROM TABLE.

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                   40  K*(2200) MASS (MEV)

M        20 2240.       20.           LISSAUER  70 HBC      9. K+ P            11/71
M   C      (2200.)   APPROX.          SLATTERY  71 RVUE    8-13 K+ P           11/71
M   C   COMPILATION OF (ANTIHYP.-NUCLEON) MASS IN K+ P 8.-13.  GEV/C          11/71

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                   40  K*(2200) WIDTH (MEV)

W        20   80.       20.           LISSAUER  70 HBC      9. K+ P            11/71
W   C      (200.)    APPROX.          SLATTERY  71 RVUE    8-13 K+ P           11/71
W   C   COMPILATION OF (ANTIHYP.-NUCLEON) MASS IN K+ P 8.-13.  GEV/C          11/71

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                            REFERENCES FOR K*(2200)

ALEXANDE 68 PRL 20 755         ALEXANDER,FIRESTONE,GOLDHABER,SHEN    (LRL)
LISSAUER 70 NP B 18 491        +ALEXANDER,FIRESTONE,GOLDHABER        (LBL)

CARMCNY  71 PRL 27 1160        +CORDS,CLOPP,ERWIN,MEIERE,+  (PURD+UCO+IND)
SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

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I(2600)

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                   24  I(2600)

--->               THIS ENTRY CONTAINS HIGH-MASS, NARROW STRANGE PEAKS.
                   OMITTED FROM TABLE.

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                   24  I MASS (MEV)

M   N   130 2600.0     10.0           APOSTOLAK 77 HBC  +- 12PB P,KSPIPIPI  12/77*
M   N    NOT SEEN BY APELDOORN 78 IN THE SAME REACTION AND
M   N    WITH ABOUT THE SAME STATISTICS, BUT POORER RESOLUTION.
M   N    THE DISAGREEMENT IS AT A LEVEL OF ABOUT 2 STD.DEV.
M

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                   24  I WIDTH (MEV)

W   N   130  (10.0)  OR LESS          APOSTOLAK 77 HBC  +- 12PB P,KSPIPIPI  12/77*
W   N    SEE NOTE N ABOVE.

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                            REFERENCES FOR I

APOSTOLA 77 PL 66 B 185        APOSTOLAKIS,+     (CERN+MONS+LOIC+BELG+LALO)
APELDOOR 78 PL 72 B 487        APELDOORN,KARIMAKI,+  (AMST+HELS+LIVP+STOH)

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C=±1 MESON STATES

$D^{\pm}$

31 CHARGED D(1868,JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

D^0

32 NEUTRAL D(1863,JP=0-) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

$D^{*\pm}(2010)$

62 CHARGED D*(2010,JP=1-) I=1/2

62 CHARGED D*(2010) MASS (MEV)

M	G	(2008.)	(3.)	GOLDHAB2 77 SMAG +- E+E-		12/77*
M	P	2008.6	1.0	PERUZZI 77 SMAG +- E+E-		3/78*
M	G	FROM SIMULTANEUS FIT TO D*+,D*0,D+,AND D0,NOT INDEPENDENT OF				
M	G	FELDMAN 77 MASS DIFFERENCE BELOW.				
M	P	PERUZZI 77 MASS NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE				
M	P	BELOW AND PERUZZI 77 D0 MASS VALUE.				

62 (D*+) - (D0) MASS DIFFERENCE (MEV)

DM	30	145.3	0.5	FELDMAN 77 SMAG	D*+ TO D0 PI+	12/77*

62 (D*+) - (D*0) MASS DIFFERENCE (MEV)

EM	P	2.6	1.8	PERUZZI 77 SMAG +- E+E-		12/77*
EM	P	NOT INDEPENDENT OF FELDMAN 77 MASS DIFFERENCE ABOVE, PERUZZI 77				
EM	P	D0 MASS, AND GOLDHABER2 77 D*0 MASS.				

62 CHARGED D*(2010) WIDTH (MEV)

W	18	(20.0)	DR LESS	PERUZZI 76 SMAG +- E+E-,PSI(4030)		1/77*
W	30	(2.0)	DR LESS CL=.90	FELDMAN 77 SMAG	D*+ TO D0 PI+	12/77*

62 CHARGED D*(2010) PARTIAL DECAY MODES

		DECAY MASSES
P1	D*+(2010) INTO D0 PI+	1865+ 139
P2	D*+(2010) INTO D+ GAMMA	1876+ 0

P D*-(2010) MODES ARE CHARGE CONJUGATES OF ABOVE MODES

62 CHARGED D*(2010) BRANCHING RATIOS

R1		D*+(2010) INTO (D0 PI+)/TOTAL		(P1)		
R1	G	0.6	0.15	GOLDHAB2 77 SMAG + E+E-		12/77*
R1	G	ASSUMING THAT ISOSPIN IS CONSERVED IN THE DECAY				
R2		D*+(2010) INTO (D+ GAMMA)/TOTAL		(P2)		
R2		SEEN		GOLDHAB1 77 SMAG	RECOIL SPEC	12/77*

REFERENCES FOR CHARGED D*(2010)

PERUZZI 76 PRL 37 569	+PICCOLO,FELDMAN,NGUYEN,WISS,+ (SLAC+LBL)
FELDMAN 77 PRL 38 1313	+PERUZZI,PICCOLO,ABRAMS,ALAM+ (SLAC+LBL)
PERUZZI 77 PRL 39 1301	+PICCOLO,FELDMAN,PERL,+(SLAC,LBL,NWES+HAWA)
GOLDHAB1 77 CHICAGO APS	G.GOLDHABER (LBL+SLAC)
GOLDHAB2 77 PL 69 B 503	+WISS,ABRAMS,ALAM,BDYARSKI,+ (LBL+SLAC)

$D^{*0}(2010)$

61 NEUTRAL D*(2010,JP=1-) I=1/2

J CONSISTENT WITH 1, VALUE 0 RULED OUT (NGUYEN 77).

61 NEUTRAL D*(2010) MASS (MEV)

M	G	2006.	1.5	GOLDHAB2 77 SMAG	E+E-	12/77*
M	G	FROM SIMULTANEUS FIT TO D*+,D*0,D+,AND D0.				

61 NEUTRAL D*(2010) WIDTH (MEV)

W		(5.)	DR LESS	GOLDHAB2 76 SMAG	E+E- TO D*D*	3/77*

61 NEUTRAL D*(2010) PARTIAL DECAY MODES

		DECAY MASSES
P1	D*0(2010) INTO D0 PI0	1865+ 134
P2	D*0(2010) INTO D0 GAMMA	1865+ 0

P D*0(2010)BAR MODES ARE CHARGE CONJUGATES OF ABOVE MODES

61 NEUTRAL D*(2010) BRANCHING RATIOS

R1		D*0(2010) INTO (D0 GAMMA)/(D0 PI0 + D0 GAMMA)		(P2)/(P1+P2)		
R1	G	0.45	0.15	GOLDHAB2 77 SMAG	E+E-	12/77*
R1	G	WE QUOTE THE NORMAL FIT VALUE FROM TABLE 1. THE ISO-SPIN				
R1	G	CONSTRAINED FIT IS NOW KNOWN TO GIVE A D0 GAMMA FRACTION WHICH IS				
R1	G	TOO LARGE. SEE DETAILS IN FOOTNOTE 21 OF FELDMAN 77 REVIEW.				

REFERENCES FOR NEUTRAL D*(2010)

GOLDHAB1 76 PRL 37 255	GOLDHABER,PIERRE,ABRAMS,ALAM,+ (LBL+SLAC)
GOLDHAB2 76 SLAC CONF. 379	G.GOLDHABER (AVAIL. AS LBL-5534) (LBL+SLAC)
GOLDHAB2 77 PL 69 B 503	GOLDHABER,ABRAMS,ALAM+ (LBL+SLAC)
NGUYEN 77 PRL 39 262	+WISS,ABRAMS,ALAN,BDYARSKI,+ (LBL+SLAC) J

REVIEWS

FELDMAN 77 SLAC-204 SUM.INST	G.FELDMAN (SLAC)

$F^{\pm}$

34 F+-(2030,JP=) I=

SEE STABLE PARTICLE DATA CARD LISTINGS

$F^*(2140)$

74 F*(2140,JPG=) I=

OMITTED FROM TABLE.

74 F* MASS (MEV)

M		2140.0	60.	BRANDELIK 77 DASP	+- E+E-,PI 3 GAMMA	12/77*

74 (F*+) - (F0) MASS DIFFERENCE (MEV)

DM		120.	40.	BRANDELIK 77 DASP	+- E+E-,F GAMMA	12/77*

74 F* PARTIAL DECAY MODES

		DECAY MASSES
P1	F* INTO F GAMMA	0+ 0

74 F* BRANCHING RATIOS

R1		F* INTO (F GAMMA)/TOTAL		(P1)		
R1		PROBABLY SEEN		BRANDELIK 77 DASP	E+E-	12/77*

REFERENCES FOR F*(2140)

BRANDELI 77 PL 70 B 132	BRANDELIK,CORDS,+(AACH+DESY+HAMB+MPIM+TOKY)

EXOTIC MESON STATES

EXOTICS

50 EXOTICS

THE PURPOSE OF THIS ENTRY IS TO PROVIDE A LIST OF REFERENCES FOR EXOTIC MESON SEARCHES (SEE MAIN TEXT, SEC. 3 AND TABLE 1), AS WELL AS THEORETICALLY BASED SUGGESTIONS FOR EXPERIMENTS. NOTE THAT LIPKIN 73 PROPOSES EXPERIMENTS WHICH ARE CONCLUSIVE EVEN IF NEGATIVE RESULTS ARE OBTAINED.

REFERENCES FOR EXOTICS

REPORTS ON SEARCHES

ROSENFEL 68 PHILA.CONF.P.455	A.H.ROSENFELD (LRL)
DODD 69 PR 177 1991	+JOLDERSMA, PALMER, SAMIOS (BNL)
CHO 70 PL 32 B 409	+DERRICK,JOHNSON,MUSGRAVE,+ (ANL+NWES+KANS)
GIACOMEL 70 PL 33 B 373	G.GIACOMELLI + (BGNA+SACL+AMST+REHO+EPOL)
LYS 70 PR D 2 2525	J.LYS+ (MICH)
ROSNER 70 EXP.MESON SPECTROSCOPY,ED. C.BALTAY AND A.H.ROSENFELD,P.499	
BUHL 72 NP B 37 421	+CLINE,TERRELL (WISCONSIN)
COHEN 73 NP B 53 1	+FERBEL,SLATTERY,WERNER (ROCHESTER)
DURUSOY 73 PL 45 B 517	+BAUBILLIER,GEORGE,ARMENISE,+ (LPNP+BARI)
ALAM 74 PL 53B 207	+BRABSON,GALLOWAY,+ (IND+PURD+SLAC+VAND)
COHEN 74 BOSTON	D.COHEN REVIEW TALK (COLU)
OREN 74 NP B71 189	+COOPER,FIELDS,RHINES,WHITMORE,+ (ANL+OXF)
BALTAY 75 PL 57B 293	+CAUTIS,COHEN,KALELKAR,PISELLO,+(COLU+BING)
DAVIS 75 NP B96 426	+AMMAR,KROPAC,YARGER,+ (KANS+CCAC+ANL)
BRUNDIER 76 PL 64 B 107	BRUNDIERS,BRUN,FLURI,+ (FREIBURG+SACL+ETHZ)
BOUCROT 77 NP B 121 251	+NAVACH,RIVET,+ (LALO+CERN+CDEF+EPOL)
HOOGLAND 77 NP B 126 109	+GRAYER,HYAMS,BLUM,DITL,+ (AMST+CERN+MPIM)
HOOGLAND 77 NP B 126 109	+GRAYER,HYAMS,BLUM,DITL,+ (AMST+CERN+MPIM)
MOSER 77 NP B 129 28	F.L.MOSER (EFI)

SUGGESTIONS FOR SEARCHES

ROSNER 68 PRL 21 950,1468	J.L.ROSNER (TEL-AVIV)
ROSNER 70 EXP.MESON SPECTROSCOPY,ED. C.BALTAY AND A.H.ROSENFELD,P.499	
FAIMAN 73 PL 43 B 307	D.FAIMAN,G.GOLDHABER,Y.ZARMI (CERN)
LIPKIN 73 PR D 7 2262	H.J.LIPKIN (ARGONNE+FNAL)

Baryons
N's and Δ's

Data Card Listings
For notation, see key at front of Listings.

Note on N's and Δ's

I. Determination of Resonance Parameters

Values of masses, widths, and branching ratios are obtained mainly from partial-wave analyses. In addition to a few comprehensive partial-wave analyses, there are numerous others which are based on somewhat incomplete data or cover only a limited energy range. We also include some information from production and total cross-section experiments. This can be valuable in establishing the existence of high mass bumps, but at the lower energies these experiments have limited statistics compared to formation experiments and it is seldom clear which of several states at similar masses is being observed.

There are two main problems in obtaining reliable resonance parameters. First there is often disagreement as to just what the values of the partial-wave amplitudes are. This problem is obviously related to the quality and quantity of the data and to the procedures used to determine the amplitudes. Secondly, even if smooth curves were available for the amplitudes, there would still be some parametrization-dependent ambiguity in deciding what the resonance parameters should be. From a theoretical standpoint the most unambiguously defined resonance parameters are the pole position and residue, and it has been found in practice that, given sufficiently precise partial-wave amplitudes, these quantities can be extracted in a stable and parametrization-independent way, in spite of the fact that they require an extrapolation away from the physical region. This point has been discussed in detail with regard to the Δ(1232) in previous editions of this review.[1,2] Although the best determined pole parameters are those of the Δ(1232), there are now a number of determinations for higher lying resonances which are included in the Data Card Listings. For further discussion see the corresponding references, e.g., NOGOVA 73, SPEARMAN 74, BALL 75, LICHTENBERG 75, LONGACRE 75, CUTKOSKY 76, VASAN 76, and LONGACRE 77.

The following sections of this mini-review contain discussions of various new developments in experimental non-strange baryon spectroscopy. For a thorough discussion of earlier results see our 1976 edition[3] and the review of K. Lanius.[4] Some of the newest developments were reported at the Oxford Topical Conference on Baryon Resonances[5] in 1976, and have not yet been published. Following our standard practice, we omit such results from the Data Card Listings, but do discuss them here.

At the beginning of the Data Card Listings for N's and Δ's, we present a table giving our evaluation of the status of the N and Δ resonances based on information contained in the Listings. In the Table of Particle Properties, we do not quote values and errors for most parameters, but give only ranges for masses and widths in order to emphasize that in some cases these parameters are quite poorly determined. When in doubt about the reliability of a particular parameter, we choose the range quoted in the Tables to be conservatively large.

References for Section I

1. Particle Data Group, Rev. Mod. Phys. 43, S114 (1971).
2. Particle Data Group, Phys. Lett. 39B, 103 (1972).
3. Particle Data Group, Rev. Mod. Phys. 48, S147 (1976).
4. K. Lanius in Proceedings of the XVIII International Conference on High Energy Physics (Tbilisi, 1976), Vol. I, pg. C45.
5. Proceedings of the Topical Conference on Baryon Resonances (Oxford, 1976), edited by R. T. Ross and D. H. Saxon.

For other references see the Data Card Listings.

II. πN Partial-Wave Analyses and New Resonances

A large amount of new data on πN elastic and charge-exchange scattering was presented at the 1976 Oxford Baryon Conference. Bristol-Southampton-Rutherford[1] have measured π^+p and π^-p elastic differential cross sections (DCS) at 51 momenta between 0.4 and 2.1 GeV/c with sonic spark chambers and a single-arm spectrometer for events with small forward or backward scattering angles. Rutherford has measured the charge-exchange DCS at 22 momenta between 0.6 and 2.7 GeV/c and the polarization (POL) at 22 momenta between 0.6 and 2.3 GeV/c.[2] Liquid scintillator neutron detectors and lead scintillator gamma detectors were used. There also exist

high-statistics π^+p DCS data at 16 momenta between 1.2 and 2.3 GeV/c from Maryland-Argonne[3] and π^+p POL data at 64 momenta between 0.6 and 2.6 GeV/c from Oxford-Rutherford.[4] In comparison with these experiments, our knowledge of low energy π^-p POL remains rather weak, and there are no measurements of spin-rotation parameters.

The most recent comprehensive $\pi N \to \pi N$ amplitudes are those of CUTKOSKY 76 and Pietarinen.[5] Both of these analyses impose energy-dependent analyticity constraints in conjunction with energy-independent data fitting. They differ in the types and numbers of curves along which analyticity constraints are imposed. The CUTKOSKY 76 analysis imposes a minimal number of constraints while that of Pietarinen is more highly smoothed. In addition, the analysis of CUTKOSKY 76 includes a detailed error analysis. Neither of these analyses included the new elastic DCS data[1] or the charge-exchange DCS and POL data[2] when they were presented at Oxford in 1976. However, the analyses have continued, and Pietarinen has provided us with the final version of his amplitudes and resonance parameters obtained from fits which do include the charge-exchange data (PIETARINEN 78[6]). The amplitudes are shown in Figs. II.1 - II.6, and the resonance parameters are discussed below. The results of CUTKOSKY 76 are limited to energies below 2200 MeV, and emphasize the I = 3/2 waves. The results of this analysis for I = 3/2 and J = 1/2, 3/2, 5/2, and 7/2 are compared with PIETARINEN 78 in Figs. II.1 and II.3. In the remaining parts of Fig. II we compare the results of PIETARINEN 78 and AYED 76. AYED 76 is a thesis containing previous results of the Saclay group (referred to as AYED 74 in our 1976 edition).

The results of these and other recent analyses have significantly strengthened the evidence for many of the resonance candidates in the Data Card Listings. On the basis of the current evidence we are adding five nucleon and delta resonances to this year's Tables, and a J^P value for a previously tabulated bump. A discussion of each of these follows.

N(1700)D_{13}": AYED 76, CUTKOSKY 76, and PIETARINEN 78 find evidence for an inelastic ($x \sim 0.1$) D_{13} resonance with a mass of 1650 to 1740 MeV and a width of 60 to 120 MeV. The signal is small in all three analyses, and is accompanied by a rapidly varying background coming from the tail of the N(1520), but there is rather good agreement on the resonance parameters. A 100-MeV wide D_{13} resonance at 1680 MeV is observed in $\pi^-p \to K^0\Lambda$ by BAKER 77, and similar states have appeared in some of the ambiguous solutions resulting from earlier associated-production analyses. The $\pi N \to \pi\pi N$ analyses of LONGACRE 75 and LONGACRE 77 find a D_{13} resonance of similar mass, but with various estimates of the width ranging from 100 to 600 MeV. Although no single analysis appears to be capable of definitively establishing this state, we have decided on the basis of the collective evidence to include it in the Tables.

N(2200)G_{19}: A 190-MeV wide G_{19} resonance at 2130 MeV was first found by AYED 76, and has been confirmed by PIETARINEN 78 (see Fig. II.6) and Hendry[7] though with somewhat higher mass and width. The low energy tail of this resonance is also apparent in the results of CUTKOSKY 76. Though the elasticity is small, $x \sim 0.1$, the resonance signal is strong because of its high spin.

N(2650)$I_{1\,11}$: The N(2650) has been in the Tables for some time as a bump with unknown J^P. PIETARINEN 78 has now found a clear signal for a 400-MeV wide $11/2^-$ resonance near this mass (see also Ref. 5), and we have added this J^P value to the Tables. Hendry[7] also finds an $11/2^-$ state near this mass, but with a width of 900 MeV. The strong possibility that there are other, less prominent nucleon resonances in this region remains; e.g., PIETARINEN 78 also finds a weaker signal for a $13/2^+$ state.

Δ(1690)P_{33}": All recent πN analyses claim the existence of one or two P_{33} resonances in the mass range 1500 - 2000 MeV. These are divided into two categories in the Data Card Listings, called the Δ(1690) and Δ(2160). The situation with the Δ(2160) is unclear, and it may well represent several unresolved resonances with different J^P values. However, there is general agreement that the Δ(1690) is a rather inelastic ($x \sim 0.1$ to 0.2) P_{33} resonance with a mass of 1650 to 1900 MeV, and a width of 150 to 350 MeV. The wide range of reported masses and widths may be due to the tail of the Δ(1232) which

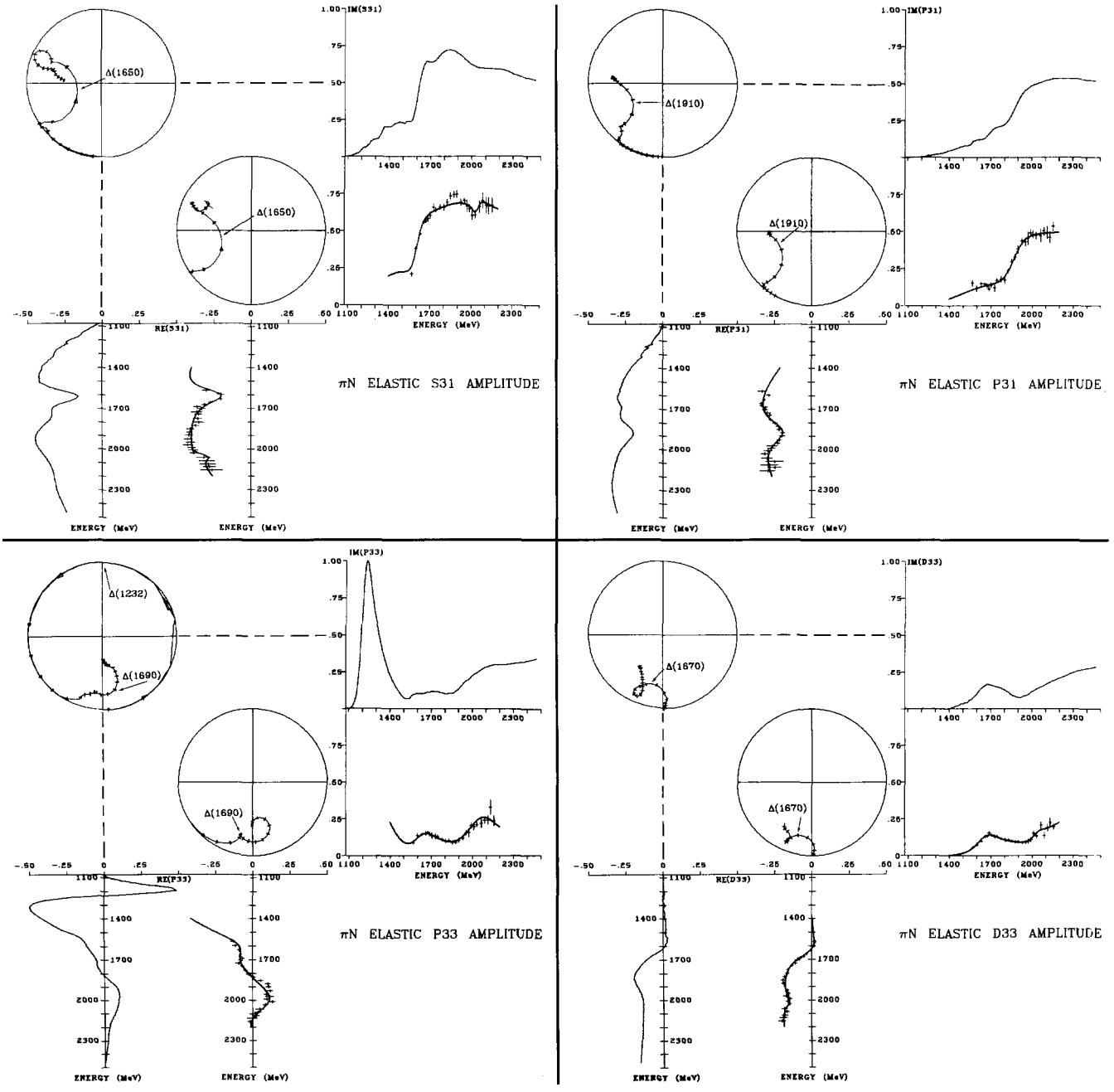

Fig. II.1. Amplitudes for I = 3/2 πN elastic scattering in the J = 1/2 and J = 3/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from CUTKOSKY 76 (results of energy-independent fitting are shown as data points; the curves show an energy-dependent fit). The upper plot for each wave is from PIETARINEN 78. The different locations of the Δ(1690) in the P_{33} amplitudes of CUTKOSKY 76 and PIETARINEN 78 illustrate the possibility that there may be more than one P_{33} resonance in or near the 1650 - 1900 MeV region.

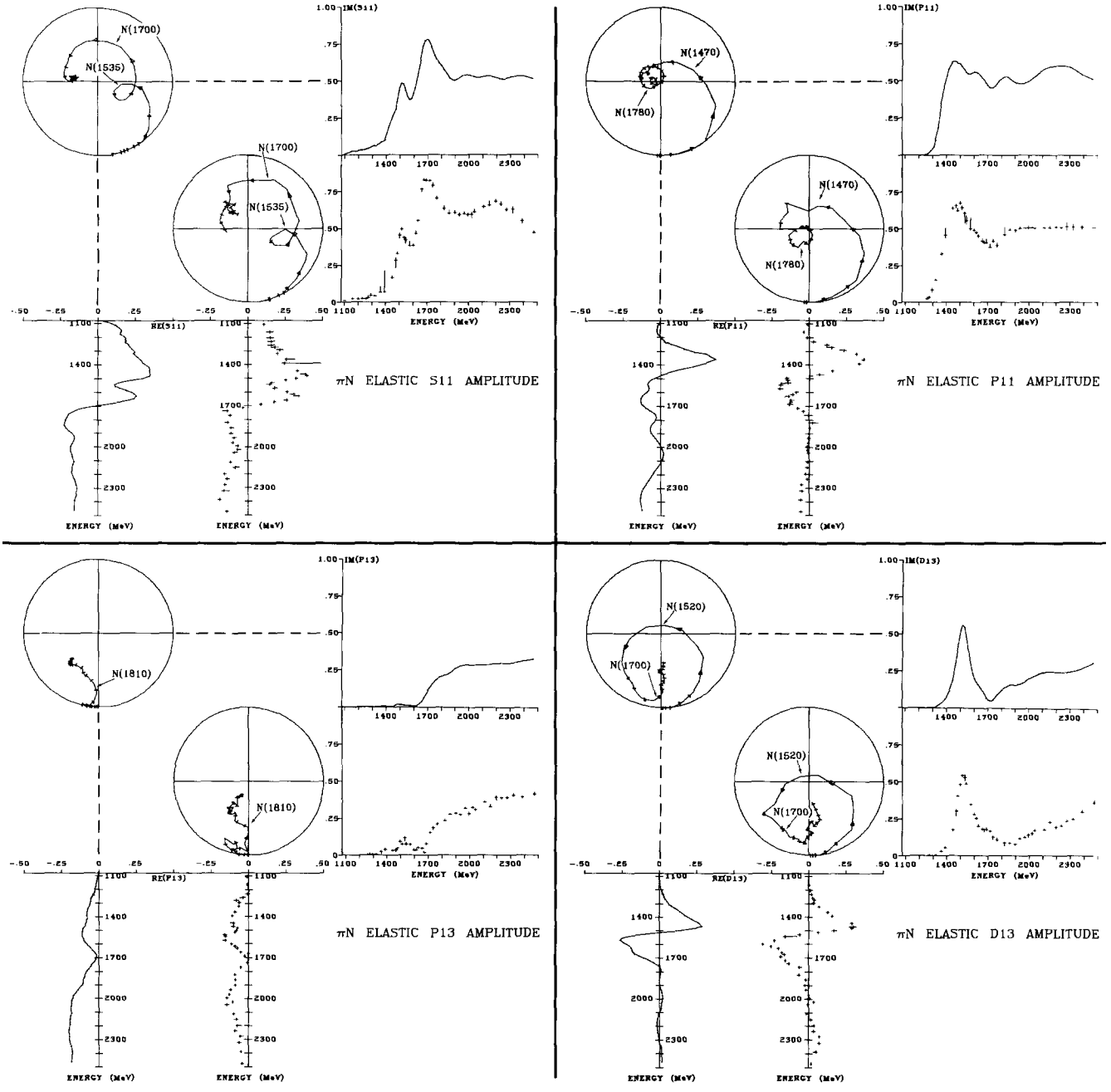

Fig. II.2. Amplitudes for I = 1/2 πN elastic scattering in the J = 1/2 and J = 3/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from AYED 76; the upper plot is from PIETARINEN 78.

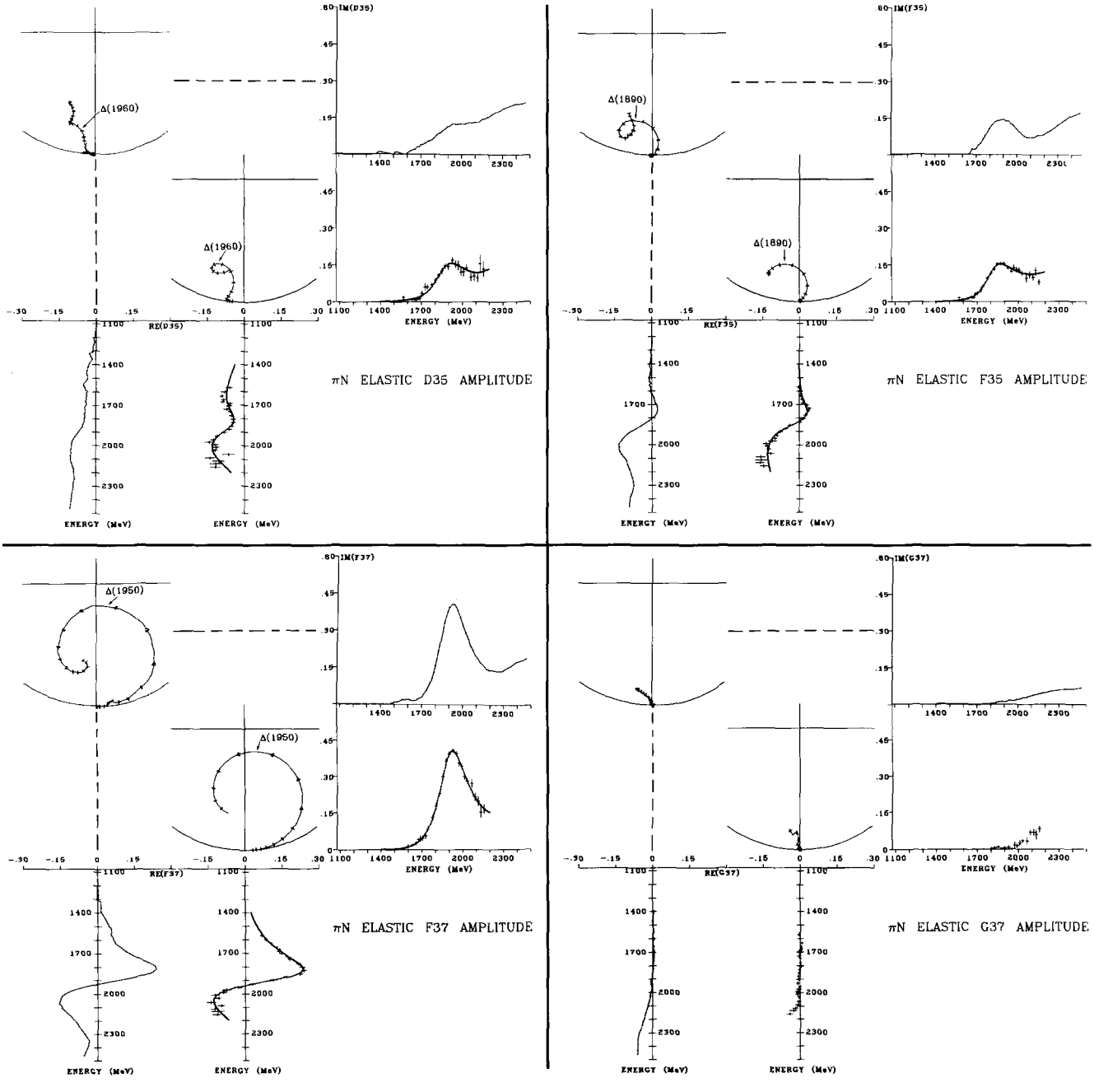

Fig. II.3. Amplitudes for I = 3/2 πN elastic scattering in the J = 5/2 and J = 7/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from CUTKOSKY 76 (results of energy-independent fitting are shown as data points; the curves show an energy-dependent fit). The upper plot for each wave is from PIETARINEN 78.

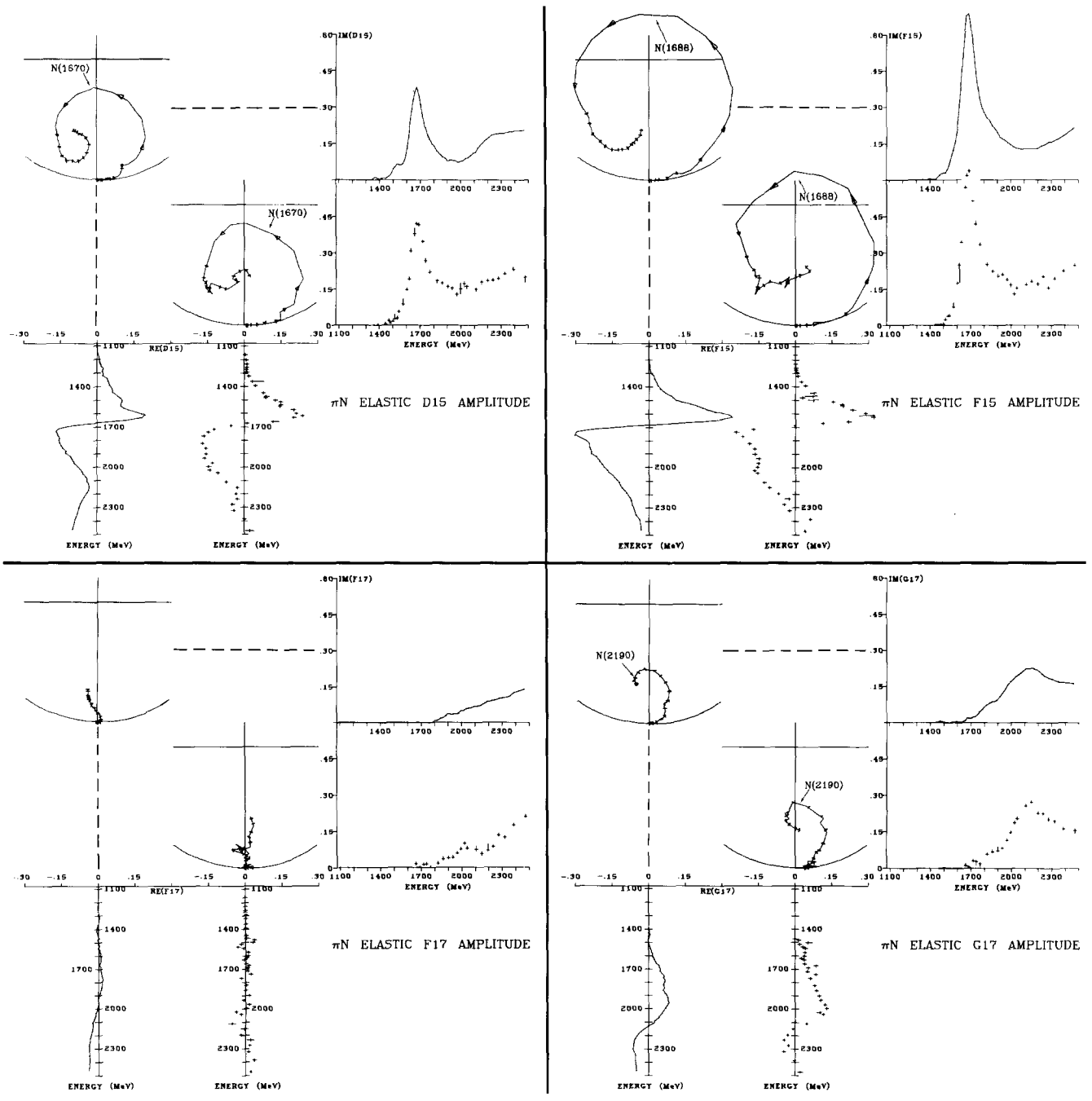

Fig. II.4. Amplitudes for I = 1/2 πN elastic scattering in the J = 5/2 and J = 7/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from AYED 76; the upper plot is from PIETARINEN 78.

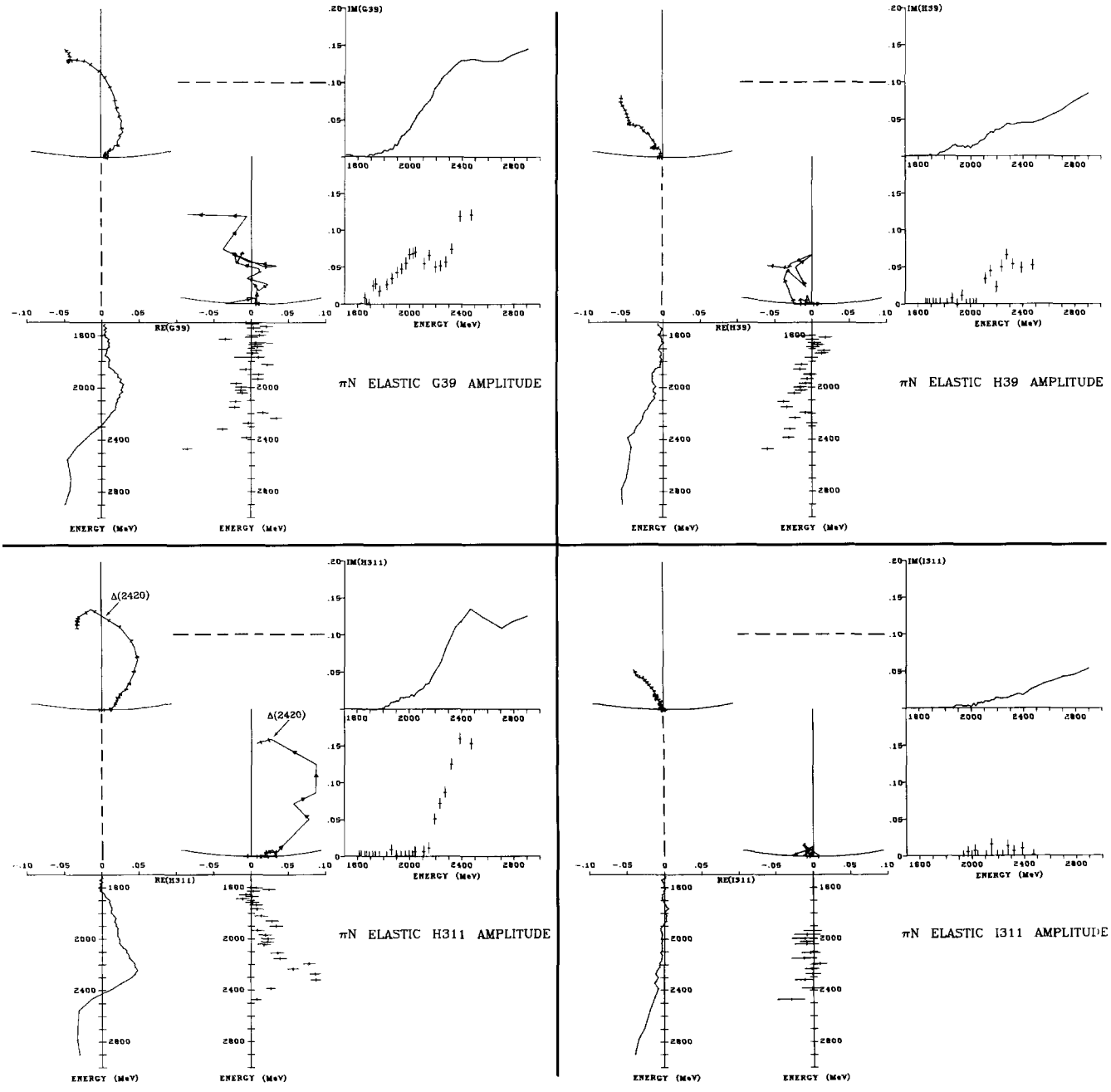

Fig. II.5. Amplitudes for I = 3/2 πN elastic scattering in the J = 9/2 and J = 11/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All energy axes run from 1500 to 3000 MeV. The established resonance in the $H_{3\,11}$ wave is indicated on its Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from AYED 76; the upper plot is from PIETARINEN 78.

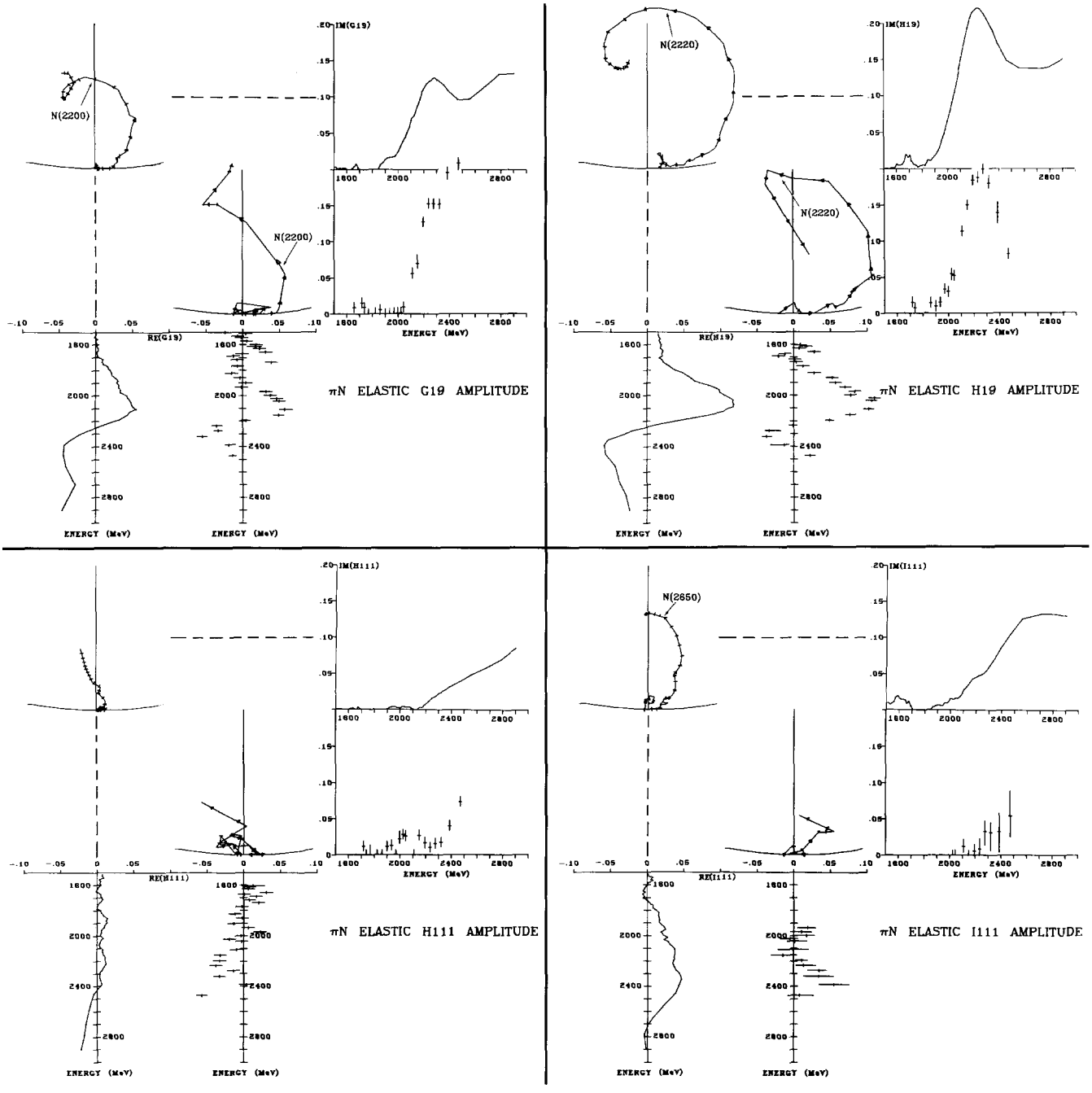

Fig. II.6. Amplitudes for I = 1/2 πN elastic scattering in the J = 9/2 and J = 11/2 waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at integer multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from 1500 to 3000 MeV. The established resonances in these waves are indicated on the Argand plots. The results of two different analyses are shown; the energy axes for the two analyses are aligned for ease of comparison. The lower Argand plot for each wave is from AYED 76; the upper plot is from PIETARINEN 78.

is an appreciable background at the lower end of this mass range, or to the presence of more than one P_{33} resonance in or near this mass range. Supporting evidence for the Δ(1690) comes from the $\pi N \to \pi\pi N$ analyses of LONGACRE 75 and LONGACRE 77, but with an even wider range of possible mass values.

Δ(1960)D_{35}: AYED 76, CUTKOSKY 76, PIETARINEN 78, and several earlier analyses find evidence for a D_{35} resonance with a mass of about 1900 MeV. The reported widths span a large range from 100 to 400 MeV, and there is disagreement about the strength of the elastic coupling, which is at most $x \sim 0.15$. However, a detailed study by CUTKOSKY 76 of the extent to which this resonance is required by current data has confirmed its existence.

Δ(2160): The Δ(2160) has been omitted from the Tables in past years because there are many conflicting claims of delta resonances in this region with different J^P values. The newest analyses do not do much to clear up this confusion. However, the pronounced dip in backward π^+p elastic scattering found by REY 74 clearly indicates some sort of resonance activity in the region, so we are tabulating the Δ(2160) as a bump with unknown J^P.

In addition to the above new Table entries, there are many more possible N and Δ resonances suggested by recent analyses which cannot yet be considered established. Of particular interest is the region around 1900 to 2200 MeV, where there are possible S_{31}, D_{13}, D_{15}, F_{15}, and F_{17} states which are supported to some extent by all three of AYED 76, CUTKOSKY 76, and PIETARINEN 78, as well as by some earlier analyses. In addition, the results of PIETARINEN 78 and Hendry[7] at higher energies indicate that high-spin N and Δ states up to masses of 4000 MeV are visible in current data.

References for Section II

1. D. J. Bardsley et al., in Proceedings of the Topical Conference on Baryon Resonances (Oxford, 1976), edited by R. T. Ross and D. H. Saxon, pg. 66.
2. R. M. Brown et al., in Oxford Conference Proceedings (ibid.), pg. 75; R. M. Brown et al., Rutherford Laboratory preprint RL-76-093 (1976); R. M. Brown et al., Nucl. Phys. B117, 12 (1976).
3. K. Abe et al., Phys. Rev. D10, 3556 (1974).
4. J. F. Martin et al., Nucl. Phys. B89, 253 (1975).
5. E. Pietarinen, in Oxford Conference Proceedings (op.cit.), pg. 20.
6. E. Pietarinen, private communication, 1978.
7. A. W. Hendry, in Oxford Conference Proceedings (op.cit.), pg. 29 and LBL-7524, Feb. 1978.

For other references see the Data Card Listings.

III. The ππN Channel

In the isobar model, the amplitude for the reaction $\pi N \to \pi\pi N$ is written

$$T = \sum \left\{ T_{\Delta\pi}^{JILL'}(E)\ BW_{\Delta}(E_{\pi N})\ X_{\Delta\pi}^{JILL'} + T_{\rho N}^{JILL'}(E)\ BW_{\rho}(E_{\pi\pi})\ X_{\rho N}^{JILL'} + T_{\varepsilon N}^{JILL'}(E)\ BW_{\varepsilon}(E_{\pi\pi})\ X_{\varepsilon N}^{JILL'} \right\} .$$

In this expression the BW's denote either appropriate Breit-Wigner's or the corresponding two-body amplitude from πN or ππ partial-wave analyses. The functions X contain all the angular information; these are well defined functions depending only on which isobars are used in the model. The partial-wave amplitudes, $T_{\Delta\pi}^{JILL'}$, etc., may be indicated by

$$\Delta\pi, LL'_{2I2J} \qquad \rho N, LL'_{2I2J} \qquad \varepsilon N, LL'_{2I2J}$$

where L is the incoming (πN) angular momentum, and L' is the outgoing angular momentum between the isobar [ρ, ε(= ππ I = 0, S wave), Δ] and the remaining hadron (N or π); as usual I and J are the isospin and total spin ($\vec{J} = \vec{L} + \vec{S} = \vec{L}' + \vec{S}'$), respectively. Often the ρ is given a subscript 1 or 3 which denotes twice the ρN total spin. The generalization of the model to include more quasi-two-body final states is obvious. It should be noted that one assumes the partial-wave amplitudes depend only on the c.m. energy E and not on the diparticle subenergies, $E_{\pi\pi}$ and $E_{\pi N}$.

Results from three large isobar analyses have recently become available. The earliest is that of the LBL-SLAC collaboration, LONGACRE 75 and Ref. 1 which analyzes 200K events of $\pi^-p \to \pi^-\pi^0 p$, $\pi^+\pi^- n$ and $\pi^+p \to \pi^+\pi^0 p$ in the c.m. energy range 1300 - 2000 MeV. The Saclay group has analyzed 100K events of the same reactions in the range 1360 - 1760 MeV (LONGACRE 77). Preliminary results of the Imperial

College group for $\pi^+p \to \pi^+\pi^0p$ and $\pi^+\pi^+n$ between 1430 and 1700 MeV were presented at the Oxford Baryon Conference.[2] These three analyses have been reviewed and compared by Barnham,[2] with the general conclusion that the couplings of the more prominent resonances to the πΔ channel are in good agreement, but that there remain serious disagreements over the ρN couplings. Resonance parameters, including pole positions, from LONGACRE 75 and LONGACRE 77 are included in the Data Card Listings. An interesting result of LONGACRE 77 is the claim that there are two previously unreported resonances at 1550 MeV, a 200-MeV wide P_{13} and a 100-MeV wide P_{31}, which are observed in both the πΔ and ρN channels.

Several aspects of these isobar analyses have been criticized. The most detailed and quantitative criticism has centered on two points. First, none of the present analyses include one-pion-exchange (OPE) in their parametrizations. The effects of this have been investigated by Aaron et al.[3] and by Novoseller.[4] It is found that OPE can have appreciable effects, including possible resolution of the overall phase ambiguity, above about 1700 to 1800 MeV. Second, the assumption that the partial-wave amplitudes do not depend on the diparticle subenergies is inconsistent with unitarity. The construction of a parametrization which simultaneously satisfies unitarity and has the correct analytic structure is very difficult. Much theoretical effort has gone into the construction of such parametrizations, but as yet they have not been used in a comprehensive $\pi N \to \pi\pi N$ analysis. A rough estimate of the magnitude of the unitarity corrections is given in Ref. 2. More progress has been made in the analogous 3π final state analyzed in production experiments. Discussion of the current situation, and references to earlier work which is also relevant to the ππN channel, can be found in Refs. 5 and 6.

References for Section III

1. D. J. Herndon et al., Phys. Rev. D11, 3183 (1975).
2. K. W. J. Barnham in Proceedings of the Topical Conference on Baryon Resonances (Oxford, 1976), edited by R. T. Ross and D. H. Saxon, pg. 109.
3. R. Aaron et al., Northeastern University Report NUB #2306 (October 1976).
4. D. E. Novoseller, California Institute of Technology Reports CALT-68-596 and CALT-68-608 (June 1977).
5. I. J. R. Aitchison, J. Phys. G: Nucl. Phys. 3, 121 (1977).
6. R. L. Schult and H. W. Wyld, Jr., Phys. Rev. D16, 62 (1977).

IV. Photon Couplings

IVa. Photoproduction

The couplings of γN to the N and Δ resonances can in principle be studied in any formation process such as $\gamma N \to N^* \to \pi N, \eta N, K\Lambda$, etc., provided that the strong decay channel is well understood. In practice, almost all information about the couplings comes from the partial-wave analysis of single-pion photoproduction, for which there is a large amount of experimental data. Also, elastic scattering in the πN channel has been well studied and all photoproduction analyses rely heavily on the resulting information about the resonance masses and widths.

The most important analyses of single-pion photoproduction are reviewed briefly below. The formalism for this work has been described in the mini-review in the 1976 Review of Particle Properties,[1] and readers are referred there for further information. There are three basic techniques used in the analyses.

(a) Simple Isobar Model

This is the simplest form of energy-dependent analysis. The partial waves are parametrized as smooth background to which appropriate Breit-Wigner resonant structure is added. The electric Born terms are included exactly to reproduce the forward peak in charged-pion photoproduction but the magnetic terms are assumed to be included in the background of the partial waves. The couplings for the Breit-Wigner amplitudes and the parameters for the background are varied to get the minimum χ^2 for experimental data within the required energy range. This method is sufficiently flexible to give a good fit to the experimental data. However, due to the large number of partial waves involved in the process, there are, in principle, difficulties concerning the uniqueness of the solution that is obtained. This is overcome by the form of

parametrization but it is not clear how this biases the solution.

The two important analyses of this kind are very similar. METCALF 74 is a continuation of the earlier Walker analysis[2] and fits $\gamma p \to \pi^+ n$, $\pi^0 p$ and $\gamma n \to \pi^- p$ from the first to the fourth resonance regions. FELLER 76 analyzes $\gamma p \to \pi^+ n$, $\pi^0 p$ from the first to the third resonance regions using data that was not available to the work of METCALF 74. Other isobar analyses (ROSSI 73, HEMMI1 73, HEMMI2 73, BENEVENTANO 74, and KRIVETS 74[3]) have been made on a significantly smaller scale using small and sometimes restricted data sets.

(b) Fixed-t Dispersion Relations (FTDR)

This technique invokes the resonance dominance of the imaginary parts of the photoproduction amplitudes to get a simple parametrization scheme. Only the imaginary parts of the partial waves are parametrized and the real parts of the photoproduction amplitudes are calculated using fixed-t dispersion relations. In some analyses, background terms are added to the imaginary parts of the low angular momentum partial waves, but, in general, the process can be described almost entirely by the parameters for Breit-Wigner resonances. Usually, the masses and widths are restricted to values close to those from πN phase-shift analyses but it has been shown by CRAWFORD 75 and BARBOUR 76 that it is possible to get stable values for these in photoproduction analyses for resonances from the first to the third resonance regions.

Since the number of free parameters is relatively small, this approach has fewer problems with non-unique solutions compared to more general forms of parametrization. However, it is less flexible and tends to achieve poorer fits than, for example, the isobar models. It has the advantage of containing the exact Born terms and it has built into it exactly the correlation between structure in the real and imaginary parts that is required by analyticity. The most important weakness of FTDR is caused by divergence problems in the partial-wave expansions that are used to calculate the dispersion integrands at unphysical values of t. This restricts the method to fitting data at $|t|$ values of less than 1 or 1.5 $(\text{GeV/c})^2$. Another problem is the need to know the dispersion integrands at all energies. This has been treated in recent analyses by making a simultaneous amplitude analysis above the resonance region.

FTDR analyses have been made by groups at Berkeley (MOORHOUSE 73, KNIES 74, MOORHOUSE 74), at Lancaster (DEVENISH 73, DEVENISH2 74), and at Glasgow (CRAWFORD 75, BARBOUR 76). All three groups have made analyses from the first resonance region to a center-of-mass energy of 2 GeV.

(c) Energy-Independent Analyses

These determine the partial waves by making independent fits over a range of essentially single-energy values and are thus the least biased of the techniques employed. However, to obtain unique solutions, it is necessary to use Watson's theorem[4] to fix the complex phase of most of the partial waves and it is extremely difficult to use this method above the first resonance region. Thus most analyses of this type contribute little to the knowledge of the photonic resonance couplings. Only BERENDS 77 contains an analysis of the second resonance region, and couplings are quoted for the $P'_{11}(1470)$, $D'_{13}(1520)$, and $S'_{11}(1535)$ resonances. The most interesting result is the claim that the $A^p_{3/2}$ coupling for the D'_{13} that is typically obtained in energy-dependent analyses is too large by a factor of almost two due to the omission of non-resonant background.

Resonance Couplings and Errors in the Data Card Listings

The Listings give the photonic couplings obtained in all recent and extensive photoproduction partial-wave analyses. If no errors are quoted, the authors have given a unique result without quoting an error. The Berkeley analyses and CRAWFORD 75 quote as an error the spread of values for various solutions around a central value. The Lancaster Group estimate a "real error" for each parameter of a given solution that corresponds to the change in value required to increase "the best possible χ^2" by 1%. METCALF 74 and FELLER 76 make a similar error analysis. Thus there is a large variation in the errors quoted for individual couplings. However, the variation in the values of the couplings in the various papers is generally as large as or larger than the quoted uncertainties,

indicating that the systematic effects of the various parametrizations are at least as important as the essentially statistical effects represented by the quoted errors. This is reflected in the errors given in Table IV.1 which contains the values for the couplings obtained by combining the results from the various analyses.

TABLE IV.1. The average of the couplings from MOORHOUSE 74, KNIES 74, METCALF 74, DEVINISH2 74, CRAWFORD 75, BARBOUR 76, and FELLER 76. The errors given take account of the errors quoted in these analyses and the differences between the analyses.

Resonance	Helicity	Helicity Couplings $(GeV)^{-\frac{1}{2}}$ 10^{-3} A^p_λ	A^n_λ
$P'_{11}(1470)$	1/2	-73 ± 20	37 ± 27
$D'_{13}(1520)$	1/2	-8 ± 9	-74 ± 16
	3/2	166 ± 11	-130 ± 20
$S'_{11}(1535)$	1/2	64 ± 19	-61 ± 34
$D'_{15}(1670)$	1/2	19 ± 14	-33 ± 25
	3/2	20 ± 13	-60 ± 33
$F'_{15}(1688)$	1/2	-5 ± 17	23 ± 14
	3/2	132 ± 23	-18 ± 20
$S''_{11}(1700)$	1/2	44 ± 24	-18 ± 26
$D''_{13}(1700)$	1/2	-10 ± 38	-11 ± 60
	3/2	5 ± 29	10 ± 50
$P''_{11}(1780)$	1/2	11 ± 48	7 ± 55
$P''_{13}(1810)$	1/2	26 ± 44	-6 ± 39
	3/2	-34 ± 50	-17 ± 65
		A^Δ_λ	
$P'_{33}(1232)$	1/2	-137 ± 7	
	3/2	-254 ± 5	
$S'_{31}(1650)$	1/2	43 ± 50	
$D_{33}(1670)$	1/2	67 ± 48	
	3/2	69 ± 50	
$P''_{33}(1690)$	1/2	-8 ± 35	
	3/2	-7 ± 35	
$F_{35}(1890)$	1/2	28 ± 25	
	3/2	-1 ± 57	
$P''_{31}(1910)$	1/2	-12 ± 20	
$F_{37}(1950)$	1/2	-71 ± 22	
	3/2	-71 ± 27	

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For other references see the Data Card Listings.

IVb. Electroproduction in the Resonance Region

(by F. Foster, Lancaster University)

Both the quantity and quality of the data continue to improve in this interesting but somewhat unfashionable corner of the ν, Q^2 plane. Most experiments now use the coincidence technique: detecting the scattered electron to fix the energy and momentum transfer, together with one of the final state hadrons ($p,\pi^\pm$). By this method the virtual photoproduction differential cross sections for particular exclusive channels can be determined.

At the date of the last Review many excellent data sets were already available. These included π^0 production in the first resonance region from DESY,[1,2] the Lancaster-Manchester group at Daresbury,[3] and Bonn University.[4] There was also good π^0 data in the second resonance region[5] and forward π^+ data in the second and third resonance regions from Lancaster-Manchester.[6] Much interest was generated by the η data from Daresbury, DESY, and Bonn, which is a unique indicator for the $S'_{11}(1535)$ resonance.[7-9] The total cross-section measurements from DESY,[10] Bonn,[11] and Stanford[12] gave essential information on the Q^2 variation of the resonance "peak" heights in relation to the background, and demonstrated that the longitudinal-to-transverse ratio σ_L/σ_T was everywhere very close to zero.

During the past two years much new information has become available. In particular we have the detailed data sets from DESY on single π^+ and π^0 production in the second and third resonance regions[13,14] at Q^2 values of 0.6 and 1.0 GeV^2, and new η data near the $S'_{11}(1535)$ from DESY[15,16] at 0.6, 1.0, 2.0, and 3.0 GeV^2 and Bonn[17] at Q^2 of 0.4 GeV^2. By changing the virtual photon polarization, both groups have succeeded in measuring the longitudinal

excitation of the S'_{11} resonance with the results: $\sigma_L/\sigma_T = 0.15 \pm 0.18$ ($Q^2 = 0.6$),[15] -0.06 ± 0.16 ($Q^2 = 1.10$),[16] 0.16 ± 0.10 ($Q^2 = 0.4$).[17] The Lancaster-Manchester group has taken a large amount of data on π^- and π^+ production from a deuterium target over the second and third resonance regions at Q^2 values 0.5 and 1.0 GeV^2. From this data it will be possible to extract the differential cross sections $\gamma_v n \to p\pi^-$, which are essential to the understanding of the multipole couplings to the isospin-1/2 resonances. Preliminary data were available at the Hamburg conference[18] for the π^-/π^+ ratio at $Q^2 = 0.5$ GeV^2 in the forward direction, and estimates were presented of the neutral $D'_{13}(1520)$ multipole couplings.[19]

Theoretical analyses of the data sets to extract resonance multipole couplings necessarily rely on fixed-t dispersion-relation calculations which relate the real (background) and imaginary (resonant) parts of these matrix elements. R. C. E. Devenish and D. H. Lyth[20] incorporated the constraints into an energy-dependent fitting procedure and produced the first estimates of second and third resonance multipoles up to $Q^2 = 1.5$ GeV^2 using the Lancaster-Manchester[5,6] and preliminary DESY π^0, π^+, and η data together with total cross-section measurements. Since then, Gayler[21] has used the final DESY data in the same fitting routines and has produced improved results on the couplings to the $S'_{11}(1535)$, $D'_{13}(1520)$, $F'_{15}(1688)$, and $P'_{11}(1470)$ resonances.

The present status of the couplings to the more prominent resonant states may be summarized as follows:

$P'_{33}(1232)$: There is no change from previous reviews. However, Gayler remarks[21] that while the resonance appears to be a dominantly magnetic (quark spin flip) excitation, the background, which forms an increasing fraction of the single-pion cross section as Q^2 increases, is dominantly helicity-1/2 in the $\gamma_v p$ system. This is to be expected on the basis of the quark parton model and duality.

$D'_{13}(1520)$: It is firmly established[6,13,14,21] that the transverse helicity-1/2 excitation increases rapidly as Q^2 increases from 0 to 1.0 GeV^2. The rate of increase observed depends on the details of the fitting procedures used, but is consistent with the magnetic coupling falling slowly and the electric coupling falling like a "dipole," almost as one would expect from a naive harmonic oscillator quark model.[22]

$S'_{11}(1535)$: The new data[14-17] establish beyond doubt that the excitation of this resonance falls less rapidly than its SU(6) partner $D'_{13}(1520)$ and the excitation is dominantly transverse. At $Q^2 = 0$, contributions of the D'_{13} and S'_{11} are in the ratio 4:1, while at $Q^2 = 3.0$ GeV^2 the ratio becomes an amazing 1:2. Thus the second resonant peak in total cross-section measurements at high Q^2 is dominated by the $S'_{11}(1535)$ — this may account for possible small changes in the observed shape as Q^2 increases.

$P'_{11}(1470)$: The situation here is fluid; although there are no clear signals for this resonance, some analyses[21] do require a significant contribution at $Q^2 = 1.0$ GeV^2. New π^0 and π^+ data from Lancaster-Manchester below the second resonance and from DESY at high Q^2 may clarify the position.

$F'_{15}(1688)$: Here again the helicity-1/2 to helicity-3/2 ratio is observed to increase with Q^2 as we expect from the quark model.

Some progress has been made in understanding the phenomenology of resonance electroproduction within the framework of $SU(6)_w$ symmetry.[23] Cashmore et al.,[24] for example, have shown that radiative transitions between the nucleon and members of the $\{70,1^-\}$ multiplet are consistent with only three independent amplitudes, corresponding to quark orbit flip, spin flip, and simultaneous spin-orbit excitation. (Note that the spin-orbit term is normally neglected in "naive" quark model calculations.[22]) It is necessary to find out if this relatively simple structure persists as Q^2 increases and, if it does, to determine the Q^2 variation of the three amplitudes. Using mainly the amplitudes connecting the proton and the charged D'_{13} and S'_{11} resonances, Foster[25] and Alcock et al.[26] have shown that all three excitation terms are necessary to describe electroproduction at Q^2 values up to 1 GeV^2. The orbit flip term falls rapidly, while the spin flip term remains almost constant as Q^2 increases (just like the simple quark model predictions), causing the observed helicity change-

over. The spin-orbit term has an intermediate variation with Q^2 and appears to be influential in causing the S'_{11} to dominate the D'_{13} at Q^2 values above 0.5 GeV^2. To be sure that the three terms are sufficient to describe electroproduction of the $\{70,1^-\}$ multiplet we will have to await accurate determination of more charged resonance multipoles or some measurements of the neutral isospin-1/2 resonance multipoles. The preliminary data from Lancaster-Manchester[18,19] on the process $\gamma_v n \to \pi^- p$ near the second resonance give results for M^n_{2-} and E^n_{2-} which are in fair agreement with the $SU(6)_w$ scheme.[25]

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V. Production Experiments

It is difficult to draw firm conclusions about N and Δ resonance properties from production experiments because each prominent bump seen in production is generally a coherent superposition of several resonances plus non-resonant background. However, production and formation experiments are clearly closely related, and we give parameters obtained from production experiments in the Listings, although they are not used in the Tables. Starting with this edition, we will also include a brief review of the main results of recent N and Δ production experiments. This year we concentrate on diffractive production of πN and ππN systems as this is where most of the recent experimental activity has been.

Data on the exclusive channels NN → NNπ and NNππ at high energy are now available, both from FNAL (BIEL 76) and the CERN ISR (WEBB 75, DEKERRET 76). The diffractively produced πN and ππN systems have mass shapes which are remarkably similar to those observed at lower momenta.

The low mass πN system is dominated by a broad bump peaking around 1.35 GeV, on which may be superimposed other structures at 1.5 and 1.7 GeV. The 1.35 GeV bump is produced more peripherally than those at 1.5 and 1.7 GeV (DEKERRET 76, HARRIS 77). The two higher mass peaks are probably associated with the $D'_{13}(1520)$ and $F'_{15}(1688)$, respectively.

There is mounting evidence for an appreciable $J^P = 1/2^-$ component in low mass N→Nπ diffractive dissociation. This is in violation of the Gribov-Morrison rule which would allow only $1/2^+$, $3/2^-$, $5/2^+$, etc. The reactions $\pi^\pm p \to \pi^\pm(p\pi^0)$ and $\pi^\pm(n\pi^+)$ have been analyzed by OCHS 75 at 14 GeV/c and OTTERl 77 at 16 GeV/c [who included data on $\pi^\pm p \to \pi^0(p\pi^\pm)$]. In each case the data were fitted with coherent sums of diffractive and Δ-production amplitudes. Both analyses concluded that there is

significant diffractive production of $1/2^-$ background for πN masses below 1.3 - 1.4 GeV. Moreover, the diffractively produced πN system could be described completely by $1/2^-$ and $3/2^+$ waves only (i.e., both Gribov-Morrison violating), although a sizeable $3/2^-$ contribution could not be excluded. SOTIRIOU 75 also analyzed $\pi^+ p \to \pi^+(n\pi^+)$ at 16 GeV/c for $n\pi^+$ masses below 2 GeV. In addition to enhancements associated with known resonances, a 200-MeV broad bump at 1.35 GeV was found. The J^P determination at low mass was not completely unambiguous, but the bump appears to be predominantly $1/2^-$ below 1.35 GeV, and predominately $1/2^+$ above. RUSHBROOKE 76 analyzed data on $np \to (p\pi^-)p$ from 9 to 24 GeV/c. They used a Deck-plus-resonances parametrization and found broad resonance signals in both the $1/2^-$ and $1/2^+$ waves at about 1.4 GeV, as well as a large $1/2^-$ Deck contribution peaking below 1.3 GeV. In STRACHMAN 75 the t-channel isospin-0 and isospin-1 parts of $\bar{N}N \to \bar{N}(N\pi)$ at 5.7 GeV/c were separated and the $I_t = 1$ Nπ mass spectrum found to contain known resonance peaks, while the $I_t = 0$ spectrum had only a broad bump centered at 1.35 GeV.

The low mass ππN system exhibits a broad enhancement below 2 GeV on which subsidiary peaks are superimposed at around 1.5 and 1.7 GeV. The production characteristics are consistent with diffraction.

Partial-wave analyses of diffractively produced ππN systems have recently been carried out by BLOBEL 75, CARNEY 76, BACON 77, HEINEN 77, and OTTER2 77. All the analyses use bubble chamber data in the medium energy range. BLOBEL 75 analyze $pp \to p(p\pi^+\pi^-)$ at 12 and 24 GeV/c. CARNEY 76 use a compilation of data on $K^+p \to K^+(p\pi^+\pi^-)$ between 7.3 and 16 GeV/c. The reaction $K^-p \to K^-(p\pi^+\pi^-)$ is studied by HEINEN 77 at 4.2 GeV/c and by OTTER2 77 at 10, 14.3, and 16 GeV/c. BACON 77 analyze the 10 and 16 GeV/c data of OTTER2 77 together with $\pi^\pm p \to \pi^\pm(p\pi^+\pi^-)$ at 8, 16, and 23 GeV/c.

All the analyses agree that the low mass ππN system can be adequately described assuming a dominant contribution from partial waves having spin-parities $J^P = 1/2^+$, $3/2^-$, and $5/2^+$, and having Δπ, pε, and, to a less extent, pρ decay modes only. CARNEY 76 require $J \geq 7/2$ above about 1.7 GeV. BLOBEL 75 and BACON 77 cannot rule out alternative solutions completely in terms of partial waves in the series $J^P = 1/2^-$, $3/2^+$, $5/2^-$, etc., although this conclusion is not supported by CARNEY 76. OTTER2 77 find evidence for a small contribution (of order 20%) from $5/2^-(\ell=2)\Delta\pi$ in the mass region 1.60 - 1.75 GeV in addition to partial waves satisfying the Gribov-Morrison rule. The shape of the $5/2^-$ enhancement is consistent with a Breit-Wigner form ($M \approx 1.67$ GeV, $\Gamma = 0.15$ GeV) and is interpreted as evidence for production of $D'_{15}(1670)$.

It seems clear that the enhancement at 1.5 GeV is predominantly $3/2^-(\ell=0)\Delta\pi$, although other partial waves such as $1/2^+(\ell=0)p\varepsilon$ are contributing in this region. No evidence for a resonant nature of the 1.5 GeV enhancement could be obtained from studies of relative phases (BLOBEL 75, BACON 77, HEINEN 77, OTTER2 77).

The situation concerning the peak at 1.7 GeV is more complex in that the different analyses come to different conclusions as to the detailed spin-parity decomposition. However, all analyses do agree that the major contribution is not from $5/2^+$ and thus the enhancement cannot be completely associated with the $F'_{15}(1688)$. BLOBEL 75 find that the dominant partial wave is $3/2^-(\ell=1)p\varepsilon$ with some contribution from $5/2^+(\ell=1)\Delta\pi$. CARNEY 76 cannot conclusively identify all the waves contributing to the enhancement, but both $3/2^-(\ell=1)p\varepsilon$ and $3/2^-(\ell=2)\Delta\pi$ are strong. On the other hand, BACON 77 find that $1/2^+(\ell=0)p\varepsilon$ is important in the 1.7 GeV region, together with $3/2^-(\ell=1)p\varepsilon$, $3/2^-(\ell=2)\Delta\pi$, and $5/2^+(\ell=1)\Delta\pi$. HEINEN 77 also find that spin-parity $1/2^+$ contributes, but that the decay mode is $(\ell=1)\Delta\pi$. In addition, $3/2^-(\ell=1)p\varepsilon$ and $5/2^+(\ell=2)p\varepsilon$ are present. Similarly, OTTER2 77 conclude that the 1.7 GeV enhancement is composed of several partial waves with spin-parities $1/2^+$ (or $1/2^-$ — the analysis cannot distinguish the two possibilities in this region), $3/2^-$, and $5/2^+$ all contributing, as well as $5/2^-(\ell=2)\Delta\pi$.

It is interesting to note that the Gribov-Morrison rule appears to be reasonably well satisfied for diffractively produced ππN systems, in contrast to the situation for πN diffraction dissociation. This could be connected with the fact that the Deck mechanism is expected to be important at low mass and that the major contribu-

Data Card Listings

For notation, see key at front of Listings.

tion is to S-wave states. Thus S-wave $\Delta\pi$ ($J^P = 3/2^-$) and $p\varepsilon(1/2^+)$ both give rise to spin-parities in the "allowed" series, whereas S-wave $\pi N(1/2^-)$ does not. A similar situation occurs in three-meson diffractive production, where the "allowed" series is dominant.

References for Section V

See the Data Card Listings.

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STATUS OF N* RESONANCES
THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

PARTICLE	LIJ	OVERALL STATUS	TOTAL# CR.S.	STATUS AS SEEN IN -- PI N	ETA N	K LAM	K SIG	PI DE	GAM N	OTHER CHANN.
N(939)	P11	****								
N(1470)	P11	****		****				***	***	EPS N
N(1520)	D13	****	****	****	*			***	***	RHO N
N(1535)	S11	****		****	***			*	***	RHO N
N(1540)	P13	*						*		RHO N
N(1670)	D15	****	***	****	*	*		***	***	RHO N
N(1688)	F15	****	***	****	*	*		***	***	RHO N
N(1700)	S11	****		****	*	***	**	***	***	RHO N
N(1700)	D13	***		**		**	*	**	*	RHO N
N(1780)	P11	***		***	*	**	*	***	**	RHO N
N(1810)	P13	***		***	*	**	*	*	*	RHO N
N(1990)	F17	**		**	*	*	*		*	
N(2000)	F15	**		**		*	*		*	
N(2040)	D13	**		**	*	*			*	
N(2100)	S11	*		*						
N(2100)	D15	**		**		*				
N(2190)	G17	***	***	***	*	*	*		*	
N(2200)	G19	***		***						
N(2220)	H19	***	***	***						
N(2650)	1111	***	***	***						
N(3030)		***	***	*						
N(3245)		*	*							
N(3690)		*	*							
N(3755)		*	*							
DEL(1232)P33		****	****	****	F				****	
DEL(1550)P31		*			O			*		RHO N
DEL(1650)S31		****	**	****	R			***	**	RHO N
DEL(1670)D33		***	***	***	B		*	***	*	RHO N
DEL(1690)P33		***		***	I			***	*	RHO N
DEL(1890)F35		****	*	****	D		*	*	*	RHO N
DEL(1900)S31		*	*	*	D		*			
DEL(1910)P31		****	*	****	E		*	*	*	RHO N
DEL(1950)F37		****	***	****	N		*	**	*	RHO N
DEL(1960)D35		***	*	***	F		*	*	*	
DEL(2160)		***		***	O		*			
DEL(2420)H311		***	***	***	R					
DEL(2850)		***	***	**	B					
DEL(3230)		***	***	*	I					

**** GOOD, CLEAR, AND UNMISTAKABLE.
*** GOOD, BUT IN NEED OF CLARIFICATION OR NOT ABSOLUTELY CERTAIN.
** NEEDS CONFIRMATION.
* WEAK.
* ATTRIBUTED TO THE STATE CLOSEST TO WHERE THE CROSS SECTION PEAKS.

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********

S=0 I=1/2 NUCLEON STATES (N)

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********

p

16 PROTON(938, J=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

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****** ********* ********* ********* ********* ********* ********* ********

n

17 NEUTRON(939, J=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********

N(1470)

61 N*1/2(1470, JP=1/2+) I=1/2 P'_{11}

MASS AND WIDTH ARE BEST DETERMINED FROM PARTIAL WAVE ANALYSES. WE LIST PRODUCTION EXPERIMENTS SEPARATELY -- SEE BELOW.

AYED 76 CLAIMS TWO P11 STATES IN THE 1500 MEV REGION. WE TENTATIVELY LIST BOTH HERE.

61 N*1/2(1470) MASS (MEV)

M		(1370.0)	BRANDSEN	65 RVUE	PHASE-SHIFT ANAL		9/66
M		(1380.0)	ROPER	65 RVUE	PHASE-SHIFT ANAL		9/66
M	1	(1470.0)	BAREYRE	68 RVUE	PHASE-SHIFT ANAL		11/67
M	1	WHERE CROSS SECTION IS GREATEST - EYEBALL FIT					
M	3	(1466.0)	DONNACH1	68 RVUE	PHASE-SHIFT ANAL		6/68
M	6	(1461.0)	AYED	70 IPWA			1/71
M	6	FROM ENER. DEP. FIT OF ARGAND DIAGRAM					
M	4	(1462.0)	DAVIES	70 RVUE	P-S ANAL SOL A		8/69
M	7	(1470.)	ALMEHED	72 IPWA			2/72
M		1405. TO 1420.	CRAWFORD	75 DPWA	PI N PHOTO-PROD		1/76
M	L	1415. OR 1390.	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
M	L	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.					11/75
M	2	(1413.)	AYED	76 IPWA			11/77*
M	2	(1532.)	AYED	76 IPWA			11/77*
M	2	AYED 76 FINDS 2 DIFFERENT P11 RESONANCES IN THIS REGION IN CONTRAST					11/77*
M	2	TO ALL OTHER PWAS. WE LIST BOTH TOGETHER HERE UNTIL					11/77*
M	2	SITUATION IS FURTHER CLARIFIED.					11/77*
M		(1404.)	BARBOUR	76 DPWA	PI N PHOTO-PROD		1/76
M		(1460.)	BERENDS	77 IPWA	PI-N PHOTO-PROD		1/78*
M	8	(1380.)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
M	8	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE					11/77*
M	8	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.					11/77*

61 N*1/2(1470) WIDTH (MEV)

W	1	(255.0)	BAREYRE	68 RVUE			11/67
W	3	(211.0)	DONNACH1	68 RVUE			6/68
W	6	(164.0)	AYED	70 IPWA			1/71
W	4	(391.)	DAVIES	70 RVUE	P-S ANAL SOL A		8/69
W	7	(220.)	ALMEHED	72 IPWA			2/72
W		255. TO 396.	CRAWFORD	75 DPWA	PI N PHOTO-PROD		1/76
W	L	180. OR 200.	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
W	2	(182.) (SMALLER MASS)	AYED	76 IPWA			11/77*
W	2	(75.) (LARGER MASS)	AYED	76 IPWA			11/77*
W		(330.)	BARBOUR	76 DPWA	PI N PHOTO-PROD		1/76
W		(279.)	BERENDS	77 IPWA	PI-N PHOTO-PROD		1/78*
W	8	(200.)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
		SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.					

61 N*1/2(1470) REAL PART OF POLE POSITION (MEV)

RE		(1375.) (5.)	LEE	73	FIT TO ALMEHED72		1/74
RE		(1381.)	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
RE	8	1360. OR 1333.	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

61 N*1/2(1470) 2*IMAG PART OF POLE POSITION (MEV)

IM		(216.) (10.)	LEE	73	FIT TO ALMEHED72		1/74
IM		(209.)	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
IM	8	167. OR 234.	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

61 N*1/2(1470) ABSOLUTE VALUE OF POLE RESIDUE (MEV)

ABS		(74.) (5.)	LEE	73	FIT TO ALMEHED72		1/74

61 N*1/2(1470) PHASE OF POLE RESIDUE (RADIANS)

PH		(-1.4)	LEE	73	FIT TO ALMEHED72		1/74

61 N*1/2(1470) PARTIAL DECAY MODES

		DECAY MASSES	
P1	N*1/2(1470) INTO PI N	139+ 938	
P2	N*1/2(1470) INTO N EPSILON	938+1300	
P3	N*1/2(1470) INTO N*3/2(1232) PI	1232+ 139	
P4	N*1/2(1470) INTO N PI PI	938+ 139+ 139	
P5	N*1/2(1470) INTO GAMMA N	0+ 938	
P6	N*1/2(1470) INTO N RHO	938+ 776	
P7	N*1/2(1470) INTO GAM P, HELICITY=1/2	0+ 938	
P8	N*1/2(1470) INTO GAM N, HELICITY=1/2	0+ 939	
P9	N*1/2(1470) INTO ETA N	939+ 548	
P10	N*1/2(1470) INTO K LAMBDA	497+1115	
P11	N*1/2(1470) INTO N RHO,S=1/2,P-WAVE	938+ 776	
P12	N*1/2(1470) INTO N RHO,S=3/2,P-WAVE	938+ 776	

61 N*1/2(1470) BRANCHING RATIOS

R1		N*1/2(1470) INTO (PI N)/TOTAL			(P1)		
R1	1	(0.68)	BAREYRE	68 RVUE			11/67
R1	3	(0.658)	DONNACH1	68 RVUE			6/68
R1	6	(0.564)	AYED	70 IPWA			1/71
R1	4	(0.49)	DAVIES	70 RVUE	P-S ANAL SOL A		8/69
R1	A	(0.67) (0.18)	SAXON	70 HBC	AT 1400 MEV		6/70
R1	B	(0.58) (0.09)	SAXON	70 HBC			6/70
R1	7	(0.65)	ALMEHED	72 IPWA			2/72
R1	2	(.54) (SMALLER MASS)	AYED	76 IPWA			11/77*
R1	2	(.16) (LARGER MASS)	AYED	76 IPWA			11/77*
R1	A	A AND B CORRESPOND TO THE 2 BEST SOLUTIONS. ANALYSIS IS DONE ON THRE					
R1	B	BODY DECAYS, ASSUMING ONLY P1, P2 AND P3 DECAYS PRESENT.					
		SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.					
R2		N*1/2(1470) INTO (N EPSILON)/TOTAL			(P2)		
R2		DOMINANT INELASTIC DECAY	THURNAUER	65 RVUE	-		11/67
R2		DOMINANT INELASTIC DECAY	NAMYSLOWS	66 RVUE	-		11/67
R2		DOMINANT INELASTIC DECAY	ROSENFELD	67 RVUE	-		11/67
R2		DOMINANT INELASTIC DECAY	MORGAN	68 RVUE	ISOBAR MODEL		6/68
R2	D	(0.16)	DIEM	70 IPWA	3 BODY ANALYSIS		1/71
R2	D	ASSUMING R1= 0.61					
R2	A	(0.30) (0.20)	SAXON	70 HBC			6/70
R2	B	(0.20) (0.12)	SAXON	70 HBC			6/70
R2	A	AND B CORRESPOND TO THE 2 BEST SOLUTIONS, SEE NOTE IN R1.					
R3		N*1/2(1470) INTO (N*3/2(1232) PI)/TOTAL			(P3)		
R3	D	(0.17)	DIEM	70 IPWA	3 BODY ANALYSIS		1/71
R3	D	ASSUMING R1= 0.61					
R3	A	(0.03) (0.20)	SAXON	70 HBC			6/70
R3	B	(0.22) (0.12)	SAXON	70 HBC			6/70
R3	A	AND B CORRESPOND TO THE 2 BEST SOLUTIONS, SEE NOTE IN R1.					
R3	R	(0.20)	MAKAROV	71 IPWA	0 PI- P TO PI PI N		3/72
R3	R	ASSUMES R1=0.6. MAXIMUM CM ENERGY ANALYZED WAS 1435 MEV.					
R4		N*1/2(1470) INTO (GAMMA N)/(PI N)			(P5)/(P1)		
R4	F	STRONG INDICATION	ROSSI	73 DBC	0 GAM N TO PI-P		2/73
R4	F	DISAGREES WITH OTHER DATA					2/73

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R5      N*1/2(1470) INTO (N RHO )/TOTAL                        (P6)
R5  D        (0.07)                     DIEM      70 IPWA    3 BODY ANALYSIS   1/71
R5  D      ASSUMING  R1= 0.61

R6      N*1/2(1470) INTO (GAMMA N)/TOTAL                       (P5)
R6  E        (.0006)                    MICKENS   71           THEORETICAL EST. 10/71
R6  E   TOTAL WIDTH TAKEN AS 250 MEV.

R7      N*1/2(1470) FROM PI N INTO ETA N                SQRT(P1*P9)          2/74
R7           (+.23)                     LEMOIGNE  73 DPWA    1488 TO 1685 MEV  2/74
R7  9        (+.328)                    FELTESSE  75 DPWA  0 1488 TO 1745 MEV 11/75
R7  9   SUPERCEDES LEMOIGNE 73, USES M AND W OF AYED 76 (LARGER MASS).        11/75
R7  9   AN ALTERNATIVE WHICH CAN NOT BE DISTINGUISHED FROM THIS IS TO HAVE    11/75
R7  9   A P13 RESONANCE WITH M=1530, W=79, AND COUPLING=+.271                 11/75

R8      N*1/2(1470) FROM PI N TO K LAMBDA                SQRT(P1*P10)         4/75
R8 C         -.296      .068            DEVENISH  74         0 FIXED T DISP REL  4/75
R8 C    EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD.               4/75

R9      N*1/2(1470) FROM PI N TO N*3/2(1232) PI          SQRT(P1*P3)         11/75
R9   L       (-.30)OR  -.37             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R9  8        (-.41)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
R9  8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R10     N*1/2(1470) FROM PI N TO N RHO,S=1/2,P-WAVE      SQRT(P1*P11)        11/75
R10  L       (0.0) OR  -.23             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R10 8        (+.11)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R11     N*1/2(1470) FROM PI N TO N RHO,S=3/2,P-WAVE      SQRT(P1*P12)        11/77*
R11 8        (-.18)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
R11 8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R12     N*1/2(1470) FROM PI N TO N EPSILON               SQRT(P1*P2)         11/75
R12  L       (.18)OR  +.23              LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R12 8        (+.18)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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              61  N*1/2(1470) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1470) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1          -.096      .022       DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A1         (-.080)                HEMMI1    73       + FWD PIO PHTOPROD   2/74
A1          -.055      .028       MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A1          -.079      .012       DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A1          -.066      .013       KNIES     74 DPWA    PI N PHOTO PROD    2/74
A1          -.070      .023       METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A1          -.087      .002       MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A1          -.070      .040       CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A1         (-.071)                KRIVETS   75 DPWA    PI-N PHOTO-PROD    1/78*
A1         (-.053)                BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A1          -.087      .006       FELLER    76 DPWA    PI N PHOTO-PROD    2/77*
A1         (-.076)                BERENDS   77 IPWA    PI-N PHOTO-PROD    1/78*
A1                . . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A2      N*1/2(1470) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2           .089      .056       DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A2 8       (-.001)                HEMMI2    73       0 GAM N TO PIO N     4/75
A2 8    CONVERTED TO OUR CONVENTIONS USING M AND W FROM WALKER69 AND X=.55    4/75
A2          +.002      .025       MCORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A2 F         .117      .011       ROSSI     73 DPWA  0 GAM N TO PI- P     4/75
A2 F    CONVERTED TO OUR CONVENTIONS USING M AND W FROM ROSSI73 AND X=.55     4/75
A2 5        (.083)                BENEVENT  74 DPWA  0 GAM N TO PI- P     4/75
A2 5    CONVERTED TO OUR CONVENTIONS USING M=1470 MEV, W=230 MEV, X=.55       4/75
A2           .041      .025       DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A2           .000      .013       KNIES     74 DPWA    PI N PHOTO PROD    2/74
A2           .043      .035       METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A2           .033      .013       MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A2          +.044      .007       CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A2         (+.058)                BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A2                . . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

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REFERENCES FOR N*1/2(1470)


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BRANDSEN 65 PR 139 B1566       +ODONNELL, MOORHOUSE            (DURHAM, RHEL)IJP
ROPER    65 PR 138 B190        LD ROPER,RM WRIGHT,BT FELD   (LRL-LVMR,MIT)IJP
THURNAUE 65 PRL 14 985         P G THURNAUER                           (ROCH)

NAMYSLOW 66 PR 157 1328        NAMYSLOWSKI,RAZMI,ROBERTS  (STAN,EDIN,LOIC)

ROSENFEL 67 IRVINE CONF        A H ROSENFELD, P SODING                  (LRL)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACHI 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK            (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                             (EDIN)
MORGAN   68 PR 166 1731        D MORGAN                                (RHEL)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET           (SACL)IJP
DAVIES   70 NP B21 359         A DAVIES                                (GLAS)
DIEM     70 KIEV CONF.         + SMADJA, CHAVANON, DELER, DOLBEAU+  (SACL)
SAXON    70 PR D2 1790         SAXON, MULVEY, CHINOWSKY             (OXF,LRL)

MAKAROV  71 SJNP 13 510        ,GASILOVA,NELYUBIN,++            (IOFFE INST)IJP
MICKENS  71 LNC  1  707        R E MICKENS                             (FISK)
ALMEHED  72 NP B40 157         +LOVELACE                         (LUND,RUTG)IJP

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH         (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+          (KYOTO+SAGA+KEK+TOKY)IJP
HEMMI2   73 NP B55 333         +INAGAKI,KIKUCHI,MAKI,MIYAKE+ (KYOTO,TOKYO)IJP
LEE      73 PRL 31 1029        LEE,SHAW        (UCI+ROYAL HOLLOWAY COLLEGE)IJP
LEMOIGNE 73 PURDUE CONF. 93    +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK               (GLAS+LBL)IJP
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+     (ROMA,FRAS,NAPL,PAVIA)IJP
    ALSO 71 LNC 2 1183         CARBONARA,FIORE,+     (NAPL,FRAS,PAVIA,ROMA)IJP

BENEVENT 74 NC 19A 529         BENEVENTANO,DANGELO,NOTARISTEFANI,+  (ROMA)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                 (CIT)IJP
MOORHOUS 74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD      (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                          (GLAS)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+      (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII    (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+        (LBL,SLAC)IJP
AYED     76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
BERENDS  77  MC/T/77/17        F.A.BERENDS,A.DONNACHIE           (LEID,MCHS)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE  64 PL 8 137           +BRICMAN,VALLADAS,VILLET, +   (SACLAY,CAEN) IJ
BAREYRE  65 PL 18 342          +BRICMAN, STIRLING, VILLET         (SACLAY)IJP
DALITZ   65 PL 14 159          R H DALITZ, R G MOORHOUSE          (OXF,RHEL)
JOHNSON  67 UCRL-17683 THESIS  C H JOHNSON                              (LRL)
DONNACHI 69 NP 108 433         A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
WALKER   69 PR 182 1729        R L WALKER                            (CIT)IJP
AYED     70 PL 31B 598         +BAREYRE,VILLET                       (SACLAY)
BERARDO  70 PRL 24 419         +HADDOCK,NEFKENS,...,PARSONS+..    (UCLA+LRL)
AYED     72 BATAVIA CONF       R AYED,P BAREYRE, Y LEMOIGNE             (SACL)

     THE FOLLOWING ARE THEORETICAL PAPERS CONCERNING THE N*1/2(1470) --
RESNICK  66 PR 150 1292        L RESNICK                         (NIELS BOHR)
SCHWARZ  66 PR 152 1325        J H SCHWARZ                              (LRL)
BALL     67 PR 155 1725        JS BALL, GL SHAW, DY WONG     (UCLA,UCI,UCSD)
GOLDBERG 67 PR 154 1558        H GOLDBERG                           (CORNELL)
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1470 MEV REGION - PRODUCTION EXPERIMENTS

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              91  N*1/2(1470, JP=    ) I=1/2   PRODUCTION EXPERIMENTS

              UNDER THIS HEADING WE INCLUDE ALL BUMPS WHICH LIE WELL
              BELOW 1500 MEV.  SEE THE MINI-REVIEW PRECEDING THE N
              AND DELTA LISTINGS FOR A DISCUSSION OF PRODUCTION
              EXPERIMENTS.

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              91  N*1/2(1470) MASS (MEV) (PROD.EXP.)

M         (1400.)   APPROX             COCCONI   64 CNTR +  PP 3.6-12 GEV/C
M         (1425.)   APPROX             ADELMAN   65 HBC  +  K-P 1.45 GEV/C    7/66
M         (1430.)   APPROX             ANKENBRAN 65 CNTR +  PP 7.1 GEV/C      7/66
M         (1400.)   APPROX             BELLETTIN 65 SPRK +  PP,D 10-26 GEV/C  7/66
M         (1405.)    (15.)             ANDERSON  66 SPRK +  PP, 6-30 GEV/C    7/66
M         (1410.)    (15.)             BLAIR     66 CNTR +  PP 2.8-7.9 GEV/C  7/66
M         (1400.)    (30.)             FOLEY     67 CNTR    PI+- P AND PP    11/67
M         (1450.)    (17.)             ALMEIDA   68 HBC  +  PP-P2PI ,10GEV/C 10/69
M         (1420.)   APPROX             BELL      68 HBC     PI+- P, 6 GEV/C   6/68
M         (1400.)   APPROX             LAMSA     68 HBC     PI-P , 8 GEV/C    6/68
M   S  175(1446.)    (11.)             SHAPIRA   68 DBC     INTO PPI,PN 7.0  10/69
M   S   THE EFFECT OF SHAPIRA 68, WITH MUCH IMPROVED DATA, HAS ALMOST         11/77
M   S   DISAPPEARED (YEKUTIELI 72).                                           11/77
M         (1390.)    (20.)             TAN       68 HBC     PP TO PIP, 6.1   10/69
M      120(1443.)    (15.)             RHODE     69 HBC     PP 22 GEV/C      10/69
M         (1410.)    (13.)             ANDERSON  70 MMS  -  PI- P TO PI- MMS  2/71
M         (1430.)    (20.)             BALLAM    71 HBC  +- PI+-P AT 16GEV    2/72
M         (1460.)                      BEKETOV   71 HBC  +  PI- P 4.45GEV/C   3/72
M         (1461.)    (10.)             BOESEBEC  71 RVUE    PP,PI-P,K-P PROD  3/72
M      120(1462.0)   (6.0)    120/80   MA        71 HBC  +  P P TO P N PI    10/71
M         (1425.)    (25.)             RUSHBROOKE71 HBC  +  PP TO P2PI 16GEV  2/72
M         (1411.0)   (10.0)            EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV    1/73
M       64(1410.0)   (33.0)            GAGE      72       0 PD  5.9GEV/C     12/72
M         (1464.0)   (7.0)     45/45   KARSHON   72 DBC  +  PD--PD2PI 7 GEV  12/72
M         (1250.)                      LISSAUER  72 DBC   0 K+N TO K+N* 12GV  1/78*
M         (1440.)    (15.)             RONAT     72  HBC    PI+P TO 3PI P     2/73
M         (1479.)    (8.)              LICHTMAN  74 HBC  +  PI+P TO 3PI P     4/75
M         (1430.)    (8.)              LICHTMAN  74 HBC  +  PI-P TO 3PI P     4/75
M   1     (1450.)                      BLOBEL    75 HBC  +  PP TO P(PI+PI-P)  1/76
M   1   PWA INDICATES PI+PI-P ENHANCEMENT IS PRIMARILY AN                      1/76
M   1   S-WAVE DELTA++PI- SYSTEM WITH I,JP=1/2,3/2-.                           1/76
M         (1450.)    (16.)             CAVALLI   75 SPEC +  PP TO 2N*,W=23GV  1/76
M         (1462.)    (11.)             CAVALLI   75 SPEC +  PP TO 2N*,W=31GV  1/76
M         (1466.)    (28.)             CAVALLI   75 SPEC +  PP TO 2N*,W=53GV  1/76
M         (1390.)    (10.)             MUSGRAVE  75 HBC     K+ P TO K PI N   11/75
M          1350. TO 1400.              STRACHMA  75  BC     NBAR (N PI)       1/76
M         (1450.)    (10.)             ATHERTON  76 HBC     PBAR P 5.7 GEV    2/77*
M          1400. TO 1420.              RUSHBROO  76  HBC    P PI- S1-WAVE     2/77*
M          1400. TO 1425.              RUSHBROO  76  HBC    P PI- P1-WAVE     2/77*
M         (1458.)    (20.)             APPLE     77 SPEC +  P P TO P (P PIO)  1/78*
M         (1473.)    (5.)              APPLE     77 SPEC +  P P TO P (N PI+)  1/78*
M   I     (1350.)                      CHADWICK  77 HYBR +  PI+-P  14 GEV/C   1/78*
M   I   CHADWICK 77 CONCLUDE THAT AN INTERPRETATION OF THEIR PEAK AS A        1/78*
M   I   RESONANCE IS HIGHLY IMPROBABLE.                                        1/78*
M         (1460.)    (10.)             HEINEN    77 HBC  +  K-P TO K- N*+     1/78*
M         (1470.)    (10.)             HEINEN    77 HBC   0 K-P TO KOBAR N*0  1/78*
M         (1490.)    (20.)             EKELOF    78 SPEC +  P HE--P PI PI HE  1/78*
M   B     (1250.)                      BERLAND   74 HBC  +0 ISOSPIN ANALYSIS 10/74
M   B     (1230.)                      BRAUN2    75  BC     PBAR P AND D,5.7 11/75
M   B     (1230.)                      STRACHMA  75  BC     NBAR (N PI)       1/76
M   B   THE EFFECT SEEN BY BERLAND 74 IN A PRISM PLOT ANALYSIS, BY BRAUN2     1/76
M   B   75 IN A DALITZ PLOT FIT, AND BY STRACHMAN 75 IN AN AMPLITUDE          1/76
M   B   ANALYSIS LIES WELL BELOW THE MASS OF MOST OTHER BUMPS LISTED HERE.    1/76
M   B   BRAUN2 75 AND STRACHMAN 75 ANALYSE THE SAME DATA.  BERLAND 74         1/78*
M   B   CAN EXPLAIN THE OBSERVED FEATURES OF THEIR DATA WITH A DOUBLE         1/78*
M   B   REGGE EXCHANGE MODEL.                                                  1/78*

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              91  N*1/2(1470) WIDTH (MEV) (PROD. EXP.)

W         (100.)                       BELL      68 HBC     PI+- P AND PP     6/68
W   S  175 (198.)    (40.)             SHAPIRA   68 DBC                      10/69
W         (150.)     (60.)             TAN       68 HBC  +                   10/69
W      120 (100.)    (15.)             RHODE     69 HBC     PP 22 GEV/C      10/69
W         (210.)     (15.)             ANDERSON  70 MMS  -  PI- P TO PI- MMS  2/71
W         (150.)     (40.)             BALLAM    71 HBC  +- PI+-P AT 16GEV    2/72
W         (100.)                       BEKETOV   71 HBC  +  P PI+ PI- MASS    3/72
W          (60.)     (20.)             BOESEBEC  71 RVUE    PP,PI-P,K-P PROD  3/72
W   T  120  (54.0)   (12.0)   120/80   MA        71 HBC  +  P P TO P N PI   .10/71
W   T   NARROW WIDTH SUGGESTS THIS IS NOT THE USUAL N*(1470).                 10/71
W         (125.)     (25.)             RUSHBROOKE71 HBC  +  PP TO P2PI 16GEV  2/72
W         (188.0)    (38.0)            EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV    1/73
W         (212.0)    (62.0)            GAGE      72 DBC   0 PD  5.9GEV/C     12/72
W         (124.0)    (20.0)            KARSHON   72 DBC  +  PD--PD2PI 7 GEV  12/72
W         (300.)                       LISSAUER  72 DBC   0 K+N TO K+N* 12GV  1/78*
W         (100.)     (30.)             RONAT     72  HBC    PI+P TO 3PI P     2/73
W          (50.)     (25.)             LICHTMAN  74 HBC  +  PI+P TO 3PI P     4/75
W          (62.)     (18.)             LICHTMAN  74 HBC  +  PI-P TO 3PI P     4/75
W         (250.)     (95.)             CAVALLI   75 SPEC +  PP TO 2N*,W=23GV  1/76
W         (249.)     (90.)             CAVALLI   75 SPEC +  PP TO 2N*,W=31GV  1/76
W         (205.)    (105.)             CAVALLI   75 SPEC +  PP TO 2N*,W=53GV  1/76
W         (145.)     (35.)             MUSGRAVE  75 HBC     K+ P TO K PI N   11/75
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W          (145.)     (18.)            ATHERTON  76 HBC      PBAR P 5.7 GEV     2/77*
W          (145.)     (30.)            RUSHBROO  76  HBC     P PI- S1-WAVE      2/77*
W          (273.)     (90.)            RUSHBROO  76  HBC     P PI- P1-WAVE      2/77*
W          (120.)     (20.)            APPLE     77 SPEC +   P P TO P (P PIO)   1/78*
W           (30.)     (30.)            APPLE     77 SPEC +   P P TO P (N PI+)   1/78*
W          (120.)     (20.)            HEINEN    77 HBC  +   K-P TO K- N*+      1/78*
W           (90.)     (30.)            HEINEN    77 HBC   O  K-P TO KOBAR N*O   1/78*
W          (200.)                      EKELOF    78 SPEC +   P HE--P PI PI HE   1/78*

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                  91  N*1/2(1470) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      N*1/2(1470) INTO PI N                                139+ 938
P2      N*1/2(1470) INTO N PIPI(J,I=0)                       938+ 139+ 139
P3      N*1/2(1470) INTO N*3/2(1232) PI                     1232+ 139
P4      N*1/2(1470) INTO N PI PI                             938+ 139+ 139
P5      N*1/2(1470) INTO GAMMA N                               0+ 938
P6      N*1/2(1470) INTO N RHO                               938+ 776

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                  91  N*1/2(1470) BRANCHING RATIOS (PROD. EXP.)

R1      N*1/2(1470) INTO (PI N)/TOTAL                        (P1)
R1             (.66)                   TAN       68 HBC      PP TO PIP, 6.1    10/69

R2      N*1/2(1470) INTO (N*3/2(1232) PI)/TOTAL              (P3)
R2                PROBABLY SEEN        JESPERSEN 68 HBC      PP 22 BEV/C       11/68
R2                PROBABLY SEEN        LAMSA     68 HBC      PI-P 8 BEV/C      11/68
R2                DOMINANT             BLOBEL    75 HBC  +   PP TO P(PI+PI-P)   1/78*

R3      N*1/2(1470) INTO (N*3/2(1232) PI)/(N P PI)           (P3)/(P4)
R3 P           0.5       0.2           HEINEN    77 HBC  +   K-P TO K- N*+      1/78*
R3 P     FOR THE P PI+ PI- FINAL STATE ONLY.                                    1/78*

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REFERENCES FOR N*1/2(1470) (PROD. EXP.)


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COCCONI  64 PL    8 134          +LILLETHUN,SCANLON,STAHLBRANDT, +      (CERN)
ADELMAN  65 PRL 14 1043          S L ADELMAN                   (CAMBRIDGE(CERN))
ANKENBRA 65 NC   35 1052         ANKENBRANDT,CLYDE,CORK,KEEFE,KERTH+     (LRL)
BELLETTI 65 PL   18 167          BELLETTINI,COCCONI,DIDDENS +           (CERN)
ANDERSON 66 PRL 16  855          +BLESER,COLLINS,FUJII,+            (BNL,CARN)
BLAIR    66 PRL 17  789          +TAYLOR,CHAPMAN,+  (HARWELL,QUEENMARY,RHEL)

FOLEY    67 PRL 19  397          +JONES,LINDENBAUM,LOVE,OZAKI+           (BNL)
ALMEIDA  68 PR 174 1638          +KUSHBROOKE,SCHARENGUIVEL+       (CAVE,DESY)
BELL     68 PRL 20  164          +CRENNELL,HOUGH,KARSHON,LAI+      (BNL,CUNY)
JESPERSE 68 PRL 21 1368          JESPERSEN,KANG,KERNAN+          (IOWA STATE)
LAMSA    68 PR 166 1395          +CASON,BISWAS,DERADO,GROVES,+  (NOTRE DAME)
SHAPIRA  68 PRL 21 1835          +BENARY,EISENBERG,RONAT,YAFFE+        (REHO)
TAN      68 PL 28B 195           TAN,PERL,MARTIN,VHINOWSKU +  (SLAC+LRL+UCI)
RHODE    69 PR 187 1844          RHODE, LEACOCK, KERNAN, JESPERSEN,+    (ISU)
ANDERSON 70 PRL 25 699           +BLESER,BLIEDEN,COLLINS++          (BNL,CARN)

BALLAM   71 PR D4 1946           +CHADWICK,GUIRAGOSSIAN,JOHNSON,++    (SLAC) I
BEKETOV  71 SJNP 13 605          ,ZOMBKOVSKII,KONOVALOV,KRUCHININ,++  (ITEP)IJ
BOESEBEC 71 NP B33 445           BOESEBECK,GRAESSLER,KRAUS,+++      (ABBCHLV) I
MA       71 PRL   26  333        +COLTON                            (MSU+LBL)I
RUSHBROO 71 PR D4 3273           RUSHBROOKE,WILLIAMS+BAREFORD++  (CAVE,LOIC) IJ

EDELSTEI 72 PR D5 1073           EDELSTEIN,CARRIGAN,HIEN,MCMAHON,+(CARN+BNL)
GAGE     72 NP B46 21            W GAGE,E COLTON,W CHINOWSKI             (LBL)
LISSAUER 72 PRD 6 1852           +FIRESTONE,GINESTET,GOLDHABER,TRILLING(LBL)IJP
KARSHON  72 NP B37 371           +YEKUTIELI,YAFFE,SHAPIRA,RONAT,+     (REHO) I
RONAT    72 NP B38 20            +EISENBERG,LYONS,SHAPIRA,TOAFF+        (REHO)
YEKUTIEL 72 NP B40 77            YEKUTIELI,YAFFE,SHAPIRA,RONAT +        (REHO)

BERLAND  74 NP B75 93            BERLAND,HABER,HODOUS,HULSIZER,+        (MIT)I
    ALSO 74 PL 51B 187           BERLAND,HABER,HODOUS,HULSIZER,+        (MIT)I
LICHTMAN 74 NP B81 31            LICHTMAN,BISWAS,CASON,KENNEY,MCGAHAN+(NDAM)I

BLOBEL   75 NP B97 201           +ESKREYS,FESEFELDT,FRANZ+  (BONN+HAMB+MPIM)IJP
BRAUN2   75 NP B95 503           +GERBER,MAURER,MICHALON,SCHIBY+ STBRB,LPNP I
CAVALLI  75 LNC 14 353           CAVALLI-SFORZA,CONTA+           (PAVIA+PRIN)
    ALSO 75 LNC 14 345+359       CAVALLI-SFORZA,CONTA+           (PAVIA+PRIN)
MUSGRAVE 75 NP B87 365           +PEETERS,SCREINER,WHITMORE,YUTA         (ANL)
STRACHMA 75 NP B98 120           STRACHMAN,BRAUN,GERBER,MAURER+  (LPNP+STRB)I
    ALSO 76 NP B107 330          STRACHMAN                             (LPNP)I

ATHERTON 76 NP B103 381          ATHERTON,FRENCH,SKURA,BOHM+      (CERN+PRAG)
RUSHBROO 76 PRD 13 1835          RUSHRBOOKE,RAJA,ANSORGE,CARTER,NEALE (CAVE) JP
APPLE    77 LNC 18 167           +ASH,CHENG,COYNE,GROSSMAN+       (PRIN+PAVIA)
CHADWICK 77  SLAC-PUB-2018       +CARROLL,CHALOUPKA+     (SLAC+STAN+CIT+LBL)IJP
HEINEN   77 NP B122 443          +ENGELEN,KITTEL,METZGER+   (NIJM+AMST+CERN)IJP
EKELOF   78 NP B132 212          +HERZ,HAGBERG,KULLANDER+   (CERN+UPPS+LOUC)IJ
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PAPERS NOT REFERRED TO IN DATA CARDS

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GELLERT  66 PRL 17 884           +SMITH,WOJCICKI,COLTON,SCHLEIN + (LRL,UCLA)
ALBERI   68 PR 176 1631          +APPEL,BUDNITZ,CHEN,DUNNING,GOITEIN+ (HARV)
WALKER   68 PRL 20 133           +THOMPSON,ROBERTSON,OH,LEE,HARTUNG,+ (WISC)
CLEGG    69 NP B13 222           CLEGG                                  (LANC)
ALEXANDE 73 NP B52 221           ALEXANDER,BENARY+(TEL-AVIV+HEIDELBERG+DESY)
ANSORGE  73 NP B63 93            ANSORGE,MADEN,NEALE,RUSHBROOKE         (CAVE)
BEAUPRE  73 NP B66 93                (AACH+BERL+BONN+CERN+NDAM+PENN+TOHO)I
COOPER   74 NP B79 259           COOPER,SEIDL,VANDERVELDE            (MICH)IJP
DEUTSCHM 75 NP B99 397           DEUTSCHMANN+(AACH+BONN+BERL+CERN+CRAC+HEID)
OCHS     75 NP B86 253           +DAVIDSON,DZIERBA,FIRESTONE+ (CIT+SLAC+LBL)IJP

BIEL     76 PRL 36 504,507       +BLESER,FERBEL+        (ROCH+FNAL+SLAC+NWES)
CARNEY   76 NP B110 248          +COLLEY,JONES,KENYON+ (BIRM+BRUX+CERN+MONS)IJP
DEKERRET 76 PL 63B 477,483       +NAGY,REGLER,BRANDT+   (CERN+HAMB+IPN+VIEN)
RUSHBROO 76 PRD 13 1835          RUSHBROOKE,RAJA,ANSORGE,CARTER,NEALE (CAVE)IJP
SOTIRIOU 76 NP B107 457          D.SOTIRIOU                          (CERN)IJP
BACON    77 NC 42A 431           +BARNHAM,DORNAN,EASON,POLLOCK+      (LOIC)IJP
HARRIS   77 NP B119 189          +LUBATTI,MORIYASU,BINGHAM+        (WASH+UCB)
OTTER1   77 NP B130 349          +RUDOLPH,WIECZOREK+    (AACH+BERL+BONN+CERN)IJP
OTTER2   77  AACHEN IIIB/3-77 +RUDOLPH+          (AACH+BERL+CERN+LOIC+VIEN)IJP
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N(1520)

62 N*1/2(1520, JP=3/2-) I=1/2 D'_{13}

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                  62  N*1/2(1520) MASS (MEV)

M           (1530.0)                   BRANDSEN  65 RVUE    PHASE-SHIFT ANAL  9/66
M           (1536.0)                   ROPER     65 RVUE    PHASE-SHIFT ANAL  9/66
M    1      (1510.0)                   BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    1            WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    3      (1541.0)                   DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M    6      (1523.0)                   AYED      70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    4      (1512.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M    7      (1520.)                    ALMEHED   72 IPWA                      2/72
M            1501. TO 1503.            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
M     L      1524. OR 1520.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M     L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.   11/75
M           (1525.)                    AYED      76 IPWA                     11/77*
M           (1503.)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
M           (1510.)                    BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78*
M    8      (1510.)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77*
M    8   POSITICN WHICH IS FROM SOLUTIONS S1 AND C1.                         11/77*

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                  62  N*1/2(1520) WIDTH (MEV)

W    1       (125.0)                   BAREYRE   68 RVUE                     11/67
W    3       (149.0)                   DONNACH1  68 RVUE                      6/68
W    6       (131.0)                   AYED      70 IPWA                      1/71
W    4       (106.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A
W    7       (120.)                    ALMEHED   72 IPWA                      2/72
W             115. TO  150.            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
W     L       120. OR  150.            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W            (122.)                    AYED      76 IPWA                     11/77*
W            (137.)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
W            (105.)                    BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78*
W    8       (110.)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                  62  N*1/2(1520) REAL PART OF POLE POSITION (MEV)       11/75

RE          (1514.)                    LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   8       1508. OR 1505.            LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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                  62  N*1/2(1520) 2*IMAG PART OF POLE POSITION (MEV)     11/75

IM          (146.)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   8        109. OR 107.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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                  62  N*1/2(1520) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*1/2(1520) INTO PI N                            139+ 938
P2      N*1/2(1520) INTO N*3/2(1232) PI                 1232+ 139
P3      N*1/2(1520) INTO N PI PI                         938+ 139+ 139
P4      N*1/2(1520)+ INTO NEUTRON PI+                    939+ 139
P5      N*1/2(1520)+ INTO PROTCN PI+ PI-                 938+ 139+ 139
P6      N*1/2(1520) INTO N ETA                           939+ 548
P7      N*1/2(1520) INTO N EPSILCN                       938+1300
P8      N*1/2(1520) INTO N RHO                           938+ 776
P9      N*1/2(1520) INTO GAM P, HELICITY=1/2               0+ 938
P10     N*1/2(1520) INTO GAM P, HELICITY=3/2               0+ 938
P11     N*1/2(1520) INTO GAM N, HELICITY=1/2               0+ 939
P12     N*1/2(1520) INTO GAM N, HELICITY=3/2               0+ 939
P13     N*1/2(1520) INTO K LAMBDA                        497+1115
P14     N*1/2(1520) INTO N*3/2(1232) PI,S-WAVE          1232+ 139
P15     N*1/2(1520) INTO N*3/2(1232) PI,D-WAVE          1232+ 139
P16     N*1/2(1520) INTO N RHO,S=3/2,S-WAVE              938+ 776

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                  62  N*1/2(1520) BRANCHING RATIOS

R1      N*1/2(1520) INTO (PI N)/TOTAL                       (P1)
R1   1        (0.54)                   BAREYRE   68 RVUE                     11/67
R1   3        (0.509)                  DONNACH1  68 RVUE                      6/68
R1   6        (0.593)                  AYED      70 IPWA                      1/71
R1   4        (0.45)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
R1   7        (0.58)                   ALMEHED   72 IPWA                      2/72
R1             (.56)                   AYED      76 IPWA                     11/77*
R1      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
R1
R1   ALMOST THE ENTIRE INELASTICITY IS IN N PI PI (ONLY N ETA COULD COMPETE,
R1   AND IT DOESNT).  THE N PI PI SEEMS TO BE MAINLY N*3/2(1232) PI, IN BOTH
R1   S AND D WAVES.

R2      N*1/2(1520) INTO (N*3/2(1232) PI)/TOTAL             (P4)
R2            0.20      0.05           KIRZ      66 HBC    O ASSUMING R1=0.72  9/66
R2            DOMINANT INEL DECAY      OLSSON    66 RVUE    PI P TO PI PI N   9/66
R2   D        (0.40)                   DIEM      70 IPWA    3 BODY ANALYSIS   1/71
R2   D        ASSUMING  R1= 0.5

R3      N*1/2(1520) INTO (N*3/2(1232) PI)/(N PI PI)         (P2)/(P3)
R3             LARGE                   THURNAUER 65 RVUE -                   11/67
R3             LARGE                   NAMYSLOWS 66 RVUE -                   11/67
R3             LARGE                   ROBERTS   67 RVUE -                   11/67
R3             LARGE                   ROSENFELD 67 RVUE -                   11/67
R3             LARGE                   MORGAN    68 RVUE    ISOBAR MODEL      6/68

R4      N*1/2(1520) INTO (N EPSILON)/TOTAL                  (P7)
R4            PROBABLY PRESENT         MORGAN    68 RVUE    ISOBAR MODEL      6/68
R4   D        (0.02)                   DIEM      70 IPWA    3 BODY ANALYSIS   1/71
R4   D        ASSUMING  R1= 0.5
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Baryons
N(1520), N(1535)

Data Card Listing
For notation, see key at front of Listing

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R5     N*1/2(1520) INTO (N ETA)/TOTAL                    (P6)
R5  D      (0.006)   APPROX          DAVIES    67 RVUE                  11/67
R5   DAVIES 67 GIVES SEVERAL VALUES DEPENDING ON INPUT DATA.  ALL ARE SMALL
R5  B      (0.014)                   BOTKE     69 MPWA    T POLE+ RESON.  10/69
R5  B      (0.003)  (0.001)          DEANS     69 MPWA    T POLE+ RESON.   5/70
R5  B      (0.002)OR 0.004           CARRERAS  70 MPWA    T POLE+ RESON.   5/70
R5  B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R5         SEEN                      LEMOIGNE  73 DPWA    1488 TO 1685 MEV  2/74

R6     N*1/2(1520) INTO (N RHO )/TOTAL                   (P8)
R6  D      (0.07)                    DIEM      70 IPWA    3 BODY ANALYSIS   1/71
R6  D      ASSUMING  R1= 0.5

R7     N*1/2(1520) FROM PI N TO K LAMBDA                 SQRT(P1*P13)      4/75
R7  C      -.076     .032            DEVENISH  74        0 FIXED T DISP REL  4/75
R7  C    EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD.           4/75

R8     N*1/2(1520) FROM PI N INTO N EPSILON              SQRT(P1*P7)       11/75
R8  L      (0.0) OR  +.17            LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R8  B      (+.13)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77*

R9     N*1/2(1520) FROM PI N TO N*3/2(1232) PI,S-WAVE    SQRT(P1*P14)      11/75
R9  L      (+.27)OR  +.24            LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R9  B      (+.26)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
R9  B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R10    N*1/2(1520) FROM PI N TO N*3/2(1232) PI,D-WAVE    SQRT(P1*P15       11/75
R10 L      (+.24)OR  +.30            LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R10 B      (+.21)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
R10 B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R11    N*1/2(1520) FROM PI N TO N RHO,S=3/2,S-WAVE       SQRT(P1*P16)      11/75
R11 L      (+.32)OR  +.24            LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R11 B      (+.35)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
R11 B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R12    N*1/2(1520) FROM PI N TO ETA N                    SQRT(P1*P6)       1/76
R12  9     (+.011)OR +.058           FELTESSE  75 DPWA  0 1488 TO 1745 MEV  1/76
R12  9  SUPERCEDES LEMOIGNE 73, USES M AND W OF AYED 76.                    11/77*

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                62  N*1/2(1520) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1     N*1/2(1520) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1          .010      .022           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1        (-.026)                    HEMMI     73         + FWD PIO PHTOPROD 2/74
A1          .026      .015           MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A1          -.008     .015           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1          -.019     .008           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1          -.006     .006           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1           .000     .006           MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A1          -.009     .004           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1         (+.011)                   KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78*
A1         (-.012)                   BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1          -.005     .005           FELLER    76 DPWA    PI N PHOTO-PROD   2/77*
A1         (-.021)                   BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78*
A1          . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A2     N*1/2(1520) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2          .180      .017           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2         +.194      .031           MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A2          .171      .012           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2          .169      .012           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2         +.165      .011           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2          .174      .006           MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2         +.162      .004           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2         (+.138)                   KRIVETS   75 DPWA    PI-N PHOTO-PROD   1/78*
A2         (+.158)                   BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2          +.164     .008           FELLER    76 DPWA    PI N PHOTO-PROD   2/77*
A2         (+.075)                   BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78*
A2          . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A3     N*1/2(1520) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3          -.075     .037           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A3          -.085     .014           MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A3 2        +.037     .012           ROSSI     73 DPWA  0 GAM N TO PI- P    4/75
A3 2   CONVERTED TO OUR CONVENTIONS USING M AND W FROM ROSSI73 AND X=.56     4/75
A3          (0.)                     BENEVENT  74 DPWA  0 GAM N TO PI- P    4/75
A3          -.089     .019           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A3          -.077     .005           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A3          -.066     .010           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A3          -.088     .007           MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A3          -.067     .004           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A3         (-.056)                   BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A3          . . . . . .
A3  AVERAGE MEANINGLESS (SCALE FACTOR = 3.9)

A4     N*1/2(1520) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4          -.126     .028           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A4 8      (-.087)                    HEMMI2    73         0 GAM N TO PIO N  4/75
A4 8   CONVERTED TO OUR CONVENTIONS USING M AND W FROM WALKER69 AND X=.56    4/75
A4 2        -.016     .016    .018 ROSSI     73 DPWA  0 GAM N TO PI- P    4/75
A4          -.124     .013           MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A4 5        (-.035)                  BENEVENT  74 DPWA  0 GAM N TO PI- P    4/75
A4 5   CONVERTED TO OUR CONVENTIONS USING M=1520 MEV, W=120 MEV, X=.56       4/75
A4          -.155     .019           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A4          -.120     .010           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A4          -.118     .013           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A4          -.119     .025           MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A4          -.133     .003           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A4         (-.136)                   BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A4          . . . . . .
A4  AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

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                        REFERENCES FOR N*1/2(1520)

          SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

BRANDSEN 65 PR 139 B1566       +DOGNNELL, MOORHOUSE          (DURHAM, RHEL)IJP
ROPER    65 PR 138 B190        LD ROPER,RM WRIGHT,BT FELD    (LRL-LVMR,MIT)IJP
THURNAUE 65 PRL 14 985         P G THURNAUER                 (ROCH)

KIRZ     66 PRIVATE COMM       J KIRZ                        (LRL)
     NUMBER EXTRACTED FROM DATA DISCUSSED IN KIRZ 63. Z 63.
NAMYSLOW 66 PR 157 1328        NAMYSLOWSKI,RAZMI,ROBERTS  (STAN,EDIN,LOIC)
OLSSON   66 PR 145 1309        M G OLSSON, G B YODH           (WISC,UMD)

DAVIES   67 NC 52A 1112        A T DAVIES, R G MOORHOUSE   (GLASGOW, RHEL)
ROBERTS  67 PREPRINT           R G ROBERTS                       (DURHAM)
ROSENFEL 67 IRVINE CONF        A H ROSENFELD, P SODING             (LRL)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK        (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                         (EDIN)
MORGAN   68 PR 166 1731        D MORGAN                            (RHEL)

BOTKE    69 PR 180 1417        J C BOTKE                           (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN          (UNIV S FLORIDA)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET          (SACL)IJP
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE          (DARE,MCHS)
DAVIES   70 NP B21 359         A DAVIES                            (GLAS)
DIEM     70 KIEV CONF.         + SMADJA, CHAVANON, DELER, DOLBEAU+  (SACL)
ALMEHED  72 NP B40 157         +LOVELACE                      (LUND,RUTG)IJP

DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+          (KYOTO+SAGA+KEK+TOKY)IJP
HEMMI2   73 NP B55 333         +INAGAKI,KIKUCHI,MAKI,MIYAKE+ (KYOTO,TOKYO)IJP
LEMOIGNE 73 PURDUE CONF. 93    +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK           (GLAS+LBL)IJP
ROSSI    73 NC 13A 59          +PIAZZA,SUSINNO,+      (ROMA,FRAS,NAPL,PAVIA)IJP
    ALSO 71 LNC 2 1183         CARBONARA,FIORE,+      (NAPL,FRAS,PAVIA,ROMA)IJP

BENEVENT 74 NC 19A 529         BENEVENTANO,DANGELO,NOTARISTEFANI,+   (ROMA)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD   (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                        (GLAS)IJP
FELTESSE 75 NP B93 242         +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+      (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII    (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+       (LBL,SLAC)IJP

AYED     76 CEA-N-1921         AYED (THESIS)                       (SACL)IJP
BARBOUR  76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD        (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
BERENDS  77  MC/T/77/17        F.A.BERENDS,A.DONNACHIE          (LEID,MCHS)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                    (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET       (SACL)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

KIRZ     63 PR 130 2481        J KIRZ, J SCHWARTZ, R D TRIPP       (LRL)
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET        (SACLAY)IJP
CROUCH   65 DESY CONF II 21    +   (BROWN,CEA,HARVARD,MIT,PADOVA,WEIZMANN)
DERADO   65 ATHENS CONF 244    +KENNEY,LAMSA, +          (NOTRE DAME,KENTUCKY)
MERLO    66 P ROY SOC 289 489  J P MERLO, G VALLADAS               (SACLAY)
    THE ABOVE PAPERS DISCUSS INELASTIC CHANNELS NEAR THE RESONANCE.
JOHNSON  67 UCRL-17683 THESIS  C H JOHNSON                         (LRL)
DEANS    69 PRL 177 2623       S R DEANS                   (UNIV S FLORIDA)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
WALKER   69 PR 182 1729        R L WALKER                          (CIT)IJP
AYED     70 PL 31B 598         +BAREYRE+VILLET                     (SACLAY)

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N(1535)   63  N*1/2(1535, JP=1/2-) I=1/2   S'11

          THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.
          IT IS STRONGLY ASSOCIATED WITH THE ETA N CHANNEL.

