# REVIEW OF PARTICLE PROPERTIES

## Particle Data Group

PAUL SÖDING and JOCHEN BARTELS
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ANGELA BARBARO-GALTIERI, JAMES E. ENSTROM, THOMAS A. LASINSKI, ALAN RITTENBERG, ARTHUR H. ROSENFELD, and THOMAS G. TRIPPE
*Lawrence Berkeley Laboratory, * University of California, Berkeley, California 94720, USA*

NAOMI BARASH-SCHMIDT
*Brandeis University, Waltham, Massachusetts 02154, USA*

CLAUDE BRICMAN and VLADIMIR CHALOUPKA
*CERN, 1211 Geneva 23, Switzerland*

MATTS ROOS
*Institute 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. 43, No. 2, Supplement, S1 (1971)]. Data are evaluated, listed, averaged, and summarized in tables. A data booklet is also available.

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## I. INTRODUCTION, CREDITS, CONSULTANTS

This review is an updating through January 1972 of our previous review (Particle Data Group, 1971). 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. Only then is it appropriate to state "average value obtained from *Review of Particle Properties,* Particle Data Group, Phys. Lett. 39B (1972) 1." If the list of experiments is so long that this is impractical, we suggest the form: Jones et al. 70, Smith et al. 69, ... average value and complete references in *Review of* ... .

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

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

2) *Meson resonances:* J. Bartels, V. Chaloupka, M. Roos, A.H. Rosenfeld, P. Söding.

3) *Baryon resonances:* A. Barbaro-Galtieri, C. Bricman, T. Lasinski.

*General:* All Berkeley authors.

*Consultants:* The three teams just mentioned must come to a consensus on how to treat the data and must write a number of mini-reviews. It is impractical to spread this responsibility over more than a few people in each team and still expect to meet publication deadlines. Hence we limit our number of authors (to twelve in this edition) but thereby leave gaps in our coverage, both intellectual and geographical. To help us overcome this deficiency, we have solicited the help of consultants:

- Chih-Yung Chien (Johns Hopkins University)
- Oliver E. Overseth (University of Michigan)
- LeRoy R. Price (Univ. of Calif. at Irvine)
- 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. COLLECTION AND TREATMENT OF DATA

### A. *Annual growth of data*

Fig. 1 shows the rate at which we have been recording results, as a function of year published. Through 1969 we subdivided our annual count into two parts:

1) Highest quality data. These are the results that we accept for averaging and fitting.

2) Lesser quality data; results which, for one of the reasons mentioned in para. B, below, we encoded but did not accept for averaging.

We have found that this subdivision stays at a fairly constant 60:40 ratio, and is not otherwise very informative, so we now merely count the total.

We see that the number of results per year from bubble chambers, though still dominant, is now dropping; that from counters is roughly constant.

It is of interest to compare the declining rate at which bubble chambers produce results on particle properties with the fact that the number of bubble chamber events measured each year is roughly constant.

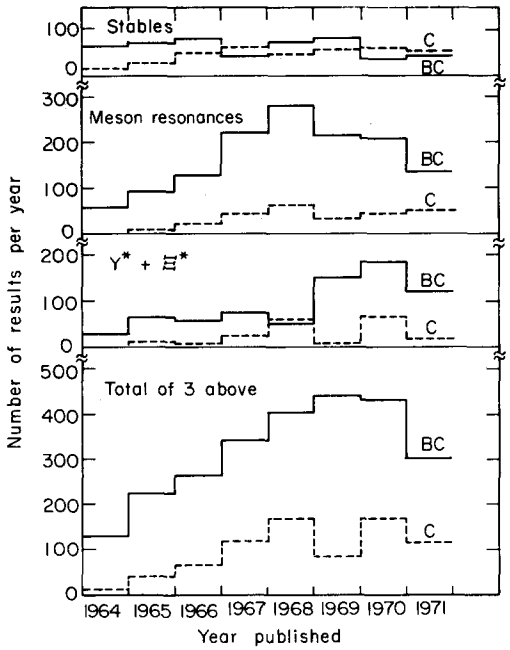


Fig. 1. Statistics on the rate of production of data on particle properties. From the top to the bottom, the number of results per year are presented for stable particles, meson resonances, Y*+ Ξ*'s, and the total of the three above. The full lines correspond to bubble-chamber techniques (BC) and interrupted lines correspond to counters, spark chambers and spectrometers (C). Note that the figure omits N* and Z*, the field where counters have overwhelmed bubble chambers, because we punch mainly results from partial wave analyses instead of primary data.

Apparently experiments have become larger and more specialized, and we now find ourselves encoding more density matrix elements for our compilations of cross sections and fewer masses and widths of bumps.

It is further of interest to compare the decreasing total rate at which we encode data on particle properties with the fact that the rate of publication of experimental papers is still growing at about 5 percent per year. Some differences are that many new experiments are above the resonance region, there are many photon and electron experiments, and many studies of inclusive reactions. Again, compilers are flooded with new data, but the great majority go into collections of cross sections.

B. *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

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, 1972) for all journals listed in the Illustrative Key. We also include preprints and conference reports which have come to our attention, but make no attempt at completeness.

Roughly 40% of our encoded results have not been accepted 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 we have corresponded with 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.
- Two experiments give contradictory results, so that it is senseless to average the data.

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 judgment. The extent to which "blind" averaging has been tempered with judgment is explained in footnotes to the Tables. In general, however, the footnotes are less complete than is the collection of notes and mini-reviews in the Data Card Listings. The reader is therefore encouraged to familiarize himself with the Data Card Listings and, ultimately, with the original experiments.

## III. CRITERIA FOR RESONANCES

An experimentalist who finds some evidence for a peak in a mass spectrum 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 any substantial claim or evidence for a new state.

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 $\gtrsim 90\%$ chance of survival. One's betting odds for survival are of course completely subjective; they are influenced mainly by the amount of information available (such as partial-wave analyses) and somewhat by the degree of controversy over interpretation and how long it will be before more information is available. 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.

More details on our acceptance criteria are as follows.

1) Consider, first, peaks where there is *no* partial-wave information:

1a) Most mesons and $\Xi^*$ peaks, plus N* and Y* peaks above 2500 MeV. Unless the peak is experimentally shaky, we put it in the table.

1b) Peaks like $A_1$, $A_3$, Q or L which are not far above the $\rho\pi$, $f\pi$, $K^*\pi$ or $K_N(1420)\pi$ threshold. Although the threshold behaviour in these channels may be described by the "Deck effect" or by its modern version "double Regge-pole exchange", the question of resonance interpretation is still open. We put these peaks into the Meson Table, but warn the reader not to conclude that we claim they are necessarily genuine resonances.

2) Consider, next, peaks for which there *are* partial-wave analyses. We can then check that the Argand plot follows roughly a left-hand circle, and that the "speed" of the amplitude also shows a maximum near the resonance energy; further, there should be data well above the resonance, showing that the speed again decreases. Indeed proper behavior of the partial-wave amplitude could accredit a resonance even if its elasticity is too small to make a noticeable peak in the cross section.

Of course, even if Argand plots are available, it may still be a matter of opinion as to what behavior constitutes a resonance. Such an example is the $K^+p$ peak (near $K\Delta$ threshold) called $Z_1(1900)$, which is discussed in a mini-review in the Baryon Data Card Listings. $K^+p$ $P_{13}$ Argand plots are displayed there, and most suggest a resonance; however, there is disagreement between the various analyses as to the speed of the amplitude, i.e., as to whether it has a Breit-Wigner type of behavior. In addition the errors on the amplitudes are still large, and we prefer to wait a bit longer before we put $Z_1$ in the Baryon Table.

Approximate Breit-Wigner behavior of a partial-wave amplitude appears to us to be the most satisfactory test for a resonance, since after all a Breit-Wigner amplitude is the Fourier transform of an exponential decay of a state with a finite lifetime. We are aware that this approximate Breit-Wigner behavior could be accidental, but can only hope that such an accident is improbable.

We now ask "How likely is it that peaks of class 1 above (not checked by partial-wave analysis) will eventually be confirmed as resonances?" We know of no experimentally convincing peak that has been shown to have *nothing* to do with a resonance. But be warned that broad peaks may be misleading: they 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 $\pi p$ 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 A1, Q, A3, and L) was partly explained by the Deck effect and later by double-Regge-pole exchange.

In summary, we enter into the Tables of Particle Properties experimentally convincing peaks unless there is contradictory information; and we expect that most of these peaks will eventually be confirmed as one or more resonances.

## IV. PARAMETERS AND CONVENTIONS

### 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.

*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 $\pi^0$, $C$ 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

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

Equations (3) and (5) combine to give

$$C_n P = -(-1)^S \tag{5.1}$$

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

* 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).

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 $\bar{q}q$.

The unitary triplets 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 quark model. But it is slightly less obvious that even some *octets* are forbidden by the model, for example those with $(J^P)C_n = (1^-)$-, $(2^+)$-, ... . Such states are also not observed, and this is an additional piece of evidence for the quark model.

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

The top part of table 1 shows all the low angular momentum states that can be formed from $\bar{q}q$. Note that half of the $J^P$ states can be formed by both a triplet and a singlet $\bar{q}q$ state, e.g. $^3P_1$, $^1P_1$ or $^3D_2$, $^1D_2$. Eq. (3) shows that $^3P_1$ and $^1P_1$ have opposite $C_n$, so the $\bar{q}q$ model allows both. But the states $^3P_0$ and $^3P_2$ have no $^1P$ counterparts. According to eq. (5.1) they have $C_nP = +1$, and with the $\bar{q}q$ model there is no way to form a state with a $J^P$ of $^3P_{0,2}$ (i.e. $J^P$ = Normal) and with $C_nP = -1$. As mentioned, such octets have not shown up. With the help of table 1 one can also see that the special state $^1S_0$, $C_nP = +1$, cannot be formed, so has Abnormal $C$.

*Baryons and mesons*

Well-established quantum numbers are underlined (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 "?" the ones for which there is almost no evidence.

Table I. $I^G(J^P)$ of mesons from $\bar{q}q$ model. For the distinction between abnormal $J^P$ and abnormal C, see text below Eq. (5). 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 $(J^P)\boxed{\text{N or A}}$ CP, is a redundant intermediate step intended to make the table easier to read.

| Parity | $\bar{q}q$ State CP − | $\bar{q}q$ State CP + | $(J^P)\boxed{\text{N or A}}$ CP (Normal or abnormal) | $I^G(J^P)C_n$ | Examples and comments |
|---|---|---|---|---|---|
| Parity − | $^1S_0$ | | $(0^-)_A{}^-$ | $0^+(0^-)+$<br>$1^-(0^-)+$ | $\eta, \eta'$<br>$\pi$ |
| | | $^3S_1$ | $(1^-)_N{}^+$ | $0^-(1^-)-$<br>$1^+(1^-)-$ | $\omega, \phi$<br>$\rho$ |
| Parity + | $^1P_1$ | | $(1^+)_A{}^-$ | $0^-(1^+)-$<br>$1^+(1^+)-$ | <br>B |
| | | $^3P_0$ | $(0^+)_N{}^+$ | $0^+(0^+)+$<br>$1^-(0^+)+$ | $\epsilon$, S*<br>$\pi_N(1016)$ |
| | | $^3P_1$ | $(1^+)_A{}^+$ | $0^+(1^+)+$<br>$1^-(1^+)+$ | <br>A1 |
| | | $^3P_2$ | $(2^+)_N{}^+$ | $0^+(2^+)+$<br>$1^-(2^+)+$ | f, f'<br>A2 |
| Parity − | $^1D_2$ | | $(2^-)_A{}^-$ | $0^+(2^-)+$<br>$1^-(2^-)+$ | Regge recurrence of $^1S_0$, $0^-$ |
| | | $^3D_1$ | $(1^-)_N{}^+$ | same as $^3S_1$ | |
| | | $^3D_2$ | $(2^-)_A{}^+$ | $0^-(2^-)-$<br>$1^+(2^-)-$ | Regge recurrence of top abnormal-C state below: $(J^P)C_n = (0^-)-$ |
| | | $^3D_3$ | $(3^-)_N{}^+$ | $J > 2$ | |
| 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 | $(0^-)_A{}^+$ | $0^-(0^-)-$<br>$1^+(0^-)-$ | All except $J^P = 0^-$ are $J^P$ = normal, CP = −1 |
| | $(1^-)_N{}^-$ | $0^+(1^-)+$<br>$1^-(1^-)+$ | |
| | $(0^+)_N{}^-$ | $0^-(0^+)-$<br>$1^+(0^+)-$ | |
| | $(2^+)_N{}^-$ | $0^-(2^+)-$<br>$1^+(2^+)-$ | |
| | $(3^-)_N{}^-$ | $0^+(3^-)+$<br>$1^-(3^-)+$ | |

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 part of table 2.

Table 2
Particle name conventions

| | Name | $I$ | $Y$ | $S$ | $G$ |
|---|---|---|---|---|---|
| ↑ | $\eta$ | 0 | 0 | 0 | + |
| | $\phi$ | 0 | 0 | 0 | − |
| Mesons | $\rho$ | 1 | 0 | 0 | + |
| | $\pi$ | 1 | 0 | 0 | − |
| | $K^+, K^0$ | ½ | +1 | +1 | |
| ↓ | $K^-, \bar{K}^0$ | ½ | −1 | −1 | |
| ↑ | N | ½ | +1 | 0 | |
| | $\Delta$ | 3/2 | +1 | 0 | |
| | $Z_0, Z_1$ | 0, 1 | +2 | +1 | |
| Baryons | $\Lambda$ | 0 | 0 | −1 | |
| | $\Sigma$ | 1 | 0 | −1 | |
| | $\Xi$ | ½ | −1 | −2 | |
| ↓ | $\Omega$ | 0 | −2 | −3 | |

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. Thus $K_N(1420)$. 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 *baryons* ($B = 1$) no attempt has been made to attach a subscript about $J$ and $P$. The name conventions for baryons are given in the second part of table 2. 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), $\Lambda$(1405), $\Sigma$(1765), etc.]. The $J^P$ assignments are reported in the Baryon Table as $\frac{1}{2}^+, \frac{3}{2}^-, \frac{5}{2}^+$, etc., and also by the symbols $P_{11}$, $D_{13}$, $F_{15}$, which refer to the $\pi$p 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 $\Delta$ and just $I$ for Z, $\Lambda$ and $\Sigma$).

When two *baryons* have identical quantum numbers we warn the reader by adding a *prime* to the symbol for the heavier one, e.g., p, N′(1470, $\frac{1}{2}^+$). In the case of baryon resonances described by Argand diagrams which exhibit more than one resonance, we use one prime for the first, two for the second, ...; thus the series of which the proton is the stable member becomes: p, N′(1470, $\frac{1}{2}^+$), N″(1780, $\frac{1}{2}^+$).

If there is only one resonance on an Argand plot, and thus no need for distinctions, we use no primes.

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

C. *Masses and widths*

An unstable particle of mass $M$, decaying with a mean life $\tau$, has a wave function

$$\psi(t) \propto \exp\{-i\omega t - t/2\tau\} = \exp\{-\frac{i}{\hbar}(M - i\tfrac{1}{2}\Gamma)\,t\}$$

where $\Gamma = \hbar/\tau$. Its Fourier transform is

$$\psi(m) \propto 1/(M - m - \tfrac{1}{2}\,i\Gamma)$$

which we call a non-relativistic Breit-Wigner resonance.

For the metastable particles in the Stable Particle Table, we tabulate $\tau$, but for resonances which decay by the strong interaction, we tabulate $\Gamma$, which is the full width at half maximum of $|\psi(m)|^2$.

In practice, values of $M$ and $\Gamma$ are extracted from data via *models*, and we cannot average these values if the models are dissimilar. In the next few paragraphs we discuss this point in slightly more detail, using the example of an $s$-channel resonance.

An *elastic* nonrelativistic Breit-Wigner $T$-matrix element is usually written

$$T_{11} = \tfrac{1}{2}\Gamma/(M - m - \tfrac{1}{2}\,i\Gamma)\,. \qquad (6)$$

Here $\Gamma(m)$ is the width for decay into the channel 1, with angular momentum $l$. It contains barrier-penetration factors which can vary rapidly with energy; near threshold, $\Gamma(m)$ should start up as $q^{2l+1}$, and then

level off. Various $m$-dependences are used, mostly variants of the general form

$$\Gamma(m) \propto [q^2/\{1+(qR)^2\}]^l\, q. \tag{7}$$

For a choice of forms, see Jackson (1967), Pišut and Roos (1968), and Barbaro-Galtieri (1968). Of course the detailed shape of the amplitude and also the value of $\Gamma$ will depend slightly on the form chosen.

The width is also related to the behavior of $T$ at resonance. It is easy to show (Herndon et al., 1970) that, ignoring terms in $\mathrm{d}\Gamma/\mathrm{d}m$,

$$\text{"Speed"(res)} = |\mathrm{d}T/\mathrm{d}m|_{m=M} = x_e/(\tfrac{1}{2}\Gamma(M)) \tag{8}$$

where the elasticity, $x_e = \Gamma_e/\Gamma$, is introduced next. More detailed properties of "Speed" are discussed in the baryon mini-review at the front of the Baryon Data Card Listings of our April 1971 edition (Particle Data Group, 1971).

For an *inelastic* resonance feeding into channel $\beta$,

$$T_{1\beta} = \frac{\frac{1}{2}\sqrt{\Gamma_1\Gamma_\beta}}{M-m-\frac{1}{2}\mathrm{i}\Gamma} = \sqrt{x_1 x_\beta}\,\frac{\frac{1}{2}\Gamma}{M-m-\frac{1}{2}\mathrm{i}\Gamma} \tag{9}$$

where

$$\Gamma = \sum_1^N \Gamma_\beta\,, \qquad x_\beta = \Gamma_\beta/\Gamma\,, \tag{10}$$

and $x_1$ (called the elasticity) is often written $x_e$.

The channel cross section $\sigma_{1\beta}$ for the reaction $1\to\beta$ is

$$\sigma_{1\beta} = 4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})|T_{1\beta}|^2. \tag{11}$$

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

Resonances seen in production are even more complicated. $\sqrt{\Gamma_1}$ disappears from $T$, and must be replaced with some model-dependent parametrization of the production process.

In conclusion, we have seen that because of the energy dependence of $\Gamma$ even the amplitude $T$ for a resonance does not have a full-width at half-maximum equal to $\Gamma$ (but it does peak at or near $M$). Then kinematic factors enter into the cross section for formation [eq. (11)] or production, and displace the observed peak away from $M$. For quantitative examples, see Barbaro-Galtieri (1968).

Most of the useful information on the N, $\Delta$, $\Lambda$, and $\Sigma$ *baryon resonances* with $M < 2000$ *MeV* has come from partial-wave analysis. Masses and widths of most of these states are dependent on the model, as well as on the data used by the different groups that performed these analyses; therefore, the masses in the Baryon Table are not averages, but plausible guesses, and the errors are "external errors" based on the consistency among different analyses. For the procedures adopted, different from resonance to resonance, see the appropriate mini-review in the Data Card Listings. *Resonances* with mass $M > 2000$ *MeV* have been detected primarily in total-cross-section experiments.

We can use eq. (11) to relate the height of the peak at resonance $\sigma_{\mathrm{res}}$ to the elasticity $x_e$. At resonance the *channel* cross section is

$$\sigma_{\mathrm{res}}(1\to\beta) = 4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})\,x_e x_\beta \tag{12}$$

and the *total* cross section is

$$\sigma_{\mathrm{res}}(\text{total}) = 4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})\,x_e\,. \tag{13}$$

If $J$ is known, we can solve for $x_e$. If $J$ is not known, the product $(J+\frac{1}{2})x_e$ is given in the Baryon Table.

D. *SU(3) sign conventions for $\Lambda$ and $\Sigma$ resonances*

Consider the partial width $\Gamma_\beta$ of a resonance decaying into the channel $\beta$. We can always define a coupling constant such that

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

In this case the inelastic (eq. (9)) amplitude for such a resonance will go as

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

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) assignments of $\Lambda$ and $\Sigma$ resonances. See appendix II for further details.

In the Data Card Listings for $\Lambda$ and $\Sigma$ resonances, we tabulate measured values for $(x_1 x_\beta)^{\frac{1}{2}} \propto G_1 G_\beta$. 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. This convention is shown in fig. 2 from Levi Setti (1969).

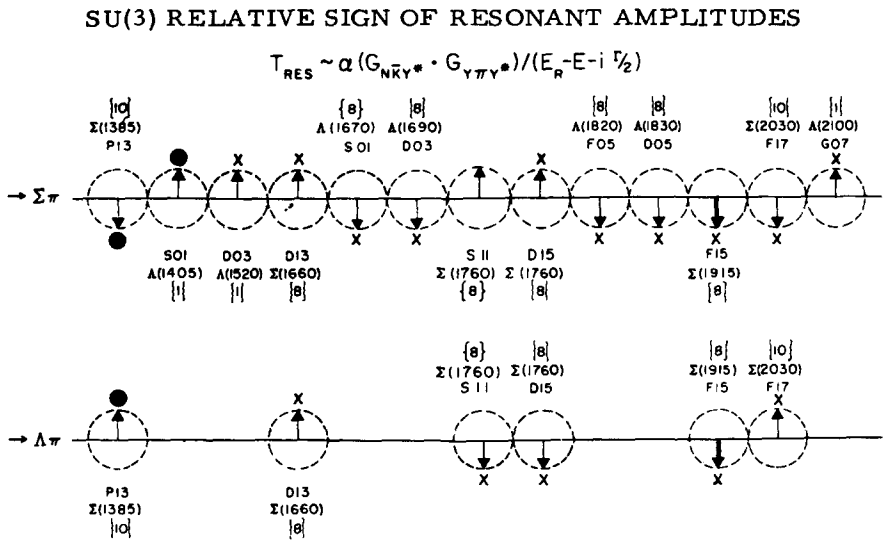


Fig. 2. Plot adapted from Levi Setti (1969) showing the sign convention adopted here for the $\Sigma\pi$ and $\Lambda\pi$ amplitudes. Once the signs of one $I = 0$ and one $I = 1$ amplitude are fixed, the others can be measured relative to these two. Arrows here indicate signs predicted by SU(3); X marks 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.

E. *Muon-decay parameters*

The $\mu$-decay parameters describe the momentum spectrum ($\rho$ and $\eta$), the asymmetry ($\xi$ and $\delta$), 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

$$\sum_i \langle \bar{e} | \Gamma_i | \mu \rangle \langle \bar{\nu} | \Gamma_i (C_i + C_i' \gamma_5) | \nu \rangle , \tag{14}$$

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:

$$\rho = [3g_A^2 + 3g_V^2 + 6g_T^2]/D , \tag{15}$$

$$\eta = [g_S^2 - g_P^2 + 2g_A^2 - 2g_V^2]/D , \tag{16}$$

for the asymmetry parameters:

$$\xi = [+6g_S g_P \cos\phi_{SP} - 8g_A g_V \cos\phi_{AV} + 14g_T^2 \cos\phi_{TT}]/D , \tag{17}$$

$$\delta = [-6g_A g_V \cos\phi_{AV} + 6g_T^2 \cos\phi_{TT}]/D\xi , \tag{18}$$

and for the parameter describing the helicity of the electron:

$$h = \pm [2g_S g_P \cos\phi_{SP} - 8g_A g_V \cos\phi_{AV} - 6g_T^2 \cos\phi_{TT}]/D . \tag{19}$$

Here

$$D = g_S^2 + g_P^2 + 4g_V^2 + 6g_T^2 + 4g_A^2 \tag{20}$$

$$g_i^2 = |C_i|^2 + |C_i'|^2 , \tag{21}$$

and

$$\cos\phi_{ij} = \mathrm{Re}(C_i^* C_j' + C_i' C_j^*) . \tag{22}$$

The quantities $g_i$ are defined to be real non-negative numbers, and the $\phi_{ij}$ 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 $\phi_{AV}$ is the phase angle between $C_A$ and $C_V$ in the complex plane.

By using the above equations and the experimental determinations of $\rho$, $\eta$, $\xi$, $\delta$, and $h$, limits can be placed on $g_S/g_V$, $g_A/g_V$, $g_T/g_V$, $g_P/g_V$, and $\phi_{AV}$. 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 $\rho$ and $\eta$ are highly correlated, so they can only report $\rho$ for $\eta \equiv 0$ and $\eta$ for $\rho \equiv \frac{3}{4}$. The values for $\rho$ and $\eta$ 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 $\phi_{AV}$ 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 $\phi_{AV}$ 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 $\mu$ section of the Stable Particle Data Card Listings.

## F. *K-decay parameters*

### F.1. *Dalitz plot for $K \to 3\pi$ decays*

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

$$|M|^2 \propto 1 + g\frac{(s_3 - s_0)}{m_{\pi^+}^2} + h\left(\frac{s_3 - s_0}{m_{\pi^+}^2}\right)^2 + j\frac{(s_2 - s_1)}{m_{\pi^+}^2} + \ldots \tag{23}$$

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

$$s_i = (P_K - P_i)^2 = (m_K - m_i)^2 - 2m_K T_i \qquad i = 1, 2, 3 \tag{24}$$

$$s_0 = \tfrac{1}{3}\sum_i s_i = \tfrac{1}{3}(m_K^2 + m_1^2 + m_2^2 + m_3^2)\,. \tag{25}$$

Here the $P_i$ are 4-vectors, $m_i$ and $T_i$ are mass and kinetic energy of the $i$-th 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 $\tau^+$ and $\tau^-$, 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 F.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 $K_L^0$ sections of the Stable Particle Data Card Listings.

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

### F.2. *Form factors in $K_{l3}$ leptonic decays*

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

$$M \propto f_+(q^2)[(P_K + P_\pi)_\mu\, \bar{u}_l\gamma_\mu(1+\gamma_5)u_\nu] + f_-(q^2)[m_l\bar{u}_l(1+\gamma_5)u_\nu]\,, \tag{26}$$

where $P_K$ and $P_\pi$ are the four momenta of K and $\pi$ 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

$$f_\pm(q^2) = f_\pm(0)[1 + \lambda_\pm(q/m_\pi)^2]\,; \tag{27}$$

and $\xi$, the ratio of the two form factors,

$$\xi = f_-/f_+\,. \tag{28}$$

The quantity $\xi$ can be determined in different ways:

1) By measuring the $K_{\mu3}/K_{e3}$ branching ratio and comparing it with the theoretical ratio as given in terms of $\xi(0) = f_-(0)/f_+(0)$.

$$\Gamma(K^{\pm}_{\mu 3})/\Gamma(K^{\pm}_{e3}) = 0.6457 + 0.1264\,\mathrm{Re}\,\xi + 0.0192\,|\xi|^2 + 1.4115\lambda_+ + 0.4754\,\lambda_-\,\mathrm{Re}\,\xi + 0.0080\lambda_+\,\mathrm{Re}\,\xi\,, \tag{29}$$

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

See Cabibbo (1966) and Fearing et al. (1970) (for the charge-dependent formulae). 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 $\lambda_+$ parameter, whereas the $K_{\mu 3}$ distribution is dependent upon $\lambda_-$, $\lambda_+$, $\xi$. Often experimenters have measured only the momentum spectrum of either the $\pi$ 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 $\xi$ 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 $\mu$ is expected to be polarized in the direction $\boldsymbol{A}$ with $\boldsymbol{P} = \boldsymbol{A}/|\boldsymbol{A}|$, where $\boldsymbol{A}$ is given (Cabibbo and Maksymowicz, 1964) by

$$\boldsymbol{A} = \alpha_1(\xi)\,\boldsymbol{p}_\mu - \alpha_2(\xi)\left\{\frac{\boldsymbol{p}_\mu}{m_\mu}\left[m_K - E_\pi + \frac{\boldsymbol{p}_\pi\cdot\boldsymbol{p}_\mu}{|\boldsymbol{p}_\mu|^2}(E_\mu - m_\mu)\right] + \boldsymbol{p}_\pi\right\} + m_K\,\mathrm{Im}\,\xi(q^2)\,(\boldsymbol{p}_\pi \times \boldsymbol{p}_\mu)\,. \tag{30}$$

If time-reversal invariance holds, $\xi$ 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. (26), would contain

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

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 $\xi$, $\lambda_\pm$, and the upper limits on $|f_S/f_+|$ and $|f_T/f_+|$ are given in the $K^{\pm}$ and $K^0_L$ 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.

F.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

$$A_S(K_S \to \pi^+\pi^-\pi^0)/A_L(K_L \to \pi^+\pi^-\pi^0) \equiv x + iy \tag{31}$$

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 non-zero $y$. We give the result for (31) in the $K^0_L$ section of the Stable Particle Table and under Branching Ratio R4 in the $K^0_S$ 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 (23) describing the Dalitz plot distribution for $\tau^{\pm}$, $\tau^0$ 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. (23), we choose to list $\sigma_\pm$ from the equivalent expression

$$|M|^2 \propto 1 + \sigma_\pm \frac{2}{\sqrt{3}}\,\frac{T_+ - T_-}{T_{\pm\,\max}} + (CP\ \text{nonviolating terms}) \tag{32}$$

where $T_\pm$ are the kinetic energies of the charged pions. We have momentarily abandoned the form involving the Mandelstam variables $s_i$ in favor of (32) 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 $K^0_L$ section of the Stable Particle Data Card Listings. Note that only upper limits have been reported for this quantity.

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

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

$$\delta = \frac{\Gamma(K_L \to \pi^- l^+ \nu) - \Gamma(K_L \to \pi^+ l^- \nu)}{\Gamma(K_L \to \pi^- l^+ \nu) + \Gamma(K_L \to \pi^+ l^- \nu)} . \tag{33}$$

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

$$\delta = 2 \frac{1 - |x|^2}{|1 - x|^2} \operatorname{Re} \epsilon \tag{34}$$

where $x$ is the $\Delta S = \Delta Q$-violating parameter defined in Section F.4 and $\epsilon$ is the parameter of the expansion

$$|K_L\rangle = \frac{(1+\epsilon)|K\rangle - (1-\epsilon)|\bar{K}\rangle}{[2(1+|\epsilon|^2)]^{\frac{1}{2}}} , \tag{35a}$$

$$|K_S\rangle = \frac{(1+\epsilon)|K\rangle + (1-\epsilon)|\bar{K}\rangle}{[2(1+|\epsilon|^2)]^{\frac{1}{2}}} . \tag{35b}$$

We give $\delta$ 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 $\delta$ 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

$$\eta_{+-} = \frac{A(K_L \to \pi^+\pi^-)}{A(K_S \to \pi^+\pi^-)} = |\eta_{+-}| \exp(i\phi_{+-}) , \tag{36}$$

$$\eta_{00} = \frac{A(K_L \to \pi^0\pi^0)}{A(K_S \to \pi^0\pi^0)} = |\eta_{00}| \exp(i\phi_{00}) , \tag{37}$$

$\epsilon$, defined in eqs. (35) above, and

$$\epsilon' = \tfrac{1}{2} i\sqrt{2}\, [\exp i(\delta_2 - \delta_0)]\ \operatorname{Im}(A_2/A_0) . \tag{38}$$

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

$$\langle I=0|T|K\rangle = \exp(i\delta_0)\, A_0 , \tag{39a}$$

$$\langle I=2|T|K\rangle = \exp(i\delta_2) A_2 . \tag{39b}$$

Wu and Yang (1964) have derived the relationships

$$\eta_{+-} = \epsilon + \epsilon' , \tag{40a}$$

$$\eta_{00} = \epsilon - 2\epsilon' . \tag{40b}$$

At present many models have been proposed to explain the experimental results on *CP* violation, but more data are needed before the cause of *CP* violation can be ascertained.

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

F.4. $\Delta S = \Delta Q$ *rule in* $K^0$ *decays*

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

$$x = A(\bar{K}^0 \to \pi^- l^+ \nu)/A(K^0 \to \pi^- l^+ \nu) . \tag{41}$$

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

G. *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 $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$. For both modes we use the convention

$$\text{Asymmetry} = f(+) - f(-)$$

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

H. *Baryon-decay parameters*

H.1. *A/V ratio for baryon leptonic decays*

The baryon part of the matrix element for these decays may be written as

$$\langle B_f | \gamma_\lambda (g_V - g_A \gamma_5) | B_i \rangle , \tag{42}$$

where $B_i$ and $B_f$ represent initial and final baryons, and $g_A$ and $g_V$ the axial and vector coupling constants. Here the Pauli representation is used for the $\gamma$ matrices. The definition of $g_A/g_V$ is

$$g_A/g_V = |g_A/g_V| \exp(i\delta) , \tag{43}$$

where $\delta$ 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 $g_A/g_V$ therefore 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 $g_A/g_V$ in neutron beta decay is negative.

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 $\delta$.

H.2. *Asymmetry parameters in nonleptonic hyperon decays.*

The transition matrix for the hyperon decay may be written as

$$M = s + p(\boldsymbol{\sigma} \cdot \boldsymbol{q}) , \tag{44}$$

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

$$\alpha = 2\,\mathrm{Re}\,(s^* p)/(|s|^2 + |p|^2) , \tag{45a}$$

$$\beta = 2\,\mathrm{Im}\,(s^* p)/(|s|^2 + |p|^2) , \tag{45b}$$

$$\gamma = (|s|^2 - |p|^2)/(|s|^2 + |p|^2) . \tag{45c}$$

With the transition matrix (44), the angular distribution of the decay baryon, in the hyperon rest system, is of the form

$$I = 1 + \alpha \boldsymbol{P}_Y \cdot \boldsymbol{q} , \tag{46}$$

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

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

$$\boldsymbol{P}_B = \frac{(\alpha + \boldsymbol{P}_Y \cdot \boldsymbol{q})\boldsymbol{q} + \beta(\boldsymbol{P}_Y \times \boldsymbol{q}) + \gamma \boldsymbol{q} \times (\boldsymbol{P}_Y \times \boldsymbol{q})}{1 + \alpha \boldsymbol{P}_Y \cdot \boldsymbol{q}} , \tag{47}$$

where $\boldsymbol{P}_B$ 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 $\boldsymbol{P}_Y$ are defined. Note that $\alpha$ is the helicity of the decay baryon for unpolarized hyperons.

The three parameters $\alpha$, $\beta$, and $\gamma$ satisfy the relation

$$\alpha^2 + \beta^2 + \gamma^2 = 1 . \tag{48}$$

It is then convenient to describe hyperon nonleptonic decays in terms of the two independent parameters $\alpha$ and the angle $\phi$ defined by

$$\beta = (1 - \alpha^2)^{\frac{1}{2}} \sin\phi , \tag{49a}$$

$$\gamma = (1 - \alpha^2)^{\frac{1}{2}} \cos\phi , \tag{49b}$$

which has a more nearly Gaussian distribution than $\beta$ or $\gamma$. Evidently

$$-\tfrac{1}{2}\pi \leqslant \phi \leqslant \tfrac{1}{2}\pi \quad \text{for} \quad \gamma > 0 , \tag{50a}$$

$$+\tfrac{1}{2}\pi \leqslant \phi \leqslant \tfrac{3}{2}\pi \quad \text{for} \quad \gamma < 0 . \tag{50b}$$

In discussing time-reversal invariance, the quantity of interest is $\Delta$, defined by

$$\alpha = 2|s|\,|p| \cos\Delta/(|s|^2 + |p|^2) , \tag{51a}$$

$$\beta = -2|s|\,|p| \sin\Delta/(|s|^2 + |p|^2) ; \tag{51b}$$

that is $\Delta$ is the phase angle of $s$ relative to $p$. Evidently

$$-\tfrac{1}{2}\pi \leqslant \Delta \leqslant \tfrac{1}{2}\pi \quad \text{for} \quad \alpha > 0 , \tag{52a}$$

$$+\tfrac{1}{2}\pi \leqslant \Delta \leqslant \tfrac{3}{2}\pi \quad \text{for} \quad \alpha < 0 . \tag{52b}$$

Under the assumption of time-reversal invariance, the angle $\Delta$ must satisfy the relation

$$\Delta = \delta_s - \delta_p , \tag{53}$$

modulo $\pi$, where $\delta_s$ and $\delta_p$ are the pion-baryon scatter-

* Note that Lee and Yang (1957) contains a misprint. The minus sign in the definition of $\beta$ 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.

ing 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 $\alpha$ and $\phi$ 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 $\alpha$, $\phi$, and $\Delta$ with errors; and for convenience we also give the central value of $\gamma$, without an error.

## V. 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 ($\sigma$). Upper and lower limits represent 68.3% confidence bounds ($1\sigma$), 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 V.B below.

Quantities that have changed more than $1\sigma$ since our April 1971 edition (Particle Data Group, 1971) 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

$$\bar{x} \pm \delta\bar{x} = \sum \omega_i x_i / \sum \omega_i \pm (\sum \omega_i)^{-\frac{1}{2}} ;$$

$$\omega_i = 1/(\delta x_i)^2 , \qquad (54)$$

* 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.

where the sums run over $N$ experiments. We also calculate $\chi^2$ and compare it with its expectation value of $N-1$. If $\chi^2 > N-1$, we increase the error $\delta\bar{x}$ in eq. (54) by a factor

$$S = [\chi^2/(N-1)]^{\frac{1}{2}} . \qquad (55)$$

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).

We do our best to resolve these cases. If we cannot, we *assume* that *all* experimentalists underestimated their errors by the same scale factor. If we scale up all input errors by this factor, $\chi^2$ returns to $N-1$, and of course the output error scales up by the same factor.

If all the experiments have errors of about the same size, the above procedure is straightforward. If, however, there are both precise and imprecise (large errors) measurements of a particular quantity, one must be very careful not to permit the imprecise ones to "dilute" the scale factor. See our January 1970 edition (Particle Data Group, 1970) for the prescription we use to handle this effect.

We often plot an ideogram to guide the reader in deciding which data he might reject before making his own selected average.

For further discussion of ideograms and scale factors, we refer the reader to Section IX of our January 1970 edition (Particle Data Group, 1970).

### 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 $P_i$, $\Gamma_i$, and $R_j$ subject to the constraint $\Sigma P_i = 1$. When, in

† We are also able to fit *products* of rates from formation experiments as given in eq. (12).

addition, the input $R_j$ are contradictory so that scale factors may have to be introduced, one has to resort to iterative procedures.

The Data Card Listings give the values of the fitted $R_j$, $P_i$, and $\Gamma_i$, together with the error matrices of the $P_i$ and of the $\Gamma_i$. For details about this procedure the reader is referred to the text of the January 1970 edition (Particle Data Group, 1970), Section IV.B.

## VI. PARTICLE DATA GROUP PUBLICATIONS

To obtain a reprint of this report, or any of the items listed below, write either Scientific Information Service, CERN, or Technical Information Division, Lawrence Berkeley Laboratory, whichever is closer.

### A. *Pocket-sized particle data booklet*

In addition to the present complete, full size version of the Review of Particle Properties available from CERN and LBL, a pocket-size data booklet is available. It contains the first part of this report, up to the Data Card Listings. The complete set of pocket-size items available comprises the data booklet, a 16-month diary, a mini-atlas contributed by Digital Equipment Corporation, and a plastic cover. Any of these items that you have requested in the past will automatically be sent to you, but please note that our mailing lists are self-cancelling; unless you return the request card that is sent once a year, your name will be removed from our mailing list. If you wish to order any items in bulk we must charge 25 cents (US) for each of the pocket-sized items.

### B. *Other compilations*

We compile data not only on particle properties, but also on other aspects of strong interactions ($\pi$N, KN, pN, ... cross sections; partial wave amplitudes, etc.) Until 1971, our reports were called UCRL 20 000; they are now numbered LBL 50, ..., 99. In the front of each of these reports is a list of all relevant compilations. A complementary series of compilations is produced by the CERN HERA Group. Both series are available from both LBL and CERN.

### C. *Next edition*

We currently produce a new Review of Particle Properties every April. It is published alternately by Physics Letters and by Reviews of Modern Physics.

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# TABLES OF PARTICLE PROPERTIES

April 1972

"Now go, write it before them in a table, and note it in a book,
that it may be for the time to come for ever and ever."
Isaiah 30:7-8

" . . . or at least until the next edition."
Particle Data Group

N. Barash-Schmidt, A. Barbaro-Galtieri, J. Bartels, C. Bricman, V. Chaloupka, J. E. Enstrom, T. A. Lasinski, A. Rittenberg, M. Roos, A. H. Rosenfeld, P. Söding, and T. G. Trippe

(Closing date for data: Feb. 1, 1972)

## 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 1971.*

| 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) |
|---|---|---|---|---|---|---|
| $\gamma$ | $0,1(1^-)^-$ | $0(<2)10^{-21}$ | stable | stable | | |
| $\nu$ | $\nu_e$ $J=\frac{1}{2}$ | $0(<60$ eV$)$ | stable | stable | | |
| | $\nu_\mu$ | $0(<1.2)$ | | | | |
| $e$ | $J=\frac{1}{2}$ | 0.5110041 ±.0000016 | stable ($>2\times10^{21}$y) | stable | | |
| $\mu$ | $J=\frac{1}{2}$ | 105.6594 ±.0004 | *2.1994×10$^{-6}$* *±.0006* S=1.1* | $e\nu\bar{\nu}$ | 100 | 53 |
| | | $m^2=$ 0.0112 | $c\tau=6.593\times10^4$ | $e\gamma\gamma$ | $(<1.6)10^{-5}$ | 53 |
| | | | | $3e$ | $(<6)10^{-9}$ | 53 |
| | $m_\mu-m_{\pi^\pm}=-33.917$ ±.011 | | | $e\gamma$ | $(<2.2)10^{-8}$ | 53 |
| $\pi^\pm$ | $1^-(0^-)$ | 139.576 ±.011 | $2.6024\times10^{-8}$ ±.0024 | $\mu\nu$ | 100 % | 30 |
| | | $m^2=$ 0.0195 | $c\tau=780.2$ | $e\nu$ | $(1.24\pm0.03)10^{-4}$ | 70 |
| | | | $(\tau^+-\tau^-)/\bar{\tau}=$ | $\mu\nu\gamma$ | [c] $(1.24\pm0.25)10^{-4}$ | 30 |
| | | | $(0.05\pm0.07)$% | $\pi^0e\nu$ | $(1.02\pm0.07)10^{-8}$ | 5 |
| | | | (test of CPT) | $e\nu\gamma$ | [c] $(3.0\pm0.5)10^{-8}$ | 70 |
| | | | | $e\nu e^+e^-$ | $(<3.4)10^{-8}$ | 70 |
| $\pi^0$ | $1^-(0^-)^+$ | 134.972 ±.012 | $0.84\times10^{-16}$ ±.10 S=2.1* | $\gamma\gamma$ | $(98.84\pm0.04)$% | 67 |
| | | $m^2=$ 0.0182 | $c\tau=2.5\times10^{-6}$ | $\gamma e^+e^-$ | $(1.16\pm0.04)$% | 67 |
| | | | | $\gamma\gamma\gamma$ | $(<5)10^{-6}$ | 67 |
| | $m_{\pi^\pm}-m_{\pi^0}=$ 4.6043 ±.0037 | | | $e^+e^-e^+e^-$ | [d] $(3.47)10^{-5}$ | 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) | Partial decay mode: Mode | Fraction[a] | p or $p_{max}$[b] (MeV/c) |
|---|---|---|---|---|---|---|
| $K^\pm$ | $\frac{1}{2}(0^-)$ | 493.84 ±0.10 | $1.2371\times10^{-8}$ ±.0026 S=1.9* | $\mu\nu$ | (63.77±0.28)% S=1.1* | 236 |
| | | | $c\tau$=370.8 | $\pi\pi^0$ | (20.92±0.29)% S=1.2* | 205 |
| | | $m^2$=0.244 | $(\tau^+-\tau^-)/\bar{\tau}$= | $\pi\pi^-\pi^+$ | (5.58±0.03)% S=1.1* | 126 |
| | | | (.11±.09)% | $\pi\pi^0\pi^0$ | (1.68±0.04)% | 133 |
| | | | (test of CPT) | $\mu\pi^0\nu$ | (3.20±0.11)% S=1.8* | 215 |
| | | | S=1.2* | $e\pi^0\nu$ | (4.86±0.07)% S=1.1* | 228 |
| | | | | $e\pi^0\pi^0\nu$ | $(1.8^{+2.4}_{-0.6})\,10^{-5}$ | 207 |
| | | $m_{K^\pm}-m_{K^0}$ =-3.95 ±0.13 S=1.1* | | $\pi\pi^\mp e^\pm\nu$ | (*3.7 ±0.2*) *$10^{-5}$* | 204 |
| | | | | $\pi\pi^\pm e^\mp\nu$ | (<5) $10^{-7}$ | 204 |
| | | | | $\pi\pi^\mp\mu^\pm\nu$ | (0.9 ±0.4) $10^{-5}$ | 151 |
| | | | | $\pi\pi^\pm\mu^\mp\nu$ | (<3) $10^{-6}$ | 151 |
| | | | | $e\nu$ | (1.30±0.18) $10^{-5}$ | 247 |
| | | | | $e\nu\gamma$ | [c](<7) $10^{-5}$ | 247 |
| | | | | $\pi\pi^0\gamma$ | [c](2.2 ±0.7) $10^{-4}$ | 205 |
| | | | | $\pi\pi^+\pi^-\gamma$ | [c](10 ±4) $10^{-5}$ | 126 |
| | | | | $\pi e\nu\gamma$ | [c](3.7 ±1.4) $10^{-4}$ | 227 |
| | | | | $\pi e^+e^-$ | (<0.4) $10^{-6}$ | 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 |
| | | | | $\pi\nu\bar{\nu}$ | (<1.2) $10^{-6}$ | 227 |
| | | | | $\pi\gamma$ | (<4) $10^{-6}$ | 227 |
| $K^0$ | $\frac{1}{2}(0^-)$ | 497.79 ±0.15 S=1.1* | 50% $K_{Short}$, 50% $K_{Long}$ | | | |
| $K^0_S$ | $\frac{1}{2}(0^-)$ | $m^2$=0.248 | $0.862\times10^{-10}$ ±.006 S=1.2* | $\pi^+\pi^-$ | (68.85±0.31)% S=1.1* | 206 |
| | | | $c\tau$=2.58 | $\pi^0\pi^0$ | (31.15)% | 209 |
| | | | | $\mu^+\mu^-$ | (<.7) $10^{-5}$ | 225 |
| | | | | $e^+e^-$ | (<35) $10^{-5}$ | 249 |
| | | | | $\pi^+\pi^-\gamma$ | [c](2.3 ±0.8) $10^{-3}$ | 206 |
| | | | | $\gamma\gamma$ | (<2) $10^{-3}$ | 249 |
| $K^0_L$ | $\frac{1}{2}(0^-)$ | | $5.172\times10^{-8}$ ±0.042 | $\pi^0\pi^0\pi^0$ | (21.4 ±0.7)% S=1.1* | 139 |
| | | | $c\tau$=1550 | $\pi^+\pi^-\pi^0$ | (12.6 ±0.3)% | 133 |
| | | | | $\pi\mu\nu$ | (26.8 ±0.6)% | 216 |
| | | | | $\pi e\nu$ | (39.0 ±0.6)% | 229 |
| | | | | $\pi e\nu\gamma$ | [c](1.3 ±0.8)% | 229 |
| | | $m_{K_L}-m_{K_S}$ = $0.5402\times10^{10}\,\hbar\,sec^{-1}$ ± 0.0035 | | $\pi^+\pi^-$ | (0.157±0.005)% | 206 |
| | | | | $\pi^0\pi^0$ | (0.094±0.019)% S=1.5* | 209 |
| | | | | $\pi^+\pi^-\gamma$ | [c](<0.4) $10^{-3}$ | 206 |
| | | $\frac{\Gamma(K_S\to\pi^+\pi^-\pi^0)}{\Gamma(K_L\to\pi^+\pi^-\pi^0)}$ <0.45 | | $\pi^0\gamma\gamma$ | (<2.4) $10^{-4}$ | 231 |
| | | | | $\gamma\gamma$ | (*4.9 ±0.4*) *$10^{-4}$* | 249 |
| | | (test of CP) | | $e\mu$ | (<1.6) $10^{-9}$ | 238 |
| | | | | $\mu^+\mu^-$ | (<1.9) $10^{-9}$ | 225 |
| | | | | $e^+e^-$ | (<1.6) $10^{-9}$ | 249 |
| $\eta$ | $0^+(0^-)^+$ | 548.8 ±0.6 S=1.4* | $\Gamma$=(2.63±0.58)keV | | | |
| | | $m^2$=0.301 | Neutral decays 71.1% | $\gamma\gamma$ | (38.0 ±1.0)% S=1.2* | 274 |
| | | | | $\pi^0\gamma\gamma$ | [e](3.1 ±1.1)% S=1.2* | 258 |
| | | | | $3\pi^0$ | (30.0 ±1.1)% S=1.1* | 180 |
| | | | Charged decays 28.9% | $\pi^+\pi^-\pi^0$ | (24.0 ±0.6)% S=1.1* | 175 |
| | | | | $\pi^+\pi^-\gamma$ | (4.9 ±0.2)% S=1.1* | 236 |
| | | | | $\pi^0e^+e^-$ | (<0.04)% | 258 |
| | | | | $\pi^+\pi^-e^+e^-$ | (0.1 ±0.1)% | 236 |
| | | | | $\pi^+\pi^-\pi^0\gamma$ | (<0.2)% | 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 |
| p | $\frac{1}{2}(\frac{1}{2}^+)$ | 938.2592 ±0.0052 | stable | | | |
| | | $m^2$=0.8803 | (> $2\times10^{28}$y) | | | |
| n | $\frac{1}{2}(\frac{1}{2}^+)$ | 939.5527 ±0.0052 | [e](0.935±0.014)$10^3$ | $pe^-\nu$ | 100 % | 1 |
| | | $m^2$ =0.8828 | $c\tau$ = $2.80\times10^{13}$ | | | |
| | | $m_p-m_n$= -1.29344 ±0.00007 | | | | |

# 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) |
|---|---|---|---|---|---|---|
| $\Lambda$ | $0(\frac{1}{2}^+)$ | 1115.59 ±0.05 S=1.2* $m^2$= 1.245 | $2.521\times10^{-10}$ ±.021 S=1.2* $c\tau$ = 7.56 | $p\pi^-$ | ( 64.2 ±0.5 )% | 100 |
| | | | | $n\pi^0$ | ( 35.8 ±0.5 )% | 104 |
| | | | | $pe\nu$ | ( 8.13±0.29)$10^{-4}$ | 163 |
| | | | | $p\mu\nu$ | ( 1.62±0.35)$10^{-4}$ | 131 |
| $\Sigma^+$ | $1(\frac{1}{2}^+)$ | 1189.42 ±0.11 S= 1.7* $m^2$= 1.415 | $0.800\times10^{-10}$ ±.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]( 1.31±0.24)$10^{-4}$ | 185 |
| | | $m_{\Sigma^+}-m_{\Sigma^-}$= -7.92 ±.13 S= 1.6* | | $\Lambda e^+\nu$ | ( 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 |
| $\Sigma^0$ | $1(\frac{1}{2}^+)$ | 1192.48 ±0.11 S= 1.3* $m^2$=1.422 | <$1.0\times10^{-14}$ $c\tau$<$3\times10^{-4}$ | $\Lambda\gamma$ | 100 % | 74 |
| | | | | $\Lambda e^+e^-$ | [d]( 5.45 )$10^{-3}$ | 74 |
| $\Sigma^-$ | $1(\frac{1}{2}^+)$ | 1197.34 ±0.10 S= 1.5* $m^2$ = 1.434 | [e]$1.484\times10^{-10}$ ±.019 S=1.6* $c\tau$ = 4.45 | $n\pi^-$ | 100 % | 193 |
| | | | | $ne^-\nu$ | ( 1.10±0.05)$10^{-3}$ | 230 |
| | | | | $n\mu^-\nu$ | ( 0.45±0.04)$10^{-3}$ | 210 |
| | | | | $\Lambda e^-\nu$ | ( 0.60±0.06)$10^{-4}$ | 79 |
| | | $m_{\Sigma^0}-m_{\Sigma^-}$=-4.86 ±.06 | | $n\pi^-\gamma$ | [c]( 1.0 ±0.2 )$10^{-4}$ | 193 |
| $\Xi^0$ | $\frac{1}{2}(\frac{1}{2}^+)$[f] | 1314.7 ±0.7 $m^2$= 1.729 | $3.03\times10^{-10}$ ±.18 $c\tau$ = 9.08 | $\Lambda\pi^0$ | 100 % | 135 |
| | | | | $p\pi^-$ | ( <0.9 )$10^{-3}$ | 299 |
| | | $m_{\Xi^0}-m_{\Xi^-}$ =-6.6 ±.7 | | $pe^-\nu$ | ( <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 |
| $\Xi^-$ | $\frac{1}{2}(\frac{1}{2}^+)$[f] | 1321.30 ±0.15 $m^2$= 1.746 | $1.660\times10^{-10}$ ±.037 S=1.1* $c\tau$ = 4.98 | $\Lambda\pi^-$ | 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 |
| $\Omega^-$ | $0(\frac{3}{2}^+)$[f] | 1672.5±.5 $m^2$= 2.797 | $1.3^{+0.4}_{-0.3}\times10^{-10}$ $c\tau$ = 3.9 | $\Xi^0\pi^-$ | Total of 28 events seen | 294 |
| | | | | $\Xi^-\pi^0$ | | 290 |
| | | | | $\Lambda K^-$ | | 211 |

*S = Scale factor = $\sqrt{\chi^2/(N-1)}$, where N ≈ number of experiments. S should be ≈ 1. If S > 1, we have enlarged the error of the mean, $\delta x$, i.e., $\delta x \to S\delta x$. 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 $\Xi$ and $J^P$ for $\Omega^-$ not yet measured. Values reported are SU(3) predictions.

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

ADDENDUM TO

# Stable Particle Table

| | Magnetic moment | | $\mu$ Decay parameters [a] |
|---|---|---|---|
| e | 1.001 159 6577 ±.000 000 0035 | $\frac{e\hbar}{2m_e c}$ | |
| $\mu$ | 1.001 166 16 ±.000 000 31 | $\frac{e\hbar}{2m_\mu c}$ | $\rho = 0.752\pm0.003$ $\eta = -0.12\pm0.21$ <br> $\xi = 0.972\pm0.013$ $\delta = 0.755\pm0.009$ $h = 1.00\pm0.13$ <br> $\lvert g_A/g_V\rvert = 0.86^{+0.33}_{-0.11}$ $\phi = 180° \pm 15°$ |

| | Mode | Partial rate ($sec^{-1}$) | | $\Delta I = \frac{1}{2}$ rule for $K^\pm \to 3\pi$ | Form factors for leptonic decays |
|---|---|---|---|---|---|
| $K^\pm$ | $\mu\nu$ | $(51.55\pm0.25)10^6$ | S=1.2* | $\pi^+\pi^+\pi^-$ $c_g = -.206\pm.007$ | See Stable Particle Data Card Listings for $\lambda$ and $\xi$ |
| | $\pi\pi^0$ | $(16.91\pm0.24)10^6$ | S=1.2* | $\pi^-\pi^+\pi^-$ $c_g = -.194\pm.007$ | |
| | $\pi\pi^+\pi^-$ | $(4.51\pm0.02)10^6$ | S=1.1* | $\pi^+\pi^0\pi^0$ $c_g = .527\pm.017$ | |
| | $\pi\pi^0\pi^0$ | $(1.36\pm0.04)10^6$ | | See also Stable Particle Data Card Listings and Appendix I | |
| | $\mu\pi^0\nu$ | $(2.59\pm0.09)10^6$ | S=1.8* | | |
| | $e\pi^0\nu$ | $(3.92\pm0.06)10^6$ | S=1.2* | | |

| | | | | CP violation parameters | $I=\frac{1}{2}$ rule for $K_L^0 \to 3\pi$ |
|---|---|---|---|---|---|
| $K_S^0$ | $\pi^+\pi^-$ | $(0.799\pm.006)10^{10}$ | S=1.2* | $\lvert\eta_{+-}\rvert = (1.96\pm0.03)10^{-3}$, $\phi_{+-} = (43\pm3)°$ | $\pi^+\pi^-\pi^0$ $c_g = .60\pm.03$ S=3.1* |
| | $\pi^0\pi^0$ | $(0.361\pm.004)10^{10}$ | S=1.2* | | See Data Cards & App. I |
| $K_L^0$ | $\pi^0\pi^0\pi^0$ | $(4.13\pm0.13)10^6$ | S=1.1* | $\lvert\eta_{00}\rvert = (2.09\pm0.12)10^{-3}$, $\phi_{00} = (43\pm19)°$ S=1.2* | $\Delta S = -\Delta Q$ <br> Re $x = -.003\pm.026$ S=1.5* <br> Im $x = -.007\pm.039$ S=1.2 |
| | $\pi^+\pi^-\pi^0$ | $(2.43\pm0.06)10^6$ | | Charge asymmetry: | |
| | $\pi\mu\nu$ | $(5.18\pm0.12)10^6$ | | $\delta = \frac{\Gamma(K_L^0\to\ell^+) - \Gamma(K_L^0\to\ell^-)}{\Gamma(K_L^0\to\ell^+)+\Gamma(K_L^0\to\ell^-)} = .32\pm.03 \times 10^{-2}$ | Form factors for leptonic decays <br> See Stable Particle Data Card Listings for $\lambda$, $\xi$ |
| | $\pi e\nu$ | $(7.54\pm0.13)10^6$ | | | |
| | $\pi^+\pi^-$ | $(3.03\pm0.10)10^4$ | | | |
| | $\pi^0\pi^0$ | $(1.81\pm0.36)10^4$ | S=1.5* | | |

| | Mode | Asymmetry parameter |
|---|---|---|
| $\eta$ | $\pi^+\pi^-\pi^0$ | $(1.2\pm0.5)\%$ S=1.3* |
| | $\pi^+\pi^-\gamma$ | $(1.1\pm1.3)\%$ |

| | Magnetic moment ($e\hbar/2m_p c$) | Decay parameters [b] Measured: | $\alpha$ | $\phi$(degree) | Derived: $\gamma$ | $\Delta$(degree) | $g_A/g_V$ [b] | $g_V/g_A$ [b] |
|---|---|---|---|---|---|---|---|---|
| p | 2.792782 ±.000017 | | | | | | | |
| n | -1.913148 ±.000066 | $pe^-\nu$ | | | | | -1.242±0.008 S=1.2* [$\delta$=(178.6±0.9)] | |
| $\Lambda$ | -0.67 ±.06 | $p\pi^-$ | 0.645±0.016 | (-6.3±3.5)° | 0.76 | $(7.4^{+4.0}_{-4.1})°$ | | |
| | | $n\pi^0$ | 0.649±0.046 | | | | | |
| | | $pe\nu$ | | | | | -0.66±0.06 S=1.2* | |
| $\Sigma^+$ | 2.59 ±.46 | $p\pi^0$ | -0.991±0.019 | (22±90)° | 0.12 | $(183^{+11}_{-12})°$ | | |
| | | $n\pi^+$ | +0.066±0.016 | (167±20)° | -0.97 | $(-73^{+136}_{-10})°$ | | |
| | | $p\gamma$ | $-1.03^{+.52}_{-.42}$ | S=1.1* | | | | |
| $\Sigma^-$ | | $n\pi^-$ | -0.069±0.008 | (10±15)° | 0.98 | $(249^{+12}_{-115})°$ | See Data Cds. | |
| | | $ne^-\nu$ | | | | | | |
| | | $\Lambda e^-\nu$ | | | | | | 0.35±0.18 |
| $\Xi^0$ | | $\Lambda\pi^0$ | -0.35±0.08 | (25±21)° S=1.3* | 0.85 | $(228^{+16}_{-37})°$ | | |
| $\Xi^-$ | | $\Lambda\pi^-$ | -0.40±0.03 | (-4±8)° S=1.1* | 0.91 | $(170^{+18}_{-17})°$ | | |

*S = scale factor. Quoted error includes scale factor; see footnote to main Stable Particle Table for definition.

a. $\lvert g_A/g_V\rvert$ defined by $g_A^2 = \lvert C_A\rvert^2 + \lvert C'_A\rvert^2$, $g_V^2 = \lvert C_V\rvert^2 + \lvert C'_V\rvert^2$, and $\Sigma\langle \bar{e}\lvert\Gamma_i\rvert\mu\rangle\langle\bar{\nu}\lvert\Gamma_i(C_i + C'_i\gamma_5)\rvert\nu\rangle$;

$\phi$ defined by $\cos\phi = -R_e(C^*_A C'_V + C'_A C^*_V)/g_A g_V$ [for more details, see text Section IV E]

b. The definition of these quantities is as follows [for more details on sign convention, see text Section IV H]:

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

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

c. The definition of the slope parameter of the Dalitz plot is as follows: $\lvert M\rvert^2 = 1 + g\left(\frac{s_3 - s_0}{m_{\pi^+}^2}\right)$.

# Meson Table

April 1972

*Quantities in italics have changed by more than one (old) standard deviation since April 1971*

| 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 % | | p or $p_{max}$ [b] (MeV/c) |
|---|---|---|---|---|---|---|---|---|
| $\pi^\pm(140)$ | $1^-(0^-)+$ | 139.58 | 0.0 | 0.019483 | See Stable Particle Table | | | |
| $\pi^0(135)$ | | 134.97 ±.9 | 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 | $0^+(0^+)+$ | $\delta_0^0$ is near 80°-90° in mass region 800-1000 MeV, with probably only slow variation below and cusp at $K\bar{K}$ threshold. Inelasticity ≈0 below 2 $m_K$. | | | | | | |
| See note on ππ S wave¶. | | | | | | | | |
| $\rho(765)$ | $1^+(1^-)-$ | 765 ±10 [c] | 135 ±20 [c] | 0.585 ±.103 | ππ | ≈100 | | 356 |
| | | | | | $e^+e^-$ | *0.0042±.0004* (d) | | 382 |
| | | | | | $\mu^+\mu^-$ | 0.0067±.0012 (d) | | 368 |
| | | | | | For upper limits, see footnote (e) | | | |
| $\omega(784)$ | $0^-(1^-)-$ | 783.9 ±0.3 S=1.3* | *10.0* ±*0.6* | 0.614 ±.008 | $\pi^+\pi^-\pi^0$ | 89.7±4.0 | S=1.1* | 328 |
| | | | | | $\pi^+\pi^-$ | *1.2±0.3* | *S=1.4** | 366 |
| | | | | | $\pi^0\gamma$ | 9.0±1.0 | | 380 |
| | | | | | $e^+e^-$ | 0.0075±.0016 | S=1.8* | 392 |
| → | | | | | For upper limits, see footnote (f) | | | |
| $\eta'(958)$ or $X^0$ | $0^+(\ ^-)+$ | 957.1 ±0.6 | < 4 | 0.916 <.004 | ηππ | 68.1±2.2 | | 230 |
| | | | | | $\pi^+\pi^-\gamma$ (mainly $\rho^0\gamma$) | 30.1±2.3 | S=1.1* | 458 |
| | $J^P = 0^-$ or $2^-$ | | | | γγ | *1.8±0.3* | | 479 |
| | | | | | For upper limits, see footnote (h) | | | |
| $\pi_N(975)$ | $1^-(0^+)+$ | ~ 975 | ~ 60 | 0.950 | ηπ (g) | | | 304 |
| Possibly related to the I=1 $K\bar{K}$ threshold enhancement | | | | | | | | |
| $S^*$ | $0^+(0^+)+$ | ~ 1000 | | 1.000 | Seen as I=0 $K\bar{K}$ threshold enhancement; appears coupled to the ππ channel. | | | |
| See notes on ππ and $K\bar{K}$ S wave¶. | | | | | | | | |
| $\Phi(1019)$ | $0^-(1^-)-$ | 1019.1 ±0.5 S=1.8* | *4.4* ±*.3* | 1.039 ±.004 | $K^+K^-$ | 49.1±2.0 | | 126 |
| | | | | | $K_LK_S$ | *30.7±2.4* | *S=1.4** | 109 |
| | | | | | $\pi^+\pi^-\pi^0$ (incl. ρπ) | 17.5±2.5 | S=1.1* | 461 |
| | | | | | ηγ | *2.6±1.2* | *S=1.9** | 362 |
| | | | | | $e^+e^-$ | .032±.003 | S=1.9* | 510 |
| | | | | | $\mu^+\mu^-$ | .025±.003 | | 498 |
| | | | | | For upper limits, see footnote (i) | | | |
| $A_1(1070)$ | $1^-(1^+)+$ | ~ 1070 | | 1.14 | ρπ | ~ 100 | | 232 |
| Broad enhancement in the $J^P=1^+$ ρπ partial wave; not clear if resonant¶. | | | | | | | | |
| B(1235) | $1^+(1^+)-$ | 1233 ±10 § | 100 ±20 § | 1.52 ±.12 | ωπ | ≈ 100 | | 348 |
| | | | | | ππ | < 30 | Absence suggests $J^P$ = Abnormal | 600 |
| | | | | | $K\bar{K}$ | < 2 | | 369 |
| | | | | | For other upper limits, see footnote (j) | | | |
| f(1260) | $0^+(2^+)+$ | 1269 ±10 § | 156 ±25 § | 1.60 ±.20 | ππ | ≈ 80 | | 619 |
| | | | | | $2\pi^+2\pi^-$ | 6±2 | | 556 |
| | | | | | $K\bar{K}$ | ≈ 6 | | 393 |

# Meson Table *(cont'd)*

| Name | $I^G(J^P)C_n$ ⊢⊣ estab. | Mass M (MeV) | Full Width Γ (MeV) | $M^2 \pm \Gamma M$ [a] $(GeV)^2$ | Partial decay mode: Mode | Fraction % | p or $p_{max}$ [b] (MeV/c) |
|---|---|---|---|---|---|---|---|
| D(1285) | $0^+(A\ )+$ | 1286 ±4 | *21* ±*10* | 1.65 ±.03 | ηππ | Probably seen | 484 |
| | | S=1.3* | *S=1.3** | | $K\bar{K}\pi$ | Seen | 305 |
| | | | | | †[$\pi_N(975)\pi$ | Seen] | 246 |
| | $J^P = 0^-, 1^+, 2^-$, with $1^+$ favoured | | | | $2\pi^+2\pi^-$ (prob. $\rho^0\pi^+\pi^-$) | Seen | 565 |
| $A_2(1310)$ | $1^-(2^+)+$ | 1310 ±10 § | 100 ±20 § | 1.72 ±.13 | ρπ | 76.8±1.8 | 416 |
| | | | | | ηπ | 16.3±1.5 | 529 |
| | | | | | $K\bar{K}$ | 5.8±0.8 | 428 |
| Controversy whether unsplit or split¶. | | | | | η′(958)π | 1.1±1.1 S=1.3* | 280 |
| E(1422) | $0^+(\ )+$ | 1422 ±4 | 69 ±8 | 2.02 ±.10 | $K^*\bar{K} + \bar{K}^*K$ | 50±10 | 154 |
| | | | | | $\pi_N(975)\pi$ | 50±10 | 357 |
| → | $J^P = 0^-$ or $1^+$ | | | | ππη | < 60 | 568 |
| f′(1514) | $0^+(2^+)+$ | 1514 ±5 | 73 ±23 S=1.8* | 2.29 ±.11 | $K\bar{K}$ | 72±12 | 570 |
| | | | | | $K^*\bar{K} + \bar{K}^*K$ | 10±10 | 294 |
| | | | | | ππ | < 14 (k) | 744 |
| | | | | | ηππ | 18±10 | 624 |
| | | | | | ηη | < 40 | 521 |
| $F_1(1540)$ | $1\ (A\ )$ | 1540 ±5 | 40 ±15 | 2.37 ±.06 | $K^*\bar{K} + \bar{K}^*K$ | Only mode seen | 321 |
| Evidence based on only one experiment | | | | | | | |
| $A_3(1640)$ | $1^-(2^-)+$ | ~ 1640 | | 2.69 | fπ | Dominant | 306 |
| | | | | | ωππ (m) | | 597 |
| Broad enhancement in the $J^P = 2^-$ fπ partial wave; not clear if resonant¶. | | | | | | | |
| Φ(1675) | $0^-(N\ )-$ | 1664 ±13 S=1.2* | 141 ±17 | 2.77 ±.23 | ρπ | Dominant | 647 |
| | | | | | 3π | Possibly observed | 804 |
| | | | | | 5π | 10±10 | |
| g(1680) | $1^+(3^-)-$ | 1680 ±20 § | 160 ±30 § | 2.82 ±.27 | 2π | ~ 40 (ℓ) | 828 |
| | | | | | 4π (incl. ππρ,ρρ,$A_2\pi$,ωπ) | ~ 50 (ℓ) | 781 |
| | | | | | $K\bar{K}$ | ~ 3 (ℓ) | 677 |
| $J^P$, M and Γ from the 2π mode(ℓ). | | | | | $K\bar{K}\pi$ (incl. $K^*\bar{K}$) | ~ 3 (ℓ) | 617 |
| S(1930) | $1^+(\ )-$ | ~ 1930 | 30 ±20 § | 3.72 ±.06 | $\bar{p}p$ | Possibly seen | 226 |
| | | | | | ππ | Possibly seen | 955 |
| Seen in $\pi^-p \to (MM)^-p$ ; may be related to the structure seen in 460 MeV/c $\bar{p}p$ backwards scattering¶. | | | | | | | |
| → See note (p) for other possible heavy states. | | | | | | | |
| $K^+(494)$ | $1/2(0^-)$ | 493.84 | | 0.244 | See Stable Particle Table | | |
| $K^0(498)$ | | 497.79 | | 0.248 | | | |
| $K^*(892)$ | $1/2(1^-)$ | *891.7* ±*0.5* | 50.1 ±1.1 | 0.795 ±.045 | Kπ | ≈ 100 | 288 |
| | | | | | Kππ | < 0.2 | 216 |
| → | | (Charged mode; $m^0 - m^\pm = 6.1\pm1.5$ MeV) | | | | | |
| κ | $1/2(0^+)$ | | $\delta_0^1$ is near 90°, with slow variation, in mass region 1200-1400 MeV. In addition, $\delta_0^1$ may be resonant at M ~ 890 MeV, Γ ~ 30 MeV. | | | | |
| See note on Kπ S wave¶. | | | | | | | |

# Meson Table *(cont'd)*

| Name | $I^G(J^P)C_n$ ⊢estab. | Mass M (MeV) | Full Width Γ (MeV) | $M^2$ ±ΓM[a] $(GeV)^2$ | Partial decay mode: Mode | Fraction % | p or $p_{max}$[b] (MeV/c) |
|---|---|---|---|---|---|---|---|
| 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) | 1/2(1⁺) | 1280 to 1400 | | | †[Kρ | Seen ] | |
| | Resonance interpretation unclear[n]. | | | | | | |
| $K_N(1420)$ | 1/2(2⁺) | *1421*§ ±5§ | 100§ ±10§ | 2.02 ±.14 | Kπ | < 56.3±3.0 | 616 |
| | | | | | K*π | > 27.8±2.7 | 415 |
| | | | | | Kρ | > 9.5±2.5 | 324 |
| | | See note (o). | | | Kω | > 4.5±1.7 | 304 |
| → → | | | | | Kη | > 2.0±2.0 | 482 |
| L(1770) | 1/2(A) | 1763§ ±10§ | $100^{+100}_{-50}$§ | 3.11 ±.18 | Kππ | Dominant | 787 |
| | | | | | Kπππ | Seen | 756 |
| ‡ | $J^P=2^-$ favoured, 1⁺ and 3⁺ not excluded. | | | | †[$K_N(1420)\pi$ and other subreactions¶] | | |

→ Data on the following candidates, excluded above, are listed among the data cards¶ :

M(953), H(990), $\eta_N(1080)$, $A_{1.5}(1170)$, $X_{I=0}(1430)$, $X_{I=1}(1440)$, $X^-(1795)$, $\eta/\rho(1830)$, $\phi/\pi(1830)$, $\rho(2100)$, T(2200), $\rho(2275)$, $N\bar{N}(2350)$, U(2375), $N\bar{N}(2375)$, $X^-(2500)$, $X^-(2620)$, X(2800), $X^-(2880)$, X(3030), $X^-(3075)$, $X^-(3145)$, $X^-(3475)$, $X^-(3535)$; $K_A^{I=3/2}(1175)$, $K_A^{I=3/2}(1265)$, $K_N(1370)$, $K_N(1660)$, $K_N(1760)$, $K_N(1850)$, $K^*(2200)$, $K^*(2800)$.

¶ 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) The values given for M(ρ) and Γ(ρ) and their errors are not average values from various experiments, but rather are intended to give the range where we believe the actual values are most likely to fall. Contrast the results tabulated in this note (references in the Meson Data Card Listings).

| | M(MeV) | Γ(MeV) | |
|---|---|---|---|
| $\rho^0$ | 775±7 | 149±23 | From $e^+e^- \to \pi^+\pi^-$, fitted to Gounaris-Sakurai formula. |
| $\rho^0$ | 768±10 | 140±14 | |
| $\rho^-$ | 764±2 | 147±4 | From physical region fits to $\pi N \to \pi\pi N$, using energy-dep. width. |
| $\rho^0$ | 775±3 | 145±9 | |
| $\rho^0$ | 768±2 | 132±13 | |
| $\rho^0$ | 759±7 | 119±20 | From pole extrapol. in $\pi N \to \pi\pi N$ |
| $\rho^-$ | 760 | 131 | |

(d) The $e^+e^-$ branching ratio is from $e^+e^- \to \pi^+\pi^-$ experiments only. The ωρ interference is then due to ωρ 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 ωρ interference. The error reflects this uncertainty; see notes in Meson Data Card Listings. If eμ 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 ρ(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 ω(784) are $\pi^+\pi^-\gamma < 5\%$, $\pi^0\pi^0\gamma < 1\%$, η + neutral(s) < 1.5%, $\mu^+\mu^- < 0.02\%$, $\pi^0\mu^+\mu^- < 0.2\%$.

(g) See Meson Data Card Listings for a typed note and an entry "π(950-1020)", which contains the data referred to as δ(962), $\pi_N(975)$, and $\pi_N(1016)$ in our April 1971 edition.

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

# Meson Table *(cont'd)*

(i) Empirical limits on fractions for other decay modes of $\phi(1019)$ are $\pi^+\pi^- < 0.03\%$, $\pi^+\pi^-\gamma < 4\%$, $\omega\gamma < 5\%$, $\rho\gamma < 2\%$, $\pi^0\gamma < 0.35\%$.

(j) Empirical limits on fractions for decay modes of B(1235): $\pi\pi < 30\%$, $K\bar{K} < 2\%$, $4\pi < 50\%$, $\phi\pi < 1.5\%$, $\eta\pi < 25\%$, $(\bar{K}K)^{\pm}\pi^0 < 8\%$, $K_SK_S\,\pi^{\pm} < 2\%$, $K_SK_L\,\pi^{\pm} < 6\%$.

(k) There is only a weak indication for a $K^*\bar{K} + \bar{K}^*K$ mode of the f′(1514). If this mode does not exist, the $K\bar{K}$ branching fraction will have to be reported as 80 ± 13% (rather than 72 ± 12% as given in the table), and $\eta\pi\pi$ as 20 ± 13%.

(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) A possible $\omega\pi\pi$ decay mode of the A3 has mass 1690 MeV and width 80 MeV.

(n) 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. Only the $K_A(1240)$ or C seems well established, whereas possible structures from 1280 to 1400 MeV cannot be disentangled. For the whole Q region the decay rate into $K^*(892)\pi$ is large, and a $K\rho$ decay is seen. The $K\eta$, $K\omega$, and $K\pi$ are less than a few percent.

(o) $K_N(1420)$ properties are uncertain because both principal modes have energy-dependent backgrounds:-$K\pi$ mode: Firestone et al. (LBL 516, subm. Phys. Rev. 1972) find a large S-wave phase shift with $\sin^2\delta_0$ peaking at ≈1350 MeV, which probably caused older experiments to overestimate both Γ and the $K\pi$ branching fraction. Instead of our average of 56%, $K\pi$ fraction could be 40-50%, with other fractions raised accordingly. $K\pi\pi$ mode is contaminated with diffractively produced $Q^{\pm}$.

The tabulated mass of 1421 MeV comes only from charged $K_N(1420) \rightarrow K\pi$ measurements (to avoid $Q^{\pm}$ contamination); the average of the neutral $K_N(1420)$ mass is also 1420 MeV (i.e., $m^0 - m^{\pm} \approx 0$) but see typed note "K*(892) Mass" in Meson Data Card Listings.

(p) We tabulate here Y = 0 bumps with M ≥ 1700 MeV, for which no satisfactory grouping into particles is yet possible. See Meson Data Card Listings.

| Name | $I^G$ | $J^P$ | M (MeV) | Γ (MeV) | Decay modes observed | Tentative grouping |
|---|---|---|---|---|---|---|
| $K\bar{K}(1740)$ | 1 | | 1740 | ≈ 120 | $K^0K^{\pm}$ | R(1750) |
| R3(1750) | 1,2 | | 1748 ± 15 | ≤ 38 | $(MM)^-$ | |
| $\pi\pi(1764)$ | | | 1764 ± 15 | $87^{+14}_{-20}$ | $\pi^+\pi^-$ | |
| $K\bar{K}\pi(1820)$ | 0,1,2 | | 1820 ± 12 | 50 ± 23 | $K_SK^0\pi^0$ | 1830 region |
| R4(1830) | 1,2 | | 1830 ± 15 | ≤ 30 | $(MM)^-$ | |
| $\eta/\rho(1830)$ | + | | 1832 ± 6 | 42 ± 11 | $\pi^+\pi^-\pi^+\pi^-$ | |
| $\phi/\pi(1830)$ | - | | 1848 ± 11 | 67 ± 27 | $\omega\pi^+\pi^-$, possibly $\omega\rho^0$ | |
| $X^-(2086)$ | 1,2 | | 2086 ± 38 | ≈ 150 | $(MM)^-$ backward | ρ(2100) |
| ρ (2120) | $1^+$ | $3^-$(?) | 2120 | < 249 | $\pi^+\pi^-$, $\bar{p}p$ | |
| $\pi\pi(2157)$ | $1^+$ | (odd)- | 2157 ± 10 | 68 ± 22 | $\pi^+\pi^0$ | T region |
| $K\bar{K}\omega(2176)$ | $0^-,1^+$ | | 2176 ± 5 | $20^{+16}_{-2}$ | $K_SK_S\omega$ | |
| $N\bar{N}(2190)$ | $1^-$ | | 2190 | 20-80 | $\rho^0\rho^0\pi^0$, $\bar{p}p$ | Seems to require >1 resonance |
| | 1 | | 2190 ± 10 | ≈ 85 | Structure in $N\bar{N}$ total σ | |
| T (2195) | 1,2 | | 2195 ± 15 | ≤ 13 | $(MM)^-$ | |
| $3\pi(2207)$ | ≤ $3^-$ | | 2207 ± 13 | 62 ± 52 | $\pi^+\pi^-\pi^0$ | |
| $4\pi(2207)$ | $1^+,2^+,3^+$ | | 2207 ± 22 | ≈ 130 | $\rho^-\pi^+\pi^-$ | |
| $X^-(2260)$ | 1,2 | | 2260 ± 18 | ≤ 25 | $(MM)^-$ backward | ρ(2275) |
| ρ (2290) | $1^+$ | $5^-$(?) | 2290 | < 165 | $\pi^+\pi^-$, $\bar{p}p$ | |
| $N\bar{N}(2350)$ | 1 | | 2350 ± 10 | ≈ 140 | Structure in $N\bar{N}$ total σ | U region |
| $X^-(2370)$ | 1,2 | | 2370 ± 17 | ≈ 57 | $(MM)^-$ backward | |
| $N\bar{N}(2375)$ | 0 | | 2375 ± 10 | ≈ 190 | Structure in $N\bar{N}$ total σ | |
| U (2380) | 1,2 | | 2382 ± 24 | < 30 | $(MM)^-$ | |
| $X^-(2500)$ | 1,2 | | 2500 ± 32 | ≈ 87 | $(MM)^-$ backward | |
| $X^-(2620)$ | 1,2 | | 2620 ± 20 | 85 ± 30 | $(MM)^-$ | 2650 region |
| $4\pi(2676)$ | (1,2,3)+ | | 2676 ± 27 | ≈ 150 | $\rho^-\pi^+\pi^-$ | |
| $X^-(2800)$ | 1,2 | | 2800 ± 20 | 46 ± 10 | $(MM)^-$ | 2850 region |
| $X^+(2820)$ | 1,2 | | 2820 ± 10 | 50 ± 10 | $(K\bar{K}\pi\pi)$+ | |
| $X^-(2880)$ | 1,2 | | 2880 ± 20 | ≤ 15 | $(MM)^-$ | |
| $X^+(3013)$ | $1^-$ | | 3013 ± 5 | < 40 | $7\pi$ | 3020 region |
| $X^-(3025)$ | 1,2 | | 3025 ± 20 | ≈ 25 | $(MM)^-$ | |
| NN(3035) | + | | 3035 ± 25 | 200 ± 60 | $4\pi$, $6\pi$ | |
| $X^-(3075)$ | 1,2 | | 3075 ± 20 | ≈ 25 | $(MM)^-$ | |
| $X^-(3145)$ | 1,2 | | 3145 ± 20 | ≤ 10 | $(MM)^-$ | |
| $X^-(3475)$ | 1,2 | | 3475 ± 20 | ≈ 30 | $(MM)^-$ | |
| $X^-(3535)$ | 1,2 | | 3535 ± 20 | ≈ 30 | $(MM)^-$ | |

# Baryon Table

April 1972

[ See notes on N's and Δ's, on possible $Z^{*}$'s, and on $Y^{*}$'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) ⊢⊣ estab. | π or K Beam T(GeV) p(GeV/c) σ = 4πλ̄² (mb) | Mass M[b] (MeV) | Full Width Γ[b] (MeV) | M² ± ΓM[c] (GeV²) | Partial decay mode Mode | Fraction % | p or p_max[d] (MeV/c) |
|---|---|---|---|---|---|---|---|---|
| p | 1/2(1/2⁺) | | 938.3 | | 0.880 | See Stable Particle Table | | |
| n | | | 939.6 | | 0.883 | | | |
| N'(1470) | 1/2(1/2⁺) $P'_{11}$ | T=0.53πp<br>p=0.66<br>σ=27.8 | 1435 to 1505 | 165 to 400 | 2.16 ±0.34 | Nπ<br>Nππ | 60<br>40 | 420<br>368 |
| N'(1520) | 1/2(3/2⁻) $D'_{13}$ | T=0.61<br>p=0.74<br>σ=23.5 | 1510 to 1540 | 105 to 150 | 2.31 ±0.18 | Nπ<br>Nππ<br>[Δ(1236)π][e]<br>Nη | 50<br>50<br>[dominant][e]<br>~0.6 | 456<br>410<br>224 |
| N'(1535) | 1/2(1/2⁻) $S'_{11}$ | T=0.64<br>p=0.76<br>σ=22.5 | 1500 to 1600 | 50 to 160 | 2.36 ±0.18 | Nπ<br>Nη[n]<br>Nππ[n] | 35<br>55<br>~10 | 467<br>182<br>422 |
| N'(1670)[i] | 1/2(5/2⁻) $D'_{15}$ | T=0.87<br>p=1.00<br>σ=15.6 | 1655 to 1680 | 105 to 175 | 2.79 ±0.24 | Nπ<br>Nππ<br>[Δ(1236)π][e]<br>ΛK<br>Nη | 40<br>60<br>[44][e]<br><.3<br><1[j] | 560<br>525<br>357<br>200<br>368 |
| N'(1688)[i] | 1/2(5/2⁺) $F'_{15}$ | T=0.90<br>p=1.03<br>σ=14.9 | 1680 to 1692 | 105 to 180 | 2.85 ±0.21 | Nπ<br>Nππ<br>[Δ(1236)+π][e]<br>ΛK<br>Nη | 60<br>40<br>[26][e]<br><.2<br><.5[j] | 572<br>538<br>371<br>231<br>388 |
| N''(1700)[i] | 1/2(1/2⁻) $S''_{11}$ | T=0.92<br>p=1.05<br>σ=14.3 | 1665 to 1765 | 100 to 400 | 2.89 ±0.42 | Nπ<br>ΛK<br>Nη | -65<br>5 | 580<br>250<br>340 |
| N''(1780)[i] | 1/2(1/2⁺) $P''_{11}$ | T=1.07<br>p=1.20<br>σ=12.2 | 1650 to 1860 | 50 to 450 | 3.17 ±0.51 | Nπ<br>ΛK<br>Nη | 30<br>~7<br>~10[j] | 633<br>353<br>476 |
| N(1860) | 1/2(3/2⁺) $P_{13}$ | T=1.22<br>p=1.36<br>σ=10.4 | 1770 to 1900 | 180 to 330 | 3.46 ±0.57 | Nπ<br>Nππ<br>ΛK<br>Nη | 25<br><br>~5<br>~4[j] | 685<br>657<br>437<br>545 |
| N(2190) | 1/2(7/2⁻) $G_{17}$ | T=1.94<br>p=2.07<br>σ=6.21 | 2000 to 2260 | 270 to 325 | 4.80 ±0.67 | Nπ<br>Nππ | 25 | 888<br>868 |
| N(2220) | 1/2(9/2⁺) $H_{19}$ | T=2.00<br>p=2.14<br>σ=5.97 | 2200 to 2245 | 260 to 330 | 4.93 ±0.65 | Nπ<br>Nππ | 15 | 905<br>887 |
| N(2650) | 1/2( ? ⁻) | T=3.12<br>p=3.26<br>σ=3.67 | 2650 | 360 | 7.02 ±0.95 | Nπ<br>Nππ | (J+1/2)x =0.45[f] | 1154<br>1140 |
| N(3030) | 1/2( ? ) | T=4.27<br>p=4.41<br>σ=2.62 | 3030 | 400 | 9.18 ±1.21 | Nπ<br>Nππ | (J+1/2)x =0.05[f] | 1366<br>1354 |
| Δ'(1236)[m] | 3/2(3/2⁺) $P'_{33}$ | T=0.195 (++)<br>p=0.304<br>σ=91.8 | 1230 to 1236 | 110 to 122 | 1.53 ±0.14 | Nπ<br>Nπ⁺π⁻<br>Nγ | 99.4<br>0<br>~0.6 | 231<br>90<br>262 |
| | | Pole Position[m]: | 1211 | ±i50 | | | | |
| Δ(1650) | 3/2(1/2⁻) $S_{31}$ | T=0.83<br>p=0.96<br>σ=16.4 | 1615 to 1695 | 130 to 200 | 2.72 ±0.28 | Nπ<br>Nππ | 28<br>72 | 547<br>511 |

N →

# Baryon Table *(cont'd)*

| Particle[a] | I (J^P) ⊢⊣ estab. | π or K Beam T(GeV) p(GeV/c) σ = 4πλ² (mb) | Mass M[b] (MeV) | Full Width Γ[b] (MeV) | M² ± ΓM[c] (GeV²) | Partial decay mode: Mode | Fraction % | p or p_max[d] (MeV/c) |
|---|---|---|---|---|---|---|---|---|
| Δ(1670) | 3/2(3/2⁻) $D_{33}$ | T=0.87<br>p=1.00<br>σ=15.6 | 1650 to 1720 | 175 to 300 | 2.79 ±0.40 | Nπ<br>Nππ | 15 | 560<br>525 |
| Δ(1890) | 3/2(5/2⁺) $F_{35}$ | T=1.28<br>p=1.42<br>σ=9.88 | 1840 to 1920 | 135 to 350 | 3.57 ±0.49 | Nπ<br>Nππ | 17 | 704<br>677 |
| Δ(1910) | 3/2(1/2⁺) $P_{31}$ | T=1.33<br>p=1.46<br>σ=9.54 | 1780 to 1935 | 230 to 420 | 3.65 ±0.62 | Nπ<br>Nππ | 25 | 716<br>691 |
| Δ(1950) | 3/2(7/2⁺) $F_{37}$ | T=1.41<br>p=1.54<br>σ=8.90 | 1930 to 1980 | 140 to 220 | 3.80 ±0.39 | Nπ<br>Δ(1236)π<br>ΣK<br>Σ(1385)K | 45<br>≈50<br>~ 2<br>1.4 | 741<br>571<br>460<br>232 |
| Δ(2420) | 3/2(11/2⁺) | T=2.50<br>p=2.64<br>σ=4.68 | 2320 to 2450 | 270 to 350 | 5.86 ±0.75 | Nπ<br>Nππ | 11<br>>20 | 1023<br>1006 |
| Δ(2850) | 3/2( ?⁺ ) | T=3.71<br>p=3.85<br>σ=3.05 | 2850 | 400 | 8.12 ±1.14 | Nπ<br>Nππ | (J+1/2)x =0.25[f] | 1266<br>1254 |
| Δ(3230) | 3/2( ? ) | T=4.94<br>p=5.08<br>σ=2.25 | 3230 | 440 | 10.4 ±1.4 | Nπ<br>Nππ | (J+1/2)x =0.05[f] | 1475<br>1464 |
| Z* | Z* | Evidence for states with hypercharge 2 is controversial. See the Baryon Data Card Listings for discussion and display of data. | | | | | | |
| Λ | 0(1/2⁺) | | 1115.6 | | 1.24 | See Stable Particle Table | | |
| Λ'(1405) | 0(1/2⁻) $S'_{01}$ | p<0 K⁻p | 1405 ±5[g] | 40 ±10[g] | 1.97 ±0.06 | Σπ | 100 | 142 |
| Λ'(1520) | 0(3/2⁻) $D'_{03}$ | p=0.389<br>σ=84.5 | 1518 ±2[g] | 16 ±2[g] | 2.30 ±0.02 | NK̄<br>Σπ<br>Λππ<br>Σππ | 45±1<br>42±1<br>9.6±.7<br>1.0±.1 | 234<br>258<br>250<br>140 |
| Λ''(1670) | 0(1/2⁻) $S''_{01}$ | p=0.74<br>σ=28.5 | 1670 | 15 to 38 | 2.79 ±0.04 | NK̄<br>Λη<br>Σπ | ~20<br>~35<br>~45 | 410<br>64<br>393 |
| Λ''(1690) | 0(3/2⁻) $D''_{03}$ | p=0.78<br>σ=26.1 | 1690 | 27 to 85 | 2.86 0.09 | NK̄<br>Σπ<br>Λππ<br>Σππ | ~20[h]<br>~60<br>~ 2<br>≤18 | 429<br>409<br>415<br>352 |
| Λ'(1815) | 0(5/2⁺) $F'_{05}$ | p=1.05<br>σ=16.7 | 1820 ±5[g] | 64 to 104 | 3.30 ±0.15 | NK̄<br>Σπ<br>Σ(1385)π | 62<br>11<br>4 | 542<br>508<br>362 |
| Λ'(1830) | 0(5/2⁻) $D'_{05}$ | p=1.09<br>σ=15.8 | 1835 | 74 to 150 | 3.37 ±0.20 | NK̄<br>Σπ<br>Λππ | ~10<br>~30<br>~11 | 554<br>519<br>536 |
| Λ(2100) | 0(7/2⁻) $G_{07}$ | p=1.68<br>σ=8.68 | 2100 | 60 to 140 | 4.41 ±0.22 | NK̄<br>Σπ<br>Λη<br>ΞK<br>Λω | 25<br>~ 5<br>< 3<br><10 | 748<br>699<br>617<br>483<br>443 |
| Λ(2350) | 0( ? ) | p=2.29<br>σ=5.85 | 2350 | 140 to 324 | 5.52 ±0.55 | NK̄ | (J+1/2)x =0.7[f] | 913 |

# Baryon Table *(cont'd)*

| Particle[a] | I (J^P) ⊢⊣ estab. | π or K Beam T(GeV) p(GeV/c) σ = 4πλ̄² (mb) | Mass M[b] (MeV) | Full Width Γ[b] (MeV) | M² ± ΓM[c] (GeV²) | Partial decay mode: Mode | Fraction % | p or p_max[d] (MeV/c) |
|---|---|---|---|---|---|---|---|---|
| Σ | 1(1/2⁺) | | (+)1189.4<br>(0)1192.5<br>(-)1197.3 | | 1.41<br>1.42<br>1.43 | See Stable Particle Table | | |
| Σ'(1385) | 1(3/2⁺)P'₁₃ | p<0 K⁻p | (+)1383±1<br>S=1.3*<br>(-)1386±2<br>S=2.2* | (+)36±3<br>S=1.9*<br>(-)36±6<br>S=3.5*! | 1.92<br>±0.05 | Λπ<br>Σπ | 89±5<br>11±5<br>S=1.9* | 208<br>117 |
| Σ'(1670)[k] | 1(3/2⁻) D'₁₃ | p=0.74<br>σ=28.5 | 1670 | 50 | 2.79<br>±0.08 | NK̄<br>Σπ<br>Λπ<br>Σππ<br>[Λ(1405)π][e]<br>Λππ | ~8 | 410<br>387<br>447<br>326<br>207<br>397 |
| | Mass, width and elasticity are the values obtained in partial wave analyses for a D₁₃ resonance. For more results see the Baryon Data Card Listings and footnote k. | | | | | | | |
| Σ''(1750) | 1(1/2⁻) S''₁₁ | p=0.91<br>σ=20.7 | 1750 | 50 to 80 | 3.06<br>±0.11 | NK̄<br>Λπ<br>Ση | ~15<br>seen<br>seen | 483<br>507<br>54 |
| Σ(1765) | 1(5/2⁻) D₁₅ | p=0.94<br>σ=19.6 | 1765 ±5[g] | ~120 | 3.12<br>±0.21 | NK̄<br>Λπ<br>Λ(1520)π<br>Σ(1385)π<br>Σπ | ~42<br>~15<br>~14<br>~4<br>~1 | 496<br>518<br>187<br>315<br>461 |
| Σ'(1915)[i] | 1(5/2⁺) F'₁₅ | p=1.25<br>σ=13.0 | 1910 | 70 | 3.65<br>±0.13 | NK̄<br>Λπ<br>Σπ | ~11 | 612<br>619<br>568 |
| | Formation and production experiments do not agree on Σπ/Λπ ratio. | | | | | | | |
| Σ(2030) | 1(7/2⁺) F₁₇ | p=1.52<br>σ=9.93 | 2030 | 100 to 170 | 4.12<br>±0.27 | NK̄<br>Λπ<br>Σπ<br>ΞK | ~20<br>~20<br>~3<br>< 2 | 700<br>700<br>652<br>412 |
| Σ(2250) | 1( ? )<br>– | p=2.04<br>σ=6.76 | 2250 | 100 to 230 | 5.06<br>±0.37 | NK̄<br>Σπ<br>Λπ | (J+1/2)x =0.3[f] | 849<br>842<br>799 |
| Σ(2455) | 1( ? )<br>– | p=2.57<br>σ=5.09 | 2455 | ~120 | 6.03<br>±0.29 | NK̄ | (J+1/2)x =0.2[f] | 979 |
| Σ(2620) | 1( ? )<br>– | p=2.95<br>σ=4.30 | 2620 | ~175 | 6.86<br>±0.46 | NK̄ | (J+1/2)x =0.3[f] | 1064 |
| Ξ[ℓ] | 1/2(1/2⁺) | | (0)1314.7<br>(-)1321.3 | | 1.73<br>1.75 | See Stable Particle Table | | |
| Ξ(1530)[ℓ] | 1/2(3/2⁺)<br>p-wave | (0) 1531.3±0.5<br>S=1.4*<br>(-) 1535.8±1.0 | (0) 9.2±0.8<br>(-) 16.2±4.6 | | 2.34<br>±0.01 | Ξπ | 100 | 144 |
| Ξ(1820)[ℓ] | 1/2( ? ) | | 1795 to 1870 | 12 to 99 | 3.31<br>±0.10 | ΛK̄<br>Ξπ<br>Ξ(1530)π<br>ΣK̄ | | 396<br>413<br>234<br>306 |
| | All four decay modes have been seen. Branching ratios not quoted because there may be more than one state here. | | | | | | | |
| Ξ(1940)[ℓ] | 1/2( ? ) | | 1894 to 1961 | 42 to 140 | 3.72<br>±0.18 | Ξπ<br>Ξ(1530)π | | 499<br>336 |
| | Seen in both final states; not clear if one, or more, states present. | | | | | | | |
| Ω⁻ | 0(3/2⁺) | | 1672.5 | | 2.80 | See Stable Particle Table | | |

Σ

Ξ

# Baryon Table *(cont'd)*

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

→ An arrow at the left of the Table indicates a candidate that has been omitted because the evidence for the existence of the effect and (or) for its interpretation as a resonance is open to considerable question. See the Baryon Data Card Listings for information on the following: N(1700) $D''_{13}$, N(1990) $F_{17}$, N(2040) $D'''_{13}$, N(2100) $S'''_{11}$, N(2100) $D''_{15}$, N(2175) $F''_{15}$, N(3245), N(3690), N(3755), Δ(1690) $P''_{33}$, Δ(1960) $D_{35}$, Δ(2160) $P'''_{33}$, $Z_0$(1780), $Z_0$(1865), $Z_1$(1900), Λ(1330), Λ(1750) $P_{01}$, Λ(1860) $P_{03}$, Λ(1870) $S'''_{01}$, Λ(2010) $D'''_{03}$, Λ(2020) $F_{07}$, Λ(2110) $F''_{05}$ or $D''_{05}$, Λ(2585), Σ(1440), Σ(1480), Σ(1620) $S'_{11}$, Σ(1620) $P'_{11}$ , Σ(1670)[k], Σ(1690), Σ(1880) $P''_{11}$, Σ(1940) $D''_{13}$, Σ(2070) $F''_{15}$, Σ(2080) $P''_{13}$, Σ(2100) $G_{17}$, Σ(3000), Ξ(1630), Ξ(2030), Ξ(2250), Ξ(2500).

a. For the baryon states, the name [such as N'(1470)] contains the mass, which may be different for each new analysis. The value chosen is the rounded average from Table I of the note on N's and Δ's in the Baryon Data Card Listings. For $Y^*$'s and $\Xi^*$'s, the mass is an educated guess obtained by looking at the reported values. The convention for using primes in the names is as follows: when there is more than one resonance on a given Argand diagram, the first has been designated with a prime, the second with a double prime, etc. The name (col. 1) is the same as can be found in large print in the Baryon Data Card Listings.

b. See note on N's and Δ's in the Baryon Data Card Listings. 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 here where the spread in parameters arises because different models or procedures have been applied to a common set of data. Where only one value is given it is either because only one experiment reports that state or because the various experiments agree. An error is quoted only when the various experiments averaged have taken into account the systematic errors.

c. For this column M is the rounded average which also appears in the name column. For the N's and Δ's, Γ is the average quoted on Table II of the N's and Δ's note in the Baryon Data Card Listings; for the $Y^*$'s and $\Xi^*$'s, Γ is taken as the center of the interval given in the column labeled "Γ".

d. 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 using the averaged central mass values, without taking into account the widths of the resonances.

e. Square brackets indicate a sub-reaction of the previous unbracketed decay mode.

f. This state has been seen only in total cross sections. J is not known; x is $\Gamma_{el}/\Gamma$.

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

h. In previous editions we quoted a larger elasticity. It was required by unitarity because of the large value of $x \cdot x_e$ for the Λππ decay. A partial wave analysis of new data of the Λππ channel yields smaller values of $x \cdot x_e$ allowing a smaller elasticity, which is more consistent with partial-wave analysis in the elastic channel.

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

j. Value obtained in an energy-dependent partial-wave analysis which uses a t-channel-poles-plus-resonance parametrization. The values of the couplings obtained for the resonances may be affected by double counting.

k. In this energy region the situation is still confused. Formation experiments suggest two states: $P_{11}$(1620) decaying mainly into Σπ, and $D_{13}$(1670) with branching fractions Σπ(40%), Λπ(10%), Σππ (< 14%). Production experiments report four states: Σ(1620) seen only in the Λπ mode, $\Sigma_1$(1660) with appreciable Λπ and Σπ modes. $\Sigma_2$(1660) with main decay mode Λ(1405) + π (that is, Σππ), and Σ(1690) seen in the Λπ mode. Of these four, $\Sigma_1$ and $\Sigma_2$ seem to be on firmer ground than the other two and both seem to have $J^P = 3/2^-$ like the $D_{13}$(1670) seen in formation experiments. Two resonances of the same spin and parity have been hypothesized as the origin of much of the complexity observed in production experiments. With the addition of the $P_{11}$(1620), there are three candidates that eventually might be required to clarify the situation.

ℓ. Only Ξ(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 Ξ(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.

m. See note on Δ(1236) in the Baryon Data Card Listings. Values of mass and width are dependent upon resonance shape used to fit the data. The pole position appears to be much less dependent upon the parametrization used.

n. The preliminary results of DIEM 70 quoted in the Baryon Data Card Listings have been revised so that they are now in agreement with the values quoted in the present table (G. Smadja, private communication).

# PHYSICAL AND NUMERICAL CONSTANTS*

## PHYSICAL CONSTANTS

| | | |
|---|---|---|
| $N$ | = | $6.022169(40)\times10^{23}$ mole$^{-1}$ (based on $A_{C12} = 12$) |
| $c$ | = | $2.9979250(10)\times10^{10}$ cm sec$^{-1}$ |
| $e$ | = | $4.803250(21)\times10^{-10}$ esu $= 1.6021917(70)\times10^{-19}$ coulomb |
| 1 MeV | = | $1.6021917(70)\times10^{-6}$ erg |
| $\hbar$ | = | $6.582183(22)\times10^{-22}$ MeV sec |
| | = | $1.0545919(80)\times10^{-27}$ erg sec |
| $\hbar c$ | = | $1.9732891(66)\times10^{-11}$ MeV cm $= 197.32891(66)$ MeV fermi |
| | = | $0.6240088(21)$ GeV mb$^{1/2}$ |
| $\alpha$ | = | $e^2/\hbar c = 1/137.03602(21)$ |
| $k_{Boltzmann}$ | = | $1.380622(59)\times10^{-16}$ erg K$^{-1}$ |
| | = | $8.61708(37)\times10^{-11}$ MeV K$^{-1}$ = 1 eV/11604.85(49)K |
| $m_e$ | = | $0.5110041(16)$ MeV $= 9.109558(54)\times10^{-31}$ kg |
| $m_p$ | = | $938.2592(52)$ MeV $= 1836.109(11)\, m_e = 6.72211(63) m_{\pi^\pm}$ |
| | = | $1.00727661(8) m_1$ (where $m_1 = 1$ amu $= \frac{1}{12} m_{C12} = 931.4812(52)$MeV) |
| $r_e$ | = | $e^2/m_e c^2 = 2.817939(13)$ fermi (1 fermi $= 10^{-13}$cm) |
| $\lambdabar_e$ | = | $\hbar/m_e c = r_e \alpha^{-1} = 3.861592(12)\times10^{-11}$cm |
| $a_\infty$ Bohr | = | $\hbar^2/m_e e^2 = r_e \alpha^{-2} = 0.52917715(81)$A (1A $= 10^{-8}$cm) |
| $\sigma_{Thomson}$ | = | $\frac{8}{3}\pi r_e^2 = 0.6652453(61)\times10^{-24}$cm$^2$ = 0.6652453(61) barns |
| $\mu_{Bohr}$ | = | $e\hbar/2m_e c = 0.5788381(18)\times10^{-14}$ MeV gauss$^{-1}$ |
| $\mu_{nucleon}$ | = | $e\hbar/2m_p c = 3.152526(21)\times10^{-18}$ MeV gauss$^{-1}$ |
| $\frac{1}{2}\omega^e_{cyclotron}$ | = | $e/2m_e c = 8.794014(27)\times10^6$ rad sec$^{-1}$ gauss$^{-1}$ |
| $\frac{1}{2}\omega^p_{cyclotron}$ | = | $e/2m_p c = 4.789484(27)\times10^3$ rad sec$^{-1}$ gauss$^{-1}$ |

Hydrogen-like atom (nonrelativistic, $\mu$ = reduced mass):

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

$R_\infty = m_e e^4/2\hbar^2 = m_e c^2 \alpha^2/2 = 13.605826(45)$ eV (Rydberg)

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

| | | |
|---|---|---|
| 1 year (sidereal) | = | 365.256 days $= 3.1558\times10^7$ sec ($\approx \pi\times10^7$ 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 | = | $6.6732(31)\times10^{-8}$ cm$^3$g$^{-1}$sec$^{-2}$ |
| 1 calorie (thermochemical) | = | 4.184 joules |
| 1 atmosphere | = | 1033.2275 g cm$^{-2}$ |
| 1 eV per particle | = | 11604.85(49) °K (from $E = kT$) |

## NUMERICAL CONSTANTS

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

*Compiled by Stanley J. Brodsky, based mainly on the adjustment of the fundamental physical constants by B. N. Taylor, W. H. Parker, and D. N. Langenberg, Rev. Mod. Phys. 41, 375 (1969). The figures in parentheses correspond to the 1 standard deviation uncertainty in the last digits of the main number.

# CLEBSCH-GORDAN COEFFICIENTS AND SPHERICAL HARMONICS

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

Notation:

| J | J | ... |
|---|---|---|
| M | M | ... |
| $m_1$ | $m_2$ | |
| $m_1$ | $m_2$ | Coefficients |
| . | . | |
| . | . | |

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

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

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

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

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

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

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

**1/2 × 1/2**

| J | M | $m_1$ | $m_2$ | Coefficients |
|---|---|---|---|---|
| 1 | +1 | +1/2 | +1/2 | 1 |
| 1 | 0 | +1/2 | -1/2 | 1/2 |
| | | -1/2 | +1/2 | 1/2 |
| 0 | 0 | +1/2 | -1/2 | 1/2 |
| | | -1/2 | +1/2 | -1/2 |
| 1 | -1 | -1/2 | -1/2 | 1 |

**1 × 1/2**

| J | M | $m_1$ | $m_2$ | Coefficients |
|---|---|---|---|---|
| 3/2 | +3/2 | +1 | +1/2 | 1 |
| 1/2 | +1/2 | +1 | -1/2 | 1/3 |
| | | 0 | +1/2 | 2/3 |
| | | 0 | -1/2 | 2/3 |
| | | -1 | +1/2 | 1/3 |
| 1/2 | -1/2 | -1 | -1/2 | 2/3 |
| | | 0 | -1/2 | 1/3 |
| 3/2 | -3/2 | -1 | -1/2 | 1 |

**2 × 1/2**

| J | M | $m_1$ | $m_2$ | Coefficients |
|---|---|---|---|---|
| 5/2 | +5/2 | +2 | +1/2 | 1 |
| 3/2 | +3/2 | +2 | -1/2 | 1/5 |
| | | +1 | +1/2 | 4/5 |
| 3/2 | +1/2 | +2 | -3/2 | 4/5 |
| | | +1 | -1/2 | 1/5 |
| | | 0 | +1/2 | 2/5 |
| 1/2 | +1/2 | +1 | -3/2 | 3/5 |
| | | 0 | -1/2 | 3/5 |
| | | -1 | +1/2 | 2/5 |
| 1/2 | -1/2 | 0 | -3/2 | 3/5 |
| | | -1 | -1/2 | 2/5 |
| 3/2 | -3/2 | -1 | -3/2 | 4/5 |
| | | -2 | +1/2 | 1/5 |
| 5/2 | -5/2 | -2 | -1/2 | 1 |

**3/2 × 1/2**

| J | M | $m_1$ | $m_2$ | Coefficients |
|---|---|---|---|---|
| 2 | +2 | +3/2 | +1/2 | 1 |
| 1 | +1 | +3/2 | -1/2 | 1/4 |
| | | +1/2 | +1/2 | 3/4 |
| 1 | 0 | +3/2 | -3/2 | 2 |
| | | +1/2 | -1/2 | 0 |
| | | -1/2 | +1/2 | 0 |
| 1 | -1 | +1/2 | -3/2 | 1/2 |
| | | -1/2 | -1/2 | 1/2 |
| | | -3/2 | +1/2 | 1/2 |
| 2 | -2 | -1/2 | -3/2 | 3/4 |
| | | -3/2 | +1/2 | 1/4 |
| 3/2 | -3/2 | -3/2 | -1/2 | 1 |

**2 × 1**

| J | M | $m_1$ | $m_2$ | Coefficients |
|---|---|---|---|---|
| 3 | +3 | +2 | +1 | 1 |
| 2 | +2 | +2 | +2 | 1/3 |
| | | +1 | +1 | 2/3 |
| 2 | +1 | +2 | -1 | 1/15 |
| | | +1 | 0 | 8/15 |
| | | 0 | +1 | 6/15 |
| 1 | 0 | +1 | -1 | 1/5 |
| | | 0 | 0 | 3/5 |
| | | -1 | +1 | 1/5 |
| 0 | 0 | +2 | -1 | 1/3 |
| | | +1 | 0 | 1/3 |
| | | 0 | +1 | 1/3 |
| 1 | -1 | +1 | -2 | 1/6 |
| | | 0 | -1 | 2/3 |
| | | -1 | +1 | 1/6 |
| 2 | -2 | 0 | -2 | 1/2 |
| | | -1 | -1 | 1/2 |
| 3 | -3 | -1 | -2 | 1 |

**3/2 × 1**

| J | M | $m_1$ | $m_2$ | Coefficients |
|---|---|---|---|---|
| 5/2 | +5/2 | +3/2 | +1 | 1 |
| 3/2 | +3/2 | +3/2 | 0 | 2/5 |
| | | +1/2 | +1 | 3/5 |
| 3/2 | +1/2 | +3/2 | -1 | 1/10 |
| | | +1/2 | 0 | 3/5 |
| | | -1/2 | +1 | 3/10 |
| 1/2 | -1/2 | +3/2 | -2 | 1/10 |
| | | +1/2 | -1 | 3/10 |
| | | -1/2 | 0 | 3/5 |
| | | -3/2 | +1 | 1/10 |
| 3/2 | -3/2 | +1/2 | -2 | 1/2 |
| | | -1/2 | -1 | 3/10 |
| | | -3/2 | 0 | 3/5 |
| 5/2 | -5/2 | -1/2 | -2 | 1/2 |
| | | -3/2 | -1 | 1/2 |
| 3 | -3 | -3/2 | -2 | 1 |

**1 × 1**

| J | M | $m_1$ | $m_2$ | Coefficients |
|---|---|---|---|---|
| 2 | +2 | +1 | +1 | 1 |
| 1 | +1 | +1 | 0 | 1/2 |
| | | 0 | +1 | 1/2 |
| 1 | 0 | +1 | -1 | 1/2 |
| | | 0 | 0 | 0 |
| | | -1 | +1 | 1/2 |
| 0 | 0 | +1 | -1 | 1/3 |
| | | 0 | 0 | 1/3 |
| | | -1 | +1 | 1/3 |
| 1 | -1 | 0 | -1 | 1/2 |
| | | -1 | 0 | 1/2 |
| 2 | -2 | -1 | -1 | 1 |

## SU(3) CONVENTIONS

for Isoscalar Factor Table on next page

Since January 1970 we have used the convention that the first particle shall be a baryon, the second a meson (R. Levi Setti, Proceedings of Lund Conference, 1969, p. 339 and Table II). Note, for comparison, that the de Swart table of 8×8 is merely labeled with symbols like ($I_1 = 1/2$, $Y_1 = 1$, $I_2 = 1$, $Y_2 = 0$), which can be read either as ($N\pi$) or ($K\Sigma$). Since there are no decuplet mesons, however, his 8×10 table is unambiguous; it must be read with the meson first.

The de Swart convention violates the other convention that the $N, N\pi$ coupling shall be D + F (as opposed to -D + F). To get D + F one must use the first line of the "N" table, which reads. . . $3\sqrt{5}/10\,|8_D\rangle + 1/2\,|8_F\rangle$ as opposed to. . . $-3\sqrt{5}/10\,|8_D\rangle + 1/2\,|8_F\rangle$. The first line must then be labeled $N\pi$ rather than $K\Sigma$, i.e., with the baryon first.

