

REVIEW OF PARTICLE PROPERTIES

Particle Data Group

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This review of the properties of leptons, mesons, and baryons is an updating of Review of Particle Properties, Particle Data Group [Rev. Mod. Phys. 42 (1970) 87]. Data are evaluated, listed, averaged, and summarized in tables. A data booklet is also available.

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I. INTRODUCTION AND CREDITS

* The Berkeley Particle Data Center is jointly supported by the US Atomic Energy Commission and the Office of the Standard Reference Data of the National Bureau of Standards.

This review is an updating through mid-June 1970 of our previous review [1].

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 the 1969 and 1970 articles [1,2].

We remind the reader that it is inappropriate to make reference to this compilation instead of to an original work. In our *data card listings* we provide references to all original data quoted by us.

The responsibilities of the authors of this compilation (who prefer to be quoted as the 'Particle Data Group') can roughly be broken down as follows:

Stable particles (excluding eta meson): A. Barbaro-Galtieri and N. Barash-Schmidt. Our consultants: μ decays, S. E. Derenzo; K form factors, C. Y. Chien.

Eta meson: L. R. Price.

Meson resonances: M. Roos, A. H. Rosenfeld, P. Söding. Our specialist on bumps near threshold (A1, Q, A3, L) is C. Y. Chien.

Baryon resonances: A. Barbaro-Galtieri, C. Bricman, T. Lasinski, C. G. Wohl.

General: A. H. Rosenfeld, A. Rittenberg, L. R. Price.

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

II. SELECTION AND ORGANIZATION OF DATA

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

- (i) Stable particles, immune to decay via the strong interaction.
- (ii) Meson resonances.
- (iii) Baryon resonances.

This division is 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 illustrated key thereto. Data that have not been used in the averages 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 and has not been verified by its 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* 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.

Further details about our selection of data can be found in the text of the 1969 edition [2], Section III.

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*, on the other hand, we wish to be more conservative, and to include only those peaks or resonances that have a $\approx 90\%$ chance of survival. The 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.

More details on our acceptance criteria are as follows.

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

1a) Most mesons and Ξ^* peaks, plus N^* and Y^* peaks above 2200 MeV. Unless the peak is experimentally shaky, we put it in the table.

1b) Peaks not far above some threshold, e.g., $A1 \rightarrow \rho\pi$ or $A3 \rightarrow f\pi$, and their K^* counterparts Q and L. These are at least partly explained by the

'Deck effect', or its more modern version 'double-Regge-pole (DRP) exchange'. But the notion of duality tells us that 'to explain is not to explain away', i.e., the 'explanation of a peak' with the DRP model need not contradict its interpretation as an s -channel resonance. So we put these four peaks on the meson table, but add comments like 'A1 interpretation not clear; 160 MeV above $\rho\pi$ threshold'. For more discussion of this problem, see the A1 mini-review in the listings.

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 at the resonance energy; further, there should be data above the resonance, showing that the speed again decreases. Indeed proper behavior of the partial-wave amplitude will accredit a resonance even if its elasticity is too small to make a noticeable peak.

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 listings. Kp 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 on the 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 (no way to check them with 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 πp bumps at 1512 and 1688 MeV as single resonances, whereas partial-wave analysis shows that each contains several resonances.

- Abrams et al. have reported broad peaks in the $\bar{N}N$ total cross section at 2190, 2345, and 2380 MeV. One of these indeed overlaps our tabulated $U(2375)$ meson, whose width is given as 30 MeV. But $\bar{p}p$ s -channel experiments, which can study all the final states formed at c.m. energies near 2345 MeV, show that the rest of the $\bar{p}p(2345)$ peak, which is 140-MeV wide, must be attributed to a jumble of many different, unresolved effects. So we do not accept as a single resonance the whole $\bar{N}N(2345)$ peak, whose width is measured as 140 MeV.

Despite these cases where a resonance has turned out to be narrower than a bump, and only partly to explain the bump, *most* baryon enhancements have been confirmed by partial-wave analysis. A relevant example is the following:

- 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. Thus nowadays we say that the s -channel resonance *confirms* the production peak, and that this supports one's confidence in duality.

In summary, we enter onto the tables 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. 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.

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

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

‡ Most texts define it as in eq. (1); see, e.g., Gasiorowicz [3]; however, sometimes the rotation is taken about I_x . The difference between the two conventions is mentioned in a footnote in Källén [4].

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. $I=1/2$ states 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 $(J^P)_{\bar{N} \text{ or } A}$ CP, is a redundant intermediate step intended to make the table easier to read.

Parity -	$\bar{q}q$ State		$(J^P)_{\bar{N} \text{ or } A}$ CP Normal or abnormal	$I^G(J^P)_{C_n}$	Examples and comments
	CP -	CP +			
Parity -	$1S_0$	-	$(0^-)_{A^-}$	$\begin{cases} 0^+(0^-)+ \\ 1^-(0^-)+ \end{cases}$	η, η' π
		+	$(1^-)_{N^+}$	$\begin{cases} 0^-(1^-)- \\ 1^+(1^-)- \end{cases}$	ω, ϕ ρ
Parity +	$1P_1$	-	$(1^+)_{A^-}$	$\begin{cases} 0^-(1^+)- \\ 1^+(1^+)- \end{cases}$	B
		+	$(0^+)_{N^+}$	$\begin{cases} 0^+(0^+)+ \\ 1^-(0^+)+ \end{cases}$	$\eta_{0^+}(1060)$ $\pi_{N^+}(1016)$
		-	$(1^+)_{A^+}$	$\begin{cases} 0^+(1^+)+ \\ 1^-(1^+)+ \end{cases}$	A1
		+	$(2^+)_{N^+}$	$\begin{cases} 0^+(2^+)+ \\ 1^-(2^+)+ \end{cases}$	f, f' A2
Parity -	$1D_2$	-	$(2^-)_{A^-}$	$\begin{cases} 0^-(2^-)+ \\ 1^+(2^-)+ \end{cases}$	Regge recurrence of $1S_0, 0^-$
		+	$(1^-)_{N^+}$	same as $3S_1$	
		-	$(2^-)_{A^+}$	$\begin{cases} 0^-(2^-)- \\ 1^+(2^-)- \end{cases}$	Regge recurrence of top abnormal-C state below: $(J^P)_{C_n} = (0^-)-$
Parity +	$1F_3$	-	$(3^+)_{A^-}$	$\{J > 2\}$	
		+	$(2^+)_{N^+}$	same as $3P_2$	Another A2?
		-	$(3^+)_{A^+}$	$\{J > 2\}$	
		+	$(4^+)_{N^+}$	etc.	

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

Abnormal C states Have no $\bar{q}q$ model	$(0^-)_{A^+}$	$\begin{cases} 0^-(0^-)- \\ 1^+(0^-)- \end{cases}$	All except $J^P = 0^-$ are $J^P = \text{normal},$ $CP = -1$
	$(1^-)_{N^-}$	$\begin{cases} 0^+(1^-)+ \\ 1^-(1^-)+ \end{cases}$	
	$(0^+)_{N^-}$	$\begin{cases} 0^-(0^+)- \\ 1^+(0^+)- \end{cases}$	
	$(2^+)_{N^-}$	$\begin{cases} 0^-(2^+)- \\ 1^+(2^+)- \end{cases}$	
	$(3^-)_{N^-}$	$\begin{cases} 0^+(3^-)+ \\ 1^-(3^-)+ \end{cases}$	

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

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

where C_n (n for neutral) is the eigenvalue C would have if applied to the neutral member of the multiplet. Thus, for a π^0 , C has the eigenvalue $+1$, and since $I=1$, $G=-1$. For 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 quark spins coupling to give a spin S . Then one can show that the charge-conjugation eigenvalue (defined in eq. (2)) is

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

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

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

The parity is

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

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

$$C_n P = -(-1)^S,$$

so all singlets ($^1S_0, ^1P_1, \dots$) have $C_n P = -1$, and all triplets ($^3S_1, \dots$) have $C_n P = +1$.

If, instead of $\bar{q}q$, we consider the meson as a state of *boson-antiboson* (e.g., $A_2 \rightarrow \bar{K}K$), 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.

For proofs see our 1969 text [2], and appendix by C. Zemach. We repeat here the summary table I that we used in 1969 as table II.

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.

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 atomic mass number A ($=0$ for mesons), its hypercharge Y , its isospin I , and, for a non-strange meson, its G parity. We choose

$$\begin{aligned} I=0 &; & \eta & \text{ if } G \text{ is even, } & \phi & \text{ if it is odd;} \\ I=1 &; & \rho & \text{ if } G \text{ is even, } & \pi & \text{ if it is odd;} \\ I=\frac{1}{2} &; & K & & & \\ I=\frac{3}{2} &; & L & \text{ (if ever established).} & & \end{aligned}$$

To crowd even more information onto the symbol, we add a subscript giving J^P . Thus $\eta_{0+}(1070)$. If J^P is not known, but must be 'normal' ($0^+, 1^-, 2^+, \dots$), 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, $K_A(1320)$.

For *baryons* no attempt has been made to attach a subscript about J and P . The symbols are

$$\begin{aligned} Z_I & \text{ for } Y=2, \quad I=0, 1; \\ N & \text{ for } Y=1, \quad I=\frac{1}{2}; \\ \Delta & \text{ for } Y=1, \quad I=\frac{3}{2}; \\ \Lambda & \text{ for } Y=0, \quad I=0; \\ \Sigma & \text{ for } Y=0, \quad I=1; \\ \Xi & \text{ for } Y=-1, \quad I=\frac{1}{2}; \\ \Omega & \text{ for } Y=-2, \quad I=0. \end{aligned}$$

For stable baryons of each Y and I 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 assignment is reported in the 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 partial-wave amplitude where the resonant state occurs (the first subscript refers to the isospin state).

When two *mesons* or *baryons* have identical quantum numbers we warn the reader by adding a *prime* to the symbol for the heavier one, e.g., η, η' ; f, f' ; $p, N'(1470, \frac{1}{2}^+)$. 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.

C. Masses and widths

In the tables, columns are headed Mass M , and Width Γ . We speak loosely of M as the position of a resonant peak, and of Γ as its full width at half maximum. We now want to make these statements more precise. Values of M and Γ 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* non-relativistic Breit-Wigner T -matrix element is usually written

$$T_{11} = \frac{\frac{1}{2}\Gamma}{M - m - \frac{1}{2}i\Gamma}.$$

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

$$\Gamma(m) \propto \left(\frac{q^2}{q^2 + x^2} \right)^l \frac{q}{m}.$$

For a choice of forms, see Jackson [5], Pisut and Roos [6], and Barbaro-Galtieri [7]. Of course the detailed shape of the amplitude will depend on the form chosen. So, although Γ is *related* to the full width, it is best measured in terms of the behaviour of T at resonance. It is easy to show [8] that the relation is

$$\text{'Speed' (res)} = \left| \frac{dT}{dE} \right|_{\text{res}} = \frac{x_e}{\frac{1}{2}\Gamma},$$

where the elasticity, $x_e = \Gamma_e/\Gamma$, is introduced next.

For an *inelastic* resonance feeding into channel β ,

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

where

$$\Gamma = \sum_1^N \Gamma_\beta, \quad x_\beta = \Gamma_\beta/\Gamma,$$

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

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

$$\sigma_{1\beta} = 4\pi\lambda^2(J + \frac{1}{2}) |T_{1\beta}|^2. \quad (6)$$

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 Γ even the amplitude T for a resonance does not have a full-width at half-maximum equal to Γ (but it does peak at or near M). Then kinematic factors enter into the cross section for formation (eq. (6)) or production, and displace the observed peak away from M . For quantitative examples, see Barbaro-Galtieri [7].

Most of the useful information on the N , Δ , Λ , and Σ *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 main baryon tables 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. (6) to relate the height of the peak at resonance σ_{res} to the elasticity x_e . At resonance the *channel* cross section is

$$\sigma_{\text{res}}(1 \rightarrow \beta) = 4\pi\lambda^2(J + \frac{1}{2}) x_e x_\beta \quad (7)$$

and the *total* cross section is

$$\sigma_{\text{res}}(\text{total}) = 4\pi\lambda^2(J + \frac{1}{2}) x_e. \quad (8)$$

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. Muon-decay parameters

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

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

where the summation is taken over $i = S, V, T, A, P$. Using the definitions and sign conventions of Kinoshita and Sirlin [9], we have

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

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

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

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

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

where

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

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

and

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

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

By using the above equations and the experimental values of ρ, η, ξ, δ , and h we can place limits on $g_S/g_V, g_A/g_V, g_T/g_V, g_P/g_V$, and ϕ_{AV} . Note that most experiments study only the upper end of the spectrum where ρ and η are highly correlated, so they can only report ρ for $\eta \equiv 0$ and η for $\rho \equiv \frac{3}{4}$. The values for ρ and η we use here were obtained by combining measurements of both upper and lower ends of the spectrum and are nearly uncorrelated.

We have defined a χ^2 that indicates how significantly ρ, η, ξ, δ , and h deviate from their experimental values $\rho_0, \eta_0, \xi_0, \delta_0$, and h_0 in units of their experimental uncertainties $\sigma_\rho, \sigma_\eta, \sigma_\xi, \sigma_\delta$, and σ_h :

$$\chi^2 = [(\rho - \rho_0)^2 / \sigma_\rho^2] + [(\eta - \eta_0)^2 / \sigma_\eta^2] + [(\xi - \xi_0)^2 / \sigma_\xi^2] + [(\delta - \delta_0)^2 / \sigma_\delta^2] + [(h - h_0)^2 / \sigma_h^2].$$

The standard-error matrix techniques have not been used here because the χ^2 contours are far from elliptical in shape. For example, g_A/g_V versus ϕ_{AV} has a χ^2 contour that resembles the letter V, and the best-fit values are at the apex. Accordingly we have determined limits for $g_S/g_V, g_A/g_V, g_T/g_V, g_P/g_V$, and ϕ_{AV} as the largest and smallest values within the $\chi_{\min}^2 + 1$ hypersurface. The results, listed in the *data cards*, 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.

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

E. K-decay parameters

CP violation in K^0 decays. Parameters of current interest are

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

$$\eta_{00} = A(K_L^- \rightarrow \pi^0 \pi^0) / A(K_S^- \rightarrow \pi^0 \pi^0) = |\eta_{00}| \exp(i\phi_{00}).$$

The phases ϕ_{+-} and ϕ_{00} have been measured directly, whereas the magnitudes $|\eta_{+-}|$ and $|\eta_{00}|$ are derived parameters. We have used, as far as we could, the directly measured quantities as input and have calculated $|\eta_{+-}|$ 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 components.

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

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

We list $\text{Re}\{x\}$ and $\text{Im}\{x\}$.

Form factors in K_{l3} leptonic decays

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

$$\langle \pi | J_\lambda | K \rangle \propto [f_+(q^2)(P_K + P_\pi)_\lambda + f_-(q^2)(P_K - P_\pi)_\lambda],$$

where P_K and P_π are the four momenta of K and π mesons; 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 λ_\pm , the energy dependence of the $f_\pm(q^2)$ form factor,

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

and ξ , the ratio of the two form factors,

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

The quantity ξ can be determined in different ways:

1) by measuring the $K_{\mu 3}/K_{e 3}$ branching ratio and comparing it with the theoretical ratio as given in terms of $\xi(0) = f_-(0)/f_+(0)$. $\Gamma(K_{\mu 3})/\Gamma(K_{e 3}) = 0.6457 + 0.1269 \operatorname{Re} \xi + 0.0193 |\xi|^2 + 1.390\lambda_+ + 0.476\lambda_- \operatorname{Re} \xi$ (see CABIBBO 66 in K^+ card listings). Note that the first constant has been changed to 0.6457; the previous value was a misprint† which we copied from CABIBBO 66.

2) by measuring the π or lepton momentum spectra and comparing them with the predicted spectra, which are functions of ξ (see, for example, BRENE 61 in the K^+ card listings).

3) by measuring the muon polarization in $K_{\mu 3}$ decay. In the rest frame of the K the μ is expected to be polarized in the direction A with $P = A/|A|$, where A is given (CABIBBO 64 in K^+ card listings) by

$$A = \alpha_1(\xi) p_\mu - \alpha_2(\xi) \{ (p_\mu/m_\mu) [m_K - E_\pi] + (p_\pi \cdot p_\mu)(E_\mu - m_\mu)/|p_\mu|^2 + p_\pi \} + m_\mu \operatorname{Im} \xi(q^2)(p_\pi \times p_\mu).$$

If time-reversal invariance holds, ξ is real, and thus there is no polarization perpendicular to the K-decay plane. See the note in the *listings*, after K^+ decays, for discussions of experimental results.

F. Baryon-decay parameters

A/V ratio for baryon leptonic decays. The baryon part of the matrix element for these decays may be written as

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

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 γ matrices. The definition of g_A/g_V is

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

$$g_A/g_V = |g_A/g_V| e^{i\delta},$$

where $\delta = 0 + n\pi$ if time-reversal invariance holds (see JACKSON 57 in neutron card listings).

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

Asymmetry parameters in non-leptonic hyperon decays. The transition matrix for the hyperon decay may be written as

$$M = s + p(\sigma \cdot q), \quad (9)$$

where s and p are the parity-changing and the parity-conserving amplitudes, respectively, σ is the Pauli spin operator, and 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

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

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

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

With the transition matrix (9), the angular distribution of the decay baryon, in the hyperon rest system, is of the form

$$I = 1 + \alpha P_Y \cdot q,$$

where $P_Y = \langle Y | \sigma | Y \rangle$ is the hyperon polarization.

The polarization P_B of the decay baryon is‡

$$P_B = \frac{(\alpha + P_Y \cdot q)q + \beta(P_Y \times q) + \gamma q \times (P_Y \times q)}{1 + \alpha P_Y \cdot q},$$

where P_B is defined in that rest system of the baryon obtained by a Lorentz transformation along q from the hyperon rest system in which q and P_Y are defined. Note that α is the helicity of the decay baryon for unpolarized hyperons.

‡ Lee and Yang [10]. Note that ref. [10] contains a misprint. The minus sign in the definition of β should be replaced by a 2. In addition, our unit vector q is the direction of the baryon, whereas their unit vector p is the direction of the pion.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

On the *data cards* we list α and ϕ for each decay since they are the most closely related to the experiments and are essentially uncorrelated. Whenever necessary we have changed the signs of the reported values, so as to agree with our conventions. In the stable particles *table* we give α , ϕ , and Δ with errors; and for convenience we also give the central value of γ , without an error.

[‡] This value for $\delta_s - \delta_p$ is derived from the phase-shift analyses by Roper et al. [11]. The error is our estimation of the uncertainty.

V. STATISTICAL PROCEDURES

This section is a much abbreviated version of sect. IX in the text of the previous edition [1], to which the reader is referred for details. See also the mini-review on K^* masses and mass differences in the *data card listings*.

A. Confidence levels and errors

Quoted errors represent one standard deviation (σ). Upper and lower limits represent 68.3% confidence bounds (1σ), unless otherwise stated.

The errors in the *tables* and the errors of the averages in the *listings* often include a scale factor S ; see sect. V.B below.

Quantities that have changed more than 1σ since our 1969 edition [2] are italicized in the *tables*. For a discussion see sect. V.B in the text of the previous edition [1].

B. Unconstrained averaging, scale factors

In the absence of constraints, we calculate a weighted average

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

$$\omega_i = [1 / (\delta x_i)^2], \quad (10)$$

where the sums run over N experiments. We also calculate χ^2 and compare it with its expectation value of $N-1$.

If $\chi^2 > N-1$, we increase the error $\delta\bar{x}$ in eq. (10) by a factor

$$S = [\chi^2 / (N-1)]^{\frac{1}{2}}. \quad (11)$$

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, χ^2 returns to $N-1$, and of course the output error scales up by the same factor.

If all the experiments have errors of about the same size, the above 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 previous edition [1] 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 discussions of ideograms and scale factors, we refer the reader to sect. IX in the text of the previous edition [1].

C. Constrained fits

The information on partial-decay fractions P_i and partial widths $W_i = P_i \Gamma_{\text{tot}}$ is often given by branching fractions 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 i .

In these cases we fit all available information on the P_i , W_i , and R_j subject to the constraint $\Sigma P_i = 1$. When, in addition, the input R_j are contradicting 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 W_i , together with the error matrices of the P_i and of the W_i . For details about this procedure the reader is referred to the text of the previous edition [1], sect. IV.B.

VI. PARTICLE DATA GROUP PUBLICATIONS

A. Pocket-sized particle data booklet

In addition to the present version of the Review of Particle Properties available from CERN and LRL, a pocket booklet is available. This contains the tables only, plus some additional useful information, selected for high-energy physicists. The complete pocket version comprises the data booklet, a 16-month diary, a mini-atlas, and a plastic cover. If you are on our mailing list, any of these items which you have requested will automatically be sent to you. If you wish to order them in bulk we must charge 25 cents (US) for each of the pocket-sized items. Please note that there are no wallet sheets for this edition.

B. Other compilations

The following reports of the Particle Data

† We are also able to fit *products* of rates from formation experiments as given in eq. (7).

Group and of the CERN HERA Group are available from both CERN and LRL:

1. Cross sections

π^+N Elastic Scattering Data, G. Giacomelli, P. Pini and R. Stagni, CERN/HERA 69-1.
 K^+N Reactions, Particle Data Group (L. R. Price, N. Barash-Schmidt, O. Benary, R. W. Bland, A. H. Rosenfeld and C. G. Wohl), UCRL-20 000 K^+N (1969).
 YN Reactions, Particle Data Group (O. Benary, N. Barash-Schmidt, L. R. Price, A. H. Rosenfeld and G. Alexander), UCRL-20 000 YN (1970).
 NN Reactions, Particle Data Group (O. Benary, L. R. Price and G. Alexander), UCRL-20 000 NN (1970).
 Elastic Scattering Data, G. C. Fox and C. Quigg, UCRL-20 001 (1970).
 $\bar{p}p$ into Hyperon-Antihyperon, B. Sadoulet, CERN/HERA 69-2.

2. Partial-wave amplitudes

πN , Particle Data Group (D. J. Herndon, A. Barbaro-Galtieri and A. H. Rosenfeld), UCRL-20 030 (1970).

Each of these reports in turn lists relevant references. A further list of references can be found in: 'Compilation of coupling constants and low-energy parameters' by G. Ebel, H. Pilkuhn and F. Steiner, Nucl. Phys. B17 (1970) 1.

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J. Bartels has assisted with the meson data, and Arlene Wells and Jane Zoba have helped with all the data processing. We thank J. D. Jackson and C. Quigg for comments.

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- [11] L. D. Roper, R. M. Wright and B. T. Feld, *Phys. Rev.* 138 (1965) B190.

PARTICLE PROPERTIES

1

August 1970

From Review of Particle Properties, UCRL-8030.

N. Barash-Schmidt, A. Barbaro-Galtieri, C. Bricman, C. Y. Chien, T. Lasinski,
L. R. Price, A. Rittenberg, Matts Roos, A. H. Rosenfeld, Paul Söding, and C. G. Wohl

(Closing date for data: July 1, 1970)

Stable Particles

Quantities in italics have changed by more than one (old) standard deviation since January 1970.

Name	$G(J^P)C$	Mass (MeV) Mass ² (GeV) ²	Mean life (sec) $c\tau$ (cm)	Decays		p or p ^{max} (MeV/c) ^b	
				Partial mode	Fraction ^a		
γ	$0, 1(1^-)^-$	$0(<2.)10^{-21}$	stable	stable			
ν	ν_e $J = \frac{1}{2}$ ν_μ	$0(<60 \text{ eV})$ $0(<1.6)$	stable	stable			
e	$J = \frac{1}{2}$	0.5110041 $\pm.0000016$	stable ($>2 \times 10^{21} \text{ y}$)	stable			
μ	$J = \frac{1}{2}$ $m_\mu - m_{\pi^\pm} = -33.919$ $\pm.014$	105.6599 $\pm.0014$ $m^2 = 0.0112$	2.1983×10^{-6} $\pm.0008$ $c\tau = 6.592 \times 10^4$	$e\nu\bar{\nu}$	100	53	
				$e\gamma\gamma$	(<1.6)	10^{-5}	53
				$3e$	(<1.3)	10^{-7}	53
				$e\gamma$	(<2)	10^{-8}	53
π^\pm	$1^-(0^-)$	139.579 $\pm.014$ $m^2 = 0.0195$	2.6024×10^{-8} $\pm.0024$ $c\tau = 781$ $(\tau^+ - \tau^-)/\bar{\tau} = (0.05 \pm 0.07)\%$ (test of CPT)	$\mu\nu$	100	30	
				$e\nu$	(1.24 ± 0.03)	10^{-4}	70
				$\mu\nu\gamma$	^c (1.24 ± 0.25)	10^{-4}	30
				$\pi^0 e\nu$	(1.02 ± 0.07)	10^{-8}	5
				$e\nu\gamma$	^c (3.0 ± 0.5)	10^{-8}	70
π^0	$1^-(0^-)^+$	134.975 $m^2 = 0.0177$ $m_{\pi^\pm} - m_{\pi^0} = 4.6041$ $\pm.0037$	0.76×10^{-16} $\pm.15, S=2.0^*$ $c\tau = 2.28 \times 10^{-6}$	$\gamma\gamma$	(98.83 ± 0.04)	67	
				$\gamma e^+ e^-$	(1.17 ± 0.04)	67	
				$\gamma\gamma\gamma$	(<5)	10^{-6}	67
				$e^+ e^- e^+ e^-$	^d (3.47)	10^{-5}	67

Name	$I^G(J^P)C$	Mass (MeV) Mass ² (GeV) ²	Mean life (sec) $c\tau$ (cm)	Decays		p or p_{\max} (MeV/c) ^b
				Partial mode	Fraction ^a	
Λ	$0(\frac{1}{2}^+)$ $m^2 = 1.245$	1115.60 ± 0.08 $S = 1.3^*$	2.51×10^{-10} $\pm .03$ $S = 1.3^*$ $c\tau = 7.54$	$p\pi^-$	(65.3 ± 1.3)%	$S = 1.1^*$ 100
				$n\pi^0$	(34.7)%	104
				$p\nu$	(0.80 ± 0.06) 10^{-3}	163
				$p\mu\nu$	(1.35 ± 0.60) 10^{-4}	131
Σ^+	$1(\frac{1}{2}^+)$ $m^2 = 1.412$ $m_{\Sigma^+} - m_{\Sigma^-} = -7.92$ $\pm .13$	1189.40 ± 0.19 $S = 1.7^*$	0.802×10^{-10} $\pm .007$ $c\tau = 2.41$	$p\pi^0$	(51.7 ± 0.8)%	189
				$n\pi^+$	(48.3 ± 0.8)%	185
				$p\gamma$	(1.16 ± 0.17) 10^{-3}	225
				$n\pi^+\gamma$	(1.3 ± 0.3) 10^{-4}	185
				$\Delta e^+\nu$	(2.02 ± 0.47) 10^{-5}	72
				$\Delta e^+\nu$	(< 2.3) 10^{-5}	202
	$\Gamma(\Sigma^+ \rightarrow l^+ n\nu) < .037$					
	$\Gamma(\Sigma^- \rightarrow l^- n\nu)$					
Σ^0	$1(\frac{1}{2}^+)$ $m^2 = 1.422$	1192.46 ± 0.12 $S = 1.2^*$	$< 1.0 \times 10^{-14}$ $c\tau < 3 \times 10^{-4}$	$\Lambda\gamma$	100 %	75
				Δe^+e^-	d(5.45) 10^{-3}	
Σ^-	$1(\frac{1}{2}^+)$ $m^2 = 1.434$ $m_{\Sigma^0} - m_{\Sigma^-} = 4.86$ $\pm .07$	1197.32 ± 0.11 $S = 1.3^*$	1.49×10^{-10} $\pm .03$ $S = 2.1^*$ $c\tau = 4.47$	$n\pi^-$	100 %	193
				$ne^-\nu$	(1.06 ± 0.05) 10^{-3}	230
				$n\mu^-\nu$	(0.45 ± 0.04) 10^{-3}	210
				$\Delta e^-\nu$	(0.60 ± 0.06) 10^{-4}	79
				$n\pi^-\gamma$	c(1.0 ± 0.2) 10^{-4}	193
Ξ^0	$\frac{1}{2}(\frac{1}{2}^+)^f$ $m^2 = 1.728$ $m_{\Xi^0} - m_{\Xi^-} = 6.6$ $\pm .7$	1314.7 ± 0.7	3.03×10^{-10} $\pm .18$ $c\tau = 9.10$	$\Delta\pi^0$	100 %	135
				$p\pi^-$	(< 0.9) 10^{-3}	299
				$pe^-\nu$	(< 1.3) 10^{-3}	323
				$\Sigma^+e^-\nu$	(< 1.5) 10^{-3}	119
				$\Sigma^-e^+\nu$	(< 1.5) 10^{-3}	112
				$\Sigma^+\mu^-\nu$	(< 1.5) 10^{-3}	64
				$\Sigma^-\mu^+\nu$	(< 1.5) 10^{-3}	49
				$p\mu^-\nu$	(< 1.3) 10^{-3}	309
Ξ^-	$\frac{1}{2}(\frac{1}{2}^+)^f$ $m^2 = 1.746$	1321.25 ± 0.18	1.66×10^{-10} $\pm .04$ $S = 1.1^*$ $c\tau = 4.98$	$\Lambda\pi^-$	100 %	139
				$\Lambda e^-\nu$	g(0.67 ± 0.23) 10^{-3}	190
				$\Sigma^0 e^-\nu$	(< 0.5) 10^{-3}	122
				$\Delta\mu^-\nu$	(< 1.3) 10^{-3}	163
				$\Sigma^0\mu^-\nu$	(< 0.5)%	70
				$n\pi^-$	(< 1.1) 10^{-3}	303
Ω^-	$0(\frac{3}{2}^-)$ $m^2 = 2.797$	1672.5 ± 5 $m^2 = 2.797$	$1.3^{+0.4}_{-0.3} \times 10^{-10}$ $c\tau = 3.9$	$\Xi^0\pi^-$	} Total of 28 events seen	293
				$\Xi^-\pi^0$		289
				ΛK^-		210

* $S = \text{Scale factor} = \sqrt{\chi^2 / (N-1)}$, where $N \approx$ number of experiments. S should be ≈ 1 . If $S > 1$, we have enlarged the error of the mean, δx , i. e., $\delta x \rightarrow S\delta x$. This convention is still inadequate, since if $S \gg 1$, the experiments are probably inconsistent, and therefore the real uncertainty is probably even greater than $S\delta x$. See text and ideogram in 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 data card listings for energy limits used in measuring this branching ratio.
- d. Theoretical value; see also data card listings.
- e. See note in data card listings.
- f. Predicted from SU(3).
- g. Assumes rate for $\Xi^- \rightarrow \Sigma^0 e^-\nu$ small compared with $\Xi^- \rightarrow \Lambda e^-\nu$.

Magnetic moment							
e	1.001 159 557 ±.000 000 030	$\frac{e\hbar}{2m_e c}$	μ Decay parameters ^a				
μ	1.001 166 16 ±.000 000 31	$\frac{e\hbar}{2m_\mu c}$	$\rho = 0.752 \pm 0.003$ $\xi = 0.972 \pm 0.013$ $|g_A/g_V| = 0.86^{+0.33}_{-0.11}$	$\eta = -0.12 \pm 0.21$ $\delta = 0.755 \pm 0.009$ $\phi = 180^\circ \pm 15^\circ$	$h = 1.00 \pm 0.13$		
K^\pm	Mode	Partial rate (sec⁻¹)	$\Delta I = \frac{1}{2}$ rule				
	$\mu\nu$ $\pi\pi^0$ $\pi\pi^+\pi^-$ $\pi\pi^0\pi^0$ $\mu\pi^-\nu$ $e\pi^0\nu$	(51.54±0.30)10 ⁶ (16.95±0.25)10 ⁶ (4.51±0.03)10 ⁶ (1.38±0.04)10 ⁶ (2.58±0.09)10 ⁶ (3.93±0.06)10 ⁶	S=1.3* S=1.2* S=1.1* S=2.0* S=1.2*	See Appendix I		Form factors See listings for λ, ξ	
K_S^0	$\pi^+\pi^-$ $\pi^0\pi^0$	(0.797±.008)10 ¹⁰ (0.363±.006)10 ¹⁰	S=1.2* S=1.3*	CP violation parameters			
	$\pi^0\pi^0\pi^0$ $\pi^+\pi^-\pi^0$ $\pi\mu\nu$ $\pi e\nu$ $\pi^+\pi^-$ $\pi^0\pi^0$	(3.99 ± 0.20)10 ⁶ (2.35 ± 0.10)10 ⁶ (4.98 ± 0.22)10 ⁶ (7.22 ± 0.29)10 ⁶ (0.029 ± 0.001)10 ⁶ (0.023 ± 0.006)10 ⁶	S=1.3* S=1.4* S=1.5* S=1.5* S=1.2* S=1.5*	$\eta_{+-} = \frac{A(K_L \rightarrow \pi^+\pi^0)}{A(K_S \rightarrow \pi^+\pi^0)} = |\eta_{+-}| e^{i\phi_{+-}}$ $|\eta_{+-}| = (1.92 \pm 0.05)10^{-3}, \phi_{+-} = (44 \pm 5)^\circ$ $|\eta_{00}| = (2.5 \pm 0.8)10^{-3}, \phi_{00} = (23 \pm 32)^\circ$ $S=1.4^*$ $S=1.5^*$	$\Delta S = -\Delta Q$ Re x = .021 ± 0.036 S=1.7* Im x = -.099 ± 0.047		
η	Mode	Asymmetry parameter					
	$\pi^+\pi^-\pi^0$ $\pi^+\pi^-\gamma$	(1.2 ± 0.5)% (1.2 ± 1.2)%					
	Magnetic moment ($e\hbar/2m_p c$)	Decay parameters ^b				g_A/g_V ^b	g_V/g_A ^b
		Measured		Derived			
		α	$\phi(\text{degree})$	γ	$\Delta(\text{degree})$		
p	2.792782 ±.000017						
n	-1.913148 ±.000066	$pe^-\nu$			-1.231 ± 0.010 [$\delta = (176.1 \pm 6.4)^\circ$]		
Λ	-0.73 ±.16 S=1.2*	$p\pi^-$	0.645 ± 0.016	(-6.3 ± 3.5)°	0.76	(7.5 ± 3.9)°	
		$n\pi^0$ $pe\nu$	0.649 ± 0.046			-0.83 ± 0.18 S=1.3*	
Σ^+	2.57 ±.52	$p\pi^0$	-0.991 ± 0.019	(22 ± 90)°	0.12	183 ⁺¹¹ -12	
		$n\pi^+$	+0.068 ± 0.016	(167 ± 20)°	-0.97	-73 ⁺¹³³ -10	
		$p\gamma$	-1.03 ⁺⁵² -.44				
Σ^-		$n\pi^-$ $ne^-\nu$ $\Lambda e^-\nu$	-0.078 ± 0.020 S=1.7*	(10 ± 15)°	0.98	(246 ⁺¹⁴ -108)°	0.25 ± 0.11
		$\Lambda\pi^0$	-0.35 ± 0.08	(25 ± 21)° S=1.3*	0.85	(229 ⁺¹⁴ -38)°	0.35 ± 0.18
Ξ^0		$\Lambda\pi^0$	-0.35 ± 0.08	(25 ± 21)° S=1.3*	0.85	(229 ⁺¹⁴ -38)°	
Ξ^-		$\Lambda\pi^-$	-0.41 ± 0.04	(-3 ± 9)° S=1.3*	0.90	(172 ± 18)°	

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

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

ϕ defined by $\cos \phi = -\text{Re}(C_A^* C'_V + C'_A C_V^*) / g_A g_V$ [for more details, see text].

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

$$\alpha = \frac{2|s||p|\cos\Delta}{|s|^2 + |p|^2}; \quad \beta = \frac{-2|s||p|\sin\Delta}{|s|^2 + |p|^2}; \quad \gamma = \sqrt{1-\alpha^2}\sin\phi; \quad \delta = \sqrt{1-\alpha^2}\cos\phi.$$

g_A/g_V defined by $\langle B_f | \gamma_\lambda (g_V - g_A \gamma_5) | B_i \rangle$;
 δ defined by $g_A/g_V = |g_A/g_V| e^{i\delta}$.

Mesons

August 1970

Quantities in italics have changed by more than one (old) standard deviation since January, 1969.

Name	$I^G(J^P)C_n$ estab. ? = guess	Mass M (MeV)	Width Γ (MeV)	M^2 $\pm \Gamma M^2$ (GeV) ²	Partial decay modes		p or p _{max} (MeV/c) ^b
					Mode	Fraction %	
$\pi^\pm(140)$ $\pi^0(135)$	$1^-(0^-)_+$	139.58 134.97	0.0 7.2 eV ± 1.2 eV	0.019483 0.018217	See Stable Particles Table		
$\eta(549)$	$0^+(0^-)_+$	548.8 ± 0.6	2.70 keV ± 6.7 keV	0.301 ± 0.000	All neutral $\pi^+\pi^-\pi^0 + \pi^+\pi^-\gamma$	72 28	See Stable Particles Table
$\eta_{0^+}(700)$ or ϵ	$0^+(0^+)_+$	≈ 700	$\gg 100$	≈ 0.5	$\pi\pi$	100	≈ 320
δ_{00} seems to stay near 90° from 650 to 900 MeV; see note in listings							
$\rho(765)$	$1^+(1^-)_-$	765. ^(c) ± 10	125. ^(c) ± 20	0.585 ± 0.095	$\pi\pi$ e^+e^- $\mu^+\mu^-$ For upper limits, see footnote (e)	≈ 100 .0060 \pm .0008 (d) .0067 \pm .0012 (d)	356 382 368
$\omega(784)$	$0^-(1^-)_-$	783.7 ± 0.4 S = 1.7*	11.9 ± 1.3 S = 1.1*	0.614 ± 0.009	$\pi^+\pi^-\pi^0$ $\pi^+\pi^-$ $\pi^0\gamma$ e^+e^- For upper limits, see footnote (g)	89.7 \pm 4.0 1.0 \pm 0.25 (f) 9.4 \pm 1.2 0.0066 \pm .0017, S = 1.4*	328 366 380 392
$\eta'(958)$ or X^0	$0^+(0^-)_+$ J ^P = 2 ⁻	957.7 ± 0.8	< 4 not excluded (see note in listings)	0.917 < .004	$\eta\pi\pi$ $\rho^0\gamma$ $\gamma\gamma$ [note (h)] For upper limits see footnote (i)	65.7 \pm 4.0 29.6 \pm 2.6, S = 1.2* 4.7 \pm 2.9	231 173 479
$\delta(966)$	≥ 1 ()	966 ± 5	< 5	0.933 < .005	$\eta\pi$ possibly seen		308
$\pi_N(1016)$ $\rightarrow K\bar{K}$	$1^-(0^+)_+$	1016 ± 10	≈ 25	1.032 ± 0.025	$K^\pm K^0$ $\eta\pi$	Only mode seen < 80	111 342
Resonance, virtual bound state, or antibound state, still not distinguished							
$\phi(1019)$	$0^-(1^-)_-$	1018.8 ± 0.5 S = 1.9*	4.0 ± 0.2	1.039 ± 0.004	K^+K^- $K_L K_S$ $\pi^+\pi^-\pi^0$ (incl. $\rho\pi$) e^+e^- $\mu^+\mu^-$ For upper limits see footnote (j)	46.9 \pm 2.3 34.8 \pm 2.3, S = 1.1* 18.3 \pm 2.6 0.034 \pm .002 0.035 \pm .035 - .018	125 108 461 509 498
$\eta_{0^+}(1060)$ or S^*	$0^+(0^+)_+$	1060 _§ ± 20 _§	see (k)	1.13 ± 0.09	$\pi\pi$ $K\bar{K}$	< 65 > 35	513 190
if resonance							
Resonance and scattering length both possible							
A1(1070)	$1^-(1^+)_+$	1070 _§ ± 20 _§	95 _§ ± 35 _§	1.14 ± 0.10	3π [see note (l) on $\rho\pi$] $K\bar{K}$	≈ 100 < 0.25	488 201
J ^P = 2 ⁻ not excluded							
Resonance interpretation slightly in doubt; only 160 MeV above $\rho\pi$ threshold. See note (t).							
B(1235)	$1^+(1^+)_-$	1235 _§ ± 15 _§	102 _§ ± 20 _§	1.53 ± 0.13	$\omega\pi$ $\pi\pi$ $K\bar{K}$ For other upper limits see footnote (m)	≈ 100 < 30 < 2	Absence sug- gests J ^P = Abn. 371
f(1260)	$0^+(2^+)_+$	1264 _§ ± 10 _§	150 _§ ± 25 _§	1.60 ± 0.19	$\pi\pi$ $2\pi^+2\pi^-$ $K\bar{K}$ indic. seen	≈ 100 < 4 ≈ 3	616 553 389

Name	$I^G(J^P)C_n$ → estab. ? = guess	Mass M (MeV)	Width Γ (MeV)	$M_{(a)}^2$ $\pm \Gamma M^2$ (GeV) ²	Partial decay modes		P or P _{max} (MeV/c) ^b
					Mode	Fraction %	
D(1285)	$0^+(A)^+$ J ^P = 0 ⁻ , 1 ⁺ , 2 ⁻ , with 1 ⁺ favored	1288 ±7	33 ±5	1.66 ±0.04	K $\bar{K}\pi$ [mainly $\pi_N(1016)$]	Seen	307
					$\pi\pi\eta$	Possibly large	485
					$\delta(966)\pi$	Possibly seen	25
					$\pi\pi\rho$	Not seen	354
A _L (1280)	$1^-(2^+)_{\pm}$	1280 ±3	20 ±3	1.64 ±0.028	In $\pi\rho \rightarrow \rho A_2$, split $A_2^- (\rightarrow \rho^0 \pi^-, K^0 K^-)$ seen in CERN Boson Spectr. expts., but no convincing split seen in A ₂ ⁺ expts. Probably two interfering resonances are needed to explain all the data.	409	
A _H (1320)	$1^-(2^+)_{\pm}$	1323 ±5	20 ±3	1.74 ±0.028		420	
	S = 2.3* S = 1.1* S = 2.7*					523 271	
E(1422)	$0^+(0^-)_{\pm}$ J ^P = 1 ⁺ not excluded See note in listings	1422 ±4	69 ±8	2.02 ±0.10	K [*] $\bar{K} + \bar{K}^*K$	50 ± 10	153
					$\pi_N(1016)\pi$	50 ± 10	326
					$\pi\pi\eta$	< 60	568
					$\pi\pi\rho$	Not seen	457
f'(1514)	$0^+(2^+)_{\pm}$	1514 ±5	73 ±23	2.29 ±0.11	K \bar{K}	72 ± 12	570 294 744 624 521
					K [*] $\bar{K} + \bar{K}^*K$	10 ± 10	
					$\pi\pi$	< 14	
					$\eta\pi\pi$	18 ± 10	
					$\eta\eta$	< 40	
$\pi/\rho(1540)$ or F ₁	$1_1(A)$	1540 ±5	40 ±15	2.37 ±0.06	K [*] $\bar{K} + \bar{K}^*K$	Only mode seen	321
					Evidence based on only one experiment		
$\pi_A(1640)$ or A ₃	$1^-(A)_{\pm}$	1642 ±7	108 ±19	2.67 ±0.15	f π	Dominant	310
					3 π	Possibly observed	792
					$\omega\pi\pi$	Possibly observed	597
Resonance interpretation in doubt; only 240 MeV above f π threshold, see note (t)							
$\rho_N(1670)$ or g	$1^+(N)_{\pm}$	1670 ^(o) ±20 [§]	167 ±30 [§]	2.77 ±0.28	2 π	Dominant	823
					K \bar{K}	8 ⁺⁸ -3	670
(J ^P = 1 ⁻ , 3 ⁻ , ... with 3 ⁻ favored) under $\rho(1700)$ below. This does not imply that $\rho_N(1670)$ and $\rho(1700)$ are different resonances.							
$\rho(1700)$ → 4 π	$1^+(\)_{\pm}$	1700 [§] ±20 [§]	125 [§] ±25 [§]	2.90 ±0.21	4 π		792
					$\dagger[\pi^{\pm}A_2(\rightarrow \pi^{\pm}\pi^{\mp}\pi^0)/\text{all}(\pi^{\pm}\pi^{\mp}\pi^0)]$	40 ± 20	330
					$\dagger[\pi^{\pm}\omega(\rightarrow \pi^{\pm}\pi^{\mp}\pi^0)/\text{all}(\pi^{\pm}\pi^{\mp}\pi^0)]$	25 ± 10	661
					$\dagger[\rho^{\pm}\rho^0]$	Seen]	371
					$\pi^{\pm}\phi/\pi^{\pm}\pi^{\mp}\pi^0$	< 11	532
					$\pi^{\pm}2\pi^{\mp}2\pi^0/\pi^{\pm}\pi^{\mp}\pi^0$	< 15	698
$\dagger[\pi\pi\rho]$	Seen]	644					
See note (p) for states grouped as R(1750), S(1930), $\rho(2100)$, T(2200), $\rho(2275)$, and $N\bar{N}(2345)$.							
U(2375)	$1^+(\)^-$	2370 ±8	30 ±20 [§]	5.62 ±0.07	Seen in $\pi^-\bar{p} \rightarrow pU^-$ and $\bar{p}p \rightarrow \bar{K}K^*\pi\pi$, and $\bar{p}p \rightarrow K_S^0 K_S^0 \omega$, $K_S^0 K_L^0 (\pi\pi^0)$, last 2 modes → C = -1, I = 1.		
See Note (q) for heavier states.							
K ⁺ (494) K ⁰ (498)	$1/2(0^-)$	493.82 497.76		0.244 0.248	See Stable Particles Table		
K [*] (892)	$1/2(1^-)$	892.1 ±0.4	50.6 ±0.7	0.796 ±0.045	K π K $\pi\pi$	≈ 100 0.2	288 216
(Charged mode; $m^0 - m^{\pm} = 8 \pm 3$)							

Name	$I^G(J^P)C_n$ → estab. ? = guess	Mass M (MeV)	Width Γ (MeV)	M^2 $\pm \Gamma$ M^2 (GeV) ²	Partial decay modes		p or p _{max} (MeV/c) b		
					Mode	Fraction %			
K _A (1240) or C	1/2(1 ⁺)	1247 ±8 S = 1.3*	40-130 (q)	1.54 ±0.08	Resonance interpretation unclear; only 270 MeV above K* π threshold; see notes (r) and (t)				
					K $\pi\pi$ †[K* π †[K ρ	Only mode seen Large Seen]			
K _A (1250 to 1400)	1/2(1 ⁺) J ^P = 2 ⁻	1280 to 1360 not completely ruled out	See note (t)						
K _N (1420) or K**	1/2(2 ⁺) J ^P = 3 ⁻	1412.7 ±4.4 S = 1.2*	96 ±7 S = 1.3*	1.985 ±.135	K π	49.2 ± 3.4	609		
					K* π	36.3 ± 3.1		S = 1.5*	406
					K ρ	8.0 ± 3.5		S = 1.6*	311
					K ω	4.2 ± 1.3		S = 1.1*	291
		See note (s). still possible			K η	2.2 ± 1.6	S = 1.4*	474	
K _A (1775) or L	1/2(A) J ^P = 1 ⁺ , 2 ⁻ favored	1773 ±9	See note (t)	3.15 ±.14	K $\pi\pi$ [K*(1420) π	Only mode seen Large; in K ⁺ p experi- ments dominant]			
Resonance interpretation unclear; only 215 MeV above K _N (1420) π threshold; see note (t).									

⇒ The following bumps, excluded above, are listed among the data cards: σ (410); H(990); η_V (1080); A1.5(1170); $\rho\rho$ (1410); K_SK_S(1440); ϕ (1650); R(1750); η or ρ (1830) → 4 π ; ϕ or π (1830) → $\omega\pi\pi$; S(1930); ρ (2100); T(2200); ρ (2275); ρ (2345); NN_{I=4}(2345); NN_{I=0}(2380); X⁻(2500); X⁻(2620); X⁻(2800); X⁻(2880); X⁻(3030); X⁻(3075); X⁻(3145); X⁻(3475); X⁻(3535); K_N(1080-1260); K_{A(I=3/2)}(1175); K_{A(I=3/2)}(1265); K_N(1660); K*(2240) → $\bar{N}N$. (See note (q).)

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

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

§ This is only an educated guess; the error given is larger than the error of the average of the published values (see 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 $\Gamma(\rho)$ 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 listings):

	M(MeV)	Γ (MeV)	
ρ^0	774±5	111±5	From $e^+e^- \rightarrow \pi^+\pi^-$, fitted to Gounaris-Sakura formula.
ρ^0	768±10	140±14	
ρ^-	764±2	147±4	From physical region fits to $\pi N \rightarrow \pi\pi N$, using energy-dependent width.
ρ^0	775±3	145±9	
ρ^0	768±2	132±13	From pole extrapolation in $\pi N \rightarrow \pi\pi N$
ρ^-	755±5	110±9	
ρ^0	759±7	119±20	

Energy-independent width is a narrow-resonance approximation which tends to give lower mass and width.

- (d) The e^+e^- branching ratio is from $e^+e^- \rightarrow \pi^+\pi^-$ experiments only. The $\omega\rho$ interference is then due to $\omega\rho$ mixing only, and is expected to be small. See note in listings. The $\mu^+\mu^-$ branching ratio is compiled from 3 experiments; each possibly with substantial $\omega\rho$ interference. The error reflects this uncertainty; see notes in listings. If $e\mu$ universality holds, $\Gamma(\rho^0 \rightarrow \mu^+\mu^-) = \Gamma(\rho^0 \rightarrow e^+e^-) \times$ phase space correction.
- (e) Empirical limits on fractions for other decay modes of $\rho(765)$ are $\pi^\pm\gamma < 0.2\%$, $\pi^\pm\eta < 0.8\%$, $\pi^+\pi^+\pi^-\pi^- < 0.15\%$, $\pi^\pm\pi^+\pi^-\pi^0 < 0.2\%$.
- (f) Depends mainly on one experiment, $\gamma C \rightarrow \pi^+\pi^- C$. Uncertainties about ρ shape and production mechanism could increase error.
- (g) Empirical limits on fractions for other decay modes of $\omega(784)$ are $\pi^+\pi^-\gamma < 5\%$, $\pi^0\pi^0\gamma < 0.7\%$, $\eta +$ neutral(s) $< 1.5\%$, $\mu^+\mu^- < 0.02\%$, $\pi^0\mu^+\mu^- < 0.2\%$.
- (h) This $\eta' \rightarrow \gamma\gamma$ value is from a constrained fit under the assumption that $\eta\pi\pi$, $\rho^0\gamma$, and $\gamma\gamma$ are the only existing decay modes. Note that direct measurement of the $\eta' \rightarrow \gamma\gamma$ branching fraction gave the slightly different result of $(5.5^{+3.6}_{-3.0})\%$.
- (i) Empirical limits on fractions for other decay modes of $\eta'(958)$: $\pi^+\pi^- < 2\%$, $\pi^+\pi^-\pi^0 < 5\%$, $\pi^+\pi^+\pi^-\pi^0 < 1\%$, $\pi^+\pi^+\pi^-\pi^-\pi^0 < 1\%$, $6\pi < 1\%$, $\pi^+\pi^-e^+e^- < 0.6\%$, $\pi^0e^+e^- < 1.3\%$, $\eta e^+e^- < 1.1\%$, $\pi^0\rho^0 < 4\%$, $\pi^0\omega < 8\%$.

