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REVIEW OF PARTICLE PROPERTIES

Particle Data Group

Vladimir CHALOUPKA and Claude BRICMAN
CERN, 1211 Genève 23, Switzerland

Angela BARBARO-GALTIERI, Denyse M. CHEW*, Robert L. KELLY,
Thomas A. LASINSKI, Alan RITTENBERG, Arthur H. ROSENFELD,
Thomas G. TRIPPE and Fumiyo UCHIYAMA
Lawrence Berkeley Laboratory‡, University of California, Berkeley, California 94720, USA

Naomi BARASH-SCHMIDT
Brandeis University, Waltham, Massachusetts 02154, USA

Paul SÖDING
DESY, 2000 Hamburg 52, Germany

Matts ROOS
Department of Nuclear Physics, University of Helsinki, Helsinki 17, Finland

This review of the properties of leptons, mesons, and baryons is an updating of Review of Particle Properties, Particle Data Group [Rev. Mod. Phys. 45, No. 2, Part II, Supplement (1973)]. Data are evaluated, listed, averaged, and summarized in tables.

CONTENTS

* On leave of absence from University of Paris VI.

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Miscellaneous tables, figures and formulae

Data card listings

I. INTRODUCTION, CREDITS, CONSULTANTS

This review is an updating through January 1974 of our previous review (Particle Data Group, 1973). In this version of the text we concentrate on topics that are either new or essential. For complementary information on our standard procedures the reader is referred to our January 1970 article (Particle Data Group, 1970).

Again 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 of the authors of this compilation can roughly be broken down as follows:

1) *Stable particles:* A. Barbaro-Galtieri, N. Barash-Schmidt and T.G. Trippe.

2) *Meson resonances:* V. Chaloupka, D.M. Chew, M. Roos and P. Söding.

3) *Baryon resonances:* A. Barbaro-Galtieri, C. Bricman, R.L. Kelly, T.A. Lasinski and F. Uchiyama.

General: All Berkeley authors.

Consultants: To overcome unavoidable gaps in our coverage, both intellectual and geographical, we have solicited the help of consultants:

- Chih-Yung Chien (Johns Hopkins University)
- Ronald Crawford (University of Glasgow)
- James E. Enstrom (Lawrence Berkeley Laboratory)
- Anatoli Kuznetsov (JINR, Dubna)
- R. Gordon Moorhouse (University of Glasgow)
- Horst Oberlack (Max Planck Inst. for Physics and Astrophysics, Munich)
- Oliver E. Overseth (University of Michigan)
- Mark Sakitt (Brookhaven National Laboratory).

The usefulness of this compilation depends in large part on the interaction between the users and 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

2) Meson resonances

3) Baryon resonances.

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

1) Tables of Particle Properties (also available in a separate data booklet)

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 date (February 1, 1974) for all journals listed in the Illustrative Key. We also include preprints and unpublished conference reports which have come to our attention, but make no attempt at completeness.

Roughly 40% of our encoded results are not used for averaging. They are set off in parentheses: our reasoning is then often given in a footnote below the

data. If the reason is not given, it is one of the following:
• The quantity 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.
• The result is inconsistent with others, e.g., because of different methods employed, rendering averaging meaningless. See, for example, the entries listed under the S(1930) meson, which contain both a wide peak formed in $\bar{p}p$ interactions and narrow peaks reported in production experiments.

When the data for a particle have received special treatment or when they 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 judgement. The extent to which "blind" averaging has been tempered with judgement 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 therefore encouraged to familiarize himself with the Data Card Listings and, ultimately, with the original experiments.

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.

a) 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. It is usually* defined by

$$G = C \exp(i\pi I_y). \tag{1}$$

A neutral nonstrange 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

$$G = C_n(-1)^I, \tag{2}$$

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 the 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 in eq. (2)] is

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

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

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

The parity is

$$P = -(-1)^l. \tag{5}$$

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

$$C_nP = -(-1)^S \tag{6}$$

so all singlet ($^1S_0$, $^1P_1$, ...) have $C_nP = -1$, and all triplet ($^3S_1$, ...) 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., $A2 \to \bar{K}K$), it turns out that some signs cancel, and eqs. (3) and (4) [not (5)!] apply *unchanged*. Of course the mesons are usually spinless and 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 $\bar{q}q$.

* 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).

The unitary 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 unitary octets and singlets. The non-observation of "exotic" mesons (i.e., mesons in more complicated supermultiplets) is of course one of the bases of the naive quark model. But 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 also 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 I 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 I one can also see that the special state ${}^1S_0$, $C_nP = +1$, cannot be formed, so has Abnormal C.

b) General remarks

Well-established quantum numbers are underlined in the Tables of Particle Properties (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 hypercharge Y, and, for a nonstrange meson, its G parity. For convenience, we also list the strangeness S, which is related to Y and B by

$$S = Y - B.$$

The name conventions for mesons are given in the first parte of table II.

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" ($0^+, 1^-, 2^+, \ldots$), 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 is "Abnormal", and we write, for example, $K_A(1240)$.

For *some* pairs of *mesons* with supposedly identical quantum numbers, we also uses 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 II. For stable baryons of each I and Y we use the symbol standing alone; for resonances, the mass is in parentheses [i.e., N(1688), Λ(1405), Σ(1765), etc.]. The J^P assignments are reported in the Baryon Table

Table II
Particle name conventions.

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

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(1019) and possible future higher-mass $I^G = 0^-$ mesons that decay mainly into $K\bar{K}$.

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

	$\bar{q}q$ State CP −	$\bar{q}q$ State CP +	$(J^P)_{\text{N or A}}$ CP (Normal or abnormal)	$I^G(J^P)C_n$	Examples and comments
Parity −	$^1S_0$		$(0^-)_A-$	$0^+(0^-)+$ $1^-(0^-)+$	η, η', E ? π
		$^3S_1$	$(1^-)_N+$	$0^-(1^-)-$ $1^+(1^-)-$	ω, φ ρ
Parity +	$^1P_1$		$(1^+)_A-$	$0^-(1^+)-$ $1^+(1^+)-$	 B
		$^3P_0$	$(0^+)_N+$	$0^+(0^+)+$ $1^-(0^+)+$	ε, S* δ ?
		$^3P_1$	$(1^+)_A+$	$0^+(1^+)+$ $1^-(1^+)+$	D ? A1
		$^3P_2$	$(2^+)_N+$	$0^+(2^+)+$ $1^-(2^+)+$	f, f' A2
Parity −	$^1D_2$		$(2^-)_A-$	$0^+(2^-)+$ $1^-(2^-)+$	 A3
		$^3D_1$	$(1^-)_N+$	same as $^3S_1$	ρ' ?
		$^3D_2$	$(2^-)_A+$	$0^-(2^-)-$ $1^+(2^-)-$	Regge recurrence of the abnormal-C state $(J^P)C_n = (0^-)$.
		$^3D_3$	$(3^-)_N+$	$0^-(3^-)-$ $1^+(3^-)-$	 g
Parity +	$^1F_3$		$(3^+)_A-$	J > 2	
		$^3F_2$	$(2^+)_N+$	same as $^3P_2$	
		$^3F_3$	$(3^+)_A+$	J > 2	
		$^3F_4$	$(4^+)_N+$	etc.	

ABNORMAL C STATES THAT CANNOT COME FROM $\bar{q}q$ MODEL

Abnormal C states Have no $\bar{q}q$ model	$(0^-)_A+$	$0^-(0^-)-$ $1^+(0^-)-$	All except $J^P = 0^-$ are J^P = normal, CP = −1
	$(1^-)_N-$	$0^+(1^-)+$ $1^-(1^-)+$	
	$(0^+)_N-$	$0^-(0^+)-$ $1^+(0^+)-$	
	$(2^+)_N-$	$0^-(2^+)-$ $1^+(2^+)-$	
	$(3^-)_N-$	$0^+(3^-)+$ $1^-(3^-)+$	

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.

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 ($\pi\pi$, Kπ, $\pi\pi\pi$) 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 referred to as 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 (i.e., $\pi\pi \to \pi\pi$ or $\bar{\mathrm{K}}\mathrm{N} \to \bar{\mathrm{K}}\mathrm{N}$).

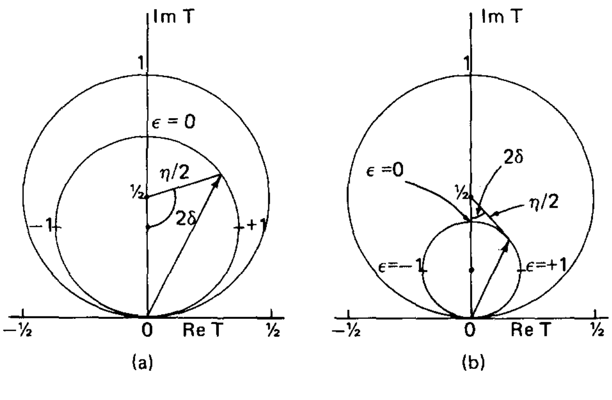

Fig. 1. Argand plots for the partial wave amplitude T_{11}. The outer circles are the unitarity bound (η = 1). The inner circles correspond to the Breit-Wigner approximation of eq. (2) for a) $x_1 = \Gamma_1/\Gamma = 0.75$ and b) $x_1 = 0.4$; $\epsilon = 2(M-E)/\Gamma$.

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 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 called the *resonance mass.* Eq. (2) is, of course, not the only possible description of a resonant amplitude; it suffices to illustrate the properties of partial-wave amplitudes which we associate with resonance behaviour 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 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

$$\Gamma = \sum_{1}^{N} \Gamma_\beta, \quad x_\beta = \Gamma_\beta/\Gamma \qquad (5)$$

and x_1 (called the elasticity) is often written x_e. (Note that in the Data Card Listings we use the symbol P_β rather than 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 behaviour in the Argand diagram (Im $T_{1\beta}$ versus Re $T_{1\beta}$) are

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

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

2) A maximum in the speed near resonance, given approximately by

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

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 $90°(x_1 > 1/2)$ or $0°(x_1 < 1/2)$ and η dips to its minimum value.

These simple properties can be used to judge the presence or absence of resonance behaviour in an Argand plot. However, it must 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 threshold, in which case a K-matrix-like parametrization is more appropriate.

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 tabluate 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

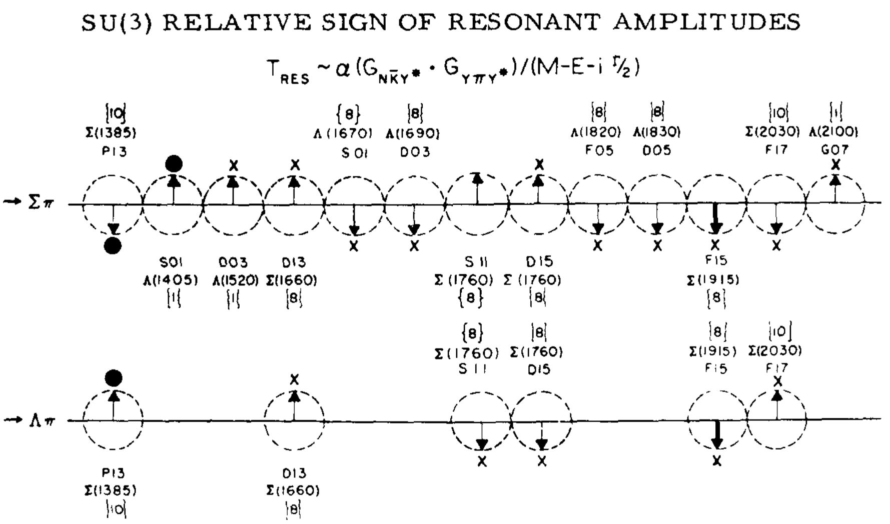

Fig. 2. Plot adapted from Levi Setti (1969) showing the sign convention adopted here for the $\Sigma\pi$ and $\Lambda\pi$ amplitudes. Once the signs of one $I = 0$ and one $I = 1$ amplitude are fixed, the others can be measured relative to these two. Arrows here indicate signs predicted by $SU(3)$; ×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

$\bar{K}N \to \Lambda(1405) \to \Sigma\pi$ 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 (DWPA) 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 momentum 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 non-resonant 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 behaviour 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

$$X_\alpha / X_\beta = \Gamma_\alpha / \Gamma_\beta . \qquad (9)$$

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

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

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 or evidences 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 fur survival are of course subjective; therefore no precise criteria can be defined. 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 behaviour 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 behaviour 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 behaviour 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 analysis of Giacomelli (1973) finds a preferred class of solutions which exhibit a resonance-like loop in the P_{01} wave near 1740 MeV (see fig. 6 of the $S = +1$ mini-review in the Baryon Data Card Listings). However, Giacomelli points 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. In this case, however, the current evidence now seems to conclusively rule out the previously suspected resonant effect in the P_{13} partial wave.

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 behaviour 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 becoming 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 (triangle graphs, double counting, unitarity), 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. Because the behaviour near threshold in these channels may be described by the Deck effect (double Regge exchange), the resonance interpretation is questionable. Several years ago we put these peaks into the Meson Table, but warned the reader not to include that we claim they are necessarily genuine resonances.

Partial-wave analyses of multimeson systems in reactions like $\pi N \to (\pi\pi\pi)$ are becoming available (Ascoli, 1973). There are several important aspects to such analyses:

i) for a given t, the $\pi\pi\pi$ vertex is assumed to be independent of the NN vertex;

ii) the $\pi\pi\pi$ decay is assumed to proceed through quasi-two-body states ($\rho\pi$, $\epsilon\pi$, etc.) in the spirit of the isobar model;

iii) in order to keep the number of parameters manageable, certain more or less plausible assumptions are made.

Through such an analysis, the A_2 peak has been confirmed to be a resonance with an observed Breit-Wigner-like phase change relative to other partial waves. In contrast, peaks like A_1 and A_3 show an enhancement in a "pure J^P" mass plot but reveal no relative 90° phase change. While this observation suggests that the A_1 and A_3 bumps to a larger part are due to non-resonant effects, mechanisms can still be invented that reproduce the A_1 "partial-wave" associating the A_1 with a pole on an unphysical sheet.

We now ask "How likely is it that the peaks of class (d) and (e) above (not checked by partial-wave analysis) will eventually be confirmed as Breit-Wigner resonances?" Most experimentally convincing peaks have been shown to be associated with resonances. But be warned of the sometimes drastic effects of thresholds (see, e.g., Solzhenitsyn, 1973); also, broad peaks may contain several resonances, or they may include a resonance narrower than the peak, plus some other complications; for example:

Before 1966 we might have tabulated the πp bumps at 1520 and 1688 MeV as single resonances, whereas partial-wave analysis shows that each contains several resonances.

Before the $N'(1470, P_{11})$ was confirmed in partial-wave analyses, it was seen as a missing-mass or p$\pi\pi$ peak produced peripherally in high-energy pp collisions, and (like A_1, Q and A_3) was partly explained by the Deck effect and later by double-Regge-pole exchange.

Thus, we enter into the Tables of Particle Properties experimentally convincing peaks unless there is contradictory information; and we can expect that most of these peaks will eventually be confirmed as one or more resonances. But we can easily give examples of experimentally convincing peaks which in all likelihood have nothing to do with resonances: such are the K^+p and pp total cross-section bumps near 1.2 and 3 GeV/c, respectively, and the low-energy ABC and DEF effects in the S-wave $\pi\pi$ system.

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*

B.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^0_L, we parametrize the Dalitz plot distribution by the expression

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

where $m_{\pi^+}^2$ has been introduced so as to make the coefficients g, h, and j 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 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 measures the quadratic dependence on s_3. 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.

At present there is no compelling experimental evidence for either the h or the j term (for upper limits on the j term, see section B.3(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^0_L 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.

B.2. Form factors in K_{l3} leptonic decays

Assuming that only the vector current contributes to these decays, we write the matrix element as

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

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 $q^2 = (P_K - P_\pi)^2$, the square of the momentum transfer to the leptons. The parameters we list are $\lambda_\pm$, the energy dependence of the $f_\pm(q^2)$ form factor, assuming the form

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

and ξ, the ratio of the two form factors,

$$\xi = f_-/f_+.$$

The quantity ξ can be determined in different ways:

1) By measuring the $K_{\mu 3}/K_{e3}$ branching ratio and comparing it with the theoretical ratio as given in terms of $\xi(0) = f_-(0)/f_+(0)$.

$$\Gamma(K^\pm_{\mu 3})/\Gamma(K^\pm_{e3}) = 0.6457 + 0.1264 \operatorname{Re}\xi + 0.0192|\xi|^2 + 1.4115\lambda_+ + 0.4754\lambda_- \operatorname{Re}\xi + 0.0080\lambda_+ \operatorname{Re}\xi,$$

$$\Gamma(K^0_{\mu 3})/\Gamma(K^0_{e3}) = 0.6452 + 0.1246 \operatorname{Re}\xi + 0.0186|\xi|^2 + 1.3162\lambda_+ + 0.4370\lambda_- \operatorname{Re}\xi + 0.0064\lambda_+ \operatorname{Re}\xi.$$

See Cabibbo (1966) and Fearing et al. (1970) (for the charge-dependent formulas). Note that the first constant has been changed to 0.6457; the earlier value was a misprint †, which we copied from Cabibbo (1966).

2) By studying the Dalitz plot of the $K_{\mu 3}$ decay. The K_{e3} Dalitz plot distribution is only dependent upon the λ_+ parameter, whereas the $K_{\mu 3}$ distribution

† We thank Drs. H.W. Fearing and J. Smith for calling this mistake to our attention.

is dependent upon λ_-, λ_+, ξ. Often experimenters have measured only the momentum spectrum of either the π or the lepton and compared it with the predicted spectrum. See the note on form factors in the $K^\pm$ Data Card Listings for a discussion of this method. For a formula relating the Dalitz plot variables to ξ, see for example Brene et al. (1961).

3) 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 A with $P = A/|A|$, where A is given (Cabibbo and Maksymowicz, 1964) by

$$A = \alpha_1(\xi) p_\mu - a_2(\xi)\left\{\frac{p_\mu}{m_\mu}\left[m_K - E_\pi + \frac{p_\pi \cdot p_\mu}{|p_\mu|^2}(E_\mu - m_\mu)\right] + p_\pi\right\} + m_K \operatorname{Im} \xi(q^2)(p_\pi \times p_\mu).$$

If time-reversal invariance holds, ξ is real, and thus there is no polarization perpendicular to the K-decay plane.

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 experimental results for ξ, $\lambda_\pm$, and the upper limits on $|f_S/f_+|$ and $|f_T/f_+|$ are given in the $K^\pm$ and K_L^0 sections of the Stable Particle Data Card Listings. See the note on form factors in the $K^\pm$ Data Card Listings for discussions of these results.

B.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

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

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

$$|M|^2 \propto 1 + \sigma_\pm (2/\sqrt{3})(T_+ - T_-)/T_{\pm\,\max} + (CP \text{ nonviolating terms}), \qquad (5)$$

where $T_\pm$ are the kinetic energies of the charged pions. We have momentarily abandoned the form involving the Mandelstam variables s_i in favour 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* $K_L \to \pi^\mp l^\pm \nu$ *decays.* The quantity measured and compiled here is

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

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 B.4, and ϵ is the parameter of the expansion

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

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

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

$$\eta_{+-} = A(\mathrm{K_L}\to\pi^+\pi^-)/A(\mathrm{K_S}\to\pi^+\pi^-) = |\eta_{+-}|\exp(\mathrm{i}\phi_{+-}),$$

$$\eta_{\mathrm{oo}} = A(\mathrm{K_L}\to\pi^{\mathrm{o}}\pi^{\mathrm{o}})/A(\mathrm{K_S}\to\pi^{\mathrm{o}}\pi^{\mathrm{o}}) = |\eta_{\mathrm{oo}}|\exp(\mathrm{i}\phi_{\mathrm{oo}}),$$

ϵ, defined in eqs. (6) above, and

$$\epsilon' = \tfrac{1}{2}\mathrm{i}\sqrt{2}\,[\exp \mathrm{i}(\delta_2-\delta_{\mathrm{o}})]\ \mathrm{Im}\,(A_2/A_{\mathrm{o}}).$$

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

$$\langle I=0|T|\mathrm{K}\rangle = \exp(\mathrm{i}\delta_{\mathrm{o}})A_{\mathrm{o}},$$

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

Wu and Yang (1964) have derived the relationships

$$\eta_{+-} = \epsilon + \epsilon',$$

$$\eta_{\mathrm{oo}} = \epsilon - 2\epsilon'.$$

We give η_{+-}, η_{oo}, ϕ_{+-}, and ϕ_{oo} in the Addendum to the Stable Particle Table. The phases are measured directly, whereas the magnitudes η_{+-} and η_{oo} are derived parameters. We use, as far as we can, the directly measured quantities as input and calculate η_{+-} and η_{oo} 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 $|\eta_{\mathrm{oo}}|^2$ in a separate list at the end of the *CP*-violating parameters section of the $\mathrm{K_L^o}$ section of the Stable Particle Data Card Listings.

B.4. $\Delta S = \Delta Q$ rule in $\mathrm{K^o}$ decays

The relative amount of $\Delta S \neq \Delta Q$ component present is measured by the parameter x, defined as

$$x = A(\overline{\mathrm{K}}^{\mathrm{o}}\to\pi^- l^+\nu)/A(\mathrm{K^o}\to\pi^- l^+\nu).$$

We list Re $\{x\}$ and Im $\{x\}$ for both $\mathrm{K_{e3}}$ and $\mathrm{K_{\mu3}}$ 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*

As a test of possible *C* violation in electromagnetic interactions, a number of experiments have looked for possible charge asymmetries in the decays $\eta\to\pi^+\pi^-\pi^{\mathrm{o}}$ and $\eta\to\pi^+\pi^-\gamma$. For both modes we use the convention

$$\text{Asymmetry} = \frac{N^+ - N^-}{N^+ + N^-}$$

where $N^\pm$ means the number of events with the $\pi^{(\pm)}$ energy greater than the $\pi^{(\mp)}$ energy in the η rest frame. We list the asymmetry parameters in the η section of the Stable Particle Data Card Listings and give average values in the Addendum to the Stable Particle Table.

D. *Baryon-decay parameters*

D.1. A/V ratio for baryon leptonic decays

Consider the decay

$$\mathrm{B_i} \to \mathrm{B_f} + \ell + \nu.$$

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

$$\langle \mathrm{B_f}|\gamma_\lambda(g_{\mathrm{V}} - g_{\mathrm{A}}\gamma_5) + (g_{\mathrm{W}}/m_{\mathrm{B_i}})\sigma^{\lambda\nu}q_\nu|\mathrm{B_i}\rangle,$$

where $\mathrm{B_i}$ and $\mathrm{B_f}$ 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 definition of $g_{\mathrm{A}}/g_{\mathrm{V}}$ is

$$g_{\mathrm{A}}/g_{\mathrm{V}} = |g_{\mathrm{A}}/g_{\mathrm{V}}|\exp(\mathrm{i}\delta),$$

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

In neutron beta decay the measurements are consistent with time reversal, so $g_{\mathrm{A}}/g_{\mathrm{V}}$ is nearly real and has been considered to be such in all the baryon leptonic decays. Notice that by using the above definition of the matrix element with the Pauli representations, the value of $g_{\mathrm{A}}/g_{\mathrm{V}}$ 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 $g_{\mathrm{A}}/g_{\mathrm{V}}$ (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).

We compile the ratio g_A/g_V with its sign, for those decays for which it has been measured. For the neutron beta decay we compile also the phase δ.

All the coupling constants and decay rates for baryon leptonic decays are related by Cabibbo's theory (Cabibbo, 1964). The latest fits to this theory can be found in Ebenhöh (1971) and Roos (1973).

D.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

$$I = 1 + \alpha \boldsymbol{P}_{\mathrm{Y}}\cdot\boldsymbol{q},$$

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

In the notation of Lee and Yang (1957) the polarization $\boldsymbol{P}_{\mathrm{B}}$ of the decay baryon is ‡

$$\boldsymbol{P}_{\mathrm{B}} = \frac{(\alpha+\boldsymbol{P}_{\mathrm{Y}}\cdot\boldsymbol{q})\boldsymbol{q} + \beta(\boldsymbol{P}_{\mathrm{Y}}\times\boldsymbol{q}) + \gamma\boldsymbol{q}\times(\boldsymbol{P}_{\mathrm{Y}}\times\boldsymbol{q})}{1+\alpha\boldsymbol{P}_{\mathrm{Y}}\cdot\boldsymbol{q}},$$

where $\boldsymbol{P}_{\mathrm{B}}$ is defined in that rest system of the baryon obtained by a Lorentz transformation along $\boldsymbol{q}$ from the hyperon rest system in which $\boldsymbol{q}$ and $\boldsymbol{P}_{\mathrm{Y}}$ 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,

$$\Delta = \delta_s - \delta_p = (6.8 \pm 2.0)\ \text{deg.}\ ‡$$

In the Stable Particle Data Card Listings we give α

‡ 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.

‡ This value for $\delta_s-\delta_p$ is derived from the phase-shift analyses by Roper et al. (1965). The error is our estimation of the uncertainty.

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

This section is a much abbreviated version of section IX in the text of our January 1970 edition (Particle Data Group, 1970) to which the reader is referred for details. See also the mini-review on K* masses and mass differences in the K*(892) section of the Meson Data Card Listings.

A. *Confidence levels and errors*

Quoted errors represent one standard deviation (σ). Upper and lower limits represent 68.3% confidence bounds (1σ), unless otherwise stated. The errors in the Tables of Particle Properties and the errors of the averages in the Data Card Listings often include a scale factor S; see section VII.B. below.

Quantities that have changed more than 1σ since our April 1973 edition (Particle Data Group, 1973) are italicized in the Tables of Particle Properties. For a discussion see section V.B. in the text of the 1970 edition (Particle Data Group, 1970).

B. *Unconstrained averaging, scale factors*

In the absence of constraints, we calculate a weighted average

$$\bar{x} \pm \delta\bar{x} = \sum w_i x_i / \sum w_i \pm \left(\sum w_i\right)^{-1/2}; \qquad w_i = 1/(\delta \bar{x}_i)^2, \tag{1}$$

where the sums run over N experiments. We also calculate χ^2 and compare it with its expectation value of $N-1$. If $\chi^2 > N-1$, we increase the error $\delta\bar{x}$ in eq. (1) by a factor

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

It is easy to design statistical tests for determining whether one experiment (or a group of experiments) is consistent with the other experiments. However, statistics does not tell us who is wrong in case of contradictions. When $S \gg 1$, one can conclude either that:
1) some (or all) experiments are wrong, or
2) some (or all) experiments have underestimated their errors, or
3) the experiments do not measure the same quantity (systematic errors).

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C. *Constrained fits*

The information on partial-decay fractions P_i ‡ and partial widths $\Gamma_i = P_i \Gamma_{\text{total}}$ is frequently given by branching ratios R_j, say, $R_1 = P_1/(P_1+P_2)$, $R_2 = P_2/P_3$, $R_3 = P_1/P_2$, $R_4 = P_3/(P_1+P_2+P_3)$, etc.

The number of experimental inputs R_j is often greater than the number of decay modes. In these cases we fit all available information on the P_i, Γ_i, and R_j subject to the constraint $\Sigma P_i = 1$. When, in addition, the input R_j are contradictory so that scale factors may have to be introduced, one has to resort to iterative procedures.

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ACKNOWLEDGMENTS

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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

This section is a much abbreviated version of section IX in the text of our January 1970 edition (Particle Data Group, 1970) to which the reader is referred for details. See also the mini-review on K* masses and mass differences in the K*(892) section of the Meson Data Card Listings.

A. *Confidence levels and errors*

Quoted errors represent one standard deviation (σ). Upper and lower limits represent 68.3% confidence bounds (1σ), unless otherwise stated. The errors in the Tables of Particle Properties and the errors of the averages in the Data Card Listings often include a scale factor S; see section VII.B. below.

Quantities that have changed more than 1σ since our April 1973 edition (Particle Data Group, 1973) are italicized in the Tables of Particle Properties. For a discussion see section V.B. in the text of the 1970 edition (Particle Data Group, 1970).

B. *Unconstrained averaging, scale factors*

In the absence of constraints, we calculate a weighted average

$$\bar{x} \pm \delta\bar{x} = \sum w_i x_i / \sum w_i \pm (\sum w_i)^{-1/2}; \qquad w_i = 1/(\delta \bar{x}_i)^2, \tag{1}$$

where the sums run over N experiments. We also calculate χ^2 and compare it with its expectation value of $N-1$. If $\chi^2 > N-1$, we increase the error $\delta\bar{x}$ in eq. (1) by a factor

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

It is easy to design statistical tests for determining whether one experiment (or a group of experiments) is consistent with the other experiments. However, statistics does not tell us who is wrong in case of contradictions. When $S \gg 1$, one can conclude either that:
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TABLES OF PARTICLE PROPERTIES

April 1974

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R. L. Kelly, T. A. Lasinski, A. Rittenberg, M. Roos, A. H. Rosenfeld
P. Söding, T. G. Trippe, and F. Uchiyama

(Closing date for data: Feb. 1, 1974)

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 1973.

Particle	$I^G(J^P)C_n$	Mass (MeV) Mass^2 (GeV)^2	Mean Life (sec) $c\tau$ (cm)	Partial decay mode: Mode	Fraction[a]	p or p_{max}[b] (MeV/c)
γ	$0,1(1^-)^-$	$0(<2)10^{-21}$	stable	stable		
ν ν_e	$J=\frac{1}{2}$	0(< 60 eV)	stable	stable		
ν_μ		0(< 1.2)				
e	$J=\frac{1}{2}$	0.5110034	stable	stable		
		±.0000014	$(>2\times10^{21}$y)			
μ	$J=\frac{1}{2}$	105.65948	2.1994×10^{-6}	$e\nu\bar{\nu}$	100 %	53
		±.00035	±.0006 S=1.1*	$e\gamma\gamma$	$(<1.6)10^{-5}$	53
		$m^2=0.01116$	$c\tau=6.593\times10^4$	3e	$(<6)10^{-9}$	53
		$m_\mu-m_{\pi^\pm}=-33.909$		$e\gamma$	$(<2.2)10^{-8}$	53
		±.006				
$\pi^\pm$	$1^-(0^-)$	139.5688	2.6030×10^{-8}	$\mu\nu$	100 %	30
		±.0064	±.0023	$e\nu$	$(1.24\pm0.03)10^{-4}$	70
		$m^2=0.0195$	$c\tau=780.4$	$\mu\nu\gamma$	c$(1.24\pm0.25)10^{-4}$	30
			$(\tau^+-\tau^-)/\bar{\tau}=$	$\pi^0 e\nu$	$(1.02\pm0.07)10^{-8}$	5
			(0.05±0.07)%	$e\nu\gamma$	c$(3.0\pm0.5)10^{-8}$	70
			(test of CPT)	$e\nu e^+e^-$	$(<3.4)10^{-8}$	70
π^0	$1^-(0^-)^+$	134.9645	0.84×10^{-16}	$\gamma\gamma$	(98.83±0.05)%	67
		±.0074	±.10 S=2.1*	γe^+e^-	(1.17±0.05)%	67
		$m^2=0.0182$	$c\tau=2.5\times10^{-6}$	$\gamma\gamma\gamma$	$(<5)10^{-6}$	67
		$m_{\pi^\pm}-m_{\pi^0}=4.6043$		$e^+e^-e^+e^-$	d$(3.47)10^{-5}$	67
		±.0037		$\gamma\gamma\gamma\gamma$	$(<6.1)10^{-5}$	67

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C_n$	Mass (MeV) Mass^2 (GeV)^2	Mean life (sec) $c\tau$ (cm)	Mode	Fraction[a]	p or p_{max}[b] (MeV/c)
$K^{\pm}$	$\frac{1}{2}(0^-)$	493.707	1.2371×10^{-8}	$\mu\nu$	(63.54±0.19)%	236
		±0.037	±.0026 S=1.9*	$\pi\pi^0$	(21.12±0.17)%	205
			$c\tau$=370.8	$\pi\pi^-\pi^+$	(5.59±0.03)% S=1.1*	125
		m^2=0.244	$(\tau^+-\tau^-)/\bar{\tau}$=	$\pi\pi^0\pi^0$	(1.73±0.05)% S=1.4*	133
			(.11±.09)%	$\mu\pi^0\nu$	(3.20±0.09)% S=1.7*	215
			(test of CPT)	$e\pi^0\nu$	(4.82±0.05)% S=1.1*	228
			S=1.2*	$e\pi^0\pi^0\nu$	($1.8\,^{+2.4}_{-0.6}$) 10^{-5}	207
		$m_{K^\pm}-m_{K^0}$= -3.99		$\pi\pi^{\mp}e^{\pm}\nu$	(3.7 ±0.2) 10^{-5}	203
		±0.13		$\pi\pi^{\pm}e^{\mp}\nu$	(< 5) 10^{-7}	203
		S=1.1*		$\pi\pi^{\mp}\mu^{\pm}\nu$	(0.9 ±0.4) 10^{-5}	151
				$\pi\pi^{\pm}\mu^{\mp}\nu$	(< 3) 10^{-6}	151
				$e\nu$	(1.38±0.20) 10^{-5}	247
				$e\nu\gamma$	c(< 7) 10^{-5}	247
				$\pi\pi^0\gamma$	h,c(2.71±0.19) 10^{-4}	205
				$\pi\pi^+\pi^-\gamma$	c(10 ±4) 10^{-5}	125
				$\mu\pi^0\nu\gamma$	c(< 6) 10^{-5}	215
				$e\pi^0\nu\gamma$	c(3.7 ±1.4) 10^{-4}	228
				πe^+e^-	(< 0.26) 10^{-6}	227
				$\pi^{\mp}e^{\pm}e^{\pm}$	(< 1.5) 10^{-5}	227
				$\pi\mu^+\mu^-$	(< 2.4) 10^{-6}	172
				$\pi\gamma\gamma$	c(< 3.5) 10^{-5}	227
				$\pi\gamma\gamma\gamma$	c(< 3) 10^{-4}	227
				$\pi\nu\bar{\nu}$	(< 0.6) 10^{-6}	227
				$\pi\gamma$	(< 4) 10^{-6}	227
				$e\pi^{\mp}\mu^{\pm}$	(< 3) 10^{-8}	214
				$e\pi^{\pm}\mu^{\mp}$	(< 1.4) 10^{-8}	214
				$\mu\nu\nu\bar{\nu}$	c(< 6) 10^{-6}	236
K^0	$\frac{1}{2}(0^-)$	497.70	50% K_{Short}, 50% K_{Long}			
		±0.13				
K^0_S	$\frac{1}{2}(0^-)$	S=1.1*	0.886×10^{-10}	$\pi^+\pi^-$	(68.77±0.26)% S=1.1*	206
		m^2=0.248	±.007 S=2.4*	$\pi^0\pi^0$	(31.23±0.26)%	209
			$c\tau$=2.66	$\mu^+\mu^-$	(< 0.3) 10^{-6}	225
				e^+e^-	(<35) 10^{-5}	249
				$\pi^+\pi^-\gamma$	c(2.0 ±0.4) 10^{-3}	206
				$\gamma\gamma$	(< 0.4) 10^{-3}	249
K^0_L	$\frac{1}{2}(0^-)$		5.179×10^{-8}	$\pi^0\pi^0\pi^0$	(21.3 ±0.6)% S=1.1*	139
			±0.040	$\pi^+\pi^-\pi^0$	(*11.9* ±*0.4*)% S=2.2*	133
			$c\tau$=1553	$\pi\mu\nu$	(27.5 ±0.5)% S=1.1*	216
				$\pi e\nu$	(39.0 ±0.6)% S=1.1*	229
				$\pi e\nu\gamma$	c(1.3 ±0.8)%	229
		$m_{K_L}-m_{K_S}$ = $0.5403\times10^{10}\,\hbar\ \mathrm{sec}^{-1}$		$\pi^+\pi^-$	(*0.177±0.018*)% S=4.9*	206
		±0.0035		$\pi^0\pi^0$	(0.093±0.019)% S=1.5*	209
				$\pi^+\pi^-\gamma$	c(< 0.4) 10^{-3}	206
				$\pi^0\gamma\gamma$	(< 2.4) 10^{-4}	231
				$\gamma\gamma$	(4.9± 0.4) 10^{-4}	249
				$e\mu$	(< 1.6) 10^{-9}	238
				$\mu^+\mu^-$	i(< 1.6) 10^{-8}	225
				e^+e^-	(< 1.6) 10^{-9}	249
				$e^+e^-\gamma$	(< 2.8) 10^{-5}	249
η	$0^+(0^-)^+$	548.8	$^e\Gamma$=(2.63±0.58)keV	$\gamma\gamma$	(38.0 ±1.0)% S=1.2*	274
		±0.6	Neutral decays	$\pi^0\gamma\gamma$	e(3.1 ±1.1)% S=1.2*	258
		S=1.4*	71.1%	$3\pi^0$	(30.0 ±1.1)% S=1.1*	180
		m^2=0.301		$\pi^+\pi^-\pi^0$	(23.9 ±0.6)% S=1.1*	175
				$\pi^+\pi^-\gamma$	(5.0 ±0.1)%	236
				$\pi^0e^+e^-$	(< 0.04)%	258
				$\pi^+\pi^-$	(< 0.15)%	236
			Charged decays 28.9%	$\pi^+\pi^-e^+e^-$	(0.1 ±0.1)%	236
				$\pi^+\pi^-\pi^0\gamma$	(< 6) 10^{-4}	175
				$\pi^+\pi^-\gamma\gamma$	(< 0.2)%	236
				$\mu^+\mu^-$	(2.2 ±0.8) 10^{-5}	253
				$\mu^+\mu^-\pi^0$	(< 5) 10^{-4}	211

Stable Particle Table *(cont'd)*

Particle	$I^G(J^P)C_n$	Mass (MeV) Mass^2 (GeV)^2	Mean Life (sec) $c\tau$ (cm)	Partial decay mode Mode	 Fraction[a]	 p or p_{max}[b] (MeV/c)
p	$\frac{1}{2}(\frac{1}{2}^+)$	*938.2796* *± 0.0027* m^2 =0.8804	stable (> 2×10^{28}y)			
n	$\frac{1}{2}(\frac{1}{2}^+)$	*939.5731* *± 0.0027* m^2 =0.8828 $m_p - m_n$ =-1.29344 ±0.00007	918±14 $c\tau$ =2.75×10^{13}	$pe^-\nu$	100 %	1
Λ	$0(\frac{1}{2}^+)$	1115.60 ±0.05 S=1.2* m^2 =1.245	*2.578* $\times 10^{-10}$ ±*.021* S=1.6* $c\tau$ =7.73	$p\pi^-$	(64.2±0.5)%	100
				$n\pi^0$	(35.8±0.5)%	104
				$pe\nu$	(8.13±0.29)10^{-4}	163
				$p\mu\nu$	(1.57±0.35)10^{-4}	131
				$p\pi^-\gamma$	c(0.85±0.14)10^{-3}	100
Σ^+	$1(\frac{1}{2}^+)$	1189.37 ±0.06 S=1.8* m^2 =1.415 $m_{\Sigma^+} - m_{\Sigma^-}$ =-7.99 ±.08 S=1.2*	0.800×10^{-10} ±.006 $c\tau$ =2.40	$p\pi^0$	(51.6±0.7)%	189
				$n\pi^+$	(48.4±0.7)%	185
				$p\gamma$	(1.24±0.18)10^{-3} S=1.4*	225
				$n\pi^+\gamma$	c(0.93±0.10)10^{-3}	185
				$\Lambda e^+\nu$	(2.02±0.47)10^{-5}	72
			$\frac{\Gamma(\Sigma^+\to \ell^+ n\nu)}{\Gamma(\Sigma^-\to \ell^- n\nu)}$ <.035	$n\mu^+\nu$	(< 2.4)10^{-5}	202
				$ne^+\nu$	(< 1.0)10^{-5}	224
				pe^+e^-	(< 7)10^{-6}	225
Σ^0	$1(\frac{1}{2}^+)$	1192.48 ±0.08 m^2=1.422	<1.0×10^{-14} $c\tau$<3×10^{-4}	$\Lambda\gamma$	100 %	74
				Λe^+e^-	d(5.45)10^{-3}	74
Σ^-	$1(\frac{1}{2}^+)$	1197.35 ±0.06 m^2=1.434 $m_{\Sigma^0} - m_{\Sigma^-}$ =-4.87 ±.06	1.482×10^{-10} ±.017 S=1.5* $c\tau$ =4.44	$n\pi^-$	100 %	193
				$ne^-\nu$	(1.08±0.04)10^{-3}	230
				$n\mu^-\nu$	(0.45±0.04)10^{-3}	210
				$\Lambda e^-\nu$	(0.60±0.06)10^{-4}	79
				$n\pi^-\gamma$	c(1.0 ±0.2)10^{-4}	193
Ξ^0	$\frac{1}{2}(\frac{1}{2}^+)^f$	1314.9 ±0.6 m^2=1.729 $m_{\Xi^0} - m_{\Xi^-}$ =-6.4 ±.6	2.96×10^{-10} ±.12 $c\tau$ =8.93	$\Lambda\pi^0$	100 %	135
				$p\pi^-$	(< 0.9)10^{-3}	299
				$pe^-\nu$	(< 1.3)10^{-3}	323
				$\Sigma^+e^-\nu$	(< 1.5)10^{-3}	119
				$\Sigma^-e^+\nu$	(< 1.5)10^{-3}	112
				$\Sigma^+\mu^-\nu$	(< 1.5)10^{-3}	64
				$\Sigma^-\mu^+\nu$	(< 1.5)10^{-3}	49
				$p\mu^-\nu$	(< 1.3)10^{-3}	309
Ξ^-	$\frac{1}{2}(\frac{1}{2}^+)^f$	1321.29 ±0.14 m^2=1.746	1.652×10^{-10} ±.023 S=1.1* $c\tau$ =4.95	$\Lambda\pi^-$	100 %	139
				$\Lambda e^-\nu$	g(0.70±0.21)10^{-3}	190
				$\Sigma^0e^-\nu$	(< 0.5)10^{-3}	123
				$\Lambda\mu^-\nu$	(< 1.3)10^{-3}	163
				$\Sigma^0\mu^-\nu$	(< 0.5)%	70
				$n\pi^-$	(< 1.1)10^{-3}	303
				$ne^-\nu$	(< 1.0)%	327
Ω^-	$0(\frac{3}{2}^+)^f$	1672.2±.4 m^2=2.797	$1.3^{+0.3}_{-0.2}\times10^{-10}$ $c\tau$ = 3.9	$\Xi^0\pi^-$	Total of 41 events seen	293
				$\Xi^-\pi^0$		290
				ΛK^-		

ADDENDUM TO

Stable Particle Table

	Magnetic moment		μ Decay parameters[j]
e	1.001 159 6567 ±.000 000 0035	$\frac{e\hbar}{2m_e c}$	
μ	1.001 166 16 ±.000 000 31	$\frac{e\hbar}{2m_\mu c}$	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 $\lvert g_A/g_V \rvert = 0.86^{+0.33}_{-0.11}$ φ = 180° ±15°

$K^\pm$

Mode	Partial rate (sec^{-1})	
$\mu\nu$	$(51.36\pm0.19)10^6$	S=1.2*
$\pi\pi^0$	$(17.07\pm0.15)10^6$	S=1.1*
$\pi\pi^+\pi^-$	$(4.52\pm0.02)10^6$	S=1.1*
$\pi\pi^0\pi^0$	$(1.40\pm0.04)10^6$	S=1.4*
$\mu\pi^0\nu$	$(2.58\pm0.07)10^6$	S=1.7*
$e\pi^0\nu$	$(3.90\pm0.04)10^6$	S=1.1*

$\Delta I = \frac{1}{2}$ rule for $K \to 3\pi$ [k]

$K^+\to\pi^+\pi^+\pi^-$	g=-.214±.005	S=1.7*
$K^-\to\pi^-\pi^+\pi^-$	g=-.214±.007	S=2.7*
$K^\pm\to\pi^\pm\pi^0\pi^0$	g= .522±.020	S=1.3*
$K_L^0\to\pi^0\pi^+\pi^-$	g= .610±.021	S=2.6*

K_S^0

$\pi^+\pi^-$	n(0.776±.006)10^{10}	S=1.8*
$\pi^0\pi^0$	n(0.352±.004)10^{10}	S=1.3*

Form factors for $K_{\ell3}$ decays (see Data Card Listings for ξ, λ_+^μ and λ_0^μ)

K_{e3}^+ λ_+^e=.029±.004 K_{e3}^0 λ_+^e=.026±.004

K_L^0

$\pi^0\pi^0\pi^0$	$(4.11\pm0.13)10^6$	S=1.1*
$\pi^+\pi^-\pi^0$	$(2.31\pm0.07)10^6$	S=2.0*
$\pi\mu\nu$	$(5.31\pm0.11)10^6$	S=1.1*
$\pi e\nu$	$(7.53\pm0.12)10^6$	S=1.1*
$\pi^+\pi^-$	n(3.42 ±0.36)10^4	S=4.6*
$\pi^0\pi^0$	n(1.80 ±0.36)10^4	S=1.5*

CP violation parameters [ℓ,n]

$|\eta_{+-}|=(2.17\pm.07)10^{-3}$ S=3.4* $|\eta_{00}|=(2.25\pm.09)10^{-3}$ S=1.1*

$\phi_{+-}=(46.6\pm2.5)°$ S=1.5* $\phi_{00}=(49\pm13)°$

$|\eta_{+-0}|^2<0.12$ $|\eta_{000}|^2<1.2$ δ=(.34±.01)10^{-2} S=1.1*

ΔS = -ΔQ

Re x=.000±.022 S=1.5*   Im x = .012±.030 S=1.2*

η

Mode	Asymmetry parameter
$\pi^+\pi^-\pi^0$	(0.12±.17)%
$\pi^+\pi^-\gamma$	(0.88±.40)%

	Magnetic moment ($e\hbar/2m_p c$)	Decay parameters[m]	Measured α	Measured φ(degree)	Derived γ	Derived Δ(degree)	g_A/g_V	g_V/g_A
p	2.7928456 ±.0000011							
n	-1.913148 ±.000066	$pe^-\nu$					-1.250±.09 δ=(181.1±1.3)°	
Λ	-0.67 ±.06	$p\pi^-$	0.647±0.013	(-6.5±3.5)°	0.76	$(7.6^{+4.0}_{-4.1})°$		
		$n\pi^0$	0.651±0.045					
		$pe\nu$					-0.66±0.05 S=1.2*	
Σ⁺	2.62 ±.41	$p\pi^0$	-0.979±0.016	(36±34)°	0.17	(187±6)°		
		$n\pi^+$	+0.066±0.016	(167±20)° S=1.1*	-0.97	$(-73^{+136}_{-10})°$		
		$p\gamma$	$-1.03^{+.52}_{-.42}$					
Σ⁻	-1.6 to 0.8	$n\pi^-$	-0.069±0.008	(10±15)°	0.98	$(249^{+12}_{-115})°$		
		$ne^-\nu$					See Data Cds.	
		$\Lambda e^-\nu$						0.37±0.20
Ξ⁰		$\Lambda\pi^0$	-0.44±0.08 S=1.3*	(21±12)°	0.84	$(216^{+13}_{-19})°$		
Ξ⁻	-1.93 ±.75	$\Lambda\pi^-$	-0.393±0.023	(2±7)° S=1.2*	0.92	(184±15)°		

Stable Particle Table *(cont'd)*

*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, δx, i.e., $\delta x \rightarrow S\,\delta x$. 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 ideogram in Stable Particle Data Card Listings.

a. Quoted upper limits correspond to a 90% confidence level.
b. In decays with more than two bodies, p_{max} is the maximum momentum that any particle can have.
c. See Stable Particle Data Card Listings for energy limits used in this measurement.
d. Theoretical value; see also Stable Particle Data Card Listings.
e. See note in Stable Particle Data Card Listings.
f. P for Ξ and J^P for Ω^- not yet measured. Values reported are SU(3) predictions.
g. Assumes rate for $\Xi^- \rightarrow \Sigma^0 e^- \nu$ small compared with $\Xi^- \rightarrow \Lambda e^- \nu$.
h. The direct emission branching ratio is $(1.56 \pm .35) \times 10^{-5}$.
i. This upper limit is above the contradictory results of Carithers et al. $(1.0^{+.7}_{-.35}) \times 10^{-8}$, and Clark et al. $(< 0.19) \times 10^{-8}$. See note in Stable Particle Data Card Listings.
j. $|g_A/g_V|$ defined by $g_A^2 = |C_A|^2 + |C'_A|^2$, $g_V^2 = |C_V|^2 + |C'_V|^2$, and $\Sigma \langle \bar{e}\, |\Gamma_i|\, \mu \rangle \langle \bar{\nu}\, |\Gamma_i (C_i + C'_i \gamma_5)|\, \nu \rangle$;
ϕ defined by $\cos\phi = -R_e(C^*_A C'_V + C'_A C^*_V)/g_A g_V$ [for more details, see text Section VI A].
k. The definition of the slope parameter of the Dalitz plot is as follows [see also text Section VI B.1]: $|M|^2 = 1 + g\left(\frac{s_3 - s_0}{m^2_{\pi^+}}\right)$.
ℓ. The definition for the CP violation parameters is as follows [see also text Section VI B.3]:

$$\delta = \frac{\Gamma(K^0_L \rightarrow \ell^+) - \Gamma(K^0_L \rightarrow \ell^-)}{\Gamma(K^0_L \rightarrow \ell^+) + \Gamma(K^0_L \rightarrow \ell^-)} \qquad |\eta_{+-0}|^2 = \frac{\Gamma(K^0_S \rightarrow \pi^+\pi^-\pi^0)}{\Gamma(K^0_L \rightarrow \pi^+\pi^-\pi^0)} \qquad |\eta_{000}|^2 = \frac{\Gamma(K^0_S \rightarrow \pi^0\pi^0\pi^0)}{\Gamma(K^0_L \rightarrow \pi^0\pi^0\pi^0)}.$$

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

$\alpha = \frac{2\,\|s\|\,\|p\| \cos\Delta}{\|s\|^2 + \|p\|^2}$;	$\beta = \sqrt{1-\alpha^2}\sin\phi$;	g_A/g_V defined by $\langle B_f \|\gamma_\lambda (g_V - g_A\gamma_5)\| B_i \rangle$;
$\beta = \frac{-2\,\|s\|\,\|p\| \sin\Delta}{\|s\|^2 + \|p\|^2}$	$\gamma = \sqrt{1-\alpha^2}\cos\phi$.	δ defined by $g_A/g_V = \|g_A/g_V\| e^{i\delta}$.

n. The $K^0_S \rightarrow \pi\pi$ and $K^0_L \rightarrow \pi\pi$ rates (and branching fractions) are from independent fits and do not include results of K^0_L-K^0_S 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.

Meson Table

April 1974

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[1].

Quantities in italics have changed by more than one (old) standard deviation since April 1973.

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)
$\pi^\pm(140)$	$1^-(0^-)+$	139.57	0.0	0.019483	See Stable Particle Table			
$\pi^0(135)$		134.96	7.8 eV ±.9 eV	0.018217				
$\eta(549)$	$0^+(0^-)+$	548.8 ±0.6	2.63 keV ±.58 keV	0.301 ±.000	All neutral	71	See Stable Particle Table	
					$\pi^+\pi^-\pi^0 + \pi^+\pi^-\gamma$	29		
ε	$0^+(0^+)+$	$\lesssim 700$[c]	$\gtrsim 600$[c]		ππ			
Existence of pole not established. See note on ππ S wave¶.								
$\rho(770)$	$1^+(1^-)-$	770 ±10 §	150 ±10 §	0.593 ±.116	ππ	≈100		359
					e^+e^-	0.0043±.0005 (d)		385
					$\mu^+\mu^-$	0.0067±.0012 (d)		370
					For upper limits, see footnote (e)			
$\omega(783)$	$0^-(1^-)-$	*782.7* *±0.6* §	10.0 ±.4	0.613 ±.008	$\pi^+\pi^-\pi^0$	90.0±0.6	S=1.2*	327
					$\pi^+\pi^-$	1.3±0.3	S=1.5*	366
					$\pi^0\gamma$	8.7±0.5		380
					e^+e^-	0.0076±.0017	S=1.9*	391
					For upper limits, see footnote (g)			
$\eta'(958)$ or X^0	$0^+(\ ^-)+$ J=0 or 2	*957.6* *±0.3*	< 1	0.917 <.001	$\eta\pi\pi$	70.6±2.5	S=1.4*	234
					$\rho^0\gamma$	27.4±2.2	S=1.6*	458
					$\gamma\gamma$	1.9±0.3		479
					For upper limits, see footnote (h)			
$\delta(970)$	$1^-(0^+)+$	976 ±10 §	50 ±20 §	0.953 ±.049	ηπ	seen		315
					ρπ	< 25		139
Possibly a virtual bound state of the I = 1 $K\bar{K}$ system¶.								
$S^*(993)$	$0^+(0^+)+$	∿ 993[c] ±5	40[c] ±8	0.986 ±.040	$K\bar{K}$			near threshold
					ππ			479
See notes on ππ and $K\bar{K}$ S wave¶.								
$\Phi(1019)$	$0^-(1^-)-$	1019.7 ±0.3 S=1.9*	4.2 ±.2	1.040 ±.004	K^+K^-	46.6±2.5	S=1.6*	127
					K_LK_S	34.6±2.2	S=1.6*	111
					$\pi^+\pi^-\pi^0$ (incl. ρπ)	15.8±1.5	S=1.2*	462
					ηγ	3.0±1.1	S=1.6*	362
					e^+e^-	.032±.002	S=1.4*	510
					$\mu^+\mu^-$	.025±.003		499
					For upper limits, see footnote (i)			
$A_1(1100)$	$1^-(1^+)+$	∿ 1100	∿ 300	1.21 ±.33	ρπ	∿ 100		253
Broad enhancement in the $J^P=1^+$ σπ partial wave; not a Breit-Wigner resonance¶.								
B(1235)	$1^+(1^+)-$	1237 ±10 §	120 ±20 §	1.53 ±.12	ωπ	only mode seen		352
					[D/S amplitude ratio = .24±.06]			
					For upper limits, see footnote (j)			

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 $\pm\Gamma M^{(a)}$ $(\mathrm{GeV})^2$	Partial decay mode: Mode	Fraction (%) [Upper limits are 1σ (%)]	p or p_{max}[b] (MeV/c)
f(1270)	$0^+(2^+)+$	1270	170	1.61	$\pi\pi$	83±5§	619
		±10§	±30§	±.22	$2\pi^+2\pi^-$	4±1§	556
					$K\bar{K}$	4±3 S=1.5*	394
					For upper limits, see footnote (f)		
D(1285)	$0^+(A\ )+$	1286	30	1.65	$K\bar{K}\pi$	seen	305
		±10§	±20§	±.03	$\eta\pi\pi$	seen	484
					†[$\delta(970)\pi$	seen]	245
	$J^P = 0^-, 1^+, 2^-$, with 1^+ favoured				$2\pi^+2\pi^-$ (prob. $\rho^0\pi^+\pi^-$)	seen	565
$A_2(1310)$	$1^-(2^+)+$	1310	100	1.72	$\rho\pi$	71.5±1.8 S=1.2*	413
		±10§	±10§	±.13	$\eta\pi$	15.2±1.2	529
					$\omega\pi\pi$	8.6±1.8 S=1.3*	354
					$K\bar{K}$	4.7±0.6	428
					$\eta'(958)\pi$	<1	280
E(1420)	$0^+(A\ )+$	1416	60	2.01	$K\bar{K}\pi$	∿ 40	421
		±10§	±20§	±.08	†[$K^*\bar{K} + \bar{K}^*K$	∿ 20]	130
					$\eta\pi\pi$	∿ 60	564
					†[$\delta(970)\pi$	possibly seen]	352
f'(1514)	$0^+(2^+)+$	1516	40	2.29	$K\bar{K}$	only mode seen	572
		±3	±10	±.06			
					For upper limits, see footnote (k)		
$F_1(1540)$	$1\ (A\ )$	1540	40	2.37	$K^*\bar{K} + \bar{K}^*K$	only mode seen	321
		±5	±15	±.06			
Evidence based on only one experiment							
ρ'(1600)	$1^+(1^-)-$	∿ 1600	∿ 400	2.56	4π	dominant	738
				±.64	†[$\rho\pi^+\pi^-$	seen with $\pi^+\pi^-$ in S-wave]	575
					$\pi\pi$	possibly seen	788
					$K\bar{K}$	< 8	629
$A_3(1640)$	$1^-(2^-)+$	∿ 1640	∿ 300	2.69	$f\pi$		305
				±.49			
Broad enhancement in the $J^P = 2^-$ $f\pi$ partial wave; not a Breit-Wigner resonance.¶							
ω(1675)	$0^-(N\ )-$	1666	142	2.78	$\rho\pi$	seen	647
		±10§	±20§	±.24	3π	possibly seen	805
					5π	possibly seen	778
					†[$\omega\pi\pi$	possibly seen]	614
g(1680)	$1^+(3^-)-$	1686	180	2.84	2π	26±5§ (ℓ)	831
		±20§	±30§	±.30	4π (incl. $\pi\pi\rho, \rho\rho, A_2\pi, \omega\pi$)	∿ 70 (ℓ)	784
	J^P, M and Γ from the 2π mode[(ℓ)].				$K\bar{K}$	∿ 2 (ℓ)	680
					$K\bar{K}\pi$ (incl. $K^*\bar{K}$)	∿ 3 (ℓ)	621
See note (1) for possible heavier states.							
$K^+(494)$	$1/2(0^-)$	493.71		0.244	See Stable Particle Table		
$K^0(498)$		497.70		0.248			
$K^*(892)$	$1/2(1^-)$	892.2	49.8	0.796	$K\pi$	≈ 100	288
		±0.5	±1.1	±.044	$K\pi\pi$	< 0.2	216
					$K\gamma$	< 0.16	310
		(Charged mode; $m^0 - m^\pm = 6.1\pm1.5$ MeV)					

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)
κ	$\underline{1/2}(0^+)$	δ_0^1 goes slowly through 90° near 1300 MeV.					
See note on Kπ S wave¶.							
Q { $K_A(1240)$ or C	$1/2(1^+)$	1242 ±10	127 ±25	1.54 ±.16	Kππ	only mode seen	
		seen in $\bar{p}p$ at rest			†[K*π	large]	
$K_A(1280$ to $1400)$	$\underline{1/2}(1^+)$	1280 to 1400			†[Kρ	seen]	
See note (m).					†[$K(\pi\pi)_{\ell=0}$	possibly seen]	
$K^*(1420)$	$\underline{1/2}(2^+)$	1421§ ±5§	100§ ±10§	2.02 ±.14	Kπ	55.0±2.7	616
					K*π	29.5±2.5	414
					Kρ	9.2±2.4	319
		See note (n).			Kω	4.4±1.7	306
					Kη	2.0±2.0	482
L(1770)	$\underline{1/2}(A)$	1765§ ±10§	140§ ±50§	3.11 ±.25	Kππ	dominant	788
					Kπππ	seen	757
					†[K*(1420)π and other subreactions¶]		
	$J^P=2^-$ favoured, 1^+ and 3^+ not excluded.						

See note (1) for possible heavier states.

(1) Contents of Meson Data Card Listings

Non-strange (Y = 0) entry	$I^G(J^P)C_n$	entry	$I^G(J^P)C_n$	entry	$I^G(J^P)C_n$	Strange (|Y| = 1) entry	$I(J^P)$
π (140)	$1^-(0^-)+$	→ η_N (1080)	$0^+(N\ )+$	ρ′ (1600)	$1^+(1^-)-$	K (494)	$1/2(0^-)$
η (549)	$0^+(0^-)^+$	A_1 (1100)	$1^-(1^+)+$	A_3 (1640)	$1^-(2^-)+$	K* (892)	$1/2(1^-)$
ε (600)	$0^+(0^+)+$	→ M (1150)		ω (1675)	$0^-(N\ )-$	κ	$1/2(0^+)$
ρ (770)	$1^+(1^-)-$	→ $A_{1.5}$(1170)	1^-	g (1680)	$1^+(3^-)-$	Q	$1/2(1^+)$
ω (783)	$0^-(1^-)-$	B (1235)	$1^+(1^+)-$	→ X (1690)	−	K*(1420)	$1/2(2^+)$
→ M (940)		→ ρ′ (1250)	$1^+(1^-)-$	→ X (1795)	1	→ K_N(1660)	1/2
→ M (953)	+	f (1270)	$0^+(2^+)+$	→ S (1930)	1	→ K_N(1760)	1/2
η′ (958)	$0^+(0^-)+$	D (1285)	$0^+(A\ )+$	→ A_4 (1960)	1^-	L (1770)	1/2(A)
δ (970)	$1^-(0^+)+$	A_2 (1310)	$1^-(2^+)+$	→ ρ (2100)	1^+	→ K_N(1850)	
→ H (990)	$0^-(A\ )-$	E (1420)	$0^+(A\ )+$	→ T (2200)	1	→ K*(2200)	
S* (993)	$0^+(0^+)+$	→ X (1430)	0	→ ρ (2275)	1^+	→ K*(2800)	
φ (1019)	$0^-(1^-)-$	→ X (1440)	1	→ U (2360)	1		
→ M (1033)		f′ (1514)	$0^+(2^+)+$	→ $N\bar{N}$ (2375)	0	→ Exotics	
→ B_1(1040)	1^+	F_1 (1540)	1 (A)	→ X(2500-3600)			

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.

¶ 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 $(M - i\Gamma/2)$. For both ε and S^* the pole is on Riemann Sheet 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, $\Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times$ phase space correction.

(e) Empirical limits on fractions for other decay modes of $\rho(765)$ are $\pi^{\pm}\gamma < 0.5\%$, $\pi^{\pm}\eta < 0.8\%$, $\pi^+\pi^+\pi^-\pi^- < 0.15\%$, $\pi^{\pm}\pi^+\pi^-\pi^0 < 0.2\%$.

(f) Empirical limits on fractions for other decay modes of f(1270) are $\eta\pi\pi < 15\%$; $K^0K^-\pi^+$ + c.c. < 6%.

(g) 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%, $\mu^+\mu^- < 0.02\%$, $\pi^0\mu^+\mu^- < 0.2\%$, $\eta\gamma < 0.5\%$.

(h) Empirical limits on fractions for other decay modes of $\eta'(958)$: $\pi^+\pi^- < 2\%$, $\pi^+\pi^-\pi^0 < 5\%$, $\pi^+\pi^+\pi^-\pi^- < 1\%$, $\pi^+\pi^+\pi^-\pi^-\pi^0 < 1\%$, $6\pi < 1\%$, $\pi^+\pi^-e^+e^- < 0.6\%$, $\pi^0e^+e^- < 1.3\%$, $\eta e^+e^- < 1.1\%$, $\pi^0\rho^0 < 4\%$, $\pi^0\omega + \gamma\omega < 8\%$.

(i) Empirical limits on fractions for other decay modes of $\phi(1019)$ are $\pi^+\pi^- < 0.03\%$, $\pi^+\pi^-\gamma < 0.7\%$, $\omega\gamma < 5\%$, $\rho\gamma < 2\%$, $\pi^0\gamma < 0.35\%$, $2\pi^+2\pi^-\pi^0 < 1\%$.

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

(k) Empirical limits on fractions for other decay modes of f'(1514) are $\pi^+\pi^- < 20\%$, $\eta\eta < 50\%$, $\eta\pi\pi < 30\%$, $K\bar{K}\pi + K^*\bar{K} < 35\%$, $2\pi^+2\pi^- < 32\%$.

(ℓ) We assume as a working hypothesis that peaks with $I^G = 1^+$ observed around 1.7 GeV all come from g(1680). For indications to the contrary see Meson Data Card Listings.

(m) See Q-region note in Meson Data Card Listings. Some investigators see a broad enhancement in mass $(K\pi\pi)$ from 1250-1400 MeV (the Q region), and others see structure. The $K\eta$, $K\omega$, and $K\pi$ modes are less than a few percent.

(n) The tabulated mass of 1421 MeV comes from the $K\pi$ mode; the $K\pi\pi$ mode can be contaminated with diffractively produced $Q^{\pm}$.

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	$\theta_{lin.}$	$\theta_{quadr.}$
$(0^-)+$ or: $(0^-)+$	π, K, η; η' π, K, η; E	24 ± 1° 16 ± 1°	10 ± 1° 6 ± 1°
$(1^-)-$	ρ, K^*, ϕ; ω	36 ± 1°	39 ± 1°
$(2^+)+$	A_2, $K^*(1420)$, f'; f	29 ± 2°	31 ± 2°

Baryon Table

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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(1116)	P01	****	Σ(1193)	P11	****	Ξ(1317)	P11	****
N(1470)	P11	****	Δ(1650)	S31	****	Λ(1330)		Dead	Σ(1385)	P13	****	Ξ(1530)	P13	****
N(1520)	D13	****	Δ(1670)	D33	***	Λ(1405)	S01	****	Σ(1440)		Dead	Ξ(1630)		**
N(1535)	S11	****	Δ(1690)	P33	*	Λ(1520)	D03	****	Σ(1480)		*	Ξ(1820)		***
N(1670)	D15	****	Δ(1890)	F35	***	Λ(1670)	S01	****	Σ(1620)	S11	**	Ξ(1940)		***
N(1688)	F15	****	Δ(1900)	S31	*	Λ(1690)	D03	****	Σ(1620)	P11	**	Ξ(2030)		**
N(1700)	S11	****	Δ(1910)	P31	***	Λ(1750)	P01	**	Σ(1670)	D13	****	Ξ(2250)		*
N(1700)	D13	**	Δ(1950)	F37	****	Λ(1815)	F05	****	Σ(1670)		**	Ξ(2500)		**
N(1780)	P11	***	Δ(1960)	D35	**	Λ(1830)	D05	***	Σ(1690)		**			
N(1810)	P13	***	Δ(2160)		**	Λ(1860)	P03	**	Σ(1750)	S11	***	Ω(1672)	P03	****
N(1990)	F17	**	Δ(2420)	H311	***	Λ(1870)	S01	**	Σ(1765)	D15	****			
N(2000)	F15	**	Δ(2850)		***	Λ(2010)	D03	**	Σ(1840)	P13	*			
N(2040)	D13	**	Δ(3230)		***	Λ(2020)	F07	**	Σ(1880)	P11	**			
N(2100)	S11	*				Λ(2100)	G07	****	Σ(1915)	F15	****			
N(2100)	D15	*	Z0(1780)	P01	*	Λ(2110)	?05	*	Σ(1940)	D13	***			
N(2190)	G17	***	Z0(1865)	D03	*	Λ(2350)		****	Σ(2000)	S11	*			
N(2220)	H19	***	Z1(1900)	P13	*	Λ(2585)		***	Σ(2030)	F17	****			
N(2650)		***	Z1(2150)		*				Σ(2070)	F15	*			
N(3030)		***	Z1(2500)		*				Σ(2080)	P13	**			
N(3245)		*							Σ(2100)	G17	**			
N(3690)		*							Σ(2250)		****			
N(3755)		*							Σ(2455)		***			
									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, on possible Z^*'s, and on Y^*'s and Ξ^*'s 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: Mode	Fraction %	p or p_{max}[d] (MeV/c)
p n	1/2(1/2$^+$)		938.3 939.6		0.880 0.883	See Stable Particle Table		
N(1470)	1/2(1/2$^+$) P'_{11}	p = 0.66 σ = 27.8	1400 to 1470	165 to 300 (250)	2.16 ±0.37	Nπ	~60	420
						Nη	~9	d
						Nππ	~35	368
						[Nε	~6][e]	d
						[Δπ	~16][e]	177
						[Nρ	<5][e]	d
						pγ[f]	0.12-0.32	435
						nγ[f]	<0.24	435
N(1520)	1/2(3/2$^-$) D'_{13}	p = 0.74 σ = 23.5	1510 to 1540	105 to 150 (125)	2.31 ±0.19	Nπ	~55	456
						Nππ	~45	410
						[Nε	<5][e]	d
						[Nρ	~18][e]	d
						[Δπ	~23][e]	228
						Nη	0.2-1.4	d
						pγ[f]	0.57-0.79	471
						nγ[f]	0.36-0.56	471
N(1535)	1/2(1/2$^-$) S'_{11}	p = 0.76 σ = 22.5	1500 to 1600	50 to 160 (100)	2.36 ±0.15	Nπ	~35	467
						Nη	~55	182
						Nππ	~10	422
						[Nρ	~2][e]	d
						[Nε	~2][e]	d
						pγ[f]	0.04-0.32	481
						nγ	0.04-0.12	481

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: Mode	Fraction %	p or p_{max}[d] (MeV/c)
N(1670)[g]	1/2($5/2^-$)D'_{15}	p = 1.00	1670 to	115 to	2.79	$N\pi$	~40	560
		σ = 15.6	1685	175	±0.23	$N\pi\pi$	~60	525
				(140)		[$\Delta\pi$	~50][e]	360
						ΛK	<1	200
						$N\eta$	<1[h]	368
						$p\gamma$[f]	<0.04	572
						$n\gamma$[f]	0.01-0.13	572
N(1688)[g]	1/2($5/2^+$)F'_{15}	p = 1.03	1680 to	105 to	2.85	$N\pi$	~60	572
		σ = 14.9	1690	180	±0.24	$N\pi\pi$	~40	538
				(140)		[$N\epsilon$	~13][e]	340
						[$N\rho$	~12][e]	d
						[$\Delta\pi$	~11][e]	375
						ΛK	<0.1	231
						$N\eta$	<0.3[h]	388
						$p\gamma$[f]	0.20-0.44	583
						$n\gamma$[f]	<0.04	583
N(1700)[g]	1/2($1/2^-$)S''_{11}	p = 1.05	1665 to	100 to	2.89	$N\pi$	~55	580
		σ = 14.3	1765	300	±0.34	$N\pi\pi$	~25	547
				(200)		[$N\epsilon$	~10][e]	355
						[$N\rho$	~10][e]	d
						[$\Delta\pi$	~7][e]	385
						ΛK	~5	250
						ΣK	<3	109
						$N\eta$	~3[h]	340
						$p\gamma$[f]	<0.24	591
						$n\gamma$[f]	<0.24	591
N(1780)[g]	1/2($1/2^+$)P''_{11}	p = 1.20	1650 to	50 to	3.17	$N\pi$	~20	633
		σ = 12.2	1860	350	±0.36	$N\pi\pi$	>40	603
				(200)		[$N\epsilon$	16-40][e]	440
						[$N\rho$	20-45][e]	249
						[$\Delta\pi$	8-20][e]	448
						ΛK	<7	353
						ΣK	~7	267
						$N\eta$	2-20[h]	476
						$p\gamma$[f]	<0.08	643
						$n\gamma$[f]	<0.08	643
N(1810)	1/2($3/2^+$)P_{13}	p = 1.26	1770 to	180 to	3.28	$N\pi$	~25	652
		σ = 11.5	1860	330	±0.45	$N\pi\pi$	>50	624
				(250)		[$N\rho$	45-55][e]	297
						ΛK	~5	386
						$N\eta$	~4[h]	503
N(2190)	1/2($7/2^-$)G_{17}	p = 2.07	2000 to	150 to	4.80	$N\pi$	~25	888
		σ = 6.21	2260	325	±0.55			
				(250)				
N(2220)	1/2($9/2^+$)H_{19}	p = 2.14	2200 to	260 to	4.93	$N\pi$	~15	905
		σ = 5.97	2245	330	±0.67			
				(300)				
N(2650)	1/2($?^-$)	p = 3.26	~2650	~360	7.02	$N\pi$	(J+1/2)x	1154
		σ = 3.67		(360)	±0.95		~0.45[j]	
N(3030)	1/2(?)	p = 4.41	~3030	~400	9.18	$N\pi$	(J+1/2)x	1366
		σ = 2.62		(400)	±1.21		~0.05[j]	
Δ(1232)[k]	3/2($3/2^+$)P'_{33}	p = 0.30	1230 to	110 to	1.52	$N\pi$	~99.4	227
		σ = 94.3	1236	122	±0.14	$N\pi^+\pi^-$	~0	80
				(110)		$p\gamma$[f]	0.70-0.74	259
	Δ(++) Pole position:[k] $M-i\Gamma/2 = (1211.6\pm0.7) - i(49.4\pm1.7)$							
Δ(1650)	3/2($1/2^-$)S'_{31}	p=0.96	1615 to	140 to	2.72	$N\pi$	~30	547
		σ =16.4	1695	200	±0.23	$N\pi\pi$	~70	511
				(140)		[$N\rho$	10-26][e]	d
						[$\Delta\pi$	~50][e]	344
						$p\gamma$[f]	0.02-0.034	558

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 Mode	 Fraction %	 p or p_{max}[d] (MeV/c)
Δ(1670)	$3/2(3/2^-)D_{33}$	p = 1.00 σ = 15.6	1650 to 1720	190 to 270 (260)	2.79 ±0.43	Nπ Nππ [Nρ [Δπ $p\gamma^f$	~15 >60 ~30][e] ~40][e] 0.1-0.7	560 525 d 361 572
Δ(1890)	$3/2(5/2^+)F_{35}$	p = 1.42 σ = 9.88	1840 to 1920	140 to 350 (250)	3.57 ±0.47	Nπ Nππ [Nρ [Δπ ΣK $p\gamma^f$	~17 >50 40-60][e] 8-20][e] <3 <0.3	704 677 403 531 400 712
Δ(1910)	$3/2(1/2^+)P_{31}$	p = 1.46 σ = 9.54	1780 to 1935	200 to 340 (300)	3.65 ±0.57	Nπ Nππ [Nρ [Δπ ΣK	~25 ? small][e] small][e] ~6	716 691 429 545 420
Δ(1950)	$3/2(7/2^+)F_{37}$	p = 1.54 σ = 8.90	1930 to 1980	170 to 270 (230)	3.80 ±0.45	Nπ Nππ [Nρ [Δπ ΣK Σ(1385)K $p\gamma^f$	~40 >25 8-14][e] 16-26][e] ~2 ~1.4 0.16-0.34	741 716 471 574 460 232 749
Δ(2420)	$3/2(11/2^+)$	p = 2.64 σ = 4.68	2320 to 2450	250 to 350 (300)	5.86 ±0.73	Nπ Nππ	~11 >20	1023 1006
Δ(2850)	$3/2(\ ?^+\ )$	p = 3.85 σ = 3.05	~2850	~400 (400)	8.12 ±1.14	Nπ	(J+1/2)x ~0.25[j]	1266
Δ(3230)	3/2(?)	p = 5.08 σ = 2.25	~3230	~440 (440)	10.43 ±1.42	Nπ	(J+1/2)x ~0.05[j]	1475
Z*	Evidence for states with strangeness +1 is controversial. See the Baryon Data Card listings for discussion and display of data.							
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[ℓ]	40±10[ℓ] (40)	1.97 ±0.06	Σπ	100	142
Λ(1520)	$0(3/2^-)D'_{03}$	p = 0.389 σ = 84.5	1518 ±2[ℓ]	16 ±2[ℓ] (16)	2.31 ±0.02	$N\bar{K}$ Σπ Λππ Σππ	45±1 41±1 10±.5 .8±.1	234 258 250 140
Λ(1670)	$0(1/2^-)S''_{01}$	p = 0.74 σ = 28.5	1660 to 1680	23 to 40 (35)	2.79 ±0.06	$N\bar{K}$ Λη Σπ	15-35 15-25 30-50	410 64 393
Λ(1690)	$0(3/2^-)D''_{03}$	p = 0.78 σ = 26.1	1690 ±10[ℓ]	30 to 70 (60)	2.86 ±0.10	$N\bar{K}$ Σπ Λππ Σππ	20-30 30-50 <25 <25	429 409 415 352
Λ(1815)	$0(5/2^+)F'_{05}$	p = 1.05 σ = 16.7	1820 ±5[ℓ]	70 to 100 (85)	3.29 ±0.15	$N\bar{K}$ Σπ Σ(1385)π	~61 ~11 15-20	542 508 362
Λ(1830)	$0(5/2^-)D'_{05}$	p = 1.09 σ = 15.8	1810 to 1840	70 to 120 (95)	3.35 ±0.17	$N\bar{K}$ Σπ Λη	~10 20-60 ~2	554 519 367
Λ(2100)	$0(7/2^-)G_{07}$	p = 1.68 σ = 8.68	2090 to 2120	80 to 140 (120)	4.41 ±0.25	$N\bar{K}$ Σπ Λη ΞK Λω	~30 ~5 <3 <3 <3	748 699 617 483 443

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: Mode	Fraction %	p or p_{max}[d] (MeV/c)
Λ(2350)	0(?)	p = 2.29 σ = 5.85	~2350	140 to 320 (240)	5.52 ±0.56	$N\bar{K}$	(J+1/2)x ~0.9[j]	913
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[j]	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	(+)1383±1 S=1.2[m] (-)1387±1 S=2.4[m]	(+)35±2 S=2.0[m] (-)42±5 S=3.5[m] (35)	1.92 ±0.05	Λπ Σπ	88±2 12±2	208 117
Σ(1670)[n]	$1(3/2^-)D'_{13}$	p = 0.74 σ = 28.5	1670 ±10[ℓ]	35 to 60 (50)	2.79 ±0.08	$N\bar{K}$ Σπ Λπ	~8 30-60 ~12	410 387 447
Σ(1750)	$1(1/2^-)S''_{11}$	p = 0.91 σ = 20.7	1700 to 1790	50 to 100 (75)	3.06 ±0.13	$N\bar{K}$ Λπ Σπ Ση	12-45 5-18 6-19 11-44	483 507 450 54
Σ(1765)	$1(5/2^-)D_{15}$	p = 0.94 σ = 19.6	1765 ±5[ℓ]	~120 (120)	3.12 ±0.21	$N\bar{K}$ Λπ Λ(1520)π Σ(1385)π Σπ	~41 ~13 ~15 ~10 ~1	496 518 187 315 461
Σ(1915)[g,o]	$1(5/2^+)F'_{15}$	p = 1.25 σ = 13.0	1900 to 1930	50 to 120 (80)	3.67 ±0.15	$N\bar{K}$ Λπ Σπ	~14 ~6 ~6	612 619 568
Σ(1940)[i]	$1(3/2^-)D''_{13}$	p = 1.32 σ = 12.0	1865 to 1950	110 to 280 (220)	3.76 ±0.43	$N\bar{K}$ Λπ Σπ	~21 ~4 < 7	678 680 589
Σ(2030)	$1(7/2^+)F_{17}$	p = 1.52 σ = 9.93	2020 to 2040	120 to 170 (140)	4.12 ±0.28	$N\bar{K}$ Λπ Σπ ΞK	~20 ~20 ~4 < 2	700 700 652 412
Σ(2250)	1(?)	p = 2.04 σ = 6.76	2245 to 2280	100 to 230 (160)	5.06 ±0.36	$N\bar{K}$	(J+1/2)x ~0.3[j]	849
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[j]	979
Σ(2620)	1(?)	p = 2.95 σ = 4.30	~2620	~175 (175)	6.86 ±0.46	$N\bar{K}$	(J+1/2)x ~0.3[j]	1064
Ξ	$1/2(1/2^+)$		(0)1314.9 (-)1321.3		1.729 1.746	See Stable Particle Table		
Ξ(1530)[p]	$1/2(3/2^+)P_{13}$		(0)1531.8±0.3 S=1.3[m] (-)1535.1±0.7	(0) 9.1±0.5 (-) 10.6±2.6 (10)	2.34 ±0.02	Ξπ	100	144
Ξ(1820)[p,q]	1/2(?)		1795 to 1870	12 to 100 (60)	3.31 ±0.11	$\Lambda\bar{K}$ $\Sigma\bar{K}$ Ξπ Ξ(1530)π	seen seen seen seen	396 306 413 234
Ξ(1940)[p,r]	1/2(?)		1920 to 1960	40 to 140 (90)	3.76 ±0.17	Ξπ Ξ(1530)π	seen seen	499 336
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 a rounded average of the reported values in the Data Card Listings. The convention for using primes in the spectroscopic notation for the quantum numbers in Col. 2 [such as P'_{11}] is as follows: no prime is attached when the Data Card Listings include only one resonance on the given Argand diagram; 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.

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 M and Γ of most baryons we report here an interval 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. 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 give 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. In the case of N^* and Δ decays into isobar modes we have used the isobar model results of HERNDON 74 in addition to data from the listings (where available) to estimate the branching fractions. The results of HERNDON 74 are shown in Table III.1 of the mini-review preceding the N^* Data Card Listings.

f. The tabulated radiative fractions involve a sum over two helicities (1/2, 3/2). In the case of I = 1/2 resonances, there are two distinct isospin couplings, whence γp and γn. For conventions and further details, 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 experiments results see the Baryon Data Card Listings.

h. Value obtained in an energy-dependent partial-wave analysis which uses a t-channel-poles-plus-resonance parametrization.

i. There may be more than one state in this region. The only analysis which reports an elastic coupling (LEA 73) also finds unusually low mass and width values. Note that all branching fractions quoted here depend on the elasticity of LEA 73.

j. This state has been seen only in total cross sections. J is not known; x is Γ_{el}/Γ.

k. See note on $\Delta(1232)$ in the Baryon Data Card Listings. Values of mass and width are dependent upon resonance shape used to fit the data. The pole position appear to be much less dependent upon the parametrization used.

ℓ. 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).

m. Quoted error includes an S (scale) factor. See first footnote to Stable Particle Table.

n. In this energy region the situation is still confused. In addition to the effect at ~ 1670 MeV seen in both production and formation experiments, recent formation experiments have found evidence for fairly narrow ($\Gamma \sim 50$ MeV) S_{11} and/or P_{11} states near 1620 MeV. A narrow bump in the I = 1 $\bar{K}N$ total cross section has also been seen recently at ~ 1590 MeV. It is not clear how many states really exist here. No one has reported a strong coupling of any of these states to $\bar{K}N$ but there is much disagreement about branching ratios into $\pi\Lambda$ and $\pi\Sigma$. See the mini-reviews preceding the $\Sigma(1620)$ and $\Sigma(1670)$ Data Card Listings for more information.

o. Formation and production experiments do not agree on the $\Sigma\pi/\Lambda\pi$ ratio.

p. Only $\Xi(1530)$ is firmly established; information on the other states comes from experiments that have poor statistics due to the fact that the cross sections for S = - 2 states are very low. For Ξ states, because of the meager statistics, we lower our standards and tabulate resonant effects if they have at least a four-standard-deviation statistical significance and if they are seen by more than one group. So $\Xi(2030)$, with main decay mode $\Sigma\bar{K}$, reported as a 3.5-standard-deviation effect is not tabulated. See the Baryon Data Card Listings for the other states.

q. All four decay modes shown have been seen. Branching ratios are not quoted because there may be more than one state here.

r. This bump has been seen in both final states shown; it is not clear if one, or more, states are present.

PHYSICAL AND NUMERCAL CONSTANTS*

PHYSICAL CONSTANTS

		Uncert. (ppm)
N	$= 6.022045(31)\times 10^{23}$ mole^{-1}	5.1
c	$= 2.99792458(1.2)\times 10^{10}$ cm sec^{-1}	0.004
e	$= 4.803242(14)\times 10^{-10}$ esu $= 1.6021892(46)\times 10^{-19}$ coulomb	2.9; 2.9
1 MeV	$= 1.6021892(46)\times 10^{-6}$ erg	2.9
$\hbar = h/2\pi$	$= 6.582173(17)\times 10^{-22}$ MeV sec $= 1.0545887(57)\times 10^{-27}$ erg sec	2.6; 5.4
$\hbar c$	$= 1.9732857(51)\times 10^{-11}$ MeV cm $= 197.32857(51)$ MeV Fermi	2.6; 2.6
	$= 0.6240078(16)$ GeV mb$^{1/2}$	2.6
α	$= e^2/\hbar c = 1/137.03604(11)$	0.82
$k_{\text{Boltzmann}}$	$= 1.380662(44)\times 10^{-16}$ erg °K^{-1}	32
	$= 8.61735(27)\times 10^{-11}$ MeV °K^{-1} = 1 eV/11604.50(36)°K	31; 31
m_e	$= 0.5110034(14)$ MeV $= 9.109534(47)\times 10^{-31}$ kg	2.8; 5.1
m_p	$= 938.2796(27)$ MeV $= 1836.15152(70) m_e = 6.72270(31)\, m_{\pi^\pm}$	2.8; 0.38; 46
	$= 1.007276470(11) m_1$ ($m_1 \equiv 1$ amu$=\frac{1}{12} m_{C^{12}} = 931.5016(26)$ MeV	0.011
m_d	$= 1875.628(5)$ MeV	3
r_e	$= e^2/m_e c^2 = 2.8179380(70)$ fermi (1 fermi $= 10^{-13}$ cm)	2.5
$\lambda\!\!\!^{-}_e$	$= \hbar/m_e c = r_e \alpha^{-1} = 3.8615905(64)\times 10^{-11}$ cm	1.6
$a_{\infty\text{Bohr}}$	$= \hbar^2/m_e e^2 = r_e \alpha^{-2} = 0.52917706(44)$A (1A $= 10^{-8}$ cm)	0.82
σ_{Thompson}	$= \frac{8}{3}\pi r_e^2 = 0.6652448(33)\times 10^{-24}$ cm^2 (10^{-24} cm^2 = 1 barn)	4.9
μ_{Bohr}	$= e\hbar/2m_e c = 0.57883785(95)\times 10^{-14}$ MeV gauss^{-1}	1.6
μ_{nucleon}	$= e\hbar/2m_p c = 3.1524515(53)\times 10^{-18}$ MeV gauss^{-1}	1.7
$\frac{1}{2}\omega^e_{\text{cyclotron}}$	$= e/2m_e c = 8.794023(25)\times 10^{6}$ rad sec^{-1} gauss^{-1}	2.8
$\frac{1}{2}\omega^p_{\text{cyclotron}}$	$= e/2m_p c = 4.789378(13)\times 10^{3}$ rad sec^{-1} gauss^{-1}	2.8

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

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

$R_\infty = m_e e^4/2\hbar^2 = m_e c^2\alpha^2/2 = 13.605804(36)$ eV (Rydberg) 2.6

$pc = 0.3\ H\rho$ (MeV, kilogauss, cm); 0.3 (which is $10^{-11}c$) enters because there are ≈300 practical volts/esu volt.

1 year (sidereal)	= 365.256 days $= 3.1558\times 10^{7}$ sec ($\approx\pi\times 10^{7}$ sec)
density of dry air	= 1.205 mg cm^{-3} (at 20°C, 760 mm)
acceleration by gravity	= 980.62 cm sec^{-2} (sea level, 45°)
gravitational constant	$= 6.6732(31)\times 10^{-8}$ cm^{3}g^{-1} sec^{-2}
1 calorie (thermochemical)	= 4.184 joules
1 atomosphere	= 1033.2275 g cm^{-2} = 1.01325 bar
1 eV per particle	= 11604.50(36) °K (from E = kT)

NUMERICAL CONSTANTS

π	= 3.1415927	1 rad	= 57.2957795 deg	$\sqrt{\pi}$	= 1.7724539
e	= 2.7182818	$1/e$	= 0.3678794	$\sqrt{2}$	= 1.4142136
ln2	= 0.6931472	ln10	= 2.3025851	$\sqrt{3}$	= 1.7320508
$\log_{10}2$	= 0.3010300	$\log_{10}e$	= 0.4342945	$\sqrt{10}$	= 3.1622777

*Prepared by Stanley J. Brodsky, based mainly on the adjustment of the fundamental physical constants by E. R. Cohen and B. N. Taylor, J. Phys. Chem. Ref. Data 2, 663 (1973). The figures in parentheses correspond to the 1 standard deviation uncertainty in the last digits of the main number. (Updated April 1974.)

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:

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

1/2 × 1/2

m_1 m_2	J=1, M=+1
+1/2 +1/2	1

m_1 m_2	1, 0	0, 0
+1/2 -1/2	1/2	1/2
-1/2 +1/2	1/2	-1/2

m_1 m_2	1, -1
-1/2 -1/2	1

1 × 1/2

m_1 m_2	3/2, +3/2
+1 +1/2	1

m_1 m_2	3/2, +1/2	1/2, +1/2
+1 -1/2	1/3	2/3
0 +1/2	2/3	-1/3

m_1 m_2	3/2, -1/2	1/2, -1/2
0 -1/2	2/3	1/3
-1 +1/2	1/3	-2/3

m_1 m_2	3/2, -3/2
-1 -1/2	1

2 × 1

m_1 m_2	3, +3
+2 +1	1

m_1 m_2	3, +2	2, +2
+2 0	1/3	2/3
+1 +1	2/3	-1/3

m_1 m_2	3, +1	2, +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

m_1 m_2	3, 0	2, 0	1, 0
+1 -1	1/5	1/2	3/10
0 0	3/5	0	-2/5
-1 +1	1/5	-1/2	3/10

m_1 m_2	3, -1	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

m_1 m_2	3, -2	2, -2
-1 -1	2/3	1/3
-2 0	1/3	-2/3

m_1 m_2	3, -3
-2 -1	1

1 × 1

m_1 m_2	2, +2
+1 +1	1

m_1 m_2	2, +1	1, +1
+1 0	1/2	1/2
0 +1	1/2	-1/2

m_1 m_2	2, 0	1, 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

m_1 m_2	2, -1	1, -1
0 -1	1/2	1/2
-1 0	1/2	-1/2

m_1 m_2	2, -2
-1 -1	1

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

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

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

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

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

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

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

2 × 1/2

m_1 m_2	5/2, +5/2
+2 1/2	1

m_1 m_2	5/2, +3/2	3/2, +3/2
+2 -1/2	1/5	4/5
+1 +1/2	4/5	-1/5

m_1 m_2	5/2, +1/2	3/2, +1/2
+1 -1/2	2/5	3/5
0 +1/2	3/5	-2/5

m_1 m_2	5/2, -1/2	3/2, -1/2
0 -1/2	3/5	2/5
-1 +1/2	2/5	-3/5

m_1 m_2	5/2, -3/2	3/2, -3/2
-1 -1/2	4/5	1/5
-2 +1/2	1/5	-4/5

m_1 m_2	5/2, -5/2
-2 -1/2	1

3/2 × 1/2

m_1 m_2	2, +2
+3/2 +1/2	1

m_1 m_2	2, +1	1, +1
+3/2 -1/2	1/4	3/4
+1/2 +1/2	3/4	-1/4

m_1 m_2	2, 0	1, 0
+1/2 -1/2	1/2	1/2
-1/2 +1/2	1/2	-1/2

m_1 m_2	2, -1	1, -1
-1/2 -1/2	3/4	1/4
-3/2 +1/2	1/4	-3/4

m_1 m_2	2, -2
-3/2 -1/2	1

3/2 × 1

m_1 m_2	5/2, +5/2
+3/2 +1	1

m_1 m_2	5/2, +3/2	3/2, +3/2
+3/2 0	2/5	3/5
+1/2 +1	3/5	-2/5

m_1 m_2	5/2, +1/2	3/2, +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

m_1 m_2	5/2, -1/2	3/2, -1/2	1/2, -1/2
+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

m_1 m_2	5/2, -3/2	3/2, -3/2
-1/2 -1	3/5	2/5
-3/2 0	2/5	-3/5

m_1 m_2	5/2, -5/2
-3/2 -1	1

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

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

3/2 × 3/2

m_1 m_2	3, +3
+3/2 +3/2	1

m_1 m_2	3, +2	2, +2
+3/2 +1/2	1/2	1/2
+1/2 +3/2	1/2	-1/2

m_1 m_2	3, +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

m_1 m_2	3, 0	2, 0	1, 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

m_1 m_2	3, -1	2, -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

m_1 m_2	3, -2	2, -2
-1/2 -3/2	1/2	1/2
-3/2 -1/2	1/2	-1/2

m_1 m_2	3, -3
-3/2 -3/2	1

2 × 3/2

m_1 m_2	7/2, +7/2
+2 +3/2	1

m_1 m_2	7/2, +5/2	5/2, +5/2
+2 +1/2	3/7	4/7
+1 +3/2	4/7	-3/7

m_1 m_2	7/2, +3/2	5/2, +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

m_1 m_2	7/2, +1/2	5/2, +1/2	3/2, +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

m_1 m_2	7/2, -1/2	5/2, -1/2	3/2, -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

m_1 m_2	7/2, -3/2	5/2, -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

m_1 m_2	7/2, -5/2	5/2, -5/2
-1 -3/2	4/7	3/7
-2 -1/2	3/7	-4/7

m_1 m_2	7/2, -7/2
-2 -3/2	1

2 × 2

m_1 m_2	4, +4
+2 +2	1

m_1 m_2	4, +3	3, +3
+2 +1	1/2	1/2
+1 +2	1/2	-1/2

m_1 m_2	4, +2	3, +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

m_1 m_2	4, +1	3, +1	2, +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

m_1 m_2	4, 0	3, 0	2, 0	1, 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

m_1 m_2	4, -1	3, -1	2, -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

m_1 m_2	4, -2	3, -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

m_1 m_2	4, -3	3, -3
-1 -2	1/2	1/2
-2 -1	1/2	-1/2

m_1 m_2	4, -4
-2 -2	1

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

$$d^1_{1,1} = \frac{1+\cos\theta}{2} \qquad d^1_{10} = -\frac{\sin\theta}{\sqrt{2}}$$

$$d^1_{1-1} = \frac{1-\cos\theta}{2}$$

$$d^1_{00} = \cos\theta$$

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

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

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

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

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

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

$$d^2_{2,2} = \left(\frac{1+\cos\theta}{2}\right)^2$$

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

$$d^2_{20} = \frac{\sqrt{6}}{4}\sin^2\theta$$

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

$$d^2_{2,-2} = \left(\frac{1-\cos\theta}{2}\right)^2$$

$$d^2_{1,1} = \frac{1+\cos\theta}{2}(2\cos\theta-1)$$

$$d^2_{10} = -\sqrt{\frac{3}{2}}\sin\theta\cos\theta$$

$$d^2_{1,-1} = \frac{1-\cos\theta}{2}(2\cos\theta+1)$$

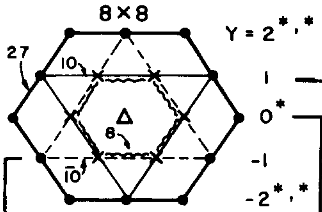
$$d^2_{00} = \left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$$

Sign convention is that of Wigner (Group Theory, Academic Press, New York, 1959), also used by Condon and Shortley (The Theory of Atomic Spectra, Cambridge Univ. Press, New York, 1953), Rose (Elementary Theory of Angular Momentum, Wiley, New York, 1957), and Cohen (Tables of the Clebsch-Gordan Coefficients, Atomics International, Canoga Park, Calif., 1958). Note that the widely reproduced tables of Cohen have several typographical mistakes. The signs and numbers in the current tables have been calculated by computer programs written independently by Cohen and at LBL. **(Table extended 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

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

ξ_1	$\underset{+}{27}$	$\underset{+}{8}_D$	$\underset{-}{8}_F$	$\underset{-}{10^*}$
$N\pi$	$\sqrt{5}/10$	$3\sqrt{5}/10$	$1/2$	$-1/2$
ΣK	$-\sqrt{5}/10$	$-3\sqrt{5}/10$	$1/2$	$-1/2$
$N\eta$	$3\sqrt{5}/10$	$-\sqrt{5}/10$	$1/2$	$1/2$
ΛK	$3\sqrt{5}/10$	$-\sqrt{5}/10$	$-1/2$	$-1/2$

$Y = 1 \quad I = 3/2$ Δ

ξ_1	$\underset{+}{27}$	$\underset{-}{10}$
$N\pi$	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΣK	$\sqrt{2}/2$	$\sqrt{2}/2$

$Y = 0 \quad I = 0$ Λ

ξ_1	$\underset{+}{27}$	$\underset{+}{8}_D$	$\underset{+}{1}$	$\underset{-}{8}_F$
$N\bar{K}$	$\sqrt{15}/10$	$\sqrt{10}/10$	$1/2$	$\sqrt{2}/2$
ΞK	$-\sqrt{15}/10$	$-\sqrt{10}/10$	$-1/2$	$\sqrt{2}/2$
$\Sigma\pi$	$-\sqrt{10}/20$	$-\sqrt{15}/5$	$\sqrt{6}/4$	0
$\Lambda\eta$	$3\sqrt{30}/20$	$-\sqrt{5}/5$	$-\sqrt{2}/4$	0

$Y = 0 \quad I = 1$ Σ

ξ_1	$\underset{+}{27}$	$\underset{+}{8}_D$	$\underset{-}{8}_F$	$\underset{-}{10}$	$\underset{-}{10^*}$
$N\bar{K}$	$\sqrt{5}/5$	$-\sqrt{30}/10$	$\sqrt{6}/6$	$-\sqrt{6}/6$	$\sqrt{6}/6$
ΞK	$\sqrt{5}/5$	$-\sqrt{30}/10$	$-\sqrt{6}/6$	$\sqrt{6}/6$	$-\sqrt{6}/6$
$\Sigma\pi$	0	0	$\sqrt{6}/3$	$\sqrt{6}/6$	$-\sqrt{6}/6$
$\Sigma\eta$	$\sqrt{30}/10$	$\sqrt{5}/5$	0	$1/2$	$1/2$
$\Lambda\pi$	$\sqrt{30}/10$	$\sqrt{5}/5$	0	$-1/2$	$-1/2$

$Y = -1 \quad I = 1/2$ Ξ

ξ_1	$\underset{+}{27}$	$\underset{+}{8}_D$	$\underset{-}{8}_F$	$\underset{-}{10}$
$\Xi\pi$	$-\sqrt{5}/10$	$-3\sqrt{5}/10$	$1/2$	$1/2$
$\Sigma\bar{K}$	$\sqrt{5}/10$	$3\sqrt{5}/10$	$1/2$	$1/2$
$\Xi\eta$	$3\sqrt{5}/10$	$-\sqrt{5}/10$	$-1/2$	$1/2$
$\Lambda\bar{K}$	$3\sqrt{5}/10$	$-\sqrt{5}/10$	$1/2$	$-1/2$

$Y = -1 \quad I = 3/2$

ξ_1	$\underset{+}{27}$	$\underset{-}{10^*}$
$\Xi\pi$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Sigma\bar{K}$	$\sqrt{2}/2$	$\sqrt{2}/2$

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.

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

ξ_1	$\underset{-}{27}$	$\underset{+}{8}$
$\Delta\pi$	$-\sqrt{5}/5$	$-2\sqrt{5}/5$
ΣK	$-2\sqrt{5}/5$	$\sqrt{5}/5$

$Y = 1 \quad I = 3/2$ Δ

ξ_1	$\underset{+}{35}$	$\underset{-}{27}$	$\underset{-}{10}$
$\Delta\pi$	$1/4$	$-\sqrt{5}/4$	$\sqrt{10}/4$
$\Delta\eta$	$\sqrt{5}/4$	$3/4$	$\sqrt{2}/4$
ΣK	$\sqrt{10}/4$	$-\sqrt{2}/4$	$-1/2$

$Y = 0 \quad I = 0$ Λ

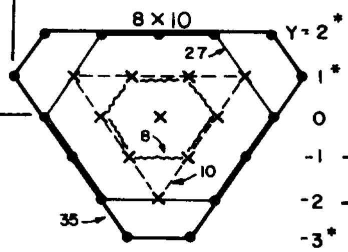
ξ_1	$\underset{-}{27}$	$\underset{+}{8}$
$\Sigma\pi$	$-\sqrt{10}/5$	$-\sqrt{15}/5$
ΞK	$-\sqrt{15}/5$	$\sqrt{10}/5$

$Y = 0 \quad I = 1$ Σ

ξ_1	$\underset{+}{35}$	$\underset{-}{27}$	$\underset{-}{10}$	$\underset{+}{8}$
$\Sigma\pi$	$\sqrt{3}/6$	$-3\sqrt{5}/10$	$\sqrt{3}/3$	$-\sqrt{30}/15$
$\Sigma\eta$	$\sqrt{2}/2$	$\sqrt{30}/10$	0	$-\sqrt{5}/5$
ΞK	$\sqrt{3}/3$	$-\sqrt{5}/5$	$-\sqrt{3}/3$	$\sqrt{30}/15$
$\Delta\bar{K}$	$\sqrt{3}/6$	$\sqrt{5}/10$	$\sqrt{3}/3$	$2\sqrt{30}/15$

$Y = 0 \quad I = 2$

ξ_1	$\underset{+}{35}$	$\underset{-}{27}$
$\Sigma\pi$	$\sqrt{3}/2$	$-1/2$
$\Delta\bar{K}$	$1/2$	$\sqrt{3}/2$



Multiplicity of 35;
● = 1, × = 2

$Y = -1 \quad I = 1/2$ Ξ

ξ_1	$\underset{+}{35}$	$\underset{-}{27}$	$\underset{-}{10}$	$\underset{+}{8}$
$\Xi\pi$	$1/4$	$-7\sqrt{5}/20$	$\sqrt{2}/4$	$-\sqrt{5}/5$
$\Xi\eta$	$3/4$	$3\sqrt{5}/20$	$-\sqrt{2}/4$	$-\sqrt{5}/5$
ΩK	$\sqrt{2}/4$	$-3\sqrt{10}/20$	$-1/2$	$\sqrt{10}/5$
$\Sigma\bar{K}$	$1/2$	$\sqrt{5}/10$	$\sqrt{2}/2$	$\sqrt{5}/5$

$Y = -1 \quad I = 3/2$

ξ_1	$\underset{+}{35}$	$\underset{-}{27}$
$\Xi\pi$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Sigma\bar{K}$	$\sqrt{2}/2$	$\sqrt{2}/2$

$Y = -2 \quad I = 0$ Ω^-

ξ_1	$\underset{+}{35}$	$\underset{-}{10}$
$\Omega\eta$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Xi\bar{K}$	$\sqrt{2}/2$	$\sqrt{2}/2$

$Y = -2 \quad I = 1$

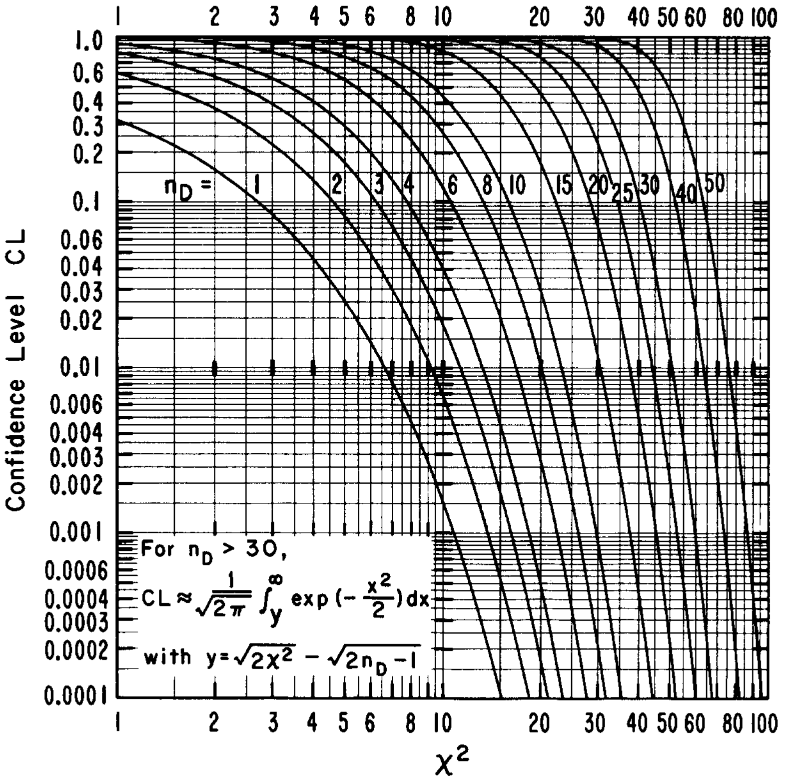
ξ_1	$\underset{+}{35}$	$\underset{-}{27}$
$\Omega\pi$	$1/2$	$-\sqrt{3}/2$
$\Xi\bar{K}$	$\sqrt{3}/2$	$1/2$

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.

χ^2 Confidence Level vs. χ^2 for n_D Degrees of Freedom



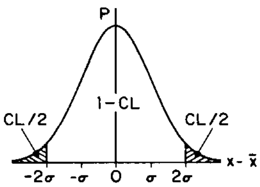
A.1. Normal Distribution

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

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

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

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



[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.

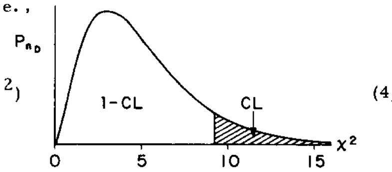
A.2. Chi-squared Distribution

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

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

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.,

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



[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,

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

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

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \tag{6}$$

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)

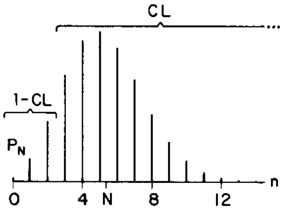
A.3. Poisson Distribution

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

$$y_e = \frac{1}{N} \sum_n y_n \quad \text{and} \tag{9}$$

$$\sigma_e^2 = \frac{1}{N-1} \sum_n (y_n - y_e)^2 \tag{10}$$

are unbiased estimates of $\bar{y}$ and σ^2. The variance of 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

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

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:

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

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

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

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,

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

where

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

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 $\{y - \bar{y}\}$):

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

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

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 P. Sadoulet, Statistical Methods in Experimental Physics (North-Holland, Amsterdam and London, 1971).

Revised and expanded April 1974.

RELATIVISTIC KINEMATICS*

DEFINITIONS AND GENERAL FORMULAE

Notation: We define any 4-vector p by its components:

$$p \equiv (p_0, \vec{p}) \text{ with } \begin{cases} p_0 \equiv E \equiv \text{the energy} \\ \vec{p} \equiv (P_{\parallel}, \vec{P}_{\perp}), \end{cases}$$

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
$$p^{lab} = (E^{lab}, P_{\parallel}^{lab}, \vec{P}_{\perp}^{lab}), \tag{1}$$
$$p^{cm} = (E^{cm}, P_{\parallel}^{cm}, \vec{P}_{\perp}^{cm}). \tag{2}$$

The 4-vector scalar products are defined by
$$A \cdot B = A_0 B_0 - \vec{A} \cdot \vec{B},$$
so that
$$p^{lab} \cdot p^{lab} = p^{cm} \cdot p^{cm} = m^2.$$

General Invariant Definitions and Related Formulae:

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

1) The invariant mass squared of particles i and j is
$$s_{ij} \equiv m_{ij}^2 \equiv (p_i + p_j)^2 = m_i^2 + m_j^2 + 2(E_i E_j - \vec{P}_i \cdot \vec{P}_j). \tag{3}$$

Using the function $\Delta(x, y, z)$ defined by
$$\Delta(x, y, z) \equiv x^2 + y^2 + z^2 - 2xy - 2yz - 2zx$$
$$= [x - (\sqrt{y} + \sqrt{z})^2][x - (\sqrt{y} - \sqrt{z})^2], \tag{4}$$

We have the relations:

- in the particle j rest frame ($\vec{P}_j = 0$), the x axis being along $\vec{P}_i$,
$$p_i^{(j)} = \left(\frac{s_{ij} - m_i^2 - m_j^2}{2m_j}, \frac{\sqrt{\Delta(s_{ij}, m_i^2, m_j^2)}}{2m_j}, 0 \right); \tag{5}$$
- in the particle ij rest frame ($\vec{P}_j = -\vec{P}_i$), the x axis being along $\vec{P}_i$,
$$p_i^{(ij)} = \left(\frac{s_{ij} + m_i^2 - m_j^2}{2\sqrt{s_{ij}}}, \frac{\sqrt{\Delta(s_{ij}, m_i^2, m_j^2)}}{2\sqrt{s_{ij}}}, 0 \right). \tag{6}$$

From (5) and (6),
$$P_i^{(ij)} = \frac{m_j}{\sqrt{s_{ij}}} P_i^{(j)}. \tag{7}$$

Some useful relations involving s_{ij}:

- for the Dalitz plot (3-body problem, $X \to 1 + 2 + 3$),
$$\sum_{i<j} s_{ij} = \sum_i m_i^2 + m_{123}^2 = \text{const.} \quad (i, j = 1, 2, 3) \tag{8}$$
with $m_{123}^2 = (p_1 + p_2 + p_3)^2 = m_X^2$;
- for the triangle plot (4-body problem, $X \to 1+2+3+4$),
$$\sum_{i<j} s_{ij} = 2 \sum_i m_i^2 + m_{1234}^2 = \text{const.} \quad (i, j = 1, 2, 3, 4) \tag{9}$$
with $m_{1234}^2 = (p_1 + p_2 + p_3 + p_4)^2 = m_X^2$.

2) The invariant momentum transfer squared between particles i and k is
$$t_{ik} \equiv (p_i - p_k)^2 = m_i^2 + m_k^2 - 2(E_i E_k - \vec{P}_i \cdot \vec{P}_k). \tag{10}$$

PARTICULAR CASES AND ASYMPTOTIC VALUES (≃)

If E_i and E_j are such that $E_i \simeq P_i$ ($>> m_i$) and $E_j \simeq P_j$ ($>> m_j$), for example in colliding beams, then
$$s_{ij} \simeq 4 |\vec{P}_i| |\vec{P}_j| \cos^2 \left(\frac{\theta_{ij}}{2} \right), \tag{3a}$$
θ_{ij} being the supplement of the angle between the directions of particles i and j.

For the initial state a (beam) + b (target):

- in the lab frame ($\vec{P}_a = \vec{P}_{inc}$, $\vec{P}_b = 0$),
$$s \equiv s_{ab} = m_a^2 + m_b^2 + 2 m_b E_a^{lab}, \tag{3-1}$$
so that: $s \simeq 2 m_b P_{inc}$. (3-1a)
- in the center of mass frame ($\vec{P}_b = -\vec{P}_a$),
$$s \equiv s_{ab} = (E_a^{cm} + E_b^{cm})^2 \tag{3-2}$$
so that: $s \simeq 4(P_a^{cm})^2$ (3-2a)

or $P_a^{cm} \simeq \frac{\sqrt{s}}{2}$; (3-2b)

and
$$\begin{cases} p_a = \left(\frac{s + m_a^2 - m_b^2}{2\sqrt{s}}, \frac{m_b}{\sqrt{s}} P_{inc}, 0 \right) & (6\text{-}1) \\ p_b = \left(\frac{s + m_b^2 - m_a^2}{2\sqrt{s}}, \frac{-m_b}{\sqrt{s}} P_{inc}, 0 \right). & (6\text{-}2) \end{cases}$$

If E_i and E_k are such that $E_i \simeq P_i$ ($>> m_i$) and $E_k \simeq P_k$ ($>> m_k$), then
$$t_{ik} \simeq -4 |\vec{P}_i| |\vec{P}_k| \sin^2 \left(\frac{\theta_{ik}}{2} \right), \tag{10a}$$
θ_{ik} being the angle between particles i and k.