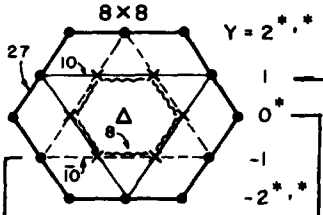
Levi Setti further advocates the convention of writing the baryon first for SU(2) as well as SU(3). For example, the sign of the amplitudes as plotted on his and our Argand plots comes from using our SU(2) Clebsch-Gordan coefficients (Condon Shortley notation) and writing the baryon first. To make it easier to abide by this universal convention we have changed de Swart's 8×10 (SU(3) table to 10×8, with the help of his Eq. (14.3):

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

# SU(3) ISOSCALAR FACTORS

Adapted from J. J. de Swart, Rev. Mod. Phys. 35, 916 (1963)
(See note on previous page concerning conventions)

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




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

| $\xi_1 \rightarrow$ | $27_+$ | $8_{+D}$ | $8_{-F}$ | $10^*_-$ |
|---|---|---|---|---|
| $N\pi$ | $\sqrt{5}/10$ | $3\sqrt{5}/10$ | $1/2$ | $-1/2$ |
| $\Sigma K$ | $-\sqrt{5}/10$ | $-3\sqrt{5}/10$ | $1/2$ | $-1/2$ |
| $N\eta$ | $3\sqrt{5}/10$ | $-\sqrt{5}/10$ | $1/2$ | $1/2$ |
| $\Lambda K$ | $3\sqrt{5}/10$ | $-\sqrt{5}/10$ | $-1/2$ | $-1/2$ |

$Y = 1 \quad I = 3/2$ Δ

| $\xi_1 \rightarrow$ | $27_+$ | $10_-$ |
|---|---|---|
| $N\pi$ | $\sqrt{2}/2$ | $-\sqrt{2}/2$ |
| $\Sigma K$ | $\sqrt{2}/2$ | $\sqrt{2}/2$ |

$Y = 0 \quad I = 0$ Λ

| $\xi_1 \rightarrow$ | $27_+$ | $8_{+D}$ | $1_+$ | $8_{-F}$ |
|---|---|---|---|---|
| $N\bar{K}$ | $\sqrt{15}/10$ | $\sqrt{10}/10$ | $1/2$ | $\sqrt{2}/2$ |
| $\Xi K$ | $-\sqrt{15}/10$ | $-\sqrt{10}/10$ | $-1/2$ | $\sqrt{2}/2$ |
| $\Sigma\pi$ | $-\sqrt{10}/20$ | $-\sqrt{15}/5$ | $\sqrt{6}/4$ | $0$ |
| $\Lambda\eta$ | $3\sqrt{30}/20$ | $-\sqrt{5}/5$ | $-\sqrt{2}/4$ | $0$ |

$Y = 0 \quad I = 1$ Σ

| $\xi_1 \rightarrow$ | $27_+$ | $8_{+D}$ | $8_{-F}$ | $10_-$ | $10^*_-$ |
|---|---|---|---|---|---|
| $N\bar{K}$ | $\sqrt{5}/5$ | $-\sqrt{30}/10$ | $\sqrt{6}/6$ | $-\sqrt{6}/6$ | $\sqrt{6}/6$ |
| $\Xi K$ | $\sqrt{5}/5$ | $-\sqrt{30}/10$ | $-\sqrt{6}/6$ | $\sqrt{6}/6$ | $-\sqrt{6}/6$ |
| $\Sigma\pi$ | $0$ | $0$ | $\sqrt{6}/3$ | $\sqrt{6}/6$ | $-\sqrt{6}/6$ |
| $\Sigma\eta$ | $\sqrt{30}/10$ | $\sqrt{5}/5$ | $0$ | $1/2$ | $1/2$ |
| $\Lambda\pi$ | $\sqrt{30}/10$ | $\sqrt{5}/5$ | $0$ | $-1/2$ | $-1/2$ |

$Y = -1 \quad I = 1/2$ Ξ

| $\xi_1 \rightarrow$ | $27_+$ | $8_{+D}$ | $8_{-F}$ | $10_-$ |
|---|---|---|---|---|
| $\Xi\pi$ | $-\sqrt{5}/10$ | $-3\sqrt{5}/10$ | $1/2$ | $1/2$ |
| $\Sigma\bar{K}$ | $\sqrt{5}/10$ | $3\sqrt{5}/10$ | $1/2$ | $1/2$ |
| $\Xi\eta$ | $3\sqrt{5}/10$ | $-\sqrt{5}/10$ | $-1/2$ | $1/2$ |
| $\Lambda\bar{K}$ | $3\sqrt{5}/10$ | $-\sqrt{5}/10$ | $1/2$ | $-1/2$ |

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

| $\xi_1 \rightarrow$ | $27_+$ | $10^*_-$ |
|---|---|---|
| $\Xi\pi$ | $\sqrt{2}/2$ | $-\sqrt{2}/2$ |
| $\Sigma\bar{K}$ | $\sqrt{2}/2$ | $\sqrt{2}/2$ |

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

| $\xi_1 \rightarrow$ | $27_-$ | $8_+$ |
|---|---|---|
| $\Delta\pi$ | $-\sqrt{5}/5$ | $-2\sqrt{5}/5$ |
| $\Sigma K$ | $-2\sqrt{5}/5$ | $\sqrt{5}/5$ |

$Y = 1 \quad I = 3/2$ Δ

| $\xi_1 \rightarrow$ | $35_+$ | $27_-$ | $10_-$ |
|---|---|---|---|
| $\Delta\pi$ | $1/4$ | $-\sqrt{5}/4$ | $\sqrt{10}/4$ |
| $\Delta\eta$ | $\sqrt{5}/4$ | $3/4$ | $\sqrt{2}/4$ |
| $\Sigma K$ | $\sqrt{10}/4$ | $-\sqrt{2}/4$ | $-1/2$ |

$Y = 0 \quad I = 0$ Λ

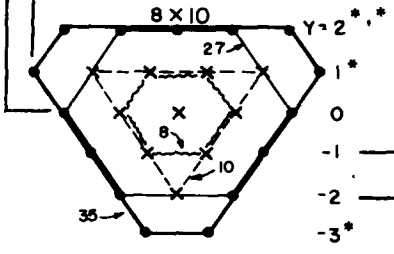
| $\xi_1 \rightarrow$ | $27_-$ | $8_+$ |
|---|---|---|
| $\Sigma\pi$ | $-\sqrt{10}/5$ | $-\sqrt{15}/5$ |
| $\Xi K$ | $-\sqrt{15}/5$ | $\sqrt{10}/5$ |

$Y = 0 \quad I = 1$ Σ

| $\xi_1 \rightarrow$ | $35_+$ | $27_-$ | $10_-$ | $8_+$ |
|---|---|---|---|---|
| $\Sigma\pi$ | $\sqrt{3}/6$ | $-3\sqrt{5}/10$ | $\sqrt{3}/3$ | $-\sqrt{30}/15$ |
| $\Sigma\eta$ | $\sqrt{2}/2$ | $\sqrt{30}/10$ | $0$ | $-\sqrt{5}/5$ |
| $\Xi K$ | $\sqrt{3}/3$ | $-\sqrt{5}/5$ | $-\sqrt{3}/3$ | $\sqrt{30}/15$ |
| $\Delta\bar{K}$ | $\sqrt{3}/6$ | $\sqrt{5}/10$ | $\sqrt{3}/3$ | $2\sqrt{30}/15$ |

$Y = 0 \quad I = 2$

| $\xi_1 \rightarrow$ | $35_+$ | $27_-$ |
|---|---|---|
| $\Sigma\pi$ | $\sqrt{3}/2$ | $-1/2$ |
| $\Delta\bar{K}$ | $1/2$ | $\sqrt{3}/2$ |




Multiplicity of 35;

● = 1, × = 2

$Y = -1 \quad I = 1/2$ Ξ

| $\xi_1 \rightarrow$ | $35_+$ | $27_-$ | $10_-$ | $8_+$ |
|---|---|---|---|---|
| $\Xi\pi$ | $1/4$ | $-7\sqrt{5}/20$ | $\sqrt{2}/4$ | $-\sqrt{5}/5$ |
| $\Xi\eta$ | $3/4$ | $3\sqrt{5}/20$ | $-\sqrt{2}/4$ | $-\sqrt{5}/5$ |
| $\Omega K$ | $\sqrt{2}/4$ | $-3\sqrt{10}/20$ | $-1/2$ | $\sqrt{10}/5$ |
| $\Sigma\bar{K}$ | $1/2$ | $\sqrt{5}/10$ | $\sqrt{2}/2$ | $\sqrt{5}/5$ |

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

| $\xi_1 \rightarrow$ | $35_+$ | $27_-$ |
|---|---|---|
| $\Xi\pi$ | $\sqrt{2}/2$ | $-\sqrt{2}/2$ |
| $\Sigma\bar{K}$ | $\sqrt{2}/2$ | $\sqrt{2}/2$ |

$Y = -2 \quad I = 0$ $\Omega^-$

| $\xi_1 \rightarrow$ | $35_+$ | $10_-$ |
|---|---|---|
| $\Omega\eta$ | $\sqrt{2}/2$ | $-\sqrt{2}/2$ |
| $\Xi\bar{K}$ | $\sqrt{2}/2$ | $\sqrt{2}/2$ |

$Y = -2 \quad I = 1$

| $\xi_1 \rightarrow$ | $35_+$ | $27_-$ |
|---|---|---|
| $\Omega\pi$ | $1/2$ | $-\sqrt{3}/2$ |
| $\Xi\bar{K}$ | $\sqrt{3}/2$ | $1/2$ |

# C.M. ENERGY AND MOMENTUM VS. BEAM MOMENTUM

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

| PBEAM (MEV/C) | -----C.M. ENERGY------ (MEV) | | | | -MOMENTUM IN C.M.-- (MEV/C) | | | |
|---|---|---|---|---|---|---|---|---|
| | γp ep | πp | Kp | pp | γp ep | πp | Kp | pp |
| 0 | 939 | 1078 | 1432 | 1877 | 0 | 0 | 0 | 0 |
| 20 | 958 | 1079 | 1432 | 1877 | 20 | 17 | 13 | 10 |
| 40 | 977 | 1083 | 1433 | 1877 | 38 | 35 | 26 | 20 |
| 60 | 996 | 1089 | 1434 | 1877 | 56 | 52 | 39 | 30 |
| 80 | 1015 | 1096 | 1436 | 1878 | 74 | 68 | 52 | 40 |
| | | T(PI) = PBEAM - 59 MEV | | | | | | |
| 100 | 1033 | 1105 | 1439 | 1879 | 91 | 85 | 65 | 50 |
| 120 | 1051 | 1116 | 1441 | 1880 | 107 | 101 | 78 | 60 |
| 140 | 1069 | 1127 | 1445 | 1882 | 123 | 117 | 91 | 70 |
| 160 | 1087 | 1139 | 1449 | 1883 | 138 | 132 | 104 | 80 |
| 180 | 1104 | 1152 | 1453 | 1885 | 153 | 147 | 116 | 90 |
| | | T(PI) = PBEAM - 92 MEV | | | | | | |
| 200 | 1121 | 1165 | 1457 | 1887 | 167 | 161 | 129 | 99 |
| 220 | 1137 | 1178 | 1462 | 1889 | 182 | 175 | 141 | 109 |
| 240 | 1154 | 1192 | 1468 | 1892 | 195 | 189 | 153 | 119 |
| 260 | 1170 | 1206 | 1474 | 1894 | 209 | 202 | 166 | 129 |
| 280 | 1186 | 1219 | 1480 | 1897 | 222 | 215 | 178 | 138 |
| | | T(PI) = PBEAM - 107 MEV | | | | | | |
| 300 | 1201 | 1233 | 1486 | 1900 | 234 | 228 | 189 | 148 |
| 320 | 1217 | 1247 | 1493 | 1903 | 247 | 241 | 201 | 158 |
| 340 | 1232 | 1261 | 1500 | 1906 | 259 | 253 | 213 | 167 |
| 360 | 1247 | 1274 | 1507 | 1910 | 271 | 265 | 224 | 177 |
| 380 | 1262 | 1288 | 1514 | 1913 | 282 | 277 | 235 | 186 |
| | | T(PI) = PBEAM - 115 MEV | | | | | | |
| 400 | 1277 | 1302 | 1522 | 1917 | 294 | 288 | 247 | 196 |
| 420 | 1292 | 1315 | 1530 | 1921 | 305 | 300 | 258 | 205 |
| 440 | 1306 | 1329 | 1538 | 1925 | 316 | 311 | 268 | 214 |
| 460 | 1320 | 1342 | 1546 | 1929 | 327 | 322 | 279 | 224 |
| 480 | 1335 | 1356 | 1554 | 1933 | 337 | 332 | 290 | 233 |
| | | T(PI) = PBEAM - 120 MEV | | | | | | |
| 500 | 1349 | 1369 | 1563 | 1938 | 348 | 343 | 300 | 242 |
| 520 | 1362 | 1382 | 1572 | 1943 | 358 | 353 | 310 | 251 |
| 540 | 1376 | 1395 | 1580 | 1947 | 368 | 363 | 321 | 260 |
| 560 | 1390 | 1408 | 1589 | 1952 | 378 | 373 | 331 | 269 |
| 580 | 1403 | 1421 | 1598 | 1957 | 388 | 383 | 341 | 278 |
| | | T(PI) = PBEAM - 123 MEV | | | | | | |
| 600 | 1416 | 1434 | 1607 | 1962 | 397 | 393 | 350 | 287 |
| 620 | 1430 | 1446 | 1616 | 1967 | 407 | 402 | 360 | 296 |
| 640 | 1443 | 1459 | 1625 | 1973 | 416 | 412 | 370 | 304 |
| 660 | 1456 | 1472 | 1634 | 1978 | 425 | 421 | 379 | 313 |
| 680 | 1468 | 1484 | 1644 | 1984 | 434 | 430 | 388 | 322 |
| | | T(PI) = PBEAM - 125 MEV | | | | | | |
| 700 | 1481 | 1496 | 1653 | 1989 | 443 | 439 | 397 | 330 |
| 720 | 1494 | 1509 | 1662 | 1995 | 452 | 448 | 406 | 339 |
| 740 | 1506 | 1521 | 1671 | 2001 | 461 | 457 | 415 | 347 |
| 760 | 1519 | 1533 | 1681 | 2007 | 470 | 465 | 424 | 355 |
| 780 | 1531 | 1545 | 1690 | 2013 | 478 | 474 | 433 | 364 |
| | | T(PI) = PBEAM - 127 MEV | | | | | | |
| 800 | 1543 | 1557 | 1699 | 2019 | 486 | 482 | 442 | 372 |
| 820 | 1555 | 1569 | 1709 | 2025 | 495 | 490 | 450 | 380 |
| 840 | 1567 | 1580 | 1718 | 2031 | 503 | 499 | 459 | 388 |
| 860 | 1579 | 1592 | 1728 | 2037 | 511 | 507 | 467 | 396 |
| 880 | 1591 | 1604 | 1737 | 2043 | 519 | 515 | 475 | 404 |
| | | T(PI) = PBEAM - 129 MEV | | | | | | |
| 900 | 1603 | 1615 | 1747 | 2049 | 527 | 523 | 483 | 412 |
| 920 | 1615 | 1627 | 1756 | 2056 | 535 | 531 | 492 | 420 |
| 940 | 1626 | 1638 | 1765 | 2062 | 542 | 538 | 500 | 428 |
| 960 | 1638 | 1649 | 1775 | 2069 | 550 | 546 | 508 | 435 |
| 980 | 1649 | 1661 | 1784 | 2075 | 558 | 554 | 515 | 443 |
| | | T(PI) = PBEAM - 130 MEV | | | | | | |
| 1000 | 1660 | 1672 | 1794 | 2082 | 565 | 561 | 523 | 451 |
| 1020 | 1672 | 1683 | 1803 | 2088 | 573 | 569 | 531 | 458 |
| 1040 | 1683 | 1694 | 1812 | 2095 | 580 | 576 | 538 | 466 |
| 1060 | 1694 | 1705 | 1822 | 2102 | 587 | 583 | 546 | 473 |
| 1080 | 1705 | 1716 | 1831 | 2108 | 594 | 591 | 553 | 481 |
| | | T(PI) = PBEAM - 131 MEV | | | | | | |
| 1100 | 1716 | 1726 | 1840 | 2115 | 601 | 598 | 561 | 488 |
| 1120 | 1727 | 1737 | 1850 | 2122 | 609 | 605 | 568 | 495 |
| 1140 | 1738 | 1748 | 1859 | 2129 | 616 | 612 | 575 | 502 |
| 1160 | 1748 | 1758 | 1868 | 2135 | 622 | 619 | 583 | 510 |
| 1180 | 1759 | 1769 | 1877 | 2142 | 629 | 626 | 590 | 517 |
| | | T(PI) = PBEAM - 131 MEV | | | | | | |
| 1200 | 1770 | 1780 | 1887 | 2149 | 636 | 633 | 597 | 524 |
| 1220 | 1780 | 1790 | 1896 | 2156 | 643 | 639 | 604 | 531 |
| 1240 | 1791 | 1800 | 1905 | 2163 | 650 | 646 | 611 | 538 |
| 1260 | 1801 | 1811 | 1914 | 2170 | 656 | 653 | 618 | 545 |
| 1280 | 1812 | 1821 | 1923 | 2177 | 663 | 660 | 624 | 552 |
| | | T(PI) = PBEAM - 132 MEV | | | | | | |
| 1300 | 1822 | 1831 | 1932 | 2184 | 669 | 666 | 631 | 559 |
| 1320 | 1832 | 1841 | 1941 | 2191 | 676 | 673 | 638 | 565 |
| 1340 | 1843 | 1851 | 1950 | 2198 | 682 | 679 | 645 | 572 |
| 1360 | 1853 | 1862 | 1959 | 2205 | 689 | 685 | 651 | 579 |
| 1380 | 1863 | 1872 | 1968 | 2212 | 695 | 692 | 658 | 585 |
| | | T(PI) = PBEAM - 133 MEV | | | | | | |
| 1400 | 1873 | 1881 | 1977 | 2219 | 701 | 698 | 664 | 592 |
| 1420 | 1883 | 1891 | 1986 | 2226 | 708 | 704 | 671 | 599 |
| 1440 | 1893 | 1901 | 1995 | 2233 | 714 | 711 | 677 | 605 |
| 1460 | 1903 | 1911 | 2004 | 2240 | 720 | 717 | 684 | 612 |
| 1480 | 1912 | 1921 | 2013 | 2247 | 726 | 723 | 690 | 618 |
| | | T(PI) = PBEAM - 133 MEV | | | | | | |

| PBEAM (MEV/C) | -----C.M. ENERGY------ (MEV) | | | | -MOMENTUM IN C.M.-- (MEV/C) | | | |
|---|---|---|---|---|---|---|---|---|
| | γp ep | πp | Kp | pp | γp ep | πp | Kp | pp |
| 1500 | 1922 | 1930 | 2022 | 2254 | 732 | 729 | 696 | 624 |
| 1520 | 1932 | 1940 | 2031 | 2261 | 738 | 735 | 702 | 631 |
| 1540 | 1942 | 1950 | 2039 | 2268 | 744 | 741 | 709 | 637 |
| 1560 | 1951 | 1959 | 2048 | 2275 | 750 | 747 | 715 | 643 |
| 1580 | 1961 | 1969 | 2057 | 2282 | 756 | 753 | 721 | 650 |
| | | T(PI) = PBEAM - 133 MEV | | | | | | |
| 1600 | 1970 | 1978 | 2065 | 2289 | 762 | 759 | 727 | 656 |
| 1620 | 1980 | 1988 | 2074 | 2296 | 768 | 765 | 733 | 662 |
| 1640 | 1989 | 1997 | 2083 | 2304 | 773 | 770 | 739 | 668 |
| 1660 | 1999 | 2006 | 2091 | 2311 | 779 | 776 | 745 | 674 |
| 1680 | 2008 | 2016 | 2100 | 2318 | 785 | 782 | 751 | 680 |
| | | T(PI) = PBEAM - 134 MEV | | | | | | |
| 1700 | 2018 | 2025 | 2109 | 2325 | 791 | 788 | 756 | 686 |
| 1720 | 2027 | 2034 | 2117 | 2332 | 796 | 793 | 762 | 692 |
| 1740 | 2036 | 2043 | 2126 | 2339 | 802 | 799 | 768 | 698 |
| 1760 | 2045 | 2053 | 2134 | 2346 | 807 | 805 | 774 | 704 |
| 1780 | 2054 | 2062 | 2143 | 2353 | 813 | 810 | 779 | 710 |
| | | T(PI) = PBEAM - 134 MEV | | | | | | |
| 1800 | 2064 | 2071 | 2151 | 2360 | 818 | 816 | 785 | 716 |
| 1820 | 2073 | 2080 | 2159 | 2367 | 824 | 821 | 791 | 721 |
| 1840 | 2082 | 2089 | 2168 | 2374 | 829 | 827 | 796 | 727 |
| 1860 | 2091 | 2098 | 2176 | 2381 | 835 | 832 | 802 | 733 |
| 1880 | 2100 | 2107 | 2184 | 2388 | 840 | 837 | 808 | 739 |
| | | T(PI) = PBEAM - 134 MEV | | | | | | |
| 1900 | 2108 | 2115 | 2193 | 2395 | 845 | 843 | 813 | 744 |
| 1920 | 2117 | 2124 | 2201 | 2402 | 851 | 848 | 818 | 750 |
| 1940 | 2126 | 2133 | 2209 | 2409 | 856 | 853 | 824 | 756 |
| 1960 | 2135 | 2142 | 2217 | 2416 | 861 | 859 | 829 | 761 |
| 1980 | 2144 | 2150 | 2226 | 2423 | 867 | 864 | 835 | 767 |
| | | T(PI) = PBEAM - 135 MEV | | | | | | |
| 2000 | 2153 | 2159 | 2234 | 2430 | 872 | 869 | 840 | 772 |
| 2020 | 2161 | 2168 | 2242 | 2437 | 877 | 874 | 845 | 778 |
| 2040 | 2170 | 2176 | 2250 | 2444 | 882 | 879 | 851 | 783 |
| 2060 | 2179 | 2185 | 2258 | 2451 | 887 | 885 | 856 | 789 |
| 2080 | 2187 | 2194 | 2266 | 2458 | 892 | 890 | 861 | 794 |
| | | T(PI) = PBEAM - 135 MEV | | | | | | |
| 2100 | 2196 | 2202 | 2274 | 2465 | 897 | 895 | 866 | 799 |
| 2120 | 2204 | 2211 | 2282 | 2472 | 902 | 900 | 872 | 805 |
| 2140 | 2213 | 2219 | 2290 | 2479 | 907 | 905 | 877 | 810 |
| 2160 | 2221 | 2227 | 2298 | 2486 | 912 | 910 | 882 | 815 |
| 2180 | 2230 | 2236 | 2306 | 2493 | 917 | 915 | 887 | 821 |
| | | T(PI) = PBEAM - 135 MEV | | | | | | |
| 2200 | 2238 | 2244 | 2314 | 2500 | 922 | 920 | 892 | 826 |
| 2220 | 2246 | 2253 | 2322 | 2507 | 927 | 925 | 897 | 831 |
| 2240 | 2255 | 2261 | 2330 | 2514 | 932 | 930 | 902 | 836 |
| 2260 | 2263 | 2269 | 2338 | 2520 | 937 | 934 | 907 | 841 |
| 2280 | 2271 | 2277 | 2346 | 2527 | 942 | 939 | 912 | 846 |
| | | T(PI) = PBEAM - 135 MEV | | | | | | |
| 2300 | 2280 | 2286 | 2353 | 2534 | 947 | 944 | 917 | 852 |
| 2320 | 2288 | 2294 | 2361 | 2541 | 951 | 949 | 922 | 857 |
| 2340 | 2296 | 2302 | 2369 | 2548 | 956 | 954 | 927 | 862 |
| 2360 | 2304 | 2310 | 2377 | 2555 | 961 | 959 | 932 | 867 |
| 2380 | 2312 | 2318 | 2384 | 2561 | 966 | 963 | 937 | 872 |
| | | T(PI) = PBEAM - 135 MEV | | | | | | |
| 2400 | 2320 | 2326 | 2392 | 2568 | 970 | 968 | 941 | 877 |
| 2420 | 2328 | 2334 | 2400 | 2575 | 975 | 973 | 946 | 882 |
| 2440 | 2336 | 2342 | 2407 | 2582 | 980 | 977 | 951 | 887 |
| 2460 | 2344 | 2350 | 2415 | 2589 | 984 | 982 | 956 | 892 |
| 2480 | 2352 | 2358 | 2423 | 2595 | 989 | 987 | 960 | 897 |
| | | T(PI) = PBEAM - 136 MEV | | | | | | |
| 2500 | 2360 | 2366 | 2430 | 2602 | 994 | 991 | 965 | 901 |
| 2520 | 2368 | 2374 | 2438 | 2609 | 998 | 996 | 970 | 906 |
| 2540 | 2376 | 2382 | 2445 | 2616 | 1003 | 1001 | 975 | 911 |
| 2560 | 2384 | 2390 | 2453 | 2622 | 1007 | 1005 | 979 | 916 |
| 2580 | 2392 | 2398 | 2460 | 2629 | 1012 | 1010 | 984 | 921 |
| | | T(PI) = PBEAM - 136 MEV | | | | | | |
| 2600 | 2400 | 2405 | 2468 | 2636 | 1017 | 1014 | 988 | 926 |
| 2620 | 2408 | 2413 | 2475 | 2643 | 1021 | 1019 | 993 | 930 |
| 2640 | 2415 | 2421 | 2483 | 2649 | 1025 | 1023 | 998 | 935 |
| 2660 | 2423 | 2429 | 2490 | 2656 | 1030 | 1028 | 1002 | 940 |
| 2680 | 2431 | 2436 | 2498 | 2663 | 1034 | 1032 | 1007 | 944 |
| | | T(PI) = PBEAM - 136 MEV | | | | | | |
| 2700 | 2439 | 2444 | 2505 | 2669 | 1039 | 1037 | 1011 | 949 |
| 2720 | 2446 | 2452 | 2512 | 2676 | 1043 | 1041 | 1016 | 954 |
| 2740 | 2454 | 2459 | 2520 | 2682 | 1048 | 1045 | 1020 | 958 |
| 2760 | 2462 | 2467 | 2527 | 2689 | 1052 | 1050 | 1025 | 963 |
| 2780 | 2469 | 2474 | 2534 | 2696 | 1056 | 1054 | 1029 | 968 |
| | | T(PI) = PBEAM - 136 MEV | | | | | | |
| 2800 | 2477 | 2482 | 2542 | 2702 | 1061 | 1058 | 1034 | 972 |
| 2820 | 2484 | 2490 | 2549 | 2709 | 1065 | 1063 | 1038 | 977 |
| 2840 | 2492 | 2497 | 2556 | 2715 | 1069 | 1067 | 1042 | 981 |
| 2860 | 2499 | 2505 | 2563 | 2722 | 1074 | 1071 | 1047 | 986 |
| 2880 | 2507 | 2512 | 2570 | 2728 | 1078 | 1076 | 1051 | 990 |
| | | T(PI) = PBEAM - 136 MEV | | | | | | |
| 2900 | 2514 | 2520 | 2578 | 2735 | 1082 | 1080 | 1056 | 995 |
| 2920 | 2522 | 2527 | 2585 | 2742 | 1086 | 1084 | 1060 | 999 |
| 2940 | 2529 | 2534 | 2592 | 2748 | 1091 | 1088 | 1064 | 1004 |
| 2960 | 2537 | 2542 | 2599 | 2755 | 1095 | 1093 | 1069 | 1008 |
| 2980 | 2544 | 2549 | 2606 | 2761 | 1099 | 1097 | 1073 | 1013 |
| | | T(PI) = PBEAM - 136 MEV | | | | | | |

| PBEAM (GEV/C) | ---C.M. ENERGY--- (GEV) | | | -MOMENTUM IN C.M.- (GEV/C) | | |
|---|---|---|---|---|---|---|
| | γp ep πp | Kp | pp | γp ep πp | Kp | pp |
| 3.0 | 2.56 | 2.61 | 2.77 | 1.10 | 1.08 | 1.02 |
| 3.2 | 2.63 | 2.68 | 2.83 | 1.14 | 1.12 | 1.06 |
| 3.4 | 2.70 | 2.75 | 2.89 | 1.18 | 1.16 | 1.10 |
| 3.6 | 2.77 | 2.82 | 2.96 | 1.22 | 1.20 | 1.14 |
| 3.8 | 2.83 | 2.88 | 3.02 | 1.26 | 1.24 | 1.18 |
| | | T(PI) = PBEAM - .137 GEV | | | | |
| 4.0 | 2.90 | 2.95 | 3.08 | 1.29 | 1.27 | 1.22 |
| 4.2 | 2.96 | 3.01 | 3.14 | 1.33 | 1.31 | 1.26 |
| 4.4 | 3.03 | 3.07 | 3.19 | 1.36 | 1.34 | 1.29 |
| 4.6 | 3.09 | 3.13 | 3.25 | 1.40 | 1.38 | 1.33 |
| 4.8 | 3.15 | 3.19 | 3.31 | 1.43 | 1.41 | 1.36 |
| | | T(PI) = PBEAM - .138 GEV | | | | |
| 5.0 | 3.21 | 3.25 | 3.36 | 1.46 | 1.44 | 1.40 |
| 5.2 | 3.27 | 3.31 | 3.42 | 1.49 | 1.48 | 1.43 |
| 5.4 | 3.32 | 3.36 | 3.47 | 1.53 | 1.51 | 1.46 |
| 5.6 | 3.38 | 3.42 | 3.52 | 1.56 | 1.54 | 1.49 |
| 5.8 | 3.43 | 3.47 | 3.58 | 1.59 | 1.57 | 1.52 |
| | | T(PI) = PBEAM - .138 GEV | | | | |
| 6.0 | 3.49 | 3.52 | 3.63 | 1.61 | 1.60 | 1.55 |
| 6.2 | 3.54 | 3.58 | 3.68 | 1.64 | 1.63 | 1.58 |
| 6.4 | 3.59 | 3.63 | 3.73 | 1.67 | 1.65 | 1.61 |
| 6.6 | 3.65 | 3.68 | 3.78 | 1.70 | 1.68 | 1.64 |
| 6.8 | 3.70 | 3.73 | 3.83 | 1.73 | 1.71 | 1.67 |
| | | T(PI) = PBEAM - .138 GEV | | | | |
| 7.0 | 3.75 | 3.78 | 3.87 | 1.75 | 1.74 | 1.70 |
| 7.2 | 3.80 | 3.83 | 3.92 | 1.78 | 1.76 | 1.72 |
| 7.4 | 3.85 | 3.88 | 3.97 | 1.81 | 1.79 | 1.75 |
| 7.6 | 3.89 | 3.93 | 4.02 | 1.83 | 1.82 | 1.78 |
| 7.8 | 3.94 | 3.97 | 4.06 | 1.86 | 1.84 | 1.80 |
| | | T(PI) = PBEAM - .138 GEV | | | | |
| 8.0 | 3.99 | 4.02 | 4.11 | 1.88 | 1.87 | 1.83 |
| 8.2 | 4.04 | 4.07 | 4.15 | 1.91 | 1.89 | 1.85 |
| 8.4 | 4.08 | 4.11 | 4.20 | 1.93 | 1.92 | 1.88 |
| 8.6 | 4.13 | 4.16 | 4.24 | 1.95 | 1.94 | 1.90 |
| 8.8 | 4.17 | 4.20 | 4.29 | 1.98 | 1.96 | 1.93 |
| | | T(PI) = PBEAM - .138 GEV | | | | |
| 9.0 | 4.22 | 4.25 | 4.33 | 2.00 | 1.99 | 1.95 |
| 9.2 | 4.26 | 4.29 | 4.37 | 2.03 | 2.01 | 1.97 |
| 9.4 | 4.31 | 4.33 | 4.41 | 2.05 | 2.03 | 2.00 |
| 9.6 | 4.35 | 4.38 | 4.46 | 2.07 | 2.06 | 2.02 |
| 9.8 | 4.39 | 4.42 | 4.50 | 2.09 | 2.08 | 2.04 |
| | | T(PI) = PBEAM - .139 GEV | | | | |
| 10.0 | 4.43 | 4.46 | 4.54 | 2.12 | 2.10 | 2.07 |
| 10.5 | 4.54 | 4.57 | 4.64 | 2.17 | 2.16 | 2.12 |
| 11.0 | 4.64 | 4.67 | 4.74 | 2.22 | 2.21 | 2.18 |
| 11.5 | 4.74 | 4.77 | 4.84 | 2.28 | 2.26 | 2.23 |
| 12.0 | 4.84 | 4.86 | 4.93 | 2.33 | 2.31 | 2.28 |
| | | T(PI) = PBEAM - .139 GEV | | | | |
| 12.5 | 4.94 | 4.96 | 5.03 | 2.38 | 2.36 | 2.33 |
| 13.0 | 5.03 | 5.05 | 5.12 | 2.43 | 2.41 | 2.38 |
| 13.5 | 5.12 | 5.15 | 5.21 | 2.47 | 2.46 | 2.43 |
| 14.0 | 5.21 | 5.24 | 5.30 | 2.52 | 2.51 | 2.48 |
| 14.5 | 5.30 | 5.32 | 5.39 | 2.57 | 2.56 | 2.53 |
| | | 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 | 2.78 | 2.77 | 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 |
| 60.0 | 10.65 | 10.66 | 10.69 | 5.28 | 5.28 | 5.26 |
| 70.0 | 11.50 | 11.51 | 11.54 | 5.71 | 5.71 | 5.69 |
| 80.0 | 12.29 | 12.30 | 12.32 | 6.11 | 6.10 | 6.09 |
| 90.0 | 13.03 | 13.04 | 13.06 | 6.48 | 6.48 | 6.46 |
| | | 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 |
| 500.0 | 30.65 | 30.65 | 30.66 | 15.31 | 15.31 | 15.30 |
| 1000.0 | 43.33 | 43.33 | 43.34 | 21.65 | 21.65 | 21.65 |
| 1500.0 | 53.06 | 53.06 | 53.07 | 26.52 | 26.52 | 26.52 |
| | | T(PI) = PBEAM - .140 GEV | | | | |

# SPECIAL RELATIVITY, PHASE SPACE, AND CROSS SECTIONS

Notation. 4-vector in c.m. $p = (w, \vec{p})$; in lab $P = (W, \vec{P})$, $T = W - m$.
Solid-angle element $d\omega = 2\pi d\cos\theta$; $d\Omega = 2\pi d\cos\Theta$.
$p^2 = w^2 - \vec{p}^{\,2} = m^2$ is an invariant. Cross section $\sigma$ is invariant.

Lorentz Transformation

$$\begin{pmatrix} w \\ p_x \\ p_y \\ p_z \end{pmatrix} = \begin{pmatrix} \bar{\gamma} & -\bar{\eta} & 0 & 0 \\ -\bar{\eta} & \bar{\gamma} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} W \\ P_x \\ P_y \\ P_z \end{pmatrix}$$

If $\theta$ and $\Theta$ are measured with respect to the transformation axis x,

$$\frac{P_\perp}{P_x} = \tan\theta = \frac{|\vec{P}|\sin\Theta}{-\bar{\eta}W + \bar{\gamma}|\vec{P}|\cos\Theta}. \tag{1}$$

If particle 1 is beam, 2 is target, then $(W_2, \vec{P}_2) = (m_2, \vec{0})$ and
$\bar{\gamma} = (W_1 + m_2)/\sqrt{s}$, $\bar{\eta} \equiv \bar{\gamma}\bar{\beta} = |\vec{P}_1|/\sqrt{s}$, $|\vec{p}_1| = |\vec{p}_2| = \bar{\eta} m_2 = |\vec{P}_1| m_2/\sqrt{s}$. (2)
For $m_1 = m_2$, $\bar{\gamma}^2 = 1 + T_1/2m_1$.

General Lorentz Transformation [characterized by $\vec{\bar{\beta}}$, with $\bar{\gamma} = (1 - \vec{\bar{\beta}}^{\,2})^{-1/2}$ and $\vec{\bar{\eta}} = \bar{\gamma}\vec{\bar{\beta}}$]: $w = \bar{\gamma}W - \vec{\bar{\eta}}\cdot\vec{P}$; $\vec{p} = \vec{P} - \vec{\bar{\eta}}\,\frac{W + w}{\bar{\gamma} + 1}$.

A Useful Transformation: Consider two 4-vectors $Q = (E, \vec{Q})$ and $q = (e, \vec{q})$. In the rest frame of $Q$ $[Q' = (M, \vec{0})]$, q becomes $(q \to q')$

$$e' = Q\cdot q/M \quad \text{and} \quad \vec{q}' = \vec{q} - f\vec{Q},$$

where $Q^2 = M^2$ and $f = (e + e')/(E + M)$. These equations follow from example (b), p. 34 of Hagedorn.* They are particularly useful when Q is a sum of four-vectors that correspond to a resonant state.

Invariants. Notation: $1 + 2 \to 1' + 2'$.

$$s = (p_1 + p_2)^2 = m_1^2 + m_2^2 + 2(w_1 w_2 - \vec{p}_1\cdot\vec{p}_2), \tag{3}$$

$$t = (p_i' - p_i)^2 = m_i^2 + m_i'^2 - 2(w_i w_i' - \vec{p}_i\cdot\vec{p}_i'), \quad (i = 1, 2), \tag{4}$$

$$u = (p_1' - p_2)^2 = (p_2' - p_1)^2 \quad [\text{use (6), below}]. \tag{5}$$

General relation: $s + t + u = m_1^2 + m_1'^2 + m_2^2 + m_2'^2$. (6)
In lab system $P_2 = (m_2, \vec{0})$, and writing $W = m + T$,

$$s = m_1^2 + m_2^2 + 2W_1 m_2 = (m_1 + m_2)^2 + 2T_1 m_2, \tag{3,lab}$$

$$t = m_2^2 + m_2'^2 - 2W_2' m_2 = (m_2 - m_2')^2 - 2T_2' m_2. \tag{4,lab}$$

In c.m. system $dt = +2|\vec{p}_i|\,|\vec{p}_i'|\,d\cos\theta$. (4,cm)
For elastic scattering $(m_1 = m_1', m_2 = m_2')$, (4) and (5) in c.m. become

$$t = -2\vec{p}^{\,2}(1 - \cos\theta) = -4\vec{p}^{\,2}\sin^2\theta/2, \tag{4,el}$$

$$u = (m_1^2 - m_2^2)^2/s - 2\vec{p}^{\,2}(1 + \cos\theta) = (m_1^2 - m_2^2)^2/s - 4\vec{p}^{\,2}\cos^2\theta/2. \tag{5,el}$$

For elastic scattering, using (4,lab), (4,el), and (2),

$$T_2' = \frac{2\vec{P}_1^{\,2} m_2}{s}\sin^2\left(\frac{\theta}{2}\right) \text{(useful for calculating } \delta\text{-ray energies).} \tag{7}$$

Two-Body States. Energies and momenta in c.m.

$$w_1 = \frac{s + m_1^2 - m_2^2}{2\sqrt{s}}, \quad \vec{p}_1^{\,2} = \vec{p}_2^{\,2} = \frac{1}{4s}\left[s - (m_1 + m_2)^2\right]\left[s - (m_1 - m_2)^2\right]. \tag{8}$$

3- and 4-Body States. Let $m_{ij}^2 = (p_i + p_j)^2$, etc.; then

$$\sum_{i<j} m_{ij}^2 = \Sigma m_i^2 + m_{123}^2 = \text{const.} \; (i, j = 1, 2, 3) \; [\text{follows from (6)}] \tag{9}$$

$$\left.\begin{aligned} &= 2\Sigma m_i^2 + m_{1234}^2 = \text{const.} \\ \sum_{i<j<k} m_{ijk}^2 &= \Sigma m_i^2 + 2m_{1234}^2 = \text{const.} \end{aligned}\right\} \; (i, j, k = 1, 2, 3, 4.) \tag{10}$$

$R_n$, Invariant Volume in n-Body Momentum Space

A useful invariant is $\int d^4p\,\delta(p^2 - m^2) = \int \frac{d^3\vec{p}}{2w} = \int \frac{p^2 d|\vec{p}|\,d\omega}{2w} = \frac{1}{2}\int |\vec{p}|\,dw\,d\omega$.
$R_2 = \pi|\vec{p}_1|/\sqrt{s}$, $R_3 = \pi^2\int dw_1 dw_2 = (\pi^2/4s)\int dm_{12}^2 dm_{23}^2$.

Recurrence Relation for Factoring $R_n$ (see, e.g., Hagedorn, p. 93*):

Write $N \to 1, 2, \cdots, k, k+1, \cdots, n$ $(R_n)$,
as $N \to K, k+1, \cdots, n$ $(R_{n-k+1})$; $K \to 1, 2, \cdots, k$ $(R_k)$ — then $R_n = \int d(m_K^2) R_k R_{n-k+1}$,
or as $N \to K, L$; $K \to k+1, \cdots, n$ $(R_\ell)$; $L \to 1, 2, \cdots, k$ $(R_k)$ — then $R_n = \int d(m_K^2) d(m_L^2) R_k R_\ell \frac{\pi p(KL)}{\sqrt{s}}$

Cross Sections and Decay Rates†

For a system of n particles with overall four-momentum p and final momenta $q_1, \cdots, q_n$ $[q_i = (e_i, \vec{q}_i)]$, define Lorentz Invariant Phase Space

$$d\,\text{LIPS}(s; q_1, \cdots, q_n) = (2\pi)^4\delta^4\left(p - \sum_i q_i\right)\frac{1}{(2\pi)^{3n}}\prod_{i=1}^{n}\frac{d^3\vec{q}_i}{2e_i}. \tag{11}$$

Note that $R_n = (2\pi)^{3n-4}\int d\,\text{LIPS}$.

For $1 + 2 \to n$ particles or $1 \to n$ particles, in general $|i\rangle \to |f\rangle$,

$$\sigma_{if} = \frac{1}{4F}\int |T_{if}|^2\, d\,\text{LIPS}(s; q_1, \cdots, q_n), \tag{12}$$

or

$$\Gamma_{if} = \frac{1}{2m_1}\int |T_{if}|^2\, d\,\text{LIPS}(m_1^2; q_1, \cdots, q_n), \tag{13}$$

where $T_{if}$ is an invariant matrix element. F is Møller's invariant flux factor, $F^2 = (p_1\cdot p_2)^2 - p_1^2 p_2^2$. In every system where $\vec{p}_1$ and $\vec{p}_2$ are collinear, $F = w_1 w_2|\vec{v}_1 - \vec{v}_2|$ $(\vec{v} = \vec{p}/w)$. If 1 is beam, 2, target $(\vec{p}_2 = 0)$, then $F = |\vec{P}_1| m_2 = |\vec{p}_1|\sqrt{s}$.

For elastic scattering in c.m., $\frac{d\,\text{LIPS}}{d\Omega} = \frac{1}{(4\pi)^2}\frac{|\vec{p}_1|}{\sqrt{s}}$, and (12) yields

$$\frac{d\sigma}{d\Omega} = \frac{|T|^2}{(8\pi)^2 s} \quad \text{or} \quad \frac{d\sigma}{dt} = \frac{|T|^2}{64\pi|\vec{p}_1|^2 s}. \tag{14}$$

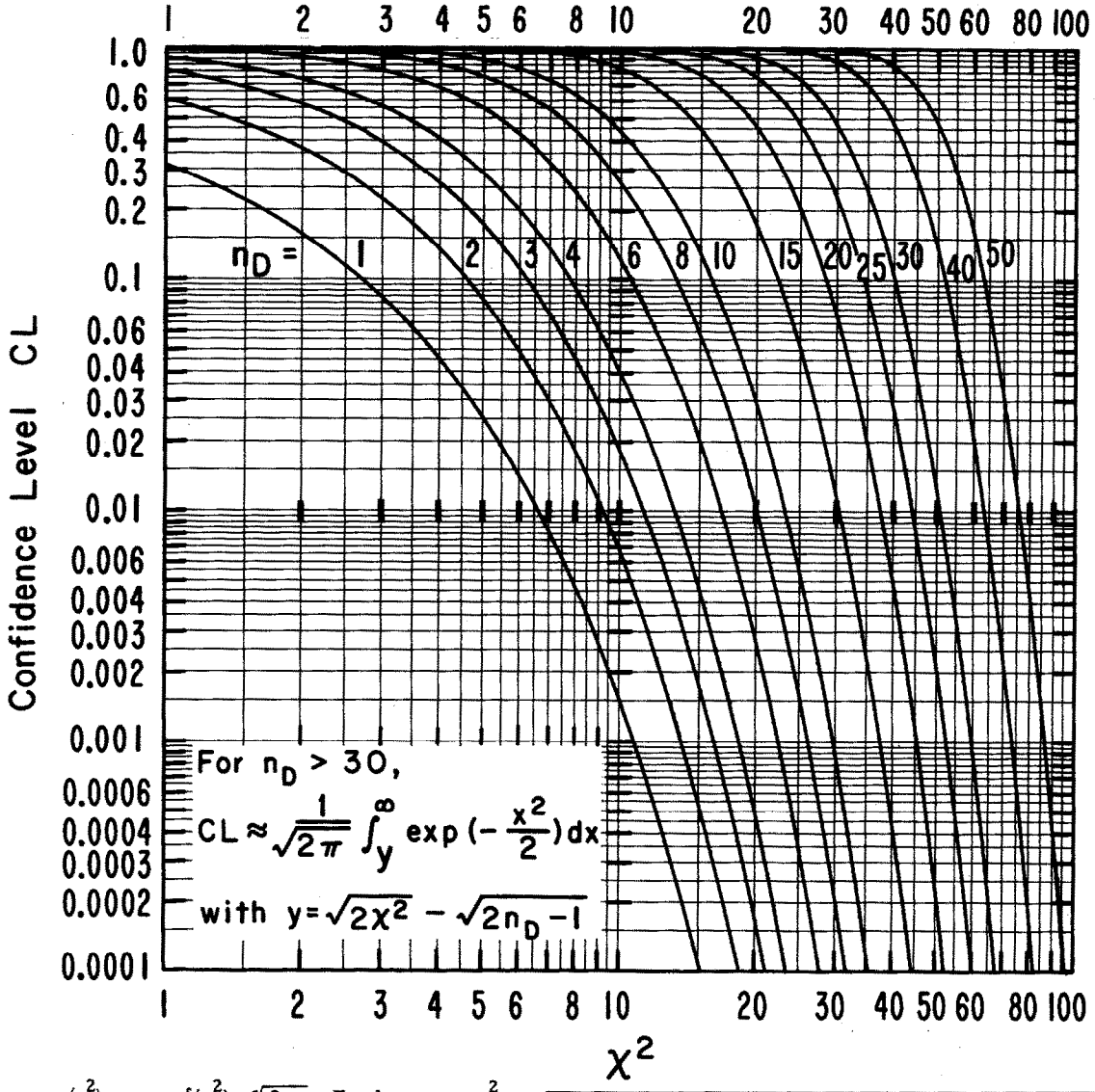
The normalization is such that the optical theorem reads

$$\text{Im}\,T|_{t=0} = 2|\vec{p}_1|\sqrt{s}\,\sigma_{tot}. \tag{15}$$

The choice of Eq. (11) implies a particular normalization of any spinors that may occur in T.† The advantage of this normalization is that it greatly simplifies the structure of T 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.

*R. Hagedorn, Relativistic Kinematics, W. A. Benjamin, New York, 1964.
†See, for example, Chaps. 1 and 2 of H. Pilkuhn, The Interactions of Hadrons, John Wiley & Sons, New York, 1967.

## CONFIDENCE LEVEL VS. $\chi^2$ FOR $n_D$ DEGREES OF FREEDOM




For any $n_D$, $\langle\chi^2\rangle = n_D$, $\delta(\chi^2) = \sqrt{2n_D}$. For large $n_D$, $\chi^2$ becomes normally distributed about $n_D$. Thus in the notation of the box in the figure,

$$y_1 = (\chi^2 - n_D)/\sqrt{2n_D} \text{ has unit s.d.}$$

A better approximation, due to Fisher,* is that $\chi$, not $\chi^2$, is normally distributed, specifically

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \text{ has unit s.d.}$$

One sees then that $y_1$ underestimates small C.L.'s. Thus for n = 50 and $\chi^2 = 80$, $y_1 = 3.0$ and C.L. = 0.13% vs. $y_2 = 2.7$, C.L. = 0.35%.

*R. A. Fisher, Statistical Methods for Research Workers, Oliver and Boyd, Edinburgh.

The Poisson distribution for x, when expected value is $\bar{x}$:

$$P(x, \bar{x}) = \bar{x}^x e^{-\bar{x}}/x!$$

Approximation for n! :

$$\sqrt{2\pi n}\,(n/e)^n < n! < \sqrt{2\pi n}\,(n/e)^n[1 + 1/(12n - 1)]$$

### GAUSSIANLIKE DISTRIBUTIONS

The distribution

$$P_{2n+1}(x) = \frac{1}{2^n n!\,\sigma^{2n+2}}\, x^{2n+1} \exp\left[-\frac{x^2}{2\sigma^2}\right]$$

is normalized so that $\int_0^\infty P_{2n+1}(x)dx = 1$; the normalization is valid for $n > -1$ and not necessarily integral $((\frac{1}{2})! = \sqrt{\pi}/2)$. For $n = -1/2$ it reduces to the Gaussian distribution. Through a change of variables it yields the $\chi^2$ distribution for $n_D$ degrees of freedom:

$$P_{n_D}(\chi^2) = \frac{1}{2^{n_D/2}\left(\frac{n_D}{2} - 1\right)!}\,(\chi^2)^{n_D/2-1} \exp\left[-\chi^2/2\right].$$

Relation between standard deviation $\sigma$ and mean deviation $\alpha$:

$$2\sigma^2 = \pi\alpha^2;\ \sigma = 1.4826 \text{ probable error.}$$

Odds against exceeding one standard deviation = 2.15:1; two, 21:1; three, 370:1; four, 16,000:1; five, 1,700.000:1.

# ATOMIC AND NUCLEAR PROPERTIES OF MATERIALS

| Material | Z | A | Cross Section $\sigma$[a] barns | | Collision Length $L_{coll}$[b] g cm$^{-2}$ | cm | Minimum $-dE/dx$[c] MeV g$^{-1}$ cm$^2$ | MeV cm$^{-1}$ | Radiation Length $L_{rad}$[d] g cm$^{-2}$ | cm | Density $\rho$ g cm$^{-3}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $H_2$ | 1 | 1.01 | 0.063 | | 26.5 | 374[e] | 4.13 | 0.292[e] | 62.8 | 887[e] | 0.0708[e] |
| $D_2$ | 1 | 2.01 | 0.100 | | 33.4 | 202[e] | 2.07 | 0.342[e] | 126 | 764[e] | 0.165[e] |
| He | 2 | 4.00 | 0.16 | | 42.0 | 336[e] | 1.94 | 0.243[e] | 93.1 | 745[e] | 0.125[e] |
| Li | 3 | 6.94 | 0.23 | | 50.4 | 94.4 | 1.69 | 0.902 | 83.3 | 156 | 0.534 |
| Be | 4 | 9.01 | 0.28 | See notes a and b. | 55.0 | 29.8 | 1.60 | 2.96 | 66.0 | 35.7 | 1.848 |
| C | 6 | 12.01 | 0.33 | | 60.4 | f | 1.78 | f | 43.3 | f | ≈1.55[f] |
| $N_2$ | 7 | 14.01 | 0.36 | | 63.6 | 78.7[e] | 1.81 | 1.46[e] | 38.6 | 47.8[e] | 0.808[e] |
| Ne | 10 | 20.18 | 0.465 | | 72.1 | 60.1[e] | 1.73 | 2.08[e] | 29.1[i] | 24.3[e,i] | 1.200[e,k] |
| Al | 13 | 26.98 | 0.57 | | 79.2 | 29.3 | 1.62 | 4.37 | 24.3 | 9.00 | 2.70 |
| Fe | 26 | 55.85 | 0.92 | | 101.2 | 12.9 | 1.48 | 11.6 | 13.9 | 1.77 | 7.87 |
| Cu | 29 | 63.54 | 1.00 | | 105.4 | 11.8 | 1.44 | 12.9 | 13.0 | 1.45 | 8.96 |
| Sn | 50 | 118.69 | 1.55 | WARNING: | 129.7 | 17.7 | 1.28 | 9.4 | 8.9 | 1.22 | 7.31 |
| W | 74 | 183.85 | 2.02 | | 150.8 | 7.81 | 1.17 | 22.6 | 6.8 | 0.35 | 19.3 |
| Pb | 82 | 207.19 | 2.20 | | 156.2 | 13.8 | 1.13 | 12.8 | 6.4 | 0.56 | 11.35 |
| U | 92 | 238.03 | 2.42 | | 163.6 | ≈ 8.63 | 1.09 | ≈ 20.7 | 6.1 | ≈ 0.32 | ≈ 18.95 |
| Air | | | | | 64.6 | 53610[g] | 1.81 | 0.0022[g] | 37.2 | 30870[g] | 0.001205[g] |
| Freon ($CF_3Br$) | | | | | 87.1 | ≈ 58 | 1.52 | ≈ 2.3 | 16.7 | ≈11 | ≈ 1.5 |
| $H_2$ (bubble chamber, 27° K) | | | | See notes a and b. | 26.5 | 442[h] | 4.13 | 0.248[h] | 62.8 | 1050[h] | ≈ 0.060[h] |
| H-Ne mixture (bubble chamber)[j] | | | | | 67.3 | 96.1 | 1.83 | 1.28 | 29.8[i] | 42.6[i] | 0.70 |
| $H_2O$ | | | | | 57.2 | 57.2 | 2.03 | 2.03 | 36.4 | 36.4 | 1.00 |
| Ilford Emulsion | | | | | 103.0 | 27.0 | 1.44 | 5.49 | 11.2 | 2.94 | 3.815 |
| LiF | | | | | 63.8 | 24.2 | 1.69 | 4.46 | 39.8 | 15.1 | 2.64 |
| Mylar ($C_5H_4O_2$) | | | | | 59.1 | 42.8 | 1.91 | 2.64 | 40.4 | 29.3 | 1.38 |
| NaI | | | | WARNING: | 119.0 | 32.4 | 1.32 | 4.84 | 9.5 | 2.59 | 3.67 |
| Polyethylene ($CH_2$) | | | | | 51.0 | ≈ 55 | 2.09 | ≈ 1.92 | 45.3 | ≈ 49 | ≈ 0.92 |
| Polystyrene (CH)[ℓ] | | | | | 54.9 | ≈ 52 | 2.03 | ≈ 2.13 | 44.3 | ≈ 42 | ≈ 1.05 |
| Propane ($C_3H_8$, bubble chamber) | | | | | 48.9 | 119 | 2.28 | 0.94 | 45.9 | 112 | 0.41 |

a. $\sigma = \sigma_{natural} = \pi(\hbar/m_\pi c)^2 \times A^{2/3} = 62.8\ \text{mb} \times A^{2/3}$

b. $L_{coll} = A/(N\sigma_{natural}) = 26.5\ \text{g cm}^{-2} \times A^{1/3}$

NOTE: These quantities are calculated assuming a "nuclear radius" = $(\hbar/m_\pi c)\,A^{1/3} = (1.4f)\,A^{1/3}$. Thus they are to be taken as a guide only; actual "nuclear radii" are somewhat more complicated.

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 Physics JETP 18, 187 (1964).

e. For liquid phase at 1 atm. and boiling temperature.

f. Density variable.

g. At 20° C.

h. May vary by about ±3% depending on operating conditions.

i. From F. R. Huson, Ionization Loss, Range, Straggling and Multiple Scattering, BNL 11386 (1967).

j. 53.7 atomic percent Ne.

k. Density of gas at STP = $0.900 \times 10^{-3}$ g cm$^{-3}$, i.e., $0.75 \times 10^{-3}$ times the density (1.200) of the boiling liquid.

ℓ. Typical scintillator; e.g., PILOT B has an atomic ratio H/C = 1.1.

## MULTIPLE COULOMB SCATTERING*

The rms projected angle $\theta$ due to multiple Coulomb scattering (only) of a particle of charge z (in units of electron charge), momentum p (in MeV/c), and velocity v (in units of c) is

$$\theta_{proj} = z\frac{15}{pv}\sqrt{\frac{L}{L_{rad}}}\,(1+\epsilon)\ \text{radians;}$$

where L = length in scatterer.

For $L \geqslant 1/10\ L_{rad}$, $\epsilon$ is generally < 1/10. The distribution of $\theta$ is not truly Gaussian.†

The rms projected displacement y on traversing an absorber of thickness L is

$$y_{rms} = L\theta_{proj}/\sqrt{3}.$$

*Mainly from G. Z. Molière, Naturforsch. 3(a), 78 (1948).

†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).

## RADIOACTIVITY AND RADIATION PROTECTION

Unit of activity = Curie:
1 Ci = $3.7 \times 10^{10}$ disintegrations/sec

Unit of exposure dose for x and $\gamma$ radiation = Roentgen:
1 R = 1 esu/cm$^3$ = 87.8 erg/g ($5.49 \times 10^7$ MeV/g) of air

Unit of absorbed dose = rad:
1 rad = 100 erg/g ($6.25 \times 10^7$ MeV/g) in any material

Unit of dose equivalent (for protection) = rem:
rems (Roentgen equivalents for man) = rads × QF,
where QF (quality factor) depends upon the type of radiation and other factors. For $\gamma$ rays and HE protons, QF ≈ 1; for thermal neutrons, QF ≈ 3; for fast neutrons, QF ranges up to 10; and for $\alpha$ particles and heavy ions, QF ranges up to 20.

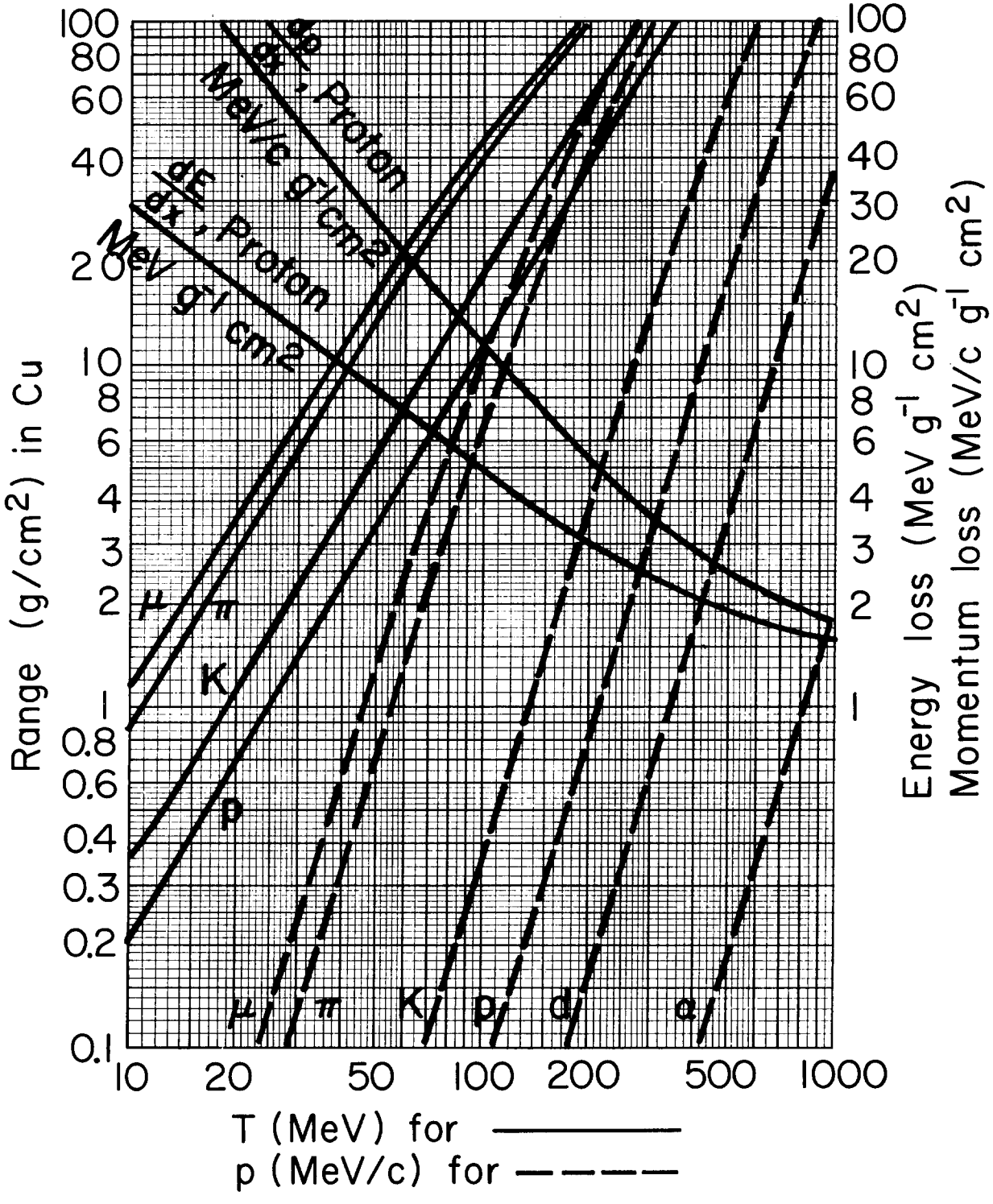
Maximum permissible occupational dose for the whole body:
5 rem/year (or ≈ 100 millirem/week)

Fluxes (per cm$^2$) to liberate 1R in carbon:
$3 \times 10^7$ minimum ionizing singly charged particles
$0.9 \times 10^9$ 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
cosmic radiation (charged particles + neutrons) ~25
cosmic radiation ($\gamma$ rays) ~25
radiation from rocks and air ($\gamma$ rays) ~73
} mrem/yr

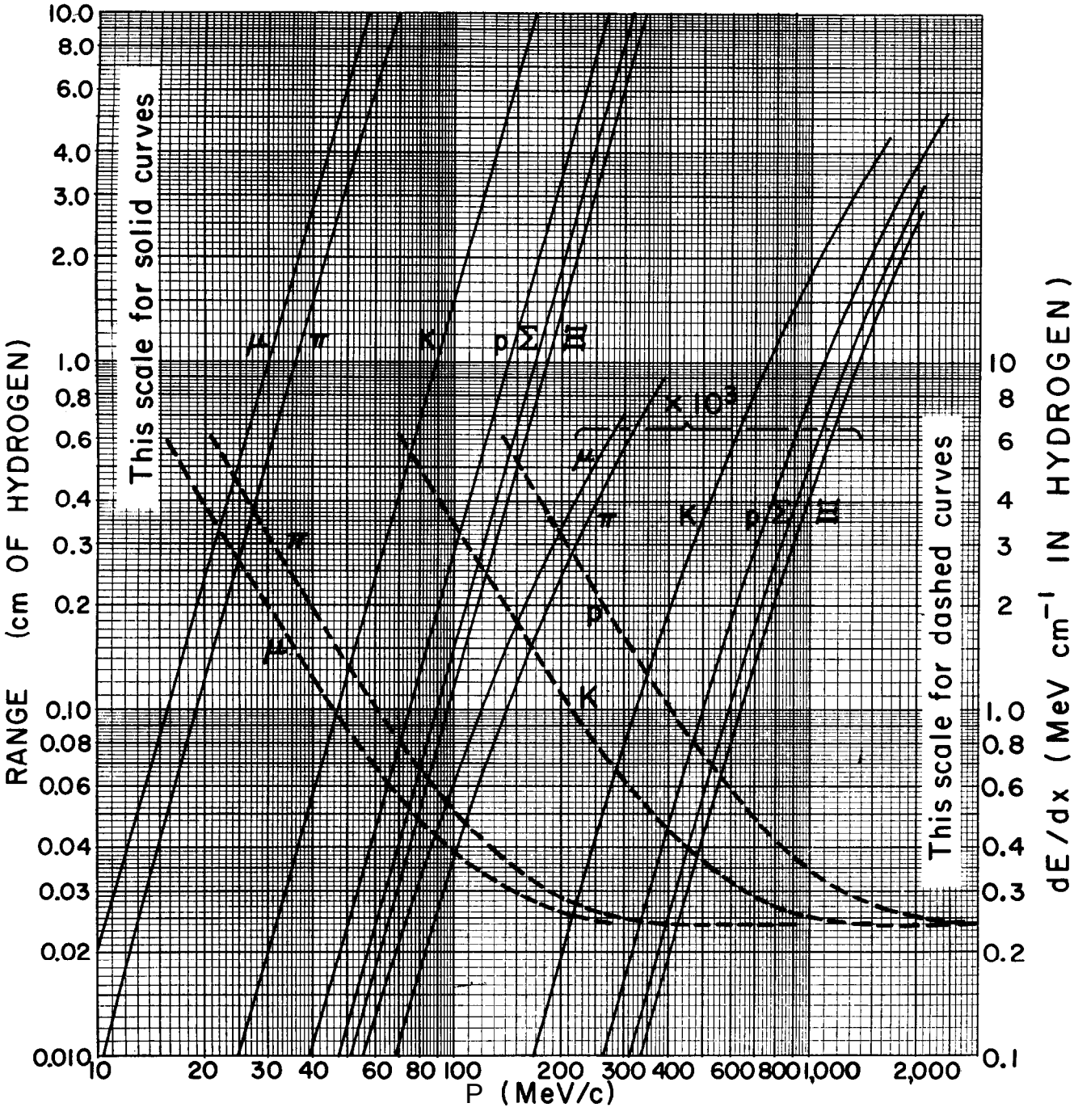
Cosmic ray background in counters: ~ 1/min/cm$^2$/ster

## RANGE AND ENERGY LOSS IN COPPER



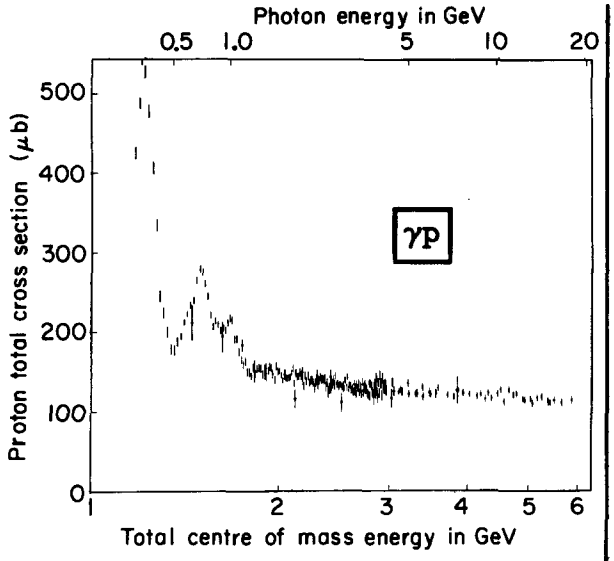

Range and energy/momentum loss in copper, based on a calculation assuming a nominal mean excitation potential of 310 eV. (Calculation by W. A. Aron, UCRL-1325, 1951). The abscissa is to be read as kinetic energy T for the solid curves and momentum p for the dashed curves.

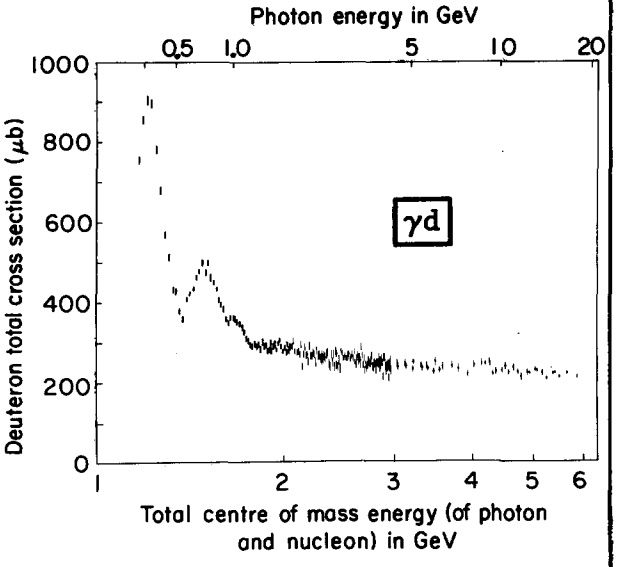
# RANGE AND ENERGY LOSS IN LIQUID HYDROGEN



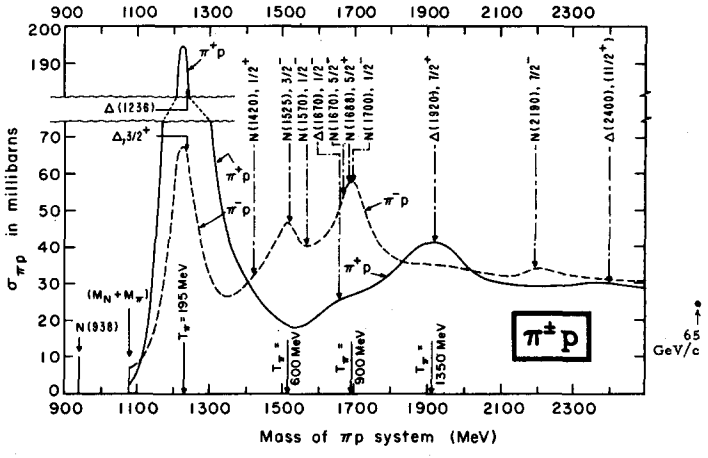

**Range and energy loss in liquid hydrogen bubble chamber, determined by a $\mu^+$ range of $1.103 \pm 0.003$ cm from the $\pi^+ \rightarrow \mu^+ \nu$ decay. Liquid hydrogen conditions: $T = 27.6 \pm 0.1$°K; $P = 48 \pm 5$ psia; $\rho = (5.86 \pm 0.06) 10^{-2}$ g/cm$^3$. (Data by Clark and Diehl, UCRL-3789, 1957.) Bubble chamber physicists: note that the number of bubbles per cm is proportional to $1/\beta^2$, not to dE/dx.**

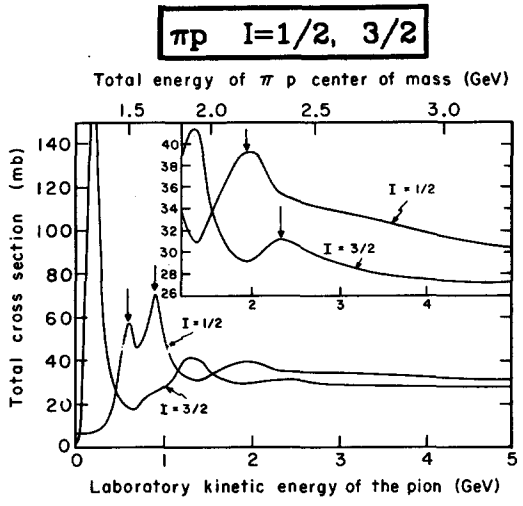
# CROSS SECTION PLOTS



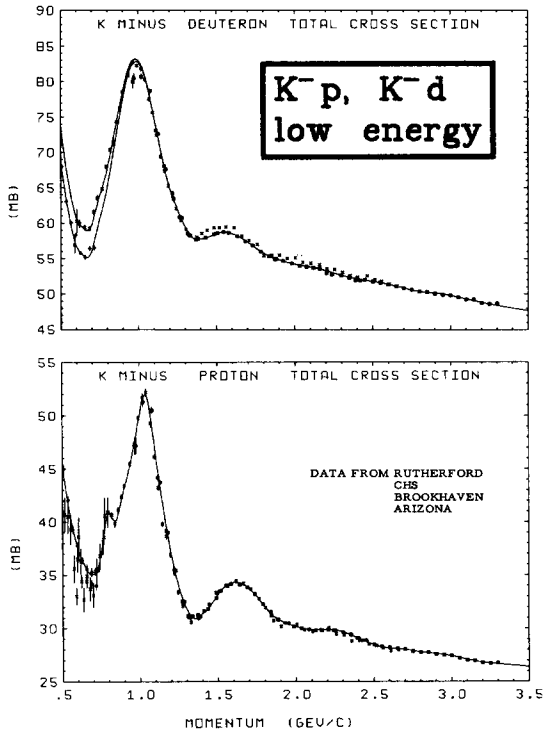

$\sigma_{tot}(\gamma p)$ and $\sigma_{tot}(\gamma d)$ from the Glasgow, Sheffield, DNPL Collaboration, Daresbury preprints DNPL/P88 (sub. Phys. Rev. D) and DNPL/P105 (sub. Nucl. Phys. B). Figures through the courtesy of G. M. Lewis, Glasgow.

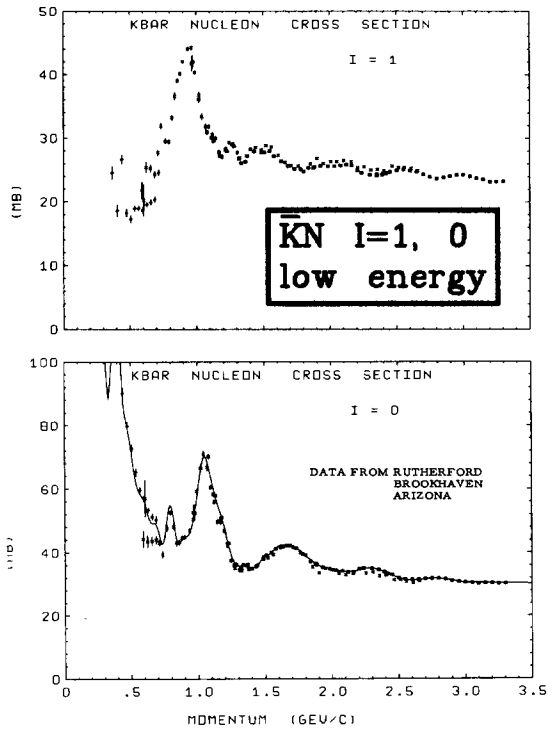


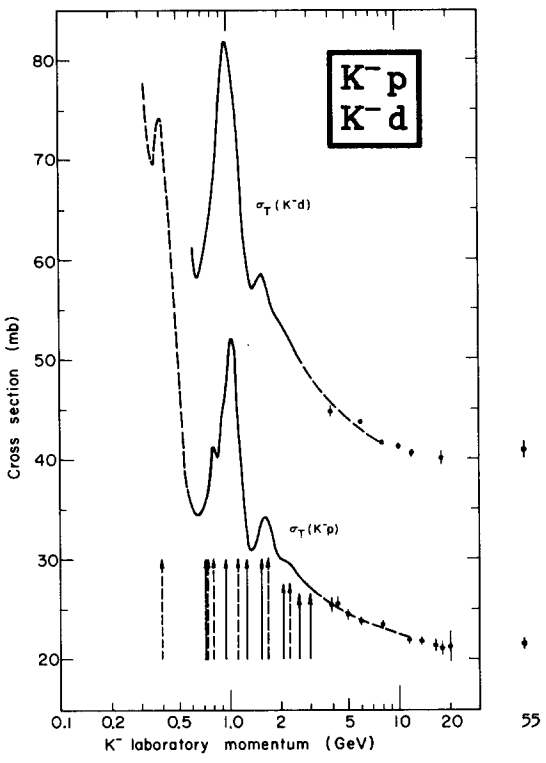

From A. Barbaro-Galtieri in Advances in Particle Physics, Vol. 2, edited by R. L. Cool and R. E. Marshak (Wiley & Sons, 1968). The $\pi^-$ point at 65 GeV/c is taken from IHEP-CERN Collab., Phys. Letters 30B, 500 (1969).

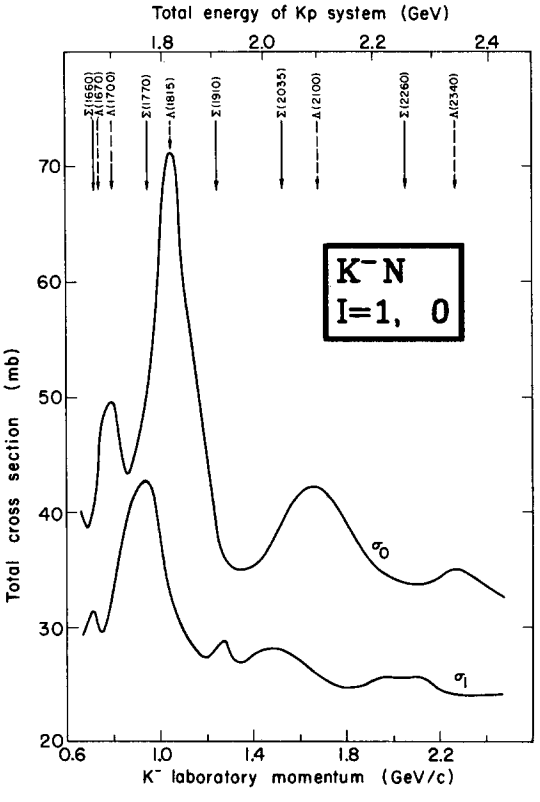
# CROSS SECTION PLOTS



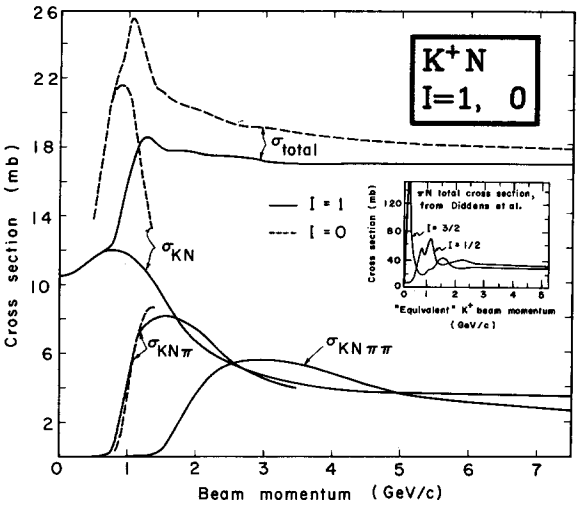

Compiled and unfolded by G. R. Lynch, Proc. 1970 Duke Baryon Conference.



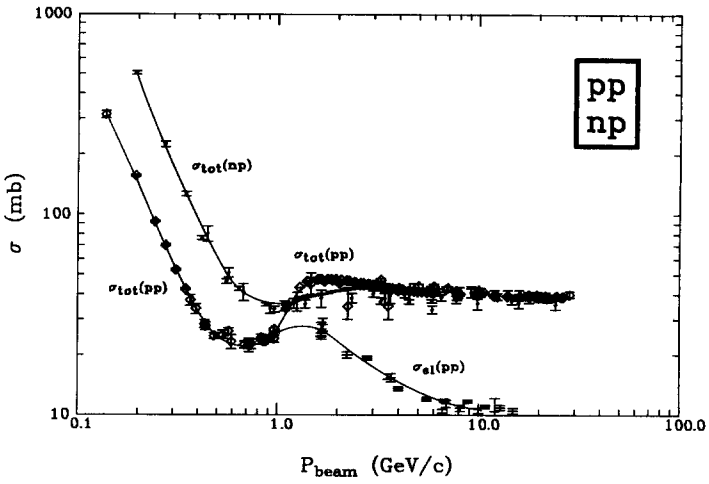




From A. Barbaro-Galtieri in Advances in Particle Physics, Vol. 2, edited by R. L. Cool and R. E. Marshak (Wiley & Sons, 1968). The points at 55 GeV/c are taken from IHEP-CERN Collab., Phys. Letters 30B, 500 (1969).

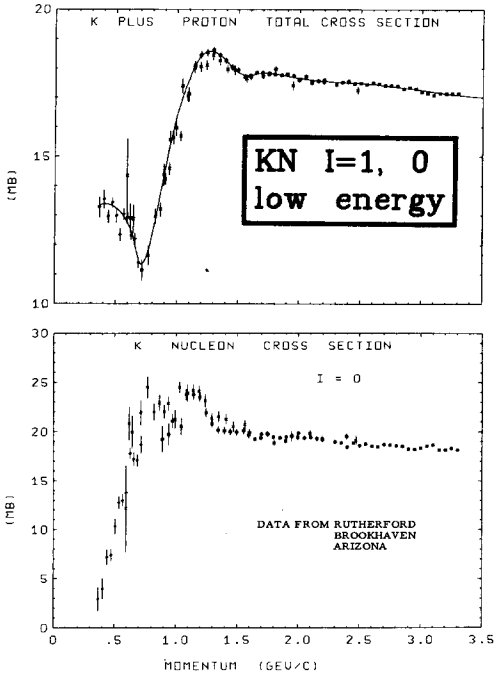
# CROSS SECTION PLOTS



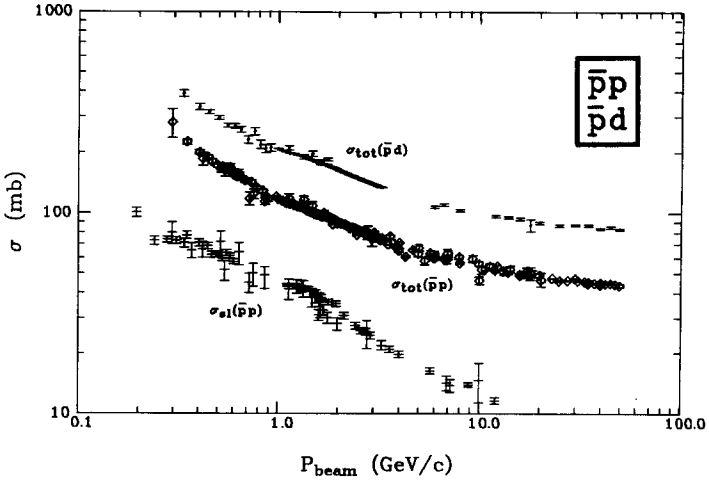

$K^+N$ cross sections from Particle Data Group, "A Compilation of $K^+N$ Reactions," UCRL-20 000 $K^+N$ (Sept. 1969).




pp and np cross sections from Particle Data Group, "NN and ND Interactions -- A Compilation", UCRL-20 000 NN (August 1970).




Compiled and unfolded by G. R. Lynch, Proc. 1970 Duke Baryon Conference.




$\bar{p}p$ and $\bar{p}d$ cross sections from Particle Data Group, "A Compilation of $\bar{N}N$ and $\bar{N}D$ Reactions", LBL-58 (to appear, 1972).

# DATA CARD LISTINGS

## Illustrative Key

Name of particle as it appears in table.

Arrow indicates this particle omitted from table.

```
XX(1200)   74 XX MESON (1200,JPG=  -)  I=1
           ORIGINALLY CALLED XXX
           OMITTED FROM TABLE
```

Particle name, and quantum numbers (if known).

Particle code (for internal use only).

General comments on particle.

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).

```
                    74 XX(1200) MASS (MEV)
M          1216.      11.          MERRILL   66 HBC    0 3.2 K-P        7/66
M   L  1500 1192.1    (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       1/72*
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       1/72*
W       . . . . . . . . .
W   AVG    38.4       6.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                     (SEE IDEOGRAM BELOW )
```

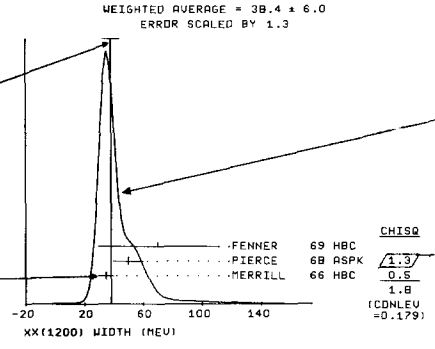
Reaction producing particle, or comments.

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 $\chi^2$ (if no entry present, experiment not used in calculating $\chi^2$ or scale factor because of large error).




```
                    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       1/72*
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)

****** ********* ********* ********* ********* ********* ********* ********

                    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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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 |
| 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 |

### Conferences

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

### Institutions

Names of institutions are frequently abbreviated. We use mainly the four-letter code proposed by the HERA group at CERN in 1969; however, starting in January 1971 we have revised some of the US entries to follow more closely the abbreviations in common usage, e.g., LSU instead of LOUI for Louisiana State University. Revised and new entries are marked by an asterisk. We have not yet revised the older cards and apologize for the temporarily double entries.

| | | |
|---|---|---|
| AACH | TECHNISCHE UNIV. AACHEN | AACHEN, GERMANY |
| AERE | ATOMIC ENERGY RES. ESTAB. | HARWELL, BERKS., ENGLAND |
| AMES | IOWA STATE UNIV. | AMES, IOWA, USA |
| ANL | ARGONNE NAT. LAB. | ARGONNE, ILL., USA |
| ANNA | UNIV. OF MICHIGAN | ANN ARBOR, MICH., USA |
| ARIZ | UNIV. OF ARIZONA | TUSCON, ARIZ., USA |
| ATEN | NUCLEAR RES. CENTRE DEMOKRITOS | ATHENS, GREECE |
| ATHO | OHIO UNIV. | ATHENS, OHIO, USA |
| BARI | UNIV. DEGLI STUDI DI BARI | BARI, ITALY |
| BELG | INST. INTERUNIV. DES SCI. NUC. | BRUXELLES, BELGIUM |
| BERG | FYSISK INSTITUTT | BERGEN, NORWAY |
| BERK | UNIV. OF CALIF. AT BERKELEY | BERKELEY, CALIF., USA |
| BERL | INST. HOCHENERGIEPHYS. DAW | ZEUTHEN/BERLIN, DDR |
| BERN | UNIV. BERN | BERN, SWITZERLAND |
| BGNA | UNIV. DI BOLOGNA | BOLOGNA, ITALY |
| BIRM | BIRMINGHAM UNIV. | BIRMINGHAM, ENGLAND |
| BNL | BROOKHAVEN NATIONAL LAB. | UPTON, L.I., N. Y., USA |
| BOHR | NIELS BOHR INSTITUTE | COPENHAGEN, DENMARK |
| BONN | UNIV. BONN | BONN, GERMANY |
| 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 |
| BUFF | STATE UNIV. OF NEW YORK AT BUFFALO | BUFFALO, N. Y., USA |
| CAEN | LAB. DE PHYS. CORPUSCULAIRE | CAEN, FRANCE |
| CALT | CALIF. INSTITUTE OF TECHNOLOGY | PASADENA, CALIF., USA |
| 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 |
| CCNY | CITY COLLEGE OF NEW YORK | NEW YORK, N. Y., USA |
| 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 |
| *CIT | CALIF. INSTITUTE OF TECHNOLOGY | PASADENA, CALIF., USA |
| 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 |
| CWM | COLLEGE OF WILLIAM AND MARY | WILLIAMSBURG, VA., USA |
| 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 |
| *EFI | ENRICO FERMI INST. FOR NUCL. STUDIES | CHICAGO, ILL., USA |
| EFIN | 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 |
| FLAS | FLORIDA STATE UNIV. | TALLAHASSEE, FLA., 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 |
| GEVA | UNIV. DE GENEVE | GENEVA, SWITZERLAND |
| GLAS | UNIV. OF GLASGOW | GLASGOW, SCOTLAND |
| GRAZ | UNIV. GRAZ | GRAZ, AUSTRIA |
| 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 |
| 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 |
| INRC | INST. FOR NUCLEAR RESEARCH | CRACOW, POLAND |
| IOWA | UNIV. OF IOWA | IOWA CITY, IOWA, USA |
| IPN | INST. DE PHYS. NUCLEAIRE | ORSAY, FRANCE |
| IPNP | INSTITUT DE PHYSIQUE NUCLEAIRE | PARIS, FRANCE |
| IPPG | INSTITUTE OF PHYSICS, CSAV | PRAGUE, CZECHOSLOVAKIA |
| IRAD | INSTITUTE DU RADIUM | PARIS, FRANCE |
| IRVN | UNIV. OF CALIF. AT IRVINE | IRVINE, CALIF., USA |
| *ISU | IOWA STATE UNIV. | AMES, IOWA, USA |
| ITEP | INST. FOR TEOR. AND EXP. PHYS. | MOSCOW, USSR |
| *JAGL | JAGELLONIAN UNIV. | CRACOW, POLAND |
| JHOP | JOHNS HOPKINS UNIV. | BALTIMORE, MD., USA |
| *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 |
| KRAK | JAGELLONIAN UNIV. | KRAKOW, POLAND |
| LANC | LANCASTER UNIV. | LANCASTER, ENGLAND |
| LASL | U. C. LOS ALAMOS SCIENTIFIC LAB. | LOS ALAMOS, N. M., USA |
| LEBD | LEBEDEV PHYSICS INST. | MOSCOW, USSR |
| LEHI | LEHIGH UNIV. | BETHLEHEM, PA., USA |
| LEID | INST. LORENTZ | LEIDEN, NETHERLANDS |
| LHEB | LAB. DES HAUTES ENERGIES | BRUXELLES, BELGIUM |
| LIVP | LIVERPOOL UNIV. | LIVERPOOL, ENGLAND |
| LJCP | LABORATOIRE JOLIOT-CURIE | PARIS, FRANCE |
| LOIC | IMPERIAL COL. OF SCI. AND TECH. | LONDON, ENGLAND |
| *LQOM | QUEEN MARY COLLEGE | LONDON, ENGLAND |
| LOUC | UNIVERSITY COLLEGE | LONDON, ENGLAND |
| LOUI | LOUISIANA STATE UNIV. | BATON ROUGE, LA., USA |
| LOWC | WESTFIELD COLLEGE | LONDON, ENGLAND |
| LRL | U. C. LAWRENCE RADIATION 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 |
| MASS | UNIV. OF MASSACHUSETTS | AMHERST, MASS., USA |
| MCGI | MCGILL UNIV. | MONTREAL, CANADA |
| MCHS | UNIV. MANCHESTER | MANCHESTER, ENGLAND |
| MICH | MICHIGAN STATE UNIV. | EAST LANSING, MICH., USA |
| *MICH | UNIV. OF MICHIGAN | ANN ARBOR, MICH., USA |
| MILA | UNIV. DI MILANO | MILANO, ITALY |
| MINN | UNIV. OF MINNESOTA | MINNEAPOLIS, MINN., USA |
| *MIOH | MIAMI UNIV. | OXFORD, OHIO, USA |
| MIT | MASSACHUSETTS INST. OF TECHNOLOGY | CAMBRIDGE, MASS., USA |
| MODE | ISTITUTO DI FISICA DELLA UNIVERSITA | MODENA, ITALY |
| 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 |
| MUOX | MIAMI UNIV. | OXFORD, OHIO, 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 |
| NORD | NORDISK INS. FOR TEOR. ATOMFYS. | COPENHAGEN, DENMARK |
| NOVO | INST. OF NUCL. PHYS. | NOVOSIBIRSK, USSR |
| NWES | NORTHWESTERN UNIV. | EVANSTON, ILL., USA |
| NYU | NEW YORK UNIV. | NEW YORK, N. Y., USA |
| OHIO | OHIO STATE UNIV. | COLUMBUS, OHIO, 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 |
| OTTA | NATIONAL RESEARCH COUNCIL | OTTAWA, CANADA |
| OXF | OXFORD UNIV. | OXFORD, ENGLAND |
| PADO | UNIV. OF PADOVA | PADOVA, ITALY |
| PENN | UNIV. OF PENNSYLVANIA | PHILADELPHIA, PA., USA |
| PISA | UNIV. DI PISA | PISA, ITALY |
| PITH | PHYSIK. INST. DER TECH. HOCHSCHULE | AACHEN, GERMANY |
| PITT | UNIV. OF PITTSBURGH | PITTSBURGH, PA., USA |
| *PPA | PRINCETON-PENN. PROTON ACCEL. | PRINCETON, N. J., USA |
| PPPA | PRINCETON-PENN. PROTON ACCEL. | PRINCETON, N. J., USA |
| *PRAG | INSTITUTE OF PHYSICS, CSAV | PRAGUE, CZECHOSLOVAKIA |
| PRIN | PRINCETON UNIV. | PRINCETON, N. J., USA |
| PURD | PURDUE UNIV. | LAFAYETTE, IND., USA |
| QMCL | QUEEN MARY COLLEGE | LONDON, ENGLAND |
| REHO | WEIZMANN INST. OF SCI. | REHOVOTH, ISRAEL |
| RHEL | RUTHERFORD HIGH ENERGY LAB. | CHILTON, DID., BERKS., ENGLAND |
| RISO | RESEARCH ESTAB. RISO | ROSKILDE, DENMARK |
| RIVS | UNIV. OF CALIF. AT RIVERSIDE | RIVERSIDE, CALIF., USA |
| ROCH | UNIV. OF ROCHESTER | ROCHESTER, N. Y., USA |
| ROMA | UNIV. DEGLI STUDI DI ROMA | ROME, ITALY |
| RUTG | RUTGERS UNIV. | NEW BRUNSWICK, N. J., USA |
| SACL | CNTR. D'ETUDES NUC. SACLAY | GIF-SUR-YVETTE, FRANCE |
| *SEAT | SEATTLE PACIFIC COLLEGE | SEATTLE, WASH., USA |
| SERP | INST. OF HIGH EN. PHYS. | SERPUKOV, USSR |
| *SETO | SETON HALL UNIV. | SOUTH ORANGE, N. J., USA |
| SHAM | UNIV. OF SOUTHAMPTON | SOUTHAMPTON, ENGLAND |
| SLAC | STANFORD LINEAR ACCEL. CENTER | STANFORD, CALIF., USA |
| SOFI | BULGARIAN ACAD. OF SCI. | SOFIA, BULGARIA |
| SPC | SEATTLE PACIFIC COLLEGE | SEATTLE, WASH., USA |
| STAN | STANFORD UNIV. | STANFORD, CALIF., USA |
| STEV | STEVENS INST. OF TECH. | HOBOKEN, N. J., USA |
| STLO | WASHINGTON 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 |
| SYR | SYRACUSE UNIV. | SYRACUSE, N. Y., USA |
| *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 |
| TORI | UNIV. DI TORINO | TORINO, ITALY |
| TRST | UNIV. OF TRIESTE | TRIESTE, ITALY |
| TUFT | TUFTS UNIV. | MEDFORD, MASS., USA |
| *UCB | UNIV. OF CALIF. AT BERKELEY | BERKELEY, CALIF., USA |
| *UCI | UNIV. OF CALIF. AT IRVINE | IRVINE, CALIF., USA |
| UCLA | UNIV. OF CALIF. AT LOS ANGELES | LOS ANGELES, CALIF., 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 |
| UPNJ | UPSALA COLLEGE | EAST ORANGE, N. J., USA |
| UTAH | UNIV. OF UTAH | SALT LAKE CITY, UTAH, USA |
| UVC | UNIV. OF VIRGINIA | CHARLOTTESVILLE, VA., 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 |
| WPLB | H. H. WILLS PHYS. LAB., U. OF BRISTOL | BRISTOL, ENGLAND |
| *WUSL | WASHINGTON UNIV. | ST. LOUIS, MO., USA |
| YALE | YALE UNIV. | NEW HAVEN, CONN., USA |
| ZEEM | ZEEMAN LAB., UNIV. OF AMSTERDAM | AMSTERDAM, NETHERLANDS |

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CODE EVENTS QUANTITY  ERROR+  ERROR-  REFERENCE YR TECN SIGN COMMENTS  DATE
     ABOVE                                                            PUNCHED
  BACKGROUND

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## $\gamma$

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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

                          0  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 PRL 26 1395       N M KROLL                           (SLAC)

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## $\nu_e$

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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
M            (0.15) OR LESS            HAMILTON  53 CNTR
M            (0.55)   (0.28)           FRIEDMAN  58 CNTR
M             0.06  OR LESS  CL=.90    BERGKVIS  69 CNTR     EL.STATIC.MAG.SP 11/69

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                          REFERENCES

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

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)
BERGKVIS 69 CERN 69-7 91      KARL-ERIK BERGKVIST            (UNIV STOCKHOLM)

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## $\nu_\mu$

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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    0. 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   S   USES SHAFER VALUE FOR PI+ MASS-CRANE (PRL-TOBEPUB)VALUE FOR MU MASS  12/71*
    B   CALCULTED BY US FROM M**2. MAY BE AFFECTED BY PI- MASS
    B   PROBLEM. SEE FOOTNOTE IN PI- MASS SECTION.

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                          REFERENCES
                          2  MU-NEUTRINO  (0,J=1/2)

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 + (COLUM+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 25 B 376       +LOKEN,PEWITT,MCKENZIE,KEYES+(ARG+CARN+NWU)
FRANK    68  VIENNA ABS.  365 FRANK,GAMET,LAKIN            (SHAM+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)

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## $e$

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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
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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         (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         (1.0011596644) +-(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 R  RICH 68 IS REEVALUATION OF WILKINSON 63

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

SCHUPP   61 PR  121   1       A A SCHUPP,R W PIDD,H R CRANE     (MICHIGAN)
WILKINSO 63 PR 130 852        D T WILKINSON,H R CRANE           (MICHIGAN)
COHEN    65 RMP 37 537        E R COHEN, J W M DUMOND      (NAASC+CALTECH)
MOE      65 PR 140 B 992      M K MOE,F REINES      (CASE INST TECHNOLOGY)
RICH     66 PRL  17  271      A RICH, H R CRANE                 (MICHIGAN)
RICH     68 PRL 20 967        A RICH                            (MICHIGAN)
TAYLOR   69 RMP 41 375        +PARKER,LANGENBERG           (PRIN+UCI+PENN)
WESLEY   70 PRL 24 1320       J C WESLEY,A.RICH                 (MICHIGAN)
WESLEY   71 PR A4 1341        J C WESLEY,A RICH                 (MICHIGAN)
GILLELAN 72 PR A5 38          J GILLELAND,A RICH                (MICHIGAN)

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## $\mu$

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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) (.0014)          TAYLOR    69 RVUE    USING NEW E/H     7/70
M           105.6594    .0004          CROWE     72 CNTR                      2/72*
M          . . . . . . . . .
M   FIT     105.6594    .0004 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/72*
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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  RATIO OF MEAN LIFE OF MU+ TO MU-

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*MUON MASS))

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 F     (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       2/72*
MMR  C     3.183336  .000013           CRANE     71 CNTR    HFS SPLITTING   2/72*
MMR F     (3.183337)(.000013)          DEVOE     71 CNTR    HFS SPLITTING   2/72*
MMR  F     3.183326  .000013           FAVART    71 CNTR    HFS SPLITTING   2/72*
MMR  H     3.1833467 .0000082          CROWE     72 CNTR +  PRECESSION       2/72*
MMR F FAVART 71 SUPERCEDES EHRLICH 69 AND DEVOE 71
MMR C CRANE 71 SUPERCEDES THOMPSON 69
MMR H CROWE 72 SUPERCEDES HAGUE 70
MMR        . . . . . . . . .
MMR AVG    3.18334010.0000060  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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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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# Stable Particles

## $\mu$, $\pi^{\pm}$

# Data Card Listings

*For notation, see key at front of Listings.*

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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 ORDER
R2   V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED BY
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 IV E


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
RHOP  9213    0.745    0.025              PLANO     60 HBC  +  WHOLE SPECTRUM  10/69
RHOP        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           10/69
RHO C       PARAMETER 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 SUFFICTIENTLY WELL              10/69
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 SUPERCEEDS 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+-, RESPECIVELY)
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           10/69
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

GA          AXIALVECTOR 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 AXIALVECTOR 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
                                4  MUON  (106,J=1/2)

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 40  452       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                      (EFINS)
PARKER    62 NC  23  485        S PARKER,S PENMAN                    (EFINS)

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 +        (PENNA)
FRANKEL2  63 PR 130  351        S FRANKEL,W FRATI,J HALPERN +        (PENNA)
HUTCHINS  63 PR 131 1351        HUTCHINSON,MENES,PATLACH,SHAPIRO (COLUMBIA)
MEYER     63 PR  132  2693      S L MEYER,ANDERSON,BLESER,LEDERMAN+ (COLUM)

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 ROJULA,SOERGEL           (CERN)
GUREVICH  64  PL  11  185       GUREVICH,MAKARIYNA+       (KURCHATOV,MOSCOW)
PONTECOR  64 DUBNA CONF         PONTECORVO,SULYAEV                 (MOSCOW)
PARKER    64 PR 1338 768        S PARKER,H L ANDERSON,C REY          (EFINS)

PEOPLES   66 NEVIS-147 (UNPUB) J PEOPLES                           (COLUMBIA)
GUREVICH 67  IAE 1297           GUREVICH,MAKARIYNA,MISHAKOVA+   (KURCHATOV)
SCHWARTZ 67  PR 162 1306        D M SCHWARTZ                         (EFINS)
SHERWOOD 67  PR 156 1475        B A SHERWOOD                         (EFINS)
BAILEY    68  PL  28B   287     +BARTL,VON BOCHMANN,BROWN,FARLEY+    (CERN)
FRYBERGE 68  PR 166 1379        D FRYBERGER                          (EFINS)

DERENZO   69  PR 181 1854       S DERENZO                            (EFINS)
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+LRL)
HUTCHINS 70 PRL 24 1254         HUTCHINSON,LARSON,SCHOEN,SOBER,+      (PPA)
CRANE     71 PRL 27 474         +CASPERSON,CRANE,EGAN,HUGHES+        (YALE)
DEVOE     71 PRL 25 1779(ER)    +MCINTGRE,MAGNON,STOWELL,SWANSON+ (CHICAGO)
    ALSO  71 PRL 26 213         DEVOE,MCINTGRE,MAGNON,STOWELL+    (CHICAGO)
FAVART    71 PRL 27 1336        +MCINTYRE,STOWELL,TELEGDI,DEVOE+  (CHICAGO)
KORENCH1 71 SJNP 13 190         KORENCHENKO,KOSTIN,MISHCHEL-MAKHER+  (JINR)
KORENCH2 71 SJNP 13 728         KORENCHENKO,KOSTIN,MITSEL-MAKHER+    (JINR)
CROWE     72 SUBMITTED TO PR    +HAGUE,ROTHBERG,SCHENCK,+         (LBL+WASH)
WILLIAMS 72 SUBMITTED TO PR     R W WILLIAMS, D L WILLIAMS     (WASHINGTON)

                                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 +    (EFINS)
LATHROP   60 NC   17 114        J LATHROP,R A LUNDY,S PENMAN +       (EFINS)
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                            (EFINS)
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                    8  CHARGED PION  (140,JPG=0--)  I=1
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                    8  CHARGED PI  MASS (MEV)

M           139.37     0.20            CROWE     54 CNTR  -
M           139.68     0.15            BARKAS    56 EMUL +
M           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    B  THE AUTHORS STATE THAT THE THIRD ORDER VACUUM POLARIZATION            2/72*
M    B  CORRECTION WHICH THEY USED WAS INCORRECT.  PRELIMINARY ESTIMATES      2/72*
M    B  YIELD AN INCREASE OF THIS VALUE BY 15-20 KEV (G. BACKENSTOSS,         2/72*
M    B  PRIVATE COMMUNICATION).                                               2/72*
M           . . . . . . . . .
M    AVG    139.577    0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M    FIT    139.576    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/72*

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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     33.917    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/72*

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                    8  ((MASS PI+)-(MASS PI-))/AVERAGE    (PERCENT)

DM            0.02     0.05            AYRES     71 CNTR                      3/71

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                    8  CHAR.PI 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           . . . . . . . . .
T    AVG     26.024    0.024    0.024  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)

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                    8 MEAN LIFE DIFFERENCE,(+)-(-)/AVGE. (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 PER CENT TOO LARGE BECAUSE OF A SYSTEMATIC ERROR IN THE PIO           2/72*
    D DETECTION EFFIECIENCY.  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
                                  8 CHARGED PION (140,JPG=0--)I=1

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                (ROME I F)

ANDERSON 60 PR 119 2050          H L ANDERSON,T FUJII,R H MILLER +     (EFINS)
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  (COLUM)

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)
  SEE ALSO  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)
AYRES    71 PR 30 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)
BOOTH    70 PL 32B 723           +JOHNSON,WILLIAMS,WORMALD              (LIVP)
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,MISHCHEL-MAKHER+  (JINR)

                                 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 MASS DIFFERENCE (PI+-)-(PIO)(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  PIO  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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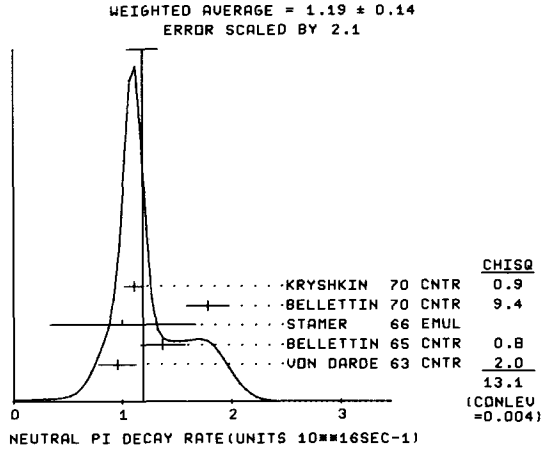


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                    9  NEUTRAL PION PARTIAL DECAY MODES

                                                          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

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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

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                                  REFERENCES
                                  9 NEUTRAL PION (135,JPG=0--)I=1

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+NRLW)
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)
KOLLER   63   SEE ALSO STAMER 66
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  1368 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)
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**K±**

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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            493.87     0.19            KUNSELMAN  71 CNTR  - KAONIC ATOMS     10/71*
M            . . . . . . . . . .
M   AVG      493.83     0.10    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   FIT      493.84     0.10   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)    2/72*
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            10  (K+)-(K-) MASS DIFFERENCE (MEV)

DM    1.5M  (-0.032)  (0.090)           FORD       72 ASPK +- PRELIMINARY       2/72*
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            10  CHAR.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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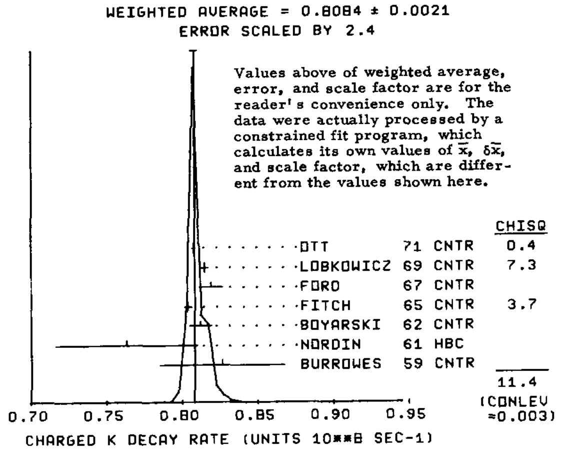


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            10 MEAN LIFE DIFFERENCE,(+)-(-)/AVGE. (PERCENT)

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      POSIT.K INTO PI+ PI- E+NEU            K E+ 4     139+ 139+  .5+   0
P8      POSIT.K INTO PI+ PI+ E-NEU            K E- 4     139+ 139+  .5+   0
P9      POSIT.K INTO PI+ PI- MU+ NEU          K+MU+ 4    139+ 139+ 105+   0
P10     POSIT.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 PI E NEUTRINO GAMMA      PI E NEU GAM 139+ .5+  0+   0
P19     NEG.  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
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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      51.55      0.25   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

W2     CHARG. 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       4.513     0.023  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

W3     CHAR. K INTO (TAU) - (TAU PRIME)  (UNITS 10**6 SEC-1)  (G3-G4)
W3     USED FOR DELTA I=1/2 TEST
W3          . . . . . . . . . .
W3  FIT       3.158     0.039  FROM FIT

W4     CHAR. K INTO (MU PIO NEU) + (E PIO NEU)  (UNITS 10**6 SEC-1) (G5+G6)
W4     USED FOR DELTA I=1/2 TEST
W4          . . . . . . . . . .
W4  FIT       6.51      0.12   FROM FIT
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            10  DECAY RATES DIFF.,(+)-(-)/AV.      (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            0.08      0.12          FORD       70 ASPK    SEE NOTE F         11/70
D2  F THE LAST IS THE COMBINED RESULT OF FORD 67 AND FORD 70
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

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)     (0.24)         EDWARDS    71 OSPK    PRELIMINARY         2/72*
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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          . . . . . . . . . .
R1  FIT      63.77      0.28   FROM FIT

R2     CHAR. K INTO (PI PIO)/TOTAL    (UNITS 10**-2)      (P2)
R2  O        (27.7)    (2.7)          BIRGE      56 EMUL +
R2  O        (23.2)    (2.2)          ALEXANDER  57 EMUL +
R2  O   EARLIER EXPERIMENTS NOT AVERAGED
R2           (21.0)    (0.6)          CALLAHAN   65 HLBC    SEE R17
R2           (21.6)    (0.6)          TRILLING   65 RVUE                        6/66
R2          . . . . . . . . . .
R2  FIT      20.92      0.29   FROM FIT

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 P  INCLUDES EVENTS OF TAYLOR 59
R3          . . . . . . . . . .
R3  AVG       5.521     0.098   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R3  FIT       5.583     0.030  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                        (SEE IDEOGRAM BELOW )
```
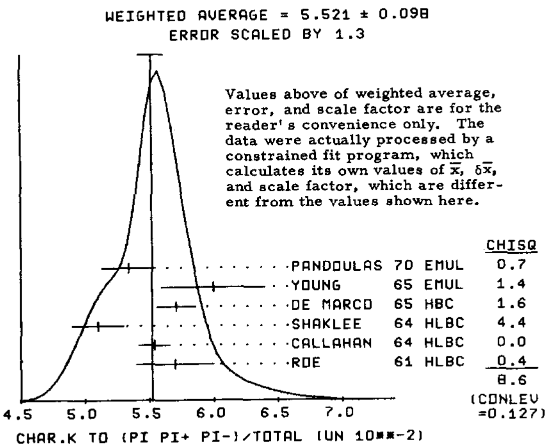



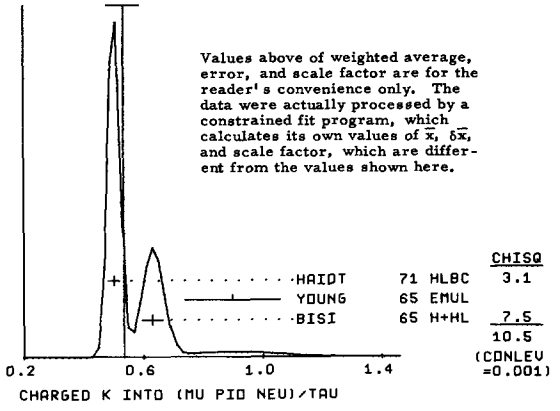
# Data Card Listings

*For notation, see key at front of Listings.*



```
R4      CHAR. K INTO (PI 2PIO)/TOTAL  (UNITS 10**-2)      (P4)
R4  0         (2.1)    (0.5)            BIRGE     56 EMUL +
R4  0         (2.2)    (0.4)            ALEXANDER 57 EMUL +
R4  0         (1.5)    (0.2)            TAYLOR    59 EMUL +
R4  0   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 P  INCLUDES EVENTS OF TAYLOR 59
R4          . . . . . . . . . .
R4  AVG       1.613    0.087   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  FIT       1.677    0.044  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      CHAR. K INTO (MU PIO NEU)/TOTAL (UNITS 10**-2)    (P5)
R5  0         (2.8)    (1.0)            BIRGE     56 EMUL +
R5  0         (5.9)    (1.3)            ALEXANDER 57 EMUL +
R5  0         (2.8)    (0.4)            TAYLOR    59 EMUL +
R5  0   EARLIER EXPERIMENTS NOT AVERAGED
R5          . . . . . . . . . .
R5  FIT       3.20     0.11   FROM FIT

R6      CHAR. K INTO (E PIO NEU)/TOTAL (UNITS 10**-2)     (P6)
R6  0         (3.2)    (1.3)            BIRGE     56 EMUL +
R6  0         (5.1)    (1.3)            ALEXANDER 57 EMUL +
R6  0   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          . . . . . . . . . .
R6  AVG       4.78     0.26    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  FIT       4.855    0.070  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       24.12    0.29   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

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) (P17)
R12     ALL VALUES GIVEN HERE ASSUME A PHASE SPACE PION ENERGY SPECTRUM        2/72*
R12           1.1      OR LESS  CL=.95  CHEN      68 OSPK +  T(PI) 60-90 MEV   5/68
R12           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     72 HLBC +  6-102,114-127MEV  2/72*

R13     CHAR. K INTO (PI PIO 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+  55-80 MEV   10/69
R13      24   (2.4)    (0.8)            EDWARDS   71 OSPK    PRELIMINARY       2/72*

R14     CHAR. K INTO (PI PI+ PI- GAMMA)/TOTAL (UNITS 10**-4) (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           0.4      OR LESS          CLINE     67 FBC  +                    11/67

R16     CHAR. K INTO (PI MU+ MU-)/TOTAL (UNITS 10**-6)    (P16)
R16           3.0      OR LESS  CL=.90  CAMERINI  65 FBC  +                     8/66
R16           2.4      OR LESS  CL=.90  BISI      67 DBC  +                    11/67

R17     CHAR. K INTO (PI PIO)/TAU                         (P2)/(P3)
R17     134   3.24     0.34             YOUNG     65 EMUL +                    . 8/66
R17    1045   3.96     0.15             CALLAHAN  66 FBC  +                     9/66
R17         . . . . . . . . . .
R17 AVG       3.84     0.27    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17 FIT       3.746    0.058  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

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       0.3004   0.0078 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R19     CHAR. K INTO (MU PIO NEU)/TAU                     (P5)/(P3)
R19    2175   0.632    0.035            BISI      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       0.573    0.019  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)
                       (SEE IDEOGRAM BELOW )

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       0.870    0.013  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
```

WEIGHTED AVERAGE = 0.536 ± 0.054
ERROR SCALED BY 3.2

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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       5.733    0.090  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R24     CHAR. K INTO (PI PIO)/(MU NEU)                    (P2)/(P1)
R24           0.3253   0.0065           AUERBACH  67 OSPK +                     8/67
R24    1600   0.305    0.018            ZELLER    69 ASPK +                    10/69
R24         . . . . . . . . . .
R24 AVG       0.3230   0.0065  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R24 FIT       0.3280   0.0059 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R25     CHAR. K INTO (E PIO NEU)/(MU NEU)                 (P6)/(P1)
R25     472   0.0797   0.0054           AUERBACH  67 OSPK +                     8/67
R25     THE VALUE .0785+-.0025 GIVEN IN THE ABOVE REF IS AN AVERAGE OF
R25     AUERBACH 67 R25 AND CESTER 66 R23.
R25     960    .0775   .0033            BOTTERIL1 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         . . . . . . . . . .
R25 AVG       0.0753   0.0025  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R25 FIT       0.0761   0.0011 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R26     CHAR. K INTO (MU PIO NEU)/(MU NEU)                (P5)/(P1)
R26     310   0.0602   0.0046           AUERBACH  67 OSPK +                     8/67
R26     424   0.055    0.004            GARLAND   68 OSPK +                     4/68
R26     240   0.054    0.009            ZELLER    69 ASPK +                    10/69
R26         . . . . . . . . . .
R26 AVG       0.0569   0.0029  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R26 FIT       0.0502   0.0018 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

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      11.421   0.085  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      66   2.15     0.35             CLARK     70 OSPK                      11/70
R28         . . . . . . . . . .
R28 AVG       2.04     0.28    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 A 1398    (0.604)  (0.022)          EICHTEN   68 HLBC                      10/68
R29 AH        (0.596)  (0.025)          HAIDT     71 HLBC +                    12/70
R29                    COMMENTS
R29  H        HAIDT 71 IS A REANALYSIS OF EICHTEN 68
R29 A      ONLY INDIVIDUAL RATIOS INCLUDED IN FIT--SEE R19 AND R20--          11/68
R29  C FROM THIS EXPERIMENT 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
R29  C SHOW LARGE DISAGREEMENTS WITH THE REST OF THE DATA.
R29         . . . . . . . . . .
R29 AVG       0.670    0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R29 FIT       0.659    0.022  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.8)

R30     CHAR. K INTO (PI E NEU GAMMA)/(PI E NEU)          (P18)/(P6)
R30 R         (0.012)  (0.008)          BELLOTT1  67 HLBC +  EGAM GT 30MEV   11/67
R30  R  13    0.0076   0.0028           ROMANO    71 HLBC    EGAM GT 10MEV   10/71*
R30 R  WE USE LOWEST E(GAMMA) CUT. SEE ROMANO 71 FOR DEPENDENCE ON THIS CUT  2/72*

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         (100.0)  OR LESS  CL=.90   CAMERINI  69 HLBC +  TEST NEUTR.CURR.   5/70
R32  K        1.2    OR LESS  CL=.90   KLEMS     71 OSPK +  T(PI) GT 117 MEV  8/71*
R32  K  ASSUMES PI+ SPECTRUM SAME AS PIO SPECTRUM IN KE3 DECAY

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       3.329    0.086  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*
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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       5.1       1.3  CLINE     72 HLBC +                  . 2/72*
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              CHARGED K CONSTRAINED FIT
          OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING
          RATIOS USES 46 DATA POINTS TO DETERMINE SIX
          QUANTITIES.  OVERALL FIT HAS  CHISQ=73.9.  MAIN
          CONTRIBUTION (13.5) 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 | .638+-.003 | | | | | |
| P 2 | -.850 | .209+-.003 | | | | |
| P 3 | -.138 | -.062 | .056+-.080 | | | |
| P 4 | -.127 | -.051 | .145 | .017+-.000 | | |
| P 5 | -.257 | -.188 | .083 | .002 | .032+-.001 | |
| P 6 | -.230 | -.198 | .168 | .009 | .481 | .049+-.001 |

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 $\Gamma_{total}$, 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 | .515+-.003 | | | | | |
| G 2 | -.669 | .169+-.002 | | | | |
| G 3 | -.106 | -.038 | .045+-.000 | | | |
| G 4 | -.099 | -.041 | .139 | .014+-.000 | | |
| G 5 | -.213 | -.176 | .083 | .002 | .026+-.001 | |
| G 6 | -.166 | -.173 | .165 | .010 | .482 | .039+-.001 |

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## Note on Slope Parameter for $K \to 3\pi$ Decays

As was discussed in Section IV F.1 of the text, for the $3\pi$ decays of the K mesons we list the slope parameter "g" which is defined by

$$|M|^2 \propto 1 + g \frac{(s_3 - s_0)}{m_{\pi^+}^2} \qquad (1)$$

where

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

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

$\underline{p}_K, \underline{p}_i$ are the four-vectors for the K and the $i^{th}$ pion, and the index 3 refers to the odd pion. (4)

We refer to the three possible charged decays as $\tau$, $\tau'$, $\tau^0$

$\tau^{\pm}$ $\quad K^{\pm} \to \pi^+\pi^-\pi^{\pm}$

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

$\tau^0$ $\quad K_2^0 \to \pi^+\pi^-\pi^0$

where the odd pion is the third one.