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                        63  N*1/2(1535) MASS (MEV)

M          (1519.0)                   HENDRY    65 RVUE    ETA N + S11 PI N  9/66
M          (1570.0)                   MICHAEL   66 RVUE    FITS BAREYRE S11  7/66
M   N      (1557.0) OR  1565.0        UCHIYAMA- 66 RVUE    FITS N ETA DATA   9/66
M   N    FITTING GIVES TWO SOLUTIONS.  PROBLEMS MATCHING PI P PHASE SHIFT
M   1      (1535.0)                   BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M   1            WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M   3      (1591.0)                   DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M          (1535.0)   (10.0)          DELCOURT  69 CNTR    PHOTOPRODUCT.     8/69
M   6      (1534.0)                   AYED      70 IPWA                      1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4      (1502.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   7      (1500.)                    ALMEHED   72 IPWA                      2/72
M    2     (1551.)                    HICKS     73 MPWA    GAM P-ETA P      9/73
M   2   CNLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.      9/73
M   2   M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.     9/73
M          1507. TO 1530.             CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
M   L      1520. OR 1510.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M   L   THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.    11/75
M          (1519.)                    AYED      76 IPWA                     11/77*
M          (1501.)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
M          (1500.)                    BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78*
M          (1547.)      (6.)          BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78*
M   8      (1520.)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
M   8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE  11/77*
M   8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                          11/77*

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                        63  N*1/2(1535) WIDTH (MEV)

W          (130.0)                    HENDRY    65 RVUE                      9/66
W          (130.0)                    MICHAEL   66 RVUE                      7/66
W   N      (156.0) OR  144.0          UCHIYAMA- 66 RVUE    SEE NOTE ON MASS  9/66
W   1      (155.0)                    BAREYRE   68 RVUE                     11/67
W   3      (268.0)     APPROX         DONNACH1  68 RVUE                      6/68
W          (120.0)                    DELCOURT  69 CNTR    PHOTOPRODUCT.     8/69
W   6      (96.0)                     AYED      70 IPWA                      1/71
W   4      (36.0)                     DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W   7      (50.)                      ALMEHED   72 IPWA                      2/72
W    2     (134.)                     HICKS     73 MPWA    GAM P-ETA P      9/73
W          114. TO  167.              CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
W   L       75. OR  100.              LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W          (75.)                      AYED      76 IPWA                     11/77*
W          (128.)                     BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
W          (57.)                      BERENDS   77 IPWA    PI-N PHOTO-PROD   1/78*
W          (139.)      (33.)          BHANDARI  77 DPWA  0 USES ETA N CUSP   1/78*
W   8      (135.)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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63 N*1/2(1535) REAL PART OF POLE POSITION (MEV) 11/75

RE (1496.) LONGACRE 75 IPWA PI N TO 2PI N 11/75
RE (1519.) (4.) BHANDARI 77 DPWA 0 USES ETA N CUSP 1/78*
RE 8 1525. OR 1527. LONGACRE 77 IPWA PI N TO 2PI N 11/77*

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63 N*1/2(1535) 2*IMAG PART OF POLE POSITION (MEV) 11/75

IM (103.) LONGACRE 75 IPWA PI N TO 2PI N 11/75
IM (140.) (32.) BHANDARI 77 DPWA 0 USES ETA N CUSP 1/78*
IM 8 135. OR 123. LONGACRE 77 IPWA PI N TO 2PI N 11/77*

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63 N*1/2(1535) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER 20. 21. BHANDARI 77 DPWA 0 USES ETA N CUSP 1/78*

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63 N*1/2(1535) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR 13. 8. BHANDARI 77 DPWA 0 USES ETA N CUSP 1/78*

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63 N*1/2(1535) PARTIAL DECAY MODES

DECAY MASSES
P1 N*1/2(1535) INTO PI N 139+ 938
P2 N*1/2(1535) INTO N ETA 939+ 548
P3 N*1/2(1535) INTO N PI PI 938+ 139+ 139
P4 N*1/2(1535) INTO N EPSILON 938+1300
P5 N*1/2(1535) INTO N*3/2(1232) PI 1232+ 139
P6 N*1/2(1535) INTO N RHO 938+ 776
P7 N*1/2(1535) INTO GAM P, HELICITY=1/2 0+ 938
P8 N*1/2(1535) INTO GAM N, HELICITY=1/2 0+ 939
P9 N*1/2(1535) INTO K LAMDBA 497+1115
P10 N*1/2(1535) INTO N RHO,S=1/2,S-WAVE 938+ 776

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63 N*1/2(1535) BRANCHING RATIOS

R1 N*1/2(1535) INTO (PI N)/TOTAL (P1)
R1 (0.69) HENDRY 65 RVUE 9/66
R1 (0.32) MICHAEL 66 RVUE 9/66
R1 N (0.71) OR 0.28 UCHIYAMA- 66 RVUE SEE NOTE ON MASS 9/66
R1 (0.31) OR 0.43 DAVIES 67 RVUE PIP TO N ETA,B,C 11/67
R1 3 (0.696) DONNACHI 68 RVUE 6/68
R1 (0.33) DELCOURT 69 CNTR 8/69
R1 6 (0.397) AYED 70 IPWA 1/71
R1 4 (0.36) DAVIES 70 RVUE P-S ANAL SOL A 8/69
R1 7 (0.25) ALMEHED 72 IPWA 2/72
R1 (.34) AYED 76 IPWA 11/77*
R1 (.297) (.026) BHANDARI 77 DPWA 0 USES ETA N CUSP 1/78*

R2 N*1/2(1535) INTO (N ETA)/TOTAL (P2)
R2 DOMINANT INEL DECAY HENDRY 65 RVUE 9/66
R2 (0.68) MICHAEL 66 RVUE 9/66
R2 N (0.29) OR 0.71 UCHIYAMA- 66 RVUE SEE NOTE ON MASS 9/66
R2 (0.69) OR 0.45 DAVIES 67 RVUE PIP TO N ETA,B,C 11/67
R2 B (0.4) (0.1) DEANS 69 MPWA T POLE+ RESON. 5/70
R2 (0.66) DELCOURT 69 MPWA 8/69
R2 B (0.69) OR 0.696 CARRERAS 70 MPWA T POLE+ RESON. 5/70
R2 B PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R2 THE VALUES OF R2 LISTED ABOVE ARE INCOMPATIBLE WITH THE RESULTS
R2 OF DIEM ET AL. (70)

R3 N*1/2(1535) INTO (N*3/2(1232) PI)/TOTAL (P5)
R3 D (0.07) DIEM 70 IPWA 3 BODY ANALYSIS 1/71
R3 D ASSUMING R1= 0.34

R4 N*1/2(1535) INTO (N EPSILON)/TOTAL (P4)
R4 D (0.26) DIEM 70 IPWA 3 BODY ANALYSIS 1/71
R4 D ASSUMING R1= 0.34

R5 N*1/2(1535) INTO (N RHO)/TOTAL (P6)
R5 D (0.20) DIEM 70 IPWA 3 BODY ANALYSIS 1/71
R5 D ASSUMING R1= 0.34

R6 N*1/2(1535) INTO GAMMA PROTON/TOTAL (P7) 9/73
R6 5 .0042 .0014 DEANS 72 MPWA P ETA PHOTOPROD. 9/73
R6 5 BR=(DEANS72 RADIATIVE WIDTH)/(NOMINAL FULL WIDTH=100 MEV) 9/73
R6 5 THE HICKS73 ENTRY UNDER R7 IS A MORE RECENT RESULT BY SAME GROUP. 9/73

R7 N*1/2(1535) FROM GAMMA PROTON TO ETA PROTON SQRT(P2*P7) 9/73
R7 2 (.0366) HICKS 73 MPWA GAM P-ETA P 9/73

R8 N*1/2(1535) FROM PI N INTO ETA N SQRT(P1*P2) 2/74
R8 (+.43) LEMOIGNE 73 DPWA 1488 TO 1685 MEV 2/74
R8 A (+.48) FELTESSE 75 DPWA 0 1488 TO 1745 MEV 11/75
R8 A SUPERCEDES LEMOIGNE 73, USES M AND W OF AYED 76. 11/77*

R9 N*1/2(1535) FROM PI N TO K LAMBDA SQRT(P1*P9) 4/75
R9 C -.691 .214 DEVENISH 74 0 FIXED T DISP REL 4/75
R9 C EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD. 4/75

R10 N*1/2(1535) FROM PI N TO N*3/2(1232) PI SQRT(P1*P5) 11/75
R10 L (0.0) OR -.06 LONGACRE 75 IPWA PI N TO 2PI N 11/75
R10 8 (.00) LONGACRE 77 IPWA PI N TO 2PI N 11/77*

R11 N*1/2(1535) FROM PI N TO N RHO,S=1/2,S-WAVE SQRT(P1*P10) 11/75
R11 L (+.12)OR +.09 LONGACRE 75 IPWA PI N TO 2PI N 11/75
R11 8 (+.10) LONGACRE 77 IPWA PI N TO 2PI N 11/77*

R12 N*1/2(1535) FROM PI N TO N EPSILON SQRT(P1*P4) 11/75
R12 L (.1) OR -.09 LONGACRE 75 IPWA PI N TO 2PI N 11/75
R12 8 (-.08) LONGACRE 77 IPWA PI N TO 2PI N 11/77*

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63 N*1/2(1535) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
REVIEW PRECEDING THE BARYON LISTINGS.

A1 N*1/2(1535) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1 .042 .023 DEVENISH 73 DPWA PI N PHOTO PROD 2/74
A1 (.015) HEMMI1 73 + FWD PI0 PHTOPROD 2/74
A1 +.053 .020 MOORHOUS 73 DPWA PI N PHOTO-PROD 2/73
A1 .078 .020 DEVENIS2 74 DPWA PI N PHOTO-PROD 4/75
A1 .056 .020 KNIES 74 DPWA PI N PHOTO PROD 2/74
A1 +.063 .013 METCALF 74 DPWA PI N PHOTO-PROD 2/74
A1 .036 .002 MOORHOUS 74 DPWA PI N PHOTO-PROD 2/74
A1 +.082 .007 CRAWFORD 75 DPWA PI N PHOTO-PROD 1/76
A1 (+.062) KRIVETS 75 DPWA PI-N PHOTO-PROD 1/78*
A1 (+.063) BARBOUR 76 DPWA PI N PHOTO-PROD 1/76
A1 +.070 .004 FELLER 76 DPWA PI N PHOTO-PROD 2/77*
A1 (+.034) BERENDS 77 IPWA PI-N PHOTO-PROD 1/78*
A1 . . . .
A1 AVERAGE MEANINGLESS (SCALE FACTOR = 5.5)

A2 N*1/2(1535) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2 -.026 .029 DEVENISH 73 DPWA PI N PHOTO PROD 2/74
A2 -.048 .021 MOORHOUS 73 DPWA PI N PHOTO-PROD 2/73
A2 8 -.031 .024 ROSSI 73 DPWA 0 GAM N TO PI- P 4/75
A2 8 CONVERTED TO OUR CONVENTIONS USING M AND W FROM ROSSI73 AND X=.36 4/75
A2 9 (-.078) BENEVENT 74 DPWA 0 GAM N TO PI- P 4/75
A2 9 CONVERTED TO OUR CONVENTIONS USING M=1520 MEV, W=80 MEV, X=.36 4/75
A2 -.037 .023 DEVENIS2 74 DPWA PI N PHOTO-PROD 4/75
A2 -.052 .005 KNIES 74 DPWA PI N PHOTO PROD 2/74
A2 -.051 .021 METCALF 74 DPWA PI N PHOTO-PROD 2/74
A2 -.027 .009 MOORHOUS 74 DPWA PI N PHOTO-PROD 2/74
A2 -.088 .011 CRAWFORD 75 DPWA PI N PHOTO-PROD 1/76
A2 (-.109) BARBOUR 76 DPWA PI N PHOTO-PROD 1/76
A2 . . . .
A2 AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)

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REFERENCES FOR N*1/2(1535)

HENDRY 65 PL 18 171 A W HENDRY, R G MOORHOUSE (RHEL)
REVIEWS EARLY PHASE-SHEFT-ANALYSIS RESULTS AND PI- P TO ETA N
EXPERIMENTS. WE TAKE NUMBERS FROM THE SOLUTION USING BRANDSEN 65.
MICHAEL 66 PL 21 93 C MICHAEL (OXF)
UCHIYAMA 66 PR 149 1220 F UCHIYAMA-CAMPBELL, R K LOGAN (ILL)IJP
DAVIES 67 NC 52A 1112 A T DAVIES, R G MOORHOUSE (GLASGOW,RHEL)

BAREYRE 68 PR 165 1731 P BAREYRE, C BRICMAN, G VILLET (SACLAY)IJP
DONNACH1 68 PL 26B 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
ALSO 68 VIENNA 139 DONNACHIE RAPPORTEUR.S TALK (GLAS)
ALSO 68 THESIS R G KIRSOPP (EDIN)
DEANS 69 PR 185 1797 S DEANS, J WOOTEN (UNIV S FLORIDA)
DELCOURT 69 PL 29B 75 DELCOURT,LEFRANCOIS,PEREZ-Y-JORBA,+ (ORSA)

AYED 70 KIEV CONF R AYED,P BAREYRE, G VILLET (SACL)IJP
CARRERAS 70 NP 16B 35 B CARRERAS, A DONNACHIE (DARE,MCHS)
DAVIES 70 NP B21 359 A DAVIES (GLAS)
DIEM 70 KIEV CONF. + SMADJA, CHAVANON, DELER, DOLBEAU+ (SACL)

ALMEHED 72 NP B40 157 +LOVELACE (LUND,RUTG)IJP
DEANS 72 PN 3 217 +JACOBS, LYONS, HICKS (U S FL TAMPA+CARN)
DEVENISH 73 PL 47B 53 DEVENISH,RANKIN,LYTH (LOUC+BONN+LANC)IJP
HEMMI1 73 PL 43B 79 HEMMI,INAGAKI+ (KYOTO+SAGA+KEK+TOKY)IJP
HICKS 73 PRD 7 2614 +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP
LEMOIGNE 73 PURDUE CONF. 93 +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOUS 73 PL 43B 44 MOORHOUSE, OBERLACK (GLAS+LBL)IJP
ROSSI 73 NC 13A 59 +PIAZZA,SUSINNO,+ (ROMA,FRAS,NAPL,PAVIA)IJP
ALSO 71 LNC 2 1183 CARBONARA,FIORE,+ (NAPL,FRAS,PAVIA,ROMA)IJP

BENEVENT 74 NC 19A 529 BENEVENTANO,DANGELO,NOTARISTEFANI,+ (ROMA)IJP
DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227 DEVENISH,LYTH,RANKIN (DESY,LANC,BONN)IJP
KNIES 74 PRD 9 2680 KNIES,MOORHOUSE,OBERLACK (LBL,GLAS)IJP
METCALF 74 NP B76 253 W J METCALF,R L WALKER (CIT)IJP
MOORHOUS 74 PRD 9 1 MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125 R L CRAWFORD (GLAS)IJP
FELTESSE 75 NP B93 242 +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS 75 SJNP 20 430 +MIROSHNICHENKO,NIKIFOROV,SANIN+ (KIEV)IJP
ALSO 74 SJNP 19 112 KRIVETS,NIKIFOROV,SANIN,SHALATSKII (KIEV)IJP
LONGACRE 75 PL 55B 415 +ROSENFELD,LASINSKI,SMADJA+ (LBL,SLAC)IJP

AYED 76 CEA-N-1921 AYED (THESIS) (SACL)IJP
BARBOUR 76 NP B111 358 I. M. BARBOUR,R. L. CRAWFORD (GLAS)IJP
FELLER 76 NP B104 219 +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
BERENDS 77 MC/T/77/17 F.A.BERENDS,A.DONNACHIE (LEID,MCHS)IJP
BHANDARI 77 PRD 15 192 R BHANDARI,Y-A CHAO (CARN)IJP
LONGACRE 77 NP B122 493 LONGACRE,DOLBEAU (SACL)IJP
ALSO 76 NP B108 365 DOLBEAU,TRIANTIS,NEVEU,CADIET (SACL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE 65 PL 18 342 + BRICMAN, STIRLING, VILLET (SACLAY)IJP
BRANDSEN 65 PR 139 B1566 +ODONNELL, MOORHOUSE (DURHAM, RHEL)IJP
BASIS OF NUMBERS WE QUOTE FROM HENDRY 65.
JOHNSON 67 UCRL-17683 THESIS C H JOHNSON (LRL)
LOVELACE 67 HEIDELBERG C. 79 C LOVELACE (CERN)IJP
DONNACHI 69 NP 10B 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 PL 31B 598 +BAREYRE+VILLET (SACLAY)

THE FOLLOWING ARTICLES DEAL WITH THE REACTIONS PI- P TO ETA N AND GAMMA P TO ETA P NEAR THRESHOLD. THE DATA AND THE THEORETICAL ARTICLES ARE USEFUL IN UNDERSTANDING THE BEHAVIOR OF THE S11 AMPLITUDE AS DETERMINED IN PI P PHASE-SHIFT ANALYSES. FURTHER REFERENCES MAY BE FOUND IN THEM.

MAINLY EXPERIMENTAL --
BULOS 64 PRL 13 486 + (BROWN,BRANDEIS,HARVARD,MIT,PADOVA) I
BACCI 66 NC 45A 983 +PENSO,SALVINI,MENCUCCINI,+ (ROMA,FRASCATI)IJP
JONES 66 PL 23 597 +BINNIE,DUANE,HORSEY,MASON,+ (LOIC,RHEL)
RICHARDS 66 PRL 16 1221 +CHIU,EANDI,HELMHOLZ,KENNEY,+ (LRL,HAWAII) IJ
PREPOST 67 PRL 18 82 R PREPOST, D LUNDQUIST, D QUINN (STANFORD)
BLOOM 68 PRL 21 1100 +HEUSCH, PRESCOTT, ROCHESTER (CIT)
BULOS 69 PR 187 1827 +LANOU,BORDNER,BASTIEN+(BOST+HARV+MIT+PENN)
HEUSCH 70 PRL 25 1381 +PRESCOTT,ROCHESTER,WINSTEIN (CIT)
BINNIE 73 PRD 8 2789 +CAMILLERI,DEBENHAM,DUANE,+ (LOIC,SHMP)

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         MAINLY THEORETICAL --
BALL      66 PR 149 1191      J S BALL                              (UCLA)
DOBSCN    66 PR 146 1022      P N DOBSON                          (HAWAII)
MINAMI    66 PR 147 1123      S MINAMI                             (OSAKA)
DEANS     67 PR 161 1466      S R DEANS, W G HOLLADAY        (VANDERBILT)
LCGAN     67 PR 153 1634      R K LOGAN, F UCHIYAMA-CAMPBELL         (ILL)
MENCUCCI  67 NC 48A 579       C MENCUCCINI, A REALE             (FRASCATI)
MINAMI    67 PR 162 1619      S MINAMI                             (OSAKA)
MOSS      67 PR 163 1785      T A MOSS                               (LSU)
DEANS     68 PR 165 1886      S R DEANS, W G HOLLADAY        (VANDERBILT)
PAL       68 PR 167 1350      B K PAL                     (NPL NEW DELHI)
BALL      69 PR 177 2257      +GARG+SHAW                        (UCLA+UCI)
LEFIEVRE  70 NC 66A 349       +LERUSTE                              (CDEF)
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N(1540) — P'_{13}

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                 109  N*1/2(1540, JP=3/2+) I=1/2                          11/77*

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                 109  N*1/2(1540) MASS (MEV)                              11/77*

M   8    (1540.)                   LONGACRE  77 IPWA   PI N TO 2PI N      11/77*
M   8  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77*
M   8  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77*

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                 109  N*1/2(1540) WIDTH (MEV)                             11/77*

W   8    (200.)                    LONGACRE  77 IPWA   PI N TO 2PI N      11/77*

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                 109  N*1/2(1540) REAL PART OF POLE POSITION (MEV)        11/77*

RE  8    1535. OR 1482.            LONGACRE  77 IPWA   PI N TO 2PI N      11/77*

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                 109  N*1/2(1540) 2*IMAG PART OF POLE POSITION (MEV)      11/77*

IM  8     207. OR 314.             LONGACRE  77 IPWA   PI N TO 2PI N      11/77*

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                 109  N*1/2(1540) PARTIAL DECAY MODES                     11/77*

                                                      DECAY MASSES
P1     N*1/2(1540) INTO PI N                          139+ 938
P2     N*1/2(1540) INTO N RHO,S=1/2,P-WAVE            938+ 776
P3     N*1/2(1540) INTO N RHO,S=3/2,P-WAVE            938+ 776
P4     N*1/2(1540) INTO N*3/2(1232) PI,P-WAVE        1232+ 139
P5     N*1/2(1540) INTC N EPSILON                     938+1300

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                 109  N*1/2(1540) BRANCHING RATIOS                        11/77*

R1     N*1/2(1540) FROM PI N TO N RHO,S=1/2,P-WAVE      SQRT(P1*P2)       11/77*
R1  8      (-.08)                  LONGACRE  77 IPWA   PI N TO 2PI N      11/77*

R2     N*1/2(1540) FROM PI N TO N RHO,S=3/2,P-WAVE      SQRT(P1*P3)       11/77*
R2  8      (.00)                   LONGACRE  77 IPWA   PI N TO 2PI N      11/77*

R3     N*1/2(1540) FROM PI N TO N*3/2(1232) PI,P-WAVE   SQRT(P1*P4)       11/77*
R3  8      (+.11)                  LONGACRE  77 IPWA   PI N TO 2PI N      11/77*

R4     N*1/2(1540) FROM PI N TO N EPSILON               SQRT(P1*P5)       11/77*
R4  8      (.00)                   LONGACRE  77 IPWA   PI N TO 2PI N      11/77*

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                           REFERENCES FOR N*1/2(1540)

LONGACRE 77 NP B122 493      LONGACRE,DOLBEAU                      (SACL)IJP
    ALSO 76 NP B108 365      DOLBEAU,TRIANTIS,NEVEU,CADIET         (SACL)IJP
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1520 MEV REGION – PRODUCTION EXPERIMENTS

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                 8  N*1/2(1520, JP=    ) I=1/2   PRODUCTION EXPERIMENTS

                 SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS
                 FOR A DISCUSSION OF PRODUCTION EXPERIMENTS.

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                 8  N*1/2(1520) MASS (MEV) (PROD. EXP.)

M          1507.0     6.0           A-BORELLI 67 HBC   0 PBAR P 5.7 GEV    10/71
M          1503.      6.            ANDERSON  70 MMS   - PI- P TO PI- MMS   2/71
M          1500.0    10.0           AMALDI    71 SAS     P P AT 24 GEV     10/71
M          1512.0     2.0           ELLIS     71 CNTR    MMS PP 3.7 GEV/C  10/71
M          1460. TO 1510.           MORSE     71 HBC  +0 PI-P,  7 GEV/C    11/77*
M         (1510.0)  (20.0)          MORSE     71 HBC  +  PI-P, 25 GEV/C    11/77*
M          1501.0     5.7           EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV     1/73
M   1     (1500.)                   OH        72 DBC   0 PI-N TO PI-PI-P    2/73
M   1   DETERMINE J=3/2,D13 PROBABLE                                        2/73
M          1515.     11.            COOPER    74 HBC   0 D P CEX            4/75
M         (1490.)                   BRAUN1    75 HBC     PBAR P 5.7 GEV    11/75
M          1510.      7.            MUSGRAVE  75 HBC     K+ P TO K PI N    11/75
M         (1500.)                   STRACHMA  75  BC     NBAR (N PI)        1/76
M          1500.      8.            WEBB      75 ISR  +  P P TO P N*        1/76
M          1515.      5.            ROUGE     77 OMEG  0 PI-P 9,12 GEV/C    1/78*

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                 8  N*1/2(1520) WIDTH (MEV) (PROD. EXP.)

W          55.0      15.0           A-BORELLI 67 HBC   0 PBAR P 5.7 GEV    10/71
W         120.       10.            ANDERSON  70 MMS   - PI- P TO PI- MMS   2/71
W         118.0      20.0           AMALDI    71 SAS     P P AT 24 GEV     10/71
W          88.0       2.0           ELLIS     71 CNTR    MMS PP 3.7 GEV/C  10/71
W          80. TO   120.            MORSE     71 HBC  +  PI-P,  7 GEV/C    11/77
W        (100.0)    (30.0)          MORSE     71 HBC  +  PI-P, 25 GEV/C    11/77
W         140.0      43.0           EDELSTEIN 72 MMS  +  PP 6 TO 30 GEV     1/73
W         106.       39.     33.    COOPER    74 HBC   0 D P CEX            4/75
W        (200.)                     BRAUN1    75 HBC     PBAR P 5.7 GEV    11/75
W         101.       26.            MUSGRAVE  75 HBC     K+ P TO K PI N    11/75
W         150.       50.            WEBB      75 ISR  +  P P TO P N*        1/76
W         105.       17.            ROUGE     77 OMEG  0 PI-P 9,12 GEV/C    1/78

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                 8  N*1/2(1520) PARTIAL DECAY MODES (PROD. EXP.)

                                                      DECAY MASSES
P1     N*1/2(1520) INTO PI N                          139+ 938
P2     N*1/2(1520) INTO N*3/2(1232) PI               1232+ 139
P3     N*1/2(1520) INTO N PI PI                       938+ 139+ 139
P4     N*1/2(1520)+ INTO NEUTRON PI+                  939+ 139
P5     N*1/2(1520)+ INTO PROTON PI+ PI-               938+ 139+ 139
P6     N*1/2(1520) INTO N ETA                         939+ 548
P7     N*1/2(1520) INTO N PIPI(J,I=0)                 939+ 139+ 139
P8     N*1/2(1520) INTO N RHO                         938+ 776

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                 8  N*1/2(1520) BRANCHING RATIOS (PROD. EXP.)

R1     N*1/2(1520) INTO (N PI)/TOTAL                        (P1)
R1         N*(1520)  INTO   (N PI)/TOTAL   PRODUCTION EXPERIMENTS
R1           0.78      0.24          BASSOMPIE 67 HBC  +  K+P TO K* N*      11/68

R2     N*1/2(1520) INTO (NEUTRON PI+)/(P PI+ PI-)           (P4)/(P5)
R2           0.77      0.45          ALEXANDER 67 HBC  +  PP 5.5 BEV/C       9/66

R3     N*1/2(1520) INTO (N PI)/(N PI PI)                    (P1)/(P3)
R3           1.25      0.44     0.71 A-BORELLI 67 HBC   0 PBAR P 5.7 BEV/C   9/66

R4     N*1/2(1520) INTO (N*3/2(1232) PI)/(N PI PI)          (P2)/(P3)
R4           0.00      0.09          A-BORELLI 67 HBC                        9/66

R5     N*1/2(1520) INTO (N PI PI)/TOTAL                     (P3)
R5          (0.08) OR LESS           BASSOMPIE 67 HBC  +  K+P TO K* N*      11/68

R6     N*1/2(1520) INTO (N ETA)/TOTAL                       (P6)
R6           0.22      0.14          BASSOMPIE 67 HBC  +  K+P TO K* N*      11/68

R7     N*1/2(1520) INTO (PI N)/(PI N*3/2(1232))             (P1)/(P2)
R7          (0.42) OR LESS           LEE       67 HBC     PI-P 3.6  GEV/C   11/67

R8     N*1/2(1520) INTO (N PIPI(J,I=0))/TOTAL               (P7)
R8              MAIN DECAY MODE      MORSE     71 HBC  +  PI-P 7,25 GEV/C   11/77*

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                       REFERENCES FOR N*1/2(1520) (PROD. EXP.)

A-BORELL 67 NC 47 232       ALLES-BORELLI,FRENCH,FRISK,MICHEJDA  (CERN)
ALEXANDE 67 PR 154 1284     ALEXANDER,BENARY,CZAPEK,+  (WEIZMANN(CERN))
BASSOMPI 67 PL 25B 440      BASSOMPIERRE, +            (CERN,BRUXELLES)
LEE      67 PR 159 1156     +MOEBS,ROE,SINCLAIR,VANDER VELDE      (MICH)

ANDERSON 70 PRL 25 699      +BLESER,BLIEDEN,COLLINS++         (BNL,CARN)

AMALDI   71 PL  34B 435     +BIANCASTELLI,BOSIO,+  (I SANITA ROMA+CERN)
ELLIS    71 PRL 27 442      +MAGLICH,NOREM,SANNES,SILVERMAN      (RUTG)
MORSE    71 PR D4 133       +OH,WALKER,CARROLL,LYNCH +     (WISC+TNTO)IJ

EDELSTEI 72 PR D5 1073      EDELSTEIN,CARRIGAN,HIEN,MCMAHON,+(CARN+BNL)
JOHNSTAD 72 NP B42 588      +MOLLERUD+...+JACOBSEN(BOHR,HELS,OSLO,STOH)IJP
OH       72 PL 42B 497      +FUNG,KERNAN,POE,SCHALK,SHEN          (UCR)IJP

COOPER   74 NP B79 259      COOPER,SEIDL,VANDERVELDE              (MICH)

BRAUN1   75 NP B95 481      +GERBER,MAURER,MICHALON,SCHIBY+ (STRB,LPNP)I
MUSGRAVE 75 NP B87 365      +PEETERS,SCREINER,WHITMORE,YUTA        (ANL)
STRACHMA 75 NP B98 120      STRACHMAN,BRAUN,GERBER,MAURER+  (LPNP+STRB)I
   ALSO  76 NP B107 330     STRACHMAN                            (LPNP)I
WEBB     75 PL 55B 331      +TRILLING,TELEGDI+       (AACH+UCLA+UCR+CERN)
   ALSO  75 PL 55B 336      +TRILLING,TELEGDI+       (AACH+UCLA+UCR+CERN)
ROUGE    77 PL 69B 115      +DE ROSNY,FLEURY,RIVET+    (LPNP+CDEF+LALO)

                            PAPERS NOT REFERRED TO IN DATA CARDS

BIEL     76 PRL 36 504,5C7  +BLESER,FERBEL+         (ROCH+FNAL+SLAC+NWES)
RUSHBROO 76 PRD 13 1835     RUSHBROOKE,RAJA,ANSORGE,CARTER,NEALE (CAVE)IJP
SOTIRIOU 76 NP B107 457     D.SOTIRIOU                          (CERN)IJP
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N(1670) — D'_{15}

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            64  N*1/2(1670, JP=5/2-) I=1/2
            THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                 64  N*1/2(1670) MASS (MEV)

M        (1650.0)       APPROX       BRANDSEN  65 RVUE   PHASE-SHIFT ANAL  7/66
M   1    (1680.0)                    BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
M   1           WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M   3    (1678.0)                    DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M        (1674.0)                    DUKE      68 CNTR   PI-P EL + POL     6/68
M   6    (1675.0)                    AYED      70 IPWA                     1/71
M   6  FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4    (1669.0)                    DAVIES    70 RVUE   P-S ANAL  SOL A   8/69
M   7    (1683.)                     ALMEHED   72 IPWA                     2/72
M          1652. TO 1687.            CRAWFORD  75 DPWA   PI N PHOTO-PROD   1/76
M    L     1660. OR 1660.            LONGACRE  75 IPWA   PI N TO 2PI N    11/75
M    L THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.  11/75
M        (1660.)                     AYED      76 IPWA                    11/77*
M        (1687.)                     BARBOUR   76 DPWA   PI N PHOTO-PROD   1/76
M   8    (1650.)                     LONGACRE  77 IPWA   PI N TO 2PI N    11/77*
M   8  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTICN S2, EXCEPT FOR THE POLE 11/77*
M   8  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77*

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Data Card Listings

For notation, see key at front of Listings.


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                    64  N*1/2(1670) WIDTH (MEV)
W   1       (135.0)                 BAREYRE   68 RVUE                        11/67
W   3       (173.0)                 DONNACH1  68 RVUE                         6/68
W   6       (143.0)                 AYED      70 IPWA                        1/71
W   4       (115.0)                 DAVIES    70 RVUE    SOL A AND B         8/69
W   7       (150.)                  ALMEHED   72 IPWA                        2/72
W             165. TO  185.         CRAWFORD  75 DPWA    PI N PHOTO-PROD     1/76
W     L       145. OR  150.         LONGACRE  75 IPWA    PI N TO 2PI N      11/75
W           (146.)                  AYED      76 IPWA                       11/77*
W           (172.)                  BARBOUR   76 DPWA    PI N PHOTO-PROD     1/76
W   8       (130.)                  LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                    64  N*1/2(1670) REAL PART OF POLE POSITION (MEV)        11/75
RE          (1663.)                 LONGACRE  75 IPWA    PI N TO 2PI N      11/75
RE  8        1649. OR 1650.         LONGACRE  77 IPWA    PI N TO 2PI N      11/77*

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                    64  N*1/2(1670) 2*IMAG PART OF POLE POSITION (MEV)      11/75
IM          (146.)                  LONGACRE  75 IPWA    PI N TO 2PI N      11/75
IM  8        127. OR 127.           LONGACRE  77 IPWA    PI N TO 2PI N      11/77*

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                    64  N*1/2(1670) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1      N*1/2(1670) INTO PI N                                    139+ 938
P2      N*1/2(1670) INTO N ETA                                   939+ 548
P3      N*1/2(1670) INTO LAMBDA K                               1115+ 497
P4      N*1/2(1670) INTO N*3/2(1232) PI                         1232+ 139
P5      N*1/2(1670) INTO N PI PI                                 938+ 139+ 139
P6      N*1/2(1670) INTO GAM P, HELICITY=1/2                       0+ 938
P7      N*1/2(1670) INTO GAM P, HELICITY=3/2                       0+ 938
P8      N*1/2(1670) INTO GAM N, HELICITY=1/2                       0+ 939
P9      N*1/2(1670) INTO GAM N, HELICITY=3/2                       0+ 939
P10     N*1/2(1670) INTO SIGMA K                                 493+1189
P11     N*1/2(1670) INTO N*3/2(1232) PI,D-WAVE                  1232+ 139
P12     N*1/2(1670) INTO N RHO,S=3/2,D-WAVE                      938+ 776
P13     N*1/2(1670) INTO N EPSILON                               938+1300

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                    64  N*1/2(1670) BRANCHING RATIOS
R1      N*1/2(1670) INTO (PI N)/TOTAL                    (P1)
R1  1         (0.41)                BAREYRE   68 RVUE                        11/67
R1  3         (0.391)               DONNACH1  68 RVUE                         6/68
R1  6         (0.392)               AYED      70 IPWA                        1/71
R1  4         (0.50)                DAVIES    70 RVUE    P-S ANAL  SOL A      8/69
R1  7         (0.45)                ALMEHED   72 IPWA                        2/72
R1            (.41)                 AYED      76 IPWA                       11/77*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

R2      N*1/2(1670) INTO (N ETA)/TOTAL                   (P2)
R2            (0.02) OR LESS        TRIPP     67 RVUE                        8/67
R2  B         (0.018)               BOTKE     69 MPWA    T POLE + RESON.    10/69
R2  B         (0.006)  (0.004)      DEANS     69 MPWA    T POLE + RESON.     5/70
R2  B         (0.006)OR 0.012       CARRERAS  70 MPWA    T POLE + RESON.     5/70
R2  B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R3      N*1/2(1670) INTO (LAMBDA K)/TOTAL                (P3)
R3            (0.016)OR LESS        TRIPP     67 RVUE                        8/67
R3  B         (0.001)OR LESS        RUSH      68 MPWA    T POLE + RESON.     8/69
R3  B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R3            (0.0028)OR LESS CL=.63  WAGNER  71 IPWA    PI-P TO K LAMB      1/71

R4      N*1/2(1670) INTO (N*3/2(1232) PI)/TOTAL          (P4)
R4 E 12600    0.63    0.1             BRODY     71  HBC    PI-P--2PI N,PWA    6/70
R4 E        ASSUMES ELASTIC BRANCHING RATIO 0.42+-0.04

R5      N*1/2(1670) FROM PI N TO K LAMBDA                SQRT(P1*P3)          4/75
R5            -.034     .006        DEVENISH  74       0 FIXED T DISP REL   4/75
R5      COUPLING TO LAMBDA K NOT REQUIRED IN THE ANALYSIS OF BAKER77.         1/78*

R6      N*1/2(1670) FROM PI N TO ETA N                   SQRT(P1*P2)          11/75
R6  2         (0.01)OR  (+.009)     FELTESSE  75 DPWA  0 1488 TO 1745 MEV  11/75
R6  2   USES M AND W OF AYED 76.                                             11/75

R7  *   N*1/2(1670) FROM PI N TO K SIGMA                 SQRT(P1*P10)         11/75
R7  2       LESS THAN .003            DEANS     75 DPWA    PI N TO K SIGMA   11/75
R7  2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                              11/75
R7  2   DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77            1/78*
R7  2   ARGUND 1920 MEV.                                                     1/78*

R8      N*1/2(1670) FROM PI N TO N*3/2(1232) PI,D-WAVE   SQRT(P1*P11)         11/75
R8  L         (-.45)OR  -.50        LONGACRE  75 IPWA    PI N TO 2PI N      11/75
R8  8         (-.46)                LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
R8  8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R9      N*1/2(1670) FROM PI N INTO N RHO,S=3/2,D-WAVE    SQRT(P1*P12)         11/77*
R9  8         (+.15)                LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
R9  8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R10     N*1/2(1670) FROM PI N INTO N EPSILON              SQRT(P1*P13)         11/77*
R10 8         (-.03)                LONGACRE  77 IPWA    PI N TO 2PI N      11/77*

   SEE NOTE PRECEDING THE N*1/2(1688) INELASTIC DECAY MODE MEASUREMENTS.

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                    64  N*1/2(1670) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1670) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1            .027      .030        DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A1          (.023)                  HEMMIL    73         + FWD PIO PHTOPROD 2/74
A1          +.011     .012          MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A1           .019     .021          DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A1           .013     .014          KNIES     74 DPWA    PI N PHOTO PROD    2/74
A1          +.010     .013          METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A1           .019     .007          MOORHOUS  74 DPWA    PI N PHOTO PROD    2/74
A1          +.027     .009          CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A1          (+.004)                 KRIVETS   75 DPWA    PI-N PHOTO-PROD    1/78*
A1          (+.008)                 BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A1           +.034     .004         FELLER    76 DPWA    PI N PHOTO-PROD    2/77*
A1          . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

A2      N*1/2(1670) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2            .036      .030        DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A2          +.021       .020        MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A2           .014       .004        DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A2           .014       .008        KNIES     74 DPWA    PI N PHOTO PROD    2/74
A2          +.042       .024        METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A2           .016       .002        MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A2          +.015       .006        CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A2        (+.021)                   KRIVETS   75 DPWA    PI-N PHOTO-PROD    1/78*
A2        (+.021)                   BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A2          +.019     .009          FELLER    76 DPWA    PI N PHOTO-PROD    2/77*
A2          . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A3      N*1/2(1670) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3          -.060       .062        DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A3          +.010       .040        MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A3          -.029       .023        DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A3          -.043       .006        KNIES     74 DPWA    PI N PHOTO PROD    2/74
A3           .004       .015        METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A3          -.017       .004        MOORHOUS  74 DPWA    PI N PHOTO PROD    2/74
A3          -.052       .003        CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A3        (-.058)                   BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A3          . . . . . . . . .
A3  AVERAGE MEANINGLESS (SCALE FACTOR = 4.4)

A4      N*1/2(1670) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4          -.072       .022        DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A4          -.035       .014        MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A4          -.068       .020        DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A4          -.071       .030        KNIES     74 DPWA    PI N PHOTO PROD    2/74
A4          -.009       .029        METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A4          -.049       .004        MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A4          -.083       .007        CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A4        (-.080)                   BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A4          . . . . . . . . .
A4  AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

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                          REFERENCES FOR N*1/2(1670)

BRANDSEN 65 PL 19 420       +DONNELL, MOORHOUSE              (DURHAM, RHEL)IJP

TRIPP    67 NP B3 10        + LEITH, +        (LRL,SLAC,CERN,HEID,SACLAY)

BAREYRE  68 PR 165 1731     P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACH1 68 PL 268 161      A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
   ALSC  68 VIENNA 139      DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
   ALSC  68 THESIS          R G KIRSOPP                           (EDIN)
DUKE     68 PR 166 1448     +JONES,KEMP,MURPHY,THRESHER, +   (RHEL,OXF)IJP
     INSIGHTFUL QUALITATIVE ARGUMENTS CONCERNING EXISTENCE AND IJP.
RUSH     68 PR 173 1776     J E RUSH                          (UNIV ALABAMA)

BOTKE    69 PR 180 1417     J C BOTKE                             (UCSB)
DEANS    69 PR 185 1797     S DEANS, J WOOTEN            (UNIV S FLORIDA)

AYED     70 KIEV CONF       R AYED,P BAREYRE, G VILLET            (SACL)IJP
CARRERAS 70 NP 168 35       B CARRERAS, A DONNACHIE          (DARE,MCHS)
DAVIES   70 NP B21 359      A DAVIES                              (GLAS)

BRODY    71 PL 348 665      +CASHMORE+..+HERNDON+..           (SLAC+LRL)
WAGNER   71 NP B25 411      F WAGNER, C LOVELACE                  (CERN)

ALMEHED  72 NP B40 157      +LOVELACE                        (LUND,RUTG)IJP

DEVENISH 73 PL 47B 53       DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HEMMIL   73 PL 43B 79       HEMMI,INAGAKI+           (KYOTO+SAGA+KEK+TOKY)IJP
MOORHOUS 73 PL 43B 44       MOORHOUSE, OBERLACK               (GLAS+LBL)IJP

DEVENISH 74 NP B81 330      DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227      DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680      KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253      W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PRD 9 1         MOORHOUSE,OBERLACK,ROSENFELD      (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125      R L CRAWFORD                          (GLAS)IJP
DEANS    75 NP B96 90       +MITCHELL,MONTGOMERY,+        (SFLA,ALABAMA)IJP
FELTESSE 75 NP B93 242      +AYED,BAREYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KRIVETS  75 SJNP 20 430     +MIROSHNICHENKO,NIKIFOROV,SANIN+      (KIEV)IJP
   ALSC  74 SJNP 19 112     KRIVETS,NIKIFOROV,SANIN,SHALATSKII    (KIEV)IJP
LONGACRE 75 PL 55B 415      +ROSENFELD,LASINSKI,SMADJA+       (LBL,SLAC)IJP

AYED     76 CEA-N-1921      AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358     I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
FELLER   76 NP B104 219     +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
LONGACRE 77 NP B122 493     LONGACRE,DOLBEAU                      (SACL)IJP
   ALSC  76 NP B108 365     DOLBEAU,FRIANTIS,NEVEU,CADIET         (SACL)IJP

                          PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE  65 PL 18 342       + BRICMAN, STIRLING, VILLET           (SACLAY)IJP
DUKE     65 PRL 15 468      +JONES,KEMP,MURPHY,PRENTICE, +    (RHEL,OXF)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                          (LRL)
DEANS    69 PRL 177 2623    S R DEANS                     (UNIV S FLORIDA)
DONNACH1 69 NP 10B 433      A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598      +BAREYRE+VILLET                       (SACLAY)
BAKER    77 NP B126 365     +BLISSET,BLOODWORTH,BROOME,HART+      (RHEL)IJP
WINNIK   77 NP B128 66      +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I

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N(1688)

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                    65  N*1/2(1688, JP=5/2+) I=1/2  F'15
      THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                    65  N*1/2(1688) MASS (MEV)
M           (1680.0)                  BRANDSEN  65 RVUE    PHASE SHIFT ANAL   7/66
M   1       (1690.0)                  BAREYRE   68 RVUE    PHASE-SHIFT ANAL  11/67
M   1             WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M   3       (1687.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL   6/68
M           (1682.0)                  DUKE      68 CNTR    PI-P EL + POL      6/68
M   6       (1682.0)                  AYED      70 IPWA                       1/71
M   6   FROM ENER. DEP. FIT OF APGAND DIAGRAM
M   4       (1685.0)                  DAVIES    70 RVUE    P-S ANAL  SOL A    8/69
M   7       (1688.)                   ALMEHED   72 IPWA                       2/72
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Baryons
N(1688)

Data Card Listings
For notation, see key at front of Listings.

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M          1674. TO 1676.                 CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
M         (1685.)                         KNASEL    75 DPWA  0 PI- P TO K0 LAM   11/75
M    L     1680. OR 1670.                 LONGACRE  75 IPWA    PI N TO 2PI N      11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.        11/75
M         (1679.)                         AYED      76 IPWA                       11/77*
M         (1680.)                         BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
M    B    (1660.)                         LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
M    B  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE      11/77*
M    B  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                              11/77*

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                        65  N*1/2(1688) WIDTH (MEV)

W    1       (110.0)                         BAREYRE   68 RVUE                     11/67
W    3       (177.0)                         DONNACH1  68 RVUE                     6/68
W    6       (109.0)                         AYED      70 IPWA                     1/71
W    4       (104.0)                         DAVIES    70 RVUE    P-S ANAL  SOL A  8/69
W    7       (140.)                          ALMEHED   72 IPWA                     2/72
W             115. TO  124.                   CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
W            (155.)                          KNASEL    75 DPWA  0 PI- P TO K0 LAM   11/75
W    L        125. OR  130.                  LONGACRE  75 IPWA    PI N TO 2PI N      11/75
W            (126.)                          AYED      76 IPWA                       11/77*
W            (120.)                          BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
W    B       (150.)                          LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                        65  N*1/2(1688) REAL PART OF POLE POSITION (MEV)          11/75

RE         (1688.)                         LONGACRE  75 IPWA    PI N TO 2PI N      11/75
RE   8      1656. OR 1653.                 LONGACRE  77 IPWA    PI N TO 2PI N      11/77*

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                        65  N*1/2(1688) 2*IMAG PART OF POLE POSITION (MEV)       11/75

IM         (132.)                          LONGACRE  75 IPWA    PI N TO 2PI N      11/75
IM   8      145. OR 143.                   LONGACRE  77 IPWA    PI N TO 2PI N      11/77*

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                        65  N*1/2(1688) PARTIAL DECAY MODES

                                                                    DECAY MASSES
P1      N*1/2(1688) INTO PI N                                      139+ 938
P2      N*1/2(1688) INTO N ETA                                     939+ 548
P3      N*1/2(1688) INTO LAMBDA K                                 1115+ 497
P4      N*1/2(1688) INTO N*3/2(1232) PI                           1232+ 139
P5      N*1/2(1688) INTO N PI PI                                   938+ 139+ 139
P6      N*1/2(1688) INTO GAM P, HELICITY=1/2                         0+ 938
P7      N*1/2(1688) INTO GAM P, HELICITY=3/2                         0+ 938
P8      N*1/2(1688) INTO GAM N, HELICITY=1/2                         0+ 939
P9      N*1/2(1688) INTO GAM N, HELICITY=3/2                         0+ 939
P10     N*1/2(1688) INTO N EPSILON                                 938+1300
P11     N*1/2(1688) INTO N RHO                                     938+ 776
P12     N*1/2(1688) INTO N*3/2(1232) PI,P-WAVE                    1232+ 139
P13     N*1/2(1688) INTO N*3/2(1232) PI,F-WAVE                    1232+ 139
P14     N*1/2(1688) INTO N RHO,S=3/2,P-WAVE                        938+ 776
P15     N*1/2(1688) INTO N RHO,S=3/2,F-WAVE                        938+ 776
P16     N*1/2(1688) INTO SIGMA K                                   493+1189

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                        65  N*1/2(1688) BRANCHING RATIOS

R1      N*1/2(1688) INTO (PI N)/TOTAL                          (P1)
R1   1      (0.64)                          BAREYRE   68 RVUE                     11/67
R1   3      (0.560)                         DONNACH1  68 RVUE                     6/68
R1   6      (0.593)                         AYED      70 IPWA                     1/71
R1   4      (0.54)                          DAVIES    70 RVUE        SOL A AND B  8/69
R1   7      (0.65)                          ALMEHED   72 IPWA                     2/72
R1           (.59)                          AYED      76 IPWA                     11/77*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

    MORE INFORMATION ON THE INELASTIC DECAY MODES OF THE 1690 MEV
    BUMP, AS SEEN IN PRODUCTION EXPERIMENTS, MAY BE FOUND BELOW

R2      N*1/2(1688) INTO (N ETA)/TOTAL                         (P2)
R2           (0.015)OR LESS                 TRIPP     67 RVUE                     8/67
R2   B       (0.0004)                       BOTKE     69 MPWA    T POLE + RESON.  10/69
R2   B       (0.003)  (0.002)               DEANS     69 MPWA    T POLE + RESON.  5/70
R2   B       (0.0005)OR .001                CARRERAS  70 MPWA    T POLE + RESON.  5/70
R2   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R3      N*1/2(1688) INTO (N ETA)/(PI N)                        (P2)/(P1)
R3           (0.027)OR LESS                 HEUSCH    66 RVUE +  PI0, ETA PHOTO    9/66

R4      N*1/2(1688) INTO (LAMBDA K)/TOTAL                      (P3)
R4           (0.0013)OR LESS                TRIPP     67 RVUE                     8/67
R4   B       (0.001)OR LESS                 RUSH      68 MPWA    T POLE + RESON.  5/70
R4   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R4           (0.001)OR LESS  CL=.63         WAGNER    71 IPWA    PI-P TO K LAMB   1/71

R5      N*1/2(1688) INTO (N*3/2(1232) PI)/TOTAL                (P4)
R5 E 12600   (0.13)   (0.04)  SOLN.A        BRODY     71  HBC    PI-P--2PI N/PWA  6/70
R5 E 12600   (0.39)   (0.10)  SOLN.B        BRODY     71  HBC    PI-P--2PI N/PWA  6/70
R5 E       ASSUMES ELASTIC BRANCHING RATIO 0.62+-0.06

R6      N*1/2(1688) FROM PI N TO K LAMBDA                      SQRT(P1*P3)          4/75
R6            -.009     .009               DEVENISH  74       0 FIXED T DISP REL  4/75
R6           (.01)                          KNASEL    75 DPWA  0 PI- P TO K0 LAM   11/75
R6      COUPLING TO LAMBDA K NOT REQUIRED IN THE ANALYSIS OF BAKER77.            1/78*

R7      N*1/2(1688) FROM PI N TO N EPSILON                     SQRT(P1*P10)         11/75
R7   L       (-.28)OR  -.30                 LONGACRE  75 IPWA    PI N TO 2PI N      11/75
R7   B       (-.31)                         LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
R7   B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R8      N*1/2(1688) FROM PI N TO N*3/2(1232) PI,P-WAVE         SQRT(P1*P12)         11/75
R8   L       (+.26)OR  +.25                 LONGACRE  75 IPWA    PI N TO 2PI N      11/75
R8   B       (+.27)                         LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
R8   B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R9      N*1/2(1688) FROM PI N TO N*3/2(1232) PI,F-WAVE         SQRT(P1*P13)         11/75
R9   L       (0.) OR  (-.08)                LONGACRE  75 IPWA    PI N TO 2PI N      11/75
R9   B       (-.07)                         LONGACRE  77 IPWA    PI N TO 2PI N      11/77*

R10     N*1/2(1688) FROM PI N TO N RHO,S=3/2,P-WAVE            SQRT(P1*P14)         11/75
R10  L       (+.27)OR  +.30                 LONGACRE  75 IPWA    PI N TO 2PI N      11/75
R10  B       (+.23)                         LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
R10  B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R11     N*1/2(1688) FROM PI N TO N RHO,S=3/2,F-WAVE            SQRT(P1*P15)         11/77*
R11  B       (+.15)                         LONGACRE  77 IPWA    PI N TO 2PI N      11/77*
R11  B   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R12     N*1/2(1688) FROM PI N TO K SIGMA                       SQRT(P1*P16)         11/75
R12  2       LESS THAN .001                 DEANS     75 DPWA    PI N TO K SIGMA  11/75
R12  2   RANGE GIVEN IS FROM 3 OF 4 BEST SOLUTIONS, NOT PRESENT IN SLTN.1.      11/75
R12  2   DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77               1/78*
R12  2   AROUND 1920 MEV.                                                       1/78*

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                        65  N*1/2(1688) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*1/2(1688) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1           .015      .023                 DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A1         (-.003)                         HEMMI1    73       + FWD PI0 PHTOPROD   2/74
A1          -.008      .004                 MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A1           .027      .019                 DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A1          -.016      .014                 KNIES     74 DPWA    PI N PHOTO PROD    2/74
A1          -.008      .011                 METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A1          -.014      .003                 MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A1          -.013      .002                 CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A1         (+.003)                         KRIVETS   75 DPWA    PI-N PHOTO-PROD    1/78*
A1         (-.004)                         BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A1          -.009      .002                FELLER    76 DPWA    PI N PHOTO-PROD    2/77*
A1           . . . . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

A2      N*1/2(1688) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2           .146      .031                 DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A2          +.100      .012                 MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A2           .163      .011                 DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A2           .097      .007                 KNIES     74 DPWA    PI N PHOTO PROD    2/74
A2           .129      .016                 METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A2           .147      .006                 MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A2          +.135      .006                 CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A2         (+.107)                         KRIVETS   75 DPWA    PI-N PHOTO-PROD    1/78*
A2         (+.132)                         BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A2          +.121      .010                FELLER    76 DPWA    PI N PHOTO-PROD    2/77*
A2           . . . . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 2.8)

A3      N*1/2(1688) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3           .035      .049                 DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A3          +.017      .014                 MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A3           .031      .028                 DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A3           .023      .005                 KNIES     74 DPWA    PI N PHOTO PROD    2/74
A3           .008      .018                 METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A3           .023      .003                 MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A3          +.021      .001                 CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A3         (+.034)                         BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A3           . . . . . . . . .
A3  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A4      N*1/2(1688) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4          -.018      .039                 DEVENISH  73 DPWA    PI N PHOTO PROD    2/74
A4          -.005      .018                 MOORHOUS  73 DPWA    PI N PHOTO-PROD    2/73
A4          -.021      .028                 DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
A4           .001      .018                 KNIES     74 DPWA    PI N PHOTO PROD    2/74
A4           .00       .030                 METCALF   74 DPWA    PI N PHOTO-PROD    2/74
A4          -.041      .004                 MOORHOUS  74 DPWA    PI N PHOTO-PROD    2/74
A4          -.015      .004                 CRAWFORD  75 DPWA    PI N PHOTO-PROD    1/76
A4         (-.028)                         BARBOUR   76 DPWA    PI N PHOTO-PROD    1/76
A4           . . . . . . . . .
A4  AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)


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                              REFERENCES FOR N*1/2(1688)

          SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

BRANDSEN 65 PL 19 420          +DONNELL, MOORHOUSE          (DURHAM, RHEL)IJP
HEUSCH   66 PRL 17 1019        C A HEUSCH, C Y PRESCOTT, R F OASHEN  (CIT)
TRIPP    67 NP B3 10           + LEITH, +       (LRL,SLAC,CERN,HEID,SACLAY)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET      (SACLAY)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK              (GLAS)
    ALSO 68 THESIS             R G KIRSOPP                               (EDIN)
DUKE     68 PR 166 1448        +JONES,KEMP,MURPHY,THRESHER, +    (RHEL,OXF)IJP
RUSH     68 PR 173 1776        J E RUSH                         (UNIV ALABAMA)

BOTKE    69 PR 180 1417        J C BOTKE                                 (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN              (UNIV S FLORIDA)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET                (SACL)IJP
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE           (DARE,MCHS)
DAVIES   70 NP B21 359         A DAVIES                                  (GLAS)

BRODY    71 PL 34B 253         +CASHMORE+..+HERNDON+..                (SLAC+LRL)
WAGNER   71 NP B25 411         F WAGNER, C LOVELACE                      (CERN)

ALMEHED  72 NP B40 157         +LOVELACE                          (LUND,RUTG)IJP
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HEMMI1   73 PL 43B 79          HEMMI,INAGAKI+          (KYOTO+SAGA+KEK+TOKY)IJP
MOORHOUS 73 PL 43B 44          MOORHOUSE, OBERLACK                (GLAS+LBL)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK           (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                    (CIT)IJP
MOORHOUS 74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD       (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                              (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP
KNASEL   75 PRD 11 1           +LINDQUIST,NELSON+          (CHIC,WUSL,OSU,ANL)IJP
KRIVETS  75 SJNP 20 430        +MIROSHNICHENKO,NIKIFOROV,SANIN+          (KIEV)IJP
    ALSO 74 SJNP 19 112        KRIVETS,NIKIFOROV,SANIN,SHALATSKII        (KIEV)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+          (LBL,SLAC)IJP

AYED     76 CEA-N-1921         AYED (THESIS)                             (SACL)IJP
BARBOUR  76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD              (GLAS)IJP
FELLER   76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
LONGACRE 77 NP B122 493        LONGACRE,DOLBEAU                          (SACL)IJP
    ALSO 76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET             (SACL)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

CROUCH   65 DESY CONF II 21    +   (BROWN,CEA,HARVARD,MIT,PADOVA,WEIZMANN)
DERADO   65 ATHENS CONF 244    +KENNEY,LAMSA, +       (NOTRE DAME,KENTUCKY)
DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +    (RHEL,OXF)IJP
MERLO    66 P ROY SOC 289 489  J P MERLO, G VALLADAS                     (SACLAY)
ROBERTS  67 PREPRINT           R G ROBERTS                               (DURHAM)
BANNER   68 PR 166 1347        +DETOEUF,FAYOUX,HAMEL, +        (SACLAY,CAEN)
     THE ABOVE PAPERS DISCUSS INELASTIC CHANNELS NEAR THE BUMP.
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Data Card Listings

For notation, see key at front of Listings.


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BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACLAY)IJP
DEANS    69 PRL 177 2623       S R DEANS                  (UNIV S FLORIDA)
DONNACHI 69 NP 108 433         A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598         +BAREYRE+VILLET                      (SACLAY)
BAKER    77 NP B126 365        +BLISSET,BLODWORTH,BROOME,HART+       (RHEL)IJP
WINNIK   77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY           (HAIF)I

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N(1700) 66 N*1/2(1700, JP=1/2-) I=1/2 **S_{11}**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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66 N*1/2(1700) MASS (MEV)

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M          (1695.0)                    BRANDSEN  65 RVUE    PHASE-SHIFT ANAL  9/66
M          (1700.0)                    MICHAEL   66 RVUE    FITS BAREYRE S11  7/66
M    G     (1710.0)                    BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    G          WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    3     (1710.0)                    DONNACH1  68 RVUE    PHASE-SHIFT ANAL  8/68
M          (1705.0)   (10.0)           ORITO     69 RVUE    K LAMBDA PS ANAL  8/69
M    6     (1689.0)                    AYED      70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    4     (1766.0)                    DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M          (1678.0)                    SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
M    A     (1685.0)                    WAGNER    71 IPWA    PI-P TO K LAMB   1/71
M    A   THERE ARE 3 SIMILAR SOLUTIONS
M    7     (1670.)                     ALMEHED   72 IPWA                     2/72
M    2     (1699.)                     HICKS     73 MPWA    GAM P-ETA P      9/73
M    2   ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.     9/73
M    2   M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.    9/73
M    1     (1860.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
M    1   S11 AMPLITUDE LARGE BUT NOT RESONANT IN SOLUTION 1 OF LANGBEIN73    9/73
M    1   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF     1/78*
M    1   WINNIK77 AROUND 1920 MEV.                                          1/78*
M          (1675.)                     KNASEL    75 DPWA  0 PI- P TO KO LAM 11/75
M    L     1675. OR 1660.              LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    L   THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.   11/75
M          (1673.)                     AYED      76 IPWA                    11/77*
M          (1676.)                     BARBOUR   76 DPWA    PI N PHOTO-PROD  1/76
M    D     (1700.)     (5.)            BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
M    E     (1680.)                     BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
M    D   THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET     1/78*
M    E   ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.           1/78*
M    8     (1700.)                     LONGACRE  77 IPWA    PI N TO 2PI N   11/77*
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77*
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                        11/77*
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66 N*1/2(1700) WIDTH (MEV)

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W          (240.0)                     MICHAEL   66 RVUE                     7/66
W    1     (260.0)                     BAREYRE   68 RVUE                    11/67
W    3     (300.0)                     DONNACH1  68 RVUE                     8/69
W          (104.0)   (15.0)            ORITO     69 RVUE                     8/69
W    6     (166.0)                     AYED      70 IPWA                     1/71
W    4     (404.0)                     DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W    4   SOL B GIVES 121 MEV                                                 2/73
W          (99.0)                      SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
W    A     (110.0)OR(140.0)            WAGNER    71 IPWA    PI-P TO K LAMB   1/71
W    7     (120.)                      ALMEHED   72 IPWA                     2/72
W    2     (195.)                      HICKS     73 MPWA    GAM P-ETA P      9/73
W    1     (200.)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
W          (170.)                      KNASEL    75 DPWA  0 PI- P TO KO LAM 11/75
W    L      150. OR  130.              LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W          (150.)                      AYED      76 IPWA                    11/77*
W          (194.)                      BARBOUR   76 DPWA    PI N PHOTO-PROD  1/76
W    D     (130.)     (10.)            BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
W    E      (90.)                      BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
W    8     (170.)                      LONGACRE  77 IPWA    PI N TO 2PI N   11/77*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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66 N*1/2(1700) REAL PART OF POLE POSITION (MEV) 11/75

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RE        (1648.)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   8     1699. OR 1698.             LONGACRE  77 IPWA    PI N TO 2PI N   11/77*
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66 N*1/2(1700) 2*IMAG PART OF POLE POSITION (MEV) 11/75

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IM         (117.)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   8      174. OR 173.              LONGACRE  77 IPWA    PI N TO 2PI N   11/77*
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66 N*1/2(1700) PARTIAL DECAY MODES

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                                                              DECAY MASSES
P1     N*1/2(1700) INTO PI N                                  139+ 938
P2     N*1/2(1700) INTO N ETA                                 939+ 548
P3     N*1/2(1700) INTO LAMBDA K                             1115+ 497
P4     N*1/2(1700) INTO GAM P, HELICITY=1/2                     0+ 938
P5     N*1/2(1700) INTO GAM N, HELICITY=1/2                     0+ 939
P6     N*1/2(1700) INTO N PI PI                               938+ 139+ 139
P7     N*1/2(1700) INTO N EPSILON                             938+1300
P8     N*1/2(1700) INTO N RHO                                 938+ 776
P9     N*1/2(1700) INTO K SIGMA                               493+1189
P10    N*1/2(1700) INTO N RHO,S=1/2,S-WAVE                    938+ 776
P11    N*1/2(1700) INTO N RHO,S=3/2,D-WAVE                    938+ 776
P12    N*1/2(1700) INTO N*3/2(1232) PI                       1232+ 139
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66 N*1/2(1700) BRANCHING RATIOS

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R1     N*1/2(1700) INTO (PI N)/TOTAL                    (P1)
R1          (1.0)        APPROX      MICHAEL   66 RVUE                     7/66
R1   3      (0.79)                   DONNACH1  68 RVUE                     8/69
R1   6      (0.642)                  AYED      70 IPWA                     1/71
R1   4      (0.56)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
R1   7      (0.5)                    ALMEHED   72 IPWA                     2/72
R1           (.54)                   AYED      76 IPWA                    11/77*
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R2     N*1/2(1700) FROM PI N TO K LAMBDA                SQRT(P1*P3)          4/75
R2          (.20)    (.05)           ORITO     69 RVUE                     4/75
R2   A     (.21)OR .23                WAGNER    71 IPWA    PI- P TO K LAMB   4/75
R2          -.179      .033          DEVENISH  74         0 FIXED T DISP REL 4/75
R2          (.12)                    KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
R2   D     (-.23)    (.01)           BAKER     77 IPWA  0 PI- P TO K LAM.   1/78*
R2   E     (-.25)                    BAKER     77 DPWA  0 PI- P TO K LAM.   1/78*

R3     N*1/2(1700) INTO (LAMBDA K)/TOTAL                (P3)
R3   B      (0.028)      APPROX.     RUSH      68 MPWA    T POLE + RESON.   8/69
R3   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R4     N*1/2(1700) INTO (N ETA)/TOTAL                   (P2)
R4   B      (0.013)                  BOTKE     69 MPWA    T POLE + RESON.  10/69
R4   B      (0.03)   (0.02)          DEANS     69 MPWA    T POLE + RESON.   8/69
R4   C      (0.19) OR 0.27           CARRERAS  70 MPWA    T POLE + RESON.   5/70
R4   B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R4   C   CARRERAS 70 USES REGGE POLES + RESONANCES. VALUES SUSPICIOUSLY LARG

R5     N*1/2(1700) FROM GAMMA PROTON TO K LAMBDA         SQRT(P3*P4)          9/73
R5          (0.002)OR LESS           ORITO2    69 CNTR    K LAM PHOTOPRO   10/71
R5          (0.0072)                 SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
R5           (.0060)                 DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

R6     N*1/2(1700) FROM GAMMA PROTON TO ETA PROTON       SQRT(P2*P4)          9/73
R6   2      (.0101)                  HICKS     73 MPWA    GAM P-ETA P       9/73

R7     N*1/2(1700) FROM PI N TO K SIGMA                  SQRT(P1*P9)          9/73
R7   1      (.11)                    LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R7   5      (.066)TO  .137           DEANS     75 DPWA    PI N TO K SIGMA  11/75
R7   5   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                           11/75
R7           (.20)                   KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75

R8     N*1/2(1700) FROM PI N TO N*3/2(1232) PI           SQRT(P1*P12)         11/75
R8   L      (-.16)OR  -.15           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8   8      (-.29)                   LONGACRE  77 IPWA    PI N TO 2PI N   11/77*
R8   8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R9     N*1/2(1700) FROM PI N TO N RHO,S=1/2,S-WAVE       SQRT(P1*P10)         11/75
R9   L      (.23)OR  +.16            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R9   8      (-.17)                   LONGACRE  77 IPWA    PI N TO 2PI N   11/77*

R10    N*1/2(1700) FROM PI N TO N RHO,S=3/2,D-WAVE       SQRT(P1*P11)         11/77*
R10  8      (-.29)                   LONGACRE  77 IPWA    PI N TO 2PI N   11/77*
R10  8   LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.

R11    N*1/2(1700) FROM PI N TO N EPSILON                SQRT(P1*P7)          11/75
R11  L      (-.23)OR  -.25           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R11  8       (.00)                   LONGACRE  77 IPWA    PI N TO 2PI N   11/77*
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66 N*1/2(1700) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

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A1     N*1/2(1700) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1          .024      .033           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1         +.066      .042           MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A1          .029      .018           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1          .058      .018           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1         +.012      .015           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1          .054      .005           MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A1         +.044      .018           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1        (+.044)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1         +.068      .009           FELLER    76 DPWA    PI N PHOTO-PROD   2/77*
A1          . . . . . .
A1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

A2     N*1/2(1700) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2          -.010      .043           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2          -.072      .066           MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A2          -.006      .031           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2          -.015      .035           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2          -.019      .022           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2          -.027      .009           MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2          -.103      .010           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2         (-.022)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2          . . . . . .
A2   AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)
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REFERENCES FOR N*1/2(1700)


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BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE          (DURHAM, RHEL)IJP

MICHAEL  66 PL 21 93           C MICHAEL                              (OXF)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139         DONNACHIE  RAPPORTEUR,S TALK           (GLAS)
    ALSC 68 THESIS             R G KIRSOPP                            (EDIN)
RUSH     68 PR 173 1776        J E RUSH                        (UNIV ALABAMA)

BOTKE    69 PR 180 1417        J C BOTKE                              (UCSB)
DEANS    69 PR 185 1797        S DEANS, J WOOTEN              (UNIV S FLORIDA)
ORITO    69 LNC 1 936          S ORITO,S SASAKI                (TOKYO-OSAKA)
ORITO2   69 INS J 113          S ORITO (THESIS)                       (TOKYO)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET             (SACL)IJP
CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE          (DARE,MCHS)
DAVIES   70 NP B21 359         A DAVIES                               (GLAS)
SCHORSCH 70 NP  B25 179        +TIETGE,WEILNBOECK                     (MPIM)

WAGNER   71 NP B25 411         F WAGNER, C LOVELACE                   (CERN)

ALMEHED  72 NP B40 157         +LOVELACE                         (LUND,RUTG)IJP
DEANS    72 PRD 6 1906         DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HICKS    73 PRD 7 2614         +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                   (MUNICH)IJP
MOORHOUS 73 PRD 9 1            MOORHOUSE, OBERLACK          (GLAS+LBL)IJP

DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227         DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253         W J METCALF,R L WALKER                 (CIT)IJP
MOORHOUS 74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125         R L CRAWFORD                           (GLAS)IJP
DEANS    75 NP B96 90          +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP
KNASEL   75 PRD 11 1           +LINDQUIST,NELSON+          (CHIC,WUSL,OSU,ANL)IJP
LONGACRE 75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+       (LBL,SLAC)IJP
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Baryons
N(1700)

Data Card Listings
For notation, see key at front of Listings.

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AYED      76 CEA-N-1921          AYED (THESIS)                          (SACL)IJP
BARBOUR   76 NP B111 358         I. M. BARBOUR,R. L. CRAWFORD           (GLAS)IJP
FELLER    76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
BAKER     77 NP B126 365         +BLISSET,BLOODWORTH,BROOME,HART+       (RHEL)IJP
LONGACRE  77 NP B122 493         LONGACRE,DOLBEAU                       (SACL)IJP
    ALSO  76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET          (SACL)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE   65 PL 18 342           + BRIGMAN, STIRLING, VILLET            (SACLAY)IJP
JOHNSON   67 UCRL-17683 THESIS   C H JOHNSON                              (LRL)
DEANS     69 PR  177 2623        S R DEANS                    (UNIV S FLORIDA)
DONNACHI  69 NP 108 433          A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
AYED      70 PL 31B 598          +BAREYRE+VILLET                        (SACLAY)
WINNIK    77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY              (HAIF)I

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N(1700) 18 N*1/2(1700, JP=3/2-) I=1/2 **D$_{13}$**

AYED 76, LONGACRE 75, AND LONGACRE 77 FIND EVIDENCE FOR THIS STATE. THERE IS ADDITIONAL EVIDENCE FROM ASSOCIATED PRODUCTION.

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                        18  N*1/2(1700) MASS  (MEV)

M    3     (1730.)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M    3     (1680.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69
M    A     (1780.0)                   WAGNER    71 IPWA    PI-P TO K LAMB    1/71
M    A  D13 RESONATES ONLY IN ONE OUT OF 3 POSSIBLE SOL.
M         (1670.)                    DEANS     72 MPWA    GAM P-K LM,SOL D  9/73
M    1    (1790.)                    LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
M    1  NOT SEEN IN SOLUTION 2 OF LANGBEIN73                                 9/73
M    1  DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF      1/78*
M    1  WINNIK77 AROUND 1920 MEV.                                           1/78*
M    L     1710. OR 1710.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.   11/75
M         (1710.)                    AYED      76 IPWA                     11/77*
M    D    (1670.)    (10.)           BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
M    E    (1690.)                    BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
M    D  THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET      1/78*
M    E  ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.           1/78*
M    8    (1660.)                    LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
M    8  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77*
M    8  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                         11/77*

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                        18  N*1/2(1700) WIDTH (MEV)

W         (90.)                      DEANS     72 MPWA    GAM P-K LM,SOL D  9/73
W    1    (120.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
W    L     100. OR  300.             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W         (100.)                     AYED      76 IPWA                     11/77*
W    D    (90.)    (25.)             BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
W    E    (100.)                     BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
W    8    (600.)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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                        18  N*1/2(1700) REAL PART OF POLE POSITION (MEV)      11/75

RE       (1710.)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE   8    1616. OR 1613.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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                        18  N*1/2(1700) 2*IMAG PART OF POLE POSITION (MEV)   11/75

IM       (607.)                      LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM   8    577. OR 575.               LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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                        18  N*1/2(1700) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     N*1/2(1700) INTO PI N                                  139+ 938
P2     N*1/2(1700) INTO LAMBDA K                             1115+ 497
P3     N*1/2(1700) INTO GAM P,HELICITY=3/2                     0+ 938
P4     N*1/2(1700) INTO GAM P,HELICITY=1/2                     0+ 938
P5     N*1/2(1700) INTO GAM N,HELICITY=3/2                     0+ 939
P6     N*1/2(1700) INTO GAM N,HELICITY=1/2                     0+ 939
P7     N*1/2(1700) INTO K SIGMA                              493+1189
P8     N*1/2(1700) INTO N EPSILON                            938+1300
P9     N*1/2(1700) INTO N*3/2(1232) PI,S-WAVE               1232+ 139
P10    N*1/2(1700) INTO N*3/2(1232) PI,D-WAVE               1232+ 139
P11    N*1/2(1700) INTO N RHO,S=3/2,S-WAVE                   938+ 776

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                        18  N*1/2(1700) BRANCHING RATIOS

R1     N*1/2(1700) FROM GAMMA PROTON TO K LAMBDA          SQRT((P3+P4)*P2)     9/73
R1          (.0077)                    DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

R2     N*1/2(1700) FROM PI N TO K SIGMA                   SQRT(P1*P7)          9/73
R2   1       (.10)                    LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
R2   2     LESS THAN .017             DEANS     75 DPWA    PI N TO K SIGMA  11/75
R2   2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                            11/75

R3     N*1/2(1700) INTO PI N/TOTAL                        (P1)
R3          (.09)                     AYED      76 IPWA                     11/77*

R4     N*1/2(1700) FROM PI N TO K LAMBDA                  SQRT(P1*P2)          4/75
R4          +.026     .019           DEVENISH  74          0 FIXED T DISP REL  4/75
R4   D      (-.03)    (.004)         BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
R4   E      (-.03)                   BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*

R5     N*1/2(1700) FROM PI N TO N EPSILON                 SQRT(P1*P8)         11/75
R5   L      (-.2) OR  -.2            LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R5   8       (.00)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R6     N*1/2(1700) FROM PI N TO N*3/2(1232) PI,S-WAVE     SQRT(P1*P9)         11/75
R6   L      (+.15)OR  +.16           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R6   8       (.00)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R7     N*1/2(1700) FROM PI N TO N*3/2(1232) PI,D-WAVE     SQRT(P1*P10)        11/75
R7   L      (-.10)OR  -.14           LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R7   8       (+.12)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R8     N*1/2(1700) FROM PI N TO N RHO,S=3/2,S-WAVE        SQRT(P1*P11)        11/75
R8   L      (0.) OR  (-.07)          LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8   8      (+.07)                   LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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                        18  N*1/2(1700) PHOTON DECAY AMPL(GEV**-1/2)

     FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
   REVIEW PRECEDING THE BARYON LISTINGS.

A1     N*1/2(1700) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1          -.103     .130           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1          -.048     .050           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1          -.015     .040           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1           .0       .034           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1         (.023)                    MOORHOUS  74 DPWA    PI N PHOTO PROD   2/74
A1          -.012     .010           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1         (-.005)                   BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1          -.014     .025           FELLER    76 DPWA    PI N PHOTO-PROD   2/77*
A1        . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A2     N*1/2(1700) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2          .055      .065           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2         -.006      .014           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2          .030      .040           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2          .0        .029           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2         (.035)                    MOORHOUS  74 DPWA    PI N PHOTO PROD   2/74
A2         -.012      .010           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2        (-.009)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2          .0        .014           FELLER    76 DPWA    PI N PHOTO-PROD   2/77*
A2        . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A3     N*1/2(1700) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3          .013      .222           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A3         -.021      .098           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A3         -.036      .040           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A3          .0        .034           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A3        (-.015)                    MOORHOUS  74 DPWA    PI N PHOTO PROD   2/74
A3         +.081      .015           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A3        (+.017)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A3        . . . . . .
A3  AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

A4     N*1/2(1700) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4          -.088     .087           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A4          -.026     .067           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A4           .024     .024           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A4           .0       .044           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A4         (.028)                    MOORHOUS  74 DPWA    PI N PHOTO PROD   2/74
A4          +.107     .025           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A4        (+.022)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A4        . . . . . .
A4  AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)

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                        REFERENCES FOR N*1/2(1700)

DONNACH2  68 VIENNA 139          DONNACHIE  RAPPORTEUR,S TALK              (GLAS)
KIRSOPP   68 THESIS              R G KIRSOPP                              (EDIN)
WAGNER    71 NP B25 411          F WAGNER, C LOVELACE                     (CERN)
DEANS     72 PRD 6 1906          DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
DEVENISH  73 PL 47B 53           DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
LANGBEIN  73 NP B53 251          LANGBEIN,WAGNER                        (MUNICH)IJP

DEVENISH  74 NP B81 330          DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2  74 PL 52B 227          DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES     74 PRD 9 2680          KNIES,MOORHOUSE,OBERLACK            (LBL,GLAS)IJP
METCALF   74 NP B76 253          W J METCALF,R L WALKER                  (CIT)IJP
MOORHOUS  74 PRD 9 1             MOORHOUSE,OBERLACK,ROSENFELD        (GLAS+LBL)IJP

CRAWFORD  75 NP B97 125          R L CRAWFORD                             (GLAS)IJP
DEANS     75 NP B96 90           +MITCHELL,MONTGOMERY,+           (SFLA,ALABAMA)IJP
LONGACRE  75 PL 55B 415          +ROSENFELD,LASINSKI,SMADJA+          (LBL,SLAC)IJP

AYED      76 CEA-N-1921          AYED (THESIS)                          (SACL)IJP
BARBOUR   76 NP B111 358         I. M. BARBOUR,R. L. CRAWFORD           (GLAS)IJP
FELLER    76 NP B104 219         +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
BAKER     77 NP B126 365         +BLISSET,BLOODWORTH,BROOME,HART+       (RHEL)IJP
LONGACRE  77 NP B122 493         LONGACRE,DOLBEAU                       (SACL)IJP
    ALSO  76 NP B108 365         DOLBEAU,TRIANTIS,NEVEU,CADIET          (SACL)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS.

HERNDON   72 LBL 1065            +...ROSENFELD...+CASHMORE+...          (LBL,SLAC)
WINNIK    77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY              (HAIF)I

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1700 MEV REGION – PRODUCTION EXPERIMENTS

20 N*1/2(1700, JP=) I=1/2 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS FOR DISCUSSION OF PRODUCTION EXPERIMENTS.

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                        20  N*1/2(1700) MASS (MEV) (PROD. EXP.)

M          (1695.0)    (9.0)          A-BORELLI 67 HBC   +  PBAR P 5.7 BEV/C  8/67
M          (1734.0)   (21.0)          ALMEIDA   68 HBC   +  PP 10 BEV/C       9/69
M          (1730.0)   (18.0)          GALLOWAY  68 HBC      PI-P 6 GEV/C      8/69
M    1     (1712.0)    (6.0)          BARNES    69 HBC      K-P TO K-P 2PI    7/70
M    1     IJP CONSISTENT WITH S11(1700) OR P11(1780) IN FORMATION
M    A     (1667.0)    (5.0)          BENVENUTI 69 DBC    0 PI-D 2.26 GEV     5/70
M    A        J CONSISTENT WITH 5/2 OR 7/2
M    B  190(1693.)    (15.)          RHODE     69 HBC      PP 22 GEV/C       10/69
M    B  JP IS PROBABLY 5/2+
M         (1691.)     (4.)           ANDERSON  70 MMS   -  PI- P TO PI- MMS  2/71
M      177(1710.)    (10.)           CIRBA     70 HBC   +  PI+ P TO P+3PI    2/71
M       40(1763.)    (25.)           COOPER    70 HBC   +  LAMB. K PROD.     2/71
M      505(1730.0)   (15.0)          CRENNELL  70 HBC   +  PI-P,PI+P 6 GEV   1/71
M       60(1710.)                    KUZNETSOV 70 HLBC  -  LAMB. K PROD.     2/71
M    A     (1719.0)    (6.0)          WILLMANN  70 HBC   +  PI+P 13. GEV      5/70
M    A        J CONSISTENT WITH 5/2 OR 7/2
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M          (1694.0)     (8.0)              AMALDI     71 SAS      P P AT 24 GEV      10/71
M          (1730.)     (20.)               BALLAM     71 HBC  +-  PI+-P AT 16GEV      2/72
M          (1700.)                         BEKETOV    71 HBC  +   PI- P 4.45GEV/C     3/72
M          (1711.)     (10.)               BOESEBEC   71 RVUE     PP,PI-P,K-P PROD    3/72
M          (1672.0)     (4.0)              ELLIS      71 CNTR     MMS PP 3.7 GEV/C   10/71
M        80(1650.0)    (10.0)      80/120  MA         71 HBC  +   P P TO P N PI      10/71
M          (1700.0)    (10.0)              MORSE      71 HBC  +   PI-P    25 GEV/C    3/72
M           1670. TO 1730.                 MORSE      71 HBC  +0  PI-P   7   GEV/C    3/72
M          (1720.)     (20.)               RUSHBROOKE71 HBC  +   PP TO P2PI 16GEV    2/72
M          (1690.3)     (4.5)              EDELSTEIN  72 MMS  +   PP 6 TO 30 GEV      1/73
M          (1668.0)    (19.0)      24/45   KARSHON    72 DBC  +   PO--PD2PI 7 GEV    12/72
M  C       (1715.0)     (5.0)              LAMSA      72 HBC  +   PI+-P 8TO18 GEV     1/73
M  C     ANALYSIS GIVES JP = 5/2+
M    2     (1660.)  (15.                   OH         72 DBC   0 PI-N TO PI-PI-P     2/73
M    2   DETERMINE J=5/2,F15 PROBABLE                                                2/73
M          (1720.)     (15.)               RONAT      72  HBC     PI+P TO 3PI P       2/73
M   3      (1820.)                         DAVIDSON   74 HBC   + PI-P TO PI- OM P 10/74
M   3    OMEGA PROTON ENHANCEMENT,MOMENTS ANALYSIS CONSISTENT WITH 2J=1 OR 3 10/74
M          (1732.)      (7.)               LICHTMAN   74 HBC  +   PI+P TO 3PI P       4/75
M          (1694.)     (10.)               LICHTMAN   74 HBC  +   PI-P TO 3PI P       4/75
M   5      (1810.)     (15.)               ATHERTO2   75 HBC      PBAR P 5.7 GEV      2/77*
M   5    CMEGA PROTON ENHANCEMENT, MOMENTS ANALYSIS CONSISTENT WITH S STATE.  2/77*
M   4      (1700.)                         BLOBEL     75 HBC  +   PP TO P(PI+PI-P)    1/76
M   4    PWA INDICATES PI+PI-P ENHANCEMENT IS PRIMARILY A                             1/76
M   4    P-WAVE P EPSILON SYSTEM WITH I,JP=1/2,3/2-.                                  1/76
M           1660. TO 1670.                 BRAUN1     75 HBC      PBAR P 5.7 GEV     11/75
M          (1691.)     (11.)               CAVALLI    75 SPEC +   PP TO 2N*,W=23GV    1/76
M          (1691.)      (8.)               CAVALLI    75 SPEC +   PP TO 2N*,W=31GV    1/76
M          (1715.)     (10.)               CAVALLI    75 SPEC +   PP TO 2N*,W=53GV    1/76
M          (1686.)     (12.)               MUSGRAVE   75 HBC      K+ P TO K PI N     11/75
M          (1650.)                         STRACHMA   75  BC      NBAR (N PI)         1/76
M          (1678.)      (4.)               WEBB       75 ISR  +   P P TO P N*         1/76
M          (1691.)      (4.)               ATHERTON   76 HBC      PBAR P 5.7 GEV      2/77*
M          (1680.)     (25.)               APPLE      77 SPEC +   P P TO P (P PIO)    1/78*
M          (1660.)     (20.)               APPLE      77 SPEC +   P P TO P (N PI+)    1/78*
M          (1690.)     (10.)               HEINEN     77 HBC  +   K-P TO K- N*+       1/78*
M          (1670.)     (10.)               HEINEN     77 HBC   0 K-P TO KOBAR N*O   1/78*
M  F       (1670.)                         OTTER2     77 HBC  +   K-P TO K- N*+       1/78*
M  F     FROM PARTIAL WAVE ANALYSIS OF P PI+ PI- SYSTEM.  SHAPE OF                   1/78*
M  F     5/2-D(DELTA PI) WAVE IS COMPATIBLE WITH A BREIT-WIGNER.                      1/78*
M          (1677.)      (2.)               ROUGE      77 OMEG  0 PI-P 9,12 GEV/C     1/78*
M          (1710.)     (20.)               EKELOF     78 SPEC +   P HE--P PI PI HE    1/78*
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20 N*1/2(1700) WIDTH (MEV) (PROD. EXP.)

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W           (70.0)     (20.0)              A-BORELLI 67 HBC                           9/69
W          (140.0)     (57.0)              ALMEIDA    68 HBC  +                       9/69
W           (55.0)     (15.0)              GALLOWAY   68 HBC                          8/69
W   1       (70.0)     (15.0)              BARNES     69 HBC      K-P TO K-P 2PI      7/70
W   A      (105.0)     (16.0)              BENVENUTI 69 DBC   0                       5/70
W   B  190 (235.)      (50.)               RHODE      69 HBC      PP 22 GEV/C        10/69
W          (130.)      (10.)               ANDERSON   70 MMS  -   PI- P TO PI- MMS    2/71
W      177  (66.)      (26.)               CIRBA      70 HBC  +   PI+ P AT 5 GEV/C    2/71
W          (102.)      (40.)               COOPER     70 HBC  +   PI+P, 5.5 GEV/C     2/71
W      505 (130.0)     (30.0)              CRENNELL   70 HBC  +                       1/71
W       60 (220.)                          KUZNETSOV 70 HLBC -   PI-P, 4 GEV/C       2/71
W   A       (63.0)     (12.0)              WILLMANN   70 HBC  +                       5/70
W          (152.0)     (15.0)              AMALDI     71 SAS      P P AT 24 GEV      10/71
W          (120.)      (50.)               BALLAM     71 HBC  +-  PI+-P AT 16GEV      2/72
W           (57.)      (15.)               BOESEBEC   71 RVUE     PP,PI-P,K-P PROD    3/72
W          (102.0)      (9.0)              ELLIS      71 CNTR     MMS PP 3.7 GEV/C   10/71
W       80  (94.0)     (20.0)      80/120  MA         71 HBC  +   P P TO P N PI      10/71
W           (70.)      (20.)               MORSE      71 HBC  +   PI-P    25 GEV/C    3/72
W            70. TO   120.                 MORSE      71 HBC  +0  PI-P   7   GEV/C    3/72
W          (120.)      (40.)               RUSHBROOKE71 HBC  +   PP TO P2PI 16GEV    2/72
W          (133.0)     (26.0)              EDELSTEIN  72 MMS  +   PP 6 TO 30 GEV      1/73
W          (168.0)     (64.0)              KARSHON    72 DBC  +   PD--PD2PI 7 GEV    12/72
W           (80.0)  APPROX.                LAMSA      72 HBC      PI P   18.5 GEV/C 12/72
W    2     (128.)   (40.                   OH         72 DBC   0 PI-N TO PI-PI-P     2/73
W           (60.)      (40.)               RONAT      72  HBC     PI+P TO 3PI P       2/73
W          (157.)      (12.)               ABE        74      +   P+P->P+X,JCBN PK    4/75
W   3      (120.)                          DAVIDSON   74 HBC   + PI-P TO PI- OM P 10/74
W           (34.)      (14.)               LICHTMAN   74 HBC  +   PI+P TO 3PI P       4/75
W           (48.)      (20.)               LICHTMAN   74 HBC  +   PI-P TO 3PI P       4/75
W   5       (87.)      (20.)               ATHERTO2   75 HBC      PBAR P 5.7 GEV      2/77*
W          (140.)                          BRAUN1     75 HBC      PBAR P 5.7 GEV     11/75
W          (188.)     (112.)               CAVALLI    75 SPEC +   PP TO 2N*,W=23GV    1/76
W          (133.)      (38.)               CAVALLI    75 SPEC +   PP TO 2N*,W=31GV    1/76
W          (100.)      (10.)               CAVALLI    75 SPEC +   PP TO 2N*,W=53GV    1/76
W          (135.)      (20.)               MUSGRAVE   75 HBC      K+ P TO K PI N     11/75
W          (148.)      (16.)               WEBB       75 ISR  +   P P TO P N*         1/76
W          (194.)      (10.)               ATHERTON   76 HBC      PBAR P 5.7 GEV      2/77*
W          (150.)     (100.)               APPLE      77 SPEC +   P P TO P (P PIO)    1/78*
W          (150.)      (70.)               APPLE      77 SPEC +   P P TO P (N PI+)    1/78*
W          (120.)      (20.)               HEINEN     77 HBC  +   K-P TO K- N*+       1/78*
W           (90.)      (30.)               HEINEN     77 HBC   0 K-P TO KOBAR N*O   1/78*
W  F       (150.)                          OTTER2     77 HBC  +   K-P TO K- N*+       1/78*
W          (130.)       (6.)               ROUGE      77 OMEG  0 PI-P 9,12 GEV/C     1/78*
W          (200.)                          EKELOF     78 SPEC +   P HE--P PI PI HE    1/78*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED
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20 N*1/2(1700) PARTIAL DECAY MODES (PROD. EXP.)

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                                                             DECAY MASSES
P1      N*1/2(1700) INTO PI N                              139+ 938
P2      N*1/2(1700) INTO N PI PI                           938+ 139+ 139
P3      N*1/2(1700) INTO N*3/2(1232) PI                   1232+ 139
P4      N*1/2(1700)+ INTO NEUTRON PI+                      939+ 139
P5      N*1/2(1700)+ INTO PROTON PI+ PI-                   938+ 139+ 139
P6      N*1/2(1700)+ INTO N*3/2(1232)++ PI-               1232+ 139
P7      N*1/2(1700) INTO N ETA                             939+ 548
P8      N*1/2(1700) INTO LAMBDA K                         1115+ 497
P9      N*1/2(1700) INTO SIGMA K                          1189+ 493
P10     N*1/2(1700) INTO OMEGA PROTON                      783+ 938
P11     N*1/2(1700) INTO RHOO PROTON                       776+ 938
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20 N*1/2(1700) BRANCHING RATIOS (PROD. EXP.)

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R1      N*1/2(1700) INTO (PI N)/(PI N*3/2(1232))          (P1)/(P3)
R1           (0.77) OR LESS            LEE        67 HBC      PI-P 3.6 GEV/C     11/67
R1   A       (9.0)  OR MORE            BENVENUTI 69 DBC   0                       5/70

R2      N*1/2(1700) INTO (N ETA)/(N PI + N PI PI)         (P7)/(P1+P2)
R2           (0.025)OR LESS            KRAEMER    64 DBC  +   PI+D 1.2
R2           (0.042)OR LESS  CL=.95    A-BORELLI 67 HBC  +   PBAR P 5.7 BEV/C    9/69

R3      N*1/2(1700) INTO (LAMBCA K)/(P PI+ PI-)           (P8)/(P5)
R3           (0.034)OR LESS            ALEXANDER 67 HBC  +   PP 5.5 BEV/C       11/67
R3           (0.07) OR LESS  CL=.95    CIRBA      70 HBC      PI+P AT 5 GEV/C     2/71
R3           (0.01)                    BAKSAY     76 ISR  +   PP--N*P             1/78*

R4      N*1/2(1700) INTO (LAMBDA K)/(N PI + N PI PI)      (P8)/(P1+P2)
R4           (0.013)OR LESS  CL=.95    A-BORELLI 67 HBC  +                        8/67
R4            SEEN                     CHINOWSKY 68 HBC      PP TO K+ Y N         6/68
R4   1      LIMITS 0.025 TO 0.11       BARNES     69 HBC      K-P TO K-P 2PI       7/70
R4     25     0.025     0.005          CRENNELL   70 HBC  +                        1/71
R4   A       LESS THAN   0.025         WILLMANN   70 HBC      PI+P TO 3PI P        6/70
R4     25   SEEN. CONS. WITH J=1/2     MORSE      71 HBC   0 PI-P   7   GEV/C     3/72

R5      N*1/2(1700) INTO (N PI)/(N PI PI)                 (P1)/(P2)
R5           (1.26) OR LESS  CL=.95    A-BORELLI 67 HBC  +                        8/67
R5            0.025     0.13           CRENNELL   70 HBC  +                        1/71

R6      N*1/2(1700) INTO (N*3/2(1232) PI)/(N PI PI)       (P3)/(P2)
R6            NO EVIDENCE              A-BORELLI 67 HBC  +                        8/67
         SEE MERLO 66 FOR A REVIEW.

R7      N*1/2(1700) INTO (NEUTRON PI+)/(P PI+ PI-)        (P4)/(P5)
R7            0.67      0.40           ALEXANDER 67 HBC  +  PP 5.5 BEV/C       11/67
R7            0.47      0.25           A-BORELLI 67 HBC     PBAR P 5.5 GEV/C   7/70
R7           . . . . . . . . . .
R7   AVG      0.53      0.21      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7   STUDENT  0.53      0.23      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R8      N*1/2(1700) INTO (N*3/2(1232)++ PI-)/(P PI+ PI-) (P6)/(P5)
R8            0.74      0.14           ALEXANDER 67 HBC  +  PP 5.5 BEV/C       11/67
R8            1.0       0.3            ALMEIDA    68 HBC  +  PP 10 BEV/C         9/66
R8           (0.83)                    KAYAS      68 HBC     PP 8.1 BEV/C       11/68
R8   1       LESS THAN   0.15          BARNES     69 HBC     K-P TO K-P 2PI      7/70
R8           (0.50) OR LESS  CL=.95    CIRBA      70 HBC     PI+P AT 5 GEV/C     2/71
R8            NO EVIDENCE              CRENNELL   70 HBC  +                       1/71
R8   A       (2.3)     (1.6)           WILLMANN   70 HBC     PI+P TO 3PI P       6/70
R8           (1.0)  OR MORE  CL=.95    BEKETOV    71 HBC  +  DEL(1232)++ PI-     3/72
R8            0.75      0.75           BOESEBEC   71 RVUE    PP,PI-P,K-P PROD    3/72
R8            0.35      0.20           RUSHBROOKE71 HBC  +  PP TO P2PI 16GEV    2/72
R8 C          0.65      0.15           LAMSA      72 HBC     PI P   18.5 GEV/C 12/72
R8           (0.40)                    BLOBEL     75 HBC  +  PP TO P(PI+PI-P)    1/78*
R8            0.3       0.1            HEINEN     77 HBC  +  K-P TO K- N*+       1/78*
R8            0.42      0.08           EKELOF     78 SPEC +  P HE--P PI PI HE    1/78*
R8           . . . . . . . . . .
R8   AVG      0.471     0.078     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R8   STUDENT  0.465     0.064     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R9      N*1/2(1700) INTO (SIG K)/(LAMB K)                 (P9)/(P8)
R9           LESS THAN    .20          COOPER     70 HBC  +  PI+P, 5.5 GEV/C     2/71

R10     N*1/2(1700) INTO (PI N)+/(OMEGA PROTON)           (P1)/(P10)
R10      LESS THAN .36 (90 PCT CL)     DAVIDSON   74 HBC   + PI-P TO PI- OM P 10/74

R11     N*1/2(1700) INTO (RHOO PROTON)/(OMEGA PROTCN)     (P11)/(P10)
R11      LESS THAN .12 (90 PCT CL)     DAVIDSON   74 HBC   + PI-P TO PI- OM P 10/74

        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED
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REFERENCES FOR N*1/2(1700) (PROD. EXP.)


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KRAEMER   64 PR 136 B496          +MADANSKY,+  (J HOPKINS,NWESTERN,WOODSTOCK) I

ALEXANDE 67 PR 154 1284           ALEXANDER,BENARY,CZAPEK,+  (WEIZMANN(CERN))
A-BORELL 67 NC 47 232             ALLES-BORELLI,FRENCH,FRISK,MICHEJDA  (CERN)
LEE       67 PR 159 1156          +MOEBS,ROE,SINCLAIR,VANDER VELDE      (MICH)

ALMEIDA   68 PR 174 1638          +RUSHBROOKE, +              (CAVE,DESY(CERN))
CHINOWSK 68 PR 165 1466           CHINOWSKY,KINSEY,KLEIN, +         (LRL,SLAC)
GALLOWAY 68 PL 27B 250            GALLOWAY,ALYEA,CRITTENDEN,PRICKETT,+  (IND)
KAYAS     68 NP B5 169            +GUYADER,SENE,YIOU,ALITTI,+  (ORSAY,SACLAY)

BARNES    69 PRL 23 1516          +BASSANO+CHUNG+EISNER+FLAMINTO+KINSON (BNL)IJ
BENVENUT 69 PR 187 1852           BENVENUTI, MARQUIT, OPPENHEIMER (MINN,COLO)
RHODE     69 PR 187 1844          RHODE, LEACOCK, KERNAN, JESPERSEN,+   (ISU)

ANDERSON 70 PRL 25,699            +BLESER,BLIEDEN,COLLINS++          (BNL,CARN)
CIRBA     70 NP B23,533           +VANDERHAGEN+   (EPOL,DURH,NIJM, TORI,BONN)
COOPER    70 NP B23,605           +MANNER,MUSGRAVE,POLLARD,VOYVODIC      (ANL)
CRENNELL 70 PRL 25 187            +LAI, LOUIE, SCARR, SIMS               (BNL)
KUZNETSOV70 SJNP 10,332           +MELNIKOV,RYLTSEVA,CHADRAA,BALINTP    (JINR)
WILLMANN 70 PRL 24 1260           +LAMSA,GAIDOS,EZELL                  (PURD)IJ

AMALDI    71 PL  34B 435          +BIANCASTELLI,BOSIO,+  (I SANITA ROMA+CERN)
BALLAM    71 PR D4 1946           +CHADWICK,GUIRAGOSSIAN,JOHNSON,++    (SLAC) I
BEKETOV   71 SJNP 13 605          ,ZOMBKOVSKII,KONOVALOV,KRUCHININ,++  (ITEP)IJ
BOESEBEC 71 NP B33 445            BOESEBECK,GRAESSLER,KRAUS,+++     (ABBCHLV) I
ELLIS     71 PRL 27 442           +MAGLICH,NOREM,SANNES,SILVERMAN       (RUTG)
MA        71 PRL  26  333         +COLTON                            (MSU+LBL)I
MORSE     71 PR D4 133            +OH,WALKER,CARROLL,LYNCH +       (WISC+TNTO)I
RUSHBROO 71 PR D4 3273            RUSHBROOKE,WILLIAMS+BAREFORD++  (CAVE,LOIC) IJ

EDELSTEI 72 PR D5 1073            EDELSTEIN,CARRIGAN,HIEN,MCMAHON,+(CARN+BNL)
JOHNSTAD 72 NP B42 588            +MOLLERUD+...+JACOBSEN(BOHR,HELS,OSLO,STOH) IJP
KARSHON   72 NP B37 371           +YEKUTIELI,YAFFE,SHAPIRA,RONAT,+      (REHO) I
LAMSA     72 NP B37 364           +WILLMANN+..+GO,BISWAS+...     (PURD,NDAM) IJP
OH        72 PL 42B 497           +FUNG,KERNAN,POE,SCHALK,SHEN          (UCR)IJP
RONAT     72 NP B38 20            +EISENBERG,LYONS,SHAPIRA,TOAFF+       (REHO)

ABE       74 PL 53B 114           +ALSPECTOR,BOMBEROWITZ+       (RUTG,UPNJ,FSU)
DAVIDSON 74 PRL 32 855            DAVIDSON,DZIERBA,FIRESTONE,+  (CIT+BNL+LBL)I
LICHTMAN 74 NP B81 31             LICHTMAN,BISWAS,CASON,KENNEY,MCGAHAN+(NDAM)I

ATHERTO2 75 NC 30A 505            ATHERTON,BAR-NIR,FRENCH,SKURA+  (CERN+PRAG)
BLOBEL    75 NP B97 201           +ESKREYS,FESEFELDT,FRANZ+  (BONN+HAMB+MPIM)IJP
BRAUN1    75 NP B95 481           +GERBER,MAURER,MICHALON,SCHIBY+ (STRB,LPNP)I
CAVALLI   75 LNC 14 353           CAVALLI-SFORZA,CONTA+            (PAVIA+PRIN)
    ALSO  75 LNC 14 345+359       CAVALLI-SFORZA,CONTA+            (PAVIA+PRIN)
MUSGRAVE 75 NP B87 365            +PEETERS,SCREINER,WHITMORE,YUTA        (ANL)
STRACHMA 75 NP B98 120            STRACHMAN,BRAUN,GERBER,MAURER+  (LPNP+STRB)I
WEBB      75 PL 55B 331           +TRILLING,TELEGDI+       (AACH+UCLA+UCR+CERN)
    ALSO  75 PL 55B 336           +TRILLING,TELEGDI+       (AACH+UCLA+UCR+CERN)

ATHERTON 76 NP B103 381           ATHERTON,FRENCH,SKURA,BOHM+       (CERN+PRAG)
BAKSAY    76 PL 61B 405           +BOHM,CHANG,ELLIS,FOETH+     (AACH+UCR+CERN)I
APPLE     77 LNC 18 167           +ASH,CHENG,COYNE,GROSSMAN+        (PRIN+PAVIA)
HEINEN    77 NP B122 443          +ENGELEN,KITTEL,METZGER+   (NIJM+AMST+CERN)IJP
OTTER2    77  AACHEN IIIB/3-77    +RUDOLPH+          (AACH+BERL+CERN+LOIC+VIEN)IJP
ROUGE     77 PL 69B 115           +DE ROSNY,FLEURY,RIVET+       (LPNP+CDEF+LALO)
EKELOF    78 NP B132 212          +HERZ,HAGBERG,KULLANDER+    (CERN+UPPS+LOUC)IJ

                                  PAPERS NOT REFERRED TO IN DATA CARDS.

MERLO     66 P ROY SOC 289 489    J P MERLO, G VALLADAS                (SACLAY)
LISSAUER 72 PRD 6 1852            +FIRESTONE,GINESTET,GOLDHABER,TRILLING(LBL)IJP
ANTIPOV   75 NP B99 189           +ASCOLI,BAUD+         (CERN-IHEP BOSON SPEC)
LEDNICKY 75 PL 58B 89             R. LEDNICKY                            (JINR)
BIEL      76 PRL 36 504,507       +BLESER,FERBEL+         (ROCH+FNAL+SLAC+NWES)
CARNEY    76 NP B110 248          +COLLEY,JONES,KENYON+ (BIRM+BRUX+CERN+MONS)IJP
DEKERRET 76 PL 63B 477,483        +NAGY,REGLER,BRANDT+    (CERN+HAMB+IPN+VIEN)
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Baryons
N(1700), N(1780)

Data Card Listings
For notation, see key at front of Listings.

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RUSHBROO 76 PRD 13 1835      RUSHBROOKE,RAJA,ANSORGE,CARTER,NEALE (CAVE)IJP
SOTIRIOU 76 NP B107 457      D.SOTIRIOU                           (CERN)IJP

BACON    77 NC 42A 431       +BARNHAM,DORNAN,EASON,POLLOCK+           (LOIC)IJP
CHADWICK 77  SLAC-PUB-2018   +CARROLL,CHALOUPKA+      (SLAC+STAN+CIT+LBL)IJP
HARRIS   77 NP B119 189      +LUBATTI,MORIYASU,BINGHAM+       (WASH+UCB)
HOFMANN  77 NP B125 404      +IDSCHOK,SCHRODER,BLOBEL+  (BONN+DESY+MPIM)I

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N(1780) 14 N*1/2(1780, JP=1/2+) I=1/2 **P''11**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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14 N*1/2(1780) MASS (MEV)

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M   3      (1751.0)                    DONNACH1  68 RVUE    PHASE-SHIFT ANAL   8/69
M          (1640.0)   (70.0)           ORITO     69 RVUE    K LAMBDA PS ANAL   8/69
M          (1700.0)                    ORITO2    69 CNTR    K LAM PHOTOPRO    10/71
M   6      (1645.0)                    AYED      70 IPWA                      1/71
M   6  FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4      (1770.0)                    DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M          (1809.0)                    SCHORSCH  70 DPWA    K LAM PHOTOPRO.   10/71
M   A      (1685.0)OR(1740.0)          WAGNER    71 IPWA    PI-P TO K LAMB    1/71
M   A  THERE ARE 3 SIMILAR SOLUTIONS
M   7      (1720.)                     ALMEHED   72 IPWA                      2/72
M    2     (1728.)                     HICKS     73 MPWA    GAM P-ETA P       9/73
M    2  ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.       9/73
M    2  M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.      9/73
M   F      (1780.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
M   F      (1780.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
M   F  DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF       1/78*
M   F  WINNIK77 AROUND 1920 MEV.                                            1/78*
M          (1670.)                     KNASEL    75 DPWA  0 PI- P TO KO LAM 11/75
M    L     1730. OR 1710.              LONGACRE  75 IPWA    PI N TO 2PI N     11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.     11/75
M          (1730.)                     AYED      76 IPWA                      11/77*
M   D      (1625.)    (10.)            BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
M   E      (1650.)                     BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
M   D  THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET       1/78*
M   E  ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.             1/78*
M   8      (1720.)                     LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
M   8  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE  11/77*
M   8  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                          11/77*

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14 N*1/2(1780) WIDTH (MEV)

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W   3      (327.0)                     DONNACH1  68 RVUE                     8/69
W          (310.0)   (50.0)            ORITO     69 RVUE                     8/69
W          (210.0)                     ORITO2    69 CNTR    K LAM PHOTOPRO   10/71
W   6      (50.0)                      AYED      70 IPWA                     1/71
W   4      (445.0)                     DAVIES    70 RVUE    SOL A            8/69
W          (280.0)                     SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
W   A      (160.0)OR(220.0)            WAGNER    71 IPWA    PI-P TO K LAMB   1/71
W   7      (160.)                      ALMEHED   72 IPWA                     2/72
W    2     (203.)                      HICKS     73 MPWA    GAM P-ETA P      9/73
W   F      (130.)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 1 9/73
W   F      (130.)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 2 9/73
W          (174.)                      KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
W    L     (165.) OR (75.)             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
W          (164.)                      AYED      76 IPWA                     11/77*
W   D      (160.)     (6.)             BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
W   E      (95.)                       BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
W   8      (120.)                      LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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14 N*1/2(1780) REAL PART OF POLE POSITION (MEV) 11/75

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RE         (1708.)                     LONGACRE  75 IPWA    PI N TO 2PI N    11/75
RE  8       1720. OR 1711.             LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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14 N*1/2(1780) 2*IMAG PART OF POLE POSITION (MEV) 11/75

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IM          (17.)                      LONGACRE  75 IPWA    PI N TO 2PI N    11/75
IM  8       123. OR 115.               LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

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14 N*1/2(1780) PARTIAL DECAY MODES

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                                                              DECAY MASSES
P1     N*1/2(1780) INTO PI N                                  139+ 938
P2     N*1/2(1780) INTO LAMBDA K                             1115+ 497
P3     N*1/2(1780) INTO N ETA                                 939+ 548
P4     N*1/2(1780) INTO GAM P, HELICITY=1/2                     0+ 938
P5     N*1/2(1780) INTO GAM N, HELICITY=1/2                     0+ 939
P6     N*1/2(1780) INTO N PI PI                               938+ 139+ 139
P7     N*1/2(1780) INTO N EPSILON                             938+1300
P8     N*1/2(1780) INTO N RHO                                 938+ 776
P9     N*1/2(1780) INTO K SIGMA                               493+1189
P10    N*1/2(1780) INTO N*3/2(1232) PI                       1232+ 139
P11    N*1/2(1780) INTO N RHO,S=1/2,P-WAVE                    938+ 776
P12    N*1/2(1780) INTO N RHO,S=3/2,P-WAVE                    938+ 776

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14 N*1/2(1780) BRANCHING RATIOS

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R1     N*1/2(1780) INTO (PI N)/TOTAL                                (P1)
R1  3       (0.32)                     DONNACH1  68 RVUE                     8/69
R1  6       (0.149)                    AYED      70 IPWA                     1/71
R1  4       (0.43)                     DAVIES    70 RVUE    SOL A            8/69
R1  7       (0.2)                      ALMEHED   72 IPWA                     2/72
R1           (.17)                     AYED      76 IPWA                    11/77*

R2     N*1/2(1780) FROM PI N TO K LAMBDA                    SQRT(P1*P2)       4/75
R2          (.06)    (.03)             ORITO     69 RVUE                     4/75
R2  A       (.16)OR .21                WAGNER    71         PI- P TO K LAMB  4/75
R2          -.150     .038             DEVENISH  74       0 FIXED T DISP REL 4/75
R2           (.10)                     KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
R2  D       (-.05)    (.03)            BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
R2  E       (-.10)                     BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*

R3     N*1/2(1780) INTO (LAMBDA K)/TOTAL                            (P2)
R3  B       (0.003)TO 0.065            RUSH      68 MPWA    T POLE + RESON.   8/69
R3  B  PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R4     N*1/2(1780) INTO (N ETA)/TOTAL                               (P3)
R4  B       (0.19)                     BOTKE     69 MPWA    T POLE + RESON.  10/69
R4  B       (0.09)   (0.05)            DEANS     69 MPWA    T POLE + RESON.   5/70
R4  B       (0.015)OR 0.035            CARRERAS  70 MPWA    T POLE + RESON.   5/70
R4  B  PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R5     N*1/2(1780) FROM GAMMA PROTON TO K LAMBDA                SQRT(P2*P4)       9/73
R5          (0.0027)                   ORITO2    69 CNTR    K LAM PHOTOPRO   10/71
R5          (0.0088)                   SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71
R5           (.0104)                   DEANS     72 MPWA    GAM P-K LM,SOL D  9/73

R6     N*1/2(1780) FROM GAMMA PROTON TO ETA PROTON               SQRT(P3*P4)       9/73
R6  2       (.0075)                    HICKS     73 MPWA    GAM P-ETA P       9/73

R7     N*1/2(1780) FROM PI N TO K SIGMA                          SQRT(P1*P9)       9/73
R7  F       (.11)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
R7  F       (.14)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R7  1       (.075)TO  .203             DEANS     75 DPWA    PI N TO K SIGMA  11/75
R7  1  RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                             11/75

R8     N*1/2(1780) FROM PI N TO N*3/2(1232) PI                   SQRT(P1*P10)      11/75
R8  L       (.13)OR  -.20              LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R8  8       (+.17)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R9     N*1/2(1780) FROM PI N TO N RHO,S=1/2,P-WAVE               SQRT(P1*P11)      11/75
R9  L       (+.32)OR  +.20             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R9  8       (-.19)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R10    N*1/2(1780) FROM PI N TO N RHO,S=3/2,P-WAVE               SQRT(P1*P12)      11/77*
R10 8       (-.31)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R11    N*1/2(1780) FROM PI N TO N EPSILON                        SQRT(P1*P7)       11/75
R11 L       (+.18)OR  +.28             LONGACRE  75 IPWA    PI N TO 2PI N    11/75
R11 8       (+.26)                     LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R12    N*1/2(1780) FROM PI N TO ETA N                            SQRT(P1*P3)       11/75
R12 5       (+.382)TO +.383            FELTESSE  75 DPWA  0 1488 TO 1745 MEV 11/75
R12 5  USES N AND W OF AYED 76.  NOTE THAT THIS GIVES A BRANCHING           11/77*
R12 5  RATIO TO ETA N OF ABOUT 80 PCT, IN STRONG DISAGREEMENT WITH          11/75
R12 5  EARLIER EXPERIMENTS.                                                 11/75

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14 N*1/2(1780) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

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A1     N*1/2(1780) INTO GAM P, HELICITY=1/2 (GEV**-1/2)
A1           .022      .057            DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1          +.026      .028            MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A1          -.014      .021            DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1           .022      .015            KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1          -.068      .024            METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1           .016      .025            MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A1          +.062      .007            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1         (+.005)                     BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1          +.053      .019            FELLER    76 DPWA    PI N PHOTO-PROD   2/77*
A1           . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.6)

A2     N*1/2(1780) INTO GAM N, HELICITY=1/2 (GEV**-1/2)
A2          -.028      .067            DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2          +.027      .022            MOORHOUS  73 DPWA    PI N PHOTO-PROD   2/73
A2          -.060      .061            DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2           .027      .015            KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2           .048      .045            METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2           .057      .022            MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2          -.020      .016            CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2         (-.010)                     BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2           . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

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REFERENCES FOR N*1/2(1780)

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DONNACH1 68 PL 26B 161       A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139       DONNACHIE  RAPPORTEUR.S TALK            (GLAS)
    ALSO 68 THESIS           R G KIRSOPP                             (EDIN)
RUSH     68 PR 173 1776      J E RUSH                          (UNIV ALABAMA)

BOTKE    69 PR 180 1417      J C BOTKE                                (UCSB)
DEANS    69 PR 185 1797      S DEANS, J WOOTEN                (UNIV S FLORIDA)
ORITO    69 LNC 1 936        S ORITO,S SASAKI                   (TOKYO-OSAKA)
ORITO2   69 INS J 113        S ORITO (THESIS)                         (TOKYO)

AYED     70 KIEV CONF        R AYED,P BAREYRE, G VILLET               (SACL)IJP
CARRERAS 70 NP 168 35        B CARRERAS, A DONNACHIE             (DARE,MCHS)
DAVIES   70 NP B21 359       A DAVIES                                 (GLAS)
SCHORSCH 70 NP  B25 179      +TIETGE,WEILNBOECK                       (MPIM)

WAGNER   71 NP B25 411       F WAGNER, C LOVELACE                     (CERN)

ALMEHED  72 NP B40 157       +LOVELACE                          (LUND,RUTG)IJP
DEANS    72 PRD 6 1906       DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP

DEVENISH 73 PL 47B 53        DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HICKS    73 PRD 7 2614       +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP
LANGBEIN 73 NP B53 251       LANGBEIN,WAGNER                      (MUNICH)IJP
MOORHOUS 73 PL 43B 44        MOORHOUSE, OBERLACK                 (GLAS+LBL)IJP

DEVENISH 74 NP B81 330       DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227       DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680       KNIES,MOORHOUSE,OBERLACK            (LBL,GLAS)IJP
METCALF  74 NP B76 253       W J METCALF,R L WALKER                   (CIT)IJP
MOORHOUS 74 PRD 9 1          MOORHOUSE,OBERLACK,ROSENFELD        (GLAS+LBL)IJP

CRAWFORD 75 NP B97 125       R L CRAWFORD                             (GLAS)IJP
DEANS    75 NP B96 90        +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP
FELTESSE 75 NP B93 242       +AYED,BAKEYRE,BORGEAUD,DAVID,ERNWEIN+(SACL)IJP
KNASEL   75 PRD 11 1         +LINDQUIST,NELSON+          (CHIC,WUSL,OSU,ANL)IJP
LONGACRE 75 PL 55B 415       +ROSENFELD,LASINSKI,SMADJA+      (LBL,SLAC)IJP

AYED     76 CEA-N-1921       AYED (THESIS)                            (SACL)IJP
BARBOUR  76 NP B111 358      I. M. BARBOUR,R. L. CRAWFORD             (GLAS)IJP
FELLER   76 NP B104 219      +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
BAKER    77 NP B126 365      +BLISSET,BLOODWORTH,BROOME,HART+         (RHEL)IJP
LONGACRE 77 NP B122 493      LONGACRE,DOLBEAU                         (SACL)IJP
    ALSO 76 NP B108 365      DOLBEAU,TRIANTIS,NEVEU,CADIET            (SACL)IJP
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Data Card Listings

For notation, see key at front of Listings.