- (j) Empirical limits on fractions for other decay modes of $\phi(1019)$ are $\pi^+\pi^- < 5\%$, $\eta\gamma < 8\%$, η +neutrals $< 13\%$, $\pi^+\pi^-\gamma < 4\%$, $\omega\gamma < 5\%$, $\rho\gamma < 2\%$, $\pi^0\gamma < 0.35\%$.
- (k) Width of $\eta_0 \rightarrow K_S K_S$: Average value from three bubble chamber experiments is $\Gamma = 63 \pm 11$ MeV, whereas two spark chamber experiments give $\Gamma > 100$ MeV. The latter also allow a scattering-length fit.
- (l) $\rho\pi$ fraction of 3π mode difficult to distinguish because ρ bands cover most of the Dalitz plot.
- (m) Empirical limits on fractions for decay modes of $B(1235)$: $\pi\pi < 30\%$, $K\bar{K} < 2\%$, $4\pi < 50\%$, $\phi\pi < 1.5\%$, $\eta\pi < 25\%$, $(KK)^\pm\pi^0 < 8\%$, $K_S K_S \pi^\pm < 2\%$, $K_S K_L \pi^\pm < 6\%$.
- (n) 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 $80 \pm 13\%$ (rather than $72 \pm 12\%$ as given in the table), and $\eta\pi\pi$ as $20 \pm 13\%$.
- (o) See B. French's compilation (Proc. 14th International Conf. High Energy Physics, Vienna, 1968, p. 91) for possible mass difference of charged and neutral $\rho_N(1660)$: $M = 1640 \pm 20$ MeV, $\Gamma = 120 \pm 30$ MeV for ρ_N^\pm , $M = 1680 \pm 15$ MeV, $\Gamma = 200 \pm 50$ MeV for ρ_N^0 .
- (p) We tabulate here $Y = 0$ bumps with $M \geq 1700$ MeV, for which no satisfactory grouping into particles is yet possible. See listings.

Name	I^G	(J^P)	M(MeV)	Γ (MeV)	Decay modes observed	Tentative grouping
R2(1700)	1, 2		1700±15	≤30	(MM) ⁻ → 1/3/>3 charg. part. ≈ 43/56/1	$\rho(1710)$
K \bar{K} (1740)	1		1740	≈120	$K^0 K^\pm$	R(1750)
R3(1750)	1, 2		1748±15	≤38	(MM) ⁻ → 1/3/>3 charg. part. >14/<80/15	
$\rho(1900)$	1 ⁺ , 2 ⁺		1900±40	216±105	$\pi^+\pi^0$	S region
N \bar{N} (1925)	0, 1		1925	≈10	Structure in $\bar{p}p$ backward el. scattering	
S(1929)	1, 2		1929±14	≤35	(MM) ⁻ → 3 charged particles ≈ 92%	Seems to require >1 resonance
N \bar{N} (1945)	0, 1		1945	≈22	Structure in $\bar{p}p$ backward el. scattering	
$\rho\pi(1985)$	1 ⁺ , 2 ⁺ , 3 ⁺		1985	≈100	$\rho^-\pi^+\pi^-$	}
X ⁻ (2086)	1, 2		2086±38	≈150	(MM) ⁻ backward	
$\rho(2120)$	1 ⁺	3 ⁻ (?)	2120	<249	$\pi^+\pi^-$, $\bar{p}p$	
N \bar{N} (2190)	1 ⁻		2190	20-80	$\rho^0 \rho^0 \pi^0$, $\bar{p}p$	T region
	1		2190±10	≈85	Structure in N \bar{N} total σ	
T(2195)	1, 2		2195±15	≤13	(MM) ⁻ → 3 charged particles ≈ 94%	Seems to require >1 resonance
3 $\pi(2207)$	≤3 ⁻		2207±13	62±52	$\pi^+\pi^-\pi^0$	
4 $\pi(2200)$	1 ⁺ , 2 ⁺ , 3 ⁺		2200	≈130	$\rho^-\pi^+\pi^-$	}
KK $\omega(2176)$	0 ⁻ , 1 ⁺		2176±5	20±10	$K_S^0 K_S^0 \omega$		$\rho(2275)$
X ⁻ (2260)	1, 2		2260±18	≤25	(MM) ⁻ backward	
$\rho(2290)$	1 ⁺	5 ⁻ (?)	2290	<165	$\pi^+\pi^-$, $\bar{p}p$	
N \bar{N} (2345)	1		2345±10	≈140	Structure in N \bar{N} total σ	
N \bar{N} (2380)	0		2380±10	≈140	Structure in N \bar{N} total σ	
U(2375)	1 ⁺		Included on the main Meson Table, and summarized in listings			
X ⁻ (2500)	1, 2		2500±32	≈87	(MM) ⁻ backward	
X ⁻ (2620)	1, 2		2620±20	85±30	(MM) ⁻	
X ⁻ (2800)	1, 2		2800±20	46±10	(MM) ⁻	
X ⁻ (2880)	1, 2		2880±20	≤15	(MM) ⁻	
X ⁻ (3030)	1, 2		3025±20	≈25	(MM) ⁻	
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) ⁻	

- (q) Width of $K_A(1240)$ depends on experiment.
- (r) See Q-region note in 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 the structures from 1280 to 1360 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.
- (s) The mass comes only from charged $K_N(1420) \rightarrow K\pi$ measurements, since it is not well determined in the $K\pi\pi$ system with Q effect present; see typed note under $K^*(892)$ mass in listings.
- (t) Four bumps (A1, A3, Q, L) appear, in mass spectra, as broad enhancements (200-400 MeV wide) centered about 200 MeV above threshold; they can be interpreted as either resonances or kinematic effects. Widths and branching ratios are published, and compiled in the listing, but in some cases we do not average them because they are very sensitive to difficult background subtractions. For more discussion, see notes in data card listings.

Mixing Angles from Quadratic SU(3) Mass Formula:

$J^P = 0^-$ Possible Nonet [$\pi, K, \eta; \eta'$]	$\theta = 10.4 \pm 0.2^\circ$	Of the two iso-singlets, the "mainly-octet" one is written first, followed by a semicolon.
$= 0^-$ Alternative Nonet [$\pi, K, \eta; E$]	$\theta = 6.2 \pm 0.1^\circ$	
$= 1^-$ [$\rho(765 \pm 10), K^*, \phi; \omega$]	$\theta = 39.6 \pm 0.7^\circ$	
$= 2^+$ [$A_2(1300 \pm 20), K_N(1420), f'; f$]	$\theta = 32.0 \pm 2.5^\circ$	

Baryons

August 1970

[See notes on N's and Δ's, on possible Z*'s, and on Y*'s at the beginning of those sections in the data listings; also see notes on individual resonances in the listings.]

Particle or resonance ^a	I (J ^P)	π or K Beam		Mass ^b (MeV)	Γ ^b (MeV)	M ² ± ΓM ^c (GeV ²)	Decay modes		p or P _{max} (MeV/c)
		T(GeV) p(GeV/c) σ = 4πλ ² (mb)	Partial mode				Fraction %		
p	<u>1/2(1/2⁺)</u>			938.3		0.880	See Stable Particles		
n	<u>1/2(1/2⁺)</u>			939.6		0.883			
N'(1470)	<u>1/2(1/2⁺)</u> P' ₁₁	T=0.53πp p=0.66 σ=27.8	1435 to 1505	200 to 400	2.16 ±0.36	Nπ Nππ	60 40	420 368	
N'(1520)	<u>1/2(3/2⁻)</u> D' ₁₃	T=0.61 p=0.74 σ=23.5	1510 to 1540	105 to 150	2.31 ±0.18	Nπ Nππ Nη	50 50 ~0.6	456 410 150	
N'(1535)	<u>1/2(1/2⁻)</u> S' ₁₁	T=0.64 p=0.76 σ=22.5	1500 to 1600	50 to 160	2.36 ±0.18	Nπ Nη Nππ	34 66 small	467 182 422	
N(1670) ⁱ	<u>1/2(5/2⁻)</u> D ₁₅	T=0.87 p=1.00 σ=15.6	1655 to 1680	105 to 175	2.79 ±0.24	Nπ Nππ [Δ(1236)π] ^e ΔK Nη	42 58 [44] ^e <.1 ^j <1 ^j	560 525 357 200 368	
N(1688) ⁱ	<u>1/2(5/2⁺)</u> F ₁₅	T=0.90 p=1.03 σ=14.9	1680 to 1692	105 to 180	2.85 ±0.21	Nπ Nππ [Δ(1236)+π] ^e ΔK Nη	60 40 [26] ^e <.1 ^j <.5 ^j	572 538 371 231 388	
N''(1700) ⁱ	<u>1/2(1/2⁻)</u> S'' ₁₁	T=0.92 p=1.05 σ=14.3	1665 to 1765	100 to 400	2.89 ±0.44	Nπ ΔK Nη	70 5	580 250 340	
N''(1780) ⁱ	<u>1/2(1/2⁺)</u> P'' ₁₁	T=1.07 p=1.20 σ=12.2	1750 to 1860	270 to 450	3.17 ±0.62	Nπ ΔK Nη	34 ~1 ~10 ^j	633 353 476	
N(1860)	<u>1/2(3/2⁺)</u> P ₁₃	T=1.22 p=1.36 σ=10.4	1840 to 1900	310 to 450	3.46 ±0.62	Nπ Nππ ΔK Nη	27 <16	685 657 437 545	
N(1990)	<u>1/2(7/2⁺)</u> F ₁₇	T=1.49 p=1.63 σ=8.34	1980 to 2000	220 to 250	3.96 ±0.47	Nπ Nππ	11	766 743	
N'''(2040)	<u>1/2(3/2⁻)</u> D''' ₁₃	T=1.60 p=1.73 σ=7.70	2030 to 2060	240 to 290	4.16 ±0.56	Nπ Nππ	17	797 775	
N(2190)	<u>1/2(7/2⁻)</u> G ₁₇	T=1.94 p=2.07 σ=6.21	2000 to 2260	~300	4.80 ±0.65	Nπ Nππ	35	888 868	
N(2650)	<u>1/2(?⁻)</u>	T=3.12 p=3.26 σ=3.67	2650	360	7.02 ±0.95	Nπ Nππ	(J+1/2) _x =0.45 ^f	1154 1140	
N(3030)	<u>1/2(?)</u>	T=4.27 p=4.41 σ=2.62	3030	400	9.18 ±1.21	Nπ Nππ	(J+1/2) _x =0.05 ^f	1366 1354	
Δ(1236)	<u>3/2(3/2⁺)</u> P' ₃₃	T=0.195(++) p=0.304 σ=91.8 m ₀ -m ₊₊ = .45±.85 m ₋ -m ₊₊ = 7.9±6.8	1236.0 ±0.6	120 ±2	1.53 ±0.15	Nπ Nπ ⁺ π ⁻ Nγ	99.4 0 ~0.6	231 89 262	
Δ(1650)	<u>3/2(1/2⁻)</u> S ₃₁	T=0.83 p=0.96 σ=16.4	1620 to 1695	130 to 250	2.72 ±0.25	Nπ Nππ	27 73	547 511	

N

++

BARYONS

Particle or resonance ^a	I (J ^P)	π or K Beam		Γ^b (MeV)	$M \pm \Gamma M^c$ (GeV ²)	Decay modes		p or p _{max} (MeV/c)
		T(GeV) p(GeV/c) $\sigma = 4\pi\lambda^2$ (mb)	Mass ^b (MeV)			Partial mode	Fraction %	
Δ (1670)	$3/2(3/2^-) D_{33}$	T=0.87 p=1.00 $\sigma=15.6$	1650 to 1690	175 to 300	2.79 ± 0.40	N π N $\pi\pi$	13	560 525
Δ (1890)	$3/2(5/2^+) F_{35}$	T=1.28 p=1.42 $\sigma=9.88$	1840 to 1910	135 to 380	3.57 ± 0.52	N π N $\pi\pi$	17	704 677
Δ (1910)	$3/2(1/2^+) P_{31}$	T=1.33 p=1.46 $\sigma=9.54$	1835 to 1935	230 to 420	3.65 ± 0.62	N π N $\pi\pi$	25	716 691
Δ (1950)	$3/2(7/2^+) F_{37}$	T=4.41 p=1.54 $\sigma=8.90$	1935 to 1980	140 to 220	3.80 ± 0.39	N π $\Delta(1236)\pi$ ΣK $\Sigma(1385)K$ $\Delta(1236)\rho$	45 ≈ 50 2.4 1.4 seen	741 571 460 232
Δ (2420)	$3/2(11/2^+) \text{---}$	T=2.50 p=2.64 $\sigma=4.68$	2420	310	5.86 ± 0.75	N π N $\pi\pi$	11 >20	1023 1006
Δ (2850)	$3/2(?^+)$	T=3.71 p=3.85 $\sigma=3.05$	2850	400	8.12 ± 1.14	N π N $\pi\pi$	(J+1/2) _x =0.25 f	1266 1254
Δ (3230)	$3/2(?)$	T=4.94 p=5.08 $\sigma=2.25$	3230	440	10.4 ± 1.4	N π N $\pi\pi$	(J+1/2) _x =0.05 f	1475 1464
Z* Evidence for states with hypercharge 2 is controversial. See listings for discussion and display of data.								
Λ	$0(1/2^+)$		1115.6		1.24	See Stable Particles		
Λ (1405)	$0(1/2^-) S_{01}$	p < 0 K ⁻ p	1405 $\pm 5^g$	40 $\pm 10^g$	1.97 ± 0.06	$\Sigma\pi$	100	142
Λ' (1520)	$0(3/2^-) D'_{03}$	p=0.389 $\sigma=84.5$	1518 $\pm 2^g$	16 $\pm 2^g$	2.30 ± 0.02	N \bar{K} $\Sigma\pi$ $\Lambda\pi\pi$ $\Lambda\eta$ $\Sigma\pi\pi$	46 ± 1 41 ± 1 9.6 ± 6 .8 ± 2 1.0 ± 2	237 260 252 351 144
Λ' (1670)	$0(1/2^-) S'_{01}$	p=0.74 $\sigma=28.5$	1670	15 to 38	2.79 ± 0.04	N \bar{K} $\Lambda\eta$ $\Sigma\pi$	20 35 45	410 66 393
Λ'' (1690)	$0(3/2^-) D''_{03}$	p=0.78 $\sigma=26.1$	1690	27 to 85	2.86 0.09	N \bar{K} $\Sigma\pi$ $\Lambda\pi\pi$ $\Sigma\pi\pi$	30 ^h 40 20 10	429 409 415 352
Λ (1815)	$0(5/2^+) F_{05}$	p=1.05 $\sigma=16.7$	1820 $\pm 5^g$	64 to 100	3.30 ± 0.15	N \bar{K} $\Sigma\pi$ $\Sigma(1385)\pi$	64 11 17	537 504 358
Λ (1830)	$0(5/2^-) D_{05}$	p=1.09 $\sigma=15.8$	1835	66 to 150	3.37 ± 0.20	N \bar{K} $\Sigma\pi$	10 30	550 515
Λ (2100)	$0(7/2^-) G_{07}$	p=1.68 $\sigma=8.68$	2100	60 to 145	4.41 ± 0.22	N \bar{K} $\Sigma\pi$ $\Lambda\eta$ ΞK $\Lambda\omega$	25 ~ 1 < 3 < 10	748 699 617 483 443
Λ (2350)	$0(?)$	p=2.29 $\sigma=5.85$	2350	140 to 324	5.52 ± 0.55	N \bar{K}	(J+1/2) _x =0. f	913

Particle or resonance ^a	I (J ^P)	π or K Beam		Mass ^b (MeV)	Γ^b (MeV)	$M^2 \pm \Gamma M^c$ (GeV ²)	Decay modes		P or P _{max} ^d (MeV/c)
		T(GeV) p(GeV/c)	$\sigma = 4\pi\lambda^2$ (mb)				Partial mode	Fraction %	
Σ	<u>1(1/2⁺)</u>			(+)1189.4 (0)1192.5 (-)1197.3		1.41 1.42 1.43	See Stable Particles		
Σ (1385)	<u>1(3/2⁺)</u> P ₁₃	p < 0 K ⁻ p		(+)1383±1 S=1.3* (-)1386±2 S=2.2*	(+)36±3 S=1.9* (-)36±6 S=3.5*!	1.92 ±0.05	$\Lambda\pi$ $\Sigma\pi$	90±3 10±3 S=1.4*	208 117
Σ (1670) ^k	<u>1(3/2⁻)</u> D ₁₃	p=0.74 σ =28.5		1670	50	2.79 ±0.08	$N\bar{K}$ $\Sigma\pi$ $\Lambda\pi$ $\Sigma\pi\pi$ [Λ (1405) π] ^e $\Lambda\pi\pi$	9	410 387 447 326 207 397
Σ (1750)	<u>1(1/2⁻)</u> S ₁₁	p=0.91 σ =20.7		1750	50 to 80	3.06 ±0.11	$N\bar{K}$ $\Lambda\pi$ $\Sigma\eta$	~15 seen seen	483 507 55
Σ (1765)	<u>1(5/2⁻)</u> D ₁₅	p=0.94 σ =19.6		1765 ±5 ^g	~120	3.12 ±0.21	$N\bar{K}$ $\Lambda\pi$ Λ (1520) π Σ (1385) π $\Sigma\pi$	44 14 15 13 ~1	496 518 187 315 461
Σ (1910) ⁱ	<u>1(5/2⁺)</u> F ₁₅	p=1.25 σ =13.0		1905	70	3.65 ±0.13	$N\bar{K}$ $\Lambda\pi$ $\Sigma\pi$	11 7 4	613 619 568
Σ (2030)	<u>1(7/2⁺)</u> F ₁₇	p=1.52 σ =9.93		2030	100 to 170	4.12 ±0.27	$N\bar{K}$ $\Lambda\pi$ $\Sigma\pi$ ΞK	10 to 27 14 to 38 1 to 3 < 2	700 700 652 412
Σ (2250)	1(?) —	p=2.04 σ =6.76		2250	200	5.06 ±0.45	$N\bar{K}$	(J+1/2) _x =0.3 ^f	849
Σ (2455)	1(?) —	p=2.57 σ =5.09		2455	100	6.03 ±0.25	$N\bar{K}$	(J+1/2) _x =0.2 ^f	979
Σ (2595)	1(?) —	p=2.95 σ =4.30		2595	~140	6.73 ±0.36	$N\bar{K}$	(J+1/2) _x =0.3 ^f	1064
Ξ^l	<u>1/2(1/2⁺)</u>			(0)1314.7 (-)1321.3		1.73 1.75	See Stable Particles		
Ξ (1530) ^l	<u>1/2(3/2⁺)</u>			(0)1528.9±1.1 (-)1533.8±1.9	7.3 ±1.7	2.34 ±0.01	$\Xi\pi$	100	144
Ξ (1820) ^l	1/2(?)			1795 to 1870	12 to 99	3.31 ±0.10	$\Lambda\bar{K}$ $\Xi\pi$ Ξ (1530) π $\Sigma\bar{K}$		396 413 234 306
Ξ (1930) ^l	1/2(?)			1894 to 1964	42 to 140	3.72 ±0.18	$\Xi\pi$ Ξ (1530) π		499 336
				Seen in both final states; not clear if one, or more, states present.					
Ω^-	<u>0(3/2⁺)</u>			1672.4		2.80	See Stable Particles		

- * Quoted error includes an S(scale) factor. See footnote to Stable Particles 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 listings for information on the following: N(1700) D₁₃, N(3245), N(3690), N(3755), Δ(1690) P₃₃, Δ(1960) D₃₅, Δ(2160) P₃₃, Z₀(1780), Z₀(1865), Z₁(1900), Λ(1330), Λ(1750) P₀₁, Λ(1860) F₀₇, Λ(2010) D₀₃, Λ(2015) F₀₇, Σ(1440), Σ(1480), Σ(1620) P₁₁, Σ(1660) D₁₃, Σ(1690), Σ(1880) P₁₁, Σ(1940) D₁₃, Σ(2080) P₁₃, Σ(2130) G₁₇, 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 II of the note on N's and Δ's in the baryon listings. For Y*_s and Ξ*_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 listings.
- b. See note on N's and Δ's in baryon 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 listings; for the Y*_s and Ξ*_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 Γ_{e1}/Γ.
- g. This is only an educated guess; the error given is larger than the error of the average of the published values (see listings for the latter).
- h. Reported values of elasticity range from .18 to .34, each with a small error; x=.30 is only a guess. All the other branching fractions are dependent upon this choice. The reported values of x·x_e for the other channels favor the large value of x. An x=.25 or lower would violate unitarity.
- i. Only information coming from partial-wave analyses has been used here. For the production experiments results see the 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: P₁₁(1620) decaying mainly into Σπ, and D₁₃(1670) with branching fractions Σπ(40%), Λπ(10%), Σππ(<14%). Production experiments report four states: Σ(1620) seen only in the Λπ mode, Σ₁(1660) with appreciable Λπ and Σπ modes, Σ₂(1660) with main decay mode Λ(1405)+π (that is, Σππ), and Σ(1690) seen in the Λπ mode. Of these four, Σ₁ and Σ₂ seem to be on firmer ground than the other two and both seem to have J^P = 3/2⁻ like the D₁₃(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 P₁₁(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 ΣK, reported as a 3.5-standard-deviation effect, is not tabulated. See the listings for the other states.

GENERAL ATOMIC AND NUCLEAR CONSTANTS*

N	=	6.022169(40) × 10 ²³ mole ⁻¹ (based on A _{C12} = 12)
c	=	2.9979250(10) × 10 ¹⁰ cm sec ⁻¹
e	=	4.803250(21) × 10 ⁻¹⁰ esu = 1.6021917(70) × 10 ⁻¹⁹ coulomb
1 MeV	=	1.6021917(70) × 10 ⁻⁶ erg
ħ	=	6.582183(22) × 10 ⁻²² MeV sec
	=	1.0545919(80) × 10 ⁻²⁷ erg sec
ħc	=	1.9732891(66) × 10 ⁻¹¹ MeV cm = 197.32891(66) MeV fermi
α	=	e ² /ħc = 1/137.03602(24)
k Boltzmann	=	1.380622(59) × 10 ⁻¹⁶ erg K ⁻¹
	=	8.61708(37) × 10 ⁻¹¹ MeV K ⁻¹ = 1 eV/11604.85(49)K
m _e	=	0.5110041(16) MeV = 9.109558(54) × 10 ⁻³¹ kg
m _p	=	938.2592(52) MeV = 1836.109(11) m _e = 6.72211(63) m _{π±}
	=	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)
λ _e	=	ħ/m _e c = r _e α ⁻¹ = 3.861592(12) × 10 ⁻¹¹ cm
a _∞ Bohr	=	ħ ² /m _e e ² = r _e α ⁻² = 0.52917715(81) Å (1 Å = 10 ⁻⁸ cm)
σ Thomson	=	$\frac{8}{3}\pi r_e^2$ = 0.6652453(61) × 10 ⁻²⁴ cm ² = 0.6652453(61) barns
μ Bohr	=	eħ/2m _e c = 0.5788381(18) × 10 ⁻¹⁴ MeV gauss ⁻¹
μ nucleon	=	eħ/2m _p c = 3.152526(21) × 10 ⁻¹⁸ MeV gauss ⁻¹
$\frac{1}{2}\omega^e$ cyclotron	=	e/2m _e c = 8.794014(27) × 10 ⁶ rad sec ⁻¹ gauss ⁻¹
$\frac{1}{2}\omega^p$ cyclotron	=	e/2m _p c = 4.789484(27) × 10 ³ rad sec ⁻¹ gauss ⁻¹

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

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

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

pc = 0.3 Hρ (MeV, kilogauss, cm); 0.3 (which is 10⁻¹¹ c) enters because there are ≈ 300 "volts"/esu volt.

1 year (sidereal)	=	365.256 days = 3.1557 × 10 ⁷ sec (≈ π × 10 ⁷ sec)
density of dry air	=	1.205 mg cm ⁻³ (at 20°C, 760 mm)
acceleration by gravity	=	980.62 cm sec ⁻² (sea level, 45°)
gravitational constant	=	6.6732(31) × 10 ⁻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

π	=	3.1415927	1 rad	=	57.2957795 deg
e	=	2.7182818	1/e	=	0.3678794
ln 2	=	0.6931472	ln 10	=	2.3025851
log ₁₀ 2	=	0.3010300	log ₁₀ e	=	0.4342945

*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.

Note: A $\sqrt{\quad}$ 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	Coefficients
	\vdots	\vdots	\vdots

$1/2 \times 1/2$

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

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

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

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

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

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

$2 \times 1/2$

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

$3/2 \times 1/2$

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

$1 \times 1/2$

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

2×1

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

$3/2 \times 1$

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

1×1

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

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

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

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

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

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

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

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

$$Y_l^{-m} = (-1)^m Y_l^m$$

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

Caption for SU(3) Isoscalar Coefficient Tables (next page)

Starting Jan. 1970 we have relabeled the 8x8 table (and changed the 8x10 table) to conform with the convention that the first particle shall be a baryon, the second a meson. This convention is advocated by R. Levi Setti in his report to the 1969 Lund Conference, and our coefficients now agree with Levi Setti's Table II.

The changes that have been made, and their motivation, are as follows: The deSwart table of 8x8 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, his 8x10 table is unambiguous; it must be read with the meson first. Accordingly, before 1970 we labeled the meson first on both tables.

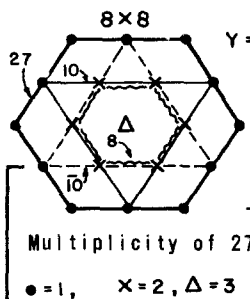
We now realize that this old convention violates the other convention that the $N, N\pi$ coupling shall be $D + F$ (as opposed to $-D + F$). To get $D + F$ we must use the first line of the "N" table, which reads $\dots 3 \sqrt{5/10} |8_D\rangle + 1/2 |8_F\rangle$ as opposed to $\dots -3 \sqrt{5/10} |8_D\rangle + 1/2 |8_F\rangle$. 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 deSwart's 8x10 SU(3) table to 10x8, with the help of his Eq. (14.3):

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

SU(3) ISOSCALAR FACTORS, adapted from J.J. de Swart, Rev. Mod. Phys. 35, 916 (1963).

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



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

		$Y=1 I=\frac{1}{2} N$				$Y=1 I=\frac{1}{2} \Delta$					
$\xi_1 \rightarrow$		$\underline{27}$	$\underline{8}_D$	$\underline{8}_F$	$\underline{10}^{(*)}$	$\underline{27}$	$\underline{10}$				
$N\pi$		$\sqrt{5}/10$	$3\sqrt{5}/10$	$1/2$	$-1/2$	$\sqrt{2}/2$	$-\sqrt{2}/2$				
ΣK		$-\sqrt{5}/10$	$-3\sqrt{5}/10$	$1/2$	$-1/2$	$\sqrt{2}/2$	$-\sqrt{2}/2$				
$N\eta$		$3\sqrt{5}/10$	$-\sqrt{5}/10$	$1/2$	$1/2$						
ΔK		$3\sqrt{5}/10$	$-\sqrt{5}/10$	$-1/2$	$-1/2$						

		$Y=0 I=0 \Lambda$				$Y=0 I=1 \Sigma$					
$\xi_1 \rightarrow$		$\underline{27}$	$\underline{8}_D$	$\underline{1}$	$\underline{8}_F$	$\underline{27}$	$\underline{8}_D$	$\underline{8}_F$	$\underline{10}$	$\underline{10}^*$	
NK		$\sqrt{15}/10$	$\sqrt{10}/10$	$1/2$	$\sqrt{2}/2$	$\sqrt{5}/5$	$-\sqrt{30}/10$	$-\sqrt{6}/6$	$-\sqrt{6}/6$	$-\sqrt{6}/6$	
ΞK		$-\sqrt{15}/10$	$-\sqrt{10}/10$	$-1/2$	$\sqrt{2}/2$	$\sqrt{5}/5$	$-\sqrt{30}/10$	$-\sqrt{6}/6$	$\sqrt{6}/6$	$-\sqrt{6}/6$	
$\Sigma\pi$		$-\sqrt{10}/20$	$-\sqrt{15}/5$	$\sqrt{6}/4$	0	0	$\sqrt{6}/3$	$\sqrt{6}/6$	$\sqrt{6}/6$	$-\sqrt{6}/6$	
$\Delta\eta$		$3\sqrt{30}/20$	$-\sqrt{5}/5$	$-\sqrt{2}/4$	0	$\sqrt{30}/10$	$\sqrt{5}/5$	0	$1/2$	$1/2$	
						$\sqrt{30}/10$	$\sqrt{5}/5$	0	$-1/2$	$-1/2$	

		$Y=-1 I=\frac{1}{2} III$				$Y=-1 I=\frac{1}{2}$	
$\xi_1 \rightarrow$		$\underline{27}$	$\underline{8}_D$	$\underline{8}_F$	$\underline{10}$	$\underline{27}$	$\underline{10}^{(*)}$
$\Xi\pi$		$-\sqrt{5}/10$	$-3\sqrt{5}/10$	$1/2$	$1/2$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Sigma\bar{K}$		$\sqrt{5}/10$	$3\sqrt{5}/10$	$1/2$	$1/2$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Xi\eta$		$3\sqrt{5}/10$	$-\sqrt{5}/10$	$-1/2$	$1/2$		
$\Delta\bar{K}$		$3\sqrt{5}/10$	$-\sqrt{5}/10$	$1/2$	$-1/2$		

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

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

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

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

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

		$Y=1 I=\frac{1}{2} N$				$Y=1 I=\frac{1}{2} \Delta$		
$\xi_1 \rightarrow$		$\underline{27}$	$\underline{8}$			$\underline{35}$	$\underline{27}$	$\underline{10}$
$\Delta\pi$		$-\sqrt{5}/5$	$-2\sqrt{5}/5$			$1/4$	$-\sqrt{5}/4$	$\sqrt{10}/4$
ΣK		$-2\sqrt{5}/5$	$\sqrt{5}/5$			$\sqrt{5}/4$	$3/4$	$\sqrt{2}/4$
						$\sqrt{10}/4$	$-\sqrt{2}/4$	$-1/2$

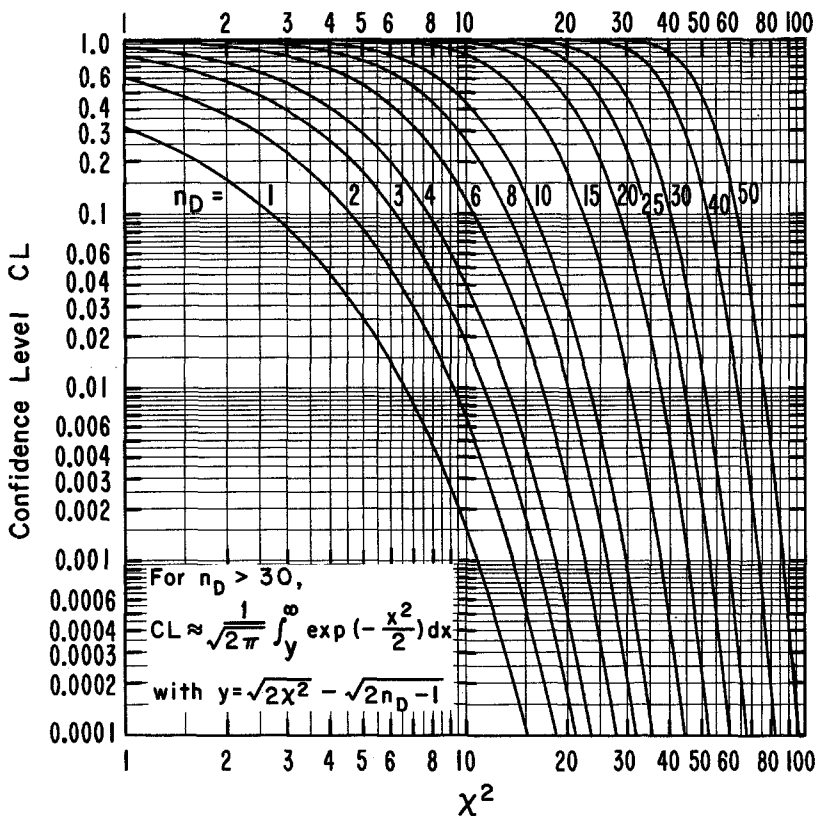
		$Y=0 I=0 \Lambda$				$Y=0 I=1 \Sigma$				$Y=0 I=2$	
$\xi_1 \rightarrow$		$\underline{27}$	$\underline{8}$			$\underline{35}$	$\underline{27}$	$\underline{10}$	$\underline{8}$	$\underline{35}$	$\underline{27}$
$\Xi\pi$		$-\sqrt{10}/5$	$-\sqrt{15}/5$			$\sqrt{3}/6$	$-3\sqrt{5}/10$	$\sqrt{3}/3$	$-\sqrt{30}/15$	$\sqrt{3}/2$	$-1/2$
ΞK		$-\sqrt{15}/5$	$\sqrt{10}/5$			$\sqrt{2}/2$	$\sqrt{30}/10$	0	$-\sqrt{5}/5$	$1/2$	$\sqrt{3}/2$
						$\sqrt{3}/3$	$-\sqrt{5}/5$	$-\sqrt{3}/3$	$\sqrt{30}/15$		
						$\sqrt{3}/6$	$\sqrt{5}/10$	$\sqrt{3}/3$	$2\sqrt{30}/15$		

		$Y=-1 I=\frac{1}{2} III$				$Y=-1 I=\frac{1}{2}$	
$\xi_1 \rightarrow$		$\underline{35}$	$\underline{27}$	$\underline{10}$	$\underline{8}$	$\underline{35}$	$\underline{27}$
$\Xi\pi$		$1/4$	$-7\sqrt{5}/20$	$\sqrt{2}/4$	$-\sqrt{5}/5$	$\sqrt{2}/2$	$-\sqrt{2}/2$
$\Xi\eta$		$3/4$	$3\sqrt{5}/20$	$-\sqrt{2}/4$	$-\sqrt{5}/5$	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΩK		$\sqrt{2}/4$	$-3\sqrt{10}/20$	$-1/2$	$\sqrt{10}/5$	$\sqrt{2}/2$	$\sqrt{2}/2$
$\Sigma\bar{K}$		$1/2$	$\sqrt{5}/10$	$\sqrt{2}/2$	$\sqrt{5}/5$		

		$Y=-2 I=0 \Omega^-$		$Y=-2 I=1$	
$\xi_1 \rightarrow$		$\underline{35}$	$\underline{10}$	$\underline{35}$	$\underline{27}$
$\Omega\eta$		$\sqrt{2}/2$	$-\sqrt{2}/2$	$1/2$	$-\sqrt{3}/2$
ΞK		$\sqrt{2}/2$	$\sqrt{2}/2$	$\sqrt{3}/2$	$1/2$

Multiplicity of 35;
•=1, x=2

CONFIDENCE LEVEL VS. χ^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 , χ^2 becomes normally distributed about n_D . Thus in the notation of the box in the figure,

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

A better approximation, due to Fisher,† is that χ , not χ^2 , is normally distributed, specifically

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

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.

GAUSSIANLIKE DISTRIBUTIONS

For $n > -1$ but not necessarily integral:

$$\int_0^\infty x^{2n+1} \exp\left[-\frac{x^2}{2\sigma^2}\right] dx = 2^n n! \sigma^{2n+2}; \left(\frac{1}{2}\right)! = \sqrt{\pi}/2$$

Relation between standard deviation σ and mean deviation α :

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

Odds against exceeding one standard deviation = 2.15:1; two, 24:1; three, 370:1; four, 16,000:1; five, 1,700,000:1.

Atomic and Nuclear Properties of Materials

Material	Z	A	Cross Section σ^a barns	Collision Length		Minimum $-dE/dx^b$		Radiation Length L_{rad}^d		Density ρ g cm ⁻³
				L_{coll}^b g cm ⁻²	cm	MeV g ⁻¹ cm ²	MeV cm ⁻¹	g cm ⁻²	cm	
H ₂	1	1.01	0.063	26.5	374	4.15	0.292	58.0	819	0.0708 ^e
D ₂	1	2.01	0.100	33.4	202	2.07	0.342	116	703	0.165 ^e
He	2	4.00	0.16	42.0	336	1.94	0.242	85.4	683	0.425 ^e
Li	3	6.94	0.23	50.4	94.3	1.69	0.902	78.7	148	0.534
Be	4	9.01	0.28	55.0	29.9	1.60	2.96	63.7	34.7	1.848
C	6	12.01	0.33	60.4	f	1.78	f	42.4	f	=1.55 ^f
N ₂	7	14.01	0.36	63.6	78.9	1.81	1.46	37.8	46.7	0.808 ^g
Ne	10	20.18	0.465	72.1	60.1	1.73	2.08	29.1 ⁱ	24.2 ⁱ	1.200 ^{g,k}
Al	13	26.98	0.57	79.2	29.3	1.62	4.37	24.0	8.9	2.70
Fe	26	55.85	0.92	101.2	12.8	1.48	11.6	13.9	1.8	7.87
Cu	29	63.54	1.00	105.4	11.8	1.44	12.9	12.0	1.34	8.96
Sa	50	118.69	1.55	129.7	17.8	1.28	9.4	8.89	1.22	7.31
W	74	183.85	2.02	150.8	7.80	1.17	22.6	6.89	0.36	19.3
Pb	82	207.19	2.20	156.2	13.8	1.13	12.8	6.52	0.58	11.35
U	92	238.03	2.42	163.6	≈8.63	1.09	≈20.6	6.13	≈0.32	≈18.95
Air				64.6	53620	1.81	0.0022	36.5	30290	0.001205 ^g
Freon (CF ₃ Br)				87.1	≈58.0	1.52	≈2.3	16.6	≈11	≈1.5
H ₂ (bubble chamber, 27°K)				26.5	442	4.13	0.248	58.0	970	≈0.060 ^h
H-Ne mixture (bubble chamber) ^j				67.3	96.1	1.83	1.28	29.8 ⁱ	42.5 ⁱ	.70
H ₂ O				57.2	57.2	2.03	2.03	35.7	35.7	1.00
Iford Emulsion				103.0	27.0		5.49	11.2	2.91	3.815
LiF				63.8	24.2	1.69	4.46	39.0	14.8	2.64
Mylar (C ₅ H ₈ O ₂)				59.1	42.8	1.91	2.64	39.6	28.7	1.38
NaI				119.0	32.4	1.32	4.84	9.58	2.61	3.67
Polyethylene (CH ₂)				51.0	≈5.5	2.09	≈1.92	44.1	≈8	≈0.92
Polystyrene (CH) [*]				54.9	≈5.3	2.03	≈2.14	43.4	≈41.3	≈1.05
Propane (C ₃ H ₈ bubble chamber)				48.9	119.3	2.28	0.935	44.6	109	0.41

a. $\sigma = \sigma_{\text{natural}} = \pi(h/m_0c)^2 \times A^{2/3} = 62.8 \text{ mb} \times A^{2/3}$
 b. $L_{\text{coll}} = A/(N\sigma_{\text{natural}}) = 26.5 \text{ g cm}^{-2} \times A^{1/3}$
 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 High Energy and Nuclear Physics Data Handbook, W. Galbraith and W. S. C. Williams, Ed. (N. I. R. N. S., Rutherford Lab., Chilton, Didcot, Berks.) 1964
 e. Liquid phase at 1 atm, and boiling temperature. f. density variable g. at 20°C
 h. May vary by about ±3%, depending on operation 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 = $0.900 \times 10^{-3} \text{ g cm}^{-3}$, i. e. 0.75×10^{-3} times the density (1.200) of the boiling liquid.
 [*] Typical scintillator, e. g. PILOT B has H/C = 1.1.

MULTIPLE COULOMB SCATTERING^b

The rms projected angle θ due to multiple Coulomb scattering (only) of a particle of charge z , momentum P , velocity V is

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

where L = length in scatterer.

For $L \geq 1/10 L_{\text{rad}}$ ϵ is generally $< 1/10$. The distribution of θ is not truly Gaussian.^c The rms projected displacement y on traversing an absorber of thickness L is $y_{\text{rms}} = L\theta_{\text{proj}}/\sqrt{3}$.

RADIOACTIVITY

1 curie = 3.7×10^{10} disintegrations/sec
 1 R = 87.8 ergs/g air = 5.49×10^7 MeV/g air
 Fluxes (per cm²) to liberate 1 R in carbon:
 3×10^7 minimum ionizing singly charged particles
 0.9×10^9 photons of 1 MeV energy.

(These fluxes are actually correct to within a factor of two for all materials.)

1 R of radiation, particularly for neutrons, may produce up to ~10 "rem" (R equivalent for man), even 20 "rem" for α and other heavy ions.

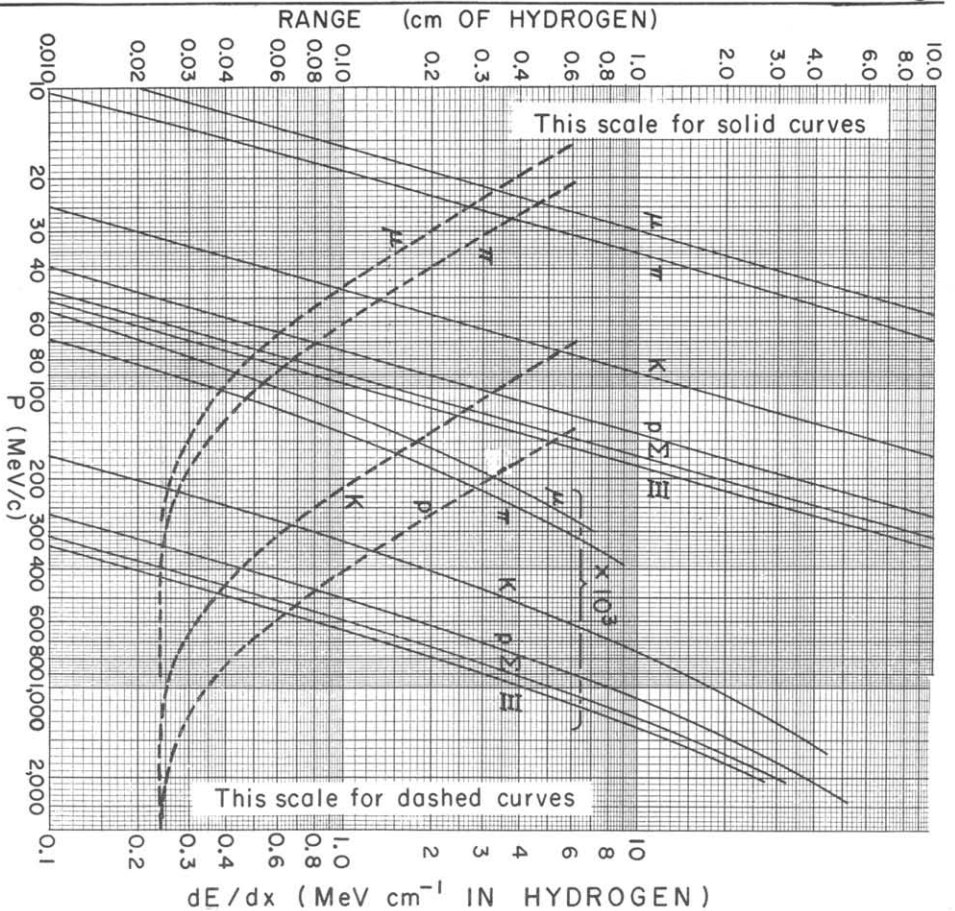
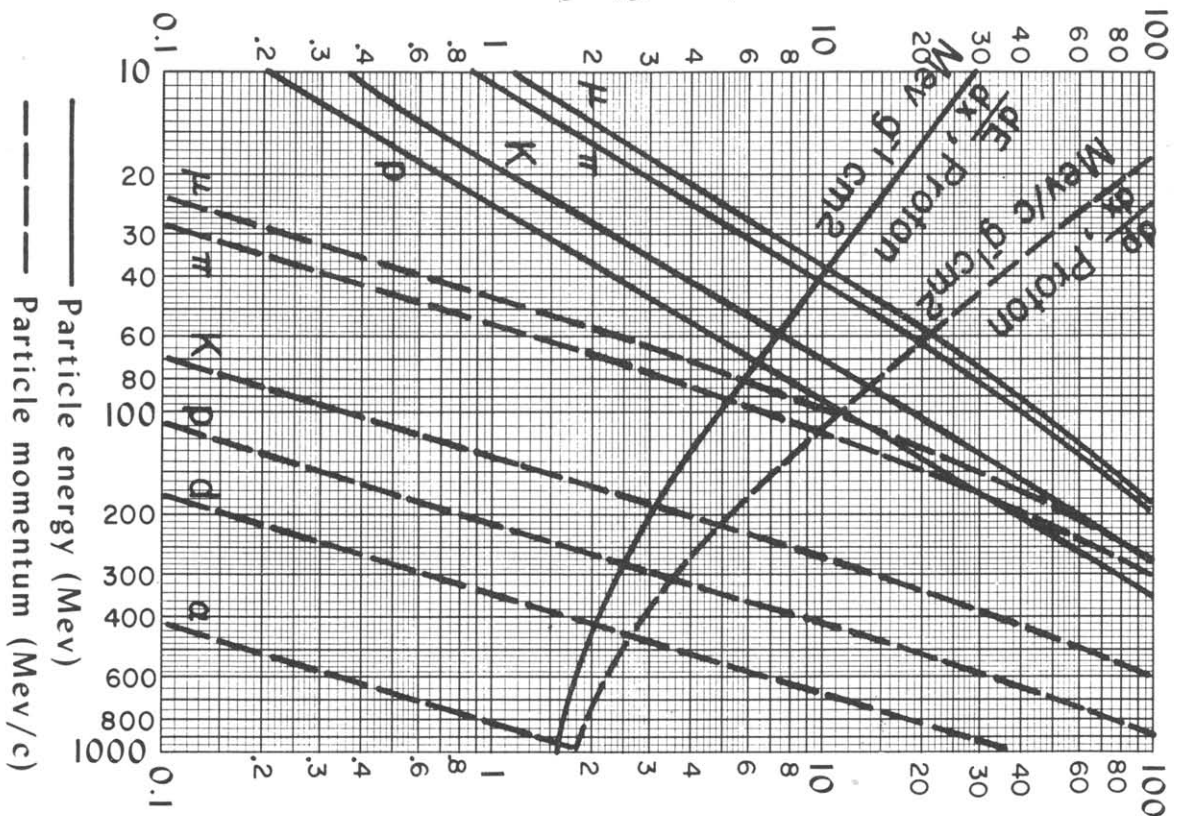
Natural background: 120 → 130 millirem/year
 divided as follows:

cosmic radiation - charged part, +neutrons ~ 25 millirem/yr
 " " - γ ~ 25 " "
 Rock and air - γ ~ 73 " "

The permissible occupational dose for the whole body: 100 millirem/week, but 1.25 rem per calendar quarter.

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

c. 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).



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

ILLUSTRATED KEY FOR DATA CARD LISTINGS

Name of particle as it appears in table. **XX(1200)**

Arrow indicates this particle omitted from table. **ORIGINALLY CALLED XXX**
OMITTED FROM TABLE

Quantity tabulated below. **74 XX(1200) MASS (MEV)**

M	L	1216.	11.	MERRILL	66 HBC	0 3.2 K-P	7/66
M	L	150(1192.)	(16.)	LYNCH	67 HBC	+ 2.7 PI-P	6/67
M	L	1198.		LYNCH DATA HAS QUESTIONABLE BACKGROUND SUBTRACTION			
M	M	1208.1	10.	PIERCE	68 ASPK	+ 2.1 K-P	9/68
M	M	1210.	8.	FENNER	69 HBC	0 4.2 PI+P	9/69*
M	M	80		SMITH	69 MMS	- 3.5 PI-P	10/69*

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

Symbols used to key together data card and related comments. **S** **S**

Number of events above background. **80**

Measured values (parentheses indicate value not used in average). **1206.9** **5.1**

Average value (and error) of quantity measured. **± Error (- field blank if error symmetric).**

74 XX(1200) WIDTH (MEV)

W	50.	10.	PIERCE	68 ASPK	+ 2.1 K-P	9/68
W	(60.)	OR LESS	SMITH	69 MMS	- 3.5 PI-P	10/69*

74 XX(1200) PARTIAL DECAY MODES

P1	XX(1200) INTO 3P1	DECAY MASSES
P2	XX(1200) INTO K KBAR	139+ 139+ 139
		493+ 493

74 XX(1200) BRANCHING RATIOS

R1	XX(1200) INTO 3P1/TOTAL	(P1)/TOTAL	
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	VALUE FROM CONSTRAINED FIT		
R1	0.675	0.012	
R2	XX(1200) INTO KKBAR/TOTAL	(P2)/TOTAL	
R2	.35	.05	PIERCE 68 ASPK + 2.1 K-P 9/68
R2	VALUE FROM CONSTRAINED FIT		
R2	0.325	0.012	
R3	XX(1200) INTO KKBAR/3P1	(P2)/(P1)	
R3	.50	.03	FENNER 69 HBC 0 4.2 PI+P 9/69*
R3	.41	.04	SMITH 69 MMS 3.5 PI-P 10/69*
R3	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)		
R3	0.468	0.043	
R3	0.480	0.029	

References listed by year, then author.

Abbreviated reference form used on data cards above.

Journal, report, preprint, etc. (see abbreviations below.)