There is no strong evidence so far that a second order term is needed in Eq. (1). 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.

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:

$$Y = -\frac{3}{2}\frac{s_3 - s_0}{m_K Q} + \Delta, \text{ with } \Delta = \frac{m_{12} - m_3}{Q}\left(2 - \frac{m_3 + m_{12}}{m_K}\right)$$

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

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

# Data Card Listings

*For notation, see key at front of Listings.*

For the reader's convenience we give a table of numerical values for Q, $T_{3\,max}$, $\Delta$, $c_y$ and $c_t$, obtained using the masses from our August 1970 edition.

For the reader's convenience we give a table of numerical values for Q, $T_{3\,max}$, $\Delta$, $c_y$ 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 | $T_{3\,max}$ | $\Delta$ | $c_y$ | $c_t$ |
|---|---|---|---|---|---|
| $\tau^{\pm}$ | 74.96 | 48.15 | 0 | 0.7894 | 0.0924 |
| $\tau'^{\pm}$ | 84.24 | 53.27 | -0.0789 | 0.7025 | -0.0778 |
| $\tau^0$ | 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

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

The relevant transformation is then

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

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

```
                    10  CHARGED K   ENERGY DEPENDENCE OF DALITZ PLOT

            RELATED TEXT SECTION IV F.1, APPENDIX I, AND MINI-REVIEW ABOVE

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

GT+  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  K+ INTO PI+ PI+ PI-
GT+         THESE EXPTS FIT M**2=1+AY*Y. WE LIST G IN THE MAIN LISTING AND
GT+         GIVE AY AT RIGHT. G=-1.5*AY*(MPI**2)/(MK*Q). SEE NOTE ABOVE.
GT+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+   1.5M  (-0.2169) (0.0026)        FORD      72 ASPK +- PRELIMINARY         2/72*
GT+  39819   -0.201    0.008          HOFFMASTE 72 HLBC +  INCLUDES GRAUMAN    1/71
GT+ G       EMULS. DATA ADDED - ALL EVENTS INCLUDED BY HOFFMASTER 72           1/71
GT+ Z  ALSO INCLUDES DBC EVENTS
GT+         . . . . . . . . . .
GT+ AVG      -0.2057   0.0069  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

```
GT-  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  K- INTO PI- PI- PI+
GT-         FOR DEFINITION OF AY SEE NOTE UNDER S1OGT+
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- F  NO RADIATIVE CORRECTIONS INCLUDED
GT- M  ALSO INCLUDES DBC EVENTS
GT-         . . . . . . . . . .
GT- AVG      -0.1937   0.0067  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

DG  ((GT+)-(GT-))/((GT+)+(GT-)) IN PERCENT
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   1157    0.602    0.049         AUBERT    70 HLBC +  ONE PARAM. FIT      2/72+
GTP   1527    0.602    0.061         AUBERT    70 HLBC +  THREE PARAM. FIT. 2/72*
GTP    198    0.516    0.074         PANDOULAS 70 EMUL +                      10/70
GTP         . . . . . . . . . .
GTP AVG       0.527    0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
------ --------- --------- --------- --------- --------- --------- --------
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## Note on $K^+$ and $K^0$ Form Factors

The definition of all the variables listed in this section can be found in Section IV F.2 of the text. As in the past we keep the values of $\xi$ as obtained in the $\mu$ polarization measurements ($\xi_B$) separated from the values obtained from branching ratios and spectra ($\xi_A$), but combine them in order to display in an ideogram the discrepancies in Re $\xi$.

Many approximations are usually made to extract these 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 $\xi$ so far is consistent with 0, and this is usually assumed in most of the experiments.

3) The $q^2$ dependence of the $f_{\pm}$ form factors is assumed to be linear, as in Eq. (27) in the main text.

4) Radiative corrections are not serious; they change $\lambda_+$ by about 0.005 (GINSBERG 67 and 70).

5) Momentum transfer dependence of $\xi$. From Eq. (27) and Eq. (28) in the main text, it is clear that <u>in the first approximation</u> one has

$$\xi(q^2) = \xi(0)[1 + (\lambda_- - \lambda_+)t] ,$$

where $t = q^2/m_\pi^2$. This shows that the three parameters $\xi(0)$, $\lambda_-$, and $\lambda_+$ can be highly correlated. Many of the old experiments have assumed $\lambda_+ = \lambda_- = 0$; however, recently it has become clear that in order to eliminate the discrepancies between $\xi_A$ and $\xi_B$, $\lambda_+$ and $\lambda_-$ should be included in the fits. We discuss each method of determining $\xi$ separately.

a) Branching ratio analysis. From Eq. (29) in the main text it is clear that $\frac{d\xi}{d\lambda_+} \approx -\frac{1.4}{0.125} \approx -11$. Therefore for $\lambda_+ = 0.05$, $\Delta\xi = -0.55$. The old hypothesis $\lambda_+ = 0$ certainly is not very good.

b) Dalitz plot analysis. From Eq. (26) in the main text, it appears that the Dalitz plot distribution of the $K_{e3}$ decay is essentially dependent only upon $\lambda_+$ and independent from $\xi$; therefore, the values of $\lambda_+$ obtained from $K_{e3}$ data can be directly averaged.

On the other hand for the $K_{\mu 3}$ Dalitz plot, all three parameters are involved and they are correlated. For example, CHIEN 70 (in a neutral K experiment) find that $\lambda_+$ is not sensitive to $\xi$ and $\lambda_-$ variations, whereas $\xi$ and $\lambda_-$ are highly correlated. HAIDT 71 (in a $K^+$ experiment) find that the uncorrelated parameters are $\xi(0)$ and $\xi(6.8)$. Because of these correlations, we list the values of $\lambda_+$ from $K_{\mu 3}$ decays separately from those obtained from $K_{e3}$ decays and do not list $\lambda_-$ at all. We refer the reader to the original papers for discussion of the $\lambda_-$ parameter.

c) Muon polarization analysis. The $\mu$ polarization depends only on $\xi(q^2)$; the $\lambda_+$ and $\lambda_-$ parameters do not appear explicitly in Eq. (30) in the main text. For large statistics one could determine $\xi(q^2)$ and then derive $\xi(0)$, $\lambda_+$, and $\lambda_-$. This has not been possible with the statistics available so far.

In addition to the most common correlation among $\xi$, $\lambda_+$, and $\lambda_-$, there are many experimental difficulties. For example, in the Dalitz plot both $\xi$ and $\lambda_+$ are most sensitive to the low $E_\pi$ region, which happens to be the least populated area; hence, the parameters are determined with a very small fraction of the data. Many experiments are sensitive only to part of the Dalitz plot. Others fit only one projection of it, which may yield more than one solution.

In conclusion, due to various experimental difficulties and inhomogeneous treatment of the data by the various experiments, in this edition we continue our past policy of not quoting average values, and limit our review to a listing of experimental data. Again, as in the past, the table does not include any values for $\lambda$ and $\xi$.

For a recent review on $K_{\ell 3}$ form factors, see Gaillard and Chounet.[1]

## Reference

1. M. K. Gaillard and L. M. Chounet, $K_{\ell 3}$ Form Factors, CERN 70-14 (May 1970), and Phys. Letters 32B, 505 (1970).

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                    10  CHARGED K FORM FACTORS                                  8/67

          RELATED TEXT SECTION IV F.2 AND MINI-REVIEW ABOVE

             F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT
             FS AND FT REFER TO THE SCALAR AND TENSOR TERM

XIA     XIA = F-/F+ (DETERMINED FROM SPECTRA AND KMU3/KE3)   ---------------
XIA      SOME OF THE OLDER EXPERIMENTS HAVE EVALUATED XI ASSUMING THAT IT IS
XIA      INDEPENDENT OF THE MOMENTUM TRANSFER (T), I.E., THEY SET L+=L-=0.
XIA      OTHERS HAVE ASSUMED A VALUE FOR L+ AND USED L-=0. ONLY RECENTLY
XIA      BOTH L+,L- AND XI(0) (OR THREE RELATED PARAMETERS) HAVE BEEN INCLU-
XIA      DED IN THE FITS . SEE HAIDT 71. (OR CHIEN 70 FOR KOL) .
XIA L    76  (+1.8)    (1.6)              BROWN     62 XEBC +  MU+,PIO SPECTRA    8/67
XIA L    87  (+0.7)    (0.5)              GIACOMELL 64 EMUL +  MU+ SPECTRUM       8/67
XIA L        (-0.1)    (0.7)              JENSEN    64 XEBC +  MU+,PIO SPECTRN    8/67
XIA L        (-0.17)   (0.75)   (0.99)    SHAKLEE   64 XEBC +  KMU3/KE3           8/67
XIA L        (+0.6)    (0.5)              BISI 1    65 HBC  +  KMU3/KE3           8/67
XIA          BTWN +0.2 AND +1.4           CUTTS     65 OSPK +  MU+ SPECTRUM       8/67
XIA L 1509   (+0.4)    (0.4)              CALLAHA1  66 FRBC +  KMU3/KE3           8/67
XIA   2648     0.0      1.1        0.9    CALLAHA1  66 FRBC +  MU+ SPECTRUM       8/67
XIA    444    +0.72     0.80              CALLAHA1  66 FRBC +  P+O SPEC,FIX MU    8/67
XIA L        (+0.75)   (0.50)             AUERBACH  67 OSPK +  KMU3/KE3           8/67
XIA E 1398   (-0.60)   (0.20)             EICHTEN   68 HLBC +  KMU3/KE3 T=4.     10/68
XIA B 5601   (-0.08)   (0.15)             BOTTERIL2 68 ASPK +  KM3/KE3,LM+=.023   6/68
XIA L   78   (-0.5)    (0.9)              EISLER    68 HLBC +  PIO SPECT,LM+-=0   6/68
XIA L  976   (+1.0)    (0.6)              GARLAND   68 OSPK +  KMU3/KE3,LM+-=0    4/68
XIA            0.91     0.82              ZELLER    69 ASPK +  KM3/KE3 NOTE Z    10/69
XIA  B        -0.35     0.22              BOTTERIL  70 OSPK    KM3/KE3,LM+=.045 10/69
XIA  H3240    -0.80     0.50              HAIDT     71 HLBC +  D.P. L+=.055,T=7  2/72*
XIA   3240    -0.50     1.5               HAIDT     71 HLBC +  D.P. L+=.055,T=0  2/71
XIA   1505    -0.72     0.21              HAIDT     71 HLBC +  KM3/KE3, L+=.029  2/71
XIA  H  CORRECTED VALUE OBTAINED USING FIGURE 18B                               2/72*
XIA  H  VALUES AT T=0 AND AT T=6.8 ARE UNCORRELATED                             2/72*
XIA  B  T=0  BOTTERIL 70 IS REEVALUATION OF BOTTERIL2 68 WITH DIFF. L+         10/69
XIA E        EICHTEN 68 REPLACED BY HAIDT 71
XIA  E  T=4  ASSUMES  L+=.023+-.008 - INSENSITIVE TO L-
XIA L   L+ AND  L-  ASSUMED TO BE ZERO - NOT AVERAGED
XIA Z   T=0 ZELLER 69 ASSUMES L+=0.023 ,L-=0
XIA          . . . . . . . . . .
XIA AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

XIB     XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)   ------------
XIB     THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+-
XIB     NECESSARY, T SHOULD BE SPECIFIED.
XIB   2100   +1.2       2.4       1.8    BORREANI  65 HLBC +  POLARIZATION       8/67
XIB    397   -1.4       1.8              CALLAHA1  66 FRBC +  TOTAL POLA-.       8/67
XIB   2950   -0.7       0.9       3.3    CALLAHA1  66 FRBC +  LONG. POLAR.       8/67
XIB   3133   -0.95      0.3              CUTTS     68 OSPK +  TOTAL POL. T=3     6/68
XIB  H6000   -0.6       1.1              HAIDT     71 HLBC +  TOTAL POL. T=0     2/72*
XIB  H6000   -1.0       0.3              HAIDT     71 HLBC +  TOTAL POL. T=4.9   2/72*
XIB  H  HAIDT 71 VALUES AT T=0 AND T=4.9 ARE UNCORRELATED.
XIB          . . . . . . . . . .
XIB AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

RXI       REAL PART OF XI   (COMBINED XIA AND XIB)
RXI   2100   +1.2       2.4       1.8    BORREANI  65 HLBC +  MU POL
RXI   2648    0.0       1.1       0.9    CALLAHA1  66 FRBC +  MU+ SP.
RXI    444   +0.72      0.37             CALLAHAN  66 FRBC +  PIO SP.
RXI    397   -1.4       1.8              CALLAHAN  66 FRBC +  MU POL (TOT.)
RXI   2950   -0.7       0.9       3.3    CALLAHAN  66 FRBC +  MU POL (LONG.)
RXI   3133   -0.95      0.3              CUTTS     68 OSPK +  MU POL T=3
RXI           0.91      0.82             ZELLER    69 ASPK +  B.R.
RXI          -0.35      0.22             BOTTERIL  70 OSPK    KM3/KE3,LM+=.045 10/69
RXI   6000   -1.0       0.5              HAIDT     71 HLBC +  LM+=.060  T=0      2/72*
RXI   6000   -0.97      0.2              HAIDT     71 HLBC +  LM+=.060  T=5.1    2/72*
RXI          . . . . . . . . . .
RXI AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)
                          (SEE IDEOGRAM BELOW )
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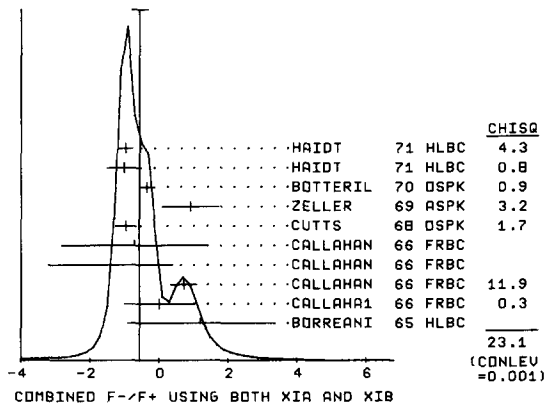


COMBINED F-/F+ USING BOTH XIA AND XIB

```
IXI        IMAGINARY PART OF XI (TEST OF T REVERSAL)    ------------------
IXI          0.1       0.4       0.3    BETTELS   68 HLBC    POLARIZATION      10/69

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*

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*
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L+E      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY)   ---------
L+E       FOR RAD. CORR. TO THE DALITZ PLOT, SEE GINSBERG 67.
L+E    217   +0.036     .045            BROWN     62 XEBC +  PIO SPEC,NO R.C.
L+E    407   -0.010     .029            JENSEN    64 XEBC .+  PIO SPEC,NO R.C.   8/67
L+E    230   -0.04      .05             BORREANI  64 HBC  +  E+ SPEC,NO R.C.    8/67
L+E    854    0.045    0.017     0.018 BELLOTT2  67 FBC  +  DLTZ PLT, R.C.    11/67
L+E   1393   +0.016     .016            IMLAY     67 OSPK + DLTZ PLT,NO R.C.    8/67
L+E    515   +0.028     .013      .014 KALMUS    67 FBC  + E,PI SPEC,NO R.C.   8/67
L+E    960    (.08)    (.04)            BOTTERIL1 68 ASPK + E SPEC  USES R.C.   6/68
L+E     90   -0.02     0.08      0.12  EISLER    68 HLBC + PIO SPEC,NO R.C.    6/68
L+E   1458     .045     .015            BOTTERIL  70 OSPK    PIO SPECTRUM RC  10/69
L+E   2707    0.027    0.010            STEINER   71 HLBC DLTZ PLT,USES R.C.  11/71*
L+E         . . . . . . . . . .
L+E AVG        0.0280   0.0058  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)
L+M      FOR RAD. CORR. TO DALITZ PLOT OF KMU3  SEE GINSBERG 70
L+M            0.055    0.025           HAIDT     71 HLBC    KMU3 DAL. PLOT    2/71

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

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.      E R COHEN,K M CROWE,J DUMOND   (AI+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       (MICHIGAN)
KALMUS    64 PRL    13    99      +KERNAN,PU,POWELL,DOWD            (LRL,WISC)
SHAKLEE   64 PR   136 B 1423      SHAKLEE,JENSEN,ROE,SINCLAIR       (MICHIGAN)

BIRGE     65 PR 139 B 1600        BIRGE,ELY,GIDAL,CAMERINI,CLINE +  (LRL+WIS)
BISI      65 NC    35  768        BISI,BORREANI,CESTER,FERRARO +       (TURIN)
BISI 1    65 PR 139 B 1068        BISI,MARZARI-CHIESA,RINAUDO   (TURINO,INFN)
BORREANI  65 PR 140 B1686         BORREANI,GIDAL,RINAUDO,CAFORIO+(BARI,TURIN)
CALLAHAN  65 PRL   15  129        A CALLAHAN,D CLINE               (WISCONSIN)
CAMERINI  65 NC    37 1795        CAMERINI,CLINE,GIDAL,KALMUS,KERNAN(WIS+LRL)
CLINE     65 PL    15  293        A CLINE,W F FRY                  (WISCONSIN)

DE MARCO  65 PR 140 B 1430        DE MARCO,GROSSO,RINAUDO        (TURINO+CERN)
FITCH     65 PR 140 B 1088        FITCH,QUARLES,WILKINS  (PRINCETON+MT HOLYK)
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)
TRILLING  65    IS 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)
CESTER    66    SEE ALSO FOOTNOTE 1 OF AUERBACH 67

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,FIORINI,PULLIA+             (MILAN)
BISI      67 PL 25B  572          BISI,CESTER,CHIESA,VIGONE           (TORINO)
BOTTERIL  67 PRL  19  982         BOTTERILL,BROWN,CORBETT,CULLIGAN + (OXFORD)
BOTTERIL  67   SEE ALSO BOTTERILL 68
BOWEN     67 PR 154 1314          BOWEN,MANN,MCFARLANE,HUGHES+(PENN-PRINCETO)

CLINE     67 HEIDELBERG CONF      CLINE,HAGGERTY,SINGLETON,FRY+    (WISCONSIN)
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+
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)
CUTTS     68 PRL 20 955           CUTTS,STIENING,WIEGAND,DEUTSCH     (LRL,MIT)
  ALSO    65 PR 138 B969          CUTTS,ELIOFF,STIENING                  (LRL)
  ALSO    69 PR 184 1380          +STIENING,WIEGAND,DEUTSCH          (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)

CAMERINI  69 PRL 23 326           +LJUNG,SHEAFF,CLINE              (WISCONSIN)
DAVISON   69 PR   180 1333        +BACASTOW,BARKAS,EVANS,FUNG,PORTER+  (RIVS)
ELY       69 PR   180 1319        ELY,GIDAL,HAGOPIAN,KALMUS+    (UCL,WIS,LRL)
EMMERSON  69 PRL 23 393           EMMERSON,QUIRK                      (OXFORD)

HERZO     69 PR 186 1403          +BANNER,BEIER,BERTRAM,EDWARDS +        (ILL)
LOBKOWIC  69 PR 185 1676          +MELISSINOS,NAGASHIMA,TEWKSBURY+ (ROCH,BNL)
   ALSO   66 PRL 17 548           LOBKOWICZ,MELISSINOS,NAGASHIMA+  (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)

AUBERT    70  LAL-1238 (KIEV)     +HEUSSE,PASCAUD,VIALLE+         (ORSA+BRUX)
BOTTERIL  70 PL 31B 325           +BROWN,CLEGG,CORBETT,CULLIGAN+         (OXF)
CLARK     70 UCRL 20079           +CORK,ELIOFF,KERTH,MCREYNOLDS+         (LRL)
FORD      70 PRL 25 1370          +PIROUE,REMMEL,SMITH,SOUDER           (PRIN)
GRAUMAN   70 PR D1 1277           +KOLLER,TAYLOR,PANDOULAS+ (STEV,SETON,LEHI)
  ALSO    69 PRL 23 737           +KOLLER,TAYLOR,PANDOULAS+ (STEV,SETON,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)
EDWARDS   71 COO-1195-230         +BEIERS,BERTRAM,HERZO,KOESTER+         (ILL)
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           R. KUNSELMAN                       (WYOMING)
OTT       71 PR D3 52             OTT,PRITCHARD                         (QMCL)
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

CLINE     72 PREPRINT             D CLINE, D LJUNG                 (WISCONSIN)
FORD      72 TO BE PUBL. IN PL    +PIROUE,REMMEL,SMITH,SOUDER      (PRINCETON)
HOFFMAST  72 NP B36 1             HOFFMASTER,KOLLER,TAYLOR+  (STEV,SETO,LEHI)
LJUNG     72 PRL 28 523           D LJUNG                          (WISCONSIN)

       QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BLOCK     62 CERN CONF 371        BLOCK,LENDINARA,MONARI         (NWU+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+WIS+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           +STEIN+(AACH+BARI+CERN+EPOL+NIJM+ORS+PA+TO)
FEARING   70 PR D3 542            +FISCHBACK,SMITH                 (SUNY+BOHR)
GINSBERG  70 PR D1 229            E S GINSBERG                     (IIT HAIFA)

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## $K^0$

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                  11  NEUTRAL K  (JP=0-)  I=1/2

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                  11  KO 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      497.79     0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/72*
                         (SEE IDEOGRAM BELOW )
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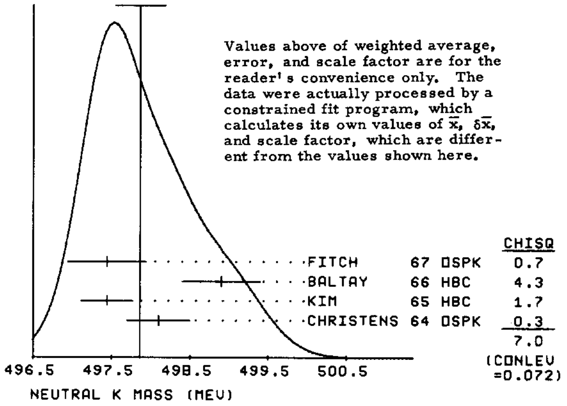
WEIGHTED AVERAGE = 497.87 ± 0.32
ERROR SCALED BY 1.5

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                  11  KO-K CH. 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       3.95      0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)  2/72*

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                                  REFERENCES
                                  11 NEUTRAL K (JP=0-)I=1/2

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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## $K_S^0$

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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     20000    0.865    0.009          HILL      68 DBC                   6/68
T    B  KOS MEAN LIFE NOT THE PRIMARY QUANTITY MEASURED IN THIS EXPT.     6/68
T    H   HILL 68 GIVES A DETAILED DISCUSSION OF SYSTEMATICS ENCOUNTERED
T    H   IN THIS TYPE OF EXPERIMENT.
T            . . . . . . . . .
T    AVG        0.8619   0.0062   0.0062 AVERAGE (ERROR INCL. SCALE FACTOR OF 1.2)
T    FIT        0.8619   0.0058 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                         (SEE IDEOGRAM BELOW )
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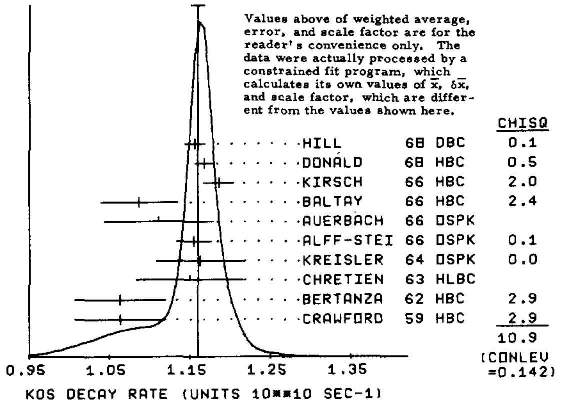
WEIGHTED AVERAGE = 1.1602 ± 0.0084
ERROR SCALED BY 1.2

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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

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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        0.6885    0.0031 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        0.3115    0.0031 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                         (SEE IDEOGRAM BELOW )

R3          KOS INTO (PI+ PI-)/(PIO PIO)                 (P1)/(P2)
R3      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     6380     2.22      0.08          MORSE     72 DBC                       2/72*
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           . . . . . . . . . .
R3   AVG        2.217     0.038   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R3   FIT        2.210     0.032  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                         (SEE IDEOGRAM BELOW )

R4      (KOS INTO PI+ PI- PIO)/(KOL INTO PI+ PI- PIO)
R4      TEST OF CP VIOLATION - SEE TEXT SECTION IV F.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 C      THIS IS THE COMBINED RESULT OF ANDERSON 65 AND WEBBER 70
R4      99    1.2   OR LESS  CL=.90   CHO       71 DBC                        4/71*
R4      98    1.0   OR LESS  CL=.90   JAMES     71 HBC                        6/71*
R4   M  50   (1.2)  OR LESS  CL=.95   MEISNER   71 HBC   0 CL=.9 NOT AVAIL.   2/71
R4   M    THESE AUTHORS FIND REAL(A)= 2.75+-.65 , ABOVE VALUE AT RE(A)=0      2/71
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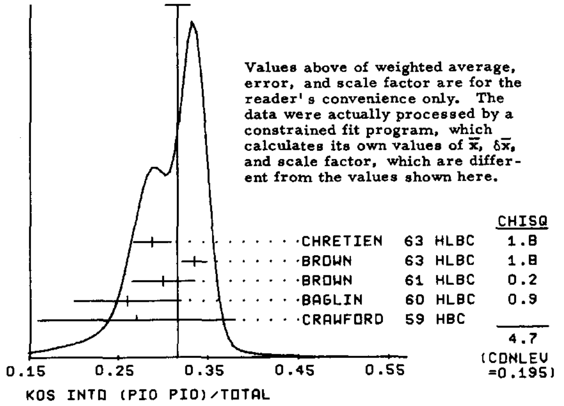
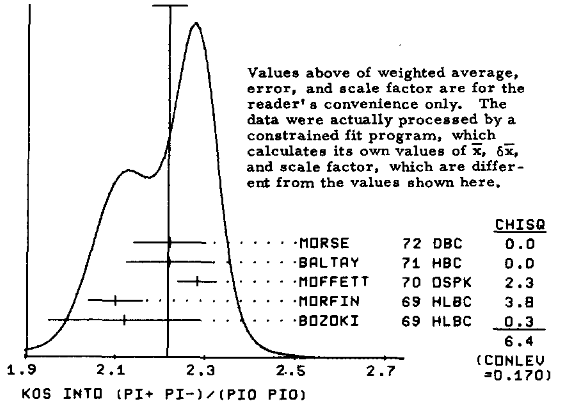
WEIGHTED AVERAGE = 0.316 ± 0.014
ERROR SCALED BY 1.3




WEIGHTED AVERAGE = 2.217 ± 0.038
ERROR SCALED BY 1.3

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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   S     VALUE CALCULATED BY US,USING 2.3 INSTEAD OF 1 EVENT, 90 PERC.CL  10/69

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

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)/TOTAL
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       0   (2.0)  OR LESS  CL=.90   MORSE     72 DBC                       2/72*
R8 R     THESE LIMITS ARE FOR MAXIMUM INTERFERENCE IN KS-KL TO 2 GAMMAS     12/71*

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                          REFERENCES
            12  SHORT-LIVED NEUTRAL K (498, JP=0-)  I=1/2

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 +  (PARIS EP)
BOWEN    60 PR   119 2030       BOWEN,HARDY,REYNOLDS,SUN,MOORE+(PRINCE+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 0105       BERTANZA,CONNOLLY,CULWICK,EISLER +     (BNL)
            (BERTANZA 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+MICHIGAN)
KREISLER 64 PR   136 B 1074     M KREISLER,O OVERSETH,J CRONIN  (PRINCETON)
ANDERSON 65 PRL  14 475         +CRAWFOR,GOLDEN,STERN,BINFORD +  (LRL+WISC)

ALFF-STE 66 PL  21 595          ALFF-STEINBERGER,HEUER,KLEINKNECHT + (CERN)
AUERBACH 66 PR 149 1052         AUERBACH,DOBBS,LANDE,MANN,SCIULLI+    (PENN)
             SEE ALSO AUERBACH 65
BALTAY   66 PR 142   932        BALTAY,SANDWEISS,STONEHILL +      (YALE+BNL)
BEHR     66 PL   22  540        BEHR,BRISSON,PETIAU+ (EP,MILAN,PADUA,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)
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BOTT-BOD 67 PL 24B 194         BOTT-BODENHAUSEN,DE BOUARD,CASSEL+   (CERN)
DONALD   68 PL 27B 58          DONALD,EDWARDS,NISAR+(LIVERPOOL,CERN,PARIS)
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                 (ANN ARBOR)
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)
MORSE    72 PRL 28 388         +NAUENBERG,BIERMAN,SAGER+   (COLO,PRIN,UMD)

                               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   (PRINCE+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)
TRILLING 65   IS 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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### Note on $K^0_L$ - $K^0_S$ Mass Difference

Because the mass difference is now known almost as precisely as the $K^0_S$ lifetime, we no longer give the mass difference in units of inverse $K^0_S$ lifetimes. Following the convention of recent mass difference experiments (FAISSNER 69, CULLEN 70, ARONSON 70, CARNEGIE 71), we now give $\Delta M/\hbar$ in units of $10^{10}$ $sec^{-1}$. For ease of comparison, other experiments have been converted to these units by dividing by the $K^0_S$ lifetime. We have used the value of the $K^0_S$ lifetime given in this review ($0.862\times 10^{-10}$ sec) in those cases where the author's value is not given.

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                 13  KOL-KOS  MASS DIFFERENCE
  WE GIVE (K0L-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   ASS.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 UNCERTIANTY 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  T   A KOS MEAN LIFE OF 0.862 10**-10 SEC WAS USED IN CONVERTING THE MASS      1/71
D  T   DIFFERENCE FROM UNITS OF INVERSE KOS MEAN LIVES TO ABSOLUTE UNITS.        1/71
D  T   VALUES NOT BEARING THIS FOOTNOTE EITHER WERE GIVEN IN ABSOLUTE UNITS      1/71
D  T   OR WERE CONVERTED USING THE AUTHORS VALUE OF THE KOS MEAN LIFE.           1/71
D          . . . . . . . . . .
D   AVG        0.5402   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  71 CNTR  0                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       5.172    0.042  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 13  KOL PARTIAL DECAY MODES

                                                     DECAY MASSES
P1       KOL INTO 3PIO                  TAU O PRIME   134+ 134+ 134
P2       KOL INTO PI+ PI- PIO           TAU O         139+ 139+ 134
P3       KOL INTO PI MU NEUTRINO        KL MU3        139+ 105+   0
P4       KOL INTO PI E NEUTRINO         KL E3         139+  .5+   0
P5       KOL INTO PI+ PI-               KL PI+ PI-    139+ 139
P6       KOL INTO MU+ MU-               KL 2MU        105+ 105
P7       KOL INTO E+ E-                 KL 2E          .5+  .5
P8       KOL INTO E MU                  KL EMU         .5+ 105
P9       KOL INTO TWO GAMMAS            KL 2GAMMA       0+   0
P10      KOL INTO PI+ PI- GAMMA         KL PI+-G      139+ 139+   0
P11      KOL INTO PIO PIO               KL 2PIO       134+ 134
P12      KOL INTO PI E NEU GAMMA        KL E3GAM      139+  .5+   0+    0
P13      KOL INTO PIO TWO GAMMAS        KL PI2GAMMA   134+   0+   0

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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       4.13     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       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      IN THE OVERALL FIT THIS RATE IS WELL DETERMINED BY THE MEAN LIFE AND
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          . . . . . . . . . .
W2   AVG       2.38     0.17     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
W2   FIT       2.431    0.056  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
                        (SEE IDEOGRAM BELOW )
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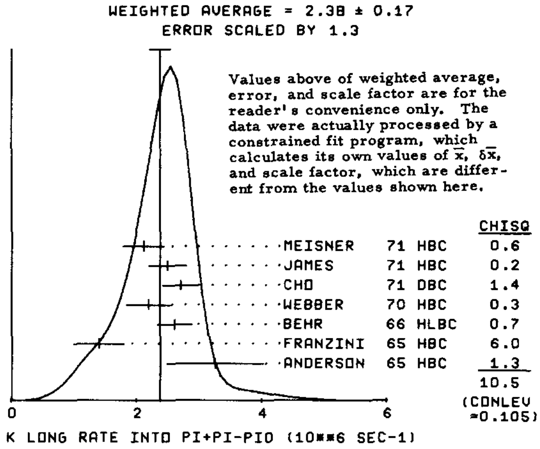


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W3      KOL INTO PI E NEUTRINO        (UNITS 10**6 SEC-1)  (G4)
W3            7.52      0.85      0.72  AUBERT     65 HLBC    DS=DQ,CP ASSUMED   8/67
W3     620    7.81      0.56            CHAN       71 HBC                       2/72*
W3         . . . . . . . . . .
W3   AVG      7.71      0.46     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W3   FIT      7.54      0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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      0.17   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

W5      KOL INTO LEPTONIC (KMU3+KE3) (UNITS 10**6 SEC-1) (G3+G4)
W5    D 109     9.85    1.15      1.05  FRANZINI  65 HBC                        2/72*
W5   C  335   (10.3)   (0.8)            HILL      67 DBC     K+N TO KO P        8/67
W5    D 393    11.6     0.9             CHO       70 DBC     K+N TO KOP        10/70
W5    D 252    13.1     1.3             WEBBER    71 HBC     K- P TO KOBAR N    2/72*
W5   C  CHO 70 INCLUDES EVENTS OF HILL 67
W5    D  ASSUMES DS=DQ RULE
W5         . . . . . . . . . .
W5   AVG     11.39      0.84     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
W5   FIT     12.72      0.16   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                        (SEE IDEOGRAM BELOW )
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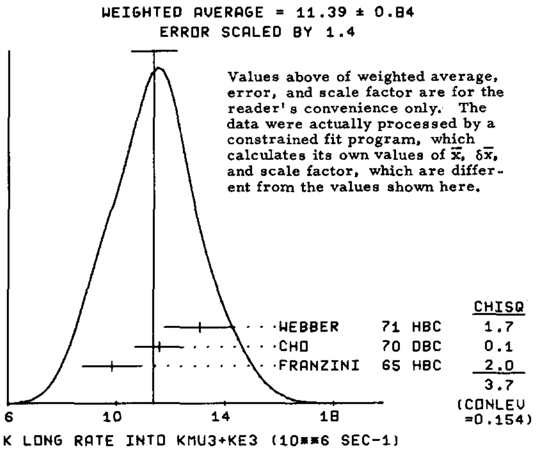


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W6      KOL INTO PI MU NEUTRINO      UNITS 10**6 SEC-1)    (G3)
W6      19     4.54      1.24      1.08  LOWYS       67 HLBC                      8/67
W6                • • • • • • • • • •
W6  FIT            5.18      0.12    FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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13 KOL BRANCHING RATIOS

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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          0.273     0.011   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      558    0.157     0.010              EVANS      69 HLBC                    10/69
R2              • • • • • • • • • •
R2  AVG          0.1612    0.0038  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2. FIT          0.1604    0.0034 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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          0.3421    0.0065 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          0.4975    0.0066 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5      KOL INTO (PI E NEU)/((PI E NEU)+(PI MU NEU))          (P4)/(P3+P4)
R5      320    0.415     0.120              ASTIER     61 CC
R5              • • • • • • • • • •
R5  FIT          0.5925    0.0075 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R6      KOL INTO (PI+ PI- PIO)/TOTAL                            (P2)
R6
R6              • • • • • • • • • •
R6  FIT          0.1257    0.0027 FROM FIT

R7      KOL INTO (LEPTON PI NEUTRINO)/TOTAL                     (P3+P4)
R7
R7              • • • • • • • • • •
R7  FIT          0.6581    0.0065 FROM FIT

R8        KOL INTO (2 GAMMA)/TOTAL     (UN. 10**-4)          (P9)
R8  C           (1.3)     (0.6)             CRIEGEE    66 OSPK                    8/66
R8        32     6.7       2.2              TODOROFF   67 OSPK   REPL.  CRIEGEE66 11/68
R8  K     33    (7.4)     (1.6)             CRONIN 1   67 OSPK                    11/67
R8        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 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          5.13      0.70    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              • • • • • • • • • •
R9  AVG          1.992     0.073   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R9  FIT          2.002     0.063  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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              0.67      0.13             KULYUKINA 68 CC                        2/71
R10 B           (0.71)    (0.04)            BEILLIERE 69 HLBC                     10/69
R10 B   BEILLIERE 69 IS A SCANNING EXPT USING SAME EXPOSURE AS BUDAGOV 68
R10     1309     0.648     0.030            EVANS      69 HLBC                    10/69
R10     3548     0.68      0.08             BASILE     70 OSPK                    10/70
R10             • • • • • • • • • •
R10 AVG          0.687     0.024    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R10 FIT          0.688     0.021   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
                           (SEE IDEOGRAM BELOW )
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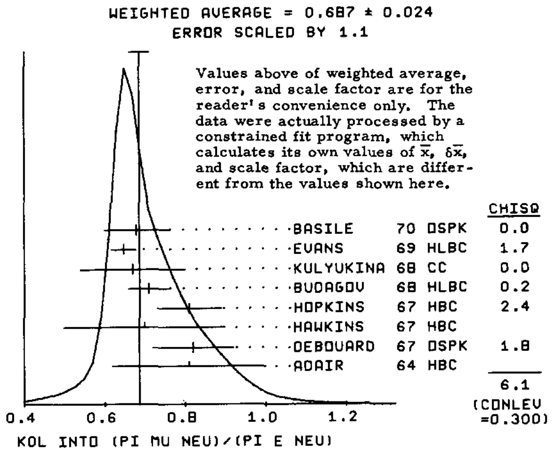


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R11     KOL INTO (MU+MU-)/CHARGED    (UNITS 10**-6)          (P6)/(P2+P3+P4)
R11         100.0    OR LESS               ANIKINA    65 CC                        6/66
R11         250.0    OR LESS   CL=.90      ALFF-STEI 66 OSPK                       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 0    97    (0.90)    (0.18)            NEAGU      61 CC
R15 0          (1.01)    (0.16)            LUERS      64 HBC                       8/66
R15 0   894    (0.99)    (0.023)           KULYUKINA 66 CC                         9/66
R15 0 1539    (1.06)    (0.05)             VERHEY     66 OSPK                      8/67
R15 0   LOW PRECISION EXPTS NOT AVERAGED.  FOR MORE PRECISE VALUE,
R15 0   SEE S13A2 (BENNETT 70, MARX 70)

R16     KOL INTO(MU+ PI- NEU)/(MU- PI+ NEU)
R16     1M     1.0081    0.0027            DORFAN     67 OSPK                     11/67
R16     SEE ALSO S13A2 AND S13AL IN THE CP VIOLATION SECTION                      2/71

R17        KOL INTO (PIO PIO)/TOTAL  (UNITS 10**-3)      (P11)
R17 C     7   (1.2)     (1.5)     (1.2)  CRIEGEE    66 OSPK                       7/66
R17 C   CRIEGEE EXPT NOT DESIGNED TO MEASURE 2 PIO DECAY MODE
R17 G  189    (2.5)     (0.8)            GAILLARD  69 OSPK    E00=3.6+-0.6       5/69
R17 G   LATEST RESULT OF THIS EXPERIMENT GIVEN BY FAISSNER 70 R19                1/71
R17             • • • • • • • • • •
R17 FIT          0.94      0.19    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             • • • • • • • • • •
R18 AVG          1.81      0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 FIT          1.700     0.070  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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     0.091  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)
                           (SEE IDEOGRAM BELOW )

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          2.384     0.076  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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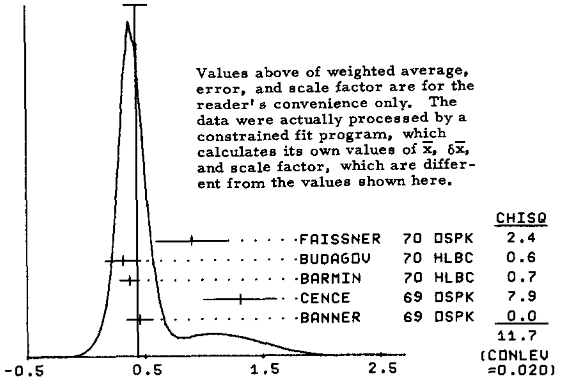
WEIGHTED AVERAGE = 0.439 ± 0.098
ERROR SCALED BY 1.7

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|---|---|---|---|---|---|---|---|
| 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) | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 | 0.12 | OR LESS CL=.90 | CLARK | 71 ASPK | | 6/71* |
| R22 | 0 | 1.8 | OR LESS CL=.90 | DARRIULAT | 70 ASPK | | 11/70 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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* |

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NEUTRAL K CONSTRAINED FIT
OVERALL FIT OF MEAN LIFE, WIDTHS AND BRANCHING RATIOS USES 60 DATA POINTS TO DETERMINE SIX QUANTITITES. OVERALL FIT HAS CHISQ=51.2.

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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 | .214+-.007 | | | | | |
| P 2 | -.224 | .126+-.003 | | | | |
| P 3 | -.445 | -.107 | .268+-.006 | | | |
| P 4 | -.544 | -.109 | -.408 | .390+-.006 | | |
| P 5 | -.260 | .025 | .119 | .145 | .002+-.000 | |
| P11 | .143 | -.041 | -.076 | -.093 | -.045 | .001+-.000 |

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 $\Gamma_{total}$, 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 | .041+-.001 | | | | | |
| G 2 | -.106 | .024+-.001 | | | | |
| G 3 | -.289 | .023 | .052+-.001 | | | |
| G 4 | -.341 | .044 | -.186 | .075+-.001 | | |
| G 5 | -.173 | .097 | .193 | .227 | .000+-.000 | |
| G11 | .151 | -.023 | -.053 | -.063 | -.032 | .000+-.000 |

---

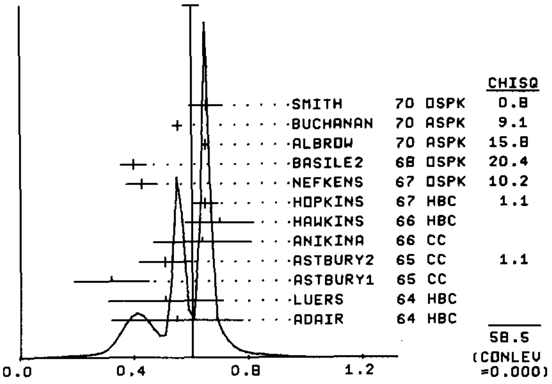
13 NEUTRAL K ENERGY DEPENDENCE OF DALITZ PLOT

RELATED TEXT SECTION IV F.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 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. | | | | | | 3/71 |
| GTO | | . . . . . . . . . | | | | | |
| GTO AVG | | 0.603 | 0.028 | AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.1) (SEE IDEOGRAM BELOW ) | | | |

WEIGHTED AVERAGE = 0.603 ± 0.028
ERROR SCALED BY 3.1

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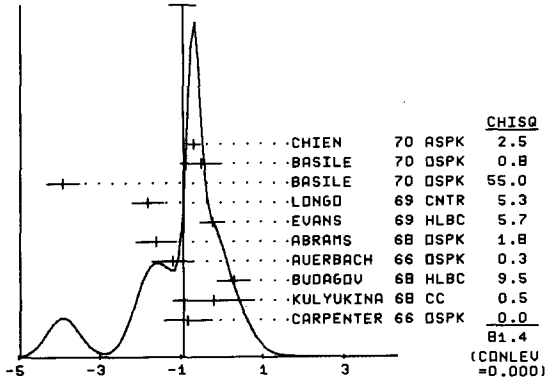
13 KOL FORM FACTORS

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

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| XIA | XIA = F-/F+ (DETERMINED FROM SPECTRA AND KMU3/KE3) -------------- | | | | | | | |
| XIA | SOME OF THE OLDER EXPERIMENTS HAVE EVALUATED XI ASSUMING THAT IT IS | | | | | | | |
| XIA | INDEPENDENT OF THE MOMENTUM TRANSFER (T), I.E., THEY SET L+=L-=0. | | | | | | | |
| XIA | OTHERS HAVE ASSUMED A VALUE FOR L+ AND USED L-=0. ONLY RECENTLY | | | | | | | |
| XIA | BOTH L+,L- AND XI(0) (OR THREE RELATED PARAMETERS) HAVE BEEN INCLU- | | | | | | | |
| XIA | DED IN THE FITS. SEE CHIEN 70. | | | | | | | |
| XIA L | 389 | (+1.1) | (0.9) | (1.3) | ADAIR | 64 HBC | KMU3/KE3 | 8/67 |
| XIA L | | (+0.66) | (0.9) | (1.3) | LUERS | 64 HBC | KMU3/KE3 | 8/67 |
| XIA L | 1371 | (+1.2) | (0.8) | . | CARPENTER | 66 OSPK | MU,PI SPECTRA | 8/67 |
| XIA | C1371 | -0.82 | 0.6 | | CARPENTER | 66 OSPK | MU,PI SPECTRA.C. | 8/67 |
| XIA | | -0.2 | 0.8 | 1.2 | KULYUKINA | 68 CC | MU,PI SPECTRA | 2/71 |
| XIA | 770 | +0.3 | +0.4 | | BUDAGOV | 68 HLBC | KM3/KE3,LM+=.023 | 11/68 |
| XIA | 1309 | -0.22 | 0.30 | | EVANS | 69 HLBC | KM3/KE3,LM+=.02 | 10/69 |
| XIA | 3140 | -3.9 | 0.4 | | BASILE | 70 OSPK + | DLTZ PLOT L+=.02 | 10/70 |
| XIA | 3548 | -0.50 | 0.5 | | BASILE | 70 OSPK + | KM3/KE3,LM+=.02 | 10/70 |
| XIA | H 26K | -0.680 | 0.12 | 0.20 | CHIEN | 70 ASPK | DAL.PLT. L+=.08 | 2/71 |
| XIA C | 2ND CARPENTER VALUE ALLOWS ENERGY DEP OF F+,F- | | | | | | | |
| XIA H | CHIEN 70 VALUE AT L-=0 . L- AND XI(0) ARE HIGHLY CORRELATED | | | | | | | 2/71 |
| XIA L | LM+ AND LM- ASSUMED TO BE ZERO - NOT AVERAGED | | | | | | | |
| XIA | | . . . . . . . . . | | | | | | |
| XIA AVERAGE | MEANINGLESS (SCALE FACTOR = 3.8) | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| XIB | XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3) ------------ | | | | | | | |
| XIB | THE MU POLARIZATION IS A MEASURE OF XI(T). NO ASSUMPTIONS ON L+- | | | | | | | |
| XIB | NECESSARY, T SHOULD BE SPECIFIED. | | | | | | | |
| XIB | FOR RAD. CORR. TO MUON POLARIZATION IN KMU3, SEE GINSBERG 71. | | | | | | | 2/72* |
| XIB | 2608 | -1.2 | 0.5 | | AUERBACH | 66 OSPK | POLARIZATION | 8/67 |
| XIB | 638 | -1.6 | 0.5 | | ABRAMS | 68 OSPK | POLARIZATION | 5/69 |
| XIB | | -1.81 | 0.50 | 0.26 | LONGO | 69 CNTR | POL. T=2.65 | 11/69 |
| XIB | | . . . . . . . . . | | | | | | |
| XIB AVERAGE | MEANINGLESS (SCALE FACTOR = 1.0) | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| RXI | REAL PART OF XI (COMBINED XIA AND XIB) | | | | | | | |
| RXI | 1371 | -0.82 | 0.6 | | CARPENTER | 66 OSPK | MU PI, SP. | |
| RXI | | -0.2 | 0.8 | 1.2 | KULYUKINA | 68 CC | MU PI, SP. | |
| RXI | 770 | +0.3 | +0.4 | | BUDAGOV | 68 HLBC | B.R. | |
| RXI | 2608 | -1.2 | 0.5 | | AUERBACH | 66 OSPK | POL. | |
| RXI | 638 | -1.6 | 0.5 | | ABRAMS | 68 OSPK | POL. | |
| RXI | 1309 | -0.22 | 0.30 | | EVANS | 69 HLBC | B.R. | |
| RXI | | -1.81 | 0.50 | 0.26 | LONGO | 69 CNTR | POL. T=2.65 | |
| RXI | 3140 | -3.9 | 0.4 | | BASILE | 70 OSPK + | DLTZ T=0 | 10/70 |
| RXI | 3548 | -0.50 | 0.5 | | BASILE | 70 OSPK + | B.R. | 10/70 |
| RXI | H 26K | -0.680 | 0.12 | 0.20 | CHIEN | 70 ASPK | DAL.PLT. T=0 | 2/71 |
| RXI | | . . . . . . . . . | | | | | | |
| RXI AVERAGE | MEANINGLESS (SCALE FACTOR = 3.0) (SEE IDEOGRAM BELOW ) | | | | | | | |




COMBINED F-/F+ USING XIA AND XIB (KOL)

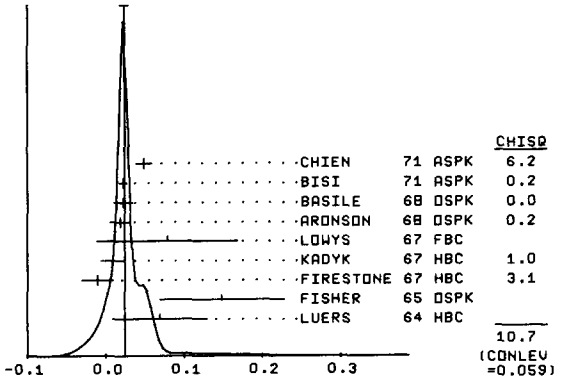
```
IXI       IMAGINARY PART OF XI  (TEST OF T REVERSAL)   -------------------
IXI          -0.2      0.6            ABRAMS    68 OSPK    MU POLARIZATION  10/69
IXI          -0.02     0.08           LONGO     69 CNTR    POL. T=2.65      11/69
IXI        . . . . . . . . .
IXI AVG      -0.023    0.079   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

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

L+E     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KO E3 DECAY)     ------
L+E     FOR RAD. CORR. TO THE DALITZ PLOT OF KE3+ SEE GINSBERG 67.
L+E    153   +0.07      .06            LUERS     64 HBC     DLTZ PLOT,NO R.C
L+E    577   +0.15      .08            FISHER    65 OSPK    DLTZ PLT,NO R.C.  8/67
L+E    762   -0.01      .02            FIRESTONE 67 HBC     DLTZ PLT,NO R.C.  8/67
L+E    531   +0.01      .015           KADYK     67 HBC     E+PI SPEC,NO R.C  8/67
L+E    240   +0.08      .10      .08   LOWYS     67 FBC     PI SPEC, RAD COR  8/67
L+E   1000    0.02     0.013           ARONSON   68 OSPK    PI SPECTRUM       5/69
L+E   4800   +0.023     0.012           BASILE    68 OSPK    DLTZ PLT,NO R.C.  3/68
L+E    42K    0.023     0.005           BISI      71 ASPK    DLTZ PLT,R.C.    12/71*
L+E    16K    0.05      0.01            CHIEN     71 ASPK    DLTZ PLT,NO R.C.  6/71*
L+E        . . . . . . . . .
L+E AVG      0.0252   0.0055  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                              (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.0252 ± 0.0055
ERROR SCALED BY 1.5




LAMBDA+ FOR KE3 DECAY

```
L+M     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KMU3 DECAY)
L+M     FOR RAD. CORR. TO DALITZ PLOT OF KMU3  SEE GINSBERG 70
L+M  C 25K    0.07     0.02           CHIEN     70 ASPK  0 KMU3 DALITZ PLOT  3/71
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.                                          3/71

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```
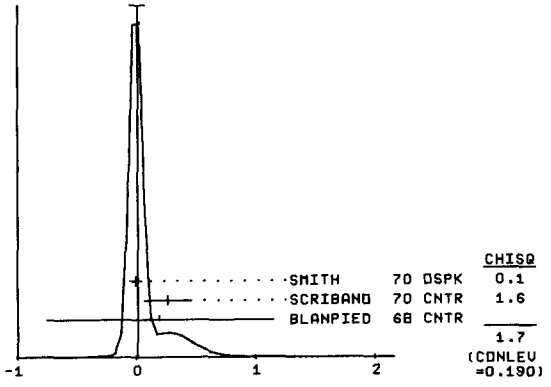

13  CP VIOLATION PARAMETERS IN KOL DECAYS

RELATED TEXT SECTION IV F.3 AND MINI-REVIEW BELOW

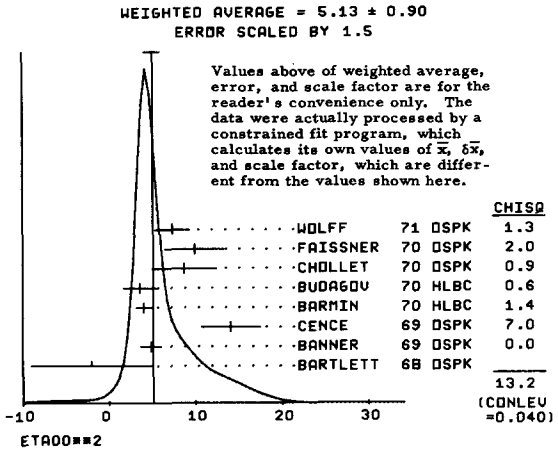
```
--------------------13 CHARGE ASYMMETRY IN TAU DECAYS----------------------
TEXT SECTION IV F.3 B

     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 )
```

WEIGHTED AVERAGE = 0.016 ± 0.063
ERROR SCALED BY 1.3




DECAY ASYMMETRY FOR PI+ PI- PIO

```
--------------------13  CHARGE ASYMMETRY IN LEPTONIC DECAYS (PERCENT)------
TEXT SECTION IV F.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     0.490    0.160           PACIOTTI  69 OSPK                     2/72*
A1      9M     0.21     0.10            MCCARTHY  71 CNTR                     2/72*
A1 D PACIOTTI 69 IS A REANALYSIS OF DORFAN 67
A1         . . . . . . . . .
A1  AVG        0.29     0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

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  B SAAL 69 IS A REANALYSIS OF BENNETT 67
A2         . . . . . . . . .
A2  AVG        0.323    0.042   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

AL     KOL INTO ((L+)-(L-))/((L+)+(L-))  (COMBINED A1 AND A2) (PERCENT)
AL     10M     0.246    0.059           SAAL      69 CNTR                     2/71
AL D    1M     0.490    0.160           PACIOTTI  69 OSPK                     2/72*
AL     10M     0.346    0.033           MARX      70 CNTR                     2/71
AL      9M     0.21     0.10            MCCARTHY  71 CNTR                     2/72*
AL    600K     0.36     0.18            ASHFORD   72 ASPK                     2/72*
AL         . . . . . . . . .
AL  AVG        0.320    0.029   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

--------------------13  PARAMETERS FOR KOL INTO 2PI DECAY------------------
TEXT SECTION IV F.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
     E00 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, AND (ETA00/ETA+-) OF DARRIULAT 71.

E00     (ETA00)**2 = (A(KL TO 2PIO)/A(KS TO 2PIO))**2  (UNITS 10**-6)   ---
E00      0   -2.       7.0             BARTLETT  68 OSPK                    10/69
E00     57    4.9      1.2             BANNER    69 OSPK                     2/72*
E00    133   14.1      3.4             CENCE     69 OSPK                    10/69
E00 F  180  (13.)     (4.)             GAILLARD  69 OSPK                    10/69
E00     29    4.08     0.9             BARMIN    70 HLBC                    12/70
E00     30    3.61     1.9             BUDAGOV   70 HLBC                    10/70
E00  C        8.7      3.7             CHOLLET   70 OSPK    CU REG.,4 GAMMAS  2/72*
E00  F 172    9.9      3.4             FAISSNER  70 OSPK                    12/70
E00  C  56    7.4      2.0             WOLFF     71 OSPK    CU REG.,4GAMMAS  12/71*
E00  C  CHOLLET 70 GIVES ETA00=(1.23+-0.24)*(REGEN AMPL,2GEV/C CU)/10000MB   2/72*
E00  C  WOLFF 71   GIVES ETA00=(1.13+-0.12)*(REGEN AMPL,2GEV/C CU)/10000MB   2/72*
E00  C  WE COMPUTE BOTH ETA00**2 VALUES FOR (REGEN AMPL,2GEV/C CU)=24+-2MB.  2/72*
E00  C  THIS REGEN AMPL RESULTS FROM AVERAGING OVER FAISSNER 69,             2/72*
E00  C  EXTRAPOLATED USING OPTICAL MODEL CALCULTIONS OF BOHM ET AL.          2/72*
E00  C  PL 27B 594 (1968) AND THE DATA OF BALATS 71. (FROM H. FAISSNER,      2/72*
E00  C  PRIVATE COMMUNICATION)                                               2/72*
E00  F  FAISSNER 70 CONTAINS SAME 2PIO EVENTS AS GAILLARD 69
E00        . . . . . . . . .
E00 AVG        5.13     0.90    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
E00 FIT        4.38     0.50   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  3/72*
                         (SEE IDEOGRAM BELOW )

E+-    ETA+-  = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3  -------------
E+-     45   (1.94)                    CHRISTENS 64 OSPK                    10/69
E+-     54   (2.02)                    GALBRAITH 65 OSPK                    10/69
E+-          (1.86)                    BASILE    66 OSPK                    10/69
E+-          (1.935)                   BOTT-BODE 66 OSPK                    10/69
E+-    525    1.91      .06            FITCH     67 OSPK                    10/69
E+-        . . . . . . . . .
E+- FIT        1.959    0.031  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  3/72*

ER     RATIO OF ETA00 OVER ETA+-
ER             1.00     0.06            DARRIULAT 71 ASPK                    3/72*
ER            (1.10)   (0.13)           KNAPP     72 OSPK    PRELIMINARY     3/72*
ER         . . . . . . . . .
ER  FIT        1.068    0.062  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  3/72*
```

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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          FIRESTONE 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+-          . . . . . . . . .
F+- AVG      43.3      3.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                      COMMENTS
F+-  C      BENNETT 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                  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                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                   9/71*
F+-  D      DM DEPENDENCE OF BALATS 71 IS 198*(DM-.544) DEG                   9/71*
F+-  N      BENNETT 69 IS A REEVALUATION OF BENNETT2 68                      11/69

F00     PHASE OF ETA 00    (DEGREES)   ------------------------------
F00    FIRST QUADRANT PREFERRED        GOBBI     69 OSPK                    11/69
F00          51.      30.             CHOLLET   70 OSPK    CU REG.,4 GAMMAS 10/70
F00     56   38.0     25.0            WOLFF     71 OSPK    CU REG.,4GAMMAS  12/71*
F00          . . . . . . . . .
F00 AVG      43.3     19.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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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

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

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

$$\phi_{+-} = \phi_{00} = (42.96 \pm 0.27)^\circ$$

and

$$\mathrm{Re}\,\epsilon = (1.434 \pm 0.023) \times 10^{-3} .$$

These can be compared with the experimental values

$$\phi_{+-} = (43.3 \pm 3.2)^\circ$$

$$\phi_{00} = (43 \pm 19)^\circ$$

$$\mathrm{Re}\,\epsilon = (1.60 \pm 0.17) \times 10^{-3}$$

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

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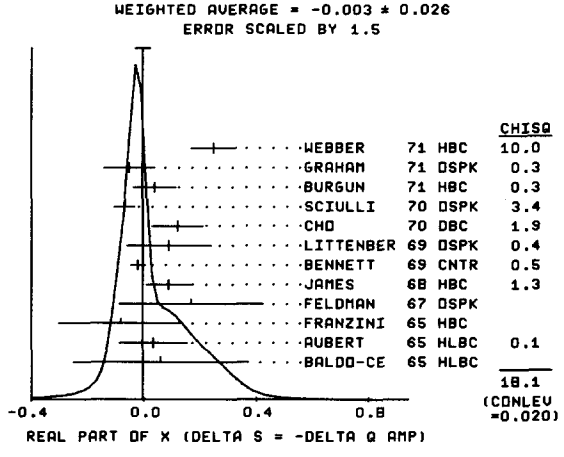
                    13 X =(DS=-DQ AMPLITUDE /DS=+DQ AMPLITUDE)

        RELATED TEXT SECTION IV F.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   -0.08     0.09           CHO       70 DBC     K+D TO KOPP     10/70
REX   1079   -0.069    0.036          SCIULLI   70 OSPK    PI-P            11/70
REX    222    0.04     0.07     0.08  BURGUN    71 HBC     K+P TO KOPPI+    2/72*
REX G  342  (-0.13)   (0.11)         MANTSCH   71 OSPK    KE3  FROM KO LMB  2/72*
REX G  100   (0.04)   (0.10)   (0.13) GRAHAM    71 OSPK    KMU3 FROM KO LMB  2/72*
REX  G 442   -0.05     0.09           GRAHAM    71 OSPK    PI-P TO KO LMBDA. 2/72*
REX    252    0.25     .07      .09  WEBBER    71 HBC     K-P TO KBAR N    10/69
REX G   SECOND GRAHAM 71 VALUE IS FIRST GRAHAM 71 VALUE COMBINED WITH        2/72*
REX G   MANTSCH 71.                                                          2/72*
REX  B      BENNETT 69 IS A REANALYSIS OF BENNETT1 68
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          . . . . . . . . .
REX AVG     -0.003    0.026    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                              (SEE IDEOGRAM BELOW )
```

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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   1079    0.108    0.092    0.074 SCIULLI   70 OSPK    PI-P             11/70
IMX    222    0.12     0.08     0.09  BURGUN    71 HBC     K+P TO KOPPI+     2/72*
IMX G  342   (-0.04)   (0.16)         MANTSCH   71 OSPK    KE3  FROM KO LMB  2/72*
IMX G  100   (0.12)   (0.17)   (0.16) GRAHAM    71 OSPK    KMU3 FROM KO LMB  2/72*
IMX  G 442    0.05     0.13           GRAHAM    71 OSPK    PI-P TO KO LMBDA. 2/72*
IMX    252    0.0      .08            WEBBER    71 HBC     K-P TO KBAR N    10/69
IMX G   SECOND GRAHAM 71 VALUE IS FIRST GRAHAM 71 VALUE COMBINED WITH        2/72*
IMX G   MANTSCH 71.                                                          2/72*
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          . . . . . . . . .
IMX AVG     -0.007    0.039    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                              (SEE IDEOGRAM BELOW )
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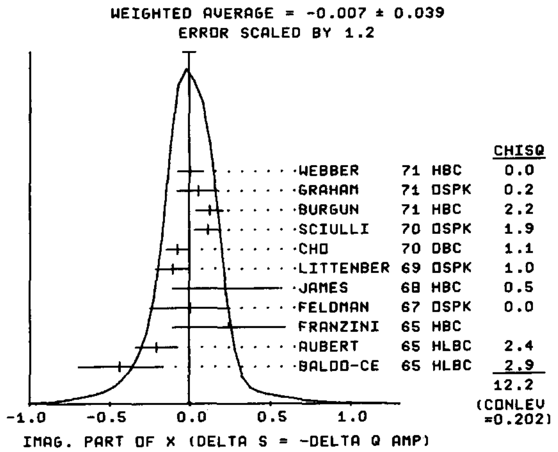


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REFERENCES
13 LONG-LIVED NEUTRAL K (498, JP=0-) I=1/2


| | |
|---|---|
| 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 + (PARIS+EP) |
| 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 (PARIS+EP) |
| ADAIR 64 PL 12 67 | R K ADAIR,L B LEIPUNER (YALE+BNL) |
| ALEKSANY 64 DUBNA 2 102 | ALEKSANYAN,ALIKHANYAN,VARTAZARYAN+ (EREVAN) |
| SEE ALSO 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 (PRINCETN) |
| FUJII 64 DUBNA 2 146 | FUJII,JOVANOVICH,TURKOT+ (BNL,MARYLAND,MIT) |
| LUERS 64 PR 133 B 1276 | LUERS,MITTRA,WILLIS,YAMAMOTO (BNL) |
| ANIKINA 65 JINR P 2488 | ANIKINA,VARDENGA,ZHURAVLEVA,KOTLYA+ (DUBNA) |
| ANDERSON 65 PRL 14 475 | ANDERSON,CRAWFORD,GOLDEN,STERN + (LRL+WISC) |
| ASTBURY1 65 PL 16 80 | ASTBURY,FINOCCHIARO,BEUSCH + (CERN+ZURICH) |
| ASTBURY1 65 SEE ALSO M PEPIN | HELV.PHYS. ACTA 39 523 |
| 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+ (PARIS+ORSAY) |
| AUBERT 65 SEE ALSO LOWYS 67 | |
| BALDO-CE 65 NC 38 684 | BALDO-CEOLIN,CALIMANI,CIAMPOLILLO + (PADVA) |
| CHRISTEN 65 PR 140 B 74 | CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON) |
| FISHER 65 ANL 7130 83 | FISHER,ABASHIAN,ABRAMS,CARPENTER+ (ILLINOIS) |
| 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+BRIST+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 + (MOSCOW) |
| 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) |
| AUERBACH 66 SEE ALSO PRL 14 192 | |
| BALDO-CE 66 NC 45A 733 | BALDO-CEOLIN,CALIMANI,CIAMPOLILLO+ (PADUA) |
| BASILE 66 BALATON CONF | BASILE,CRONIN,THEVENET + (SACLAY) |
| BEHR 66 PL 22 540 | BEHR,BRISSON,BALDO-CEOLIN,AUBERT+(PADUA,EP) |
| 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+MD+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+ (URBANA) |
| 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+ORSAY+MPI) |
| DEVLIN 67 PRL 18 54 | DEVLIN,SOLOMON,SHEPARD,BEALL+ (PRINC+MARY.) |
| ALSO 68 PR 169 1045 | SAYER,BEALL,DEVLIN,SHEPHARD+(MD+PPA+PALMER) |
| DORFAN 67 PRL 19 987 | DORFAN,ENSTROM,RAYMOND,SCHWARTZ +(SLAC+LRL) |
| FELDMAN 67 PR 155 1611 | FELDMAN,FRANKEL,HIGHLAND,SLOAN (U OF 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+ (EP,ORSAY) |
| 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+(MOSCOW) |
| 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,ORSAY,PARIS) |
| ALSO 68 PL 28B 215 | +CUNDY,MYATT,NEZRICK+ (CERN,ORSAY,EP) |
| CARNEGIE 68 PRINC TR44 THESIS | R.K.CARNEGIE (PRINCETON) |
| JAMES 68 NP B8 365 | F JAMES, H BRIAND (PARIS,CERN) |
| ALSO 68 PRL 21 257 | HELLAND,LONGO,YOUNG (UCLA,MICHIGAN) |
| KULYUKIN 68 JETP 26 20 | KULYUKINA,MESTVIRISHVILI,NEAGU+ (JINR) |
| KUNZ 68 THESIS (PU 46) | P F KUNZ (PRINCETON) |
| MELHOP 68 PR 172 1613 | MELHOP MURTY BOWLES,BURNETT+ (LA JOLLA) |
| THATCHER 68 PR 174 1674 | THATCHER,ABASHIAN,ABRAMS,CARPENTER + (ILL) |
| BANNER 69 PR 188 2033 | +CRONIN,LIU,PILCHER (PRINCETON) |
| ALSO 68 PRL 21 1103 | BANNER,CRONIN,LIU,PILCHER (PRINCETON) |
| ALSO 68 PRL 21 1107 | BANNER CRONIN,LIU,PILCHER (PRINCETON) |
| BEILLIER 69 PL 30B 202 | BEILLIERE,BOUTANG,LIMON (EPOL) |
| BENNETT 69 PL 29B 317 | +NYGREN,SAAL,STEINBERGER+ (COLU,BNL) |
| BOHM 69 NP B9 605 | +DARRIULAT,GROSSO,KAFTANOV+ (CERN) |
| ALSO 68 PL 27B 321 | BOHM,DARRIULAT,GROSSO,KAFTANOV (CERN) |
| BOTT-BOD 69 CERN 69-7 329 | BOTT-BODENHAUSEN,DE BOUARD,CASSEL+ (CERN) |
| CENCE 69 PRL 22 1210 | CENCE,JONES,PETERSON,STENGER+ (HAWAII,LRL) |
| EVANS 69 PRL 23 427 | EVANS,GOLDEN,MUIR,PEACH+ (EDINBURGH,CERN) |
| FAISSNER 69 PL 30B 204 | +FOETH,STAUDE,TITTEL+ (AACH,CERN,TORI) |
| FOETH 69 PL 30B 282 | +HOLDER,RADERMACHER + (AACHEN,CERN,TORINO) |
| GAILLARD 69 NC 59A 453 | +GALBRAITH,HUSSRI,JANE+ (CERN,RUTH,AACHEN) |
| ALSO 67 PRL 18 20 | +KRIENEN,GALBRAITH,HUSSRI+ (CERN+RUTH+AACH) |
| GOBBI 69 PRL 22 685 | +GREEN,HAKEL,MOFFETT,ROSEN,GOZ+ (ROCH+RUTG) |
| LITTENBE 69 PRL 22 654 | LITTENBERG,FIELD,PICCIONI,MEHLHOP+ (USCD) |
| LONGO 69 PR 181 1808 | M J LONGO,K K YOUNG,J A HELLAND (ANNA,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,JHOP,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,ORSAY,EP) |
| 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+(EFIN,ILL) |
| MARX 70 PL 32B 219 | +NYGREN,PEOPLES,STEINBERGER+(COL,HARV,CERN) |
| ALSO 70 THESIS,NEVIS 179 | JAY MARX (COLUMBIA) |
| SCIULLI 70 PRL 25 1214 | +GALLIVAN,BINNIE,GOMEZ,MALLARY,PECK+ (CALT) |
| 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+ (JHOP,SLAC,UCLA) |
| 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) |
| DARRIULA 71 AMST CONF 144 | DARRIULAT,DEUTSCH+ (AACH,CERN,TORI) |
| ENSTROM 71 PR D4 2629 | +AKAVIA,COOMBES,DORFAN+ (SLAC,STAN) |
| ALSO 70 THESIS (SLAC 125) | J E ENSTROM (STANFORD) |
| GRAHAM 71 COO-1195-208 PRE. | +ABASHIAN,JONES,MANTSCH,ORR+ (ILL,NEAS) |
| HILL 71 PR D4 7 | +SAKITT,SKJEGGESTAD,CANTER+ (BNL,CARN,CASE) |
| JAMES 71 PL 35B 265 | +MONTANET,PAUL,PAULI+ (CERN,SACL,OSLO) |
| MANTSCH 71 COO-1195-210 PRE. | +ABASHIAN,GRAHAM,JONES,ORR+ (ILL,NEAS) |
| MCCARTHY 71 THESIS, LBL-550 | R L MC CARTHY (LBL) |
| 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) |
| VOSBURGH 71 PRL 26 866 | +DEVLIN,ESTERLING,GOZ,BRYMAN+ (RUTG,MASA) |
| 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) |
| ASHFORD 72 PL 38B 47 | +BROWN,MASEK,MAUNG,MILLER,RUDERMAN+ (UCSD) |
| KNAPP 72 BAPS 17 84 | +BANNER,CRONIN,HOFFMAN,KNAPP,SHOCHET (PRIN) |

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                                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+   (EP+MILAND+PADOVA)
MESTVIRI 65 JINR P 2449         MESTVIRISHVILI,NYAGU,PETROV,RUSAKOV+ (JINR)
TRILLING 65 UCRL 16473          GEORGE H TRILLING                      (LRL)
TRILLING 65   IS 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+COL)
  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+COL)
SCHMIDT  67 NEVIS 160(THESIS) P. SCHMIDT                            (COLUMBIA)
CRONIN   68 VIENNA CONF P.281 CRONIN,RAPPORTEURS TALK              (PRINCETON)
GINSBERG 70 PR D1 229           E S GINSBERG                       (IIT HAIFA)
HEUSSE   70 LNC  3 449          +AUBERT,PASCAUD,VIALLE                 (ORSAY)
GINSBERG 71 PR D4 2893          E S GINSBERG                            (MIT)

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```

## $\eta$

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

        FOR C. BALTAYS 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 )
```
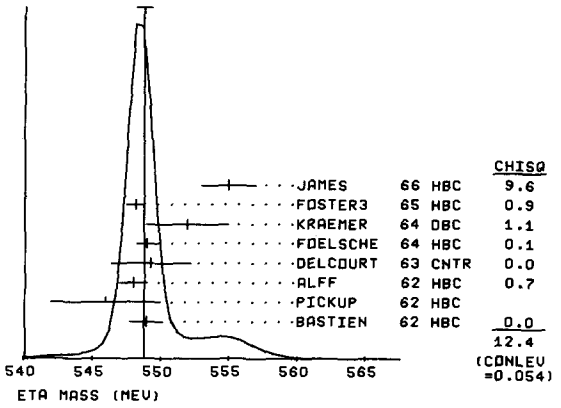

WEIGHTED AVERAGE = 548.82 ± 0.56
ERROR SCALED BY 1.4

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

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

                    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

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                    14 ETA DECAY RATES

W1      ETA INTO 2GAMMA (UNITS KEV)                       (P1)
W1          (0.93)   (0.2)          BEMPORAD  67 CNTR     PRIMAKOFF EFFECT 11/67
```

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 $\eta$-meson," Nuovo Cimento 69A, 109 (1970) for a critique of this technique.

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### Note on Eta Decay into Neutrals

As is well known, there are great inconsistencies among the various experiments that report etas decaying into neutrals. The controversy is over whether the mode $\eta \to \pi^0\gamma\gamma$ is $\approx 0$ (as some experiments indicate) or $\gtrsim$ 20% (as other experiments indicate).

The discrepancies are displayed in the ideogram below, in which all eleven relevant experiments have been converted to a common ratio, $\pi^0\gamma\gamma$/neutrals. Also upper limits, < x, have been converted to 0 ± x. The confidence level for consistency of all eleven is $< 10^{-5}$!

In previous editions we were able to point out that it was the older experiments which gave the > 20% values, whereas the more recent experiments had been giving $\lesssim$ 1%. However, the recent experiment of COX 70 gives about 8 ± 3%, so the controversy is not yet settled.

We feel that we should consider all eleven experiments on an a priori equal basis, and then follow the prescription of deleting large $\chi^2$ experiments until the confidence level rises to some reasonable value. If we remove the Feldman and DiGiugno experiments, $\chi^2$ decreases from 46 (for all eleven) to about 10 (for the remaining 9). Accordingly we have removed those 2 experiments and used the remaining nine experiments in our overall fit.

# Stable Particles

## $\eta$



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                WEIGHTED AVERAGE = 0.061 ± 0.031
                   ERROR SCALED BY 2.3
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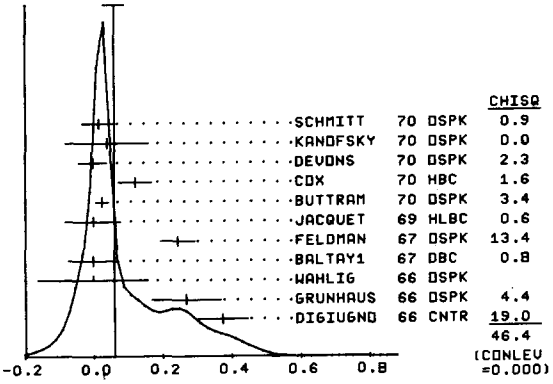


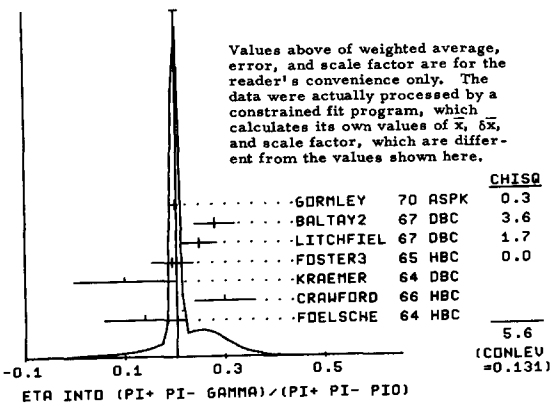

```
                    14 ETA   BRANCHING RATIOS
R1        ETA INTO NEUTRALS/CHARGED                          (P1+P2+P7)/(P3+P4)
R1   N   10   (2.5)   (1.0)          PICKUP    62 HBC
R1   N   53   (3.20)  (1.26)         BASTIEN   62 HBC
R1   N        (2.7)   (0.8)          SHAFER    62 HBC
R1             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 CLEARLY SEPARATE 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    0.083  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    0.054  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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 ERRORS 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          . . . . . . . . .
R4   AVG       0.2041   0.0079  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R4   FIT       0.2044   0.0069 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
                        (SEE IDEOGRAM BELOW )
```

```
                WEIGHTED AVERAGE = 0.2041 ± 0.0079
                   ERROR SCALED BY 1.4
```

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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       1.339    0.056  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)
R6   FIT       0.790    0.039  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                        (SEE IDEOGRAM BELOW )
```
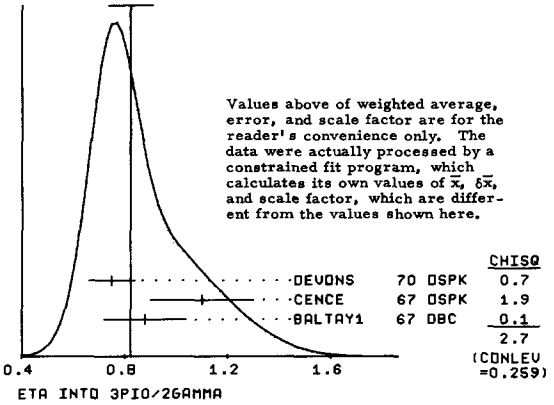

```
                WEIGHTED AVERAGE = 0.824 ± 0.085
                   ERROR SCALED BY 1.2
```

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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       1.585    0.065  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R8      ETA INTO NEUTRAL/(PI+ PI- PIO)                            (P1+P2+P7)/(P3)
R8     280     3.6      0.8          KRAEMER   64 DBC
R8             3.8      1.1          PAULI     64 DBC                                 7/66
R8             2.89     0.56         ALFF-STE1 66 HBC                                 9/66
R8     244     3.6      0.6          FLATTE2   67 HBC                                 1/68
R8          . . . . . . . . .
R8   AVG       3.35     0.35    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8   FIT       2.97     0.10   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

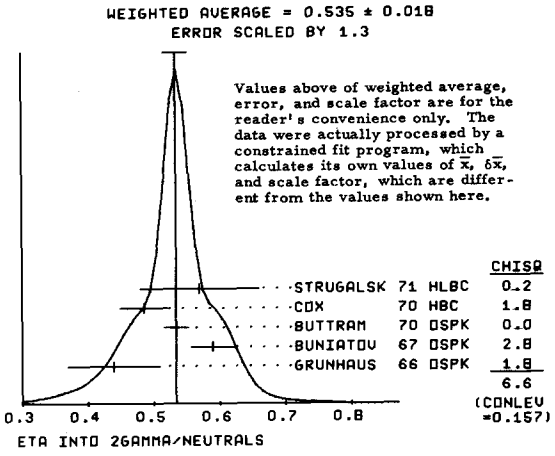
R12     ETA INTO 2 GAMMA/NEUTRALS                                 (P1)/(P1+P2+P7)
R12 S         (0.416)  (0.044)       DIGIUGNO  66 CNTR    ERROR DOUBLED               6/66
R12             .44      .07         GRUNHAUS  66 OSPK                                8/67
R12 S         (.579)   (.052)        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
R12             .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 )

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 (2GAMMA)/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)
```

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R17      ETA INTO (PI+PI-PIO GAMMA)/(PI+PI-PIO)          (P10)/(P3)
R17          (.07) OR LESS            FLATTE    67 HBC                        8/67
R17          (.009)OR LESS            PRICE     67 HBC                        8/67
R17          (.016)OR LESS  CL=.95    BALTAY2   67 DBC                       11/67
R17         (0.017)OR LESS  CL=.90    ARNOLD    68 HLBC                       9/68

R18      ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PIO)            (P11)/(P3)
R18          (.009)OR LESS            PRICE     67 HBC                        8/67
R18          (.016)OR LESS  CL=.95    BALTAY2   67 DBC                       11/67

R19    ETA INTO 3PIO/(PI+ PI- PIO)                       (P2)/(P3)
R19          1.3       .4             BAGLIN2   67 HLBC                       8/67
R19          1.47     0.20      0.17  BULLOCK   68 HLBC                       9/68
R19    199   1.50      .15       .29  BAGLIN    69 HLBC                       7/69
R19        . . . . . . . . .
R19 AVG      1.46     0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 FIT      1.252    0.059  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 DSPK                      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   0.0069 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R22    ETA INTO (PIZRO 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 DSPK                      4/68

R24    ETA INTO MU+MU-PIO/TOTAL  (UNITS 10**-4)          (P14)
R24          5.    OR LESS           WEHMANN   68 DSPK                      4/68

R25    ETA INTO MU+MU-/2GAMMA    (UNITS 10**-5)          P(12)/(P1)
R25          5.9      2.2            HYAMS     69 DSPK                      7/69

R26    ETA INTO (PIO 2GAMMA)/(3PIO + PIO 2GAMMA)         (P7)/(P2+P7)
R26  N       0.1      0.3            KANOFSKY  70 DSPK                      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       2/71
R26  N       THE ARTICLE THAT A CENTRAL VALUE OF 0.0 IS ABOUT AS PROBABLE    2/71
R26  N       AS THE QUOTED VALUE OF 0.1                                      2/71
R26        . . . . . . . . .
R26 FIT      0.094    0.032  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
```

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 | .380+-.010 | | | | |
| P 2 | -.275 | .300+-.011 | | | |
| P 3 | -.340 | -.196 | .240+-.006 | | |
| P 4 | -.230 | -.143 | .459 | .049+-.002 | |
| P 7 | -.420 | -.592 | -.091 | -.052 | .031+-.011 |

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14 ETA C-NONCONSERVING DECAY PARAMETER

RELATED TEXT SECTION IV G AND MINI-REVIEW BELOW

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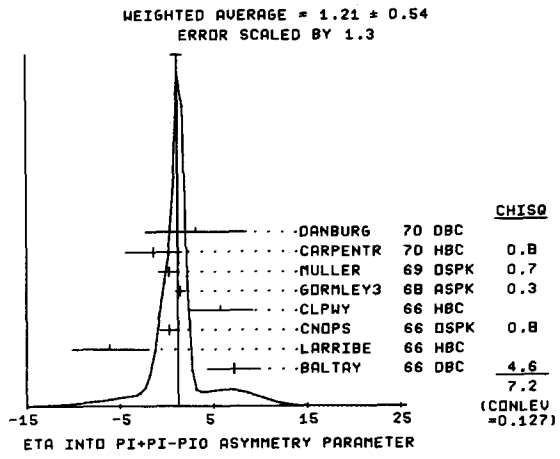
A    DECAY ASYMMETRY PARAMETER FOR PI+ PI- PIO    (UNITS 10**-2)
A     1351    7.2      2.8            BALTAY    66 DBC                       8/66
A      705   -6.1      4.0            LARRIBE   66 HBC                       8/67
A    10665    0.3      1.0            CNOPS     66 DSPK                      8/67
A     1300    5.8      3.4            CLPWY     66 HBC                       8/66
A    36800    1.5       .5            GORMLEY3  68 ASPK                      6/68
A    10709     .3      1.1            MULLER    69 DSPK                      9/69
A     1138   -1.4      3.             CARPENTR  70 HBC                       6/70
A      349    3.2      5.4            DANBURG   70 DBC                       2/71
A          . . . . . . . . .
A    AVG      1.21     0.54    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                              (SEE HISTOGRAM BELOW )
```