RELATIVISTIC KINEMATICS (Cont'd)

For the reaction $a + b \to c + d$,

$$s \equiv s_{ab} = s_{cd};$$

$$t \equiv t_{ac} = t_{bd} = t_{min} - 4\,P_a P_c \sin^2\left(\frac{\theta_{ac}}{2}\right), \quad (11)$$

with $t_{min} = (E_a - E_c)^2 - (P_a - P_c)^2$

$$= \left[\frac{m_a^2 - m_c^2 - m_b^2 + m_d^2}{2\sqrt{s}}\right]^2 - \left[\sqrt{\left(\frac{s + m_a^2 - m_b^2}{2\sqrt{s}}\right)^2 - m_a^2} - \sqrt{\left(\frac{s + m_c^2 - m_d^2}{2\sqrt{s}}\right)^2 - m_c^2}\right]^2; \quad (11\text{-}1)$$

$$u \equiv t_{ad} = t_{bc} = u_{min} - 4 P_a P_d \sin^2\left(\frac{\theta_{ad}}{2}\right). \quad (11\text{-}2)$$

A general relation between the invariants is

$$s + t + u = m_a^2 + m_b^2 + m_c^2 + m_d^2. \quad (11\text{-}3)$$

In the c.m.: $dt = 2\,|\vec{P}_a|\,|\vec{P}_c|\,d(\cos\theta_{ac})$. (11a)

1) If the masses are different

$(m_c \neq m_a,\ m_d \neq m_b)$:

$$t_{min} \simeq -\frac{(m_a^2 - m_c^2)(m_b^2 - m_d^2)}{s}, \quad (11\text{-}1a)$$

$$u_{min} \simeq -\frac{(m_a^2 - m_d^2)(m_b^2 - m_c^2)}{s}. \quad (11\text{-}2a)$$

2) If $m_a = m_c$, $m_b \neq m_d$,

$$t_{min} \simeq -\frac{m_a^2 (m_b^2 - m_d^2)^2}{s^2}. \quad (11\text{-}1b)$$

3) For elastic scattering $(a + b \to a' + b')$,

$$t_{min} = 0, \quad t_{aa'} = -4P^2 \sin^2\left(\frac{\theta_{aa'}}{2}\right) \quad (11b)$$

$$dt_{aa'} = 2P^2 d(\cos\theta_{aa'}) \quad (11c)$$

$$u_{min} = \frac{(m_a^2 - m_b^2)^2}{s} \quad (11\text{-}2\text{-}1)$$

Relations Between the Particle j and Particle ij Frames: Lorentz Transformations

Defining, for any particle

$$P_\pm^{(j)} = E^{(j)} \pm P_\parallel^{(j)} \quad (12)$$

$$P_\pm^{(ij)} = E^{(ij)} \pm P_\parallel^{(ij)}, \quad (13)$$

and

$$e^{\pm\xi_{ij}} = \frac{s_{ij} + m_j^2 - m_i^2 \pm \sqrt{\Delta(s_{ij}, m_i^2, m_j^2)}}{2\, m_j \sqrt{s_{ij}}} \quad (14)$$

(see formulae (14-b), (19), and (31) for other equivalent definitions of ξ),

$$e^{\xi_{ij}} \simeq \frac{\sqrt{s_{ij}}}{m_j} \quad (14a) \quad \text{and} \quad \xi_{ij} \simeq \ln \frac{\sqrt{s_{ij}}}{m_j}. \quad (14b)$$

For the initial state a(beam) + b(target):

$$e^{\pm\xi} = \frac{s + m_b^2 - m_a^2 \pm \sqrt{\Delta(s, m_a^2, m_b^2)}}{2\, m_b \sqrt{s}} \quad (14\text{-}1)$$

then:

$$P_\pm^{(ij)} = e^{\mp\xi_{ij}}\, P_\pm^{(j)} \quad (15)$$

$$\vec{P}_\perp^{(ij)} = \vec{P}_\perp^{(j)}, \quad (16)$$

for a movement taking place along $\vec{P}_i$.

$$P_\pm^{cm} = e^{\mp\xi}\, P_\pm^{lab}, \quad (15\text{-}1)$$

$$\vec{P}_\perp^{cm} = \vec{P}_\perp^{lab}; \quad (16\text{-}1)$$

The general Lorentz transformation has the matrix form

$$\begin{pmatrix} E \\ P_\parallel \\ \vec{P}_\perp \end{pmatrix}^{(ij)} = \begin{pmatrix} \gamma & -\eta & 0 \\ -\eta & \gamma & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} E \\ P_\parallel \\ \vec{P}_\perp \end{pmatrix}^{(j)}, \quad (17)$$

characterized by $\vec{\beta} = \vec{P}_i^{(j)}/(E_i^{(j)} + m_j)$, $\beta_\parallel = |\vec{\beta}|$, $\gamma = 1/\sqrt{1-\beta^2}$, and $\vec{\eta} = \vec{\beta}\gamma$. The space part can be written in the vector form

$$\vec{P}^{(ij)} = \vec{P}^{(j)} - \vec{\eta}\, \frac{E^{(j)} + E^{(ij)}}{\gamma + 1}. \quad (18)$$

$$\gamma = \frac{s + m_b^2 - m_a^2}{m_b \sqrt{s}} = \frac{m_b + E_a^{lab}}{\sqrt{s}}, \quad (20\text{-}1)$$

$$\eta = \frac{\sqrt{\Delta(s, m_a^2, m_b^2)}}{m_b \sqrt{s}} = \frac{P_{inc}}{\sqrt{s}}. \quad (21\text{-}1)$$

Combining (15) and (17):

$$\beta_\parallel = \tanh \xi_{ij} \quad (19)$$

$$\gamma = \cosh \xi_{ij} \quad (20)$$

$$\eta = \sinh \xi_{ij}. \quad (21)$$

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

To Lorentz transform any vector $p_1 = (E_1, \vec{P}_1)$, given in a frame containing some other vector $p_2 = (E_2, \vec{P}_2)$, into the frame where $p_2 = (m_2, 0)$ (i.e., the p_2 rest frame), one may use the relations:

$$E_1' = \frac{E_1 E_2 - \vec{P}_1 \cdot \vec{P}_2}{m_2} = \frac{p_1 \cdot p_2}{m_2}, \quad (17\text{-}1)$$

$$\vec{P}_1' = \vec{P}_1 - \vec{P}_2 \left(\frac{E_1 + E_1'}{E_2 + m_2}\right), \quad (18\text{-}1)$$

where $p_1' = (E_1', \vec{P}_1')$ is the transformed vector, and $m_2^2 = p_2^2$. These are derived from (17) and (18) using $\gamma = E_2/m_2$ and $\vec{\eta} = \vec{P}_2/m_2$.

RELATIVISTIC KINEMATICS (Cont'd)

Rapidity Variable: Definition and Kinematic Relations

Definition: in any system, for a particle of energy E and longitudinal momentum $P_{\parallel}$,

$$y \equiv \frac{1}{2}\ln\left(\frac{E+P_{\parallel}}{E-P_{\parallel}}\right) = \tanh^{-1}\left(\frac{P_{\parallel}}{E}\right)$$

$$= \frac{1}{2}\ln\left(\frac{P_+}{P_-}\right) = \ln\left(\frac{P_+}{m_\perp}\right) = -\ln\left(\frac{P_-}{m_\perp}\right), \qquad (22)$$

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

$$y^{lab} \simeq \frac{1}{2}\ln\left(\frac{p^{lab} + p_{\parallel}^{lab}}{p^{lab} - p_{\parallel}^{lab}}\right) \simeq \ln(\mathrm{ctn}\frac{\theta}{2}). \qquad (22a)$$

From (15) and (22), $y^{lab} = y^{cm} + \xi$. (23)

From (22),
$$\begin{cases} P_+ = m_\perp\, e^{+y} & (24)\\ P_- = m_\perp\, e^{-y} & (25)\\ E = m_\perp \cosh y & (26)\\ P_{\parallel} = m_\perp \sinh y . & (27)\end{cases}$$

From (3), $s_{12} = m_1^2 + m_2^2 + 2m_{\perp 1} m_{\perp 2}\cosh(y_1 - y_2) - 2\vec{P}_{\perp 1}\cdot\vec{P}_{\perp 2}$. (28-1)

$$s_{12} \simeq m_{\perp 1}\, m_{\perp 2}\, e^{(y_1 - y_2)}, \qquad (28\text{-}1a)$$

and the rapidity gap between the two particles 1 and 2 is:

$$y_1 - y_2 \simeq \ln\left(\frac{s_{12}}{m_{\perp 1} m_{\perp 2}}\right). \qquad (28\text{-}1b)$$

From (10), $t_{12} = m_1^2 + m_2^2 - 2m_{\perp 1} m_{\perp 2}\cosh(y_1 - y_2) + 2\vec{P}_{\perp 1}\cdot\vec{P}_{\perp 2}$. (28-2)

The target (b) and beam (a) rapidities, y_b and y_a, are given by

in the lab frame:
$$\begin{cases} y_b^{lab} = 0 & (29)\\ y_a^{lab} \text{ from } s_{ab}; & (30)\end{cases}$$

$$\underbrace{s = s_{ab} \simeq m_a m_b\, e^{y_a^{lab}}}_{} = m_a m_b\, e^{(y_a^{cm} - y_b^{cm})}, \qquad (30a)$$

$$\longrightarrow y_a^{lab} \simeq \ln\left(\frac{s}{m_a m_b}\right), \qquad (30b)$$

and with (3-1a) $y_a^{lab} \simeq \ln\left(\dfrac{2P_{inc}}{m_a}\right)$. (30c)

in the cm frame:
$$\begin{cases} \text{from (23) and (29), } y_b^{cm} = -\xi & (31)\\ \text{from (23), } y_a^{cm} = y_a^{lab} - \xi. & (32)\end{cases}$$

From (14b), $y_b^{cm} \simeq -\ln\left(\dfrac{\sqrt{s}}{m_b}\right)$, (31a)

and with (30a), $y_a^{cm} \simeq \ln\left(\dfrac{\sqrt{s}}{m_a}\right)$. (32a)

Scaling Variable: Definitions

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

1) Feynman's definition:

$$x = P_{\parallel}^{cm}/P_{max}^{cm} \qquad (33)$$

with $$P_{max}^{cm} = \frac{\sqrt{\Delta(s, m_c^2, m_{X,min}^2)}}{2\sqrt{s}} \qquad (34)$$

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

$$P_{max}^{cm} \simeq \frac{\sqrt{s}}{2} \qquad (34a)$$

and $$x \simeq \frac{2P_{\parallel}^{cm}}{\sqrt{s}}. \qquad (33a)$$

A relationship between x and m_X^2 which becomes useful at high energies derives from

$$m_X^2 = (p_a + p_b - p_c)^2 = s + m_c^2 - 2p_c\cdot(p_a + p_b). \qquad (35)$$

Using (33a) and (35),

$$x \simeq 1 - \frac{m_X^2}{s}. \qquad (33b)$$

2) An alternative definition:

$$x' = P_{\parallel}^{cm}/P_{\parallel\, max}^{cm} \qquad (36)$$

with $$P_{\parallel\, max}^{cm} = \sqrt{\left(P_{max}^{cm}\right)^2 - P_\perp^2}. \qquad (37)$$

For $P_\perp$ fixed as $s \to \infty$

$$x' \simeq \frac{2P_{\parallel}^{cm}}{\sqrt{s}} \simeq x. \qquad (36a)$$

- For *electro- and photoproduction:*

1) Bjorken's formula:

$$\omega = \frac{2m_p \nu}{q^2}, \qquad (38)$$

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

ω^{-1} is sometimes called x.

2) Bloom-Gilman's definition:

$$\omega' = \omega + \frac{m_p^2 - q^2}{q^2}. \qquad (39)$$

For q^2 and ν large (Bjorken limit),

$$\omega' \simeq \omega - 1. \qquad (39a)$$

RELATIVISTIC KINEMATICS (Cont'd)

Cross Sections and Decay Rates

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

$$d\,\mathrm{LIPS}(s; p_1, \cdots, p_n) = (2\pi)^4 \delta^4(p - \sum_i p_i) \frac{1}{(2\pi)^{3n}} \prod_{i=1}^{n} \frac{d^3 \vec{P}_i}{2E_i} . \tag{40}$$

$$\text{For 2-body: } d\,\mathrm{LIPS}(s, p_1, p_2) = \frac{1}{(2\pi)^2} \delta^4(p - p_1 - p_2)\, d^4p \frac{|\vec{P}_1^{cm}|}{4\sqrt{s}} d\Omega_1^{cm} . \tag{40-1}$$

$$\text{For 3-body: } d\,\mathrm{LIPS}(s, p_1, p_2, p_3) = \frac{1}{(2\pi)^5} \delta^4(p - p_1 - p_2 - p_3) d^4p \frac{1}{32s} ds_{12} ds_{23} d\alpha d\cos\beta d\gamma, \tag{40-2}$$

where α, β, and γ are Euler angles.

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

$$\sigma_{if} = \frac{1}{4F} \int |\mathcal{M}_{if}|^2 \, d\,\mathrm{LIPS}(s; p_1, \cdots, p_n), \tag{41}$$

or

$$\Gamma_{if} = \frac{1}{2m_X} \int |\mathcal{M}_{if}|^2 \, d\,\mathrm{LIPS}(m_X^2; p_1, \cdots, p_n), \tag{42}$$

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 (40-1) and (41) yield

$$\frac{d\sigma}{d\Omega} = \frac{|\mathcal{M}|^2}{(8\pi)^2 s} \quad \text{or} \quad \frac{d\sigma}{dt} = \frac{|\mathcal{M}|^2}{64\pi |\vec{P}_a^{cm}|^2 s} . \tag{43}$$

The normalization is such that the optical theorem reads

$$\mathrm{Im}\, \mathcal{M}|_{t=0} = 2 |\vec{P}_a^{cm}| \sqrt{s}\, \sigma_{tot} . \tag{44}$$

The choice of Eq. (40) 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.

A useful invariant is $\int d^4p\, \delta(p^2 - m^2) = \int \frac{d^3\vec{P}}{2E}$, so that the invariant cross section is $E \frac{d^3\sigma}{dP^3}$. The following table gives the value of the invariant cross section for different sets of variables useful for the study of the inclusive reaction a + b → c + X.

Longitudinal variable of particle c	Transverse variable of particle c	Corresponding invariant cross section
$P_\parallel^{cm}$	$P_\perp$	$\frac{E^{cm}}{\pi} \frac{d^2\sigma}{dP_\parallel^{cm} dP_\perp^2}$ (averaged over azimuth)
y	$m_\perp$	$\frac{1}{\pi} \frac{d^2\sigma}{dy\, dP_\perp^2}$ (averaged over azimuth)
x	$P_\perp$	$\frac{E^{cm}}{P_{max}^{cm}} \cdot \frac{1}{\pi} \frac{d^2\sigma}{dx dP_\perp^2} \simeq \frac{2E^{cm}}{\pi\sqrt{s}} \frac{d^2\sigma}{dx dP_\perp^2}$ (averaged over azimuth)
P^{lab}	θ^{lab}	$\frac{E^{lab}}{(P^{lab})^2} \frac{d^3\sigma}{dP^{lab} d\Omega^{lab}}$
$m_X^2 = (p_a + p_b - p_c)^2$	t_{ac}	$\frac{\sqrt{\Delta(s, m_a^2, m_b^2)}}{\pi} \frac{d^2\sigma}{dm_X^2 dt_{ac}}$ (averaged over azimuth)

*For more formulae and details, see, e. g.,

W. R. Frazer et al., Rev. Mod. Phys. 44, 284 (1972).
J. Kasman in M. E. Law et al., LBL-80 (1972), Part III.
H. Pilkuhn, The Interactions of Hadrons, John Wiley & Sons, New York, 1967, Chaps. 1 and 2.
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C.M. ENERGY AND MOMENTUM VS. BEAM MOMENTUM

$$E_{cm} dE_{cm} = m_p dT_{beam} = m_p v_{beam} dP_{beam} \approx m_p dP_{beam}$$

EAM V/C)	-----C.M. ENERGY------ (MEV) γp ep	πp	Kp	pp	-MOMENTUM IN C.M.-- (MEV/C) 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							
00	1033	1105	1439	1879	91	85	65	50
20	1051	1116	1441	1880	107	101	78	60
40	1069	1127	1445	1882	123	117	91	70
60	1087	1139	1449	1883	138	132	104	80
80	1104	1152	1453	1885	153	147	116	90
	T(PI) = PBEAM - 92 MEV							
00	1121	1165	1457	1887	167	161	129	99
20	1137	1178	1462	1889	182	175	141	109
40	1154	1192	1468	1892	195	189	153	119
60	1170	1206	1474	1894	209	202	166	129
80	1186	1219	1480	1897	222	215	178	138
	T(PI) = PBEAM - 107 MEV							
00	1201	1233	1486	1900	234	228	189	148
20	1217	1247	1493	1903	247	241	201	158
40	1232	1261	1500	1906	259	253	213	167
60	1247	1274	1507	1910	271	265	224	177
80	1262	1288	1514	1913	282	277	235	186
	T(PI) = PBEAM - 115 MEV							
00	1277	1302	1522	1917	294	288	247	196
20	1292	1315	1530	1921	305	300	258	205
40	1306	1329	1538	1925	316	311	268	214
60	1320	1342	1546	1929	327	322	279	224
80	1335	1356	1554	1933	337	332	290	233
	T(PI) = PBEAM - 120 MEV							
00	1349	1369	1563	1938	348	343	300	242
20	1362	1382	1572	1943	358	353	310	251
40	1376	1395	1580	1947	368	363	321	260
60	1390	1408	1589	1952	378	373	331	269
80	1403	1421	1598	1957	388	383	341	278
	T(PI) = PBEAM - 123 MEV							
00	1416	1434	1607	1962	397	393	350	287
20	1430	1446	1616	1967	407	402	360	296
40	1443	1459	1625	1973	416	412	370	304
60	1456	1472	1634	1978	425	421	379	313
80	1468	1484	1644	1984	434	430	388	322
	T(PI) = PBEAM - 125 MEV							
00	1481	1496	1653	1989	443	439	397	330
20	1494	1509	1662	1995	452	448	406	339
40	1506	1521	1671	2001	461	457	415	347
60	1519	1533	1681	2007	470	465	424	355
80	1531	1545	1690	2013	478	474	433	364
	T(PI) = PBEAM - 127 MEV							
00	1543	1557	1699	2019	486	482	442	372
20	1555	1569	1709	2025	495	490	450	380
40	1567	1580	1718	2031	503	499	459	388
60	1579	1592	1728	2037	511	507	467	396
80	1591	1604	1737	2043	519	515	475	404
	T(PI) = PBEAM - 129 MEV							
00	1603	1615	1747	2049	527	523	483	412
20	1615	1627	1756	2056	535	531	492	420
40	1626	1638	1765	2062	542	538	500	428
60	1638	1649	1775	2069	550	546	508	435
80	1649	1661	1784	2075	558	554	515	443
	T(PI) = PBEAM - 130 MEV							
00	1660	1672	1794	2082	565	561	523	451
20	1672	1683	1803	2088	573	569	531	458
40	1683	1694	1812	2095	580	576	538	466
60	1694	1705	1822	2102	587	583	546	473
80	1705	1716	1831	2108	594	591	553	481
	T(PI) = PBEAM - 131 MEV							
00	1716	1726	1840	2115	601	598	561	488
20	1727	1737	1850	2122	609	605	568	495
40	1738	1748	1859	2129	616	612	575	502
60	1748	1758	1868	2135	622	619	583	510
80	1759	1769	1877	2142	629	626	590	517
	T(PI) = PBEAM - 131 MEV							
00	1770	1780	1887	2149	636	633	597	524
20	1780	1790	1896	2156	643	639	604	531
40	1791	1800	1905	2163	650	646	611	538
60	1801	1811	1914	2170	656	653	618	545
80	1812	1821	1923	2177	663	660	624	552
	T(PI) = PBEAM - 132 MEV							
00	1822	1831	1932	2184	669	666	631	559
20	1832	1841	1941	2191	676	673	638	565
40	1843	1851	1950	2198	682	679	645	572
60	1853	1862	1959	2205	689	685	651	579
80	1863	1872	1968	2212	695	692	658	585
	T(PI) = PBEAM - 133 MEV							
00	1873	1881	1977	2219	701	698	664	592
20	1883	1891	1986	2226	708	704	671	599
40	1893	1901	1995	2233	714	711	677	605
60	1903	1911	2004	2240	720	717	684	612
80	1912	1921	2013	2247	726	723	690	618
	T(PI) = PBEAM - 133 MEV							

PBEAM (MEV/C)	-----C.M. ENERGY------ (MEV) γp ep	πp	Kp	pp	-MOMENTUM IN C.M.-- (MEV/C) 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	2436	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) γp ep πp	Kp	pp	-MOMENTUM IN C.M.- (GEV/C) 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					

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 useful only for preliminary design.

A.1 Scintillators: Photon yield $\approx 1\gamma/100$ eV in plastic scintillator[1] and $\approx 1\gamma/25$ eV in Na I.[1,2]

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

$$\theta_c = \text{arc}\cos\left(\frac{1}{\beta n}\right) \sim \sqrt{2\left(1-\frac{1}{\beta n}\right)} \; .$$

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

Number of photons N per cm:

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

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

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

A.4 Bubble, Streamer, Wire Chambers:

Chamber Type	Accuracy(rms)	Resolution Time	Dead Time
Bubble	$\pm$ 75μ	$\approx$ 1 ms	$\approx$ 1/20 s[a)]
Streamer	$\pm$ 300μ	$\approx$ 40 μs	$\approx$ 180 ms
Optical Spark	$\pm$ 200μ[b)]	$\approx$ 2 μs	$\approx$ 10 ms
Magnetostrictive Spark	$\pm$ 500μ	$\approx$ 2 μs	$\approx$ 10 ms
Proportional	$\geq \pm$ 300μ[c,d)]	$\approx$ 50 ns	$\approx$ 200 ns
Drift	$\pm$ 50 to 300μ	$\approx$ 2 ns[e)]	$\approx$ 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 $\pm$ 150μ parallel to anode wire.
e) For two chambers.

A.5 Shower Detectors: Typical energy resolution for incident electron in the 1 GeV range, E in GeV.

Na I (20 rad. lengths)[5]: $\dfrac{2\%}{E^{1/4}}$ (FWHM)

Lead Glass (14 rad. lengths)[6]: $\dfrac{8\text{-}12\%}{\sqrt{E}}$ (FWHM)

Lead Scintillator Sandwich (10 rad. lengths)[7]: $\dfrac{22\%}{\sqrt{E}}$ (FWHM)

(10 lead plates, each 1 radiation length, and scintillators, each 1 cm in thickness).

A.6 Proportional Chamber Wire Instability: The limit on the voltage V for a wire tension T is given by[8]

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

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 $\leq$ t) gives[9]

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

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 on the conditions of measurement. Some typical sea-level values[10] are given below:

I_v vertical flux
J_1 total flux crossing a unit horizontal area
J_2 total flux crossing a sphere of unit radius

	Total Intensity	Hard component	Soft component
I_v	1.14×10^{-2}	0.83×10^{-2}	0.31×10^{-2} cm^{-2}sec^{-1}sterad^{-1}
J_1	1.79×10^{-2}	1.27×10^{-2}	0.52×10^{-2} cm^{-2}sec^{-1}
J_2	2.41×10^{-2}	1.68×10^{-2}	0.73×10^{-2} cm^{-2}sec^{-1}

Very approximately, about 75% of all particles at sea-level are penetrating, and are μ mesons. 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 $\sim$0.1% of all particles.

C. PASSAGE OF PARTICLES THROUGH MATTER

C.1 dE/dx[11]: Energy loss for particles heavier than an electron and having charge $z|e|$:

$$-\frac{dE}{dx} = z^2 D\frac{Z}{A}\frac{1}{\beta^2}\left[\ln\left(\frac{2m_e c^2\beta^2 T^I_{max}}{(1-\beta^2)I^2}\right) - 2\beta^2 - K\right]$$

where $D = 2\pi N r_e^2 m_e c^2 = 0.1535$ MeV cm^2/g, Z and A are charge and mass number of the material, $\beta = v/c$ for the incident particle, T^I_{max} is the maximum energy δ ray considered to be ionization loss, I is the mean ionization potential ($I \approx Z\times10$ eV), and K includes the shell correction (maximum $\approx$ 10% around $\beta = 0.1$), density effect (important above $\sim$5 GeV/c), and the z^3 correction[12] (important at low velocity, a few percent at $\beta \approx 0.1$). Figures are given below for energy loss and range in lead (with scaling indicated for copper, aluminum, and carbon) and in hydrogen, with T^I_{max} taken to be T_{max} as defined in Sec. C.2 below.

C.2 δ rays[13]: Number N per g/cm^2 per MeV of δ rays of kinetic energy T produced by an incident particle of momentum p and velocity β (Rutherford formula):

$$\frac{dN}{dT\,dx} = D\frac{Z}{A}\frac{1}{\beta^2 T^2} \; ,$$

where D is defined in the dE/dx section. This expression is valid for any unit charge incident particle if $T \ll T_{max}$. T_{max} is the maximum δ-ray energy, given by

$$T_{max} = \frac{2m_e c^2(pc)^2}{s} = \frac{2\beta^2\gamma^2 m_e c^2}{1+2\gamma\frac{m_e}{M}+\frac{m_e^2}{M^2}}$$

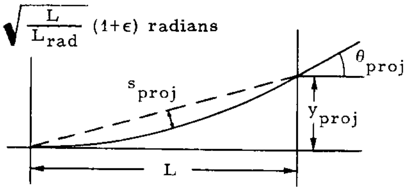
where m_e and M are the electron and incident particle masses and s is their center-of-mass energy squared.

C.3 Multiple Coulomb Scattering[14]: Sketched below are the multiple scattering angle θ, displacement y, and sagitta s, of a particle of charge $z|e|$, passing through a scatterer of thickness L. All quantities are rms projected:

$$\theta_{proj} = z\frac{15\text{MeV}/c}{p\beta}\sqrt{\frac{L}{L_{rad}}}(1+\epsilon) \text{ radians}$$

$$y_{proj} = \frac{L\theta_{proj}}{\sqrt{3}}$$

$$s_{proj} = \frac{L\theta_{proj}}{4\sqrt{3}}$$



For $L \geq 1/10\, L_{rad}$, ϵ is generally < 1/10. The distribution of θ is not truly Gaussian.[15]

C.4 Electron Range in Lead, Copper, Carbon and Hydrogen: See figure following.

C.5 Fractional Energy Loss for Electrons and Positrons in Lead: See figure following.

C.6 Contributions to Photon Cross Section in Lead: See figure following.

C.7 Photon Cross Section: See figure following.

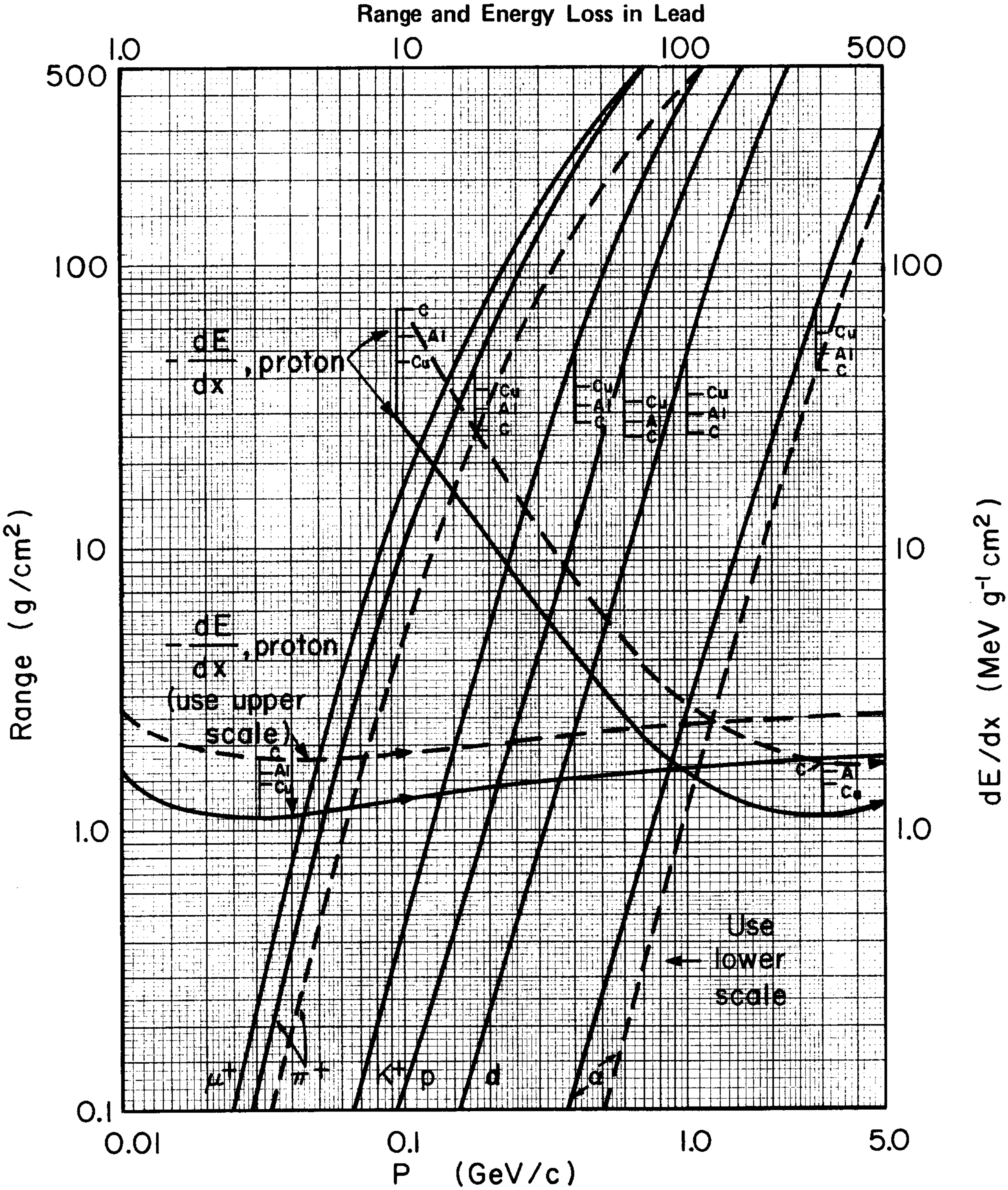
D. ATOMIC AND NUCLEAR PROPERTIES OF MATERIALS

See table following.

*Prepared April 1974 by Sherwood Parker and Bernard Sadoulet.

References for this section may be found after the following figures and the Atomic and Nuclear Properties Table.

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



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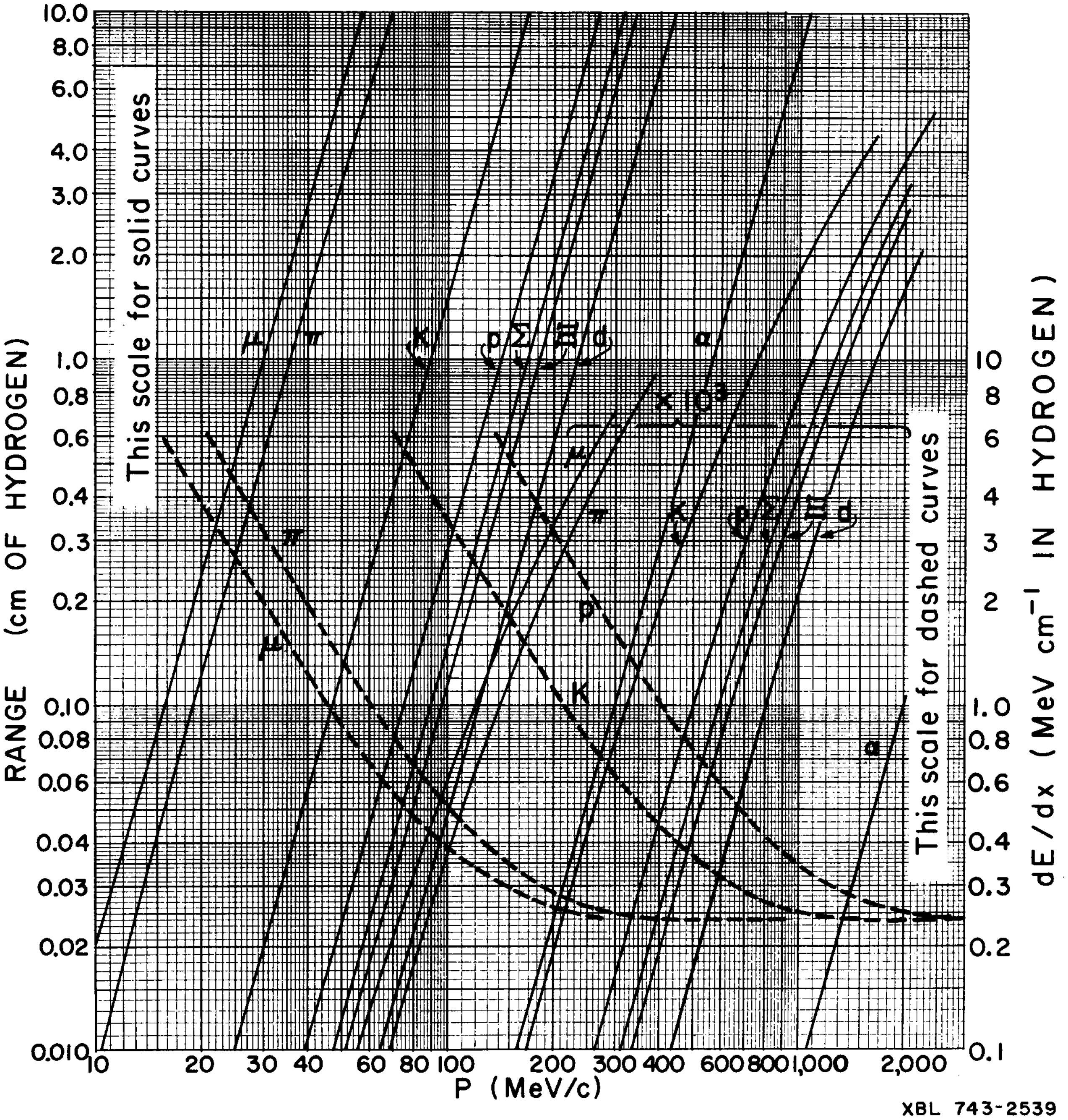
Range and energy loss in lead are calculated using the program written by Hans Bischel (UCRL-17538 + density correction). The excitation potential for Pb is assumed to be 820 eV (See Table I of the above reference for the other elements). Scaling to Cu, Al, and C are indicated. The dotted lines are for carbon. The energy losses above 5 GeV/c are also plotted as implied by arrows; note that the scale at the top of the plot should be used for this portion of the graph.

For other beam particles, see scaling law on next page.

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

Range and Energy Loss in Liquid Hydrogen



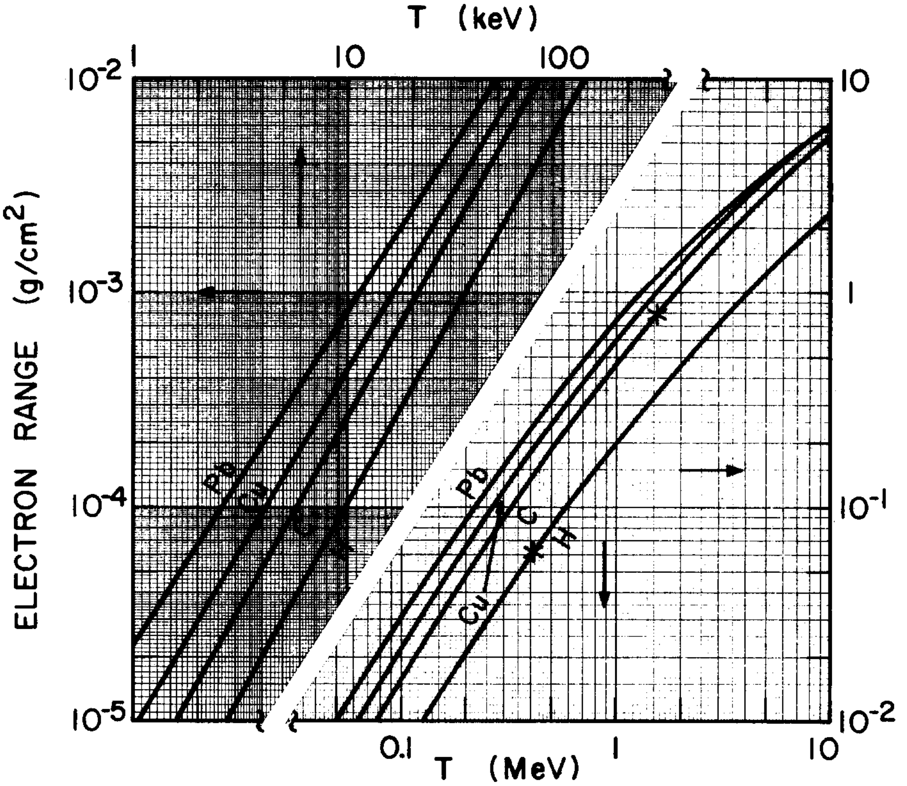
Range and energy loss in liquid hydrogen bubble chamber, determined by a μ^+ range of 1.103 ± 0.003 cm from the $\pi^+ \to \mu^+ \nu$ decay. Liquid hydrogen conditions: $T = 27.6 \pm 0.1$ °K; $P = 48 \pm 5$ psia; $\rho = (5.86 \pm 0.06) 10^{-2}$ g/cm^3. (Data by Clark and Diehl, UCRL-3789, 1957.) Bubble chamber physicists: note that the number of bubbles per cm is proportional to $1/\beta^2$, not to dE/dx. For the more linear portions of the solid (range) curves, $R \propto p^{3.6}$. For other absorbers and more details, see UCRL-2426 Rev. (1966).

Scaling law for particles of other mass or charge: 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

$$R_b(M_b, z_b, p_b) = \left[\frac{M_b/M_a}{z_b^2/z_a^2} \right] R_a(M_a, z_a, p_a = p_b M_a/M_b) .$$

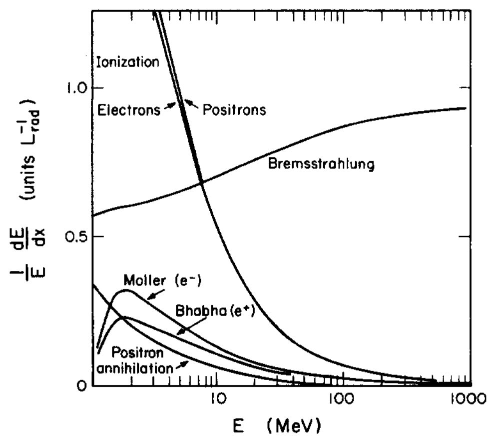
PARTICLE DETECTORS, ABSORBERS, AND RANGES (Cont'd)

Electron Range in Lead, Copper, Carbon, and Hydrogen



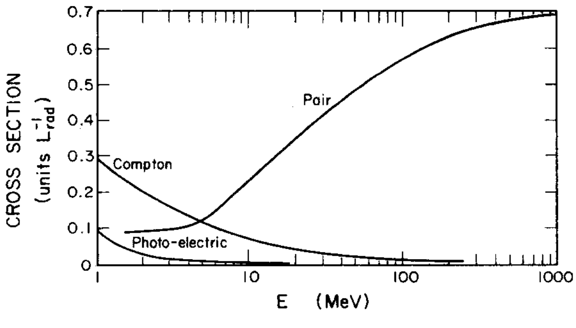
Range of electrons. This range is the total path length; the practical range is shorter because of multiple Coulomb scattering. This scattering becomes increasingly important as the electron slows down. E.g., for a fast electron, the rms projected angle due to multiple Coulomb scattering reaches 1 radian 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. See Berger and Seltzer, NASA SP-3012 (1964) and P. Trower, UCRL-2426, Vol. II 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

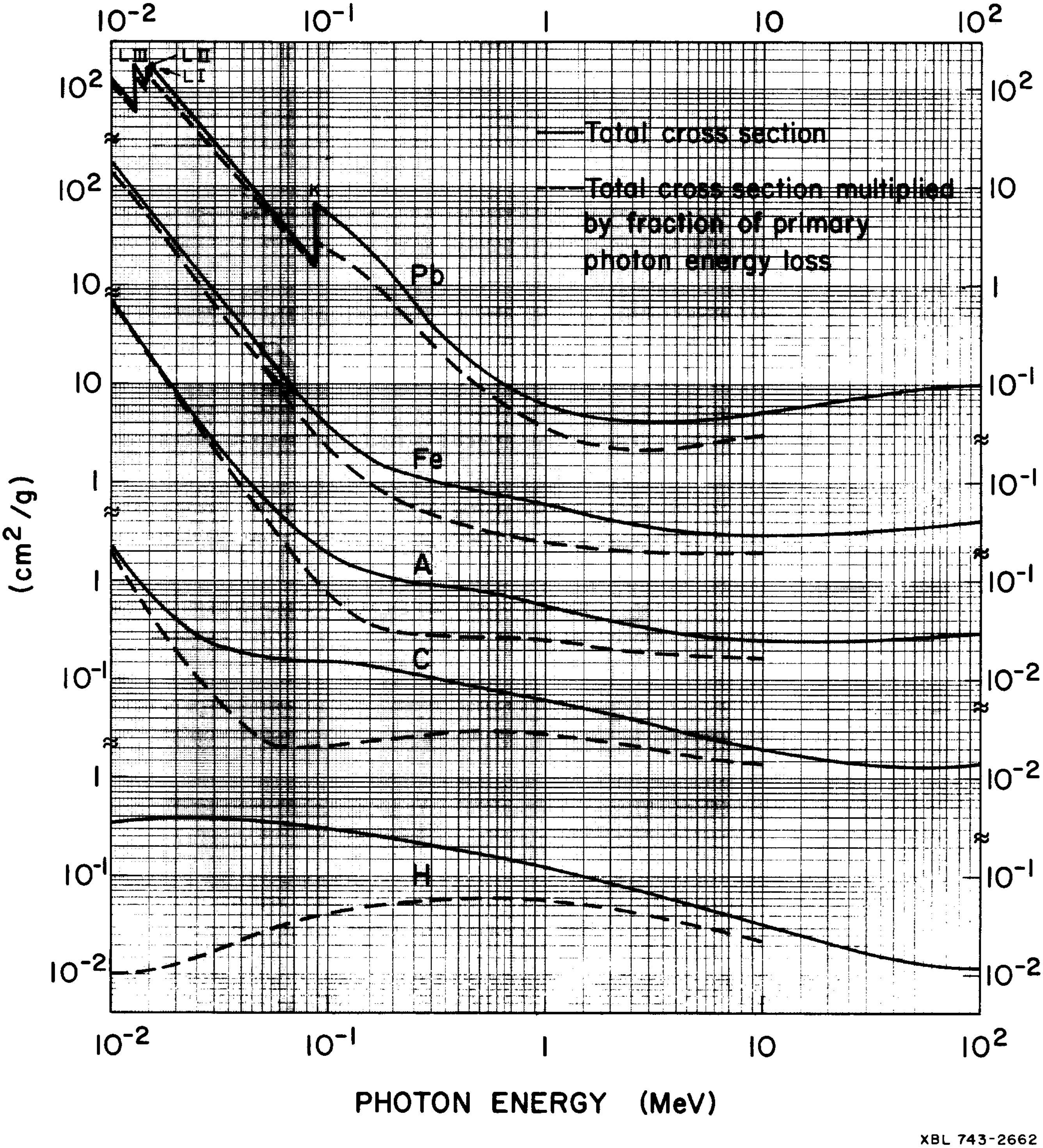


Photon cross section in lead in inverse radiation lengths as a function of photon energy. The intensity of photons can be expressed as $I = I_0 \exp(-\sigma x)$, where σ is read above and x is the path length in radiation lengths.

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/cm^2.

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

Photon Cross Sections



The photon cross section as a function of photon energy for various substances. The solid curve for each substance gives the total cross section in (cm^2/g). The dashed curve is the total cross section multiplied by the fraction of energy deposited by the photon (different from solid curve because of Compton scattering and bremsstrahlung of secondary electrons). See 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/cm²]	Nuclear collision length $L_{coll.}$ [b] [cm]	Absorption length λ [b] [cm]	dE/dx min [c] [MeV/(g/cm²)]	dE/dx min [c] [MeV/cm]	Radiation length L_{rad} [d] [g/cm²]	Radiation length L_{rad} [d] [cm]	Density [e] [g/cm³] ( ) is for gas [g/ℓ]	Refractive index n [e]; ( ) is $(n-1)\times10^6$ for gas
H_2	1	1.01	0.039	43.0	607.4	789.5	4.12	0.292	62.8	887	0.0708 (0.090)	1.112 (140)
D_2	1	2.01	0.074	45.1	273.3	341.7	2.07	0.342	126	764	1.65	1.128
He	2	4.00	0.134	49.6	396.5	477.8	1.94	0.243	93.1	745	0.125 (0.178)	1.024 (35)
Li	3	6.94	0.215	53.6	100.4	120.6	1.65	0.902	83.3	156	0.534	-
Be	4	9.01	0.270	55.4	30.0	36.7	1.61	2.97	66.0	35.7	1.848	-
C	6	12.01	0.340	58.7	≈ 37.8	49.9	1.78	≈ 2.76	43.3	≈ 67.0	≈ 1.55 [f]	-
N_2	7	14.01	0.390	59.7	73.8	99.4	1.82	1.47	38.6	47.8	0.808 (1.25)	1.205 (300)
Ne	10	20.18	0.520	64.4	53.7	74.9	1.73	2.08	29.1	24.3	1.207 (0.90)	1.092 (67)
Al	13	26.98	0.650	68.9	25.5	37.2	1.62	4.37	24.3	9.0	2.70	-
Ar	18	39.95	0.890	74.5	53.2	80.9	1.51	2.11	19.7	14.1	1.40 (1.78)	1.233 (283)
Fe	26	55.85	1.160	79.9	10.2	17.1	1.48	11.6	13.9	1.77	7.87	-
Cu	29	63.54	1.270	83.1	9.3	14.8	1.44	12.9	13.0	1.45	8.96	-
Sn	50	118.69	2.040	96.6	13.2	22.8	1.28	9.4	8.9	1.22	7.31	-
W	74	183.85	2.810	108.6	5.6	10.3	1.17	22.6	6.8	0.35	19.3	-
Pb	82	207.19	3.080	111.7	9.8	18.5	1.13	12.8	6.4	0.56	11.35	-
U	92	238.03	3.380	116.9	≈ 6.2	12.0	1.09	≈ 20.7	6.1	≈ 0.32	≈ 18.95	-
Air (gas at 20°C)				60.2	50 000 [g]		1.82	0.0022 [g]	37.2	30 870 [g]	0.001205 [g] (1.29)	- (293)
H_2O				58.3	58.3		2.03	2.03	36.4	36.4	1.00	1.33
H_2 (bubble chamber 26°K) [h]				43.0	683		4.12	0.26	62.8	990	≈ 0.063 [h]	1.112
D_2 (bubble chamber 31°K) [h]				45.1	322		2.07	0.29	126	900	≈ 0.140 [h]	1.110
H-Ne mixture (50 mole per cent) [i]				62.9	154.5		1.84	0.75	29.9	73.5	0.407	1.092
Propane (C_3H_8) [j]				55.0	134		2.28	0.98	45.9	110	0.41 [j] (2.0)	1.25 [j] (1005)
Freon 13B1 (CF_3Br) [j] (see other Freons below)				74.3	49.5		1.52	≈ 2.3	16.7	≈ 11	≈ 1.50 [j] (8.71)	1.238 [j] (750)
Ilford emulsion				79.5	20.8		1.44	5.49	11.2	2.94	3.815	-
NaI				91.9	25.0		1.32	4.84	9.5	2.59	3.67	1.775
LiF				61.1	23.1		1.69	4.46	39.3	15.1	2.64	1.394
Polyethylene (CH_2)				55.7	59.6		2.09	≈ 1.95	45.3	≈ 49	0.92-0.95	-
Mylar ($C_5H_4O_2$)				58.5	42.1		1.91	2.65	40.5	29.2	1.39	-
Polystyrene, scintillator (CH) [k]				57.0	55.2		2.03	1.97	44.3	43	1.032	1.581
Plexiglas ($C_5H_8O_2$); also called Lucite				57.7	48.9		1.95	1.65	40.5	34.5	1.16-1.20	≈ 1.49
Spark or proportional chamber [ℓ]				0.5%		0.3%	-	0.073	2.7%		0.046	-
Shielding concrete [m]				64.9	26.0		1.70	4.25	26.6	10.6	2.5	-
CO_2 (used in Čerenkov counters)											(1.79) [n]	(420) [n]
Freon 12 (CCl_2F_2) (used in Čerenkov counters)											(4.93) [n]	(1080) [n]
Freon 13 ($CCl\,F_3$) (used in Čerenkov counters)											(4.26) [n]	(720) [n]

* Table revised January 1974 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 ≈ $\frac{1}{2}$ per cent/GeV (from 5-25 GeV).

[b] $L_{coll} = A/(N\cdot\sigma)$. In the absorption length the elastic scattering is subtracted.

[c] From W. H. Barkas and M. J. Berger, Tables of Energy Losses and Ranges of Heavy Charged Particles, NASA SP-3013 (1964).

[d] Mainly from O. I. Dovzhenko and A. A. Pomanskii, Soviet Phys. JETP 18, 187 (1964); for some recent to-be-published results, see Y. Tsai, SLAC-PUB 1365 (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 operation conditions.

[i] Values for typical working condition with H_2 target; 50 mole per cent, 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/cm², also valid for earth (typical ρ = 2.15) from CERN-LHL-RHEL Shielding exp. UCRL-17841 (1968).

[n] At 26°C and 1 atm. Indices of refraction from E. R. Hayes, R. A. Schluter, and A. Tamosaitis, ANL-6916 (1964).

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

References for Particle Detectors, Absorbers, and Ranges section above.

1. Methods of Experimental Physics, Yuan and Wu, editors, Academic Press, 1961, Vol. 5A, p. 127.
2. R. K. Swank, Ann. Rev. Nuc. Sci. 4, 137 (1954) and G. Wright, Proc. Phys. Soc. B68, 929 (1955).
3. Methods of Experimental Physics, Yuan and Wu, editors, Academic Press, 1961, Vol. 5A, p. 163.
4. Nuclear Enterprises Catalogue.
5. E. B. Hughes et. al., IEEE Transactions on Nuclear Science, NS-19, No. 3, 126 (1972).
6. M. Holder e. al., Phys. Letters 40B, 141 (1972) and J. S. Beale et. al., "A Lead-Glass Čerenkov Detector for Electrons and Photons," CERN Writeup, Intl. Conf. on Instrumentation in H.E.P., Frascati (1973).
7. J. K. Walker and T. R. Knasel, Rev. Sci. Instr. 37, 913 (1966).
8. T. Trippe, CERN NP Internal Report 69-18 (1969).
9. S. Parker and R. Jones, LBL-797 (1972), and A. Morse and B. Feshbach, Methods of Theoretical Physics, McGraw-Hill, New York, 1953, p. 1236.
10. B. Rossi, Rev. Mod. Phys. 20, 537 (1948).
11. H. Bichsel, Passage of Charged Particles Through Matter, American Institute of Physics Handbook, McGraw-Hill, 1972, Sec. 8, p. 142.
12. H. H. Heckman et. al., Phys. Rev. Lett. 22, 871 (1969) and J. D. Jackson et. al., Phys. Rev. B 6, 4131 (1972).
13. See B. Rossi, High Energy Particles (Prentice Hall, 1952), Section 2.3 for more accurate formulae.
14. Mainly from G. Z. Moliere, Naturforsch. 3(a), 78 (1948).
15. See, for example, the experimental work of A. D. Hansen, L. H. Lanzl, E. M. Lyman, and M. B. Scott, Phys. Rev. 84, 634 (1951).

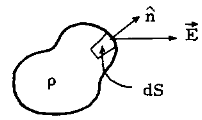
ELECTROMAGNETIC RELATIONS

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:	$\vec{E} = -\vec{\nabla}V,\ \vec{B} = \vec{\nabla}\times\vec{A}$	$\vec{E} = -\vec{\nabla}V,\quad \vec{B} = \vec{\nabla}\times\vec{A}$
Materials:	$\vec{D} = \epsilon\vec{E},\ \vec{B} = \mu\vec{H}$	$\vec{D} = \epsilon\,\epsilon_0\,\vec{E},\ \vec{B} = \mu\mu_0\,\vec{H}$
Force:	$\vec{F} = q(\vec{E} + \frac{\vec{v}}{c}\times\vec{B})$	$\vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$
Maxwell:	$\vec{\nabla}\cdot\vec{E} = 4\pi\rho$,	$\vec{\nabla}\cdot\vec{D} = \rho$,
	$\vec{\nabla}\times\vec{E} = -\frac{1}{c}\frac{\partial\vec{B}}{\partial t}$,	$\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$,
	$\vec{\nabla}\cdot\vec{B} = 0$,	$\vec{\nabla}\cdot\vec{B} = 0$,
	$\vec{\nabla}\times\vec{B} = \frac{4\pi\vec{J}}{c} + \frac{1}{c}\frac{\partial\vec{E}}{\partial t}$	$\vec{\nabla}\times\vec{H} = \vec{J} + \frac{\partial\vec{D}}{\partial t}$

Integral Forms (MKSA)

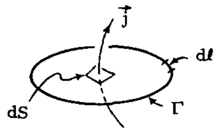
1. Gauss' theorem:



$$\int_{\text{surface}} \vec{E}\cdot\hat{n}\ dS = \int_{\text{volume}} \rho/\epsilon_0\ dV$$

(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:

$$Z = \frac{(1+i)\rho}{w\delta};$$

$$\rho = \text{resistivity} \begin{cases} \sim 1.7\times10^{-8}\ \Omega\,\text{m for Cu} \\ \sim 2.8\times10^{-8}\ \Omega\,\text{m for Al} \end{cases}$$

δ = effective skin depth

$$= \sqrt{\frac{\rho}{\pi\nu\mu\mu_0}} \approx \frac{6.6\ \text{cm}}{\sqrt{\nu(\text{sec}^{-1})}} \quad \text{for Cu}$$

Capacitance C and Inductance L per Unit Length (MKSA)

1. For flat plates of width w, separated by $d \ll w$:

$$C = \frac{\epsilon\,\epsilon_0 w}{d}\ ;\quad L = \mu\mu_0\frac{d}{w}\ .$$

2. For coax cable of interior and exterior radii r_1 and r_2:

$$C = \frac{2\pi\,\epsilon\,\epsilon_0}{\ln(r_2/r_1)}\ ;\quad L = \frac{\mu\mu_0}{2\pi}\ln(r_2/r_1);$$

$$\epsilon = \text{dielectric constant} \begin{cases} 2 \text{ to } 6 \text{ for plastics} \\ 4 \text{ to } 8 \text{ for porcelain, glasses} \end{cases}$$

μ = magnetic susceptibility

Transmission Lines (No Loss) (MKSA)

Velocity $= 1/\sqrt{LC} = c/\sqrt{\mu\epsilon}$

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, John Wiley & Sons, New York, 1962, for more formulae and details. (Prepared April 1974.)

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 $\times$ QF,
where QF (quality factor) depends upon the type of radiation and other factors. For γ rays and HE protons, QF $\approx$ 1; for thermal neutrons, QF $\approx$ 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 $\approx$ 100 millirem/week)

Fluxes (per cm^2) to liberate 1R in carbon:
3×10^7 minimum ionizing singly charged particles
0.9×10^9 protons of 1 MeV energy
(These fluxes are correct to within a factor of 2 for all materials.)

Natural background: 120 to 130 millirem/year
$\left.\begin{array}{ll}\text{cosmic radiation (charged particles + neutrons)} & \sim 25\\ \text{cosmic radiation } (\gamma \text{ rays}) & \sim 25\\ \text{radiation from rocks and air } (\gamma \text{ rays}) & \sim 73\end{array}\right\}\text{mrem/yr}$
Cosmic ray background in counters: ~ 1/min/cm^2/ster

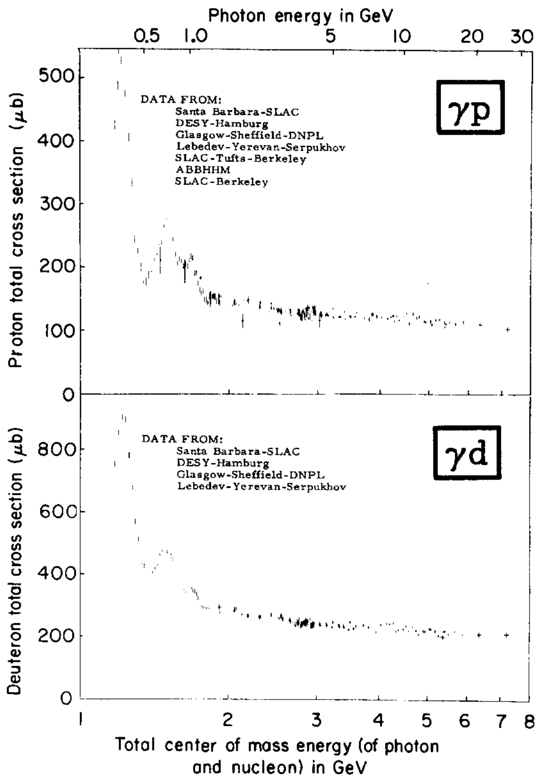
PERIODIC TABLE OF THE ELEMENTS

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 A 39.948
19 K 39.102	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 65.37	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 102.905	46 Pd 106.4	47 Ag 107.868	48 Cd 112.40	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 192.2	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)	89– Acti- nides	104	105													

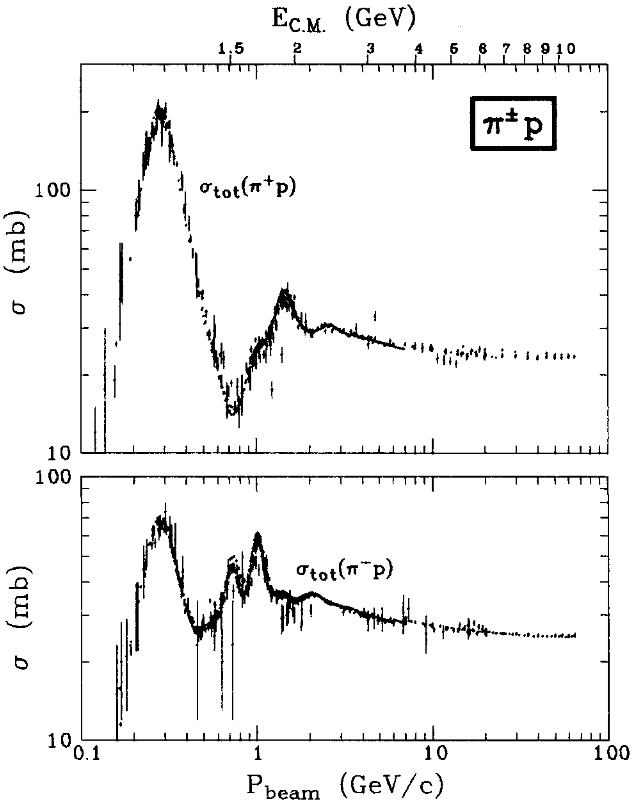
57 La 138.91	58 Ce 140.12	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97	Rare earths (Lanthanide series)
89 Ac (227)	90 Th 232.038	91 Pa 231.036	92 U 238.03	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (256)	102 No (254)	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, 1973-74.* (Particle Data Group update, April 1974.)

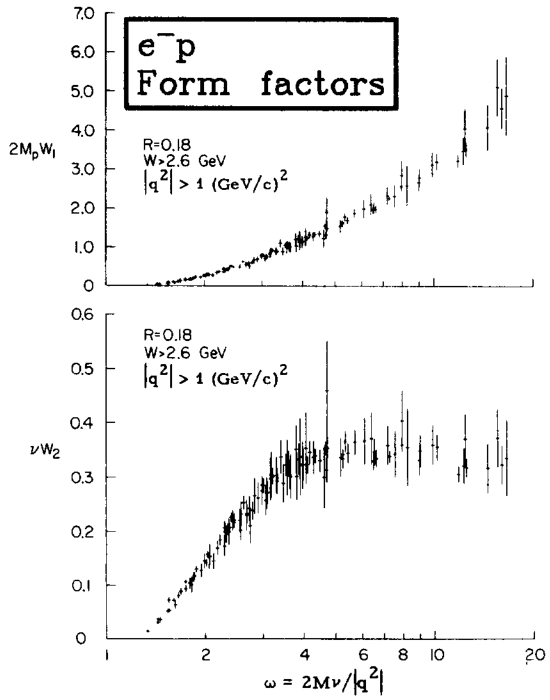
CROSS SECTION PLOTS



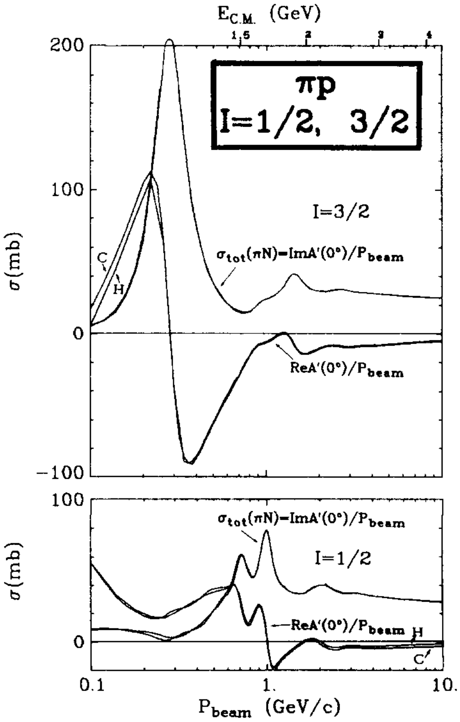
$\sigma_{tot}(\gamma p)$ and $\sigma_{tot}(\gamma d)$ as compiled by G. M. Lewis, Glasgow.



$\pi^{\pm}p$ total cross-section data from the Particle Data Group compilation "πN Two-Body Scattering Data," LBL-63 (1973).

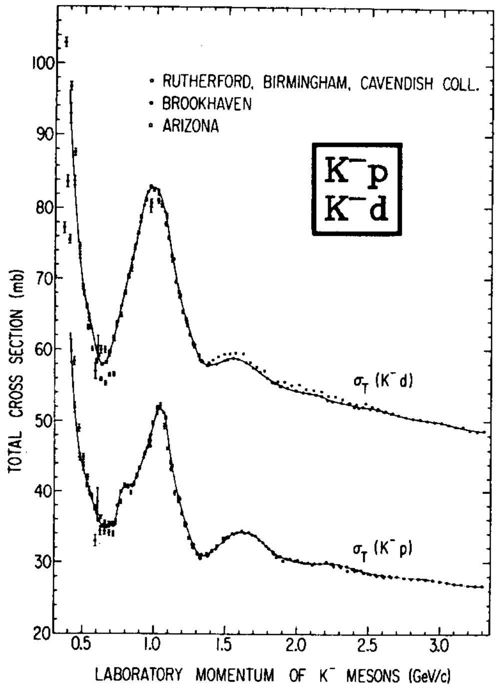


Inelastic electroproduction form factors for a virtual space-like photon scattering on a proton, from SLAC-MIT, Phys. Rev. D5, 528 (1972). $R = \sigma_S/\sigma_T$, the ratio of the longitudinal to transverse cross sections. See L. Hand, Phys. Rev. 129, 1834 (1963).

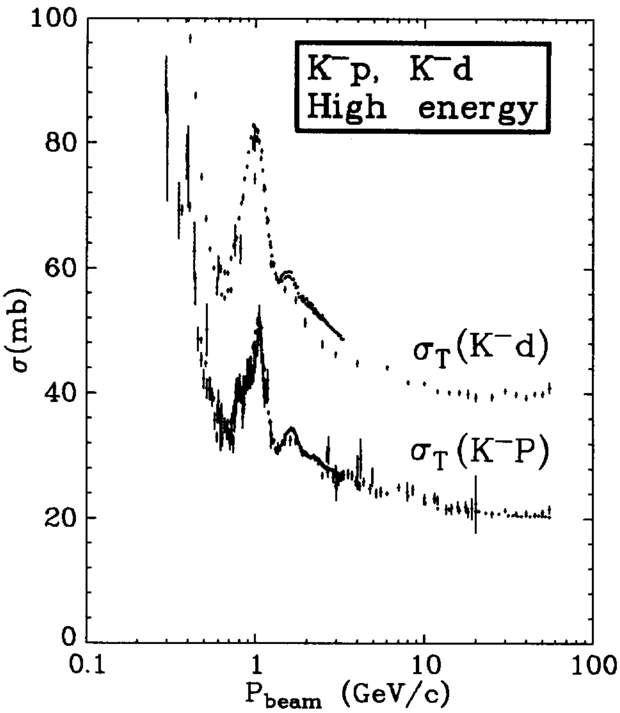


Interpolations of πN total cross sections for I=3/2 and 1/2, and the corresponding real parts of the forward amplitudes as calculated from dispersion relations by A. A. Carter and J. R. Carter (RHEL ppt. RL-73-024, 1973; labeled C above) and by G. Hohler and H. P. Jakob (priv. comm., 1972; labeled H 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 $mb/(GeV/c)^2$.

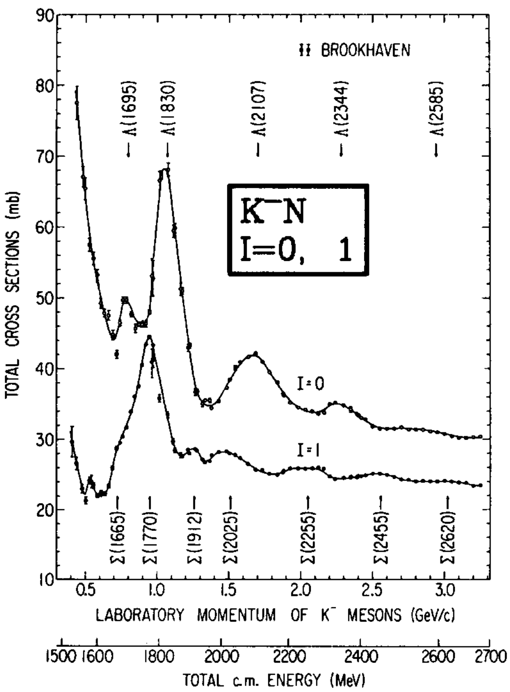
CROSS SECTION PLOTS (Cont'd)



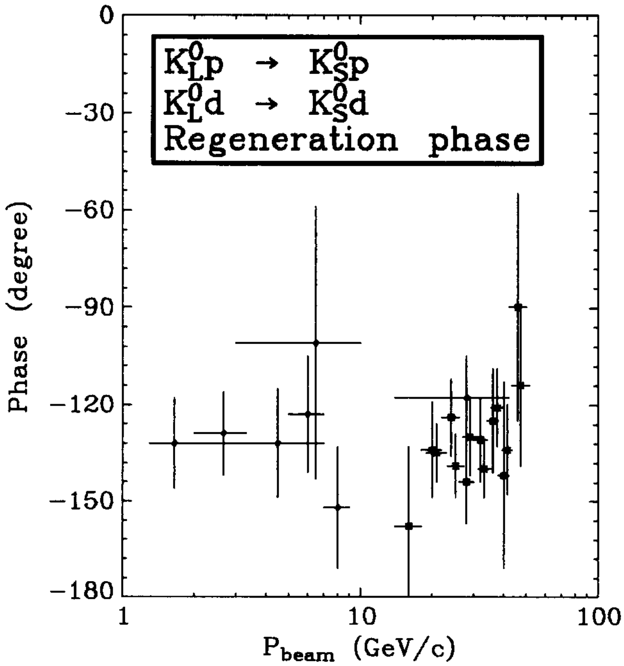
K^-p and K^-d total cross-section data compiled by Li et al., Proc. 1973 Purdue Conf. on Baryon Resonances. The solid curve passes through the Brookhaven data.



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.

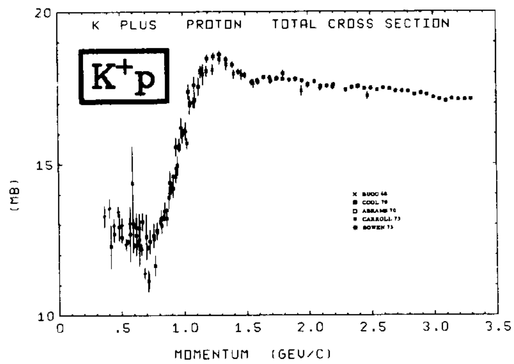


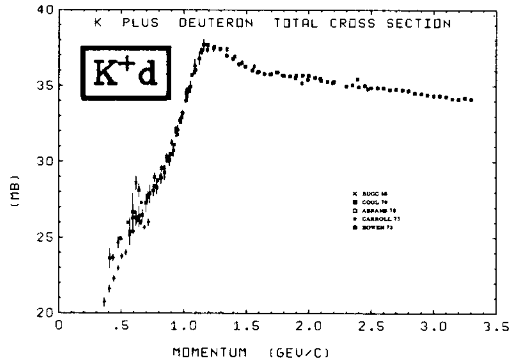
K^-N total cross sections for I = 0 and I = 1 below 3.3 GeV/c. Compiled and unfolded by Li et al., Proc. 1973 Purdue Conf. on Baryon Resonances.



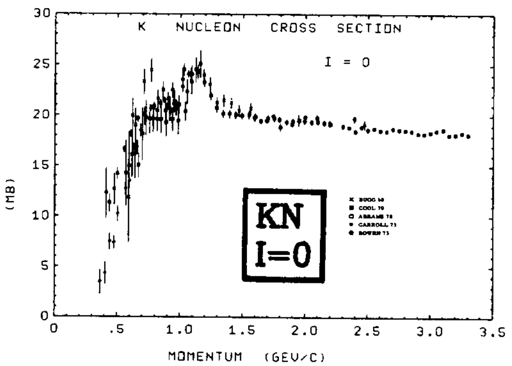
Phases of forward amplitudes for $K^0_Lp \rightarrow K^0_Sp$ (◇,□) and $K^0_Ld \rightarrow K^0_Sd$ (*). The deuterium data are shifted 1 GeV/c higher to avoid overlap with the proton data. ◇-p, compiled by Particle Data Group, LBL-55; □-p, V. Birnlev et al; JINR-E1-6851 (1972); *-d, K.-F. Albrecht et al., Phys. Lett. 48B, 257 (1974).

CROSS SECTION PLOTS (Cont'd)

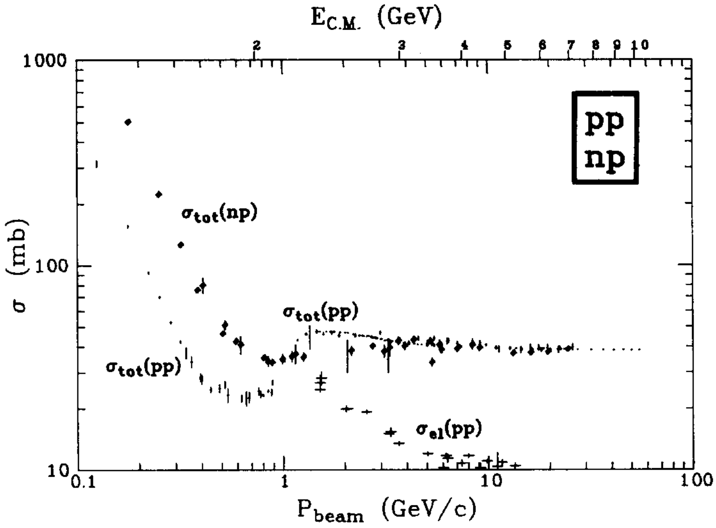




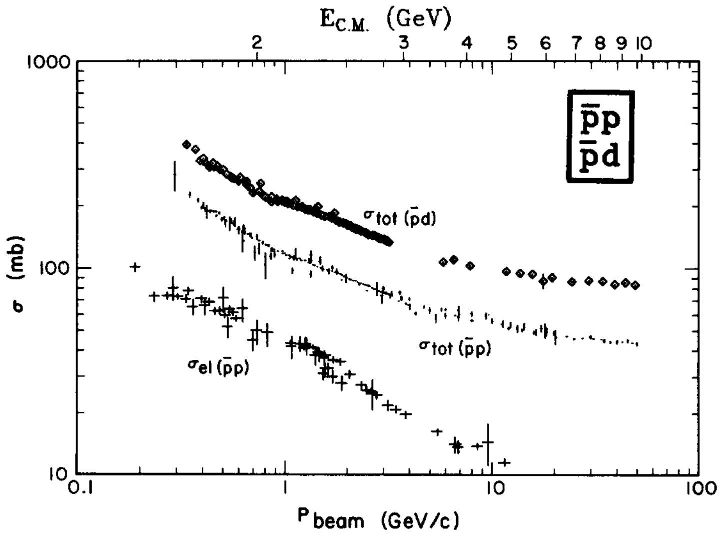
Compilation of recent K^+p and K^+d total cross-section measurements. References can be found in the Baryon Data Card Listings.



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).



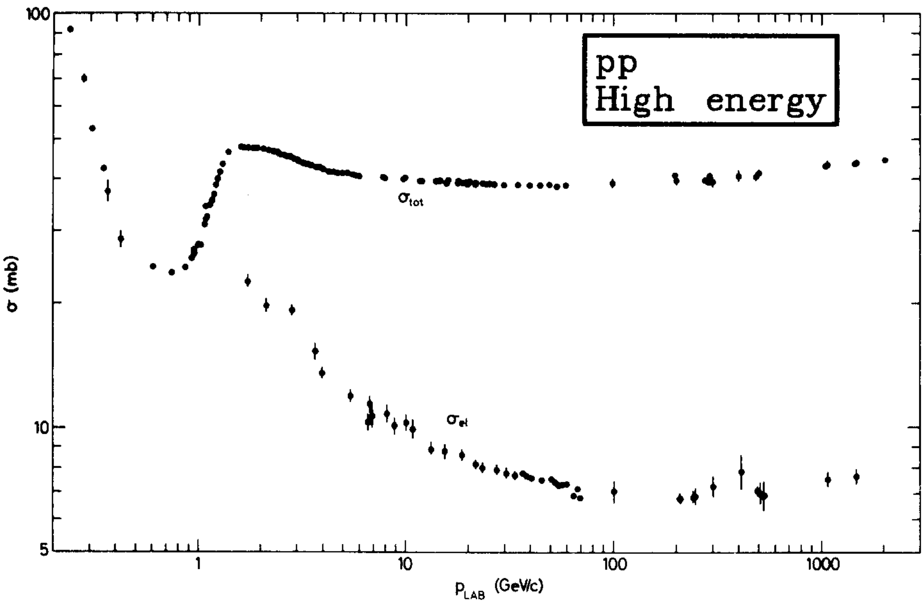
pp and np cross sections from Particle Data Group, "NN and ND Interactions -- A Compilation", UCRL-20 000 NN (August 1970); some points at higher energies added since original compilation.



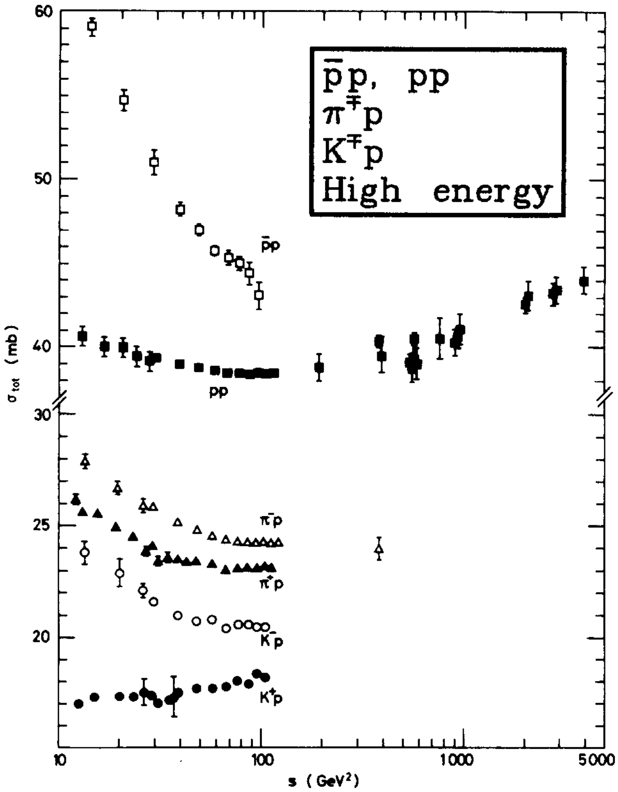
XBL 743-2661

$\bar{p}p$ and $\bar{p}d$ cross sections from Particle Data Group, " A Compilation of $\bar{N}N$ 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.



$\bar{p}p$, pp, $\pi^{\mp}p$, and $K^{\mp}p$ total cross-section data versus $s(\approx 2m_p p_{lab})$, as compiled by U. Amaldi, CERN.

DATA CARD LISTINGS

Illustrative Key

Name of particle as it appears in table.

Arrow indicates this particle omitted from table.

Quantity tabulated below.

Code for quantity tabulated (M=mass, W=width, etc.)

Symbols used to key together data card and related comments.

Number of events above background.

Measured values (parentheses indicate value not used in average).

± Error in measured value (– field blank if error symmetric; parentheses on error only indicate data not used in average due to problems with error estimation).

Average value (and error) of quantity measured.

Vertical bar indicates average; width of horizontal bar on top is error (scaled) in average.

Value and error for each experiment.

Partial decay mode (labeled by P_i).

Branching ratio (labeled by R_j).

Value (and error) of quantity measured, as determined from constrained fit (using all measured branching ratios for this particle).

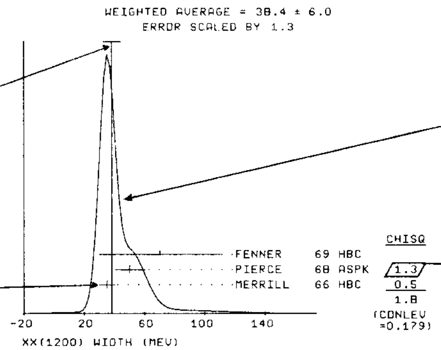
References listed by year, then author.

Abbreviated reference form used on data cards above.

Journal, report, preprint, etc. (see abbreviations on next page).

XX(1200)

```
74 XX MESON (1200,JPG=  -)  I=1
   ORIGINALLY CALLED XXX
   OMITTED FROM TABLE
------ --------- --------- --------- --------- --------- --------- --------
                 74  XX(1200) MASS (MEV)
M         1216.       11.         MERRILL   66 HBC    0 3.2 K-P      7/66
M   L 150 (1192.)    (16.)        LYNCH     67 HBC   +- 2.7 PI-P     6/67
M   L  LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION
M         1198.       10.     7.  PIERCE    68 ASPK  +  2.1 K-P      9/68
M        (1208.)                  FENNER    69 HBC    0 4.2 PI+P     9/69
M   S  80 1210.       8.          SMITH     70 MMS    - 3.5 PI-P     1/74*
M   S  SUPERSEDES EARLIER RESULT
M         . . . . . . . . . .
M   AVG   1206.9      5.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
------ --------- --------- --------- --------- --------- --------- --------
                 74  XX(1200) WIDTH (MEV)
W         35.         5.          MERRILL   66 HBC    0 3.2 K-P      7/66
W         50.         10.         PIERCE    68 ASPK  +  2.1 K-P      9/68
W         70.         40.         FENNER    69 HBC    0 4.2 PI+P     9/69
W        (60.)        OR LESS     SMITH     70 MMS    - 3.5 PI-P     1/74*
W         . . . . . . . . . .
W   AVG   38.4        6.0      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                    (SEE IDEOGRAM BELOW )
```

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------ --------- --------- --------- --------- --------- --------- --------
                 74  XX(1200) PARTIAL DECAY MODES

                                                       DECAY MASSES
P1      XX(1200) INTO 3PI                              139+ 139+ 139
P2      XX(1200) INTO K KBAR                           493+ 493
------ --------- --------- --------- --------- --------- --------- --------
                 74  XX(1200) BRANCHING RATIOS

R1      XX(1200) INTO 3PI/TOTAL                        (P1)
R1              .66       .02     MERRILL   66 HBC    0 3.2 K-P      7/66
R1  L          (.68)     (.03)    LYNCH     67 HBC   +- 2.7 PI-P     6/67
R1  L   LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION
R1              . . . . . . . . .
R1  FIT       0.675     0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2      XX(1200) INTO KKBAR/TOTAL                      (P2)
R2              .35       .05     PIERCE    68 ASPK  +  2.1 K-P      9/68
R2              . . . . . . . . .
R2  FIT       0.325     0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

R3      XX(1200) INTO KKBAR/3PI                        (P2)/(P1)
R3              .50       .03     FENNER    69 HBC    0 4.2 PI+P     9/69
R3              .41       .04     SMITH     70 MMS    - 3.5 PI-P     1/74*
R3              . . . . . . . . .
R3  AVG       0.468     0.043   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
R3  FIT       0.480     0.026   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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                        REFERENCES FOR XX(1200)

MERRILL   66 PRL 16 143      A. MERRILL                  (SACLAY+CERN)
LYNCH     67 PR 155 610      B. LYNCH                           (BNL)
PIERCE    68 PL 27B 230      N. PIERCE                          (LRL)
FENNER    69 NC 61B 372      D. FENNER,B. BEANE            (NYSE+AMEX)
SMITH     70 PRL 24 14       J. SMITH                          (SLAC)
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Particle name, and quantum numbers (if known).

Particle code (for internal use only).

General comments on particle.

Abbreviated reference for this result; full reference given below.

Measurement technique (see abbreviations on next page.)

Charge(s) of particle detected.

Reaction producing particle, or comments.

Date this result punched (asterisk indicates result added or changed since previous edition).

Scale factor > 1 indicates inconsistent data.

Ideogram to display inconsistent data; curve is sum of Gaussians, one for each experiment (area of Gaussian = 1/error; width of Gaussian = ± error).

Contribution of experiment to χ^2 (if no entry present, experiment not used in calculating χ^2 or scale factor because of large error).

Branching ratio R_j in terms of partial decay mode fractions P_i above.

Author(s)

Institution(s) of author(s) (see abbreviations on next page).

Illustrative Key *(cont'd)*

Abbreviations

Journals

APAH	Acta Phys. Acad. Hungarica
ADVP	Advances in Physics
ANP	Annals of Physics
ARNS	Annual Reviews of Nuclear Science
BAPS	Bulletin of the American Physical Society
JETP	English Translation of Soviet Physics JETP
JETPL	Letters to Soviet Physics JETP
LNC	Letters to Nuovo Cimento
NC	Nuovo Cimento
NP	Nuclear Physics
PL	Physics Letters
PN	Particles and Nuclei
PPSL	Proceedings of the Physical Society of London
PR	Physical Review
PRL	Physical Review Letters
PRSL	Proceedings of the Royal Society of London
RMP	Reviews of Modern Physics
SJNP	Soviet Journal of Nuclear Physics
ZPHY	Zeitschrift für Physik

Measurement techniques

ASPK	Automatic spark chambers
CC	Cloud chamber
CNTR	Counters, electronics
DBC	Deuterium bubble chamber
DPWA	Energy-dependent partial wave analysis
EMUL	Emulsions
HBC	Hydrogen bubble chamber
HEBC	Helium bubble chamber
HLBC	Heavy liquid bubble chamber
IPWA	Energy-independent partial wave analysis
MMS	Missing mass spectrometer
MPWA	Model-dependent partial wave analysis
OSPK	Optical spark chambers
RVUE	Review of previous experimental data
STRC	Streamer chamber

Conferences

Conferences are referred to by the location in which they were held (e.g., DUBNA, BOULDER, LUND, etc.).

Institutions

AACH	TECHNISCHE UNIV. AACHEN	AACHEN, GERMANY
AERE	ATOMIC ENERGY RES. ESTAB.	HARWELL, BERKS., ENGLAND
AMST	UNIV. OF AMSTERDAM	AMSTERDAM, NETHERLANDS
ANKA	MIDDLE EAST TECHNICAL UNIV.	ANKARA, TURKEY
ANL	ARGONNE NAT. LAB.	ARGONNE, ILL., USA
ARIZ	UNIV. OF ARIZONA	TUCSON, ARIZ., USA
ATEN	NUCLEAR RES. CENTRE DEMOKRITOS	ATHENS, GREECE
BARI	UNIV. DI BARI	BARI, ITALY
BELG	INST. INTERUNIV. DES SCI. NUC.	BRUXELLES, BELGIUM
BERG	FYSISK INSTITUTT	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	BROCKHAVEN NATIONAL LAB.	UPTON, L.I., N. Y., USA
BOHR	NIELS BOHR INSTITUTE	COPENHAGEN, DENMARK
BONN	UNIV. BONN	BONN, GERMANY
BOST	BOSTON UNIV.	BOSTON, MASS., USA
BRAN	BRANDEIS UNIV.	WALTHAM, MASS., USA
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
CARL	CARLTON 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
CDEF	COLLEGE DE FRANCE	PARIS, FRANCE
CEA	CAMBRIDGE ELECTRON ACCEL.	CAMBRIDGE, MASS., USA
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., LSA
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
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
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
FRAS	LAB. NAZIONALI DEL SINCROTRONE	FRASCATI, ITALY
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
GSCO	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
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
IND	UNIV. OF INDIANA	BLOOMINGTON, IND., USA
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	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
KIAE	KURCHATOV INST. OF ATOMIC ENERGY	MOSCOW, USSR
KNTY	UNIV. OF KENTUCKY	LEXINGTON, KY., USA
LALO	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
LEBD	LEBEDEV PHYSICS INST.	MOSCOW, USSR
LEHI	LEHIGH UNIV.	BETHLEHEM, PA., USA
LEID	INST. LORENTZ	LEIDEN, NETHERLANDS
LINZ	LINZ INSTITUT FUR PHYSIK, KEPLER HOCH.	LINZ, AUSTRIA
LIVP	LIVERPOOL UNIV.	LIVERPOOL, ENGLAND
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
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
MANH	MANHATTAN COLLEGE	NEW YORK, N. Y., USA
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
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
MONS	UNIV. DE L'ETAT	MONS, BELGIUM
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
NAGO	NAGOYA UNIV.	NAGOYA, JAPAN
NAL	NATIONAL ACCELERATOR LAB.	BATAVIA, ILL., USA
NAPL	UNIV. DI NAPOLI	NAPOLI, ITALY
NDAM	UNIV. OF NOTRE DAME	NOTRE DAME, IND., USA
NEAS	NORTHEASTERN UNIV.	BOSTON, MASS., USA
NEVI	NEVIS LAB.	IRVINGTON-ON-HUDSON, N.Y., USA
NIJM	R. K. UNIV. NIJMEGEN	NIJMEGEN, NETHERLANDS
NLJ	NAT. LAB FOR HIGH ENERGY PHYS., JAPAN	IBARAKI-KEN, JAPAN
NORD	NORDISK INS. FOR TEOR. ATOMFYS.	COPENHAGEN, DENMARK
NOVO	INST. OF NUCL. PHYS.	NOVOSIBIRSK, USSR
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
OSLO	OSLO UNIV.	OSLO, NORWAY
OSU	OHIO STATE UNIV.	COLUMBUS, OHIO, USA
OXF	OXFORD UNIV.	OXFORD, ENGLAND
PADO	UNIV. DI PADOVA	PADOVA, ITALY
PATR	UNIV. OF PATRAS	PATRAS, GREECE
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
PPAG	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
ROCH	UNIV. OF ROCHESTER	ROCHESTER, N. Y., USA
ROMA	UNIV. DI ROMA	ROMA, ITALY
RUTG	RUTGERS UNIV.	NEW BRUNSWICK, N. J., USA
SACL	CNTR. D'ETUDES NUC. SACLAY	GIF-SUR-YVETTE, FRANCE
SAGA	SAGA UNIV.	SAGA, JAPAN
SEAT	SEATTLE PACIFIC COLLEGE	SEATTLE, WASH., USA
SERP	INST. OF HIGH EN. PHYS.	SERPUKOV, USSR
SETO	SETON HALL UNIV.	SOUTH ORANGE, N. J., USA
SHMP	UNIV. OF SOUTHAMPTON	SOUTHAMPTON, ENGLAND
SLAC	STANFORD LINEAR ACCEL. CENTER	STANFORD, CALIF., 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	SUSSEX UNIV.	SUSSEX, ENGLAND
SYRA	SYRACUSE UNIV.	SYRACUSE, N. Y., USA
TELA	UNIV. OF TEL-AVIV	TEL-AVIV, ISRAEL
TENN	UNIV. OF TENNESSEE	KNOXVILLE, TENN., USA
TNTO	UNIV. OF TORONTO	TORONTO, CANADA
TOHO	TOHOKU UNIV.	SENDAI, JAPAN
TOKY	UNIV. OF TOKYO	TOKYO, JAPAN
TORI	UNIV. DI TORINO	TORINO, ITALY
TRST	UNIV. DI TRIESTE	TRIESTE, ITALY
TUFT	TUFTS UNIV.	MEDFORD, MASS., USA
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
UTAH	UNIV. OF UTAH	SALT LAKE CITY, UTAH, USA
VAND	VANDERBILT UNIV.	NASHVILLE, TENN., USA
VIEN	INST. FOR HIGH EN. PHYS., A. A. S.	VIENNA, AUSTRIA
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
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

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                   0 GAMMA (0,J=1)
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                   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  F   VALIDITY QUESTIONABLE ACCORDING TO AUTHORS AND KROLL 71.                3/72
M  P   SEE CRITICISM IN GOLDHABER 71                                          3/72

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                          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)

                          PAPERS NOT REFERRED TO IN DATA CARDS

GOLDHABE 71 RMP 43 277        A S GOLDHABER, M M NIETO  (STON+BOHR+UCSB)
KROLL    71 PPL 26 1395       N M KROLL                           (SLAC)

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ν_e

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                   1 E-NEUTRINO (0,J=1/2)
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                   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*

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                          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)

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ν_μ

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                   2 MU-NEUTRINO (0,J=1/2)
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                   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   O. K- HE        11/67
M          (0.46)    (0.64)   (0.46)  FRANK     68 CNTR   PRELIMINARY      9/68
M  B       (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        1.15   OR LESS  CL=.90    BACKENSTO 73 CNTR   M**2=-0.29+-0.90  1/73
M  B    BACKENSTOSS 73 REPLACES BACKENSTOSS 71 AND USES THEIR NEW PI- MASS.  1/73
M  B    WE CALCULATE UPPER LIMIT FROM M**2.                                  1/73
M  S    SHRUM 71 USES SHAFER 67 PI- MASS VALUE AND CRANE 71 MU MASS VALUE.  1/73

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                          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,NORTON,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)
FRANK    68 VIENNA ABS.  365  FRANK,GAMET,LAKIN          (SHMP+LIVP+STAN)
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)

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                   3 ELECTRON (0.5,J=1/2)
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                   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*

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                   3 ELECTRON MEAN LIFE (UNITS 10**21 YR)

T            2.0  OR MORE          MOE        65 CNTR                      6/66

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                   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**-10TAYLOR     69 RVUE                  . 2/71
MM       (1.001159644)  +-(7)* 10**-9 WESLEY    70 CNTR                    6/70
MM       (1.0011596577)+-(35)*10**-10WESLEY     71 CNTR  -                 2/72
MM       (1.0011603)    +-(12)*10**-7 GILLELAND 72 CNTR  +                 2/72
MM        1.0011596567 +-(35)*10**-10COHEN      73 RVUE                    3/74*
MM R    RICH 68 IS REEVALUATION OF WILKINSON 63.

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                          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

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                   4 MUON (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   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            . . . . . . . . .
M   FIT     105.6595     .0003  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) 3/74*

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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             2.20026   0.00081        WILLIAMS  72 CNTR +                  2/72
T             . . . . . . . . .
T   AVG       2.19936   0.00061  0.00061 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.1)

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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 FOR A REVIEW OF THEORY AND EXPERIMENTS.                 3/74*
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

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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 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

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                         4  MUON PARTIAL DECAY MODES

                                                           DECAY MASSES
P1       MUON INTO E (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

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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

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      KORENCHENKO2 71 ASSUMES A CONSTANT MATRIX ELEMENT.                  2/72
R2 F      FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND
R2        ORDER V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED B
R2        ASSUMING A CONSTANT MATRIX ELEMENT.

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

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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)

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)

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)

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)

GS       SCALAR COUPLING CONSTANT IN MUON DECAY  (IN UNITS OF GV)
GS          (0.33) OR LESS           DERENZO   69 RVUE                        10/69

GS       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

COFFIN   58 PR 109 973          +GARWIN,PENMAN,LEDERMAN,SACHS     (COLUMBIA)
LUNDY    58 PRL 1 38            +SENS,SWANSON,TELEGDI,YOVANOVITCH (CHICAGO)
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)
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 PL     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+  (CCLU)

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 RUJULA,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)
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)
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+LPL)
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

                                PAPERS NOT REFERRED TO IN DATA CARDS

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)
VOSSLER  69 NC 63A 423          C VOSSLER                             (EFI)
RICH     72 RMP 44 250          A RICH,J C WESLEY                    (MICH)
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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     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    AVG        139.5682   0.0068  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    FIT        139.5688   0.0064 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)    3/74*

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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             . . . . . . . . . .
D    AVG         33.915    0.019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    FIT         33.909    0.006  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)    3/74*
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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)
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              8  ((PI+) - (PI-))/AVG., MEAN LIFE DIFFERENCE (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)
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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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              8  CHARGED PION BRANCHING RATIOS

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           1.247     0.028            DI CAPUA   64 CNTR
R2           . . . . . . . . .
R2  AVG      1.242     0.026     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)
    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      143   3.0      0.5              DEPOMMI2   63 CNTR      GAM KE 50-90 MEV  6/66

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

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                     REFERENCES FOR CHARGED PION

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)
BARTLETT  64 PR 136B 1452       BARTLETT,DEVONS,MEYER,ROSEN        (COLUMBIA)
DI CAPUA  64 PR 133B 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                         (NAL)
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,PAZUVAEV+         (SERP)

                                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
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              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)
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              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   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            . . . . . . . . .
T   AVG      0.839     0.103     0.092  AVERAGE (ERROR INCL. SCALE FACTOR OF 2.1)
                                       (SEE IDEOGRAM BELOW )
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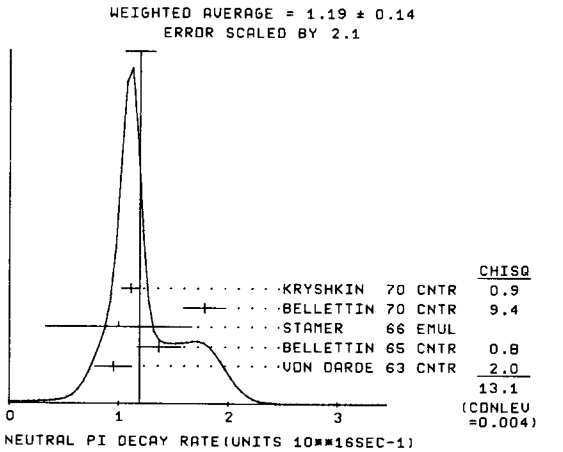


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              9  NEUTRAL PION PARTIAL DECAY MODES

                                                           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
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              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)

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          (3.47)   THEORETICAL CAL. KROLL      55           QUANTUM ELECT.     9/66
R3      146    3.18      0.30          SAMIOS     62 HBC      SEE NOTE N BELOW   6/66
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*

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Stable Particles

π^0, $K^{\pm}$

Data Card Listings

For notation, see key at front of Listings.

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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)
KROLL    55 PR 98 1355          N KROLL ,W WADA              (COLUMBIA+NRL)
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)
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)

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$K^{\pm}$

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                    10   CHARGED K (494,JP=0-) I=1/2

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                    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   A      KUNSELMAN 74 UPDATES KUNSELMAN 71 WITH IMPROVED KAONIC ATOM CALC.   3/74*
M              . . . . . . . . . .
M    AVG       493.702   0.037   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    FIT       493.707   0.037  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*

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                    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

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                    10   CHARGED K MEAN LIFE (UNITS 10**-8)

T          CHAR. K MEAN LIFE
T    O          (0.95)   (0.36)    (0.25) ILOFF      56 EMUL
T    O   52     (1.60)   (0.3)     (0.3)  EISENBERG 58 EMUL
T                1.21     0.06      0.06  BURROWES   59 CNTR
T    O   33     (1.38)   (0.24)    (0.24) FREDEN     60 EMUL
T    O          (1.25)   (0.22)    (0.17) BARKAS     61 EMUL
T    O   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    O   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    FIT         1.2371   0.0026 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)
                          (SEE IDEOGRAM BELOW )
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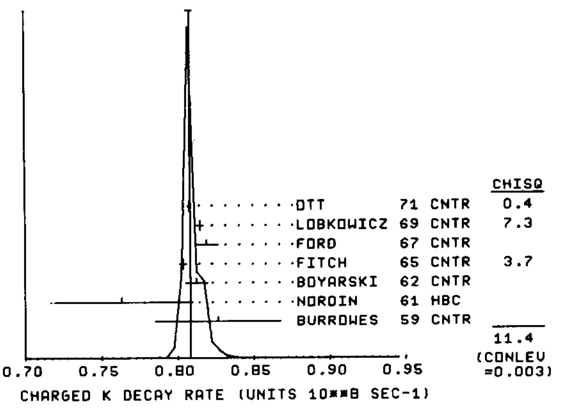
WEIGHTED AVERAGE = 0.8084 ± 0.0021
ERROR SCALED BY 2.4

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           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)

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           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 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
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

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              CHARGED K CONSTRAINED FIT
          OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
          RATIOS USES 55 DATA POINTS TO DETERMINE SIX
          QUANTITIES.  OVERALL FIT HAS  CHISQ=77.7.  MAIN
          CONTRIBUTION (13.3) COMES FROM R19 OF HAIDT
          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	.6354+-.0019					
P 2	-.7965	.2112+-.0017				
P 3	-.1727	-.0170	.0559+-.0003			
P 4	-.1826	.0614	.2053	.0173+-.0005		
P 5	-.2110	-.2392	-.1238	-.3299	.0320+-.0009	
P 6	-.3011	-.1254	.1257	.0157	.2273	.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	.5136+-.0019					
G 2	-.4486	.1707+-.0015				
G 3	-.0986	.0120	.0452+-.0002			
G 4	-.1187	.0726	.2074	.0140+-.0004		
G 5	-.1268	-.2098	-.1284	-.3261	.0258+-.0007	
G 6	-.1458	-.0755	.1299	.0212	.2347	.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       51.36      0.19   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        4.516     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     0.092  FROM FIT
```

```
              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)

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)

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           . . . . . . . . . .
D5   AVG       1.0       3.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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              10  CHARGED K BRANCHING RATIOS

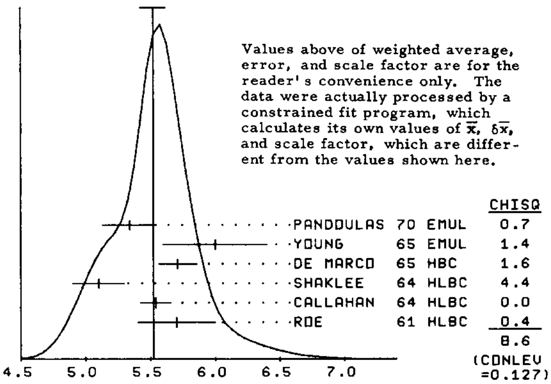
R    O      OLD DATA EXCLUDED

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      63.54      0.19   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      CHAR. K INTO (PI PI0)/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      21.12      0.17   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   FIT       5.587     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 2PI0)/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   FIT       1.732     0.045  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)
                                (SEE IDEOGRAM BELOW )
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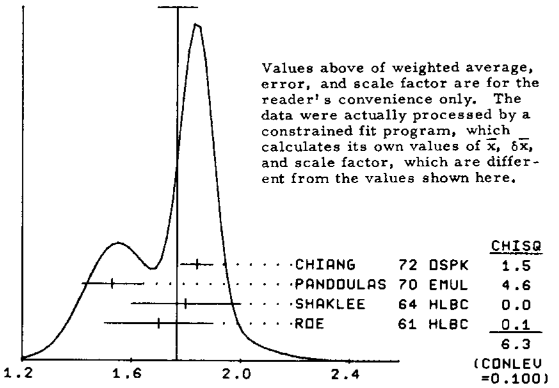
WEIGHTED AVERAGE = 1.767 ± 0.071
ERROR SCALED BY 1.4

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R5      CHAR. K INTO (MU PI0 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     0.087  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R6      CHAR. K INTO (E PI0 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   FIT       4.825     0.054  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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   FIT      24.32      0.17   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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*

R13     CHAR. K INTO (PI PI0 GAMMA)/TOTAL (UNITS 10**-4) (P13)
R13      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  A2100     2.71      0.19            ABRAMS     72 ASPK +- PI+ KE 55-90 MEV  1/73
R13      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  L  17     6.8       3.7       2.1   LJUNG      73 HLBC +  PI+ KE 55-102MEV  9/73*
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 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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            1.53    OR LESS  CL=.90   CLARKE     73 ASPK +  THREE TRACK EVTS  3/74*
R15            0.26    OR LESS  CL=.90   CLARKE     73 ASPK +  TWO TRACK EVENTS  3/74*
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
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```
R17     CHAR. K INTO (E PIO NEU)/(MU2+PI2) (UNITS 10**-2)(P6)/(P1+P2)
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 FIT         3.780     0.037  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                          (SEE IDEOGRAM BELOW )
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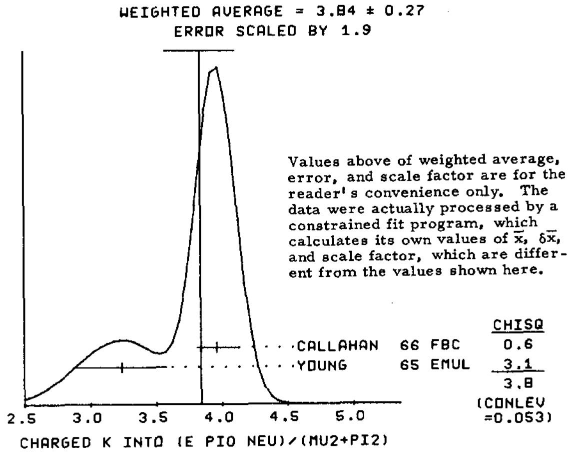


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R18     CHAR. K INTO (PI 2PIO)/TAU                                  (P4)/(P3)
R18    2027     0.303     0.009            BISI       65 H+HL +              . 8/66
R18      17     0.393     0.099            YOUNG      65 EMUL +                8/66
R18             . . . . . . . . .
R18 AVG         0.3037    0.0090   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 FIT         0.3099    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            BISI1      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 FIT         0.572     0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)
                          (SEE IDEOGRAM BELOW )
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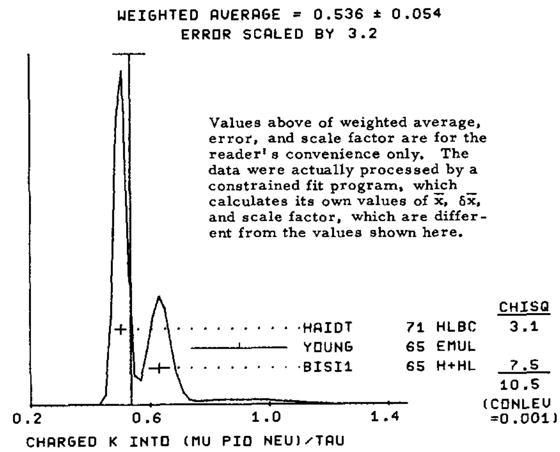


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R20     CHAR. K INTO (E PIO NEU)/TAU                                (P6)/(P3)
R20     230     0.90      0.06             BORREANI   64 HBC  +              . 8/66
R20      37     0.90      0.16             YOUNG      65 EMUL +              . 8/66
R20     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  H  HAIDT 71 IS A REANALYSIS OF EICHTEN 68.
R20             . . . . . . . . .
R20 AVG         0.858     0.018    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R20 FIT         0.864     0.010  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             . . . . . . . . .
R21 AVG         6.64      0.40     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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             . . . . . . . . .
R23 AVG         6.02      0.15     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R23 FIT         5.699     0.069  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  A  AUERBACH 67 CHANGED FROM .3253+-.0065.  SEE COMMENT WITH RATIO R26.   1/74*
R24             . . . . . . . . .
R24 AVG         0.3251    0.0073   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R24 FIT         0.3324    0.0036 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 FIT         0.07593   0.00093 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 ACCORDING TO A REANALYSIS BY    1/74*
R26  A  W. K. MC FARLANE. PRIVATE COMMUNICATION.  THE REANALYSIS BRINGS THE   1/74*
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 FIT         0.0503    0.0014 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

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         11.373    0.074    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             . . . . . . . . .
R28 AVG         2.16      0.31     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R29     CHAR. K INTO (MU PIO NEU)/(E PIO NEU)                 (P5)/(P6)
R29  C1509      0.703     0.056            CALLAHA1    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                        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             . . . . . . . . .
R29 AVG         0.680     0.013    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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                                                        (P18)/(P6)
R30             1.2       0.8              BELLOTT1   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)         (P8)/(P7)              2/72
R37      0      0.013 OR LESS  CL=.95    BOURQUIN   71 ASPK                     12/71

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 +  MU KE 60-100 MEV 11/73*
R41  P  PANG 73 ASSUMES MU SPECTRUM FROM NEU-NEU INTERACTION OF BARDIN 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        0.2284   0.0033 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        0.0820   0.0022 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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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

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

where

$$s_i = (\underline{p}_K - \underline{p}_i)^2 = (m_K - m_i)^2 - 2\,m_K T_i \qquad (2)$$

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

$\underline{p}_K, \underline{p}_i$ are the four-vectors for the K and the i^{th} 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:

$$\tau^{\pm} \qquad K^{\pm} \to \pi^{\pm}\pi^{\pm}\pi^{\mp}$$

$$\tau'^{\pm} \qquad K^{\pm} \to \pi^0\pi^0\pi^{\pm}$$

$$\tau^0 \qquad K_2^0 \to \pi^+\pi^-\pi^0.$$

There is no strong evidence so far (but see FORD 72 discussion below) that a second order term in (s_3-s_0) is needed in Eq. (1), nor that the term in (s_2-s_1) is present. A value of $j \neq 0$ indicates CP violation as would a value of g for τ^+ different from that for τ^-. The CP violation tests in τ decays are listed as $\frac{(g^+-g^-)}{g_{average}}$ for charged K and as $\sigma^{\pm}$ for neutral K (see Sec. VI B.3b in the text).

As for the coefficient h, most of the experimenters have fitted their data with a second order term, which turned out to be consistent with zero. We use the value of g obtained when the second order term was dropped from the fit. HEUSSE 70 have studied the $K_L^0 \to \pi^0\pi^0\pi^0$ decay where only a second order term could explain deviation from uniformity of the Dalitz plot. They also get results consistent with a zero coefficient. ALBROW 70 have studied $K_L^0 \to \pi^+\pi^-\pi^0$ and found that the fit to the Dalitz plot improves if second and third order terms are added (CL goes from 24% to 48%), but the fit with no higher orders is a perfectly acceptable one (CL = 24%). FORD 72 have studied $K^{\pm} \to \pi^{\pm}\pi^{\mp}\pi^{\pm}$ and find that the χ^2/DF goes from 1.38 to 1.20 for DF$\approx$150 when the second order and the 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.

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 two of 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

$$Y = \frac{3T_3 - Q}{Q}\,, \quad Q = m_K - \sum m_i\,.$$

The relevant formulae are:

$$Y = -\frac{3}{2}\,\frac{s_3-s_0}{m_K Q} + \Delta, \text{ with } \Delta = \frac{m_1-m_3}{Q}\left(2 - \frac{m_3+m_1}{m_K}\right)$$

and

$$\boxed{g = \frac{-c_y a_y}{1+a_y\Delta}}\,, \quad \text{with } c_y = \frac{3}{2}\,\frac{m_{\pi^+}^2}{m_K Q}\,.$$

(b) For the analysis of K^0 decay the expression often used is:

$$|M|^2 = 1 + 2a_t\,\frac{m_K}{m_{\pi^+}^2}\,(2T_3 - T_{3\,max})$$

with

$$T_{3\,max} = \frac{m_K^2 + m_3^2 - 4m_{12}^2}{2m_K} - m_3\,.$$

The relevant transformations are

$$T_3 = -\frac{s_3-s_0}{2m_K} + \frac{Q}{3}\,(1+\Delta)$$

and

$$\boxed{g = \frac{-2a_t}{1+a_t c_t}} \ , \text{ with } c_t = \frac{2m_K}{m_{\pi^+}^2}\left[\tfrac{2}{3}Q(1+\Delta) - T_{3\,max}\right].$$

For the reader's convenience we give a table of numerical values for Q, $T_{3\,max}$, Δ, c_y and c_t, obtained using the masses from our August 1970 edition. The g values quoted in these Data Card Listings would not be changed if the current mass values were used.

	Q	$T_{3\,max}$	Δ	c_y	c_t
$\tau^{\pm}$	74.96	48.15	0	0.7894	0.0924
$\tau'^{\pm}$	84.24	53.27	-0.0789	0.7025	-0.0778
τ^0	83.54	53.92	0.0798	0.7028	0.3176

Some K^0 authors use the above form of matrix element:

$$|M|^2 = 1 + 2a_u \frac{m_K}{m_{\pi^+}^2}(2T_3 - T_{3\,max}) \ ,$$

but define

$$T_{3\,max} = \tfrac{2}{3}Q \ .$$

The relevant transformation is then

$$g = \frac{-2a_u}{1+a_u c_u}, \text{ with } c_u = \frac{4m_K}{3m_{\pi^+}^2}Q\Delta = 0.2272.$$

Older K^0 analyses were done using

$$|M|^2 = 1 + a_v \frac{T_3}{m_K} \ .$$

The relevant transformation is then

$$g = \frac{-c_v a_v}{1 + d_v a_v}$$

with

$$c_v = \frac{m_{\pi^+}^2}{2m_K^2} = 0.0393$$

and $d_v = \dfrac{Q}{3m_K}(1+\Delta) = 0.0604$.