REFERENCES FOR XX(1200)

MERRILL 66 PRL 16 143	A. MERRILL	(SACLAY+CERN)
LYNCH 67 PR 155 610	B. LYNCH	(BNL)
PIERCE 68 PL 278 230	N. PIERCE	(LRL)
FENNER 69 NC 61B 372	D. FENNER, B. BEANE	(NYSE+AMEX)
SMITH 69 PRL 22 147	J. SMITH	(SLAC)

ABBREVIATIONS

Journals

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
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
ZPHY	Zeitschrift für Physik

Conferences

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

Measurement techniques

ASPK	Automatic spark chambers
CC	Cloud chamber
CNTR	Counters, 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

Institutions

Since January 1969, when we have had to abbreviate an institutional name on the data cards, we have used the following (which is the list used by the HERA group at CERN):

AACH	TECHNISCHE UNIV. AACHEN, AACHEN, GERMANY	MANH	MANHATTAN COLLEGE, NEW YORK, N. Y., USA
AERE	ATOMIC EN. RES. ESTAB., HARWELL, BERKS., ENGLAND	MANZ	UNIV. MAINZ, MAINZ, GERMANY
AMES	IOWA STATE UNIV., AMES, IOWA, USA	MASS	UNIV. OF MASSACHUSETTS, AMHERST, MASS., USA
ANL	ARGONNE NAT. LAB., ARGONNE, ILL., USA	MGCI	MC GILL UNIV., MONTREAL, CANADA
ANNA	UNIV. OF MICHIGAN, ANN ARBOR, MICH., USA	MCHS	UNIV. MANCHESTER, MANCHESTER, ENGLAND
ARIZ	UNIV. OF ARIZONA, TUSCON, ARIZ., USA	MICH	MICHIGAN STATE UNIV., EAST LANSING, MICH., USA
ATEN	NUCLEAR RES. CENTRE DEMOKRITOS, ATHENS, GREECE	MILA	UNIV. DI MILANO, MILANO, ITALY
ATHO	OHIO UNIV., ATHENS, OHIO, USA	MINN	UNIV. OF MINNESOTA, MINNEAPOLIS, MINN., USA
BARI	UNIV. DEGLI STUDI DI BARI, BARI, ITALY	MIT	MASSACHUSETTS INST. OF TECH., CAMBRIDGE, MASS., USA
BELG	INST. INTERUNIV. DES SCI. NUC., BRUXELLES, BELGIUM	MODE	ISTITUTO DI FISICA DELLA UNIVERSITA, MODENA, ITALY
BERG	FYSISK INSTITUTT, BERGEN, NORWAY	MPIM	MAX-PLANCK-INST. FUR PHYS.-ASTROPHYS., MUNICH, GERM.
BERK	UNIV. OF CALIFORNIA, BERKELEY, CALIF., USA	MSNA	INS. DI FISICA DELL UNIV., MESSINA, ITALY
BERL	INST. HOCHENERGIEPHYS. DAW, ZEUTHEN/BERLIN, DDR	MUOX	MIAMI UNIVERSITY, OXFORD, OHIO, USA
BERN	UNIV. BERN, BERN, SWITZERLAND	NAGO	NAGOYA UNIVERSITY, NAGOYA, JAPAN
BGNA	UNIV. DI BOLOGNA, BOLOGNA, ITALY	NAL	NATIONAL ACCELERATOR LAB., BATAVIA, ILLINOIS
BIRM	BIRMINGHAM UNIV., BIRMINGHAM, ENGLAND	NAPL	UNIV. DI NAPOLI, NAPOLI, ITALY
BNL	BROOKHAVEN NAT. LAB., UPTON, L.I., N. Y., USA	NASA	LEWIS RES. CNTR., NASA, CLEVELAND, OHIO
BOHR	NIELS BOHR INSTITUTE, COPENHAGEN, DENMARK	NOAM	UNIV. OF NOTRE DAME, NOTRE DAME, INDIANA, USA
BONN	UNIV. BONN, BONN, GERMANY	NEAS	NORTHEASTERN UNIV., BOSTON, MASS., USA
BRAN	BRANDEIS UNIV., WALTHAM, MASS., USA	NEVI	NEVIS LAB., IRVINGTON-ON-HUDSON, NEW YORK, USA
BROW	BROWN UNIV., PROVIDENCE, R. I., USA	NIJM	R. K. UNIV. NIJMEGEN, NIJMEGEN, NETHERLANDS
BRUX	UNIV. LIBRE DE BRUXELLES, BRUXELLES, BELGIUM	NORD	NORDISK INS. FOR TEOR. ATOMFYS., COPENHAGEN, DENMARK
BUCH	BUCHAREST STATE UNIV., BUCHAREST, ROMANIA	NOVO	INST. OF NUCL. PHYS., NOVOSIBRSK, USSR
BUFF	ST. UNIV. OF NEW YORK AT BFLO, BUFFALO, N.Y., USA	NWES	NORTHWESTERN UNIV., EVANSTON, ILL., USA
CAEN	LAB. DE PHYS. CORPUSCULAIRE, CAEN, FRANCE	NYU	NEW YORK UNIV., NEW YORK, N. Y., USA
CALT	CALIF. INSTITUTE OF TECH., PASADENA, CALIF., USA	OHIO	OHIO STATE UNIV., COLUMBUS, OHIO, USA
CARL	CARLTON UNIVERSITY, OTTAWA, CANADA	OREG	UNIVERSITY OF OREGON, EUGENE, ORE., USA
CARN	CARNEGIE-MELLON UNIV., PITTSBURGH, PA., USA	ORNL	OAK RIDGE NATIONAL LAB., OAK RIDGE, TENN., USA
CASE	CASE WESTERN RESERVE UNIV, CLEVELAND, OHIO, USA	ORSA	UNIV. DE PARIS, FAC. DES SCI., ORSAY, FRANCE
CAVE	CAVENDISH LAB., CAMB. UNIV., CAMBRIDGE, ENGLAND	ORUC	UNION CARBIDE NUCL. DIV., OAK RIDGE, TENN., USA
CCNY	CITY COLLEGE OF NEW YORK, NEW YORK, N. Y., USA	OSLO	OSLO UNIV., OSLO, NORWAY
CDEF	COLLEGE DE FRANCE, PARIS, FRANCE	OTTA	NATIONAL RESEARCH COUNCIL, OTTAWA, CANADA
CEA	CAMBRIDGE ELECTRON ACCEL., CAMBRIDGE, MASS., USA	OXF	OXFORD UNIV., OXFORD, ENGLAND
CERN	EUROPEAN ORG. FOR NUC. RES., GENEVA, SWITZERLAND	PADO	UNIV. OF PADOVA, PADOVA, ITALY
CHIC	UNIV. OF CHICAGO, CHICAGO, ILL., USA	PENN	UNIV. OF PENNSYLVANIA, PHILADELPHIA, PA., USA
COLO	UNIV. OF COLORADO, BOULDER, COLO., USA	PISA	UNIV. DI PISA, PISA, ITALY
COLU	COLUMBIA UNIV., NEW YORK, N. Y., USA	PITH	PHYSIK. INST. DER TECH. HOCHSCHULE, AACHEN, GERMANY
CORN	CORNELL UNIV., ITHACA, N. Y., USA	PITT	UNIV. OF PITTSBURGH, PITTSBURGH, PA., USA
CWM	COL. OF WILLIAM AND MARY, WILLIAMSBURG, VA., USA	PPL	PALMER PHYS. LAB., PRINCETON UNIV., PRINCETON, N.J.
DARE	DARESBUURY NUC. PHYS. LAB., DARESBUURY, ENGLAND	PPPA	PRINCETON-PENN. PROTON ACCEL., PRINCETON, N.J., USA
DART	DARTMOUTH COLLEGE, HANOVER, NEW HAMPSHIRE	PRAG	HIGH TECHNICAL SCHOOL, PRAGUE, CZECHOSLOVAKIA
DESY	DEUTSCHES ELEKTROEN-SYNCH., HAMBURG, GERMANY	PRIN	PRINCETON UNIV., PRINCETON, N. J., USA
DUKE	DUKE UNIVERSITY, DURHAM, N.C., USA	PSEH	STAATSINST. FUR EXPERIMENTALPHYSIK, HAMBURG, GERMANY
DURH	UNIV. OF DURHAM, DURHAM, ENGLAND	PURD	PURDUE UNIV., LAFAYETTE, IND., USA
EFIN	ENRICO FERMI INST. FOR NUC. STU., CHICAGO, ILL., USA	QMCL	QUEEN MARY COLLEGE, LONDON, ENGLAND
EPOL	ECOLE POLYTECHNIQUE, PARIS, FRANCE	REHO	WEIZMANN INST. OF SCI., REHOVOTH, ISRAEL
ETHZ	EIDENOSSISCHE TECH. HOCH., ZURICH, SWITZERLAND	RHEL	RUTHERFORD HIGH EN. LAB., CHILTON, DIO, BERK. ENGLAND
FIRZ	UNIV. DI FIRENZE, FIRENZE, ITALY	RISO	RESEARCH ESTAB. RISO, ROSKILE, DENMARK
FLAS	FLORIDA STATE UNIV., TALLAHASSEE, FLA., USA	RIVS	UNIV. OF CALIFORNIA, RIVERSIDE, CALIF., USA
FLOR	UNIV. OF FLORIDA, GAINSVILLE, FLA., USA	ROCH	UNIV. OF ROCHESTER, ROCHESTER, N. Y., USA
FRAS	LAB. NAZIONALI DEL SINCROTRONE, FRASCATI, ITALY	ROMA	UNIV. DEGLI STUDI DI ROMA, ROME, ITALY
GENO	UNIV. DI GENOVA, GENOVA, ITALY	RUTG	RUTGERS UNIV., NEW BRUNSWICK, N. J., USA
GEVA	UNIV. DE GENEVE, GENEVA, SWITZERLAND	SACL	CNTR. D'ETUDES NUC. SACLAY, GIF-SUR-YVETTE, FRANCE
GLAS	UNIV. OF GLASGOW, GLASGOW, SCOTLAND	SERP	INST. OF HIGH EN. PHYS., SERPUKOV, USSR
GRAZ	UNIV. GRAZ, GRAZ, AUSTRIA	SHAM	UNIV. OF SOUTHAMPTON, SOUTHAMPTON, ENGLAND
HAMB	UNIV. HAMBURG, HAMBURG, GERMANY	SLAC	STANFORD LINEAR ACCEL. CNTR., STANFORD, CALIF., USA
HARV	HARVARD UNIV., CAMBRIDGE, MASS., USA	SOFI	BULGARIAN ACAD. OF SCI., SOFIA, BULGARIA
HAWA	UNIV. OF HAWAII, HONOLULU, HAWAII, USA	SPC	SEATTLE PACIFIC COLLEGE, SEATTLE, WASH., USA
HEID	UNIV. HEIDELBERG, HEIDELBERG, GERMANY	STAN	STANFORD UNIV., STANFORD, CALIF., USA
HELS	HELSINGIN YLIOPISTO, HELSINKI, FINLAND	STEV	STEVENS INST. OF TECH., HOBOKEN, N. J., USA
IIT	ILLINOIS INST. OF TECH., CHICAGO ILL., USA	STLO	WASHINGTON UNIV., ST. LOUIS, MO., USA
ILL	UNIV. OF ILLINOIS, URBANA, ILL., USA	STOH	STOCKHOLMS UNIV., STOCKHOLM, SWEDEN
IND	UNIV. OF INDIANA, BLOOMINGTON, IND., USA	STON	STATE U. OF N.Y., STONY BROOK, L.I., NEW YORK, USA
INRC	INST. FOR NUCLEAR RESEARCH, CRACOW, POLAND	STRB	CENTRE DES RES. NUCLEAIRES, STRASBOURG, FRANCE
INRW	INST. FOR NUCLEAR RESEARCH, WARSAW, POLAND	SUSS	SUSSEX UNIV., SUSSEX, ENGLAND
IOWA	UNIV. OF IOWA, IOWA CITY, IOWA, USA	SYR	SYRACUSE UNIV., SYRACUSE, N. Y., USA
IPN	INST. DE PHYS. NUCLEAIRE, ORSAY, FRANCE	TELA	UNIVERSITY OF TEL-AVIV, TEL-AVIV, ISRAEL
IPNP	INSTITUT DE PHYSIQUE NUCLEAIRE, PARIS, FRANCE	TENN	UNIV. OF TENNESSEE, KNOXVILLE, TENN., USA
IPPG	INSTITUTE OF PHYSICS, CSAV, PRAGUE, CZECHOSLOVAKIA	TNTO	UNIV. OF TORONTO, TORONTO, CANADA
IRAD	INSTITUTE DU RADIUM, PARIS, FRANCE	TORI	UNIV. DI TORINO, TORINO, ITALY
IRVN	UNIV. OF CALIFORNIA, IRVINE, CALIF., USA	TRST	UNIV. OF TRIESTE, TRIESTE, ITALY
ITEP	INST. FOR TEOR. AND EXP. PHYS., MOSCOW, USSR	TUFT	TUFTS UNIV., MEDFORD, MASS., USA
JHOP	JOHNS HOPKINS UNIV., BALTIMORE, MD., USA	UCLA	UNIV. OF CALIF., LOS ANGELES, CALIF., USA
JINR	JOINT INST. FOR NUCL. RESEARCH, DUBNA, USSR	UCND	UNION CARBIDE NUCL. DIV., OAK RIDGE, TENN.
KANS	UNIV. OF KANSAS, LAWRENCE, KANSAS, USA	UCSB	UNIV. OF CALIFORNIA, SANTA BARBARA, CALIF., USA
KARL	TECHNISCHE UNIV. KARLSRUHE, KARLSRUHE, GERMANY	UCSC	UNIV. OF CALIFORNIA, SANTA CRUZ, CALIF., USA
KRAK	JAGELLONIAN UNIV., KRAKOW, POLAND	UCSD	UNIV. OF CALIF AT SAN DIEGO, LA JOLLA, CALIF., USA
LANC	LANCASTER UNIV., LANCASTER, ENGLAND	UMD	UNIV. OF MARYLAND, COLLEGE PARK, MD., USA
LASL	U.C. LOS ALAMOS SCIENTIFIC LAB., LOS ALAMOS, N.M.	UPNJ	UPSALA COLLEGE, EAST ORANGE, NEW JERSEY, USA
LEBD	LEBEDEV PHYSICS INST., MOSCOW, USSR	UTAH	UNIV. OF UTAH, SALT LAKE CITY, UT., USA
LEHI	LEHIGH UNIVERSITY, BETHLEHEM, PA., USA	UVAC	UNIV. OF VIRGINIA, CHARLOTTESVILLE, VA., USA
LEID	INST. LORENTZ, LEIDEN, NETHERLANDS	VAND	VANDERBILT UNIV., NASHVILLE, TENN., USA
LHEB	LAB. DES HAUTES ENERGIES, BRUXELLES, BELGIUM	VPI	VIRGINIA POLYTECHNIC INST., BLACKSBURG, VA., USA
LIVP	LIVERPOOL UNIV., LIVERPOOL, ENGLAND	WARS	UNIV. OF WARSAW, WARSAW, POLAND
LJCP	LABORATOIRE JOLIOT-CURIE, PARIS, FRANCE	WASH	UNIV. OF WASHINGTON, SEATTLE, WASH., USA
LOIC	IMPERIAL COL. OF SCI. AND TECH., LONDON, ENGLAND	WIEN	UNIV. WIEN, WIEN, AUSTRIA
LOUC	UNIVERSITY COLLEGE, LONDON, ENGLAND	WISC	UNIV. OF WISCONSIN, MADISON, WISC., USA
LOUI	LOUISIANA STATE UNIV., BATON ROUGE, LA., USA	WPLB	H.H.WILLS PHYS. LAB./ U. OF BRISTOL, BRISTOL, ENG.
LRL	U.C. LAWRENCE RAD. LAB., BERKELEY, CALIF., USA	YALE	YALE UNIV., NEW HAVEN, CONN., USA
LUND	UNIV. I LUND, LUND, SWEDEN	ZEEM	ZEEMAN LAB. UNIV. OF AMSTERDAM, AMSTERDAM, NETH.
MADR	JUNTA DE ENERGIA NUCLEAR, MADRID, SPAIN		

DATA CARD LISTINGS

STABLE PARTICLES

I.E. IMMUNE TO STRONG DECAY

*See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.*

CODE EVENTS QUANTITY ERROR+ ERROR- REFERENCE YR TECH SIGN COMMENTS DATE
ABCEV BACKGROUND PUNCHED

γ 0 GAMMA (0,J=1)
0 GAMMA MASS (IN UNITS OF 10**+21 MEV)

M	(6.)	OR LESS	PATEL	65	SATELLITE DATA	10/69
M	(6.)	OR LESS	GINTSBURG	64	SATELLITE DATA	10/69
M	(2.3)	OR LESS	GOLDBER	68	SATELLITE DATA	10/69

REFERENCES
0 GAMMA

GINTSBUR	64	SOV. ASTR.	AJ7 536 M.	A. GINTSBURG	(ACAD SCI,USSR)
PATEL	65	PL	14 105	V. L. PATEL	(DURHAM)
GOLDBER	68	PRL	21 367	A. GOLDBER, M. NIETO	(STONY BROOK)

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

M	LESS THAN	0.25	LANGER	52	CNTR
M	LESS THAN	0.15	HAMILTON	53	CNTR
M	LESS THAN	0.55 +OR-	FRIEDMAN	58	CNTR
M	LESS THAN	0.06	BERGKVIST	69	CNTR

EL.STATIC.MAG.SP 11/69

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, R P ALFORD, L GROSS	(PRINCETON)
FRIEDMAN	58	PR	109 2214	LEWIS FRIEDMAN, INCOLN G SMITH	(RNL)
BERGKVIST	69	CERN	69-7 91	KARL-ERIK BERGKVIST	(UNIV STOCKHOLM)

ν_μ 2 MU-NEUTRINO (0,J=1/2)
2 MU-NEUTRINO MASS (MEV)

M	(3.5)	OR LESS	BARKAS	56	EMUL	
M	(4.0)	OR LESS	DUDZIAK	59	CNTR	
M	(3.6)	OR LESS	FEINBERG	63	RVUE	
M	(3.0)	OR LESS	ALLCOCK	65	RVUE	
M	(2.5)	OR LESS	BARDON	65	ASPK	
M	(2.1)	OR LESS	SHAFFER	65	CNTR	
M	(1.6)	OR LESS	BOOTH	67	CNTR	
M	(2.2)	OR LESS, CL=0.90	HYMAN	67	HEBC	
M	(0.46)	(0.64)	(0.46)	FRANK	68	CNTR

C.L.=0.67 9/68

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, MORTON, PEGPLES + (CCLUM+STONY BROOK)	
SHAFFER	65	PRL	14 923	R E SHAFFER, CROWE, JENKINS	(LRL)
BOOTH	67	PL	268 39	BOOTH, JOHNSON, WILLIAMS, WERMALD	(LIVERPOOL)
HYMAN	67	PL	25 B 376	+LOKEN, PEWITT, MCKENZIE, KEYES+(ARG+CARN+NU)	
FRANK	68	VIENNA	ABS. 365	FRANK, GAMET, LAKIN	(SHAN+LIVP+STAN)

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, MORTON, PEGPLES + (CCLUM+STONY BROOK)	
SHAFFER	65	PRL	14 923	R E SHAFFER, CROWE, JENKINS	(LRL)
BOOTH	67	PL	268 39	BOOTH, JOHNSON, WILLIAMS, WERMALD	(LIVERPOOL)
HYMAN	67	PL	25 B 376	+LOKEN, PEWITT, MCKENZIE, KEYES+(ARG+CARN+NU)	
FRANK	68	VIENNA	ABS. 365	FRANK, GAMET, LAKIN	(SHAN+LIVP+STAN)

e 3 ELECTRON (0.5,J=1/2)
3 ELECTRON MASS (MEV)

M	(0.5110060±0.00002)	COHEN	65	RVUE
M	.5110041 ±.0000016	TAYLOR	69	RVUE

USING NEW E/H 7/70*

3 ELECTRON LIFETIME (UNITS 10**+21 YR)

T	OVER	2.0	MDE	65	CNTR
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6/66

3 ELECTRON MAGNETIC MOMENT(E/2ME)

MM	(1.0011609±0.000024)	SCHUPP	61	CNTR	-
MM	(1.001159622) ±-(27)*10**+9	WILKINSON	63	CNTR	-
MM	(1.001168) ±(0.00011)	RICH	66	CNTR	+ POSITRON
MM	(1.001159557) ±-(30)*10**+9	RICH	68	CNTR	-
MM	R RICH 68 IS REEVALUATION OF WILKINSON 63				
MM	(1.001159644) ±-(7)*10**+9	WESLEY	70	CNTR	- NEW MEAS.

6/66
8/66
6/68
6/70*

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

SCHUPP	61	PR	121 1	A A SCHUPP, R W PIDG, H R CRANE	(MICHIGAN)
WILKINSO	63	PR	130 952	D T WILKINSON, H R CRANE	(MICHIGAN)
COHEN	65	RMP	67 537	E R COHEN, J W P DUMOND	(NAASC+CALTECH)
MDE	65	PR	140 B 992	M K MCE, 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	(ANNA)

μ 4 MUON (106,J=1/2)
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*

4 MUON LIFETIME (UNITS 10**+6)

T	2.198	0.001	0.001	FARLEY	62	CNTR
T	2.203	0.004		LUNDY	62	CNTR
T	2.202	0.003	0.003	ECKHAUSE	63	CNTR
T	2.197	0.002	0.002	MEYER	63	CNTR
T	2.198	0.002	0.002	MEYER	63	CNTR
T	AVG	2.1983	0.0008	0.0008	AVERAGE	(ERROR INCLUDES SCALE FACTOR OF 1.0)

CONLEV=98 11/67

4 RATIO OF LIFETIME OF MU+ TO MU-

DT	1.000	0.001	MEYER	63	CNTR
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LIFETIME MU+/MU- 7/66

4 MUON PARTIAL DECAY MODES

P1	MUON INTO E (E-NEU) (MU-NEU)	.5+	0+	0
P2	MUON INTO E 2GAMMA	.5+	0+	0
P3	MUON INTO SELECTRONS	.5+	.5+	.5
P4	MUON INTO E GAMMA	.5+	0	

DECAY MASSES

4 MUON BRANCHING RATIOS

R1	MUON INTO E+2GAMMA (IN UNITS OF 10**+5)	(P2)/(P1)
R1	(1.6)OR LESS	C.L.= .90 FRANKEL 63 OSPK
R2	MUON INTO 3E (IN UNITS OF 10**+7)	(P3)/(P1)
R2 F	(5.0)OR LESS	C.L.= .90 PARKER 62 CNTR
R2 F	(1.3)OR LESS	C.L.= .90 ALIKHANOV 62 OSPK
R2 F	(1.5)OR LESS	C.L.= .90 FRANKEL 63 CNTR
R2 F	(1.25)OR LESS	C.L.= .90 BABAEV 63 OSPK
R2 F	FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND ORDER	
R2	V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGNIFICANTLY CHANGED BY ASSUMING A CONSTANT MATRIX ELEMENT.	
R3	MUON INTO E+GAMMA (IN UNITS OF 10**+8)	(P4)/(P1)
R3	(4.3)OR LESS	C.L.= .90 FRANKEL 63 OSPK
R3	(2.2)OR LESS	C.L.= .90 PARKER 64 OSPK

4 MUON ANOMALOUS MAGN. MOMENT (10**+6*(2MUON MASS))

MM	1162.0	5.0	CHARPAK	62	CNTR	+
MM	(1165.75)	(0.71)	BAILEY	68	CNTR	+ STCR. RINGS
MM	(1166.25)	(0.24)	BAILEY	68	CNTR	- STCR. RINGS
MM	B	ERRORS STATISTICAL. VALUES COMBINED TO GIVE MU+- VALUE BELOW				
MM	1166.16	0.31	BAILEY	68	CNTR	+ STCR. RINGS
MM	AVG	1166.14	0.31	AVERAGE	(ERROR INCLUDES SCALE FACTOR OF 1.0)	

5/69
5/69
5/69

4 MUON DECAY PARAMETERS

RHO	RHO PARAMETER	(V-A THEORY PREDICTS RHO=0.75)
RHO C	(0.741) (0.027)	DUDZIAK 59 CNTR + 20-53 MEV E+
RHO P	9213 0.745 0.025	PLANC 60 HBC + WHOLE SPECTRUM
RHO P	THC PARAMETER FIT TO RHO AND ETA	
RHO C	2276 (0.751) (0.034)	BLOCK 62 HEBC - WHOLE SPECTRUM
RHO D	(0.64) (0.04)	BARLOW 64 CNTR - WHOLE SPECTRUM
RHO D	(0.661) (0.016)	BARLOW 64 CNTR + WHOLE SPECTRUM
RHO D	(0.867) (0.035)	PONTECORV 64 CC -
RHO C	RESULTS IN DOUBT	

10/69
10/69
10/69
10/69
10/69
10/69

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

PHI 800K (0.7503) (0.0026) PEOPLES 66 ASPK + 20-53 MEV E+ 10/69
RHO C 280K (0.7601) (0.0091) SHERWOOD 67 ASPK + 25-53 MEV E+ 10/69
RHO C 170K (0.7621) (0.0088) 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. 10/69
RHO 0.7518 0.0026 DERENZO 69 RVUE 10/69
RHO AVG 0.7517 0.0026 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) 10/69
ETA ETA PARAMETER (V-A THEORY PREDICTS ETA=0) 10/69
ETA P 9213 (-2.0) (0.9) PLANC 60 HBC + WHOLE SPECTRUM 10/69
ETA P TWO PARAMETER FIT TO RHO AND ETA- PLANC 60 DISCOUNTS VALUE FOR ETA 10/69
ETA C 800K (0.051) (0.51) 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 10/69
ETA C 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) 10/69
XSI 9K 0.97 0.05 BARON 59 CNTR BRGMFORM TARGET 10/69
XSI 8354 0.93 0.06 PLANC 60 HBC + 8.8 KGAUSS 10/69
XSI A (0.903) (0.027) ALI-ZADE 61 EMUL + 27 KGAUSS 10/69
XSI A DEPOLARIZATION BY MEDIUM NOT KNOWN SUFFICIENTLY WELL 10/69
XSI G 66K (0.975) (0.030) GUREVICH 64 EMUL 140 KGAUSS 10/69
XSI G 0.975 0.014 GUREVICH 67 EMUL 10/69
XSI G GUREVICH 67 SUPERCEEDS GUREVICH 64 10/69
XSI 0.972 0.013 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) 10/69
DELTA DELTA PARAMETER (V-A THEORY PREDICTS DELTA=0.75) 10/69
DEL 8354 0.78 0.05 PLANC 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 AVG 0.7551 0.0085 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) 10/69
HELICITY OF DECAY ELECTRON (V-A THEORY PREDICTS HELICITY=+1 FOR E+, RESPECTIVELY) 10/69
HEL WE HAVE FLIPPED THE SIGN FOR E- SO OUR PROGRAMS CAN AVERAGE 10/69
HEL D (0.28) (0.16) DICK 63 CNTR + ANNIHILATION 10/69
HEL D IN DOUBT - POSITIVE POSSIBLY 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 DULCIS 64 CNTR + BHABHA SCATT 10/69
HEL 29K 0.89 0.28 SCHWARTZ 67 DSPK - MOLLER SCATT 10/69
HEL AVG 1.00 0.13 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) 10/69
GS SCALAR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV) 10/69
GS (0.33) OR LESS DERENZO 69 RVUE 10/69
GA AXIALVECTOR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV) 10/69
GA 0.86 0.33 0.11 DERENZO 69 RVUE 10/69
FAV PHASE BETWEEN VECTOR AND AXIALVECTOR COUPLINGS (DEGREES) 10/69
FAV 180. 15. DERENZO 69 RVUE 10/69
GT TENSOR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV) 10/69
GT (0.28) OR LESS DERENZO 69 RVUE 10/69
GP PSEUDOSCALAR COUPLING CONSTANT IN MUON DECAY (IN UNITS OF GV) 10/69
GP (0.33) OR LESS DERENZO 69 RVUE 10/69

REFERENCES
4 MUON (106,J=1/2)
BARON 59 PRL 2 56 M BARON, D BERLEY, L LEDERMAN (COLUMBIA)
CUOZIAK 59 PR 114 336 W DUOZIAK, R SAGANE, J VEDDER (LRL)
PLANC 60 PR 119 1400 R J PLANC (COLUMBIA)
ALI-ZADE 61 JETP 40 452 ALI-ZADE, GUREVICH, NIKOLSKI (USSR)
KRUGER 61 UCRL-9322 (UNPUB) H KRUGER (LRL)
ALIKHAND 62 CERN CONF 423 A I ALIKHAND, A BABAIEV + (ITEP MOSCOW)
BLOOM 62 NC 23 1114 BLOOM, FORINI, KIKUCHI + (DUKE, BLOOMING, MILANO)
CHARPAK 62 PL 1 16 G CHARPAK, F J M FARLEY, R L GARNIN + (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)
BABAIEV 63 JETP 16 1397 BABAIEV, BALATS, KAFITANOV, LANDSBERG + (ITEP)
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)
FRANKEL 63 NC 27 894 S FRANKEL, W FRATI, J HALPERN + (PENNA)
FRANKEL 63 PR 130 351 S FRANKEL, W FRATI, J HALPERN + (PENNA)
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)
DULCIS 64 PL 9 62 +HEINTZE, DE RUJULA, SCERCEL (CERN)
GUREVICH 64 PL 11 185 GUREVICH, MAKARIYNA + (KURCHATOV, MOSCOW)
PONTECORO 64 DURNA CONF PCNTECORO, SULTAYEV (MOSCOW)
PARKER 64 PR 133B 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 288 287 +BARTL, VON BOCHMANN, BROWN, FARLEY + (CERN)
FRYBERGER 68 PR 166 1379 D FRYBERGER (EFINS)
DERENZO 69 PR 161 1854 S DERENZO (EFINS)
TAYLOR 69 RMP 41 375 +PARKER, LANGENBERG (PRIN+UCI+PENN)
VOSSLER 69 NC 63A 423 C VOSSLER (EFINS)
PAPERS NOT REFERRED TO IN DATA CARDS
FISHER 59 PRL 3 349 FISHER, LEONIC, LUNDY, MEUNIER, STROOT (CERN)
ASTBURY 60 ROCH CONF 60 542 ASTBURY, HATTERSLEY, HUSSAIN + (LIVERPOOL)
DEVONS 60 PR 5 330 DEVONS, GIDAL, LEDERMAN, SHAPIRO (COLUMBIA)
LATHROP 60 NC 17 109 J LATHROP, R A LUNDY, V L TELEGGI + (EFINS)
LATHROP 60 NC 17 114 J LATHROP, R A LUNDY, S PENMAN + (EFINS)
FEITER 60 PRL 5 22 REITER, ROMANOWSKI, SUTTON + (CARNEGIE)
TELEGGI 60 ROCH CONF 60 713 V L TELEGGI (CERN)
CHARPAK 61 PRL 6 128 CHARPAK, FARLEY, GARNIN, MULLER, SENS + (CERN)
HUTCHINS 61 PRL 7 129 D P HUTCHINSON, J MENES + (COLUMBIA)
SPAPIRO 62 PR 125 1022 G SHAPIRO, L M LEDERMAN (COLUMBIA)
FEINBERG 63 ANNS 13 431 GERALD FEINBERG, L M LEDERMAN (COLUMBIA)
FAIRLEY 66 NC 45A 281 FAIRLEY, BAILEY, BRUNN, GIESCH + (CERN)

8 CHARGED PION (140, JPC=0--) I=1
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 AVG 139.577 0.013 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M FIT 139.578 0.013 VALUE FROM CONSTRAINED FIT 6/68
8 PI+ MU+ MASS DIFFERENCE (MEV)
D 34.00 0.076 BARKAS 56 EMUL
D 33.89 0.076 BARKAS 56 EMUL
D AVG 33.945 0.055 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D FIT 33.920 0.013 VALUE FROM CONSTRAINED FIT 6/68
8 ((MASS PI+) - (MASS PI-)) / AVERAGE (PERCENT)
DM 0.02 0.05 GREENBERG 69 CNTR 5/70*
8 CHAR-PI LIFETIME (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 HERRISON 62 RVUE
T 26.02 0.04 ECKHAUSE 65 CNTR +
T 25.6 0.3 BARON 66 CNTR +
T 25.9 0.3 DUNAITSSEV 66 CNTR
T N [26.40] (0.08) KINSEY 66 CNTR +
T N SYSTEMATIC ERRORS IN CALIBR. IN THIS EXP. DISCUSSED BY NORDBERG 67 6/66
T 26.6 0.24 LOBKOWICZ 66 CNTR
T (26.6) (0.2) AYRES 67 CNTR OLD, RETRACTED 11/69
T 26.04 0.05 NORDBERG 67 CNTR +
T 26.02 0.04 GREENBERG 69 CNTR 5/70*
T AVG 26.024 0.024 0.024 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
8 MEANLIFE DIFFERENCE, (+) - (-) / AVE. (PERCENT)
DT N THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W-1.
DT 0.23 0.40 LOBKOWICZ 66 CNTR SEE NOTE L 5/66
DT L ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS 9/66
DT 0.4 0.7 BARON 66 CNTR 7/66
DT (0.56) (0.28) AYRES 67 CNTR OLD, RETRACTED 10/66
DT -0.14 0.25 PETRUKHIN 68 CNTR 8/68
DT 0.055 0.071 AYRES 69 CNTR NEW EXPT 10/69
DT AVG 0.053 0.068 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
8 CHARGED PION PARTIAL DECAY MODES
P1 CHAR-PION INTO MU (MU-NEU) DECAY MASSES 105+ 0
P2 CHAR-PION INTO E (E-NEU) 105+ 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
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 C.028 DI CAPUA 64 CNTR
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 36 0.97 0.20 BARTLETT 64 OSPK
R3 38 1.07 0.21 BACASTOW 65 OSPK +
R3 43 1.10 0.26 BERTRAM 65 OSPK 6/66
R3 332 1.00 0.08 0.10 DUNAITSSEV 65 CNTR 7/66
R3 DEPOMHIER 68 CNTR 3/68
R3 AVG 1.023 0.069 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4 CHAR-PION INTO E NEU GAMMA (UNITS 10** -8) (P5)/(P1)
R4 143 3.0 0.5 DEPOMHIER 63 CNTR GAM KE 50-90 MEV 6/66

REFERENCES
8 CHARGED PION (140, JPC=0--) I=1
CROWE 54 PR 96 470 K M CROWE, R PHILLIPS (LRL)
BARKAS 56 PR 101 778 W H BARKAS, W BIRNBAUM, F M SMITH (LRL)
CROWE 57 NC 5 941 K M CROWE (STANFORD HEPL)
CASTAGNOL 58 PR 112 1779 C CASTAGNOLI, H MUGHNIK (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)
MERRISON 62 ACVP 11 1 A W MERRISON (LIVERPOOL)
P DEPOMHIER, HEINTZE, RUBBIA, SOERDEL (CERN)
BARTLETT 63 PL 7 285 BARTLETT, DEVONS, PENER, RUSSEN (COLUMBIA)
BARTLETT 64 PR 136B 1462 DI CAPUA, GARLAND, PONDROM, STRELZOFF (COLUM)
BACASTOW 65 PR 139 8407 +GHESQUIERE, WIEGAND, LARSEN (LRL+SLAC)
BERTRAM 65 PR 139 B 617 BERTRAM, MEYER, CARRIGAN + (MICH+CARNEGIE)
DUNAITSSEV 65 JETP 20 58 DUNAITSSEV, PETRUKHIN, PROKOSHIN + (DUBNA)
ECKHAUSE 65 PL 19 348 ECKHAUSE, HARRIS, SHULER + (WILLIAM AND MARY)
BARON 66 PRL 16 775 BARON, CORE, DCRFAN, KRIEGER + (COLUMBIA)
DUNAITSSEV 66 PL 23 283 +KUTYIN, PROKOSHIN, RASUVAEV, SIMONOV (DUBNA)
KINSEY 66 PR 144 1132 KINSEY, LOBKOWICZ, NORDBERG (ROCHESTER UNIV)
LOBKOWICZ 66 PRL 17 548 LOBKOWICZ, HELISSINGS, NAGASHIMA + (ROCH+BNL)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

AYRES 67 PL 243 483 D S AYRES,CALDWELL, GREENBERG, KURZ+ (LRL)
ALSO 67 PR 157 1288 AYRES,CALDWELL, GREENBERG, KENNEY, KURZ+ (LRL)
NORDBERG 67 PL 248 594 NORDBERG, LCKBKWICZ, BURMAN (ROCHESTER UNIV)
SHAFFER 67 PR 163 1451 ROBERT E. SHAFFER (LRL)
SEE ALSO PRL 14 923 SHAFFER, CROWE, JENKINS (LRL)

DEPOMMIER 68 NUC PHYS B4 189 DEPOMMIER, DUCLOS, HEINTZE, KLEINKNECHT+(CERN)
PETRUKHI 68 JINR-P1-3862 PETRUKHIN, RYKALIN, KHAIINS, CISEK (DUBNA)
AYRES 69 UCRL-18369 DAVID S AYRES (THISIS) (LRL)
ALSO 68 PRL 21 261 AYRES, CORMACK, GREENBERG, KENNEY+ (LRL, UCSB)
GREENBER 69 PRL 23 1267 +AYRES, CORMACK, KENNEY, CALDWELL+ (LRL, UCSB)

PAPERS NOT REFERRED TO IN DATA CARDS

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, JPC=0--1) I=1
9 PI MASS DIFFERENCE (PI+-)-(PI0)(MEV)

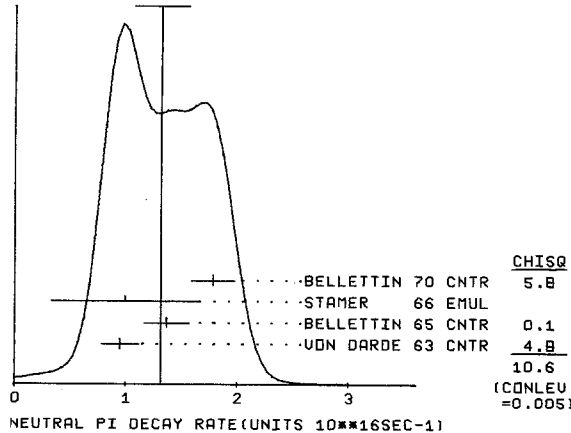
D	(5.37)	(1.0)	PANOFSKY 51 CNTR -
D	4.50	0.31	CHINOWSKY 54 CNTR -
D	4.62	0.05	HADDOCK 59 CNTR -
D	4.60	0.04	HILLMAN 59 CNTR -
D	4.55	0.07	CASSELS 59 CNTR -
D	4.6056	0.0055	CZIRR 63 CNTR -
D	4.59	0.03	PETRUKHIN 63 CNTR -
D	4.6034	0.0052	VASILEVSK 66 CNTR -
D	AVG	4.6041	0.0037 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

9 PION LIFETIME (UNITS 10**16)

T	N	76	(1.9)	(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
T			1.05	0.18	0.18	VON DARDE 63 CNTR
T	N	75	(1.7)	(0.5)	SHME 64 EMUL	6/66
T	N	67	0.730	0.105	BELLETTINI 65 CNTR	6/66
T	N	67	(1.6)	(0.6)	(0.5)	EVANS 65 EMUL
T	N	OLD	EMULSION MEASUREMENTS NOT USED BECAUSE OF POSSIBLE SYSTEMATIC SHIFT TO LARGER LIFETIME VALUES			
T	K	232	1.0	0.5	STAMER 66 EMUL	8/67
T	K	INCLUDES	EVENTS OF KOLLER 63			8/67
T			(0.6)	(0.08)	BRAUNSCHEIG 68 CNTR	9/68
T			0.56	0.06	BELLETTINI 70 CNTR	PRIM.EFF. ON NUC 7/70*
T	AVG		0.76	0.15	0.13 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)	

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 1.32 ± 0.24
ERROR SCALED BY 2.3



9 NEUTRAL PION PARTIAL DECAY MODES

P1	PIO INTO 2 GAMMA	DECAY MASSES	0+ 0
P2	PIO INTO E+ E- GAMMA	+5+ -5+ 0	
P3	PIO INTO 4 ELECTRONS	+5+ -5+ -5+ 0	.5
P4	PIO INTO 3 GAMMA	0+ 0+ 0	

9 NEUTRAL PION BRANCHING RATIOS

R1	PIO INTO (GAMMA E+ E-)/(2GAMMA)	(P2)/(P1)	
R1	(0.01196) THEORETICAL CALC. JOSEPH 60	QUANTUM ELECT.	9/66
R1	27 0.0117 0.0015	BUDAGOV 60 HBC	
R1	3071 0.01166 0.00047	SAMIOS 61 HBC	PI-P TO PION
R1	SAMIOS VALUE USES PANOFSKY RATIO = 1.62		
R1	AVG	0.0117	0.0004 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2	PIO INTO (3 GAMMA)/(2 GAMMA)	(P4)/(P1)	
R2	0 (5.0) OR LESS	DUCLOS 65 CNTR	CL 90 PERCENT 6/66
R2	(5.0) OR LESS	KUTIN 65 CNTR	90 PERCENT C.L. 3/68
R3	PIO INTO (E+ E- E-)/(2 GAMMA)	(P3)/(P1)	
R3	(3.47) THEORETICAL CALC. KRULL 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	

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

W K H PANOFSKY, R L AAMODT, J HADLEY (LRL)
W CHINOWSKY, J STEINBERGER (COLUMBIA)
H KRULL, H WADA (COLUMBIA+NRL)
CASSELS, JONES, MURPHY, O. NEILL (LIVERPOOL)
HADDOCK, ABASHIAN, CROWE, CZIRR (LRL)
HILLMAN, MIDDELKOP, YAMAGATA, ZAVATTINI (CERN)

BUDAGOV 60 JETP 11 755 BUDAGOV, VIKTOR, DZHELEPCV, ERMOLOV + (JINR)
JOSEPH 60 NC 16 997 D W JOSEPH (LEP)
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 PUESCHL (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 PROKOSHIN (JINR)
VON DARDE 63 PL 4 51 VON DARDE, DEKKERS, MERMOD, VAN PUTTEN+(CERN)

SHME 64 PR 1368 1839 H SHME, F M SMITH, W H BARKAS (LRL)
BELLETTINI 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, PROKOSHIN (JINR)

STAMER 66 PR 151 1108 STAMER, TAYLOR, KOLLER, HUETTER+ (STEVENS)
VASILEVSK 66 PL 23 281 VASILEVSK, VISHNYAKOV, OUNAITSEV + (DUBNA)

9/66 BRAUNSCHEIG 68 VIENNA ABS. 297 BRAUNSCHEIG, HUSMANN, LUBELSMEYER+ (BONN)
BELLETTINI 70 NC 66A 243 BELLETTINI, BEMPORAD, LUBELSMEYER+ (PISA+BONN)

K^{\pm}

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

M	493.9	0.2	COHEN 57 RVUE +
M	493.7	0.3	BARKAS 63 EMUL -
M	493.78	0.17	GREINER 65 EMUL + VIA TAU DECAY 7/66
M	AVG	493.81	0.12 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M	FIT	493.82	0.11 VALUE FROM CONSTRAINED FIT 6/68

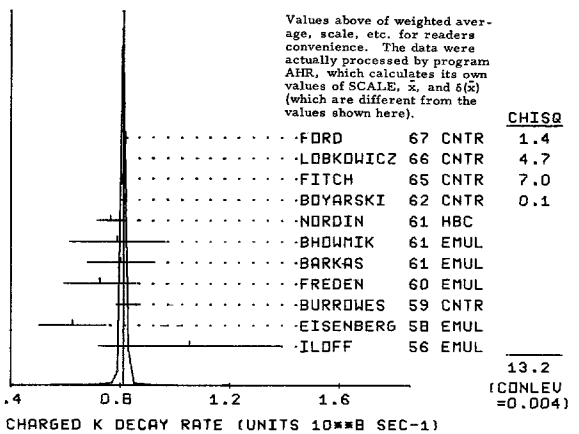
10 CHARGED K LIFETIME (UNITS 10**8)

CHARGED K CONSTRAINED FIT
OVERALL FIT OF LIFETIME, WIDTHS AND BRANCHING RATIOS USES 48 DATA POINTS TO DETERMINE SEVEN QUANTITIES. OVERALL FIT HAS CHISQ=74. MAIN CONTRIBUTION (12.7) COMES FROM R19 OF EICHTEN 68 (WE SEE NO REASON TO REJECT THIS EXPERIMENT AT THIS TIME)

CHAR. K LIFETIME

T	52	0.95	0.36	0.25	ILOFF 56 EMUL
T		1.60	0.3	0.3	EISENBERG 58 EMUL
T		1.21	0.06	0.06	BURROWS 59 CNTR
T	33	1.38	0.24	0.24	FREDEN 60 EMUL
T		1.25	0.22	0.17	BARKAS 61 EMUL
T	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 +
T		1.2265	0.0036		LOBKOWICZ 66 CNTR +
T		1.221	0.011		FORD 67 CNTR +
T	G	(1.244)	(0.005)		GIACOMELLI 67 CNTR +
T	G	GIACOMELLI 67 VALUE	JUST A CHECK ON APPARATUS		
T	AVG	1.2343	0.0052	0.0052	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.)
T	FIT	1.2349	0.0043		VALUE FROM CONSTRAINED FIT (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 0.8102 ± 0.0034
ERROR SCALED BY 2.1



See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

10 LIFETIME DIFFERENCE, (+) - (-) / AVGE. (PERCENT)			
OT N	THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.		
OT	-0.049	0.097	LCBKVIC2 66 CNTR SEE NOTE L
OT L	ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS		
OT	0.47	0.30	FORD 67 CNTR
OT	0.00	0.15	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
OT	AVG	0.00	0.15
OT	AVG	0.00	0.15
10 DECAY RATES DIFF., (+) - (-) / AV. (PERCENT)			
O1	DIFFERENCE IN K MU2 RATES ((W1+) - (W1-)) / W1		
O1	-0.54	0.41	FORD 67 CNTR
O2	DIFFERENCE IN TAL RATES ((W2+) - (W2-)) / W2		
O2	-0.04	0.21	FORD 67 CNTR
O2	-0.50	0.90	FLETCHER 67 OSPK
O2	0.00	0.15	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
O2	AVG	-0.06	0.20
O3	DIFFERENCE IN TAU PRIME RATES ((W4+) - (W4-)) / AVERAGE		
O3	1802	-1.1	1.8 HERZC 69 OSPK
O4	DIFFERENCE IN K FI2 RATES ((W2+) - (W2-)) / AVERAGE		
O4	0.8	1.2	HERZC 69 OSPK
10 CHARGED K PARTIAL DECAY MODES			
P1	CHAR. K INTO MU (NEU)	K MU2	105+ 0
P2	CHAR. K INTO PI P10	K PI2	139+ 134
P3	CHAR. K INTO PI P1+ P1-	TAU	139+ 139+ 139
P4	CHAR. K INTO PI P2P10	TAU PRIME	139+ 134+ 134
P5	CHAR. K INTO MU P10 NEU	K MU3	105+ 134+ 0
P6	CHAR. K INTO E P10 NEU	K E3	5+ 134+ 0
P7	POSIT+K INTO PI+ P1- E+NEU	K E+ 4	139+ 139+ 5+ 0
P8	POSIT+K INTO PI+ P1+ E-NEU	K E- 4	139+ 139+ 5+ 0
P9	POSIT+K INTO PI+ P1- MU+ NEU	K+MU+ 4	139+ 139+ 105+ 0
P10	POSIT+K INTO PI+ P1+ MU- NEU	K+MU- 4	139+ 139+ 105+ 0
P11	CHAR. K INTO E NEU	K E 2	5+ 0
P12	CHAR. K INTO MU NEU GAMMA	K MU RAD	105+ 0+ 0
P13	CHAR. K INTO PI P10 GAMMA	K PI RAD	139+ 134+ 0
P14	CHAR. K INTO PI P1+ P1- GAMMA	TAU RAD	139+ 139+ 139+ 0
P15	CHAR. K INTO PI E+ E-	PI 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
10 CHARGED K DECAY RATES			
W1	CHAR. K INTO MU NEU (K MU)	(UN. 10**6 SEC-1) (P1)	
W1	51.2	0.8	FORD 67 CNTR +- 8/67
W1	51.64	0.30	VALUE FROM CONSTRAINED FIT
W1	FIT	51.64	0.30
W2	CHAR. K INTO PI P1+ P1- (TAL)	(UN. 10**6 SEC-1) (P3)	
W2	4.496	0.030	FORD 67 CNTR +- 8/67
W2	4.513	0.029	VALUE FROM CONSTRAINED FIT
W2	FIT	4.513	0.029
W3	CHAR. K INTO (TAU) - (TAU PRIME)	(UNITS 10**6 SEC-1) (P3-P4)	
W3	USED FOR DELTA I=1/2 TEST		
W3	3.135	0.044	VALUE FROM CONSTRAINED FIT
W3	FIT	3.135	0.044
W4	CHAR. K INTO (MU P10 NEU) + (E PIC NEU)	(UNITS 10**6 SEC-1) (P5+P6)	
W4	USED FOR DELTA I=1/2 TEST		
W4	6.50	0.12	VALUE FROM CONSTRAINED FIT
W4	FIT	6.50	0.12
10 CHARGED K BRANCHING RATIOS			
R 0	OLD DATA EXCLUDED		
R1	CHAR. K INTO MU NEU (MU2)	(UNITS 10**6 SEC-1) (P1) / TOTAL	
R1	(58.5)	(3.0)	BIRGE 56 EMUL + 8/66
R1	(56.9)	(2.6)	ALEXANDER 57 EMUL + 8/66
R1	63.77	0.29	VALUE FROM CONSTRAINED FIT
R1	FIT	63.77	0.29
R2	CHAR. K INTO PI P10 (PI2)	(UNITS 10**6 SEC-1) (P2) / TOTAL	
R2	(27.7)	(2.7)	BIRGE 56 EMUL + 8/66
R2	(25.2)	(2.2)	ALEXANDER 57 EMUL + 8/66
R2	(21.0)	(0.6)	CALLAHAN 65 HLBC SEE R17 8/66
R2	(21.6)	(0.6)	TRILLING 65 RVUE 8/66
R2	20.93	0.29	VALUE FROM CONSTRAINED FIT
R2	FIT	20.93	0.29
R3	CHAR. K INTO PI P1+ P1- (TAU)	(UNITS 10**6 SEC-1) (P3) / TOTAL	
R3	(5.6)	(0.4)	BIRGE 56 EMUL + 8/66
R3	(6.8)	(0.4)	ALEXANDER 57 EMUL + 8/66
R3	(5.2)	(0.3)	TAYLOR 59 EMUL + 8/66
R3	5.7	0.3	ROE 61 HLBC + 8/66
R3	2332	5.54	0.12 CALLAHAN 64 HLBC + 8/66
R3	540	5.4	0.2 SHAKLEE 64 HLBC + 8/66
R3	5.71	0.15	DE MARCO 65 HBC 8/66
R3	44	6.0	0.4 YOUNG 65 EMUL + 8/66
R3	5.55	0.11	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R3	5.374	0.035	VALUE FROM CONSTRAINED FIT (SEE IDEOGRAM BELOW)
R3	FIT	5.374	0.035
R4	CHAR. K INTO PI P2P10 (TAU PRIME)	(UNITS 10**6 SEC-1) (P4) / TOTAL	
R4	(2.1)	(0.3)	BIRGE 56 EMUL + 8/66
R4	(2.2)	(0.4)	ALEXANDER 57 EMUL + 8/66
R4	(1.5)	(0.2)	TAYLOR 59 EMUL + 8/66
R4	1.7	0.2	ROE 61 HLBC + 8/66
R4	108	1.8	0.2 SHAKLEE 64 HLBC + 8/66
R4	1.75	0.14	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4	1.702	0.048	VALUE FROM CONSTRAINED FIT
R4	FIT	1.702	0.048

WEIGHTED AVERAGE = 5.55 ± 0.11
ERROR SCALED BY 1.4

Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, \bar{x} , and $\delta(\bar{x})$ (which are different from the values shown here).