H. Yuta and S. Okubo [Phys. Rev. Letters 21, 781 (1968)] have pointed out that an asymmetry in the decay $\eta \to \pi^+\pi^-\pi^0$ of about 2% need not imply a breakdown of C invariance, since an asymmetry of this amount could be caused by an interference between the $\eta$ and the $3\pi$ background. Gormley et al. [Phys. Rev. Letters 22, 198 (1969)], however, believe that this effect can account for only $\leq 0.23\%$ in their experiment (above). Also see: A. Frenkel and G. Vesztergombi, "C-Violation in $\eta$-Decay," Nucl. Phys. B15, 429 (1970) and K. Taggart, "Asymmetry and Background in $\eta \to 3\pi$," Phys. Rev. D 2, 1960 (1970).

```
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 DSPK                      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          . . . . . . . . .
B    AVG       1.1       1.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

PEVSNER  61 PRL 7 421           PEVSNER,KRAEMER,NUSSBAUM,RICHARDSON + (JHU)

ALFF     62 PRL 9 322           ALFF,BERLEY,COLLEY,BRUGGER +  (CQL+RUTGERS)
BASTIEN  62 PRL 8 114           BASTIEN,BERGE,DAHL,FERRO-LUZZI +       (LRL)
CHRETIEN 62 PRL 9 127           CHRETIEN+  (BRAND+BROWN+HARVARD+MIT+PADOVA)
PICKUP   62 PRL 8 329           E PICKUP,ROBINSON,SALANT      (NRC+CAN+BNL)
SHAFER   62 CERN CONF 307       J SHAFER,FERRO-LUZZI,MURRAY +       (UC+LRL)

BACCI    63 PRL 11 37           BACCI,PENSO,SALVINI +  (ROME U+CNEN FRASCA)
BUSCHBEC 63 SIENA CONF 1 156    BUSCHBECK-CZAPP,COOPER +  (VIENNA+CERN+AMS)
CRAWFORD 63 PRL 10 546          F S CRAWFORD,LLOYD,FOWLER          (LRL+DUKE)
    AND      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 +  (LPCHE+SACLAY IF+ROME+INFN)

FOELSCHE 64 PR 134 B 1138       H W FOELSCHE,H L KRAYBILL                (YALE)
KRAEMER  64 PR 136 B 496        KRAEMER,MADANSKY,FIELDS +   (JHU+NW U+WOOD)
PAULI    64 PL 13 351           E PAULI,A MULLER              (LPCHE+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+ (NAP+TRST+FRASC)
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,+(ICL+RUTH)
WAHLIG   66 PRL  17  221        WAHLIG,SHIBATA,MANNELLI           (MIT+PISA)
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BAGLIN1  67 PL 24B 637          BAGLIN,BEZAGUET,DEGRANGE,+       (E.POLY+UC)
BAGLIN2  67 BAPS 12 567         BAGLIN,BEZAGUET,DEGRANGE,+       (E.POLY+UC)
BALTAY1  67 PRL 19 1495         BALTAY,FRANZINI,KIM,NEWMAN+    (COLUM+BRAND)
BALTAY2  67 PRL 19 1498         BALTAY,FRANZINI,KIM,NEWMAN+(COLUM+STONY BK)
BEMPORAD 67 PL 25B 380          BEMPORAD,BRACCINI,FOA,LUBELSMEY+(PISA,BONN)
    AND      PRIVATE COMMUNICATION
BILLING  67 PL 25B 435          BILLIG,BULLOCK,ESTEN,GOVAN,+        (UCL,OXF)
BONAMY   67 HEIDELBERG CONF.    BONAMY,SONDEREGGER                   (SACLAY)
BUNIATOV 67 PL 25B 560          BUNIATOV,ZAVATTINI,DEINET,+     (CERN,KARLS)
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+(RUTH+SACLAY)
PRICE    67 PRL 18 1207         L.R.PRICE,F.S.CRAWFORD                (LRL)

ARNOLD   68 PL 27B 466          +PATY,BAGLIN,BINGHAM+ (STRB+MADR+EPOL+BERK)
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+COR+MCGILL)

BAGLIN   69 PL 29B 445          BAGLIN,BEZAGUET,+      (EPOL,BERK,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,SYR)
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)

         QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BASTIEN  62 PRL 8 114           BASTIEN,BERGE,DAHL,FERRO-LUZZI,MILLER+(LRL)
CARMONY  62 PRL 8 117           D CARMONY,A ROSENFELD,VAN DE WALLE    (LRL)
ROSENFEL 62 PRL 8 293           A ROSENFELD,D CARMONY,VAN DE WALLE    (LRL)

             REFERENCES ON ETA ASYMMETRY PARAMETERS

BALTAY   66 PRL  16  1224       BALTAY,FRANZINI,KIM,KIRSCH+(COLUM+STONY BK)
CNOPS    66 PL 22 546           CNOPS,FINOCCHIARO,LASSALLE,+(CERN+ZUR+SACL)
CRAWFORD 66 PRL  16  333        F.S.CRAWFORD,L.R.PRICE                (LRL)
LARRIBE  66 PL 23 600           LARRIBE,LEVEQUE,MULLER,PAULI,+  (SACL+RUTH)
CLPWY    66 PR 149  1044        COLUMBIA,LRL,PURDUE,WISCONSIN,YALE

BOWEN    67 PL 24B 206          BOWEN,CNOPS ,FINOCCHIARO,+  (CERN+ZUR+SACL)
LITCHFIE 67 PL 24B 486          LITCHFIELD,RANGAN,SEGAR,SMITH+(RUTH+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)

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                    16  PROTON  (938,J=1/2)  I=1/2
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                    16  PROTON  MASS (MEV)

M          (938.256)  (0.005)        COHEN      65 RVUE                    7/66
M           938.2592    .0052        TAYLOR     69 RVUE    USING NEW E/H   7/70

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                    16  PROTON MEAN LIFE  (UNITS 10**26 YR)

T          (.000001)OR MORE          GOLDHABE   54 TH 232 FISS.MODE INDEPEN
T           (0.0021)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(0.000030)       COHEN      65 RVUE
MM          2.792782  .000017        TAYLOR     69 RVUE    USING NEW E/H   7/70

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      16   PROTON ELECTRIC DIPOLE MOMENT  (IN UNITS OF 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
                          16 PROTON (938,J=1/2) I=1/2

GOLDHABE 54 PR 96 1157 FNOTE2 GOLDHABER,F REINES+         (LOS ALAMOS,BNL)
FLEROV   57 SOV PHYS DOK 3 78 FLEROV,KLOCHKOV,SKOBKIN,TERENTEV      (USSR)
BACKENST 60 NC   16  749      BACKENSTOSS,FRAUENFELDER,HYAMS +      (CERN)
COHEN    65 RMP 37 537        E R COHEN, J W M DUMOND     (NAASC+CALTECH)
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)

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                    17  NEUTRON (939,J=1/2)  I=1/2
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                    17  NEUTRON MASS (MEV)

 T          939.5527    .0052         TAYLOR     69 RVUE    USING NEW E/H   7/70
 T      TAYLOR DETERMINATION OF NEUTRON MASS NOT INDEPENDENT OF             7/70
 T      NEUTRON-PROTON MASS DIFFERENCE MEASUREMENTS BELOW.                  7/70

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                    17  NEUTRON-PROTON MASS DIF.(MEV)

D  M          1.29344  0.00007        MATTAUCH   65 RVUE                   3/71
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  ( IN UNITS OF 10**-23 E CM)
              TEST OF C VIOLATION IN THE EM INTERACTION

EDM          (5.)   OR LESS           BAIRD      69 MBR                   10/69

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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
    E  ERROR CHANGED BECAUSE ERROR IN CROSS SECTION FOR NEUTRON ABSORPTION
    E  IN GOLD HAS BEEN REDUCED
T             0.935    0.014          CHRISTENS 67 PILE                    3/68

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                    17  BETA DECAY COUPLING CONSTANTS

        RELATED TEXT SECTION IV H.1

AV      GA/GV  (SEE TEXT FOR SIGN CONVENTION)
AV  B       (-1.18)   (0.02)          BHALLA     66 RVUE                  11/67
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 EP       (-1.26)   (0.02)          CHRISTENS  70 CNTR PE,NEUT SPIN CORREL 10/71*
AV  P       (-1.258)  (0.014)         PAUL       70 RVUE    N DECAY ALONE   3/72*
AV   P       -1.240    0.007          PAUL       70 RVUE    N DEC.+ FT VALUE 3/72*
AV E         -1.27     0.025          EROZOLIMS  71 CNTR PE,NEUT SPIN CORREL 10/71*
AV   P  PAUL 70 VALUE OBTAINED FITTING ALL THE DATA UP TO CHRISTENSEN 70    3/72*
AV  C   CONFORTO VALUE COMBINES FREE NEUTRON DATA TO 1967. REPL. BY PAUL 70 3/72*
AV E    THESE EXPERIMENTS MEASURE THE ABSOLUTE VALUE OF GA/GV ONLY         10/71*
AV  B   THIS VALUE NOT USED SINCE CORRESPONDING  LIFETIME HAS BEEN DISCARDE
AV          * * * * * * * * *
AV  AVG      -1.2422   0.0078  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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       178.6      0.9           PAUL       70 RVUE    N DEC.+ FT VALUE 3/72*
F    P  PAUL 70 VALUE OBTAINED BY FITTING ALL AVAILABLE DATA TO 1970       3/72*
F   C   CONFORTO VALUE COMBINES FREE NEUTRON DATA TO 1967. REPL. BY PAUL 70 3/72*
F   S    ONLY STATISTICAL ERROR QUOTED

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                          REFERENCES
                          17 NEUTRON (939,J=1/2) I=1/2

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   (M. PLANCK INST. CHEM.,+)
BHALLA   66 PL 19  691        C P BHALLA                         (ALABAMA)
CHRISTEN 67 PL 26B 11         +NIELSEN,BAHNSEN,BROWN,RUSTAD(RISO-DENMARK)
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   68 PL 27B 557        EROZOLIMSKY,BONDARENKO  +  (KURC IN MOSCOW)
PAUL     70 NP A154 160       H PAUL                             (WIEN)
EROZOLIM 71 JETPL 13 252      EROZOLIMSKII,BONDARENKO +     (KURC MOSCOW)

                              PAPERS NOT REFERRED TO IN DATA CARDS

JACKSON  57 PR 106 517        JACKSON,TREIMAN,WYLD             (PRINCETON)
COHEN    65 RMP 37 537        E R COHEN,DUMOND       (NAASC+CAL INST TECH)

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                    18  LAMBDA (1115,JP=1/2+)  I=0
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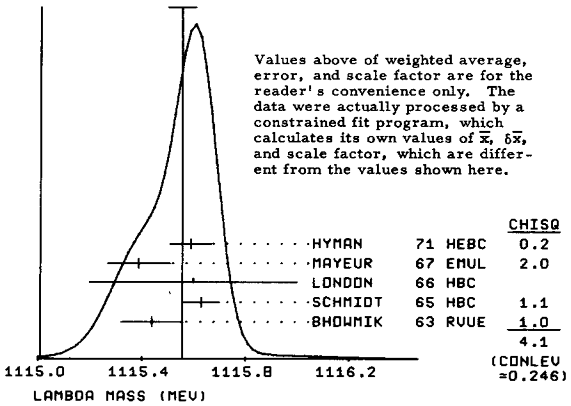
                    18  LAMBDA  MASS (MEV)

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.

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 1115.63     0.07             SCHMIDT   65 HBC   SEE NOTE N          6/68
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     71 HEBC                     11/71*
M    B   AVERAGE OF VERY INCONSISTENT DATA. ERROR STATISTICAL ONLY.             3/72*
M    B   AUTHORS DETECT SYSTEMATIC EFFECT OF ABOUT .15 MEV, WHICH THEY ATTRI    3/72*
M    B   BUTE 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    1115.558    0.052   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
M    FIT    1115.593    0.049  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)    2/72*
                       (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 1115.558 ± 0.052
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 $\overline{x}$, $\delta\overline{x}$, 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  BOLDT     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    S      ERROR PURELY STATISTICAL
T           . . . . . . . . . .
T    AVG      2.521     0.021     0.021  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.2)
                       (SEE IDEOGRAM BELOW )

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                    18  MEAN LIFE DIFFERENCE,(LAMBDA-ANTILAMDA)/AVERAGE

DT            0.044     0.085           BADIER    67 HBC     2.4 PBAR P        8/67

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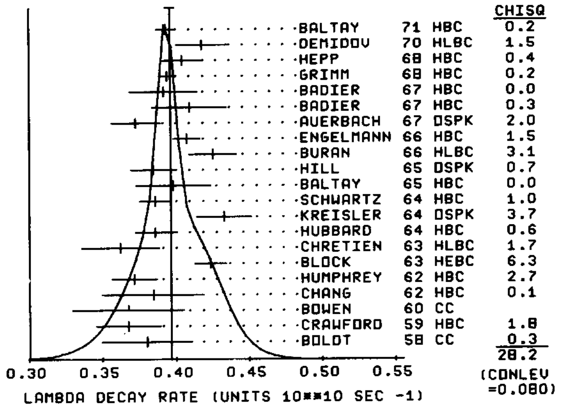
WEIGHTED AVERAGE = 0.3967 ± 0.0033
ERROR SCALED BY 1.2

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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  (IN UNITS OF 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**-14 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

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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)

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 B      14   1.5      0.5             BAGGETT2  72 HBC     STOP.K-           2/72*
R4 B     ERROR CHANGED BY E.LEITNER (PRIV.COMM.) FROM 0.6
R4          . . . . . . . . . .
R4   AVG       1.62     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 K0 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)

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18 LAMBDA DECAY PARAMETERS

RELATED TEXT SECTION IV H AND APPENDIX III

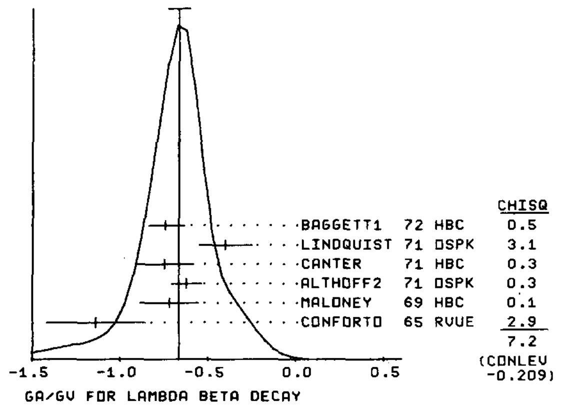
A- ALPHA LAMBDA- (LAMBDA INTO PI- PROTON)
A- 1156 0.62 0.07 CRONIN 63 CNTR LAMBDA FROM PI-P 8/67
A- (0.663) (0.022) BERGE 66 RVUE INCLUDES ABOVE 9/66
A- 10130 0.645 0.017 OVERSETH 67 OSPK LAMBDA FROM PI-P 8/67
A- M 2529 (0.747) (0.086) MERRILL 68 HBC REPL BY DAUBER 68 6/68
A- 3520 0.67 0.06 DAUBER 69 HBC FROM XI DECAY 6/68
A- . . . . . . . . . .
A- AVG 0.645 0.016 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

A0 ALPHA0 /ALPHA- FOR LAMBDA (L INTO PI0 N/L INTO PI- P)
A0 1.10 0.27 CORK 60 CNTR
A0 O 4760 1.000 0.068 OLSEN 70 OSPK PI+N TO K+ LAMBDA 5/70
A0 O DONE BY COMPARING PROT DISTRIB WITH N DISTRIB FROM LAMBDA DECAY
A0 . . . . . . . . . .
A0 AVG 1.006 0.056 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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 REP BY ANDERSSON 11/68
F- -6.7 4.5 ANDERSSON 68 OSPK 11/68
F- . . . . . . . . . .
F- AVG -6.3 3.5 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

AV GA/GV FOR LAMBDA BETA DECAY (SEE TEXT SEC. IV H.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 -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 LAMBDAS 2/72*
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 C EXPTS INCLUDED IN CONFORTO 65, RVUE 6/68
AV M EXPT MEASURES ONLY THE ABSOLUTE VALUE OF A/V
AV A USES E AND PROTON UP-DOWN ASYMM AND E-NEU CORRELATIONS 2/72*
AV L LINDQUIST 71 GETS THREE VALUES. WE AVERAGE THE ONE WHICH USES 10/71*
AV L ALL DATA. 10/71*
AV . . . . . . . . . .
AV AVG -0.665 0.063 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
(SEE IDEOGRAM BELOW )

WEIGHTED AVERAGE = -0.665 ± 0.063
ERROR SCALED BY 1.2

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REFERENCES
18 LAMBDA (1115,JP=1/2+) I=0

EISLER 57 NC 5 1700 EISLER,PLANO,SAMIOS,SCHWARTZ + (COLUM+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 + (PARIS-EP)
BOWEN 60 PR 119 2030 BOWEN,HARDY,REYNOLDS,SUN + (PRINCETON)
CORK 60 PR 120 1000 CORK,KERTH,WENZEL,CRONIN,COOL (LRL+PR+BNL)
COLUMBIA 60 ROCH CONF 726 M SCHWARTZ + (COLUMBIA)
HUMPHREY 61 PRL 6 478 HUMPHREY,KIRZ,ROSENFELD,RHEE + (LRL+SYRAC)

ANDERSON 62 CERN CONF 832 ANDERSON,CRAWFORD,GOLDEN,LLOYD + (LRL)
AUBERT 62 NC 25 479 AUBERT,BRISSON,HENNESSY,SIX + (PARIS-EP)
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,KIKUCHI + (NW+BLGNA)
BROWN 63 PR 130 769 BROWN,KADYK,TRILLING,ROE + (LRL+MICHIGAN)
CHRETIEN 63 PR 131 2208 CHRETIEN,CROUCH+ (BRAND+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+ (EP+CERN+UC LOND+RHEL+BERG)
HUBBARD 64 PR 135 B 183 HUBBARD,BERGE,KALBFLEISCH,SHAFER + (LRL)
KERNAN 64 PR 133 B 1271 KERNAN,POWELL,SANDLER + (LRL+UN-COLL-LOND)
KREISLER 64 PR 136 B 1074 M N KREISLER,O OVERSETH,J CRONIN (PRINCE)
LIND 64 PR 135 B 1483 LIND,BINFORD,GOOD,STERN (WISCONSIN)
RONNE 64 PL 11 357 RONNE+ (CERN+EP+UCOL-LONDON+UNIV.BERGEN)
SCHWARTZ 64 UCRL 11360 THESIS JOSEPH ADAM SCHWARTZ (LRL)

BAGLIN 65 NC 35 977 BAGLIN + (EP,CERN,UC LONDON,RUTH,BERGEN)
BALTAY 65 PR 140 B 1027 BALTAY,SANDWEISS,CULWICK,KOPP + (YALE+BNL)
BARLOW 65 PL 18 64 J BARLOW,BLAIR,CONFORTO+ (CERN+RUTH+PENNA)
CHARRIER 65 PL 15 66 CHARRIERE,GIBSON+ (EPUL+BRIST+CERN+MPI)
ALSO NC 46A 205 CHARRIERE,GIBSON + (EPUL,BRIST,CERN, MPI)
CONFORTO 65 EC INT HERZEGNOVI G CONFORTO (CERN)
ELY 65 PR 137 B1302 ELY,GIDAL,KALMUS,POWELL + (LRL,UC LONDON)
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)
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+(HEIDBG+WEIZM)
GIBSON 66 NC 45A 882 W M GIBSON,K GREEN (BRIS)
LONDON 66 PR 143 1034 LONDON,RAU,GOLDBERG,LICHTMAN+ (BNL+SYRACUS)

AUERBACH 67 NC 47A 19 AUERBACH,BOWEN,DOBBS,LANDE,MANN+ (U OF PA)
BADIER 67 PL 25B 152 +BONNET,BRIANDET,SADOULET (EP (PARIS))
MAYEUR 67 U.LIBR.BRUX.BUL32 C.MAYEUR,E.TOMPA,J.WICKENS (UL.BRUX+UC.LON)
CLELAND 67 PL 26B 45 CLELAND,BIENLEIN,CONFORTO+ (CERN,GVA,LUND)
OVERSETH 67 PRL 19 391 O E OVERSETH, R F ROTH (MICHIGAN+PRINCETON)

ANDERSSO 68 VIENNA ABS. 270 ANDERSSON,BIENLEIN,CLELAND +(CERN,GVA,LUND)
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 + (AERL+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,ANNA)

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)
HYMAN 71 ANL-HEP 7133 +BUNNELL,DERRICK,FIELDS,KATZ+ (ANL,CARN)
LINDQUIS 71 PRL 27 612 LINDQUIST,SUMNER+ (CHIC,WUSL,OHIO,ANL)

BAGGETT1 72 ZPHY 249 4 +BAGGETT,EISELE,FILTHUTH,FREHSE+ (HEID)
BAGGETT2 72 SUBMITTED TO ZPHY +BAGGETT,EISELE,FILTHUTH,FREHSE+ (HEID)

PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 62 CERN CONF 236 ARMENTEROS+(CERN+EP+LONDON+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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**Σ⁺** 19 SIGMA+ (1189,JP=1/2+) I=1

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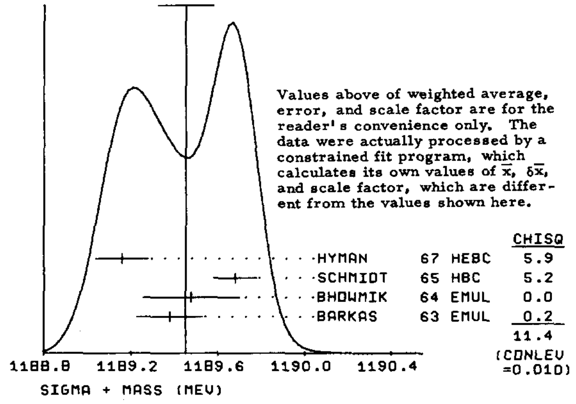
19 SIGMA+ MASS (MEV)

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 1189.68 0.10 SCHMIDT 65 HBC SEE NOTE N 6/68
M 1189.16 0.12 HYMAN 67 HEBC 6/68
M . . . . . . . . . .
M AVG 1189.45 0.13 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
M FIT 1189.42 0.11 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.7) 2/72*
(SEE IDEOGRAM BELOW )

WEIGHTED AVERAGE = 1189.45 ± 0.13
ERROR SCALED BY 1.9

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### Note on $\Sigma^\pm$ Lifetime Errors

When combining lifetimes, we first convert mean lives $\tau$ to decay rates $\Gamma$, since for small numbers of events the distribution of the decay rates is more nearly Gaussian. However, in checking input data it is useful to bear in mind the theoretical minimum statistical error $\delta_{min}(\tau)$ in the mean life itself. This is

$$\delta_{min} = \frac{\tau}{\sqrt{N_{eff}}} ,$$

$$N_{eff} = N\left[1 - x^2 \frac{e^x}{(e^x - 1)^2}\right] ,$$

where N = number of decays seen over the time interval $\Delta t$ and $x = \Delta t/\tau$.

Thus we have checked the errors quoted in the various experiments for consistency with this minimum error. CHANG 66 turned out to have underestimated his errors in both the $\Sigma^+$ and the $\Sigma^-$ lifetimes. We have therefore redone his $\chi^2$ minimization, using his published data, and found the errors that we now quote.

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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 NOTE PRECEDING SIGMA+ LIST.    11/69
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               . . . . . . . . . .
MM  AVG          2.59      0.46     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

R3      SIGMA+ INTO (LAMBDA E+ NEU)/TOTAL (UNIT 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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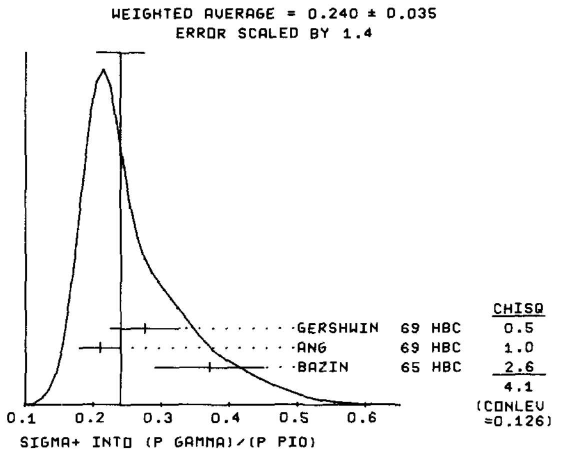


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R5      SIGMA+  INTO (N E+ NEU)/(N PI+)  (UNITS 10**-5)  (P7)/(P2)
R5 E     0     16220 EFFECTIVE DENOM.  COURANT    64 HBC     SEE NOTE E       11/67
R5 E     0      2720 EFFECTIVE DENOM.  MURPHY     64 HBC     SEE NOTE E       11/67
R5 E     1      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+  INTO (N MU+ NEU)/(PI+N)   (UNITS 10**-5) (P6)/(P2)
R6       1      (120)ANALYSED EVENTS   GALTIERI   62 EMUL    NO RATIO QUOTED  11/67
R6 E     0     10150 EFFECTIVE DENOM.  COURANT    64 HBC     SEE NOTE E       11/67
R6 E     0      1710 EFFECTIVE DENOM.  NAUENBERG  64 HBC     SEE NOTE E       11/67
R6 U     2     62000 EFFECTIVE DENOM.  EISELE2    69 HBC                       6/68
R6       0     33800 EFFECTIVE DENOM.  BAGGETT    69 HBC                      11/68
R6 E                 EFFECTIVE DENOM.  TAKEN FROM EISELE 67                   11/67
R6            . . . . . . . . . .
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+ INTO (PROTON E+ E-)/TOTAL   (UNIT 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+ NU)/ SIGMA- INTO (N MU- NU)
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+ NU)/ SIGMA- INTO (N E- NU)
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 E     EISELE2 REPLACED BY EBENHOH 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 CONFIDENCE LEVEL           2/71

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                   19 SIGMA+ DECAY PARAMETERS

       RELATED TEXT SECTION IV H 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 -
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# Stable Particles

## $\Sigma^+$, $\Sigma^-$



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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  D 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 H  DECAY PROTONS SCATTERED OFF CARBON
AO          . . . . . . . . . .
AO  AVG      -0.991    0.019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

F+      PHI+ ANGLE (SIG+ INTO N PI)  SIN(PHI)/COS(PHI)=BETA/GAMMA  (DEGREE)
F+  D  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 CON
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)/COS(PHI)=BETA/GAMMA (DEG)
FO H          22.0     90.0           HARRIS    70 OSPK PI+P TO SIG+ K+      5/70
FO H  DECAY PROTONS SCATTERED OFF CARBON

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REFERENCES

19 SIGMA + (1189,JP=1/2+) I=1


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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   (ROCHES)
CORK     60 PR 120 1000        CORK,KERTH,WENZEL,CRONIN,COOL (LRL+PRI+BNL)
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+HEIDLB+MD+NRL +BNL)
MURPHY   64 PR 134 B 188       C THORNTON MURPHY                (WISCONSIN)
NAUENBER 64 PRL 12 679         NAUENBERG,MARATECK,BLUMENFELD+ (COL+RUT+PR)
WILLIS   64 PRL 13 291         WILLIS,COURANT,ENGELMAN+ (BNL+CERN+HEID+MD)

BALTAY   65 PR 140 B 1027      BALTAY,SANDWEISS,CULWICK,KOPP +  (YALE+BNL)
BAZIN    65 PRL 14 154         BAZIN,BLUMENFELD,NAUENBERG + (PRINCE+COLUM)
BAZIN2   65 PR 140  B1358         BAZIN,PLANO,SCHMIDT+ (PRINCE,RUTG,COLUM)
CARAYAN  65 PR 138 B 433       CARAYANNOPOULOS,TAUTFEST,WILLMANN  (PURDUE)
QUARENI  65 NC 40 A 928        QUARENI,CARTACCI +      (BOL+FIR+GEN+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+MASS+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+ (HEIDELB.)
HYMAN    67 PL 25 B 376        +LOKEN,PEWITT,MCKENZIE,KEYES+(ARG+CARN+NWU)
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-COLLAOR
MAST     68 PRL 20 1312        MAST,GERSHWIN,ALSTON-GARNJOST +          (LRL)

ANG      69 ZPHYS 228 151      +EBENHOH,EISELE,ENGELMANN,FILTHUTH+  (HEID)
BAGGETT  69 MDDP-TR-973        N V BAGGETT (THESIS)                      (MD)
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)
  SEE 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,MASS,YALE)
EBENHOH  70 KIEV CONF          +EISELE,ENGELMANN,FILTHUTH,FOHLISCH+ (HEID)
   ALSO  70 ZPHY 228 151       ANG,EISELE,ENGELMANN,FILTHUTH +      (HEID)
EISELE   70 ZPHY 238 372       +FILTHUTH,HEPP,PRESSER,ZECH     (HEIDELBERG)
HARRIS   70 PRL 24 165         +OVERSETH,PONDROM,DETTMANN      (ANNA,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

                               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,BERLEY+(COLU+RUT+BNL)
    ALSO 65 PR 137 B 1105      ALFF,GELFAND,BRUGGER,BERLEY+(COLUM+RUT+BNL)
COURANT  63 SIENA CONF 1 73    COURANT,FILTHUTH,BURNSTEIN,DAY+ (CERN+MARY)
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## $\Sigma^-$

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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 1197.47    0.11          SCHMIDT   65 HBC  SEE NOTE N          6/68
M          . . . . . . . . . .
M   FIT    1197.34    0.10   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.5)  2/72*

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                20 SIGMA- MASS DIFFER.(-)-(+)(MEV)

D       87    8.25    0.40          BARKAS    63 EMUL  -
D     2500    8.25    0.25          DOSCH     65 HBC
D          . . . . . . . . . .
D   AVG       8.25    0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D   FIT       7.92    0.13   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)  2/72*

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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    0.24          SCHMIDT   65 HBC  SEE NOTE N          6/68
DL     2279 81.64    0.09          HEPP      68 HBC                      8/68
DL          . . . . . . . . . .
DL  AVG     81.666   0.077   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DL  FIT     81.751   0.083  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)  2/72*

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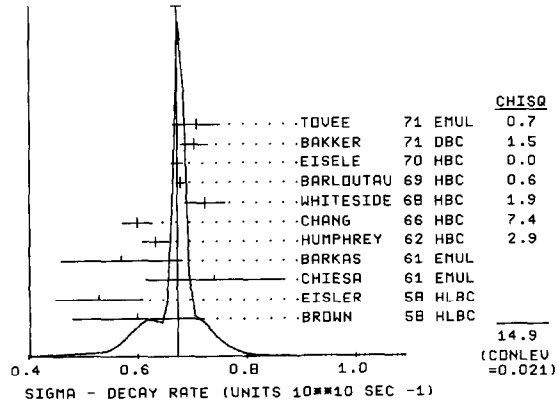
                20  SIGMA- MEAN LIFE (UNITS 10**-10)

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  C       CHANG ERROR 0.026 RAISED BY US. SEE NOTE PRECEDING SIGMA+ LIST.  11/69
T   S      ERROR PURELY STATISTICAL
T          . . . . . . . . . .
T   AVG      1.484   0.019    0.018  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.6)
                     (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 0.6738 ± 0.0085
ERROR SCALED BY 1.6

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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)
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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            (1.11)   (0.15)           SECHIZOR   68 HBC     PRELIMINARY         10/68
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  A       ANG1 REPLACED BY EBENHOH 70                                            2/71
R2          . . . . . . . . . .
R2  AVG        1.096    0.046    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      SIGMA - INTO (LAMBDA E- NEU)/(N PI-) (UNITS 10**-4) (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     P(PI-) LT 110       10/69

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                    20 SIGMA- DECAY PARAMETERS

          RELATED TEXT SECTION IV H AND APPENDIX III

A-      ALPHA SIGMA-
A-            (-0.16)   (0.21)          TRIPP      62 HBC     REPL.BY BANGERTE
A-  0 6500  (-0.010)  (0.043)           BANGERTER 66 HBC      K-P TO SIG- PI+      7/66
A-  0 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 CON
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 IV H.1 FOR SIGN CONV)
AV       PREDICTED TO BE ZERO BY CONSERVED VECTOR CURRENT THEORY
AV   B  45    0.31     0.30            BARASH     67 HBC                          11/67
AV   B                BARASH 67 MEASURED ABSOLUTE VALUE
AV   S  81   +0.22     0.28            EISELE1    69 HBC                          10/68
AV   S  51    0.7      0.4             BALTAY     69 HBC     USING SIG+-           4/69
AV   S                SIGN CHANGED TO AGREE WITH OUR CONVENTION
AV          . . . . . . . . . .
AV  AVG       0.35     0.18     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

AV1     GA/GV FOR SIGMA TO NEUTRON BETA DECAY(TEXT SEC IV H.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     43   -0.4      0.52     1.5    ELLIS     71 ASPK   POLARIZED SIGMAS    10/71*
AV1 E       (+0.10)   (0.11)   (0.11) ELLIS     71 RVUE   SUM LIKEL.(+SOL)    10/71*
AV1 E       (-0.27)   (0.13)   (0.17) ELLIS     71 RVUE   SUM LIKEL.(-SOL)    10/71*
AV1  C  COLLERAINE AND EISELE MEASURE THE ABSOLUTE VALUE OF GA/GV.             11/68
AV1      GERSHWIN 69, BOGERT 70, EBENHOH 70, AND ELLIS 71 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 71 HAS COMBINED THE MAXIMUM LIKELIHOODS OF COLLERAINE 69,      3/72*
AV1 E    EISELE2 69, GERSHWIN 69, ELLIS 71, 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

20 SIGMA-(1198,JP=1/2+)I=1


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BROWN     58 CERN CONF 270      BROWN,GLASER,GRAVES,PERL,CRONIN +     (MICH)
EISLER    58 NC SER10 10 150    EISLER,BASSI,CONVERSI +  (COL+BNL+BOL+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   (MARY)
COURANT   64 PR 136 B 1791      COURANT,FILTHUTH+  (CERN+HEIDLB+MD+NRL+BNL)
MILLER    64 PL 11 262          MILLER,STANNARD,BEZAGUET+ (LOND+PARIS+BERG)
MURPHY    64 PR 134 B 188       C THORNTON MURPHY                 (WISCONSIN)
NAUENBER  64 PRL 12 679         NAUENBERG,SCHMIDT,MARATECK+ (COL+RUT+PRINC)

BAZIN     65 PR 140 B 1358      BAZIN,PLANO,SCHMIDT +    (PRINC+RUTG+COLUM)
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,MASS,YALE)
BIERMAN   68 PRL 20 1459        BIERMAN,KOUNOSU,NAUENBERG +     (PRINCETON)
GERSHWIN  68 PRL 20 1270        GERSHWIN,ALSTON-GARNJOST,BANGERTER+    (LRL)
HEPP      68 ZEIT.PHYS. 214 71  V.HEPP,H. SCHLEICH                (HEIDELBERG)
SECHIZOR  68 TO BE PUBL.        DAY,GLASSER,KNOP+ VIENNA 375      (MARYLAND)
WHITESID  68 NC  54A  537       H. WHITESIDE,J. GOLLUB             (OBERLIN)

ANG 1     69 ZPHY 223 103       ANG,EISELE,ENGELMANN,FILTHUTH +       (HEID)
ANG 2     69 ZPHY 228 151       +EBENHOR,EISELE,ENGELMANN,FILTHUTH+   (HEID)
BAGGETT   69 PRL  23 249        BAGGETT,KEHOE,SNOW              (UNIV MARYLAND)
BALTAY    69 PRL 22 615         BALTAY,FRANZINI,NEWMAN,NORTON+   (COLU,STON)
BANGERTE  69 UCRL-19244         ROGER ODELL BANGERTER (THESIS)         (LRL)
BANGERT1  69 PR 187 1821        BANGERTER,GARNJOST,GALTIERI,GERSHWIN+  (LRL)
BARLOUTA  69 NP B14 153         BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
COLLERAI  69 PRL 23 198         COLLERAINE,DAY,GLASSER,KNOP+(UNIV MARYLAND)
EISELE1   69 ZPHY 221 1         +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+    (HEID)
EISELE2   69 ZPHY 223 487       EISELE,ENGELMANN,FILTHUTH,FOHLISCH+   (HEID)
GERSHWIN  69 UCRL-19246         LAWRENCE KENNETH GERSHWIN (THESIS)     (LRL)

BERLEY    70 PR D1 2015         +YAMIN,HERTZBACH,KOFLER +   (BNL,MASS,YALE)
BOGERT    70 PR D2 6            +LUCAS,TAFT,WILLIS,BERLEY + (BNL,MASS,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)
ELLIS     71 RPP-H-79 PREPRINT  OXF,AERE,RHEL,QMCL,LYON,NWES,ITEP COLLABOR
TOVEE     71 NP B33 493         LOUC,BELGRADE,BERL,BRUX,DUBLIN,WARS COLLAB

                                PAPERS NOT REFERRED TO IN DATA CARDS

BROWN     57 PR 108 1036        J BROWN, D GLASER, M PERL  (MICHIGAN + BNL)
NIETO     68 RMP 40 140         M NIETO                            (STON)
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## $\Sigma^0$

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                    21  SIGMA 0  (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    4.99     0.13            SCHMIDT   65 HBC  SEE NOTE N            6/68
D1          . . . . . . . . . .
D1  AVG       4.849    0.069   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D1  FIT       4.863    0.064  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/72*

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                    21  (SIGMA 0) - (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      76.89     0.10   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)  2/72*

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                    21  SIGMA0 MEAN LIFE (UNITS 10**-14)

T            (1.0)  OR LESS            DAVIS     62 EMUL

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                    21  SIGMA 0 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1       SIGMA 0 INTO LAMBDA GAMMA                      1115+   0
P2       SIGMA 0 INTO LAMBDA E+ E-                      1115+  .5+  .5

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                    21  SIGMA 0 BRANCHING RATIOS

R1      SIGMA 0 INTO(LAMBDA E+ E-)/TOTAL                (P2)/(P1+P2)
R1          (0.00545)   THEORET. CAL. FEINBERG  58        QUANTUM ELECT.    9/66

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REFERENCES

21 SIGMA 0(1193,JP=1/2+)I=1


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FEINBERG 58 PR 109 1019         G.FEINBERG                             (BNL)
DAVIS    62 PR 127 605          D DAVIS,R SETTI,M RAYMOND,G TOMASIN    (CHI)
BURNSTEI 64 PRL 13 66           BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW   (MARY)
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+USNRL)

         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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## $\Xi^-$

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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 LAMDA MASS OF 1115.589-M(XI) IS 1322.18 IF M(LAMBDA) IS 1115.84
M          . . . . . . . . . .
M   AVG     1321.35     0.17    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   FIT     1321.30     0.15   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/72*


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# Stable Particles

## $\Xi^-$, $\Xi^0$

# Data Card Listings

*For notation, see key at front of Listings.*

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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  S   THE ERROR IS STATISTICAL ONLY
M1          . . . . . . . . .
M1  AVG    1321.12     0.37    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M1  FIT ASSUMES XI- AND ANTI XI- MASSES EQUAL

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                    22  MASS DIFFERENCE,(XI-)-(ANTI-XI-) IN 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  - K-P AT 1.8 GEV/C  2/71

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                    22  XI-  MEAN LIFE (UNITS 10**-10)

T   H   11   (3.5)    (3.4)    (1.23) WANG      61 HLBC
T   H   18   (1.28)   (0.41)   (0.25) FOWLER    61 HLBC
T   H (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
T      517    1.86      0.15     0.14  JAUNEAU   63 FBC
T       62    1.55      0.31     0.31  SCHNEIDER 63 HBC
T      356   (1.77)    (0.12)          CARMONY   64 HBC    REP BY PJERROU 65
T      794    1.69      0.07           HUBBARD   64 HBC
T      246    1.70      0.12           PJERROU   65 HBC                     11/67
T   S    6   (1.37)    (0.51)          CHIEN     66 HBC  -  6.9 PBAR P       9/67
T      299    1.80      0.16           LONDON    66 HBC                      6/66
T   S        (1.67)    (0.07)          BURGUN    68 HBC     K-P AT 1.3-1.8    2/71
T     2610    1.61      0.04           DAUBER    69 HBC                      6/68
T   S   THE ERROR IS STATISTICAL ONLY
T           . . . . . . . . .
T   AVG       1.660     0.037    0.035  AVERAGE (ERROR INCL. SCALE FACTOR OF 1.1)

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                    22  XI+BAR 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

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                    22  XI- PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI- INTO LAMBDA PI-                              1115+ 139
P2      XI- INTO LAMBDA E- NEUTRINO                      1115+  .5+   0
P3      XI- INTO NEUTRON PI-                              939+ 139
P4      XI- INTO LAMBDA MU- NEUTRINO                     1115+ 105+   0
P5      XI- INTO SIGMA0 E- NEUTRINO                      1192+  .5+   0
P6      XI- INTO SIGMA0 MU- NEUTRINO                     1192+ 105+   0
P7      XI- INTO NEUTRON E- NEUTRINO                      939+  .5+   0

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                    22  XI- BRANCHING RATIOS

R1      XI- INTO (LAMBDA E- NEU)/(LAMBDA PI-) (UNITS 10**-3) (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) (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) (P4)
R3           12.0    OR LESS            BERGE     66 HBC                     6/68
R3            1.3    OR LESS            DAUBER    69 HBC                     6/68

R4      XI- INTO (SIGMA0 E- NEUTRINO)/TOTAL (UNITS 10**-3) (P5)
R4            3.0    OR LESS            BERGE     66 HBC                     6/68
R4            0.5    OR LESS            DAUBER    69 HBC                     6/68

R5      XI- INTO (SIGMA0 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 (SIGMA0 E- NEU + LAMBDA E- NEU)/TOTAL (10**-3) (P2+P5)
R7       17    0.68      0.22          DUCLOS    71 OSPK    SEE NOTE D      10/71*
R7  D    THIS EXPERIMENT CANNOT DISTINGUISH SIGMA0 FROM LAMBDA. THE CABIBBO
R7  D    THEORY EXPECT SIGMA0 RATE ABOUT A FACTOR 6 SMALLER THAN THE LAMBDA
R7  D    TO GET A VALUE FOR THE TABLE R7 HAS BEEN AVERAGED WITH R1 -

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                    22  XI- DECAY PARAMETERS

        RELATED TEXT SECTION IV H 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   A   USED ALPHALAMBDA = 0.647 PLUS OR MINUS 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      -0.402    0.031    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   A   USED ALPHALAMBDA = 0.647 PLUS OR MINUS 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      -4.3      8.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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REFERENCES


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                    22  XI -  (1321,JP=1/2 )  I=1/2

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+      (PARIS+CERN+LOND+RUTH+BERGEN)
    ALSO 63 PL  5  261         JAUNEAU,MORELLET+ (EP,CERN,LON,RUTH,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+ (PARIS+SAC+ZEE)
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                         (RVUE)
LONDON   66 PR 143 1034        LONDON,RAU,GOLDBERG,LICHTMAN+ (BNL+SYRACUS)
CHIEN    66 PR  152  1171      +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
SHEN     67 PL 25 B 443        B.C.SHEN,A.FIRESTONE,G.GOLDHABER  (UCB+LRL)
TRIPPE   67 PRIV. COMM.        T. TRIPPE                             (UCLA)

BURGUN   68 NP B8 447          +MEYER,PAULI,TALLINI, +    (SACL+CDEF+RHEL)
HUBBARD  68 PRL 20 465         HUBBARD,BERGE,DAUBER                   (LRL)
MERRILL  68 PR 167 1202        MERRILL,SHAFER                        (LRL)J

DAUBER   69 PR  179 1272       +BERGE,HUBBARD,MERRILL,MILLER          (LRL)J
BINGHAM  70 PR D1 3010         +COOK,HUMPHREY,SANDER,WILLIAMS+ (UCSD,WASH)
GOLDWASS 70 PR D1 1960         GOLDWASSER, SCHULTZ                    (ILL)
STONE    70 PL 32B 515         +BERLINGHIERI,BROMBERG,COHEN,FERBEL +(ROCH)

DUCLOS   71 NP B32 493         +FREYTAG,HEINTZE,HEINZELMAN,JONES+    (CERN)
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## $\Xi^0$

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                    23  XI 0  (1314,JP=1/2 ) I=1/2

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                    23  XI 0  MASS (MEV)

M        1 1313.4      1.8            PALMER    68 HBC                      3/68
M          . . . . . . . . .
M   FIT    1314.73     0.70   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/72*

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                    23  XI        MASS DIFFERENCE (-)-(0)(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       6.56      0.68   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)  2/72*

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                    23  XI 0 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          . . . . . . . . .
T   AVG       3.03      0.18     0.16   AVERAGE (ERROR INCL. SCALE FACTOR OF 1.0)

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                    23  XI 0  PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      XI 0 INTO LAMBDA PIO                             1115+ 134
P2      XI 0 INTO PROTON PI-                              938+ 139
P3      XI 0 INTO PROTON E- NEU                           938+  .5+   0
P4      XI 0 INTO SIGMA+ E- NEU                          1189+  .5+   0
P5      XI 0 INTO SIGMA- E+ NEU                          1197+  .5+   0
P6      XI 0 INTO SIGMA+ MU- NEUTRINO                    1189+ 105+   0
P7      XI 0 INTO SIGMA- MU+ NEUTRINO                    1197+ 105+   0
P8      XI 0 INTO PROTON MU- NEUTRINO                     938+ 105+   0

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                    23  XI 0  BRANCHING RATIOS

R1      XIO INTO (PROTON PI-)/(LAMBDA PIO) (UNITS 10**-3) (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) (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
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R3      XIO INTO (SIGMA+ E- NEU)/(LAMBDA PIO) (UNITS 10**-3) (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) (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  XI 0 DECAY PARAMETER

       RELATED TEXT SECTION IV H AND APPENDIX III

A       ALPHA XI 0
A             -0.09      0.46             PJERROU    65 HBC     SEE NOTE D BELOW  6/68
A       146   -0.13      0.17             BERGE      66 HBC     SEE NOTE D BELOW  6/68
A  L     46   -0.2       0.4              LONDON     66 HBC     SEE NOTE D BELOW  6/68
A   M   490  (-0.33)    (0.11)            MERRILL    66 HBC     SEE NOTE D BELOW  6/68
A  A    739   -0.43      0.09             DAUBER     69         SEE NOTE A BELOW
A  A     USED ALPHALAMBDA = 0.647 PLUS OR MINUS 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           . . . . . . . . .
A   AVG       -0.351     0.077   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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  A     USED ALPHALAMBDA = 0.647 PLUS OR MINUS 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           . . . . . . . . .
F   AVG       24.8       20.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                             (SEE IDEOGRAM BELOW )
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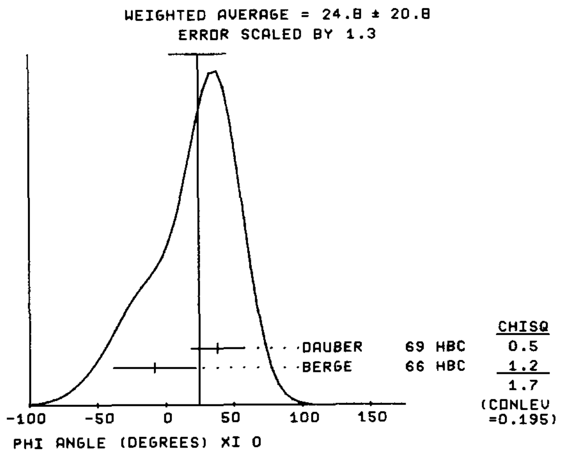


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REFERENCES

23 XI 0(1314,JP=1/2)I=1/2

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ALVAREZ  59 PRL 2 215          ALVAREZ,EBERHARD,GOOD,GRAZIANO,TICHO+ (LRL)
JAUNEAU  63 SIENA CONF 1 1     JAUNEAU+      (PARIS+CERN+LOND+RUTH+BERGEN)
   ALSO  63 PL 4 49            JAUNEAU+      (PARIS+CERN+LOND+RUTH+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+SYRACUS)
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,SYR)
DAUBER   69 PR  179 1262       +BERGE,HUBBARD,MERRILL,MILLER         (LRL)
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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        1(1620.0)   (25.0)    (10.0) EISENBERG 54 EMUL
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        6 1671.9      1.2            SPETH     69 HBC     K-P 10. GEV/C    11/69
M           . . . . . . . . . .
M   AVG    1672.49     0.52    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  24  OMEGA+BAR 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        1 (2.3)                      SPETH     69 HBC                      10/69
T        1 (0.31)                     SPETH     69 HBC                      10/69

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                  24 OMEGA- PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      OMEGA INTO LAMBDA K-                              1115+ 493
P2      OMEGA INTO XI 0 PI-                               1314+ 139
P3      OMEGA INTO XI- PI 0                               1321+ 134

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                  24  OMEGA- BRANCHING RATIOS

R1         OMEGA- INTO LAMBDA K-                          (P1)
R1       2   EVENTS                   PALMER    68 HBC                      11/69
R1       3   EVENTS                   SCHULTZ   68 HBC                      11/69
R1       5   EVENTS  1 AMBIG. XIO PI- SCOTTER   68 HBC                      11/69
R1       6   EVENTS                   SPETH     69 HBC                      11/69

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       1   EVENT                    SPETH     69 HBC                      11/69

R3         OMEGA- INTO XI- PIO                            (P3)
R3       1   EVENT                    PALMER    68 HBC                      11/69
R3       1   EVENT                    SCOTTER   68 HBC                      11/69

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REFERENCES
24 OMEGA-(1675,JP=3/2+)  I=0

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EISENBER 54 PR 96 541          Y EISENBERG                        (CORNELL)
ABRAMS   64 PRL 13 670         + BURNSTEIN,GLASSER +       (MARYLAND+USNRL)
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 +       (BIR+GLA+IC+MUN+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,SYR)
SCHULTZ  68 PR  168  1509      SCHULTZ+     (ILL,ARGONNE,NORTHWESTERN,WISC)
SCOTTER  68 PL 26B 474         SCOTTER+(BIRM,GLASGOW,IC LONDON,MUNICH,OXF)
SPETH    69 PL  29B 252        SPETH+    (AACHEN,BERLIN,CERN,LONDON,VIENNA)
FIRESTON 71 PRL 26 410         +GOLDHABER,LISSAUER,SHELDON,TRILLING  (LRL)
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CODE EVENTS QUANTITY  ERROR+  ERROR-  REFERENCE YR TECN SIGN COMMENTS  DATE.
     ABOVE                                                          PUNCHED
  BACKGROUND
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$\pi$

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                PI MESON (JPG=0--)  I=1
            SEE LISTINGS OF STABLE PARTICLES
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$\eta$

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                ETA    (549,   JPG=0-+)   I=0
            SEE LISTINGS OF STABLE PARTICLES
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$\epsilon$

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                14  PI PI S WAVE, CALLED EPSILON
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## S-wave $\pi\pi$ Interactions in the Region 280-1400 MeV

$\pi\pi$ interactions in the $I^G(J^P)C = 0^+(0^+)+$ wave can be described by the elastic phase shift $\delta_0^0$ from the $\pi\pi$ threshold ($\approx$280 MeV) up to the region of the $K\bar{K}$ threshold ($\approx$990 MeV). But starting slightly below $K\bar{K}$ threshold, a coupled two-channel formalism is required. At the very least — until full two-channel studies appear — the phase shift $\delta_0^0$ has to be supplemented by an elasticity parameter $\eta_0^0$. At higher energies, still more channels open up, and have to be taken into account: the $4\pi$ channel is becoming noticeable around 1100 MeV, $\rho\pi\pi$ appears around 1300 MeV, etc. (See HYAMS 70, OH 70, ALSTON-GARNJOST 71).

Resonances claimed throughout this region in the past have been named $\omega_{ABC}$, $\sigma$, $\epsilon$, $\eta_{0^+}(700\text{-}1000)$, $S^*$, and $\eta_{0^+}(1070)$, all with the same quantum numbers. At present, it seems necessary to consider only two poles, the $\epsilon$ pole and the $S^*$ pole. Whether either one actually corresponds to a resonance depends more on the definition of a resonance than on the data. It is becoming increasingly clear that the description of the phase shift by two parameters, "mass" and "width," is insufficient. Moreover, the choice of the two parameters is by no means obvious: those describing the $\epsilon$ pole may be several hundred MeV different from those describing $\delta_0^0$ at 90°. We therefore no longer quote "mass" and "width," but rather discuss the experimental information on $\delta_0^0$ (see the figures).

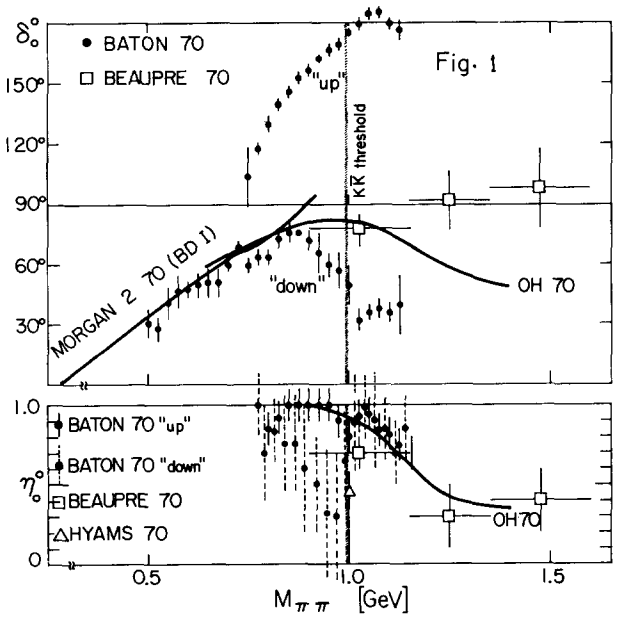


Fig. 1. The $\pi\pi$ S-wave, I = 0 phase shift parameters, showing some solutions available through 1971. BATON 70 actually presented two "down" solutions; the one we plot allowed for inelasticity, the other corresponded to a purely elastic hypothesis. The new $4\pi$ data of ALSTON-GARNJOST 71 show that the $\pi\pi$ channel is essentially elastic up to $K\bar{K}$ thresh-threshold; if we had plotted the elastic fit of BATON 70, it would have agreed better with the newer fits in Fig. 2.

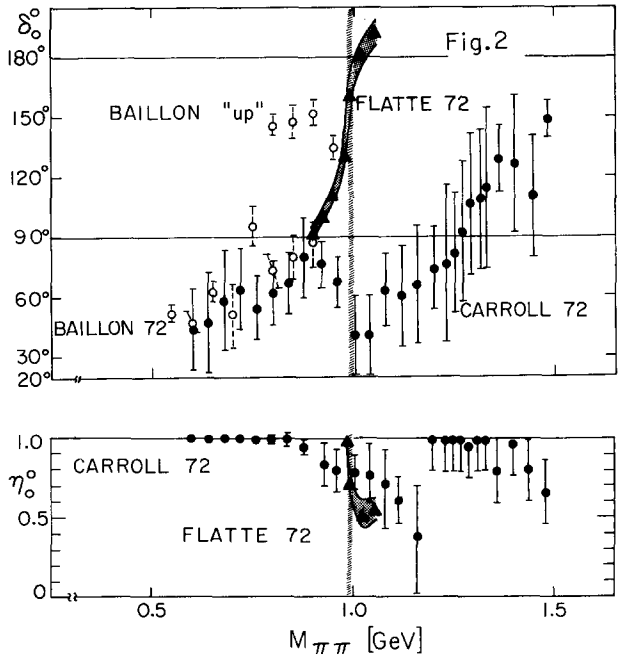


Fig. 2. The $\pi\pi$ S-wave, I = 0 phase shift parameters, as given by three very recent solutions: BAILLON 72, CARROLL 72 and FLATTE 72. Energy-dependent fits are indicated by lines, or (when errors were available) by dots (indicating the central value in each bin used) and an error band (FLATTE 72). Energy-dependent solutions are indicated with central values and errors; the solutions of BATON 70 are not strictly energy-independent since they were actually determined from smooth curves through the data.

From the $\pi\pi$ threshold $\delta_0^0$ rises monotonically with a small scattering length (for a review, see EBEL 71, Sec. 3.5).

No structure or resonant behavior is indicated near threshold in data from the reaction $\pi^- p \to \pi\pi N$. In fact, the only structures claimed in this region are due to reactions involving the nuclei d, $H^3$, or $He^3$ (BOOTH 63, HALL 69, BRODY 70, BANAIGS 71), for which the background may be difficult to assess.

In the region below the $\rho$ meson (500-700 MeV), $\delta_0^0$ continues to rise slowly, all "up" solutions ($\delta_0^0$ near 90°) being excluded (BATON 70). In the mass region between the $\rho$ and $K\bar{K}$ threshold, solutions conflict. BATON 70 found ambiguous "up" and "down" solutions (see Fig. 1), while CARROLL 72 (40% of whose data is that of OH 70) find only one solution (Fig. 2), which agrees with the "down" solution of BATON 70. However, CARROLL 72 note that their results do not completely rule out $\delta_0^0$ rising rapidly through 90° near 1000 MeV, since their statistics are weak in that region. Using a qualitative coupled-channel ($\pi\pi$ and $K\bar{K}$) analysis, FLATTE 72 also agree with the "down" solution of BATON 70 around 900 MeV, but find a resonance at 990 MeV (Fig. 2), which is the $\pi\pi$ mode of the $S^*$, as is discussed below. Finally, indirect information from elastic $\pi\pi$ scattering in the crossed channel (NIELSEN 70, ELVEKJAER 71, HAMILTON 71) excludes the "up" solution and agrees with the "down" solution of BATON 71 and the BD1 solution of MORGAN2 70.

Given the crude methods and inferior statistics in the past, most of the old $\pi^+\pi^-$ phase shift analyses (e.g., MALAMUD 69, SCHARENGUIVEL 69, 70) and the Chew-Low-extrapolated $\pi^0\pi^0$ cross sections (e.g., DEINET 69, BENSINGER 71) have solutions that do not contradict this behavior.

Near 1000 MeV, $\delta_0^0$ feels the influence of two strong effects: the $K\bar{K}$ threshold and the $S^*$ pole, which may be located anywhere near the threshold. The $K\bar{K}$ threshold manifests itself clearly by the sudden increase of $\pi\pi$ inelasticity (HYAMS 70, ALSTON-GARNJOST 71). $\delta_0^0$, already near 90°, probably shoots towards 180° and has a cusp (discontinuity) at $K\bar{K}$ threshold (FLATTE 72).

We list the $S^*$ parameters separately under "S-wave $K\bar{K}$ interactions." They should not be taken too seriously, since all except FLATTE 72 are based on simple one-channel analyses.

For reviews, see BEUSCH 70, LYNG PETERSEN 71.

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                                REFERENCES

SAMIOS   62 PRL 9 139          +BACHMAN,LEA+                (BNL+CCNY+CO+KY)

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,GODDEN,MARSHALL +     (COLORADO+IOWA)
LOVELACE 66 PL  22  332        LOVELACE,HEINZ,DONNACHIE                 (CERN)

ANDERSON 67 PRL 18 89          +FUKUI+KESSLER+   (CHIC+ANL+OTT+MCGILL+QMC)
CLEGG    67 PR 163 1664        A.B.CLEGG                            (LANCASTER)
CORBETT  67 PR 156 1451        +DAMERELL+MIDDLEMAS+NEWTON     (OXF+RUTHERF)
GUTAY    67 PRL 18 142         +JOHNSON+LOEFFLER+MCILWAIN+   (PURDUE+UCRL)
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       (HOBOKEN,NJ)
EISENHAN 68 PRL 20 758         EISENHANDLER,MISTRY,MOSTEK +        (CORNELL)
FOSTER   68 NP B 6 107         +GAVILLET+LABROSSE+MONTANET+   (CERN+PARIS)
HYAMS    68 NP B7 1            +KOCH,POTTER,..VON LINDERN,LOREN(CERN+MPIN)
JONES    68 PR 166 1405        +CALDWELL+ZACHAROV+HARTING+BLEULER+  (CERN)
JOHNSON  68 PR 176 1651        +POIRIER,BISWAS,GUTAY,DERADO+(ND+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,GHESQUIERS+ (CERN+CDEF)

DAVISON  69 PR 180 1333        +BACASTOW,BARKAS,+                 (RIVS+BERK)
DEINET   69 PL 30 B 359        +MENZIONE,MULLER,STAUDENMAIER,+ (KARL+CERN)
ELY      69 PR 180 1319        +GIDAL,HAGOPIAN,+              (BERK+LOUC+WISC)
FELDMAN  69 PRL 22 316         +FRATI,GLEESON,HALPERN,NUSSBAUM,+      (PENN)
GUTAY    69 NP B 12 31         +CARMONY,CSONKA,LOEFFLER,MEIERE     (PURDUE)
HALL     69 NP B 12 573        +MURRAY,RIDDIFORD                (BIRMINGHAM)
HOPKINSO 69 NC 59 A 181        J.HOPKINSON,R.G.ROBERTS                 (CERN)
MALAMUD  69 ARGONNE CONF.P.93  E.MALAMUD, P.SCHLEIN                    (UCLA)
MORGAN   69 NP B 10 261        D.MORGAN,G.SHAW                         (RHEL)
ROBERTS  69 PL 29 B 368        R.G. ROBERTS, F. WAGNER                 (CERN)
SCHAREN1 69 ARGONNE CONF.306   SCHARENGUIVEL                        (PURDUE)
SCHAREN2 69 PR 186 1387        SCHARENGUIVEL(PURD+LRL+CERN+COLO+PENN+TNTO)
SMITH    69 PRL 23 335         G.A.SMITH, R.J.MANNING            (MICH+LRL)
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)
BEAUPRE  70  CERN PHYS 70 42   +DEUTSCHMANN,GRAESSLER,+   (AACH+BERL+CERN)
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+MUN+ETH+IC+HAWAII)
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)
BENSINGE 71 PL 36 B 134        BENSINGER,ERWIN,THOMPSON,W.D.WALKER  (WISC)
EBEL     71 NP B 33 317        +MULLENSIEFEN+   (KARL+CERN+LOUC+RHEL+NIJM)
ELVEKJAE 71  PREPRINT RPP/C22  F.ELVEKJAER,H.NIELSEN          (NORDITA+RHEL)
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                                 (IRVN)
LYNG PET 71 PHYS.REPRTS 2 155  J.LYNG PETERSEN (REVIEW)                 (CERN)
MORGAN   71  PREPRINT RPP/C30  D.MORGAN                                 (RHEL)

BAILLON  72 SLAC 1016.SUBM.PL  +CARNEGIE,KLUGE,LETIH,LYNCH,RATCLIFF (SLAC)
BRODY    72  PREP. UPR-0002E   H.BRODY                        (PENNSYLVANIA)
CARROLL  72 PRL 28 318         +DIAMOND,FIREBAUGH,MATTHEWS,+   (WISC+TNTO)
FLATTE   72  PL 38 B 232       +ALSTON-GARNJOST,BARBARO-GALTIERI,+   (LBL)
                               ANALYSIS OF DATA OF ALSTON-G 71

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## $\rho(765)$

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9 RHO (765, JPG = 1-+)  I=1
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                    9 RHO  MASS (MEV)

 THERE ARE WIDE FLUCTUATIONS IN THE MEASURED VALUES FOR MASS AND WIDTH OF
 THE RHO DUE TO DIFFERENCES IN PRODUCTION MECHANISM, BACKGROUND, METHOD
 OF ANALYSIS AND PARAMETRIZATION.  UNCERTAINTIES IN THEORY GIVE RISE TO
 SYSTEMATIC ERRORS OF ABOUT 20 MEV IN MASS AND WIDTH.

 THE FOLLOWING ENTRIES ARE THE MOST SIGNIFICANT ONES. THEY ILLUSTRATE
 THE DISCREPANCIES, AND ARE ALSO REPEATED IN FOOTNOTE (C) OF THE MESON
 TABLE.

▷1 BATON 67,70  (RHO-0 FROM POLE EXTRAPOLATION)
▷2 HYAMS 68     (RHO 0 FROM PHYSICAL REGION FITS)
▷3 MARATECK 68  (RHO 0 FROM POLE EXTRAPOLATION)
▷4 PISUT 68     (RHO-0 FROM PHYSICAL REGION FITS)
▷5 LEFRANCOIS71 (RHO 0 INTERFERING WITH OMEGA,FROM E+E- COLL.BEAMS)
▷6 AUSLENDER 69 (RHO 0 FROM E- E+ COLLIDING BEAMS)
▷7 MALAMUD 69   (RHO 0 FROM PHYSICAL REGION FITS)
▷8 ROOS 69      (COMPILATION OF RHO 0 FROM E+ E- COLLIDING BEAMS)
▷9 SCHARENGUIVEL 69 (RHO 0 FROM POLE EXTRAPOLATION)
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M+  CHARGE PLUS ONLY
M+  R       (760.0)    (9.0)               CARMONY    64 HBC   +   3.5 PI+P,TCUT 4
M+           760.      10.                 ARMENISE   65 HBC   +   2.8 PI+P
M+  R       (765.0)    (5.0)               ALFF-STEI  66 HBC   +   2-3 PI+ P         6/66
M+  R       (783.0)    (6.0)               JAMES      66 HBC   +   2.1 PI+ P         6/66
M+  R       (758.0)   (10.0)               JAMES      66 HBC   +   2.1 PI+,TCUT2.5   8/66
M+           777.0      7.0                ABC COLL.  68 HBC   +   8 PI+P TO P+3PI   5/68
M+           . . . . . . . . . .
M+  AVG      771.4      8.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

M+  CHARGE PLUS AND MINUS
M+  S       (750.0)    (3.0)               BALTAY     66 HBC   +-  0.0 PBAR P
M+           755.      10.                 ALLES-BOR  67 HBC   +-  5.7 PBAR P       12/66
M+           730.      11.                 BARLOW     67 HBC   +-  1.2 PBAR P       11/66
M+           782.       5.                 FOSTER     68 HBC   +-  PBAR P AT REST    6/68
M+           . . . . . . . . . .
M+  AVG      770.0     13.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.3)

M-  CHARGE MINUS ONLY
M-          (748.0)                        KENNEY     62 HBC   -   1.2 PI-P
M-     130  (775.0)                        GUIRAGOSS  63 HBC   -   3.3 PI-P
M-  R       (768.0)    (5.0)               BLIEDEN    65 MMSP  -   3-5 PI- P         6/66
M-           772.0     19.0                FIDECARO   66 OSPK  -   2.5 PI-,T CUT18  11/66
M-  R       (760.0)    (5.0)               HAGOPIAN1  66 HBC   -   3.0 PI- P         6/66
M-  R       (770.0)    (5.0)               HAGOPIAN2  66 HBC   -   2.14 PI-P         9/67
M-  R       (765.0)    (5.0)               HAGOPIAN2  66 HBC   -   2.14 PI-,TCUT12   9/67
M-  R 6014  (757.6)    (6.6)               JACOBS     66 HBC   -   2-3PI-            6/68
M-  R 2775  (753.5)   (10.5)               JACOBS     66 HBC   -   2-3PI-,T CUT 20   6/68
M-  R       (749.0)    (3.0)               WEST       66 HBC   -   2.1 PI- P        10/66
M-           752.0     14.0                BANNER     67 MMS   -   1.8 PI-P,  P+MM   9/67
M-  C 7666  (755.0)    (5.0)           ▷1 BATON      67 HBC   -   2.8 PI- P        10/67
M-           751.       5.                 CLEAR      67 HBC   -   3 PI- P           7/67
M-           764.       4.                 EISNER     67 HBC   -   4.2 PI-P          9/67
M-  R       (777.0)    (6.0)               MILLER     67 HBC   -   2.7 PI-,T CUT 5   9/66
M-  R       (775.0)    (5.0)               MILLER     67 HBC   -   2.7 PI-,T CUT10   9/66
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-   12773   764.3      1.9        1.8 ▷4 PISUT      68 RVUE  -   1.7-3.2PI-,CT10   6/68
M-  A12773  (764.3)   (19.2)      (3.3) ▷4 PISUT      68 RVUE  -   1.7-3.2PI-,CT10   6/68
M-  A   ERRORS ARE 2 STD AND INCLUDE SYSTEMATIC UNCERTAINTIES FROM THEORY
M-           776.0      4.0                REYNOLDS   69 HBC   -   2.26 PI- P        5/70
M-           . . . . . . . . . .
M-  AVG      764.6      3.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)

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          (735.0)   (10.0)               ALYEA      65 DBC    0 2.2 K- P           6/66
MO          (750.0)                        CLARK      65 OSPK   0 1.5 PI-P
MO  S       (750.0)   (15.0)               GUTAY      65 HBC    0 2.0 PI- P          6/66
MO           768.0     14.0                ACCENSI    66 HBC    0 5.7 PBARP          6/66
MO  R       (750.0)    (5.0)               ALFF-STEI  66 HBC    0 2-3 PI+ P          6/66
MO  S       (751.)     (6.)                BALTAY     66 HBC    0 0.0 PBARP          6/66
MO  P       (728.0)    (8.0)               CAMBRIDGE  66 HBC    0 1.0-6.0 GAMMA P 10/66
MO  S       (773.0)   (12.0)               CASON      66 HBC    0 7.0 PI- P          9/66
MO  R       (775.0)    (5.0)               HAGOPIAN1  66 HBC    0 3.0 PI- P          6/66
MO  R       (770.0)    (5.0)               HAGOPIAN2  66 HBC    0 2.14 PI-P          9/67
MO  R       (770.)     (5.)                HAGOPIAN2  66 HBC    0 2.1 PI-,TCUT 12    2/67
MO  R 7760  (763.3)    (6.0)               JACOBS     66 HBC    0 2-3PI-             6/68
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           765.       5.                 ASBURY 2   67 CNTR   0 GAMMA + PB         8/67
MO  R       (768.0)    (2.0)               BACON      67 HBC    0 1.7 PI-P         . 9/67
MO           745.       9.                 BARLOW     67 HBC    0 1.2 PBAR P        11/66
MO     327   750.      10.                 DANYSZ     67 HBC    0 3.0 PB P,6 PI      7/67
MO  O  240  (752.)    (10.)                DANYSZ     67 HBC    0 3.0 PB P,7 PI      6/68
MO  O        SELECTION ON OMEGA.
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          (777.0)    (5.0)               POIRIER    67 HBC    0 8.0 PI- P         11/67
MO           770.0      3.0                ABC COLL.  68 HBC    0 8 PI+P TO P+3PI.  5/68
MO  R       (775.0)    (2.0)               ARMENISE   68 DBC    0 5.1 PI+D           6/68
MO           763.      15.                 BLECHSCHM  68 HBC    0 GAMMA P (BREMS)    6/68
MO           745.0      5.0                DONALD     68 HBC    0 1.2 PB P,4 PR.     9/68
MO           776.       5.                 FOSTER     68 HBC    0 PBAR P AT REST     6/68
MO    2250   775.0      3.0            ▷2 HYAMS      68 OSPK   011.2 PI- P          9/68
MO  S       (765.0)    (6.0)               JONES      68 OSPK   0 12PI-, T LT 2.5.  5/68
MO  S       (745.0)   (13.0)               JONES      68 OSPK   0 18PI-, T LT 2.5   5/68
MO  S       (760.0)    (9.0)               JONES      68 OSPK   0 18PI-,T2.5 TO 5   5/68
MO  S       (749.0)    (5.0)               JONES      68 OSPK   0 12PI-,T 5 TO 10   5/68
MO  S       (761.0)    (6.0)               JONES      68 OSPK   0 18PI-,T 5 TO 10   5/68
MO  S       (750.0)    (8.0)               JONES      68 OSPK   0 12PI-,T10 TO 15   5/68
MO  S       (780.0)   (10.0)               JONES      68 OSPK   0 18PI-,T10 TO 15   5/68
MO  S       (760.0)    (5.0)               KEY        68 HBC    0 3.0 PI- P          5/68
MO           766.       4.                 LAMSA      68 HBC    0 8.0 PI-P          11/67
MO  P       (740.0)   (10.0)               LANZEROTT  68 CNTR   0 GAMMA P(BREMS)   10/66
MO  E       (770.0)    (4.0)               AUGUSTI1   69 OSPK   0 E+E- COLL.BEAMS   4/69
MO  L       (773.5)    (5.4)           ▷5 AUGUSTI2   69 OSPK   0 E+E- COLL.BEAMS   8/69
MO  L   SUPERSEDED BY LEFRANCOIS 71
MO           AUGUSTIN 2 TAKES ACCOUNT OF RHO-OMEGA INTERFERENCE, AND
MO           INCLUDES DATA OF AUGUSTIN 1.
MO  E       (754.0)    (9.0)           ▷6 AUSLENDER  69 OSPK   0 E+E- COLL.BEAMS   6/68
MO           SEE ALSO HAISSINSKI 69, WHO FITS AUSLENDER 69 DATA
MO  E       (768.)    (10.)                HAISSINSK  69 RVUE   0 E+E- COLL.BEAMS   9/69
MO           HAISSINSKI 69 IS FIT TO AUSLENDER 68 DATA
MO           768.4      2.4            ▷7 MALAMUD    69 RVUE   0 2-4 PI-P           5/70
MO  S       (755.0)   (15.0)               MOTT       69 HBC    0 4.1-5.5 K- P       7/69
MO           771.0      3.0                REYNOLDS   69 HBC    0 2.26 PI- P         5/70
MO           770.0      5.0            ▷8 ROOS       69 RVUE   0 E+E- COLL.BEAMS   9/69
MO  C       (759.0)    (7.0)           ▷9 SCHAREN    69 HBC    0 2-4 PI- P          5/70
MO           765.0     10.0                ALVENSLEB  70 CNTR   0 GAMMA A(BREMS)     5/70
MO  C12630  (760.0)                    ▷1 BATON      70 HBC    0 2.8 PI- P          1/71
MO           765.0      3.0                BINGHAM    70 HBC    0 2.8 GAMMA P        5/70
MO           760.0      3.0                BINGHAM    70 HBC    0 4.7 GAMMA P        5/70
MO           767.7      1.9                BIGGS      70 CNTR   0PHOTOPRODUCTION     6/70
MO  S       (765.0)    (6.0)               GALLOWAY   70 HBC    0 5.97 PI- P         1/71
MO           775.4      7.3                LEFRANCOI  71 OSPK   0 E+E- COLL.BEAMS   2/72*
MO           . . . . . . . . . .
MO  AVG      767.2      1.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

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            744.       9.                 FRENCH     67 HBC  +-0 3-4 PBAR P        6/67
M            775.0      2.0                JOHNSON    68 HBC   -0 3.7-4.2 PI- P     7/69
M            . . . . . . . . . .
M   AVG      773.5      2.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M        ----------NOTES----------
M   C    FROM POLE EXTRAPOLATION
M   E    INCLUDED IN ROOS 69 RVUE
M   P    PHOTOPRODUCTION,UNCORRECTED FOR PRODUCTION E-DEPENDENCE
                                     OR BACKGROUND INTERFERENCE
M   R    INCLUDED IN PISUT 68 RVUE
M   S    S-WAVE BREIT-WIGNER FIT, CANNOT BE COMBINED WITH OTHER VALUES
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                    9  RHO(0) - RHO(+-) MASS DIFFERENCE (MEV)

D          2.4       2.1                PISUT      68 RVUE     PI N TO RHO N      6/68

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                    9  RHO  WIDTH (MEV)

W       SEE NOTE ON RHO MASS ABOVE

W+  CHARGE PLUS ONLY
W+           90.0      10.0                SACLAY     63 HBC   +   2.8 PI+P
W+  R        (77.0)   (20.0)               CARMONY    64 HBC   +   3.5 PI+P,TCUT 4
W+           160.      10.                 ARMENISE   65 HBC   +   2.8 PI+P
W+  R       (100.0)                        ALFF-STEI  66 HBC   +   2-3 PI+ P         6/66
W+  R       (177.0)   (15.0)               JAMES      66 HBC   +   2.1 PI+ P         7/66
W+  R       (147.0)   (19.0)               JAMES      66 HBC   +   2.1 PI+,TCUT2.5   8/66
W+           149.0     22.0                ABC COLL.  68 HBC   +   8 PI+P TO P+3PI   5/68
W+           . . . . . . . . . .
W+  AVG      127.2     24.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.6)

W+  CHARGE PLUS AND MINUS
W+  S       (150.0)   (30.0)               BALTAY     66 HBC   +-  0.0 PBARP         6/66
W+  S       (150.0)   (30.0)               BALTAY     66 HBC   +-  0.0 PBARP         6/66
W+           146.      31.                 ALLES-BOR  67 HBC   +-  5.7 PBAR P       12/66
W+           130.      25.                 BARLOW     67 HBC   +-  1.2 PBAR P       11/66
W+           145.      10.                 FOSTER     68 HBC   +-  PBAR P AT REST    6/68
W+           . . . . . . . . . .
W+  AVG      143.2      8.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W-  CHARGE MINUS ONLY
W-     130  (125.0)                        GUIRAGOSS  63 HBC   -   3.3 PI-P
W-      98  (180.0)                        BONDAR     64 HBC   -   4.1 PI-P
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       (130.0)   (20.0)               HAGOPIAN2  66 HBC   -   2.14 PI-P         9/67
W-  R       (135.0)   (20.0)               HAGOPIAN2  66 HBC   -   2.14 PI-,TCUT12   9/67
W-  R 6014  (139.5)   (15.0)               JACOBS     66 HBC   -   2-3PI-            6/68
W-  R 2775  (137.1)   (20.0)               JACOBS     66 HBC   -   2-3PI-,T CUT 20   6/68
W-  R       (149.0)   (13.0)               WEST       66 HBC   -   2.1 PI- P        10/66
W-           100.0     30.0                BANNER     67 MMS   -   1.8 PI-P,  P+MM   9/67
W-  C 7666  (110.0)    (9.0)           ▷1 BATON      67 HBC   -   2.8 PI- P        10/67
W-           133.      11.                 EISNER     67 HBC   -   4.2 PI-P          9/67
W-  R       (137.0)   (17.0)               MILLER     67 HBC   -   2.7 PI-,T CUT 5   9/66
W-  R       (145.0)   (12.0)               MILLER     67 HBC   -   2.7 PI-,T CUT10   9/66
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-   12773   147.3      4.0        3.9 ▷4 PISUT      68 RVUE  -   1.7-3.2PI-,CT10   6/68
W-           151.0     10.0                REYNOLDS   69 HBC   -   2.26 PI- P        5/70
W-           . . . . . . . . . .
W-  AVG      145.7      3.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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           110.0     20.0                ALYEA      65 DBC    0 2.2 K- P           6/66
WO          (130.0)                        CLARK      65 OSPK   0 1.5 PI-P
WO  S        (80.0)   (15.0)               GUTAY      65 HBC    0 2.0 PI- P          6/66
WO            72.0     30.0                ACCENSI    66 HBC    0 5.7 PBARP          6/66
WO  R       (100.0)                        ALFF-STEI  66 HBC    0 2-3 PI+ P          6/66
WO  S       (174.)    (31.)                BALTAY     66 HBC    0 0.0 PBARP          6/66
WO  P       (175.0)                        CAMBRIDGE  66 HBC    0 5-6 GAM P          9/66
WO  S        (57.0)   (25.0)    (15.0)     CASON      66 HBC    0 7.0 PI- P          9/66
WO  R       (120.0)   (10.0)               HAGOPIAN1  66 HBC    0 3.0 PI- P          6/66
WO  R       (130.0)   (20.0)               HAGOPIAN2  66 HBC    0 2.14 PI-P          9/67
WO  R       (135.0)   (20.0)               HAGOPIAN2  66 HBC    0 2.14 PI-P,LOW T    9/67
WO  R 7760  (136.4)   (12.0)               JACOBS     66 HBC    0 2-3PI-             6/68
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           130.       5.                 ASBURY 2   67 CNTR   0 GAMMA + PB         8/67
WO  R       (148.0)    (8.0)               BACON      67 HBC    0 1.7 PI-P           9/67
WO            92.      42.                 BARLOW     67 HBC    0 1.2 PBAR P        11/66
WO     327   135.      25.                 DANYSZ     67 HBC    0 3.0 PB P,6 PI      7/67
WO  O  240   (80.)    (30.)                DANYSZ     67 HBC    0 3.0 PB P,7 PI      6/68
WO  O        SELECTION ON OMEGA
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          (135.0)   (10.0)               POIRIER    67 HBC    0 8.0 PI- P         11/67
WO           165.0     10.0                ABC COLL.  68 HBC    0 8 PI+P TO P+3PI    5/68
WO  R       (167.0)    (6.0)               ARMENISE   68 DBC    0 5.1 PI+D           6/68
WO           126.      20.                 BLECHSCHM  68 HBC    0 GAMMA P (BREMS)    6/68
WO           150.0     13.0                DONALD     68 HBC    0 1.2 PB P,4 PR.     9/68
WO           132.      10.                 FOSTER     68 HBC    0 PBAR P AT REST     6/68
WO    2250   145.0      9.0            ▷2 HYAMS      68 OSPK   011.2 PI- P          9/68
WO  S       (129.0)   (19.0)               JONES      68 OSPK   0 12PI-, T LT 2.5.  5/68
WO  S       (169.0)   (41.0)               JONES      68 OSPK   0 18PI-, T LT 2.5   5/68
WO  S       (175.0)   (30.0)               JONES      68 OSPK   0 18PI-,T2.5 TO 5   5/68
WO  S       (157.0)   (16.0)               JONES      68 OSPK   0 12PI-,T 5 TO 10   5/68
WO  S       (157.0)   (19.0)               JONES      68 OSPK   0 18PI-,T 5 TO 10   5/68
WO  S       (102.0)   (25.0)               JONES      68 OSPK   0 12PI-,T10 TO 15   5/68
WO  S       (157.0)   (31.0)               JONES      68 OSPK   0 18PI-,T10 TO 15   5/68
WO  S       (113.0)   (16.0)               KEY        68 HBC    0 3.0 PI- P          5/68
WO           111.       8.                 LAMSA      68 HBC    0 8.0 PI-P          11/67
WO  S       (160.0)   (10.0)               LANZEROTT  68 CNTR   0 GAMMA P            5/68
WO  C14890  (105.0)   (15.0)           ▷3 MARATECK   68 HBC    0 1.9-3.0 PI- P      9/68
WO           122.0      7.0        6.0 ▷8 ROOS       69 RVUE   0 E+E- COLL.BEAMS   9/69
WO  E       (111.0)    (6.0)               AUGUSTI1   69 OSPK   0 E+E- COLL.BEAMS   4/69
WO  L       (110.7)    (5.3)           ▷5 AUGUSTI2   69 OSPK   0 E+E- COLL.BEAMS   8/69
WO  L   SUPERSEDED BY LEFRANCOIS 71
WO           AUGUSTIN 2 TAKES ACCOUNT OF RHO-OMEGA INTERFERENCE, AND
WO           INCLUDES DATA OF AUGUSTIN 1.
WO  E       (105.0)   (20.0)           ▷6 AUSLENDER  69 OSPK   0 E+E- COLL.BEAMS   6/68
WO           SEE ALSO HAISSINSKI 69, WHO FITS AUSLENDER 69 DATA
WO  E       (140.)    (14.)                HAISSINSK  69 RVUE   0 E+E- COLL.BEAMS   9/69
WO  H        ABOVE VALUE FROM FIT TO AUSLENDER 68 DATA
WO           132.0     13.0            ▷7 MALAMUD    69 RVUE   0 2-4 PI-P           5/70
WO  S       (130.0)   (40.0)               MOTT       69 HBC    0 4.1-5.5 K- P       7/69
WO           127.0      7.0                REYNOLDS   69 HBC    0 2.26 PI- P         5/70
WO  C       (119.0)   (20.0)           ▷9 SCHAREN    69 HBC    0 2-4 PI- P          5/70
WO           140.0      5.0                ALVENSLEB  70 CNTR   0 GAMMA A(BREMS)     5/70
WO  C12630  (131.0)                    ▷1 BATON      70 HBC    0 2.8 PI- P          1/71
WO           132.0      6.0                BINGHAM    70 HBC    0 2.8 GAMMA P        5/70
WO           141.0      5.0                BINGHAM    70 HBC    0 4.7 GAMMA P        5/70
WO           146.1      2.9                BIGGS      70 CNTR   0PHOTOPRODUCTION     6/70
WO  S       (120.0)    (7.0)               GALLOWAY   70 HBC    0 5.97 PI- P         1/71
WO           149.      23.                 LEFRANCOI  71 OSPK   0 E+E- COLL.BEAMS   2/72*
WO           . . . . . . . . . .
WO  AVG      137.5      2.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

W   MIXED CHARGES
W      290  (110.0)                        CHADWICK   63 HBC  +-0 0.0 PBAR P
W             98.      30.                 FRENCH     67 HBC  +-0 3-4 PBAR P        6/67
W            154.0      6.0                JOHNSON    68 HBC   -0 3.7-4.2 PI- P     7/69
W            . . . . . . . . . .
W   AVG      151.8      5.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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W          ----------NOTES----------

W    C     FROM POLE EXTRAPOLATION
W    E     INCLUDED IN ROOS 69 RVUE
W    R     INCLUDED IN PISUT 68 RVUE
W    P     PHOTOPRODUCTION, UNCORRECTED (SEE NOTE P UNDER RHO MASS)
W    S     S-WAVE BREIT-WIGNER FIT, CANNOT BE COMBINED WITH OTHER VALUES

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                   9  RHO PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      RHO INTO 2PI                                  139+ 139
P2      RHO INTO 4PI                                  139+ 139+ 139+ 139
P3      RHO INTO PI GAMMA                             139+   0
P4      RHO INTO E+ E-                                 .5+  .5
P5      RHO INTO PI ETA (VIOLATES G)                  139+ 548
P6      RHO INTO MU+ MU-                              105+ 105
P7      RHO 0 INTO PI+ PI- PI0  (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- PI0) / (PI+- PI0)
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      RHO 0 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 H23
R2   M          ONE PION EXCHANGE MODEL USED IN THIS ESTIMATION

R3      RHO INTO(E+ E-)/(PI+PI-)    (UNITS 10**-4)          (P4)/(P1)
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Note on $\rho^0 \rightarrow e^+e^-$

Extraction of a ratio for $\rho^0 \rightarrow e^+e^-$ is complicated by interference with $\omega^0$ decay. In photoproduction, $\gamma A \rightarrow e^+e^-A$, there is substantial interference between the allowed $(\rho^0, \omega) \rightarrow e^+e^-$ decays. The interference in the colliding-beam reaction $e^+e^- \rightarrow \pi^+\pi^-$ is due to G parity violating mixing of the overlapping $\rho^0$ and $\omega$ resonances; it alters the results for the rate $\Gamma(\rho^0 \rightarrow e^+e^-)$ only by a small amount. Therefore we use at present, for the average, only the values from the $e^+e^- \rightarrow \pi^+\pi^-$ experiments.

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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   LE        (0.663)  (0.085)           AUGUSTI1  69 OSPK    E+E- COLLID.BEAM  4/69
R3   L     SUPERSEDED BY LEFRANCOIS 71
R3    E          ASSUMING RHO WIDTH 111MEV
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               0.40     0.05            LEFRANCOI 71 OSPK   0 E+E- COLL.BEAMS  2/72*
R3            . . . . . . . . . .
R3   AVG         0.420    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- PI0)/(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 PR 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+CCNY+COLUM+KENT)
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+(SAC+ORSAY+BARI+BOLO)
CHADWICK 63 PRL 10 62            CHADWICK,DAVIES,DERRICK,CRESTI +  (OXF+PAD)
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+IMP-COL+MPI)
CARMONY  64 DUBNA CONF 1 486     CARMONY,HOA,LANDER,NG.H.XUONG,YAGER   (UCSD)
GOLDHABE 64 PRL 12 336           GOLDHABER,BROWN,KADYK,SHEN,TRILLING(LRL+UC)

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                (FLORIDA)
LANZEROT 65 PRL 15 210           LANZEROTTI,BLUMENTHAL,EHN,FAISSLER +(HARVD)
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+ (COL+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)
HAGOPIA1 66 PR 145 1128          HAGOPIAN,SELOVE,ALITTI,BATON+ (PENN+SACLAY)
HAGOPIA2 66 PR  152  1183        HAGOPIAN,PAN     (PENNSYLVANIA,LRL-BERKELEY)
HUSON    66 PL 20 91             HUSON,ALLARD,DRIJARD,HENNESSY +  (ORSAY+EP)
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+TING+(DESY+COL)
ASBURY 2 67 PRL 19 865           +BECKER+BERTRAM+JOOS+JORDAN+TING+(DESY+COL)
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+CDF+IR+LIVERPOOL)
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+WALKER+(TO+ANL+WIS)
DANYSZ   67 NC 51 A 801          DANYSZ+FRENCH+SIMAK                   (CERN)
EISNER   67 PR 164 1699          +JOHNSON+KLEIN+PETERS+SAHNI+YEN+    (PURDUE)
FRENCH   67 NC 52A 442           +KINSON+MCDONALD+RIDDIFORD+      (CERN+BIRM)
HERTZBAC 67 PR 155  1461         HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
   (SEE ALSO ZDANIS 65)
HUWE     67 PL 24B 252           +MARQUIT+OPPENHEIMER+SCHULTZ+WILSON   (COL)
HYAMS    67 PL 24B 634           +KOCH+PELLETT+POTTER+VONLINDERN+ (CERN+MUN)
MILLER   67 PR 153 1423          MILLER,GUTAY,JOHNSON,LOEFFLER +     (PURDUE)
POIRIER  67 PR 163 1462          +BISWAS,CASON,DERADO,KENNEY+ (NOTRDAM+PENN)

ABC COLL 68 NP 84 501                    AACHEN+BERLIN+CERN COLLABORATION
ARMENISE 68 NC 54A 999           +GHIDINI,FORINO+ (BARI+BOLOGN+FIRENZ+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+MANCH)
  (SEE ALSO 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+PARIS)
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,DERADO+(ND+PURD+SLAC)
KEY      68 PR 166 1430          +PRENTICE+COOPER+MANNER+WALKER+(TO+ANL+WIS)
LAMSA    68 PR 166 1395          +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
LANZEROT 68 PR 166 1365          LANZEROTTI,BLUMENTHAL,EHN,FAISSLER +(HARVD)
MARATECK 68 PRL 21 1613          +HAGOPIAN,+  (PENN+LRL+COLO+PURO+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,+ (AMES+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+      (FLAS)
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  PREPRINT            BLOODWORTH,JACKSON,PRENTICE,YOON (TORONTO)
DEERY    71 PR D 3 635           +BISWAS,CASON,GROVES,JOHNSON,+ (NOTRE DAME)
DRIVER   71  DESY 71/56          +HEINLOTH,HOHNE,HOFMANN,JANATA,KAROW+(DESY)
EISENBER 71  SLAC-PUB-933        EISENBERG,HABER,BALLAM,CHADWICK+(REHO+STAN)
LEFRANCO 71  PREPRINT LAL1256    J.LEFRANCOIS                         (ORSAY)
PARROUR  71  PREPRINT LAL1257    G.PARROUR  (THESIS)                  (ORSAY)

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## ω(784)

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1  OMEGA (784,JPG=1--)  I=0
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                    1  OMEGA  MASS (MEV)

              HERE WE LIST ONLY EXPERIMENTS IN WHICH THE EFFECTS
              OF MASS RESOLUTION HAVE BEEN EVALUATED.

M    FROM K1-K1 MODE
M       64  779.4      1.4         ARMENTERO 62 HBC      0.0 PBAR P K1K1
M      155  779.5      1.5         BARASH    67 HBC      0.0 PBAR P K1K1 11/71*
M      510  781.0      0.6         BIZZARRI  71 HBC      0.0 P PBAR K1K1 11/71*
M           . . . . . . . . . .
M    AVG     780.60     0.52   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M    FROM OTHER THAN K1-K1 MODE.
M      400  782.0      1.0         ALFF      62 HBC      2.3-2.9 PI+P
M       34  784.0      1.0         ARMENTERO 63 HBC      0.0 PBAR P
M      220  781.0      2.0         KRAEMER   64 DBC      1.2 PI+D
M           785.6      1.2         MILLER D  65 HBC     SEEN WITH K+K-
M      666  786.0      1.0         JAMES     66 HBC      2.1 PI+P          6/66
M     2198  783.4      0.7         BALTAY    67 HBC     0.0 PBAR P         9/66
M           784.8      1.1         KEY       68 HBC      3 PI-P           11/67
M     2400  782.4      0.5         BIZZARRI  69 HBC      0 PBAR P          9/69
M      250  784.       1.          DANBURG   70 DBC      1.2 PI+ D        11/71*
M      500  786.       1.          DANBURG   70 DBC      1.4 PI+ D        11/71*
M      600  784.       1.          DANBURG   70 DBC      1.7 PI+ D        11/71*
M      500  786.       1.          DANBURG   70 DBC      1.9 PI+ D        11/71*
M      400  785.       1.          DANBURG   70 DBC      2.1 PI+ D        11/71*
M      200  785.       2.          DANBURG   70 DBC      2.3 PI+ D        11/71*
M      750  784.1      1.2         ABRAMOVIC 70 HBC      3.9 PI- P         6/70
M           784.0      0.7         ATHERTON  70 HBC     3.6 PBAR P, 7 PI   5/70
M           783.2      1.6         BIGGS     70 CNTR    PHOTOPRODUCTION    6/70
M      260  781.0      2.0         CASON     70 HBC      8.0 PI-P,4PI
M      248  783.4      1.0         BIZZARRI  71 HBC      0.0 P PBAR K+K- 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                                11/71*
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        2/71
M           . . . . . . . . . .
M    AVG     783.85     0.28   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                       (SEE IDEOGRAM BELOW )
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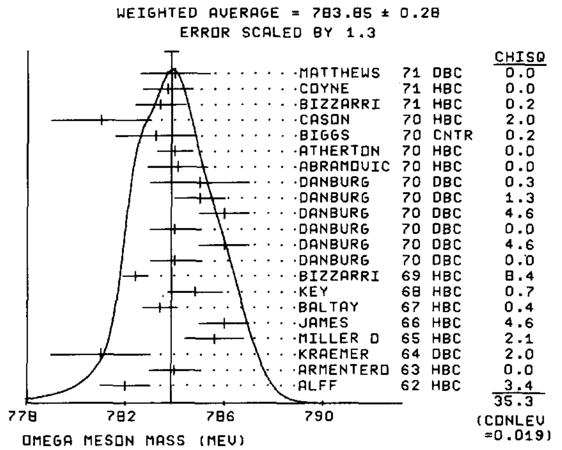


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                    1  OMEGA FULL WIDTH (MEV)

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      666  (20.0)  OR LESS        JAMES     66 HBC      2.1 PI+P         6/66
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   A        (16.2)     (3.2)      AUGUSTI1  69 OSPK    E+ E- COLL.BEAMS  2/72*
W   A   SUPERSEDED BY LEFRANCOIS 71                                       2/72*
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             9.2       1.0        LEFRANCOI 71 OSPK    E+E- COLL. BEAMS  2/72*
W           . . . . . . . . . .
W    AVG      9.98      0.56   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    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

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                    1  OMEGA  BRANCHING RATIOS
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### Note on the Branching Fractions of ω(784)

Note that the errors of the decay branching fractions in the Meson Table are different from their values below (under "FROM FIT"), the table values being more conservative. The FIT only takes into account the established decay modes $\pi^+\pi^-\pi^0$, $\pi^+\pi^-$, and neutrals, the latter defined as $\pi^0\gamma$. In the Meson Table we have also taken into account the upper limits, $L_i$ (one-standard-deviation values), on the $\eta\gamma$, $\pi^+\pi^-\gamma$, and $\pi^0\pi^0\gamma$ decays by treating them as if they were measurement results of value $0 \pm L_i$.

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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          . . . . . . . . . .
R1  AVG       0.1043     0.0091  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT       0.1004     0.0071 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2      OMEGA INTO (PI+ PI-)/(PI+ PI- PIO).  SEE ALSO R15 (PI)/(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           (0.0015)OR MORE CL=.95      HAGOPIAN  71 HBC      2.3 PI- P       1/71
R2          . . . . . . . . . .
R2  AVG       0.0263     0.0051  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT       0.0139     0.0029 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

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       29   0.078      0.029            LEFRANCOI 71 OSPK    E+E- COLL. BEAMS  2/72*
R3          . . . . . . . . . .
R3  AVG       0.087      0.015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  FIT       0.1004     0.0071 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           (0.16) OR LESS   CL=.90      LEFRANCOI 71 OSPK    E+E- COLL. BEAMS  2/72*

R8      OMEGA INTO(ETA PIO +ETA GAM)/(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       0.0990     0.0071 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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          (0.27) OR LESS   CL=.90      LEFRANCOI 71 OSPK    E+E- COLL. BEAMS  2/72*

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             BOLLINI 1 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 S        (0.76)    (0.14)             AUGUSTI1  69 OSPK     SEE NOTE E       2/72*
R13 S    SUPERSEDED BY LEFRANCOIS 71                                             2/72*
R13 E  FROM E+ E- COLLIDING BEAMS, ASSUMING OMEGA WIDTH 12.2+-1.3 MEV            4/69
R13           0.82       0.10             LEFRANCOI 71 OSPK    E+E- COLL. BEAMS  2/72*
R13         . . . . . . . . . .
R13 AVG       0.75       0.16    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
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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         . . . . . . . . .
R14 AVG       0.081     0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R14 FIT       0.0901    0.0058 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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)PARROUR    71 OSPK   0 E+E- COLL.BEAMS  2/72*
R15         . . . . . . . . .
R15 AVG       0.0100    0.0019  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
            FOR COMPILATIONS, SEE GOLDHABER 70 AND ROOS 70
R15         . . . . . . . . .
R15 FIT       0.0125    0.0026 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

R16    OMEGA INTO  (ETA GAMMA) / (ALL NEUTRALS)           (P6)/(P3+...)
R16          (0.24) OR LESS  CL=.90    DEINET     69 OSPK                         9/69
R16          (0.25) OR LESS  CL=.90    DAKIN      71 OSPK    1.4 PI- P,N MMO  11/71*

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      71 OSPK    1.4 PI- P,N MMO  11/71*
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      71 OSPK    1.4 PI- P,N MMO  11/71*
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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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 1 .897+-.006
P 2   -.325    .012+-.003
P 3   -.938      -.022    .090+-.005
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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+NW)
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+COLL+FRANCE)
STEVENSO 62 PR 125 687           STEVENSON,ALVAREZ,MAGLIC,ROSENFELD     (LRL)

ARMENTER 63 SIENA CONF 1 296     ARMENTEROS,EDWARDS,JACOBSEN+   (CERN+PARIS)
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+ (COLUM+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,FIELDS+ (JHU+NW+WOOD)

BINNIE   65 PL 18 348            BINNIE,DUANE,JANE,W JONES+ (IC-LOND+MANCHS)
GALTIERI 65 PRL 14 279           A BARBARO GALTIERI,R D TRIPP           (LRL)
MILLER D 65 CU-237(NEVIS 131)    DAVID C MILLER  (THESIS)          (COLUMBIA)
   MILLER 65 INCLUDES DATA OF    GELFAND 63 ABOVE
ZDANIS   65 PRL 14 721           ZDANIS,MADANSKY,KRAEMER,HERTZBACH+(JHU+BNL)

ALFF-STE 66 PR 145 1072          ALFF-STEINBERGER,BERLEY,BRUGGER+ (COL+RUTG)
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+    (PENNA)
HERTZBAC 67 PR 155, 1461         HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
   (SEE ALSO ZDANIS 65)

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+WALKER+(TO+ANL+WIS)
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+CDF)
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)
ANGELOW  70 YAD.FIZ. 12 788      +GRAMENITSKY,KANASIRSKY,KERATSCHEW,+ (JINR)
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)
BIZZARRI 70 PRL 25 1385          +CIAPETTI,DORE,GASPERO,GUIDONI,+ (ROMA+SYR)
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)
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+CDF)
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)
DAKIN    71 PL 36 B 607          +HAUSER,KREISLER,MISCHKE,RITSKO (PRINCETON)
FIELDS   71 PRL 27 1749          +COOPER,RHINES,ALLISON             (ANL+OXF)
HAGOPIAN 71  BAPS 16             S.HAGOPIAN                       (FSU+PENN)
LEFRANCO 71  PREPRINT LAL1256 J.LEFRANCOIS                           (ORSAY)
MATTHEWS 71 PRL 26 400           +PRENTICE,YOON,CARROLL,WALKER,+ (TNTO+WISC)
MOFFEIT  71 NP B 29 349          +BINGHAM,FRETTER,BALLAM+(LRL+UCB+SLAC+TUFT)
PARROUR  71  PREPRINT LAL1257 G.PARROUR  (THESIS)                    (ORSAY)
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## M(953)

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              59    M(953)   G=+1

                    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 X0    2/72*
M    M   MISSING MASS SPECTRUM SHOWED THIS PEAK AT 953.4 INSTEAD OF
M    M   ETA PRIM (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 X0    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                              765+   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


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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+CALTECH)

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 X0
                   (JP = 2- NOT YET EXCLUDED,)
                   (SEE NOTE ON QUANTUM NUMBERS AT END OF ETA
                    PRIME LISTINGS)

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              2    ETA PRIME MASS (MEV)

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            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         7  955.0     10.0             COHN      66 DBC      3.3 PI+D          6/66
M            959.0      3.0             LONDON    66 HBC      2.2 K-P           6/66
M            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 X0    11/71*
M       535  957.4      1.4             BASILE1   71 CNTR    1.6 PI- P,N X0    11/71*
M           . . . . . . . . .
M    AVG     957.09     0.57    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 X0   11/71*

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                    2   ETA PRIME PARTIAL DECAY MODES

                                                            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+ 765
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 APPROX.)
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+ 765
P19         ETA PRIME INTO  PIO OMEGA (VIOLATES C)         134+ 783

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                    2   ETA PRIME BRANCHING RATIOS
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### Note on $\eta'$ (958) Branching Fractions

In our calculation of the branching fractions of the $\eta'$ (958) we assume the decay modes $\eta\pi\pi$ (including $\eta\pi^0\pi^0$, 71% of the $\eta'$ 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, $R = 1.8 \pm 0.2$.

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R1          ETA PRIME INTO (PI+ PI- ETA (NEUTRAL DEC.))/TOTAL (P1N)
R1  K   68   (0.36)   (0.05)            KALBFLEIS 64 HBC       2.7 K-P          10/66
R1  K        KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
R1     281    0.314    0.026            RITTENBER 69 HBC       1.7-2.7 K-P       9/69
R1          . . . . . . . . .
R1  FIT       0.309    0.016  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2          ETA PRIME INTO (PI+ PI- NEUTRALS) / TOTAL     (P1N+P2C)
R2      33    0.35     0.06             BADIER     65 HBC      3.0 K-P          10/66
R2      39    0.4      0.1              LONDON     66 HBC      2.2 K-P          10/66
R2          . . . . . . . . .
R2  AVG       0.363    0.051   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT       0.380    0.014  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R3          ETA PRIME INTO (PI+ PI- ETA (CHRGD.DECAY))/TOTAL (P1C)
R3  K   44   (0.12)   (0.02)            KALBFLEIS 64 HBC       2.7 K-P          10/66
R3  K        KALBFLEISCH 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       0.1255   0.0063 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4          ETA PRIME INTO (PI+ PI- NEUTRALS (EXCLUDING  (P2C)
R4          PI+ PI- ETA (NEUTR.DEC.))) / TOTAL
R4  K   10   (0.05)   (0.04)            KALBFLEIS 64 HBC       2.7 K-P          10/66
R4  K        KALBFLEISCH 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       0.0713   0.0059 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5          ETA PRIME INTO (NEUTRALS) / TOTAL             (P2N+P4)
R5  K   54   (0.25)   (0.05)            KALBFLEIS 64 HBC       2.7 K-P          10/66
R5  K        KALBFLEISCH 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 X0   11/71*
R5          . . . . . . . . .
R5  AVG       0.190    0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  FIT       0.194    0.015  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                       (SEE IDEOGRAM BELOW )
```
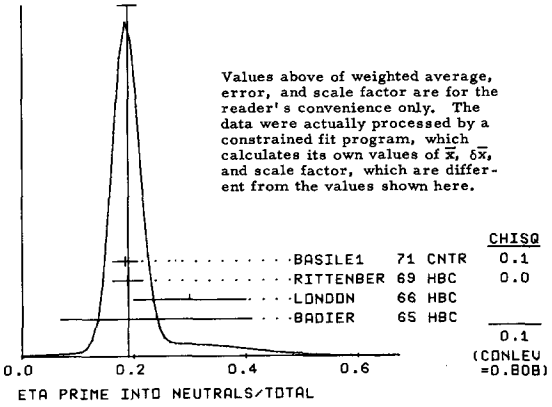

WEIGHTED AVERAGE = 0.190 ± 0.016
ERROR SCALED BY 1.0

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R6          ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL (P3)
R6  K   42   (0.22)   (0.04)            KALBFLEIS 64 HBC       2.7 K-P          10/66
R6  K        KALBFLEISCH 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       0.301    0.023  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
                       (SEE IDEOGRAM BELOW )
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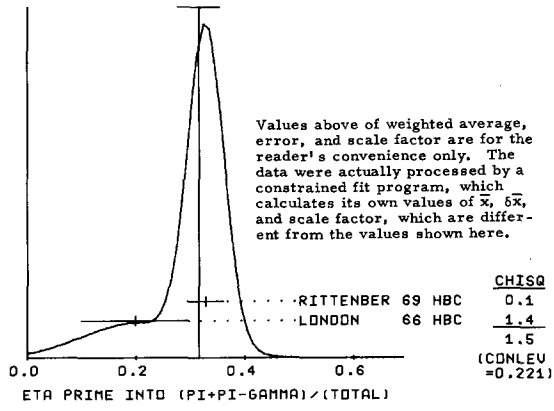
WEIGHTED AVERAGE = 0.316 ± 0.038
ERROR SCALED BY 1.2

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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       0.442    0.048  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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) /TOTAL             (P19)
R11           (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       0.442    0.048  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)
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R19          ETA PRIME INTO (2 GAMMA)/TOTAL                    (P4)
R19       5    0.055    0.036    0.030 BOLLINI    68 CNTR     1.9 PI- P          2/72*
R19       7    0.126    0.075          BENSINGER 70 DBC      2.2 PI+ D          1/71
R19      41    0.017    0.004          BASILE2   71 CNTR     1.6 PI- P,N X0    11/71*
R19      31    0.020    0.008    0.006 HARVEY    71 OSPK     3.65 PI- P,N X0   11/71*
R19          . . . . . . . . .
R19 AVG        0.0184   0.0035  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 FIT        0.0184   0.0036 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R20          ETA PRIME INTO (PI+PI-)/TOTAL                     (P11)
R20            (0.02) OR LESS          RITTENBER 69 HBC      1.7-2.7 K-P        9/69

R21          ETA PRIME INTO (PI+PI-PI0)/TOTAL                  (P12)
R21            (0.05) OR LESS          RITTENBER 69 HBC      1.7-2.7 K-P        9/69

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

R23          ETA PRIME INTO (PI+PI+PI-PI-PI0)/TOTAL            (P14)
R23            (0.01) OR LESS          RITTENBER 69 HBC      1.7-2.7 K-P

R24          ETA PRIME INTO (PI+PI+PI-PI- NEUTRALS)/TOTAL (PI6+...)
R24            (0.01) OR LESS          RITTENBER 69 HBC      1.7-2.7 K-P        9/69

R25          ETA PRIME INTO (RHO0 GAMMA)/(ALL PI+ PI- GAMMA) (P6)/(P3)
R25              0.94     0.20          AGUILAR   70 HBC      3.9-4.6K-P         1/71

R26          ETA PRIME INTO (PI0 PI0 ETA INTO 3 PI0)/TOTAL (P2N(3PI0))
R26       4    0.11     0.06          BENSINGER 70 DBC      2.2 PI+ D          1/71
R26          . . . . . . . . .
R26 FIT        0.0740   0.0061 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
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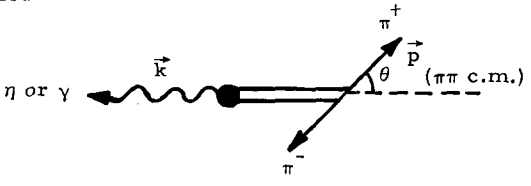
FITTED PARTIAL DECAY MODE BRANCHING FRACTIONS

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  .434+-.022
P 2   -.446    .247+-.020
P 3   -.585     -.452    .301+-.023
P 4    .028     -.208      .008    .018+-.003
```

## Note on Uncertainty in the $J^P$ Assignment of $\eta'(958)$

For the dominant (68%) $\pi\pi\eta$ decay mode of the $\eta'$, since the Dalitz plot population is rather flat (DAUBER 64, LONDON 66, RITTENBERG 69, DUFEY 69), and in particular does not vanish at the edges of the plot, the $J^P$ = Normal series may be ruled out.




In the notation of the sketch, any Normal matrix element would have a factor $\sin\theta$ and would thus go to zero at the edge of the Dalitz plot [C. Zemach, Phys. Rev. 133, B1201 (1964)].

Since $1^+$ is excluded by the observation of the $\gamma\gamma$ decay mode, this leaves us with $0^-$, $2^-$, $\cdots$ of the Abnormal series. Unfortunately, no information permits us at present to distinguish between $0^-$ and $2^-$ (OGIEVETSKY 71).

The $\pi\pi\eta$ decay mode (RITTENBERG 69, LONDON 66, DUFEY 69) is fitted better with $J^P = 0^-$ than with $J^P = 2^-$, but the latter cannot be excluded, either when comparing the simplest matrix elements with the Dalitz plot density distribution or when judging from the $\theta$-dependence or the $\eta$ energy dependence of the squared element (OGIEVETSKY 71).

Turning to the 30% mode $\eta' \to \pi^+\pi^-\gamma$, which RITTENBERG 69 has shown to be mainly $\rho^0\gamma$ decay, one gets a good fit with both $J^P = 0^-$ [$d\sigma/d(\cos\theta) \propto \sin^2\theta$] and $J^P = 2^-$ [$d\sigma/d(\cos\theta) \propto 6 + \sin^2\theta$] for the simplest possibility of pure M1 transition or, e.g., $d\sigma/d(\cos\theta) \propto 1.48 + \sin^2\theta$ from the matrix element with minimum momentum dependence (OGIEVETSKY 71), so no distinction is possible here.

Moreover, the possible existence of an additional resonance, M(953), which decays into $\pi\pi\gamma$ but not into $\rho^0\gamma$, makes a study of the $\pi\pi\gamma$ final state even more ambiguous.

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                                REFERENCES FOR ETA PRIME

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)
KALBFLEI  64 PRL 13 349         G.R.KALBFLEISCH,D.DAHL,A.RITTENBERG   (LRL)JP

BADIER    65 PL 17 337          BADIER,DEMOULIN,BARLOUTAUD +(PAR+SAC+ZEEMA)
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+UNCAR)
LONDON    66 PR 143 1034        LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)IJP

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)

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)

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)

                                PAPERS NOT REFERRED TO IN THE DATA CARDS

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+AMSTD+BOLOG+WEIZM+E.P.)I=0
DUFEY     69 PL 29 B 605        +GOBBI,POUCHON,CNDPS,+      (ETHZ+CERN+SACL)IJP
BARDADIN  71 PR D4 2711         BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)
OGIEVETS  71 PL 25 B 69         OGIEVETSKY,TYBOR,ZASLAVSKY            (DUBNA)
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## $\pi(950-1020)$

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36  PI (950-1020,JPG=0+-) I=1
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The I = 1 peaks in this region can be subdivided into three types:

1) Missing-mass peaks without information on the final state, except that $I \neq 0$ (e.g., the $\delta$-meson peak of KIENZLE 65).

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 the common entry "$\pi$(950-1020)," we tacitly imply that there is at present no experimental need to associate them with two different poles. More complete studies of the mass dependence of the $K\bar{K}$ threshold effect, using coupled channel analysis, are needed to clarify this question.

Note, however, two kinematic effects that can produce peaks in this region of the $\eta\pi$ mass:

a) In the reactions $K^-n \to \Lambda\pi^-$(MM) and $K^-p \to \Lambda\pi^+\pi^-$(MM) (studied by CRENNELL 69, MILLER 69) with selection of the missing mass (MM) in the $\eta(549)$ region, a spurious $\delta$ peak can arise from contamination with $\Lambda p^-\pi^0$ final states. This has been pointed out by CRENNELL 69.

b) In final states containing many pions [e.g., $2\pi^+2\pi^-\pi^0$, $(3\pi)^\pm\pi^0$], and with the $\omega$ copiously produced, the constraint of at least one $\eta$ combination in the $\pi^\pm\pi^+\pi^-\pi^0$ mass "fakes" a peak in the mass region around 960 MeV owing to reflections from the $\omega$. This remark (by YIOU 70) may apply to the observations of DEFOIX 68 and CAMPBELL 69, but not to BARDADIN 71, who takes it into account.

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                    36  PI(950-1020) MASS (MEV

M  SEEN IN MISSING MASS ONLY
M      262  962.0      5.0            KIENZLE   65 MMS   -  3-5 PI- P          9/66
M           966.0      8.0            OOSTENS   66 MMS  +  3.8 PP TO D + MM.  9/66
M           975.0      6.0            ABOLINS   70 MMS  +  3.8-6.3 PP--D+MM. 1/71
M           . . . . . . . .
M   AVG     967.1      4.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

M  ETA PI FINAL STATE ONLY.
M          (968.)     APPROX.         CHUNG S   68 HBC   -  3.2 PI-P           5/70
M          (975.0)                    DEFOIX    68 HBC  +-  1.2 PB P,ETA PI   3/69
M           970.0     15.0            BARNES    69 HBC   -  4-5 K-P,PI-ETA     9/69
M          (988.0)   (10.0)           MILLER    69 HBC   -  4.5 K-N,ETA PI     7/69
M           980.0     10.0            AMMAR     70 HBC  +- 4.1,5.5K-,ETA PI   5/70
M       21  948.0      7.0            BARDADIN  71 HBC  +- 8 PI+P,P DO PI     2/72*
M           . . . . . . . .
M   AVG     960.0     10.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

M  K KBAR ONLY
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

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                    36  PI(950-1020) WIDTH (MEV)

W  SEEN IN MISSING MASS ONLY
W      262   (5.0)  OR LESS           KIENZLE   65 MMS   -  3-5 PI- P          9/66
W           (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  ETA PI  FINAL STATE ONLY
W           (25.0)                    DEFOIX    68 HBC  +-  1.2 PB P,ETA PI   3/69
W           (50.0)  OR LESS           BARNES    69 HBC   -  4-5 K-P,PI-ETA     9/69
W           (60.0)   (30.0)           MILLER    69 HBC   -  4.5 K-N,ETA PI     7/69
W            80.0     30.0            AMMAR     70 HBC  +- 4.1,5.5K-,ETA PI   5/70
W       21   31.0     28.0            BARDADIN  71 HBC  +- 8 PI+P,P DO PI   . 2/72*
W           . . . . . . . .
W   AVG      53.8     24.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

W  K KBAR ONLY
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  PI(950-1020) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1        PI(950-1020) INTO 3 PI                          134+ 134+ 134
P2        PI(950-1020) INTO ETA PI                        548+ 134
P3        PI(950-1020) INTO RHO PI                        765+ 134
P4        PI(950-1020) INTI K KBAR                        493+ 497

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                    36  PI(950-1020) BRANCHING RATIOS

R1        CHARGED DELTA OF KIENZLE 65 INTO (1 CHARGED)/(3 OR MORE CHARGED)
R1           1.3       0.9       0.7  KIENZLE   65 MMS   -  3-5 PI- P          9/66

R2        PI(950-1020) INTO ETA PI/TOTAL                  (P2)
R2         SEEN                       BARNES    69 HBC   -  4-5 K-P,PI-ETA     9/69

R3        PI(950-1020) INTO (RHO PI)/(ETA PI)             (P3)/(P2)
R3           (0.25) OR LESS  CL=.70   AMMAR     70 HBC  +- 4.1,5.5K-,ETA PI   5/70

R4        PI(950-1020) INTO (K KBAR)/(ETA PI)             (P4)/(P2)
R4           (0.2)  OR LESS  CL=.70   AMMAR     70 HBC  +- 4.1,5.5K-,ETA PI   5/70
R4           (0.2)  OR MORE           ASTIER    67 HBC     0. PBAR P        . 9/67

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                    REFERENCES FOR PI(950-1020)

TURKOT    63 SIENNA CONF 1 561 +COLLINS,FUJII,KEMP+        (BNL+PITTSBURGH)

ARMENTER 65 PL 17 344          ARMENTEROS,EDWARDS,JACOBSEN +  (CERN+PARIS)
BARASH   65 PR  139 B  1659    +FRANZINI,KIRSCH,MILLER,STEINBERGER+(COLUM)
KIENZLE  65 PL  19  438        + MAGLIC,LEVRAT,LEFEBVRES +          (CERN)
ROSENFEL 65 OXFORD CONF 58     A H ROSENFELD                     (LRL--RVUE)

ALLEN D  66 PL 22  543         +GP FISHER,G GODDEN,L MARSHALL,SEARS (COLO)G=+
BALTAY   66 PR  142 B  932     +LACH,SANDWEISS,TAFT,YEH,STONEHILL+  (YALE)
FOCACCI  66 PRL  17  890       + KIENZLE,LEVRAT,MAGLIC,MARTIN       (CERN)
OOSTENS  66 PL  22  708        +CHAVANON,CROZON,TOCQUEVILLE    (SACLAY,CF)I=1

ALLISON  67 PL 25B 619         +CRUZ+    (OXF+MUN+BIRM+RUTH+GLASG+LON(IC))
ASTIER   67 PL  25 B  294      +MONTANET,BAUBILLIER,DUBOC+  (CDF+CERN+IDR)
  ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.
BAILLON  67 NC 50A 393         +EDWARDS+D.ANDLAU+ASTIER+    (CERN+CDF +IR)
BANNER 1 67 PL  25 B  300      +FAYOUX,HAMEL,ZSEMBERY,CHEZE+ (SACLAY+CAEN)
BANNER 2 67 PL 25 B 569        +CHEZE,HAMEL,MAREL,TEIGER,CROZON+(CDF+SACL)
BARLOW   67 NC  50 A  701      +MONTANET,D-ANDLAU+(CERN+CDF+IDR+LIVERPOOL)
CONFORTO 67 NP B3 469          CONFORTO,MARECHAL,MONTANET+(CERN+PARIS+LIV)

CHUNG S  68 PR 165 1491         +O.DAHL, J. KIRZ, D.H.MILLER          (LRL)
DEFOIX   68 PL 28 B 353        +RIVET,SIAUD,CONFORTO,SHIVELY(CDF+IPE+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+SYR)
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,+ (AMES+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,+ (AMES+COLO)

ABOLINS  70 PRL 25 469         +GRAVEN,MCCARTHY,G.SMITH,L.SMITH+ (LRL+UCD)
AMMAR    70 PR D 2 438         +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+OTTA+NAGOYA)
BARDADIN 71 PR D4 2711         BARDADIN-OTWINOWSKA,HOFMOKL,MICHEJDA+(WARS)

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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 STATISTICALLY
SIGNIFICANT EVIDENCE FOR THE PRE-1968 H-ENHANCE-
MENT THEREFORE REMAINS (BARBARO-GALTIERI 69).
HOWEVER, GOLDHABER 69 REPORT A NEW (PI+PI-PI0)
ENHANCEMENT AT ABOUT THE SAME MASS, M=1000 MEV,
SEEN UNDER CONDITIONS DIFFERENT FROM THOSE OF THE
EARLIER OBSERVATIONS.  OMITTED FROM TABLE.

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                    REFERENCES ON  H MESON

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   (OAK R.+UNIV.TENN)
ROSENFEL 67 RMP 39 1,APPENDIX  ROSENFELD,BARBARO-GALTIERI+(LRL+CERN+YALE)
ARMENISE 68 PL 26B 336         +GHIDINI,FORINO+ (BARI+BOLOGN+FIRENZ+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)

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## $S^*$

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                    3 S*  (1000,JPG=0++)I=0
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### S-wave $K\bar{K}$ Interactions in the Region 990-1200 MeV

Under this entry we list parameters of the $S^*$ pole in the $I^G(J^P)C = 0^+(0^+)+$ wave. For discussion, see the entry "S-wave $\pi\pi$ interactions," near the beginning of these Meson Data Card Listings.

Note that possible evidence of D-wave $\pi\pi$ interactions in the $S^*$ region is listed separately under $\eta_N(1080)$.

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3 S* (1000) MASS (MEV)

M (1000.0) APPROX BINGHAM 62 HLBC 6-18 PI-N
M (1000.0) APPROX BIGI 62 HBC 10.0 PI-P
M (1000.0) ERWIN 62 HBC 2.10 PI-P 10/66
M 30(1030.0) APPROX. BALTAY 64 HBC 3.7 PBAR P
M (1025.0) APPROX. BARMIN 64 HLBC 2.8 PI-P 6/66
M 20(1068.0) (10.0) CRENNELL 66 HBC 6.0 PI- P 6/66
M 120 SCATT.LENGTH FITS BETTER. HESS 66 HBC 1.6-4.2 PI- P 10/66
M 730(1079.0) (6.0) (5.0) BEUSCH 67 OSPK 5,7,12 PI-P 9/67
M 54(1030.) (10.) ALITTI 68 HBC,DBC 3.6-5.0 K- N 7/69
M (1046.0) (7.0) AGUILAR- 69 HBC 0.7,1.2 PBAR P 7/69
M AGUILAR 69 SEES INDICATION OF D-WAVE IN ETA(1060) REGION.
M H (1070.) (SEE NOTE (1)) HOANG 69 OSPK 4 PI-P,KS KS N 5/70
M H (1040.) (SEE NOTE (2)) HOANG 69 OSPK 4 PI-P,KS KS N 5/70
M H (1030.) (SEE NOTE (3)) HOANG 69 OSPK 4 PI-P,KS KS N 5/70
M H SCATTERING LENGTH FITS EQUALLY WELL. VALUES ARE (IN F) 5/70
M H +-(1.2 +0.3/-0.4),NO SIGNIFICANT IM PART (FOR 4 GEV/C DATA) 5/70
M H +-(1.0 +-0.3 ),NO SIGNIFICANT IM PART (FOR 5 GEV/C DATA) 5/70
M B (1112.) (SEE NOTE (1)) BEUSCH 70 OSPK 4,6 PI-P 5/70
M B (1053.) (SEE NOTE (2)) BEUSCH 70 OSPK 4,6 PI-P 5/70
M B SCATTERING LENGTH FITS ONLY WITH EFFECTIVE RANGE. VALUE (F) IS 5/70
M B +-(1.3 + 0.35 *I), WITH EFF.RANGE = 1.4 F.(NOTE THAT SCATT. 5/70
M LENGTH PLUS EFFECTIVE RANGE TERM ALWAYS SIMULATE RESONANCE IF
M RELATIVE SIGN CHOSEN NEGATIVE.)
M F (990.) APPROX. FLATTE 72 HBC 7. PI+ P 2/72*
M F EFFECTIVE RANGE PARAMETRIZATION WOULD FIT EQUALLY WELL 2/72*
M
M (1) FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 0. 5/70
M (2) FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 1. 5/70
M (3) FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 2. 5/70
M A
M A AVERAGING NOT MEANINGFUL

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3 S* (1000) WIDTH (MEV)

W 20 (80.0) (15.0) CRENNELL 66 HBC 6.0 PI-P 6/66
W (168.0) (21.0) (19.0) BEUSCH 67 OSPK 5,7,12 PI-P 9/67
W BEUSCH 67 ASSUME NO S WAVE SCATTERING LENGTH. WITH S WAVE THE WIDTH
W BECOMES NARROWER THAN QUOTED ABOVE.
W 54 (45.0) (35.0) (15.0) ALITTI 68 HBC,DBC 3.6-5.0 K- N 7/69
W (40.0) (20.0) AGUILAR- 69 HBC 0.7,1.2 PBAR P 7/69
W H (200.) (SEE NOTE (1)) HOANG 69 OSPK 4 PI-P,KS KS N 5/70
W H (160.) (SEE NOTE (2)) HOANG 69 OSPK 4 PI-P,KS KS N 5/70
W H (150.) (SEE NOTE (3)) HOANG 69 OSPK 4 PI-P,KS KS N 5/70
W H SCATTERING LENGTH FITS EQUALLY WELL. SEE UNDER MASS ABOVE. 5/70
W B (361.) (SEE NOTE (1)) BEUSCH 70 OSPK 4,6 PI-P 5/70
W B (208.) (SEE NOTE (2)) BEUSCH 70 OSPK 4,6 PI-P 5/70
W B SCATT. LENGTH WITH EFFECTIVE RANGE ALSO FITS. SEE UNDER MASS. 5/70
W
W (1) FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 0. 5/70
W (2) FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 1. 5/70
W (3) FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 2. 5/70
W A
W A AVERAGING NOT MEANINGFUL

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3 S* (1000) PARTIAL DECAY MODES

DECAY MASSES
P1 S* (1000) INTO KKBAR
P2 S* (1000) INTO PIPI

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3 S* (1000) BRANCHING RATIOS

R1 S* (1000) INTO (PI PI)/(K KBAR) (P2)/(P1)
R1 (2.5) OR LESS CL=.90 CRENNELL 66 HBC 7/66
R1 1.0 0.6 0.3 LAI 68 HBC 6 PI- P 11/68
R1 F 32K FIT OF FLATTE 72 MAKES THIS RATIO MEANING- 7. PI+P;DEL++2PI.
R1 F LESS BUT GIVES COUPLINGS G(PI-PI)/G(KBAR K)=2/5

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REFERENCES FOR S* (1000)

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 + (PARIS+EC POLY+CERN)
ERWIN 62 PRL 9 34 ERWIN,HOYER,MARCH,WALKER,WANGLER (WIS+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+CDF+IR+LIVERPOOL)
BEUSCH 67 PL 25 B 357 +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+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+CDF)
ALSO BARLOW 67
ALSO 69 NP B 14 195 M.AGUILAR-BENITEZ,J.BARLOW,+ (CERN+CDF)
HOANG 69 NC 61 A 325 T.F.HOANG (ANL)
HOANG 69 PR 184 1363 +EARTLY,PHELAN,ROBERTS,+ (ANL+ILL(CH)+NDAM)

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 (ETH+CERN)
HYAMS 70 PHILA.CONF.P.41 +KOCH,BEUSCH,+ (CERN+MUNI+ETH+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)
FLATTE 72 PL 38 B 232 +ALSTON-GARNJOST,BARBARO-GALTIERI,+ (LBL)

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## φ(1019)

4 PHI (1019,JPG=1-- ) I=0

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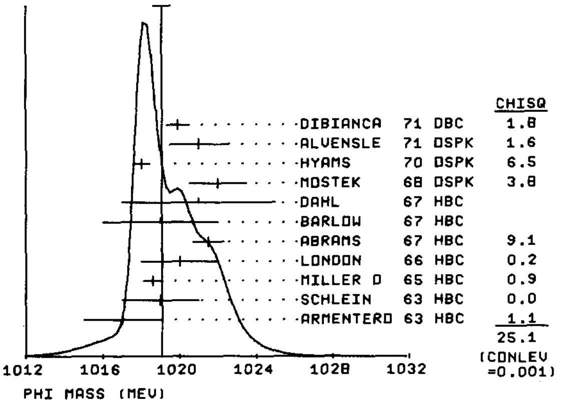
4 PHI MASS (MEV)

M 1017.0 2.0 ARMENTERO 63 HBC 0.0 PBAR P
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 (1020.) (1.) SABRE 70 DBC 3.0 K- N 1/71
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 87(1020.7) (0.8) SIDOROV 71 OSPK E+ E- COLL.BEAMS 2/72*
M 410(1019.9) (0.3) STOTTLEMY 71 HBC 2.9 K-P,Y K KBAR 11/71*
M . . . . . . . . . . .
M AVG 1019.09 0.45 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
(SEE IDEOGRAM BELOW )

WEIGHTED AVERAGE = 1019.09 ± 0.45
ERROR SCALED BY 1.8

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4 PHI WIDTH (MEV)

W 3.4 1.7 ARMENTERO 63 HBC 0.0 PBAR P
W 34 (5.0) OR LESS SCHLEIN 63 HBC 2.0 K-P
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 (10.) OR LESS BARLOW 67 HBC 1.2 PBAR P 11/66
W 165 (4.5) (3.0) (2.0) MOSTEK 68 OSPK 1.8 GAMMA + C 6/68
W A (4.09) (0.29) BIZOT 70 OSPK E+ E- COLL.BEAMS. 2/72*
W A SUPERSEDED BY LEFRANCOIS 71 2/72*
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 (4.7) (0.7) LEFRANCOI 71 OSPK E+E- COLL. BEAMS 2/72*
W 110 (4.5) (3.0) (4.0) STOTTLEMY 71 HBC 2.9 K-P,Y K KBAR 11/71*
W . . . . . . . . . . .
W AVG 4.39 0.34 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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4 PHI PARTIAL DECAY MODES

DECAY MASSES
P1 PHI INTO K+ K- 493+ 493
P2 PHI INTO KL KS 497+ 497
P3 PHI INTO PI+ PI- PIO (INCLUDING RHO PI) 139+ 139+ 134
P4 PHI INTO ETA GAMMA 548+ 0
P5 PHI INTO E+ E- .5+ .5
P6 PHI INTO MU+ MU- 105+ 105
P7 PHI INTO PIO GAMMA 134+ 0
P8 PHI INTO PI+ PI- (VIOLATES G) 139+ 139
P9 PHI INTO PI+PI-GAMMA 139+ 139+ 0
P10 PHI INTO OMEGA GAMMA (VIOLATES C) 783+ 0
P11 PHI INTO ETA PIO (VIOLATES C) 548+ 134
P12 PHI INTO RHO GAMMA (VIOLATES C) 765+ 0
P13 PHI INTO ETA NEUTRALS

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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 0.491 0.020 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

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 0.030 BALAKIN 71 OSPK E+ E- COLL.BEAMS 11/71*
R2 . . . . . . . . . . .
R2 AVG 0.308 0.069 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9)
R2 FIT 0.307 0.024 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.4)

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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        0.175     0.025   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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        0.384     0.024   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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        0.220     0.038   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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            . . . . . . . . . .
R7  FIT        0.57      0.11    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        (53.)   OR LESS             GALTIERI   65 HBC     2.7 K- P            10/66
R10         (7.4)  OR LESS             CHASE      67 CNTR      PHOTOPROD.         6/68
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)

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 A   10  (0.020)  (0.0075)          BENAKSAS   70 OSPK          E+ E-          2/72*
R11 A   SUPERSEDED BY LEFRANCOIS 71                                               2/72*
R11     19    0.021     0.0065         LEFRANCOI  71 OSPK    E+E- COLL. BEAMS     2/72*
R11     27    0.073     0.018          BASILE     72 CNTR    1.8 PI- P            1/72*
R11           . . . . . . . . . .
R11 AVG        0.027     0.017   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
R11 FIT        0.026     0.012   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.9)

R12        PHI INTO (PI+ PI- GAMMA)/(K KBAR)                  (P9)/(P1+P2)
R12         (0.05) OR LESS             LINDSEY    65 HBC       2.7 K-P           10/66

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           . . . . . . . . . .
R16 AVG        3.15      0.34    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

R17        PHI INTO (PIO GAMMA)/(TOTAL)                       (P7)
R17          (.0035)OR LESS            BEMPORAD   69 CNTR     5.5 GAMMA N         7/69
R17 A       (0.0024)OR LESS CL=.95     BENAKSAS   70 OSPK          E+ E-          2/72*
R17 A     SUPERSEDED BY LEFRANCOIS 71                                             2/72*
R17      6   (.0025)  (.0009)          LEFRANCOI  71 OSPK    E+E- COLL. BEAMS     2/72*

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*
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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 | .491+-.020 | | | |
| P 2 | -.346 | .307+-.024 | | |
| P 3 | -.447 | -.570 | .175+-.025 | |
| P 4 | -.079 | -.211 | -.204 | .026+-.012 |

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REFERENCES FOR PHI


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BERTANZA 62 PRL 9 180          BERTANZA,BRISSON,CONNOLLY,HART +  (BNL+SYR)
ARMENTER 63 SIENA CONF 2 70    ARMENTEROS,EDWARDS,ASTIER+ (CERN+CDF-PARIS)
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+ (PAR+LPCHE+ZEE)
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 +     (SYR+ROME)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+CDF+IR+LIVERPOOL)
CHASE    67 PRL 18 710         R.C.CHASE,P.ROTHWELL,R.WEINSTEIN(CEA+NEAST)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                (LRL)
HERTZBAC 67 PR 155  1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
KHACHATU 67 PL 24B 349         KHACHATURYAN+AZIMOV+BALDIN+BELOUSOV+(DUBNA)

ABRAMS   68 PR 175 1697        +GLASSER,KEHOE,SECHI-ZORN,WOLSKY (MARYLAND)
ASTVACAT 68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
    ALSO 67 PRL 19 869         ASBURY,BECKER,BERTRAM,TING+ (DESY+COLUMBIA)
BECKER   68 PRL 21 1504        +BERTRAM,BINKLEY,JORDAN,KNASEL+  (DESY+MIT)
BINNIE   68 PL 27B 106         +DUANE+FARUQI+HORSEY+      (I.C.LON+RUTHERF)
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)

BALAKIN  69  IYAF 327 TRANS    +BUDKER,KORSHUNOV,MISHNEV,SIDOROV+   (NOVO)
   SEE ALSO SIDOROV 69
BEMPORAD 69 PL 29 B 383        +BRACCINI,CASTALDI,LUBELSMEYER,+(PISA+BONN)
MOY      69  THESIS            KEN MIN MOY       (NORTH-EASTERN UNIVERSITY)
SCOTTER  69 NC 62 A 1057       +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)
SIDOROV  69 LIVERPOOL SYMP.ON ELECTRONS+PHOTONS,P.227, SIDOROV      (NOVO)

BALAKIN  70  PREPRINT          +BUTLER,PAKHTUSOVA,SIDOROV,SKRINSKY,+(NOVO)
BENAKSAS 70  LAL 1240          +COSME,JEAN-MARIE,JULLIAN,LAPLANCHE+ (ORSA)
BIZOT    70 PL 32 416          +BUON,CHATELUS,JEANJEAN,LALANNE,+    (ORSA)
   SEE ALSO 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)
SABRE    70  PREPRINT          SABRE COLLABOR.  (SACLOAMST+BGNA+REHO+EPOL)

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,+      (PITT)
CHATELUS 71  LAL 1247(THESIS) Y.CHATELUS                     (STRASBOURG)
HAYES    71 PR D 4 899         +IMLAY,JOSEPH,KEIZER,STEIN           (CORN)
LEFRANCO 71  PREPRINT LAL1256 J.LEFRANCOIS                         (ORSAY)
SIDOROV  71  CORNELL SYMPOS.   V.A.SIDOROV                    (NOVOSIBIRSK)
STOTTLEM 71  THESIS            A.R.STOTTLEMYER                   (MARYLAND)

ALVENSLE 72 PRL 28 66          ALVENSLEBEN,BECKER,BIGGS,BINKLEY+(MIT+DESY)
BASILE   72  SUBM. TO PL       +DALPIAZ,FRABETTI,ZICHICHI+(CERN+BGNA+STRB)
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## $A_1$(1070)

10  A1 MESON (1070, JPG=1+-)  I=1

The $A_1$(1070) peak has been mainly observed in "elastic" forward production without quantum number exchange. There are also observations of structure in the $A_1$ mass region in "inelastic" reactions with production of additional mesons, and in backward production from pions (see Data Card Listings). The indications for $A_1$ production in charge exchange reactions, or in $\bar{p}p$ annihilation, are not significant. 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 (ASCOLI 71); there may be additional narrower structure of unknown $J^P$ on top of it. The width is hard to define as it is not clear what part of the structure, if any, is resonant. The broad enhancement can apparently be reproduced (also for backward production) in Reggeized exchange models (BERGER 71), i.e., by what is known as the Deck effect. A knowledge of the relative phases of the three-pion partial waves as a function of the mass is obviously required before one can decide whether or not there is a resonance in this region.

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                    10  A1 MESON  MASS (MEV)

M       MASS AND WIDTH MIGHT HAVE LARGE SYSTEMATIC
M       ERRORS DUE TO COMPLICATED BEHAVIOR OF BACKGROUND.

M   PRODUCED BY PIONS, RESONANCE INTERP. CONFUSED BY DECK EFFECT
M
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
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                                                                            .
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 MESON  WIDTH (MEV)

W       SEE NOTE UNDER A1 MESON MASS.

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
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
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 MEANINGFULL

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                    10  A1 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      A1 INTO RHO PI                                   765+ 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

ADERHOLZ 64 PL 10 226          AACH+BERL+BIRM+BONN+DESY+HAMB+IMP.COL+ MPI
DEUTSCHM 66 PL 20 82           DEUTSCHMANN,STEINBERG +  (AACH+BERLIN+CERN)

ALLISON  67 PL 25B 619         +CRUZ+    (OXF+MUN+BIRM+RUTH+GLASG+LOV(IC))
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)

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+MIL+SACL)
CHUNG    68 PR 165 1491        S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER     (LRL)
FRIDMAN  68 PR 167 1268        +MAURER,MICHALON,OUDET+(HEIDELB+STRASBOURG)
JUNKMANN 68 NP B8 471          +COCCONI+          (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430        +PRENTICE+COOPER+MANNER+WALKER+(TO+ANL+WIS)

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)
JUHALA   69 PR 184  1461       +LEACOCK,RHODE,KOPELMAN,LIBBY,+ (AMES+COLO)

ARMENISE 70 LNC 4  199         +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
CASO     70 LNC 3  707         +CORDS,COSTA,DARO+(GENO+DESY+HAM+MILA+SACL)
    ALSO CASO 68
CRENNELL 70 PRL 24 781         +KARSHON,LAI,SCARR,SIMS                (BNL)
RABIN    70 PRL 24 925         +GALTIERI,DERENZO,FLATTE,FRIEDMAN+     (LRL)
SHIH     70  BNL 14059-REV     +YOUNG                                 (BNL)

BUHL     71  PREPRINT          +CLINE,TERREL                   (WISCONSIN)
RINAUDO  71 NC 5 A 239         +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP

                               PAPERS NOT REFERRED TO IN DATA CARDS

BELLINI  63 NC 29 896          BELLINI,FIORINI,HERZ,NEGRI,RATTI     (MILAN)
GOLDHABE 64 PRL 12 336         GOLDHABER,BROWN,KADYK,SHEN,TRILLING(LRL+UC)
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+       (SAC+BOL)
ALLARD   66 NC 46A 737         +DRIJARD+HENNESSY+   (ORSAY+MILAN+SAC+BERK)
HESS     66 UCRL-16832         R I HESS (THESIS, BERKELEY)            (LRL)
SLATTERY 67 NC 50A 377         +KRAYBILL+FORMAN+FERBEL          (YALE+ROCH)  JP
ARMENISE 68 PL 26 B  336       +FORINO+CARTACCI+     (BARI+BOL+FIR+ORSAY)
CNOPS    68 PRL 21 1609        +HOUGH,COHN,BUGG+ (BNL+ORNL+ORUC+TENN+PENN)
DONALD   69 NP B 11 551        +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)
FAYOLLE  69 NP B 13 40         +DE MONTAIGNAC,MORAND,STRACHMAN+     (PARIS)
KENYON   69 PRL 23 146         +KINSON,SCARR,+                 (BNL+ORUC+ORNL)
CHIEN2   70  JHU 7011          C.Y.CHIEN                      (JOHNS HOPKINS)
CHIEN1   70  TORONTO PREPRINT  +CHAO,JOHNSTON,PRENTICE,WALKER   (TOR+WISC)
BRANDENB 70 NP B16 369         +BRENNER,IOFFREDO,JOHNSON,KIM+     (HARVARD)
GARELICK 70 PHILAD.CONF.P.205  D.A.GARELICK,REVIEW            (NORTHEASTERN)
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)
LAMSA    71  PREPRINT          +EZELL,GAIDOS,WILLMANN                (PURD)  JP

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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 $\pi^+$, 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+NDAME+SLAC)
WHITEHEA 68 NC 53 A 817        C.WHITEHEAD +      (HARWELL+STHAMPT+U.C.LON)

OH       69 PRL 23 331         +WALKER,CARROLL,FIREBAUGH,+     (WISC+TNTO)
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BATON    70 PL 33 B 528        +LAURENS,REIGNIER                   (SACLAY)
DIAZ     70 NP B 16 239        +GAVILLET,LABROSSE,MONTANET+     (CERN+CDEF)
CLAYTON  70 NP B 22 85         +MASON,MUIRHEAD,RIGOPOULOS,+     (LIVP+ATEN)
OH       70 PR D 1 2494        +GARFINKEL,MORSE,WALKER,PRENTICE(WISC+TNTO)
REYNOLDS 70 NP B 21 77         +ALBRIGHT,BRADLEY,+   (ATHO+FLAS+MINN+COLO)
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## $A_{1.5}$(1170)

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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  ON  A 1.5 (1170)
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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)
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## B(1235)

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11  B MESON (1235,JPG=1++) I=1

JP=1+ PREFERRED, 2+,3-,.. IMPROBABLE (ASCOLI 68,
WERBROUCK 70).

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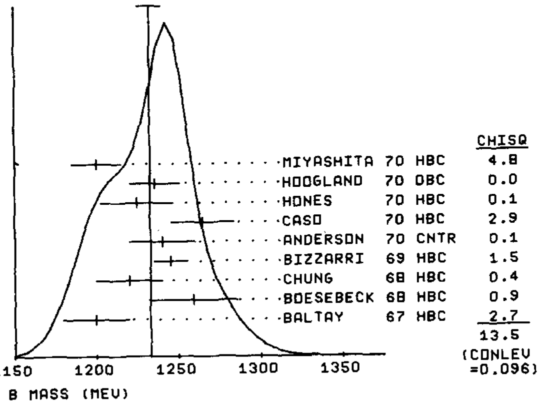
                     11  B MESON  MASS (MEV)

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     IN THE 3-4 PI-P DATA,THE B ENHANCEMENT MAY BE DECK EFFECT (CHUNG 68)
M      300 1245.      10.           BIZZARRI  69 HBC  +-  0 PBAR P        9/69
M   B       OVERLAPPING B-MESON BANDS TAKEN INTO ACCOUNT BY BIZZARRI
M          1240.0     20.0          ANDERSON  70 CNTR   0 5-18 GAMMA P   11/70
M          1265.0     19.0          CASO      70 HBC  - 11.2PI-P          5/70
M        (1272.0)   (15.0)          CASON     70 HBC  -   8.0 PI-P,4PI
M          1200.0   (10.0)          EROFEEV   70 HBC  -   3.25 PI- P      1/71
M          1225.0     22.0          HONES     70 HBC  +  18.5 PI+ P      11/70
M          1236.0     15.0          HOOGLAND  70 DBC  -   3.0 K- D        2/71
M          1200.0     15.0          MIYASHITA 70 HBC  -   6.7 PI-P,4PI
M   P    (1230.)    (10.)           POLS      70 HBC  +  5. PI+ P        11/71*
M   P   HANDDRAWN BACKGROUND.ERRORS STATISTICAL ONLY.                    11/71*
M          . . . . . . . . .
M   AVG    1232.9      7.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                           (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 1232.9 ± 7.2
ERROR SCALED BY 1.3

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                     11  B MESON  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      300   83.        12.         BIZZARRI  69 HBC  +-  0 PBAR P        9/69
W   B       OVERLAPPING B-MESON BANDS TAKEN INTO ACCOUNT BY BIZZARRI
W          (100.0)   APPROX.        ANDERSON  70 CNTR   0 5-18+GAMMA P   11/70
W          (150.0)                  CASO      70 HBC  - 11.2PI-P          5/70
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   AVG     104.4       9.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                           (SEE IDEOGRAM BELOW )
```
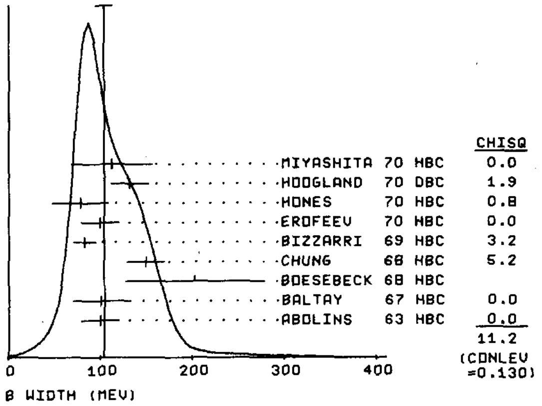