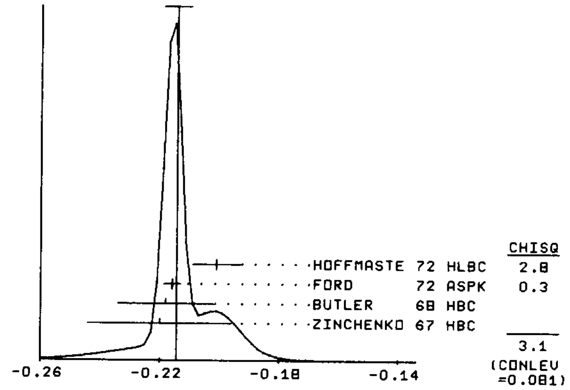
```
                    10  CHARGED K ENERGY DEPENDENCE OF DALITZ PLOT

          RELATED TEXT SECTION VI B.1, APPENDIX I, AND MINI-REVIEW ABOVE

         MATRIX ELEMENT SQUARED =  1 + G (S3-SO)/(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+Z  5428   -0.22      0.024              ZINCHENKO 67 HBC  +  AY=0.28+-.03      10/69
GT+   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+ 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+ G   EMULS. DATA ADDED - ALL EVENTS INCLUDED BY HOFFMASTER 72              1/71
GT+ Z   ALSO INCLUDES DBC EVENTS.
GT+         . . . . . . . . .
GT+ AVG      -0.2144    0.0045  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                       (SEE IDEOGRAM BELOW )
```

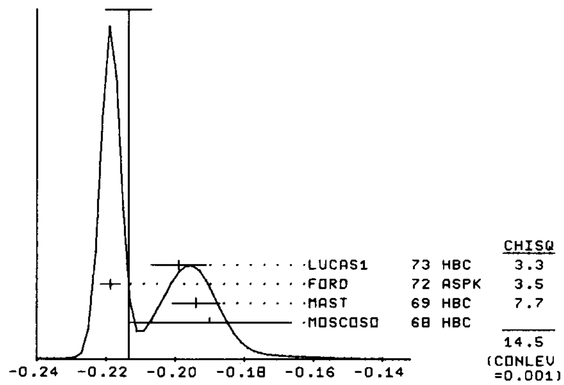
WEIGHTED AVERAGE = -0.2144 ± 0.0045
ERROR SCALED BY 1.7



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-M  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- 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- F   NO RADIATIVE CORRECTIONS INCLUDED.
GT- M   ALSO INCLUDES DBC EVENTS.
GT-         . . . . . . . . .
GT- AVG      -0.2135   0.0066  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
                       (SEE IDEOGRAM BELOW )
```

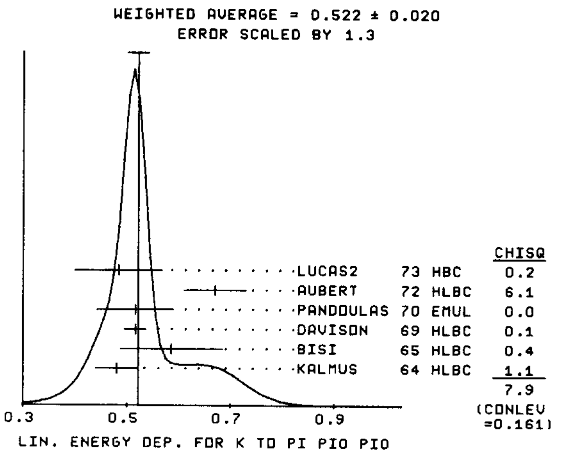
WEIGHTED AVERAGE = -0.2135 ± 0.0066
ERROR SCALED BY 2.7



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              PANDOULAS 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  A  WE GIVE LINEAR TERM OF HIGHER ORDER FIT. EQ.I OF APP.II,AUBERT 72.   1/73
GTP         . . . . . . . . .
GTP AVG       0.522     0.020   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                       (SEE IDEOGRAM BELOW )
```



Note on $K^{\pm}_{\ell 3}$ and $K^{0}_{\ell 3}$ Form Factors

The definitions of the parameters ξ, λ_+, λ_-, $|f_S/f_+|$ and $|f_T/f_+|$ can be found in Sec. VI B.2 of the text. Many approximations are usually made to extract these or related parameters from the experimental data.

1) Scalar and tensor currents: there is no evidence for scalar or tensor currents, so pure vector current is usually assumed.

2) Im ξ so far is consistent with 0, and this is usually assumed in most of the experiments.

3) Radiative corrections are usually included. For corrections see GINSBERG 67, 70, 71, 73 (K^0_L) and BECHERRAWY 70, and for inner bremsstrahlung difficulties, see DONALDSON 73 (K^0_L).

K_{e3} Experiments

The f_- term of the matrix element assuming a pure vector current (Eq. 2, text Sec. 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}: $\lambda_+ = 0.0285 \pm 0.0043$

K^0_{e3}: $\lambda_+ = 0.0257 \pm 0.0043$ (S = 1.3)

where the K^0_{e3} error has been multiplied by the scale factor 1.3 to compensate for inconsistencies (see ideogram in K^0_L section L+E).

$K_{\mu 3}$ Experiments

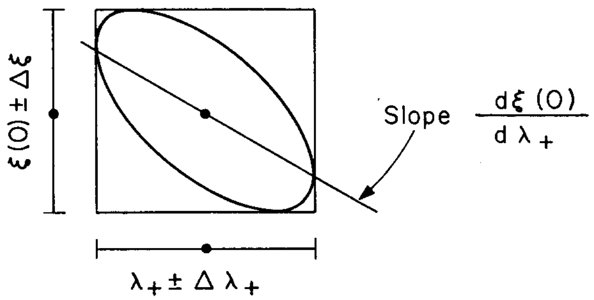
The matrix element for $K_{\mu 3}$ decay is more complicated than in K_{e3} decay because the f_- term is present. Most experiments appear to be compatible with the assumption that f_+ depends linearly on t and that f_- is constant. Only DALLY 72 ($K^0_{\mu 3}$) appears to require $\lambda_- \neq 0$ (by about 3 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 DONALDSON 73 (also $K^0_{\mu 3}$).

λ_+, $\xi(0)$ Parametrization: The type and number of parameters used to express the matrix element vary from experiment to experiment. In order to facilitate comparison between experiments, we take all experiments which are compatible with the above assumptions (f_+ linear, f_- constant) and express their results in terms of the parameters λ_+ and $\xi(0)$, i.e., with

$$f_+(t) = f_+(0)(1 + \lambda_+ \frac{t}{m_\pi^2}) ,$$

$$\xi(t) = \frac{f_-(t)}{f_+(t)} = \frac{f_-(0)}{f_+(0)} (1 + \lambda_+ \frac{t}{m_\pi^2})^{-1}$$

Our Data Card Listings also contain the 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 (sections XIA, XIC) and the λ_0 data cards (section L0).



XBL 743-2682

λ_+, λ_0 Parametrization: Recent experiments, e.g. DBBPSS 73 (preliminary, AIX) and DONALDSON 73 (both $K^0_{\mu 3}$) 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

$$f_0(t) = f_+(t) + \frac{t}{m_K^2 - m_\pi^2} f_-(t) .$$

Both DBBPSS and DONALDSON assume linear t dependence given by

$$f_0(t) = f_0(0)\ (1 + \lambda_0 \frac{t}{m_\pi^2}).$$

Unless $f_-(t)$ diverges at $t = 0$, $f_0(0)$ must equal $f_+(0)$. Preliminary reports of the DONALDSON et al. experiment indicated such a possibility, but with modified radiative corrections, they obtain $f_0(0)/f_+(0) = 1.06\pm0.03$, and obtain good fits when they assume $f_0(0) = f_+(0)$.

With the assumption that $f_0(0) = f_+(0)$, the two parametrizations, $(\lambda_+, \xi(0))$ and (λ_+, λ_0) are equivalent. The transformation from the first parametrization to the second is given by

$$\lambda_0 = \lambda_+ + a\xi(0),$$

$$\Delta\lambda_0^2 = (1 + 2a\frac{d\xi(0)}{d\lambda_+})\ \Delta\lambda_+^2 + a^2\Delta\xi^2,$$

$$\frac{d\lambda_0}{d\lambda_+} = 1 + a\frac{d\xi(0)}{d\lambda_+}\ ,$$

where $$a = m_\pi^2/(m_K^2 - m_\pi^2)\ .$$

(λ_+, λ_0) correlations tend to be less strong than $(\lambda_+, \xi(0))$ correlations. However, as can be seen by the likelihood contours in Figs. 1 and 2, correlations cannot be ignored, even in the (λ_+, λ_0) parametrization.

Dalitz plot experiments (abbreviated DP on the data cards) and pion spectrum experiments (PI) frequently give their results in one of the above forms, or the authors have supplied us with such results.

The $\xi(0)$ results for these experiments are listed in section XIA.

If the error (but not the value) is parenthesized, e.g., CARPENTER 66 and PEACH 73 (both $K^0_{\mu3}$), the measurement is for a fixed value of λ_+ given in the footnotes. The same is true for λ_0 values (section L0). Such values and their correlations with λ_+ give rise to the bands in Figs. 1 and 2.

Unparenthesized values are associated with λ_+ (L+M) measurements and give rise to the error ellipses in Figs. 1 and 2.

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^+ section XIA), where the published errors and correlation violate the constraint $|C_{\lambda\xi}| < 1$ on the normalized correlation coefficient $C_{\lambda\xi}$ given by

$$C_{\lambda\xi} = \frac{\Delta\lambda_+}{\Delta\xi}\ \frac{d\xi(0)}{d\lambda_+}.$$

In some cases, e.g., ABBC1 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 ξ (t). Instead, we use

$$\xi(0) = \xi(t^*)\ (1 + \lambda_+ t^*),$$

$$\frac{d\xi(0)}{d\lambda^+} = \frac{d\xi(t^*)}{d\lambda_+}\ (1 + \lambda_+ t^*) + \xi(t^*)\ t^*,$$

with their $\lambda_+ = 0.027$ values: $\xi(6.6) = -0.34\pm0.20$ and $d\xi(6.6)/d\lambda_+ = -14$. We obtain

$$\xi(0) = (-0.40\pm0.24) - 19\,(\lambda_+ - 0.027),$$

or for their fitted $\lambda_+ = 0.025\pm0.017$ we get $\xi(0) = -0.36\pm0.40$.

Branching ratio experiments cannot determine λ_+ and $\xi(0)$ simultaneously, but simply fix a relationship between them, given in Sec. VI B.2 of the text. Results are usually quoted as values of $\xi(0)$ at fixed λ_+. We list these results in section XIB, but we do not average them because the λ_+ values differ. Instead, we use our fitted value of $\Gamma(K_{\mu3})/\Gamma(K_{e3})$ which includes the branching ratios from these experiments. The relations given in the text are then used to determine values of $\xi(0)$ and $d\xi(0)/d\lambda_+$ at $\lambda_+ = 0.03$. $\xi(0)$ is given as the FIT value at the end of section XIB. The scale factor is the amount by which the error has been multiplied in order to compensate for discrepancies in the branching ratios.

The FIT value and correlation are converted to a λ_0 value at $\lambda_+ = 0.03$ and a (λ_+, λ_0) correlation, given as the KMU3/KE3 value in the L0 section.

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 $\xi(t)$. For small λ_+ and assuming $\lambda_- = 0$, we have

$$\xi(0) \approx \langle\xi(t)\rangle\ (1 + \lambda_+ \langle\frac{t}{m_\pi^2}\rangle),$$

$$\frac{d\xi(0)}{d\lambda_+} \approx \langle\xi(t)\rangle\ \langle\frac{t}{m_\pi^2}\rangle.$$

The first relation shows that we can treat all polarization measurements as measurements of $\xi(0)$ assuming $\lambda_+ = 0$. Since all have $\lambda_+ = 0$, we can average them. From the second relation, the correlation with λ_+ can be obtained if we know $\langle t/m_\pi^2 \rangle$ weighted by $\xi(t)$ sensitivity. The $\langle t/m_\pi^2 \rangle$ values from different experiments can also be averaged by weighting with the inverse square of the $\langle \xi(t) \rangle$ errors; see e.g. K^+ section XIC.

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 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. A χ^2 fit to all of the results in Fig. 1 yields

$$K^+_{\mu 3}: \quad \lambda_+ = .028 \pm .006 \qquad \frac{d\lambda_0}{d\lambda_+} = -.14$$
$$\lambda_0 = -.008 \pm .006$$
$$\chi^2/DF = 33/15$$

with corresponding values

$$\xi(0) = -.44 \pm .11 \qquad \frac{d\xi(0)}{d\lambda} = -14.$$

The largest contributors to the χ^2 are CHIANG 72 with 10.5 and the polarization results, BETTELS 68 with 5.4 and CUTTS 69 with 4.2.

The $K^0_{\mu 3}$ results show little consistency. The overall χ^2 is 59 for 9 degrees of freedom (the lower DBBPSS 73 solution was not included).

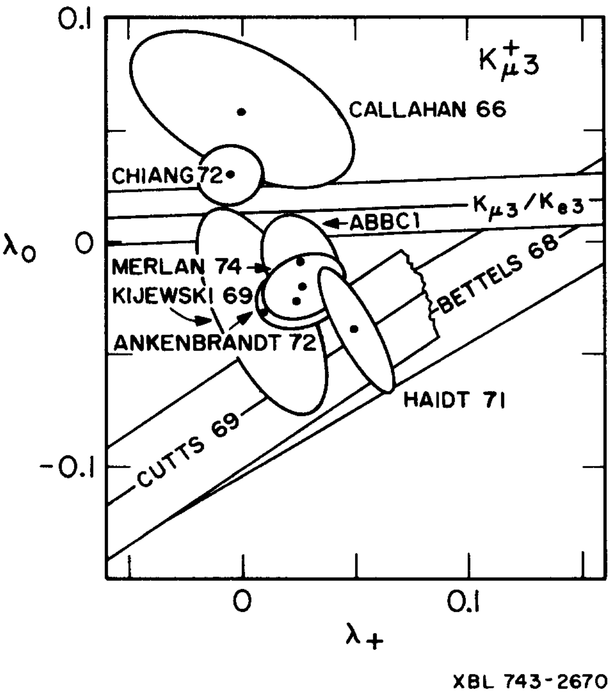


Fig. 1. One-standard-deviation ($e^{-1/2}$) likelihood contours in the (λ_+, λ_0) plane for $K^+_{\mu 3}$.

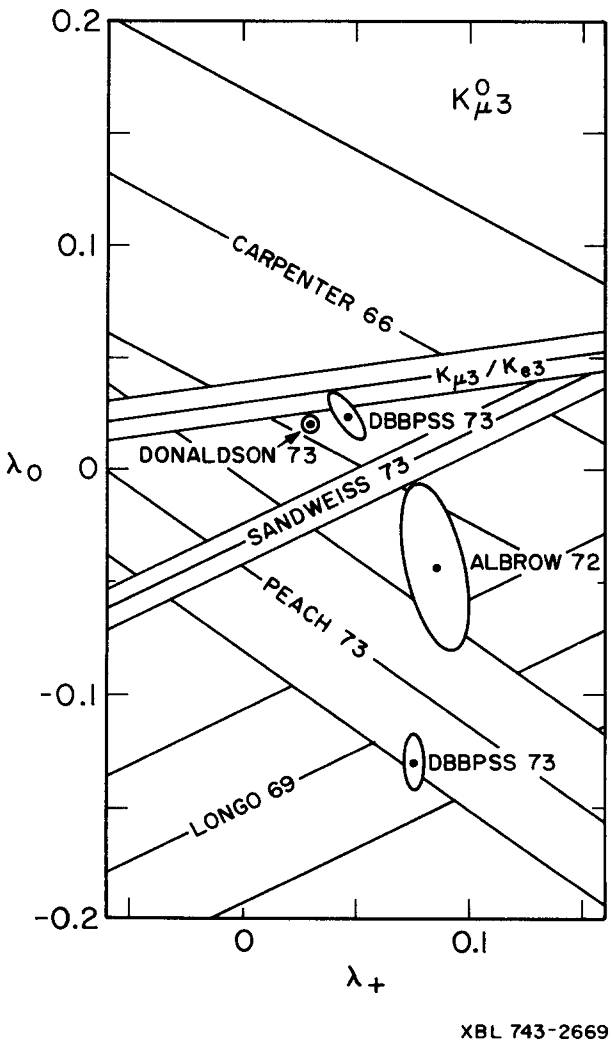


Fig. 2. One-standard-deviation ($e^{-1/2}$) likelihood contours in the (λ_+, λ_0) plane for $K^0_{\mu 3}$.

The DONALDSON 73 result

$$\lambda_{+} = .030 \pm .003$$
$$\lambda_{0} = .020 \pm .003$$

clearly dominates the statistics. Their λ_{+} value is consistent with the K_{e3} value of λ_{+}, and with the pole approximation

$$f_{+}(t) = f_{+}(0)\ \frac{m_{K^*}^2}{m_{K^*}^2 - t}\ .$$

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.

The new polarization result of SANDWEISS 73 brings the polarization λ_0 a less negative value than previous polarization results but is still three standard deviations below the DONALDSON value.

Many of the changes in this section were stimulated by the comments and criticism of L. M. Chounet, and by the excellent reviews of Gaillard and Chounet[1] and Chounet, Gaillard, and Gaillard.[2]

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).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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.
        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.
        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  (+1.8)     (0.6)              BROWN      62 XEBC +  DP+BR, L+=0        1/74*
XIA       87  (+0.7)     (0.5)              GIACOMELL  64 EMUL +  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   D1897   -0.36       0.40              ABBC1      73 HLBC +  DP, DXI/DL=-19     3/74*
XIA   N 490   (-0.8)     (0.8)              ARNOLD     73 HLBC +  DP, DXI/DL=-20     1/74*
XIA   M6527   -0.57       0.24              MERLAN     74 ASPK +  DP, DXI/DL= -9     3/74*
XIA J    JENSEN 64 GIVES L+M=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 DXIO=.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 DXIO=.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   ABBC1 73 GIVES XI(T)=-.34+-.20, DXI(T)/DL+=-14 FOR L+=.027, T=6.6 .       3/74*
XIA  D   WE CALCULATE ABOVE XI(O) AND DXI(O)/DL+ FOR THEIR L+=.025+-.017 .         3/74*
XIA  N   ARNOLD 73 FIG. 3 WAS USED TO OBTAIN XIA AND DXI/DL.  PRELIMINARY.         1/74*
XIA  M   MERLAN 74 FIG.5 WAS USED TO OBTAIN DXI/DL.                                3/74*
XIA          . . . . . . . . . .
XIA AVG     -0.32      0.20     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                                (SEE IDEOGRAM BELOW )
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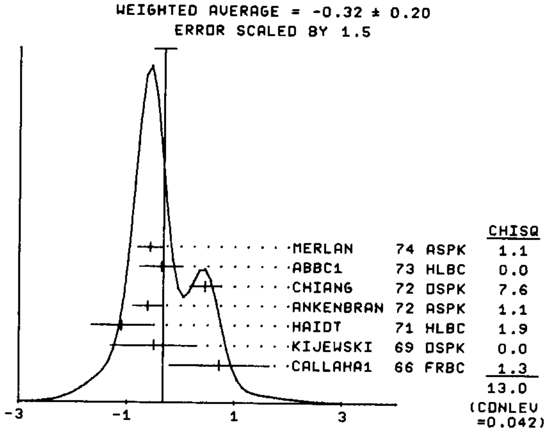

XI(O) = F-/F+ FROM SPECTRA

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XIB      XIB = F-/F+ (DETERMINED FROM KMU3/KE3)   ---------------------------
XIB       THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN 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 ARE OBTAINED DIRECTLY FROM THE FITTED KMU3/KE3 RATIO (R29)      1/74*
XIB       (SEE TEXT SEC. VI B.2) WITH L+=0.03.  THE CORRELATION DXI/DL=-11.9     1/74*
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  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          . . . . . . . . . .
XIB AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)
XIB FIT         -0.20      0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)  1/74*

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       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 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 POL DXI/DL(FIG.5) POSITIVE.  WE DISREGARD THIS RESULT.       3/74*
XIC          . . . . . . . . . .
XIC AVG      -0.97      0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
XIC      AVERAGE FOR BETTELS 68 AND CUTTS 69 HAS T=4.45 AND DXI/DL=-4.35 .      1/74*

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)

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          ABBC1      73 HLBC +  DP                 3/74*
L+M     490   (0.025)   (0.030)         ARNOLD     73 HLBC +  DP, PRELIMINARY    1/74*
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 AVG       0.0200    0.0076  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

LO       LAMBDA 0 (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 W    444   +0.058     0.036          CALLAHA1   66 FRBC +  PI,DLO/DL+=-0.37   1/74*
LO L   6000   -0.081    (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   -0.077    (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   -0.006     0.022          ABBC1      73 HLBC +  DP,DLO/DL+=-0.51   3/74*
LO      490  (-0.040)   (0.040)         ARNOLD     73 HLBC +  DP, PRELIMINARY    1/74*
LO    K       +0.014    (0.012)         KMU3/KE3   74 RVUE +  BR,DLO/DL+=+0.04   3/74*
LO M   6527   -0.019     0.015          MERLAN     74 ASPK +  DP,DLO/DL+=+0.27   3/74*
LO W     LO CALCULATED BY US FROM XIO, L+M, AND DXI/DL.                          1/74*
LO L     LO VALUE IS FOR L+=0.  CALCULATED BY US FROM XIO AND DXI/DL.            1/74*
LO    D  ABBC1 73 GIVES LO=+.007+-.020 FOR L+=.027 .  WE USE THIS LO, DXI/DL     3/74*
LO    D  (SEE SEC. XIA) AND THEIR L+=.025+-.017 TO GET THE ABOVE LO,DLO/DL+.     3/74*
LO    K  KMU3/KE3 74 VALUE IS FOR L+=.03 AND CORRESPONDS TO XIB FIT RESULT.      3/74*
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           . . . . . . . . . .
LO  AVG      -0.004     0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                                (SEE IDEOGRAM BELOW )
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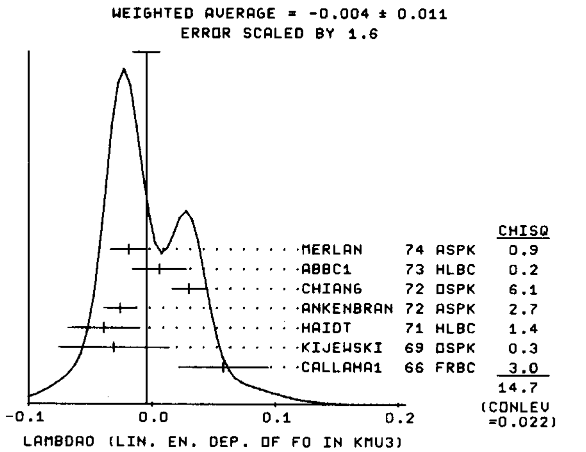


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L+E      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY)  ---------
L+E      FOR RAD.COR. OF KE3 DP SEE GINSBURG 67 AND BECHERRAWY 70.                3/74*
L+E    217   +0.036     .045            BROWN     62 XEBC +  PI, NO RC
L+E    407   -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            ABBC2     73 HLBC +  DP, NO RC           3/74*
L+E  A   ABBC2 STATE THAT RC OF GINSBERG 67 WOULD LOWER L+E BY 0.002 BUT         3/74*
L+E  A   THAT RC OF BECHERRAWY 70 DISAGREES WITH GINSBERG 67.                    3/74*
L+E            . . . . . . . . . .
L+E AVG       0.0285   0.0043  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

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

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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)
BELLOTT1 67 HEIDELBERG CONF     BELLOTTI,PULLIA                     (MILAN)
BELLOTT2 67 NC 52A  1287        BELLOTTI,FIORINI,PULLIA             (MILAN)
    ALSO 66 PL   20  690        BELLOTTI,F+ORINI,PULL+A+            (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,CORBETT,CULLIGAN+  (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)
PANDOULA 70 PR D2 1205          +TAYLOR,KOLLER,GRAUMAN +        (STEV,SETO)

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,STEINING            (CHIC,LRL)
    ALSO 70 PRL 24 1086         KLEMS,HILDEBRAND,STEINING       (LRL,CHIC)
    ALSO 70 PRL 25 473          KLEMS,HILDEBRAND,STIENING       (LRL,CHIC)

KUNSELMA 71 PL 34B 485          P. 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+NAL+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)

ABBC1    73 PL 47B 182          AACHEN+BARI+BRUSSELS+CERN COLLABORATION
ABBC2    73 PL 47B 185          AACHEN+BARI+BRUSSELS+CERN COLLABORATION
ABRAMS   73 PRL 30 500          +CARROLL,KYCIA,LI,MENES,MICHAEL +     (BNL)
ARNOLD   73 SUBMITTED TO PR     C L ARNOLD, B P ROE, D SINCLAIR      (MICH)
BACKENST 73 PL 43B 431          BACKENSTOSS,BAMBERGER+(CERN+KARL+HEID+STOH)
CABLE    73 PR D8 3807          +HILDEBRAND,PANG,STIENING         (EFI+LBL)
CLARKE   73 THESIS(UNPUBL.)     D B CLARKE                      (WISCONSIN)

LJUNG    73 PR D8 1307          D.LJUNG,D.CLINE                      (WISC)
    ALSO 72 PRL 28 523          D.LJUNG                              (WISC)
    ALSO 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,STEINING   (EFI+ARIZ+LBL)
    ALSO 72 PL 40B 699          CABLE,HILDEBRAND,PANG,STEINING    (EFI+LBL)
SMITH    73 NP B60 411          +BOOTH,RENSHALL,JONES+ (GLAS+LIVP+OXF+RHEL)
KMU3/KE3 74 THIS REVIEW         CALCULATED BY US. SEE NOTES IN SEC. XIB, LO.
KUNSELMA 74 PR (TO BE PUBL.)    R.KUNSELMAN                          (WYOM)
MERLAN   74 PR D9 107           +KASHA,WANDERER,ADAIR+      (YALE+BNL+LASL)

        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   FIT        497.70     0.13  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/74*
                          (SEE IDEOGRAM BELOW )
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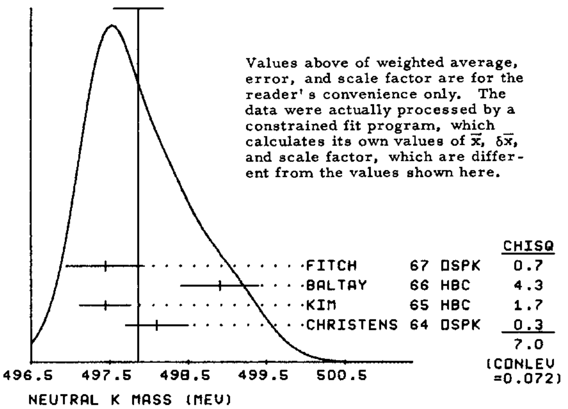
WEIGHTED AVERAGE = 497.87 ± 0.32
ERROR SCALED BY 1.5

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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   FIT        3.99       0.13  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/74*

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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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                 12  KOS MEAN LIFE (UNITS 10**-10 SEC)
T        KOS MEAN LIFE
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   O   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  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  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            . . . . . . . . .
T   AVG       0.8862   0.0072   0.0072 AVERAGE (ERROR INCL. SCALE FACTOR OF 2.6)
T   FIT       0.8862   0.0066 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.4)
                       (SEE IDEOGRAM BELOW )
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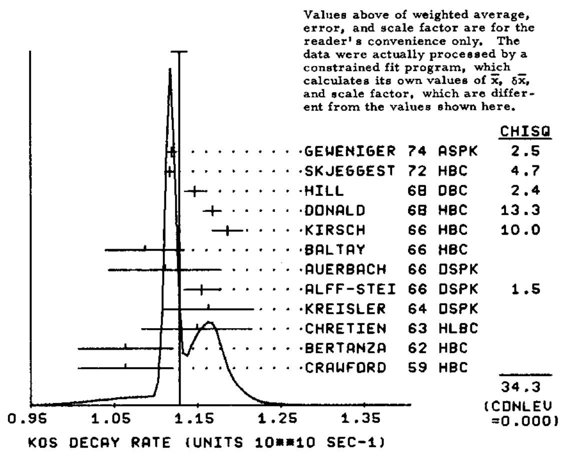
WEIGHTED AVERAGE = 1.1284 ± 0.0091
ERROR SCALED BY 2.6

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                 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

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                 12  KOS BRANCHING RATIOS

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  1648     0.684     0.011         DOYLE     69 HBC     PI-P TO LAM.KO    2/71
R1  U   ANDERSON RESULT NOT PUBLISHED, EVENTS ADDED TO DOYLE SAMPLE           2/71
R1            . . . . . . . . .
R1  AVG        0.684     0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT        0.6877    0.0026 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  FIT        0.3123    0.0026 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                         (SEE IDEOGRAM BELOW )
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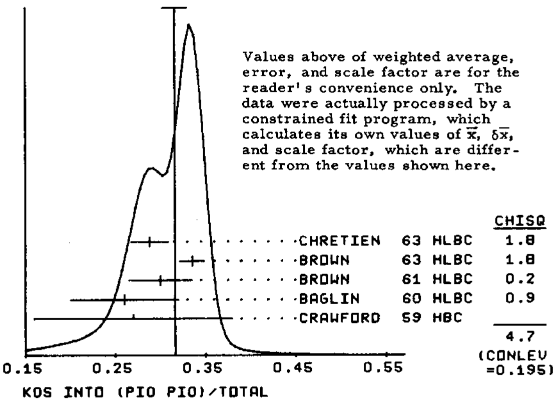
WEIGHTED AVERAGE = 0.316 ± 0.014
ERROR SCALED BY 1.3



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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    2.22     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 TC KO P P     9/73*
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       2.207    0.030    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R3  FIT       2.202    0.026  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 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 B     BURGUN 73 ESTIMATES THAT DIRECT EMISSION CONTRIBUTION IS .3+-.6 .   11/73*
R6             . . . . . . . . .
R6  AVG        2.90      0.54     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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   BARMIN2   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*

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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 D105      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,D 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,STONEHILL +     (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)

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,DAVIDENKO,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,BUPRIS,ENGLER+    (BNL+CARN)
MALLARY  73 PR D7 1953          +BINNIE,GALLIVAN,GOMEZ,PECK,SCIULLI+  (CIT)
GEWENIGE 74 SUBMITTED TO PL     GEWENIGER,GJESDAL,PRESSER+       (CERN+HEID)

                    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  T            (2.20)   (0.35)            FITCH     61 CNTR
D                0.84     0.29      0.22   GOOD      61 HLBC
D  T             1.02     0.23             CAMERINI  62 HLBC    SEE NOTE C BELOW  8/67
D   C   VALUE CHANGED FROM 1.7 (SEE TABLE 1 OF CAMERINI 66)                       8/67
D  T             0.55     0.24             AUBERT    65 HLBC                      6/66
D                0.26     0.36      0.26   BALDO-CEO 65 HLBC    ASSUMES CP CONS.
D  T A           0.64     0.12             CHRISTENS 65 OSPK                      6/66
D     A CHRISTENSON 65 HAS BEEN CORRECTED FOR INTERFERENCE BY FITCH 65 FTNOT      1/71
D  T            (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  V    VISHNEVSKY 65 NOT CORRECTED FOR INTERFERENCE EFFECTS                      3/68
D                0.514    0.039            ALFF-STEI 66 OSPK                      6/66
D        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  T     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    N   ERROR IGNORES UNCERTAINTY OF PHASE SHIFTS.  THESE EVENTS ARE            10/71
D    N   USED IN HILL 71.
D        95      0.62     0.10      0.16   CHANG     66 HBC     KO+P INTO HYPER.  8/67
D                0.81     0.17             FUJII     66 OSPK    IRON REGENERATOR  9/66
D        59      0.74     0.34             MEISNER1  66 HBC     SEE NOTE M1       6/66
D   M1      + SIGN FAVORED                 MEISNER2  66 HBC                       9/66
D                0.38     0.16             JOVANOVIC 66 OSPK    C+URANIUM REGEN. 11/66
D  T    136    + 0.64     0.19             CANTER    67 DBC     KO+D INTO HYPER. 11/67
D                0.65     0.11             MISCHKE   67 OSPK                     .11/67
D       590      0.59     0.13             BALATZ    68 OSPK    AL REGENERATOR    3/68
D                0.520    0.044            CARNEGIE  68 HBC     GAP METHOD        3/68
D  T            +0.487    0.046            MELHOP    68 OSPK    ST.STEEL REGEN    6/68
D  B             0.547    0.024            BOTT-BOD  69 OSPK    C REGEN           1/71
D  B    BOTT-BOD 69 IS A REEVALUATION OF BOTT-BOD 66                              1/71
D  F             0.555    0.020            FAISSNER  69 ASPK    REGEN IN CU      10/69
D  F    ESTIMATED ADDITIONAL SYSTEMATIC UNCERTAINTY LESS THAN TWO PERCENT         1/71
D                0.542    0.006            CULLEN    70 CNTR                      1/71
D                0.542    0.006            ARONSON   70 ASPK    GAP METHOD        1/71
D                0.481    0.052     0.075  BALATS    71 OSPK                      9/71
D                0.534    0.007            CARNEGIE  71 ASPK    GAP METHOD        8/71
D  TH   119 (+ 0.67)     (0.14)            HILL      71 DBC                      10/71
D   H    THE PRIMARY RESULT OF THIS EXPERIMENT IS THAT DM IS POSITIVE.           10/71
D   H    THE MAGNITUDE MAY HAVE AN ADDITIONAL SYSTEMATIC ERROR OF ABOUT 0.12 10/71
D      1757      0.557    0.038            FACKLER   73 OSPK                     11/73*
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               . . . . . . . . .
D   AVG          0.5403   0.0035    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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   FIT          5.179     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 0 PRIME     134+ 134+ 134
P2      KOL  INTO PI+ PI- PIO                TAU 0           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
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                  NEUTRAL K CONSTRAINED FIT
              OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
              RATIOS USES 65 DATA POINTS TO DETERMINE SIX
              QUANTITITES.  OVERALL FIT HAS CHISQ=102.
              THE LARGEST CONTRIBUTION TO THE CHISQ COMES FROM
              MESSNER 73 (15.0).   THIS EXPERIMENT IS
              CONSISTENT WITH THE MOST RECENT ETA+- RESULTS.

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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  .2126+-.0061
 P 2   -.0616   .1194+-.0037
 P 3   -.4760    -.2958   .2751+-.0054
 P 4   -.5712    -.2783     -.2445   .3902+-.0058
 P 5   -.1984    -.7035      .3295     .3233  .0018+-.0002
 P11    .1357    -.0097     -.0791    -.0948     -.0348  .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  .0411+-.0013
 G 2    .0247   .0231+-.0007
 G 3   -.3010    -.1853   .0531+-.0011
 G 4   -.3447    -.1459     -.0633  .0753+-.0012
 G 5   -.1694    -.6709      .3240     .3115  .0003+-.0000
 G11    .1447     .0034     -.0551    -.0631     -.0319  .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         4.11      0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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       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         2.36      0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
W2  FIT         2.306     0.074  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.0)
                          (SEE IDEOGRAM BELOW )

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  FIT         7.53      0.12   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        15.15      0.16   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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  FIT        12.85      0.16   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                          (SEE IDEOGRAM BELOW )
```
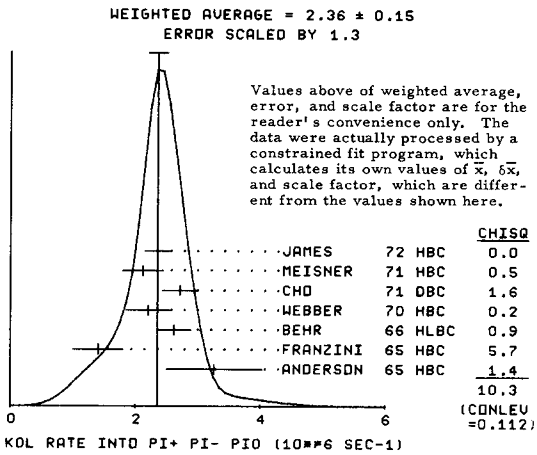
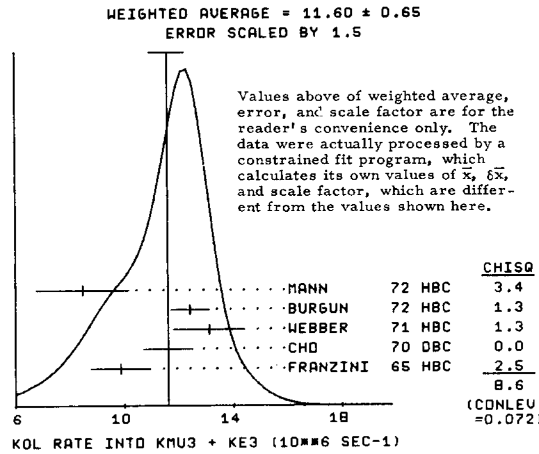
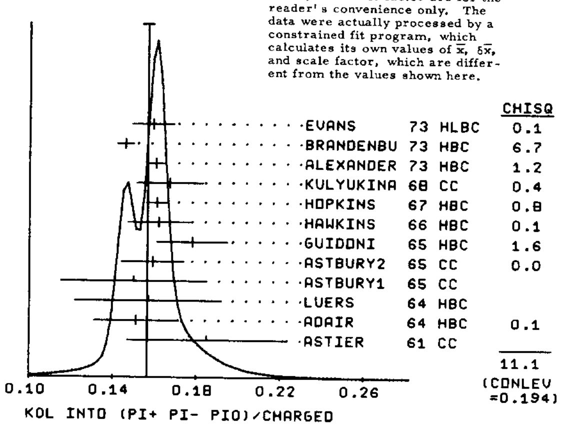






```
W6      KOL  INTO PI MU NEUTRINO UNITS 10**6 SEC-1)        (G3)
W6       19     4.54      1.24      1.08  LOWYS     67 HLBC                    8/67
W6              . . . . . . . . . .
W6  FIT         5.31      0.11   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
------ --------- --------- --------- --------- --------- --------- --------

                    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  FIT         0.2709    0.0099 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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              . . . . . . . . . .
R2  AVG         0.1564    0.0026  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R2  FIT         0.1522    0.0048 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.4)
                          (SEE IDEOGRAM BELOW )

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         0.3506    0.0061 FROM FIT

R4      KOL  INTO (PI E NEUTRINO)/CHARGED                   (P4)/(P2+P3+P4)
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         0.488     0.033   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  FIT         0.4972    0.0061 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

WEIGHTED AVERAGE = 0.1564 ± 0.0026
ERROR SCALED BY 1.2

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 $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

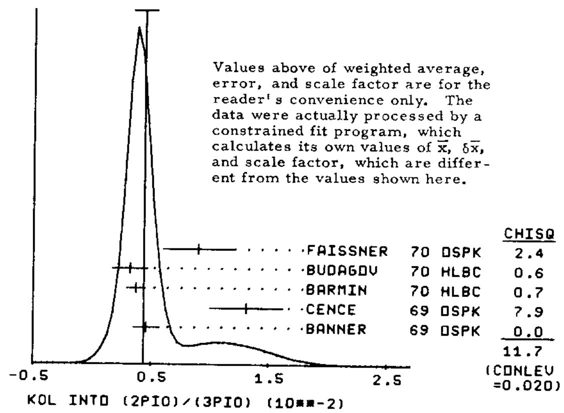



```
R5      KOL INTO (PI F NEU)/((PI E NEU)+(PI MU NEU))        (P4)/(P3+P4)
R5      320     0.415    0.120          ASTIER    61 CC
R5              . . . . . . . . . .
R5  FIT         0.5865   0.0066 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6      KOL INTO (PI+ PI- PIO)/TOTAL                        (P2)
R6
R6              . . . . . . . . . .
R6  FIT         0.1194   0.0037 FROM FIT

R7      KOL INTO (LEPTON PI NEUTRINO)/TOTAL                 (P3+P4)
R7
R7              . . . . . . . . . .
R7  FIT         0.6653   0.0069 FROM FIT

R8      KOL INTO (2 GAMMA)/TOTAL (UN. 10**-4)               (P9)
R8  C          (1.3)    (0.6)           CRIFGEE   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       90     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)

R9      KOL INTO (PI+ PI-)/CHARGED (UNIT 10**-3)            (P5)/(P2+P3+P4)
R9       45     2.0      0.4            CHRISTENS 64 OSPK ETA +- = 1.94
R9       54     2.08     0.35           GALBRAITH 65 OSPK ETA +- = 2.02
R9              1.93     0.26           BASILE    66 OSPK ETA +- = 1.86       . 9/66
R9              1.993    0.080          BOTT-BODE 66 OSPK ETA +- = 1.935        9/66
R9  M 4200     (2.60)   (0.07)          MESSNER   73 ASPK ETA +- = 2.23         6/73*
R9  M  FROM SAME DATA AS R27 MESSNER 73,BUT WITH DIFFERENT NORMALIZATION.       6/73*
R9              . . . . . . . . . .
R9  AVG         1.992    0.073   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R9  FIT         2.26     0.23   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 5.1)

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 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         0.705    0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R10 FIT         0.705    0.019  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

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         0.93     0.19    FROM FIT

R18     KOL INTO (3PIO)/(PI+PI-PIO)                             (P1)/(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 FIT         1.780    0.078  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

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     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   F FAISSNER 70 CONTAINS SAME 2PIO EVENTS AS GAILLARD 69 R17
R19             . . . . . . . . . .
R19 AVG         0.439    0.098   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R19 FIT         0.439    0.088  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)
                         (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.439 ± 0.098
ERROR SCALED BY 1.7

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.

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R20     KOL INTO (PI+ PI-)/(KE3 + KMU3) (UNITS 10**-3)   (P5)/(P3+P4)
R20     309     2.51     0.23           DEBOUARD  67 OSPK                       6/68
R20     525     2.35     0.19           FITCH     67 OSPK    ETA+-=1.91+-.06    6/68
R20             . . . . . . . . . .
R20 AVG         2.41     0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R20 FIT         2.67     0.26   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 4.7)

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)
```

Note on the $K_L^0 \to \mu^+\mu^-$ Controversy

The $K_L^0 \to \mu^+\mu^-$ branching ratios (R22) given by CLARK 71 and CARITHERS(1 and 2) 73 are incompatible.

CARITHERS2 73 uses the same basic spectrometer as CARITHERS1 (three X-Y proportional chambers, hydrogen Čerenkov for electrons, and muon counters) with several modifications: an extra muon hodoscope was added to improve background rejection, some concrete was moved further downstream from the last chamber to reduce backscattering, and the spectrometer magnet bending was increased from 210.6 to 240 MeV/c transverse momentum to improve the separation between the signal and the background process $K_L^0 \to \pi\mu\nu \to \mu\mu\nu\bar{\nu}$. CARITHERS(1 and 2) find 6 and 3 events, respectively, and give consistent rates for $K_L^0 \to \mu^+\mu^-$.

CLARK 71 observe no events but would expect around 11 based on the combined CARITHERS 73 rate.

The theoretical lower limit for $\Gamma(K_L^0 \to \mu^+\mu^-)/\Gamma(K_L^0 \to \pi^+\pi^-)$ based on unitarity considerations is 3×10^{-6}, [1] in agreement with the CARITHERS(1 and 2) 73 value: $(5.8^{+4}_{-2})\times10^{-6}$ and considerably above the CLARK 71 upper limit: $< 1.2\times10^{-6}$ (90% confidence level).

We know of no basis on which to reject either experiment. We therefore raise the upper limit to encompass the results of both experiments until the discrepancy is resolved. The 90% confidence level upper limit for the combined CARITHERS result is $\Gamma(K_L^0 \to \mu^+\mu^-)/\Gamma(K_L^0 \to \pi^+\pi^-) < 9\times10^{-6}$ or $\Gamma(K_L^0 \to \mu^+\mu^-)/\Gamma(K_L^0 \to \text{all}) < 1.6\times10^{-8}$, where we have used $\Gamma(K_L^0 \to \pi^+\pi^-)/\Gamma(K_L^0 \to \text{all}) = (1.8\pm0.2)\times10^{-3}$, our 1974 value.

Reference

1. C. Quigg and J. D. Jackson, UCRL-18487 (1968).

```
R22     KOL INTO (MU+MU-)/(PI+PI-) (UNITS 10**-5)         (P6)/(P5)
R22       0   14.0   OR LESS  CL=.90   FOETH      69 ASPK                   5/70
R22       0    1.8   OR LESS  CL=.90   DARRIULAT  70 ASPK                  11/70
R22       0    0.12  OR LESS  CL=.90   CLARK      71 ASPK                   6/71
R22 C     6   (0.67)   (0.61)   (0.31) CARITHE1   73 ASPK                   6/73*
R22 C     3   (0.45)   (0.6)    (0.3)  CARITHE2   73 ASPK                  10/73*
R22  C    9    0.58     0.4      0.2   CARITHE2   73 ASPK                  10/73*
R22  C  SECOND CARITHE2  VALUE IS COMBINED AVG OF THE TWO CARITHERS EXPTS  10/73*
R22  C  ERRORS REPRESENT 90 PERCENT CON. LEV. (5 PERCENT IN EACH TAIL).    10/73*

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        1.49     0.19   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 6.2)

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*
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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

```
MATRIX ELEMENT SQUARED =  1 + G (S3-S0)/(MPI+**2)

GTO  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  KLONG INTO PI+ PI- PIO
GTO     79     0.55     0.23            ADAIR     64 HBC  AV=-7.6 +- 1.7      . 3/71
GTO     77     0.51     0.20            LUERS     64 HBC  AV=-7.3 +- 1.6        3/71
GTO     66     0.32     0.13            ASTBURY1  65 CC   AV=-5.5 +- 1.5        3/71
GTO    310     0.51     0.09            ASTBURY2  65 CC   AV=-(7.3 +.6 -.8)     3/71
GTO    280     0.64     0.17            ANIKINA   66 CC   AV=-(8.2 +.9 -1.3)    3/71
GTO    126     0.70     0.12            HAWKINS   66 HBC  AV=-8.6 +- 0.7        3/71
GTO   1350     0.649    0.044           HOPKINS   67 HBC  AT=-0.294 +- .018    10/69
GTO   1198     0.428    0.055           NEFKENS   67 OSPK AU=-0.204 +- .025     3/71
GTO   2446     0.400    0.045           BASILE2   68 OSPK AT=-0.188 +- .020     3/71
GTO  29000     0.651    0.012           ALBROW    70 ASPK AY=-0.862 +- .015     1/71
GTO  B 36K     0.555    0.016           BUCHANAN  70 ASPK AU=-0.261 +- .007     3/71
GTO   4400     0.656    0.058           SMITH     70 OSPK AT=-0.297 +- .024     3/71
GTO    180     0.50     0.11            JAMES     72 HBC                        1/73
GTO   1486     0.608    0.043           KRENZ     72 HLBC AT=-0.277 +- .018    11/72
GTO    384     0.688    0.074           METCALF   72 ASPK AT=-0.31  +- .03     11/72
GTO            0.619    0.032           ALEXANDER 73 HBC                        1/74*
GTO   3200     0.73     0.04            BRANDENBU 73 HBC                        1/74*
GTO   B   BUCHANAN 70 GIVES A=0.257 +- .005 FOR A QUADRATIC FIT WITH             3/71
GTO   B   STATISTICAL ERRORS ONLY.  THE A VALUE USED HERE IS FOR A LINEAR        3/71
GTO   B   FIT AND INCLUDES SYSTEMATIC ERRORS. QUADRATIC FIT DOES NOT             1/73
GTO   B   IMPROVE CHI SQUARED PROBABILITY.                                       1/73
GTO          . . . . . . . . .
GTO AVG        0.610    0.021    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)
                                 (SEE IDEOGRAM BELOW )
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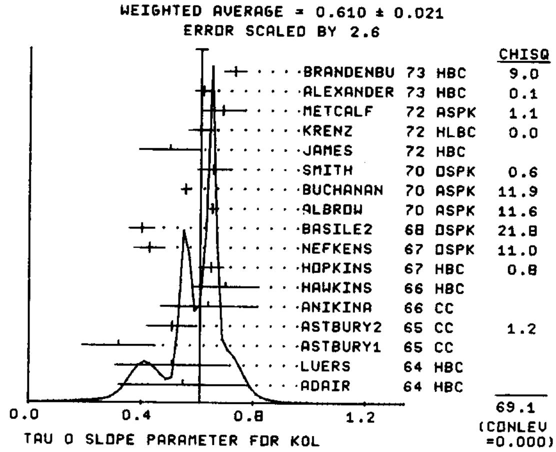


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13 KOL FORM FACTORS

RELATED TEXT SECTION VI B.2 AND MINI-REVIEW ON FORM FACTORS IN THE CHARGED K SECTION OF THE DATA CARD LISTINGS ABOVE.

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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.
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  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  D 82K  (-0.26)   (0.21)          DBBPSS    73 WIRE   DP, DXI/DL=-24    3/74*
XIA D  82K  (-2.41)   (0.17)          DBBPSS    73 WIRE   DP, DXI/DL=-9.4   3/74*
XIA   1.6M   +0.01     0.04           DONALDSON 73 ASPK   MU,INDEP OF L+,T  1/74*
XIA  P1385   -1.00    (0.45)          PEACH     73 HLBC   DP, DXI/DL=-20    1/74*
XIA Z  32K  (-0.20)   (0.15)          ZDANIS    73 WIRE   DP, DXI/DL UNKN.  3/74*
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 L-=0.  IT CORRESPONDS TO LAMBDA=-0.37+-0.15.    1/74*
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  DBBPSS 73 IS CALCULATED BY US FROM LO, L+, AND DLO/DL+.  THEY FIND  3/74*
XIA  D  TWO SOLUTIONS.  THE FIRST HAS L+=.046+-.008 IN AGREEMENT WITH KE3.  3/74*
XIA  D  PRELIMINARY.                                                        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 Z   ZDANIS 73 ASSUMES (L+M)+-(DL+M)=(L+E)+-2*(DL+E)=.044+-.012.  DXI/DL 3/74*
XIA Z   IS NOT GIVEN SO WE CAN*T OBTAIN THE XIA+-DXIA VALUE ASSOCIATED WITH 3/74*
XIA Z   THEIR MEASURED VALUE, L+M=.046+-.030 .  PRELIMINARY                 3/74*
XIA          . . . . . . . . .
XIA AVG        0.005    0.040   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

XIB    XIB = F-/F+ (DETERMINED FROM KMU3/KE3)   ----------------------------
XIB     THE KMU3/KE3 BRANCHING RATIO FIXES A RELATIONSHIP BETWEEN 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 ARE OBTAINED DIRECTLY FROM THE FITTED KMU3/KE3 RATIO (R10)   1/74*
XIB     (SEE TEXT SEC. VI B.2) WITH L+=0.03.  THE CORRELATION DXI/DL=-10.1  1/74*
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 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)
XIB FIT       +0.16     0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0) 1/74*
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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      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  52.2M   -0.385     0.105          SANDWEISS 73 CNTR    POL,DXI/DL=-6      1/74*
XIC T   T VALUE NOT GIVEN.                                                     1/74*
XIC  L  LONGO 69 T=3.3 CALC. FROM DXI/OL=-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         . . . . . . . . .
XIC AVG      -0.49      0.37   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.6)

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         . . . . . . . . .
IXI AVG      -0.051     0.039  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)         DBBPSS    73 WIRE    DP                 3/74*
L+M D  82K   (0.076)   (0.004)         DBBPSS    73 WIRE    DP                 3/74*
L+M   1.6M    0.030     0.003          DONALDSON 73 ASPK    DP                 1/74*
L+M    32K   (0.046)   (0.030)         ZDANIS    73 WIRE    DP, PRELIMINARY    3/74*
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  DBBPSS 73 GETS TWO SOLUTIONS.  FIRST AGREES WITH L+E. PRELIMINARY.     3/74*
L+M         . . . . . . . . .
L+M AVG       0.0321    0.0029  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

LO      LAMBDA 0 (LINEAR ENERGY DEPENDENCE OF FO 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 L  1371   +0.10     (0.07)          CARPENTER 66 OSPK    DP,DLO/DL+=-0.54   1/74*
LO L         -0.155    (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   D 82K  (+0.024)   (0.011)         DBBPSS    73 WIRE    DP,DLO/DL+=-1.06   3/74*
LO  D  82K  (-0.130)   (0.014)         DBBPSS    73 WIRE    DP,DLO/DL+=+0.20   3/74*
LO    1.6M   +0.020     0.003          DONALDSON 73 ASPK    DP,DLO/DL+ UNKN.   1/74*
LO P  1385   -0.060    (0.038)         PEACH     73 HLBC    DP,DLO/DL+=-0.71   1/74*
LO L  2.2M   -0.033    (0.009)         SANDWEISS 73 CNTR    POL,DLO/DL+=+.49   1/74*
LO  Z  32K  (+0.032)   (0.010)         ZDANIS    73 WIRE    DP,DLO/DL+ UNKN.   3/74*
LO   K       +0.044    (0.013)         KMU3/KE3  74 RVUE    BR,DLO/DL+=+0.14   3/74*
LO L    LO VALUE IS FOR L+=0.  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*
LO P    PEACH 73 ASSUMES L+=0.025.  CALCULATED BY US FROM XIO AND DXIO/DL+.    1/74*
LO  R   BRANDENBURG 73 IS INCLUDED IN THE KMU3/KE3 74 VALUE CALC. BY US.       3/74*
LO   D  DBBPSS 73 GETS TWO SOLUTIONS.  FIRST AGREES WITH L+E. PRELIMINARY.     3/74*
LO  Z   ZDANIS 73 ASSUMES (L+M)+-(DL+M)=(L+E)+-2*(DL+E)=.044+-.012. DLO/DL+    3/74*
LO  Z   IS NOT GIVEN SO WE CANNOT OBTAIN THE LO+-DLO VALUE ASSOCIATED WITH     3/74*
LO  Z   THEIR MEASURED VALUE, L+M=.046+-.030  .  PRELIMINARY                   3/74*
LO   K  KMU3/KE3 74 VALUE IS FOR L+=.03 AND CORRESPONDS TO XIB FIT RESULT.     3/74*
LO          . . . . . . . . .
LO  AVG       0.0198    0.0030  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

L+E      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KO 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 Z 500K   (0.031)  (0.0025)         GJESDAL   73         DP                 3/74*
L+E Z  26K   (0.044)  (0.006)          ZDANIS    73 WIRE    DP, USES RC        3/74*
L+E Z   PRELIMINARY.                                                           3/74*
L+E         . . . . . . . . .
L+E AVG       0.0257   0.0043  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                               (SEE IDEOGRAM BELOW )
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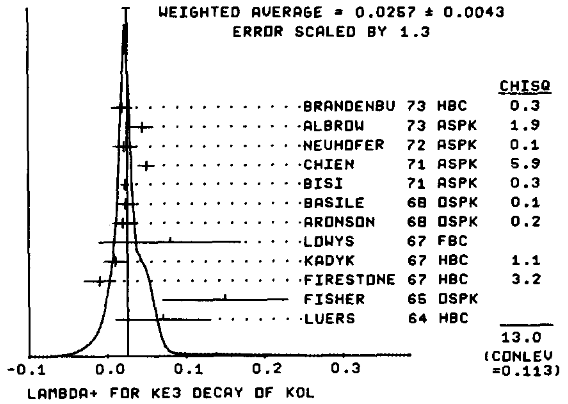


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FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS FOR KE3 DECAY(ABS. VALUE)----
FS              0.15  OR LESS  CL=.68   KULYUKINA 67 CC                       10/69
FS     5600     0.19  OR LESS  CL=.95   ALBROW    73 ASPK                      9/73*

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*

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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- PIO   (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)
                                  (SEE IDEOGRAM BELOW )
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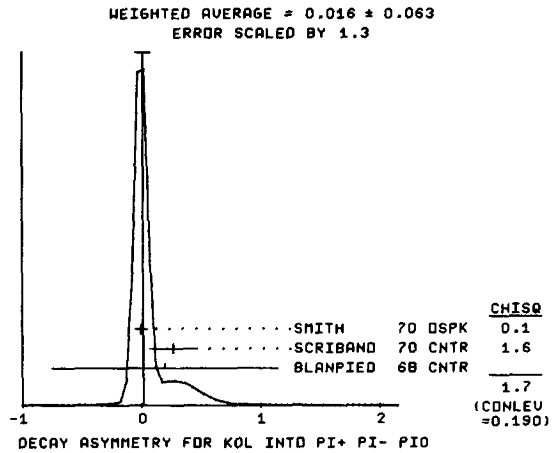


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--------------------13  CHARGE ASYMMETRY IN LEPTONIC DECAYS (PERCENT)------
TEXT SECTION VI B.3 C

      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     0.323     0.026         GEWENIG1   74 ASPK                     3/74*
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         0.326     0.023   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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      0.365     0.017         GEWENIG1   74 ASPK                     3/74*
A2  B SAAL 69 IS A REANALYSIS OF BENNETT 67
A2           . . . . . . . . .
A2  AVG         0.349     0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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      0.323     0.026         GEWENIG1   74 ASPK   KMU3              3/74*
AL     34M      0.365     0.017         GEWENIG1   74 ASPK   KE3               3/74*
AL       SEE FOOTNOTES IN SECTIONS A1 AND A2 ABOVE.                            1/73
AL           . . . . . . . . .
AL  AVG         0.343     0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
                                  (SEE IDEOGRAM BELOW )
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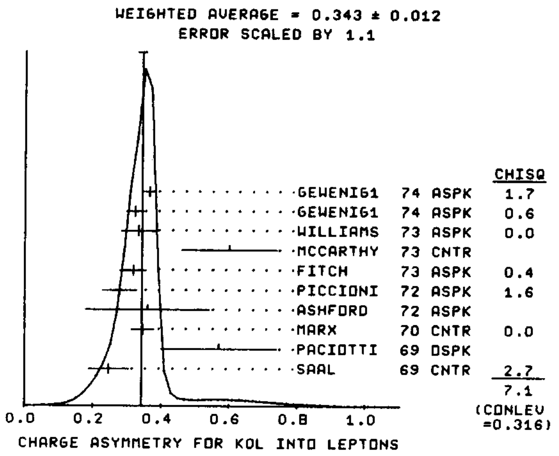

Note on $K_L^0 \to 2\pi$ and K_S Regeneration

Some experiments obtain ϕ_{+-} (the phase of η_{+-}) using K_S, $K_L \to \pi^+\pi^-$ interference behind a regenerator. In these interference experiments the measured quantity is the difference of ϕ_{+-} and the regeneration phase ϕ_R, as shown in the expression below. After the regenerator, the intensity of the $\pi^+\pi^-$ decays in the forward direction is

$$I(t,p) = S(p)\,[\,|R(p)|^2\, e^{-\Gamma_S t} + |\eta_{+-}|^2\, e^{-\Gamma_L t} + 2|R(p)|\,|\eta_{+-}| \times e^{-(\Gamma_S+\Gamma_L)t/2} \cos(\Delta m\, t + \phi_R(p) - \phi_{+-})], \quad (1)$$

where:

t is the decay time in the K^0 rest frame,

$\Delta m = m_L - m_S$, and m_L, Γ_L, m_S, Γ_S are the masses and decay rates of the long- and short-lived K^0,

$\eta_{+-} = |\eta_{+-}|\, e^{i\phi_{+-}}$ is the ratio of decay amplitudes $A(K_L \to \pi^+\pi^-)/A(K_S \to \pi^+\pi^-)$,

S(p) is propotional to the K_L momentum spectrum, and

$R(p) = |R(p)|\, e^{i\phi_R(p)}$ is the transmission-regenerated K_S amplitude (relative to the K_L):

$$R(p) = \pi N \Lambda i\, \frac{[f_0(p) - \bar{f}_0(p)]}{p} \left\{ \frac{1 - e^{-\frac{1}{2}\Gamma_S \ell(p)[1 - 2i\Delta m/\Gamma_S]}}{\frac{1}{2}\Gamma_S [1 - 2i\,\Delta m/\Gamma_S]} \right\}, \quad (2)$$

where

$\ell(p)$ is the thickness of regenerator measured in units of the mean decay length of K_S,

N is the number of nuclei per cubic centimeter,

Λ is the K_S mean decay length, and

$f_0(p)$, $\bar{f}_0(p)$ are the forward scattering amplitude of K^0 and $\bar{K}^0$.

From (1) above it is clear that the value of ϕ_{+-} is correlated with the value of Δm and ϕ_R. Usually Δm is a parameter of the fit and ϕ_R is determined by some other means (optical model calculations, time dependence of the charge asymmetry in K_{e3} decay, etc.).

We list ϕ_{+-} and give in comment cards both the value of ϕ_R used by the authors and the Δm dependence of ϕ_{+-}.

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--------------------13  PARAMETERS FOR KOL INTO 2PI DECAY-----------------
TEXT SECTION VI 8.3 D

     ETA+- = A(KL TO PI+PI-)/A(KS TO PI+PI-)
     ETA00 = A(KL TO PIOPIO)/A(KS TO PIOPIO)

     THE FITTED VALUES OF ETA+- AND ETA00 GIVEN BELOW ARE DERIVED
     PRIMARILY FROM THE FITTED BRANCHING RATIOS FOR THE TWO PION DECAY
     MODES OF KOL AND KOS.  FOR THE QUANTITIES MEASURED BY INDIVIDUAL
     EXPERIMENTS SEE THE KOL BRANCHING RATIOS R9 AND R20 (ETA+-) AND
     R17 AND R19 (ETA00).  FOR THE READER'S CONVIENENCE WE LIST THE
     DERIVED QUANTITIES ETA+- (CALLED E+- BELOW) AND (ETA00)**2 (CALLED
     EOS BELOW).  HOWEVER, THE FIT FOR ETA+- AND ETA00 USES ONLY THOSE
     VALUES BELOW WHICH ARE INDEPENDENT OF BRANCHING RATIO MEASUREMENTS--
     ETA00 OF CHOLLET 70 AND WOLFF 71, (ETA00/ETA+-) OF BANNER1 72
     AND HOLDER 72, AND ETA+- OF GEWENIGER2 74.

EOS     (ETA00)**2 = (A(KL TO 2PIO)/A(KS TO 2PIO))**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 X  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 X   SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
EOS  C  CHOLLET 70 GIVES ETA00=(1.23+-0.24)*(REGEN AMPL,2GEV/C CU)/1000OMB   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 2PIO EVENTS AS GAILLARD 69
EOS          . . . . . . . . . .
EOS AVG      7.7       1.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
EOS FIT      5.06      0.40   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  3/74*
EOS THIS FIT VALUE CORRESPONDS TO ETA00=2.25+-0.09                            3/74*

E+-     ETA+-  = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3  ------------
E+- X   45   (1.94)                     CHRISTENS 64 OSPK                  10/69
E+- X   54   (2.02)                     GALBRAITH 65 OSPK                  10/69
E+- X        (1.86)                     BASILE    66 OSPK                  10/69
E+- X        (1.935)                    BOTT-BODE 66 OSPK                  10/69
E+- X  525   (1.91)    (.06)            FITCH     67 OSPK                  10/69
E+-           2.30     0.035            GEWENIG2  74 ASPK                   3/74*
E+- X   SEE NOTE ABOVE REGARDING FITTED VALUES OF ETA+- AND ETA00.
E+-          . . . . . . . . . .
E+- FIT       2.17     0.07   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 3.4)  3/74*

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  FIT      1.038     0.038  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*

F+-     PHASE OF ETA +-          (DEGREES)  ------------------------------
F+-      DM IS (KOL-KOS MASS DIFFERENCE / HBAR) IN UNITS OF 10**10 SEC-1    2/71
F+-            SEE SECTION D OF KOL LISTINGS FOR LATEST VALUE
F+-      WE HAVE ADDED THE MASS DEPENDENCE AND PROPAGATED THE ERROR IN DM   2/71
F+-      USING DM=0.5398+-0.0033 FOR BENNETT 69, BOHM 69, FAISSNER 69,      2/71
F+-      JENSEN 70, AND BALATS 71. THE APRIL 1972 DM(0.5402+-0.0035) WOULD  3/72
F+-      NOT MAKE A SIGNIFICANT CHANGE IN THE PHASE.                        3/72
F+-          45.0      50.0             FITCH     65 OSPK   BE REGEN      11/67
F+-          30.0      45.0             FIPESTONE 66 HBC                  11/67
F+-          70.0      21.0             BOTT-BODE 67 OSPK   C REGEN       11/67
F+-          25.0      35.0             MISCHKE   67 OSPK   CU REGEN       7/68
F+- N       (51.0)    (11.0)            BENNETT2  68 CNTR   CU REG. USES   8/68
F+-  C       34.5      10.0             BENNETT   69 CNTR   CU REGEN       2/71
F+-  B       47.6      12.1             BOHM      69 OSPK   VACUUM REGEN   2/71
F+-  F       46.2       7.4             FAISSNER  69 ASPK   CU REGEN       2/71
F+-  J       43.4       4.4             JENSEN    70 ASPK   VACUUM REGEN   2/71
F+-  D       38.0      12.0             BALATS    71 OSPK   CU REGEN       9/71
F+-  P       36.2       6.1             CARNEGIE  72 ASPK   CU REGEN       1/73
F+-  G       49.3       2.1             GEWENIG2  74 ASPK   VACUUM REGEN   3/74*
F+-          . . . . . . . . . .
F+- AVG      46.6       1.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
F+-  FIT     46.6       2.5   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)  3/74*
                       COMMENTS
F+-  N  BENNETT 69 IS A REEVALUATION OF BENNETT2 68.                        11/69
F+-  C  BENNET 69 USES MEASUREMENT OF (F+-)-(PHIF) OF ALFF-STEI 66            2/71
F+-  C  BENNETT 69 F+-= 34.9+-10.0, NOT INCLUDING ERROR IN DM                 2/71
F+-  C  DM DEPENDENCE OF BENNETT 69 IS 69*(DM-0.545) DEG. FR=-49.9+-5.4DEG.  2/71
F+-  B  BOHM 69 F+-=41+-12, NOT INCLUDING ERROR IN DM.                        2/71
F+-  B  DM DEPENDENCE OF BOHM 69 IS 479*(DM-0.526) 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, NOT INCLUDING ERROR IN DM.                 2/71
F+-  F  DM DEPENDENCE OF FAISSNER 69 IS 205*(DM-0.555) DEG. FR=-42.7+-5DEG.  2/71
F+-  J  JENSEN 70 F+-=42.4+-4.0, NOT INCLUDING ERROR IN DM.                   2/71
F+-  J  DM DEPENDENCE OF JENSEN 70 IS 576*(DM-0.538) DEG.                     2/71
F+-  D  BALATS 71 F+-=39+-12, NOT INCLUDING ERROR IN DM. FR=-43+-4 DEG.       9/71
F+-  D  DM DEPENDENCE OF BALATS 71 IS 198*(DM-.544) DEG.                      9/71
F+-  P  CARNEGIE 72 INSENSITIVE TO DM. FR=-56.2+-5.2 DEG..                    1/73
F+-  G  GEWENIGER2 74 F+-=49.4+-1.0 NOT INCLUDING ERROR IN DM.                3/74*
F+-  G  DM DEPENDENCE OF GEWENIGER2 74 IS 565*(DM-0.540) DEG.                 3/74*
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FOO      PHASE OF ETA 00     (DEGREES)      ---------------------------------
FOO     FIRST QUADRANT PREFERRED        GOBBI      69 OSPK                       11/69
FOO  C         51.        30.           CHOLLET    70 OSPK    CU REG.,4 GAMMAS 10/70
FOO  W  56    38.0       25.0           WOLFF      71 OSPK    CU REG.,4GAMMAS  12/71
FOO           . . . . . . . . . .
FOO AVG       43.3       19.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FOO  FIT      49.1       13.2    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*
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

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   FIT        2.5      13.2    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*

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Superweak Model Predictions for $\phi_{\eta_{+-}}$ and $\phi_{\eta_{00}}$

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

$$\mathrm{Re}\,\epsilon = |\eta_{+-}|\left[1 + \left(\frac{2\Delta m\,\tau_S}{\hbar}\right)^2\right]^{-1/2} .$$

The K^0_L-K^0_S mass difference, the K_S lifetime, and $|\eta_{+-}|$ given in the Stable Particle Table result in the predictions that

$$\phi_{+-} = \phi_{00} = (43.76 \pm 0.28)^\circ$$

and

$$\mathrm{Re}\,\epsilon = (1.567 \pm 0.051) \times 10^{-3}.$$

These can be compared with the experimental values

$$\phi_{+-} = (46.6 \pm 2.5)^\circ$$
$$\phi_{00} = (49 \pm 13)^\circ$$
$$\mathrm{Re}\,\epsilon = (1.72 \pm 0.10) \times 10^{-3}$$

where ϵ has been computed from δ, the charge asymmetry parameter for leptonic K^0_L decays, and (Re x, Im x), the $\Delta S = -\Delta Q$ amplitude, using Eq. (34) of the text.

```
            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  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.
REX  U  BURGUN 72 IS A FINAL RESULT WHICH INCLUDES BURGUN 71.                  11/73*
REX  B  BENNETT 69 IS A REANALYSIS OF BENNETT1 68
REX G   SECOND GRAHAM 72 VALUE IS FIRST GRAHAM 72 VALUE COMBINED WITH           2/72
REX G   MANTSCH 72.                                                             2/72
REX           . . . . . . . . . .
REX AVG      -0.000      0.022    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                        (SEE IDEOGRAM BELOW )
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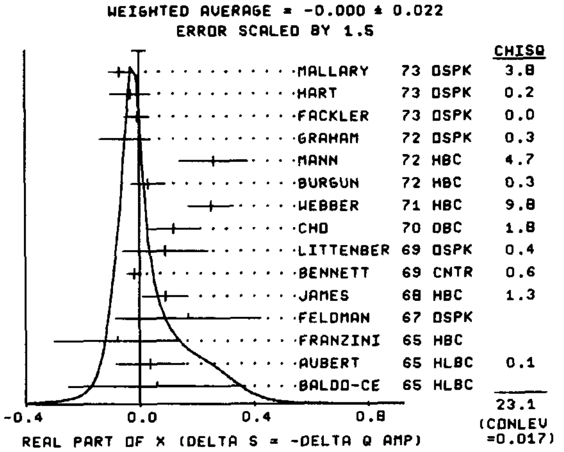


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IMX      IMAGINARY PART OF X (ASSUMES M(KL)-M(KS) POSITIVE -- SEE S13D)
IMX  C 152   -0.44      0.32       0.19  BALDO-CE   65 HLBC    K+ CHARGE EXCHNG  3/68
IMX    196   -0.21      0.11       0.15  AUBERT     65 HLBC    K+ CHARGE EXCHNG  3/68
IMX  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  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.
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       0.012     0.030   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                       (SEE IDEOGRAM BELOW )
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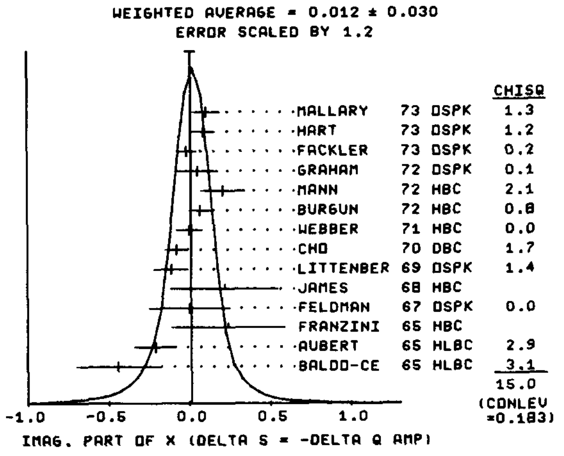

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REFERENCES FOR KOL


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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)

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)
    ALSO 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)
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Stable Particles

K^0_L

Data Card Listings

For notation, see key at front of Listings.

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 CHRISTENSON,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 BALATON 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,DODD+ (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)
ALSO 65 PL 15 58 DE BOUARD,DEKKERS,SCHARFF+ (CERN+ORSA+MPIM)

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 88 365 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 59 605 +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 +BARYLON,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)
ALSO 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 D.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 DALLY

CHO 71 PR D3 1557 +DRALLE,CANTER,ENGLER,FISK+ (CARN,BNL,CASE)
CLARK 71 PRL 26 1667 +ELIOFF,FIELD,FRISCH,JOHNSON,KERTH+ (LRL)
ALSO 70 UCRL 19709-THESIS ROLLAND JOHNSON (LRL)
ALSO 71 UCRL 20264-THESIS HENRY FRISCH (LRL)
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
ALSO 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,SAETRE+ (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)
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)
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)
DBBPSS 73 KFKI-73-46(BUDA) 2ND.AIX(DUBNA+BUDA+BERL+PRAG+SERP+SOFI COL.)
DONALDSO 73 PRL 31 337 DONALDSON,FRYBERGER,HITLIN,LIU+ (SLAC+UCSC)
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)
GJESDAL 73 2ND AIX CONF +KAMAE,PRESSER,STEFFEN,STEINBER+(CERN+HEID)
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 + (COLO+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)
ZDANIS 73 2ND AIX CONF. +RESVANIS,PEVSNER,MADANSKY+ (JHU+SLAC+UCLA)

GEWENIG1 74 SUBMITTED TO PL GEWENIGER,GJESDAL,KAMAE,PRESSER+(CERN+HEID)
ALSO 74 CERN INT. REPT. VERA LUTH (THESIS-INT. REPT. 74-4) (HEID)
GEWENIG2 74 SUBMITTED TO PL GEWENIGER,GJESDAL,PRESSER+ (CERN+HEID)
KMU3/KE3 74 THIS REVIEW CALCULATED BY US. SEE NOTES IN SEC. XIB, LO.

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)

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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)

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                  14  ETA (549,JPG=0-+) I=0

      FOR C. BALTAY'S REVIEW OF THE ETA MESON, SEE PROC. UNIV. OF PENN.
      CONF. ON MESON SPECTROSCOPY (W.A.BENJAMIN, N.Y., 1968)

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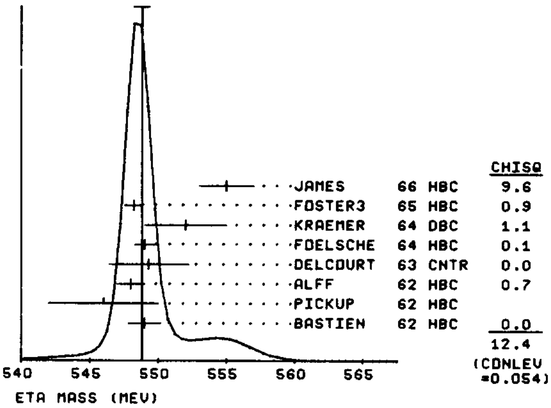
                  14  ETA MASS (MEV)

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)
                     (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 548.82 ± 0.56
ERROR SCALED BY 1.4

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                  14  ETA WIDTH (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
W           (4.0)  OR LESS           BALTAY     66 DBC               6/66
W            (.9)  OR LESS  CL=.95   JONES      66 CNTR              7/66
    ALSO SEE ETA DECAY RATES (BELOW).                                8/67

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                  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

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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 7
P 1 .3800+-.0098
P 2   -.2753   .3000+-.0107
P 3   -.3378     -.2108   .2391+-.0056
P 4   -.2976     -.1878      .8103   .0496+-.0013
P 7   -.4163     -.5941     -.0942     -.0797  .0313+-.0111

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                  14  ETA DECAY RATES

W1    ETA INTO 2GAMMA (UNITS KEV)                               (G1)
W1         (0.93)   (0.2)          BEMPORAD  67 CNTR    PRIMAKOFF EFFECT 11/67
```

Note on Eta Width

The above value for $\Gamma_{\gamma\gamma}$ assumes that $\Gamma_{\gamma\gamma}/\Gamma_{total} = 31.4\%$. However, the results of that experiment may be stated more generally than is given in the paper, as

$$\Gamma_{\gamma\gamma} \times \frac{\Gamma_{\gamma\gamma}}{\Gamma_{total}} = 0.380 \pm 0.083 \text{ keV}$$

(private communication from C. Bemporad). Thus our new value of

$$\Gamma_{\gamma\gamma}/\Gamma_{total} = 38.0 \pm 1.0\%$$

would give

$$\Gamma_{\gamma\gamma} = 1.00 \pm 0.22 \text{ keV}$$

and

$$\Gamma_{total} = 2.63 \pm 0.58 \text{ keV}.$$

See G. Benfatto, "Coherent Nuclear Photoproduction of the η-meson," Nuovo Cimento 69A, 109 (1970) for a critique of this technique.

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                  14  ETA BRANCHING RATIOS

R1      ETA INTO NEUTRALS/CHARGED                         (P1+P2+P7)/(P3+P4)
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  FIT      2.464    0.080  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2      ETA INTO 2GAMMA/CHARGED                           (P1)/(P3+P4)
R2           0.99     0.48         CRAWFORD  63 HBC
R2           . . . . . . . . .
R2  FIT      1.316    0.053  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
```
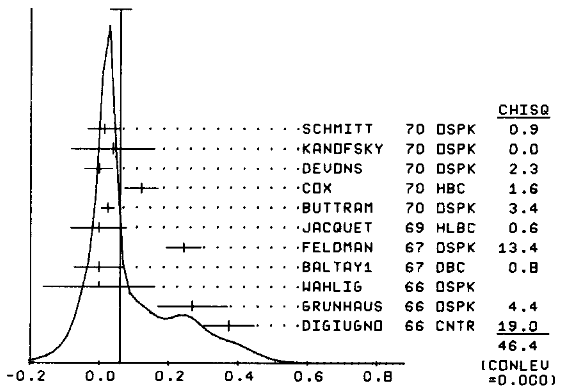

Note on $\eta \to \pi^0 \gamma\gamma$

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.

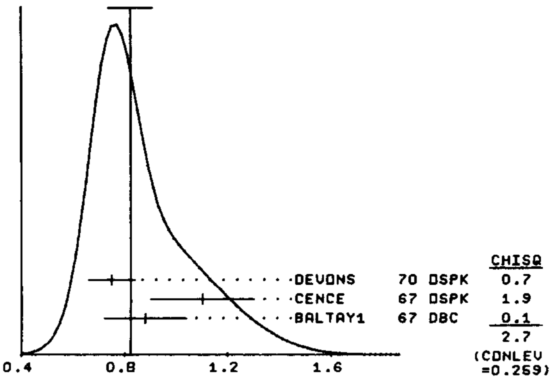
WEIGHTED AVERAGE = 0.061 ± 0.031
ERROR SCALED BY 2.3



ETA B.R. INTO (PIO 2GAMMA)/NEUTRALS

```
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  FIT       0.044     0.016  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)
P4  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  FIT       1.342     0.055  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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)
F6  FIT       0.790     0.039  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                        (SEE IDEOGRAM BELOW )
```

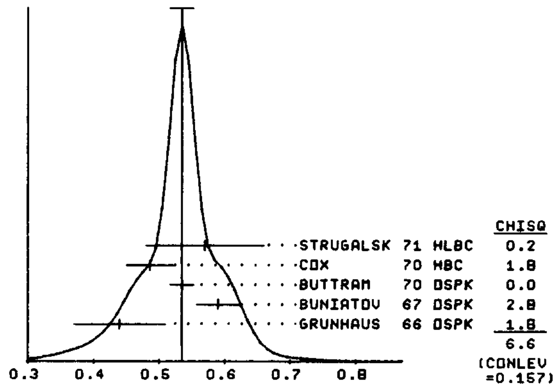
WEIGHTED AVERAGE = 0.824 ± 0.085
ERROR SCALED BY 1.2



ETA INTO (3PIO)/(2GAMMA)

```
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  FIT       1.589     0.064  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 B     ERROR INCREASED FROM PUBLISHED VALUE 0.5 BY BLOODWORTH, PRIV. COMM.   1/73
R8          . . . . . . . . . .
R8  AVG       3.28      0.31     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  FIT       2.975     0.097  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R9      ETA INTO (E+E-PIO)/(PI+PI-PIO) (UNITS 10**-2)      (P5)/(P3)
R9            1.1    OR LESS           PRICE     65 HBC
R9       0    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

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
P12            .486     .036           COX       70 HBC                        6/70
R12           0.57      0.09           STRUGALSK 71 HLBC                       5/71
R12         . . . . . . . . . .
R12 AVG       0.535     0.018    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R12 FIT       0.534     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



ETA INTO (2 GAMMA)/NEUTRALS

```
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         . . . . . . . . . .
R13 AVG       0.397     0.025    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R13 FIT       0.422     0.015  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       0.082     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

R16     ETA INTO 2GAMMA/(3PIO + PIO 2GAMMA)                 (P1)/(P2+P7)
R16           0.80       .25           BACCI     63 CNTR                       7/66
R16         . . . . . . . . . .
R16 FIT       1.147     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
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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 FIT      1.255     0.058  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      1.184     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 FIT      0.7113    0.0067 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      0.094     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*

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14 ETA C-NONCONSERVING DECAY PARAMETER

RELATED TEXT SECTION VI C AND MINI-REVIEW BELOW

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A   DECAY ASYMMETRY PARAMETER FOR PI+ PI- PIO   (UNITS 10**-2)
A     1351     7.2       2.8             BALTAY    66 DBC                  8/66
A     1300     5.8       3.4             CLPWY     66 HBC                  8/66
A    10665    (0.3)     (1.0)            CNOPS     66 OSPK REPL BY MULLER 69 8/67
A      705    -6.1       4.0             LARRIBE   66 HBC                  8/67
A   G36800    (1.5)     (.5)             GORMLEY3  68 ASPK               . 6/68
A    10709      .3       1.1             MULLER    69 OSPK                 9/69
A     1138    -1.4       3.              CARPENTR  70 HBC                  6/70
A      349     3.2       5.4             DANBURG   70 DBC                  2/71
A  L  220K    -0.05      0.22            LAYTER    72 ASPK                 8/72
A  L  165K     0.28      0.26            JANE1     74 OSPK                 3/74*
A  L    ALSO REPORTS SEXTANT AND QUADRANT ASYMMETRIES.                    8/72
A   G   GORMLEY3 68 ASYMMETRY PROBABLY DUE TO UNMEASURED (E X B) SPK. CH.  3/74*
A   G   EFFECTS.  NEW EXPTS. WITH (E X B) CONTROLS DONT OBSERVE ASYMMETRY. 3/74*
A            . . . . . . . . . .
A   AVG        0.12      0.17    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                                 (SEE IDEOGRAM BELOW )
```
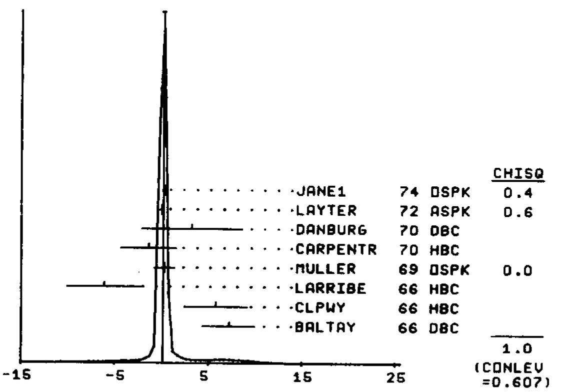

WEIGHTED AVERAGE = 0.12 ± 0.17
ERROR SCALED BY 1.0



ETA INTO PI+PI-PIO ASYMMETRY PARAMETER

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B   DECAY ASYMMETRY PARAMETER FOR PI+ PI- GAMMA (UNITS 10**-2)
B       33    -2.       17.              CRAWFORD  66 HBC                 11/66
B             -4.        8.              LITCHFIEL 67 DBC                  8/67
B  N  1620     1.5       2.5             MULLER    69 OSPK                 9/69
B  N  ABOVE EXPERIMENT IS SENSITIVE ONLY TO UPPER .4 OF GAMMA-RAY SPECTRUM
B     7257     1.22      1.56            GORMLEY   70 ASPK                 6/70
B      36K     0.5       0.6             THALER    72 ASPK                 8/72
B      35K     1.2       0.6             JANE2     74 OSPK                 3/74*
B            . . . . . . . . . .
B   AVG        0.88      0.40    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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REFERENCES FOR ETA


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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)
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)
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)
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)
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)

BUTTRAM  70 PRL 25 1358        +KREISLER,MISCHKE                      (PRIN)
COX      70 PRL 24 534         COX,FORTNEY,GOLSON                     (DUKE)
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)
THALER   73 PR D7 2569         +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN      (COLU)
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QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS


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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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REFERENCES ON ETA ASYMMETRY PARAMETERS


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BALTAY   66 PRL  16  1224      BALTAY,FRANZINI,KIM,KIRSCH+      (COLU+STON)
CNOPS    66 PL 22 546          CNOPS,FINOCCHIARS,LASSALLE,(CERN,ETHZ,SACL)
CRAWFORD 66 PRL  16  333       F.S.CRAWFORD,L.R.PRICE                  (LRL)
CLPWY    66 PR 149  1044       COLUMBIA,LRL,PURDUE,WISCONSIN,YALE
LARRIBE  66 PL 23 600          LARRIBE,LEVEQUE,MULLER,PAULI,+  (SACL+RHEL)

BOWEN    67 PL 24B 206         BOWEN,CNOPS ,FINOCCHIARO,+ (CERN+ETHZ+SACL)
LITCHFIE 67 PL 24B 486         LITCHFIELD,RANGAN,SEGAP,SMITH+(RHEL+SACLAY)
GORMLEY3 68 PRL 21 402         GORMLEY,HYMAN,LEE,NASH,PEOPLES+   (COLU+BNL)
MULLER   69 THESIS             ARMAND MULLER                          (STRB)
CARPENTR 70 PR D1 1303         CARPENTER,BINKLEY,CHAPMAN,COX,DAGAN+ (DUKE)
DANBURG  70 PR D2 2564         +ABOLINS,DAHL,DAVIES,HOCH,KIRZ,+        (LRL)
LAYTER   72 PRL 29 316         +APPEL,KOTLEWSKI,LEE,STEIN,THALER      (COLU)
THALER   72 PRL 29 313         +APPEL,KOTLEWSKI,LAYTER,LEE,STEIN      (COLU)
JANE1    74 PL 48B 260         +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
JANE2    74 PL 48B 265         +JONES,LIPMAN,OWEN,PENNEY+ (RHEL+LOWC+SUSS)
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16 PROTON (938,J=1/2) I=1/2

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16 PROTON MASS (MEV)

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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    B    KROPP AND BACKENSTOSS SENSITIVE TO PARTICULAR DECAY MODES OF PROT
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                16  PROTON MAGNET. MOMENT(E/2MP)

MM        (2.792763)(.000030)        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          -2.83     0.10          FOX        72                             11/72
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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

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                         REFERENCES FOR PROTON

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)
BUTTON   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        FOX,BARNES,EISENSTEIN+ (CARN+VPI+WILL+WYOM)
COHEN    73 J.PHYS.CHEM.REF.DATA 2, P.663, E.R.COHEN,B.N.TAYLOR

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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
------ --------- --------- --------- --------- --------- --------- --------

                17  (NEUTRON) - (PROTON) MASS DIFFERENCE (MEV)

D  M      (1.29344)(0.00007)         MATTAUCH   65 RVUE                         3/71
D          1.293428 0.000034         COHEN      74 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
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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        (5.)    OR LESS           BAIRD      69 MBR  INCLUDED IN DRESS73  10/69
EDM         0.32     0.75            DRESS      73 MBR  .LT.10**-23 CL=.80    6/73*
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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.
------ --------- --------- --------- --------- --------- --------- --------

                17  NEUTRON BETA DECAY COUPLING CONSTANTS

        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)         KROPP     73 RVUE    N DECAY ALONE     1/73
AV   P      -1.250    0.009          KROPP     73 RVUE    N DEC.+ FT VALUE  1/73
AV  C   CONFORTO 67 COMBINES FREE NEUTRON DATA TO 1967.  REPL. BY KROPP 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

F       PHASE ANGLE OF GA RELATIVE TO GV  (DEGREES)
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   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

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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)

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)
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)
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)
COHEN    74  PRIVATE COMM.    E.R.COHEN(NORTH AMER. AVIATION SCI. CENTER)

                              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    FIT     1115.599    0.048    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  3/74*
                                  (SEE IDEOGRAM BELOW )
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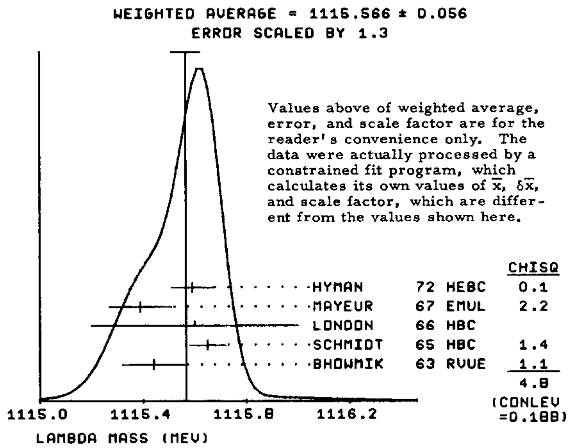

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

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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)
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                    18  LAMBDA MEAN LIFE (UNITS 10**-10)