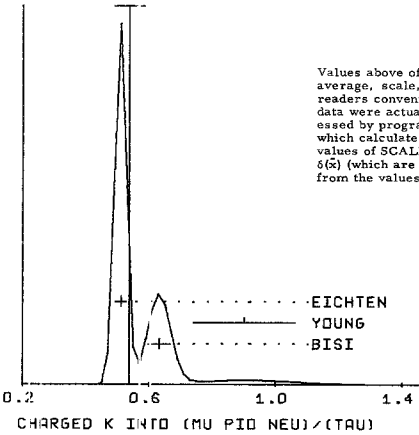
Source	Value	Scale
YOUNG	65 EMUL	1.3
DE MARCO	65 HBC	1.2
SHAKLEE	64 HLBC	5.0
CALLAHAN	64 HLBC	0.0
ROE	61 HLBC	0.3
CHISO	7.7	0.3

(CONLEV = 0.102)

R5	CHAR. K INTO MU P10 NEU (MU3)	(UNITS 10**6 SEC-1) (P5) / TOTAL	
R5	(2.8)	(1.0)	BIRGE 56 EMUL + 8/66
R5	(5.9)	(1.3)	ALEXANDER 57 EMUL + 8/66
R5	(2.8)	(0.4)	TAYLOR 59 EMUL + 8/66
R5	3.18	0.11	VALUE FROM CONSTRAINED FIT
R5	FIT	3.18	0.11
R6	CHAR. K INTO E P10 NEU (E3)	(UNITS 10**6 SEC-1) (P6) / TOTAL	
R6	(3.2)	(1.3)	BIRGE 56 EMUL + 8/66
R6	(5.1)	(1.3)	ALEXANDER 57 EMUL + 8/66
R6	5.0	0.5	ROE 61 HLBC + 8/66
R6	4.7	0.3	SHAKLEE 64 HLBC + 8/66
R6	4.78	0.26	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6	4.847	0.072	VALUE FROM CONSTRAINED FIT
R6	FIT	4.847	0.072
R7	CHAR. K INTO (PI2 + MU3) / (TCTAL)	(P2+P5) / TOTAL	
R7	WE COMBINE THESE TWO MODES FOR EXPTS MEASURING THEM IN XENON BC BECAUSE OF DIFFICULTIES OF SEPARATING THEM THERE		
R7	23.4	1.1	ROE 61 HLBC + 8/66
R7	886	25.4	0.9 SHAKLEE 64 HLBC + 8/66
R7	24.60	0.98	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R7	24.11	0.29	VALUE FROM CONSTRAINED FIT
R7	FIT	24.11	0.29
R8	POSIT+K INTO PI+ P1+ E- NEU	(UNITS 10**6 SEC-1) (P8) / TOTAL	
R8	0	OR LESS	BIRGE 65 FBC + 95 PER CT CONF 8/66
R8	0	OR LESS	ELY 69 HLBC + 95 PER CT CONF 10/69
R9	POSIT+K INTO PI+ P1- MU+ NEU	(UNITS 10**6 SEC-1) (P9) / TOTAL	
R9	1	0.77	0.54 0.50 CLINE 65 FBC + 8/66
R10	POSIT+K INTO PI+ P1+ MU- NEU	(UNITS 10**6 SEC-1) (P10) / TOTAL	
R10	0	(3.0) OR LESS	BIRGE 65 FBC + 95 PER CT CONF 8/66
R11	CHAR. K INTO E NEU	(UNITS 10**6 SEC-1) (P11) / TOTAL	
R11	(160.0)	OR LESS	BORREANI 64 HBC + CONLEV=0.95 8/66
R11	4	2.1	1.8 1.3 BOWEN 67 OSPK + 8/66
R11	BOWEN RESULT SHOULD BE CORRECTED TO 1.9+(1.7-1.2) BECAUSE OF K+ TO E- NEU GAMMA DECAYS BEFORE COMPARING WITH BOTTERILL 67 R28		
R12	CHAR. K INTO PI GAMMA / (TCTAL)	(UNITS 10**6 SEC-1) (P17) / TOTAL	
R12	(1.1)	OR LESS	CHEN 68 OSPK + 8/66
R13	CHAR. K INTO PI P10 GAMMA	(UNITS 10**6 SEC-1) (P13) / TOTAL	
R13	18	(2.2)	(0.7) CLINE 64 FBC + P1+ KE 55-80 MEV 8/66
R13	C	(1.9)	OR LESS EMERSON 69 OSPK P1+ 55-80 MEV 10/69
R13	E	90 PER CENT CONFIDENCE 10/69	
R14	CHAR. K INTO PI P1+ P1- GAMMA	(UNITS 10**6 SEC-1) (P14) / TOTAL	
R14	1.0	0.4	STAMER 65 EMUL + 8/66
R15	CHAR. K INTO PI E+ E-	(UNITS 10**6 SEC-1) (P15) / TOTAL	
R15	1	(1.1)	OR LESS CAMERINI 64 FBC + 8/66
R15	(0.4)	OR LESS	CLINE 67 FBC + 8/66
R15	(4.4)	OR LESS	BISI 67 DBC + 90 PER CT CONF 11/67
R16	CHAR. K INTO PI MU+ MU-	(UNITS 10**6 SEC-1) (P16) / TOTAL	
R16	(3.0)	OR LESS	CAMERINI 65 FBC + 90 PER CT CONF 8/66
R16	(2.4)	OR LESS	BISI 67 DBC + 90 PER CT CONF 11/67
R17	CHAR. K INTO (PI PIC) / TAU	(P2) / (P3)	
R17	134	3.24	0.34 YOUNG 65 EMUL + 8/66
R17	1045	3.96	0.15 CALLAHAN 66 FBC + 8/66
R17	3.84	0.27	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17	3.755	0.061	VALUE FROM CONSTRAINED FIT
R17	FIT	3.755	0.061
R18	CHAR. K INTO (PI P2PIC) / TAU	(P4) / (P3)	
R18	2027	0.303	0.005 BISI 65 H+HL + 8/66
R18	17	0.393	0.695 YOUNG 65 EMUL + 8/66
R18	0.3037	0.0090	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18	0.3054	0.0085	VALUE FROM CONSTRAINED FIT
R18	FIT	0.3054	0.0085
R19	CHAR. K INTO (MU P10 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	1505	0.510	0.017 EICHTEN 68 HLBC + 8/66
R19	0.537	0.048	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.1)
R19	0.571	0.021	VALUE FROM CONSTRAINED FIT (SEE IDEOGRAM BELOW)
R19	FIT	0.571	0.021

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 0.537 ± 0.048
ERROR SCALED BY 3.1



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of (SCALE, X, and $\delta(X)$) (which are different from the values shown here).

CHISQ
2.4
7.4
9.9
(CONLEV = 0.002)

R20	CHAR. K INTO (E P10 NEU)/TAU	(P6)/(IP3)	
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	BELLCTT2 67 HLBC	11/67
R20	1385 0.846 0.021	EICHTEN 68 HLBC +	11/68
R20	AVG	0.857 0.019	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R20	FIT	0.870 0.013	VALUE FROM CONSTRAINED FIT
R21	PCSIIT,K INTO (P1+ P1- E+ NEU)/TAU(UNITS 10**4)(P7)/(P3)		
R21	69 6.7 1.5	BIRGE 65 FBC +	8/66
R21	265 5.83 0.63	ELY 69 HLBC	11/68
R21	AVG	5.96 0.58	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R22	PCSIIT,K INTO (P1+ P1- MU+ NEU)/TAU(UNITS 10**4)(P9)/(P3)		
R22	1 (2.5) APPROX	GREINER 64 EMUL +	8/66
R22	7 2.57 1.55	BISI 67 DBC +	11/67
R23	CHAR. K INTO (E P10 NEU)/(MU2+PI2)(UNITS 10**2)(P6)/(P1+P2)		
R23	1675 5.89 0.21	CESTER 66 OSPK +	8/67
R23	911C 6.16 0.22	ESCHSTRUT 68 OSPK +	3/68
R23	AVG	6.02 0.15	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R23	FIT	5.723 0.092	VALUE FROM CONSTRAINED FIT
R24	CHAR. K INTO (PI PIC1)/(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	AVG	0.3230 0.0065	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R24	FIT	0.3282 0.0059	VALUE FROM CONSTRAINED FIT
R25	CHAR. K INTO (E PIC NEU)/(MU NEU)	(P6)/(P1)	
R25	472 0.0797 0.0054	AUERBACH 67 OSPK +	8/67
R25	THE VALUE .0715+-0.0025 GIVEN IN THE ABOVE REF IS AN AVERAGE OF AUERBACH 67 R25 AND CESTER 66 R23.		
R25	56C 0.0775 0.0033	BCTTERT1 68 ASPK +	5/68
R25	561 0.069 0.006	GARLAND 68 OSPK +	4/68
R25	35C 0.069 0.006	ZELLER 69 ASPK +	10/69
R25	AVG	0.0753 0.0025	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R25	FIT	0.0760 0.0012	VALUE FROM CONSTRAINED FIT
R26	CHAR. K INTO (MU PIC NEU)/(MU NEU)	(P5)/(P1)	
R26	31C 0.0602 0.0046	AUERBACH 67 OSPK +	8/67
R26	424 0.055 0.004	GARLAND 68 OSPK +	4/68
R26	24C 0.054 0.009	ZELLER 69 ASPK +	10/69
R26	AVG	0.0569 0.0029	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R26	FIT	0.0499 0.0019	VALUE FROM CONSTRAINED FIT
R27	CHAR. K INTO (MU NEU)/(TAU)	(P1)/(P3)	
R27	427 (10.38) (0.82)	YOUNG 65 EMUL +	5/66
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	FIT	11.44 0.10	VALUE FROM CONSTRAINED FIT
R28	CHAR. K INTO (E NEU)/(MU NEU) (UNITS 10**5) (P11)/(P1)		
R28	10 1.9 0.7	C.5 BCTTERT1 67 ASPK +	11/67
R28	8 1.8 0.8	C.6 MACEK 69 ASPK +	4/65
R28	AVG	1.86 0.46	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R29	CHAR. K INTO (MU P10 NEU)/(E P10 NEU)	(P5)/(P6)	
R29	C1509 0.703 0.056	CALLAPAI 66 HLBC	6/68
R29	A 1398 (0.6C4) (0.022)	EICHTEN 68 HLBC	10/68
R29	5601 0.657 0.017	BOTTER12 68 ASPK +	6/68
R29	COMMENTS		
R29	ONLY INDIVIDUAL RATIOS INCLUDED IN FIT--SEE R19 AND R20--		
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	AVG	0.67C 0.016	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R29	FIT	0.656 0.023	VALUE FROM CONSTRAINED FIT
R30	CHAR. K INTO PI E NEU GAMMA/PI E NEU	(P18)/(P6)	
R30	B 0.012 0.008	BELLCTT1 67 HLBC +	11/67
R30	B GAMMA ENERGY GREATER THAN 30 MEV		
R31	K- INTO PI+ E- E-/TOTAL (UNITS 10**5)	(P19)/TOTAL	
R31	TEST OF LEPTON NUMBER CONSERVATION		
R31	(1.5) OR LESS	CHANG 68 HBC - CL=	3/68

R32	CHAR. K INTO PI NEU NEU/ TOTAL (UNITS 10**6)	(P20)/TOTAL
R32	C (100.0) OR LESS	CAMERINI 69 HLBC + TEST NEUTR.CURR. 5/70*
R32	90 PERCENT CONFIDENCE	
R32	K (1.2) OR LESS	KLEMS 70 OSPK 5/70*
R32	K ASSUMES PI+ SPECTRUM SAME AS P10 SPECTRUM IN KE3 DECAY	
R33	CHAR. K INTO (TAU)/(TAU PRIME)	(P3/P4)
R33	USED FOR DELTA 1=1/2 TEST	
R33	FIT	3.275 0.091 VALUE FROM CONSTRAINED FIT

Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \delta P_j)$.

P 1	P 2	P 3	P 4	P 5	P 6	
P 1	.638+-0.03					
P 2	-.831	.209+-0.003				
P 3	-.167	-.084	.056+-0.000			
P 4	-.149	-.062	.204	.C17+-0.000		
P 5	-.267	-.194	.094	.008	.032+-0.001	
P 6	-.246	-.208	.185	.021	.458	.048+-0.001

Fitted Partial Decay Rates

Diagonal elements are $W_i \pm \delta W_i$; $W_i = \Gamma_{total} P_i$; $\delta W_i = \sqrt{\langle \delta W_i \delta W_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta W_i \delta W_j \rangle / (\delta W_i \delta W_j)$.

W 1	W 2	W 3	W 4	W 5	W 6	
W 1	.516+-0.003					
W 2	-.421	.169+-0.003				
W 3	-.086	-.027	.045+-0.000			
W 4	-.088	-.059	.191	.014+-0.000		
W 5	-.163	-.160	.097	.009	.026+-0.001	
W 6	-.088	-.140	.183	.022	.502	.039+-0.001

Note on K^+ and K^0 Form Factors

The definition of all the variables listed in this section can be found in the text. As in the past we keep the values of ξ as obtained in μ polarization measurements (ξ_B) separated from the values obtained from branching ratios and spectra (ξ_A).

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) $\text{Im } \xi$ so far is consistent with 0 and this is usually assumed in most of the experiments.

3) λ_- -- The data are very sensitive to λ_- , which is quite dependent on other parameters. At the present time there is no evidence for an energy dependence of f_- , but the data are not inconsistent with a large λ_- (see CRONIN 68, who uses $\lambda_- = -0.14$).

4) λ_+ is small and many experiments assume it to be zero.

However, λ_+ and ξ are very highly correlated. For example, using the relation

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

for the $K_{\mu 3}/K_{e 3}$ branching ratio given in the text, the contribution of the λ_+ term (taking $\lambda_+ = 0.03$) is $\Delta\xi = (-1.39 \times 0.03)/0.127 = -0.33$. For this reason we have not averaged the values of ξ_A that were obtained from branching ratios because different values of λ_+ were used to derive ξ . On the other hand the Dalitz plot distribution of the $K_{e 3}$ decay is essentially dependent only upon the λ_+ parameter and independent from ξ , therefore the values of λ_+ obtained from $K_{e 3}$ data can be directly averaged.

5) Radiative corrections are not serious; they change λ_+ by about 0.005 (GINSBERG 67 and 70).

In addition to the commonest correlation between ξ and λ_+ , there are many experimental difficulties. For example, in the Dalitz plot both ξ and λ_+ are most sensitive to the low E_π 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 to only part of the Dalitz plot, others fit only one projection of it.

As for the μ polarization measurements, the value of ξ is less sensitive to the q^2 dependence; in fact, the polarization depends only on ξ and not on λ_+ .

In conclusion, due to various experimental difficulties and inhomogeneous treatment of the data by the various experiments, in this edition, as always done in the past, we do not quote average values and limit this review to a listing of experimental data. Again, as in the past, the table will not include any values for λ and ξ .

We point out that the only published experiment (the X_2 collaboration) that determines ξ from all the three methods mentioned in the text (see HAIDT-2 69) shows no disagreement

at all. The overall fit of the data of this experiment gives $\xi(5.0) = -0.58 \pm 0.13$, for $\lambda_+ = +0.029$ and $\lambda_- = -0.13$.

For a recent review on K_{13} form factors, see Gaillard and Chounet.¹

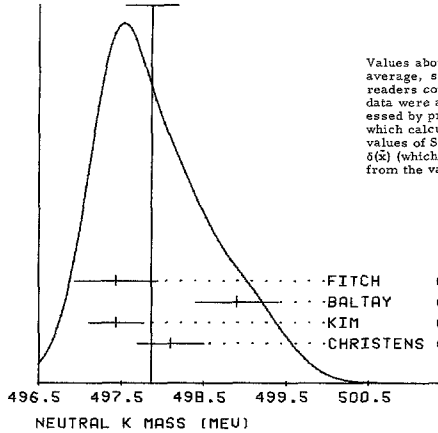
Reference

1. M. K. Gaillard and L. M. Chounet, K_{13} Form Factors, CERN 70-14 (May 1970).

10 CHARGED K FORM FACTORS									
F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT FS AND FT REFER TO THE SCALAR AND TENSOR TERM									
XIA = F-/F+ (DETERMINED FROM SPECTRA AND KMU3/KE3) -----									
UNLESS OTHERWISE NOTED, THE EXPERIMENTS BELOW EVALUATE XI ASSUMING THAT IT IS INDEPENDENT OF MOMENTUM TRANSFER, I.E. THEY SET LM+=LM-=0 AND REPORT THEIR RESULT AS XI AT T=0. IN REALITY, HOWEVER, THEY HAVE MEASURED XI OVER SOME REGION WHERE T IS NOT ZERO									
XIA	76	+1.8	1.6	BROWN	62	XEBC +	MU+,PI0	SPECTRA	8/67
XIA	87	+0.7	0.5	GIACOMPELLI	64	EMUL +	MU+ SPECTRUM	8/67	
XIA		-0.1	0.7	JENSEN	64	XEBC +	MU+,PI0 SPECTRUM	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		BTMN +0.2	AND +1.4	CUTTS	65	OSPK +	MU+ SPECTRUM	8/67	
XIA L	1509	(+0.4)	(0.4)	CALLAHAN	66	FRBC +	KMU3/KE3	8/67	
XIA	2648	0.0	1.1	0.9 CALLAHAN	66	FRBC +	MU+ SPECTRUM	8/67	
XIA	444	+0.72	0.80	CALLAHAN	66	F-BC +	P+0 SPEC, FIX MU	8/67	
XIA L		(+0.75)	(0.50)	AUERBACH	67	OSPK +	KMU3/KE3	8/67	
XIA	E1398	-0.60	0.20	EICHTEN	68	HLBC +	KMU3/KE3 T=4	10/69	
XIA B	5601	(-0.08)	(0.15)	BOTTERIL2	68	ASPK +	KMU3/KE3, LM+=0.23	6/68	
XIA	78	-0.5	0.9	EISLER	68	HLBC +	PI0 SPECT, LM+=0	6/68	
XIA L	976	(+1.0)	(0.6)	GARLAND	68	OSPK +	KMU3/KE3, LM+=0	4/68	
XIA B		-0.35	0.22	BOTTERIL2	70	OSPK +	KMU3/KE3, LM+=-0.45	10/65	
XIA	H3240	-0.36	0.24	HAIDT 1	69	HLBC +	DAL+ PLOT T=0	10/69	
XIA	H3240	-0.36	0.24	HAIDT 1	69	HLBC +	DAL+ PLOT T=6.8	10/69	
XIA		0.91	0.82	ZELLER	69	ASPK +	KMU3/KE3 NOTE Z	10/69	
XIA B	T=0	BOTTERIL 69 IS REEVALUATION OF BOTTERIL2 68 WITH DIFF. LM+							
XIA E	T=6	ASSUMES LM+=0.023+-0.008 INSENSITIVE TO LM-							
XIA H	HAIDT 69 ASSUMES LM+=-0.25-VALUES AT T=0, T=6.8 ARE UNCORRELATED								
XIA L	LM+ AND LM- ASSUMED TO BE ZERO - ACT AVERAGED								
XIA Z	T=0	ZELLER 69 ASSUMES LM+=0.023, LM-=0							
XIA	.....							
XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3) -----									
MEAS OF XI USING POLARIZATION IS LESS SENSITIVE TO FORM FACTOR VARIATIONS.									
XIB	2100	+1.2	2.4	1.8	BORREANI	65	HLBC +	POLARIZATION	8/67
XIB	397	-1.4	1.8		CALLAHAN	66	F-BC +	TOTAL POLA+	8/67
XIB	2950	-0.7	0.9	3.3	CALLAHAN	66	FRBC +	LONG+ POLAR.	8/67
XIB	H6000	-0.6	1.1		BETTELS	68	FRBC +	TOTAL PCL. T=0	11/69
XIB	H6000	-1.0	0.3		BETTELS	68	FRBC +	TOTAL PCL. T=4.9	11/69
XIB	3133	-0.95	0.3		CUTTS	68	OSPK +	TOTAL PCL. T=3	6/68
XIB B	BETTELS 68 VALUES AT T=0 AND T=4.9 ARE UNCORRELATED								
XIB	.....							
RXI REAL PART OF XI (COMBINED XIA AND XIB)									
RXI	76	+1.8	1.6	BROWN	62	XEBC +			
RXI	87	+0.7	0.5	GIACOMPELLI	64	EMUL +			
RXI		-0.1	0.7	JENSEN	64	XEBC +			
RXI	2648	0.0	1.1	0.9 CALLAHAN	66	FRBC +			
RXI	444	+0.72	0.80	CALLAHAN	66	FRBC +			
RXI	1398	-0.60	0.20	EICHTEN	68	HLBC +			
RXI	78	-0.5	0.9	EISLER	68	HLBC +			
RXI B		-0.35	0.22	BOTTERIL2	70	OSPK +	KMU3/KE3, LM+=-0.45	10/69	
RXI	H3240	-0.36	0.24	HAIDT 1	69	HLBC +			
RXI	H3240	-0.36	0.24	HAIDT 1	69	HLBC +			
RXI		0.91	0.82	ZELLER	69	ASPK +			
RXI	2100	+1.2	2.4	1.8	BORREANI	65	HLBC +		
RXI	397	-1.4	1.8		CALLAHAN	66	FRBC +		
RXI	2950	-0.7	0.9	3.3	CALLAHAN	66	FRBC +		
RXI	H6000	-1.0	0.3		BETTELS	68	FRBC +		
RXI	H6000	-0.6	1.1		BETTELS	68	FRBC +		
RXI	3133	-0.95	0.3		CUTTS	68	OSPK +		
RXI	.....							
(SEE IDEOGRAM BELOW)									
IXI IMAGINARY PART OF XI (TEST OF T REVERSAL) -----									
IXI	0.1	0.4	0.3	BETTELS	68	HLBC	POLARIZATION		10/69
FS F+/F+ RATIO OF SCALAR TC F+ COUPLINGS (ABS. VALUE) -----									
FS	(.18)	OR LESS		BELLOT2	67	HLBC	90 PERC. CONFLV		10/69
FS	(.30)	OR LESS		KALMUS	67	HLBC	+ 95 PERC. CONFLV		10/69
FS	(0.23)	OR LESS		BOTTERIL1	68	ASPK	CL=90 PERCENT		8/66
FT FT+/F+ RATIO OF TENSOR TC F+ COUPLINGS (ABS. VALUE) -----									
FT	(.58)	OR LESS		BELLOT2	67	HLBC	90 PERC. CONFLV		10/69
FT	(1.1)	OR LESS		KALMUS	67	HLBC	+ 95 PERC. CONFLV		10/69
FT	(0.58)	OR LESS		BOTTERIL1	68	ASPK	CL=90 PERCENT		8/66
LM+ LAMBDA + (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY) -----									
LM+	FOR RAD. CORR. TO THE DALITZ PLOT, SEE GINSBERG 67.								
LM+	FOR RAD. CORR. TO DALITZ PLOT OF KMU3 SEE GINSBERG 70								

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

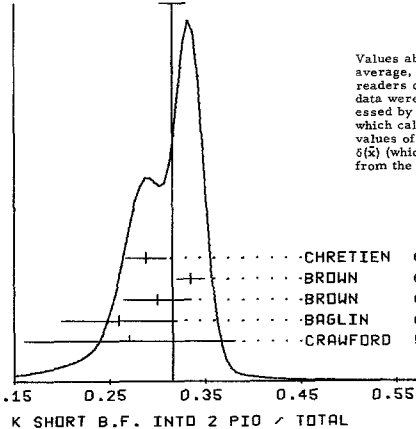
WEIGHTED AVERAGE = 497.87 ± 0.32
ERROR SCALED BY 1.5



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, x, and s(x) (which are different from the values shown here).

Table listing CHISO values for various experiments: FITCH (67 DSPK, 0.7), BALTAY (66 HBC, 4.3), KIM (65 HBC, 1.7), CHRISTENS (64 DSPK, 0.3), and a total of 7.0 (CONLEV = 0.072).

WEIGHTED AVERAGE = 0.316 ± 0.014
ERROR SCALED BY 1.3



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, x, and s(x) (which are different from the values shown here).

Table listing CHISO values for various experiments: CHRETIEN (63 HLBC, 1.8), BROWN (63 HLBC, 1.8), BROWN (61 HLBC, 0.2), BAGLIN (60 HLBC, 0.9), CRAWFORD (59 HBC, 4.7), and a total of 4.7 (CONLEV = 0.195).

Kg

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

Table with columns T, D, O, and values for various experiments like BOLDT, CRAWFORD, BERTANZA, CHRETIEN, etc. Includes a summary row for AVG and FIT.

12 KOS PARTIAL DECAY MODES

Table listing decay modes for P1, P2, P3, P4, and P5, including KOS INTO P1+, P1-, P10, P10+, P10-, P1+, P1-, and P1- GAMMA.

12 KOS BRANCHING RATIOS

Table listing branching ratios for R1, R2, R3, R4, R5, and R6, including KOS INTO (P1+ P1-)/TOTAL and KOS INTO (P10 P10+)/TOTAL.

Table listing KCS INTO (P1+ P1-)/(P10 P10) for R3, R4, R5, and R6, including values for BOZOKI, GOBBI, and MORFIN.

Table listing KOS INTO (P1+ P1-)/(KOL INTO P1+ P1- P10) for R4, R5, R6, and R7, including CPT ASSUMED TO BE GOOD and various branching ratios.

Table listing KOS INTO (P1+ P1- GAMMA)/(P1- (UNL.)) for R6, R7, and R8, including values for BELLCITTI and WEBBER.

REFERENCES

Table listing references for 12 SHORT-LIVED NEUTRAL K (498, JP=0-) I=1/2, including BOLDT, CRAWFORD, BAGLIN, BROWN, BERTANZA, etc.

PAPERS NOT REFERRED TO IN DATA CARDS

Table listing papers not referred to in data cards, including BIRGE, MULLER, FITCH, GOOD, CRAWFORD, AUERBACH, TRILLING, etc.

Kl

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

13 KOL-KOS MASS DIFFERENCE (UNITS ARE INVERSE KOS LIFETIME)

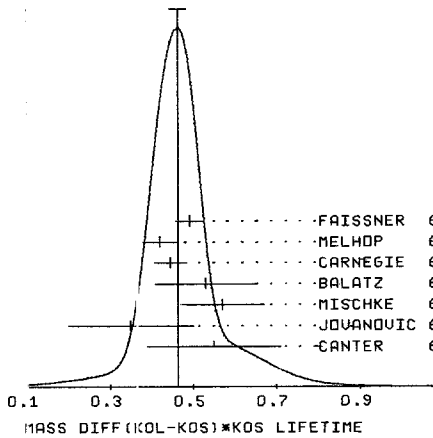
Table listing KOL-KOS MASS DIFFERENCE for D, C, and N, including values for FITCH, GOOD, CAMERINI, AUBERT, BALDC-CEO, etc.

STABLE PARTICLES

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

D	M1	+ SIGA FAVORED	MEISNER2	66 HBC	9/66
D	136	+ 0.55	CANTER	67 DBC	11/67
D		+0.35	JOVANOVIC	66 DSPK	C+URANIUM REGEN. 11/66
D		0.57	MISCHKE	67 DSPK	11/67
D	590	0.53	BALATZ	68 DSPK	AL REGENERATOR 3/68
D		0.445	CARNEGIE	68 HBC	GAP METHOD 3/68
D		+0.42	MELHOP	68 DSPK	ST-STEEL REGEN 6/68
D		0.491	FAISSNER	69 ASPK	REGEN IN CU 10/69
C		.....		
D	AVG	0.473	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		
		0.014	(SEE IDEOGRAM BELOW)		

WEIGHTED AVERAGE = 0.463 ± 0.020
ERROR SCALED BY 0.9



CHISO	CHISO
0.7	0.7
1.2	1.2
0.2	0.2
0.3	0.3
1.1	1.1
0.6	0.6
4.1	4.1
0.532	0.532

NEUTRAL K CONSTRAINED FIT
OVERALL FIT OF LIFETIME, WIDTHS AND BRANCHING RATIOS USES 52 DATA POINTS TO DETERMINE SEVEN QUANTITIES. OVERALL FIT HAS CHISO=51. VALUES OF BRANCHING RATIOS CHANGED MAINLY BECAUSE OF NEW MEASUREMENT OF R10 (EVANS 69). W2 AND W5 ARE RESPONSIBLE FOR THE LARGE SCALE FACTOR IN WIDTHS AND LIFETIME.

13 KOL LIFETIME (MICROSEC)

T	ASSUMED DS=0J AND DELTA I=1/2	CRAWFORD	59 HBC		
T	34	0.081	0.032	0.024	BARDCN 58 CC
T	15	0.051	0.024	0.013	DARMCN 62 FBC
T		0.053	0.006		FUJII 64 DSPK 8/67
T	1700	0.061	0.015	0.012	ASTBURY3 65 CC 8/67
T		0.0515	0.0014		DEVLIN 67 CNTR 8/67
T	L	(0.0501)	(0.005)		LOWYS 67 HLBC SEE NOTE L BELOW 8/67
T	L	SUM OF PARTIAL DECAY RATES			
T	AVG	0.0520	0.0014	0.0013	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
T	FIT	0.0538	0.0019		VALUE FROM CONSTRAINED FIT

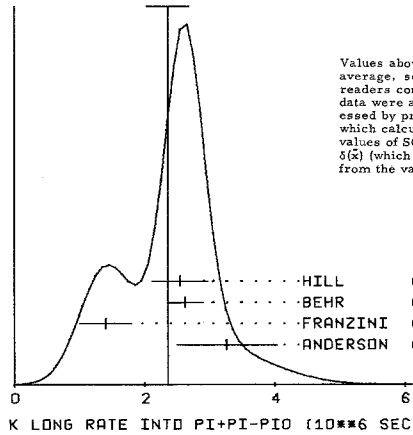
13 KOL PARTIAL DECAY MODES

P1	KOL INTO P10	DECAY MASSES	
P2	KOL INTO P1+ P1- P10	134+	134+ 134
P3	KOL INTO P1 MU NEUTRINO	139+	139+ 134
P4	KOL INTO P1 E NEUTRINO	139+	+5+ 0
P5	KOL INTO P1+ P1-	139+	139
P6	KOL INTO MU+ MU-	105+	105
P7	KOL INTO E+ E-	+5	+5
P8	KOL INTO E MU	+5	105
P9	KOL INTO TWO GAMMAS	0+	0
P10	KOL INTO P1+ P1- GAMMA	139+	139+ 0
P11	KOL INTO P10 P10	134+	134

13 KOL DECAY RATES

W1	KOL INTO P10 P10 P10	(UNITS 10**6 SEC-1) (P1)
W1	54	5.22 1.03
W1		0.84 BEHR 66 HLBC ASSUMES CP 8/66
W1	FIT	3.99 0.20 VALUE FROM CONSTRAINED FIT
W2	KOL INTO P1+ P1- P10	(UNITS 10**6 SEC-1) (P2)
W2	18	3.25 0.77
W2	14	1.4 0.4
W2	136	2.62 0.28
W2		0.27 BEHR 66 HLBC ASSUMES CP 8/66
W2		2.54 C.43
W2		HILL 66 DBC 9/66
W2	AVG	2.36 0.36
W2	FIT	2.345 0.099
		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
		VALUE FROM CONSTRAINED FIT
		(SEE IDEOGRAM BELOW)
W3	KOL INTO P1 E NEUTRINO	(UNITS 10**6 SEC-1) (P4)
W3		7.52 0.85
W3		0.72 AUBERT 65 HLBC DS=00,CP ASSUMED 8/67
W3	FIT	7.22 0.29
		VALUE FROM CONSTRAINED FIT
W4	KOL INTO CHARGED (3-BODY)	(UNITS 10**6 SEC-1) (P2+P3+P4)
W4	98	15.1 1.9
W4		AUERBACH 66 DSPK 8/67
W4	FIT	14.95 0.53
		VALUE FROM CONSTRAINED FIT

WEIGHTED AVERAGE = 2.36 ± 0.32
ERROR SCALED BY 1.7



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, x, and S(x) (which are different from the values shown here).

CHISO	CHISO
0.2	0.2
0.9	0.9
5.7	5.7
1.4	1.4
B.2	B.2
0.042	0.042

W5	KOL INTO LEPTONIC (KMU3+KE3) (UNITS 10**6 SEC-1) (P3+P4)				
W5	109	9.4	1.3	FRANZINI 65 HBC	6/66
W5	54	11.3	1.9	GOLDEN 66 HBC	9/66
W5	335	10.3	0.8	HILL 67 DBC	8/67
W5	AVG	10.19	0.64	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	
W5	FIT	12.20	0.45	VALUE FROM CONSTRAINED FIT	
W6	KOL INTO P1 MU NEUTRINO (UNITS 10**6 SEC-1) (P3)				
W6	19	4.54	1.24	1.08 LOWYS 67 HLBC	8/67
W6	FIT	4.98	0.22	VALUE FROM CONSTRAINED FIT	

13 KOL BRANCHING RATIOS

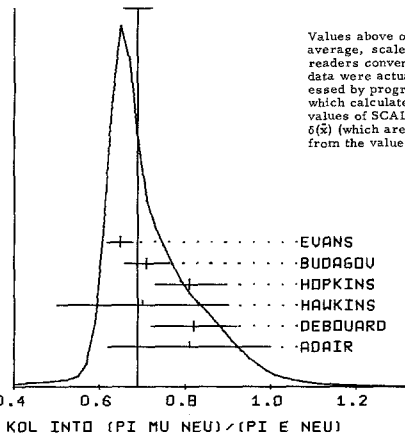
R1	KOL INTO (P10 P10 P10)/CHARGED	(P1)/(P2+P3+P4)
R1	24	0.24 0.08
R1		0.31 0.06
R1	549	0.251 0.014
R1	444	0.277 0.021
R1	AVG	0.260 0.011
R1	FIT	0.275 0.011
R2	KOL INTO (P1+ P1- P10)/CHARGED	(P2)/(P2+P3+P4)
R2	59	0.185 0.038
R2	79	0.151 0.020
R2	75	0.157 0.03
R2	66	0.15 0.03
R2	326	0.159 0.015
R2	556	0.178 0.017
R2	1729	(0.144) (0.004)
R2	126	0.162 0.015
R2	180	0.17 0.03
R2		0.161 0.005
R2	558	0.157 0.010
R2	AVG	0.1611 0.0038
R2	FIT	0.1612 0.0037
R3	KOL INTO (P1 MU NEUTRINO)/CHARGED	(P3)/(P2+P3+P4)
R3	C 251	(0.356) (0.07)
R3	C 172	(0.39) (0.08)
R3	C 330	(0.32) (0.07)
R3	C THIS MODE NOT MEASURED INDEPENDENTLY FROM R2 AND R4	
R3	FIT	0.3423 0.0083
R4	KOL INTO (P1 E NEUTRINO)/CHARGED	(P4)/(P2+P3+P4)
R4	153	0.487 0.05
R4	202	0.46 0.08
R4	500	0.51 0.06
R4	AVG	0.4931 0.053
R4	FIT	0.4965 0.0084
R5	KOL INTO (P1 E NEU)/(P1 E NEU)+(P1 MU NEU)	(P4)/(P3+P4)
R5	320	0.415 0.120
R5	FIT	0.5919 0.0097
R6	KOL INTO (P1+ P1- P10)/TOTAL	(P2)/TOTAL
R6	FIT	0.1261 0.0029
R7	KOL INTO (LEPTON P1 NEUTRINO)/TOTAL	(P3+P4)/TOTAL
R7	FIT	0.6563 0.0069
R8	KOL INTO (2 GAMMA)/TOTAL	(UN. 10**4) (P9)/TOTAL
R8	C	(1.3) (0.6)
R8	32	6.7 2.2
R8	33	7.4 1.8
R8	C	CRIEGEE 66 REPLACED BY TODDROFF 67
R8	AVG	7.2 1.3
		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

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	AVG	1.992 0.073	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	
R9	FIT	2.001 0.063	VALUE FROM CONSTRAINED FIT	

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	DEBUARD 67 OSPK	SEE NOTE N BELOW 11/67
R10	273 0.7 0.2	HAWKINS 67 HBC	8/67
R10	0.81 0.08	HOPKINS 67 HBC	8/67
R10	(0.625) (0.04)	BASILE 68 OSPK	10/68
R10	0.71 0.05	BUDAGOV 68 HLBC	10/68
R10	(0.71) (0.04)	BELLIERE 69 HLBC	10/69
R10	B BELLIERE 69 IS A SCANNING EXPT USING SAME EXPOSURE AS BUDAGOV 68		
R10	1309 0.648 0.030	EVANS 69 HLBC	10/69
R10	AVG	0.688 0.033	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R10	FIT	0.689 0.028	VALUE FROM CONSTRAINED FIT (SEE IDECGRAM BELOW)

WEIGHTED AVERAGE = 0.688 ± 0.033
ERROR SCALED BY 1.4



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, \bar{x} , and $\delta(\bar{x})$ (which are different from the values shown here).

EVANS	69 HLBC	1.8
BUDAGOV	68 HLBC	0.2
HOPKINS	67 HBC	2.3
HAWKINS	67 HBC	
DEBUARD	67 OSPK	1.7
ADAIR	64 HBC	
		6.0
		(CONLEU = 0.110)

R11	KOL INTO (MU+MU-)/CHARGE	(UNITS 10**6)	(P6)/(P2+P3+P4)	
R11	(100.0) OR LESS	ANKINA 65 CC		6/66
R11	(50.0) OR LESS	ABASHIAN 66 OSPK	90 PER CT CONF	8/66
R11	(250.0) OR LESS	ALFF-STEI 66 OSPK	0.90 CONF, LEVEL	9/66
R11	(2.0) OR LESS	BOTT-BODE 67 OSPK	90 PER CT CONF	8/67
R11	(35.0) OR LESS	FITCH 67 OSPK	90 PER CT CONF	3/68

R12	KOL INTO (PI+ PI- GAMMA)/TOTAL	(UNITS 10**3)	(P10)/TOTAL	
R12	(15.0) OR LESS	ANKINA 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	THATCHER 68 OSPK	90 PER CT CONF	10/68

R13	KOL INTO (E E-)/CHARGED	(UNITS 10**6)	(P7)/(P2+P3+P4)	
R13	(100.0) OR LESS	ANKINA 65 CC		6/66
R13	(50.0) OR LESS	ABASHIAN 66 OSPK	90 PRCT CONF	6/66
R13	(200.0) OR LESS	ALFF-STEI 66 OSPK	90 PRCT CONF	6/66
R13	(23.0) OR LESS	BOTT-BODE 67 OSPK	90 PER CT CONF	8/67

R14	KOL INTO (E MU)/CHARGED	(UNITS 10**4)	(P8)/(P2+P3+P4)	
R14	(10.0) OR LESS	ANKINA 65 CC		6/66
R14	(1.0) OR LESS	CARPENTER 66 OSPK	90 PER CT CONF	8/66
R14	(0.107) OR LESS	BCTT-BODE 67 OSPK	90 PER CT CONF	8/67
R14	(0.08) OR LESS	FITCH 67 OSPK	90 PER CT CONF	3/68

R15	KOL INTO (E+ PI- NEU)/(E- PI+ NEU)			
R15	0 97 (0.90) (0.18)	NEAGU 61 CC		
R15	0 894 (1.011) (0.16)	LUERS 64 HBC		8/66
R15	0 894 (0.991) (0.023)	KULYUKINA 66 CC		9/66
R15	0 1535 (1.06) (0.05)	VERHEY 66 OSPK		8/67
R15	0 LCM PRECISION EXPTS NOT AVERAGED. FOR MORE PRECISE VALUE,			
R15	0 SEE S1342 (BENNETT 70, MARX 70)			

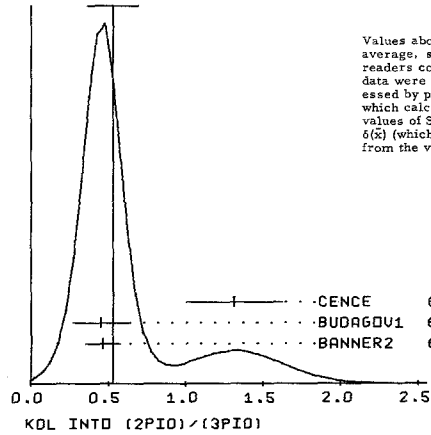
R16	KOL INTO (MU+ PI- NEU)/(MU- PI+ NEU)			
R16	3200 1.02 0.04	ARASHIAN 66 OSPK		8/66
R16	10**6 1.0081 0.0027	DORFAN 67 OSPK		11/67

R17	KOL INTO (PIO P10)/TOTAL	(UNITS 10**3)	(P11)/TOTAL	
R17	C 7 (1.2) (1.5) (1.2)	CRIGEE 66 OSPK		7/66
R17	C CRIGEE EXPT NOT DESIGNED TO MEASURE 2 P10 DECAY MODE			
R17	189 2.5 0.8	GAILLARD 69 OSPK	E00=3.6+-0.6	5/69
R17	FIT	1.21 0.30	VALUE FROM CONSTRAINED FIT	

R18	KOL INTO (3P10)/(PI+PI-PI0)	(P1)/(P2)	
R18	188 2.0 0.6	ALEKSANYA 64 HBC	9/66
R18	1010 1.80 0.13	BUDAGOV 68 HLBC	10/68
R18	AVG	1.81 0.13	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18	FIT	1.703 0.075	VALUE FROM CONSTRAINED FIT

R19	KOL INTO (2P10)/(3P10)	(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 CRONIN 2 IS FURTHER ANALYSIS OF CRONIN 1, NOW BOTH WITHDRAWN			11/68
R19	58 0.46 0.11	BANNER2 68 OSPK	ETA00=2.3+-0.3	10/68
R19	24 0.45 0.18	BUDAGOV 68 HLBC	ETA00=2.2+-0.4	10/69
R19	NG EVENTS SEEN	BARTLETT 68 OSPK	SEE E00 BELOW	11/68
R19	133 1.31 0.31	CENCE 69 OSPK	ETA00=3.7+-0.5	10/69
R19	AVG	0.53 0.17	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)	
R19	FIT	0.56 0.14	VALUE FROM CONSTRAINED FIT (SEE IDECGRAM BELOW)	

WEIGHTED AVERAGE = 0.53 ± 0.17
ERROR SCALED BY 1.9



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, \bar{x} , and $\delta(\bar{x})$ (which are different from the values shown here).

CENCE	69 DSPK	6.3
BUDAGOV1	68 HLBC	0.2
BANNER2	68 DSPK	0.4
		6.9
		(CONLEU = 0.031)

R20	KOL INTO (PI+ PI-)/(KE3 + KMU3)	(UNITS 10**3)	(P5)/(P3+P4)	
R20	309 2.51 0.23	DEBOLARD 67 OSPK		6/68
R20	525 2.35 0.19	FITCH 67 OSPK	ETA+-=1.91+-0.06	6/68
R20	AVG	2.41 0.15	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	
R20	FIT	2.386 0.076	VALUE FROM CONSTRAINED FIT	

R21	(2 GAMMA)/(3 P10)	(UNITS 10**3)	(P9)/(P1)	
R21	16 2.5 0.7	ARNOLD 68 HLBC	VACUUM DECAY	11/68
R21	115 2.24 0.28	BANNER1 68 OSPK	SEE NOTE B	11/68
R21	B THIS IS NEW EXPER. -NCT TO BE CONF. WITH 88 OF CRONIN 1 67-			11/68
R21	AVG	2.28 0.26	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	

R22	KOL INTO (MU+MU-)/(PI+PI-)	(UNITS 10**4)	(P6)/(P5)	
R22	(1.4) OR LESS	FOETH 69 ASPK		5/70*
R23	KOL INTO (E+ E-)/(PI+PI-)	(UNITS 10**4)	(P7)/(P5)	
R23	(1.0) OR LESS	FOETH 69 ASPK		5/70*

Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \delta P_j)$.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.215+-0.007					
P 2	-.229	.126+-0.003				
P 3	-.375	-.090	.268+-0.007			
P 4	-.486	-.089	-.552	.388+-0.008		
P 5	-.276	-.028	-.107	-.138	.002+-0.000	
P 6	.124	-.043	-.061	-.080	-.046	.001+-0.000

Fitted Partial Decay Rates

Diagonal elements are $W_i \pm \delta W_i$; $\delta W_i = \sqrt{\langle \delta W_i \delta W_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta W_i \delta W_j \rangle / (\delta W_i \delta W_j)$.

	W 1	W 2	W 3	W 4	W 5	W 6
W 1	3.99+- .20					
W 2	-.553	2.35+- .10				
W 3	.471	.646	4.98+- .22			
W 4	.511	.705	.545	7.22+- .29		
W 5	.435	-.622	.636	.686	.029+-0.001	
W 6	.201	-.110	-.093	-.101	.086	.023+-0.005

13 KOL FORM FACTORS

FOR DISCUSSION OF FORM FACTORS SEE NOTE PRECEDING K+ FORM FACTORS

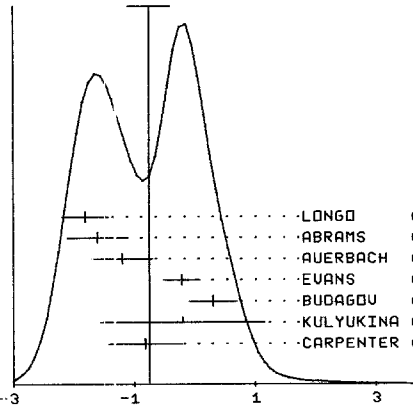
X1A	X1A = F-/F+ (DETERMINED FROM SPECTRA AND KMU3/KE3)	
X1A	UNLESS OTHERWISE NOTED, THE EXPERIMENTS BELOW EVALUATE X1 ASSUMING THAT IT IS INDEPENDENT OF MOMENTUM TRANSFER,	
X1A	I.E. THEY SET LM+LM=0 AND REPORT THEIR RESULT AS X1 AT T=0.	
X1A	IN REALITY, HOWEVER, THEY HAVE MEASURED X1 OVER SOME REGION WHERE T IS NOT ZERO	
X1A	L 389 (+1.1) (0.9) (1.3)	ADAIR 64 HBC KMU3/KE3 8/67
X1A	L (+0.66) (0.9) (1.3)	LUERS 64 HBC KMU3/KE3 8/67
X1A	L 1371 (+1.2) (0.8)	CARPENTER 66 OSPK MU,PI SPECTRA 8/67
X1A	C1371 -0.82 0.6	CARPENTER 66 OSPK MU,PI SPECTRA.C. 8/67
X1A	C 2ND CARPENTER VALUE ALLOWS ENERGY DEP OF F+/F-	
X1A	-0.2 1.0 1.7	KULYUKINA 66 CC MU,PI SPECTRA 8/67
X1A	(-3.9) (0.11)	BASILE 68 OSPK + DALITZ PLOT 10/68
X1A	(-0.4) (0.3)	BASILE 68 OSPK + KMU3/KE3 10/68
X1A	770 +0.3 +0.4	BUDAGOV 68 HLBC KMU3/KE3,LM+-0.23 11/68
X1A	1309 -0.22 0.30	EVANS 69 HLBC KM3/KE3,LM+-0.2 10/69
X1A	L LM+ AND LM- ASSUMED TO BE ZERO - NOT AVERAGED	
X1A		
X1B	X1B = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)	
X1B	MEAS OF X1 USING POLARIZATION IS LESS SENSITIVE TO FORM FACTOR VARIATIONS.	
X1B	2608 -1.2 0.5	AUERBACH 66 OSPK POLARIZATION 8/67
X1B	638 -1.6 0.5	ABRAMS 68 OSPK POLARIZATION 5/69
X1B	-1.81 0.50	LONGC 69 CNTR POL. T=2.65 11/69
X1B		

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

RXI	REAL PART OF XI	IMAGINARY PART OF XI	(COMBINED XIA AND XIB)	EXPERIMENT	STATUS
1371	+1.21	(0.8)		CARPENTER	66 DSPK
1371	-0.32	0.6		CARPENTER	66 DSPK
	-0.2	1.0	1.7	KULYUKINA	66 CC
	(-3.9)	(0.1)		BASILEI	68 DSPK +
	(-0.4)	(0.3)		BASILEI	68 DSPK +
770	+0.3	+0.4		BUDAGCV	68 HLBC
1309	-0.22	0.30		EVANS	69 HLBC
26CB	-1.2	0.5		AUERBACH	66 DSPK
638	-1.6	0.5		ABRAMS	68 DSPK
	-1.81	0.50	0.26	LONGC	69 CNTR

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = -0.75 ± 0.35
ERROR SCALED BY 2.1



EXPERIMENT	STATUS	CHISQ
LONGC	69 CNTR	7.8
ABRAMS	68 DSPK	2.9
AUERBACH	66 DSPK	0.8
EVANS	69 HLBC	3.1
BUDAGCV	68 HLBC	6.9
KULYUKINA	66 CC	
CARPENTER	66 DSPK	0.0
		21.5
(CONLEU = 0.001)		

COMBINED F-/F+ USING BOTH XIA AND XIB

IXI	IMAGINARY PART OF XI (TEST OF T REVERSAL)	EXPERIMENT	STATUS	MU POLARIZATION	DATE
IXI	-0.2	0.6	ABRAMS	68 DSPK	10/69
IXI	-0.02	0.08	LONGC	69 CNTR	11/69
IXI	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)				
IXI AVG	-0.020	0.079			

FS	FS/F+ RATIO OF SCALAR TO F+ COUPLINGS (ABS. VALUE) OR LESS	EXPERIMENT	STATUS	PERCENT COLE	DATE
FS	0.15	0.6	KULYUKINA	67 CC	10/69
FT	FT/F+ RATIO OF TENSER TO F+ COUPLINGS (ABS. VALUE) OR LESS	EXPERIMENT	STATUS	PERCENT COLE	DATE
FT	11.0	0.6	KULYUKINA	67 CC	10/69

LM+	LAMBDA + LINEAR ENERGY DEPENDENCE OF F+ IN K0 E3 DECAY	EXPERIMENT	STATUS	DATE		
LM+	FCR RAD. CORR. TO THE DALITZ PLOT OF KE3, SEE GINSBERG 67.					
LM+	FCR RAD. CORR. TO DALITZ PLOT OF KMU3 SEE GINSBERG 70					
LM+	153	+0.07	0.06	LUERS	64 DLTZ PLY, NO RAD CORR	8/67
LM+	577	+0.15	0.08	FISHER	65 OSPDLTZ PLY, NO RAD CORR	8/67
LM+	762	-0.01	0.02	FIRESTONE	67 HBC DLTZ PLY, NO RAD CORR	8/67
LM+	531	+0.01	0.015	KADYK	67 HBC E, PI SPEC, NO RAD COR	8/67
LM+	240	+0.08	0.10	LOWYS	67 FBC PI SPEC, RAD CORR	8/67
LM+	1000	0.02	0.013	ARNSON	68 DSPK PI SPECTRUM	5/69
LM+	4800	+0.023	0.012	BASILE	68 DSPK DLTZ PLY, NO RAD COR	3/68
LM+ AVG	0.0172	0.020	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

13 NEUTRAL K ENERGY DEPENDENCE OF DALITZ PLOT

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

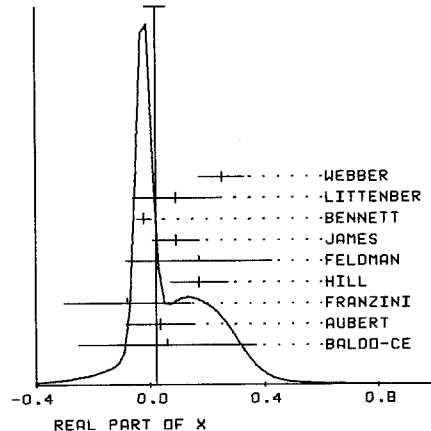
GTO	LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS	KLUNG INTO P10 PI+PI-	EXPERIMENT	STATUS	DATE	
GTO	1350	(0.651)	(0.044)	HOPKINS	67 HBC	10/69
GTO	1198	0.437	0.057	NEFKENS	67 DSPK	10/69
GTO	2446	0.382	0.040	BASILE2	68 DSPK	10/69
GTO AVG	0.400	0.033	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

13 X = (OS=CQ AMPLITUDE / OS=+OQ AMPLITUDE)

REX	REAL PART OF X	EXPERIMENT	STATUS	DATE				
REX C	152	0.06	0.18	0.44	BALCO-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	335	0.17	0.10		HILL	67 DBC	K+D YIELDS KOPP	11/67
REX	116	0.17	0.16	0.35	FELDMAN	67 DSPK	PI-P TO K0 LMBDA	11/67
REX B	(0.031)	(0.03)			BENNETT	68 CNTR		11/68
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 DSPK	K+ TO KOP	4/69
REX	262	0.25	0.07	0.09	WEBBER	69 HBC	K-P TO KBAR N	10/69
REX B	BENNETT 69 IS A REANALYSIS OF BENNETT1 68							
REX C	BALCO-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 AVG	0.021	0.036	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)					
(SEE IDEOGRAM BELOW)								

IMX	IMAGINARY PART OF X (ASSUMES P(KL)-M(KS) PCISITIVE -- SEE S13D)	EXPERIMENT	STATUS	DATE				
IMX C	152	-0.44	0.32	0.19	BALCO-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

WEIGHTED AVERAGE = 0.021 ± 0.036
ERROR SCALED BY 1.7



EXPERIMENT	STATUS	CHISQ
WEBBER	69 HBC	8.2
LITTENBER	69 DSPK	0.2
BENNETT	69 CNTR	2.7
JAMES	68 HBC	0.7
FELDMAN	67 DSPK	
HILL	67 DBC	2.2
FRANZINI	65 HBC	
AUBERT	65 HLBC	0.0
BALCO-CE	65 HLBC	
		14.1
(CONLEU = 0.015)		

IMX	EXPERIMENT	STATUS	DATE					
IMX	116	0.0	0.25	FELDMAN	67 DSPK	PI-P TO K0 LMBDA	11/67	
IMX H	335	-0.20	0.10	HILL	67 DBC	K+D YIELDS KOPP	11/67	
IMX	121	+0.22	0.37	JAMES	68 HBC	PBAR P	5/69	
IMX	686	-0.11	0.10	0.11	LITTENBER	69 DSPK	K+ TO KOP	4/69
IMX	262	0.0	0.08	WEBBER	65 HBC	K-P TO KBAR N	10/69	
IMX C	BALCO-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 H	FTNOTE 10 OF HILL 67 SHOULD READ +0.58; NOT -0.58 (PRIV COMM)							
IMX	3/68							
IMX AVG	-0.099	0.047	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					

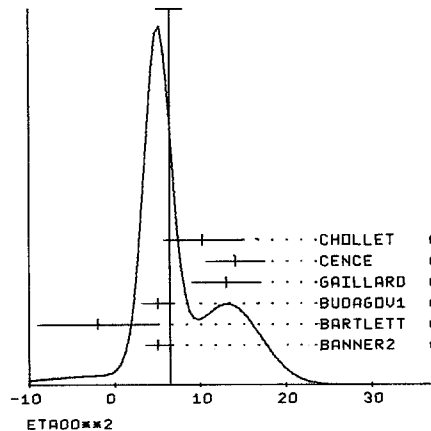
13 CP VIOLATION PARAMETERS

ETA+ = A(KL TO PI+PI-)/A(KS TO PI+PI-)
ETA00 = A(KL TO P10P10)/A(KS TO P10P10)

THE MAGNITUDES OF ETA+ AND OF ETA00 ARE DERIVED FROM BR. RATIOS. FOR THE QUANTITIES MEASURED BY THE INDIVIDUAL EXPERIMENTS SEE LISTINGS OF S13R9 AND S13R2 (ETA+) AND OF S13R17 AND S13R19 (ETA00). FOR THE READER'S CONVENIENCE WE LIST HERE THE DERIVED QUANTITIES ETA+ (E+) AND (ETA00)**2, CALLED EOS

EOS	(ETA00)**2 = (A(KL TO 2P10)/A(KS TO 2P10))**2 (UNITS 10**-6)	EXPERIMENT	STATUS	DATE			
EOS	56	5.06	1.4	BANNER2	68 DSPK	10/69	
EOS	0	-2.1	7.0	BARTLETT	68 DSPK	10/69	
EOS	24	5.05	1.9	BUDAGCVI	68 HLBC	10/69	
EOS	180	13.	4.	GAILLARD	69 DSPK	10/69	
EOS	133	14.1	3.4	CENCE	68 DSPK	10/69	
EOS	10.3	4.5		CHOLLET	69 DSPK	CU REG. 4 GAMMAS	10/69
EOS AVG	6.4	1.5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)				
(SEE IDEOGRAM BELOW)							

WEIGHTED AVERAGE = 6.4 ± 1.5
ERROR SCALED BY 1.5



EXPERIMENT	STATUS	CHISQ
CHOLLET	69 DSPK	0.7
CENCE	69 DSPK	5.1
GAILLARD	69 DSPK	2.7
BUDAGCVI	68 HLBC	0.5
BARTLETT	68 DSPK	1.5
BANNER2	68 DSPK	1.0
		11.5
(CONLEU = 0.043)		

E+-	ETA+ = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3	EXPERIMENT	STATUS	DATE		
E+-	45	(1.94)		CHRISTENS	64 DSPK	10/69
E+-	54	(2.02)		GALBRAITH	65 DSPK	10/69
E+-	(1.861)			BASILE	66 DSPK	10/69
E+-	(1.935)			BOTT-BODE	66 DSPK	10/69
E+-	525	1.91	0.06	FITCH	67 DSPK	10/69

See the illustrated key preceding the data card listings. Data in parentheses have not been included in our averages.