WEIGHTED AVERAGE = 104.4 ± 9.0
ERROR SCALED BY 1.3

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                 11  B MESON PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      B MESON INTO OMEGA+PI                            783+ 139
P2      B MESON INTO 2PI+ 2PI-                           139+ 139+ 139+ 139
P3      B MESON INTO K KBAR                              493+ 493
P4      B MESON INTO PI PI                               139+ 139
P5      B MESON INTO PI PHI                              134+1019
P6      B MESON INTO ETA PI (FORBIDDEN BY G)             548+ 139
P7      B MESON INTO K KBAR PI                           493+ 493+ 139

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                 11  B MESON  BRANCHING RATIOS

R1      B INTO  4PI/(OMEGA PI)                          (P2)/(P1)
R1           (0.5)  OR LESS           ABOLINS   63 HBC  +   3.5 PI+P

R2      B MESON 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 MESON INTO (PI PI)/(PI OMEGA)                 (P4)/(P1)
R3           (0.3)  OR LESS           ADERHOLZ  64 HBC      4.0 PI+P       7/66

R4      B MESON 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 MESON INTO (ETA PI) / (PI OMEGA)              (P6)/(P1)
R5           (0.25) OR LESS  CL=.90   BALTAY    67 HBC  +- 0.0 PBAR P      2/67

R6      B+- INTO ((K KBAR)+- PI0) / (PI OMEGA)
R6           (0.08) OR LESS  CL=.90   BALTAY    67 HBC  +- 0.0 PBAR P      2/67

R6      B+- INTO (KS KS PI+-) / (PI OMEGA)
R6           (0.02) OR LESS  CL=.90   BALTAY    67 HBC  +- 0.0 PBA- P      2/67

R6      B+- INTO (KS KL PI+-) / (PI OMEGA)
R6           (0.06) OR LESS  CL=.90   BALTAY    67 HBC  +- 0.0 PBAR P      2/67

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                     REFERENCES FOR B MESON
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ABOLINS  63 PRL 11 381         ABOLINS,LANDER,MEHLHOP,XUONG,YAGER    (UCSD)
ADERHOLZ 64 PL 10 240          AACHEN+BERLIN+BIRM+BONN+HAMBUR+IC-LOND+MPI
GOLDHABE 65 PRL 15 118         G GOLDHABER,S GOLDHABER,KADYK,SHEN     (LRL)

BALTAY   67 PRL 18 93          +SEVERIENS+YEH+ZANELLO             (COL+BNL)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                (LRL)
LEE      67 PR 159 1156        +MOEBS,ROE,SINCLAIR,VANDERVELDE (MICHIGAN)

BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983        +CONTE+CORDS+DIAZ+    (GENOVA+HAMB+MIL+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+CDF)

ANDERSON 70 PR D 1 27          +GUSTAVSON,JOHNSON,+  (SLAC+CALT+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 YAD.FIZ. 11 805    +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)

                               PAPERS NOT REFERRED TO IN THE DATA CARDS

BONDAR   63 PL 5 209           BONDAR,DODO+ (AACHEN+BIRM+HAMB+IC-LOND+MPI)
CARMONY  64 PRL 12 254         CARMONY,LANDER,RINDFLEISCH,XUONG,YAGER (UC) JP
BALLAM   67 HEIDBG CONF P.33   +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)
SLATTERY 67 NC 50A 377         +KRAYBILL+FORMAN+FERBEL         (YALE+ROCH)
ASCOLI   68 PRL 20 1411        +CRAWLEY,MORTARA,SHAPIRO           (URBANA)  JP
WERBROUC 70 LNC 4 1267         WERBROUCK,RINAUDO,+    (TORI+NIJM+BONN+LBL)JP
BUHL     71  PREPRINT          +CLINE,TERREL                   (WISCONSIN)
DEVONS   71 PRL 27 1614        +KOZLOWSKI,HORWITZ,+              (COLU+SYR)
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## f(1260)

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5 F (1260,JPG=2++) I=0
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                    5  F   MASS (MEV)

M          1240.0     20.0              ACCENSI   66 HBC     5.7 PBAR P         6/66
M     1416 1267.0     10.0              JACOBS    66 HBC    2-3 PI-P,T CUT20  10/67
M         (1255.)    (13.)              BARLOW    67 HBC   (K01 K01 MODE)    .11/66
M          1276.      11.               RABIN     67 HBC    8.5 PI+ P          9/67
M          1261.       4.               ARMENISE  68 DBC    5.1 PI+N,P PI+ -   6/68
M          1270.       5.               ARMENISE  68 DBC    5.1 PI+N,P PI0 0   6/68
M          1265.       8.               BOESEBECK 68 HBC    8 PI+ P            6/68
M          1267.      15.               LAMSA     68 HBC    8 PI-P            10/67
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          1270.0     15.0              WHITEHEAD 68 ASPK    3.2 PI-P,PI+PI-N  6/68
M      161 1269.0     21.0              ARMENISE  69 DBC     5.1 PI+D,3PI++-   5/70
M          1255.0     10.0              DONALD    69 HBC     1.2 PB P,2PI      8/69
M         (1270.0)                      CASO      69 HBC     11. PI- P,N2PI    8/69
M          1265.      16.               AGUILAR   70 HBC     3.9-4.6 K- P      1/71
M          1275.0     13.0              ARMENISE  70 HBC   0 9 PI+ N -- F P    1/71
M          1273.0      7.0              ARMENISE  70 HBC   0 9 PI+ N -- MM P   1/71
M     C    1277.      16.               EISENSTE  70 DBC     4.2 PI+ N         1/71
M     C    INCLUDES 14 MEV SYSTEMATIC ERROR ESTIMATED FROM RHO MASS SHIFT
M      600 1275.0     10.0              OH        70 HBC    1.26 PI- P,P F     1/71
M          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          . . . . . . . . . . .
M   AVG    1269.2      1.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    5  F   WIDTH (MEV)

W           100.0     25.0              SELOVE    62 HBC     3.0 PI-P
W           102.0     46.0              ACCENSI   66 HBC     5.7 PBAR P        6/66
W     1416   99.0     10.0              JACOBS    66 HBC    2-3 PI-P,T CUT20 10/67
W           (82.)    (34.)              BARLOW    67 HBC   (K01 K01 MODE)   .11/66
W           155.      17.               RABIN     67 HBC    8.5 PI+ P         9/67
W           216.      13.               ARMENISE  68 DBC    5.1 PI+N,P PI+ -  6/68
W           188.      15.               ARMENISE  68 DBC    5.1 PI+N,P PI0 0  6/68
W           128.      23.               BOESEBECK 68 HBC    8 PI+ P           6/68
W           172.      49.               FOSTER    68 HBC    PBAR P AT REST    6/68
W           113.      30.               LAMSA     68 HBC    8 PI-P           10/67
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           160.0     20.0              WHITEHEAD 68 ASPK   3.2 PI-P,PI+PI-N  6/68
W      161  216.0     60.0              ARMENISE  69 DBC     5.1 PI+D,3PI++-  5/70
W           150.0     30.0              DONALD    69 HBC     1.2 PB P,2PI     8/69
W           141.      35.               AGUILAR   70 HBC     3.9-4.6 K- P     1/71
W           131.0     25.0              ARMENISE  70 HBC   0 9 PI+ N -- MM P  1/71
W           173.0     11.0              ARMENISE  70 HBC   0 9 PI+ N -- F P   1/71
W      600  120.0     15.0              OH        70 HBC    1.26 PI- P,P F    1/71
W           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          . . . . . . . . . . .
W   AVG     156.4      9.2      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
                               (SEE IDEOGRAM BELOW )
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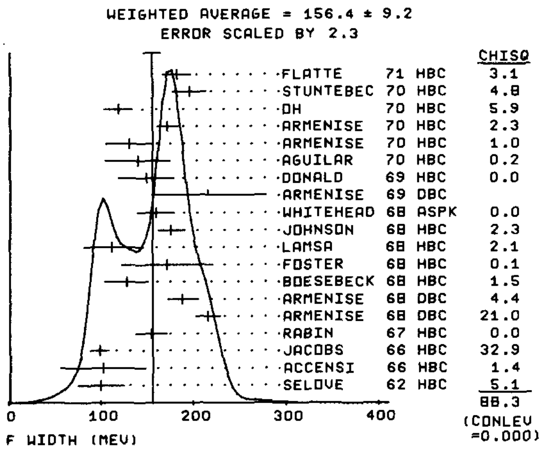


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                    5  F   PARTIAL DECAY MODES

                                                            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

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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     250     0.85      0.05              BEAUPRE   70 HBC    08 PI+ P,DELTA++F  1/71
R10     600     0.8       0.04              OH        70 HBC    01.26 PI- P,P F    1/71
R10           . . . . . . . . . . .
R10 AVG         0.820     0.031    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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     600      0.07      0.02              OH        70 HBC    1.26 PI- P,P F   1/71
R1            . . . . . . . . . . .
R1  AVG         0.061     0.015    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-           10/66
R2              0.00      0.16              WANGLER   65 HBC     3.0 PI-P
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     600      0.06      0.02              OH        70 HBC    1.26 PI- P,P F     1/71
R2             (0.13)    (0.05)             BISWAS    71 HBC    18.5 PI+- P       11/71*
R2            . . . . . . . . . . .
R2  AVG         0.056     0.019    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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REFERENCES FOR F


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SELOVE   62 PRL 9 272            SELOVE,HAGOPIAN,BRODY,BAKER,LEBOY   (PENNA)
BONDAR   63 PL 5 153             BONDAR+ (AACHEN+BIRM+BONN+DESY+IC-LOND+MPI)
GUIRAGOS 63 PRL 11 85            Z.G.T. GUIRAGOSSIAN                   (LRL)
HAGOPIAN 63 PRL 10 533           V HAGOPIAN,W SELOVE                 (PENNA)
VEILLET  63 PRL 10 29            VEILLET,HENNESSY,BINGHAM,BLOCH+ (PAR+MILAN)

ADERHOLZ 64 PL 10 240            AACHEN+BERLIN+BIRM+BONN+HAMBUR+IC-LOND+MPI  IJ
BRUYANT  64 PL 10 232            BRUYANT,GOLDBERG,HOLDER,FLEURY,HUC(CERN+PA) I
LEE      64 PRL 12 342           LEE,ROE,SINCLAIR,VANDERVELDE     (MICHIGAN)
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+CDF+IR+LIVERPOOL)
BEUSCH   67 PL 25 B 357          +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+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+ (NOTRDAM+PENN)
RABIN    67 THESIS               M. RABIN                          (RUTGERS)

ARMENISE 68 NC 54 A 999          +FORINO+CARTACCI+(BARI+BOLOG+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+PARIS)
JOHNSON  68 PR 176 1651          +POIRIER,BISWAS,GUTAY,DERADO+(ND+PURD+SLAC)
    ALSO BONDAR 63, LEE 64, DERADO 65, EISNER 67
LAMSA    68 PR 166 1395          +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
    ALSO POIRIER 67
WHITEHEA 68 NC 53A 817           +MCEWEN,OTT,AITKEN+   (AERE+SHAMPT+UC.LOND)

ADERHOLZ 69 NP B 11 259          +BARTSCH,+          (AACH+BERL+CERN+KRAK+WARS)
AGUILAR- 69 PL 29 B  241         M.AGUILAR-BENITEZ,J.BARLOW,+     (CERN+CDF)
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+SYR)
ARMENISE 70 LNC 4  199           +GHIDINI,FORING,CARTACCI,+ (BARI+BGNA+FIRZ)
BADIER   70 NP B 22 512          +BONNET,DREVILLON,BAUBILLIER,+  (EPOL+IPNP)
BEAUPRE  70  CERN PHYS 70 42     +DEUTSCHMANN,GRAESSLER,+    (AACH+BERL+CERNJ)
EISENSTE 70  COO 1195 194        EISENSTEIN,GORDON                     (ILL)
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  J)
BISWAS   71  PREPRINT            +CASON,HARRINGTON,KENNEY,SHEPHARD    (NDAM)
FARBER   71 NP B 29 237          +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
FLATTE   71 PL 34 B 551          +ALSTON-GARNJOST,BARBARO-GALTIERI,+   (LBL)
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## D(1285)

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8 D MESON (1285,JPG=  +) I=0

(JP=0-,1+,2- WITH 1+ FAVORED.)

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                    8  D MESON  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          . . . . . . . . . . .
M   AVG     1285.7      3.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                               (SEE IDEOGRAM BELOW )

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                    8  D MESON 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  RESOLUTION NOT UNFOLDED                                                11/71*
W          . . . . . . . . . . .
W   AVG       20.6      9.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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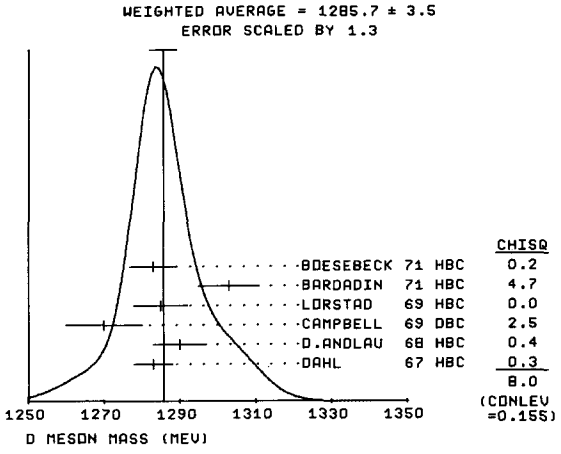


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                    8   D MESON PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          D MESON INTO K KBAR PI                      497+ 497+ 134
P2          D MESON INTO PI PI RHO                      134+ 134+ 765
P3          D MESON INTO ETA PI PI                      548+ 134+ 134
P4          D MESON INTO PI(975) PI                     975+ 134
P5          D MESON INTO 2PI+ 2PI-                      139+ 139+ 139+ 139
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                    8  D MESON BRANCHING RATIOS

R1          D MESON 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 MESON INTO (K KBAR PI)/(ETA PI PI)        (P1)/(P3)
R2            (0.124)  (0.035)        DEFOIX    68 HBC      1.2 PB P,7 PI    3/69

R3          D MESON 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

R4          D MESON 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 MESON

D.ANDLAU 65 PL 17 347          +BARLOW,ADAMSON,+       (CDEF+CERN+IRAD+LIVP)
MILLER   65 PRL 14 1074        +CHUNG,DAHL,HESS,HARDY,KIRZ,+       (LRL+UC)
BARLOW   67 NC  50 A  701      +MONTANET,D-ANDLAU+(CERN+CDF+IDR+LIVERPOOL)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                (LRL)I JP
D.ANDLAU 68 NP  B 5  693       +ASTIER,BARLOW,MONTANET+ (CDF+CERN+RAD+LIV)I JP
DEFOIX   68 PL 28 B 353        +RIVET,SIAUD,CONFORTO,SHIVELY(CDF+IPE+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,+        (CDF+CERN)  JP
OTWINOWS 69 PL 29 B 529        S.OTWINOWSKI                          (WARSAW)
AMMAR    70 PR                 +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

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## $A_2$(1310)

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12  A2 MESON (1310,JPG=2+-)  I=1
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There is now a clear experimental controversy on the issue of whether the $A_2$ is split or not. The evidence for non-split seems to be rather convincing by now, but we consider that the really decisive experiment is still to come. The following remarks are relevant to the present situation:

(a) The confidence levels given normally for fits with a single BW, dipole, or 2 coherent or incoherent BW depend on the size and number of bins used and the treatment of adjustable parameters. For more involved methods see LYNCH 71 (who fits the data to a mixture of a dipole and a BW and gets a "duplicity parameter") or GETTNER 71 (who defines a "figure of merit" $\Delta\chi^2$, dependent on statistics, mass resolution and a signal/background ratio).

(b) There exists a "natural bias" of preferring the dipole shape (LYNCH 71, AGUILAR 71).

(c) The division between splitting and non-splitting experiments is not simply correlated to any physical property such as $A_2$ charge, momentum transfer, beam energy, decay mode, etc. In fact, the two most significant experiments — CHIKOVANI 67 ("split") and BOWEN 71 ("unsplit") — have nearly identical experimental conditions.

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                12  A2  MESON MASS (MEV), K KBAR, UNSPLIT

MK  N   THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
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       730 1313.0      4.0                  FOLEY     71 CNTR  - 20.3 PI- P,K- KS  2/71
MK S  1500 1319.0      3.0                    GRAYER    71 ASPK  - 17.2 PI-P,K-KS P  2/72*
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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            12  A2 MESON MASS  (MEV),3PI,ETA PI MODES.UNSPLIT.

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      6/66
M           (1300.0)                         SEIDLITZ  65 DBC  -  3.2 PI-D           6/66
M            1290.0      10.0                BARNES    66 HBC  -  6.0 PI-P           6/66
M            1310.0      10.0                BENSON    66 DBC   0 3.65 PI+D          6/66
M      1800(1310.0)     (10.0)   COMP.BY     FERBEL    66 RVUE +-  PI+- P          10/66
M      1060 1286.        8.                 LEVRAT    66 MMS  -   6-7 PI- P        2/67
M       137 1285.       20.                 BALTAY    67 HBC   0 8.5 PI+ P          7/67
M      4000 1307.       16.                 CHIKOVANI 67 MMS  -  7 PI- P            8/67
M           1269.        9.                 DANYSZ    67 HBC  +-  3,3.6 PBAR P      7/67
M           1311.0       6.0                ARMENISE  68 DBC   0 5.1 PI+D           9/67
M           1282.0      15.0                BALLAM    68 HBC  - 16.0 PI- P           9/68
M           1320.       10.                 BOESEBECK 68 HBC   0 8 PI+ P            6/68
M   B       (1280.)     (10.)               BOESEBECK 68 HBC  +   8 PI+ P            6/68
M   B       ASSUMING A1 AND A1.5 MESONS OF FIXED MASS AND WIDTH
M           1310.       20.                 CHUNG     68 HBC  -  2.7-4.5 PI- P      5/68
M           1287.0      10.0                CRENNELL  68 HBC  -  6.0 PI-P,X-        6/68
M           1275.       17.                 FRIDMAN   68 HBC  +-  5.7 PBAR P         6/68
M           1280.       12.                 KEY       68 HBC  -  3 PI-P            11/67
M           (1301.0)    (8.0)               VON KROGH 68 HBC  -  6.7 PI- P          9/68
M           1300.0       4.0                JUNKMANN  68 HBC  -  16. PI- P, 5PI     9/69
M   A       (1299.)     (14.)               LAMSA     68 HBC  -  8 PI- P            1/71
M           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       189 1312.0       7.0                ALSTON-GA 70 HBC  +  7.0 PI+P,PI ETA     1/71
M           1313.0       7.0                BOCKMANN  70 HBC   05. PI+P             5/70
M          (1290.0)                         CAROLL    70 HBC  -  7 PI- P            1/71
M          (1310.0)                         CAROLL    70 DBC   0 7 PI+ D           1/71
M          (1305.0)                         CAROLL    70 HBC   0 25 PI- P           1/71
M           1288.0      10.0                CASO      70 HBC  - 11.2PI-P,PI RHO     5/70
M           1300.0      20.0                CASO      70 HBC  - 11.2PI-P,PI ETA     5/70
M           1335.0      15.0                DIAZ      70 HBC  +- 0. PBAR P, 4 PI    5/70
M           1300.0      20.0      14.0      DZIERBA   70 HBC  -  8. PI- P,PI 5TI   11/71*
M   D      (1330.0)    (15.0)               GARFINKEL 70 DBC  -  4.5 K-D,LAMBDA     1/71
M   D   MAY BE DIFFERENT OBJECT,JPC=2++. COMPARE CRENNELL 69.
M          (1274.0)    (22.0)               GORDON    70 DBC   0 4.2 PI+ D          1/71
M           1288.0       7.0                JOHNSTON  70 HBC  -  7.PI-P,PI-ETA P     1/71
M   A       ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5)
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   X      (1307.)     (7.)                BLOODWORT 71 HBC  +  5.45 PI+ P,P 3PI    2/72*
M   X   DEPLETION OF EVENTS NEAR 1300 MEV
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   C       (1307.)     (12.)               BUHL      71 HBC  - 2.5 PI- P          11/71*
M   C       BACKWARD PRODUCTION                                                    11/71*
M           1320.       20.                 ESPIGAT   72 HBC  +- 0.PBAR P,ETA 2PI  11/71*
M           . . . . . . . . . .
M   AVG     1302.5      1.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                        (SEE IDEOGRAM BELOW )

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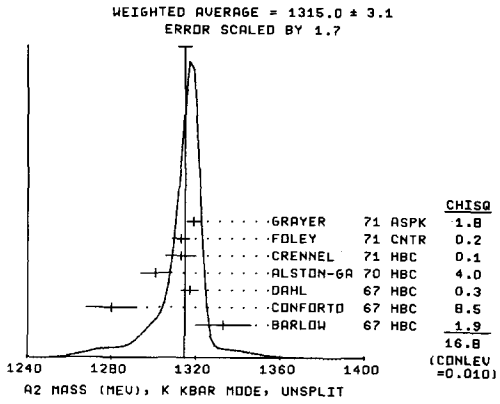


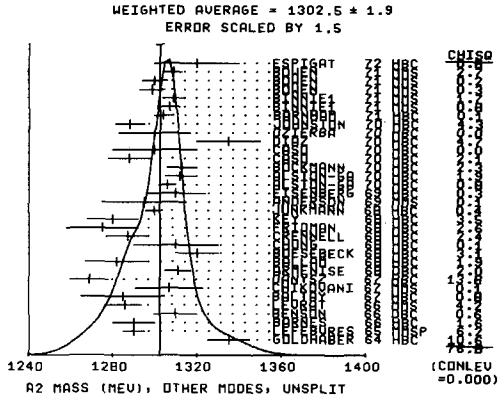


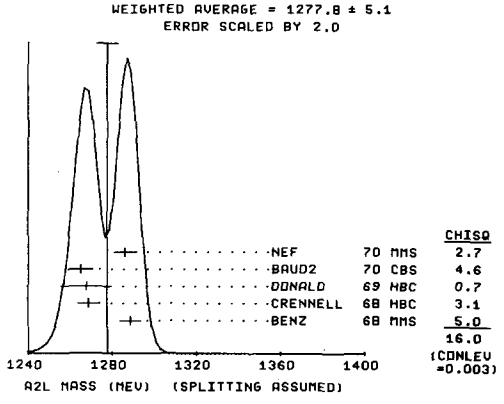


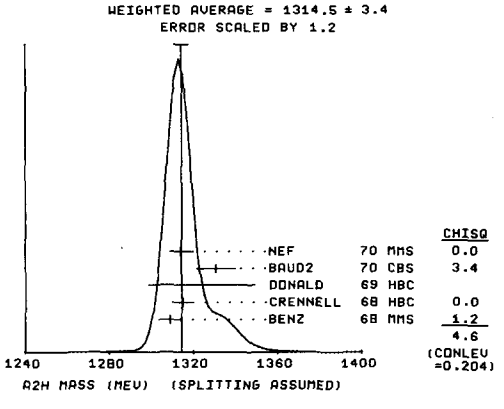


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                    12  A2L MESON MASS (MEV)  (ASSUME SPLITTING)

ML  A     (1274.)    (16.)            CHIKOVANI 67 MMS   -  6.7 PI- P          6/68
ML  A    INCLUDED IN BENZ 68 FIT OF 2 COHERENT SYMMETRIC POLES.
ML          1289.      5.             BENZ      68 MMS   -  2.65 PI- P       12/68
ML          1269.0     5.0            CRENNELL  68 HBC   -  6.0 PI-P,X-       6/68
ML  BZ    (1281.0)    (3.0)           AGUILAR 1 69 HBC  +- 0-1.2 PB P,K1K+-   5/69
ML   Z     AGUILAR 1 69 INCLUDES BARLOW 67, CONFORTO 67.
ML  C     (1289.0)   (10.0)           CRENNELL  69 DBC   -  3.9 K- N,PI-RHO   8/69
ML  C  MAY BE DIFFERENT OBJECT. JP=1- FAVORED OVER 2+,2-,1+.
ML  C  NOTE THAT IGJP=1-1- IS EXOTIC IN THE QUARK MODEL.
ML          1268.0     12.0           DONALD    69 HBC  +-  1.2 PB P(4 PI)   9/69
ML  B     (1276.)     (6.)            BAUD1     70 MMS   - 7. PI-P, P KKBAR 11/69
ML       35 1265.0     6.0            BAUD2     70 CBS   - 11.PI-P,P ETA PI  5/70
ML  B     (1275.0)    (6.0)           BOCKMANN  70 HBC  +  5. PI+P,INCOHER.  5/70
ML  B     (1287.0)    (2.2)           BASILE    70 CNTR   0 3.16 PI- P        1/71
ML       60 1286.      5.0            NEF       70 MMS   - 7. PI-P, P KKBAR 11/69
ML  B        FIT TO TWO INCOHERENT BREIT WIGNERS
ML          . . . . . . . . . .
ML          AVG BELOW IS BASED ONLY ON VALUES FROM COHERENT FITS.
ML          . . . . . . . . . .
ML  AVG     1277.8      5.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                       (SEE IDEOGRAM ABOVE )

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                    12  A2H MESON MASS (MEV)  (ASSUME SPLITTING)

MH  A     (1320.)    (16.)            CHIKOVANI 67 MMS   -  6.7 PI- P          6/68
MH  A    INCLUDED IN BENZ 68 FIT OF 2 COHERENT SYMMETRIC POLES.
MH          1309.      5.             BENZ      68 MMS   -  2.65 PI- P       12/68
MH          1315.0     5.0            CRENNELL  68 HBC   -  6.0 PI-P,X-       6/68
MH  BZ    (1325.0)    (3.0)           AGUILAR 1 69 HBC  +- 0-1.2 PB P,K1K+-   5/69
MH   Z     AGUILAR 1 69 INCLUDES BARLOW 67, CONFORTO 67.
MH          1324.0     25.0           DONALD    69 HBC  +-  1.2 PB P(4 PI)   9/69
MH  B     (1323.)     (6.)            BAUD1     70 MMS   - 7. PI-P, P KKBAR 11/69
MH       35 1331.0     9.0            BAUD2     70 CBS   - 11.PI-P,P ETA PI  5/70
MH  B     (1338.0)    (4.0)           BOCKMANN  70 HBC  +  5. PI+P,INCOHER.  5/70
MH  B     (1329.0)    (1.9)           BASILE    70 CNTR   0 3.16 PI- P        1/71
MH       60 1314.      5.0            NEF       70 MMS   - 7. PI-P, P KKBAR 11/69
MH  B        FIT TO TWO INCOHERENT BREIT WIGNERS
MH          . . . . . . . . . .
MH          AVG BELOW IS BASED ONLY ON VALUES FROM COHERENT FITS.
MH          . . . . . . . . . .
MH  AVG     1314.5      3.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                       (SEE IDEOGRAM ABOVE )

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                    12  A2  MESON WIDTH(MEV), K KBAR, UNSPLIT

WK  N    THE NEUTRAL MODE CAN INTERFERE WITH THE F MESON
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+KO      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      730 114.0     10.0            FOLEY     71 CNTR  - 20.3 PI- P,K- KS   2/71
WK     1500 123.0      7.0            GRAYER    71 ASPK  - 17.2 PI-P,K-KS P 11/71*
WK          . . . . . . . . . .
WK  AVG      105.8     11.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.4)
                       (SEE IDEOGRAM BELOW )
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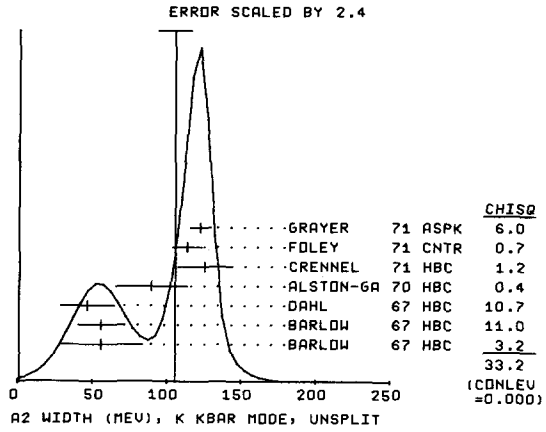


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         12  A2 MESON WIDTH (MEV),3PI,ETA PI MODES.UNSPLIT.

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        6/66
W            (140.0)                        SEIDLITZ  65 DBC   -  3.2 PI-D        6/66
W              70.0     10.0                BARNES    66 HBC   -  6.0 PI-P        6/66
W             100.      15.                 BENSON    66 DBC   0 3.65 PI+D        1/67
W       1800  (80.0)   (10.0)   COMP.BY     FERBEL    66 RVUE +-  PI+- P         10/66
W       1060   98.      5.                  LEVRAT    66 MMS   -  6,7 PI- P       2/67
W        137  100.      25.                 BALTAY    67 HBC   0 8.5 PI+ P        7/67
W   A         (84.)    (30.)    (20.)       CASON     67 HBC   -  8 PI- P         5/67
W   A         ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AT 1190 MEV
W       4000   90.      15.                 CHIKOVANI 67 MMS   -  7 PI- P         8/67
W              45.      22.                 DANYSZ    67 HBC  +-  3,3.6 PBAR P    7/67
W              96.0     16.0                ARMENISE  68 DBC   0 5.1 PI+D         9/67
W             125.0     40.0                BALLAM    68 HBC   - 16.0 PI- P       9/68
W             (90.)   APPROX.               BOESEBECK 68 HBC   +  8 PI+ P         6/68
W              56.      21.                 BOESEBECK 68 HBC   0 8 PI+ P          6/68
W              80.      20.                 CHUNG     68 HBC   -  2.7-4.5 PI- P   5/68
W              94.0     30.0     20.0       CRENNELL  68 HBC   -  6.0 PI-P,X-     6/68
W             (80.)   APPROX.               FRIDMAN   68 HBC  +-  5.7 PBAR P      6/68
W              91.      18.                 KEY       68 HBC   -  3 PI-P         11/67
W             (40.0)   (25.0)               VON KROGH 68 HBC   -  6.7 PI- P       9/68
W              52.0     16.0                JUNKMANN  68 HBC   -  16. PI- P, 5PI  9/69
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   E   BACKGROUND SUBTRACTION MODEL-DEPENDENT.                                   5/70
W              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        189  103.0     20.0                ALSTON-GA 70 HBC   +  7.0 PI+P,PI ETA 1/71
W              70.0     29.0                BOCKMANN  70 HBC    05. PI+P          5/70
W            (102.0)                        CAROLL    70 HBC   -  7 PI- P         1/71
W            (122.0)                        CAROLL    70 DBC   0 7 PI+ D          1/71
W             (85.0)                        CAROLL    70 HBC   0 25 PI- P         1/71
W             135.0     26.0                CASO      70 HBC   - 11.2PI-P,PI RHO  5/70
W            (120.0)                        CASO      70 HBC   - 11.2PI-P,PI ETA  5/70
W   D         (41.0)   (20.0)   (16.0)      DZIERBA   70 HBC   -  8. PI- P,PI ETA 11/70
W              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   D   MAY BE DIFFERENT OBJECT,JPC=2++. COMPARE CRENNELL 69.
W            (215.0)   (22.0)               GORDON    70 DBC   0 4.2 PI+ D        1/71
W   A         ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5)
W              38.0     15.0                JOHNSTON  70 HBC   -  7.PI-P,PI-ETA P 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   X         (72.)    (25.)                BLOODWORT 71 HBC   +  5.45 PI+ P,P 3PI 2/72*
W   X   DEPLETION OF EVENTS NEAR 1300 MEV
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             120.      30.                 ESPIGAT   72 HBC  +- 0.PBAR P,ETA 2PI 11/71*
W   D         STRONGLY DEPENDENT ON BACKGROUND SUBTRACTION
W             . . . . . . . . . .
W   AVG        94.9     2.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                                 (SEE IDEOGRAM BELOW )
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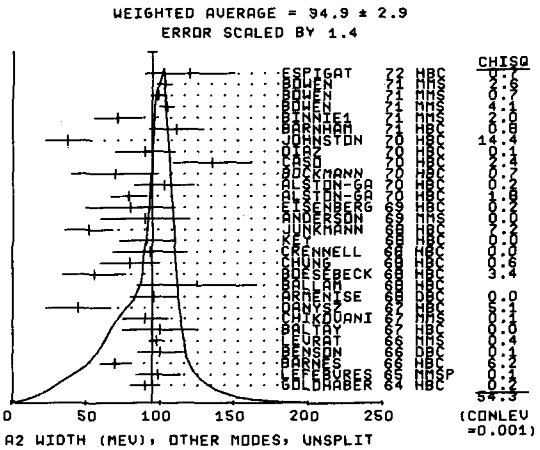


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         12  A2L MESON WIDTH (MEV) (ASSUME SPLITTING)

WL  A        (29.)     (10.)                CHIKOVANI 67 MMS   +  6,7 PI- P        6/68
WL  A    INCLUDED IN BENZ 68 FIT OF 2 COHERENT SYMMETRIC POLES.
WL             22.       5.                 BENZ      68 MMS   -  2.65 PI- P      12/68
WL             24.0     10.0                CRENNELL  68 HBC   -  6.0 PI-P,X-      6/68
WL  BZ        (22.0)   (10.0)    (7.0)      AGUILAR 1 69 HBC  +- 0-1.2 PB P,K1K+-  5/69
WL   Z     AGUILAR 1 69 INCLUDES BARLOW 67, CONFORTO 67.
WL  C         (40.0)  OR LESS               CRENNELL  69 DBC   -  3.9 K- N,PI-RHO  8/69
WL  C   MAY BE DIFFERENT OBJECT. JP=1- FAVORED OVER 2+,2-,1+.
WL  C   NOTE THAT IGJP=1-1- IS EXOTIC IN THE QUARK MODEL.
WL              5.0     12.0      5.0       DONALD    69 HBC  +-  1.2 PB P(4 PI)   9/69
WL  B         (27.0)   (13.0)               BOCKMANN  70 HBC   +  5. PI+P,INCOH5R= 5/70
WL  B         (23.0)    (8.8)               BASILE    70 CNTR  0 3.16 PI- P        1/71
WL             20.      10.0                NEF       70 MMS   - 7. PI-P, P KKBAR 11/69
WL  B      FIT TO TWO INCOHERENT BREIT WIGNERS
WL         . . . . . . . . . .
WL         AVG BELOW IS BASED ONLY ON VALUES FROM COHERENT FITS.
WL         . . . . . . . . . .
WL  AVG        18.8      3.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
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         12  A2H MESON WIDTH (MEV) (ASSUME SPLITTING)

WH  A        (35.)     (10.)                CHIKOVANI 67 MMS   -  6,7 PI- P        6/68
WH  A    INCLUDED IN BENZ 68 FIT OF 2 COHERENT SYMMETRIC POLES.
WH             22.       5.                 BENZ      68 MMS   -  2.65 PI- P      12/68
WH             12.0     10.0                CRENNELL  68 HBC   -  6.0 PI-P,X-      6/68
WH  BZ        (22.0)   (10.0)    (7.0)      AGUILAR 1 69 HBC  +- 0-1.2 PB P,K1K+-  5/69
WH   Z     AGUILAR 1 69 INCLUDES BARLOW 67, CONFORTO 67.
WH             21.0     10.0                DONALD    69 HBC  +-  1.2 PB P(4 PI)   9/69
WH  B         (17.0)    (5.0)               BOCKMANN  70 HBC   +  5. PI+P,INCOHER. 5/70
WH  B         (10.2)   (14.8)   (10.2)      BASILE    70 CNTR  0 3.16 PI- P        1/71
WH             30.      10.0                NEF       70 MMS   - 7. PI-P, P KKBAR 11/69
WH  B      FIT TO TWO INCOHERENT BREIT WIGNERS
WH         . . . . . . . . . .
WH         AVG BELOW IS BASED ONLY ON VALUES FROM COHERENT FITS.
WH         . . . . . . . . . .
WH  AVG        21.6      3.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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         12  A2 MESON PARTIAL DECAY MODES

                                                          DECAY MASSES
P1       A2 MESON INTO RHO PI                             765+ 139
P2       A2 MESON INTO K KBAR                             493+ 497
P3       A2 MESON INTO ETA PI                             548+ 139
P4       A2 MESON INTO ETA PRIME PI                       957+ 139
P5       A2 MESON INTO PI+ PI- PIO EXCL.RHO PI. (SMALL,   139+ 139+ 134
                          NOT USED IN FIT)
P6       A2 MESON INTO PI+ PI- PI- EXCL.RHO PI. (SMALL,   139+ 139+ 139
                          NOT USED IN FIT)
P7       A2 MESON INTO PI GAMMA                           139+   0
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         12  A2 MESON  BRANCHING RATIOS

R1       A2 MESON  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       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  N         (0.14)   (0.05)               BOCKMANN  70 HBC   0 5.0 PI+P          9/69
R1             0.07     0.05                BOCKMANN  70 HBC   +  5.0 PI+P         9/69
R1  N   THE NEUTRAL MODE CAN INTERFERE WITH F.
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 71 (SEE UNDER R2 AND R8)                              11/71*
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
R1           . . . . . . . . . .
R1  AVG        0.075    0.011    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT        0.076    0.011  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
                               (SEE IDEOGRAM BELOW )
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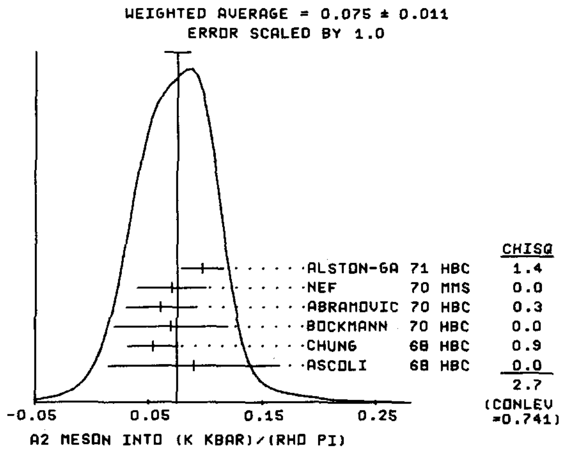


```
R2       A2 MESON INTO (ETA PI)/TOTAL                          (P3)
R2      34     0.15     0.04                BARNHAM   71 HBC   +  3.7 PI+ P       11/71*
R2             0.13     0.04                ESPIGAT   72 HBC  +- 0.PBAR P,        11/71*
R2           . . . . . . . . . .
R2  AVG        0.140    0.028    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT        0.163    0.015  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3       A2 MESON 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           . . . . . . . . . .
R3  AVG        0.225    0.027    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  FIT        0.212    0.024  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4       A2 MESON INTO (ETA PRIME PI) / TOTAL                  (P4)
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*
R4           . . . . . . . . . .
R4  FIT        0.011    0.010  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)
```

```
R5       A2 MESON INTO (ETA PRIME PI)/(RHO PI)                    (P4)/(P1)
R5       14     0.07      0.03              ASCOLI     68 HBC   -  5.0 PI-P         6/68
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             . . . . . . . . . . .
R5   AVG        0.057     0.023    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5   FIT        0.014     0.014   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R6       A2 MESON INTO (PI+ PI- PI0) / (RHO PI)                   (P5)/(P1)
R6             (0.17) OR LESS               BENSON     66 DBC    0 3.7 PI+D

R7       A2 MESON 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        2.79      0.50    FROM FIT

R8       A2 MESON INTO (K KBAR)/ TOTAL                            (P2)
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             . . . . . . . . . . .
R8   FIT        0.0584    0.0079 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9       A2 MESON 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 MESON INTO (PI GAMMA)/TOTAL                           (P7)
R11 R          (0.005)  (0.005)  (0.003)EISENBERG 71 HBC      PHOTOPRODUCTION   11/71*
R11 R    PION EXCHANGE MODEL USED IN THIS ESTIMATION                              11/71*
```

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 .768+-.018
P 2   -.245     .058+-.008
P 3   -.729       -.181     .163+-.015
P 4   -.480       -.075       -.068     .011+-.011
```

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REFERENCES FOR A2


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ADERHOLZ 64 PL 10 248           AACHEN+BERLIN+BIRM+BONN+HAMB+IC-LONDON+MPI
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
CHUNG    65 PRL  15  325        +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FORINO   65 PL 19 68            +GESSAROLI+LENDINARA+(BOL+BARI+FIR+ORS+SAC)
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+CCNY)
BENSON   66 MICH COO-1112-4     G.C.BENSON, THESIS                (MICHIGAN)
   ALSO 66 PRL 16 1177          G BENSON,LOVELL,MARQUIT,ROE  +    (MICHIGAN)
EHRLICH  66 PR 152 1194         R. EHRLICH,W.SELOVE,H.YUTA    (PENNSYLVANIA)
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+BOL+FIR+ORSAY)
BALTAY   67 PL 25B 160          +KIRSCH+KUNG+YEH+RABIN  (COLUM+BNL+RUTGERS)
BARLOW   67 NC 50A 701          +LILLESTOL+MONTANET+(CERN+CDF+IR+LIVERPOOL)
BARTSCH  67 PL 25B 48           +DEUTSCHMANN+GROTE+COCCONI+(AACH+BERL+CERN)
BEUSCH   67 PL 25 B 357         +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+CERN)
CASON    67 PRL 18 880          +LAMSA,BISWAS,DERADO,GROVES,+    (NOTREDAME)
   ALSO LAMSA 68
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+CF+IPN+LIVERPOOL)
CONTE    67 NC  51 A  175       +TOMASINI,CORDS+ (GENOVA+HAM+MILANO+SACLAY)
DAHL     67 PR 163 1377         +HARDY+HESS+KIRZ+MILLER               (LRL)
DANYSZ   67 NC 51 A 801         DANYSZ+FRENCH+SIMAK                  (CERN)

ARMENISE 68 PL 26B 336          ARMENISE,FORINO,+        (BARI+BOL+FIR+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+MIL+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+(HEIDELB+STRASBOURG)
JUNKMANN 68 NP B8 471           +COCCONI,+           (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430         +PRENTICE+COOPER+MANNER+WALKER+(TO+ANL+WIS)
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+KRAK+WARS)
AGUILAR 169 PL 29 B  62         +BARLOW,JACOBS,DELLA NEGRA+(CERN+CDF +LIVP)
    ALSO BARLOW 67,CONFORTO 67
AGUILAR 269 PL 29 B  241        M.AGUILAR-BENITEZ,J.BARLOW,+      (CERN+CDF)
ANDERSON 69 PRL 22 1390         +COLLINS,+                        (BNL+CARN)
ARMENISE 69 LNC 2 501           +GHIDINI,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
CHIKOVAN 69 PL 28 B  526        CERN MISSING MASS SPECTROMETER GROUP (CERN) JP
CRENNELL 69 PRL 22 1327         +KARSHON,KWAN WU LAI,+                (BNL)IJP
DONALD   69 NP B 12 325         +EDWARDS,FOSTER,MOORE            (LIVERPOOL)
EISENBER 69 PRL 23 1322         EISENBERG,HABER,BALLAM,CHADWICK+(REHO+SLAC)
VETLITSK 69 YAD.FIZ. 9 596      VETLITSKY,GRIGOREYEV,GRISHIN,GUZHAVIN+(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)
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)IC
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)

ALSTON-GA71 PL 34 B 156         +BARBARO,BUHL,DERENZO,EPPERSON,FLATTE+(LRL)
BARNHAM  71 PRL 26 1494         +ABRAMS,BUTLER,COYNE,GOLDHABER,HALL,+ (LBL)
BINNIE1  71 PL 36 B 257         +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHAM)
BINNIE2  71 PL 36 B 537         +CAMILLERI,DUANE,FARUQI,BURTON,+(LOIC+SHAM)
BLOODWOR 71  PREPRINT           BLOODWORTH,JACKSON,PRENTICE,YOON     (TNTO)
BOWEN    71 PRL 26 1663         +FARLES,FAISSLER,BLIEDEN,+       NEAS+STON
BUHL     71  PREPRINT           +CLINE,TERREL                   (WISCONSIN)
CLAYTON  71  PREPRINT           +MASON,MUIRHEAD,RIGOPOULOS,+    (LIVP+ATEN)
CRENNEL  71 PL 35 B 185         +GORDON,KWAN-WU LAI,SCARR              (BNL)
EISENBER 71  SLAC-PUB-933       EISENBERG,HABER,BALLAM,CHADWICK+(REHO+STAN)
FARBER   71 NP B 29 237         +DE PINTO,BISWAS,CASON,DEERY,KENNEY,+(NDAM)
RINAUDO  71 NC 5 A 239          +BOECKMANN,MAJOR+(TORI+BONN+DURH+NIJM+EPOL) JP
FOLEY    71 PRL 26 413          +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)
GRAYER   71 PL 34 B 333         +HYAMS,JONES,SCHLEIN,BLUM,DIETL+(CERN+MPIM)

ESPIGAT  72 NP B 36 93          +GHESQUIERE,LILLESTOL,MONTANET  (CERN+CDEF)

                                PAPERS NOT REFERRED TO IN DATA CARDS

CHUNG    64 PRL 12 621          +DAHL,HARDY,HESS,KALBFLEISCH,KIRZ,+   (LRL)
LANDER   64 PRL 13 346 A        LANDER,ABOLINS,CARMONY,HENDRICKS +   (UCSD)  JP
ADERHOLZ 65 PR 138 B 897        (AACHEN+BERL+BIRM+BONN+HAMB+LOND+MUENCHEN)
ALITTI   65 PL 15 69            ALITTI,BATON,DELER,CRUSSARD+ (SACLAY+BOLOG)  JP
SLATTERY 67 NC 50A 377          +KRAYBILL+FORMAN+FERBEL           (YALE+ROCH)  JP
BAUD3    70 PL 31 B 401         CERN BOSON SPECTROMETER GROUP         (CERN)
AGUILAR  71 PR D 4 2583         AGUILAR-BENITEZ,EISNER,KINSON          (BNL)
BEKETOV  71 SJNP 4 765          +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+  (ITEP)  JP
GETTNER  71  PREPRINT NUB2092 M.GETTNER                              (NEAS)
LYNCH    71 UCRL 20022 AND 71 AMSTERDAM CONF.  G.LYNCH                (LBL)
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## E(1422)

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6  E MESON  (1422,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 MESON MASS (MEV)

M             1425.       7.           BAILLON    67 HBC     0. PBAR P          11/66
M             1420.0     20.0          DAHL       67 HBC      1.6-4.2 PI- P     10/66
M             1423.      10.           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             . . . . . . . . . . .
M    AVG      1422.5      4.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                6 E MESON 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             . . . . . . . . . . .
W    AVG       69.3       7.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                6 E MESON PARTIAL DECAY MODES

                                                         DECAY MASSES
P1           E INTO K K*(890)                          493+ 891
P2           E INTO K KBAR PI                          497+ 497+ 139
P3           E MESON INTO PI PI RHO                    134+ 134+ 765
P4           E INTO PI(975) PI                         975+ 139
P5           E INTO ETA PI PI                          548+ 139+ 139

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                6  E MESON BRANCHING RATIOS

R1           E INTO K K*(890)/((K K*)+(PI(1016) PI))          (P1)/(P1+P4)
R1              .50        .10         BAILLON    67 HBC      0.0 PBAR P        11/66

R2           E MESON INTO (PI PI RHO) / (K KBAR PI)           (P3)/(P2)
R2             (2.0)  OR LESS          DAHL       67 HBC    0 CHARGED PI ONLY 10/66

R3       E MESON INTO (ETA 2 PI)/(K KBAR PI)                  (P5)/(P2)
R3             (1.5)  OR LESS  CL=.95  FOSTER     68 HBC   -  PBAR P,PBA REST  9/69

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REFERENCES FOR E MESON


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BAILLON  67 NC 50A  393         +EDWARDS+D.ANDLAU+ASTIER+       (CERN+CDF+IR)
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+UC)
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,+      (CDF+CERN)  JP
DEVONS   71 PRL 27 1614         +KOZLOWSKI,HORWITZ,+              (COLU+SYR)
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# Mesons

## $X_{I=0}(1430)$, $X_{I=1}(1440)$, $f'(1514)$, $F_1(1540)$



### $X_{I=0}(1430)$

```
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.

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                29  X(1430)  MASS (MEV)

M   -------RHOO RHOO MODE-------
M        (1410.0)                    BETTINI   66 DBC   0  0. PBARP TO 5PR  9/66

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)

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                29  X(1430) WIDTH (MEV)

W   -------RHOO RHOO MODE-------
W        (90.0)                      BETTINI   66 DBC   0 0. PBAR P TO 5PR  9/66

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)

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                          REFERENCES FOR X(1430)

BETTINI  66 NC 42A 695        +CRESTI,LIMENTANI,LORIA,PERUZZO+ (PAD+PISA)
ABRAMS   67 PRL 18 620        +KEHOE,GLASSER,SECHI-ZORN,WOLSKY (MARYLAND)
BARLOW   67 NC  50 A  701     +MONTANET,D-ANDLAU+(CERN+CDF+IDR+LIVERPOOL)
BEUSCH   67 PL 25 B 357       +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+CERN)
DONALD   69 NP B 11 551       +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)

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### $X_{I=1}(1440)$

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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          . . . . . . . . .
M   AVG    1437.5      5.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                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          . . . . . . . . .
W   AVG     46.4     17.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                          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+CDF+IDR+LIVERPOOL)
BEUSCH   67 PL 25 B 357       +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+CERN)
FOLEY    71 PRL 26 413        +LOVE,OZAKI,PLATNER,LINDENBAUM,+ (BNL+CUNY)

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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(1514) 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        70 1513.0     7.0           BARNES    67 HBC     4.6, 5. K- P     10/67
M          . . . . . . . . .
M   AVG    1514.0      4.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                13  F PRIME(1514) 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        70   87.0    15.0           BARNES    67 HBC     4.6, 5. K- P     10/67
W          . . . . . . . . .
W   AVG     73.2      22.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
                        (SEE IDEOGRAM BELOW )
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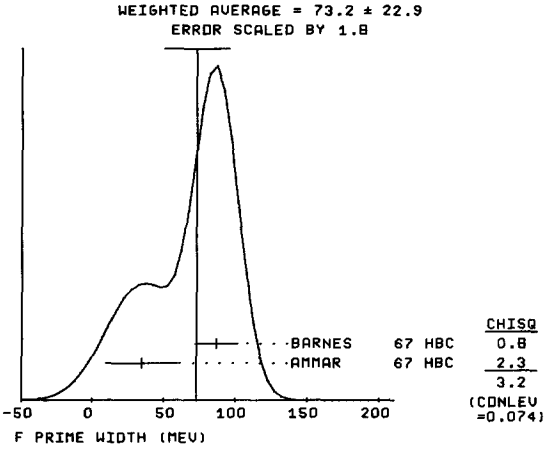


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                13  F PRIME PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          F PRIME INTO PI+ PI-                        139+ 139
P2          F PRIME INTO K KBAR                         497+ 497
P3          F PRIME INTO K K*(890)                      493+ 891
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

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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            (0.18) OR LESS           BARNES    67 HBC      4.6, 5.0 K- P   10/67

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             0.25      0.13          BARNES    67 HBC      4.6, 5.0 K- P   10/67

R5          F PRIME INTO (PI K KBAR + K K*(890))/(K KBAR) (P6+P3)/(P2)
R5            (0.4)  OR LESS  CL=.67   AMMAR     67 HBC                      10/67
R5            (0.14) OR LESS           BARNES    67 HBC      4.6, 5.0 K- P   10/67

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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 +      (NWU+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,+       (CDF+CERN)  JP
SCOTTER  69 NC 62 A 1057      +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)

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### $F_1(1540)$

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47  F1 (1540,JPG=   ) I=1

JP = 2-,1+ FAVORED .
ALSO CONTAINS PHOTOPRODUCED BUMP AT 1550 MEV,I UNKNOWN

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                47  F1 (1540)  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   D     (1550.0)   (40.0)          DAVIER    69 STRC   04.5-18 BREMS,4PI 11/69
M   D      WITH STATISTICS INCREASED FOURFOLD (MAY 70), DAVIER ET AL STILL
M   D      FIND A BROAD  FOUR PION ENHANCEMENT, BUT LITTLE EVIDENCE FOR A1+
M   D      STRUCTURE. NO INFORMATION ON ISOSPIN.
M        25(1543.0)    (3.0)         DUBOC     71 HBC    0 1.1-1.2 PBAR P . 2/72*

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                47  F1 (1540) 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   D     (260.0)  (110.0)            DAVIER    69 STRC   04.5-18 BREMS,4PI 11/69
M   D      SEE NOTE UNDER MASS ABOVE.
W        25  (16.0)   (10.0)          DUBOC     71 HBC    0 1.1-1.2 PBAR P   2/72*

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                47  F1 (1540) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          PI/RHO (1540) INTO K KBAR PI                134+ 497+ 497
P2          PI/RHO (1540) INTO K*(890) KBAR             891+ 497

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                          REFERENCES FOR F1

ADERHOLZ 69 NP B 11 259       +BARTSCH,+        (AACH+BERL+CERN+KRAK+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)
DAVIER   69  SLAC-PUB-666     +DERADO,FRIES,LIU,MOZLEY,ODIAN,PARK+ (SLAC)
DUBOC    71 PL 34 B 343       +GOLDBERG,MAKOWSKI,TOUCHARD,+   (IPNP+LIVP)

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## $A_3(1640)$

34 A3 (1640, JPG=2--) I = 1

It is not clear whether the $A_3$ peak is just a broad $J^P = 2^- f\pi$ enhancement near threshold (ASCOLI 71, CASO 72), or whether there exist other decay modes or additional structure. The situation is reminiscent of that of the $A_1$.

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                  34  A3 (1640)  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          (1650.0)                  IOFFREDO  68 HBC  - 13-20 PI-P,PI-F    9/68
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          (1660.)     (7.)          HARRISON  71 HBC  - 20. PI- P,P 3PI . 2/72*
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           . . . . . . . . . .
M    AVG    1640.6      5.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                       (SEE IDEOGRAM BELOW )
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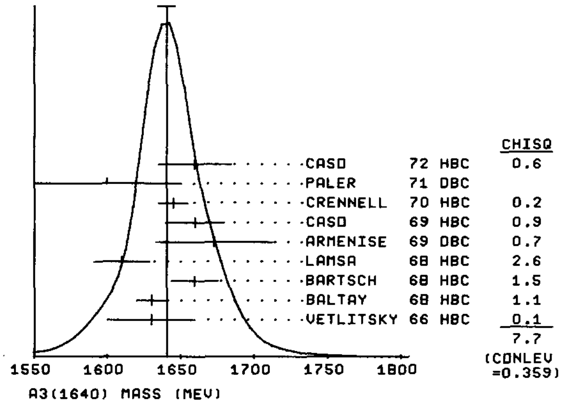
WEIGHTED AVERAGE = 1640.6 ± 5.8
ERROR SCALED BY 1.0

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M       OMEGA PI PI PEAKS AND THE R2
M          1689.      10.            DANYSZ    67 HBC    0 3,3.6 PBAR P     7/67
M    M     1700.      15.            DUBAL     67 MMS  -  7,11.5,12PI- P    7/67
M    M  R2 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
M          1670.0     18.0           YOST      68 HBC    04.3 K-P,LMBD.5PI  9/68
M          1695.0     20.0           BARNES    69 HBC    0 4.6 K-P,OMEG2PI  8/69
M          . . . . . . . . . .
M    AVG   1689.3      7.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  34  A3 (1640)  WIDTH (MEV)

W        20 (100.)                   VETLITSKY 66 HBC  -  4.7 PI-P          6/66
W            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           100.      50.      30.   LAMSA     68 HBC  -  8.0 PI-P  PI-F   11/67
W    P   OBSERVED IN (OMEGA PI+PI-) AND (OMEGA RHO0) MODES IN RATIO 2/1
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           (60.)    (20.)           HARRISON  71 HBC  - 20. PI- P,P 3PI . 2/72*
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           . . . . . . . . . .
W    AVG    116.0     17.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W         OMEGA PI PI PEAKS AND THE R2
W    R       (21.)    OR LESS        LEVRAT    66 MMS  -  7,12 PI- P        7/67
W    R    R2 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
W            38.       18.           DANYSZ    67 HBC    0 3,3.6 PBAR P     7/67
W            50.0      15.0          YOST      68 HBC    04.3 K-P,LMBD.5PI  9/68
W            90.       20.           BARNES    69 HBC    0 4.6 K-P,OMEG2PI  8/69
W            . . . . . . . . . .
W    AVG     56.3      14.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

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                  34  A3 (1640)  PARTIAL DECAY MODES

                                                              DECAY MASSES
P1          A3(1640) INTO 3 PI                              134+ 134+ 134
P2          A3(1640) INTO RHO PI                            134+ 765
P3          A3(1640) INTO ETA PI                            134+ 548
P4          A3(1640) INTO 5 PI
P5          A3(1640) INTO K K*(890)                         497+ 891
P6          A3(1640) INTO K KBAR PI                         497+ 497+ 134
P7          A3(1640) INTO K KBAR                            497+ 497
P8          A3(1640) INTO F PI                             1269+ 134
P9          A3(1640) INTO OMEGA PI PI                       783+ 134+ 134

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                  34  A3 (1640)  BRANCHING RATIOS

R2          A3(1640)+- 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             CONSISTENT WITH 0.0    IOFFREDO  68 HBC   - 13-20 PI-P       9/68
R2            (.18) OR LESS  CL=.95   PALER     71 DBC  +  13.P++ D,D(3P+)+ 11/71*

R3          A3(1640)+- 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             SEEN                   IOFFREDO  68 HBC  - 13-20 PI-P,PI-F   9/68
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*

R4          R1 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R4            (0.37)/   0.59 /   0.04 FOCACCI   66 MMS  -  3-12 PI-P        10/66

R5          A3(1640) +- 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(1640)+- 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

R7          A3(1640) INTO (OMEGA PI PI)/(F PI)              (P9)/(P8)
R7  P         (4.)   OR MORE          BARNES    69 HBC    0 4.6 K-P,OMEG2PI  8/69
R7  P          NOT CLEAR IF (OMEGA PI+PI-) PEAK IS DECAY MODE OF PI(1640)

R8          A3(1640)+- INTO (RHO PI)/(F PI)                 (P2)/(P8)
R8             0.03      0.37     0.03 CASO     69 HBC  -  11 PI- P         5/70

R9          A3(1640)+- INTO (PI+- PI+ PI-)/(F PI)           (P1C-P8)/(P8)
R9             0.06      0.47     0.06 CASO     69 HBC  -  11 PI- P         5/70

R10         A3(1640)+- 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 (1640)


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FORINO    65 PL 19 68          +GESSAROLI+LENDINARA+(BOL+BARI+FIR+ORS+SAC)
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+    (COLMB+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+MIL+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)
YOST      68  UMD  T.REPORT849 +YODH,EINSCHLAG,DAY,GLASSER            (UMD)

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 CASO 68.

BRANDENB  70 NP B16 369        +BRENNER,IOFFREDO,JOHNSON,KIM+    (HARVARD)
CRENNELL  70 PRL 24 781        +KARSHON,LAI,SCARR,SIMS                (BNL)
CHIEN1    70  TORONTO PREPRINT +CHAO,JOHNSTON,PRENTICE,WALKER   (TOR+WISC)
CHIEN2    70 PHILAD.CONF.P.275 C.Y.CHIEN, REVIEW          (JOHNS HOPKINS)
MIYASHIT  70 PR D 1 771        MIYASHITA,VON KROGH,KOPELMAN,LIBBY   (COLO)

ASCOLI    71  AMSTERDAM CONF.  +KRUSE,+ PRESNTED AT AMSTERDAM CONF.  (ILL)
BEKETOV   71 SJNP 4 765        +SOMBKOWSKY,KONOWALOV,KRUTSCHININ,+  (ITEP)  JP
CLAYTON   71  PREPRINT         +MASON,MUIRHEAD,RIGOPOULOS,+    (LIVP+ATEN)
HARRISON  71  PREPRINT         +HEYDA,JOHNSON,KIM,LAW,MUELLER,+     (HARV)
PALER     71 PRL 26 1675       +BADEWITZ,BARTON,MILLER,PALFREY,TEBES(PURD)

CASO      72 NP B 36 349       +MADDOCK,BASSLER+(DURH+GENO+DESY+MILA+SACL)

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## $\phi(1675) \to \rho^0\pi^0$

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45  PHI (1675,JPG= -) I=0

THIS 3 PI BUMP OVERLAPS IN MASS THE PI(1640) F PI BUMP
CALLED THE A3, BUT IN SOME EXPTS. ONE CAN ESTABLISH THAT
THE ENHANCEMENT IS RHO 0 PI INSTEAD OF F PI, SO THE
PHI(1675) AND THE PI(1640) HAVE DIFFERENT ISPIN.
MATTHEWS 71 SUGGEST JP = NORMAL, A POSSIBLE RECURRENCE
OF THE OMEGA MESON.

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                    45  PHI (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 PHI(1675) IS OBSERVED IN THIS EXPERIMENT
M         . . . . . . . . . .
M   AVG   1663.6     12.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                     (SEE IDEOGRAM BELOW )
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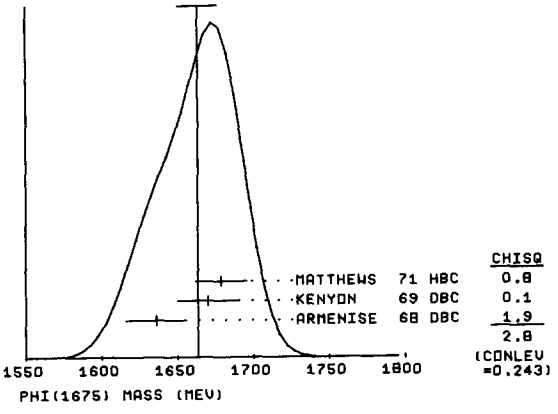
WEIGHTED AVERAGE = 1663.6 ± 12.9
ERROR SCALED BY 1.2

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                    45  PHI (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 PHI(1675) IS OBSERVED IN THIS EXPERIMENT
W         . . . . . . . . . .
W   AVG    141.4     17.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    45  PHI (1675)  PARTIAL DECAY MODES

                                                      DECAY MASSES
P1        PHI (1675) INTO 3 PI                      134+ 134+ 134
P2        PHI (1675) INTO 5 PI                      134+ 134+ 134+ 134
P3        PHI (1675) INTO RHO PI                    765+ 134

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                    45  PHI (1675)  BRANCHING RATIOS

R1        PHI (1675) INTO (5 PI)/(3 PI)             (P2)/(P1)
R1          0.10      0.10          KENYON    69 DBC    0 8. PI + D         8/69

R2        PHI (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 PHI(1675) IS OBSERVED IN THIS EXPERIMENT

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                    45  PHI (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 PHI (1675)

ARMENISE 68 PL 268 336          +GHIDINI,FORINO+ (BARI+BOLOGN+FIRENZ+ORSAY)
KENYON   69 PRL 23 146          +KINSON,SCARR,+          (BNL+ORUC+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)

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## $g(1680)$

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15  G(1680,JPG = 3-+)  I=1

THIS ENTRY CONTAINS THE 2PI,4PI,K KBAR AND K KBAR PI
PEAKS IN THE REGION OF 1700 MEV,AS WELL AS THE R PEAKS FROM MMS.
THE JP DETERMINATION AND THE MASS AND WIDTH IN THE TABLE COME FROM
THE 2PI DECAY MODE. ANALYSES OF 2PI USING OPE MODEL SUGGEST ELASTICITY
CONSIDERABLY LESS THAN 1 (BARTSCH 70,MATTHEWS 71) , BUT THE
DISCREPANCIES IN MASSES , WIDTHS AND BRANCHING RATIOS INDICATE POSSIBLE
PRESENCE OF MORE THAN ONE STATE IN THIS REGION (SEE BARNHAM 70).
FOR CONVENIENCE  WE HAVE COLLECTED ALL THE DATA HERE UNDER A COMMON
ENTRY, WITHOUT IMPLYING THAT THEY ARE NECESSARILY ALL RELATED.
FOR REVIEW SEE BARTSCH 70.

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                    15  G(1680) 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  T       1687.      21.           STUNTEBEC 70 HDBC   0 8. PI-P,5.4 PI+D  2/72*
M  T    FROM FIT WITH SINGLE BW
M  L      (1655.)    (4.)           STUNTEBEC 70 HDBC   0 8. PI-P,5.4 PI+D  2/72*
M  L    FROM FIT WITH 2 BW
M  H      (1764.)    (15.)          STUNTEBEC 70 HDBC   0 8. PI-P,5.4 PI+D  2/72*
M  H    FROM FIT WITH 2 BW
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          . . . . . . . . . .
M   AVG    1681.7     12.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                     (SEE IDEOGRAM BELOW )
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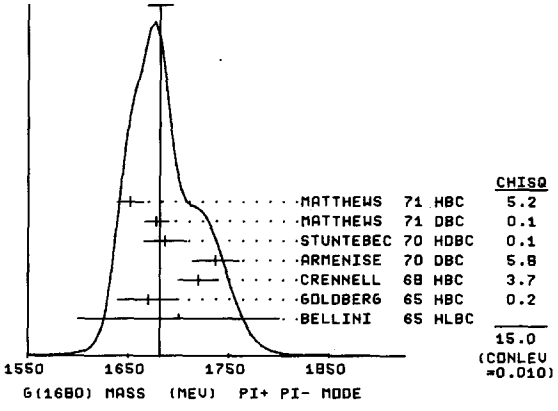
WEIGHTED AVERAGE = 1681.7 ± 12.0
ERROR SCALED BY 1.7

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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          1710.      23.           BISWAS    68 HBC  -    8. PI- P         2/72*
M   J     (1675.0)   (10.0)         JOHNSTON  68 HBC   - 7.0 PI- P          6/68
M   J     NOT SEPARATED FROM 2 PI DECAY
M         (1627.)    (12.)    (17.) BARNHAM   70 HBC  +  10 K+ P,RHO PIPI   6/70
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         . . . . . . . . . .
M   AVG    1711.6     10.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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 RHOO BAND
M    M    (1700.0)                  MAURER    70 HBC    05.7 PBAR P,7 PI   2/71
M    M    (1700.0)                  BRAUN     71 HBC    G5.7 PBAR P,7 PI  11/71*
M    M  SEEN IN 2 RHOO, 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          . . . . . . . . . .
M   AVG    1634.2     10.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M     R PEAKS FROM MMS
M
M   R1    (1632.)    (15.)          FOCACCI   66 MMS  -   7-12 PI-P,P MMS  2/72*
M   R2    (1700.)    (15.)          FOCACCI   66 MMS  -   7-12 PI-P,P MMS  2/72*
M   R3    (1748.)    (15.)          FOCACCI   66 MMS  -   7-12 PI-P,P MMS  2/72*
M   R     (1700.0)   (47.0)         ANDERSON  69 MMS  -  16 PI- P,BACKW    8/69

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                   15  G(1680) 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  T       267.       72.        46.          STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D  2/72*
W  T    FROM FIT WITH SINGLE BW
W   L       (20.)     (8.)                    STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D  2/72*
W   L   FROM FIT WITH 2 BW
W    H      (87.)    (14.)      (20.)         STUNTEBEC 70 HDBC  0 8. PI-P,5.4 PI+D  2/72*
W    H  FROM FIT WITH 2 BW
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          . . . . . . . . .
W   AVG     157.3     22.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW )
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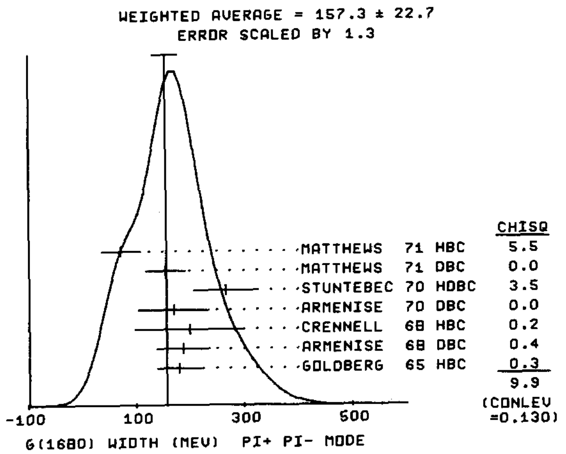


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W     (2PI)+- MODE
W
W           200.0    100.0                    CRENNELL  68 HBC   -  6.0 PI- P        12/68
W          (200.)                             BARISH    69 HBC   -  8 PI- P           5/70
W      122  180.0     30.0                    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           162.      58.       40.           BISWAS    68 HBC   -  8. PI- P          2/72*
W   J       (90.0)   (20.0)                   JOHNSTON  68 HBC   -  7.0 PI- P         6/68
W   J      NOT SEPARATED FROM 2 PI DECAY
W           (72.)    (29.)     (20.)          BARNHAM   70 HBC   + 10 K+ P,RHO PIPI   6/70
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          . . . . . . . . .
W   AVG     127.6     20.7     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

M     R PEAKS FROM MMS
W
W   R1      (21.)   OR LESS                   FOCACCI   66 MMS   -   7-12 PI-P,P MMS  2/72*
W   R2      (30.)   OR LESS                   FOCACCI   66 MMS   -   7-12 PI-P,P MMS  2/72*
W   R3      (38.)   OR LESS                   FOCACCI   66 MMS   -   7-12 PI-P,P MMS  2/72*
W   R      (195.0)                            ANDERSON  69 MMS   -  16 PI- P,BACKW    8/69

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                   15  G(1680) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1          G(1680)     INTO PI PI                        139+ 139
P2          G(1680)     INTO 4PI                          139+ 139+ 139+ 139
P3          G(1680)     INTO 2 RHO                        765+ 765
P4          G(1680)     INTO PI PI RHO                    139+ 139+ 765
P5          G(1680)     INTO A2 PI                       1310+ 139
P6          G(1680)     INTO K KBAR                       497+ 497
P7          G(1680)     INTO OMEGA PI                     139+ 783
P8          G(1680)     INTO K KBAR PI                    497+ 497+ 139
P9          G(1680)     INTO PHI PI                      1019+ 139

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                   15  G(1680) BRANCHING RATIOS

R1     G(1680)  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

R2          G(1680)     INTO (PI+- PI0) / (ALL PI+- PI+ PI- PI0) (P1)/(P2C)
R2  D        (0.08) OR LESS          BALTAY    68 HBC  +   7-8.5 PI+ P        6/68
R2  D        USING DATA OF DEUTSCHMANN 65 ON PI+P TO PI+ PI0 P                6/68
R2            0.8       0.2          JOHNSTON  68 HBC  -   7. PI- P          2/72*
R2            0.8       0.15         BARTSCH   70 HBC  +  8. PI+ P            2/72*
R2           (0.12) OR LESS          BALLAM    71 HBC  -   16. PI- P        . 2/72*
R2          . . . . . . . . .
R2  AVG       0.80      0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3          G(1680)+-   INTO (2PI)/(2RHO)                 (P1)/(P3)
R3           (0.48) OR LESS          BISWAS    68 HBC  -   8. PI- P           2/72*

R4          G(1680)+-   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(1680)+-   INTO (K KBAR PI)/(2PI)            (P8)/(P1)
R5            0.10       0.03        BARTSCH   70 HBC  +  8. PI+ P            2/72*

R6          G(1680)+-   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(1680)+-   INTO  (2 RHO)/(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           (0.63) OR MORE          BISWAS    68 HBC  -   8. PI- P           2/72*
R7            SEEN                   JOHNSTON  68 HBC  -  7 PI-P              6/68
R7            0.7        0.15        BARTSCH   70 HBC  +  8. PI+ P            2/72*

R8          G(1680)+-   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(1680)+-   INTO  (PI+- A20)/(ALL 4PI)        (P7)/(P2)
R9                          (WITH A20 INTO (PI+ PI- PI0))
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*

R10         G(1680)+-   INTO  (PI OMEGA)/(ALL 4PI)        (P9)/(P2)
R10                         (WITH OMEGA INTO(PI+ PI- PI0))
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         . . . . . . . . .
R10 AVG       0.184     0.050   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R11         G(1680)+-   INTO (PI PHI)/(ALL 4PI)
R11          (0.11) OR LESS          BALTAY    68 HBC  +   7,8.5 PI+P         6/68

R12         G(1680)+-   INTO (PI+- 2PI+ 2PI- PI0)/(ALL PI+- PI+ PI- PI0)
R12          (0.15) OR LESS          BALTAY    68 HBC  +   7,8.5 PI+ P        6/68

R13         R  MESON 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(1680)

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+PARIS+ORSAY+MILAND+CEA-SACL)

EHRLICH   66 PR 152 1194         R. EHRLICH,W.SELOVE,H.YUTA    (PENNSYLVANIA)
FOCACCI   66 PRL  17  890        CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT    66 PL   22  714        CERN MISSING MASS SPECTROMETER GROUP (CERN)
SEGUINOT  66 PL 19 712           CERN MISSING MASS SPECTROMETER GROUP (CERN)

ABRAMS    67 PRL 18 620          +KEHOE+GLASSER+SECHI-ZORN+WOLSKY (MARYLAND)
DANYSZ    67 PL 24B 309          +FRENCH+KINSON+SIMAK+         (CERN+LIVERPOOL)
DUBAL     67 NP B3 435           +FOCACCI+KIENZLE+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+BOLOG+FIRENZE+ORSAY)I
BALTAY    68 PRL 20 887          +KUNG+YEH+FERBEL+     (COLMB+ROCH+RUTG+YALE)I=1
BISWAS    68 PRL 21 50           +CASON,DZIERBA,GROVES,KENNEY,+          (NDAM)
BOESEBEC  68 NP B 4 501          BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO      68 NC 54 A 983         +CONTE+CORDS+DIAZ+    (GENOVA+HAMB+MIL+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+KRAK+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+MPIMJ)=3-
MATTHEWS  71 NP B 331            +PRENTICE,YOON,CARROLL,+         (TNTO+WISC)JP3-
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**$X^-$(1795)**

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63  X-(1795) 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                  (SYR)

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**$\eta_A/\rho_A$(1830) $\to 4\pi, K^*\bar{K}$**

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42  ETA OR RHO (1830) G=+1 (JPG=  +) I GTE 0

THIS ENTRY CONTAINS 4 PI AND K PI KBAR AND THE
R4 MMS PEAK. R4 IS ONLY A 3 STANDARD DEVIATION
EFFECT. OMITTED FROM TABLE.

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                   42 MASS (MEV)

M       110 1832.       6.             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
M    R                                                    IN RHOO BAND
M    M     (1830.)     (15.)           DUBAL      67 MMS   -  7,11.5,12.PI- P  6/68
M    M      MISSING MASS R4 PEAK,FINAL STATE UNKNOWN
M           1820.       12.            FRENCH     67 HBC     OSEE NOTE K BELOW  7/67
M    K      SEEN IN 3.-3.6 PBAR P TO (KS KO PIO...). G PARITY UNKNOWN
M           . . . . . . . . . .
M    AVG    1829.6       5.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                   42 WIDTH (MEV)

W       110   42.       11.            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
W    R                                                    IN RHOO BAND
W    M       (30.0)  OR LESS           DUBAL      67 MMS   - 7,11.5,12 PI-P     6/68
W    M       MISSING MASS R4 PEAK,FINAL STATE UNKNOWN
W            50.        23.            FRENCH     67 HBC     OSEE NOTE K BELOW  7/67
W    K       SEEN IN 3.-3.6 PBAR P TO (KS KO PIO...). G PARITY UNKNOWN
W            . . . . . . . . . .
W    AVG     43.5       9.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                   42 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          ETA OR RHO (1830) INTO 4 PI                   139+ 139+ 139+ 139
P2          ETA OR RHO (1830) INTO RHO PI PI              139+ 139+ 765
P3          ETA OR RHO (1830) INTO RHO RHO                765+ 765
P4          ETA OR RHO (1830) INTO K KBAR PI              134+ 497+ 497

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                        REFERENCES

DANYSZ   67 PL 24B 309         +FRENCH+KINSON+SIMAK+        (CERN+LIVERPOOL)
DUBAL    67 NP B3 435          CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO  68 THESIS 1456        L.DUBAL                              (GENEVE)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+      (CERN+BIRM)

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**$\phi_A/\pi_A$(1830) $\to 5\pi, K^*\bar{K}$**

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43  PHI OR PI (1830) G=-1 (JPG=  -) I GTE 0

THIS ENTRY CONTAINS OMEGA PI PI AND K PI KBAR
AND THE R4 MMS PEAK. R4 IS ONLY A 3 STANDARD
DEVIATION EFFECT. I=1 IF (OMEGA RHO) MODE
EXISTS. OMITTED FROM TABLE.

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                   43  MASS (MEV)

M    O     (1848.)     (11.)           DANYSZ     67 HBC     0 3,3.6 PBAR P      7/67
M    O      OBSERVED IN (OMEGA PI+ PI-) (AND POSSIBLY (OMEGA RHO(0))) MODE
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    M     (1830.)     (15.)           DUBAL      67 MMS   -  7,11.5,12.PI- P   6/68
M    M      MISSING MASS R4 PEAK,FINAL STATE UNKNOWN

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                   43  WIDTH (MEV)

W    O       (67.)     (27.)           DANYSZ     67 HBC     0 3,3.6 PBAR P      7/67
W    O       OBSERVED IN (OMEGA PI+ PI-) (AND POSSIBLY (OMEGA RHO(0))) MODE
W    K       (50.)     (20.)           FRENCH     67 HBC     0 3-4 PBAR P        7/67
W    K       OBSERVED IN (KS KO PIO...) MODE  (G-PARITY UNKNOWN)
W    M       (30.0)  OR LESS           DUBAL      67 MMS   - 7,11.5,12 P+-P     6/68
W    M       MISSING MASS R4 PEAK,FINAL STATE UNKNOWN

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                   43 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          PHI (1830) INTO 5 PI                          139+ 139+ 139+ 139
P2          PHI (1830) INTO OMEGA PI PI                   139+ 139+ 783
P3          PHI (1830) INTO OMEGA RHO                     783+ 765
P4          PHI (1830) INTO K KBAR PI                     134+ 497+ 497

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                        REFERENCES

DANYSZ   67 NC 51A 801         DANYSZ+FRENCH+SIMAK                   (CERN)
DUBAL    67 NP B3 435          CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO  68 THESIS 1456        L.DUBAL                              (GENEVE)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+      (CERN+BIRM)

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**S(1930) REGION**

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31 S(1930,JPG=    ) I=1 OR 2

THIS ENTRY CONTAINS, BESIDES THE S(1930) SEEN BY
CHIKOVANI 66 WITH A MMS,AND A STRUCTURE OBSERVED IN
PBAR P BACKWARD ELASTIC SCATTERING, VARIOUS OTHER
PEAKS NEARBY.

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                   31  S (1930)  MASS (MEV)

M          1929.0     14.0           CHIKOVANI 66 MMSP  -  12.0 PI-P           8/66
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   K      1975.0     12.0           KRAMER    70 HBC   +  13.1 PI+ P,2PI    11/70
M   K      HAS IG=1+ FROM ABSENCE OF PI+PI+ PEAK. THUS JP=(ODD)-.            11/70
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   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 71 .
M   B     (1968.)                    BENVENUTI 71 HBC   0  .1 - .8 PBAR P    2/72*
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          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)

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                   31  S (1930) WIDTH (MEV)

W         (35.0)  OR LESS            CHIKOVANI 66 MMSP  -  12.0 PI-P           8/66
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   K     (52.0)  OR LESS  CL=.90    KRAMER    70 HBC   +  13.1 PI+ P,2PI    11/70
W   K     HAS IG=1+ FROM ABSENCE OF PI+PI+ PEAK. THUS JP=(ODD)-.             11/70
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

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                   31  S MESON PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      S  INTO PI+ PI-                                   139+ 139
P2      S  INTO PBAR P                                    938+ 938

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                   31 D(SIGMA)/D(T) ( MICROBARNS/(GEV/C)**2 )

CS           35.0      12.0          FOCACCI   66 MMS  .22 LTE T LTE .36    9/66

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                        REFERENCES FOR S(1930)

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)

MONTANET 69 LUND CONF.P.189    L.MONTANET, RAPPORTEUR               (CERN)

ASTIER   70 KIEV CONF.         RAPP.TALK ON BOSON RESONANCES         (CDF)
CASO     70 LNC 3  707         +COROS,COSTA,DARO+(GENO,DESY,HAM,MILA,SACL)
CLINE    70  PREP.,TO BE PUB.  D.CLINE,J.ENGLISH,D.D.REEDER        (WISC)J
KRAMER   70 PRL 25 396         +BARTON,GUTAY,LICHTMAN,MILLER,+    (PURDUE)
LYS      70  PREPRINT          J.LYS                            (MICHIGAN)

BENVENUT 71 PRL 27 283         BENVENUTI,CLINE,RUTZ,REEDER,SCHERER  (WISC)
BIZZARRI 71  PREPRINT          R.BIZZARRI                           (ROMA)
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)

SMITH    72  REVIEW            G.SMITH,REVIEW TALK AT LAUSANNE 72    (MSU)

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**$\rho$(~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.
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         (2120.)                    NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI   9/69

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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.

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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,+  (CALT+ROCH+BNL)

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## T(2200) REGION

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32 T(2200,JPG=    ) I=1 OR 2

THIS ENTRY CONTAINS, BESIDES THE T(2200) SEEN BY
CHIKOVANI 66 WITH A MMS, VARIOUS OTHER PEAKS NEARBY.
FOR REVIEWS,SEE MONTANET 69, KALBFLEISCH 70
OMITTED FROM TABLE.

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                    32 T(2200)  MASS (MEV)

M          2195.0     15.0            CHIKOVANI 66 MMSP  -  12.0 PI-P        8/66
M    B    (2190.)    (10.)            ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
M    B     SEEN AS BUMP IN I=1 STATE. WIDTH MUCH LARGER THAN IN
M    B     THE MMSP EXPT.  SEE ALSO COOPER 68
M    B     BRICMAN (69) SEES NO BUMP, SPIN LESS THAN 5 IS SO EXCLUDED
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-PI0)
M          2190.0     10.0            CLAYTON   67 HBC  +- 2.5PBAR,A2+OMEGA 10/67
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          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     D    2157.0     10.0            KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
M     D    HAS IG=1+ FROM ABSENCE OF PI+PI+ PEAK. THUS JP=(ODD)-.           11/70
M          . . . . . . . . .
M    AVG   2184.7      9.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
                              (SEE IDEOGRAM BELOW )
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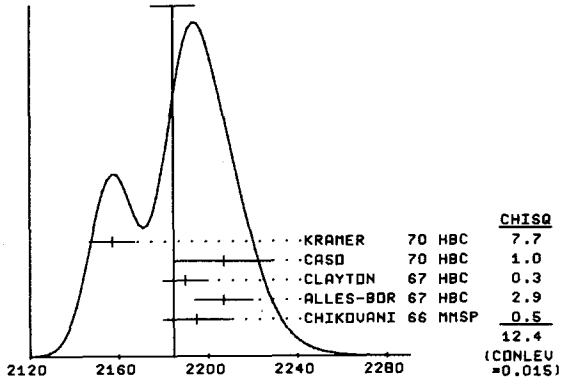
WEIGHTED AVERAGE = 2184.7 ± 9.8
ERROR SCALED BY 1.8

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                    32 T(2200) WIDTH (MEV)

W          (13.0)  OR LESS            CHIKOVANI 66 MMSP  -  12.0 PI-P        8/66
W    B     (85.)                      ABRAMS    67 CNTR    S CHANNEL NBAR N  7/67
W    B      SEE NOTE B UNDER T(2200) MASS ABOVE.
W          62.       52.              ALLES-BOR 67 HBC    0 5.7 PBAR P       12/66
W    K     BETWEEN 20 AND 80 MEV      KALBFLEIS 69 HBC    0 S-CHANNEL PBARP  7/69
W    K      SEEN IN PBAR P TO RHOO RHOO PIO. IG=1-.
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     D    68.0      22.0             KRAMER    70 HBC  +  13.1 PI+ P,2PI   11/70
W     D    HAS IG=1+ FROM ABSENCE OF PI+PI+ PEAK. THUS JP=(ODD)-.           11/70
W          . . . . . . . . .
W    AVG   67.1      20.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    32 D(SIGMA)/D(T) ( MICROBARNS/(GEV/C)**2 )

CS         29.0      10.0             FOCACCI   66 MMS  .22 LTE T LTE .36    9/66

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                    32 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS         (5.5)                      ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
CS  K      (0.5)     (0.1)            KALBFLEIS 69 HBC    0S CHANNEL NBAR N  7/69
CS          SEEN IN PBAR P TO RHOO RHOO PIO.IG=1-.

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                         REFERENCES FOR T(2200)

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)
   ALSO ABRAMS 70
ALLES-BO 67 NC 50 A 776         ALLES-BORELLI,FRENCH,FRISK,+    (CERN+BONN)G=-
CLAYTON  67 HEIDBG.CONF.P.57    +MASON,MUIRHEAD,FILIPPAS+  (LIVPOOL+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 CASO 69
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,LOBKOVICZ+   (CALT+BNL+ROCH)

SMITH    72  REVIEW             G.SMITH,REVIEW TALK AT LAUSANNE 72    (MSU)

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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.
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         (2290.)                     NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI  9/69

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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,+  (CALT+ROCH+BNL)

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## $N\bar{N}_{I=1}$(2350)

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58 N NBAR (2350) I=1

OMITTED FROM TABLE

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                    58 MASS

M    B    (2350.)    (10.)            ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71
M    B     SEEN AS BUMP IN I=1 STATE. WIDTH MUCH LARGER THAN IN MMS EXPT.

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                    58 WIDTH

W    B    (140.)                     ABRAMS    67 CNTR    S CHANNEL PBAR N  7/67
W    B     SEEN AS BUMP IN I=1 STATE. WIDTH MUCH LARGER THAN IN MMS EXPT.

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                    58 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS         (3.2)                      ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71

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                         REFERENCES FOR N NBAR (2350)

ABRAMS   67 PRL 18 1209         +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)
ABRAMS   70 PR D 1 1917         +COOL,GIACOMELLI,KYCIA,LEONTIC,LI,+   (BNL)

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## U(2375) REGION

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                    33 U(2375)      I=1

THE ORIGINAL EVIDENCE OF CHIKOVANI 66 FROM MISSING-MASS SPECTRO-
METER APPEARED TO BE CONFIRMED LATER IN S-CHANNEL ANTIPROTON-NUCLEON
EXPERIMENTS (RING 69, OH 70). WITH ADDITION OF MORE DATA, HOWEVER,
SOME OF THIS EVIDENCE BECAME LESS CONVINCING, AND SOME CAUSED CON-
TROVERSY BETWEEN GROUPS (CHAPMAN 71).
   IN THIS SITUATION WE FEEL THE U(2375) IS AGAIN IN NEED OF FURTHER
CONFIRMATION.
                         OMITTED FROM TABLE.

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                    33 U(2375)  MASS (MEV)

M          2382.0     24.0            CHIKOVANI 66 MMSP  -  12.0 PI-P        8/66
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    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         (2420.0)   (25.0)           JOHNSON   70 HBC   -  12.0 PI- P       1/71
M    N     2360.0     25.0            OH        70 HDBC  -OPBAR(P,N),K+K2PI 11/71*
M    N     NO EVIDENCE FOR THIS BUMP SEEN IN THE PBAR P DATA OF CHAPMAN 71  11/71*
M          . . . . . . . . .
M    AVG   2370.7     12.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

                    33 U(2375) WIDTH (MEV)

W          (30.0)  OR LESS            CHIKOVANI 66 MMSP  -  12.0 PI-P        8/66
W          (57.)                      ANDERSON  69 ASPK  - 16 PI- BKSCAT    11/69
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          (80.0)  OR LESS            JOHNSON   70 HBC   -  12.0 P+- P       1/71
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*

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                    33 D(SIGMA)/D(T) ( MICROBARNS/(GEV/C)**2 )

CS         42.0      14.0             FOCACCI   66 MMS  .28 LTE T LTE .36    9/66

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

                    33  U MESON BRANCHING RATIOS

R1        U- MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R1         (0.30)/   0.45 /   0.25  FOCACCI   66 MMS   -                  10/66

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```
                                REFERENCES FOR U(2375)

CHIKOVAN 66 PL   22  233        CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL  17  890        CERN MISSING MASS SPECTROMETER GROUP (CERN)

CLAYTON  67 HEIDBG.CONF.P.57    +MASON,MUIRHEAD,FILIPPAS+  (LIVPOOL+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)
RING2    69                     JOINT PREPRINT COMBINES RING1 AND OH 70

JOHNSON  70  UH 511 77 70       +PETERS,STENGER,YEE                (HAWAII)
LYS      70  PREPRINT           J.LYS                           (MICHIGAN)
OH       70 PRL 24 1257         +PARKER,EASTMAN,SMITH,SPRAFKA,MA      (MSU)
SMITH    70  PREPRINT           G.A.SMITH                             (MSU)

CHAPMAN  71 PR D4 1275          +GREEN,LYS,MURPHY,RING,+         (MICHIGAN)
FIELDS   71 PRL 27 1749         +COOPER,RHINES,ALLISON            (ANL+OXF)
YOH      71 PRL 26 922          +BARISH,CAROLL,LOBKOVICZ+   (CALT+BNL+ROCH)

SMITH    72  REVIEW             G.SMITH,REVIEW TALK AT LAUSANNE 72    (MSU)

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```

## $N\bar{N}_{I=0}$(2375)

```
41  N NBAR (2375) I=0

EVIDENCE FOR RESONANCE PRELIMINARY.
OMITTED FROM TABLE

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

                41 MASS

M          2375.      10.            ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71

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

                41 WIDTH

W          (190.)                    ABRAMS    70 CNTR    S CHANNEL NBAR N  1/71

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

                41 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS           (2.5)                   ABRAMS    70 CNTR                      1/71

****** ********* ********* ********* ********* ********* ********* ********

                                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)

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```

## $X^-$(2500)

```
46   X- (2500, JPG=   ) I=1 OR 2

OMITTED FROM TABLE

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

                46  X- (2500)  MASS (MEV)

M          2500.0     32.0           ANDERSON  69 MMS   -  16 PI- P,BACKW9  8/69

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

                46  X- (2500)  WIDTH (MEV)

W           (87.0)                   ANDERSON  69 MMS   -  16 PI- P,BACKW9  8/69

****** ********* ********* ********* ********* ********* ********* ********

                                REFERENCES FOR X-(2500)

ANDERSON 69 PRL 22 1390         +COLLINS,+                        (BNL+CARN)

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## $X^-$(2620)

```
48   X- (2620, JPG=   ) I=1 OR 2

OMITTED FROM TABLE

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

                48  X- (2620)  MASS (MEV)

M      550 2620.      20.            BAUD      69 MMS   -  8.-10. PI- P     9/69
M          2676.0     27.0           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          . . . . . . . . .
M    AVG   2639.8     26.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                      (SEE IDEOGRAM BELOW )

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                48  X- (2620)  WIDTH (MEV)

W      550   85.      30.            BAUD      69 MMS   -  8.-10. PI- P     9/69
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
```

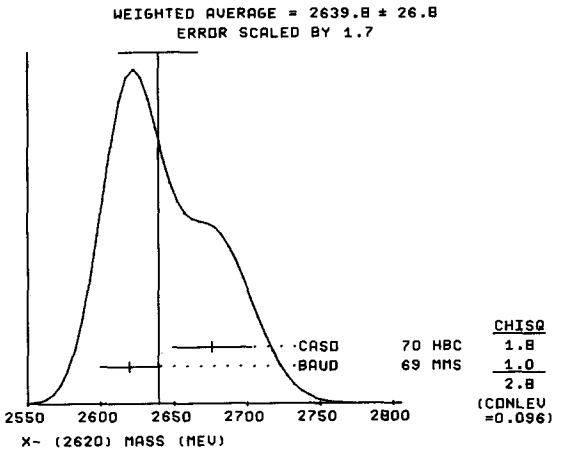


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****** ********* ********* ********* ********* ********* ********* ********

                                REFERENCES FOR X-(2620)

BAUD     69 PL  30B 129         CERN BOSON SPECTROMETER GROUP         (CERN)
CASO     70 LNC 3 707           +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)

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## X(2800)

```
49   X  (2800, JPG=   ) I=1 OR 2

OMITTED FROM TABLE

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                49  X  (2800)  MASS (MEV)

M      640 2800.      20.            BAUD      69 MMS   -  8.-10. PI- P     9/69
M    C  15 2820.      10.            SABAU     71 HBC   +  8. PI+ P        11/71*
M    C     SEEN IN (K KBAR PI PI)+ MASS DISTRIBUTION                       11/71*
M          . . . . . . . . .
M    AVG   2816.0      8.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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

                49  X  (2800)  WIDTH (MEV)

W      640   46.      10.            BAUD      69 MMS   -  8.-10. PI- P     9/69
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*
W          . . . . . . . . .
W    AVG     48.0      7.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

****** ********* ********* ********* ********* ********* ********* ********

                                REFERENCES FOR X (2800)

BAUD     69 PL  30B 129         CERN BOSON SPECTROMETER GROUP         (CERN)
SABAU    71 LNC 1 514           +URETSKY                           (BUCH+ANL)

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****** ********* ********* ********* ********* ********* ********* ********
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## $X^-$(2880)

```
50   X- (2880, JPG=   ) I=1 OR 2

OMITTED FROM TABLE

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

                50  X- (2880)  MASS (MEV)

M      230 2880.      20.            BAUD      69 MMS   -  8.-10. PI- P     9/69

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

                50  X- (2880)  WIDTH (MEV)

W      230  (15.)   OR LESS          BAUD      69 MMS   -  8.-10. PI- P     9/69

****** ********* ********* ********* ********* ********* ********* ********

                                REFERENCES FOR X-(2880)

BAUD     69 PL  30B 129         CERN BOSON SPECTROMETER GROUP         (CERN)

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## X(3030)

```
53   X  (3030, JPG=   ) I=1 OR 2

OMITTED FROM TABLE

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

                53  X  (3030)  MASS (MEV)

M  A       3035.0     25.0           ALEXANDER 70 HBC      7. PBAR P,7 PI  11/71*
M  A       DECAY TO 6 PIONS.WIDTH INCOMPAT. WITH BAUD 70 AND YOST 71.     11/71*
M          3025.0     20.0           BAUD      70 MMS   - 10.5-13 PI- P     5/70
M  Y    43 3013.       5.            YOST      71 HBC   +  11.PI+ P,P(8PI)+ 11/71*
M  Y       4.3 S.D. EFFECT  . DECAY TO 7 PIONS                             11/71*
M          . . . . . . . . .
M    AVG   3014.5      4.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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```
                    53  X  (3030)  WIDTH (MEV)

W  A        200.0      60.0            ALEXANDER 70 HBC      7. PBAR P,7 PI  11/71*
W  A       DECAY TO 6 PIONS.WIDTH INCOMPAT. WITH BAUD 70 AND YOST 71.       11/71*
W          (25.0)  APPROX.            BAUD      70 MMS   - 10.5-13 PI- P     5/70
W  Y    43 (40.)   OR LESS            YOST      71 HBC  +  11.PI+ P,P(8PI)+ 11/71*
W  Y       4.3 S.D. EFFECT  . DECAY TO 7 PIONS                               11/71*

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                              REFERENCES FOR X(3030)

ALEXANDE 70 PRL 25 63          +BAR-NIR,DAGAN,GIDAL,GRUNHAUS+   (TEL-AVIV)
BAUD     70 PL 31 B 549        CERN BOSON SPECTROMETER GROUP        (CERN)
YOST     71 PR D 3 642         +MORRIS,ALBRIGHT,BRUCKER,LANNUTTI    (FLAS)

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**X⁻(3075)**

```
                    54  X- (3075, JPG=   ) I=1 OR 2

                              OMITTED FROM TABLE

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

                    54  X- (3075)  MASS (MEV)

M          3075.0     20.0            BAUD      70 MMS   - 10.5-13 PI- P     5/70

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

                    54  X- (3075)  WIDTH (MEV)

W           (25.0)  APPROX.            BAUD      70 MMS   - 10.5-13 PI- P     5/70

****** ********* ********* ********* ********* ********* ********* ********

                              REFERENCES FOR X-(3075)

BAUD     70 PL 31 B 549        CERN BOSON SPECTROMETER GROUP        (CERN)

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****** ********* ********* ********* ********* ********* ********* ********
```

**X⁻(3145)**

```
                    55  X- (3145, JPG=   ) I=1 OR 2

                              OMITTED FROM TABLE

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

                    55  X- (3145)  MASS (MEV)

M          3145.0     20.0            BAUD      70 MMS   - 10.5-15 PI- P     5/70

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

                    55  X- (3145)  WIDTH (MEV)

W           (10.0)  OR LESS            BAUD      70 MMS   - 10.5-15 PI- P     5/70

****** ********* ********* ********* ********* ********* ********* ********

                              REFERENCES FOR X-(3145)

BAUD     70 PL 31 B 549        CERN BOSON SPECTROMETER GROUP        (CERN)

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```

**X⁻(3475)**

```
                    56  X- (3475, JPG=   ) I=1 OR 2

                              OMITTED FROM TABLE

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

                    56  X- (3475)  MASS (MEV)

M          3475.0     20.0            BAUD      70 MMS   - 14-15.5 PI- P     5/70

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

                    56  X- (3475)  WIDTH (MEV)

W           (30.0)  APPROX.            BAUD      70 MMS   - 14-15.5 PI- P     5/70

****** ********* ********* ********* ********* ********* ********* ********

                              REFERENCES FOR X-(3475)

BAUD     70 PL 31 B 549        CERN BOSON SPECTROMETER GROUP        (CERN)

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****** ********* ********* ********* ********* ********* ********* ********
```

**X⁻(3535)**

```
                    57  X- (3535, JPG=   ) I=1 OR 2

                              OMITTED FROM TABLE

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

                    57  X- (3535)  MASS (MEV)

M          3535.0     20.0            BAUD      70 MMS   - 14-15.5 PI- P     5/70

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

                    57  X- (3535)  WIDTH (MEV)

W           (30.0)  APPROX.            BAUD      70 MMS   - 14-15.5 PI- P     5/70

****** ********* ********* ********* ********* ********* ********* ********

                              REFERENCES FOR X-(3535)

BAUD     70 PL 31 B 549        CERN BOSON SPECTROMETER GROUP        (CERN)

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**K**

```
                    K MESON          ( JP=0- )   I=1/2

                 SEE LISTINGS OF STABLE PARTICLES

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**K*(892)**

```
                    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          . . . . . . . . .
M   AVG    891.71     0.50     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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 DE BAERE ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE.    11/69
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          . . . . . . . . .
M   AVG    896.45     0.68     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                               (SEE IDEOGRAM BELOW )
```
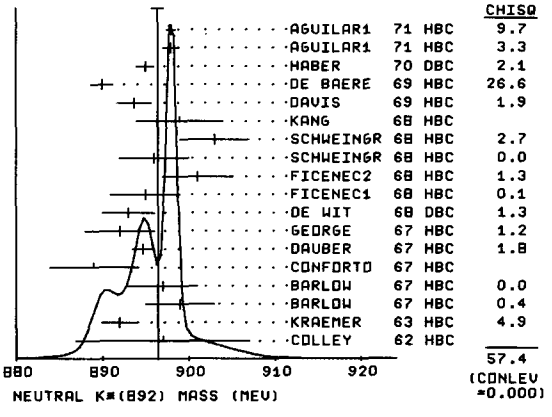

WEIGHTED AVERAGE = 896.45 ± 0.68
ERROR SCALED BY 2.0

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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)
```

Note on $K^*(892)$ Masses and Mass Difference

1) All mass values listed above come from physical region fits of Breit-Wigner functions. However, a recent $K\pi$ phase shift analysis (BINGHAM 72) indicates that part of the $K^*(892)$ peak may be due to a large S wave (see note "S-wave $K\pi$ interactions"). Because the S-wave phase shift is ambiguous ("up" and "down") in the $K^*(892)$ region, BINGHAM 72 find two solutions for the P wave:

"up" solution $m \approx 900$ MeV, $\Gamma \approx 48$ MeV

"down" solution $m \approx 895$ MeV, $\Gamma > 48$ MeV.

2) 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:

$$\delta_{min}(m) = \frac{\Gamma}{\sqrt{N}}, \quad \delta_{min}(\Gamma) = 4\frac{\Gamma}{\sqrt{N}} .$$

(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.

3) There are two more difficulties in measuring a mass difference $m(K^{*0}) - m(K^{*\pm})$ 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 $\Gamma/2$.

Some reactions (symmetric under reflection of $I_z$) are immune to this difficulty. Thus compare the mass of $K^{*0}$ produced in

$$\pi^- p \to \Lambda \pi^- K^+$$

with the mass of $K^{*+}$ in the $I_z$-reflected reaction

$$\pi^+ n \to \Lambda \pi^+ K^0.$$

The final-state amplitudes of each will contain not only the $|K^*\rangle$ with I-spin 1/2, but also an interfering I = 3/2 P-wave, which we can call $|K^*_{3/2}\rangle$. But $I_z$ symmetry forces $\langle \pi^- p | \Lambda K^{*0}\rangle$ to equal $\langle \pi^+ n | \Lambda K^{*+}\rangle$; and similarly for the two $K^*_{3/2}$ amplitudes, so that the shifting of the $K^*$ peak is the same in both reactions. Nobody has published a mass difference exploiting this fact.

```
                    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+ PI0)  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+ PI0)  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-PI0)  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-PI0)  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   56.3      2.6       2.3    AGUILAR1  71 HBC  -   3.9,4.6 K- P     11/71*
W          . . . . . . . .
W   AVG      50.1      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 DE BAERE ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE.        11/69
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          . . . . . . . .
W   AVG      51.7      1.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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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

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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

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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+PADU)
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)  (AMSTERD)
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+CDF+IDR+LIVERPOOL)
BOMSE     67 PR 158 1298        +BORENSTEIN+COLE+GILLESPIE+  (JOHN HOPKINS)
CONFORTO  67 NP B3 469          +MARECHAL,MONTANET+ (CERN+CF+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+I.C.+VIENNA)
DE WIT    68  THESIS            S. DE WIT                       (AMSTERDAM)
FICENEC1  68 PR 169 1034        +HULSIZER+SWANSON+TROWER            (URBANA)
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,AMMAR+(ANL+NW)

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)
LIND      69 NP B 14 1          +ALEXANDER,FIRESTONE,FU,GOLDHABER     (LRL) JP
JUHALA    69 PR 184  1461       +LEACOCK,RHODE,KOPELMAN,LIBBY,+ (AMES+COLO)

ATHERTON  70 NP B 16 416        +FRANEK,FRENCH,FRISK,BEDNAR+    (CERN+PRAG)
CHARRIER  70  CERN PHYS 70-50   CHARRIERE,DRIJARD,DUNWOODIE,+   (LHEB+CERN)
DE BAERE  70  CERN PHYS 70 41   +DEBAISIEUX,DE WOLF,DUFOUR,+    (LHEB+CERN)
HABER     70 NP B 17 289        +SHAPIRA,ALEXANDER+   (REHO+SACL+BGNA+EPOL)
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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)
BRUNET   71  RPP/H/76 (PREP.)   +DANYSZ,GOLDSACK,+     (CDEF+SACL+LOIC+WSTF)
BUCHNER  71 NP B 29 381         +DEHM,GOEBEL,GOLDSCHMIDT,+ (MPIM+CERN+BELG)
CORDS    71 PR D 4 1974         +CARMONY,ERWIN,METERE,+      (PURD+UCD+IUPU)
MERCER   71 NP B32 381          +ANTICH,CALLAHAN,CHIEN,COX,+ (JOHN HOPKINS)
YUTA     71 PRL 26 1502         +DERRICK,ENGELMANN,MUSGRAVE        (ANL+EFI)

BINGHAM  72 NP B                +          (INTERNATIONAL K+ COLLABORATION)
DEUTSCHM 72 NP B 36 373         DEUTSCHMANN,+          (ABCLV COLLABORATION)
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## κ

19 K PI S WAVE, CALLED KAPPA

### S-wave Kπ Interactions in the Region 750-1700 MeV

Kπ interactions in the $I(J^P) = 1/2(0^+)$ wave can be described by the elastic phase shift $\delta_0^1$ from the Kπ threshold (≈630 MeV) up to at least 1100 MeV (BINGHAM 72). The first inelastic S-wave thresholds are Kππ and Kη, neither of which is known to be important below 1400 MeV. Apart from the inelastic thresholds, the S-wave ππ and Kπ interactions are reminiscent of each other. Thus, the remarks in the ππ section about the meaningfulness of resonance parameters apply.

There are two intrinsic ambiguities in the solutions plotted below:

1) Any phase shift can be shifted modulo 180°.

2) If one amplitude is dominant [e.g., the P wave near $K^*(892)$ or the D wave near $K^*(1420)$], then the observed S-P or S-D interference can be explained by two ambiguous S-wave solutions, shown as S' and S in Fig. 2, and known as "up" or "down."

The combination of these two sorts of ambiguities leads to the multiple paths plotted in Fig. 1. Simplicity favors the most slowly varying ("down") solutions, but where the authors give both, we plot both.

Figure 1 displays the $\delta_0^1$ solutions of four experimental groups:

1) BINGHAM 72 (an international $K^+$ collaboration), using data on $K^+p \to K\pi\Delta^{++}$ up to 12.7 GeV/c, find two solutions for $\delta_0^1$, neither of which is a priori preferred:

- "up," a resonant κ with m ~ 890 MeV, Γ ≤ 30 MeV (this requires $\delta_1^1$ to be resonant near 900 MeV with ~ 48 MeV width);
- "down," a slowly rising $\delta_0^1$ reaching ~ 70° at about 1100 MeV (requiring $\delta_1^1$ to be resonant at about 895 MeV). Note that the up-down ambiguity is limited to the region 850-920 MeV. Above 920 MeV the "up" solution joins the "down" solution, since all phase shift values are determined only modulo 180°.