T       188     2.63     0.21     0.21  BOLOT       58 CC
T       825     2.72     0.16     0.16  CRAWFORD    59 HBC
T       140     2.72     0.29     0.27  BOWEN       60 CC
T       186     2.60     0.28     0.20  CHANG       62 HBC
T       799     2.69     0.11     0.11  HUMPHREY    62 HBC
T      2239     2.36     0.06     0.06  BLOCK       63 HEBC
T       706     2.76     0.20           CHRETIEN    63 HLBC
T       794     2.59     0.09           HUBBARD     64 HBC
T      2260     2.31     0.10           KREISLER    64 OSPK
T      1378     2.59     0.07           SCHWARTZ    64 HBC
T       635     2.51     0.16           BALTAY      65 HBC                         6/66
T      2534     2.6      0.1            HILL        65 OSPK
T       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      2213     2.452    0.056    0.054 ENGELMANN   66 HBC                         9/66
T       585     2.68     0.13     0.11  AUERBACH    67 OSPK                        8/67
T               2.44     0.15           BADIER      67 HBC       2.4 PBAR P        6/68
T               2.55     0.15           BADIER      67 HBC       2.4 PBAR P,ANTIL  6/68
T      8342     2.535    0.035          GRIMM       68 HBC                         6/68
T      2600     2.47     0.08           HEPP        68 HBC                         8/68
T      1059     2.39     0.10           DEMIDOV     70 HLBC PI-P, 3.86 GEV/C      12/70
T      4572     2.54     0.04           BALTAY      71 HBC    K-P AT REST          6/71
T      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   S    ERROR PURELY STATISTICAL.
T               . . . . . . . . . .
T   AVG         2.578    0.021    0.021  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.6)
                (SEE IDEOGRAM BELOW )
```
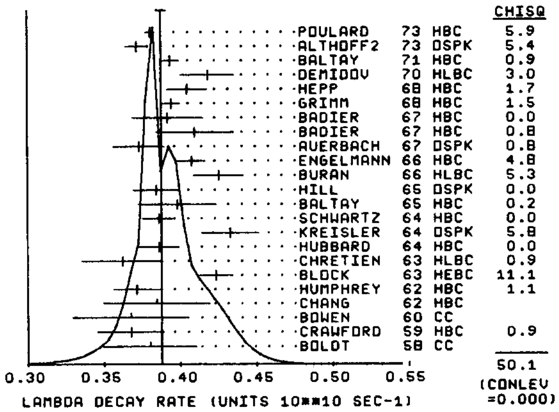

WEIGHTED AVERAGE = 0.3879 ± 0.0031
ERROR SCALED BY 1.6

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             18  (LAMBDA - ANTILAMBDA)/AVG., MEAN LIFE DIFFERENCE

DT              0.044     0.085            BADIER     67 HBC     2.4 PBAR P         8/67

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             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              . . . . . . . . . .
MM  AVG         -0.672    0.061    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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             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

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             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

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             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  FIT         0.6419    0.0049 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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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  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 KO 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)

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  C    218    1.32      0.15             LINDQUIST   71 OSPK    PI-P TO KO LAM     3/72
R5  C    CALCULATED BY US FROM R3 ASSUMING THE AUTHORS USED (P PI-)/TOT=2/3          3/72
R5              . . . . . . . . . .
R5  AVG         1.267     0.044    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

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             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-              . . . . . . . . . .
A-  AVG         0.647     0.013    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

AO      ALPHAO /ALPHA- FOR LAMBDA (L INTO PIO N/L INTO PI- P)
AO              1.10      0.27             CORK        60 CNTR
AO O    4760    1.000     0.068            OLSEN       70 OSPK PI+N TO K+ LAMBDA     5/70
AO              . . . . . . . . . .
AO  AVG         1.006     0.066    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
AO 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)

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   (-0.32)   (0.13)    (0.17)  LINDQUIST   71 OSPK  UP-DOWN ASYMMETRY    9/71
AV ML    173   (-0.68)   (0.27)    (0.54)  LINDQUIST   71 OSPK  E-NEU CORRELATION    9/71
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  A    ALTHOFF1 73 INCLUDES DATA OF ALTHOFF2 71.  USES PROT SPECTRUM AND           7/73*
AV  A    THREE SPIN ASSYMETRIES.                                                     7/73*
AV M     EXPT MEASURES ONLY THE ABSOLUTE VALUE OF A/V
AV  L    LINDQUIST 71 GETS THREE VALUES.  WE AVERAGE THE ONE THAT USES              10/71
AV  L    ALL DATA.                                                                  10/71
AV              . . . . . . . . . .
AV  AVG         -0.658    0.054    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                          (SEE IDEOGRAM BELOW )
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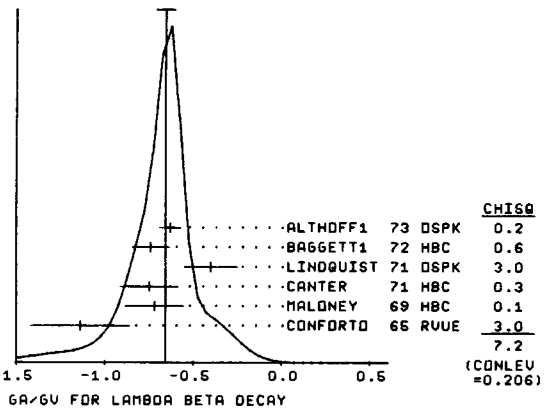
WEIGHTED AVERAGE = -0.658 ± 0.064
ERROR SCALED BY 1.2

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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      RONNE+          (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+       (EPCL+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)
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)

                                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
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                     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    FIT   1189.366     0.057  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)  3/74*
                        (SEE IDEOGRAM BELOW )
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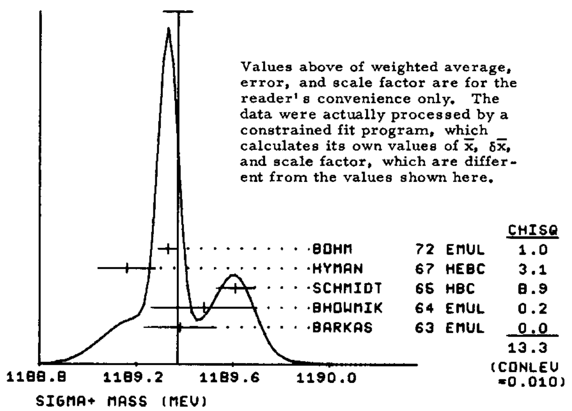
WEIGHTED AVERAGE = 1189.371 ± 0.060
ERROR SCALED BY 1.8

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                     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  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          0.8004    0.0058   0.0057 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)

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                     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         . . . . . . . . . . .
MM  AVG          2.62      0.41    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    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)

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*
R2           . . . . . . . . . .
R2  AVERAGE MEANINGLESS (SCALE FACTOR = 5.9)

R3      SIGMA+ INTO (LAMBDA 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)

R4      SIGMA+ INTO (P GAMMA)/(P PIO) (UNITS 10**-2)      (P5)/(P1)
R4        1    (0.68) 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)
                          (SEE IDEOGRAM BELOW )
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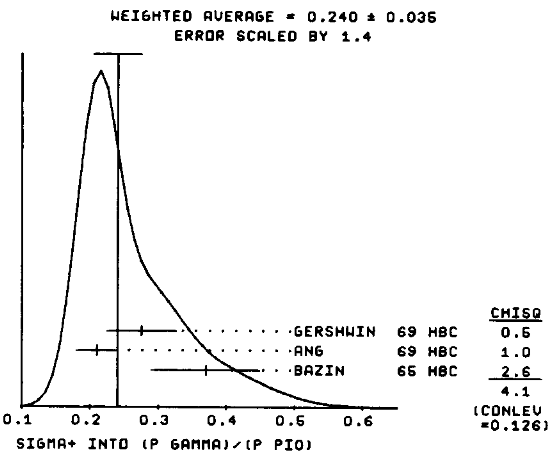


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R5      SIGMA+ INTO (N E+ NEU)/(N PI+) (UNITS 10**-5)     (P7)/(P2)
R5 E      0     16220 EFFECTIVE DENOM.  COURANT   64 HBC      SEE NOTE E       11/67
R5 E      0      2720 EFFECTIVE DENOM.  MURPHY    64 HBC      SEE NOTE E       11/67
R5 E      1      9690 EFFECTIVE DENOM.  NAUENBERG 64 HBC      SEE NOTE E        6/68
R5        0    (32406)EFFECTIVE DENOM.  BIERMAN   68 HBC                        6/68
R5 UA     0    (80400)EFFECTIVE DENOM.  EISELE2   69 HBC   +  STOP K-           6/68
R5 U      1     30000 EFFECTIVE DENOM.  NORTON    69 HBC                       11/69
R5 U      0    110200 EFFECTIVE DENOM.  EBENHOH   70 HBC      STOP K-          12/70
R5 U                  EFFECTIVE DENOM. CALCULATED BY US
R5 E                  EFFECTIVE DENOM.  TAKEN FROM EISELE 67                   11/67
R5  A      EISELE2 69 REPLACED BY EBENHOH 70
R5           . . . . . . . . . .
R5      4.0     2.0   OR LESS  CL=.90   OUR AVERAGE USING ALL ABOVE             12/70
R5       NUMBER OF EVENTS INCREASED TO 4.0 FOR 90PC CONFIDENCE LEVEL             2/71

R6      SIGMA+ INTC (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 NCTE 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           . . . . . . . . . .
R6      5.3     4.9   OR LESS  CL=.90   OUR AVERAGE USING ALL ABOVE             11/69
R6       NUMBER OF EVENTS INCREASED TO 5.3 FOR 90PC CONFIDENCE LEVEL             2/71
R6                    SEE NOTES ACCOMPANYING R5

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      6.7     0.035 OR LESS  CL=.90   OUR AVERAGE  USING R5 AND R6            2/71
R7       NUMBER OF EVENTS INCREASED TO 6.7 FOR 90PC CONFIDENCE LEVEL             2/71

R8      SIGMA+ INTC (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      5.3     0.095 OR LESS  CL=.90   OUR AVERAGE  USING R6                   2/71
R9       NUMBER OF EVENTS INCREASED TO 5.3 FOR 90PC CONFIDENCE LEVEL             2/71

R10     (SIGMA+ INTO N E+ NEU)/(SIGMA- INTC N E- NEU)
R10 E     0    (0.03) OR LESS  CL=.90   EISELE2   69 HBC  +- STOP K-            10/69
R10       0     0.019 OR LESS  CL=.90   EBENHOH   70 HBC     STOP K-           .12/70
R10       0     0.12  OR LESS  CL=.95   COLE      71 HBC     STOP K-            10/71
R10       0     0.018 OR LESS  CL=.90   SECHIZORN 73 HBC     STOP K-,POISSON    8/73*
R10 E      EISELE2 REPLACED BY EBENHCH 70
R10          . . . . . . . . . .
R10     4.0     0.016 OR LESS  CL=.90   OUR AVERAGE  USING R5                   2/71
R10      NUMBER OF EVENTS INCREASED TO 4.0 FOR 90PC CCNFIDENCE LEVEL             2/71

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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 O         OLD RESULTS,HAVE BEEN REPLACED . SEE BELOW -

A+       ALPHA 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)

AO       ALPHA SIGMAO (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)

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)

AG       ALPHA SIGMAG (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)/CCS(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)

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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  81358       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)

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)
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ANG       69 ZPHYS 228 151      +EBENHOH,EISELE,ENGELMANN,FILTHUTH+  (HEID)
BAGGETT   69 MODP-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)
EBENHOH   70 KIEV CONF          +EISELE,ENGELMANN,FILTHUTH,FOHLISCH+ (HEID)
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)

                                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

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                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)  3/74*

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                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    FIT        7.99     0.08   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  3/74*

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                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   FIT       81.755    0.054  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*

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                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  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         1.482    0.017    0.017  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.5)
                          (SEE IDEOGRAM BELOW )

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                20  SIGMA- MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM         BTWN -1.6 AND +0.8          FOX       73 CNTR    SIG-ATOM FINE ST  3/74*

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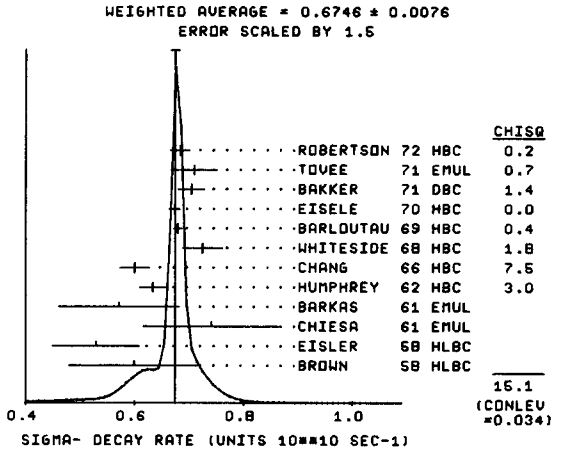


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                20  SIGMA- PARTIAL DECAY MODES

                                                       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

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                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)

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       601     1.09      0.06          EBENHOH   70 HBC     STOP K-         .12/70
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    ANG1 REPLACED BY EBENHOH 70.                                          2/71
R2              . . . . . . . . . .
R2   AVG        1.082     0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)

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*
R4              . . . . . . . . . .
R4   AVERAGE MEANINGLESS (SCALE FACTOR = 5.7)

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                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)

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)

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    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
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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  C  49    0.23      0.16            COLLERAIN 69 HBC  NEUTRON SCATTER.    10/69
AV1  C  33    0.37      0.26      0.19  EISELE2   69 HBC  NEUTRON SCATTER.   .10/69
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  S       -0.20      0.28            EBENHOH   70 HBC     E- SPECTRUM       3/72
AV1  C  36    0.29      0.28      0.29  BALTAY    72 HBC     NEUTRON SCATTER   6/72
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  C  COLLERAINE,EISELE,BALTAY MEASURE ABSOLUTE VALUE OF GA/GV.             6/72
AV1     GERSHWIN 69, BOGERT 70, EBENHOH 70, AND ELLIS 72 MEASURE THE SIGN.
AV1     BUT NEITHER HAS A DEFINITE SIGN DETERMINATION. SINCE THE SIGN IS
AV1     UNDETERMINED THE AVERAGE OF THE SIX VALUES IS MEANINGLESS.
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  S  SIGN CHANGED TO AGREE WITH OUR CONVE. INCLUDES BIERMAN 68 EVENTS.     3/72
AV1          . . . . . . . . .
AV1 AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                                 REFERENCES FOR SIGMA-

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        +EBENHOH,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)
EBENHOH   70 KIEV CONF           +EISELE,ENGELMANN,FILTHUTH,FOHLISCH+ (HEID)
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
ROBERTSO  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)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

BROWN     57 PR 108 1036         J BROWN, D GLASER, M PERL        (MICH+BNL)
NIETO     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   FIT       4.874    0.063  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*
                                (SEE IDEOGRAM BELOW )
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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          . . . . . . . . .
DL   FIT       76.88     0.08    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*
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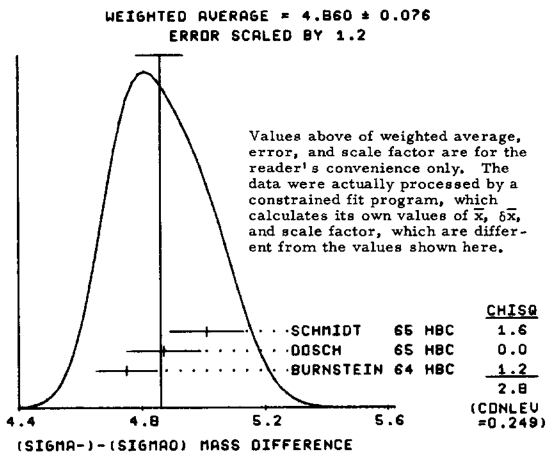

Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\bar{x}$, $\delta\bar{x}$, and scale factor, which are different from the values shown here.

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                  21  SIGMA0 MEAN LIFE (UNITS 10**-14)
T             (1.0)  OR LESS             DAVIS     62 EMUL
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                  21  SIGMA0 PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      SIGMA0 INTO LAMBDA GAMMA                          1115+   0
P2      SIGMA0 INTO LAMBDA E+ E-                          1115+  .5+  .5
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                  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

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                           REFERENCES FOR SIGMA0

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)

                               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 1115.589-M(XI) IS 1322.18 IF M(LAMBDA) IS 1115.  4/68
M      268 1321.12     0.41              WILQUET   72 HLBC                     1/73
M           . . . . . . . . .
M   AVG    1321.31     0.16    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   FIT    1321.29     0.14  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*
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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  FIT     1321.29     0.14  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*
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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		1134	-2.2	0.8	COOL	72	OSPK	- 1.8 GEV/C K-P	1/73
MM			. . . .						
MM	AVG		-1.93	0.75	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				

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	S	2436	(1.637)	(0.050)		COOL	72	OSPK	1.74-1.87 GEV/C K-P	11/73*
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	THE ERROR IS STATISTICAL ONLY								
T			. . . .							
T	AVG		1.652	0.023	0.022	AVERAGE (ERROR INCL. SCALE FACTOR OF 1.1)				

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								

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

22 XI- BRANCHING RATIOS

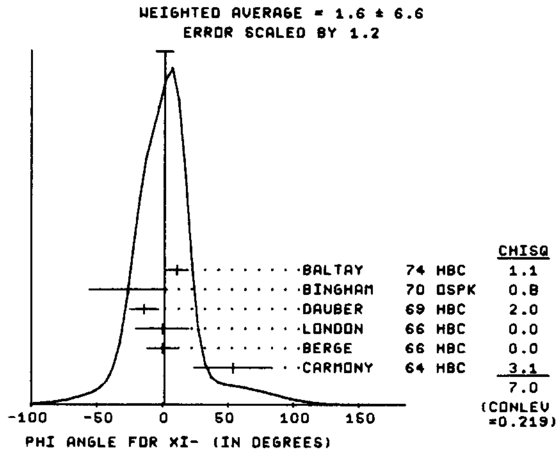
R1	XI- INTO (LAMBDA E- NEU)/(LAMBDA PI-) (UNITS 10**-3)							
R1							(P2)/(P1)	
R1	1	(155)EFFECTIVE DENOM.			CARMONY	63 HBC		11/67
R1	0	(260)EFFECTIVE DENOM.			JAUNEAU	63 HBC		11/67
R1	0	(220)EFFECTIVE DENOM.			BERGE	66 HBC		11/67
R1	1	(155)EFFECTIVE DENOM.			LONDON	66 HBC		11/67
R1	0	(717)EFFECTIVE DENOM.			TRIPPE	67 HBC		11/67
R1	2	(1976)EFFECTIVE DENOM.			HUBBARD	68 HBC		6/68
R1	4	1.15	0.90	0.55	HUBBARD	68 RVUE		
R1	HUBBARD 68 (RVUE) INCLUDES ALL ABOVE EVENTS							6/68
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
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
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
R5	XI- INTO (SIGMAO MU- NEUTRINO)/TOTAL						(P6)	
R5		0.005	OR LESS		BERGE	66 HBC		7/66
R6	XI- INTO (N E- NEUTRINO)/(LAMBDA PI-)						(P7)/(P1)	
R6		0.01	OR LESS	CL=.90	BINGHAM	65 RVUE		9/66
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.							

22 XI- DECAY PARAMETERS

RELATED TEXT SECTION VI D AND APPENDIX III

A		ALPHA XI-							
A	D		(-0.44)	(0.12)	JAUNEAU	63	FBC	SEE NOTE D BELOW	6/68
A	D	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	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)							6/68
A	L	LONDON 66 USES ALPHA-LAMBDA = 0.62							
A	M	DATA OF MERRILL 68 INCLUDED IN DAUBER 68.							
A	O	OLD DATA NOT INCLUDED IN AVERAGE.							
A			. . . .						
A	AVG		-0.393	0.023	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				

F		PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)							
F	O		(-16.0)	(45.0)	JAUNEAU	63	FBC	SEE NOTE D BELOW	6/68
F	O	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	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 68 FOR DETAILED DISCUSSION)							
F	L	LONDON 66 USES ALPHA-LAMBDA = 0.62							
F	M	DATA OF MERRILL 68 INCLUDED IN DAUBER 68.							
F	O	OLD DATA NOT INCLUDED IN AVERAGE.							
F			. . . .						
F	AVG		1.6	6.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)				
					(SEE IDEOGRAM BELOW)				



REFERENCES FOR XI-

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
BADIER1	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 88 447	+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)
COOL	72 PRL 29 1630	+GIACOMELLI,JENKINS,KYCIA,LEONTIC,LI+ (BNL)
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

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23 XIO (1314,JP=1/2) I=1/2

23 XIO 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	FIT		1314.90	0.55	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)			3/74*

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                      23  (XI-) - (XIO) 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   FIT        6.40     0.55  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/74*

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                      23  XIO 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  M    MAYEUR 72 VALUE MODIFIED BY ERRATUM.                                  1/74*
T  B    BALTAY 74 INCLUDES BRIDGEWATER 72.                                    3/74*
T              . . . . . . . . . .
T   AVG        2.96     0.12     0.11   AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)

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                      23  XIO PARTIAL DECAY MODES

                                                             DECAY MASSES
P1       XIO INTO LAMBDA PIO                               1115+ 134
P2       XIO INTO PROTON PI-                                938+ 139
P3       XIO INTO PROTON E- NEU                             938+  .5+    0
P4       XIO INTO SIGMA+ E- NEU                            1189+  .5+    0
P5       XIO INTO SIGMA- E+ NEU                            1197+  .5+    0
P6       XIO INTO SIGMA+ MU- NEUTRINO                      1189+ 105+    0
P7       XIO INTO SIGMA- MU+ NEUTRINO                      1197+ 105+    0
P8       XIO INTO PROTON MU- NEUTRINO                       938+ 105+    0

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                      23  XIO BRANCHING RATIOS

R1       XIO INTO (PROTON PI-)/(LAMBDA PIO) (UNITS 10**-3)
R1                                                      (P2)/(P1)
R1            27.0    OR LESS            TICHO      63 HBC                    6/68
R1             5.0    OR LESS            HUBBARD    66 HBC                    6/68
R1             0.9    OR LESS            DAUBER     69 HBC                    6/68

R2       XIO INTO (PROTON E- NEU)/(LAMBDA PIO) (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

R3       XIO INTO (SIGMA+ E- NEU)/(LAMBDA PIO) (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

R4       XIO INTO (SIGMA- E+ NEU)/(LAMBDA PIO) (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

R5       XIO 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

R6       XIO 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

R7       XIO 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

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                      23  XIO DECAY PARAMETER

          RELATED TEXT SECTION VI D AND APPENDIX III

A        ALPHA XI O
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)
                             (SEE IDEOGRAM BELOW )
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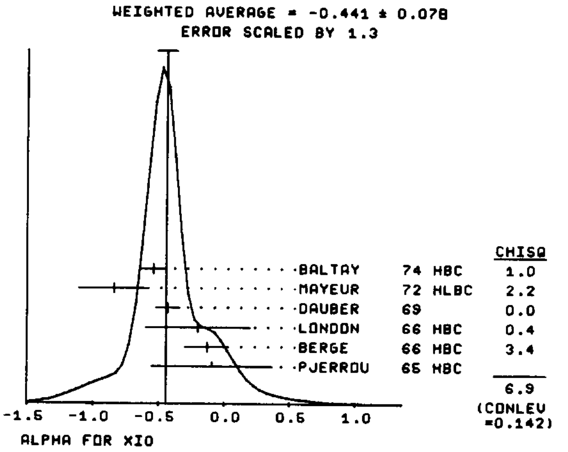


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F        PHI ANGLE  (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGREES)
F        146   -8.       30.            BERGE     66 HBC    SEE NOTE D BELOW  6/68
F   M   490 (107.0)     (46.0)          MERRILL   66 HBC    SEE NOTE D BELOW  6/68
F  A    739   38.        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)

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                           REFERENCES FOR XIO

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 26B  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
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                     24  OMEGA- (1675,JP=3/2+) I=0
                  QUANTUM NUMBERS ASSIGNED FROM SU3

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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 1673.0       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   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           . . . . . . . . . .
M   AVG     1672.18      0.42    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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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                    24  OMEGA- MEAN LIFE (UNITS 10**-10 SEC)

T   A   1   (1.63)                     ABRAMS    64 HBC                     7/66
T   A   1   (0.7)                      BARNES 1  64 HBC                     7/66
T   A   1   (1.4)                      BARNES 2  64 HBC                     7/66
T   A   1   (1.85)                     COLLEY    65 HBC                     7/66
T   A   1   (1.5)                      RICHARDSO 65 HBC                     7/66
T   A   1   (0.93)                     ABCLV COL 68 HBC                    11/67
T   A   1   (2.6)                      ABCLV COL 68 HBC                    11/67
T   A   1   (1.6)                      ABCLV COL 68 HBC                    11/67
T   A   1   (0.21)                     ABCLV COL 68 HBC                    11/67
T   A   1   (1.20)                     SCHULTZ   68 HBC                    11/67
T   A   1   (0.06)                     SCHULTZ   68 HBC                    11/67
T   A   1   (0.63)                     SCHULTZ   68 HBC                    11/67
T   A   1   (0.25)                     SCOTTER   68 HBC                     6/68
T   A   1   (0.30)                     SCOTTER   68 HBC                     6/68
T   A   1   (0.71)                     SCOTTER   68 HBC                     6/68
T   A   1   (0.08)                     SCOTTER   68 HBC                     6/68
T   A   1   (1.04)                     SCOTTER   68 HBC                     6/68
T   A   1   (2.38)                     SCOTTER   68 HBC                     6/68
T   A   ALLISON INCLUDES ALL ABOVE + 3 MORE BNL EVENTS, UNPUBLISHED.        6/68
T       21    1.31     0.37     0.24   ALLISON   68 RVUE                    6/68
T       16    1.39     0.45     0.31   ABCLV     73 HBC    K-P 10. GEV/C   12/73*
T            . . . . . . . . .
T   AVG       1.34     0.28     0.20   AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)

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                    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

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                    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*

R2      OMEGA- INTO XIO PI-                          (P2)
R2       1   EVENTS                ABRAMS    64 HBC                        11/69
R2       4   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*

P3      OMEGA- INTO XI- PIO                          (P3)
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*

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                              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)

ABCLV CO 68 NUC PHYS B4 326     AACHEN+BERLIN+CERN+LONDON IMP.COLL.+VIENNA
ALLISON  68 PRIV. COMM.         JOHN ALLISON                       (LANCASTER)
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)

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PARTICLE SEARCHES

Heavy Leptons

Two types of searches for heavy leptons have been made. The first type uses the fact that we can calculate the transition rate for the decay of a heavy lepton to states involving other leptons, with or without pions. Production mechanisms are also considered to be well known, proceeding via the electromagnetic interaction. BERNARDINI 73 and BARISH 73 are of this type.

The second method (BUSHNIN 73) is to look for charged, weakly interacting, long-lived particles.

Intermediate Bosons ($W^{\pm}_{0}$ and Φ^0)

Experimentally, W bosons could be produced by hadrons, muons, or neutrinos. They can decay into leptons or into hadrons. At present, there is no positive evidence for the existence of W bosons, although there have been several searches. We list upper limits on the mass and on production cross section.

All gauge theories postulate, in addition to the vector boson W, at least one scalar boson (Higgs' scalar), Φ^0. The couplings of the Higgs' scalar are model-dependent, and limits on its mass depend on M_W. We list these limits and add in comment cards the assumptions made.

Quarks

Three main techniques have been used in the experimental search for quarks: accelerators, cosmic rays, and searches in stable matter. The most recent limits using each of these techniques are given in the Data Card Listings. Accelerator experiments generally measure quark production cross sections (we quote these in Section C) and differential cross sections (D). Cosmic ray experiments measure quark flux (F), and searches in stable matter measure quark concentration (RHO). Some of the accelerator and cosmic ray experiments have looked for fractionally charged particles, and some have looked for high-mass, low-velocity particles. We give the fractional charge, mass ranges, velocity ranges, and other information in the notes on the right hand side of the card and below the data cards.

Magnetic Monopoles

Two main techniques have been used in the search for magnetic monopoles: accelerator and stable matter searches.

In accelerator searches strong magnetic fields are used to extract magnetic monopoles trapped in beam dumps. Cross-section limits are calculated using the reaction pp → pp MM.

Searches in matter have been made on sediments at the bottom of the Atlantic Ocean (FLEISCHER 69) and at the bottom of the Pacific Ocean (KOLM 71). Both experiments used high magnetic fields in attempting to extract monopoles from the matter. ROSS 73 searched a lunar rock sample using an electromagnetic detector which measures a current change induced in a superconducting circuit when traversed by a magnetically charged object.

We list the cross-section limits from these experiments with the range of Dirac charges to which each experiment is sensitive.

HEAVY LEPTON SEARCHES

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M       HEAVY LEPTON MASS LIMITS (GEV)
M    C   0   (2.0)  OR MORE  CL=.90    BARISH     73 ASPK + 50,145GEV NEU,NAL  2/74*
M    D   0   (1.4)  OR MORE  CL=.95    BERNARDIN 73 ASPK    E+E-, FRASCATI    2/74*
M    D   0   (1.0)  OR MORE  CL=.95    BERNARDIN 73 ASPK    E+E-, FRASCATI    2/74*
M  B  NONE BTWN 0.55 AND 4.5           BUSHNIN    73 CNTR    70GEV P,SERPUKOV  2/74*
M    E   0   (2.4)  OR MORE  CL=.90    EICHTEN    73 HLBC +  1-10 GEV NEU      3/74*
M    O   0   (1.5)  OR MORE  CL=.95    ORITO      74 ASPK +- E+E- FRASCATI     3/74*
M    C  BARISH 73 LOOKED FOR DECAY TO (MU+ 2NEUTRINOS). ASSUMES BR.FRAC.=.3   2/74*
M    D  BERNARDINI 73 FIRST VALUE ASSUMES UNIVERSAL COUPLING TO ORDINARY      2/74*
M    D  LEPTONS.  SECOND VALUE ALSO ASSUMES COUPLING TO HADRONS.              2/74*
M  B    BUSHNIN 73 MASSES ASSUME MEAN LIFE ABOVE .7 AND 30*10**-9 RSPCTVLY.  2/74*
M  B    CALCULATED FROM CROSS SEC(C) BELOW AND 30 GEV MUON PAIR PROD. DATA.  2/74*
M    E  EICHTEN 73 LOOKED FOR HEAVY MUON DECAYING INTO E+ ENEU+MUNEU,         3/74*
M    E  ASSUMED TO BE 15 PERCENT OF ALL DECAYS.                              3/74*
M    O  ORITO 74 LOOKED FOR H+H- PAIRS GIVING MU-E PAIRS. MASS LIMIT REFERS  3/74*
M    O  TO HEAVY ELECTRON, HEAVY MUON OR HEAVY LEPTON WITH OWN L NUMBER.     3/74*
M    O  COUPLING TO HADRON ASSUMED FROM THEORETICAL MODELS.                  3/74*

C       DIFFERENTIAL HEAVY LEPTON PRODUCTION CROSS SEC(10**-38 CM**2/SR-GEV)
C  B     0   (4.0)  OR LESS  CL=.90    BUSHNIN    73 CNTR 70 GEV P, SERPUKOV   2/74*
C  B    BUSHNIN 73 HEAVY LEPTON PATH TRAVERSES 400 GM/CM**2 ABSORBER.         2/74*
C  B    DIFFERENTIAL CROSS-SECTION MEASURED AT P=30 GEV/C THETA= 2 MRAD.      3/74*

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REFERENCES FOR HEAVY LEPTON SEARCHES


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BARISH    73 PRL 31 410        +BARTLETT,BUCHHOLZ,HUMPHREY+          (CIT+NAL)
BERNARDI  73 NC 17A 383        +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)
ORITO     74 PL 48B 165        +VISENTIN,CERADINI,CONVERSI +        (FRAS+ROMA)
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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+ TO LEP+NEU=.5  2/74*
M    C   0   (4.7)  OR MORE  CL=.90    BARISH     73 ASPK +  W+ TO LEP+NEU=.8  2/74*
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*

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         +BIENLEIN,BOHM,DARDEL,FAISSNER+           (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+NAL)
CONVERSI  73 PL 46B 269        +D.ANGELO,GATTO,PAOLUZZI                  (ROME)
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QUARK SEARCHES

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C       QUARK PRODUCTION CROSS SECT. FROM ACCELERATOR EXPTS  (10**-34 CM**2)
C    A   0   (0.004)OR LESS  CL=.90    ANTIPOV    69 CNTR Q= -2/3  M=0-5GEV    2/74*
C    B   0   (3.0)  OR LESS            BOTT-BODE 72 CNTR Q=+-1/3  M=0-22GEV   2/74*
C    B   0   (6.0)  OR LESS            BOTT-BODE 72 CNTR Q=+-2/3  M=0-13GEV   2/74*
C    L   0   (0.1)  OR LESS            LEIPUNER   73 CNTR Q=  1/3  M=0-12GEV   2/74*
C    L   0   (0.1)  OR LESS            LEIPUNER   73 CNTR Q=  2/3  M=0-12GEV   2/74*
C    L   0(5000.0)  OR LESS            LEIPUNER   73 CNTR Q=  4/3  M=0-12GEV   2/74*
C    A  ANTIPOV 69 IS A SERPUKHOV 70 GEV/C P EXPT. MASS LIMIT FROM NN=NNQQ.  2/74*
C    B  BOTT-BODENHAUSEN 72 IS A CERN ISR 26+26 GEV P+P EXPERIMENT.          2/74*
C    L  LEIPUNER 73 IS AN NAL 300 GEV P EXPERIMENT.                          2/74*

D       DIFFERENTIAL QUARK PROD.CROSS SEC, ACCL.EXPTS.(10**-36 CM**2/SR-GEV)  2/74*
D    D   0   (1.5)  OR LESS            DORFAN     65 CNTR BE TARG  M=3-7GEV    2/74*
D    D   0   (3.0)  OR LESS            DORFAN     65 CNTR FE TARG  M=3-7GEV    2/74*
D    D  DORFAN 65 IS A 30 GEV/C P EXPERIMENT AT BNL.                         2/74*

F       QUARK FLUX FROM COSMIC RAY EXPERIMENTS (10**-10/CM**2-SR-SEC)        2/74*
F    M   2                             MCCUSKER  62 CC   Q=2/3                2/74*
F     C  0    (3.0)  OR LESS           BJORNBOE  68 CNTR M=5GEV OR MORE       2/74*
F        0 (220.0)   OR LESS           FRANZINI  68 CNTR V=.5-.9C  M=2GEV UP  2/74*
F        0 (240.0)   OR LESS  CL=.95   KASHA     68 OSPK V=.5-.75C M=5-15GEV  2/74*
F        0    (0.50) OR LESS  CL=.90   FUKUSHIMA 69 CNTR Q=1/3  SEA LEVEL     2/74*
F        0    (7.5)  OR LESS  CL=.90   FUKUSHIMA 69 CNTR Q=2/3  SEA LEVEL     2/74*
F     B  0    (1.0)  OR LESS  CL=.90   BOHM      72 CNTR Q=1/3                2/74*
F     B  0    (1.0)  OR LESS  CL=.90   BOHM      72 CNTR Q=2/3                2/74*
F    M  MC CUSKER 62 CLAIMS 2 CANDIDATES.  LATER SIMILAR EXPTS. SEE NONE.     2/74*
F     C BJORNBOE 68 LOOKED FOR DELAYED PARTICLES AFTER AIR SHOWERS.           2/74*
F     B BOHM 72 IS FLUX IN 10**14 TO 10**15 EV AIR SHOWERS                    2/74*

RHO     QUARK CONCENTRATION IN MATTER (QUARKS PER NUCLEON)
RHO      0    3 E-29 OR LESS           CHUPKA    66 CNTR    SEAWATER          2/74*
RHO      0    1 E-16 OR LESS           GALLINARO 66 CNTR    GRAPHITE          2/74*
RHO      0    4 E-19 OR LESS           STOVER    67 CNTR    IRON              2/74*
RHO      0    1 E-20 OR LESS           RANK      68 CNTR    OIL               2/74*
RHO      0    1 E-24 OR LESS           COOK      69 CNTR    SEAWATER          2/74*
RHO      0    1 E-23 OR LESS           COOK      69 CNTR    ROCK SAMPLES      2/74*

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REFERENCES FOR QUARK SEARCHES


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MCCUSKER 62 PRL 23 658         MCCUSKER,CAIRNS                       (SYDNEY)
DORFAN   65 PRL 14 999         +EADES,LEDERMAN,LEE,TING                (COLU)
CHUPKA   66 PRL 17 60          +SCHIFFER,STEVENS                        (ANL)
GALLINAR 66 PL 23 609          GALLINARO,MORPURGO                      (GENO)
STOVER   67 PR 164 1599        + MORAN,TRISCHKA                        (SYRA)
BJORNBOE 68 NC B53 241         +DAMGARD,HANSEN,CHATTERJEE+        (BCHR+BERN)
FRANZINI 68 PRL 21 1013        FRANZINI,SHULMAN                        (COLU)
KASHA    68 PR 172 1297        +STEFANSKI                          (BNL+YALE)
RANK     68 PR 176 1635        D.M.RANK                                (MICH)
ANTIPOV  69 PL 29B 245         +KARPOV,KHROMOV,LANDSBERG,LAPSHIN+      (SERP)
COOK     69 PR 188 2092        +DEPASQUALI,FRAUENFELDER,PEACOCK +       (ILL)
FUKUSHIM 69 PR 178 2058        FUKUSHIMA,KIFUNE,KONDO,KOSHIBA+         (TOKY)
BOHM     72 PRL 28 326         +DIEMONT,FAISSNER,FASOLD,KRISOR+        (AACH)
BOTT-BOD 72 PL 40B 693         +CALDWELL,FABJAN,GRUHN,PEAK+       (CERN+MPIM)
LEIPUNER 73 PRL 31 1226        +LARSEN,SESSOMS,SMITH,WILLIAMS+     (BNL+YALE)
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PAPERS NOT REFERRED TO IN DATA CARDS

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ZAITSEV  72 SJNP 15 656        +LANDSBERG  -REVIEW PAPER-              (SERP)
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MAGNETIC MONOPOLE SEARCHES

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C       MONOPOLE PROD. CROSS SECTION - ACCELERATOR EXP. (10**-43 CM**2)/NUCL
C     G  0   (4.0)  OR LESS  CL=.95   GUREVICH  72 EMUL    M=0-5 GEV          3/74*
C     C  0  (60.0)  OR LESS  CL=.95   CARRIGAN  73 CNTR Q=1/6-24 DIRAC CHAR   3/74*
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*

CS      MONOPOLE PROD. CROSS SECTION - SEARCH IN MATTER     (CM**2)/NUCLEON
CS    F  0    1 E-42 OR LESS  CL=.90  FLEISCHER 69 CNTR    M=1 GEV            3/74*
CS    F  0    1 E-40 OR LESS  CL=.90  FLEISCHER 69 CNTR    M=10 GEV           3/74*
CS    F  0    5 E-37 OR LESS  CL=.90  FLEISCHER 69 CNTR    M=100 GEV          3/74*
CS    F  0    2 E-29 OR LESS  CL=.90  FLEISCHER 69 CNTR    M=1000 GEV         3/74*
CS    F  0    1 E-29 OR LESS  CL=.90  FLEISCHER 69 CNTR    M=10000 GEV        3/74*
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    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 EXTRACT MONOP. IN DEEP SEAWATER Q=.2-27 DIRAC CHAR   3/74*
CS    R ROSS 73 TRIED TO EXTRACT MONOP. IN LUNAR DUST    Q=.4-36 DIRAC CHAR   3/74*
CS    R OR LARGER CHARGES EXCEPT FOR G= N*36*GO, WITH N INTEGER.  THEY ALSO   3/74*
CS    R REPORT LIMIT OF FLUX IN LUNAR MATERIAL AS 1.7*10**-4 MONOP./GRAM.     3/74*

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REFERENCES FOR MAGNETIC MONOPOLE SEARCHES


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FLEISCHE 69 PR 184 1393        FLEISCHER,HART,JACOBS+       (GESC+UNCS+GSCO)
KOLM     71 PR D4 1285         +VILLA,ODIAN                       (MIT+SLAC)
GUREVICH 72 PL 38B 549         +KHAKIMOV,MARTEMIANOV+       (KIAE+NOVO+SERP)
    ALSO 72 JETP 34 917        BARKOV, GUREVICH,            (KIAE+NOVO+SERP)
CARRIGAN 73 PR D8 3717         +NEZRICK,STRAUSS                        (NAL)
ROSS     73 PR D8 698          +EBERHARD,ALVAREZ,WATT             (LBL+SLAC)
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S=0 MESON STATES

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$\pi^{\pm}$

8 CHARGED PION (140,JPG=0--) I=1
SEE STABLE PARTICLE DATA CARD LISTINGS

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π^0

9 NEUTRAL PION (135,JPG=0--) I=1
SEE STABLE PARTICLE DATA CARD LISTINGS

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η

14 ETA (549,JPG=0-+) I=0
SEE STABLE PARTICLE DATA CARD LISTINGS

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ϵ

14 PI PI S WAVE, CALLED EPSILON

S-Wave $\pi\pi$ Interactions in the Region 280 - 1900 MeV

In this note, we discuss information on the isoscalar $\pi\pi$ S wave in terms of its phase shift δ_0^0 from threshold to 1900 MeV.

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), these parameters can still not be unambiguously determined from present experimental information (BASDEVANT 73). 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). However, all one knows is a

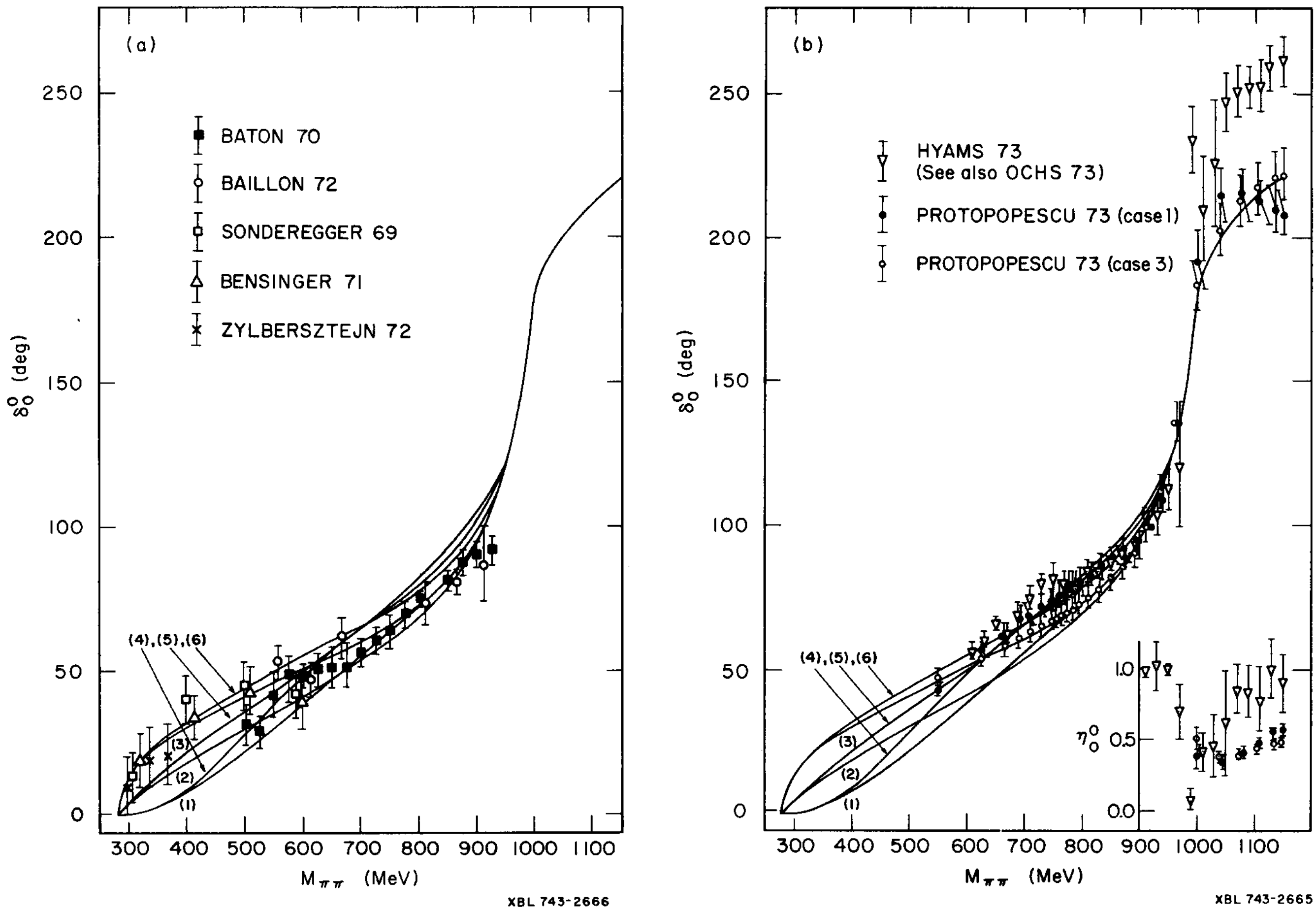

Fig. 1. Plots of the S-wave, I = 0 $\pi\pi$ phase shift, as determined by several experiments. The curves are from BASDEVANT 73. Solutions (1), (2), and (3) are S-wave phase shifts obtained by fitting the data of BATON 70 (the values used for the scattering length are -0.06, 0.16, and 0.58, respectively). Solutions (4), (5), and (6) are S-wave phase shifts obtained by fitting the data of PROTOPOPESCU 72 (the values used for the scattering length are -0.05, 0.16, and 0.6, respectively).

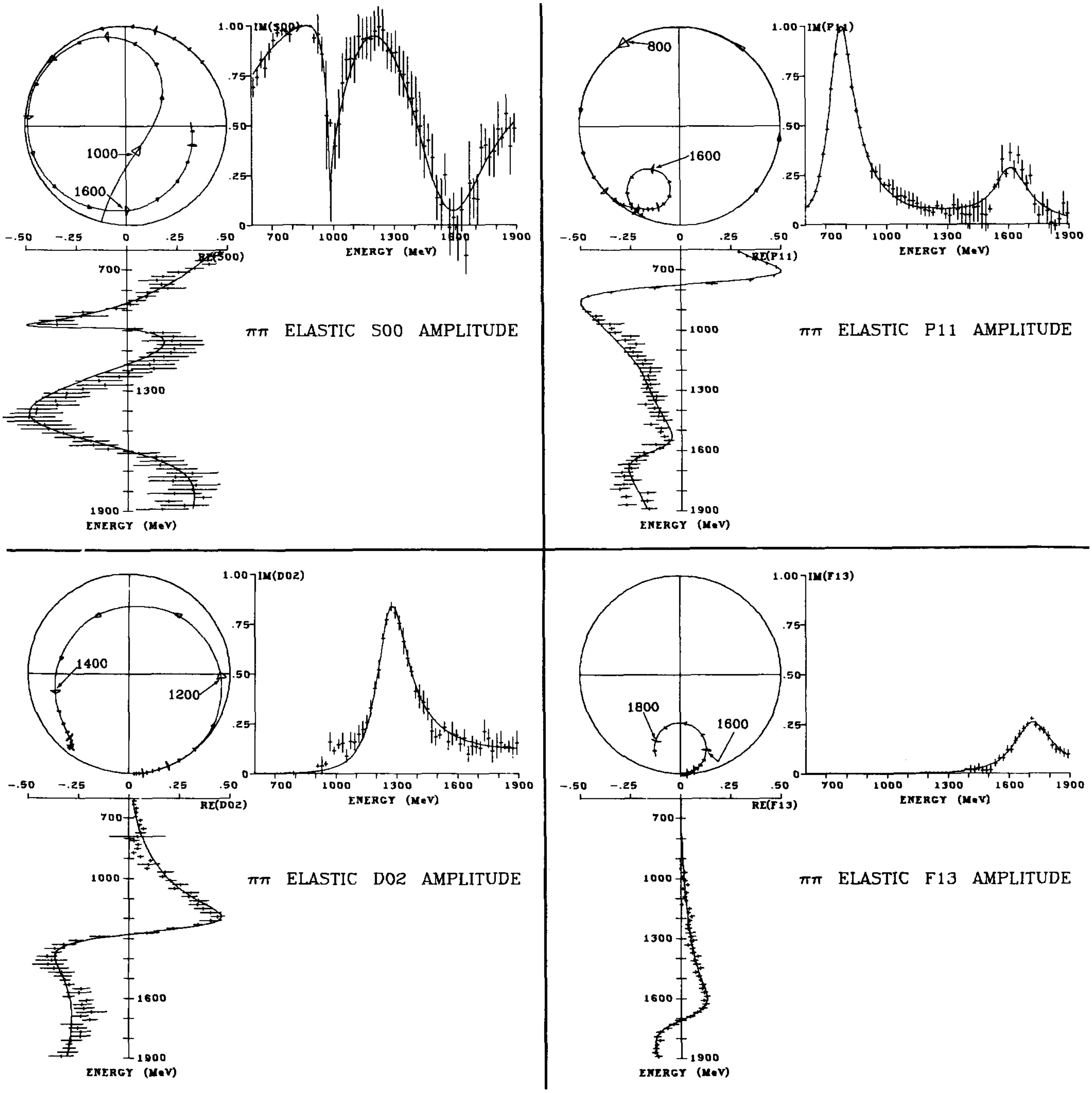

Fig. 2. Amplitudes for ππ elastic scattering in the S_{00}, P_{11}, D_{02}, and F_{13} waves from OCHS 73 (thesis), published in HYAMS 73. The data points with error bars are the results of the energy-independent analysis of OCHS 73; the curves and Argand plots are from the energy-dependent analysis. 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 even multiples of 50 MeV and a base-to-tip length of 5 MeV. Arrows occurring at multiples of 200 MeV are wider than the rest, and a few of these are labeled explicitly. All the energy axes run from 600 to 1900 MeV. Established resonances in these waves are the ϵ and $S^*(993)$ in the S_{00} wave, the ρ(770) and ρ' (1600) in the P_{11} wave, the f(1270) and f' (1514) (which, however, has not been observed to decay into two pions) in the D_{02} wave, and the g(1680) in the F_{13} wave.

region of finite extent within which a_0^0 must lie. It is therefore not established whether, e. g. , the Weinberg predictions are supported by experiment.

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 kinematic conditions change. Thus they must be kinematic effects (DUBAL 71, BRODY2 72, RISSER 73, ANJOS 73).

The region of elastic $\pi\pi$ 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). Up to the ρ meson mass region, 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).

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 by the observation of a very rapid decrease in the S-wave amplitude between 950 and 980 MeV (FLATTE 72, GAIDOS 72, HYAMS 73, BINNIE 73). The size of the observed drop corresponds to a change from nearly the unitarity limit to zero, i. e. , to a phase-shift change from about 90° at 900 MeV to 180°.

In accordance with this, energy-dependent phase-shift analyses (PROTOPOPESCU 73, HYAMS 73) using two-channel ($\pi\pi$ and $K\bar{K}$) effective range parametrization, find a (qualitatively) unique solution from 550 MeV to 1900 MeV. After having reached 180° near the $K\bar{K}$ threshold, inelasticity sets in and δ_0^0 continues to rise through 270° near 1200 MeV, reaching about 400° at 1900 MeV (HYAMS 73). (Note, however, that a two-channel analysis may no longer be adequate at the highest energies).

Independent evidence for the correctness of this ("down") solution comes from experiments on $\pi^0\pi^0$ scattering (APEL 72, SKUJA 73, BRAUN 73). They observe a wide $\pi^0\pi^0$ enhancement at ~ 800 MeV which is much better described by the "down" solution than the "up" solution. Furthermore, indirect information from elastic $\pi\pi$ scattering in the crossed channel (ELVEKJAER 72, NIELSEN 72) is compatible with the "down" but not with the "up" solution.

It is clear that the behavior of δ_0^0 is much too complicated to allow a description in terms of one or several Breit-Wigner resonances. We therefore list the positions of the poles of the T matrix, found by searching in the complex energy plane, using the best-fit parameters of the K-matrix or M-matrix. The best fit of PROTOPOPESCU 73 obtains two poles on the second sheet, the $S^*(993)$ and the $\epsilon(600)$. The $S^*(993)$ is connected with the rapid variation of δ_0^0 near the $K\bar{K}$ threshold discussed above, and is also responsible for the large $K\bar{K}$ I = 0 S-wave scattering length. The $\epsilon(600)$ pole is very far from the real axis and therefore much less certain; it is inferred from the large size and slow variation of the S-wave amplitude between 600 and 900 MeV, but PROTOPOPESCU 73 can fit this behavior also without an ϵ pole. HYAMS 73 region". This includes the $S^*(993)$ and two new poles at energies (1049 + 250i) MeV and (1537 + 233i) MeV. In addition HYAMS 73 find 9 unspecified distant poles. Thus they confirm that the $\epsilon(600)$ pole (or poles) is far from the real axis. This agrees also with BASDEVANT 72, who present a set of $\pi\pi$ amplitudes consistent with crossing, unitarity, and analyticity and with the $\pi\pi$ phase shifts up to 1100 MeV; their amplitude has a very wide ϵ ($\Gamma >$ 650 MeV).

We list the S^* parameters separately under S-wave I = 0 $K\bar{K}$ interactions.

For a recent review see BASDEVANT 73 and GRAYER 74.

14 REAL PART OF POLE POSITION (MEV)

M	(650.0)	OR LESS	BASDEVANT 72 RVUE	SHEET 2		1/73
M	660.0	100.0	PROTOPOPE 73 HBC	SHEET 2	7. PI+P	1/74*

14 NEGATIVE IMAG. PART OF POLE POSITION (MEV)
CORRESPONDS TO HALF WIDTH, NOT FULL WIDTH.

W	(325.0)	OR MORE	BASDEVANT 72 RVUE		1/73
W	320.0	70.0	PROTOPOPE 73 HBC	7. PI+ P	1/74*

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 + TRIPP (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,GOODEN,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 +MURPAY,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)
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.PAPER BASDEVANT,BONNIER,+ (PARIS VI +GLAS+NORD)
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.O.SHUSTER (SACL)
SKUJA 73 PRL 31 653 +WAHLIG,RISSER,PRIPSTEIN,NELSON,+ (LBL)
VILLET 73 PREPRINT +DAVID,AYED,BAREYRE,BORGEEAUD,+ (SACL)

GRAYER 74 CERN PREPRINT +HYAMS,JONES,BLUM,DIETL (CERN+MPIM)

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ρ(770)

9 RHO (770, JPG = 1-+) I=1

9 RHO MASS (MEV)

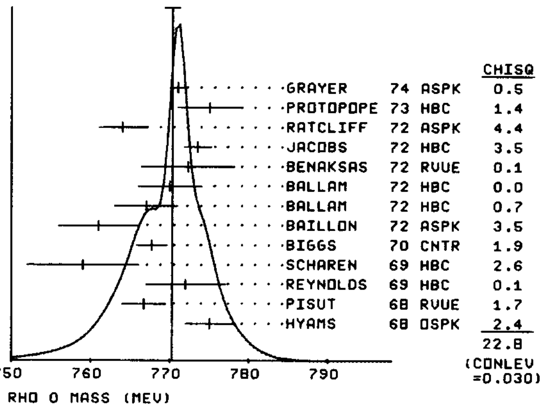
M WE NO LONGER LIST S-WAVE BREIT-WIGNER FITS, PBAR P DATA WITH HIGH
M COMBINATORIAL BACKGROUND, AND INSIGNIFICANT OR DOUBTFUL DATA.

M 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 ONLY
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.) (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 X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
M . . . .
M AVG 765.9 2.2 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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 5/68
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 X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
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 C12630 (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 0 17 PI-P,N PI+PI- 1/74*
MO H FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
MO C 32000 775.0 4.0 PROTOPOPE 73 HBC 0 7.1 PI+P,TCUT.4 2/74*
MO (777.1) (0.5) ROOS 73 RVUE 0 PHASE SHIFTS 2/74*
MO 771. 1. GRAYER 74 ASPK 0 17 PI-P,N PI+PI- 2/74*
MO . . . .
MO AVG 770.32 0.91 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 770.32 ± 0.91
ERROR SCALED BY 1.4



M ----------NOTES----------

M C FROM POLE EXTRAPOLATION
M R INCLUDED IN PISUT 68 RVUE
M B INCLUDED IN BENAKSAS 72 REVUE VALUE
M P FROM PHOTOPRODUCTION, MODEL DEPENDENT.
M Z ERRORS INCREASED BY US. SEE TYPED NOTE ON K* MASS.

9 (RHO0) - (RHO+-) MASS DIFFERENCE (MEV)

D 2.4 2.1 PISUT 68 RVUE PI N TO RHO N 6/68

9 RHO WIDTH (MEV)

W SEE NOTE ON RHO MASS 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 X SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
W . . . .
W AVG 147.6 3.5 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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 X     SYSTEMATIC ERRORS ADDED CORRESP. TO SPREAD OF DIFFERENT FITS.
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  C12630   (131.0)                BATON      70 HBC     0 2.8 PI- P          1/71
WO      140K  146.1     2.9         BIGGS      70 CNTR    OPHOTOPRODUCTION     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    0 2.9-4.7 GAMMA P    2/74*
WO   H       (152.)    (2.)         HYAMS      73 ASPK    0 17 PI-P,N PI+PI-   1/74*
WO   H    FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
WO C   32000  160.0    10.0         PROTOPOPE  73 HBC     0 7.1 PI+P,TCUT.4    2/74*
WO           (150.3)   (1.0)        ROOS       73 RVUE    0 PHASE SHIFTS       2/74*
WO            161.      4.          GRAYER     74 ASPK    0 17 PI-P,N PI+PI-   2/74*
WO            . . . . . . . . .
WO   AVG      150.4     2.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                               (SEE IDEOGRAM BELOW )
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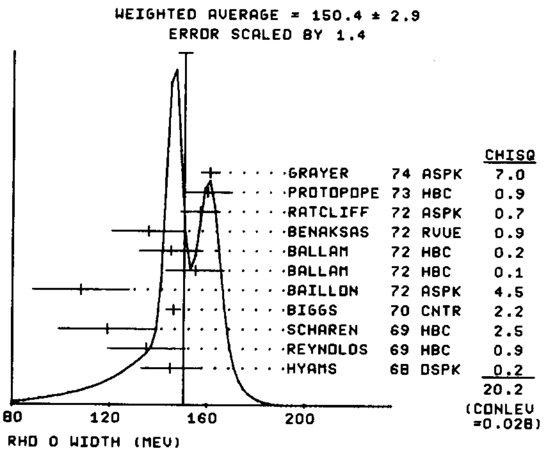


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W        ----------NOTES----------

W    C   FROM POLE EXTRAPOLATION
W    R   INCLUDED IN PISUT 68 RVUE
W    B   INCLUDED IN BENAKSAS 72 REVUE VALUE
W    P   FROM PHOTOPRODUCTION, MODEL DEPENDENT.
W   Z    ERRORS INCREASED BY US. SEE TYPED NOTE ON K* MASS.

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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       RHOO INTO PI+ PI- PIO (VIOLATES G)               139+ 139+ 134

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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                          (P3)/(P1)
R2   M        (0.02) OR LESS           LANZEROTT 65 CNTR      GAMMA P(BREMS)  11/66
R2            (0.005)OR LESS  CL=.97   FIDECARO  66 OSPK  -                   10/66
R2            (0.007)OR LESS           HUSON     66 HLBC  -  15 PI-PB          6/66
R2   M        (0.002)OR LESS  CL=.90   GERMAN CO 69 HBC
R2   M         ONE PION EXCHANGE MODEL USED IN THIS ESTIMATION
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Note on $\rho^0 \to e^+e^-$

Extraction of a ratio for $\rho^0 \to e^+e^-$ is complicated by interference with ω^0 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 we use at present, for the average, only the values from the $e^+e^- \to \pi^+\pi^-$ experiments.

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R3      RHO INTO(E+ E-)/(PI+PI-) (UNITS 10**-4)              (P4)/(P1)
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)

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 NOTE UNDER RHO INTO E+E- 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)

R6      RHO 0 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

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REFERENCES FOR RHO


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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 + (OXF+PADO)
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 PR  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+PIDDIFORD+     (CERN+BIRM)
HERTZBAC 67 PR 155  1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
    ALSO 65 ZDANIS
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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,KOPELMAN,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 PRL 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)
ROOS 73 PREPRINT 63 M.ROOS (HELSINKI)

GRAYER 74 NP G.GRAYER,HYAMS,BLUM,DIETL,+ (CERN+MPIM)

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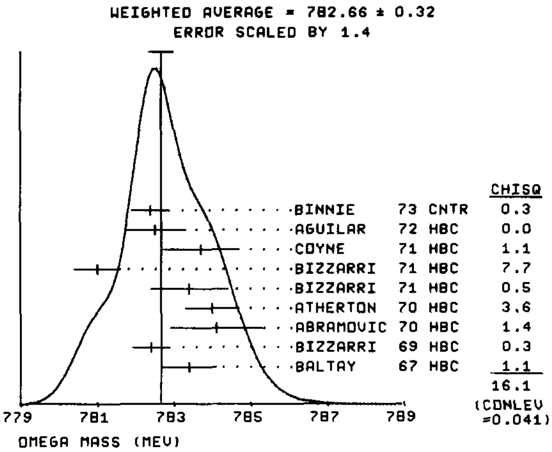
ω(783)

1 OMEGA (783,JPG=1--) I=0

1 OMEGA MASS (MEV)

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		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			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	B	10000	782.4	0.5	BINNIE	73	CNTR	PI-P, OMEGA N	1/74*
M	B	OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM							
M									
M			. . . .						
M	AVG		782.66	0.32	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)				
				(SEE IDEOGRAM BELOW)					



1 OMEGA FULL WIDTH (MEV)

W		34	9.0	3.0	ARMENTERO	63	HBC	0.0 PBAR P	
W			13.4	2.0	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	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	10000	10.2	0.6	BINNIE	73	CNTR	PI-P, OMEGA N	1/74*
W	B	OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. MASS RESOL.=4.8 MEV FWHM							
W			. . . .						
W	AVG		9.98	0.38	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				

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 (ONLY NEUTRAL INPUT TO FIT)	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 $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, 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 1	.8999+-.0056		
P 2	-.5698	.0130+-.0027	
P 3	-.8760	.1028	.0872+-.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	FIT		0.0969	0.0057	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)					

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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           (0.013)                   PURNS     73 HBC       .6-1.1 PBAR P     1/74*
R2            . . . . . . . . .
R2 AVG        0.0259   0.0049  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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            0.079    0.012           BINNIE    73 CNTR    PI-P, OMEGA N       1/74*
R3            . . . . . . . . .
R3 AVG        0.0863   0.0093  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3 FIT        0.0969   0.0057 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R4      OMEGA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)            (P4)/(P1)
R4           (0.05) OR LESS            FLATTE    66 HBC       1.8 K-P           9/66

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            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

R8      OMEGA INTO (ETA PIO + ETA GAMMA)/(PI+ PI- PIO)   (P9+P6)/(P1)
R8           (0.017)OR LESS            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       0.0955   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)

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 FIT       0.0872   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           . . . . . . . . .
R15 AVG       0.0102   0.0019  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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 PIO 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 (PIO 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        PIO GAMMA AS THE ONLY NEUTRAL DECAY.                              11/71

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REFERENCES FOR OMEGA


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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+NAL)
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.PRCC153    +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)

BINNIE    73  AIX CONF.PAPER      +CARR,DEBENHAM,DUANE,GARBUTT,+  (LOIC+SHMP)
BURNS     73 PR D 7 1310          +CONDON,KIM,MANDELKERN,PRICE,SCHULTZ  (UCI)

ROOS      74  PREPRINT 72         M.ROOS,J.ROUSKU                  (HELSINKI)
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M(940) →MM

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            66  M(940)

                EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.

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                66  M(940) MASS  (MEV)

M   N     55  940.5       1.7          CHESHIRE  72 MMS   0 2.4 PI- P,N MM    12/72
M   N     NOT SEEN BY BINNIE 72 AT THRESHOLD.
M   N     NOT SEEN BY BINNIE 74 AT 2 GEV/C                                    2/74*

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                66  M(940) WIDTH  (MEV)

W   N     55  (10.4)  OR LESS  CL=.90  CHESHIRE  72 MMS   0 2.4 PI- P,N MM    12/72

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                66  M(940) BRANCHING RATIOS

R1       M(940) INTO (NEUTRAL)/(TWO-CHARGE)/(FOUR-CHARGE)
R1              0.12      0.86      0.02  CHESHIRE  72 MMS   0 2.4 PI- P,N MM  12/72

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                      REFERENCES FOR M(940)

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)

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M(953) $\rightarrow \gamma\pi^+\pi^-$ $\not\rightarrow \gamma\rho^0$

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59  M (953,JPG=  +)

               WHILE MASS AND WIDTH ARE CONSISTENT WITH THOSE OF
               THE ETA PRIME(958), THE (PI+ PI- GAMMA) DECAY DOES
 NOT SHOW A RHOO SIGNAL, UNLIKE THE ETA PRIME. THIS IS TAKEN AS EVIDENCE
 FOR A NEW PARTICLE. WHILE THIS DIFFERENCE IN DALITZ PLOT DISTRIBUTIONS
 APPEARS SIGNIFICANT, IT STILL NEEDS FURTHER CONFIRMATION TO BE REGARDED
 AS WELL ESTABLISHED. POSSIBLY SEEN IN MMS .
               OMITTED FROM TABLE.

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                  59  M MASS (MEV)

M       68  953.0      2.0            AGUILAR   70 HBC     3.9-4.6K-P,P K-M  1/71
M   M     (953.4)    (1.5)    (3.8)  MAGLICH   71 MMS     3.8 P D,HE3 XO    2/72
M   M   MISSING MASS SPECTRUM SHOWED THIS PEAK AT 953.4 INSTEAD OF
M   M   ETA PRIME (958).  PEAK LISTED UNDER M BECAUSE OF MASS
M   M   COINCIDENCE.  THE 1.5 MEV ERROR MAY BE UNDERESTIMATED BY
M   M   A FACTOR OF 2 (SEE BRODY 72, TABLE III).  OBSERVED PEAK COULD
M   M   THEN WELL CORRESPOND TO ETA PRIME.

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                  59  M WIDTH (MEV)

W       68  (10.0)  OR LESS  CL=.95  AGUILAR   70 HBC     3.9-4.6K-P,P K-M  1/71
W   M       (15.)   OR LESS          MAGLICH   71 MMS     3.8 P D,HE3 XO    2/72

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                  59  M PARTIAL DECAY MODES

                                                  DECAY MASSES
P1     M INTO PI+ PI- GAMMA                       139+ 139+   0
P2     M INTO RHOO GAMMA                          770+   0
P3     M INTO PI+ PI- ETA                         139+ 139+ 548
P4     M INTO PIO ETA                             134+ 548
P5     M INTO PI+ PI- PIO                         139+ 139+ 134

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                  59  M BRANCHING RATIOS

R1     M INTO (RHOO GAMMA)/(ALL PI+ PI- GAMMA)         (P2)/(P1)
R1      58     0.05     0.1         AGUILAR   70 HBC    3.9-4.6K-P,P K-M  1/71

R2     M INTO (PI+ PI- GAMMA)/(PI+ PI- ETA NEUTR.)      (P1)/(P3N)
R2      58     1.2      0.3         AGUILAR   70 HBC    3.9-4.6K-P,P K-M  1/71

R3     M INTO (PI+ PI- PIO)/TOTAL                       (P5)
R3      58     NOT OBSERVED         AGUILAR   70 HBC    3.9-4.6K-P,P K-M  1/71

R4     M INTO (PIO ETA NEUTR.)/TOTAL                    (P4N)
R4      58     NOT OBSERVED         AGUILAR   70 HBC    3.9-4.6K-P,P K-M  1/71

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                      REFERENCES FOR M

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)
BRODY    72 UPR-3E.SUBM.TO PR +GROVES,NOREM,CVIJANOVICH,+(PENN+RUTG+UPNJ)

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$\eta'(958)$

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    2  ETA PRIME (958,JPG=0-+) I=0

       KNOWN ALSO AS XO

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                  2  ETA PRIME MASS (MEV)

M   O   ONLY EXPERIMENTS GIVING ERROR LESS THAN 3 MEV KEPT FOR AVERAGING    12/72
M        85 (957.0)                  DAUBER    64 HBC     1.95 K-P
M   K       (958.0)    (1.0)         KALBFLEIS 64 HBC     2.7 K-P            6/66
M   K        KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
M   O       (957.0)    (3.0)         BADIER    65 HBC     3.0 K-P
M         8  960.0      2.0          TRILLING  65 HBC     3.65 PI+ P         9/66
M   O     7 (955.0)   (10.0)         COHN      66 DBC     3.3 PI+D           6/66
M   O       (959.0)    (3.0)         LONDON    66 HBC     2.2 K-P            6/66
M   O       (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            956.0      2.0          AGUILAR   70 HBC    3.9-4.6K-P          1/71
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      957.59     0.24    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  2  ETA PRIME WIDTH (MEV)

W        85   (4.0)  OR LESS         DAUBER    64 HBC     1.95 K-P
W   K         (7.0)  OR LESS         KALBFLEIS 64 HBC     2.7 K-P            6/66
W   K         KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
W            (30.0)  OR LESS         BADIER    65 HBC     3.0 K-P
W            (15.0)  OR LESS         LONDON    66 HBC     2.2 K-P            6/66
W            (10.)   OR LESS         RITTENBER 69 HBC     1.7-2.7 K- P
W            (20.0)  OR LESS         AGUILAR   70 HBC    3.9-4.6K-P          1/71
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*

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                  2  ETA PRIME PARTIAL DECAY MODES
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                                                        DECAY MASSES
P1     ETA PRIME INTO PI+ PI- ETA                       139+ 139+ 548
                 P1(N)  ETAS DECAY INTO ALL NEUTRALS
                 P1(C)  ETAS DECAY CHARGED
P2     ETA PRIME INTO PIO PIO ETA                       134+ 134+ 548
                 P2(N)  ETAS DECAY INTO ALL NEUTRALS
                 P2(C)  ETAS DECAY CHARGED
P3     ETA PRIME INTO PI+ PI- GAMMA                     139+ 139+   0
                 (INCLUDING RHO GAMMA)
P4     ETA PRIME INTO GAMMA GAMMA                         0+   0
P6     ETA PRIME INTO RHOO GAMMA                          0+ 770
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 PIO E+ E- (VIOLATES C IN          134+  .5+  .5
                                    BORN APPRCX.)
P17    ETA PRIME INTO ETA E+ E- (VIOLATES C IN          548+  .5+  .5
                                    BORN APPROX.)
P18    ETA PRIME INTO PIO RHO 0 (VIOLATES C)            134+ 770
P19    ETA PRIME INTO PIO OMEGA (VIOLATES C)            134+ 782
P20    ETA PRIME INTO GAMMA OMEGA                         0+ 782

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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 .4620+-.0230
P 2   -.4811    .2445+-.0207
P 3   -.5979      -.4059    .2741+-.0224
P 4    .1285      -.1991      -.0788    .0194+-.0029

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                  2  ETA PRIME BRANCHING RATIOS                          .
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Note on η' (958) Branching Fractions

In our calculation of the branching fractions of the η' (958) we assume the decay modes $\eta\pi\pi$ (including $\eta\pi^0\pi^0$, 71% of the η's have neutral decays), $\rho^0\gamma$, and $\gamma\gamma$.

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 = 1.9 ± 0.2.

```
R1      ETA PRIME INTO (PI+ PI-ETA (NEUTRAL DEC.))/TOTAL (PIN)
R1  K   68   (0.36)   (0.05)        KALBFLE2  64 HBC      2.7 K-P           10/66
R1  K          KALBFLEISCH2 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       0.328    0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

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  FIT       0.399    0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

R3      ETA PRIME INTO (PI+ PI- ETA (CHRGD.DECAY))/TOTAL (PIC)
R3  K   44   (0.12)   (0.02)        KALBFLE2  64 HBC      2.7 K-P           10/66
R3  K          KALBFLEISCH2 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  FIT       0.1335   0.0066 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R4      ETA PRIME INTO (PI+ PI- NEUTRALS (EXCLUDING        (P2C)
R4          PI+ PI- ETA (NEUTR.DEC.))) / TOTAL
R4  K   10   (0.05)   (0.04)        KALBFLE2  64 HBC      2.7 K-P           10/66
R4  K          KALBFLEISCH2 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       0.0707   0.0060 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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          KALBFLEISCH2 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  FIT       0.193    0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

Mesons

$\eta'(958)$


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R6     ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL
R6                                                        (P3)
R6  K   42   (0.22)   (0.04)          KALBFLE2  64 HBC      2.7 K-P          10/66
R6  K           KALBFLEISCH2 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  FIT       0.274    0.022  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R7     ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/(PI PI ETA)
R7                                                        (P3)/(P1+P2)
R7            0.25     0.14           DAUBER    64 HBC      1.95 K-P         10/66
R7           . . . . . . . . . .
R7  FIT       0.388    0.044  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)


R8     ETA PRIME INTO (PIO 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 (PIO RHOO)/TOTAL                        (P18)
R10         (0.04) OR LESS            RITTENBER 65 HBC                2.7 K-P   10/66

R11    ETA PRIME INTO (PIO OMEGA + GAMMA OMEGA)/TOTAL    (P19+P20)
P11         (0.08) OR LESS            RITTENBER 65 HBC                2.7 K-P   10/66

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

R16    ETA PRIME INTO (6 PI)/TOTAL                            (P15)
R16          (0.01) OR LESS           LONDON    66 HBC      COMPILATION      10/66

R18    ETA PRIME INTO (RHOO GAMMA)/(PI PI ETA)                (P6)/(P1+P2)
R18           0.31     0.15           DAVIS     68 HBC      5.5 K- P          9/68
R18          . . . . . . . . . .
R18 FIT       0.388    0.044  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)


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 S   41   (0.017)  (0.004)          BASILE2   71 CNTR     1.6 PI- P,N XO   12/72
R19 S   SUPERSEDED BY DALPIAZ 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          . . . . . . . . . .
R19 AVG       0.0181   0.0030  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 FIT       0.0194   0.0029 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-PIO)/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-PIO)/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      (P16+...)
R24         (0.01) OR LESS            RITTENBER 69 HBC       1.7-2.7 K-P       9/69


R25    ETA PRIME INTO (RHOO 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          . . . . . . . . . .
R25 AVG       1.082    0.077   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R26    ETA PRIME INTO (PIO PIO ETA INTO 3 PIO)/TOTAL    (P2N(3PIO))
R26      4    0.11     0.06           BENSINGER 70 DBC      2.2 PI+ D         1/71
R26          . . . . . . . . . .
R26 FIT       0.0734   0.0062 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)


R27-   ETA PRIME INTO (PI+ PI- GAMMA)/(PI+ PI- ETA(NEUTRAL DEC.))
R27                                                      (P3)/(P1N)
R27             0.54     0.10           AGUILAR   72 HBC     3.9,4.6 K- P     12/72
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            . . . . . . . . . .
R27 AVG         0.74     0.16   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
R27 FIT         0.834    0.099  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)
                         (SEE IDEOGRAM BELOW )

R28    ETA PRIME INTO (2 GAMMA)/(PIO PIO 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         0.112    0.021  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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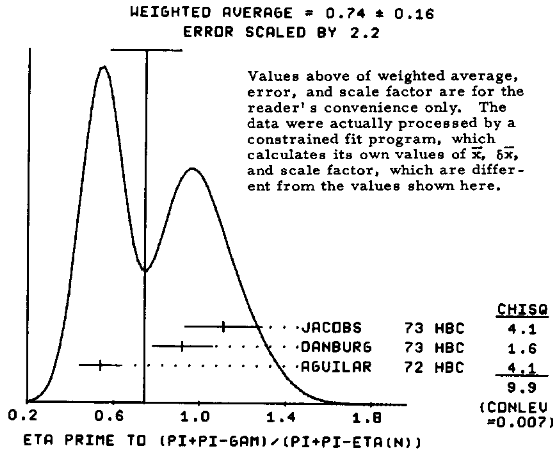

Note on the J^P Assignment of $\eta'(958)$

From the Dalitz plot analyses of the $\eta' \to \pi\pi\eta$ and $\eta' \to \pi^+\pi^-\gamma$ decays, and from the observation of a $\eta' \to \gamma\gamma$ 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. On the other hand, the observation of KALBFLEISCH 73 of an anisotropy in the decays of very forward produced η' would imply J = 2, if confirmed; although the effect is seen in the largest single data sample available (the BNL-University of Michigan experiment with ~ 1400 η' decays from the reaction $K^- p \to \Lambda\eta'$ at 2.2 GeV/c), its statistical significance is only ~ 3 standard deviations.

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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+ZEEM)
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 25 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

DUANE     74 PRL 32 425          +BINNIE,CAMILLERI,CARR,DEBENHAM+(LOIC+SHMP)
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δ(970) →ηπ,···

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36  DELTA(970,JPG=0+-) I=1
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Under this entry, we list three types of I = 1 peaks near $K\bar{K}$ threshold.

1) Missing-mass peaks, some of them controversial.
2) $\eta\pi$ decays, peaking slightly below $K\bar{K}$ threshold. This defines $I^G = 1^-$ and J^P = Normal.
3) Threshold enhancements in the $(K\bar{K})^{\pm}$ system with I = 1. The Q value is low and J^P therefore probably 0^+.

In listing them together under a common entry we do not imply that they are necessarily all related. However, the $K\bar{K}$ threshold enhancement may be due to a virtual bound state that could also be responsible for the $\eta\pi$ peaks (ASTIER 67). More complete studies of the mass dependence of the $K\bar{K}$ threshold effect, using coupled channel analysis, are needed to clarify this question.

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                   36  DELTA(970) MASS  (MEV)

M  PEAKS SEEN IN MISSING MASS EXPERIMENTS
M   K  262 (962.0)    (5.0)             KIENZLE   65 MMS   -  3-5 PI- P        9/66
M   K   NOT SEEN BY BANNER1 67 (1.8 PI- P)
M   O       (966.0)   (8.0)             OOSTENS   66 MMS   +  3.8 PP TO D + MM  9/66
M   O   NOT SEEN BY BANNER2 67 AND ANDERSON 71
M            975.0     6.0              ABOLINS   70 MMS   +  3.8-6.3 PP--D+MM  1/71
M   N  215 (962.9)    (1.7)             CHESHIRE  72 MMS   0 2.4 PI- P,N MM   12/72
M   N   NOT SEEN BY BINNIE 72 AT THRESHOLD.
M   N   NOT SEEN BY BINNIE 74 AT 2 GEV/C

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  3/69
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 DO PI    2/72
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          . . . . . . . . . .
M   AVG     976.4      5.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M  K KBAR ONLY, SEE THE TYPED NOTE ABOVE
M      143(1003.3)     7.0+SYSTEMATIC ROSENFELD 65 RVUE +-                  . 8/66
M           SCAT. LENGTH 2 TO 6 FERMIS.BALTAY    66 HBC      3.7 PBAR P      8/66
M   A  100(1016.)     (10.)             ASTIER    67 HBC  +-  0 PBAR P      . 7/67
M   A   SCATT.LENGTH ALSO FITS, SEE BELOW
M       SCATT.LENGTH +2.5 +-1. FERMI  ASTIER    67 HBC  +-  0-1.2 PBAR P     7/67
M       OR CMPLX, RE PART=-2.3 F      ......    .. ...  ..  ..... .... .     7/67
M                  IM PART=.5F OR LESS ......   .. ...  ..  ..... .... .     7/67
M   B         (1.8)      (0.4)      (0.3)  DUBOC     72 HBC     1.2 PBAR P,3PI2K 12/72
M   B  ABSOLUTE VALUE OF SCAT.LENGTH                                        12/72

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                   36  DELTA(970) WIDTH  (MEV)

W  PEAKS SEEN IN MISSING MASS EXPERIMENTS
W   S  262   (5.0)  OR LESS             KIENZLE   65 MMS   -  3-5 PI- P        9/66
W   S       (10.0)  OR LESS             OOSTENS   66 MMS   +  3.8 PP TO D + MM  9/66
W            60.0     16.0      10.0    ABOLINS   70 MMS   +  3.8-6.3 PP--D+MM  1/71
W   S  215   (5.9)  OR LESS  CL=.90     CHESHIRE  72 MMS   0 2.4 PI- P,N MM   12/72
W   S   SEE NOTES ON DELTA MASS ABOVE

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  3/69
W       20  (50.0)  OR LESS             BARNES    69 HBC   -  4-5 K-P,PI-ETA   9/69
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          . . . . . . . . . .
W   AVG     46.9      11.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W  K KBAR ONLY, SEE THE TYPED NOTE ABOVE
W      143  (57.0)    13.0+SYSTEMATIC ROSENFELD 65 RVUE +-                   8/66
W   A  100  (25.) APPROX.               ASTIER    67 HBC  +- SEE NOTE A ABOVE  9/67

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                   36  DELTA(970) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      DELTA(970)   INTO ETA PI                       548+ 134
P2      DELTA(970)   INTO 3 PI
P3      DELTA(970)   INTO RHO PI                       770+ 134
P4   S  DELTA(970)   INTO K KBAR                       770+ 134
P4   S   SEE THE TYPED NOTE ABOVE                      770+ 134

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                   36  DELTA(970) BRANCHING RATIOS

R1      DELTA(970)   INTO (RHO PI)/(ETA PI)                (P3)/(P2)
R1          (0.25) OR LESS  CL=.70   AMMAR      70 HBC  +- 4.1,5.5K-,ETA PI. 5/70

R10     CHARGED DELTA OF KIENZLE 65 INTO (1 CHARGED)/(3 OR MORE CHARGED)
R10          1.3        0.9        0.7   KIENZLE   65 MMS   -  3-5 PI- P       9/66

R11     DELTA OF CHESHIRE 72 INTO (NEUTRAL)/(TWO-CHARGE)/(FOUR-CHARGE)
R11         (0.10)    (0.82)    (0.08) CHESHIRE  72 MMS   0 2.4 PI- P,N MM   12/72

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                         REFERENCES FOR DELTA

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 GOODEN,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 258 619        +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,+           (COEF+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.PAPER   +KEY,+   (TNTO+RHEL+BNL+LBL+ROCH+SLAC+WISC)

BINNIE   74 PRL 32 392        +CAMILLERI,CARR,DEBENHAM,+       (LOIC+SHMP)

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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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S*(993)

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 3  S* (993,JPG=0++) I=0

WE ONLY LIST DETERMINATIONS OF POLE POSITION.
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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Under this entry we list parameters of the S^* pole in the isoscalar S wave. [Possible evidence of D-wave $\pi\pi$ interactions in the S^* region is listed separately under $\eta_N(1080)$].

As noted under the entry ϵ ("S-wave $\pi\pi$ Interactions"), near the beginning of these Meson Data Card

Listings, the S^* is associated with a very rapid drop in the $\pi\pi$ S-wave elasticity. The inelastic channel responsible for this drop is $\pi\pi \rightarrow K\overline{K}$. Thus the $K\overline{K}$ isoscalar S-wave scattering length comes out very large, and the reason is the strong coupling of the $S^*(993)$ to the $K\overline{K}$ system.

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                     3  REAL PART OF THE S* POLE POSITION (MEV)

M  H        970.      30.      130.    HOANG      69 OSPK    4. PI-P,KS KS N    1/73
M  H        920.      80.       90.    HOANG      69 OSPK    5. PI-P,KS KS N    1/73
M  H     CALCULATED FROM SCATTERING LENGTH FIT OF HOANG 69.
M  B       (965.)                      BEUSCH     70 OSPK    4,6 PI-P         . 1/73
M  B     CALCULATED FROM SCATTERING LENGTH FIT OF BEUSCH 70.
M          (996.0)                     BASDEVANT 72 RVUE    SHEET 2            1/73
M           997.       6.              PROTOPOPE 73 HBC     SHEET 2 7. PI+ P   1/74*
M  S        987.       7.              BINNIE     73 CNTR    PI- P,S* N         1/74*
M  S     OBSERVED BY THRESHOLD-CROSSING TECHNIQUE. POSSIBLY IMPORTANT
M  S     S-CHANNEL EFFECTS.
M          1007.      20.              HYAMS      73 ASPK  0 17 PI-P,N PI+PI-   1/74*
M           . . . . . . . . . .
M   AVG     993.2      4.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                     3  NEGATIVE IMAG. PART OF THE S* POLE POSITION  (MEV)
                    CORRESPONDS TO HALF-WIDTH, NOT FULL WIDTH.

W  H         40.      40.       60.    HOANG      69 OSPK    4. PI-P,KS KS N    1/73
W  H         30.      30.       70.    HOANG      69 OSPK    5. PI-P,KS KS N    1/73
W  B        (13.)                      BEUSCH     70 OSPK    4,6 PI-P           1/73
W           (65.0)                     BASDEVANT 72 RVUE                       1/73
W  P         27.       8.              PROTOPOPE 73 HBC     7. PI+ P           1/74*
W  P     ANOTHER SOLUTION HAS 52 MEV AND NO EPSILON POLE.
W  S         24.       7.              BINNIE     73 CNTR    PI- P,S* N         1/74*
W            15.       5.              HYAMS      73 ASPK  0 17 PI-P,N PI+PI-   1/74*
W            . . . . . . . . . .
W   AVG      20.0      3.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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REFERENCES FOR S*


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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)
FUJII     73 NC 13 A 311          Y.FUJII,M.KATO                      (TOKYO)
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)
PROTOPOP  73 PR D 7 1280          PROTOPOPESCU,GARNJOST,GALTIERI,FLATTE+(LBL)
VILLET    73  PREPRINT            +DAVID,AYED,BAREYRE,BORGEEAUD,+      (SACL)

GRAYER    74 CERN PREPRINT        +HYAMS,JONES,BLUM,DIETL         (CERN+MPIM)
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ϕ(1019)

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                4  PHI (1019,JPG=1-- ) I=0

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                4  PHI MASS (MEV)

M          1019.0      2.0              SCHLEIN    63 HBC    2.0 K- P          .
M          1018.6      0.5              MILLER D   65 HBC      0.0 PBAR P    8/66
M          1020.0      2.0              LONDON     66 HBC      2.2 K-P       6/66
M          1021.5      0.8              ABRAMS     67 HBC    4.2 K- P       11/67
M          1019.       3.               BARLOW     67 HBC      1.2 PBAR P   11/66
M          1021.0      4.0              DAHL       67 HBC      1-4 PI- P     9/66
M      165 1022.       1.5              MOSTEK     68 OSPK   1.8 GAMMA + C   6/68
M          1018.       0.5       0.35   HYAMS      70 OSPK   11. PI- P       6/70
M          1021.0      1.5              ALVENSLE   71 OSPK   GAMMA+C         1/72
M          1019.9      0.6              DIBIANCA   71 DBC    4.93 K- N       1/72
M      410(1019.9)    (0.3)             STOTTLEMY  71 HBC    2.9 K-P,Y K KBAR 11/71
M      120 1019.6      0.3              AGUILAR    72 HBC    3.9,4.6 K- P   12/72
M      100 1019.9      0.4              AGUILAR    72 HBC    3.9,4.6 K- P   12/72
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          . . . . . . . . . .
M   AVG    1019.69     0.28    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                       (SEE IDEOGRAM BELOW )
```
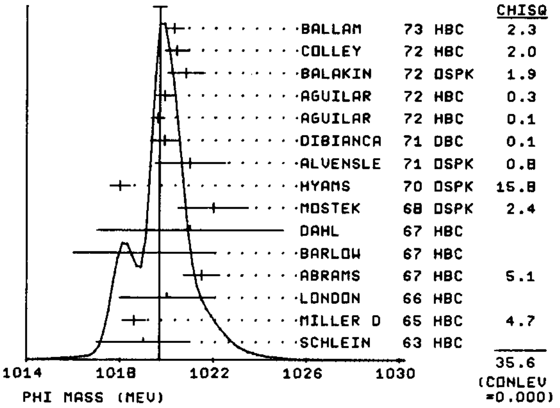

WEIGHTED AVERAGE = 1019.69 ± 0.28
ERROR SCALED BY 1.9



<u>FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS</u>

The matrix below is derived from the error matrix for the fitted partial decay mode branching fractions, P_i, as follows: The <u>diagonal</u> elements are $P_i \pm \delta P_i$, where $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, while the <u>off-diagonal</u> elements are the <u>normalized</u> 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.

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        P 1         P 2        P 3        P 4
P 1  .4659+-.0252
P 2   -.7434   .3458+-.0225
P 3   -.4493     -.1047  .1580+-.0155
P 4   -.1444     -.1976     -.1687  .0304+-.0107


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                4  PHI BRANCHING RATIOS                                        .

R1      PHI INTO (K+ K-)/TOTAL                          (P1)
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  C        (0.493)   (0.044)        BIZOT      70 OSPK   E+ E- COLL.BEAMS 11/71
R1  C SUPERSEDED BY CHATELUS 71                                             11/71
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            . . . . . . . . . .
R1  AVG       0.507     0.022    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT       0.466     0.025   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R2      PHI INTO (KL KS)/TOTAL                          (P2)
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            . . . . . . . . . .
R2  AVG       0.325     0.071    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)
R2  FIT       0.346     0.022   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

R3      PHI INTO (PI+ PI- PIO (INCL.RHO PI))/TOTAL      (P3)
R3      30    0.12      0.08          LINDSEY    66 HBC      2.7 K-P       .10/66
R3            . . . . . . . . . .
R3  FIT       0.158     0.015   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  FIT       0.426     0.027   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

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            . . . . . . . . . .
R6  FIT       0.195     0.023   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            0.69      0.14          BIZOT1     70 OSPK   E+ E- COLL.BEAM   1/71
R7            0.47      0.06          COSME 1    74 OSPK   E+E- COLL.BEAMS   2/74*
R7            . . . . . . . . . .
R7  AVG       0.504     0.080    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R7  FIT       0.457     0.056   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

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)
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Data Card Listings

For notation, see key at front of Listings.


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R11     PHI INTO (ETA GAMMA)/TOTAL                         (P4)
R11           (0.2)  OR LESS          BADIER    65 HBC      3.0 K-P            10/66
R11           (0.08) OR LESS          LINDSEY   66 HBC      2.7 K-P            10/66
R11      27    0.073    0.019         BASILE    72 CNTR    1.8 PI- P           12/72
R11      25    0.026    0.007         BENAKSAS2 72 OSPK    E+E- COLL.BEAMS .  2/73
R11           . . . . . . . . . .
R11 AVG        0.032    0.015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R11 FIT        0.030    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

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*

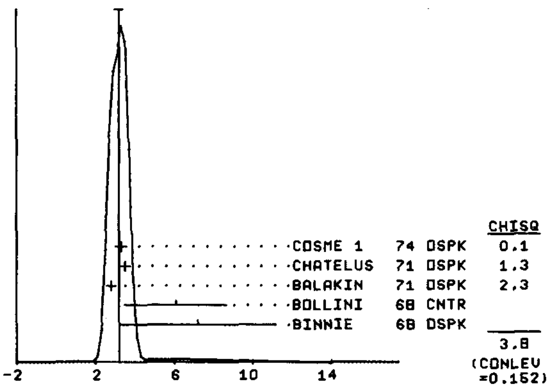
R13     PHI INTO (ETA NEUTRALS)/(K KBAR)                   (P13)/(P1+P2)
R13           (0.15) OR LESS          LINDSEY   66 HBC      2.7 K-P            10/66

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 C         (3.45)   (0.27)         BIZOT     70 OSPK    E+ E- COLL.BEAMS 11/71
R16 C SUPERSEDED BY CHATELUS 71                                                 11/71
R16            2.81     0.25          BALAKIN   71 OSPK     E+ E- COLL.BEAM 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           . . . . . . . . . .
R16 AVG        3.19     0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                               (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 3.19 ± 0.21
ERROR SCALED BY 1.4



PHI INTO E+E- (UNITS 10**-4)

```
4   PHI WIDTH (MEV)

W             3.5       1.0                 MILLER D   65 HBC     0.0 PBAR P      . 8/66
W             6.0       4.0                 LONDON     66 HBC     2.2 K-P           6/66
W             1.8       3.0       1.5       ABRAMS     67 HBC    4.2 K- P          11/67
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             3.3       1.5       0.9       HYAMS      70 OSPK   11. PI- P          6/70
W             4.67      0.42                BALAKIN    71 OSPK    E+ E- COLL.BEAM 11/71
W             5.5       1.3       1.1       DIBIANCA   71 DBC    4.93 K- N          1/72
W      110   (4.5)     (3.0)     (4.0)      STOTTLEMY  71 HBC    2.9 K-P,Y K KBAR 11/71
W      120    4.6       1.0       0.8       AGUILAR    72 HBC    3.9,4.6 K- P      12/72
W      100    4.7       1.3       1.0       AGUILAR    72 HBC    3.9,4.6 K- P      12/72
W      131    5.0       1.3                 COLLEY     72 HBC    10.K+ P,K+ P PHI 12/72
W      100    3.8       0.9                 BALLAM     73 HBC    2.8 - 9.3 G P      1/74*
W             3.81      0.37                COSME 2    74 OSPK   E+E- COLL.BEAMS    2/74*
W            . . . . . . . . . .
W    AVG      4.16      0.18    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)                  782+   0
P11     PHI INTO ETA PIO (VIOLATES C)                      548+ 134
P12     PHI INTO RHO GAMMA (VIOLATES C)                    770+   0
P13     PHI INTO ETA NEUTRALS
P14     PHI INTO 5PI

R17     PHI INTO (PIO GAMMA)/(TOTAL)                   (P7)
R17            (.0035)OR LESS         BEMPORAD  69 CNTR    5.5 GAMMA N      7/69
R17      7   (0.0025) (0.0012)        BENAKSAS2 72 OSPK   E+E- COLL. BEAMS   2/73

R18     PHI INTO (PI+ PI-)/(TOTAL) (UNITS 10**-4)       (P8)
R18      (SEE ALSO R8)
R18      (500.)   OR LESS              LINDSEY2  65 HBC     1.7-2.7 K-P     .
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.BEAM  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          . . . . . . . . . .
R19 AVG        0.97      0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R19 FIT        0.742     0.083  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7)

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        0.339     0.045  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R21     PHI INTO (2PI+ 2PI- PIO)/(K+ K-)
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+ZEEM)
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
LINDSEY2 65 UCRL 16526         JAMES S. LINDSEY (THESIS)              (LRL)
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 248 349         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 278 106         +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)
BALAKIN  69  IYAF 327 TRANS    +BUDKER,KORSHUNOV,MISHNEV,SIDOROV+   (NOVO)
    ALSO 69 SIDOROV
BEMPORAD 69 PL 29 B 383        +BRACCINI,CASTALDI,LUBELSMEYER,+(PISA+BONN)
MOY      69  THESIS            KEN MIN MOY       (NORTHEASTERN UNIVERSITY)
SCOTTER  69 NC 62 A 1057       +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)
SIDOROV  69 LIVERPOOL SYMP.ON FLECTRONS+PHOTONS,P.227, SIDOROV      (NOVO)

BALAKIN  70  PREPRINT          +BUTLER,PAKHTUSOVA,SIDOROV,SKRINSKY,+(NOVO)
BIZOT    70 PL 32 416          +BUON,CHATELUS,JEANJEAN,LALANNE,+    (ORSA)
    ALSO 69 PEREZ-Y-JORBA, LIVERPOOL SYMP.69
BIZOT1   70  PRIV.COMM.        PEREZ-Y-JORBA                        (ORSA)
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)
HAYES    71 PR D 4 899         +IMLAY,JOSEPH,KEIZER,STEIN           (CORN)
STOTTLEM 71  THESIS            A.R.STOTTLEMYER                  (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)
BENAKSAS272 PL 42 B 511        +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+(ORSAY)
COLLEY   72 NP B 50 1          +JOBES,RIDDIFORD,GRIFFITHS,+    (BIRM+GLAS)

BALLAM   73 PR D 7 3150        +CHADWICK,EISENBERG,BINGHAM,+    (SLAC+LBL)

COSME 1  74 PL 48 B 155        +JEAN-MARIE,JULLIAN,LAPLANCHE,+     (ORSAY)
COSME 2  74 PL 48 B 159        +JEAN-MARIE,JULLIAN,LAPLANCHE,+     (ORSAY)
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M(1033) →MM

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67 M(1033)

EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.

67  M(1033) MASS  (MEV)

M  N     240 1032.6       2.3            GARFINKEL 72 MMS   0 2.4 PI- P,N MM     1/74*
M  N     NOT SEEN BY BINNIE 74 AT 2 GEV/C.

67  M(1033) WIDTH  (MEV)

W       240    16.2       4.8       7.5   GARFINKEL 72 MMS   0 2.4 PI- P,N MM   12/72

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REFERENCES FOR M(1033)


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GARFINKE 72 PRL 29 1477        GARFINKEL,HOFFMAN,JACOBEL,+ (PURD+ANL+IOWA)
BINNIE   74 PRL 32 392         +CAMILLERI,CARR,DEBENHAM,+        (LOIC+SHMP)
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$B_1(1040)$ $\to\omega\pi$

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48  B1(1040)  IG=1+

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
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                    48  B1(1040) MASS (MEV)

M    S    (1040.)                   DEFOIX     73 HBC   +- 0.7 PBAR P,7 PI    1/74*
M    S  SEEN IN DECAY OF A2 INTO B1 PI. NOT SEEN BY DIAZ 74.
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                    48  B1(1040) WIDTH (MEV)

W    S     (55.)                    DEFOIX     73 HBC   +- 0.7 PBAR P,7 PI    1/74*
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                    48  B1(1040) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     B1(1040) INTO OMEGA PI                            139+ 782
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                    REFERENCES FOR B1(1040)

DEFOIX    73 PL 43 B 141        +DOBRZYNSKI,ESPIGAT,NASCIMENTO,+      (CDEF)
DIAZ      74 PRL 32 260         +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)
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$\eta_N(1080)$ $\to\pi\pi$

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30  ETA N (1080, JPG=N +) I=0 J GREATER THAN 1
    SOME EXPERIMENTS SUGGEST J=2.

    OMITTED FROM TABLE
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Note on $\pi^+\pi^-$ Peaks Called $\eta_N(1080)$

The $\eta_N(1080)$ is seen in $\pi^-p\to\pi^+\pi^-n$ predominantly at backward decay angles, $\cos\theta < -0.75$. OH 70 state that this "bump is almost certainly the result of P-D interference."

Note that the selection made in some HBC experiments to reduce the background under the $\eta_N(1080)$ in the reaction $\pi^-p\to\pi^+\pi^-n$ may lead to a sample of events ambiguous with $\pi^-p\to p\pi^-\pi^0\pi^0$. This is so because selection on small momentum transfer to the $\pi^+\pi^-$ system, together with large $\pi^-_{in}\pi^-_{out}$ scattering angle, leads to rather high lab momenta of the π^+, so that ionization cannot be used to discriminate between the two hypotheses (BATON 70, footnote, p. 525; and private communications from G. Laurens).

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                    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)
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                    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)

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                    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)
BATON     70 PL 33 B 528        +LAURENS,ZEIGNIER                    (SACLAY)
CLAYTON   70 NP B 22 85         +MASON,MUIRHEAD,RIGOPOULOS,+      (LIVP+ATEN)
DIAZ      70 NP B 16 239        +GAVILLET,LABROSSE,MONTANET,+     (CERN+COEF)
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)
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$A_1(1100)$

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10  A1(1100, JPG=1+-) I=1
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The $A_1\to\rho\pi$ bump has been mainly observed in the diffraction-like process $\pi N\to(\pi\pi\pi)N$ without quantum number exchange and at small momentum transfer. There are also observations of structure in the A_1 mass region in reactions with production of additional mesons, in backward production from pions, and in $\bar{p}p$ annihilations (see Data Card Listings).

The dominant effect in the A_1 mass region is a broad $J^P=1^+\rho\pi$ S-wave enhancement starting from $\rho\pi$ threshold; it has a maximum at ~ 1100 MeV and a width of the order of 300 MeV. In partial-wave analyses of the three-pion system (ASCOLI 72, ANTIPOV1 73), one finds very little phase variation of the $J^P=1^+(\ell=0)\rho\pi$ amplitude relative to various other ("background") amplitudes. Though not completely model-independent, these results suggest that at most a small part of the A_1 enhancement corresponds to a $J^P=1^+$ resonance. In fact ASCOLI1 73 show that the observed behavior of the partial waves of the $\pi\pi\pi$ system is qualitatively reproduced by a Reggeized pion exchange model (so-called Deck model). Complete solution of the A_1 problem will probably come from partial-wave analyses of the 3π system from non-diffractive reactions.

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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
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     T   (1150.)                    ANTIPOV1  73 CNTR -  25.,40. PI- P        1/74*
M     T  MASS AND WIDTH SEEN TO DEPEND ON T, UNIQUE DET. IMPOSSIBLE            1/74*
M
M    PRODUCED BY PIONS,BACKWARDS SCATT.
M         (1115.0)   (20.0)          ANDERSON  69 MMS  -  16 PI- P,BACKW9     8/69
M         (1046.)    (10.)           BUHL      71 HBC  - 2.5 PI- P           .11/71
M
M    PRODUCED BY PBARS, SEE TYPED NOTE.
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-, SEE TYPED NOTE.
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+, SEE TYPED NOTE.
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 AND TYPED NOTE.
M    A
M    A       AVERAGING NOT MEANINGFUL

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                    10  A1 WIDTH (MEV)

W   PRODUCED BY PIONS, RESONANCE INTERP. CONFUSED BY DECK EFFECT
W
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      FOR JP=1+ (RHO PI) STATE                                         11/71
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   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
W   PRODUCED BY PIONS,BACKWARDS SCATT.
W         (98.0)    (45.0)   (20.0)   ANDERSON  69 MMS  -  16 PI- P,BACKW9   8/69
W
W   PRODUCED BY PBARS, SEE TYPED NOTE.
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-, SEE TYPED NOTE.
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+, SEE TYPED NOTE.
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 AND TYPED NOTE.
W         (130.0)   (20.0)            BERLINGHI 69 HBC  + 0 12.7 K+ P        9/69
W  A
W  A      AVERAGING NOT MEANINGFUL

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                    10  A1 PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      A1 INTO RHO PI                                         770+ 139
P2      A1 INTO KBAR K                                         493+ 497
P3      A1 INTO ETA PI                                         548+ 139
P4      A1 INTO ETA PRIME PI                                   957+ 139
P5      A1 INTO 3 PI                                           139+ 139+ 139

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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,FORINO,CARTACCI,+ (BARI+BGNA+FIRZ)
BRANDENB 70 NP B16 369           +BRENNER,IOFFREDO,JOHNSON,KIM+        (HARVARD)
CASO     70 LNC 3  707           +CORDS,COSTA+       (GENO+DESY+HAMB+MILA+SACL)
    ALSO 68 CASO
CRENNELL 70 PRL 24 781           +KARSHON,LAI,SCARR,SIMS                    (BNL)
CHIEN1   70  TORONTO PREPRINT    +CHAO,JOHNSTON,PRENTICE,WALKER   (TNTO+WISC)
CHIEN2   70  JHU 7011            C.Y.CHIEN                      (JOHNS HOPKINS)
GARELICK 70 PHILAD.CONF.P.205    D.A.GARELICK,REVIEW              (NORTHEASTERN)
RABIN    70 PRL 24 925           +GALTIERI,DERENZO,FLATTE,FRIEDMAN+         (LRL)
SHIH     70  BNL 14059-REV       +YOUNG                                     (BNL)

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)
BUHL     71  PREPRINT            +CLINE,TERREL                       (WISCONSIN)
LAMSA    71  PREPRINT            +EZELL,GAIDOS,WILLMANN                    (PURD)  JP
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.         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 PRL 31 795           +CHAPIN,CUTLER,HOLLOWAY,KOESTER,KRUSE+(ILL)
ASCOLI 2 73 PR D 8 3894          +JONES,WEINSTEIN,WYLD                     (ILL)  JP
ATHERTON 73 PL 43 B 249          +FRANEK,FRENCH,GHIDINI,HILPERT,+         (CERN)
READ     73 NP B 64 511          B.J.READ                                 (DESY)

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M(1150) →MM

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68  M(1150)

EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.

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                    68  M(1150) MASS  (MEV)

M       65 1148.3      3.3              JACOBEL   72 MMS   0 2.4 PI- P,N MM   12/72

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                    68  M(1150)  WIDTH  (MEV)

W       65   15.0      9.0      11.7    JACOBEL   72 MMS   0 2.4 PI- P,N MM   12/72

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                        REFERENCES FOR M(1150)

JACOBEL  72 PRL 29 671          +GARFINKEL,HOFFMAN,+          (IOWA+PURD+ANL)

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$A_{1.5}(1170)$ →3π

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44  A 1.5 (1170, JPG=  -) I=1

THIS ENTRY LISTS REFERENCES TO PEAKS OF LOW STATISTI-
CAL SIGNIFICANCE IN THE 3 PI SYSTEM BETWEEN THE A1 AND
THE A2. OMITTED FROM TABLE.

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                        REFERENCES FOR A 1.5

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)
MORSE    72 NP B 43 77        +OH,WALKER,JOHNSTON,YOON            (WISC+TNTO)

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B(1235)

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11  B (1235,JPG=1++) I=1

FOR A POSSIBLE JP=1- STATE  IN THIS MASS REGION
SEE ENTRY RHO PRIME(1250).

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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        25(1250.)   ESTIMATED         LEE       67 HBC  -   3.6 PI- P         1/68
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    B  300(1245.)   (10.)             BIZZARRI  69 HBC  +-  0 PBAR P         12/72
M    B   SUPERSEDED BY FRENKIEL 72
M            1240.0   20.0             ANDERSON  70 CNTR   0 5-18 GAMMA P     11/70
M    C     (1265.0)  (19.0)            CASO      70 HBC   - 11.2PI-P           2/73
M    C   SUPERSEDED BY AFZAL 73
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    \     (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            . . . . . . . . . .
M   AVG      1236.8    5.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                           (SEE IDEOGRAM BELOW )
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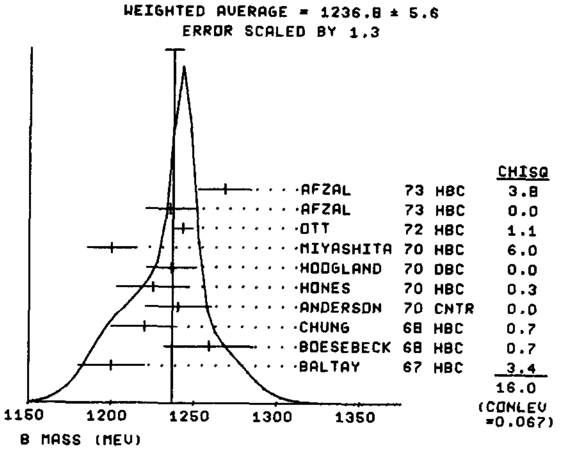


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                 11  B WIDTH (MEV)

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,4PI
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                HOOGLAND   70 DBC  -  3.0 K- D         2/71
W            113.0       44.0                MIYASHITA  70 HBC  -  6.7 PI-P,4PI
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            . . . . . . . . . .
W   AVG      118.3       8.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 11  B PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      B INTO OMEGA+PI                                       782+ 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+1019
P6      B INTO ETA PI (FORBIDDEN BY G)                        548+ 139
P7      B INTO K KBAR PI                                      493+ 493+ 139

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                 11  B BRANCHING RATIOS

R10     D/S RATIO FOR B(1235) INTO OMEGA PI
R10
R10           0.21       0.07               CHUNG      73 HBC  +  7.1 PI+P         1/74*
R10           0.3        0.1                CHALOUPKA 74 HBC   -  3.9-7.5 PI-P     1/74*
R10           . . . . . . . . . .
R10 AVG       0.240      0.057    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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)+- PIO) / (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

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                             REFERENCES FOR B

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)
HOOGLAND 70 PL 33 B 631       SABRE COLLABOR.  (ZEEM+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,_ILLESTOL,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)
CHUNG    73 PL 47 B 526       +PROTOPOPESCU,LYNCH,FLATTE,+ (BNL+LBL+UCSC)  JP
COHEN    73 PR D 8 23         +FERBEL,SLATTERY                  (ROCHESTER)

CHALOUPK 74 PL                CHALOUPKA,FERRANDO,ALITTI,+     (CERN+SACL)  JP
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ρ'(1250)

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69  RHO PRIME(1250,JPG=1-+) I=1

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
FOR A REVIEW THROUGH 1972, SEE BRAMON 73

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                 69  RHO PRIME(1250) MASS  (MEV)

M          1256.    10.                FRENKIEL  72 HBC  +- 0.PBARP,OMEGA2PI  1/74*

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                 69  RHO PRIME(1250) WIDTH  (MEV)

W          130.     20.                FRENKIEL  72 HBC  +- 0.PBARP,OMEGA2PI  1/74*

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                   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)
BALLAM   73  SLAC-PUB-1364     +CHADWICK,BINGHAM,FRETTER,+ (SLAC+LBL+MPIM)
BRAMON   73 LNC 8 659          A.BRAMON                          (FRASCATI)
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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 PIO 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+D    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    H     (1279.)      (3.)          HYAMS     73 ASPK  0 17 PI-P,N PI+PI-   1/74*
M    H    FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
M           1258.        4.           GRAYER    74 ASPK  0 17 PI-P,N PI+PI-   2/74*
M
M   E     EVIDENCE FOR A STRUCTURE CLAIMED                               12/72
M   T     ERROR INCREASED BY US. SEE TYPED NOTE ON K* MASS.
M           . . . . . . . . . .
M    AVG    1267.2       2.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                                 (SEE IDEOGRAM BELOW )
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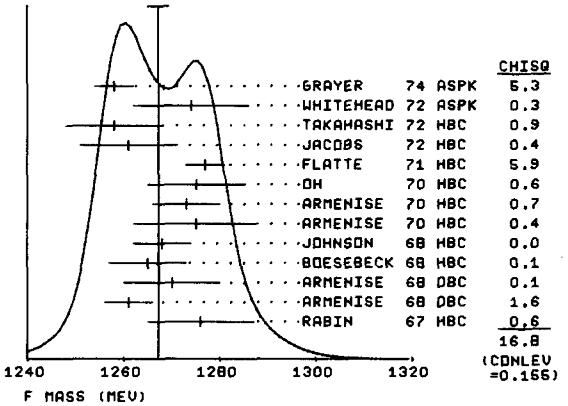
WEIGHTED AVERAGE = 1267.2 ± 2.2
ERROR SCALED BY 1.2

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                     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 PIO 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+D  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    H        (202.)    (6.)         HYAMS     73 ASPK  0 17 PI-P,N PI+PI-  1/74*
W    H   FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
W              192.      9.          GRAYER    74 ASPK  0 17 PI-P,N PI+PI-  2/74*
W
W   E    EVIDENCE FOR A STRUCTURE CLAIMED                                  12/72
W   T    ERROR INCREASED BY US. SEE TYPED NOTE ON K* MASS.
W           . . . . . . . . .
W    AVG       172.5     8.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                       (SEE IDEOGRAM BELOW )
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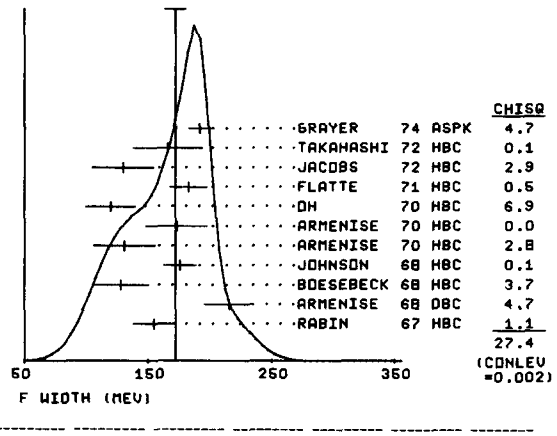
WEIGHTED AVERAGE = 172.5 ± 8.4
ERROR SCALED BY 1.7

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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 K KBAR                                497+ 497
P4      F INTO K KBAR PI                             497+ 497+ 139
P5      F INTO ETA PI PI                             548+ 139+ 139

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                     5  F BRANCHING RATIOS

R10     F PARTIAL WAVE (I.E. I=1, JP=2+) AMPLITUDE AT F RESONANCE
R10         WE TABULATE X = 1/2 (1 + ETA).  THIS SHOULD BE PI PI FRACTION
R10         FOR PURE BW WITH NO BACKGROUND.
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
R10            0.84      0.02          HYAMS     73 ASPK  0 17 PI-P,N PI+PI-  1/74*
R10          . . . . . . . . .
R10 AVG        0.834     0.017    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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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
R1    D  CORRECTED BY O.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 FO    1/74*
R1            (0.033)OR LESS  C.L.=.90 BUGG      73 DBC     8. PI+N,P FO    1/74*
R1     285     0.065     0.010     0.017 LOUIE     74 HBC     3.9 PI- P       1/74*
R1           . . . . . . . . .
R1   AVG       0.0439    0.0057   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      F INTO (K KBAR)/(PI PI)                             (P3)/(P1)
R2          DETERMINATION DIFFICULT BECAUSE PROXIMITY OF A2 WHICH HAS SAME
R2          NEUTRAL (K KBAR) MODES. SINCE INTERFERENCE MAY BE CONSTRUCTIVE
R2          OR DESTRUCTIVE, EVEN UPPER LIMITS ARE DUBIOUS.
R2      SOME UPPER LIMITS (X OR LESS) HAVE BEEN PUNCHED AS (0 +-X)
R2          (0.00)    (0.09)               BARMIN    65 HLBC     2.8 PI-         2/73
R2          (0.00)    (0.16)               WANGLER   65 HBC      3.0 PI-P        2/73
R2           PROBABLY SEEN                 BARLOW    67 HBC     1.2 PBAR P--K1K1 11/66
R2          (0.047)   (0.012)+ SYST.       BEUSCH    67 OSPK    5,7,12 PI-P    . 9/67
R2     D     0.05      0.05                DAHL      67 HBC      1.6-4.2 PI- P  10/66
R2     D     CORRECTED BY O.DAHL                                              11/71
R2   A      (0.031)   (0.012)              ADERHOLZ  69 HBC      8 PI+ P,K+K-PI-  8/69
R2   A       K+K- PEAK IS AT ABOUT 1260 MEV WHILE (KKBAR)+ PEAKS AT 1320.
R2   A       ALSO (CROSSSECTION*BRANCHING RATIO) FOR A2 IS SMALL.
R2          (0.06)    (0.02)               OH        70 HBC     1.26 PI- P,P F   1/73
R2 L        (0.07) OR LESS  CL=.95         AGUILAR   72 HBC     3.9,4.6 K- P    12/72
R2 L         0.0       0.04                LIMIT ABOVE RESTATED FOR AVERAGING   12/72
R2 L    SMALL (CROSS SECTION*BRANCHING RATIO) FOR A2                           12/72
R2           0.13      0.05                BISWAS    72 HBC     18.5 PI+- P      1/73
R2          (0.02) OR LESS  CL=.85         WHITEHEAD 72 ASPK    3.1-3.6 PI- P   12/72
R2           0.03      0.02                TOET      73 HBC     5 PI+P,P PI+ FO  1/74*
R2         . . . . . . . . .
R2   AVG     0.036     0.025   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                      (SEE IDEOGRAM BELOW )
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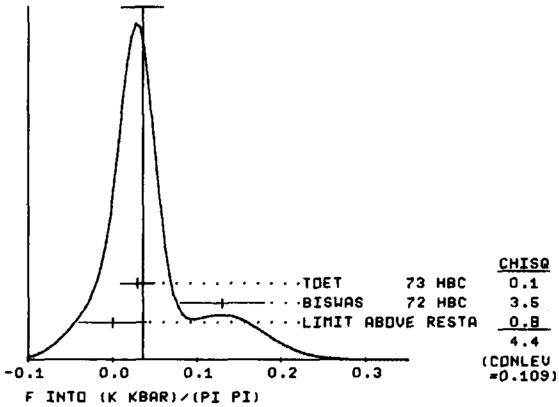
WEIGHTED AVERAGE = 0.036 ± 0.025
ERROR SCALED BY 1.5

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R3      F INTO (KO K- PI+ AND C.C.)/(PI PI)                 (P4)/(P1)
R3           (0.07) OR LESS  CL=.95   AGUILAR   72 HBC      3.9,4.6 K- P     12/72

R4      F  INTO (ETA PI PI)/(PI PI)                         (P5)/(P1)
R4           (0.19) OR LESS  CL=.95   AGUILAR   72 HBC      3.9,4.6 K- P     12/72

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REFERENCES FOR F


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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)
    ALSO  63BONDAR, LEE 64, DERADO 65, EISNER 67
LAMSA     68 PR 166 1395        +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
    ALSO 67 POIRIER
WHITEHEA  68 NC 53A 817         +MCEWEN,OTT,AITKEN+         (AERE+SHMP+LOUC)
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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)

GRAYER   74 NP                 G.GRAYER,HYAMS,BLUM,DIETL,+      (CERN+MPIM)
LOUIE    74 PL                 +ALITTI,GANDOIS,MALLET,+         (SACL+CERN)
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D(1285)

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           8  D (1285,JPG=  +) I=0

           (JP=0-,1+,2- WITH 1+ FAVORED.)
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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 1296.      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          . . . . . . . . . .
M   AVG     1286.1     2.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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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          . . . . . . . . . .
W   AVG     20.6      9.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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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+ 770
P3      D INTO ETA PI PI                                548+ 134+ 134
P4      D INTO DELTA PI                                 976+ 134
P5      D INTO 2PI+ 2PI-                                139+ 139+ 139+ 139

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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(970)).
R2         . . . . . . . . . .
R2  AVG      0.173     0.039   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

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

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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)
DOBRZYNS 71  PRIV.COMMUN.      L.DOBRZYNSKI                     (CERN+CDEF)
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)
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A_2(1310)

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12  A2 (1310,JPG=2+-) I=1
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We list the A_2 as an ordinary Breit-Wigner resonance. For discussion of the reported splitting see our April 72 and April 73 editions.

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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
M       130(1310.0)                 FORINO    65 DBC  + 0 4.5 PI+ D      10/66
M      1425 1290.0     (5.0)        LEFEBVRES 65 MMSP  -  5.6,6.0 PI-P    1/73
M          (1300.0)                 SEIDLITZ  65 DBC   -  3.2 PI-D        6/66
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        6/66
M      1060 1286.      (8.)         LEVRAT    66 MMS   -   6-7 PI- P      1/73
M      4000 1307.      16.          CHIKOVANI 67 MMS   -  7 PI- P         8/67
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-GA 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           1335.0     15.0         DIAZ      70 HBC  +- 0. PBAR P, 4 PI  5/70
M  D       (1330.0)   (15.0)        GARFINKEL 70 DBC   -  4.5 K-D,LAMBDA  1/71
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
M  O   ONLY EXPERIMENTS GIVING ERROR LESS THAN 20 MEV KEPT FOR AVERAGING  12/72
M  D   MAY BE DIFFERENT OBJECT, ALTHOUGH JPC=2++. COMPARE CRENNELL 69.
M  A   ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AND/OR A1
M  P   FROM A FIT TO JP=2+ RHO PI
M          . . . . . . . . . .
M  AVG      1308.5      1.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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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       12(1315.0)                       ADERHOLZ  69 HBC  +   8 PI+ P,K+K0     8/69
MK      132 1301.0      7.0               ALSTON-GA 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
MK  N   THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
MK S    SYSTEMATIC ERROR IN MASS SCALE SUBTRACTED
MK         . . . . . . . . . .
MK  AVG     1315.0      3.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                             (SEE IDEOGRAM BELOW )
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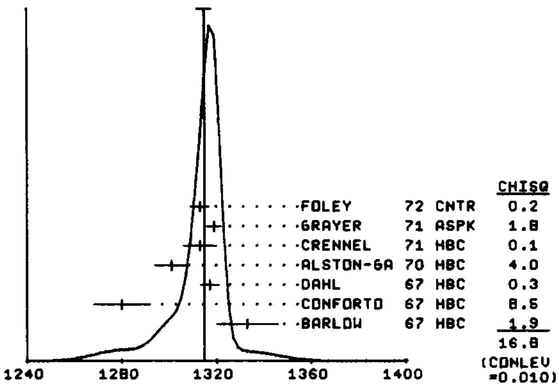
WEIGHTED AVERAGE = 1316.0 ± 3.1
ERROR SCALED BY 1.7



A2 MASS (MEV), K KBAR MODE

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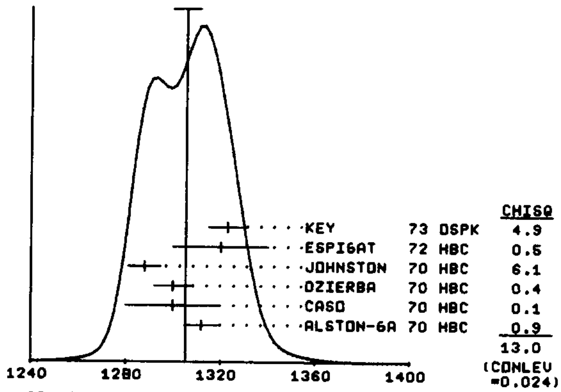
                 12  A2 MASS (MEV),  ETA PI MODE

M      189 1312.0      7.0          ALSTON-GA 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 1288.       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     1000 1323.       8.           KEY       73 OSPK -  6.PI-P,P PI-ETA    1/74*
M    M 6200(1324.)    (8.)          CONFORTO  73 OSPK -  6.PI-P,P MMS-      1/74*
M    M   MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA
M          . . . . . . . . .
M    AVG   1305.3      5.8    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                      (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 1305.3 ± 5.8
ERROR SCALED BY 1.6



A2 MASS (MEV) , ETA PI MODE

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                 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
W     1425   99.0    (15.0)               LEFEBVRES 65 MMSP  -  6.0 PI-P          1/73
W          (140.0)                        SEIDLITZ  65 DBC   -  3.2 PI-D          6/66
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         1/67
W     1060   98.      (5.)                LEVRAT    66 MMS   -  6,7 PI- P         1/73
W     4000   90.      15.                 CHIKOVANI 67 MMS   -  7 PI- P           8/67
W      260   96.0     16.0                ARMENISE  68 DBC    0 5.1 PI+D          9/67
W  O   120  (56.)    (21.)                BOESEBECK 68 HBC    0 8 PI+ P           1/73
W  O        (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            90.0     10.0      50.0      ANDERSON  69 MMS   -  16 PI- P,BACKW9   8/69
W  AE 241 (164.0)    (20.0)               ARMENISE  69 DBC  +   5.1 PI+D,3PI++-   5/70
W  O        (80.0)   (30.0)               EISENBERG 69 HBC  +  4.3,5.3 GAMMA P   12/69
W      941   79.0     12.0                ALSTON-GA 70 HBC  +  7.0 PI+P,3PI P     1/71
W  O   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  O        (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  O   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
W  O   ONLY EXPERIMENTS GIVING ERROR LESS THAN 20 MEV KEPT FOR AVERAGING   12/72
W  E   BACKGROUND SUBTRACTION MODEL-DEPENDENT.                              5/70
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  P   FROM A FIT TO JP=2+ RHO PI
W             . . . . . . . . .
W  AVG       99.7      2.4    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
```
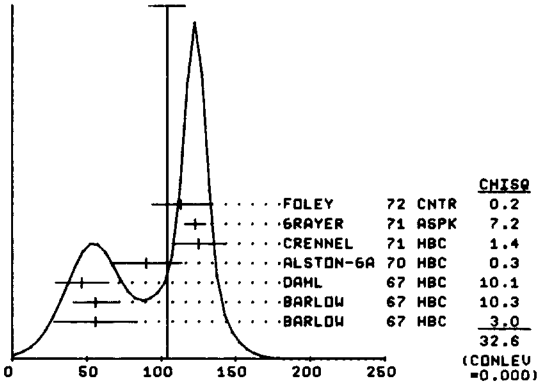

```
                 12  A2 WIDTH (MEV), K KBAR MODE

WK       60   56.0     28.0                BARLOW    67 HBC  +-  1.2 PBAR P, KK    9/67
WK       80   56.0     15.0                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       12  (34.0)                        ADERHOLZ  69 HBC  +   8 PI+ P,K+K0      8/69
WK      132   90.0     24.0                ALSTON-GA 70 HBC  +  7.0 PI+P,K+KS P    1/71
WK      190  125.0     19.0     16.0       CRENNEL   71 HBC   - 4.5 PI- P,KSK-P  11/71
WK     1500  123.0      7.0                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  N   THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
WK          . . . . . . . . .
WK  AVG     104.2      12.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
                         (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 104.2 ± 12.1
ERROR SCALED BY 2.3



A2 WIDTH (MEV), K KBAR MODE

```
                 12  A2 WIDTH (MEV), ETA PI MODE

W       189  103.0     20.0                ALSTON-GA 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   M   MISSING MASS WITH ENRICHED MMS=ETA PI-, ETA = 2 GAMMA
W   T   ERROR INCREASED BY US. SEE TYPED NOTE ON K* MASS.
W           . . . . . . . . .
W   AVG      108.1      7.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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```
                 12  A2 PARTIAL DECAY MODES

                                                             DECAY MASSES
P1       A2 INTO RHO PI                                     770+ 139
P2       A2 INTO K KBAR                                     493+ 497
P3       A2 INTO ETA PI                                     548+ 139
P4       A2 INTO OMEGA PI PI                                139+ 139+ 782
P5 S     A2 INTO PI+ PI- PI0 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                               957+ 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 $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$, 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 .7155+-.0175
P 2   -.0742   .0469+-.0058
P 3   -.3361     -.1083   .1518+-.0120
P 4   -.7399     -.1802     -.3072   .0858+-.0177
```

```
                 12  A2 BRANCHING RATIOS

R1      A2 INTO (K KBAR) / (RHO PI)                      (P2)/(P1)
R1          (0.08) OR LESS              LANDER    64 HBC  +   3.5 PI+P         10/66
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  S         (0.14)    (0.05)          BOCKMANN  70 HBC   0 5.0 PI+P          2/74*
R1  S         (0.07)    (0.05)          BOCKMANN  70 HBC  +   5.0 PI+P          2/74*
R1  S    SUPERSEDED BY TOET 73 (SEE R8)
R1             0.06      0.03           ABRAMOVIC 70 HBC  -  3.93 PI- P         1/71
R1  E         (0.024)   (0.006)         DIAZ      70 HBC  +- 0. PBAR P, 4 PI  11/71
R1  E SUPERSEDED BY ESPIGAT 72 (SEE UNDER R2 AND R8)                           11/71
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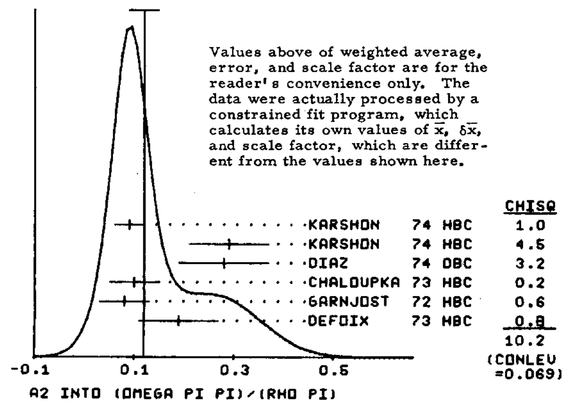
```
R1             0.07      0.03              NEF        70 MMS   -  7.0 PI- P          6/70
R1      113    0.097     0.018             ALSTON-GA 71 HBC   +  7.0 PI+ P          2/71
P1       50    0.056     0.014             CHALOUPKA 73 HBC   -  3.9 PI- P,P A2     2/73
R1            . . . . . . . . . .
R1   AVG       0.0677    0.0089  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1   FIT       0.0655    0.0084 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   FIT       0.166     0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            (0.072)OR LESS               DONALD     68 HBC   +- 1.2 PBAR P         6/68
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-GA 71 HBC   +  7.0 PI+ P          2/71
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            . . . . . . . . . .
R3   AVG       0.221     0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3   FIT       0.212     0.019  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 S           0.02   OR LESS   CL=.97     BARNHAM    71 HBC   +  3.7 PI+ P        . 2/72
R4 S           0.0       0.01              LIMIT ABOVE RESTATED FOR AVERAGING     2/72

R5      A2 INTO (ETA PRIME PI)/(RHO PI)                   (P8)/(P1)
R5   S   14   (0.07)    (0.03)             ASCOLI     68 HBC   -  5.0 PI-P          12/72
R5   S    SUPERSEDED BY EISENSTEIN 73
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-GA 71 HBC   +  7.0 PI+ P          2/71
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       3.24      0.50   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  2/74*
R8            (0.09)    (0.04)             TOET       73 HBC    0 5.PI+P,PI+P K KB  2/74*
R8            . . . . . . . . . .
R8   AVG       0.039     0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   FIT       0.0513    0.0062 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
R11 R     PION EXCHANGE MODEL USED IN THIS ESTIMATION                             11/71

R12     A2 INTO (OMEGA PI PI)/(RHO PI)                    (P4)/(P1)
R12  D         0.19      0.08              DEFOIX     73 HBC    0 0.7 PBAR P,7 PI   1/74*
R12  D    DECAYS TO B1(1040) PI, B1 INTO OMEGA PI .
R12  D    ERROR INCREASED TO ACCOUNT FOR POSSIBLE SYST. ERRORS
R12  D    OF COMPLICATED ANALYSIS.
R12            0.08      0.05              GARNJOST   72 HBC    0 7.1 PI+ P          2/73
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  2/74*
R12  K   60    0.09      0.03              KARSHON    74 HBC   +  4.9 PI+P,P A2+    2/74*
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.
R12           . . . . . . . . . .
R12 AVG        0.120     0.030   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R12 FIT        0.120     0.027  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.120 ± 0.030
ERROR SCALED BY 1.4

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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)
   ALSO  68 LAMSA
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            +BARLOW,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)
   ALSO  67 BARLOW,67 CONFORTO
VETLITSK 69 SJNP 9 596             VETLITSKY,GRIGOREYEV,GRISHIN,+       (ITEP)

ABRAMOVI 70 NP B 29 466            ABRAMOVICH,BLUMENFELD,BRUYANT,+      (CERN)  JP
ALSTON-GA70 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       (PURDUE)JC
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-GA71 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)
DAMGAARD 72  UNPUBLISHED MEMO +LECHANOINE,MARTIN                 (BOHR+GEVA)
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)
GARNJOST 72  PRIV.COMMUNIC.        M.ALSTON-GARNJOST                      (LBL)
GETTNER  72  PREPRINT NUB2145 M.GETTNER                                  (NEAS)
KIENZLE  72  UNPUBLISHED MEMO W.KIENZLE                                  (CERN)
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
BLOODWOR 73  AIX CONF. PAPER       BLOODWORTH,FRIDMAN,JACKSON,PATEL,+  (IPPC)
CASON    73 NP B 64 14             +MADDEN,BISHOP,BISWAS,KENNEY,+         (NDAM)
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CHALOUPK 73 PL 44 B 211       CHALOUPKA,DOBRZYNSKI,FERRANDO,LOSTY,+(CERN)
CONFORTO 73 PL 45 B 154       +MOBLEY,KEY,PERPOST,+    (EFI+NAL+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+NAL+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  PREP.WIS 74/2 PH +MIKENBERG,PTILUCK,EISENBERG,RONAT,+ (REHO)
```


E(1420)

```
6  E (1420,JPG=A +) I=0

BAILLON 67 FAVOR JP=0-. DAHL 67 FAVOR 1+ BUT DO NOT
EXCLUDE 2-, 0-. LORSTAD 69 FIND 0- OR 1+.
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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          . . . . . . . . .
M    AVG   1415.5     4.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
```

```
                  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          . . . . . . . . .
W    AVG     59.8     6.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

```
                  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+ 770
P4    E INTO DELTA PI                                    976+ 139
P5    E INTO ETA PI PI                                   548+ 139+ 139
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```
                  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
```

REFERENCES FOR E


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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)
```


$X_0(1430)$ $\rightarrow K_SK_S, \rho^0\rho^0$

```
29  X (1430,JPG=   ) I=0

EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.
PEAKS SEEN IN (KS KS) SPECTRA QUOTED UNDER
X(1440) (I=1) AS WELL.
```

```
                  29  X(1430) MASS (MEV)

M     -------RHOO RHOO MODE-------
M          (1410.0)               BETTINI   66 DBC     0 0. PBAR N,5 PI    2/74*
M          (1435.)                DEFOIX    73 HBC     0 0. PBAR P,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          . . . . . . . . .
M    AVG   1437.5     5.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

```
                  29  X(1430) WIDTH (MEV)

W     -------RHOO RHOO MODE-------
W          (90.0)                 BETTINI   66 DBC     0 0. PBAR N,5 PI    2/74*
W          (100.)                 DEFOIX    73 HBC     0 0. PBAR P,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          . . . . . . . . .
W    AVG    46.4     17.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

REFERENCES FOR X(1430)


```
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,ASTBU+           (ETHZ+CERN)
DONALD   69 NP B 11 551       +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)
DEFOIX   73  AIX CONF.PAPER   +ESPIGAT,+                      (CDEF+CERN)
```


$X_1(1440)$ $\rightarrow K_SK_S$

```
38  X (1440,JPG=   ) I=1

EVIDENCE NOT COMPELLING.OMITTED FROM TABLE.
PEAKS SEEN IN (KS KS) SPECTRA QUOTED UNDER
X(1430) (I=0) AS WELL.
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```
                  38  X(1440) MASS (MEV)

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)
```

```
                  38  X(1440) WIDTH (MEV)

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)
```

REFERENCES FOR X(1440)


```
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)
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'(1514)

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13  F PRIME (1514,JPG=2++) I=0
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```
                  13  F PRIME MASS (MEV)

M        14(1480.0)               CRENNELL  66 HBC     6.0 PI- P           8/66
M     B   5(1460.)   (10.)        ABRAMS    67 HBC     4.25 K- P           5/67
M     B    BACKGROUND ESTIMATION DIFFICULT.                                5/67
M          1515.0     7.0         AMMAR     67 HBC     5.5 K-P             9/67
M     S  70(1513.0)  (7.0)        BARNES    67 HBC     4.6, 5. K- P       12/72
M     S    SUPERSEDED BY AGUILAR 72
M       100 1519.     7.          AGUILAR   72 HBC     3.9,4.6 K- P       12/72
M        46 1514.     4.          COLLEY    72 HBC     10.K+ P            12/72
M        47 1521.     7.          VIDEAU    72 HBC     4.K- P,L FPRIME    12/72
M          . . . . . . . . .
M    AVG   1516.1     2.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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```
                  13  F PRIME WIDTH (MEV)

W     B   5 (53.)    (18.)        ABRAMS    67 HBC     4.25 K- P           5/67
W     B    BACKGROUND ESTIMATION DIFFICULT.                                5/67
W            35.0    25.0         AMMAR     67 HBC     5.5 K-P             9/67
W     S  70 (87.0)   (15.0)       BARNES    67 HBC     4.6, 5. K- P       12/72
W     S    SUPERSEDED BY AGUILAR 72
W       100  69.     22.          AGUILAR   72 HBC     3.9,4.6 K- P       12/72
W        46  28.     15.          COLLEY    72 HBC     10.K+ P            12/72
W     E  47  40.     20.          VIDEAU    72 HBC     4.K- P,L FPRIME    12/72
W     E    ERROR INCREASED BY US.SEE TYPED NOTE ON K* MASS.               12/72
W          . . . . . . . . .
W    AVG     39.9     9.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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```
                  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
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                  13  F PRIME BRANCHING RATIOS

R1    F PRIME INTO (PI+ PI-)/(K KBAR)                (P1)/(P2)
R1         (0.2)  OR LESS  CL=.67  AMMAR    67 HBC     5.5 K-P             9/67
R1         (0.36) OR LESS  CL=.95  AGUILAR  72 HBC     3.9,4.6 K- P       12/72
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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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                              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)  JP
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)
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$F_1(1540)$ $\to K\bar{K}\pi$

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47  F1 (1540,JPG=   ) I=1

JP = 2-,1+ FAVORED .
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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

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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

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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

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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)
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$\rho'(1600)$ $\to 4\pi$

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65  RHO PRIME(1600,JPG=1-+) I=1
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The ρ' was first seen in

$$\gamma \text{ (real or virtual)} \to \rho'^0 \to \rho^0\pi^+\pi^-$$

with the $\pi^+\pi^-$ pair apparently in an S wave (BINGHAM 72, SILVESTRINI 72, DAVIER 73). Evidence for a 2π decay comes from phase-shift analysis of $\pi^-p \to \pi^-\pi^+n$ data (HYAMS 73). This evidence has been characterized as "plausible, though not yet compelling" (GRAYER 74).