PAPERS NOT REFERRED TO IN DATA CARDS.

```
DEANS     69 PR  177 2623      S R DEANS                        (UNIV S FLORIDA)
DONNACHI  69 NP  108 433       A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
AYED      70 PL  318 598       +BAREYRE+VILLET                      (SACLAY)
WINNIK    77 NP  B128 66       +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I
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N(1810) P''13

15 N*1/2(1810, JP=3/2+) I=1/2

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

15 N*1/2(1810) MASS (MEV)

```
M   3     (1860.0)                    DONNACHI  68 RVUE    PHASE-SHIFT ANAL   6/68
M   X     (1860.0)       APPROX       LEA       69 CNTR    PI-P ELASTIC       8/69
M   X  SEE ALSO APLIN 71
M   6     (1766.0)                    AYED      70 IPWA                       1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   4     (1844.0)                    DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   A     (1800.0)                    WAGNER    71 IPWA    PI-P TO K LAMB     1/71
M   A  P13 RESONATES ONLY IN ONE OUT OF 3 POSSIBLE SOLUTIONS
M   7     (1850.)                     ALMEHED   72 IPWA                       2/72
M    1    (1833.)                     HICKS     73 MPWA    GAM P-ETA P        9/73
M    1  ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.       9/73
M    1  M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.      9/73
M      (1850.)                       KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
M    L   1695. OR 1720.              LONGACRE  75 IPWA    PI N TO 2PI N     11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.    11/75
M      (1696.)                       AYED      76 IPWA                      11/77*
M   D    (1640.)     (10.)           BAKER     77 IPWA  0 PI- P TO K LAM.   1/78*
M   E    (1710.)                     BAKER     77 DPWA  0 PI- P TO K LAM.   1/78*
M   D  THE TWO ENTRIES FOR BAKER 77 ARE FOR AN IPWA USING THE BARRELET       1/78*
M   E  ZERO METHOD AND A CONVENTIONAL ENERGY-DEPENDENT ANALYSIS.             1/78*
M   8    (1750.)                     LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
M   8  ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE  11/77*
M   8  POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                           11/77*
```

15 N*1/2(1810) WIDTH (MEV)

```
W   3     (296.00)                    DONNACHI  68 RVUE                       8/69
W   6     (182.0)                     AYED      70 IPWA                       1/71
W   4     (449.0)                     DAVIES    70 RVUE    SOL A              8/69
W   4  SOL B GIVES 307 MEV                                                    2/73
W   A     (220.0)                     WAGNER    71 IPWA    PI-P TO K LAMB     1/71
W   7     (300.)                      ALMEHED   72 IPWA                       2/72
W    1    (250.)                      HICKS     73 MPWA    GAM P-ETA P        9/73
W      (327.)                        KNASEL    75 DPWA  0 PI- P TO KO LAM   11/75
W    L   115. OR  150.                LONGACRE  75 IPWA    PI N TO 2PI N     11/75
W      (117.)                        AYED      76 IPWA                      11/77*
W   D    (200.)     (50.)           BAKER     77 IPWA  0 PI- P TO K LAM.   1/78*
W   E    (500.)                     BAKER     77 DPWA  0 PI- P TO K LAM.   1/78*
W   8    (130.)                     LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
          SEE THE NOTES ACCOMPANYING THE MASSES QUOTED
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15 N*1/2(1810) REAL PART OF POLE POSITION (MEV) 11/75

```
RE       (1716.)                     LONGACRE  75 IPWA    PI N TO 2PI N     11/75
RE  8     1745. OR 1748.             LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
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15 N*1/2(1810) 2*IMAG PART OF POLE POSITION (MEV) 11/75

```
IM       (124.)                      LONGACRE  75 IPWA    PI N TO 2PI N     11/75
IM  8     135. OR 123.               LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
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15 N*1/2(1810) PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1     N*1/2(1810) INTO PI N                              139+ 938
P2     N*1/2(1810) INTO LAMBDA K                         1115+ 497
P3     N*1/2(1810) INTO N ETA                             939+ 548
P4     N*1/2(1810) INTO N PI PI                           938+ 139+ 139
P5     N*1/2(1810) INTO GAM P,HELICITY=3/2                  0+ 938
P6     N*1/2(1810) INTO GAM P,HELICITY=1/2                  0+ 938
P7     N*1/2(1810) INTO GAM N,HELICITY=3/2                  0+ 939
P8     N*1/2(1810) INTO GAM N,HELICITY=1/2                  0+ 939
P9     N*1/2(1810) INTO SIGMA K                           493+1189
P10    N*1/2(1810) INTO N RHO,S=1/2,P-WAVE                938+ 776
P11    N*1/2(1810) INTO N RHO,S=3/2,P-WAVE                938+ 776
P12    N*1/2(1810) INTO N*3/2(1232) PI,P-WAVE            1232+ 139
P13    N*1/2(1810) INTO N EPSILON                         938+1300
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15 N*1/2(1810) BRANCHING RATIOS

```
R1     N*1/2(1810) INTO (PI N)/TOTAL                              (P1)
R1  3      (0.21)                     DONNACHI  68 RVUE                      8/69
R1  6      (0.149)                    AYED      70 IPWA                      1/71
R1  4      (0.40)                     DAVIES    70 RVUE    SOL A             8/69
R1  7      (0.25)                     ALMEHED   72 IPWA                      2/72
R1          (.14)                     AYED      76 IPWA                     11/77*

R2     N*1/2(1810) INTO (LAMBDA K)/TOTAL                          (P2)
R2  B      (0.014)TO 0.16             RUSH      68 MPWA    T POLE + RESON.   8/69
R2  B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R3     N*1/2(1810) INTO (N ETA)/TOTAL                             (P3)
R3  B      (0.0364)                   BOTKE     69 MPWA    T POLE + RESON.  10/69
R3  B      (0.003)  (0.003)           DEANS     69 MPWA    T POLE + RESON.   5/70
R3  B      (0.030)OR 0.094            CARRERAS  70 MPWA    T POLE + RESON.   5/70
R3  B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R4     N*1/2(1810) FROM PI N TO K LAMBDA                      SQRT(P1*P2)      4/75
R4  A       (.12)                     WAGNER    71 IPWA    PI- P TO K LAMB   4/75
R4          -.067      .033           DEVENISH  74         0 FIXED T DISP REL 4/75
R4          (.13)                     KNASEL    75 DPWA  0 PI- P TO KO LAM  11/75
R4  D      (-.06)     (.02)           BAKER     77 IPWA  0 PI- P TO K LAM.  1/78*
R4  E      (-.09)                     BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*

R5     N*1/2(1810) FROM GAMMA PROTON TO K LAMBDA              SQRT((P5+P6)*P2)   9/73
R5          (.0082)                   DEANS     72 MPWA    GAM P-K LM,SOL D   9/73

R6     N*1/2(1810) FROM GAMMA PROTON TO ETA PROTON            SQRT((P5+P6)*P3)   9/73
R6  1       (.0052)                   HICKS     73 MPWA    GAM P-ETA P        9/73

R7     N*1/2(1810) FROM PI N TO K SIGMA                       SQRT(P1*P9)       11/75
R7  2       (.051)TO .087             DEANS     75 DPWA    PI N TO K SIGMA   11/75
R7  2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                               11/75
R7  2   DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77             1/78*
R7  2   AROUND 1920 MEV.                                                      1/78*

R8     N*1/2(1810) FROM PI N TO N RHO,S=1/2,P-WAVE            SQRT(P1*P10)      11/75
R8  L       (-.35)OR  -.40            LONGACRE  75 IPWA    PI N TO 2PI N     11/75
R8  8       (+.26)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77*

R9     N*1/2(1810) FROM PI N TO N RHO,S=3/2,P-WAVE            SQRT(P1*P11)      11/77*
R9  8       (-.15)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77*

R10    N*1/2(1810) FROM PI N TO N*3/2(1232)PI,P-WAVE          SQRT(P1*P12)      11/77*
R10 8       (+.17)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77*

R11    N*1/2(1810) FROM PI N TO N EPSILON                     SQRT(P1*P13)      11/77*
R11 8       (+.19)                    LONGACRE  77 IPWA    PI N TO 2PI N     11/77*
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15 N*1/2(1810) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

```
A1     N*1/2(1810) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1          -.022      .094           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A1           .025      .034           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1          -.004      .032           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1           .0        .025           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1          +.022      .012           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1         (+.086)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1          . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A2     N*1/2(1810) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2          -.001      .106           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A2          -.087      .057           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2          -.006      .030           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2           .0        .022           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2          -.016      .016           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2         (-.060)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2          . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

A3     N*1/2(1810) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3           .132      .173           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A3           .013      .045           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A3           .014      .014           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A3           .0        .050           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A3          -.037      .022           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A3         (-.020)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A3          . . . . . .
A3  AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

A4     N*1/2(1810) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4           .080      .133           DEVENISH  73 DPWA    PI N PHOTO PROD   2/74
A4          -.083      .090           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A4          -.008      .025           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A4           .0        .044           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A4          -.038      .015           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A4         (+.046)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A4          . . . . . .
A4  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
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REFERENCES FOR N*1/2(1810)


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DONNACHI 68 PL 26B 161       A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139       DONNACHIE  RAPPORTEUR,S TALK           (GLAS)
    ALSO 68 THESIS           R G KIRSOPP                            (EDIN)
RUSH     68 PR 173 1776      J E RUSH                        (UNIV ALABAMA)

BOTKE    69 PR 180 1417      J C BOTKE                              (UCSB)
DEANS    69 PR 185 1797      S DEANS, J WOOTEN                (UNIV S FLORIDA)
LEA      69 PL 29B 584       LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)

AYED     70 KIEV CONF        R AYED,P BAREYRE, G VILLET             (SACL)IJP
CARRERAS 70 NP 16B 35        B CARRERAS, A DONNACHIE          (DARE,MCHS)
DAVIES   70 NP B21 359       A DAVIES                               (GLAS)

WAGNER   71 NP B25 411       F WAGNER, C LOVELACE                   (CERN)

ALMEHED  72 NP B40 157       +LOVELACE                        (LUND,RUTG)IJP
DEANS    72 PRD 6 1906       DEANS,JACOBS, LYONS,MONTGOMERY (SOUTH FLA.)IJP
DEVENISH 73 PL 47B 53        DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HICKS    73 PRD 7 2614       +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP

DEVENISH 74 NP B81 330       DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
DEVENIS2 74 PL 52B 227       DEVENISH,LYTH,RANKIN        (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680       KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253       W J METCALF,R L WALKER                 (CIT)IJP

CRAWFORD 75 NP B97 125       R L CRAWFORD                           (GLAS)IJP
DEANS    75 NP B96 90        +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP
KNASEL   75 PRD 11 1         +LINDQUIST,NELSON+       (CHIC,WUSL,OSU,ANL)IJP
LONGACRE 75 PL 55B 415       +ROSENFELD,LASINSKI,SMADJA+       (LBL,SLAC)IJP

AYED     76 CEA-N-1921       AYED (THESIS)                          (SACL)IJP
BARBOUR  76 NP B111 358      I. M. BARBOUR,R. L. CRAWFORD           (GLAS)IJP
BAKER    77 NP B126 365      +BLISSET,BLOODWORTH,BROOME,HART+       (RHEL)IJP
LONGACRE 77 NP B122 493      LONGACRE,DOLBEAU                       (SACL)IJP
    ALSO 76 NP B108 365      DOLBEAU,TRIANTIS,NEVEU,CADIET          (SACL)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS.


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DEANS     69 PR  177 2623      S R DEANS                        (UNIV S FLORIDA)
DONNACHI  69 NP  108 433       A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
AYED      70 PL  318 598       +BAREYRE+VILLET                      (SACLAY)
APLIN     71 NP  B32 253       +COWAN,GIBSON,GILMORE++          (RHEL,BRISTOL)
MA        76 PRD 13 3027       E. MA,G. L. SHAW                   (GREG+UCI)IJP
WINNIK    77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY          (HAIF)I
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Baryons

N(1990), N(2000), N(2040)

Data Card Listings

For notation, see key at front of Listings.

N(1990) → 17 N*1/2(1990, JP=7/2+) I=1/2 **F17**

17 N*1/2(1990) MASS (MEV)

M	3	(1983.0)		DONNACH1	68 RVUE	PHASE-SHIFT ANAL	
M	3	(1995.)		KIRSOPP	68 RVUE	PHASE SHIFT ANAL	10/69
M	3	WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1					10/69
M	X	(2000.0)	APPROX	LEA	69 CNTR	PI-P ELASTIC	8/69
M	X	SEE ALSO APLIN 71					
M	7	(2000.)		ALMEHED	72 IPWA		2/72
M	H	(1970.)		HICKS	73 MPWA	GAM P-ETA P	9/73
M	H	ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.					9/73
M	H	M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.					9/73
M	1	(1960.)		LANGBEIN	73 IPWA	PI N-K SIG,SOL 1	9/73
M	1	NOT SEEN IN SOLUTION 2 OF LANGBEIN73					9/73
M	1	DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF					1/78*
M	1	WINNIK77 AROUND 1920 MEV.					1/78*
M		(2049.)		AYED	76 IPWA		11/77*

17 N*1/2(1990) WIDTH (MEV)

W	3	(225.0)		DONNACH1	68 RVUE		8/69
W	3	(250.)		KIRSOPP	68 RVUE	PHASE SHIFT ANAL	10/69
W	7	(200.)		ALMEHED	72 IPWA		2/72
W	H	(300.)		HICKS	73 MPWA	GAM P-ETA P	9/73
W	1	(170.)		LANGBEIN	73 IPWA	PI N-K SIG,SOL 1	9/73
W		(119.)		AYED	76 IPWA		11/77*

17 N*1/2(1990) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*1/2(1990) INTO PI N	139+ 938
P2	N*1/2(1990) INTO N PI PI	938+ 139+ 139
P3	N*1/2(1990) INTO N ETA	939+ 548
P4	N*1/2(1990) INTO LAMBDA K	1115+ 497
P5	N*1/2(1990) INTO GAM P,HELICITY=3/2	0+ 938
P6	N*1/2(1990) INTO GAM P,HELICITY=1/2	0+ 938
P7	N*1/2(1990) INTO GAM N,HELICITY=3/2	0+ 939
P8	N*1/2(1990) INTO GAM N,HELICITY=1/2	0+ 939
P9	N*1/2(1990) INTO K SIGMA	493+1189

17 N*1/2(1990) BRANCHING RATIOS

R1		N*1/2(1990) INTO (PI N)/TOTAL			(P1)		
R1	3	(.09)		KIRSOPP	68 RVUE	PHASE SHIFT ANAL	10/69
R1	7	(0.15)		ALMEHED	72 IPWA		2/72
R1		(.06)		AYED	76 IPWA		11/77*
R2		N*1/2(1990) INTO (N ETA)/TOTAL			(P3)		
R2	B	(0.02) (0.02)		DEANS	69 MPWA	T POLE + RESON.	5/70
R2	B	PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING					
R3		N*1/2(1990) FROM GAMMA PROTON TO K LAMBDA			SQRT((P5+P6)*P4)		9/73
R3		.0034		DEANS	72 MPWA	GAM P-K LM,SOL D	9/73
R4		N*1/2(1990) FROM GAMMA PROTON TO ETA PROTON			SQRT((P5+P6)*P3)		9/73
R4	H	(.0045)		HICKS	73 MPWA	GAM P-ETA P	9/73
R5		N*1/2(1990) FROM PI N TO K SIGMA			SQRT(P1*P9)		9/73
R5	1	(.06)		LANGBEIN	73 IPWA	PI N-K SIG,SOL 1	9/73
R5	2	(.010)TO .023		DEANS	75 DPWA	PI N TO K SIGMA	11/75
R5	2	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.					11/75
R6		N*1/2(1990) FROM PI N TO K LAMBDA			SQRT(P1*P4)		4/75
R6		-.021 .033		DEVENISH	74	0 FIXED T DISP REL	4/75

17 N*1/2(1990) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	N*1/2(1990) INTO GAM P, HELICITY=1/2 (GEV**-1/2)					1/76
A1	(+.011)		BARBOUR	76 DPWA	PI N PHOTO-PROD	1/76
A2	N*1/2(1990) INTO GAM P, HELICITY=3/2 (GEV**-1/2)					1/76
A2	(-.008)		BARBOUR	76 DPWA	PI N PHOTO-PROD	1/76
A3	N*1/2(1990) INTO GAM N, HELICITY=1/2 (GEV**-1/2)					1/76
A3	(-.099)		BARBOUR	76 DPWA	PI N PHOTO-PROD	1/76
A4	N*1/2(1990) INTO GAM N, HELICITY=3/2 (GEV**-1/2)					1/76
A4	(-.070)		BARBOUR	76 DPWA	PI N PHOTO-PROD	1/76

REFERENCES FOR N*1/2(1990)

DONNACH1	68 PL 26B 161	A DONNACHIE, R G KIRSOPP, C LOVELACE	(CERN)IJP
KIRSOPP	68 THESIS	R G KIRSOPP	(EDIN)
DEANS	69 PR 185 1797	S DEANS, J WOOTEN	(UNIV S FLORIDA)
LEA	69 PL 29B 584	LEA,CADES,WARD,COWAN,+	(RHEL,BRISTOL,DARE)
ALMEHED	72 NP B40 157	,LOVELACE	(RUTG)IJP
DEANS	72 PRD 6 1906	DEANS,JACOBS, LYONS,MONTGOMERY	(SOUTH FLA.)IJP
HICKS	73 PRD 7 2614	+DEANS,JACOBS,LYONS+	(CARN+ORNL+SOUTH FLA.)IJP
LANGBEIN	73 NP B53 251	LANGBEIN,WAGNER	(MUNICH)IJP
DEVENISH	74 NP B81 330	DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)	
DEANS	75 NP B96 90	+MITCHELL,MONTGOMERY,+	(SFLA,ALABAMA)IJP
AYED	76 CEA-N-1921	AYED (THESIS)	(SACL)IJP
BARBOUR	76 NP B111 358	I. M. BARBOUR,R. L. CRAWFORD	(GLAS)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

DEANS	69 PR 177 2623	S R DEANS	(UNIV S FLORIDA)
AYED	70 PL 31B 598	+BAREYRE,VILLET	(SACLAY)
APLIN	71 NP B32 253	+COWAN,GIBSON,GILMORE++	(RHEL,BRISTOL)
MA	76 PRD 13 3027	E. MA,G. L. SHAW	(OREG+UCI)IJP
WINNIK	77 NP B128 66	+TOAFF,REVEL,GOLDBERG,BERNY	(HAIF)I

N(2000) → 06 N*1/2(2000, JP=5/2+) I=1/2 **F''15**

06 N*1/2(2000) MASS (MEV)

M	7	(2175.)		ALMEHED	72 IPWA		2/72
M		(1930.)		DEANS	72 MPWA	GAM P-K LM,SOL D	9/73
M	1	(1970.)		LANGBEIN	73 IPWA	PI N-K SIG,SOL 2	9/73
M	1	NOT SEEN IN SOLUTION 1 OF LANGBEIN73					9/73
M		(2025.)		AYED	76 IPWA		11/77*

06 N*1/2(2000) WIDTH (MEV)

W	7	(150.)		ALMEHED	72 IPWA		2/72
W		(112.)		DEANS	72 MPWA	GAM P-K LM,SOL D	9/73
W	1	(170.)		LANGBEIN	73 IPWA	PI N-K SIG,SOL 2	9/73
W		(157.)		AYED	76 IPWA		11/77*

06 N*1/2(2000) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*1/2(2000) INTO PI N	139+ 938
P2	N*1/2(2000) INTO LAMBDA K	1115+ 497
P3	N*1/2(2000) INTO GAM P,HELICITY=3/2	0+ 938
P4	N*1/2(2000) INTO GAM P,HELICITY=1/2	0+ 938
P5	N*1/2(2000) INTO GAM N,HELICITY=3/2	0+ 939
P6	N*1/2(2000) INTO GAM N,HELICITY=1/2	0+ 939
P7	N*1/2(2000) INTO K SIGMA	493+1189

06 N*1/2(2000) BRANCHING RATIOS

R1		N*1/2(2000) INTO (PI N)/TOTAL			(P1)		
R1	7	(0.25)		ALMEHED	72 IPWA		2/72
R1		(.08)		AYED	76 IPWA		11/77*
R2		N*1/2(2000) FROM GAMMA PROTON TO K LAMBDA			SQRT((P3+P4)*P2)		9/73
R2		(.0022)		DEANS	72 MPWA	GAM P-K LM,SOL D	9/73
R3		N*1/2(2000) FROM PI N TO K SIGMA			SQRT(P1*P7)		9/73
R3	1	(.05)		LANGBEIN	73 IPWA	PI N-K SIG,SOL 2	9/73
R3	2	(.022)		DEANS	75 DPWA	PI N TO K SIGMA	11/75
R3	2	VALUE GIVEN IS FROM SOLUTION 1, NOT PRESENT IN SOLUTIONS 2,3,4.					11/75

REFERENCES FOR N*1/2(2000)

ALMEHED	72 NP B40 157	,LOVELACE	(RUTG)IJP
DEANS	72 PRD 6 1906	DEANS,JACOBS, LYONS,MONTGOMERY	(SOUTH FLA.)IJP
LANGBEIN	73 NP B53 251	LANGBEIN,WAGNER	(MUNICH)IJP
DEANS	75 NP B96 90	+MITCHELL,MONTGOMERY,+	(SFLA,ALABAMA)IJP
AYED	76 CEA-N-1921	AYED (THESIS)	(SACL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

MA	76 PRD 13 3027	E. MA,G. L. SHAW	(OREG+UCI)IJP

N(2040) → 16 N*1/2(2040, JP=3/2-) I=1/2 **D''13**

16 N*1/2(2040) MASS (MEV)

M	3	(2057.0)		DONNACH1	68 RVUE	PHASE-SHIFT ANAL	6/68
M	3	(2030.)		DONNACH2	68 RVUE	PHAS.SHIFT-CERN1	10/69
M	3	(2040.)		KIRSOPP	68 RVUE	PHASE SHIFT ANAL	10/69
M	3	WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1					10/69
M	X	(2030.0)	APPROX	LEA	69 CNTR	PI-P ELASTIC	8/69
M	X	SEE ALSO APLIN 71					
M	7	(2075.)		ALMEHED	72 IPWA		2/72
M	1	(2090.)		HICKS	73 MPWA	GAM P-ETA P	9/73
M	1	ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.					9/73
M	1	M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.					9/73
M		(2029.)		AYED	76 IPWA		11/77*

16 N*1/2(2040) WIDTH (MEV)

W		(293.0)		DONNACH1	68 RVUE		8/69
W	3	(290.)		DONNACH2	68 RVUE	PHAS.SHIFT-CERN1	10/69
W	3	(240.)		KIRSOPP	68 RVUE	PHASE SHIFT ANAL	10/69
W	7	(150.)		ALMEHED	72 IPWA		2/72
W	1	(224.)		HICKS	73 MPWA	GAM P-ETA P	9/73
W		(116.)		AYED	76 IPWA		11/77*

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

16 N*1/2(2040) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*1/2(2040) INTO PI N	139+ 938
P2	N*1/2(2040) INTO N PI PI	938+ 139+ 139
P3	N*1/2(2040) INTO N ETA	939+ 548
P4	N*1/2(2040) INTO LAMBDA K	1115+ 497
P5	N*1/2(2040) INTO GAM P,HELICITY=3/2	0+ 938
P6	N*1/2(2040) INTO GAM P,HELICITY=1/2	0+ 938
P7	N*1/2(2040) INTO GAM N,HELICITY=3/2	0+ 939
P8	N*1/2(2040) INTO GAM N,HELICITY=1/2	0+ 939
P9	N*1/2(2040) INTO SIGMA K	493+1189

16 N*1/2(2040) BRANCHING RATIOS

```
R1     N*1/2(2040) INTO (PI N)/TOTAL                          (P1)
R1  3        (.26)                  DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3        (.15)                  KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  7      (0.3)                    ALMEHED   72 IPWA                      2/72
R1           (.10)                  AYED      76 IPWA                     11/77*

R2     N*1/2(2040) INTO (N ETA)/TOTAL                         (P3)
R2  B        (0.)   OR 0.009       CARRERAS  70 MPWA    T POLE + RESON.   5/70
R2  B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

R3     N*1/2(2040) FROM GAMMA PROTON TO K LAMBDA          SQRT((P5+P6)*P4)    9/73
R3           (.0070)                DEANS     72 MPWA    GAM P-K LM,SOL D    9/73

R4     N*1/2(2040) FROM GAMMA PROTON TO ETA PROTON        SQRT((P5+P6)*P3)    9/73
R4  1        (.0037)                HICKS     73 MPWA    GAM P-ETA P         9/73

R5     N*1/2(2040) FROM PI N TO K SIGMA                   SQRT(P1*P9)        11/75
R5  2        (.014)TO  .037         DEANS     75 DPWA    PI N TO K SIGMA    11/75
R5  2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                             11/75
R5  2   DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77           1/78*
R5  2   AROUND 1920 MEV.                                                    1/78*
```

16 N*1/2(2040) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

```
A1     N*1/2(2040) INTO GAM P, HELICITY=1/2  (GEV**-1/2)
A1           .026     .052         DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75

A2     N*1/2(2040) INTO GAM P, HELICITY=3/2  (GEV**-1/2)
A2           .128     .057         DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75

A3     N*1/2(2040) INTO GAM N, HELICITY=1/2  (GEV**-1/2)
A3           .053     .083         DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75

A4     N*1/2(2040) INTO GAM N, HELICITY=3/2  (GEV**-1/2)
A4           .100     .141         DEVENIS2  74 DPWA    PI N PHOTO-PROD    4/75
```

REFERENCES FOR N*1/2(2040)

```
DONNACH1 68 PL 26B 161      A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139      DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
KIRSOPP  68 THESIS          R G KIRSOPP                           (EDIN)

LEA      69 PL 29B 584      LEA,DADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)

CARRERAS 70 NP 16B 35       B CARRERAS, A DONNACHIE               (DARE,MCHS)

ALMEHED  72 NP B40 157      +LOVELACE                        (LUND,RUTG)IJP
DEANS    72 PRD 6 1906      DEANS,JACOBS, LYONS,MONTGOMERY  (SOUTH FLA.)IJP
HICKS    73 PRD 7 2614      +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP

DEVENIS2 74 PL 52B 227      DEVENISH,LYTH,RANKIN          (DESY,LANC,BONN)IJP
DEANS    75 NP B96 90       +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP
AYED     76 CEA-N-1921      AYED (THESIS)                         (SACL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACH1 69 NP 10B 433      A DONNACHIE, R KIRSOPP                (GLAS+EDIN)
AYED     70 PL 31B 598      +BAREYRE,VILLET                         (SACLAY)
APLIN    71 NP  B32 253     +COWAN,GIBSON,GILMORE++          (RHEL,BRISTOL)
MA       76 PRD 13 3027     E. MA,G. L. SHAW                  (OREG+UCI)IJP
WINNIK   77 NP B128 66      +TOAFF,REVEL,GOLDBERG,BERNY             (HAIF)I
```

N(2100)

04 N*1/2(2100, JP=1/2-) I=1/2 S''_{11}

04 N*1/2(2100) MASS (MEV)

```
M          (2070.)                 ROYCHOUD  71 DPWA                    3/72
M    7     (2100.)                 ALMEHED   72 IPWA                    2/72
M          (2280.)                 AYED      76 IPWA                   11/77*
```

04 N*1/2(2100) WIDTH (MEV)

```
W    7      (200.)                 ALMEHED   72 IPWA                    2/72
W           (320.)                 AYED      76 IPWA                   11/77*
```

04 N*1/2(2100) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1     N*1/2(2100) INTO PI N                              139+ 938
```

04 N*1/2(2100) BRANCHING RATIOS

```
R1     N*1/2(2100) INTO (PI N)/TOTAL                          (P1)
R1  7        (0.5)                  ALMEHED   72 IPWA                    2/72
R1           (.15)                  AYED      76 IPWA                   11/77*
```

REFERENCES FOR N*1/2(2100)

```
ROYCHOUD 71 NP B27 125      R K ROYCHOUDHURY,B H BRANSDEN         (DURH)IJP
ALMEHED  72 NP B40 157      +LOVELACE                        (LUND,RUTG)IJP
AYED     76 CEA-N-1921      AYED (THESIS)                         (SACL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

MA       76 PRD 13 3027     E. MA,G. L. SHAW                  (OREG+UCI)IJP
```

N(2100)

05 N*1/2(2100, JP=5/2-) I=1/2 D''_{15}

05 N*1/2(2100) MASS (MEV)

```
M    7     (2100.)                 ALMEHED   72 IPWA                    2/72
M          (2076.)                 AYED      76 IPWA                   11/77*
M    E     (1870.)                 BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
M    E   IN ADDITION TO THE LISTED PARAMETERS OBTAINED IN A DPWA, BAKER 77   1/78*
M    E   SEE A POSSIBLE EFFECT ABOVE 2000 MEV IN AN IPWA.                    1/78*
```

05 N*1/2(2100) WIDTH (MEV)

```
W    7      (150.)                 ALMEHED   72 IPWA                    2/72
W           (206.)                 AYED      76 IPWA                   11/77*
W    E       (53.)                 BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
```

05 N*1/2(2100) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1     N*1/2(2100) INTO PI N                              139+ 938
P2     N*1/2(2100) INTO LAMBDA K                          1115+ 497
```

05 N*1/2(2100) BRANCHING RATIOS

```
R1     N*1/2(2100) INTO (PI N)/TOTAL                          (P1)
R1  7        (0.2)                  ALMEHED   72 IPWA                    2/72
R1           (.09)                  AYED      76 IPWA                   11/77*

R2     N*1/2(2100) FROM PI N TO LAMBDA K                  SQRT(P1*P2)
R2  E        (-.06)                 BAKER     77 DPWA  0 PI- P TO K LAM.  1/78*
```

REFERENCES FOR N*1/2(2100)

```
ALMEHED  72 NP B40 157      +LOVELACE                        (LUND,RUTG)IJP
AYED     76 CEA-N-1921      AYED (THESIS)                         (SACL)IJP
BAKER    77 NP B126 365     +BLISSET,BLOODWORTH,BROOME,HART+      (RHEL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

MA       76 PRD 13 3027     E. MA,G. L. SHAW                  (OREG+UCI)IJP
```

XXXXXXXXXX

N(2100) BUMPS

114 N*1/2(2100, JP=) I=1/2 PRODUCTION EXPERIMENT

RESONANCE-LIKE BUMP OBSERVED IN PP TO P(N PI+) AT CERN ISR (DE KERRET 76). THE ENHANCEMENT SHOWS UP MORE CLEARLY WHEN EVENTS CORRESPONDING TO TRANSVERSAL DECAYS OF THE (N PI+) SYSTEM ARE SELECTED, CONTRARY TO WHAT WOULD BE EXPECTED FOR A DIFFRACTIVE-LIKE EFFECT.

114 N*1/2(2100) MASS (MEV) (PROD. EXPERIMENTS)

```
Z14M          2100.                  DE KERRET 76 ISR  +  P(N PI+)E**=45GE
```

114 N*1/2(2100) PARTIAL DECAY MODES (PROD. EXP.)

```
                                                          DECAY MASSES
Z14P1  N*1/2(2100) INTO PI N                              1115+ 497
```

REFERENCES FOR N*1/2(2100) PROD. EXPERIMENTS

```
DEKERRET 76 PL 63B 477,483     +NAGY,REGLER,BRANDT+    (CERN+HAMB+IPN+VIEN)
```

N(2190)

71 N*1/2(2190, JP=7/2-) I=1/2 G_{17}

THIS RESONANCE IS WELL ESTABLISHED.

71 N*1/2(2190) MASS (MEV)

```
M          (2190.0)                DIDDENS   63 CNTR    PI+- P TOTAL
M          (2210.0)                HOHLER    64 RVUE    DATA + DISP REL
M          (2190.0)       APPROX   YOKOSAWA  66 CNTR    PI- P DSIG + POL   7/66
M    3     (2265.0)                DONNACH1  68 RVUE    PHASE-SHIFT ANAL   6/68
M          (2000.0)       APPROX   LEA       69 CNTR    PI-P ELASTIC       8/69
M           2180.      25.         ANDERSON  70 MMS  -  PI- P TO PI- MMS   2/71
M    6     (2158.0)                AYED      70 IPWA                       1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M          (2260.0)                HULL      70 MPWA    SMALL ANGLE PI-P   1/71
M          (2160.0)   (50.0)       AMALDI    71 CNTR    P P AT 24 GEV     10/71
M          (2160.)                 BRANSDEN  71 DPWA                       3/72
M          (2200.)                 ROYCHOUD  71 DPWA                       3/72
M    7     (2225.)                 ALMEHED   72 IPWA                       2/72
M          (2190.)                 OTT       72 MPWA  0 PI-P BKWD ELSTC   2/73
M    1     (2208.)                 HICKS     73 MPWA    GAM P-ETA P        9/73
M    1   ONLY STATES FROM TABLE VII OF HICKS73 ARE INCLUDED IN LISTINGS.     9/73
M    1   M AND W ARE FROM SOLUTION C2,BR=SQRT(G)/W WITH G FROM TABLE VII.    9/73
M          (2208.)    (20.)        ABE       74       +  P+P->P+X,JCBN PK   4/75
M          (2141.)                 AYED      76 IPWA                      11/77*
```

Baryons
N(2190), N(2200), N(2220)

Data Card Listings
For notation, see key at front of Listings.

71 N*1/2(2190) WIDTH (MEV)

W		(200.0)			DIDDENS	63 CNTR		
W		(200.0)			HOHLER	64 RVUE		7/66
W		(220.0)		APPROX	YOKOSAWA	66 CNTR		7/66
W	3	(298.0)			DONNACHI	68 RVUE		6/68
W		275.	70.		ANDERSON	70 MMS	- PI- P TO PI- MMS	2/71
W	6	(325.0)			AYED	70 IPWA		1/71
W		(239.0)			HULL	70 MPWA	SMALL ANGLE PI-P	1/71
W	7	(150.)			ALMEHED	72 IPWA		2/72
W	1	(193.)			HICKS	73 MPWA	GAM P-ETA P	9/73
W		(243.)			AYED	76 IPWA		11/77*

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

71 N*1/2(2190) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*1/2(2190) INTO PI N	139+ 938
P2	N*1/2(2190) INTO LAMBDA K	1115+1700
P3	N*1/2(2190) INTO N PI PI	938+ 139+ 139
P4	N*1/2(2190) INTO GAM P,HELICITY=3/2	0+ 938
P5	N*1/2(2190) INTO GAM P,HELICITY=1/2	0+ 938
P6	N*1/2(2190) INTO GAM N,HELICITY=3/2	0+ 939
P7	N*1/2(2190) INTO GAM N,HELICITY=1/2	0+ 939
P8	N*1/2(2190) INTO ETA N	548+ 938
P9	N*1/2(2190) INTO SIGMA K	493+1189

71 N*1/2(2190) BRANCHING RATIOS

R1		N*1/2(2190) INTO (PI N)/TOTAL				(P1)		
R1		(0.3)		APPROX	DIDDENS	63 CNTR		7/66
R1		(0.3)		APPROX	YOKOSAWA	66 CNTR		7/66
R1	3	(0.349)			DONNACHI	68 RVUE		6/68
R1	6	(0.150)			AYED	70 IPWA		1/71
R1		(0.09)			HULL	70 MPWA	SMALL ANGLE PI-P	1/71
R1	7	(0.35)			ALMEHED	72 IPWA		2/72
R1		(.25)			OTT	72 MPWA	0 PI-P BKWD ELSTC	2/73
R1		(.16)			AYED	76 IPWA		11/77*
R2		N*1/2(2190) FROM GAMMA PROTON TO K LAMBDA				SQRT((P4+P5)*P2)		9/73
R2		(.0161)			DEANS	72 MPWA	GAM P-K LM,SOL D	9/73
R3		N*1/2(2190) FROM GAMMA PROTON TO ETA PROTON				SQRT((P4+P5)*P8)		9/73
R3		(.0094)			HICKS	73 MPWA	GAM P-ETA P	9/73
R4		N*1/2(2190) FROM PI N TO K SIGMA				SQRT(P1*P9)		11/75
R4	4	(.014)TO .019			DEANS	75 DPWA	PI N TO K SIGMA	11/75
R4	4	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.						11/75
R4	4	DEANS75 DISAGREES WITH P1+ P TO K+ SIGMA+ DATA OF WINNIK77						1/78*
R4	4	AROUND 1920 MEV.						1/78*

REFERENCES FOR N*1/2(2190)

DIDDENS	63 PRL 10 262	+JENKINS, KYCIA, RILEY	(BNL) I
HOHLER	64 PL 12 149	G HOHLER, J GIESECKE	(KARLSRUHE) I
YOKOSAWA	66 PRL 16 714	+SUHA,HILL,ESTERLING, BOOTH	(ANL,CHIC) JP
DONNACHI	68 PL 26B 161	A DONNACHIE, R G KIRSOPP, C LOVELACE	(CERN)IJP
ALSO	68 VIENNA 139	DONNACHIE RAPPORTEUR.S TALK	(GLAS)
ALSO	68 THESIS	R G KIRSOPP	(EDIN)
LEA	69 PL 29B 584	LEA,OADES,WARD,COWAN,+	(RHEL,BRISTOL,DARE)
ANDERSON	70 PRL 25,699	+BLESER,BLIEDEN,COLLINS++	(BNL,CARN)
AYED	70 KIEV CONF	R AYED,P BAREYRE, G VILLET	(SACL)IJP
HULL	70 PR D2 1783	J HULL, R LEACOCK	(ISU)
AMALDI	71 PL 34B 435	+BIANCASTELLI,BOSIO,+	(I SANITA ROMA+CERN)
BRANSDEN	71 NP B26 511	,OGDEN	(DURH)IJP
ALSO	70 NP B16 461	ROYCHOUDHURY,PERRIN,BRANSDEN	(DURH)IJP
ROYCHOUD	71 NP B27 125	R K ROYCHOUDHURY,B H BRANSDEN	(DURH)IJP
ALMEHED	72 NP B40 157	+LOVELACE	(LUND,RUTG)IJP
DEANS	72 PRD 6 1906	DEANS,JACOBS, LYONS,MONTGOMERY	(SOUTH FLA.)IJP
OTT	72 PL 42B 133	+TRISCHUK,VAVRA,RICHARDS,+	(MCGI,STLO,IOWA)IJP
ALSO	72 MCGILL THESIS	J.VAVRA	(MCGI) JP
HICKS	73 PRD 7 2614	+DEANS,JACOBS,LYONS+	(CARN+ORNL+SOUTH FLA.)IJP
ABE	74 PL 53B 114	+ALSPECTOR,BOMBEROWITZ+	(RUTG,UPNJ,FSU)
DEANS	75 NP B96 90	+MITCHELL,MONTGOMERY,+	(SFLA,ALABAMA)IJP
AYED	76 CEA-N-1921	AYED (THESIS)	(SACL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

BARGER	66 PRL 16 913	V BARGER, D CLINE	(WISC) P
CARROLL	66 PRL 16 288	+CORBETT,DAMERELL,MIDDLEMAS, +	(RHEL,OXF)J-L
CARROLL	66 PRL 17 1274	+CORBETT,DAMERELL,MIDDLEMAS, +	(RHEL,OXF)J-L
ERRATUM CHANGING THE RATHER WEAK DETERMINATION OF J-L TO +1			(2.)
KORMANYO	66 PRL 16 709	KORMANYOS,KRISCH,OFALLON, +	(MICH,ANL) P
BUSZA	67 NC 52A 331	+DAVIS,DUFF,HEYMANN, +	(LOUC,WESTFIELD)
AYED	70 PL 31B 598	+BAREYRE,VILLET	(SACLAY)
MA	76 PRD 13 3027	E. MA,G. L. SHAW	(OREG+UCI)IJP
WINNIK	77 NP B128 66	+TOAFF,REVEL,GOLDBERG,BERNY	(HAIF)I

XXXXXXXXX

N(2200)

113 N*1/2(2200, JP=9/2-) I=1/2 **G_{19}**

113 N*1/2(2200) MASS (MEV)

Z13M	2133.		AYED	76 IPWA

113 N*1/2(2200) WIDTH (MEV)

Z13W	193.		AYED	76 IPWA

113 N*1/2(2200) PARTIAL DECAY MODES

		DECAY MASSES
Z13P1	N*1/2(2200) INTO PI N	493+1189

113 N*1/2(2200) BRANCHING RATIOS

Z13R1	N*1/2(2200) INTO (PI N)		(TOTAL		(P1))
Z13R1	.09		AYED	76 IPWA	

REFERENCES FOR N*1/2(2200)

AYED	76 CEA-N-1921	AYED (THESIS)	(SACL)IJP

N(2220)

90 N*1/2(2220, JP=9/2+) I=1/2 **H_{19}**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

90 N*1/2(2220) MASS (MEV)

M		(2200.)	APPROX.	BUSZA	67 OSPK	LEG.POLYN.ANAL.	2/71
M	6	(2221.0)		AYED	70 IPWA		1/71
M	6	FROM ENER. DEP. FIT OF ARGAND DIAGRAM					
M		(2245.0)		HULL	70 MPWA	SMALL ANGLE PI-P	1/71
M		(2249.)		AYED	76 IPWA		11/77*

90 N*1/2(2220) WIDTH (MEV)

W	6	(258.0)		AYED	70 IPWA		1/71
W		(329.0)		HULL	70 MPWA	SMALL ANGLE PI-P	1/71
W		(347.)		AYED	76 IPWA		11/77*

90 N*1/2(2220) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*1/2(2220) INTO PI N	139+ 938
P2	N*1/2(2220) INTO N ETA	939+ 548

90 N*1/2(2220) BRANCHING RATIOS

R1		N*1/2(2220) INTO (PI N)/TOTAL				(P1)	
R1	6	(0.140)		AYED	70 IPWA		1/71
R1		(0.15)		HULL	70 MPWA	SMALL ANGLE PI-P	1/71
R1		(.20)		AYED	76 IPWA		11/77*

REFERENCES FOR N*1/2(2220)

BUSZA	67 NC 52A 331	+DAVIS,DUFF,HEYMANN,NIMMON +	(LOUC+LOWC)
AYED	70 KIEV CONF	R AYED,P BAREYRE, G VILLET	(SACL)IJP
HULL	70 PR D2 1783	J HULL, R LEACOCK	(ISU)
AYED	76 CEA-N-1921	AYED (THESIS)	(SACL)IJP

PAPERS NOT REFERED TO IN DATA CARDS

AYED	70 PL 31B 598	+BAREYRE,VILLET	(SACLAY)
MA	76 PRD 13 3027	E. MA,G. L. SHAW	(OREG+UCI)IJP

2200 MEV REGION – PRODUCTION EXPERIMENTS

111 N*1/2(2200, JP=?) I=1/2 PRODUCTION EXPERIMENTS

WE LIST HERE BUMPS OBSERVED IN THE RANGE 2000-2400 MEV.

111 N*1/2(2200) MASS (MEV) (PROD. EXP.)

M	2160.	50.	AMALDI	71 SAS +	P P TO P MM	1/78*
M	2120.	30.	APPLE	77 SPEC +	P P TO P (P PIO)	1/78*
M	2362.	20.	APPLE	77 SPEC +	P P TO P (N PI+)	1/78*
M	. . . . .					
M	AVERAGE MEANINGLESS (SCALE FACTOR = 5.0)					

111 N*1/2(2200) WIDTH (MEV) (PROD. EXP.)

W	125.	70.	APPLE	77 SPEC +	P P TO P (P PIO)	1/78*
W	75.	50.	APPLE	77 SPEC +	P P TO P (N PI+)	1/78*
W	. . . . .					
W	AVG 91.9	40.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
W	STUDENT 91.8	44.4	AVERAGE USING STUDENT10(H/1.11) — SEE MAIN TEXT			

REFERENCES FOR N*1/2(2200)

AMALDI	71 PL 34B 435	+BIANCASTELLI,BOSIO,MATTHIAE+	(SANI+CERN)
APPLE	77 LNC 18 167	+ASH,CHENG,COYNE,GROSSMAN+	(PRIN+PAVIA)

Data Card Listings

For notation, see key at front of Listings.

N(2650)

72 N*1/2(2650, JP=11/2-) I=1/2 I_{111}

ROYCHOUDHURY 71 CLAIM F15(2400) AND G19(2400) TO BE POSSIBLE RESONANCES. BRANSDEN 71 FIND THE POSSIBLE RESONANT CANDIDATES S11(2520) AND H19(2590). RECENT PI N PWA'S ESTABLISH THE EXISTENCE OF A JP=11/2- STATE IN THIS REGION, BUT THE STRONG POSSIBILITY THAT THERE ARE ALSO OTHER STATES REMAINS. SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS.

72 N*1/2(2650) MASS (MEV) (PROD. EXP.)

M	(2700.0)			ALVAREZ	64 CNTR	PI PHOTOPROD	
M	(2660.0)			HOHLER	64 RVUE	DATA + DISP REL	
M	(2600.0)		APPROX	WAHLIG	64 OSPK	0 PI-P CH EX	
M	(2633.0)			BARGER	66 FIT	TOTAL + CH EX	11/67
M	2649.0	10.0		CITRON	66 CNTR	PI+- P TOTAL	7/66

72 N*1/2(2650) WIDTH (MEV) (PROD. EXP.)

W	(100.0)		ALVAREZ	64 CNTR		
W	(200.0)		HOHLER	64 RVUE		7/66
W	(425.0)		BARGER	66 FIT	TOTAL + CH EX	11/67
W	360.0	20.0	CITRON	66 CNTR		7/66

72 N*1/2(2650) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	N*1/2(2650) INTO PI N	139+ 938
P2	N*1/2(2650) INTO LAMBDA K	1115+ 497
P3	N*1/2(2650) INTO N PI PI	938+ 139+ 139

72 N*1/2(2650) BRANCHING RATIOS (PROD. EXP.)

R1	N*1/2(2650) INTO (PI N)/TOTAL				(P1)		
R1	ONLY (J+1/2)*(PI N/TOTAL) MEASURED FOR THIS STATE						
R1	B	(0.4561)	(0.018)	BARGER	66 RVUE	TOTAL + CH EXC.	11/67
R1		0.436	0.028	CITRON	66 CNTR	TOTAL CROSS-SEC.	11/67
R1	B	(0.30)		BARGER	67 RVUE	USES KORMANYOS67	11/67
R1	B	USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE					
R1	B	FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.					
R1	D	(0.24)		DIKMEN	67 RVUE	USES KORMANYOS66	11/67
R1	D	USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES					
R1		(0.06)		KORMANYOS	67 CNTR	PI-P AT 180 DEG.	11/67

REFERENCES FOR N*1/2(2650) (PROD. EXP.)

ALVAREZ	64 PRL 12 710	+BAR-YAM,KERN,LUCKEY,OSBORNE, +	(MIT,CEA)
HOHLER	64 PL 12 149	G HOHLER, J GIESECKE	(KARLSRUHE) I
WAHLIG	64 PRL 13 103	+MANNELLI,SODICKSON,FACKLER,WARD, +	(MIT)
BARGER	66 PR 151 1123	V BARGER, M OLSSON	(WISC)
CITRON	66 PR 144 1101	+GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +	(BNL) I
BARGER	67 PR 155 1792	V BARGER, D CLINE	(WISC) P
DIKMEN	67 PRL 18 798	F N DIKMEN	(MICH)
KORMANYO	67 PR 164 1661	KORMANYOS, KRISCH, OFALLON, +	(MICH,ANL) P

PAPERS NOT REFERRED TO IN DATA CARDS.

BAACKE	67 NC 51A 761	J BAACKE, M YVERT	(KARLSRUHE,ORSAY)J-L
DOLEN	68 PR 166 1768	R DOLEN, D HORN, C SCHMID	(CIT)
WAHLIG	68 PR 168 1515	M A WAHLIG, I MANNELLI	(MIT,PISA)

FINAL VERSION OF DATA USED IN WAHLIG 64. IN CONFUNCTION WITH CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

BRANSDEN 71	NP B26 511	,GGDEN	(DURH)IJP
ALSO 70	NP B16 461	ROYCHOUDHURY,PERRIN,BRANSDEN	(DURH)IJP
ROYCHOUD 71	NP B27 125	R K ROYCHOUDHURY,B H BRANSDEN	(DURH)IJP

N(3030) BUMPS

73 N*1/2(3030, JP=) I=1/2 PRODUCTION EXPERIMENTS

73 N*1/2(3030) MASS (MEV) (PROD. EXP.)

M	(3080.0)			HOHLER	64 RVUE	DATA + DISP REL	7/66
M	(3030.0)			CITRON	66 CNTR	PI+- P TOTAL	7/66

73 N*1/2(3030) WIDTH (MEV) (PROD. EXP.)

W	(400.0)		CITRON	66 CNTR		7/66

73 N*1/2(3030) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	N*1/2(3030) INTO PI N	139+ 938
P2	N*1/2(3030) INTO N PI PI	938+ 139+ 139

73 N*1/2(3030) BRANCHING RATIOS (PROD. EXP.)

R1	N*1/2(3030) INTO (PI N)/TOTAL				(P1)		
R1	ONLY (J+1/2)*(PI N/TOTAL) MEASURED FOR THIS STATE						
R1	B	(0.088)	(0.016)	BARGER	66 RVUE	TOTAL + CH EXC.	11/67
R1		(0.048)		CITRON	66 CNTR	TOTAL CROS.SEC.	11/67
R1	B	(0.12)		BARGER	67 CNTR	USES KORMANYOS66	11/67
R1	B	USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE					
R1	B	FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.					
R1	D	(0.016)		DIKMEN	67 RVUE	USES KORMANYOS67	11/67
R1	D	USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES					

REFERENCES FOR N*1/2(3030) (PROD. EXP.)

HOHLER	64 PL 12 149	G HOHLER, J GIESECKE	(KARLSRUHE) I
BARGER	66 PR 151 1123	V BARGER, M OLSSON	(WISC)
CITRON	66 PR 144 1101	+GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +	(BNL) I
BARGER	67 PR 155 1792	V BARGER, D CLINE	(WISC) P
DIKMEN	67 PRL 18 798	F N DIKMEN	(MICH)

PAPERS NOT REFERRED TO IN DATA CARDS

KORMANYO	67 PR 164 1661	KORMANYOS, KRISCH, OFALLON, +	(MICH,ANL) P
DOLEN	68 PR 166 1768	R DOLEN, D HORN, C SCHMID	(CIT)

N?(3245) BUMPS

74 N* /2(3245, JP=) PRODUCTION EXPERIMENTS

EXISTENCE NOT CONCLUSIVELY ESTABLISHED. I-SPIN NOT DETERMINED, BUT THE NARROW WIDTH PRECLUDES IDENTIFICATION WITH THE N*3/2(3230). OMITTED FROM TABLE.

74 N* /2(3245) MASS (MEV) (PROD. EXP.)

M	3245.0	10.0		KORMANYOS	67 CNTR	PI-P 180 DEG EL	6/68

74 N* /2(3245) WIDTH (MEV) (PROD. EXP.)

W	(35.0)	OR LESS		KORMANYOS	67 CNTR	6/68

74 N* /2(3245) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	N* /2(3245) INTO PI N	139+ 938

74 N* /2(3245) BRANCHING RATIOS (PROD. EXP.)

R1	N* /2(3245) INTO (PI N)/TOTAL				(P1)		
R1	J IS NOT KNOWN. FOLLOWING IS (J+1/2)*(PI N)/TOTAL						
R1		(0.37)		KORMANYOS	67 CNTR		6/68

REFERENCES FOR N* /2(3245) (PROD. EXP.)

KORMANYO	67 PR 164 1661	KORMANYOS, KRISCH, OFALLON, +	(MICH,ANL) P

N(3690) BUMPS

75 N*1/2(3690, JP=) I=1/2 PRODUCTION EXPERIMENTS

A BUMP SEEN IN THE INVARIANT MASS OF A VERY COMPLICATED STATE (N + SEVEN PIS), SO AS EVIDENCE FOR A NEW RESONANCE IT IS NOT CONCLUSIVE. NOT INCLUDED IN TABLE.

75 N*1/2(3690) MASS (MEV) (PROD. EXP.)

M	3690.0	10.0		BARTKE	67 HBC	+ PI+P 8 PRONGS	8/67

75 N*1/2(3690) WIDTH (MEV) (PROD. EXP.)

W	50.0	30.0		BARTKE	67 HBC	+ 8/67

75 N*1/2(3690) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	N*1/2(3690) INTO N + 7 PIS	

REFERENCES FOR N*1/2(3690) (PROD. EXP.)

BARTKE	67 PL 24B 118	+CZYZEWSKI,DANYSZ,+	(CRACOW,ORSAY) I

N?(3755) BUMPS

76 N* /2(3755, JP=) PRODUCTION EXPERIMENTS

A SMALL PEAK IN THE (P P PBAR) INVARIANT MASS FROM 8.4 BEV/C PI+ P TO PI+ P P PBAR EVENTS. AS EVIDENCE FOR A NEW RESONANCE IT IS NOT CONCLUSIVE. OMITTED FROM TABLE.

76 N* /2(3755) MASS (MEV) (PROD. EXP.)

M	3755.0	8.0		EHRLICH	68 HBC	+ PI+ P P PBAR	6/68

76 N* /2(3755) WIDTH (MEV) (PROD. EXP.)

W	40.0	20.0		EHRLICH	68 HBC	+ 6/68

76 N* /2(3755) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	N* /2(3755) INTO PI+ P P PBAR	139+ 938+ 938+ 938

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                                REFERENCES FOR N* /2(3755) (PROD. EXP.)

EHRLICH  68 PRL 20 686          R EHRLICH,R J PLANO,J B WHITTAKER (RUTGERS)

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                    S=0 I=3/2 NUCLEON STATES (Δ)

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Δ(1232)        33  N*3/2(1232, JP=3/2+) I=3/2        P'33

               THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.
               SEE CARTER 71 AND CARTER 73 FOR PI N CROSS-SECTION
               DATA IN THIS REGION.

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                          33  N*3/2(1232)  MASS (MEV)

M          (1234.)                        ROPER     65 DPWA ++0 PHASE SHIFT AN.
M          (1235.)                        ALMEHED   72 IPWA                        2/72
M    3     (1243.3)   (1241.7)            CHENG     73          FIT CARTER 71      2/74
M    3   THE TWO ENTRIES ARE FROM TWO DIFFERENT PARAMETRIZATIONS OF THE            2/74
M    3   RESONANCE CONTRIBUTUION TO THE P33 PHASE SHIFT.                           2/74
M          (1230.4)                       TSCHANG   73          FIT CARTER71 P33   1/74
M          (1231.)                        AYED      76 IPWA                        11/77*

M++         1236.0       0.55            OLSSON    65 RVUE ++ TOTAL-SIGMA DATA
M++  2      1231.0       1.5             CARTER    71 MPWA ++ PI+P SIG. TOTAL     1/74
M++  1      1231.1        .2             CARTER    73 IPWA ++ PI N 88-310 MEV     9/73
M++  1   EXPERIMENTAL QUANTITY-SEE CARTER73 FOR COULOMB BARRIER CORRECTIONS       9/73
M++  2   EXPERIMENTAL QUANTITY-SEE CARTER71 FOR COULOMB BARRIER CORRECTIONS       1/74
M++         . . . . . .
M++ AVERAGE MEANINGLESS (SCALE FACTOR = 8.4)

M+         (1231.8)                       BERENDS   75 IPWA +  GAM P TO PI NUC     4/75
M+          1230.6       1.8             CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
M+         (1231.7)                       BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76

MO          1236.45      0.65            OLSSON    65 RVUE  0
MO          1232.9       0.6             CARTER    71 MPWA  0 PI-P SIG. TOTAL    1/71
MO          . . . . . .
MO  AVERAGE MEANINGLESS (SCALE FACTOR = 4.0)

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                          33  N*3/2(1232) WIDTH (MEV)

W          (120.)                         ROPER     65 DPWA ++0 PHASE SHIFT AN.
W          (129.)                         ALMEHED   72 IPWA                        2/72
W    3     (152.2)    (145.8)             CHENG     73          FIT CARTER 71      2/74
W          (120.)                         TSCHANG   73          FIT CARTER71 P33   1/74
W          (109.)                         AYED      76 IPWA                        11/77*

W++         120.0        2.0             OLSSON    65 RVUE ++
W++  2      111.1        1.8             CARTER    71 MPWA ++ PI+P SIG. TOTAL     1/74
W++  1      111.5         .4             CARTER    73 IPWA ++ PI N 88-310 MEV     9/73
W++         . . . . . .
W++ AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

W+          120.2        3.9             CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
W+         (117.4)                        BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76

WO          119.6        2.4             OLSSON    65 RVUE  0
WO          114.7        3.0             CARTER    71 MPWA  0 PI-P SIG TOT.      1/71
WO          . . . . . .
WO  AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                    33  (N*0) - (N*++) MASS DIFFERENCE (MEV)

D   R        (0.45)   (0.85)            OLSSON    65 RVUE
D    2         1.3      1.9             CARTER    71 MPWA ++ PI+-P SIG. TOTAL    1/74
D    1         1.4       .4             CARTER    73 IPWA    PI N 88-310 MEV     9/73
D   R      REDUNDANT WITH DATA IN MASS LISTING.
D          . . . . . .
D   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    33  (N*0)-(N*++) WIDTH DIFFERENCE (MEV)                     9/73

WD   2        6.5      2.2             CARTER    71 MPWA ++ PI+-P SIG. TOTAL    1/74
WD   1       10.3      1.3             CARTER    73 IPWA    PI N 88-310 MEV     9/73
WD          . . . . . .
WD  AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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                    33  N*3/2(1232) REAL PART OF POLE POSITION(MEV)

REE  M     (1214.)                        MICHAEL   67                             2/74
REE        (1211.)                        BALL      72                             2/73
REE  P      1211.6       0.7             PDG       72          FIT DELTA 33       2/73
REE 3      (1210.7)   (1210.7)            CHENG     73          FIT CARTER 71      2/74
REE         1214.5      10.              NOGOVA    73          FIT ALMEHED72      2/74
REE        (1213.)                        SPEARMAN  74          FIT ZERO TRJCTRY   4/75
REE  M  FIT INCLUDES OLSSON 65 PARAMETERS PLUS SCATTERING LENGTH PLUS 6
REE  M  PHASE SHIFT VALUES FOR TPI=120 TO 492 MEV.
REE  P  ERROR EST. FROM FITS WITH SOMEWHAT VARYING ASSUMPTIONS
REE         . . . . . .
REE AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R++  U      1211.5        .6             BALL      75      ++ FIT CARTER 73     11/75
R++  U      1210.9        .8             LICHTENB  75      ++ FIT CARTER 73     11/75
R++  C      1209.6        .5             VASAN     76      ++ FIT CARTER 73     1/76
R++  C  FROM FITS TO COULOMB CORRECTED CARTER 73 PHASE SHIFT.                     1/76
R++  U    (1210.5)TO(1210.8)              VASAN     76      ++ FIT CARTER 73     1/76
R++  U  FROM FITS TO UNCORRECTED CARTER 73 PHASE SHIFT.                          1/76
R++         . . . . . .
R++ AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)

RE+         1208.        2.             CAMPBELL  76      +  FIT PHOTO-PROD    2/77*

REO  U     (1211.6)                       BALL      75       0 FIT CARTER 73     11/75
REO  U      1210.9       1.4             LICHTENB  75       0 FIT CARTER 73     11/75
REO  C      1210.75       .6             VASAN     76       0 FIT CARTER 73     1/76
REO  U     (1210.2)                       VASAN     76       0 FIT CARTER 73     1/76
REO         . . . . . .
REO AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    33  N*3/2(1232) IMAG PART OF POLE POSITION(MEV)

IME  M      (52.)                         MICHAEL   67                             2/74
IME         (50.)                         BALL      72                             2/73
IME  P       49.5       1.8             PDG       72          FIT DELTA 33       2/73
IME 3       (50.7)    (50.6)             CHENG     73          FIT CARTER 71      2/74
IME          48.6       5.               NOGOVA    73          FIT ALMEHED72      2/74
IME         (49.)                         SPEARMAN  74          FIT ZERO TRJCTRY   4/75
IME         . . . . . .
IME AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

I++  U       50.1        .6             BALL      75      ++ FIT CARTER 73     11/75
I++  U       49.6        .75            LICHTENB  75      ++ FIT CARTER 73     11/75
I++  C       50.4        .5             VASAN     76      ++ FIT CARTER 73     1/76
I++  U     (49.9)TO (50.0)               VASAN     76      ++ FIT CARTER 73     1/76
I++         . . . . . .
I++ AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

IM+          53.        2.             CAMPBELL  76      +  FIT PHOTO-PROD    2/77*

IMO  U      (53.0)                        BALL      75       0 FIT CARTER 73     11/75
IMO  U       53.25      1.75            LICHTENB  75       0 FIT CARTER 73     11/75
IMO  C       52.8        .6             VASAN     76       0 FIT CARTER 73     1/76
IMO  U     (52.9)TO (53.1)               VASAN     76       0 FIT CARTER 73     1/76
IMO         . . . . . .
IMO AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    33  N*3/2(1232) ABSOLUTE VALUE OF POLE RESIDUE (MEV)

ABS        (53.)                          BALL      73          FIT DELTA 33       9/73

A++  C   (52.4)TO (53.2)                  VASAN     76      ++ FIT CARTER 73     1/76
A++  U   (52.1)TO (52.4)                  VASAN     76      ++ FIT CARTER 73     1/76

ABO  C   (54.8)TO (55.0)                  VASAN     76      ++ FIT CARTER 73     1/76
ABO  U   (55.2)TO (55.3)                  VASAN     76      ++ FIT CARTER 73     1/76

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                    33  N*3/2(1232) PHASE OF POLE RESIDUE (RADIANS)

PH         (-.81)                         BALL      73          FIT DELTA 33       9/73

P++  C   (-.822)TO -.833                  VASAN     76      ++ FIT CARTER 73     1/76
P++  U   (-.823)TO -.830                  VASAN     76      ++ FIT CARTER 73     1/76

PHO  C   (-.840)TO -.847                  VASAN     76      ++ FIT CARTER 73     1/76
PHO  U   (-.848)TO -.856                  VASAN     76      ++ FIT CARTER 73     1/76

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                    33  N*3/2(1232) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     N*3/2(1232) INTO N PI                                      938+ 139
P2     N*3/2(1232) INTO N GAMMA                                   938+   0
P3     N*3/2(1232) INTO N PI PI                                   938+ 139+ 139
P4     N*3/2(1232) INTO GAM NUCLEON, HELICITY=1/2                   0+ 938
P5     N*3/2(1232) INTO GAM NUCLEON, HELICITY=3/2                   0+ 938

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                    33  N*3/2(1232) BRANCHING RATIOS

R1     N*3/2(1232) INTO (N GAMMA)/(N PI) (PERCENT)          (P2)/(P1)
R1           0.55      0.02             DALITZ    66 RVUE                        7/68
R1           0.53      0.025            BERENDS   71 IPWA    PHOTOPROD. ANAL.    10/71
R1          . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2     N*3/2(1232)0 INTO (N PI)/TOTAL                       (P1)
R2  2        (.99)                      CARTER    71 MPWA ++ PI+-P SIG. TOTAL  1/74
R2           (1.)                       AYED      76 IPWA                      11/77*

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                    33  N*3/2(1232) PHOTON DECAY AMPL(GEV**-1/2)

        FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
      REVIEW PRECEDING THE BARYON LISTINGS.

A1     N*3/2(1232) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1          -.144      .014             DEVENISH  73 DPWA    PI N PHOTO PROD      2/74
A1          -.142      .006             MOORHOUS  73 DPWA    PI N PHOTO-PROD      2/73
A1          -.138      .004             KNIES     74 DPWA    PI N PHOTO PROD      2/74
A1          -.140      .006             METCALF   74 DPWA    PI N PHOTO-PROD      2/74
A1          -.142      .001             MOORHOUS  74 DPWA    PI N PHOTO-PROD      2/74
A1          -.130      .002             CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
A1         (-.139)                      KRIVETS   75 DPWA    PI-N PHOTO-PROD      1/78*
A1         (-.129)                      BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76
A1          -.141      .004             FELLER    76 DPWA    PI N PHOTO-PROD      2/77*
A1          . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)

A2     N*3/2(1232) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2          -.262      .015             DEVENISH  73 DPWA    PI N PHOTO PROD      2/74
A2          -.259      .016             MOORHOUS  73 DPWA    PI N PHOTO-PROD      2/73
A2          -.253      .002             KNIES     74 DPWA    PI N PHOTO PROD      2/74
A2          -.254      .007             METCALF   74 DPWA    PI N PHOTO-PROD      2/74
A2          -.261      .001             MOORHOUS  74 DPWA    PI N PHOTO-PROD      2/74
A2          -.248      .002             CRAWFORD  75 DPWA    PI N PHOTO-PROD      1/76
A2         (-.253)                      KRIVETS   75 DPWA    PI-N PHOTO-PROD      1/78*
A2         (-.251)                      BARBOUR   76 DPWA    PI N PHOTO-PROD      1/76
A2          -.256      .003             FELLER    76 DPWA    PI N PHOTO-PROD      2/77*
A2          . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 3.7)

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                          REFERENCES FOR N*3/2(1232)

OLSSON   65 PRL 14 118        M G OLSSON                              (WISC)
ROPER    65 PR 138 B190       L D ROPER, R M WRIGHT, B T FELD    (LRL+MIT)IJP

DALITZ   66 PR 146 1180       DALITZ,SUTHERLAND                       (OXFORD)
    CONTAINS REFERENCES TO EARLIER WORK ON DELTA PHOTOPRODUCTION.

MICHAEL  67 PR 156 1677       MICHAEL                                 (RHEL)IJP
BERENDS  71 NP  B30 575       +WEAVER                            (CEA,MIT,TUFT)
CARTER   71 NP B26 445        +WILLIAMS, BUGG, BUSSEY, DANCE     (CAVE,RHEL)
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Δ(1232), Δ(1550)

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ALMEHED  72 NP B40 157        +LOVELACE                          (LUND,RUTG)IJP
BALL     72 PRL 28 1143       +CAMPBELL,LEE,SHAW            (UTAH,BOIS,UCI)
PDG      72 PL 39B 103        SODING,BARTELS,+  (DESY+LBL+BRAN+CERN+HELS)IJP
BALL     73 PRD 7 2789        BALL,LEE,SHAW                      (UTAH+UCI)IJP
CARTER   73 NP B58 378        CARTER,BUGG,CARTER    (CAVENDISH+QUEEN MARY)IJP
CHENG    73 PRD 7 2249        CHENG,LICHTENBERG                  (IND)IJP
DEVENISH 73 PL 47B 53         DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
MOORHOUS 73 PL 43B 44         MOORHOUSE, OBERLACK              (GLAS+LBL)IJP
NOGOVA   73 NP B61 445        NOGOVA,PISUT(IP SLOVAK ACAD SCI,COMENIUS U)IJP
    ALSO 73 NP B61 438        NOGOVA,PISUT+(IP SLOVK ACAD SCI,COMENIUS U)IJP
    ALSC 73 NP B65 544        NOGOVA,PISUT+(IP SLOVK ACAD SCI,COMENIUS U)IJP
TSCHANG  73 NP B59 445        TSCHANG,PARKINSON          (FLOR+GAINESVILLE)IJP

KNIES    74 PRD 9 2680        KNIES,MOORHOUSE,OBERLACK          (LBL,GLAS)IJP
METCALF  74 NP B76 253        W J METCALF,R L WALKER                (CIT)IJP
MOORHOUS 74 PRD 9 1           MOORHOUSE,OBERLACK,ROSENFELD      (GLAS+LBL)IJP
SPEARMAN 74 PRD 10 1660       T D SPEARMAN          (TRINITY COLLEGE,DUBLIN)

BALL     75 PRD 11 1171       J S BALL,R L GOBLE                    (UTAH)IJP
BERENDS  75 NP B84 342        BERENDS,DONNACHIE                 (LEID,MCHS)
CRAWFORD 75 NP B97 125        R L CRAWFORD                       (GLAS)IJP
KRIVETS  75 SJNP 20 430       +MIROSHNICHENKO,NIKIFOROV,SANIN+      (KIEV)IJP
    ALSO 74 SJNP 19 112       KRIVETS,NIKIFOROV,SANIN,SHALATSKII    (KIEV)IJP
LICHTENB 75 LNC 12 616        D B LICHTENBERG                        (IND)IJP

AYED     76 CEA-N-1921        AYED (THESIS)                         (SACL)IJP
BARBOUR  76 NP B111 358       I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
CAMPBELL 76 PRD 14 2431       CAMPBELL,SHAW,BALL          (BOIS+UCI+UTAH)IJP
FELLER   76 NP B104 219       +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
VASAN    76 NP B106 535       S. S. VASAN                           (CARN)IJP
    ALSO 76 NP B106 526       S. S. VASAN                           (CARN)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI 68 PL 26B 161        DONNACHIE,LOVELACE,KIRSOPP            (CERN)
FONDA    73 PRD 8 353         FONDA,GHIRARDI,SHAW      (ICTP-TRIESTE+TRST)IJP
HENYEY   74 PR D9 302         HENYEY,KANE                           (MICH)IJP
OLSSON   74 LNC 10 333        OLSSON                                (CERN)IJP
PFEIL    74 NP B73 166        PFEIL,ROLLNIK,STANKOWSKI              (BONN)
SUZUKI   74 NP B68 413        SUZUKI,KUROKAWA,KONDO                 (TOKYO)

GANENKO  75 SJNP 22 522       +KRIVETS,MIROSHNICHENKO,NIKIFOROV+    (KIEV)IJP
NIGRO    75 NP B84 201        NIGRO,SPILLANTINI,VALENTE         (PADO,FRAS)
GANENKO1 76 SJNP 24 284       +KRIVETS,MIROSHNICHENKO,NIKIFOROV+    (KIEV)IJP
GANENKO2 76 SJNP 24 594       +GORBENKO,KRIVETS,KOLESNIKOV+         (KIEV)IJP
ZABEV    76 SJNP 24 70        ZABEV,KUZNETSOV,STUKOV                (TMSK)IJP
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1232 MEV REGION – PRODUCTION EXPERIMENTS

81 N*3/2(1232, JP=3/2+) I=3/2 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS FOR A DISCUSSION OF PRODUCTION EXPERIMENTS.

81 N*3/2(1232) MASS (MEV) (PROD. EXP.)

```
M          1217.       8.          ANDERSON  70 MMS  -  PI- P TO PI- MMS  2/71
M          1227.0      7.0         ELLIS     71 CNTR    MMS PP 3.7 GEV/C  10/71
M          . . . . . .
M   AVG    1222.7      5.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT1222.7      5.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M++       (1232.0)    (6.0)        FERRO-LUZ 65 HBC  ++ K+P TO K0 P PI+
M++       (1236.0)                 DEANS     66 RVUE ++ PI+P TOTAL          7/66
M++       (1233.4)    (4.4)        GIDAL     66 DBC  ++ D D TO NN(NN) PI   7/66
M++       (1224.0)    (2.0)        HABER     70 DBC     K-D TO 4 BOD(P)     7/70
M++        1236.0      2.0         COLTON    72 HBC  ++ PP TO PI+PN 7GEV   1/73
M++        1226.0      2.0         COLTON    72 HBC  ++  TO PI+PI-PP       1/73
M++        1222.0      3.0         COLTON    72 HBC  ++ TO PI+PI-PIOPP     1/73
M++        1226.0      2.0         COLTON    72 HBC  ++ TO PI+PI-PI-PN     1/73
M++       (1231.)     (3.)         LEWIS     73 HBC  ++ K+ P TO K P 2PI   1/76
M++        1219.       5.          LICHTMAN  74 HBC  ++ PI+P TO 3PI P      4/75
M++        1213.       3.          LICHTMAN  74 HBC  ++ PI-P TO 3PI P      4/75
M++       (1224.)      5. TO 10.   BRAUN2    75  BC     PBAR P AND D,5.7 11/75
M++        1224. TO 1228.          ATHERTON  76 HBC     PBAR P 5.7 GEV     2/77*
M++        . . . . . .
M++ AVG   1226.3       3.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.1)
M++ STUDENT1225.3      1.4     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M+         1224. TO 1230.          BRAUN1    75 HBC     PBAR P 5.7 GEV    11/75
M+   1     1256.       15.         APPLE     77 SPEC +  P P TO P (N PI+)  1/78*
M+   1  NOT SEEN IN P P TO P (P PI0).                                      1/78*

MO         1231.       11.         COOPER    74 HBC   0 D P CEX           4/75
MO        (1230.)                  BRAUN1    75 HBC     PBAR P 5.7 GEV    11/75
MO        (1220.)      5. TO 10.   BRAUN2    75  BC     PBAR P AND D,5.7  11/75

M-        (1241.3)    (5.1)        GIDAL     66 DBC  -                     7/66
M-         1239.0      5.0         COLTON    72 HBC  -  TO PI+PI-PI-PN     1/73
```

81 (N*-) - (N*++) MASS DIFFERENCE (MEV) (PROD. EXP.)

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D           7.9        6.8         GIDAL     66 DBC
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81 N*3/2(1232) WIDTH (MEV) (PROD. EXP.)

```
W          115.        5.          ANDERSON  70 MMS  -  PI- P TO PI- MMS  2/71
W          105.0       7.0         ELLIS     71 CNTR    MMS PP 3.7 GEV/C  10/71
W          141.        11.         MUSGRAVE  75 HBC     K+ P TO K PI N     11/75
W          . . . . . .
W   AVG    115.2       7.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
W   STUDENT 114.5      4.6     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W++       (125.0)     (30.0)       FERRO-LUZ 65 HBC  ++
W++       (121.0)                  DEANS     66 RVUE ++                   7/66
W++       (124.0)     (14.0)       GIDAL     66 DBC  ++                   7/66
W++       (120.0)      (8.0)       HABER     70 DBC     K-D TO 4 BOD(P)   7/70
W++        115.0       6.0         COLTON    72 HBC  ++ PP TO PI+PN 7GEV  1/73
W++        127.0       5.0         COLTON    72 HBC  ++  TO PI+PI-PP      1/73
W++        122.0       9.0         COLTON    72 HBC  ++ TO PI+PI-PIOPP    1/73
W++        106.0       7.0         COLTON    72 HBC  ++ TO PI+PI-PI-PN    1/73
W++       (146.)      (10.)        LEWIS     73 HBC  ++ K+ P TO K P 2PI   1/76
W++        166.        14.         LICHTMAN  74 HBC  ++ PI+P TO 3PI P      4/75
W++        134.         7.         LICHTMAN  74 HBC  ++ PI-P TO 3PI P      4/75
W++       (110.)      10. TO 20.   BRAUN2    75  BC     PBAR P AND D,5.7  11/75
W++         96. TO  113.           ATHERTON  76 HBC     PBAR P 5.7 GEV     2/77*
W++        . . . . . .
W++ AVG    123.2       5.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
W++ STUDENT 123.3      3.7     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

W+         110. TO  130.           BRAUN1    75 HBC     PBAR P 5.7 GEV    11/75
W+   1      20.       60.    20.   APPLE     77 SPEC +  P P TO P (N PI+)  1/78*

WO         109.       32.    25.   COOPER    74 HBC   0 D P CEX           4/75
WO        (120.)                   BRAUN1    75 HBC     PBAR P 5.7 GEV    11/75
WO        (120.)      10. TO 20.   BRAUN2    75  BC     PBAR P AND D,5.7  11/75

W-        (149.0)     (18.0)       GIDAL     66 DBC  -                     7/66
W-         237.0       22.0        COLTON    72 HBC  -  TO PI+PI-PI-PN     1/73
```

REFERENCES FOR N*3/2(1232) (PROD. EXP.)


```
FERRO-LU 65 NC 36 1101        FERRO-LUZZI,GEORGE, +                  (CERN)
DEANS    66 PREPRINT          S R DEANS, W G HOLLADAY          (VANDERBILT)
GIDAL    66 PR 141 1261       G GIDAL, A KERNAN, S KIM                (LRL)

ANDERSON 70 PRL 25 699        +BLESER,BLIEDEN,COLLINS++          (BNL,CARN)
HABER    70 NP B17B 289       +SHAPIRA,MERRILL,MONARI++       (SABRE COLL)
ELLIS    71 PRL 27 442        +MAGLICH,NOREM,SANNES,SILVERMAN         (RUTG)
COLTON   72 PR D6 95          E COLTON, A KIRSCHBAUM                  (LBL)
LEWIS    73 NP B60 283        +ALLEN,JACOBS,DANYSZ,ISLAM+(LOWC+LOIC+CDEF)

COOPER   74 NP B79 259        COOPER,SEIDL,VANDERVELDE                (MICH)
LICHTMAN 74 NP B81 31         LICHTMAN,BISWAS,CASON,KENNEY,MCGAHAN+(NDAM)I

BRAUN1   75 NP B95 481        +GERBER,MAURER,MICHALON,SCHIBY+ (STRB,LPNP)I
BRAUN2   75 NP B95 503        +GERBER,MAURER,MICHALON,SCHIBY+ (STRB,LPNP)I
MUSGRAVE 75 NP B87 365        +PEETERS,SCREINER,WHITMORE,YUTA          (ANL)

ATHERTON 76 NP B103 381       ATHERTON,FRENCH,SKURA,BOHM+      (CERN+PRAG)I
APPLE    77 LNC 18 167        +ASH,CHENG,COYNE,GROSSMAN+       (PRIN+PAVIA)

                              PAPERS NOT REFERRED TO IN DATA CARDS

ALEXANDE 73 NP B52 221        ALEXANDER,BENARY+(TEL-AVIV+HEIDELBERG+DESY)
BEAUPRE  73 NP B66 93              (AACH+BERL+BONN+CERN+NDAM+PENN+TOHOJI
BERLAND  74 NP B75 93         BERLAND,HABER,HODOUS,HULSIZER,+          (MIT)I
    ALSO 74 PL 51B 187        BERLAND,HABER,HODOUS,HULSIZER,+          (MIT)I
ATHERTON 75 NC 30A 505        ATHERTON,BAR-NIR,FRENCH,SKURA+   (CERN+PRAG)I
STRACHMA 75 NP B98 120        STRACHMAN,BRAUN,GERBER,MAURER+   (LPNP+STRB)I
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Δ(1550) P'31

110 N*3/2(1550, JP=1/2+) I=3/2 11/77*

110 N*3/2(1550) MASS (MEV) 11/77*

```
M    8     (1550.)                 LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77*
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                       11/77*
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110 N*3/2(1550) WIDTH (MEV) 11/77*

```
W    8      (110.)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
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110 N*3/2(1550) REAL PART OF POLE POSITION (MEV) 11/77*

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RE   8      1554. OR 1553.          LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
```

110 N*3/2(1550) 2*IMAG PART OF POLE POSITION (MEV) 11/77*

```
IM   8       105. OR 104.           LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
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110 N*3/2(1550) PARTIAL DECAY MODES 11/77*

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                                                          DECAY MASSES
P1     N*3/2(1550) INTO PI N                            139+ 938
P2     N*3/2(1550) INTO N*3/2(1232) PI                  1232+ 139
P3     N*3/2(1550) INTO N RHO,S=3/2                      938+ 776
```

110 N*3/2(1550) BRANCHING RATIOS 11/77*

```
R1     N*3/2(1550) FROM PI N TO N*3/2(1232) PI          SQRT(P1*P2)      11/77*
R1   8      (+.11)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77*

R2     N*3/2(1550) FROM PI N TO N RHO,S=3/2             SQRT(P1*P3)      11/77*
R2   8      (+.08)                  LONGACRE  77 IPWA    PI N TO 2PI N    11/77*
```

REFERENCES FOR N*3/2(1550)


```
LONGACRE 77 NP B122 493       LONGACRE,DOLBEAU                        (SACL)IJP
    ALSO 76 NP B108 365       DOLBEAU,TRIANTIS,NEVEU,CADIET           (SACL)IJP
```

Baryons

Δ(1650), Δ(1670)

Δ(1650) 82 N*3/2(1650, JP=1/2-) I=3/2 **S_{31}**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

82 N*3/2(1650) MASS (MEV)

M		(1648.0) (12.0)	DEVLIN	65 CNTR	PI+- P TOTAL		
M	1	(1695.0)	BAREYRE	68 RVUE	PHASE-SHIFT ANAL		11/67
M	1	WHERE CROSS SECTION IS GREATEST - EYEBALL FIT					
M	3	(1635.0)	DONNACHI	68 RVUE	PHASE-SHIFT ANAL		6/68
M	6	(1614.0)	AYED	70 IPWA			1/71
M	6	ENER. DEP. FIT OF ARGAND DIAGRAM					
M	4	(1617.0)	DAVIES	70 RVUE	P-S ANAL SOL A		8/69
M	7	(1620.)	ALMEHED	72 IPWA			2/72
M		1622. TO 1688.	CRAWFORD	75 DPWA	PI N PHOTO-PROD		1/76
M	L	1625. OR 1600.	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
M	L	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.					11/75
M		(1623.)	AYED	76 IPWA			11/77*
M		(1680.)	BARBOUR	76 DPWA	PI N PHOTO-PROD		1/76
M	8	(1580.)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
M	8	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE					11/77*
M	8	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.					11/77*

82 N*3/2(1650) WIDTH (MEV)

W	1	(250.0)	BAREYRE	68 RVUE			11/67
W	3	(177.0)	DONNACHI	68 RVUE			6/68
W	6	(142.0)	AYED	70 IPWA			1/71
W	4	(141.0)	DAVIES	70 RVUE	P-S ANAL SOL A		8/69
W	7	(140.)	ALMEHED	72 IPWA			2/72
W		125. TO 214.	CRAWFORD	75 DPWA	PI N PHOTO-PROD		1/76
W	L	160. OR 150.	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
W		(161.)	AYED	76 IPWA			11/77*
W		(246.)	BARBOUR	76 DPWA	PI N PHOTO-PROD		1/76
W	8	(120.)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
W		SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.					

82 N*3/2(1650) REAL PART OF POLE POSITION (MEV) 11/75

RE		(1583.)	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
RE	8	1575. OR 1572.	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

82 N*3/2(1650) 2*IMAG PART OF POLE POSITION (MEV) 11/75

IM		(143.)	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
IM	8	119. OR 128.	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

82 N*3/2(1650) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*3/2(1650) INTO PI N	139+ 938
P2	N*3/2(1650) INTO N PI PI	938+ 139+ 139
P3	N*3/2(1650) INTO GAM NUCLEON, HELICITY=1/2	0+ 938
P4	N*3/2(1650) INTO N*3/2(1232) PI	1232+ 139
P5	N*3/2(1650) INTO N RHO	938+ 776
P6	N*3/2(1650) INTO N RHO,S=1/2,S-WAVE	938+ 776
P7	N*3/2(1650) INTO N RHO,S=3/2,D-WAVE	938+ 776

82 N*3/2(1650) BRANCHING RATIOS

R1		N*3/2(1650) INTO (PI N)/TOTAL			(P1)		
R1	3	(0.284)	DONNACHI	68 RVUE			6/68
R1	6	(0.317)	AYED	70 IPWA			1/71
R1	4	(0.28)	DAVIES	70 RVUE	P-S ANAL SOL A		8/69
R1	7	(0.35)	ALMEHED	72 IPWA			2/72
R1		(.32)	AYED	76 IPWA			11/77*
R2		N*3/2(1650) FROM PI N TO N*3/2(1232) PI			SQRT(P1*P4)		11/75
R2	L	(+.40)OR +.40	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
R2	8	(+.39)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
R2	8	LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.					
R3		N*3/2(1650) FROM PI N TO N RHO,S=1/2,S-WAVE			SQRT(P1*P6)		11/75
R3	L	(.18)OR -.28	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
R3	8	(-.08)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
R4		N*3/2(1650) FROM PI N TO N RHO,S=3/2,D-WAVE			SQRT(P1*P7)		11/77*
R4	8	(+.13)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

82 N*3/2(1650) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	N*3/2(1650) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)					
A1	.004	.033	DEVENISH	73 DPWA	PI N PHOTO PROD	2/74
A1	(.113)		HEMMI1	73	+ FWD PIO PHTOPROD	2/74
A1	+.090	.076	MOORHOUS	73 DPWA	PI N PHOTO-PROD	2/73
A1	-.10	.017	DEVENIS2	74 DPWA	PI N PHOTO-PROD	4/75
A1	.033	.015	KNIES	74 DPWA	PI N PHOTO PROD	2/74
A1	.105	.038	METCALF	74 DPWA	PI N PHOTO-PROD	2/74
A1	.078	.066	MOORHOUS	74 DPWA	PI N PHOTO-PROD	2/74
A1	+.044	.027	CRAWFORD	75 DPWA	PI N PHOTO-PROD	1/76
A1	(+.058)		KRIVETS	75 DPWA	PI-N PHOTO-PROD	1/78*
A1	(+.055)		BARBOUR	76 DPWA	PI N PHOTO-PROD	1/76
A1	-.005	.016	FELLER	76 DPWA	PI N PHOTO-PROD	2/77*
A1	. . . . .					
A1	AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)					

REFERENCES FOR N*3/2(1650)

DEVLIN	65 PRL 14 1031	T J DEVLIN,J SOLOMON,G BERTSCH (PRINCETON) I	
BAREYRE	68 PR 165 1731	P BAREYRE, C BRICMAN, G VILLET	(SACLAY)IJP
DONNACHI	68 PL 268 161	A DONNACHIE, R G KIRSOPP, C LOVELACE	(CERN)IJP
ALSO	68 VIENNA 139	DONNACHIE RAPPORTEUR'S TALK	(GLAS)
ALSO	68 THESIS	R G KIRSOPP	(EDIN)
AYED	70 KIEV CONF	R AYED,P BAREYRE, G VILLET	(SACL)IJP
DAVIES	70 NP B21 359	A DAVIES	(GLAS)
ALMEHED	72 NP B40 157	+LOVELACE	(LUND,RUTG)IJP
DEVENISH	73 PL 47B 53	DEVENISH,RANKIN,LYTH	(LOUC+BONN+LANC)IJP
HEMMI1	73 PL 43B 79	HEMMI,INAGAKI+	(KYOTO+SAGA+KEK+TOKY)IJP
MOORHOUS	73 PL 43B 44	MOORHOUSE, OBERLACK	(GLAS+LBL)IJP
DEVENIS2	74 PL 52B 227	DEVENISH,LYTH,RANKIN	(DESY,LANC,BONN)IJP
KNIES	74 PRD 9 2680	KNIES,MOORHOUSE,OBERLACK	(LBL,GLAS)IJP
METCALF	74 NP B76 253	W J METCALF,R L WALKER	(CIT)IJP
MOORHOUS	74 PRD 9 1	MOORHOUSE,OBERLACK,ROSENFELD	(GLAS+LBL)IJP
CRAWFORD	75 NP B97 125	R L CRAWFORD	(GLAS)IJP
KRIVETS	75 SJNP 20 430	+MIROSHNICHENKO,NIKIFOROV,SANIN+	(KIEV)IJP
ALSO	74 SJNP 19 112	KRIVETS,NIKIFOROV,SANIN,SHALATSKII	(KIEV)IJP
LONGACRE	75 PL 55B 415	+ROSENFELD,LASINSKI,SMADJA+	(LBL,SLAC)IJP
AYED	76 CEA-N-1921	AYED (THESIS)	(SACL)IJP
BARBOUR	76 NP B111 358	I. M. BARBOUR,R. L. CRAWFORD	(GLAS)IJP
FELLER	76 NP B104 219	+FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP	
LONGACRE	77 NP B122 493	LONGACRE,DGLBEAU	(SACL)IJP
ALSO	76 NP B108 365	DGLBEAU,TRIANTIS,NEVEU,CADIET	(SACL)IJP
		PAPERS NOT REFERRED TO IN DATA CARDS.	
CARRUTHE	60 PRL 4 303	P CARRUTHERS	(CORNELL) I
DEVLIN	62 PR 125 690	T J DEVLIN, B J MOYER, V PEREZ-MENDEZ	(LRL) I
HELLAND	64 PR 134 B1062	+DEVLIN,HAGGE,LONGO,MOYER,WOOD	(LRL) I
BAREYRE	65 PL 18 342	+ BRICMAN, STIRLING, VILLET	(SACLAY)IJP
JOHNSON	67 UCRL-17683 THESIS	C H JOHNSON	(LRL)
DONNACHI	69 NP 10B 433	A DONNACHIE, R KIRSOPP	(GLAS+EDIN)
AYED	70 PL 31B 598	+BAREYRE,VILLET	(SACLAY)
BOWLER	70 NP 17B 331	+CASHMORE	(U. OXFORD)
DEANS	75 NP B96 90	+MITCHELL,MONTGOMERY,+	(SFLA,ALABAMA)IJP

Δ(1670) 10 N*3/2(1670, JP=3/2-) I=3/2 **D_{33}**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

10 N*3/2(1670) MASS (MEV)

M	3	(1691.0)	DONNACHI	68 RVUE	PHASE-SHIFT ANAL		8/69
M	6	ENER. DEP. FIT OF ARGAND DIAGRAM					
M	4	(1649.0)	DAVIES	70 RVUE	P-S ANAL SOL A		8/69
M	7	(1700.)	ALMEHED	72 IPWA			2/72
M		1612. TO 1624.	CRAWFORD	75 DPWA	PI N PHOTO-PROD		1/76
M		(1600.) (10.)	GAIDOS	75 HBC	++ PI+P TO N* 2PI		1/76
M	L	1725. OR 1680.	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
M	L	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.					11/75
M		(1723.)	AYED	76 IPWA			11/77*
M		(1629.)	BARBOUR	76 DPWA	PI N PHOTO-PROD		1/76
M	8	(1600.)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
M	8	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE					11/77*
M	8	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.					11/77*

10 N*3/2(1670) WIDTH (MEV)

W	3	(269.0)	DONNACHI	68 RVUE			8/69
W	6	(258.0)	AYED	70 IPWA			1/71
W	4	(188.0)	DAVIES	70 RVUE	SOL A		8/69
W	7	(260.)	ALMEHED	72 IPWA			2/72
W		210. TO 268.	CRAWFORD	75 DPWA	PI N PHOTO-PROD		1/76
W		(180.) (35.) (20.)	GAIDOS	75 HBC	++ PI+P TO N* 2PI		1/76
W	L	190. OR 240.	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
W		(192.)	AYED	76 IPWA			11/77*
W		(222.)	BARBOUR	76 DPWA	PI N PHOTO-PROD		1/76
W	8	(200.)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
W		SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.					

10 N*3/2(1670) REAL PART OF POLE POSITION (MEV) 11/75

RE		(1681.)	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
RE	8	1600. OR 1594.	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

10 N*3/2(1670) 2*IMAG PART OF POLE POSITION (MEV) 11/75

IM		(245.)	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
IM	8	208. OR 201.	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

10 N*3/2(1670) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*3/2(1670) INTO PI N	139+ 938
P2	N*3/2(1670) INTO N PI PI	938+ 139+ 139
P3	N*3/2(1670) INTO K SIGMA	493+1189
P4	N*3/2(1670) INTO GAM NUCLEON, HELICITY=1/2	0+ 938
P5	N*3/2(1670) INTO GAM NUCLEON, HELICITY=3/2	0+ 938
P6	N*3/2(1670) INTO N*3/2(1232) PI	1232+ 139
P7	N*3/2(1670) INTO N*3/2(1232) PI,S-WAVE	1232+ 139
P8	N*3/2(1670) INTO N*3/2(1232) PI,D-WAVE	1232+ 139
P9	N*3/2(1670) INTO N RHO,S=3/2,S-WAVE	938+ 776

Data Card Listings

For notation, see key at front of Listings.

10 N*3/2(1670) BRANCHING RATIOS

R1		N*3/2(1670) INTO (PI N)/TOTAL				(P1)		
R1	3	(0.14)		DONNACH1	68 RVUE			8/69
R1	6	(0.217)		AYED	70 IPWA			1/71
R1	4	(0.12)		DAVIES	70 RVUE	SOL A		8/69
R1	7	(0.16)		ALMEHED	72 IPWA			2/72
R1		(.17)		AYED	76 IPWA			11/77*
R2		N*3/2(1670) INTO (K SIGMA)/TOTAL				(P3)		
R2	1	(.00002)OR LESS		FEUERBACH	70 RVUE	PI P TO K+ SIG+		7/70
R2	1	ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68						
R2	1	MODEL USED MAY DOUBLE COUNT.						
R3		N*3/2(1670) FROM PI N TO N*3/2(1232) PI,S-WAVE				SQRT(P1*P7)		11/75
R3	L	(-.25)OR -.24		LONGACRE	75 IPWA	PI N TO 2PI N		11/75
R3	8	(-.30)		LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
R3	8	LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.						
R4		N*3/2(1670) FROM PI N TO N*3/2(1232) PI,D-WAVE				SQRT(P1*P8)		11/75
R4	L	(0.) OR (-.10)		LONGACRE	75 IPWA	PI N TO 2PI N		11/75
R4	8	(-.05)		LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
R5		N*3/2(1670) FROM PI N TO N RHO,S=3/2,S-WAVE				SQRT(P1*P9)		11/75
R5	L	(.20)OR +.30		LONGACRE	75 IPWA	PI N TO 2PI N		11/75
R5	8	(-.04)		LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
R6		N*3/2(1670) FROM PI N TO K SIGMA				SQRT(P1*P3)		11/75
R6	2	(.001)TO .011		DEANS	75 DPWA	PI N TO K SIGMA		11/75
R6	2	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.						11/75
R6	2	DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77						1/78*
R6	2	AROUND 1920 MEV.						1/78*

10 N*3/2(1670) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	N*3/2(1670) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)						
A1	.036	.052	DEVENISH	73 DPWA	PI N PHOTO PROD		2/74
A1	+.068	.042	MOORHOUS	73 DPWA	PI N PHOTO-PROD		2/73
A1	.054	.029	DEVENIS2	74 DPWA	PI N PHOTO-PROD		4/75
A1	.078	.009	KNIES	74 DPWA	PI N PHOTO PROD		2/74
A1	.0	.048	METCALF	74 DPWA	PI N PHOTO-PROD		2/74
A1	.041	.028	MOORHOUS	74 DPWA	PI N PHOTO-PROD		2/74
A1	+.101	.011	CRAWFORD	75 DPWA	PI N PHOTO-PROD		1/76
A1	(+.120)		BARBOUR	76 DPWA	PI N PHOTO-PROD		1/76
A1	+.072	.033	FELLER	76 DPWA	PI N PHOTO-PROD		2/77*
A1	. . . . .						
A1	AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)						
A2	N*3/2(1670) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)						
A2	.110	.039	DEVENISH	73 DPWA	PI N PHOTO PROD		2/74
A2	+.022	.052	MOORHOUS	73 DPWA	PI N PHOTO-PROD		2/73
A2	.072	.014	DEVENIS2	74 DPWA	PI N PHOTO-PROD		4/75
A2	.070	.009	KNIES	74 DPWA	PI N PHOTO PROD		2/74
A2	.0	.041	METCALF	74 DPWA	PI N PHOTO-PROD		2/74
A2	.021	.020	MOORHOUS	74 DPWA	PI N PHOTO-PROD		2/74
A2	+.116	.024	CRAWFORD	75 DPWA	PI N PHOTO-PROD		1/76
A2	(+.117)		BARBOUR	76 DPWA	PI N PHOTO-PROD		1/76
A2	+.087	.023	FELLER	76 DPWA	PI N PHOTO-PROD		2/77*
A2	. . . . .						
A2	AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)						

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REFERENCES FOR N*3/2(1670)

DONNACH1 68 PL 26B 161	A DONNACHIE, R G KIRSOPP, C LOVELACE	(CERN)IJP
ALSO 68 VIENNA 139	DONNACHIE RAPPORTEUR'S TALK	(GLAS)
ALSO 68 THESIS	R G KIRSOPP	(EDIN)
AYED 70 KIEV CONF	R AYED,P BAREYRE, G VILLET	(SACL)IJP
DAVIES 70 NP B21 359	A DAVIES	(GLAS)
FEUERBAC 70 NP 16B 85	FEUERBACHER+HOLLADAY	(VANDERBILT)
ALMEHED 72 NP B40 157	+LOVELACE	(LUND,RUTG)IJP
DEVENISH 73 PL 47B 53	DEVENISH,RANKIN,LYTH	(LOUC+BONN+LANC)IJP
MOORHOUS 73 PL 43B 44	MOORHOUSE, OBERLACK	(GLAS+LBL)IJP
DEVENIS2 74 PL 52B 227	DEVENISH,LYTH,RANKIN	(DESY,LANC,BONN)IJP
KNIES 74 PRD 9 2680	KNIES,MOORHOUSE,OBERLACK	(LBL,GLAS)IJP
METCALF 74 NP B76 253	W J METCALF,R L WALKER	(CIT)IJP
MOORHOUS 74 PRD 9 1	MOORHOUSE,OBERLACK,ROSENFELD	(GLAS+LBL)IJP
CRAWFORD 75 NP B97 125	R L CRAWFORD	(GLAS)IJP
DEANS 75 NP B96 90	+MITCHELL,MONTGOMERY,+	(SFLA,ALABAMA)IJP
GAIDOS 75 PRD 12 2565	GAIDOS,MILLER	(PURD)IJP
LONGACRE 75 PL 55B 415	+ROSENFELD,LASINSKI,SMADJA+	(LBL,SLAC)IJP
AYED 76 CEA-N-1921	AYED (THESIS)	(SACL)IJP
BARBOUR 76 NP B111 358	I. M. BARBOUR,R. L. CRAWFORD	(GLAS)IJP
FELLER 76 NP B104 219	+FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP	
LONGACRE 77 NP B122 493	LONGACRE,DOLBEAU	(SACL)IJP
ALSO 76 NP B108 365	DOLBEAU,TRIANTIS,NEVEU,CADIET	(SACL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACH1 69 NP 10B 433	A DONNACHIE, R KIRSOPP	(GLAS+EDIN)
AYED 70 PL 31B 598	+BAREYRE,VILLET	(SACLAY)
BOWLER 70 NP 17B 331	+CASHMORE	(U. OXFORD)
WINNIK 77 NP B128 66	+TOAFF,REVEL,GOLDBERG,BERNY	(HAIF)I

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Δ(1690)

19 N*3/2(1690, JP=3/2+) I=3/2 **P″33**

RECENT ANALYSES INDICATE A P''33 RESONANCE SOMEWHERE IN THE 1650-1900 MEV REGION. SEE ALSO THE N*3/2(2160) LISTINGS.

19 N*3/2(1690) MASS (MEV)

M	3	(1690.)	DONNACH2	68 RVUE	PHAS.SHIFT-CERN1		10/69
M	3	(1690.)	KIRSOPP	68 RVUE	PHASE SHIFT ANAL		10/69
M	3	WHERE MAX. ABSORPTION IS -DONNACHI, 2 ,KIRSOPP EYEBALL FIT CERN 1					10/69
M	6	(1801.0)	AYED	70 IPWA			1/71
M	6	ENER. DEP. FIT OF ARGAND DIAGRAM					
M	7	(1680.)	ALMEHED	72 IPWA			2/72
M	L	1900. OR 1640.	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
M	L	THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.					11/75
M		(1900.)	AYED	76 IPWA			11/77*
M	8	(1560.)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
M	8	ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE					11/77*
M	8	POSITION WHICH IS FROM SOLUTIONS S1 AND C1.					11/77*

19 N*3/2(1690) WIDTH (MEV)

W	3	(281.)	DONNACH2	68 RVUE	PHAS.SHIFT-CERN1		10/69
W	3	(240.)	KIRSOPP	68 RVUE	PHASE SHIFT ANAL		10/69
W	6	(598.0)	AYED	70 IPWA			1/71
W	7	(220.)	ALMEHED	72 IPWA			2/72
W	L	205. OR 300.	LONGACRE	75 IPWA	PI N TO 2PI N		11/75
W		(204.)	AYED	76 IPWA			11/77*
W	8	(150.)	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
		SEE THE NOTES ACCOMPANYING MASSES QUOTED					

19 N*3/2(1690) REAL PART OF POLE POSITION (MEV)

RE	(1609.)		LONGACRE	75 IPWA	PI N TO 2PI N		11/75
RE	8	1541. OR 1542.	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

19 N*3/2(1690) 2*IMAG PART OF POLE POSITION (MEV)

IM	(323.)		LONGACRE	75 IPWA	PI N TO 2PI N		11/75
IM	8	178. OR 178.	LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

19 N*3/2(1690) PARTIAL DECAY MODES

		DECAY MASSES
P1	N*3/2(1690) INTO PI N	139+ 938
P2	N*3/2(1690) INTO K SIGMA	493+1189
P3	N*3/2(1690) INTO N*3/2(1232) PI,P-WAVE	1232+ 139
P4	N*3/2(1690) INTO N*3/2(1232) PI,F-WAVE	1232+ 139
P5	N*3/2(1690) INTO N RHO,S=1/2,P-WAVE	938+ 776
P6	N*3/2(1690) INTO N RHO,S=3/2,P-WAVE	938+ 776

19 N*3/2(1690) BRANCHING RATIOS

R1		N*3/2(1690) INTO (PI N)/TOTAL				(P1)		
R1	3	(.10)		DONNACH2	68 RVUE	PHAS.SHIFT-CERN1		10/69
R1	3	(.08)		KIRSOPP	68 RVUE	PHASE SHIFT ANAL		10/69
R1	6	(0.135)		AYED	70 IPWA			1/71
R1	7	(0.1)		ALMEHED	72 IPWA			2/72
R1		(.19)		AYED	76 IPWA			11/77*
R2		N*3/2(1690) INTO (K SIGMA)/TOTAL				(P2)		
R2	1	(.00002)OR LESS		FEUERBACH	70 RVUE	PI P TO K+ SIG+		7/70
R2	1	ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68						
R2	1	MODEL USED MAY DOUBLE COUNT.						
R3		N*3/2(1690) FROM PI N TO K SIGMA				SQRT(P1*P2)		11/75
R3	2	(.006)TO .042		DEANS	75 DPWA	PI N TO K SIGMA		11/75
R3	2	RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.						11/75
R3	2	DEANS75 DISAGREES WITH PI+ P TO K+ SIGMA+ DATA OF WINNIK77						1/78*
R3	2	AROUND 1920 MEV.						1/78*
R4		N*3/2(1690) FROM PI N TO N*3/2(1232) PI,P-WAVE				SQRT(P1*P3)		11/75
R4	L	(-.36)OR -.30		LONGACRE	75 IPWA	PI N TO 2PI N		11/75
R4	8	(-.34)		LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
R4	8	LONGACRE 77 CONSIDER THIS COUPLING TO BE WELL DETERMINED.						
R5		N*3/2(1690) FROM PI N TO N*3/2(1232) PI,F-WAVE				SQRT(P1*P4)		11/77*
R5	8	(+.07)		LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
R6		N*3/2(1690) FROM PI N TO N RHO,S=1/2,P-WAVE				SQRT(P1*P5)		11/77*
R6	8	(-.10)		LONGACRE	77 IPWA	PI N TO 2PI N		11/77*
R7		N*3/2(1690) FROM PI N TO N RHO,S=3/2,P-WAVE				SQRT(P1*P6)		11/77*
R7	8	(-.10)		LONGACRE	77 IPWA	PI N TO 2PI N		11/77*

19 N*3/2(1690) PHOTON DECAY AMPL(GEV**-1/2)

FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-REVIEW PRECEDING THE BARYON LISTINGS.

A1	N*3/2(1690) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)						
A1	.016	.055	DEVENISH	73 DPWA	PI N PHOTO PROD		2/74
A1	-.033	.037	DEVENIS2	74 DPWA	PI N PHOTO-PROD		4/75
A1	.003	.015	KNIES	74 DPWA	PI N PHOTO PROD		2/74
A1	.0	.038	METCALF	74 DPWA	PI N PHOTO-PROD		2/74
A1	.0	.020	FELLER	76 DPWA	PI N PHOTO-PROD		2/77*
A1	. . . . .						
A1	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)						
A2	N*3/2(1690) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)						
A2	.074	.064	DEVENISH	73 DPWA	PI N PHOTO PROD		2/74
A2	.008	.046	DEVENIS2	74 DPWA	PI N PHOTO-PROD		4/75
A2	-.034	.022	KNIES	74 DPWA	PI N PHOTO PROD		2/74
A2	.0	.033	METCALF	74 DPWA	PI N PHOTO-PROD		2/74
A2	.0	.015	FELLER	76 DPWA	PI N PHOTO-PROD		2/77*
A2	. . . . .						
A2	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)						

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REFERENCES FOR N*3/2(1690)

DONNACH2 68 VIENNA 139	DONNACHIE RAPPORTEUR'S TALK	(GLAS)
KIRSOPP 68 THESIS	R G KIRSOPP	(EDIN)
AYED 70 KIEV CONF	R AYED,P BAREYRE, G VILLET	(SACL)IJP
FEUERBAC 70 NP 16B 85	FEUERBACHER+HOLLADAY	(VANDERBILT)
ALMEHED 72 NP B40 157	+LOVELACE	(LUND,RUTG)IJP
DEVENISH 73 PL 47B 53	DEVENISH,RANKIN,LYTH	(LOUC+BONN+LANC)IJP
DEVENIS2 74 PL 52B 227	DEVENISH,LYTH,RANKIN	(DESY,LANC,BONN)IJP
KNIES 74 PRD 9 2680	KNIES,MOORHOUSE,OBERLACK	(LBL,GLAS)IJP
METCALF 74 NP B76 253	W J METCALF,R L WALKER	(CIT)IJP

Baryons

Δ(1690), Δ(1890), Δ(1900)

Data Card Listings

For notation, see key at front of Listings.

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DEANS     75 NP B96 90          +MITCHELL,MONTGOMERY,+        (SFLA,ALABAMA)IJP
LONGACRE  75 PL 58B 415         +ROSENFELD,LASINSKI,SMADJA+     (LBL,SLAC)IJP

AYED      76 CEA-N-1921         AYED (THESIS)                        (SACL)IJP
FELLER    76 NP B104 219        +FUKUSHIMA,HORIKAWA,KAJIKAWA+(NAGOYA+OSAKA)IJP
LONGACRE  77 NP B122 493        LONGACRE,DOLBEAU                     (SACL)IJP
    ALSO  76 NP B108 365        DOLBEAU,TRIANTIS,NEVEU,CADIET        (SACL)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS.

AYED      70 PL 31B 598         +BAREYRE,VILLET                        (SACLAY)
BOWLER    70 NP 17B 331         +CASHMORE                           (U. OXFORD)
WINNIK    77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY             (HAIFA)I

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Δ(1890) 11 N*3/2(1890, JP=5/2+) I=3/2 **F35**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                        11  N*3/2(1890) MASS (MEV)

M    3      (1913.0)                    DONNACH1  68 RVUE    PHASE-SHIFT ANAL  8/69
M    6      (1837.0)                    AYED      70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    4      (1841.0)                    DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M    7      (1875.)                     ALMEHED   72 IPWA                      2/72
M     1      1890. TO 1986.             MEHTANI   72 DPWA    PI+P TO PI+PIOP   9/73
M    5      (1890.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
M    5      (1890.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
M    5   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF       1/78*
M    5   WINNIK77 AROUND 1920 MEV.                                            1/78*
M     L      1870. OR 1830.             LONGACRE  75 IPWA    PI N TO 2PI N     11/75
M     L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.    11/75
M        (1869.)                        AYED      76 IPWA                     11/77*
M         1885.      27.                CUTKOSKY  76 IPWA                     11/77*

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                        11  N*3/2(1890) WIDTH (MEV)

W    3      (350.0)                     DONNACH1  68 RVUE                      8/69
W    6      (198.0)                     AYED      70 IPWA                      1/71
W    4      (136.0)                     DAVIES    70 RVUE    SOL A             8/69
W    7      (250.)                      ALMEHED   72 IPWA                      2/72
W     1      273. TO 322.               MEHTANI   72 DPWA    PI+P TO PI+PIOP   9/73
W    5      (180.)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
W    5      (140.)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
W     L       255. OR  220.             LONGACRE  75 IPWA    PI N TO 2PI N     11/75
W        (255.)                         AYED      76 IPWA                     11/77*
W         310.      90.                 CUTKOSKY  76 IPWA                     11/77*
         SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)

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                        11  N*3/2(1890) REAL PART OF POLE POSITION (MEV)      11/75

REE      (1813.)                       LONGACRE  75 IPWA    PI N TO 2PI N     11/75
REE       1825.      12.                CUTKOSKY  76 IPWA                     11/77*

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                        11  N*3/2(1890) 2*IMAG PART OF POLE POSITION (MEV)    11/75

IME      (193.)                        LONGACRE  75 IPWA    PI N TO 2PI N     11/75
IME       250.      36.                CUTKOSKY  76 IPWA                     11/77*
GV

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                        11  N*3/2(1890) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER        13.5      3.5               CUTKOSKY  76 IPWA                     11/77*

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                        11  N*3/2(1890) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        -11.      5.                CUTKOSKY  76 IPWA                     11/77*

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                        11  N*3/2(1890) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     N*3/2(1890) INTO PI N                                      139+ 938
P2     N*3/2(1890) INTO N PI PI                                   938+ 139+ 139
P3     N*3/2(1890) INTO K SIGMA                                   493+1189
P4     N*3/2(1890) INTO N*3/2(1232) PI                            1232+ 139
P5     N*3/2(1890) INTO GAM NUCLEON, HELICITY=1/2                   0+ 938
P6     N*3/2(1890) INTO GAM NUCLEON, HELICITY=3/2                   0+ 938
P7     N*3/2(1890) INTO N RHO                                     938+ 776
P8     N*3/2(1890) INTO N*3/2(1232) PI,P-WAVE                     1232+ 139
P9     N*3/2(1890) INTO N*3/2(1232) PI,F-WAVE                     1232+ 139
P10    N*3/2(1890) INTO N RHO,S=3/2,P-WAVE                        938+ 776

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                        11  N*3/2(1890) BRANCHING RATIOS

R1     N*3/2(1890) INTO (PI N)/TOTAL                          (P1)
R1   3      (0.16)                     DONNACH1  68 RVUE                      8/69
R1   6      (0.147)                    AYED      70 IPWA                      1/71
R1   4      (0.20)                     DAVIES    70 RVUE    SOL A             8/69
R1   7      (0.18)                     ALMEHED   72 IPWA                      2/72
R1           (.14)                     AYED      76 IPWA                     11/77*
R1            .140     .008            CUTKOSKY  76 IPWA                     11/77*
GV

R2     N*3/2(1890) INTO (K SIGMA)/TOTAL                       (P3)
R2   1      (0.008)OR LESS             FEUERBACH 70 RVUE    PI P TO K+ SIG+   7/70
R2   1    ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
R2   1    MODEL USED MAY DOUBLE COUNT.

R3     N*3/2(1890) INTO (SIGMA K)*(PI N)/TOTAL**2             (P3*P1)
R3           (.0016)OR LESS             KALMUS    70 DPWA    PI+P TO K+ SIG+   1/71

R4     N*3/2(1890) FROM PI N TO N*3/2(1232) PI                SQRT(P1*P4)
R4   1     .19 TO .23                 MEHTANI   72 DPWA    PI+P TO PI+PIOP   9/73
R4   1  MOSTLY F WAVE DECAY                                                   9/73

R5     N*3/2(1890) FROM PI N TO K SIGMA                       SQRT(P1*P3)       9/73
R5   5      (.06)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
R5   5      (.06)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R5   2      (.021)TO  .054             DEANS     75 DPWA    PI N TO K SIGMA  11/75
R5   2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                             11/75

R6     N*3/2(1890) FROM PI N TO N*3/2(1232) PI,F-WAVE         SQRT(P1*P9)      11/75
R6   L      (-.12)OR  -.20             LONGACRE  75 IPWA    PI N TO 2PI N     11/75

R7     N*3/2(1890) FROM PI N TO N RHO,S=3/2,P-WAVE            SQRT(P1*P10)     11/75
R7   L      (-.28)OR  -.33             LONGACRE  75 IPWA    PI N TO 2PI N     11/75

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                        11  N*3/2(1890) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1     N*3/2(1890) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1            .019      .027           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1            .042      .016           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1          +.047       .067           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1          -.003       .009           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1        (+.035)                      BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1       . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)

A2     N*3/2(1890) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2            .078      .020           DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2            -.022     .020           KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2            -.028     .066           METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2            -.021     .036           CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2          (-.013)                    BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2       . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 2.2)

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REFERENCES FOR N*3/2(1890)

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DONNACH1  68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSC  68 VIENNA 139         DONNACHIE  RAPPORTEUR'S TALK           (GLAS)
    ALSC  68 THESIS             R G KIRSOPP                            (EDIN)

AYED      70 KIEV CONF          R AYED,P BAREYRE, G VILLET             (SACL)IJP
DAVIES    70 NP B21 359         A DAVIES                               (GLAS)
FEUERBAC  70 NP 16B 85          FEUERBACHER+HOLLADAY                (VANDERBILT)
KALMUS    70 PR D2 1824         G KALMUS, G BORREANI, J LOUIE           (LRL)

ALMEHED   72 NP B40 157         +LOVELACE                          (LUND,RUTG)IJP
MEHTANI   72 PRL 29 1634        +FUNG, KERNAN, SCHALK, +             (UCR +LBL)
LANGBEIN  73 NP B53 251         LANGBEIN,WAGNER                       (MUNICH)IJP
DEVENIS2  74 PL 52B 227         DEVENISH,LYTH,RANKIN              (DESY,LANC,BONN)IJP
KNIES     74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK           (LBL,GLAS)IJP
METCALF   74 NP B76 253         W J METCALF,R L WALKER                 (CIT)IJP

CRAWFORD  75 NP B97 125         R L CRAWFORD                           (GLAS)IJP
DEANS     75 NP B96 90          +MITCHELL,MONTGOMERY,+        (SFLA,ALABAMA)IJP
LONGACRE  75 PL 58B 415         +ROSENFELD,LASINSKI,SMADJA+     (LBL,SLAC)IJP

AYED      76 CEA-N-1921         AYED (THESIS)                        (SACL)IJP
BARBOUR   76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD           (GLAS)IJP
CUTKOSKY  76 PRL 37 645         CUTKOSKY,HENDRICK,KELLY          (CARN+LBL)IJP
    ALSO  76 OXFORD CONF. 49    CUTKOSKY,HENDRICK,CHAO+       (CARN+LBL+BRIS)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS.

AYED      70 PL 31B 598         +BAREYRE+VILLET                        (SACLAY)
WINNIK    77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY             (HAIFA)I

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Δ(1900) 30 N*3/2(1900, JP=1/2-) I=3/2 **S'31** 9/73

THIS EFFECT IS SEEN IN TWO CHANNELS.

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                        30  N*3/2(1900) MASS (MEV)                            9/73

M    2      (1920.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
M    2      (1870.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
M    2   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF       1/78*
M    2   WINNIK77 AROUND 1920 MEV.                                            1/78*
M        (2001.)                        AYED      76 IPWA                     11/77*

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                        30  N*3/2(1900) WIDTH (MEV)                           9/73

W    2      (140.)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
W    2      (160.)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
W        (307.)                         AYED      76 IPWA                     11/77*
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                        30  N*3/2(1900) PARTIAL DECAY MODES                   9/73

                                                                  DECAY MASSES
P1     N*3/2(1900) INTO PI N                                      139+ 938
P2     N*3/2(1900) INTO K SIGMA                                   493+1189

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                        30  N*3/2(1900) BRANCHING RATIOS                      9/73

R1     N*3/2(1900) FROM PI N TO K SIGMA                       SQRT(P1*P2)       9/73
R1   2      (.11)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
R1   2      (.12)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R1   1      (.076)                     DEANS     75 DPWA    PI N TO K SIGMA  11/75
R1   1   VALUE GIVEN IS FROM SOLUTION 1, NOT PRESENT IN SOLUTIONS 2,3,4.      11/75

R2     N*3/2(1900) INTO PI N/TOTAL                            (P1)
R2           (.08)                      AYED      76 IPWA                     11/77*

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                              REFERENCES FOR N*3/2(1900)

LANGBEIN 73 NP B53 251        LANGBEIN,WAGNER                          (MUNICH)IJP
DEANS    75 NP B96 90         +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP
AYED     76 CEA-N-1921        AYED (THESIS)                            (SACL)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

WINNIK   77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY              (HAIF)I

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Δ(1910)

12 N*3/2(1910, JP=1/2+) I=3/2 **P'31**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                              12 N*3/2(1910) MASS (MEV)

M    3      (1934.0)                    DONNACHI   68 RVUE    PHASE-SHIFT ANAL   8/69
M    6      (1783.0)                    AYED       70 IPWA                       1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    4      (1914.0)                    DAVIES     70 RVUE    P-S ANAL  SOL A    8/69
M    7      (1900.)                     ALMEHED    72 IPWA                       2/72
M    9      (1980.)                     LANGBEIN   73 IPWA    PI N-K SIG,SOL 1  9/73
M    9      (1950.)                     LANGBEIN   73 IPWA    PI N-K SIG,SOL 2  9/73
M    9   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF       1/78*
M    9   WINNIK77 ARGUND 1920 MEV.                                            1/78*
M        (1789.)                     AYED       76 IPWA                       11/77*
M         1940.       30.            CUTKOSKY   76 IPWA                       11/77*
M    8   (1790.)                     LONGACRE   77 IPWA    PI N TO 2PI N     11/77*
M    8   ALL LONGACRE77 PARAMETERS ARE FROM SOLUTION S2, EXCEPT FOR THE POLE 11/77*
M    8   POSITION WHICH IS FROM SOLUTIONS S1 AND C1.                          11/77*

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                              12 N*3/2(1910) WIDTH (MEV)

W    3      (339.0)                     DONNACHI   68 RVUE                      8/69
W    6      (308.0)                     AYED       70 IPWA                       1/71
W    4      (290.)                      DAVIES     70 RVUE    SOL A              8/69
W    7      (200.)                      ALMEHED    72 IPWA                       2/72
W    9      (190.)                      LANGBEIN   73 IPWA    PI N-K SIG,SOL 1  9/73
W    9      (170.)                      LANGBEIN   73 IPWA    PI N-K SIG,SOL 2  9/73
W        (221.)                        AYED       76 IPWA                       11/77*
W         380.       130.              CUTKOSKY   76 IPWA                       11/77*
W    8   (170.)                        LONGACRE   77 IPWA    PI N TO 2PI N     11/77*
         SEE NOTES ACCOMPANYING MASSES QUOTED

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                              12 N*3/2(1910) REAL PART OF POLE POSITION (MEV)

REE       1863.       15.             CUTKOSKY   76 IPWA                       11/77*
REE 8     1792. OR 1801.              LONGACRE   77 IPWA    PI N TO 2PI N     11/77*

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                              12 N*3/2(1910) 2*IMAG PART OF POLE POSITION (MEV)

IME        250.       34.             CUTKOSKY   76 IPWA                       11/77*
IME 8      172. OR 165.               LONGACRE   77 IPWA    PI N TO 2PI N     11/77*

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                              12 N*3/2(1910) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         -4.        5.             CUTKOSKY   76 IPWA                       11/77*

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                              12 N*3/2(1910) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        -27.        5.             CUTKOSKY   76 IPWA                       11/77*

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                              12 N*3/2(1910) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     N*3/2(1910) INTO PI N                                      139+ 938
P2     N*3/2(1910) INTO N PI PI                                   938+ 139+ 139
P3     N*3/2(1910) INTO K SIGMA                                   493+1189
P4     N*3/2(1910) INTO N*3/2(1232) PI                            1232+ 139
P5     N*3/2(1910) INTO GAM NUCLEON, HELICITY=1/2                   0+ 938
P6     N*3/2(1910) INTO N RHO,S=3/2                               938+ 776

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                              12 N*3/2(1910) BRANCHING RATIOS

R1     N*3/2(1910) INTO (PI N)/TOTAL                          (P1)
R1 3        (0.30)                     DONNACHI   68 RVUE                      8/69
R1 6        (0.128)                    AYED       70 IPWA                       1/71
R1 4        (0.18)                     DAVIES     70 RVUE    SOL A              8/69
R1 7        (0.33)                     ALMEHED    72 IPWA                       2/72
R1          (.16)                      AYED       76 IPWA                       11/77*
R1           .225      .025            CUTKOSKY   76 IPWA                       11/77*

R2     N*3/2(1910) INTO (K SIGMA)/TOTAL                       (P3)
R2 1        (0.008)OR LESS             FEUERBACH 70 RVUE     PI P TO K+ SIG+   7/70
R2 1        ASSUME MASS, WIDTH, X(ELAST.) OF DONNACHIE 68
R2 1        MODEL USED MAY DOUBLE COUNT.