2) MERCER 71, using the first half of the data of BINGHAM 72, give phase shifts up to 1230 MeV, ignoring possible inelasticity.

3) YUTA 71, using 5.5 GeV/c $K^-p \to K\pi N$, agree with the solutions of BINGHAM 72, their "down" solution agreeing also with MERCER 71, ignoring possible inelasticity up to 1250 MeV.

4) FIRESTONE 71 [see $K_N(1370)$] and 72, using 12 GeV/c $K^+n \to K^+\pi^-p$, have continued Kπ partial wave analysis up to 1700 MeV. They find that $\delta_0^1$ crosses 90° just below the $K^*(1420, 2^+)$, and, indeed, near 1420 MeV, shows the "up-down" ambiguity mentioned above. Their unique solutions are plotted as solid crosses, their ambiguous ones as pairs of dashed crosses joined by dashed vertical lines. They have drawn, and we copy, some of the many possible paths connecting the ambiguous solutions.

As in the ππ case, the large, slowly varying Kπ phase shift would correspond to a κ pole with a large width and a location which may be far from the 90° point.

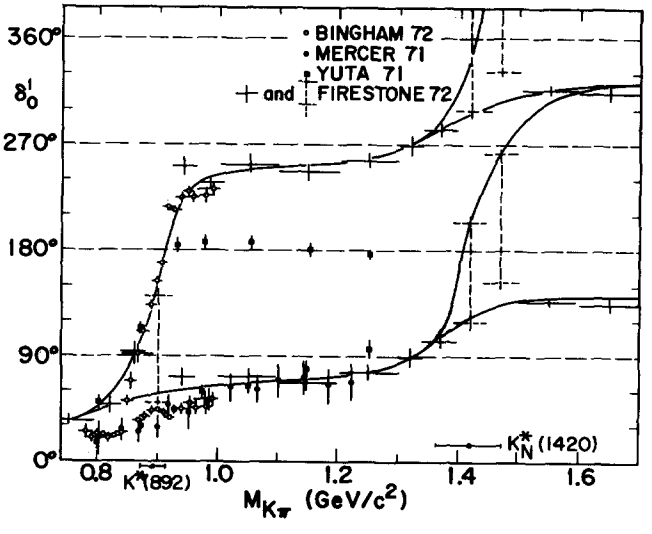
For readers who are unfamiliar with the origin of the "up-down" ambiguity, we present a brief sketch, in terms of the multiple branches near the D-wave $K^*(1420)$ shown in Fig. 1. In this mass region we consider only $S_{1/2}$ and $D_{1/2}$ waves; then

$$\sigma \propto |S|^2 + 5|D|^2, \quad \langle Y_1 \rangle = \langle Y_3 \rangle = 0,$$

and

$$\sigma\langle Y_2 \rangle \propto 4.5\, \mathrm{Re}\, S^* D + 3.2\, |D|^2, \quad \sigma\langle Y_4 \rangle \propto |D|^2 .$$

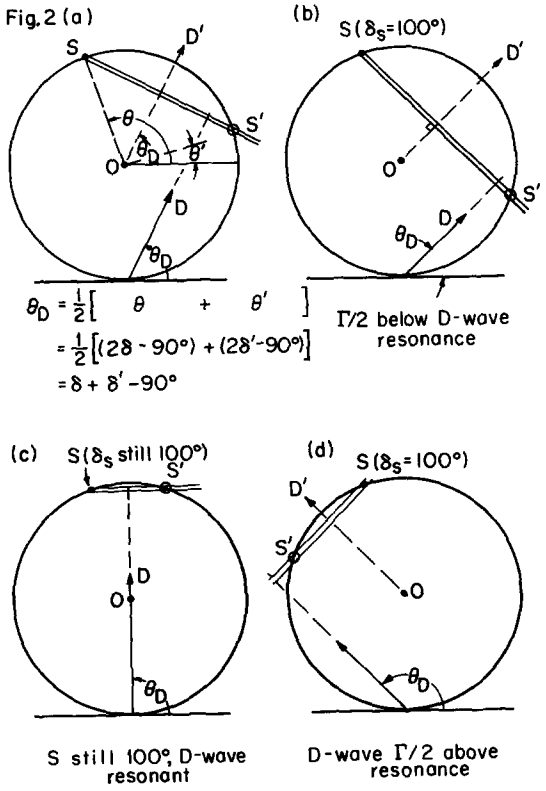
Suppose one takes D as a known resonant amplitude, and solves for S, using only the un-normalized moments $\sigma\langle Y_2 \rangle$ and $\sigma\langle Y_4 \rangle$. S enters only in $\langle Y_2 \rangle$ and only then in the form $\mathrm{Re}\, S^* D = SD \cos\theta_{SD} \equiv \underline{S} \cdot \underline{D}$.

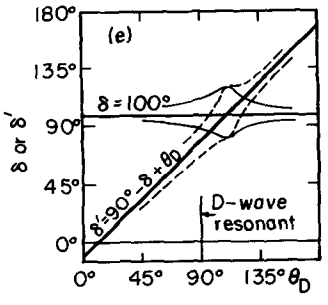


## $\kappa$, $K_{A,I=3/2}(1175)$, $K_{A,I=3/2}(1265)$, Q

This situation is sketched in Fig. 2. A constant "real" S ( $\approx 100°$ according to FIRESTONE 72) is plotted as a fixed black dot, the ambiguous moving solution S' as an open circle. Lines of constant $\underline{S}\cdot\underline{D}$ lie on a perpendicular to D, running through the "real" S. The general case is plotted in Fig. 2(a). Consider the dashed line OD' parallel to D, drawn from the center of the unitary circle. One can see by inspection that OD' is the bisector of the angle SOS', so the angle $\theta_D$ of OD' is the average of the angles $\theta$ and $\theta'$, which S and S' subtend from the center of the circle with respect to the horizontal. This leads to the well-known result

$$\delta' = 90° - \delta + \theta_D. \qquad (1)$$




Figures 2(b), (c), and (d) show that as D moves through resonance, S' also moves counterclockwise and crosses S near resonance. Moreover, at this crossing point the perpendicular to D is tangent to the unitary circle, so that $\delta$ and $\delta'$ are insensitive to $\underline{S}\cdot\underline{D}$ and so are badly determined.

Figure 2(e) displays $\delta'$ vs $\theta_D$ according to (1) for a constant "real" $\delta$ of 100°. The errors are plotted assuming a typical error in $\langle Y_2 \rangle$ of $\pm$ 0.02.

Far from the D-wave resonance, the data on $\sigma \propto |S|^2 + 5|D|^2$ can sometimes resolve the ambiguity.

REFERENCES

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)

ASTIER 70 KIEV CONF. RAPP.TALK ON BOSON RESONANCES (CDF)

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)

BINGHAM 72 NP B + (INTERNATIONAL K+ COLLABORATION)
FIRESTON 72 LBL 516, SUBM. PR +GOLDHABER, LISSAUER, TRILLING (LBL)PWA

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### $K_{A,I=3/2}(1175)$

24 KA 3/2 (1175,JP= ) I = 3/2

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE. FOR A DISCUSSION SEE ROSENFELD 68 AND GIACOMELLI 70 WHO CONCLUDES THAT IF THIS STATE HAS WIDTH NOT LARGER THAN 100 MEV, THEN ITS PRODUCTION CROSS SECTION IS 1 OR 2 ORDERS OF MAGNITUDE SMALLER THAN THAT OF NON-EXOTIC K*S.

REFERENCES ON KA3/2(1175)

WANGLER 64 PL 9 71 T P WANGLER,A R ERWIN,W D WALKER (WISCONS)
MILLER 65 PL 15 74 MILLER,KOVACS,MCILWAIN,PALFREY + (PURDUE)
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)
GIACOMELLI 70 PL 33 B 373 G.GIACOMELLI + (BGNA+SACL+ZEEM+REHO+EPOL)

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### $K_{A,I=3/2}(1265)$

25 KA 3/2 (1265,JP= ) I = 3/2

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE. FOR A DISCUSSION SEE ROSENFELD 68.

REFERENCES ON K*3/2 (1265)

FRENCH 67 NC 52A 442 +KINSON+MCDONALD+RIDDIFORD+ (CERN+BIRM)
ROSENFEL 68 PHILA.CONF.P.455 A.H.ROSENFELD (LRL)
CHO 70 PL 32 B 409 +DERRICK,JOHNSON,MUSGRAVE,+ (ANL+NWES+KANS)

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### Q REGION, $K\pi\pi(1240-1400)$

28 Q REGION I=1/2

There is a peak in the $K^*\pi$ spectrum centered at about 1300 MeV, or just about 270 MeV above $K^*\pi$ threshold. The $Q(\rightarrow K^*\pi)$ may be a hypercharge = 1 analog of the $A_1$ ($\rightarrow \rho\pi$).

However, in the case of the Q region, there are two additional complications:

1) The $K^*_A(1240)$ or "C" meson, with width only 120 MeV, seems to be produced nondiffractively in $\bar{p}p$ capture at rest.

2) The Q peak in the $K\pi\pi$ mass distribution does not have a simple Breit-Wigner shape (FIRESTONE 70 and private communication from V. Henri, LBL).

It can be fitted by two Breit-Wigner shapes (5 parameter fit) at all energies with reasonable $\chi^2$ (FIRESTONE 70).

The dominant $J^P$ assignment throughout the Q region is $1^+$. $K^*\pi$ is the dominant decay mode. While there is $K\rho$ and interference between $K^*\pi$ and $K\rho$, there is no evidence for other decay modes. BARNHAM 70 give evidence that the $K\rho$ and $K^*\pi$ $J^P = 1^+$ amplitudes vary at different rates, and therefore suggest that there are <u>two</u> $1^+$ resonances here. From the coherent production of Q in $K^-d$ experiments, I = 1/2 is confirmed.

For a recent review see SLATTERY 71.

FORMAT OF THE CARDS AND IDEOGRAMS BELOW: Because of the evidence that the Q region covers more than one phenomenon, the data cards are arranged not in our usual chronological sequence, but by <u>increasing mass</u>.

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                    28  Q REGION MASSES (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    A       ERRORS OF ASTIER 69 ARE STATISTICAL. TRUE UNCERTAINTY IS LARGER
M       45(1300.)                        CRENNELL   67 HBC     0 6 PI- P,LK2PI     7/67
M
M    PRODUCED BY K BEAMS
M    C      (1230.0)    (15.0)           BASSOMPIE  67 HBC  +   5. K+ P          11/67
M    C      (1240.0)     (5.0)           BARNHAM    70 HBC  +  10.0 K+P,K 2PI      5/71*
M    C      (1243.)      (8.)            GARFINKEL  71 DBC  +  9. K+ D            11/71*
M    C      (1260.0)    (10.0)           ALEXANDER  69 HBC      9.0 K+ P           5/70
M           1260.        20.             FARBER     70 HBC  +   12.7 K+ P         6/70
M          (1270.)    APPROX.            DE BAERE   67 HBC  +   3.5 K+ P           7/67
M    C      (1280.)                      SHEN       66 HBC  + 0 4.6 K+P,5 BODY    11/67
M    C   35(1280.0)    (10.0)           BASSOMPIE  67 HBC  +   5. K+ P          11/67
M           1281.        7.              FRIEDMAN   69 HBC  --  2.6,2.7 K- P   . 9/69
M       21 1300.0       10.0             ERWIN      69 HBC    0 3.5 K+P(K* PI)    9/69
M           1300.0      10.0             ABRAMS     70 HBC  +   2.5-3.2 K+ P     11/70
M       45 1301.0       10.0             BISHOP     69 HBC  +   3.5 K+P(K* PI)    9/69
M          (1300.)    APPROX.            BARBARO    69 HBC  +   12.K+ P (K 2PI)   9/69
M       12 1320.0       25.0             ALMEIDA    65 HBC  +   3-5 K+  P          8/66
M    C  70(1320.0)    (10.0)             SHEN       66 HBC  +   4.6 K+  P          8/66
M    C      (1320.0)    (15.0)           BASSOMPIE  67 HBC  +   5. K+ P          11/67
M           (1325.0)                     DENEGRI    71 DBC   - 12.6 K-D,K 2PI D   5/71*
M           1335.0       6.0             BARTSCH    68 HBC     10. K-P,K NPI   . 9/69
M    C      (1344.)      (8.)            GARFINKEL  71 DBC  +  9. K+ D            11/71*
M    C      (1380.0)    (20.0)           ALEXANDER  69 HBC      9.0 K+ P           5/70
M    C      (1420.0)     (5.0)           BARNHAM    70 HBC  +  10.0 K+P,K 2PI      5/71*
M    C       SPLIT THE Q REGION INTO SEVERAL PEAKS. NOT AVERAGED.
M            . . . . . . . . .
M    AVG    1298.8       11.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.4)
                          (SEE IDEOGRAM BELOW )
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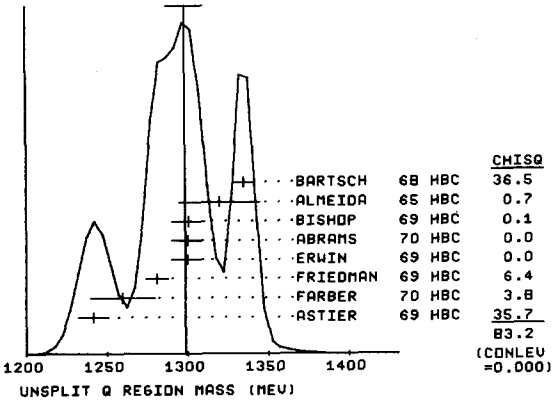
WEIGHTED AVERAGE = 1298.8 ± 11.3
ERROR SCALED BY 3.4

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                    28  Q REGION WIDTHS (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    A       ERRORS OF ASTIER 69 ARE STATISTICAL. TRUE UNCERTAINTY IS LARGER
W       45  (60.)                       CRENNELL   67 HBC     0 6 PI- P           7/67
W
W    PRODUCED BY K BEAMS
W    M=1230                               BASSOMPIE  67
W    C      (60.0)      (20.0)           BASSOMPIE  67 HBC  +   5. K+ P          11/67
W    M=1240                               BARNHAM    70
W    C      (110.0)     (15.0)           BARNHAM    70 HBC  +  10.0 K+P,K 2PI      5/71*
W    M=1243                               GARFINKEL  71
W    C      (70.)       (26.)    (18.)   GARFINKEL  71 DBC  +  9. K+ D            11/71*
W    M=1260                               ALEXANDER  69
W    C      (40.0)      (10.0)           ALEXANDER  69 HBC      9.0 K+ P           5/70
W    M=1260                               FARBER     70
W           180.         28.             FARBER     70 HBC  +   12.7 K+ P         6/70
W    M=1270 APPROX.                       DE BAERE   67
W           (200.)     APPROX.            DE BAERE   67 HBC  +  3.5 K+ P           7/67
W    M=1280                               SHEN       66
W    C      (100.0)     (20.0)           SHEN       66 HBC  + 0 4.6 K+P,5 BODY    11/67
W    M=1280                               BASSOMPIE  67
W    C   35 (80.0)      (20.0)           BASSOMPIE  67 HBC  +   5. K+ P          11/67
W    M=1281                               FRIEDMAN   69
W            51.         22.             FRIEDMAN   69 HBC   -  2.6,2.7 K- P      9/69
W    M=1300                               ERWIN      69
W       21   40.0        15.0             ERWIN      69 HBC    0 3.5 K+P(K* PI)    9/69
W    M=1300                               ABRAMS     70
W            80.0        20.0             ABRAMS     70 HBC  +   2.5-3.2 K+ P     11/70
W    M=1301                               BISHOP     69
W       45   40.0        10.0             BISHOP     69 HBC  +   3.5 K+P(K* PI)    9/69
W    M=1300 APPROX.                       BARBARO    69
W    B       250. APPROX.                 BARBARO    69 HBC  +   12.K+ P (K 2PI)   9/69
W    B       NO BACKGROUND SUBTRACTION.
W    M=1320                               ALMEIDA    65
W       12   60.0        20.0             ALMEIDA    65 HBC  +   3-5 K+P           8/66
W    M=1320                               SHEN       66
W    C   70 (80.0)      (20.0)           SHEN       66 HBC  +   4.6 K+P           8/66
W    M=1320                               BASSOMPIE  67
W    C      (60.0)      (20.0)           BASSOMPIE  67 HBC  +   5. K+ P          11/67
W    M=1325                               DENEGRI    71
W           (180.0)                      DENEGRI    71 DBC   - 12.6 K-D,K 2PI D   5/71*
W    M=1325                               BARTSCH    68
W            196.0       16.0             BARTSCH    68 HBC     10. K- P,K NPI   . 9/69
W    M=1344                               GARFINKEL  71
W    C      (60.)      OR LESS            GARFINKEL  71 DBC  +  9. K+ D            11/71*
W    M=1380                               ALEXANDER  69
W    C      (120.0)     (20.0)           ALEXANDER  69 HBC      9.0 K+ P           5/70
W    M=1420                               BARNHAM    70
W    C      (120.0)     (15.0)           BARNHAM    70 HBC  +  10.0 K+P,K 2PI      5/71*
W    C       SPLIT THE Q REGION INTO SEVERAL PEAKS. NOT AVERAGED.
W            . . . . . . . . .
W    AVG     82.5        21.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.8)
                          (SEE IDEOGRAM BELOW )
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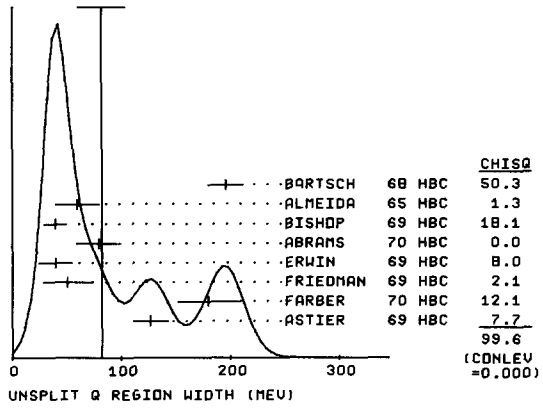
WEIGHTED AVERAGE = 82.5 ± 21.6
ERROR SCALED BY 3.8

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                    28  Q REGION PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          Q REGION INTO K*(890) PI                     493+ 139+ 139
P2          Q REGION INTO K RHO                          493+ 139+ 139
P3          Q REGION INTO K PI                           493+ 139+ 139
P4          Q REGION INTO K ETA                          493+ 139+ 139
P5          Q REGION INTO K OMEGA                        493+ 139+ 139
P6          Q REGION INTO K PI PI                        493+ 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
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
R9          Q REGION INTO (K+ PI-) / (K+0 PI0+ PI-)
R9          (0.2)  OR LESS  CL=.90    CRENNELL  67 HBC    0 6.0 PI-P            7/67
R10         Q REGION INTO (K0 PI+ PI- PI0) / (K+0 PI0+ PI-)
R10         (0.1)  OR LESS  CL=.90    CRENNELL  67 HBC    0 6.0 PI-P            7/67
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    PRODUCED BY K BEAMS
R1          Q REGION PEAK INTO (K PI) / (K*(890) PI)      (P3)/(P1)
R1            (0.8)  OR LESS              SHEN      66 HBC     4.6 K+P, 5 BODY  11/67
R1          Q REGION PEAK INTO K*(890) PI AND K RHO (OVERLAPPING BANDS)(P1+P
R1       70   (1.0)                       SHEN      66 HBC  +   4.6 K+P          8/66
R2          Q REGION PEAK INTO (K OMEGA)/(K*(890) PI)     (P5)/(P1)
R2            (0.1)  OR LESS              SHEN      66 HBC  +   4.6 K+P         10/66
R8          Q REGION PEAK INTO (K PI) / (K*(890) PI)      (P3)/(P1)
R8            (0.30) OR LESS              SHEN      66 HBC  +   4.6 K+P         10/66
R1  A       Q REGION INTO K*(890) PI AND K RHO (OVERLAPPING BANDS) (P1+P2)
R1     200    (1.0)                      BERLINGHI 67 HBC  +   12.7 K+ P         7/67
R2  A       Q REGION INTO (K PI) / TOTAL                  (P3)
R2            (0.02) OR LESS              BERLINGHI 67 HBC  +   12.7 K+ P        11/67
R2            (0.02) OR LESS  CL=.95      BARTSCH   68 HBC   - 10.0 K- P
R3          Q REGION INTO (K ETA) / TOTAL                 (P4)
R3            (0.02) OR LESS              BERLINGHI 67 HBC  +   12.7 K+ P        11/67
R4          Q REGION INTO (K OMEGA) / TOTAL               (P5)
R4            (0.02) OR LESS              BERLINGHI 67 HBC  +   12.7 K+ P        11/67
R5          Q REGION INTO (K RHO) / (K*(890) PI)          (P2)/(P1)
R4      12    0.01      0.005             BARTSCH   68 HBC   -  10.0 K- P         9/68
R5            0.91      0.25              BERLINGHI 67 HBC  +   12.7 K+ P        11/67
R5     701    0.4       0.1               BARTSCH   68 HBC   - 10.0 K- P          9/68
R5          . . . . . . . . .
R5  AVG       0.47      0.18    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R6          Q REGION INTO (K PI) / (K*(890) PI)           (P3)/(P1)
R6            (0.21) OR LESS              DE BAERE  67 HBC  +   3.5 K+ P        11/66
R7          Q REGION INTO (K PI PI) / TOTAL               (P5)
R7     201    0.22      0.08              BARTSCH   68 HBC   - 10.0 K- P          9/68
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                          REFERENCES FOR Q REGION

       PRODUCED BY BEAMS OTHER THAN K MESONS

ARMENTER 64 DUBNA CONF 1 577  R ARMENTEROS,EDWARDS,D-ANDLAU +     (CERN+CDF)
                        SEE ALSO PL 9, 207
    ALSO    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+(CAMBR)

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)
   AND PRIVATE COMMUNICATION BY B. JONGEJANS

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)
COLLEY   69 NC A 59 519       +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
WERNER   69 PR 188 2023       +AMMAR,DAVIS,KROPAC,YARGER,CHO,+ (NWES+ANL) 1+
BISHOP   69 NP B 9 403        +GOSHAW,ERWIN,WALKER                   (WISC)
ERWIN    69 NP B 9 364        +WALKER,GOSHAW,WEINBERG     (WISC+PRIN+VAND)
FRIEDMAN 69  UCRL-18860       J.FRIEDMAN,PH.D. THESIS                (LRL)
CHIEN    69 PL 29B 433        +MALAMUD,MELLEMA,RUDNICK,SCHLEIN+    (UCLA)
CHUNG    69 PR 182 1443       +EISNER+BALI+LUERS                     (BNL)
WERNER   69 PR 188 2023       +AMMAR,DAVIS,KROPAC,YARGER,CHO+   NWES+ANL

ABRAMS   70 PR D 1 2433       +EISENSTEIN,KIM,MARSHALL,O-HALLORAN,+ (ILL)
ANTICH   70 NP B 20 201       +CARSON,CHIEN,COX,DENEGRI,ETTLINGER,+ (JHU)  1+
BOWLER   70 PL 31 B 318       M.G.BOWLER                           (OXFORD)
FARBER   70 PR D 1 78         +FERBEL,SLATTERY,YUTA                  (ROCH)  1+
FIRESTON 70 PHILAD.CONF.P.229 A. FIRESTONE REVIEW                    (LRL)
BARNHAM  70 NP B 25 49        +COLLEY,GRIFFITHS,ALPER,+   (BIRM+GLAS+OXF)  1+

DENEGRI  71 NP B 28 13        +ANTICH,CALLAHAN,CARSON,CHIEN,COX,+  (JHOP)  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)

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## $K_N(1370)$

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21  KN (1370,JP=  )

NEEDS FURTHER CONFIRMATION TO BE REGARDED
AS WELL ESTABLISHED. OMITTED FROM THE TABLE.
                JP=0+ FAVORED, THIS INTERPRETATION PLOTTED IN
                KAPPA MINIREVIEW.   1-,2+ NOT RULED OUT.
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                    21  KN (1370)  MASS (MEV)

M  E      (1370.)   APPROX.            FIRESTONE 71 DBC   0 12. K+ N,K+PI- P  2/72*
M  E    EVIDENCE BASED ON A SHARP CHANGE OF THE (K PI) ANGULAR
M  E    DISTRIBUTION AT 1400 MEV.
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                    21  KN (1370) WIDTH (MEV)

W  E      (150.)    OR LESS            FIRESTONE 71 DBC   0 12. K+ N,K+PI- P  2/72*
****** ********* ********* ********* ********* ********* ********* ********

                          REFERENCES FOR KN(1370)

FIRESTON 71 PRL 26 1460       FIRESTONE,GOLDHABER,LISSAUER           (LRL)

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## $K_N(1420)$

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22  KN (1420,JP=2+) I=1/2

JP = 3- IS UNLIKELY BUT NOT YET COMPLETELY RULED OUT.
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                    22  KN(1420) MASS (MEV)

M   FOR DIFFICULTIES IN MEASURING MASS DIFFERENCE, SEE TYPED NOTE UNDER K*

M   CHARGED ONLY, WITH FINAL STATE K PI
M          1440.      24.0     40.    DE BAERE  67 HBC  +  3.5 K+P (K+ PI0) 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          . . . . . . . . .
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   B  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)

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)    10/66
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          . . . . . . . . .
M   AVG    1421.3      2.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                              (SEE IDEOGRAM BELOW )
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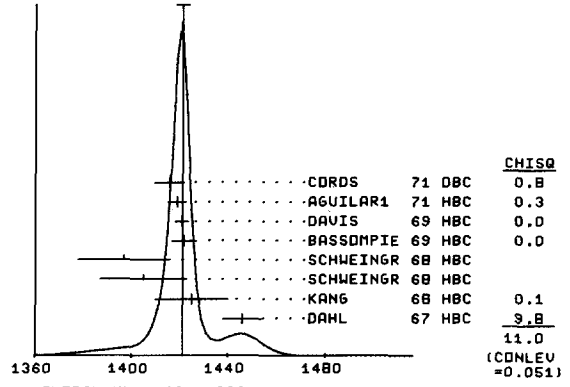
WEIGHTED AVERAGE = 1421.3 ± 2.6
ERROR SCALED BY 1.5

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                    22  KN(1420) WIDTH (MEV)

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,KO PI+ P      1/72*
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)
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W   NEUTRAL ONLY
W          61.0      24.0                 DAHL       67 HBC    0 3.8-4.2 PI- P    9/66
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 BASSOMP. ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K* TYPED NOTE.  11/69
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           . . . . . . . . .
W   AVG    108.3      7.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
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                22  KN (1420) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1         KN(1420) INTO K PI                            493+ 139
P2         KN(1420) INTO K*(890) PI                      891+ 139
P3         KN(1420) INTO K RHO                           493+ 765
P4         KN(1420) INTO K OMEGA                         493+ 783
P5         KN(1420) INTO K ETA                           493+ 548

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                22  KN(1420) BRANCHING RATIOS

R1        KN(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        0.563    0.030   FROM FIT

R2        KN(1420) INTO (K*(890) 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        0.278    0.027   FROM FIT

R3        KN(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        0.095    0.025   FROM FIT

R4        KN(1420) INTO (K OMEGA)/TOTAL                    (P4)
R4             0.07     0.04           BADIER     65 HBC      3.0 K-P          6/66
R4            . . . . . . . . .
R4  FIT        0.045    0.017   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R5        KN(1420) INTO (K ETA)/TOTAL                      (P5)
R5             0.02     0.02           BADIER     65 HBC      3.0 K-P          6/66
R5            . . . . . . . . .
R5  FIT        0.020    0.020   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)
R 5           (0.025)OR LESS           BASSOMPIE 69 HBC       5.0 K+ P         9/68

R6        KN(1420) INTO (K*(890) 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  Q         (0.9)    (0.2)           BASSOMPIE 69 HBC    + 0 5 K+P           9/69
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            . . . . . . . . .
R6  AVG        0.496    0.062    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  FIT        0.494    0.062   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R7        KN(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        KN(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        KN(1420) INTO (K RHO) / (K*(890) 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        0.34     0.11    FROM FIT

R10       KN(1420) INTO (K OMEGA) / (K*(890) PI)           (P4)/(P2)
R10 O         (0.10)   (0.04)          FIELD      67 HBC    - 3.8 K- P         6/67
R10           . . . . . . . . .
R10 FIT        0.162    0.066   FROM FIT

R11       KN(1420) INTO (K ETA) / (K*(890) PI)             (P5)/(P2)
R11 Q         (0.07)   (0.04)          FIELD      67 HBC    - 3.8 K- P         6/67
R11           . . . . . . . . .
R11 FIT        0.071    0.074   FROM FIT

R12       KN(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        0.035    0.036   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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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 .563+-.030
P 2   -.332    .278+-.027
P 3   -.367      -.374    .095+-.025
P 4   -.226      -.233      -.118    .045+-.017
P 5   -.388      -.210      -.079      -.050    .020+-.020
```

Warning: Kπ mode may be overestimated. See footnote (o) of Meson Table.

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                         REFERENCES FOR KN(1420)

BADIER    65 PL 19 612          BADIER,DEMOULIN,GOLDBERG+ (EP+SACLY+ZEEMAN)
CHUNG     65 PRL  15  325       +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER    (LRL)
FOCARDI   65 PL 16 351          FOCARDI,MINGUZZI RANZI,SERRA+ (BOLOGNA+CEN)

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+I.C.+VIENNA)
    ALSO 66 PL 22 357           BARTSCH,DEUTSCHMANN,MORRISON+   (ABCL(IC)V)
ANTICH    68 PRL 21 1842       +CALLAHAN,CARSON,COX,DENEGRI,+         (JHOP)
DUBAL     68 THESIS   1456      L.DUBAL                             (GENEVE)
KANG      68 PR 176 1587        Y.W.KANG                              (IOWA)
SCHWEING  68 PR 166 1317        SCHWEINGRUBER,DERRICK,FIELDS,AMMAR+(ANL+NW)
   ALSO  67  THESIS             F.L.SCHWEINGRUBER   (NORTHWESTERN,EVANSTON)

BASSOMPI  69 NP  B13 189        BASSOMPIERE,GOLDSCHMIDT-CLERM.+ (CERN+BRUX) JP
    ALSO 69 DE BAERE
    ALSO 70 DE BAERE
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)
    ALSO 70 DE BAERE
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,+ (I66)
AGUILAR   70 PRL 25 1362        AGUILAR-BENITEZ,BASSANO,EISNER,+ (BNL+PURD)
BIRMINGH  70  KIEV CONF.        ASTIER RAPPORTEURS TALK      (BIRM+GLAS+OXF)
CHARRIER  70  CERN PHYS 70-50  CHARRIERE,DRIJARD,DUNWOODIE,+    (LHEB+CERN)
DE BAERE  70  CERN PHYS 70 41  +DEBAISIEUX,DE WOLF,DUFOUR,+      (LHEB+CERN)

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)

DEUTSCHM  72 NP B 36 373        DEUTSCHMANN,+            (ABCLV COLLABORATION)
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## $K_N(1660)$

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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*(890) PI), AND (K*(1420) PI)
M     J    MODES. K PI BUMP INTERFERES MOSTLY WITH DELTA(1236).

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             27  KN (1660) WIDTH (MEV)

W            60.0      20.0          JOBES     67 HBC   +   5. K+ P          11/67

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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*(890) PI                        891+ 139
P4      KN*(1660) INTO KN*(1430) 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)
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## $K_N(1760)$

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             60  KN(1760)

             NEEDS FURTHER CONFIRMATION.OMITTED FROM THE TABLE.
             FAVORED JP IS 3- , I=1/2 .

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             60  KN(1760) MASS  (MEV)

M    C   76(1753.)    (12.)            CARMONY   71 DBC    0 9. K+ N          11/71*

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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*

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## $K_N(1760)$, $L(1770)$, $K_N(1850)$, $K^*(2200)$, $K^*(2800)$

*For notation, see key at front of Listings.*

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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*(890) PI                          891+ 139
P3      KN(1760) INTO K RHO                               493+ 765
P4      KN(1760) INTO KN(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*(890) PI + K RHO)        (P1)/(P2+P3)
R1  E        (0.40)   (0.10)          CARMONY   71 DBC    0 9. K+ N        11/71*

R2      KN(1760) INTO (K*(890) 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*(890) PI + K RHO)/(K PI PI)     (P2+P3)/(P5)
R4  E        (1.)     (0.12)          CARMONY   71 DBC    0 9. K+ N        11/71*

R5      KN(1760) INTO (KN(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)

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## $L(1770)$

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                    23   L (1770, JP=  )  I = 1/2

                    FOR REVIEWS SEE HUGHES 71,SLATTERY 71 .

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                    23  L (1770) 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        11/67
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   C     (1753.0)   (10.0)         BIRMINGH. 70 HBC  +  10.K+P,K(1420)PI 11/71*
M   C     (1773.0)   (20.0)         BIRMINGH. 70 HBC  +  10.K+P,K* 2PI    11/71*
M          1760.0     15.0          LUDLAM    70 HBC  -   12.6 K- P        1/71
M   C   BIRMINGH. 70 SUPERSEDED BY COLLEY 71                               11/71*
M   C     (1761.0)   (10.0)         COLLEY    71 HBC  +  10.K+P,K 2PI    .11/71*
M         (1740.0)                  DENEGRI   71 DBC  - 12.6 K-D,K 2PI D  5/71*
M          . . . . . . . . .
M   AVG    1763.2      7.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    23  L (1770) 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        11/67
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   C     (174.0)   (23.0)   (18.0) BIRMINGH. 70 HBC  +  10.K+P,K(1420)PI 11/71*
W   C     (155.0)   (22.0)         BIRMINGH. 70 HBC  +  10.K+P,K* 2PI    11/71*
W           50.0      40.0     20.0 LUDLAM    70 HBC  -   12.6 K- P        1/71
W   C   BIRMINGH. 70 SUPERSEDED BY COLLEY 71                               11/71*
W   C      (91.)     (12.)          COLLEY    71 HBC  +  10.K+P,K 2PI    .11/71*
W         (130.0)                  DENEGRI   71 DBC  - 12.6 K-D,K 2PI D  5/71*
W          . . . . . . . . .
W   AVG     71.6      16.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                    23  L (1770) 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*(890) PI                                 891+ 134
P5      L INTO K*(890) RHO                                891+ 765
P6      L INTO K*(890) OMEGA                              891+ 783
P7      L INTO K*(890) PI PI                              891+ 134+ 134

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                    23  L (1770) 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  -    0.6 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   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+   (JOHNSHOP)
BARTSCH  68 NP B8 9            +COCCONI,+       (AACH+BERL+CERN+LOIC+VIEN)

ANDREWS  69 PRL 22 731         +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
BARBARO  69 PRL 22 1207        BARBARO-GALTIERI,DAVIS,FLATTE,+      (LRL)
COLLEY   69 NC A 59 519        +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)
AGUILAR  70 PRL 25 54          AGUILAR-BENITEZ,BARNES,BASSANO,CHUNG,+(BNL)
BARTSCH  70 PL 33 B 186        +DEUTSCHMANN,+   (AACH+BERL+CERN+LOIC+VIEN)
BIRMINGH 70  PREPRINT          BIRMINGHAM GLASGOW COLL.        (BIRM+GLAS)
CHARRIER 70  CERN PHYS 70-50   CHARRIERE,GOLDSCHMIDT-C,DEBAERE+(CERN+BRUX)
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,+  (JHOP)  JP
HUGHES   71  PREPRINT          I.S.HUGHES,TALK AT BOLOGNA CONF.  (GLASGOW)
SLATTERY 71  UR-875-332(PREP)  P.SLATTERY,A REVIEW OF STRANGE MESONS(ROCH)

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## $K_N(1850)$

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                    61  KN(1850)

                    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)

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## $K^*(2200)$

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                    40  K*(2200)

                    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        +CORDS,CLOPP,ERWIN,MEIERE,+  (PURD+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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                    52  K*(2800)

                    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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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 m of the derivative $|dT/dm|$ of a partial-wave amplitude T. (See section IV C 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/dm are sensitive to variations in T. It is difficult enough to determine T(m); 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 $|dT/dm|_{m=M} = 2x/\Gamma$.

Consider for example the $P_{33}$ partial-wave amplitude in $\pi$-N scattering. Since its elasticity (x) is one, we have

$$T(m) = \frac{\Gamma(m)/2}{M-m-i\Gamma(m)/2} \quad . \qquad (1)$$

If we let $\Gamma'(m) = d\Gamma/dm$, then we find that

$$\text{"Speed"} = \left|\frac{dT}{dm}\right| = \frac{2}{\Gamma}\,\frac{1+(M-m)\Gamma'/\Gamma}{1+4(M-m)^2/\Gamma^2} \quad . \qquad (2)$$

To estimate where Eq. (2) is maximum, we let $\delta = M-m$ ($|\delta| < \Gamma/2$) and keep only linear terms in $\delta$. Thus

$$\left|\frac{dT}{dm}\right| \approx \frac{2}{\Gamma}\left(1+\delta\frac{\Gamma'}{\Gamma}\right). \qquad (3)$$

Since all reasonable parametrizations of $\Gamma(m)$ agree that $\Gamma' \geq 0$, we may conclude that to first order the "speed" will have its maximum value at an energy less than the resonant value, m=M.

This effect is illustrated in Fig. 1, which is taken from UCRL-20030 $\pi$N.[1] For the $P_{33}$ partial wave, the CERN experimental and CERN Kirsopp solutions indicate the instability of $|dT/dm|$ 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

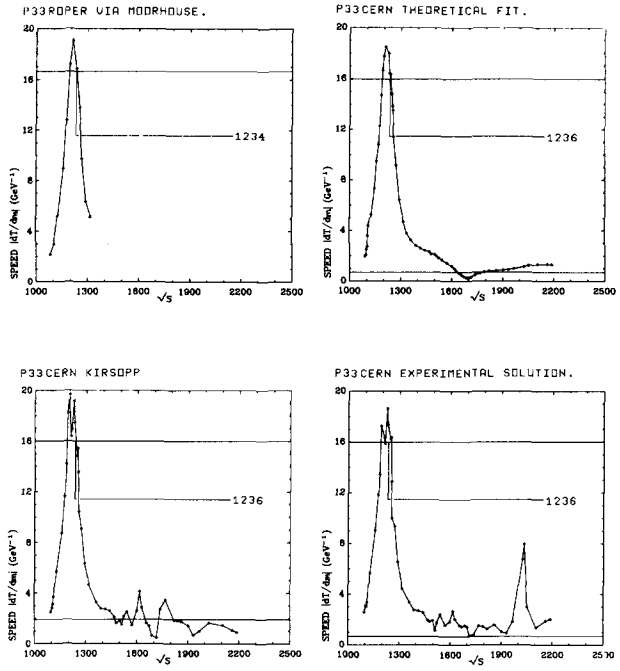


Fig 1. Speed plots as computed from four solutions compiled in Ref. 1. ($\sqrt{S}$ = m = c. m. energy in MeV)

and width of the 33-resonance from the maximum speed, we would get M ≈ 1220 MeV and Γ = 108 MeV. For additional discussion on the mass and width of this resonance, see the mini-review at the beginning of the Δ(1236) listings.

Reference

1. D. Herndon, et al., "πN Partial-Wave Amplitudes, a Compilation," UCRL-20030 πN, Feb. 1970.

Note on N's and Δ's

Recent Partial-Wave Analyses

There now exist two complete partial-wave analyses performed after the beginning of 1970. The earlier analysis, AYED 70, is an update of the previous Saclay analyses. These are essentially energy-independent solutions selected on the basis of various energy "smoothness" criteria. The more recent analysis, ALMEHED 72, is a continuation of the "CERN group" program, which uses "smoothness" criteria supplemented by constraints from partial-wave dispersion relations. For a discussion of earlier partial-wave analyses see Refs. 1 and 2.

For the purposes of comparison, we show Argand plots of the solutions in Figs. 1 and 2. The tick

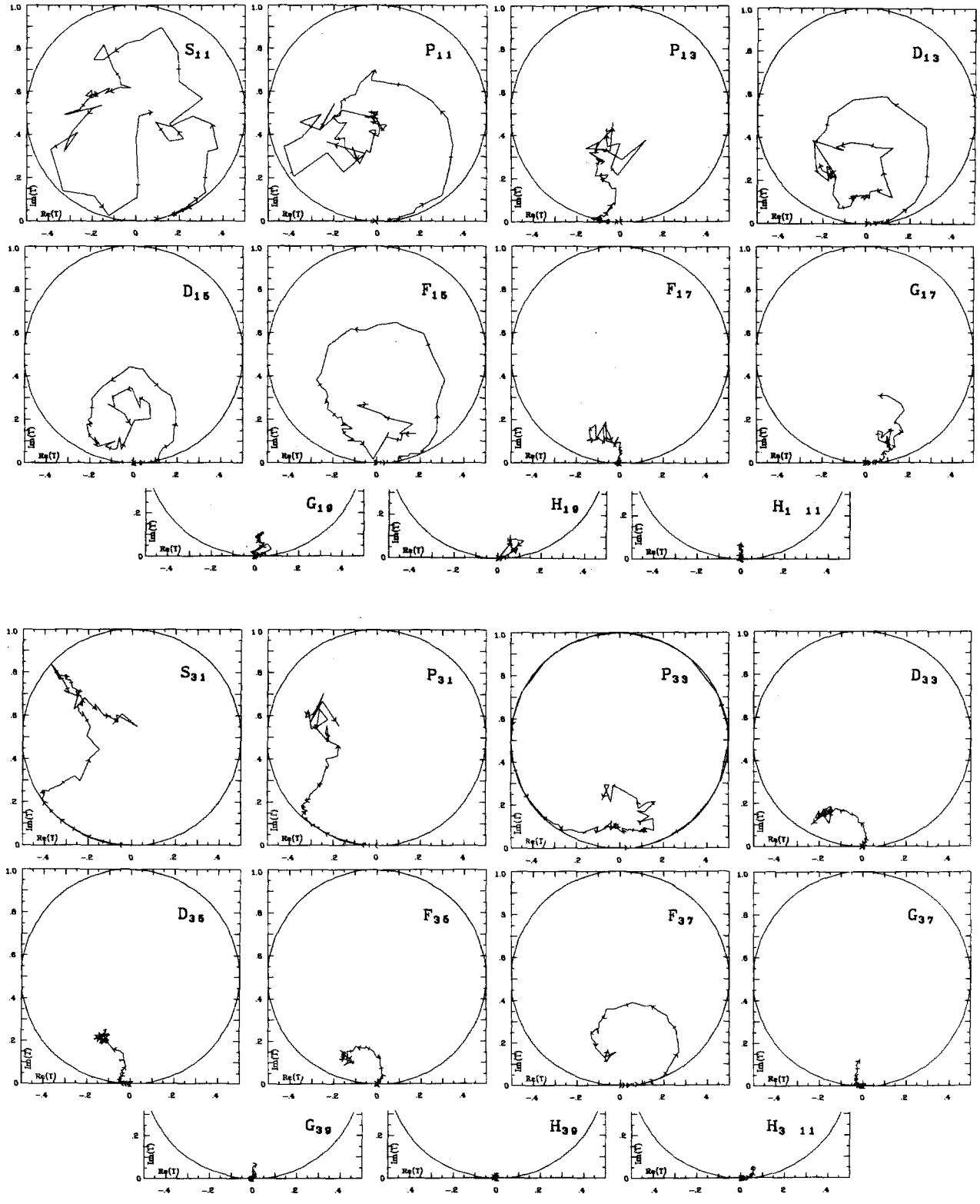


Fig. 1. πN Argand plots from the solution of ALMEHED 72. Arrowheads and tick marks are at 50-MeV intervals. The last arrowhead is at 2200 MeV; the sense of increasing energy is indicated by the arrowheads.

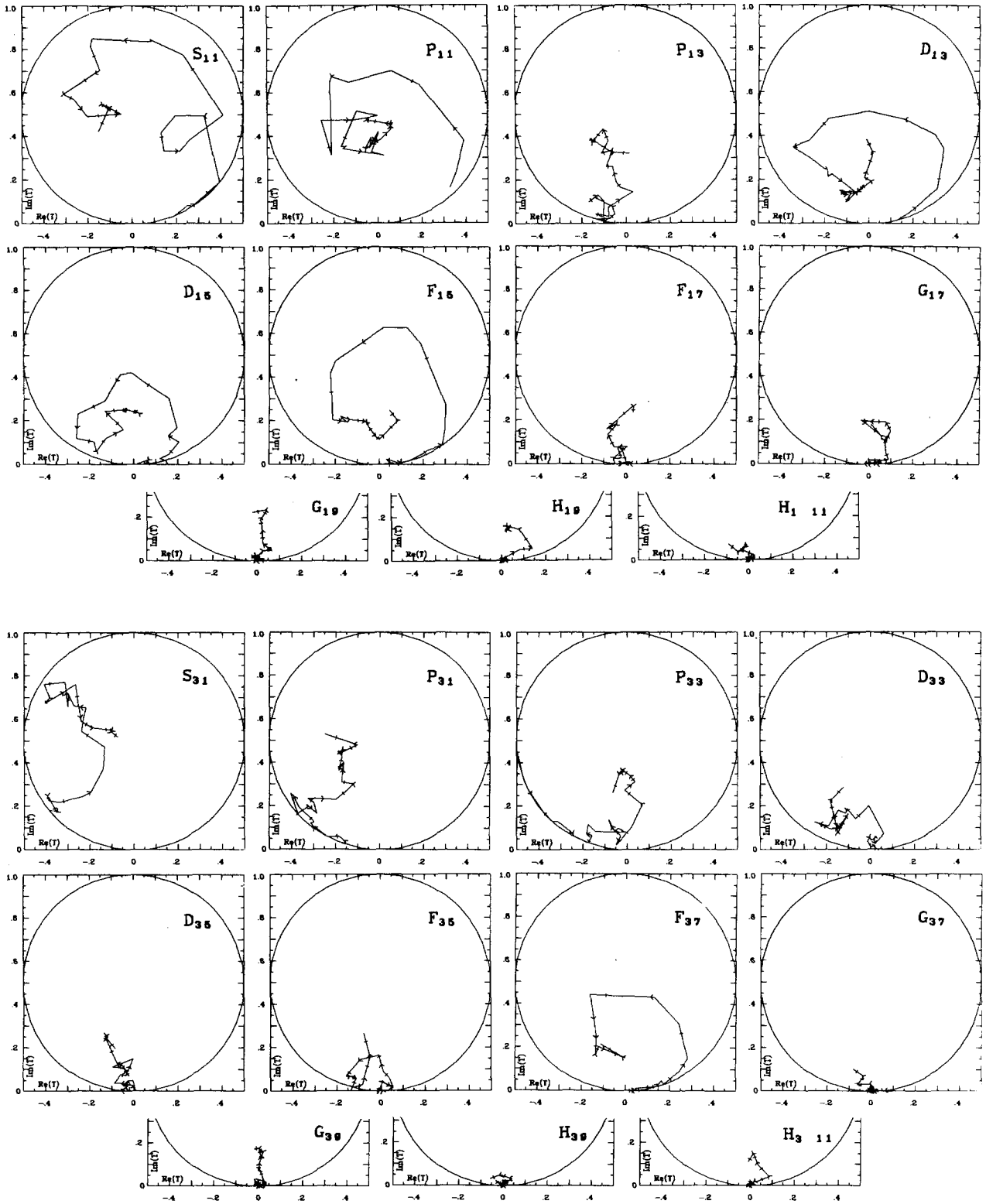


Fig. 2. πN Argand plots from the "minimum surface" solution of AYED 70 [Phys. Letters 31B, 598 (1970)]. To conserve space, we arbitrarily do not show the "minimum path" solution; it is not significantly different. Arrowheads and tick marks are at 50-MeV intervals; the last arrowhead is at 2400 MeV.

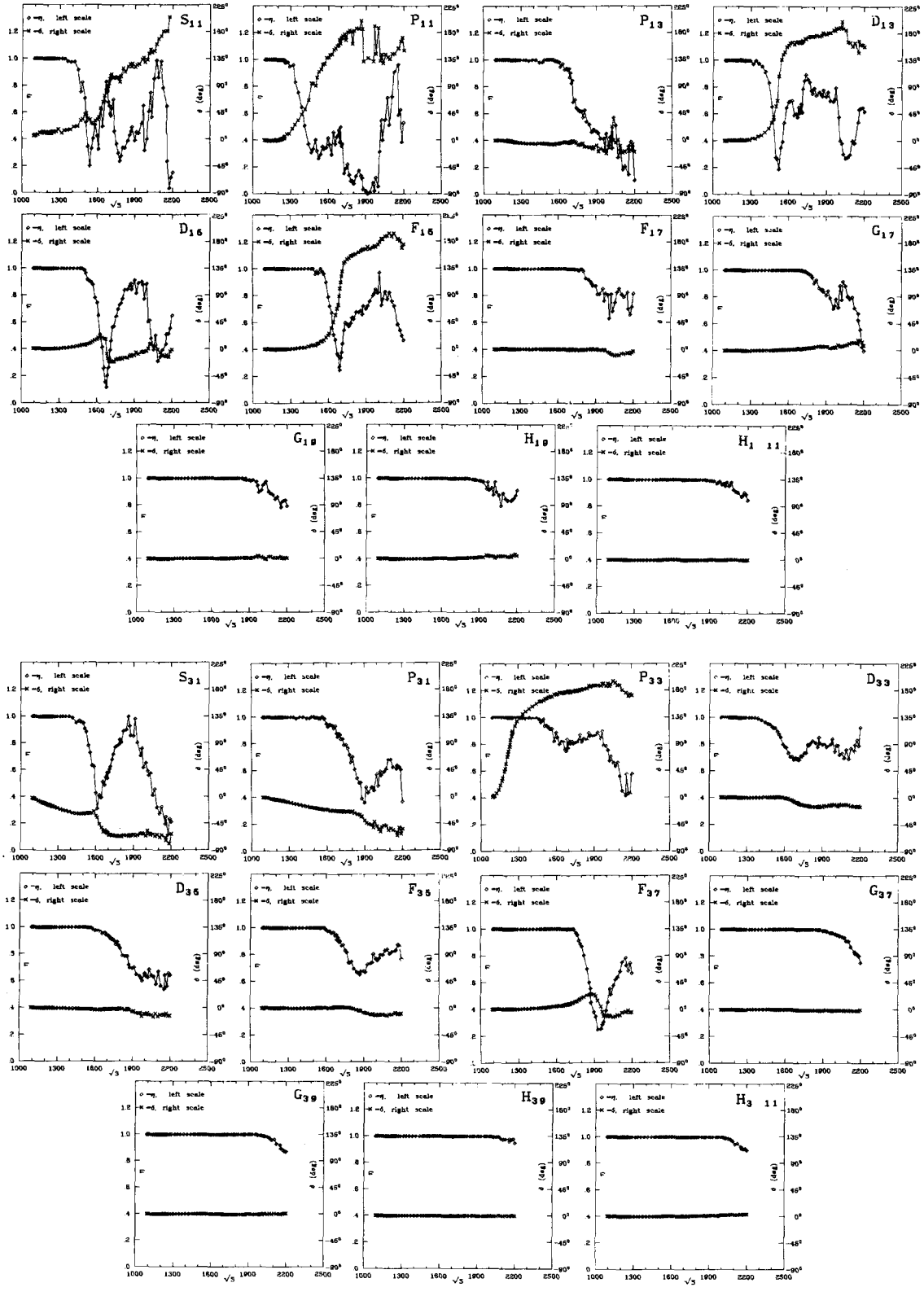


Fig. 3. δ and η versus c.m. energy (in MeV) from the πN partial-wave analysis solution of ALMEHED 72. × denotes δ (right-hand scale), ◇ denotes η (left-hand scale).

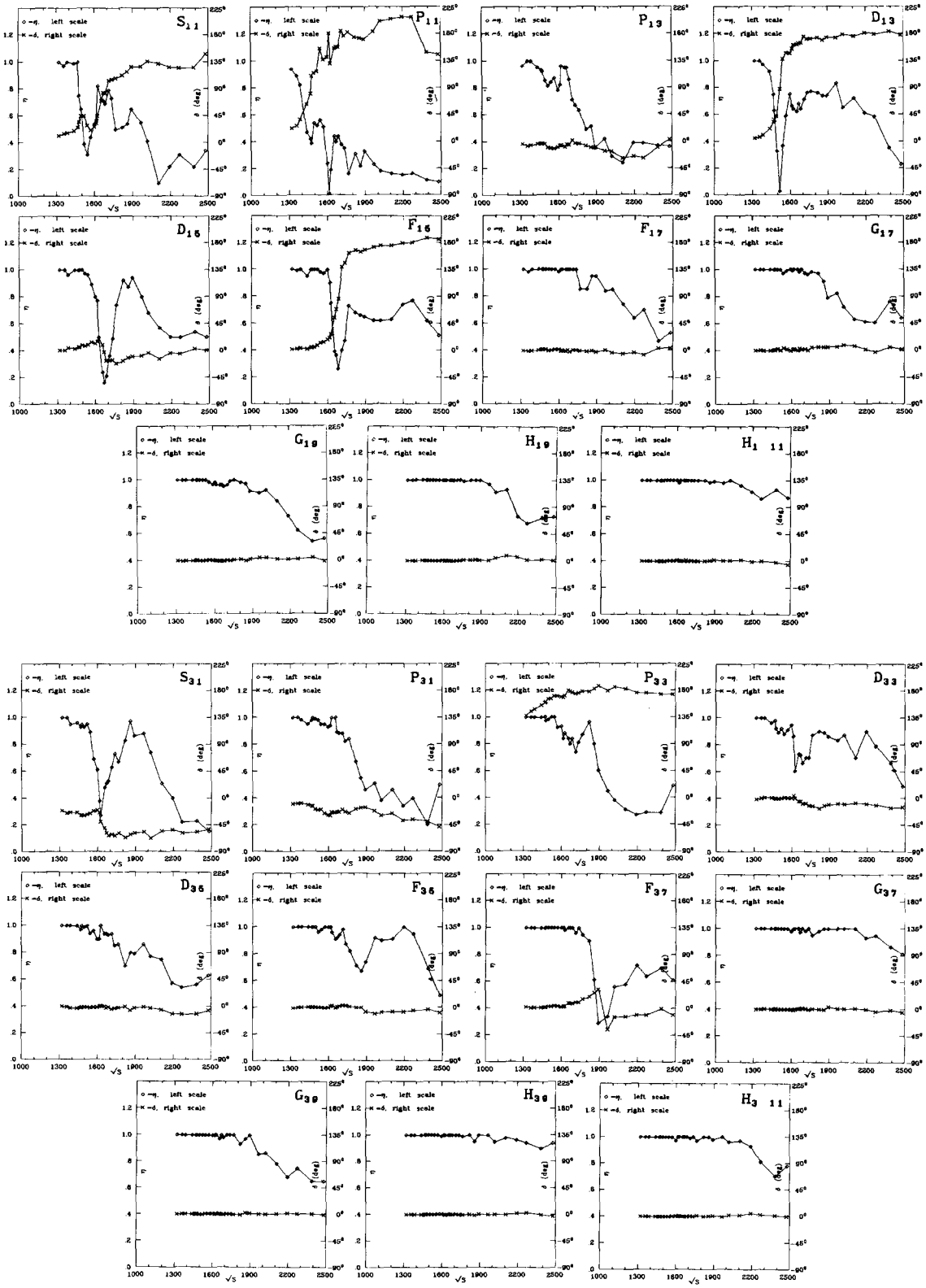


Fig. 4. δ and η versus c.m. energy (in MeV) from the πN partial-wave analysis "minimum surface" solution of AYED 70 [ Phys. Letters 31B, 598(1970)]. × denotes δ (right-hand scale), ◇ denotes η (left-hand scale).

marks and arrowheads on the lines connecting points at discrete energies are spaced at 50-MeV intervals. The AYED 70 analysis extends in c.m. energy from 1400 to 2450 MeV; the ALMEHED 72 analysis, from 1100 to 2200 MeV. In addition, we also show in Figs. 3 and 4 plots of $\delta$ and $\eta$ versus c.m. energy ($\sqrt{s}$) for the same two solutions.

Spread in Values of Resonance Parameters

Values of masses, widths, and branching ratios can be obtained only 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 the two complete phase-shift analyses discussed above, we have other analyses, done by using complete data, by several 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 ($\eta$'s and $\delta$'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 the Comments on the Mass and Width of Δ(1236), below.)

In order to make the reader aware of these problems, we present in Table I all the different values for M, Γ, x, in those cases when more than one group report values. We also present in this table the mean values of these parameters and the "Indep. External Error" of the individual values:

$$\langle \delta x_i \rangle = \sqrt{\frac{1}{N}\sum_i (x_i - \bar{x})^2}.$$

The error $\delta\bar{x}$ of the mean is of course smaller by another factor $1/\sqrt{N}$, but we avoid giving it because we feel that $\bar{x}$, $\delta\bar{x}$, have little meaning here. In order that the reader may appreciate the spread in the values of M, Γ, x given in Table I, we discuss briefly the different methods used to determine these parameters. AYED 70 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, quotes only one method, usually where the absorption is maximum. The Glasgow group (DAVIES 70) uses Breit-Wigner parametrization; A and B differ in the starting values of the minimization (CERN I solution was used for solution B). For some states no parameters have been quoted by the authors.

In Table II we give our evaluation of the N and Δ resonances based on information contained in the Data Card 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 the large indeterminancy of these parameters.

Availability of Partial-Wave Analyses and Data

All the solutions mentioned in this note, including AYED 70 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. 2. In addition, the extensive input data used by ALMEHED 72 (courtesy of C. Lovelace) are also available on tape from the Particle Data Group.

References

1. Particle Data Group, Rev. Mod. Phys. 43, No. 2, Part II, S1 (1971).
2. D.J. Herndon, A. Barbaro-Galtieri, A. H. Rosenfeld, UCRL-20030 πN (Feb. 1970).

## Table I. Mean Values of Resonance Parameters for N's and Δ's.

| Partial wave | Reference | | Method | M | Γ | x |
|---|---|---|---|---|---|---|
| **P11(1470)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1470 | 220 | .65 |
| 2 | AYED | 70 | | 1461 | 164 | .56 |
| 3 | BAREYRE | 68 | X-SEC | 1470 | 255 | .68 |
| 4 | BAREYRE | 68 | SPEED | 1505 | 205 | .68 |
| 5 | BERKELEY | 67 | | DEF | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1466 | 211 | .66 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1470 | 211 | .66 |
| 8 | KIRSOPP | 68 | ABS. | 1466 | 211 | .66 |
| 9 | GLASGOW | 68 | (SOLN A) | 1462 | 391 | .49 |
| 10 | GLASGOW | 68 | (SOLN B) | 1436 | 224 | .46 |
| | AVERAGE | | | 1467 | 232 | .61 |
| | INDEP. EXTERNAL ERROR | | | 17 | 60 | .08 |
| **D13(1520)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1520 | 120 | .58 |
| 2 | AYED | 70 | | 1523 | 131 | .59 |
| 3 | BAREYRE | 68 | X-SEC | 1510 | 125 | .54 |
| 4 | BAREYRE | 68 | SPEED | 1515 | 110 | .54 |
| 5 | BERKELEY | 67 [1] | | 1526 | 114 | .57 |
| 6 | DONNACHIE-1 | 68 | ABS. | 1541 | 149 | .51 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1520 | 114 | .57 |
| 8 | KIRSOPP | 68 | ABS. | 1526 | 115 | .57 |
| 9 | GLASGOW | 68 | (SOLN A) | 1512 | 106 | .45 |
| 10 | GLASGOW | 68 | (SOLN B) | 1512 | 125 | .49 |
| | AVERAGE | | | 1520 | 121 | .54 |
| | INDEP. EXTERNAL ERROR | | | 9 | 12 | .04 |
| **S11(1535)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1500 | 50 | .25 |
| 2 | AYED | 70 | | 1534 | 96 | .40 |
| 3 | BAREYRE | 68 | X-SEC | 1535 | 155 | --- |
| 4 | BAREYRE | 68 | SPEED | 1515 | 105 | --- |
| 5 | BERKELEY | 67 [1] | | 1548 | 116 | .33 |
| 6 | DONNACHIE-1 | 68 | ABS. | 1591 | (268) | .70 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1550 | 116 | .33 |
| 8 | KIRSOPP | 68 | ABS. | 1540 | 160 | .30 |
| 9 | GLASGOW | 68 | (SOLN A) | 1502 | (36) | .36 |
| 10 | GLASGOW | 68 | (SOLN B) | 1499 | 53 | .35 |
| | AVERAGE | | | 1531 | 106 | .38 |
| | INDEP. EXTERNAL ERROR | | | 27 | 38 | .13 |
| **D15(1670)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1683 | 150 | .45 |
| 2 | AYED | 70 | | 1675 | 143 | .39 |
| 3 | BAREYRE | 68 | X-SEC | 1680 | 135 | .41 |
| 4 | BAREYRE | 68 | SPEED | 1655 | 105 | .41 |
| 5 | BERKELEY | 67 | | DEF | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1678 | 173 | .39 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1680 | 173 | .39 |
| 8 | KIRSOPP | 68 | ABS. | 1678 | 175 | .39 |
| 9 | GLASGOW | 68 | (SOLN A) | 1669 | 115 | .50 |
| 10 | GLASGOW | 68 | (SOLN B) | 1667 | 115 | .43 |
| | AVERAGE | | | 1674 | 143 | .42 |
| | INDEP. EXTERNAL ERROR | | | 8 | 26 | .04 |
| **F15(1688)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1688 | 140 | .65 |
| 2 | AYED | 70 | | 1682 | 109 | .59 |
| 3 | BAREYRE | 68 | X-SEC | 1690 | 110 | .64 |
| 4 | BAREYRE | 68 | SPEED | 1680 | 105 | .64 |
| 5 | BERKELEY | 67 [1] | | 1692 | 132 | .68 |
| 6 | DONNACHIE-1 | 68 | ABS. | 1687 | 177 | .56 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1690 | 132 | .68 |
| 8 | KIRSOPP | 68 | ABS. | 1692 | 130 | .68 |
| 9 | GLASGOW | 68 | (SOLN A) | 1685 | 104 | .54 |
| 10 | GLASGOW | 68 | (SOLN B) | 1684 | 123 | .54 |
| | AVERAGE | | | 1687 | 126 | .62 |
| | INDEP. EXTERNAL ERROR | | | 4 | 21 | .05 |
| **S11(1700)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1670 | 120 | .50 |
| 2 | AYED | 70 | | 1689 | 166 | .64 |
| 3 | BAREYRE | 68 | X-SEC | 1710 | 260 | --- |
| 4 | BAREYRE | 68 | SPEED | 1665 | 110 | --- |
| 5 | BERKELEY | 67 [1] | | 1709 | 300 | .79 |
| 6 | DONNACHIE-1 | 68 | ABS. | --- | --- | --- |
| 7 | DONNACHIE-2 | 68 | ABS. | 1710 | 300 | .79 |
| 8 | KIRSOPP | 68 | ABS. | 1709 | 300 | .79 |
| 9 | GLASGOW | 68 | (SOLN A) | 1766 | 404 | .56 |
| 10 | GLASGOW | 68 | (SOLN B) | 1671 | 121 | .51 |
| | AVERAGE | | | 1700 | 231 | .65 |
| | INDEP. EXTERNAL ERROR | | | 29 | 99 | .12 |
| **D13(1700)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | AMB | | |
| 2 | AYED | 70 | | AMB | | |
| 3 | BAREYRE | 68 | X-SEC | | | |
| 4 | BAREYRE | 68 | SPEED | POSS | | |
| 5 | BERKELEY | 67 | | POSS | | |
| 6 | DONNACHIE-1 | 68 | ABS. | --- | --- | --- |
| 7 | DONNACHIE-2 | 68 | ABS. | 1730 | | |
| 8 | KIRSOPP | 68 | ABS. | 1680 | | |
| 9 | GLASGOW | 68 | (SOLN A) | NOT | | |
| 10 | GLASGOW | 68 | (SOLN B) | NOT | | |
| | AVERAGE | | | 1705 | | |
| | INDEP. EXTERNAL ERROR | | | 25 | | |
| **P11(1780)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1720 | 160 | .2 |
| 2 | AYED | 70 | | 1645 | 50 | .15 |
| 3 | BAREYRE | 68 | X-SEC | PROB | | |
| 4 | BAREYRE | 68 | SPEED | PROB | | |
| 5 | BERKELEY | 67 | | PROB | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1751 | 327 | .32 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1750 | 327 | .32 |
| 8 | KIRSOPP | 68 | ABS. | 1860 | 270 | .32 |
| 9 | GLASGOW | 68 | (SOLN A) | 1770 | 445 | .43 |
| 10 | GLASGOW | 68 | (SOLN B) | (1867) | (525) | .30 |
| | AVERAGE | | | 1749 | 263 | .29 |
| | INDEP. EXTERNAL ERROR | | | 64 | 127 | .08 |
| **P13(1860)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1850 | 300 | .25 |
| 2 | AYED | 70 | | 1766 | 182 | .15 |
| 3 | BAREYRE | 68 [2] | X-SEC | AMB | | |
| 4 | BAREYRE | 68 [2] | SPEED | AMB | | |
| 5 | BERKELEY | 67 [2] | | AMB | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1863 | 296 | .21 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1860 | 296 | .21 |
| 8 | KIRSOPP | 68 | ABS. | 1900 | 325 | .25 |
| 9 | GLASGOW | 68 | (SOLN A) | 1844 | 449 | .40 |
| 10 | GLASGOW | 68 | (SOLN B) | 1854 | 307 | .26 |
| 11 | LEA | 69 | | 1860 | --- | --- |
| | AVERAGE | | | 1850 | 308 | .25 |
| | INDEP. EXTERNAL ERROR | | | 35 | 72 | .07 |
| **F17(1990)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 2000 | 200 | .15 |
| 2 | AYED | 70 | | NOT | | |
| 3 | BAREYRE | 68 [2] | X-SEC | | | |
| 4 | BAREYRE | 68 [2] | SPEED | | | |
| 5 | BERKELEY | 67 [2] | | | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1983 | 225 | .13 |
| 7 | DONNACHIE-2 | 68 | ABS. | --- | --- | --- |
| 8 | KIRSOPP | 68 | ABS. | 1995 | 250 | .09 |
| 9 | GLASGOW | 68 [3] | (SOLN A) | | | |
| 10 | GLASGOW | 68 [3] | (SOLN B) | | | |
| 11 | LEA | 69 | | 2000 | --- | --- |
| | AVERAGE | | | 1994 | 225 | .12 |
| | INDEP. EXTERNAL ERROR | | | 7 | 20 | .02 |
| **D13(2040)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 2075 | 150 | .30 |
| 2 | AYED | 70 | | NOT | | |
| 3 | BAREYRE | 68 [2] | X-SEC | | | |
| 4 | BAREYRE | 68 [2] | SPEED | | | |
| 5 | BERKELEY | 67 [2] | | | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 2057 | 293 | .26 |
| 7 | DONNACHIE-2 | 68 | ABS. | 2030 | 290 | .11 |
| 8 | KIRSOPP | 68 | ABS. | 2040 | 240 | .15 |
| 9 | GLASGOW | 68 [2] | (SOLN A) | | | |
| 10 | GLASGOW | 68 [2] | (SOLN B) | | | |
| 11 | LEA | 69 | | 2030 | --- | --- |
| | AVERAGE | | | 2046 | 243 | .20 |
| | INDEP. EXTERNAL ERROR | | | 17 | 58 | .08 |
| **G17(2190)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 2225 | 150 | .35 |
| 2 | AYED | 70 | | 2158 | 325 | .15 |
| 3 | BAREYRE | 68 [2] | X-SEC | | | |
| 4 | BAREYRE | 68 [2] | SPEED | | | |
| 5 | BERKELEY | 67 [2] | | | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 2265 | 298 | .35 |
| 7 | DONNACHIE-2 | 68 | ABS. | 2190 | 300 | .35 |
| 8 | KIRSOPP | 68 | ABS. | 2265 | 300 | .35 |
| 9 | GLASGOW | 68 [3] | (SOLN A) | (1906) | (319) | (.14) |
| 10 | GLASGOW | 68 [3] | (SOLN B) | | | |
| 11 | LEA | 69 | | 2000 | | |
| | AVERAGE | | | 2184 | 275 | .31 |
| | INDEP. EXTERNAL ERROR | | | 91 | 63 | .08 |
| **S31(1650)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1620 | 140 | .35 |
| 2 | AYED | 70 | | 1614 | 142 | .32 |
| 3 | BAREYRE | 68 | X-SEC | 1695 | 250 | --- |
| 4 | BAREYRE | 68 | SPEED | 1650 | 130 | --- |
| 5 | BERKELEY | 67 | | DEF | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1635 | 177 | .28 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1640 | 177 | .28 |
| 8 | KIRSOPP | 68 | ABS. | 1635 | 180 | .28 |
| 9 | GLASGOW | 68 | (SOLN A) | 1617 | 141 | .28 |
| 10 | GLASGOW | 68 | (SOLN B) | 1623 | 140 | .25 |
| | AVERAGE | | | 1637 | 164 | .29 |
| | INDEP. EXTERNAL ERROR | | | 23 | 35 | .03 |
| **P33(1690)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1680 | 220 | .10 |
| 2 | AYED | 70 | | 1801 | 598 | .14 |
| 3 | BAREYRE | 68 | X-SEC | AMB | | |
| 4 | BAREYRE | 68 | SPEED | AMB | | |
| 5 | BERKELEY | 67 | | POSS | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1688 | 281 | .10 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1690 | 281 | .10 |
| 8 | KIRSOPP | 68 | ABS. | 1690 | 240 | .08 |
| 9 | GLASGOW | 68 | (SOLN A) | NOT | | |
| 10 | GLASGOW | 68 | (SOLN B) | NOT | | |
| | AVERAGE | | | 1710 | 324 | .10 |
| | INDEP. EXTERNAL ERROR | | | 46 | 139 | .02 |
| **D33(1670)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1700 | 260 | .16 |
| 2 | AYED | 70 | | 1722 | 258 | .22 |
| 3 | BAREYRE | 68 | X-SEC | POSS | | |
| 4 | BAREYRE | 68 | SPEED | POSS | | |
| 5 | BERKELEY | 67 | | AMB | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1691 | 269 | .14 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1690 | 269 | .14 |
| 8 | KIRSOPP | 68 | ABS. | 1690 | 300 | .13 |
| 9 | GLASGOW | 68 | (SOLN A) | 1649 | 188 | .12 |
| 10 | GLASGOW | 68 | (SOLN B) | 1650 | 174 | .13 |
| | AVERAGE | | | 1685 | 245 | .15 |
| | INDEP. EXTERNAL ERROR | | | 24 | 43 | .03 |
| **F35(1890)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1875 | 250 | .18 |
| 2 | AYED | 70 | | 1837 | 198 | .15 |
| 3 | BAREYRE | 68 | X-SEC | POSS | | |
| 4 | BAREYRE | 68 | SPEED | POSS | | |
| 5 | BERKELEY | 67 | | PROB | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1913 | 350 | .16 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1910 | 350 | .16 |
| 8 | KIRSOPP | 68 | ABS. | 1910 | 380 | .15 |
| 9 | GLASGOW | 68 | (SOLN A) | 1841 | 136 | .20 |
| 10 | GLASGOW | 68 | (SOLN B) | 1852 | 150 | .19 |
| | AVERAGE | | | 1877 | 259 | .17 |
| | INDEP. EXTERNAL ERROR | | | 32 | 94 | .02 |
| **P31(1910)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1900 | 200 | .33 |
| 2 | AYED | 70 | | 1783 | 308 | .13 |
| 3 | BAREYRE | 68 [2] | X-SEC | AMB | | |
| 4 | BAREYRE | 68 [2] | SPEED | AMB | | |
| 5 | BERKELEY | 67 [2] | | PROB | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1934 | 339 | .30 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1930 | 339 | .30 |
| 8 | KIRSOPP | 68 | ABS. | 1930 | 425 | .25 |
| 9 | GLASGOW | 68 | (SOLN A) | 1914 | 290 | .18 |
| 10 | GLASGOW | 68 | (SOLN B) | 1834 | 231 | .24 |
| | AVERAGE | | | 1889 | 305 | .25 |
| | INDEP. EXTERNAL ERROR | | | 54 | 69 | .07 |
| **F37(1950)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 1925 | 200 | .40 |
| 2 | AYED | 70 | | 1931 | 197 | .50 |
| 3 | BAREYRE | 68 | X-SEC | 1975 | 180 | .57 |
| 4 | BAREYRE | 68 | SPEED | 1980 | 140 | --- |
| 5 | BERKELEY | 67 | | DEF | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1946 | 221 | .39 |
| 7 | DONNACHIE-2 | 68 | ABS. | 1950 | 221 | .39 |
| 8 | KIRSOPP | 68 | ABS. | 1946 | 220 | .39 |
| 9 | GLASGOW | 68 | (SOLN A) | 1935 | 196 | .51 |
| 10 | GLASGOW | 68 | (SOLN B) | 1935 | 212 | .39 |
| | AVERAGE | | | 1947 | 199 | .44 |
| | INDEP. EXTERNAL ERROR | | | 18 | 25 | .07 |
| **D35(1960)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 2200 | 600 | .16 |
| 2 | AYED | 70 | | NOT | | |
| 3 | BAREYRE | 68 [2] | X-SEC | AMB | | |
| 4 | BAREYRE | 68 [2] | SPEED | AMB | | |
| 5 | BERKELEY | 67 [2] | | | | |
| 6 | DONNACHIE-1 | 68 | ABS. | 1954 | 311 | .15 |
| 7 | DONNACHIE-2 | 68 | ABS. | --- | --- | --- |
| 8 | KIRSOPP | 68 | ABS. | 1970 | 400 | .12 |
| 9 | GLASGOW | 68 [2] | (SOLN A) | | | |
| 10 | GLASGOW | 68 [2] | (SOLN B) | | | |
| 11 | LEA | 69 | | 1950 | --- | --- |
| | AVERAGE | | | 2018 | 437 | .14 |
| | INDEP. EXTERNAL ERROR | | | 105 | 121 | .02 |
| **P33(2160)** | | | | | | |
| 1 | ALMEHED | 72 | ABS. | 2150 | 200 | .30 |
| 2 | AYED | 70 | | NOT | | |
| 3 | BAREYRE | 68 [2] | X-SEC | | | |
| 4 | BAREYRE | 68 [2] | SPEED | | | |
| 5 | BERKELEY | 67 [2] | | POSS | | |
| 6 | DONNACHIE-1 | 68 | ABS. | | | |
| 7 | DONNACHIE-2 | 68 | ABS. | | | |
| 8 | KIRSOPP | 68 | ABS. | 2160 | 260 | .25 |
| 9 | GLASGOW | 68 [2] | (SOLN A) | | | |
| 10 | GLASGOW | 68 [2] | (SOLN B) | | | |
| | AVERAGE | | | 2155 | 230 | .28 |
| | INDEP. EXTERNAL ERROR | | | 5 | 30 | .02 |

( ) VALUES IN PARENTHESES HAVE NOT BEEN USED IN THE AVERAGES.
[1] VALUES QUOTED BY LOVELACE, RAPPORTEUR TALK AT HEIDELBERG CONFERENCE (1967), P. 109.
[2] THIS STATE IS VERY CLOSE TO OR BEYOND THEIR HIGHEST ENERGY.
[3] GLASGOW A HAS A G17 STATE AT THIS MASS, GLASGOW B MAY HAVE AN F17 AND A G17; HOWEVER, THIS ENERGY REGION IS VERY CLOSE TO THEIR HIGHEST ENERGY.

AMB AMBIGUOUS
DEF DEFINITE
NOT NOT SEEN
POSS POSSIBLE
PROB PROBABLE

TABLE II. 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*(1470) | P11 | **** | | **** | | | | *** | | RHO N |
| N*(1520) | D13 | **** | **** | **** | * | | | *** | * | RHO N |
| N*(1535) | S11 | **** | | **** | *** | | | | | RHO N |
| N*(1670) | D15 | **** | *** | **** | * | * | | *** | * | |
| N*(1688) | F15 | **** | *** | **** | * | * | | *** | * | RHO N |
| N*(1700) | S11 | **** | | **** | * | *** | | | * | |
| N*(1700) | D13 | * | | * | | | | | | |
| N*(1780) | P11 | *** | | *** | * | ** | | | * | |
| N*(1860) | P13 | *** | | *** | * | ** | | | | |
| N*(1990) | F17 | * | | * | * | | | | | |
| N*(2040) | D13 | * | | * | * | | | | | |
| N*(2100) | S11 | * | | * | * | | | | | |
| N*(2100) | D15 | * | | * | * | | | | | |
| N*(2175) | F15 | * | | * | * | | | | | |
| N*(2190) | G17 | *** | *** | *** | | | | | | |
| N*(2220) | H19 | *** | *** | *** | | | | | | |
| N*(2650) | | *** | *** | | | | | | | |
| N*(3030) | | *** | *** | | | | | | | |
| N*(3245) | | * | * | | | | | | | |
| N*(3690) | | * | * | | | | | | | |
| N*(3755) | | * | * | | | | | | | |
| DE(1236) | P33 | **** | **** | **** | F | | | | * | |
| DE(1650) | S31 | **** | | **** | O | | | | | |
| DE(1670) | D33 | *** | *** | *** | R | | | | | |
| DE(1690) | P33 | * | | * | B | | | | | |
| DE(1890) | F35 | *** | * | *** | I | | | | | |
| DE(1910) | P31 | *** | | *** | | D | | | | |
| DE(1950) | F37 | **** | *** | **** | | D | * | ** | | |
| DE(1960) | D35 | * | * | * | | E | * | | | |
| DE(2160) | P33 | * | | * | | 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.

CODE EVENTS ABOVE BACKGROUND, QUANTITY, ERROR+, ERROR-, REFERENCE, YR, TECN, SIGN, COMMENTS, DATE PUNCHED

**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)** 61 N*1/2(1470, JP=1/2+) I=1/2 **$P'_{11}$**

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE ABOVE

THE MASS AND WIDTH ARE BEST DETERMINED FROM PHASE-SHIFT ANALYSES. WE LIST PRODUCTION EXPERIMENTS SEPARATELY--SEE BELOW.

61 N*1/2(1470) MASS (MEV)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| M | | (1380.0) | ROPER | 65 | RVUE | PHASE-SHIFT ANAL | 9/66 |
| M | | (1370.0) | BRANDSEN | 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 | 2 | (1505.0) | BAREYRE | 68 | RVUE | PHASE-SHIFT ANAL | 11/67 |
| M | 2 | WHERE SPEED IS GREATEST - EYEBALL FIT | | | | | |
| M | 3 | (1466.0) | DONNACH1 | 68 | RVUE | PHASE-SHIFT ANAL | 6/68 |
| M | 3 | (1470.) | DONNACH2 | 68 | RVUE | PHAS.SHIFT-CERN1 | 10/69 |
| M | 3 | (1466.) | KIRSOPP | 68 | RVUE | PHASE SHIFT ANAL | 10/69 |
| M | 3 | WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1 | | | | | 10/69 |
| M | 4 | (1462.0) | DAVIES | 70 | RVUE | P-S ANAL SOL A | 8/69 |
| M | 5 | (1436.0) | DAVIES | 70 | RVUE | P-S ANAL SOL B | 8/69 |
| M | 5 | SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68) | | | | | |
| M | 6 | (1461.0) | AYED | 70 | IPWA | | 1/71 |
| M | 6 | FROM ENER. DEP. FIT OF ARGAND DIAGRAM | | | | | |
| M | 7 | (1470.) | ALMEHED | 72 | IPWA | | 2/72* |

61 N*1/2(1470) WIDTH (MEV)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| W | 1 | (255.0) | BAREYRE | 68 | RVUE | | 11/67 |
| W | 2 | (205.0) | BAREYRE | 68 | RVUE | | 11/67 |
| W | 3 | (211.0) | DONNACH1 | 68 | RVUE | | 6/68 |
| W | 3 | (211.) | DONNACH2 | 68 | RVUE | PHAS.SHIFT-CERN1 | 10/69 |
| W | 3 | (210.) | KIRSOPP | 68 | RVUE | PHASE SHIFT ANAL | 10/69 |
| W | 4 | (391.) | DAVIES | 70 | RVUE | P-S ANAL SOL A | 8/69 |
| W | 5 | (224.) | DAVIES | 70 | RVUE | P-S ANAL SOL B | 8/69 |
| W | 6 | (164.0) | AYED | 70 | IPWA | | 1/71 |
| W | 7 | (220.) | ALMEHED | 72 | IPWA | | 2/72* |

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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 SIGMA (SIGMA MESON) | 938+ 0 |
| P3 | N*1/2(1470) INTO N*3/2(1236) PI | 1236+ 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 (PIPI, I=1) | 938+ 765 |

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 | 3 | (.66) | | DONNACH2 | 68 | RVUE | PHAS.SHIFT-CERN1 | 10/69 |
| R1 | 3 | (.66) | | KIRSOPP | 68 | RVUE | PHASE SHIFT ANAL | 10/69 |
| R1 | 4 | (0.49) | | DAVIES | 70 | RVUE | P-S ANAL SOL A | 8/69 |
| R1 | 5 | (0.46) | | DAVIES | 70 | RVUE | P-S ANAL SOL B | 8/69 |
| R1 | 6 | (0.564) | | AYED | 70 | IPWA | | 1/71 |
| 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 | A | AND B CORRESPOND TO THE 2 BEST SOLUTIONS. ANALYSIS IS DONE ON THREE | | | | | | |
| R1 | B | BODY DECAYS, ASSUMING ONLY P1, P2 AND P3 DECAYS PRESENT. | | | | | | |
| R1 | 7 | (0.65) | | ALMEHED | 72 | IPWA | | 2/72* |
| | | SEE THE NOTES ACCOMPANYING THE MASSES QUOTED. | | | | | | |
| R2 | | N*1/2(1470) INTO (N SIGMA)/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 | 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. | | | | | | |
| R2 | D | (0.16) | | DIEM | 70 | IPWA | 3 BODY ANALYSIS | 1/71 |
| R2 | D | ASSUMING R1= 0.61 | | | | | | |
| R3 | | N*1/2(1470) INTO (N*3/2(1236) PI)/TOTAL | | | | | (P3) | |
| 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 | D | (0.17) | | DIEM | 70 | IPWA | 3 BODY ANALYSIS | 1/71 |
| R3 | D | ASSUMING R1= 0.61 | | | | | | |
| R3 | R | (0.20) | | MAKAROV | 71 | IPWA | O 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 | | SOME INDICATION | | LODI-RIZZ | 70 | DBC | GAM-N TO PI-P | 7/70 |
| 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. | | | | | | |

REFERENCES -- N*1/2(1470)


| | | | |
|---|---|---|---|
| ROPER | 65 PR 138 B190 | LD ROPER,RM WRIGHT,BT FELD | (LRL-LVMR,MIT)IJP |
| BRANDSEN | 65 PR 139 B1566 | +ODONNELL, MOORHOUSE | (DURHAM,RTHFD)IJP |
| THURNAUE | 65 PRL 14 985 | P G THURNAUER | (ROCH) |
| NAMYSLOW | 66 PR 157 1328 | NAMYSLOWSKI,RAZMI,ROBERTS | (STAN,EDINB,IC) |
| 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 |
| DONNACH2 | 68 VIENNA 139 | DONNACHIE RAPPORTEUR.S TALK | (GLAS) |
| KIRSOPP | 68 THESIS | R G KIRSOPP | (EDIN) |
| MORGAN | 68 PR 166 1731 | D MORGAN | (RTHFD) |
| AYED | 70 KIEV CONF | R AYED,P BAREYRE, G VILLET | (SACL)IJP |
| DAVIES | 70 NP B21 359 | A DAVIES | (GLAS) |
| DIEM | 70 KIEV CONF. | + SMADJA, CHAVANON, DELER, DOLBEAU+ | (SACL) |
| LODI-RIZ | 70 LNC 3 697 | +FIORE,PIAZZA+... | (PAVIA+ROMA+CNEN+NAPOLI) |
| 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 U.) |
| ALMEHED | 72 SUB.NP B | ,LOVELACE | (RUTG)IJP |

PAPERS NOT REFERRED TO IN DATA CARDS.

| | | | |
|---|---|---|---|
| BAREYRE | 64 PL 8 137 | +BRICMAN,VALLADAS,VILLET, + | (SACLAY,CAEN) IJ |
| BAREYRE | 65 PL 18 342 | +BRICMAN, STIRLING, VILLET | (SACLAY)IJP |
| DALITZ | 65 PL 14 159 | R H DALITZ, R G MOORHOUSE | (OXF,RTHFD) |
| 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) |

FOR PHOTONIC COUPLINGS SEE

| | | | |
|---|---|---|---|
| MOORHOUSE | 70 NP B23,181 | +RANKIN | (GLAS) |
| WALKER | 69 PR 182,1729 | R.L.WALKER | (CALT) |

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) |

## 1470 MEV REGION - PRODUCTION EXPERIMENTS

61 N*(1470)

**N(1470) BUMPS**

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IT IS NOT CLEAR THAT THE BUMP SEEN IN PRODUCTION EXPE-
RIMENTS AT LOW INVARIANT MASS CORRESPONDS TO THE P11
RESONANT STATE.  DIFFRACTION SCATTERING SEEMS TO BE TH.
DOMINANT FEATURE IN THIS MASS REGION- SEE GELLERT 66,
WALKER 68 AND CLEGG 68 FOR DISCUSSION OF THIS POINT.
WE LIST VALUES OF MASSES AND WIDTHS FROM THESE EXPERIMENTS FOR
THE READER'S CONVENIENCE- THE LIST MAY NOT BE COMPLETE.
THE CNTR AND SPRK EXPERIMENTS SEE A BUMP IN THE MISSING MASS
PLOT. THE HBC EXPERIMENTS SEE ENHANCEMENTS MAINLY IN THE
P PI PI MASS PLOT. PRODUCTION OF THIS STATE IN GAMMA-P OR
GAMMA-D IS VERY SMALL, SEE ALBERI 68.

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                    N*1/2(1470)  MASS (MEV)  PROD. EXPE.

M          (1425.)   APPROX            ADELMAN   65 HBC  +  K-P 1.45 GEV/C    7/66
M          (1400.)   APPROX            COCCONI   64 CNTR +  PP 3.6-12 GEV/C
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    S   TAN 68, SHAPIRA 68 ARE ONLY PRODUCTION EXPERIMENT TO SEE PPI DECAY
M    S   HOWEVER THE EFFECT OF SHAPIRA 68,WITH MUCH IMPROVED DATA,HAS ALMOST  3/72*
M    S   DISAPPEARED (YEKUTIEL1 71).

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                    N*1/2(1470) WIDTH (MEV)  PROD. EXPE.

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*

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                    N*1/2(1470) BRANCHING RATIOS  PROD. EXP.

R1         N*1/2(1470) INTO (PI P)/TOTAL       PRODUC. EXPER.
R1            (.66)                    TAN       68 HBC     PP TO PIP, 6.1   10/69

R2         N*1/2(1470) INTO (N*3/2(1236) PI)/TOTAL   PROD. EXP.
R2            PROBABLY SEEN             LAMSA     68 HBC     PI-P 8 BEV/C     11/68
R2            PROBABLY SEEN             JESPERSEN 68 HBC     PP 22 BEV/C      11/68

R3         N*1/2(1470) INTO (N SIGMA)/TOTAL            PROD. EXP.
R3            MAIN DECAY MODE           MORSE     71 HBC  +  PI-P 7.25 GEV/C   3/72*

****** ********* ********* ********* ********* ********* ********* ********

                          REFERENCES -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,CCNY)
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,CHINOWSKY +  (SLAC+LRL+UCI)
RHODE    69 PR 187 1844         RHODE, LEACOCK, KERNAN, JESPERSEN,+  (AMES)
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
YEKUTIEL 71  WIS 71/48 PH       YEKUTIELI,YAFFE,SHAPIRA,RONAT +       (REHO)

                          PAPERS NOT REFERRED TO IN DATA CARDS

GELLERT  66 PRL 17 884          +SMITH,VOJCICKI,COLTON,SCHLEIN + (LRL,UCLA)
ALBERI   68 PR 176 1631         +APPEL,BUDNITZ,CHEN,DUNNING,GOITEIN+ (HARV)
CLEGG    68  PREPRINT           A B CLEGG
WALKER   68 PRL 20 133          +THOMPSON,ROBERTSON,OH,LEE,HARTUNG,+ (WISC)

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                          END PRODUCTION EXPERIMENTS

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**N(1520)** 62 N*1/2(1520, JP=3/2-) I=1/2 **$D'_{13}$**

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FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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                    62  N*1/2(1520) MASS (MEV)

M          (1536.0)                  ROPER     65 RVUE    PHASE-SHIFT ANAL  9/66
M          (1530.0)                  BRANDSEN  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    2     (1515.0)                  BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    2                WHERE SPEED IS GREATEST - EYEBALL FIT
M    3     (1541.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M    3     (1520.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M    3 -   (1526.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
M    4     (1512.0)                  DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M    5     (1512.0)                  DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M    5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M    6     (1523.0)                  AYED      70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    7     (1520.)                   ALMEHED   72 IPWA                      2/72*

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                    62  N*1/2(1520) WIDTH (MEV)

W    1     (125.0)                   BAREYRE   68 RVUE                     11/67
W    2     (110.0)                   BAREYRE   68 RVUE                     11/67
W    3     (149.0)                   DONNACH1  68 RVUE                      6/68
W    3     (114.)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W    3     (115.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W    4     (106.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A
W    5     (125.0)                   DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
W    6     (131.0)                   AYED      70 IPWA                      1/71
W    7     (120.)                    ALMEHED   72 IPWA                      2/72*
     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(1236) PI              1236+ 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 SIGMA (SIGMA MESON)        939+   0
P8         N*1/2(1520) INTO N RHO ( PIPI, I=1)           938+ 765

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                    62  N*1/2(1520) BRANCHING RATIOS

R1         N*1/2(1520) INTO (PI N)/TOTAL                 (P1)
R1   1       (0.54)                  BAREYRE   68 RVUE                     11/67
R1   3       (0.509)                 DONNACH1  68 RVUE                      6/68
R1   3        (.57)                  DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1   3        (.57)                  KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1   4       (0.45)                  DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
R1   5       (0.49)                  DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
R1   6       (0.593)                 AYED      70 IPWA                      1/71
R1   7       (0.58)                  ALMEHED   72 IPWA                      2/72*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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(1236) PI, IN BOTH
R1  S AND D WAVES.

R2         N*1/2(1520) INTO (N*3/2(1236) PI)/TOTAL       (P4)
R2           DOMINANT INEL DECAY     OLSSON    66 RVUE    PI P TO PI PI N   9/66
R2           0.20      0.05          KIRZ      66 HBC  0  ASSUMING R1=0.72  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(1236) 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 SIGMA) / 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

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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                          REFERENCES -- N*1/2(1520)

          SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

BRANDSEN 65 PR 139 B1566        +ODONNELL, MOORHOUSE          (DURHAM,RTHFD)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.
NAMYSLOW 66 PR 157 1328         NAMYSLOWSKI,RAZMI,ROBERTS   (STAN,EDINB,IC)
OLSSON   66 PR 145 1309         M G OLSSON, G B YODH                (WISC,WD)

DAVIES   67 NC 52A 1112         A T DAVIES, R G MOORHOUSE   (GLASGOW,RTHFD)
ROBERTS  67 PREPRINT            R G ROBERTS                          (DURHAM)
ROSENFEL 67 IRVINE CONF         A H ROSENFELD, P SODING               (LRL)
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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
DONNACH2 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
KIRSOPP  68 THESIS             R G KIRSOPP                           (EDIN)
MORGAN   68 PR 166 1731        D MORGAN                             (RTHFD)

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 SUB.NP B           ,LOVELACE                            (RUTG)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

KIRZ     63 PR 130 2481        J KIRZ, J SCHWARTZ, R D TRIPP         (LRL)
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET         (SACLAY)IJP
CROUCH   65 DESY CONF II 21    +   (BROWN,CEA,HARVARD,MIT,PADOVA,WEIZMANN)
DERADO   65 ATHENS CONF 244    +KENNEY,LAMSA, +          (NOTRE DAME,KENTUCKY)
MERLO    66 P ROY SOC 289 489  J P MERLO, G VALLADAS                 (SACLAY)
     -- THE ABOVE PAPERS DISCUSS INELASTIC CHANNELS NEAR THE RESONANCE.
JOHNSON  67 UCRL-17683 THESIS  C H JOHNSON                            (LRL)
DEANS    69 PRL 177 2623       S R DEANS                           (FLORIDA)
DONNACH1 69 NP 10B 433         A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598         +BAREYRE+VILLET                     (SACLAY)

          FOR PHOTONIC COUPLINGS SEE
MOORHOUSE70 NP B23,181         +RANKIN                               (GLAS)
WALKER   69 PR 182,1729        R.L.WALKER                            (CALT)

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**N(1535)** **$S'_{11}$**

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63  N*1/2(1535, JP=1/2-) I=1/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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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   2    (1515.0)                  BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M   2          WHERE SPEED IS GREATEST - EYEBALL FIT
M   3    (1591.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   3    (1550.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M   3    (1440.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M   3  WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1 10/69
M        (1535.0)   (10.0)         DELCOURT  69 CNTR    PHOTOPRODUCT.     8/69
M   4    (1502.0)                  DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   5    (1499.0)                  DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M   5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M   6    (1534.0)                  AYED      70 IPWA                      1/71
M   6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   7    (1500.)                   ALMEHED   72 IPWA                      2/72*

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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   2    (105.0)                   BAREYRE   68 RVUE                     11/67
W   3    (268.0)    APPROX         DONNACH1  68 RVUE                      6/68
W   3    (116.)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W   3    (160.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W        (120.0)                   DELCOURT  69 CNTR    PHOTOPRODUCT.     8/69
W   4     (36.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W   4     (36.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W   6     (96.0)                   AYED      70 IPWA                      1/71
W   7     (50.)                    ALMEHED   72 IPWA                      2/72*
     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 SIGMA (SIGMA MESON)      938+   0
P5       N*1/2(1535) INTO D(1236) PI                1236+ 139
P6       N*1/2(1535) INTO N RHO (PI PI, I=1)         938+ 765

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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  3       (.33)                  DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3       (.3)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1         (0.33)                  DELCOURT  69 CNTR                      8/69
R1  4      (0.36)                  DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
R1  5      (0.35)                  DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
R1  6      (0.397)                 AYED      70 IPWA                      1/71
R1  7      (0.25)                  ALMEHED   72 IPWA                      2/72*

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         (0.66)                  DELCOURT  69 MPWA                      8/69
R2  B      (0.4)   (0.1)           DEANS     69 MPWA    T POLE+ RESON.    5/70
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 (D(1236) PI)/TOTAL         (P4)
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 SIGMA)/TOTAL            (P5)
R4  D      (0.26)                  DIEM      70 IPWA    3 BODY ANALYSIS   1/71
R4  D    ASSUMING  R1= 0.34

         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

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                         REFERENCES -- N*1/2(1535)

HENDRY   65 PL 18 171          A W HENDRY, R G MOORHOUSE            (RTHFD)
     --  REVIEWS EARLY PHASE-SHIFT-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,RTHFD)

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
DONNACH2 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
KIRSOPP  68 THESIS             R G KIRSOPP                           (EDIN)
DELCOURT 69 PL 29B 75          DELCOURT,LEFRANCOIS,PEREZ-Y-JORBA,+   (ORSA)
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 SUB.NP B           ,LOVELACE                            (RUTG)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

BRANDSEN 65 PR 139 B1566       +ODONNELL, MOORHOUSE          (DURHAM,RTHFD)IJP
     --  BASIS OF NUMBERS WE QUOTE FROM HENDRY 65.
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET         (SACLAY)IJP
LOVELACE 67 HEIDELBERG C. 79   C LOVELACE                            (CERN)IJP
JOHNSON  67 UCRL-17683 THESIS  C H JOHNSON                            (LRL)
DONNACH1 69 NP 10B 433         A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598         +BAREYRE+VILLET                     (SACLAY)

          FOR PHOTONIC COUPLINGS SEE
MOORHOUSE70 NP B23,181         +RANKIN                               (GLAS)
WALKER   69 PR 182,1729        R.L.WALKER                            (CALT)

          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
RICHARDS 66 PRL 16 1221        +CHIU,EANDI,HELMHOLZ,KENNEY,+  (LRL,HAWAII) IJ
JONES    66 PL 23 597          +BINNIE,DUANE,HORSEY,MASON,+ (IMPCOL,RTHFD)
BACCI    66 NC 45A 983         +PENSO,SALVINI,MENCUCCINI,+ (ROME,FRASCATI)IJP
PREPOST  67 PRL 18 82          R PREPOST, D LUNDQUIST, D QUINN  (STANFORD)
BLOOM    68 PRL 21 1100        +HEUSCH, PRESCOTT, ROCHESTER        (CALTECH)
BULOS    69 PR 187 1827        +LANDU,BORDNER,BASTIEN +  (BU+HAR+MIT+PA)
HEUSCH   70 PRL 25,1381        +PRESCOTT,ROCHESTER,WINSTEIN          (CALT)
          MAINLY THEORETICAL --
DOBSON   66 PR 146 1022        P N DOBSON                          (HAWAII)
MINAMI   66 PR 147 1123        S MINAMI                             (OSAKA)
BALL     66 PR 149 1191        J S BALL                              (UCLA)
LOGAN    67 PR 153 1634        R K LOGAN, F UCHIYAMA-CAMPBELL         (ILL)
MENCUCCI 67 NC 48A 579         C MENCUCCINI, A REALE             (FRASCATI)
DEANS    67 PR 161 1466        S R DEANS, W G HOLLADAY         (VANDERBILT)
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                              (CDF)

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## 1520 MEV REGION - PRODUCTION EXPERIMENTS

**N(1520) BUMPS**

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8 N*(1520)

THIS INFORMATION REFERS TO EITHER THE D13 OR THE S11
STATE SEEN AT THIS MASS

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                 8  N*(1520)  MASS (MEV)    PROD. EXP.

M        1503.      6.            ANDERSON  70 MMS   - PI- P TO PI- MMS  2/71
M        1507.0     6.0           A-BORELLI 67 HBC    O PBAR P 5.7GEV   10/71*
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*

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                 8  N*(1520)  WIDTH(MEV)    PROD. EXP.

W         120.     10.            ANDERSON  70 MMS   - PI- P TO PI- MMS  2/71
W          55.0    15.0           A-BORELLI 67 HBC    O PBAR P 5.7GEV   10/71*
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*

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                 8  N*(1520)  BRANCHING RATIOS    PROD. EXP.

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*(1520) INTO (NEUTRON PI+)/(P PI+ PI-)
R2         0.77     0.45           ALEXANDER 67 HBC  +  PP 5.5 BEV/C      9/66

R3       N*(1520) INTO (N PI)/(N PI PI)
R3         1.25     0.44     0.71  A-BORELLI 67 HBC  0  PBAR P 5.7 BEV/C  9/66

R4       N*(1520)  INTO   (N*3/2(1236) PI)/(N PI PI)   PROD. EXP.
R4         0.00     0.09           A-BORELLI 67 HBC                       9/66
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R5          N*(1520) INTO (N PI PI)/TOTAL
R5            (0.08) OR LESS            BASSOMPIE 67 HBC  +  K+P TO K* N*     11/68

R6          N*(1520)  INTO   (N ETA)/TOTAL          PROD. EXP.
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(1236))
R7            (0.42) OR LESS            LEE       67 HBC     PI-P 3.6  GEV/C  11/67

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                                REFERENCES  -N*(1520)-    PROD. EXP.

A-BORELL 67 NC 47 232          ALLES-BORELLI,FRENCH,FRISK,MICHEJDA  (CERN)
ALEXANDE 67 PR 154 1284        ALEXANDER,BENARY,CZAPEK,+  (WEIZMANN(CERN))
BASSOMPI 67 PL 25B 440         BASSOMPIERRE, +            (CERN,BRUXELLES)
LEE      67 PR 159 1156        +MOEBS,ROE,SINCLAIR,VANDER VELDE     (MICH)

ANDERSON 70 PRL 25,699         +BLESER,BLIEDEN,COLLINS++        (BNL,CARN)
AMALDI   71 PL  34B 435        +BIANCASTELLI,BOSIO,+  (I SANITA ROMA+CERN)
ELLIS    71 PRL 27 442         +MAGLICH,NOREM,SANNES,SILVERMAN      (RUTG)

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                    END PRODUCTION EXPERIMENTS

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## N(1670)

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64  N*1/2(1670, JP=5/2-) I=1/2
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**D'15**

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FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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                    64  N*1/2(1670) MASS (MEV)

M          (1650.0)        APPROX       BRANDSEN  65 RVUE    PHASE-SHIFT ANAL  7/66
M          (1674.0)                     DUKE      68 CNTR    PI-P EL + POL     6/68
M    1     (1680.0)                     BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    1          WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    2     (1655.0)                     BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    2          WHERE SPEED IS GREATEST - EYEBALL FIT
M    3     (1678.0)                     DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M    3     (1680.)                      DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M    3     (1678.)                      KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
M    4     (1669.0)                     DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M    5     (1667.0)                     DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M    5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M    6     (1675.0)                     AYED      70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    7     (1683.)                      ALMEHED   72 IPWA                      2/72*

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                    64  N*1/2(1670) WIDTH (MEV)

W    1     (135.0)                      BAREYRE   68 RVUE                     11/67
W    2     (105.0)                      BAREYRE   68 RVUE                     11/67
W    3     (173.0)                      DONNACH1  68 RVUE                      6/68
W    3     (173.)                       DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W    3     (175.)                       KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W    4     (115.0)                      DAVIES    70 RVUE      SOL A AND B     8/69
W    6     (143.0)                      AYED      70 IPWA                      1/71
W    7     (150.)                       ALMEHED   72 IPWA                      2/72*
      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+ 497
P4          N*1/2(1670) INTO N*3/2(1236) PI             1236+ 139
P5          N*1/2(1670) INTO N PI PI                     938+ 139+ 139

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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   3         (.39)                     DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1   3         (.39)                     KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1   4        (0.50)                     DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
R1   5        (0.43)                     DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
R1   6        (0.392)                    AYED      70 IPWA                      1/71
R1   7        (0.45)                     ALMEHED   72 IPWA                      2/72*
      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 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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                                REFERENCES -- N*1/2(1670)

BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE          (DURHAM,RTHFD)IJP
TRIPP    67 NP B3 10           + LEITH, +     (LRL,SLAC,CERN,HEIDEL,SACLAY)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
DUKE     68 PR 166 1448        +JONES,KEMP,MURPHY,THRESHER, +  (RTHFD,OXF)IJP
      -- INSIGHTFUL QUALITATIVE ARGUMENTS CONCERNING EXISTENCE AND IJP.
KIRSOPP  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)

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 SUB.NP B           ,LOVELACE                             (RUTG)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +  (RTHFD,OXF)IJP
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET          (SACLAY)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                               (LRL)
DEANS    69 PRL 177 2623       S R DEANS                            (FLORIDA)
DONNACH1 69 NP 10B 433         A DONNACHIE, R KIRSOPP              (GLAS+EDIN)
AYED     70 PL 31B 598         +BAREYRE+VILLET                       (SACLAY)

        FOR PHOTONIC COUPLINGS SEE
WALKER   69 PR 182,1729        R.L.WALKER                              (CALT)

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## N(1688)

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65  N*1/2(1688, JP=5/2+) +=1/2
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**F'15**

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FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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                    65  N*1/2(1688) MASS (MEV)

M          (1680.0)                     BRANDSEN  65 RVUE    PHASE SHIFT ANAL  7/66
M          (1682.0)                     DUKE      68 CNTR    PI-P EL + POL     6/68
M    1     (1690.0)                     BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    1          WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    2     (1680.0)                     BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    2          WHERE SPEED IS GREATEST - EYEBALL FIT
M    3     (1687.0)                     DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M    3     (1690.)                      DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M    3     (1692.)                      KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
M    4     (1685.0)                     DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M    5     (1684.0)                     DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M    5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M    6     (1682.0)                     AYED      70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    7     (1688.)                      ALMEHED   72 IPWA                      2/72*

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                    65  N*1/2(1688) WIDTH (MEV)

W    1     (110.0)                      BAREYRE   68 RVUE                     11/67
W    2     (105.0)                      BAREYRE   68 RVUE                     11/67
W    3     (177.0)                      DONNACH1  68 RVUE                      6/68
W    3     (132.)                       DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W    3     (130.)                       KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W    4     (104.0)                      DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W    5     (123.0)                      DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
W    6     (109.0)                      AYED      70 IPWA                      1/71
W    7     (140.)                       ALMEHED   72 IPWA                      2/72*
      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(1236) PI             1236+ 139
P5          N*1/2(1688) INTO N PI PI                     938+ 139+ 139

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                    65  N*1/2(1688) BRANCHING RATIOS

R1          N*1/2(1688) INTO (PI N)/TOTAL                (P1)
R1   1        (0.64)                     BAREYRE   68 RVUE                     11/67
R1   3        (0.560)                    DONNACH1  68 RVUE                      6/68
R1   3         (.68)                     DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1   3         (.68)                     KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1   4        (0.54)                     DAVIES    70 RVUE      SOL A AND B     8/69
R1   6        (0.593)                    AYED      70 IPWA                      1/71
R1   7        (0.65)                     ALMEHED   72 IPWA                      2/72*
      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            (0.0013)R 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 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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                          REFERENCES -- N*1/2(1688)

        SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE          (DURHAM,RTHFD)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,HEIDEL,SACLAY)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
DUKE     68 PR 166 1448        +JONES,KEMP,MURPHY,THRESHER, +  (RTHFD,OXF)IJP
KIRSOPP  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)

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 SUB.NP B           ,LOVELACE                            (RUTG)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +  (RTHFD,OXF)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)
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
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                             (LRL)
DEANS    69 PR  177 2623       S R DEANS                           (FLORIDA)
DONNACH1 69 NP 10B 433         A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598         +BAREYRE+VILLET                     (SACLAY)

         FOR PHOTONIC COUPLINGS SEE
WALKER   69 PR 182,1729        R.L.WALKER                            (CALT)

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**N(1700)** 66 N*1/2(1700, JP=1/2-) I=1/2 **$S''_{11}$**

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FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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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    2     (1665.0)                  BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M    2            WHERE SPEED IS GREATEST - EYEBALL FIT
M    3     (1710.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL  8/68
M    3     (1710.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M    3     (1709.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
M          (1705.0)   (10.0)         ORITO     69 RVUE    K LAMBDA PS ANAL  8/69
M    4     (1766.0)                  DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M    5     (1671.0)                  DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M    5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M    6     (1689.0)                  AYED      70 IPWA                      1/71
M    6   FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M    A     (1685.0)                  WAGNER    71 IPWA    PI-P TO K LAMB    1/71
M    A  THERE ARE 3 SIMILAR SOLUTIONS
M          (1678.0)                  SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71*
M    7     (1670.)                   ALMEHED   72 IPWA                      2/72*

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                    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    2     (110.0)                   BAREYRE   68 RVUE                     11/67
W    3     (300.0)                   DONNACH1  68 RVUE                      8/69
W    3     (300.)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W    3     (300.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W          (104.0)   (15.0)          ORITO     69 RVUE                      8/69
W    4     (404.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W    5     (121.0)                   DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
W    6     (166.0)                   AYED      70 IPWA                      1/71
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*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

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                    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 N GAMMA                    938+   0

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                    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   3        (.79)                  DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1   3        (.79)                  KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1   4       (0.56)                  DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
R1   5       (0.51)                  DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
R1   6       (0.642)                 AYED      70 IPWA                      1/71
R1   7       (0.51)                  ALMEHED   72 IPWA                      2/72*

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 N GAMMA TO LAMBDA K           SQRT(P3*P4)
R5           (0.002)OR LESS          0-+TO2    6  CNT-    K LAM PHOTOP-O   10/71*
R5           (0.0072)                SCHORSCH  70 DPWA    K LAM PHOTOPRO.  10/71*

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                          REFERENCES -- N*1/2(1700)

BRANDSEN 65 PL 19 420          +ODONNELL, MOORHOUSE          (DURHAM,RTHFD)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
DONNACH2 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
KIRSOPP  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 SUB.NP B           ,LOVELACE                            (RUTG)IJP

                               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                           (FLORIDA)
DONNACH1 69 NP 10B 433         A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598         +BAREYRE+VILLET                     (SACLAY)

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**N(1700)** 18 N*1/2(1700,JP=3/2-) I=1/2 **$D''_{13}$**

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FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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                    18  N*1/2(1700) MASS  (MEV)

M    3     (1680.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M    3     (1730.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 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.

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                    18  N*1/2(1700) WIDTH (MEV)

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                    18  N*1/2(1700) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1         N*1/2(1700) INTO PI N                       139+ 938

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                          REFERENCES -- 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)

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## 1700 MEV REGION – PRODUCTION EXPERIMENTS

**N(1700) BUMPS** 20 N*(1700)

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PARTIAL WAVE ANALYSIS REQUIRES AT LEAST FOUR I=1/2 STATES IN THE 1670 T
1780 REGION (D15, F15, S11, P11) AND AT LEAST ONE I=3/2 STATE (D33).
OBVIOUSLY DIFFERENT EXPERIMENTS ARE SEEING DIFFERENT STATES AND OFTEN I
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.

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                   20  N* (1700)    MASS (MEV)

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   B  190(1693.)     (15.)               RHODE     69 HBC      PP 22 GEV/C      10/69
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   A      (1719.0)    (6.0)              WILLMANN  70 HBC   +  PI+P 13. GEV      5/70
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            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   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
M               . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 2.3)

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                   20  N* (1700)    WIDTH (MEV)

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   B  190 (235.)     (50.)               RHODE     69 HBC      PP 22 GEV/C      10/69
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            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               . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                   20  N*(1700)     BRANCHING RATIOS

R1         N*   (1700) INTO (PI N)/(PI N*3/2(1236))       PROD. EXP.
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*   (1700) INTO (N ETA)/(N PI + N PI PI)      PROD. EXP.
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*   (1700) INTO (LAMBDA K)/(P PI+ PI-)        PROD. EXP.
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*   (1700) INTO (LAMBDA K)/(N PI + N PI PI)   PROD. EXP.
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   A        LESS THAN   0.025         WILLMANN  70  HBC     PI+P TO 3PI P     6/70
R4       25     0.025     0.005         CRENNELL  70 HBC   +                    1/71
R4       25   SEEN. CONS. WITH J=1/2    MORSE     71 HBC    0 PI-P   7   GEV/C  3/72*

R5         N*   (1700) INTO (N PI)/(N PI PI)              PROD. EXP.
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*   (1700) INTO (N*3/2(1236) PI)/(N PI PI)    PROD. EXP.
R6              NO EVIDENCE             A-BORELLI 67 HBC   +                    8/67
           SEE MERLO 66 FOR A REVIEW.

R7         N*   (1700) INTO (NEUTRON PI+)/(P PI+ PI-)     PROD. EXP.
R7              0.67      0.40          ALEXANDER 67 HBC   +  PP 5.5 BEV/C     11/67
R7              0.47      0.25          A-BORELLI    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*   (1700) INTO (N*(1236)++ PI-)/(P PI+ PI-) PROD. EXP.
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(1236)++ 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             . . . . . . . . . .
R8   AVG        0.61      0.18      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

R          N*   (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 -- N* IN PRODUCT EXPERIMENTS


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KRAEMER   64 PR 136 B496        +MADANSKY,+  (J HOPKINS,NWESTERN,WOODSTOCK) I
ALEXANDE 67 PR 154 1284         ALEXANDER,BENARY,CZAPEK,+  (WEIZMANN(CERN))
A-BORELL 67 NC 47 232           ALLES-BORELLI,FRENCH,FRISK,MICHEJDA  (CERN)
LEE       67 PR 159 1156        +MOEBS,ROE,SINCLAIR,VANDER VELDE      (MICH)

ALMEIDA   68 PR 174 1638        +RUSHBROOKE, +             (CAVNDSH,DESY(CERN))
CHINOWSK 68 PR 165 1466         CHINOWSKY,KINSEY,KLEIN, +          (LRL,SLAC)
KAYAS     68 NP B5 169          +GUYADER,SENE,YIOU,ALITTI,+  (ORSAY,SACLAY)
GALLOWAY 68 PL 27B 250          GALLOWAY,ALYEA,CRITTENDEN,PRICKETT,+  (IND)

BARNES    69 PRL 23 1516        +BASSANO+CHUNG+EISNER+FLAMINTO+KINSON (BNL)IJ
RHODE     69 PR 187 1844        RHODE, LEACOCK, KERNAN, JESPERSEN,+  (AMES)
BENVENUT 69 PR 187 1852         BENVENUTI, MARQUIT, OPPENHEIMER (MINN,COLO)

ANDERSON 70 PRL 25,699          +BLESER,BLIEDEN,COLLINS++         (BNL,CARN)
CIRBA     70 NP B23,533         +VANDERHAGEN+     (EPOL,DURH,NIJM,TORI,PIUB)
COOPER    70 NP B23,605         +MANNER,MUSGRAVE,POLLARD,VOYVODIC      (ANL)
CRENNELL 70 PRL 25 187          +LAI, LOUIE, SCARR, SIMS               (BNL)
KUZNETSOV70 SJNP 10,332         +MELNIKOV,RYLTSEVA,CHADRAA,BALINTP    (JINR)
WILLMANN 70 PRL 24 1260         +LAMSA,GAIDOS,EZELL                  (PURD)IJ

AMALDI    71 PL  34B 435        +BIANCASTELLI,BOSIO,+  (I SANITA ROMA+CERN)
BALLAM    71 PR D4 1946         +CHADWICK,GUIRAGOSSIAN,JOHNSON,++    (SLAC) I
BEKETOV   71 SJNP 13 605        ,ZOMBKOVSKII,KONOVALOV,KRUCHININ,++  (ITEP)IJ
BOESEBEC 71 NP B33 445          BOESEBECK,GRAESSLER,KRAUS,+++     (ABBCHLV) I
ELLIS     71 PRL 27 442         +MAGLICH,NOREM,SANNES,SILVERMAN       (RUTG)
MA        71 PRL  26  333       +COLTON                           (MSU+LBL)I
MORSE     71 PR D4 133          +OH,WALKER,CARROLL,LYNCH +       (WISC+TNTO)I
RUSHBROO 71 PR D4 3273          RUSHBROOKE,WILLIAMS+BAREFORD++  (CAVE,LOIC) IJ

                                PAPERS NOT REFERRED TO IN DATA CARDS.

MERLO     66 P ROY SOC 289 489 J P MERLO, G VALLADAS              (SACLAY)
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                        END PRODUCTION EXPERIMENTS

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## N(1780) — $P''_{11}$

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                   14  N*1/2(1780, JP=1/2+) I=1/2

                   FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                   PRECEDING N*1/2(1470).

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                   14  N*1/2(1780) MASS (MEV)

M   3      (1751.0)                      DONNACH1   68 RVUE     PHASE-SHIFT ANAL  8/69
M   3      (1750.)                       DONNACH2   68 RVUE     PHAS.SHIFT-CERN1 10/69
M   3      (1860.)                       KIRSOPP    68 RVUE     PHASE SHIFT ANAL 10/69
M   3    WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
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   4      (1770.0)                      DAVIES     70 RVUE     P-S ANAL   SOL A  8/69
M   5      (1867.0)                      DAVIES     70 RVUE     P-S ANAL   SOL B  8/69
M   5   SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M   6      (1645.0)                      AYED       70 IPWA                       1/71
M   6    FROM ENER. DEP. FIT OF ARGAND DIAGRAM
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          (1809.0)                      SCHORSCH   70 DPWA     K LAM PHOTOPRO.  10/71*
M   7      (1720.)                       ALMEHED    72 IPWA                       2/72*

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                   14  N*1/2(1780) WIDTH (MEV)

W   3      (327.0)                       DONNACH1   68 RVUE                       8/69
W   3      (327.)                        DONNACH2   68 RVUE     PHAS.SHIFT-CERN1 10/69
W   3      (270.)                        KIRSOPP    68 RVUE     PHASE SHIFT ANAL 10/69
W          (310.0)    (50.0)             ORITO      69 RVUE                       8/69
W          (210.0)                       ORITO2     69 CNTR     K LAM PHOTOPRO   10/71*
W   4      (445.0)                       DAVIES     70 RVUE              SOL A    8/69
W   5      (525.0)                       DAVIES     70 RVUE              SOL B    8/69
W   6       (50.0)                       AYED       70 IPWA                       1/71
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*
         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 N GAMMA                     938+   0

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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  3          (.32)                     DONNACH2   68 RVUE     PHAS.SHIFT-CERN1 10/69
R1  3          (.32)                     KIRSOPP    68 RVUE     PHASE SHIFT ANAL 10/69
R1  4         (0.43)                     DAVIES     70 RVUE              SOL A    8/69
R1  5         (0.30)                     DAVIES     70 RVUE              SOL B    8/69
R1  6         (0.149)                    AYED       70 IPWA                       1/71
R1  7         (0.2)                      ALMEHED    72 IPWA                       2/72*

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 N GAMMA TO LAMBDA K              SQ-T(P2*P4)
R5           (0.0027)                    ORITO2     69 CNTR     K LAM PHOTOPRO   10/71*
R5           (0.0088)                    SCHO-SCH   70 DPWA     K LAM PHOTOPRO.  10/71*

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REFERENCES -- N*1/2(1780)


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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)
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)
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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 SUB.NP B           ,LOVELACE                              (RUTG)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS.

DEANS     69 PR  177 2623       S R DEANS                           (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(1860) — $P_{13}$

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15  N*1/2(1860, JP=3/2+) I=1/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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                    15  N*1/2(1860) MASS (MEV)

M   3     (1860.0)                 DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   3     (1860.)                  DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M   3     (1900.)                  KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M   3   WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1   10/69
M   4     (1844.0)                 DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   5     (1854.0)                 DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M   5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 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   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*

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                    15  N*1/2(1860) WIDTH (MEV)

W   3     (296.00)                 DONNACH1  68 RVUE                      8/69
W   3     (296.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W   3     (325.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W   4     (449.0)                  DAVIES    70 RVUE             SOL A    8/69
W   5     (307.0)                  DAVIES    70 RVUE             SOL B    8/69
W   6     (182.0)                  AYED      70 IPWA                      1/71
W   A     (220.0)                  WAGNER    71 IPWA    PI-P TO K LAMB    1/71
W   7     (300.)                   ALMEHED   72 IPWA                      2/72*
          SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                    15  N*1/2(1860) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1        N*1/2(1860) INTO  PI N                         139+ 938
P2        N*1/2(1860) INTO  LAMBDA K                    1115+ 497
P3        N*1/2(1860) INTO N ETA                         939+ 548
P4        N*1/2(1860) INTO N PI PI                       938+ 139+ 139

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                    15  N*1/2(1860) BRANCHING RATIOS

R1        N*1/2(1860) INTO (PI N)/TOTAL                  (P1)
R1  3       (0.21)                 DONNACH1  68 RVUE                      8/69
R1  3        (.21)                 DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3        (.25)                 KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  4       (0.40)                 DAVIES    70 RVUE             SOL A    8/69
R1  5       (0.26)                 DAVIES    70 RVUE             SOL B    8/69
R1  6       (0.149)                AYED      70 IPWA                      1/71
R1  7       (0.25)                 ALMEHED   72 IPWA                      2/72*

R2        N*1/2(1860) 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(1860) 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(1860) INTO (LAMBDA K)*(PI N)/TOTAL**2    (P2*P1)
R4  A       (0.015)                WAGNER    71 IPWA    PI-P TO K LAMB    1/71

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REFERENCES -- N*1/2(1860)


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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)
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 SUB.NP B           ,LOVELACE                              (RUTG)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS.

DEANS     69 PR  177 2623       S R DEANS                           (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) — $F_{17}$

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17  N*1/2(1990, JP=7/2+) I=1/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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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*

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                    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*

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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

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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*

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

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REFERENCES -- N*1/2(1990)


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DONNACH1  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)
DEANS     69 PR 185 1797        S DEANS, J WOOTEN           (UNIV S FLORIDA)

ALMEHED   72 SUB.NP B           ,LOVELACE                              (RUTG)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS.

DEANS     69 PR  177 2623       S R DEANS                           (FLORIDA)
AYED      70 PL 31B 598         +BAREYRE,VILLET                      (SACLAY)
APLIN     71 NP  B32 253        +COWAN,GIBSON,GILMORE++       (RHEL,BRISTOL)

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### N(2040) — $D'''_{13}$

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16  N*1/2(2040, JP=3/2-) I=1/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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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*

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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*
    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

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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*

R2        N*1/2(2040) INTO (N ETA)/TOTAL                 (P3)
R2  B       (0.)    OR 0.009       CARRERAS  70 MPWA    T POLE + RESON.   5/70
R2  B   PARAMETRIZATION USED COULD BE IN DANGER OF DOUBLE COUNTING

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REFERENCES -- N*1/2(2040)


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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)
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CARRERAS 70 NP 16B 35          B CARRERAS, A DONNACHIE          (DARE,MCHS)

ALMEHED  72 SUB.NP B           ,LOVELACE                             (RUTG)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)

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04  N*1/2(2100, JP=1/2-) I=1/2
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$S'''_{11}$

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  SEE THE NOTE ON N'S AND DELTAS PRECEDING THE
BARYON DATA CARD LISTINGS.

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                  04  N*1/2(2100) MASS (MEV)

M   7      (2100.)                 ALMEHED    72 IPWA                     2/72*
M          (2070.)                 ROYCHOUD   71 DPWA                     3/72*

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                  04  N*1/2(2100) WIDTH (MEV)

W   7      (200.)                  ALMEHED    72 IPWA                     2/72*

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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*

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                         REFERENCES -- N*1/2(2100)
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ROYCHOUD 71 NP B27 125        R K ROYCHOUDHURY,B H BRANSDEN       (DURH)IJP
ALMEHED  72 SUB.NP B          ,LOVELACE                           (RUTG)IJP
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## N(2100)

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05  N*1/2(2100, JP=5/2-) I=1/2
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$D''_{15}$

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  SEE THE NOTE ON N'S AND DELTAS PRECEDING THE
BARYON DATA CARD LISTINGS.

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                  05  N*1/2(2100) MASS (MEV)

M   7      (2100.)                 ALMEHED    72 IPWA                     2/72*

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                  05  N*1/2(2100) WIDTH (MEV)

W   7      (150.)                  ALMEHED    72 IPWA                     2/72*

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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*

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                         REFERENCES -- N*1/2(2100)
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ALMEHED  72 SUB.NP B          ,LOVELACE                           (RUTG)IJP
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## N(2175)

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06  N*1/2(2175, JP=5/2+) I=1/2
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$F''_{15}$

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  SEE THE NOTE ON N'S AND DELTAS PRECEDING THE
BARYON DATA CARD LISTINGS.

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                  06  N*1/2(2175) MASS (MEV)

M   7      (2175.)                 ALMEHED    72 IPWA                     2/72*

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                  06  N*1/2(2175) WIDTH (MEV)

W   7      (150.)                  ALMEHED    72 IPWA                     2/72*

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                  06  N*1/2(2175) PARTIAL DECAY MODES

                                                           DECAY MASSES
P1         N*1/2(2175) INTO PI N                         139+ 938

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                  06  N*1/2(2175) BRANCHING RATIOS

R1         N*1/2(2175) INTO (PI N)/TOTAL                 (P1)
R1  7        (0.25)                ALMEHED    72 IPWA                     2/72*

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                         REFERENCES -- N*1/2(2175)
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ALMEHED  72 SUB.NP B          ,LOVELACE                           (RUTG)IJP
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## N(2190)

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71  N*1/2(2190, JP=7/2-) I=1/2
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$G_{17}$

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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   3      (2190.)                     DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69
M   3      (2265.)                     KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69
M   3    WHERE MAX. ABSORPTION IS ~DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
M          (2000.0)       APPROX       LEA       69 CNTR   PI-P ELASTIC      8/69
M   6      (2158.0)                    AYED      70 IPWA                     1/71
M   6    FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M           2180.      25.             ANDERSON  70 MMS  - PI- P TO PI- MMS  2/71
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*

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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)                     DONNACH1  68 RVUE                     6/68
W   3      (300.)                      DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69
W   3      (300.)                      KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69
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*
       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

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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)                   DONNACH1  68 RVUE                     6/68
R1  3         (.35)                    DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69
R1  3         (.35)                    KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69
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*

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                         REFERENCES -- 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         (ARG,CHI) JP

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)

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 SUB.NP B          ,LOVELACE                           (RUTG)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.

CARROLL  66 PRL 16 288        +CORBETT,DAMERELL,MIDDLEMAS, +  (RTHFD,OXF)J-L
CARROLL  66 PRL 17 1274       +CORBETT,DAMERELL,MIDDLEMAS, +  (RTHFD,OXF)J-L
     --  ERRATUM CHANGING THE RATHER WEAK DETERMINATION OF J-L TO +1/2.
KORMANYO 66 PRL 16 709        KORMANYOS,KRISCH,OFALLON, +      (MICH,ARG) P
BARGER   66 PRL 16 913        V BARGER, D CLINE                    (WISC) P
BUSZA    67 NC 52A 331        +DAVIS,DUFF,HEYMANN, +   (UNICOL,WESTFIELD)
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## N(2220)

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90  N*1/2(2220, JP=9/2+) I=1/2                    H10

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

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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

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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

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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

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                         REFERENCES -- N*1/2(2220)

BUSZA    67 NC 52A 331        +DAVIS,DUFF,HEYMANN,NIMMON +      (UCL+WCL)
AYED     70 KIEV CONF         R AYED,P BAREYRE, G VILLET          (SACL)IJP
HULL     70 PR D2 1783        J HULL, R LEACOCK                     (ISU)

                         PAPERS NOT REFERED TO IN DATA CARDS

AYED     70 PL 31B 598        +BAREYRE,VILLET                     (SACLAY)

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**M > 2200 MEV – PRODUCTION AND $\sigma_{TOTAL}$ EXPERIMENTS**

**BUMPS**

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## N(2650)

```
72  N*1/2(2650, JP=    -) I=1/2

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)

M          (2700.0)                   ALVAREZ   64 CNTR    PI PHOTOPROD
M          (2600.0)       APPROX      WAHLIG    64 OSPK 0  PI-P CH EX
M          (2660.0)                   HOHLER    64 RVUE    DATA + DISP REL
M           2649.0     10.0           CITRON    66 CNTR    PI+- P TOTAL      7/66
M          (2633.0)                   BARGER    66 FIT     TOTAL + CH EX    11/67

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

                    72  N*1/2(2650) WIDTH (MEV)

W          (100.0)                    ALVAREZ   64 CNTR
W          (200.0)                    HOHLER    64 RVUE                     7/66
W           360.0     20.0            CITRON    66 CNTR                     7/66
W          (425.0)                    BARGER    66 FIT     TOTAL + CH EX    11/67

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                    72  N*1/2(2650) PARTIAL DECAY MODES

                                                            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

R1         N*1/2(2650) INTO (PI N)/TOTAL                  (P1)
R1    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1           0.436    0.028          CITRON    66 CNTR    TOTAL CROSS-SEC. 11/67
R1  B       (0.456)  (0.018)         BARGER    66 RVUE    TOTAL + CH EXC.  11/67
R1  B       (0.30)                   BARGER    67 RVUE    USES KORMANYOS67 11/67
R1  B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
R1  B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  D        (0.24)                  DIKMEN    67 RVUE    USES KORMANYOS66 11/67
R1  D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1           (0.06)                  KORMANYOS 67 CNTR    PI-P AT 180 DEG. 11/67

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                         REFERENCES -- N*1/2(2650)

ALVAREZ  64 PRL 12 710        +BAR-YAM,KERN,LUCKEY,OSBORNE, +   (MIT,CEA)
WAHLIG   64 PRL 13 103        +MANNELLI,SODICKSON,FACKLER,WARD, +   (MIT)
HOHLER   64 PL 12 149         G HOHLER, J GIESECKE            (KARLSRUHE) I
CITRON   66 PR 144 1101       +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER   66 PR 151 1123       V BARGER, M OLSSON                   (WISC)
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,ARG) 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          (CAL TECH)
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.