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, ROOS 73). Note also that the mass dependence of the width will be strongly affected by the inelastic channels with their rather high thresholds.

```
                     65  RHO PRIME MASS (MEV)

M        (1600.)   APPROX.          BARBARINO 72 OSPK  0 E+ E- TO 4 PI     1/73
M      400 1430.     50.            BINGHAM   72  HBC  0 9.3 GAM P,P 4PI  12/72
M   S  400(1500.)                   SMADJA    72  HBC  0 9.3 GAM P,P 4PI  12/72
M   S   LATER FITS GIVEN BY BINGHAM 72
M    N    (1620.)    (30.)          DAVIER    73 STRC  0 6-18 G P,P 4PI    1/74*
M    N  FITTED VALUES DEPEND STRONGLY ON ASSUMED SHAPE OF RESONANCE,
M    N  BACKGROUND AND PHASE SPACE
M         1590.      20.            HYAMS     73 ASPK  0 17 PI-P,N PI+PI-  1/74*
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.0)

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                     65  RHO PRIME WIDTH (MEV)

W      400  650.     100.           BINGHAM   72  HBC  0 9.3 GAM P,P 4PI  12/72
W         (350.)   APPROX.          SILVESTRI 72 OSPK  0 E+ E- TO 4 PI     1/73
W   S  400 (600.)                   SMADJA    72  HBC  0 9.3 GAM P,P 4PI  12/72
W   S   EXPTL. FULL WIDTH AT HALF MAX.  LATER FITS GIVEN BY BINGHAM 72
W    N    (310.)     (70.)          DAVIER    73 STRC  0 6-18 G P,P 4PI    1/74*
W    N  SEE NOTE N ABOVE
W   H     (180.)     (50.)          HYAMS     73 ASPK  0 17 PI-P,N PI+PI-  1/74*
W   H   QUESTIONABLE PARAMETRIZATION OF MASS-DEP. WIDTH

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                     65  RHO PRIME PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     RHO PRIME INTO RHO PI PI                         139+ 139+ 770
P2     NEUTRAL RHO PRIME INTO ALL 4 CHARGED PI MODES    139+ 139+ 139+ 139
P3     RHO PRIME INTO RHO RHO                           770+ 770
P4     RHO PRIME INTO PI PI                             139+ 139
P5     RHO PRIME INTO KBAR K                            493+ 493
P6     RHO PRIME INTO PI OMEGA                          139+ 782
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  0 E+E- TO 4 PI      1/73
R1 S         (.80)                  BINGHAM   72  HBC  0 9.3 GAM P,P 4PI   1/73
R1 S       DOMINANT                 DAVIER    72 STRC  0 4.5-18. G P,P4PI  1/73
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  0 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           0.25      0.05          HYAMS     73 ASPK  0 17 PI-P,N PI+PI-  1/74*
R5  E       (0.15) OR LESS           EISENBERG 73 HBC   0 5 PI+ P,DEL++2PI  1/74*
R5  E   ESTIMATED USING OPE MODEL.

R6     RHO PRIME INTO (PI+ PI- PIO PIO)/(4PI, ALL CHARGED)
R6                                                      (P7)/(P2)
R6           (1.)   OR LESS  ESTIMATE DAVIER    73 STRC  0 6-18 G P,P 4PI    1/74*

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                              REFERENCES FOR RHO PRIME

DAVIER    69 SLAC PUB 666       +DERADO, FRIES, LIU, MOZLEY, ODIAN + (SLAC) G

ALVENSLE 71 PRL 26 273          ALVENSLEBEN,BECKER,BERTRAM,CHEN,+(DESY+MIT) G
BRAUN     71 NP B30 213         +FRIDMAN, GERBER, GIVERNAUD,+  (STRASBOURB) G
BULOS     71 PRL 26 149         +BUSZA,KEHOE,BENISTON,+  (SLAC+UMD+IBM+LBL) G
DAVIER    71  CORNELL CONF.PAP  +DERADO,FRIES,LIU,MOZLEY,ODIAN,PARK,+(SLAC)     .

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)
MORTARA   72  COO-1195-249      D.W.MORTARA                             (ILL)
SILVESTR 72  BATAV.CONF.        V.SILVESTRINI RAPPORTEUR TALK     (FRASCATI)
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)
PARK      73 NP B 58 45         J.C.H.PARK                           (MPIM)  JP
ROOS      73  PREPRINT 63       M.ROOS                           (HELSINKI)

GRAYER    74 NP                 G.GRAYER,HYAMS,BLUM,DIETL,+      (CERN+MPIM)
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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 diffraction-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. There appears to be little variation of the $J^P = 2^-$ $f\pi$ phase in the A_3 mass region (ANTIPOV 73, ASCOLI 73). The situation thus resembles that of the A_1 with however some additional complications:

- The A_3 region is not well described by the Deck-like model of ASCOLI2 73.
- THOMPSON 74 have performed a partial-wave analysis of the $\pi^+\pi^+\pi^-$ system from 13 GeV/c $\pi^+p \rightarrow \pi^+\pi^+\pi^-p$. They claim evidence for a rotation of the 2^- $f\pi$ S wave in the Argand diagram.
- ANTIPOV1 73 observe some evidence for an enhancement in the 2^+ $f\pi$ P wave with $M \sim 1.75$ GeV, $\Gamma \sim 200$ MeV. The relative phases are not inconsistent with a resonance interpretation.

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                    34  A3 MASS (MEV)

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
M            1630.       10.            BALTAY     68 HBC  +  7, 8.5 PI+ P       6/68
M            1660.0      16.0           BARTSCH    68 HBC  +  8. PI+ P,3PI P     8/69
M            1610.       19.            LAMSA      68 HBC  -  8.0 PI-P, PI-F    11/67
M        297 1673.0      40.0           ARMENISE   69 DBC  +  5.1 PI+D,3PI++-    5/70
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      5/70
M            1645.0      10.0           CRENNELL   70 HBC  -  6. PI- P,F PI      5/70
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)+.11/71
M        260 1660.       25.            CASO       72 HBC  +  11.7 PI+ P        11/71
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      1/74*
M   P        1660.       10.            ASCOLI     73 HBC  -  5.-25.PI- P,P A3   1/74*
M   P E      1600.       10.            THOMPSON   74 HBC  +  13. PI+ P,P A3+    2/74*
M     E   EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
M   P     FROM A FIT TO JP=2- F PI
M            . . . . . . . . . .
M   AVG      1636.9      7.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

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                    34  A3 WIDTH (MEV)

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    8/69
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)+.11/71
W    J        200. TO 400.              CASO       72 HBC  + 11.7 PI+ P         1/72
W    J        FROM PARTIAL-WAVE ANALYSIS,FOR JP=2-(F PI)-STATE
W        260  190.       100.           CASO       72 HBC  + 11.7 PI+ P        11/71
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      1/74*
W   P         270.       60.            ASCOLI     73 HBC  - 5.-25.PI- P,P A3   1/74*
W   P E       310.       40.            THOMPSON   74 HBC  + 13. PI+ P,P A3+    2/74*
W     E   EVIDENCE FOR A ROTATION OF THE PHASE CLAIMED.
W   P     FROM A FIT TO JP=2- F PI
W            . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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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+ 770
P3      A3 INTO ETA PI                                     134+ 548
P4      A3 INTO 5 PI
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                                      1270+ 134
P9      A3 INTO OMEGA PI PI                                782+ 134+ 134

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                    34  A3 BRANCHING RATIOS

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

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          5/70

R9      A3+- INTO (PI+- PI+ PI-)/(F PI)                   (P1C-P8)/(P8)
R9            0.06       0.47       0.06  CASO    69 HBC  -   11 PI- P          5/70
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                                                11/71

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                         REFERENCES FOR A3

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+     (NOTREDAME)

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    73 PR D 7 669         INTERNAT. COLLABORATION            (ILL+)  JP
ASCOLI 2  73 PR D 8 3894        +JONES,WEINSTEIN,WYLD               (ILL)  JP

THOMPSON  74 PRL 32 331         +BADEWITZ,GAIDOS,MCILWAIN,PALER,+   (PURD)  JP
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$\omega(1675) \rightarrow \rho^0\pi^0$

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45  OMEGA (1675,JPG=  -) I=0, FORMERLY PHI(1675).
NAME CHANGED 1973.
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This resonance overlaps in its 3π mode with the A_3, but in some experiments one can establish the decay mode $\rho^0\pi^0$, i.e. I = 0. MATHEWS 71 suggest J^P= Normal. The decays into 5π and $\omega\pi^+\pi^-$ need further confirmation [see also the entry X(1690)].

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                    45  OMEGA(1675) MASS (MEV)

M            1636.0     20.0              ARMENISE  68 DBC    0 5.1 PI+D          9/68
M            1670.0     20.0              KENYON    69 DBC     8 PI+ D,3PI 2P     8/69
M           (1640.00)                     ARMENISE  70 DBC     9. PI+ D           1/71
M    G      (1616.0)   (30.0)             GORDON    70 DBC    0 4.2 PI+ D         1/71
M        100 1679.0     17.0              MATTHEWS  71 HBC    06.95 PI D,2P 3PI   1/71
M    G    NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT
M     Q 150(1680.)     (20.)              BLOODWORT 73 HBC  5.5 PI+P,PI+P(5PI)0   1/74*
M     F 500 1678.       14.               DIAZ      74 DBC   0 6.PI+N,P(3PI)0     1/74*
M     F   FROM (RHO PI) MODE
M     Q 100 1660.       13.               DIAZ      74 DBC   0 6.PI+N,P(5PI)0     1/74*
M     Q   FROM (OMEGA PI PI) MODE
M            . . . . . . . . . .
M    AVG     1666.3      7.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    45  OMEGA(1675) WIDTH (MEV)

W            112.0     60.0              ARMENISE  68 DBC    0 5.1 PI+D         9/68
W            100.0     40.0              KENYON    69 DBC     8 PI+ D,3PI 2P    8/69
W    G      (188.0)   (47.0)             GORDON    70 DBC    0 4.2 PI+ D        1/71
W       100  155.0     20.0              MATTHEWS  71 HBC    06.95 PI D,2P 3PI  1/71
W    G   NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT
W     Q 150 (130.)    (60.)              BLOODWORT 73 HBC  5.5 PI+P,PI+P(5PI)0  1/74*
W     F 500  167.      40.               DIAZ      74 DBC    0 6.PI+N,P(3PI)0   1/74*
W     F  FROM (RHO PI) MODE
W     Q 100  122.      39.               DIAZ      74 DBC    0 6.PI+N,P(5PI)0   1/74*
W     Q  FROM (OMEGA PI PI) MODE
W          . . . . . . . . . . .
W    AVG     142.1     14.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    45  OMEGA(1675) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1      OMEGA(1675) INTO 3 PI (INCL. RHO PI)              134+ 134+ 134
P2      OMEGA(1675) INTO 5 PI (INCL. OMEGA PI+PI-)        134+ 134+ 134+ 134
P3      OMEGA(1675) INTO RHO PI                           770+ 134
P4      OMEGA(1675) INTO OMEGA PI+ PI-                    782+ 134+ 134
P5      OMEGA(1675) INTO B(1235) PI                      1237+ 134

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                    45  OMEGA(1675) BRANCHING RATIOS

R1      OMEGA(1675) INTO (5 PI)/(3 PI)                   (P2)/(P1)
R1             (0.10)    (0.10)          KENYON    69 DBC    0 8. PI + D      . 8/69
R1      200     0.97      0.28           DIAZ      74 DBC  0 6.PI+N,P(5PI)0     1/74*

R2      OMEGA(1675) INTO (RHO PI)/(3 PI)                 (P3)/(P1)
R2   G         (0.75)    (0.11)          GORDON    70 DBC    0 4.2 PI+ D        1/71
R2      100    (0.70) OR MORE            MATTHEWS  71 HBC    0 6.95 PI D,2P3PI 11/71
R2   G   NOT CERTAIN IF OMEGA(1675) OBSERVED IN THIS EXPERIMENT

R3      OMEGA(1675) INTO (OMEGA PI+ PI-)/(RHO PI)        (P4)/(P3)
R3      100     0.47      0.18           DIAZ      74 DBC  0 6.PI+N,P(5PI)0     1/74*

R4      OMEGA(1675) INTO (B(1235) PI)/(RHO PI)           (P5)/(P3)
R4          POSSIBLY SEEN                DIAZ      74 DBC  0 6.PI+N,P(5PI)0     1/74*

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                    45  OMEGA(1675)  CROSS SECTIONS

CS             FOR A COMPILATION SEE MATTHEWS 71 HBC     06.95 PI D,2P 3PI  1/71

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                         REFERENCES FOR OMEGA(1675)

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)
GORDON   70  COO 1195 179    THESIS,ILLINOIS                        (ILL)

MATTHEWS 71 PR D 3 2561      +PRENTICE,YOON,CARROLL,+         (TNTO+WISC)
MATTHEW1 71 LNC 1 361        +PRENTICE,YOON,CARROLL,+         (TNTO+WISC)

BLOODWOR 73  AIX CONF. PAPER  BLOODWORTH,FRIDMAN,JACKSON,PATEL,+   (IPPC)
DIAZ     74 PRL 32 260       +DIBIANCA,FICKINGER,ANDERSON,+  (CASE+CARN)

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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 26% is found at resonance in the ππ elastic partial-wave analysis (HYAMS 73); 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 reported indicate that there may be more than one $I^G = 1^+$ meson in this region (BARNHAM 70, HOLMES 72). 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   0 6.1 PI-P         6/66
M         (1640.0)                       FORINO    65 DBC    0 4.5 PI+D         6/66
M          1670.0     30.0               GOLDBERG  65 HBC    0 6 PI+D, 8 PI-P
M         (1683.)    (13.)               ARMENISE  68 DBC    0 5.1 PI+ D      . 6/68
M          1720.0     20.0               CRENNELL  68 HBC    0 6.0 PI- P       12/68
M         (1655.0)   (10.0)              JOHNSTON  68 HBC    0 7.0 PI- P      . 6/68
M         (1750.0)                       CASO      69 HBC    0 11. PI- P,N2PI   8/69
M          1737.0     23.0               ARMENISE  70 DBC    0 9 PI+ N          1/71
M          1687.      21.                STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D  2/72
M          1678.      12.                MATTHEWS  71 DBC    0  7. PI+ N        2/72
M          1652.      13.                MATTHEWS  71 HBC    0  7. PI- P        2/72
M    G    (1713.)    (4.)                HYAMS     73 ASPK  0 17 PI-P,N PI+PI-  1/74*
M    G   FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
M          1693.      8.                 GRAYER    74 ASPK  0 17 PI-P,N PI+PI-  2/74*
M          . . . . . . . . . . .
M    AVG   1686.5     8.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                     (SEE IDEOGRAM BELOW )
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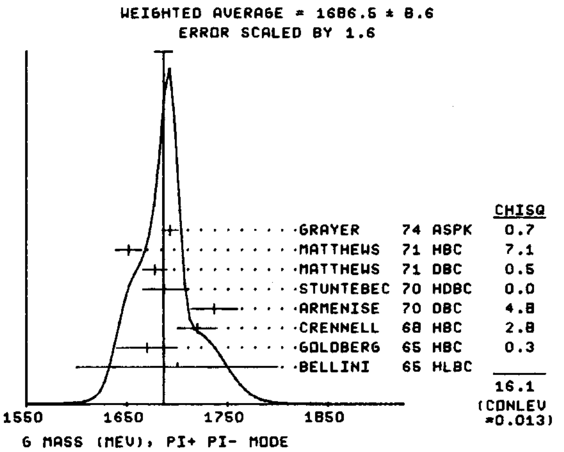


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M      (2PI)+- MODE
M
M          1640.0     25.0               CRENNELL  68 HBC  -  6.0 PI- P        12/68
M         (1600.)                        BARISH    69 HBC  -  8 PI- P           5/70
M      122 1650.0     35.0               BARTSCH   70 HBC  +  8 PI+ P,2 PI      5/70
M         (1652.0)   (15.0)              KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
M          . . . . . . . . . . .
M    AVG   1643.4     20.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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    0 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       13(1650.0)                       ADERHOLZ  69 HBC  +   8 PI+ P,K+KO     8/69
M          1690.0     16.0               ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI  8/69
M          . . . . . . . . . . .
M    AVG   1673.2     23.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

M      (4PI)+- MODE
M
M          1720.      15.                BALTAY    68 HBC  +   7, 8.5 PI+ P     6/68
M    S    (1710.)    (23.)               BISWAS    68 HBC  -    8. PI- P        2/72
M    S   SUPERSEDED BY CASON 73                                                 1/74*
M    J    (1675.0)   (10.0)              JOHNSTON  68 HBC  -  7.0 PI- P         6/68
M    B    (1627.)    (12.)     (17.)     BARNHAM   70 HBC  +  10 K+ P,RHO PIPI  1/73
M    B   INCLUDED IN HOLMES 72
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      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         (1700.)                        BALLAM    71 HBC  -  16. PI- P        2/72
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   FROM RHO- RHO0 MODE
M          . . . . . . . . . . .
M    AVG   1682.1     18.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)

M      (4PI)0 MODE
M
M    R     80 1717.    7.                DANYSZ    67 HBC    OSEE NOTE R BELOW  5/67
M    R     SEEN IN 2.5-3 PBAR P. 2PI+2PI-,WITH 0,1,2 PI+PI- PAIRS IN RHO0 BAND
M      M  (1700.0)                       MAURER    70 HBC    05.7 PBAR P,7 PI   2/71
M      M  (1700.0)                       BRAUN     71 HBC    05.7 PBAR P,7 PI  11/71
M      M  SEEN IN 2 RHO0, NOT IN 4 PI OUTSIDE RHO BANDS,

M      OMEGA 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          . . . . . . . . . . .
M    AVG   1634.2     10.0      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M       R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPT SEE A2 MINIREVIEW)  1/73
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     P    (1700.0)  (47.0)              ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69

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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         (200.0)                        CASO      69 HBC    0 11. PI- P,N2PI   8/69
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
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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   G     (228.)     (10.)               HYAMS     73 ASPK  0 17 PI-P,N PI+PI-   1/74*
W   G   FROM PHASE SHIFT ANALYSIS OF GRAYER 74 DATA.
W          200.       18.                GRAYER    74 ASPK  0 17 PI-P,N PI+PI-   2/74*
W          . . . . . . . . . .
W   AVG    178.2      17.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                   (SEE IDEOGRAM BELOW )
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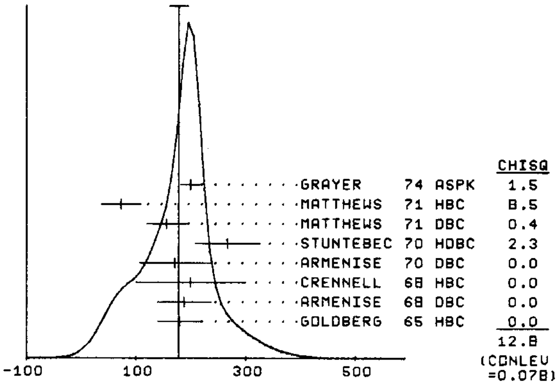
WEIGHTED AVERAGE = 178.2 ± 17.0
ERROR SCALED BY 1.3



G WIDTH (MEV), PI+ PI- MODE

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W     (2PI)+- MODE
W
W          200.0     100.0               CRENNELL  68 HBC  -  6.0 PI- P       12/68
W         (200.)                         BARISH    69 HBC  -  8 PI- P          5/70
W     122  180.0      30.0               BARTSCH   70 HBC  +  8 PI+ P,2 PI     5/70
W         (40.0)    (32.0)               KRAMER    70 HBC  +  13.1 PI+ P,2PI  11/70
W          . . . . . . . . . .
W   AVG    181.7      28.7    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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      13 (100.0)                        ADERHOLZ  69 HBC  +   8 PI+ P,K+KO     8/69
W         112.0      60.0                ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI  8/69
W          . . . . . . . . . .
W   AVG     91.7      37.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W     (4PI)+- MODE
W
W          100.       35.                BALTAY    68 HBC  +   7, 8.5 PI+ P     6/68
W   S     (162.)     (58.)     (40.)     BISWAS    68 HBC  -   8. PI- P         2/72
W   S   SUPERSEDED BY CASON 73                                                 1/74*
W   J     (90.0)    (20.0)               JOHNSTON  68 HBC  -   7.0 PI- P        6/68
W   J      NOT SEPARATED FROM 2 PI DECAY
W   B     (72.)      (29.)     (20.)     BARNHAM   70 HBC  +  10 K+ P,RHO PIPI  1/73
W   B   INCLUDED IN HOLMES 72
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     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   FROM RHO- RHOO MODE
W          . . . . . . . . . .
W   AVG    127.7      17.3    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W     (4PI)0 MODE
W
W   R  80  (40.)     (12.)               DANYSZ    67 HBC    OSEE NOTE R BELOW. 5/67
W   R   SEEN IN 2.5-3 PBAR P. 2PI+2PI-,WITH 0,1,2 PI+PI- PAIRS IN RHOO BAND

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     R PEAKS FROM MMS. (FOR DIFFICULTIES WITH MMS EXPT SEE A2 MINIREVIEW)  1/73
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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                   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                                    770+ 770
P4      G INTO PI PI RHO                                139+ 139+ 770
P5      G INTO A2 PI                                   1310+ 139
P6      G INTO K KBAR                                   497+ 497
P7      G INTO OMEGA PI                                 139+ 782
P8      G INTO K KBAR PI                                497+ 497+ 139
P9      G INTO PHI PI                                  1019+ 139
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                   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              0.26      0.02           HYAMS     73 ASPK  0 17 PI-P,N PI+PI-   1/74*
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R2      G INTO (PI+- PIO) / (ALL PI+- PI+ PI- PIO)        (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+ PIO 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)

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            INDICATION SEEN            EHRLICH   66 HBC  +-0 7.9 PI- P         3/67
R4            INDICATION SEEN            ABRAMS    67 HBC   0 4.25 K- P          6/67
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)

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)

R7      G+- INTO (2RHO)/(ALL 4PI)                         (P3)/(P2)
R7            SEEN                       DANYSZ    67 HBC    0 3-4 PBAR P        5/68
R7            SEEN                       BALTAY    68 HBC  +   7,8.5 PI+ P       6/68
R7  S         (0.63) OR MORE             BISWAS    68 HBC  -   8. PI- P          2/72
R7  S    SUPERSEDED BY CASON 73                                                  1/74*
R7            SEEN                       JOHNSTON  68 HBC   - 7 PI-P             6/68
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)

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+- A20)/(ALL 4PI)
R9                          (WITH A20 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            (0.6)      (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            . . . . . . . . . .
R10 AVG        0.184      0.050    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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     R FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R13 R1        (0.37)/    (0.59)/  0.04 FOCACCI   66 MMS  -   7-12 PI-P,P MMS  2/72
R13 R2        (0.42)/    (0.56)/  0.01 FOCACCI   66 MMS  -   7-12 PI-P,P MMS  2/72
R13 R3        (0.14)/    (0.80)/  0.05 FOCACCI   66 MMS  -   7-12 PI-P,P MMS  2/72

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                              REFERENCES FOR G
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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 4?5          +FOCACCI+KIENZLE+LECHANOINE+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+COROS+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)
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)
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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)

GRAYER    74 NP                  G.GRAYER,HYAMS,BLUM,DIETL,+     (CERN+MPIM)

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X(1690) $\to \omega\pi\pi$

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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 73
M  A       1670.0     18.0           YOST      68 HBC    04.3 K-P,LMBD.5PI  2/74*
M  A       1695.0     20.0           BARNES    69 HBC    0 4.6 K-P,OMEG2PI  2/74*
M  A    NOT SEEN  WITH THREE TIMES BIGGER STATISTICS IN K- P 4.2 GEV/C
M  A    (CHALOUPKA 74)
M          . . . . . . . . . .
M   AVG    1681.2     13.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 64  X(1690) WIDTH (MEV)

W   N      (38.)    (18.)            DANYSZ    67 HBC    0 3,3.6 PBAR P     1/73
W  A        50.0     15.0            YOST      68 HBC    04.3 K-P,LMBD.5PI  1/73
W  A        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)

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                      REFERENCES FOR X(1690)

DANYSZ    67 NC 51 A 801        DANYSZ+FRENCH+SIMAK                   (CERN)
YOST      68  UMD  T.REPORT849 +YODH,EINSCHLAG,DAY,GLASSER             (UMD)
BARNES    69 PRL 23 142         +CHUNG,EISNER,FLAMINIO,+               (BNL)
OREN      73  ANL/HEP 7351      +COOPER,FIELDS,RHINES,WHITMORE,+  (ANL+OXF)
CHALOUPK  74  PRIV.COMMUN.      V.CHALOUPKA                           (CERN)

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X⁻(1795)

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63  X- (1795,JPG=    ) I=1

SEEN AS A (PBAR N) BOUND STATE IN PBAR D ANNIHILATIONS
AT REST. NEEDS FURTHER CONFIRMATION.OMITTED FROM TABLE.

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                 63  X-(1795) MASS (MEV)

M    D    1794.5      1.4              GRAY      71 DBC  -  0.PBAR D          1/72
M    D    DECAYS TO FOUR OR MORE PIONS

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                 63  X-(1795) WIDTH(MEV)

W    D      (8.)   OR LESS  CL=.95   GRAY      71 DBC  -  0.PBAR D          1/72
W    D    DECAYS TO FOUR OR MORE PIONS.

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                      REFERENCES FOR X-(1795)

GRAY      71 PRL 26 1491         +HAGERT,KALOGEROPOULOS               (SYRA)
BOGDANOV  72 PRL 28 1418        BOGDANOVA,DALKAROV,SHAPIRO            (ITEP)
GRAY      73 PRL 30 1091        +PAPADOPOULOU,KARAGEROPOULOS,+  (ATEN+SYRA)

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S(1930) REGION

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31  S (1930,JPG=   )
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This entry contains the structure observed in the s-channel $N\overline{N}$ annihilations, as well as various peaks claimed in this region by production experiments. Note that part of the criticism of a resonant interpretation of the structure observed in $\overline{p}p$ backward elastic scattering (CLINE 70, D'ANDLAU 71) was based on the absence of a bump in the total $\overline{p}p$ cross section. Such a bump has now been observed by CARROLL 74. In view of the past difficulties with the S region, we prefer to wait for further clarification, before entering the S meson into the table of established resonances.

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                 31  S MASS (MEV)

M       S CHANNEL NBAR N
M   C     (1940.)     (8.)          CLINE     70 HBC   0  .25-.74 PBAR P   2/72
M   C     (1939.)                   D*ANDLAU  71 HBC   0  .37-.65 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   1/74*
M
M   C   FROM FIT OF A SINGLE BW FORMULA TO THE PBAR P BACKWARD ELASTIC
M   C   CROSS SECTION  / COS(THETA) IN (-.9,-1.0) /.  SOME INDICATIONS
M   C   OF AN ADDITIONAL STRUCTURE IN BOTH DATA.
M   C   RESONANT INTERPRETATION QUESTIONED BY LYS 70 AND BIZZARRI 72 .
M
M   B   SEEN AS A BUMP IN THE PBAR P - KS KL  CROSS SECTION WITH JPC=1--.
M   B   BASED ON ONLY 71 EVENTS OF THIS REACTION.
M   B   NOT SEEN BY CARSON 72 WITH 69 EVENTS.                             12/72
M   B   BURNS 73 FIND COMPARABLE C=+1 AND C=-1 ABOVE 700 MEV/C             1/74*
M
M  S    STATIST. SIGNIFICANT NARROW BUMP OBSERVED IN TOTAL PBAR P
M  S    AND PBAR D CROSS-SECTIONS. ISOSPIN NOT KNOWN.

M       PEAKS FROM PRODUCTION EXPERIMENTS
M   N     (1929.0)   (14.0)         CHIKOVANI 66 MMSP  -  12.0 PI-P        12/72
M   N   NOT SEEN BY BOWEN 73.
M          1900.      40.           BOESEBECK 68 HBC  +   8 PI+ P,PI+ PIO  6/68
M  A       1973.0     15.0          CASO      70 HBC  - 11.2PI- P,NOTE C   5/70
M  A       SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) 5/70
M          1975.0     12.0          KRAMER    70 HBC  +  13.1 PI+ P,2PI  .11/70
M          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)

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                 31  S WIDTH (MEV)

W       S CHANNEL NBAR N
W   C      (49.)      (9.)          CLINE     70 HBC   0  .25-.74 PBAR P   2/72
W   C      (63.)                    D*ANDLAU  71 HBC   0  .37-.65 PBAR P   2/72
W   C   SEE REMARKS UNDER MASS ABOVE
W   B      (35.)                    BENVENUTI 71 HBC   0  .1 - .8 PBAR P   2/72
W   B   SEE REMARKS UNDER MASS ABOVE
W  S         9.        4.       3.  CARROLL   74 CNTR    S CHAN.PBAR P,D   1/74*
W  S    SEE NOTE S ABOVE.

W       PEAKS FROM PRODUCTION EXPERIMENTS
W   N      (35.0)  OR LESS          CHIKOVANI 66 MMSP  -  12.0 PI-P        12/72
W   N   NOT SEEN BY BOWEN 73.
W          216.      105.           BOESEBECK 68 HBC  +   8 PI+ P,PI+ PIO  6/68
W  A       (80.0)                   CASO      70 HBC  - 11.2PI- P,NOTE C   5/70
W  A       SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) 5/70
W          (52.0)  OR LESS  CL=.90  KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70

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                 31  S PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      S INTO PI+ PI-                                   139+ 139
P2      S INTO PBAR P                                    938+ 938

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                      REFERENCES FOR S

CHIKOVAN 66 PL  22  233        CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL  17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)
BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CLINE    68 PRL 21 1268        +ENGLISH,REEDER,TERRELL,TWITTY  (WISCONSIN)

CASO     70 LNC 3  707         +CORDS,COSTA,+   (GENO,DESY,HAMB,MILA,SACL)
CLINE    70  PREPRINT          D.CLINE,J.ENGLISH,D.D.REEDER          (WISC)J
KRAMER   70 PRL 25 396         +BARTON,GUTAY,LICHTMAN,MILLER,+    (PURDUE)
LYS      70  PREPRINT          J.LYS                                  (MICH)

BENVENUT 71 PRL 27 283         BENVENUTI,CLINE,RUTZ,REEDER,SCHERER  (WISC)
CLINE    71  REVIEW            D.CLINE,TALK AT ANL WORKSHOP JULY 71 (WISC)
D*ANDLAU 71  PREPRINT          +ASTIER,PETRI,+                 (CDEF+PISA)
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)
CARSON   72  BAT.CONF.PAP.498 +BUTTON-SHAFER,YAMAMOTO,+        (MASA+TOKY)
DIEBOLD  72  BATAV.CONF.       R.DIEBOLD  RAPPORTEUR TALK             (ANL)
WOHLMUT  72  BAT.CONF.PAP.275 +YEE,JOHNSON,PETERS,STENGER          (HAWAII)

BOWEN    73 PRL 30 332         +EARLES,FAISSLER,BLIEDEN,+      (NEAS+STON)
BURNS    73 PR D 8 1286        +CONDON,DONAHUE,MANDELKERN,PRICE,+    (UCI)
DONNACHI 73 LNC 7 285          A.DONNACHIE,P.R.THOMAS         (MANCHESTER)
KIENZLE  73 PR D 7 3520        W.KIENZLE                             (CERN)

CARROLL  74 PRL 32 247         +CHIANG,KYCIA,LI,MAZUR,MICHAEL,+       (BNL)

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A₄(1960)

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43  A4 (1960,JPG=  -)  I=1

OMITTED FROM TABLE.
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This entry contains the diffractive-like 3π and 5π bumps in the region of 1900 MeV, as well as various peaks nearby. Note that existence of an S-wave $g\pi$ threshold bump (as continuation to A_1 and A_3) is not unexpected.

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                 43  A4 MASS  (MEV)

M        (1900.)                    HUSON     68 HLBC -  16.PI-A,A 5PI     2/74*
M   B   40(1960.)    (30.)          BASTIEN   73 DBC  -  15.PI-D,D 3PI     2/74*
M   B   MARGINAL STATISTICAL SIGNIFICANCE.

M       VARIOUS 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)
M          1829.       20.          HARRISON  72 HBC  -  13,20 PI-P,P 3PI  2/74*
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                 A4  WIDTH  (MEV)

W   B   40 (200.)                 BASTIEN    73 DBC   -  15.PI-D,D 3PI       2/74*

W       VARIOUS PEAKS
W        127.      69.            HARRISON   72 HBC   -  13,20 PI-P,P 3PI   2/74*
W   K    (50.)    (20.)           FRENCH     67 HBC    0 3-4 PBAR P          7/67

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                           REFERENCES FOR A4

DANYSZ    67 NC 51A 801          DANYSZ+FRENCH+SIMAK                      (CERN)
FRENCH    67 NC 52A 442          +KINSON+MCDONALD+RIDDIFORD+        (CERN+BIRM)
HUSON     68 PL 28 B 208         +LUBATTI,BELLINI,BINGHAM,+ (ORSA+MILA+LBL)
BEMPORAD  71 NP B 33 397         +DUFEY,COOLING,+           (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)
BASTIEN   73 UPPSALA CONF. 73    +DUNN,HARRIS,LUBATTI,BINGHAM,+     (SEAT+UCB)
OREN      73   ANL/HEP 7351      +COOPER,FIELDS,RHINES,WHITMORE,+   (ANL+OXF)

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ρ(~2100) REGION →

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51  RHO (2100, JPG=  +) I=1

NICHOLSON 69 SUGGEST IG=1+,JP=3- FROM  ANALYSIS OF
DIFFERENTIAL CROSS-SECTIONS FOR PBAR PI -- 2PI.
NOT SUPPORTED BY EHRLICH 72,EISENHANDLER 73.
OMITTED FROM TABLE.

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                 51  RHO (2100) MASS (MEV)

M        2086.0     38.0          ANDERSON  69 MMS   -  16 PI- P,BACKW     8/69
M   S    (2120.)                  NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI    1/74*
M   S   SEE ALSO NICHOLSON 73
M        50(2070.)                TAKAHASHI 72 HBC    .8. PI- P,N 2PI      1/73

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                 51  RHO (2100) WIDTH (MEV)

W        (150.0)                  ANDERSON  69 MMS   -  16 PI- P,BACKW     8/69
W   N    (249.)                   NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI    9/69
W   N     THE WIDTH INCLUDES RESOLUTION.
W        50 (160.)                TAKAHASHI 72 HBC    8. PI- P,N 2PI       1/73

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                          REFERENCES FOR RHO(2100)

ANDERSON 69 PRL 22 1390          +COLLINS,BLIEDEN+                  (BNL+CARN)
NICHOLSO 69 PRL 23 603           NICHOLSON,BARISH,DELORME,+   (CIT+ROCH+BNL)

EHRLICH  72 PRL 28 1147          +ETKIN,GLODIS,HUGHES,KONDO,LU,MORI,+ (YALE)
TAKAHASH 72 PR D 6 1266          TAKAHASHI,BARISH,+       (TOHO+PENN+NDAM+ANL)
EISENHAN 73 PL 47 B 536          EISENHANDLER,+           (LOQM+LIVP+DARE+RHEL)
NICHOLSO 73 PR D 7 2572          NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

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T(2200) REGION →

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32  T (2200,JPG=    )

THIS ENTRY CONTAINS VARIOUS PEAKS NEAR 2200 MEV.
OMITTED FROM TABLE.
FOR REVIEWS SEE BERTANZA 72, DIEBOLD 72.

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                 32  T MASS (MEV)

M        S CHANNEL NBAR N
M   B     2190.      10.          ABRAMS     70 CNTR    S CHANNEL NBAR N   1/73
M   B    SEEN AS BUMP IN I=1 STATE. SEE ALSO COOPER 68.
M   B     BRICMAN (69) SEES NO BUMP, SPIN LESS THAN 5 IS SO EXCLUDED
M    K    (2190.0)                KALBFLEIS 69 HBC    0 S-CHANNEL PBARP    7/69
M    K     SEEN IN PBAR P TO RHOO RHOO PIO. IG=1-.
M    K    NOT SEEN BY DONALD 73.
M         2193.       2.          ALSPECTOR 73 CNTR    S CHANNEL PBAR P.  1/74*
M     S   (2141.)                 DONALD     73 HBC   0 S CHANNEL PBAR P  1/74*
M     S   SEEN IN FINAL STATE (OMEGA PI+ PI-)
M             . . . . . . . . .
M    AVG    2192.9      2.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M        PEAKS FROM PRODUCTION EXPERIMENTS
M   N    (2195.0)   (15.0)        CHIKOVANI 66 MMSP  -  12.0 PI-P         12/72
M   N    NOT SEEN BY BOWEN 73.
M         2207.       13.         ALLES-BOR 67 HBC    0 5.7 PBAR P        12/66
M   A     ALLES-BORELLI 67 SEE NEUTRAL MODE ONLY (PI+PI-PIO)
M         2190.0     10.0         CLAYTON   67 HBC  +- 2.5PBAR,A2+OMEGA 10/67
M         2207.0     22.0         CASO      70 HBC   - 11.2PI- P,NOTE C. 5/70
M   C     SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) 5/70
M         2157.0     10.0         KRAMER    70 HBC   +  13.1 PI+ P,2PI   .11/70
M             . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)

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                 32  T WIDTH (MEV)

W        S CHANNEL NBAR N
W   B     (85.)                   ABRAMS     67 CNTR    S CHANNEL NBAR N   7/67
W   B      SEE NOTE B UNDER T(2200) MASS ABOVE.
W   K     BETWEEN 20 AND 80 MEV   KALBFLEIS 69 HBC    0 S-CHANNEL PBARP    7/69
W          98.        8.          ALSPECTOR 73 CNTR    S CHANNEL PBAR P   1/74*
W     S    (14.)                  DONALD     73 HBC   0 S CHANNEL PBAR P  1/74*
W     S   SEEN IN FINAL STATE (OMEGA PI+ PI-)

W        PEAKS FROM PRODUCTION EXPERIMENTS
W   N     (13.0)  OR LESS         CHIKOVANI 66 MMSP  -  12.0 PI-P          8/66
W          62.       52.          ALLES-BOR 67 HBC    0 5.7 PBAR P        12/66
W         (130.0)                 CASO      70 HBC   - 11.2PI- P,NOTE C. 5/70
W   C     SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) 5/70
W          68.0      22.0         KRAMER    70 HBC   +  13.1 PI+ P,2PI    11/70
W             . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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            32  SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS A        (5.5)                 ABRAMS     70 CNTR    S CHANNEL NBAR 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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                          REFERENCES FOR T

CHIKOVAN 66 PL   22  233          CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL  17  890          CERN MISSING MASS SPECTROMETER GROUP (CERN)
  ALSO   69 CASO
ABRAMS   67 PRL 18 1209           +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+     (BNL)
ALLES-BO 67 NC 50 A 776           ALLES-BORELLI,FRENCH,FRISK,+    (CERN+BONN)G=-
CLAYTON  67 HEIDBG.CONF.P.57      +MASON,MUIRHEAD,FILIPPAS+(LIVERPOOL+ATHENS)
COOPER   68 PRL 20 1059           +HYMAN,MANNER,MUSGRAVE,VOYVODIC          (ANL)

BRICMAN  69 PL 29 B 451           +FERRO-LUZZI,BIZARD,+         (CERN+CAEN+SACL)
CASO     69 NC 62 A 755           +CONTE,BENZ,+          (GENO+DESY+HAMB+MILA+SACL)
KALBFLEI 69 PL 29 B  259          G.KALBFLEISCH,R.STRAND,V.VANDERBURG     (BNL)
MONTANET 69 LUND CONF.P.189       L.MONTANET, RAPPORTEUR                 (CERN)

ABRAMS   70 PR D 1 1917           +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+     (BNL)
CASO     70 LNC 3 707             +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
  ALSO   69 CASO
KALBFLEI 70 PHILAD.CONF.P.409 G.KALBFLEISCH AND D.MILLER REVUES           (BNL)
KRAMER   70 PRL 25 396            +BARTON,GUTAY,LICHTMAN,MILLER,+      (PURDUE)

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,LCBKOVICZ+       (CIT+BNL+ROCH)

ALEXANDE 72 NP B 45 29            ALEXANDER,BAR-NIR,BEVARY,DAGAN,+        (TELA)
BERTANZA 72  CERN 72-10           L.BERTANZA REVIEW AT CHEXBRES 72        (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)
MING MA  72 NP B 51 77            +EASTMAN,OH,PARKER,SMITH,SPRAFKA         (MSU)
WOHLMUT  72   BAT.CONF.PAP.275 +YEE,JOHNSON,PETERS,STENGER              (HAWAII)

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)
DONALD   73 NP B 61 333           +EDWARDS,GIBBINS,BRIAND,DUBOC,+ (LIVP+LPNP)
DONNACHI 73 LNC 7 285             A.DONNACHIE,P.R.THOMAS            (MANCHESTER)
KIENZLE  73 PR D 7 3520           W.KIENZLE                               (CERN)

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ρ(~2275) REGION →

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52  RHO (2275, JPG=  +) I=1

NICHOLSON 69 SUGGEST IG=1+,JP=5- FROM  ANALYSIS OF
DIFFERENTIAL CROSS-SECTIONS FOR PBAR PI -- 2PI.
NOT SUPPORTED BY EHRLICH 72,EISENHANDLER 73.
OMITTED FROM TABLE.

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                 52  RHO(2275) MASS (MEV)

M        2260.0     18.0          ANDERSON  69 MMS   -  16 PI- P,BACKW     8/69
M   S    (2290.)                  NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI    1/74*
M   S   SEE ALSO NICHOLSON 73.

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                 52  RHO(2275) WIDTH (MEV)

W        (25.0)   OR LESS         ANDERSON  69 MMS   -  16 PI- P,BACKW     8/69
W   N    (165.)                   NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI    9/69
W   N     THE WIDTH INCLUDES RESOLUTION.

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                          REFERENCES FOR RHO(2275)

ANDERSON 69 PRL 22 1390          +COLLINS,BLIEDEN+                  (BNL+CARN)
NICHOLSO 69 PRL 23 603           NICHOLSON,BARISH,DELORME,+   (CIT+ROCH+BNL)
EHRLICH  72 PRL 28 1147          +ETKIN,GLODIS,HUGHES,KONDO,LU,MORI,+ (YALE)
EISENHAN 73 PL 47 B 536          EISENHANDLER,+           (LOQM+LIVP+DARE+RHEL)
NICHOLSO 73 PR D 7 2572          NICHOLSON,DELORME,CARROLL,+  (CIT+ROCH+BNL)

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U(2360) REGION →

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33  U (2360,JPG=    ) I=1

THIS ENTRY CONTAINS THE BROAD BUMP OBSERVED
IN THE S CHANNEL NBAR N, AND VARIOUS OTHER PEAKS,
MOSTLY CONTROVERSIAL. OMITTED FROM TABLE.
FOR REVIEW SEE ASTBURY 72, DIEBOLD 72.

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                 33  U(2360)  MASS (MEV)

M        S CHANNEL NBAR N
M   R     (2370.0)   (10.0)       RING       69 HBC    0 S-CHANNEL PBARP 11/71
M   R      NOT CONFIRMED IN EXTENSION OF THE EXP..SEE CHAPMAN 71.        11/71
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   1/73
M    I    (2359.)     (2.)        ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74*
M    I    ISOSPINS 0 AND 1 NOT SEPARATED

M        PEAKS FROM PRODUCTION EXPERIMENTS
M   M     (2382.0)   (24.0)       CHIKOVANI 66 MMS   -  12.0 PI-P         12/72
M   N    NOT SEEN BY BOWEN 73.
M   C     (2324.0)   (20.0)       CLAYTON   67 HBC  +- 2.5PBAR,A2+OMEGA 11/69
M   C      MAY BE DIFFERENT OBJECT. VALUE QUOTED IN HEIDELBERG PROC. OF
M   C      2380 +- 10 IS MISTAKE... PRIV. COMM. FROM MUIRHEAD.
M          2370.      17.         ANDERSON  69 ASPK  - 16 PI- BKSCAT      11/69
M         (2420.0)   (25.0)       JOHNSON   70 HBC   -  12.0 PI- P         1/71
M        73(2374.)    (4.)        ATHERTON  71 HBC    0 5.7 PBAR P        2/73

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Mesons

U(2360), $N\bar{N}_{I=0}$(2375), X(2500–3600)

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                 33  U(2360)  WIDTH (MEV)

W       S CHANNEL NBAR N
W          (140.)                   ABRAMS     67 CNTR    S CHANNEL PBAR N  1/73
W   R       (40.0)  OR LESS         RING       69 HBC    0 S-CHANNEL PBARP 11/71
W   R      NOT CONFIRMED IN EXTENSION OF THE EXP..SEE CHAPMAN 71.           11/71
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  11/71
W   I       (165.)    (18.)    (8.)  ALSPECTOR 73 CNTR    S CHANNEL PBAR P  1/74*
W   I   ISOSPINS 0 AND 1 NOT SEPARATED

W       PEAKS FROM PRODUCTION EXPERIMENTS
W   M       (30.0)  OR LESS         CHIKOVANI 66 MMS   -  12.0 PI-P         8/66
W   N   NOT SEEN BY BOWEN 73.
W           (57.)                   ANDERSON  69 ASPK  - 16 PI- BKSCAT     11/69
W           (80.0)  OR LESS         JOHNSON   70 HBC   -  12.0 P+- P        1/71
W       73  (24.)   OR LESS         ATHERTON  71 HBC   0 5.7 PBAR P         2/73

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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 U(2360)

CHIKOVAN 66 PL  22  233      CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL  17  890     CERN MISSING MASS SPECTROMETER GROUP (CERN)

ABRAMS   67 PRL 18 1209      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)
CLAYTON  67 HEIDBG.CONF.P.57 +MASON,MUIRHEAD,FILIPPAS+(LIVERPOOL+ATHENS)
    ALSO 71 PRIV.COMM.       W.MUIRHEAD                          (LIVP)

ANDERSON 69 PRL 22 1390      +BLESER,BIRNBAUM,EDELSTEIN,+      (BNL+CARN)
BRICMAN  69 PL 29 B 451      +FERRO-LUZZI,BIZARD,+        (CERN+CAEN+SACL)
CASO     69 LNC 3 707        +CONTE,BENZ,+    (GENO+DESY+HAMB+MILA+SACL)
RING1    69  MICH PREPRINT   +CHAPMAN,CHURCH,LYS,MURPHY,VANDERVELD(MICH)
RING     69                  JOINT PREPRINT COMBINES RING1 AND OH 70

ABRAMS   70 PR D 1 1917      +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)
JOHNSON  70  UH 511 77 70    +PETERS,STENGER,YEE                (HAWAII)
LYS      70  PREPRINT        J.LYS                                (MICH)
OH       70 PRL 24 1257      +PARKER,EASTMAN,SMITH,SPRAFKA,MA      (MSU)
SMITH    70  PREPRINT        G.A.SMITH                             (MSU)

ATHERTON 71  CERN PHYS.71-18 +CELNIKIER,CLAYTCN,FRANEK,FRENCH,+   (CERN)
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.     R.DIEBOLD  RAPPORTEUR TALK            (ANL)
DONALD   72  BAT.CONF.PAP.265 INTERNAT.COLLABORATION             (LIVP+)
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)
WOHLMUT  72  BAT.CONF.PAP.275 +YEE,JOHNSON,PETERS,STENGER       (HAWAII)

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)
KIENZLE  73 PR D 7 3520      W.KIENZLE                            (CERN)
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$N\bar{N}_{I=0}$(2375)

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41  N NBAR (2375,JPG=    ) I=0

          EVIDENCE FOR RESONANCE PRELIMINARY.
          OMITTED FROM TABLE.

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                 41  N NBAR(2375) MASS

M          2375.      10.           ABRAMS     70 CNTR   S CHANNEL NBAR N  1/71
M   I     (2359.)    (2.)           ALSPECTOR 73 CNTR    S CHANNEL PBIR P  1/74*
M   I   ISOSPINS 0 AND 1 NOT SEPARATED

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                 41  N NBAR(2375) 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   I   ISOSPINS 0 AND 1 NOT SEPARATED

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                 41  N NBAR(2375) SIGMA (MB) FOR FORMATION BN

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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                              REFERENCES FOR N NBAR (2375)

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)
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X(2500–3600)

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46  X(2500-3600)

THIS ENTRY CONTAINS VARIOUS HIGH MASS
NON-STRANGE PEAKS. OMITTED FROM TABLE.
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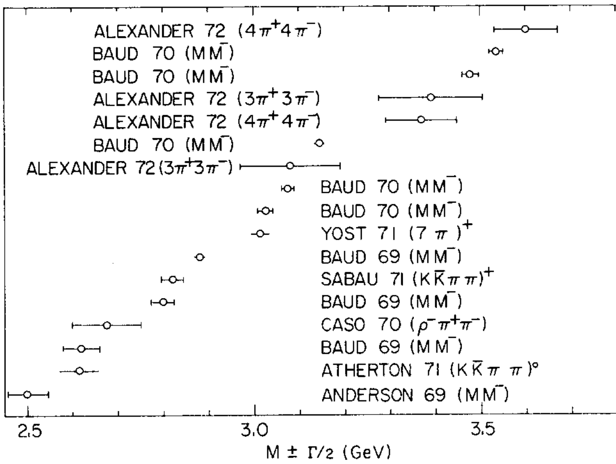
The high mass region is covered nearly continuously by evidence for peaks of various widths and decay modes (see figure). As a satisfactory grouping into particles is not yet possible, we list all the Y = 0 bumps with M > 2400 MeV together by increasing mass. Note that ANTIPOV 72 ($\pi^- p \to pMM^-$ at 25 and 40 GeV/c) see no narrow bumps.



Masses and widths of reported enhancements with Y = 0, M > 2400 MeV. (—O— indicates that upper limit only was reported for the width.)

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                 46  X(2500-3600)  MASSES AND WIDTHS  (MEV)

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       66 2613.       7.           ATHERTON  71 HBC   0 5.7 PBAR P        2/73
W       66  (90.)    OR LESS        ATHERTON  71 HBC   0 5.7 PBAR P        2/73

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
W   C      SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) 5/70

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
W   C      SEEN IN (K KBAR PI PI)+ MASS DISTRIBUTION                      11/71

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
W   Y      4.3 S.D. EFFECT  . DECAY TO 7 PIONS                             11/71

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- 7

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   D      3080.      20.           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
W   D       220.      70.           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
    D   DECAYS TO 3PI+ 3PI-

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   D      3370.      10.           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
W   D       150.      40.           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
    D   DECAYS TO 4PI+ 4PI-

M   D      3390.      20.           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
W   D       220.     100.           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
    D   DECAYS TO 3PI+ 3PI-

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

M   D      3600.      20.           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
W   D       140.      20.           ALEXANDER 72 HBC   0 6.94 PBAR P       1/73
    D   DECAYS TO 4PI+ 4PI-

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                              REFERENCES FOR X(2500-3600)

ANDERSON 69 PRL 22 1390      +COLLINS,+                        (BNL+CARN)
BAUD     69 PL  30B 129      CERN BOSON SPECTROMETER GROUP         (CERN)
ALEXANDE 70 PRL 25 63        +BAR-NIR,DAGAN,GIDAL,GRUNHAUS+   (TEL-AVIV)
BAUD     70 PL 31 B 549      CERN BOSON SPECTROMETER GROUP         (CERN)
CASO     70 LNC 3 707        +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)
ATHERTON 71  CERN PHYS.71-18 +CELNIKIER,CLAYTCN,FRANEK,FRENCH,+   (CERN)
SABAU    71 LNC 1 514        +URETSKY                        (BUCH+ANL)
YOST     71 PR D 3 642       +MORRIS,ALBRIGHT,BRUCKER,LANNUTTI     (FSU)
ALEXANDE 72 NP B 45 29       ALEXANDER,BAR-NIR,BEVARY,DAGAN,+     (TELA)
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S=±1 MESON STATES

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K±

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          10  CHARGED K (494,JP=0-) I=1/2
              SEE STABLE PARTICLE DATA CARD LISTINGS
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K0

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          11  NEUTRAL K (498,JP=0-) I=1/2
              SEE STABLE PARTICLE DATA CARD LISTINGS
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K*(892)

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          18  K* (892,JP=1-) I=1/2
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              18  K*(892) MASS (MEV)

M  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
M           898.0     5.0              CHADWICK  63 HBC  +   1.5 K+P
M     3870  891.0     1.0              WOJCICKI  64 HBC  -   1.7 K-P
M           889.5     2.5              ADELMAN   65 HBC  -   1.5 K-P           6/66
M           895.0     3.0              GELSEMA   65 HBC  -   1.5 K-P
M           895.      3.               BOMSE     67 HBC  +  2.3 K+P            7/67
M           891.      2.               DE BAERE  67 HBC  +  3.5 K+P (KO PI+)   7/67
M           892.5     2.5              DE BAERE  67 HBC  +  3.5 K+P (K+ PIO)   7/67
M           898.      4.               SALLSTROM 67 HBC  +  3. K+ P (KO PI+)   7/67
M           883.      5.               SALLSTROM 67 HBC  +  3. K+ P (K+ PIO)   7/67
M           890.      3.               BARLOW    67 HBC  +-  1.2 PBAR P        2/72
M           889.      3.               BARLOW    67 HBC  +-  1.2 PBAR P       11/66
M           896.0     5.0              CONFORTO  67 HBC  +-  0. PBAR P         9/67
M           893.      4.               ADERHOLZ  68 HBC  -   10 K- P           6/68
M           891.      4.               FICENEC1  68 HBC  -   1.3 K-P (K-PIO)   9/67
M           887.      3.               FICENEC1  68 HBC  -   1.3 K-P (KOPI-)   9/67
M           890.0     5.0              FICENEC2  68 HBC  -   2.7 K- P(K-PIO)   2/69
M           892.0     3.0              FICENEC2  68 HBC  -   2.7 K- P(KOPI-)   2/69
M           896.0     4.0              SCHWEINGR 68 HBC  -   4.1 K-P           9/67
M           892.0     2.0              SCHWEINGR 68 HBC  -   5.5 K-P           9/67
M           884.0     5.0              KANG      68 HBC  -   4.6 K- P          7/69
M           891.0     2.0              CRENNELL  69 DBC  -   3.9 K-N (KOPI-)   7/69
M           892.0     3.0              ERWIN     69 HBC  +   3.5 K+ P          9/69
M     2886 (894.)    (1.)              FRIEDMAN  69 HBC  -   2.1  K-P (3BDY)   2/72
M      728 (892.)    (2.)              FRIEDMAN  69 HBC  -   2.45 K-P (3BDY)   2/72
M     3229 (892.)    (1.)              FRIEDMAN  69 HBC  -   2.6  K-P (3BDY)   2/72
M     1027 (892.)    (1.)              FRIEDMAN  69 HBC  -   2.7  K-P (3BDY)   2/72
M           895.      2.               LIND      69 HBC  +   9. K+ P           9/69
M     4404  892.2     1.5              AGUILAR1  71 HBC  -   3.9,4.6 K- P     11/71
M     1300  894.3     1.1              CLARK     73 HBC  -  3.3 K-P,P PI- KO  2/74*
M           . . . . . . . . . .
M   AVG     892.15    0.48     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

M  NEUTRAL ONLY. BUT WE DONT USE THIS FOR MASS DIFF. - SEE TYPED NOTE
M       70  897.0    10.0              COLLEY    62 HBC    0 2.0 PI-P
M      200  892.0     2.0              KRAEMER   63 HBC    0 2.3 K+P
M      150 (885.0)                     SMITH     63 HBC    0 2.3 PI-P
M           899.      4.               BARLOW    67 HBC    0 1.2 PBAR P       11/66
M           897.      4.               BARLOW    67 HBC    0 1.2 PBAR P       11/66
M           889.0     5.0              CONFORTO  67 HBC    0 0. PBAR P         9/67
M           894.7     1.3              DAUBER    67 HBC    0  2.0 K- P        12/66
M           892.0     4.0              GEORGE    67 HBC    0 5.0 K+ P         11/67
M           893.      3.               DE WIT    68 DBC    0 3. K- D           9/69
M  F        895.      4.               FICENEC1  68 HBC    0 1.3 K-P (K-PI+)  11/69
M  F        901.      4.               FICENEC2  68 HBC    0 2.7 K-P (K-PI+)  11/69
M  F FICENEC ERROR RAISED       SEE TYPED NOTE
M           896.0     4.0              SCHWEINGR 68 HBC    0 4.1 K-P           9/67
M           903.0     4.0              SCHWEINGR 68 HBC    0 5.5 K-P           9/67
M           899.0     5.0              KANG      68 HBC    0 4.6 K- P          7/69
M    10700  893.7     2.0              DAVIS     69 HBC    0 12. K+ P          9/69
M  D  2000  890.0     1.25             DE BAERE  69 HBC    0 5.0 K+ P          9/69
M  D          ERRORS ENLARGED BY US TO  GAMMA/SQRT(N). SEE TYPED NOTE.
M     4000  895.0     1.0              HABER     70 DBC    0 3. K-N            5/70
M     2934  897.9     0.8              AGUILAR1  71 HBC    0 3.9,4.6 K- P     11/71
M     5362  898.0     0.5              AGUILAR1  71 HBC    0 3.9,4.6 K- P     11/71
M  D  1700  898.4     1.3              BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P  12/72
M     3186  896.0     1.0              LEWIS     73 HBC    0 2.1-2.7 K+P      2/74*
M   C      (894.0)   (1.3)             LINGLIN   73 HBC    0 2-13 K+P,K+PI-   1/74*
M   C   FROM POLE EXTRAPOLATION, USING WORLD K+P DST
M           . . . . . . . . . .
M   AVG     896.51    0.60     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                      (SEE IDEOGRAM BELOW )
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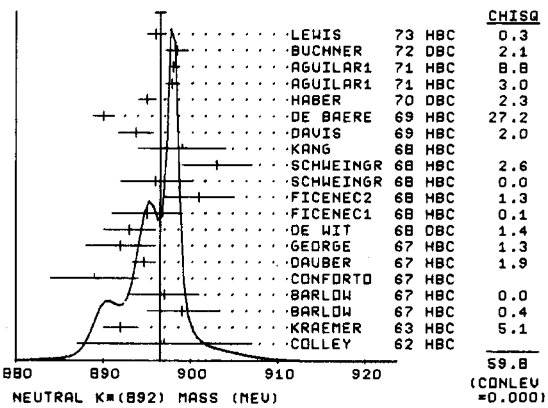
WEIGHTED AVERAGE = 896.51 ± 0.60

ERROR SCALED BY 1.9



Note on $K^*(892)$ Masses and Mass Differences

(1) Impossibly 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:

$$\delta_{\min}(m) = \frac{\Gamma}{\sqrt{N}}, \qquad \delta_{\min}(\Gamma) = 4\frac{\Gamma}{\sqrt{N}} .$$

(For detailed discussion see the April 1971 edition of this note). We have increased some unrealistic errors and scaled up some errors that are inconsistent.

(2) There are two more difficulties in measuring a mass difference $m(K^{*0}) - m(K^{*+})$ of ~7 MeV when the half-width $\Gamma/2$ of the K^* is 25 MeV:

(a) The two charges of K^* have different topologies; this introduces differences in the measuring and fitting of the events, which can also produce mass shifts.

(b) Interferences between the resonant amplitude and background can in general shift the peak in the mass spectrum by some fraction of $\Gamma/2$.

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              18  K*(0) - K*(+-) MASS DIFF. (MEV)

D      330   6.3      6.0              BARASH    67 HBC     0 PBAR P          8/67
D     1400   6.5      5.0              FICENEC1  68 HBC     1.3 K- P          2/69
D     1600   9.5      5.0              FICENEC2  68 HBC     2.7 K- P          2/69
D     7338   5.7      1.7              AGUILAR1  71 HBC   -0 3.9,4.6 K- P    11/71
D          . . . . . . . . . .
D   AVG      6.1      1.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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              18  K*(892) WIDTH (MEV)

W  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
W           46.0      8.0              CHADWICK  63 HBC  +   1.5 K+P
W     3870  46.0      3.0              WOJCICKI  64 HBC  -   1.7 K-P
W           51.0      3.0              ADELMAN   65 HBC  -   1.5 K-P           6/66
W           47.0      4.0              FERRO-LUZ 65 HBC  +   3.0 K+P
W           50.0     15.0              GELSEMA   65 HBC  -   1.5 K-P
W           50.       5.               BOMSE     67 HBC  +  2.3 K+P            7/67
W           53.       8.               DE BAERE  67 HBC  +  3.5 K+P (K+ PIO)   7/67
W           68.      10.               SALLSTROM 67 HBC  +  3. K+ P (KO PI+)   7/67
W           47.      10.               SALLSTROM 67 HBC  +  3. K+ P (K+ PIO)   7/67
W           44.       7.               BARLOW    67 HBC  +-  1.2 PBAR P       11/66
W           43.       9.               BARLOW    67 HBC  +- 1.2 PBAR P        11/66
W           53.       7.               BARLOW    67 HBC  +-  1.2 PBAR P       11/66
W           58.       7.               ADERHOLZ  68 HBC  -   10 K- P           6/68
W           58.      16.               FICENEC1  68 HBC  -   1.3 K-P (K-PIO)   9/67
W           44.      13.               FICENEC1  68 HBC  -   1.3 K-P (KOPI-)   9/67
W           41.0      8.0              SCHWEINGR 68 HBC  -   4.1 K-P           9/67
W           47.0      4.0              SCHWEINGR 68 HBC  -   5.5 K-P           9/67
W           57.0     13.0              FICENEC2  68 HBC  -   2.7 K- P(K-PIO)   2/69
W           48.0      9.0              FICENEC2  68 HBC  -   2.7 K- P(KOPI-)   2/69
W           52.0      8.0              KANG      68 HBC  -   4.6 K- P          7/69
W          (27.0)    (8.0)    (6.0)    ERWIN     69 HBC  +   3.5 K+ P        . 9/69
W          (53.)     (3.)              FRIEDMAN  69 HBC  -   2.1  K-P (3BDY)   2/72
W          (49.)     (4.)              FRIEDMAN  69 HBC  -   2.45 K-P (3BDY)   2/72
W          (46.)     (2.)              FRIEDMAN  69 HBC  -   2.6  K-P (3BDY)   2/72
W          (49.)     (3.)              FRIEDMAN  69 HBC  -   2.7  K-P (3BDY)   2/72
W           50.       7.               LIND      69 HBC  +   9. K+ P           5/70
W     4404  54.3      2.6      2.3     AGUILAR1  71 HBC  -   3.9,4.6 K- P     11/71
W     1300  48.2      2.8              CLARK     73 HBC  -  3.3 K-P,P PI- KO  2/74*
W          . . . . . . . . . .
W   AVG     49.8      1.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W  NEUTRAL ONLY.
W       70  60.0     10.0              COLLEY    62 HBC    0 2.0 PI-P
W      200  50.0      5.0              KRAEMER   63 HBC    0 2.3 K+P
W           53.      13.               BARLOW    67 HBC    0 1.2 PBAR P       11/66
W           34.       8.               BARLOW    67 HBC    0 1.2 PBAR P       11/66
W           44.       4.               DAUBER    67 HBC    0  2.0 K- P        12/66
W           58.       8.               DE WIT    68 DBC    0 3. K- D           9/69
W           52.      12.               FICENEC1  68 HBC    0 1.3 K-P (K-PI+)   9/67
W           50.0      8.0              FICENEC2  68 HBC    0 2.7 K- P(K-PI+)   2/69
W           48.0      8.0              KANG      68 HBC    0 4.6 K- P          7/69
W           51.0     11.0              SCHWEINGR 68 HBC    0 5.5 K-P           9/67
W           53.0     11.0              SCHWEINGR 68 HBC    0 4.1 K-P           9/67
W    10700  53.2      1.6              DAVIS     69 HBC    0 12. K+ P          9/69
W  D  2000  58.0      5.0              DE BAERE  69 HBC    0 5.0 K+ P          9/69
W  D          ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE.
W     4000  54.0      3.0              HABER     70 DBC    0 3. K-N            5/70
W     2934  55.8      4.2      3.4     AGUILAR1  71 HBC    0 3.9,4.6 K- P     11/71
W     5362  48.5      2.2              AGUILAR1  71 HBC    0 3.9,4.6 K- P     11/71
W  D  1700  51.4      5.0              BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P  12/72
W     3186  46.0      2.0              LEWIS     73 HBC    0 2.1-2.7 K+P      2/74*
W   C      (46.5)    (1.5)             LINGLIN   73 HBC    0 2-13 K+P,K+PI-   1/74*
W   C   FROM POLE EXTRAPOLATION, USING WORLD K+P DST
W          . . . . . . . . . .
W   AVG     50.6      1.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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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,COH  1/73

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                         REFERENCES FOR K*(892)

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)
KRAEMER  63 ATHENS CONF 130    R KRAEMER L MADANSKY +      (JOHNS HOPKINS)
SMITH    63 PRL 10 138         SMITH,SCHWARTZ,MILLER,KALBFLEISCH,HUF+(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 83 469          +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)

ADERHOLZ 68 NP B 5  567        +DEUTSCHMANN+  (AACH+BERL+CERN+LOIC+VIENNA)
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)
ERWIN    69 NP B 9 364         +WALKER,GOSHAW,WEINBERG    (WISC+PRIN+VAND)
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)
DE BAERE 70  CERN PHYS 70 41   +DEBAISIEUX,DE WOLF,DUFOUR,+    (BELG+CERN)
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)
CHARRIER 72 NP B 51 317        CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
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+ZEEM)

BERTHON  73 NP B 63 54         +MONTANET,PAUL,BERTRANET,+      (CERN+SACL)
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)

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 κ        19  K PI S WAVE, CALLED KAPPA(750-1700 MEV)
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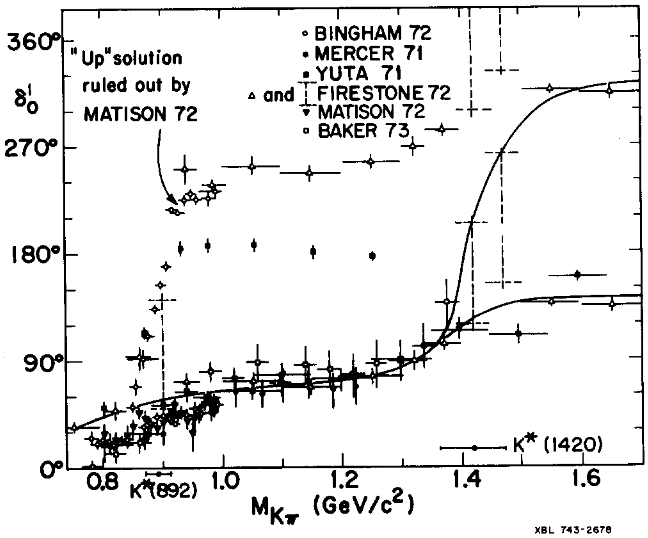
S-Wave $K\pi$ Interactions in the Region 750 - 1700 MeV

$K\pi$ interactions in the $I(J^P) = 1/2(0^+)$ wave can be described by the elastic phase shift δ_0^1 from the $K\pi$ threshold (~630 MeV) up to at least 1100 MeV (BINGHAM 72). The first inelastic S-wave thresholds are $K\pi\pi\pi$ and $K\eta$, neither of which is known to be important below 1400 MeV. Apart from the inelastic thresholds, the S-wave $\pi\pi$ and $K\pi$ interactions are reminiscent of each other.



S-wave $K\pi$ phase shift. An "up-down" ambiguity occurs at the mass of $K^*(892)$, $K^*(1420)$,..., which can be resolved by precise measurement of $\sigma(K\pi)$. At $K^*(892)$, the "up" solution was ruled out by MATISON 72; earlier "up" solutions are plotted only to show historical progress.

All phase-shift solutions (MERCER 71, YUTA 71, BINGHAM 72, FIRESTONE 71, 72, MATISON 72, BAKER 73, GALTIERI 73) share the following intrinsic ambiguities:

1) The standard modulo 180° ambiguity.

2) If one amplitude is dominant [the P wave near $K^*(892)$ or the D wave near $K^*(1420)$], then the observed S-P or S-D interference can be explain by two ambiguous S-wave solutions, known as "up" and "down". For an illustration see our 1972 edition.

The resulting "up-down" ambiguity of the S-wave phase shift in the $K^*(892)$ region (BINGHAM 72) was restricted by an analysis of 12 GeV/c $K^+p \to K^+\pi^-\Delta^{++}$ (MATISON 72, GALTIERI 73) to only two points at 890 and 900 MeV, where the P wave goes through 90°. The "up" solution is therefore excluded, except for a possibility of a very narrow ($\Gamma <$ 7 MeV) S-wave resonance. Moreover, CHUNG 72 imposes positivity on physical region $K\pi$ moments, and finds a narrow resonance most unlikely.

FIRESTONE 71 and 72 and YUTA 73 have continued $K\pi$ partial-wave analysis up to 1700 MeV. They find that δ_0^1 crosses 90° near 1300 MeV, and indeed shows the "up-down" ambiguity near the $K^*(1420)$.

Meanwhile several groups have attempted to clarify the situation around 1300 MeV. CORDS 72, FRATI 72, and ROUGE 72 give some support to the resonant S-wave interpretation of FIRESTONE 71. The other groups (AGUILAR 72, BUCHNER 72, CRENNELL 72, ENGELMANN 72, BAKER 73) agree that the S wave is important but not necessarily resonant. In analogy with the ππ case, where a possible ϵ pole is located several hundred MeV below the observed $\pi^0\pi^0$ peak and quite far from the real axis, the 1300 bump could also be caused by a quite distant κ pole.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                              REFERENCES FOR KAPPA

TRIPPE    68 PL 28 B 203          +CHIEN,MALAMUD,MELLEMA,SCHLEIN,+      (UCLA)

CRENNELL 69 PRL 22 487            +KARSHON,LAI,O.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)
CRENNELL 72 PR D 6 1220           +GORDON,KWAN-WU LAI,SCARR                (BNL)
DIEBOLD   72  BATAV.CONF.         R.DIEBOLD  RAPPORTEUR TALK               (ANL)
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)
ROUGE     72 NP B 46 29           +VIDEAU,VOLTE,DE BRION,+            (EPOL+SACL)
MATISON   72 LBL 1537 (THESIS) REVISED VERSION WILL GO TO PHYS.REV.     LBL

BAKER     73  IC/HEP/73/12        +BANNERJEE,CAMPBELL,HALL,ISLAM,+(LOIC+LOWC)
CORDS     73 NP B 54 109          +CARMONY,LANDER,MEIERE,+     (PURD+UCD+IUPU)
GALTIERI 73  PREP.LBL 1772        +MATISON,GARNJOST,FLATTE,FRIEDMAN,+    (LBL)
LINGLIN   73 NP B 55 408          D.LINGLIN                               (CERN)
YUTA      73 NP B 52 70           +ENGELMANN,MUSGRAVE,FORMAN,+        (ANL+EFI)

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Q REGION, Kππ(1240–1400)

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                    28  Q REGION I=1/2
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The main effect in the Q region is a broad bump in the Kππ spectrum between 1200 and 1400 MeV, i.e., not far above $K^*(892)\pi$ threshold, produced by K beams without charge exchange (for its absence in charge exchange, see WERNER 73). In particular, it has been observed in coherent K^+d interactions (FIRESTONE 72) and in coherent interactions on heavy nuclei (BINGHAM 73). The dominant J^P assignment throughout the whole region is 1^+ and $I = 1/2$.

The following points are relevant to the rather complex situation in the Q region:

- The broad Q peak does not have simple Breit-Wigner shape. It can be fitted at all energies by a superposition of two Breit-Wigner amplitudes (FIRESTONE 70, BARNHAM 71, BOWLER 71, BARLOUTAUD 73).

- Although evidence for narrower states in the Q region has been reported from non-diffractive reactions (π^-p, $\bar{p}p$), these have not been clearly identified with the two Breit-Wigner amplitudes.

- DEUTSCHMANN 74 have performed a partial-wave analysis of the Kππ system from $K^-p \to K^-\pi^-\pi^+p$ at 10 and 16 GeV/c. They claim that more than one J^P state is required to describe the Q [and L(1770)] enhancements.

- The Q bump was observed with a similar shape in the backward direction by FIRESTONE1 72.

- In addition to the dominant modes $K^*\pi$ and Kρ, there is some evidence for a Kππ mode, with the ππ or the Kπ system in an S wave. (ALEXANDER 69, BARNHAM 71, DAVIS 72, BARLOUTAUD 73, DEUTSCHMANN 74).

- **Analyses of the interference between the $K^*\pi$ and Kρ modes show the relative magnitude and relative** phase of the two amplitudes varying with Kππ mass. This is suggestive of the presence of two $J^P = 1^+$ resonances coming possibly from a mixing between the strange members of the $J^{PC} = 1^{++}$ ("A_1") and 1^{+-}(B) nonets (GOLDHABER 67, BARNHAM 71, BOWLER 71, GARFINKEL 71, FIRESTONE 72, BOWLER 74).

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                    28  Q  REGION MASS  (MEV)

M    PRODUCED BY BEAMS OTHER THAN K MESONS
M          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    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   . 9/69
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)    9/69
M        21 1300.0      10.0            ERWIN      69 HBC     0 3.5 K+P(K* PI)    9/69
M           1281.        7.             FRIEDMAN   69 HBC  -    2.6,2.7 K- P      9/69
M           1300.0      10.0            ABRAMS     70 HBC  +    2.5-3.2 K+ P     11/70
M           1260.       20.             FARBER     70 HBC  +    12.7 K+ P       . 6/70
M          (1325.0)                     DENEGRI    71 DBC   - 12.6 K-D,K 2PI D  5/71
M           1296.        5.             BARLOUTAU 73 HBC  -  14.3 K-P,P K-2PI  2/74*
M           1283.        6.             BARLOUTAU 73 HBC  -  14.3 K-P,P K02PI  2/74*
M           1315.        7.             BINGHAM    73 HLBC -  5.5-12.7 COH K-A  2/74*
M           1260.       10.             LEWIS      73 HBC  +  2.1-2.7 K+ P      1/74*
M    F     (1260.)      (5.)            LEWIS      73 HBC  +  2.1-2.7 K+ P      1/74*
M    F   FROM NON-PERIPHERAL EVENTS (T GT 0.8)
M          . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 2.9)

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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        12/72
ML          1240.0       5.0            BARNHAM    70 HBC  +  10.0 K+P,K 2PI   12/72
ML          1243.        8.             GARFINKEL 71 DBC  +  9. K+ D          12/72
ML          1228.       14.             ANDERSON   72 DBC  -  7.3 K- D         12/72
ML         (1260.)                      DAVIS      72 HBC  +  12. K+ P         12/72
ML          1234.       12.             FIRESTONE 72 DBC  +  12. K+ D          2/73
ML          . . . . . . . . . .
ML   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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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        12/72
MH          1380.0      20.0            ALEXANDER 69 HBC       9.0 K+ P        12/72
MH          1420.0       5.0            BARNHAM    70 HBC  +  10.0 K+P,K 2PI   12/72
MH          1344.        8.             GARFINKEL 71 DBC  +  9. K+ D          12/72
MH          1414.       15.             ANDERSON   72 DBC  -  7.3 K- D         12/72
MH         (1420.)                      DAVIS      72 HBC  +  12. K+ P         12/72
MH          1368.       18.             FIRESTONE 72 DBC  +  12. K+ D          2/73
MH          . . . . . . . . . .
MH   AVERAGE MEANINGLESS (SCALE FACTOR = 4.9)

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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    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 . 9/69
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)  9/69
W       21   40.0      15.0           ERWIN     69 HBC    0 3.5 K+P(K* PI)  9/69
W             51.      22.            FRIEDMAN  69 HBC  -   2.6,2.7 K- P    9/69
W            80.0      20.0           ABRAMS    70 HBC  +   2.5-3.2 K+ P   11/70
W           180.       28.            FARBER    70 HBC  +   12.7 K+ P    . 6/70
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 2/74*
W           266.       21.            BARLOUTAU 73 HBC  - 14.3 K-P,P K02PI 2/74*
W           150.       70.            LEWIS     73 HBC  + 2.1-2.7 K+ P     1/74*
W    F     (47.)     (18.)            LEWIS     73 HBC  + 2.1-2.7 K+ P     1/74*
W    F  FROM NON-PERIPHERAL EVENTS (T GT 0.8)
W          . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 6.9)

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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  12/72
WL           40.0      10.0               ALEXANDER 69 HBC      9.0 K+ P        12/72
WL          110.0      15.0               BARNHAM   70 HBC  + 10.0 K+P,K 2PI    12/72
WL           70.       26.       18.      GARFINKEL 71 DBC  + 9. K+ D           12/72
WL          111.       33.                ANDERSON  72 DBC  - 7.3 K- D          12/72
WL         (120.)                         DAVIS     72 HBC  + 12. K+ P          12/72
WL          188.       21.                FIRESTONE 72 DBC  + 12. K+ D           2/73
WL          . . . . . . . . . .
WL  AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

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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         12/72
WH          120.0      20.0               ALEXANDER 69 HBC      9.0 K+ P        12/72
WH          120.0      15.0               BARNHAM   70 HBC  + 10.0 K+P,K 2PI    12/72
WH          (60.)    OR LESS              GARFINKEL 71 DBC  + 9. K+ D           12/72
WH           89.       24.                ANDERSON  72 DBC  - 7.3 K- D          12/72
WH          (80.)                         DAVIS     72 HBC  + 12. K+ P          12/72
WH          241.       30.                FIRESTONE 72 DBC  + 12. K+ D           2/73
WH          . . . . . . . . . .
WH  AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

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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+ 770
P3      Q REGION INTO K PI                                497+ 139
P4      Q REGION INTO K ETA                               497+ 548
P5      O REGION INTO K OMEGA                             497+ 782
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+0 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+0 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 INTC (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)

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


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        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)
    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

        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    (ROCH)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+LOIC+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,MELLEMA,RUDNICK,SCHLEIN+     (UCLA)
CHUNG    69 PR 182 1443       +EISNER+BALI+LUERS                     (BNL)
COLLEY   69 NC A 59 519       +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+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+
BARNHAM  70 NP B 25 49        +COLLEY,GRIFFITHS,ALPER,+   (BIRM+GLAS+OXF)  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+
SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

ANDERSON 72 PR D 6 1823       +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BINGHAM  72 NP B 48 589       +EISENSTEIN,GRARD,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)
CRENNELL 72 PR D 6 1220       +GORDON,KWAN-WU LAI,SCARR              (BNL)
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        +FARWEL,+        (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,+(LOWC+LOIC+CDEF)
WERNER   73 PR D 7 1275       +SLATTERY,FERBEL                 (ROCHESTER)

BOWLER   74  SUBM.TO NP B     +DAINTON,KADDOURA,AITCHISON         (OXFORD)  JP
DEUTSCHM 74 PL B              DEUTSCHMANN,+     (AACH+BERL+CERN+LOIC+VIEN)  JP
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K*(1420)

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22  K* (1420,JP=2+) I=1/2

          JP = 3- IS UNLIKELY BUT NOT YET COMPLETELY RULED OUT.

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                    22  K*(1420) MASS (MEV)

M    FOR DIFFICULTIES IN MEASURING MASS DIFFERENCE, SEE TYPED NOTE
M    UNDER K*(892)

M    CHARGED ONLY, WITH FINAL STATE K PI
M           1440.       24.0      40.   DE BAERE  67 HBC  +  3.5 K+P (K+ PIO) 10/66
M           1423.       21.             ADERHOLZ  68 HBC  -   10 K- P (K PI)   6/68
M           1401.0      20.0            SCHWEINGR 68 HBC  -   4.1 K- P (K PI)  2/72
M           1427.0       9.0            SCHWEINGR 68 HBC  -   5.5 K- P (K PI)  9/67
M           1425.0      15.0            BISHOP    69 HBC  +   3.5 K+ P         9/69
M           1416.0      10.0            CRENNELL  69 DBC  -   3.9 K-N (KOPI-)  7/69
M           1414.       11.             LIND      69 HBC  +   9. K+ P(KO PI+)  9/69
M           1430.       10.             ABRAMS    70 HBC  +  2.5-3.2 K+P,K2PI 11/70
M      1400 1420.0       3.1            AGUILAR1  71 HBC  -   3.9,4.6 K- P    11/71
M       200 1425.        6.             BARNHAM   71 HBC  +  K+ P,KO PI+ P     1/72
M    C  130(1418.)      (6.)            CLARK     73 HBC  -  3.3 K-P,P PI- KO  2/74*
M    C  CLARK 73 DO NOT SEE THE K*(1420) AT 3.13 GEV/C
M           . . . . . . . . . . .
M    AVG    1421.3       2.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M    CHARGED ONLY, WITH OTHER FINAL STATES
M           1400.0      20.0            BADIER    65 HBC  -  3.  K- P (K*PI) 10/66
M        20 1440.0      20.0            DUBAL     68 MMS  -  11.5 K- P         6/68
M   8   240 1396.        6.             BASSOMPIE 69 HBC  +   5 K+P (K 2PI)   11/69
M          (1411.)      (7.)            FRIEDMAN  69 HBC  -  2.7 K-P (K 2PI)   2/72
M           . . . . . . . . . . .
M    AVG    1399.7       8.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
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M    CHARGED AND NEUTRAL
M            1404.0     15.0              FOCARDI   65 HBC   -0 3.  K- P (K PI) 10/66
M            1390.0     30.0              SHEN      66 HBC  + 0 4.6 K+ P (K PI) 10/66
M            1430.0     10.0              SHEN      66 HBC  + 0 4.6 K+ P (K*PI) 10/66
M            1423.0      7.0              BASSANO   67 HBC   -0 4.6, 5.0 K- P   10/67
M            1420.0     10.0              GOLDHABER 67 HBC       9.0 K+ P(K 2PI) 10/67
M            . . . . . . . . .
M    AVG     1421.2      4.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M    NEUTRAL ONLY
M           (1446.0)    (7.9)             DAHL      67 HBC    0 4.PI- P (KPI)     2/74*
M            1425.0     15.0              KANG      68 HBC    0 4.6 K- P           7/69
M            1405.0     18.0              SCHWEINGR 68 HBC    0 4.1 K- P (K PI)    9/67
M            1397.0     19.0              SCHWEINGR 68 HBC    0 5.5 K- P (K PI)    9/67
M  B    420 1422.        5.               BASSOMPIE 69 HBC    0 5 K+P (K PI)      11/69
M  B BASSOMP. ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE K* TYPED NOTE.  11/69
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-     1/74*
M   C    FROM POLE EXTRAPOLATION, USING WORLD K+P DST
M            . . . . . . . . .
M    AVG     1421.8      1.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
                                 (SEE IDEOGRAM BELOW )
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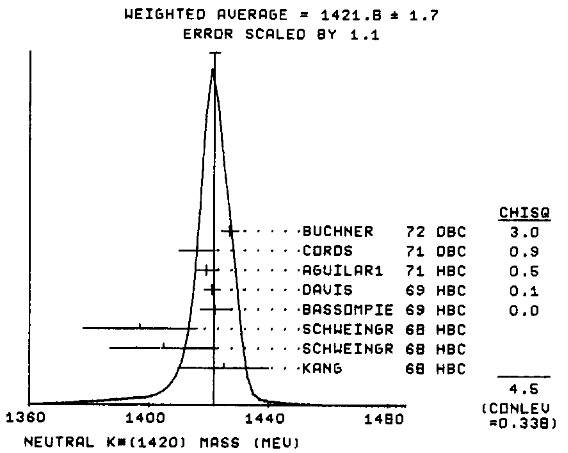

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22 K*(1420) WIDTH (MEV)

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W    CHARGED ONLY, WITH FINAL STATE K PI
W           175.       57.               ADERHOLZ  68 HBC   -  10 K- P (K PI)     6/68
W           110.0      25.0              BISHOP    69 HBC   +  3.5 K+ P           9/69
W            96.       18.               LIND      69 HBC   +  9. K+ P            5/70
W            80.0      20.0              ABRAMS    70 HBC   +  2.5-3.2 K+P,K2PI 11/70
W      1400  94.7      15.1     12.5     AGUILAR1  71 HBC   -  3.9,4.6 K- P      11/71
W       200 115.       20.               BARNHAM   71 HBC   +  K+ P,K0 PI+ P      1/72
W   C   130 (42.)     (12.)              CLARK     73 HBC   -  3.3 K-P,P PI- K0   2/74*
W   C  CLARK 73 DO NOT SEE THE K*(1420) AT 3.13 GEV/C
W           . . . . . . . . .
W    AVG     99.1       8.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W    CHARGED ONLY, WITH OTHER FINAL STATES
W           105.0      30.0              BADIER    65 HBC   -  3.0 K-P            6/66
W   B   240 110.       25.               BASSOMPIE 69 HBC   +  5 K+P (K 2PI)     11/69
W           (43.)     (13.)              FRIEDMAN  69 HBC   -  2.7 K-P (K 2PI)    2/72
W           . . . . . . . . .
W    AVG    108.0      19.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W    CHARGED AND NEUTRAL
W            92.0      14.0              FOCARDI   65 HBC   -0 3.0 K- P (K PI)
W            75.0      25.0              SHEN      66 HBC   + 04.6 K+ P           8/66
W            65.0      20.0              BASSANO   67 HBC   -0 4.6, 5.0 K- P    10/67
W            80.0      20.0              GOLDHABER 67 HBC      9.0 K+ P(K 2PI) 10/67
W           107.0      20.0              SCHWEINGR 68 HBC   -0 4.1+5.5 K-P        9/67
W           . . . . . . . . .
W    AVG     85.9       8.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W    NEUTRAL ONLY
W           (61.0)    (24.0)             DAHL      67 HBC    0 3.8-4.2 PI- P      2/74*
W           116.0      17.0              KANG      68 HBC    0 4.6 K- P           7/69
W   B   420 110.       21.               BASSOMPIE 69 HBC    0 5 K+P (K PI)      11/69
W   B         ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K* TYPED NOTE.
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       600 144.       22.               CORDS     71 DBC   0 9. K+ N,K+ PI- P   2/72
W   B  1100 109.       12.               BUCHNER   72 DBC   0 4.6 K+ N,K+ PI-P 12/72
W    C      (61.0)    (14.0)             LINGLIN   73 HBC   0 2-13 K+P,K+PI-     1/74*
W    C   FROM POLE EXTRAPOLATION, USING WORLD K+P DST
W           . . . . . . . . .
W    AVG    111.1       5.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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22 K*(1420) PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1      K*(1420) INTO K PI                              493+ 139
P2      K*(1420) INTO K*(892) PI                        892+ 139
P3      K*(1420) INTO K RHO                             493+ 770
P4      K*(1420) INTO K OMEGA                           493+ 782
P5      K*(1420) INTO K ETA                             493+ 548
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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 1  .5495+-.0274
P 2   -.2293    .2945+-.0247
P 3   -.3950     -.3925   .0923+-.0241
P 4   -.2443     -.2458     -.1182   .0440+-.0166
P 5   -.4097     -.2442     -.0787     -.0502   .0197+-.0200
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22 K*(1420) BRANCHING RATIOS

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R1       K*(1420) INTO (K PI)/TOTAL                            (P1)
R1   R         (0.37)    (0.19)          BADIER    65 HBC      3.0 K-P            6/66
R1   R         (0.39)    (0.11)          BASSANO   67 HBC   -  4.6, 5.0 K- P     10/67
R1   R          WE CANNOT USE THIS STATISTICALLY REDUNDANT RATIO. AUTHORS
R1   R          OBTAIN IT MERELY BY SUBTRACTING FROM UNITY THEIR
R1   R          MEASUREMENTS OF OTHER RATIOS.
R1             . . . . . . . . .
R1   FIT        0.550     0.027   FROM FIT

R2       K*(1420) INTO (K*(892) PI) / TOTAL                    (P2)
R2   Q          (.41)    (0.14)          BADIER    65 HBC      3.0 K-P            6/66
R2   Q         (0.47)    (0.10)          BASSANO   67 HBC   -  4.6, 5.0 K- P     10/67
R2             . . . . . . . . .
R2   FIT        0.295     0.025   FROM FIT

R3       K*(1420) INTO (K RHO)/TOTAL                           (P3)
R3   Q         (0.14)    (0.05)          BADIER    65 HBC      3.0 K-P            6/66
R3   Q         (0.14)    (0.10)          BASSANO   67 HBC    0 4.6, 5.0 K- P     10/67
R3             . . . . . . . . .
R3   FIT        0.092     0.024   FROM FIT

R4       K*(1420) INTO (K OMEGA)/TOTAL                         (P4)
R4              0.07      0.04           BADIER    65 HBC      3.0 K-P            6/66
R4             . . . . . . . . .
R4   FIT        0.044     0.017   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5       K*(1420) INTO (K ETA)/TOTAL                           (P5)
R5              0.02      0.02           BADIER    65 HBC      3.0 K-P            6/66
R5             (0.025)OR LESS            BASSOMPIE 69 HBC      5.0 K+ P           9/68
R5             . . . . . . . . .
R5   FIT        0.020     0.020   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6       K*(1420) INTO (K*(892) PI) / (K PI)                   (P2)/(P1)
R6        6     0.33      0.33           CHUNG     65 HBC  + 0  3.9-4.2 PI- P     8/66
R6              0.65      0.20           SHEN      66 HBC    0  N* PRODUCED      10/66
R6   Q         (0.63)    (0.20)          SHEN      66 HBC  +    NO N* PRODUCED 10/66
R6              0.52      0.12           SCHWEINGR 68 HBC    0 4.1+5.5 K- P     10/67
R6   B         (0.9)     (0.2)           BASSOMPIE 69 HBC  + 0 5 K+P              1/73
R6   B   SUPERSEDED BY CHARRIERE 72
R6   Q   84    (0.93)    (0.11)          BISHOP    69 HBC      3.5 K+ P           9/69
R6              0.47      0.08           AGUILAR1  71 HBC      3.9,4.6 K- P      11/71
R6              0.78      0.15           CHARRIERE 72 HBC   0 5. K+ P,K P 3PI     1/73
R6             . . . . . . . . .
R6   AVG        0.537     0.058   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6   FIT        0.536     0.057  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R7       K*(1420) INTO (K OMEGA) / K PI                        (P4)/(P1)
R7             (0.08) OR LESS            SHEN      66 HBC      4.6 K+P            8/66
R7             (0.2)  OR LESS            BASSOMPIE 69 HBC  +    5 K+ P            9/69
R7              0.13      0.07           BASSOMPIE 69 HBC   0 5 K+ P              9/69
R7              0.05      0.04           AGUILAR1  71 HBC      3.9-4.6 K- P      11/71
R7             . . . . . . . . .
R7   AVG        0.070     0.035   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7   FIT        0.080     0.031  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R8       K*(1420) INTO (K RHO) / (K PI)                        (P3)/(P1)
R8             (0.09) OR LESS            CHUNG     65 HBC  + 0  3.9-4.2 PI- P     8/66
R8              0.26      0.16           SCHWEINGR 68 HBC    0 4.1+5.5 K- P     10/67
R8             (0.2)  OR LESS            BASSOMPIE 69 HBC  +    5 K+ P            9/69
R8             (0.3)  OR LESS            BASSOMPIE 69 HBC    0 5 K+ P             9/69
R8   Q   15    (0.11)    (0.06)          BISHOP    69 HBC      3.5 K+ P           9/69
R8              0.16      0.05           AGUILAR1  71 HBC      3.9,4.6 K- P      11/71
R8             . . . . . . . . .
R8   AVG        0.169     0.048   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   FIT        0.168     0.048  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9       K*(1420) INTO (K RHO) / (K*(892) PI)                  (P3)/(P2)
R9             (0.39) OR LESS            BASSOMPIE 67 HBC  +    5. K+ P           9/67
R9             (0.40) OR LESS  CL=.90    FIELD     67 HBC   - 3.8 K- P            6/67
R9             . . . . . . . . .
R9   FIT        0.313     0.095   FROM FIT

R10      K*(1420) INTO (K OMEGA) / (K*(892) PI)                (P4)/(P2)
R10 Q          (0.10)    (0.04)          FIELD     67 HBC   - 3.8 K- P            6/67
R10            . . . . . . . . .
R10 FIT         0.149     0.061   FROM FIT

R11      K*(1420) INTO (K ETA) / (K*(892) PI)                  (P5)/(P2)
R11 Q          (0.07)    (0.04)          FIELD     67 HBC   - 3.8 K- P            6/67
R11            . . . . . . . . .
R11 FIT         0.067     0.069   FROM FIT

R12      K*(1420) INTO (K ETA) / (K PI)                        (P5)/(P1)
R12            (0.02) OR LESS            BISHOP    69 HBC      3.5 K+ P           9/69
R12            (0.04) OR LESS  CL=.95    AGUILAR1  71 HBC      3.9-4.6 K- P      11/71
R12            . . . . . . . . .
R12 FIT         0.036     0.037   FROM FIT

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.
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REFERENCES FOR K*(1420)


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BADIER    65 PL 19 612          BADIER,DEMOULIN,GOLDBERG+(EPOL+SACL+ZEEMAN)
CHUNG     65 PRL  15  325       +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FOCARDI   65 PL 16 351          FOCARDI,MINGUZZI RANZI,SERRA+(BOLOGNA+SACL)
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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         BASSOMPIERRE,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)
SLATTERY 71  UR-875-332(PREP)   P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

BUCHNER  72 NP B 45 333         +DEHM,CHARRIERE,CORNET,+    (MPIM+CERN+BRUX)
CHARRIER 72 NP B 51 317         CHARRIERE,DRIJARD,DE BAERE,+    (CERN+BELG)
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+ZEEM)

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)

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KN(1660)

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                         27  KN (1660, JP=   ) I = 1/2

                 EVIDENCE NOT COMPELLING, OMITTED FROM TABLE

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                      27  KN(1660) MASS (MEV)

M          (1660.0)                  CARMONY    67 HBC   -  3.8 K-P,OMEGA K 11/67
M           1660.0     10.0          JOBES      67 HBC   +  5. K+ P         11/67
M    J      CLAIMED BY JOBES IN (K PI), (K*(892) PI), AND (K*(1420) PI)
M    J      MODES. K PI BUMP INTERFERES MOSTLY WITH DELTA(1236).
M          (1660.)                   CHARRIERE 72 HBC   0 5. K+ P,K P 3PI   1/73

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                      27  KN(1660) WIDTH (MEV)

W            60.0      20.0          JOBES      67 HBC   +  5. K+ P         11/67
W           (60.)                    CHARRIERE 72 HBC   0 5. K+ P,K P 3PI   1/73

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                      27  KN(1660) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       KN(1660) INTO K PI                                  493+ 139
P2       KN(1660) INTO K PI PI                               493+ 139+ 139
P3       KN(1660) INTO K*(892) PI                            892+ 139
P4       KN(1660) INTO K*(1420) PI                          1421+ 139

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                          REFERENCES FOR KN(1660)

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 72 NP B 51 317         CHARRIERE,DRIJARD,DE BAERE,+     (CERN+BELG)

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KN(1760)

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                  60  KN (1760,JP=   )

                  NEEDS FURTHER CONFIRMATION.OMITTED FROM THE TABLE.
                  CARMONY 71 FAVORS JP=3-, AGUILAR 73 NEEDS J GT 0.

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                      60  KN(1760) MASS (MEV)

M    C    76(1753.)     (12.)        CARMONY    71 DBC    0 9. K+ N          11/71
M         65(1760.)                  AGUILAR    73 HBC    0 7.3 K-P,N K+ PI-  1/74*

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                      60  KN(1760) WIDTH (MEV)

W    C    76  (60.)     (20.)        CARMONY    71 DBC    0 9. K+ N          11/71
W    C    DISAGREEMENT BETWEEN THE FIT AND DATA ON BOTH SIDES OF THE SIGNAL  11/71
W         65  (80.)  OR LESS         AGUILAR    73 HBC    0 7.3 K-P,N K+ PI-  1/74*

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                   60  KN(1760) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       KN(1760) INTO K PI                                  493+ 139
P2       KN(1760) INTO K*(892) PI                            892+ 139
P3       KN(1760) INTO K RHO                                 493+ 770
P4       KN(1760) INTO K*(1420) PI                          1421+ 139
P5       KN(1760) INTO K PI PI                               493+ 139+ 139

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                   60  KN(1760) BRANCHING RATIOS

R1       KN(1760) INTO (K PI)/(K*(892) PI + K RHO)        (P1)/(P2+P3)
R1   ES        (0.40)    (0.10)         CARMONY   71 DBC    0 9. K+ N      11/71
R1    S   STATIST. COMPATIBLE WITH THE WEAK K PI PI SIGNAL OF AGUILAR 73.   1/74*

R2       KN(1760) INTO (K*(892) PI)/(K PI PI)             (P2)/(P5)
R2   E         (0.40)    (0.15)         CARMONY   71 DBC    0 9. K+ N      11/71

R3       KN(1760) INTO (K RHO)/(K PI PI)                  (P3)/(P5)
R3   E         (0.60)    (0.25)         CARMONY   71 DBC    0 9. K+ N      11/71

R4       KN(1760) INTO (K*(892) PI + K RHO)/(K PI PI)     (P2+P3)/(P5)
R4   E         (1.)      (0.12)         CARMONY   ,1 DBC    0 9. K+ N      11/71

R5       KN(1760) INTO (K*(1420) PI)/(K PI PI)            (P4)/(P5)
R5   E         (0.06) OR LESS           CARMONY   71 DBC    0 9. K+ N      11/71
R5   E   DIFFICULT BACKGROUND SUBTRACTION . ERRORS STATISTICAL ONLY .      11/71

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                          REFERENCES FOR KN(1760)

CARMONY  71 PRL 27 1160         +CORDS,CLOPP,ERWIN,MEIERE,+ (PURD+UCD+IUPU)
AGUILAR  73 PRL 30 672          +CHUNG,EISNER,PROTOPOPESCU,SAMIOS,+   (BNL)

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L(1770)

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                  23  L (1770, JP=   ) I = 1/2

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                      23  L MASS (MEV)

M         20(1780.)                  BERLINGHI 67 HBC  +   12.7 K+P          7/67
M           (1760.0)    (15.0)       JOBES     67 HBC  +   5. K+ P           1/73
M    B      (1785.0)    (12.0)       BARTSCH   68 HBC      10.0 K- P        11/71
M    B       INCLUDED IN BARTSCH 70                                         11/71
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)

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                      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    B      (127.0)     (43.0)       BARTSCH   68 HBC      10.0 K- P        11/71
W    B       INCLUDED IN BARTSCH 70                                         11/71
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)

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                      23  L PARTIAL DECAY MODES

                                                              DECAY MASSES
P1       L INTO K PI PI                                      497+ 134+ 134
P2       L INTO K*(1420) PI                                  134+1421
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+ 770
P6       L INTO K*(892) OMEGA                                892+ 782
P7       L INTO K*(892) PI PI                                892+ 134+ 134

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                      23  L BRANCHING RATIOS

R1       L INTO (K*(1420) 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 .                                 11/71

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                          REFERENCES FOR L(1770)

BARTSCH  66 PL 22 357           +DEUTSCHMANN,+    (AACH+BERL+CERN+LOIC+VIEN)
BERLINGH 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)
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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)
CHIEN    70  PHILA.CONF.P.275 C.Y.CHIEN                    (JOHNS HOPKINS)
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)
SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

ANDERSON 72 PR D 6 1823         +FRANKLIN,GODDEN,KOPELMAN,LIBBY,TAN  (COLO)
BLIEDEN  72 PL 39 B 668         +FINOCCHIARO,BOWEN,EARLES,+      (STON+NEAS)
CHARRIER 72 NP B 51 317         CHARRIERE,DRIJARD,DE BAERE,+     (CERN+BELG)
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          +FARWEL,+      (LBL+ORSAY+BNL+SACLAY+MILAN)
DEUTSCHM 74 PL B                DEUTSCHMANN,+     (AACH+BERL+CERN+LOIC+VIEN)  JP

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K_N(1850)

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                         61  KN (1850,JP=  )

STRUCTURE IS SEEN IN THE K PI SCATTERING ANGULAR DISTRIBUTION
AT MASSES NEAR 1850 MEV.THE MOST SIMPLE EXPLANATION INVOLVES
A RAPIDLY INCREASING F-WAVE AMPLITUDE,POSSIBLY INDICATING
PRESENCE OF A JP=3- RESONANCE.
NEEDS FURTHER CONFIRMATION. OMITTED FROM THE TABLE.

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                 61  KN(1850) MASS (MEV)

M   I     (1850.)   APPROX.          FIRESTONE 71 DBC    0 12.K+ N,K+ PI-P 11/71

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                 61  KN(1850) WIDTH (MEV)

W   I     (300.)   APPROX.           FIRESTONE 71 DBC    0 12.K+ N,K+ PI-P 11/71
W   I     APPARENT INTERFERENCE WITH OTHER AMPLITUDES PRECLUDES            11/71
W   I     PRECISE DETERMINATION .                                           11/71

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                         REFERENCES FOR KN(1850)

FIRESTON 71 PL 36 B 513         FIRESTONE,GOLDHABER,LISSAUER,TRILLING (LBL)
WALUCH   73 PR D 8 2237         +FLATTE,FRIEDMAN                      (LBL)

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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)

CARMONY  71 PRL 27 1160         +COROS,CLOPP,ERWIN,MEIERE,+  (PURO+UCD+IND)
SLATTERY 71  UR-875-332(PREP) P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

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K^*(2800)

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                         62  K* (2800,JP=  )

                 NEEDS FURTHER CONFIRMATION.OMITTED FROM THE TABLE.

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                 62  K*(2800) MASS (MEV)

M    H  59(2800.)                   HUGHES     71 HBC  +  10.K+P,P MMS+     11/71

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                 62  K*(2800) WIDTH (MEV)

W    H  59  (40.)   OR LESS         HUGHES     71 HBC  +  10.K+P,P MMS+     11/71
W    H     ONLY SEEN IN MISSING MASS DISTRIBUTION,NOT IN FITTED EVENTS.    11/71
W    H     PROBABLY DECAYS INTO (3 CHARGED + 2 OR MORE NEUTRAL) PARTICLES  11/71

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                         REFERENCES FOR K*(2800)

HUGHES    71  PREPRINT          +MC*CORMICK,PROCTER,TURNBULL       (GLASGOW)

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EXOTICS

The purpose of this entry is to provide a list of references for searches for exotic mesons (see Main Text, Sec. III and Table I), as well as theoretically based suggestions for experiments. Note that LIPKIN 73 proposes experiments which are conclusive even if negative results are obtained.

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                         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+ZEEM+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    72  PREP. UR 413     D.COHEN+                              (ROCH)
COHEN    73 NP B 53 1         +FERBEL,SLATTERY,WERNER          (ROCHESTER)
FRENCH   73  AIX CONF.PAPER   B.R.FRENCH                            (CERN)

                         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+NAL)

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Note on N's and Δ's: I. Determination of Resonance Parameters

A. Spread in Values of Resonance Parameters

Values of masses, widths, and branching ratios are obtained mainly from phase-shift analyses. In production experiments, in fact, it is seldom clear which of the many states at similar masses is being observed. In addition to a few complete phase-shift analyses, we have other analyses, done by using somewhat incomplete data, by various different groups, but we are quite far from having reliable masses and widths derived therefrom.

There are essentially two problems in obtaining reliable resonance parameters. First there is often disagreement as to just what the values of the phase shifts (η's and δ's) are. This problem is obviously related to the quality and quantity of the data and to the procedures used to determine or choose the phase shifts. Secondly, even if smooth curves were available for the phase shifts, there would still be some ambiguity in deciding what the resonant parameters are. We might hope that some sort of energy-dependent fit to the smooth phase shifts would yield unique parameters. Unfortunately, however, a sufficiently clever combination of background and/or resonances could fit the phase shifts, satisfy elastic unitarity, and still yield the wrong parameters. (See I. B. and I. C. below.)

We list the values of M, Γ and x quoted by the various authors with a comment on the method used to derive such parameters. We now discuss briefly the different methods used. AYED 74 analyze their phase-shift results with an energy-dependent background and Breit-Wigner amplitudes. BAREYRE 68 uses two methods: 1) cross-section method — the energy where the total cross section is maximum; 2) speed method — the energy where the speed of variation of the amplitude in the Argand plot is maximum. CERN, as well as ALMEHED 72, usually associate a resonance with simultaneous clear structure in η and δ. The Glasgow group (DAVIES 70) uses Breit-Wigner parametrization; their solutions A and B differ in the starting values of the minimization (CERN I solution was used for solution B). Only the parameters from solution A are included in the listings. For some states no parameters have been quoted by the authors.

At the beginning of the Data Card Listings for N's and Δ's, we present a table giving our evaluation 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 parameters, but only give ranges for masses and widths in order to emphasize that in some cases these parameters are quite poorly determined.

B. Note on Speed Plots

In the discussion which follows, we use the term "speed plot" to indicate a plot showing the variation with c.m. energy E of the derivative $|dT/dE|$ of a partial-wave amplitude T. (See section IV.A of the main text.) In principle such plots are a very sensitive and useful means of searching for a resonance. A rapid increase in speed followed by a rapid decrease is certainly a good indication of the presence of a resonance. In practice these plots must be judiciously used because:

1) The values of dT/dE are sensitive to variations in T. It is difficult enough to determine T(E); finding its derivative is necessarily more difficult.

2) Once the speed plot tells us that a resonance is present, the determination of precise parameters from such a plot requires additional considerations:

a) the maximum of the speed is not necessarily at the resonance mass,

b) the width cannot simply be obtained by the relation $|dT/dE|_{E=M} = 2x/\Gamma$.

Consider for example the P_{33} partial-wave amplitude in π-N scattering. Since its elasticity (x) is one, we have

$$T(E) = \frac{\Gamma(E)/2}{M-E-i\Gamma(E)/2}. \qquad (1)$$

If we let $\Gamma'(E) = d\Gamma/dE$, then we find that

$$\text{"Speed"} = \left|\frac{dT}{dE}\right| = \frac{2}{\Gamma}\,\frac{1+(M-E)\Gamma'/\Gamma}{1+4(M-E)^2/\Gamma^2}. \qquad (2)$$

To estimate where Eq. (2) is maximum, we let $E = M + \delta$ and find that for small δ,

$$\frac{d}{dE}\left|\frac{dT}{dE}\right| = -\frac{16}{\Gamma^3}\left(\frac{\Gamma\Gamma'}{8}+\delta\right) + \mathcal{O}(\delta^2). \qquad (3)$$

Since all reasonable parametrizations of Γ(E) agree that $\Gamma' \geq 0$, we may conclude that the "speed" will have its maximum value at an energy about $\Gamma\Gamma'/8$ less than the resonant value, E = M.

This effect is illustrated in Fig. I.1, which is taken from UCRL-20030 πN.[1] For the P_{33} partial wave, the CERN experimental and CERN Kirsopp solutions indicate the instability of $|dT/dE|$ in the region of a resonance (the other solutions are "smooth" by the nature of the analysis). In addition, each of the plots, quite consistently, gives $2/\Gamma \approx 16$ GeV^{-1} at a resonant mass of ~1236 MeV. This corresponds to a width at resonance of ~125 MeV. The speed, however, peaks some 10 to 15 MeV lower in mass and at a value of ~18.5 GeV^{-1}. Hence, were we to estimate the mass and width of the 33-resonance from the maximum speed, we would get $M \approx 1220$ MeV and $\Gamma = 108$ MeV.

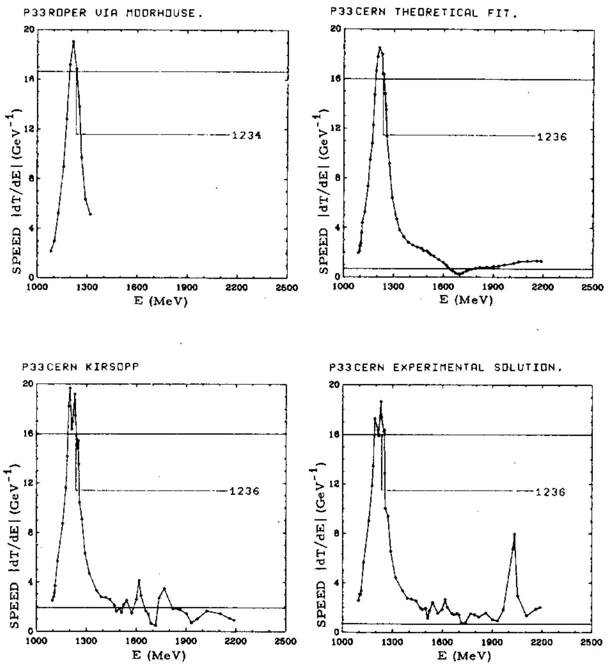

Fig. I.1 Speed plots as computed from four solutions compiled in Ref. 1. E is the c.m. energy.

C. Comments on the Mass and Width of Δ(1232)

In previous editions[2,3] we presented exhaustive studies of the resonance parameters for the Δ(1232). We concluded[3] that if any parameters are "unique" they are those given by the pole position.

On the basis of that study we have entered the pole position in both the Table and the Data Card Listings. We remind the reader of our conclusions.

1) Over a reasonable energy interval on the real axis, all parametrizations of the amplitude are equally good provided:

a) they fit the data,

b) they are unitary and have sensible threshold behavior (e.g., $\delta_\ell \propto q^{2\ell+1}$).

2) For good fits to the same data, the resonance mass and width on the real axis depend upon the parametrization used (background +BW, different BW's, etc.). Indeed, we found that the fitted mass parameter ranged from 1230 to 1235 MeV, and the width from 109 to 124 MeV. Clearly, it is meaningless for us to average masses and widths corresponding to either different parametrizations or significantly different sets of data.

3) For good fits to the same data, the pole position is essentially independent of the parametrization.

An analysis of the Δ(1232) pole position which in principle seems more general has been made by NOGOVA 73. It is unfortunate, however, that these authors did not use the same phase shift "data" as in ref. 2 and 3.

D. Availability of Partial-Wave Analyses and Data

All the solutions mentioned in this note, including AYED 74 and ALMEHED 72, are available on tape from the Particle Data Group. This tape is essentially an updated version of the one corresponding to the compilation of ref. 1. In addition, a tape of the extensive input data used by ALMEHED 72[4] and a booklet of enlarged reproductions of all the baryon Argand plots (N, Δ, Z^*, and Y^*) shown in the following pages are available from the Particle Data Group, LBL, Berkeley.

References for Section I

1. D. J. Herndon, A. Barbaro-Galtieri, A. H. Rosenfeld, UCRL-20030 πN (Feb. 1970).
2. Particle Data Group, Rev. Mod. Phys. 43, S114 (1971).
3. Particle Data Group, Phys. Lett. 39B, 103 (1972).
4. C. Lovelace et al., LBL-63 (April 1973).

Note on N's and Δ's: II. $\pi N \to \pi N, \eta N, K\Sigma$

The most recent available $\pi N \to \pi N$ amplitudes are from the analysis of the Saclay group, AYED 74. These are shown in Figs. II.1-II.6. The analysis included the recent Berkeley[1] and Saclay[2] charge exchange data as well as the precise $\pi^\pm p$ differential cross-section measurements in the Δ(1232) region ($180 \le P_{LAB} \le 408$ MeV/c) by Bussey et al.[3] These

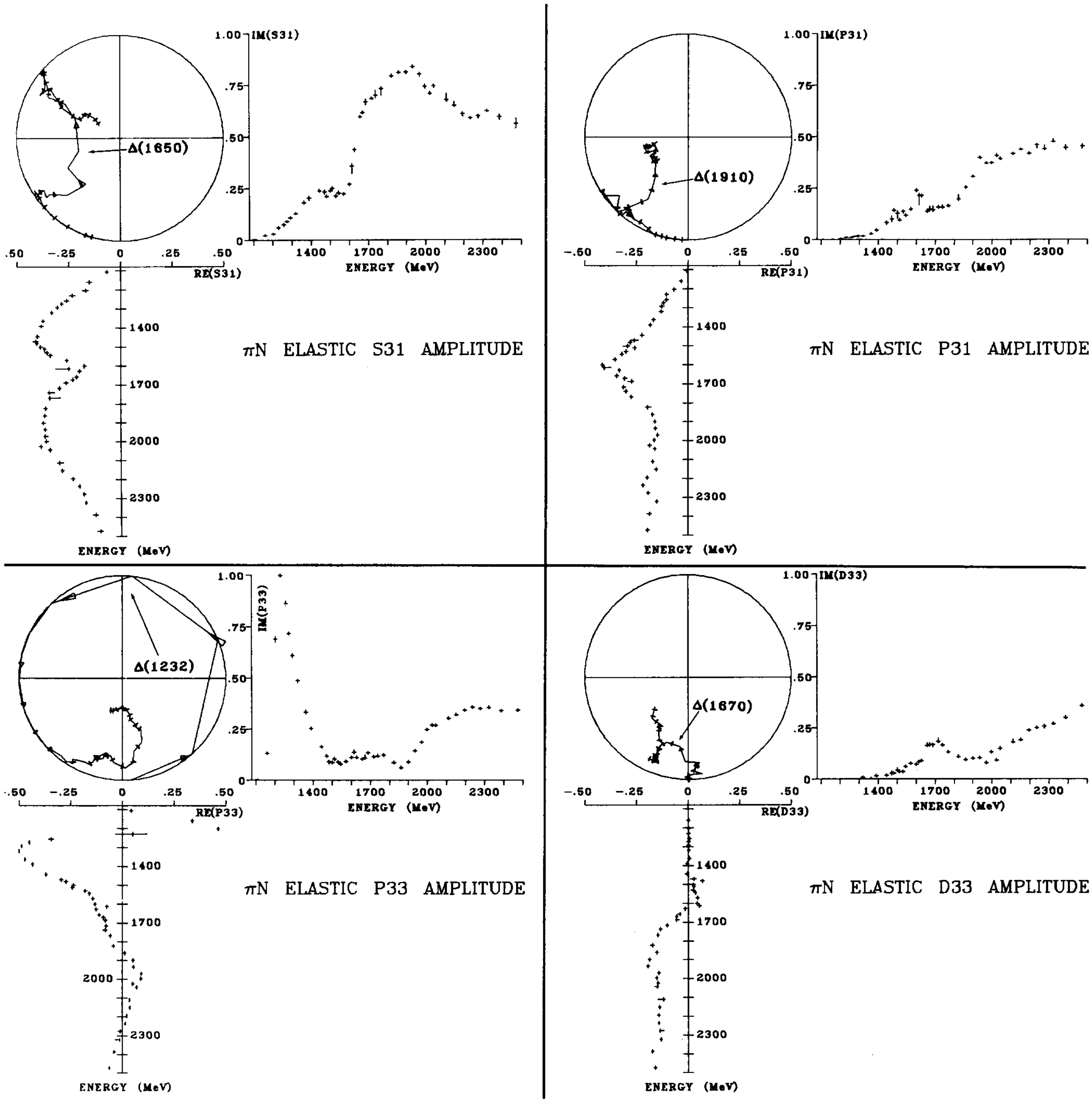

Fig. II.1. Amplitudes for I = 3/2 πN elastic scattering in the J = 1/2 and J = 3/2 waves from AYED 73. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. Established resonances in these waves are the Δ(1650), Δ(1910), Δ(1232), and Δ(1670) in the S_{31}, P_{31}, P_{33}, and D_{33} waves, respectively; these are indicated on the above Argand plots. See the Data Card Listings and the accompanying mini-review for other possible resonances in the S_{31} and P_{33} waves.

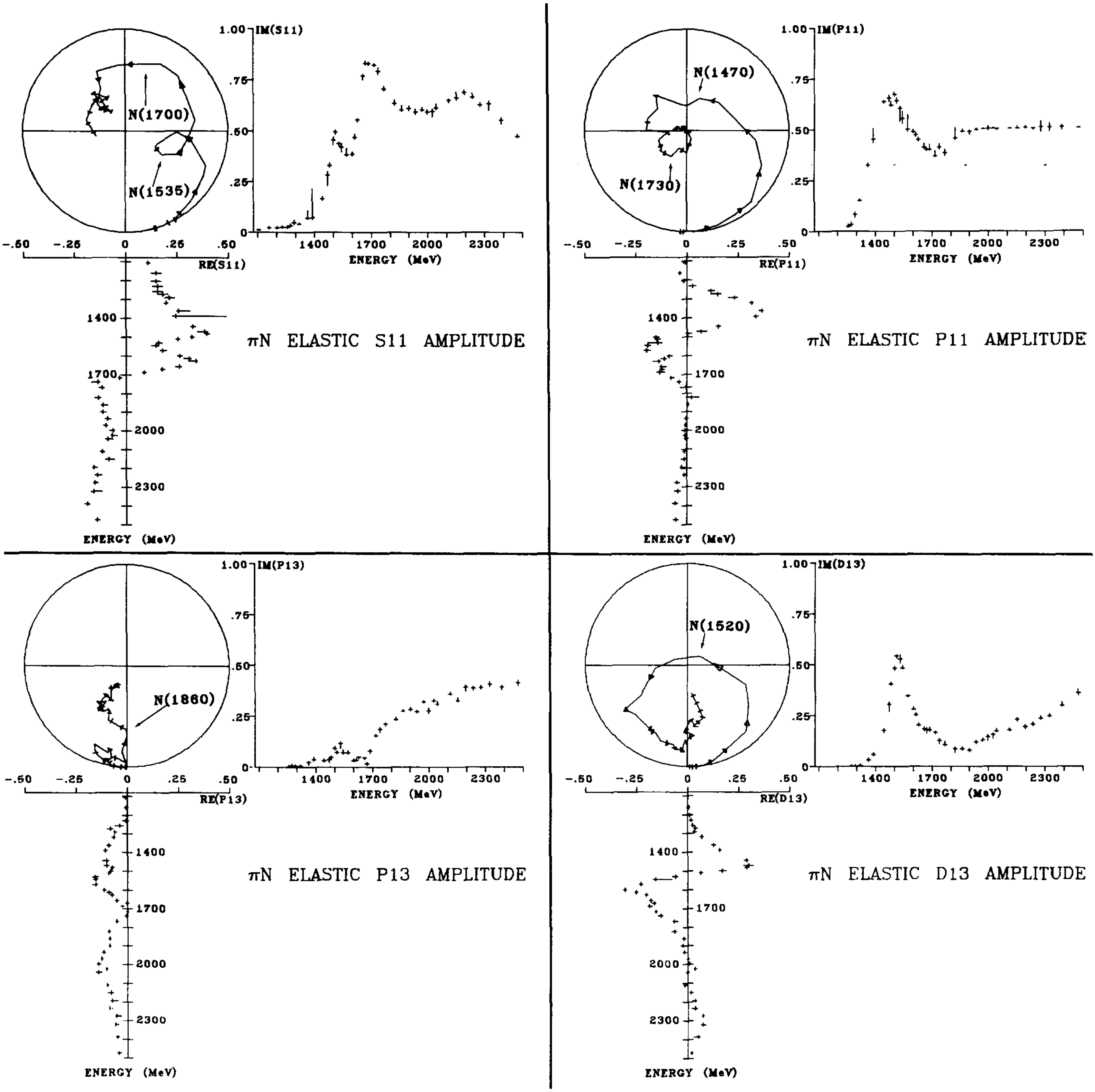

Fig. II.2. Amplitudes for I = 1/2 πN elastic scattering in the J = 1/2 and J = 3/2 waves from AYED 73. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2000 MeV. Established resonances in these waves are the N(1535) and N(1700) in the S_{11} wave, the N(1470) and N(1780) in the P_{11} wave, the N(1860) in the P_{13} wave, and the N(1520) in the D_{13} wave; these are indicated on the above Argand plots. The P_{11} wave also contains the nucleon pole, 138 MeV below threshold. See the Data Card Listings and the accompanying mini-review for other possible resonances in the S_{11}, P_{11}, and D_{13} waves.

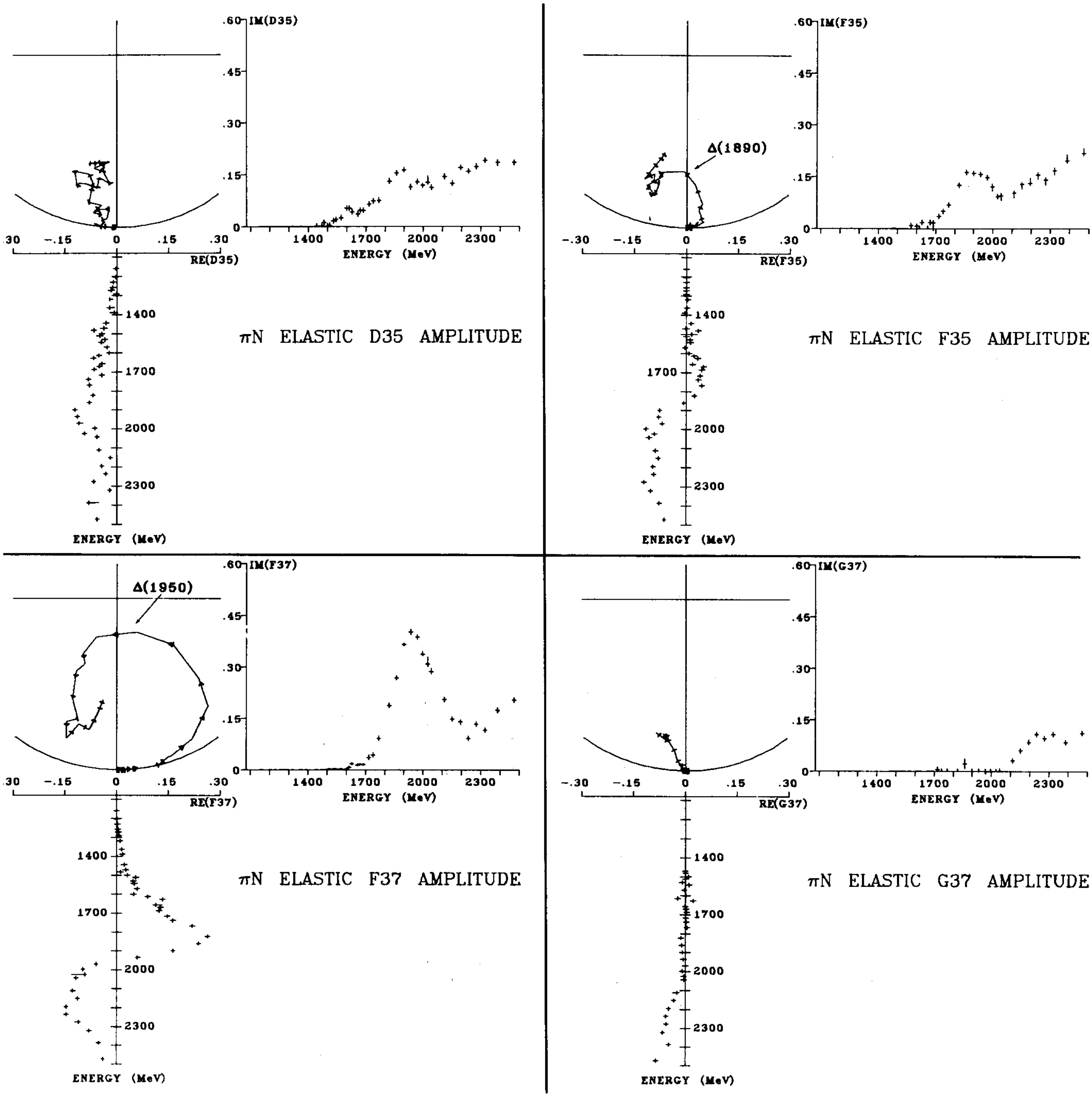

Fig. II.3. Amplitudes for I = 3/2 πN elastic scattering in the J = 5/2 and J = 7/2 waves from AYED 73. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. Established resonances in these waves are the Δ(1890) and Δ(1950) in the F_{35} and F_{37} waves, respectively; these are indicated on the above Argand plots. See the Data Card Listings for another possible resonance in the D_{35} wave.

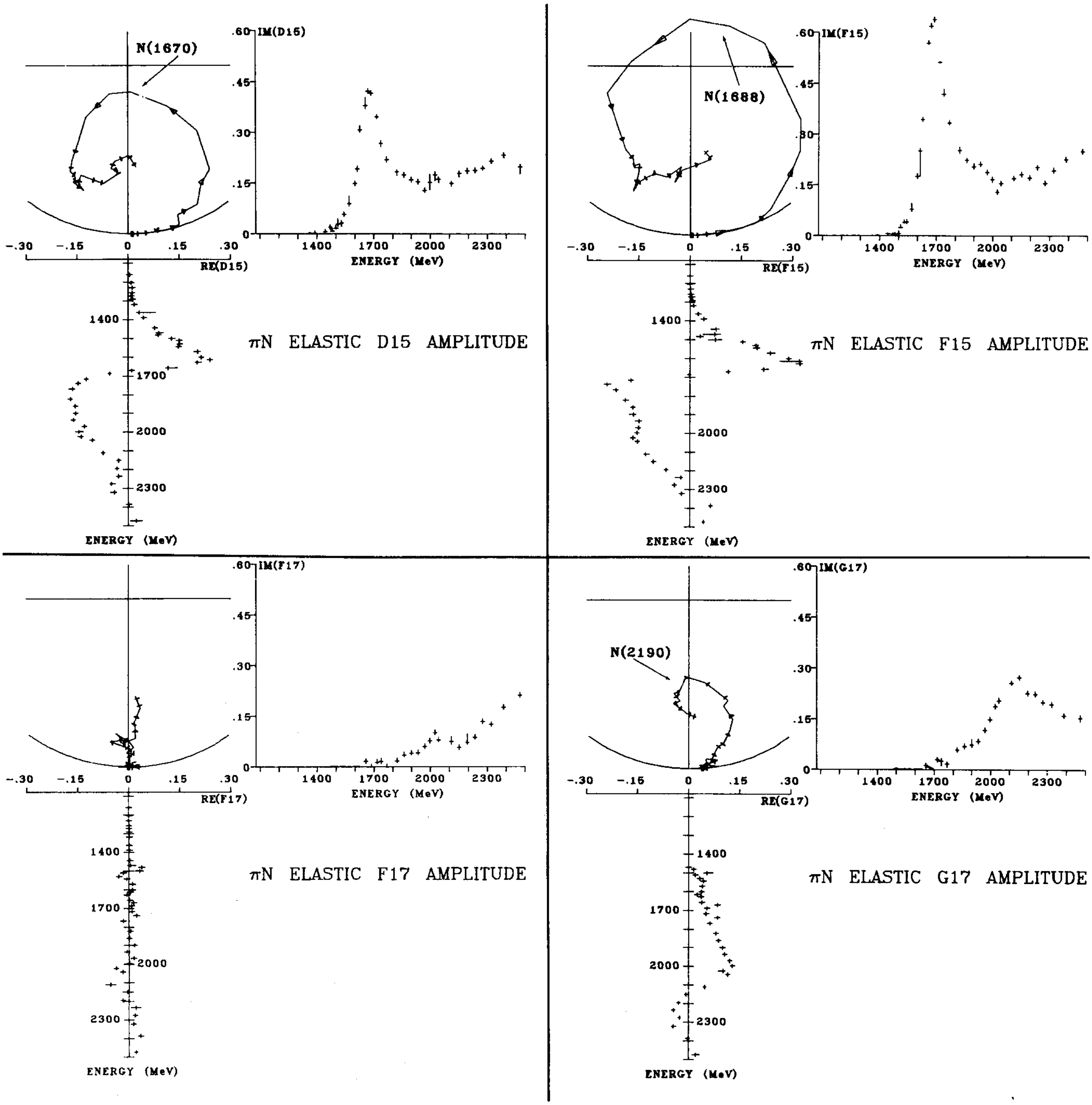

Fig. II.4. Amplitudes for I = 1/2 πN elastic scattering in the J = 5/2 and J = 7/2 waves from AYED 73. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from elastic threshold to 2500 MeV. Established resonances in these waves are the N(1670), N(1688), and N(2190) in the D_{15}, F_{15}, and G_{17} waves, respectively; these are indicated on the above Argand plots. See the Data Card Listings and the accompanying mini-review for other possible resonances in the D_{15}, F_{15}, and F_{17} waves.

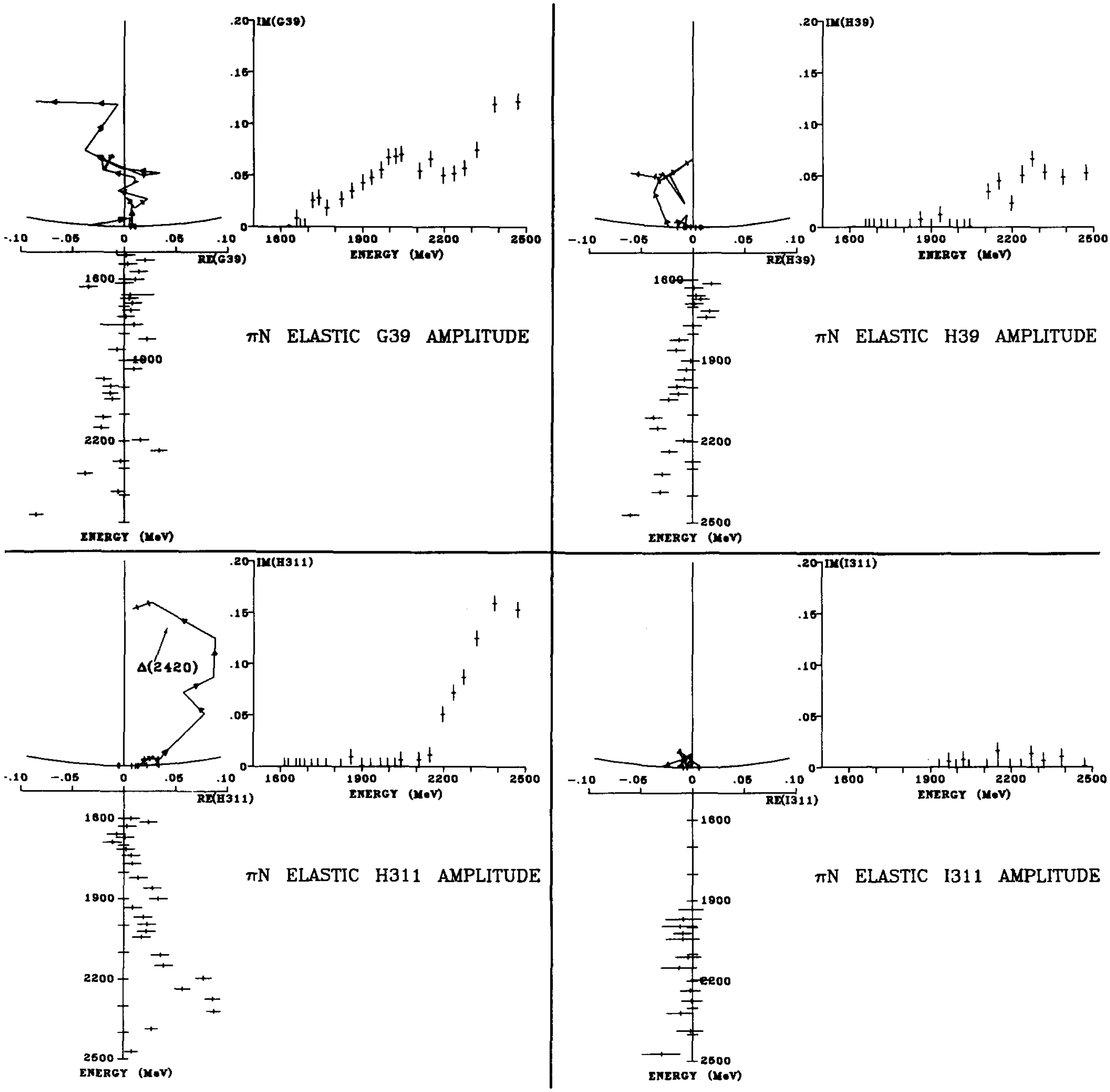

Fig. II.5. Amplitudes for I = 3/2 πN elastic scattering in the J = 9/2 and J = 11/2 waves from AYED 73. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 50 MeV and a base-to-tip length of 5 MeV. All energy axes run from 1500 to 2500 MeV. The only established resonance in these waves is the Δ(2420) in the $H_{3\,11}$ wave; it is indicated on the above $H_{3\,11}$ Argand plot. See the Data Card Listings and the accompanying mini-review for another possible resonance in the G_{39} wave.

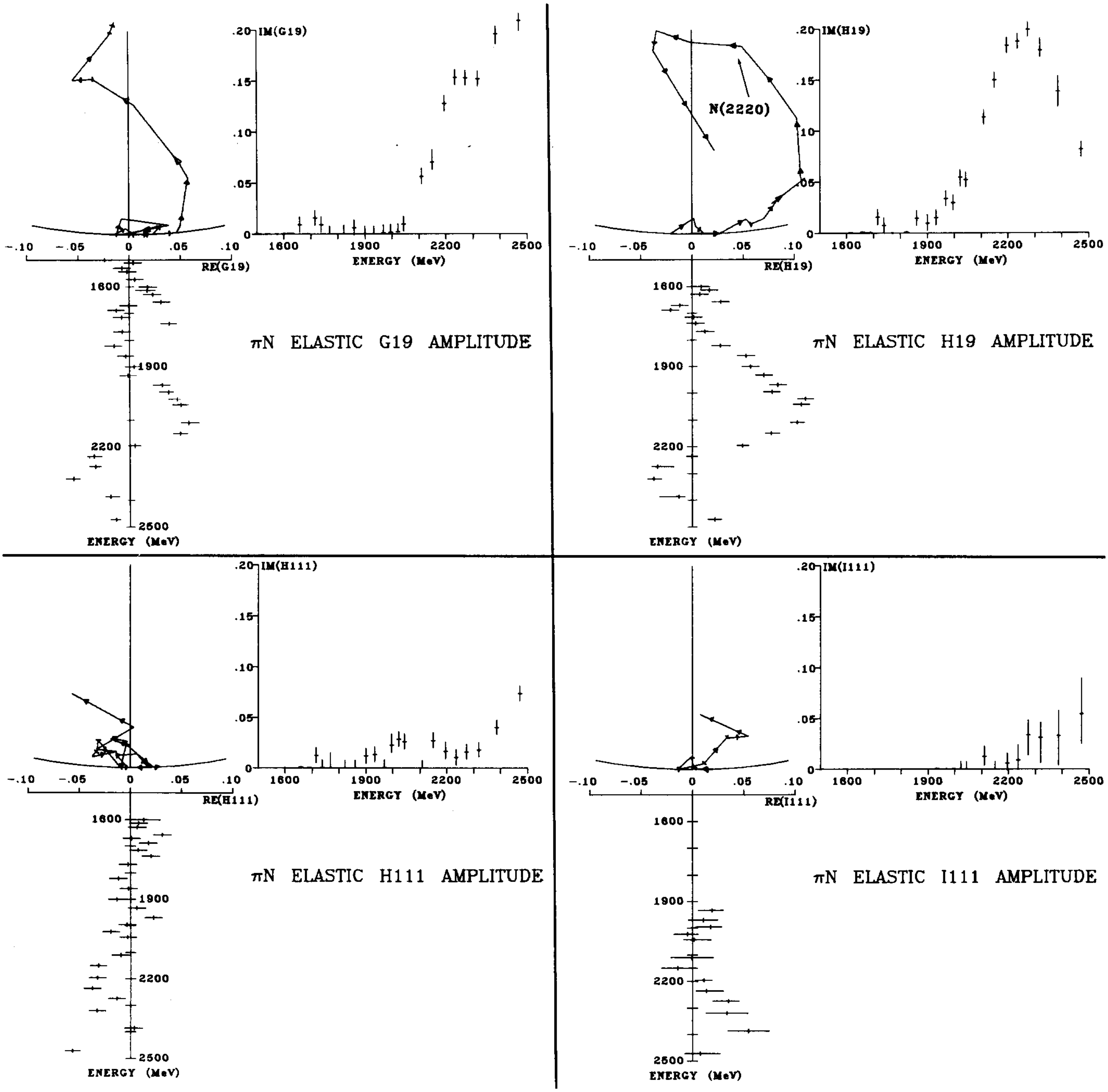

Fig. II.6. Amplitudes for I = 1/2 πN elastic scattering in the J = 9/2 and J = 11/2 waves from AYED 73. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 50 MeV and a base-to-tip length of 5 MeV. All the energy axes run from 1500 to 2500 MeV. The only established resonance in these waves is the N(2220) in the H_{19} wave; it is indicated on the above H_{19} Argand plot. See the Data Card Listings and the accompanying mini-review for another possible resonance in the G_{19} wave.

data are so good, in fact, that an extensive treatment of Coulomb effects is necessary for a proper description in terms of partial waves. This has been done by CARTER 73 who obtain, in the process, rather precise values for the Δ(1232) electromagnetic mass splittings.

The figure captions summarize the known resonances in the various partial waves. We restrict our discussion here to mentioning the possible new effects seen in recent analyses. All resonance parameters quoted under AYED 74 derive from energy-dependent fits (Breit-Wigner with background) to the partial-wave amplitudes which were determined in an essentially energy-independent analysis.

$\underline{S''_{31}}$: In Fig. II.1, the energy-dependent fit of AYED 74 suggests that the broad structure around 2000 MeV is associated with a second resonance with

$$M = 2001 \text{ MeV}, \Gamma_{tot} = 307 \text{ MeV}, x_{el} = 0.08.$$

There is some additional evidence for such an effect from LANGBEIN 73, an energy-independent analysis of KΣ associated production.

$\underline{P''_{33}}$: Similarly the small dip in the imaginary part of P_{33} and the zero in the real part around 1900 MeV are interpreted in the energy-dependent fit as a second P_{33} resonance,

$$M = 1904 \text{ MeV}, \Gamma_{tot} = 204 \text{ MeV}, x_{el} = 0.19.$$

In this case LANGBEIN 73 give confirming evidence in only one of their two solutions for $\pi N \rightarrow K\Sigma$. Note that ALMEHED 72 ("CERN") found two effects, one at ~1680 MeV and another at ~2150 MeV.

$\underline{P_{31}}$: The P_{31} resonance mass quoted by AYED 74 (M = 1786 MeV) is considerably lower than in previous analyses (except AYED 70) which find M in the region 1900 to 1950 MeV; LANGBEIN 73 would prefer this higher mass.

$\underline{S'''_{11}}$: In Fig. II.2 are shown the low spin I = 1/2 waves of AYED 74. They associate the broad effect at ~ 2300 MeV with a third S_{11} resonance:

$$M = 2283 \text{ MeV}, \Gamma_{tot} = 310 \text{ MeV}, x_{el} = 0.14.$$

LANGBEIN 73 find, perhaps, a similar effect at ≈ 1900 MeV; their analysis, however, extends only to 2137 MeV.

$\underline{P'_{11}}$: AYED 74 claim the "Roper" to be split:

$$P_{11} \begin{cases} M_{low} = 1413 \text{ MeV}, \Gamma_{tot} = 187 \text{ MeV}, x_{el} = 0.55; \\ M_{high} = 1532 \text{ MeV}, \Gamma_{tot} = 89 \text{ MeV}, x_{el} = 0.12. \end{cases}$$

While such a splitting might be a natural explanation for the relatively low mass and broad width of the "Roper" as seen in production experiments, the evidence in Fig. II.2 - especially the projections - seems only tentative. Considerably more data are needed to substantiate such small effects. The new Saclay ηn data and partial-wave analysis of LEMOIGNE 73 are not inconsistent with the parameters of the high mass state. However, it is possible that this splitting could be explained by simultaneously fitting the elastic and ηn data, taking proper account of the ηn threshold at 1490 MeV.

$\underline{D''_{13}}$: A somewhat larger effect in this wave at ~ 1700 MeV is identified by AYED 74 as a second D_{13} resonance:

$$M = 1710 \text{ MeV}, \Gamma_{tot} = 100 \text{ MeV}, x_{el} = 0.09.$$

The projections reveal a shoulder in the imaginary part and a small dip in the real part. A similar effect exists in ALMEHED 72, but was not claimed as a resonance. One solution of LANGBEIN 73 shows evidence for a D_{13} effect around 1790 MeV. Recent pion photoproduction analyses and the LBL-SLAC $\pi\pi N$ analysis have also sound evidence for this state (see III and IV below).

$\underline{D'''_{13}}$: Along with ALMEHED 72, AYED 74 find evidence for a D_{13} state at ~ 2000 MeV:

$$M = 2029 \text{ MeV}, \Gamma_{tot} = 116 \text{ MeV}, x_{el} = 0.10.$$

The evidence in the projections seems even less than for the effect at 1700 MeV. LANGBEIN 73 find no evidence in the KΣ channel.

$\underline{D''_{15}}$: The rapid decrease in the real part of this amplitude around 2100 MeV (see Fig. II.4) is associated with a second D_{15} resonance by AYED 74:

$$M = 2100 \text{ MeV}, \Gamma_{tot} = 220 \text{ MeV}, x_{el} = 0.08.$$

These parameters are in reasonable agreement with those of ALMEHED 72.

$\underline{F''_{15}}$: The broad shoulder in the real part and dip in the imaginary part are identified with a second F_{15}

resonance by AYED 74:

$$M = 1989 \text{ MeV}, \ \Gamma_{tot} = 179 \text{ MeV}, \ x_{el} = 0.08.$$

ALMEHED 72 find an effect at ~ 2200 MeV; this, however, is near the maximum energy of their analysis.

Higher Waves. Besides confirming the already accepted $H_{3\,11}$ and H_{19}, AYED 74 present evidence for two additional states in the 2200 MeV region:

G_{39}: $M = 2174$ MeV, $\Gamma_{tot} = 205$ MeV, $x_{el} = 0.04$;

G_{19}: $M = 2133$ MeV, $\Gamma_{tot} = 193$ MeV, $x_{el} = 0.10$.

The G_{39} effect in Fig. II.5 is not too convincing. Notice that ALMEHED 72 claimed a P_{33} resonance in this same region; see Δ(2160) for further possibilities in this mass region. In contrast, the evidence for G_{19}, Fig. II.6, looks quite good; note, in particular, the behavior of the real part projection in the region 1900 - 2500 MeV.

References for Section II

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Note on N's and Δ's: III. The Nππ Channel

A. Current Status of Nππ Partial-Wave Analyses

In the isobar model, the amplitude for the reaction πN → Nππ is written

$$T = \Sigma \left\{ T^{JILL'}_{\Delta\pi}(E)\, BW_{\Delta}(E_{\pi N}) X^{JILL'}_{\Delta\pi} + T^{JILL'}_{\rho N}(E)\, BW_{\rho}(E_{\pi\pi}) X^{JILL'}_{\rho N} + T^{JILL'}_{\epsilon N}(E)\, BW_{\epsilon}(E_{\pi\pi}) X^{JILL'}_{\epsilon N} \right\}.$$

In this expression the BW's denote either appropriate Breit-Wigners or the corresponding two-body amplitude. 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, $T^{JILL'}_{\Delta\pi}$, etc., may be indicated by

$$\Delta\pi, LL'_{2I2J} \qquad \rho N, LL'_{2I2J} \qquad \epsilon N, LL'_{2I2J}$$

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 has a subscript 1 or 3 which denotes twice the ρN total spin. 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 $E_{\pi N}$.

At the Purdue Conference on baryon resonances, it was observed that the phases of the LBL-SLAC[1] Δπ isobar amplitudes were inconsistent with predictions[2] deriving from the Melosh transformation between constituent and current quarks (current-quark scheme). As the same predictions follow from ℓ-broken $SU(6)^2_W$, the LBL-SLAC group was encouraged (by D. Faiman) to investigate the possibility of another solution consistent with these symmetry schemes.

In general one might hope that the output of partial-wave analyses could be used to discriminate among competing theories. In this case, however, there were at least two rather obvious reasons why the LBL-SLAC solution might not be unique:

1. The c.m. energy range covered by the analysis was $1300 \lesssim E \lesssim 2000$ MeV. Unfortunately the data available for this analysis were incomplete in that a gap existed in the interval $1550 \lesssim E \lesssim 1650$. Thus the Purdue solution,[1] in particular the relative resonance phases, depended on a particular choice of continuation through this gap.
2. In the initial stages of the analysis some 60 partial waves (120 parameters) were considered as candidates for making important contributions to the Nππ cross sections. In order to make the analysis at all feasible, this set had to be decreased to a more manageable number through a combination of statistical (e.g., neglect of waves with magnitude $\lesssim 0.1$ in preliminary analyses) and physical (e.g., $D_{15}(1670)$ believed to have ~ 50% decay mode into Nππ) considerations. Of course, one can never be sure that waves discarded in this manner are truly unimportant.

With these problems in mind a new solution was found which included (i.e., did not set to zero) four small waves required by ℓ-broken $SU(6)_W$. This solution[4] is shown in Fig. III.1. The arrowheads on these plots are spaced every 20 MeV, the last one being at 1940 MeV for each wave. The points not

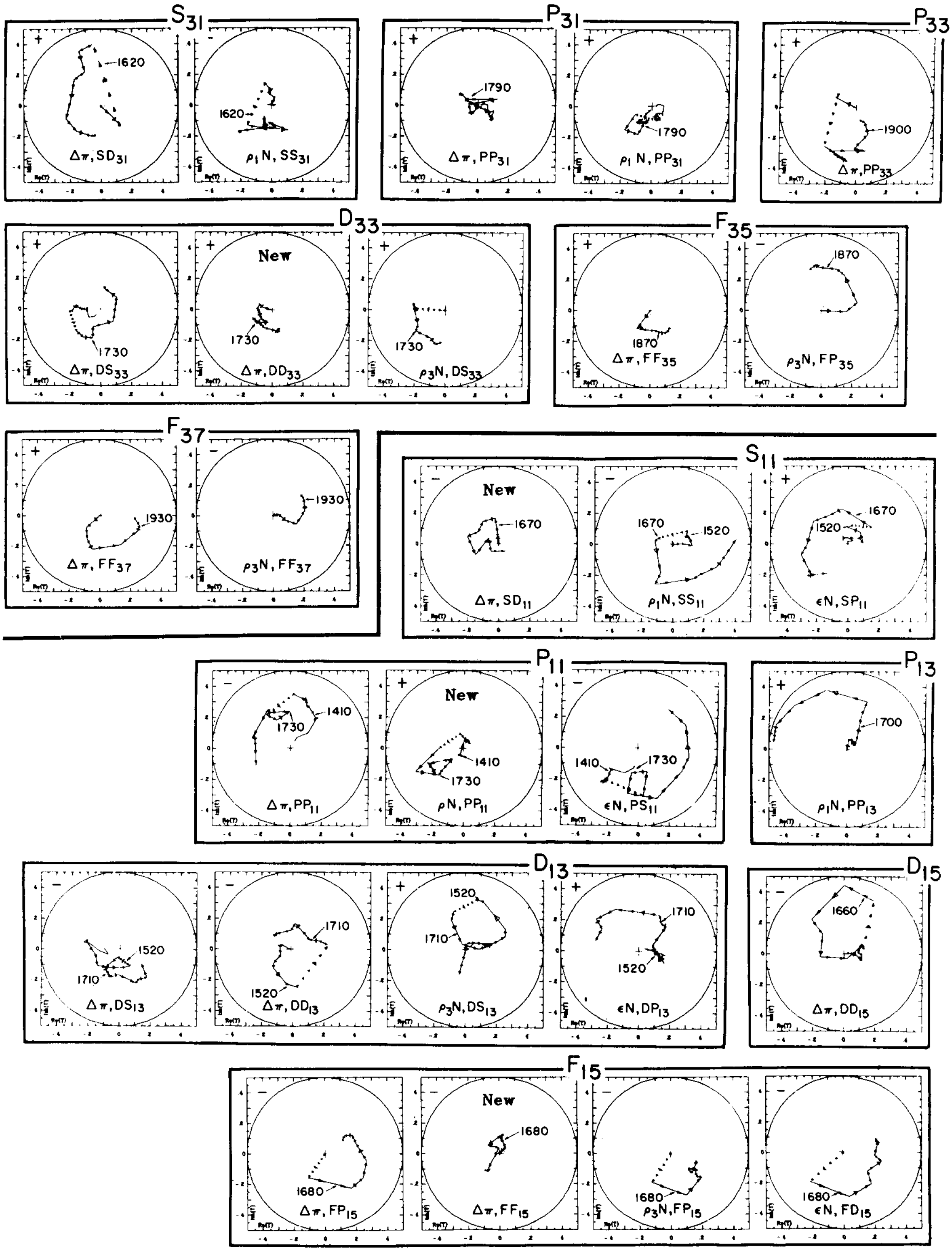

Fig. III.1. An alternate solution of the LBL-SLAC isobar analysis of $\pi N \to N\pi\pi$. See the text for notation. The sign in the upper left-hand corner of each plot indicates how to transform from the sign conventions of this group to that of the "baryon-first" convention. (See main text, Sec. IV.B.)

connected by straight lines indicate the energy gap in the data available for the analysis. The numbers (1620, 1730, etc.) are the resonance masses found by AYED 74 (see Sec. II above). The new waves are so labeled; notice that they are still fairly small in magnitude.

If we compare this solution to the old one,[1] we find that the P_{33}, D_{33}, F_{35}, F_{37}, P_{13}, D_{15}, and F_{15} waves have not been significantly altered in structure, but have all been rotated by ~ 180°. In contrast, S_{31}, P_{31}, S_{11}, P_{11}, and D_{13} have undergone considerable change in both structure and phase. In a sense this is not surprising since these waves (except for P_{31} which was small to begin with) all contain resonances which are either in, or overlap, the region of the gap ($1550 \lesssim E \lesssim 1650$): Δ(1650) S_{31}, N(1535) S_{11}, N(1470) P_{11}, and N(1520) D_{13}.

With regard to symmetry schemes, we can briefly summarize[3,6] the situation as follows:

1. Δπ: Both ℓ-broken $SU(6)_W$ and the current-quark scheme can accommodate the resonance signs given by this solution. The quark model makes predictions that agree with this solution with the exception of Δπ FP_{15}(1688) and Δπ FF_{15}(1688) which are predicted to have the same sign.
2. ρN: The current-quark model makes no predictions here without an additional assumption such as vector meson dominance; the consequences of such an assumption have not yet been investigated. Both ℓ-broken $SU(6)_W$ and the quark model can make predictions for this mode. There may be some disagreement between the predictions of the quark model and the signs of resonance coupling found in the LBL-SLAC analysis. However, as discussed in Sec. C below, the results of this solution for ρN may be less reliable with increasing energy.

For an excellent introduction to these symmetry schemes, we recommend the comparison of M. Kugler.[6]

B. Resonance Parameters

In Table III.1 we show estimates[4] of resonance parameters associated with the amplitudes of this analysis. They were obtained in two ways. Those labeled "A" were found from the amplitudes shown in Fig. III.1 and from the elastic amplitudes of AYED 74. Those labeled "K" were found from the smooth coupled-channel K-matrix fitted amplitudes of Longacre.[5] In both methods, the parameters derive from simple "ruler and compass" estimates of the resonance parameters from the corresponding Argand plots. For example, we have in the $\Delta_L\pi$ column for the FP_{15} wave

$$\sqrt{x_{el}\, x_{\Delta_L \pi}} \approx \begin{Bmatrix} -0.26 \text{ A} \\ -0.25 \text{ K} \end{Bmatrix} \approx \text{diameter of resonance "circle".}$$

The sign indicates whether, ignoring background effects, the resonance circles tend to point up (+) or down (-). Of course, the overall phase of these amplitudes cannot be found from the Nππ data alone; the orientation of the Argand amplitudes in Fig. III.1 was determined with the additional constraints of unitarity and continuity in energy.[5] For alternative resonance parameters as well as the complex energy poles corresponding to these resonances, we refer the reader to Ref. 5.

The two sets of values in Table III.1 give us, perhaps, some feeling for the uncertainty in estimating these parameters. In most instances the agreement in both magnitudes and resonance phases is satisfactory. Notice, however, that there are disagreements in <u>signs</u> for some of the S_{11}(1700), P_{11}(1470), and P_{11}(1780) couplings. As these are all comparatively small effects, we have some measure of the spread in resonance parameters which may be associated with these amplitudes. Some comments on possible biases in the isobar model itself are given in Sec. C below.

Some information on isobar couplings from other analyses is available. MEHTANI 72, analyzing data on the Δπ channel in the region $1820 \leq E \leq 2090$ MeV, find

$$\Delta\pi\ FF_{35}(1890):\quad \sqrt{x_{el}\, x_{\Delta\pi}} = 0.19 - 0.23$$

$$\Delta\pi\ FF_{37}(1950):\quad \sqrt{x_{el}\, x_{\Delta\pi}} = 0.37 - 0.48.$$

These couplings are in fair agreement with the LBL-SLAC results. Note, however, that MEHTANI 72 find no evidence for ρN coupling (see Sec. C below) to these states.

DIEM 70 analyzing data overlapping the gap region ($1550 \lesssim E \lesssim 1650$) find couplings similar in magnitude for P_{11}(1470) to ρN and D_{13}(1520) to Δπ (total) and εN. However, their couplings for S_{11}(1520) are typically a factor of 3 greater than those estimated by LBL-SLAC.

Table III.1. Estimates of resonance parameters from isobar amplitudes. A/K indicate two methods of estimation (see text). In columns labeled x_{el}, $\Delta_L\pi$, etc., one finds the coupling ($\sqrt{x_1x_2}$) and partial width for both methods. Blank entries indicate either no coupling due to quantum number considerations, or that the amplitude was set to zero.

Resonance	M(MeV) A/K	Γ_{tot}(MeV) A/K	x_{el} A/K	$\Delta_L\pi$ A/K	$\Delta_{L'}\pi$ A/K	ρ_3N A/K	ρ_1N A/K	ϵN A/K	Σx_i A/K
S_{11}	1520 / 1510	75 / 100	$N\pi$ .34 26 / .20 20	SD_{11} 0.0 0.0 / +.06 2			SS_{11} +.12 3 / +.09 4	SP_{11} +.10 2 / +.09 4	.41 / .30
S_{11}	1675 / 1660	150 / 130	$N\pi$ .54 81 / .45 58	SD_{11} +.16 7 / +.15 6			SS_{11} -.23 15 / +.16 8	SP_{11} +.23 15 / +.25 18	.79 / .69
S_{31}	1625 / 1600	160 / 150	$N\pi$ .32 51 / .40 60	SD_{31} +.40 80 / +.40 60			SS_{31} -.18 16 / -.28 30		.92 / 1.00
P_{11}	1415 / 1390	180 / 200	$N\pi$ .54 97 / .55 110	PP_{11} +.30 30 / +.37 50			PP_{11} 0.0 0.0 / +.23 20	PS_{11} -.18 11 / +.23 20	.77 / 1.00
P_{11}	1730 / 1710	165 / 75	$N\pi$ .17 28 / .20 15	PP_{11} -.13 16 / +.20 15			PP_{11} -.32 99 / -.20 15	PS_{11} +.18 31 / +.28 30	1.05 / 1.00
P_{13}	1695 / 1720	115 / 150	$N\pi$ .14 16 / .20 30				PP_{13} +.35 101 / +.40 120		1.02 / 1.00
P_{33}	1900 / 1640	205 / 300	$N\pi$ .19 39 / .10 30	PP_{33} -.36 140 / -.3 270					.87 / 1.00

Resonance	M(MeV) A/K	Γ_{tot}(MeV) A/K	x_{el} A/K	$\Delta_L\pi$ A/K	$\Delta_{L'}\pi$ A/K	ρ_3N A/K	ρ_1N A/K	ϵN A/K	Σx_i A/K
D_{13}	1525 / 1520	120 / 150	$N\pi$ .56 67 / .60 90	DS_{13} -.27 16 / -.24 15	DD_{13} -.24 12 / -.30 23	DS_{13} +.32 22 / +.24 15		DP_{13} 0.0 0.0 / -.17 7	.98 / 1.00
D_{13}	1710 / 1710	100 / 300	$N\pi$ .09 9 / .10 30	DS_{13} -.15 25 / -.16 75	DD_{13} +.10 11 / +.14 60	DS_{13} 0.0 0.0 / -.07 15		DP_{13} +.20 44 / +.20 120	.89 / 1.00
D_{33}	1725 / 1680	190 / 240	$N\pi$ .17 32 / .20 48	DS_{33} -.25 70 / -.24 72	DD_{33} 0.0 0.0 / -.10 12	DS_{33} +.20 45 / +.30 108			.77 / 1.00
D_{15}	1660 / 1660	145 / 150	$N\pi$ .41 59 / .45 67	DD_{15} +.45 72 / +.50 83					.90 / 1.00
F_{15}	1680 / 1670	125 / 130	$N\pi$ .59 74 / .59 78	FP_{15} -.26 14 / -.25 13	FF_{15} 0.0 0.0 / +.08 1	FP_{15} -.27 15 / -.30 19		FD_{15} -.28 16 / -.30 19	.95 / 1.00
F_{35}	1870 / 1830	255 / 220	$N\pi$ .14 36 / .18 40	FF_{35} -.12 26 / -.20 48		FP_{35} +.28 143 / +.33 132			.80 / 1.0
F_{37}	1930 / 1925	235 / 240	$N\pi$ .41 96 / .40 96	FF_{37} -.25 36 / -.32 60		FF_{37} +.18 19 / +.24 36			.64 / .80

C. Biases

We now discuss two possible biases which could affect the results of the LBL-SLAC analysis:

1) the neglect of higher partial waves;
2) the assumption that the partial-wave amplitudes ($T_{\Delta\pi}^{JILL'}$, etc.) are independent of the diparticle subenergies.

A UCR-LBL collaboration has made[7] an extensive analysis of the reaction $\pi^+p \rightarrow \pi^0\pi^+p$ in the region $1820 \lesssim E \lesssim 2090$ MeV. As noted above, they too found that $\Delta^{++}\pi^0$ production was well described by $\Delta(1950)$ formation in the FF_{37} wave. At the same time, however, they found from the ρ^+ density matrix that ρ^+p production could be quite well described by one pion exchange. Their results indicate that the inclusion of higher partial waves, associated with one pion exchange, could substantially affect both the strength and the phases of the ρN and ϵN couplings found by the LBL-SLAC analysis. In short, one must be cautious in accepting these couplings above ~1800 MeV.

Recently, several authors[8,9,10] have emphasized that the assumption that the partial-wave amplitudes are independent of the diparticle subenergies may be too severe an approximation. Indeed, it is known both from potential theory,[9,10] in the context of the Faddeev equations, and also from considerations of three-body unitarity[8,10] that this dependence on subenergies could be quite strong. The physical consequences of a subenergy dependence are readily appreciated. As it stands, the isobar model specifies how isobars, contributing to the same I, J^P partial wave, interfere in phase across the Dalitz plot. Since this specification is in principle incorrect, it is conceivable that the phases shown in Fig. III.1 are also incorrect.

The phenomenological consequence of these considerations is that the partial-wave amplitudes should become

$$T^{JILL'}_{\Delta\pi}(E) \longrightarrow T^{JILL'}_{\Delta\pi}(E, E_{\pi N}),$$

with similar replacements for the ρN and ϵN amplitudes. Clearly, such a formulation of the isobar model is impractical simply because there would be many parameters to be determined for only one partial wave. Some simple approximations for $T^{JILL'}_{\Delta\pi}(E, E_{\pi N})$, etc., are given in Refs. 8 and 10. It remains, however, an open question as to just how important the subenergy dependence is.

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Note on N's and Δ's: IV. Photon Couplings

(R. L. Crawford and R. G. Moorhouse, Glasgow Univ.)

Photon couplings can be studied in reactions like

$$\gamma N \rightarrow N^* \rightarrow \pi N,\ K\Lambda,\ K\Sigma,\ \pi\Delta \ldots$$

A partial-wave analysis of these formation processes is the standard technique to determine the coupling strengths $g(N^*N\gamma)$. Up to now almost all results are derived from analysis of pion photoproduction. In the following we therefore outline the formulation of pion photoproduction and define the conventions in which results will be quoted.

The process $\gamma N \rightarrow N^* \rightarrow \pi N$ for a specific intermediate resonance can be symbolically described as

$$\langle \pi N | H_\pi | N^* \rangle \langle N^* | H_\gamma | \gamma N \rangle \ .$$

The first term is measured in strong interactions, e.g. by partial-wave analysis of πN elastic scattering. A common feature of almost all analyses of pion photoproduction is a strong reliance on the knowledge of resonance parameters from πN phase-shift analyses. Very few attempts are made to determine new πN resonance parameters, partly because of lack of precise enough data, partly because photoproduction is complicated by the fact that the photon has spin states ±1 and can react as an isoscalar or isovector. Consequently in general, several couplings for $N^* \rightarrow \gamma N$ (2 for Δ, 4 for N) have to be determined.

Isospin Decomposition

If we use the conventional framework for the isospin decomposition, without an isotensor component, the reactions leading to the four possible final charge states are described by three isospin amplitudes. One set of these consists of the amplitudes A^Δ, A^p, and A^n, which are respectively the amplitudes for the reaction to proceed by an I = 3/2 state, an I = 1/2 state with charge = +1, and an I = 1/2 state with charge = 0:

$$\begin{aligned} A(\gamma p \rightarrow \pi N) &= C^{3/2}_{\pi N} A^\Delta + C^{1/2}_{\pi N} A^p, \\ A(\gamma n \rightarrow \pi N) &= C^{3/2}_{\pi N} A^\Delta + C^{1/2}_{\pi N} A^n, \end{aligned} \tag{1}$$

The C-G coefficients, $C^I_{\pi N}$ for the coupling to a specific πN state are given explicitly by

$$\begin{aligned} A(\gamma p \rightarrow \pi^+ n) &= -\sqrt{1/3}\, A^\Delta - \sqrt{2/3} A^p, \\ A(\gamma p \rightarrow \pi^o p) &= \sqrt{2/3}\, A^\Delta - \sqrt{1/3}\, A^p, \\ A(\gamma n \rightarrow \pi^- p) &= \sqrt{1/3}\, A^\Delta - \sqrt{2/3}\, A^n, \\ A(\gamma n \rightarrow \pi^o n) &= \sqrt{2/3}\, A^\Delta + \sqrt{1/3}\, A^n. \end{aligned} \tag{2}$$

Walker's[1] amplitudes A^{V3}, A^{V1} and A^S for the production of an isospin eigenstate by the isovector and isoscalar parts of the electromagnetic current are given by

$$\begin{aligned} A^{V3} &= A^{\Delta} \\ A^{V1} &= 1/2(A^{n} - A^{p}), \\ A^{S} &= 1/2(A^{n} + A^{p}). \end{aligned} \tag{3A}$$

The alternative formalism using the amplitudes $A^{(0)}$, $A^{(1)}$, and $A^{(3)}$ is related to Walker's by

$$\begin{aligned} A^{(0)} &= \sqrt{3/2}\, A^{S}, \\ A^{(1)} &= \sqrt{3}\quad A^{V1}, \\ A^{(3)} &= \sqrt{1/3}\, A^{V3}. \end{aligned} \tag{3B}$$

Partial Waves

The S-matrix element for pion photoproduction $(\gamma N_1 \to \pi N_2)$ is written in the form

$$S_{fi} = i(2\pi)^5\, \delta^4(P_f - P_i) W (k\omega E_1 E_2)^{-1/2} A \tag{4}$$

where P_f and P_i are the total 4-momenta in the final and initial state, k, ω, E_1, and E_2 denote the c.m. energies of photon, pion, initial and final nucleon, and W is the total c.m. energy.

For a partial-wave analysis it is convenient to decompose A into helicity amplitudes[2]. Choosing the x-z plane as the scattering plane, the z-axis along the photon direction, and θ as the c.m. scattering angle between photon and pion, we define helicity amplitudes $A_{\mu\gamma}(W,\theta)$ (ignoring isospin labels). Here μ and λ denote the total final and initial helicities, $\mu = \lambda_\pi - \lambda_2$, $\lambda = \lambda_\gamma - \lambda_1$. Since $\lambda_\gamma = \pm 1$ and $\lambda_{1,2} = \pm 1/2$, we have a set of 8 helicity amplitudes. Because of parity conservation[2] only 4 are independent, which we choose by fixing $\lambda_\gamma = +1$. We thus consider $A_{\pm 1/2,\, 1/2}$ and $A_{\pm 1/2,\, 3/2}$. They are normalized such that the differential cross section is given by

$$\frac{d\sigma}{d\Omega} = \frac{1}{2}\, \frac{q}{k} \sum_{\lambda,\mu} |A_{\mu\lambda}|^2 .$$

Each of these is expanded in the usual way[2]

$$A_{\mu\lambda}(W,\theta) = \sum_j (2j+1) A^j_{\mu\lambda}(W)\, d^j_{\lambda\mu}(\theta) \tag{5}$$

into partial wave amplitudes $A^j_{\mu\lambda}(W)$ of total angular momentum j (but mixed parity) and the Wigner rotation functions.

We define amplitudes of definite parity by

$$\begin{aligned} C_\lambda^{\ell +}(W) &= \frac{1}{\sqrt{2}}[A^j_{1/2\lambda}(W) + A^j_{-1/2\lambda}(W)] \\ C_\lambda^{(\ell+1)-}(W) &= \frac{1}{\sqrt{2}}[A^j_{1/2\lambda}(W) - A^j_{-1/2\lambda}(W)] \end{aligned} \tag{6}$$

where $\lambda = 1/2,\ 3/2$. The superscripts $\ell\pm$ refer in the usual notation to states with pion orbital angular momentum ℓ and total angular momentum $j = \ell \pm 1/2$.