R3     N*3/2(1910) FROM PI N TO K SIGMA                       SQRT(P1*P3)       9/73
R3 9        (.11)                      LANGBEIN   73 IPWA    PI N-K SIG,SOL 1  9/73
R3 9        (.15)                      LANGBEIN   73 IPWA    PI N-K SIG,SOL 2  9/73
R3 2        (.082)TO  .184             DEANS      75 DPWA    PI N TO K SIGMA   11/75
R3 2    RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                                11/75

R4     N*3/2(1910) FROM PI N TO N*3/2(1232) PI                SQRT(P1*P4)       11/77*
R4 8        (-.06)                     LONGACRE   77 IPWA    PI N TO 2PI N     11/77*

R5     N*3/2(1910) FROM PI N TO N RHO,S=3/2                   SQRT(P1*P6)       11/77*
R5 8        (-.29)                     LONGACRE   77 IPWA    PI N TO 2PI N     11/77*

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                              12 N*3/2(1910) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
     REVIEW PRECEDING THE BARYON LISTINGS.

A1     N*3/2(1910) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1          .000      .025           DEVENISZ   74 DPWA    PI N PHOTO-PROD   4/75
A1          .010      .012           KNIES      74 DPWA    PI N PHOTO PROD   2/74
A1         -.032      .065           METCALF    74 DPWA    PI N PHOTO-PROD   2/74
A1         -.009      .013           CRAWFORD   75 DPWA    PI N PHOTO-PROD   1/76
A1        (-.031)                    BARBOUR    76 DPWA    PI N PHOTO-PROD   1/76
A1     . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                              REFERENCES FOR N*3/2(1910)

DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO 68 VIENNA 139        DONNACHIE  RAPPORTEUR'S TALK             (GLAS)
    ALSO 68 THESIS            R G KIRSOPP                              (EDIN)

AYED     70 KIEV CONF         R AYED,P BAREYRE, G VILLET               (SACL)IJP
DAVIES   70 NP B21 359        A DAVIES                                 (GLAS)
FEUERBAC 70 NP 168 85         FEUERBACHER+HOLLADAY                  (VANDERBILT)

ALMEHED  72 NP B40 157        +LOVELACE                          (LUND,RUTG)IJP
LANGBEIN 73 NP B53 251        LANGBEIN,WAGNER                       (MUNICH)IJP

DEVENIS2 74 PL 52B 227        DEVENISH,LYTH,RANKIN            (DESY,LANC,BONN)IJP
KNIES    74 PRD 9 2680        KNIES,MCGRHOUSE,OBERLACK             (LBL,GLAS)IJP
METCALF  74 NP B76 253        W J METCALF,R L WALKER                   (CIT)IJP

CRAWFORD 75 NP B97 125        R L CRAWFORD                             (GLAS)IJP
DEANS    75 NP B96 90         +MITCHELL,MONTGOMERY,+          (SFLA,ALABAMA)IJP

AYED     76 CEA-N-1921        AYED (THESIS)                            (SACL)IJP
BARBOUR  76 NP B111 358       I. M. BARBOUR,R. L. CRAWFORD             (GLAS)IJP
CUTKOSKY 76 PRL 37 645        CUTKOSKY,HENDRICK,KELLY          (CARN+LBL)IJP
    ALSO 76 OXFORD CONF. 49   CUTKOSKY,HENDRICK,CHAO+       (CARN+LBL+BRIS)IJP
LONGACRE 77 NP B122 493       LONGACRE,DOLBEAU                         (SACL)IJP
    ALSO 76 NP B108 365       DOLBEAU,TRIANTIS,NEVEU,CADIET            (SACL)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS.

CARYANN  65 PR 138 B433       CARAYANNOPOULOS,TAUTFEST,WILLMANN        (PURD)
    A PARTIAL WAVE ANALYSIS OF PI+P TO SIGMA+ K+
AYED     70 PL 31B 598        +BAREYRE+VILLET                       (SACLAY)
WINNIK   77 NP B128 66        +TOAFF,REVEL,GOLDBERG,BERNY              (HAIF)I

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Δ(1950)

83 N*3/2(1950, JP=7/2+) I=3/2 **F37**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                              83 N*3/2(1950) MASS (MEV)

M          (1920.0)                    DUKE       65 CNTR    PI-P EL + POL     6/68
M          (1950.0)        APPROX      YOKOSAWA   66 CNTR    PI- P DSIG + POL  7/66
M    1     (1975.0)                    BAREYRE    68 RVUE    PHASE-SHIFT ANAL 11/67
M    1           WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    3     (1946.0)                    DONNACHI   68 RVUE    PHASE-SHIFT ANAL  6/68
M    6     (1931.0)                    AYED       70 IPWA                       1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    4     (1935.0)                    DAVIES     70 RVUE    P-S ANAL  SOL A   8/69
M          (1950.0)   (30.0)           KALMUS     70 DPWA    PI+P TO K+ SIG+   1/71
M          (1930.)                     ROYCHOUD   71 DPWA                       3/72
M    7     (1925.)                     ALMEHED    72 IPWA                       2/72
M    2      1920 TO 1951               MEHTANI    72 MPWA    PI+P TO PI+PIOP   9/73
M    L      1930. OR 1925.             LONGACRE   75 IPWA    PI N TO 2PI N     11/75
M    L  THE 2 SETS OF PARAMETERS ARE FROM METHODS 1 AND 2 OF LONGACRE 75.     11/75
M          (1928.)                     AYED       76 IPWA                       11/77*
M           1945.        7.            CUTKOSKY   76 IPWA                       11/77*

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                              83 N*3/2(1950) WIDTH (MEV)

W          (170.0)                     DUKE       65 CNTR                       7/66
W          (200.0)         APPROX      YOKOSAWA   66 CNTR                       7/66
W    1     (180.0)                     BAREYRE    68 RVUE                      11/67
W    3     (221.0)                     DONNACHI   68 RVUE                       6/68
W    6     (197.0)                     AYED       70 IPWA                       1/71
W    4     (221.0)                     DAVIES     70 RVUE    SOL A              8/69
W          (300.0)   (60.0)            KALMUS     70 DPWA    PI+P TO K+ SIG+   1/71
W    7     (200.)                      ALMEHED    72 IPWA                       2/72
W    2      234 TO 269                 MEHTANI    72 MPWA    PI+P TO PI+PIOP   9/73
W    L       235. OR  240.             LONGACRE   75 IPWA    PI N TO 2PI N     11/75
W          (237.)                      AYED       76 IPWA                       11/77*
W           305.       40.            CUTKOSKY   76 IPWA                       11/77*
         SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                              83 N*3/2(1950) REAL PART OF POLE POSITION (MEV)       11/75

REE       (1924.)                     LONGACRE   75 IPWA    PI N TO 2PI N     11/75
REE       (1915.)                     VASAN2     76         FIT AYED 76       11/77*
REE        1895.       10.            CUTKOSKY   76 IPWA                       11/77*

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                              83 N*3/2(1950) 2*IMAG PART OF POLE POSITION (MEV)     11/75

IME       (258.)                      LONGACRE   75 IPWA    PI N TO 2PI N     11/75
IME       (220.)                      VASAN2     76         FIT AYED 76       11/77*
IME        260.       24.            CUTKOSKY   76 IPWA                       11/77*

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                              83 N*3/2(1950) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER         50.        6.            CUTKOSKY   76 IPWA                       11/77*

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                              83 N*3/2(1950) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR        -25.        9.            CUTKOSKY   76 IPWA                       11/77*

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Baryons

Δ(1950), Δ(1960)


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                    83  N*3/2(1950) PARTIAL DECAY MODES

                                                                          DECAY MASSES
P1      N*3/2(1950) INTO PI N                                            139+ 938
P2      N*3/2(1950) INTO SIGMA K                                        1189+ 493
P3      N*3/2(1950) INTO N*3/2(1232) PI                                 1232+ 139
P4      N*3/2(1950) INTO Y*1(1385) K                                    1384+ 493
P5      N*3/2(1950) INTO N*3/2(1232) RHO                                1232+ 776
P6      N*3/2(1950) INTO NEUTRON PI+ PI+                                 939+ 139+ 139
P7      N*3/2(1950) INTO N*3/2(1232) PI PI (NOT RHO)                    1232+ 139+ 139
P8      N*3/2(1950) INTO GAM NUCLEON, HELICITY=1/2                       0+ 938
P9      N*3/2(1950) INTO GAM NUCLEON, HELICITY=3/2                       0+ 938
P10     N*3/2(1950) INTO N RHO                                           938+ 776
P11     N*3/2(1950) INTO N*3/2(1232) PI,F-WAVE                          1232+ 139
P12     N*3/2(1950) INTO N*3/2(1232) PI,H-WAVE                          1232+ 139
P13     N*3/2(1950) INTO N RHO,S=3/2,F-WAVE                              938+ 776

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                    83  N*3/2(1950) BRANCHING RATIOS

R1      N*3/2(1950) INTO (PI N)/TOTAL                                   (P1)
R1              (0.41)                  DUKE      65 CNTR    VERY ENERGY DEP   7/66
R1              (0.4)          APPROX   YOKOSAWA  66 CNTR                      7/66
R1  1           (0.57)                  BAREYRE   68 RVUE                      11/67
R1  3           (0.386)                 DONNACH1  68 RVUE                       6/68
R1  6           (0.496)                 AYED      70 IPWA                       1/71
R1  4           (0.51)                  DAVIES    70 RVUE    SOL A              8/69
R1  7           (0.4)                   ALMEHED   72 IPWA                       2/72
R1               (.41)                  AYED      76 IPWA                      11/77*
R1               .396      .010         CUTKOSKY  76 IPWA                      11/77*
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

R2      N*3/2(1950) INTO (SIGMA K)*(PI N)/TOTAL**2                      (P2*P1)
R2              SEEN                    BORREANI  68 HBC     PI+P 1.35-1.68    10/69
R2  1           (0.004)  (0.008)        FEUERBACH 70 RVUE    PI P TO K+ SIG+    7/70
R2  1       ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
R2  1       MODEL USED MAY DOUBLE COUNT.
R2              0.0081   0.0013         KALMUS    70 DPWA    PI+P TO K+ SIG+   1/71

R3      N*3/2(1950) FROM PI N TO N*3/2(1232) PI                         SQRT(P1*P3)
R3  2       .37 TO .48                  MEHTANI   72 MPWA    PI+P TO PI+PIOP    9/73
R3  2   MOSTLY F WAVE DECAY                                                   9/73

R4      N*3/2(1950) FROM PI N TO SIGMA K                                SQRT(P1*P2)       9/73
R4               (.04)                  LANGBEIN  73 IPWA    PI N-K SIG,SOL 1  9/73
R4               (.05)                  LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R4  5            (.022)TO  .040         DEANS     75 DPWA    PI N TO K SIGMA  11/75
R4  5   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                                11/75
R4  5   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF         1/78*
R4  5   WINNIK77 AROUND 1920 MEV.                                              1/78*

R5      N*3/2(1950) FROM PI N TO N*3/2(1232) PI,F-WAVE          SQRT(P1*P11)      11/75
R5  L           (-.25)OR  -.32          LONGACRE  75 IPWA    PI N TO 2PI N      11/75

R6      N*3/2(1950) FROM PI N TO N RHO,S=3/2,F-WAVE             SQRT(P1*P13)      11/75
R6  L           (.18)OR  -.24           LONGACRE  75 IPWA    PI N TO 2PI N      11/75

    MORE INFORMATION ON INELASTIC DECAY MODES OF BUMPS, SEEN IN PRODUCTION
    EXPERIMENTS AROUND 1950 MEV, MAY BE FOUND IN THE NEXT ENTRY

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                    83  N*3/2(1950) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*3/2(1950) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)
A1              -.088      .025         DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A1              -.070      .012         KNIES     74 DPWA    PI N PHOTO PROD   2/74
A1              -.059      .029         METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A1             (-.080)                  MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A1              -.053      .005         CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1             (-.076)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A1                . . . . . .
A1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

A2      N*3/2(1950) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2              -.080      .021         DEVENIS2  74 DPWA    PI N PHOTO-PROD   4/75
A2              -.078      .010         KNIES     74 DPWA    PI N PHOTO PROD   2/74
A2              -.093      .024         METCALF   74 DPWA    PI N PHOTO-PROD   2/74
A2             (-.180)                  MOORHOUS  74 DPWA    PI N PHOTO-PROD   2/74
A2              -.038      .014         CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2             (-.065)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76
A2                . . . . . .
A2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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                            REFERENCES FOR N*3/2(1950)

DUKE      65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +    (RHEL,OXF)IJP
YOKOSAWA  66 PRL 16 714         +SUWA, HILL, ESTERLING, BOOTH     (ANL,CHIC)IJP

BAREYRE   68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET      (SACLAY)IJP
BORREANI  68 UCRL 18350          BORREANI,KALMUS                      (LRL)
DONNACH1  68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
    ALSO  68 VIENNA 139         DONNACHIE  RAPPORTEUR'S TALK          (GLAS)
    ALSO  68 THESIS             R G KIRSOPP                           (EDIN)

AYED      70 KIEV CONF          R AYED,P BAREYRE, G VILLET            (SACL)IJP
DAVIES    70 NP B21 359         A DAVIES                              (GLAS)
FEUERBAC  70 NP 16B 85          FEUERBACHER+HOLLADAY               (VANDERBILT)
KALMUS    70 PR D2 1824         G KALMUS, G BORREANI, J LOUIE         (LRL)

ROYCHOUD  71 NP B27 125         R K ROYCHOUDHURY,B H BRANSDEN         (DURH)IJP

ALMEHED   72 NP B40 157         +LOVELACE                          (LUND,RUTG)IJP
MEHTANI   72 PRL 29 1634        +FUNG, KERNAN, SCHALK, +             (UCR +LBL)
LANGBEIN  73 NP B53 251         LANGBEIN,WAGNER                       (MUNICH)IJP

DEVENIS2  74 PL 52B 227         DEVENISH,LYTH,RANKIN              (DESY,LANC,BONN)IJP
KNIES     74 PRD 9 2680         KNIES,MOORHOUSE,OBERLACK             (LBL,GLAS)IJP
METCALF   74 NP B76 253         W J METCALF,R L WALKER                 (CIT)IJP
MOORHOUS  74 PRD 9 1            MOORHOUSE,OBERLACK,ROSENFELD         (GLAS+LBL)IJP

CRAWFORD  75 NP B97 125         R L CRAWFORD                          (GLAS)IJP
DEANS     75 NP B96 90          +MITCHELL,MONTGOMERY,+            (SFLA,ALABAMA)IJP
LONGACRE  75 PL 55B 415         +ROSENFELD,LASINSKI,SMADJA+          (LBL,SLAC)IJP

AYED      76 CEA-N-1921         AYED (THESIS)                         (SACL)IJP
BARBOUR   76 NP B111 358        I. M. BARBOUR,R. L. CRAWFORD          (GLAS)IJP
CUTKOSKY  76 PRL 37 645         CUTKOSKY,HENDRICK,KELLY            (CARN+LBL)IJP
    ALSO  76 CXFORD CONF. 49    CUTKOSKY,HENDRICK,CHAO+         (CARN+LBL+BRIS)IJP
VASAN2    76 NP B106 526        S. S. VASAN                           (CARN)IJP

                            PAPERS NOT REFERRED TO IN DATA CARDS.

HOHLER    63 NP 48 470          G HOHLER, G EBEL                   (KARLSRUHE) I
LAYSON    63 NC 27 724          W M LAYSON                              (CERN) IJ
AUVIL     64 NC 33 473          P AUVIL, C LOVELACE                    (LOIC)IJP
HELLAND   64 PR 134 B1062       +DEVLIN,HAGGE,LONGO,MOYER,WOOD          (LRL) IJ
HOHLER    64 PL 12 149          G HOHLER, J GIESECKE               (KARLSRUHE) I
HOLLADAY  65 PR 139 B1348       W G HOLLADAY                       (VANDERBILT)
JOHNSON   67 UCRL-17683 THESIS  C H JOHNSON                            (LRL)
DONNACHI  69 NP 10B 433         A DONNACHIE, R KIRSOPP             (GLAS+EDIN)
AYED      70 PL 31B 598         +BAREYRE+VILLET                        (SACLAY)
AYED      74 PRIVATE COMMCTN.   AYED,BAREYRE                           (SACL)IJP
    ALSO  73 AIX CONFERENCE     AYED,BAREYRE                           (SACL)IJP
WINNIK    77 NP B128 66         +TOAFF,REVEL,GOLDBERG,BERNY            (HAIF)I

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Δ(1960) 13 N*3/2(1960, JP=5/2-) I=3/2 D_{35}

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                    13  N*3/2(1960) MASS (MEV)

M   3       (1954.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   3       (1970.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M   X       (1950.0)        APPROX    LEA       69 CNTR    PI-P ELASTIC      8/69
M   X   SEE ALSO APLIN 70
M   3     WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69
M   7       (2200.)                   ALMEHED   72 IPWA                       2/72
M   1       (1960.)                   LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
M   1   NOT SEEN IN SOLUTION 1 OF LANGBEIN73                                  9/73
M   1   DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF       1/78*
M   1   WINNIK77 AROUND 1920 MEV.                                            1/78*
M       (1894.)                       AYED      76 IPWA                      11/77*
M        1925.      20.               CUTKOSKY  76 IPWA                      11/77*

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                    13  N*3/2(1960) WIDTH (MEV)

W   3       (311.00)                  DONNACH1  68 RVUE                       8/69
W   3       (400.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W   7       (600.)                    ALMEHED   72 IPWA                       2/72
W   1       (150.)                    LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
W           (121.)                    AYED      76 IPWA                      11/77*
W            350.      100.           CUTKOSKY  76 IPWA                      11/77*
        SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                    13  N*3/2(1960) REAL PART OF POLE POSITION (MEV)

REE          1860.      15.           CUTKOSKY  76 IPWA                      11/77*

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                    13  N*3/2(1960) 2*IMAG PART OF POLE POSITION (MEV)

IME           276.      40.           CUTKOSKY  76 IPWA                      11/77*

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                    13  N*3/2(1960) REAL PART OF ELASTIC POLE RESIDUE (MEV)

RER            12.       3.           CUTKOSKY  76 IPWA                      11/77*

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                    13  N*3/2(1960) IMAG PART OF ELASTIC POLE RESIDUE (MEV)

IMR           -15.       4.           CUTKOSKY  76 IPWA                      11/77*

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                    13  N*3/2(1960) PARTIAL DECAY MODES

                                                                          DECAY MASSES
P1      N*3/2(1960) INTO PI N                                            139+ 938
P2      N*3/2(1960) INTO K SIGMA                                         493+1189

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                    13  N*3/2(1960) BRANCHING RATIOS

R1      N*3/2(1960) INTO (PI N)/ TOTAL                                  (P1)
R1  3           (.154)                  DONNACH1  68 RVUE    PHASE SHIFT ANA. 10/69
R1  3           (.12)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  7          (0.25)                   ALMEHED   72 IPWA                       2/72
R1              (.08)                   AYED      76 IPWA                      11/77*
R1               .133      .013         CUTKOSKY  76 IPWA                      11/77*

R2      N*3/2(1960) INTO (K SIGMA)/TOTAL                                (P2)
R2  1           (0.013)  (0.01)         FEUERBACH 70 RVUE    PI P TO K+ SIG+   7/70
R2  1       ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
R2  1       MODEL USED MAY DOUBLE COUNT.

R3      N*3/2(1960) FROM PI N TO K SIGMA                        SQRT(P1*P2)       9/73
R3  1           (.08)                   LANGBEIN  73 IPWA    PI N-K SIG,SOL 2  9/73
R3  2           (.018)TO  .035          DEANS     75 DPWA    PI N TO K SIGMA  11/75
R3  2   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                                11/75

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                    13  N*3/2(1960) PHOTON DECAY AMPL(GEV**-1/2)

      FOR DEFINITION OF GAMMA-NUCLEON DECAY AMPLITUDES, SEE MINI-
    REVIEW PRECEDING THE BARYON LISTINGS.

A1      N*3/2(1960) INTO GAM NUCLEON, HELICITY=1/2 (GEV**-1/2)                    1/76
A1              +.003      .016         CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A1             (-.085)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76

A2      N*3/2(1960) INTO GAM NUCLEON, HELICIYT=3/2 (GEV**-1/2)                    1/76
A2              -.010      .032         CRAWFORD  75 DPWA    PI N PHOTO-PROD   1/76
A2             (+.066)                  BARBOUR   76 DPWA    PI N PHOTO-PROD   1/76

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                            REFERENCES FOR N*3/2(1960)

DONNACH1  68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP   68 THESIS             R G KIRSOPP                           (EDIN)
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Data Card Listings

For notation, see key at front of Listings.


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LEA       69 PL 29B 584          LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)
FEUERBAC  70 NP 16B 85           FEUERBACHER+HOLLADAY          (VANDERBILT)
ALMEHED   72 NP B40 157          +LOVELACE                     (LUND,RUTG)IJP

LANGBEIN  73 NP B53 251          LANGBEIN,WAGNER                (MUNICH)IJP

CRAWFORD  75 NP B97 125          R L CRAWFORD                      (GLAS)IJP
DEANS     75 NP B96 90           +MITCHELL,MONTGOMERY,+       (SFLA,ALABAMA)IJP

AYED      76 CEA-N-1921          AYED (THESIS)                     (SACL)IJP
BARBOUR   76 NP B111 358         I. M. BARBOUR,R. L. CRAWFORD      (GLAS)IJP
CUTKOSKY  76 PRL 37 645          CUTKOSKY,HENDRICK,KELLY      (CARN+LBL)IJP
    ALSO  76 OXFORD CONF. 49     CUTKOSKY,HENDRICK,CHAO+      (CARN+LBL+BRIS)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS.

DENNACHI  69 NP 10B 433          A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
AYED      70 PL 31B 598          +BAREYRE+VILLET                   (SACLAY)
APLIN     71 NP B32 253          +COWAN,GIBSON,GILMORE++      (RHEL,BRISTOL)
WINNIK    77 NP B128 66          +TOAFF,REVEL,GOLDBERG,BERNY        (HAIF)I
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1950 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

70 N*3/2(1950, JP=) I=3/2 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS
FOR A DISCUSSION OF PRODUCTION EXPERIMENTS

70 N*3/2(1950) MASS (MEV) (PROD. EXP.)

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M          (1922.0)        APPROX       CGOL      56 CNTR    PI+ P TOTAL        7/66
M          (1912.0)   (15.0)            BRISSON   61 CNTR    PI+ P TOTAL        7/66
M          (1900.0)    (9.0)            DEVLIN    65 CNTR    PI+ P TOTAL
M   N      (2080.0)   (12.0)            YOON      67 HBC  +  3 BEV/C PI-P        8/67
M   N       THIS BUMP IS NOT SEEN BY CHUNG 68 AT 3.2 GEV/C
M          (1860.0)                     COLTON    72 HBC  ++ PP TO PI+PN 7GEV   1/73
M          (1895.)    (15.)             COLLEY    74 HBC  ++ K+P TO K+PPI+PI-  10/74
M          (1890.)     5. TO 10.        BRAUN2    75  BC     PBAR P AND D,S,T  11/75
M   C      (1881.)    (6.)              CHUNG     75 HBC  ++ PI+ P AND K+ P      1/76
M   C   MOST PROBABLE JP ASSIGNMENT IS 7/2+.                                     1/76
M          (1880.)    (10.)             GAIDOS    75 HBC  ++ PI+P TO N* 2PI      1/76
M  .M   1K 1849. TO 1893.               ZEMANY    77 HBC  ++ PI+P  10.3 GEV/C  1/78*
M   M   FROM N PI AND N PI PI MODES                                              1/78*
M   S   37(1927.)    (35.)             ZEMANY    77 HBC  ++ PI+P  10.3 GEV/C  1/78*
M   S   FROM SIGMA KBAR MODE ONLY                                               1/78*
```

70 N*3/2(1950) WIDTH (MEV) (PROD. EXP.)

```
W          (256.0)   (39.0)            DEVLIN    65 CNTR
W           (40.0)   (20.0)            YOON      67 HBC  +                      8/67
W          (180.0)                     COLTON    72 HBC  ++ PP TO PI+PN 7GEV   1/73
W          (230.)     (50.)            COLLEY    74 HBC  ++ K+P TO K+PPI+PI-  10/74
W          (120.)      10. TO 20.      BRAUN2    75  BC     PBAR P AND D,S,T  11/75
W   C      (219.)     (23.)            CHUNG     75 HBC  ++ PI+ P AND K+ P      1/76
W          (180.)     (30.)            GAIDOS    75 HBC  ++ PI+P TO N* 2PI      1/76
W   M   1K  205. TO  273.               ZEMANY    77 HBC  ++ PI+P  10.3 GEV/C  1/78*
W   S   37  (40.)     (73.)            ZEMANY    77 HBC  ++ PI+P  10.3 GEV/C  1/78*
```

70 N*3/2(1950) PARTIAL DECAY MODES (PROD. EXP.)

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                                                                 DECAY MASSES
P1     N*3/2(1950) INTO PI N                                      139+ 938
P2     N*3/2(1950) INTO SIGMA K                                  1189+ 493
P3     N*3/2(1950) INTO N*3/2(1232) PI                           1232+ 139
P4     N*3/2(1950) INTO Y*1(1385) K                              1384+ 493
P5     N*3/2(1950) INTO N*3/2(1232) RHO                          1232+ 776
P6     N*3/2(1950) INTO NEUTRON PI+ PI+                           939+ 139+ 139
P7     N*3/2(1950) INTO N*3/2(1232) PI PI (NOT RHO)              1232+ 139+ 139
P8     N*3/2(1950) INTO PROTON PI+ PI0                            938+ 139+ 139
P9     N*3/2(1950) INTO PI PI N                                   139+ 139+ 938
```

70 N*3/2(1950) BRANCHING RATIOS (PROD. EXP.)

```
R1     N*3/2(1950) INTO (PI N)/TOTAL                                  (P1)
R1          (0.57)   (0.12)            DEVLIN    65 CNTR
R1          (0.48)   (0.15)            ZEMANY    77 HBC  ++ PI+P  10.3 GEV/C  1/78*

R2     N*3/2(1950) INTO (SIGMA K)/(PI N)                              (P2)/(P1)
R2           0.059    0.024            CHINOWSKY 68 HBC  ++ PP TO P SIG K     11/68

R3     N*3/2(1950) INTO N*3/2(1232) PI PI (NOT RHO)                   (P7)
R3           SEEN                      CHINOWSKY 68 HBC  ++ PP TO (P 3PI) N   11/68
R3           SEEN                      BOGGILD   70  HBC    PP TO N3PI(NTRL)    6/70

R4     N 3/2(1950) INTO (PI N)/(N*3/2(1232) PI)                       (P1)/(P3)
R4          (0.55) OR LESS             LEE       67 HBC     PI-P 3.63 BEV/C    11/67

R5     N*3/2(1950) INTO ((PI N)*(NEUTRON PI+ PI+))/TOTAL**2
R5                                                                    (P1*P6)
R5           0.05     0.013            GALLOWAY  68 RVUE ++ PI+P TO N 2PI+      6/68

R6     N*3/2(1950) INTO (Y*1(1385) K)/(PI N)                          (P4)/(P1)
R6           0.035    0.015            CHINOWSKY 68 HBC  ++ PP TO P LAM K PI  11/68

R7     N*3/2(1950) INTO (N*3/2(1232) RHO)/(PI N)                      (P5)/(P1)
R7          (0.45)    APPROX           CHINOWSKY 68 HBC  ++ PP TO (P 3PI) N   11/68
R7     THIS INCLUDES CORRECTION FOR UNSEEN DECAY (ISPIN FACTOR 5/3).

R8     N*3/2(1950) INTO (N*3/2(1232) RHO)/TOTAL                       (P5)
R8          SEEN                       YOON      67 HBC  +                      8/67
R8          NOT SEEN                   BOGGILD   70  HBC    PP TO N3PI(NTRL)    6/70

R9     N*3/2(1950) INTO (PROTON PI+ PI0)/TOTAL                        (P8)
R9          (0.26)   (0.07)            ZEMANY    77 HBC  ++ PI+P  10.3 GEV/C  1/78*

R10    N*3/2(1950) INTO (NEUTRON PI+ PI+)/TOTAL                       (P6)
R10         (0.24)   (0.07)            ZEMANY    77 HBC  ++ PI+P  10.3 GEV/C  1/78*

R11    N*3/2(1950) INTO (SIGMA K)/TOTAL                               (P2)
R11         (0.027)  (0.009)           ZEMANY    77 HBC  ++ PI+P  10.3 GEV/C  1/78*

R12    N*3/2(1950) INTO (PI PI N)/(PI N + PI PI N)                    (P9)/(P1+P9)
R12 D       (0.35)   (0.08)            GAIDOS    75 HBC  ++ PI+P TO N* 2PI     1/78*
R12 D   ASSUMING (PI PI N) IS ALL N*3/2(1232) PI, WHICH AGREES WITH DATA       1/78*
R12 R       (0.30)   (0.07)            GAIDOS    75 HBC  ++ PI+P TO N* 2PI     1/78*
R12 R   ASSUMING (PI PI N) IS ALL RHO PI                                      1/78*
```

REFERENCES FOR N*3/2(1950) (PROD. EXP.)

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COOL      56 PR 103 1082         R COOL, O PICCIONI, D CLARK              (BNL) I
BRISSON   61 NC 19 210           +DETOEUF,FALK-VAIRANT,VAN ROSSUM,+  (SACLAY) I
DEVLIN    65 PRL 14 1031         T J DEVLIN,J SOLOMON,G BERTSCH   (PRINCETON) I
LEE       67 PR 159 1156         +MOEBS,ROE,SINCLAIR,VANDER VELDE         (MICH)
YOON      67 PL 24B 307          +BERENYI,KEY,PRENTICE, +      (TORONTO,WISC)

CHINOWSK  68 PR 171 1421         CHINOWSKY,CONDON,KINSEY,KLEIN,+   (LRL,SLAC)
CHUNG     68 PR 165 1491         S U CHUNG,DAHL,KIRZ,MILLER                (LRL)
GALLOWAY  68 PL 26B 334          K F GALLOWAY                        (INDIANA) I

BOGGILD   70 NP B16 503          +KOREA-AHO+JACOBSEN+ (BOHR+ HELS+OSLO+STOH)
COLTON    72 PR D6 95            E COLTON, A KIRSCHBAUM                    (LBL)
COLLEY    74 NP B69 205          COLLEY,HUQ,JOBES,KINSON,MILNE,+ (BIRM+GLAS)I
BRAUN2    75 NP B95 503          +GERBER,MAURER,MICHALON,SCHIBY+ STBRB,LPNP I
CHUNG     75 PL 57B 384          +PROTOPOPESCU,EISNER+   (BNL+CASE+LBL+UCSC)IJP
    ALSO  75 PRD 12 693          CHUNG,PROTOPOPESCU,EISNER+  (BNL+CASE+UCSC)IJP
GAIDOS    75 PRD 12 2565         GAIDOS,MILLER                        (PURD)IJP
ZEMANY    77  TORONTO PREPRINT   +BEAUFAYS,GODDARD,KENNEDY,KEY+   (TNTO+BNL)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS.

DEUTSCHM  75 NP B99 397          DEUTSCHMANN+(AACH+BONN+BERL+CERN+CRAC+HEID)
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Δ(2160)

9 N*3/2(2160,) I=3/2

EARLY ANALYSES FOUND EVIDENCE FOR A RESONANCE NEAR THIS MASS IN THE P33 PARTIAL WAVE, AND UNLESS STATED OTHERWISE, ALL DATA CARDS BELOW APPLY TO THIS WAVE. IN ADDITION, ROYCHOUDHURY 71 FIND POSSIBLE EVIDENCE FOR P31, D33, AND D35 RESONANCES IN THIS MASS REGION. IN A SIMILAR ANALYSIS BRANSDEN 71 FOUND SOME EVIDENCE FOR S31, D33, AND D35 RESONANCES IN THIS REGION. VON SCHLIPPE 72 SUGGESTS A G39. A PRONOUNCED SHARP DIP IS OBSERVED IN PI+ P BACKWARD SCATTERING AT 2200 MEV BY REY 74. DUAL INTERFERENCE MODEL ANALYSIS OF MA 75 FINDS SIGNAL FOR P33, P31, AND D35, BUT NOT FOR G39. AYED 76 FINDS A G39 RESONANCE IN THIS MASS REGION. THE EFFECT SEEN IN K SIG PRODUCTION IS 100 MEV LOWER IN MASS.

9 N*3/2(2160) MASS (MEV)

```
M   3      (2160.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M          (2120.)                    ROYCHOUD  71 DPWA                       3/72
M   7      (2150.)                    ALMEHED   72 IPWA                       2/72
M    1     (1980.)                    LANGBEIN  73 IPWA    PI N-K SIG,SOL 1   9/73
M    1  NOT SEEN IN SOLUTION 2 OF LANGBEIN73                                   9/73
M    1  DEANS75 AND LANGBEIN73 DISAGREE WITH PI+ P TO K+ SIGMA+ DATA OF        1/78*
M    1  WINNIK77 AROUND 1920 MEV.                                             1/78*
M   4      (2196.)    (46.)    (41.)  REY       74 MPWA ++ PI+ P 180 DEG CS 10/74
M   4   BAKER 74 AND REY 74 FIND NEGATIVE PARITY (SPIN UNDETERMINED).
M   2      (2170.)                    AYED      76 IPWA                       11/77*
M   2   AYED 76 RESULT IS A G39 RESONANCE.                                     11/77*
```

9 N*3/2(2160) WIDTH (MEV)

```
W   3      (260.)                     KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W   7      (200.)                     ALMEHED   72 IPWA                       2/72
W    1     (190.)                     LANGBEIN  73 IPWA    PI N-K SIG,SOL 1   9/73
W   4      (302.)    (143.)           REY       74 MPWA ++ PI+ P 180 DEG CS 10/74
W   2      (205.)                     AYED      76 IPWA                       11/77*
       SEE THE NOTES ACCOMPANYING MASSES QUOTED
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9 N*3/2(2160) PARTIAL DECAY MODES

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                                                                 DECAY MASSES
P1     N*3/2(2160) INTO PI N                                      139+ 938
P2     N*3/2(2160) INTO K SIGMA                                   493+1189
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9 N*3/2(2160) BRANCHING RATIOS

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R1     N*3/2(2160) INTO (PI N)/TOTAL                                  (P1)
R1  3       (.25)                      KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  7      (0.31)                      ALMEHED   72 IPWA                       2/72
R1  2       (.04)                      AYED      76 IPWA                      11/77*
R1  4   REY74 FINDS (J+1/2)X=.81+/-(.54/.39)                                  10/74

R2     N*3/2(2160) FROM PI N TO K SIGMA                          SQRT(P1*P2)    9/73
R2   1      (.08)                      LANGBEIN  73 IPWA    PI N-K SIG,SOL 1   9/73
R2   5     (.048)TO  .120              DEANS     75 DPWA    PI N TO K SIGMA   11/75
R2   5   RANGE GIVEN IS FROM FOUR BEST SOLUTIONS.                            11/75
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REFERENCES FOR N*3/2(2160)

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KIRSOPP   68 THESIS              R G KIRSOPP                              (EDIN)
ROYCHOUD  71 NP B27 125          R K ROYCHOUDHURY,B H BRANSDEN            (DURH)IJP

ALMEHED   72 NP B40 157          +LOVELACE                          (LUND,RUTG)IJP
LANGBEIN  73 NP B53 251          LANGBEIN,WAGNER                     (MUNICH)IJP

REY       74 PRL 32 908          REY,LENNOX,POIRIER,PRETZL        (NDAM+MPIM)IP
    ALSO  74 PRL 33 250          REY,LENNOX,POIRIER,PRETZL        (NDAM+MPIM)IP
    ALSO  75 PRD 11 1777         LENNOX,POIRIER,REY,SANDER+  (NDAM+FNAL+ANL)IP
DEANS     75 NP B96 90           +MITCHELL,MONTGOMERY,+        (SFLA,ALABAMA)IJP
AYED      76 CEA-N-1921          AYED (THESIS)                       (SACL)IJP
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                    PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI 69 NP 108 433       A DONNACHIE,R KIRSOPP           (GLAS+EDIN)
BRANSDEN 71 NP B26 511       ,OGDEN                              (DURH)IJP
    ALSO 70 NP B16 461       ROYCHOUDHURY,PERRIN,BRANSDEN        (DURH)IJP
VON SCHL 72 LNC 4 767        VON SCHLIPPE                        (LOWC)IJP .
BAKER    74 PRL 32 251       BAKER,EARTLY,PRETAL,PRUSS,+ (FNAL,ANL,NDAM)P
MA       75 PRD 11 1832      MA,SHAW                        (UCSB,SLAC)IJP
WINNIK   77 NP B128 66       +TOAFF,REVEL,GOLDBERG,BERNY         (HAIF)I

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Δ(2420) — $H_{3\ 11}$

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               84  N*3/2(2420, JP=11/2+)  I=3/2

               BOTH ROYCHOUDHURY 71 AND BRANSDEN 71 SEE A POSSIBLE
               RESONANT F35 IN THIS MASS REGION. IN ADDITION BRANSDEN
               71 FIND A RESONANT P33 AT 2600 MEV.


               84  N*3/2(2420) MASS (MEV)

M   6     (2312.0)                   AYED      70 IPWA                        1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M         (2400.)                    BRANSDEN  71 DPWA                        3/72
M         (2400.)                    ROYCHOUD  71 DPWA                        3/72
M         (2440.)                    OTT       72 MPWA  0 PI-P BKWD ELSTC     2/73
M   1     (2404.)     (63.)          REY       74 MPWA ++ PI+ P 180 DEG CS   10/74
M         (2392.)                    AYED      76 IPWA                       11/77*

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               84  N*3/2(2420) WIDTH (MEV)

W   6     (347.0)                    AYED      70 IPWA                        1/71
W   1     (484.)      (79.)          REY       74 MPWA ++ PI+ P 180 DEG CS   10/74
W         (289.)                     AYED      76 IPWA                       11/77*

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               84  N*3/2(2420) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      N*3/2(2420) INTO PI N                                139+ 938
P2      N*3/2(2420) INTO SIGMA K                            1197+ 493

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               84  N*3/2(2420) BRANCHING RATIOS

R1      N*3/2(2420) INTO (PI N)/TOTAL                     (P1)
R1  6        (0.113)                 AYED      70 IPWA                        1/71
R1  7        (.4)                    OTT       72 MPWA  0 PI-P BKWD ELSTC     2/73
R1  1        (.157)   (.070)    (.035)REY      74 MPWA ++ PI+ P 180 DEG CS   10/74
R1  1   REY 74 DETERMINES (J+1/2)X ONLY, WE HAVE DIVIDED BY 6.               10/74
R1           (.09)                   AYED      76 IPWA                       11/77*

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                         REFERENCES FOR N*3/2(2420)

AYED     70 KIEV CONF        R AYED,P BAREYRE, G VILLET          (SACL)IJP

BRANSDEN 71 NP B26 511       ,OGDEN                              (DURH)IJP
    ALSO 70 NP B16 461       ROYCHOUDHURY,PERRIN,BRANSDEN        (DURH)IJP
ROYCHOUD 71 NP B27 125       R K ROYCHOUDHURY,B H BRANSDEN       (DURH)IJP
OTT      72 PL 42B 133       +TRISCHUK,VAVRA,RICHARDS,+ (MCGI,STLO,IOWA)IJP
    ALSO 72 MCGILL THESIS    J. VAVRA                            (MCGI) JP

REY      74 PRL 32 908       REY,LENNOX,POIRIER,PRETZL       (NDAM+MPIM)IP
    ALSO 74 PRL 33 250       REY,LENNOX,POIRIER,PRETZL       (NDAM+MPIM)IP
    ALSO 75 PRD 11 1777      LENNOX,POIRIER,REY,SANDER+  (NDAM+FNAL+ANL)IP
AYED     76 CEA-N-1921       AYED (THESIS)                       (SACL)IJP

                         PAPERS NOT REFERRED TO IN DATA CARDS.

BELLAMY  67 PRL 19 476       +BUCKLEY,DOBINSON, +       (WESTFIELD,LOUC) JP

AYED     70 PL 31B 598       +BAREYRE+VILLET                     (SACLAY)

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2420 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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               69  N*3/2(2420, JP=     ) I=3/2   PRODUCTION EXPERIMENTS

               SEE THE MINI-REVIEW PRECEDING THE N AND DELTA LISTINGS
               FOR A DISCUSSION OF PRODUCTION EXPERIMENTS.

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               69  N*3/2(2420) MASS (MEV) (PROD. EXP.)

M         (2360.0)                   DIDDENS   63 CNTR    PI+ P TOTAL
M         (2520.0)   (40.0)          ALVAREZ   64 CNTR    PI PHOTOPROD        7/66
M         (2440.0)                   HOHLER    64 RVUE    DATA + DISP REL
M         (2400.0)        APPROX     WAHLIG    64 OSPK  0 PI-P CH EX
M   B     (2452.0)                   BARGER    66 RVUE    TOTAL + CH EX      11/67
M   B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
M   B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
M          2423.0     10.0           CITRON    66 CNTR    PI+ P TOTAL         7/66

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               69  N*3/2(2420) WIDTH (MEV) (PROD. EXP.)

W          (200.0)                   DIDDENS   63 CNTR
W          (245.0)                   HOHLER    64 RVUE                        7/66
W   B      (275.0)                   BARGER    66 RVUE    TOTAL + CH EX      11/67
W           310.0     20.0           CITRON    66 CNTR                        7/66

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               69  N*3/2(2420) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      N*3/2(2420) INTO PI N                                139+ 938
P2      N*3/2(2420) INTO SIGMA K                            1197+ 493
P3      N*3/2(2420) INTO N*3/2(1232) PI                     1232+ 139
P4      N*3/2(2420) INTO NEUTRON PI+ PI+                     939+ 139+ 139

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               69  N*3/2(2420) BRANCHING RATIOS (PROD. EXP.)

R1      N*3/2(2420) INTO (PI N)/TOTAL                     (P1)
R1           (0.067)       APPROX     DIDDENS   63 CNTR    ASSUMING J=11/2    7/66
R1            0.113     0.0036        CITRON    66 CNTR    ASSUMING J=11/2    7/66
R1  B        (0.12)                   BARGER    67 FIT     ASSUMING J=11/2   11/67
R1  D        (0.163)                  DIKMEN    67 FIT     ASSUMING J=11/2   11/67
R1  D   USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1           (0.06)                   KORMANYOS 67 CNTR    ASSUMING J=11/2   11/67

R2      N*3/2(2420) INTO (PI N)*(NEUTRON PI+ PI+)/(TOTAL**2)
R2                                                        (P1*P4)
R2            0.0195    0.0048        GALLOWAY  68 RVUE                       6/68

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                         REFERENCES FOR N*3/2(2420) (PROD. EXP.)

DIDDENS  63 PRL 10 262       +JENKINS, KYCIA, RILEY                (BNL) I
ALVAREZ  64 PRL 12 710       +BAR-YAM,KERN,LUCKEY,OSBORNE, +   (MIT,CEA)
HOHLER   64 PL 12 149        G HOHLER, J GIESECKE            (KARLSRUHE) I
WAHLIG   64 PRL 13 103       +MANNELLI,SODICKSON,FACKLER,WARD, +   (MIT)
BARGER   66 PR 151 1123      V BARGER, M OLSSON                   (WISC)
CITRON   66 PR 144 1101      +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I

BARGER   67 PR 155 1792      V BARGER, D CLINE                    (WISC) P
DIKMEN   67 PRL 18 798       F N DIKMEN                           (MICH)
KORMANYO 67 PR 164 1661      KORMANYOS, KRISCH, OFALLON, +    (MICH,ANL) P
GALLOWAY 68 PL 26B 334       K F GALLOWAY                      (INDIANA) I

                         PAPERS NOT REFERRED TO IN DATA CARDS.

BAACKE   67 NC 51A 761       J BAACKE, M YVERT          (KARLSRUHE,ORSAY)J-L
DOBROWOL 67 PL 24B 203       DOBROWOLSKI,GUSKOV,LIKHACHEV, +     (DUBNA) P
DOLEN    68 PR 166 1768      R DOLEN, D HORN, C SCHMID              (CIT)
WAHLIG   68 PR 168 1515      M A WAHLIG, I MANNELLI             (MIT,PISA)
    FINAL VERSION OF DATA USED IN WAHLIG 64.  IN CONJUNCTION WITH
    CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES
    COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

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Δ(2850) BUMPS

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               85  N*3/2(2850, JP=     +) I=3/2   PRODUCTION EXPERIMENTS


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               85  N*3/2(2850) MASS (MEV) (PROD. EXP.)

M         (2870.0)                   HOHLER    64 RVUE    DATA + DISP REL
M         (2700.0)        APPROX     WAHLIG    64 OSPK  0 PI-P CH EX
M         (2850.0)                   BARDADIN  66 HBC  ++ N* TO P + 3 PIS    7/66
M          2850.0     12.0           CITRON    66 CNTR    PI+ P TOTAL         7/66
M         (2883.)     (26.)     (28.)REY       74 MPWA ++ PI+ P 180 DEG CS   10/74

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               85  N*3/2(2850) WIDTH (MEV) (PROD. EXP.)

W         (150.0)                    BARDADIN  66 HBC  ++                     7/66
W          400.0      40.0           CITRON    66 CNTR                        7/66
W         (380.)     (141.)    (201.)REY       74 MPWA ++ PI+ P 180 DEG CS   10/74

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               85  N*3/2(2850) PARTIAL DECAY MODES (PROD. EXP.)

                                                              DECAY MASSES
P1      N*3/2(2850) INTO PI N                                139+ 938
P2      N*3/2(2850) INTO P PI PI PI                          938+ 139+ 139+ 139
P3      N*3/2(2850) INTO N PI PI                             938+ 139+ 139

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               85  N*3/2(2850) BRANCHING RATIOS (PROD. EXP.)

R1      N*3/2(2850) INTO (PI N)/TOTAL                     (P1)
R1     ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1  B        (0.224)  (0.016)        BARGER    66 RVUE    TOTAL + CH EXC.   11/67
R1            0.261    0.048         CITRON    66 CNTR    TOTAL CROSS.SEC.  11/67
R1  B        (0.40)                  BARGER    67 RVUE    USES KORMANYOS66  11/67
R1  B   USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
R1  B   FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  C        (0.49)                  DIKMEN    67 RVUE    USES KORMANYOS67  11/67
R1  C   USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1           (0.39)                  DOBROWOLS 67 CNTR    PI+P AT 180 DEG
R1           (0.10)                  KORMANYOS 67 CNTR    PI-P AT 180 DEG.  11/67
R1  D        (0.06) OR LESS  CL=.95  HALDORSE  72 HBC     PP  19  GEV/C     12/72
R1  D    UPPER LIMIT ON ELASTICITY.ALSO FIND J=9/2 OR MORE.
R1           (.28)     (.13)    (.19) REY      74 MPWA ++ PI+ P 180 DEG CS  10/74

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                         REFERENCES FOR N*3/2(2850) (PROD. EXP.)

HOHLER   64 PL 12 149        G HOHLER, J GIESECKE            (KARLSRUHE) I
WAHLIG   64 PRL 13 103       +MANNELLI,SODICKSON,FACKLER,WARD, +   (MIT)
BARDADIN 66 PL 21 357        BARDADIN-OTWINOWSKA,DANYSZ, +      (WARSAW)
BARGER   66 PR 151 1123      V BARGER, M OLSSON                   (WISC)
CITRON   66 PR 144 1101      +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I

BARGER   67 PR 155 1792      V BARGER, D CLINE                    (WISC) P
DIKMEN   67 PRL 18 798       F N DIKMEN                           (MICH)
DOBROWOL 67 PL 24B 203       DOBROWOLSKI,GUSKOV,LIKHACHEV, +     (DUBNA) P
KORMANYO 67 PR 164 1661      KORMANYOS, KRISCH, OFALLON, +    (MICH,ANL) P
HALDORSE 72 NC 10A 468       HALDORSEN,JACOBSEN                   (OSLO) IJ
REY      74 PRL 32 908       REY,LENNOX,POIRIER,PRETZL       (NDAM+MPIM)IP
    ALSO 74 PRL 33 250       REY,LENNOX,POIRIER,PRETZL       (NDAM+MPIM)IP
    ALSO 75 PRD 11 1777      LENNOX,POIRIER,REY,SANDER+  (NDAM+FNAL+ANL)IP

                         PAPERS NOT REFERRED TO IN DATA CARDS.

BAACKE   67 NC 51A 761       J BAACKE, M YVERT          (KARLSRUHE,ORSAY)J-L
DOLEN    68 PR 166 1768      R DOLEN, D HORN, C SCHMID              (CIT)
WAHLIG   68 PR 168 1515      M A WAHLIG, I MANNELLI             (MIT,PISA)
    FINAL VERSION OF DATA USED IN WAHLIG 64.  IN CONJUNCTION WITH
    CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES
    COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

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Data Card Listings

For notation, see key at front of Listings.

Δ(3230) BUMPS

86 N*3/2(3230, JP=) I=3/2 PRODUCTION EXPERIMENTS

86 N*3/2(3230) MASS (MEV) (PROD. EXP.)

M	(3230.0)			CITRON	66 CNTR	PI+ P TOTAL	7/66
M	(3296.)	(79.)	(78.)	REY	74 MPWA ++ PI+ P 180 DEG CS		10/74

86 N*3/2(3230) WIDTH (MEV) (PROD. EXP.)

W	(440.0)			CITRON	66 CNTR		7/66
W	(687.)	(1043.)	(323.)	REY	74 MPWA ++ PI+ P 180 DEG CS		10/74

86 N*3/2(3230) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	N*3/2(3230) INTO PI N	139+ 938
P2	N*3/2(3230) INTO N PI PI	938+ 139+ 139

86 N*3/2(3230) BRANCHING RATIOS

R1	N*3/2(3230) INTO (PI N)/TOTAL			(P1)		
R1	ONLY (J+1/2)*(PI N/TOTAL) MEASURED FOR THIS STATE					
R1	B	(0.03)	(0.01)	BARGER	66 RVUE	TOTAL + CH EXC. 11/67
R1		(0.06)		CITRON	66 CNTR	TOTAL CROS. SEC. 11/67
R1	B	(0.03) TO 0.1		BARGER	67 CNTR	USES KORMANYOS66 11/67
R1	B	USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE				
R1	B	FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.				
R1	D	(0.25)		DIKMEN	67 RVUE	USES KORMANYOS67 11/67
R1	D	USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES				
R1		(.45)	(.09)	(.13) REY	74 MPWA ++ PI+ P 180 DEG CS	10/74

REFERENCES FOR N*3/2(3230) (PROD. EXP.)

BARGER	66 PR 151 1123	V BARGER, M OLSSON	(WISC)
CITRON	66 PR 144 1101	+GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +	(BNL) I
BARGER	67 PR 155 1792	V BARGER, D CLINE	(WISC) P
DIKMEN	67 PRL 18 798	F N DIKMEN	(MICH)
REY	74 PRL 32 908	REY,LENNOX,POIRIER,PRETZL	(NDAM+MPIM)IP
ALSO	74 PRL 33 250	REY,LENNOX,POIRIER,PRETZL	(NDAM+MPIM)IP
ALSO	75 PRD 11 1777	LENNOX,POIRIER,REY,SANDER+	(NDAM+FNAL+ANL)IP

PAPERS NOT REFERRED TO IN DATA CARDS

KORMANYC	67 PR 164 1661	KORMANYOS, KRISCH, OFALLON, +	(MICH,ANL) P
DOLEN	68 PR 166 1768	R DOLEN, D HORN, C SCHMID	(CIT)

EXOTIC NUCLEONS - 1640 MEV REGION

EXOTIC NUCLEONS

THIS IS NOT A COMPLETE LIST. WE WILL TABULATE EXOTICS FROM NOW ON

EX(1640, JP=) I=5/2

THIS IS NOT A COMPLETE LIST. WE TABULATE ONLY FROM 1970 ON.

IN A MISSING MASS EXPERIMENT, PI+ P TO PI- X+++, BIRULEV 71 FIND NO EVIDENCE FOR EXOTIC (I=5/2) RESONANCES IN THE MASS INTERVAL 1.2 TO 2.2 GEV.

EX(1640) MASS (MEV)

M	A	29 1627.	12.	PRICE	70 DBC	-- K-D AT 4.91GEV/C	3/71
M	A	FOUR S. D. EFFECT					

EX(1640) WIDTH (MEV)

W	B	29	30.	OR LESS CL=.90	PRICE	70 DBC -- PI-PI-N BUMP	3/71
W	B	CROSS SECTION 13.0+-3.9 MICROBARNS					

EX(1640) CROSS SECTION LIMITS (MICROBARN)

CS	B	40.	OR LESS	BANNER	70 OSPK +++ PI+P,1.9 GEV/C	7/70
CS	B	I=5/2 LIMIT GIVEN ABOVE IS FOR MASS RANGE 1540-1750 MEV				

REFERENCES FOR EX(1640)

BANNER	70 NP B15 205	+CHEZE,HAMEL,TEIGER,ZACCONE +	(SACLAY)
PRICE	70 PL 33B,533	+BERG,SALANT,WATERS,WEBSTER,WEINBERG	(VAND)

PAPERS NOT REFERRED TO IN DATA CARDS

AMMANN	71 PL 34B 533	+CARMONY,GAREINKEL,GUTAY,MILLER,YEN	(PURD)
BIRULEV	71 SJNP 12 536	+VOVENKO,GUSKOV,DOBROVOLSKII,++	(JINR)
JOHNSON	71 PL 34B 428	D JOHNSON	(ANL)

Note on the S = +1 Baryon System

Since our 1976 edition was published, new measurements have been made of the $K^0p \to K^+n$ differential cross section (DCS) from 0.6 to 1.5 GeV/c (ARMITAGE 77), the $K^+n \to K^0p$ DCS at 700, 800, and 900 MeV/c (SAKITT 77), K^+d scattering below 600 MeV/c (GLASSER 77), and the quasi-two-body DCS's for $K^+N \to K\Delta$ and $K^+N \to K^*N$ below 1.5 GeV/c (GIACOMELLI2 76). There has been one partial-wave analysis (GIACOMELLI1 76), which searched for a Z_1^* decaying into $K\Delta$, but found no evidence for such an effect. The evidence for the existence of Z^*'s remains inconclusive. For detailed reviews see our previous edition[1] and the Oxford Conference talk of MARTIN 76.

References

1. Particle Data Group, Rev. Mod. Phys. 48, S188 (1976).

See the Data Card Listings for other references.

S=1 I=0 EXOTIC STATES (Z_0)

$Z_0(1780)$ → **P_{01}**

95 Z*0(1780, JP=1/2+) I=0

SEE THE MINI-REVIEW PRECEDING THIS LISTING.

WILSON 72 AND GIACOMELLI 74 FIND SOME SOLUTIONS WITH RESONANT-LIKE BEHAVIOR IN THE P01 PARTIAL WAVE. THE EFFECT SEEN IN THE I=0 TOTAL CROSS SECTIONS, IF A RESONANCE, MUST HAVE SPIN=1/2, BECAUSE THE INELASTIC CROSS SECTION IS VERY SMALL AND THE TOTAL CROSS SECTION IS ABOUT 4*PI/K**2.

95 Z*0(1780) MASS (MEV)

M		1780.0	10.0	COOL	70 CNTR +	K+P, D TOTAL	1/71
M	D	SEEN		DOWELL	70 CNTR	K+P,D TOTAL	7/70
M	D	SEE ALSO DISCUSSION OF LYNCH 70					7/70
M	W	(1800.)		WILSON	72 PWA	K+N P01 WAVE	3/72
M	W	ESTIMATE OF PARAMETERS FROM BW + QUADRATIC BACKGROUND FIT TO P01.					3/72
M	1	(1750.)		CARROLL	73 CNTR	KN I=0 TCS,FIT 1	9/73
M	1	(1825.)		CARROLL	73 CNTR	KN I=0 TCS,FIT 2	9/73
M	1	FIT 1=FIT OF SINGLE L=1 BW+BACKGROUND TO I=0 TCS FROM .4-1.1 GEV/C					9/73
M	1	FIT 2=FIT OF L=1 AND L=2 BWS TO SAME DATA,SEE Z0(1865) FOR L=2 PART					9/73
M		(1740.)		GIACOMEL	74 PWA	.38-1.51 GEV/C	10/74

95 Z*0(1780) WIDTH (MEV)

W		(565.0)		COOL	70 CNTR +	K+P, D TOTAL	1/71
W	W	(300.)		WILSON	72 PWA	K+N P01 WAVE	3/72
W	1	(600.)		CARROLL	73 CNTR	KN I=0 TCS,FIT 1	9/73
W	1	(845.)		CARROLL	73 CNTR	KN I=0 TCS,FIT 2	9/73
W		(300.)		GIACOMEL	74 PWA	.38-1.51 GEV/C	10/74

95 Z*0(1780) PARTIAL DECAY MODES

		DECAY MASSES
P1	Z*0(1780) INTO K N	493+ 939

95 Z*0(1780) BRANCHING RATIOS

R1	Z*0(1780) INTO (K N)/TOTAL			(P1)		
R1		(0.95)		COOL	70 CNTR +	K+P, D TOTAL	1/71
R1	W	(0.85)		WILSON	72 PWA	K+N P01 WAVE	3/72
R1	1	(.75)		CARROLL	73 CNTR	IF J=1/2,FIT 1	9/73
R1	1	(.91)		CARROLL	73 CNTR	IF J=1/2,FIT 2	9/73
R1		(.85)		GIACOMEL	74 PWA	.38-1.51 GEV/C	10/74

REFERENCES FOR Z*0(1780)

COOL 70 DUKE CONF 47 R L COOL (BNL)
ALSO 69 PL 30B 564 ABRAMS,COOL,GIACOMELLI,KYCIA,LI + (BNL)
ALSO 70 PR D1 1887 COOL,GIACOMELLI,KYCIA,LEONTIC,LI + (BNL)
DOWELL 70 DUKE 53 J.D. DOWELL (BIRM)
WILSON 72 NP B42 445 +GRIFFITHS,HIRATA + (BGNA+GLAS+ROMA+TRST)
CARROLL 73 PL 45B 531 +KYCIA,LI,MICHAEL,MOCKETT,RAHM+ (BNL)I
GIACOMEL 74 NP B71 138 GIACOMELLI,+ (BGNA+GLAS+ROMA+TRST)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

LYNCH 70 DUKE 9 G LYNCH (REVIEWER OF CR.SEC. DATA) (LRL)
HIRATA 71 NP B30 157 +GOLDHABER,HALL,SEEGER,THRILLING,WOHL (LBL)IJP
BOWEN 73 PR D7 22 +JENKINS,KALBACH,PETERSEN + (ARIZ+MICH)
JOHNSON 74 PL 50B 343 JOHNSON,VLASSOPULOS (CERN,DURH)
CAMERON 75 PALERMO CONF. +CAPILUPPI+ (BGNA+EDIN+GLAS+PISA+RHEL)IJP
BIGI 76 NP B110 25 +CAMERON+ (BGNA+EDIN+GLAS+PISA+RHEL)IJP

EXPERIMENTS MAINLY ABOUT ELASTIC CHANNELS --
GOLDHABE 62 PRL 9 135 GOLDHABER,CHINOWSKY,GOLDHABER+ (LRL+UCLA)IJP
RAY 69 PR 183 1183 RAY,BURRIS,FISK,KRAEMER,HILL+ +CARN+BNL
ARMITAGE 72 NAL PAPER 391 +ASTON,DUERDOTH,ELLISON, + (MCHS+DARE)
GIACOME1 72 NP B42 437 GIACOMELLI + (BGNA+GLAS+ROMA+TRST)
GIACOMEL 73 NP B56 346 GIACOMELLI,+ (BGNA+GLAS+ROMA+TRST)
ALSO 73 BGNA PPT. AE-73/4 GIACOMELLI,GRIFITHS,+ (BGNA+GLAS+ROMA+TRST)
LONDON 74 PRD 9 1569 LONDON (BNL)IJP
ALEXANDE 75 PL 58B 484 ALEXANDER,BAR-NIR,BENARY+ (TELA+HEID)IJP
DAMERELL 75 NP B94 374 +HOTCHKISS,WICKENS,BENTLEY+ (RHEL,BIRM)

EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS --
GIACOMEL 72 NP B37 577 GIACOMELLI + (BGNA+GLAS+ROMA+TRST)
ARMITAGE 77 NP B123 11 +ASTON,DUERDOTH,ELLISON,FITTON+ (MCHS+DARE)
GLASSER 77 PRD 15 1200 +SNOW,TREVVETT,BURNSTEIN,FU,PETRI+(UMD+IIT)
SAKITT 77 PRD 15 1846 +SKELLY,THOMPSON (BNL)

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$Z_0(1865)$ → 96 Z*0(1865, JP=3/2-) I=0 **D_{03}**

THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K* N THRESHOLD. SEE HIRATA 68 AND 70. WILSON 72 AND GIACOMELLI2 73 REPORT PARTIAL WAVE ANALYSES. AARON 73 CLAIMS A RESONANCE IN A MODEL DEPENDENT PWA. SEE ALSO Z*0(1780).

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96 Z*0(1865) MASS (MEV)

M		(1860.0)	(15.0)	CARTER	67 THEO	DISPERSION REL.	8/67
M		(1868.0)	(10.0)	COOL	70 CNTR	K+P, D TOTAL	8/67
M		(1830.)		AARON	73 MPWA	I=0 KN .6-1.6G/C	9/73
M	1	(1840.)		CARROLL	73 CNTR	KN I=0 TCS,FIT 2	9/73
M	1	FIT2=FIT OF L=1 AND L=2 BWS TO I=0 TCS FROM .4-1.1 GEV/C.					9/73
M	1	SEE Z0(1780) FOR FIT 1 AND L=1 PART OF FIT 2.					9/73

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96 Z*0(1865) WIDTH (MEV)

W		(200.0)	(50.0)	CARTER	67 THEO		8/67
W		(160.0)	(30.0)	COOL	70 CNTR		8/67
W		(100.)		AARON	73 MPWA	I=0 KN .6-1.6G/C	9/73
W	1	(75.)		CARROLL	73 CNTR	KN I=0 TCS,FIT 2	9/73

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96 Z*0(1865) PARTIAL DECAY MODES

		DECAY MASSES
P1	Z*0(1865) INTO K N	493+ 939
P2	Z*0(1865) INTO N K*(892)	938+ 892

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96 Z*0(1865) BRANCHING RATIOS

R1		Z*0(1865) INTO (K N)/TOTAL				(P1)	
R1		(.155)	(.025)	CARTER	67 THEO	IF J=3/2	9/73
R1		(.115)	(.025)	COOL	70 CNTR	IF J=3/2	9/73
R1	1	(.085)		CARROLL	73 CNTR	IF J=3/2,FIT 2	9/73
R2		Z*0(1865) INTO N K*(892)				(P2)	
R2		MAIN INELASTIC DECAY		HIRATA	68 HBC		11/68

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REFERENCES FOR Z*0(1865)

CARTER 67 PRL 18 801 A A CARTER (CAVENDISH)
HIRATA 68 PRL 21 1485 HIRATA, WOHL, GOLDHABER, TRILLING (LRL)
COOL 70 PR D1 1887 COOL,GIACOMELLI,KYCIA,LEONTIC,LI + (BNL)
ALSO 66 PRL 17 102 +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
ALSO 69 PL 30B 564 ABRAMS,COOL,GIACOMELLI,KYCIA,LI + (BNL)
AARON 73 PRD 7 1401 AARON,RICH,HOGAN,SRIVASTAVA (LASL+NEAS)IJP
CARROLL 73 PL 45B 531 +KYCIA,LI,MICHAEL,MOCKETT,RAHM+ (BNL)I

PAPERS NOT REFERRED TO IN DATA CARDS

HIRATA 70 DUKE 429 +GOLDHABER,SEEGER,TRILLING+WOHL (LRL)
AARON 71 PRL 26 407 +AMADO+SILBAR (NEAS,PENN,LASL)IJP
HIRATA-1 71 NP B33 445 +GOLDHABER,HALL,SEEGER,TRILLING,WOHL (LBL)
GIACOMEL 72 NP B37 577 GIACOMELLI + (BGNA+GLAS+ROMA+TRST)
WILSON 72 NP B42 445 +GRIFFITHS,HIRATA + (BGNA+GLAS+ROMA+TRST)

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S=1 I=1 EXOTIC STATES (Z_1)

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$Z_1(1900)$ → 97 Z*1(1900, JP=3/2+) I=1 **P_{13}**

THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K-DELTA THRESHOLD. SEE THE MINIREVIEW PRECEDING Z*0(1780)

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97 Z*1(1900) MASS (MEV)

M	1	(1932.0)		AYED	70 IPWA	P13,SOL.I	6/70
M	1	(1899.0)		AYED	70 IPWA	P13,SOL.II	6/70
M	1	(2030.0)		AYED	70 IPWA	S11,SCL.III	6/70
M	1	THREE SOLNS IN ORDER OF DECREASING SIGNIFICANCE. THOUGH AYED 70					
M	1	GIVE PARAMETERS,THEY CONCLUDE RESONANT INTERPRETATION DOUBTFUL.					
M	2	(1830.)		BARNETT	70 IPWA	P13,SOLN III	9/73
M	2	RESONANCE SIGNAL BARELY ABOVE BACKGROUND DUE TO THE LARGE ERRORS					
M	2	IN THE AMPLITUDES RESULTING FROM THE ANALYSIS					
M		1900.0	10.0	COOL	70 CNTR ++	K+P TOTAL	1/71
M		(1880.)		ALBROW	71 IPWA ++	SOL. GAMMA	10/71
M	K	(1890.)		KATO	71 IPWA	SOL I(FIT BW)	10/71
M	K	(2040.)		KATO	71 IPWA	SOL II(FIT BW)	10/71
M	K	KATO 71 ESTIMATE RESONANCE PARAMETERS -- UPDATED PHASE SHIFTS					3/72
M	K	PUBLISHED IN MILLER 72.					3/72

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97 Z*1(1900) WIDTH (MEV)

W	1	(520.0)	AYED	70 IPWA	K+P	6/70
W	1	(397.0)	AYED	70 IPWA	K+P	6/70
W	1	(557.0)	AYED	70 IPWA	K+P	6/70
W	2	(120.)	BARNETT	70 IPWA	P13,SOLN III	9/73
W		(240.0)	COOL	70 CNTR ++	K+- TOTAL	1/71
W		(190.)	ALBROW	71 IPWA ++	SOL. GAMMA	10/71
W	K	(280.)	KATO	71 IPWA	SOL I(FIT BW)	10/71
W	K	(260.)	KATO	71 IPWA	SOL II(FIT BW)	10/71

SEE THE NOTES ACCOMPANYING MASSES QUOTED.

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97 Z1*(1900) REAL PART OF POLE POSITION 4/75

REE	(1787.)	ARNDT	74 DPWA	K+ P ELASTIC	4/75

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97 Z1*(1900) IMAGINARY PART OF POLE POSITION 4/75

IME	(100.)	ARNDT	74 DPWA	K+ P ELASTIC	4/75

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97 Z*1(1900) PARTIAL DECAY MODES

		DECAY MASSES
P1	Z*1(1900) INTO K N	493+ 938
P2	Z*1(1900) INTO N*3/2(1232) K	1232+ 493

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97 Z*1(1900) BRANCHING RATIOS

R1		Z*1(1900) INTO (K N)/TOTAL			(P1)	
R1		(0.10) OR LESS	CARTER	67 THEO	DISPERSION REL.	8/67
R1	1	(0.16)	AYED	70 IPWA		6/70
R1	1	(0.20)	AYED	70 IPWA		6/70
R1	1	(0.17)	AYED	70 IPWA		6/70
R1	2	(.12)	BARNETT	70 IPWA	P13,SOLN III	9/73
R1		(0.12) (ASSUMING J=3/2)	COOL	70 CNTR ++	K+P TOTAL	1/71
R1		(0.15)	ALBROW	71 IPWA ++	SOL. GAMMA	10/71
R1	K	(0.22)	KATO	71 IPWA	SOL I(FIT BW)	10/71
R1	K	(0.27)	KATO	71 IPWA	SOL II(FIT BW)	10/71

SEE NOTES ACCOMPANYING THE MASSES QUOTED.

R2		Z*1(1900) INTO K N*3/2(1232)			(P2)	
R2		MAIN INELASTIC DECAY	BLAND	67 HBC ++		8/67
R2		NO EVIDENCE, SPEED HAS MINIM.	GRIFFITHS	72 HBC	K+P .9-1.5 GEV/C	3/72

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REFERENCES FOR Z*1(1900)

BLAND 67 PRL 18 1077 +BOWLER,BROWN,G+S GOLDHABER,SEEGER,+ (LRL)
CARTER 67 PRL 18 801 A A CARTER (CAVENDISH)

AYED 70 PL 32B 404 +BAREYRE, FELTESSE, VILLET (SACLAY)IJP
BARNETT 70 U MD,RPT 70-101 BARNETT,GOLDMAN,LAASANEN,STEINBERG (UMD)IJP
ALSO 70 DUKE 443 BARNETT,GOLDMAN,LAASANEN,STEINBERG (UMD)IJP
COOL 70 PR D1 1887 +GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I
ALSO 66 PRL 17 102 COOL,GIACOMELLI,KYCIA,LEONTIC,LI + (BNL)

ALBROW 71 NP B30 273 +ANDERSON,ALMEHED,....,UDO,WAGNER (CERN)IJP
ALSO 70 DUKE 375 ERNE,SENS,WAGNER (CERN)IJP
KATO 71 H.E.PHEN.,MORIOND +KOEHLER,....,YOKOSAWA+BURLESON (ANL,NWES)IJP
ALSO 70 DUKE 367 A. YOKOSAWA (ANL)IJP
ALSO 70 PRL 24 615 KATO,KOEHLER,NOVEY,YOKOSAWA+ (ANL,NWES)IJP

GRIFFITH 72 NP B38 365 +HIRATA,HUGHES + (BGNA+GLAS+ROMA+TRST)
MILLER 72 NP B37 401 +NOVEY,YOKOSAWA,CUTKOSKY + (ANL+CARN+NWES)IJP

ARNDT 74 PRL 33 987 ARNDT,HACKMAN,ROPER,STEINBERG (VPI,UMD)IJP

Data Card Listings

For notation, see key at front of Listings.


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                    PAPERS NOT REFFERED TO IN Z*1 DATA CARDS

     TOTAL-CROSS-SECTION EXPERIMENTS ---
BUGG     68 PR 168 1466      +GILMORE,KNIGHT, +          (RHEL,BIRM,CAVE) I
BOWEN    70 PR D2 2599       +CALDWELL, DEKMEN, JENKINS, KALBACH,+(ARIZ) I
BOWEN    73 PR D7 22         +JENKINS,KALBACH,PETERSEN +      (ARIZ+MICH)
CARROLL  73 PL 458 531       +KYCIA,LI,MICHAEL,MOCKETT,RAHM+        (BNL)

     A K-MATRIX ANALYSIS OF SOME OF THE EARLY K+P DATA ---
HITE     67 THESIS           G E HITE                          (ILLINOIS)

     THEORETICAL AND MODEL DEPENDENT ANALYSES
CARRERAS 70 NP B19 349       B CARRERAS, A DONNACHIE   (DARESBURY, MCHS)
ALCOCK   73 NP B56 301       ALCOCK,COTTINGHAM                  (BRIS)IJP
ALCOCK   76 NP B102 173      ALCOCK,COTTINGHAM,DAVIS            (BRIS)IJP

     EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS ---
BLAND    68 UCRL-18131 THESIS R W BLAND                          (LRL)
BLAND    69 NP B13 595       +BOWLER, BROWN, KADYK, GOLDHABER, +    (LRL)
BLAND    70 NP B18 537       +BOWLER, BROWN, GOLDHABER,             (LRL)
   BLAND 69 AND BLAND 70 REPLACE BLAND 67 AND BLAND 68.
HIRATA-1 71 NP B33 445       +GOLDHABER,HALL,SEEGER,TRILLING,WOHL   (LBL)
BRUNET   72 NP B37 114       BRUNET,NARJOUX,DANYSZ+(CDEF+SACL+LOIC+LOWC)
GRIFFITH 72 NP B38 365       +HIRATA,HUGHES,JACOBS+(BGNA,GLAS,ROMA,TRST)IJP
LOKEN    72 PR D6 2346       +BARISH,GOMEZ,DAVIES,SCHLEIN,+    (CIT,UCLA)
BERTHON  73 NP B63 54        BERTHON,MONTANET,PAUL,SAETRE+     (CERN+SACL)
LEWIS    73 NP B60 283       LEWIS,ALLEN,JACOBS,DANYSZ+ (LOWC+LOIC+CDEF)
LESQUOY  75 NP B99 346       +MULLER,TRIANTIS,BERTHON+         (SACL+CERN)IJP
MUSGRAVE 75 NP B87 365       +PEETERS,SCREINER,WHITMORE,YUTA        (ANL)
GIACOM-2 76 NP B111 365      GIACOMELLI+MANDRIOLI+ (BGNA+GLAS+ROMA+TRST)
ARMITAGE 77 NP B123 11       +ASTON,DUERDOTH,ELLISON,FITTON+ (MCHS+DARE)
GLASSER  77 PRD 15 1200      +SNOW,TREVVETT,BURNSTEIN,FU,PETRI+(UMD+IIT)
SAKITT   77 PRD 15 1846      +SKELLY,THOMPSON                       (BNL)

     THE MAIN ELASTIC SCATTERING AND POLARIZATION EXPERIMENTS --
CARROLL  68 PRL 21 1282      +FISCHER, LUNDBY, PHILLIPS, +     (BNL,ROCH)
ANDERS-1 69 PL 28B 611       ANDERSSON, DAUM, ERNE, LAGNAUX, +      (CERN)
ANDERS-2 69 PL 30B 56        ANDERSSON, DAUM, ERNE, LAGNAUX, +      (CERN)
ASBURY   69 PRL 23 194       +DOWELL, KATO, LUNDQUIST, NOVEY, +(ANL,UMD)
BLAND    69 PL 29B 618       R W BLAND, G GOLDHABER, G H TRILLING   (LRL)
BARBER   70 PL 32B 214       +BROOME, DUFF, HEYMANN, IMRIE,+ (LOUC,RHEL)IJP
GIACOMEL 70 NP B20 301       GIACOMELLI, GRIFFITHS,(BGNA,GLAS,ROMA,TRST)IJP
HALL     70 DUKE    435      +BLAND,GOLDHABER,TRILLING              (LRL)
REBKA    70 PRL 24 160       +ROTHBERG, ETKINS, GLODIS, +           (YALE)IJP
ADAMS    71 PR D4 2637       +DAVIES,DOWELL,GRAYER,HATTERS+  (BIRM+RHEL)
BARNETT  71 PL 34B 655       +LAASANEN,STEINBERG  +  (UMD+ANL+NWES+FNAL)
EHRLICH  71 PRL 26 925       +ETKIN,GLODIS,HUGHES,KONDO,LU,MORI+  (YALE)
WHITMORE 71 PR D3 1092       +ABRAMS,EISENSTEIN,KIM,CHALLORAN,+     (ILL)
ADAMS    72  NAL PAPER 326   +COX,DAVIES,DOWELL,GRAYER +      (BIRM+RHEL)
CHARLES  72 PL 40B 289       +COWAN,EDWARDS,GIBSON,+     (BRIS,RHEL,SHMP)
   ALSO  72  NAL PAPER 287   CHARLES,COWAN,EDWARDS +     (BRIS+RHEL+SHMP)
DANYSZ   72 NP B42 29        +PENNEY,STEWART,THOMPSON,+ (LOIC,CDEF,LOWC)
ADAMS    73 NP B66 36        ADAMS,COX,DAVIES,DOWELL,+       (BIRM+RHEL)IJP
BARBER   73 NP B61 125       BARBER,BROOME,BUSZA,DAVIES,DUFF+(LOUC+RHEL)
BARNETT  73 PRD 8 2751       BARNETT,LAASANEN+          (UMD+ANL+NWES+FNAL)
CHARLES  73 PURDUE CONF. 179 CHARLES,EDWARDS,+          (SHMP+AARH+RHEL+BRIS)
CAMERON  74 NP B78 93        CAMERON,HIRATA,JENNINGS,+   (GLAS,BGNA,TRST)IJP
YUTA     74 NP B81 189       YUTA,BOCK,MUSGRAVE,PEETERS,SCHREINER,+(ANL)I
ABE      75 PRD 11 1719      +BARNETT,GOLDMAN,LAASANEN+         (UNL,ANL)
ADAMS    75 NP B87 41        +CARTER,COOK,GLASS,GREEN               (WASH)
PATTON   75 PRL 34 975       +BARLETTA,EHRLICH,ETKIN+     (YALE,TOKY,BNL)

     PARTIAL-WAVE ANALYSES (SEE ALSO ADAMS 73 AND CAMERON 74)
CARRERA1 70 NP B23 525       B CARRERAS, A DONNACHIE                (DARE)IJP
   ALSO  70 DUKE 447         +DONNACHIE,KIRSOPP          (DARE+MCHS+EDIN)
ERNE     70 DUKE 375         +SENS,WAGNER                           (CERN)IJP
LEA      71 NP  B26 413      +MARTIN,THOMPSON                (RHEL,LOUC)IJP
LOVELACE 71 NP  B28 141      +WAGNER                                (CERN)IJP
CUTKOSKY 72  NAL PAPER 210   +HICKS,KELLY,SHIH,JOHNSON     (CARN+ILL+ANL)
EHRLICH  72  NAL PAPER 447   +ETKIN,GLODIS,HUGHES,LU,PATTON +       (YALE)
MARTIN   72  PREPRINT        B.R.MARTIN, C.E.MILLER                 (LOUC)
MARTIN   75 NP B94 413       B R MARTIN                             (LOUC)
CUTKOSKY 76 NP B102 139      CUTKOSKY,HICKS,KELLY,+        (CARN+IIT+ANL)IJP
GIACOM-1 76 NP B110 67       GIACOMELLI+MANDRIOLI             (BGNA+GLAS)IJP

     EARLIER ANALYSES THAT DO NOT INCLUDE RECENT POLARIZATION DATA --
LEA      68 PR 165 1770      LEA, MARTIN, OADES             (RHEL,BNL,CERN)
MARTIN   68 PRL 21 1286      B R MARTIN                             (BNL)
CUTKOSKY 70 PR D1 2547       R E CUTKOSKY, B B DEO      (CARNEGIE-MELLON) I

     LATEST REVIEW TALKS AND PAPERS
LEVISETT 69 LUND CONF 341    R LEVI SETTI  (RAPPORTEUR)          (CHICAGO)
GOLDHABE 70 DUKE   407       G.GOLDHABER (REVIEWER)                 (LRL)
DOWELL   72  NAL REVIEW      REVIEW TALK IN BARYON SESSION          (BIRM)
LOVELACE 72  NAL REVIEW      RAPPORTEUR'S TALK                      (RUTG)
DOWELL   73 PURDUE CONF. 157 DOWELL                                 (BIRM)
CUTKOSKY 74 LONDON CONF II-54 CUTKOSKY                              (CARN)
KELLY    75 ANL-HEP-CP-75-58 REVIEW TALK IN BARYON SESSION          (LBL)
URBAN    75 PL 60B 77        URBAN                                  (LBL)
MARTIN   76 OXFORD CONF. 409 RAPPORTEUR'S TALK                      (LOUC)

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$Z_1(2150)$ BUMPS →

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93  Z*1(2150, JP=    ) I=1

A SMALL BUMP IN TOTAL CROSS SECTION AT
PK=1.8 GEV/C

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                    93  Z*1(2150) MASS (MEV)

M          2150.      20.             ABRAMS    70 CNTR ++ K+P TOTAL        10/71
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                    93  Z*1(2150) WIDTH (MEV)

W          (175.)                     ABRAMS    70 CNTR +  K+P TOTAL        10/71
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                    93  Z*1(2150) PARTIAL DECAY MODES

                                                                DECAY MASSES
P1     Z*1(2150) INTO K N                                       493+ 938
------ --------- --------- --------- --------- --------- --------- --------

                    93  Z*1(2150) BRANCHING RATIOS

R1     Z*1(2150) INTO (K N)/TOTAL                        (P1)
R1      J IS NOT KNOWN, THE FOLLOWING IS (J+1/2)*P1
R1          (0.04)                 ABRAMS    70 CNTR +  K+P TOTAL        10/71

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                          REFERENCES FOR Z*1(2150)

ABRAMS   70 PR  D1 1917      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI +    (BNL)
   ALSO 67 PRL 19 257        ABRAMS,COOL,GIACOMELLI,KYCIA,LEONTIC+ (BNL)

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$Z_1(2500)$ BUMPS →

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94  Z*1(2500, JP=    ) I=1

A SMALL BUMP IN TOTAL CROSS SECTION AT
PK=2.7 GEV/C

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                    94  Z*1(2500) MASS (MEV)

M          2500.      20.             ABRAMS    70 CNTR ++ K+P TOTAL        10/71
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                    94  Z*1(2500) WIDTH (MEV)

W          (160.)                     ABRAMS    70 CNTR ++ K+P TOTAL        10/71
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                    94  Z*1(2500) PARTIAL DECAY MODES

                                                                DECAY MASSES
P1     Z*1(2500) INTO K N                                       493+ 938
------ --------- --------- --------- --------- --------- --------- --------

                    94  Z*1(2500) BRANCHING RATIOS

R1     Z*1(2500) INTO (K N)/TOTAL                        (P1)
R1      J IS NOT KNOWN, THE FOLLOWING IS (J+1/2)*P1
R1          (0.03)                 ABRAMS    70 CNTR ++ K+P TOTAL        10/71

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                          REFERENCES FOR Z*1(2500)

ABRAMS   70 PR  D1 1917      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI +    (BNL)
   ALSO 67 PRL 19 257        ABRAMS,COOL,GIACOMELLI,KYCIA,LEONTIC+ (BNL)

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Z_1 CROSS SECTION LIMITS

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                    3  Z*1 CROSS SECTION LIMITS

      SEE MINIREVIEW PRECEDING Z*0

CS  UNITS MICROBARNS
CS          LESS THAN  50.          BASSOMPIE 68 HBC     K+P TO Z*+ PI+   10/69
CS  A LESS THAN .2     +.3    -.1   ANDERSON  69 ASPK +  PI-P TO K-Z*+    10/69
CS  A       ABOVE LIMIT FOR  M=1.2 TO 1.4 GEV -  CL= 99 P.C.
CS  B LESS THAN 1.4    +1.9   -.5   ANDERSON  69 ASPK +  PI-P TO K-Z*+    10/69
CS  B       ABOVE LIMIT FOR  M=1.5 TO 2.5 GEV

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                    REFERENCES FOR Z*1 CROSS SECTION LIMITS

BASSOMPI 68 PL 27B 468       BASSOMPIERRE, +            (CERN,BRUXELLES)
ANDERSON 69 PL 29B 136       +BLESER, BLIEDEN, COLLINS, + (BNL,CARNEGIE)

                    PAPERS NOT REFERRED TO IN DATA CARDS

TYSON    67 PRL 19 255       +GREENBERG,HUGHES,LU,MINEHART,MORI,  (YALE)
MORI     68 PL 28B 152       +GREENBERG,HUGHES,LU,ROTHBERG, +     (YALE)
MORI     69 PR 185 1687      +GREENBERG, HUGHES, LU, MINEHART, +  (YALE)
     MORI 69 REPLACES TYSON 67 AND MORI 68.

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Note on Λ's and Σ's

The number of confirmed resonances has increased slowly but steadily in the last few years, and since our last edition (1976) we have added three more states to the Y^* portion of the Baryon Table. There remains, however, a large number of proposed, but unconfirmed, resonances, and some of the states we enter in the Data Card Listings may really be more than one resonance.

All the recently proposed Y^*'s are only weakly coupled to their two-body decay channels $\bar{K}N$, $\Lambda\pi$,

and $\Sigma\pi$. For this reason they appear as very small peaks or make no appearance at all in invariant mass distributions. Rather, when the two-body reactions $\bar{K}N \to \bar{K}N$, $\bar{K}N \to \Lambda\pi$, and $\bar{K}N \to \Sigma\pi$ are partial-wave analyzed, some of the amplitudes are found to traverse resonance-like counterclockwise circles. The results of partial-wave analysis give J^P information, whereas a peak seen in an invariant mass distribution or a total cross section often cannot be analyzed for its quantum numbers. We will keep information coming from formation experiments and from production experiments separate whenever necessary.

Formation Experiments

Partial-wave analyses have been performed mainly for the channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$; a few results exist also for ΞK, $\Lambda\omega$, and some quasi-two-body channels. With a few exceptions (e.g., BAILLON 75 and VANHORN 75 for the $\Lambda\pi$ channel), the great majority of the analyses done so far cover rather narrow energy ranges, usually corresponding to a single bubble chamber experiment. A disturbing feature that appears when examining the partial waves obtained in such analyses is that they do not always join smoothly with the partial waves given in analyses done for the same channel over a different energy range.

More ambitious analyses treat all channels simultaneously so that unitarity constraints are automatically obeyed and the resonances appear with the same masses and widths in the different channels. The multi-channel analyses done prior to 1974 (KIM 71, LANGBEIN 72, and LEA 73) included the three two-body channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$, and were carried out in the mass range 1.5 to 1.9 GeV. This is the mass range of a particular bubble chamber experiment (ARMENTEROS 68), the only one which at that time had relatively good statistical accuracy.

In recent years, additional experimental results have been obtained. Bubble chamber experiments now exist with better statistics in the mass range already considered (HEMINGWAY 75, RLIC 77) and with somewhat lower statistical accuracy up to a mass of 2.5 GeV (BELLEFON1 75, 2 75, 77, and 78). However, the most important recent contributions to this field, for the $\bar{K}N$ channel at least, are from electronic counter experiments. These provide results which are difficult if not impossible to get in a conventional bubble chamber experiment. They include high-statistics measurement of the $K^-p \to \bar{K}^0n$ total[1] and differential cross section[2] at low energies, K^-p elastic polarization measurements,[3] and K^-n elastic angular distributions (DECLAIS 77 and Ref. 4).

We may expect that improved partial-wave analyses over a wide energy range will be performed in the near future in order to disentangle the rather unsatisfactory present situation. Even though the unconfirmed resonances (one- and two-star states in Table 1) are often "seen" in several analyses with more or less compatible parameters, the corresponding partial-wave behavior is often very different in each of these analyses. Thus the confidence one has in the existence of these resonances is rather weak.

Three analyses published in final form since the previous edition of this Review are discussed below. Two of them are multi-channel analyses, fitting data from the three channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$, and covering a wide mass range.

a) In the recent analysis of the Rutherford Laboratory-Imperial College collaboration (RLIC 77) the mass range extends from 1480 to 2170 MeV. The data used have been carefully selected in order to eliminate inconsistencies (usually the older and statistically less accurate points have been rejected). Angular distributions were directly used in the fit except when the quality of the data was such that no loss of information occurred by using Legendre coefficients (e.g., $K^-p \to \Sigma^0\pi^0$). In this work, a conventional energy-dependent analysis is performed first for each of the three channels ($\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$). As usual, the presence of a resonance in a partial wave is detected by comparing the goodness of the fit when this wave is parametrized as a smooth background to the alternative fit when a Breit-Wigner is added to the background. The 3 separate fits are then considered together in order to obtain a real multi-channel analysis. Internal consistency requires that the masses and widths of the resonances be the same in each of the 3 channels. The final fit has been

done with these resonance parameters fixed and equal to a "weighted average" of the three values.

Some suspected resonances are confirmed by this analysis, but many other reported "resonance effects" are not found and new possible resonances are proposed. The situation in particular for the low partial waves and for low energy is still very confused.

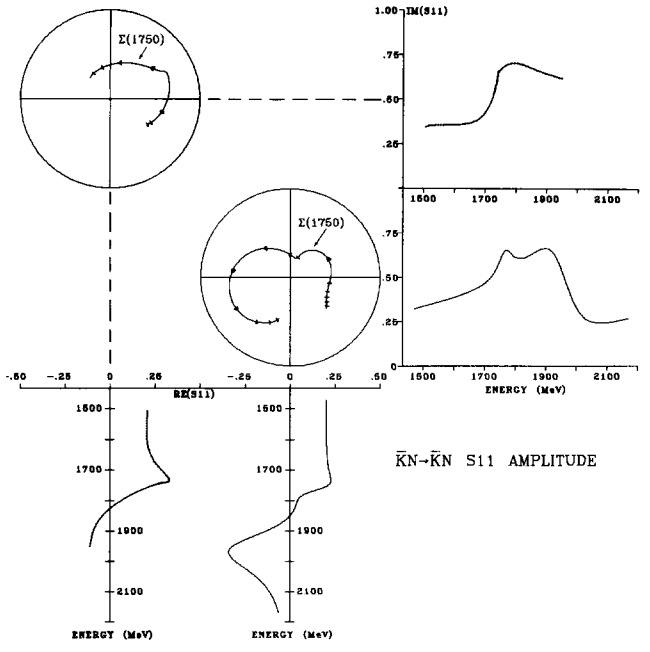
b) The analysis of B. Martin and M. Pidcock (MARTIN 77) is a multi-channel energy-dependent partial-wave analysis with parametrized K-matrix elements. The mass range covered is 1.54 to ~2 GeV. Here the 3 channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$ are always considered simultaneously, a fictitious channel being introduced to account for the global effect of the remaining final states. The $\Lambda\eta$ and $\Sigma\eta$ channels have thresholds within the above mass range and they may induce a "cusp effect". In order not to exclude such a possibility, an additional channel, opening up at the right energy, is also included for the S waves. (It is known that the inelasticities in the S waves are largely due to the production of the η meson, and a similar effect is seen in S-wave πN elastic scattering.) These additional channels, for which no data are fitted, have large cross sections, so it is not clear if such a multi-channel analysis really imposes more stringent unitarity constraints than those already contained in single-channel fits. For this analysis also, a careful selection of the available data has been made. The number of data points which have been fitted amounts to about 12,000. Some of the experimental points have been renormalized in order to suppress unphysical discontinuities in the data. The various channels or types of data may have very different numbers of data points; it would be possible to have a good overall χ^2 with some pieces of data being badly fitted. This was prevented by introducing weights for the various types of data so that each type is reasonably well fitted.

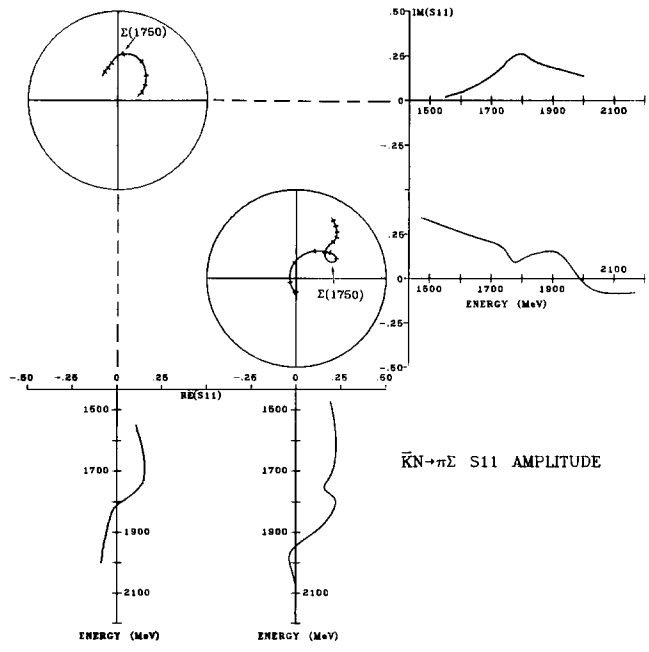
Resonances can appear as poles of the K-matrix, but the K-matrix parameters thus deduced are difficult to compare to those obtained in the more conventional analyses. Two other methods in which the resonance parameters are calculated from the poles of the T-matrix are also given. We list the results of these two methods in the Data Card Listings. It should be noted that no claim for uniqueness of the proposed solution is made; in fact, another solution with almost the same χ^2/N was presented at the Oxford Conference.[5] This latter solution has not been retained as it was not in agreement with present ideas about the low energy behavior of some waves.

c) The single-channel $\bar{K}N$ analysis of ALSTON 78 is worth mentioning because it includes a large amount of new data[1-3] not previously used by other analyses. A preliminary version of this work has already been published.[1] It is a conventional energy-dependent analysis, covering the mass range 1.5 to 1.94 GeV, which uses a unitary background parametrization expressed in terms of scattering lengths. The cusp effects observed at the $\Lambda\eta$ and $\Sigma\eta$ thresholds are included by the introduction of a square-root singularity in the energy variation of the S-wave resonance widths. All the confirmed states are observed, but most of the less well established resonances (one and two stars in Table I) are neither observed nor required.

d) Other analyses: Preliminary results of a $\bar{K}N$ single-channel analysis by Hansen *et al.*[6] have been reported. They incorporate more theoretical ingredients than any of the analyses done so far. We have not yet included these results in the Listings. In this energy-independent analysis, invariant amplitudes at fixed t are used as supplementary constraints in the fit. These fixed-t amplitudes themselves are computed using dispersion relations for which not only experimental data but also a first estimate of the partial waves is needed. The method requires that the process of estimating the fixed-t amplitudes and then the partial-wave amplitudes be iterated a few times until full consistency is obtained. This kind of analysis may eventually provide us with more reliable partial-wave amplitudes which satisfy fixed-t analyticity and crossing.

In the Listings, the resonance parameters obtained in the latest single-channel analyses are given. These usually cover a limited mass range, but include new data not yet incorporated in the





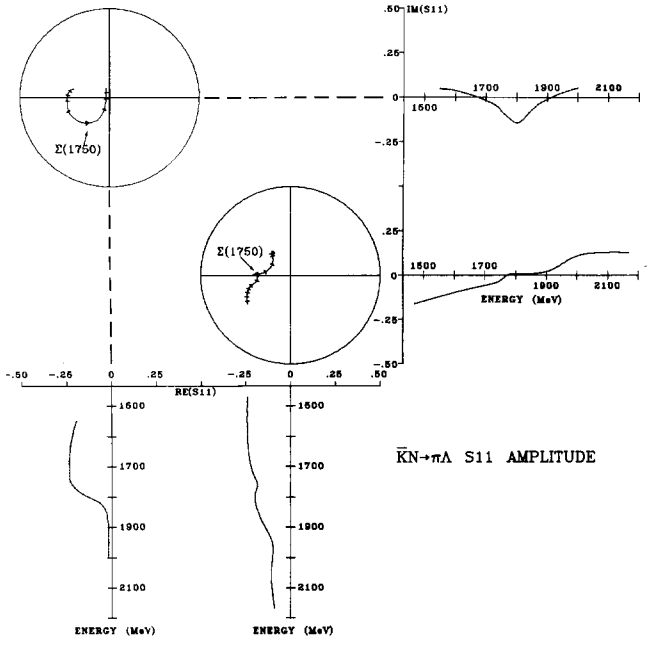
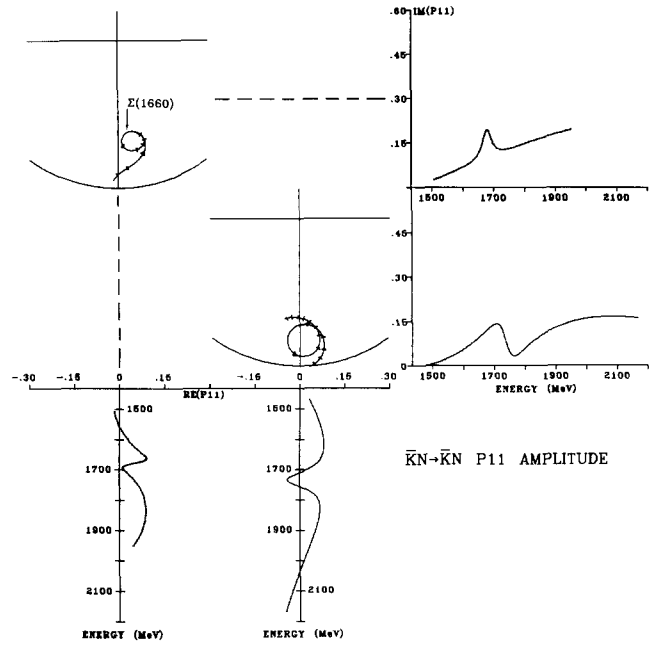
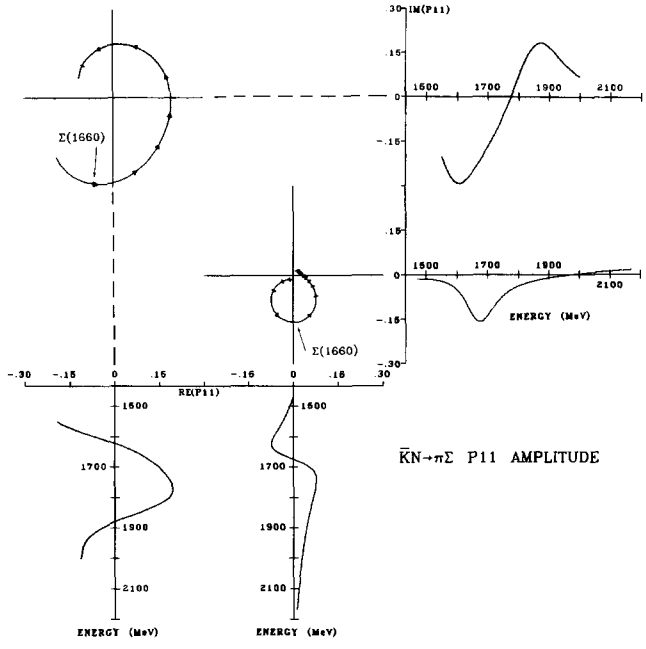


Fig. 1. Amplitudes for $\bar{K}N$ scattering in the S_{11} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the Σ(1750), is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.





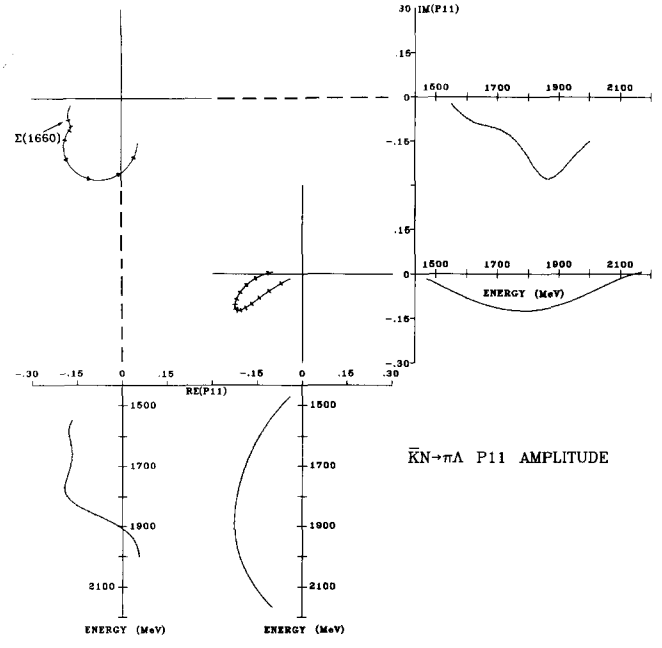
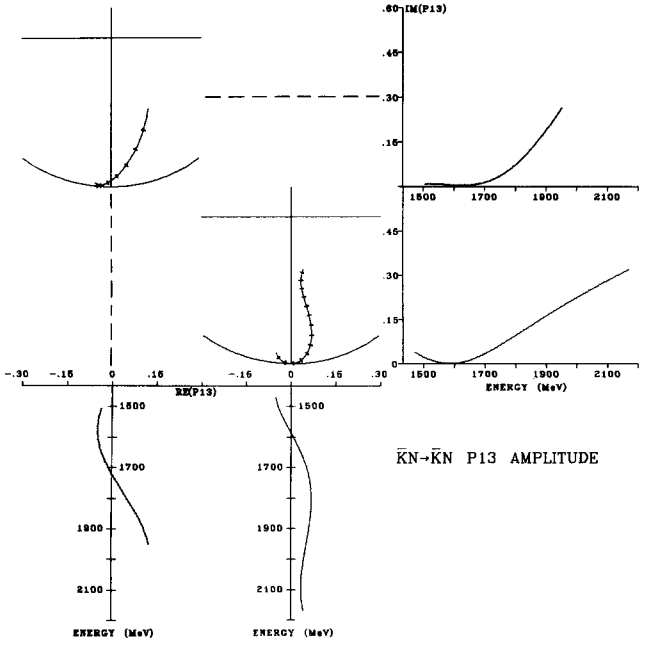
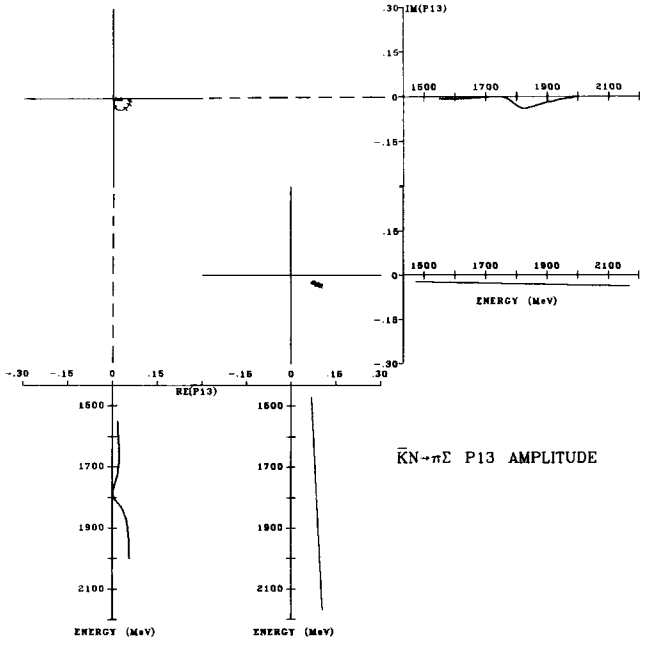


Fig. 2. Amplitudes for $\bar{K}N$ scattering in the P_{11} partial wave. The energy dependence for each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the $\Sigma(1660)$, is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.





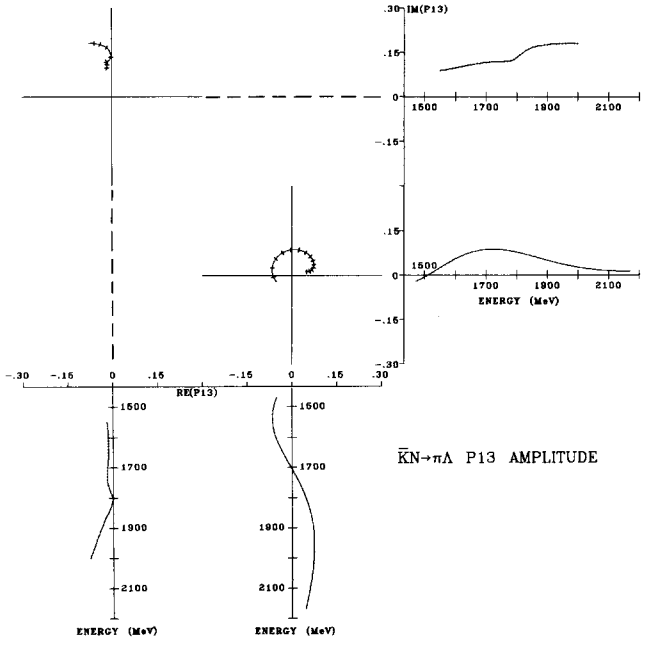
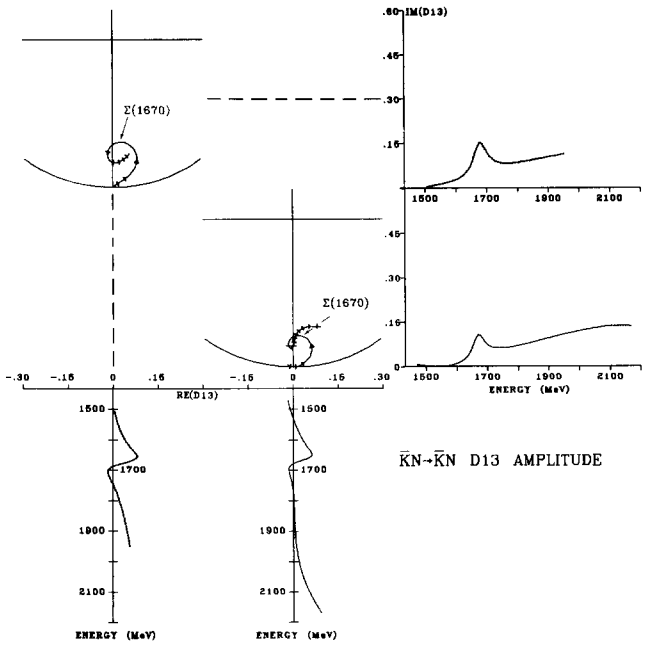
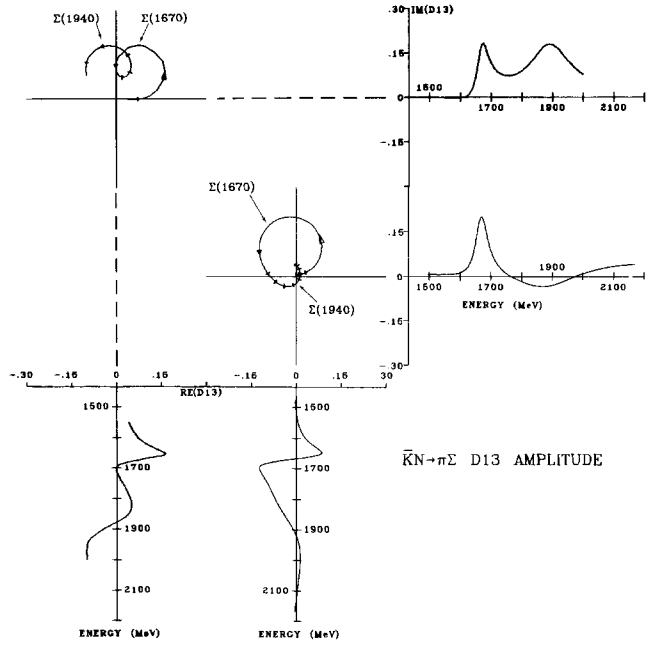


Fig. 3. Amplitudes for $\bar{K}N$ scattering in the P_{13} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots. The only established resonance in this wave, the Σ(1385), lies below elastic threshold and is not shown. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.





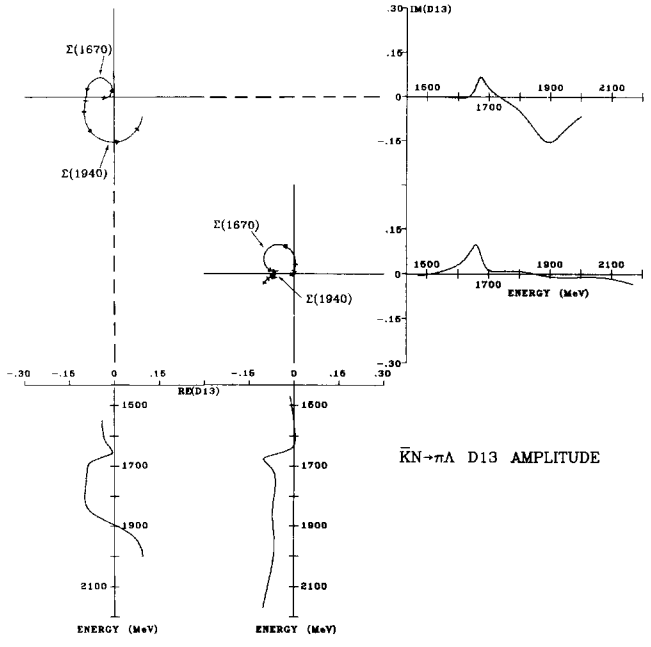
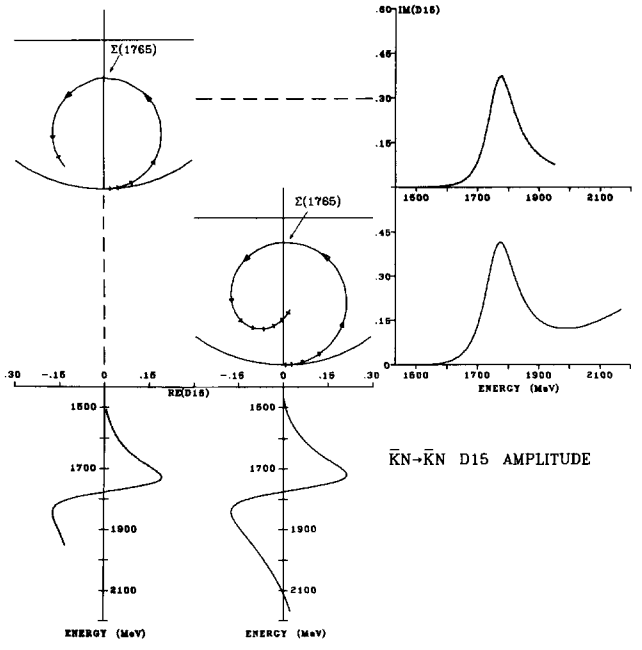
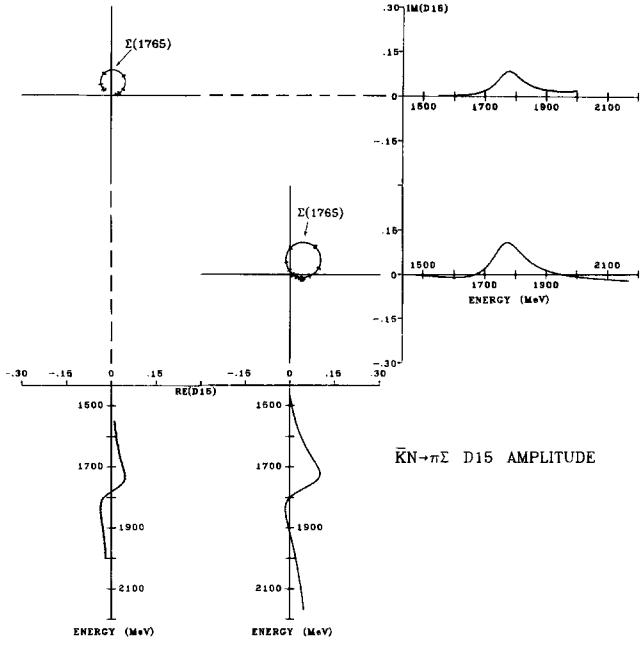


Fig. 4. Amplitudes for $\bar{K}N$ scattering in the D_{13} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonances in this wave, the Σ(1670) and the Σ(1940), are indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.





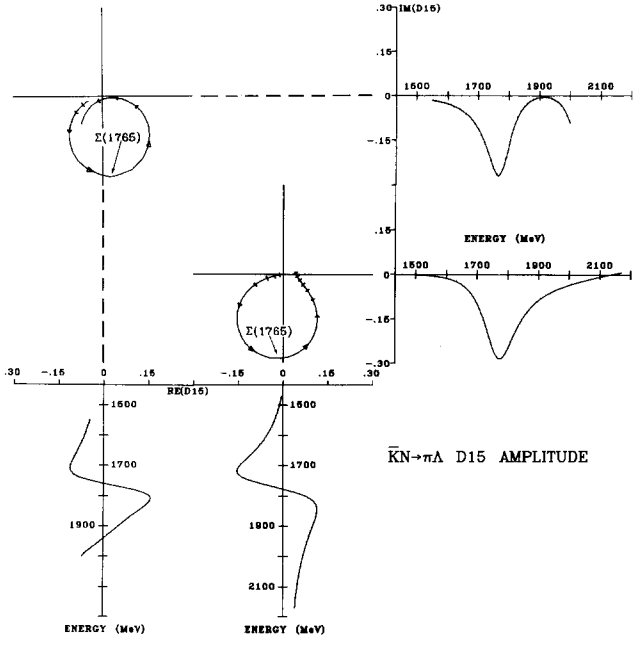
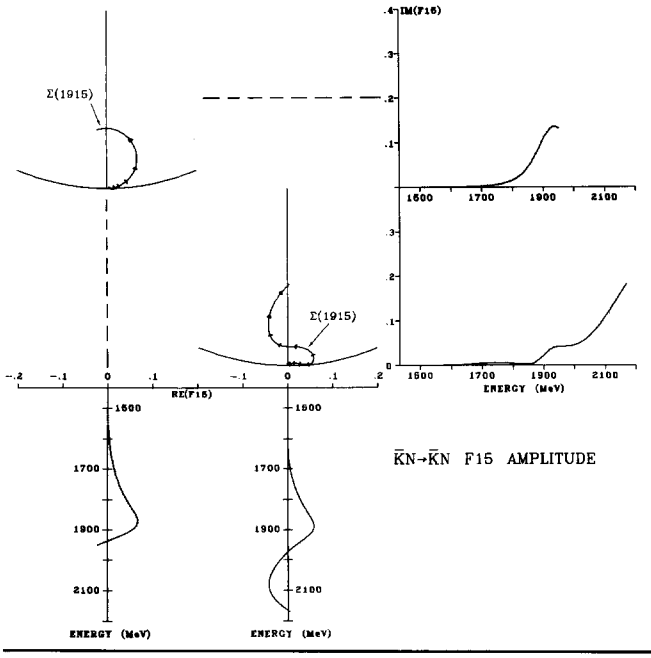
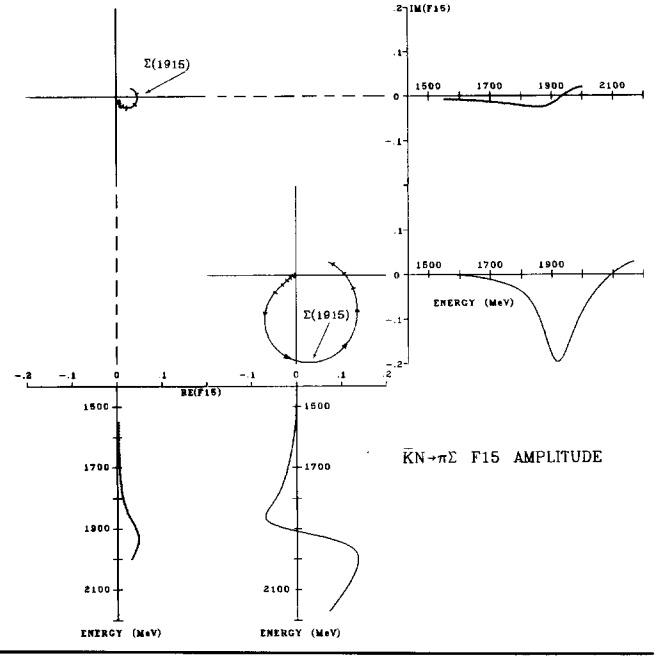


Fig. 5. Amplitudes for $\bar{K}N$ scattering in the D_{15} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the Σ(1765), is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.





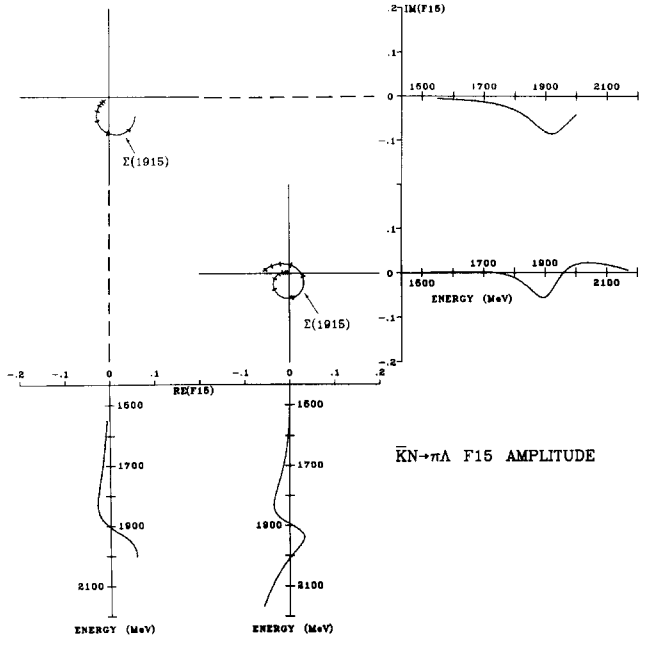
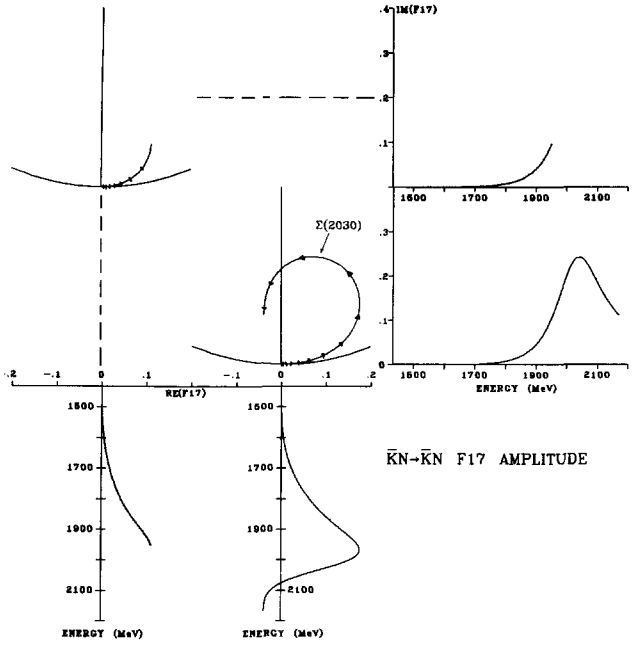
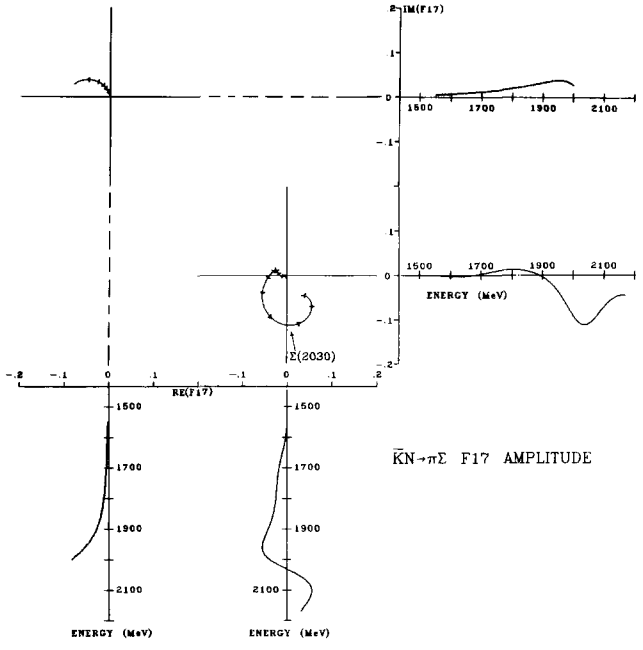


Fig. 6. Amplitudes for $\bar{K}N$ scattering in the F_{15} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the Σ(1915), is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.





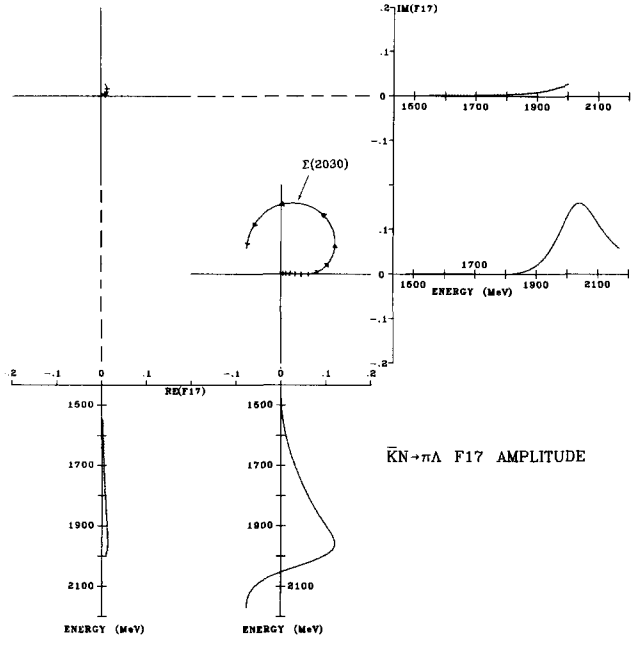


Fig. 7. Amplitudes for $\bar{K}N$ scattering in the F_{17} partial wave. The energy dependence for each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the only established resonance in this wave, the Σ(2030), is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the inelastic channels.

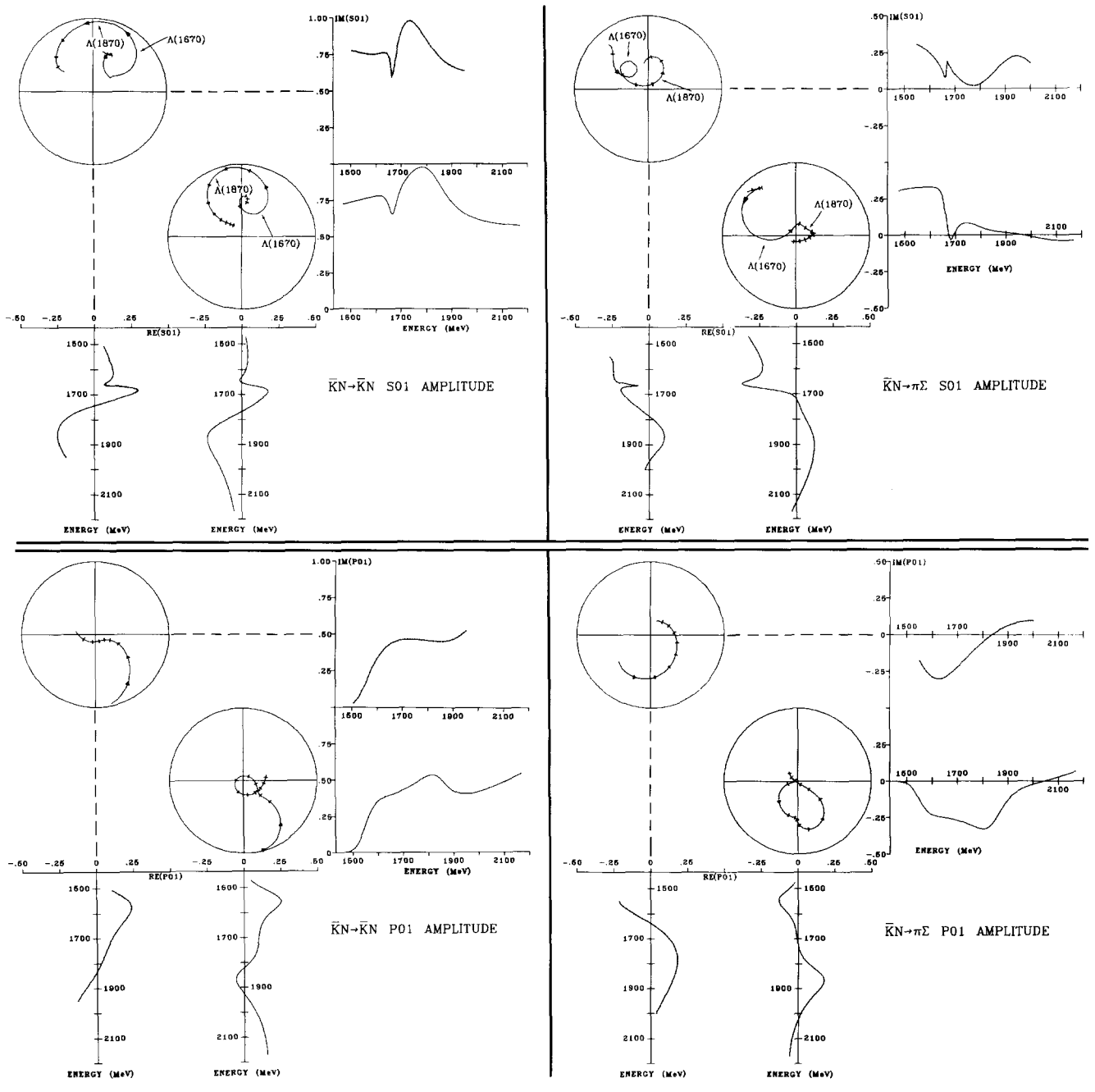


Fig. 8. Amplitudes for $\bar{K}N$ scattering in the S_{01} and P_{01} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonances Λ(1670) and Λ(1870) are indicated. The only other established resonance in these waves is the Λ(1405), which lies below elastic threshold in the S_{01} wave and is not shown. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the πΣ channel.

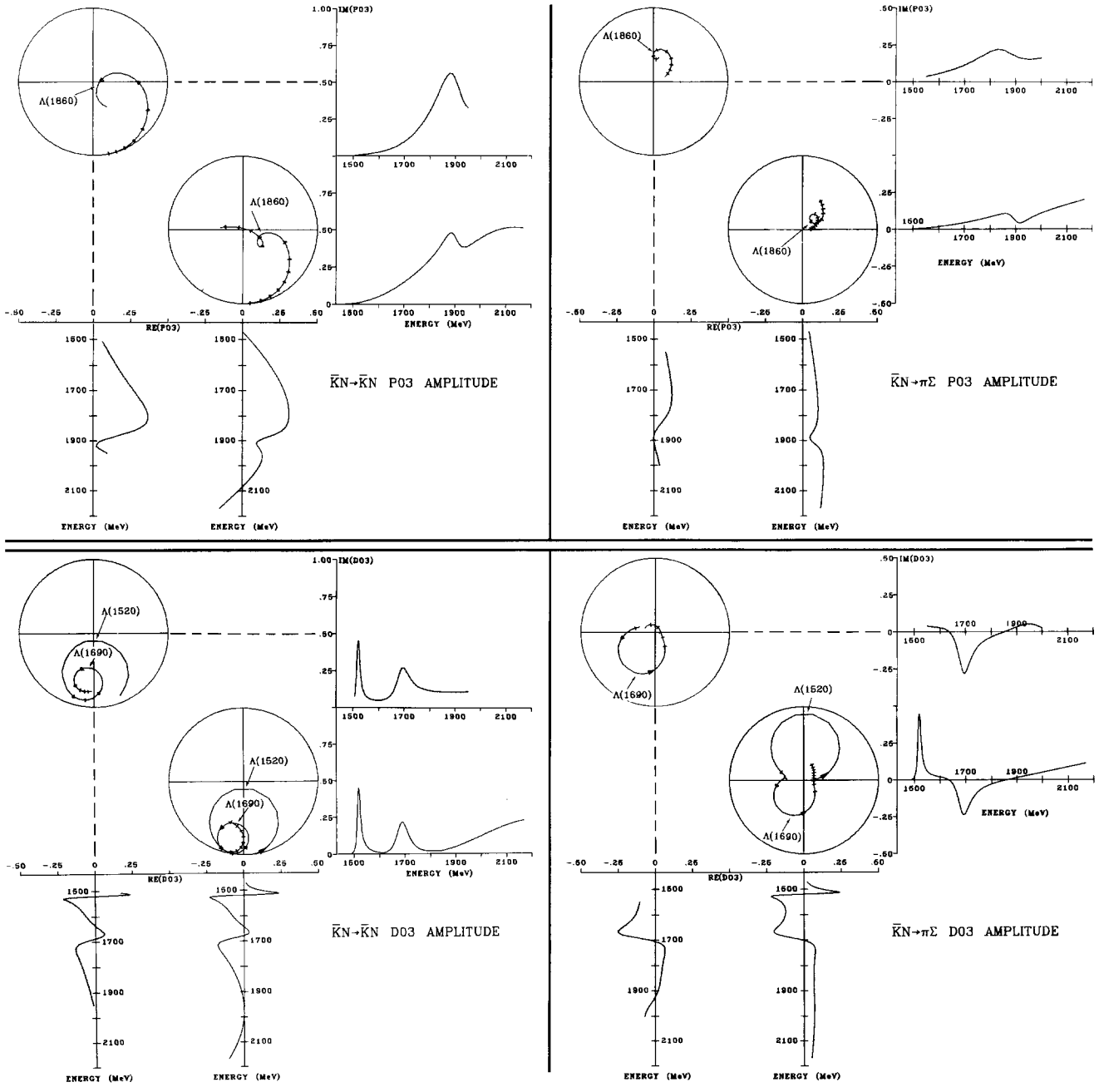


Fig. 9. Amplitudes for $\bar{K}N$ scattering in the P_{03} and D_{03} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonances Λ(1520), Λ(1690), and Λ(1860) are indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the πΣ channel.

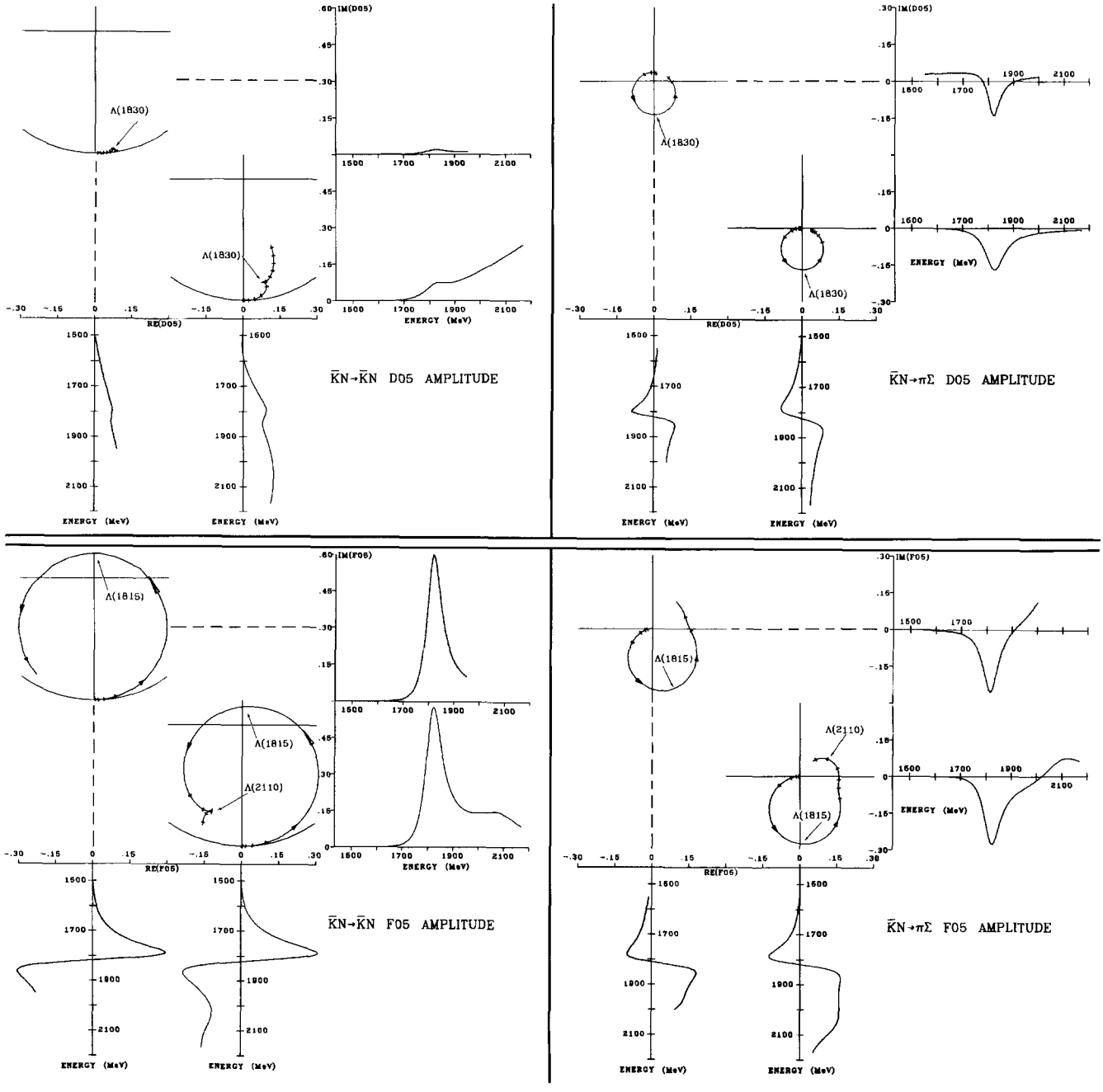


Fig. 10. Amplitudes for $\bar{K}N$ scattering in the D_{05} and F_{05} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonances Λ(1815) Λ(1830), and Λ(2110) are indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the πΣ channel.

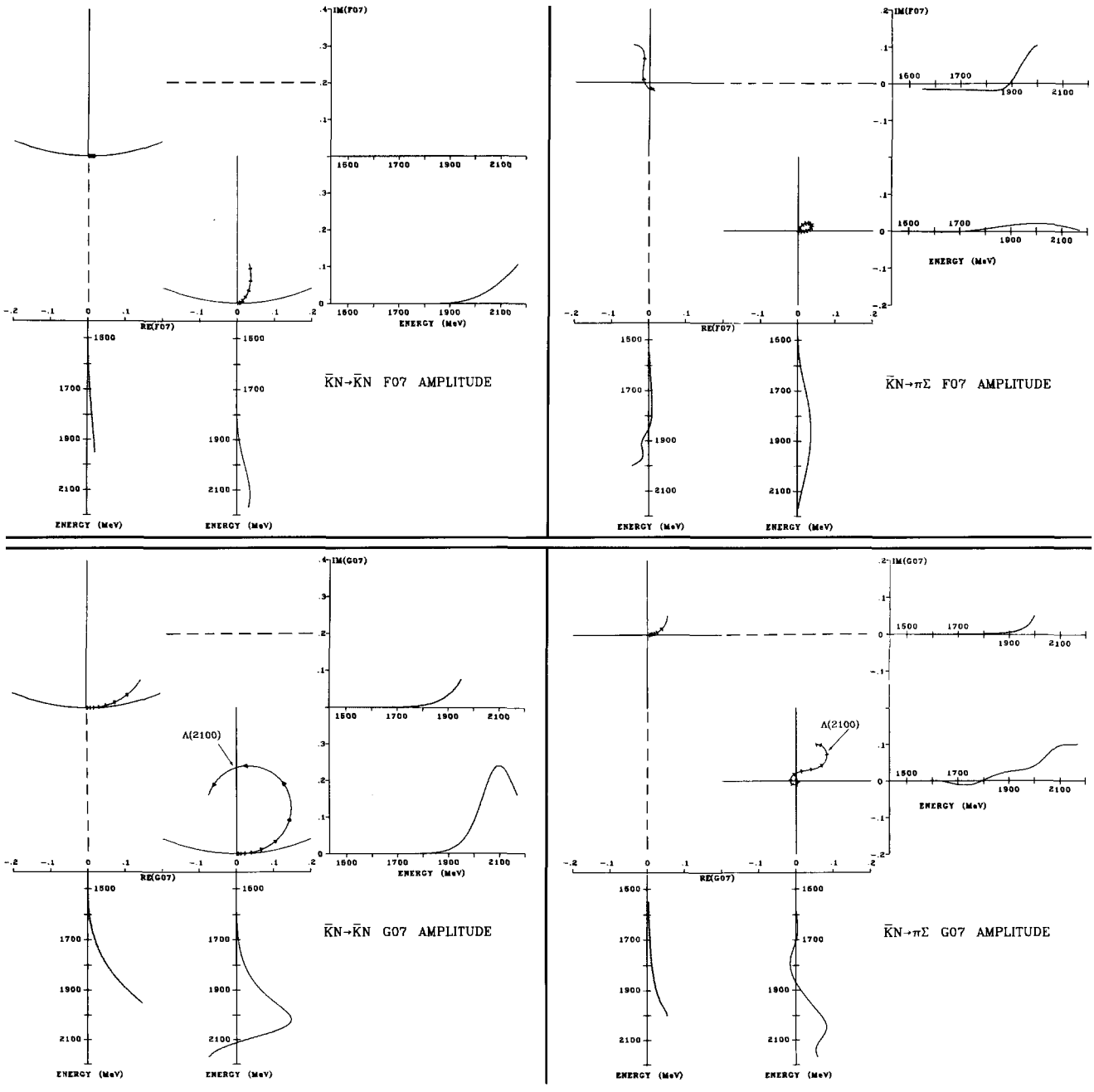


Fig. 11. Amplitudes for $\bar{K}N$ scattering in the F_{07} and G_{07} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts versus energy, in alignment with the corresponding Argand plot. In addition, arrows with bases positioned at integral multiples of 50 MeV and a base-to-tip length of 5 MeV are plotted on the Argand plots, and the established resonance Λ(2100) is indicated. The results of two different analyses are shown for each channel; the energy axes all run from elastic threshold to 2200 MeV and are aligned for ease of comparison. The lower plot for each channel is from RLIC 77. The upper plot is from ALSTON 78 for the elastic channel and from MARTIN 77 for the πΣ channel.

multi-channel analyses described above. In particular, the Saclay-Collège de France collaboration has now published three separate energy-dependent analyses for the channels $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$ extending up to a mass of 2.5 GeV (BELLEFON 78, 76, and 77, respectively). They indicate that the bumps seen in total cross sections at these higher energies are made up of many resonant states.

For a brief description of the older analyses we refer to the previous editions of this compilation.

Production Experiments

This type of experiment is often difficult to analyze. Information on $I = 0$ states is possible only when there is no $I = 1$ state at a similar mass. The main controversies at the present time concern resonances in the 1600 to 1700 MeV region. See the mini-reviews on Σ(1620) and Σ(1670) in these Listings.

Figures

Argand plots of fifteen $S = -1$ partial waves are shown in Figs. 1 through 11. The analyses shown were picked largely for illustrative purposes rather than on the basis of our judgment of their quality; for the $\bar{K}N$ channel, we chose to show the amplitudes obtained by RLIC 77 and ALSTON 78, and for the $\Lambda\pi$ and $\Sigma\pi$ channels those from RLIC 77 and MARTIN 77.

Errors on Masses and Widths

Often the quoted errors in partial-wave analyses are only statistical, and the values of masses and widths can change by more than these errors when a new parametrization is used. For this reason we report the values of M, Γ, and x_i obtained by different authors even if they analyze the same data. The spread of these masses and widths is certainly a better estimate of the uncertainties than the statistical errors. Sometimes the errors quoted are obtained by the inspection of various fits done with different hypotheses (see, for example, BERTHON 70, GALTIERI 70, VANHORN 75, RLIC 76). For three states, Λ(1520), Λ(1815), and Σ(1765), there are enough data available to perform an overall fit of the various x_i of the type discussed in the main text (Sec. VII B). In this case we are forced to use the errors, however small they may be, but we warn the reader that the final errors are not to be taken seriously.

In conclusion, in the Baryon Table we choose not to give errors on masses and total widths determined primarily by partial-wave analyses, but, whenever necessary, to show a range of values. As for the branching ratios, we use the errors when needed to perform an overall fit, but we caution the reader.

Conclusions

Table I is an attempt to evaluate the status of the various Y^*'s. The evaluations are of course partly subjective. A blank indicates that there is no corresponding evidence at all. This may mean either that the relevant couplings are small or that the resonance does not really exist. The Baryon Table includes only the well established resonances. It seems clear, however, that whereas any particular one of the questionable resonances may disappear with the next analysis, there are probably many new resonances underlying those already established.

References

1. M. Alston-Garnjost *et al.*, Phys. Rev. Lett. 38, 1003 and 1007 (1977).
2. M. Alston-Garnjost *et al.*, LBL-6492 (1977); submitted to Phys. Rev. D.
3. R. D. Ehrlich *et al.*, Phys. Lett. 71B, 455 (1977).
4. C. Damerell *et al.*, Nucl. Phys. B129, 397 (1977).
5. B. R. Martin, in Proceedings of the Topical Conference on Baryon Resonances (Oxford, 1976), edited by R. T. Ross and D. H. Saxon, pg.285.
6. P. N. Hansen *et al.*, in Oxford Conference Proceedings (ibid.), pg.275.

For other references, see the Data Card Listings.

Baryons

Λ's and Σ's, Λ, Λ(1330), Λ(1405)

Data Card Listings

For notation, see key at front of Listings.

TABLE I. STATUS OF Y* RESONANCES
THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

PARTICLE	LIJ	OVERALL STATUS	STATUS AS SEEN IN -- TOTAL* CR. SEC.	KBAR N	LAM PI	SIG PI	OTHER CHANNELS
LAM(1115)	P01	****					WEAK TO N PI
LAM(1330)		DEAD					
LAM(1405)	S01	****		****	F	****	
LAM(1520)	D03	****	****	****	O	****	LAM2PI,LAM GAM
LAM(1600)	P01	**		**	R	*	
LAM(1670)	S01	****		****	B	****	LAM ETA
LAM(1690)	D03	****	****	****	I	****	LAM2PI,SIG2PI
LAM(1800)	P01	**		***	D	**	
LAM(1800)	G09	*		*	D	*	
LAM(1815)	F05	****	****	****	E	****	SIG(1385) PI
LAM(1830)	D05	****		***	N	****	
LAM(1860)	P03	***	**	***	F	**	
LAM(1870)	S01	***		***	O	**	
LAM(2010)		**			R	*	LAM OMG
LAM(2020)	F07	*		*	B	*	
LAM(2100)	G07	****	****	****	I	***	XI K,LAM OMG
LAM(2110)	F05	***		**	D	*	LAM OMG
LAM(2350)		****	****	****	D		
LAM(2585)		***	***	*	E		
SIG(1193)	P11	****					WEAK TO N PI
SIG(1385)	P13	****			****	****	
SIG(1480)	PE	*		*	*	*	
SIG(1580)	D13	**	**	*	**		
SIG(1620)	S11	**		**	*	*	
SIG(1620)	PE	**		*	**		LAM 2-PI
SIG(1660)	P11	***		***	*	**	
SIG(1670)	D13	****	**	****	****	****	SEVERAL OTHERS
SIG(1670)	PE	**		**	**	**	SEVERAL OTHERS
SIG(1690)	PE	**	*	*	**	*	LAM 2-PI
SIG(1750)	S11	***		**	**	*	SIG ETA
SIG(1765)	D15	****	****	****	****	***	SEVERAL OTHERS
SIG(1770)	P11	*		*	*		
SIG(1840)	P13	*		*	**	*	
SIG(1880)	P11	**		**	**		
SIG(1915)	F15	****	***	***	****	***	
SIG(1940)	D13	***		*	***	**	
SIG(2000)	S11	*			*		
SIG(2030)	F17	****	****	****	****	**	XI K
SIG(2070)	F15	*				*	
SIG(2080)	P13	**			**		
SIG(2100)	G17	*			*	*	
SIG(2250)		****	****	*	*	*	
SIG(2455)		***	***	*			
SIG(2620)		***	***	*			
SIG(3000)		**		*	*		

**** GOOD, CLEAR, AND UNMISTAKABLE.
*** GOOD, BUT IN NEED OF CLARIFICATION OR NOT ABSOLUTELY CERTAIN.
** NEEDS CONFIRMATION.
* WEAK.

* ATTRIBUTED TO THE STATE CLOSEST TO WHERE THE CROSS SECTION PEAKS.

S=−1 I=0 HYPERON STATES (Λ)

Λ

18 LAMBDA(1115, JP=1/2+) I=0

SEE STABLE PARTICLE DATA CARD LISTINGS

Λ(1330) BUMPS

87 Y*0(1330, JP=) I=0 PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

A PEAK WAS SEEN NEAR 1330 MEV IN THE LAMBDA GAMMA SPECTRUM IN THREE PI-PROPANE EXPERIMENTS (YUNG-CHANG 64, BUBELEV 67, AND BOZOKI 68). ALL MORE RECENT RESULTS INDICATE THAT THERE IS NO RESONANACE NEAR THIS MASS VALUE.

REFERENCES FOR Y*0(1330) (PROD. EXP.)

Y-CHANG	64	DUBNA CONF I 615	YUNG-CHANG, IN, KLADNITSKAYA, + (DUBNA)
BUBELEV	67	PL 24B 246	+CHADRAA, CHUVILG, + (JINR,BUCHAREST,CERN)
DAHL	67	PR 163 1377	DAHL, HARDY, HESS, KIRZ, MILLER (LRL)
BOZOKI	68	PL 28B 360	+FENYVES, GEMESY, + (BUDAPEST,DUBNA)
TAN	69	PRL 23 101	T H TAN (SLAC)
MAYEUR	70	PL 33B 441	+VAN BINST,WILQUET+++ (BRUX,CERN,TUFT)
COLAS	75	NP B91 253	COLAS,FARWELL,FERRER,SIX (ORSA)

Λ(1405) 37 Y*0(1405, JP=1/2-) I=0 PRODUCTION EXPERIMENTS **S'_{01}**

THIS RESONANCE CAN BE IDENTIFIED WITH THE VIRTUAL BOUND STATE IN THE KBAR-N SYSTEM FOUND IN THE ANALYSIS OF LOW ENERGY K-P INTERACTION. WE LIST SUCH EXPERIMENTS SEPARATELY BELOW. WE USE ONLY PRODUCTION EXPERIMENTS FOR AVERAGING OF MASSES AND WIDTHS.

37 Y*0(1405) MASS (MEV) (PROD. EXP.)

M		(1405.0)			ALSTON	61 HBC	K-P 1.15 BEV/C	
M		(1410.0)			ALEXANDER	62 HBC	PI-P 2.1 BEV/C	
M		(1405.0)			ALSTON	62 HBC	K-P 1.2-.5 BEV/C	
M		(1382.0)	(8.0)		ENGLER	65 HDBC	PI-P, PI+D 1.68	7/66
M		1400.0	24.0		MUSGRAVE	65 HBC	PBAR P 3-4 BEV/C	7/66
M	67	1400.0	5.0		BIRMINGHA	66 HBC	K-P 3.5	9/67
M	120	1405.0	5.0		GALTIERI	68 DBC	K-D 2.1-2.7BEV/C	6/68
M		. . . . .						
M	AVG	1402.4	3.5		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
M	STUDENT	1402.4	3.9		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

37 Y*0(1405) WIDTH (MEV) (PROD. EXP.)

W		(20.0)			ALSTON	61 HBC		7/66
W		35.0	5.0		ALEXANDER	62 HBC		
W		(50.0)			ALSTON	62 HBC		
W		(89.0)	(20.0)		ENGLER	65 HDBC		7/66
W		60.0	20.0		MUSGRAVE	65 HBC		7/66
W	67	50.0	10.0		BIRMINGHA	66 HBC	K-P 3.5	9/67
W	120	35.0	8.0		GALTIERI	68 DBC	K-D 2.1-2.7BEV/C	6/68
W		. . . . .						
W	AVG	38.1	3.9		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
W	STUDENT	37.9	4.3		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			

37 Y*0(1405) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*0(1405) INTO SIGMA PI	1197+ 139

REFERENCES FOR Y*0(1405) (PROD. EXP.)

ALSTON	61 PRL 6 698	+ALVAREZ,EBERHARD,GOOD,GRAZIANO, +	(LRL) I
ALEXANDE	62 PRL 8 447	ALEXANDER,KALBFLEISCH,MILLER,SMITH	(LRL) I
ALSTON	62 CERN CONF 311	+ALVAREZ,FERRO-LUZZI,ROSENFELD, +	(LRL) I
ENGLER	65 PRL 15 224	+FISK,KRAEMER,MELTZER,WESTGARD,+	(CARN,BNL) IJ
MUSGRAVE	65 NC 35 735	+PETMEZAS,+ (BIRM,CERN,EPOL,LOIC,SACLAY)	
BIRMINGH	66 PR 152 1148	BIRMINGHAM,GLASGOW,LOIC, OXFORD,RUTHERFORD	
GALTIERI	68 PRL 21 573	BARBARO-GALTIERI,CHADWICK +	(LRL,SLAC)

1405 MEV REGION: EXTRAPOLATIONS BELOW THRESHOLD

24 Y*0(1405, JP=1/2-) I=0
EXTRAPOLATION BELOW THRESHOLD

SEE NOTE IN Y*0(1405) PRODUCTION EXPERIMENTS -THE DIFFICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ 67.

THE QUESTION ON WHETHER Y*(1405) IS A KBAR-N BOUND STATE OR A CDD POLE (DALITZ 70, RAJASEKARAN 72 HAS BEEN INVESTIGATED BY CLINE 71, MARTIN 71, GALTIERI 72, AND DOBSON 72. THE LAST TWO PAPERS CONCLUDE THAT THE DATA CANNOT TELL THE DIFFERENCE.
THE (N KBAR)/(PI SIGMA) COUPLING RATIO IS DISCUSSED BY OADES 77.

24 Y*0(1405) MASS (MEV)

M		1410.7	(1.0)		KIM	65 HBC	0-EFF-RANGE FIT	7/66
M		1409.6	(1.7)		SAKITT	65 HBC	0-EFF-RANGE FIT	7/66
M				DATA OF SAKITT ARE USED IN FIT BY KITTEL.				
M		1407.5	(1.2)		KITTEL	66 HBC	0-EFF-RANGE FIT	7/66
M		1403.0	(3.0)		KIM	67 HBC	K MATRIX FIT(KP)	8/67
M		1416.0	(4.0)		MARTIN	69 HBC	CONST. K MATRIX	10/69
M		(1421.0)			MARTIN	70 RVUE	CONST. K MATRIX	6/70
M	1	(1406.)			CHAO	73 OPWA	0-RNG. FIT.SOL B	9/73
M	1	SEE ALSO THE ACCOMPANYING PAPER OF THOMAS73.						9/73

24 Y*0(1405) WIDTH (MEV)

W		37.0	(3.2)		KIM	65 HBC		7/66
W		28.2	(4.1)		SAKITT	65 HBC		7/66
W		34.1	(4.1)		KITTEL	66 HBC		7/66
W		50.0	(5.0)		KIM	67 HBC	K MATRIX FIT(KP)	8/67
W		29.0	(6.0)		MARTIN	69 HBC	CONST. K MATRIX	10/69
W		(20.0)			MARTIN	70 RVUE	CONST. K MATRIX	6/70
W	1	(55.)			CHAO	73 OPWA	0-RNG. FIT.SOL B	9/73
W	1	ASYMMETRIC RESONANCE SHAPE,W/2=41 MEV BELOW RESONANCE,14 MEV ABOVE.						9/73

REFERENCES FOR Y*0(1405) (FROM EXTRAPOLATIONS)

KIM	65 PRL 14 29	J K KIM	(COLUMBIA)IJP
SAKITT	65 PR 139 B719	+DAY,GLASSER,SEEMAN,FRIEDMAN, +	(UMD,LRL)IJP
KITTEL	66 PL 21 349	W KITTEL, G OTTER, I WACEK	(VIENNA)IJP
KIM	67 PRL 19 1074	J KIM	(YALE)JP
MARTIN	69 PR 183 1352	B R MARTIN, M SAKITT	(LOUC+BNL)
MARTIN	70 NP B16 479	A D MARTIN, G G ROSS	(DURHAM)IJP
CHAO	73 NP B56 46	CHAO,KRAEMER,THOMAS,MARTIN	(RHEL+CARN+LOUC)IJP
ALSC	73 NP B56 15	THOMAS,ENGLER,FISK,KRAEMER	(CARN)IJ

Data Card Listings

For notation, see key at front of Listings.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                    PAPERS NOT REFERRED TO IN DATA CARDS

ABRAMS    65 PR 139 B454        G S ABRAMS, B SECHI-ZORN                    (UMD)IJP
DONALD    66 PL 22 711          + EDWARDS, LYS, NISAR, MOORE      (LIVERPOOL)
KADYK     66 PRL 17 599         +OREN, G+S GOLDHABER, TRILLING             (LRL)IJP
    FIT SOLUTIONS GIVING AN I*0 S1                              (2 RESONANCE.)
    ABRAMS 65, KADYK 66, AND DONALD 66 SUPPORT THOSE EFFECTIVE-RANGE-
DALITZ    67 PR 153 1617        DALITZ, WONG, RAJASEKARAN   (OXFORD,BOMBAY)
DALITZ    70 DUKE-HR 70 03      R D DALITZ                                 (OXF)
CLINE     71 PRL 26 1194        D CLINE,R LAUMANN,J MAPP                   (WISC)
MARTIN    71 PL 35B 62          A D MARTIN,B R MARTIN,ROSS (DURH+LOUC+RHEL)
DOBSON    72 PR D6 3256         P N DOBSON,R MCELHANEY                     (HAWA)
GALTIERI  72 LBL 555            A.BARBARO-GALTIERI                         (LBL)
RAJASEKA  72 PR D5 610          RAJASEKARAN                                (TATA)
    ALSC EARLIER PAPERS CITED IN RAJASEKARAN72
SHAW      73 PURDUE CONF. 417   SHAW                                       (UCI)IJP
OADES     77 NC 42A 462         G.C.OADES,G.RASCHE                (AARH+ZURI)IJP

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Λ(1520)

38 Y*0(1520, JP=3/2-) I=0 — D'03

PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL WITH EACH OTHER, THERFORE, THEY HAVE NOT BEEN SEPARATED FOR THIS PARTICLE.

THE DECAY MODE LAMBDA PI PI IS LARGELY DUE TO Y*1(1385) PI. ONLY THE VALUES OF (Y*1(1385) PI)/(LAMBDA PI PI) GIVEN BY MAST 72 AND CORDEN 75 ARE BASED ON REAL 3-BODY PARTIAL WAVE ANLAYSES (THE OLDER RESULTS BEING OBTAINED USING CRUDER METHODS). THE DISCREPANCY BETWEEN THE 2 RESULTS IS ESSENTIALLY DUE TO THE DIFFERENT HYPOTHESIS MADE CONCERNING THE SHAPE OF THE EPSILON MESON.

38 Y*0(1520) MASS (MEV)

M	145	1517.2	3.0	GALTIERI	63	DBC	K-D 1.51 BEV/C	
M		1519.4	2.0	WATSON	63	HBC	K-P ALL CHANNELS	
M	29	1520.0	4.0	ALMEIDA	64	HBC	K-P 1.45 BEV/C	
M		(1511.0)	(15.0)	MUSGRAVE	65	HBC	PBAR P 3-4 BEV/C	7/66
M	30	(1510.0)	(2.0)	BIRMINGHA	66	HBC	K-P 3.5	9/67
M	B	1517.2	1.2	BURKHARDT	69	HBC	K-P .8-1.2 GEV/C	10/69
M	B	QUOTED ERROR INCREASED TO ACCOUNT FOR DISAGREEMENT BETWEEN						
M	B	TWO MEASUREMENTS DONE BY SAME AUTHORS (K-P AND SIGMA PI)						
M		(1519.)		KIM	71	DPWA	K-MATRIX ANAL.	3/71
M	1669	1517.+/-1. TO 1521.+/-1.		BERTHON	74	HBC	0 QUASI 2 BODY CS	10/74
M	2000	1519.4	.3	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75
M	4K	1519.7	0.3	CAMERON	77	HBC	K-P 0.96-1.36GEV	1/78*
M		1519.	1.	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
M		1520.	.5	ALSTON	78	DPWA	KBAR N ELASTIC	1/78*
M		. . . . .						
M	AVG	1519.53	0.22	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)				
M	STUDENT	1519.54	0.21	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

38 Y*0(1520) WIDTH (MEV)

W		16.4	2.0	WATSON	63	HBC		
W		(19.0)	(19.0)	MUSGRAVE	65	HBC		7/66
W	30	(50.0)	(10.0)	BIRMINGHA	66	HBC	K-P 3.5	9/67
W		(18.0)	OR LESS	DAHL	67	HBC		9/66
W		14.7	1.8	BURKHARDT	69	HBC	K-P .8-1.2 GEV/C	10/69
W		(16.)		KIM	71	DPWA	K-MATRIX ANAL.	3/71
W	2000	15.5	1.6	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75
W	4K	16.3	0.5	CAMERON	77	HBC	K-P 0.96-1.36GEV	1/78*
W		15.	.5	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
W		15.4	.5	ALSTON	78	DPWA	KBAR N ELASTIC	1/78*
W		. . . . .						
W	AVG	15.56	0.28	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
W	STUDENT	15.54	0.33	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				

38 Y*0(1520) PARTIAL DECAY MODES

		DECAY MASSES	
P1	Y*0(1520) INTO KBAR N	497+ 939	
P2	Y*0(1520) INTO SIGMA PI	1197+ 139	
P3	Y*0(1520) INTO LAMBDA PI PI	1115+ 139+ 139	
P4	Y*0(1520) INTO LAMBDA GAMMA	1115+ 0	
P5	Y*0(1520) INTO SIGMA0 GAMMA	1192+ 0	
P6	Y*0(1520) INTO SIGMA PI PI	1197+ 139+ 139	
P7	Y*0(1520) INTO (Y*1(1385)+PI)	1384+ 139	
P8	Y*0(1520) INTO Y*1(1385) PI INTO LAMBDA PI PI	1115+ 139+ 139	
	NOTE THAT P8/P7 IS THE BRANCHING FRACTION FOR Y*1(1385) INTO LM PI		9/73
P9	Y*0(1520) INTO LAMBDA EPSILON	1518+1300	

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{(\delta P_i \delta P_i)}$, while the off-diagonal elements are the normalized correlation coefficients $(\delta P_i \delta P_j)/(\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4503+-.0056					
P 2	-.6215	.4199+-.0064				
P 3	-.2288	-.3931	.0945+-.0043			
P 4	-.0653	-.1167	-.0468	.0078+-.0014		
P 5	-.1675	-.2995	-.1202	-.0248	.0190+-.0034	
P 6	-.0249	-.0446	-.0179	-.0037	-.0095	.0086+-.0005

38 Y*0(1520) BRANCHING RATIOS

R1	Y*0(1520) INTO (SIGMA PI)/(KBAR N)						(P2)/(P1)	
R1		1.72	.78	MUSGRAVE	65	HBC		8/67
R1		0.96	0.20	DAHL	67	HBC	PI-P 1.6-4 GEV/C	9/66
R1		0.73	0.11	DAUBER	67	HBC	K-P AT 2.GEV/C	8/67
R1		1.06	.14	SCHEUER	68	DBC	0 K-N 3 GEV/C	10/69
R1		0.82	0.08	BURKHARDT	69	HBC	K-P .8-1.2 GEV/C	10/69
R1		(1.06)	(.12)	BERTHON	74	HBC	0 QUASI 2 BODY CS	10/74
R1	4	.98	.03	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
R1	4	KBAR N TO SIGMA PI AMPLITUDE AT RESONANCE IS +-.46 +/- .01						1/76
R1		. . . . .						
R1	AVG	0.951	0.044	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)				
R1	STUDENT	0.957	0.032	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R1	FIT	0.933	0.023	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)				
R2	Y*0(1520) INTO (LAMBDA PI PI)/(KBAR N)						(P3)/(P1)	
R2		0.17	0.05	DAHL	67	HBC	PI-P 1.6-4 GEV/C	9/66
R2		0.21	0.18	DAUBER	67	HBC	K-P AT 2.GEV/C	8/67
R2		.19	.04	SCHEUER	68	DBC	0 K-N 3 GEV/C	10/69
R2		0.22	0.03	BURKHARDT	69	HBC	K-P .8-1.2 GEV/C	10/69
R2		(0.21)		KIM	71	DPWA	K-MATRIX ANAL.	3/71
R2		(.27)	(.13)	BERTHON	74	HBC	0 QUASI 2 BODY CS	10/74
R2		. . . . .						
R2	AVG	0.202	0.021	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R2	STUDENT	0.202	0.024	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R2	FIT	0.210	0.010	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)				
R3	Y*0(1520) INTO (SIGMA PI)/(LAMBDA PI PI)						(P2)/(P3)	
R3		4.5	1.0	ARMENTERO	65	HBC		7/66
R3		3.3	1.1	BIRMINGHA	66	HBC	K-P 3.5	9/67
R3		3.9	1.0	UHLIG	67	HBC	K-P .9-1.0 BEV/C	9/66
R3		. . . . .						
R3	AVG	3.94	0.59	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R3	STUDENT	3.94	0.65	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R3	FIT	4.44	0.24	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)				
R4	Y*0(1520) INTO (LAMBDA GAMMA)/TOTAL (PERCENT)						(P4)	
R4	238	0.80	0.14	MAST	68	HBC	0 USING ELAST=.45	11/68
R4		. . . . .						
R4	FIT	0.78	0.14	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R5	Y*0(1520) INTO (SIGMA0 GAMMA)/TOTAL (PERCENT)						(P5)	
R5	S	2.0	.35	MAST	68	HBC	SEE NOTE S	10/69
R5	S	RATIOS CALCULATED FROM R4,ASSUMING SU(3). NEEDED TO CONSTRAIN						
R5	S	ALL THE Y*0(1520) BRANCHING RATIOS TO BE UNITY.						
R5		. . . . .						
R5	FIT	1.90	0.34	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R6	Y*0(1520) INTO (KBAR N)/TOTAL						(P1)	
R6		0.29	0.05	WATSON	63	HBC	K-P ALL CHANNELS	10/71
R6		.447	.018	GALTIERI	69	HBC	K- P .28-.45 G/C	10/69
R6		0.47	0.03	COLLEY	71	DBC	K-N 1.5 GEV PROD	10/71
R6		(0.45)		KIM	71	DPWA	K-MATRIX ANAL.	3/71
R6		.448	.014	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75
R6		(.421)		MAST	76	HBC	0 K- P CEX	1/76
R6		.47	.01	RLIC	77	DPWA	KBAR N MULTICHNL	1/76
R6		.45	.03	ALSTON	78	DPWA	KBAR N ELASTIC	1/78*
R6		. . . . .						
R6	AVG	0.457	0.012	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)				
R6	STUDENT	0.4577	0.0083	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R6	FIT	0.4503	0.0056	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)				
R7	Y*0(1520) INTO (SIGMA PI)/TOTAL						(P2)	
R7		0.55	0.09	WATSON	63	HBC	K-P ALL CHANNELS	10/71
R7		0.418	.017	GALTIERI	69	HBC	0 K-P .28-.45GEV/C	6/69
R7		0.43	(0.03)	COLLEY	71	DBC	K-N 1.5 GEV PROD	10/71
R7		(0.461)		KIM	71	DPWA	K-MATRIX ANAL.	3/71
R7	3	.426	.014	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75
R7	3	SUPERSEDES COLLEY 71						1/76
R7		. . . . .						
R7	AVG	0.425	0.011	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R7	STUDENT	0.424	0.012	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R7	FIT	0.4199	0.0064	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)				
R8	Y*0(1520) INTO (SIGMA PI PI)/TOTAL						(P6)	
R8		.010	.0015	GALTIERI	69	HBC	0 K-P .28-.45GEV/C	10/69
R8	2	.0085	.0006	MAST2	73	MPWA	K-P TO 2PI SIG	9/73
R8	2	BASED ON ASSUMED ELASTICITY OF .46						9/73
R8	A	.007	.002	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75
R8	A	CONSIDERABLE FRACTION OF THE SIGMA PI PI DECAY PROCEEDS VIA THE						4/75
R8	A	Y*1(1385) PI INTERMEDIATE STATE.						4/75
R8		. . . . .						
R8	AVG	0.00858	0.00054	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R8	STUDENT	0.00858	0.00059	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R8	FIT	0.00856	0.00054	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R9	Y*0(1520) TO Y*1(1385) PI TO LM PI PI/LM PI PI						(P8)/(P3)	9/73
R9	MORE THAN	0.10		CLINE	69	OBC	K-P TO 2PI LAM N	9/69
R9	B	0.39	0.10	BURKHARDT	71	HBC	LAM. 3PI PROD.	3/71
R9	C	(1.0)		CHAN	72	IPWA	K-P TO LAM 2PI	2/73
R9	M	0.82	0.10	MAST	73	IPWA	K-P TO 2PI LAM	12/72
R9		.58	.22	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75
R9	B	CENTRAL BIN(1514-1524) GIVES .74+-.10 -- OTHER BINS LOWER BY 2-5SIG						
R9	C	ONLY THE Y*(1385)DS03 SEEMS TO CONTRIBUTE						
R9	M	BOTH Y*(1385)DS03 AND SIGMA (PI PI)DP03 CONTRIBUTE						
R9		. . . . .						
R9	AVERAGE MEANINGLESS (SCALE FACTOR = 2.2)							
R10	Y*0(1520) INTO (Y*1(1385) PI)/TOTAL						(P7)	
R10		0.041	0.005	CHAN	72	HBC	K-P TO LAM 2PI	3/71
R11	Y*0(1520) INTO (LAMBDA PI PI)/TOTAL						(P3)	
R11		0.10	(0.02)	COLLEY	71	DBC	K-N 1.5 GEV PROD	10/71
R11	1	.11	.01	MAST	73	IPWA	K-P TO 2PI LAM	9/73
R11	1	BASED ON ASSUMED ELASTICITY OF .46+/-.02						9/73
R11	3	.091	.006	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75
R11	3	SUPERSEDES COLLEY 71						1/76
R11		. . . . .						
R11	AVG	0.0960	0.0084	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)				
R11	STUDENT	0.0956	0.0062	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R11	FIT	0.0945	0.0043	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)				
R12	Y*0(1520) INTO (LAMBDA EPSILON)/TOTAL						(P9)	4/75
R12		.20	.08	CORDEN	75	DBC	K- D 1.4-1.8GV/C	4/75

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                              REFERENCES FOR Y*0(1520)

GALTIERI 63 PL 6 296          A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)
WATSCN   63 PR 131 2248       M B WATSON, M FERRO-LUZZI, R D TRIPP  (LRL)IJP
ALMEIDA  64 PL 9 204          S P ALMEIDA, G R LYNCH                (CERN)
ARMENTER 65 PL 19 338         ARMENTEROS,F-LUZZI, +    (CERN,HEID,SACLAY)
MUSGRAVE 65 NC 35 735         +PETMEZAS,+     (BIRM,CERN,EPOL,LOIC,SACLAY)

BIRMINGH 66 PR  152  1148     BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
DAHL     67 PR 163 1377       DAHL,HARDY,HESS,KIRZ,MILLER             (LRL)
DAUBER   67 PL 24B 525        +MALAMUD,SCHLEIN,SLATER,STORK           (UCLA)
UHLIG    67 PR 155 1448       +CHARLTON,CONDON,GLASSER,YODH,+    (UMD,NRL)
MAST     68 PRL 21 1715       MAST,ALSTON,BANGERTER,GALTIERI+         (LRL)
SCHEUER  68 NP B8 503         SABRE COLLAB.     (SACL+AMST+BGNA+REHO+EPOL)

BURKHARD 69 NP B14 106        +FILTHUTH+KLUGE+..    (HEID+EFI+CERN+SACLAY)
CLINE    69 LNC 2 407         +LAUMANN+MAPP                          (WISC)
GALTIERI 69 LUND 352          BARBARO-GALTIERI,BANGERTER,MAST,TRIPP (LRL)
    ALSO 70 DUKE 95           R D TRIPP                              (LRL)

BURKHARDT71 NP  B27 64        +FILTHUTH,KLUGE,OBERLACK++ (HEID+CERN+SACL)
COLLEY   71 NP  B31 61        +COX,EASTWOOD,FRY+..  (BIRM+EDIN+GLAS+LOIC)
KIM      71 PRL 27 356        J K KIM                             (HARV)IJP
    ALSO 70 DUKE 161          J. K. KIM                           (HARV)IJP

CHAN     72 PRL 28 256        +BUT.-SHAFER,HERTZBACH,KOFLER++ (MASA,YALE)
MAST     73 PR D7 5           +ALSTON-GARNJOST,BANGERTER,+...      (LBL)IJP
MAST2    73 PRD 7 3212        +BANGERTER,ALSTON-GARNJOST,+         (LBL)IJP
BERTHON  74 NC 21A 146        BERTHON,TRISTRAM,+    (CDEF+RHEL+SACL+STRB)
CORDEN   75 NP B84 306        CORDEN,COX,DARTNELL,KENYON,ONEALE,+  (BIRM)

MAST     76 PRD 14 13         MAST,ALSTON-GARNJOST,BANGERTER+        (LBL)
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTCN   78  LBL-6784         +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY      (LBL+MTHO+CERN)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

BERLEY   70 PR D1 1996        +YAMIN,KOFLER,MANN,MEISNER+ (BNL,MASA,YALE)IJP
GOLOWICH 74 PRD 10 3861       EUGEN GOLOWICH                         (SLAC)
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$\Lambda(1600)$ — 101 Y*0(1600, JP=1/2+) I=0 — P'_{01} — 1/76

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                 101  Y*0(1600) MASS (MEV)                          1/76

M   1    (1570.)                  KIM      71 DPWA   K-MATRIX ANAL.   1/76
M   1  POSSIBLE EFFECT IN SIGMA PI AND KBAR N CHANNELS.
M         1620.0     10.0         LANGBEIN 72 IPWA   MULTICHANNEL     1/76
M   2     1646.      7.           CARROLL  76 DPWA   I=0 TOTAL CS     2/77*
M   3     1572. OR 1617.          MARTIN   77 DPWA   KBAR N MULTICHNL 11/77*
M   3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M   3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M         1573.      25.          RLIC     77 DPWA   KBAR N MULTICHNL 1/76
M         1703.      100.         ALSTON   78 DPWA   KBAR N ELASTIC   1/78*
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

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                 101  Y*0(1600) WIDTH (MEV)                         1/76

W   1     (50.)                   KIM      71 DPWA   K-MATRIX ANAL.   1/76
W          60.0     10.0          LANGBEIN 72 IPWA   MULTICHANNEL     1/76
W   2     (20.)                   CARROLL  76 DPWA   I=0 TOTAL CS     2/77*
W   3     247. OR 271.            MARTIN   77 DPWA   KBAR N MULTICHNL 11/77*
W         147.      50.           RLIC     77 DPWA   KBAR N MULTICHNL 1/76
W         593.      200.          ALSTON   78 DPWA   KBAR N ELASTIC   1/78*
W          . . . . . . . . . .
W   AVG       64.6      16.8    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
W   STUDENT   63.6      10.9    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
       SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                 101  Y*0(1600) PARTIAL DECAY MODES                 1/76

                                                     DECAY MASSES
P1     Y*0(1600) INTO KBAR N                        497+ 939
P2     Y*0(1600) INTO SIGMA PI                     1197+ 139

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                 101  Y*0(1600) BRANCHING RATIOS                    1/76

R1     Y*0(1600) INTO (KBAR N)/TOTAL                    (P1)             1/76
R1          0.25      0.15        LANGBEIN 72 IPWA   MULTICHANNEL        1/76
R1   2  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.04   SEEN BY CARROLL 76  2/77*
R1   3        (.30)OR .29         MARTIN   77 DPWA   KBAR N MULTICHNL 11/77*
R1             .24       .04      RLIC     77 DPWA   KBAR N MULTICHNL    1/76
R1             .14       .05      ALSTON   78 DPWA   KBAR N ELASTIC      1/78*
R1          . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

R2     Y*0(1600) FROM KBAR N INTO SIGMA PI              SQRT(P1*P2)      1/76
R2          0.28      0.09        LANGBEIN 72 IPWA   MULTICHANNEL        1/76
R2        NOT SEEN                HEPP2    76 DPWA -0 K- NUC TO SIG PI   2/77*
R2   3      (-.39)CR -.39         MARTIN   77 DPWA   KBAR N MULTICHNL 11/77*
R2          -.16       .04        RLIC     77 DPWA   KBAR N MULTICHNL    1/76
R2          . . . . . . . . . .
R2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

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                              REFERENCES FOR Y*0(1600)

KIM      71 PRL 27 356        J K KIM                             (HARV)IJP
    ALSC 70 DUKE 161          J. K. KIM                           (HARV)IJP

LANGBEIN 72 NP B47 477        +WAGNER                             (MPIM)IJP

CARROLL  76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+      (BNL)I
HEPP2    76 PL 65B 487        +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE       (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                      (LOUC)
    ALSC 77 NP B126 285       MARTIN,PIDCOCK                      (LOUC)IJP
RLIC     77 NP B119 362       GCPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTCN   78  LBL-6784         +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
    ALSC 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY      (LBL+MTHO+CERN)IJP
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$\Lambda(1670)$ — 40 Y*0(1670, JP=1/2-) I=0 — S''_{01}

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                 SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

                  THIS RESONANCE IS WELL ESTABLISHED.

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                 40  Y*0(1670) MASS (MEV)

M   M    (1666.0)OR(1675.0)         BERLEY    65 HBC    0 K-P TO LAM ETA    7/66
M   M     THE FIRST VALUE ASSUMES THE BRANCHING RATIO INTO LAMBDA ETA IS
M       SMALL, THE SECOND THAT IT IS LARGE.  BECAUSE THE RESONANCE IS NEAR
M       THE LAMBDA ETA THRESHOLD, THE BRANCHING RATIO AFFECTS THE MOMENTUM
M       DEPENDENCE OF THE TOTAL WIDTH, AND THUS ALSO THE RESONANCE PARA-
M       METERS OBTAINED BY FITTING TO THE DATA.
M   N    (1663.0)     (3.0)        ARMENT-1  68 HBC    0 ELASTIC, CH EXCH 11/68
M   N    (1678.0)     (2.0)        ARMENT-2  68 HBC    0 K-P TO SIGMA PI  11/68
M   A     1674.0      (5.0)        ARMENT-3  69 HBC    0 MULTICHANNEL      9/69
M   N     1662.0      (3.0)        ARMENT-4  69 HBC    0 ELAST,CH.EXC.ED   9/69
M   N     1680.0      (1.0)        ARMENT-4  69 HBC    0 K-P TO SIG PI.ED  9/69
M         1674.0                   BERLEY    69 HBC    0 K-P TO SIGMA PI   6/70
M         1683.0      (5.0)        GALTIERI  70 HBC    0 SIG PI,EDPWA      7/70
M         1670.                    KIM       71 DPWA     K-MATRIX ANAL.    3/71
M         1640.0     (40.0)        LANGBEIN  72 IPWA     MULTICHANNEL    .12/72
M         1700.      (10.)         BAXTER    73 DPWA   0 K- P TO NEUTRALS 10/74
M         1672.      (1.)          HART      73 DPWA     EL+CX,.7-.8GEV/C  2/74
M         1665.      (5.)          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M         1675.      (2.)          HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77*
M   2    (1664.)                   MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
M   2  MARTIN 77 OBTAINS IDENTICAL RESONANCE PARAMETERS FROM THE
M   2  T-MATRIX POLE AND FROM A B-W FIT.
M         1670.      (5.)          RLIC      77 DPWA     KBAR N MULTICHNL  1/76
M         1671.      (3.)          ALSTON    78 DPWA     KBAR N ELASTIC    1/78*
M   A            THE MULTICHANNEL ANALYSIS INCLUDES ELASTIC AND SIGMA PI .  10/69
M   N     THE APPARENT DISCREPANCY BETWEEN THESE RESULTS IS PROBABLY NOT
M       SERIOUS.  THE ERRORS GIVEN ARE JUST STATISTICAL.  THE SYSTEMATIC
M       ERRORS THAT RESULT FROM THE RESTRICTIVE PARAMETRIZATION FORCED ON
M       THE PARTIAL-WAVE AMPLITUDES ARE NOT INCLUDED, AND CAN BE LARGE.

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                 40  Y*0(1670) WIDTH (MEV)

W   M        (22.0)OR(15.0)        BERLEY    65 HBC    0 SEE NOTE M ABOVE  7/66
W   N       (26.0)     (8.0)       ARMENT-1  68 HBC    0 SEE NOTE N ABOVE 11/68
W   N       (26.0)     (5.0)       ARMENT-2  68 HBC    0                  11/68
W   A        23.0      (3.0)       ARMENT-3  69 HBC    0                   9/69
W   N        38.0     (15.0)       ARMENT-4  69 HBC    0 ELAST,CH EXC.ED   9/69
W   N        33.0      (5.0)       ARMENT-4  69 HBC    0 K-P TO SIG PI.ED  9/69
W            31.0                  BERLEY    69 HBC    0 K-P TO SIGMA PI   6/70
W            25.0      (5.0)       GALTIERI  70 HBC    0 SIG PI,EDPWA      7/70
W            35.                   KIM       71 DPWA     K-MATRIX ANAL.    3/71
W            45.0     (20.0)       LANGBEIN  72 IPWA     MULTICHANNEL     12/72
W            65.      (20.)        BAXTER    73 DPWA   0 K- P TO NEUTRALS 10/74
W            19.       (2.)        HART      73 DPWA     EL+CX,.7-.8GEV/C  2/74
W            19.       (5.)        PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W            46.       (5.)        HEPP2     76 DPWA -0 K- NUC TO SIG PI   2/77*
W   2       (12.)                  MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
W            45.      (10.)        RLIC      77 DPWA     KBAR N MULTICHNL  1/76
W            29.       (5.)        ALSTON    78 DPWA     KBAR N ELASTIC    1/78*
             SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                 40  Y*0(1670) PARTIAL DECAY MODES

                                                     DECAY MASSES
P1     Y*0(1670) INTO KBAR N                        497+ 939
P2     Y*0(1670) INTO LAMBDA ETA                   1115+ 548
P3     Y*0(1670) INTO SIGMA PI                     1189+ 139
P4     Y*0(1670) INTO SIGMA(1385) PI                139+1384

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                 40  Y*0(1670) BRANCHING RATIOS

R1     Y*0(1670) INTO (KBAR N)/TOTAL                     (P1)
R1  P       (0.14)    (0.04)       ARMENT-1  68 HBC    0 OLD DATA          11/68
R1           0.17                  ARMENT-3  69 HBC    0                    9/69
R1  P        0.14     (0.04)       ARMENT-4  69 HBC    0 NEW DATA           9/69
R1  A       (0.39)    (0.05)       CONFORTO  71 HBC    0 K-P,ELAST,CEX      6/70
R1           0.28                  KIM       71 DPWA     K-MATRIX ANAL.     3/71
R1           0.35     (0.06)       LANGBEIN  72 IPWA     MULTICHANNEL      12/72
R1            .36      (.03)       HART      73 DPWA     EL+CX,.7-.8GEV/C   2/74
R1  2       (.15)                  MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
R1            .20      (.03)       RLIC      77 DPWA     KBAR N MULTICHNL   1/76
R1            .17      (.03)       ALSTON    78 DPWA     KBAR N ELASTIC     1/78*
R1  A    EFFECT BELOW REGION ANALYZED. VALUE OF .18 DOES NOT
R1  A  AFFECT FIT OR VALUES OF OTHER PARAMETERS.
R1  P    THIS IS THE DIAMETER OF THE CIRCLE IN THE ARGAND PLOT.  IT IS
R1     SUPERIMPOSED ON A LARGE BACKGROUND.

R2     Y*0(1670) FROM KBAR N TO LAMBDA ETA               SQRT(P1*P2)
R2  M       (0.20) OR 0.23         BERLEY    65 HBC    0 SEE NOTE M ABOVE   7/66
R2          (0.26)                 ARMENT-3  69 HBC    0                    9/69
R2          (0.24)                 KIM       71 DPWA     K-MATRIX ANAL.     3/71
R2           +.20      (.05)       BAXTER    73 DPWA   0 K- P TO NEUTRALS  10/74
       SEE THE NOTES ACCOMPANYING MASSES QUOTED

R3     Y*0(1670) FROM KBAR N TO SIGMA PI                 SQRT(P1*P3)
R3  1     (-0.25)    (0.06)        ARMENT-2  68 HBC    0 OLD DATA
R3  1     (-0.27)                  ARMENT-3  69 HBC    0                    9/69
R3  1     (-0.30)    (0.03)        ARMENT-4  69 HBC    0 NEW DATA           9/69
R3  1  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R3         -0.27                   BERLEY    69 HBC    0 K-P TO SIGMA PI    6/70
R3         -0.29     (0.03)        GALTIERI  70 HBC    0 SIG PI,EDPWA       7/70
R3         -0.38                   KIM       71 DPWA     K-MATRIX ANAL.     3/71
R3          -.28      (.05)        BAXTER    73 DPWA   0 K- P TO NEUTRALS  10/74
R3          -.23      (.03)        LONDON    75 HLBC   0 K- P TO SIGO PIO   4/75
R3          -.29      (.03)        HEPP2     76 DPWA -0 K- NUC TO SIG PI    2/77*
R3  2      (-.13)                  MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
R3          -.31      (.03)        RLIC      77 DPWA     KBAR N MULTICHNL   1/76
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Λ(1670), Λ(1690), Λ(1800)

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R4     Y*0(1670) FROM KBAR N TO SIGMA(1385) PI          SQRT(P1*P4)
R4          -.18      .05          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74

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                              REFERENCES FOR Y*0(1670)

BERLEY    65 PRL 15 641        +CONNOLLY, HART, RAUM, STONEHILL, +    (BNL)IJP
ARMENT-1  68 NP B8 195         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2  68 NP B8 223         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP

ARMENT-3  69 LUND PAPER 229    ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
    VALUES ARE QUOTED IN LEVI SETTI 69.
ARMENT-4  69 NP B14 91         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BERLEY    69 PL 30B 430        + HART, RAHM, WILLIS, YAMAMOTO          (BNL)IJP
GALTIERI  70 DUKE 173          A. BARBARO GALTIERI                     (LRL)IJP

CONFORTO  71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM       71 PRL 27 356        J K KIM                                 (HARV)IJP
    ALSO  70 DUKE 161          J. K. KIM                               (HARV)IJP
LANGBEIN  72 NP B47 477        +WAGNER                                 (MPIM)IJP
BAXTER    73 NP B67 125        BAXTER,BUCKINGHAM,CORBETT,DUNN,+   (OXFORD)IJP
HART      73 PURDUE CONF. 311  +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
PREVOST   74 NP B69 246        PREVOST,BARLOUTAUD,+          (SACL+CERN+HEID)
LONDON    75 NP B85 289        LONDON,YU,BOYD,+  (BNL,CERN,EPOL,ORSA,TORI)

HEPP2     76 PL 65B 487        +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
MARTIN    77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
    ALSO  77 NP B126 266       MARTIN,PIDCOCK                          (LOUC)
    ALSO  77 NP B126 285       MARTIN,PIDCOCK                          (LOUC)IJP
RLIC      77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON    78  LBL-6784        +KENNEY,POLLARD,ROSS+         (LBL+MTHO+CERN)IJP
    ALSO  77 PRL 38 1007       ALSTON-GARNJOST,KENNEY        (LBL+MTHO+CERN)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

BIRMINGH  66 PR 152 1148         (BIRMINGHAM,GLASGOW,LOIC,OXFORD,RUTHERFD)
LEVISETT  69 LUND 339        R LEVI SETTI  (RAPPORTEUR)          (CHICAGO)

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Λ(1690) 55 Y*0(1690, JP=3/2-) I=0 **D″03**

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THIS RESONANCE IS WELL ESTABLISHED.

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                              55  Y*0(1690) MASS (MEV)

M          (1696.0)     (3.0)          ARMENT-1  68 HBC    0 ELASTIC, CH EXCH 11/68
M          (1681.0)     (2.0)          ARMENT-3  68 HBC    0 K-P TO SIGMA PI  11/68
M           1681.       (8.)           BARTLEY   68 DBC    0 K-P AND K-D DATA 11/68
M           1695.0      (4.0)          BUGG      68 CNTR   0 K-P, D TOTAL        7/68
M    M     (1697.0)     (2.0)          CONFORTO  68 HBC    0 ELASTIC, CH EXCH 11/68
M    M    THE Y*0(1690) IS AT THE EDGE OF THE ENERGY REGION ANALYZED BY
M    M  CONFORTO. THE SAME DATA AS WELL AS OTHERS EXTENDING TO LOWER
M    M  ENERGIES ARE INCLUDED IN ARMENTEROS 1.
M     A     1691.0      (2.0)          ARMENT-4  69 HBC    0 ELAS,CH EXC.ED      9/69
M     A   ANALYSIS INCLUDES OLD AND NEW DATA OF CHS COLLAB.  .43-.8 GEV/C
M     A   THE APPARENT DISCREPANCY BETWEEN THE SIGMA PI AND OTHER RESULTS IS
M     A PROBABLY NOT SERIOUS.  THE ERRORS GIVEN ARE JUST STATISTICAL.  THE
M     A SYSTEMATIC ERRORS THAT RESULT FROM THE RESTRICTIVE PARAMETRIZATION
M     A OF THE PARTIAL-WAVE AMPLITUDES ARE NOT INCLUDED, AND CAN BE LARGE.
M     A     1688.0      (2.0)          ARMENT-4  69 HBC    0 K-P TO SIG PI,ED    9/69
M           1689.0                     BERLEY    69 HBC    0 K-P TO SIGMA PI     6/70
M           1701.0      (4.0)          BERTANZA  69 HBC    0 ELASTIC, CH EXCH    9/69
M           1680.0      (5.0)          GALTIERI  70 HBC    0 SIG PI,EDPWA        7/70
M           1688.0      (3.0)          CONFORTO  71 HBC    0 K-P,ELAST,CEX       6/70
M           1690.                      KIM       71 DPWA     K-MATRIX ANAL.      3/71
M           1680.0     (20.0)          LANGBEIN  72 IPWA     MULTICHANNEL       12/72
M           1670.      (10.)           BAXTER    73 DPWA   0 K- P TO NEUTRALS   10/74
M           1684.       (3.)           HART      73 DPWA     EL+CX,.7-.8GEV/C     2/74
M    2      1692.       (4.)           CARROLL   76 DPWA     I=0 TOTAL CS         2/77*
M           1690.       (3.)           HEPP2     76 DPWA -0 K- NUC TO SIG PI    2/77*
M    3      1687. OR 1689.             MARTIN    77 DPWA     KBAR N MULTICHNL   11/77*
M    3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M    3  ANOTHER 3/2- LAMBDA AT 1966 MEV IS ALSO SUGGESTED BY MARTIN77.
M    3  BUT IS VERY UNCERTAIN.
M           1690.       (5.)           RLIC      77 DPWA     KBAR N MULTICHNL    1/76
M           1692.       (5.)           ALSTON    78 DPWA     KBAR N ELASTIC      1/78*

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                              55  Y*0(1690) WIDTH (MEV)

W           (35.0)      (7.0)          ARMENT-1  68 HBC    0 OLD DATA           11/68
W           (85.0)      (7.0)          ARMENT-3  68 HBC    0 OLD DATA           11/68
W            48.        (15.)          BARTLEY   68 DBC    0 K-P AND K-D DATA   11/68
W            60.0       (7.0)          BUGG      68 CNTR   0                      7/68
W    M      (27.0)      (5.0)          CONFORTO  68 HBC    0 SEE NOTE M ABOVE   11/68
W     A      31.0       (7.0)          ARMENT-4  69 HBC    0 ELAS,CH EXC.ED       9/69
W     A      72.0       (6.0)          ARMENT-4  69 HBC    0 K-P TO SIG PI ED     9/69
W            57.0                      BERLEY    69 HBC    0 K-P TO SIGMA PI      6/70
W            28.0       (8.0)          BERTANZA  69 HBC    0                      9/69
W            85.0      (10.0)          GALTIERI  70 HBC    0 SIG PI,EDPWA         7/70
W            64.0       (5.0)          CONFORTO  71 HBC    0 K-P,ELAST,CEX        6/70
W            55.                       KIM       71 DPWA     K-MATRIX ANAL.       3/71
W            40.0      (10.0)          LANGBEIN  72 IPWA     MULTICHANNEL        12/72
W            30.       (10.)           BAXTER    73 DPWA   0 K- P TO NEUTRALS    10/74
W            86.        (9.)           HART      73 DPWA     EL+CX,.7-.8GEV/C     2/74
W    2      (38.)                      CARROLL   76 DPWA     I=0 TOTAL CS         2/77*
W           82.        (8.)           HEPP2     76 DPWA -0 K- NUC TO SIG PI    2/77*
W    3      62. OR 62.                 MARTIN    77 DPWA     KBAR N MULTICHNL   11/77*
W           60.        (5.)           RLIC      77 DPWA     KBAR N MULTICHNL     1/76
W           64.       (10.)           ALSTON    78 DPWA     KBAR N ELASTIC       1/78*
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                              55  Y*0(1690) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     Y*0(1690) INTO KBAR N                                      497+ 939
P2     Y*0(1690) INTO SIGMA PI                                   1189+ 139
P3     Y*0(1690) INTO LAMBDA PI PI                               1115+ 139+ 139
P4     Y*0(1690) INTO SIGMA PI PI                                1189+ 139+ 139
P5     Y*0(1690) INTO Y*1(1385) PI S-WAVE                         139+1384
P6     Y*0(1690) INTO LAMBDA ETA                                 1115+ 548

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                              55  Y*0(1690) BRANCHING RATIOS

   THE SUM OF ALL THE QUOTED BRANCHING RATIOS IS MORE THAN 1.0.  THE
TWO-BODY RATIOS ARE FROM PARTIAL WAVE ANALYSES, AND THUS PROBABLY ARE
MORE RELIABLE THAN THE THREE-BODY RATIOS, WHICH ARE DETERMINED FROM
BUMPS IN CROSS SECTIONS.  OF THE LATTER, THE SIGMA PI PI BUMP LOOKS
MORE SIGNIFICANT (THE ERROR GIVEN FOR THE LAMBDA PI PI RATIO LOOKS UN-
REASONABLY SMALL).  HARDLY ANY OF THE SIGMA PI PI DECAY CAN BE VIA
Y*1(1385), FOR THEN NINE TIMES AS MUCH LAMBDA PI PI DECAY WOULD BE
REQUIRED.

R1     Y*0(1690) INTO (KBAR N)/TOTAL                          (P1)
R1          (0.18)    (0.03)          ARMENT-1  68 HBC    0                    11/68
R1          (0.23)                    BUGG      68 CNTR   0 ASSUMING J=3/2      7/68
R1     M    (0.22)    (0.03)          CONFORTO  68 HBC    0 SEE NOTE M ABOVE   11/68
R1           0.18     (0.02)          ARMENT-4  69 HBC    0 NEW DATA             9/69
R1           0.28     (0.04)          BERTANZA  69 HBC    0                      9/69
R1     N    (0.34)    (0.02)          CONFORTO  71 HBC    0 K-P,ELAST,CEX        6/70
R1           0.22                     KIM       71 DPWA     K-MATRIX ANAL.       3/71
R1           0.15     (0.05)          LANGBEIN  72 IPWA     MULTICHANNEL        12/72
R1            .24     (.01)           HART      73 DPWA     EL+CX,.7-.8GEV/C     2/74
R1   3      (.28)OR .26               MARTIN    77 DPWA     KBAR N MULTICHNL   11/77*
R1            .24     (.03)           RLIC      77 DPWA     KBAR N MULTICHNL     1/76
R1            .22     (.03)           ALSTON    78 DPWA     KBAR N ELASTIC       1/78*
R1   2  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.48   SEEN BY CARROLL 76         2/77*
R1   N  EFFECT IS AT END OF REGION ANALYZED. THIS COULD AFFECT VALUE OF X1.

R2     Y*0(1690) FROM KBAR N TO SIGMA PI                      SQRT(P1*P2)
R2   1       (-0.33)   (0.02)          ARMENT-3  68 HBC    0 OLD DATA           11/68
R2   1       (-0.36)   (0.02)          ARMENT-4  69 HBC    0 NEW DATA             9/69
R2   1  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT)     10/74
R2           -0.27                     BERLEY    69 HBC    0 K-P TO SIGMA PI      6/70
R2           -0.31     (0.03)          GALTIERI  70 HBC    0 SIG PI,EDPWA         7/70
R2           -0.40                     KIM       71 DPWA     K-MATRIX ANAL.       3/71
R2            0.26     (0.07)          LANGBEIN  72 IPWA     MULTICHANNEL        12/72
R2            -.20     (.03)           BAXTER    73 DPWA   0 K- P TO NEUTRALS    10/74
R2            -.28     (.03)           LONDON    75 HLBC   0 K- P TO SIGO PIO     4/75
R2            -.29     (.03)           HEPP2     76 DPWA -0 K- NUC TO SIG PI    2/77*
R2   3      (-.30)OR -.28               MARTIN    77 DPWA     KBAR N MULTICHNL   11/77*
R2            -.25     (.03)           RLIC      77 DPWA     KBAR N MULTICHNL     1/76

R3     Y*0(1690) FROM KBAR N TO LAMBDA PI PI                  SQRT(P1*P3)
R3   B       (0.25)   (0.02)          BARTLEY   68 HDBC   0 LAM 2PI CROS SEC   11/68
R3   B   ONLY CROSS-SECTION DATA USED. ENHANCEMENT NOT SEEN BY PREVOST 71,       3/72

R4     Y*0(1690) FROM KBAR N TO SIGMA PI PI                   SQRT(P1*P4)
R4          (0.21)                    ARMENT-2  68 HDBC   0 K-N TO SIG PI PI   11/68

R5     Y*0(1690) FROM KBAR N INTO LAMBDA ETA                  SQRT(P1*P6)
R5           .00      (.03)          BAXTER    73 DPWA   0 K- P TO NEUTRALS    10/74

R6     Y*0(1690) FROM KBAR N TO Y*1(1385) PI S-WAVE           SQRT(P1*P5)
R6           +.27      .04           PREVOST   74 DPWA 0- K-N TO S(1385)PI    10/74

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                              REFERENCES FOR Y*0(1690)

ARMENT-1  68 NP B8 195         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2  68 NP B8 216         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
ARMENT-3  68 NP B8 223         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BARTLEY   68 PRL 21 1111       +CHU,DOWD,GREENE,+     (TUFTS,FSU,BRANDEIS) I
BUGG      68 PR 168 1466       +GILMORE, KNIGHT, +          (BIRM,CAVE,RHEL) I
    ALSO  67 PRL 18 62         DAVIES,DOWELL,+              (BIRM,CAVE,RHEL) I
CONFORTO  68 NP B8 265         +HARMSEN, LASINSKI, +     (CHICAGO,HEIDEL)IJP

ARMENT-4  69 NP B14 91         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BERLEY    69 PL 30B 430        + HART, RAHM, WILLIS, YAMAMOTO          (BNL)IJP
BERTANZA  69 PR 177 2036       +BIGI,CARRARA,CASALI, +      (PISA,BNL,YALE)IJP

GALTIERI  70 DUKE 173          A. BARBARO GALTIERI                     (LRL)IJP
CONFORTO  71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM       71 PRL 27 356        J K KIM                                 (HARV)IJP
    ALSO  70 DUKE 161          J. K. KIM                               (HARV)IJP
LANGBEIN  72 NP B47 477        +WAGNER                                 (MPIM)IJP
BAXTER    73 NP B67 125        BAXTER,BUCKINGHAM,CORBETT,DUNN,+   (OXFORD)IJP
HART      73 PURDUE CONF. 311  +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
PREVOST   74 NP B69 246        PREVOST,BARLOUTAUD,+          (SACL+CERN+HEID)

LONDON    75 NP B85 289        LONDON,YU,BOYD,+  (BNL,CERN,EPOL,ORSA,TORI)
CARROLL   76 PRL 37 806        +CHIANG,KYCIA,LI,MAZUR,MICHAEL+         (BNL)I
HEPP2     76 PL 65B 487        +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP

MARTIN    77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
    ALSO  77 NP B126 266       MARTIN,PIDCOCK                          (LOUC)
    ALSO  77 NP B126 285       MARTIN,PIDCOCK                          (LOUC)IJP
RLIC      77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON    78  LBL-6784        +KENNEY,POLLARD,ROSS+         (LBL+MTHO+CERN)IJP
    ALSO  77 PRL 38 1007       ALSTON-GARNJOST,KENNEY        (LBL+MTHO+CERN)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

PREVOST   71  AMSTERDAM CONF   + CHS COLLABORATION          (CERN+HEID+SACL)

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Λ(1800) 77 Y*0(1800, JP=1/2+) I=0 **P″01**

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THE EVIDENCE FOR THIS STATE IS SOMEWHAT CONFUSED. IT WAS FIRST SUGGESTED IN A PARTIAL WAVE ANALYSIS OF KBAR N DATA BY THE BEHAVIOUR OF THE P01 AMPLITUDE WHEN IT WAS PARAMETRIZED AS A TWO-STRAIGHT-LINE BACKGROUND (ARMENTEROS 68).

ALMOST ALL THE RECENT ANALYSES CONTAIN A P01 STATE, AND SOMETIMES TWO, BUT THE MASSES, WIDTHS, AND BRANCHING RATIOS OBTAINED IN THE DIFFERENT ANALYSES VARY GREATLY.

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                              77  Y*0(1800) MASS (MEV)

M           (1745.0)                  ARMENTERO 68 HBC    0 ELASTIC, CH EXCH 11/68
M           (1740.0)                  BAILEY    69 DPWA   0 ELASTIC, CH EXCH 10/70
M           (1800.0)                  ARMENTERO 70 HBC    0 ELASTIC, CH EX     6/70
M           (1750.0)                  ARMENTERO 70 HBC    0 SIGMA PI           6/70
M    N      (1690.0)    (10.0)        GALTIERI  70 HBC    0 SIG PI,EDPWA       7/70
M    N    ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED   1/71
M           (1755.)                   KIM       71 DPWA     K-MATRIX ANAL.     3/71
M            1780.0      20.0         LANGBEIN  72 IPWA     MULTICHANNEL      12/72
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M          1746.      10.                  PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
M    1     1735.       5.                  CARROLL   76 DPWA    I=0 TOTAL CS      2/77*
M    3     1861. OR 1953.                  MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
M    3  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    3  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1853.      20.                  RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.5)
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77 Y*0(1800) WIDTH (MEV)

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W          (147.0)                         ARMENTERO 68 HBC   0
W          (300.0)                         BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
W           (30.0)                         ARMENTERO 70 HBC   0 ELASTIC, CH EX    6/70
W           (70.0)                         ARMENTERO 70 HBC   0 SIGMA PI          6/70
W    N      (22.0)                         GALTIERI  70 HBC   0 SIG PI,EDPWA      7/70
W           (35.)                          KIM       71 DPWA    K-MATRIX ANAL.    3/71
W           120.0      10.0                LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W            46.       20.                 PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
W    1      (28.)                          CARROLL   76 DPWA    I=0 TOTAL CS      2/77*
W    3      535. OR 585.                   MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
W           166.       20.                 RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)
        SEE THE NOTES ACCOMPANYING MASSES QUOTED
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77 Y*0(1800) PARTIAL DECAY MODES

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                                                         DECAY MASSES
P1      Y*0(1800) INTO KBAR N                          497+ 939
P2      Y*0(1800) INTO SIGMA PI                       1197+ 139
P3      Y*0(1800) INTO SIGMA(1385) PI                  139+1384
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77 Y*0(1800) BRANCHING RATIOS