Table with columns for particle type (F+, F0, F-), phase of eta, and various parameters like DM, KOL, and asymmetry values. Includes sub-sections for 13 ASYMMETRY PARAMETERS and 13 CHARGE ASYMMETRY IN LEPTONIC DECAYS.

Table listing particle decays and associated researchers. Columns include particle type, phase of eta, and names of researchers or institutions. Includes a section for 14 ETA MASS (MEV) and 14 ETA WIDTH (MEV).

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

14 ETA PARTIAL DECAY MODES

			DECAY MASSES
P1	ETA INTO 2GAMMA		0+ 0
P2	ETA INTO 3PI0		134+ 134+ 134
P3	ETA INTO PI+ PI- PI0		139+ 139+ 0
P4	ETA INTO PI+ PI- GAMMA		139+ 139+ 0
P5	ETA INTO E+E-PI0	VIOLATES C IN E.M.I.	134+ .5+ .5
P6	ETA INTO E+E-PI+PI-		139+ 139+ .5+ .5
P7	ETA INTO PI0 2GAMMA		134+ 0+ 0
P8	ETA INTO E+E-GAMMA		.5+ .5+ 0
P9	ETA INTO 2PI0 GAMMA	VIOLATES C	134+ 134+ 0
P10	ETA INTO PI+PI-PI0 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-PI0		105+ 105+ 134

14 ETA DECAY RATES

W1	ETA INTO 2GAMMA (UNITS KEV)		(P1)
W1	(0.93) (0.2)	BEMPCRAD 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

$$\Gamma_{\gamma\gamma}/\Gamma_{total} = 37.5 \pm 1.6\%$$

would give

$$\Gamma_{\gamma\gamma} = 1.01 \pm 0.23 \text{ keV}$$

and

$$\Gamma_{total} = 2.70 \pm 0.67 \text{ keV.}$$

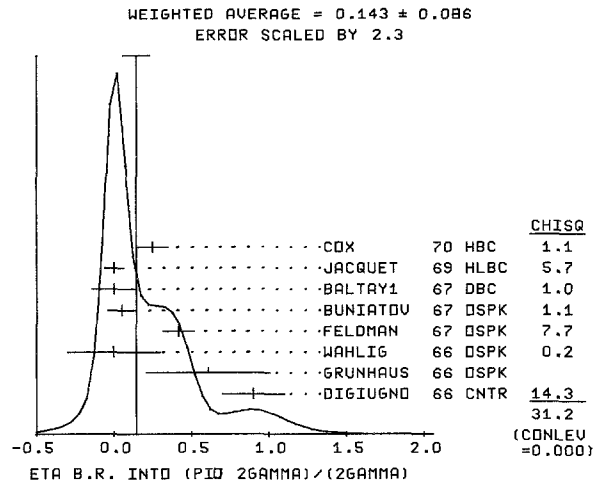
ETA DECAY INTO NEUTRALS

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 $\eta \rightarrow \pi^0 \gamma\gamma$ is ≈ 0 (as some experiments indicate) or $\gtrsim 20\%$ (as other experiments indicate).

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

In our last couple of editions we were able to point out that it was the older experiments which gave the $\gtrsim 20\%$ values, whereas the more recent experiments had been giving ~ 0 . However, the recent experiment of COX 70 gives about $25 \pm 10\%$, so the controversy is not yet settled.

We feel that we should consider all eight experiments on an a priori equal basis, and



then follow the prescription of deleting large χ^2 experiments until the confidence level rises to some reasonable value. If we remove the Feldman and DiGiugno experiments, χ^2 decreases from 34 (for all eight) to about 6 (for the remaining 6). Accordingly we have removed these experiments and used the remaining six experiments in our overall fit.

14 ETA BRANCHING RATIOS
(P9) IS ASSUMED = 0 IN ALL RATIOS

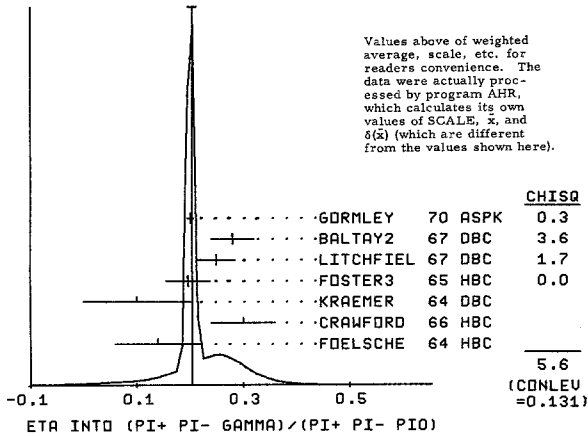
R1	ETA INTO NEUTRALS/CHARGED		(P1+P2+P7)/(P3+P4)
R1 N	10 (2.5)	(1.0)	PICKUP 62 HBC
R1 N	53 (3.20)	(1.26)	BASTIEN 62 HBC
R1 N	(2.7)	(0.8)	SHAFER 62 HBC
R1	2.6	.9	RUSCHBECK 63 HBC
R1 N	280 (4.5)	(1.0)	JAMES 66 HBC
R1 N	THESE EXPERIMENTS HAVE NOT BEEN USED IN COMPUTING THE AVERAGES		
R1 N	AS THEY WERE UNABLE 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
R1			
R1 AVG	2.64	0.22	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1 FIT	2.60	0.15	VALUE FROM CONSTRAINED FIT
R2	ETA INTO 2GAMMA/CHARGED		(P1)/(P3+P4)
R2	0.99	0.48	CRAWFORD 63 HBC
R2			
R2 FIT	1.351	0.092	VALUE FROM CONSTRAINED FIT

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

R3	ETA INTO (PI0 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 ALTHDRS.			
R3	.27	.10	GRUNHAUS 66 DSPK	8/67
R3 S	(.244) (.09)	FELDMAN 67 DSPK		8/67
R3 S	SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.			
R3	.028	.044	BUNIATOV 67 DSPK	11/67
R3	(.061) OR LESS	SHAPIRO 69 DSPK		9/69
R3	.122	.052	COX 70 HBC	6/70*
R3	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)			
R3 AVG	0.090	0.052		
R3 FIT	0.065	0.032	VALUE FROM CONSTRAINED FIT	

R4	ETA INTO (PI+ PI- GAMMA)/(PI+ PI- PIC)	(P4)/(P3)		
R4	0.14	0.08	FOELSCH 64 HBC	
R4 M	(0.73) (0.25)	PAULI 64 DBC		
R4 M	THIS EXPERIMENT HAS NOT BEEN INCLUDED IN THE AVERAGES SINCE			
R4 M	IT IS 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	.156	.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	.201	.006	GORMLEY 70 ASPK	6/70*
R4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)			
R4 AVG	0.2041	0.0079		
R4 FIT	0.2041	0.0074	VALUE FROM CONSTRAINED FIT	

WEIGHTED AVERAGE = 0.2041 ± 0.0079
ERROR SCALED BY 1.4



R5	ETA INTO (3PI0)+ 2/3(PI0 2GAMMA)/ PI+PI-PI0	(P2+2/3P7)/P3		
R5	0.83	0.32	CRAWFORD 63 HBC	7/66
R5	2.0	1.0	FOELSCH 64 HBC	7/66
R5	0.90	0.24	FOSTER1 65 HBC	7/66
R5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R5 AVG	0.91	0.19		
R5 FIT	1.44	0.10	VALUE FROM CONSTRAINED FIT	

R6	ETA INTO 3PI0/2GAMMA	(P21)/(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 DSPK	1/68
R6 C	(1.06) (0.31)	STRUGALSK 68 HLBC	CONFERENCE REPORT	1/68
R6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R6 AVG	0.97	0.12		
R6 FIT	0.800	0.078	VALUE FROM CONSTRAINED FIT	

R7	ETA INTO 2GAMMA/(PI+ PI- P10)	(P11)/(P3)		
R7	1.61	0.39	FOSTER1 65 HBC	
R7	401	1.72	BAGLIN 69 HLBC	7/69
R7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R7 AVG	1.69	0.21		
R7 FIT	1.63	0.11	VALUE FROM CONSTRAINED FIT	

R8	ETA INTO NEUTRAL/(PI+ PI- PIC)	(P1+P2+P7)/(P3)		
R8	28C	3.6	0.8	KRAEMER 64 DBC
R8		3.8	1.1	PAULI 64 DBC
R8		2.89	0.56	ALFF-STEI 66 HBC
R8	244	3.6	0.6	FLATTE2 67 HBC
R8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R8 AVG	3.35	0.35		
R8 FIT	3.13	0.18	VALUE FROM CONSTRAINED FIT	

R9	ETA INTO (E+E-PI0)/(PI+PI-PI0)	(UNITS 10**2) (P5)/(P3)		
R9	(1.1) OR LESS	PRICE 65 HBC		
R9	0 (0.77) OR LESS	FOSTER2 65 HBC	.9 CONF-LEVEL	8/67
R9	(.42) OR LESS	BAGLINI 67 HLBC	.9 CONF-LEVEL	11/67
R9	0 (1.6) OR LESS	BILLING 67 HLBC		

R10	ETA INTO (E+E-PI+PI-)/TOTAL	(UNITS 10**2) (P6)/TOTAL		
R10	(0.71) 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

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 DSPK	8/67
R12 S	(.579) (.052)	FELDMAN 67 DSPK		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	(.42) OR LESS	BUNIATOV 67 DSPK		11/67
R12	.486	.036	COX 70 HBC	6/70*
R12	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)			
R12 AVG	0.531	0.041		
R12 FIT	0.519	0.021	VALUE FROM CONSTRAINED FIT	

R13	ETA INTO 3PI0/NEUTRALS	(P2)/(P1+P2+P7)		
R13 S	(0.209) (0.054)	DIGIUGNO 66 CNTR	ERROR DOUBLED	6/66
R13 R	(.29) (.10)	GRUNHAUS 66 DSPK		8/67
R13 S	(.177) (.035)	FELDMAN 67 DSPK		8/67
R13 S	SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.			
R13 R	(.41) (1.03)	BUNIATOV 67 DSPK		11/67
R13 R	REDUNDANT INFORMATION FROM THIS EXPERIMENT			
R13	.392	.042	COX 70 HBC	6/70*
R13	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)			
R13 FIT	0.416	0.031	VALUE FROM CONSTRAINED FIT	

R14	ETA INTO PI0 (2GAMMA)/2GAMMA	(P7)/(P1)		
R14	(.5) OR LESS	MAHLING 66 SPRK	.9 CONF LEVEL	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 C	(0.30) (0.22)	STRUGALSK 68 HLBC	CONFERENCE REPORT	11/68
R14	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)			
R14 FIT	0.125	0.063	VALUE FROM CONSTRAINED FIT	

R15	ETA INTO (E+E-PI0)/TCTAL	(UNITS 10**2) (P5)/TOTAL		
R15	(0.71) OR LESS	RITTENBER 65 HBC		6/66
R15	(0.084) OR LESS	BAZIN 68 DBC	.9 CONF LEVEL	6/68

R16	ETA INTO 2GAMMA/(3PI0 + PI0 2GAMMA)	(P1)/(P2+P7)		
R16	0.80	.25	BAGGI 63 CNTR	7/66
R16	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R16 FIT	1.081	0.093	VALUE FROM CONSTRAINED FIT	

R17	ETA INTO (PI+PI-PI0 GAMMA)/(PI+PI-PI0)	(P10)/(P3)		
R17	(.071) OR LESS	FLATTE 67 HBC		8/67
R17	(.0091) OR LESS	PRICE 67 HBC		8/67
R17	(.0161) OR LESS	BALTAY2 67 DBC	.95 CONF LEVEL	11/67
R17	(0.017) OR LESS	ARNOLD 68 HLBC	.9 CONF LEVEL	9/68

R18	ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PI0)	(P11)/(P3)		
R18	(.0091) OR LESS	PRICE 67 HBC		8/67
R18	(.0161) OR LESS	BALTAY2 67 DBC	.95 CONF LEVEL	11/67

R19	ETA INTO 3PI0/(PI+ PI- PI0)	(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	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R19 AVG	1.46	0.13		
R19 FIT	1.30	0.11	VALUE FROM CONSTRAINED FIT	

R20	ETA INTO 2GAMMA/((3PI0)+2/3(PI0 2GAMMA))	(P1)/(P2+2/3P7)		
R20	1.10	.5	MULLER 63 DBC	7/66
R20	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R20 FIT	1.132	0.093	VALUE FROM CONSTRAINED FIT	

R21	ETA INTO NEUTRALS/TOTAL	(P1+P2+P7)/TOTAL		
R21	.79	.08	BUNIATOV 67 DSPK	11/67
R21	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R21 FIT	0.722	0.012	VALUE FROM CONSTRAINED FIT	

R22	ETA INTO (PI20 2GAMMA)/TOTAL	(P7)/TOTAL		
R22	(.12) OR LESS	JACQUET 69 HLBC	.95 CONF-LEVEL	6/70*
R22	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
R22 FIT	0.047	0.023	VALUE FROM CONSTRAINED FIT	

R23	ETA INTO MU+MU-/TOTAL	(UNITS 10**5) (P12)/TOTAL		
R23	C (2.) OR LESS	WEHMANN 68 DSPK	.95 CONF-LEVEL	4/68

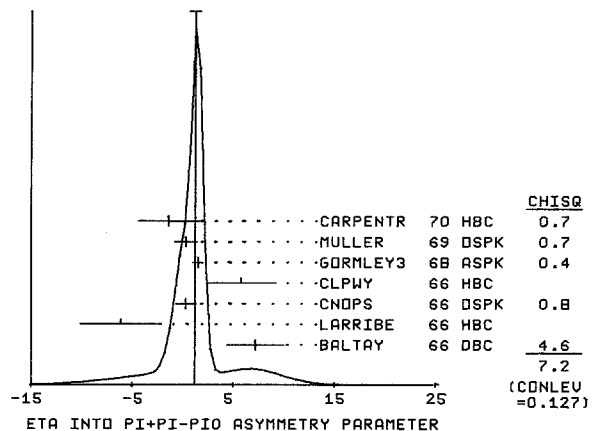
R24	ETA INTO MU+MU-PI0/TCTAL	(UNITS 10**4) (P14)/TOTAL		
R24	(5.) OR LESS	WEHMANN 68 DSPK		4/68

R25	ETA INTO MU+MU-/2GAMMA	(UNITS 10**5) (P12)/(P1)		
R25	5.9	2.2	HYANS 69 DSPK	7/69

14 ETA C-NONCONSERVING DECAY PARAMETER

A	DECAY ASYMMETRY PARAMETER FOR PI+ PI- PI0	(UNITS 10**2)		
A	1351	7.2	2.8	BALTA 66 DBC
A	705	-0.1	4.0	LARRIBE 66 HBC
A	10665	0.3	1.0	CNCP5 66 DSPK
A	1300	5.8	3.4	CLPWY 66 HBC
A	36800	1.5	.5	GORMLEY3 68 ASPK
A	10709	-1.3	1.1	MULLER 69 DSPK
A	1138	-1.4	3.	CARPENTR 70 HBC
A	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)			
A AVG	1.20	0.54		

WEIGHTED AVERAGE = 1.20 ± 0.54
ERROR SCALED BY 1.3



See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Table with columns: DECAY ASYMMETRY PARAMETER FOR P+, P-, GAMMA (UNITS 10**--2), and values for various experiments like CRAWFORD, BOWEN, MITCHELL, etc.

H. Yuta and S. Okubo [Phys. Rev. Letters 21, 781 (1968)] have pointed out that an asymmetry in the decay eta -> pi+ pi- pi0 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 3pi background. Gormley et al. [Phys. Rev. Letters 22, 108 (1969)], however, believe that this effect can account for only <= 0.23% in their experiment (above). Also see: A. Frenkel and G. Vesztergombi, "C-Violation in eta-Decay," Nucl. Phys. B15, 429 (1970).

Fitted Partial Decay Mode Branching Fractions

Diagonal elements are P_i + delta P_i; delta P_i = sqrt(<delta P_i^2>). Off-diagonal elements are correlation coefficients = <delta P_i delta P_j> / (delta P_i delta P_j).

Table with columns P1, P2, P3, P4, P7 and values for various decay modes like P1, P2, P3, P4, P7.

REFERENCES
14 ETA(549, JPC=0-+1=0)

Table listing references for eta(549) with authors like PEVSNER, ALFF, BASTIEN, etc. and their respective publications.

Table listing references for eta(549) with authors like ARNOLD, BAZIN, BULLOCK, etc. and their respective publications.

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

Table with columns: 16 PROTON (938, J=1/2) I=1/2, 16 PROTON MASS (MEV), and values for COHEN, TAYLOR, etc.

Table with columns: 16 PROTON LIFETIME (UNITS 10**26 YR), and values for GOLDHABER, FLEROV, etc.

Table with columns: 16 PROTON MAGNET. MOMENT (E/2MP), and values for COHEN, TAYLOR, etc.

Table with columns: 16 PROTON ELECTRIC DIPOLE MOMENT (IN UNITS OF 10**--23 E CM), and values for EDM, HARRISON, etc.

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

Table listing references for proton with authors like GOLDHABER, FLEROV, BACKENSTOSS, etc. and their respective publications.

Table with columns: 17 NEUTRON (939, J=1/2) I=1/2, 17 NEUTRON MASS (MEV), and values for COHEN, TAYLOR, etc.

Table with columns: 17 NEUTRON-PROTON MASS DIFF. (MEV), and values for BONDELID, SALGC, etc.

Table with columns: 17 NEUTRON MAGNETIC MOMENT (MAGNETONS, 938.2 MEV), and values for COHEN, etc.

Table with columns: 17 NEUTRON ELECTRIC DIPOLE MOMENT (IN UNITS OF 10**--23 E CM), and values for EDM, BAIRD, etc.

REFERENCES
17 NEUTRON LIFETIME (UNITS 10**3 SEC)

THE MEASUREMENT OF THE NEUTRON LIFETIME BY SOGNOVSKII 59 HAS BEEN DISCARDED SINCE 1. IT DISAGREES WITH THE BETTER AND MORE RECENT RESULT OF CHRISTENSEN 67. 2. THE VALUE OF GAYGV DERIVED FROM THE NEW VALUE OF THE LIFETIME AGREES WELL WITH THE GAYGV VALUE OBTAINED FROM THE FREE NEUTRON DATA.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

T (1.012) (0.021) SC5NOVSKI 59 FILE SEE NOTE E 7/68
E ERROR CHANGED BECAUSE ERROR IN CROSS SECTION FOR NEUTRON ABSORPTION
E IN GOLD HAS BEEN REDUCED
T 0.932 0.014 CHRISTENS 67 FILE 3/68

17 BETA DECAY COUPLING CONSTANTS
AV GA/GV (SEE TEXT FOR SIGN CONVENTION)
AV B (-1.18) (0.021) BHALLA 66 RVUE 11/67
AV -1.250 0.044 CONFORTO 67 RVUE SEE NOTE C BELOW
AV -1.23 0.01 CHRISTENS 67 CNTR SEE NOTE D BELOW 11/68
AV B THIS VALUE NOT USED SINCE CORRESPONDING LIFETIME HAS BEEN DISCARDED
AV C CONFORTO VALUE COMBINES ALL FREE NEUTRON DECAY DATA
AV D CHRISTENSON MEASUREMENT NOT SENSITIVE TO SIGN OF GA/GV
AV AVG -1.2310 0.0098 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

F PHASE ANGLE OF GA RELATIVE TO GV (DEGREES)
F C VALUE DERIVED FROM FREE NEUTRON DECAY ONLY
F C (1176.1) (6.4) CONFORTO 67 RVUE 11/68
F S (1176.7) (1.3) ERZOLIM 68 CNTR POLAR. NETRON 10/69
F S ONLY STATISTICAL ERROR QUOTED

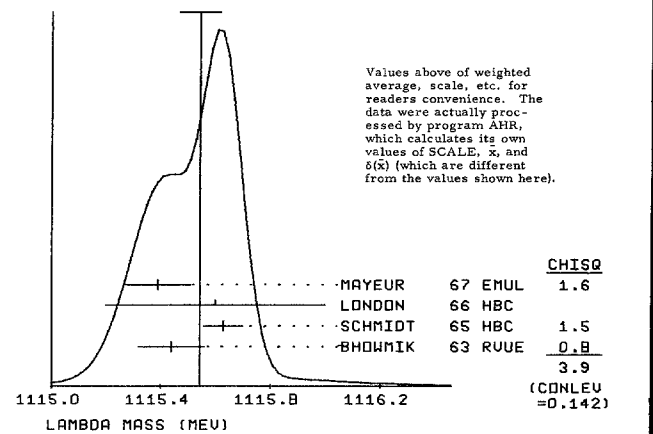
REFERENCES
17 NEUTRON (639,J=1/2) I=1/2
CCHEN 56 PR 104 283 V W CHEN, CORAGLD, RAMSEY (BNL+HARVARD)
SC5NOVSK 59 JETP 9 717 SC5NOVSKI, SPIVAK, PROKOFEV + (IAE MOSCOW)
RODELID 60 PR 120 887 BONDELIC, BUTLER, KENNEDY + (USNRL-CATH UNIV)
SALGO 64 NP 53 457 R SALGO, STAUB, WINKLER, ZAMBONI (ZURICH)

BHALLA 66 PL 15 691 C P BHALLA (ALABAMA)
CHRISTEN 67 PL 268 11 *NIELSEN, BAHNSEN, BRONN, RUSTAD (RISO-DENMARK)
CONFORTO 67 ACTA PHYS ACAD HUNGARICA 22 15 G. CONFORTO (CERN)
ERZOLIM 68 PL 278 557 ERZOLIMSKY, BONDARENKO + (KURC IN MOSCOW)
BAIRD 69 PR 179 1285 *MILLER, DRESS, RAMSEY (ORNL+HARV)
TAYLOR 69 RMP 41 375 *PARKER, LANGENBERG (PRIN+UCI+PENN)

PAPERS NOT REFERRED TO IN DATA CARDS
JACKSON 57 PR 106 517 JACKSON, TREIMAN, NYLD (PRINCETON)
COHEN 65 RMP 37 537 E R COHEN, DUMOND (NAASC+CAL INST TECH)

Λ
18 LAMBDA (1115, JP=1/2+) I=0
18 LAMBDA MASS (MEV)
P N SINCE OUR FINAL VALUES FOR THE SIGMA AND LAMBDA MASSES COME FROM
P N DOING AN OVERALL FIT TO ALL MEASURED MASSES AND MASS DIFFERENCES,
P N WE HAVE USED THE UNCORRELATED MEASUREMENTS FROM SCHMIDT 65 RATHER
P N THAN THE ONES COMING FROM THE OVERALL FIT REPORTED IN THAT PAPER.
P N SINCE THERE SEEMS TO BE NO CONVINCING ARGUMENT AS TO WHY ONE SHOULD
P N IGNORE DATA USING RANGE MEASUREMENTS, WE HAVE INCLUDED HERE VALUES
P 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(1115.65) (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 MAYELR 67 EMUL 11/67
M S ERROR PURELY STATISTICAL
M AVG 1115.544 0.075 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
M FIT 1115.60 0.08 VALUE FROM CONSTRAINED FIT 6/68
(SEE IDEOGRAM BELOW)

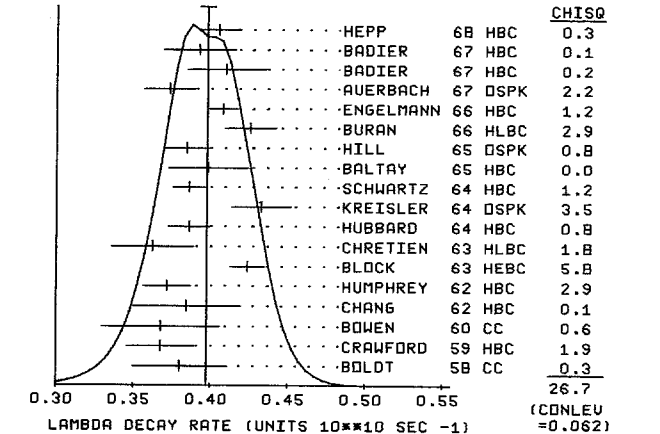
WEIGHTED AVERAGE = 1115.544 ± 0.075
ERROR SCALED BY 1.4



18 LAMDA - ANTI LAMDA 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 AVG 0.083 0.083 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

18 LAMBDA LIFETIME (UNITS 10**10)
T 188 2.63 0.21 0.21 BOLOT 58 CC
T 825 2.72 0.16 0.16 CRAWFCRO 59 HBC
T 140 2.72 0.29 0.29 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 0.20 CHRETIEN 63 HLBC
T 794 2.59 0.09 0.09 HUBBARD 64 HBC
T 2260 2.31 0.10 0.10 KREISLER 64 DSPK
T 1378 2.59 0.07 0.07 SCHWARTZ 64 HBC
T 635 2.51 0.16 0.16 BALTAY 65 HBC 6/66
T 2534 2.6 0.1 0.1 HILL 65 DSPK
T 916 2.35 0.09 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 (2.71) (0.20) CHIEN 66 HBC 6.9 PBAR P, ANTI 9/67
T 2213 2.452 0.056 0.056 ENGELMANN 66 HBC
T 585 2.68 0.13 0.11 AUERBACH 67 DSPK
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, ANTI 6/68
T G 8342 (2.535) (0.35) GRIMP 68 HBC 6/68
T 2600 2.47 0.08 0.08 HEPP 68 HBC 8/68
T S ERROR PURELY STATISTICAL
T G TEMPORARELY NOT AVERAGED SINCE ERRORS ARE ONLY STATISTICAL 11/68
T AVG 2.514 0.030 0.029 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
(SEE IDEOGRAM BELOW)

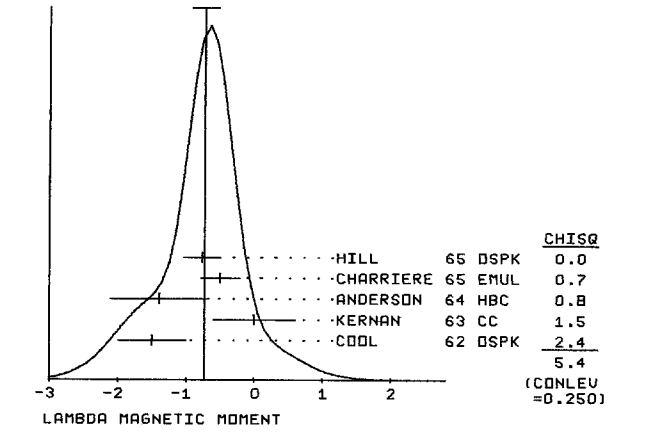
WEIGHTED AVERAGE = 0.3978 ± 0.0047
ERROR SCALED BY 1.3



18 LIFETIME DIFFERENCE (LAMBDA-ANTI LAMBDA)/AVERAGE
DT 0.044 0.085 BADIER 67 HBC 2.4 PBAR P 8/67

18 LAMBDA MAGNETIC MOMENT (MAGNETONS, 938.26 MEV)
MM -1.5 0.5 COOL 62 DSPK
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 -0.77 0.27 HILL 65 DSPK 9/66
MM AVG -0.73 0.20 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = -0.73 ± 0.20
ERROR SCALED BY 1.2



18 LAMDA - ANTI LAMDA 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 AVG 0.083 0.083 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

18 LAMBDA PARTIAL DECAY MODES

		DECAY MASSES	
P1	LAMBDA INTO PROTON P1-	938+ 139	
P2	LAMBDA INTO NEUTRON P1C	939+ 134	
P3	LAMBDA INTO PROTON MU- NEUTRINO	938+ 105+ 0	
P4	LAMBDA INTO PROTON E- NEUTRINO	938+ +5+ 0	

18 LAMBDA BRANCHING RATIOS

R1	LAMBDA INTO (P P1-)/(P P1-)+(N P1O)	(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	
P1 U	UNPUBLISHED NCT AVERAGED	
R1	903 0.643 0.016 HUMPHREY 62 HBC	
R1	.....
R1	AVG 0.640 0.014 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	
R1	FIT 0.653 0.013 VALUE FROM CONSTRAINED FIT	

R2	LAMBDA INTO (N P1O)/(P P1-)+(N P1O)	(P2)/(P1+P2)
R2	0.23 0.09 EISLER 57 HBC	
R2	0.43 0.14 CRAWFORD 59 HBC	
R2	0.28 0.08 BAGLIN 60 HBC	
R2	0.35 0.05 BROWN 63 HBC	
R2	75 0.291 0.034 CHRETIEN 63 HBC	
R2	.....
R2	AVG 0.304 0.025 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	
R2	FIT 0.347 0.013 VALUE FROM CONSTRAINED FIT	

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	150 0.82 0.12 0.13 ELY 63 FBC	
R3 O	2C (1.55) (0.34) LIND 64 HBC	
R3	102 0.78 0.12 BAGLIN 64 FBC	
R3	143 0.80 0.08 MALONEY 69 HBC	10/69
R3 O	LOW STATISTICS EXPERIMENTS NOT AVERAGED	7/70*
R3	.....
R3	AVG 0.800 0.059 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	

R4 LAMBDA INTO (P MU- NEU)/TOTAL (UNITS 10**4) (P3)/(P1+P2)

R4	1 (0.2) OR GREATER GORD 62 HBC	
R4	1 (1.0) OR LESS ALSTON 63 HBC	
R4	2 (1.0) GR 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 RCKNE 64 FBC	
R4	.....
R4	AVG 1.35 0.60 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	

18 LAMBDA DECAY PARAMETERS

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 DVERSETH 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-	3320 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)	
AC	ALPHA /ALPHA- FOR LAMBDA (L INTO P1O N/L INTO PI- P)	
AC	476C 1.10 0.27 GORK 60 CNTR	
AC	0 DONE BY COMPARING PROT DISTRIB WITH N DISTRIB FROM LAMBDA DECAY	5/70*
AC	.....
AC	AVG 1.006 0.066 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 DVERSETH 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)	

AL ASYMMETRY PARAMETER IN ELECTRON - LAMBDA SPIN CORRELATION

AL	0.06 0.19 BARLCK 65 OSPK	7/66
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AV GA/GV FOR LAMBDA BETA DECAY (SEE TEXT FOR SIGN CONVENTION)

AV C	22 (-1.63) LIND 64 HBC	6/68
AV C	102 ABS VALUE GREATER THAN 0.6 BAGLIN 65 HLBC	6/68
AV C	BETW 0. AND -1.1 BARLCK 65 OSPK	6/68
AV C	102 ABS VALUE GREATER THAN 0.7 ELY 65 HLBC 95 PCT CONF LEV	6/68
AV C	-1.14 0.23 0.33 CCMFCRTO 65 RVUE	11/67
AV C	EXPTS INCLUDED IN CCMFCRTO 65, RVUE	6/68
AV	30 (-0.23) (0.20) (C.33) CHU 68 OSPK PRELIMINARY	11/68
AV M	148 -0.72 0.14 0.19 MALONEY 69 HBC	10/69
AV H	MALONEY 69 MEASURES THE ABSOLUTE VALUE CF A/V	
AV	.....
AV	AVG -0.83 0.18 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)	

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

EISLER 57 NC 5 1700	EISLER, PLANO, SAMIOS, SCHWARTZ + (COLUM+BNL)
BGLDT 58 PRL 1 148	E BOLDT, D C CALDWELL, Y PAL (MIT)
CRAWFORD 59 PKL 2 266	CRAWFORD, CRESTI, DOUGLASS, GOOD + (LRL)
BAGLIN 60 NC 18 1043	BAGLIN, BLOCH, BRISSEN, HENNESSY + (PARIS-EP)
BOWEN 60 PR 119 2030	BOWEN, HARDY, REYNOLDS, SUN + (PRINCETON)
CCRK 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, BRISSEN, HENNESSY, SIX + (PARIS-EP)
CHANG 62 THESIS DUKE	CHUEN CHUEN CHANG (DUKE)
COOL 62 PR 127 2223	COOL, HILL, MARSHALL + (BNL+MIT+NYU+ANL)
GOJD 62 PRL 9 518	M L GOJD, V G LIND (WISCONSIN)
HUMPHREY 62 PR 127 1305	H HUMPHREY, R ROSS (LRL)
ALSTON 63 UCRL 10926	ALSTON, KIRZ, NEUFELD, SOLMITZ, WCHLMUT (LRL)
BHOWMIK 63 NC 28 1494	B BHOWMIK, D P GOYAL (DELHI)
BLOCK 63 PR 130 766	BLOCK, GESSARLI, RATTI, KIKUCHI + (NW+BULGNA)
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, C E OVERSETH (PRINCETON)
ELY 63 PR 131 868	ELY, GIDAL, KALMUS, OSWALD, POWELL + (LRL)
KERNAN 63 PR 129 870	KERNAN, NOVEY, WARSZAW, 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 LONDON+RHEL+BERG)
HUBBARD 64 PR 135 B 183	HUBBARD, BERGE, KALBFLEISCH, SCHAFFER + (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 (PRINCETON)
LIND 64 PR 135 B 1483	LIND, BINFORD, GOGG, STERN (WISCONSIN)
RCKNE 64 PL 11 357	RCKNE+ (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, CCMFCRTO + (CERN+RUTH+PENNA)
CHARRIERE 65 PL 15 66	CHARRIERE, GIBSON+ (EPUL+BRIST+CERN+MPI)
ALSO NC 46A 205	CHARRIERE, GIBSON + (EPUL+BRIST, CERN, MPI)
CCNFORTO 65 EC INT HERZEGNOVI	G CCNFORTO (CERN)
ELY 65 PR 137 B1302	ELY, GIDAL, KALMUS, POWELL + (LRL, UC LONDON)
HILL 65 PRL 15 85	D A HILL, K K LI, JEAKINS (BNL+MIT)
SCHMIDT 65 PR 140 B 1328	P SCHMIDT (COLUMBIA)
BERGE 66 BERKELEY 46	BERGE, CARIBBC (RVUE)
BURAN 66 PL 20 318	BURAN, EIVINDSON, SKJEGGESTAD, TOFTE + (OSLO)
CHIEN 66 PR 152 1171	+ LACH, SANDWEISS, TAFT, YEHE, OREN + (YALE+BNL)
ENGELMAN 66 NC 45A 1038	ENGELMANN, FILTHUTH, ALEXANDER+ (HETDBG+WEIZM)
LONDON 66 PR 143 1034	LONDON, RAU, GCLBERG, LICHTMAN+ (BNL+SYRAC)

AUERBACH 67 NC 47A 19 AUERBACH, BOWEN, DOBBS, LANDE, MANN+ (U OF PA)

BADIER 67 PL 258 152 + BNNET, BRIANDET, SADOULET (EP (PARIS))

MAYER 67 U-LIBR. BRUX. BUL 32 C. MAYER, E. TOMPA, J. WICKENS (UL-BRUX+UC-LON)

CLELAND 67 PL 268 45 CLELAND, BLENLEIN, CONFORTO + (CERN, GVA, LUND)

OVERSETH 67 PRL 19 391 O E OVERSETH, R F ROTH (MICHIGAN+PRINCETON)

ANDERSSON 68 VIENNA ABS. 270	ANDERSSON, BIENLEIN, CLELAND + (CERN, GVA, LUND)
CHU 68 VIENNA POSTDEADLN	CHU, PHILLIPS, + (ARGONNE, CHICAGO, OHIO, WASH)
GRIMP 68 NC 54A 181	H.-J. GRIMP (HEIDELBERG)
HEPP 68 ZPHYS 214 71	V. HEPP, H. SCHLEICH (HEIDELBERG)
MERRILL 68 PR 157 1202	MERRILL, SCHAFFER (LRL)
DAUBER 69 PR 179 1262	+ BERGE, HUBBARD, MERRILL, MILLER (LRL)
MALONEY 69 PRL 23 425	MALONEY, SECHI-ZORN (UNIV MARYLAND)
OLSEN 70 PRL 24 843	+ PONDROFF, HANDLER, LINDEN, SMITH + (WISC, ANNA)

PAPERS NOT REFERRED TO IN DATA CARDS

ARMENTER 62 CERN CONF 236 ARMEATEROS+ (CERN+EP+LONDON+BIRM+CEN-SACLAY)

BALTAY 62 CERN CONF 233 BALTAY, FOWLER, SANDWEISS, CULWICK+ (YALE+BNL)

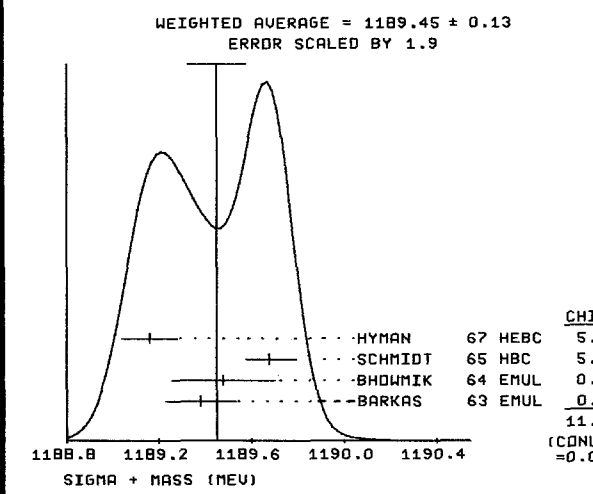
BERGE 63 THESIS (BERKELEY) J PETER BERGE (LRL)

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

Σ+ 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	5 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) 6/68
M	FIT 1189.40 0.19 VALUE FROM CONSTRAINED FIT (SEE ICECGRAM BELW)



Note on Σ± Lifetime Errors
When combining lifetimes, we first convert mean lives τ to decay rates Γ, since for small numbers of events the Γ are more

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

nearly Gaussian distributed. 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

$$\delta_{\min} = \frac{\tau}{\sqrt{N_{\text{eff}}}} \quad (1)$$

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

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

Consider the Σ^- mean life of CHANG 66: $1.67 \pm 0.026 \times 10^{-10}$ sec., based on 3267 events. The Σ^- were produced by K^- stopping in a hydrogen bubble chamber. Since stopping Σ^- were not included in the analysis, the decays were observed for only 2.7×10^{-10} sec. Then $x = 1.62$, and N_{eff} is about N/5. Equation (1) then gives $\delta_{\min} = 0.065$, or 2.5 times larger than that quoted by CHANG 66.

In order to evaluate the actual error we have redone the χ^2 minimization described by CHANG 66, using his published data, and find $\delta(\tau)$ to be 0.075.

We find his Σ^+ lifetime error also to be too small, and have redone his analysis to give ± 0.032 .

19 SIGMA+ LIFETIME (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 HLCB
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
T	900	0.76	0.03		CARYAN	65 HBC
T C	1300	0.83	0.032		CHANG	66 HBC
T C		CHANG ERROR	0.018	RAISED BY US	SEE NOTE PRECEDING SIGMA- LIST.	11/69
T S	125	(0.86)	(0.15)		CHIEN	66 HBC + 6.9 PBAR P
T S	117	(1.10)	(0.24)		CHIEN	66 HBC - 6.9 PBAR P, ANTI
T	381	0.80	0.07		COOK	66 DSPK
T	10664	0.803	0.008		BARLCUTAU	69 HBC
T S		ERROR PURELY STATISTICAL				
T						
T	AVG	0.8020	0.0072	0.0071	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	

19 SIGMA+ MAGNETIC MOMENT (MAGNETONS, 938.26 MEV)

MM	381	1.5	1.1	COOK	66 DSPK	7/66
MM	52	3.5	1.5	KOTELCHUC	67 EMUL	8/67
MM	51	3.0	1.2	SULLIVAN	67 EMUL	PHCTPRODUCTION
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
MM						6/68
MM	AVG	2.57	0.52	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		

19 SIGMA+ PARTIAL DECAY MODES

P1	SIGMA + INTO PROTON PICO		DECAY MASSES
P2	SIGMA + INTO NEUTRON PICO		938+ 134
P3	SIGMA + INTO NEUTRON PICO + GAMMA		939+ 139
P4	SIGMA + INTO LAMBDA E+ NEU		1115+ .54 0
P5	SIGMA + INTO PROTON GAMMA		938+ 0
P6	SIGMA + INTO NEUTRON MU+ NEUTRINO		939+ 105+ C
P7	SIGMA + INTO NEUTRON E+ NEUTRINO		939+ .5+ 0
P8	SIGMA + INTO PROTON E+ E-		938+ .5+ .5

19 SIGMA+ BRANCHING RATIOS

R1	SIGMA+ INTO (NEUTRON PICO)/(NUCLEON PICO)	(P2)/(P1+P2)	
R1	308	0.490	0.024 HUMPHREY 62 HBC
R1	534	0.46	0.02 CHANG 66 HBC
R1	1331	0.488	0.010 BARLCUTAU 69 HBC
R1			K-P 4-1.2 GEV/C 11/69
R1	AVG	0.4833	0.0084 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

SIGMA+ INTO (NEUT PICO + GAMMA)/(PI+NU) (UNITS 10^{*-3}) (P3)/(P2)

R2	ABOUT 1.8	BAZIN2	65 HBC	P1+ LT 116 MEV/C	8/67	
R2	29	0.27	0.05	ANG	69 HBC	P1+ LT 110 MEV/C 11/68

SIGMA+ INTO (LAMBDA E+ NEU)/TOTAL (UNIT 10^{*-5}) (P4)/TOTAL

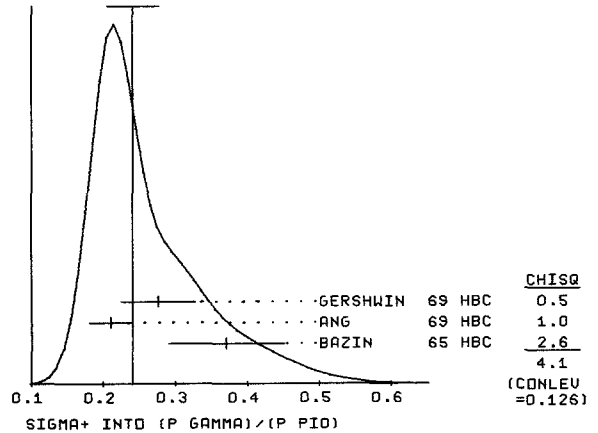
R3	W 4	(3.3)	(1.7)	WILLIS	64 HBC	STOP K-	9/66
R3	W			EVENTS FROM THIS EXPERIMENT INCLUDED IN EISELEI	69		11/69
R3	6	2.0	0.8	SARASH	67 HBC	STOP K-	8/67
R3	5	1.6	0.7	BALTAY	69 HBC	STOP K-	11/69
R3	10	2.9	1.0	EISELEI	69 HBC	STOP K-	10/69
R3	AVG	2.02	0.47	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

SIGMA+ INTO (P GAMMA)/(P PICO) (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)		QUARENTI	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	AVG	0.240	0.035	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)			

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 0.240 ± 0.035
ERROR SCALED BY 1.4



SIGMA+ INTO (N E+ NEU)/(N PICO) (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	E	EFFECTIVE DENOM.	TAKEN FROM EISELEI	67		11/67
R5	0	(32406)EFFECTIVE DENOM.	BIERMAN	68 HBC		6/68
R5	U 0	(80400)EFFECTIVE DENOM.	EISELEI	69 HBC		6/68
R5	U 1	(130000)EFFECTIVE DENOM.	NORTON	69 HBC		11/69
R6	U	EFFECTIVE DENOM. CALCULATED BY US				
R5	2	(0.7) OR LESS C.L.=90	OUR AVERAGE USING ALL ABOVE			11/69

SIGMA+ INTO (N MU+ NEU)/(PI+NU) (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	(1110)EFFECTIVE DENOM.	NAUENBERG	64 HBC	SEE NOTE E	11/67
R6	U 2	(62000)EFFECTIVE DENOM.	EISELEI	69 HBC		6/68
R6	0	(33800)EFFECTIVE DENOM.	BAGGETT	69 HBC		11/68
R6	3	(0.9) OR LESS C.L.=90	OUR AVERAGE USING ALL ABOVE			11/69
R6		SEE NOTES ACCOMPANYING R5				

SIGMA+ INTO LEPTONS / SIGMA- INTO LEPTONS

R7	N 5	(0.02)	OUR AVERAGE			6/68
R7	N	AVERAGE OF ALL DATA IN R5 AND R6 UP TO BIERMAN 68.				6/68
R7	0	(0.034)OR LESS	BAGGETT	67 HBC		6/68
R7	1	(0.08) OR LESS	NORTON	69 HBC		10/69

SIGMA+ INTO (PROTON E+ E-)/ TOTAL (UNIT 10^{*-6}) (P8)/TOTAL

R8	1	(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 PROTON GAMMA DECAY -LIPIT 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	EISELEI	69 HBC +- STOP K-	10/69
R10	SIGMA+ INTO (N E+ NU)/ SIGMA- INTO (N E- NU)						
R10	0	(0.03) OR LESS	EISELEI	69 HBC	+- STOP K-	10/69	

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

19 SIGMA+ DECAY PARAMETERS
ALPHA+/ALPHA FOR SIGMA+ (SIG+ TO PI+ N)/(SIG+ TO P10 P)
A+0 ALPHA+0.04 0.11 CORK 60 CNTR SIG+ FROM PI+P
A+0 (10.20) (0.24) TRIPP 62 HBC + REPLAC BY BANGER

REFERENCES
19 SIGMA+ (1198,JP=1/2+) I=1

EVANS 60 NC 15 873 BRIST+BRUSS+IAS-U-COL-DUBLIN+LON+MILAN+PAD
FREDEN 60 NC 16 611 S FREDEN, H KORNLUM, R WHITE (LRL)
KAPLON 60 ANP 9 139 M KAPLON, A PELISSINOS, YAMANOUCHE (ROCHES)
CORK 60 PR 120 1000 CORK, KERTH, WENZEL, CROBIN, COOL (LRL+PRJ+BNL)
PLSCHEL 60 NP 20 254 M PUSCHEL (MAX PLANCK INST)

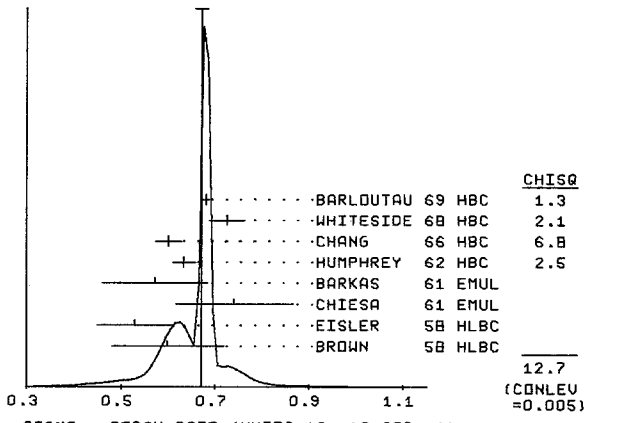
20 SIGMA- (1198,JP=1/2+) I=1
SIGMA- MASS (MEV)
M N SEE NOTE PRECEDING LAMBDA MASS LISTINGS
M 3000 1197.47 0.11 SCHMIDT 65 HBC SEE NOTE N 6/68
M FIT 1197.32 0.11 VALUE FROM CONSTRAINED FIT 6/68

20 SIGMA- MASS DIFFER. (-)(+)(MEV)
D 87 8.25 0.40 BARKAS 63 EMUL -
D 2500 8.25 0.25 DOSCH 65 HBC
D AVG 8.25 0.21 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D FIT 7.92 0.18 VALUE FROM CONSTRAINED FIT 6/68

20 (SIGMA-) - (LAMBDA) MASS DIFFERENCE (MEV)
DL N SEE NOTE PRECEDING LAMBDA MASS LISTINGS.
DL 81 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 0.04 HEPP 68 HBC 8/68

20 SIGMA- LIFETIME (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 C-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 C CHANG ERROR 0.026 RAISED BY US. SEE NOTE PRECEDING SIGMA+ LIST. 11/69
T S 61 (2.08) (0.22) CHIEI 66 HBC - 6.9 PBAR P 9/67
T S 64 (1.46) (0.31) CHIEI 66 HBC + 6.9 PBAR P, ANTI 9/67
T S ERROR PURELY STATISTICAL
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 AVG 1.490 0.031 0.030 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2. (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 0.671 ± 0.014
ERROR SCALED BY 2.1



20 SIGMA- PARTIAL DECAY MODES
P1 SIGMA - INTO NEUTRON PI- 939+ 139
P2 SIGMA - INTO NEUTRON PI- GAMMA 939+ 139+ 0
P3 SIGMA - INTO NEUTRON MU- NEUTRINO 939+ 105+ 0
P4 SIGMA - INTO NEUTRON E- NEUTRINO 939+ 5+ 0
P5 SIGMA - INTO LAMBDA E- NEUTRINO 1115+ 5+ 0

20 SIGMA- BRANCHING RATIOS
R1 SIGMA - INTO (N MU- NEU)/(N PI-) (UNITS 10**+3) (P3)/(P1)
R1 22 0.66 0.15 COURANT 64 HBC
R1 11 0.56 0.20 BAZIN 65 HBC FROM STOP. K- 6/66
R1 56 0.43 0.09 BAGGETT 69 HBC STOP. K- 10/69
R1 72 0.43 0.06 ANG 1 69 HBC STOP. K- 10/69
R1 13 0.38 0.13 NORTON 69 HBC STOP. K- 10/69
R1 AVG 0.450 0.043 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

20 SIGMA- BRANCHING RATIOS
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 PRG
R2 31 1.4 0.3 COURANT 64 HBC
R2 180 1.11 0.09 BIERMAN 68 HBC 6/68

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Table with columns for particle ID, mass difference, and various parameters. Includes entries for R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R48, R49, R50, R51, R52, R53, R54, R55, R56, R57, R58, R59, R60, R61, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R76, R77, R78, R79, R80, R81, R82, R83, R84, R85, R86, R87, R88, R89, R90, R91, R92, R93, R94, R95, R96, R97, R98, R99, R100.