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)

```
73  N*1/2(3030, JP=     ) I=1/2

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                    73  N*1/2(3030) MASS (MEV)

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)

W          (400.0)                    CITRON    66 CNTR                      7/66

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

                    73  N*1/2(3030) PARTIAL DECAY MODES

                                                            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

R1         N*1/2(3030) INTO (PI N)/TOTAL                  (P1)
R1    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1          (0.048)                  CITRON    66 CNTR    TOTAL CROS.SEC.  11/67
R1  B       (0.088)  (0.016)         BARGER    66 RVUE    TOTAL + CH EXC.  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 -- N*1/2(3030)

HOHLER   64 PL 12 149         G HOHLER, J GIESECKE            (KARLSRUHE) I
CITRON   66 PR 144 1101       +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER   66 PR 151 1123       V BARGER, M OLSSON                   (WISC)
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,ARG) P
DOLEN    68 PR 166 1768       R DOLEN, D HORN, C SCHMID          (CAL TECH)

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## $N_7$(3245)

```
74  N*   (3245, JP=    +)

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)

M          3245.0     10.0            KORMANYOS 67 CNTR    PI-P 180 DEG EL   6/68

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

                    74  N*  /2(3245) WIDTH (MEV)

W           (35.0)  OR LESS           KORMANYOS 67 CNTR                      6/68

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                    74  N*  /2(3245) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1         N*  /2(3245) INTO PI N                          139+ 938

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

                    74  N*  /2(3245) BRANCHING RATIOS
      J IS NOT KNOWN.  FOLLOWING IS (J+1/2)*(PI N)/TOTAL
R1          (0.37)                   KORMANYOS 67 CNTR                      6/68

****** ********* ********* ********* ********* ********* ********* ********

                         REFERENCES -- N*  /2(3245)

KORMANYO 67 PR 164 1661       KORMANYOS, KRISCH, OFALLON, +    (MICH,ARG) P

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```

# Data Card Listings

*For notation, see key at front of Listings.*



**N(3690)**

```
75  N*1/2(3690, JP=     ) I=1/2

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.

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

                75  N*1/2(3690) MASS (MEV)

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)

W          50.0     30.0            BARTKE    67 HBC   +                   8/67

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                75  N*1/2(3690) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1       N*1/2(3690) INTO N + 7 PIS

****** ********* ********* ********* ********* ********* ********* ********

                        REFERENCES -- N*1/2(3690)

BARTKE   67 PL 24B 118        +CZYZEWSKI,DANYSZ,+          (CRACOW,ORSAY) I

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****** ********* ********* ********* ********* ********* ********* ********
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**$N_\gamma$(3755)**

```
76  N* /2(3755, JP=     )

A SMALL PEAK IN THE (P P PBAR) INVARIANT MASS FROM
8.4 BEV/C PI+ P TO PI+ P P PBAR EVENTS.  AS EVIDENCE
FOR A NEW RESONANCE IT IS NOT CONCLUSIVE.  OMITTED
FROM TABLE.

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

                76  N* /2(3755) MASS (MEV)

M        3755.0      8.0            EHRLICH   68 HBC  +  PI+ P P PBAR      6/68

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

                76  N* /2(3755) WIDTH (MEV)

W          40.0     20.0            EHRLICH   68 HBC  +                    6/68

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

                76  N* /2(3755) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1       N* /2(3755) INTO PI+ P P PBAR

****** ********* ********* ********* ********* ********* ********* ********

                        REFERENCES -- N* /2(3755)

EHRLICH  68 PRL 20 686        R EHRLICH,R J PLANO,J B WHITTAKER (RUTGERS)

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                END PRODUCTION EXPERIMENTS

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**Δ(1236)**

```
33  N*3/2(1236, JP=3/2+) I=3/2                    P'33

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.
   SEE THE ACCOMPANING NOTE, 'COMMENTS ON THE MASS AND WIDTH OF
DELTA(1236)'.
```

## Comments on the Mass and Width of Δ(1236)

In the last edition of Review of Particle Properties,[1] we indicated some difficulties with the determination of the mass and width of Δ(1236). We present here some further efforts toward the resolution of these difficulties.

The basic observation of our previous note was that the $\delta_{33}$ phase shifts, which CARTER 71 extract from their recent cross-section measurements, could not be fit with any reasonable 3-parameter function (Breit-Wigner form or polynomial for $q^3 \cot \delta_{33}$). There are two aspects of this problem which we discuss in the present note:

1. The various phase-shift data points may not be of equally good quality.[2] In particular, if the last point of CARTER 71 is ignored as a bad fluctuation, then adequate 3-parameter fits can be obtained.

2. If we assume all the data points to be equally good, then 4-parameter functions are required to fit them. In this case we have a problem of interpretation in that the mass and width parameters depend on what function we choose to use.

### Fits to the Data

The mass and width parameters from our fits are shown in Table I. The numbers in the column labeled "Points" indicate the number of data points in each fit. The 13- and 14-point fits are to the data of CARTER 71; the 17- and 19-point fits supplement the CARTER 71 data with recent phase shifts[3] from ALMEHED 72. As indicated, three different Breit-Wigner parametrizations and a polynomial fit were tried. The formulae used are:

1) STANDARD: $\tan \delta = \dfrac{E_R \Gamma(q)}{(E_R^2 - E^2)}$,

$$\Gamma(q) = \Gamma_R \left(\frac{q}{q_R}\right)^3 \left[\frac{1 + (q_R r)^2}{1 + (q r)^2}\right],$$

where E is the c.m. energy of the πN system, q the c.m. momentum of the pion, $E_R$ and $\Gamma_R$ the mass and width of the resonance at resonant energy, $q_R$ the value of q at resonance, and r a radius of interaction;

2) LAYSON: $\tan \delta = \dfrac{\Gamma(E_\pi)}{2(E_0 - E_\pi)}$,

$$\Gamma(E_\pi) = \frac{4 m_p (qr)^3 \gamma^2}{(E_\pi + E_0)[1 + (qr)^2]},$$

where $E_\pi$ is the pion c.m. energy, $E_0$ the resonant value of $E_\pi$, $\gamma^2$ a reduced width, $m_p$ the mass of the proton, and the remaining quantities as above;

3) CHEW-LOW: $\tan \delta = \dfrac{E_R \Gamma(q)}{2E(E_R - E)}$,

$$\Gamma(q) = \frac{\lambda q (qr)^2}{1 + (qr)^2};$$

4) POLYNOMIAL: $q^3 \cot \delta = \sum_{n=1}^{N} a_n q^{2n-2}$,

For further details on the parametrization see Refs. 1 and 6.

In the 4-parameter fits, a background phase $\delta = \tan^{-1}(aq^3)$ is added to the Breit-Wigner phase in the case of the STANDARD, LAYSON and CHEW-LOW

forms. This addition insures unitarity to the extent that the $P_{33}$ wave is purely elastic. The STANDARD (2R) form refers to the Standard Breit-Wigner form, but with two radii.

As for the statistical significance of these fits, the 13- and 17-point, 3-parameter fits all yield good $\chi^2$'s, whereas the 14- and 19-point fits are bad. In the case of the 4-parameter fits, the 13-, 14-, and 17-point fits all yield good $\chi^2$'s. The 19-point fits are poor, although they are much better than the 3-parameter fits ($\chi^2$'s of ~30 for 4 parameters compared with $\chi^2$'s of ~ 90 for 3 parameters). No significant difference in the $\chi^2$ is noted among the different formulae used for a given set of points.

Mass and Width of Δ(1236) on the Real Axis

What can be said about the mass and width of Δ(1236) from these fits ? In Table I [6] we also indicate the spread in values for these parameters by dM and dΓ/2. Thus for 3-parameter, 14- point fits the spread in parameters among the 4 fits is dM = 0.2 and dΓ/2 = 0.3 MeV; if we vary the number of points in the fit, the spread in the parameters for the STANDARD form is dM = 0.4 and dΓ/2 = 0.9 MeV. While the spread in the 13- and 17- point fits seems rather small, it must be emphasized that these fits are statistically significant only because certain phase-shift measurements have been rejected as being incorrect by many standard deviations.

When we consider the 4-parameter fits, we immediately note that the spread in mass and width is quite a bit greater. Since these parameters represent the better fits to the data, then on the basis of Table I the most conservative values we can quote for these parameters are

M = 1232.9 ± 2.2 MeV, Γ = 116.4 ± 7.2 MeV.

These values are the mean of the maximum variation in values found in Table I.

Pole Position of the Δ(1236)

The reason for this large spread in values is actually rather obvious. Notice that whenever we use a pure (no "background") Breit-Wigner or polynomial parametrization the mass is always 1231.4 MeV with a spread of at most 0.5 MeV. This value is consistent with the energy where $\delta_{33}$ passes through 90°. On the other hand, when we add a background to the Breit-Wigner, the mass value is consistently higher, while the total phase still passes through 90° at ~ 1231 MeV. Since both types of fits describe the data equally well, we have the apparent problem of choosing between equally valid parametrizations.

It has been suggested by Coleman [4] and recently shown by Ball et al. [5], that this problem is removed if we take the mass and width to be given by the actual pole position of the Δ(1236) in the complex energy plane.

Using the above fits, we have searched for poles in the scattering amplitude

$$A = \frac{q^2}{q^3 \cot\delta - iq^3}$$

on the second sheet. For a given complex energy, this sheet is defined by considering only those values of complex q such that Im q < 0. Our results are shown in Table II. [6] Recalling that some of the measured phases may be wrong, we can quote conservative values for the mass and width based on the spread of pole positions in Table II:

$M_{pole}$ = 1211.6 ± 0.7 MeV, $\Gamma_{pole}$ = 99.1 ± 2.7 MeV.

Comparing these results to those on the real axis, we are tempted to conclude that the pole position is indeed better determined. To provide further evidence for this conclusion, we performed an error analysis of the 14-point standard Breit-Wigner-plus-background fit. On the real axis we find

M = 1234.09 ± 0.64 MeV, Γ = 120.58 ± 2.25 MeV.

Note that the errors are roughly the same as those of CARTER 71. Using the full error matrix, we found for the pole position:

$M_{pole}$ = 1211.11 ± 0.24 MeV, Γ = 100.01 ± 0.56 MeV.

Although standard error propagation techniques may not be correct in this instance, they certainly give results in the same direction as our more conservative estimates.

Concluding Remarks

1. All parametrizations of the data on the real axis are equally good provided:

a) they fit the data,

b) they are unitary and have sensible "cut" features ($\delta_\ell \propto q^{2\ell+1}$).

2. For good fits to the same data, the resonance mass and width on the real axis depend upon the parametrization used (4-parameter fits have a much larger spread in M and Γ/2 than the 3-parameter fits).

3. For good fits to the same data, the pole positions will be essentially independent of the parametrization.

Table I. Mass and half-width values obtained in the various fits to the $\delta_{33}$ phase shifts. $N_p$ indicates the number of parameters used in the fit. (Table taken from Ref. 6).

| Points | $N_p$ | STANDARD | | STANDARD(2R) | | LAYSON | | CHEW-LOW | | POLYNOMIAL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | Γ/2 | M | Γ/2 | M | Γ/2 | M | Γ/2 | M | Γ/2 | pμ | dΓ/2 |
| 13 | 3 | 1230.9 | 55.4 | | | 1231.0 | 55.5 | 1231.0 | 55.5 | 1231.0 | 55.5 | 0.1 | 0.1 |
| 14 | 3 | 1230.7 | 54.6 | | | 1230.9 | 54.9 | 1230.8 | 54.8 | 1230.9 | 54.9 | 0.2 | 0.3 |
| 17 | 3 | 1230.9 | 55.5 | | | 1231.0 | 55.6 | 1231.0 | 55.6 | 1231.0 | 55.6 | 0.1 | 0.1 |
| 19 | 3 | 1231.1 | 55.1 | | | 1231.2 | 55.4 | 1231.2 | 55.3 | 1231.2 | 55.4 | 0.1 | 0.3 |
| dM, dΓ/2 | | 0.4 | 0.9 | | | 0.3 | 0.7 | 0.4 | 0.8 | 0.4 | 0.7 | | |
| 13 | 4 | 1232.8 | 58.3 | 1231.2 | 55.9 | 1232.8 | 58.3 | 1232.5 | 57.8 | 1230.9 | 55.3 | 1.9 | 3.0 |
| 14 | 4 | 1234.0 | 60.1 | 1231.4 | 56.0 | 1233.7 | 59.7 | 1233.5 | 59.3 | 1231.4 | 56.0 | 3.6 | 4.1 |
| 17 | 4 | 1232.3 | 57.6 | 1231.1 | 55.8 | 1231.7 | 56.7 | 1231.8 | 56.9 | 1231.1 | 55.7 | 1.3 | 1.9 |
| 19 | 4 | 1235.0 | 61.8 | 1231.7 | 56.6 | 1234.8 | 61.6 | 1234.6 | 61.3 | 1231.7 | 56.6 | 3.3 | 5.2 |
| dM, dΓ/2 | | 2.7 | 4.2 | 0.6 | 0.8 | 3.1 | 4.9 | 2.8 | 6.7 | 0.8 | 1.3 | | |

Table II. Results of the extrapolation to the pole in Sheet II for the various resonance forms discussed in the text, using the parameters of Table I. M and Γ/2 (in MeV) represent the pole location in the complex energy plane. (Table taken from Ref. 6).

| Points | $N_p$ | STANDARD | | STANDARD(2R) | | LAYSON | | CHEW-LOW | | POLYNOMIAL | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | Γ/2 | M | Γ/2 | M | Γ/2 | M | Γ/2 | M | Γ/2 | dM | dΓ/2 |
| 13 | 3 | 1211.6 | 48.4 | | | 1211.6 | 48.8 | 1211.6 | 48.7 | 1211.6 | 48.8 | 0.0 | 0.4 |
| 14 | 3 | 1212.1 | 48.2 | | | 1212.0 | 48.6 | 1212.0 | 48.6 | 1212.0 | 48.6 | 0.1 | 0.4 |
| 17 | 3 | 1211.6 | 48.4 | | | 1211.5 | 48.8 | 1211.5 | 48.7 | 1211.4 | 48.8 | 0.2 | 0.4 |
| 19 | 3 | 1212.3 | 48.7 | | | 1212.2 | 49.1 | 1212.2 | 49.0 | 1212.2 | 49.1 | 0.1 | 0.4 |
| dM, dΓ/2 | | 0.7 | 0.5 | | | 0.7 | 0.5 | 0.7 | 0.4 | 0.8 | 0.5 | | |
| 13 | 4 | 1211.3 | 49.4 | 1211.4 | 49.5 | 1211.2 | 49.6 | 1211.3 | 49.5 | 1211.7 | 48.6 | 0.4 | 1.0 |
| 14 | 4 | 1211.2 | 50.0 | 1211.4 | 50.2 | 1211.1 | 50.0 | 1211.2 | 50.0 | 1211.3 | 50.2 | 0.3 | 0.2 |
| 17 | 4 | 1211.3 | 49.2 | 1211.4 | 49.2 | 1211.4 | 49.1 | 1211.3 | 49.2 | 1211.5 | 49.1 | 0.2 | 0.1 |
| 19 | 4 | 1210.9 | 50.5 | 1211.2 | 50.9 | 1210.9 | 50.5 | 1210.9 | 50.5 | 1211.1 | 50.9 | 0.3 | 0.4 |
| dM, dΓ/2 | | 0.4 | 1.3 | 0.2 | 1.7 | 0.5 | 1.4 | 0.4 | 1.3 | 0.6 | 2.4 | | |

## References

1. Particle Data Group, Rev. Mod. Phys. 43, No. 2, Part II, S1 (1971).
2. Dr. A. A. Carter, private communication.
3. Almehed and Lovelace, Rutgers U. Preprint (submitted to Nucl. Phys. B, 1972).
4. S. Coleman, remark at the Erice Summer School on Subnuclear Physics (1971). See Ref. 6.
5. Ball, Campbell, Lee, and Shaw, University of Utah Preprint, 1972.
6. A. Barbaro-Galtieri, Lectures delivered at the Erice Summer School on Subnuclear Physics, Lawrence Berkeley Laboratory Report LBL-555; to be published by Academic Press (1971).
7. T. A. Lasinski, Lawrence Berkeley Laboratory Group A Memo 742 (1972).

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                    33  N*3/2(1236)  MASS (MEV)

M          (1234.)                    ROPER     65 DPWA 0++ PHASE SHIFT AN.
M          (1235.)                    ALMEHED   72 IPWA                      2/72*
M++         1236.0      0.55          OLSSON    65 RVUE ++ TOTAL-SIGMA DATA
M++         1230.0      0.6           CARTER    71 MPWA ++ PI+P SIG. TOTAL   1/71
M++        . . . . . . . . . .
M++ AVG     1233.3      3.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 7.4)

MO          1236.45     0.65          OLSSON    65 RVUE 0
MO          1232.9      0.6           CARTER    71 MPWA 0  PI-P SIG. TOTAL   1/71
MO         . . . . . . . . . .
MO  AVG     1234.5      1.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 4.0)

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                    33  N*3/2(1236) WIDTH (MEV)

W          (120.)                     ROPER     65 DPWA 0++ PHASE SHIFT AN.
W          (129.)                     ALMEHED   72 IPWA                      2/72*
W++         120.0      2.0            OLSSON    65 RVUE ++
W++         112.8      3.0            CARTER    71 MPWA ++ PI+P SIG TOT.     1/71
W++        . . . . . . . . . .
W++ AVG     117.8      3.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)

WO          119.6      2.4            OLSSON    65 RVUE 0
WO          114.7      3.0            CARTER    71 MPWA 0  PI-P SIG TOT.     1/71
WO         . . . . . . . . . .
WO  AVG     117.7      2.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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                    33  N*(0) - N*(++) MASS DIFFERENCE (MEV)

D   R        (0.45)   (0.85)          OLSSON    65 RVUE
D   R        (2.9)    (0.85)          CARTER    71 MPWA    PI+- P SIG.TOT.   2/71
D   R      REDUNDANT WITH DATA IN MASS LISTING.

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                    33  N*3/2(1236) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1         N*3/2(1236) INTO N PI                        938+ 139
P2         N*3/2(1236) INTO N GAMMA                     938+   0
P3         N*3/2(1236) INTO N PI PI                     938+ 139+ 139

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                    33  N*3/2(1236) BRANCHING RATIOS

R1         N*3/2(1236) 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(1336) 0 INTO (N PI)/TOTAL                (P1)
R2           (0.99)                   CARTER    71 MPWA 0  PI-P FORM. EXPER  1/71

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                          REFERENCES -- N*3/2(1236)

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)

CARTER    71 NP B26 445        +WILLIAMS, BUGG, BUSSEY, DANCE  (CAVE,RHEL)
BERENDS   71 NP  B30 575       +WEAVER                        (CEA-MIT+TUFT)

ALMEHED   72 SUB.NP B          ,LOVELACE                          (RUTG)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACHI 68 PL 26B 161         DONNACHIE,LOVELACE,KIRSOPP         (CERN)

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**Δ(1236) BUMPS**

### Δ(1236) PRODUCTION EXPERIMENTS

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                    81  N*3/2(1236, JP=3/2+)  I=3/2

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                    81  N*3/2(1236) MASS (MEV)

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 KO P PI+
M++       (1233.4)    (4.4)           GIDAL     66 DBC  ++ D D TO NN(NN) PI  7/66
M++       (1236.0)                    DEANS     66 RVUE ++ PI+P TOTAL        7/66
M++       (1224.0)    (2.0)           HABER     70  DBC    K-D TO 4 BOD(P)   7/70
M-        (1241.3)    (5.1)           GIDAL     66 DBC  -                    7/66

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                    81  N*(-) - N*(++) MASS DIFFERENCE (MEV)

D            7.9       6.8            GIDAL     66 DBC

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                    81  N*3/2(1236) WIDTH (MEV)

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++       (124.0)   (14.0)           GIDAL     66 DBC  ++                   7/66
W++       (121.0)                    DEANS     66 RVUE ++                   7/66
W++       (120.0)    (8.0)           HABER     70  DBC    K-D TO 4 BOD(P)   7/70
W-        (149.0)   (18.0)           GIDAL     66 DBC  -                    7/66

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                          REFERENCES -- N*3/2(1236)  PROD. EXPERIMENTS

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)

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**Δ(1650)** **$S_{31}$**

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                    82  N*3/2(1650, JP=1/2-) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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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   2      (1650.0)                   BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M   2            WHERE SPEED IS GREATEST - EYEBALL FIT
M   3      (1635.0)                   DONNACHI  68 RVUE    PHASE-SHIFT ANAL  6/68
M   3      (1640.)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M   3      (1635.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M   3   WHERE MAX. ABSORPTION IS -DONNACHI, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
M   4      (1617.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   5      (1623.0)                   DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M   5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACHI 68)
M   6      (1614.0)                   AYED      70 IPWA                      1/71
M   6   ENER. DEP. FIT OF ARGAND DIAGRAM
M   7      (1620.)                    ALMEHED   72 IPWA                      2/72*

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                    82  N*3/2(1650) WIDTH (MEV)

W   1      (250.0)                    BAREYRE   68 RVUE                     11/67
W   2      (130.0)                    BAREYRE   68 RVUE                     11/67
W   3      (177.0)                    DONNACHI  68 RVUE                      6/68
W   3      (177.)                     DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W   3      (180.)                     KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W   4      (141.0)                    DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
W   5      (140.0)                    DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
W   6      (142.0)                    AYED      70 IPWA                      1/71
W   7      (140.)                     ALMEHED   72 IPWA                      2/72*
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

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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)                  DONNACHI  68 RVUE                      6/68
R1  3         (.28)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3         (.28)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  4        (0.28)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
R1  5        (0.25)                   DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
R1  6        (0.317)                  AYED      70 IPWA                      1/71
R1  7        (0.35)                   ALMEHED   72 IPWA                      2/72*

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                          REFERENCES -- N*3/2(1650)

DEVLIN   65 PRL 14 1031        T J DEVLIN,J SOLOMON,G BERTSCH  (PRINCETON) I

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACHI 68 PL 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)

AYED     70 KIEV CONF          R AYED,P BAREYRE, G VILLET             (SACL)IJP
DAVIES   70 NP B21 359         A DAVIES                               (GLAS)

ALMEHED  72 SUB.NP B           ,LOVELACE                              (RUTG)IJP

                               PAPERS NOT REFERRED TO IN DATA CARDS.

CARRUTHE 60 PRL 4 303          P CARRUTHERS                       (CORNELL) I
DEVLIN   62 PR 125 690         T J DEVLIN, B J MOYER, V PEREZ-MENDEZ (LRL) I
HELLAND  64 PR 134 B1062       +DEVLIN,HAGGE,LONGO,MOYER,WOOD         (LRL) I
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET        (SACLAY)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                             (LRL)
DONNACHI 69 NP 10B 433         A DONNACHIE, R KIRSOPP            (GLAS+EDIN)
AYED     70 PL 31B 598         +BAREYRE,VILLET                      (SACLAY)
BOWLER   70 NP 17B 331         +CASHMORE                           (U. OXFORD)

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**Δ(1670)** **$D_{33}$**

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                    10  N*3/2(1670, JP=3/2-) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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                    10  N*3/2(1670) MASS (MEV)

M   3      (1691.0)                   DONNACHI  68 RVUE    PHASE-SHIFT ANAL  8/69
M   3      (1690.)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M   3      (1690.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M   3   WHERE MAX. ABSORPTION IS -DONNACHI, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
M   4      (1649.0)                   DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   5      (1650.0)                   DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M   5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACHI 68)
M   6      (1722.0)                   AYED      70 IPWA                      1/71
M   6   ENER. DEP. FIT OF ARGAND DIAGRAM
M   7      (1700.)                    ALMEHED   72 IPWA                      2/72*

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                    10  N*3/2(1670) WIDTH (MEV)

W   3       (269.0)                     DONNACH1   68 RVUE                       8/69
W   3       (269.)                      DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69
W   3       (300.)                      KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69
W   4       (188.0)                     DAVIES     70 RVUE              SOL A   8/69
W   5       (174.0)                     DAVIES     70 RVUE              SOL B   8/69
W   6       (258.0)                     AYED       70 IPWA                      1/71
W   7       (260.)                      ALMEHED    72 IPWA                      2/72*
       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

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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  3          (.14)                    DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3          (.13)                    KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69
R1  4         (0.12)                    DAVIES     70 RVUE              SOL A   8/69
R1  5         (0.13)                    DAVIES     70 RVUE              SOL B   8/69
R1  6         (0.217)                   AYED       70 IPWA                      1/71
R1  7         (0.16)                    ALMEHED    72 IPWA                      2/72*

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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                               REFERENCES -- N*3/2(1670)

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)

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 SUB.NP B            ,LOVELACE                             (RUTG)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)
BOWLER   70 NP 17B 331          +CASHMORE                           (U. OXFORD)

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**Δ(1690)** **P''33**

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                    19  N*3/2(1690,JP=3/2+) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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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*

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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*

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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

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                    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*

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.

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                               REFERENCES -- N*3/2(1690)

DONNACH2 68 VIENNA 139          DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
KIRSOPP  68 THESIS              R G KIRSOPP                           (EDIN)

FEUERBAC 70 NP 16B 85           FEUERBACHER+HOLLADAY           (VANDERBILT)
AYED     70 KIEV CONF           R AYED,P BAREYRE, G VILLET            (SACL)IJP

ALMEHED  72 SUB.NP B            ,LOVELACE                             (RUTG)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     70 PL 31B 598          +BAREYRE,VILLET                        (SACLAY)
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BOWLER   70 NP 17B 331          +CASHMORE                           (U. OXFORD)

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**Δ(1890)** **F35**

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                    11  N*3/2(1890, JP=5/2+) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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                    11  N*3/2(1890) MASS (MEV)

M   3       (1913.0)                    DONNACH1   68 RVUE    PHASE-SHIFT ANAL  8/69
M   3       (1910.)                     DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69
M   3       (1910.)                     KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69
M   3    WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1   10/69
M   4       (1841.0)                    DAVIES     70 RVUE    P-S ANAL  SOL A   8/69
M   5       (1852.0)                    DAVIES     70 RVUE    P-S ANAL  SOL B   8/69
M   5   SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M   6       (1837.0)                    AYED       70 IPWA                      1/71
M   6    FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   7       (1875.)                     ALMEHED    72 IPWA                      2/72*

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                    11  N*3/2(1890) WIDTH (MEV)

W   3       (350.0)                     DONNACH1   68 RVUE                       8/69
W   3       (350.)                      DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69
W   3       (380.)                      KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69
W   4       (136.0)                     DAVIES     70 RVUE              SOL A   8/69
W   5       (150.0)                     DAVIES     70 RVUE              SOL B   8/69
W   6       (198.0)                     AYED       70 IPWA                      1/71
W   7       (250.)                      ALMEHED    72 IPWA                      2/72*
        SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)

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                    11  N*3/2(1890) PARTIAL DECAY MODES

                                                             DECAY MASSES
P1          N*3/2(1890) INTO  PI N                          139+ 938
P2          N*3/2(1890) INTO N PI PI                        938+ 139+ 139
P3          N*3/2(1890) INTO K SIGMA                        493+1189
P4          N*3/2(1890) INTO D(1236) PI                    1236+ 139

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                    11  N*3/2(1890) BRANCHING RATIOS

R1          N*3/2(1890) INTO (PI N)/TOTAL                   (P1)
R1  3         (0.16)                    DONNACH1   68 RVUE                       8/69
R1  3          (.16)                    DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3          (.15)                    KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69
R1  4         (0.20)                    DAVIES     70 RVUE              SOL A   8/69
R1  5         (0.19)                    DAVIES     70 RVUE              SOL B   8/69
R1  6         (0.147)                   AYED       70 IPWA                      1/71
R1  7         (0.18)                    ALMEHED    72 IPWA                      2/72*

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

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                               REFERENCES -- N*3/2(1890)

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)

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 SUB.NP B            ,LOVELACE                             (RUTG)IJP

                                PAPERS NOT REFERRED TO IN DATA CARDS.

AYED     70 PL 31B 598          +BAREYRE+VILLET                        (SACLAY)

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**Δ(1910)** **P31**

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                    12  N*3/2(1910, JP=1/2+) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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                    12  N*3/2(1910) MASS (MEV)

M   3       (1934.0)                    DONNACH1   68 RVUE    PHASE-SHIFT ANAL  8/69
M   3       (1930.)                     DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69
M   3       (1930.)                     KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69
M   3    WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1   10/69
M   4       (1914.0)                    DAVIES     70 RVUE    P-S ANAL  SOL A   8/69
M   5       (1834.0)                    DAVIES     70 RVUE    P-S ANAL  SOL B   8/69
M   5   SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M   6       (1783.0)                    AYED       70 IPWA                      1/71
M   6    FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M   7       (1900.)                     ALMEHED    72 IPWA                      2/72*

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                    12  N*3/2(1910) WIDTH (MEV)

W   3       (339.0)                     DONNACH1   68 RVUE                       8/69
W   3       (339.)                      DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69
W   3       (425.)                      KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69
W   4       (290.)                      DAVIES     70 RVUE              SOL A   8/69
W   5       (231.0)                     DAVIES     70 RVUE              SOL B   8/69
W   6       (308.0)                     AYED       70 IPWA                      1/71
W   7       (200.)                      ALMEHED    72 IPWA                      2/72*
        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 D(1236) PI                         1236+ 139

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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)                  DONNACH1  68 RVUE                    8/69
R1  3          (.30)                  DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3         (.25)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  4         (0.18)                  DAVIES    70 RVUE              SOL A   8/69
R1  5         (0.24)                  DAVIES    70 RVUE              SOL B   8/69
R1  6         (0.128)                 AYED      70 IPWA                      1/71
R1  7         (0.33)                  ALMEHED   72 IPWA                      2/72*

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.

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                          REFERENCES -- N*3/2(1910)

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)

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 SUB.NP B          ,LOVELACE                            (RUTG)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS.

CARYANN  65 PR 138 B433       CARAYANNOPOULOS,TAUTFEST,WILLMANN    (PURD)
 ---      A PARTIAL WAVE ANALYSIS OF PI+P TO SIGMA+ K+
AYED     70 PL 31B 598        +BAREYRE+VILLET                     (SACLAY)

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**Δ(1950)** **$F_{37}$**

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                    83  N*3/2(1950, JP=7/2+) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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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   2       (1980.0)                BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
M   2             WHERE SPEED IS GREATEST - EYEBALL FIT
M   3       (1946.0)                DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   3       (1950.)                 DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
M   3       (1946.)                 KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M   3    WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69
M   4       (1935.0)                DAVIES    70 RVUE    P-S ANAL  SOL A   8/69
M   5       (1931.0)                DAVIES    70 RVUE    P-S ANAL  SOL B   8/69
M   5        SOL B IS A FIT TO DONNACHIE 68 SOLUTION
M   6       (1931.0)                AYED      70 IPWA                      1/71
M   6     FROM ENER. DEP. FIT OF ARGAND DIAGRAM
M           (1950.0)   (30.0)       KALMUS    70 DPWA    PI+P TO K+ SIG+   1/71
M           (1930.)    (20.)        MEHTANI   71 MPWA ++ PI+P 1.8-2.1 GEV  2/72*
M           (1930.)                 ROYCHOUD  71 DPWA                      3/72*
M   7       (1925.)                 ALMEHED   72 IPWA                      2/72*

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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   2       (140.0)                 BAREYRE   68 RVUE                     11/67
W   3       (221.0)                 DONNACH1  68 RVUE                      6/68
W   3       (221.)                  DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
W   3       (220.)                  KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W   4       (221.0)                 DAVIES    70 RVUE              SOL A   8/69
W   5       (212.0)                 DAVIES    70 RVUE              SOL B   8/69
W   6       (197.0)                 AYED      70 IPWA                      1/71
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
W           (300.0)   (60.0)        KALMUS    70 DPWA    PI+P TO K+ SIG+   1/71
W           (227.)    (12.)   (30.) MEHTANI   71 MPWA ++ PI+P TO (1236)PI  2/72*
W   7       (200.)                  ALMEHED   72 IPWA                      2/72*

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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(1236) PI                     1236+ 139
P4          N*3/2(1950) INTO Y*1(1385) K                        1385+ 493
P5          N*3/2(1950) INTO N*3/2(1236) RHO                    1236+ 765
P6          N*3/2(1950) INTO NEUTRON PI+ PI+                     939+ 139+ 139
P7          N*3/2(1950) INTO N*3/2(1236) PI PI (NOT RHO)        1236+ 139+ 139

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                    83  N*3/2(1950) BRANCHING RATIOS

R1          N*3/2(1950) INTO (PI N)/TOTAL                       (P1)
R1            (0.41)                DUKE      65 CNTR    VERY ENERGY DEP   7/66
R1            (0.4)         APPROX  YOKOSAWA  66 CNTR                      7/66
R1  1         (0.57)                BAREYRE   68 RVUE                     11/67
R1  3         (0.386)               DONNACH1  68 RVUE                      6/68
R1  3          (.39)                DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69
R1  3          (.39)                KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  4         (0.51)                DAVIES    70 RVUE              SOL A   8/69
R1  5         (0.39)                DAVIES    70 RVUE              SOL B   8/69
R1  6         (0.496)               AYED      70 IPWA                      1/71
R1  7         (0.4)                 ALMEHED   72 IPWA                      2/72*
      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) INTO (D(1236) PI)*(PIN)/TOTAL**2  (P3*P1)
R3            0.23     0.04         FUNG      68 HBC  ++ PI+P TO PI+PIO P 11/68
R3            0.24     0.01    0.03 MEHTANI   71 MPWA ++                   2/72*
R3          . . . . . . . . .
R3  AVG       0.238    0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

    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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                          REFERENCES -- N*3/2(1950)

DUKE     65 PRL 15 468        +JONES,KEMP,MURPHY,PRENTICE, +  (RTHFD,OXF)IJP
YOKOSAWA 66 PRL 16 714        +SUWA, HILL, ESTERLING, BOOTH     (ARG,CHI)IJP

BAREYRE  68 PR 165 1731       P BAREYRE, C BRICMAN, G VILLET      (SACLAY)IJP
BORREANI 68 UCRL 18350         BORREANI,KALMUS                        (LRL)
DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK         (GLAS)
FUNG     68 VIENNA CONF.      FUNG, KERNAN, KALMUS, BIRGE (RIVERSIDE,LRL)
KIRSOPP  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)

MEHTANI  71 AMSTERDAM CONF.   +FUNG,KERNAN,WILLIAMSON+BIRGE,++  (UCR,LBL)IJP
ROYCHOUD 71 NP B27 125        R K ROYCHOUDHURY,B H BRANSDEN        (DURH)IJP

ALMEHED  72 SUB.NP B          ,LOVELACE                            (RUTG)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS.

LAYSON   63 NC 27 724         W M LAYSON                            (CERN) IJ
HOHLER   63 NP 48 470         G HOHLER, G EBEL                 (KARLSRUHE) I
AUVIL    64 NC 33 473         P AUVIL, C LOVELACE                (IMPCOL)IJP
HOHLER   64 PL 12 149         G HOHLER, J GIESECKE             (KARLSRUHE) I
HELLAND  64 PR 134 B1062      +DEVLIN,HAGGE,LONGO,MOYER,WOOD        (LRL) IJ
HOLLADAY 65 PR 139 B1348      W G HOLLADAY                     (VANDERBILT)
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                            (LRL)
DONNACH1 69 NP 10B 433        A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
AYED     70 PL 31B 598        +BAREYRE+VILLET                     (SACLAY)

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**Δ(1960)** **$D_{35}$**

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                    13  N*3/2(1960, JP=5/2-) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*1/2(1470).

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                    13  N*3/2(1960) MASS (MEV)

M   3       (1954.0)                DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   3       (1970.)                 KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
M   X       (1950.0)        APPROX  LEA       69 CNTR    PI-P ELASTIC      8/69
M   X  SEE ALSO APLIN 70
M   3   WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69
M   7       (2200.)                 ALMEHED   72 IPWA                      2/72*

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                    13  N*3/2(1960) WIDTH (MEV)

W   3       (311.00)                DONNACH1  68 RVUE                      8/69
W   3       (400.)                  KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
W           (182.0)                 MEHTANI   70 MPWA    PRELIMINARY       1/71
W   7       (600.)                  ALMEHED   72 IPWA                      2/72*

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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
P4          N*3/2(1960) INTO D(1236) PI                         1236+ 139

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                    13  N*3/2(1960) BRANCHING RATIOS

R1          N*3/2(1960) INTO (PI N)/ TOTAL                      (P1)
R1  3         (.154)                DONNACH1  68 RVUE    PHASE SHIFT ANA. 10/69
R1  3         (.12)                 KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69
R1  7        (0.25)                 ALMEHED   72 IPWA                      2/72*

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.

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                          REFERENCES -- N*3/2(1960)

DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP  68 THESIS            R G KIRSOPP                          (EDIN)

LEA      69 PL 29B 584        LEA,OADES,WARD,COWAN,+   (RHEL,BRISTOL,DAR)

FEUERBAC 70 NP 16B 85         FEUERBACHER+HOLLADAY            (VANDERBILT)

ALMEHED  72 SUB.NP B          ,LOVELACE                            (RUTG)IJP

                              PAPERS NOT REFERRED TO IN DATA CARDS.

DONNACH1 69 NP 10B 433        A DONNACHIE, R KIRSOPP           (GLAS+EDIN)
AYED     70 PL 31B 598        +BAREYRE+VILLET                     (SACLAY)
APLIN    71 NP B32 253        +COWAN,GIBSON,GILMORE++      (RHEL,BRISTOL)

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## 1950 MEV REGION – PRODUCTION AND $\sigma_{TOTAL}$ EXPERIMENTS

**Δ(1950) BUMPS**

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                    70  N* (1950)

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                    70  N* (1950)   MASS (MEV)

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

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                    70  N* (1950)   WIDTH (MEV)

W         (256.0)   (39.0)           DEVLIN    65 CNTR
W           40.0     20.0            YOON      67 HBC  +                    8/67

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                    70  N* (1950)   BRANCHING RATIOS

R1        N*   (1950) INTO (PI N)/TOTAL                    PROD. EXP.
R1          (0.57)   (0.12)          DEVLIN    65 CNTR

R2        N*   (1950) INTO (SIGMA K)/(PI N)                PROD. EXP.
R2          0.059    0.024           CHINOWSKY 68 HBC  ++ PP TO P SIG K    11/68

R3        N*   (1950) INTO N*3/2(1236) PI PI (NOT RHO)
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*   (1950) INTO (PI N)/(N*3/2(1236) PI)         PROD. EXP.
R4          (0.55) OR LESS           LEE       67 HBC     PI-P 3.63 BEV/C   11/67

R5    N*  (1950) INTO ((PI N)*(NEUTRON PI+ PI+))/TOTAL     PROD. EXP.
R5          0.05     0.013           GALLOWAY  68 RVUE ++ PI+P TO N 2PI+    6/68

R6        N*   (1950) INTO (Y*1(1385) K)/(PI N)            PROD. EXP.
R6          0.035    0.015           CHINOWSKY 68 HBC  ++ PP TO P LAM K PI 11/68

R7        N*   (1950) INTO (N*3/2(1236) RHO)/(PI N)        PROD. EXP.
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*   (1950) INTO (N*3/2(1236) RHO)/TOTAL
R8              SEEN                 YOON      67 HBC  +                    8/67
R8          NOT SEEN                 BOGGILD   70  HBC    PP TO N3PI(NTRL)  6/70

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                          REFERENCES -- N* IN PRODUCT EXPERIMENTS

COOL      56 PR 103 1082        R COOL, O PICCIONI, D CLARK            (BNL) I
BRISSON   61 NC 19 210          +DETOEUF,FALK-VAIRANT,VAN ROSSUM,+ (SACLAY) I
DEVLIN    65 PRL 14 1031        T J DEVLIN,J SOLOMON,G BERTSCH  (PRINCETON) I
LEE       67 PR 159 1156        +NOEBS,ROE,SINCLAIR,VANDER VELDE       (MICH)
YOON      67 PL 248 307         +BERENYI,KEY,PRENTICE, +     (TORONTO,WISC)

CHINOWSK  68 PR 171 1421        CHINOWSKY,CONDON,KINSEY,KLEIN,+  (LRL,SLAC)
CHUNG     68 PR 165 1491        S U CHUNG,DAHL,KIRZ,MILLER             (LRL)
GALLOWAY  68 PL 26B 334         K F GALLOWAY                     (INDIANA) I
BOGGILD   70 NP B16 503         +KOREA-AHO+JACOBSEN+  (COP+HELS+OSLO+STOCK)
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                    END PRODUCTION EXPERIMENTS

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**Δ(2160)** → $P''_{33}$

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                    9  N*3/2(2160,JP=3/2+) I=3/2

ROYCHOUDHURY 71 FIND POSSIBLE EVIDENCE FOR P31,D33,AND
D35 RESONANCES IN THIS MASS REGION. IN A SIMILAR ANALYS
BRANSDEN 71 FOUND SOME EVIDENCE FOR S31,D33,AND D35 RES
NACES IN THIS REGION.

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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*

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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*

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                    9  N*3/2(2160) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1        N*3/2(2160) INTO PI N                         139+ 938

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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*

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                          REFERENCES -- 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 SUB.NP B          ,LOVELACE                              (RUTG)IJP
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                          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

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**Δ(2420)** → $H_3$ 11

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                    84  N*3/2(2420, JP=11/2+)  I=3/2

BOTH ROYCHOUDHURY 71 AND BRANSDEN 71 SEE A POSSIBLE
RESONANT F35 IN THIS MASS REGION. IN ADDITION BRANSDEN
71 FIND A RESONANT P33 AT 2600 MEV.

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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.)                   ROYCHOUD  71 DPWA                     3/72*
M         (2400.)                   BRANSDEN  71 DPWA                     3/72*

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                    84  N*3/2(2420) WIDTH (MEV)

W   6     (347.0)                   AYED      70 IPWA                     1/71

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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

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                          REFERENCES -- 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

                          PAPERS NOT REFERRED TO IN DATA CARDS.

BELLAMY  67 PRL 19 476        +BUCKLEY,DOBINSON, +     (WESTFIELD,UNICOL) JP

AYED     70 PL 31B 598        +BAREYRE+VILLET                     (SACLAY)
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## M > 2200 MEV – PRODUCTION AND $\sigma_{TOTAL}$ EXPERIMENTS

**BUMPS**

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Δ(2420)             84  N*3/2(2420)            I=3/2

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                    84  N*3/2(2420) MASS (MEV)

M         (2360.0)                  DIDDENS   63 CNTR    PI+ P TOTAL
M         (2520.0)   (40.0)         ALVAREZ   64 CNTR    PI PHOTOPROD       7/66
M         (2400.0)       APPROX     WAHLIG    64 OSPK 0  PI-P CH EX
M         (2440.0)                  HOHLER    64 RVUE    DATA + DISP REL
M          2423.0     10.0          CITRON    66 CNTR    PI+ P TOTAL        7/66
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.

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                    84  N*3/2(2420) WIDTH (MEV)

W         (200.0)                   DIDDENS   63 CNTR
W         (245.0)                   HOHLER    64 RVUE                    7/66
W          310.0     20.0           CITRON    66 CNTR                    7/66
W   B     (275.0)                   BARGER    66 RVUE    TOTAL + CH EX     11/67

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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
P3        N*3/2(2420) INTO N*3/2(1236) PI              1236+ 139
P4        N*3/2(2420) INTO NEUTRON PI+ PI+              939+ 139+ 139

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                    84  N*3/2(2420) BRANCHING RATIOS

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) (P1*P4)
R2          0.0195   0.0048         GALLOWAY  68 RVUE                    6/68

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                                REFERENCES -- N*3/2(2420)

DIDDENS   63 PRL 10 262          +JENKINS, KYCIA, RILEY                    (BNL) I
ALVAREZ   64 PRL 12 710          +BAR-YAM,KERN,LUCKEY,OSBORNE, +    (MIT,CEA)
WAHLIG    64 PRL 13 103          +MANNELLI,SODICKSON,FACKLER,WARD, +    (MIT)
HOHLER    64 PL 12 149           G HOHLER, J GIESECKE                (KARLSRUHE) I
CITRON    66 PR 144 1101         +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER    66 PR 151 1123         V BARGER, M OLSSON                      (WISC)

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,ARG) 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           (CAL TECH)
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)

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85  N*3/2(2850, JP=    +) I=3/2

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                    85  N*3/2(2850) MASS (MEV)

M         (2700.0)        APPROX      WAHLIG    64 OSPK 0  PI-P CH EX
M         (2870.0)                    HOHLER    64 RVUE    DATA + DISP REL
M          2850.0      12.0           CITRON    66 CNTR    PI+ P TOTAL        7/66
M         (2850.0)                    BARDADIN  66 HBC  ++ N* TO P + 3 PIS    7/66

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                    85  N*3/2(2850) WIDTH (MEV)

W          400.0      40.0           CITRON    66 CNTR                       7/66
W         (150.0)                    BARDADIN  66 HBC  ++                    7/66

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                    85  N*3/2(2850) PARTIAL DECAY MODES

                                                          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

R1        N*3/2(2850) INTO (PI N)/TOTAL                 (P1)
R1    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1          0.261    0.048         CITRON    66 CNTR    TOTAL CROSS.SEC. 11/67
R1  B       (0.224)  (0.016)       BARGER    66 RVUE    TOTAL + CH EXC.  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  D       (0.49)                 DIKMEN    67 RVUE    USES KORMANYOS67 11/67
R1  D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1          (0.10)                 KORMANYOS 67 CNTR    PI-P AT 180 DEG. 11/67
R1          (0.39)                 DOBROWOLS 67 CNTR    PI+P AT 180 DEG

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                                REFERENCES -- N*3/2(2850)

WAHLIG    64 PRL 13 103          +MANNELLI,SODICKSON,FACKLER,WARD, +    (MIT)
HOHLER    64 PL 12 149           G HOHLER, J GIESECKE                (KARLSRUHE) I
CITRON    66 PR 144 1101         +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARDADIN  66 PL 21 357           BARDADIN-OTWINOWSKA,DANYSZ, +       (WARSAW)
BARGER    66 PR 151 1123         V BARGER, M OLSSON                      (WISC)

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,ARG) 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           (CAL TECH)
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)

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86  N*3/2(3230, JP=     ) I=3/2

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                    86  N*3/2(3230) MASS (MEV)

M         (3230.0)                   CITRON    66 CNTR    PI+ P TOTAL        7/66

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                    86  N*3/2(3230) WIDTH (MEV)

W         (440.0)                    CITRON    66 CNTR                       7/66

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                    86  N*3/2(3230) PARTIAL DECAY MODES

                                                          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    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE

R1          (0.06)                   CITRON    66 CNTR    TOTAL CROS. SEC. 11/67
R1  B       (0.03)   (0.01)          BARGER    66 RVUE    TOTAL + CH EXC.  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 -- N*3/2(3230)

CITRON    66 PR 144 1101         +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER    66 PR 151 1123         V BARGER, M OLSSON                      (WISC)
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,ARG) P
DOLEN     68 PR 166 1768         R DOLEN, D HORN, C SCHMID           (CAL TECH)

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                          END PRODUCTION EXPERIMENTS

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## EXOTIC NUCLEONS

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                                30  CROSS SECTIONS LIMITS FOR EXOTIC NUCLEONS

          THIS IS NOT A COMPLETE LIST. WE WILL TABULATE EXOTICS FROM NOW ON

CS   LT. 40 MB  I=5/2, M=1540-1750    BANNER    70 OSPK +++ PI+P,1.9 GEV/C   7/70

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                                REFERENCES --- EXOTIC NUCLEONS

BANNER    70 NP B15 205          +CHEZE,HAMEL,TEIGER,ZACCONE +       (SACLAY)

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## EX(1640)

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92 EX(1640,JP=    )I=

AMMANN 71 AND JOHNSON 71 WITH COMPARABLE (OR
BETTER) STATISTICS AND AT MOMENTA NEAR 4.91 ARGUE
STRONGLY THAT THE EFFECT SEEN BY PRICE 70 IS A
STATISTICAL FLUCTUATION.

                  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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                    92 EX(1640) MASS (MEV)
M   A   29(1627.)    (12.)            PRICE     70 DBC  -- K-D AT 4.91GEV/C  3/71
7   A  FOUR S. D. EFFECT

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                    92 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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                                REFERENCES -- EX(1640)

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 Possible Z*'s

Although much work has been done on the strangeness +1 reactions during the past few years, it is not yet clear whether the peaks seen in total KN cross sections near 1 GeV/c are resonances; see Fig. 1. Since positive-strangeness baryons cannot be made from three quarks, it is very important to find out if these peaks are resonances.

(a) I = 0 System. New total-cross-section data have been reported by the Arizona group in the 0.36 to 0.72 GeV/c region (BOWEN 70). The old $K^+p$ and $K^+d$ total cross sections have been reanalyzed by

ABRAMS 69. They made a new unfolding of the isospin-0 total cross section and found that the well-known peak in this cross section just above 1.0 GeV/c (M~ 1865 MeV) has a companion at about 0.8 GeV/c (M~ 1780 MeV). COOL 70 adds the new data of BOWEN 70 to the analysis and obtains the two possible results shown in Fig. 2a for the I = 0 cross section. DOWELL 70 also reports similar results. The choice of two possibilities depends mostly on the disagreement between the data and very little on the method of unfolding, as discussed by LYNCH 70.

Until the $K^+p$ and $K^+d$ cross sections are remeasured in this region, the lower peak, though probable, cannot be considered definitely established. There is, however, no doubt about there being a large broad peak in the isospin-0 elastic cross section. The inelastic cross section is very small until the $K^*N$ threshold at 1.08 GeV/c is approached, then it rises rapidly (HIRATA 68 and HIRATA 70), as shown in Fig. 2c. Subtracting this from total cross sections gives the two possible results of Fig. 2b. Fitting the elastic peak with a Breit-Wigner resonance form, one gets a mass of ~ 1780 MeV and an anomalously large width, nearly 600 MeV. The resonance (if it exists) must be nearly entirely elastic because the inelastic cross section is small at the peak. If J were greater than 1/2, the resonant peak would exceed the observed height of $4\pi\lambda^2$. This fixes the spin as 1/2, and means that there is little cross section left over for other partial waves. Of course it is quite possible that in fact the peak is not caused by a resonance at all.

Recently new differential cross section data on the elastic charge-exchange have been reported by HIRATA 71 (5 momenta in the 0.87 to 1.59 GeV/c region) and by GIACOMELLI 71 (13 momenta in the 0.64 to 1.51 GeV/c region). Attempts to perform partial-wave analyses for the I = 0 system have been reported by HIRATA 71 and recently by WILSON 71. The first analysis, though not extensive, finds a large $P_{01}$ partial wave which does not go through 90° as expected for an elastic resonance. WILSON 71 report energy-dependent and energy-independent analyses of all existing data, which yield nine solutions. The two favored ones (called C and D) explain all the data in terms of a few dominant waves and suggest resonance formation in the $P_{01}$ amplitude. (M=1800 MeV, $\Gamma$ = 300 MeV, x = 0.85). However before accepting this solution, a lot more data, especially polarizations, are needed.

(b) I = 1 System. New data have been reported by ADAMS 71 (elastic cross section), ALBROW 71 (polarization and $d\sigma/d\Omega$), BARNETT 71 (polarization), and ERLICH 71 (polarization). Three new partial-wave analyses have been published: one by a CERN experimental group (ALBROW 71), and by Lovelace and Wagner (LOVELACE 71) and another by the ANL group (MILLER 72). The first analysis, ALBROW 71, is an energy-independent phase-shift analysis from threshold to 2.5 GeV/c and uses the "shortest path method" (SPM) to link the solutions. The LOVELACE 71 analysis uses a conventional fit (SPM) for the "low" partial waves, whereas the "high" partial waves are taken from the Veneziano formula. They determine the parameters needed for the "high" partial waves by doing a Regge fit to high energy data. The MILLER 72 analysis uses a new method, ACE (accelerated convergence expansion), in which high partial waves are included through conformal mapping as suggested by CUTKOSKY 70. The results of ACE are then compared with the two solutions obtained by the same group through conventional partial-wave analysis.

The new analyses, as the old ones, yield more than one solution to choose from, which indicates that the data are not good enough to eliminate some of the possibilities. Certainly more data of the conventional type, measurements of the R and A parameters, and the simultaneous analysis of elastic and inelastic channels (copious inelastic data are desirable at the moment) could improve the understanding of this system.

The $P_{13}$ amplitude still remains the best candidate for a resonance in the $K^+p$ system. The preferred $P_{13}$ Argand plots obtained by some of the groups are shown in Fig. 3. Each analysis in one way or another gets at least one solution with a counterclockwise $P_{13}$ amplitude. Resonant $P_{13}$ is preferred by REBKA 70, GIACOMELLI 70, ALBROW 71, and MILLER 72; the results of the other analyses are not so clear cut.

AYED 70 claim that the speed of variation of the amplitude as a function of the energy is nearly as well fit by a smoothly varying background as by a broad (500-MeV) Breit-Wigner amplitude superimposed on a background.

BARBER 70 include the data up to 2.3 GeV/c. Their preferred solution is shown in Fig. 3 and shows no structure in the speed. The other one looks resonant.

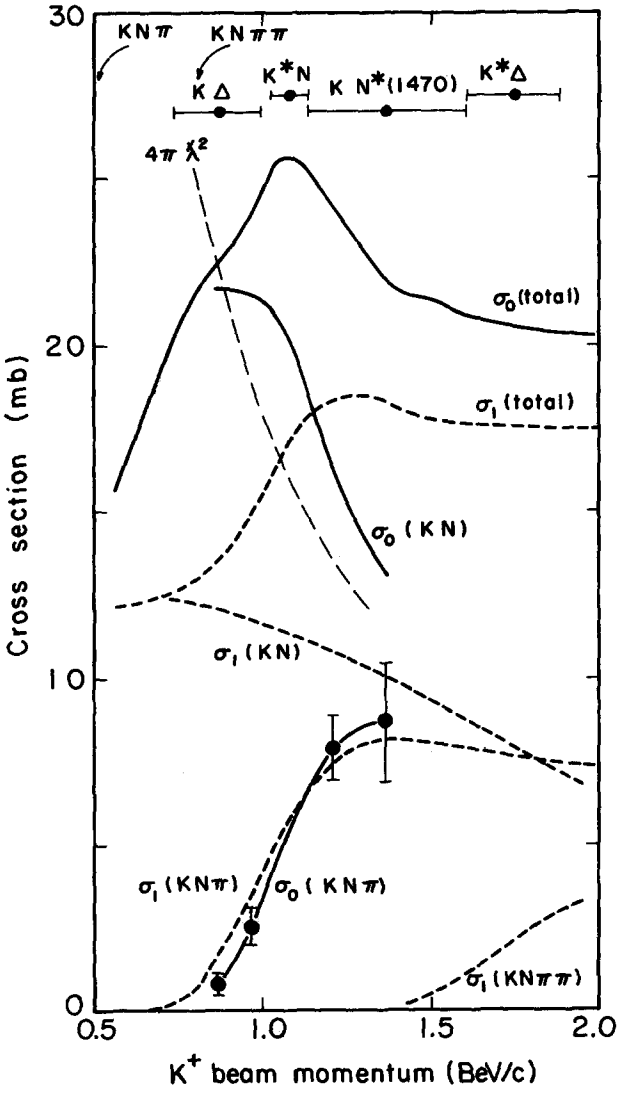


Fig. 1.
KN total and partial cross sections. Subscripts indicate isospin. Total cross sections are from CARTER 68, which uses data from COOL 66 and BUGG 68. Isospin-1 partial cross sections are adapted from a compilation made by BLAND 68. Isospin-0 partial cross sections are from HIRATA 68. Thresholds for various processes are indicated at the top.

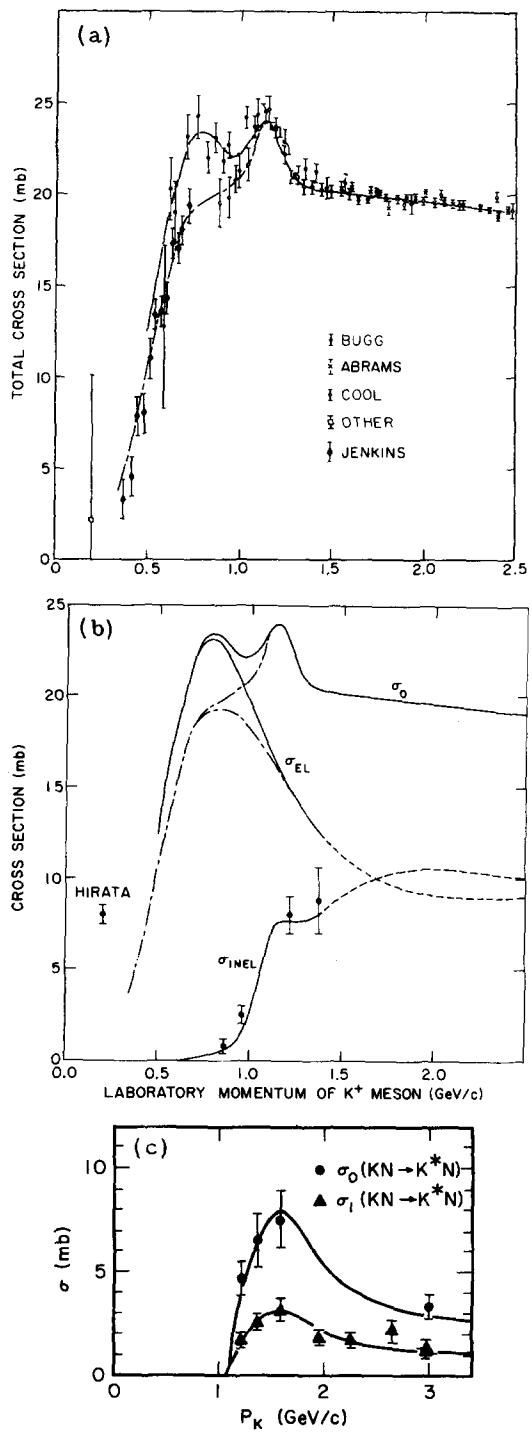


Fig. 2.
(a) The I = 0 KN cross section evaluated by COOL 70. The new data of Jenkins are reported in BOWEN 70.

(b) The I = 0 cross sections as obtained by the two possible interpretations of the data. This shows the uncertainties in the 0.8 to 1.2 GeV/c region.

(c) Energy dependence of the I-spin 0 and I-spin 1 cross sections for the reaction $KN \rightarrow K^*N$ HIRATA 70.

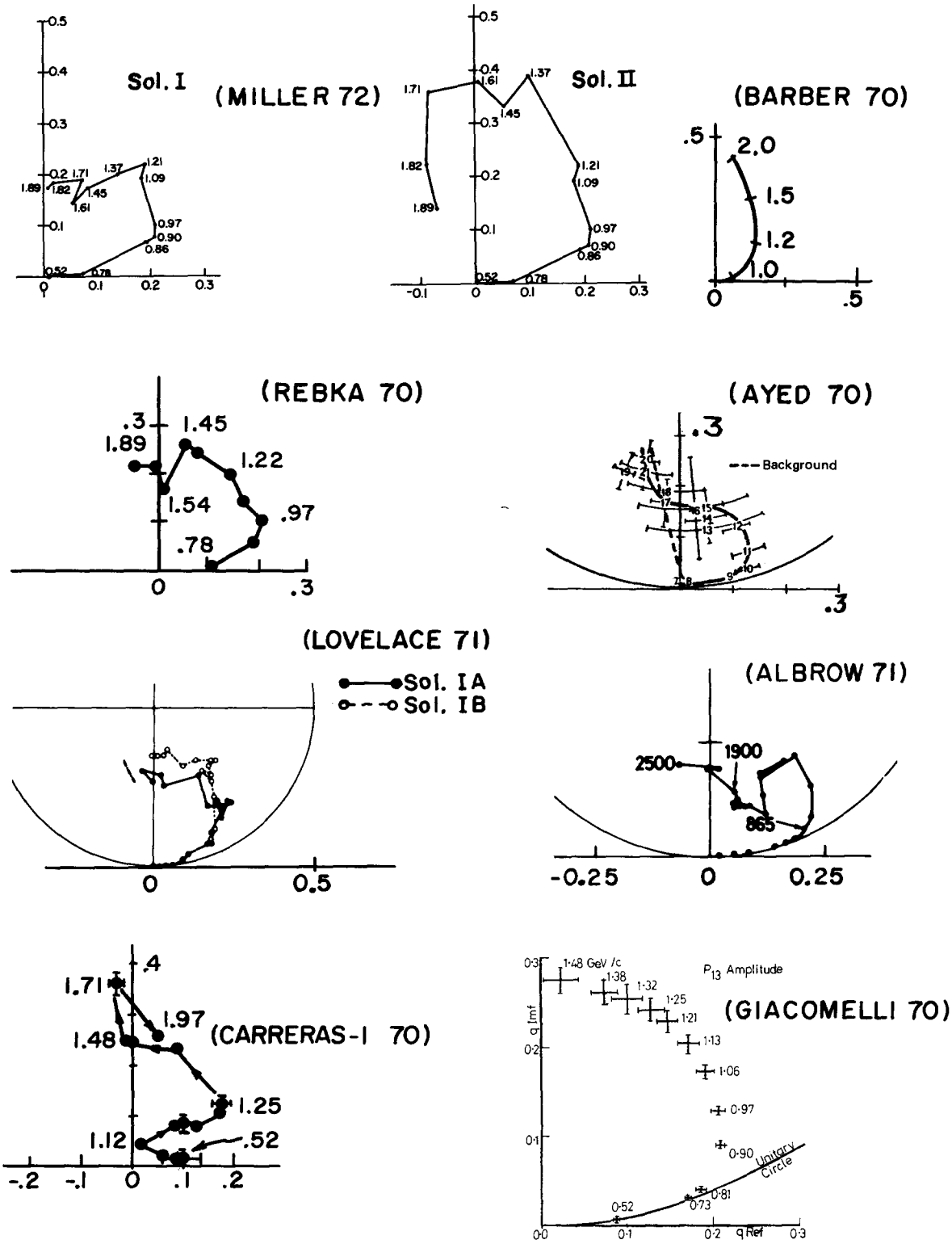


Fig. 3. Argand plots for the $P_{13}$ partial wave as obtained in partial-wave analyses performed by the authors indicated. (CARRERAS-1 70 plotted by us from $\eta$, $\delta$.)

BARNETT 70 got two solutions: the preferred one shows no resonant behavior; the other one might be resonant, but the errors on the amplitudes are too large to believe any circle drawn among them.

CARRERAS-1 70 get a $P_{13}$ amplitude similar to that found in other analyses, which can be interpreted as having resonant behavior, but do not feel that the resonance interpretation is compelling.

The LOVELACE 71 preferred solution is a "non-resonant" solution; that is, the $P_{13}$ amplitude moves toward the center of the Argand diagrams, by describing a very slow circular arc which bears no relation to the total cross-section bump. Of course "resonant-solutions" are also found, but seem to be less favored by the fit.

The $S_{11}$ amplitude. It should be mentioned that AYED 70 and CARRERAS 70 find solutions which require a positive $S_{11}$ amplitude. These solutions are believed to be less likely than the ones with negative $S_{11}$. See GOLDHABER 70, the previous edition of Review of Particle Properties,[1] LEA 71, and MILLER 72 for discussions of these solutions.

Threshold effects. Another possible way to describe the $P_{13}$ amplitude would be in terms of a coupled-channel threshold effect: the KN amplitude becomes rapidly absorptive as it feeds the rapidly increasing $K\Delta$ channel. The main question still remains: Is it also a resonance? If it is, its elasticity is small ($\approx 0.2$) and it decays mainly into $K\Delta$. Partial-wave analyses in this channel do not seem to favor the resonant hypothesis at this time. See BLAND 67 and GRIFFITHS 72. But a definite conclusion has yet to be made and awaits much more data.

Production experiments. One more comment on exotic resonances is that, as pointed out by ERNE 70, the present upper limits for the cross sections for production of broad exotic resonances are not very small; that is, they are of the same order as cross sections for $Y^*$ or $N^*$ production.

Conclusions. The existence of exotic resonances is still an open question. It looks to us that the following are needed:

1) More high-precision data in the critical region where the peaks are seen.

2) For the I = 1 system, measurements of the R and A parameters seem to be necessary to resolve the ambiguities.

3) For the I = 0 states it would be very useful, however difficult it may be, to measure polarization for the elastic cross section.

4) Simultaneous study of elastic and inelastic channels should certainly help.

References

1. Particle Data Group, Rev. Mod. Phys. 43, No. 2, Part II (1971).

## $Z_0(1780)$

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95  Z*0(1780, JP=1/2 ) I=0

THIS EFFECT, 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.

HIRATA 71 ARGUE THAT IT IS THE P01 WAVE WHICH
IS LARGE. HOWEVER, THEY CONCLUDE THAT P01 NEED NOT PASS THROUGH 90
DEGREES TO EXPLAIN THE RELEVANT DATA IN THE 1 GEV/C REGION.
  WILSON 71 FIND SOME SOLUTIONS WITH RESONANT-LIKE BEHAVIOR IN THE P01
PARTIAL WAVE.

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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    71 PWA     K+N P01 WAVE      3/72*
M   W   ESTIMATE OF PARAMETERS FROM BW + QUADRATIC BACKGROUND FIT TO P01.    3/72*

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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    71 PWA     K+N P01 WAVE      3/72*

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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    71 PWA     K+N P01 WAVE      3/72*

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                          REFERENCES -- 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    71 GLASGOW PREPR.     +GRIFFITHS,HIRATA +   (BGNA+GLAS+ROMA+TRST)

                                PAPERS NOT REFERRED TO IN DATA CARDS

LYNCH     70 DUKE 9             G LYNCH (REVIEWER OF CR.SEC. DATA)     (LRL)
GIACOMEL  71 BOLOGNA PREPR.     GIACOMELLI +          (BGNA+GLAS+ROMA+TRST)
HIRATA    71 NP 830 157         +GOLDHABER,HALL,SEEGER,THRILLING,WOHL (LBL)IJP

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## $Z_0(1865)$

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96  Z*0(1865, JP=    ) I=0

THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K* N
THRESHOLD. SEE HIRATA 68 AND 70. WILSON 71 REPORTS A
PARTIAL WAVE ANALYSIS.  SEE ALSO Z*0(1780)

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                    96  Z*0(1865) MASS (MEV)

M        (1868.0)   (10.0)            KYCIA     67 CNTR    K+P, D TOTAL      8/67
M        (1860.0)   (15.0)            CARTER    67 THEO    DISPERSION REL.   8/67

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                    96  Z*0(1865) WIDTH (MEV)

W        (160.0)    (30.0)            KYCIA     67 CNTR                      8/67
W        (200.0)    (50.0)            CARTER    67 THEO                      8/67

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                    96  Z*0(1865) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1         Z*0(1865) INTO K N                             493+ 939
P2         Z*0(1865) INTO N K*(890)                       938+ 891

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                    96  Z*0(1865) BRANCHING RATIOS

R1         Z*0(1865) INTO (K N)/TOTAL                          (P1)
R1           (0.40)   (0.05)          KYCIA     67 CNTR    IF J=1/2          8/67
R1           (0.31)   (0.05)          CARTER    67 THEO    IF J=1/2          8/67

R2         Z*0(1865) INTO N K*(890)                            (P2)
R2           MAIN INELASTIC DECAY     HIRATA    68 HBC                      11/68

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                                REFERENCES -- Z*0(1865)

CARTER    67 PRL 18 801         A A CARTER                        (CAVENDISH)
KYCIA     67 PRIVATE COMM.      T F KYCIA                                (BNL) I
    ALSO 69 PL 30B 564          ABRAMS,COOL,GIACOMELLI,KYCIA,LI +        (BNL)
    ALSO 70 PR D1 1887          COOL,GIACOMELLI,KYCIA,LEONTIC,LI +       (BNL)
HIRATA    68 PRL 21 1485        HIRATA, WOHL, GOLDHABER, TRILLING        (LRL)

                                PAPERS NOT REFERRED TO IN DATA CARDS

COOL      66 PRL 17 102         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
     --  SLIGHTLY REVISED RESULTS FROM KYCIA 67 REPLACE COOL 66 --
HIRATA    70 DUKE    429        +GOLDHABER,SEEGER,TRILLING+WOHL          (LRL)
AARON     71 PRL 26 407         +AMADO+SILBAR                (NEAS,PENN,LASL)IJP
GIACOMEL  71 BOLOGNA PREPR.     GIACOMELLI +            (BGNA+GLAS+ROMA+TRST)
HIRATA-1  71 NP B33 445         +GOLDHABER,HALL,SEEGER,TRILLING,WOHL  (LBL)
WILSON    71 GLASGOW PREPR.     +GRIFFITHS,HIRATA +   (BGNA+GLAS+ROMA+TRST)

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## $Z_1(1900)$

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97  Z*1(1900, JP=    ) I=1

THIS EFFECT IS STRONGLY ASSOCIATED WITH THE K N*
THRESHOLD.  IF A RESONANCE, THE SPIN-PARITY IS ALMOST
CERTAINLY 3/2+.
SEE THE MINIREVIEW PRECEDING Z*0

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                    97  Z*1(1900) MASS (MEV)

M          1900.0     10.0          COOL      70 CNTR ++ K+P TOTAL        1/71
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     (1840.0)                 BARNETT   70 IPWA    P13,SOLN III     7/70
M    2      RESONANCE SIGNAL BARELY ABOVE BACKGROUND DUE TO THE LARGE ERRORS
M    2      IN THE AMPLITUDES RESULTING FROM THE ANALYSIS
M           (1880.)                 ALBROW    71 IPWA ++  SOL. GAMMA     10/71*
M    K      (1890.)                 KATO      71 IPWA    SOL  I(FIT BW)  10/71*
M    K      (2040.)                 KATO      71 IPWA    SOL II(FIT BW)  10/71*
M    K    KATO 71 ESTIMATE RESONANCE PARAMETERS -- UPDATED PHASE SHIFTS    3/72*
M    K    PUBLISHED IN MILLER 72.                                          3/72*

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                    97  Z*1(1900) WIDTH (MEV)

W           (240.0)                 COOL      70 CNTR ++ K+P TOTAL        1/71
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       (80.0)                 BARNETT   70 IPWA    K+P EIPWA        7/70
W           (190.)                  ALBROW    71 IPWA ++  SOL. GAMMA     10/71*
W    K      (288.)                  KATO      71 IPWA    SOL  I(FIT BW)  10/71*
W    K      (260.)                  KATO      71 IPWA    SOL II(FIT BW)  10/71*
       SEE THE NOTES ACCOMPANYING MASSES QUOTED.

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                    97  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(1236) K               1236+ 493

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                    97  Z*1(1900) BRANCHING RATIOS

R1          Z*1(1900) INTO (K N)/TOTAL                      (P1)
R1            (0.10) OR LESS          CARTER    67 THEO    DISPERSION REL.  8/67
R1            (0.12) (ASSUMING J=3/2) COOL      70 CNTR ++ K+P TOTAL        1/71
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         (0.09)                  BARNETT   70 IPWA    K+P EIPWA        7/70
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(1236)                    (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 -- 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 DUKE    443        +GOLDMAN,LAASANEN,STEINBERG        (MARYLAND)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+      (ARG,NWES)IJP
MILLER    72 NP B37 401         +NOVEY,YOKOSAWA,CUTKOSKY +  (ANL+CARN+NWES)IJP

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                                PAPERS NOT REFFERED TO IN Z*1 DATA CARDS

     TOTAL-CROSS-SECTION EXPERIMENTS  ---
BUGG      68 PR 168 1466        +GILMORE,KNIGHT, +    (RTHFD,BRMGHM,CVNDSH) I
BOWEN     70 PR D2 2599         +CALDWELL, DIKMEN, JENKINS, KALBACH,+(ARIZ) I

     DISPERSION-RELATION CALCULATION USING TOTAL-CROSS-SECTION DATA  ---
CARTER    68 PREPRINT           A A CARTER                        (CAVENDISH)

     A K-MATRIX ANALYSIS OF SOME OF THE EARLY K+P DATA ---
HITE      67 THESIS             G E HITE                          (ILLINOIS)

     REGGE-POLE ANALYSES --
CARRERAS 70 NP B19 349          B CARRERAS, A DONNACHIE   (DARESBURY,MANCH)

     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)

     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)
ASBURY    69 PRL 23 194         +DOWELL, KATO, LUNDQUIST, NOVEY, + (ARG,MD)
BLAND     69 PL 29B 618         R W BLAND, G GOLDHABER, G H TRILLING  (LBL)
ANDERS-2 69 PL 30B 56           ANDERSSON, DAUM, ERNE, LAGNAUX, +    (CERN)
BARBER    70 PL 32B 214         +BRODME, DUFF, HEYMANN, IMRIE,+ (LOUC,RHEL)IJP
GIACOMEL 70 NP B20 301          GIACOMELLI, GRIFFITHS,(BGNA,GLAS,ROMA,TRST)IJP
HALL      70 DUKE    435        +BLAND,GOLDHABER,TRILLING                (LRL)
REBKA     70 PRL 24 160         +ROTHBERG, ETKINS, GLODIS, +         (YALE)IJP
ADAMS     71 PR  D4 2637        +DAVIES,DOWELL,GRAYER,HATTERS+  (BIRM+RUTH)
BARNETT   71 PL 34B 655         +LAASANEN,STEINBERG  +  (MARY+ANL+NWES+NAL)
EHRLICH   71 PRL 26 925         +ETKIN,GLODIS,HUGHES,KONDO,LU,MORI+  (YALE)
GRIFFITH 72 NP TO BE PUBL.      +HIRATA,HUGHES +      (BGNA+GLAS+ROMA+TRST)

     PHASE SHIFT ANALYSES
CARRERA1 70 NP B23 525          B CARRERAS, A DONNACHIE                  (DARE)IJP
  ALSO   70 DUKE 447            +DONNACHIE,KIRSOPP       (DARE+MCHS+U.EDINB)
LEA      71 NP  B26 413         +MARTIN,THOMPSON                   (RHEL,LOUC)IJP
LOVELACE 71 NP  B28 141         +WAGNER                                  (CERN)IJP

     EARLIER ANALYSES THAT DO NOT INCLUDE RECENT POLARIZATION DATA --
LEA       68 PR 165 1770        LEA, MARTIN, OADES            (RTHFD,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)

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## $Z_1(2150)$

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93  Z*1(2150, JP=    ) I=1

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                    93  Z*1(2150)  MASS (MEV)

M           2150.      20.          ABRAMS    70 CNTR ++  K+P TOTAL      10/71*

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                    93  Z*1(2150) WIDTH (MEV)

W           (175.)                  ABRAMS    70 CNTR ++  K+P TOTAL      10/71*

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                    93  Z*1(2150) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      Z*1(2150) INTO K N                                493+ 938

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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 -- 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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## $Z_1(2500)$

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94  Z*1(2500, JP=    ) I=1

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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 -- 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 (MICROBARNS)

        SEE MINIREVIEW PRECEDING Z*0

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 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 in the $\pi N \to \pi N$ reaction, so also are the recently discovered $Y^*$'s only weakly coupled in the $\bar{K}N \to \bar{K}N$, $\bar{K}N \to \Lambda\pi$, and $\bar{K}N \to \Sigma\pi$ reactions. The older, well-established resonances are usually clearly visible as peaks in cross sections, as characteristic variations of angular distributions of 2-body final states, and (or) as peaks in invariant-mass distributions of subsets of particles in 3-or-more-body final states. Although some of the newer and less-well-established resonances are seen as small peaks in invariant-mass distributions, many of them make no direct appearance at all, often because there are many states at the same mass and it is not clear which ones (or how many) are being observed. Rather when the 2-body reactions are partial-wave analyzed, some of the amplitudes are found to traverse resonance-like counterclockwise circles. Clearly the results of partial-wave analysis give the $J^P$ 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. A good review is given by MILLER 70.[1] Also, the branching ratios of $\Sigma(1915)$ $F_{15}$ as measured in formation and production experiments do not agree. This is probably due to two facts: 1) the elasticity is small, 2) the nearby $D_{13}(1940)$ may contribute to production experiments.

Formation experiments. Partial-wave analyses have been performed on $\bar{K}N$, $\Lambda\pi$, $\Sigma\pi$ and $\Xi K$ 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. Usually many solutions are found and even when it is required that solutions at neighboring energies join smoothly, it is not possible to select a unique overall solution. To overcome this, one specifies the form of the energy dependence of some or all of the partial-wave amplitudes. Analyses in which the energy dependence of all the amplitudes is specified are called energy dependent. When referring to results of this type of analysis, the technique listed is DPWA. Thus an amplitude known to resonate will be given a Breit-Wigner form, whereas an amplitude not a priori known to resonate may be tried alternately with a resonance form and with some simple nonresonant form, the choice between these then being made by comparing the goodness-of-fit for the two fits.

Analyses in which most of the amplitudes are left unspecified are called (not quite correctly) energy independent. The technique used for these analyses is listed as IPWA. Figure 1 shows results of such an analysis of the reaction $K^-p \to \Lambda\pi$ by ARMENTEROS 70. The $D_{15}$ amplitude was fixed as the $\Sigma(1765)$, with resonance parameters obtained from an earlier energy-dependent analysis. This amplitude acts as an analyzer for the other amplitudes, which were allowed to vary freely. The $S_{11}$ and $D_{13}$ amplitudes appear to resonate. Figure 2 shows results of a similar analysis, also by ARMENTEROS 70, of the reaction $K^-p \to \Sigma\pi$. Here the $D_{03}\Lambda(1520)$, $D_{13}\Sigma(1670)$, $D_{03}\Lambda(1690)$, $D_{15}\Sigma(1765)$, $F_{05}\Lambda(1820)$, and $F_{15}\Sigma(1910)$ were fixed. It appears that several of the other amplitudes may resonate too. It should be clear from the figures that it is not always possible to decide whether or not an amplitude resonates. Neither is it possible to determine very accurately the parameters of the amplitudes that do resonate, nor to assign meaningful errors to the parameters. The state of knowledge of the newer $Y^*$'s is rather more qualitative than quantitative.

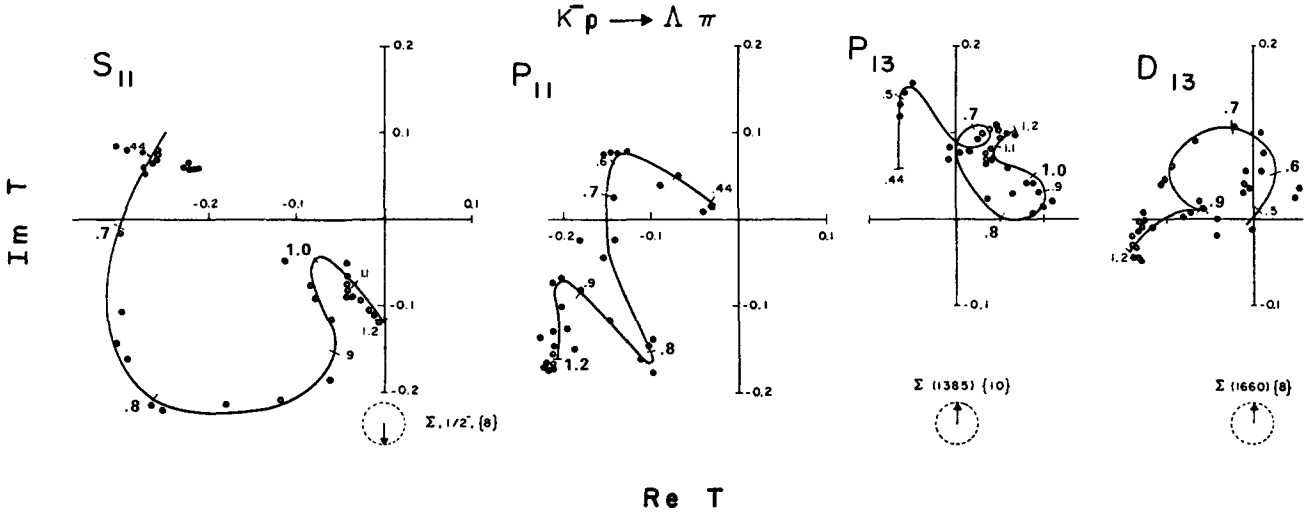


Fig. 1. Partial-wave amplitudes for the reaction $K^-p \to \Lambda\pi$, as determined in the energy-independent analysis of ARMENTEROS 69. The $K^-$ laboratory momenta are indicated. The arrows in a circle, drawn in the lower part of the imaginary axes, fix the sign convention used. See LEVI SETTI 69. Notice that the sign convention used here is different from the one of the Argand plots of our 1969 edition [Rev. Mod. Phys. 41, 109 (1969)].

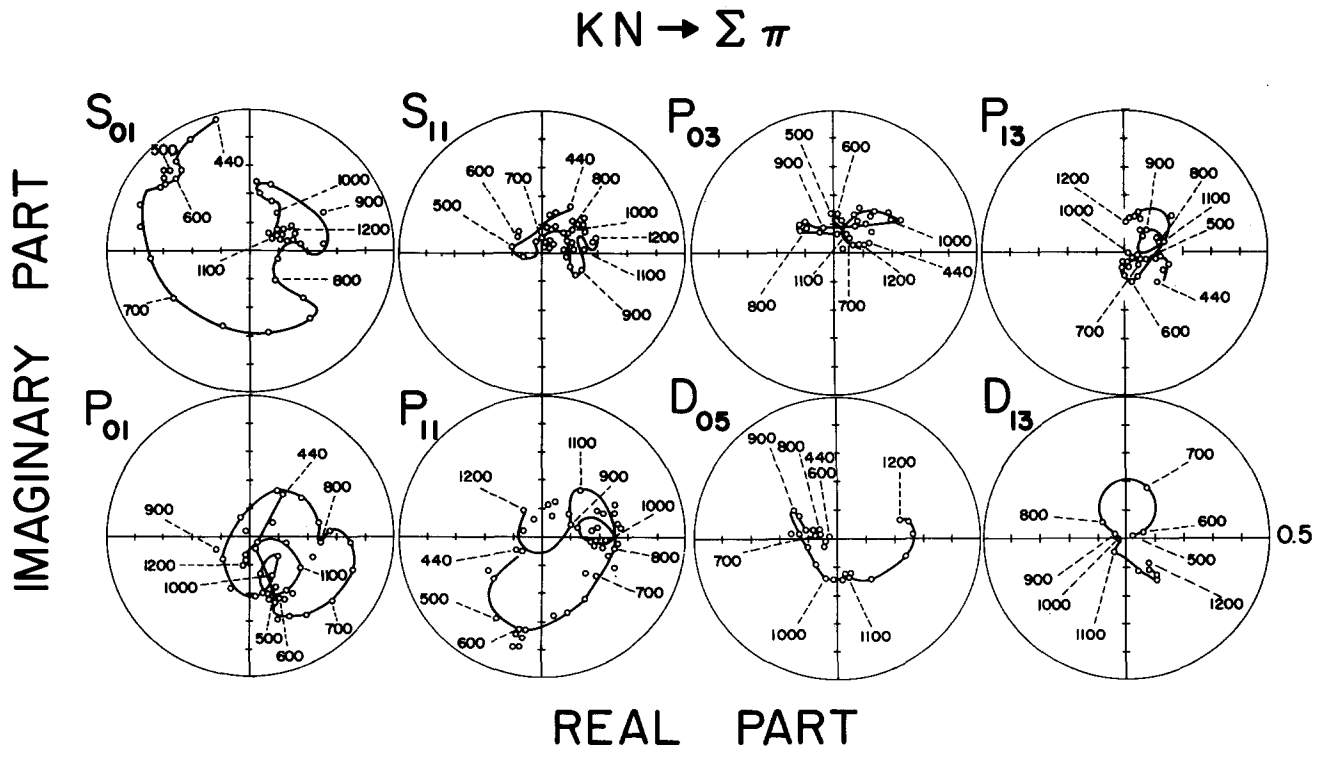


Fig. 2. Partial-wave amplitudes for the reaction $K^-p \to \Sigma\pi$, as determined in the energy-independent analysis of ARMENTEROS 70. The $K^-$ laboratory momenta are indicated. Here again the sign convention follows LEVI SETTI 69.

Partial-wave analyses above 1.1 GeV/c. One of us[2] has reviewed this energy region at the Duke Conference on Hyperon Resonances. The $\Lambda\pi$ channel has been analyzed by five groups, using different sets of data points that are in very good agreement with each other. LITCHFIELD 70 has used all the data, which plotted together show absolutely no discrepancies. In spite of this fact the five analyses agree only on three of the eight partial waves used to fit the data! And all five groups claim to obtain a good fit.

The problem here, more than insufficient data, is that the $\Lambda\pi$ channel alone is not constrained very much and a large number of solutions can be found. This is especially true at these high energies where the number of partial waves involved is very large. For the $\Sigma\pi$ channel, where two I-spin states are present, the interference terms certainly help to reduce the number of possible solutions. Above 1850 MeV, Table I lists 6 Λ states and 7 Σ states, but in view of the above difficulties, most of the new states have been classified "needs confirmation". Clearly, resonances have to show up very strongly in at least one channel before they are accepted without reservation.

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.

Recently it has become the custom to quote errors as obtained by inspection of various fits done with different hypotheses [see for example BERTHON 70 and GALTIERI 70 under Σ(1915)]. These errors are probably more realistic. On the other hand, the value of the parameter itself may be consistent with other determinations and often may even be the best available value. In such circumstances we put only the error in parentheses to remind the reader of the additional uncertainty due to model dependent assumptions. For two states, Λ(1820) and Σ(1765), there is 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 chose not to give errors on masses and total widths determined in partial-wave analyses, but, whenever necessary, we give a range of values. As for the branching ratios, we use the errors when needed to perform an overall fit, but we caution the reader.

Conclusions. Table I is an attempt to evaluate the status of the various $Y^*$'s. The evaluations are of course partly subjective. A blank indicates that there is no corresponding evidence at all. This may mean either that the relevant couplings are small or that the resonance does not really exist. The Baryon Table includes only the well-established resonances. It seems clear, however, that whereas any particular one of the questionable resonances may disappear with the next analysis, there definitely are many new resonances underlying those we are more familiar with.

### References

1. D. H. Miller, in Proceedings of the Duke Conference on Hyperon Resonances (1970), p. 229.
2. A. Barbaro-Galtieri, in Proceedings of the Duke Conference on Hyperon Resonances (1970), p. 173.

TABLE I. STATUS OF Y* RESONANCES
THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE. THE OTHERS AWAIT CONFIRMATION.

| PARTICLE | LIJ | OVERALL STATUS | TOTAL# CR. SEC. | STATUS AS SEEN IN -- KBAR N | LAM PI | SIG PI | OTHER CHANNELS |
|---|---|---|---|---|---|---|---|
| LAM(1115) | P01 | **** | | | | | WEAK TO N PI |
| LAM(1330) | | * | | | | | LAM GAM |
| 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(2020) | F07 | ** | | | O | ** | |
| LAM(2100) | G07 | **** | **** | **** | R | *** | |
| LAM(2110) | | * | | * | B | * | |
| LAM(2350) | | **** | **** | **** | I | | |
| LAM(2585) | | ** | ** | * | D | | |
| SIG(1190) | P11 | **** | | | | | WEAK TO N PI |
| SIG(1385) | P13 | **** | | | **** | **** | |
| SIG(1440) | PE | * | | | * | | |
| SIG(1480) | PE | * | | * | * | * | |
| SIG(1620) | S11 | ** | | ** | | * | |
| SIG(1620) | P11 | ** | | * | | ** | |
| SIG(1620) | PE | ** | | | ** | | LAM 2-PI |
| SIG(1670) | D13 | **** | ** | ** | *** | **** | SEVERAL OTHERS |
| SIG(1670) | PE | ** | | | | | LAM(1405) PI |
| SIG(1690) | PE | ** | * | | ** | | LAM 2-PI |
| SIG(1750) | S11 | *** | | ** | ** | | SIG ETA |
| SIG(1765) | D15 | **** | **** | **** | **** | ** | SEVERAL OTHERS |
| SIG(1880) | P11 | ** | | ** | ** | | |
| SIG(1915) | F15 | *** | *** | ** | *** | ** | |
| SIG(1940) | D13 | ** | | | ** | ** | |
| SIG(2030) | F17 | **** | **** | **** | **** | ** | |
| 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.

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18  LAMBDA  (1115,JP=1/2+)  I=0

SEE STABLE PARTICLE DATA CARD LISTINGS
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## Λ(1330) BUMPS

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87  Y*0(1330, JP=     ) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

A PEAK IS SEEN NEAR 1330 MEV IN THE LAMBDA GAMMA SPEC-
TRUM 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 POSSI-
BILITY OF THERE BEING A Y*0(1330) WITH A NARROW WIDTH (LT 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 KO +
(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.

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                    REFERENCES -- Y*0(1330)

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)

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## Λ(1405) BUMPS

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37  Y*0(1405, JP=1/2-) I=0   S'01

THIS RESONANCE CAN BE IDENTIFIED WITH THE VIRTUAL BOUND
STATE IN THE KBAR-N SYSTEM FOUND IN THE ANALYSIS OF LOW
ENERGY K-P INTERACTION.  WE LIST SUCH EXPERIMENTS SEPA-
RATELY BELOW.  WE USE ONLY PRODUCTION EXPERIMENTS FOR
AVERAGING OF MASSES AND WIDTHS -

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                    37  Y*0(1405) MASS (MEV)

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           1400.0      24.0       MUSGRAVE  65 HBC     PBAR P 3-4 BEV/C   7/66
M          (1382.0)     (8.0)      ENGLER    65 HDBC    PI-P, PI+D 1.68    7/66
M       67 1400.0        5.0       BIRMINGHA 66 HBC      3.5 K- P          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)

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                    37  Y*0(1405) WIDTH (MEV)

W           (20.0)                ALSTON    61 HBC                        7/66
W            35.0        5.0      ALEXANDER 62 HBC
W           (50.0)                ALSTON    62 HBC
W            60.0       20.0      MUSGRAVE  65 HBC                        7/66
W           (89.0)     (20.0)     ENGLER    65 HDBC                       7/66
W       67   50.0       10.0      BIRMINGHA 66 HBC      3.5 K- P          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)

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                    37  Y*0(1405) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1          Y*0(1405) INTO SIGMA PI                    1197+ 139

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                    REFERENCES -- Y*0(1405)

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
MUSGRAVE 65 NC 35 735          +PETMEZAS,+ (BIRMGHM,CERN,EP,IMPCOL,SACLAY)
ENGLER   65 PRL 15 224         +FISK,KRAEMER,MELTZER,WESTGARD,+ (CRNG,BNL) IJ

BIRMINGH 66 PR  152  1148      BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
GALTIERI 68 PRL 21 573         BARBARO-GALTIERI,CHADWICK +       (LRL,SLAC)

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### Λ(1405) EXTRAPOLATION BELOW THRESHOLD

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SEE NOTE IN Y*0(1405) PRODUCTION EXPERIMENTS -THE DIF-
FICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO
THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ 67.

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                    37  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

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                    37  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

****** ********* ********* ********* ********* ********* ********* *******

                    REFERENCES -- Y*0(1405) FROM EXTRAPOLATIONS

KIM      65 PRL 14 29          J K KIM                        (COLUMBIA)IJP
SAKITT   65 PR 139 B719        +DAY,GLASSER,SEEMAN,FRIEDMAN, +    (MD,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              (UCL+BNL)
MARTIN   70 NP B16 479         A D MARTIN, G G ROSS               (DURHAM)IJP

                    PAPERS NOT REFERRED TO IN DATA CARDS

ABRAMS   65 PR 139 B454        G S ABRAMS, B SECHI-ZORN                (MD)IJP
DALITZ   67 PR 153 1617        DALITZ, WONG, RAJASEKARAN   (OXFORD,BOMBAY)
DONALD   66 PL 22 711          + EDWARDS, LYS, NISAR, MOORE    (LIVERPOOL)
KADYK    66 PRL 17 599         +OREN, G+S GOLDHABER, TRILLING        (LRL)IJP
      -- ABRAMS 65, KADYK 66, AND DONALD 66 SUPPORT THOSE EFFECTIVE-RANGE-
         FIT SOLUTIONS GIVING AN I=0 S1/2 RESONANCE.
CLINE    71 PRL 26 1194        D CLINE,R LAUMANN,J MAPP              (WISC)

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                    END -EXTRAPOLATION BELOW THRESHOLD-

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## Λ(1520)

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38  Y*0(1520, JP=3/2-) I=0   D'03

PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL
WITH EACH OTHER ,THEREFORE THEY HAVE NOT BEEN SEPARATED
FOR THIS PARTICLE

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                    38  Y*0(1520) MASS (MEV)

M          1519.4       2.0       WATSON    63 HBC     K-P ALL CHANNELS
M      145 1517.2       3.0       GALTIERI  63 DBC     K-D 1.51 BEV/C
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      3.5 K- P          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      3.5 K- P          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 SIGMAO GAMMA               1192+   0
P6          Y*0(1520) INTO SIGMA PI PI                1197+ 139+ 139
P7          Y*0(1520) INTO (Y*1(1385)+PI)             1385+ 139

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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          0.73      0.11       DAUBER    67 HBC     K-P AT 2.GEV/C    8/67
R1          0.96      0.20       DAHL      67 HBC     PI-P 1.6-4 GEV/C  9/66
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     0.916     0.036  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

R2     Y*0(1520) INTO (LAMBDA PI PI)/(KBAR N)            (P3)/(P1)
R2          0.21      0.18       DAUBER    67 HBC     K-P AT 2.GEV/C    8/67
R2          0.17      0.05       DAHL      67 HBC     PI-P 1.6-4 GEV/C  9/66
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     0.213     0.016  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      3.5 K- P          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     4.30      0.34   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)
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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     2.01      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          (0.45)                   KIM       71 DPWA   K-MATRIX ANAL.    3/71
R6           0.47      0.03          COLLEY    71 DBC    K-N 1.5 GEV PROD 10/71*
R6         . . . . . . . . . .
R6   AVG     0.439     0.033   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R6   FIT     0.4519    0.0091 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          (0.46)                   KIM       71 DPWA   K-MATRIX ANAL.    3/71
R7           0.43      0.03          COLLEY    71 DBC    K-N 1.5 GEV PROD 10/71*
R7         . . . . . . . . . .
R7   AVG     0.424     0.015   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7   FIT     0.4138    0.0094 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         . . . . . . . . . .
R8   FIT     0.0100    0.0015 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9      Y*0(1520) INTO (Y*1(1385) PI)/(LAM PI PI)             (P7)/(P3)
R9        MORE THAN    0.10          CLINE     69  DBC   K-D TO 2PI LAM N  9/69
R9           0.39      0.10          BURKHARDT 71 HBC     LAM. 3PI PROD.   3/71

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*
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<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.

| | P 1 | P 2 | P 3 | P 4 | P 5 | P 6 |
|---|---|---|---|---|---|---|
| P 1 | .452+-.009 | | | | | |
| P 2 | -.680 | .414+-.009 | | | | |
| P 3 | -.289 | -.379 | .096+-.007 | | | |
| P 4 | -.064 | -.059 | -.039 | .008+-.001 | | |
| P 5 | -.160 | -.148 | -.099 | -.008 | .020+-.003 | |
| P 6 | -.068 | -.063 | -.042 | -.003 | -.009 | .010+-.001 |

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REFERENCES -- Y*0(1520)


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WATSON    63 PR 131 2248       M B WATSON, M FERRO-LUZZI, R D TRIPP  (LRL)IJP
GALTIERI  63 PL 6 296          A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)
ALMEIDA   64 PL 9 204          S P ALMEIDA, G R LYNCH                (CERN)
MUSGRAVE  65 NC 35 735         +PETMEZAS,+ (BIRMGHM,CERN,EP,IMPCOL,SACLAY)
ARMENTER  65 PL 19 338         ARMENTEROS,F-LUZZI, +  (CERN,HEIDEL,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,+  (MD,USNRL)
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                      (U. 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++ (MASS,YALE)

                               PAPERS NOT REFERRED TO IN DATA CARDS

BERLEY    70 PR D1,1996        +YAMIN,KOFLER,MANN,MEISNER+ (BNL,MASS,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    N     1662.0      (3.0)        ARMENT-4  69 HBC  0  ELAST,CH.EXC.ED   9/69
M    N     1680.0      (1.0)        ARMENT-4  69 HBC  0  K-P TO SIG PI.ED  9/69
M    A     1674.0      (5.0)        ARMENT-3  69 HBC  0  MULTICHANNEL      9/69
M          1674.0                   BERLEY    69 HBC  0  K-P TO SIGMA PI   6/70
M          1683.0      (5.0)        GALTIERI  70 HBC  0  SIG PI,EDPWA      7/70
M          1670.                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
M    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 PARAMETERIZATION 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
              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   P        0.14     (0.04)       ARMENT-4  69 HBC  0  NEW DATA          9/69
R1            0.17                  ARMENT-3  69 HBC  0                    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   A     EFFECT BELOW REGION ANALYSED. VALUE OF .18 DOES NOT
R1   A   AFFECT FIT OR VALUES OF OTHER PARAMETERS
R1   P    THIS IS THE DIAMETER OF THE CIRCLE IN THE ARGAND PLOT.  IT IS
R1      SUPERIMPOSED ON A LARGE BACKGROUND.