```
R1      Y*0(1800) INTO (KBAR N)/TOTAL                          (P1)
R1           (0.4)                         ARMENTERO 68 DPWA  0 ELASTIC, CH EXCH 11/68
R1           (0.55)                        BAILEY    69 DPWA  0 ELASTIC, CH EXCH 10/70
R1           (0.15)                        ARMENTERO 70 DPWA  0 ELASTIC, CH EXCH 10/70
R1           (0.30)                        KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1            0.36      0.05               LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R1   3       (.52)OR .49                   MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R1             .21       .04               RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1   1  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.29   SEEN BY CARROLL 76           2/77*
R1           . . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

R2      Y*0(1800) FROM KBAR N INTO SIGMA PI                    SQRT(P1*P2)
R2  2        (+0.20)                       ARMENTERO 70 DPWA  0 K-P TO SIGMA PI   6/70
R2  2   PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R2  N        (-0.13)    (0.03)             GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
R2           (0.17)                        KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2           (0.01) OR LESS                LANGBEIN  72 IPWA    MULTICHANNEL     12/72
R2   3       (+.25)OR +.23                 MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R2            -.24       .04               RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      Y*0(1800) FROM KBAR N TO SIGMA(1385) PI                SQRT(P1*P3)
R3              +.18      .10              PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
        SEE THE NOTES ACCOMPANYING MASSES QUOTED
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REFERENCES FOR Y*0(1800)


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ARMENTER 68 NP B8 195          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BAILEY   69 THESIS UCRL-50617  DAVID SAAL BAILEY             (LRL LIVERMORE)IJP
ARMENTER 70 DUKE CONF 123      ARMENTEROS, BAILLON, +         (CERN, HEIDEL)IJP
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                      (LRL)IJP
KIM      71 PRL 27 356         J K KIM                                (HARV)IJP
    ALSO 70 DUKE 161           J. K. KIM                              (HARV)IJP
LANGBEIN 72 NP B47 477         +WAGNER                                (MPIM)IJP

PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+         (SACL+CERN+HEID)
CARROLL  76 PRL 37 806         +CHIANG,KYCIA,LI,MAZUR,MICHAEL+          (BNL)I
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
    ALSO 77 NP B126 266        MARTIN,PIDCOCK                           (LOUC)
    ALSO 77 NP B126 285        MARTIN,PIDCOCK                         (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
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Λ(1800)

102 Y*0(1800, JP=9/2-) I=0 **G_{09}** 1/76

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THIS NARROW RESONANCE SEEMS NECESSARY TO FIT A PEAK
IN THE A7 COEFFICIENT OF THE K-P ANGULAR DISTRIBUTION.
IT IS NOT REQUIRED IN ANY OTHER CHANNEL.

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102 Y*0(1800) MASS (MEV) 1/76

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M          1808.       5.                  RLIC      77 DPWA    KBAR N MULTICHNL  1/76
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102 Y*0(1800) WIDTH (MEV) 1/76

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W            27.       5.                  RLIC      77 DPWA    KBAR N MULTICHNL  1/76
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102 Y*0(1800) PARTIAL DECAY MODES 1/76

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                                                         DECAY MASSES
P1      Y*0(1800) INTO KBAR N                          497+ 939
P2      Y*0(1800) INTO SIGMA PI                       1197+ 139
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102 Y*0(1800) BRANCHING RATIOS 1/76

```
R1      Y*0(1800) INTO (KBAR N)/TOTAL                          (P1)               1/76
R1               .04       .01             RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2      Y*0(1800) FROM KBAR N INTO SIGMA PI                    SQRT(P1*P2)        1/76
R2             LESS THAN .04               RLIC      77 DPWA    KBAR N MULTICHNL  1/76
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REFERENCES FOR Y*0(1800)


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RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
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Λ(1815)

39 Y*0(1815, JP=5/2+) I=0 **F'_{05}**

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THIS STATE IS WELL ESTABLISHED. MOST OF THE QUOTED ERRORS ARE STATISTICAL ONLY. THE SYSTEMATIC ERRORS DUE TO THE PARTICULAR PARAMETRIZATION USED IN THE P.W.A. ARE NOT INCLUDED. FOR THIS REASON WE DO NOT CALCULATE WEIGHTED AVERAGES FOR MASS AND WIDTH.

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39 Y*0(1815) MASS (MEV)

```
M    N      1813.0     (2.0)          ARMENT-1  67 HBC    0 K-P TO SIGMA PI    8/67
M    N      1816.0     (4.0)          BELL      67 HDBC   0 K-N TO SIGMA PI   11/67
M    N      1817.0     (2.0)          ARMENT-3  68 HBC    0 ELASTIC, CH EXCH  11/68
M    N      1819.0     (4.0)          BUGG      68 CNTR   0 K-P, D TOTAL       6/68
M    N      1825.0     (1.0)          BRICMAN   70 CNTR   0 TOTAL AND CH EX    6/70
M    N      1819.0     (1.0)          BRICMAN1  70 DPWA     SIGTOT,ELAS,CHEX   1/71
M           1830.0    (10.0)          COOL      70 CNTR     K-P, D TOTAL      10/70
M           1820.0    (10.0)          GALTIERI  70 DPWA   0 K-P TO SIGMA PI    7/70
M    N      1818.0     (2.0)          CONFORTO  71 DPWA   0 ELASTIC, CH EXCH   6/70
M           1810.                     KIM       71 DPWA     K-MATRIX ANAL.     3/71
M    N      1823.0     (3.0)          KANE      72 DPWA   0 K-P TO PI SIG     10/71
M    N      1818.0     (3.0)          LANGBEIN  72 IPWA     MULTICHANNEL      12/72
M          (1830.)                    DECLAIS   77 DPWA     KBAR N TO KBAR N   1/78*
M    2      1817. OR 1819.            MARTIN    77 DPWA     KBAR N MULTICHNL  11/77*
M    2  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    2  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M    N      1822.      (2.)           RLIC      77 DPWA     KBAR N MULTICHNL   1/76
M           1819.      (2.)           ALSTON    78 DPWA     KBAR N ELASTIC     1/78*
M    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED    1/71
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39 Y*0(1815) WIDTH (MEV)

```
W             87.0    (15.0)          ARMENT-1  67 HBC    0                    8/67
W             64.0    (12.0)          BELL      67 HDBC   0                   11/67
W    N        71.0     (4.0)          ARMENT-3  68 HBC    0 ELASTIC, CH EXCH  11/68
W    N        75.0     (7.0)          BUGG      68 CNTR   0 K-P, D TOTAL       6/68
W    N        80.0     (6.0)          BRICMAN   70 CNTR   0 TOTAL AND CH EX    6/70
W    N        79.0     (3.0)          BRICMAN1  70 DPWA     SIGTOT,ELAS,CHEX   1/71
W            100.0                    COOL      70 CNTR     K-P, D TOTAL      10/70
W            100.0    (20.0)          GALTIERI  70 DPWA   0 K-P TO SIGMA PI    7/70
W    N        90.0     (4.0)          CONFORTO  71 DPWA   0 ELASTIC, CH EXCH   6/70
W             70.                     KIM       71 DPWA     K-MATRIX ANAL.     3/71
W    N       104.0    (16.0)          KANE      72 DPWA   0 K-P TO PI SIG     10/71
W    N        70.0     (5.0)          LANGBEIN  72 IPWA     MULTICHANNEL      12/72
W            (82.)                    DECLAIS   77 DPWA     KBAR N TO KBAR N   1/78*
W    2        76. OR 76.              MARTIN    77 DPWA     KBAR N MULTICHNL  11/77*
W    N        81.      (5.)           RLIC      77 DPWA     KBAR N MULTICHNL   1/76
W             72.      (5.)           ALSTON    78 DPWA     KBAR N ELASTIC     1/78*
         SEE THE NOTES ACCOMPANYING MASSES QUOTED
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39 Y*0(1815) PARTIAL DECAY MODES

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                                                         DECAY MASSES
P1      Y*0(1815) INTO KBAR N                          497+ 939
P2      Y*0(1815) INTO SIGMA PI                       1189+ 139
P3      Y*0(1815) INTO Y*1(1385) PI P-WAVE             139+1384
P4      Y*0(1815) INTO SIGMA PI PI                    1192+ 139+ 139
P5      Y*0(1815) INTO ETA LAMBDA                      548+1115
P6      Y*0(1815) INTO Y*1(1385) PI F-WAVE             139+1384
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FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.6008+-.0193					
P 2	-.4763	.1155+-.0078				
P 3	-.1042	.0496	.1034+-.0287			
P 4	-.3565	-.0111	-.8126	.1579+-.0334		
P 5	-.0579	.0276	.0060	-.2343	.0153+-.0085	
P 6	-.0361	.0172	.0038	-.1750	.0021	.0070+-.0063

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39 Y*0(1815) BRANCHING RATIOS

ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE TO PARAMETRIZATION USED IN THE P.W.A. THEY SHOULD BE INCREASED.

```
R1      Y*0(1815) INTO (KBAR N)/TOTAL                          (P1)
R1              0.62      0.02            ARMENT-3  68 HBC    0 ELASTIC, CH EXCH 11/68
R1             (0.72)                     BUGG      68 CNTR   0 K-P, D TOTAL      6/68
R1              0.65      0.02            BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
R1              0.58      0.02            BRICMAN1  70 DPWA     SIGTOT,ELAS,CHEX  1/71
R1             (0.8)                      COOL      70 CNTR     K-P, D TOTAL     10/70
R1              0.63      0.01            CONFORTO  71 DPWA   0 ELASTIC, CH EXCH  6/70
R1             (0.52)                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
R1              0.47      0.02            LANGBEIN  72 IPWA     MULTICHANNEL     12/72
R1              (.51)                     DECLAIS   77 DPWA     KBAR N TO KBAR N  1/78*
R1   2          (.59)OR .58               MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
R1               .57       .02            RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R1               .60       .03            ALSTON    78 DPWA     KBAR N ELASTIC    1/78*
R1           . . . . . . . . . .
R1  AVG         0.601     0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.2)
R1  STUDENT     0.6128    0.0100  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R1  FIT         0.601     0.019  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 3.0)
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R2      Y*0(1815) FROM KBAR N INTO SIGMA PI                 SQRT(P1*P2)
R2   1      -0.27      0.01          ARMENT-1  67 DPWA  0 K-P TO SIGMA PI   10/74
R2   1 PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R2           0.23      0.025         BELL      67 DPWA  0 K-P TO SIGMA PI   11/67
R2          -0.26      0.03          GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
R2          (0.26)                   KIM       71 DPWA    K-MATRIX ANAL.     3/71
R2          -0.268     0.027         KANE      72 DPWA  0 K P TO PI SIG     10/71
R2           0.25      0.03          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R2   2      (-.25)OR -.25            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R2           -.28       .03          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2          . . . . . . . . . .
R2  AVG MOD  0.2645    0.0078  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  STUDENT  0.2650    0.0087  AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R2  FIT      0.2635    0.0078 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      Y*0(1815) FROM KBAR N TO Y*1(1385) PI P-WAVE        SQRT(P1*P3)
R3  A       (0.3)     (0.05)         ARMENT-2  67 HBC   0 K-P TO LAM P+ P+
R3           +.27       .03          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
R3           +.167      .054         CAMERON2  77 DPWA  0 K-P TO S(1385)PI  1/78*
R3          . . . . . . . . . .
R3  AVG      0.246     0.044   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R3  STUDENT  0.248     0.031   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
R3  FIT      0.249     0.034  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R4      Y*0(1815) INTO (Y*1(1385) PI)/TOTAL                 (P3)
R4           0.20      0.05          BIRGE     65 HBC   0 K-P TO LAM PI PI  7/66
R4          . . . . . . . . . .
R4  FIT      0.103     0.029  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

R5      Y*0(1815) INTO (SIGMA PI PI)/TOTAL                  (P4)
R5   P      NO CLEAR SIGNAL          ARMENT-4  68 HDBC  0 K-N TO SIG PI PI 11/68
R5   P   THERE IS A SUGGESTION OF A BUMP, ENOUGH TO BE CONSISTENT WITH
R5     WHAT IS EXPECTED FROM SIGMA PI DECAY OF THE Y*1(1385) -- ABOUT 0.02.
R5          . . . . . . . . . .
R5  FIT      0.158     0.033  FROM FIT

R6      Y*0(1815) FROM KBAR N TO ETA LAMBDA                 SQRT(P1*P5)        9/73
R6          -.096      .040     .020 RADER     73 MPWA                          9/73
R6          . . . . . . . . . .
R6  FIT      0.096     0.027  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R7      Y*0(1815) FROM KBAR N TO Y*1(1385) PI F-WAVE        SQRT(P1*P6)
R7          -.065      .029          CAMERON2  77 DPWA  0 K-P TO S(1385)PI  1/78*
R7          . . . . . . . . . .
R7  FIT      0.065     0.029  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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REFERENCES FOR Y*0(1815)


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BIRGE    65 ATHENS CONF  296  +ELY,KALMUS,KERNAN,LOUIE,SAHOURIA, +  (LRL)IJP
ARMENT-1 67 PL 24B 158        ARMENTEROS, F LUZZI, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 67 ZEIT PHYS 202 486 ARMENTEROS, F LUZZI, + (CERN,HEIDEL,SACLAY)IJP
BELL     67 PRL 19 936        R B BELL                              (LRL)IJP
ARMENT-3 68 NP B8 195         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-4 68 NP B8 216         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
BUGG     68 PR 168 1466       +GILMORE, KNIGHT,    +     (RHEL+BIRM+CAVE) I

BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
BRICMAN1 70 PL 33B 511        +FERRO-LUZZI,LAGNAUX                 (CERN)
COOL     70 PR D1 1887        +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                    (LRL)IJP

CONFORTO 71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
    ALSO 70 DUKE 161          J. K. KIM                            (HARV)IJP

KANE     72 PR D5 1583        D F KANE                              (LBL)IJP
LANGBEIN 72 NP B47 477        +WAGNER                              (MPIM)IJP
RADER    73 NC 16A 178        +BARLOUTAUD,+     (SACL+HEID+CERN+RHEL+CDEF)
PREVOST  74 NP B69 246        PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)

CAMERON2 77  RL-77-119/A      +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
DECLAIS  77  CERN 77-16       +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                       (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78  LBL-6784         +KENNEY,POLLARD,ROSS+      (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY     (LBL+MTHO+CERN)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS

THE FOLLOWING PAPERS ARE NOW OF ONLY HISTORICAL INTEREST --

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CHAMBERL 62 PR 125 1696       CHAMBERLAIN,CROWE,KEEFE,KERTH, +       (LRL) I
GALTIERI 63 PL 6 296          A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)IJ
SODICKSO 64 PR 133 B757       SODICKSON,MANNELLI,FRISCH,WAHLIG (MIT(BNL)) J
HOLLEY   65 UCRL-16274 THESIS W R HOLLEY                            (LRL) J
BIRMINGH 66 PR  152  1148     BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
COOL     66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LUNDBY +     (BNL)I
GELFAND  66 PRL 17 1224       +HARMSEN,LEVI-SETTI,PREDAZZI+      (EFI,ANL)
ARMENTER 67 NP B3 592         ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)IJP
CONFORTO 68 NP B8 265         +HARMSEN, LASINSKI, +       (CHICAGO,HEIDEL)IJP
LASINSKI 68 PR 163 1792       LASINSKI, LEVI SETTI, PREDAZZI    (CHICAGO) JP
PREVOST  71  AMSTERDAM CONF   + CHS COLLABORATION          (CERN+HEID+SACL)
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Λ(1830)   56 Y*0(1830, JP=5/2-) I=0 D_{05}

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THE BEST EVIDENCE FOR THIS RESONANCE COMES FROM THE SIGMA PI CHANNEL. IT IS WELL ESTABLISHED.

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                    56  Y*0(1830) MASS (MEV)

M    N      1827.0     (3.0)         ARMENTERO 67 HBC   0 K-P TO SIGMA PI    8/67
M    N      1837.0    (11.0)         BELL      67 HBC   0 K-P TO SIGMA PI   11/67
M    N      1807.0    (10.0)         ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
M           1840.0    (15.0)         GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
M    N      1831.0     (5.0)         CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
M           1830.                    KIM       71 DPWA    K-MATRIX ANAL.     3/71
M    K     (1720.)                   KIM       71 DPWA    K-MATRIX ANAL.     3/71
M           1832.0     (5.0)         KANE      72 DPWA  0 K-P TO PI SIG     10/71
M           1810.0    (10.0)         LANGBEIN  72 IPWA    MULTICHANNEL      12/72
M    1      1817. OR 1818.           MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
M    1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1825.     (10.)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M    K POSSIBLE EFFECT MAINLY IN SIGMA PI.  NOT CLEAR IF UNCORRELATED
M    K WITH THE 1830 EFFECT
M    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED  1/71

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                    56  Y*0(1830) WIDTH (MEV)

W             75.0      (9.0)        ARMENTERO 67 HBC   0 K-P TO SIGMA PI    8/67
W             74.0     (18.0)        BELL      67 HBC   0 K-P TO SIGMA PI    8/67
W            123.0     (32.0)        ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
W            150.0     (30.0)        GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
W            104.0     (35.0)        CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
W             80.                    KIM       71 DPWA    K-MATRIX ANAL.     3/71
W    K       (20.)                   KIM       71 DPWA    K-MATRIX ANAL.     3/71
W             88.0     (10.0)        KANE      72 DPWA  0 K-P TO PI SIG     10/71
W             60.0     (20.0)        LANGBEIN  72 IPWA    MULTICHANNEL      12/72
W    1        56. OR 56.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
W             94.      (10.)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
       SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                    56  Y*0(1830) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Y*0(1830) INTO KBAR N                            497+ 939
P2      Y*0(1830) INTO SIGMA PI                         1189+ 139
P3      Y*0(1830) INTO Y*1(1385) PI D-WAVE               139+1384
P4      Y*0(1830) INTO ETA LAMBDA                        548+1115

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                    56  Y*0(1830) BRANCHING RATIOS

R1      Y*0(1830) INTO (KBAR N)/TOTAL                      (P1)
R1            0.09     (0.01)        ARMENTERO 68 HBC   0 ELASTIC, CH EXCH 11/68
R1            0.03     (0.02)        BRICMAN1  70 DPWA    SIGTOT,ELAS,CHEX  1/71
R1            0.05     (0.02)        CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
R1           (0.24)                  KIM       71 DPWA    K-MATRIX ANAL.     3/71
R1            0.10     (0.03)        LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R1   1       (.04)OR .04             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R1             .04      (.03)        RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1             .02      (.02)        ALSTON    78 DPWA    KBAR N ELASTIC    1/78*

R2      Y*0(1830) FROM KBAR N INTO SIGMA PI                SQRT(P1*P2)
R2   A      (-0.15)    (0.02)        ARMENTERO 67 DPWA  0 K-P TO SIGMA PI   10/74
R2   A  PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT) 10/74
R2            0.19     (0.01)        BELL      67 DPWA  0 K-P TO SIGMA PI   11/67
R2           -0.16     (0.03)        GALTIERI  70 DPWA  0 K-P TO SIGMA PI    7/70
R2            0.15                   KIM       71 DPWA    K-MATRIX ANAL.     3/71
R2           -0.138    (0.018)       KANE      72 DPWA  0 K-P TO PI SIG     10/71
R2            0.27     (0.07)        LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R2   1      (-.17)OR -.17            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R2            -.17      (.03)        RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3      Y*0(1830) FROM KBAR N TO ETA LAMBDA                SQRT(P1*P4)         9/73
R3           -.044      .020         RADER     73 MPWA                          9/73

R4      Y*0(1830) FROM KBAR N TO Y*1(1385) PI D-WAVE       SQRT(P1*P3)
R4            +.13      .03          PREVOST   74 DPWA 0- K-N TO S(1385)PI 10/74
R4   2       -.141      .014         CAMERON2  77 DPWA  0 K-P TO S(1385)PI  1/78*
R4   2  CAMERON2 77 UPPER LIMIT ON G-WAVE DECAY IS 0.03                     1/78*
R4          . . . . . . . . . .
R4  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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REFERENCES FOR Y*0(1830)


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ARMENTER 67 PL 24B 198        ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
BELL     67 PRL 19 936        R B BELL                              (LRL)IJP
ARMENTER 68 NP B8 195         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
CONFORTO 68 NP B8 265         +HARMSEN, LASINSKI, +       (CHICAGO,HEIDEL)IJP
    IS SUPERSEDED BY CONFORTO 71.
BRICMAN1 70 PL 33B 511        +FERRO-LUZZI,LAGNAUX                 (CERN)
GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                    (LRL)IJP

CONFORTO 71 NP  B34  41       +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356        J K KIM                              (HARV)IJP
    ALSO 70 DUKE 161          J. K. KIM                            (HARV)IJP
KANE     72 PR D5 1583        D F KANE                              (LBL)IJP
LANGBEIN 72 NP B47 477        +WAGNER                              (MPIM)IJP
RADER    73 NC 16A 178        +BARLOUTAUD,+     (SACL+HEID+CERN+RHEL+CDEF)

PREVOST  74 NP B69 246        PREVOST,BARLOUTAUD,+        (SACL+CERN+HEID)

CAMERON2 77  RL-77-119/A      +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSC 77 NP B126 266       MARTIN,PIDCOCK                       (LOUC)
    ALSC 77 NP B126 285       MARTIN,PIDCOCK                       (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78  LBL-6784         +KENNEY,POLLARD,ROSS+      (LBL+MTHO+CERN)IJP
    ALSC 77 PRL 38 1007       ALSTON-GARNJOST,KENNEY     (LBL+MTHO+CERN)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS

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PREVOST  71  AMSTERDAM CONF   + CHS COLLABORATION          (CERN+HEID+SACL)
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Λ(1860)   60 Y*0(1860, JP=3/2+) I=0 P_{03}

THE JP=3/2+ ASSIGNMENT IS CONSISTENT WITH ALL AVAILABLE DATA (INCLUDING POLARIZATION) AND RECENT PARTIAL WAVE ANALYSES. THE DOMINANT INELASTIC MODES REMAIN UNKNOWN. SEE ALSO Y*0(2010) MINI-REVIEW.

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                    60  Y*0(1860) MASS (MEV)

M    A  F07 1864.0       2.0         ARMENTERO 68 DPWA  0 ELASTIC, CH EXCH 11/68
M     N     1870.0       5.0         BUGG      68 CNTR  0 K-P TOTAL         7/68
M    A  F07 1877.0       6.0         BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
M           1870.0       6.0         BRICMAN1  70 DPWA  0 SIGTOT,ELAS,CHEX  1/71
M     N     1883.0      10.0         CONFORTO  71 DPWA  0 ELASTIC, CH EXCH  6/70
M    1     (1710.)                   KIM       71 DPWA    K-MATRIX ANAL.     3/71
M           1850.0      20.0         LANGBEIN  72 IPWA    MULTICHANNEL      12/72
M     2    (1868.)                   LEA       73 DPWA    MULTICHNL K-MTRX  9/73
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Baryons

Λ(1860), Λ(1870), Λ(2010)


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M          1894.       10.              HEMINGWA  75 DPWA   0 K- P TO KBAR N    11/75
M     3   (1900.)                       NAKKASYA  75 DPWA   0 K-P TO LAM. OMG.  1/76
M          SEEN                         BACCARI   77 IPWA   0 K-P TO LAM. OMG.  1/78*
M     4    1856. OR 1868.               MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
M     4  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M     4  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1900.       5.               RLIC      77 DPWA     KBAR N MULTICHNL  1/76
M          1908.       10.              ALSTON    78 DPWA     KBAR N ELASTIC    1/78*
M   A    THESE TWO ANALYSES GAVE THE FOI ASSIGNMENT, THEY HAVE TO BE           1/71
M   A    DISCARDED IN VIEW OF CONFORTO 70 AND BRICMAN1 70
M   N    DUE TO PARTICULAR PARAMETERIZATION USED,ERROR CAN BE LARGE             1/71
M   1  POSSIBLE EFFECT MAINLY IN SIGMA PI. WE TENTATIVELY LIST IT HERE.
M   2    ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.      9/73
M   3    FOUND IN ONE OF TWO BEST SOLUTIONS.                                   1/76
M                . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)


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                        60  Y*0(1860) WIDTH (MEV)

W   A  FOI    39.0      7.0            ARMENTERO 68 DPWA   0 ELASTIC, CH EXCH 11/68
W    N         40.0      10.0           BUGG      68 CNTR   0 K-P TOTAL         7/68
W   A  FOI    24.0      15.0           BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
W              37.0      10.0           BRICMAN1  70 DPWA   0 SIGTOT,ELAS,CHEX  1/71
W    N         80.0      20.0           CONFORTO  71 DPWA   0 ELASTIC, CH EXCH  6/70
W   1        (20.)                      KIM       71 DPWA     K-MATRIX ANAL.    3/71
W              125.0     20.0           LANGBEIN  72 IPWA     MULTICHANNEL      12/72
W   2        (323.8)                    LEA       73 DPWA     MULTICHNL K-MTRX  9/73
W              107.      10.            HEMINGWA  75 DPWA   0 K- P TO KBAR N    11/75
W   3        (100.)                     NAKKASYA  75 DPWA   0 K-P TO LAM. OMG.  1/76
W   4        191. OR 193.               MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
W              72.       10.            RLIC      77 DPWA     KBAR N MULTICHNL  1/76
W              119.      20.            ALSTON    78 DPWA     KBAR N ELASTIC    1/78*
W         SEE THE NOTES ACCOMPANYING MASSES QUOTED
W                . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.8)

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                        60  Y*0(1860) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     Y*0(1860) INTO KBAR N                                     497+ 939
P2     Y*0(1860) INTO SIGMA PI                                  1189+ 139
P3     Y*0(1860) INTO LAMBDA OMEGA                              1115+ 783
P4     Y*0(1860) INTO Y*1(1385) PI P-WAVE                        139+1384
P5     Y*0(1860) INTO Y*1(1385) PI F-WAVE                        139+1384

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                        60  Y*0(1860) BRANCHING RATIOS

R1     Y*0(1860) INTO (KBAR N)/TOTAL                          (P1)
R1   A FOI     0.12      0.02           ARMENTERO 68 HBC    0 ELASTIC, CH EXCH 11/68
R1              (J+1/2)P1= 0.40         BUGG      68 CNTR   0                   7/68
R1   A FOI     0.07      0.02           BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
R1              0.14      0.02           BRICMAN1  70 DPWA   0 SIGTOT,ELAS,CHEX  1/71
R1   N         0.25      0.03           CONFORTO  71 DPWA   0 ELASTIC, CH EXCH  6/70
R1              0.37      0.05           LANGBEIN  72 IPWA     MULTICHANNEL      12/72
R1   2         (.32)                    LEA       73 DPWA     MULTICHNL K-MTRX  9/73
R1                .24       .04         HEMINGWA  75 DPWA   0 K- P TO KBAR N    11/75
R1   4         (.36)OR .34              MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
R1                .18       .02         RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R1                .34       .05         ALSTON    78 DPWA     KBAR N ELASTIC    1/78*
R1         SEE THE NOTES ACCOMPANYING MASSES QUOTED
R1                . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 2.6)

R2     Y*0(1860) INTO SIGMA PI                                (P2)
R2   P      PROBABLY SEEN              GALTIERI  68 DBC    0 K-N TO SIG PI PI 11/68
R2               (0.03) OR LESS        LANGBEIN  72 IPWA     MULTICHANNEL      12/72
R2   P  POSSIBLY THIS BUMP SEEN AT 1840+-10 MEV WITH A WIDTH OF 35+-10 MEV
R2     IS THE Y*0(1830), WHICH DECAYS STRONGLY TO SIGMA PI.  HOWEVER THE
R2     NARROW WIDTH HERE ARGUES FOR ITS BEING THE Y*0(1860).

R3     Y*0(1860) FROM KBAR N TO SIGMA PI                      SQRT(P1*P2)          9/73
R3   2         (+.15)                   LEA       73 DPWA     MULTICHNL K-MTRX  9/73
R3   4         (+.15)OR +.14            MARTIN    77 DPWA     KBAR N MULTICHNL 11/77*
R3                -.09      .03         RLIC      77 DPWA     KBAR N MULTICHNL  1/76

R4     Y*0(1860) FROM KBAR N INTO LAMBDA OMEGA                SQRT(P1*P3)          1/76
R4   3         (.032)                   NAKKASYA  75 DPWA   0 K-P TO LAM. OMG.  1/76

R5     Y*0(1860) FROM KBAR N INTO Y*1(1385) PI P-WAVE   SQRT(P1*P4)
R5          LESS THAN 0.03              CAMERON2  77 DPWA   0 K-P TO S(1385)PI  1/78*

R6     Y*0(1860) FROM KBAR N INTO Y*1(1385) PI F-WAVE   SQRT(P1*P5)
R6              +.126     .055          CAMERON2  77 DPWA   0 K-P TO S(1385)PI  1/78*

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                        REFERENCES FOR Y*0(1860)

ARMENTERO68 NP B8 195       ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BUGG     68 PR 168 1466     +GILMORE, KNIGHT, +          (RHEL,BIRM,CAVE) I
GALTIERI 68 PRL 21 573      BARBARO-GALTIERI, MATISON, +      (LRL,SLAC)

BRICMAN  70 PL 31B 152      +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
BRICMAN1 70 PL 33B 511      +FERRO-LUZZI,LAGNAUX                  (CERN)
CONFORTO 71 NP  B34  41     +LEVI SETTI,LASINSKI,.OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356      J K KIM                               (HARV)IJP
    ALSO 70 DUKE 161        J. K. KIM                             (HARV)IJP
LANGBEIN 72 NP B47 477      +WAGNER                               (MPIM)IJP

LEA      73 NP B56 77       +MARTIN,MOORHOUSE+  (RHEL+LOUC+GLAS+AARHUS)IJP
HEMINGWA 75 NP B91 12       HEMINGWAY,EADES,HARMSEN+    (CERN,HEID,MPIM)IJP
NAKKASYA 75 NP B93 85       A. NAKKASYAN                          (CERN)IJP

CAMERON2 77  RL-77-119/A    +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
MARTIN   77 NP B127 349     MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
    ALSO 77 NP B126 266     MARTIN,PIDCOCK                        (LOUC)
    ALSC 77 NP B126 285     MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362     GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78  LBL-6784       +KENNEY,POLLARD,ROSS+         (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007     ALSTON-GARNJOST,KENNEY        (LBL+MTHO+CERN)IJP

                        PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 67 NP B3 592       ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
    REPLACED BY ARMENTEROS 68 AND CONFORTO 68.
CONFORTO 68 NP B8 265       +HARMSEN, LASINSKI, +       (CHICAGO,HEIDEL)IJP
    SUPERSEDED BY CONFORTO 71.
LEVISETT 69 LUND 339        R.LEVI SETTI  (RAPPORTEUR)            (EFI)
ALBROW   71 NP  B29 413     +ANDERSON,BOSNJAKOVIC,DAUM,ERNZ,+     (CERN)
BACCARI  77 NC 41A 96       +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP


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Λ(1870)                 36  Y*0(1870, JP=1/2-) I=0          S01

                        THE S01 AMPLITUDE SHOWS A RATHER CLEAR SECOND RESONANCE
                        BEHAVIOR IN THE 1700-1900 MEV REGION.  THERE ARE WIDE
                        DISAGREEMENTS AMONG THE MASS, WIDTH, AND COUPLING
                        DETERMINATIONS.

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                        36  Y*0(1870) MASS (MEV)

M          (1872.0)   (10.0)           BRICMAN   70 DPWA   TOT, ELAS, CHEX     1/71
M          (1780.)                    KIM       71 DPWA   K-MATRIX ANAL.      3/71
M           1830.0    (20.0)          LANGBEIN  72 IPWA   MULTICHANNEL        12/72
M   1    1767. OR 1842.               MARTIN    77 DPWA   KBAR N MULTICHNL   11/77*
M   1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M   1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1825.      (20.)           RLIC      77 DPWA   KBAR N MULTICHNL    1/76
M          1725.      (20.)           ALSTON    78 DPWA   KBAR N ELASTIC      1/78*

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                        36  Y*0(1870) WIDTH (MEV)

W          (100.0)    (20.0)          BRICMAN   70 DPWA   TOT, ELAS, CHEX     1/71
W           (40.)                     KIM       71 DPWA   K-MATRIX ANAL.      3/71
W           70.0      (15.0)          LANGBEIN  72 IPWA   MULTICHANNEL        12/72
W   1      435. OR 473.               MARTIN    77 DPWA   KBAR N MULTICHNL   11/77*
W          230.       (20.)           RLIC      77 DPWA   KBAR N MULTICHNL    1/76
W          185.       (20.)           ALSTON    78 DPWA   KBAR N ELASTIC      1/78*

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                        36  Y*0(1870) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     Y*0(1870) INTO KBAR N                                     497+ 939
P2     Y*0(1870) INTO SIGMA PI                                  1197+ 139
P3     Y*0(1870) INTO Y*1(1385) PI                               139+1384

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                        36  Y*0(1870) BRANCHING RATIOS

R1     Y*0(1870) INTO (KBAR N)/TOTAL                          (P1)
R1          (0.18)    (0.02)          BRICMAN   70 DPWA   TOT, ELAS, CHEX     1/71
R1          (0.80)                    KIM       71 DPWA   K-MATRIX ANAL.      3/71
R1           0.35     (0.15)          LANGBEIN  72 IPWA   MULTICHANNEL        12/72
R1   1      (1.21)OR .70               MARTIN    77 DPWA   KBAR N MULTICHNL   11/77*
R1            .37       (.05)         RLIC      77 DPWA   KBAR N MULTICHNL    1/76
R1            .28       (.05)         ALSTON    78 DPWA   KBAR N ELASTIC      1/78*

R2     Y*0(1870) FROM KBAR N TO SIGMA PI                      SQRT(P1*P2)
R2          (0.24)                    KIM       71 DPWA   K-MATRIX ANAL.      3/71
R2   1      (-.74)OR -.43             MARTIN    77 DPWA   KBAR N MULTICHNL   11/77*
R2            -.08      (.05)         RLIC      77 DPWA   KBAR N MULTICHNL    1/76

R3     Y*0(1870) FROM KBAR N INTO Y*1(1385) PI          SQRT(P1*P3)
R3            -.056      .028         CAMERON2  77 DPWA   0 K-P TO S(1385)PI  1/78*

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                        REFERENCES FOR Y*0(1870)

BRICMAN  70 PL 33B 511      C BRICMAN, M FERRO-LUZZI, J P LAGNAUX(CERN)IJP
KIM      71 PRL 27 356      J K KIM                               (HARV)IJP
    ALSO 70 DUKE 161        J. K. KIM                             (HARV)IJP
LANGBEIN 72 NP B47 477      +WAGNER                               (MPIM)IJP

CAMERON2 77  RL-77-119/A    +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
MARTIN   77 NP B127 349     MARTIN,PIDCOCK,+MOORHOUSE         (LOUC+GLAS)IJP
    ALSO 77 NP B126 266     MARTIN,PIDCOCK                        (LOUC)
    ALSO 77 NP B126 285     MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362     GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78  LBL-6784       +KENNEY,POLLARD,ROSS+         (LBL+MTHO+CERN)IJP
    ALSO 77 PRL 38 1007     ALSTON-GARNJOST,KENNEY        (LBL+MTHO+CERN)IJP


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Λ(2010)                 89  Y*0(2010,       ) I=0

                        SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                        SEVERAL AMBIGUOUS RESONANCE POSSIBILITIES ARISE FROM
                        THE ANALYSES LISTED HERE.  POSSIBLE QUANTUM NUMBERS
                        ARE D3 (GALTIERI 70, SIGMA PI), D3+F5 OR P3+D5 OR
                        P1+D3 (BRANDSTETTER 72, LAMBDA OMEGA).  A MORE RECENT
    LAMBDA OMEGA ANALYSIS (NAKKASYAN 75) FINDS TWO BEST SOLUTIONS, EACH
    WITH THE Y*0(2100) AND ONE ADDITIONAL RESONANCE WHICH CAN BE EITHER
    THE Y*0(1860,JP=3/2+) OR THE Y*0(2110,JP=5/2+).

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                        89  Y*0(2010) MASS (MEV)

M          (2010.0)   (30.0)          GALTIERI  70 DPWA   0 K-P TO SIGMA PI   7/70
M   1      1935. TO 1971.             BRANDSTE  72 DPWA   0 K-P TO LAM. OMG.  1/74
M   1      1951. TO 2034.             BRANDSTE  72 DPWA   0 K-P TO LAM. OMG.  1/74
M   1  PARAMETERS QUOTED ARE RANGES FROM THREE BEST FITS, THE LOWER          11/75
M   1  (HIGHER) MASS STATE PROBABLY HAS J.LE.3/2(5/2).                       11/75

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Data Card Listings

For notation, see key at front of Listings.

89 Y*0(2010) WIDTH (MEV)

W		(130.0)	(50.0)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70
W	1	180. TO 240. (LWR. MASS)		BRANDSTE	72 DPWA	0 K-P TO LAM. OMG.		1/74
W	1	73. TO 154. (HGR. MASS)		BRANDSTE	72 DPWA	0 K-P TO LAM. OMG.		1/74

SEE THE NOTES ACCOMPANYING MASSES QUOTED

89 Y*0(2010) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*0(2010) INTO KBAR N	497+ 939
P2	Y*0(2010) INTO SIGMA PI	1197+ 139
P3	Y*0(2010) INTO LAMBDA OMEGA	1115+ 783

89 Y*0(2010) BRANCHING RATIOS

R1	Y*0(2010) FROM KBAR N TO SIGMA PI					SQRT(P1*P2)		
R1		(-0.20)	(0.04)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70
R2	Y*0(2010) FROM KBAR N INTO LAMBDA OMEGA					SQRT(P1*P3)		
R2	1	(.17) TO .25 (LWR.)		BRANDSTE	72 DPWA	0 K-P TO LAM. OMG.		1/74
R2	1	(.04) TO .15 (HGR.)		BRANDSTE	72 DPWA	0 K-P TO LAM. OMG.		1/74

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REFERENCES FOR Y*0(2010)

GALTIERI 70 DUKE CONF 173 — A BARBARO-GALTIERI (LRL)IJP
BRANDSTE 72 NP B39 13 — BRANDSTETTER,BUTTERWORTH,+ (RHEL+CDEF+SACL)

PAPERS NOT REFERRED TO IN DATA CARDS.