20 SIGMA- DECAY PARAMETERS

Table listing decay parameters for ALPHA SIGMA- and other particles, including values for alpha, beta, and gamma.

Table listing PHASE ANGLE (SIN(PHI)/COS(PHI)) and other parameters for various particles.

Table listing parameters for GA/GV FOR SIGMA TO LAMBDA BETA DECAY and other related data.

Table listing parameters for GA/GV FOR SIGMA TO NEUTRON BETA DECAY and other related data.

REFERENCES

Large table of references for various experiments and publications, including authors and journal information.

PAPERS NOT REFERRED TO IN DATA CARDS

Table listing papers not referred to in data cards, including author names and journal titles.

Table with header 21 SIGMA C (1193,JP=1/2*) I=1, listing parameters for Sigma C particles.

Table with header 21 (SIGMA I - (LAMBDA) MASS DIFFERENCE (MEV), listing mass differences for Sigma I and Lambda particles.

Table with header 21 SIGMA LIFETIME (UNITS 10**14), listing lifetimes for Sigma particles.

Table with header 21 SIGMA C PARTIAL DECAY MODES, listing partial decay modes for Sigma C particles.

REFERENCES

Table of references for Sigma C partial decay modes, including author names and journal information.

Table with header 22 XI- (1321,JP=1/2) I=1/2, listing parameters for Xi- particles.

Table with header 22 MASS DIFFERENCE, (XI-)-(ANTI-XI-) IN MEV, listing mass differences for Xi- and anti-Xi- particles.

Table with header 22 XI- LIFETIME (UNITS 10**10), listing lifetimes for Xi- particles.

Table with header 22 XI- PARTIAL DECAY MODES, listing partial decay modes for Xi- particles.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

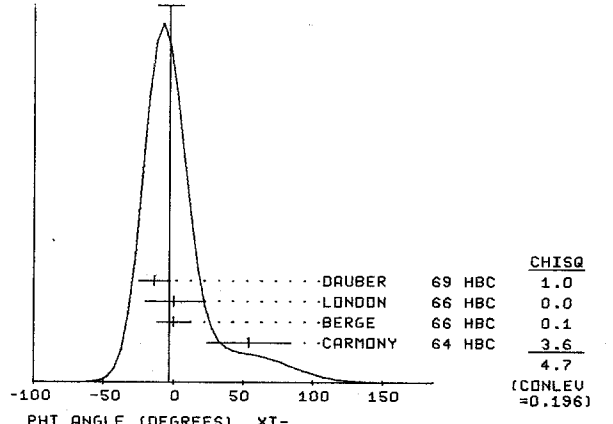
22 XI- BRANCHING RATIOS

Table with columns for branching ratios and associated researchers. Includes entries for XI- INTO (LAMBDA E- NEU) and XI- INTO (SIGMA E- NEUTRINO).

22 XI- DECAY PARAMETERS

Table with columns for decay parameters (alpha, phi angle) and associated researchers. Includes entries for ALPHA XI- and PHI ANGLE.

WEIGHTED AVERAGE = -3.0 ± 9.1
ERROR SCALED BY 1.3



REFERENCES

Table listing references for the data, including authors like Fowler, Wang, and Brwn, and publication details like PRL 6 134.

Table listing researchers and their associated publications or institutions, such as CARMONY, PIERRO, FERRO-LUZZI, etc.

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

Table with columns for mass (MEV) and mass difference (-)(-)(MEV). Includes entries for 23 XI 0 MASS (MEV) and 23 XI 0 MASS DIFFERENCE.

Table with columns for lifetime (UNITS 10**+10). Includes entries for 23 XI 0 LIFETIME.

Table with columns for partial decay modes and decay masses. Includes entries for XI 0 INTO LAMBDA P I O and XI 0 INTO PROTON PI-.

Table with columns for branching ratios. Includes entries for XI 0 INTO (PROTON PI-)/(LAMBDA P I O).

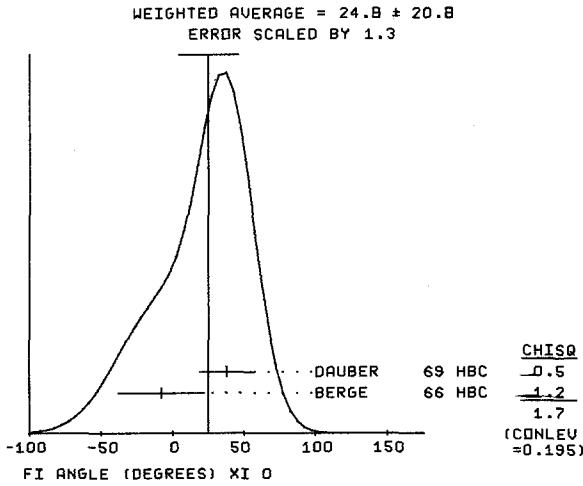
Table with columns for branching ratios. Includes entries for XI 0 INTO (SIGMA+ E- NEU)/(LAMBDA P I O).

Table with columns for branching ratios. Includes entries for XI 0 INTO (SIGMA+ MU- NEU)/TOTAL.

Table with columns for decay parameters. Includes entries for ALPHA XI 0 and weighted averages.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

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 735 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 AVG 24.0 20.8 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
(SEE IDECGRAM BELOW)



REFERENCES

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

ALVAREZ 59 PRL 2 215	ALVAREZ, EBERHARD, GOOD, GRAZIANO, TICHO+ (LRL)
JAUNEAU 63 SIENA CONF 1 1	JAUNEAU+ (PARIS+CERN+LOND+RUTH+BERGEN)
ALSC 63 PL 4 49	JAUNEAU+ (PARIS+CERN+LOND+RUTH+BERGEN)
TICHO 63 BNL CCFN 410	HAROLD K TICHO (UCLA)
CARMONY 64 PRL 12 482	CARMONY, PJERRU, SCHLEIN, SLATER, STORK+(UCLA)
HUBBARD 64 PR 135 B 183	HUBBARD, BERGE, KALBFLEISCH, SHAFER + (LRL)
PJERRUCU 65 PRL 14 275	+ SCHLEIN, SLATER, SMITH, STORK, TICHO (UCLA)
PJERRUCU 65 THESIS	G M PJERRUCU (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 CCFN	MERRILL, SHAFER, BERGE (LRL)
CF. 66 UCRL 16455	DEANE MERRILL (THESIS, BERKELEY) (LRL)
PALMER 68 PL 268 323	PALMER, RADDJICIC, RAU, RICHARDSON+ (BNL, SYR)
DAUBER 69 PR 179 1262	+BERGE, HUBBARD, MERRILL, MILLER (LRL)



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

QUANTUM NUMBERS ASSIGNED FROM SU3

THERE ARE 28 REPRCTED OMEGA- EVENTS
SEE PREVIOUS EDITION (RMP 41 109) FOR MORE DETAILS

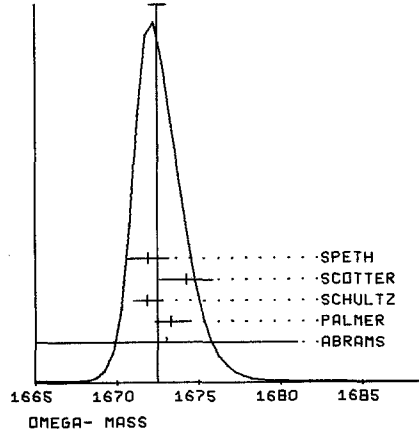
24 OMEGA- MASS (MEV)

M	1(1620.0)	(25.0)	(10.0)	EISENBERG 54 EMUL	INTO XI- P10
M	1 1673.0	8.0		ABRAMS 64 HBC	
M	3 1673.3	1.0		PALMER 68 HBC	K-P 4.6, 5.0 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 6.0 GEV/C 11/69
M	6 1671.9	1.2		SPETH 69 HBC	K-P 10.0 GEV/C 11/69
M					
M	AVG	1672.49	0.52	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0) (SEE IDECGRAM BELOW)	

24 OMEGA- LIFETIME (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	(1.05)	COLLEY 65 HBC	7/66
T A	1	(1.5)	RICHARDSON 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

WEIGHTED AVERAGE = 1672.49 ± 0.52
ERROR SCALED BY 1.0



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.					
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

24 OMEGA- PARTIAL DECAY MODES

P1	OMEGA- INTO LAMBDA K-	938+ 105+ 0
P2	OMEGA- INTO XI 0 PI-	938+ 105+ 0
P3	OMEGA- INTO XI- PI 0	938+ 105+ 0

24 OMEGA- BRANCHING RATIOS

27 EXAMPLES OF OMEGA- DECAYS HAVE BEEN REPORTED. 16 HAVE
DECAYED INTO LAMBDA K-, 9 INTO XI 0 PI-, 2 INTO XI- PI 0, AND ONE IS
AMBIGUOUS BETWEEN LAMBDA K- AND XI 0 PI-.

R1	2	EVENTS	PALMER 68 HBC	P1	11/69
R1	3	EVENTS	SCHULTZ 68 HBC		11/69
R1	5	EVENTS	SCOTTER 68 HBC		11/69
R1	6	EVENTS	SPETH 69 HBC		11/69
R2	1	EVENTS	ABRAMS 64 HBC	P2	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	1	EVENT	PALMER 68 HBC	P3	11/69
R3	1	EVENT	SCOTTER 68 HBC		11/69

REFERENCES

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

EISENBERG 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+RHUL)
RICHARDS 65 BAPS 10 115	RICHARDSON, BARNES, CRENNELL+ (BNL+SYRACUS)
SAMIOS 65 ARGONNE CONF 189	N P SAMIOS (RVUE) BNL
ABCLV COL 68 NUC PHYS 84 326	AACHEN+BERLIN+CERN+LONDON IMP.COLL.+VIENNA
ALLISON 68 PRIV. COMM.	JOHN ALLISON (LANCASTER)
PALMER 68 PL 268 323	PALMER, RADDJICIC, RAU, RICHARDSON+ (BNL, SYR)
SCHULTZ 68 PR 168 1509	SCHULTZ+ (ILL, ARGONNE, NORTHWESTERN, WISC)
SCOTTER 68 PL 268 474	SCOTTER+(BIRM, GLASGOW, IC LONDON, MUNICH, OXF)
SPETH 69 PL 298 252	SPETH+ (AACHEN, BERLIN, CERN, LONDON, VIENNA)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

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

PI

PI MESON (JPG=0--) I=1
SEE LISTING OF STABLE PARTICLES

SIGMA(410)

7 SIGMA MESON (410, JPG=0++) I=0
NO EVIDENCE FOR RESONANCE
OMITTED FROM TABLE.
SEE NOTE ON ETA 0+(1700)

REFERENCES ON SIGMA

Table listing references for Sigma meson, including authors like SAMIOS, BLOKHINT, BARISH, etc., and their respective publications.

ETA

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

ETA 0+(~700) OR E

14 ETA 0+(700, JPG=0++) I=0
ALSO CALLED EPSILON (720)

Information about the pi pi system in the I = 0 S-wave comes mainly from phase-shift analyses of the reactions pi- p -> pi+ pi- n (BATON 65, GUTAY 67, JOHNSON 67, WALKER 67, BISWAS 68, MARATECK 68, MALAMUD 69, SCHARENGUIVEL 69). Although no method of pi pi phase-shift analysis used is free from serious objections, the fact that all analysts find the S-wave phase shift delta^0 to be near pi/2 in the region 650 to 900 MeV is quite impressive.

Further support is lent by studies of the pi^0 pi^0 system (DEINET 69, and others with less statistics), annihilation into 3 pi and 4 pi, studies of pi+ pi- in other reactions, and dispersion-relation calculations. Below we list the more important references.

Since there is yet little information on delta^0 above 900 MeV, all that can be said about the width is that it is apparently well over 100 MeV.

REFERENCES

Table listing references for pi pi system, including authors like BATON, DURAND, LOVELACE, CLEGG, etc., and their respective publications.

RHO(765)

9 RHO (765, JPG = 1-) I=1

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.

Table listing significant rho meson entries with details like author, year, and production method.

CHARGE PLUS ONLY

Table listing rho meson data for charge plus only, including mass and width values.

CHARGE PLUS AND MINUS

Table listing rho meson data for charge plus and minus, including mass and width values.

CHARGE MINUS ONLY

Table listing rho meson data for charge minus only, including mass and width values.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

9 RHO BRANCHING RATIOS

Table with columns for RHO INT0, RHO INT1, RHO INT2, RHO INT3, and RHO INT4. Each entry includes a name, a numerical value, and a reference number.

Extraction of a rate for rho0 -> e+e- is complicated by interference with omega0 decay. In photoproduction, gamma A -> e+e- A, there is substantial interference between the allowed (rho0, omega) -> e+e- decays. The interference in the colliding-beam reaction e+e- -> pi+pi- is due to G parity violating mixing of the overlapping rho0 and omega resonances; it alters the results for the rate Gamma(rho0 -> e+e-) only by a small amount. Therefore we use at present, for the average, only the values from the e+e- -> pi+pi- experiments.

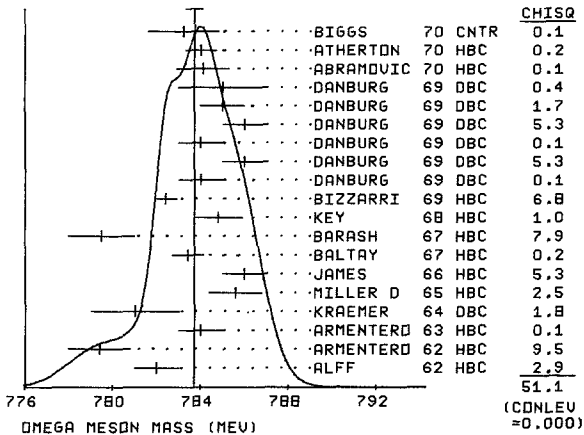
Table with columns for RHO INT0, RHO INT1, RHO INT2, RHO INT3, and RHO INT4. Each entry includes a name, a numerical value, and a reference number.

Table with columns for ANDERSON, ALBERT, ABOLINS, and others. Each entry includes a name, a numerical value, and a reference number.

Large table with multiple columns containing names, numerical values, and reference numbers. Includes a box labeled 'omega(784)' and a section for 'OMEGA MASS (MEV)'.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 783.70 ± 0.38
ERROR SCALED BY 1.7



1 OMEGA PARTIAL DECAY MODES

Mode	Decay Masses
P1 OMEGA INTO PI+ PI- P10	139+ 139+ 134
P2 OMEGA INTO PI+ PI- (VIOLATES G)	139+ 139
P3 OMEGA INTO P10 GAMMA (ONLY NEUTRAL INPUT TO FIT)	134+ 0
P4 OMEGA INTO PI+ PI- GAMMA	139+ 139+ 0
P5 OMEGA INTO ZP10 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 P10 (VIOLATES C)	548+ 134
P10 OMEGA INTO 3 GAMMA	0+ 0+ 0
P11 OMEGA INTO P10 MU+ MU-	134+ 105+ 105

1 OMEGA BRANCHING RATIOS

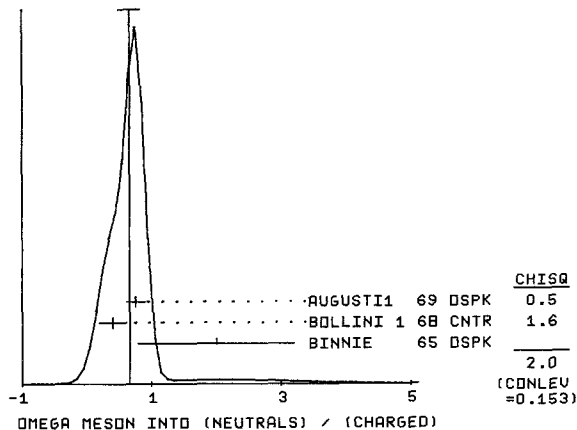
Note on the branching ratios of $\omega(784)$

Note that the errors of the decay branching ratios in the Meson Table are slightly different from their values below (under "VALUE FROM CONSTRAINED FIT"), the table values being more conservative. The CONSTRAINED FIT only takes into account the decay modes $\pi^+ \pi^- 0$, $\pi^+ \pi^-$, and neutrals, the latter defined as $\pi^0 \gamma$. In the Meson Table we have also taken into account the upper limits, L_1 (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 $0 \pm L_1$.

R1	OMEGA INTO NEUTRAL/(PI+ PI- P10)		
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)
R1	850	0.134	0.026 DIGUGNON 66 CNTR 1.4 PI-P
R1	348	0.097	0.016 FLATTE 66 HBC 1.8 K-P
R1	0.06	0.05	0.02 JAMES 66 HBC 2.1 PI+P
R1	19	0.10	0.03 BARASH 67 HBC 0.0 PBAR P
R1	AVG	0.1048	0.0091 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1	FIT	0.1050	0.0072 VALUE FROM CONSTRAINED FIT
R2	OMEGA INTO (PI+ PI-)/(PI+ PI- P10). SEE ALSO R15		
R2	(.0021)DR MORE,C.L.=0.9	FLATTE 70 HBC	1.5 K-P 8/69
R2	(0.011)DR MORE,C.L.=0.95	ABRAMOVIC 70 HBC	3.9 PI-P 6/70*
R2	(0.023)DR MORE,C.L.=0.95	CHAPMAN 70 HBC	1.6-2.2 P PBAR 6/70*
R2	F	FLATTE TO SEES NO SIGNAL AT 1.7, 2.1, 2.6 GEV/C.	
R2	P	(0.035)DR LESS,C.L.=0.95	BIZZARRI 70 DBC PBAR N AT REST 6/70*
R2	R	0.022	0.009 0.01 RODS 70 RVUE 6/70*
R2	R	COMBINED FROM BIZZARRI 70 AND ABRAMOVICH 70 6/70*	
R2	FIT	0.0104	0.0028 VALUE FROM CONSTRAINED FIT
R3	OMEGA INTO (P10 GAMMA) / (PI+ PI- P10)		
R3	(0.125)	(0.025)DR	GRTR. BARMIN 64 PXBC 2.8 PI-P
R3	0.13	0.04	JACQUET 69 HLBC 10/67
R3	FIT	0.1050	0.0072 VALUE FROM CONSTRAINED FIT

R4	OMEGA INTO (PI+ PI- GAMMA)/(PI+ PI- P10)		
R4	(0.05) OR LESS	FLATTE 66 HBC	1.8 K-P 9/66
R6	OMEGA INTO (MU+ MU-)/(PI+ PI- P10)(UNITS 10**-3)		
R6	(1.2) OR LESS	GALTIERI 65 HBC	2.7 K-P
R6	(1.7)DR LESS	FLATTE 66 HBC	1.8 K-P 9/66
R6	(0.2) OR LESS	WILSON 69 DSPK	12 PI- ON C,FE 9/69
R7	OMEGA INTO (2P10 GAMMA)/(P10 GAMMA)		
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
R8	OMEGA INTO (ETA P10 + ETA GAMMA)/(PI+ PI- P10)		
R8	(0.017) OR LESS	FLATTE 66 HBC	1.8 K-P 9/66
R8	(0.045)DR LESS	JACQUET 69 HLBC	CL=0.95 4/70*
R9	OMEGA INTO (NEUTRALS) / (CHARGED)		
R9	0.124	0.021	FELDMAN 67 DSPK 1.2 PI-P 3/67
R9	FIT	0.1039	0.0071 VALUE FROM CONSTRAINED FIT
R10	OMEGA INTO (2P10 GAMMA)/(PI+ PI- P10)		
R10	(0.08) OR LESS	JACQUET 69 HLBC	CL=0.95 4/70*
R11	OMEGA INTO (ETA GAMMA)/(P10 GAMMA)		
R11	(0.58) (0.30)	STRUGALSK 69 HLBC	2.34 PI+ N 8/69
R12	OMEGA INTO (P10 MU+ MU-) / TOTAL (UNITS 10**-3)		
R12	(2.) OR LESS	WEHMANN 68 DSPK	12 PI- FE 6/68
R13	OMEGA INTO (E+ E-)/TOTAL (UNITS 10**-4)		
R13	2.	1.2	BINNIE 65 DSPK 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 DSPK ASSUME SU(3)+MIXING 10/66
R13	H	NOT RESOLVED FROM RHO DECAY.	
R13	A	(0.55) (0.13)	ASTVACATU 68 DSPK ASSUME SU(3)+MIXING 6/68
R13	A	NOT RESOLVED FROM RHO DECAY. ERROR STATISTICAL ONLY.	
R13	Z	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	E	0.76	0.14 AUGUSTI1 69 DSPK SEE NOTE E 9/68
R13	E	FROM E+ E- COLLIDING BEAMS, ASSUMING OMEGA WIDTH 12.2+-1.3 MEV 4/69	
R13	AVG	0.66	0.17 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) (SEE IDEOGRAM BELOW)
R14	OMEGA INTO NEUTRALS / TOTAL		
R14	0.084	0.015	BOLLINI 68 CNTR 2.1 PI-P 6/68
R14	0.079	0.019	DEINET 69 DSPK 1.5 PI-P 9/69
R14	AVG	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	
R14	FIT	0.0961	0.0059 VALUE FROM CONSTRAINED FIT
R15	OMEGA INTO (PI P11)/(TOTAL). SEE ALSO R2		
R15	0.032	0.028	0.019 AUGUSTI2 69 DSPK E+E- COLL.BEAMS 8/69
R15	(0.003)DR MORE,C.L.=0.95	GOLDBER 69 HBC	3.7-4.0 PI+P 11/69
R15	(0.014)DR MORE,C.L.=0.95	ALLISON 70 HBC	1.3-1.7 PBAR P 6/70*
R15	0.0080	0.0028	0.0022BIGGS 70 CNTR PHOTOPRODUCTION 6/70*
R15	AVG	0.0083	0.0025 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R15	FIT	0.0093	0.0025 VALUE FROM CONSTRAINED FIT
R16	OMEGA INTO (ETA GAMMA) / (ALL NEUTRALS)		
R16	(0.24) OR LESS (CL=0.9)	DEINET 69 DSPK	9/69
R17	OMEGA INTO (2 P10 GAMMA) / (ALL NEUTRALS)		
R17	(0.19) OR LESS (CL=0.9)	DEINET 69 DSPK	9/69
R18	OMEGA INTO (P10 GAMMA) / (ALL NEUTRALS)		
R18	(0.81) OR GREATER (CL=0.9)	DEINET 69 DSPK	9/69

WEIGHTED AVERAGE = 0.66 ± 0.17
ERROR SCALED BY 1.4



See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Partial Decay Mode Branching Fractions

Diagonal elements are P_i ± δP_i; δP_i = √<δP_iδP_i>. Off-diagonal elements are correlation coefficients = <δP_iδP_j> / (δP_i, δP_j).

Table with 3 columns: P 1, P 2, P 3. Values include 0.897+-0.006, -0.374, 0.009+-0.003, -0.91e, -0.025, 0.094+-0.006.

***** REFERENCES FOR OMEGA *****

Table listing references for Omega mesons, including authors like Maglic, Alvarez, Rosenfeld, Stevenson, and various institutions like CERN and JHU.

MILLET 65 INCLUDES DATA OF ZDANIS 65 PRL 14 721

Table listing various meson decays and their corresponding references, such as ALFF-STEINBERGER, DIGIUGNO, FLATTE, JAMES, BALTAY, etc.

***** PRIVATE COMM. RICHARD WILSON (SEE ALSO PR 178 2095) (HARV) *****

η'(958) 2 ETA PRIME (958, JPC=0+-) I=0
KNOWN ALSO AS X0 (JP = 2- NOT YET EXCLUDED,) (SEE NOTE ON QUANTUM NUMBERS AT END OF ETA PRIME LISTINGS)

Table for 2 ETA PRIME MASS (MEV) with columns for mass values and error bars, including entries for DAUBER, KALBFLEISCH, and BADIOER.

Table for 2 ETA PRIME PARTIAL DECAY MODES, listing decay channels like P1, P2, P3 and their corresponding branching ratios.

Table for 2 ETA PRIME BRANCHING RATIOS, listing ratios for various decay modes and their uncertainties.

Table for 2 ETA PRIME WIDTH (MEV) with columns for width values and error bars, including entries for DAUBER, KALBFLEISCH, and BADIOER.

Table for 2 ETA PRIME PARTIAL DECAY MODES, listing decay channels like P1, P2, P3 and their corresponding branching ratios.

2 ETA PRIME BRANCHING RATIOS

In our calculation of the constrained branching fractions of the η' (958) we assume the following decay modes:

- (a) ηππ (including ηπ0π0, 71% of the η' s neutral),
(b) ρ0γ,
(c) γγ.

Note that the γγ value measured by BOLLINI 68 (5.5+3.6/-3.0%) is slightly different from the result of the overall fit (4.7 ± 2.9%) because of independent measurements of (η' → all neutrals)/(η' → total). In the fit we do not use the constraint

R = Γ(η' → ηπ+π-) / Γ(η' → ηπ0π0) = 2

from I-spin conservation. The result of the fit is in agreement with it, R = 2.0 ± 0.4.

Table for 2 ETA PRIME (958, JPC=0+-) I=0, listing decay channels and branching ratios.

Table for 2 ETA PRIME MASS (MEV), listing mass values and error bars.

Table for 2 ETA PRIME PARTIAL DECAY MODES, listing decay channels and branching ratios.

Table for 2 ETA PRIME BRANCHING RATIOS, listing ratios for various decay modes and their uncertainties.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

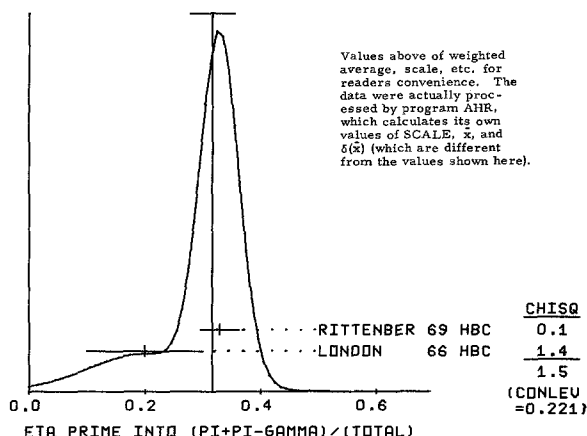
R5	ETA PRIME INTO (NEUTRALS) / TOTAL				
P3 K	54 (0.251) (0.05)	KALBFLEIS 64 HBC	2.7 K-P	10/66	
R5 K		SUPERSEDED BY RITTENBERG 69			
R5	16 0.24 0.17	BADIER 65 HBC	3.0 K-P	10/66	
R5	32 0.3 0.1	LONDON 66 HBC	2.2 K-P	10/66	
R5	123 0.189 0.026	RITTENBERG 69 HBC	1.7-2.7 K-P	9/69	
R5	AVG	0.197 0.027	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)		
R5	FIT	0.205 0.021	VALUE FROM CONSTRAINED FIT		
R6	ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL				
R6 K	42 (0.221) (0.04)	KALBFLEIS 64 HBC	2.7 K-P	10/66	
R6 K		SUPERSEDED BY RITTENBERG 69			
R6 B	35 (0.341) (0.09)	BADIER 65 HBC	3.0 K-P	10/66	
R6 B		CONTOVERSIAL BACKGROUND SUBTRACTION			
R6	20 0.2 0.1	LONDON 66 HBC	2.2 K-P	10/66	
R6	298 0.329 0.033	RITTENBERG 69 HBC	1.7-2.7 K-P	9/69	
R6	AVG	0.316 0.038	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)		
R6	FIT	0.296 0.026	VALUE FROM CONSTRAINED FIT (SEE IDEOGRAM BELOW)		

Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \delta P_j)$.

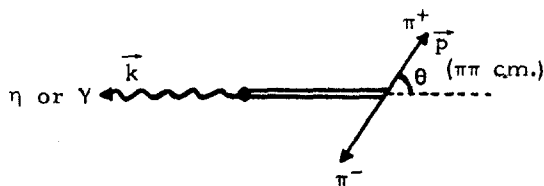
	P 1	P 2	P 3	P 4
P 1	.436+- .023			
P 2	-.455	.221+- .043		
P 3	-.386	-.342	.296+- .026	
P 4	.154	-.786	-.004	.047+- .029

WEIGHTED AVERAGE = 0.316 ± 0.038
ERROR SCALED BY 1.2



UNCERTAINTY IN THE J^P ASSIGNMENT OF $\eta'(958)$

For the dominant (66%) $\pi\pi\eta$ decay mode of the η' , 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 $J^P = \text{Normal}$ series may be ruled out.



By 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)].

This leaves the Abnormal series $0^-, 1^+, 2^-, \dots$. In the discussion below, the confidence levels are values from RITTENBERG 69, based on fits of 278 $\pi^+\pi^-\eta_{\text{neut}}$ decays (see ~ 100 more in the compilation by LONDON 66):

$J^P = 0^-$: The simplest matrix element M is constant; confidence level = 7%.
 1^+ : $M = k$. This simply does not fit (confidence level $< 10^{-10}$). Of course a strong $\pi\pi$ final-state interaction could help, but it seems unlikely that it could make the fit acceptable.
 2^- : $M = akk + bpp$, where a and b are arbitrary. Here, according to London et al., $|M|^2$ gives a good fit to the data with $b \approx 3a$. According to Rittenberg, it gives a confidence level of 0.6%, also with $b \approx 3a$.

R7	ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/(PI PI ETA)				
R7	0.25 0.14	DAUBER 64 HBC	1.95 K-P	10/66	
R7	AVG	0.451 0.060	VALUE FROM CONSTRAINED FIT		
R8	ETA PRIME INTO (PI0 E+ E-)/TOTAL				
R8	(0.013) OR LESS	RITTENBERG 65 HBC	2.7 K-P	10/66	
R9	ETA PRIME INTO (ETA E+ E-)/TOTAL				
R9	(0.011) OR LESS	RITTENBERG 65 HBC	2.7 K-P	10/66	
R10	ETA PRIME INTO (PI0 RHO0)/TOTAL				
R10	(0.04) OR LESS	RITTENBERG 65 HBC	2.7 K-P	10/66	
R11	ETA PRIME INTO (PI0 OMEGA) / TOTAL				
R11	(0.08) OR LESS	RITTENBERG 65 HBC	2.7 K-P	10/66	
R12	ETA PRIME INTO (PI+ PI- E+ E-)/TOTAL				
R12	(0.006) OR LESS	RITTENBERG 65 HBC	2.7 K-P	10/66	
R13	ETA PRIME INTO (2 PI)/TOTAL				
R13	(0.07) OR LESS COMP.BY LONDON	66 HBC		10/66	
R14	ETA PRIME INTO (3 PI)/TOTAL				
R14	(0.07) OR LESS COMP.BY LONDON	66 HBC		10/66	
R15	ETA PRIME INTO (4 PI)/TOTAL				
R15	(0.01) OR LESS COMP.BY LONDON	66 HBC		10/66	
R16	ETA PRIME INTO (6 PI)/TOTAL				
R16	(0.01) OR LESS COMP.BY LONDON	66 HBC		10/66	
R18	ETA PRIME INTO (RHOO GAMMA)/(PI PI ETA)				
R18	0.31 0.15	DAVIS 68 HBC	5.5 K-P	9/68	
R18	AVG	0.451 0.060	VALUE FROM CONSTRAINED FIT		
R19	ETA PRIME INTO (2 GAMMA)/TOTAL				
R19	5 0.055 0.036 0.030	BOLLINI 68 CNTR	1.9 PI-P	9/68	
R19	AVG	0.047 0.031	VALUE FROM CONSTRAINED FIT		
R20	ETA PRIME INTO (PI+PI-)/TOTAL				
R20	(0.02) OR LESS	RITTENBERG 69 HBC	1.7-2.7 K-P	9/69	
R21	ETA PRIME INTO (PI+PI-PI0)/TOTAL				
R21	(0.05) OR LESS	RITTENBERG 69 HBC	1.7-2.7 K-P	9/69	
R22	ETA PRIME INTO (PI+PI+PI-PI-)/TOTAL				
R22	(0.01) OR LESS	RITTENBERG 69 HBC	1.7-2.7 K-P	9/69	
R23	ETA PRIME INTO (PI+PI+PI-PI-PI0)/TOTAL				
R23	(0.01) OR LESS	RITTENBERG 69 HBC	1.7-2.7 K-P	9/69	
R24	ETA PRIME INTO (PI+PI+PI-PI- NEUTRALS)/TOTAL				
R24	(0.01) OR LESS	RITTENBERG 69 HBC	1.7-2.7 K-P	9/69	

See the illustrated key preceding the data card listings.

▲ Data in parentheses have not been included in our averages.

A recent spark chamber experiment at CERN (DUFEY 69), based on the Dalitz plot distribution of about 300 $\pi^+\pi^-\eta_{\text{neut}}$ decays, leads to the following similar conclusions:

$J^P = 0^-$: This fits well (if one allows the matrix element to vary linearly with the η kinetic energy).

1^+ : Excluded (unless one assumes very drastic form factors).

2^- : Cannot be excluded. The simplest matrix element (see above) gives a poor fit (3%, with $|b/a| \approx 4$), but it can easily be improved with a slightly more complicated matrix element.

Hence, to rule out $J^P = 2^-$, one turns to the 30% mode $\eta^1 \rightarrow \pi^+\pi^-\gamma$, and the usual J^P assignment is based heavily on this Dalitz plot. The plot by Rittenberg, with 132 events, shows that the decay is mainly $\rho^0\gamma$, and the θ distribution shows a strong preference for equatorial decays:

$J^P = 0^-$: Fits well. The only matrix element is magnetic dipole, M_1 . $|M_1|^2$ predicts $d\sigma/d\omega \propto \sin^2\theta$, and the confidence level is 47%.

1^+ : Does not fit (confidence level = 0.002%). The matrix element yields a $1 + \cos^2\theta$ distribution.

2^- : Fits well. Again the simplest transition is M_1 , and this time the predicted distribution is $6 + \sin^2\theta$, with a confidence level of 14%.

We should warn that the $\pi\pi\gamma$ decay has a very high Q value ($0 < k < 460$ MeV), with the average value of k about 200 MeV. Hence we must not be too quick to consider only the smallest powers of k/M_{η^1} in matrix elements. Specifically this warning means the following. We in this note have considered only the lowest possible multipole transition. Thus the 14% confidence level quoted above for the 2^- hypothesis was based on an M_1 matrix element. But of course E_2 is also possible, and has an independent coupling that could be large. It can interfere with M_1 to give almost any distri-

bution. Rittenberg finds a confidence level of 46% for $J^P = 2^-$ when a variable amount of E_2 is included in the matrix element. The 1^+ fit can also be improved by adding higher-order matrix elements. So the $\pi\pi\gamma$ mode is likely to be somewhat unreliable. We want to thank V. I. Ogievetsky and W. Tybor for pointing this out to us. (See Zaslavsky, Ogievetsky, and Tybor, JINR Preprint E2-4061, Dubna, 1968).

So all available Dalitz plot data for both modes seem to permit $J^P = 2^-$. London et al. have a qualitative remark that the 2^- hypothesis is inconsistent with their observed ~3:1 ratio of $\pi\pi\eta:\pi\pi\gamma$, and Rittenberg finds no correlations between the decay plane of the η^1 and the production coordinate system, but neither of these observations, although adding weight against 2^- , rules it out.

Finally, we note that, since a $J = 1$ particle cannot decay into $\gamma\gamma$, an observation of a $\gamma\gamma$ decay excludes $J^P = 1^+$. BOLLINI 68 observed five events of this kind over a background of only about one event. The probability that this is due to a statistical fluctuation of the background is less than 1%; hence at the same level of confidence, $J^P = 1^+$ can be excluded.

REFERENCES FOR ETA PRIME			
DAUBER	64 PRL 13 449	DAUBER, SLATER, SMITH, STORK, TICH0	(UCLA)JP
ALSO	64 DUBNA CONF 1 418	DAUBER, SLATER, L T SMITH, STORK, TICH0	(UCLA)
KALBFLEI	64 PRL 13 349	G.R. KALBFLEISCH, O. 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 15 856	RITTENBERG, KALBFLEISCH	(LRL+BNL)
TRILLING	65 PL 19 427	+BROWN, GOLDBERS, 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)JP	
BOLLINI	68 NC 58 A 289	+BUHLER, DALPIAZ, MASSAMA (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

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

MARTIN	66 PL 22,352	MARTIN, CRITTENDEN, SCHROEDER	(INDIANA UII)
BARBARO	68 PRL 20 349	BARBARO-GALTIERI, MATISON, RITTENBERG+ (LRL)I=0	
BARLOUTA	68 PL 26 B 674	BARLOUTAUD+ (SACLAY+MSTD+BDLGG+WEIZ+HE-P.)I=0	
DUFEY	69 PL 29 B 605	+GOBBI, POUCHON, CNOPS, + (ETHZ+CERN+SACL)JP	

$\delta(966)$ 36 DELTA MESON (966, J^G=) I = 1Note on $\delta(966)$

The $\delta^-(966)$ was originally seen with the CERN MMS, KIENZLE 65. Other missing-mass spectrometers (OOSTENS 66, BANNER-1 67, BANNER-2 67) have added nothing conclusive to this evidence.

A claim in the 2π system (ALLEN 66) has been contradicted (JACOBS 66, WEST 66, CLEAR 67, ROOS 67), and claims in the 3π system (ALLISON 67, JUHALA 68) likewise (SAMIOS 68, KRUSE 69). For discussion, see SAMIOS 68 and MAGLIĆ 69.

Recent support comes from BARNES 69 and AMMAR 70, who see a peak in the $\eta\pi$ system, and who claim that it cannot be explained by the kinematic effect discussed below under 2a.

The following references have possible relevance to the existence of the $\delta(966)$:

1) The $\pi_N(1016)$ may be interpreted as a virtual bound state in the $K\bar{K}$ channel. It would then correspond to a narrow resonance at about 975^{+15}_{-10} MeV (ASTIER 67) in open channels, e. g., $\eta\pi$ or 5π .

2) Further $\eta\pi$ enhancements have been reported at masses in the 960-980 MeV region. As evidences for a resonance they are however not yet convincing, because there are kinematic effects that can produce $\eta\pi$ peaks in that mass region:

a) In the reactions $K^-n \rightarrow \Lambda\pi^-(MM)$ and $K^-p \rightarrow \Lambda\pi^+\pi^-(MM)$ (studied by CRENNELL 69, MILLER 69) with selection of the missing mass (MM) in the $\eta(549)$ region, a spurious $\delta(966)$ peak can arise from contamination with $\Lambda\rho^-\pi^0$ 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 ω

copiously produced, the constraint of at least one η combination in the $\pi^\pm\pi^+\pi^-\pi^0$ mass "fakes" a bump in the mass region around 960 MeV, due to reflections from the ω . This remark (by NELLEN 69) may apply to the observations of DEFOIX 68, CAMPBELL 69, and OTWINOWSKI 69.

If we accept $\delta \rightarrow \pi\eta$ by strong decay, then $I^G = 1^-$; nonobservation of 3π decay can be explained by choosing $J^P = 0^+$, or simply by saying that 3π background is too large to permit detection. These quantum numbers $1^-(0^+)$ are then the same as those most likely for $\pi_N(1016)$, which could be just the $\bar{K}K$ decay mode of $\delta(966)$.

An unattractive alternative is to believe that δ is really very narrow, and guess that its $\pi\eta$ decay is G-violating electromagnetic. (It is not clear whether there would be competition from $\pi\pi\eta$ decay, which is strong but has much smaller phase space.) However, in this electromagnetic (em) case, one would also expect slightly faster decay into $\pi\pi$, and we are not sure whether this mode should have been detected. To see why we expect $\pi\pi$ decay, note that these em decays into $\pi^-\pi^0$ or $\pi^-\eta$ involve emission and reabsorption of a photon, with rates proportional to e^4 (also $\pi\pi$ has slightly larger phase space than $\pi\eta$). Neutral em decays (as in the familiar $\eta^0 \rightarrow 3\pi$) have selection rules either

$$\Delta G = \text{Yes}, \quad \Delta |I| = 1,$$

or

$$\Delta G = \text{No}, \quad \Delta |I| = 2,$$

but charged decays ($\delta^- \rightarrow \pi^-\pi^0$ or $\pi^-\eta$) have no such rules (except $\Delta |I| \leq 2$).

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

36 DELTA MESON MASS (MEV)

Table listing meson mass data for 36 Delta Meson Mass (MeV) with columns for experiment name, mass value, error, and other parameters.

WEIGHTED AVERAGE = 966.0 ± 5.0
ERROR SCALED BY 1.2

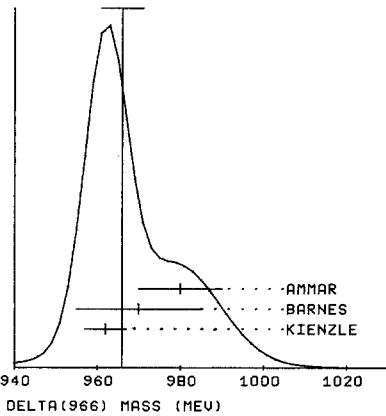


Table with columns CHISQ and CONLEV, showing values for different experiments like AMMAR, BARNES, KIENZLE.

36 DELTA MESON WIDTH (MEV)

Table listing meson width data for 36 Delta Meson Width (MeV) with columns for experiment name, width value, error, and other parameters.

36 DELTA MESON PARTIAL DECAY MODES

Table listing partial decay modes for 36 Delta Meson with columns for mode name and branching ratios.

36 DELTA MESON BRANCHING RATIOS

Table listing branching ratios for 36 Delta Meson with columns for mode name, ratio, and other parameters.

REFERENCES ON DELTA MESON

Table listing references on Delta Meson with columns for author, year, and journal.

Table listing references on H(990) with columns for author, year, and journal.

H(990)

35 H (990, JPG=A -) I=0

IT IS SHOWN BY BARBARO-GALTIERI 68 THAT THE PRE-1968 H ENHANCEMENT IS COMPATIBLE WITH BEING ENTIRELY DUE TO MISIDENTIFIED RHOO-GAMMA DECAYS OF ETA PRIME(958).

REFERENCES ON H MESON

Table listing references on H meson with columns for author, year, and journal.

pi_N(1016) -> KK

16 pi(1016, JPG=0+-) I=1

STILL NOT DECIDED WHETHER (K KBAR) RESONANCE, VIRTUAL BOUND STATE OR ANTIBOUND STATE. MAY BE RELATED TO THE DELTA (966)

16 pi(1016) MASS (MEV)

Table listing mass data for 16 pi(1016) with columns for experiment name, mass value, error, and other parameters.

16 pi(1016) WIDTH (MEV)

Table listing width data for 16 pi(1016) with columns for experiment name, width value, error, and other parameters.

16 pi(1016) PARTIAL DECAY MODES

Table listing partial decay modes for 16 pi(1016) with columns for mode name and decay masses.

16 pi(1016) BRANCHING RATIOS

Table listing branching ratios for 16 pi(1016) with columns for mode name, ratio, and other parameters.

REFERENCES FOR pi(1016)

Table listing references for pi(1016) with columns for author, year, and journal.

phi(1019)

4 phi(1019, JPG=1---) I=0

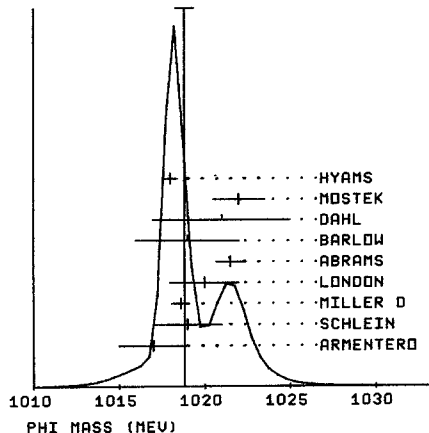
4 phi MASS (MEV)

Table listing mass data for 4 phi with columns for experiment name, mass value, error, and other parameters.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

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
M	1018.	0.5	0.35	HYAMS	70 OSPK	11. PI- P
M	.....	.....	.....	.....	.....	6/70*
AVG	1018.84	0.53	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)			
			(SEE IDEOGRAM BELOW)			

WEIGHTED AVERAGE = 1018.84 ± 0.53
ERROR SCALED BY 1.9



CHISQ	
HYAMS	70 OSPK
MOSTEK	68 OSPK
DAHL	67 HBC
BARLOW	67 HBC
ABRAMS	67 HBC
LONDON	66 HBC
MILLER D	65 HBC
SCHLEIN	63 HBC
ARMENTERO	63 HBC
0.8	
20.8	
(CONLEV = 0.002)	

4 PHI WIDTH (MEV)			
W	3.4	1.7	ARMENTERO 63 HBC
W	34	(5.0) OR LESS	SCHLEIN 63 HBC
W	3.5	1.0	MILLER D 65 HBC
W	6.0	4.0	LONDON 66 HBC
W	1.8	3.0	1.5 ABRAMS 67 HBC
W	(10.1) OR LESS	(2.0)	BARLOW 67 HBC
W	(4.5)	(3.0)	MOSTEK 68 OSPK
W	4.09	0.29	BIZOT 70 OSPK
W	4.1	0.5	BALAKIN 69 OSPK
W	3.3	1.5	0.9 HYAMS 70 OSPK
W	.....	.....	.....
W	AVG	4.00	0.23
AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

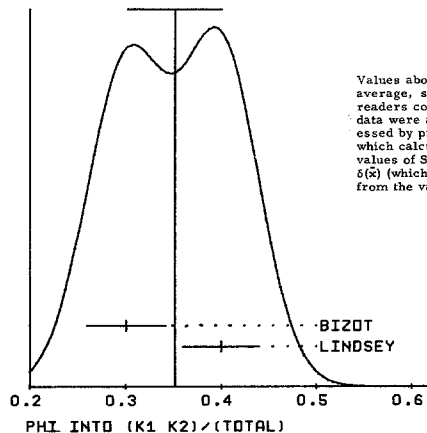
4 PHI PARTIAL DECAY MODES			
DECAY MASSES			
P1	PHI INTO K+ K-		493+ 493
P2	PHI INTO K0L K02		497+ 497
P3	PHI INTO PI+ PI- P10 (INCLUDING RHO PI)		139+ 139+ 134
P4	PHI INTO PI+ PI- (VIOLATES G)		139+ 139
P5	PHI INTO E+ E-		5+ 5
P6	PHI INTO MU+ MU-		105+ 105
P7	PHI INTO P10 GAMMA		134+ 0
P8	PHI INTO ETA GAMMA		548+ 0
P9	PHI INTO PI+PI- GAMMA		139+ 139+ 0
P10	PHI INTO OMEGA GAMMA (VIOLATES C)		783+ 0
P11	PHI INTO ETA P10 (VIOLATES C)		548+ 134
P12	PHI INTO RHO GAMMA (VIOLATES C)		765+ 0

4 PHI BRANCHING RATIOS			
R1	PHI INTO (K+ K-)/TOTAL		493+ 493
R1 B	27 (0.26)	(0.06)	BADIER 65 HBC (SEE NOTE B BELOW)
R1	252 0.48	0.04	LINDSEY 66 HBC
R1	0.493	0.044	BIZOT 70 OSPK
R1	.....	.....	E+ E- COLL.BEAMS 6/70*
R1 AVG	0.486	0.030	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1 FIT	0.469	0.023	VALUE FROM CONSTRAINED FIT
R2	PHI INTO (K1 K2)/TOTAL		497+ 497
R2 B	25 (0.23)	(0.06)	BADIER 65 HBC (SEE NOTE B BELOW)
R2	167 0.40	0.04	LINDSEY 66 HBC
R2	0.301	0.041	BIZOT 70 OSPK
R2	.....	.....	E+ E- COLL.BEAMS 6/70*
R2 AVG	0.352	0.049	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
R2 FIT	0.348	0.023	VALUE FROM CONSTRAINED FIT

(SEE IDEOGRAM BELOW)

R3	PHI INTO (PI+ PI- P10 (INCL. RHO PI))/TOTAL		139+ 139+ 134
R3	30 0.12	0.08	LINDSEY 66 HBC
R3	0.206	0.036	BIZOT 70 OSPK
R3	.....	.....	E+ E- COLL.BEAMS 6/70*
R3 AVG	0.192	0.033	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3 FIT	0.183	0.025	VALUE FROM CONSTRAINED FIT
R5	PHI INTO (K1 K2)/(K KBAR)		139+ 139
R5	10 0.40	0.10	SCHLEIN 63 HBC
R5	52 0.48	0.07	BADIER 65 HBC
R5	0.44	0.07	LONDON 66 HBC
R5	.....	.....	2.2 K-P
R5 AVG	0.448	0.044	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5 FIT	0.426	0.024	VALUE FROM CONSTRAINED FIT
R6	PHI INTO (PI+ PI- P10 (INCL. RHO PI))/(K KBAR)		139+ 139
R6	0.30	0.15	LONDON 66 HBC
R6	.....	.....	2.2 K-P
R6 FIT	0.224	0.038	VALUE FROM CONSTRAINED FIT

WEIGHTED AVERAGE = 0.352 ± 0.049
ERROR SCALED BY 1.7



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, x, and δ(x) (which are different from the values shown here).