Unitarity of the S-matrix imposes a phase condition on the C amplitudes known as Watson's theorem. It states that in the elastic region the phase of each $C_\lambda^{\ell\pm}$ is equal to the scattering phase of the corresponding πN partial wave.

Since we are interested in intermediate resonances, we approximate the energy dependence of $C_\lambda^{\ell\pm}(W)$ by a Breit-Wigner form with background

$$C_\lambda^{\ell\pm}(W) = s\left\{\frac{\Gamma^\lambda(N^*\to\gamma N)\Gamma(N^*\to\pi N)}{k\cdot q}\right\}^{1/2} \frac{W}{W^2 - m_R^2 - iW\Gamma} + \text{background} \tag{7}$$

where s is the sign of the amplitude, m_R the resonance energy, and k, q the c.m. momenta in the initial, final states. In the following discussion of resonance couplings we use the notation $\tilde{A}$ for the imaginary part of the resonance contribution to an amplitude A(W) evaluated at resonance $(W = m_R)$; thus

$$\tilde{C}_\lambda^{\ell\pm} = s\left\{\frac{\Gamma_\gamma^\lambda \Gamma_\pi}{k\cdot q\cdot \Gamma^2}\right\}^{1/2} \tag{8}$$

A dominant feature in pion photoproduction is the Born approximation which contains the nucleon pole in the s- and u-channel and the pion pole in the t-channel. It reproduces, e.g., the experimentally observed forward peak in charged pion photoproduction. In partial-wave analyses the sign factor s is well determined relative to the Born terms.

Introducing helicity amplitudes $A_\lambda^{j^P}$ for the decay $N^*(j^P) \to (\gamma N)_\lambda$ (where j^P labels spin and parity of the N^*), we can calculate the radiative width Γ_γ^λ [3],

$$\Gamma_\gamma^\lambda = \frac{k^2}{\pi}\, \frac{m_N}{m_R}\, \frac{1}{2j+1} (\tilde{A}_\lambda^{j^P})^2 \tag{9}$$

where m_N is the nucleon mass. Introducing this expression into Eq. (8) we find

$$\tilde{C}_\lambda^{\ell\pm} = \left\{\frac{1}{(2j+1)\pi}\, \frac{k}{q}\, \frac{m_N}{m_R}\, \frac{\Gamma_\pi}{\Gamma^2}\right\}^{1/2} \tilde{A}_\lambda^{j^P}. \tag{10}$$

We quote results of partial-wave analyses in terms of the amplitudes $\tilde{A}_\lambda^{j^P}$ in units of $GeV^{-1/2}$.

The total radiative width Γ_γ and the corresponding contribution $\sigma_T^{j^P}$ of the partial waves $C_\lambda^{\ell\pm}$ to the total cross section are given by

$$\Gamma_\lambda = \sum_{\lambda=-3/2}^{3/2} \Gamma_\gamma^\lambda = \frac{k^2}{\pi}\, \frac{m_N}{m_R}\, \frac{2}{2j+1} \{(\tilde{A}_{1/2}^{j^P})^2 + (\tilde{A}_{3/2}^{j^P})^2\} \tag{11}$$

$$\sigma_T^{j^P} = (C_{\pi N}^I)^2\, 2\frac{m_N}{m_R}\, \frac{\Gamma_\pi}{\Gamma^2} \left\{(\tilde{A}_{1/2}^{j^P})^2 + (\tilde{A}_{3/2}^{j^P})^2\right\}. \tag{12}$$

The Hebb-Walker amplitudes[1], $\tilde{A}_{\ell\pm}$, $\tilde{B}_{\ell\pm}$, are related to the $\tilde{A}^{jP}_{\lambda}$ by

$$\tilde{A}_{\ell\pm} = \mp\left\{\frac{1}{(2j+1)\pi}\,\frac{k}{q}\,\frac{m_N}{m_R}\,\frac{\Gamma_\pi}{\Gamma^2}\right\}^{1/2} C^I_{\pi N}\tilde{A}^{jP}_{1/2}\,, \quad (13)$$

$$\tilde{B}_{\ell\pm} = \pm\left\{\frac{1}{(2j+1)\pi}\,\frac{k}{q}\,\frac{m_N}{m_R}\,\frac{\Gamma_\pi}{\Gamma^2}\right\}^{1/2}$$

$$\times\left\{\frac{16}{(2j-1)(2j+3)}\right\}^{1/2} C^I_{\pi N}\tilde{A}^{jP}_{3/2}\,. \quad (14)$$

We see from (2), (7), (8), and (9) that, apart from the factor $[16/(2j-1)(2j+3)]^{1/2}$, these are just the imaginary part of the resonance part of the amplitude (2) at resonance. Consequently they are more directly related to experiment than the $\tilde{A}^{jP}_{\lambda}$, which incorporate an additional uncertainty of the partial width $\Gamma(N^* \to \pi N)$.

Methods of Partial-Wave Analaysis

(a) Simple isobar model: In this method the partial-wave amplitudes are formulated as in (7) (or similarly), with the resonance, or resonances, part built using knowledge of m_R, Γ, and $\Gamma(N^* \to \pi N)$ from πN elastic partial-wave analysis; the parametrization of the background is author-dependent, as indeed is the detailed form of the resonance term, but the background is generally assumed to vary more slowly than the resonances. When the partial waves of Eq. (7) have been combined to form the angular-dependent amplitude of Eq. (5), the Born amplitudes given by the Feynman diagrams of Fig. IV.1 must be added. (Alternatively, these Born amplitudes may previously have been projected into partial waves and included in the background terms of Eq. (7).

As indicated in Fig. IV.1, the photon couples to the nucleon through both the electric charge, e, and the anomalous moment, μ. The minimum gauge-invariant form which includes the pion pole is given

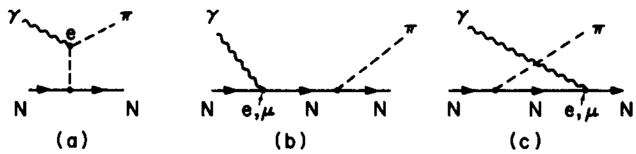


Fig. IV.1. Feynman diagrams for the Born terms in pion photoproduction. The couplings of the photon to the pion and nucleon are indicated, e representing a coupling via charge, and μ a coupling via anomalous moment.

by the pion pole term plus the nucleon pole terms with electric charge interaction only; we can refer to these as the electric Born terms. Generally, only the electric Born terms are included explicitly, because they reproduce the forward peak for charged photoproduction, and the magnetic terms can be assumed included in the real parts of background and resonances in Eq. (7). However this certainly raises problems of principle since some of the electric Born terms might also be subsumed in the background and resonances.

The best values of the resonance couplings, $\Gamma^\lambda(N^* \to \gamma N)$, and background parameters are found as those which give minimum χ^2 for all data within the energy range, in the usual manner for DPWA.

(b) Fixed-t dispersion relations (FTDR): The difficulties of principle with the Born approximation in the simple isobar model are among the reasons which have led to the use of FTDR:

$$\mathrm{Re}\,A_i^{(\pm,0)}(s,t) = B_i^{(\pm,0)}(s,t)$$

$$+ \int_{(M_N+m_\pi)^2}^{\infty} ds' \left\{\frac{\mathrm{Im}\,A_i^{(\pm,0)}(s',t)}{s'-s} + \xi_i\,\frac{\mathrm{Im}\,A_i^{(\mp,0)}(s',t)}{s'-u}\right\} \quad (15)$$

for the invariant amplitudes $A_i^{(\pm,0)}(s,t)$ $(i = 1, 2, 3, 4)$, where $B_i^{(\pm,0)}(s,t)$ are the Born amplitudes[4] of Fig. IV.1 ($\xi_1 = \xi_2 = \xi_4 = 1$, $\xi_3 = -1$; ±, 0 denote $\gamma p \to \pi^+ n$, $\gamma n \to \pi^- p$, $\gamma p \to \pi^0 p$, respectively). $A_i^{(\pm,0)}(s,t)$ can be expressed in terms of the helicity amplitudes, and vice-versa, by standard formulae.[4] $B_i^{(\pm,0)}(s,t)$ includes both the electric Born and the anomalous magnetic moment terms, and no ambiguity arises as in the simple isobar model, because all the real part (including the "resonant" real part) is manufactured by the unique prescription (15).

The Im $A_i^{(\pm,0)}(s,t)$ are constructed using the imaginary part only of Eq. (7), or alternative formulae;[4] the Re $A_i^{(\pm,0)}(s,t)$ are constructed from (15); and minimization of χ^2 to find the unknown parameters of (7) is done as usual in DPWA.

A second advantage of FTDR over the simple isobar model is that imaginary parts appear to be resonance dominated[1,4] (though not resonance saturated), and this is not true of the real part; the FTDR method only parametrizes the imaginary parts, and the smaller influence therein of the background terms of Eq. (7) is helpful. This advantage is diminished by the need, apparent from Eq. (15), to parametrize

Im $A_i^{(\pm,0)}(s,t)$ outside the energy region of data fitting, thus effectively adding extra background parameters. Another, and in principle more serious, disadvantage is that Im $A_i^{(\pm,0)}(s',t)$ in Eq. (15) is required to be known for t outside the physical range corresponding to s'; formally indeed these unphysical amplitudes are given through the partial-wave series (5), and this is how the method calculates them. While the convergence of (5) is not proved for important parts of the unphysical region, Devenish, Lyth, and Rankin[5] have surmised on the basis of the Mandelstam representation that the method is good up to $-t \lesssim 1(\mathrm{GeV}/c)^2$ in $\pi^\pm$ and $-t \lesssim 1.5(\mathrm{GeV}/c)^2$ in π^0 photoproduction.

The use of FTDR in pion photoproduction has a longer history in the first resonance region,[6] where their role was envisaged as largely predictive or synthetic; the independently motivated extension, by the Berkeley[4,7] and Lancaster[9] based groups, to a larger energy region also changed their role to almost purely analytic.

Definitions of Resonance Parameters and Errors

From analyses which use a form like that of Eq. (7), there are reported in the Data Card Listings and Table IV.1, photonic resonance couplings which are obtained through Eq. (9) from a Breit-Wigner partial width; the FTDR method uses only the imaginary part of Eq. (7). The FTDR method of MOORHOUSE1 73,[7] MOORHOUSE2 73,[4] and KNIES 73[8] uses a K-matrix ansatz for the imaginary part; in those cases it is the corresponding K-matrix pole quantity that is reported. (Regrettably no authors give also partial widths corresponding to T-matrix residues.)

If no errors are assigned, the authors have given a unique result without quoting an error. MOORHOUSE1 73,[7] MOORHOUSE2 73,[4] and KNIES 73[8] quote as error the spread around a central value of a number of solutions. DEVENISH 73[9] estimate a "real error" for each parameter of a given solution, corresponding to a 1% increase of "best-possible χ^2"; the quoted final value is the mean of the resulting extreme values over 3 solutions, with final errors corresponding to the spread of these values allowing for individual "real errors."

The variation between the central values of various papers is generally greater than the quoted error of an individual paper, and this is reflected in the rather large errors given in the Table below.

Table IV.1 Photon resonance couplings.

State	λ	Helicity couplings, Analyses average(1): $\tilde{A}^p_\lambda$ $(\mathrm{GeV})^{-1/2}\times10^{-3}$	Helicity couplings, Analyses average(1): $\tilde{A}^n_\lambda$ $(\mathrm{GeV})^{-1/2}\times10^{-3}$	Helicity couplings, Quarks(2): $\tilde{A}^p_\lambda$ $(\mathrm{GeV})^{-1/2}\times10^{-3}$	Helicity couplings, Quarks(2): $\tilde{A}^n_\lambda$ $(\mathrm{GeV})^{-1/2}\times10^{-3}$
P'_{11}	1/2	-76 ± 20	40 ± 45	27	-18
D'_{13}	1/2	-8 ± 18	-76 ± 13	-34	-31
	3/2	177 ± 15	-124 ± 10	109	-109
S'_{11}	1/2	58 ± 25	-42 ± 13	156	-108
D'_{15}	1/2	22 ± 10	-29 ± 38	0	-38
	3/2	25 ± 12	-53 ± 30	0	-53
F'_{15}	1/2	-1 ± 15	21 ± 15	-10	30
	3/2	126 ± 24	-15 ± 15	60	0
S''_{11}	1/2	36 ± 30	-27 ± 40	0	30
D''_{13}	1/2	-60 ± 60	-10 ± 100	0	-10
	3/2	40 ± 40	-30 ± 80	0	-40
P''_{11}	1/2	22 ± 10	27 ± 15	-40	10
P'_{13}	1/2	-13 ± 30	70 ± 70	100	-30
	3/2	-4 ± 30	40 ± 60	-30	0
		$\tilde{A}^\Delta_\lambda = \tilde{A}^{V3}_\lambda$		$\tilde{A}^\Delta_\lambda = \tilde{A}^{V3}_\lambda$	
P'_{33}	1/2	-141 ± 3		-108	
	3/2	-259 ± 5		-187	
S'_{31}	1/2	57 ± 35		47	
D_{33}	1/2	64 ± 28		88	
	3/2	83 ± 50		84	
P''_{33}	1/2	10 ± 30		23	
	3/2	20 ± 50		39	
F_{35}	1/2	44 ± 30		-20	
	3/2	-25 ± 20		-90	
P_{31}	1/2	-10 ± 20		-30	
F_{37}	1/2	-64 ± 12		-50	
	3/2	-88 ± 15		-70	

(1) Average of the available couplings from MOORHOUSE1 73, MOORHOUSE2 73, DEVENISH 73, KNIES 73, METCALF 74, and CRAWFORD 73; for the F_{35}, P_{31}, and F_{37} only KNIES 73 and METCALF 74 are used. The errors given are an estimate, generally giving the spread of the results from the different authors.

(2) The naive, ℓ-excitation, quark model is used in the 4-dimensional oscillator form of Feynman, Kislinger, and Ravndal. The non-relativistic quark model with recoil gives generally very similar results.

Recent Partial-Wave Analyses

(a) Simple isobar model: Previous analyses[1,10-12] had considerably less data available and are not included in the Data Card Listings.

METCALF 74[14] uses the methods of Walker[1] to analyze data ($\gamma p \to \pi^+ n$, $\pi^0 p$; $\gamma n \to \pi^- p$) from the 1st through the 4th resonance region. Thus the partial-wave amplitudes are parametrized as in Eq. (7), with the background taken to be an independent number at each energy fitted, and the electric Born terms are added.

(b) Fixed-t dispersion relations: MOORHOUSE1 73,[7] MOORHOUSE2 73,[4] analyze data ($\gamma p \to \pi^+ n$, $\pi^0 p$; $\gamma n \to \pi^- p$) from the 1st through the 3rd resonance region ($1160 < E_{c.m.} < 1780$ MeV), parametrizing the imaginary parts of the (T-matrix) helicity partial-wave amplitudes $A^j_{\mu\lambda}(W)$ of (5) via 3-channel K-matrix formulae, roughly $K_{ij} = \sum_r \gamma_i^{(r)} \gamma_j^{(r)} / (E^{(r)} - E)$; ($i, j = 1, 2, 3$; $1 = \pi N$, $2 =$ inelastic hadron channel, $3 = \gamma N$); $\gamma_1^{(r)}$, $\gamma_2^{(r)}$, $E^{(r)}$ are previously determined from fits to πN elastic partial-wave amplitudes. The $E^{(r)}$ may be resonance poles or background poles, $\gamma_3^{(r)}$ are the parameters to be determined by χ^2 minimization, and when $E^{(r)}$ is a resonance pole $(\gamma_3^{(r)})^2 \propto \Gamma^\lambda(N^* \to \gamma N)$. MOORHOUSE1 73[7] is the average of 7 solutions with the quoted error giving the spread of those solutions; χ^2/data-point for the solutions ranges from 9.7 (with 52 variable parameters) to 5.7 (with 75). In MOORHOUSE2 73[4] the same group present the average for 3 solutions with χ^2/data-point between 4.0 (56) and 3.0 (74); again the quoted error is the spread, but the authors remark that the sample of 3 solutions is too small to give a realistic error. KNIES 73[8] uses the same method, with additional recent polarization data, from the 1st through the 4th resonance region ($1160 < E_{c.m.} < 1995$ MeV); their 4 solutions have χ^2/data-point varying from 3.48 to 4.66. Of these 3 analyses only that of KNIES 73[8] actually fits data in the energy region of the Δ(1950) F_{37} — the other determinations being through the low-energy real-part tail of the Δ(1950) — so the KNIES 73[8] result on Δ(1950) is most reliable.

DEVENISH 73[9] analyze data from the 1st through the 3rd resonance region and parametrize the imaginary parts as Breit-Wigner formulae without background, except that in the case of S-wave π^0, a nonresonant background is allowed. The fixed-t dispersion integral is cut off at ~1.9 GeV c.m. energy but in some fits a real-part background of the form $(a + bt)$ or $(a + bt)\times(s - u)$ is added for, respectively, crossing-even or odd amplitudes, in order to allow for contributions above 2 GeV. The quoted results are formed in the manner described in the previous section from 3 solutions having χ^2/data-point of 10.5 (37), 3.0 (68), and 4.7 (68); the first and third of these solutions use a modified χ^2 in which the different types of charge and polarization data have equal weight.

CRAWFORD 74[15] is an FTDR analysis from the 1st through the 3rd resonance region with one solution having χ^2/data-point 5.1 (68).

(c) Energy-independent analyses: A number of groups[16-19] have made energy-independent analyses for photon laboratory energies < 450 MeV. Deviations of D and higher waves from the Born approximation are found to be small, and full use is made of Watson's theorem to give the complex phases of the partial waves and thus to reduce the number of free parameters. Discrepancies have been reported between the results of these analyses and the partial waves obtained from FTDR containing only Δ(1232); some of these appear to persist for the FTDR analyses of (b) above.[20]

An average of the analyses of (a) and (b) above is given in the Table. We see a quantitative determination of the larger couplings of the prominent resonances Δ(1232) P_{33}, N(1520) D_{13}, N(1688) F_{15}, Δ(1950) F_{37}, and qualitative and sign determinations in most other cases.

Electroproduction in the Resonance Region

At present, any attempt to get quantitative information about the partial waves for pion electroproduction restricts us mainly to the first resonance region and in particular to the analysis of coincidence measurements of π^0 production.[21,22,24-27] The information which can be obtained is the virtual photon mass squared, q^2, dependence of the magnetic coupling to the P_{33} resonance, and the ratios of the electric and scalar multipoles to the magnetic multipole.

The experimental data do no permit a complete partial-wave analysis, but the dominance of $M_{1+}^{(3)}$ allows the evaluation of $|M_{1+}|$, $\mathrm{Re}(E_{1+}M_{1+}^*)/|M_{1+}|^2$, and $\mathrm{Re}(S_{1+}M_{1+}^*)/|M_{1+}|^2$, where these are in terms of the multipoles for π^0 production. Due to the large size of $M_{1+}^{(3)}$ relative to the other partial waves and because the P_{33} multipoles are purely imaginary at the resonance, these can be taken to be $\mathrm{Im}\, M_{1+}^{(3)}$,

$E^{(3)}_{1+}/M^{(3)}_{1+}$, and $S^{(3)}_{1+}/M^{(3)}_{1+}$ at the resonance.

The q^2 dependence of $M^{(3)}_{1+}$ is expressed in the form factor $G^*_M(q^2)$[21]

$$G^*_M(q^2) = 2M\left(\frac{3}{2\alpha}\ \frac{|\vec{k}|}{\sin^2\delta_{33}}\ \frac{\Gamma\,|M_{1+}|^2}{\vec{q}^{\,2}}\right)^{1/2},$$

where $\vec{k}$ and $\vec{q}$ are respectively the center-of-mass three-momenta of the pion and the virtual photon. The behavior of G^*_M relative to the nucleon form factors is best shown by normalizing it to $G^*_M(0) = 3$ and the nucleon dipole $G_D(q^2) = (1+q^2/0.71)^{-2}$. The results of these analyses are shown in Fig. IV.2. Also shown are the results from the single-arm measurements of Bortel et al.[23] and from direct evaluation of $M^{(3)}_{1+}$ in an analysis,[28] using fixed-t dispersion relations, of the differential cross-section data of Ref. 22. It is clearly established that $G^*_M(q^2)$ decreases faster than the nucleon dipole.

The measurements of the ratios of $E^{(3)}_{1+}$ and $S^{(3)}_{1+}$ to $M^{(3)}_{1+}$ (Figs. IV.3a and IV.3b) are all consistent with these being small. However, $S^{(3)}_{1+}$ is established as being non-zero and is apparently negative with a value about 10% of that for $M^{(3)}_{1+}$. This is a small violation of the quark model selection rule[29] which predicts that the scalar excitation of the P_{33} should have zero coupling.

The knowledge of electroproduction in the second and third resonance region is at present limited by the lack of experimental data. The electroproduction of the N(1535) S_{11} resonance has been examined in η production.[30,31] Only the total cross section has been measured, but it is found that the form factor falls much more slowly with q^2 than the nucleon dipole. The main interest in this region is in the couplings for the D_{13} and F_{15} resonances to determine whether there is appreciable scalar excitation and whether the helicity 1/2 amplitudes become important as q^2 increases as required by the harmonic oscillator quark model. The situation is not yet clear, and it appears possible at present to have either significant scalar or helicity 1/2 effects.[32,20]

Information in this Edition

The Baryon Table contains the branching fractions Γ_γ/Γ for 12 resonances.

The Data Card Listings contain the photon resonance coupling ($\tilde{A}^{j\,P}_{\lambda}$ for p, n and Δ) results of the analyses by: Moorhouse and Oberlack[7] (MOORHOUSE1 73); Moorhouse, Oberlack and Rosenfeld[4] (MOORHOUSE2 73); Knies, Moorhouse and Oberlack[8] (KNIES 73); Devenish, Lyth and Rankin[9] (DEVENISH

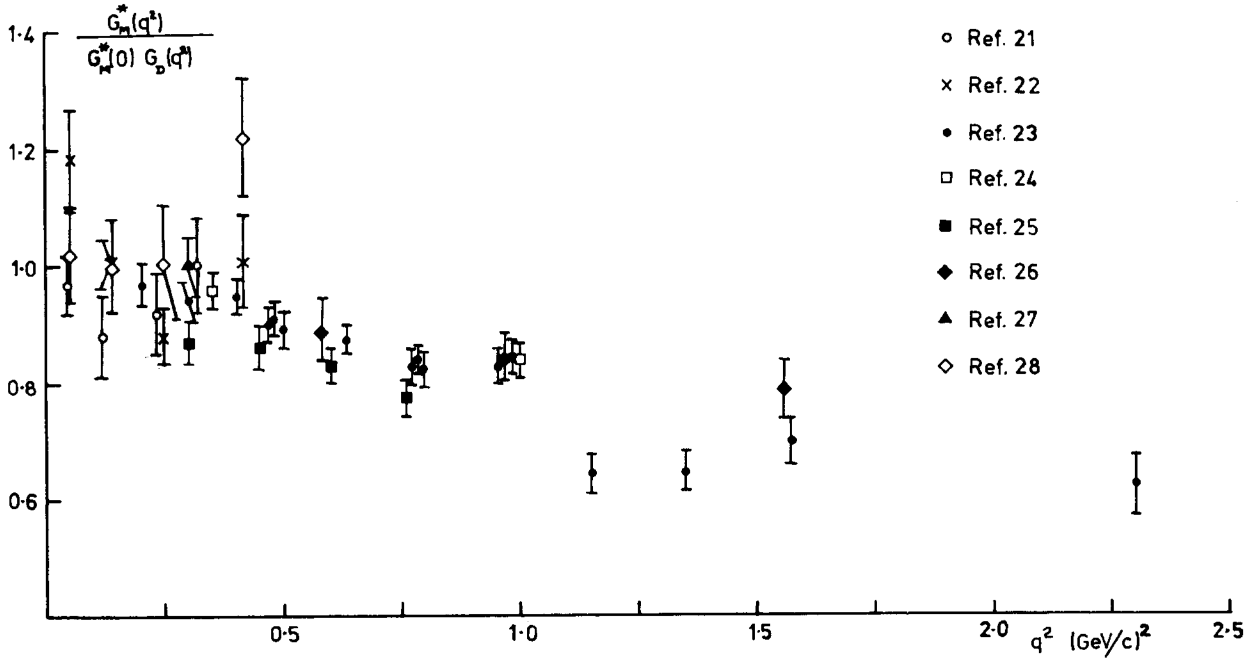
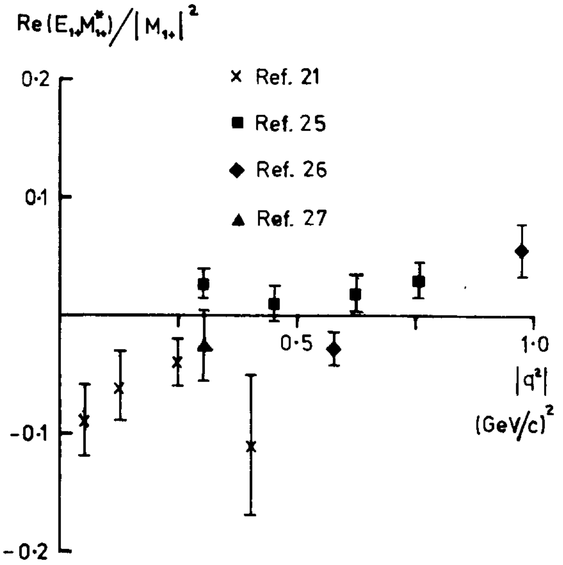


Fig. IV.2. The Δ(1232) magnetic form factor $G^*_M(q^2)$ normalized to $G^*_M(0) = 3$ and the nucleon dipole form factor $G_D(q^2) = (1 + q^2/0.71)^{-2}$.



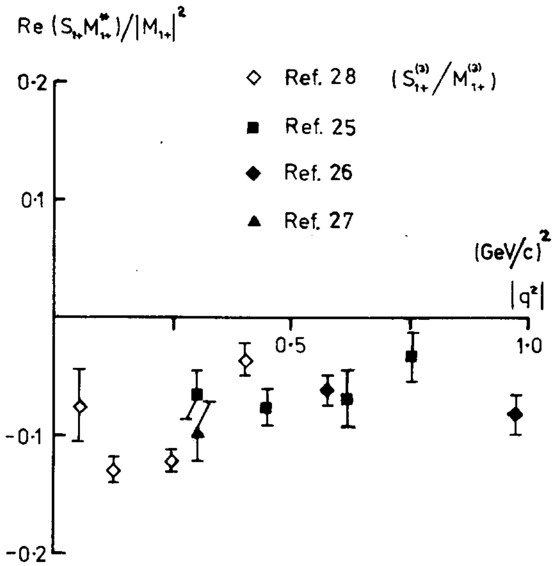


Fig. IV.3. The ratios $\mathrm{Re}(E_{1+} M^*_{1+})/|M_{1+}|^2$ and $\mathrm{Re}(S_{1+} M^*_{1+})/|M_{1+}|^2$ for π^0 electroproduction at the Δ(1232).

73). These are, as of February 1974, the only published analyses to analyze all three principal photoreactions ($\gamma p \to \pi^+ n$, $\pi^0 p$; $\gamma n \to \pi^- p$) over a considerable energy range since that of Walker (1969).[1, 12] A new analysis using the methods of Walker[1] has been carried out by Metcalf and Walker[14] and has been added to the Data Card Listings as METCALF 74, replacing the preliminary results last year listed as WALKER 73. Another recent analysis[15] over a considerable energy range is CRAWFORD 74. Single-energy analyses over the first resonance region only[16, 17] are in agreement for the P_{33} amplitude at resonance with the above continuous-energy analyses; the resonance coupling is not quoted by these authors.

The average of the listed results along with an estimate of the error from the spread of all the results is given in Table IV.1; we give results from a naive (ℓ-excitation) quark model for comparison.

References for Section IV

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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.

			STATUS AS SEEN IN --							
PARTICLE	LIJ	OVERALL STATUS	TOTAL≠ CR.S.	PI N	ETA N	K LAM	K SIG	PI DE	GAM N	OTHER CHANN.
N(940)	P11	****								
N*(1470)	P11	****		****				***	**	EPS N
N*(1520)	D13	****	****	****	*			***	***	RHO N
N*(1535)	S11	****		****	***				***	RHO N
N*(1670)	D15	****	***	****	*	*		***	*	
N*(1688)	F15	****	***	****	*	*		***	**	RHO N
N*(1700)	S11	****		****	*	***			**	EPS N
N*(1700)	D13	**		**		*	*	*	*	EPS N
N*(1780)	P11	***		***	*	**		***	*	EPS 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*(2220)	H19	***	***	***						
N*(2650)		***	***	*						
N*(3030)		***	***	*						
N*(3245)		*	*							
N*(3690)		*	*							
N*(3755)		*	*							
DE(1232)	P33	****	****	****	F				****	
DE(1650)	S31	****	**	****	O			**	**	RHO N
DE(1670)	D33	***	***	***	R			**	*	
DE(1690)	P33	*		*	B			**	*	
DE(1890)	F35	***	*	***	I		*	*	*	RHO N
DE(1900)	S31	*	*	*			*			
DE(1910)	P31	***	*	***	D		*	*	*	RHO N
DE(1950)	F37	****	***	****	D		*	**	*	RHO N
DE(1960)	D35	**	*	*	E		*	*		
DE(2160)		*		*	N		*			
DE(2420)	H311	***	***	***	F					
DE(2850)		***	***	**	O					
DE(3230)		***	***	*	R					

**** 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

n

17 NEUTRON (939, J=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

N(1470) **P'_{11}**

61 N*1/2(1470, JP=1/2+) I=1/2

MASS AND WIDTH ARE BEST DETERMINED FROM PARTIAL WAVE ANALYSES. WE LIST PRODUCTION EXPERIMENTS SEPARATELY -- SEE BELOW.

AYED 74 CLAIM 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)	DONNACHI	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	2	(1413.)	AYED	74	IPWA		2/74*
M	2	(1532.)	AYED	74	IPWA		2/74*
M	2	AYED 74 FIND 2 DIFFERENT P11 RESONANCES IN THIS REGION IN CONTRAST					2/74*
M	2	TO ALL PREVIOUS PWAS. WE LIST BOTH TOGETHER HERE UNTIL THE					2/74*
M	2	SITUATION IS FURTHER CLARIFIED.					2/74*

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                 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   2      (187.)  (SMALLER MASS)   AYED      74 IPWA                    2/74*
W   2       (89.)  (LARGER MASS)    AYED      74 IPWA                    2/74*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                 61  N*1/2(1470) REAL PART OF POLE POSITION (MEV)        1/74*
PEE       (1375.)    (5.)           LEE       73           FIT TO ALMEHED72  1/74*

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                 61  N*1/2(1470) IMAG PART OF POLE POSITION (MEV)        1/74*
IME       (108.)     (5.)           LEE       73           FIT TO ALMEHED72  1/74*

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                 61  N*1/2(1470) ABSOLUTE VALUE OF POLE RESIDUE (MEV)    1/74*
ABS        (74.)     (5.)           LEE       73           FIT TO ALMEHED72  1/74*

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                 61  N*1/2(1470) PHASE OF POLE RESIDUE (RADIANS)         1/74*
PH         (-1.4)                   LEE       73           FIT TO ALMEHED72  1/74*

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                 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+ 700
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+ 770
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

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                 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           (.549)(SMALLER MASS) AYED     74 IPWA                    2/74*
R1  2           (.123)(LARGER MASS)  AYED     74 IPWA                    2/74*
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

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*

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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)                HEMMI     73       + FWD PI0 PHTOPROD   2/74*
A1            -.066      .013       KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A1            -.055      .028       MOORHOU1  73 DPWA    PI N PHOTO-PROD    2/73
A1            -.087      .002       MOORHOU2  73 DPWA    PI N PHOTO-PROD    2/74*
A1           (-.079)                CRAWFORD  74 DPWA    PI N PHOTO PROD    2/74*
A1            -.070     .023        METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A1          . . . . . . . . . .
A1  AVG      -0.0863    0.0031   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

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             .000      .013       KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A2            +.002      .025       MOORHOU1  73 DPWA    PI N PHOTO-PROD    2/73
A2             .033      .013       MOORHOU2  73 DPWA    PI N PHOTO-PROD    2/74*
A2            (.071)                CRAWFORD  74 DPWA    PI N PHOTO PROD    2/74*
A2             .043      .035       METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A2          . . . . . . . . . .
A2  AVG       0.0180    0.0098   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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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
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)

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, CHAVANCN, 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
HEMMI    73 PL 43B 79           HEMMI,INAGAKI+           (KYOTO+SAGA+NLJ+TOKY)IJP
KNIES    73 LBL-2410            KNIES,MOORHOUSE,OBERLACK          (LBL+GLAS)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
MOORHOU1 73 PL 43B 44           MOORHOUSE, OBERLACK                (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590            MOORHOUSE,OBERLACK,ROSENFELD       (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

AYED     74 PRIVATE COMMCTN.    AYED,BAREYRE                         (SACL)IJP
    ALSO 73 AIX CONFERENCE      AYED,BAREYRE                         (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT      R L CRAWFORD                             (GLAS)
    ALSO 73 BONN CONFERENCE     R L CRAWFORD                             (GLAS)
METCALF  74 CALT-68-425         W J METCALF, R L WALKER                   (CIT)

                                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 10B 433          A DONNACHIE, R KIRSOPP              (GLAS+EDIN)
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

                 THE BUMP SEEN IN PRODUCTION EXPERIMENTS AT LOW INVARIAN
                 MASS MOST LIKELY CORRESPONDS TO THE P11 (SEE ABOVE)
                 RESONANT STATE, IF ANY.  THE HBC EXPERIMENTS SEE
                 ENHANCEMENTS MAINLY IN THE P PI PI MASS PLOT.  FOR ZERO
                 CHARGE EXCHANGE, SUCH FINAL STATES ARE KNOWN TO HAVE
    LARGE DECK-TYPE BACKGROUND.  THIS FACT COMPLICATES THE INTERPRETATION
    OF THIS BUMP AS A RESONANCE.

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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     (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          1460. TO 1510.               MORSE     71 HBC  +0 PI-P,  7 GEV/C    3/72
M         (1510.0)   (20.0)             MORSE     71 HBC  +  PI-P, 25 GEV/C    3/72
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         (1440.)    (15.)              RONAT     72  HBC    PI+P TO 3PI P     2/73
M   S    TAN 68, SHAPIRA 68, AND GAGE 72 ARE ONLY PRODUCTION EXPERIMENTS TO
M   S    SEE PPI DECAY.  HOWEVER THE EFFECT OF SHAPIRA 68, WITH MUCH IMPROVE
M   S    DATA, HAS ALMST DISAPPEARED (YEKUTIELI 72).

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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    S       (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             80. TO   120.               MORSE       71 HBC   +  PI-P,  7 GEV/C     3/72
W           (100.0)     (30.0)            MORSE       71 HBC   +  PI-P, 25 GEV/C     3/72
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           (100.)      (30.)             RONAT       72  HBC     PI+P TO 3PI P      2/73
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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+ 770
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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

R3      N*1/2(1470) INTO (N PIPI(J,I=0))/TOTAL       (P2)
R3               MAIN DECAY MODE      MORSE      71 HBC   +  PI-P 7,25 GEV/C    3/72

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                 REFERENCES FOR N*1/2(1470) (PROD. EXP.)

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      +RUSHBROOKE,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
MORSE    71 PR D4 133        +OH,WALKER,CARROLL,LYNCH +  (WISC+TNTO)IJ
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)
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)

                             PAPERS NOT REFERRED TO IN DATA CARDS

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)

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N(1520)

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  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)                   DONNACHI  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          (1525.)                    AYED      74 IPWA                       2/74*
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                      62  N*1/2(1520) WIDTH (MEV)

W     1    (125.0)                    BAREYRE   68 RVUE                      11/67
W     3    (149.0)                    DONNACHI  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          (122.)                     AYED      74 IPWA                       2/74*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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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 PROTON PI+ PI-                 938+ 139+ 139
P6      N*1/2(1520) INTO N ETA                           939+ 548
P7      N*1/2(1520) INTO N EPSILON                       938+ 700
P8      N*1/2(1520) INTO N RHO                           938+ 770
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
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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)               DONNACHI  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            (.558)                AYED      74 IPWA                          2/74*
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)
P2            0.20      0.05        KIRZ      66 HBC   0 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

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
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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           -.019      .008        KNIES     73 DPWA    PI N PHOTO PROD     2/74*
A1           -.026      .015        MOORHOU1  73 DPWA    PI N PHOTO-PROD     2/73
A1            .000      .006        MOORHOU2  73 DPWA    PI N PHOTO-PROD     2/74*
A1          (-.004)                 CRAWFORD  74 DPWA    PI N PHOTO PROD     2/74*
A1           -.006      .006        METCALF   74 DPWA    PI N PHOTO-PROD     2/74*
A1           . . . . . . . . .
A1  AVG     -0.0072     0.0043   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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            .169      .012        KNIES     73 DPWA    PI N PHOTO PROD     2/74*
A2           +.194      .031        MOORHOU1  73 DPWA    PI N PHOTO-PROD     2/73
A2            .174      .006        MOORHOU2  73 DPWA    PI N PHOTO-PROD     2/74*
A2           (.181)                 CRAWFORD  74 DPWA    PI N PHOTO PROD     2/74*
A2           +.165      .011        METCALF   74 DPWA    PI N PHOTO-PROD     2/74*
A2           . . . . . . . . .
A2  AVG      0.1726     0.0046   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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           -.077      .005        KNIES     73 DPWA    PI N PHOTO PROD     2/74*
A3           -.085      .014        MOORHOU1  73 DPWA    PI N PHOTO-PROD     2/73
A3           -.088      .007        MOORHOU2  73 DPWA    PI N PHOTO-PROD     2/74*
A3          (-.062)                 CRAWFORD  74 DPWA    PI N PHOTO PROD     2/74*
A3           -.066      .010        METCALF   74 DPWA    PI N PHOTO-PROD     2/74*
A3           . . . . . . . . .
A3  AVG     -0.0790     0.0040   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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           -.120      .010        KNIES     73 DPWA    PI N PHOTO PROD     2/74*
A4           -.124      .013        MOORHOU1  73 DPWA    PI N PHOTO-PROD     2/73
A4           -.119      .025        MOORHOU2  73 DPWA    PI N PHOTO-PROD     2/74*
A4          (-.138)                 CRAWFORD  74 DPWA    PI N PHOTO PROD     2/74*
A4           -.118      .013        METCALF   74 DPWA    PI N PHOTO-PROD     2/74*
A4           . . . . . . . . .
A4  AVG     -0.1207     0.0064   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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     +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)

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)
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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
HEMMI    73 PL 43B 79           HEMMI,INAGAKI+         (KYOTO+SAGA+NLJ+TOKY)IJP
KNIES    73 LBL-2410            KNIES,MOORHOUSE,OBERLACK      (LBL+GLAS)IJP
LEMOIGNE 73 PURDUE CONF. 93     +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOU1 73 PL 43B 44           MOORHOUSE, OBERLACK           (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590            MOORHOUSE,OBERLACK,ROSENFELD  (GLAS+LBL)IJP

AYED     74 PRIVATE COMMCTN.    AYED,BAREYRE                      (SACL)IJP
    ALSO 73 AIX CONFERENCE      AYED,BAREYRE                      (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT      R L CRAWFORD                          (GLAS)
    ALSO 73 BONN CONFERENCE     R L CRAWFORD                          (GLAS)
METCALF  74 CALT-68-425         W J METCALF, R L WALKER                (CIT)

                                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 REONANCE.
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                              (LRL)
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)

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N(1535) S'_{11}

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          63  N*1/2(1535, JP=1/2-) I=1/2

          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  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          (1520.)                 AYED      74 IPWA                     2/74*

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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           (.080)                 AYED      74 IPWA                     2/74*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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+ 700
P5        N*1/2(1535) INTO N*3/2(1232) PI             1232+ 139
P6        N*1/2(1535) INTO N RHO                       938+ 770
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

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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)                DONNACH1  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           (.36)                 AYED      74 IPWA                     2/74*

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*

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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)                HEMMI     73       + FWD PIO PHTOPROD 2/74*
A1            .056      .020       KNIES     73 DPWA    PI N PHOTO PROD  2/74*
A1           +.053      .020       MOORHOU1  73 DPWA    PI N PHOTO-PROD  2/73
A1            .036      .002       MOORHOU2  73 DPWA    PI N PHOTO-PROD  2/74*
A1           (.095)                CRAWFORD  74 DPWA    PI N PHOTO PROD  2/74*
A1           +.063      .013       METCALF   74 DPWA    PI N PHOTO-PROD  2/74*
A1          . . . . . . . . .
A1  AVG      0.0370    0.0040   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)

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           -.052      .005       KNIES     73 DPWA    PI N PHOTO PROD  2/74*
A2           -.048      .021       MOORHOU1  73 DPWA    PI N PHOTO-PROD  2/73
A2           -.027      .009       MOORHOU2  73 DPWA    PI N PHOTO-PROD  2/74*
A2          (-.047)                CRAWFORD  74 DPWA    PI N PHOTO PROD  2/74*
A2           -.051      .021       METCALF   74 DPWA    PI N PHOTO-PROD  2/74*
A2          . . . . . . . . .
A2  AVG     -0.0460    0.0059   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

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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
HEMMI    73 PL 43B 79           HEMMI,INAGAKI+         (KYOTO+SAGA+NLJ+TOKY)IJP
HICKS    73 PRD 7 2614          +DEANS,JACOBS,LYONS+ (CARN+ORNL+SOUTH FLA.)IJP
KNIES    73 LBL-2410            KNIES,MOORHOUSE,OBERLACK      (LBL+GLAS)IJP
LEMOIGNE 73 PURDUE CONF. 93     +GRANET,MARTY,AYED,BAREYRE,BORGEAUD,+(SACL)IJP
MOORHOU1 73 PL 43B 44           MOORHOUSE, OBERLACK           (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590            MOORHOUSE,OBERLACK,ROSENFELD  (GLAS+LBL)IJP

AYED     74 PRIVATE COMMCTN.    AYED,BAREYRE                      (SACL)IJP
    ALSO 73 AIX CONFERENCE      AYED,BAREYRE                      (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT      R L CRAWFORD                          (GLAS)
    ALSO 73 BONN CONFERENCE     R L CRAWFORD                          (GLAS)
METCALF  74 CALT-68-425         W J METCALF, R L WALKER                (CIT)

                                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 108 433          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 AMPLI-
          TUDE 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)
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BULOS     69 PR 187 1827         +LANOU,BORDNER,BASTIEN+(BOST+HARV+MIT+PENN)
HEUSCH    70 PRL 25 1381         +PRESCOTT,ROCHESTER,WINSTEIN             (CIT)
           MAINLY THEORETICAL --
BALL      66 PR 149 1191         J S BALL                                (UCLA)
DOBSON    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)
LOGAN     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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1520 MEV REGION – PRODUCTION EXPERIMENTS

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                     8  N*1/2(1520, JP=     ) I=1/2

                     THIS INFORMATION REFERS TO EITHER THE D13 OR THE S11
                     STATE SEEN AT THIS MASS.  FOR SPIN-PARITY ANALYSIS OF
                     THIS MASS REGION, SEE JOHNSTAD 72.

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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 CNTR    P P AT 24 GEV    10/71
M          1512.0     2.0            ELLIS     71 CNTR    MMS PP 3.7 GEV/C 10/71
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

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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 CNTR    P P AT 24 GEV    10/71
W            88.0     2.0            ELLIS     71 CNTR    MMS PP 3.7 GEV/C 10/71
W           140.0    43.0            EDELSTEIN 72 MMS   + PP 6 TO 30 GEV    1/73

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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+ 770

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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

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                               REFERENCES FOR N*1/2(1520) (PROD. EXP.)
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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)

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
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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         (1660.)                     AYED      74 IPWA                      2/74*

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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         (146.)                      AYED      74 IPWA                      2/74*
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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+ 4?7
P4      N*1/2(1670) INTO N*3/2(1232) PI                 1232+ 139
P5      N*1/2(1670) INTO N PI PI                         938+ 1?9+ 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

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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          (.415)                    AYED      74 IPWA                      2/74*
        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          (0.01) OR LESS            TRIPP     67 RVUE                      8/67
R3  B       (0.00) OR LESS            RUSH      68 MPWA    T POLE + RESON.   8/69
R3  B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING
R3          (0.00) 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

  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)                    HEMMI     73       + FWD PIO PHTOPROD  2/74*
A1            .013      .014          KNIES     73 DPWA    PI N PHOTO PROD   2/74*
A1           +.011      .012          MOORHOU1  73 DPWA    PI N PHOTO-PROD   2/73
A1            .019      .007          MOORHOU2  73 DPWA    PI N PHOTO-PROD   2/74*
A1          (.054)                    CRAWFORD  74 DPWA    PI N PHOTO PROD   2/74*
A1           +.010      .013          METCALF   74 DPWA    PI N PHOTO-PROD   2/74*
A1          . . . . . . . . . .
A1  AVG        0.0157    0.0050  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            .014      .008          KNIES     73 DPWA    PI N PHOTO PROD   2/74*
A2           +.021      .020          MOORHOU1  73 DPWA    PI N PHOTO-PROD   2/73
A2            .016      .002          MOORHOU2  73 DPWA    PI N PHOTO-PROD   2/74*
A2          (.024)                    CRAWFORD  74 DPWA    PI N PHOTO PROD   2/74*
A2           +.042      .024          METCALF   74 DPWA    PI N PHOTO-PROD   2/74*
A2          . . . . . . . . . .
A2  AVG        0.0162    0.0019  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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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           -.043      .006          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A3           +.010      .040          MOORHOU1  73 DPWA    PI N PHOTO-PROD    2/73
A3           -.017      .004          MOORHOU2  73 DPWA    PI N PHOTO-PROD    2/74*
A3          (-.067)                   CRAWFORD  74 DPWA    PI N PHOTO PROD    2/74*
A3            .004      .015          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A3          . . . . . . . . .
A3  AVG     -0.0235    0.0093  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9)

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           -.071      .030          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A4           -.035      .014          MOORHOU1  73 DPWA    PI N PHOTO-PROD    2/73
A4           -.049      .004          MOORHOU2  73 DPWA    PI N PHOTO-PROD    2/74*
A4          (-.084)                   CRAWFORD  74 DPWA    PI N PHOTO PROD    2/74*
A4           -.009      .029          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A4          . . . . . . . . .
A4  AVG     -0.0483    0.0038  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                              REFERENCES FOR N*1/2(1670)

BRANDSEN 65 PL 19 420            +ODONNELL, 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
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 KIPSOPP                          (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 16B 35            B CARRERAS, A DONNACHIE        (DARE,MCHS)
DAVIES   70 NP B21 359           A DAVIES                             (GLAS)

BRODY    71 PL 34B 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
HEMMI    73 PL 43B 79            HEMMI,INAGAKI+       (KYOTO+SAGA+NLJ+TOKY)IJP
KNIES    73 LBL-2410             KNIES,MOORHOUSE,OBERLACK      (LBL+GLAS)IJP
MOORHOU1 73 PL 43B 44            MOORHOUSE, OBERLACK           (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590             MOORHOUSE,OBERLACK,ROSENFELD  (GLAS+LBL)IJP

AYED     74 PRIVATE COMMCTN.     AYED,BAREYRE                      (SACL)IJP
  ALSO   73 AIX CONFERENCE       AYED,BAREYRE                      (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT       R L CRAWFORD                         (GLAS)
  ALSO   73 BONN CONFERENCE      R L CRAWFORD                         (GLAS)
METCALF  74 CALT-68-425          W J METCALF, R L WALKER               (CIT)

                         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)
DONNACHI 69 NP 10B 433           A DONNACHIE, R KIRSOPP          (GLAS+EDIN)
AYED     70 PL 31B 598           +BAREYRE+VILLET                     (SACLAY)

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N(1688)   65 N*1/2(1688, JP=5/2+) T=1/2   **F'_{15}**

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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)                    DONNACHI  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 ARGAND DIAGRAM
M    4    (1685.0)                    DAVIES    70 RVUE    P-S ANAL  SOL A    8/69
M    7    (1688.)                     ALMEHED   72 IPWA                       2/72
M         (1680.)                     AYED      74 IPWA                       2/74*

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                    65  N*1/2(1688) WIDTH (MEV)

W    1    (110.0)                     BAREYRE   68 RVUE                      11/67
W    3    (177.0)                     DONNACHI  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         (126.)                      AYED      74 IPWA                       2/74*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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+ 700
P11    N*1/2(1688) INTO N RHO                         938+ 770

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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)                    DONNACHI  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         (.593)                     AYED      74 IPWA                       2/74*
     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 +  PIO, ETA PHOTO     9/66

R4     N*1/2(1688) INTO (LAMBDA K)/TOTAL                   (P3)
R4         (0.00) 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

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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)                   HEMMI     73       + FWD PIO PHTOPROD   2/74*
A1           -.016      .014          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A1           -.008      .004          MOORHOU1  73 DPWA    PI N PHOTO-PROD    2/73
A1           -.014      .003          MOORHOU2  73 DPWA    PI N PHOTO-PROD    2/74*
A1          (.009)                    CRAWFORD  74 DPWA    PI N PHOTO PROD    2/74*
A1           -.008      .011          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A1          . . . . . . . . .
A1  AVG     -0.0115    0.0023  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            .097      .007          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A2           +.100      .012          MOORHOU1  73 DPWA    PI N PHOTO-PROD    2/73
A2            .147      .006          MOORHOU2  73 DPWA    PI N PHOTO-PROD    2/74*
A2          (.138)                    CRAWFORD  74 DPWA    PI N PHOTO PROD    2/74*
A2            .129      .016          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A2          . . . . . . . . .
A2  AVG      0.123     0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.3)

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            .023      .005          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A3           +.017      .014          MOORHOU1  73 DPWA    PI N PHOTO-PROD    2/73
A3            .023      .003          MOORHOU2  73 DPWA    PI N PHOTO-PROD    2/74*
A3          (.044)                    CRAWFORD  74 DPWA    PI N PHOTO PROD    2/74*
A3            .008      .018          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A3          . . . . . . . . .
A3  AVG      0.0225    0.0025  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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            .001      .018          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A4           -.005      .018          MOORHOU1  73 DPWA    PI N PHOTO-PROD    2/73
A4           -.041      .004          MOORHOU2  73 DPWA    PI N PHOTO-PROD    2/74*
A4          (-.024)                   CRAWFORD  74 DPWA    PI N PHOTO PROD    2/74*
A4            .00       .030.         METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A4          . . . . . . . . .
A4  AVG     -0.0367    0.0078  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)

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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            +ODONNELL, MOORHOUSE          (DURHAM, RHEL)IJP
HEUSCH   66 PRL 17 1019          C A HEUSCH, C Y PRESCOTT, R F DASHEN  (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
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)
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
HEMMI    73 PL 43B 79            HEMMI,INAGAKI+       (KYOTO+SAGA+NLJ+TOKY)IJP
KNIES    73 LBL-2410             KNIES,MOORHOUSE,OBERLACK      (LBL+GLAS)IJP
MOORHOU1 73 PL 43B 44            MOORHOUSE, OBERLACK           (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590             MOORHOUSE,OBERLACK,ROSENFELD  (GLAS+LBL)IJP

AYED     74 PRIVATE COMMCTN.     AYED,BAREYRE                      (SACL)IJP
  ALSO   73 AIX CONFERENCE       AYED,BAREYRE                      (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT       R L CRAWFORD                         (GLAS)
  ALSO   73 BONN CONFERENCE      R L CRAWFORD                         (GLAS)
METCALF  74 CALT-68-425          W J METCALF, R L WALKER               (CIT)
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                         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.
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 318 598        +BAREYRE+VILLET                      (SACLAY)

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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)

M        (1695.0)                  BRANDSEN  65 RVUE     PHASE-SHIFT ANAL  9/66
M        (1700.0)                  MICHAEL   66 RVUE     FITS BAREYRE S11  7/66
M   1    (1710.0)                  BAREYRE   68 RVUE     PHASE-SHIFT ANAL 11/67
M   1       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        (1672.)                   AYED      74 IPWA                       2/74*

                         66 N*1/2(1700) WIDTH (MEV)

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        (179.)                    AYED      74 IPWA                       2/74*
    SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

                         66 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 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+ 700
P8       N*1/2(1700) INTO N RHO                             938+ 770
P9       N*1/2(1700) INTO K SIGMA                           493+1189

                         66 N*1/2(1700) BRANCHING RATIOS

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          (.586)                     AYED      74 IPWA                   2/74*

R2       N*1/2(1700) INTO (LAMBDA K)*(PI N)/TOTAL**2   (P3*P1)
R2          0.039    0.019             ORITO     69 RVUE                   8/69
R2  A       (0.043)OR 0.054            WAGNER    71 IPWA     PI-P TO K LAMB    1/71

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*
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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.

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           .058      .018          KNIES     73 DPWA   PI N PHOTO PROD   2/74*
A1          +.066      .042          MOORHOU1  73 DPWA   PI N PHOTO-PROD   2/73
A1           .054      .005          MOORHOU2  73 DPWA   PI N PHOTO-PROD   2/74*
A1          (.003)                   CRAWFORD  74 DPWA   PI N PHOTO PROD   2/74*
A1          +.012      .015          METCALF   74 DPWA   PI N PHOTO-PROD   2/74*
A1
A1  AVG      0.0500    0.0086   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

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          -.015      .035          KNIES     73 DPWA   PI N PHOTO PROD   2/74*
A2          -.072      .066          MOORHOU1  73 DPWA   PI N PHOTO-PROD   2/73
A2          -.027      .009          MOORHOU2  73 DPWA   PI N PHOTO-PROD   2/74*
A2          (.005)                   CRAWFORD  74 DPWA   PI N PHOTO PROD   2/74*
A2          -.019      .022          METCALF   74 DPWA   PI N PHOTO-PROD   2/74*
A2
A2  AVG     -0.0247    0.0079   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                         REFERENCES FOR N*1/2(1700)

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)
   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 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
KNIES    73 LBL-2410           KNIES,MOORHOUSE,OBERLACK        (LBL+GLAS)IJP
LANGBEIN 73 NP B53 251         LANGBEIN,WAGNER                     (MUNICH)IJP
MOORHOU1 73 PL 43B 44          MOORHOUSE, OBERLACK             (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590           MOORHOUSE,OBERLACK,ROSENFELD    (GLAS+LBL)IJP

AYED     74 PRIVATE COMMCTN.   AYED,BAREYRE                          (SACL)IJP
   ALSO  73 AIX CONFERENCE     AYED,BAREYRE                          (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT     R L CRAWFORD                            (GLAS)
   ALSO  73 BONN CONFERENCE    R L CRAWFORD                            (GLAS)
METCALF  74 CALT-68-425        W J METCALF, R L WALKER                  (CIT)

                         PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE  65 PL 18 342          + BRICMAN, 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 318 598         +BAREYRE+VILLET                       (SACLAY)
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N(1700)

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18 N*1/2(1700, JP=3/2-) I=1/2 D''_{13}

A NEW, PRELIMINARY ENERGY DEPENDENT ANALYSIS BY AYED 72 INDICATES THE PRESENCE OF THIS STATE. AYED 74 DEFINITELY REQUIRE THIS STATE. IN ADDITION AN ISOBAR MODEL ANALYSIS BY HERNDON 72 SHOWS EVIDENCE FOR THIS STATE IN THE SIGMA N AND DELTA PI CHANNELS. THERE IS ADDITIONAL EVIDENCE FROM K SIGMA ASSOCIATED PRODUCTION AND PI N, K LAMBDA PHOTOPRODUCTION. SEE THE N* MINI REVIEW.

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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        (1710.)                 AYED      74 IPWA                      2/74*

                         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        (100.)                  AYED      74 IPWA                      2/74*

                         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
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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*

R3      N*1/2(1700) INTO PI N/TOTAL                      (P1)
R3           (.089)                    AYED       74 IPWA                      2/74*

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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            -.015      .040          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A1            (.023)                   MOORHOU2  73 DPWA    PI N PHOTO PROD    2/74*
A1              .0       .034          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A1          . . . . . . . . . . .
A1  AVG     -0.010      0.025   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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             .030      .040          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A2            (.035)                   MOORHOU2  73 DPWA    PI N PHOTO PROD    2/74*
A2              .0       .029          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A2          . . . . . . . . . . .
A2  AVG      0.015      0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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            -.036      .040          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A3           (-.015)                   MOORHOU2  73 DPWA    PI N PHOTO PROD    2/74*
A3              .0       .034          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A3          . . . . . . . . . . .
A3  AVG     -0.015      0.026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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             .024      .024          KNIES     73 DPWA    PI N PHOTO PROD    2/74*
A4            (.028)                   MOORHOU2  73 DPWA    PI N PHOTO PROD    2/74*
A4              .0       .044          METCALF   74 DPWA    PI N PHOTO-PROD    2/74*
A4          . . . . . . . . . . .
A4  AVG      0.013      0.020   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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
KNIES    73 LBL-2410           KNIES,MOORHOUSE,OBERLACK         (LBL+GLAS)IJP
LANGBEIN 73 NP B53 251         LANGREIN,WAGNER                     (MUNICH)IJP
MOORHOU2 73 LBL-1590           MOORHOUSE,OBERLACK,ROSENFELD     (GLAS+LBL)IJP
AYED     74 PRIVATE COMMCTN.   AYED,BAREYRE                          (SACL)IJP
   ALSO  73 AIX CONFERENCE     AYED,BAREYRE                          (SACL)IJP
METCALF  74 CALT-68-425        W J METCALF, R L WALKER                (CIT)

                               PAPERS NOT REFERRED TO IN DATA CARDS.

HERNDON  72 LBL 1065           +...ROSENFELD...+CASHMCRE+...     (LBL,SLAC)
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1700 MEV REGION – PRODUCTION EXPERIMENTS

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                    20  N*1/2(1700, JP=    ) I=1/2

                    PARTIAL WAVE ANALYSIS REQUIRES AT LEAST FOUR I=1/2 STAT
                    IN THE 1670 TO 1780 REGION (D15, F15, S11, P11) AND AT
                    LEAST ONE I=3/2 STATE (D33). OBVIOUSLY, DIFFERENT EXPE
                    IMENTS ARE SEEING DIFFERENT STATES AND OFTEN IT IS NOT
    CLEAR WHAT ISOSPIN STATE IS BEING OBSERVED.  NO EFFORT WAS MADE
    TO SEPARATE THESE EXPERIMENTS ACCORDING TO JP, SINCE NONE OF THE
    REPORTED JP IS FIRMLY ESTABLISHED.  WE LIST ALL THE INFORMATION HERE,
    BUT WE HAVE NOT USED IT IN THE BARYON TABLE.
       FOR SPIN-PARITY ANALYSIS OF THIS MASS REGION, SEE JOHNSTAD 72 AND
    LAMSA 72.

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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    A     (1667.0)    (5.0)             BENVENUTI 69 DBC   0 PI-D 2.26 GEV      5/70
M    B  190(1693.)    (15.)              RHODE     69 HBC     PP 22 GEV/C       10/69
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          (1694.0)    (8.0)             AMALDI    71 CNTR    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  +  PD--PD2PI 7 GEV   12/72
M    C     (1715.0)    (5.0)             LAMSA     72 HBC  +  PI+-P 8TO18 GEV    1/73
M     2    (1660.)  (15.                 OH        72 DBC   0 PI-N TO PI-PI-P    2/73
M          (1720.)    (15.)              RONAT     72  HBC    PI+P TO 3PI P      2/73
M    C    ANALYSIS GIVES JP = 5/2+
M     2   DETERMINE J=5/2,F15 PROBABLE                                           2/73
M    B  JP IS PROBABLY 5/2+
M    1      IJP CONSISTENT WITH S11(1700) OR P11(1780) IN FORMATION
M    A        J CONSISTENT WITH 5/2 OR 7/2
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                    20  N*1/2(1700) WIDTH (MEV) (PROD. EXP.)

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 CNTR    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
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                    20  N*1/2(1700) PARTIAL DECAY MODES (PROD. EXP.)

                                                              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

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                    20  N*1/2(1700) BRANCHING RATIOS (PROD. EXP.)

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 (LAMBDA 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

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 HBG  +                    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)

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          . . . . . . . . . . .
R8  AVG        0.66      0.10    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

R9      N*1/2(1700) INTO (SIG K)/(LAMB K)                PROD. EXP.
R9           LESS THAN    .20          COOPER    70 HBC  +  PI+P, 5.5 GEV/C   2/71

        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                               REFERENCES FOR N*1/2(1700) (PROD. EXP.)

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
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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,NOPEM,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)

                                 PAPERS NOT REFERRED TO IN DATA CARDS.

MERLO     66 P ROY SOC 289 489 J P MERLO, G VALLADAS                  (SACLAY)
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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)

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         (1780.)                       LANGBEIN  73 IPWA   PI N-K SIG,SOL 1  9/73*
M         (1780.)                       LANGBEIN  73 IPWA   PI N-K SIG,SOL 2  9/73*
M         (1729.)                       AYED      74 IPWA                     2/74*

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                  14  N*1/2(1780) WIDTH (MEV)

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          (130.)                       LANGBEIN  73 IPWA   PI N-K SIG,SOL 1  9/73*
W          (130.)                       LANGBEIN  73 IPWA   PI N-K SIG,SOL 2  9/73*
W          (217.)                       AYED      74 IPWA                     2/74*
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                  14  N*1/2(1780) PARTIAL DECAY MODES

                                                     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+ 700
P8      N*1/2(1780) INTO N RHO                       938+ 770
P9      N*1/2(1780) INTO K SIGMA                     493+1189

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                  14  N*1/2(1780) BRANCHING RATIOS

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            (.188)                    AYED      74 IPWA                     2/74*

R2      N*1/2(1780) INTO (LAMBDA K)*(PI N)/TOTAL**2         (P2*P1)
R2            0.004    0.003            ORITO     69 RVUE                     8/69
R2  A        (0.025)OR 0.043            WAGNER    71 IPWA   PI-P TO K LAMB    1/71

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            (.11)                     LANGBEIN  73 IPWA   PI N-K SIG,SOL 1  9/73*
R7            (.14)                     LANGBEIN  73 IPWA   PI N-K SIG,SOL 2  9/73*

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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.

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              .022     .015          KNIES     73 DPWA   PI N PHOTO PROD   2/74*
A1             +.026     .028          MOORHOU1  73 DPWA   PI N PHOTO-PROD   2/73
A1              .016     .025          MOORHOU2  73 DPWA   PI N PHOTO-PROD   2/74*
A1             -.068     .024          METCALF   74 DPWA   PI N PHOTO-PROD   2/74*
A1          . . . . . . . . . .
A1  AVG        0.005    0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

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     .015          KNIES     73 DPWA   PI N PHOTO PROD   2/74*
A2             +.027     .022          MOORHOU1  73 DPWA   PI N PHOTO-PROD   2/73
A2              .057     .022          MOORHOU2  73 DPWA   PI N PHOTO-PROD   2/74*
A2              .048     .045          METCALF   74 DPWA   PI N PHOTO-PROD   2/74*
A2          . . . . . . . . . .
A2  AVG        0.033    0.010   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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 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
KNIES    73 LBL-2410            KNIES,MOORHOUSE,OBERLACK           (LBL+GLAS)IJP
LANGBEIN 73 NP B53 251          LANGBEIN,WAGNER                      (MUNICH)IJP
MOORHOU1 73 PL 43B 44           MOORHOUSE, OBERLACK                (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590            MOORHOUSE,OBERLACK,ROSENFELD       (GLAS+LBL)IJP
AYED     74 PRIVATE COMMCTN.    AYED,BAREYRE                           (SACL)IJP
    ALSO 73 AIX CONFERENCE      AYED,BAREYRE                           (SACL)IJP
METCALF  74 CALT-68-425         W J METCALF, R L WALKER                   (CIT)

                                PAPERS NOT REFERRED TO IN DATA CARDS.

DEANS    69 PR  177 2623        S R DEANS                     (UNIV S FLORIDA)
DONNACHI 69 NP 10B 433          A DONNACHIE, R KIRSOPP              (GLAS+EDIN)
AYED     70 PL 31B 598          +BAREYRE+VILLET                        (SACLAY)
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N(1810)

15 N*1/2(1810, JP=3/2+) I=1/2   **P13**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                  15  N*1/2(1810) MASS (MEV)

M   3     (1860.0)                      DONNACH1  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         (1696.)                       AYED      74 IPWA                     2/74*

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                  15  N*1/2(1810) WIDTH (MEV)

W   3      (296.00)                     DONNACH1  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          (117.)                       AYED      74 IPWA                     2/74*
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                  15  N*1/2(1810) PARTIAL DECAY MODES

                                                     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

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Data Card Listings

For notation, see key at front of Listings.

Baryons

N(1810), N(1990), N(2000)

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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)                 DONNACH1   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          (145.)                  AYED       74 IPWA                      2/74*

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) INTO (LAMBDA K)*(PI N)/TOTAL**2         (P2*P1)
R4  A        (0.015)                WAGNER     71 IPWA     PI-P TO K LAMB    1/71

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*

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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          -.004      .032         KNIES     73 DPWA     PI N PHOTO PROD   2/74*
A1           .0        .025         METCALF   74 DPWA     PI N PHOTO-PROD   2/74*
A1          • • • • • • • • •
A1  AVG     -0.002    0.019    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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          -.006      .030         KNIES     73 DPWA     PI N PHOTO PROD   2/74*
A2           .0        .022         METCALF   74 DPWA     PI N PHOTO-PROD   2/74*
A2          • • • • • • • • •
A2  AVG     -0.002    0.017    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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           .014      .014         KNIES     73 DPWA     PI N PHOTO PROD   2/74*
A3           .0        .050         METCALF   74 DPWA     PI N PHOTO-PROD   2/74*
A3          • • • • • • • • •
A3  AVG      0.014    0.013    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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          -.008      .025         KNIES     73 DPWA     PI N PHOTO PROD   2/74*
A4           .0        .044         METCALF   74 DPWA     PI N PHOTO-PROD   2/74*
A4          • • • • • • • • •
A4  AVG     -0.004    0.021    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                         REFERENCES FOR N*1/2(1810)

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)
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
KNIES    73 LBL-2410          KNIES,MOORHOUSE,OBERLACK         (LBL+GLAS)IJP
AYED     74 PRIVATE COMMCTN.  AYED,BAREYRE                         (SACL)IJP
   ALSO 73 AIX CONFERENCE     AYED,BAREYRE                         (SACL)IJP
METCALF  74 CALT-68-425       W J METCALF, R L WALKER               (CIT)

                         PAPERS NOT REFERRED TO IN DATA CARDS.

DEANS    69 PR  177 2623      S R DEANS                  (UNIV S FLORIDA)
DONNACHI 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)
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N(1990) → 17 N*1/2(1990, JP=7/2+) I=1/2 **F_{17}**

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     THE MOST RECENT PI N PARTIAL WAVE ANALYSIS, AYED 74,
     FINDS EVIDENCE FOR THIS STATE.  THERE IS ALSO SOME
     INDICATION IN THE K SIGMA CHANNEL, LANGBEIN 73.

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                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    1    (1970.)                  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    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         (2049.)                  AYED       74 IPWA                        2/74*

                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    1    (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       74 IPWA                        2/74*

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                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

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                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           (.064)                AYED       74 IPWA                       2/74*

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   1       (.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*

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                         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,OADES,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
AYED     74 PRIVATE COMMCTN.  AYED,BAREYRE                         (SACL)IJP
   ALSO 73 AIX CONFERENCE     AYED,BAREYRE                         (SACL)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)
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N(2000) → 06 N*1/2(2000, JP=5/2+) I=1/2 **F''_{15}**

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     THE MOST RECENT PI N PARTIAL WAVE ANALYSIS, AYED 74,
     FINDS EVIDENCE FOR THIS STATE.  THERE IS ALSO SOME
     INDICATION IN THE K SIGMA CHANNEL, LANGBEIN 73.

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                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         (1989.)                  AYED       74 IPWA                        2/74*

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                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         (179.)                   AYED       74 IPWA                        2/74*

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                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

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                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       74 IPWA                       2/74*

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*
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                              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
AYED      74 PRIVATE COMMCTN.     AYED,BAREYRE                           (SACL)IJP
   ALSO   73 AIX CONFERENCE       AYED,BAREYRE                           (SACL)IJP

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N(2040) 16 N*1/2(2040, JP=3/2-) I=1/2 **D''_{13}**

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THIS STATE IS NOW SEEN BY THE SACLAY GROUP, AYED 74.

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            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      74 IPWA                      2/74*

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            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      74 IPWA                      2/74*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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            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

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            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            (.100)                  AYED      74 IPWA                      2/74*

R2      N*1/2(2040) INTO (N ETA)/TOTAL                   (P3)
R2  8         (0.)   OR 0.009         CARRERAS  70 MPWA    T POLE + RESON.   5/70
R2  8   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*

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                              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,OADES,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
AYED      74 PRIVATE COMMCTN.     AYED,BAREYRE                           (SACL)IJP
   ALSO   73 AIX CONFERENCE       AYED,BAREYRE     -                     (SACL)IJP

                                  PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI  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)

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N(2100) 04 N*1/2(2100, JP=1/2-) I=1/2 **S''_{11}**

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NOW ALSO SEEN BY SACLAY, AYED 74.

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            04  N*1/2(2100) MASS (MEV)

M         (2070.)                     ROYCHOUD  71 DPWA                      3/72
M  7      (2100.)                     ALMEHED   72 IPWA                      2/72
M         (2283.)                     AYED      74 IPWA                      2/74*

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            04  N*1/2(2100) WIDTH (MEV)

W  7      (200.)                      ALMEHED   72 IPWA                      2/72
W         (310.)                      AYED      74 IPWA                      2/74*

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            04  N*1/2(2100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*1/2(2100) INTO PI N                             139+ 938

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            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          (.14)                     AYED      74 IPWA                      2/74*

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                              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      74 PRIVATE COMMCTN.     AYED,BAREYRE                           (SACL)IJP
   ALSO   73 AIX CONFERENCE       AYED,BAREYRE                           (SACL)IJP

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N(2100) 05 N*1/2(2100, JP=5/2-) I=1/2 **D''_{15}**

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NOW ALSO SEEN BY SACLAY, AYED 74.

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            05  N*1/2(2100) MASS (MEV)

M  7      (2100.)                     ALMEHED   72 IPWA                      2/72
M         (2100.)                     AYED      74 IPWA                      2/74*

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            05  N*1/2(2100) WIDTH (MEV)

W  7      (150.)                      ALMEHED   72 IPWA                      2/72
W         (220.)                      AYED      74 IPWA                      2/74*

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            05  N*1/2(2100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      N*1/2(2100) INTO PI N                             139+ 938

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            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          (.08)                     AYED      74 IPWA                      2/74*

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                              REFERENCES FOR N*1/2(2100)

ALMEHED   72 NP B40 157           +LOVELACE                        (LUND,RUTG)IJP
AYED      74 PRIVATE COMMCTN.     AYED,BAREYRE                           (SACL)IJP
   ALSO   73 AIX CONFERENCE       AYED,BAREYRE                           (SACL)IJP

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N(2190) 71 N*1/2(2190, JP=7/2-) I=1/2 **G_{17}**

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ROYCHOUDHURY 71 FIND SOME INDICATION OF P11 AND F17 IN
THIS REGION.BRANSDEN 71 ALSO FIND P11,F15,AND G19 RESO-
NANT NEAR THIS MASS.

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            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         (2141.)                     AYED      74 IPWA                      2/74*
M  2      (2133.)                     AYED      74 IPWA                      2/74*
M  2   THIS IS A G19 RESONANCE LISTED HERE UNTIL CONFIRMED.                  2/74*

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                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      74 IPWA                        2/74*
W    2     (193.)                        AYED      74 IPWA                        2/74*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                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+1765
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

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                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  O PI-P BKWD ELSTC     2/73
R1            (.161)                     AYED      74 IPWA                        2/74*
R1   2        (.095)                     AYED      74 IPWA                        2/74*

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            (.0194)                    HICKS        73 MPWA   GAM P-ETA P       9/73*

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REFERENCES FOR N*1/2(2190)


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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          +SUWA,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
AYED     74 PRIVATE COMMCTN.  AYED,BAREYRE                            (SACL)IJP
    ALSO 73 AIX CONFERENCE    AYED,BAREYRE                            (SACL)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     70 PL 31B 598          +BAREYRE,VILLET                        (SACLAY)

          QUANTUM NUMBER DETERMINATIONS 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)
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N(2220) 90 N*1/2(2220, JP=9/2+) I=1/2 **H19**

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                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        74 IPWA                      2/74*

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                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        74 IPWA                      2/74*

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                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

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                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            (.204)               AYED       74 IPWA                          2/74*

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REFERENCES FOR N*1/2(2220)


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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     74 PRIVATE COMMCTN.    AYED,BAREYRE                         (SACL)IJP
    ALSO 73 AIX CONFERENCE      AYED,BAREYRE                         (SACL)IJP

                                PAPERS NOT REFERED TO IN DATA CARDS

AYED     70 PL 31B 598          +BAREYRE,VILLET                        (SACLAY)
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N(2650) BUMPS 72 N*1/2(2650, JP=) I=1/2 PRODUCTION EXPERIMENTS

ROYCHOUDHURY 71 CLAIM F15(2400) AND G19(2400) TO BE POSSIBLE RESONANCES. BRANSDEN 71 FIND THE POSSIBLE RESONANT CANDIDATES S11(2520) AND H19(2590).

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                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  O 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

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                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

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                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

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                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        (0.456)   (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.+PESON. 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

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REFERENCES FOR N*1/2(2650) (PROD. EXP.)


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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          ,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
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N(3030) BUMPS

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73  N*1/2(3030, JP=     ) I=1/2  PRODUCTION EXPERIMENTS

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                 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

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                 73  N*1/2(3030) WIDTH (MEV) (PROD. EXP.)

W         (400.0)                   CITRON    66 CNTR                      7/66

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                 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

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                 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

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                          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)
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$N_?$(3245) BUMPS

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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.

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                 74  N* /2(3245) MASS (MEV) (PROD. EXP.)

M        3245.0     10.0            KORMANYOS 67 CNTR    PI-P 180 DEG EL   6/68

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                 74  N* /2(3245) WIDTH (MEV) (PROD. EXP.)

W         (35.0)  OR LESS           KORMANYOS 67 CNTR                      6/68

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                 74  N* /2(3245) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     N* /2(3245) INTO PI N                            139+ 938

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                 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

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                          REFERENCES FOR N* /2(3245) (PROD. EXP.)

KORMANYO 67 PR 164 1661        KORMANYOS, KRISCH, OFALLON, +     (MICH,ANL) P
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N(3690) BUMPS

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75  N*1/2(3690, JP=     ) I=1/2  PRODUCTION EXPERIMENTS

A BUMP SEEN IN THE INVARIANT MASS OF A VERY COMPLI-
CATED STATE (N + SEVEN PIS), SO AS EVIDENCE FOR
A NEW RESONANCE IT IS NOT CONCLUSIVE.  NOT INCLUDED
IN TABLE.

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                 75  N*1/2(3690) MASS (MEV) (PROD. EXP.)

M        3690.0     10.0            BARTKE    67 HBC  +  PI+P 8 PRONGS     8/67

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                 75  N*1/2(3690) WIDTH (MEV) (PROD. EXP.)

W          50.0     30.0            BARTKE    67 HBC  +                    8/67

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                 75  N*1/2(3690) PARTIAL DECAY MODES (PROD. EXP.)

                                                          DECAY MASSES
P1     N*1/2(3690) INTO N + 7 PIS

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                          REFERENCES FOR N*1/2(3690) (PROD. EXP.)

BARTKE    67 PL 24B 118        +CZYZEWSKI,DANYSZ,+          (CRACOW,ORSAY) I
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$N_?$(3755) BUMPS

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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.

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                 76  N* /2(3755) MASS (MEV) (PROD. EXP.)

M        3755.0      8.0            EHRLICH   68 HBC  +  PI+ P P PBAR      6/68

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                 76  N* /2(3755) WIDTH (MEV) (PROD. EXP.)

W          40.0     20.0            EHRLICH   68 HBC  +                    6/68

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                 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 PLANC,J B WHITTAKER (RUTGERS)
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S=0 I=3/2 NUCLEON STATES (Δ)

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Δ(1232) P'_{33}

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33  N*3/2(1232, JP=3/2+) I=3/2

CARTER 71 REPORT NEW PRECISE CROSS SECTION MEASURE-
MENTS FOR PI+P,PI-P AND CHARGE EXCHANGE. THEIR ANALYSIS
COMBINES TOTAL CROSS SECTION DATA WITH THE PHASE SHIFTS
OF DONNACHIE 68 (USED FOR THE BACKGROUND UNDER THE P33)
THE CHARGE EXCHANGE DATA WERE NOT USED.
  OLSON 65 HAS DONE A SIMILAR ANALYSIS ON OLDER DATA, USING ROPER 65
PHASE SHIFTS WITH A FREE OVERALL NORMALIZATION.
    IN ADDITION TO DATA USED IN CARTER 71, NEW, ACCURATE DIFFERENTIAL
 CROSS SECTION DATA ARE USED BY CARTER 73 TO DETERMINE THE N*3/2(1232)
 PARAMETERS.

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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           (1234.)                    AYED       74 IPWA                       2/74*

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)

MO             1236.45      0.65       OLSSON     65 RVUE  O
MO             1232.9       0.6        CARTER     71 MPWA  O 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            (120.)                    AYED       74 IPWA                       2/74*
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)

WO             119.6        2.4        OLSSON     65 RVUE  O
WO             114.7        3.0        CARTER     71 MPWA  O 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    AVG     1.40     0.39    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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   AVG     9.3      1.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
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              33  N*3/2(1232) REAL PART OF POLE POSITION(MEV)

REE       (1214.)                  MICHAEL    67          FIT OLSSON 65    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  P  ERROR EST. FROM FITS WITH SOMEWHAT VARYING ASSUMPTIONS
REE         . . . . . . . . .
REE.AVG    1211.61    0.70    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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              33  N*3/2(1232) IMAG PART OF POLE POSITION(MEV)

IME       (52.)                    MICHAEL    67          FIT OLSSON 65    2/74*
IME       (50.)                    BALL       72                           2/73
IME  P     49.5       1.5          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         . . . . . . . . .
IME AVG    49.4       1.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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*
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              33  N*3/2(1232) PHASE OF POLE RESIDUE (RADIANS)

PH        (-.81)                   BALL       73          FIT DELTA 33     9/73*
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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   AVG    0.542     0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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       74 IPWA                      2/74*
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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          -.138     .004         KNIES      73 DPWA    PI N PHOTO PROD   2/74*
A1          -.142     .006         MOORHOU1   73 DPWA    PI N PHOTO-PROD   2/73
A1          -.142     .001         MOORHOU2   73 DPWA    PI N PHOTO-PROD   2/74*
A1         (-.140)                 CRAWFORD   74 DPWA    PI N PHOTO PROD   2/74*
A1          -.140     .006         METCALF    74 DPWA    PI N PHOTO-PROD   2/74*
A1          . . . . . . . . .
A1   AVG   -0.14174   0.00094 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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          -.253     .002         KNIES      73 DPWA    PI N PHOTO PROD   2/74*
A2          -.259     .016         MOORHOU1   73 DPWA    PI N PHOTO-PROD   2/73
A2          -.261     .001         MOORHOU2   73 DPWA    PI N PHOTO-PROD   2/74*
A2         (-.263)                 CRAWFORD   74 DPWA    PI N PHOTO PROD   2/74*
A2          -.254     .007         METCALF    74 DPWA    PI N PHOTO-PROD   2/74*
A2          . . . . . . . . .
A2   AVG   -0.2593    0.0032  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.6)

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REFERENCES FOR N*3/2(1234)


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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)

ALMEHED  72 NP B40 157        +LOVELACE                   (LUND,RUTG)IJP
BALL     72 PRL 28 1143       +CAMPBELL,LEE,SHAW          (UTAH,BOISE,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
KNIES    73 LBL-2410          KNIES,MOORHOUSE,OBERLACK       (LBL+GLAS)IJP
MOORHOU1 73 PL 43B 44         MOORHOUSE, OBERLACK            (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590          MOORHOUSE,OBERLACK,ROSENFELD   (GLAS+LBL)IJP
NOGOVA   73 NP B61 445        NOGOVA,PISUT(IP SLOVAK AC.J SCI,COMENIUS U)IJP
   ALSO  73 NP B61 438        NOGOVA,PISUT+(IP SLOVK ACAD SCI,COMENIUS U)IJP
   ALSO  73 NP B65 544        NOGOVA,PISUT+(IP SLOVK ACAD SCI,COMENIUS U)IJP
TSCHANG  73 NP B59 445        TSCHANG,PARKINSON      (FLOR+GAINESVILLE)IJP

AYED     74 PRIVATE COMMCTN.  AYED,BAREYRE                         (SACL)IJP
   ALSO  73 AIX CONFERENCE    AYED,BAREYRE                         (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT    R L CRAWFORD                          (GLAS)
   ALSO  73 BONN CONFERENCE   R L CRAWFORD                          (GLAS)
METCALF  74 CALT-68-425       W J METCALF, R L WALKER                (CIT)

                              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
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1232 MEV REGION – PRODUCTION EXPERIMENTS

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              81  N*3/2(1232, JP=3/2+)  I=3/2

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              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++       (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++         . . . . . . . . .
M++ AVG    1228.4      2.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
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
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              81  (N*-) - (N*++) MASS DIFFERENCE (MEV) (PROD. EXP.)

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           . . . . . . . . .
W    AVG   111.6       4.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
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 DBCC    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++         . . . . . . . . .
W++ AVG    118.8       4.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
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

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REFERENCES FOR N*3/2(1232) (PROD. EXP.)


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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 17B 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)

                              PAPERS NOT REFERRED TO IN DATA CARDS

ALEXANDE 73 NP B52 221        ALEXANDER,BENARY+(TEL-AVIV+HEIDELBERG+DESY)
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Δ(1650) S'_{31}

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              82  N*3/2(1650, JP=1/2-) I=3/2

              THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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              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         (1623.)                  AYED      74 IPWA                      2/74*
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                 82  N*3/2(1650) WIDTH (MEV)

W   1      (250.0)                   BAREYRE    68 RVUE                      11/67
W   3      (177.0)                   DONNACH1   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          (161.)                    AYED       74 IPWA                       2/74*
W       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                 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+ 770

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                 82  N*3/2(1650) BRANCHING RATIOS

R1      N*3/2(1650) INTO (PI N)/TOTAL                      (P1)
R1  3        (0.284)                 DONNACH1   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
P1  7        (0.35)                  ALMEHED    72 IPWA                       2/72
R1            (.315)                 AYED       74 IPWA                       2/74*

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                 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)                  HEMMI      73       + FWD PIO PHTOPROD   2/74*
A1            .033      .015         KNIES      73 DPWA    PI N PHOTO PROD    2/74*
A1           +.090      .076         MOORHOU1   73 OPWA    PI N PHOTO-PROD    2/73
A1            .078      .066         MOORHOU2   73 OPWA    PI N PHOTO-PROD    2/74*
A1           (.030)                  CRAWFORD   74 DPWA    PI N PHOTO PROD    2/74*
A1            .105      .038         METCALF    74 DPWA    PI N PHOTO-PROD    2/74*
A1          . . . . . . . . . . .
A1  AVG      0.040     0.014    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                              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
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)

ALMEHED  72 NP B40 157         +LOVELACE                        (LUND,RUTG)IJP
DEVENISH 73 PL 47B 53          DEVENISH,RANKIN,LYTH          (LOUC+BONN+LANC)IJP
HEMMI    73 PL 43B 79          HEMMI,INAGAKI+          (KYOTO+SAGA+NLJ+TOKY)IJP
KNIES    73 LBL-2410           KNIES,MOORHOUSE,OBERLACK            (LBL+GLAS)IJP
MOORHOU1 73 PL 43B 44          MOORHOUSE, OBERLACK                 (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590           MOORHOUSE,OBERLACK,ROSENFELD        (GLAS+LBL)IJP

AYED     74 PRIVATE COMMCTN.   AYED,BAREYRE                          (SACL)IJP
    ALSO 73 AIX CONFERENCE     AYED,BAREYRE                          (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT     R L CRAWFORD                          (GLAS)
    ALSO 73 BONN CONFERENCE    R L CRAWFORD                          (GLAS)
METCALF  74 CALT-68-425        W J METCALF, R L WALKER                (CIT)

                               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)
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Δ(1670)

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10  N*3/2(1670, JP=3/2-) I=3/2     D33

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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                 10  N*3/2(1670) MASS (MEV)

M   3      (1691.0)                  DONNACH1   68 RVUE    PHASE-SHIFT ANAL   8/69
M   6      (1722.0)                  AYED       70 IPWA                       1/71
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          (1723.)                   AYED       74 IPWA                       2/74*

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                 10  N*3/2(1670) WIDTH (MEV)

W   3       (269.0)                  DONNACH1   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           (192.)                   AYED       74 IPWA                       2/74*
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                 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

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                 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            (.166)                 AYED       74 IPWA                       2/74*

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.

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                 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            .078      .009         KNIES      73 DPWA    PI N PHOTO PROD    2/74*
A1           +.068      .042         MOORHOU1   73 DPWA    PI N PHOTO-PROD    2/73
A1            .041      .028         MOORHOU2   73 DPWA    PI N PHOTO-PROD    2/74*
A1           (.097)                  CRAWFORD   74 DPWA    PI N PHOTO PROD    2/74*
A1            .0        .048         METCALF    74 DPWA    PI N PHOTO-PROD    2/74*
A1          . . . . . . . . . . .
A1  AVG      0.0712    0.0086   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            .070      .009         KNIES      73 DPWA    PI N PHOTO PROD    2/74*
A2           +.022      .052         MOORHOU1   73 DPWA    PI N PHOTO-PROD    2/73
A2            .021      .020         MOORHOU2   73 DPWA    PI N PHOTO-PROD    2/74*
A2           (.130)                  CRAWFORD   74 DPWA    PI N PHOTO PROD    2/74*
A2            .0        .041         METCALF    74 DPWA    PI N PHOTO-PROD    2/74*
A2          . . . . . . . . . . .
A2  AVG      0.061     0.012    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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
KNIES    73 LBL-2410           KNIES,MOORHOUSE,OBERLACK            (LBL+GLAS)IJP
MOORHOU1 73 PL 43B 44          MOORHOUSE, OBERLACK                 (GLAS+LBL)IJP
MOORHOU2 73 LBL-1590           MOORHOUSE,OBERLACK,ROSENFELD        (GLAS+LBL)IJP

AYED     74 PRIVATE COMMCTN.   AYED,BAREYRE                          (SACL)IJP
    ALSO 73 AIX CONFERENCE     AYED,BAREYRE                          (SACL)IJP
CRAWFORD 74 GLAS. PREPRINT     R L CRAWFORD                          (GLAS)
    ALSO 73 BONN CONFERENCE    R L CRAWFORD                          (GLAS)
METCALF  74 CALT-68-425        W J METCALF, R L WALKER                (CIT)

                               PAPERS NOT REFERRED TO IN DATA CARDS.

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)
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Δ(1690)

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19  N*3/2(1690, JP=3/2+) I=3/2     P''33

THE ENERGY DEPENDENT FITS OF AYED 73 AND 74 TO THE ARGA
DIAGRAM INDICATE RESONANCE SOMEWHERE IN THE 1800-2000 M
REGION.  THE OTHER GROUPS, WHICH USE MAXIMUM ABSORPTION
AS A CRITERION, PLACE THE MASS AT ABOUT 1700 MEV.  THERE MAY BE SOME
WEAK COUPLING TO GAMMA N.

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                 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 -DONNACH1, 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          (1904.)                   AYED       74 IPWA                       2/74*

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                 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           (204.)                   AYED       74 IPWA                       2/74*

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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

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		(.194)	AYED	74	IPWA		2/74*
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.					

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		.003	.015	KNIES	73	DPWA	PI N PHOTO PROD	2/74*
A1		.0	.038	METCALF	74	DPWA	PI N PHOTO-PROD	2/74*
A1		. . . .						
A1	AVG	0.003	0.014	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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		-.034	.022	KNIES	73	DPWA	PI N PHOTO PROD	2/74*
A2		.0	.033	METCALF	74	DPWA	PI N PHOTO-PROD	2/74*
A2		. . . .						
A2	AVG	-0.016	0.021	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)				

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 168 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
KNIES 73 LBL-2410 — KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
AYED 74 PRIVATE COMMCTN. — AYED,BAREYRE (SACL)IJP
ALSO 73 AIX CONFERENCE — AYED,BAREYRE (SACL)IJP
METCALF 74 CALT-68-425 — W J METCALF, R L WALKER (CIT)

PAPERS NOT REFERRED TO IN DATA CARDS.

AYED 70 PL 31B 598 — +BAREYRE,VILLET (SACLAY)
BOWLER 70 NP 17B 331 — +CASHMORE (U. OXFORD)

Δ(1890)

11 N*3/2(1890, JP=5/2+) I=3/2 F_{35}

THE EXISTENCE OF THIS RESONANCE IS WELL ESTABLISHED.

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		(1890.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73*
M		(1890.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73*
M		(1869.)	AYED	74	IPWA		2/74*

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		(180.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73*
W		(140.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73*
W		(255.)	AYED	74	IPWA		2/74*
		SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)					

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+ 770

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		(.144)	AYED	74	IPWA		2/74*
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		(.06)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73*
R5		(.06)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73*

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		.042	.016	KNIES	73	DPWA	PI N PHOTO PROD	2/74*
A1		+.047	.067	METCALF	74	DPWA	PI N PHOTO-PROD	2/74*
A1		. . . .						
A1	AVG	0.042	0.016	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
A2		N*3/2(1890) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)						
A2		-.022	.020	KNIES	73	DPWA	PI N PHOTO PROD	2/74*
A2		-.028	.066	METCALF	74	DPWA	PI N PHOTO-PROD	2/74*
A2		. . . .						
A2	AVG	-0.023	0.019	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				

REFERENCES FOR N*3/2(1890)

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)

ALMEHED 72 NP B40 157 — +LOVELACE (LUND,RUTG)IJP
MEHTANI 72 PRL 29 1634 — +FUNG, KERNAN, SCHALK, + (UCR +LBL)
KNIES 73 LBL-2410 — KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
LANGBEIN 73 NP B53 251 — LANGBEIN,WAGNER (MUNICH)IJP
AYED 74 PRIVATE COMMCTN. — AYED,BAREYRE (SACL)IJP
ALSO 73 AIX CONFERENCE — AYED,BAREYRE (SACL)IJP
METCALF 74 CALT-68-425 — W J METCALF, R L WALKER (CIT)

PAPERS NOT REFERRED TO IN DATA CARDS.

AYED 70 PL 31B 598 — +BAREYRE+VILLET (SACLAY)

Δ(1900)

30 N*3/2(1900, JP=1/2-) I=3/2 S''_{31} 9/73*

THIS EFFECT IS SEEN IN TWO CHANNELS.

30 N*3/2(1900) MASS (MEV) 9/73*

M	(1920.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73*
M	(1870.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73*
M	(2001.)	AYED	74	IPWA		2/74*

30 N*3/2(1900) WIDTH (MEV) 9/73*

W	(140.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73*
W	(160.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73*
W	(307.)	AYED	74	IPWA		2/74*

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

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	(.11)				PI N-K SIG,SOL 1	9/73*
R1	(.12)				PI N-K SIG,SOL 2	9/73*
R2	N*3/2(1900) INTO PI N/TOTAL				(P1)	
R2	(.076)	AYED	74	IPWA		2/74*

REFERENCES FOR N*3/2(1900)

LANGBEIN 73 NP B53 251 — LANGBEIN,WAGNER (MUNICH)IJP
AYED 74 PRIVATE COMMCTN. — AYED,BAREYRE (SACL)IJP
ALSO 73 AIX CONFERENCE — AYED,BAREYRE (SACL)IJP

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		(1980.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73*
M		(1950.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73*
M		(1786.)	AYED	74	IPWA		2/74*

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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		(190.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 1	9/73*
W		(170.)	LANGBEIN	73	IPWA	PI N-K SIG,SOL 2	9/73*
W		(222.)	AYED	74	IPWA		2/74*

SEE NOTES ACCOMPANYING MASSES QUOTED

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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	938+ 770

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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		(.158)	AYED	74	IPWA		2/74*

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 (.11) LANGBEIN 73 IPWA PI N-K SIG,SOL 1 9/73*
R3 (.15) LANGBEIN 73 IPWA PI N-K SIG,SOL 2 9/73*

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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 .010 .012 KNIES 73 DPWA PI N PHOTO PROD 2/74*
A1 -.032 .065 METCALF 74 DPWA PI N PHOTO-PROD 2/74*
A1 . . . .
A1 AVG 0.009 0.012 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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REFERENCES FOR N*3/2(1910)

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)

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
KNIES 73 LBL-2410 KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
LANGBEIN 73 NP B53 251 LANGBEIN,WAGNER (MUNICH)IJP
AYED 74 PRIVATE COMMCTN. AYED,BAREYRE (SACL)IJP
ALSO 73 AIX CONFERENCE AYED,BAREYRE (SACL)IJP
METCALF 74 CALT-68-425 W J METCALF, R L WALKER (CIT)

PAPERS NOT REFERRED TO IN DATA CARDS.

CARAYANN 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)

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Δ(1950)

83 N*3/2(1950, JP=7/2+) I=3/2 **F_{37}**

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		(1928.)		AYED	74	IPWA		2/74*

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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		(237.)		AYED	74	IPWA		2/74*

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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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+ 770
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+ 770

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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)		DONNACHI	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		(.405)		AYED	74	IPWA		2/74*

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*

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 -.370 .012 KNIES 73 DPWA PI N PHOTO PROD 2/74*
A1 (-.080) MOORHOU2 73 DPWA PI N PHOTO-PROD 2/74*
A1 -.059 .029 METCALF 74 DPWA PI N PHOTO-PROD 2/74*
A1 . . . .
A1 AVG -0.068 0.011 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

A2 N*3/2(1950) INTO GAM NUCLEON, HELICITY=3/2 (GEV**-1/2)
A2 -.078 .010 KNIES 73 DPWA PI N PHOTO PROD 2/74*
A2 (-.180) MOORHOU2 73 DPWA PI N PHOTO-PROD 2/74*
A2 -.093 .024 METCALF 74 DPWA PI N PHOTO-PROD 2/74*
A2 . . . .
A2 AVG -0.0802 0.0092 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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)
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)

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)
KNIES 73 LBL-2410 KNIES,MOORHOUSE,OBERLACK (LBL+GLAS)IJP
LANGBEIN 73 NP B53 251 LANGBEIN,WAGNER (MUNICH)IJP
MOORHOU2 73 LBL-1590 MOORHOUSE,OBERLACK,ROSENFELD (GLAS+LBL)IJP
AYED 74 PRIVATE COMMCTN. AYED,BAREYRE (SACL)IJP
ALSO 73 AIX CONFERENCE AYED,BAREYRE (SACL)IJP
METCALF 74 CALT-68-425 W J METCALF, R L WALKER (CIT)

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                                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 108 433         A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
AYED      70 PL 318 598         +BAREYRE+VILLET                     (SACLAY)

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Δ(1960) →

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13 N*3/2(1960, JP=5/2-) I=3/2
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D35

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THIS EFFECT IS SEEN IN TWO CHANNELS.

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                  13  N*3/2(1960) MASS (MEV)

M   3      (1954.0)                    DONNACHI1  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 -DONNACHI1, 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          (1889.)                     AYED       74 IPWA                      2/74*

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                  13  N*3/2(1960) WIDTH (MEV)

W   3      (311.00)                    DONNACHI1  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       74 IPWA                      2/74*

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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)                     DONNACHI1  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          (.081)                     AYED       74 IPWA                      2/74*

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*

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                        REFERENCES FOR N*3/2(1960)

DONNACHI1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP   68 THESIS             R G KIRSOPP                           (EDIN)

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
AYED      74 PRIVATE COMMCTN.   AYED,BAREYRE                        (SACL)IJP
   ALSO   73 AIX CONFERENCE     AYED,BAREYRE                        (SACL)IJP

                        PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI  69 NP 108 433         A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
AYED      70 PL 31B 598         +BAREYRE+VILLET                     (SACLAY)
APLIN     71 NP B32 253         +COWAN,GIBSON,GILMORE++      (RHEL,BRISTOL)

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1950 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                  70  N*3/2(1950, JP=     ) I=3/2

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                  70  N*3/2(1950) MASS (MEV) (PROD. EXP.)

M          (1922.0)        APPROX      COOL       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

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                  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

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                  70  N*3/2(1950) PARTIAL DECAY MODES (PROD. EXP.)

                                                              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+ 770
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

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                  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

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

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                  REFERENCES FOR N*3/2(1950) (PROD. EXP.)

COOL      56 PR 103 1092        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-AHC+JACOBSEN+ (BOHR+ HELS+OSLO+STOH)
COLTON    72 PR D6 95           E COLTON, A KIRSCHBAUM                 (LRL)

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Δ(2160) →

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9 N*3/2(2160,          ) I=3/2

SEVERAL ANALYSES HAVE 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 SUGGEST A G39.
   THE MOST RECENT PI N ANALYSIS FINDS A G39 RESONANCE IN THIS MASS
REGION.  THE EFFECT SEEN IN K SIG PROD. IS 100 MEV LOWER IN MASS.

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                  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   2      (2174.)                     AYED       74 IPWA                      2/74*
M   2   AYED 74 RESULT IS A G39 RESONANCE.                                     2/74*

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                  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   2      (205.)                      AYED       74 IPWA                      2/74*

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                  9  N*3/2(2160) PARTIAL DECAY MODES

                                                              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

R1      N*3/2(2160) INTO (PI N)/TOTAL                        (P1)
R1  3       (.25)                      KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69
R1  7       (0.3)                      ALMEHED    72 IPWA                      2/72
R1  2       (.045)                     AYED       74 IPWA                      2/74*

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*

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                                 REFERENCES FOR N*3/2(2160)

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
AYED     74 PRIVATE COMMCTN.     AYED,BAREYRE                          (SACL)IJP
    ALSO 73 AIX CONFERENCE       AYED,BAREYRE                          (SACL)IJP

                                 PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI 69 NP 10B 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 .

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Δ(2420)

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84  N*3/2(2420, JP=11/2+)  I=3/2
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H3 11

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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.

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                 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         (2392.)                    AYED      74 IPWA                        2/74*

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                 84  N*3/2(2420) WIDTH (MEV)

W   6     (347.0)                    AYED      70 IPWA                        1/71
W         (289.)                     AYED      74 IPWA                        2/74*

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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            (.109)                 AYED      74 IPWA                        2/74*

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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
AYED     74 PRIVATE COMMCTN.     AYED,BAREYRE                          (SACL)IJP
    ALSO 73 AIX CONFERENCE       AYED,BAREYRE                          (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

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                 69  N*3/2(2420) MASS (MEV) (PROD. EXP.)

M         (2360.0)                   DIODENS   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)                    DIODENS   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

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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

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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.

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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

                                 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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Δ(3230) BUMPS

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86  N*3/2(3230, JP=     ) I=3/2  PRODUCTION EXPERIMENTS

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                86  N*3/2(3230) MASS (MEV) (PROD. EXP.)

M        (3230.0)                     CITRON    66 CNTR    PI+ P TOTAL       7/66

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                86  N*3/2(3230) WIDTH (MEV) (PROD. EXP.)

W        (440.0)                      CITRON    66 CNTR                      7/66

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                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

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                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
R2  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

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                              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)

                              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)

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EXOTIC NUCLEONS – 1640 MEV REGION

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        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.

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                     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

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                     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

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                     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

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                              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,GARFINKEL,GUTAY,MILLER,YEN  (PURD)
BIRULEV  71 SJNP 12  536      +VOVENKO,GUSKOV,DOBROVOLSKII,++      (JINR)
JOHNSON  71 PL   34B 428      D JOHNSON                             (ANL)

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Note on the S=+1 Baryon System

Models based on states of three quarks have been successful in the description of the spectrum and decay of the known baryon resonances. Three quarks can not produce S=+1 baryon resonances (Z^*'s), and this has probably been the primary motivation for the great amount of experimental effort that has gone into S=+1 baryon physics below ~ 2 GeV/c during the last several years. In addition, the S=+1 system offers an opportunity to study single and double pion production in a small number of rather distinct quasi-two-body channels ($K\Delta$, K^*N, and $K^*\Delta$). Recent developments in the field are summarized below.

I=1 System

The most recent K^+p total cross-section data is from BNL (CARROLL 73; 0.41 to 1.06 GeV/c) and Arizona-Michigan (BOWEN 73; 0.57 to 1.16 GeV/c). Neither measurement exhibits the dip of approximately 1.5 mb at 0.7 GeV/c reported by BUGG 68 and BOWEN 70. Recent differential elastic cross-section measurements (including extensions and final results of previously reported results) have come from Bologna-Glasgow-Rome-Trieste (BGRT 73; 0.14 to 0.73 GeV/c), Birmingham-RHEL (ADAMS 73; 0.43 to 0.94 GeV/c), Bristol-RHEL-Aarhus-Southampton (CHARLES 73; 0.7 to 1.9 GeV/c), Maryland-ANL (ABE 73; 0.86 to 2.12 GeV/c), and UCL-RHEL (BARBER 73; 1.37 to 2.26 GeV/c). Below 750 MeV/c (where the inelastic cross section is less than 0.1 mb) the total elastic cross sections from the first three above experiments also fail to exhibit the dip seen in earlier total cross-section experiments. Coulomb interference effects are observed by BGRT 73 and ADAMS 73; both confirm the early conclusion of GOLDHABER 62 that the low energy S-wave interaction is repulsive. New high-statistics data on single and double pion production in K^+p scattering has been reported by CERN-Saclay (BERTHON1 73; 1.21, 1.29, 1.38, and 1.69 GeV/c). The I=1 total and partial cross sections are shown as dashed lines in Fig. 1.

The most recent partial-wave analyses of the elastic channel have been performed by ADAMS 73 and CUTKOSKY 73. Both analyses used recent high-statistics cross-section data and the high partial waves calculated from two and three pion exchange by ALCOCK 73. The energy-dependent ADAMS 73 analysis included data at energies up to 1.5 GeV/c, but was aimed primarily at determining the amplitudes below 1.0 GeV/c. Below about 0.5 GeV/c a zero-effective-range scattering-length parametrization was used for S and P waves with D and F waves set to zero; at higher energies the η and δ parameters of the S, P, D, and F waves were taken to be polynomials in c. m. momentum. Waves with $\ell \geq 4$

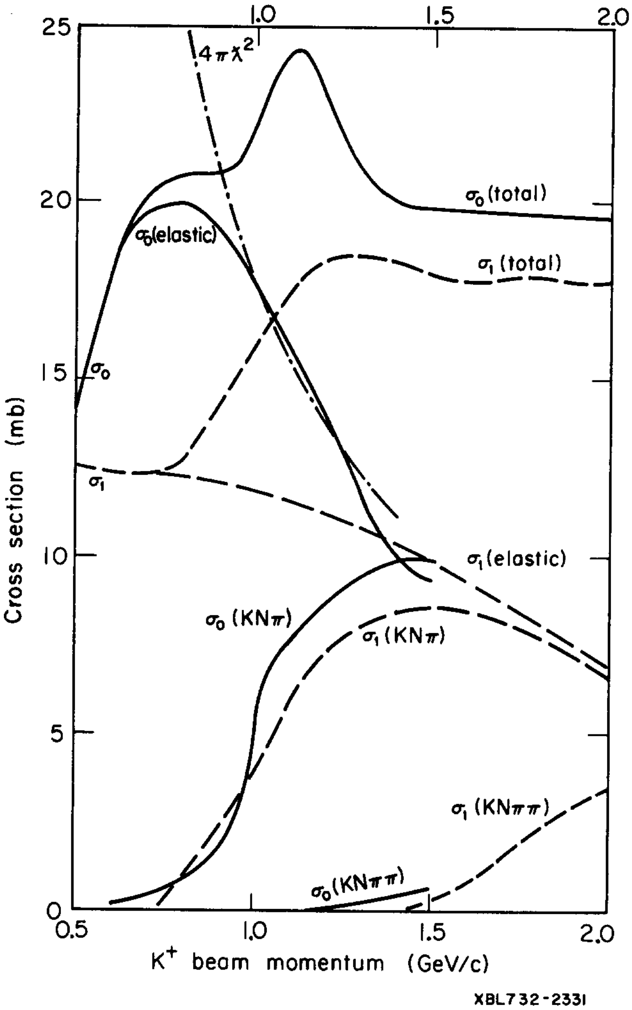

Fig. 1. KN total and partial cross sections. Subscripts indicate isospin; I = 1 (I = 0) cross sections are indicated by dashed (solid) curves. The total cross-section curves are from CARROLL 73, who use their recent data and that of BOWEN 73 as well as older data. The elastic I = 1 curve is hand drawn through new and old elastic data. The inelastic I = 1 curves are taken from LOKEN 72. The inelastic I = 0 curves are taken from GIACOMELLI 72, and the elastic I = 0 curve is obtained by subtracting these from the I = 0 total cross-section curve of CARROLL 73.

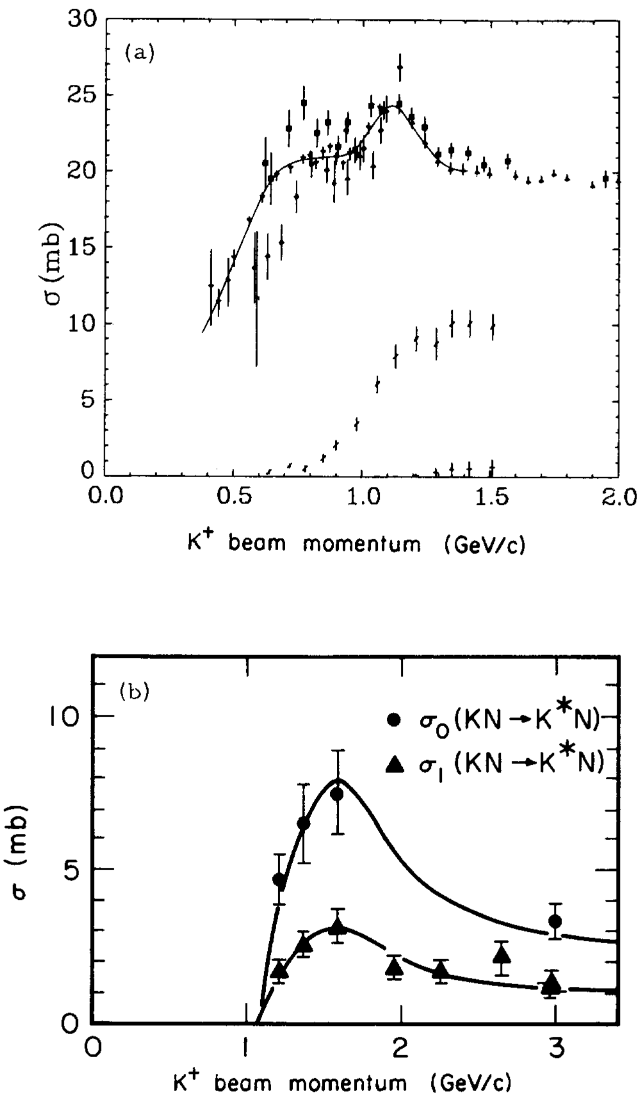

Fig. 2.
(a) Unfolded I=0 cross sections as quoted by the various authors discussed in the Z* mini-review:

◊ BOWEN 73 σ_T
□ BUGG 68 σ_T (as unfolded by CARROLL 73)
▽ CARROLL 73 σ_T
△ COOL 70 σ_T
⁄ GIACOMELLI 72 $\sigma(\pi KN)$
– GIACOMELLI 72 $\sigma(\pi\pi KN)$

(b) Energy dependence of the isospin 0 and isospin 1 cross sections for the reaction $KN \to K^*N$ (HIRATA 70).

were set to the values calculated by ALCOCK 73. The best χ^2 values obtained were about 2250 for 1600 degrees of freedom of which an estimated 300 comes from inconsistent data. Two solutions were found; they are essentially identical below 1 GeV/c but differ significantly at higher energies. The CUTKOSKY 73 analysis included data from 0.8 to 2.5 GeV/c. The ACE parametrization (see MILLER 72) was used along with contributions from exchange-degenerate $\Lambda+\Sigma$ and $\rho+A_2$ exchange. Imaginary parts of the ALCOCK 73 high partial waves were included as part of the data set in the fitting. An iterative fitting procedure was followed in which energy-independent fitting was alternated with energy smoothing using a parametrization based on partial-wave dispersion relations. Typical χ^2 per degree of freedom (χ^2/NDF) values were 1.0 to 1.1. Neither of the above analyses found evidence for the existence of a Z^*.

Results of these two analyses are shown in Figs. 3 and 4. Solution 2 of ADAMS 73 is plotted below 1.0 GeV/c with errors[1] on real and imaginary parts ranging from 3% to 50% for the various waves. The data set used for the results plotted included the preliminary BGRT 73 data mentioned above. This solution agrees qualitatively with CUTKOSKY 73 at higher energies; solution 1 disagrees. The results[2] of CUTKOSKY 73 are plotted from 0.8 to 2.5 GeV/c. Previous analyses using less data (particularly cross-section data) have found a wide range of solutions, some of which disagree with ADAMS 73 and CUTKOSKY 73. The most likely candidate for an I=1 Z^* has been in the P_{13} wave around 1900 MeV. For comparison we show results for this wave from a number of previous analyses in Fig. 5.

An energy-independent multi-channel partial-wave analysis of the I=1 KN, $K\Delta$, and K^*N channels at 1.21, 1.29, 1.38, and 1.69 GeV/c has been performed by BERTHON2 73. It was not possible to draw any firm conclusions about the K^*N channel or to discriminate between results of other analyses of the elastic channel alone. Results on the $K\Delta$ channel indicate four comparably large waves; SD_{11}, PP_{13}, DD_{15}, and (at the higher energies) FF_{17}. This is in contrast to earlier analyses (e.g., GRIFFITH 72) which found this channel to be dominated by the PP_{13} wave over most of the 1.0 to 1.5 GeV/c region. BERTHON2 73 find (like GRIFFITH 72) no indication in the $K\Delta$ channel of rapid phase variations signaling possible resonant effects.

<u>I=0 System</u>

The experiments of CARROLL 73 and BOWEN 73 (see above) measured K^+d total cross sections in the same energy ranges as their K^+p measurements. These experiments agree rather well with each other and with older data except that the CARROLL 73 cross sections are systematically higher than those of BOWEN 70 (0.36 to 0.72 GeV/c). Unfolded I=0 cross sections, new and old, are shown in Fig. 2(a); the disagreement between CARROLL 73 and BOWEN 73 at low energies is primarily due to differences in the unfolding procedure. The I=0 cross section unfolded from the new K^+p and K^+d data rises to a plateau in the 0.7 to 0.9 GeV/c region and has a hump of about 3 mb in the 0.9 to 1.3 GeV/c region. Older data had indicated a hump of comparable size in the plateau region. As shown in Figs. 1 and 2(b), the plateau is associated with a broad peak in the elastic cross section while the hump is associated with a rising K^*N cross section.

Partial-wave analyses of the I=0 elastic channel have been reported by GIACOMELLI2 73 and AARON 73. GIACOMELLI2 73 fit data in the 0.38 to 1.51 GeV/c region, including new K^+n differential cross-section data of the BGRT collaboration (GIACOMELLI1 73; 0.64 to 1.51 GeV/c). Three types of partial-wave analysis (all with S, P, and D waves only) were used to analyse these data: an energy-dependent analysis (ED) using the parametrization of LEA 68 and I=1 partial waves from previous solutions of GIACOMELLI 70, ALBROW 71, and LOVELACE 71; an energy-independent analysis (EI-1) which included K^+p data and determined both the I=0 and I=1 partial waves; and an energy-independent analysis (EI-2) in which the I=1 partial waves were fixed at the values of ALBROW 71's solution γ. In analyses EI-1 and EI-2 several variants of the LOVELACE 71 shortest-path technique were used to link solutions at different energies. The solutions found by these different methods fell into three main families denoted A, C, and D, the best χ^2/NDF values being

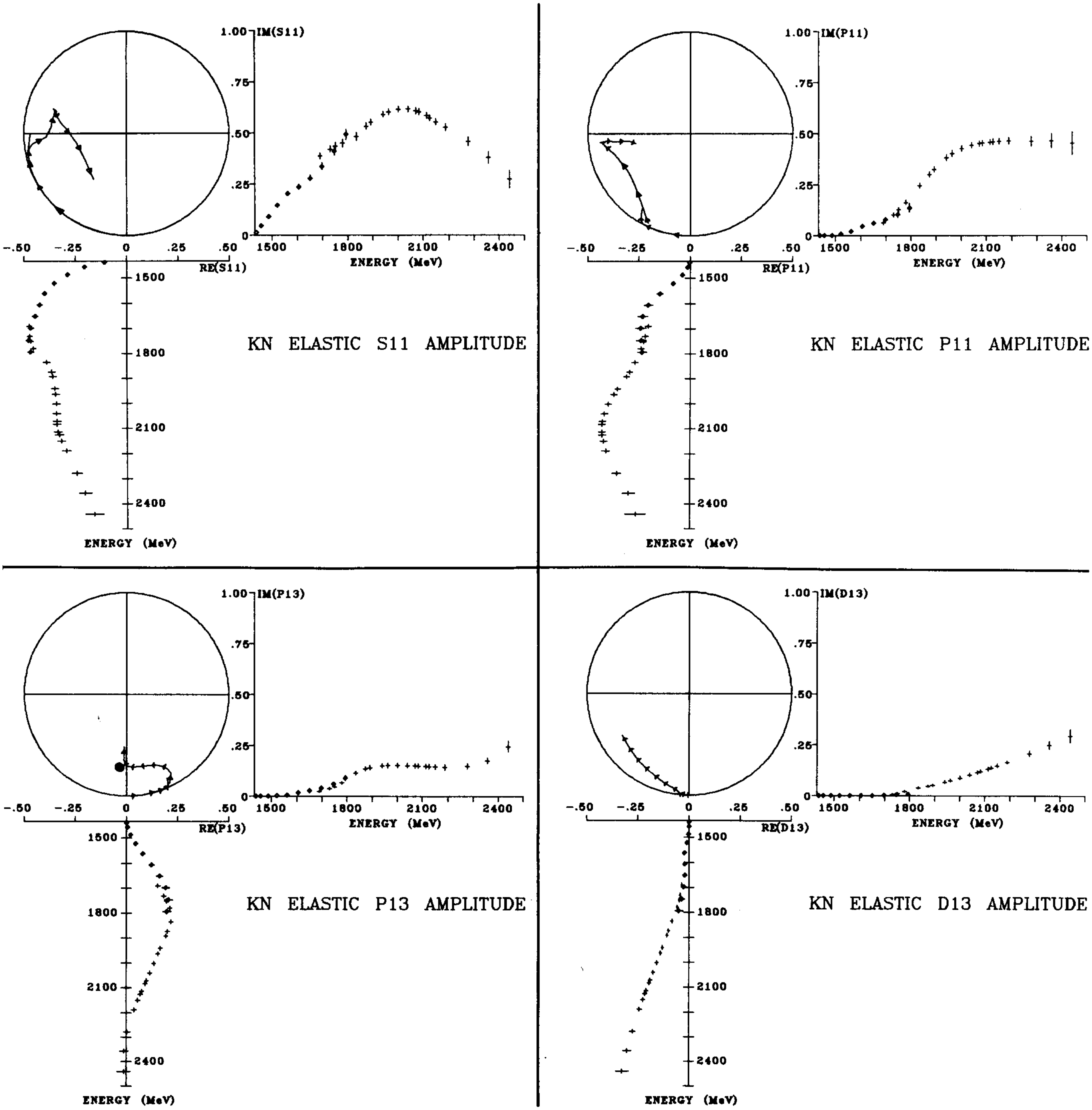

Fig. 3. Amplitudes for I = 1 KN elastic scattering in the J = 1/2 and J = 3/2 waves from ADAMS 73 (⏀) and CUTKOSKY 73 (┼). The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 100 MeV and a base-to-tip length of 20 MeV. All the energy axes run from elastic threshold to 2500 MeV.

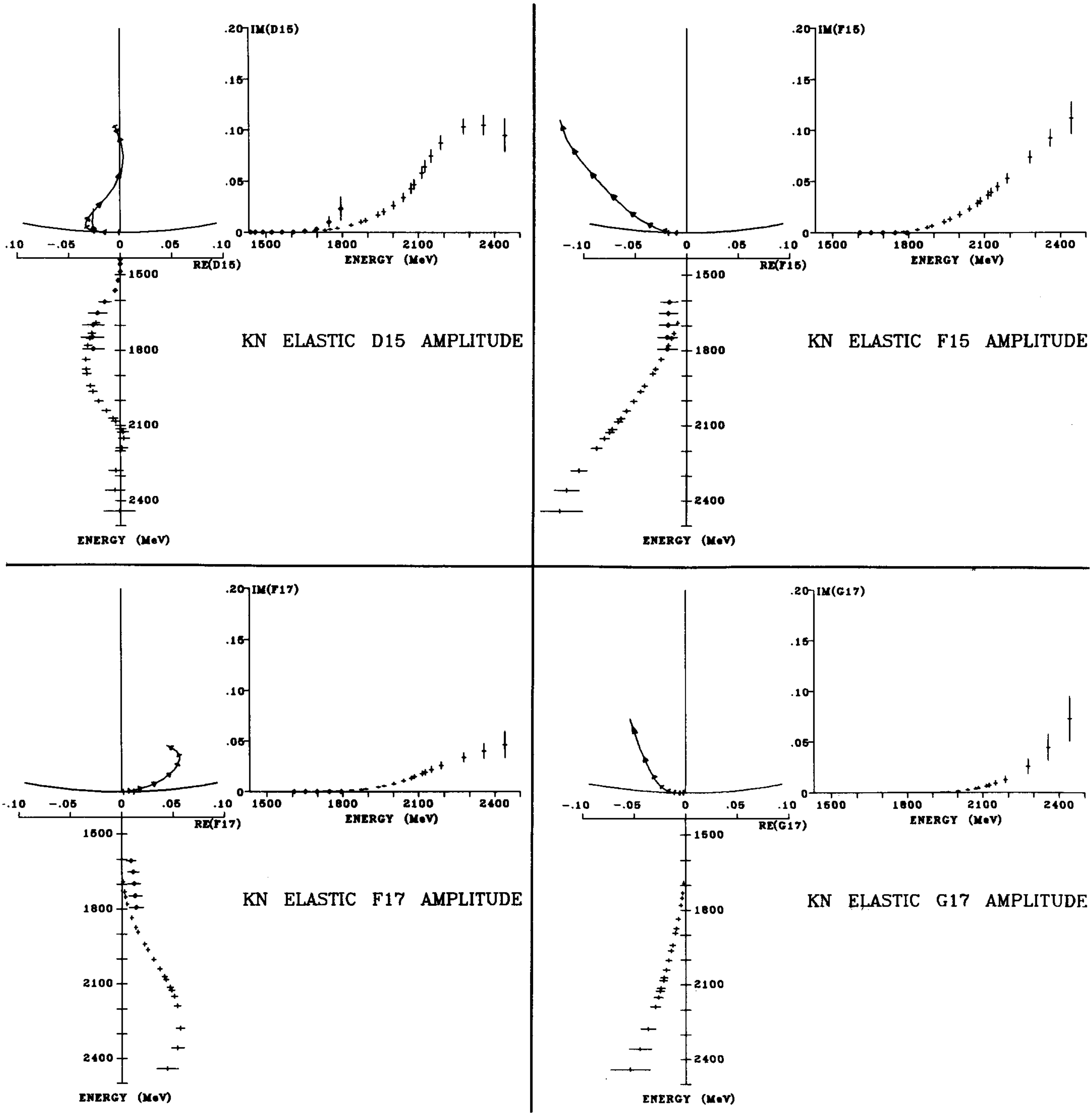

Fig. 4. Amplitudes for I = 1 KN elastic scattering in the J = 5/2 and J = 7/2 waves from ADAMS 73 (⏀) and CUTKOSKY 73 (⸸). The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 100 MeV and a base-to-tip length of 20 MeV. All the energy axes run from elastic threshold to 2500 MeV.

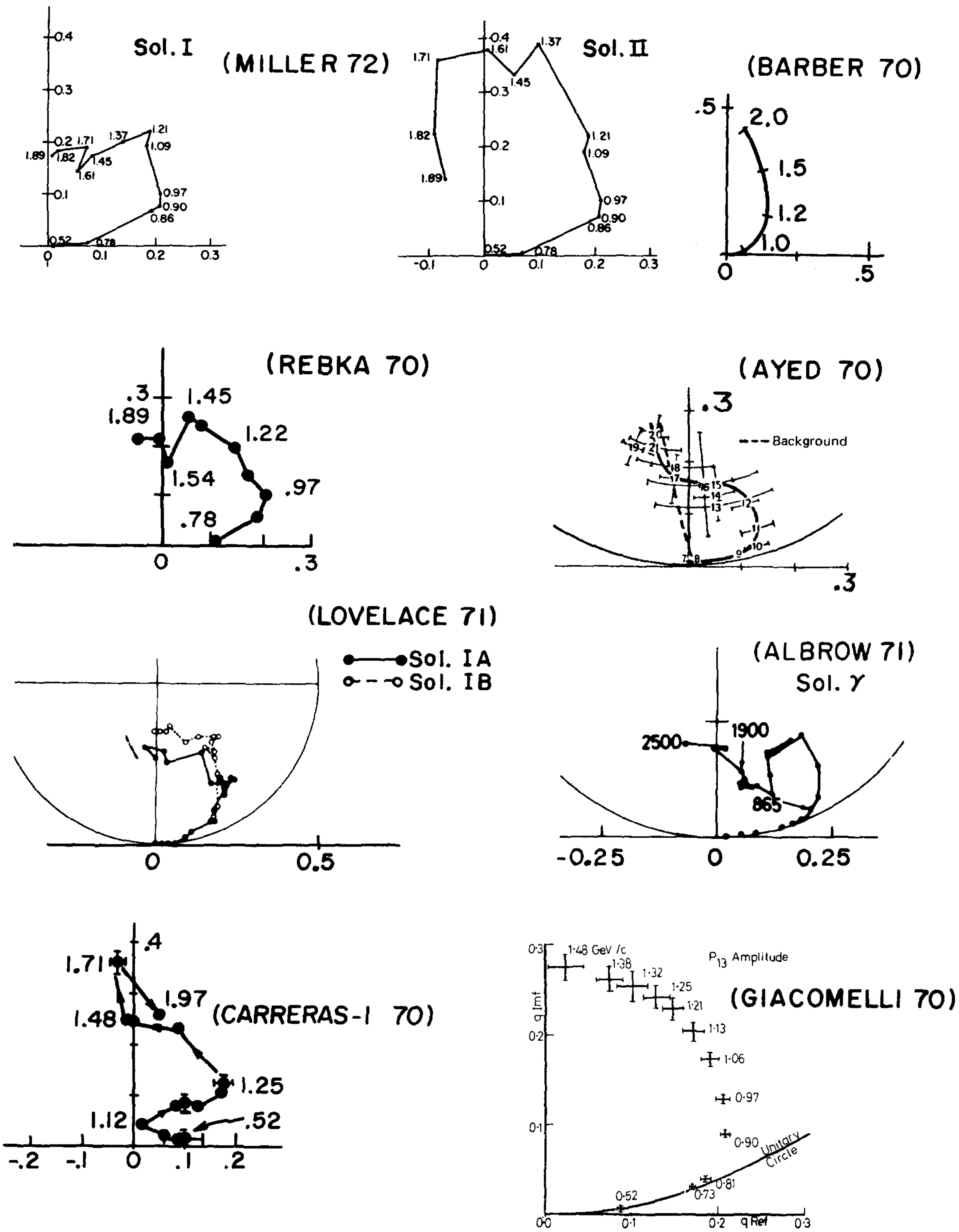

Fig. 5. Argand plots for the P_{13} partial wave as obtained in partial-wave analyses performed by the authors indicated. (CARRERAS-1 70 plotted by us from η, δ.)

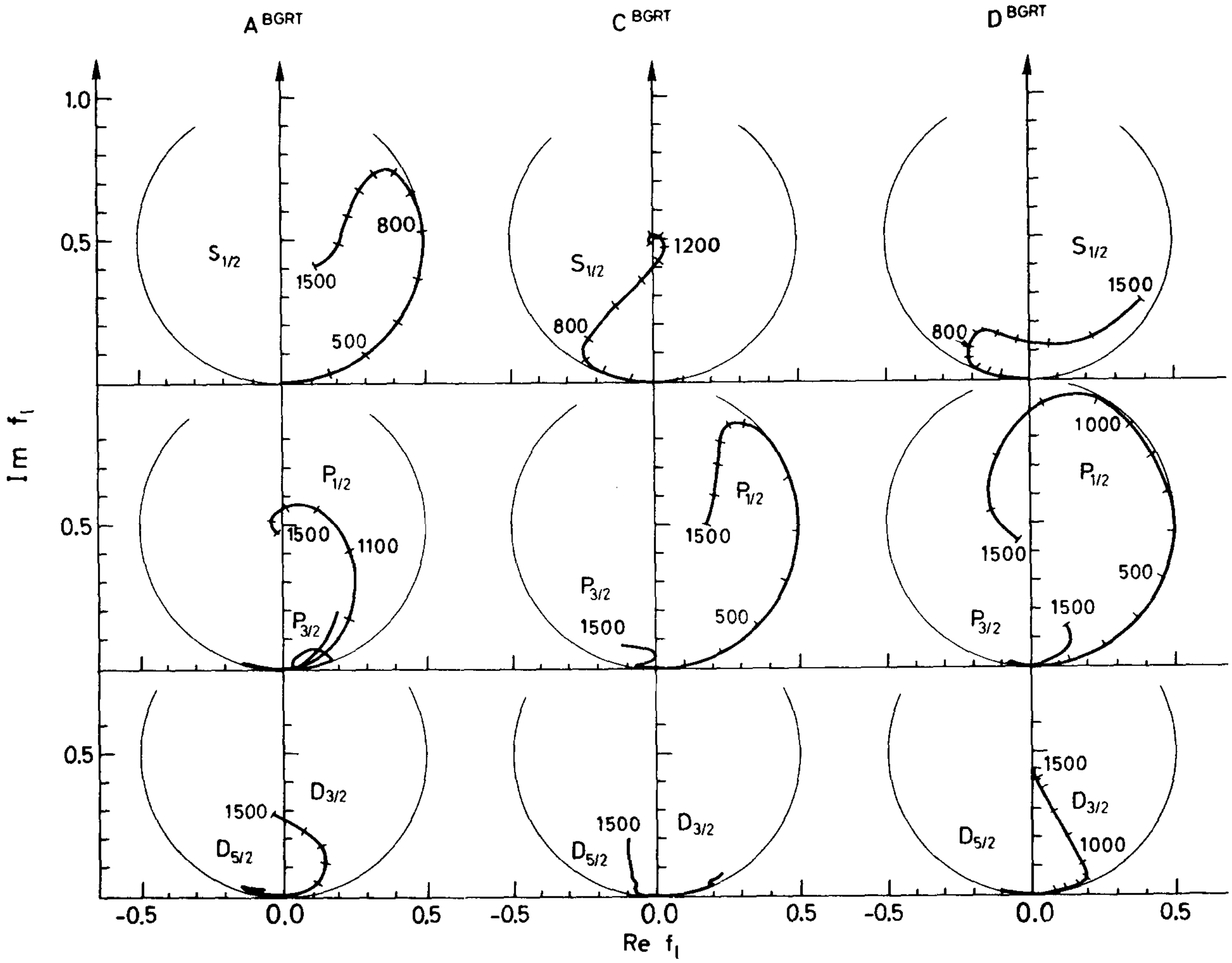

Fig. 6. Amplitudes for I = 0 KN elastic scattering from GIACOMELLI2 73. The energy dependence of the amplitudes is indicated by tick marks at even multiples of 100 MeV. These are results of the energy-dependent analysis exemplifying the three main classes of solutions found in the complete analysis.

1.4-1.9, 1.6-1.7, and 1.5-1.8, respectively. Examples of each class from an ED analysis using the I=1 partial waves of GIACOMELLI 70 are shown in Fig. 6. Some criteria for choice between these solutions are offered by comparison with particular features of the data. The single existing measurement of $K^+n \to K^0p$ polarization (RAY 69; 0.60 GeV/c) is consistent with classes C and D only. The I=0 total cross sections of CARROLL 73 and BOWEN 73 were not included in the fitting, but comparison is made with CARROLL 73 and the data are found to be consistent with class D only. LONDON 73 has calculated $K_Lp \to K_Sp$ amplitudes by combining the best (i.e., lowest χ^2) energy-dependent solution from each of GIACOMELLI2 73's classes with existing I=1 KN and $\overline{K}$N solutions and compared the results with $K_Lp \to K_Sp$ cross-section data. He finds that the class D solution is preferred. No conclusive evidence for Z^*'s emerges from the analysis of GIACOMELLI2 73; the most likely candidate is the class D P_{01} wave, but GIACOMELLI2 73 point out that the resonance interpretation is questionable for some of the class D solutions and for all of the class C solutions. A Breit-Wigner plus quadratic background fit to the class D P_{01} wave yields the following parameters: M=1740 MeV, Γ = 300 MeV, x = 0.85.

AARON 73 fit $K^+n \rightarrow K^0p$ differential cross-section data and I=0 total cross-section data (not including CARROLL 73 and BOWEN 73) in the range 0.64 to 1.58 GeV/c using the results of earlier analyses for the I=1 channel. The analysis is a model-dependent one including all waves through G_{09} with the δ parameters parametrized as polynomials in c. m. momentum and the η parameters taken from AARON 71; these are calculated from a model in which all inelasticity in the I=0 KN channel is due to K^*N production via one pion exchange. Chi-squared values of about 560 for 353 degrees of freedom are obtained, and three types of solutions are found. However only two solutions (A and B) are consistent with the CEX polarization data of RAY 69, and both show counterclockwise loops in the D_{03} wave and corresponding peaks in the speed plots. AARON 73 interpret this as a resonance of mass 1830 MeV and width 100 MeV. The S_{01} (P_{01}) wave is found to show weaker indications of resonance behavior in solution A (B) only.

Production Experiments

There are no new developments in production experiments, and the observation of ERNE 70 that present upper limits for Z^* production are not small still holds. Cross-section limits for the production of broad Z^*'s are comparable to the observed N^* and Y^* production cross sections.

Figures

It has been necessary to reduce the Argand plots in Figs. 3 and 4 somewhat excessively because of space limitations. A booklet of reproductions and enlargements of all of the Argand plots in the Baryon mini-reviews is available on request from the Particle Data Group, LBL, Berkeley.

References

1. J. D. Dowell, private communication.
2. R. E. Cutkosky, private communication.

See the Data Card Listings for other references.

S=1 I=0 EXOTIC STATES (Z_0)

$Z_0(1780)$ — P_{01}

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                95  Z*0(1780, JP=1/2+) I=0

                SEE THE MINI-REVIEW PRECEDING THIS LISTING.

                WILSON 72 AND GIACOMELLI2 73 FIND SOME SOLUTIONS
                WITH RESONANT-LIKE BEHAVIOR IN THE P01 PARTIAL WAVE.
                THE EFFECT SEEN THE 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.

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                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.)                       GIACOME2 73  PWA    .38-1.51 GEV/C    1/74*

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                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.)                        GIACOME2 73  PWA    .38-1.51 GEV/C    1/74*

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                95  Z*0(1780) PARTIAL DECAY MODES

                                                               DECAY MASSES
P1      Z*0(1780) INTO K N                                   493+ 939

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                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)                     GIACOME2 73  PWA    .38-1.51 GEV/C    1/74*

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                             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
GIACOME2 73 SUBMTD TO NP     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)

     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)
GIACOME1 73 NP B56 346       GIACOMELLI,+           (BGNA+GLAS+ROMA+TRST)
    ALSO 73 BGNA PPT. AE-73/4 GIACOMELLI,GRIFITHS,+ (BGNA+GLAS+ROMA+TRST)
LONDON   73 BNL PREPRT. 18470 LONDON                                 (BNL)IJP

     EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS --
GIACOMEL 72 NP B37 577       GIACOMELLI +           (BGNA+GLAS+ROMA+TRST)

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$Z_0(1865)$ — D_{03}

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                96  Z*0(1865, JP=3/2-) I=0

                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*

            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

            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
```

```
                      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)
```