NAKKASYA 75 NP B93 85 — A. NAKKASYAN (CERN)IJP

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Λ(2020)

27 Y*0(2020, JP=7/2+) I=0 **F07**

EFFECTS IN THIS PARTIAL WAVE HAVE OBSERVED AT SOMEWHAT DIFFERENT ENERGIES IN TWO CHANNELS. HOWEVER, LITCHFIELD 71 NOTE THAT THE NEED FOR THIS STATE IN THEIR ANALYSIS RESTS SOLELY ON A POSSIBLY INCONSISTENT POLARIZATION MEASUREMENT AT 1.784 GEV/C. THE STATE WAS NOT REQUIRED IN THE KBAR N TO KBAR N ANALYSIS OF HEMINGWAY 75, BUT COULD NOT BE CONCLUSIVELY RULED OUT. IT IS NOW SEEN IN THE NEW ANALYSIS OF DECLAIS 77 WHICH INCLUDES K- NEUTRON ELASTIC DIFFERENTIAL CROSS SECTION DATA, AND IS WEAKLY SUPPORTED BY BACCARI 77.

27 Y*0(2020) MASS (MEV)

M		(2020.0)	(20.0)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70
M		(2100.)	(30.)	LITCHFIE	71 DPWA	K-P TO KBAR N		10/71
M		(2140.)		BACCARI	77 DPWA	0 K-P TO LAM. OMG.		1/78*
M		(2117.)		DECLAIS	77 DPWA	KBAR N TO KBAR N		1/78*

27 Y*0(2020) WIDTH (MEV)

W		(160.0)	(30.0)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70
W		(120.)	(30.)	LITCHFIE	71 DPWA	K-P TO KBAR N		10/71
W		(128.)		BACCARI	77 DPWA	0 K-P TO LAM. OMG.		1/78*
W		(167.)		DECLAIS	77 DPWA	KBAR N TO KBAR N		1/78*

27 Y*0(2020) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*0(2020) INTO KBAR N	497+ 939
P2	Y*0(2020) INTO SIGMA PI	1197+ 139
P3	Y*0(2020) INTO LAMBDA OMEGA	1115+ 783

27 Y*0(2020) BRANCHING RATIOS

R1	Y*0(2020) INTO (KBAR N)/TOTAL					(P1)		
R1		(0.05)	(0.02)	LITCHFIE	71 DPWA	K-P TO KBAR N		10/71
R1		(.05)		DECLAIS	77 DPWA	KBAR N TO KBAR N		1/78*
R2	Y*0(2020) FROM KBAR N TO SIGMA PI					SQRT(P1*P2)		
R2		(-0.15)	(0.02)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70
R3	Y*0(2020) FROM KBAR N TO LAMBDA OMEGA					SQRT(P1*P3)		1/78*
R3	LESS THAN .05			BACCARI	77 DPWA	0 K-P TO LAM. OMG.		1/78*

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REFERENCES FOR Y*0(2020)

GALTIERI 70 DUKE CONF 173 — A BARBARO-GALTIERI (LRL)IJP
LITCHFIE 71 NP B30 125 — LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

BACCARI 77 NC 41A 96 — +POULARD,REVEL,TALLINI+ (SACL+CDEF)IJP
DECLAIS 77 CERN 77-16 — +DUCHON,LOUVEL,PATRY,SEGUINOT+ (CAEN+CERN)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

HEMINGWA 75 NP B91 12 — HEMINGWAY,EADES,HARMSEN+ (CERN,HEID,MPIM)IJP

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Λ(2100)

41 Y*0(2100, JP=7/2-) I=0 **G07**

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE ANALYSES. PARAMETERS OF PEAKS SEEN IN CROSS-SECTIONS AND INVARIANT-MASS DISTRIBUTIONS AROUND 2100 MEV ARE GIVEN IN A SEPARATE ENTRY BELOW.

41 Y*0(2100) MASS (MEV)

M		(2120.0)		WOHL	66 HBC	K-P CH EX		7/66
M	A	(2080.0)	(10.0)	BURGUN	68 DPWA	0 K-P TO XI K		10/69
M	L	(2130.0)	(20.0)	BERTHON1	70 DPWA	0 K-P TO SIGMA PI		10/70
M		2110.0	(20.0)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70
M		2100.	(15.)	LITCHFIE	71 DPWA	K-P TO KBAR N		10/71
M	L	2110.0	(30.0)	LITCHFIE	71 DPWA	K-P TO SIG PI		10/71
M	1	2113. TO 2154.		BRANDSTE	72 DPWA	0 K-P TO LAM. OMG.		1/74
M		2092.0	(12.0)	KANE	72 DPWA	0 K-P TO PI SIG		10/71
M		2105.	(10.)	HEMINGWA	75 DPWA	0 K- P TO KBAR N		11/75
M	2	2110. OR 2089.		NAKKASYA	75 DPWA	0 K-P TO LAM. OMG.		11/75
M	3	(2094.)		BACCARI	77 DPWA	0 K-P TO LAM. OMG.		1/78*
M		(2094.)		DECLAIS	77 DPWA	KBAR N TO KBAR N		1/78*
M		2110.	(10.)	RLIC	77 DPWA	KBAR N MULTICHNL		1/76
M		2106.	(30.)	BELLEFON	78 DPWA	0 KBAR N TO KBAR N		1/78*
M	2	QUOTED PARAMETERS CORRESPOND TO THE TWO BEST SOLUTIONS FOUND.						11/75
M	2	EACH HAS THE Y*0(2100) AND ONE ADDITIONAL RESONANCE (P3 OR F5).						11/75
M	A	BURGUN 68 SEE A RESONANCE-LIKE EFFECT IN THIS REGION IN THE REACTION K-P TO XI K. HOWEVER, AS THEY POINT OUT, IT IS NOT CLEAR WHETHER IT IS MAINLY THE G07 Y*0(2100) OR INSTEAD A SO FAR OTHERWISE UNOBSERVED RESONANCE WITH A SPIN LESS THAN 7/2.						
M	L	LITCHFIELD 71 IS AN UPDATE OF BERTHON1 70						3/72
M	1	PARAMETERS QUOTED ARE RANGES FROM THREE BEST FITS.						1/74

41 Y*0(2100) WIDTH (MEV)

W		(145.0)		WOHL	66 HBC			7/66
W	A	(80.0)	(10.0)	BURGUN	68 DPWA	0 K-P TO XI K		10/69
W		140.0	(15.0)	BERTHON1	70 DPWA	0 K-P TO SIGMA PI		10/70
W		60.0	(25.0)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70
W	B	(170.) TO 300.	.	LITCHFIE	71 DPWA	K-P TO KBAR N		10/71
W	B	LARGER VALUE CORRESPONDS TO PURE B.W. LOWER VALUE , TO B.W. + BCKGRD						
W	L	140.0	(50.0) (30.0)	LITCHFIE	71 DPWA	K-P TO SIG PI		10/71
W	1	208. TO 229.		BRANDSTE	72 DPWA	0 K-P TO LAM. OMG.		1/74
W		144.0	(26.0)	KANE	72 DPWA	0 K-P TO PI SIG		10/71
W		241.	(30.)	HEMINGWA	75 DPWA	0 K- P TO KBAR N		11/75
W	2	244. OR 302.		NAKKASYA	75 DPWA	0 K-P TO LAM. OMG.		11/75
W	3	(98.)		BACCARI	77 DPWA	0 K-P TO LAM. OMG.		1/78*
W		(250.)		DECLAIS	77 DPWA	KBAR N TO KBAR N		1/78*
W		250.	(30.)	RLIC	77 DPWA	KBAR N MULTICHNL		1/76
W		157.	(40.)	BELLEFON	78 DPWA	0 KBAR N TO KBAR N		1/78*

SEE THE NOTES ACCOMPANYING MASSES QUOTED

41 Y*0(2100) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*0(2100) INTO KBAR N	497+ 939
P2	Y*0(2100) INTO SIGMA PI	1197+ 139
P3	Y*0(2100) INTO XI K	1321+ 497
P4	Y*0(2100) INTO LAMBDA OMEGA	1115+ 783
P5	Y*0(2100) INTO ETA LAMBDA	548+1115

41 Y*0(2100) BRANCHING RATIOS

R1	Y*0(2100) INTO (KBAR N)/TOTAL					(P1)		
R1		(0.25)		WOHL	66 HBC			7/66
R1	D	(0.33)		DAUM	68 CNTR	K-P ELA,POL,SIGT		7/70
R1		0.30	(.03)	LITCHFIE	71 DPWA	K-P TO KBAR N		10/71
R1		.31	(.03)	HEMINGWA	75 DPWA	0 K- P TO KBAR N		11/75
R1		(.29)		DECLAIS	77 DPWA	KBAR N TO KBAR N		1/78*
R1		.30	(.03)	RLIC	77 DPWA	KBAR N MULTICHNL		1/76
R1		.24	(.06)	BELLEFON	78 DPWA	0 KBAR N TO KBAR N		1/78*
R1	D	DAUM 68 ASSUMES (J+1/2)*X VALUE SEEN IN TOTAL CROSS SECTION.						
R2	Y*0(2100) FROM KBAR N INTO SIGMA PI					SQRT(P1*P2)		
R2	L	(+0.16)	(0.02)	BERTHON1	70 DPWA	0 K-P TO SIGMA PI		10/70
R2		+0.06	(0.03)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70
R2	L	0.16	(0.05)	LITCHFIE	71 DPWA	K-P TO SIG PI		10/71
R2		+0.096	(0.037)	KANE	72 DPWA	0 K-P TO PI SIG		10/71
R2		+.12	(.04)	RLIC	77 DPWA	KBAR N MULTICHNL		1/76
R3	Y*0(2100) FROM KBAR N TO XI K					SQRT(P1*P3)		
R3		(0.05)		TRIPP	67 RVUE	0 K-P TO XI K		8/67
R3	B	(0.09)	(0.01)	BURGUN	68 DPWA	0 K-P TO XI K		10/69
R3		(0.003)		MULLER	69 DPWA	0		7/70
R3		0.035	0.C18	LITCHFIE	71 DPWA	K-P TO XI K		3/72
R3	B	BURGUN 68 UPDATED BY LITCHFIELD 71, WHO TAKES SOLUTION C OF BURGUN						3/72
R4	Y*0(2100) FROM KBAR N INTO LAMBDA OMEGA					SQRT(P1*P4)		
R4	1	(.05) TO .11		BRANDSTE	72 DPWA	0 K-P TO LAM. OMG.		1/74
R4	2	(.122)OR .154		NAKKASYA	75 DPWA	0 K-P TO LAM. OMG.		11/75
R4	3	(-.070)		BACCARI	77 DPWA	0 GD3T-WAVE		1/78*
R4	3	(+.011)		BACCARI	77 DPWA	0 GG17-WAVE		1/78*
R4	3	(+.008)		BACCARI	77 DPWA	0 GG37-WAVE		1/78*
R4	3	NOTE THAT THE 3 ENTRIES FOR BACCARI77 ARE FOR 3 DIFFERENT WAVES.						1/78*
R5	Y*0(2100) FROM KBAR N TO ETA LAMBDA					SQRT(P1*P5)		9/73
R5		-.050	.020	RADER	73 MPWA			9/73

SEE THE NOTES ACCOMPANYING MASSES QUOTED

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REFERENCES FOR Y*0(2100)

WOHL 66 PRL 17 107 — C G WOHL, F T SOLMITZ, M L STEVENSON (LRL)IJP
TRIPP 67 NP B3 10 — + LEITH, + (LRL,SLAC,CERN,HEIDEL,SACLAY)
BURGUN 68 NP B8 447 — +MEYER,PAULI, + (SACLAY,COLFRANCE,RHEL)
DAUM 68 NP B7 19 — +ERNE, LAGNAUX, SENS, STEUER, UDO (CERN)JP
CONFIRMS THE SPIN-PARITY ASSIGNMENT.
MULLER 69 THESIS,UCRL 19372 R A MULLER (LRL)

Baryons

Λ(2100), Λ(2110), Λ(2325)

Data Card Listings

For notation, see key at front of Listings.

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BERTHON1 70 NP 824 417          +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)IJP
GALTIERI 70 DUKE CONF 173       A BARBARO-GALTIERI                  (LRL)IJP
LITCHFIE 71 NP  B30 125         LITCHFIELD,...+LESQUOY,+... (RHEL+CDEF+SACL)IJP

BRANDSTE 72 NP B39 13           BRANDSTETTER+...+TALLINI    (RHEL,CDEF,SACL) IJP
KANE     72 PR D5 1583          D F KANE                            (LBL)IJP
RADER    73 NC 16A 178          +BARLOUTAUD,+      (SACL+HEID+CERN+RHEL+CDEF)

HEMINGWA 75 NP B91 12           HEMINGWAY,EADES,HARMSEN+    (CERN,HEID,MPIM)IJP
NAKKASYA 75 NP B93 85           A. NAKKASYAN                        (CERN)IJP

BACCARI  77 NC 41A 96           +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
DECLAIS  77  CERN 77-16         +DUCHON,LOUVEL,PATRY,SEGUINOT+   (CAEN+CERN)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
BELLEFON 78 NC 42A 403          +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP
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Λ(2110)

35 Y*0(2110, JP=5/2+) I=0 — F''_{05}

BERTHON1 70 FIND EITHER F05 OR D05 POSSIBLE IN THE SIG PI CHANNEL, WITH F05 SLIGHTLY PREFERRED. IN THE KBAR N CHANNEL, LITCHFIELD 71 (SAME GROUP) FIND ONLY D05. AS USUAL, THE STATISTICS ARE MUCH BETTER IN THE ELASTIC CHANNEL.

ALTHOUGH KANE 72 FINDS AN F05 EFFECT, THE UNUSUALLY BROAD WIDTH MAY INVALIDATE A RESONANT INTERPRETATION. HOWEVER RLIC 77, BELLEFON 77, AND BELLEFON 78 ALSO FIND AN F05. THE EVIDENCE FOR F05 FROM THE LAMBDA OMEGA ANALYSES, NAKKASYAN 75 AND BACCARI 77, IS QUITE WEAK, BUT THEY GIVE NO EVIDENCE IN FAVOR OF D05. THE WEIGHT OF THE EVIDENCE IS THUS IN FAVOR OF F05. SEE ALSO THE Y*0(2010) MINI-REVIEW.

35 Y*0(2110) MASS (MEV)

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M          (2110.)     (10.)          BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
M      D05 2140.       40.           LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
M    A     (2141.0)    (6.0)         KANE      72 DPWA  0 K-P TO PI SIG     10/71
M    1     (2103.)                   NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76
M          (2137.)                   BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78*
M          (2140.)     (20.)         BELLEFON  77 DPWA  0 K- P TO SIG PI    11/77*
M          (2100.)     (50.)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M    2     (2106.)     (50.)         BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78*
M    A  RESONANCE OUTSIDE RANGE OF DATA.
M    1  FOUND IN ONE OF TWO BEST SOLUTIONS.                                  1/76
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35 Y*0(2110) WIDTH (MEV)

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W          (185.)      (30.)          BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
W      D05  120.       40.           LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
W    A     (504.0)     (10.0)        KANE      72 DPWA  0 K-P TO PI SIG     10/71
W    1     (391.)                    NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76
W          (132.)                    BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78*
W          (140.)      (20.)         BELLEFON  77 DPWA  0 K- P TO SIG PI    11/77*
W          (200.)      (50.)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W    2     (251.)      (50.)         BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78*
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35 Y*0(2110) PARTIAL DECAY MODES

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                                                          DECAY MASSES
P1     Y*0(2110) INTO KBAR N                               497+ 939
P2     Y*0(2110) INTO SIGMA PI                            1197+ 139
P3     Y*0(2110) INTO LAMBDA OMEGA                        1115+ 783
P4     Y*0(2110) INTO Y*1(1385) PI P-WAVE                  139+1384
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35 Y*0(2110) BRANCHING RATIOS

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R1     Y*0(2110) FROM KBAR N TO SIGMA PI                  SQRT(P1*P2)
R1          (+.17)      (.03)         BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
R1   A      (+0.156)    (0.013)       KANE      72 DPWA  0 K-P TO PI SIG     10/71
R1          (+.14)      (.01)         BELLEFO2  76 DPWA  0 K- P TO SIG PI    1/76
R1          (+.10)      (.03)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2     Y*0(2110) INTO (KBAR N)/TOTAL                      (P1)
R2     D05   0.14       0.04          LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
R2           (.07)       (.03)         RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2   2       (.27)       (.6)          BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78*
R2   2  THE LARGE ELASTICITY ERROR OF BELLEFON 78 IS PROBABLY A MISPRINT.      1/78*

R3     Y*0(2110) FROM KBAR N INTO LAMBDA OMEGA            SQRT(P1*P3)          1/76
R3   1       (.112)                   NAKKASYA  75 DPWA  0 K-P TO LAM. OMG.  1/76
R3        LESS THAN .05               BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78*

R4     Y*0(2110) FROM KBAR N TO Y*1(1385) PI P-WAVE       SQRT(P1*P4)
R4   2       -.071       .025          CAMERON2  77 DPWA  0 K-P TO S(1385)PI  1/78*
R4   2  CAMERON2 77 UPPER LIMIT ON F-WAVE DECAY IS 0.03                        1/78*
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REFERENCES FOR Y*0(2110)

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BERTHON1 70 NP B24 417          +VRANA,BUTTERWORTH,+      (CDEF,RHEL,SACLAY)IJP
LITCHFIE 71 NP  B30 125         LITCHFIELD,...+LESQUOY,+... (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583          D F KANE                            (LBL)IJP

NAKKASYA 75 NP B93 85           A. NAKKASYAN                        (CERN)IJP
BACCARI  77 NC 41A 96           +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
BELLEFON 77 NC 37A 175          DE BELLEFON,BERTHON,BILLOIR+     (CDEF+SACL)IJP
CAMERON2 77  RL-77-119/A        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
RLIC     77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP
BELLEFON 78 NC 42A 403          +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP
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2100 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

25 Y*0(2100, JP=) I=0 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

SEE THE NOTE TO THE G07 Y*0(2100), WHICH PRECEDES THIS ENTRY. HERE WE LIST ONLY PARAMETERS OF PEAKS IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. THE CROSS-SECTION PEAKS ARE AT LEAST DOMINANTLY ASSOCIATED WITH THE Y*0(2100), BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTABLISHED OTHER RESONANCES IN THIS REGION.

25 Y*0(2100) MASS (MEV) (PROD. EXP.)

```
M          (2097.0)    (6.0)          BOCK      65 HBC     PBAR P 5.7 BEV/C  7/66
M           2100.0     (7.0)          BUGG      68 CNTR    K-P, D TOTAL      6/68
M           2121.0     (5.0)          BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
M           2107.0     (10.0)         COOL      70 CNTR    K-P, D TOTAL      10/70
M          (2135.0)    (20.0)         LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71
```

25 Y*0(2100) WIDTH (MEV) (PROD. EXP.)

```
W           (24.0)     (14.0)  (24.0) BOCK      65 HBC     INTO KBAR N (P1)  7/66
W           140.0      (15.0)         BUGG      68 CNTR                      6/68
W           147.0      (15.0)         BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
W           185.0                     COOL      70 CNTR    K-P, D TOTAL      10/70
W           (40.0)                    LU        70 CNTR  0 GAMMA P TO K+ Y*  1/71
```

25 Y*0(2100) PARTIAL DECAY MODES (PROD. EXP.)

```
                                                          DECAY MASSES
P1     Y*0(2100) INTO KBAR N                               497+ 939
P2     Y*0(2100) INTO KBAR N PI                            497+ 939+ 139
P3     Y*0(2100) INTO LAMBDA ETA                          1115+ 548
P4     Y*0(2100) INTO LAMBDA OMEGA                        1115+ 783
```

25 Y*0(2100) BRANCHING RATIOS (PROD. EXP.)

```
R1     Y*0(2100) INTO (KBAR N)/TOTAL                      (P1)
R1       THESE VALUES OF ELASTICITIES ASSUME J=7/2 --
R1          0.305                  BUGG      68 CNTR                      6/68
R1          0.24    (0.02)         BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
R1          0.4                    COOL      70 CNTR    K-P, D TOTAL      10/70

R2     Y*0(2100) INTO KBAR N PI                           (P2)
R2          SEEN                   BOCK      65 HBC

R3     Y*0(2100) FROM KBAR N INTO LAMBDA ETA              SQRT(P1*P3)
R3          (0.09) OR LESS         FLATTE 2  67 HBC   0 K-P TO LAM ETA     6/68

R4     Y*0(2100) INTO (LAMBDA OMEGA)/TOTAL                (P4)
R4          (0.1)  OR LESS         FLATTE 1  67 HBC   0 K-P TO LAM OMEGA    8/67
```

REFERENCES FOR Y*0(2100) (PROD. EXP.)

```
BOCK     65 PL 17 166           +COOPER,FRENCH,KINSON, +        (CERN,SACLAY)
FLATTE 1 67 PR 155 1517         S M FLATTE                            (LRL)
FLATTE 2 67 PR 163 1441         S M FLATTE, G G WOHL                  (LRL)
BUGG     68 PR 168 1466         +GILMORE,KNIGHT, +          (RHEL,BIRM,CAVE) I

BRICMAN  70 PL 31B 152          +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR D1 1867          +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
LU       70 PR D2 1846          +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

                                PAPERS NOT REFERRED TO IN DATA CARDS

COOL     66 PRL 16 1228         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
```

Λ(2325)

112 Y*0(2325, JP=3/2-) I=0 — D''_{03}

BACCARI 77 FIND THIS STATE WITH JP EITHER 3/2- OR 3/2+ IN A DPWA OF K- P TO LAMBDA OMEGA FROM 2070 TO 2436 MEV. A SUBSEQUENT SEMI-ENERGY-INDEPENDENT PWA FROM THRESHOLD TO 2436 MEV SELECTS 3/2-. BELLEFON 78 (SAME GROUP) ALSO SEE THIS STATE IN A DPWA OF K- P ELASTIC AND CHARGE-EXCHANGE DATA IN THE SAME ENERGY RANGE, AND FIND JP=3/2- OR 3/2+. THEY AGAIN PREFER JP=3/2-, BUT ONLY ON THE BASIS OF MODEL DEPENDENT CONSIDERATIONS.

112 Y*0(2325) MASS (MEV)

```
M    3     2327.       20.           BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78*
M          2342.       30.           BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78*
M          . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
```

112 Y*0(2325) WIDTH (MEV)

```
W    3     160.        40.           BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78*
W          177.        40.           BELLEFON  78 DPWA  0 KBAR N TO KBAR N   1/78*
W          . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
```

```
               112  Y*0(2325) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      Y*0(2325) INTO KBAR N                             497+ 939
P2      Y*0(2325) INTO LAMBDA OMEGA                       1115+ 783

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               112  Y*0(2325) BRANCHING RATIOS

R1      Y*0(2325) FROM KBAR N TO LAMBDA OMEGA             SQRT(P1*P2)
R1   3          .06       .02          BACCARI   77 IPWA  0 DS33-WAVE       1/78*
R1   3          .05       .02          BACCARI   77 DPWA  0 DD13-WAVE       1/78*
R1   3          .08       .03          BACCARI   77 DPWA  0 DD33-WAVE       1/78*
R1   3  NOTE THAT THE 3 ENTRIES FOR BACCARI77 ARE FOR 3 DIFFERENT WAVES.    1/78*
R1             . . . . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R2      Y*0(2325) INTO (KBAR N)/TOTAL                     P1
R2              .19       .06          BELLEFON  78 DPWA  0 KBAR N TO KBAR N  1/78*

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                        REFERENCES FOR Y*0(2325)

BACCARI  77 NC 41A 96         +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
BELLEFON 78 NC 42A 403        +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP

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Λ(2350) BUMPS

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         42  Y*0(2350, JP=    ) I=0        PRODUCTION EXPERIMENTS

         SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

         DAUM 68 FAVORS JP=7/2- OR 9/2+. BRICMAN 70 FAVORS 9/2+.
         LASINSKI 71 SUGGESTS THREE STATES IN THIS REGION
         USING A POMERON + RESONANCES MODEL.  THERE ARE NOW ALSO
   THREE FORMATION EXPERIMENTS FROM THE COLLEGE DE FRANCE-SACLAY GROUP
   WHICH WE INCLUDE HERE, BELEFON 77, BACCARI 77, AND BELLEFON 78, WHICH
   FIND 9/2+ IN DPWAS OF KBAR N TO SIGMA PI, LAMBDA OMEGA, AND KBAR N.

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               42  Y*0(2350) MASS (MEV) (PROD. EXP.)

M         2340.0     (7.0)          BUGG      68 CNTR   K-P, D TOTAL      6/68
M         2358.0     (6.0)          BRICMAN   70 CNTR 0 TOTAL AND CH EX   6/70
M         2344.0    (15.0)          COOL      70 CNTR   K-P, D TOTAL     10/70
M        (2360.0)   (20.0)          LU        70 CNTR 0 GAMMA P TO K+ Y*  1/71
M        (2372.)                    BACCARI   77 DPWA 0 K-P TO LAM. OMG.  1/78*
M         2365.      20.            BELLEFON  77 DPWA 0 K- P TO SIG PI   11/77*
M         2370.      50.            BELLEFON  78 DPWA 0 KBAR N TO KBAR N  1/78*
M            . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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               42  Y*0(2350) WIDTH (MEV) (PROD. EXP.)

W          140.0    (20.0)          BUGG      68 CNTR   K-P, D TOTAL      6/68
W          324.0    (30.0)          BRICMAN   70 CNTR 0 TOTAL AND CH EX   6/70
W         (190.0)                   COOL      70 CNTR   K-P, D TOTAL     10/70
W          (55.0)                   LU        70 CNTR 0 GAMMA P TO K+ Y*  1/71
W         (257.)                    BACCARI   77 DPWA 0 K-P TO LAM. OMG.  1/78*
W          110.      20.            BELLEFON  77 DPWA 0 K- P TO SIG PI   11/77*
W          204.      50.            BELLEFON  78 DPWA 0 KBAR N TO KBAR N  1/78*
W            . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)

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               42  Y*0(2350) PARTIAL DECAY MODES (PROD. EXP.)

                                                           DECAY MASSES
P1      Y*0(2350) INTO KBAR N                             497+ 939
P2      Y*0(2350) INTO SIGMA PI                           1197+ 139
P3      Y*0(2350) INTO LAMBDA OMEGA                       1115+ 783

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               42  Y*0(2350) BRANCHING RATIOS (PROD. EXP.)

R1      Y*0(2350) INTO (KBAR N)/TOTAL                     (P1)
R1              .12       .04          BELLEFON  78 DPWA  0 KBAR N TO KBAR N  1/78*

R2      Y*0(2350) FROM KBAR N INTO SIGMA PI               SQRT(P1*P2)         1/76
R2             -.11       .02          BELLEFON  77 DPWA  0 K- P TO SIG PI   11/77*

R3      Y*0(2350) FROM KBAR N TO LAMBDA OMEGA             SQRT(P1*P3)         1/78*
R3          LESS THAN .05              BACCARI   77 DPWA  0 K-P TO LAM. OMG.  1/78*

R4      Y*0(2350) INTO (KBAR N)/TOTAL                     (J+1/2)*(P1)
R4         J IS NOT DETERMINED IN THESE EXPTS.  THE FOLLOWING IS (J+1/2)*PI
R4          (0.57)                     BUGG      68 CNTR    K-P, D TOTAL      3/78*
R4           1.1       0.25            BRICMAN   70 CNTR  0 TOTAL AND CH EX   3/78*
R4          (1.0)                      COOL      70 CNTR    K-P, D TOTAL      3/78*

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                        REFERENCES FOR Y*0(2350) (PROD. EXP.)

BUGG      68 PR 168 1466     +GILMORE,KNIGHT, +          (RHEL,BIRM,CAVE) I
DAUM      68 NP B7 19        +ERNE, LAGNAUX, SENS, STEUER, UDO    (CERN)JP
BRICMAN   70 PL 31B 152      +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL      70 PR D1 1887      +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
LU        70 PR D2 1846      +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

BACCARI   77 NC 41A 96       +POULARD,REVEL,TALLINI+          (SACL+CDEF)IJP
BELLEFCN  77 NC 37A 175      DE BELLEFON,BERTHON,BILLOIR+     (CDEF+SACL)IJP
BELLEFCN  78 NC 42A 403      +BERTHON,BILLOIR,BRUNET+         (CDEF+SACL)IJP

                             PAPERS NOT REFERRED IN DATA CARDS
COOL      66 PRL 16 1228     +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
    SUPERSEDED BY COOL 70.
LASINSKI  71 NP  B29  125    T A LASINSKI                          (EFI)IJP
BELLEFO2  75 NC 28A 289      DE BELLEFON,BERTHON,BILLOIR+     (CDEF+SACL)
    PRESENTLY LISTED UNDER Y*1(2250), BUT ISOSPIN UNDETERMINED.

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Λ(2585) BUMPS

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         7  Y*0(2585, JP=    ) I=0        PRODUCTION EXPERIMENTS

         SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

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               7  Y*0(2585) MASS (MEV) (PROD. EXP.)

M         2585.0     45.0           ABRAMS    70 CNTR   K-P, D TOTAL     10/70
M        (2530.0)   (25.0)          LU        70 CNTR 0 GAMMA P TO K+ Y*  1/71

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               7  Y*0(2585) WIDTH (MEV) (PROD. EXP.)

W         (300.0)                   ABRAMS    70 CNTR   K-P, D TOTAL     10/70
W         (150.0)                   LU        70 CNTR 0 GAMMA P TO K+ Y*  1/71

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               7  Y*0(2585) PARTIAL DECAY MODES (PROD. EXP.)

                                                           DECAY MASSES
P1      Y*0(2585) INTO KBAR N                             497+ 939

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               7  Y*0(2585) BRANCHING RATIOS (PROD. EXP.)

R1      Y*0(2585) INTO (KBAR N)/TOTAL                     (P1)
R1         J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1          (1.0)                   ABRAMS    70 CNTR   K-P, D TOTAL     10/70
R1  C       (0.12)    (0.12)        BRICMAN   70 CNTR   TOTAL AND CH EX  10/70
R1  C   RESONANCE AT END OF REGION ANALYZED -- NO CLEAR SIGNAL.

****** ********* ********* ********* ********* ********* ********* ********

                        REFERENCES FOR Y*0(2585) (PROD. EXP.)

ABRAMS    70 PR 1D 1917      +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN   70 PL 31B 152      +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
LU        70 PR D2 1846      +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

                             PAPERS NOT REFERRED TO IN DATA CARDS

COOL      66 PRL 16 1228     +GIACOMELLI,KYCIA,LEONTIC,LUNDBY +    (BNL)I

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S=−1 I=1 HYPERON STATES (Σ)

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Σ⁺

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         19  SIGMA+(1189, JP=1/2+) I=1

         SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ⁻

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         20  SIGMA-(1198, JP=1/2+) I=1

         SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ⁰

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         21  SIGMA0(1193, JP=1/2+) I=1

         SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ(1385) P'_{13}

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         43  Y*1(1385, JP=3/2+) I=1

         SERIOUS INCOMPATIBILITIES EXIST BETWEEN DIFFERENT
         MEASUREMENTS OF THE Y*(1385) MASS AND WIDTH. THESE
         INCOMPATIBILITIES ARE AT LEAST PARTIALLY ACCOUNTED FOR
         BY SOME EXPERIMENTS QUOTING UNREALISTICALLY SMALL
   ERRORS. WE CONSISTENTLY INCREASE UNREALISTIC ERRORS BEFORE AVERAGING
   (SEE THE TYPED NOTE ON K*(892)).
   IN THE LISTINGS BELOW WE ATTEMPT TO OBTAIN THE BEST VALUES FOR THE
   SEPARATE CHARGE STATE MASSES AND WIDTHS. THUS WE DO NOT USE RESULTS
   QUOTED FOR MIXED CHARGES.
   WE NO LONGER USE EVERY PUBLISHED VALUE, BUT AVERAGE ONLY THE MOST
   SIGNIFICANT DETERMINATIONS. NEITHER DO WE AVERAGE RESULTS FROM
   INCLUSIVE EXPERIMENTS WITH LARGE BACKGROUNDS OR RESULTS WHICH ARE NOT
   ACCOMPANIED BY AT LEAST A DISCUSSION ON EXPERIMENTAL RESOLUTION.
   NEVERTHELESS SYSTEMATIC DIFFERENCES BETWEEN EXPERIMENTS REMAIN (SEE
   THE IDEOGRAMS INSERTED IN THE DATA CARD LISTINGS BELOW). THESE
   DIFFERENCES COULD ARISE FROM INTERFERENCE EFFECTS THAT CHANGE WITH
   PRODUCTION MECHANISM AND/OR BEAM MOMENTUM. THEY CAN ALSO BE ACCOUNTED
   FOR IN PART BY DIFFERENCES IN THE PARAMETRIZATIONS EMPLOYED (SEE
   BORENSTEIN 74 FOR A DISCUSSION ON THIS POINT). THUS BORENSTEIN 74 USE A
   BREIT-WIGNER WITH ENERGY INDEPENDENT WIDTH, SINCE A P-WAVE WAS FOUND
   TO GIVE UNSATISFACTORY FITS. CAMERON2 77 USE THE SAME FORM.
   ON THE OTHER HAND HOLMGRAN 77 OBTAIN A GOOD FIT TO THEIR LAMBDA PI MASS
   SPECTRUM WITH A P-WAVE BREIT-WIGNER, BUT INCLUDE THE PARTIAL WIDTH FOR
   THE SIGMA PI DECAY MODE IN THE PARAMETRIZATION.

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               43  Y*1(1385) MASS (MEV)

M      141(1384.0)                  ALSTON    60 HBC  +- K-P 1.15 BEV/C
M         (1385.0)                  BERGE     61 HBC  +- K-P .4-.85 BEV/C
M       38(1384.0)                  MARTIN    61 HBC  +0 K20 P .98 BEV/C
M         (1392.0)    (7.0)         COLLEY    62 HLBC -0 PI- PRP 2. BEV/C
M         (1389.0)    (3.0)         BALTAY    65 HBC  +- PBAR P 3.7 BEV/C  7/66
M         (1392.0)   (10.0)         MUSGRAVE  65 HBC  +-0PBAR P 3-4 BEV/C  7/66
M      200(1384.8)    (2.0)         ATHERTON  71 HBC  +- LAM PI+ + C.C.   11/77*
M      190(1380.)     (5.)          AMMANN    73 DBC  +- K-N 4.5GEV/C     11/77*
M      200(1386.)                   ATHERTO1  75 HBC  +-0PBAR P 5.7 GEV/C  1/76
```

Baryons

Σ(1385)

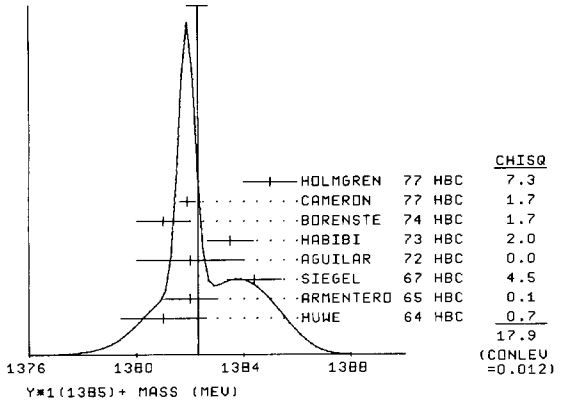
Data Card Listings

For notation, see key at front of Listings.

```
MO     106(1381.0)     (4.0)           CURTIS     63 OSPK  0 PI-P 1.5 BEV/C
MO E   240 1385.1       2.5            THOMAS     73 HBC   0 PI-P TO PIOKOLM  11/77*
MO E    ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
MO 2  3100 1380.        2.             BORENSTE   74 HBC   0 K-P TO(1385)+PIS 11/77*
MO 2    FROM FIT TO LAM PIO MASS SPECTRUM (IN LAM PI+ PI- PIO EVENTS) WITH
MO 2    WO FIXED AT 34 MEV.
MO                . . . . . .
MO  AVG     1382.0      2.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
MO  STUDENT1381.9       1.9     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

M+ E   154(1376.0)     (3.9)           ELY        61 HLBC +  K-P 1.11 BEV/C   11/77*
M+     170(1375.0)     (3.9)           COOPER     64 HBC  +  K-P 1.45 BEV/C   11/77*
M+     859 1381.0       1.6           HUWE       64 HBC  +  K-P 1.22 BEV/C
M+     750 1382.0       1.0           ARMENTERO  65 HBC  +  K-P .9-1.2 BEV/C
M+ E   250(1384.3)     (1.9)           SMITH      65 HBC  +  K-P 1.8 BEV/C    11/77*
M+ E   250(1382.6)     (2.1)           SMITH      65 HBC  +  K-P 1.95 BEV/C   11/77*
M+ E    62(1383.0)     (8.0)           BIRMINGHA  66 HBC  +  K-P 3.5 GEV/C   11/77*
M+     135(1378.0)     (5.0)           LONDON     66 HBC  +  K-P 2.24 BEV/C   11/77*
M+    1260 1384.4       1.0           SIEGEL     67 HBC  +  K-P AT 2.1 GEV/C 10/69
M+      46(1390.0)     (6.0)           AGUILAR    70 HBC  +  K-P 4 GEV/SIG.PI 11/77*
M+     400 1382.0       2.0           AGUILAR    72 HBC  +  K-P TO LAM+PIS   10/74
M+    2300 1383.5        .85          HABIBI     73 HBC  +  K-P TO 2PI LAM    9/73
M+  R 3740(1382.)      (1.)            BERTHON    74 HBC  +  K-P 1263-1843MEV 10/74
M+  R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
M+     6846 1381.       1.            BORENSTE   74 HBC  +  K-P TO(1385)+PIS 10/74
M+  I     (1380.)      (2.)            BARDADIN   75 HBC  +  K- P 14.3 GEV/C  11/77*
M+ HI  22K(1385.)      (3.)            BARREIRO   77 HBC  +  K-P AT 4.2 GEV    11/77*
M+ H    INCLUDES DATA OF HOLMGREN 77
M+    6900 1381.9       0.3           CAMERON    77 HBC  +  K-P 0.96-1.36GEV 11/77*
M+    2594 1385.        1.            HOLMGREN   77 HBC  +  K-P AT 4.2 GEV    11/77*
M+
M+  I   FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
M+ E    ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M+                . . . . . .
M+  AVG     1382.29     0.39    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
M+  STUDENT1382.20     0.31    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                              (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 1382.29 ± 0.39
ERROR SCALED BY 1.6

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M-      93(1382.0)     (3.0)           DAHL       61 DBC  -  K-D 0.45 BEV/C   11/77*
M- E   224(1376.0)     (4.4)           ELY        61 HLBC -  K-P 1.11 BEV/C   11/77*
M-     200(1392.0)     (6.2)           COOPER     64 HBC  -  K-P 1.45 BEV/C   11/77*
M- E  1086 1385.3       1.9           HUWE       64 HBC  -  K-P 1.15-1.30GEV 11/77*
M-    1380 1384.0       1.0           ARMENTERO  65 HBC  -  K-P .9-1.2 BEV/C
M- E   120(1391.5)     (2.6)           SMITH      65 HBC  -  K-P 1.8 BEV/C    11/77*
M- E    58(1399.8)     (2.2)           SMITH      65 HBC  -  K-P 1.95 BEV/C   11/77*
M-      15(1389.0)     (9.0)           LONDON     66 HBC  -  K-P AT 2.24 GEV  11/77*
M-     370 1390.7       2.0           SIEGEL     67 HBC  -  K-P AT 2.1 GEV/C 10/69
M-    1900 1390.7       1.2           HABIBI     73 HBC  -  K-P TO 2PI LAM    9/73
M- E   630 1387.1       1.9           THOMAS     73 HBC  -  PI-P TO PI-K+LM   11/77*
M-  R 3060(1389.)      (1.)            BERTHON    74 HBC  -  K-P 1263-1843MEV 10/74
M-  R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
M-     2303 1383.       2.            BORENSTE   74 HBC  -  K-P TO(1385)+PIS 10/74
M-  I     (1383.)      (2.)            BARDADIN   75 HBC  -  K- P 14.3 GEV/C  11/77*
M- HI  12K(1387.)      (3.)            BARREIRO   77 HBC  -  K-P AT 4.2 GEV    11/77*
M- H    INCLUDES DATA OF HOLMGREN 77
M-    9720 1387.6       0.3           CAMERON    77 HBC  -  K-P 0.96-1.36GEV 11/77*
M-     193 1391.        3.            HOLMGREN   77 HBC  -  K-P AT 4.2 GEV    11/77*
M-
M-  I   FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
M- E    ERROR ENLARGED BY US TO GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
M-                . . . . . .
M-  AVG     1387.44     0.58    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
M-  STUDENT1387.53      0.31    AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
                              (SEE IDEOGRAM BELOW )
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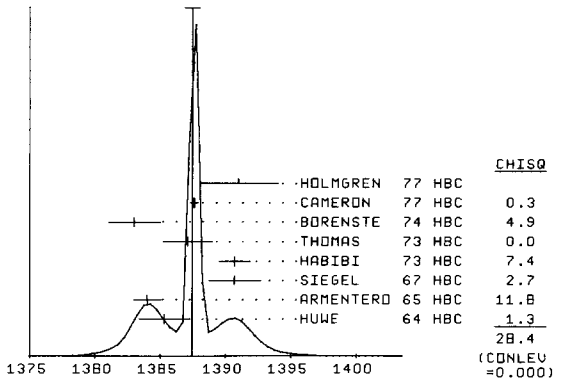
WEIGHTED AVERAGE = 1387.44 ± 0.58
ERROR SCALED BY 2.2

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                              43  (Y*-) - (Y*+) MASS DIFFERENCE (MEV)

D-+ R         (0.0)     (4.2)           ELY        61 HLBC +- K-P 1.11 BEV/C    8/66
D-+ R        (17.)      (7.)            COOPER     64 HBC  +- K-P 1.45 BEV/C   10/69
D-+ R         (4.3)     (2.2)           HUWE       64 HBC  +- K-P 1.22 BEV/C    8/66
D-+ R         (2.0)     (1.5)           ARMENTERO  65 HBC  +- K-P .9-1.2 BEV/C  8/66
D-+ R         (7.2)     (2.1)           SMITH      65 HBC  +- K-P 1.8 BEV/C     9/66
D-+ R        (17.2)     (2.0)           SMITH      65 HBC  +- K-P 1.95 BEV/C    9/66
D-+ R        (11.0)     (9.0)           LONDON     66 HBC  +- K-P 2.24 BEV/C    8/66
D-+           9.0       6.0             LONDON     66 HBC  +- LAMBDA 3 PI EVTS  7/66
D-+ R         (6.3)     (2.0)           SIEGEL     67 HBC  +- K-P AT 2.1 GEV/C 10/69
D-+ R         (7.2)     (1.4)           HABIBI     73 HBC  +- K-P TO 2PI LAM    9/73
D-+ R       BETWEEN -2 AND +6 CL=.95    BORENSTE   74 HBC  +- K-P TO(1385)+PIS 11/77*
D-+
D-+ R   REDUNDANT WITH DATA IN MASS LISTINGS

                              43  (Y*0) - (Y*+) MASS DIFFERENCE (MEV)

D0+ R       BETWEEN -4 AND +4 CL=.95    BORENSTE   74 HBC  +0 K-P TO(1385)+PIS 11/77*
D0+ R   REDUNDANT WITH DATA IN MASS LISTINGS

                              43  (Y*-) - (Y*0) MASS DIFFERENCE (MEV)

D-0 R         (2.0)     (2.4)           THOMAS     73 HBC  -0 PI-P TO PI-K+LM   11/77*
D-0 R   REDUNDANT WITH DATA IN MASS LISTINGS

                              43  Y*1(1385) WIDTH (MEV)

W      141   (64.0)                    ALSTON     60 HBC  +- K-P 1.15 BEV/C
W            (40.0)                    BERGE      61 HBC  +- K-P .4-.85 BEV/C
W       38   (20.0)  OR LESS           MARTIN     61 HBC  +0 K20 P .98 BEV/C
W            (80.0)   (10.0)           COLLEY     62 HLBC -0 PI- PRP 2. BEV/C
W            (26.0)    (5.0)           BALTAY     65 HBC  +- PBAR P 3.7 BEV/C  7/66
W            (38.0)    (9.0)           MUSGRAVE   65 HBC  +-0PBAR P 3-4 BEV/C  7/66
W   T 200    (20.)     (4.)            ATHERTON   71 HBC  +- LAM PI+ + C.C.    11/77*
W   T  FIT B.W. + PHASE SPACE BCKGRD
W   R 200    (35.)     (5.)            ATHERTON   71 HBC  +- LAM PI+ + C.C.    11/77*
W   R  FIT B.W. AND NO BCKGRD
W      190   (61.)     (10.)           AMMANN     73 DBC  +- K-N 4.5GEV/C      11/77*
W      200   (89.)     (23.)           ATHERTON1  75 HBC  +-0PBAR P 5.7 GEV/C  11/77*
W  D          (20.)     (10.)           ALSTON     78 DPWA -0 KBAR N ONLY       1/78*
W  D    WITH MASS FIXED AT 1385 MEV.  FROM RESULTS OF PARTIAL WAVE ANALYSIS    1/78*
W  D    OF KBAR N SYSTEM EXTRAPOLATED BELOW THRESHOLD.                         1/78*

W      106   (30.0)    (9.0)           CURTIS     63 OSPK  0 PI-P 1.5 BEV/C
WO E   240   39.3      10.2            THOMAS     73 HBC   0 PI-P TO PIOKOLM  11/77*
WO E    ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
WO  C 3100   (53.)      (8.)           BORENSTE   74 HBC   0 K-P TO(1385)+PIS 11/77*
WO  C 3100 CONSISTENT WITH WO=W+=W-     BORENSTE   74 HBC   0 K-P TO(1385)+PIS 11/77*

W+ E   154   (48.0)   (16.0)           ELY        61 HLBC +  K-P 1.11 BEV/C    11/77*
W+ E   170   (51.0)   (16.0)           COOPER     64 HBC  +  K-P 1.45 BEV/C    11/77*
W+ E   859    46.5      6.4           HUWE       64 HBC  +  K-P 1.15-1.30GEV 11/77*
W+ E   750    32.0      4.7           ARMENTERO  65 HBC  +  K-P .95-1.20 GEV 11/77*
W+ E   250   (30.3)    (7.5)           SMITH      65 HBC  +  K-P 1.8 BEV/C     11/77*
W+ E   250   (33.1)    (8.3)           SMITH      65 HBC  +  K-P 1.95 BEV/C    11/77*
W+ E    62   (25.0)   (32.0)           BIRMINGHA  66 HBC  +  K-P 3.5 GEV/C    11/77*
W+ E  1260    36.0      4.0           SIEGEL     67 HBC  +  K-P AT 2.1 GEV/C  11/77*
W+ E    46   (33.)     (20.0)          AGUILAR    70 HBC  +  K-P 4 GEV/SIG.PI 11/77*
W+     400    32.5      6.0           AGUILAR    72 HBC  +  K-P TO LAM+PIS    10/74
W+ E  2300    38.3      3.2           HABIBI     73 HBC  +  K-P TO 2PI LAM    11/77*
W+  R 3740   (48.)     (3.)            BERTHON    74 HBC  +  K-P 1263-1843MEV 10/74
W+  R   ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.
W+ 1  6846    34.       1.6           BORENSTE   74 HBC  +  K-P TO(1385)+PIS 11/77*
W+ 1  RESULTS FROM LAM PI+ PI- AND LAM PI+ PI- PIO COMBINED BY US.
W+  I         (40.)     (3.2)           BARDADIN   75 HBC  +  K- P 14.3 GEV/C  11/77*
W+ HI  22K   (43.)      (5.)            BARREIRO   77 HBC  +  K-P AT 4.2 GEV    11/77*
W+ H    INCLUDES DATA OF HOLMGREN 77
W+    6900    35.5      1.9           CAMERON    77 HBC  +  K-P 0.96-1.36GEV 11/77*
W+    2594    34.       2.            HOLMGREN   77 HBC  +  K-P AT 4.2 GEV    11/77*
W+
W+  I   FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM
W+ E    ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.
W+                . . . . . .
W+  AVG     34.96     0.92    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W+  STUDENT 34.9       1.0     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT
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W-			(40.0)		DAHL	61 DBC	-	K-D 0.45 BEV/C	
W-	E	224	(66.0)	(18.0)	ELY	61 HLBC	-	K-P 1.11 BEV/C	11/77*
W-	E	200	(88.0)	(24.0)	COOPER	64 HBC	-	K-P 1.45 BEV/C	11/77*
W-		1086	62.0	7.0	HUWE	64 HBC	-	K-P 1.15-1.30GEV	
W-	E	1382	38.0	4.1	ARMENTERO	65 HBC	-	K-P .95-1.20 GEV	11/77*
W-	E	120	(29.2)	(10.6)	SMITH	65 HBC	-	K-P 1.80 BEV/C	11/77*
W-	E	58	(17.1)	(8.9)	SMITH	65 HBC	-	K-P 1.95 BEV/C	11/77*
W-	E	370	31.0	6.5	SIEGEL	67 HBC	-	K-P AT 2.1 GEV/C	11/77*
W-	E	1900	51.9	4.8	HABIBI	73 HBC	-	K-P TO 2PI LAM	11/77*
W-	E	630	48.2	7.7	THOMAS	73 HBC	-	PI-P TO PI-KOLM	11/77*
W-	R	3060	(40.)	(3.)	BERTHON	74 HBC	-	K-P 1263-1843MEV	10/74

W- R ERRORS STATISTICAL ONLY. RESOLUTION NOT UNFOLDED.

W-	I	2303	35.	3.	BORENSTE	74 HBC	-	K-P TO(1385)+PIS	11/77*

W- I RESULTS FROM LAM PI+ PI- AND LAM PI+ PI- PIO COMBINED BY US.

W-	I		(47.)	(6.)	BARDADIN	75 HBC	-	K- P 14.3 GEV/C	11/77*
W-	HI	12K	(45.)	(5.)	BARREIRO	77 HBC	-	K-P AT 4.2 GEV	11/77*

W- H INCLUDES DATA OF HOLMGREN 77

W-		9720	39.2	1.7	CAMERON	77 HBC	-	K-P 0.96-1.36GEV	11/77*
W-		193	(35.)	(10.)	HOLMGREN	77 HBC	-	K-P AT 4.2 GEV	11/77*

W-

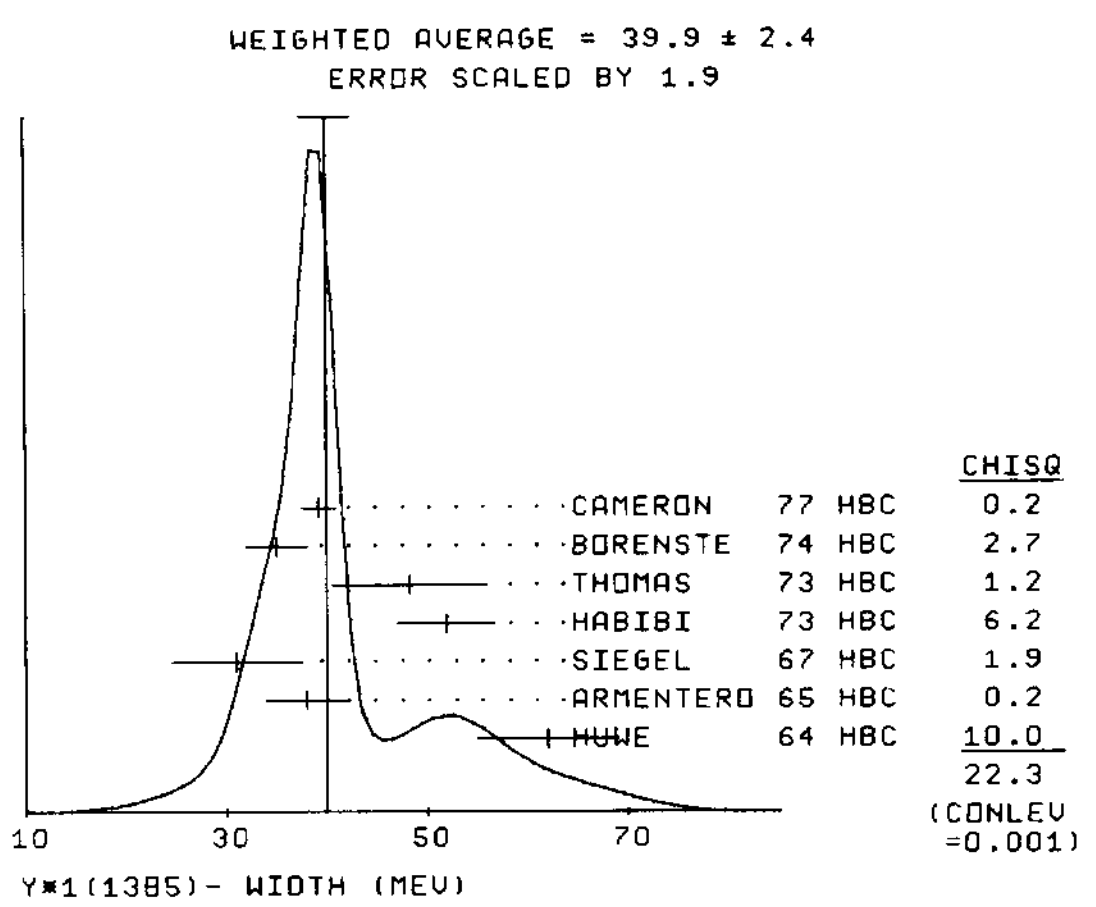
W- I FROM FIT TO INCLUSIVE LAMBDA PI SPECTRUM

W- E ERROR ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE ON K* MASS.

W- . . . .

W- AVG 39.9 2.4 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

W- STUDENT 39.4 1.5 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT (SEE IDEOGRAM BELOW)



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43 Y*1(1385) REAL PART OF POLE POSITION 4/75

RE+	1379.0	1.0	LICHTENB	74	+	EXTRAP HABIBI73	4/75
RE-	1383.0	1.0	LICHTENB	74	-	EXTRAP HABIBI73	4/75

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43 Y*1(1385) IMAGINARY PART OF POLE POSITION 4/75

IM+	17.5	1.5	LICHTENB	74	+	EXTRAP HABIBI73	4/75
IM-	22.5	1.5	LICHTENB	74	-	EXTRAP HABIBI73	4/75

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43 Y*1(1385) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(1385) INTO LAMBDA PI	1115+ 139
P2	Y*1(1385) INTO SIGMA PI	1197+ 139
P3	Y*1(1385) INTO LAMBDA GAMMA	1115+ 0
P4	Y*1(1385) INTO KBAR N	493+ 938
P5	Y*1(1385) INTO SIGMA GAMMA	1197+ 0

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43 Y*1(1385) BRANCHING RATIOS

R1 Y*1(1385) INTO (SIGMA PI)/(LAMBDA PI) (P2)/(P1)

R1	(0.04)	(0.04)	BASTIEN	61 HBC	+-		
R1	(0.04) OR LESS		ALSTON	62 HBC	+-0	K-P 1.15 BEV/C	
R1	0.09	0.04	HUWE	64 HBC	+-	K-P 1.2-1.7 GEV	
R1	0.163	0.041	ARMENTERO	65 HBC	+-	K-P .95-1.20 GEV	7/66
R1	0.08	0.06	LONDON	66 HBC	+	K-P 2.24 BEV/C	7/66
R1	0.13	0.04	PAN	69 HBC	+	PI+ P - K Y PI	12/72
R1	0.13	0.04	COLLEY	71 DBC	-0	K-N 1.5 GEV PROD	10/71
R1	.16	.07	AGUILAR	72 HBC	+	K-P 3.9,4.6 GEV	10/74
R1	.18	.04	MAST2	73 MPWA	+-	K-P - 2PI SIG/LM	9/73
R1	.10	.05	THOMAS	73 HBC	-	PI-P TO PI K Y	9/73
R1	.16	.03	BERTHON	74 HBC	+	K-P 1263-1843MEV	11/77*
R1	.11	.02	BERTHON	74 HBC	-	K-P 1263-1843MEV	11/77*
R1	.21	.05	BORENSTE	74 HBC	+	K-P TO(1385)+PIS	10/74

R1 . . . .

R1 AVG 0.133 0.011 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R1 STUDENT 0.132 0.013 AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R2 Y*1(1385) INTO LAMBDA GAMMA (P3)

R2 1 (0.17) (0.17) MEISNER 72 HBC 0 1 EVENT ONLY 1/73

R3 Y*1(1385) FROM KBAR N TO LAMBDA PI SQRT(P1*P4) 4/75

R3 C +.586 .319 DEVENISH 74 0 FIXED T DISP REL 4/75

R3 C EXTRAPOLATION OF PARAMETRIZED AMPLITUDE BELOW THRESHOLD 4/75

R4 Y*1(1385) INTO (LAMBDA GAMMA)/(LAMBDA PI) (P3)/(P1) 1/76

R4 (.06) OR LESS CL=.90 COLAS 75 HLBC 0 K-P 575-970 MEV 1/76

R5 Y*1(1385) INTO (SIGMA GAMMA)/(LAMBDA PI) (P5)/(P1) 1/76

R5 (.05) OR LESS CL=.90 COLAS 75 HLBC 0 K-P 575-970 MEV 1/76

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REFERENCES FOR Y*1(1385)

ALSTON	60 PRL 5 520	+ALVAREZ,EBERHARD,GOOD,GRAZIANO, +	(LRL)	I
BASTIEN	61 PRL 6 702	P BASTIEN,M FERRO-LUZZI,A H ROSENFELD	(LRL)	
BERGE	61 PRL 6 557	+BASTIEN,DAHL,FERRO-LUZZI,KIRZ, +	(LRL)	
DAHL	61 PRL 6 142	+HORWITZ,MILLER,MURRAY,WHITE	(LRL)	
ELY	61 PRL 7 461	+FUNG,GIDAL,PAN,POWELL,WHITE	(LRL)	J
MARTIN	61 PRL 6 283	+LEIPUNER,CHINOWSKY,SHIVELY, +	(BNL,YALE)	
ALSTON	62 CERN CONF 311	+ALVAREZ,FERRO-LUZZI,ROSENFELD, +	(LRL)	
COLLEY	62 PR 128 1930	+GELFAND,NAUENBERG, +	(COLUMBIA,RUTGERS)	JP
CURTIS	63 PR 132 1771	+COFFIN,MEYER,TERWILLIGER	(MICH)	J
COOPER	64 PL 8 365	+FILTHUTH,FRIDMAN,MALAMUD, +	(CERN,AMST)	
HUWE	64 UCRL-11291 THESIS	D O HUWE	(LRL)	JP
ALSO	69 PR 180 1824	D O HUWE	(LRL)	
ARMENTER	65 PL 19 75	ARMENTEROS, +	(CERN,HEIDEL,SACLAY)	
BALTAY	65 PR 140 B1027	+SANDWEISS,TAFT,CULWICK,KOPP, +	(YALE,BNL)	
MUSGRAVE	65 NC 35 735	+PETMEZAS,+	(BIRM,CERN,EPOL,LOIC,SACLAY)	
SMITH	65 THESIS (UCLA)	L T SMITH	(UCLA)	
BIRMINGH	66 PR 152 1148	BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD		
LONDON	66 PR 143 1034	+RAU,SAMIOS,YAMAMOTO,GOLDBERG,+	(BNL,SYRA)	J
SIEGEL	67 UCRL 18041 THESIS	D M SIEGEL	(LRL)	
PAN	69 PRL 23 808	+FORMAN	(PENN)	I
AGUILAR	70 PRL 25 58	+BARNES, BASSANO, CHUNG, EISNER,+	(BNL,SYRA)	
ATHERTON	71 NP B29 477	+CELNIKIER,CLAYTON,FRENCH,FRISK,+	(CERN)	
COLLEY	71 NP B31 61	+COX,EASTWOOD,FRY+..	(BIRM+EDIN+GLAS+LOIC)	
AGUILAR	72 PR D6 29	AGUILAR-BENITEZ,CHUNG,EISNER,SAMIOS	(BNL)	
MEISNER	72 NC 12A 62	G MEISNER	(U NC GREENSBORO+LBL)	
AMMANN	73 PRD 7 1345	+CARMONY,GARFINKEL,GUTAY,+	(PURD+IUPU)	
MAST2	73 PRD 7 3212	+BANGERTER,ALSTON-GARNJOST,+	(LBL)	IJP
ALSO	73 PRD 7 5	MAST,BANGERTER,ALSTON-GARNJOST,+	(LBL)	IJP
HABIBI	73 NEVIS 199(THESIS)	M.HABIBI	(COLUMBIA)	
ALSO	73 PURD73, PG. 387	BALTAY,BRIDGEWATER,COOPER,+	(COLUMBIA+BING)	
THOMAS	73 NP B56 15	THOMAS,ENGLER,FISK,KRAEMER	(CARN)	JP
BERTHON	74 NC 21A 146	BERTHON,TRISTRAM,+	(CDEF+RHEL+SACL+STRB)	
BORENSTE	74 PR D9 3006	BORENSTEIN,KALBFLEISCH,STRAND,+	(BNL+MICH)	
DEVENISH	74 NP B81 330	DEVENISH,FROGGATT,MARTIN	(DESY,NORDITA,LOUC)	
LICHTENB	74 PRD 10 3865	D B LICHTENBERG	(INDIANA UNIVERSITY)	
ALSO	74 PRIV. COMM.	D B LICHTENBERG	(INDIANA UNIVERSITY)	
ATHERTO1	75 NC 25A 1	ATHERTON,BAR-NIR,FRENCH	(CERN)	
BARDADIN	75 NP B98 418	BARDADIN-OTWINOWSKA+	(SACL+EPOL+RHEL)	
COLAS	75 NP B91 253	COLAS,FARWELL,FERRER,SIX	(ORSA)	
BARREIRO	77 NP B126 319	+BERGE,GANGULI,BLOKZIJL+	(CERN+AMST+NIJM)	
CAMERON2	77 RL-77-119/A	+FRANEK,GOPAL,BACON,BUTTERWORTH+	(RHEL+LOIC)	
HOLMGREN	77 NP B119 261	+AGUILAR-BENITEZ,KLUYVER+	(CERN+AMST+NIJM)	
ALSTON	78 LBL-6784	ALSTON-GARNJOST,KENNEY+	(LBL+MHCO+CERN)	
ALSO	77 PRL 38 1007	ALSTON-GARNJOST,KENNEY+	(LBL+MHCO+CERN)	

PAPERS NOT REFERRED TO IN DATA CARDS.

MALAMUD	64 PL 10 145	E MALAMUD, P E SCHLEIN	(CERN,UCLA)	JP
SHAFER	64 PR 134 B1372	J B SHAFER, D O HUWE	(LRL)	JP
HUNGERBU	74 PRD 10 2051	HUNGERBUHLER,MAJKA,+	(YALE,FNAL,BNL,PITT)	

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Σ(1480) BUMPS →

23 Y*1(1480, JP=) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

PEAKS ARE SEEN IN LAMBDA PI AND SIGMA PI SPECTRA IN THE REACTION PI+P TO K+ PI Y AT 1.7 GEV/C. ALSO THE Y POLARIZATION OSCILLATES IN THE SAME REGION.

SEE MILLER 70 FOR A DISCUSSION OF THIS STATE. HE SUGGESTS A POSSIBLE ALTERNATE EXPLANATION IN TERMS OF A REFLECTION OF N*1/2(1670) DECAY TO LAMBDA K. HOWEVER, SUCH AN EXPLANATION FOR THE K+ SIGMA+ PIO CHANNEL SEEMS UNLIKELY (SEE PAN 70) IN TERMS OF KNOWN N*3/2(1690) DECAY INTO SIGMA K. IN ADDITION SUCH REFLECTIONS WOULD ALSO HAVE TO ACCOUNT FOR THE OSCILLATION OF THE Y POLARIZATION IN THE 1480 MASS REGION.

HANSON 71, WITH FEWER DATA THAN PAN 70, CAN NEITHER CONFIRM NOR DENY THE EXISTENCE OF THIS STATE. MAST 75 SEES NO STRUCTURE IN THIS MASS REGION IN K- P TO LAMBDA PIO.

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23 Y*1(1480) MASS (MEV) (PROD. EXP.)

M	1479.	10.	PAN	70 HBC	+	PI+P TO K PI LAM	3/71
M	1465.	15.	PAN	70 HBC	+	PI+P TO K PI SIG	3/71
M	1485.	10.	CLINE	73 MPWA		K- D TO LM PI- P	9/73

M . . . .

M AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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23 Y*1(1480) WIDTH (MEV) (PROD. EXP.)

W	31.	15.	PAN	70 HBC	+	PI+P TO K PI LAM	3/71
W	30.	20.	PAN	70 HBC	+	PI+P TO K PI SIG	3/71
W	40.	20.	CLINE	73 MPWA		K- D TO LM PI- P	9/73

W . . . .

W AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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23 Y*1(1480) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*1(1480) INTO KBAR N	497+ 939
P2	Y*1(1480) INTO LAMBDA PI	1115+ 139
P3	Y*1(1480) INTO SIGMA PI	1189+ 139

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23 Y*1(1480) BRANCHING RATIOS (PROD. EXP.)

R1 Y*1(1480) INTO (SIGMA PI)/(LAMBDA PI) (P3)/(P2)

R1 0.82 0.51 PAN 70 HBC + 3/71

R2 Y*1(1480) INTO (PROTON KOBAR)/(LAMBDA PI) (P1)/(P2)

R2 0.36 0.25 PAN 70 HBC + 3/71

R3 Y*1(1480) INTO KBAR N (P1) 9/73

R3 SMALL CLINE 73 MPWA K- D TO LM PI- P 9/73

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Baryons

Σ(1480), Σ(1580), Σ(1620)

Data Card Listings

For notation, see key at front of Listings.

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                        REFERENCES FOR Y*1(1480) (PROD. EXP.)

PAN      70 PR D2, 49    +FORMAN,KO,HAGOPIAN,SELOVE              (PENN)
CLINE    73 LNC 6 205    CLINE,LAUMANN,MAPP                  (WISCONSIN)IJP

                        PAPERS NOT REFERRED TO IN DATA CARDS

YU-LI PA 69 PRL 23 806  YU-LI PAN, F L FORMAN                   (PENN) I
YU-LI PA 69 PRL 23 808  YU-LI PAN, F L FORMAN                   (PENN) I
MILLER   70 DUKE 229    D H MILLER        (REVIEW TALK)       (PURDUE)
HANSON   71 PR D4 1296  ,KALMUS,LOUIE                           (LBL) I
MAST     75 PRD 11 3078 +ALSTON-GARNJOST,BANGERTER+              (LBL)

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Σ(1580) → **D'_{13}**

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00  Y*1(1580, JP=3/2-) I=1                                          4/75

OBSERVED IN K- N I=1 TOTAL CS WITHOUT JP ASSIGNMENT AT
BNL(LI 73, CARROLL 73, CARROLL 76) AND IN PWA OF K- P
--> LAMBDA PI FOR CM ENERGIES=1560-1600 MEV BY
LITCHFIELD 74. LITCHFIELD 74 FINDS JP=3/2-.  NOT SEEN B
ENGLER 76 OR BY CAMERON 78 (WITH LARGER STATISTICS),
IN KLONG P TO PI+ LAMBDA AND PI+ SIGMA0.

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00  Y*1(1580) MASS (MEV)                                            4/75

M  L     1582.      4.          LITCHFIEL 74 DPWA  0 K- P TO LAM PI   4/75
M    C   1583.      4.          CARROLL   76 DPWA    I=1 TOTAL CS     2/77*

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00  Y*1(1580) WIDTH (MEV)                                           4/75

W  L       11.      4.          LITCHFIEL 74 DPWA  0 K- P TO LAM PI   4/75
W    C   (15.)                  CARROLL   76 DPWA    I=1 TOTAL CS     2/77*

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00  Y*1(1580) PARTIAL DECAY MODES                                   4/75

                                                          DECAY MASSES
P1     Y*1(1580) INTO KBAR N                               497+ 939
P2     Y*1(1580) INTO LAMBDA PI                           1115+ 139
P3     Y*1(1580) INTO SIGMA PI                            1197+ 139

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00  Y*1(1580) BRANCHING RATIOS                                      4/75

R1     Y*1(1580) INTO KBAR N/TOTAL                    (P1)          4/75
R1 L       +.03      .01          LITCHFIEL 74 DPWA    KBAR N MULTICHNL  4/75
R1 L    MAIN EFFECT OBSERVED BY LITCHFIELD 74 IS IN PI LAMBDA FINAL STATE.  4/75
R1 L    KBAR N AND SIGMA PI COUPLINGS ALSO ESTIMATED FROM MULTICHANNEL FIT  4/75
R1 L    INCLUDING TOTAL CROSS SECTION DATA (LI 73).                 4/75
R1   C  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.06   SEEN BY CARROLL 76  2/77*

R2     Y*1(1580) FROM KBAR N TO LAMBDA PI             SQRT(P1*P2)   4/75
R2 L       +.10      .02          LITCHFIEL 74 DPWA  0 K- P TO LAM PI  4/75
R2          NOT SEEN              ENGLER    76  HBC  +  KL  P TO PI+ LAM  2/77*
R2          NOT SEEN              CAMERON2  77 HBC  +  KL  P TO PI+ LAM  1/78*

R3     Y*1(1580) FROM KBAR N TO SIGMA PI              SQRT(P1*P3)   4/75
R3 L       +.03      .04          LITCHFIEL 74 DPWA    KBAR N MULTICHNL  4/75
R3          NOT SEEN              ENGLER    76  HBC  +  KL  P TO PI+ SIGO  2/77*
R3          NOT SEEN              CAMERON2  77 HBC  +  KL  P TO PI+ SIGO  1/78*

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                        REFERENCES FOR Y*1(1580)

LITCHFIE 74 PL 51B 509  LITCHFIELD                              (CERN)IJP
CARROLL  76 PRL 37 806  +CHIANG,KYCIA,LI,MAZUR,MICHAEL+          (BNL)I
ENGLER   76 PL 63B 231  +KEYES,KRAEMER,SCHLERETH,TANAKA+      (CARN,ANL)I
CAMERON  78 NP B132 189 +CAPILUPPI+       (BGNA+EDIN+GLAS+PISA+RHEL)I

                        PAPERS NOT REFERRED TO IN DATA CARDS.

CARROLL  73 APS BRKLY MTG 208 CARROLL,CHIANG,KYCIA,LI,MAZUR,MICHAEL+(BNL)I
LI       73 PURDUE CONF. 283  LI                                 (BNL)I

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Note on Σ(1620)

This state was first suggested by the BNL-CCNY collaboration (CRENNELL 68) who presented evidence for it in the reaction $K^- n \to \Sigma(1620)^{\pm} \pi^{\mp} \pi^-$ with $\Sigma(1620)^{\pm}$ decaying into $\Lambda\pi^{\pm}$. Since then there have been conflicting reports about this state (or states).

Total Cross-Section Experiment

A measurement of the K^-p and K^-d total cross sections in the 0.4 to 1.1 GeV/c range has been reported by the BNL group (CARROLL 76). Three narrow (10 - 15 MeV wide) bumps in the I = 1 K^-N cross section are seen at 1583, 1608, and 1633 MeV.

Formation Experiments

There is evidence from several partial-wave analyses for one or two fairly narrow states within ~50 MeV of the effect seen in production; see the entries for $\Sigma(1580,3/2^-)$, $\Sigma(1620,1/2^-)$, and $\Sigma(1660, 1/2^+)$. Note however that the various analyses do not agree on the widths and branching ratios of these states.

Production Experiments

A good review of the production experiments has been given by MILLER 70. There has been no new evidence from production experiments since 1970. The existing evidence is only in the $\Lambda\pi$ channel. The BNL-CCNY collaboration (CRENNELL 69) claimed the effect in the $\Lambda\pi$ channel with no evidence seen in $\bar{K}N$ or $\bar{K}N\pi$. SABRE 70 studied the same reaction at 3.0 GeV/c with comparable statistics and did not see any evidence for it in the $\Lambda\pi$ channel; on the contrary, they believed it to be a spurious peak resulting from misidentified Σ^0 from the production of $\Sigma(1670)$ decaying into $\Sigma^0\pi^+$. AMMANN 70 studied the same reaction at 4.5 GeV/c and reported a state at 1640 MeV, again decaying only into $\Lambda\pi$ (no evidence seen in $\Sigma\pi$ or $\bar{K}N$ channels). Upper limits on production cross sections for a 25 GeV/c Σ^- beam are reported by HUNGERBUHLER 74.

In conclusion, for understanding of the $\Sigma(1620)$ we probably have to wait for more data and for a more complete understanding of the entire mass region from 1600 to 1700 MeV. The closeness of the $\Sigma(1620)$ mass to 1670 MeV is suggestive that this effect may be related to what goes on in that region (see the "Note on Σ(1670)" below).

Σ(1620) → **S'_{11}**

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32  Y*1(1620, JP=1/2-) I=1                                          S'11

THE S11 STATE AT 1697 MEV REPORTED BY VANHORN 75 IS
INTERMEDIATE IN MASS BETWEEN THE SIGMA(1620) AND
SIGMA(1750).  WE TENTATIVELY LIST IT UNDER SIGMA(1750).
CARROLL 76 SEES TWO BUMPS IN THE I=1 TOTAL CROSS
SECTIONS NEAR THIS MASS.

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32  Y*1(1620) MASS (MEV)

M          (1620.)                    KIM       71 DPWA   K-MATRIX ANAL.   3/71
M          1630.0    (10.0)           LANGBEIN  72 IPWA   MULTICHANNEL     12/72
M  L       1608.      5.              CARROLL   76 DPWA   I=1 TOTAL CS     2/77*
M  H       1633.     10.              CARROLL   76 DPWA   I=1 TOTAL CS     2/77*
M          . . . . . . . . . .
M  AVG     1613.0    10.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
M  STUDENT1612.1      5.6     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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32  Y*1(1620) WIDTH (MEV)

W          (40.)                      KIM       71 DPWA   K-MATRIX ANAL.   3/71
W          65.0      (20.0)           LANGBEIN  72 IPWA   MULTICHANNEL     12/72
W  L       (15.)                      CARROLL   76 DPWA   I=1 TOTAL CS     2/77*
W  H       (10.)                      CARROLL   76 DPWA   I=1 TOTAL CS     2/77*

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Data Card Listings

For notation, see key at front of Listings.


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                    32  Y*1(1620) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1      Y*1(1620) INTO KBAR N                                    497+ 939
P2      Y*1(1620) INTO SIGMA PI                                  1197+ 139
P3      Y*1(1620) INTO LAMBDA PI                                 1115+ 134

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                    32  Y*1(1620) BRANCHING RATIOS

R1      Y*1(1620) INTO KBAR N                                    (P1)
R1           (0.05)                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1 A          0.05  OR LESS              WONG      71 DPWA    K-+P--LAM+PI      10/71
R1           0.22      (0.02)            LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R1   L  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.06    SEEN BY CARROLL 76        2/77*
R1   H  TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.04    SEEN BY CARROLL 76        2/77*
R1 A    K-MATRIX FIT(NEGLECTS 3-BODY CHANNELS) REQUIRES NO RESONANCE           10/71

R2      Y*1(1620) FROM KBAR N TO SIGMA PI                        SQRT(P1*P2)
R2           (0.08)                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2           0.40      (0.06)            LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R2         NOT SEEN                      HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77*

R3      Y*1(1620) FROM KBAR N TO LAMBDA PI                       SQRT(P1*P3)
R3           (0.15)                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
R3         NOT SEEN                      BAILLON   75 IPWA    KBAR N TO LAM PI 11/75

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                    REFERENCES FOR Y*1(1620)

KIM       71 PRL 27 356          J K KIM                                  (HARV)IJP
    ALSO  70 DUKE 161            J. K. KIM                                (HARV)IJP
WONG      71 NC 2A 353           N S WONG                                 (YALE)IJP
LANGBEIN  72 NP B47 477          +WAGNER                                  (MPIM)IJP

BAILLON   75 NP B94 39           P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
CARROLL   76 PRL 37 806          +CHIANG,KYCIA,LI,MAZUR,MICHAEL+          (BNL)I
HEPP2     76 PL 65B 487          +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP

                    PAPERS NOT REFERRED TO IN DATA CARDS

VANHORN   75 NP B87 145          A. J. VAN HORN                           (LBL)IJP
    ALSO  75 NP B87 157          A. J. VAN HORN                           (LBL)IJP

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1620 MEV REGION – PRODUCTION EXPERIMENTS

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                    78  Y*1(1620, JP=    ) I=1       PRODUCTION EXPERIMENTS

                    SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

                    THIS RESONANCE NEEDS CONFIRMATION. THE RESULTS OF
                    CRENNELL 69 AT 3.9 GEV/C ARE NOT CONFIRMED BY THE SABRE
    COLLABORATION AT 3.0 GEV/C (SABRE 70).  HOWEVER IN AN EXPERIMENT AT
    4.5 GEV/C, AMMANN 70 SEE A PEAK AT 1642 MEV WHICH ON THE BASIS OF
    BRANCHING RATIOS THEY DO NOT ASSOCIATE WITH THE Y*1(1670). SEE MILLER
    70 FOR A REVIEW OF THESE CONFLICTS.

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                    78  Y*1(1620) MASS (MEV)  (PROD. EXP.)

M   N      (1616.0)     (8.0)          CRENNELL  68 DBC  +- K-D 3.9 BEV/C    11/68
M   N    EVENTS OF CRENNELL 68 ARE IN THE LARGER SAMPLE OF CRENNELL 69.
M       20 1618.0       3.0           BLUMENFEL 69 HBC  +   KO LONG + PROTON  9/69
M          1619.0       8.0           CRENNELL  69 DBC  +- K-N TO LAM 3 PI    9/69
M          1642.0      12.0           AMMANN    70 DBC      K-N 4.5 GEV/C     9/73
M                . . . . . .
M   AVG    1619.4       3.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M   STUDENT1619.1       3.0     AVERAGE USING STUDENT1O(H/1.11) -- SEE MAIN TEXT

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                    78  Y*1(1620) WIDTH (MEV)  (PROD. EXP.)

W   N        (66.0)    (16.0)          CRENNELL  68 DBC  +- SEE NOTE N ABOVE 11/68
W       20   30.0      10.0            BLUMENFEL 69 HBC  +                    9/69
W            72.0      22.0      15.0  CRENNELL  69 DBC  +-                   9/69
W            55.0      24.0            AMMANN    70 DBC      K-N 4.5 GEV/C     9/73
W                . . . . . .
W   AVG      41.3      12.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
W   STUDENT  40.7      10.4     AVERAGE USING STUDENT1O(H/1.11) -- SEE MAIN TEXT
                SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                    78  Y*1(1620) PARTIAL DECAY MODES (PROD. EXP.)

                                                                  DECAY MASSES
P1      Y*1(1620) INTO KBAR N                                    497+ 939
P2      Y*1(1620) INTO LAMBDA PI                                 1115+ 139
P3      Y*1(1620) INTO Y*1(1385) PI                              1384+ 139
P4      Y*1(1620) INTO LAMBDA PI PI                              1115+ 139+ 139
P5      Y*1(1620) INTO SIGMA PI                                  1197+ 139
P6      Y*1(1620) INTO Y*0(1405) PI                              1405+ 139

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                    78  Y*1(1620) BRANCHING RATIOS (PROD. EXP.)

R1      Y*1(1620) INTO (LAMBDA PI PI)/(LAMBDA PI)                (P4)/(P3)
R1       14   (2.5)  APPROX           BLUMENFEL 69 HBC  +

R2      Y*1(1620) INTO (KBAR N)/(LAMBDA PI)                      (P1)/(P2)
R2           (0.0)     (0.1)          CRENNELL  68 DBC  +
R2            0.4       0.4           AMMANN    70 DBC      K-P 4.5 GEV/C     6/70

R3      Y*1(1620) INTO LAMBDA PI                                 (P2)
R3           LARGE                     CRENNELL  68 DBC  +-                   11/68

R4      Y*1(1620) INTO (Y*1(1385) PI)/(LAMBDA PI)                (P3)/(P2)
R4           (0.2)     (0.1)          CRENNELL  68 DBC  +-                   11/68
R4           (0.3)  OR LESS  CL=.95   AMMANN    70 DBC      K-P 4.5 GEV/C     6/70

R5      Y*1(1620) INTO (SIGMA PI)/(LAMBDA PI)                    (P5)/(P2)
R5           (1.1)(95 PC UPPER LIMIT) AMMANN    70 DBC      K-N 4.5 GEV/C     9/73

R6      Y*1(1620) INTO (Y*0(1405) PI)/(LAMBDA PI)                (P6)/(P2)
R6            0.7       0.4           AMMANN    70 DBC      K-P 4.5 GEV/C     6/70

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                    REFERENCES FOR Y*1(1620) (PROD. EXP.)

CRENNELL 68 PRL 21 648         +DELANEY, FLAMINIO, KARSHON, +   (BNL,CUNY) I
BLUMENFE 69 PL 29B 58          BLUMENFELD, KALBFLEISCH                (BNL) I
CRENNELL 69 LUND PAPER 183     +KARSHON, LAI, ONEIL, SCARR, +   (BNL,CUNY) I
    RESULTS ARE QUOTED IN LEVI SETTI 69.

AMMANN    70 PRL 24 327        + GARFINKEL, CARMONY, GUTAY,+  (PURDUE,IND)
    ALSO  73 PRD 7 1345        AMMANN,CARMONY,GARFINKEL,        (PURD+IUPU)

                    PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 68 NP B8 183          ARMENTEROS,BAILLON +         (CERN+HEID+SACL)
LEVISETT 69 LUND CONF          R LEVI SETTI    (RAPPORTEUR)          EFINS
TRIPP    69 UCRL 19361         R D TRIPP                             (LRL)
ARMENTER 70 DUKE 123           ARMENTEROS,BAILLON +         (CERN+HEID+SACL)
MILLER   70 DUKE 229           D H MILLER   (REVIEW TALK)            (PURDUE)
SABRE    70 NP B16 201         SABRE COLLAB.    (SACL,AMST,BGNA,REHO,EPOL)
HUNGERBU 74 PRD 10 2051        HUNGERBUHLER,MAJKA,+   (YALE,FNAL,BNL,PITT)

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Σ(1660)

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                    79  Y*1(1660, JP=1/2+) I=1   P'11

                    SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

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                    79  Y*1(1660) MASS (MEV)

M           1500. -- 1600.             ARMENTERO 70 HDBC -O K-N TO SIGMA PI   6/70
M           (1670.)                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
M    2      (1621.)                    LEA       73 DPWA    MULTICHNL K-MTRX  9/73
M    2  ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.      9/73
M           1658.       (4.)           HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74
M    1      (1660.)     (30.)           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
M    1  FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2              11/75
M    3      (1671.)      (2.)           PONTE     75 DPWA  O K- P TO LAM PI    1/76
M    3  FROM SOLUTION 2 OF PONTE 75, NOT PRESENT IN SOLUTION 1.               1/76
M           1668.       (25.)          VANHORN   75 DPWA  O K- P TO LAM PIO  11/75
M    4      1565. OR 1597.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
M    4  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    4  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M           1676.       (15.)          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M           1679.       (10.)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78*

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                    79  Y*1(1660) WIDTH (MEV)

W           (50.0)                     ARMENTERO 70 HDBC -O K-N TO SIGMA PI   6/70
W           (50.)                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
W    2      (51.8)                     LEA       73 DPWA    MULTICHNL K-MTRX  9/73
W           40.       (10.)            HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74
W    1      (80.)     (40.)            BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
W    3      (81.)     (10.)            PONTE     75 DPWA  O K- P TO LAM PI    1/76
W           230.      (165.)    (60.)  VANHORN   75 DPWA  O K- P TO LAM PIO  11/75
W    4      202. OR 217.               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
W           120.      (20.)            RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           38.       (10.)            ALSTON    78 DPWA    KBAR N ELASTIC    1/78*

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                    79  Y*1(1660) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1      Y*1(1660) INTO KBAR N                                    497+ 939
P2      Y*1(1660) INTO SIGMA PI                                  1197+ 139
P3      Y*1(1660) INTO LAMBDA PI                                 1115+ 139

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                    79  Y*1(1660) BRANCHING RATIOS

R1      Y*1(1660) FROM KBAR N TO SIGMA PI                        SQRT(P1*P2)
R1           (+0.2)                     ARMENTERO 70 HDBC -O K-N TO SIGMA PI   6/70
R1           (0.24)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
R1           (-.21)                     LEA       73 DPWA    MULTICHNL K-MTRX  9/73
R1  2      NOT SEEN                     HEPP2     76 DPWA -0 K- NUC TO SIG PI  2/77*
R1  4        (-.34)OR -.37              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R1            -.16      (.03)           RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2      Y*1(1660) INTO KBAR N                                    (P1)
R2           (0.14)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
R2  2         (.10)                     LEA       73 DPWA    MULTICHNL K-MTRX  9/73
R2             .11      (.02)          HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74
R2  4        (.27)OR .29                MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R2           LESS THAN .04              RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R2             .10      (.05)          ALSTON    78 DPWA    KBAR N ELASTIC    1/78*

R3      Y*1(1660) FROM KBAR N TO LAMBDA PI                       SQRT(P1*P3)
R3           (0.0)                      KIM       71 DPWA    K-MATRIX ANAL.    2/73
R3  2        (+.07)                     LEA       73 DPWA    MULTICHNL K-MTRX  9/73
R3  1        (-.04)    (.02)            BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R3  3        (+.16)    (.01)            PONTE     75 DPWA  O K- P TO LAM PI    1/76
R3             .12     (.12)    (.04)  VANHORN   75 DPWA  O K- P TO LAM PIO  11/75
R3  4        (-.10)OR -.11              MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R3           LESS THAN .04              RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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                    REFERENCES FOR Y*1(1660)

ARMENTER 70 DUKE 123           ARMENTEROS, BAILLON, +          (CERN,HEIDEL)IJP
KIM      71 PRL 27 356         J K KIM                                  (HARV)IJP
    ALSO 70 DUKE 161           J. K. KIM                                (HARV)IJP
HART     73 PURDUE CONF. 311   +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP
LEA      73 NP B56 77          +MARTIN,MOORHOUSE+  (RHEL+LOUC+GLAS+AARHUS)IJP

BAILLON   75 NP B94 39         P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
PONTE     75 PRD 12 2597       +HERTZBACH,BUTTON-SHAFER+   (MASA+TENN+UCR)IJP
VANHORN   75 NP B87 145        A. J. VAN HORN                           (LBL)IJP
    ALSO  75 NP B87 157        A. J. VAN HORN                           (LBL)IJP

HEPP2     76 PL 65B 487        +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
MARTIN    77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
    ALSO  77 NP B126 266       MARTIN,PIDCOCK                           (LOUC)
    ALSO  77 NP B126 285       MARTIN,PIDCOCK                           (LOUC)IJP
RLIC      77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON    78  LBL-6784         +KENNEY,POLLARD,ROSS+         (LBL+MTHO+CERN)IJP
    ALSO  77 PRL 38 1007       ALSTON-GARNJOST,KENNEY        (LBL+MTHO+CERN)IJP

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Baryons
Σ(1670)

Note on Σ(1670)

Production Experiments

The measured $\Sigma\pi/\Sigma\pi\pi$ branching ratio for produced Σ(1670)'s is strongly dependent on momentum transfer. This was first discovered by EBERHARD 69, who suggested the existence of two Y_1^*'s with the same mass and quantum numbers; one object with a large $\Sigma\pi\pi$ [mainly $\Lambda(1405)\pi$] decay mode produced peripherally, and another one with a large $\Sigma\pi$ decay mode produced at larger angles. This observation has been confirmed by AGUILAR-BENITEZ 70, ASPELL 74, ESTES 74, and TIMMERMANS 76. When determined, the most likely quantum numbers are $3/2^-$ [for both $\Sigma\pi$ and $\Lambda(1405)\pi$]. There is also the possibility of a third Y_1^* state, referred to as Σ(1690) in the Data Card Listings, with a large $\Lambda\pi/\Sigma\pi$ branching ratio and somewhat larger mass. The large branching ratio is the main justification for this hypothesis and needs confirmation. These problems have been reviewed by EBERHARD 73 and MILLER 70.

Formation Experiments

Two states are also observed near this mass in formation. One of these, the Σ(1670, $3/2^-$), has the same quantum numbers as those observed in production and a large $\Sigma\pi/\Sigma\pi\pi$ branching ratio. It may well correspond to the produced Σ(1670) seen at larger angles. (See TIMMERMANS 76 on this point.) The other state, the Σ(1660, $1/2^+$), has different quantum numbers from those seen in production, and its $\Sigma\pi/\Sigma\pi\pi$ branching ratio is unknown. Thus its relation to the produced Σ(1670) remains obscure. (See also the "Note on Σ(1620)" above.)

Σ(1670) 44 Y*1(1670, JP=3/2-) I=1 **D″13**

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

WELL ESTABLISHED RESONANCE. IT HAS BEEN SEEN IN BOTH FORMATION AND PRODUCTION EXPERIMENTS.

SEE LISTING OF PRODUCTION EXPERIMENTS BELOW

44 Y*1(1670) MASS (MEV)

M		1660.0			BERLEY	64 HBC	0 K-P TO LAM PIO		7/66
M		1668.	(5.)		ARMENTER	68 HBC	0 K-P ELAS.+CH.EX		11/68
M		(1661.0)	(2.0)		ARMENTE2	68 HBC	0 K-P TO SIGMA PI		11/68
M		1680.			ARMENTE4	69 DBC	K-N TO SIG- PIO		12/68
M		1663.0	(2.0)		ARMENT-5	69 HBC	0 K-P TO SIGMPI ED		9/69
M		1672.0			BERLEY	69 HBC	K-P TO SIG PI		5/70
M		1660.			ARMENTER	70 HBC	0 K-P TO LAM.PI EI		5/70
M		1681.0	(3.0)		BRUCKER	70 DBC	- K-N TO SIG 2PI		10/71
M		1662.0	(5.0)		GALTIERI	70 HBC	0 SIG PI,EDPWA		7/70
M		1665.	(10.)		GALTIERI	70 HBC	0 LAM. PI, EDPWA		7/70
M		1676.	(2.)		BUDGEN	71 DPWA	LAM PIO,CHS DATA		10/71
M		1670.			KIM	71 DPWA	K-MATRIX ANAL.		3/71
M		1675.0	(15.0)		LANGBEIN	72 IPWA	MULTICHANNEL		12/72
M		1685.	(20.)		BAILLON	75 IPWA	KBAR N TO LAM PI		11/75
M	C	(1671.)	(3.)		PONTE	75 DPWA	0 K- P TO LAM PI		1/76
M	C	FROM SOLUTION 1 OF PONTE 75.							1/76
M	D	(1655.)	(2.)		PONTE	75 DPWA	0 K- P TO LAM PI		1/76
M	D	FROM SOLUTION 2 OF PONTE 75.							1/76
M		1659.	(12.)	(5.)	VANHORN	75 DPWA	0 K- P TO LAM PIO		11/75
M		(1650.)			BELLEFON	76 IPWA	0 K- P TO LAM PI		2/77*
M		1670.	(6.)		HEPP2	76 DPWA	-0 K- NUC TO SIG PI		2/77*
M	1	1667. OR 1668.			MARTIN	77 DPWA	KBAR N MULTICHNL		11/77*
M	1	THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE							
M	1	PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.							
M		1670.	(5.)		RLIC	77 DPWA	KBAR N MULTICHNL		1/76
M		1679.	(10.)		ALSTON	78 DPWA	KBAR N ELASTIC		1/78*

44 Y*1(1670) WIDTH (MEV)

W		60.0			BERLEY	64 HBC	0	7/66
W		56.	(18.)		ARMENTER	68 HBC	0 K-P ELAS.+CH.EX	11/68
W		(44.0)	(4.0)		ARMENTE2	68 HBC	0 K-P TO SIGMA PI	11/68
W		47.0			ARMENTE4	69 DBC	K-N TO SIG- PIO	12/68
W		49.0	(4.0)		ARMENT-5	69 HBC	0 K-P TO SIGMPI ED	9/69
W		34.0			BERLEY	69 HBC		5/70
W		50.			ARMENTER	70 HBC	0 K-P TO LAMB.PI	5/70
W		30.0	(10.0)		BRUCKER	70 DBC	- K-N TO SIG 2PI	10/71
W		48.0	(5.0)		GALTIERI	70 HBC	0 SIG PI,EDPWA	7/70
W		50.	(10.)		GALTIERI	70 HBC	0 LAM. PI, EDPWA	7/70
W		59.	(4.5)		BUDGEN	71 DPWA	LAM PIO	10/71
W		40.			KIM	71 DPWA	K-MATRIX ANAL.	3/71
W		65.0	(20.0)		LANGBEIN	72 IPWA	MULTICHANNEL	12/72
W		70.	(20.)		BAXTER	73 DPWA	0 K- P TO NEUTRALS	10/74
W		85.	(25.)		BAILLON	75 IPWA	KBAR N TO LAM PI	11/75
W	C	(44.)	(11.)		PONTE	75 DPWA	0 K- P TO LAM PI	1/76
W	D	(76.)	(5.)		PONTE	75 DPWA	0 K- P TO LAM PI	1/76
W		32.	(11.)		VANHORN	75 DPWA	0 K- P TO LAM PIO	11/75
W		(80.)			BELLEFON	76 IPWA	0 K- P TO LAM PI	2/77*
W		56.	(3.)		HEPP2	76 DPWA	-0 K- NUC TO SIG PI	2/77*
W	1	46. OR 46.			MARTIN	77 DPWA	KBAR N MULTICHNL	11/77*
W		50.	(5.)		RLIC	77 DPWA	KBAR N MULTICHNL	1/76
W		56.	(20.)		ALSTON	78 DPWA	KBAR N ELASTIC	1/78*

44 Y*1(1670) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(1670) INTO KBAR N	497+ 939
P2	Y*1(1670) INTO LAMBDA PI	1115+ 139
P3	Y*1(1670) INTO SIGMA PI	1197+ 139
P4	Y*1(1670) INTO LAMBDA PI PI	1115+ 139+ 139
P5	Y*1(1670) INTO SIGMA PI PI	1197+ 139+ 139
P6	Y*1(1670) INTO Y*1(1385) PI S-WAVE	139+1384
P7	Y*1(1670) INTO Y*0(1405) PI	1405+ 139
P8	Y*1(1670) INTO LAMBDA(1520) PI	139+1518

44 Y*1(1670) BRANCHING RATIOS

R1		Y*1(1670) INTO (KBAR N)/TOTAL				(P1)		
R1		(0.09)	(0.02)		ARMENTER	68 HBC		9/69
R1		0.08	(0.02)		ARMENT-5	69 HBC	0 ELAS. +CH.EX. ED	9/69
R1		0.07			KIM	71 DPWA	K-MATRIX ANAL.	3/71
R1		0.10	(0.03)		LANGBEIN	72 IPWA	MULTICHANNEL	12/72
R1		NOT SEEN			HART	73 DPWA	EL+CX,.7-.8GEV/C	2/74
R1	1	(.07)OR .07			MARTIN	77 DPWA	KBAR N MULTICHNL	11/77*
R1		.08	(.03)		RLIC	77 DPWA	KBAR N MULTICHNL	1/76
R1		.11	(.03)		ALSTON	78 DPWA	KBAR N ELASTIC	1/78*
R2		Y*1(1670) INTO (LAMBDA PI PI)/TOTAL				(P4)		
R2		(0.11) OR LESS			ARMENTE3	68 HBC	K-P (P1=.09)	9/69
R3		Y*1(1670) INTO (SIGMA PI PI)/TOTAL				(P5)		
R3	A	(0.14) OR LESS			ARMENTE3	68 HBC	K-P AND D-P1=.09	11/68
R3	A	RATIO ONLY FOR (SIG2PI) SYSTEM IN I=1, WHICH CANNOT BE Y*1(1385)						11/68
R4		Y*1(1670) INTO (Y*0(1405) PI)/TOTAL				(P7)		
R4		(0.06) OR LESS			ARMENTE3	68 HBC	K-P AND D-P1=.09	11/68
R5		Y*1(1670) FROM KBAR N TO LAMBDA PI				SQRT(P1*P2)		
R5	2	(+0.1)			ARMENTER	70HBC	K-P TO LAMB PI	5/70
R5	2	PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT)						10/74
R5		+0.09	(0.02)		GALTIERI	70 HBC	0 LAM. PI, EDPWA	7/70
R5		.165	(.01)		BUDGEN	71 DPWA	LAM PIO	10/71
R5		0.08			KIM	71 DPWA	K-MATRIX ANAL.	3/71
R5		0.13	(0.03)		LANGBEIN	72 IPWA	MULTICHANNEL	12/72
R5		+.10	(.02)		BAXTER	73 DPWA	0 K- P TO NEUTRALS	10/74
R5		+.018	.060		DEVENISH	74	0 FIXED T DISP REL	4/75
R5		+.06	(.02)		BAILLON	75 IPWA	KBAR N TO LAM PI	11/75
R5	C	(.08)	(.01)		PONTE	75 DPWA	0 K- P TO LAM PI	1/76
R5	D	(.17)	(.01)		PONTE	75 DPWA	0 K- P TO LAM PI	1/76
R5		+.09	(.02)		VANHORN	75 DPWA	0 K- P TO LAM PIO	11/75
R5		(+.05)			BELLEFON	76 IPWA	0 K- P TO LAM PI	2/77*
R5	1	(+.08)OR +.08			MARTIN	77 DPWA	KBAR N MULTICHNL	11/77*
R5		+.10	(.02)		RLIC	77 DPWA	KBAR N MULTICHNL	1/76
R6		Y*1(1670) FROM KBAR N TO SIGMA PI				SQRT(P1*P3)		
R6		(+0.21)	(0.01)		ARMENTE2	68 HBC	0 OLD DATA	11/68
R6		+0.19			ARMENTE4	69 DBC		9/69
R6		+0.20	(0.01)		ARMENT-5	69 HBC	0 NEW DATA	9/69
R6		+0.18			BERLEY	69 HBC		5/70
R6		+0.18	(0.06)		GALTIERI	70 HBC	0 SIG PI,EDPWA	7/70
R6		0.15			KIM	71 DPWA	K-MATRIX ANAL.	3/71
R6		0.23	(0.05)		LANGBEIN	72 IPWA	MULTICHANNEL	12/72
R6		+.20	(.01)		HEPP2	76 DPWA	-0 K- NUC TO SIG PI	2/77*
R6	1	(+.18)OR +.17			MARTIN	77 DPWA	KBAR N MULTICHNL	11/77*
R6		+.21	(.02)		RLIC	77 DPWA	KBAR N MULTICHNL	1/76
R7		Y*1(1670) FROM KBAR N TO Y*1(1385) PI S-WAVE				SQRT(P1*P6)		
R7	S	(0.17)	(0.02)		SIMS	68 DBC	- LAM 2PI CROS.SEC	10/71
R7	S	SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY						3/72
R7		+.11	.03		PREVOST	74 DPWA	0- K-N TO S(1385)PI	10/74
R8		Y*1(1670) INTO (Y*0(1405)PI)*(KBAR N)/TOTAL**2				(P7*P1)		
R8		(0.03) OR LESS			BERLEY	69 HBC	0 K-P .6-.82 BEV/C	5/70
R8	B	0.007	(0.002)		BRUCKER	70 DBC	- K-N TO SIG 2PI	10/71
R8	B	ASSUMING Y*0(1405) PI CROSS SECTION BUMP DUE SOLEY TO 3/2- RESON.						10/71
R9		Y*1(1670) INTO (Y*0(1405) PI)/(Y*1(1385) PI)				(P7)/(P6)		
R9		0.23	(0.08)		BRUCKER	70 DBC	- K-N TO SIG 2PI	10/71
R10		Y*1(1670) FROM KBAR N TO LAMBDA(1520) PI				SQRT(P1*P8)		
R10	3	.081	.016		CAMERON	77 DPWA	0 P-WAVE DECAY	1/78*
R10	3	CAMERON77 UPPER LIMIT ON F-WAVE DECAY IS .03						1/78*
R10	3	ASSUMES LAMBDA(1520) ELASTICITY=.46.						1/78*

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REFERENCES FOR Y*1(1670)

BERLEY 64 DUBNA CONF I 565 +CONNOLLY,HART,RAHM,STONEHILL, + (BNL)IJP

ARMENTER 68 NP B8 195 ARMENTEROS,BAILLON + (CERN+HEID+SACLAY)IJP
ARMENTE1 68 NP B8 183 ARMENTEROS,BAILLON + (CERN+HEID+SACLAY)IJP
ARMENTE2 68 NP B8 223 ARMENTEROS+BAILLON + (CERN+HEID+SACLAY)IJP
ARMENTE3 68 PL 28B 521 ARMENTEROS,BAILLON + (CERN+HEID+SACLAY)I
SIMS 68 PRL 21 1413 SIMS,ALBRIGHT,BARTLEY,MEER+ (FSU,TUFT,BRAN)

ARMENTE4 69 NP B10 459 ARMENTEROS,BAILLON,MINTEN + (CERN+SACLAY) J
ARMENT-5 69 NP B14 91 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BERLEY 69 PL 30B 430 BERLEY,HART,RAHM,WILLIS,YAMAMOTO (BNL)

ARMENTER 70 DUKE 123 ARMENTEROS, BAILLON, + (CERN,HEID)
BRUCKER 70 DUKE 155 +HARRISON,SIMS,ALBRIGHT,CHANDLER++ (FSU)I
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP
BUDGEN 71 LNC 2 85 D BUDGEN (DURH)IJP
KIM 71 PRL 27 356 J K KIM (HARV)IJP
ALSO 70 DUKE 161 J. K. KIM (HARV)IJP

LANGBEIN 72 NP B47 477 +WAGNER (MPIM)IJP
BAXTER 73 NP B67 125 BAXTER,BUCKINGHAM,CORBETT,DUNN,+ (OXFORD)IJP
HART 73 PURDUE CONF. 311 +RICE,BACASTOW,FUNG,+ (TENN+UCR+MASA+BUFF)IJP
DEVENISH 74 NP B81 330 DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
PREVOST 74 NP B69 246 PREVOST,BARLOUTAUD,+ (SACL+CERN+HEID)

BAILLON 75 NP B94 39 P. BAILLON,P. J. LITCHFIELD (CERN,RHEL)IJP
PONTE 75 PRD 12 2597 +HERTZBACH,BUTTON-SHAFER+ (MASA+TENN+UCR)IJP
VANHORN 75 NP B87 145 A. J. VAN HORN (LBL)IJP
ALSO 75 NP B87 157 A. J. VAN HORN (LBL)IJP

BELLEFON 76 NP B109 129 DE BELLEFON,BERTHON (CDEF)IJP
HEPP2 76 PL 65B 487 +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)IJP
CAMERON 77 NP B131 399 +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN 77 NP B127 349 MARTIN,PIDCOCK,MOORHOUSE (LOUC+GLAS)IJP
ALSO 77 NP B126 266 MARTIN,PIDCOCK (LOUC)
ALSO 77 NP B126 285 MARTIN,PIDCOCK (LOUC)IJP
RLIC 77 NP B119 362 GOPAL,ROSS,VAN HORN,MCPHERSON+ (LOIC+RHEL)IJP

ALSTON 78 LBL-6784 +KENNEY,POLLARD,ROSS+ (LBL+MTHO+CERN)IJP
ALSO 77 PRL 38 1007 ALSTON-GARNJOST,KENNEY (LBL+MTHO+CERN)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

BASTIEN1 63 PRL 10 188 P L BASTIEN, J P BERGE (LRL) IJ
REPLACED BY BASTIEN 2, BUT SIMILAR AND MORE READILY AVAILABLE.
BASTIEN2 63 UCRL-10779 THESIS P L BASTIEN (LRL) IJ
T-ZADEH 63 PRL 11 470 TAHER-ZADEH,PROWSE,SCHLEIN,SLATER,+ (UCLA) JP
SEE NOTE FOLLOWING SCHLEIN 66.
SCHLEIN 66 UCLA-1016 P.E. SCHLEIN, T.G. TRIPPE (UCLA) JP
REANALYSES DATA OF TAHER-ZADEH 63 , BASTIEN 63 AND ALL PUBLISHED
LAMBDA PI CROSS SECTION DATA IN THE LIGHT OF THE NOW KNOWN
Y*1(1765) . REVERSES THE MODEL-DEPENDENT CONCLUSION OF TAHER-
ZADEH ON THE PREFERRED JP ASSIGNMENT (FROM 3 2+ TO 3 (2-).)
SMART 66 PRL 17 556 W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
ARMENTER 67 NP B3 592 ARMENTEROS,FERRO-LUZZI+ (CERN,HEID,SACLAY)
PREVOST 71 AMSTERDAM CONF + CHS COLLABORATION (CERN+HEID+SACL)

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Σ(1670) BUMPS

51 Y*1(1670, JP=) I=1 PROD. AND CROSS SECT. EXPS.

SEE NOTE PRECEDING Y*1(1670)
PROBABLY THERE ARE TWO STATES AT SAME MASS WITH SAME
QUANTUM NUMBERS, ONE DECAYING INTO SIGMA PI AND LAMBDA
PI, THE OTHER INTO Y*0(1405) PI.

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51 Y*1(1670) MASS (MEV) (PROD. EXP.)

M			(1685.0)		ALEXANDER	62 HBC	-0	PI-P 2-2.2 BEV/C	
M			1660.0	10.0	ALVAREZ	63 HBC	+	K-P 1.51 BEV/C	
M			(1665.0)	(5.0)	BUGG	68 CNTR		K-P, D TOTAL C.S	
M	P	70	(1661.)	(9.)	PRIMER	68 HBC	+	K-P 4.6-5. GEV/C	7/68
M	P		SEE BARNES 69 FOR NEW ANALYSIS OF DATA (3 TIMES MORE DATA)						10/69
M			1670.0	6.0	AGUILAR	70 HBC		SIG.PI K-P 4 GEV	5/70
M			1668.0	10.0	AGUILAR	70 HBC		SIG.2PI K-P 4GEV	5/70
M			1665.	1.0	APSELL	74 HBC		K- P 2.87 GEV/C	4/75
M		1200	1688+/-2. OR 1683+/-5.		BERTHON	74 HBC	0	QUASI 2 BODY CS	4/75
M		5	1670.	4.	CARROLL	76 DPWA		I=1 TOTAL CS	2/77*
M		5	TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.23						2/77*
M		2	1675.	10.	HEPP1	76 DBC	-	K-N 1.6-1.75 GEV	2/77*
M		2	ENHANCEMENTS IN SIG P1 AND SIG P1 P1 CHANNEL CROSS SECTIONS.						2/77*
M			1655. TO 1677.		TIMMERMA	76 HBC	+	K- P 4.2 GEV/C	2/77*
M			. . . .						
M			AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)						

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51 Y*1(1670) MASS (MEV) (PROD. EXP.)

W			(45.0)			ALEXANDER	62 HBC	-0		
W			40.0	10.0		ALVAREZ	63 HBC	+		
W			(30.0)	(15.0)		BUGG	68 CNTR			11/66
W	P	70	(60.)	(20.)		PRIMER	68 HBC	+	K-P 4.6-5. GEV/C	7/68
W			110.0	12.0		AGUILAR	70 HBC		SIG.PI K-P 4 GEV	5/70
W			135.0	40.0	30.0	AGUILAR	70 HBC		SIG.2PI K-P 4GEV	5/70
W			67.	2.4		APSELL	74 HBC		K- P 2.87 GEV/C	4/75
W			SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.							
W		5	(52.)			CARROLL	76 DPWA		I=1 TOTAL CS	2/77*
W			48. TO 63.			TIMMERMA	76 HBC	+	K- P 4.2 GEV/C	2/77*
W			. . . .							
W			AVERAGE MEANINGLESS (SCALE FACTOR = 3.2)							

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51 Y*1(1670) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*1(1670) INTO KBAR N	497+ 939
P2	Y*1(1670) INTO LAMBDA PI	1115+ 139
P3	Y*1(1670) INTO SIGMA PI	1197+ 139
P4	Y*1(1670) INTO LAMBDA PI PI	1115+ 139+ 139
P5	Y*1(1670) INTO SIGMA PI PI	1197+ 139+ 139
P6	Y*1(1670) INTO Y*1(1385) PI	1384+ 139
P7	Y*1(1670) INTO Y*0(1405) PI	1405+ 139

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51 Y*1(1670) BRANCHING RATIOS (PROD. EXP.)

R1		Y*1(1670) INTO (KBAR N)/(SIGMA PI)							(P1)/(P3)	
R1		0	(0.19) OR LESS			ALVAREZ	63 HBC	+	K-P 1.15 BEV/C	
R1			(0.5)+- .25 OR MORE			SMITH	63 HBC	-0		
R1			(0.6) OR LESS			LONDON	66 HBC	+	K-P 2.25 BEV/C	7/66
R1			(0.025)			BUGG	68 CNTR	0	ASSUMING J=3/2	11/66
R1		0	(0.24) OR LESS			PRIMER	68 HBC	+	K-P 4.6-5. GEV/C	7/68
R1			(0.26) OR LESS			BARNES	69 HBC	+	K-P 3.9-5 GEV/C	10/69
R1			(0.2) OR LESS			AGUILAR	70 HBC			5/70
R1			(0.10) OR LESS			BERTHON	74 HBC	0	QUASI 2 BODY CS	4/75
R1			(.03) OR LESS			TIMMERMA	76 HBC	+	K- P 4.2 GEV/C	2/77*
R2		Y*1(1670) INTO (LAMB.PI)/(SIG PI)							(P2)/(P3)	
R2		130	(1.20)			ALVAREZ	63 HBC	+	K-P 1.15 BEV/C	
R2			(1.2)			SMITH	63 HBC	-0		
R2			0.15	0.07		HUWE	64 HBC	+		
R2			0.6 OR LESS			LONDON	66 HBC	+	K-P 2.25 BEV/C	7/66
R2		33	0.11	0.06		BUTTON-S	68 HBC	+	K-P AT 1.7 GEV/C	10/69
R2	P	0	(0.)			PRIMER	68 HBC	+	K-P 3.9-5 GEV/C	10/69
R2	P	PRIMER 68 ASSUMED THIS DECAY TO BE ALL Y*(1690)- SEE BARNES 69 FOR								
R2	P	NEW INTERPRATATION OF DATA.(3 TIMES MORE DATA) -								
R2			0.45	0.15		BARNES	69 HBC	+	K-P 3.9-5 GEV/C	10/69
R2			(.55)	(.11)		BERTHON	74 HBC	0	QUASI 2 BODY CS	4/75
R2			.76	.09		ESTES	74 HBC	0	K-P,2.1+2.6GEV/C	11/75
R2			(.45)+/- .07 OR LESS			TIMMERMA	76 HBC	+	K- P 4.2 GEV/C	2/77*
R2			. . . .							
R2		AVERAGE MEANINGLESS (SCALE FACTOR = 3.7)								
R3		Y*1(1670) INTO (LAMB. PI PI)/(SIG PI)							(P4)/(P3)	
R3		90	(0.56)			ALVAREZ	63 HBC	+	K-P 1.15 BEV/C	
R3			(0.17)			SMITH	63 HBC	-0		
R3			(0.6) OR LESS			LONDON	66 HBC	+	K-P AT 2.25 BEV/C	7/66
R4		Y*1(1670) INTO (SIGMA PI PI)/(SIG PI)							(P5)/(P3)	
R4		180	(0.56)			ALVAREZ	63 HBC	+	K-P 1.15 BEV/C	
R4	B		LARGEST AT SMALL ANGLES			ESTES	74 HBC	0	K-P,2.1+2.6GEV/C	11/75
R4		2	(0.2)OR LESS			HEPP1	76 DBC	-	K-N 1.6-1.75 GEV	2/77*
R5		Y*1(1670) INTO (Y*0(1405) PI)/(SIG PI)							(P7)/(P3)	
R5		50	3.	1.6		LONDON	66 HBC	+	K-P 2.25 BEV/C	7/66
R5	P	17	(0.58)	(0.20)		PRIMER	68 HBC	+	K-P 4.6-5. GEV/C	7/68
R5	B		LARGEST AT SMALL ANGLES			ESTES	74 HBC	+-	K-P 2.1+2.6GEV/C	11/75
R5	BD		1.8+/-0.3 TO 0.02+/-0.07			TIMMERMA	76 HBC	+	K-P 4.2 GEV/C	11/77*
R5	D	DEPENDING ON PRODUCTION ANGLE								
R6		Y*1(1670) INTO (SIGMA PI)/(SIGMA PI PI)							(P3)/(P5)	
R6			.4 OR LESS			BIRMINGHA	66 HBC	+	K-P AT 3.5 GEV/C	11/67
R6			0.30	0.15		LONDON	66 HBC	+	K-P 2.25 GEV/C	7/66
R6	C		BETWEEN 2.5 AND 0.24			EBERHARD	69 HBC		K-P AT 2.6 GEV/C	9/69
R6	D	DEPENDING ON THE PRODUCTION ANGLE								
R6	B		VARIES WITH PROD. ANGLE			APSELL	74 HBC	+	K-P 2.87 GEV/C	4/75
R6			(1.39)	(.16)		BERTHON	74 HBC	0	QUASI 2 BODY CS	4/75
R6	B	APSELL 74, ESTES 74 AND TIMMERMANS 76 FIND STRONG BRANCHING RATIO								
R6	B	DEPENDENCE ON PRODUCTION ANGLE, AS IN EARLIER PROD. EXPERIMENTS.								
R7		Y*1(1670) INTO (Y*0(1405) PI)/(SIGMA PI PI)							(P7)/(P5)	
R7			0.90	0.10	0.16	EBERHARD	65 HBC	+	K-P 2.45 BEV/C	7/66
R7			1.00	.02		APSELL	74 HBC		K- P 2.87 GEV/C	4/75
R7			.97	.08		TIMMERMA	76 HBC		K- P 4.2 GEV/C	2/77*
R7			. . . .							
R7		AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)								
R8		Y*1(1670) INTO (Y*0(1405) PI)/(Y*1(1385) PI)							(P7)/(P6)	
R8			(0.8) OR LESS			EBERHARD	65 HBC	+	K-P 2.45 BEV/C	7/66
R9		Y*1(1670) INTO (LAMBDA PI PI)/(SIGMA PI PI)							(P4)/(P5)	
R9			0.35	0.2		BIRMINGHA	66 HBC	+	K-P AT 3.5 GEV/C	11/67
R10		Y*1(1670) INTO (LAMBDA PI)/(SIGMA PI PI)							(P2)/(P5)	
R10			(.2) OR LESS			BIRMINGHA	66 HBC	+	K-P AT 3.5 GEV/C	11/67
R11		Y*1(1670) INTO (LAMBDA PI)/(LAMBDA PI + SIG PI)							(P2)/(P2+P3)	
R11			(0.6) OR LESS			AGUILAR	70 HBC			5/70
R12		Y*1(1670) INTO (Y*1(1385) PI)/(SIGMA PI)							(P6)/(P3)	1/76
R12			(.21)+/- .05 OR LESS			TIMMERMA	76 HBC		K- P 4.2 GEV/C	2/77*

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51 Y*1(1670) QUANTUM NUMBER DETERMINATION (PROD. EXP.)

Q1		JP=3/2+	LEVEQUE	65 HBC		INTO Y*(1405)+PI	11/68
Q3		JP=3/2-	EBERHARD	67 HBC	+	INTO Y*(1405) PI	11/68
Q4	400	JP=3/2-	BUTTON-SH	68 HBC	+-	INTO SIGZERO+PI	11/68

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REFERENCES FOR Y*1(1670) (PROD. EXP.)

ALEXANDE 62 CERN CONF 320 ALEXANDER,JACOBS,KALBFLEISCH,MILLER,+ (LRL) I
ALVAREZ 63 PRL 10 184 +ALSTON,FERRO-LUZZI,HUWE, + (LRL) I
SMITH 63 ATHENS CONF 67 G A SMITH (LRL)
HUWE 64 PR 180 1824(1969) D O HUWE (LRL)
EBERHARD 65 PRL 14 466 +SHIVELY,ROSS,SIEGAL,FICENEC, + (LRL,ILL) I

BIRMINGH 66 PR 152 1148 BIRMINGHAM,GLASGOW,I.C.Y OXFORD,RUTHERFORD
LONDON 66 PR 143 1034 +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+ (BNL,SYRA) IJ
BUGG 68 PR 168 1466 +GILMORE,KNIGHT,DAVIES+ (BIRM,CAVE,RHEL)I
BUTTON-S 68 PRL 21 1123 J BUTTON SHAFER (MASA+LRL) JP
PRIMER 68 PRL 20 610 +GOLDBERG,JAEGER,BARNES,DORNAN + (SYRA,BNL)

BARNES 69 BNL 13823 +CHUNG,EISNER,FLAMINIO+ (BNL,SYRA)
EBERHARD 69 PRL 22 200 +FRIEDMAN,PRIPSTEIN,ROSS (LRL)
AGUILAR 70 PRL 25 58 +BARNES, BASSANO, CHUNG, EISNER,+(BNL,SYRA)

APSELL 74 PRD 10 1419 APSELL,FORD,GOUREVITCH+(BRAN,UMD,SYRA,TUFT)I
BERTHON 74 NC 21A 146 BERTHON,TRISTRAM,+ (CDEF+RHEL+SACL+STRB)
ESTES 74 LBL-3827 (THESIS) R. D. ESTES (LBL)

CARROLL 76 PRL 37 806 +CHIANG,KYCIA,LI,MAZUR,MICHAEL+ (BNL)I
HEPP1 76 NP B115 82 +BRAUN,GRIMM,STROBELE,THOL+(CERN,HEID,MPIM)I
TIMMERMA 76 NP B112 77 TIMMERMANS,ENGELEN+ (NIJM+CERN+AMST+OXF) JP

PAPERS NOT REFERRED TO IN DATA CARDS

LEVEQUE 65 PL 18 69 + (SACLAY,EPOL,GLASGOW,LOIC,OXF,RHEL) JP
LEE 66 PRL 17 45 Y Y LEE, D D REEDER, R W HARTUNG (WISC) JP
EBERHARD 67 PR 163 1446 +PRIPSTEIN,SHIVELY,KRUSE,SWANSON (LRL,ILL)IJP
MILLER 70 DUKE 229 D H MILLER (REVIEW TALK) (PURDUE)
EBERHARD 73 PURDUE CONF. 247 EBERHARD (LBL)IJP
HUNGERBU 74 PRD 10 2051 HUNGERBUHLER,MAJKA,+ (YALE,FNAL,BNL,PITT)

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Baryons

Σ(1690), Σ(1750)

Σ(1690) BUMPS

58 Y*1(1690, JP=) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

SEE NOTE PRECEDING Y*1(1670) LISTINGS, SEEN IN PRO. EXPERIMENTS ONLY, MAIN DECAY MODE IS LAMBDA PI.

58 Y*1(1690) MASS (MEV) (PROD. EXP.)

M		30(1715.0)	(12.0)		COLLEY	67	HBC	+ K-P 6 GEV/C	8/67
M	P	60(1694.0)	(24.0)		PRIMER	68	HBC	+ K-P 4.6-5 GEV/C	7/68
M	N	(1700.0)	(6.0)		SIMS	68	HBC	- K-N TO LAM PI PI	11/68
M		46(1682.0)	(2.0)		BLUMENFEL	69	HBC	+ KO LONG + PROTON	9/69
M		(1700.0)	(20.0)		MOTT	69	HBC	+ K-P 5.5 GEV/C	9/69
M	P	SEE Y*1(1670) LISTING-AGUILAR 70 WITH THREE TIMES THE DATA OF							
M	P	PRIMER 68 SHOW THAT THEY HAVE NO EVIDENCE FOR Y*(1690)							
M	N	THIS ANALYSIS, WHICH IS DIFFICULT AND REQUIRES SEVERAL ASSUMPTIONS							
M		AND SHOWS NO UNAMBIGUOUS Y*1(1690) SIGNAL, SUGGESTS JP=5/2+. SUCH A							
M		Y* WOULD LEAD ALL PREVIOUSLY KNOWN Y* TRAJECTORIES.							

58 Y*1(1690) WIDTH (MEV) (PROD. EXP.)

W		30 (100.0)	(35.0)		COLLEY	67	HBC	+	8/67
W		60 (105.0)	(35.0)		PRIMER	68	HBC	+	7/68
W	N	(62.0)	(14.0)		SIMS	68	HBC	- SEE NOTE N ABOVE	11/68
W		46 (25.0)	(10.0)		BLUMENFEL	69	HBC	+	9/69
W		(130.0)	(25.0)		MOTT	69	HBC	+	9/69
		SEE THE NOTES ACCOMPANYING THE MASSES QUOTED							

58 Y*1(1690) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*1(1690) INTO KBAR N	497+ 939
P2	Y*1(1690) INTO LAMBDA PI	1115+ 139
P3	Y*1(1690) INTO SIGMA PI	1197+ 139
P4	Y*1(1690) INTO Y*1(1385) PI	1384+ 139
P5	Y*1(1690) INTO LAMBDA PI PI (INCLUDING P4)	1115+ 139+ 139

58 Y*1(1690) BRANCHING RATIOS (PROD. EXP.)

R1	Y*1(1690) INTO (KBAR N)/(LAMBDA PI)							(P1)/(P2)	
R1	18	0.4	0.25		COLLEY	67	HBC	+ 6/30 EVENTS	8/67
R1		(0.2)	OR LESS		MOTT	69	HBC	+	9/69
R2	Y*1(1690) INTO (SIGMA PI)/(LAMBDA PI)							(P3)/(P2)	
R2		0.3	0.3		COLLEY	67	HBC	+ 4/30 EVENTS	8/67
R2		(0.4)	OR LESS CL=.90		MOTT	69	HBC	+	9/69
R3	Y*1(1690) INTO (Y*1(1385) PI)/(LAMBDA PI)							(P4)/(P2)	
R3		(0.5)	OR LESS		MOTT	69	HBC	+	9/69
R4	Y*1(1690) INTO (LAMBDA PI PI)/(LAMBDA PI)							(P5)/(P2)	
R4		0.5	0.25		COLLEY	67	HBC	+ 15/30 EVENTS	8/67
R4		2.0	0.6		BLUMENFEL	69	HBC	+ 31/15 EVENTS	9/69
R4		. . . . .							
R4	AVG	0.72	0.53	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)					
R4	STUDENT	0.67	0.28	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
R5	Y*1(1690) INTO (Y*1(1385) PI)/(LAMBDA PI PI)							(P4)/(P5)	
R5		SMALL			COLLEY	67	HBC	+	8/67
R5		LARGE			SIMS	68	HBC	- K-N TO L2PI	11/68

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REFERENCES FOR Y*1(1690) (PROD. EXP.)

COLLEY 67 PL 24B 489		(BIRM,GLAS,LOIC,MUNICH,OXFORD,RHEL) I
DERRICK 67 PRL 18 266	+FIELDS, LOKEN, AMMAR,	(ARGONNE,NORTHWEST) I
REPLACED BY MOTT 69.		
PRIMER 68 PRL 20 610	+GOLDBERG, JAEGER, BARNES, +	(SYRACUSE,BNL) I
SIMS 68 PRL 21 1413	+ALBRIGHT, +	(FSU,TUFTS,BRANDEIS) I
BLUMENFE 69 PL 29B 58	B J BLUMENFELD, G R KALBFLEISCH	(BNL) I
MOTT 69 PR 177 1966	+AMMAR, DAVIS, KROPAC, +(NORTHWEST,ARGONNE) I	
	PAPERS NOT REFERRED TO IN DATA CARDS	
AGUILAR 70 PRL 25 58	AGUILAR-BENITEZ,BARNES,BASSANO+	(BNL+SYRA)

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Σ(1750) **S_{11}**

57 Y*1(1750, JP=1/2-) I=1

THERE IS EVIDENCE FOR THIS STATE IN MANY PARTIAL-WAVE ANALYSES, BUT WITH RATHER WIDE VARIATIONS IN THE MASS, WIDTH AND COUPLINGS. THE LATEST ANALYSES INDICATED SIGNIFICANT COUPLINGS TO KBAR N AND LAMBDA PI, AS WELL AS SIGMA ETA WHOSE THRESHOLD IS NEARBY AT 1746 MEV (JONES 74).

57 Y*1(1750) MASS (MEV)

M		NEAR SIGMA ETA THRESHOLD			CLINE	67	DBC	- K-N TO SIGMA ETA	9/66
M		ABOUT 1750.0			MEYER	67	RVUE		9/69
M		ABOUT 1730.0			ARMENTERO	70	HDBC	-0 K-N TO LAMBDA PI	6/70
M		(1757.0)	(10.0)		CONFORTO	71	DPWA	0 ELASTIC, CH EXCH	6/70
M		(1790.)			KIM	71	DPWA	K-MATRIX ANAL.	3/71
M		(1790.0)	(15.0)		LANGBEIN	72	IPWA	MULTICHANNEL	12/72
M		(1716.)	(10.)		BAXTER	73	DPWA	0 K- P TO NEUTRALS	10/74
M		(1785.)	(12.)		CHU	74	DBC	- FIT SIG- ETA CS	10/74
M	1	(1760.)	(5.)		JONES	74	HBC	0 FIT SIGO ETA CS	1/74
M		(1739.)	(10.)		PREVOST	74	DPWA	0- K-N TO S(1385)PI	10/74
M	1	S-WAVE BW FIT TO THRSHLD C.S., NO BKGND. ERRORS STATISTICAL ONLY							1/74
M	A	(1780.)	(30.)		BAILLON	75	IPWA	KBAR N TO LAM PI	11/75
M	A	FROM SOLUTION 1 OF BAILLON 75.							11/75
M	B	(1700.)	(30.)		BAILLON	75	IPWA	KBAR N TO LAM PI	1/76
M	B	FROM SOLUTION 2 OF BAILLON 75.							1/76
M		(1697.)	(20.)	(10.)	VANHORN	75	DPWA	0 K- P TO LAM PIO	11/75
M		(1730.)			BELLEFON	76	IPWA	0 K- P TO LAM PI	2/77*
M	3	1715.	10.		CARROLL	76	DPWA	I=1 TOTAL CS	2/77*
M	4	1800. OR 1813.			MARTIN	77	DPWA	KBAR N MULTICHNL	11/77*
M	4	THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE							
M	4	PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.							
M		1770.	15.		RLIC	77	DPWA	KBAR N MULTICHNL	1/76
M		1770.	10.		ALSTON	78	DPWA	KBAR N ELASTIC	1/78*
M		. . . . .							
M	AVERAGE MEANINGLESS (SCALE FACTOR = 3.0)								

57 Y*1(1750) WIDTH (MEV)

W		ABOUT 50.0			MEYER	67	RVUE		9/69
W		ABOUT 80.0			ARMENTERO	70	HDBC	-0 K-N TO LAMBDA PI	6/70
W		(55.0)	(10.0)		CONFORTO	71	DPWA	0 ELASTIC, CH EXCH	6/70
W		(50.)			KIM	71	DPWA	K-MATRIX ANAL.	3/71
W		(100.0)	(20.0)		LANGBEIN	72	IPWA	MULTICHANNEL	12/72
W		(60.)	(20.)		BAXTER	73	DPWA	0 K- P TO NEUTRALS	10/74
W		(89.)	(33.)		CHU	74	DBC	- FIT SIG- ETA CS	10/74
W	1	(92.)	(7.)		JONES	74	HBC	0 FIT SIG+ETA CS	1/74
W		(108.)	(20.)		PREVOST	74	DPWA	0- K-N TO S(1385)PI	10/74
W	A	(140.)	(30.)		BAILLON	75	IPWA	KBAR N TO LAM PI	11/75
W	B	(160.)	(50.)		BAILLON	75	IPWA	KBAR N TO LAM PI	1/76
W		(66.)	(14.)	(12.)	VANHORN	75	DPWA	0 K- P TO LAM PIO	11/75
W		(110.)			BELLEFON	76	IPWA	0 K- P TO LAM PI	2/77*
W	3	(10.)			CARROLL	76	DPWA	I=1 TOTAL CS	2/77*
W	4	117. OR 119.			MARTIN	77	DPWA	KBAR N MULTICHNL	11/77*
W		60.	10.		RLIC	77	DPWA	KBAR N MULTICHNL	1/76
W		161.	20.		ALSTON	78	DPWA	KBAR N ELASTIC	1/78*
W		. . . . .							
W	AVERAGE MEANINGLESS (SCALE FACTOR = 4.5)								

57 Y*1(1750) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(1750) INTO KBAR N	497+ 939
P2	Y*1(1750) INTO SIGMA ETA	1197+ 548
P3	Y*1(1750) INTO LAMBDA PI	1115+ 134
P4	Y*1(1750) INTO SIGMA PI	1197+ 139
P5	Y*1(1750) INTO SIGMA(1385) PI	139+1384
P6	Y*1(1750) INTO LAMBDA(1520) PI	139+1518

57 Y*1(1750) BRANCHING RATIOS

R1	Y*1(1750) INTO (KBAR N)/TOTAL							(P1)	
R1		(0.12)	(0.05)		CONFORTO	71	DPWA	0 ELASTIC, CH EXCH	6/70
R1		(0.8)			KIM	71	DPWA	K-MATRIX ANAL.	3/71
R1		(0.45)	(0.05)		LANGBEIN	72	IPWA	MULTICHANNEL	12/72
R1	3	TOTAL CROSS SECTION BUMP WITH (J+1/2)X=.30 SEEN BY CARROLL 76							2/77*
R1	4	(.06)OR .05			MARTIN	77	DPWA	KBAR N MULTICHNL	11/77*
R1		.15	.03		RLIC	77	DPWA	KBAR N MULTICHNL	1/76
R1		.33	.05		ALSTON	78	DPWA	KBAR N ELASTIC	1/78*
R1		. . . . .							
R1	AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)								
R2	Y*1(1750) FROM KBAR N INTO SIGMA ETA							SQRT(P1*P2)	
R2	SEEN				CLINE	69	DBC	- THRESHOLD BUMP	9/69
R2	1	(.23)	(.01)		JONES	74	HBC	0 FIT SIG+ETA CS	1/74
R3	Y*1(1750) FROM KBAR N INTO LAMBDA PI							SQRT(P1*P3)	
R3	2	(-0.25)			ARMENTERO	70	IPWA	-0 K-N TO LAMBDA PI	6/70
R3	2	PUBLISHED SIGN CHANGED TO AGREE WITH LUND 1969 CONVENTION (SEE TEXT)							10/74
R3		(0.09)			KIM	71	DPWA	K-MATRIX ANAL.	3/71
R3		(0.30)	(0.05)		LANGBEIN	72	IPWA	MULTICHANNEL	12/72
R3		(-.28)	(.05)		BAXTER	73	DPWA	0 K- P TO NEUTRALS	10/74
R3		(-.120)	(.077)		DEVENISH	74		0 FIXED T DISP REL	4/75
R3	A	(-.12)	(.02)		BAILLON	75	IPWA	KBAR N TO LAM PI	11/75
R3	B	(-.13)	(.03)		BAILLON	75	IPWA	KBAR N TO LAM PI	1/76
R3		(-.13)	(.04)		VANHORN	75	DPWA	0 K- P TO LAM PIO	11/75
R3		(-.12)			BELLEFON	76	IPWA	0 K- P TO LAM PI	2/77*
R3	4	(-.10)OR -.09			MARTIN	77	DPWA	KBAR N MULTICHNL	11/77*
R3		(.04)	(.03)		RLIC	77	DPWA	KBAR N MULTICHNL	1/76
R4	Y*1(1750) FROM KBAR N TO SIGMA PI							SQRT(P1*P4)	
R4		(0.16)			KIM	71	DPWA	K-MATRIX ANAL.	3/71
R4		(0.13)	(0.02)		LANGBEIN	72	IPWA	MULTICHANNEL	12/72
R4	4	(+.06)OR +.06			MARTIN	77	DPWA	KBAR N MULTICHNL	11/77*
R4		-.09	.05		RLIC	77	DPWA	KBAR N MULTICHNL	1/76
R5	Y*1(1750) FROM KBAR N TO SIGMA(1385) PI							SQRT(P1*P4)	
R5		+.18	.15		PREVOST	74	DPWA	0- K-N TO S(1385)PI	10/74
R6	Y*1(1750) FROM KBAR N TO LAMBDA(1520) PI							SQRT(P1*P6)	
R6	5	.032	.021		CAMERON	77	DPWA	0 P-WAVE DECAY	1/78*
R6	5	ASSUMES LAMBDA(1520) ELASTICITY=.46							1/78*

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REFERENCES FOR Y*1(1750)

CLINE 67 PL 25B 41	CLINE, OLSSON	(WISCONSIN)IJP
MEYER 67 HEIDELBERG C 117	J MEYER (RAPPORTEUR)	(SACLAY)IJP
ARMENTER 70 DUKE 123	ARMENTEROS, BAILLON, +	(CERN,HEIDEL)IJP
CONFORTO 71 NP B34 41	+LEVI SETTI,LASINSKI..OBERLACK++	(EFI+HEID)IJP
KIM 71 PRL 27 356	J K KIM	(HARV)IJP
ALSO 70 DUKE 161	J. K. KIM	(HARV)IJP
LANGBEIN 72 NP B47 477	+WAGNER	(MPIM)IJP
BAXTER 73 NP B67 125	BAXTER,BUCKINGHAM,CORBETT,DUNN,+	(OXFORD)IJP
CHU 74 NC 20A 35	CHU,BARTLEY,+	(SUNY PLATTSBURGH+TUFTS+BRAN)IJP
JONES 74 NP B73 141	JONES	(U. CHICAGO)IJP
DEVENISH 74 NP B81 330	DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)	
PREVOST 74 NP B69 246	PREVOST,BARLOUTAUD,+	(SACL+CERN+HEID)
BAILLON 75 NP B94 39	P. BAILLON,P. J. LITCHFIELD	(CERN,RHEL)IJP
VANHORN 75 NP B87 145	A. J. VAN HORN	(LBL)IJP
ALSO 75 NP B87 157	A. J. VAN HORN	(LBL)IJP
BELLEFON 76 NP B109 129	DE BELLEFON,BERTHON	(CDEF)IJP
CARROLL 76 PRL 37 806	+CHIANG,KYCIA,LI,MAZUR,MICHAEL+	(BNL)I
CAMERON 77 NP B131 399	+FRANEK,GOPAL,KALMUS,MCPHERSON+	(RHEL+LOIC)IJP
MARTIN 77 NP B127 349	MARTIN,PIDCOCK,MOORHOUSE	(LOUC+GLAS)IJP
ALSO 77 NP B126 266	MARTIN,PIDCOCK	(LOUC)
ALSO 77 NP B126 285	MARTIN,PIDCOCK	(LOUC)IJP
RLIC 77 NP B119 362	GOPAL,ROSS,VAN HORN,MCPHERSON+	(LOIC+RHEL)IJP
ALSTON 78 LBL-6784	+KENNEY,POLLARD,ROSS+	(LBL+MTHO+CERN)IJP
ALSO 77 PRL 38 1007	ALSTON-GARNJOST,KENNEY	(LBL+MTHO+CERN)IJP

Data Card Listings

For notation, see key at front of Listings.

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FERRO-LU 66 BERKELEY CONF 183 M FERRO LUZZI  (RAPPORTEUR)          (CERN)
ARMENTER 68 NP B8 183         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENTER 69 LUND CONF PAPER   ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
HARRISON 70 FSU-HEP 70 3 1    W.C. HARRISON (THESIS)                (FSU)

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Σ(1765)

45 Y*1(1765, JP=5/2-) I=1 — D_{15}

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

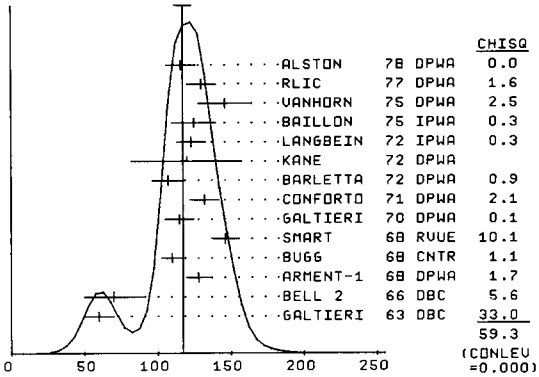
45 Y*1(1765) MASS (MEV)

M		1765.0	10.0	GALTIERI	63 DBC	0	K-D 1.51 BEV/C	
M		1755.0	10.0	ARMENTER	65 HBC	0	K-P TO Y*1520 PI	7/66
M		1760.0	10.0	BELL 1	66 DBC	-	K-N TO Y*1520 PI	7/66
M	N	1768.0	2.0	ARMENT-1	68 DPWA	0	ELASTIC, CH EXCH	11/68
M	N	1768.0	4.0	BUGG	68 CNTR		K-P, D TOTAL	11/66
M		1775.0	7.0	SMART	68 RVUE	-0	K-N TO LAMBDA PI	7/68
M		1770.0	10.0	COOL	70 CNTR		K-P, D TOTAL	10/70
M		1765.0	10.0	GALTIERI	70 DPWA	0	K-P TO LAMBDA PI	7/70
M	N	1770.0	3.0	CONFORTO	71 DPWA	0	ELASTIC, CH EXCH	6/70
M		(1765.)		KIM	71 DPWA		K-MATRIX ANAL.	3/71
M		1758.7	3.9	BARLETTA	72 DPWA	0	KPPI 0.8-1.2GEV	12/72
M		1765.0	9.0	KANE	72 DPWA	0	K-P TO PI SIG	10/71
M	N	1770.0	5.0	LANGBEIN	72 IPWA		MULTICHANNEL	12/72
M		1775.	10.	BAILLON	75 IPWA		KBAR N TO LAM PI	11/75
M		1774.	10.	VANHORN	75 DPWA	0	K- P TO LAM PIO	11/75
M		(1765.)		BELLEFON	76 IPWA	0	K- P TO LAM PI	2/77*
M	1	1772. OR 1777.		MARTIN	77 DPWA		KBAR N MULTICHNL	11/77*
M	1	THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE						
M	1	PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.						
M		1774.	5.	RLIC	77 DPWA		KBAR N MULTICHNL	1/76
M		1777.	5.	ALSTON	78 DPWA		KBAR N ELASTIC	1/78*
M	N	ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED						1/71
M		. . . . .						
M	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)							

45 Y*1(1765) WIDTH (MEV)

W		60.0	10.0	GALTIERI	63 DBC	0		
W		70.0	20.0	BELL 2	66 DBC	-		7/66
W		128.0	8.0	ARMENT-1	68 DPWA	0	ELASTIC, CH EXCH	11/68
W		110.0	7.0	BUGG	68 CNTR		K-P,D TOTAL	7/68
W		146.0	9.0	SMART	68 RVUE	-0		7/68
W		(100.0)		COOL	70 CNTR		K-P, D TOTAL	10/70
W		115.0	10.0	GALTIERI	70 DPWA	0	K-P TO LAMBDA PI	7/70
W		132.0	10.0	CONFORTO	71 DPWA	0	ELASTIC, CH EXCH	6/70
W		(100.)		KIM	71 DPWA		K-MATRIX ANAL.	3/71
W		107.2	10.9	BARLETTA	72 DPWA	0	LAM(1520)PI CH.	12/72
W		120.0	38.0	KANE	72 DPWA	0	K-P TO PI SIG	10/71
W		123.0	10.0	LANGBEIN	72 IPWA		MULTICHANNEL	12/72
W		125.	15.	BAILLON	75 IPWA		KBAR N TO LAM PI	11/75
W		146.	18.	VANHORN	75 DPWA	0	K- P TO LAM PIO	11/75
W		(120.)		BELLEFON	76 IPWA	0	K- P TO LAM PI	2/77*
W	1	102. OR 103.		MARTIN	77 DPWA		KBAR N MULTICHNL	11/77*
W		130.	10.	RLIC	77 DPWA		KBAR N MULTICHNL	1/76
W		116.	10.	ALSTON	78 DPWA		KBAR N ELASTIC	1/78*
W		. . . . .						
W	AVG	117.4	6.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)				
W	STUDENT	120.4	3.7	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
				(SEE IDEOGRAM BELOW)				

WEIGHTED AVERAGE = 117.4 ± 6.2
ERROR SCALED BY 2.2



45 Y*1(1765) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(1765) INTO KBAR N	497+ 939
P2	Y*1(1765) INTO LAMBDA PI	1115+ 134
P3	Y*1(1765) INTO Y*0(1520) PI	1518+ 139
P4	Y*1(1765) INTO Y*1(1385) PI D-WAVE	139+1384
P5	Y*1(1765) INTO SIGMA PI	1197+ 139
P6	Y*1(1765) INTO SIGMA ETA	1197+ 548
P7	Y*1(1765) INTO SIGMA PI PI	1197+ 139+ 139

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the off-diagonal elements are the normalized correlation coefficients $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

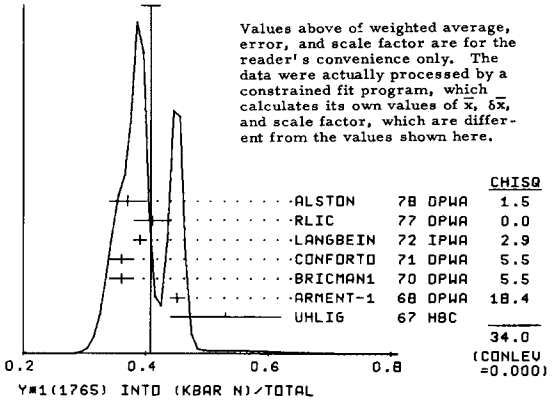
	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.4133+-.0138					
P 2	-.0510	.1400+-.0130				
P 3	-.3873	-.0146	.1929+-.0331			
P 4	-.2953	.0151	.1141	.0859+-.0090		
P 5	-.1125	.0057	.0434	.0332	.0145+-.0044	
P 6	.0836	-.3500	-.8416	-.2638	-.1350	.1534+-.0342

45 Y*1(1765) BRANCHING RATIOS

ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE TO PARAMETRIZATION USED IN THE P.W.A. THEY SHOULD BE INCREASED.

R1	Y*1(1765) INTO (KBAR N)/TOTAL					(P1)		
R1		(0.6)		GALTIERI	63 HBC	0	K-P RVUE	
R1		0.53	0.09	UHLIG	67 HBC	0		9/66
R1		0.45	0.01	ARMENT-1	68 DPWA	0	ELASTIC, CH EXCH	11/68
R1		(0.37)		BUGG	68 CNTR			11/66
R1		0.36	0.02	BRICMAN1	70 DPWA		SIGTOT,ELAS,CHEX	1/71
R1		(0.41)		COOL	70 CNTR		K-P, D TOTAL	10/70
R1		0.36	0.02	CONFORTO	71 DPWA	0	ELASTIC, CH EXCH	6/70
R1		(0.42)		KIM	71 DPWA		K-MATRIX ANAL.	3/71
R1		0.39	0.01	LANGBEIN	72 IPWA		MULTICHANNEL	12/72
R1	1	(.37)OR .36		MARTIN	77 DPWA		KBAR N MULTICHNL	11/77*
R1		.41	.03	RLIC	77 DPWA		KBAR N MULTICHNL	1/76
R1		.37	.03	ALSTON	78 DPWA		KBAR N ELASTIC	1/78*
R1		. . . . .						
R1	AVG	0.407	0.016	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)				
R1	STUDENT	0.3930	0.0093	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R1	FIT	0.413	0.014	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.4)				
				(SEE IDEOGRAM BELOW)				

WEIGHTED AVERAGE = 0.407 ± 0.016
ERROR SCALED BY 2.6



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

R2	Y*1(1765) FROM KBAR N INTO LAMBDA PI						SQRT(P1*P2)	
R2		-0.266	0.017	SMART	68 DPWA	-0	K-N TO LAMBDA PI	7/68
R2		-0.22	0.03	GALTIERI	70 DPWA	0	K-P TO LAMBDA PI	7/70
R2		(0.30)		KIM	71 DPWA		K-MATRIX ANAL.	3/71
R2		0.15	0.04	LANGBEIN	72 IPWA		MULTICHANNEL	12/72
R2		-.259	.048	DEVENISH	74	0	FIXED T DISP REL	4/75
R2		-.25	.02	BAILLON	75 IPWA		KBAR N TO LAM PI	11/75
R2		-.28	.04 .05	VANHORN	75 DPWA	0	K- P TO LAM PIO	11/75
R2		(-.30)		BELLEFON	76 IPWA	0	K- P TO LAM PI	2/77*
R2	1	(-.29)OR -.28		MARTIN	77 DPWA		KBAR N MULTICHNL	11/77*
R2		-.28	.03	RLIC	77 DPWA		KBAR N MULTICHNL	1/76
R2		. . . . .						
R2	AVG MOD	0.251	0.013	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)				
R2	STUDENT	0.253	0.012	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R2	FIT	0.241	0.012	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)				
R3	Y*1(1765) FROM KBAR N INTO Y*0(1520) PI						SQRT(P1*P3)	
R3		0.27	0.03	ARMENTERO	65 HBC	0	K-P TO Y*1520 PI	9/66
R3		0.31	0.02	BARLETTA	72 DPWA	0	K-P TO Y*1520 PI	12/72
R3	2	.305	.010	CAMERON	77 DPWA	0	K-P TO L(1520)PI	1/78*
R3	2	LISTED RATE COMBINES P- AND F-WAVE DECAYS AND ASSUMES LAMBDA(1520)						1/78*
R3	2	ELASTICITY=.46. THE CAMERON 77 RESULTS FOR THE SEPARATE P- AND						1/78*
R3	2	F-WAVE DECAYS ARE .303+/-.010 AND .037+/-.014, RESPECTIVELY.						1/78*
R3		. . . . .						
R3	AVG	0.3031	0.0086	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R3	STUDENT	0.3033	0.0093	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R3	FIT	0.282	0.023	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.9)				
R4	Y*1(1765) FROM KBAR N TO Y*1(1385) PI D-WAVE						SQRT(P1*P4)	
R4	A	(0.24)	(0.03)	ARMENT-2	67 HBC	0	K-P TO LAM PI PI	8/67
R4	S	(0.32)	(0.06)	SIMS	68 DBC	-	K-N TO LAM PI PI	11/68
R4	S	SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY						3/72
R4		+.20	.02	PREVOST	74 DPWA	0-	K-N TO S(1385)PI	10/74
R4	2	+.184	.011	CAMERON2	77 DPWA	0	K-P TO S(1385)PI	1/78*
R4	2	CAMERON2 77 UPPER LIMIT ON G-WAVE DECAY IS .03						1/78*
R4		. . . . .						
R4	AVG	0.1877	0.0096	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R4	STUDENT	0.188	0.011	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
R4	FIT	0.1884	0.0094	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				

Baryons

Σ(1765), Σ(1770), Σ(1840)

Data Card Listings

For notation, see key at front of Listings.

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R5     Y*1(1765) FROM KBAR N INTO SIGMA PI                    SQRT(P1*P5)
R5           +0.07     0.02          ARMENTERO 67 DPWA  0 K-P TO SIGMA PI  10/74
R5           +0.06     0.03          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
R5           (0.09)                  KIM       71 DPWA    K-MATRIX ANAL.    3/71
R5           +0.074    0.017         KANE      72 DPWA  0 K-P TO PI SIG     10/71
R5            0.09  OR LESS          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R5   1       (+.08)OR +.08           MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*
R5            +.13      .02          RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R5          . . . . . .
R5   AVG      0.086     0.015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R5   STUDENT  0.082     0.013   AVERAGE USING STUDENT1O(H/1.11) -- SEE MAIN TEXT
R5   FIT      0.077     0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R6     Y*1(1765) INTO (LAMBDA PI)/(KBAR N)                    (P2)/(P1)
R6           0.33      0.05          UHLIG     67 HBC   0 K-P,.9 GEV/C      9/66
R6          . . . . . .
R6   FIT      0.339     0.034  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R7     Y*1(1765) INTO (Y*0(1520)PI)/(KBAR N)                  (P3)/(P1)
R7           0.28      0.05          UHLIG     67 HBC   0 K-P,.9 GEV/C      9/66
R7          . . . . . .
R7   FIT      0.467     0.087  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 3.2)

R8     Y*1(1765) INTO (Y*1(1385)PI)/(KBAR N)                  (P4)/(P1)
R8           0.25      0.09          UHLIG     67 HBC   0 K-P,.9 GEV/C      9/66
R8          . . . . . .
R8   FIT      0.208     0.025  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R9     Y*1(1765) INTO (SIGMA PI PI)/TOTAL                     (P7)
R9   P       (0.12)                  ARMENT-2  68 HDBC -O K-N TO SIG PI PI 11/68
R9   P   FOR ABOUT 3/4 OF THIS, THE SIGMA PI SYSTEM HAS I=O AND IS ALMOST
R9   P ENTIRELY Y*0(1520).  FOR THE OTHER 1/4, THE SIGMA PI HAS I=1.  THIS
R9   P IS ABOUT WHAT IS EXPECTED FROM THE KNOWN RATE Y*1(1765) TO Y*1(1385)
R9   P PI, AS SEEN IN LAMBDA PI PI.

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                              REFERENCES FOR Y*1(1765)

GALTIERI 63 PL  6 296          A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)IJ
ARMENTER 65 PL 19 338          ARMENTEROS, +          (CERN,HEIDELBERG,SACLAY)IJP
BELL 1   66 PRL 16 203         R B BELL, R W BIRGE, Y-L PAN, R T PU  (LRL)IJP
BELL 2   66 UCRL-16936 THESIS  R B BELL                              (LRL)IJP
ARMENTER 67 PL 24B 198         ARMENTEROS,FERRO-LUZZI+   (CERN,HEID,SACLAY)IP
ARMENT-2 67 ZEIT.PHYS.202 486  ARMENTEROS,FERRO-LUZZI+   (CERN,HEID,SACLAY)
UHLIG    67 PR 155 1448        +CHARLTON,CONDON,GLASSER,YODH,+    (UMD,NRL)

ARMENT-1 68 NP B8 195          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 68 NP B8 216          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
BUGG     68 PR 168 1466        +GILMORE,KNIGHT,DAVIES+      (BIRM,CAVE,RHEL)I
SIMS     68 PRL 21 1413        SIMS,ALBRIGHT,BARTLEY,MEER+ (FSU,TUFT,BRAN)
SMART    68 PR 169 1330        W M SMART                              (LRL)IJP

BRICMAN1 70 PL 338 511         +FERRO-LUZZI,LAGNAUX                  (CERN)
COOL     70 PR D1 1887         +GIACOMELLI, KYCIA, LEONTIC, LI, +     (BNL) I
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                     (LRL)IJP

CONFORTO 71 NP  B34  41        +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
KIM      71 PRL 27 356         J K KIM                               (HARV)IJP
   ALSO  70 DUKE 161           J. K. KIM                             (HARV)IJP

BARLETTA 72 NP B40 45          W.A. BARLETTA                          (EFI) IJP
KANE     72 PR D5 1583         D F KANE                               (LBL)IJP
LANGBEIN 72 NP B47 477         +WAGNER                               (MPIM)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
PREVOST  74 NP B69 246         PREVOST,BARLOUTAUD,+          (SACL+CERN+HEID)

BAILLON  75 NP B94 39          P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
VANHORN  75 NP B87 145         A. J. VAN HORN                         (LBL)IJP
   ALSO  75 NP B87 157         A. J. VAN HORN                         (LBL)IJP

BELLEFON 76 NP B109 129        DE BELLEFON,BERTHON                   (COEF)IJP
CAMERON  77 NP B131 399        +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
CAMERON2 77  RL-77-119/A       +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
   ALSO  77 NP B126 266        MARTIN,PIDCOCK                        (LOUC)
   ALSO  77 NP B126 285        MARTIN,PIDCOCK                        (LOUC)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP

ALSTON   78  LBL-6784          +KENNEY,POLLARD,ROSS+        (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007        ALSTON-GARNJOST,KENNEY       (LBL+MTHO+CERN)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

FENSTER  66 PRL 17 841         +GELFAND,HARMSEN,L-SETTI,+ (CHIC,ANL(CERN))IJP
      -- FENSTER 66 IS SUPERSEDED BY BARLETTA 72
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +        (CHICAGO,HEIDEL)IJP
   SUPERSEDED BY CONFORTO 71.
HARRISON 70 FSU-HEP 70 3 1     W.C. HARRISON (THESIS)                 (FSU)
PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION          (CERN+HEID+SACL)

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Σ(1770) → 100 Y*1(1770, JP=1/2+) I=1 **P″11**

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                          100  Y*1(1770) MASS  (MEV)

4          (1772.0)                  KANE      72 DPWA    K-P TO SIGMA PI  11/77*
4    1       1770.      20.          BAILLON   75 IPWA    KBAR N TO PI LAM 11/75
4    1   FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.            1/76
4            1738.      10.          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
4           . . . . . .
4    AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

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                          100  Y*1(1770) WIDTH (MEV)

W            (80.)                   KANE      72 DPWA    K-P TO SIGMA PI  11/77*
W    1        80.       30.          BAILLON   75 IPWA    KBAR N TO PI LAM 11/75
W             72.       10.          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W           . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                          100  Y*1(1770) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     Y*1(1770) INTO KBAR N                                     497+ 939
P2     Y*1(1770) INTO LAMBDA PI                                 1115+ 139
P3     Y*1(1770) INTO SIGMA PI                                  1197+ 139

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                          100  Y*1(1770) BRANCHING RATIOS

R1     Y*1(1770) FROM KBAR N INTO LAMBDA PI                   SQRT(P1*P2)
R1   1       -.08      .02          BAILLON   75 IPWA    KBAR N TO PI LAM 11/75
R1            LESS THAN .04          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2     Y*1(1770) INTO (KBAR N)/TOTAL                            (P1)          1/76
R2            .14       .04          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3     Y*1(1770) FROM KBAR N INTO SIGMA PI                    SQRT(P1*P3)     1/76
R3          (-.108)                   KANE      72 DPWA    K-P TO SIGMA PI  11/77*
R3            LESS THAN .04          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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                              REFERENCES FOR Y*1(1770)

KANE     72 PR D5 1583         D F KANE                               (LBL)
BAILLON  75 NP B94 39          P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
RLIC     77 NP B119 362        GOPAL,ROSS,VAN HORN,MCPHERSON+   (LOIC+RHEL)IJP

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Σ(1840) 01 Y*1(1840, JP=3/2+) I=1 **P″13**

SEE THE MINI-REVIEWS PRECEDING THE Y*0'S.

FOR THE TIME BEING, WE LIST ALL RESONANCE CLAIMS IN THE P13 WAVE IN THE 1700-1900 MEV MASS REGION TOGETHER UNDER THIS HEADING.

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                          01  Y*1(1840) MASS (MEV)

M          1840.0    (10.0)          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
M    1     (1720.)    (30.)          BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
M    1   FROM SOLUTION 1 OF BAILLON 75, NOT PRESENT IN SOLUTION 2.            1/76
M          1925.     (200.)          VANHORN   75 DPWA  0 K- P TO LAM PIO   11/75
M    2     1798. OR 1802.            MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*
M    2   THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    2   PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.

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                          01  Y*1(1840) WIDTH (MEV)

W            120.0    (10.0)          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
W    1       (120.)    (30.)          BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
W             65.      (50.)    (20.) VANHORN   75 DPWA  0 K- P TO LAM PIO   11/75
W    2       93. OR 93.              MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*

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                          01  Y*1(1840) PARTIAL DECAY MODES

                                                                  DECAY MASSES
P1     Y*1(1840) INTO KBAR N                                     497+ 939
P2     Y*1(1840) INTO SIGMA PI                                  1197+ 139
P3     Y*1(1840) INTO LAMBDA PI                                 1115+ 134

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                          01  Y*1(1840) BRANCHING RATIOS

R1     Y*1(1840) INTO (KBAR N)/TOTAL                          (P1)
R1           0.37     (0.13)          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R1   2      (0.0)OR(0.0)              MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*

R2     Y*1(1840) FROM KBAR N INTO SIGMA PI                    SQRT(P1*P2)
R2           0.15     (0.04)          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R2   2      (-.04)OR -.04             MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*

R3     Y*1(1840) FROM KBAR N INTO LAMBDA PI                   SQRT(P1*P3)
R3           0.20     (0.04)          LANGBEIN  72 IPWA    MULTICHANNEL      12/72
R3           +.122      .078          DEVENISH  74       0 FIXED T DISP REL  4/75
R3   1       (+.11)     (.02)         BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
R3           +.06       (.04)         VANHORN   75 DPWA  0 K- P TO LAM PIO   11/75
R3   2       (+.03)OR +.03            MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*

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                              REFERENCES FOR Y*1(1840)

LANGBEIN 72 NP B47 477         +WAGNER                               (MPIM)IJP
DEVENISH 74 NP B81 330         DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
BAILLON  75 NP B94 39          P. BAILLON,P. J. LITCHFIELD      (CERN,RHEL)IJP
VANHORN  75 NP B87 145         A. J. VAN HORN                         (LBL)IJP
   ALSO  75 NP B87 157         A. J. VAN HORN                         (LBL)IJP

MARTIN   77 NP B127 349        MARTIN,PIDCOCK,MOORHOUSE          (LOUC+GLAS)IJP
   ALSO  77 NP B126 266        MARTIN,PIDCOCK                        (LOUC)
   ALSO  77 NP B126 285        MARTIN,PIDCOCK                        (LOUC)IJP

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Σ(1880) → P'''_{11}

67 Y*1(1880, JP=1/2+) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

A RESONANCE IS SUGGESTED BY SEVERAL PARTIAL-WAVE ANALYSES ACROSS THIS REGION, BUT WITH WIDE VARIATIONS IN THE MASS AND OTHER PARAMETERS. WE LIST HERE ALL CLAIMS WHICH LIE WELL ABOVE THE Y*1(1770).

67 Y*1(1880) MASS (MEV)

M		1882.0	40.0		SMART	68	DPWA	-0	K- N TO LAM PI	7/68
M		(1850.0)			BAILEY	69	DPWA	0	ELASTIC, CH EXCH	10/70
M		ABOUT 1850.0			ARMENTERO	70	IPWA	-0	ELASTIC, CH EXCH	6/70
M		1950.0	50.0		GALTIERI	70	DPWA	-0	K- N TO LAM PI	7/70
M		1920.0	30.0		LITCHFIEL	70	DPWA	-0	K- N TO LAM PI	6/70
M	2	(1898.)			LEA	73	DPWA		MULTICHNL K-MTRX	9/73
M	2	ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.								9/73
M	1	(1960.)	(30.)		BAILLON	75	IPWA		KBAR N TO LAM PI	11/75
M	1	FROM SOLUTION 1 OF BAILLON 75. NOT PRESENT IN SOLUTION 2.								1/76
M		1985.	50.		VANHORN	75	DPWA	0	K- P TO LAM PIO	11/75
M	3	1847. OR 1863.			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
M	3	THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE								
M	3	PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.								
M		. . . . .								
M		AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)								

67 Y*1(1880) WIDTH (MEV)

W		222.0	150.0		SMART	68	DPWA	-0	K- N TO LAM PI	7/68
W		(200.0)			BAILEY	69	DPWA	0	ELASTIC, CH EXCH	10/70
W		ABOUT 30.0			ARMENTERO	70	IPWA	-0	ELASTIC, CH EXCH	6/70
W		200.0	50.0		GALTIERI	70	DPWA	-0	K- N TO LAM PI	7/70
W		170.0	40.0		LITCHFIEL	70	DPWA	-0	K- N TO LAM PI	6/70
W	2	(222.2)			LEA	73	DPWA		MULTICHNL K-MTRX	9/73
W	1	(260.)	(40.)		BAILLON	75	IPWA		KBAR N TO LAM PI	11/75
W		220.	140.		VANHORN	75	DPWA	0	K- P TO LAM PIO	11/75
W	3	216. OR 220.			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
W		. . . . .								
W		AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)								

67 Y*1(1880) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(1880) INTO KBAR N	497+ 939
P2	Y*1(1880) INTO LAMBDA PI	1115+ 134
P3	Y*1(1880) INTO SIGMA PI	1197+ 139

67 Y*1(1880) BRANCHING RATIOS

R1		Y*1(1880) INTO (KBAR N)/TOTAL						(P1)	
R1		(0.22)			BAILEY	69	DPWA	0	ELASTIC, CH EXCH	10/70
R1		(0.20)			ARMENTERO	70	IPWA	-0	ELASTIC, CH EXCH	6/70
R1	2	(.31)			LEA	73	DPWA		MULTICHNL K-MTRX	9/73
R1	3	(.27)OR .27			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
R2		Y*1(1880) FROM KBAR N INTO LAMBDA PI						SQRT(P1*P2)	
R2		-0.11	0.03		SMART	68	DPWA	-0	K- N TO LAM PI	7/68
R2		-0.09	0.04		GALTIERI	70	DPWA	-0	K- N TO LAM PI	7/70
R2		-0.14	0.03		LITCHFIEL	70	DPWA	-0	K- N TO LAM PI	6/70
R2	2	(-.30)			LEA	73	DPWA		MULTICHNL K-MTRX	9/73
R2		-.169	.119		DEVENISH	74		0	FIXED T DISP REL	4/75
R2	1	(-.12)	(.02)		BAILLON	75	IPWA		KBAR N TO LAM PI	11/75
R2		+.05	.07	.02	VANHORN	75	DPWA	0	K- P TO LAM PIO	11/75
R2	3	(-.24)OR -.24			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
R2		. . . . .								
R2		AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)								
R3		Y*1(1880) FROM KBAR N TO SIGMA PI						SQRT(P1*P3)		9/73
R3	2	NOT SEEN			LEA	73	DPWA		MULTICHNL K-MTRX	9/73
R3	3	(+.30)OR +.29			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*

REFERENCES FOR Y*1(1880)

SMART	68 PR 169 1330	W M SMART	(LRL)IJP
BAILEY	69 THESIS UCRL-50617	DAVID SAAL BAILEY	(LRL LIVERMORE)IJP
ARMENTER	70 DUKE CONF 123	ARMENTEROS, BAILLON, +	(CERN, HEIDEL)IJP
GALTIERI	70 DUKE CONF 173	A BARBARO-GALTIERI	(LRL)IJP
LITCHFIE	70 NP B22 269	P J LITCHFIELD	(RUTHERFORD)IJP
LEA	73 NP B56 77	+MARTIN,MOORHOUSE+	(RHEL+LOUC+GLAS+AARHUS)IJP
DEVENISH	74 NP B81 330	DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)	
BAILLON	75 NP B94 39	P. BAILLON,P. J. LITCHFIELD	(CERN,RHEL)IJP
VANHORN	75 NP B87 145	A. J. VAN HORN	(LBL)IJP
ALSO	75 NP B87 157	A. J. VAN HORN	(LBL)IJP
MARTIN	77 NP B127 349	MARTIN,PIDCOCK,MOORHOUSE	(LOUC+GLAS)IJP
ALSO	77 NP B126 266	MARTIN,PIDCOCK	(LOUC)
ALSO	77 NP B126 285	MARTIN,PIDCOCK	(LOUC)IJP

Σ(1915) → F'_{15}

46 Y*1(1915, JP=5/2+) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THIS RESONANCE WAS FIRST SEEN IN THE TOTAL-CROSS-SECTION MEASUREMENTS OF COOL 66. IN THIS ENTRY, HOWEVER, WE LIST ONLY THE RESULTS FROM PARTIAL-WAVE ANALYSES. SEE THE NEXT ENTRY FOR THE PARAMETERS OF PEAKS SEEN AROUND 1900-1950 MEV IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. WE MAKE THIS SEPARATION BECAUSE ONLY THE PARTIAL-WAVE ANALYSES ISOLATE THE F15 WAVE. SEE ALSO THE NOTE TO THE NEXT ENTRY.

46 Y*1(1915) MASS (MEV)

M		1902.0	11.0		SMART	68	DPWA	-0	K-N TO LAMBDA PI	7/68
M		1910.0	20.0		BERTHON	70	DPWA	0	K-P TO LAMBDA PI	7/70
M		1900.0	15.0		BERTHON1	70	DPWA	0	K-P TO SIGMA PI	10/70
M	N	1936.0	(3.0)		BRICMAN1	70	DPWA		SIGTOT,ELAS,CHEX	1/71
M		1903.0	10.0		COX	70	DPWA	-	K-N TO LAMBDA PI	6/70
M		1905.0	30.0		GALTIERI	70	DPWA	0	K-P TO LAMBDA PI	7/70
M		1895.0	10.0		LITCHFIEL	70	DPWA	-0	K-N TO LAMBDA PI	6/70
M		1910.	15.		LITCHFIE	71	DPWA		K-P TO KBAR N	.10/71
M		1925.0	8.0		KANE	72	DPWA	0	K-P TO PI SIG	10/71
M		1920.	30.		BAILLON	75	IPWA		KBAR N TO LAM PI	11/75
M		1914.	10.		HEMINGWA	75	DPWA	0	K- P TO KBAR N	11/75
M		1920.	15.	20.	VANHORN	75	DPWA	0	K- P TO LAM PIO	11/75
M		(1915.)			BELLEFON	76	IPWA	0	K- P TO LAM PI	2/77*
M	3	1900.	4.		CORDEN	76	DPWA	-	K- N TO PI- LAM	2/77*
M	3	PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES.								2/77*
M	3	CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE								
M	1	1894.	5.		CORDEN1	77			K- N TO PI SIG	11/77*
M	2	1909.	5.		CORDEN1	77			K- N TO PI SIG	11/77*
M	1	THE 2 ENTRIES FOR CCORDEN177 ARE FROM 2 DIFFERENT ACCEPTABLE SLTNS.								11/77*
M		NOT SEEN			DECLAIS	77	DPWA		KBAR N TO KBAR N	1/78*
M	4	1925. OR 1933.			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
M	4	THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE								
M	4	PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.								
M		1920.	10.		RLIC	77	DPWA		KBAR N MULTICHNL	1/76
M		1937.	20.		ALSTON	78	DPWA		KBAR N ELASTIC	1/78*
M	N	ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED								1/71
M		. . . . .								
M		AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)								

46 Y*1(1915) WIDTH (MEV)

W	A	(50.0)	(20.0)		ARMENTER1	67	DPWA	0	ELASTIC, CH EXCH	11/67
W		52.0	25.0		SMART	68	DPWA	-0	K-N TO LAMBDA PI	7/68
W		60.0	20.0		BERTHON	70	DPWA	0	K-P TO LAMBDA PI	7/70
W		75.0	20.0		BERTHON1	70	DPWA	0	K-P TO SIGMA PI	10/70
W		135.0	12.0		BRICMAN1	70	DPWA		SIGTOT,ELAS,CHEX	1/71
W		77.0	27.0		COX	70	DPWA	-	K-N TO LAMBDA PI	6/70
W		70.0	20.0		GALTIERI	70	DPWA	0	K-P TO LAMBDA PI	7/70
W		70.0	15.0		LITCHFIEL	70	DPWA	-0	K-N TO LAMBDA PI	6/70
W		70.	15.		LITCHFIE	71	DPWA		K-P TO KBAR N	10/71
W		146.0	22.0		KANE	72	DPWA	0	K-P TO PI SIG	10/71
W		70.	20.		BAILLON	75	IPWA		KBAR N TO LAM PI	11/75
W		85.	15.		HEMINGWA	75	DPWA	0	K- P TO KBAR N	11/75
W		102.	18.		VANHORN	75	DPWA	0	K- P TO LAM PIO	11/75
W		(60.)			BELLEFON	76	IPWA	0	K- P TO LAM PI	2/77*
W	3	75.	14.		CORDEN	76	DPWA	-	K- N TO PI- LAM	2/77*
W	1	107.	14.		CORDEN1	77			K- N TO PI SIG	11/77*
W	2	85.	13.		CORDEN1	77			K- N TO PI SIG	11/77*
W	4	171. OR 173.			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
W		130.	10.		RLIC	77	DPWA		KBAR N MULTICHNL	1/76
W		161.	20.		ALSTON	78	DPWA		KBAR N ELASTIC	1/78*
W	A	LACK OF DATA PREVENTS FROM DETERMINING UNAMB. THIS AMPLITUDE								11/67
W		. . . . .								
W		AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)								

46 Y*1(1915) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(1915) INTO KBAR N	497+ 939
P2	Y*1(1915) INTO LAMBDA PI	1115+ 139
P3	Y*1(1915) INTO SIGMA PI	1197+ 139
P4	Y*1(1915) INTO Y*1(1385) PI P-WAVE	139+1384
P5	Y*1(1915) INTO Y*1(1385) PI F-WAVE	139+1384

46 Y*1(1915) BRANCHING RATIOS

R1		Y*1(1915) INTO (KBAR N)/TOTAL						(P1)	
R1	A	(0.12)	(.01)		ARMENTER1	67	DPWA	0	ELASTIC, CH EXCH	11/67
R1		0.18	(0.02)		BRICMAN1	70	DPWA		SIGTOT,ELAS,CHEX	1/71
R1		0.11	(0.03)		CONFORTO	71	DPWA	0	ELASTIC, CH EXCH	6/70
R1		0.15	(0.04)		LITCHFIE	71	DPWA		K-P TO KBAR N	10/71
R1		.11	(.04)		HEMINGWA	75	DPWA	0	K- P TO KBAR N	11/75
R1	4	(.08)OR .08			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
R1		.05	(.03)'		RLIC	77	DPWA		KBAR N MULTICHNL	1/76
R1		.14	(.05)		ALSTON	78	DPWA		KBAR N ELASTIC	1/78*
R2		Y*1(1915) FROM KBAR N INTO LAMBDA PI						SQRT(P1*P2)	
R2		-0.08	(0.02)		SMART	68	DPWA	-0	K-N TO LAMBDA PI	7/68
R2		-0.1	(0.02)		BERTHON	70	DPWA	0	K-P TO LAMBDA PI	7/70
R2		-0.09	(0.02)		COX	70	DPWA	-	K-N TO LAMBDA PI	6/70
R2		-0.11	(0.03)		GALTIERI	70	DPWA	0	K-P TO LAMBDA PI	7/70
R2		-0.07	(0.015)		LITCHFIEL	70	DPWA	-0	K-N TO LAMBDA PI	6/70
R2		-.087	(.056)		DEVENISH	74		0	FIXED T DISP REL	4/75
R2		-.06	(.02)		BAILLON	75	IPWA		KBAR N TO LAM PI	11/75
R2		-.09	(.02)		VANHORN	75	DPWA	0	K- P TO LAM PIO	11/75
R2		(-.10)			BELLEFON	76	IPWA	0	K- P TO LAM PI	2/77*
R2	3	-.10	.01		CORDEN	76	DPWA	-	K- N TO PI- LAM	2/77*
R2	4	(-.09)OR -.09			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
R2		-.09	(.03)		RLIC	77	DPWA		KBAR N MULTICHNL	1/76
R3		Y*1(1915) FROM KBAR N INTO SIGMA PI						SQRT(P1*P3)	
R3	A	(0.00)	(0.01)		ARMENTERO	67	DPWA	0	K-P TO SIGMA PI	11/67
R3		-0.13	(0.03)		BERTHON1	70	DPWA	0	K-P TO SIGMA PI	10/70
R3		-0.06	(0.03)		GALTIERI	70	DPWA	0	K-P TO SIGMA PI	7/70
R3		-0.137	(0.015)		KANE	72	DPWA	0	K-P TO PI SIG	10/71
R3	1	-.17	.01		CORDEN1	77			K- N TO PI SIG	11/77*
R3	2	-.15	.02		CORDEN1	77			K- N TO PI SIG	11/77*
R3	4	(-.05)OR -.05			MARTIN	77	DPWA		KBAR N MULTICHNL	11/77*
R3		-.19	(.03)		RLIC	77	DPWA		KBAR N MULTICHNL	1/76
R3		. . . . .								
R3	AVG MOD	0.1660	0.0089		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
R3	STUDENT	0.1661	0.0099		AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
R4		Y*1(1915) FROM KBAR N INTO Y*1(1385) PI P-WAVE						SQRT(P1*P4)	
R4		LESS THAN .01			CAMERON2	77	DPWA	0	K-P TO S(1385)P1	1/78*
R5		Y*1(1915) FROM KBAR N INTO Y*1(1385) PI F-WAVE						SQRT(P1*P5)	
R5		-.039	.009		CAMERON2	77	DPWA	0	K-P TO S(1385)P1	1/78*

Baryons
Σ(1915), Σ(1940)

REFERENCES FOR Y*1(1915)

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ARMENTER 67 PL 24B 198      ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)
ARMENTE1 67 NP 83 592       ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)
SMART    68 PR 169 1330     W M SMART                (LRL)IJP

BERTHON  70 NP B20 476      +RANGAN, VRANA, +(COL FRANCE, RHEL, SACLAY)IJP
BERTHON1 70 NP B24 417      +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)IJ
BRICMAN1 70 PL 33B 511      +FERRO-LUZZI,LAGNAUX     (CERN)
COX      70 NP B19 61       +ISLAM, COLLEY, +     (BIRM,EDIN,GLAS,LOIC)IJP
GALTIERI 70 DUKE CONF 173   A BARBARO-GALTIERI       (LRL)IJP
LITCHFIE 70 NP B22 269      P J LITCHFIELD           (RUTHERFORD)IJP

CONFORTO 71 NP  B34  41     +LEVI SETTI,LASINSKI..OBERLACK++ (EFI+HEID)IJP
LITCHFIE 71 NP  B30 125     LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE     72 PR D5 1583      D F KANE                 (LBL)IJP
DEVENISH 74 NP B81 330      DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)

BAILLON  75 NP B94 39       P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
HEMINGWA 75 NP B91 12       HEMINGWAY,EADES,HARMSEN+  (CERN,HEID,MPIM)IJP
VANHORN  75 NP B87 145      A. J. VAN HORN           (LBL)IJP
   ALSO  75 NP B87 157      A. J. VAN HORN           (LBL)IJP

BELLEFON 76 NP B109 129     DE BELLEFON,BERTHON      (CDEF)IJP
CORDEN   76 NP B104 382     +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

CAMERON2 77  RL-77-119/A    +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CORDEN1  77 NP B125 61      +COX,KENYON,ONEALE,STUBBS,SUMOROK+   (BIRM)IJP
DECLAIS  77  CERN 77-16     +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
MARTIN   77 NP B127 349     MARTIN,PIDCOCK,MOORHOUSE     (LOUC+GLAS)IJP
   ALSO  77 NP B126 266     MARTIN,PIDCOCK               (LOUC)
   ALSO  77 NP B126 285     MARTIN,PIDCOCK               (LOUC)IJP
RLIC     77 NP B119 362     GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP
ALSTON   78  LBL-6784       +KENNEY,POLLARD,ROSS+       (LBL+MTHO+CERN)IJP
   ALSO  77 PRL 38 1007     ALSTON-GARNJOST,KENNEY      (LBL+MTHO+CERN)IJP

                            PAPERS NOT REFERRED TO IN DATA CARDS

SMART    66 PRL 17 556      W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
   SUPERSEDED BY SMART 68.
CONFORTO 68 NP B8 265       +HARMSEN, LASINSKI, +     (CHICAGO, HEIDEL)
   SUPERSEDED BY CONFORTO 71.
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1916 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

29 Y*1(1915, JP=) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

SEE THE NOTES TO THE Y*1(1915) AND Y*1(1940), WHICH IMMEDIATELY PRECEDE AND FOLLOW THIS ENTRY. HERE WE LIST ONLY PARAMETERS OF PEAKS SEEN IN CROSS SECTIONS AND INVARIANT-MASS DISTRIBUTIONS. THE CROSS-SECTION PEAKS ARE ALMOST CERTAINLY ASSOCIATED WITH THE F15 Y*1(1915) SEEN IN PARTIAL-WAVE ANALYSES. THE INVARIANT-MASS PEAKS SEEM MORE LIKELY TO BE ASSOCIATED WITH THE D13 Y*(1940).

29 Y*1(1915) MASS (MEV) (PROD. EXP.)