CHISQ	
BIZOT	70 OSPK
LINDSEY	66 HBC
3.0	
(CONLEV = 0.084)	

R7	PHI INTO (PI+ PI- P10 (INCL. RHO PI))/(K1 K2)		139+ 139+ 134
R7	(0.3) OR LESS		BERLEY 65 HBC
R7 FIT	0.326	0.097	VALUE FROM CONSTRAINED FIT
R8	PHI INTO (PI+ PI-)/(K KBAR)		139+ 139
R8	(0.2) OR LESS		LONDON 66 HBC
R8	.....	.....	2.2 K-P
R9	PHI INTO (E+ E-)/(K+ K-)		(UNITS 10**4) (SEE ALSO R16)
R9	40 6.1	1.7	BECKER 68 CNTR
R9	.....	.....	GAMMA C
R10	PHI INTO (MU+ MU-)/TOTAL (UNITS 10**4)		(UNITS 10**4)
R10	(53.) OR LESS		GALTIERI 65 HBC
R10	(7.4) OR LESS		CHASE 67 CNTR
R10	3.5	3.5	1.8 WEHMANN 68 OSPK
R10	.....	.....	12 K- C
R11	PHI INTO (ETA GAMMA)/TOTAL		548+ 0
R11	(0.2) OR LESS		BADIER 65 HBC
R11	(0.08) OR LESS		LINDSEY 66 HBC
R11	.....	.....	3.0 K-P
R12	(0.05) OR LESS		LINDSEY 65 HBC
R12	PHI INTO (PI+ PI- GAMMA)/(K KBAR)		139+ 139
R13	PHI INTO (ETA NEUTRALS)/(K KBAR)		548+ 0
R13	(0.15) OR LESS		LINDSEY 66 HBC
R13	.....	.....	2.7 K-P
R14	PHI INTO (OMEGA GAMMA) / TOTAL		783+ 0
R14	(0.05) OR LESS		LINDSEY 66 HBC
R14	.....	.....	2.7 K-P
R15	PHI INTO (RHO GAMMA) / TOTAL		134+ 0
R15	(0.02) OR LESS		LINDSEY 66 HBC
R15	.....	.....	2.7 K-P
R16	PHI INTO (E+ E-)/TOTAL (UNITS 10**4) (SEE ALSO R9)		(UNITS 10**4) (SEE ALSO R9)
R16 A	5 (6.4)	(4.4)	(2.8) ASTVACATUROV 68 OSPK
R16 A	.....	.....	4 PI- P
R16 A	.....	.....	PHOTOGRAPHY
R16	27 7.2	3.9	BINNIE 68 OSPK
R16	9 6.1	2.6	BOLLINI 68 CNTR
R16	3.4	0.4	BALAKIN 69 OSPK
R16	3.45	0.27	BIZOT 70 OSPK
R16	.....	.....	E+ E- COLL.BEAMS 6/70*

R16 AVG	3.47	0.22	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R17	PHI INTO (P10 GAMMA)/(TOTAL)		139+ 139
R17	1.0035 OR LESS		BEMPORAD 69 CNTR
R17	.....	.....	5.5 GAMMA N
R18	PHI INTO (PI+ PI-)/(TOTAL)		139+ 139
R18	(0.05) OR LESS		LINDSEY2 65 HBC
R18	.....	.....	1.7-2.7 K-P

Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i^2 \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \delta P_j)$.

P 1	0.469+-0.023		
P 2	-0.396	-0.348+-0.023	
P 3	-0.535	-0.564	0.183+-0.026

REFERENCES FOR PHI

BERTANZA 62 PRL 9 180 BERTANZA, BRISSON, CONNOLLY, HART + (BNL+SYR)
 ARMENTERO 63 SIENA CONF 2 70 ARMENTERO, EDWARDS, ASTIER + (CERN+CONF-PARIS)
 GELFAND 63 PRL 11 438 GELFAND, MILLER, NUSSBAUM, KIRSCH + (COLUMBIA)
 GELFAND 63 DATA INCLUDED IN MILLER 65 BELOW
 SCHLEIN 63 PRL 10 368 SCHLEIN, SLATER, SMITH, STORK, TIGHO (UCLA)
 BADIER 65 PL 17 337 BADIER, DEMOULIN, BARLOUTAUD + (PAR+LPICHE+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 UCLR 16526 JAMES S. LINDSEY (THESIS) (LRL)
 MILLER D 65 CU-237(NEVIS 131) DAVID C MILLER (THESIS) (COLUMBIA)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

GRAI, L 66 PRL 17 501 +HAGERTY, BIZZARRI, CIAPETTI + (SYR+RDME)JPG
LINDSEY 66 PR 147 913 JAMES S LINDSEY, GERALD A SMITH (LRL)
LINDSEY 66 PL 20 93 J.S. LINDSEY, G.A. SMITH (LRL)
LINDSEY 66 DATA INCLUDED IN LINDSEY 66 ABOVE
LONDON 65 PR 143 1034 LONDON, PAU, SAMIOS, GOLDBERG + (BNL+SYRACUSE)

ABRAMS 67 MD TECH REP 720 GERALD ABRAMS, THESIS (MARYLAND)
BARON 67 NC 50A 701 +LILLESTOL+MONTANET+(CERN+CDF+IR+LIVERPOOL)
CHASE 67 PRL 18 710 R.C. CHASE, P. ROTHWELL, R. WEINSTEIN (CEA+NEAST)
DAH 67 PR 163 1377 +HARDY+HESS+KIRZ+MILLER (LRL)
HERTZBACH 67 PR 155 1461 HERTZBACH, KRAEMER, MADANSKI, ZDANIS+(JHU+BNL)
KHACHATURIAN 67 PL 248 349 KHACHATURIAN+AZIMOV+BALDIN+RELOUSOV+(DUBNA)

ABRAMS 68 PR 175 1697 +GLASSER, KEHOE, SECHI-ZORN, WOLSKY (MARYLAND)
ASTVAGATUROV 68 PL 27 B 45 ASTVAGATUROV, AZIMOV, BALDIN+ (JINR+MOSCOW)
ALSO 67 PRL 19 869 ASSBURY, BECKER, BERTRAM, TING+ (DESY+COLUMBIA)
BERGER 68 PRL 21 1504 +BERTRAM, BINKLEY, JORDAN, KNASEL+ (DESY+MIT)
BINNIE 68 PL 278 106 +DUANE+FRUQUET+HURSEY+ (I.C.LON+RUTHERF)
BOLLINI 68 NC 56 A 1171 +BUHLER, DALPIAZ, MASSAMA+ (CERN+BGNA+STRB)
MOSIER 68 PRL 20 1057 +EISENHANDLER, MCLELLAN, MISTRY+ (CORNELL)
WEHMANN 68 PRL 20 748 +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)

BALKIN 69 IYAF 327 TRANS +BUDKER, KORSHUNOV, MISHNEV, SIDOROV+ (NOVO)
SEE ALSO SIDOROV 69
BEMPOPAD 69 PL 29 B 383 +BRACCINI, CASTALDI, LUBELSMAYER,+ (PISA+BNL)
SCOTTER 69 NC 62 A 1057 +ERSKINE, PALER,+ (BIRM+GLAS+LOIC+MPIIM+OXF)
SIDOROV 69 LIVERPOOL SYMP. ON ELECTRONS+PHOTONS, P.227, SIDOROV (NOVO)

RIZZ 70 PRIV.COMM. +RUON, CHATELDS, JEANJEAN, LALONNE,+ (ORSA)
SEE ALSO PERIZ-Y-JORNA, LIVERPOOL SYMP. 69
HYAMS 70 PRIV.COMM. +KOCH, POTTER, V.LINDRN, LORENZ, LUTJENS (CERN)

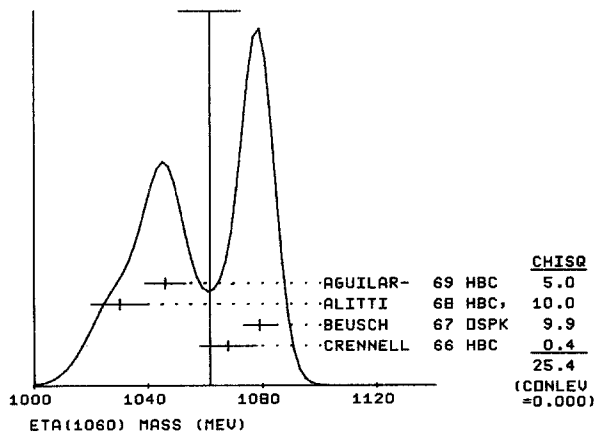
$\eta_0(1060)$
or S^*

3 ETA (1060, JPG=0+++I)=0
NAMED S* BY CRENNELL 66.
REVIEWED AT PHILA.CONF., SEE BEUSCH TO
THE DISAGREEMENT BETWEEN SOME OF THE OBSERVED WIDTHS IS
RELATED TO AN AMBIGUITY IN INTERPRETATION OF THIS KS KS PEAK EITHER AS A
RESONANCE ABOVE THRESHOLD OR AS A SCATTERING LENGTH EFFECT. FOR POSSIBLE
2 PI MODE, SEE ETA V (1080).

3 ETA (1060) MASS (MEV)

M	(1000.0)	APPROX	BINGHAM	62 HBC	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 HBC	2.8 PI-P	6/66
M	20 1068.0	10.0	CRENNELL	66 HBC	6.0 PI-P	5/70*
M	120 SCATT.LENGTH FITS BETTER.		HESS	66 HBC	1.6+4.2 PI-P	10/66
M	730 1079.0	6.0	BEUSCH	67 DSPK	5.7, 1.2 PI-P	9/67
M	54 1030.	10.	ALITTI	68 HBC, OBC	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	(1070.)	(SEE NOTE (1))	HRANG	69 DSPK 4 PI-P, KS KS N		5/70*
M	(1040.)	(SEE NOTE (2))	HOANG	69 DSPK 4 PI-P, KS KS N		5/70*
M	(1030.)	(SEE NOTE (3))	HOANG	69 DSPK 4 PI-P, KS KS N		5/70*
M	SCATTERING LENGTH FITS EQUALLY WELL. VALUES ARE (IN F)					5/70*
M	+(1.2 +0.3/-0.4), NO SIGNIFICANT IM PART (FOR 4 GEV/C DATA)					5/70*
M	+(1.0 +0.3					5/70*
M	(1112.)	(SEE NOTE (1))	BEUSCH	70 DSPK 4, 5 PI-P		5/70*
M	(1053.)	(SEE NOTE (2))	BEUSCH	70 DSPK 4, 6 PI-P		5/70*
M	SCATTERING LENGTH FITS ONLY WITH EFFECTIVE RANGE. VALUE (F) IS					5/70*
M	+(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 CHOSE NEGATIVE.)					
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	AVG	1061.7	10.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9)		(SEE IDEOGRAM BELOW)

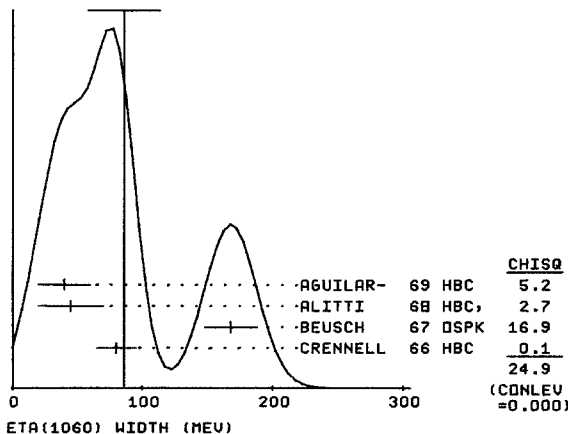
WEIGHTED AVERAGE = 1061.7 ± 10.7
ERROR SCALED BY 2.9



3 ETA (1060) WIDTH (MEV)

M	20	80.0	15.0	19.0	CRENNELL	66 HBC	6.0 PI-P	6/66
M		168.0	21.0		BEUSCH	67 DSPK	5.7, 1.2 PI-P	9/67
M					BEUSCH 67 ASSUME NO S WAVE SCATTERING LENGTH. WITH S WAVE THE WIDTH BECOMES NARROWER THAN QUOTED ABOVE.			
M	3/4	45.0	35.0	15.0	ALITTI	68 HBC, OBC	3.6-5.0 K- N	7/69
M		40.0	20.0		AGUILAR-	69 HBC	0.7, 1.2 PBAR P	7/69
M	H	(200.)	(SEE NOTE (1))		HOANG	69 DSPK 4 PI-P, KS KS N		5/70*
M	H	(160.)	(SEE NOTE (2))		HOANG	69 DSPK 4 PI-P, KS KS N		5/70*
M	H	(150.)	(SEE NOTE (3))		HOANG	69 DSPK 4 PI-P, KS KS N		5/70*
M	H	(361.)	(SEE NOTE (1))		SCATTERING LENGTH FITS EQUALLY WELL. SEE UNDER MASS ABOVE.			
M	B	(208.)	(SEE NOTE (2))		BEUSCH	70 DSPK 4, 6 PI-P		5/70*
M	B				BEUSCH	70 DSPK 4, 6 PI-P		5/70*
M					SCATT. LENGTH WITH EFFECTIVE RANGE ALSO FITS. SEE UNDER MASS.			
M	(1)				FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 0.			
M	(2)				FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 1.			
M	(3)				FIT ASSUMING BRANCHING RATIO (2 PI)/(K KBAR) OF 2.			
M	AVG	85.8	27.4		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.9) (SEE IDEOGRAM BELOW)			

WEIGHTED AVERAGE = 85.8 ± 27.4
ERROR SCALED BY 2.9



3 ETA (1060) PARTIAL DECAY MODES

P1	ETA (1060) INTO KKBAR	493+ 497
P2	ETA (1060) INTO PIPI	139+ 134

3 ETA (1060) BRANCHING RATIOS

R1	ETA (1060) INTO (PI PI)/(K KBAR)	CRENNELL	66 HBC	90 PCT CONF LEV	7/66		
R1	(2.5) OR LESS	BEUSCH	67 DSPK				
R1	1.0	0.6	0.3	LAI	68 HBC	6 PI-P	11/68

REFERENCES FOR ETA(1060)

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 PGLY+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 (CHI)+NDAM)

BEUSCH 70 PHILAD.CONF. (ETH+CERN)

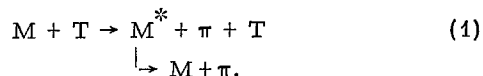
A1(1070)

10 A1 MESON (1070, JPC=1+-) I=1

The Threshold Enhancements
A1, A3, Q, and L

We present here first some general remarks about these four related peaks; second, some remarks specifically about A1.

The four peaks under study generally arise from a reaction of the form



where T is the target (proton or deuteron), M the beam particle, and M^* a resonance in the $M\pi$ system. The relevant quantities for each of the enhancements are given below:

M	$M^*(J^P)$	$M^*\pi$ enhancements mass in (MeV)	Mass threshold M^* and π (MeV)
π	$\rho(1^-)$	A1 (~ 1070)	920
π	$f^0(2^+)$	A3 (~ 1640)	1400
K	$K^*_{890}(1^-)$	K_A (~ 1300) or Q	1030
K	$K^*_{1420}(2^+)$	K_A (~ 1780) or L	1560

These enhancements share the following features:

1) Large widths (150 to 400 MeV), with little structure except for compilations discussed in the note on the Q peak.

2) Mass about 200 MeV above $M^*\pi$ threshold.

3) They are not produced strongly except in diffractive processes [reaction (1)]; exceptions are discussed in point 7 below.

4) Each enhancement has one predominant decay mode, described in reaction (1), although the Q, which is just above $K\rho$ threshold, can hardly avoid showing some $K\rho$ signal.

5) As would be required of a resonance, the enhancement seems to appear in a single partial wave. In fact for all four peaks, preliminary analyses favor a relative s-wave for the $M^*\pi$ system.

6) The productions of these enhancements

[reaction (1)] are "reasonably" well described by the Reggeized Deck model, which does not invoke resonance production in the $M^*\pi$ system. However, the duality hypothesis makes the meaning of these fits unclear.

7) There have been some reports of these enhancements produced in "nondiffractive" processes [i. e., other than reaction (1)] (e. g., Q in $\pi\pi \rightarrow \Lambda K^*\pi$, A1 in $Kp \rightarrow K\rho\rho\pi$, etc.) Sometimes this is taken as evidence supporting the resonance interpretation, since the production mechanisms are different. However, there are multi-Regge models that can produce low-mass enhancements just as the double-Regge models do. This warning was voiced by BERLINGHIERI 69 (footnote 5) as a warning against their own A1 peak produced "nondiffractively" by K^+ mesons. See also discussion of CASO 70 below.

8) There has been a considerable amount of confusion related to these enhancements. Usually the data from different experiments are quite similar except that the mass distribution from one experiment may be a smooth broad peak, while others may have one or more small peak(s) on top of it. In the former case it is natural to attribute the whole enhancement to one effect, resulting in broad width and mainly one decay mode. In the latter case one tends to perform a background subtraction and various cuts to remove the broad enhancement, which results in narrow resonances with several decay modes. The width, cross section, and branching ratio are therefore very sensitive to the assumed background since it is high and rapidly varying. This probably explains why two groups sometimes state very different conclusions while their data are actually very similar.

* * *

We have already mentioned in the text (Sec. III) and under point 6 above that for these four peaks it is not yet possible to distinguish

between two different interpretations (threshold enhancement vs resonance) which are linked by the notion of duality. Our procedure is to enter all four on the Meson Table, with a warning about the interpretation.

Note on Nondiffractive A1 Production

Very many authors have shown that A1 production according to reaction (1) above ($\pi p \rightarrow p A1$) can be described by a Reggeized Deck model. (Two recent papers are BRANDENBURG 70 and CHIEN-1 70,) Hence it is particularly interesting to see if A1 is also produced in other reactions that are free from this complication.

- ANDERSON 69 reported A1 production in $\pi^- p \rightarrow p A1^-$ in the backward direction. The A1 so produced has much steeper u dependence than exhibited by the other well-known resonances also produced in the same experiment, and this steep $d\sigma/du$ has no simple theoretical explanation. Hence we still accept this result with some reservation.

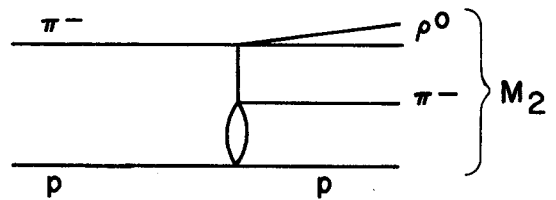
- DANYSZ 67 and FRIDMAN 68 reported A1 in $\bar{p} p \rightarrow 3\pi^+ 3\pi^- \pi^0$. However, the evidence is not overwhelming because of low statistics and high background. The further facts that A1 is neither observed in simpler final states (e.g., $\bar{p} p \rightarrow 2\pi^+ 2\pi^- \pi^0$) in the same experiments, nor observed in other $\bar{p} p$ experiments, make the case for A1 production in $\bar{p} p$ reactions quite dubious.

- ALLABY 69 measured the deuteron momentum spectra from the reaction $pp \rightarrow d + MM$ at 21.1 GeV/c. Broad peaks were observed with MM at 1100 and 1300 MeV. However, in these measurements the MM system was not observed hence it is not clear if these peaks were indeed produced in $\rho\pi$ system. Also SHIH 70 has shown that a double-Regge-pole model produces a broad A1-like enhancement in reactions in which baryon exchange dominates and a $\rho\pi$ system exists in the final state.

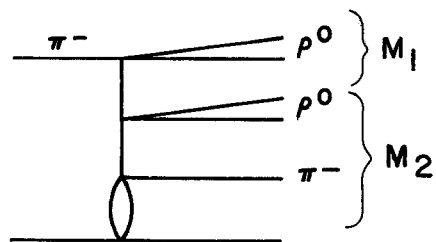
- CASO 70 study the following final states in $\pi^- p$ reactions at 11.2 GeV/c:

- (1) $\pi^- p \rightarrow p \pi^- k \pi^0, \quad k \geq 2,$
- (2) $p \pi^+ \pi^- \pi^-,$
- (3) $p \pi^+ \pi^- \pi^- \pi^0,$
- (4) $p \pi^+ \pi^- \pi^- k \pi^0, \quad k \geq 2,$
- (5) $n \pi^+ \pi^+ \pi^- \pi^-,$
- (6) $p \pi^+ \pi^+ \pi^- \pi^- \pi^-$
- (7) $n \pi^+ \pi^+ \pi^- \pi^- k \pi^0 \quad k \geq 1.$

Reactions (2) and much of (4) are of course the classical Deck examples which we are trying to avoid in this note. But the remaining reactions each do show an A1 peak, and when they are all added, the peak shows up quite well. However, we must restate here more precisely our reservation given in point 7 above. Figure A1(a) shows a double-Regge-

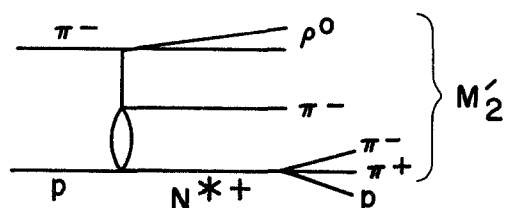


A1 (a) Reaction (2) $\pi^- p \rightarrow p \pi^- \rho^0,$
double Regge



A1 (b) Reaction (6) $\pi^- p \rightarrow p \pi^- \rho^0 \rho^0,$
triple Regge

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.



A1(c) N^* interpretation of reaction(6)

pole diagram that contributes to reaction 2. The matrix element is called M_2 , and we know that it more-or-less explains the A1 peak. Figure A1(b) shows how the DRP diagram must be modified to explain reaction (6) which involves two more pions. One can simply add one more link to the chain, and put a ρ at the new vertex. The triple-Regge-pole matrix element M_3 can then be written $M_3 = M_2 M_1$, where M_2 already contains the A1 peak, and M_1 just involves another propagator. We do not see why the extra factor M_1 should destroy the A1 peak. Then how can we say that reaction 6 is new evidence for a resonant interpretation of the A1 peak?

Another way to draw this reaction 6 is sketched in Fig. A1(c). M_2' might have much the same shape as M_2 .

One can look for new evidence where there is charge-exchange at the lower vertex, so that Pomeron exchange is forbidden. $M_2(n)$ should then simulate the A1 peak less well than $M_2(p)$. Unfortunately their charge-exchange reaction (7) does not show a very good A1 signal. We conclude that it is hard to find an independent "nondiffractive" example of A1 production.

● BERLINGHERI 69 reported A1 production in K^+p interactions at 12.6 GeV/c while RABIN 70 reported evidence against it. However, after a careful re-examination of both experiments, we conclude that--contrary to what we said in January 1970--both experiments are consistent with one another. There is some indication of A1 in BERLINGHERI 69,

and no strong evidence in RABIN 70 against it. (For details, see CHIEN 70.) The difference in point of view of the two papers is perhaps a good example of the ambiguity discussed in point 8 above. ALEXANDER 69 also reported A1 production in K^+p reactions, but the signal is not very clear in any single reaction (see A1 review in our January 1970 editions).

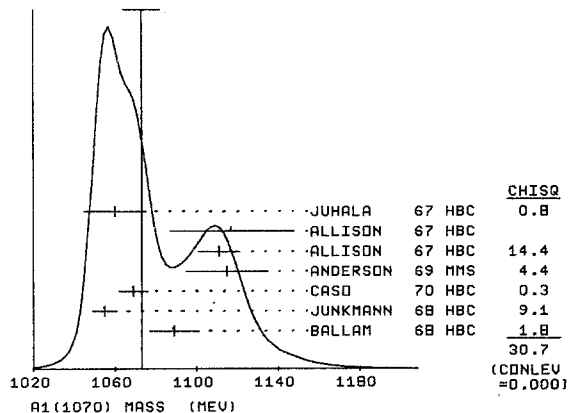
In summary, reports on A1 production in "nondiffractive" reactions (i. e., other than $\pi^\pm p \rightarrow \rho^0 \pi^\pm p$) become increasingly abundant. (For details, see GARELICK 70.) But the most striking example is still that of ANDERSON 69, and even here we have stated some reservations. CASO 70 also looks quite convincing. In general contrary to the overwhelming evidence of A1 production in $\pi^\pm p \rightarrow \rho^0 \pi^\pm p$ reactions reported in every $\pi^\pm p$ experiment, A1 production in "nondiffractive" reactions has been reported in very few experiments with much lower statistics. More experiments and re-examination of the "non-reporting" experiments are needed; e. g., it is important to examine other high-energy πp experiments for reactions 1 to 7 to compare with CASO 70.

10 A1 MESON MASS (MEV)									
MASS AND WIDTH MIGHT HAVE LARGE SYSTEMATIC ERRORS DUE TO COMPLICATED BEHAVIOR OF BACKGROUND.									
PRODUCED BY PIONS, RESONANCE INTERP. CONFUSED BY DECK EFFECT									
M	PRODUCED BY π^+								
M	(1080.0)								
M	(1080.)	APPROX.	ADERHOLZ	64 HBC	+	4.0	$\pi^+ p$		
M			BOESEBECK	68 HBC	+	8	$\pi^+ p$		6/68
M	PRODUCED BY π^-								
M	(1060.)								
M	1089.0	12.0	ASCOLI	68 HBC	-	0.5	$\pi^- p$		6/68
M	(1080.)	APPROX.	BALLAM	68 HBC	-	16.0	$\pi^- p$		9/68
M			CASO	68 HBC	-	11	$\pi^- p$		6/68
M	CASO 68	SUPERSEDED BY CASO 70							
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	(1119.)	(30.)	KEY	68 HBC	-	3	$\pi^- p$		9/68
M	S	SHOULDER ON A2 ONLY							
M	1069.0	7.0	CASO	70 HBC	-	11.2	$\pi^- p$		5/70*
M	(1120.0)		CRENNELL	70 HBC	-	6.	$\pi^- p$, F PI		5/70*
M	PRODUCED BY PIONS, BACKWARDS SCATT. NO DECK EFFECT.								
M	1115.0	20.0	ANDERSON	69 MMS	-	16	$\pi^- p$, BACKW		8/69
M	PRODUCED BY PHARS, SEE TYPED NOTE.								
M	(1054.)	(7.)	DANYSZ	67 HBC	+	3.3, 6	$\pi^- p$		7/67
M	(1042.)	(21.)	FRIDMAN	68 HBC	+	5.7	$\pi^- p$		6/68
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.	JHALA	67 HBC	+	0.4, 6-5	$K^+ p$, SBOUY		1/68
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)	BERLINGHERI	69 HBC	+	0.12, 7	$K^+ p$	9/69
M	K^+	FOR CONTRADICTIONARY EVIDENCE SEE RABIN 70 AND TYPED NOTE.							
M	AVG	1073.1	9.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)					

(SEE IDEOGRAM BELOW)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 1073.1 ± 9.2
ERROR SCALED BY 2.5



10 A1 MESON WIDTH (MEV)

SEE NOTE UNDER A1 MESON MASS.

PRODUCED BY PIONS, RESONANCE INTERP. CONFUSED BY DECK EFFECT

Produced by	Approx.	Reference	Particle	Value
(80.0)		ADERHOLZ 64 HBC	4.0 PI+P	6/68
(130.)		BOESEBECK 68 HBC	8 PI+P	

PRODUCED BY PI-

Produced by	Approx.	Reference	Particle	Value
140.0	31.0	BALLAM 68 HBC	-16.0 PI-P	9/68
(100.)		CASO 70	-11 PI-P	5/70*
CASO 68	SUPERSEDED BY CASO 70			
(125.)		CHUNG 68 HBC	-3.2, 4.2 PI-P	2/67
77.0	17.0	JUNKMANN 68 HBC	-16. PI-P, 5PI	9/69
(76.)	(145.)	KEY 68 HBC	-3.0 PI-P	11/67
K	SHOULDER ON A2 ONLY			
99.0	15.0	CASO 70	-11.2PI-P	5/70*

PRODUCED BY PIONS, BACKWARDS SCATT. NO DECK EFFECT.

Produced by	Approx.	Reference	Particle	Value
98.0	45.0	ANDERSON 69 MMS	-16 PI-P, BACKW9	8/69

PRODUCED BY PBARS, SEE TYPED NOTE.

Produced by	Approx.	Reference	Particle	Value
(33.)	(19.)	DANYSZ 67 HBC	+3, 3.6 PBAR P	7/67
(130.)		FRIDMAN 68 HBC	+5.7 PBAR P	6/68

PRODUCED BY K-, SEE TYPED NOTE.

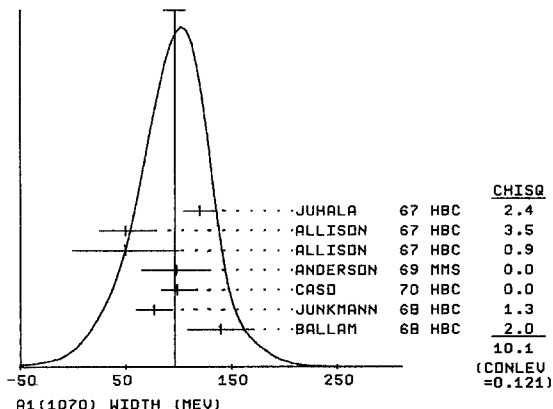
Produced by	Approx.	Reference	Particle	Value
50.	50.	ALLISON 67 HBC	+6 K-P, LAM +4 PI	1/68
50.	25.	ALLISON 67 HBC	+6 K-P, LAM +5 PI	1/68
120.	15.	JUHALA 67 HBC	0 4.6-5 K-P, 5BODY	1/68

PRODUCED BY K+, SEE TYPED NOTE.

Produced by	Approx.	Reference	Particle	Value
(160.0)	(20.0)	ALEXANDER 69 HBC	+9 K+P	9/69
(120.0)	(30.0)	BERLINGHI 69 HBC	+12.7 K+P	8/69
K+ FOR CONTRADICTORY EVIDENCE SEE		RABIN 70 AND TYPED NOTE.		
(130.0)	(25.0)	BERLINGHI 69 HBC	+0 12.7 K+P	9/69

AVG 96.6 10.1 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 96.6 ± 10.1
ERROR SCALED BY 1.3



10 A1 PARTIAL DECAY MODES

Mode	Reference	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

10 A1 BRANCHING RATIOS

Mode	Reference	Value
R1 A1 INTO (KBAR K)/(RHO PI)		10/56
R1 10.0025 OR LESS	DAHL 67 HBC	-4.0 PI-P
R1 A1 INTO (KBAR K)/(RHO PI)		10/56

REFERENCES FOR A1

ADERHOLZ 64 PL 10 226	AACH+BERL+BERN+BOHN+DESY+HAMB+IMP.CDL+ MPI
DEUTSCHMANN 66 PL 20 82	DEUTSCHMANN, STEINBERG + (AACH+BERLIN+CERN)
ALLISON 67 PL 258 619	+CRUZ+ (OXF+MUN+BRM+RUTH+GLASG+LONIC)
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+KDELMAN+ (LOWA+COLD)
ASCOLI 68 PRL 21 113	+CRAWLEY, KRUSE, MORTAR, SCHAFFER, + (ILLINOIS)
BALLAM 68 PRL 21 934	+BRDLY, CHADWICK, FRIES, GUIRAGOSSIAN + (SLAC)JP
BOESEBECK 68 NP 8 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 88 471	+COCCONI + (AACH+BERL+BOHN+CERN+MARS)
KEY 68 PR 166 1430	+PRENTICE+COOPER+MANNER+WALKER+(TO+AN+WIS)
ALEXANDER 69 PR 183 1168	G. ALEXANDER, A. FIRESTONE, G. GOLDBERGER (LRL)
ALLABY 69 PL 298 198	+BINON+DIODENS+OUELLE+KLOVNING+... (CERN)
ANDERSON 69 PRL 22 1390	+COLLINS, + (BNL+CERN)
BERLINGHI 69 PRL 23 42	BERLINGHIERI, FARBBER, + (CROCH)
JUHALA 69 PR 184 1461	+LEACOCK, RHODE, KEPPELMAN, LIBBY, + (AMES+COLD)
CASO 70 LNC 3 707	+CORDS, COSTA, DARO + (GENO, DESY, HAM, MILA, SACL)
CRENNELL 70 PRL 24 781	V10 +KARSHON, LAI, SCARR, SIMS (BNL)
RABIN 70 PRL 24 925	+ALTERI, DERENZO, FLATTE, FRIEDMAN+ (LRL)
SHIH 70 BNL 14059-REV	+YOUNG (BNL)

PAPERS NOT REFERRED TO IN DATA CARDS

BELLINI 63 NC 29 896	BELLINI, FIORINI, HERZ, NEGRI, RATTI (MILAN)
GOLDBABE 64 PRL 12 336	GOLDBABE, 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, XUDONG, YAGER (LA JOLLA) I=1
ALITTI 65 PL 15 69	ALITTI, BATON, DELER+CRUSSARD+ (SAC+POL)
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+FRANMAN+FERBEL (YALE+ROCH) JP
ARMENISE 68 PL 26 B 336	+FORIND+CARTACCI + (BARI+BOUL+FR+ORSAY)
CNOPS 68 PRL 21 1609	+MIDGH, COHN, BUGG+ (BNL+ORNL+ORUC+TENN+PERN)
DONALD 69 NP 8 11 551	+EDWARDS, BURAN, BETTINI + (LIVP+OSLO+PADO)
FAYOLLE 69 NP 8 13 40	+DE MONTAGNAC, MORAND, STRACHMAN+ (PARIS)
KENYON 69 PRL 23 146	+KINSON, SCARR, + (BNL+ORUC+ORNL)
CHIEHI 70 JHU 7011	C.-Y. CHIEHI (JOHNS HOPKINS)
CHIENI 70 TOKONTO PREPRINT	+CHAO+JOHNSTON, PRENTICE, WALKER (TOR+MISC)
BRANDENB 70 NP 816 369	+BRENNER, DOPFFROD, JOHNSON, KIM+ (HARVARD)
GARELICK 70 PROC. PHILA. CONF.	D. A. GARELICK, REVIEW (NORTHWESTERN)

$\eta_V(1080) \rightarrow \pi\pi$

30 ETA V (1080, JPG-V+) I=0 J GREATER THAN 1
OMITTED FROM TABLE

30 ETA V MASS (MEV)

Mass	Reference	Particle	Value
1060.0	15.0	MILLER 68 HBC	4.0 PI-P
70 1085.0	10.0	WHITEHEAD 68 ASPK	3.1-3.6 PI-P
NOTE THAT IN A COMPILATION OF PI N HBC DATA WITH TWICE THE STATISTICS OF WHITEHEADS COMPILATION, NO PI+ PI- PEAK IS SEEN. (P. SCHLEIN 68)			
1120.0	100.0	DH 69 HBC	7. PI- P, PI+ B
(1080.0)	40.0	DIAZ 70 HBC	0. PBAR P, 4 PI
5/70*			
AVG 1077.9	11.5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) (SEE IDEOGRAM BELOW)	

30 ETA V WIDTH (MEV)

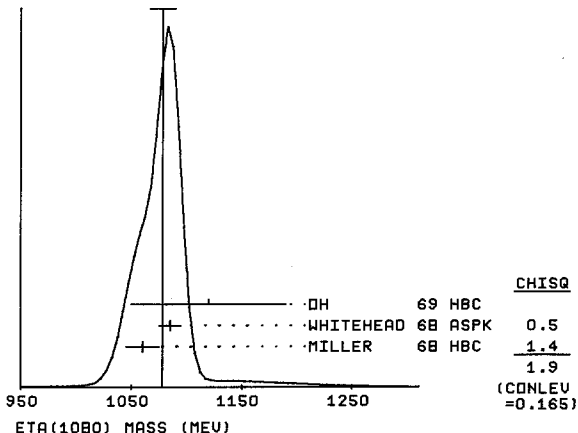
Width	Reference	Particle	Value
(70.0)	OR LESS	MILLER 68 HBC	4.0 PI-P
(25.0)	OR LESS	WHITEHEAD 68 ASPK	3.1-3.6 PI-P
150.0	100.0	DH 69 HBC	7. PI- P, PI+ D
(80.0)		DIAZ 70 HBC	0. PBAR P, 4 PI
5/70*			

REFERENCES FOR ETA V

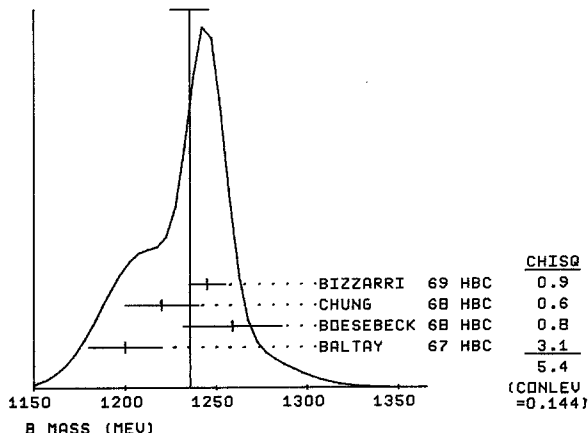
MILLER 68 PRL 21 1489	+GUTAY, JOHNSON, KENNEY+ (PURDUE+NDANG+SLAC)
SCHLEIN 68 PRIV. COMM.	P. SCHLEIN (UCCLA)
WHITEHEAD 68 NC 53 A 817	C. WHITEHEAD + (HARWELL+STHAMP+U.C.C.LON)
DH 69 PRL 23 331	+WALKER, CARROLL, FIREBAUGH, + (MISC+TNT0)
DIAZ 70 NP 8 16 239	+GAVILLET, LABROSSE, MONTANET+ (CERN+COFE)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 1077.9 ± 11.5
ERROR SCALED BY 1.4



WEIGHTED AVERAGE = 1235.5 ± 10.5
ERROR SCALED BY 1.3



A_{1.5}(1170)

A 1.5 (1170, JP= -) I=1
THIS ENTRY LISTS REFERENCES TO PEAKS OF LOW STATISTICAL SIGNIFICANCE IN THE 3 PI SYSTEM BETWEEN THE A1 AND THE A2. OMITTED FROM TABLE.

REFERENCES ON A 1.5 (1170)
BUTTERWOD 67 HEIDELR.CONF.P.28 REVIEW TALK ON MESONS AT HEIDELBERG CONF.
CASDN 67 PRL 18 880 +LAMS, BISMAS, DERADO, GROVES, + (NOTREDAME)
ASCOLI 68 PRL 21 113 +CRAWLEY, KRUSE, MORTARA, SCHAFER, + (ILLINOIS)
DONALD 68 PL 26 B 327 +FROESEN, BETTINI, + (LIVERPOOL, OSLO, PADUA)
VON KRIG 68 PL 278 253 +MIYASHITA, KOPELMAN, MARSHALL LIBBY (COLO)

JUNKMANN 68 NP 98 471 +COCCONI+ (AACH+BERL+BONN+CERN+WARS)
ARMENISE 69 LNC 2 501 +GHIDINI, FORINO, CARTACCI+ (BARI+BGNA+FIRZ)

B(1235)

11 B MESON (1235, JP=1++) I=1
ASCOLI 68 FIND JP EITHER =1+, OR = 2+, 3+,...
BIZZARRI 69 GET GOOD FIT ONLY FOR JP=1+ OR 1-.
THE SERIES JP=3-, 4-, ... SEEMS UNLIKELY BECAUSE 2PI AND K KBAR DECAYS ARE NOT OBSERVED.

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	(1250.) APPROX. CASO	68 HBC - 11 PI- P	6/68
M	C CASO 68 SUPERSEDED BY CASO 70		5/70*
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	45(1277.0) (117.0)	CASO 70 HBC - 11.2PI-P	5/70*
M	AVG 1235.5 ± 10.5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)	
		(SEE IDEOGRAM BELOW)	

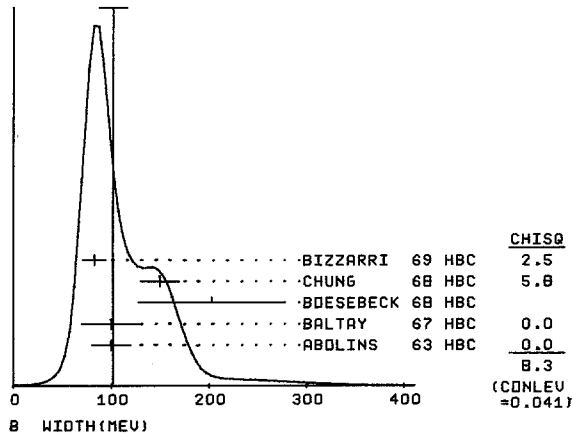
11 B MESON WIDTH (MEV)

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 + 8.0 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	(200.0)	CASO 70 HBC - 11.2PI-P	5/70*
W	AVG 101.9 ± 14.4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)	
		(SEE IDEOGRAM BELOW)	

11 B MESON PARTIAL DECAY MODES

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 PH1	134+1018
P6	B MESON INTO ETA PI (FORBIDDEN BY C)	548+ 139
P7	B MESON INTO K KBAR PI	493+ 493+ 139

WEIGHTED AVERAGE = 101.9 ± 14.4
ERROR SCALED BY 1.7



11 B MESON BRANCHING RATIOS

R1	B INTO 4PI/(OMEGA PI)	ABOLINS 63 HBC + 3.5 PI+P	
R1	(0.5) OR LESS		
R2	B MESON INTO (K KBAR)/(OMEGA PI)		
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)		
R3	(0.3) OR LESS	ADERHOLZ 64 HBC 4.0 PI+P	7/66
R4	B MESON INTO (PI PH1) / (PI OMEGA)		
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)		
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 PBAR P	2/67
R6	B+ INTO (KS KL PI+) / (PI OMEGA)		
R6	(0.06) OR LESS (CL 90)	BALTAY 67 HBC +- 0.0 PBAR P	2/67

REFERENCES FOR B MESON

ABOLINS 63 PRL 11 381	ABOLINS, LANDER, MEHLHOP, KUONG, YAGER (UCSD)
ADERHOLZ 64 PL 10 240	AACHEN+BERLIN+BIRM+BONN+HAMBUR+IC-LOND+MPI
GOLDHABER 65 PRL 15 118	G GOLDHABER, S GOLDHABER, KADYK, SHEN (LRL)
BALTAY 67 PRL 18 93	+SEVERTENS+YEH+ZANELLO (COL+BNL)
DAHL 67 PR 163 1377	+HARDY+HESS+KIRZ+MILLER (LRL)
LEE 67 PR 159 1156	+MOEBS, ROE, SINCLAIR, VANDERVELDE (MICHIGAN)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

BOESEBECK 68 NP B 4 501
CAS) 68 NC 54 A 983
CHUNG 68 PR 165 1491
BIZZARRI 69 NP B 14 169
CAS) 70 LNC
PAPERS REFERRED TO IN DATA CARDS
BONDAR 63 PL 5 209
CARVNY 64 PRL 10 254
BALLAM 67 HE1000 GDNF P.33
SLATTERY 67 NC 50A 377
ASCOLI 68 PRL 20 1411
BOESEBECK, DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
+CONTE+CORDS+DIAZ+ (GENOVA+HAMB+MILA+SACL)
S-U-CHUNG, D. DAHL, J. KIRZ, D. H. MILLER (LRL)

f(1260) 5 F (1260, JPG=2+) I=0

Table with columns for particle ID, mass (MEV), and decay modes. Includes entries for SELOVE, BONDAR, VEILLET, GURAGOSS, LEE, DERADO, ACCENSI, JACOBS, WAHLIG, BARLOW, EISNER, POTRIER, RABIN, ARMENISE, BOESEBECK, FOSTER, LAMSA, JOHNSON, WHITEHEAD, ARMENISE, DONALD, CASO.

Table with columns for particle ID, width (MEV), and decay modes. Includes entries for SELOVE, BONDAR, VEILLET, LEE, DERADO, ACCENSI, JACOBS, WAHLIG, BARLOW, EISNER, POTRIER, RABIN, ARMENISE, BOESEBECK, FOSTER, LAMSA, JOHNSON, WHITEHEAD, ARMENISE, DONALD.

Table with columns for particle ID, partial decay modes, and decay masses. Includes entries for F INTO P1+ P1-, F INTO 2P1+ 2P1-, F INTO K KBAR.

Table with columns for particle ID, branching ratios, and decay modes. Includes entries for F INTO (2P1+ 2P1-) / TOTAL, F INTO (0.08), F INTO (0.04) OR LESS, F INTO (0.07).

R2 F INTO (K KBAR) (P1 P1)
R2 DETERMINATION DIFFICULT BECAUSE PROXIMITY OF A2 WHICH HAS SAME NEUTRAL (K KBAR) MODES. SINCE INTERFERENCE MAY BE CONSTRUCTIVE OR DESTRUCTIVE, EVEN UPPER LIMITS ARE DUBIOUS.

WEIGHTED AVERAGE = 151.4 ± 15.3
ERROR SCALED BY 2.8

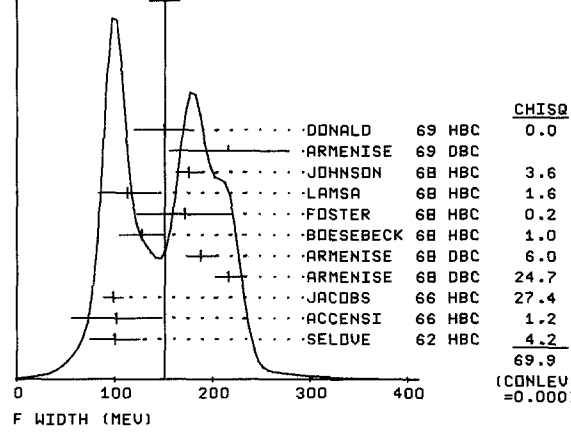


Table with columns for particle ID, mass (MEV), and decay modes. Includes entries for SELOVE, BONDAR, GURAGOSS, HAGUPIAN, VEILLET, ADERHOLZ, BRUYANT, LEE, SODICKSO, BARMIN, JOHNSON, CHUNG, DERADO, GURAGOSS, WANGLER.

Table with columns for particle ID, mass (MEV), and decay modes. Includes entries for ACCENSI, JACOBS, WAHLIG, BARLOW, BEUSCH, DAHL, EISNER, POTRIER, RABIN, ARMENISE, ASCOLI, BOESEBECK, FOSTER, JOHNSON, LAMSA, WHITEHEAD, ADERHOLZ, AGUILAR, ARMENISE, CASO, DONALD.

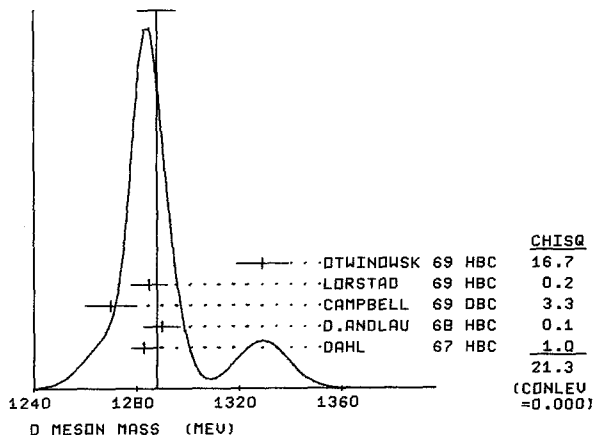
D(1285) 8 D MESON (1285, JPG= +) I=0
(JP=0-, 1+, 2- WITH 1+ FAVORED.)

Table with columns for particle ID, mass (MEV), and decay modes. Includes entries for (1290.) APPROX., 1285.0, 1290., (1310.0), 1270.0, 1285., 1329.0, 1286.1.

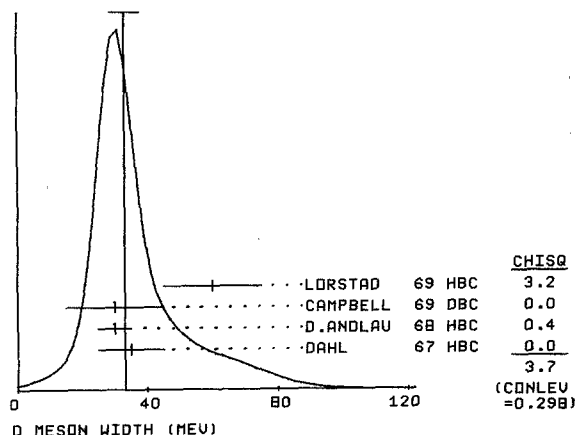
Table with columns for particle ID, width (MEV), and decay modes. Includes entries for 35.0, 30., (40.0), 30., 60., (52.0), 33.1.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 1288.1 ± 7.3
ERROR SCALED BY 2.3



WEIGHTED AVERAGE = 33.1 ± 4.6
ERROR SCALED BY 1.1



8 D MESON PARTIAL DECAY MODES

P	Decay Mode	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 DELTA(962) PI	966+ 134

8 D MESON BRANCHING RATIOS

R	Decay Mode	Charged PI ONLY	Reference
R1	D MESON INTO (PI PI RHO) / (K KBAR PI)	10/66	10/66
R1	(2.0) OR LESS		DAHL 67 HBC
R1 D	(4.0) OR LESS		DONALD 69 HBC
R1 D	THIS IS FOR (RHOO PI+ PI-)/(K KBAR PI0)	8/69	1.2 PBAR P, 5PI
R2	D MESON INTO (K KBAR PI)/(ETA PI PI)	3/69	1.2 PB P, 7 PI
R2	(0.124) (0.035)		DEFOIX 68 HBC
R3	D MESON INTO (DELTA PI)/(ETA PI PI)	5/70*	4.1, 5.5K-ETA
R3	POSSIBLY SEEN		AMMAR 70 HBC
R3 D	SEE NOTE UNDER DELTA(966) FOR FURTHER CLAIMS		

REFERENCES FOR D MESON

BARLOW 67 HC 50 A 701	+MONTANET, D-ANDLAU+(CERN+CDF+IDR+LIVERPOOL)
DAHL 67 PR 163 1377	+HARDY+HESS+KIRZ+MILLER (LRL) JP
SEE ALSO 65 PRL 14 1074	MILLER, CHUNG, DAHL, HESS, HARDY, KIRZ+ (LRL+UC)
D.ANDLAU 68 NP 8 5 693	+ASTIER, BARLOW, MONTANET+ (CDF+CERN+RAD+LIV) JP
DEFOIX 68 PL 28 B 353	+RIVET, SIAUD, CONFORTO, SHIVELY (CDF+IPE+CERN)
CAMPBELL 69 PRL 22 1204	+LICHTMAN, + (PURD)
DONALD 69 NP 8 11 591	+EDWARDS, BURAN, BETTINI, + (LIVP+OSLO+PADO)
LORSTAD 69 NP 8 14 63	S. LORSTAD, D. ANDLAU, ASTIER, + (CDF+CERN) JP
OTWINDWS 69 PL 29 B 529	+S. OTWINDWSKI (WARSAW)
AMMAR 70 PR	+KROPAC, DAVIS, DERRICK+ (KANS+WVES+ANL+WISC)

A2(1300)

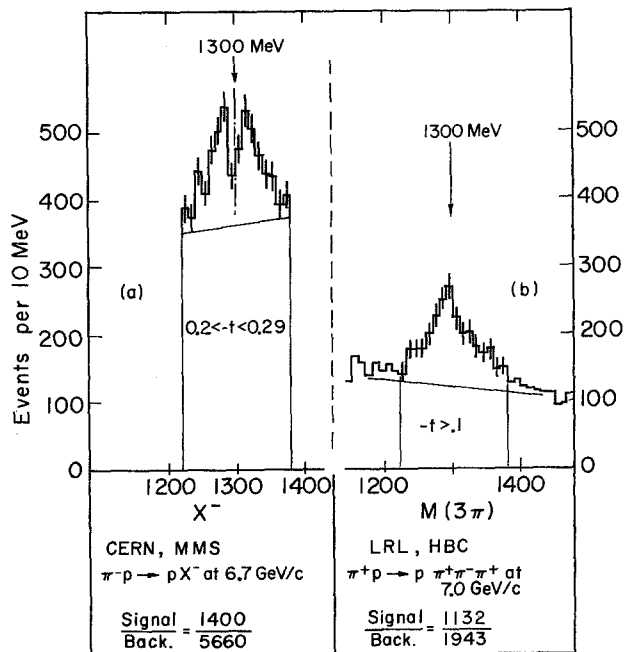
12 A2 MESON (1300, JPC=2+-) I=1

There are two major new problems with the A2:

- 1) The splitting seems to depend on the charge: when produced in π^-p reactions, the A2 seems to be split into two peaks, but a large π^+p experiment yields one broad peak.
 - 2) The branching ratios, because of the complications in the A2 signal, are in flux.
- These two points are now reviewed briefly.