S=1 I=1 EXOTIC STATES (Z_1)

$Z_1(1900)$ P_{13}

```
97  Z*1(1900, JP=3/2+) I=1

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,SOL.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

            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+P 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.

            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

            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

                      PAPERS NOT REFERRED 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, DIKMEN, JENKINS, KALBACH,+(ARIZ) I
BOWEN     73 PR D7 22          +JENKINS,KALBACH,PETERSEN +      (ARIZ+MICH)
CARROLL   73  BNL PREPRINT     +KYCIA,LI,MICHAEL,MOCKETT              (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 1973       ALCOCK,COTTINGHAM                   (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)
BERTHON1  73 NP B63 54         BERTHON,MONTANET,PAUL,SAETRE+    (CERN+SACL)
BERTHON2  73 AIX CONFERENCE    BERTHON,MONTANET,PAUL,SAETRE+   (CERN+SACL)IJP
LEWIS     73 NP B60 283        LEWIS,ALLEN,JACOBS,DANYSZ+ (LOWC+LOIC+CDEF)

     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)
RERKA     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+NAL)
EHRLICH   71 PRL 26 925        +ETKIN,GLODIS,HUGHES,KONDO,LU,MORI+   (YALE)
WHITMORE  71 PR D3 1092        +ABRAMS,EISENSTEIN,KIM,OHALLORAN,+    (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)
ABE       73 UMD PPT. 74-025   ABE,BARNETT,GOLDMAN,LAASANEN,+     (UMD+ANL)
ADAMS     73 NP B36 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,KOEHLER+(UMD+ANL+NWES+NAL)
BGRT      73 PURDUE CONF.                        /BGNA+GLAS+ROMA+TRST
CHARLES   73 PURDUE CONF. 179  CHARLES,EDWARDS,+     (SHMP+AARH+RHEL+BRIS)

     PHASE SHIFT ANALYSES
CARRERA1  70 NP B23 525        B CARRERAS, A DONNACHIE              (DARE)IJP
   ALSO   70 DUKE 447          +DONNACHIE,KIRSOPP        (DARE+MCHS+  EDIN)
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)
CUTKOSKY  73 PURDUE CONF. 175  CUTKOSKY,HICKS,KELLY,+        (CARN+IIT+ANL)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
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)
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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

            93  Z*1(2150) WIDTH (MEV)

W         (175.)                    ABRAMS    70 CNTR +  K+P TOTAL        10/71

            93  Z*1(2150) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      Z*1(2150) INTO K N                              493+ 938
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                  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

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                  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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      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 Y^*'s

The number of known or suspected Y^* states has increased considerably in the last few years, following closely a similar increase in the number of N^* states. Just as the recently discovered N^*'s are only weakly coupled to the $\pi N \to \pi N$ reaction, so also are the recently discovered Y^*'s only weakly coupled to the $\bar{K}N \to \bar{K}N$, $\bar{K}N \to \Lambda\pi$, and $\bar{K}N \to \Sigma\pi$ reactions. For this reason the newer Y^*'s are more difficult to uncover; in invariant mass distributions they usually appear as small peaks or make no appearance at all. Rather when the 2-body reactions 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.

Production Experiments

These types of experiments are often difficult to analyze. Information on $I = 0$ states is possible only when there is no $I = 1$ state at similar mass. The main controversies at the present time concern resonances in the 1600 to 1700 MeV region. See the mini-reviews on $\Sigma(1620)$ and on $\Sigma(1670)$ in these listings. The situation has not changed significantly during the last few years. For a good review, one can still refer to Miller 70.[1]

Formation Experiments

Partial-wave analyses have been performed on $\bar{K}N$, $\Lambda\pi$, $\Sigma\pi$, and ΞK, plus some quasi-2-body channels. Given the present accuracy of the data it is not possible to perform a completely energy-independent analysis, that is, solve for the partial-wave amplitudes at each energy in a model-independent way.

Three recent analyses have attempted a multichannel approach using data on the three 2-body reactions $\bar{K}N$, $\Lambda\pi$, and $\Sigma\pi$, a fictitious channel sometimes being introduced to account for the global effect of the remaining final states. The latter have large cross sections, so the present multi-channel analyses do not really impose any more stringent unitarity constraints than those already contained in the single-channel fits. However, there is an advantage in the determination of resonance parameters (masses, widths, and branching fractions) since they are fit simultaneously to data in all three channels.

a) LANGBEIN 72 (LW) performed single-energy fits at 40 momenta between 436 and 1226 MeV/c. The partial waves at each energy were expressed in a form that automatically satisfies the unitarity equation:

$$\mathrm{Im}\, T_{\bar{K}N} \geq |T_{\bar{K}N}|^2 + |T_{\Sigma\pi}|^2 + |T_{\Lambda\pi}|^2 .$$

This work is the nearest approximation to an energy-independent partial-wave analysis existing for the S=-1 system. However, the partial waves corresponding to the $D_{03}(1690)$, $D_{15}(1765)$, $F_{05}(1815)$, and $F_{17}(2030)$ resonances were constrained to have Breit-Wigner forms in the range $|E-M_R| < \Gamma$, with parameters near the expected values. Approximately 90 acceptable single-energy fits per energy were generated and were used in shortest-path searches over two regions, 1536 to 1700 MeV and 1700 to 1900 MeV. Several candidates for acceptable shortest paths were generated, and a preferred path was chosen by rejecting those that failed to reproduce known resonance behavior. Resonances in this solution were identified by loops in Argand diagrams correlated with peaks in the $\geq$ 3-body final state cross section. Resonance parameters were then extracted by fitting BW's with both multiplicative and additive background.

Our conclusion about this work is that the amplitudes which were not specifically chosen to be resonant (sometimes even those, as in the case $D_{15}(1765) \to \Lambda\pi$) show an erratic behavior which cannot be justified simply by the fluctuation of the data. This may be due to jumping between different ambiguous solutions at different energies (see the discussion of IPWA in the main text). Argand diagrams of the elastic and $\bar{K}N \to \Sigma\pi$ partial-wave amplitudes from this analysis are shown in Figs. 1-10.

b) KIM 71 (K) fit data from threshold to 1226 MeV/c using the Ross and Shaw[2] effective-range expansion of the inverse multi-channel K-matrix. The data in each of seven energy intervals bounded by 0, 534, 658, 806, 916, 1022, 1117, and 1226 MeV/c, were fit with a constant effective-range matrix. Only the $F_{15}(1915)$ was fixed to a BW form, all other waves included being parametrized by the K-matrix formalism. Resonances were identified by a method involving the appearance of loops in the Argand diagram, peaks in the speed plot, and poles of the K-matrix, the exact procedure not being reported. The parameters used to describe the K-matrix elements are not given.

c) The latest published analysis is LEA 73 (LMMO). It is a multi-channel energy-dependent partial-wave analysis with parametrized K-matrix elements. The momentum range covered is 440 to 1190 MeV/c and 99 parameters were used in the fit. Established resonances were constrained to have parameters near their generally accepted values taken from a previous edition of these tables (for this reason we do not list the results of LEA 73 for these resonances in the following data cards). New resonances are identified using poles of the K-matrix. As with KIM 71, the procedure used to get the resonance parameters is not described and the values of the fitted K-matrix elements are not given. Argand diagrams of the partial-wave amplitudes from this analysis are given in Figs. 1-10.

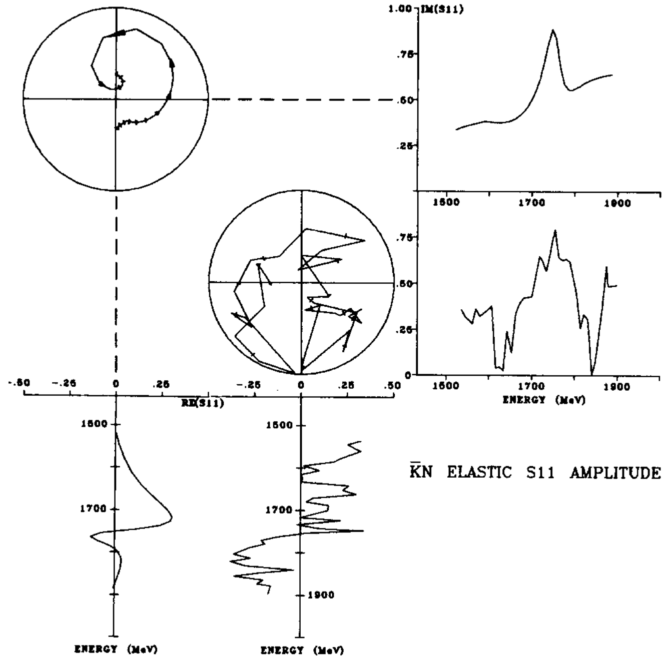
In the previous energy-dependent analyses which used simple parametrizations of the partial waves, the presence of a resonance was based on the goodness of fit for a non-resonant parametrization as compared to the fit for a BW form alone or a BW form plus smooth background. In the more recent approaches of KIM 71 and LEA 73 the procedure used is different. The K-matrix parametrization can accommodate either resonant or non-resonant behavior; the presence or absence of particular resonances depends on the particular values of the K-matrix parameters obtained in the fit. No explicit comparison of the results with alternative parametrizations is made.

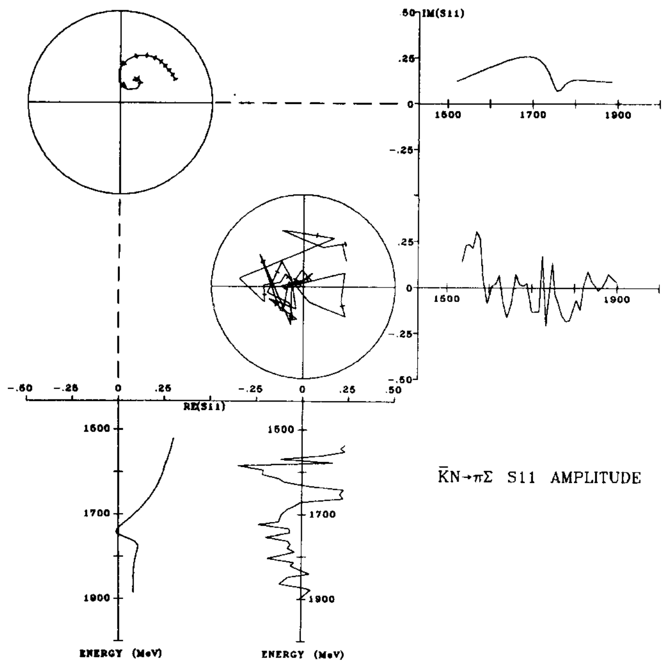
In the momentum range 400 to 1200 MeV/c the latest analysis fitting the 3 channels separately is still that of ARMENTEROS 70 (CH), a brief description of which can be found in the previous edition of this compilation. This analysis uses just as much data as the multi-channel analyses described above, and imposes a degree of energy smoothing intermediate between that of LEA 73 and LANGBEIN 72.

In Table I we list the poorly established resonances (i. e., those with only one or two stars in Table II below) in the S or P wave claimed by at least one of the four analyses mentioned above.

Table I. Comparison of recent Y^* claims. Notation is mass (MeV)/width (MeV)/strongest two-body channel; CH = CERN-Heidelberg, K = Kim, LW = Langbein and Wagner, LMMO = Lea et al.

Wave	CH	K	LW	LMMO
S_{01}		$1780/40/\bar{K}N$	$1830/70/\bar{K}N$	
P_{01}		$1570/50/?$	$1620/60/?$	
P_{01}	$1750/70/\Sigma\pi$ $1800/30/\bar{K}N$	$1755/35/\bar{K}N$	$1780/120/\bar{K}N$	
P_{03}			$1850/125/\bar{K}N$	$1868/324/\bar{K}N$
S_{11}		$1620/40/\Lambda\pi$	$1630/65/\Sigma\pi$	
S_{11}	$1730/80/\Lambda\pi$	$1790/50/\bar{K}N$	$1790/100/\bar{K}N$	
P_{11}	$1500\text{-}1600/50/\Sigma\pi$ $1850/30/\bar{K}N$	$1670/50/\Sigma\pi$		$1621/52/\Sigma\pi$ $1898/222/\bar{K}N$
P_{13}			$1840/120/\bar{K}N$	





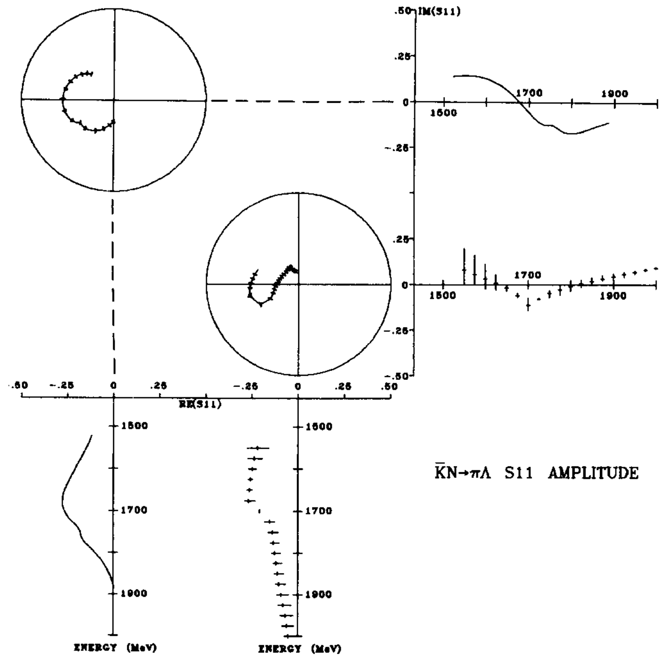
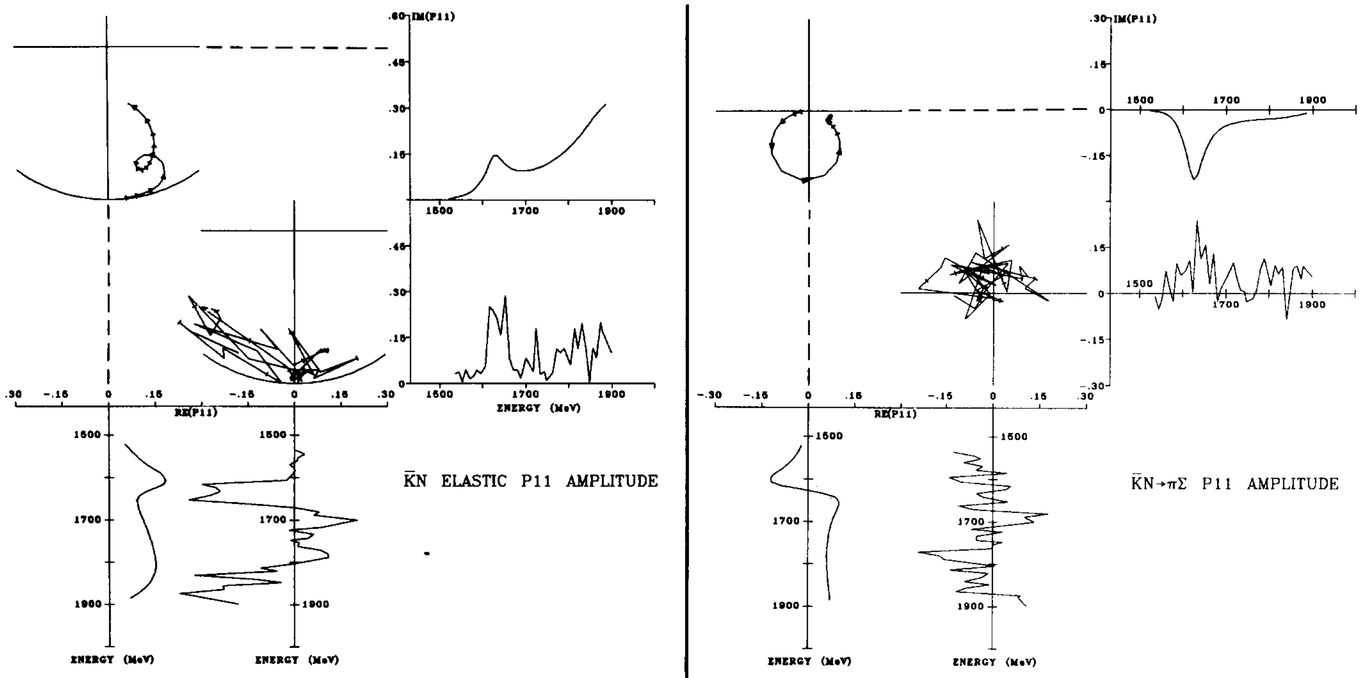


Fig. 1. Amplitudes for $\bar{K}N$ scattering in the S_{11} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each channel is from LEA 73. The lower plot is from LANGBEIN 72 for the elastic and $\pi\Sigma$ channels, and from VAN HORN 72 for the $\pi\Lambda$ channel. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. The amplitudes shown for VAN HORN 72 were obtained by averaging three energy-dependent fits (his fits H, K, R) and assigning error bars that cover the range of these three fits. The only established resonance in this wave is the $\Sigma(1750)$; see the accompanying mini-review and the Data Card Listings for other possible resonances in the S_{11} wave.



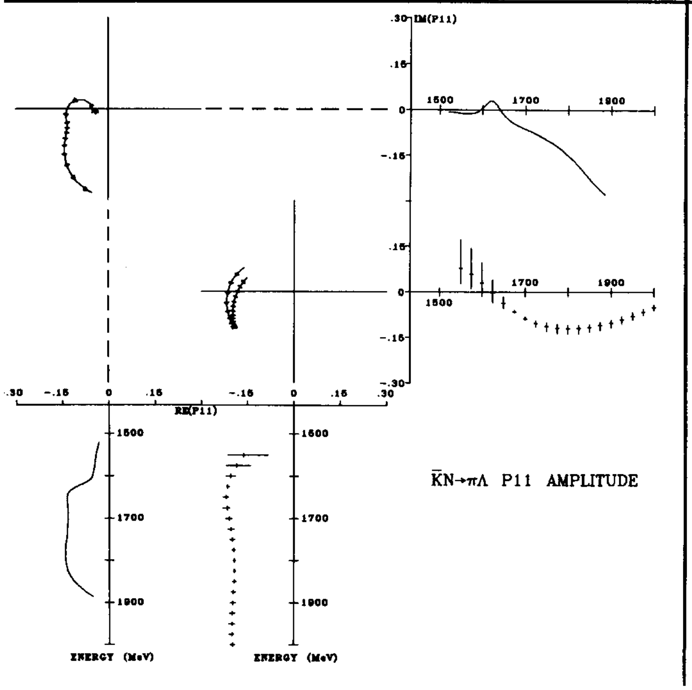
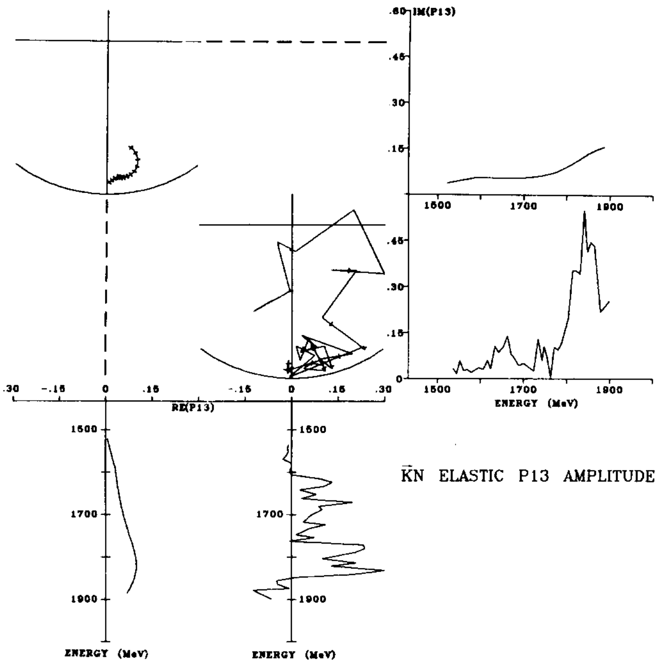
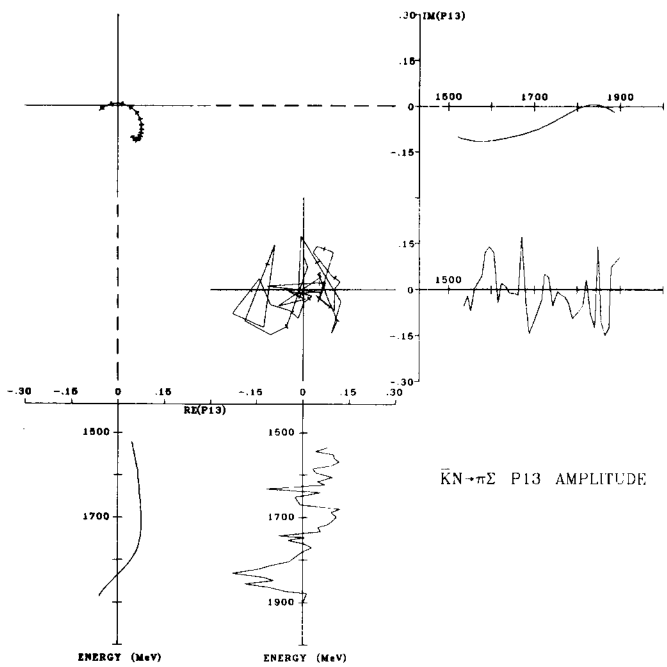


Fig. 2. Amplitudes for $\bar{K}N$ scattering in the P_{11} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each channel is from LEA 73. The lower plot is from LANGBEIN 72 for the elastic and $\pi\Sigma$ channels, and from VAN HORN 72 for the $\pi\Lambda$ channel. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. The amplitudes shown for VAN HORN 72 were obtained by averaging three energy-dependent fits (his fits H, K, R) and assigning error bars that cover the range of these three fits. This wave contains the Σ pole but no established resonances; see the accompanying mini-review and the Data Card Listings for possible resonances in the P_{11} wave.





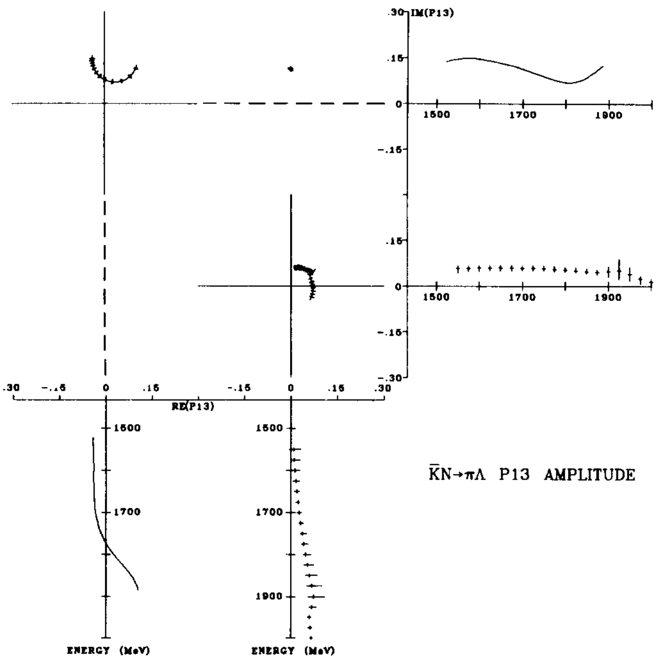
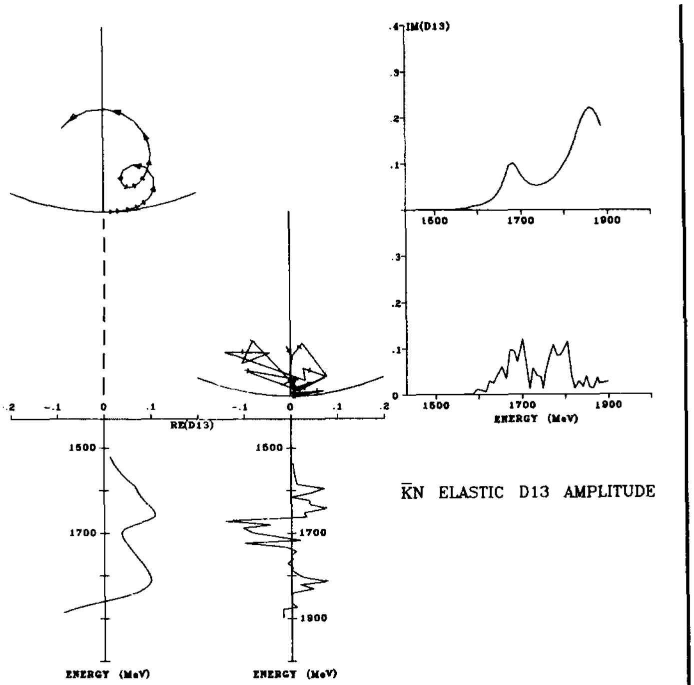
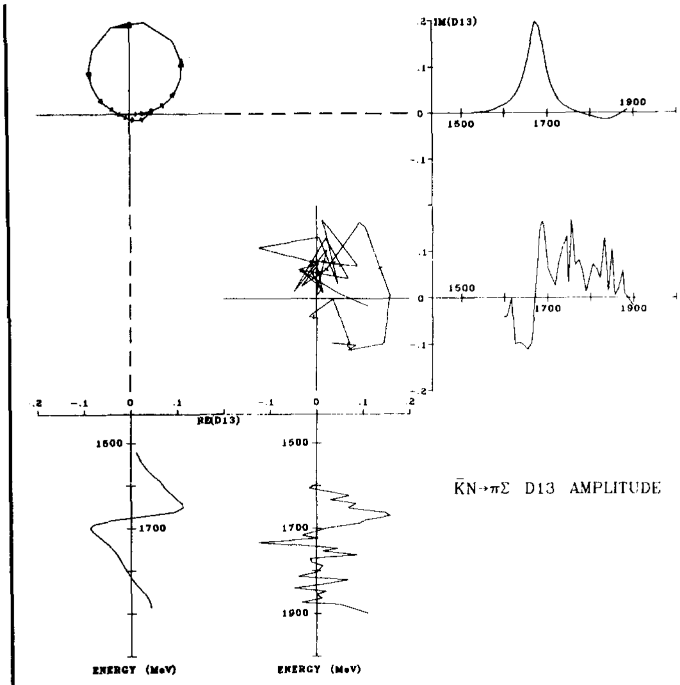


Fig. 3. Amplitudes for $\bar{K}N$ scattering in the P_{13} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each channel is from LEA 73. The lower plot is from LANGBEIN 72 for the elastic and $\pi\Sigma$ channels, and from VAN HORN 72 for the $\pi\Lambda$ channel. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. The amplitudes shown for VAN HORN 72 were obtained by averaging three energy-dependent fits (his fits H, K, R) and assigning error bars that cover the range of these three fits. The only established resonance in this wave is the $\Sigma(1385)$ which lies below elastic threshold and does not appear here; see the accompanying mini-review and the Data Card Listings for other possible resonances in the P_{13} wave.





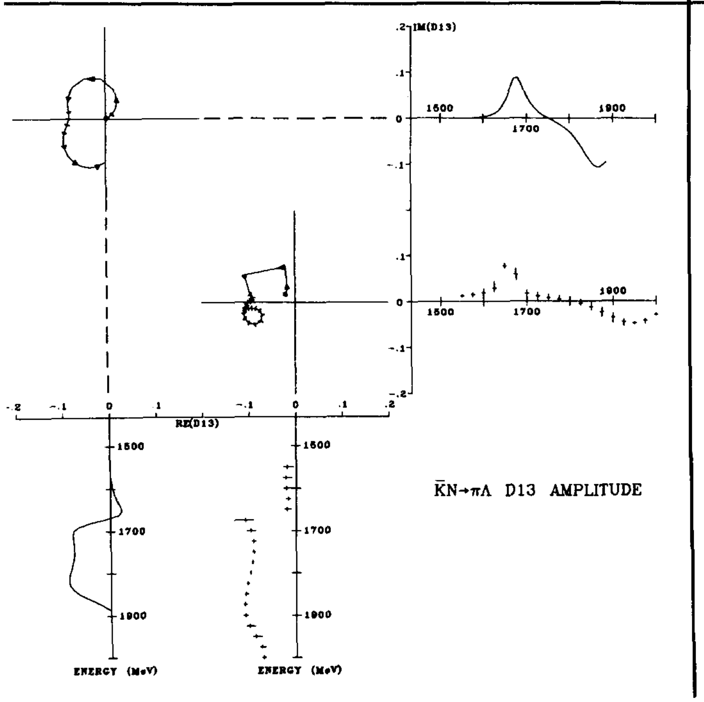
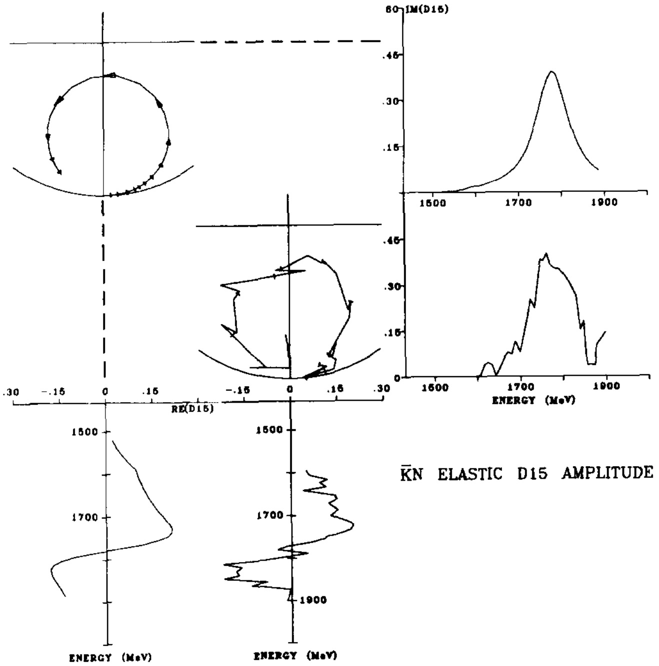
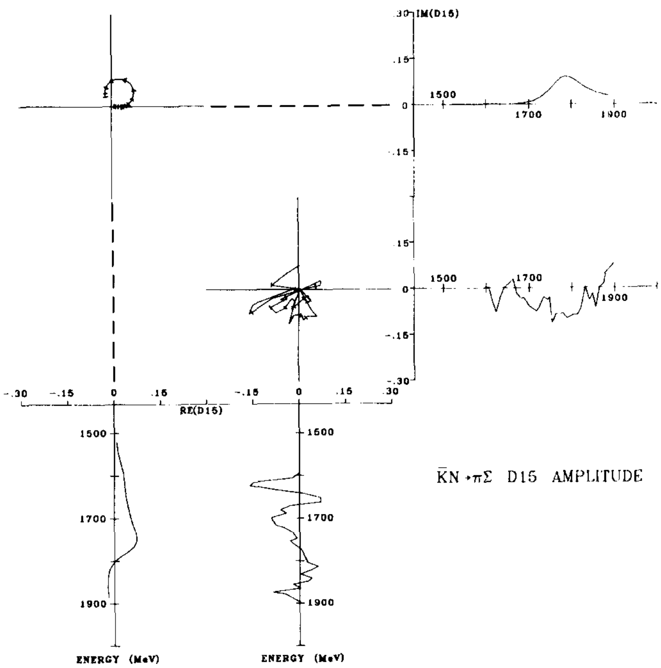


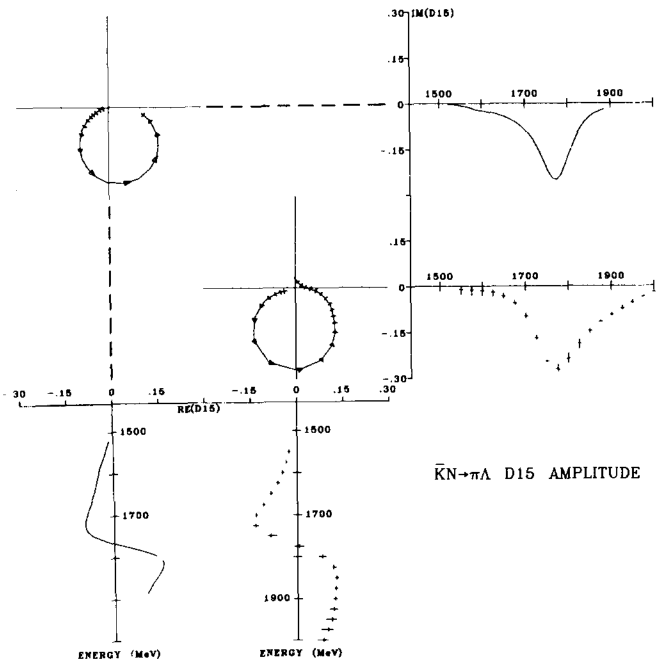
Fig. 4. Amplitudes for $\bar{K}$N scattering in the D_{13} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each channel is from LEA 73. The lower plot is from LANGBEIN 72 for the elastic and πΣ channels, and from VAN HORN 72 for the πΛ channel. The signs of the πΣ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. The amplitudes shown for VAN HORN 72 were obtained by averaging three energy-dependent fits (his fits H, K, R) and assigning error bars that cover the range of these three fits. Established resonances in the D_{13} wave are the Σ(1670) and the Σ(1940).



$\bar{K}N$ ELASTIC D15 AMPLITUDE

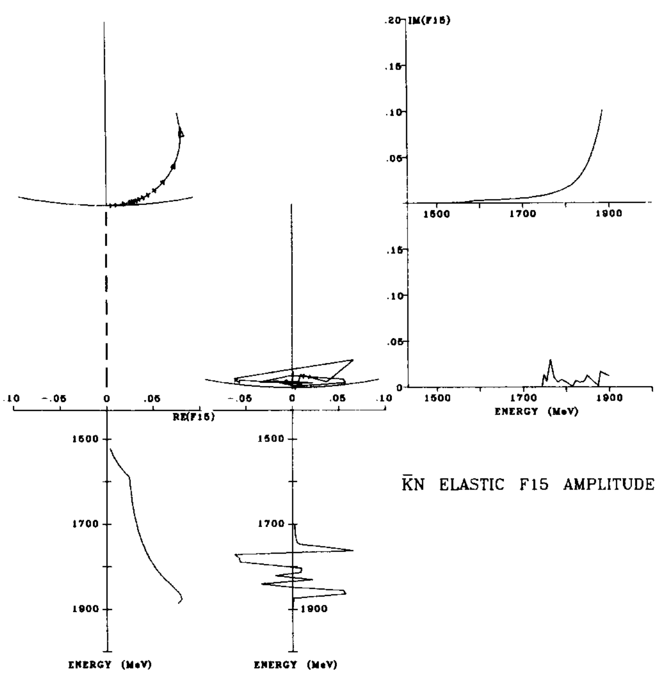


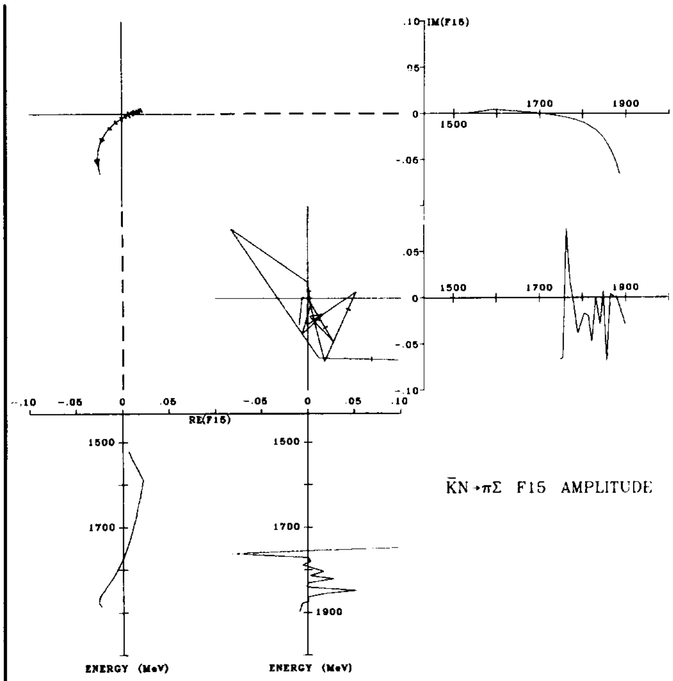
$\bar{K}N \to \pi\Sigma$ D15 AMPLITUDE



$\bar{K}N \to \pi\Lambda$ D15 AMPLITUDE

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 vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each channel is from LEA 73. The lower plot is from LANGBEIN 72 for the elastic and $\pi\Sigma$ channels, and from VAN HORN 72 for the $\pi\Lambda$ channel. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. The amplitudes shown for VAN HORN 72 were obtained by averaging three energy-dependent fits (his fits H, K, R) and assigning error bars that cover the range of these three fits. The only established resonance in the D_{15} wave is the $\Sigma(1765)$.





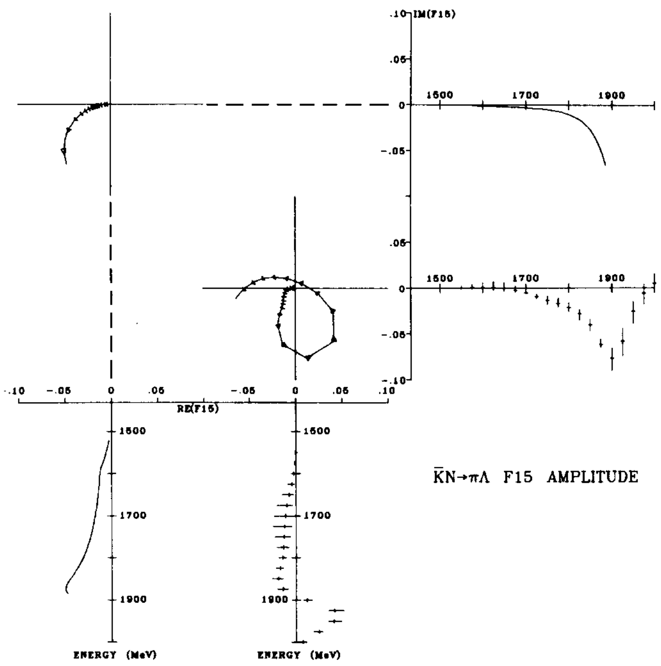
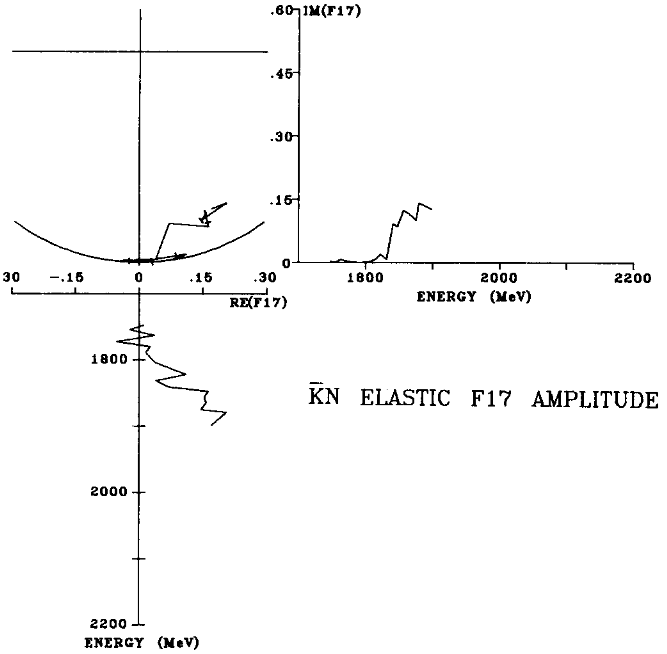
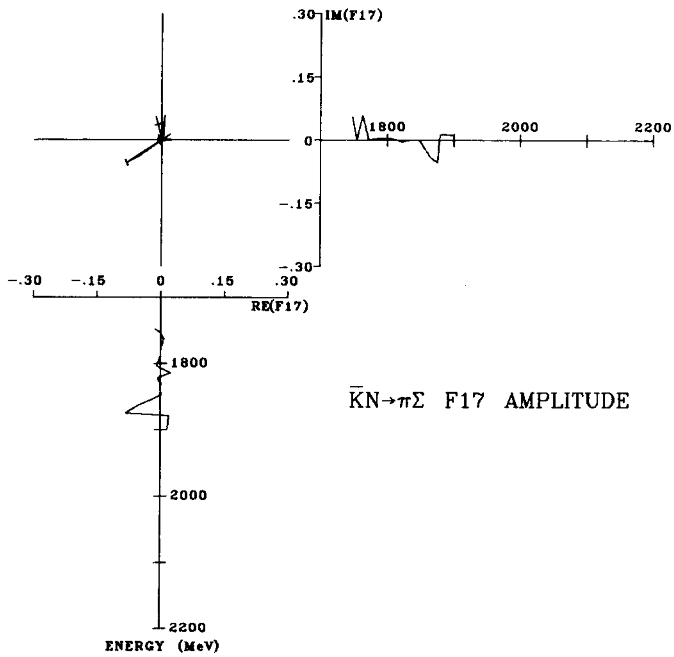


Fig. 6. Amplitudes for $\bar{K}N$ scattering in the F_{15} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each channel is from LEA 73. The lower plot is from LANGBEIN 72 for the elastic and $\pi\Sigma$ channels, and from VAN HORN 72 for the $\pi\Lambda$ channel. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. The amplitudes shown for VAN HORN 72 were obtained by averaging three energy-dependent fits (his fits H, K, R) and assigning error bars that cover the range of these three fits. The only established resonance in this wave is the $\Sigma(1915)$; see the Data Card Listings for other possible resonances in the F_{15} wave.





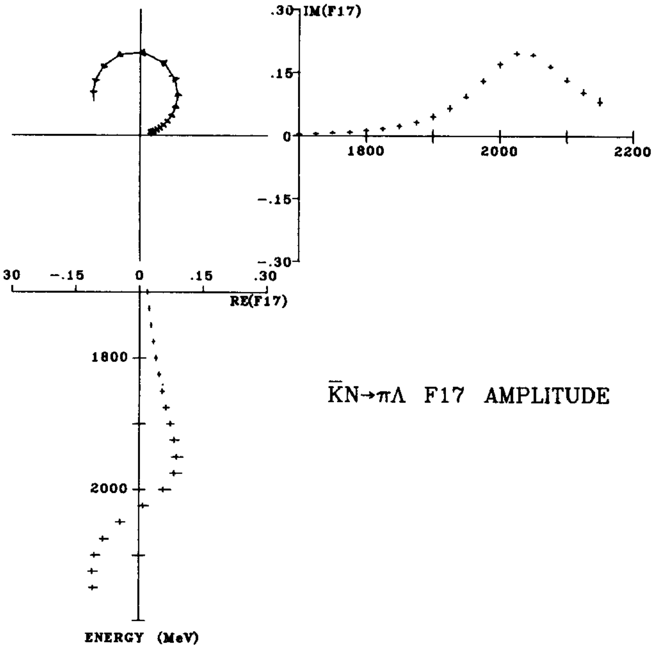


Fig. 7. Amplitudes for $\overline{K}N$ scattering in the F_{17} partial wave. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). All the energy axes run from 1700 to 2200 MeV. The amplitudes shown are from LANGBEIN 72 for the elastic and $\pi\Sigma$ channels, and from VAN HORN 72 for the $\pi\Lambda$ channel. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. The amplitudes shown for VAN HORN 72 were obtained by averaging three energy-dependent fits (his fits H, K, R) and assigning error bars that cover the range of these three fits. The only established resonance in the F_{17} wave is the $\Sigma(2030)$.

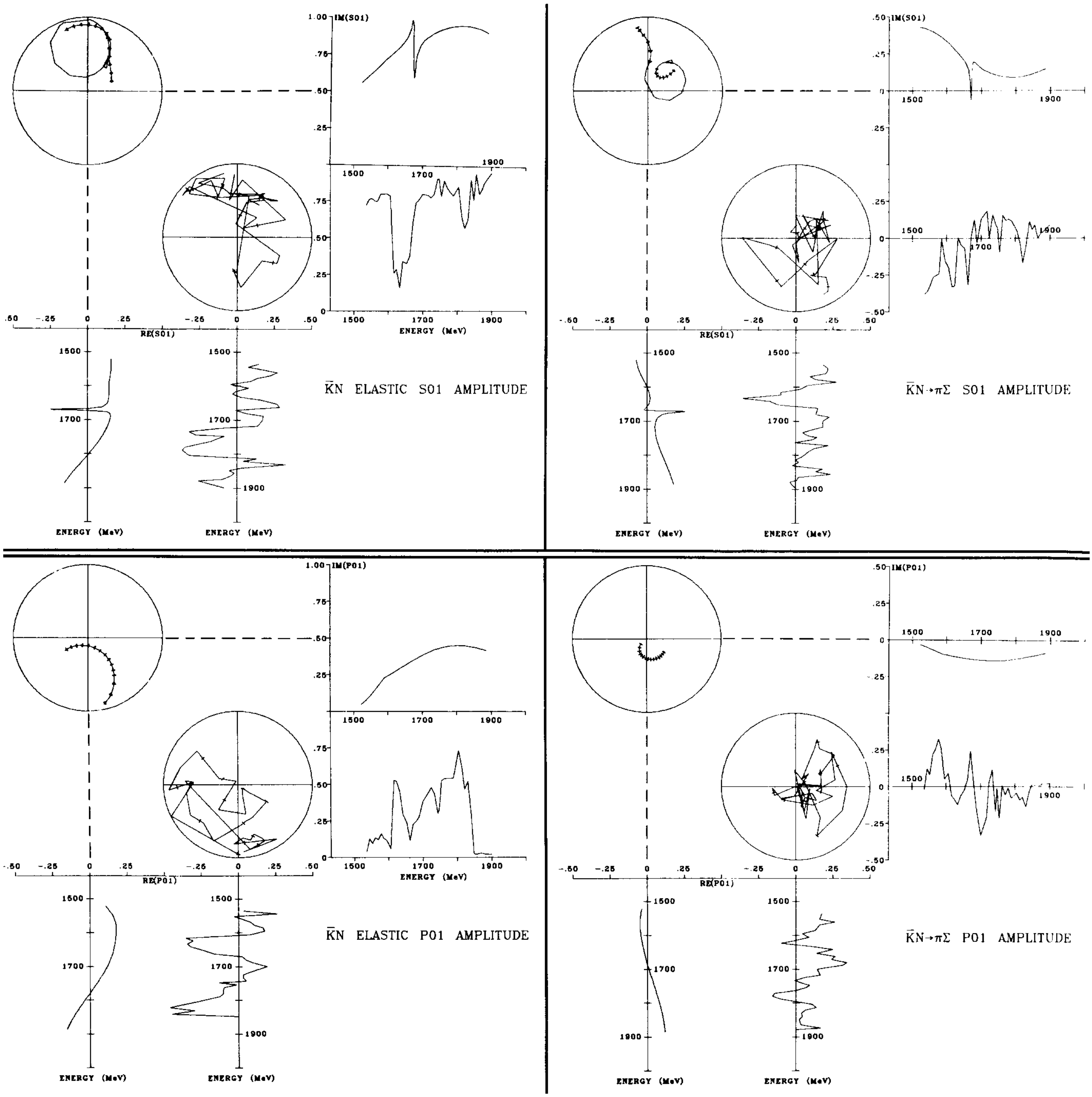


Fig. 8. Amplitudes for $\bar{K}N$ scattering in the S_{01} and P_{01} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each amplitude is from LEA 73; the lower plot is from LANGBEIN 72. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. Established resonances in the S_{01} wave are the $\Lambda(1405)$ (which lies below elastic threshold and does not appear here) and the $\Lambda(1670)$; the P_{01} wave contains the Λ pole but no established resonances. See the accompanying mini-review and the Data Card Listings for other possible resonances in the S_{01} and P_{01} waves.

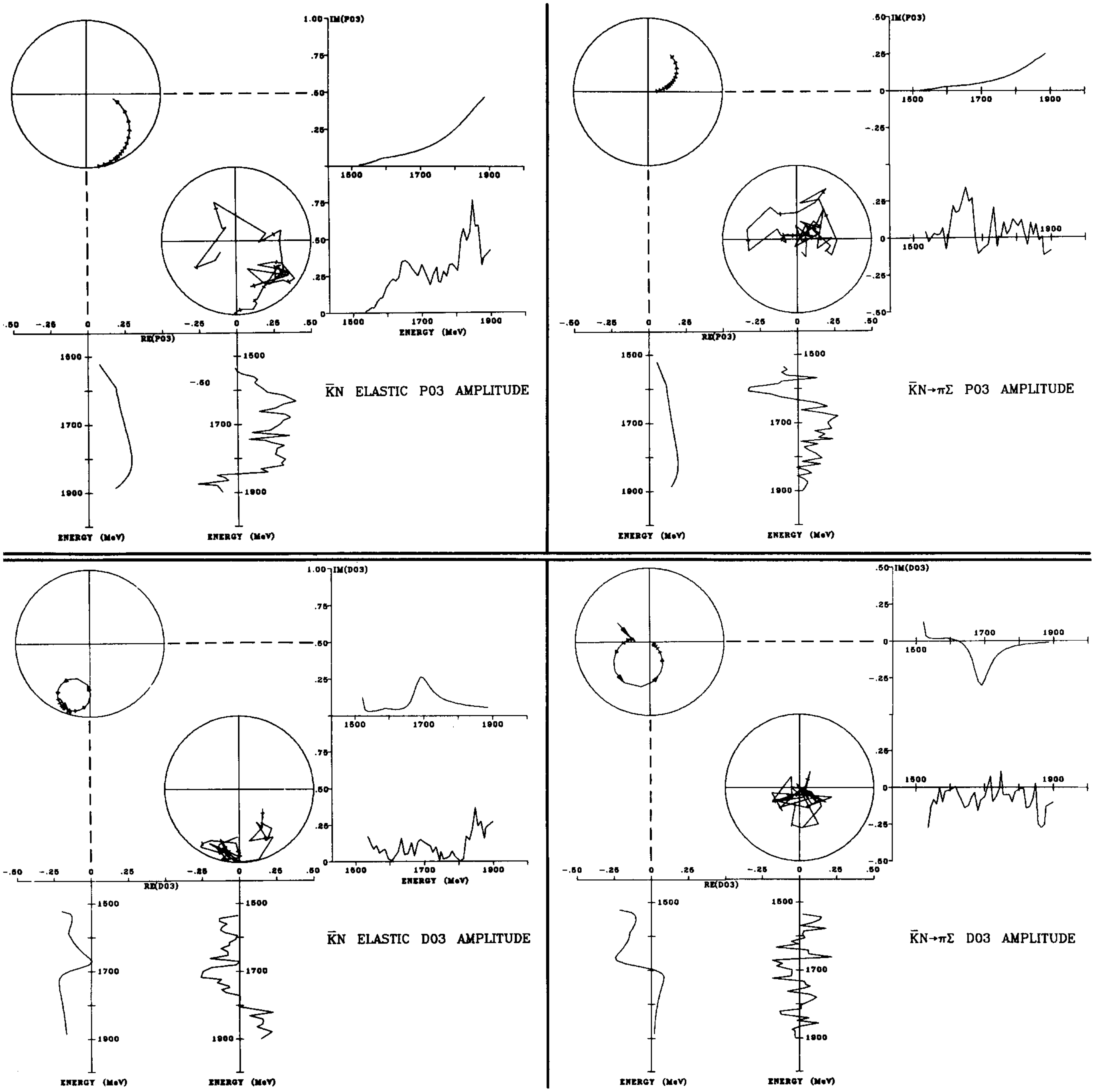


Fig. 9. Amplitudes for $\overline{K}N$ scattering in the P_{03} and D_{03} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each amplitude is from LEA 73; the lower plot is from LANGBEIN 72. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. Established resonances in the D_{03} wave are the $\Lambda(1520)$ and the $\Lambda(1690)$; there are no established resonances in the P_{03} wave. See the accompanying mini-review and the Data Card Listings for other possible resonances in the P_{03} and D_{03} waves.

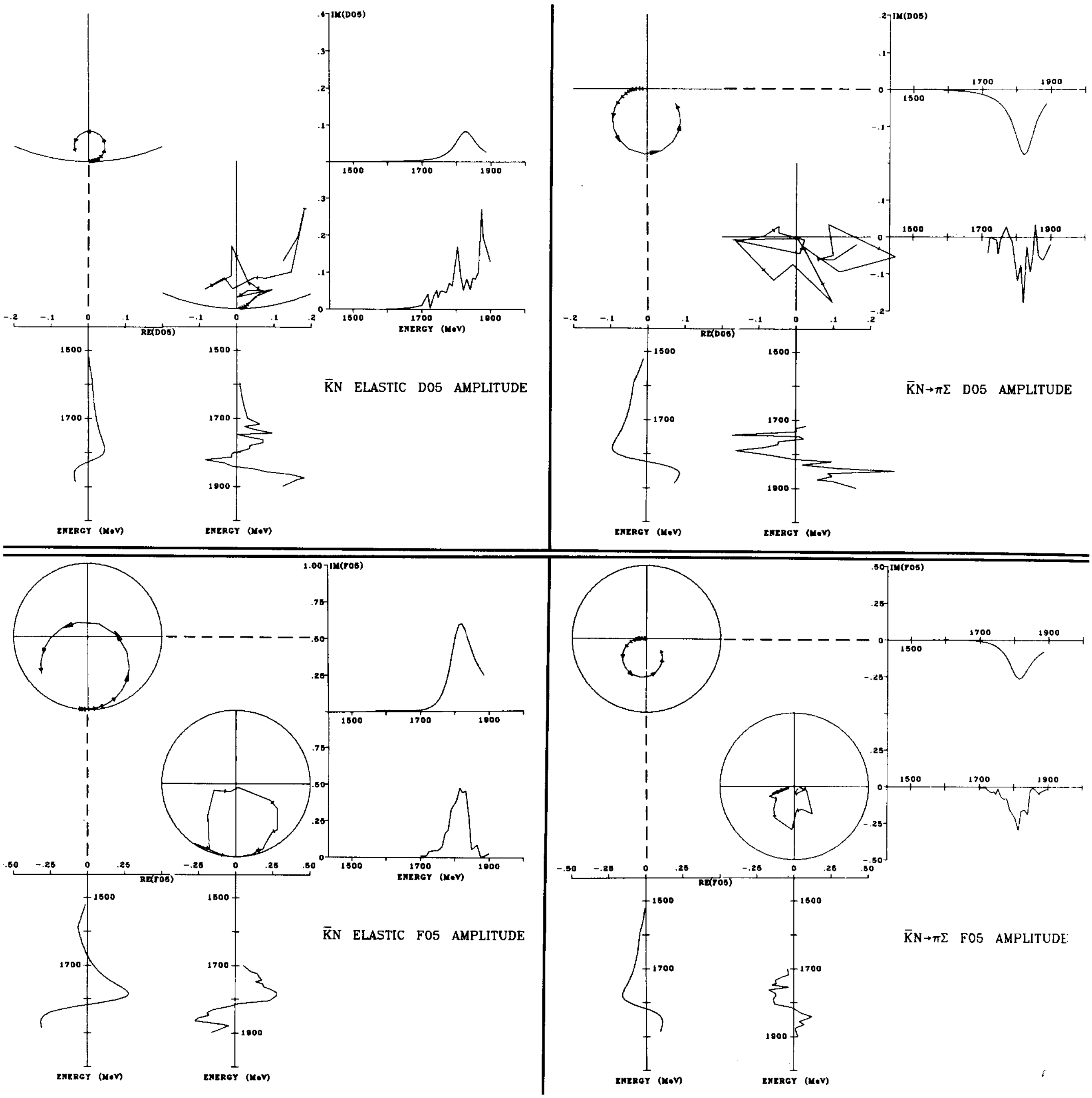


Fig. 10. Amplitudes for K̄N scattering in the D_{05} and F_{05} partial waves. The energy dependence of each amplitude is displayed by plotting its real and imaginary parts vs. energy, in alignment with the corresponding Argand plot. In addition, arrows are plotted on the Argand plots with bases positioned at even multiples of 25 MeV and a base-to-tip length of 5 MeV (except for LANGBEIN 72 where only the base is shown). The results of two different analyses are shown for each channel; the energy axes for the two analyses are aligned for ease of comparison. All the energy axes run from elastic threshold to 2000 MeV. The upper Argand plot for each amplitude is from LEA 73; the lower plot is from LANGBEIN 72. The signs of the $\pi\Sigma$ amplitudes from LANGBEIN 72 have all been changed in order to agree with the convention of LEA 73. Established resonances in these waves are the $\Lambda(1830)$ in the D_{05} wave and the $\Lambda(1815)$ in the F_{05} wave.

There are fewer analyses which extend above 1200 MeV/c; all of them are of the single-channel energy-dependent type.

A new method to compare different partial-wave analyses is one involving the properties of the "Barrelet zeroes".[3,4] Using a particular set of N partial waves, this technique can be used to generate all the 2^N-1 other sets corresponding exactly to the same cross section and polarization as the original set: VAN HORN 72 has done an energy-dependent fit of the $\Lambda\pi$ channel Legendre coefficients over the energy range 1537-2215 MeV. Using the Barrelet method, he has generated the ambiguous solutions corresponding to his best fit. Seven of them preserve the established resonances $D_{13}(1670)$, $D_{15}(1765)$, $F_{15}(1915)$, and $F_{17}(2030)$. The couplings of these resonances to the $\Lambda\pi$ channel are sometimes very different in the "ambiguous solutions" from their generally accepted values. Also new resonance structures appear in all the waves, particularly in the lower spins. This analysis is instructive in so far as demonstrating that there could be an entire constellation of other possible resonances beyond those which appear at the primitive stage of the analysis. However, one should keep in mind that these possible resonances do not necessarily correspond to a simple or even plausible parametrization of the amplitudes.

The values we have listed on the data cards correspond to the average of the 20 best original fits of this analysis (all containing the established, plus a few probable, resonances).

Figures

Argand plots of 13 S=-1 partial waves are shown in Figs. 1-10. The analyses shown were picked largely for illustrative purposes rather than on the basis of our judgment of their quality; as discussed above there are a number of analyses extant and no clear choice of the "best" ones is possible. We show LEA 73[5] and LANGBEIN 72 to allow comparison of a highly smoothed analysis with an unsmoothed shortest-path analysis. These analyses used essentially the same data. VAN HORN 72 is shown as one of the few analyses that extends beyond 1200 MeV/c. It has been necessary to reduce the figures somewhat excessively because of space limitations. A booklet of larger versions of all the Argand plots in the Baryon mini-reviews is available on request from the Particle Data Group, LBL, Berkeley.

Errors on Masses and Widths

Often the quoted errors are only statistical, but the values of masses and widths can change well above 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 and VAN HORN 72). For two states, Λ(1820) 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 (section V.C). 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, we choose not to give errors on masses and total widths determined in 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 II 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. D. H. Miller, in Proceedings of the Duke Conference on Hyperon Resonances (1970), p. 229.
2. M. Ross and G. Shaw, Ann. Phys. (N.Y.) 13, 147 (1961).
3. E. Barrelet, Nuovo Cim. 8A, 331 (1972).
4. P. Litchfield - Proceedings of the IInd Aix-en-Provence Conference (1973).
5. Numerical results provided by R. G. Moorhouse, priv. comm.

For other references see the Data Card Listings.

TABLE II. STATUS OF Y* RESONANCES
THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

			STATUS AS SEEN IN --				
PARTICLE	LIJ	OVERALL STATUS	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(1670)	S01	****		****	R	****	LAM ETA
LAM(1690)	D03	****	****	****	B	****	LAM2PI,SIG2PI
LAM(1750)	P01	**		***	I	**	
LAM(1815)	F05	****	****	****	D	****	SIG(1385) PI
LAM(1830)	D05	***		***	D	****	
LAM(1860)	P03	**	**	***	E	*	
LAM(1870)	S01	**		**	N	*	
LAM(2010)	D03	**			F	*	LAM OMG
LAM(2020)	F07	**		*	O	*	
LAM(2100)	G07	****	****	****	R	***	XI K,LAM OMG
LAM(2110)		*		*	B	*	LAM OMG
LAM(2350)		****	****	****	I		
LAM(2585)		***	***	*	D		
SIG(1190)	P11	****					WEAK TO N PI
SIG(1385)	P13	****			****	****	
SIG(1440)	PE	DEAD					
SIG(1480)	PE	*		*	*	*	
SIG(1620)	S11	**		**	*	*	
SIG(1620)	P11	**		**	*	**	
SIG(1620)	PE	**		*	**		LAM 2-PI
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(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 IS SEEN NEAR 1330 MEV IN THE LAMBDA GAMMA SPECTRUM IN THREE PI- PROPANE EXPERIMENTS (YUNG-CHANG 64, BUBELEV 67, AND BOZOKI 68). IN THE FIRST TWO, THIS WAS TAKEN AS INDIRECT EVIDENCE FOR THE Y*0(1670) DECAYING TO LAMBDA ETA, WITH THE ETA DECAYING TO TWO GAMMAS. IN THE THIRD EXPERIMENT THIS INTERPRETATION HAS BEEN RULED OUT. BOZOKI 68 MENTION THE POSSIBILITY OF THERE BEING A Y*0(1330) WITH A NARROW WIDTH (<25 MEV), BUT DEFER SERIOUS CONSIDERATION OF IT UNTIL THERE IS MORE DATA.
SHOULD SUCH A RESONANCE EXIST, IT SHOULD BE SEEN IN PI- P TO K0 + (MISSING MASS). DAHL 67 FOUND NO EVIDENCE FOR IT.
A SEARCH FOR A NEW Y*0 NEAR THE LAMBDA OR SIGMA MASS WAS MADE BY TAN 69. NONE WAS FOUND.
ANOTHER SEARCH BY MAYEUR 70 REVEALED NO EVIDENCE FOR THIS STATE.

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, CHUVILO, + (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)

Λ(1405) S'_{01}

37 Y*0(1405, JP=1/2-) I=0
PRODUCTION EXPERIMENTS

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)				

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)			

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 S'01

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) 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.

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 DPWA	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 DPWA	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	
ALSO	73 NP B56 15	THOMAS,ENGLER,FISK,KRAEMER	(CARN)IJ

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)

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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)
SHAW     73 PURDUE CONF. 417  SHAW                                 (UCI)IJP
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Λ(1520)

D'_{03}

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            38  Y*0(1520, JP=3/2-) I=0

            PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL
            WITH EACH OTHER ,THEREFORE. THEY HAVE NOT BEEN SEPARATE
            FOR THIS PARTICLE
              A POSSIBLE EXCEPTION TO ABOVE IS THE LAM PI PI
            MODE.  BOTH CHAN 72 AND MAST 73 (FORMATION) AGREE
            THAT IT IS PREDOMINANTLY Y*1(1385) PI.  HOWEVER,
            THEY DISAGREE BY A FACTOR OF 2 AS TO THE CONTRIBUTION
            OF Y*0(1520) TO THE OVERALL LAM PI PI CROSS SECTION.
            BURKHARDT 71 (PRODUCTION), WITH MUCH LESS STATISTICS,
            FIND A MUCH LOWER BRANCHING RATIO.

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            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             . . . . . . . . .
M   AVG     1517.85     0.95     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            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             . . . . . . . . .
W   AVG     15.5        1.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            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*

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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.

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        P 1          P 2          P 3          P 4          P 5          P 6
 P 1  .4508+-.0088
 P 2   -.7568   .4120+-.0092
 P 3   -.2187     -.3405   .1006+-.0054
 P 4   -.0680     -.0639     -.0325   .0080+-.0014
 P 5   -.1717     -.1614     -.0822     -.0095   .0199+-.0035
 P 6   -.0270     -.0254     -.0129     -.0015     -.0038   .0087+-.0006

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            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            . . . . . . . . .
R1  AVG     0.851       0.064    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R1  FIT     0.914       0.036    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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         (0.2)                      KIM       71 DPWA     K-MATRIX ANAL.    3/71
R2            . . . . . . . . .
R2  AVG     0.202       0.021    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT     0.223       0.014    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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  FIT     4.10        0.27     FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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         0.80     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         1.99     0.35     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            . . . . . . . . .
R6  AVG     0.439       0.033    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R6  FIT     0.4508      0.0088 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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         (0.46)                     KIM       71 DPWA     K-MATRIX ANAL.    3/71
R7            . . . . . . . . .
R7  AVG     0.424       0.015    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7  FIT     0.4120      0.0092 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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            . . . . . . . . .
R8  AVG     0.00871     0.00056  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  FIT     0.00870     0.00056  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 DBC      K-D 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  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 = 3.0)

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           . . . . . . . . .
R11 AVG     0.1080      0.0089   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R11 FIT     0.1006      0.0054   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                          REFERENCES FOR Y*0(1520)

GALTIERI 63 PL 6 296          A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)
WATSON   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

                          PAPERS NOT REFERRED TO IN DATA CARDS

BERLEY   70 PR D1 1996        +YAMIN,KOFLER,MANN,MEISNER+ (BNL,MASA,YALE)IJP
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Λ(1670)

S''_{01}

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            40  Y*0(1670, JP=1/2-) I=0

            SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

              THIS RESONANCE IS WELL ESTABLISHED.
              (SEE THE NOTE FOR THE Y*0(1330)).

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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
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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          1672.     (1.)          HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74*
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           19.      (2.)          HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74*
              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

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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   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 LA^GE 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
       SEE THE NOTES ACCOMPANYING MASSES QUOTED

R3     Y*0(1670) FROM KBAR N TO SIGMA PI                  SQRT(P1*P3)
R3         (-0.25)   (0.06)        ARMENT-2  68 HBC   0 OLD DATA
R3          -0.27                  ARMENT-3  69 HBC   0                   9/69
R3          -0.30    (0.03)        ARMENT-4  69 HBC   0 NEW DATA          9/69
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

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                         REFERENCES FOR Y*0(1670)
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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
HART     73 PURDUE CONF. 311   +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)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)

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                    55  Y*0(1690, JP=3/2-) I=0

                    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    A     1691.0    (2.0)         ARMENT-4  69 HBC   0 ELAS,CH EXC.ED    9/69
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          1684.     (3.)          HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74*
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   ANALYSIS INCLUDES OLD AND NEW DATA OF CHS COLLAB.  .43-.8 GEV/C   10/69
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.

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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           40.0     (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   6/73
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           86.      (9.)          HART      73 DPWA    EL+CX,.7-.8GEV/C  2/74*
              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                        1384+ 139

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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)
P1          (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   N  EFFECT IS AT END OF REGION ANALYZED. THIS COULD AFFECT VALUE OF X1.
P1        FROM ALL ABOVE WE ESTIMATE  X=0.20                               3/72

R2     Y*0(1690) FROM KBAR N TO SIGMA PI                  SQRT(P1*P2)
R2         (-0.33)   (0.02)        ARMENT-3  68 HBC   0 OLD DATA         11/68
R2          -0.36    (0.02)        ARMENT-4  69 HBC   0 NEW DATA          9/69
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

P3     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

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                         REFERENCES FOR Y*0(1690)
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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
HART     73 PURDUE CONF. 311   +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)IJP

                         PAPERS NOT REFERRED TO IN DATA CARDS

PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION         (CERN+HEID+SACL)
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Λ(1750)

77 Y*0(1750, 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 BEHAVIOR OF THE P01 AMPLITUDE WHEN IT WAS PARAMETRIZED AS A TWO-STRAIGHT-LINE BACKGROUND. WHEN IT WAS RE-PARAMETRIZED AS A RESONANCE SUPERIMPOSED ON A ONE-STRAIGHT-LINE BACK-GROUND, A BROAD RESONANCE RESULTED (ARMENTEROS 68). A REANALYSIS OF ESSENTIALLY THE SAME DATA, BUT THIS TIME WITH THE P01 AMPLITUDE UNCON-STRAINED, SUGGESTED A MUCH NARROWER RESONANCE AT HIGHER ENERGY (ARMEN-TEROS 70).
A WIDER AND MORE ELASTIC P01 RESONANCE AT ABOUT THE SAME MASS IS SUGGESTED BY THE ANALYSIS OF BAILEY 69. THIS USES CONSIDERABLY LESS DATA THAN THE ARMENTEROS ANALYSES. FOR THIS REASON WE DO NOT QUOTE ANY PARAMETERS FOR THE OTHER PARTIAL WAVES OBTAINED IN THIS ANALYSIS.
ARMENTEROS 70, GALTIERI 70, AND KIM 71 PRESENT EVIDENCE FOR A P01 STATE IN THE SIGMA PI CHANNEL. IN ADDITION THE ANALYSES OF KIM 71 AND LANGBEIN 72 INDICATE A SECOND POSSIBLE P01 STATE.WE TENTATIVELY LIST THESE EFFECTS TOGETHER.

77 Y*0(1750) MASS (MEV)

M	O	(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	1	(1570.)		KIM	71	DPWA	K-MATRIX ANAL.	3/71
M	A	1620.0	(10.0)	LANGBEIN	72	IPWA	MULTICHANNEL	12/72
M	B	1780.0	(20.0)	LANGBEIN	72	IPWA	MULTICHANNEL	12/72
M	A AND B CORRESPOND TO 2 DIFFERENT RESONANCES IN P01							
M	1	POSSIBLE EFFECT IN SIGMA PI AND KBAR N CHANNELS.						
M	O	OLD ANALYSIS, USING OLD DATA.						

77 Y*0(1750) WIDTH (MEV)

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	1	(50.)		KIM	71	DPWA	K-MATRIX ANAL.	3/71
W	A	60.0	(10.0)	LANGBEIN	72	IPWA	MULTICHANNEL	12/72
W	B	120.0	(10.0)	LANGBEIN	72	IPWA	MULTICHANNEL	12/72

SEE THE NOTES ACCOMPANYING MASSES QUOTED

77 Y*0(1750) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*0(1750) INTO KBAR N	497+ 939
P2	Y*0(1750) INTO SIGMA PI	1197+ 139

77 Y*0(1750) BRANCHING RATIOS

R1		Y*0(1750) 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	A	0.25	(0.15)	LANGBEIN	72	IPWA	MULTICHANNEL	12/72
R1	B	0.36	(0.05)	LANGBEIN	72	IPWA	MULTICHANNEL	12/72
R2		Y*0(1750) FROM KBAR N INTO SIGMA PI					SQRT(P1*P2)	
R2		(+0.20)		ARMENTERO	70	DPWA	0 K-P TO SIGMA PI	6/70
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	A	0.28	(0.09)	LANGBEIN	72	IPWA	MULTICHANNEL	12/72
R2	B	0.01	OR LESS	LANGBEIN	72	IPWA	MULTICHANNEL	12/72

SEE THE NOTES ACCOMPANYING MASSES QUOTED

REFERENCES FOR Y*0(1750)

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

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 ER-RORS 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.

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	N	ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED						1/71

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	(4.3)	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

SEE THE NOTES ACCOMPANYING MASSES QUOTED

39 Y*0(1815) PARTIAL DECAY MODES

		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	1384+ 139
P4	Y*0(1815) INTO SIGMA PI PI	1192+ 139+ 139
P5	Y*0(1815) INTO ETA LAMBDA	548+1115

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	.6050+-.0243				
P 2	-.5445	.1138+-.0084			
P 3	.0000	-.0000	.2000+-.0500		
P 4	-.3497	.0824	-.9150	.0660+-.0546	
P 5	-.0721	.0392	0.0000	-.1293	.0152+-.0085

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		. . . .						
R1	AVG	0.605	0.027	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.8)				
R1	FIT	0.605	0.024	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 3.4)				
R2		Y*0(1815) FROM KBAR N INTO SIGMA PI					SQRT(P1*P2)	
R2		0.27	0.01	ARMENT-1	67	DPWA	0 K-P TO SIGMA PI	8/67
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		. . . .						
R2	AVG MOD	0.2634	0.0081	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R2	FIT	0.2624	0.0081	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
R3		Y*0(1815) FROM KBAR N INTO Y*1(1385) PI					SQRT(P1*P3)	
R3	A	(0.3)	(0.05)	ARMENT-2	67	HBC	0 K-P TO LAM P+ P+	
R3		. . . .						
R3	FIT	0.348	0.044	FROM FIT				
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	0.200	0.050	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
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	0.066	0.055	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)				

REFERENCES FOR Y*0(1815)

BIRGE	65 ATHENS CONF 296	+ELY,KALMUS,KERNAN,LOUIE,SAHOURIA, +	(LRL)IJP
ARMENT-1	67 PL 24B 198	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+COEF)

PAPERS NOT REFERRED TO IN DATA CARDS

THE FOLLOWING PAPERS ARE NOW OF ONLY HISTORICAL INTEREST --

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 APPEARS TO BE 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	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

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	1384+ 139
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
R2	Y*0(1830) FROM KBAR N INTO SIGMA PI				SQRT(P1*P2)	
R2	0.15	(0.02)	ARMENTERO	67 DPWA	0 K-P TO SIGMA PI	8/67
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
R3	Y*0(1830) FROM KBAR N TO ETA LAMBDA				SQRT(P1*P4)	9/73*
R3	-.044	.020	RADER	73 MPWA		9/73*

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REFERENCES FOR Y*0(1830)

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)

PAPERS NOT REFERRED TO IN DATA CARDS

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.

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60 Y*0(1860) MASS (MEV)

M	A	F07	1864.0	2.0	ARMENTERO	68 DWPA	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		P03	1870.0	6.0	BRICMAN1	70 DPWA	0 SIGTOT,ELAS,CHEX	1/71
M	N	P03	1883.0	10.0	CONFORTO	71 DPWA	0 ELASTIC, CH EXCH	6/70
M	1	P03	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*
M	A	THESE TWO ANALYSES GAVE THE F07 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*

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60 Y*0(1860) WIDTH (MEV)

W	A	F07	39.0	7.0	ARMENTERO	68 DWPA	0 ELASTIC, CH EXCH	11/68
W	N		40.0	10.0	BUGG	68 CNTR	0 K-P TOTAL	7/68
W	A	F07	24.0	15.0	BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
W		P03	37.0	10.0	BRICMAN1	70 DPWA	0 SIGTOT,ELAS,CHEX	1/71
W	N	P03	80.0	20.0	CONFORTO	71 DPWA	0 ELASTIC, CH EXCH	6/70
W	1	P03	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*

SEE THE NOTES ACCOMPANYING MASSES QUOTED

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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

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60 Y*0(1860) BRANCHING RATIOS

R1			Y*0(1860) INTO (KBAR N)/TOTAL				(P1)	
R1	A	F07	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	F07	0.07	0.02	BRICMAN	70 CNTR	0 TOTAL AND CH EX	6/70
R1		P03	0.14	0.02	BRICMAN1	70 DPWA	0 SIGTOT,ELAS,CHEX	1/71
R1	N	P03	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*

SEE THE NOTES ACCOMPANYING MASSES QUOTED

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*

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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

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)

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Λ(1870) →

36 Y*0(1870, JP=1/2-) I=0 S'''_{01}

THE S01 AMPLITUDE SHOWS A SECOND RESONANCE BEHAVIOR AT ABOUT 1800 MEV IN 3 ANALYSES. THE ELASTICITY OF KIM 71 IS SURPRISINGLY LARGE.

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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

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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
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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
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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

R2      Y*0(1870) FROM KBAR N TO SIGMA PI                SQRT(P1*P2)
R2            (0.24)                    KIM       71 DPWA    K-MATRIX ANAL.     3/71
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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
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Λ(2010) →

D'''_{03}

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              89  Y*0(2010, JP=3/2-) I=0

              SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

              SUCH A RESONANCE IS SUGGESTED BY ONLY TWO
              PARTIAL-WAVE ANALYSES ACROSS THIS REGION.  UNTIL THERE
              IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
              BARYON TABLE.
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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  DEFINITE CLASSIFICATION OF THESE TWO STATES IS NOT POSSIBLE AT          1/74*
M    1  PRESENT,BOTH ARE LISTED HERE AWAITING FURTHER EVIDENCE. PARAMETERS      1/74*
M    1  QUOTED ARE RANGES FROM THREE BEST FITS,THE LOWER(HIGHER) MASS STATE     1/74*
M    1  PROBABLY HAS J.LE.3/2(5/2).                                             1/74*
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              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*
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              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+ 782
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              89  Y*0(2010) BRANCHING RATIOS

P1      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)
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Λ(2020) →

F_{07}

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              27  Y*0(2020, JP=7/2+) I=0

              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.
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              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
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              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
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              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
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              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

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
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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
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Λ(2100)

G_{07}

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              41  Y*0(2100, JP=7/2-) I=0

              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 THE NEXT ENTRY.  EVENTUALLY THE PARTIAL-WAVE ANALYSES SHOULD
        GIVE THE BEST RESULTS, AS THEY ISOLATE THE G07 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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              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    A      BURGUN 68 SEE A RESONANCE-LIKE EFFECT IN THIS REGION IN THE
M       REACTION K-P TO XI K.  HOWEVER, AS THEY POINT OUT, IT IS NOT CLEAR
M       WHETHER IT IS MAINLY THE G07 Y*0(2100) OR INSTEAD A SO FAR OTHERWISE
M       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*
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              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
           SEE THE NOTES ACCOMPANYING MASSES QUOTED
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              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+ 782
P5      Y*0(2100) INTO ETA LAMBDA                            548+1115
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              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   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  0 K-P TO SIG PI     10/71
R2            +0.096    (0.037)         KANE      72 DPWA  0 K-P TO PI SIG     10/71

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     0.018          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*

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)
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BERTHON1 70 NP B24 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+COEF)

Λ(2110)

35 Y*0(2110, JP=5/2-) I=0 F''_{05} or D''_{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.

35 Y*0(2110) MASS (MEV)

M		(2110.)	(10.)	BERTHON1	70 DPWA	-	K- P TO SIG PI	1/71
M		(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	A	RESONANCE OUTSIDE RANGE OF DATA.						

35 Y*0(2110) WIDTH (MEV)

W		(185.)	(30.)	BERTHON1	70 DPWA	-	K- P TO SIG PI	1/71
W		(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

35 Y*0(2110) PARTIAL DECAY MODES

		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+ 782

35 Y*0(2110) BRANCHING RATIOS

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

R2 Y*0(2110) INTO (KBAR N)/TOTAL (P1)

R2	(0.14)	(0.04)	LITCHFIE	71 DPWA		K-P TO KBAR N	10/71

REFERENCES FOR Y*0(2110)

BERTHON1 70 NP B24 417 +VRANA,BUTTERWORTH,+ (CDEF,RHEL,SACLAY)IJP
LITCHFIE 71 NP B30 125 LITCHFIELD,...+LESQUOY,+.. (RHEL+COEF+SACL)IJP
KANE 72 PR D5 1583 D F KANE (LBL)IJP

2100 MEV REGION - PRODUCTION EXPERIMENTS

25 Y*0(2100, JP=) I=0

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 (PI)	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+ 782

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, C 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 1887 +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(2350) BUMPS

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.

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

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

42 Y*0(2350) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*0(2350) INTO KBAR N	497+ 939

42 Y*0(2350) BRANCHING RATIOS (PROD. EXP.)

R1 Y*0(2350) INTO (KBAR N)/TOTAL (P1)
R1 J IS NOT KNOWN. THE FOLLOWING IS (J+1/2)*P1.

R1	(0.57)		BUGG	68 CNTR		K-P, D TOTAL	6/68
R1	1.1	0.25	BRICMAN	70 CNTR	0	TOTAL AND CH EX	6/70
R1	(1.0)		COOL	70 CNTR		K-P, D TOTAL	10/70

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)

PAPERS NOT REFERRED TO 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

Λ(2585) BUMPS

7 Y*0(2585, JP=) I=0 PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

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

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

7 Y*0(2585) PARTIAL DECAY MODES (PROD. EXP.)

		DECAY MASSES
P1	Y*0(2585) INTO KBAR N	497+ 939

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.						

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                         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+

19 SIGMA+ (1189, JP=1/2+) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ−

20 SIGMA- (1198, JP=1/2+) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ0

21 SIGMA0 (1193, JP=1/2+) I=1

SEE STABLE PARTICLE DATA CARD LISTINGS

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Σ(1385)

43 Y*1(1385, JP=3/2+) I=1 P'_{13}

FOR DISCUSSION OF INCONSISTENCY OF ERRORS AND OUR MODIFICATIONS, SEE NOTE ON K*(892)

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               FOR THE TABLES WE USE ONLY THE UNSTARRED DATA, WHICH
               ATTEMPTS TO OBTAIN THE SEPARATE CHARGE-STATE MASSES AN
               WIDTHS.  SEE HOWEVER THE IDEOGRAMS INSERTED IN LISTING
     THESE INDICATE SERIOUS SYSTEMATICS, PERHAPS ARISING FROM INTERFERENCE E
     FECTS THAT CHANGE WITH PRODUCTION MECHANISM AND BEAM MOMENTUM.
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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           1380.       5.           AMMANN     73 DBC     K-N 4.5GEV/C      9/73*
M0      106(1381.0)     (4.0)        CURTIS     63 OSPK  0 PI-P 1.5 BEV/C
M0      330 1385.1      2.0          THOMAS     73 HBC     PI-P TO PIOKOLM   9/73*

M+   E 154 1376.0       3.9          ELY        61 HLBC +  K-P 1.11 BEV/C
M+   E            ERROR OF 3.0 ENLARGED TO 3.9 BY US,BECAUSE LT STATIST.ERR. 10/69
M+     170 1375.0       3.9          COOPER     64 HBC  +  K-P 1.45 BEV/C
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+   S 250 1382.6       2.1          SMITH      65 HBC  +  K-P 1.95 BEV/C    9/66
M+   S 250 1384.3       1.9          SMITH      65 HBC  +  K-P 1.8 BEV/C     9/66
M+   S            ERROR OF 1.4 ENLARGED TO 2.1 BY US,BECAUSE <  STATIST.ER.  10/69
M+   S            ERROR OF 1.1 ENLARGED TO 1.9 BY US,BECAUSE <  STATIST.ER.  10/69
M+   B  40 1383.0       4.0          BIRMINGHA 66 HBC  +  K-P 3.5            9/67
M+   B            ERROR OF 2.0 ENLARGED TO 4.0 BY US,BECAUSE <  STATIST.ERR. 10/69
M+         1378.0       5.0          LONDON     66 HBC  +  K-P 2.24 BEV/C    7/66
M+    1260 1384.4       1.0          SIEGEL     67 HBC  +  K-P AT 2.1 GEV/C 10/69
M+         1390.0       6.0          AGUILAR    70 HBC  +  K-P 4 GEV/SIG.PI  5/70
M+         1384.8       2.0          ATHERTON   71 HBC      LAM PI+ + C.C.  10/71
M+    2300 1383.5        .85         HABIBI     73 HBC     K-P TO 2PI LAM    9/73*
M+         . . . . . . . . . .
M+   AVG   1383.01      0.56    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                        (SEE IDEOGRAM BELOW )
```
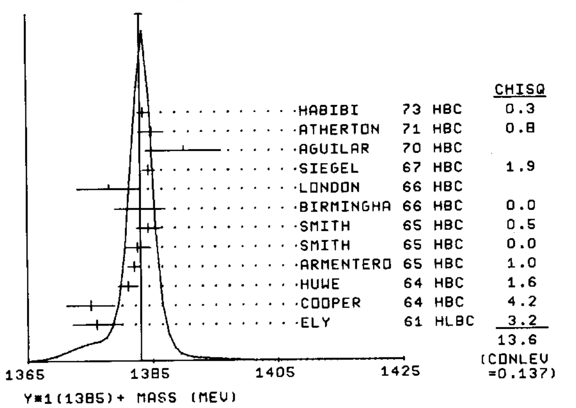