```
M        CROSS-SECTION PEAKS --
M         1905.0      5.0          BUGG      68 CNTR    K-P, D TOTAL     11/66
M         1906.0      6.0          BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
M         1912.0     10.0          COOL      70 CNTR    K-P, D TOTAL     10/70
M        INVARIANT-MASS-DISTRIBUTION PEAKS --
M        (1942.0)    (9.0)         BOCK      65 HBC     PBAR P 5.7 BEV/C
M         1940.0     11.0          AGUILAR   70 HBC   + 3.9-4.6 GEV/C K-   5/70
M        ELASTIC DCS --                                                    2/73
M   1     1931.      9.            DADO      72 HBC   0 K-P ELSTC DCS    . 2/73
M   1  G7 INDICATED BY LEGENDRE COEFFS.,G9 NOT RULED OUT.                  2/73
M     42 1979.      14.           BRIEFEL   77 HBC   + XI K MODE 2.9K-P   1/78*
M                . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.7)
```

29 Y*1(1915) WIDTH (MEV) (PROD. EXP.)

```
W        CROSS-SECTION PEAKS --
W           60.0      10.0          BUGG      68 CNTR                      11/66
W           50.0      12.0          BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
W          (30.0)                   COOL      70 CNTR    K-P, D TOTAL     10/70
W        INVARIANT-MASS-DISTRIBUTION PEAKS --
W          (36.0)    (20.0)  (36.0) BOCK      65 HBC
W           90.0      20.0          AGUILAR   70 HBC   + 3.9-4.6 GEV/C K-   5/70
W        ELASTIC DCS --                                                    2/73
W   1       70.       14.           DADO      72 HBC   0 K-P ELSTC DCS      2/73
W     42    69.       32.           BRIEFEL   77 HBC   + XI K MODE 2.9K-P   1/78*
W                . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
```

29 Y*1(1915) PARTIAL DECAY MODES (PROD. EXP.)

```
                                                          DECAY MASSES
P1     Y*1(1915) INTO KBAR N                              497+ 939
P2     Y*1(1915) INTO LAMBDA PI                           1115+ 134
P3     Y*1(1915) INTO SIGMA PI                            1197+ 139
P4     Y*1(1915) INTO XI K                                1314+ 493
```

29 Y*1(1915) BRANCHING RATIOS (PROD. EXP.)

```
R1     Y*1(1915) INTO (KBAR N)/TOTAL                          (P1)
R1        THESE VALUES OF ELASTICITIES ASSUME J=5/2 --
R1           0.06                  BUGG      68 CNTR    ASSUMING J=5/2    6/68
R1           0.07      0.02        BRICMAN   70 CNTR  0 TOTAL AND CH EX   6/70
R1           0.07                  COOL      70 CNTR    K-P, D TOTAL     10/70
R1   1  THIS ELASTICITY ASSUMES J=7/2                                      2/73
R1   1       .62       .08         DADO      72 HBC   0 K-P ELSTC DCS      2/73
R1                . . . . . .
R1   AVG       0.10      0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 6.7)
R1   STUDENT   0.077     0.022   AVERAGE USING STUDENT10(H/I.11) -- SEE MAIN TEXT

R2     Y*1(1915) INTO (KBAR N)/(SIGMA PI)                     (P1)/(P3)
R2           (.37) OR LESS         BARNES    69 HBC   + 1 STAN. DEV.       10/69

R3     Y*1(1915) INTO (LAMBDA PI)/(SIGMA PI)                  (P2)/(P3)
R3           (.28) OR LESS         BARNES    69 HBC   + 1 STAN. DEV.       10/69
```

```
R4     Y*1(1915) INTO (XI K)                                  (P4)
R4       42   SEEN                BRIEFEL   77 HBC   + K-P 2.87 GEV       1/78*
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REFERENCES FOR Y*1(1915) (PROD. EXP.)

```
BOCK     65 PL 17 166       +COOPER,FRENCH,KINSON, +      (CERN,SACLAY) I
COOL     66 PRL 16 1228     +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
BUGG     68 PR 168 1466     +GILMORE,KNIGHT,DAVIES+    (BIRM,CAVE,RHEL)I
BARNES   69 PRL 22 479      +FLAMINIO,MONTANET,SAMIOS +      (BNL+SYRA)

AGUILAR  70 PRL 25 58       AGUILAR-BENITEZ, BARNES, +       (BNL,SYRA)
BRICMAN  70 PL 318 152      +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR D1 1887      +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
DADO     72 PRL 29 1695     +BIRMAN,GOLDBERG,WEISS             (HAIF)JP
BRIEFEL  77 PRD 16 2706     +GOUREVITCH,CHANG+     (BRAN+UMD+SYRA+TUFT)

                            PAPERS NOT REFERRED TO IN DATA CARDS

PRIMER   68 PRL 20 610      +GOLDBERG,JAEGER,BARNES,DORNAN + (SYRA,BNL)
   SUPERSEDED BY BARNES 69 AND AGUILAR-BENITEZ 70.
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Σ(1940) D_{13}''

98 Y*1(1940, JP=3/2-) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL PARTIAL-WAVE ANALYSES IN THIS REGION. THIS EFFECT IS PERHAPS ASSOCIATED WITH THE BUMPS SEEN IN PRODUCTION EXPERIMENTS NEAR THIS MASS. SEE THE PRECEDING ENTRY.

98 Y*1(1940) MASS (MEV)

```
M          1940.0      50.0          GALTIERI  70 DPWA    K- N TO LAM PI     7/70
M          1940.0      40.0          GALTIERI  70 DPWA    K-P TO SIGMA PI    7/70
M          1940.0      30.0          LITCHFIEL 70 DPWA    K- N TO LAM PI     7/70
M          1985.0      (5.0)         KANE      72 DPWA  0 K-P TO PI SIG     10/71
M   2     (1865.)                    LEA       73 DPWA    MULTICHNL K-MTRX   9/73
M   2  ONLY UNCONSTRAINED STATES FROM TABLE 1 OF LEA73 ARE IN LISTINGS.      9/73
M          1940.       20.           LITCHFI2  74 DPWA  0 K-P TO L(1520)P1  10/74
M          1950.       20.           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL   10/74
M          1950.       30.           BAILLON   75 IPWA    KBAR N TO LAM PI   11/75
M          1949.       40.      60.  VANHORN   75 DPWA  0 K- P TO LAM PIO   11/75
M   4     (1940.)                    BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77*
M   4  SLIGHT BUMP IN MODULUS OF F7 WAVE.                                    2/77*
M   5     1886. OR 1893.             MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*
M   5  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M   5  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1920.       50.           RLIC      77 DPWA    KBAR N MULTICHNL   1/76
M                . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
```

98 Y*1(1940) WIDTH (MEV)

```
W           200.0      50.0          GALTIERI  70 DPWA    K- N TO LAM PI     7/70
W           200.0      50.0          GALTIERI  70 DPWA    K-P TO SIGMA PI    7/70
W           280.0      40.0          LITCHFIEL 70 DPWA    K- N TO LAM PI     7/70
W           208.0     (22.0)         KANE      72 DPWA  0 K-P TO PI SIG     10/71
W   2      (108.9)                   LEA       73 DPWA    MULTICHNL K-MTRX   9/73
W            60.       20.           LITCHFI2  74 DPWA  0 K-P TO L(1520)P1  10/74
W            70.       30.      20.  LITCHFI3  74 DPWA  0 K-P TO KBAR DEL   10/74
W           150.       75.           BAILLON   75 IPWA    KBAR N TO LAM PI   11/75
W           160.       70.      40.  VANHORN   75 DPWA  0 K- P TO LAM PIO   11/75
W   5     157. OR 159.               MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*
W           300.       80.           RLIC      77 DPWA    KBAR N MULTICHNL   1/76
W                . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.4)
```

98 Y*1(1940) PARTIAL DECAY MODES

```
                                                          DECAY MASSES
P1     Y*1(1940) INTO KBAR N                              497+ 939
P2     Y*1(1940) INTO LAMBDA PI                           1115+ 139
P3     Y*1(1940) INTO SIGMA PI                            1197+ 139
P4     Y*1(1940) INTO Y*0(1520) PI P-WAVE                  134+1518
P5     Y*1(1940) INTO Y*0(1520) PI F-WAVE                  134+1518
P6     Y*1(1940) INTO KBAR DELTA(1232) S-WAVE              493+1232
P7     Y*1(1940) INTO KBAR DELTA(1232) D-WAVE              493+1232
P8     Y*1(1940) INTO Y*1(1385) PI S-WAVE                  139+1384
```

98 Y*1(1940) BRANCHING RATIOS

```
R1     Y*1(1940) FROM KBAR N INTO LAMBDA PI                   SQRT(P1*P2)
R1          -0.12      0.04          GALTIERI  70 DPWA    K- N TO LAM PI     7/70
R1          -0.14      0.03          LITCHFIEL 70 DPWA    K- N TO LAM PI     7/70
R1   2      (-.11)                   LEA       73 DPWA    MULTICHNL K-MTRX   9/73
R1           -.153      .070         DEVENISH  74       0 FIXED Y DISP REL   4/75
R1           -.04       .02          BAILLON   75 IPWA    KBAR N TO LAM PI   11/75
R1           -.05       .03      .02 VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
R1   5      (-.15)OR -.14             MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*
R1           -.06       .03          RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R1                . . . . . .
R1   AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

R2     Y*1(1940) FROM KBAR N INTO SIGMA PI                    SQRT(P1*P3)
R2          -0.12      0.03          GALTIERI  70 DPWA    K-P TO SIGMA PI    7/70
R2          -0.093    (0.006)        KANE      72 DPWA  0 K-P TO PI SIG     10/71
R2   2     NOT SEEN                  LEA       73 DPWA    MULTICHNL K-MTRX   9/73
R2   5       (+.16)OR +.16           MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*
R2           -.08       .04          RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R2                . . . . . .
R2   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R3     Y*1(1940) INTO KBAR N                                  (P1)              9/73
R3   2       (.21)                   LEA       73 DPWA    MULTICHNL K-MTRX   9/73
R3   5         (-.14)OR .13          MARTIN    77 DPWA    KBAR N MULTICHNL  11/77*
R3             LESS THAN .04         RLIC      77 DPWA    KBAR N MULTICHNL   1/76
R3     NO SIGNAL FOR THIS STATE WITH X LARGER THAN ABOUT .03 IN THE          11/75
R3     ANALYSIS OF HEMINGWAY 75.                                            11/75
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Data Card Listings

For notation, see key at front of Listings.

Baryons

Σ(1940), Σ(2000), Σ(2030)

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R4     Y*1(1940) FROM KBAR N TO Y*0(1520) PI P-WAVE      SQRT(P1*P4)
R4   1      -.11      .04          LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R4   1  ASSUMES LAMBDA(1520) ELASTICITY=.45,SIGN RLTV. TO SIG(2030) DECAY.  10/74
R4   6     LESS THAN .03              CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78*
R4   6  ASSUMES LAMBDA(1520) ELASTICITY=.46.                                 1/78*

R5     Y*1(1940) FROM KBAR N TO Y*0(1520) PI F-WAVE      SQRT(P1*P5)
R5   1      -.08      .04          LITCHFI2  74 DPWA  0 K-P TO L(1520)PI 10/74
R5   1  ASSUMES LAMBDA(1520) ELASTICITY=.45,SIGN RLTV. TO SIG(2030) DECAY.  10/74
R5   6        .062     .021         CAMERON   77 DPWA  0 K-P TO L(1520)PI  1/78*
R5   6  ASSUMES LAMBDA(1520) ELASTICITY=.46.                                 1/78*
R5        . . . . . .
R5  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R6     Y*1(1940) FROM KBAR N TO KBAR DELTA(1232) S-WAVE SQRT(P1*P6)
R6   3      -.16      .05          LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
R6   3  SIGN RELATIVE TO SIGMA(2030) DECAY                                 10/74

R7     Y*1(1940) FROM KBAR N TO KBAR DELTA(1232) D-WAVE SQRT(P1*P7)
R7   3      -.14      .05          LITCHFI3  74 DPWA  0 K-P TO KBAR DEL  10/74
R7   3  SIGN RELATIVE TO SIGMA(2030) DECAY                                 10/74

R8     Y*1(1940) FROM KBAR N TO Y*1(1385) PI S-WAVE      SQRT(P1*P8)
R8          -.068     .025          CAMERON2  77 DPWA  0 K-P TO S(1385)PI  1/78*

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                          REFERENCES FOR Y*1(1940)

GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                      (LRL)IJP
LITCHFIE 70 NP B22 269        P J LITCHFIELD                (RUTHERFORD)IJP
KANE     72 PR D5 1583        D F KANE                                (LBL)IJP
LEA      73 NP B56 77         +MARTIN,MOORHOUSE+   (RHEL+LOUC+GLAS+AARHUS)IJP

DEVENISH 74 NP B81 330        DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
LITCHFI2 74 NP B74 19         LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI3 74 NP B74 39         LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP

BAILLON  75 NP B94 39         P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
VANHORN  75 NP B87 145        A. J. VAN HORN                          (LBL)IJP
    ALSO 75 NP B87 157        A. J. VAN HORN                          (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                     (CDEF)IJP
CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
CAMERON2 77  RL-77-119/A      +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

                          PAPERS NOT REFERRED TO IN DATA CARDS.

HEMINGWA 75 NP B91 12         HEMINGWAY,EADES,HARMSEN+        (CERN,HEID,MPIM)IJP

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Σ(2000)   02  Y*1(2000, JP=1/2-) I=1   S''11

          WE LIST HERE ALL REPORTED S11 STATES LYING ABOVE
          THE Y*1(1750)

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                          02  Y*1(2000) MASS (MEV)

M          2004.      40.            VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
M    1     1755. OR 1834.            MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
M    1  THE TWO ENTRIES FOR MARTIN 77 CORRESPOND TO EXTRACTION OF RESONANCE
M    1  PARAMETERS FROM THE T-MATRIX POLE AND FROM A B-W FIT, RESPECTIVELY.
M          1955.      15.            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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                          02  Y*1(2000) WIDTH (MEV)

W           116.      40.            VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
W    1      413. OR 450.             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
W           170.      40.            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

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                          02  Y*1(2000) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     Y*1(2000) INTO KBAR N                                  497+ 939
P2     Y*1(2000) INTO LAMBDA PI                              1115+ 134
P3     Y*1(2000) INTO SIGMA PI                               1197+ 139
P4     Y*1(2000) INTO LAMBDA(1520) PI                         139+1518

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                          02  Y*1(2000) BRANCHING RATIOS

R1     Y*1(2000) FROM KBAR N INTO LAMBDA PI              SQRT(P1*P2)
R1          NOT SEEN                  BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R1            +.07      .02     .01  VANHORN   75 DPWA  0 K-P TO LAM PIO   11/75
R1    1     (-.191OR -.18             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R1            .08       .03          RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R2     Y*1(2000) INTO (KBAR N)/TOTAL                     (P1)              1/76
R2    1     (.62)OR .57               MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R2          .44       .05            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R3     Y*1(2000) FROM KBAR N INTO SIGMA PI               SQRT(P1*P3)       1/76
R3    1     (+.26)OR +.24             MARTIN    77 DPWA    KBAR N MULTICHNL 11/77*
R3          +.20      .04            RLIC      77 DPWA    KBAR N MULTICHNL  1/76

R4     Y*1(2000) FROM KBAR N TO LAMBDA(1520) PI          SQRT(P1*P4)
R4   2      -.081     .021          CAMERON   77 DPWA  0 P-WAVE DECAY      1/78*
R4   2  ASSUMES LAMBDA(1520) ELASTICITY=.46, SIGN RLTV. TO SIG(1765) DECAY.  1/78*

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                          REFERENCES FOR Y*1(2000)

BAILLON  75 NP B94 39         P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
VANHORN  75 NP B87 145        A. J. VAN HORN                          (LBL)IJP
    ALSO 75 NP B87 157        A. J. VAN HORN                          (LBL)IJP

CAMERON  77 NP B131 399       +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
MARTIN   77 NP B127 349       MARTIN,PIDCOCK,MOORHOUSE        (LOUC+GLAS)IJP
    ALSO 77 NP B126 266       MARTIN,PIDCOCK                          (LOUC)
    ALSO 77 NP B126 285       MARTIN,PIDCOCK                          (LOUC)IJP
RLIC     77 NP B119 362       GOPAL,ROSS,VAN HORN,MCPHERSON+  (LOIC+RHEL)IJP

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Σ(2030)   47  Y*1(2030, JP=7/2+) I=1   F17

          SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

          THIS ENTRY ONLY INCLUDES RESULTS FROM PARTIAL-WAVE
          ANALYSES.  PARAMETERS OF PEAKS SEEN IN CROSS-SECTIONS
          AND INVARIANT-MASS DISTRIBUTIONS AROUND 2030 MEV ARE
    GIVEN IN THE NEXT ENTRY.  EVENTUALLY THE PARTIAL-WAVE ANALYSES SHOULD
    GIVE THE BEST RESULTS, AS THEY ISOLATE THE F17 WAVE.  THIS SUPERIORITY
    IS, HOWEVER, PROBABLY NOT YET ATTAINED, AND WE RELY ON BOTH ENTRIES
    FOR PARAMETERS GIVEN IN THE MAIN BARYON TABLE.

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                          47  Y*1(2030) MASS (MEV)

M          (2030.0)   (20.0)          WOHL      66 HBC   0 K-P TO LAM PIO    7/66
M           2032.0      6.0          SMART     68 DPWA -  K-N TO LAMBDA PI  6/68
M           2030.0     10.0          BERTHON   70 DPWA  0 K-P TO LAMBDA PI  7/70
M           2035.0     10.0          BERTHON1  70 DPWA  0 K-P TO SIGMA PI  10/70
M           2027.0      6.0          COX       70 DPWA -  K-N TO LAMBDA PI  6/70
M           2010.0     15.0          GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70
M           2000.0     20.0          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
M           2022.0      4.0          LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI  6/70
M           2025.      15.           LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
M           2034.0     14.0          KANE      72 DPWA  0 K-P TO PI SIG     10/71
M           2025.      10.           LITCHFI1  74 DPWA  0 K-P TO L(1815)PI  10/74
M           2035.      10.           LITCHFI2  74 DPWA  0 K-P TO L(1520)PI  10/74
M           2020.      30.           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL   10/74
M           2035.      15.           BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
M           2038.      10.           HEMINGWA  75 DPWA  0 K- P TO KBAR N     11/75
M           2042.      11.           VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
M          (2030.)                   BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77*
M    4      2030.       3.           CORDEN    76 DPWA  - K- N TO PI- LAM    2/77*
M    4   PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES.         2/77*
M    4   CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE.
M    C      2038.      10.           CORDEN2   77      - K- N TO K* N       11/77*
M    6      2027. TO 2057.           GOYAL     77 DPWA  - K- N TO SIG PI     1/78*
M           2040.       5.           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
M         . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                          47  Y*1(2030) WIDTH (MEV)

W          (170.0)                    WOHL      66 HBC   0                   7/66
W           160.0      16.0          SMART     68 DPWA -  K-N TO LAMBDA PI  6/68
W           165.0      30.0     15.0 BERTHON   70 DPWA  0 K-P TO LAMBDA PI  7/70
W           150.0      20.0          BERTHON1  70 DPWA  0 K-P TO SIGMA PI  10/70
W           158.0      16.0          COX       70 DPWA -  K-N TO LAMBDA PI  6/70
W           115.0      15.0          GALTIERI  70 DPWA  0 K-P TO LAMBDA PI  7/70
W           100.0      40.0          GALTIERI  70 DPWA  0 K-P TO SIGMA PI   7/70
W           170.0      15.0          LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI  6/70
W           200.       30.           LITCHFIE  71 DPWA    K-P TO KBAR N     10/71
W           118.0      12.0          KANE      72 DPWA  0 K-P TO PI SIG     10/71
W            70. TO   125.           LITCHFI1  74 DPWA  0 K-P TO L(1815)PI  10/74
W           160.       20.           LITCHFI2  74 DPWA  0 K-P TO L(1520)PI  10/74
W           200.       30.           LITCHFI3  74 DPWA  0 K-P TO KBAR DEL   10/74
W           180.       20.           BAILLON   75 IPWA    KBAR N TO LAM PI  11/75
W           172.       15.           HEMINGWA  75 DPWA  0 K- P TO KBAR N     11/75
W           178.       13.           VANHORN   75 DPWA  0 K-P TO LAM PIO    11/75
W          (160.)                    BELLEFON  76 IPWA  0 K- P TO LAM PI     2/77*
W    4      201.        9.           CORDEN    76 DPWA  - K- N TO PI- LAM    2/77*
W    C      137.       40.           CORDEN2   77      - K- N TO K* N       11/77*
W          (260.)                    DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78*
W    6      126. TO  195.            GOYAL     77 DPWA  - K- N TO SIG PI     1/78*
W           190.       10.           RLIC      77 DPWA    KBAR N MULTICHNL  1/76
W         . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

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                          47  Y*1(2030) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1     Y*1(2030) INTO KBAR N                                  497+ 939
P2     Y*1(2030) INTO LAMBDA PI                              1115+ 134
P3     Y*1(2030) INTO SIGMA PI                               1197+ 139
P4     Y*1(2030) INTO XI K                                   1321+ 497
P5     Y*1(2030) INTO Y*0(1815) PI P-WAVE                     134+1820
P6     Y*1(2030) INTO Y*0(1520) PI D-WAVE                     134+1518
P7     Y*1(2030) INTO Y*0(1520) PI G-WAVE                     134+1518
P8     Y*1(2030) INTO KBAR DELTA(1232) F-WAVE                 493+1232
P9     Y*1(2030) INTO KBAR DELTA(1232) H-WAVE                 493+1232
P10    Y*1(2030) INTO K*(892) N                               892+ 939
P11    Y*1(2030) INTO Y*1(1385) PI F-WAVE                     139+1384

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                          47  Y*1(2030) BRANCHING RATIOS

R1     Y*1(2030) INTO (KBAR N)/TOTAL                     (P1)
R1          (0.25)                    WOHL      66 HBC   0 K-P CH EX         7/66
R1  D       (0.11)                    DAUM      68 CNTR    K-P ELA,POL,SIGT  7/70
R1           0.17      0.04          CAMPBELL  71 DBC   -  K- NEUTRON ELAST  1/71
R1           0.18      0.02          LITCHFIE  71 DPWA    K-P TO KBAR N     .10/71
R1            .18       .03          HEMINGWA  75 DPWA  0 K- P TO KBAR N     11/75
R1          (.15)                     DECLAIS   77 DPWA    KBAR N TO KBAR N  1/78*
R1            .24       .02          RLIC      77 DPWA    KBAR N MULTICHNL  1/76
R1  D   DAUM 68 ASSUMES (J+1/2)*P1 VALUE SEEN IN TOTAL CROSS SECTION.
R1        . . . . . .
R1  AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)
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Baryons
Σ(2030), Σ(2070)

Data Card Listings
For notation, see key at front of Listings.

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R2     Y*1(2030) FROM KBAR N INTO LAMBDA PI                SQRT(P1*P2)
R2           (0.20)                    WOHL      66 HBC    0 K-P TO LAMBDA PI  7/66
R2           +0.21      0.01           SMART     68 DPWA -  K-N TO LAMBDA PI  6/68
R2           +0.2       0.02           BERTHON   70 DPWA   0 K-P TO LAMBDA PI  7/70
R2           +0.19      0.01           COX       70 DPWA -  K-N TO LAMBDA PI  6/70
R2           +0.16      0.03           GALTIERI  70 DPWA   0 K-P TO LAMBDA PI  7/70
R2           +0.20      0.008          LITCHFIEL 70 DPWA -0 K-N TO LAMBDA PI  6/70
R2            +.195      .053          DEVENISH  74        0 FIXED T DISP REL  4/75
R2            +.18       .02           BAILLON   75 IPWA    KBAR N TO LAM PI 11/75
R2            +.20       .01           VANHORN   75 DPWA   0 K-P TO LAM PIO   11/75
R2           (.20)                     BELLEFON  76 IPWA   0 K- P TO LAM PI    2/77*
R2  4         +.20       .01           CORDEN    76 DPWA   - K- N TO PI- LAM   2/77*
R2            +.18       .02           RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R2           . . . . . . . . .
R2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R3     Y*1(2030) FROM KBAR N INTO SIGMA PI                 SQRT(P1*P3)
R3  L       (-0.09)   (0.02)           BERTHON1  70 DPWA   0 K-P TO SIGMA PI  10/70
R3           -0.052     0.010          GALTIERI  70 DPWA   0 K-P TO SIGMA PI   7/70
R3           -0.10      0.03           LITCHFIE  71 DPWA     K-P TO SIG PI     3/72
R3  L   LITCHFIELD 71 IS AN UPDATE OF BERTHON1 70                               3/72
R3           -0.086     0.014          KANE      72 DPWA   0 K-P TO PI SIG     10/71
R3  A         -.09       .01           CORDEN1   77        - K- N TO PI SIG    11/77*
R3  B         -.06       .01           CORDEN1   77        - K- N TO PI SIG    11/77*
R3  A  THE 2 ENTRIES FOR CORDEN177 ARE FROM 2 DIFFERENT ACCEPTABLE SLTNS.      11/77*
R3  6       (-.085)   (.02)           GOYAL     77 DPWA   - K- N TO SIG PI     1/78*
R3  6  THIS COUPLING IS EXTRACTED FROM UNNORMALIZED DATA.                      1/78*
R3           -.15       .03           RLIC      77 DPWA     KBAR N MULTICHNL  1/76
R3           . . . . . . . . .
R3  AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

R4     Y*1(2030) FROM KBAR N INTO XI K                     SQRT(P1*P4)
R4           (0.05) OR LESS            TRIPP     67 RVUE   0 K-P TO XI K       8/67
R4           (0.05) OR LESS            BURGUN    68 DPWA   0 K-P TO XI K      10/69
R4           (0.023)                   MULLER    69 DPWA   0                   7/70

R5     Y*1(2030) FROM KBAR N TO Y*0(1815)  PI P-WAVE       SQRT(P1*P5)
R5  1         .18       .04           LITCHFI1  74 DPWA   0 K-P TO L(1815)PI 10/74
R5  1  ASSUMES LAMBDA(1815) ELASTICITY=.6                                      10/74
R5            .14       .02           CORDEN2   75 DBC    - KBAR PI- NUCLEON 11/75
R5           . . . . . . . . .
R5  AVG       0.148     0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  STUDENT   0.148     0.020   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R6     Y*1(2030) FROM KBAR N TO Y*0(1520) PI D-WAVE         SQRT(P1*P6)
R6  2         .14       .03           LITCHFI2  74 DPWA   0 K-P TO L(1520)PI 10/74
R6  2  ASSUMES LAMBDA(1520) ELASTICITY=.45                                     10/74
R6  3        (.10)     (.03)          CORDEN2   75 DBC    - KBAR PI- NUCLEON 11/75
R6  3  UPPER LIMIT                                                            11/75
R6  5         -.114      .010          CAMERON   77 DPWA   0 K-P TO L(1520)PI  1/78*
R6  5  ASSUMES LAMBDA(1520) ELASTICITY=.46, SIGN RLTV. TO SIG(1765) DECAY.    1/78*
R6           . . . . . . . . .
R6  AVG MOD   0.1166    0.0095  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  STUDENT   0.116     0.010   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R7     Y*1(2030) FROM KBAR N TO Y*0(1520) PI G-WAVE         SQRT(P1*P7)
R7  2         .02       .02           LITCHFI2  74 DPWA   0 K-P TO L(1520)PI 10/74
R7  2  ASSUMES LAMBDA(1520) ELASTICITY=.45                                     10/74
R7  5         -.146      .010          CAMERON   77 DPWA   0 K-P TO L(1520)PI  1/78*
R7  5  ASSUMES LAMBDA(1520) ELASTICITY=.46, SIGN RLTV. TO SIG(1765) DECAY.    1/78*
R7           . . . . . . . . .
R7  AVG MOD   0.121     0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 5.6)
R7  STUDENT   0.138     0.012   AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

R8     Y*1(2030) FROM KBAR N TO KBAR DELTA(1232) F-WAVE SQRT(P1*P8)
R8           .16       .03           LITCHFI3  74 DPWA   0 K-P TO KBAR DEL  10/74
R8  3       (.17)     (.03)          CORDEN2   75 DBC    - KBAR PI- NUCLEON 11/75
R8  3  UPPER LIMIT                                                            11/75

R9     Y*1(2030) FROM KBAR N TO KBAR DELTA(1232) H-WAVE SQRT(P1*P9)
R9           .00       .02           LITCHFI3  74 DPWA   0 K-P TO KBAR DEL  10/74

R10    Y*1(2030) FROM KBARN TO K*(892) N                    SQRT(P1*P10)
R10 C         .02       .01           CORDEN2   77        - 2FF7 WAVE        11/77*
R10 C         .12       .02           CORDEN2   77        - 4FF7 WAVE        11/77*
R10 C  THESE AMPLITUDES AT RESONANCE HAVE POSITIVE RELATIVE SIGN, AND        11/77*
R10 C  CORRESPOND TO A 7+/-3 PCT BRANCHING RATIO INTO K*(892) N.             11/77*
R10          . . . . . . . . .
R10 AVERAGE MEANINGLESS (SCALE FACTOR = 4.5)

R11    Y*1(2030) FROM KBAR N TO Y*1(1385) PI F-WAVE         SQRT(P1*P11)
R11          -.153      .026          CAMERON2  77 DPWA   0 K-P TO S(1385)PI  1/78*

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                              REFERENCES FOR Y*1(2030)

WOHL      66 PRL 17 107          C G WOHL, F T SOLMITZ, M L STEVENSON  (LRL)IJP
TRIPP     67 NP B3 10            + LEITH, +    (LRL,SLAC,CERN,HEIDEL,SACLAY)
BURGUN    68 NP B8 447           +MEYER,PAULI,TALLINI +      (SACL+CDEF+RHEL)
DAUM      68 NP B7 19            +ERNE,LAGNAUX,SENS,STEUER,UDO          (CERN)IJP
   CONFIRMS THE SPIN-PARITY ASSIGNMENT.
SMART     68 PR 169 1336         W M SMART                              (LRL)IJP
MULLER    69 THESIS,UCRL 19372 R A MULLER                               (LRL)

BERTHON   70 NP B20 476          +RANGAN, VRANA, +(COL FRANCE, RHEL, SACLAY)IJP
BERTHON1  70 NP B24 417          +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)IJP
COX       70 NP B19 61           +ISLAM, COLLEY, +      (BIRM,EDIN,GLAS,LOIC)IJP
GALTIERI  70 DUKE CONF 173       A BARBARO-GALTIERI                     (LRL)IJP
LITCHFIE  70 NP B22 269          P J LITCHFIELD                    (RUTHERFORD)IJP

CAMPBELL  71 NP B25 75           +MORTON, NEGUS, GOYAL, MILLER  (GLAS, LOIC)IJP
LITCHFIE  71 NP  B30 125         LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE      72 PR D5 1583          D F KANE                               (LBL)IJP

DEVENISH  74 NP B81 330          DEVENISH,FROGGATT,MARTIN(DESY,NORDITA,LOUC)
LITCHFI1  74 NP B74 12           LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI2  74 NP B74 19           LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP
LITCHFI3  74 NP B74 39           LITCHFIELD,HEMINGWAY,BAILLON,+  (CERN+HEID)IJP

BAILLON   75 NP B94 39           P. BAILLON,P. J. LITCHFIELD     (CERN,RHEL)IJP
CORDEN2   75 NP B92 365          +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP
HEMINGWA  75 NP B91 12           HEMINGWAY,EADES,HARMSEN+   (CERN,HEID,MPIM)IJP
VANHORN   75 NP B87 145          A. J. VAN HORN                         (LBL)IJP
   ALSO   75 NP B87 157          A. J. VAN HORN                         (LBL)IJP
BELLEFON  76 NP B109 129         DE BELLEFON,BERTHON                (CDEF)IJP
CORDEN    76 NP B104 382         +COX,DARTNELL,KENYON,ONEALE,SUMOROK+ (BIRM)IJP

CAMERON   77 NP B131 399         +FRANEK,GOPAL,KALMUS,MCPHERSON+ (RHEL+LOIC)IJP
CAMERON2  77  RL-77-119/A        +FRANEK,GOPAL,BACON,BUTTERWORTH+(RHEL+LOIC)IJP
CORDEN1   77 NP B125 61          +COX,KENYON,ONEALE,STUBBS,SUMOROK+   (BIRM)IJP
CORDEN2   77 NP B121 365         +COX,KENYON,ONEALE,STUBBS,SUMOROK+   (BIRM)IJP
DECLAIS   77  CERN 77-16         +DUCHON,LOUVEL,PATRY,SEGUINOT+  (CAEN+CERN)IJP
GOYAL     77 PRD 16 2746         D.P.GOYAL,A.V.SODHI                (DELHI UNIV.)IJP
RLIC      77 NP B119 362         GOPAL,ROSS,VAN HORN,MCPHERSON+  (LCIC+RHEL)IJP

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2030 MEV REGION — PRODUCTION AND σ_{TOTAL} EXP'TS

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                    28  Y*1(2030, JP=    ) I=1        PRODUCTION EXPERIMENTS

                    SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.


                    SEE THE NOTE TO THE F17 Y*1(2030), WHICH PRECEDES THIS
                    ENTRY.  HERE WE LIST ONLY PARAMETERS OF PEAKS IN CROSS
                    SECTIONS AND INVARIANT-MASS DISTRIBUTIONS.  THE CROSS-
   SECTION PEAKS ARE AT LEAST DOMINANTLY ASSOCIATED WITH THE Y*1(2030),
   BUT MAY CONTAIN A SMALL CONTRIBUTION FROM THE SUGGESTED BUT NOT ESTAB-
   LISHED OTHER RESONANCES IN THIS REGION.

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                    28  Y*1(2030) MASS (MEV) (PROD. EXP.)

M          (2022.0)   (20.0)          BLANPIED  65 CNTR   0 GAMMA P TO K+ Y*
M           2020.0      7.0          BUGG      68 CNTR     K-P, D TOTAL      6/68
M           2049.0      4.0          BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
M           2025.0     10.0          COOL      70 CNTR     K-P, D TOTAL     10/70
M          (2025.0)   (20.0)         LU        70 CNTR   0 GAMMA P TO K+ Y*  1/71
M           . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.8)

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                    28  Y*1(2030) WIDTH (MEV) (PROD. EXP.)

W           (120.0)   (20.0)          BLANPIED  65 CNTR   0
W            130.0     10.0          BUGG      68 CNTR                       6/68
W            126.0     11.0          BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
W            165.0                   COOL      70 CNTR     K-P, D TOTAL     10/70
W            (80.0)                  LU        70 CNTR   0 GAMMA P TO K+ Y*  1/71
W           . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    28  Y*1(2030) PARTIAL DECAY MODES (PROD. EXP.)

                                                                 DECAY MASSES
P1     Y*1(2030) INTO KBAR N                                      497+ 939
P2     Y*1(2030) INTO KBAR N PI                                   497+ 939+ 139

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                    28  Y*1(2030) BRANCHING RATIOS (PROD. EXP.)

R1     Y*1(2030) INTO (KBAR N)/TOTAL                    (P1)
R1        THESE VALUES OF ELASTICITIES ASSUME J=7/2 --
R1            0.131                 BUGG      68 CNTR                       6/68
R1            0.27      (0.02)      BRICMAN   70 CNTR   0 TOTAL AND CH EX   6/70
R1            0.12                  COOL      70 CNTR     K-P, D TOTAL     10/70
R2     Y*1(2030) INTO KBAR N PI                         (P2)
R2               SEEN               BOCK      HBC

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                              REFERENCES FOR Y*1(2030) (PROD. EXP.)

BLANPIED 65 PRL 14 741         +GREENBERG,HUGHES,KITCHING,LU,+ (YALE(CEA))
COOL      66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERSEDED BY COOL 70.
BUGG      68 PR 168 1466       +GILMORE,KNIGHT, +          (RHEL,BIRM,CAVE) I

BRICMAN   70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL      70 PR D1 1887        +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
LU        70 PR D2 1846        +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

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Σ(2070) → 34 Y*1(2070, JP=5/2+) I=1 **F''_{15}**

THIS STATE HAS BEEN SUGGESTED BY ONLY ONE PARTIAL WAVE ANALYSIS ACROSS THIS REGION. IT NEEDS CONFIRMATION THE RESONANCE PROPOSED BY KANE IS TOO BROAD TO BE USED AS EVIDENCE.

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                    34  Y*1(2070) MASS (MEV)

M           (2070.)    (10.)          BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
M           (2057.0)                  KANE      72 DPWA    K-P TO SIGMA PI   1/73

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                    34  Y*1(2070) WIDTH (MEV)

W           (140.)     (20.)          BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
W           (906.0)                   KANE      72 DPWA    K-P TO SIGMA PI   1/73

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                    34  Y*1(2070) PARTIAL DECAY MODES

                                                                 DECAY MASSES
P1     Y*1(2070) INTO KBAR N                                      497+ 939
P2     Y*1(2070) INTO SIGMA PI                                   1197+ 139

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                    34  Y*1(2070) BRANCHING RATIOS

R1     Y*1(2070) FROM KBAR N TO SIGMA                   SQRT(P1*P2)
R1           (+.12)    (.02)          BERTHON1  70 DPWA -  K- P TO SIG PI    1/71
R1           (+0.104)                 KANE      72 DPWA    K-P TO SIGMA PI   1/73

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                              REFERENCES FOR Y*1(2070)

BERTHON1 70 NP B24 417         +VRANA,BUTTERWORTH,+      (CDEF,RHEL,SACLAY)IJP
KANE      72 PR D5 1583        D F KANE                               (LBL)

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Data Card Listings

For notation, see key at front of Listings.

Baryons

Σ(2080), Σ(2100), Σ(2250)

Σ(2080) → P'''_{13}

88 Y*1(2080, JP=3/2+) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL PARTIAL-WAVE ANALYSES ACROSS THIS REGION. UNTIL THERE IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN BARYON TABLE.

88 Y*1(2080) MASS (MEV)

M		(2082.0)	(4.0)	COX	70 DPWA	- K- N TO LAM PI		6/70
M		(2070.0)	(30.0)	LITCHFIEL	70 DPWA	-0 K- N TO LAM PI		6/70
M	1	2120.	40.	BAILLON	75 IPWA	KBAR N TO LAM PI		11/75
M	1	FROM SOLUTION 1 OF BAILLON 75.						1/76
M	2	2140.	40.	BAILLON	75 IPWA	KBAR N TO LAM PI		1/76
M	2	FROM SOLUTION 2 OF BAILLON 75.						1/76
M		2140.	30.	BELLEFO1	75 DPWA	0 K- P TO LAM PIO		11/75
M	3	2070. TO 2120.		BELLEFON	76 IPWA	0 K- P TO LAM PI		2/77*
M	3	SUPERCEDES BELLEFO1 75.						2/77*
M	4	2091.	7.	CORDEN	76 DPWA	- K- N TO PI- LAM		2/77*
M	4	PREFERRED SOLUTION 3, SEE CORDEN 76 FOR OTHER POSSIBLILITES,						2/77*
M	4	INCLUDING A D15 AT THIS MASS.						2/77*
M	4	CORDEN 76 INCLUDES THE DATA OF COX 70 AS A SUBSAMPLE.						
M		. . . . .						
M	AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)							

88 Y*1(2080) WIDTH (MEV)

W		(87.0)	(20.0)	COX	70 DPWA	- K- N TO LAM PI		6/70
W		(250.0)	(40.0)	LITCHFIEL	70 DPWA	-0 K- N TO LAM PI		6/70
W	1	240.	50.	BAILLON	75 IPWA	KBAR N TO LAM PI		11/75
W	2	200.	50.	BAILLON	75 IPWA	KBAR N TO LAM PI		1/76
W		180.	20.	BELLEFO1	75 DPWA	0 K- P TO LAM PIO		11/75
W	3	(100.)		BELLEFON	76 IPWA	0 K- P TO LAM PI		2/77*
W	4	186.	48.	CORDEN	76 DPWA	- K- N TO PI- LAM		2/77*
W		. . . . .						
W	AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)							

88 Y*1(2080) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(2080) INTO KBAR N	497+ 939
P2	Y*1(2080) INTO LAMBDA PI	1115+ 139

88 Y*1(2080) BRANCHING RATIOS

R1		Y*1(2080) FROM KBAR N TO LAMBDA PI				SQRT(P1*P2)			
R1		(-0.16)	(0.03)	COX	70 DPWA	- K- N TO LAM PI			6/70
R1		(-0.09)	(0.03)	LITCHFIEL	70 DPWA	-0 K- N TO LAM PI			6/70
R1	1	-.13	.04	BAILLON	75 IPWA	KBAR N TO LAM PI			11/75
R1	2	-.13	.04	BAILLON	75 IPWA	KBAR N TO LAM PI			1/76
R1		+.19	.03	BELLEFO1	75 DPWA	0 K- P TO LAM PIO			11/75
R1	3	(-.10)		BELLEFON	76 IPWA	0 K- P TO LAM PI			2/77*
R1	4	-.10	.03	CORDEN	76 DPWA	- K- N TO PI- LAM			2/77*
R1		. . . . .							
R1	AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)								

REFERENCES FOR Y*1(2080)

COX	70 NP B19 61	+ISLAM, COLLEY, +	(BIRM,EDIN,GLAS,LOIC)IJP
LITCHFIE	70 NP B22 269	P J LITCHFIELD	(RUTHERFORD)IJP
BAILLON	75 NP B94 39	P. BAILLON,P. J. LITCHFIELD	(CERN,RHEL)IJP
BELLEFO1	75 NP B90 1	DE BELLEFON,BERTHON,BRUNET+	(CDEF,SACL)IJP
BELLEFON	76 NP B109 129	DE BELLEFON,BERTHON	(CDEF)IJP
CORDEN	76 NP B104 382	+COX,DARTNELL,KENYON,ONEALE,SUMOROK+	(BIRM)IJP

Σ(2100) → G_{17}

26 Y*1(2100, JP=7/2-) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

26 Y*1(2100) MASS (MEV)

M		(2060.0)	(20.0)	GALTIERI	70 DPWA	0 K-P TO LAMBDA PI		7/70
M		(2120.0)	(30.0)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70

26 Y*1(2100) WIDTH (MEV)

W		(70.0)	(30.0)	GALTIERI	70 DPWA	0 K-P TO LAMBDA PI		7/70
W		(135.0)	(30.0)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70

26 Y*1(2100) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(2100) INTO KBAR N	497+ 939
P2	Y*1(2100) INTO LAMBDA PI	1115+ 134
P3	Y*1(2100) INTO SIGMA PI	1197+ 139

26 Y*1(2100) BRANCHING RATIOS

R1	Y*1(2100) FROM KBAR N TO LAMBDA PI				SQRT(P1*P2)			
R1		(-0.07)	(0.02)	GALTIERI	70 DPWA	0 K-P TO LAMBDA PI		7/70
R2	Y*1(2100) FROM KBAR N TO SIGMA PI				SQRT(P1*P3)			
R2		(+0.13)	(0.02)	GALTIERI	70 DPWA	0 K-P TO SIGMA PI		7/70

REFERENCES FOR Y*1(2100)

GALTIERI 70 DUKE CONF 173 A BARBARO-GALTIERI (LRL)IJP

Σ(2250) BUMPS

48 Y*1(2250, JP=) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THE PARTIAL-WAVE ANALYSIS RESULTS ARE TOO WEAK TO WARRANT SEPARATING THEM FROM THE PRODUCTION AND CROSS-SECTION EXPERIMENTS.

LASINSKI 71 IN KBAR N, USING A POMERON+RESONANCES MODEL, AND BELLEFONI 76, BELLEFON 77, AND BELLEFON 78 (COLLEGE DE FRANCE-SACLAY GROUP) IN DPWA'S OF KBAR N TO LAMBDA PI, SIGMA PI, AND KBAR N, RESPECTIVELY, SUGGEST THE PRESENCE OF TWO RESONANCES AROUND THIS MASS VALUE.

48 Y*1(2250) MASS (MEV) (PROD. EXP.)

M		(2245.0)			BLANPIED	65 CNTR	GAMMA P TO K+ Y*	
M		(2299.0)	(6.0)		BOCK	65 HBC	PBAR P 5.7 BEV/C	
M		2250.0	7.0		BUGG	68 CNTR	K-P, D TOTAL	6/68
M		2280.	14.0		AGUILAR	70 HBC +	K- 3.9-4.6 GEV/C	5/70
M		2237.0	11.0		BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
M		2255.0	10.0		COOL	70 CNTR	K-P, D TOTAL	10/70
M		(2250.0)	(20.0)		LU	70 CNTR	0 GAMMA P TO K+ Y*	1/71
M	B	(2260.)	(30.)		BELLEFO1	75 DPWA	D5 WAVE	11/75
M	B	(2215.)	(10.)		BELLEFO1	75 DPWA	G9 OR H11 WAVE	11/75
M	B	EVIDENCE FOR 2 RESONANCES IN THIS LAMBDA PI DPWA						11/75
M	1	2300.	30.		BELLEFO2	75 HBC	0 K- P TO XI*0 KO	11/75
M	V	2251.	30.	20.	VANHORN	75 DPWA	0 K-P TO LAM PIO	11/75
M	V	VANHORN72 VALUE FROM A DPWA THAT FINDS JP=5/2+.						
M	2	(2260.)			BELLEFON	76 IPWA	0 D5 WAVE	2/77*
M	2	(2215.)			BELLEFON	76 IPWA	0 G9 WAVE	2/77*
M	2	SUPERCEDES BELLEFO1 75.						2/77*
M		2275.	20.		BELLEFON	77 DPWA	0 D5 WAVE	11/77*
M		2215.	20.		BELLEFON	77 DPWA	0 G9 WAVE	11/77*
M		2270.	50.		BELLEFON	78 DPWA	0 D5 WAVE	1/78*
M		2210.	30.		BELLEFON	78 DPWA	0 G9 WAVE	1/78*
M		. . . . .						
M	AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)							

48 Y*1(2250) WIDTH (MEV) (PROD. EXP.)

W		(150.0)			BLANPIED	65 CNTR	GAMMA P TO K+ Y*	
W		(21.0)	(17.0)	(21.0)	BOCK	65 HBC	PBAR P 5.7 GEV/C	
W		230.0	20.0		BUGG	68 CNTR	K-P, D TOTAL	6/68
W		100.0	20.0		AGUILAR	70 HBC +	K- 3.9-4.6 GEV/C	5/70
W		164.0	50.0		BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
W		(170.0)			COOL	70 CNTR	K-P, D TOTAL	10/70
W		(125.0)			LU	70 CNTR	0 GAMMA P TO K+ Y*	1/71
W	B	(100.)	(20.)		BELLEFO1	75 DPWA	D5 WAVE	11/75
W	B	(60.)	(40.)	(20.)	BELLEFO1	75 DPWA	G9 OR H11 WAVE	11/75
W	1	130.	20.		BELLEFO2	75 HBC	0 K- P TO XI*0 KO	11/75
W	V	192.	30.		VANHORN	75 DPWA	0 K-P TO LAM PIO	11/75
W	2	(100.)			BELLEFON	76 IPWA	0 D5 WAVE	2/77*
W	2	(140.)			BELLEFON	76 IPWA	0 G9 WAVE	2/77*
W		70.	20.		BELLEFON	77 DPWA	0 D5 WAVE	11/77*
W		60.	20.		BELLEFON	77 DPWA	0 G9 WAVE	11/77*
W		120.	40.		BELLEFON	78 DPWA	0 D5 WAVE	1/78*
W		80.	20.		BELLEFON	78 DPWA	0 G9 WAVE	1/78*
W		. . . . .						
W	AVERAGE MEANINGLESS (SCALE FACTOR = 2.7) SEE THE NOTES ACCOMPANYING THE MASSES QUOTED							

48 Y*1(2250) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*1(2250) INTO KBAR N	497+ 939
P2	Y*1(2250) INTO LAMBDA PI	1115+ 134
P3	Y*1(2250) INTO SIGMA PI	1197+ 139
P4	Y*1(2250) INTO KBAR N PI	497+ 939+ 139
P5	Y*1(2250) INTO XI*1/2(1530) K	1533+ 497

48 Y*1(2250) BRANCHING RATIOS (PROD. EXP.)

R1	Y*1(2250) INTO (KBAR N)/TOTAL				(P1)			
R1		.08	.02		BELLEFON	78 DPWA	0 D5 WAVE	1/78*
R1		.02	.01		BELLEFON	78 DPWA	0 G9 WAVE	1/78*
R1		. . . . .						
R1	AVERAGE MEANINGLESS (SCALE FACTOR = 2.7)							
R2	Y*1(2250) FROM KBAR N TO LAMBDA PI				SQRT(P1*P2)			
R2		(-0.18) (FOR JP=9/2-)			GALTIERI	70 DPWA	K-P TO LAMBDA PI	10/70
R2	B	(+.12)	(.03)		BELLEFO1	75 DPWA	D5 WAVE	11/75
R2	B	(-.09)	(.02)		BELLEFO1	75 DPWA	G9 OR H11 WAVE	11/75
R2	V	-.16	.03		VANHORN	75 DPWA	0 K-P TO LAM PIO	11/75
R2	2	(+.11)			BELLEFON	76 IPWA	0 D5 WAVE	2/77*
R2	2	(-.10)			BELLEFON	76 IPWA	0 G9 WAVE	2/77*
		SEE THE NOTES ACCOMPANYING THE MASSES QUOTED						
R3	Y*1(2250) FROM KBAR N TO SIGMA PI				SQRT(P1*P3)			
R3		(+0.07) (FOR JP=9/2-)			GALTIERI	70 DPWA	K-P TO SIGMA PI	10/70
R3		+.06	.02		BELLEFON	77 DPWA	0 D5 WAVE	11/77*
R3		-.03	.02		BELLEFON	77 DPWA	0 G9 WAVE	11/77*
R3		. . . . .						
R3	AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)							
R4	Y*1(2250) INTO (KBAR N)/(SIGMA PI)				(P1)/(P3)			
R4		(0.18) OR LESS			BARNES	69 HBC +	1 STAN DEV LIMIT	10/69
R5	Y*1(2250) INTO (LAMBDA PI)/(SIGMA PI)				(P2)/(P3)			
R5		(0.18) OR LESS			BARNES	69 HBC +	1 STAN DEV LIMIT	10/69
R6	Y*1(2250) FROM K- P TO XI*1/2(1530)0 KO				SQRT(P1*P5)			11/75
R6	1	.09	.02		BELLEFO2	75 HBC	0 K- P TO XI*0 KO	11/75
R6	1	SEEN IN DD5 WAVE IN NEUTRAL CHANNEL ONLY, ISOSPIN UNDETERMINED.						11/75
R7	Y*1(2250) INTO (KBAR N)/TOTAL				(J+1/2)*(P1)			
R7	J IS NOT DETERMINED IN THESE EXPTS. THE FOLLOWING IS (J+1/2)*P1.							
R7		(0.47)			BUGG	68 CNTR		3/78
R7		(0.16)	(0.12)		BRICMAN	70 CNTR	0 TOTAL AND CH EX	3/78
R7		(0.42)			COOL	70 CNTR	K-P, D TOTAL	3/78

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                              REFERENCES FOR Y*1(2250) (PROD. EXP.)
BLANPIED 65 PRL 14 741        +GREENBERG,HUGHES,KITCHING, +   (YALE(CEA))
BOCK     65 PL 17 166         +COOPER,FRENCH,KINSON, +        (CERN,SACLAY)
BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +              (RHEL,BIRM,CAVE) I
BARNES   69 PRL 22 479        +FLAMINIO,MONTANET,SAMIOS +     (BNL+SYRA)

AGUILAR  70 PRL 25 58         AGUILAR-BENITEZ, BARNES, +      (BNL,SYRA)
BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR D1 1887        +GIACOMELLI, KYCIA, LEONTIC, LI, +   (BNL) I
GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                   (LRL)IJP
LU       70 PR D2 1846        +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

BELLEFO1 75 NP B90 1          DE BELLEFO2,BERTHON,BRUNET+     (CDEF+SACL)IJP
BELLEFO2 75 NC 28A 289        DE BELLEFO2,BERTHON,BILLOIR+    (CDEF,SACL)
VANHORN  75 NP B87 145        A. J. VAN HORN                       (LBL)IJP
   ALSO  75 NP B87 157        A. J. VAN HORN                       (LBL)IJP

BELLEFON 76 NP B109 129       DE BELLEFON,BERTHON                  (CDEF)IJP
BELLEFGN 77 NC 37A 175        DE BELLEFON,BERTHON,BILLOIR+    (CDEF+SACL)IJP
BELLEFON 78 NC 42A 403        +BERTHON,BILLOIR,BRUNET+        (CDEF+SACL)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS

COOL     66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPERCEDED BY COOL 70.
DAUBER   66 PL 23 154         +SCHLEIN, SLATER, STORK, TICHO  (UCLA(LRL)) J
   SUGGESTS J#9/2 RESONANT BEHAVIOR IN SIGMA- PI+, BUT APPEARS
      INCONSISTENT WITH PARAMETERS OF COOL 66.
DAUM     68 NP B7 19          +ERNE, LAGNAUX, SENS, STEUER, UDO    (CERN)JP
LASINSKI 71 NP  B29  125      T A LASINSKI                          (EFI)IJP
HEMINGWA 75 NP B91 12         HEMINGWAY,EADES,HARMSEN+   (CERN,HEID,MPIM)IJP
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Σ(2455) BUMPS

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53  Y*1(2455, JP=    ) I=1      PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.
THERE IS ALSO SOME SLIGHT EVIDENCE FOR Y* STATES IN
THIS MASS REGION FROM THE REACTION GAMMA + P TO K+ + MISSING MASS --
SEE GREENBERG 68.

                              53  Y*1(2455) MASS (MEV) (PROD. EXP.)
M          2455.0      7.0          BUGG     68 CNTR    K-P, D TOTAL     6/68
M          2455.0     10.0          ABRAMS   70 CNTR    K-P, D TOTAL    10/70
M          . . . . . . . . .
M   AVG    2455.0      5.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   STUDENT2455.0      6.1     AVERAGE USING STUDENTIO(H/1.11) -- SEE MAIN TEXT

                              53  Y*1(2455) WIDTH (MEV) (PROD. EXP.)
W           100.0     20.0          BUGG     68 CNTR                     6/68
W           140.0                   ABRAMS   70 CNTR    K-P, D TOTAL    10/70

                              53  Y*1(2455) PARTIAL DECAY MODES (PROD. EXP.)
                                                                DECAY MASSES
P1     Y*1(2455) INTO KBAR N                                    497+ 939

                              53  Y*1(2455) BRANCHING RATIOS (PROD. EXP.)
R1     Y*1(2455) INTO (KBAR N)/TOTAL                    (P1)
R1        J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1           (0.3)                BUGG     68 CNTR                     6/68
R1            0.39                ABRAMS   70 CNTR    K-P, D TOTAL    10/70
R1   C       (0.05)   (0.05)      BRICMAN  70 CNTR  D TOTAL AND CH EX   6/70
R1   C    FIT OF TOTAL CROSS SECTION GIVEN BY BRICMAN 70 IS POOR IN
R1   C    THIS REGION.

                              REFERENCES FOR Y*1(2455) (PROD. EXP.)
BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +              (RHEL,BIRM,CAVE) I
ABRAMS   70 PR D 1917         +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)

                              PAPERS NOT REFERRED TO IN DATA CARDS
ABRAMS   67 PRL 19 678        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
   SUPERSEDED BY ABRAMS 70.
GREENBER 68 PRL 20 221        GREENBERG, HUGHES, LU, MINEHART, +    (YALE)
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Σ(2620) BUMPS

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54  Y*1(2620, JP=    ) I=1      PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                              54  Y*1(2620) MASS (MEV) (PROD. EXP.)
M          2620.0     15.0          ABRAMS   70 CNTR    K-P, D TOTAL    10/70
M          2542.      22.           DIBIANCA 75 DBC     XI K PI          1/76
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)

                              54  Y*1(2620) WIDTH (MEV) (PROD. EXP.)
W          (175.0)                 ABRAMS   70 CNTR    K-P, D TOTAL    10/70
W           221.      81.          DIBIANCA 75 DBC     XI K PI          1/76

                              54  Y*1(2620) PARTIAL DECAY MODES (PROD. EXP.)
                                                                DECAY MASSES
P1     Y*1(2620) INTO KBAR N                                    497+ 939

                              54  Y*1(2620) BRANCHING RATIOS (PROD. EXP.)
R1     Y*1(2620) INTO (KBAR N)/TOTAL                    (P1)
R1        J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1           (0.32)               ABRAMS   70 CNTR    K-P, D TOTAL    10/70
R1            0.36      0.12      BRICMAN  70 CNTR  D TOTAL AND CH EX   6/70

                              REFERENCES FOR Y*1(2620) (PROD. EXP.)
ABRAMS   67 PRL 19 678        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
   SUPERSEDED BY ABRAMS 70.
ABRAMS   70 PR 1D 1917        +COOL, GIACOMELLI, KYCIA, LEONTIC, +  (BNL) I
BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)

DIBIANCA 75 NP B98 137        DIBIANCA,ENDORFR                      (CARN)
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Σ(3000) BUMPS

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59  Y*1(3000, JP=    ) I=1      PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

ENHANCEMENT IN LAMBDA PI AND KBAR N INVARIANT MASS
SPECTRA AND IN MISSING MASS OF NEUTRALS RECOILING
AGAINST KO.  EVIDENCE NOT CONCLUSIVE.  OMITTED FROM
TABLE.

                              59  Y*1(3000) MASS (MEV) (PROD. EXP.)
M          (3000.0)                EHRLICH  66 HBC   0 PI-P 7.91 BEV/C   9/66

                              59  Y*1(3000) PARTIAL DECAY MODES (PROD. EXP.)
                                                                DECAY MASSES
P1     Y*1(3000) INTO KBAR N                                    497+ 939
P2     Y*1(3000) INTO LAMBDA PI                                1115+ 139

                              REFERENCES FOR Y*1(3000) (PROD. EXP.)
EHRLICH  66 PR 152 1194       R EHRLICH, W SELOVE, H YUTA           (PENN(BNL)) I
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EXOTIC HYPERON CROSS SECTION LIMITS

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                              THIS IS NOT A COMPLETE LIST.  WE TABULATE
                              ONLY FROM 1970 ON.

CS  UNITS MICROBARNS
CS  G       (20.)   OR LESS          GALTIERI  68 DBC     K-N TO SG-PI-PI0  7/70
CS  G  ABOVE LIMIT FOR MASS <  2.15 GEV AND GAMMA <  60 MEV- (2.1 GEV/C K-)  7/70
CS  A       (40.)   OR LESS          GALTIERI  68 DBC  -- K-N TO SG-PI-PI0  7/70
CS  A  ABOVE LIMIT FOR MASS <  2.3 GEV AND GAMMA  < 120 MEV- (2.7 GEV/C K-)  7/70

                              REFERENCES FOR EXOTIC HYPERONS
GALTIERI 68 PRL 21 573        A.BARBARO-GALTIERI,CHADWICK +    (LRL+SLAC)
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Note on Ξ Resonances

The Ξ resonance situation has long been unsettled. This is mainly because: (1) Ξ^*'s can only be produced as part of a final state, $K^- p \to \Xi^* +$ others, where the analysis is more complicated than if direct formation were possible; (2) they are so produced with small cross sections (typically a few μb); and (3) the final states are in general topologically complicated and difficult to study with purely electronic techniques. Thus over the years our knowledge of Ξ^* spectroscopy has come wholly from bubble chamber experiments, where the numbers of events available are small.

Until recently, only the Ξ(1530) could be considered as really well established. However, this year sees a significant improvement in our understanding of the Ξ^* spectrum with the data of GAY 76 and HEMINGWAY 77. We consider the data from this large bubble chamber experiment to be of

Data Card Listings

For notation, see key at front of Listings.

sufficient quality so as to definitely establish the existence of $\Xi(1820)$ and $\Xi(2030)$ as narrow states (with widths ~20 MeV). Moreover, reasonable estimates of the decay rates are now available, and, in the case of $\Xi(1820)$, a spin-parity analysis favors spin 3/2 (TEODORO 77).

As far as the other Ξ^* states are concerned, the situation continues much as before. There is evidence for at least one other state in the 1850 - 2000 MeV region and indications of several others above 2000 MeV. Indeed, numerous states are predicted to exist below 2500 MeV and the broad $\Xi(1940)$ could well be a mixture of several (HEMINGWAY 76). However, for the time being we are still forced to group together rather disparate observations and await more new results. The disagreement among various experiments is indicated by means of ideograms in the Data Card Listings.

More new results may shortly be forthcoming from two large bubble chamber experiments currently in progress (BAUBILLIER 71, MORRIS 75). In addition, future experiments with the MPS at BNL and with hyperon beams at both FNAL and CERN may further clarify the situation.

The table following this note gives our evaluation of the status of the Ξ resonances, based on data available at this time.

References

1. M. Baubillier et al., CERN Proposal TCC/71-25 and 74-14 (1971).
2. R. J. Hemingway, Proc. of the Topical Conf. on Baryon Resonances, Oxford, 1976, edited by R. T. Ross and D. H. Saxon (Science Research Council, Chilton).

For other references see the Data Card Listings.

STATUS OF XI* RESONANCES

THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.
IN THE PAST WE HAVE LOWERED OUR STANDARDS FOR XI* RESONANCES AND TABULATED STATES EVEN THOUGH THEY HAD ONLY BEEN SEEN AT LOW LEVELS OF STATISTICAL SIGNIFICANCE. NOW THAT NEW HIGH STATISTICS DATA IS BECOMING AVAILABLE, WE PROPOSE TO ADOPT SOMEWHAT STRICTER CRITERIA.

			STATUS AS SEEN IN --				
PARTICLE	LIJ	OVERALL STATUS	XI PI	LAM K	SIG K	XI* PI	OTHER CHANNELS
XI(1317)	P11	****					WEAK TO LAM PI
XI(1530)	P13	****	****				
XI(1630)		**	**				
XI(1820)	13	***	*	***	**	***	
XI(1940)		**	**			**	
XI(2030)	1	***		**	***		
XI(2120)		*		*			
XI(2250)		*					3-BODY DECAYS
XI(2500)		**		**	**		3-BODY DECAYS

**** GOOD, CLEAR, AND UNMISTAKABLE.
*** GOOD, BUT IN NEED OF CLARIFICATION OR NOT ABSOLUTELY CERTAIN.
** NEEDS CONFIRMATION.
* WEAK.

S=−2 I=1/2 HYPERON STATES (Ξ)

Ξ^-

22 XI-(1321, JP=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

Ξ^0

23 XI0(1314, JP=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

$\Xi(1530)$ P_{13}

49 XI*1/2(1530, JP=3/2+) I=1/2

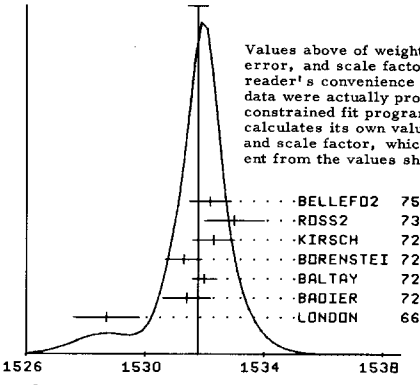
THIS IS THE ONLY WELL-ESTABLISHED XI* WHOSE PROPERTIES ARE ALL AT LEAST REASONABLY WELL-KNOWN. SPIN-PARITY 3/2+ IS FAVOURED BY THE DATA.