R2      Y*0(1670) FROM KBAR N TO LAMBDA ETA                 SQRT(P1*P2)
R2   M       (0.20) OR 0.23         BERLEY    65 HBC  0  SEE NOTE M ABOVE  7/66
R2           (0.26)                 ARMENT-3  69 HBC  0                    9/69
R2           (0.24)                 KIM       71 DPWA    K-MATRIX ANAL.    3/71
          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 -- 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
      --  ARMENTEROS 3 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

                                PAPERS NOT REFERRED TO IN DATA CARDS

BIRMING- 66 PR 152 1148         (BIRMINGHAM,GLASGOW,IMPCOL,OXFORD,RUTHERFD)
LEVISETT 69 LUND 339            R LEVI SETTI  (RAPPORTEUR)          (CHICAGO)
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**Λ(1690)** **$D''_{03}$**

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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           1695.0      (4.0)        BUGG      68 CNTR 0  K-P, D TOTAL      7/68
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    M     (1697.0)     (2.0)        CONFORTO  68 HBC  0  ELASTIC, CH EXCH 11/68
M           1701.0      (4.0)        BERTANZA  69 HBC  0  ELASTIC, CH EXCH  9/69
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           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    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            40.0       (7.0)        BUGG      68 CNTR 0                    7/68
W            48.       (15.)         BARTLEY   68 DBC   0 K-P AND K-D DATA 11/68
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            28.0       (8.0)        BERTANZA  69 HBC  0                    9/69
W            57.0                    BERLEY    69 HBC  0  K-P TO SIGMA PI   6/70
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
              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 | 1385+ 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 UNREASONABLY SMALL). HARDLY ANY OF THE SIGMA PI PI DECAY CAN BE VIA Y*1(1385), FOR THEN NINE TIMES AS MUCH LAMBDA PI PI DECAY WOULD BE REQUIRED.

R1 Y*0(1690) INTO (KBAR N)/TOTAL (P1)
R1 (0.23) BUGG 68 CNTR 0 ASSUMING J=3/2 7/68
R1 (0.18) (0.03) ARMENT-1 68 HBC 0 11/68
R1 M (0.22) (0.03) CONFORTO 68 HBC 0 SEE NOTE M ABOVE 11/68
R1 0.28 (0.04) BERTANZA 69 HBC 0 9/69
R1 0.18 (0.02) ARMENT-4 69 HBC 0 NEW DATA 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 N EFFECT IS AT END OF REGION ANALYZED. THIS COULD AFFECT VALUE OF X1.
R1 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

R3 Y*0(1690) FROM KBAR N TO LAMBDA PI PI SQRT(P1*P3)
R3 B (0.25) (0.02) BARTLEY 68 HDBC 0 LAM 2PI CROS SEC 11/68
R3 B ONLY CROSS-SECTION DATA USED. ENHANCEMENT NOT SEEN BY PREVOST 71, 3/72*
R3 B (SEE R5 BELOW) WHO MADE DPWA USING ALSO ANG. DISTRIB. AND POLARIZ. 3/72*

R4 Y*0(1690) FROM KBAR N TO SIGMA PI PI SQRT(P1*P4)
R4 (0.21) ARMENT-2 68 HDBC 0 K-N TO SIG PI PI 11/68

R5 Y*0(1690) FROM KBAR N INTO Y*1(1385) PI SQRT(P1*P5)
R5 (-0.06) PREVOST 71 DPWA 0 K-P TO LAM PI PI 10/71*

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REFERENCES -- Y*0(1690)

DAVIES 67 PRL 18 62 +DOWELL, + (BRMNGHM,CVNDSH,RTHFRD) I
-- REPLACED BY BUGG 68.
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,FLOR ST,BRANDEIS) I
BUGG 68 PR 168 1466 +GILMORE, KNIGHT, + (RTHFRD,BRMNGHM,CVNDSH) I
CONFORTO 68 NP B8 265 +HARMSEN, LASINSKI, + (CHICAGO,HEIDEL)IJP

ARMENT-4 69 NP B14 91 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BERTANZA 69 PR 177 2036 +BIGI,CARRARA,CASALI, + (PISA,BNL,YALE)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
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 REPARAMETRIZED AS A RESONANCE SUPERIMPOSED ON A ONE-STRAIGHT-LINE BACKGROUND, A BROAD RESONANCE RESULTED (ARMENTEROS 68). A REANALYSIS OF ESSENTIALLY THE SAME DATA, BUT THIS TIME WITH THE P01 AMPLITUDE UNCONSTRAINED, SUGGESTED A MUCH NARROWER RESONANCE AT HIGHER ENERGY (ARMENTEROS 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 ANALYSIS OF KIM 71 INDICATES A SECOND POSSIBLE P01 STATE AT ABOUT 1570. WE TENTATIVELY LIST THESE EFFECTS TOGETHER.

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77 Y*0(1750) MASS (MEV)

M 0 (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 1 POSSIBLE EFFECT IN SIGMA PI AND KBAR N CHANNELS.
M 0 OLD ANALYSIS, USING OLD DATA.

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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
SEE THE NOTES ACCOMPANYING MASSES QUOTED

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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 |

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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

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
SEE THE NOTES ACCOMPANYING MASSES QUOTED

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REFERENCES -- 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

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## Λ(1815)

39 Y*0(1815, JP=5/2+) I=0 **$F'_{05}$**

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THIS STATE IS WELL ESTABLISHED. MOST OF THE QUOTED ERRORS ARE STATISTICAL ONLY. THE SYSTEMATIC ERRORS DUE TO THE PARTICULAR PARAMETERIZATION USED IN THE P.W.A. ARE NOT INCLUDED. FOR THIS REASON WE DO NOT CALCULATE WEIGHTED AVERAGES FOR MASS AND WIDTH.

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39 Y*0(1815) MASS (MEV)

M N 1813.0 (2.0) ARMENT-1 67 HBC 0 K-P TO SIGMA PI 8/67
M N 1816.0 (4.0) BELL 67 HDBC 0 K-N TO SIGMA PI 11/67
M N 1817.0 (2.0) ARMENT-3 68 HBC 0 ELASTIC, CH EXCH 11/68
M N 1819.0 (4.0) BUGG 68 CNTR 0 K-P, D TOTAL 6/68
M N 1825.0 (1.0) BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70
M N 1819.0 (1.0) BRICMAN1 70 DPWA SIGTOT,ELAS,CHEX 1/71
M 1830.0 (10.0) COOL 70 CNTR K-P, D TOTAL 10/70
M 1820.0 (10.0) GALTIERI 70 DPWA 0 K-P TO SIGMA PI 7/70
M N 1818.0 (2.0) CONFORTO 71 DPWA 0 ELASTIC, CH EXCH 6/70
M 1823.0 (3.0) KANE 71 DPWA 0 K-P TO PI SIG 10/71*
M 1810. KIM 71 DPWA K-MATRIX ANAL. 3/71
M N ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED 1/71

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39 Y*0(1815) WIDTH (MEV)

W 87.0 (15.0) ARMENT-1 67 HBC 0 8/67
W 64.0 (12.0) BELL 67 HDBC 0 11/67
W N 71.0 (4.0) ARMENT-3 68 HBC 0 ELASTIC, CH EXCH 11/68
W N 75.0 (7.0) BUGG 68 CNTR 0 K-P, D TOTAL 6/68
W N 80.0 (6.0) BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70
W N 79.0 (3.0) BRICMAN1 70 DPWA SIGTOT,ELAS,CHEX 1/71
W 100.0 COOL 70 CNTR K-P, D TOTAL 10/70
W 100.0 (20.0) GALTIERI 70 DPWA 0 K-P TO SIGMA PI 7/70
W N 90.0 (4.0) CONFORTO 71 DPWA 0 ELASTIC, CH EXCH 6/70
W 104.0 (16.0) KANE 71 DPWA 0 K-P TO PI SIG 10/71*
W 70. KIM 71 DPWA K-MATRIX ANAL. 3/71
SEE THE NOTES ACCOMPANYING MASSES QUOTED

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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 | 1385+ 139 |
| P4 | Y*0(1815) INTO SIGMA PI PI | 1192+ 139+ 139 |
| P5 | Y*0(1815) INTO LAMBDA PI PI | 1115+ 139+ 139 |

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39 Y*0(1815) BRANCHING RATIOS

ERRORS QUOTED BY EXPERIMENTERS DO NOT INCLUDE UNCERTAINTY DUE TO PARAMETRIZATION USED IN THE P.W.A. THEY SHOULD BE INCREASED.

R1 Y*0(1815) INTO (KBAR N)/TOTAL (P1)
R1 0.62 0.02 ARMENT-3 68 HBC 0 ELASTIC, CH EXCH 11/68
R1 (0.72) BUGG 68 CNTR 0 K-P, D TOTAL 6/68
R1 0.65 0.02 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70
R1 0.58 0.02 BRICMAN1 70 DPWA SIGTOT,ELAS,CHEX 1/71
R1 (0.8) COOL 70 CNTR K-P, D TOTAL 10/70
R1 0.63 0.01 CONFORTO 71 DPWA 0 ELASTIC, CH EXCH 6/70
R1 (0.52) KIM 71 DPWA K-MATRIX ANAL. 3/71
R1 . . . . . . . . . .
R1 AVG 0.624 0.011 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
R1 FIT 0.6241 0.0100 FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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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      71 DPWA  0 K-P TO PI SIG    10/71*
R2              . . . . . . . . . .
R2  AVG MOD    0.2645    0.0084  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT        0.2634    0.0084 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            +0.11      0.05            PREVOST   71 DPWA  0 K-P TO LAM PI PI 10/71*
R3  A   ARMENTEROS-2 67 DATA INCLUDED IN PREVOST 71.                            3/72*
R3              . . . . . . . . . .
R3  FIT         0.157    0.053   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

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         0.039    0.027   FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.6)

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         0.225    0.029   FROM 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 | .624+-.010 | | | |
| P 2 | -.242 | .111+-.007 | | |
| P 3 | -.019 | .005 | .039+-.027 | |
| P 4 | -.347 | -.223 | -.876 | .225+-.029 |

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REFERENCES -- Y*0(1815)



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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 1D 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
KANE      71 LBL  15 (SUB PR)   D F KANE                              (LBL)IJP
KIM       71 PRL 27 356         J K KIM                              (HARV)IJP
    ALSO 70 DUKE 161            J. K. KIM                            (HARV)IJP
PREVOST  71  AMSTERDAM CONF     + CHS COLLABORATION        (CERN+HEID+SACL)
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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+ (EFINS,ARGON)
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
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**Λ(1830)** **D'05**

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             56  Y*0(1830, JP=5/2-) I=0

             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            1832.0      (5.0)          KANE      71 DPWA  0 K-P TO PI SIG    10/71*
M            1830.                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
M     K     (1720.)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
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              88.0    (10.0)           KANE      71 DPWA  0 K-P TO PI SIG    10/71*
W              80.                      KIM       71 DPWA    K-MATRIX ANAL.    3/71
W     K       (20.)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
        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                       1385+ 139

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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

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      71 DPWA  0 K-P TO PI SIG    10/71*

R3      Y*0(1830) FROM KBAR N INTO Y*1(1385) PI           SQRT(P1*P3)
R3            (+0.11)                   PREVOST   71 DPWA  0 K-P TO LAM PI PI 10/71*

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REFERENCES -- Y*0(1830)



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ARMENTER 67 PL 24B 198          ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
BELL      67 PRL 19 936         R B BELL                              (LRL)IJP
ARMENTER 68 NP B8 195           ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
CONFORTO 68 NP B8 265           +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP
    --  CONFORTO 68 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
KANE      71 LBL  15 (SUB PR)   D F KANE                              (LBL)IJP
KIM       71 PRL 27 356         J K KIM                              (HARV)IJP
  SEE ALSO  DUKE 161            J. K. KIM                            (HARV)IJP
PREVOST  71  AMSTERDAM CONF     + CHS COLLABORATION        (CERN+HEID+SACL)
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**Λ(1860)** **P03**

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             60  Y*0(1860, JP=3/2+) I=0

             SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.


             THE QUANTUM NUMBERS OF THIS STATE ARE PROBABLY 3/2+.
             AN F07 WAS FIRST SUGGESTED IN THE PHASE SHIFT ANALYSIS
             OF THE KBAR-N DATA BY ARMENTERDS 67. THE ISOSPIN-0 TOT.
   CROSS SECTION HAS A SHOULDER ON THE HIGH SIDE OF Y*0(1815) THAT IS
   COMPATIBLE WITH A STATE AT THIS MASS (BUGG 68). THE ARMENTEROS 68 AND
   CONFORTO 68 ANALYSES OF IMPROVED  KBAR-N DATA INCLUDED THE F07 STATE.
   HOWEVER IN THE NEW ANALYSES OF CONFORTO 71 AND,LATER, BRICMAN1 70 THE
   F07 IS NOT REQUIRED BY THE NEW DATA AND A P03 RESONANCE IS ACCEPTABLE.
   IN ADDITION BOTH THESE NEW ANALYSES INCLUDED RECENT POLARIZATION DATA.

   ALBROW 71 CONFIRM THE P03 ASSIGNMENT.

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                     60  Y*0(1860) MASS (MEV)

M    N      1870.0      5.0             BUGG      68 CNTR 0  K-P TOTAL         7/68
M    A  F07 1864.0      2.0             ARMENTERO 68 DWPA 0  ELASTIC, CH EXCH 11/68
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    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.

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                     60  Y*0(1860) WIDTH (MEV)

W    N          40.0     10.0           BUGG      68 CNTR 0  K-P TOTAL         7/68
W    A  F07     39.0      7.0           ARMENTERO 68 DWPA 0  ELASTIC, CH EXCH 11/68
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
          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          (J+1/2)P1= 0.40             BUGG      68 CNTR 0                    7/68
R1   A  F07     0.12      0.02          ARMENTERO 68 HBC  0  ELASTIC, CH EXCH 11/68
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
          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    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).

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                         REFERENCES -- Y*0(1860)

ARMENTERO68 NP B8 195         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BUGG     68 PR 168 1466       +GILMORE, KNIGHT, + (RTHFRD,BRMNGHM,CVNDSH) 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

                         PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 67 NP B3 592         ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
    --  ARMENTEROS 67 IS REPLACED BY ARMENTEROS 68 AND CONFORTO 68.
CONFORTO 68 NP B8 265         +HARMSEN, LASINSKI, +     (CHICAGO,HEIDEL)IJP
    --  CONFORTO 68 IS SUPERSEDED BY CONFORTO 71.
LEVISETT 69 LUND 339          R.LEVI SETTI  (RAPPORTEUR)          (EFINS)
ALBROW   71 NP  B29 413       +ANDERSON,BOSNJAKOVIC,DAUM,ERNZ,+   (CERN)

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## Λ(1870) $S'''_{01}$

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                 36  Y*0(1870, JP=1/2-) I=0

                 THE S01 AMPLITUDE SHOWS A SECOND RESONANCE BEHAVIOR AT
                 ABOUT 1800 MEV IN BOTH THE BRICMAN 70 AND KIM 71
                 ANALYSES.  THE ELASTICITIES OF THESE TWO ANALYSES ARE
                 IN BAD DISAGREEMENT.

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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

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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

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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          (0.8)                  KIM       71 DPWA   K-MATRIX ANAL.    3/71

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 -- 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
  SEE ALSO  DUKE 161       J. K. KIM                            (HARV)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 ONE BUT NOT OTHER
                 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

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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

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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

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                 89  Y*0(2010) BRANCHING RATIOS

R1       Y*0(2010) FROM KBAR N TO SIGMA PI              SQRT(P1*P2)
R1          (-0.20)  (0.04)        GALTIERI  70 DPWA 0  K-P TO SIGMA PI  7/70

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                       REFERENCES -- Y*0(2010)

GALTIERI 70 DUKE CONF 173   A BARBARO-GALTIERI                   (LRL)IJP

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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 -- 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            2110.0     (20.0)         GALTIERI  70 DPWA 0  K-P TO SIGMA PI    7/70
M    L      (2130.0)    (20.0)         BERTHON1  70 DPWA 0  K-P TO SIGMA PI   10/70
M            2092.0     (12.0)         KANE      71 DPWA  0 K-P TO PI SIG     10/71*
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    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*

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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              60.0     (25.0)         GALTIERI  70 DPWA 0  K-P TO SIGMA PI    7/70
W             140.0     (15.0)         BERTHON1  70 DPWA 0  K-P TO SIGMA PI   10/70
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             144.0     (26.0)         KANE      71 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

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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            +0.06     (0.03)         GALTIERI  70 DPWA 0  K-P TO SIGMA PI    7/70
R2   L       (+0.16)    (0.02)         BERTHON1  70 DPWA 0  K-P TO SIGMA PI   10/70
R2            +0.096    (0.037)        KANE      71 DPWA  0 K-P TO PI SIG     10/71*
R2    L        0.16     (0.05)         LITCHFIE  71 DPWA    K-P TO SIG PI     10/71*
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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*
          SEE THE NOTES ACCOMPANYING MASSES QUOTED

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                             REFERENCES -- 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)
DAUM      68 NP B7 19            +ERNE, LAGNAUX, SENS, STEUER, UDO     (CERN)JP
      --  DAUM 68 CONFIRMS THE SPIN-PARITY ASSIGNMENT.
BURGUN    68 NP B8 447           +MEYER,PAULI, +     (SACLAY,COLFRANCE,RTHFD)
MULLER    69 THESIS,UCRL 19372 R A MULLER                            (LRL)
BERTHON1  70 NP B24 417          +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)IJP
GALTIERI  70 DUKE CONF 173       A BARBARO-GALTIERI                    (LRL)IJP
KANE      71 LBL  15 (SUB PR)    D F KANE                              (LBL)IJP
LITCHFIE  71 NP  B30 125         LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

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## Λ(2110)

35 Y*0(2110,JP=5/2 )I=0 **$F''_{05}$ or $D''_{05}$**

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         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 71 FINDS AN F05 EFFECT, THE UNUSUALLY BROAD
    WIDTH MAY INVALIDATE A RESONANT INTERPRETATION.

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                   35  Y*0(2110) MASS (MEV)

M          (2110.)     (10.)           BERTHON1  70 DPWA  - K- P TO SIG PI     1/71
M    A     (2141.0)    (6.0)           KANE      71 DPWA  0 K-P TO PI SIG     10/71*
M          (2140.)    (40.)            LITCHFIE  71 DPWA    K-P TO KBAR N     10/71*
M    A  RESONANCE OUTSIDE RANGE OF DATA.

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                   35  Y*0(2110) WIDTH (MEV)

W          (185.)     (30.)            BERTHON1  70 DPWA  - K- P TO SIG PI     1/71
W    A     (504.0)    (10.0)           KANE      71 DPWA  0 K-P TO PI SIG     10/71*
W          (120.)     (40.)            LITCHFIE  71 DPWA    K-P TO KBAR N     10/71*

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                   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

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                   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      71 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*

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                             REFERENCES -- Y*0(2110)

BERTHON1 70 NP B24 417         +VRANA,BUTTERWORTH,+       (CDEF,RHEL,SACLAY)IJP
KANE     71 LBL  15 (SUB PR)   D F KANE                                (LBL)IJP
LITCHFIE 71 NP  B30 125        LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

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## M > 2100 MEV – PRODUCTION AND $\sigma_{TOTAL}$ EXPERIMENTS

## Λ(2100) BUMPS

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                   25  Y*0(2100) CROSS-SECTION AND INVARIANT-MASS PEAKS

                   SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                   SEE THE NOTE TO THE G07 Y*0(2100), WHICH PROCEEDS 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 ESTAB-
    LISHED OTHER RESONANCES IN THIS REGION.

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                   25  Y*0(2100) MASS (MEV) -- AS SEEN IN PEAKS

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

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                   25  Y*0(2100) WIDTH (MEV) -- AS SEEN IN PEAKS

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

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                   25  Y*0(2100) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          Y*0(2100) INTO KBAR N                        497+ 939
P2          Y*0(2100) INTO KBAR N PI                     497+ 939+ 139
P3          Y*0(2100) INTO LAMBDA ETA                   1115+ 548
P4          Y*0(2100) INTO LAMBDA OMEGA                 1115+ 783

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                   25  Y*0(2100) BRANCHING RATIOS -- AS SEEN IN PEAKS

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

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                        REFERENCES -- Y*0(2100) AS SEEN IN PEAKS

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, +     (RTHFD,BRMGHM,CVNDSH) I
BRICMAN   70 PL 31B 152          +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL      70 PR 1D 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
      --  COOL 66 IS SUPERSEDED BY COOL 70.

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## Λ(2350)

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                   42  Y*0(2350, JP=    ) I=0

                   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.

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                   42  Y*0(2350) MASS (MEV)

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

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                   42  Y*0(2350) WIDTH (MEV)

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

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                   42  Y*0(2350) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          Y*0(2350) INTO KBAR N                        497+ 939

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                   42  Y*0(2350) BRANCHING RATIOS

R1      Y*0(2350) INTO (KBAR N)/TOTAL                    (P1)
          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

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                        REFERENCES -- Y*0(2350)

BUGG      68 PR 168 1466         +GILMORE,KNIGHT, +     (RTHFD,BRMGHM,CVNDSH) 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 1D 1887          +GIACOMELLI, KYCIA, LEONTIC, LI, +    (BNL) I
LU        70 PR D2 1846          +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

                        PAPERS NOT REFERRED IN DATA CARDS
COOL      66 PRL 16 1228         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
      --  COOL 66 IS SUPERSEDED BY COOL 70.
LASINSKI 71 NP  B29  125         T A LASINSKI                          (EFI)IJP

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## Λ(2585)

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                   7  Y*0(2585, JP=    ) I=0

                   SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

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                   7  Y*0(2585) MASS (MEV)

M           2585.0    45.0             ABRAMS    70 CNTR    K-P, D TOTAL      10/70
M          (2530.0)  (25.0)            LU        70 CNTR 0  GAMMA P TO K+ Y*   1/71

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                   7  Y*0(2585) WIDTH (MEV)

W           (300.0)                    ABRAMS    70 CNTR    K-P, D TOTAL      10/70
W           (150.0)                    LU        70 CNTR 0  GAMMA P TO K+ Y*   1/71
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                    7  Y*0(2585) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          Y*0(2585) INTO KBAR N                         497+ 939

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                    7  Y*0(2585) BRANCHING RATIOS

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 -- Y*0(2585)

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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## Σ⁺

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                    19  SIGMA +   (1189,JP=1/2+)  I=1

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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## Σ⁻

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                    20  SIGMA -    (1198,JP=1/2+)  I=1

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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## Σ⁰

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                    21  SIGMA 0   (1193,JP=1/2+)  I=1

                    SEE STABLE PARTICLE DATA CARD LISTINGS

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## Σ(1385)  $P'_{13}$

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                    43  Y*1(1385, JP=3/2+) I=1

                     FOR DISCUSSION OF INCONSISTENCY OF ERRORS AND OUR
                     MODIFICATIONS, SEE NOTE ON K*(890)

                     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        38(1384.0)                   MARTIN    61 HBC  0+ K20 P .98 BEV/C
M         (1385.0)                    BERGE     61 HBC  +- K-P .4-.85 BEV/C
M         (1392.0)    (7.0)           COLLEY    62 HLBC 0- PI- PRP 2. BEV/C
MO      106(1381.0)   (4.0)           CURTIS    63 OSPK 0  PI-P 1.5 BEV/C
M         (1392.0)   (10.0)           MUSGRAVE  65 HBC  +-0PBAR P 3-4 BEV/C  7/66
M         (1389.0)    (3.0)           BALTAY    65 HBC  +- PBAR P 3.7 BEV/C  7/66

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 LT STATIST.ER.  10/69
M+   S             ERROR OF 1.1 ENLARGED TO 1.9 BY US,BECAUSE LT STATIST.ER.  10/69
M+   B  40 1383.0      4.0            BIRMINGHA 66 HBC  +  3.5 K- P          9/67
M+   B             ERROR OF 2.0 ENLARGED TO 4.0 BY US,BECAUSE LT 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+          . . . . . . . . .
M+  AVG     1382.81    0.68     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                               (SEE IDEOGRAM BELOW )
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 LT 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 LT STATIST.ER.  10/69
M-   S             ERROR OF 1.4 ENLARGED TO 4.0 BY US,BECAUSE LT 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-          . . . . . . . . .
M-  AVG     1385.9     1.5      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
                               (SEE IDEOGRAM BELOW )

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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      REDUNDANT WITH DATA IN MASS LISTING.

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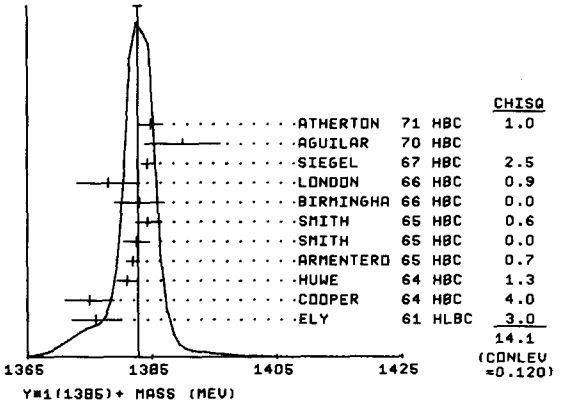


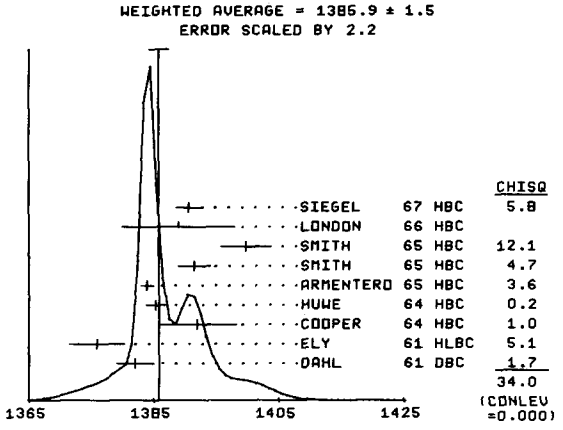


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                    43  Y*1(1385) WIDTH (MEV)

W           (64.0)                    ALSTON    60 HBC  +-
W           (20.0)  OR LESS           MARTIN    61 HBC  0+
W           (40.0)                    BERGE     61 HBC  +-
W           (80.0)    (10.0)          COLLEY    62 HLBC 0-
W           (30.0)    (9.0)           CURTIS    63 OSPK 0
W           (38.0)    (9.0)           MUSGRAVE  65 HBC  +-0                  7/66
W           (26.0)    (5.0)           BALTAY    65 HBC  +-                   7/66

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   + 3.5 K- P          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.)     36/4   ATHERTON  71 HBC     LAM PI+ + C.C.  10/71*
W+ T    FIT B.W. + PHASE SPACE BCKGRD
W+ R    40   (35.)     (5.)     39/1   ATHERTON  71 HBC     LAM PI+ + C.C.  10/71*
W+ R    FIT B.W. AND NO BCKGRD
W+          . . . . . . . . .
W+  AVG     35.9      2.6      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
                               (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-          . . . . . . . . .
W-  AVG     36.3      6.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.5)
                               (SEE IDEOGRAM BELOW )

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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

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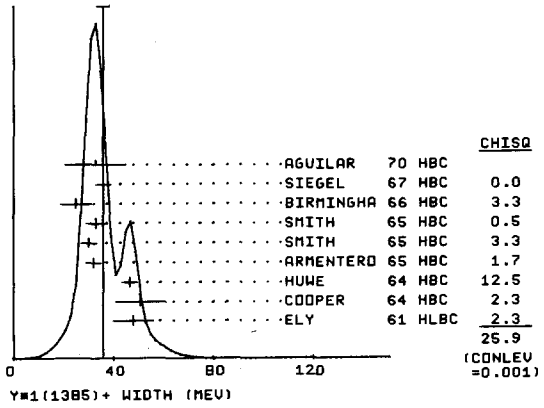
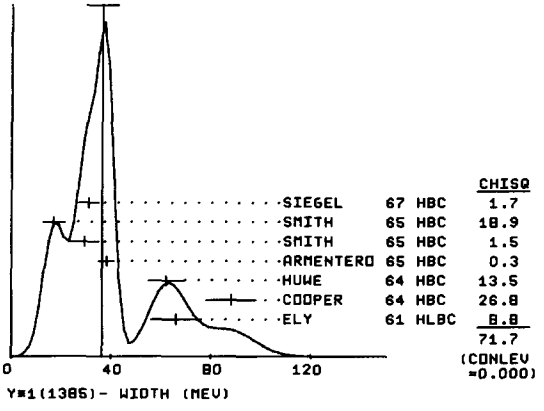
```
WEIGHTED AVERAGE = 35.9 ± 2.6
ERROR SCALED BY 1.9
```




```
WEIGHTED AVERAGE = 36.3 ± 6.3
ERROR SCALED BY 3.5
```




```
                    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           COLLEY     71 DBC     K-N 1.5 GEV PROD 10/71*
R1          . . . . . . . . . .
R1  AVG        0.125    0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                       (SEE IDEOGRAM BELOW )
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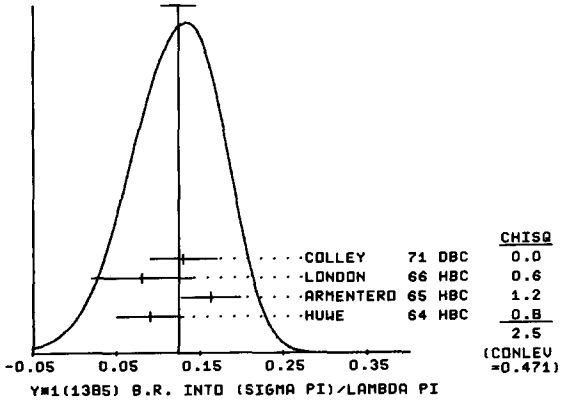
```
WEIGHTED AVERAGE = 0.125 ± 0.021
ERROR SCALED BY 1.0
```

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                    REFERENCES -- Y*1(1385)

ALSTON    60 PRL 5 520          +ALVAREZ,EBERHARD,GOOD,GRAZIANO, +     (LRL) I
DAHL      61 PRL 6 142          +HORWITZ,MILLER,MURRAY,WHITE           (LRL)
MARTIN    61 PRL 6 283          +LEIPUNER,CHINOWSKY,SHIVELY, +   (BNL,YALE)
BERGE     61 PRL 6 557          +BASTIEN,DAHL,FERRO-LUZZI,KIRZ, +      (LRL)
BASTIEN   61 PRL 6 702          P BASTIEN,M FERRO-LUZZI,A H ROSENFELD (LRL)
ELY       61 PRL 7 461          +FUNG,GIDAL,PAN,POWELL,WHITE           (LRL) J

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,AMSTR)
HUWE      64 UCRL-11291 THESIS  D O HUWE                               (LRL) JP
  ALSO    69 PR 180 1824        D O HUWE                               (LRL)

MUSGRAVE  65 NC 35 735          +PETMEZAS,+ (BIRMGHM,CERN,EP,IMPCOL,SACLAY)
ARMENTER  65 PL 19 75           ARMENTEROS, +          (CERN,HEIDEL,SACLAY)
BALTAY    65 PR 140 B1027       +SANDWEISS,TAFT,CULWICK,KOPP, +  (YALE,BNL)
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,SYCR) J
SIEGEL    67 UCRL 18041 THESIS  D M SIEGEL                             (LRL)
AGUILAR   70 PRL 25 58          +BARNES, BASSANO, CHUNG, EISNER,+ (BNL,SYR)
ATHERTON  71 NP B29 477         +CELNIKIER,CLAYTON,FRENCH,FRISK,+     (CERN)
COLLEY    71 NP  B31 61         +COX,EASTWOOD,FRY+..  (BIRM+EDIN+GLAS+LOIC)

          QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN DATA CARDS.

SHAFER    64 PR 134 B1372       J B SHAFER, D O HUWE                   (LRL) JP
MALAMUD   64 PL 10 145          E MALAMUD, P E SCHLEIN          (CERN,UCLA) JP
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### M < 1500 MEV – PRODUCTION EXPERIMENTS

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**Σ(1440) BUMPS**

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80  Y*1(1440, JP=    ) I=1
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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 -- Y*1(1440)

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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**Σ(1480) BUMPS**

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23  Y*1(1480, JP=    ) I=1
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SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

PEAKS ARE SEEN IN LAMBDA PI AND SIGMA PI SPECTRA IN THE REACTION PI+P TO K+ PI Y AT 1.7 GEV/C. ALSO THE Y POLARIZATION OSCILLATES IN THE SAME REGION.

SEE MILLER 70 FOR A DISCUSSION OF THIS STATE. HE SUGGESTS A POSSIBLE ALTERNATE EXPLANATION IN TERMS OF A REFLECTION OF N*1/2(1670) DECAY TO LAMBDA K.

HANSON 71, WITH ABOUT HALF THE STATISTICS AS PAN 70, CAN NEITHER CONFIRM NOR DENY THE EXISTENCE OF Y*1(1480).

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                    23  Y*1(1480) MASS (MEV)

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          . . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    23  Y*1(1480) WIDTH (MEV)

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          . . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

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                    23  Y*1(1480) PARTIAL DECAY MODES

                                                        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

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
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                                REFERENCES -- Y*1(1480)

PAN       70 PR D2,449          +FORMAN,KO,HAGOPIAN,SELOVE            (PENN)

                                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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                      END  PRODUCTION EXPERIMENTS
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**Σ(1620)** → **$S'_{11}$**

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                      32 Y*1(1620,JP=1/2-)I=1

                      THE K-MATRIX ANALYSIS OF KIM 71 SUGGESTS THIS STATE.

                      THE ELASTICITY IS REALLY SMALL.

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                      32  Y*1(1620) MASS (MEV)

M         (1620.)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71

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                      32  Y*1(1620) WIDTH (MEV)

W           (40.)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71

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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 A    K-MATRIX FIT(NEGLECTS 3-BODY CHANNELS) REQUIRES ND 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

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 -- 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

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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
                      ARMENTEROS 70 SUGGESTS SUCH A RESONANCE.  KIM 71 FINDS
                      A SIGNAL IN BOTH KBAR-N AND SIGMA PI.

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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

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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

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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

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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

R2     Y*1(1620) INTO KBAR N                              (P1)
R2         (0.14)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71

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                                REFERENCES -- 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

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## Note on Σ(1620)

This state was first suggested by the BNL-CCNY collaboration (CRENNELL 68) who presented evidence for it in the reaction $K^-n \to \Sigma(1620)^{\pm}\pi^{\mp}\pi^-$ with $\Sigma(1620)^{\pm}$ decaying into $\Lambda\pi^{\pm}$. Since then there have been conflicting reports about this state. A good review of the production experiments has been recently given by MILLER 70. We summarize here the situation.

Formation experiments. The CHS energy-independent (see note on $Y^*$'s) partial wave analysis (ARMENTEROS 70) shows evidence for a $P_{11}$ state at 1620 MeV in the $\Sigma\pi$ channel; this is also observed by KIM 71 in a K-matrix fit to all channels. In addition, KIM 71 reports evidence for a $S_{11}$ state at 1620, weakly coupled to $\bar{K}N$ and also coupled to $\Lambda\pi$ and $\Sigma\pi$. It is not clear at the present time with which of these two observations the CRENNELL 68 effect has to be associated.

Production experiments. 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 $\bar{K}N$ or $\bar{K}N\pi$). 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 $\Sigma^0$ from the production of Σ(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 $\bar{K}N$ 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 Σ(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.

**Σ(1620) BUMPS**

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78  Y*1(1620, JP=    ) I=1          PROD.EXP.

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.

   THERE WAS AN INDICATION OF A Y*1(1610) IN AN EARLY PHASE-SHIFT
ANALYSIS OF K-P TO LAMBDA PI.  HOWEVER MORE DETAILED ANALYSIS OF
MORE EXTENSIVE DATA BY THE SAME (CERN, HEIDELBERG, SACLAY) GROUP
FAILED TO CONFIRM THIS RESULT. THEY NOW SEE IT IN THE SIGMA PI
CHANNEL (SEE PREVIOUS ENTRY). (OLD LAMBDA PI ANALYSIS LISTED AS
ARMENTEROS 68, NEW ANALYSIS AS ARMENTEROS 70.)

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                    78  Y*1(1620) MASS (MEV)

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-P 4.5 GEV/C     6/70
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)

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-P 4.5 GEV/C     6/70
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

                                                          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                  1385+ 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

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-P 4.5 GEV/C     6/70

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 -- Y*1(1620)

CRENNELL 68 PRL 21 648          +DELANEY, FLAMINIO, KARSHON, +   (BNL,CCNY) I
BLUMENFE 69 PL 29B 58           BLUMENFELD, KALBFLEISCH                (BNL) I
CRENNELL 69 LUND PAPER 183      +KARSHON, LAI, ONEIL, SCARR, +   (BNL,CCNY) I
      -- CRENNELL 69 RESULTS ARE QUOTED IN LEVI SETTI 69.
AMMANN   70 PRL 24 327          + GARFINKEL, CARMONY, GUTAY,+  (PURDUE,IND)

                          PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 68 NP B8 183           ARMENTEROS,BAILLON +      (CERN+HEID+SALAY)
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+SALAY)
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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                          END PRODUCTION EXPERIMENTS
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### Note on Σ(1670)

Formation experiments show the presence of only one I = 1 state in this energy region with major decay modes into $\bar{K}N$ (9%), $\Lambda\pi$ (10%), $\Sigma\pi$ (40%) and a very small branching fraction into $\Sigma\pi\pi$. Its quantum numbers are $J^P = 3/2^-$.

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 now been confirmed by AGUILAR-BENITEZ 70.

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 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.

Two resonances of the same spin and parity have been hypothesized by EBERHARD 69 as the origin of much of the complexity observed in the 1600 to 1700 MeV region in production experiments. See also the note on Σ(1620).

**Σ(1670)** $D'_{13}$

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44  Y*1(1670,JP=3/2-)  I=1

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    0K-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          1670.                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
M          1676.      (2.)          BUDGEN    71 DPWA    LAM PIO,CHS DATA 10/71*

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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           40.                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
W           59.       (4.5)         BUDGEN    71 DPWA    LAM PIO          10/71*

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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                  1385+ 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

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           0.08                    KIM       71 DPWA    K-MATRIX ANAL.    3/71
R5            .165    (.01)          BUDGEN    71 DPWA    LAM PIO          10/71*

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

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*
R7          (-0.01)                  PREVOST   71 DPWA    K-P TO LAM PI PI 10/71*

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 -- 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+HEIDE+SACLAY)IJP
ARMENTE3 68 PL 28B 521         ARMENTEROS,BAILLON +      (CERN+HEID+SACLAY)I
SIMS     68 PRL 21 1413        SIMS,ALBRIGHT,BARTLEY,MEER+ (FLO+TAFTS+BRA)

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++   (FLAS)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
PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION          (CERN+HEID+SACL)

                                 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)

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## Σ(1670) PRODUCTION EXPERIMENTS

**Σ(1670) BUMPS**

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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                    44 Y*1(1670) MASS  (MEV) -----PRODUCTION

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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                    44 Y*1(1670) WIDTH (MEV) -----PRODUCTION

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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                    44 Y*1(1670) BRANCHING RATIOS   PROD. EXP.

R1     Y*1(1670) INTO (KBAR N)/(SIGMA PI) PROD. EXP.     (P1)/(P3)
R1       0   (0.19) OR LESS          ALVAREZ   63 HBC  + K-P AT 1.15 BEV/C
R1           (0.5)+- .25 OR MORE     SMITH     63 HBC  0-
R1           (0.6)  OR LESS          LONDON    66 HBC  + K-P AT 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) PROD. EXP.      (P2)/(P3)
R2     130  (1.20)                   ALVAREZ   63 HBC  + K-P AT 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 AT 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) PROD.       (P4)/(P3)
R3      90  (0.56)                   ALVAREZ   63 HBC  + K-P AT 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) PROD.       (P5)/(P3)
R4     180  (0.56)                   ALVAREZ   63 HBC  + K-P AT 1.15 BEV/C

R5     Y*1(1670) INTO (Y*0(1405) PI)/(SIG PI) PROD.      (P7)/(P3)
R5      50   3.        1.6           LONDON    66 HBC  + K-P AT 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 AT 2.25 BEV/3  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      + K-P AT 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      + K-P AT 2.45 BEV/C  7/66

R9     Y*1(1670) IN  (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 (LAMB PI)/(LAMB PI + SIG PI)       (P2)/(P2+P3)
R11         (0.6)  OR LESS           AGUILAR   70 HBC                      5/70

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                    44 QUANTUM NUMBER DETERMINATION

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 -- Y*1(1670)    PRODUC. EXPERIMENTS

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 D 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,SYCR) IJ
BARNES   69 BNL 13823          +CHUNG,EISNER,FLAMINIO+            (BNL,SYR)
BUGG     68 PR 168 1466        +GILMORE,KNIGHT,DAVIES+   (BIRMI,CAMB,RUTH)I
BUTTON-S 68 PRL 21 1123        J BUTTON SHAFER                (UNIV.MAS+LRL) JP
PRIMER   68 PRL 20 610         +GOLDBERG,JAEGER,BARNES,DORNAN +  (SYR,BNL)
AGUILAR  70 PRL 25 58          +BARNES, BASSANO, CHUNG, EISNER,+ (BNL,SYR)
EBERHARD 69 PRL 22 200         +FRIEDMAN,PRIPSTEIN,ROSS              (LRL)

                                 PAPERS NOT REFERRED TO IN DATA CARDS

LEVEQUE  65 PL 18 69            +     (SACLAY,EP,GLASGOW,IMPCOL,OXF,RTHFD) 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

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**Σ(1690) BUMPS**

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58  Y*1(1690, JP=    ) I=1

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)

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          (1700.0)   (20.0)          MOTT      69 HBC  +  K-P 5.5 GEV/C     9/69
M        46(1682.0)    (2.0)          BLUMENFEL 69 HBC  +  KO LONG + PROTON  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)

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          (130.0)   (25.0)          MOTT      69 HBC  +                    9/69
W        46  (25.0)   (10.0)          BLUMENFEL 69 HBC  +                    9/69
                SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

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                    58  Y*1(1690) PARTIAL DECAY MODES

                                                          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                 1385+ 139
P5          Y*1(1690) INTO LAMBDA PI PI (INCLUDING P4)  1115+ 139+ 139

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                    58  Y*1(1690) BRANCHING RATIOS

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 -- Y*1(1690)

COLLEY   67 PL 24B 489          (BRMGHM,GLASG,IMPCOL,MUNICH,OXFORD,RTHRFRD) I
DERRICK  67 PRL 18 266          +FIELDS, LOKEN, AMMAR, (ARGONNE,NORTHWEST) I
     --  DERRICK 67 IS REPLACED BY MOTT 69.
PRIMER   68 PRL 20 610          +GOLDBERG, JAEGER, BARNES, + (SYRACUSE,BNL) I
SIMS     68 PRL 21 1413         +ALBRIGHT, +       (FLOR ST,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+SYR)

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                    END Y*1(1670) PRODUCTION EXPERIMENTS

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**Σ(1750)** $S_{11}''$

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57  Y*1(1750, JP=1/2-) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

THERE IS NOW EVIDENCE IN THREE CHANNELS FOR AN S11 RE-
SONANCE 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 RE-
SONANCES, 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 (CON-
FORTO 71).
  KIM 71 IN A MULTICHANNEL ANALYSIS FINDS A SURPRISINGLY LARGE
ELASTICITY (.8), AND SMALLER AMPLITUDE IN THE LAMBDA PI CHANNEL.
  IN VIEW OF THESE DISCREPANCIES WE DO NOT QUOTE ANY VALUES FOR
THE BRANCHING RATIOS.

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                    57  Y*1(1750) MASS (MEV)

M          NEAR SIGMA ETA THRESHOLD   CLINE     67 DBC  -  K-N TO SIGMA ETA  9/66
M          ABOUT 1750.0               MEYER     67 RVUE                     9/69
M          ABOUT 1730.0               ARMENTERO 70 HDBC 0- K-N TO LAMBDA PI 6/70
M         (1757.0)   (10.0)           CONFORTO  71 DPWA 0  ELASTIC, CH EXCH 6/70
M         (1790.)                     KIM       71 DPWA    K-MATRIX ANAL.   3/71

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                    57  Y*1(1750) WIDTH (MEV)

W          ABOUT 50.0                 MEYER     67 RVUE                     9/69
W          ABOUT 80.0                 ARMENTERO 70 HDBC 0- K-N TO LAMBDA PI 6/70
W           (55.0)   (10.0)           CONFORTO  71 DPWA 0  ELASTIC, CH EXCH 6/70
W           (50.)                     KIM       71 DPWA    K-MATRIX ANAL.   3/71

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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

R2     Y*1(1750) FROM KBAR N INTO SIGMA ETA             SQRT(P1*P2)
R2            SEEN                    CLINE     69 DBC  -  THRESHOLD BUMP   9/69

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

R4     Y*1(1750) FROM KBAR N TO SIGMA PI                SQRT(P1*P4)
R4            (0.16)                  KIM       71 DPWA    K-MATRIX ANAL.   3/71

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                          REFERENCES -- 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

                          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)** $D_{15}$

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45  Y*1(1765, JP=5/2-) I=1

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          1746.0      8.0            FENSTER   66 HBC  0  K-P TO Y*1520 PI  9/66
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    N     1768.0      2.0            ARMENT-1  68 DPWA 0  ELASTIC, CH EXCH 11/68
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          1765.0      9.0            KANE      71 DPWA  0 K-P TO PI SIG    10/71*
M         (1765.)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
M    N   ERROR STATIST. ONLY- NO ERROR DUE TO PARTICULAR P.W.ANAL. INCLUDED  1/71
M          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.1)

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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           70.0     20.0            FENSTER   66 HBC  0                   9/66
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          128.0      8.0            ARMENT-1  68 DPWA 0  ELASTIC, CH EXCH 11/68
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          120.0     38.0            KANE      71 DPWA  0 K-P TO PI SIG    10/71*
W         (100.)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
W          . . . . . . . . .
W   AVG    113.6      9.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9)
                              (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                 1385+ 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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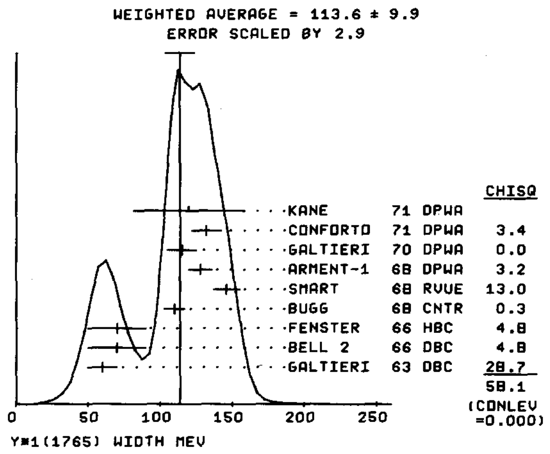


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                45  Y*1(1765) BRANCHING RATIOS

     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           (0.37)                    BUGG      68 CNTR                     11/66
R1            0.45      0.01           ARMENT-1  68 DPWA 0  ELASTIC, CH EXCH 11/68
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 DPWA    K-MATRIX ANAL.    3/71
R1          . . . . . . . . . .
R1  AVG       0.421     0.030    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.7)
R1  FIT       0.423     0.024  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 3.0)
                               (SEE IDEOGRAM BELOW )
```

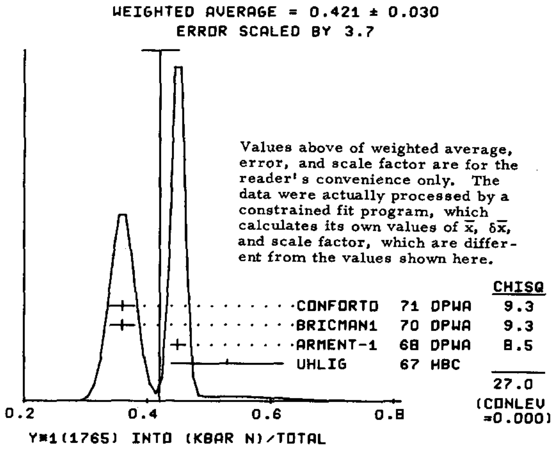


Values above of weighted average, error, and scale factor are for the reader's convenience only. The data were actually processed by a constrained fit program, which calculates its own values of $\overline{x}$, $\delta\overline{x}$, and scale factor, which are different from the values shown here.

```
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          . . . . . . . . . .
R2  AVG MOD   0.255     0.020    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2  FIT       0.248     0.013  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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            0.35      0.05           FENSTER   66 HBC  0  K-P TO Y*1520 PI  9/66
R3          . . . . . . . . . .
R3  AVG       0.291     0.035    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R3  FIT       0.242     0.021  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.3)

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
R4  S        (0.32)    (0.06)          SIMS      68 DBC  -  K-N TO LAM PI PI 11/68
R4           -0.12      0.03           PREVOST   71 DPWA  0 K-P TO LAM PI PI 10/71*
R4  A   ARMENTEROS-2 67 DATA INCLUDED IN PREVOST 71.                          3/72*
R4  S   SIMS 68 USES ONLY CROSS-SECT. DATA. RESULT USED AS UPPER LIMIT ONLY   3/72*
R4          . . . . . . . . . .
R4  FIT       0.139     0.028  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

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          +0.074      0.017          KANE      71 DPWA  0 K-P TO PI SIG    10/71*
R5          (0.09)                     KIM       71 DPWA    K-MATRIX ANAL.    3/71
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      0.345      0.039  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

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      0.328      0.048  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.1)

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      0.109      0.045  FROM FIT (ERROR INCLUDES SCALE FACTOR OF 1.2)

R9      Y*1(1765) INTO (SIGMA PI PI)/TOTAL                (P7)
R9  P        (0.12)                    ARMENT-2  68 HDBC 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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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 | .423+-.024 | | | | | |
| P 2 | -.109 | .146+-.014 | | | | |
| P 3 | .254 | -.028 | .139+-.021 | | | |
| P 4 | -.123 | .013 | -.031 | .046+-.019 | | |
| P 5 | -.143 | .016 | -.036 | .018 | .012+-.004 | |
| P 6 | -.611 | -.300 | -.671 | -.363 | -.016 | .235+-.037 |

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REFERENCES -- Y*1(1765)


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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
FENSTER  66 PRL 17 841         +GELFAND,HARMSEN,L-SETTI,+  (CHI,ARG(CERN))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,+  (MD,USNRL)

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+   (BIRMI,CAMB,RUTH)I
SIMS     68 PRL 21 1413        SIMS,ALBRIGHT,BARTLEY,MEER+ (FLO+TAFTS+BRA)
SMART    68 PR 169 1330        W M SMART                             (LRL)IJP

BRICMAN1 70 PL 33B 511         +FERRO-LUZZI,LAGNAUX                  (CERN)
COOL     70 PR 1D 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
KANE     71 LBL  15 (SUB PR)   D F KANE                              (LBL)IJP
KIM      71 PRL 27 356         J K KIM                              (HARV)IJP
    ALSO 70 DUKE 161           J. K. KIM                            (HARV)IJP
PREVOST  71  AMSTERDAM CONF    + CHS COLLABORATION         (CERN+HEID+SACL)

                               PAPERS NOT REFERRED TO IN DATA CARDS

CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +       (CHICAGO,HEIDEL)IJP
      --  CONFORTO 68 IS SUPERSEDED BY CONFORTO 71.
HARRISON 70 FSU-HEP 70 3 1     W.C. HARRISON (THESIS)                    (FSU)
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## Σ(1880)

**$P''_{11}$**

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67  Y*1(1880, JP=1/2+) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL
PARTIAL-WAVE ANALYSES ACROSS THIS REGION.  UNTIL THERE
IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
BARYON TABLE.

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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          1920.0     30.0          LITCHFIEL  70 DPWA 0- K- N TO LAM PI    6/70
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          . . . . . . . . . .
M   AVG    1914.5     21.6     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           170.0     40.0          LITCHFIEL  70 DPWA 0- K- N TO LAM PI    6/70
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          . . . . . . . . . .
W   AVG     183.4     30.6     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

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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

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          -0.14     0.03          LITCHFIEL 70 DPWA 0- K- N TO LAM PI    6/70
R2          -0.09     0.04          GALTIERI  70 DPWA 0- K- N TO LAM PI    7/70
R2        . . . . . . . . .
R2  AVG MOD  0.117    0.019   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    REFERENCES -- Y*1(1880)

SMART    68 PR 169 1330        W M SMART                          (LRL)IJP
BAILEY   69 THESIS UCRL-50617 DAVID SAAL BAILEY            (LRL LIVERMORE)IJP
ARMENTER 70 DUKE CONF 123      ARMENTEROS, BAILLON, +       (CERN, HEIDEL)IJP
GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                 (LRL)IJP
LITCHFIE 70 NP B22 269         P J LITCHFIELD                (RUTHERFORD)IJP

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**Σ(1915)** **$F_{15}$**

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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          1903.0     10.0          COX       70 DPWA -  K-N TO LAMBDA PI  6/70
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          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          1925.0      8.0          KANE      71 DPWA  0 K-P TO PI SIG    10/71*
M          1910.      15.           LITCHFIE  71 DPWA    K-P TO KBAR N   .10/71*
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           146.0     22.0          KANE      71 DPWA  0 K-P TO PI SIG    10/71*
W            70.      15.           LITCHFIE  71 DPWA    K-P TO KBAR N    10/71*
W   A   LACK OF DATA PREVENTS FROM DETERMINING UNAMB. THIS AMPLITUDE       11/67
W        . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 2.0)

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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

R3     Y*1(1915) FROM KBAR N INTO SIGMA PI              SQRT(P1*P3)
R3  A       (0.00)    (0.01)         ARMENTERO 67 DPWA 0  K-P TO SIGMA PI  11/67
R3          -0.13    (0.03)          BERTHON1  70 DPWA 0  K-P TO SIGMA PI  10/70
R3          -0.06    (0.03)          GALTIERI  70 DPWA 0  K-P TO SIGMA PI   7/70
R3          -0.137   (0.015)         KANE      71 DPWA  0 K-P TO PI SIG    10/71*

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                    REFERENCES -- Y*1(1915)

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
KANE     71 LBL  15 (SUB PR)   D F KANE                           (LBL)IJP
LITCHFIE 71 NP  B30 125        LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)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
     --  SMART 66 IS SUPERSEDED BY SMART 68.
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +     (CHICAGO, HEIDEL)
     --  CONFORTO 68 IS SUPERSEDED BY CONFORTO 71.

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**Σ(1900) BUMPS**

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29  Y*1(1900-1950) CROSS-SECTION AND PRODUCTION PEAKS

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 PROCEED 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 D13 Y*1(1940).

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                    29  Y*1(1900-1950) MASS (MEV)

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        . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.7)

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                    29  Y*1(1900-1950) WIDTH (MEV)

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        . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.2)

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                    29  Y*1(1900-1950) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          Y*1(1900-1950) INTO KBAR N                   497+ 939
P2          Y*1(1900-1950) INTO LAMBDA PI               1115+ 134
P3          Y*1(1900-1950) INTO SIGMA PI                1197+ 139

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                    29  Y*1(1900-1950) BRANCHING RATIOS

R1     Y*1(1900-1950) 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

R2     Y*1(1900-1950) INTO (KBAR N)/(SIGMA PI)          (P1)/(P3)
R2          (.37)OR LESS           BARNES    69 HBC  +  1 STAN. DEV.    10/69

R3     Y*1(1900-1950) INTO (LAMBDA PI)/(SIGMA PI)       (P2)/(P3)
R3          (.28) OR LESS          BARNES    69 HBC  +  1 STAN. DEV.    10/69

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                    REFERENCES -- Y*1(1900-1950)

BOCK     65 PL 17 166          +COOPER,FRENCH,KINSON, +      (CERN,SACLAY) I
COOL     66 PRL 16 1228        +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
     -- COOL 66 IS SUPERSEDED BY COOL 70.
BUGG     68 PR 168 1466        +GILMORE,KNIGHT,DAVIES+   (BIRMI,CAMB,RUTH)I
BARNES   69 PRL 22 479         +FLAMINIO,MONTANET,SAMIOS +      (BNL+SYRA)
AGUILAR  70 PRL 25 58          AGUILAR-BENITEZ, BARNES, +          (BNL, SYR)
BRICMAN  70 PL 31B 152         +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR 1D 1887         +GIACOMELLI, KYCIA, LEONTIC, LI, +     (BNL) I

                               PAPERS NOT REFERRED TO IN DATA CARDS

PRIMER   68 PRL 20 610         +GOLDBERG,JAEGER,BARNES,DORNAN +  (SYR,BNL)
     --  PRIMER 68 IS SUPERSEDED BY BARNES 69 AND AGUILAR-BENITEZ 70.

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**Σ(1940)** **$D''_{13}$**

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98  Y*1(1940, JP=3/2-) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL
PARTIAL-WAVE ANALYSES ACROSS THIS REGION.  UNTIL THERE
IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
BARYON TABLE.  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          1985.0      5.0          KANE      71 DPWA  0 K-P TO PI SIG    10/71*
M        . . . . . . . . .
M   AVG    1982.7      4.9     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          208.0     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      71 DPWA  0 K-P TO PI SIG    10/71*
W         . . . . . . . . .
W   AVG    219.1     16.9      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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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         . . . . . . . . .
R1  AVG MOD   0.133   0.024   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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      71 DPWA  0 K-P TO PI SIG    10/71*
R2         . . . . . . . . .
R2  AVG MOD   0.0940  0.0059  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                         REFERENCES -- Y*1(1940)

GALTIERI 70 DUKE CONF 173      A BARBARO-GALTIERI                    (LRL)IJP
LITCHFIE 70 NP B22 269         P J LITCHFIELD                  (RUTHERFORD)IJP
KANE     71 LBL  15 (SUB PR)   D F KANE                              (LBL)IJP

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**Σ(2030)** **$F_{17}$**

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                    47  Y*1(2030, JP=7/2+) I=1

                    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      71 DPWA  0 K-P TO PI SIG    10/71*
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      71 DPWA  0 K-P TO PI SIG    10/71*
W         . . . . . . . . .
W   AVERAGE MEANINGLESS (SCALE FACTOR = 1.5)

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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          +0.19    0.01             COX       70 DPWA -  K-N TO LAMBDA PI  6/70
R2          +0.2     0.02             BERTHON   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          +0.16    0.03             GALTIERI  70 DPWA 0  K-P TO LAMBDA PI  7/70
R2         . . . . . . . . .
R2  AVERAGE MEANINGLESS (SCALE FACTOR = 1.0)

R3     Y*1(2030) FROM KBAR N  INTO SIGMA PI                 SQRT(P1*P3)
R3          -0.052   0.010            GALTIERI  70 DPWA 0  K-P TO SIGMA PI   7/70
R3  L       (-0.09)  (0.02)           BERTHON1  70 DPWA 0  K-P TO SIGMA PI  10/70
R3          -0.086   0.014            KANE      71 DPWA  D K-P TO PI SIG    10/71*
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         . . . . . . . . .
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 -- 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+CDF+RHEL)
DAUM     68 NP B7 19            +ERNE,LAGNAUX,SENS,STEUER,UDO          (CERN)JP
     --  DAUM 68 CONFIRMS THE SPIN-PARITY ASSIGNMENT.
SMART    68 PR 169 1336         W M SMART                                (LRL)IJP
MULLER   69 THESIS,UCRL 19372 R A MULLER                                  (LRL)

COX      70 NP B19 61           +ISLAM, COLLEY, +     (BIRM,EDIN,GLAS,LOIC)IJP
BERTHON  70 NP B20 476          +RANGAN, VRANA, +(COL FRANCE, RHEL, SACLAY)IJP
LITCHFIE 70 NP B22 269          P J LITCHFIELD                (RUTHERFORD)IJP
GALTIERI 70 DUKE CONF 173       A BARBARO-GALTIERI                       (LRL)IJP
BERTHON1 70 NP B24 417          +VRANA, BUTTERWORTH, + (CDEF, RHEL, SACLAY)IJP

CAMPBELL 71 NP B25 75           +MORTON, NEGUS, GOYAL, MILLER  (GLAS, LOIC)IJP
KANE     71 LBL  15 (SUB PR)    D F KANE                                 (LBL)IJP
LITCHFIE 71 NP  B30 125         LITCHFIELD,...+LESQUOY,+.. (RHEL+CDEF+SACL)IJP

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**Σ(2030) BUMPS**

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                    28  Y*1(2030) CROSS-SECTION AND INVARIANT-MASS PEAKS

                    SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                    SEE THE NOTE TO THE F17 Y*1(2030), WHICH PROCEEDS 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) -- AS SEEN IN PEAKS

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)

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

                    28  Y*1(2030) WIDTH (MEV) -- AS SEEN IN PEAKS

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

                                                          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 -- AS SEEN IN PEAKS

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

****** ********* ********* ********* ********* ********* ********* ********

                         REFERENCES -- Y*1(2030) AS SEEN IN PEAKS

BLANPIED 65 PRL 14 741          +GREENBERG,HUGHES,KITCHING,LU,+ (YALE(CEA))
COOL     66 PRL 16 1228         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
     --  COOL 66 IS SUPERSEDED BY COOL 70.
BUGG     68 PR 168 1466         +GILMORE,KNIGHT, +     (RTHFD,BRMGHM,CVNDSH) I

BRICMAN  70 PL 31B 152          +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR 1D 1887          +GIACOMELLI, KYCIA, LEONTIC, LI, +     (BNL) I
LU       70 PR D2 1846          +GREENBERG, HUGHES, MINEHART, MORI,+ (YALE)

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**Σ(2070)** **$F''_{15}$**

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                    34  Y*1(2070,JP=5/2+)I=1

                    THIS STATE HAS BEEN SUGGESTED BY ONLY ONE PARTIAL
                    WAVE ANALYSIS ACROSS THIS REGION. IT NEEDS CONFIRMATION

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                    34  Y*1(2070) MASS (MEV)

M         (2070.)   (10.)            BERTHON1  70 DPWA  - K- P TO SIG PI    1/71

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                  34  Y*1(2070) WIDTH (MEV)

W          (140.)    (20.)             BERTHON1  70 DPWA  - K- P TO SIG PI    1/71

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

                  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

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

                  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

****** ********* ********* ********* ********* ********* ********* ********

                             REFERENCES -- Y*1(2070)

BERTHON1 70 NP B24 417        +VRANA,BUTTERWORTH,+      (CDEF,RHEL,SACLAY)IJP

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## Σ(2080)

P''13

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                  88  Y*1(2080, JP=3/2+) I=1

                  SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                  SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL
                  PARTIAL-WAVE ANALYSES ACROSS THIS REGION.  UNTIL THERE
                  IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
                  BARYON TABLE.

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

                  88  Y*1(2080) MASS (MEV)

M         (2082.0)    (4.0)            COX        70 DPWA -  K- N TO LAM PI    6/70
M         (2070.0)   (30.0)            LITCHFIEL 70 DPWA 0- K- N TO LAM PI    6/70

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

                  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 -- 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)

G17

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                  26  Y*1(2100, JP=7/2-) I=1

                  SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

                  SUCH A RESONANCE IS SUGGESTED BY SOME BUT NOT ALL
                  PARTIAL-WAVE ANALYSES ACROSS THIS REGION.  UNTIL THERE
                  IS MORE EVIDENCE, WE OMIT THIS STATE FROM THE MAIN
                  BARYON TABLE.

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                  26  Y*1(2100) MASS (MEV)

M         (2060.0)   (20.0)            GALTIERI  70 DPWA 0  K-P TO LAMBDA PI  7/70
M         (2120.0)   (30.0)            GALTIERI  70 DPWA 0  K-P TO SIGMA PI   7/70

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

                  26  Y*1(2100) WIDTH (MEV)

W           (70.0)   (30.0)            GALTIERI  70 DPWA 0  K-P TO LAMBDA PI  7/70
W          (135.0)   (30.0)            GALTIERI  70 DPWA 0  K-P TO SIGMA PI   7/70

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

                  26  Y*1(2100) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1          Y*1(2100) INTO KBAR N                            497+ 939
P2          Y*1(2100) INTO LAMBDA PI                        1115+ 134
P3          Y*1(2100) INTO SIGMA PI                         1197+ 139

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

                  26  Y*1(2100) BRANCHING RATIOS

R1      Y*1(2100) FROM KBAR N TO LAMBDA PI                  SQRT(P1*P2)
R1            (-0.07)   (0.02)          GALTIERI  70 DPWA 0  K-P TO LAMBDA PI  7/70

R2      Y*1(2100) FROM KBAR N TO SIGMA PI                   SQRT(P1*P3)
R2            (+0.13)   (0.02)          GALTIERI  70 DPWA 0  K-P TO SIGMA PI   7/70

****** ********* ********* ********* ********* ********* ********* ********
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                             REFERENCES -- Y*1(2100)

GALTIERI 70 DUKE CONF 173     A BARBARO-GALTIERI                        (LRL)IJP

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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## M > 2200 MEV – PRODUCTION AND $\sigma_{TOTAL}$ EXPERIMENTS

### BUMPS

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****** ********* ********* ********* ********* ********* ********* ********
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## Σ(2250)

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                  48  Y*1(2250, JP=     ) I=1

                  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-.

    LASINSKI 71 SUGGESTS TWO RESONANCES IN THIS REGION USING A POMERON
    + RESONANCES MODEL.

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                  48  Y*1(2250) MASS (MEV)

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          . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

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

                  48  Y*1(2250) WIDTH (MEV)

W          (150.0)                     BLANPIED  65 CNTR     GAMMA P TO K+ Y*
W           (21.0)   (17.0)   (21.0)  BOCK      65 HBC      PBAR P 5.7 GEV/C
W           230.0     20.0             BUGG      68 CNTR     K-P, D TOTAL      6/68
W           100.0     20.0             AGUILAR   70 HBC  +  K- 3.9-4.6 GEV/C  5/70
W           164.0     50.0             BRICMAN   70 CNTR 0  TOTAL AND CH EX   6/70
W          (170.0)                     COOL      70 CNTR     K-P, D TOTAL     10/70
W          (125.0)                     LU        70 CNTR 0  GAMMA P TO K+ Y*  1/71
W          . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 3.3)

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                  48  Y*1(2250) PARTIAL DECAY MODES

                                                              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

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                  48  Y*1(2250) BRANCHING RATIOS

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

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 -- Y*1(2250)

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, +    (RTHFD,BRMGHM,CVNDSH) I
BARNES   69 PRL 22 479        +FLAMINIO,MONTANET,SAMIOS +       (BNL+SYRA)

AGUILAR  70 PRL 25 58         AGUILAR-BENITEZ, BARNES, +        (BNL, SYR)
BRICMAN  70 PL 31B 152        +FERRO LUZZI, PERREAU,+  (CERN,CAEN,SACLAY)
COOL     70 PR 1D 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)

                             PAPERS NOT REFERRED TO IN DATA CARDS

COOL     66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
      --  COOL 66 IS SUPERSEDED 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

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## Σ(2455)

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53  Y*1(2455, JP=     ) I=1

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)

M          2455.0      7.0            BUGGS      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)

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                53  Y*1(2455) WIDTH (MEV)

W           100.0     20.0            BUGGS      68 CNTR                      6/68
W           140.0                     ABRAMS     70 CNTR    K-P, D TOTAL     10/70

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                53  Y*1(2455) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1         Y*1(2455) INTO KBAR N                        497+ 939

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                53  Y*1(2455) BRANCHING RATIOS

R1     Y*1(2455) INTO (KBAR N)/TOTAL                    (P1)
          J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1          (0.3)                   BUGGS      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 -- Y*1(2455)

BUGGS      68 PR 168 1466       +GILMORE,KNIGHT, +    (RTHFD,BRMGHM,CVNDSH) 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)
      --  ABRAMS 67 IS SUPERSEDED BY ABRAMS 70.
GREENBER 68 PRL 20 221          GREENBERG, HUGHES, LU, MINEHART, +   (YALE)

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## Σ(2620)

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54  Y*1(2620, JP=    ) I=1

SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.

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                54  Y*1(2620) MASS (MEV)

M          2620.0     15.0            ABRAMS     70 CNTR    K-P, D TOTAL     10/70

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                54  Y*1(2620) WIDTH (MEV)

W          (175.0)                   ABRAMS     70 CNTR    K-P, D TOTAL     10/70

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                54  Y*1(2620) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1         Y*1(2620) INTO KBAR N                        497+ 939

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

                54  Y*1(2620) BRANCHING RATIOS

R1     Y*1(2620) INTO (KBAR N)/TOTAL                    (P1)
R1        J IS NOT KNOWN.  THE FOLLOWING IS (J+1/2)*P1.
R1           0.36     0.12          BRICMAN    70 CNTR 0  TOTAL AND CH EX   6/70
R1          (0.32)                  ABRAMS     70 CNTR    K-P, D TOTAL     10/70

****** ********* ********* ********* ********* ********* ********* ********

                        REFERENCES -- Y*1(2620)

ABRAMS     67 PRL 19 678        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
      --  ABRAMS 67 IS 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)

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## Σ(3000)

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59  Y*1(3000, JP=    ) I=1

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 K0.  EVIDENCE NOT CONCLUSIVE.  OMITTED FROM
TABLE.

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                59  Y*1(3000) MASS (MEV)

M          (3000.0)                  EHRLICH    66 HBC  0  PI-P 7.91 BEV/C   9/66

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                59  Y*1(3000) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1         Y*1(3000) INTO KBAR N                        497+ 939
P2         Y*1(3000) INTO LAMBDA PI                    1115+ 139

****** ********* ********* ********* ********* ********* ********* ********

                        REFERENCES -- Y*1(3000)

EHRLICH  66 PR 152 1194         R EHRLICH, W SELOVE, H YUTA     (PENN(BNL)) I

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****** ********* ********* ********* ********* ********* ********* ********
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**EXOTIC HYPERONS** CROSS SECTION LIMITS (MICROBARNS)

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          THIS IS NOT A COMPLETE LIST. WE WILL TABULATE EXOTICS FROM NOW ON

CR  G       (20.)   OR LESS            GALTIERI  68 DBC     K-N TO SG-PI-PIO  7/70
CR  G  ABOVE LIMIT FOR MASS LT 2.15 GEV AND GAMMA LT 60 MEV- (2.1 GEV/C K-)  7/70
CR  A       (40.)   OR LESS            GALTIERI  68 DBC  -- K-N TO SG-PI-PIO  7/70
CR  A  ABOVE LIMIT FOR MASS LT 2.3 GEV AND GAMMA LT 120 MEV- (2.7 GEV/C K-)  7/70

****** ********* ********* ********* ********* ********* ********* ********

                        REFERENCES --- 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, $K^- + p \rightarrow \Xi^* +$ 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.

| PARTICLE | LIJ | OVERALL STATUS | STATUS AS SEEN IN -- 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.

## Ξ⁻

```
22  XI -    (1321,JP=1/2 )  I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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**$\Xi^0$**

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23  XI 0    (1314, JP=1/2 )  I=1/2

SEE STABLE PARTICLE DATA CARD LISTINGS

****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
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**$\Xi(1530)$**

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49  XI*1/2(1530, JP=3/2+) I=1/2   P13

THIS IS THE ONLY REALLY WELL-ESTABLISHED XI*.  THE
QUANTUM NUMBERS 3/2+ ARE FAVORED 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.

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                    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-    185 1536.2       1.6            KIRSCH    71 HBC  - K-P 2.87GEV/C     2/72*
M-        . . . . . . . . .
M-  AVG   1536.1       1.4     AVERAGE (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    71 HBC  0 K-P AT 3.95GEV/C 10/71*
MO    324 1531.3       0.6            BORENSTEI 71 HBC  0 K-P 2.2GEV/C     2/72*
MO    286 1532.3       0.7            KIRSCH    71 HBC  0 K-P 2.87GEV/C    2/72*
MO        . . . . . . . . .
MO  AVG   1531.31      0.59    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

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                    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          3.9         1.8            KIRSCH    71 HBC  0- K- P 2.8 GEV/C  2/72*
D   R     REDUNDANT WITH DATA IN MASS LISTING.
D        . . . . . . . . .
D  AVG     3.9         1.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    49  XI*1/2(1530) WIDTH (MEV)

WO         7.0         2.0            SCHLEIN   63 HBC  0  1.8, 1.95 GEV/C
WO         8.5         3.5            LONDON    66 HBC  0  2.24 GEV/C      7/66
WO         7.0         7.0            BERGE     66 HBC  0  1.5-1.7 GEV/C   7/66
WO        11.0         2.0            BADIER    71 HBC   0 K-P AT 3.95GEV/C 10/71*
WO         8.4         1.4            BORENSTEI 71 HBC   0 XI- PI+ MODE    2/72*
WO        11.0         1.8            KIRSCH    71 HBC   0 XI- PI+         2/72*
WO        . . . . . . . . .
WO  AVG    9.16        0.84    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                       (SEE IDEOGRAM BELOW )

          WEIGHTED AVERAGE = 9.16 ± 0.84
            ERROR SCALED BY 1.0
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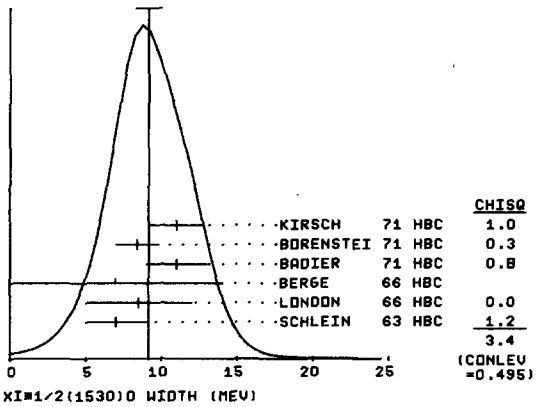


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W-        16.2      4.6            KIRSCH    71 HBC  - X+- P+0,X+0 P+-   2/72*

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                    49  XI*1/2(1530) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1        XI*1/2(1530) INTO XI PI                        1321+ 139

      OTHER STRONG DECAYS ARE FORBIDDEN BY ENERGY CONSERVATION.

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                          REFERENCES -- XI*1/2(1530)

PJERROU   62 PRL 9 114          +PROWSE,SCHLEIN,SLATER,STORK,TICHO   (UCLA) I
SCHLEIN   63 PRL 11 167         +CARMONY,PJERROU,SLATER,STORK,TICHO  (UCLA)IJP
BADIER    64 DUBNA I 593        +DEMOULIN,GOLDBERG, +      (EP,SACLAY,AMSTR) I
PJERROU   65 PRL 14 275         +SCHLEIN,SLATER,SMITH,STORK,TICHO    (UCLA)

BERGE     66 PR 147 945         +EBERHARD,HUBBARD,MERRILL,B-SHAFER,+  (LRL) I
LONDON    66 PR 143 1034        +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL,SYCR) IJ
MERRILL   66 UCRL-16455 THESIS D W MERRILL                            (LRL) JP

BADIER    71 LPNHE 9.71.(01)    +BARRELET,CHARLTON,VIDEAU             (EPOL)
BORENSTE  71 SUB.PR D           BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I
KIRSCH    71 SUB.NP B           SCHMIDT+CHANG,HEMINGWAY+(BRAN,UMD,SYR,TUFT) I
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                          PAPERS NOT REFERRED TO IN DATA CARDS

SHAFER    66 PR 142 883         BUTTON-SHAFER,LINDSEY,MURRAY,SMITH    (LRL) JP
      --  A SPIN-PARITY DETERMINATION.

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**$\Xi(1630)$**

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21  XI*1/2(1630, JP=    ) I=1/2

THIS EFFECT NEEDS CONFIRMATION.
THIS IS A 3- OR 4-STANDARD-DEVIATION BUMP SEEN IN ONE
CHANNEL IN ONE EXPERIMENT. BARTSCH 69 SEE A SMALL,BROAD
ENHANCEMENT NEAR 1650 MEV - IT IS NOT CLEAR THAT IT IS
THE SAME PHENOMENON AS BMST 70, WHO FIND CS=3.6+-1.6
MICROBARNS AT 2.87 GEV/C INCIDENT K- MOMENTUM
  BORENSTEIN 71 SEE NO EFFECT IN THIS REGION. THEY FIND CR LT 2 MUB AT 2.18.
  ROSS 72 ARGUE THAT THE EFFECT THEY SEE IS NOT THE SAME AS THAT SEEN
  BY BMST 70. ROSS 72 FIND CS= 2+-1 MICROBARNS AT 3.3 GEV/C

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                    21  XI*1/2(1630) MASS (MEV)

M        40 1635.       10.            BMST      70 HBC  0 INTO  XI- PI+     7/70
M        29 1606.        6.            ROSS      72 HBC  0 K-P AT 3.1-3.7    3/72*
M        . . . . . . . . .
M   AVG    1613.7       12.8    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)

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                    21  XI*1/2(1630) WIDTH (MEV)

W        40   57.        18.            BMST      70 HBC  0 K-P AT 2.87
W             21.         7.            ROSS      72 HBC  0 XI-PI+ K*0(890)   3/72*
W        . . . . . . . . .
W   AVG      25.7        12.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

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                    21  XI*1/2(1630) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1        XI*1/2(1630) INTO XI PI                        1321+ 139

      SEEN IN K- P TO XI- PI+ K0.

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                          REFERENCES -- XI*1/2(1630)

BMST      70 DUKE 317           BRANDEIS+MARYLAND+SYRACUSE+TUFTS  COLLAB.
BORENSTE  71 SUB.PR D           BORENSTEIN,DANBURG,KALBFLEISCH++ (BNL,MICH) I
ROSS      72 PL 38B 177         ,BURAN,LLOYD,MULVEY,RADOJICIC          (OXF) I

                          PAPERS NOT REFERRED TO IN DATA CARDS

APSELL    69 PRL 23 884         +     (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
      --  APSELL 69 IS SUPERSEDED BY BMST 70
BARTSCH   69 PL 28B 439         +    (AACHEN, BERLIN, CERN, LONDON, VIENNA)
KALBFLEI  70 DUKE CONF 331      G R KALBFLEISCH                        (BNL) I
      --  KALBFLEISCH 70 SUMMARIZES EVIDENCE FOR ISOSPIN 1/2.

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**$\Xi(1820)$**

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50  XI*1/2(1820, JP=    ) I=1/2

AS THE ACCOMPANYING IDEOGRAMS ILLUSTRATE, THE SITUATION
IS CONFUSED.  UNTIL SOME FUTURE CLARIFICATION, WE LIST
UNDER XI(1820) EVERYTHING REPORTED IN THE MASS RANGE
1750-1875 MEV.  WHEN BRANCHING RATIOS ARE REPORTED, WE
  QUOTE THEM, BUT ONLY THE MOST QUALITATIVE CONCLUSIONS ARE JUSTIFIED.
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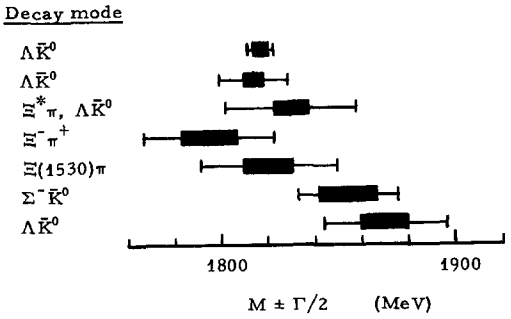
$\Xi(1820)$

Masses and widths of reported enhancements in the $\Xi(1820)$ region (solid rectangles indicate error on mass).

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                    50  XI*1/2(1820) MASS (MEV)

M          (1770.0)                    HALSTEINS 63 FBC  0- K-FR 3.5 GEV/C
M        29 1817.0      7.0            SMITH 1   65 HBC  0- LAMBDA KBAR
M        30 1814.0      4.0            BADIER    65 HBC  0  LAMBDA KBAR
M        40 1830.0     10.0            ALITTI    69 HBC  -  LAM, SIG KBAR      9/69
M        25 1830.0     10.0            CRENNELL  70 DBC  0- 3.6, 3.9 GEV/C    10/70
M        65 1795.      10.             BMST      70 HBC   0 XI-PI+ (2.9 K-P)   7/70
M        55 1820.      12.             BMST      70 HBC     XI(1530) PI        7/70
M        35 1854.      12.             BMST      70 HBC   - SIGMA- KOBAR       7/70
M        65 1871.      11.             BMST      70 HBC   0 LAMBDA  KOBAR      7/70
M   B    28 1762.0      8.0            BADIER    71 HBC     XI PI,XI2PI,K Y   10/71*
M   B    38 1838.0      5.0            BADIER    71 HBC     XI PI,XI2PI,K Y   10/71*
M   B    BADIER 71 ADDS ALL CHANNELS AND DIVIDES PEAK IN LOWER AND HIGHER M
M                  . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 3.4)
                     (SEE IDEOGRAM BELOW )
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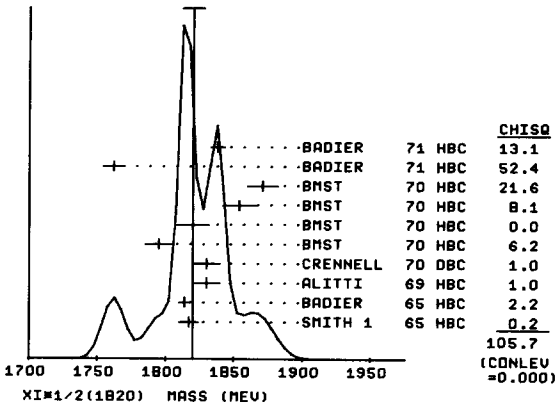


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                    50  XI*1/2(1820) WIDTH (MEV)

W          (80.0)  OR LESS            HALSTEINS 63 FBC  0- K-FR 3.5 GEV/C
W          (12.0)    (4.0)            BADIER    65 HBC  0  LAMBDA KBAR
W           30.0      7.0             SMITH 2   65 HBC  0-
W           55.0     40.0      20.0   ALITTI    69 HBC  -  LAM, SIG KBAR      9/69
W          103.0     38.0      24.0   CRENNELL  70 DBC  0- 3.6, 3.9 GEV/C    10/70
W       65  99.      31.              BMST      70 HBC     XI-PI+ (2.9 K-P)   7/70
W       55  82.      42.              BMST      70 HBC     XI(1530) PI        7/70
W       35  56.      14.              BMST      70 HBC   - SIGMA- KOBAR       7/70
W       65  58.      39.              BMST      70 HBC   0 LAMBDA  KOBAR      7/70
W   B       51.0     13.0             BADIER    71 HBC     LOWER MASS        10/71*
W   B       58.0     13.0             BADIER    71 HBC     HIGHER MASS       10/71*
W                  . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.3)
                    SEE THE NOTES ACCOMPANYING THE MASSES QUOTED
                      (SEE IDEOGRAM BELOW )
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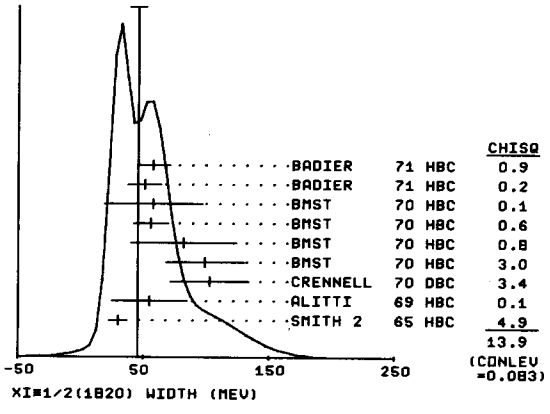


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                    50  XI*1/2(1820) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1         XI*1/2(1820) INTO LAMBDA KBAR                1115+ 497
P2         XI*1/2(1820) INTO XI PI                      1321+ 139
P3         XI*1/2(1820) INTO SIGMA KBAR                 1197+ 497
P4         XI*1/2(1820) INTO XI*1/2(1530) PI            1530+ 139
P5         XI*(1820) INTO XI PI PI (XI PI NOT XI*(1530)) 1321+ 139+ 139

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                    50  XI*1/2(1820) BRANCHING RATIOS

R1         XI*1/2(1820) INTO (LAMBDA KBAR)/TOTAL          (P1)
R1            0.3      0.15            ALITTI    69 HBC  -                  9/69

R2         XI*1/2(1820) INTO (XI PI)/TOTAL                (P2)
R2            0.1      0.1             ALITTI    69 HBC  -                  9/69

R3         XI*1/2(1820) INTO (SIGMA KBAR)/TOTAL           (P3)
R3          (0.02) OR LESS             TRIPP     67 RVUE                    8/67
R3            0.3      0.15            ALITTI    69 HBC  -                  9/69

R4         XI*1/2(1820) INTO (XI*1/2(1530) PI)/TOTAL      (P4)
R4            0.3      0.15            ALITTI    69 HBC  -                  9/69
R4          (0.25) OR LESS             DAUBER    69 HBC     K-P 2.7 BEV/C   9/69

R5         XI*1/2(1820) INTO (XI PI)/(LAMBDA KBAR)        (P2)/(P1)
R5            0.20     0.20            BADIER    65 HBC                     7/66

R6         XI*1/2(1820) INTO (XI*(1530) PI)/(LAM KBAR)    (P4)/(P1)
R6            0.26     0.13            SMITH 1   65 HBC

R7         XI*1/2(1820) INTO (XI PI PI)/(LAMBDA KBAR)     (P5)/(P1)
R7          (0.1)  OR MORE             SMITH 1   65 HBC

R8         XI(1820) INTO (XI PI)/(XI(1530) PI)            (P2)/(P4)
R8            1.5      0.6      0.4    APSELL    70 HBC  0                  6/70

R9         XI(1820) INTO (XI PI PI)/(XI(1530) PI)         (P5)/(P4)
R9            0.3      0.5             APSELL    70 HBC  0                  6/70

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                          REFERENCES -- XI*1/2(1820)

HALSTEIN 63 SIENA CONF 173     HALSTEINSLID,+ (BERGEN,CERN,EP,RTHF,UNICOL) I
SMITH 1  65 PRL 14 25          +LINDSEY,BUTTON-SHAFER,MURRAY          (LRL)IJP
BADIER   65 PL 16 171          +DEMOULIN,GOLDBERG, +     (EP,SACLAY,AMSTR) I
SMITH 2  65 ATHENS CONF 251    G A SMITH, J S LINDSEY                 (LRL)
TRIPP    67 NP B3 10           + LEITH, +    (LRL,SLAC,CERN,HEIDEL,SACLAY)
      -- USES DATA OF SMITH 1.

ALITTI   69 PRL 22 79          +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
DAUBER   69 PR 179 1262        +BERGE, HUBBARD, MERRILL, MULLER       (LRL)
CRENNELL 70 PR 1D 847          +KARSHON, LAI, ONEALL, SCARR, SCHUMANN(BNL)
APSELL   70 PRL 24 777         +     (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
BMST     70 DUKE 317           BRANDEIS+MARYLAND+SYRACUSE+TUFTS  COLLAB.
BADIER   71 LPNHE 9.71.(01)    +BARRELET,CHARLTON,VIDEAU              (EPOL)

                               PAPERS NOT REFERRED TO IN DATA CARDS

MERRILL  68 PR 167 1202        D W MERRILL, J BUTTON-SHAFER           (LRL)
      -- WEAK EVIDENCE CONCERNING JP.
APSELL   69 PRL 23 884         +     (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
      -- APSELL 69 IS SUPERSEDED BY BMST 70.
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## Ξ(1940)

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                    52  XI*1/2(1940, JP=     ) I=1/2

                    WE LIST UNDER XI(1940) EVERYTHING REPORTED IN THE MASS
                    RANGE 1875-2000 MEV.  THE SITUATION IS PERHAPS NOT
                    QUITE SO UNCLEAR AS IS THE CASE FOR THE XI(1820).

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                    52  XI*1/2(1940) MASS (MEV)

M       35 1933.0     16.0             BADIER    65 HBC  0  XI- PI+
M       27 1930.0     20.0             ALITTI    68 HBC  0  XI- PI+          11/68
M       66 1894.0     18.0             DAUBER    69 HBC  -  XI PI            11/68
M       21 1955.0     14.0             GOLDWASSE 70 HBC  -  XI PI            10/70
M      110 1954.       9.              BMST      70 HBC  0 XI-PI+ (2.9 K-P)   7/70
M       40 1961.       8.              BMST      70 HBC     XI(1530) PI       7/70
M       29 1956.0      6.0             BADIER    71 HBC     XI PI,XI2PI,K Y  10/71*
M                  . . . . . . . . . .
M    AVERAGE MEANINGLESS (SCALE FACTOR = 1.6)
                      (SEE IDEOGRAM BELOW )
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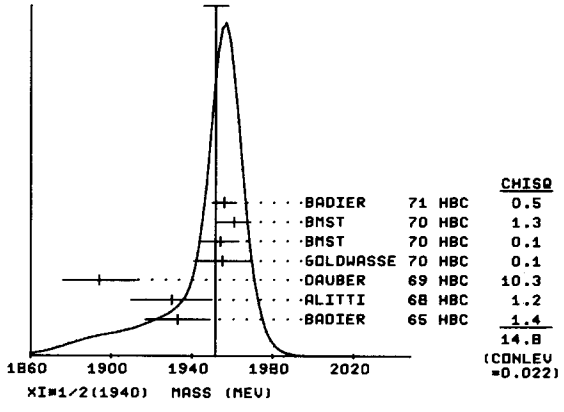


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                    52  XI*1/2(1940) WIDTH (MEV)

W       35  140.0     35.0             BADIER    65 HBC  0  XI- PI+
W       27   80.0     40.0             ALITTI    68 HBC  0  XI- PI+          11/68
W       66   98.0     23.0             DAUBER    69 HBC  -  XI PI            11/68
W       21   56.0     26.0             GOLDWASSE 70 HBC  -  XI PI            10/70
W      110  129.      30.              BMST      70 HBC   0 XI-PI+ (2.9 K-P)   7/70
W       40   42.      35.              BMST      70 HBC     XI(1530) PI       7/70
W       29   35.0     11.0             BADIER    71 HBC     XI PI,XI2PI,K Y  10/71*
W                  . . . . . . . . . .
W    AVERAGE MEANINGLESS (SCALE FACTOR = 1.8)
                      (SEE IDEOGRAM BELOW )
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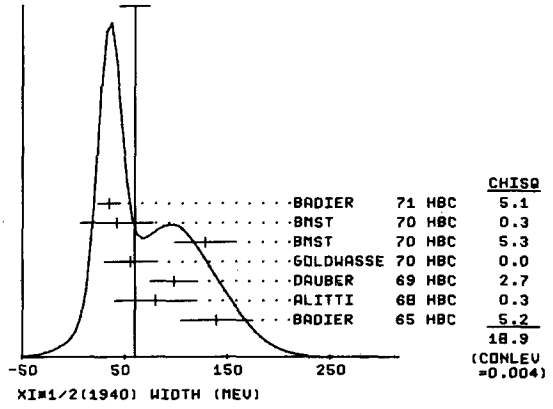


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                52  XI*1/2(1940) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          XI(1940) INTO XI PI                         1321+ 139
P2          XI(1940) INTO XI(1530) PI                   1530+ 139
P3          XI(1940) INTO XI PI PI (XI PI NOT XI(1530))  1321+ 139+ 139

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                52  XI*1/2(1940) BRANCHING RATIOS

     THE XI(1940) IS SEEN MAINLY IN XI PI AND SOME IN XI(1530) PI.  IT
   HAS BEEN LOOKED FOR IN OTHER CHANNELS BUT NOT SEEN.

R1          XI(1940) INTO (XI PI)/(XI(1530) PI)          (P1)/(P2)
R1            2.8      0.7      0.6   APSELL    70 HBC  0                  6/70

R2          XI(1940) INTO (XI PI PI)/(XI(1530) PI)       (P3)/(P2)
R2            0.0      0.3            APSELL    70 HBC  0                  6/70

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                                REFERENCES -- XI*1/2(1940)

BADIER   65 PL 16 171          +DEMOULIN,GOLDBERG, +       (EP,SACLAY,AMST) I
ALITTI   68 PRL 21 1119        +FLAMINIO,METZGER,RADOJICIC,+(BNL,SYRACUSE) I
DAUBER   69 PR 179 1262        +BERGE, HUBBARD, MERRILL, MULLER      (LRL) I
APSELL   70 PRL 24 777         +     (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
GOLDWASS 70 PR 1D 1960         E L GOLDWASSER, P F SCHULTZ      (ILLINOIS)
BMST     70 DUKE 317           BRANDEIS+MARYLAND+SYRACUSE+TUFTS  COLLAB.
BADIER   71 LPNHE 9.71.(01)    +BARRELET,CHARLTON,VIDEAU            (EPOL)

                                PAPERS NOT REFERRED TO IN DATA CARDS

APSELL   69 PRL 23 884         +     (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
      --  APSELL 69 IS SUPERSEDED BY BMST 70.

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## 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          . . . . . . . . .
M   AVERAGE MEANINGLESS (SCALE FACTOR = 1.4)

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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          . . . . . . . . .
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           1530+ 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 -- XI*1/2(2030)

ALITTI   69 PRL 22 79          +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
BARTSCH  69 PL 28B 439         +    (AACHEN, BERLIN, CERN, LONDON, VIENNA)

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****** ********* ********* ********* ********* ********* ********* ********
```

## Ξ(2250)

```
                22  XI*   (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.

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

                22  XI*   (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)

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

                22  XI*   (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

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

                22  XI*   (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

****** ********* ********* ********* ********* ********* ********* *******

                                REFERENCES -- XI*   (2250)

BARTSCH  69 PL 28B 439         +    (AACHEN, BERLIN, CERN, LONDON, VIENNA)
GOLDWASS 70 PR 1D 1960         E L GOLDWASSER, P F SCHULTZ      (ILLINOIS)

****** ********* ********* ********* ********* ********* ********* *******
****** ********* ********* ********* ********* ********* ********* *******
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## Ξ(2500)

```
                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.

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

                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)

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

                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)

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

                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           1530+ 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

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

                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      (P5)
R5            SEEN                    BARTSCH   69 HBC  0-                  9/69

R6          XI*1/2(2500) INTO XI PI PI                       (P6)
R6            SEEN                    BARTSCH   69 HBC  0-                  9/69

****** ********* ********* ********* ********* ********* ********* *******

                                REFERENCES -- XI*1/2(2500)

ALITTI   69 PRL 22 79          +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
BARTSCH  69 PL 28B 439         +    (AACHEN, BERLIN, CERN, LONDON, VIENNA)

****** ********* ********* ********* ********* ********* ********* *******
****** ********* ********* ********* ********* ********* ********* *******
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## Ω⁻

```
                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 below.

Table I. (000) or (+-0) refer to the sign of the pions into which the $K_L$ decays.

| | |
|---|---|
| $\Gamma_{K^+_{\ell 3}} = \Gamma_{K^+_{e3}} + \Gamma_{K^+_{\mu 3}}$ | $= (6.51\pm.12)\times 10^6\ \mathrm{sec}^{-1}$ |
| $\Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}}$ | $= 0.659\pm.022$ |
| $\Gamma_{K^+_{\tau}} / \Gamma_{K^+_{\tau 1}}$ | $= 3.329\pm.086$ |
| $\Gamma_{K^0_{\ell 3}} = \Gamma_{K^0_{e3}} + \Gamma_{K^0_{\mu 3}}$ | $= (12.72\pm.16)\times 10^6\ \mathrm{sec}^{-1}$ |
| $\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}}$ | $= 0.688\pm.021$ |
| $\Gamma_{K^0(000)} / \Gamma_{K^0(+-0)}$ | $= 1.700\pm.070$ |

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,

$$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 0.977\pm.022$$

and

$$\frac{\Gamma_{K^0_{\mu 3}}}{\Gamma_{K^0_{e3}}} \left[\frac{\Gamma_{K^+_{\mu 3}}}{\Gamma_{K^+_{e3}}}\right]^{-1} = 1.044\pm.047$$

These results seem to show a less than $2\sigma$ 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 ($\Gamma$) 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 $\phi_i$ are phase-space factors which have been calculated as described in Mast et al.[3] by use of a relativistic formulation and the masses and slopes from this compilation. 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 |
| $\phi_1(000) =$ | 1.487 | 1.487 | 1.441 |
| $\phi_2(+-0) =$ | 1.219 | 1.293 | 1.278 |
| $\phi_3(++-) =$ | 1.000 | 1.000 | 1.000 |
| $\phi_4(+00) =$ | 1.247 | 1.182 | 1.146 |

The slopes for the various decays have not been tabulated in the Stable Particle Table. They are as follows:

$$\left.\begin{aligned} g_{K^+_{\tau}} &= -0.206\pm0.007 \\ g_{K^-_{\tau}} &= -0.194\pm0.007 \end{aligned}\right\} -0.200\pm0.005$$

$$g_{K^+_{\tau'}} = 0.527\pm0.017,$$

$$g_{K^0(+-0)} = 0.603\pm0.028 \text{ (Error scaled } \times 3.1)$$

A difference in the $\tau^+$ and $\tau^-$ slopes would be an indication of CP violation in this decay. Since no significant 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 = 0.005±0.041,
Test 2 = -0.046±0.025,
Test 3 = 0.186±0.028,
Test 4 = 0.064±0.010,
Test 5 = 0.139±0.030.

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 and are consistent with no or very little I = 3. 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 $\Delta I = 3/2$.

The rate tests (Tests 1, 2, and 3) could differ from zero by as much as 0.1 owing to the $\pi$ mass differences and the occurrence of big slopes.[5] The error on $g_{K^0(+-0)}$ has been scaled by a factor of 3.1 to compensate for the disagreement among the determinations of this parameter. Since this error is the main contribution to the Test 5 error, the reader is cautioned to refer to the $g_{K^0(+-0)}$ ideogram in the data card listings before interpreting Test 5.

## 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 ($\omega$ and $\phi$) an additional symmetry-breaking interaction had to be 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, $\Lambda$ is the "mostly-octet" particle, $\Lambda'$ 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 $\Gamma$ 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

$$\Gamma = \frac{|T|^2 k}{M_R} M_N, \quad \text{for baryons} \tag{5'}$$

$$= \frac{|T|^2 k}{M_R^2} M_N^2, \quad \text{for mesons} \tag{5''}$$

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 $B_\ell$. We then have

$$\left.\begin{array}{l}\text{Decuplet}\\ \text{Singlet}\end{array}\right\} \Gamma = (cg)^2 B_\ell(k) \frac{M_N}{M_R} k \tag{6}$$

$$\text{Octet} \qquad \Gamma = (c_D g_D + c_F g_F)^2 B_\ell(k) \frac{M_N}{M_R} k \tag{7}$$

$$\begin{array}{l}\text{Octet-}\\ \text{Singlet}\\ \text{mixing}\end{array} \left\{\begin{array}{l} G_8 = \Lambda \cos\theta - \Lambda' \sin\theta \\ G_1 = \Lambda \sin\theta + \Lambda' \cos\theta \end{array}\right. \tag{8}$$

$$\text{with} \qquad \begin{array}{l} G_8 = c_D g_D + c_F g_F \\ G_1 = c_1 g_1. \end{array} \tag{9}$$

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 $\Gamma$ 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 $\Lambda$ and $\Lambda'$ represent the couplings for the physical states.

The relation between $g_D$, $g_F$, and the D (symmetric) and F (antisymmetric) couplings is as follows:

$$\frac{F}{D} = \frac{\sqrt{5}}{3} \frac{g_F}{g_D}. \tag{10}$$

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

$$2(\Delta + \Xi) = 3\Sigma^*(\Lambda\pi) + \Sigma^*(\Sigma\pi), \tag{11}$$

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 D) 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 $\Sigma$ state (I = 1) and a $\Lambda$ 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 and LEVI SETTI 69. The most recent published survey is by the CHS collaboration (PLANE 70). A new fit by the BNL group has been reported by Samios at the Kiev Conference‡ (SAMIOS 70). The results of the two analyses are in good agreement, although the procedures used are somewhat different. A recent fit to the $3/2^+$ decuplet has been done by BARBARO-GALTIERI 71.

In fitting the data a choice for $B_\ell$ has to be made. PLANE 70 tried two forms for $B_\ell$:

(a) The form $B_\ell = (kr)^{2\ell} D_\ell(kr)$, r being the radius of interaction and $D_\ell$ 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 $B_\ell$, 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 $\theta$ agree. This value of r does not fit resonance shapes when used in the Breit-Wigner resonant form.

Table I is a summary of the fits made so far using exact SU(3). A few comments follow.

$\frac{1}{2}^-$ - Nonet (Baryon - Eta Resonances)

For this nonet relation, (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).

$3/2^+$ Decuplet. BARBARO-GALTIERI 71 has made extensive studies of this multiplet. Fig. 1 shows some of the fits. The barrier factor

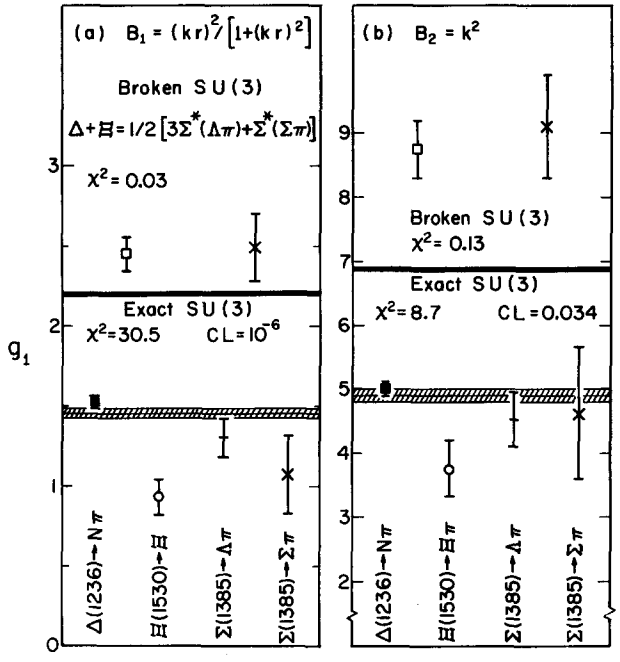


Fig. 1. SU(3) fits for the $J^P = 3/2^+$ decuplet for: (a) Blatt-Weiskopf barrier factor, (b) simplified barrier factor $k^2$. The lower part of the graph shows exact SU(3) fits, that is all four couplings which are supposed to be the same. The upper part of the graph shows broken SU(3) fits, that is data points for left and right hand side of the sum rule (11) for the couplings.

Table I. SU(3) baryon multiplets with two or more known members. The coupling constants are those for decay into baryon ($1/2^+$) octet $\otimes$ ($0^-$) meson octet. Values of $\theta$ and F/D taken from PLANE 70. The analysis reported by SAMIOS 70 finds similar results.

| $J^P$ | Octet members[a] | | | | Singlet | $\theta$(deg)[b] | F/D |
|---|---|---|---|---|---|---|---|
| $1/2^-$ | N'(1535) | $\Lambda$(1670) | $\Sigma$(1750) | [$\Xi$(1825)] | $\Lambda$(1405) | 18 ± 17 | $\left[\begin{smallmatrix}-2.9\\-0.21\end{smallmatrix}\right]$[d] |
| $3/2^-$ | N(1520) | $\Lambda$(1690) | $\Sigma$(1670) | [$\Xi$(1815)] | $\Lambda$(1520) | -25 ± 6 | 2.3 |
| $5/2^-$ | N(1670) | $\Lambda$(1830) | $\Sigma$(1765) | | | | -0.19 |
| $5/2^+$ | N(1688) | $\Lambda$(1815) | $\Sigma$(1915) | | | | 0.82[e] |
| | Decuplet members | | | | $g_{10}$[c] | | |
| $3/2^+$ | $\Delta$(1236) | $\Sigma$(1385) | $\Xi$(1530) | $\Omega^-$ | 0.93 to 1.52 | | |
| $7/2^+$ | $\Delta$(1950) | $\Sigma$(2030) | | | 0.25 to 0.97 | | |

[a]Masses in parentheses are the nominal masses used in the Baryon Table. The $\Xi$ members have masses as calculated by using formulae (1) and (2) with the mixing angle $\theta$ derived from the decay widths.

[b]Values calculated from the decay widths, Eqs. (6) through (9), and the barrier factor $k^{2\ell}$. See text for a discussion of the $3/2^-$ mixing angle.

[c]Values calculated by BARBARO-GALTIERI 71 using the BLATT-WEISKOPF 52 barrier factor. See text for a discussion of SU(3) breaking effects for the $3/2^+$ decuplet couplings.

[d]Second value of F/D obtained by using 15% for the N(1525) → N$\eta$ branching ratio instead of 60%, which is the most likely one. SAMIOS 70 report only the second value. The 15% branching ratio (Diem et al., Kiev Conference Report, 1970) has now been retracted by the authors.

[e]SAMIOS 70 finds F/D = 1.5.

dependence of the goodness of fit has been investigated: the form (b) above seems to fit the couplings better; however, as previously remarked, it does not fit resonance shapes. Dependence of the width of $\Xi(1530)$ has also been investigated. The data used for the fits of Fig. 1 are as follows:

| | | |
|---|---|---|
| $\Delta(1236)$ | $\Gamma = 115 \pm 5$ MeV | $x = 99.4 \pm 0.6\%$ |
| $\Sigma(1385) \to \Lambda\pi$ | $\Gamma = 36 \pm 6$ MeV | $x = 88 \pm 5\%$ |
| $\Sigma(1385) \to \Sigma\pi$ | $\Gamma = 36 \pm 6$ MeV | $x = 12 \pm 5\%$ |
| $\Xi(1530) \to \Xi\pi$ | $\Gamma = 7.3 \pm 1.7$ MeV | $x = 100\%$ |

Another fit, not shown in the figure, was made with the $\Xi(1530)$ width, $\Gamma = 8.8 \pm 1.8$ MeV; the fit with the $B_1$ form gave $CL = 2 \times 10^{-5}$ and the one with the $B_2$ form $CL = 16\%$. The broken SU(3) fits are shown in the upper part of the figure and the relation (11) seems to be pretty well verified.

## 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 in Table II.

Table II. Mixing angles from quadratic SU(3) mass formula. Of the two iso-singlets, the "mainly octet" one is written first, followed by a semicolon.

| $J^P$ | Octet members | $\theta$ |
|---|---|---|
| $0^-$ | possible nonet [$\pi$, K, $\eta$;$\eta'$] | 10.4±0.2° |
| $0^-$ | alternative nonet [$\pi$, K, $\eta$;E] | 6.2±0.1° |
| $1^-$ | [$\rho$(765±10), $K^*$, $\phi$;$\omega$] | 39.5±0.7° |
| $2^+$ | [A2(1300±20), $K_N$(1420), f';f] | 33.7±3.9° |

## 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).

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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

The matrix element for nonleptonic hyperon decays can be written

$$\bar{u}(A-B\gamma_5)u$$

where A and B are the parity-violating and parity-conserving amplitudes. These amplitudes are related to the decay rate ($\Gamma$ = branching fraction/lifetime) and the decay asymmetry parameters $\alpha$ and $\phi$ by[1]

$$\Gamma = C_1(|A|^2 + C_2|B|^2),$$

$$\alpha = \frac{2\,\mathrm{Re}\,A^*(\sqrt{C_2}\,B)}{|A|^2 + C_2|B|^2},$$

$$\beta = \sqrt{1-\alpha^2}\sin\phi = \frac{2\,\mathrm{Im}\,A^*(\sqrt{C_2}\,B)}{|A|^2 + C_2|B|^2},$$

$$\gamma = \sqrt{1-\alpha^2}\cos\phi = \frac{|A|^2 - C_2|B|^2}{|A|^2 + C_2|B|^2},$$

where

$$C_1 = \frac{1}{8\pi}\,\frac{q}{\mu^{\pm}}\,\frac{(M+m)^2-\mu^2}{M^2},$$

$$C_2 = \frac{(M-m)^2-\mu^2}{(M+m)^2-\mu^2},$$

and M, m, $\mu$ and q are the initial state baryon mass final state baryon mass, pion mass, and c.m. decay momentum.

The amplitudes A and B are related to S and P of Section IV H of the text by

$$S = \frac{1}{\sqrt{C_1}}\,A, \qquad P = \sqrt{\frac{C_2}{C_1}}\,B.$$

Table I summarizes the amplitudes A and B for the nonleptonic decays of the $\Lambda$, $\Sigma$, and $\Xi$ hyperons. These amplitudes have been calculated using the experimental data for mean lives, branching ratios, and the decay asymmetry $\alpha$ 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 and $\beta = 0$. 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.

TABLE I

| $M \to m+\mu$ | A | B | $C_{AB}$ |
|---|---|---|---|
| $\Lambda_- \to p+\pi^-$ | 1.52±0.01 | 10.44±0.30 | -0.390 |
| $\Sigma^+_+ \to n+\pi^+$ | 0.06±0.02 | 19.41±0.16 | 0.003 |
| $\Sigma^+_0 \to p+\pi^0$ | 1.44±0.09 | -12.57±1.03 | 0.975 |
| $\Sigma^-_- \to n+\pi^-$ | 1.96±0.01 | -0.67±0.08 | -0.030 |
| $\Xi^0_0 \to \Lambda+\pi^0$ | 1.53±0.04 | -4.61±1.05 | 0.136 |
| $\Xi^-_- \to \Lambda+\pi^-$ | 2.07±0.02 | -7.00±0.57 | 0.182 |

A and B are given in units $10^5\,\mathrm{sec}^{-1/2}$.

### 2. Tests of the $\Delta I = 1/2$ rule

(a) $\Lambda$ Decay

For $\Lambda$ decay the $\Delta I = 1/2$ rule predicts that $\Gamma_0/\Gamma_- = 0.50$ and $\alpha_0 = \alpha_-$. In order to determine the magnitude of possible $\Delta I = 3/2$ amplitudes present we write the linear expressions[2] for the $\Delta I = 3/2$ S- and P-wave amplitudes in terms of $\Delta\alpha$, where $\Delta\alpha$ is the measured value of $\alpha_0/\alpha_-$ minus the predicted value, and in terms of $\Delta\Gamma$ similarly defined. Evaluating these we find

$$\Delta\alpha = -1.54\,(S_3/S_1) + 1.61\,(P_3/P_1),$$
$$\Delta\Gamma = 1.84\,(S_3/S_1) + 0.26\,(P_3/P_1).$$

Here the $\Delta I = 3/2$ amplitudes are expressed relative to the $\Delta I = 1/2$ amplitudes. The numerical values of the coefficients depend on the ratio $P/S = \sqrt{C_2}\,B/A$. The uncertainties in the coefficients are small compared to the uncertainties in $\Delta\alpha$ and $\Delta\Gamma$. Final-state $\pi$-N interactions have been included in these relations but have a very small effect. From the Stable Particle Table,

$$\Delta\alpha = 0.006 \pm 0.066, \quad \Delta\Gamma = 0.058 \pm 0.012,$$

and hence

$$(S_3/S_1) = 0.027 \pm 0.008$$

and

$$(P_3/P_1) = 0.030 \pm 0.037.$$

The possible 3% $\Delta I = 3/2$ S-wave amplitude is due to the disagreement of decay rates with prediction. It should be emphasized, however, that at this level the results are sensitive to electromagnetic corrections, which have not been included here because we do not feel that they can be applied with confidence at this time.

(b) $\Xi$ Decay

The analysis for $\Xi$ decay is very similar to that for $\Lambda$ decay. If the $\Delta I = 1/2$ rule is valid,

$\Gamma_0(\Xi^0)/\Gamma_-(\Xi^-) = 0.50$ and $\alpha_0 = \alpha_-$. For this case the expressions linear[2] in $\Delta I = 3/2$ S- and P-wave amplitudes are

$$\Delta\alpha = 1.37\,(S_3/S_1) - 1.37\,(P_3/P_1),$$
$$\Delta\Gamma = -1.44\,(S_3/S_1) - 0.06\,(P_3/P_1).$$

From the Stable Particle Table, $\Delta\alpha = -0.127 \pm 0.203$, $\Delta\Gamma = 0.048 \pm 0.033$, and we find

$$(S_3/S_1) = -0.036 \pm 0.023$$

and

$$(P_3/P_1) = 0.057 \pm 0.143.$$

(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, $\sqrt{2}A_0 + A_+ - A_- = 0.14 \pm 0.16$ and $\sqrt{2}B_0 + B_+ - B_- = 2.30 \pm 1.70$. 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

$$\frac{A_3}{A_-} = -0.037 \pm 0.042$$

and

$$\frac{B_3}{B_+} = -0.06 \pm 0.05.$$

Thus for hyperon decay, present experimental data limit $\Delta I = 3/2$ amplitudes to less than 5%.

3. The Lee-Sugawara relation

From Table I the Lee-Sugawara[3,4] relation $\sqrt{3}\,\Sigma_0^+ + \Lambda_- - 2\,\Xi_-^- = 0$ is satisfied to $-0.13 \pm 0.21$ for the A amplitudes, and to $2.67 \pm 3.22$ for the B amplitudes.

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$$\frac{\Gamma^0}{\Gamma^-} \cong \frac{1}{2}\left\{1+3\sqrt{2}\left(\frac{[S_{11}S_{33}\cos(\delta_1-\delta_3) + P_{11}P_{33}\cos(\delta_{11}-\delta_{31})]}{S_{11}^2 + P_{11}^2}\right)\right\}.$$

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