WEIGHTED AVERAGE = 1383.01 ± 0.56
ERROR SCALED BY 1.2

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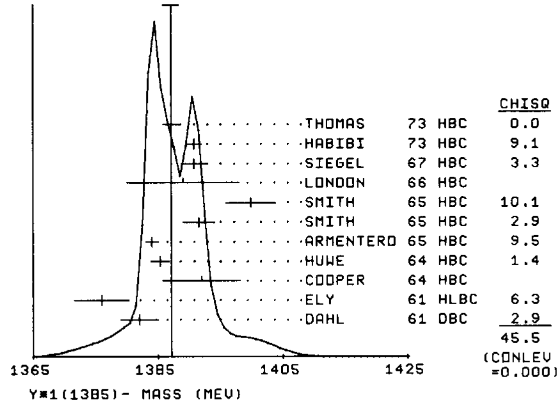
M-       93 1382.0      3.0           DAHL      61 DBC  -  K-D 0.45 BEV/C
M-   E  224 1376.0      4.4           ELY       61 HLBC -
M-   E            ERROR OF 3.0 ENLARGED TO 4.4 BY US,BECAUSE <  STATIST.ERR. 10/69
M-      200 1392.0      6.2           COOPER    64 HBC  -
M-     1086 1385.3      1.5           HUWE      64 HBC  -
M-     1380 1384.0      1.0           ARMENTERO 65 HBC  -
M-   S  120 1391.5      2.6           SMITH     65 HBC  -  K-P 1.8 BEV/C     9/66
M-   S   58 1399.8      4.0           SMITH     65 HBC  -  K-P 1.95 BEV/C    9/66
M-   S            ERROR OF 1.8 ENLARGED TO 2.6 BY US,BECAUSE <  STATIST.ER.  10/69
M-   S            ERROR OF 1.4 ENLARGED TO 4.0 BY US,BECAUSE <  STATIST.ER.  10/69
M-          1389.0      9.0           LONDON    66 HBC  -                    7/66
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-      722 1387.1      1.3           THOMAS    73 HBC     PI-P TO PI-K+LM   9/73*
M-          . . . . . . . . . .
M-   AVG    1387.1      1.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.4)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 1387.1 ± 1.3
ERROR SCALED BY 2.4



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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                       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     REDUNDANT WITH DATA IN MASS LISTING.
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                  43  Y*1(1385) WIDTH (MEV)

W          (64.0)                ALSTON    60 HBC  +-
W          (40.0)                BERGE     61 HBC  +-
W          (20.0)  OR LESS       MARTIN    61 HBC  +0
W          (80.0)   (10.0)       COLLEY    62 HLBC -0
W          (30.0)    (9.0)       CURTIS    63 OSPK  0
W          (26.0)    (5.0)       BALTAY    65 HBC  +-                    7/66
W          (38.0)    (9.0)       MUSGRAVE  65 HBC  +-0                   7/66
W           61.      10.         AMMANN    73 DBC     K-N 4.5GEV/C       9/73*
W0    330   39.3      6.1        THOMAS    73 HBC     PI-P TO PIOKOLM    9/73*

W+          48.0      8.0        ELY       61 HLBC +
W+          51.0     10.0        COOPER    64 HBC  +
W+          46.5      3.0        HUWE      64 HBC  +
W+          32.0      3.0        ARMENTERO 65 HBC  +
W+          30.3      3.1        SMITH     65 HBC  +  K-P 1.8 BEV/C      9/66
W+          33.1      3.8        SMITH     65 HBC  +  K-P 1.95 BEV/C     9/66
W+     40   25.0      6.0        BIRMINGHA 66 HBC  +  K-P 3.5            9/67
W+   1260   36.0      3.0        SIEGEL    67 HBC     K-P AT 2.1 GEV/C  10/69
W+          33.      12.0        AGUILAR   70 HBC  +  K-P 4 GEV/SIG.PI   5/70
W+ T   40   20.       4.         ATHERTON  71 HBC     LAM PI+ + C.C.    10/71
W+ T     FIT B.W. + PHASE SPACE BCKGRD
W+ R   40   35.       5.         ATHERTON  71 HBC     LAM PI+ + C.C.    10/71
W+   2300   38.3      2.6        HABIBI    73 HBC     K-P TO 2PI LAM     9/73*
W+ R     FIT B.W. AND NO BCKGRD
W+          . . . . . . . . . .
W+   AVG    35.1      2.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                      (SEE IDEOGRAM BELOW )
W-         (40.0)                DAHL      61 DBC  -
W-          66.0     10.0        ELY       61 HLBC -
W-          88.0     10.0        COOPER    64 HBC  -
W-          62.0      7.0        HUWE      64 HBC  -
W-          38.0      3.0        ARMENTERO 65 HBC  -
W-          29.2      5.7        SMITH     65 HBC  -  K-P 1.80 BEV/C     9/66
W-          17.1      4.4        SMITH     65 HBC  -  K-P 1.95 BEV/C     9/66
W-    370   31.0      4.0        SIEGEL    67 HBC     K-P AT 2.1 GEV/C  10/69
W-   1900   51.9      2.5        HABIBI    73 HBC     K-P TO 2PI LAM     9/73*
W-    722   48.2*     4.0        THOMAS    73 HBC     PI-P TO PI-KOLM    9/73*
W-          . . . . . . . . . .
W-   AVG    42.5      4.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.5)
                      (SEE IDEOGRAM BELOW )
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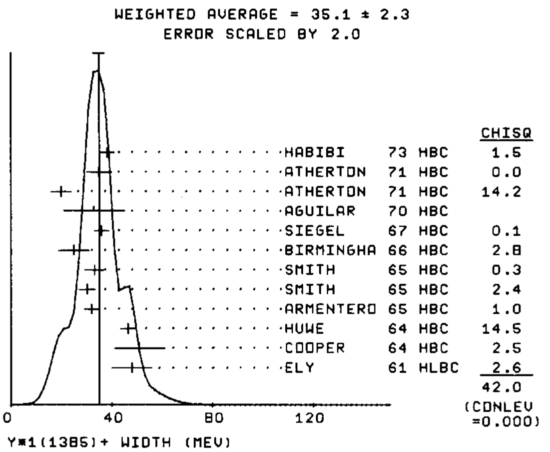

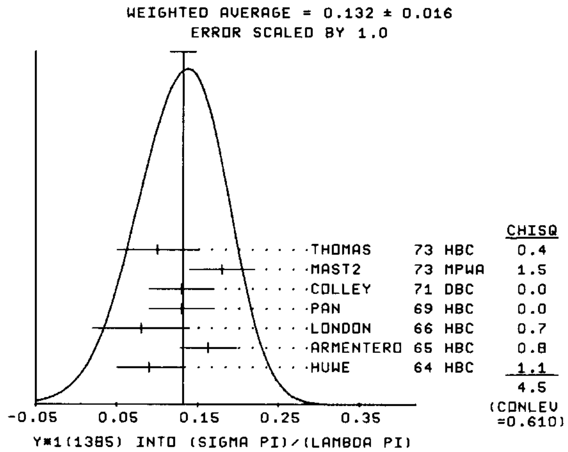

R2 Y*1(1385) INTO LAMBDA GAMMA (P3)
R2 1 (0.17) (0.17) MEISNER 72 HBC 1 EVENT ONLY 1/73

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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)

ARMENTEP 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., OXFORDYRUTHERFORD
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)
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)IJ

QUANTUM NUMBER DETERMINATIONS 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

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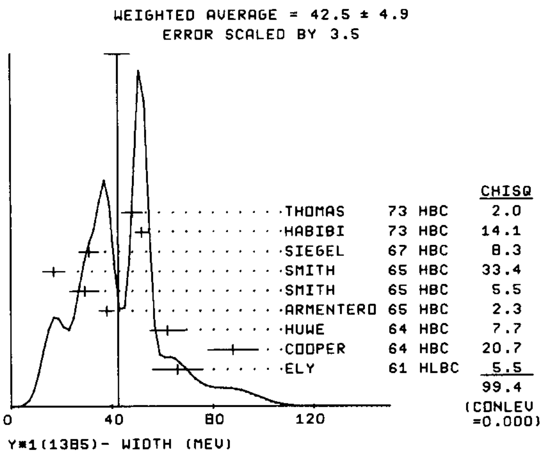

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43 Y*1(1385) PARTIAL DECAY MODES

		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

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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		
R1		0.09	0.04	HUWE	64	HBC	+-		
R1		0.163	0.035	ARMENTERO	65	HBC	+-		7/66
R1		0.08	0.06	LONDON	66	HBC	+		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		K-N 1.5 GEV PROD	10/71
R1		.18	.04	MAST2	73	MPWA		K-P TO 2PI SIG	9/73*
R1		.10	.05	THOMAS	73	HBC		PI-P TO PI K Y	9/73*
R1		. . . . .	. . . .						
R1	AVG	0.132	0.016	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					

(SEE IDEOGRAM BELOW)

Σ(1440) BUMPS →

80 Y*1(1440, JP=) I=1 PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

CLINE 68 FIND A NARROW PEAK AT 1440 MEV (JUST ABOVE THE KBAR N THRESHOLD) IN THE LAMBDA PI INVARIANT MASS FOR K- D TO LAMBDA PI- P EVENTS. THEY DISCUSS ALTERNATE INTERPRETATIONS -- THAT IT IS A RESONANCE OR A KINEMATIC EFFECT. IN CLINE 68 THE K- BEAM MOMENTUM IS 0.4 GEV/C. IN A STUDY OF THE SAME REACTION WITH A MOMENTUM OF 1.1 GEV/C, ALEXANDER 69 FIND NO PEAK. IN ADDITION, THEY ARE ABLE TO EXPLAIN THE RESULTS OF BOTH EXPERIMENTS WITHOUT INVOKING A NEW RESONANCE. A REANALYSIS OF THE CLINE 68 DATA MADE BY BUNNEL 70 SHOW AGREEMENT OF THE DATA WITH THE ALEXANDER 69 INTERPERTATION.

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REFERENCES FOR Y*1(1440) (PROD. EXP.)

CLINE 68 PRL 21 1372 D CLINE, R LAUMANN, J MAPP (WISCONSIN) I
ALEXANDE 69 PRL 22 483 ALEXANDER, HALL, JEW, + (LRL,RIVERSIDE)
BUNNELL 70 LNC 3 224 +CLINE,LAUMANN,MAPP + (NWES+WISC+ANL)

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$\Sigma(1480)$ BUMPS

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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 POS-
SIBLE 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.

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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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                     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

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Note on $\Sigma(1620)$

This state was first suggested by the BNL-CCNY collaboration (CRENNELL 68) who presented evidence for it in the reaction $K^-n \rightarrow \Sigma(1620)^{\pm}\pi^{\mp}\pi^-$ with $\Sigma(1620)^{\pm}$ decaying into $\Lambda\pi^{\pm}$. Since then there have been conflicting reports about this state.

Total Cross-Section Experiment

A new 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.[1] A clear bump about 40 MeV wide and 3-4 mb high (corresponding to $(J+1/2)\,x \sim 0.1$) is seen at a c. m. energy of 1590 MeV in the I = 1 K^-N cross section.

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.

ARMENTEROS 70 saw a possible 50 MeV effect in P_{11} in the $\Sigma\pi$ channel only.

In multi-channel analyses, KIM 71 found two narrow resonances in S_{11} and P_{11}; LANGBEIN 72 has seen only the S_{11} and LEA 73 only the P_{11} state. Note however that the branching ratios into $\overline{K}N$, $\Sigma\pi$, and $\Lambda\pi$ of the resonances found by LANGBEIN 72 or LEA 73 are <u>not</u> the same as those observed by KIM 71.

VAN HORN 72, in the $\Lambda\pi$ channel, found a narrow S_{11} and a very broad P_{11} resonance. A narrow P_{11} state is reported by HART 73 in preliminary results from an analysis of the $\overline{K}N$ channel.

Production Experiments

A good review of the production experiments has been given by MILLER 70. Here the evidence is only in the $\Lambda\pi$ channel. The BNL-CCNY collaboration, with increased data, CRENNELL 69, still claim the effect in the $\Lambda\pi$ channel (no evidence seen in $\overline{K}N$ or $\overline{K}N\pi$). SABRE 70 studied the same reaction at 3.0 GeV/c with comparable statistics and do not see any evidence for it in the $\Lambda\pi$ channel; on the contrary, they believe it to be a spurious peak resulting from misidentified Σ^0 from the production of $\Sigma(1670)$ decaying into $\Sigma^0\pi^+$. CRENNELL 69 give counter arguments to show that this is not the case in their data and the controversy goes on. AMMANN 70 studied the same reaction at 4.5 GeV/c and report a state at 1640 MeV, again decaying only into $\Lambda\pi$ (no evidence seen in $\Sigma\pi$ or $\overline{K}N$ channels). The closeness of this mass to 1670 MeV is suggestive that this effect may be related to what goes on in that region (see discussion below).

In conclusion, for $\Sigma(1620)$ we have to wait for more data and for a complete understanding of the entire mass region 1600 to 1700 MeV. The hope is that the determination of quantum numbers for each of these effects for each decay mode may eventually clarify the situation.

References

1. K. K. Li in Baryon Resonances-73 (Purdue, 1973), pg. 283; A. S. Carroll, et al. in <u>Particles and Fields-1973</u>, ed. H. H. Bingham, et al., (Berkeley, 1973), pg. 208.

Σ(1620) S'_{11}

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32  Y*1(1620, JP=1/2-) I=1
THE S11 STATE AT 1697 MEV REPORTED BY VANHORN 72 IS
INTERMEDIATE IN MASS BETWEEN THE SIGMA(1620) AND
SIGMA(1750).  WE TENTATIVELY LIST IT UNDER SIGMA(1750).

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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

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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

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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 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

R3     Y*1(1620) FROM KBAR N TO LAMBDA PI              SQRT(P1*P3)
R3         (0.15)               KIM        71 DPWA   K-MATRIX ANAL.    3/71

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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

               PAPERS NOT REFERRED TO IN DATA CARDS

VANHORN  72 LBL-1370(THESIS)                                   /LBL IJP

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Σ(1620) P'_{11}

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79  Y*1(1620, JP=1/2+) I=1

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THE PARTIAL-WAVE ANALYSIS OF K- N TO SIGMA PI BY
ARMENTOROS 73 SUGGEST SUCH A RESONANCE. NOW
FOUND ALSO IN SOME, BUT NOT ALL, MORE RECENT
ANALYSES.

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          79  Y*1(1620) MASS (MEV)

M        1500. -- 1600.         ARMENTERO 70 HDBC -0 K-N TO SIGMA PI   6/70
M       (1670.)                 KIM       71 DPWA   K-MATRIX ANAL.     3/71
M        1668.      (.25)       VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
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*

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          79  Y*1(1620) WIDTH (MEV)

W        (50.0)                 ARMENTERO 70 HDBC -0 K-N TO SIGMA PI   6/70
W        (50.)                  KIM       71 DPWA   K-MATRIX ANAL.     3/71
W        230.    (165.)  (60.)  VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
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*

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          79  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+ 139

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          79  Y*1(1620) BRANCHING RATIOS

R1     Y*1(1620) FROM KBAR N TO SIGMA PI              SQRT(P1*P2)
R1         (+0.2)               ARMENTERO 70 HDBC -0 K-N TO SIGMA PI   6/70
R1         (0.24)               KIM       71 DPWA   K-MATRIX ANAL.     3/71
R1   2     (-.21)               LEA       73 DPWA   MULTICHNL K-MTRX   9/73*

R2     Y*1(1620) 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*

R3     Y*1(1620) FROM KBAR N TO LAMBDA PI             SQRT(P1*P3)
R3         (0.0)                KIM       71 DPWA   K-MATRIX ANAL.     2/73
R3          .12    (.12)  (.04) VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
R3   2     (+.07)               LEA       73 DPWA   MULTICHNL K-MTRX   9/73*

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               REFERENCES FOR Y*1(1620)

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
VANHORN  72 LBL-1370(THESIS) A.J.VANHORN                         (LBL)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

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1620 MEV REGION - PRODUCTION EXPERIMENTS

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          78  Y*1(1620, JP=    ) I=1

          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)

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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)
              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)

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Note on Σ(1670)

Formation Experiments

Formation experiments show the presence of only one I = 1 state in this energy region with major decay modes into $\overline{K}N$ (7-10%), $\Lambda\pi$ (10-15%), $\Sigma\pi$ (30-50%),

$\Sigma\pi\pi$ (5-15%), and some $\Lambda\pi\pi$ (the experimental situation here is unclear). Its quantum numbers are $J^P = 3/2^-$.

<u>Production Experiments</u>

Production experiments are more confused. When determined, the most likely quantum numbers are also $3/2^-$ [for $\Sigma\pi$ and $\Lambda(1405)\pi$]. The measured branching ratio $R = \Sigma\pi/\Sigma\pi\pi$ changes with the momentum transfer to the proton. This was first observed by EBERHARD 69 who suggested the existence of 2 Y_1^* 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. This problem has been recently reviewed by EBERHARD 73, where some preliminary information on new experiments is also given.

The other difficulty comes from the different $\Lambda\pi/\Sigma\pi$ branching ratios reported by the various experiments. Those experiments done with K^- beams below 2 GeV/c (HUWE 64 and BUTTON-SHAFER 68) report values for the $\Lambda\pi/\Sigma\pi$ ratio in agreement with formation experiments; the others report a higher $\Lambda\pi/\Sigma\pi$ ratio. Therefore, the possibility of a third Y_1^* state, referred to as $\Sigma(1690)$ in the Data Card Listings, with a large $\Lambda\pi/\Sigma\pi$ branching ratio still exists. This large branching ratio is the main justification for this hypothesis and needs confirmation. It relies on the separation between $K^-p \to \Lambda\pi^+\pi^-$ and $K^-p \to \Sigma^0\pi^+\pi^-$, which is experimentally difficult at high energy. These problems are reviewed by MILLER 70. (See also the mini-review on $\Sigma(1620)$.)

$\boxed{\Sigma(1670)}$

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44  Y*1(1670, JP=3/2-) I=1   D'13

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

SEE NOTE ABOVE

WELL ESTABLISHED RESONANCE.  IT HAS BEEN SEEN IN BOTH
FORMATION AND PRODUCTION EXPERIMENTS.  HOWEVER THE
BRANCHING RATIOS OBTAINED BY THESE TWO METHODS SHOW
LARGE INCONSISTENCIES.

SEE LISTING OF PRODUCTION EXPERIMENTS BELOW

AS FOR THE QUANTUM NUMBERS, THE ANALYSES OF LAMBDA PI CHANNEL (IN
FORMATION EXP.) AS WELL AS THE SIGMA PI CHANNEL AGREE ON JP=3/2-.

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                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          1659.    (12.)     (5.)     VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73
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                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          32.     (11.)               VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73

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                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                        1384+ 139
P7     Y*1(1670) INTO Y*0(1405) PI                        1405+ 139

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                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*

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        +0.1                         ARMENTER  70HBC      K-P TO LAMB PI     5/70
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         +.09      (.02)             VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73

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

R7     Y*1(1670) FROM KBAR N TO Y*1(1385) PI          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

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

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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
VANHORN  72 LBL-1370(THESIS)  A.J.VANHORN                            (LBL)IJP
HART     73 PURDUE CONF. 311  +RICE,BACASTOW,FUNG,+  (TENN+UCR+MASA+BUFF)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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1670 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                     51  Y*1(1670, JP=    ) I=1        PRODUCTION EXPERIMENTS

                     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.  BRANCHING RATIOS NOT
                     DISENTANGLED YET, WE LIST THEM TOGETHER FOR NOW.

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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           . . . . . . . . . .
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               SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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           . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 3.4)

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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

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             . . . . . . . . . .
R2   AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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

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

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   A       BETWEEN 2.5 AND 0.24       EBERHARD  69 HBC     K-P AT 2.6 GEV/C  9/69
     A       DEPENDING ON THE PRODUCTION ANGLE

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

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

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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)

                               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
EBERHARD 73 PURDUE CONF. 247   EBERHARD                               (LBL)IJP

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$\Sigma(1690)$ BUMPS →

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                     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.

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                     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.

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                     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

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                     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

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                     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)

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)

57 Y*1(1750, JP=1/2-) I=1 S''_{11}

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THERE IS NOW EVIDENCE IN THREE CHANNELS FOR AN S11 RESONANCE NEAR THIS ENERGY. INTERPRETATION OF THE SIGMA ETA THRESHOLD BUMP ON ITS OWN MERITS IS NOT CONCLUSIVE (CLINE 67) -- MORE DATA ARE NEEDED. BUT BY ANALOGY WITH THE SIMILAR N ETA AND LAMBDA ETA THRESHOLD EFFECTS, WHICH ARE ALMOST CERTAINLY RESONANCES, IT SEEMS VERY LIKELY THAT THIS TOO IS A RESONANCE. SEE THE RAPPORTEUR TALKS OF FERRO LUZZI 66 AND MEYER 67 FOR DISCUSSIONS.

IN THE ENERGY-INDEPENDENT PARTIAL WAVE ANALYSIS OF K- N TO LAMBDA PI, THE S11 AMPLITUDE APPEARS TO RESONATE (ARMENTEROS 69). IN 1968 IT APPEARED TO RESONATE NEAR 1650 MEV (ARMENTEROS 68), AND WAS LISTED HEREIN AS A SEPARATE STATE. NOW IT HAS MOVED CLOSE ENOUGH TO THE OTHER EFFECTS TO BE TENTATIVELY LISTED WITH THEM, BUT THE SIZE OF THE CHANGE IN THE MASS SHOULD BE A HEALTHY WARNING THAT THE PARAMETERS GIVEN FOR RESONANCES IN LOWER PARTIAL WAVES FROM SUCH ANALYSES ARE SUBJECT TO LARGE CHANGE. (ARMENTEROS 70, FROM WHICH THE RESONANCE PARAMETERS ARE QUOTED, IS A SLIGHT UPDATING OF ARMENTEROS 69.)

THERE IS WEAKER EVIDENCE FOR THIS RESONANCE IN AN ENERGY-DEPENDENT PARTIAL-WAVE ANALYSIS OF ELASTIC AND CHARGE-EXCHANGE SCATTERING (CONFORTO 71).

KIM 71 IN A MULTICHANNEL ANALYSIS FINDS A SURPRISINGLY LARGE ELASTICITY (.8), AND SMALLER AMPLITUDE IN THE LAMBDA PI CHANNEL.

VANHORN 72 FINDS A STATE SOMEWHAT BELOW THE SIGMA ETA THRESHOLD IN AN ANALYSIS OF THE LAMBDA PI CHANNEL.

USING NEW DATA, JONES 74 FINDS A SIGMA ETA COUPLING OF 0.23.

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57 Y*1(1750) MASS (MEV)

M		NEAR SIGMA ETA THRESHOLD			CLINE	67	OBC	- K-N TO SIGMA ETA	9/66
M		ABOUT 1750.0			MEYER	67	RVUE		9/69
M		ABOUT 1730.0			ARMENTERC	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		(1697.)	(20.)	(10.)	VANHORN	72	DPWA	0 K- P TO LAM PIO	2/73
M	1	(1760.)	(5.)		JONES	74		0 FIT SIGO ETA CS	1/74*
M	1	S-WAVE BW FIT TO THRSHLD C.S., NO BKGND. ERRORS STATISTICAL ONLY							1/74*

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57 Y*1(1750) WIDTH (MEV)

W		ABOUT 50.0			MEYER	67	RVUE		9/69
W		ABOUT 80.0			ARMENTERC	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		(66.)	(14.)	(12.)	VANHORN	72	DPWA	0 K- P TO LAM PIO	2/73
W	1	(92.)	(7.)		JONES	74		0 FIT SIG+ETA CS	1/74*

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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

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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
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		0 FIT SIG+ETA CS	1/74*
R3		Y*1(1750) FROM KBAR N INTO LAMBDA PI					SQRT(P1*P3)	
R3		(-0.25)		ARMENTERO	70	IPWA	-0 K-N TO LAMBDA PI	6/70
R3		(0.09)		KIM	71	DPWA	K-MATRIX ANAL.	3/71
R3		(0.30)	(0.05)	LANGBEIN	72	IPWA	MULTICHANNEL	12/72
R3		(-.13)	(.04)	VANHORN	72	DPWA	0 K- P TO LAM PIO	2/73
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

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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
VANHORN	72 LBL-1370(THESIS)	A.J.VANHORN	(LBL)IJP
JONES	74 U. CHICAGO THESIS	JONES	(U. CHICAGO)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

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.

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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		1774.	10.	VANHORN	72	DPWA	0 K- P TO LAM PIO	2/73
M	N	ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED						1/71
M		. . . .						
M		AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)						

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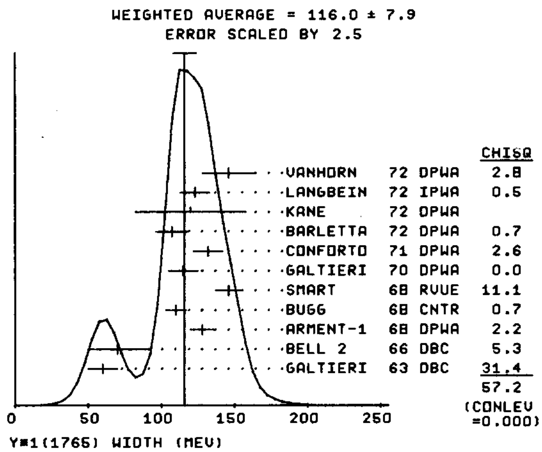
45 Y*1(1765) WIDTH (MEV)

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		146.	18.	VANHORN	72	DPWA	0 K- P TO LAM PIO	2/73
W		. . . .						
W	AVG	116.0	7.9	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)				
				(SEE IDEOGRAM BELOW)				



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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	1384+ 139
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

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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	.4113+-.0169					
P 2	.1041	.1320+-.0168				
P 3	.0887	.0372	.1566+-.0328			
P 4	.1129	.0117	.0100	.1028+-.0375		
P 5	-.1192	-.0124	-.0106	-.0135	.0118+-.0040	
P 6	-.4330	-.3456	-.6025	-.6813	-.0165	.1853+-.0585

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                 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           (0.4)                       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 OPWA     K-MATRIX ANAL.    3/71
R1            0.39      0.01             LANGBEIN  72 IPWA     MULTICHANNEL     12/72
R1          . . . . . . . . .
R1  AVG       0.409     0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.3)
R1  FIT       0.411     0.017  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.7)
                        (SEE IDEOGRAM BELOW )
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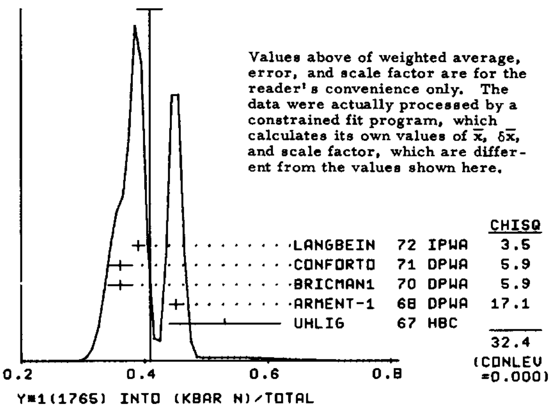
WEIGHTED AVERAGE = 0.409 ± 0.021
ERROR SCALED BY 3.3

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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           -.28       .04        .05    VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
R2          . . . . . . . . .
R2  AVG MOD   0.245     0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R2  FIT       0.233     0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)

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
P3          . . . . . . . . .
R3  AVG       0.298     0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R3  FIT       0.254     0.028  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)

R4      Y*1(1765) FROM KBAR N INTO Y*1(1385) PI            SQRT(P1*P4)
R4  A        (0.24)    (0.03)             ARMENT-2  67 HBC   0 K-P TO LAM PI PI  8/67
P4  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          . . . . . . . . .
R4  FIT       0.206     0.038  FROM FIT

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   8/67
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          . . . . . . . . .
R5  AVG       0.070     0.012   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  FIT       0.070     0.012  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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       0.321     0.042  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

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       0.381     0.080  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 2.1)

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       0.250     0.091  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9      Y*1(1765) INTO (SIGMA PI PI)/TOTAL                 (P7)
R9   P       (0.12)                       ARMENT-2  68 HDBC -0 K-N TO SIG PI PI 11/68
R9   P   FOR ABOUT 3/4 OF THIS, THE SIGMA PI SYSTEM HAS I=0 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 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

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
VANHORN  72 LBL-1370(THESIS)    A.J.VANHORN                           (LBL)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(1840) →

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              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 THESE TWO CLAIMS
              TOGETHER.

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              01  Y*1(1840) MASS (MEV)

M        1840.0    (10.0)             LANGBEIN  72 IPWA    MULTICHANNEL     12/72
M        1925.    (200.)              VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73

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              01  Y*1(1840) WIDTH (MEV)

W         120.0    (10.0)             LANGBEIN  72 IPWA    MULTICHANNEL     12/72
W          65.     (50.)    (20.)     VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73

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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

R2      Y*1(1840) FROM KBAR N INTO SIGMA PI               SQRT(P1*P2)
R2           0.15    (0.04)           LANGBEIN  72 IPWA    MULTICHANNEL     12/72

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           +.06     (.04)           VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73

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                        REFERENCES FOR Y*1(1840)

LANGBEIN 72 NP B47 477          +WAGNER                              (MPIM)IJP
VANHORN  72 LBL-1370(THESIS)    A.J.VANHORN                           (LBL)IJP
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Σ(1880) →

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              67  Y*1(1880, JP=1/2+) I=1   P''11

              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.

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              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       (1772.0)                      KANE       72 DPWA    K-P TO SIGMA PI   1/73
M        1985.      50.               VANHORN    72 DPWA  0 K- P TO LAM PIO   2/73
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        . . . . . . . . .
M  AVG   1925.6     19.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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                  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          (80.0)                      KANE      72 DPWA    K-P TO SIGMA PI    1/73
W          220.      140.              VANHORN   72 DPWA  0 K- P TO LAM PIO    2/73
W    2     (222.2)                     LEA       73 DPWA    MULTICHNL K-MTRX   9/73*
W          . . . . . . . . .
W   AVG    185.0      29.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  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

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                  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*

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           +.05       .07       .02  VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
R2   2      (-.30)                     LEA       73 DPWA    MULTICHNL K-MTRX  9/73*
R2          . . . . . . . . .
R2  AVG MOD  0.107     0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      Y*1(1880) FROM KBAR N TO SIGMA PI                  SQRT(P1*P3)        9/73*
R3          (-.108)                    KANE      72 DPWA    K-P TO SIGMA PI   9/73*
R3   2       NOT SEEN                  LEA       73 DPWA    MULTICHNL K-MTRX  9/73*

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                          REFERENCES FOR Y*1(1880)
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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
KANE      72 PR D5 1583         D F KANE                                (LBL)
VANHORN  72 LBL-1370(THESIS)   A.J.VANHORN                              (LBL)IJP
LEA       73 NP B56 77          +MARTIN,MOORHOUSE+  (RHEL+LOUC+GLAS+AARHUS)IJP
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Σ(1915)

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                  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-SEC-
                  TION 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
      (OR AT LEAST ATTEMPT TO -- THE SIGNAL IS WEAK).  THIS MASS REGION IS
      COMPLICATED AND POORLY UNDERSTOOD AND THE PEAKS MAY CONTAIN MORE THAN
      JUST THE Y*1(1915).  SEE ALSO THE NOTE TO THE NEXT ENTRY.

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                  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    B    (1985.0)   (21.0)            ISLAM     71 DPWA    KN--PI-SIG       .12/72
M    B  DISCREPANCY DUE POSSIBLY TO INSUFFICIENT STATISTICS
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.        .15       .20  VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
M    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED  1/71
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                  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    B    (159.0)    (80.0)            ISLAM     71 DPWA    KN--PI-SIG       12/72
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          102.       18.              VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
W    A   LACK OF DATA PREVENTS FROM DETERMINING UNAMB. THIS AMPLITUDE        11/67
W          . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

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                  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

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                  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

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           -.09       .02            VANHORN   72 CPWA  0 K- P TO LAM PIO   2/73

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   B      (0.06)    (0.02)           ISLAM     71 DPWA    KN--PI-SIG       12/72
R3          -0.137    (0.015)          KANE      72 DPWA  0 K-P TO PI SIG    10/71

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                          REFERENCES FOR Y*1(1915)
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ARMENTER 67 PL 24B 198          ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)
ARMENTE1 67 NP B3 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
ISLAM     71 PJSIR 14 305       +COX,COLLEY,HEATHCOTE                  (BIRM) IJP
    PAKISTAN J. SCI. IND. RES.
LITCHFIE 71 NP  B30 125         LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP
KANE      72 PR D5 1583         D F KANE                                (LBL)IJP
VANHORN  72 LBL-1370(THESIS)   A.J.VANHORN                              (LBL)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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1915 MEV REGION – PRODUCTION AND σ_{TOTAL} EXP'TS

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                  29  Y*1(1915, JP=    ) I=1

                  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 NOT-COMPLETELY-ESTABLISHED WITH THE D13 Y*(1940).

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                  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          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.9)

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                  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          . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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                  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

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                  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)
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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

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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 31B 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

                      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)

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            98  Y*1(1940, JP=3/2-) I=1   D''13

            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.

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            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         198[illegible].0     (5.0)                KANE      72 DPWA  0 K-P TO PI SIG    10/71
M         1949.      40.        60.      VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
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          . . . . . . . . .
M   AVG   1941.4     19.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            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          160.      70.        40.      VANHORN   72 DPWA  0 K- P TO LAM PIO   2/73
W    2    (108.9)                        LEA       73 DPWA    MULTICHNL K-MTRX  9/73*
W          . . . . . . . . . .
W   AVG    220.9     26.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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            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

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            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          -.05        .03        .02   VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73
R1    2     (-.11)                       LEA       73 DPWA    MULTICHNL K-MTRX  9/73*
R1          . . . . . . . . . .
R1   AVG MOD  0.093     0.030    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

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*

R3     Y*1(1940) INTO KBAR N                             (P1)                   9/73*
R3    2      (.21)                       LEA       73 DPWA    MULTICHNL K-MTRX  9/73*

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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
VANHORN  72 LBL-1370(THESIS)   A.J.VANHORN                          (LBL)IJP
LEA      73 NP B56 77          +MARTIN,MOORHOUSE+  (RHEL+LOUC+GLAS+AARHUS)IJP

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Σ(2000) →

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            02  Y*1(2000, JP=1/2-) I=1   S'''11

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            02  Y*1(2000) MASS (MEV)

M          2004.      40.                VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73

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            02  Y*1(2000) WIDTH (MEV)

W           116.      40.                VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73

            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

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            02  Y*1(2000) BRANCHING RATIOS

R1     Y*1(2000) FROM KBAR N INTO LAMBDA PI               SQRT(P1*P2)
R1              .07       .02       .01  VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73

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                      REFERENCES FOR Y*1(2000)

VANHORN  72 LBL-1370(THESIS)   A.J.VANHORN                          (LBL)IJP

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Σ(2030)

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            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         2042.      11.                 VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73
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         178.       13.                 VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73
W          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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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

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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   D  DAUM 68 ASSUMES (J+1/2)*P1 VALUE SEEN IN TOTAL CROSS SECTION.
R1          . . . . . . . . . .
R1   AVG     0.178     0.018    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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            .20       .01             VANHORN   72 DPWA  0 K-P TO LAM PIO    2/73
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          . . . . . . . . . .
R3   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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

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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)JP
   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
VANHORN  72 LBL-1370(THESIS)   A.J.VANHORN                             (LBL)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

                    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) →

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                    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.

------ --------- --------- --------- --------- --------- --------- --------

                    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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Σ(2080) →

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                    88  Y*1(2080, JP=3/2+) I=1   P'''13

                    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

------ --------- --------- --------- --------- --------- --------- --------

                    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

------ --------- --------- --------- --------- --------- --------- --------

                    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

****** ********* ********* ********* ********* ********* ********* ********

                              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

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Σ(2100) →

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                    26  Y*1(2100, JP=7/2-) I=1   G17

                    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.

------ --------- --------- --------- --------- --------- --------- --------

                    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

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                    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

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Σ(2250) BUMPS

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48  Y*1(2250, JP=    ) I=1          PRODUCTION EXPERIMENTS

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THE PHASE-SHIFT-ANALYSIS RESULTS ARE TOO WEAK TO
WARRANT SEPARATING THEM FROM THE PRODUCTION AND CROSS-
SECTION EXPERIMENTS. IN AN ANALYSIS OF ELASTIC AND
POLARIZATION DATA, DAUM 68 COULD NOT EXCLUDE ANY
POSSIBILITY FROM JP= 5/2+- TO JP= 11/2+- FOR THIS STATE. BRICMAN 70
SUGGESTS 7/2-. VANHORN72 CLAIMS 5/2+.

LASINSKI 71 SUGGESTS TWO RESONANCES IN THIS REGION USING A POMERON
+ RESONANCES MODEL.
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```
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   V     2251.      30.      20.  VANHORN   72 DPWA  0 K-P TO LAM PIO      2/73
M   V    VANHORN72 VALUE FROM A DPWA THAT FINDS JP=5/2+.
M   B    (2290.)    (26.)          BELLEFON  73 DPWA    P3 OR D5 WAVE       2/74*
M   B    (2215.)    (20.)          BELLEFON  73 DPWA    G9 OR H11 WAVE      2/74*
M   B    EVIDENCE FOR 2 RESONANCES IN THIS LAMBDA PI DPWA                   2/74*
M          . . . . . . . . .
M      AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)
```

```
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 BEV/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   V    192.       30.            VANHORN   72 DPWA  0 K-P TO LAM PIO      2/73
W   B   (150.)     (50.)           BELLEFON  73 DPWA    P3 OR D5 WAVE       2/74*
W   B   (100.)     (20.)           BELLEFON  73 DPWA    G9 OR H11 WAVE      2/74*
W         . . . . . . . . .
W   AVG  169.5      33.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 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
```

```
48  Y*1(2250) BRANCHING RATIOS (PROD. EXP.)

R1     Y*1(2250) INTO (KBAR N)/TOTAL                  (P1)
R1        J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1          (0.47)                 BUGG      68 CNTR                        6/68
R1          (0.16)   (0.12)        BRICMAN   70 CNTR  0 TOTAL AND CH EX     6/70
R1          (0.42)                 COOL      70 CNTR    K-P, D TOTAL       10/70

R2     Y*1(2250) FROM KBAR N TO LAMBDA PI             SQRT(P1*P2)
R2        THE FOLLOWING ASSUMES JP=9/2-. DATA INSUF. FOR DETERM. THIS AMP.
R2          (-0.18)                GALTIERI  70 DPWA    K-P TO LAMBDA PI   10/70
R2  V        -.16      .03         VANHORN   72 DPWA  0 K-P TO LAM PIO      2/73
R2  B       (+.22)   (.05)         BELLEFON  73 DPWA    P3 OR D5 WAVE       2/74*
R2  B       (-.10)   (.02)         BELLEFON  73 DPWA    G9 OR H11 WAVE      2/74*
            SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

R3     Y*1(2250) FROM KBAR N TO SIGMA PI              SQRT(P1*P3)
R3        THE FOLLOWING ASSUMES JP=9/2-. DATA INSUF. FOR DETERM. THIS AMP.
R3          (+0.07)                GALTIERI  70 DPWA    K-P TO SIGMA PI    10/70

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
```


```
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)
VANHORN  72 LBL-1370(THESIS)    A.J.VANHORN                         (LBL)IJP
BELLEFON 73 PURDUE CONF. 293    DE BELLEFON,BERTHON,BRUNET+    (CDEF+SACL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS

COOL     66 PRL 16 1228         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
   SUPEREDED 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
```


Σ(2455) BUMPS

```
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)
```

```
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  0 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 1D 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)
```


Σ(2620) BUMPS

```
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
```

```
54  Y*1(2620) WIDTH (MEV) (PROD. EXP.)

W        (175.0)                   ABRAMS    70 CNTR    K-P, D TOTAL       10/70
```

```
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  0 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)
```


Σ(3000) BUMPS

```
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

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-PIO	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-PIO	7/70
CS	A	ABOVE LIMIT FOR MASS < 2.3 GEV AND GAMMA < 120 MEV- (2.7 GEV/C K-)	7/70

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REFERENCES FOR EXOTIC HYPERONS

GALTIERI 68 PRL 21 573 A.BARBARO-GALTIERI,CHADWICK + (LRL+SLAC)

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Ξ Resonances

The Ξ resonance situation has long been and will probably long remain unsettled. This is because 1) they can only be produced as part of a final state, $K^- + p \to \Xi^* +$ others, and 2) they are so produced with very small cross sections (<50 μb). Thus the numbers of events available are small, and the analysis is more complicated than if direct formation were possible. Only the Ξ (1530) is really well established. There are at least two Ξ states in the 1800-2000 MeV region and there are indications of several more above 2000 MeV, but the situation is very unclear. We are forced to group together rather disparate observations and await new results. Figures in the listings point out disagreements among various experiments. The table following this note gives our evaluation of the status of the Ξ resonances, based on the meager data available at this time.

STATUS OF XI* RESONANCES
THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

			STATUS AS SEEN IN --				
PARTICLE	LIJ	OVERALL STATUS	XI PI	LAM K	SIG K	XI* PI	OTHER CHANNELS
XI(1320)	P11	****					WEAK TO LAM PI
XI(1530)	P13	****	****				
XI(1630)		**	**				
XI(1820)		***	***	***	**	***	
XI(1940)		***	***			***	
XI(2030)		**		**	**		3-BODY DECAYS
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.

****** ********* ********* ********* ********* ********* ********* ********
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S=-2 I=1/2 HYPERON STATES (Ξ)

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$\boxed{\Xi^-}$

22 XI- (1321, JP=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

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$\boxed{\Xi^0}$

23 XIO (1314, JP=1/2) I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

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****** ********* ********* ********* ********* ********* ********* ********

$\boxed{\Xi(1530)}$ $\boxed{P_{13}}$

49 XI*1/2(1530, JP=3/2+) I=1/2

THIS IS THE ONLY REALLY WELL-ESTABLISHED XI*. THE QUANTUM NUMBERS 3/2+ ARE FAVCRED 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		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-		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	XI KBAR PI (PI)	2/74*	
M-		. . . . .	. . .					
M-	AVG	1535.8	1.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
M-	FIT	1535.05	0.62	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)				
MO		76 1528.7	1.1	LONDON	66 HBC	0 K-P 2.24 GEV/C	7/66	
MO		59 1531.4	0.8	BADIER	72 HBC	0 K-P AT 3.95GEV/C	10/71	
MO		1262 1532.0	0.4	BALTAY	72 HBC	0 K-P 1.75 GEV	1/73	
MO		324 1531.3	0.6	BORENSTEI	72 HBC	0 K-P 2.2GEV/C	2/72	
MO		286 1532.3	0.7	KIRSCH	72 HBC	0 K-P 2.87GEV/C	2/72	
MO		1533.0	1.0	ROSS2	73	XI KBAR PI (PI)	2/74*	
MO		. . . . .	. . .					
MO	AVG	1531.72	0.39	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)				
MO	FIT	1531.64	0.35	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)				

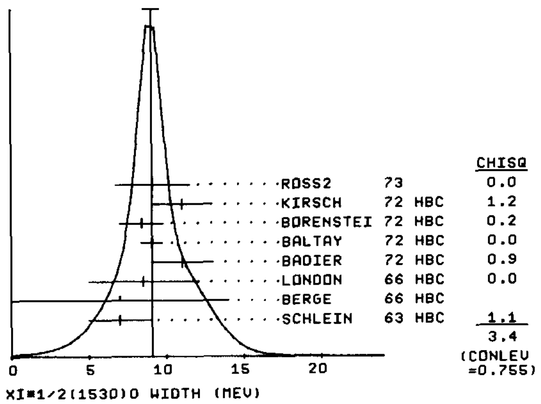
49 (XI*-) - (XI*0) MASS DIFFERENCE (MEV)

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 2.8 GEV/C	2/72
D		. . . . .	. . .				
D	AVG	2.92	0.91	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
D	FIT	3.41	0.61	FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)			

49 XI*1/2(1530) WIDTH (MEV)

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	XI KBAR PI (PI)	2/74*
WO		. . . . .	. . .				
WO	AVG	9.07	0.52	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) (SEE IDEOGRAM BELOW)			

WEIGHTED AVERAGE = 9.07 ± 0.52
ERROR SCALED BY 1.0



Ξ(2030)

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68  XI*1/2(2030, JP=    ) I=1/2

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                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     K-P 10GEV/C       9/69
M      15 2019.       7.                ROSS1     73         SIGMA KBAR        2/74*
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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                68  XI*1/2(2030) WIDTH (MEV)

W           45.0     40.0     20.0      ALITTI    69 HBC  -                    9/69
W           57.0     30.0               BARTSCH   69 HBC                       9/69
W      15   33.      17.                ROSS1     73         SIGMA KBAR        2/74*
W          . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                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 LAMBDA (OR SIGMA) KBAR PI          1115+ 497+ 139

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                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

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  -                    9/69

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  -                    9/69

R4      XI*1/2(2030) INTO (XI* PI)/(MODES P1 THRU P4)    (P4)/(P1+P2+P3+P4)
R4            (0.15) OR LESS          ALITTI    69 HBC  -  1 STD DEV LIMIT   9/69

R5      XI*1/2(2030) INTO LAMBDA (OR SIGMA) KBAR PI      (P5)
R5             SEEN                   BARTSCH   69 HBC                       9/69

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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)

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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.

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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)

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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          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 3.1)

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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          . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)

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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)

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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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Appendix I

TEST OF $\Delta I=1/2$ RULE FOR K DECAYS

The quantities of interest for making tests of theoretical predictions regarding the $\Delta I=1/2$ 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) or (+-0) refer to the sign of the pions into which the K_L decays.

$\Gamma_{K^+_{\ell 3}} = \Gamma_{K^+_{e3}} + \Gamma_{K^+_{\mu 3}}$	$= (6.484 \pm .092)\times 10^6\ \mathrm{sec}^{-1}$	
$\Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}}$	$= 0.663 \pm .018$	S=1.7
$\Gamma_{K^+_{\tau}} / \Gamma_{K^+_{\tau'}}$	$= 3.226 \pm .082$	
$\Gamma_{K^0_{\ell 3}} = \Gamma_{K^0_{e3}} + \Gamma_{K^0_{\mu 3}}$	$=$ *(12.85±.16)×10⁶* sec^{-1}	S=1.2
$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}}$	$= 0.705 \pm .019$	
$\Gamma_{K^0(000)} / \Gamma_{K^0(+-0)}$	$= 1.780 \pm .078$	S=1.2

1. Leptonic decay rates

The $\Gamma_{K_{\ell 3}}$ rates are useful in testing the leptonic $\Delta I = 1/2$ rule in the way suggested by Trilling.[1] The predictions are

$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 1.012$, a phase-space factor,[2] and

$$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}} = \Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}} .$$

From Table I,

$$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 0.991 \pm 0.019$$

and

$$\frac{\Gamma_{K^0_{\mu 3}}}{\Gamma_{K^0_{e3}}} \left[\frac{\Gamma_{K^+_{\mu 3}}}{\Gamma_{K^+_{e3}}}\right]^{-1} = 1.063 \pm .041.$$

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 listing 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 $\Delta I = 1/2$ 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 our 1973 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
$\phi_1(000) =$	1.489	1.489	1.444
$\phi_2(+-0) =$	1.221	1.294	1.279
$\phi_3(++-) =$	1.000	1.000	1.000
$\phi_4(+00) =$	1.247	1.183	1.147

For convenience, we repeat the slope parameters tabulated in the Stable Particle Table. They are as follows:

$g_{K_\tau^+}$ = -0.214 ± 0.005 S=1.7

$g_{K_\tau^-}$ = -0.214 ± 0.007 S=2.7

$\overline{g}_{K_\tau^\pm}$ = -0.214 ± 0.004

$g_{K_{\tau'}^+}$ = 0.522 ± 0.020 S=1.3

$g_{K^0\,(+-0)}$ = 0.610 ± 0.021 S=2.6

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 the two and use this value in Test 4.

We use the CNUDP factors and the rates and slopes reported here to compute the five test quantities which the $\Delta I=1/2$ rule predicts to be zero. The results are:

Test 1 = 0.051 ± 0.046
Test 2 = -0.075 ± 0.024
Test 3 = 0.251 ± 0.038
Test 4 = 0.047 ± 0.011
Test 5 = 0.135 ± 0.024

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

1. G. Trilling, K-Meson Decays, UCRL-16473, (updated from Argonne Conference Proceedings, 1965, p. 115).
2. N. Brene (CERN), private communication. In our Jan. 1968 edition we had erroneously used 1.04.
3. T. S. Mast, L. K. Gershwin, M. Alston-Garnjost, R. O. Bangerter, A. Barbaro-Galtieri, J. J. Murray, F. T. Solmitz, and R. D. Tripp, Phys. Rev. 183, 1200 (1969).
4. C. Zemach, Phys. Rev. 133, B1201 (1964).
5. C. Bouchiat and M. Veltman, Topical Conference on Weak Interactions, CERN 69-7 (1969), p. 225.

Appendix II

A. SU(3) CLASSIFICATION OF BARYON RESONANCES

There are a few multiplets that have been studied and we report here the results.

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 62 and OKUBO 62 independently. In addition, for the isospin-0 vector mesons (ω and ϕ) an additional symmetry-breaking interaction has been introduced (SAKURAI 62) 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	$\sin^2\theta = \dfrac{\Lambda - M_8}{\Lambda - \Lambda'}$	Mixing angle†	(3)
	$M_8 = \dfrac{2(N+\Xi) - \Sigma}{3}$	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 $1/M_R$ (see FEYNMAN 62).

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 factor M_R, cancelling the $1/M_R$. We are then left with

$$\Gamma = \frac{|T|^2 k}{M_R} M_N, \quad \text{for baryons} \qquad (5')$$

$$= \frac{|T|^2 k}{M_R^2} M_N^2, \quad \text{for mesons} \qquad (5'')$$

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

$$\left.\begin{array}{l}\text{Decuplet}\\ \text{Singlet}\end{array}\right\} \Gamma = (cg)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (6)$$

$$\text{Octet} \qquad \Gamma = (c_D g_D + c_F g_F)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (7)$$

$$\begin{array}{l}\text{Octet-}\\ \text{Singlet}\\ \text{mixing}\end{array} \left\{ \begin{array}{l} \Lambda = G_8 \cos\theta + G_1 \sin\theta \\ \Lambda' = -G_8 \sin\theta + G_1 \cos\theta \end{array}\right. \qquad (8)$$

$$\text{with} \qquad \begin{array}{l} G_8 = c_D g_D + c_F g_F \\ G_1 = c_1 g_1 . \end{array} \qquad (9)$$

Here c_i are the SU(3) coefficients with the sign convention adopted in this article [see note preceding the table of SU(3) isoscalar 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, 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 64 and by GUPTA 64 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 69 convention, see Fig. 2 in the text) and the sign 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, among others, in TRIPP 68 and 69, LEVI SETTI 69, SAMIOS 70 and PLANE 70. The most recent fits were made by BARBARO-GALTIERI 72 and SAMIOS 73.

In fitting the data a choice for B_ℓ has to be made. PLANE 70 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-WEISSKOPF 52. Usually r is taken to be 1 fermi (TRIPP 68).

(b) The form $B_\ell = k^{2\ell}$.

However, for their final results they used form (b). A discussion of the differences among these two forms can be found in BARBARO-GALTIERI 71. 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 isospin-0 member of the octet, $\Lambda(1690)$, the mixing angles obtained in the two cases are

$$\theta_a = (-16.1\,^{+1.4}_{-1.3})^\circ, \quad \theta_b = (-27.5\,^{+3.6}_{-3.4})^\circ,$$

in disagreement by a few standard deviations. It turns out that 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 73 used form (b) for B_ℓ.

Table I is a summary of the fits made by BARBARO-GALTIERI 72 using the barrier factor form (a) and exact SU(3). A few comments follow.

$\frac{1}{2}^-$ - Nonet (Baryon - Eta Resonances)

For this nonet Eq. (7) was multiplied by the factor

$$\left[\frac{M_R - M_B}{\bar{M}_R - \bar{M}_B}\right]^2 ,$$

where M_B is the decay baryon and $\bar{M}_R - \bar{M}_B$ = 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 axial vector current remains an octet in presence of symmetry breaking) and it was advocated by Graham et al. (GRAHAM 67). For the $1/2^-$ nonet it has been used in this form first by Gell-Mann et al. (GELL-MANN 68).

$\frac{3}{2}^+$ 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 χ^2=50 for 3 Degrees of Freedom; the one made with form (a) for B_ℓ has χ^2=24/3DF. The broken SU(3) relation (11), however, is very well satisfied.

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† 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.

Footnotes and References

†The formula has been calculated from analogy with the formula for mixing of meson states, first put in this form by S. L. Glashow and R. H. Socolow, Phys. Rev. Letters 15, 329 (1966). For the baryon formula see A. Barbaro-Galtieri, Phenomenology of Resonances and Particle Supermultiplets. UCRL-17054 (1966).

‡This is an updated version of the fits by Flaminio et al., BNL report 14572.

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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 results of fits made to all the measured two-body decay rates of each multiplet by BARBARO-GALTIERI 72 (BG72) and SAMIOS 73 (SGM73).

J^P	Octet members[a]				Singlet	BG72 θ(deg)[b]	BG72 α	SGM73 θ(deg)[b]	SGM73 α
$1/2^-$	N(1535)	Λ(1670)	Σ(1750)	[Ξ(1825)]	Λ(1405)	8±3	1.2 ±.1	d	d
$3/2^-$	N(1520)	Λ(1690)	Σ(1670)	[Ξ(1815)]	Λ(1520)	-23±4	.34±.09	-26±3	.28±.15
$5/2^-$	N(1670)	Λ(1830)	Σ(1765)				1.13±.05		1.16±.01
$5/2^+$	N(1688)	Λ(1815)	Σ(1915)				.62±.04		.46±.005
	Decuplet members[c]				g_{10}				
$3/2^+$	Δ(1232)	Σ(1385)	Ξ(1530)	Ω^-	1.78 - 2.29		χ^2= 50/3DF		
$7/2^+$	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]Coupling constants from BARBARO-GALTIERI 72.

[d]For the $J^P = 1/2^-$ octet the values of SAMIOS 73 are not quoted here, because for Λ(1405) the coupling to $\bar{K}N$ was not included in the fit and the state was assumed to couple only to $\Sigma\pi$.

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Appendix III
TEST OF $\Delta I=1/2$ RULE FOR HYPERON DECAYS

O. E. Overseth
University of Michigan

1. Nonleptonic Decay Amplitudes

In this edition we again use the new convention for the amplitudes A and B adopted last year. Some theorists have suggested that dimensionless amplitudes are more useful to them than the ones appearing in the literature. Berge (1966) used a convention with A and B in units of $\sec^{-1/2}$. Samios (1965) used a convention which gave A and B in units of $(\text{MeV-sec})^{-1/2}$. Following is the convention suggested by Jackson (1973), which gives dimensionless A and B.

The effective Lagrangian density for nonleptonic hyperon decays ($B_1 \to B_2 + \pi$) can be written

$$\mathcal{L}_{\text{eff}} = G\mu_c^2[\bar{\psi}_2(A+B\gamma_5)\psi_1]\phi_\pi,$$

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, $\gamma_5 = \begin{pmatrix} 0 & -I \\ -I & 0 \end{pmatrix}$. The invariant amplitude for the decay is

$$\mathcal{M} = G\mu_c^2[\bar{u}(p)(A+B\gamma_5)u(P)],$$

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

$$\mathcal{M} = G\mu_c^2\langle\chi_2|\sqrt{2M(E+m)}\,A + \sqrt{2M(E-m)}\,B\vec{\sigma}\cdot\hat{q}\,|\chi_1\rangle,$$

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 shows that the amplitudes s and p defined there are proportional to A and B:

$$\frac{p}{s} = \left(\frac{E-m}{E+m}\right)^{\frac{1}{2}}\frac{B}{A} = \sqrt{\frac{(M-m)^2-\mu^2}{(M+m)^2-\mu^2}}\;\frac{B}{A}.$$

Here μ is the mass of the pion entering the decay. The parameters α, β, 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 bee 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}
$\Lambda^0_- \to p + \pi^-$	1.48 ± 0.01	10.17 ± 0.24	-0.272
$\Lambda^0_0 \to n + \pi^0$	-1.08 ± 0.02	-7.28 ± 0.58	-0.744
$\Sigma^+_+ \to n + \pi^+$	0.06 ± 0.02	19.05 ± 0.16	0.003
$\Sigma^+_0 \to p + \pi^0$	1.48 ± 0.05	-12.04 ± 0.59	0.919
$\Sigma^-_- \to n + \pi^-$	1.93 ± 0.01	-0.65 ± 0.08	-0.024
$\Xi^0_0 \to \Lambda + \pi^0$	1.53 ± 0.03	-5.90 ± 1.11	0.347
$\Xi^-_- \to \Lambda + \pi^-$	2.04 ± 0.02	-6.73 ± 0.41	0.237

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 [Overseth and Pakvasa (1969)] for the ΔI = 3/2 A- and B-wave amplitudes in terms of Δα, where Δα is the measured value of α_0/α_- minus the predicted value, and in terms of ΔΓ similarly defined. Evaluating these we find

$$\Delta\alpha = -1.53\,(A_3/A_1) + 1.60\,(B_3/B_1),$$
$$\Delta\Gamma = 1.83\,(A_3/A_1) + 0.26\,(B_3/B_1).$$

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 Δα and ΔΓ. Final-state π-N 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 [Belavin and Narodetsky (1968), and Intemann (1973)], 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 [Overseth and Pakvasa (1969)]

$$\Delta\alpha = 1.38\,(A_3/A_1) - 1.38\,(B_3/B_1),$$
$$\Delta\Gamma = -1.44\,(A_3/A_1) - 0.06(B_3/B_1).$$

From the Stable Particle Table,

$$\Delta\alpha = 0.12\pm0.21,\qquad \Delta\Gamma = 0.058\pm0.024,$$

and we find

$$(A_3/A_1) = -0.035\pm0.017$$

and

$$(B_3/B_1) = -0.12\pm0.15.$$

(c) Σ Decay

The traditional test of the $\Delta I = 1/2$ 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 $\Delta I \geq 3/2$ amplitudes in Σ decay analysis, the "Σ triangle" relationship becomes

$$\sqrt{2}\,A_0 + A_+ - A_- = -3\sqrt{\frac{2}{5}}\,A_3 + \frac{2}{\sqrt{15}}\,A_5,$$

where A_3, A_5 are $\Delta I = 3/2$, $5/2$ amplitudes, respectively. There is a similar equation for the B amplitudes. From Table I,

$$\sqrt{2}\,A_0 + A_+ - A_- = 0.22 \pm 0.09$$
$$\text{and } \sqrt{2}\,B_0 + B_+ - B_- = 2.7 \pm 1.1$$

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

$$\frac{A_3}{A_-} = -0.060 \pm 0.026$$

and

$$\frac{B_3}{B_+} = -0.074 \pm 0.030.$$

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 [Lee (1964) and Sugawara (1964)] relation $\sqrt{3}\,\Sigma_0^+ + \Lambda_-^0 - 2\,\Xi_-^- = 0$ is satisfied to -0.04 ± 0.12 for the A amplitudes, and to 2.8 ± 2.1 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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