WE DO NOT USE DETERMINATIONS OF THE MASS AND THE WIDTH OF THIS STATE UNLESS THEY ARE ACCOMPANIED BY SOME DISCUSSION OF SYSTEMATICS AND RESOLUTION.

49 XI*1/2(1530) MASS (MEV)

M	MIXED CHARGES							
M	55(1529.0)	(5.0)		PJERROU	62 HBC	-0 K-P 1.8 GEV/C		
M	(1532.0)	(2.0)		BADIER	64 HBC	-0 K-P 3 GEV/C		
M-	NEGATIVE CHARGE ONLY							
M-	38 1535.7	3.2		LONDON	66 HBC	- K-P 2.24 GEV/C	7/66	
M-	334(1534.7)	(1.1)		BALTAY	72 HBC	- K-P 1.75 GEV	1/73	
M-	185 1536.2	1.6		KIRSCH	72 HBC	- K-P 2.87GEV/C	2/72	
M-	1535.3	2.0		ROSS2	73 HBC	- XI KBAR PI (PI)	2/74	
M-	48(1540.)	(3.)		BERTHON	74 HBC	- QUASI 2 BODY CS	10/74	
M-	1534.5	1.2		BELLEFO2	75 HBC	- K-P TO XI- K PI	11/75	
M-								
M-	AVG 1535.18	0.84	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
M-	STUDENT 1535.18	0.92	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
M-	FIT 1534.97	0.63	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)					
M0	NEUTRAL CHARGE ONLY							
M0	76 1528.7	1.1		LONDON	66 HBC	0 K-P 2.24 GEV/C	7/66	
M0	59 1531.4	0.8		BADIER	72 HBC	0 K-P AT 3.95GEV/C	10/71	
M0	1262 1532.0	0.4		BALTAY	72 HBC	0 K-P 1.75 GEV	1/73	
M0	324 1531.3	0.6		BORENSTEI	72 HBC	0 K-P 2.2GEV/C	2/72	
M0	286 1532.3	0.7		KIRSCH	72 HBC	0 K-P 2.87GEV/C	2/72	
M0	1533.0	1.0		ROSS2	73 HBC	XI KBAR PI (PI)	2/74	
M0	97(1533.6)	(1.4)		BERTHON	74 HBC	0 QUASI 2 BODY CS	10/74	
M0	1532.2	.7		BELLEFO2	75 HBC	0 K-P TO XI- K PI	11/75	
M0								
M0	AVG 1531.78	0.34	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)					
M0	STUDENT 1531.84	0.28	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT					
M0	FIT 1531.80	0.31	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3) (SEE IDEOGRAM BELOW)					

WEIGHTED AVERAGE = 1531.78 ± 0.34
ERROR SCALED BY 1.4



Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

			CHISQ
BELLEFO2	75	HBC	0.4
ROSS2	73	HBC	1.5
KIRSCH	72	HBC	0.5
BORENSTEI	72	HBC	0.6
BALTAY	72	HBC	0.3
BADIER	72	HBC	0.2
LONDON	66	HBC	7.9
			11.4
			(CONLEV =0.077)

49 (XI*-) - (XI*0) MASS DIFFERENCE (MEV)

D	5.7	3.0		PJERROU	65 HBC	-0 1.8-1.95 GEV/C	7/66
D R	(7.0)	(4.0)		LONDON	66 HBC	-0 2.24 GEV/C	7/66
D	2.0	3.2		MERRILL	66 HBC	-0 1.7-2.7 GEV/C	7/66
D	2.7	1.0		BALTAY	72 HBC	-0 K-P 1.75 GEV	1/73
D R	(3.9)	(1.8)		KIRSCH	72 HBC	-0 K- P 2.87 GEV/C	2/72
D R	REDUNDANT WITH DATA IN MASS LISTING.						
D							
D AVG	2.92	0.91	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
D STUDENT	2.90	0.99	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT				
D FIT	3.17	0.64	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				

Baryons

Ξ(1530), Ξ(1630), Ξ(1820)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                    49  XI*1/2(1530) WIDTH (MEV)

W-  NEGATIVE CHARGE ONLY
W-          7.8      3.5      7.8   BALTAY    72 HBC  -  K-P 1.75 GEV      1/73
W-         16.2      4.6            KIRSCH    72 HBC  -  XI- PIO,XIO PI-    2/72
W-          8.3      3.6            ROSS2     73 HBC  -  XI KBAR PI (PI)   2/74
W-          9.6      2.8            BELLEFO2  75 HBC  -  K-P TO XI- K PI   11/75
W-          . . . . . . . . .
W-  AVG    10.1      1.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W-  STUDENT 10.0     2.1      AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

WO  NEUTRAL CHARGE ONLY
WO          7.0      2.0            SCHLEIN   63 HBC   0 1.8, 1.95 GEV/C
WO          7.0      7.0            BERGE     66 HBC   0 1.5-1.7 GEV/C      7/66
WO          8.5      3.5            LONDON    66 HBC   0 2.24 GEV/C         7/66
WO         11.0      2.0            BADIER    72 HBC   0 K-P AT 3.95GEV/C  10/71
WO          9.0      0.7            BALTAY    72 HBC   0 K-P 1.75 GEV       1/73
WO          8.4      1.4            BORENSTEI 72 HBC   0 XI- PI+ MODE       2/72
WO         11.0      1.8            KIRSCH    72 HBC   0 XI- PI+            2/72
WO          9.1      2.4            ROSS2     73 HBC   0 XI KBAR PI (PI)    2/74
WO          9.5      1.2            BELLEFO2  75 HBC   0 K-P TO XI- K PI   11/75
WO          . . . . . . . . .
WO  AVG     9.14     0.48     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
WO  STUDENT 9.13     0.53     AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT

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                    49  XI*1/2(1530) REAL PART OF POLE POSITION              4/75

RE0       1531.6      0.4            LICHTENB  74       0 EXTRAP HABIBI73    4/75
RE-       1534.4      1.1            LICHTENB  74       - EXTRAP HABIBI73    4/75

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                    49  XI*1/2(1530) IMAGINARY PART OF POLE POSITION         4/75

IM0          4.45     0.35           LICHTENB  74       0 EXTRAP HABIBI73    4/75
IM-          3.9      1.75     3.9   LICHTENB  74       - EXTRAP HABIBI73    4/75

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                    49  XI*1/2(1530) PARTIAL DECAY MODES

                                                                 DECAY MASSES
P1     XI*1/2(1530) INTO XI PI                                   1321+ 139
       OTHER STRONG DECAYS ARE FORBIDDEN BY ENERGY CONSERVATION.
P2     XI*1/2(1530) INTO XI GAMMA                                1321+   0

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                    49  XI*1/2(1530) BRANCHING RATIOS (MEV)

R1     XI*1/2(1530) INTO (XI GAMMA)/TOTAL                (P2)              1/76
R1          (0.04) OR LESS  CL=.90   KALBFLEI  75 HBC  -  K-P AT 2.18 GEV   1/76

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                          REFERENCES FOR XI*1/2(1530)

PJERROU   62 PRL 9 114          +PROWSE,SCHLEIN,SLATER,STORK,TICHO    (UCLA) I
SCHLEIN   63 PRL 11 167         +CARMONY,PJERROU,SLATER,STORK,TICHO   (UCLA)IJP
BADIER    64 DUBNA 1 593        +DEMOULIN,GOLDBERG, +     (EPOL,SACLAY,AMST) I
PJERROU   65 PRL 14 275         +SCHLEIN,SLATER,SMITH,STORK,TICHO     (UCLA)

BERGE     66 PR 147 945         +EBERHARD,HUBBARD,MERRILL,B-SHAFER,+  (LRL) I
LONDON    66 PR 143 1034        +RAU,SAMIDS,YAMAMOTO,GOLDBERG,+  (BNL,SYRA) IJ
MERRILL   66 UCRL-16455 THESIS  D W MERRILL                           (LRL) JP

BADIER    72 NP B37 429         +BARRELET,CHARLTON,VIDEAU                (EPOL)
BALTAY    72 PL 42B 129         +BRIDGEWATER,COOPER,GERSHWIN,+  (COLU+BING)
    ALSO  73 NEVIS 199(THESIS)  HABIBI                                (COLUMBIA)
BORENSTE  72 PR D5 1559         BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I
KIRSCH    72 NP B40 349         SCHMIDT+CHANG,HEMINGWAY(BRAN,UMD,SYRA,TUFT) I

ROSS2     73 PURDUE CONF. 355   ROSS,LLOYD,RADOJICIC                     (OXFORD)
BERTHON   74 NC 21A 146         BERTHON,TRISTRAM,+      (CDEF+RHEL+SACL+STRB)
LICHTENB  74 PRD 10 3865        D B LICHTENBERG            (INDIANA UNIVERSITY)
    ALSO  74 PRIV. COMM.        D B LICHTENBERG            (INDIANA UNIVERSITY)
BELLEFO2  75 NC 28A 289         DE BELLEFON,BERTHON,BILLOIR+     (CDEF,SACL)
KALBFLEI  75 PRD 11 987         KALBFLEISCH,STRAND,CHAPMAN          (BNL+MICH)

                          PAPERS NOT REFERRED TO IN DATA CARDS

SHAFER    66 PR 142 883         BUTTON-SHAFER,LINDSEY,MURRAY,SMITH       (LRL) JP
    A SPIN-PARITY DETERMINATION.
HABIBI    73 NEVIS 199(THESIS)  HABIBI                                     (COLU)
HUNGERBU  74 PRD 10 2051        HUNGERBUHLER,MAJKA,+     (YALE,FNAL,BNL,PITT)
BRIEFEL   75 PRD 12 1859        +GOUREVITCH,KIRSCH+      (BRAN+UMD+SYRA+TUFT)
BRIEFEL   77 PRD 16 2706        +GOUREVITCH,CHANG+       (BRAN+UMD+SYRA+TUFT)

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Ξ(1630)

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                    21  XI*1/2(1630, JP=    ) I=1/2

          THIS EFFECT NEEDS CONFIRMATION.
          BARTSCH 69 SEE A SMALL, BROAD ENHANCEMENT NEAR
          1650 MEV - IT IS NOT CLEAR THAT IT IS THE SAME
          PHENOMENON AS BRIEFEL 77, WHO FIND CS=2.6+-0.9
          MICROBARNS AT 2.87 GEV/C INCIDENT K- MOMENTUM.
    BORENSTEIN 72 SEE NO EFFECT IN THIS REGION.  THEY FIND
    CS<2 MICROBARNS AT 2.18 GEV/C.
       ROSS 72 ARGUE THAT THE EFFECT THEY SEE IS NOT THE SAME AS THAT
    SEEN BY BRIEFEL 77 (WHOSE PRELIMINARY RESULTS WERE REPORTED IN
    BMST 70), AND FIND CS=2+-1 MICROBARNS AT 3.3 GEV/C.
    BELLEFON 75 FIND A CS OF AROUND 10 MICROBARNS NEAR 2 GEV/C,
    BUT LESS THAN 3 MICROBARNS AROUND 2.3 GEV/C.

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                    21  XI*1/2(1630) MASS (MEV)

M         29 1606.      6.           ROSS      72 HBC   0 K-P AT 3.1-3.7     3/72
M         34 1633.     12.           BELLEFO2  75 HBC   0 K-P TO XI- K PI   11/75
M         31 1624.      3.           BRIEFEL   77 HBC   0 K-P 2.87 GEV/C     1/78*
M         . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)

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                    21  XI*1/2(1630) WIDTH (MEV)

W         29   21.      7            ROSS      72 HBC   0 XI-PI+ K*0(890)    3/72
W         34   40.     15.           BELLEFO2  75 HBC   0 K-P TO XI- K PI   11/75
W  F      31  (22.5)                 BRIEFEL   77 HBC   0 K-P 2.87 GEV/C     1/78*
W  F    GOODNESS OF FIT INSENSITIVE TO VALUES BETWEEN 15 AND 30 MEV.
W  F    THE SIGNIFICANCE OF THE EFFECT IS CLAIMED TO BE ABOUT 3 STD. DEV.
W         . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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                    21  XI*1/2(1630) PARTIAL DECAY MODES

                                                                 DECAY MASSES
P1     XI*1/2(1630) INTO XI PI                                   1321+ 139

       SEEN IN K- P TO XI- PI+ KO AND XI- PIO K+.

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                          REFERENCES FOR XI*1/2(1630)

ROSS      72 PL 38B 177         ,BURAN,LLOYD,MULVEY,RADOJICIC            (OXF) I
BELLEFO2  75 NC 28A 289         DE BELLEFON,BERTHON,BILLOIR+     (CDEF,SACL)
BRIEFEL   77 PRD 16 2706        +GOUREVITCH,CHANG+       (BRAN+UMD+SYRA+TUFT)
    ALSO  70 DUKE CONF. 317     BMST      (BRANDEIS+MARYLAND+SYRACUSE+TUFTS)

                          PAPERS NOT REFERRED TO IN DATA CARDS

APSELL    69 PRL 23 884         +      (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
    SUPERSEDED BY BMST 70.
BARTSCH   69 PL 28B 439         +      (AACHEN, BERLIN, CERN, LOIC, VIENNA)
KALBFLEI  70 DUKE CONF 331      G R KALBFLEISCH                          (BNL) I
    SUMMARIZES EVIDENCE FOR ISOSPIN ONE-HALF.
BORENSTE  72 PR D5 1559         BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I
SCHMIDT   73 PURDUE CONF. 363   SCHMIDT                               (BRANDEIS)
HUNGERBU  74 PRD 10 2051        HUNGERBUHLER,MAJKA,+     (YALE,FNAL,BNL,PITT)
BRIEFEL   75 PRD 12 1859        +GOUREVITCH,KIRSCH+      (BRAN+UMD+SYRA+TUFT)

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Ξ(1820)

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                    50  XI*1/2(1820, JP=3/2 ) I=1/2

          WE LIST HERE EVERYTHING REPORTED IN THE MASS RANGE
          1750-1875 MEV.
          THE CLEAREST EVIDENCE FOR THIS STATE IS THAT OF
          GAY 76, WHO SEE AN 8 STD. DEV. ENHANCEMENT IN
          LAMBDA K-, AS WELL AS ENHANCEMENTS IN XI*(1530) PI,
          AND SIGMA KBAR. THE ENHANCEMENT OBSERVED BY GAY 76
    IS NARROW (WIDTH 21 +- 7 MEV), IN CONTRAST TO RESULTS FROM EARLIER LESS
    SIGNIFICANT DATA WHERE WIDTHS OF UP TO 100 MEV HAVE BEEN REPORTED (SEE
    THE DATA CARD LISTINGS BELOW). GAY 76 OBSERVE NO SIGNAL IN THE XI PI
    CHANNEL. IT IS POSSIBLE THAT THE XI PI ENHANCEMENTS SEEN IN THIS MASS
    REGION BY SOME EXPERIMENTS AT LOWER MOMENTUM ARE AT LEAST PARTIALLY DUE
    TO THE XI*(1940), WITH A SHAPE DISTORTED BY THE MORE LIMITED AVAILABLE
    PHASE SPACE (SMITH 65). THE SITUATION IS FURTHER CONFUSED BY SOME
    EXPERIMENTS BEING FORCED TO ADD SEVERAL DIFFERENT CHANNELS TO OVERCOME
    POOR STATISTICS (CRENNELL 70, BADIER 71).
    A SPIN PARITY ANALYSIS OF THE GAY 76 DATA BUT WITH MORE STATISTICS
    (TEODORO 77), FAVOURS J=3/2 BUT CANNOT MAKE A PARITY DISCRIMINATION.

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                    50  XI*1/2(1820) MASS (MEV)

M           (1770.0)                  HALSTEINS 63 FBC  -0 K-FR 3.5 GEV/C
M         30 1814.0       4.0         BADIER    65 HBC   0 LAMBDA KOBAR
M         29 1817.0       7.0         SMITH 1   65 HBC  -0 LAMBDA KBAR
M         40 1830.0      10.0         ALITTI    69 HBC   - LAM, SIG KBAR      9/69
M  C      25 1830.0      10.0         CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C    10/70
M  C    FROM FIT TO INCLUSIVE XI PI, XI PI PI AND LAMBDA K- SPECTRA
M  D      (1826.0)  (12.0)           CRENNELL  70 DBC  -0 3.6, 3.9 GEV/C    11/77*
M  D    FROM FIT TO INCLUSIVE XI PI AND XI PI PI SPECTRA ONLY
M  B      28 1762.0      8.0         BADIER    72 HBC  -0 XI PI,XI2PI,K Y    10/71
M  B      38 1838.0      5.0         BADIER    72 HBC  -0XI PI,XI2PI,K Y     10/71
M  B    BADIER 72 ADDS ALL CHANNELS AND DIVIDES PEAK IN LOWER AND HIGHER
M  B    MASS REGIONS. THE DATA CAN ALSO BE FITTED WITH A SINGLE BREIT-
M  B    WIGNER OF MASS 1800 AND WIDTH 150 MEV.
M    1    30 1821.       5.          ROSS1     73 HBC  -0 LAMBDA K-/KBARO   2/74
M    1    LESS SIGNIFICANT ENHANCEMENTS SEEN IN XI*(1530) PI (M=1825,W=100)
M    1    AND SIGMA KBAR (M=1810+-9,W=16+-11).
M           1807.      27.          DIBIANCA  75 DBC  -0 XI 2PI, XI* PI      1/76
M         130 1823.0     2.0         GAY       76 HBC  -  K- P AT 4.2 GEV    2/77*
M          74 1797.      19.         BRIEFEL   77 HBC   0 XI PI (2.87 K-P)   1/78*
M          68 1829.       9.         BRIEFEL   77 HBC  -0 XI(1530) PI        1/78*
M          39 1860.      14.         BRIEFEL   77 HBC  -  SIGMA- KOBAR       1/78*
M          44 1870.       9.         BRIEFEL   77 HBC   0 LAMBDA KOBAR       1/78*
M          57 1813.       4.         BRIEFEL   77 HBC  -  LAMBDA K-          1/78*
M           . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.2)
                  (SEE IDEOGRAM BELOW )
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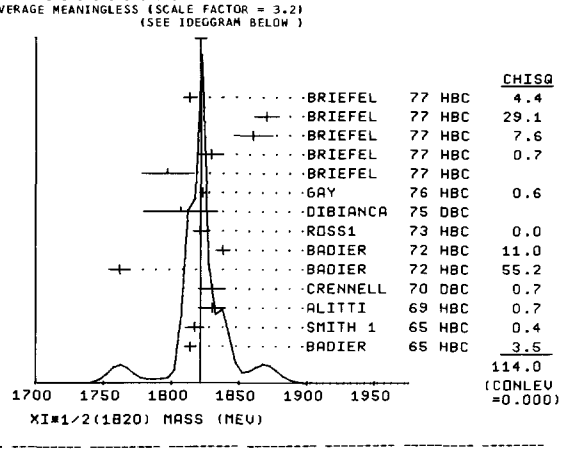
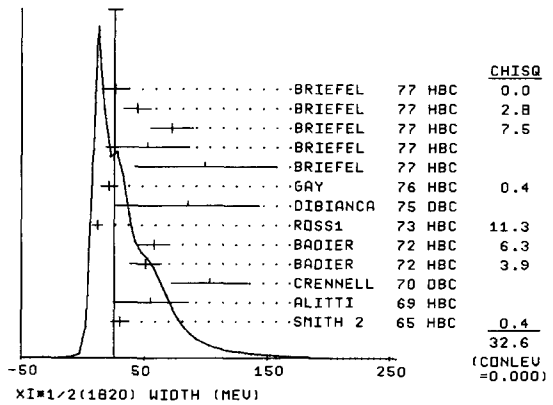


Data Card Listings

For notation, see key at front of Listings.

50 XI*1/2(1820) WIDTH (MEV)

W			(80.0)	OR LESS		HALSTEINS	63 FBC	-0 K-FR 3.5 GEV/C	
W			(12.0)	(4.0)		BADIER	65 HBC	0 LAMBDA KOBAR	
W			30.0	7.0		SMITH 2	65 HBC	-0 LAMBDA KBAR	
W			55.0	40.0	20.0	ALITTI	69 HBC	- LAM, SIG KBAR	9/69
W	C		103.0	38.0	24.0	CRENNELL	70 DBC	-0 3.6, 3.9 GEV/C	10/70
W	O		(48.0)	(36.0)	(19.0)	CRENNELL	70 DBC	-0 3.6, 3.9 GEV/C	11/77*
W	B		51.0	13.0		BADIER	72 HBC	-0 LOWER MASS	10/71
W	B		58.0	13.0		BADIER	72 HBC	-0 HIGHER MASS	10/71
W	1	30	12.	4.		ROSS1	73 HBC	-0 LAMBDA K-/KBARO	2/74
W			85.	58.		DIBIANCA	75 DBC	-0 XI 2PI, XI* PI	1/76
W		130	21.0	7.0		GAY	76 HBC	- K- P AT 4.2 GEV	2/77*
W		74	99.	57.		BRIEFEL	77 HBC	0 XI PI (2.87 K-P)	1/78*
W		68	52.	34.		BRIEFEL	77 HBC	-0 XI(1530) PI	1/78*
W		39	72.	17.		BRIEFEL	77 HBC	- SIGMA- KOBAR	1/78*
W		44	44.	11.		BRIEFEL	77 HBC	0 LAMBDA KOBAR	1/78*
W		57	26.	11.		BRIEFEL	77 HBC	- LAMBDA K-	1/78*
W	***			SEE THE NOTES ACCOMPANYING THE MASSES QUOTED ABOVE.					
W				. . . . .					
W	AVERAGE MEANINGLESS (SCALE FACTOR = 2.2)								
	(SEE IDEOGRAM BELOW)								



50 XI*1/2(1820) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI*1/2(1820) INTO LAMBDA KBAR	1115+ 497
P2	XI*1/2(1820) INTO XI PI	1321+ 139
P3	XI*1/2(1820) INTO SIGMA KBAR	1197+ 497
P4	XI*1/2(1820) INTO XI*1/2(1530) PI	1533+ 139
P5	XI*1/2(1820) INTO XI PI PI (EXCLUDING P4)	1321+ 139+ 139

FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The diagonal elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{(\delta P_i \delta P_i)}$, while the off-diagonal elements are the normalized correlation coefficients $(\delta P_i \delta P_j)/(\delta P_i \cdot \delta P_j)$. For the definitions of the individual P_i, see the listings above; only those P_i appearing in the matrix are assumed in the fit to be nonzero and are thus constrained to add to 1.

	P 1	P 2	P 3	P 4
P 1	.4974+-.0812			
P 2	-.7282	.1889+-.0505		
P 3	.1061	-.4931	.1463+-.0469	
P 4	-.7972	.5122	-.4933	.1674+-.0620

50 XI*1/2(1820) BRANCHING RATIOS

R1	XI*1/2(1820) INTO (LAMBDA KBAR)/TOTAL				(P1)	
R1	0.30	0.15	ALITTI	69 HBC	- K-P 3.9-5.0 GEV	9/69
R1	. . . . .					
R1 FIT	0.497	0.081	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)			
R2	XI*1/2(1820) INTO (XI PI)/TOTAL				(P2)	
R2	0.10	0.10	ALITTI	69 HBC	- K-P 3.9-5.0 GEV	9/69
R2	. . . . .					
R2 FIT	0.189	0.050	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)			
R21	XI*1/2(1820) INTO (XI PI)/(LAMBDA KBAR)				(P2)/(P1)	
R21	0.20	0.20	BADIER	65 HBC	0 K-P AT 3 GEV	7/66
R21	(0.36) OR LESS	CL=.95	GAY	76 HBC	- K- P AT 4.2 GEV	2/77*
R21	. . . . .					
R21 FIT	0.38	0.15	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)			
R22	XI*1/2(1820) INTO (XI PI)/(XI*1/2(1530) PI)				(P2)/(P4)	
R22	1.5	0.6	0.4	APSELL	70 HBC	0 K-P AT 2.87 GEV	6/70
R22	. . . . .					
R22 FIT	1.13	0.37	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R3	XI*1/2(1820) INTO (SIGMA KBAR)/TOTAL				(P3)	
R3	(0.02) OR LESS		TRIPP	67 RVUE		8/67
R3	0.30	0.15	ALITTI	69 HBC	- K-P 3.9-5.0 GEV	9/69
R3	. . . . .					
R3 FIT	0.146	0.047	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)			
R31	XI*1/2(1820) INTO (SIGMA KBAR)/(LAMBDA KBAR)				(P3)/(P1)	
R31	0.24	0.10	GAY	76 HBC	- K- P AT 4.2 GEV	2/77*
R31	. . . . .					
R31 FIT	0.29	0.10	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)			

R4	XI*1/2(1820) INTO (XI*1/2(1530) PI)/TOTAL				(P4)	
R4	0.30	0.15	ALITTI	69 HBC	- K-P 3.9-5.0 GEV	9/69
R4 S	(0.25) OR LESS		DAUBER	69 HBC	K-P 2.7 BEV/C	9/69
R4 S	USES IN PART THE SAME DATA AS SMITH 65					
R4	. . . . .					
R4 FIT	0.167	0.062	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)			
R41	XI*1/2(1820) INTO (XI*(1530) PI)/(LAM KBAR)				(P4)/(P1)	
R41	0.26	0.13	SMITH 1	65 HBC	-0 K-P 2.45-2.70GEV	
R41	1.0	0.3	GAY	76 HBC	- K- P AT 4.2 GEV	2/77*
R41	. . . . .					
R41 AVG	0.38	0.27	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)			
R41 STUDENT	0.35	0.14	AVERAGE USING STUDENT10(H/1.11) -- SEE MAIN TEXT			
R41 FIT	0.34	0.17	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)			
R51	XI*1/2(1820) INTO (XI PI PI)/(LAMBDA KBAR)				(P5)/(P1)	
R51	(0.1) OR MORE		SMITH 1	65 HBC	-0 K-P 2.45-2.70GEV	
R52	XI*1/2(1820) INTO (XI PI PI)/(XI*1/2(1530) PI)				(P5)/(P4)	
R52 L	(0.3)	(0.5)	APSELL	70 HBC	0 K-P AT 2.87 GEV	6/70
R52 L	OR LESS. UPPER LIMIT FOR THE 3-BODY DECAY					
R52	CONSISTENT WITH ZERO		GAY	76 HBC	- K-P AT 4.2 GEV	11/77*
R53	XI*1/2(1820) INTO XI PI PI (INCLUDING XI*(1530) PI)/(LAMBDA KBAR)					
R53					(P4+P5)/(P1)	
R53 C	(0.14) OR LESS		BADIER	65 HBC	0 1 STD.DEV.LIMIT	11/77*
R53 C	FOR THE DECAY MODE (XI- PI+ PI0) ONLY					

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REFERENCES FOR XI*1/2(1820)

HALSTEIN 63	SIENA CONF 173	HALSTEINSLID,+ (BERGEN,CERN,EPOL,RHEL,LOUC) I
BADIER 65	PL 16 171	+DEMOULIN,GOLDBERG, + (EPOL,SACLAY,AMST) I
SMITH 1 65	PRL 14 25	+LINDSEY,BUTTON-SHAFER,MURRAY (LRL)IJP
SMITH 2 65	ATHENS CONF 251	G A SMITH, J S LINDSEY (LRL)
TRIPP 67	NP B3 10	+ LEITH, + (LRL,SLAC,CERN,HEIDEL,SACLAY)
USES DATA OF SMITH 1.		
ALITTI 69	PRL 22 79	+BARNES,FLAMINIO,METZGER, + (BNL,SYRACUSE) I
DAUBER 69	PR 179 1262	+BERGE, HUBBARD, MERRILL, MULLER (LRL)
APSELL 70	PRL 24 777	+ (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
CRENNELL 70	PR 1D 847	+KARSHON, LAI, ONEALL, SCARR, SCHUMANN(BNL)
BADIER 72	NP B37 429	+BARRELET,CHARLTON,VIDEAU (EPOL)
ROSS1 73	PURDUE CONF. 345	ROSS,LLOYD,RADOJICIC (OXFORD)
DIBIANCA 75	NP B98 137	DIBIANCA,ENDORF (CARN)
GAY 76	PL 62B 477	+ARMENTEROS,BERGE,GAVILLET+(AMST+CERN+NIJM)IJ
BRIEFEL 77	PRD 16 2706	+GOUREVITCH,CHANG+ (BRAN+UMD+SYRA+TUFT)
ALSO 70	DUKE CONF. 317	BMST (BRANDEIS+MARYLAND+SYRACUSE+TUFTS)
		PAPERS NOT REFERRED TO IN DATA CARDS
SMITH 64	PRL 13 61	+LINDSEY,MURRAY,BUTTON-SHAFER+ (LRL) IJP
MERRILL 68	PR 167 1202	D W MERRILL, J BUTTON-SHAFER (LRL)
WEAK EVIDENCE CONCERNING JP.		
APSELL 69	PRL 23 884	+ (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
SUPERSEDED BY BRIEFEL 77.		
SCHMIDT 73	PURDUE CONF. 363	SCHMIDT (BRANDEIS)
BRIEFEL 75	PRD 12 1859	+GOUREVITCH,KIRSCH+ (BRAN+UMD+SYRA+TUFT)
TEODORO 77	CERN/EP/PHYS77-36	+DIAZ,DIONISI,BLOKZIJL+(AMST+CERN+NIJM+OXF) JP
ALSO 77	SLAC SUMMER INST.	HEMINGWAY REVIEW TALK (AMST+CERN+NIJM+OXF) JP
ALSO 77	BUDAPEST CONF.	SALMERON REVIEW TALK (AMST+CERN+NIJM+OXF) JP

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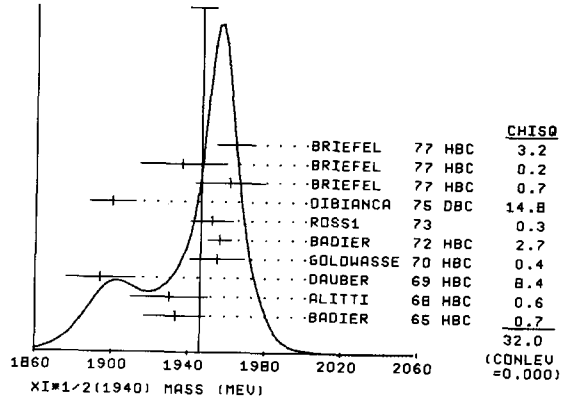
Ξ(1940)

52 XI*1/2(1940, JP=) I=1/2

WE LIST UNDER XI(1940) EVERYTHING REPORTED IN THE MASS RANGE 1875-2000 MEV.

52 XI*1/2(1940) MASS (MEV)

M	35 1933.0	16.0	BADIER	65 HBC	0 XI- PI+	
M	27 1930.0	20.0	ALITTI	68 HBC	0 XI- PI+	11/68
M	66 1894.0	18.0	DAUBER	69 HBC	- XI PI	11/68
M	21 1955.0	14.0	GOLDWASSE	70 HBC	- XI PI	10/70
M	29 1956.0	6.0	BADIER	72 HBC	XI PI,XI2PI,K Y	10/71
M	25 1952.	11.	ROSS1	73	(XI PI)-	2/74
M	1900.	12.	DIBIANCA	75 DBC	XI PI	1/76
M	139 1961.	18.	BRIEFEL	77 HBC	0 XI-PI+(2.87 K-P)	1/78*
M	44 1936.	22.	BRIEFEL	77 HBC	- XI0PI-(2.87 K-P)	1/78*
M	56 1964.	10.	BRIEFEL	77 HBC	-0 XI(1530) PI	1/78*
M	. . . . .					
M	AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)					
	(SEE IDEOGRAM BELOW)					

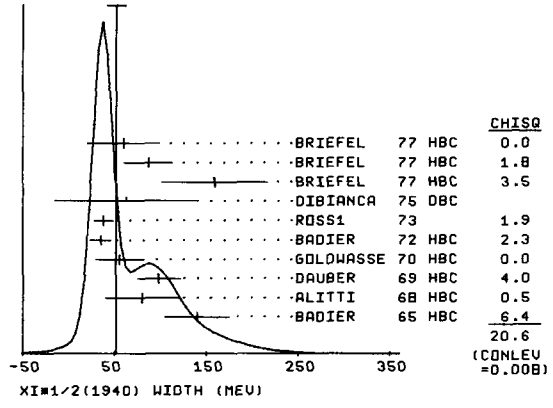


Baryons
Ξ(1940), Ξ(2030)

Data Card Listings
For notation, see key at front of Listings.

52 XI*1/2(1940) WIDTH (MEV)

W	35	140.0	35.0		BADIER	65 HBC	0 XI- PI+	
W	27	80.0	40.0		ALITTI	68 HBC	0 XI- PI+	11/68
W	66	98.0	23.0		DAUBER	69 HBC	- XI PI	11/68
W	21	56.0	26.0		GOLDWASSE	70 HBC	- XI PI	10/70
W	29	35.0	11.0		BADIER	72 HBC	XI PI,XI2PI,K Y	10/71
W		38.	10.		ROSS1	73	(XI PI)-	2/74
W		63.	78.		DIBIANCA	75 DBC	XI PI	1/76
W	139	159.	57.		BRIEFEL	77 HBC	0 XI-PI+(2.87 K-P)	1/78*
W	44	87.	26.		BRIEFEL	77 HBC	- XIOPI-(2.87 K-P)	1/78*
W	56	60.	39.		BRIEFEL	77 HBC	-0 XI(1530) PI	1/78*
W		.	.	.				
W	AVERAGE MEANINGLESS (SCALE FACTOR = 1.6) (SEE IDEOGRAM BELOW)							



52 XI*1/2(1940) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI*1/2(1940) INTO XI PI	1321+ 139
P2	XI*1/2(1940) INTO XI*(1530) PI	1533+ 139
P3	XI*1/2(1940) INTO XI PI PI (EXCLUDING P2)	1321+ 139+ 139
P4	XI*1/2(1940) INTO XIO PI-	1314+ 139
P5	XI*1/2(1940) INTO XI- PIO	1321+ 134

52 XI*1/2(1940) BRANCHING RATIOS

THE XI(1940) IS SEEN MAINLY IN XI PI AND SOME IN XI(1530) PI. IT HAS BEEN LOOKED FOR IN OTHER CHANNELS BUT NOT SEEN.

R1	XI*1/2(1940) INTO (XI PI)/(XI*1/2(1530) PI)						(P1)/(P2)	
R1	2.8	0.7	0.6	APSELL	70 HBC	0		6/70
R2	XI*1/2(1940) INTO (XI PI PI)/(XI*1/2(1530) PI)						(P3)/(P2)	
R2	0.0	0.3		APSELL	70 HBC	0		6/70
R3	XI*1/2(1940) INTO (XIO PI-)/(XI- PIO)						(P4)/(P5)	2/74
R3	1 25 2.6	6.	1.6	ROSS1	73		(XI PI)-	2/74
R3	1 THIS BR IS 2.0(0.5) FOR AN I=1/2(I=3/2) XI*(1940).							2/74

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REFERENCES FOR XI*1/2(1940)

BADIER 65 PL 16 171	+DEMOULIN,GOLDBERG, +	(EPOL,SACLAY,AMST) I
ALITTI 68 PRL 21 1119	+FLAMINIO,METZGER,RADOJICIC,+	(BNL,SYRACUSE) I
DAUBER 69 PR 179 1262	+BERGE, HUBBARD, MERRILL, MULLER	(LRL) I
APSELL 70 PRL 24 777	+	(BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
GOLDWASS 70 PR LD 1960	E L GOLDWASSER, P F SCHULTZ	(ILLINOIS)
BADIER 72 NP B37,429	+BARRELET,CHARLTON,VIDEAU	(EPOL)
ROSS1 73 PURDUE CONF. 345	ROSS,LLOYD,RADOJICIC	(OXFORD)
DIBIANCA 75 NP B98 137	DIBIANCA,ENDORF	(CARN)
BRIEFEL 77 PRD 16 2706	+GOUREVITCH,CHANG+	(BRAN+UMD+SYRA+TUFT)
ALSO 70 DUKE CONF. 317	BMST	(BRANDEIS+MARYLAND+SYRACUSE+TUFTS)

PAPERS NOT REFERRED TO IN DATA CARDS

APSELL 69 PRL 23 884	+	(BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
SUPERSEDED BY BMST 70.		
SCHMIDT 73 PURDUE CONF. 363	SCHMIDT	(BRANDEIS)
BRIEFEL 75 PRD 12 1859	+GOUREVITCH,KIRSCH+	(BRAN+UMD+SYRA+TUFT)

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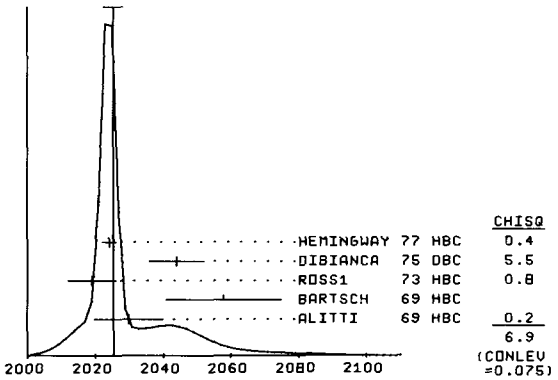
Ξ(2030)

68 XI*1/2(2030, JP=5/2 OR GREATER) I=1/2

THE EVIDENCE FOR THIS STATE HAS BEEN MUCH IMPROVED BY HEMINGWAY 77, WHO SEE AN 8 STD. DEV. ENHANCEMENT IN SIGMA KBAR AND A WEAKER COUPLING TO LAMBDA KBAR. ALITTI 68 AND HEMINGWAY 77 OBSERVE NO SIGNALS IN THE XI PI PI (OR XI*(1530) PI) CHANNEL, IN CONTRAST TO DIBIANCA 75. THE DECAY INTO LAMBDA/SIGMA KBAR PI REPORTED BY BARTSCH 69 IS ALSO NOT CONFIRMED BY HEMINGWAY 77.
A MOMENTS ANALYSIS OF THE HEMINGWAY 77 DATA INDICATES THAT THE SPIN IS GREATER THAN OR EQUAL TO 5/2 AT A LEVEL OF 3 STD. DEVIATIONS.

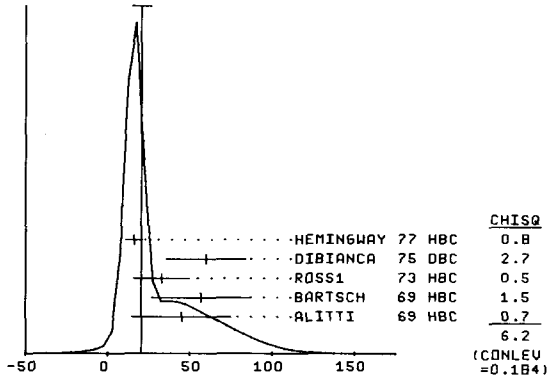
68 XI*1/2(2030) MASS (MEV)

M	42	2030.0	10.0		ALITTI	69 HBC	- K-P 3.9-5 BEV/C	9/69
M	40	2058.0	17.0		BARTSCH	69 HBC	-0 K-P 10 GEV/C	9/69
M	15	2019.	7.		ROSS1	73 HBC	-0 SIGMA KBAR	2/74
M		2044.	8.		DIBIANCA	75 DBC	-0 XI 2PI, XI* PI	1/76
M	200	2024.	2.		HEMINGWAY	77 HBC	- K-P AT 4.2 GEV	11/77*
M		.	.	.				
M	AVERAGE MEANINGLESS (SCALE FACTOR = 1.5) (SEE IDEOGRAM BELOW)							



68 XI*1/2(2030) WIDTH (MEV)

W		45.0	40.0	20.0	ALITTI	69 HBC	- K-P 3.9-5 BEV/C	9/69
W		57.0	30.0		BARTSCH	69 HBC	-0 K-P 10 GEV/C	9/69
W	15	33.	17.		ROSS1	73 HBC	-0 SIGMA KBAR	2/74
W		60.	24.		DIBIANCA	75 DBC	-0 XI 2PI, XI* PI	1/76
W	200	16.	5.		HEMINGWAY	77 HBC	- K-P AT 4.2 GEV	11/77*
W		.	.	.				
W	AVERAGE MEANINGLESS (SCALE FACTOR = 1.2) (SEE IDEOGRAM BELOW)							



68 XI*1/2(2030) PARTIAL DECAY MODES

		DECAY MASSES
P1	XI*1/2(2030) INTO XI PI	1321+ 139
P2	XI*1/2(2030) INTO LAMBDA KBAR	1115+ 497
P3	XI*1/2(2030) INTO SIGMA KBAR	1197+ 497
P4	XI*1/2(2030) INTO XI*1/2(1530) PI	1533+ 139
P5	XI*1/2(2030) INTO XI PI PI (EXCLUDING P4)	1321+ 139+ 139
P6	XI*1/2(2030) INTO LAMBDA KBAR PI	1115+ 497+ 139
P7	XI*1/2(2030) INTO SIGMA KBAR PI	1189+ 497+ 139

68 XI*1/2(2030) BRANCHING RATIOS

R1	XI*1/2(2030) INTO (XI PI)/(MODES P1 TO P4)						(P1)/(P1+P2+P3+P4)	
R1	(0.30) OR LESS			ALITTI	69 HBC		- 1 STD DEV LIMIT	9/69
R11	XI*1/2(2030) INTO (XI PI)/(SIGMA KBAR)						(P1)/(P3)	
R11	(0.19) OR LESS CL=.95			HEMINGWAY	77 HBC		- K-P AT 4.2 GEV	11/77*
R2	XI*1/2(2030) INTO (LAM KBAR)/(MODES P1 TO P4)						(P2)/(P1+P2+P3+P4)	
R2	0.25	0.15		ALITTI	69 HBC		- K-P 3.9-5 BEV/C	9/69
R21	XI*1/2(2030) INTO (LAMBDA KBAR)/(SIGMA KBAR)						(P2)/(P3)	
R21	0.22	0.09		HEMINGWAY	77 HBC		- K-P AT 4.2 GEV	11/77*

Data Card Listings

For notation, see key at front of Listings.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R3      XI*1/2(2030) INTO (SIG KBAR)/(MODES P1 TO P4)     (P3)/(P1+P2+P3+P4)
R3             0.75    0.20              ALITTI    69 HBC  -  K-P 3.9-5 BEV/C   9/69

R4      XI*1/2(2030) INTO (XI* PI)/(MODES P1 TO P4)       (P4)/(P1+P2+P3+P4)
R4             (0.15) OR LESS            ALITTI    69 HBC  -  1 STD DEV LIMIT   9/69

R41     XI*1/2(2030) INTO (XI PI PI INCLUDING XI* PI)/(SIGMA KBAR)
R41                                                       (P4+P5)/(P3)
R41 C          (0.11) OR LESS  CL=.95   HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77*
R41 C  FOR THE DECAY MODE (XI- PI+ PI-) ONLY

R6      XI*1/2(2030) INTO LAMBDA KBAR PI                  (P6)
R6             SEEN                      BARTSCH   69 HBC     K-P AT 10 GEV    11/77*

R61     XI*1/2(2030) INTO (LAMBDA KBAR PI)/(SIGMA KBAR)   (P6)/(P3)
R61            (0.32) OR LESS  CL=.95   HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77*

R7      XI*1/2(2030) INTO SIGMA KBAR PI                   (P7)
R7             SEEN                      BARTSCH   69 HBC     K-P AT 10 GEV    11/77*

R71     XI*1/2(2030) INTO (SIGMA KBAR PI)/(SIGMA KBAR)    (P7)/(P3)
R71 C          (0.04) OR LESS  CL=.95   HEMINGWAY 77 HBC  -  K-P AT 4.2 GEV   11/77*
R71 C  FOR THE DECAY MODE (SIGMA+- K- PI-+) ONLY

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                          REFERENCES FOR XI*1/2(2030)

ALITTI   69 PRL 22 79        +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
BARTSCH  69 PL 28B 439       +      (AACHEN, BERLIN, CERN, LOIC, VIENNA)
ROSS1    73 PURDUE CONF. 345 ROSS,LLOYD,RADOJICIC                (OXFORD)

DIBIANCA 75 NP B98 137       DIBIANCA,ENDORF                      (CARN)
HEMINGWA 77 PL 68B 197       HEMINGWAY,ARMENTEROS+  (AMST+CERN+NIJM+OXF) IJ
   ALSO  76 PL 62B 477       GAY,ARMENTEROS,BERGE+        (AMST+CERN+NIJM)

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Ξ(2120)

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103  XI*1/2(2120, JP=    ) I=1/2

THIS EFFECT IS REPORTED IN GAY 76 AS A
FOUR STANDARD DEVIATION ENHANCEMENT IN
LAMBDA K-. AN ANALYSIS OF THE SAME DATA BY
HEMINGWAY 77, BUT WITH ADDITIONAL STATISTICS,
POINTS OUT THAT THE SIGNIFICANCE OF THE ENHANCEMENT IS GREATLY REDUCED
IF A RESTRICTIVE FOUR-MOMENTUM CUT (U-CUT) IS MADE. THIS SUGGESTS
AN ANOMALOUS PRODUCTION MECHANISM IF THE STATE IS GENUINE.
IN NEED OF CONFIRMATION, OMITTED FROM TABLES.

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                          103  XI*1/2(2120) MASS (MEV)

M          2123.0      7.0              GAY       76 HBC  -  K- P AT 4.2 GEV   2/77*

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                          103  XI*1/2(2120) WIDTH (MEV)

W            25.0     12.0              GAY       76 HBC  -  K- P AT 4.2 GEV   2/77*

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                          103  XI*1/2(2120) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     XI*1/2(2120) INTO LAMBDA KBAR                      1115+ 497

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                          103  XI*1/2(2120) BRANCHING RATIOS

R1     XI*1/2(2120) INTO LAMBDA KBAR                      (P1)
R1            SEEN                      GAY       76 HBC  -  K- P AT 4.2 GEV   2/77*

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                          REFERENCES FOR XI*1/2(2120)

GAY      76 PL 62B 477       +ARMENTEROS,BERGE,GAVILLET+(AMST+CERN+NIJM)I
HEMINGWA 77 PL 68B 197       HEMINGWAY,ARMENTEROS+  (AMST+CERN+NIJM+OXF)

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Ξ(2250)

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22  XI*1/2(2250, JP=    )

THE EVIDENCE FOR THIS STATE IS WEAK.  BARTSCH 69 SEE
A BUMP OF NOT MUCH STATISTICAL SIGNIFICANCE IN LAMBDA-
KBAR-PI, SIGMA-KBAR-PI, AND XI-PI-PI MASS SPECTRA.
GOLDWASSER 70 SEE A NARROWER BUMP IN XI-PI-PI AT A
HIGHER MASS.  PERHAPS THEY ARE THE SAME STATE, PERHAPS
THEY ARE NOT, BUT SEE ALSO MORRIS 75.

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                          22  XI*1/2(2250) MASS (MEV)

M         35 2244.0     52.0              BARTSCH   69 HBC     K-P 10 GEV/C      9/69
M         18 2295.0     15.0              GOLDWASSE 70 HBC  -  K-P 5.5 GEV/C    10/70
M
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                          22  XI*1/2(2250) WIDTH (MEV)

W           130.0     80.0              BARTSCH   69 HBC                       9/69
W         LESS THAN   30.0              GOLDWASSE 70 HBC  -  K-P 5.5 GEV/C    10/70

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                          22  XI*1/2(2250) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     XI*1/2(2250) INTO XI PI PI                         1321+ 139+ 139
P2     XI*1/2(2250) INTO LAMBDA KBAR PI                   1115+ 497+ 139
P3     XI*1/2(2250) INTO SIGMA KBAR PI                    1197+ 497+ 139

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                          REFERENCES FOR XI*1/2(2250)

BARTSCH  69 PL 28B 439       +      (AACHEN, BERLIN, CERN, LOIC, VIENNA)
GOLDWASS 70 PR 1D 1960       E L GOLDWASSER, P F SCHULTZ       (ILLINOIS)

                             PAPERS NOT REFERRED TO IN DATA CARDS.

MORRIS   75 ANL-HEP-CP-75-58 MORRIS,OH,PARKER,SMITH,WHITMORE          (MSU)

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Ξ(2500)

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99  XI*1/2(2500, JP=    ) I=1/2

IT IS QUITE POSSIBLE THAT THE REASON THE EXPERIMENTS
DISAGREE ABOUT THE MASS AND WIDTH IS THAT THEY ARE
SEEING DIFFERENT XI*S.  FOR NOW, HOWEVER, WE GROUP
THEM TOGETHER.

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                          99  XI*1/2(2500) MASS (MEV)

M          30 2430.0     20.0              ALITTI    69 HBC  -  K-P 4.6-5 GEV/C   9/69
M          45 2500.0     10.0              BARTSCH   69 HBC  -0 K-P 10 GEV/C      9/69
M             2392.      27.               DIBIANCA  75 DBC     XI 2PI            1/76
M
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.2)

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                          99  XI*1/2(2500) WIDTH (MEV)

W           150.0     60.0     40.0   ALITTI    69 HBC  -                        9/69
W            59.0     27.0            BARTSCH   69 HBC  -0                       9/69
W            75.      69.             DIBIANCA  75 DBC     XI 2PI                1/76
W
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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                          99  XI*1/2(2500) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     XI*1/2(2500) INTO XI PI                            1321+ 139
P2     XI*1/2(2500) INTO LAMBDA KBAR                      1115+ 497
P3     XI*1/2(2500) INTO SIGMA KBAR                       1197+ 497
P4     XI*1/2(2500) INTO XI*1/2(1530) PI                  1533+ 139
P5     XI*1/2(2500) INTO LAMBDA (OR SIGMA) KBAR PI        1115+ 497+ 139
P6     XI*1/2(2500) INTO XI PI PI                         1321+ 139+ 139

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                          99  XI*1/2(2500) BRANCHING RATIOS

R1     XI*1/2(2500) INTO (XI PI)/(MODES P1 THRU P4)       (P1)/(P1+P2+P3+P4)
R1            (0.5) OR LESS             ALITTI    69 HBC     1 STD DEV LIMIT   9/69

R2     XI*1/2(2500) INTO (LAM KBAR)/(MODES P1 THRU P4)    (P2)/(P1+P2+P3+P4)
R2             0.5     0.2              ALITTI    69 HBC  -                    9/69

R3     XI*1/2(2500) INTO (SIG KBAR)/(MODES P1 THRU P4)    (P3)/(P1+P2+P3+P4)
R3             0.5     0.2              ALITTI    69 HBC  -                    9/69

R4     XI*1/2(2500) INTO (XI* PI)/(MODES P1 THRU P4)      (P4)/(P1+P2+P3+P4)
R4            (0.2) OR LESS             ALITTI    69 HBC     1 STD DEV LIMIT   9/69

R5     XI*1/2(2500) INTO (LAMBDA (OR SIGMA) KBAR PI)/TOTAL
R5                                                        (P5)
R5          SEEN                        BARTSCH   69 HBC  -0                   9/69

R6     XI*1/2(2500) INTO (XI PI PI)/TOTAL                 (P6)
R6          SEEN                        BARTSCH   69 HBC  -0                   9/69

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                          REFERENCES FOR XI*1/2(2500)

ALITTI   69 PRL 22 79        +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
BARTSCH  69 PL 28B 439       +      (AACHEN, BERLIN, CERN, LOIC, VIENNA)

DIBIANCA 75 NP B98 137       DIBIANCA,ENDORF                      (CARN)

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S=−3 I=0 HYPERON STATE (Ω)

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Ω⁻

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24  OMEGA-(1675, JP=3/2+) I=0

SEE STABLE PARTICLE DATA CARD LISTINGS
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CHARMED BARYONS

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FOR THE MINI-REVIEW ON CHARMED BARYONS,
SEE THE STABLE PARTICLE DATA CARD LISTINGS
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Λ_c^+

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33  LAMBDA/C+(2260, JP=  )

SEE STABLE PARTICLE DATA CARD LISTINGS
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Baryons

$\Sigma_c(2430)$, DIBARYONS

$\Sigma_c(2430)$

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                    104  SIGMA/C(2430, JP= )
------ --------- --------- --------- --------- --------- --------- --------
                    104  SIGMA/C MASS
M    C   1 2426.      12.              CAZZOLI   75 HBC  ++ LAMBDA/C+ PI+     3/77*
M   KC   9(2500.)                      KNAPP     76 SPEC 0  ANTILAMBDA/C-PI+  3/77*
M    C   1(2439.)   OR MORE            BARISH    77 DBC  ++ LAMBDA/C+ PI+     3/77*
M    C  SEE NOTES IN LAMBDA/C+ MASS SECTION ABOVE.                             3/77*
M    K  KNAPP 76 MAY NOT BE THE SAME STATE AS CAZZOLI 75.  DERUJULA 75         3/77*
M    K  PREDICT TWO SIGMA/C STATES AROUND 2.4-2.5 GEV.  THIS COULD BE BOTH.    3/77*
------ --------- --------- --------- --------- --------- --------- --------
                    104  SIGMA/C(2430) PARTIAL DECAY MODES
                                                                  DECAY MASSES
P1      SIGMA/C(2430) INTO LAMBDA/C+ PI                           2260+ 139
****** ********* ********* ********* ********* ********* ********* ********
                              REFERENCES FOR SIGMA/C(2430)
CAZZOLI   75 PRL 34 1125      +CNOPS,CONNOLY,LOUTTIT,MURTAGH+          (BNL)
KNAPP     76 PRL 37 882       +LEE,LEUNG,SMITH +       (COLU+HAWA+ILL+FNAL)
BARISH    77 PR D15 1         +DERRICK,DOMBECK,MUSGRAVE +        (ANL+PURD)
PICCOLO   77 PRL 39 1503      +PERUZZI,LUKE+(SLAC+STAN+LBL+UCB+NWES+HAWA)
                              THEORY AND REVIEW
DERUJULA 75 PR D12 147        +GEORGI,GLASHOW                          (HARV)
LEE       77 PR D15 157       +QUIGG,ROSNER                            (FNAL)
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Dibaryon States

This year, for the first time, we list experimental evidence related to the existence of some two-baryon resonances predicted by SU(3),[1] SU(6),[2] and the MIT bag model.[3] Reports of enhancements in B = 2 systems go back more than 10 years, but the interpretation of these enhancements remains uncertain. We are motivated to add this section because of renewed experimental and theoretical interest.

Most significant evidence is included in the Listings, but there may be omissions, especially in earlier work. We have not included evidence on nuclear properties, hypernuclei, d^*'s, or Δ's bound within the deuteron — though these may be related to effects observed in the search for dibaryon resonances. We have also omitted data on low energy $\pi^+ d \to pp$. There is a large amount of literature on this reaction which we did not have time to review adequately. Most of these experiments are addressed to the question of whether there is a resonance associated with the NΔ threshold.

The Listings are arranged in three groups of strangeness, since the difficulty and reliability of the experiments depends strongly on the strangeness.

References

1. R. J. Oakes, Phys. Rev. 131, 2239 (1963).
2. F. Dyson and N. Xuong, Phys. Rev. Lett. 13, 815 (1964).
3. R. L. Jaffe, Phys. Rev. Lett. 38, 195 (1977).

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DIBARYONS

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S=0

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                    106  STRANGENESS 0, BARYON NUMBER 2 STATES
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RECENT RESULTS USING THE POLARIZED PROTON BEAM AND TARGET AT ARGONNE GIVE EVIDENCE FOR A DIPROTON STATE THAT WAS PREVIOUSLY INACCESSIBLE. THE DATA (HIDAKA 77) SHOW A SIGNIFICANT DIP IN THE DIFFERENCE BETWEEN ANTI-PARALLEL AND PARALLEL LONGITUDINALLY POLARIZED P P TOTAL CROSS SECTIONS, IN ADDITION TO STRUCTURE IN THE P P ELASTIC SCATTERING LEGENDRE COEFFICIENTS. HIDAKA 77 INTERPRET THESE EFFECTS AS EVIDENCE FOR A 3F3 (USING 2S+1,L,J NOTATION) STATE AT 2260 MEV. A FORWARD DISPERSION RELATION ANALYSIS (GREIN 77) OF THE ARGONNE DATA FINDS A SPIN SINGLET STATE AT 2390 MEV AND A SPIN TRIPLET STATE AT 2320 MEV, WITH WIDTHS OF ABOUT 100 MEV AND 290 MEV, RESPECTIVELY. (THE DISPERSION RELATION ANALYSIS CANNOT DETERMINE J). THE POSSIBILITY (KANE 76) THAT THE THRESHOLD FOR DELTA(1232) PRODUCTION IN P P SCATTERING INDUCES RESONANT BEHAVIOR IN THE 1D2 WAVE DOES NOT APPEAR TO BE REALIZED IN THIS ANALYSIS. AN INDEPENDENT PARTIAL WAVE ANALYSIS (HOSHIZAKI 77) OF THE ARGONNE DAT FAVORS A 3F3 RESONANT STATE AT 2260 MEV, WITH A WIDTH BETWEEN 100 MEV AND 250 MEV.

MINAMI (MINAMI1 77 AND MINAMI2 77) HAS PRESENTED CRITICISM OF THE ANALYSIS OF BOTH HIDAKA 77 AND HOSHIZAKI 77, AND SUGGESTS THE OBSERVED EFFECTS ARE CONSISTENT WITH THE ABSENCE OF A RESONANCE.

FURTHER EVIDENCE FOR THE EXISTENCE OF A DIBARYON RESONANCE IN THE 2350 MEV REGION COMES FROM A PHOTODISINTEGRATION EXPERIMENT (KAMAEI 77), WHERE AN ANOMALY IN THE POLARIZATION IS CONSISTENT WITH AN I=0, J=3 STATE.

IN SPITE OF THE PROGRESS MADE BY RECENT WORK, MORE EXPERIMENTAL EVIDENCE IS NEEDED BEFORE THE EXISTENCE OF A TWO-NUCLEON RESONANCE CAN BE CONSIDERED CONFIRMED. IT IS UNLIKELY THAT THE DIPROTON(S) CAN BE FIRMLY ESTABLISHED UNTIL MUCH MORE INFORMATION ON ANGULAR DISTRIBUTIONS WITH POLARIZED BEAM AND TARGET IS AVAILABLE.

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------ --------- --------- --------- --------- --------- --------- --------
                    106  STRANGENESS 0, BARYON NUMBER 2 CROSS SECTION
CS B       SEEN                          DEBOER    75 CNTR    POL. P P ELASTIC 10/77*
CS B    DEBOER 75 OBSERVE STRUCTURE IN THE DIFFERENCE BETWEEN                   10/77*
CS B    ANTI-PARALLEL AND PARALLEL TRANSVERSE SPIN STATES IN P P SCATTERING      10/77*
CS B    AT 2,3.4,AND 5 GEV/C MOMENTA USING POLARIZED BEAM AND TARGET            10/77*
CS C       SEEN                          AUER      77 CNTR    POL. P P ELASTIC 10/77*
CS C    AUER 77 OBSERVE A LARGE DIP IN THE DIFFERENCE BETWEEN                   10/77*
CS C    ANTI-PARALLEL AND PARALLEL LONGITUDINAL SPIN STATES IN P P              10/77*
CS C    SCATTERING AT MOMENTA BETWEEN 1 AND 2.5 GEV/C.                          10/77*
CS E       SEEN                          HIDAKA    77 CNTR    POL. P P ELASTIC  2/78*
CS E    HIDAKA 77 IS FROM THE SAME EXPERIMENT AS AUER 77.                       10/77*
CS E    HIDAKA 77 PRESENT THE MOST POSITIVE EVIDENCE FOR A P P RESONANCE        10/77*
CS E    BASED ON THE ENERGY DEPENDENCE OF THE LEGENDRE COEFFICIENTS FOR         10/77*
CS E    P P ELASTIC SCATTERING IN PURE SPIN STATES, AND OF THE DIFFERENCE       10/77*
CS E    BETWEEN ANTI-PARALLEL AND PARALLEL LONGITUDINAL CROSS SECTIONS.         10/77*
CS E    THEY FAVOR S=1, L=3, J=3 QUANTUM NUMBERS.                               10/77*
------ --------- --------- --------- --------- --------- --------- --------
                    106  STRANGENESS 0, BARYON NUMBER 2 MASS (MEV)
M  D       (2390.0)                      GREIN     77 CNTR                     10/77*
M  D       (2320.0)                      GREIN     77 CNTR                     10/77*
M  D    USES DATA OF DEBOER 75 AND AUER 77 FOR DISPERSION ANALYSIS.            10/77*
M  E       (2260.0)                      HIDAKA    77 CNTR                     10/77*
M  H       (2260.)                       HOSHIZAKI 77 PWA                      10/77*
M  H    HOSHIZAKI 77 PRESENTS SOME RESULTS FROM A PARTIAL WAVE ANALYSIS OF      10/77*
M  H    ARGONNE DATA OF AUER 77. WIDTH OF THE 3F3 IS BETWEEN 90 AND 350.        10/77*
M  G       (2350.)                       KAMAE     77                          10/77*
M  G    KAMAE 77 IS A GAMMA D --> P N EXPT. BETWEEN .2 AND .8 GEV E(GAMMA)      10/77*
M  G    KAMAE 77 OBSERVE A SHARP PEAK IN POLARIZATION AT 500 MEV E(GAMMA)       10/77*
------ --------- --------- --------- --------- --------- --------- --------
                    106  STRANGENESS 0, BARYON NUMBER 2 WIDTH (MEV)
W  D       (100.0)                       GREIN     77 CNTR                     10/77*
W  D       (290.0)                       GREIN     77 CNTR                     10/77*
W  E       (200.0)                       HIDAKA    77 CNTR                     10/77*
W  H       (150.)                        HOSHIZAKI 77 PWA                      10/77*
****** ********* ********* ********* ********* ********* ********* ********
                              REFERENCES FOR STRANGENESS 0, BARY. NO. 2 STATES
DEBOER    75 PRL 34 558       +R.FERNOW,A.KRISCH,+          (MICH+ANL+STLO)
AUER      77 PL 67B 113       +E.COLTON,D.HILL,K.NIELD,+        (ANL+NWES)
   ALSO   77  ANL-HEP-CP-7707 A.YOKOSOWA                              (ANL)
GREIN     77  WU-B-76-6       W.GREIN,P.KROLL                    (KARL+WUPP)
HIDAKA    77 PL 70B 479       +BERETVAS,H.NIELD,H.SPINKA,+          (ANL) JP
   ALSO   77 PL 70B 475       I.P.AUER,A.BERETVAS,E.COLTON,D.HILL,+ (ANL)
HOSHIZAK  77 PTP 58 716       N.HOSHIZAKI                          (KYOTO) JP
   ALSO   77 PTP 57 335       N.HOSHIZAKI,T.KADOTA                 (KYOTO)
   ALSO   77 PTP 57 1099      N.HOSHIZAKI                          (KYOTO)
KAMAE     77 PRL 38 468       +I.ARAI,T.FUJII,H.IKEDA,+          (TOKY+KEK)
   ALSO   77 PRL 38 471       T.KAMAE AND T.FUJITA                 (TOKY)
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Data Card Listings

For notation, see key at front of Listings.

PAPERS NOT REFERRED TO IN DATA CARDS

KANE	76 PRD 13 2944	G.L.KANE,G.H.THOMAS	(MICH+ANL)
BRAYSHAW	76 PRL 37 1329	D.D.BRAYSHAW	(SLAC)
KLOET	77 LA-UR-77-2321	+R.R.SILBAN,R.AARON,+	(LASL+RUTG+NEAS+PENN)
MINAMI1	77 OCU-37	S.MINAMI	(OSKC)
MINAMI2	77 OCU-40	S.MINAMI	(OSKC)

S=-1

107 STRANGENESS -1, BARYON NUMBER 2 STATES

ALL OF THE POSITIVE EVIDENCE FOR A LAMBDA P RESONANCE COMES FROM EXPERIMENTS USING K- BEAMS AND NUCLEAR TARGETS, USUALLY DEUTERIUM. THIS EVIDENCE IS COMPLICATED BY NUCLEAR EFFECTS, BUT EVEN MORE SERIOUS AMBIGUITIES ARISE FROM THE FACT THAT THE MOST LIKELY LAMBDA P RESONANCE, AT 2130 MEV, LIES PRECISELY AT SIGMA NUCLEON THRESHOLD.

BRAUN 77 EXAMINE THE T DEPENDENCE OF THE 2130 MEV ENHANCEMENT AND FIND TWO COMPONENTS. THE PERIPHERALLY PRODUCED PART OF THE 2130 MEV PEAK IS NARROW AND HAS A STEEP T DEPENDENCE, WHILE THE LARGE T EVENTS FORM A BROAD ENHANCEMENT AT SIGMA NUCLEON THRESHOLD, WHICH IS INTERPRETED AS NON-RESONANT. BRAUN 77 FAVOR THE DEUTERON-LIKE 3S1 ASSIGNMENT FOR THE NARROW PEAK ON THE BASIS OF ITS PERIPHERAL PRODUCTION, BUT THEY CANNOT EXCLUDE THE POSSIBILITY THAT IT IS A NON-RESONANT CUSP EFFECT.

EXPERIMENTS USING FREE HYPERON BEAMS MAY LACK THE STATISTICAL SENSITIVITY TO OBSERVE THE 2130 MEV EFFECT SEEN IN THE NUCLEAR TARGET DATA.

107 STRANGENESS -1, BARYON NUMBER 2 CROSS SECTION (MICRO BARNS)

CS	NOT SEEN		ALEXANDER	68 HBC	LAM P ELASTIC	10/77*	
CS	NOT SEEN		BUNNEL	70 HEBC	K- STOP IN HE	10/77*	
CS	NOT SEEN		KADYK	71 HBC	LAMBDA P SCATTER	10/77*	
CS	NOT SEEN		HAUPTMAN	74 HBC	LAMBDA P ELASTIC	10/77*	
CS	(25.)	(5.)	BRAUN	77 DBC	K-D .68-.84 GEV/	2/78*	

107 STRANGENESS -1, BARYON NUMBER 2 MASS (MEV)

M	(2126.)		CLINE	68 DBC	K- AT 400 MEV/C	10/77*	
M	(2130.)		ALEXANDER	69 DBC	K- FROM.9TO1.1	10/77*	
M	(2110.)		JAIN	69 EMUL	K- AT REST	10/77*	
M F	2128.	.2	TAN	69 DBC		10/77*	
M F	STOPPING K- IN DEUTERIUM.					10/77*	
M F	SECONDARY SHOLDER OBSERVED AT 2139 MEV					10/77*	
M E	(2129.0)		EASTWOOD	71 DBC		10/77*	
M E	K- AT 1.45 AND 1.65 GEV/C					10/77*	
M I	2127.0	1.0	SIMS	71 DBC		10/77*	
M I	K-D .67 GEV TO .925.	3 + 4	BODY PEAK.			10/77*	
M S	2125.2	2.5	SHAHBAZIA	73 HLBC		10/77*	
M S	(2251.4)	(3.9)	SHAHBAZIA	73 HLBC		10/77*	
M S	N AT 7.5 AND PI- AT 4 ON C.		4 STANDARD DEVIATION PEAK.			10/77*	
M	2129.0	0.4	BRAUN	77 DBC	K-D .68-.84 GEV/	10/77*	

107 STRANGENESS -1, BARYON NUMBER 2 WIDTH (MEV)

W	(10.)		CLINE	68 DBC		10/77*	
W	(20.)		JAIN	69 EMUL		10/77*	
W F	7.	.6	TAN	69 DBC		10/77*	
W E	(20.0)		EASTWOOD	71 DBC		10/77*	
W I	8.0	1.0	SIMS	71 DBC		10/77*	
W S	20.6	5.2	SHAHBAZIA	73 HLBC		10/77*	
W S	(21.1)	(5.4)	SHAHBAZIA	73 HLBC		10/77*	
W	5.9	1.6	BRAUN	77 DBC	K-D .68-.84 GEV/	10/77*	

REFERENCES FOR STRANGENESS -1, BARY. NO. 2 STATES

ALEXANDE	68 PR 173 1452	ALEXANDER,U.KASHORN,A.SHAPIRA,+	(REHO+HEID)
CLINE	68 PRL 20 1452	+R.LAUMANN+J.MAPP	(WISC)
ALEXANDE	69 PRL 22 483	ALEXANDER,HALL,+JEW,KALMUS,KERNAN	(LBL+UCR)
JAIN	69 PR 187 1816	P.L.JAIN	(BUFF)
TAN	69 PRL 23 395	TAI HO TAN	(SLAC)
BUNNEL	70 PR D2 98	+DERRICK,FIELDS,HYMAN+KEYES	(NWES+ANL)
EASTWOOD	71 PR D3 2603	+FRY,HEATHCOTE,ISLAN,+	(BIRM+EDIN+GLAS+LOIC)
KADYK	71 NP B27 13	+ALEXANDER,CHAN,GAPOSCHKIN+TRILLING	(LBL)
SIMS	71 PR D3 1162	+ONEALL,ALBRIGHT,BRUCKER+LANNUTTI	(FSU)
SHAHBAZI	73 NP B53 19	B.SHAHBAZIAN+A.TIMONINA	(JINR)
HAUPTMAN	74 LBL-3608	J.M.HAUPTMAN (THESIS)	(LBL)
BRAUN	77 NP B124 45	+H.GRIMM,V.HEPP,H.STROBELE,+	(HEID+MPIM)

PAPERS NOT REFERRED TO IN DATA CARDS

DAHL	61 PRL 6 142	O.DAHL,N.HORWITZ,D.MILLER,J.MURRAY,+	(LBL)
COHN	64 PRL 13 668	H.O.COHN,K.BHATT,W.M.BUGG	(ORNL+TENN)
SHAHBAZI	71 JINR-E1-5935	B.SHAHBAZIAN	(JINR)

S=-2

108 STRANGENESS -2, BARYON NUMBER 2 STATES

THERE ARE NO SIGNIFICANT CLAIMS FOR RESONANCES IN THE TWO LAMBDA OR XI NUCLEON SYSTEMS, THOUGH RESONANCES ARE PREDICTED (JAFFE 77).

108 STRANGENESS -2, BARYON NUMBER 2 CROSS SECTION (MILLI BARNS/NUCLEON)

CS	(10.0)	(7.0)	BEILLIERE	72 HLBC	XI AT .8 TO 2.2	2/78*	
CS	NOT SEEN		WILQUET	75 HLBC	K- AT 2.2 GEV/C	10/77*	
CS A	NOT SEEN		GUY	77 HBC	K- PT AT 12 GEV	10/77*	
CS A	12 GEV K- ON PT PLATES FORMS LAMBDA BEAM.					10/77*	
CS A	SUGGESTS BROAD, LOW MASS PEAK IS DUE TO RESCATTERING					10/77*	

108 STRANGENESS -2, BARYON NUMBER 2 MASS (MEV)

M	(2370.0)		BEILLIERE	72 HLBC	K- AT 2.1	10/77*	
M	(2365.3)	(9.6)	SHAHBAZIA	73 HLBC	2 ST.DEV. PEAK	10/77*	

108 STRANGENESS -2, BARYON NUMBER 2 WIDTH (MEV)

W	(47.2)	(15.1)	SHAHBAZIA	73 HLBC		10/77*	

REFERENCES FOR STRANGENESS -2, BARY. NO. 2 STATES

BEILLIER	72 PL 39B 671	BEILLIERE,MAYEUR,+	(BRUX+CERN+TUFT+LOUC)
SHAHBAZI	73 NP B53 19	B.SHAHBAZIAN,A.TIMONINA	(JINR)
WILQUET	75 PL 57B 97	+KNIGHT,GUY,+	(BRUX+TUFT+LOUC+CERN+RHEL)
GUY	77 RL-77-054-A	J.G.GUY+J.KADYK	(RHEL+LBL)

PAPERS NOT REFERRED TO IN DATA CARDS

JAFFE	77 PRL 38 195	R.L.JAFFE	(SLAC+MIT)

Appendix I

TEST OF ΔI=1/2 RULE FOR K DECAYS

The quantities of interest for making tests of theoretical predictions regarding the ΔI=1/2 rule for K decay are usually partial decay rates for single channels or special sums of channels. It is not possible to compute the errors on sums, differences, and ratios of partial decay rates from the information given in the Table of Stable Particles because of the presence of off-diagonal terms in the error matrix. For this reason we give some of these quantities in Table I. Throughout this Appendix, italics are used to indicate that a quantity has changed by more than one (old) standard deviation since our previous edition, and S gives the scale factor included in the quoted error because of inconsistencies in the data (see footnote at end of Stable Particle Table for definition of S).

Table I. (000) and (+−0) refer to the sign of the pions into which the K_L decays.

$\Gamma_{K^+_{\ell 3}} = \Gamma_{K^+_{e3}} + \Gamma_{K^+_{\mu 3}}$	$= (6.484 \pm 0.089) 10^6$ sec^{-1}	
$\Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}}$	$= 0.663 \pm 0.018$	S=1.7*
$\Gamma_{K^+_\tau} / \Gamma_{K^+_{\tau'}}$	$= 3.226 \pm 0.082$	
$\Gamma_{K^0_{\ell 3}} = \Gamma_{K^0_{e3}} + \Gamma_{K^0_{\mu 3}}$	$= (12.70 \pm 0.15) 10^6$ sec^{-1}	S=1.1*
$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}}$	$= 0.695 \pm 0.017$	
$\Gamma_{K^0(000)} / \Gamma_{K^0(+-0)}$	$= 1.733 \pm 0.076$	S=1.3*

1. Leptonic decay rates

The $\Gamma_{K_{\ell 3}}$ rates are useful in testing the leptonic ΔI=1/2 rule in the way suggested by Trilling.[1] The predictions are

$$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 1.012, \text{ a phase-space factor,}^2$$

and

$$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}} = \Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}} .$$

From Table 1,

$$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 0.979 \pm 0.018$$

and

$$\frac{\Gamma_{K^0_{\mu 3}}}{\Gamma_{K^0_{e3}}} \left[\frac{\Gamma_{K^+_{\mu 3}}}{\Gamma_{K^+_{e3}}} \right]^{-1} = 1.048 \pm 0.038 .$$

These results seem to show a less than 2σ disagreement with the predictions, but the errors should be regarded with caution in view of the internal disagreements in the data. (Note the ideograms in the Data Listings for the charged K meson.)

2. Three-pion decays

We follow here the tests done by Mast et al.,[3] based on the general analysis of K decays suggested by Zemach.[4] Both decay rates (Γ) and slopes (g, the energy dependence of the Dalitz plot distributions) are used. The ΔI=1/2 rule predicts that the following test quantities are all equal to zero:

$$\text{Test 1} = \frac{2}{3} \frac{\Gamma_{K^0(000)}}{\phi_1} \left[\frac{\Gamma_{K^0(+-0)}}{\phi_2} \right]^{-1} - 1 ,$$

$$\text{Test 2} = \frac{1}{4} \frac{\Gamma_{K^+_\tau}}{\phi_3} \left[\frac{\Gamma_{K^+_{\tau'}}}{\phi_4} \right]^{-1} - 1 ,$$

$$\text{Test 3} = \frac{1}{2} \frac{\Gamma_{K^+_\tau}}{\phi_3} \left[\frac{\Gamma_{K^0(+-0)}}{\phi_2} \right]^{-1} - 1 ,$$

$$\text{Test 4} = \frac{1}{2} g_{K^+_{\tau'}} + g_{K^+_\tau} ,$$

$$\text{Test 5} = g_{K^0(+-0)} + g_{K^+_\tau} - \frac{1}{2} g_{K^+_{\tau'}} .$$

The ϕ_i are phase-space factors which have been calculated as described in Mast et al.[3] by use of a relativistic formulation and the masses and slopes from this edition. The factors labeled UDP are the relative areas of the Dalitz plots, assuming a uniform distribution. The NUDP include the observed slopes (see below). The CNUDP have been calculated by including the final-state Coulomb interaction.
The values are:

	Method		
	UDP	NUDP	CNUDP
$\phi_1(000)$ =	1.490	1.490	1.444
$\phi_2(+-0)$ =	1.221	1.303	1.287
$\phi_3(++-)$ =	1.000	1.000	1.000
$\phi_4(+00)$ =	1.247	1.178	1.142

For convenience, we repeat the slope parameters tabulated in the Stable Particle Table. They are as follows:

$g_{K^+_\tau}$	$= -0.215 \pm 0.004$	S=1.5*
$g_{K^-_\tau}$	$= -0.214 \pm 0.007$	S=2.7*
$\bar{g}_{K^\pm_\tau}$	$= -0.215 \pm 0.003$	
$g_{K^+_{\tau'}}$	$= 0.561 \pm 0.021$	S=1.7*
$g_{K^0(+-0)}$	$= 0.670 \pm 0.014$	S=1.6*

A difference in the τ^+ and τ^- slopes would be an indication of CP violation in this decay. Since no difference is observed at this time, we average he two and use this value in Test 4 and Test 5.

We use the CNUDP factors and the rates and slopes reported in this edition to compute the five test quantities which the $\Delta I=1/2$ rule predicts to be zero. The results are:

Test 1 = 0.030±0.045
Test 2 = −0.079±0.023
Test 3 = 0.216±0.020
Test 4 = 0.066±0.011
Test 5 = *0.175±0.018*

The three-pion final state can be in isospin states I = 1,2,3. Tests 1 and 2 test the existence of isospin I = 3 in the final state. Since the rate tests (Tests 1, 2, and 3) could differ from zero by as much as 0.1 owing to the mass differences and the occurrence of big slopes[5], no evidence for I=3 is found. Test 4 is related to the I=2 amplitude in the final state and indicates the presence of I=2. Tests 3 and 5 give information on the $\Delta I=3/2$ part of the I=1 amplitude relative to the $\Delta I=1/2$ part. Both tests indicate the presence of $\Delta I=3/2$.

References

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2. N. Brene (CERN), private communication. In our Jan. 1968 edition we had erroneously used 1.04.
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Appendix II

TEST OF $\Delta I=1/2$ RULE FOR HYPERON DECAYS

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1. Nonleptonic decay Amplitudes

In this edition we again use the new convention for the amplitudes A and B adopted in 1973. Some theorists have suggested that dimensionless amplitudes are more useful to them than the ones appearing in the literature. Berge[1] used a convention with A and B in units of $\sec^{-1/2}$. Samios[2] used a convention which gave A and B in units of $(\text{MeV}-\sec)^{-1/2}$. Following is the convention suggested by Jackson[3], which gives dimensionless A and B.

The effective Lagrangian density for nonleptonic hyperon decays ($B_1 \to B_2 + \pi$) can be written

$$L_{eff} = G\mu_c^2[\bar{\psi}_2(A+B\gamma_5)\psi_1]\phi_\pi,$$

where $G=10^{-5}m_p^{-2}$ is a coupling constant characteristic of first-order weak decays, μ_c is the charged pion mass, and A and B are dimensionless complex numbers giving the relative amplitudes of the parity-violating and parity-conserving decays, respectively. The matrix γ_5 is to be taken in the Pauli form, $\gamma_5=\left(\begin{smallmatrix}0 & -I\\ -I & 0\end{smallmatrix}\right)$. The invariant amplitude for the decay is

$$M = G\mu_c^2[\bar{u}(p)(A+B\gamma_5)u(P)],$$

where P is the 4-momentum of the decaying hyperon of mass M, and p is the 4-momentum of the baryon decay product of mass m. With the normalization convention, $\bar{u}_i u_i = 2m_i$, the Pauli form of the matrix element in the rest frame of the decaying hyperon is

$$M = G\mu_c^2\langle\chi_2|\sqrt{2M(E+m)}A + \sqrt{2M(E-m)}\,B\vec{\sigma}\cdot\hat{q}|\chi_1\rangle,$$

where E is the total energy of the final baryon and $\hat{q}$ is a unit vector in the direction of motion of the final baryon. Comparison with Sec. VI D of the text shows that the amplitudes s and p defined there are proportional to A and B:

$$\frac{p}{s} = \left(\frac{E-m}{E+m}\right)^{1/2}\frac{B}{A} = \left[\frac{(M-m)^2-\mu^2}{(M+m)^2-\mu^2}\right]^{1/2}\frac{B}{A}.$$

Here μ is the mass of the pion entering the decay. The parameters α, β, and γ can therefore be expressed in terms of A and B, rather than s and p, if desired.

The decay rate for $B_1 \to B_2 + \pi$ is

$$\Gamma = \frac{G^2\mu_c^4}{8\pi}\,q\left\{\left[\frac{(M+m)^2-\mu^2}{M^2}\right]|A|^2+\left[\frac{(M-m)^2-\mu^2}{M^2}\right]|B|^2\right\},$$

where q is the c.m. momentum of the decay products. For reference, the dimensionless constant in this expression has the value $(G^2\mu_c^4/8\pi) = 1.9488\times10^{-15}$.

Table I summarizes the amplitudes A and B for the nonleptonic decays of the Λ, Σ, and Ξ hyperons. These amplitudes have been calculated by using the experimental data for mean lives, branching ratios, and the decay asymmetry α given in the Stable Particle Table of this Review. Time-reversal invariance is assumed and final-state interactions are neglected, so A and B are taken to be relatively real. The subscript on the hyperon refers to the sign of the decaying pion. The statistical correlation coefficient

$$C_{AB} = \frac{\langle \Delta A \Delta B \rangle}{\sqrt{\langle \Delta A^2 \rangle \langle \Delta B^2 \rangle}}$$

is also given. The absolute signs of A and B have been assigned, using the following convention. Taking $A(\Lambda^0_-)$ as positive, the other S-wave decay amplitudes are chosen to give an approximate fit to the triangular relationships

$$\sqrt{2}A(\Sigma^+_0) + A(\Sigma^+_+) = A(\Sigma^-_-) \text{ and } \sqrt{3}A(\Sigma^+_0) + A(\Lambda^0_-) = 2A(\Xi^-_-).$$

The signs of the B amplitudes relative to those of the corresponding A amplitudes are determined by the sign of the appropriate α decay parameter.

Table I

M → m + μ	A	B	C_{AB}
Λ^0_- → p + π^-	1.47±0.01	9.98±0.24	-0.289
Λ^0_0 → n + π^0	-1.07±0.02	-7.14±0.56	-0.740
Σ^+_+ → n + π^+	0.07±0.02	19.04±0.16	0.007
Σ^+_0 → p + π^0	1.48±0.05	-11.99±0.58	0.917
Σ^-_- → n + π^-	1.93±0.01	-0.65±0.08	-0.015
Ξ^0_0 → Λ + π^0	1.55±0.03	-5.96±1.12	0.424
Ξ^-_- → Λ + π^-	2.04±0.02	-6.70±0.38	0.236

2. Tests of the ΔI=1/2 Rule

(a) Λ Decay

For Λ decay the ΔI=1/2 rule predicts that $\Gamma_0/\Gamma_- = 0.50$ and $\alpha_0 = \alpha_-$. In order to determine the magnitude of possible ΔI=3/2 amplitudes present we write the linear expressions[4] for the ΔI=3/2 A- and B-wave amplitudes in terms of $\Delta\alpha$, where $\Delta\alpha$ is the measured value of α_0/α_- minus the predicted value, and in terms of $\Delta\Gamma$ similarly defined. Evaluating these we find

$$\Delta\alpha = -1.54\,(A_3/A_1) + 1.61\,(B_3/B_1),$$
$$\Delta\Gamma = 1.84\,(A_3/A_1) + 0.25\,(B_3/B_1).$$

Here the ΔI=3/2 amplitudes are expressed relative to the ΔI=1/2 amplitudes. The numerical values of the coefficients depend on the ratio B/A. The uncertainties in the coefficients are small compared to the uncertainties in $\Delta\alpha$ and $\Delta\Gamma$. Final-state πN interactions have been included in these relations but have a very small effect. From the Stable Particle Table,

$$\Delta\alpha = 0.006\pm0.066, \quad \Delta\Gamma = 0.058\pm0.012,$$

and hence

$$(A_3/A_1) = 0.027\pm0.008$$

and

$$(B_3/B_1) = 0.030\pm0.037.$$

The possible 3% ΔI=3/2 A-wave amplitude is due to the disagreement of decay rates with prediction. At this level the results are sensitive to electromagnetic corrections. However, in Λ decay the phase space correction and the other radiative corrections appear to be about equal in magnitude and have opposite signs,[5,6] and hence cancel each other in the correction to the decay rates.

(b) Ξ Decay

The analysis for Ξ decay is very similar to that for Λ decay. If the ΔI=1/2 rule is valid, $\Gamma_0(\Xi^0)/\Gamma_-(\Xi^-) = 0.50$ and $\alpha_0 = \alpha_-$. For this case the expressions linear in ΔI=3/2 A- and B-wave amplitudes are[4]

$$\Delta\alpha = 1.38\,(A_3/A_1) - 1.38\,(B_3/B_1),$$
$$\Delta\Gamma = -1.44\,(A_3/A_1) - 0.06\,(B_3/B_1).$$

From the Stable Particle Table,

$$\Delta\alpha = 0.12\pm0.21, \quad \Delta\Gamma = 0.070\pm0.021,$$

and we find

$$(A_3/A_1) = -0.043\pm0.015$$

and

$$(B_3/B_1) = -0.13\pm0.15.$$

(c) Σ Decay

The traditional test of the ΔI=1/2 rule in Σ decay is that the amplitudes satisfy the relationship

$$\sqrt{2}\,\Sigma^+_0 + \Sigma^+_+ - \Sigma^-_- = 0\ .$$

Graphically this is equivalent to closing the Σ triangle when the amplitudes are plotted on A, B axes. Including ΔI≥3/2 amplitudes in Σ decay analysis, the "Σ triangle" relationship becomes

$$\sqrt{2}\,A_0 + A_+ - A_- = -3\sqrt{2/5}\,A_3 + \frac{2}{\sqrt{15}}\,A_5\ ,$$

where A_3 and A_5 are $\Delta I=3/2$ and $\Delta I=5/2$ amplitudes, respectively. There is a similar equation for the B amplitudes. From Table I,

$$\sqrt{2}A_0 + A_+ - A_- = 0.23\pm0.09$$

and

$$\sqrt{2}B_0 + B_+ - B_- = 2.7 \pm 1.0 \ .$$

If we neglect the $\Delta I=5/2$ amplitudes and assume all amplitudes to be real we can solve for possible $\Delta I=3/2$ amplitudes. The result is

$$\frac{A_3}{A_-} = -0.063\pm0.025$$

and

$$\frac{B_3}{B_+} = -0.076\pm0.029 \ .$$

Thus for hyperon decay, present experimental data limit $\Delta I=3/2$ amplitudes to less than about 5%.

3. The Lee-Sugawara Relation

From Table I the Lee-Sugawara relation,[7,8] $\sqrt{3}\Sigma_0^+ + \Lambda^0 - 2\Xi^- = 0$, is satisfied to -0.05 ± 0.12 for the A amplitudes, and to 2.6 ± 2.0 for the B amplitudes.

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$$\frac{\Gamma_0}{\Gamma_-} \approx \frac{1}{2}\left\{1+3\sqrt{2} \times\left[\frac{S_{11}S_{33}\cos(\delta_1-\delta_3)+P_{11}P_{33}\cos(\delta_{11}-\delta_{31})}{S_{11}^2+P_{11}^2}\right]\right\} .$$

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Appendix III

A. SU(3) CLASSIFICATION OF BARYON RESONANCES

It is established that a symmetry higher than SU(3) is necessary to classify the known baryon resonances. However, many higher-symmetry schemes have been proposed, and even for SU(6) various versions exist (for a review see Dalitz[1]). Since it is not clear which one of these schemes best fits the data, we do not review them here, but we report once again fits of baryon states into SU(3) multiplets.

For the reader's convenience, we collect here the relevant formulae.

Exact SU(3) symmetry predicts that all the members of a multiplet should have the same mass and the same couplings for decays into other multiplets. It has been found, however, that the members of the octet of stable baryons lie within 20% of their mean mass; therefore a symmetry-breaking interaction has been introduced by Gell-Mann and Okubo independently.[2] In addition, for the isospin-0 vector mesons (ω and ϕ), an additional symmetry-breaking interaction has been introduced by Sakurai[3] to take care of octet-singlet mixing. The relevant formulae for masses and decay rates are given below.

Mass Formulae

Broken SU(3) gives:

Decuplet	$\Delta - \Sigma = \Sigma - \Xi = \Xi - \Omega$	GMO	(1)
Octet	$2(N + \Xi) = 3\Lambda + \Sigma$	GMO	(2)
Octet–Singlet mixing	$\sin^2\theta = \frac{\Lambda - M_8}{\Lambda - \Lambda'}$	Mixing angle[20]	(3)
	$M_8 = \frac{2(N + \Xi) - \Sigma}{3}$	GMO	(4)

Here GMO stands for the Gell-Mann-Okubo formula; the particle symbol indicates its mass. The formulae would be the same if squared masses were used. For the nonet case, Λ is the "mostly-octet" particle, Λ' is the "mostly-singlet" particle.

Decay Rates

In terms of a relativistically invariant matrix element T, the decay rate for two-body decay of a resonance of mass M_R is

$$\Gamma \propto \frac{|T|^2 R_2}{M_R} \ , \qquad (5)$$

where $R_2=k/M_R$ is the two-body phase space factor. Since the numerator is an invariant, and since Γ must transform as $1/E$, we introduce the denominator M_R.[4]

For meson decays (see below) the rates are calculated according to Eq. (5); for baryon resonance decays into $1/2^+$ baryons and 0^- mesons, one next takes into account the fact that spin sums in $|T|^2$ introduce another factore M_R, cancelling the $1/M_R$. We are then left with

$$\Gamma = \frac{|T|^2 k}{M_R} M_N \text{ , for baryons} \qquad (5')$$

$$= \frac{|T|^2 k}{M_R^2} M_N^2 \text{ , for mesons.} \qquad (5'')$$

The powers of the nucleon mass M_N or M_N^2 have been introduced so that we can treat $|T|$ as dimensionless.

$|T|^2$ contains centrifugal barrier factors, which we call B_ℓ. We then have

$$\left.\begin{matrix}\text{Decuplet}\\ \text{Singlet}\end{matrix}\right\} \quad \Gamma = (cg)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (6)$$

$$\text{Octet} \qquad \Gamma = (c_D g_D + c_F g_F)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (7)$$

$$\left.\begin{matrix}\text{Octet-}\\ \text{Singlet}\\ \text{mixing}\end{matrix}\right\} \quad \begin{aligned} \Lambda &= G_8 \cos\theta + G_1 \sin\theta \\ \Lambda' &= -G_8 \sin\theta + G_1 \cos\theta \end{aligned} \qquad (8)$$

$$\text{with} \quad \begin{aligned} G_8 &= c_D g_D + c_F g_F \\ G_1 &= c_1 g_1 \, . \end{aligned} \qquad (9)$$

Here c_i are the SU(3) coefficients with the sign convention adopted in this article [see note in the Table of SU(3) Iscoscalar Factors and Fig. 2 in the text]. M_N is the nucleon mass, M_R is the resonance mass for which Γ is calculated, k is the center-of-mass momentum for the channel being considered, and g_i are the relevant couplings. For the case of singlet-octet mixing, formula (8) has to be used in conjunction with (6) and (7). G_8 and G_1 represent the couplings for the multiplet, and Λ and Λ' represent the couplings for the physical states.

The relation between g_D, g_F, and the parameter α is

$$\alpha = \left[1 + \frac{\sqrt{5}}{3} \frac{g_F}{g_D} \right]^{-1} . \qquad (10)$$

Exact SU(3) predicts that the couplings g_i for all the members of a multiplet are the same; however, since the symmetry is broken for the masses, it is probably broken for the widths. In the case of the $3/2^+$ decuplet, for broken SU(3) a sum rule has been derived by Becchi[5] and by Gupta[6] independently. It relates the g_i for the members of the decuplet by the relation

$$2(\Delta + \Xi) = 3\Sigma^*(\Lambda\pi) + \Sigma^*(\Sigma\pi), \qquad (11)$$

where $\Sigma^*(\Lambda\pi)$ is the coupling for the $\Sigma(1385) \to \Lambda\pi$ decay and $\Sigma^*(\Sigma\pi)$ is the coupling for the decay $\Sigma(1385) \to \Sigma\pi$.

As mentioned in the text (Sec. IV B) the determination of the relative signs of resonant amplitudes can be useful in making an SU(3) assignment of resonances. In fact the resonant amplitude $T \propto \sqrt{x_e x_i} \propto G_e G_i$, where the subscript e refers to the elastic channel and the G_e, G_i are the couplings of Eqs. (6) through (9). Assuming that all g_i are positive, the sign of the G_i are dependent upon the sign of the Clebsh-Gordon coefficients c_i. Once a sign convention is adopted (we use the Levi-Setti[7] convention, see Fig. 2 in the text) and the signs for a Σ state (I=1) and a Λ state (I=0) of known SU(3) assignment have been chosen for reference, the signs of all the other amplitudes can be useful in determining multiplet assignments. For exact SU(3) all the decays of members of a decuplet have the same sign. For octets the relative sign depends upon the value of g_D/g_F and the mixing angle, as seen from Eqs. (7) through (9).

Fits to the Data

Fits of baryon decay rates within SU(3) can be found in, among others, papers by Tripp,[8,9] Levi-Setti,[7] Samios,[10] and Plane.[11] The most recent fits were made by Barbaro-Galtieri[12] and Samios.[13] A recent fit of the decay rates within $SU(6)_w$ can be found in Litchfield et al.[14] Analysis of the baryon mass spectrum using the quark shell model has been done recently by Jones et al.[15]

For our analysis in fitting the data a choice for B_ℓ has to be made. Plane[11] tried two forms for B_ℓ:

(a) The form $B_\ell = (kr)^{2\ell} D_\ell(kr)$, r being the radius of interaction and D_ℓ the polynomials in kr given by Blatt and Weisskopf.[16] Usually r is taken to be 1 fermi.[8]

(b) The form $B_\ell = k^{2\ell}$.

However, for final results form (b) was chosen. A discussion of the differences among these two forms has been given by Barbaro-Galtieri.[17] It turns out that not only the values of the couplings, g_i, depend upon the form used for B_ℓ, but also the value obtained for the mixing angle. For the $3/2^-$ singlet, $\Lambda(1520)$, and the isospin-0 member of the octet, $\Lambda(1690)$, the mixing angles obtained in the two cases are

$$\theta_a = (-16.1^{+1.4}_{-1.3})^\circ \, , \; \theta_b = (-27.5^{+3.6}_{-3.4})^\circ \, ,$$

in disagreement by a few standard deviations. However, if a radius of interaction of r = 0.15 fermi is

used for form (a), the two values of θ agree. This value of r does not fit resonance shapes when used in the Breit-Wigner resonant form.

Samios[13] used form (b) for B_ℓ.

Table I is a summary of the fits made by us (update of Barbaro-Galtieri[12]) using the barrier factor form (a) and exact SU(3). The values of the masses, widths, and amplitudes used in the fits are taken from this edition's Tables and Listings.

1/2⁻ Nonet (Baryon-Eta Resonances)

For this nonet Eq. (7) was multiplied by the factor

$$\left[\frac{M_R - M_B}{\overline{M}_R - \overline{M}_B}\right]^2,$$

where M_B is the decay baryon and $\overline{M}_R - \overline{M}_B = 564$ MeV is the difference of the mean $1/2^-$ and $1/2^+$ baryon octet masses. This kinematic factor comes from PCAC arguments (i.e., the assumption that the axial vector current remains an octet in the presence of symmetry breaking) and it was advocated by Graham.[18] For the $1/2^-$ nonet it was used in this form first by Gell-Mann.[19]

3/2⁺ Decuplet

The agreement among the coupling constants obtained for the four rates in this decuplet is very bad. The fit made using form (b) for B_ℓ has $\chi^2 = 50$ for 3 degrees of freedom; the one made with form (a) for B_ℓ has $\chi^2/DF = 24/3$. The broken SU(3) relation (11) however, is very well satisified.

B. SU(3) CLASSIFICATION OF MESON RESONANCES

All of the discussion above applies, except that for bosons the GMO formula is usually applied to the square of the masses, as opposed to the first power for fermions. Thus for example, Eq. (2) becomes

$$4\hat{K} = 3\hat{\eta} + \hat{\pi}. \qquad (2')$$

The symbol $\hat{K}$ was introduced by Glashow and Socolow[20] for the square of the K mass, etc.

Because of the difference between Eqs. (5') and (5"), there is also an extra factor of (M_N/M_R) in Eqs (6) and (7). The three established nonets (0^-, 1^-, 2^+) and their mixing angles are listed at the bottom of the Meson Table.

Table I. SU(3) baryon multiplets with two or more known members. Values of θ and α [defined by Eqs. (8) and (10)] are the result of fits made to all the measured two-body decay rates of each mutiplet.

J^P	Octet members[a]				Singlet	θ(deg)[b]	α
$1/2^-$	N(1535)	Λ(1670)	Σ(1750)	{[Ξ(1862)], [Ξ(1778)]}	Λ(1405)	{−1±5, −27±5}[c]	{0.97±.13, 0.31±.07}[c]
$3/2^-$	N(1520)	Λ(1690)	Σ(1670)	[Ξ(1832)]	Λ(1520)	−18±3	0.33±.05
$5/2^-$	N(1670)	Λ(1830)	Σ(1765)				1.18±.01
$5/2^+$	N(1688)	Λ(1815)	Σ(1915)	[Ξ(2094)]	Λ(2110)	24±5	0.72±.03

	Decuplet members[d]				g_{10}	
$3/2^+$	Δ(1232)	Σ(1385)	Ξ(1530)	Ω⁻	1.78-2.29	$\chi^2/DF = 50/3$
$7/2^+$	Δ(1950)	Σ(2030)				

[a] Masses in parentheses are the nominal masses used in the Baryon Table. The Ξ members have masses as calculated by using formulae (1) and (2) with the mixing angle θ derived from the decay widths.
[b] See text for a discussion of the $3/2^-$ mixing angle.
[c] The first values of θ and α are obtained by using a plus sign for the amplitudes of both N(1535) → Nη and Λ(1670) → Λη. The second values use a minus sign for the second amplitude. Both fits, however, have a bad χ^2, mostly due to the two baryon-η amplitudes.
[d] Coupling constants from Ref. 12.

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Appendix IV

GROWTH OF INFORMATION

From time to time we have presented figures demonstrating the amount of experimental work which has gone into spectroscopy, and the amount of new information available as a result. The 1978 versions of these figures are shown as Figs. 1 and 2.

Figure 1 is a simple count of the number of meson resonances listed in the Tables, categorized as those "understood" -- i.e., all quantum numbers are believed known -- and those simply "listed". The rapid recent increase in both of these categories occurred because of the discovery of the J/ψ and related particles.

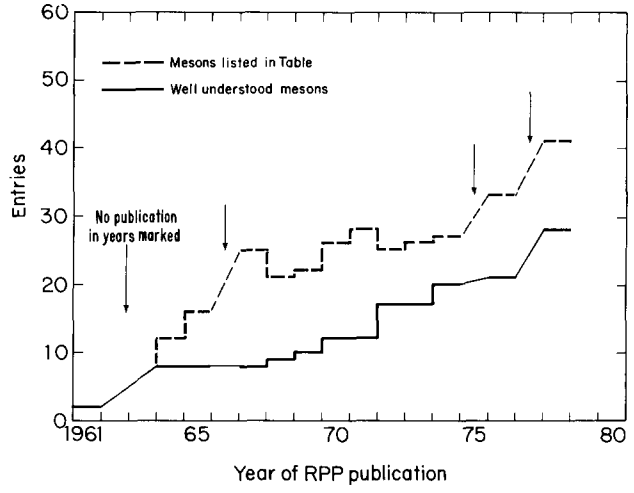

Fig. 1. Number of meson resonances listed in the Tables (dashed line) and those for which all quantum numbers are known (solid line), as a function of year of publication of the Review of Particle Properties.

In Figure 2 we present similar information for the baryon resonances, but concentrate here on the "growth of understanding". That is, the number of known baryons (we include for this figure only those with known J^P) has grown only very slowly with time (dashed line); the real progress has been in the measurement of the properties of those baryons. Therefore we show as the solid line a count of the number of baryonic properties -- mass, width, and branching ratios. Most of these results are from partial-wave analyses.

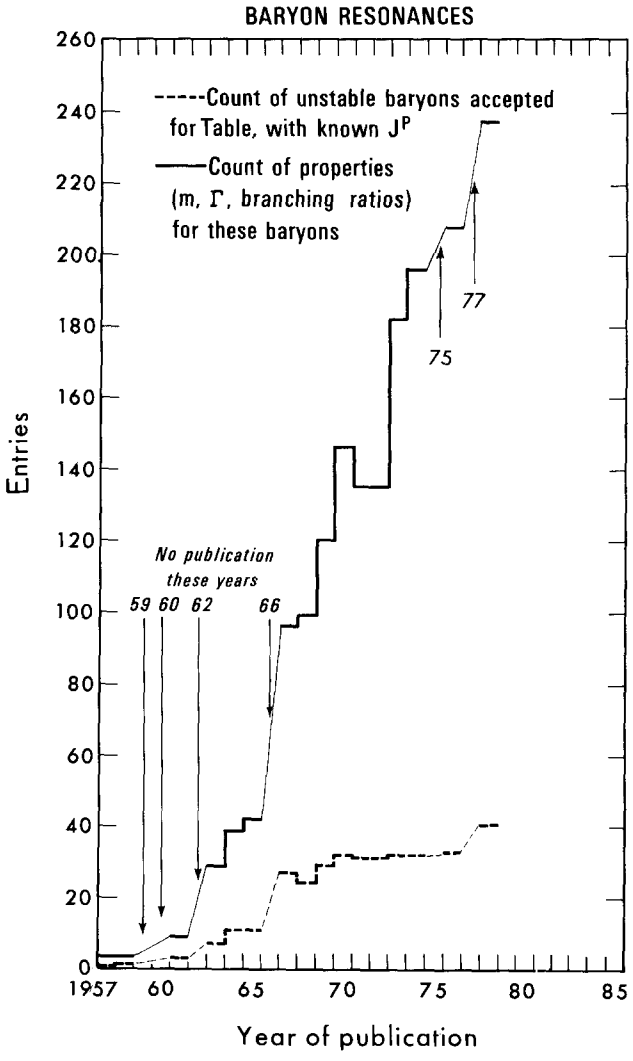

Fig. 2. Total amount of information (mass + width + branching ratios) on baryon resonances listed in the Tables, restricted to those with well-established J^P (solid line). Dashed line shows numbers of such resonances listed. Abscissa shows year of publication of Review of Particle Properties.

A history of the values of some of the constants in the Review of Particle Properties is presented in Figs. 3–7. It may be said that one can estimate the age of a high energy physicist by asking him or her the mass of the Λ. If the answer is 1115.44 MeV, he probably was deep into his graduate training in 1965.

A history of this sort has more than whimsical value. We may use it as a guide to develop a "feel" for the reliability of current values. In Fig. 3 we show how the generally accepted values for the speed of light and a couple of other constants have changed with time. The "generally accepted value" is usually an average over several experiments, performed by a compiler (in Fig. 3, the compiler is other than the Particle Data Group in all cases, although we do quote the compiled results). The abscissa on all these figures is the date of publication of the value shown. Clearly there is a general progression toward better understanding -- at least as measured by the size of the error bars. However, the size of the error bars does not tell the full story, as we can see by the frequency with which the "best" value has changed by more than one standard deviation. Changes in these values can come from several sources: a new experimental measurement, re-evaluation of an old measurement (which can come about if a previously unrecognized source of bias is discovered and corrected, or if a new value for one of the input constants, e.g. the electric charge, is available), or a change in the averaging procedure.

In Fig. 4 we show the history of some masses (including the Λ, for radioactive Λ dating of your colleagues), based on averages which we ourselves performed. These were originally presented by Rosenfeld[1] in 1975. The publication date refers to the publication of the Review of Particle Properties.

In Fig. 5 we show the best estimates for the lifetimes of some of the particles stable against strong decay. These and subsequent figures have been compiled since publication of the Rosenfeld article.[1] In Fig. 6 we show the widths of some of the resonances, and in Fig. 7, the values of some of the branching fractions. All values are taken from the Tables. Before 1964, very few branching fractions were listed in the Tables. In all cases, a representative sample is chosen, usually from those with a lot of activity (a limited number of special requests for a more complete set of such figures may be honored, for those seriously interested in the history of the "best" values of physical constants). In each figure, the heavy inner error bar represents the statistical error computed in the averaging procedure, and the thin outer error bars, when present, indicate the increase in the error due to the "scale factor". The scale factor is described in the introductory text, Sec. VII. It represents an attempt to quantify the increase in the uncertainty which is present in the case of experiments which disagree by more than a certain amount. In the case where the error represents an "educated guess," rather than a calculation, the inner error bar is absent.

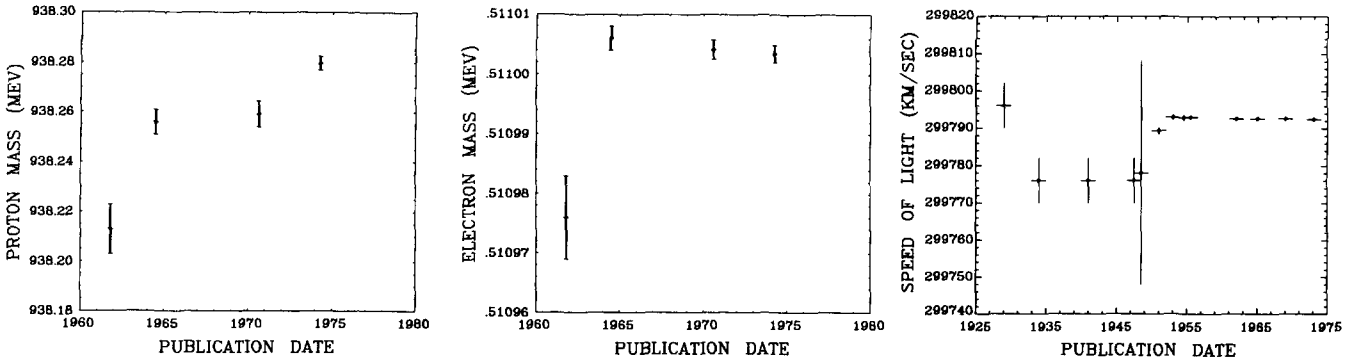

Fig. 3. The "generally accepted values" of the proton mass, the electron mass, and the speed of light, as a function of the publication date of the compilation used (not done by the Particle Data Group). Data for the speed of light plot courtesy of E. R. Cohen, Rockwell International Science Center. See the Stable Particle Data Card Listings for references on proton and electron masses.

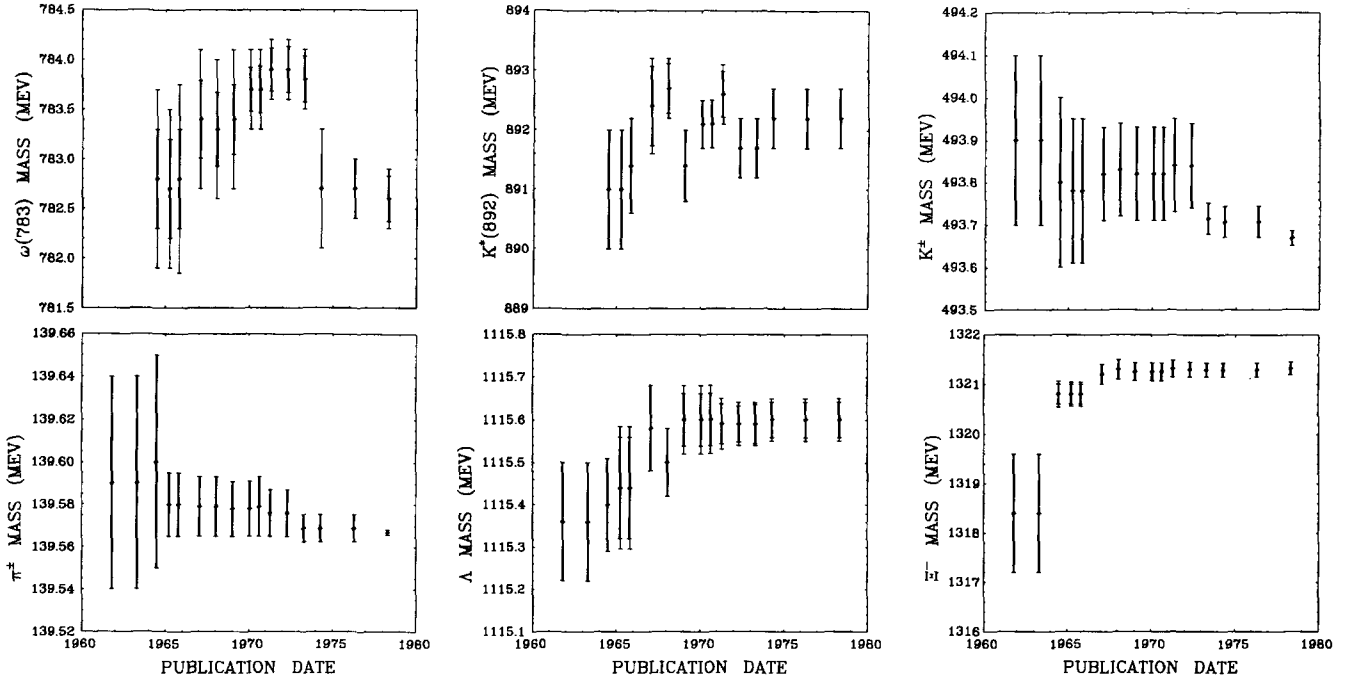

Fig. 4. Particle Data Group averages of the masses of various particles, as a function of date of publication of Review of Particle Properties (Adapted, with permission, from *Annual Review of Nuclear Science*, Volume 25. Copyright 1975 by Annual Reviews, Inc. All rights reserved). Full error bar indicates quoted error; thick-lined portion indicates quoted error with "scale factor" removed (see Sec. VII of introductory text).

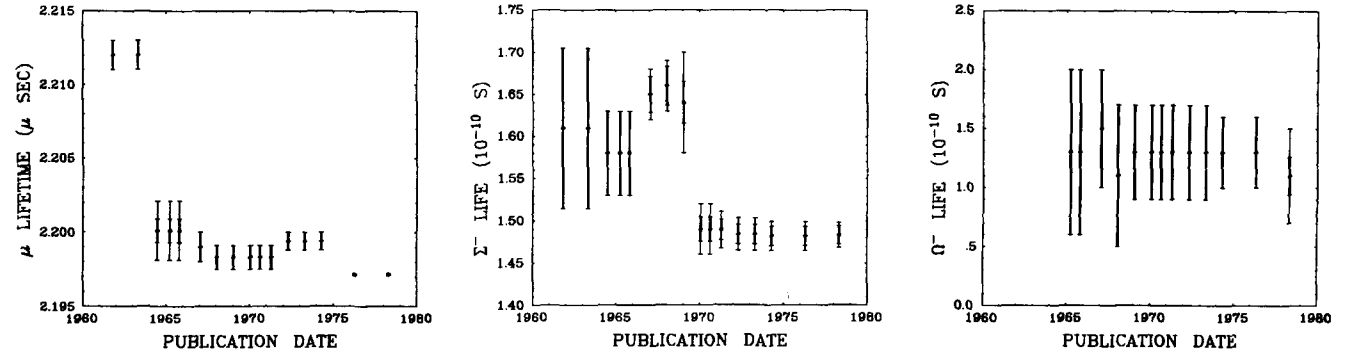

Fig. 5. Particle Data Group averages of the lifetimes of various particles, as a function of publication date of RPP.

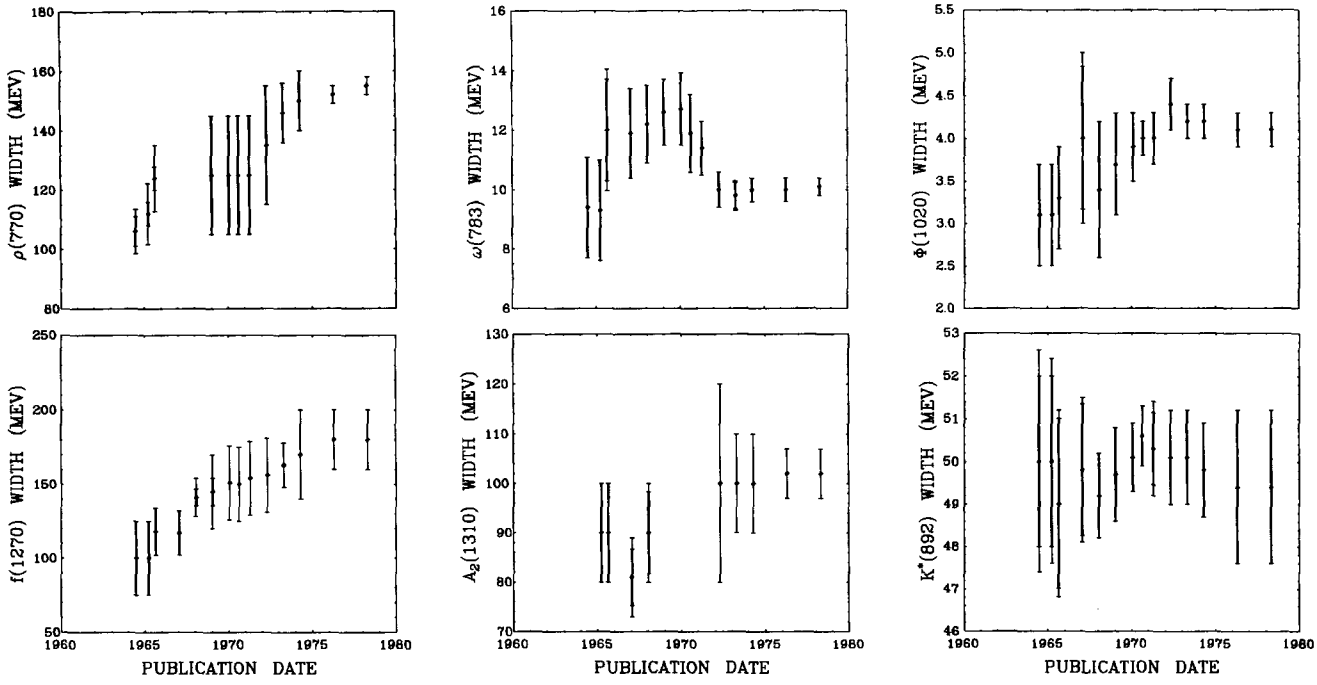

Fig. 6. Particle Data Group averages of the widths of various resonances, as a function of date of publication of RPP. The gap in the A_2 data indicates the years when the A_2 was thought to be split.

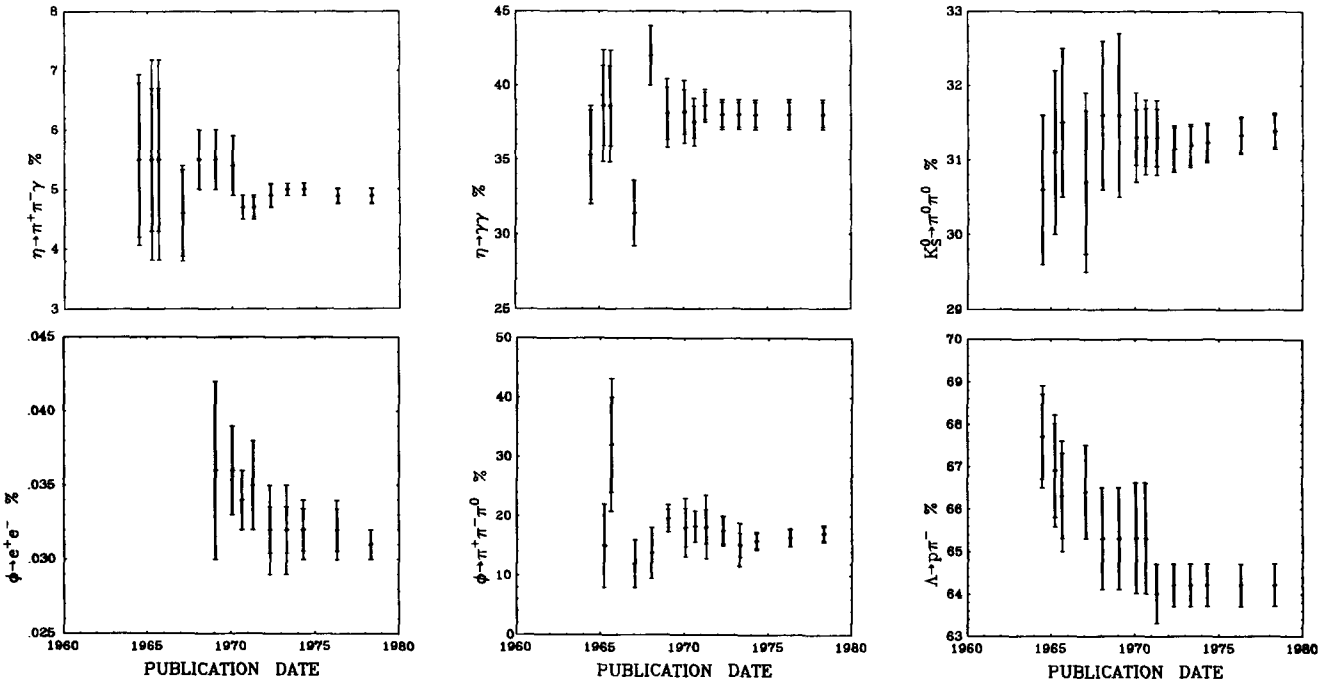

Fig. 7. Particle Data Group averages of various branching fractions, as a function of date of publication of RPP.

On the whole, the number of times the values have changed by more than one standard deviation over the years is remarkably few. Even those branching fractions which involve rare decays and which are therefore presumably difficult to measure (Fig. 7) are, for the most part, within one or two standard deviations in 1978 of their value in any year since 1960. This is in spite of the vast amount of new experimental input, and indicates the general reliability of the results.

Of course, the data points for a given quantity are hardly independent of each other, but those differing by several years frequently have quite different experimental input. The relative lack of change is a comment both on the experiments and on the averaging procedures. We, of course, are responsible only for the averages (except Fig. 3). These averages entail considerable exercise of judgment: there are conflicting experiments, experiments with impossibly small errors, "preliminary" results, and so forth. Statistical procedures will tell us that two experiments do not agree; they do not give a clue as to which (if either) is a good representation of the truth. Major decisions, and their motivations, are usually discussed on a case-by-case basis in the Data Card Listings; general comments may be found in Sec. II of the text and in Rosenfeld[1]. Note that, occasionally, the error bars increase from one publication to the next. This is usually the result of decision making by the compiler, e.g., to cease using a particular result, or because of new results in poor agreement with the old results.

We show these figures not only to demonstrate that there is not much change in these averages in the usual case, but also to show that there exist cases with relatively large changes. There is a psychological danger in preparing tables of "right" answers. The old joke about the experimenter who fights the systematics until he or she gets the "right" answer (read "agrees with previous experiments"), and then publishes, contains a germ of truth (presumably, those who compile and average experimental results are also not immune to this disease). A result can disagree with the average of all previous experiments by five standard deviations, and still be right! Hence, perhaps it is of value to show that large changes can (and do) sometimes occur.

Reference

1. A. H. Rosenfeld, Ann. Rev. Nucl. Sci. 25, 555 (1975).