1. When is the A2 split?

The experimental conflict is shown in Table I and the figure, both of which are from the review talk of A. Barbaro-Galtieri at the Philadelphia Meson Conference. A double peak is seen in a series of CERN experiments all of which used a π^- beam, and yielded a total of 2645 A2⁻ events above background. Only one peak is seen in the 7 GeV/c π^+ experiment at LRL, which yielded 1389 A2⁺. These two pion experiments are the ones shown in the figure.



Comparison of CERN and LRL data at the same incident pion momentum. (a) CERN data (resolution $\Gamma_r/2 = 16$ MeV), (b) LRL data ($\Gamma_r/2 = 6.4$ MeV).

Table I. Summary of experiments that investigated A_2 splitting. The reactions studied are $\pi^\pm p \rightarrow p A_2^\pm$, except for the last experiment, which is $\bar{p} p \rightarrow A_2^\pm \pi^\mp$. The columns "Events in peak" and "background/signal" have been evaluated by this author. Po stands for "possible, consistent with the data."

Reaction	P_{beam} (GeV/c)	Group	Ref.	Method	Decay mode ^a	$\Gamma_r/2^b$ (MeV)	$-t$ ^c pp	Events ^d in peak	Bkgd. ^d Signal	Probability of fit			
										BW	Double pole	2 coh. BW	
$\pi^- p$	2.6	CERN	2	0 deg	X^-	5.2	0.09-0.68	1100	5.3	} << 0.2% $\geq 40\%$ $\geq 40\%$			
	6, 7	CERN	16	Jac. peak	X^-	16	0.20-0.29	1400	4.0				
	7	CERN	3	CBS	$K^- K_S$	10	0.20-0.29	145	0.34		1%	$> 60\%$	Po
$\pi^- p$	6	BNL	10	HBC	$\pi^- MM$	10	0.22-0.39	100	1.5	Po ^e	Po ^e	Po ^e	
$\pi^+ p$	7	LRL	4	HBC	$\rho^0 \pi^+$	6.4	$> 0.2^f$	833	1.4	14%	0.3%	Po	
					$\eta \pi^+$	8.2	all ^f	151	0.23	} 13%	0.3%	Po	
					$K^+ K_S$	3.6	all ^f	101	0.34				
$\pi^+ p$	5	BDNPT	7	HBC	$\rho^0 \pi^+$	5	$t^i > 0.1$	108	1.3	20%	63%	Po	
$\bar{p} p$	0, 0.7, 1.2	CPL	8	HBC	$K^\pm K_S$	5	---	270	3.5	4%	65%	Po	

a. X^- stands for negative missing mass, MM stands for neutrals.

b. Γ_r is the full width of the resolution function at half maximum.

c. t_{pp} is the four-momentum transfer squared in $(\text{GeV}/c)^2$.

d. Events in peak are events above the background quoted by the authors of the various papers. Both the events in the peak and the background/signal are calculated in the region 1200 to 1400 MeV.

e. No probabilities quoted for this experiment. The fits of the first two columns were tried and the authors state that "the two-peak fit is better, although not significantly, than the one-peak fit."

f. The momentum-transfer distribution of the A_2 , as seen in the $K^+ K^0$ and $\eta \pi^+$ channels, goes to zero rapidly; only 7% of the events have $-t > 0.7 (\text{GeV}/c)^2$.

A smaller pp experiment shows a double peak (AGUILAR-1 69).

The following few paragraphs are taken from Barbaro-Galtieri's conclusion.

"Spin analyses of A_2^\pm into all three channels $\rho^0 \pi^\pm$, $\eta \pi^\pm$, $K^+ K_S$ definitely prefer the $J^P = 2^+$ assignment for the overall A_2 enhancement and for the two halves analyzed separately (for both $\rho^0 \pi^+$ and $\rho^0 \pi^-$ decays). (See also KRUSE 70.)

"The LRL experiment indicates that the two-parameter double-pole formula of Eq. (5) does not fit the data. A more general double-pole formalism, as discussed by Rebbi and Slansky, should therefore be adopted. This corresponds to fitting the data with two coherently produced resonances, as already done by the CERN group.

"Comparison of the CERN and LRL experiments, which both use pion beams, shows that at the present time the splitting of the A_2 peak does not seem to depend on the incident beam momentum whereas it may depend on the momentum transfer. A dependence on

charge of the incident beam alone, however, could probably explain the effect.

"A model that has been very popular in the corridors at this Conference and that will be discussed in Sutherland's review talk originates from the analogy with the ρ - ω interference model of Goldhaber et al. In this model two 2^+ mesons would be produced, one mostly coupled to ρ exchange, the other mostly coupled to f exchange. Since ρ and f have different isotopic spin, the two amplitudes would add in the π^+ case and subtract in the π^- case. Of course, the detailed prediction of this mode should be worked out and checked with the experiments.

"Another model, suggested by Arnold and Uretsky, considers the possibility that one of the A_2 's is an exotic resonance, that is, an isospin 2 state. The two states would mix by virtue of electromagnetic interactions.

"In conclusion, it seems to me that the double-pole structure of Eq. (5) should be abandoned and that models which predict two interfering resonances are more likely to explain all the data."

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

2. Branching Ratios

In view of the possibility that two interfering resonances are responsible for the structure seen in some mass plots, it does not seem reasonable to us to quote branching fractions in the Meson Table.

Take as an example the $K\bar{K}/\rho\pi$ ratio quoted by DIAZ 70. As the authors of that article point out, this ratio is obtained by comparing a $K\bar{K}$ signal with a mass at $M = 1280 \pm 12$ MeV (CONFORTO 67) with their signal in the 3π channel, which appears at a mass $M = 1335 \pm 15$ MeV. The authors do not have a plausible explanation for this difference in mass and warn that they might not be seeing the same object in the two channels. It is obvious that the value obtained for the branching fraction has to be taken with some caution.

Until more understanding of the mass plots is obtained, we withhold values of A2 branching fractions from the Meson Table.

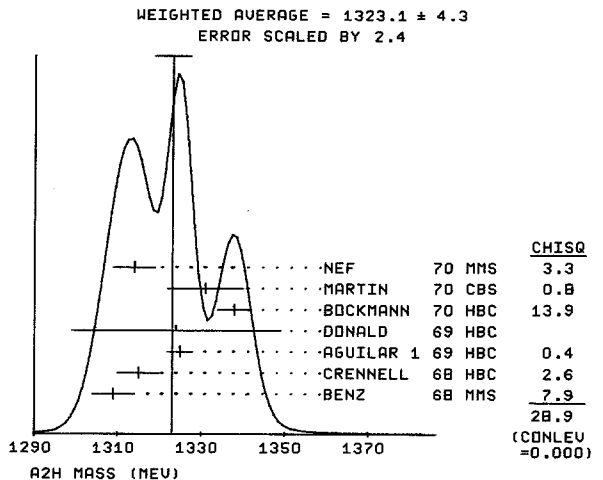
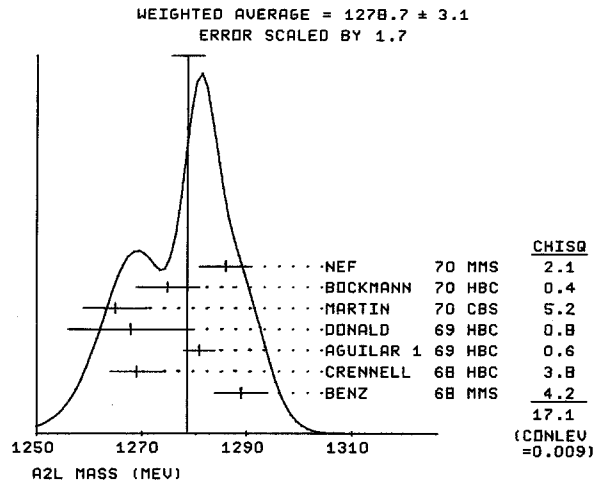
THE MASS AND WIDTH DATA ARE SEPARATED INTO 4 GROUPS
A2L CONTAINS INFORMATION ON THE LOWER PEAK(3PI,K KBAR)
A2H CONTAINS INFORMATION ON THE HIGHER PEAK(3PI,KBAR)
A2K CONTAINS INFORMATION ON K KBAR(UNPLIT,UNRESOLVED)
A2 CONTAINS THE REMAINING INFORMATION (NO SEPARATION)

12 A2L MESON MASS (MEV)

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	1281.0	3.0	AGUILAR 1 69 HBC	+ 0-1.2 PB P,KIK+	5/69
ML	AGUILAR 69 COMPIL. INCLUDES BARLOW 67,CONFORTO 67.TWO INCOH.BREITWIGNS				
ML B	(1276.)	(6.)	BAUD 70 MMS	- 7. PI-P, P KKBAR	11/69
ML B	FIT TO TWO INCOHERENT BREIT WIGNERS				
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- IS EXOTIC IN THE QUARK MODEL.				
ML	1268.0	12.0	DONALD 69 HBC	+ 1.2 PB P(4 PI)	9/69
ML	35 1265.0	6.0	MARTIN 70 CBS	- 11.PI-P, P ETA PI	5/70*
ML	1275.7	6.0	BOCKMANN 70 HBC	+ 5. PI+P, INCOHER.	5/70*
ML	60 1286.	5.0	NEF 70 MMS	- 7. PI-P, P KKBAR	11/69
ML	.....			
ML AVG	1278.7	3.1	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7) (SEE IDEOGRAM BELOW)		

12 A2H MESON MASS (MEV)

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	1325.0	3.0	AGUILAR 1 69 HBC	+ 0-1.2 PB P,KIK+	5/69
MH	AGUILAR 69 COMPIL. INCLUDES BARLOW 67,CONFORTO 67.TWO INCOH.BREITWIGNS				
MH B	(1323.1)	(6.)	BAUD 70 MMS	- 7. PI-P, P KKBAR	11/69
MH B	FIT TO TWO INCOHERENT BREIT WIGNERS				
MH	1324.0	25.0	DONALD 69 HBC	+ 1.2 PB P(4 PI)	9/69
MH	1338.0	4.0	BOCKMANN 70 HBC	+ 5. PI+P, INCOHER.	5/70*
MH	35 1331.0	9.0	MARTIN 70 CBS	- 11.PI-P, P ETA PI	5/70*
MH	60 1314.	5.0	NEF 70 MMS	- 7. PI-P, P KKBAR	11/69
MH	.....			
MH AVG	1323.1	4.3	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.4) (SEE IDEOGRAM BELOW)		



12 A2 MESON MASS (MEV), K KBAR, UNPLIT, UNRESOLVED

NOTE THAT NEUTRAL MODE CAN INTERFERE WITH F.

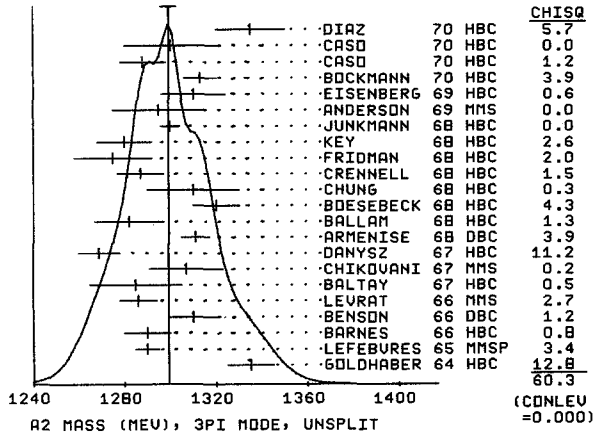
MK	80 1317.0	3.0	BARLOW 67 HBC	+ 1.2 PBAR P, KK	9/67
MK	60 1333.0	13.0	BARLOW 67 HBC	+ 1.2 PBAR P, KK	9/67
MK	1344.0	7.	BEUSCH 67 OSFK	0 5-12 PI-P, KIKI	7/67
MK	130 1280.0	12.0	CONFORTO 67 HBC	+ 0. PBAR P IN KK	9/67
MK	1317.2	4.0	DAHL 67 HBC	- 2.7-4.5 PI- P	8/67
MK	1315.7	10.8	DAHL 67 HBC	0 2.7-4.5 PI- P	8/67
MK	1311.0	5.0	CRENNELL 68 HBC	0 6.0 PI-P, KIKI	6/68
MK	12(1315.0)		ADERHOLZ 69 HBC	+ 8 PI+P, K+K0	8/69
MK	.....			
MK AVG	1317.9	4.4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2) (SEE IDEOGRAM BELOW)		

12 A2 MESON MASS (MEV), 3PI, ETA PI MODES, SPLITTING UNRESOLVED

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 FERREL	66 RVUE	PI+ P
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	(1288.)	(14.)	CASON 67 HBC	- 8 PI- P	5/67
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	ARMENSE 68 DBC	0 5.1 PI+ D	9/67
M	1282.0	15.0	BALLAN 68 HBC	- 16.0 PI- P	9/68
M	1320.	10.	BOESEBECK 68 HBC	0 8 PI+ P	6/68
M	(1280.)	(10.)	BOESEBECK 68 HBC	+ 8 PI+ P	6/68
M	B		ASSUMING A1 AND A1.5 MESONS OF FIXED MASS AND WIDTH		
M	(1300.)	APPROX.	CASO 68 HBC	- 11 PI- P	6/68
M	C		CASO 68 SUPERSEDED BY CASO 70		
M					5/70*

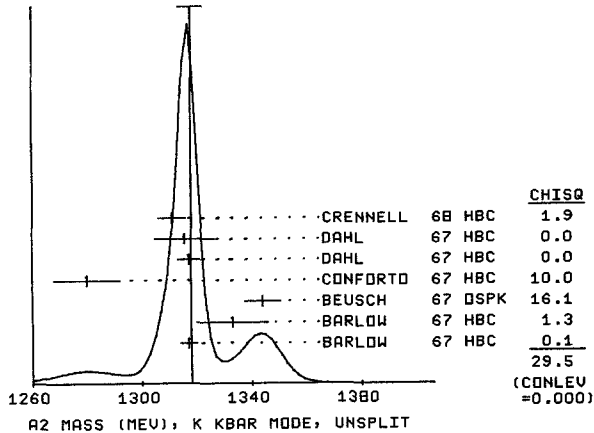
See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 1299.2 ± 3.2
ERROR SCALED BY 1.7



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	1300.0	6.0	VON KRUGH	68 HBC	- 6.7 PI- P	9/68
M	(1301.-C)	(8.0)	JUNKMANN	68 HBC	- 16. PI- P, SPI	9/69
M	1295.0	20.0	ANDERSON	69 MMS	- 16 PI- P, BACKW9	8/69
M	1310.0	14.0	ARMENISE	69 HBC	+ 5.1 PI+D, 3PI++	5/70*
M	1313.0	7.0	EISENBERG	69 HBC	+ 4.3, 5.3 GAMMA P	12/69*
M	1298.0	10.0	BOCKMANN	70 HBC	05. PI+P	5/70*
M	1300.0	20.0	CASO	70 HBC	- 11.2PI-P, PI RHO	5/70*
M	1335.0	15.0	CASO	70 HBC	- 11.2PI-P, PI ETA	5/70*
M			DIJAZ	70 HBC	+ 0. PBAR P, 4 PI	5/70*
M			ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5)			
M	AVG	1299.2	3.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7) (SEE IDEOGRAM BELOW)		

WEIGHTED AVERAGE = 1317.9 ± 4.4
ERROR SCALED BY 2.2



12 A2L MESON WIDTH (MEV)						
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	22.0	10.0	AGUILAR	1 69 HBC	+ 0-1.2 PB P, KIKX-	5/69
WL	AGUILAR 69 COMPIL. INCLUDES BARLOW 67, CONFORTO 67, TWO INCOH. BREITWIGNS					
WL C	(40.0)	OR LESS	CRENNELL	69 HBC	- 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- IS EXOTIC IN THE QUARK MODEL.					
WL	5.0	12.0	DONALD	69 HBC	+ 1.2 PB P (4 PI)	9/69
WL	27.0	13.0	BOCKMANN	70 HBC	+ 5. PI+P, INCOHER.	5/70*
WL	20.	10.0	NEF	70 MMS	- 7. PI-P, P KKBAR	11/69
WL	AVG	19.8	3.3	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		

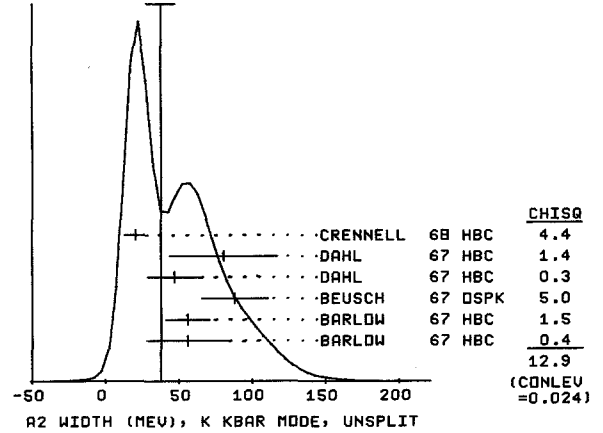
12 A2H MESON WIDTH (MEV)

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	22.0	10.0	7.0	AGUILAR	1 69 HBC	+ 0-1.2 PB P, KIKX-	5/69
WH	AGUILAR 69 COMPIL. INCLUDES BARLOW 67, CONFORTO 67, TWO INCOH. BREITWIGNS						
WH	21.0	10.0	DONALD	69 HBC	+ 1.2 PB P (4 PI)	9/69	
WH	17.0	5.0	BOCKMANN	70 HBC	+ 5. PI+P, INCOHER.	5/70*	
WH	30.	10.0	NEF	70 MMS	- 7. PI-P, P KKBAR	11/69	
WH	AVG	20.1	2.8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

12 A2 MESON WIDTH (MEV), K KBAR, UNSPLIT, UNRESOLVED

NOTE THAT NEUTRAL MODE CAN INTERFERE WITH F.									
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	130	(90.0)	23.	22.	BEUSCH	67 DSPK	0 5-12 PI-P, KIKI	7/67	
WK	47.	18.			CONFORTO	67 HBC	+ 0. PBAR P IN KK	9/67	
WK	80.5	36.5			DAHL	67 HBC	- 2.7-4.5 PI- P	8/67	
WK	21.0	10.0			DAHL	67 HBC	0 2.7-4.5 PI- P	8/67	
WK	12	(30.0)			6.0	CRENNELL	68 HBC	+ 6.0 PI-P, KIKI	6/68
WK	AVG	37.8	9.8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6) (SEE IDEOGRAM BELOW)			8/69		

WEIGHTED AVERAGE = 37.8 ± 9.8
ERROR SCALED BY 1.6



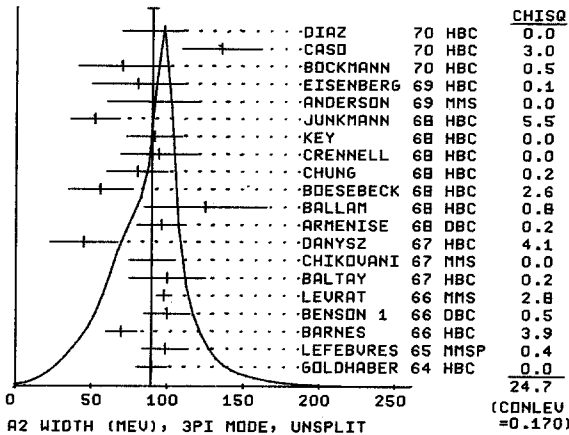
12 A2 MESON WIDTH (MEV), 3PI, ETA PI MODES, SPLITTING UNRESOLVED

W	(100.0)		A					
W	DERHOLZ	64 HBC	4.0 PI+P				V12	
W	90.0	10.0		GOLDHABER	64 HBC	+ 3.7 PI+ P		
W	1425	99.0	15.0		LEFEBURES	65 MMS	- 6.0 PI- P	6/66
W	(140.0)				SADLITZ	65 HBC	- 3.2 PI+D	6/66
W	70.0	10.0			BARNES	66 HBC	- 6.0 PI-P	6/66
W	N	(110.0)	(45.0)		BENSON	66 HBC	0 3.65 PI+D	6/66
W	SUPERSEDED BY BENSON 1 66							
W	100.	15.			BENSON 1	66 HBC	0 3.65 PI+D	1/67
W	1800	(80.0)	(10.0)	COMP. BY	FERREL	66 HBC	+ PI+ P	10/66
W	1060	98.			LEVRAT	66 MMS	- 6.7 PI+D	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	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 HBC	+ 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	C	(80.)	APPROX.		CASO	68 HBC	- 11 PI- P	6/68
W	CASO 68 SUPERSEDED BY CASO 70							
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.)			VON KRUGH	68 HBC	- 6.7 PI- P	9/68
W	52.0	16.0			JUNKMANN	68 HBC	- 16. PI- P, SPI	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 HBC	+ 5.1 PI+D, 3PI++	5/70*
W	BACKGROUND SUBTRACTION MODEL-DEPENDENT.						
W	80.0	30.0		EISENBERG	69 HBC	+ 4.3, 5.3 GAMMA P	12/69*
W	70.0	29.0		BOCKMANN	70 HBC	05. PI+P	5/70*
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	90.0	20.0		DIJAZ	70 HBC	+ 0. PBAR P, 4 PI	5/70*
W	ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5)						
W	AVG	89.6	3.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1) (SEE IDEOGRAM BELOW)			

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 89.6 ± 3.6
ERROR SCALED BY 1.1



Fitted Partial Decay Mode Branching Fractions

Diagonal elements are P1 ± ΔP1; ΔP1 = √⟨δP1δP1⟩. Off-diagonal elements are correlation coefficients = ⟨δP1δPj⟩ / (ΔP1, ΔPj).

Table with 4 columns: P 1, P 2, P 3, P 4. Rows show correlation coefficients for P1, P2, P3, and P4.

***** REFERENCES FOR A2

- ADERHOLZ 64 PL 10 248
AACHEN+BERLIN+BIRM+BDNN+HAMB+IC-LONDON+MPI
CHUNG 64 PRL 12 621
GOLDHABER 54 OUBMA CONF 1 480
LANDER 64 PRL 13 346

12 A2 MESON PARTIAL DECAY MODES

Table with 2 columns: P1, DECAY MASSES. Rows list decay modes like A2 MESON INTO RHO PI, A2 MESON INTO KBAR K, etc.

12 A2 MESON BRANCHING RATIOS

Table with 2 columns: R1, AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0). Rows list branching ratios for various decay modes.

- ARMENISE 67 PL 258 53
BALTAY 67 PL 258 160
BARLOW 67 NC 50A 701
BARTSCH 67 PL 258 48
BEUSCH 67 PL 25 8 357

- ADERHOLZ 69 NP 8 11 259
AGUILAR 169 PL 29 B 62
AGUILAR 269 PL 29 B 241
ANDERSON 69 PL 20 1319

- CHUNG 64 PRL 12 621
LANDER 64 PRL 13 346 A
ADERHOLZ 65 PP 138 B 897
ALITTI 65 PL 15 69

A2 I=2 (1320)
37 A2,2 (1320) I=2 OR GREATER
SEEN AS A BUMP IN RHO- PI- SPECTRUM.
EVIDENCE NOT COMPELLING. DROPPED.
SEE JAN. 67 EDITION.

E(1422)
6 E MESON (1422, JPC=A+) I=0
BAILLON 67 FAVOR JP=0-. DAHL 67 FAVOR 1+ BUT DO NOT
EXCLUDE 2-, 0-, LORSTAD 69 FIND 0- OR 1+.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

6 E MESON MASS (MEV)

Table with columns for mass (M), error (W), and researcher names (BAILLON, DAHL, FRENCH, LORSTAD) with associated HBC and PBAR P values.

6 E MESON WIDTH (MEV)

Table with columns for width (W), error (W), and researcher names (BAILLON, DAHL, FRENCH, LORSTAD) with associated HBC and PBAR P values.

6 E MESON PARTIAL DECAY MODES

Table listing decay masses for various meson decay modes (P1 to P5) into particles like K, K-bar, pi, pi-bar, eta, eta-bar.

6 E MESON BRANCHING RATIOS

Table listing branching ratios (R1 to R3) for meson decays into various particle combinations.

REFERENCES FOR E MESON

- List of references for E meson, including authors like Edwards, Barash, Dahl, French, Foster, Rettini, and Lorstad.

Handwritten box containing 'Ks Ks (1440)' and 'pp (1410)' with an arrow pointing to the right.

29 KSKS(1440) AND RHORHO(1410) (JPG=V +) I GTE 0
EVIDENCE NOT YET COMPELLING. OMITTED FROM TABLE. IF RHOD RHOD AND KS KS ARE MODES OF THE SAME RESONANCE, THEN I=0.

29 KSKS AND RHORHO MASS (MEV)

Table with columns for mass (M), error (W), and researcher names (BETTINI, ABRAMS, BARLOW, BEUSCH) with associated DBC and PBAR P values.

29 KSKS AND RHORHO WIDTH (MEV)

Table with columns for width (W), error (W), and researcher names (BETTINI, BARLOW, BEUSCH) with associated DBC and PBAR P values.

REFERENCES FOR KSKS(1440) AND RHORHO(1410)

- List of references for KSKS(1440) and RHORHO(1410), including authors like Cresti, Barlow, Beusch, and Bettini.

Handwritten box containing 'f'(1514)'. Below it is the text '13 F PRIME (1514, JPG=2++) I=0'.

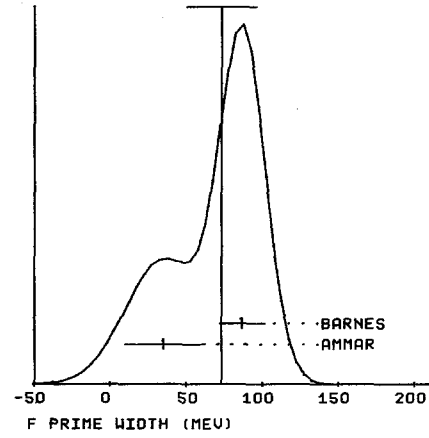
13 F PRIME(1514) MASS (MEV)

Table with columns for mass (M), error (W), and researcher names (CRENELL, ABRAMS, AMMAR, BARNES) with associated HBC and PBAR P values.

13 F PRIME(1514) WIDTH (MEV)

Table with columns for width (W), error (W), and researcher names (ABRAMS, AMMAR, BARNES) with associated HBC and PBAR P values.

WEIGHTED AVERAGE = 73.2 +/- 22.9
ERROR SCALED BY 1.8



13 F PRIME PARTIAL DECAY MODES

Table listing decay masses for various F PRIME decay modes (P1 to P6) into particles like pi, pi-bar, K, K-bar, eta, eta-bar.

13 F PRIME BRANCHING RATIOS

Table listing branching ratios (R1 to R5) for F PRIME decays into various particle combinations.

REFERENCES FOR F PRIME

- List of references for F PRIME, including authors like Crennell, ABRAMS, BARNES, ALITTI, LORSTAD, and SCOTTER.

Handwritten box containing 'pi/p(1540) or F1'. Below it is the text '47 PI/RHO (1540, JPG=) I=1'.

NAMED F1 BY AGUILAR 69
JP=2-, I+ FAVORED, 0- LESS PROBABLE.
ALSO CONTAINS PHOTOPRODUCED BUMP AT 1550 MEV, I UNKNOWN

47 PI/RHO (1540) MASS (MEV)

Table with columns for mass (M), error (W), and researcher names (ADERHOLZ, AGUILAR, DAVIER) with associated HBC and PBAR P values.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

47 PI/RHO (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 0.7PBAR+KKBARPI 11/69
W D (260.0) (110.0) DAVIER 69 STRC 04.5-18 BREMS,API 11/69
M D SEE NOTE UNDER MASS ABOVE.

47 PI/RHO (1540) PARTIAL DECAY MODES
P1 PI/RHO (1540) INTO K KBAR PI 134+ 497+ 497
P2 PI/RHO (1540) INTO K*(890) KBAR 892+ 497

REFERENCES FOR PI/RHO (1540)
ADERHOLZ 69 NP B 11 259 +BARTSCH,+ (AACH+BERL+CERN+KRAK+MARS)
AGUILAR 69 PL 29 8 379 +BARLOW,JACOBS,D ANDLAU,ASTIER+ (CERN+CDEF)
AGUILAR 1 69 NP B 14 195 +BARLOW,JACOBS,D ANDLAU,ASTIER+ (CERN+CDEF)
DAVIER 69 SLAC-PUB-666 +DERADO,FRIES,LIU,MOZLEY,ODIAN,PARK+ (SLAC)

pi_A(1640) or A3

34 PI (1640, JPC=A-) I = 1

pi_A(1640) or A3. This bump is seen in the ft spectrum in pi+ p -> pi+ pi+ pi- p reactions. It is only 230 MeV above ft threshold, and its interpretation is ambiguous. See note on A1, Q, A3, and L in these listings, just before the A1.

Recently CRENNELL 70 clearly demonstrated that A3 is an s-wave ft enhancement. A recent compilation on high-energy pi+ p data (CHIEN-2 70) also shows that ft is the only dominant mode. BRANDENBURG 70 and CHIEN-1 70 both showed that A3 production in pi- p at 7, 13, and 20 GeV/c can be described by a Reggeized Deck model.

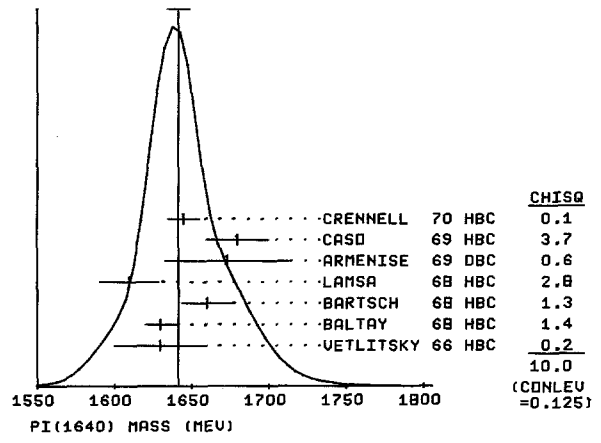
A3 production is also reported in pp and other reactions, but the statistics are relatively poor and results inconclusive.

THIS ENTRY CONTAINS G=-1 PEAKS+IN4 THE R1 PEAK.
BARTSCH 68 FIND BEST FIT WITH JP=2-. NEXT BEST 1+,0-,3+

34 PI (1640) MASS (MEV)
W 30(1600.0) 30.0 FORINO 65 DBC 04.5 PI+ D 10/66
W 20 1630.0 30.0 VETLITSKY 66 HBC - 4.7 PI- P 5/70*
W D (1689.0) (10.0) 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 O NOTE THAT THE WIDTH OF THIS PEAK IS SMALL
M P (1630.0) (15.0) DUBAL 67 MMS - 7,11.5,12PI- P 7/67
W R R1 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
W R NOTE THAT THE R1 HAS SMALLER WIDTH THAN THE OTHER ENTRIES.
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) 10. 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 Q (1670.0) (19.0) YOST 68 HBC 04.3 K-P,LMBD,5PI 9/68
W O OBSERVED IN (OMEGA PI+ PI-) BUT NOT IN (OMEGA RHO 0)
M P (1695.0) (20.0) BARNES 69 HBC 0 4.6 K-P,OMEG2PI 8/69
W P OBSERVED IN (OMEGA PI+PI-) AND (OMEGA RHO0) MODES IN RATIO 2/1
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 AVG 1641.8 7.3 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 1641.8 +/- 7.3
ERROR SCALED BY 1.3



34 PI (1640) WIDTH (MEV)
W R (21.) OR LESS LEVRAT 66 MMS - 7,12 PI- P 7/67
W R R1 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
W 20 (100.1) VETLITSKY 66 HBC - 4.7 PI- P 5/66
W O (38.1) (18.0) 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 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 Q (150.0) (15.0) YOST 68 HBC 04.3 K-P,LMBD,5PI 9/68
W O OBSERVED IN (OMEGA PI+ PI-) BUT NOT IN (OMEGA RHO 0)
W P (80.0) BARNES 69 HBC 0 4.6 K-P,OMEG2PI 8/69
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.
W (130.1) 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 AVG 107.7 18.7 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

34 PI (1640) PARTIAL DECAY MODES
P1 PI(1640) INTO 3 PI 134+ 134 134
P2 PI(1640) INTO RHO PI 134+ 765
P3 PI(1640) INTO ETA PI 134+ 548
P4 PI(1640) INTO 5 PI
P5 PI(1640) INTO K K*(890) 497+ 892
P6 PI(1640) INTO K KBAR PI 497+ 497+ 134
P7 PI(1640) INTO K KBAR 497+ 497
P8 PI(1640) INTO F PI 1264+ 134
P9 PI(1640) INTO OMEGA PI PI 783+ 134+ 134

34 PI (1640) BRANCHING RATIOS
R2 PI(1640)+ INTO (PI+- RHOO)/(ALL PI+- PI+ PI-)
R2 (0.2) OR LESS BALTAY 68 HBC + 7-8.5 PI+P 5/68
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 FERBEL 68 SUPERSEDES BALTAY 68
R2 CONSISTENT WITH 0.0 IOFFREDO 68 HBC - 13-20 PI-P 9/68
R3 PI(1640)+ INTO (PI+- F)/(ALL PI+- PI+ PI-)
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*

R4 R1 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
(0.37)/ 0.59 / 0.04 FOCACCI 66 MMS - 3-12 PI-P 10/66
R5 PI(1640)+ INTO (PI+- ETA)/(ALL PI+- PI+ PI-)
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 PI(1640)+ INTO (PI+- 2PI+ 2PI-)/(ALL PI+- PI+ PI-)
R6 (0.1) OR LESS BALTAY 68 HBC + 7,8.5 PI+ P 6/68
R6 (0.10)OR LESS CRENNELL 70 HBC - 6. PI- P, F PI 5/70*
R7 PI(1640) INTO (OMEGA PI PI)/(F PI)
R7 P (4.) OR GREATER 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 PI(1640)+ INTO (RHO PI)/(F PI)
R8 0.03 0.37 0.03 CASO 69 HBC - 11 PI- P 5/70*
R9 PI(1640)+ INTO (PI+- PI+ PI-)/(F PI)
R9 0.06 0.47 0.06 CASO 69 HBC - 11 PI- P 5/70*

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

REFERENCES FOR PI(1640)

FORINO 65 PL 19 68
FOCACCI 66 PRL 17 890
LEVAT 66 PL 22 714
LUBATTI 66 THESIS BERKELEY
VETLITSKY 66 PL 21 579

DANYSZ 67 NC 51 A 801
DUBAL 67 NP 83 435
ALSO 68 THESIS 1456

HALTAY 68 PRL 20 887
BARTSCH 68 NP 8 7 345
CASO 68 NC 54 A 983
FERBEL 68 PHILA.CONF.335
IOFFREDO 68 PRL 21 1212
LAMSIA 68 PR 166 1395
YOST 68 UMD T.REPORT849

ARMENISE 69 LNC 2 501
BAPNES 69 PRL 23 142
CASO 69 LNC 2 437
ALSO CASO 68.

CRENNELL 70 PRL 24 781
BRANDB 70 NP B16 369
CHIEN1 70 TOPDNTO PREPRINT
CHIEN2 70 PROC.PHILA.CONF.

+GESSAROLI+LENDINARA+(BOL+BARI+FR+ORS+SAC)
CERN MISSING MASS SPECTROMETER GROUP (CERN)
CERN MISSING MASS SPECTROMETER GROUP (CERN)
H.J.LUBATTI (LRL)1-2-
VETLITSKY,GUSZAVIN,KLIGER,ZOLGANOV+ (ITEP)

DANYSZ+FRENCH+SIMAK (CERN)
CERN MISSING MASS SPECTROMETER GROUP (CERN)
L.DUBAL (GENEVE)

+KUNG+YEH+FERBEL+ (COLMB+ROCH+RUTG+VALE)I=1
+KEPPEL,KRAUS,+ (AACH+BERL+CERN) JP
+CONTE+CORDOS+OJAZ+ (GENOVA+HAMB+MIL+SACL)
T.FERBEL (ROCHESTER)
+BRANDENBURG,BRENNER,EISENSTEIN+ (HARVARD)
+CASON+BISWAS+DERAOD+GROVES+ (NOTREDAME)
+YODH,EINSCHLAG,DAY,GLASSER (UMD)

+GHIDINI,FORINO,CARTACCI+ (BARI+BGNA+FRIZ)
+CHUNG,EISNER,FLAMINIO,+ (BNL)
+CONTE,TOMASINI,CANTORE+ (GENO+MILA+SACL)

+KARSHON,LAI,SCARR,SIMS (BNL)
+BRENNER,IOFFREDO,JOHNSON,KIM+ (HARVARD)
+CHAD,JOHNSTON,PRENTICE,WALKER (TOR+WISC)
C.Y.CHIEN, REVIEW (JOHNS HOPKINS)

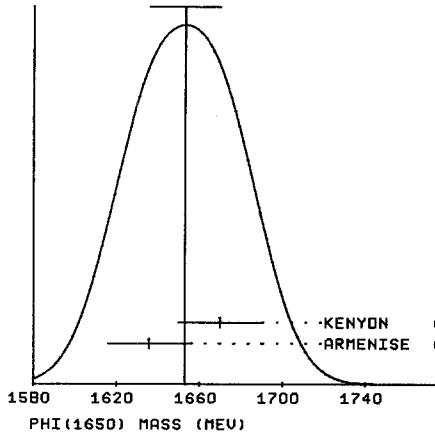
$\phi(1650) \rightarrow \rho^0 \pi^0$

45 PHI (1650, JPC= -) I=0

OMITTED FROM TABLE
THIS ENTRY CONTAINS NEUTRAL 3 PI ENHANCEMENTS FOR WHICH
A (RHO 0 PI 0) DECAY MODE, AND THEREFORE I=0, HAS BEEN
SUGGESTED. PRESENT EVIDENCE LOOKS GOOD BUT STATISTICS
IS NOT YET SUFFICIENT TO REGARD I=0 AS ESTABLISHED.
KENYON 69 GIVES EVIDENCE FOR J TO BE GREATER THAN 0

45 PHI (1650) 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	AVG	1653.0	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)			
			(SEE IDEOGRAM BELOW)			

WEIGHTED AVERAGE = 1653.0 ± 17.0
ERROR SCALED BY 1.2



CHISO
KENYON 69 DBC 0.7
ARMENISE 68 DBC 0.7
1.4
(CONLEV = 0.229)

45 PHI (1650) WIDTH (MEV)						
M	112.0	60.0	ARMENISE	68 DBC	0 5.1 PI+D	9/68
M	100.0	40.0	KENYON	69 DBC	8 PI+ D,3PI 2P	8/69
M	AVG	103.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

45 PHI (1650) PARTIAL DECAY MODES

PHI (1650) INTO 3 PI		DECAY MASSES	
P1	PHI (1650) INTO 3 PI	134+ 134+ 134	
P2	PHI (1650) INTO 5 PI	134+ 134+ 134+ 134	

45 PHI (1650) BRANCHING RATIOS

PHI (1650) INTO (5 PI)/13 PI		KENYON 69 DBC		0 8. PI + D		8/69	
R1	PHI (1650) INTO (5 PI)/13 PI	0.10					
P1		0.10					

REFERENCES FOR PHI (1650)

ARMENISE 68 PL 268 336
KENYON 69 PPL 23 146

+GHIDINI,FORINO+ (BARI+BOLOGN+FRIZEN+ORSAY)
+KINSON,SCARR,+ (BNL+ORUC+ORNL)

$\rho_N(1670)$
OR g

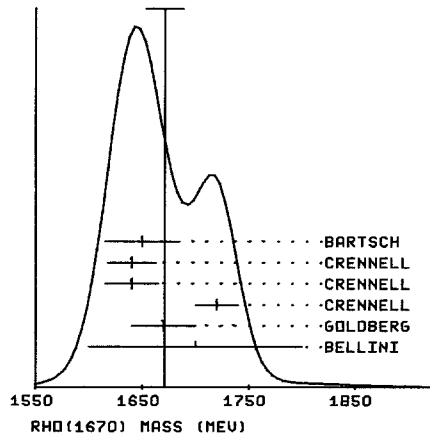
15 RHO (1660, JPC= N+) I=1
THIS ENTRY CONTAINS THE R1, G(2 PI) AND K KBAR PEAKS.
FOR POSSIBLE 4 PI MODES SEE RHO(1715)

CRENNELL 68 SUGGEST JP=3- FROM THE PI PI SCATTERING ANGLE DISTR.
BARTSCH 70 USES OPE MODEL, SUGGESTS ELASTICITY LESS THAN 1

15 RHO (1660) MASS (MEV)

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	(1630.)	(15.)	DUBAL	57 MMS	- 7,11,5,12PI- P	7/67
M	R		R1 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.			
M	R		NOTE THAT THE R1 HAS MUCH SMALLER WIDTH THAN THE OTHER ENTRIES.			
M	(1683.)	(13.)	ARMENISE	68 DBC	0 5.1 PI+ D	6/68
M	B	(1620.)	(20.)	BOESEBECK	68 HBC + 8 PI+ P	6/68
M	B	BOESEBECK 68 SUPERSEDED BY BARTSCH 70				
M	1720.0	20.0	CRENNELL	68 HBC	0 6.0 PI- P	12/68
M	1640.0	25.0	CRENNELL	68 HBC	- 6.0 PI- P	12/68
M	1640.0	20.0	25.0	CRENNELL	68 HBC + 6.0 PI-P, KBAR K	12/68
M	(1655.0)	(10.0)	JOHNSTON	68 HBC	0 7.0 PI- P	6/68
M	13(1650.0)		ADERHOLZ	69 HBC	+ 8 PI+ P, K+KO	8/69
M	(1600.)		BARISH	69 HBC	- 8 PI- P	5/70*
M	(1750.0)		CASO	69 HBC	0 11. PI- P, N2PI	8/69
M	1650.0	35.0	BARTSCH	70 HBC	+ 8 PI+ P, 2 PI	5/70*
M	AVG	1670.5	17.4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)		
				(SEE IDEOGRAM BELOW)		

WEIGHTED AVERAGE = 1670.5 ± 17.4
ERROR SCALED BY 1.6



CHISO
BARTSCH 70 HBC 0.3
CRENNELL 68 HBC 1.8
CRENNELL 68 HBC 1.5
CRENNELL 68 HBC 6.1
GOLDBERG 65 HBC 0.0
BELLINI 65 HLBC 9.8
(CONLEV = 0.044)

15 RHO (1660) WIDTH (MEV)

M	(40.0)		FORINO	65 DBC	0 4.5 PI+D	6/66
M	180.0	40.0	GOLDBERG	65 HBC	0 6 PI+D, 8 PI-P	
M	(21.)	OR LESS	LEVAT	66 MMS	- 7,12 PI- P	7/67
M	R		R1 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.			
M	R		NOTE THAT THE R1 HAS MUCH SMALLER WIDTH THAN THE OTHER ENTRIES.			
M	(188.)	(40.)	ARMENISE	68 DBC	0 5.1 PI+ D	6/68
M	B	(108.)	(40.)	BOESEBECK	68 HBC + 8 PI+ P	6/68
M	B	BOESEBECK 68 SUPERSEDED BY BARTSCH 70				
M	200.0	100.0	CRENNELL	68 HBC	- 6.0 PI- P	12/68
M	200.0	100.0	CRENNELL	68 HBC	0 6.0 PI- P	12/68
M	79.0	70.0	25.0	CRENNELL	68 HBC + 6.0 PI-P, KBAR K	12/68
M	(180.0)	(20.0)	JOHNSTON	68 HBC	0 7.0 PI- P	6/68
M	13 (100.0)	(20.0)	ADERHOLZ	69 HBC	+ 8 PI+ P, K+KO	8/69
M	(200.)		BARISH	69 HBC	- 8 PI- P	5/70*
M	(200.0)		CASO	69 HBC	0 11. PI- P, N2PI	8/69
M	180.0	30.0	BARTSCH	70 HBC	+ 8 PI+ P, 2 PI	5/70*
M	AVG	166.6	19.9	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		

15 RHO (1660) PARTIAL DECAY MODES

RHO (1660) INTO PI PI		DECAY MASSES	
P1	RHO (1660) INTO PI PI	139+ 139	
P2	RHO (1660) INTO 4PI	139+ 139	
P5	RHO (1660) INTO K KBAR	497+ 497	

15 RHO (1660) BRANCHING RATIOS
(FOR OTHER POSSIBLE MODES SEE RHO(1715) BELOW)

R1 R1 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS

R1	(0.37) / 0.59 / 0.04	FOCACCI	66 MMS	-	10/66
R3	RHO(1660) INTO (K KBAR) / (2 PI)	ELRLICH	66 HBC	+0 7.9 PI- P	3/67
R3	PROBABLY SEEN	ABRAMS	67 HBC	0 4.25 K- P	6/67
R3	0.08 0.08 0.03	CRENNELL	68 HBC	6.0 PI- P	12/68

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

REFERENCES FOR RHO(1660)

BELLINI 65 NC 40 A 948
 FIORINO 65 PL 19 65
 GOLDBERG 65 PL 17 354
 EHLICH 66 PR 152 1194
 FOCACCI 66 PRL 17 890
 LEVRAT 66 PL 22 714
 ARRAMS 67 PRL 18 620
 DUBAL 67 NP 83 435
 ALSO 68 THESIS 1456
 ARMENISE 68 NC 54 A 999
 BOESEBECK 68 NP 8 4 501
 CREMNNEL 68 PL 28 B 136
 JOHNSTON 68 PRL 20 1414
 ADERHOLZ 69 NP B 11 259
 BARIISH 69 PR 184 1375
 CASO 69 NC 62 A 755

BELLINI, DI CORATO, DUIFANO, FIORINI (MILANO)
 FIORINO, GESSAROLI + (BOLGONA+ORSAY+SACLAY)
 GOLDBERG+ICERN+PARIS+ORSAY+MILANO+CEA-SACL
 R. EHLICH, W. SELOVE, H. YUTA (PENNSYLVANIA)
 CERN MISSING MASS SPECTROMETER GROUP (CERN)
 CERN MISSING MASS SPECTROMETER GROUP (CERN)
 *KEHOE+GLASSER+SECHI-ZORN+WOLSKY (MARYLAND)
 CERN MISSING MASS SPECTROMETER GROUP (CERN)
 L. DUBAL (GENEVE)
 *FORINO+CARTACCI+(BARI+BOLOG+FIRENZE+ORSAY+I
 BOESEBECK, NEUSCHMANN, +AACHEN+BERLIN+CERN)
 *KARSHON, LAI, SCARR, SKILLICORN (BNL)
 *PRENTICE, STEINBERG, YOON (TORONTO+WISC)

*BARTSCH, + (AACH+BERL+CERN+KRAK+WARS)
 *SELOVE, BISHAS, CASO, + (PEN+NDAM+DOCH)
 *CONTE, BENZI, + (GENO+DESY+HAMB+MILA+SACL)

BARTSCH 70 CERN/0./PHYS70-4 +KRAUS, TSANGS, GROTE, KOTZAN+(AACH+BERL+CERN)

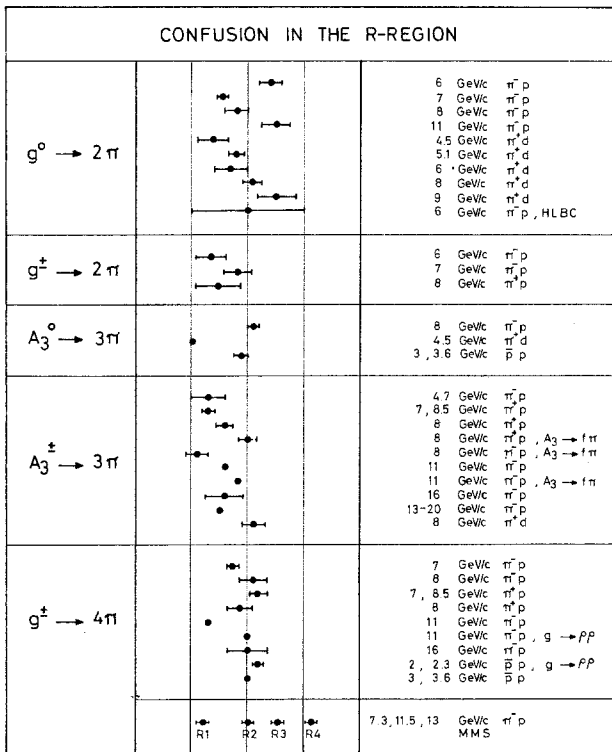
$\rho(1700)$

$\rightarrow 4\pi$

38 RHO(1710), JPC = +1 I = 1 OR 2

THIS ENTRY CONTAINS 4PI, RHO 2PI, 2RHO, OMEGA PI, AND K*KBAR ENHANCEMENTS, AND THE R2. DECAY RHO(1710) INTO 4PI MAY BE INEL. DECAYS OF G-MESON ABOVE. SEE BARTSCH 70.

CONFUSION IN THE R-REGION

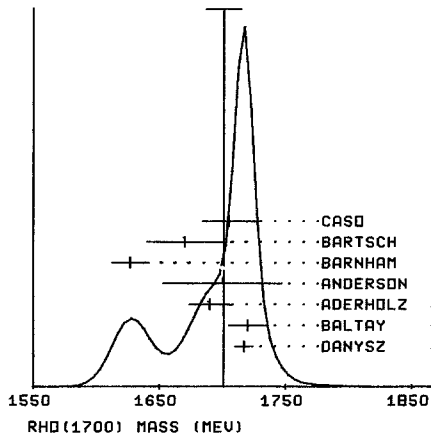


MULTI-PION EFF. MASS, GeV

This is Fig. 1 from the review of BARTSCH 70; submitted to Nucl. Phys.

J NOT SEPARATED FROM 2 PI DECAY
 M 1690.0 16.0 ADERHOLZ 69 HBC + 8 PI+ P, KKBAR PI 8/69
 M 1700.0 47.0 ANDERSON 69 MMS - 16 PI- P, BACKW 8/69
 M 1627. 12. 17. BARNHAM 70 HBC + 10 K+ P, RHO PIP 6/70*
 M 1670.0 30.0 BARTSCH 70 HBC + 8 PI+ P, 4 PI 5/70*
 M 1705.0 21.0 CASO 70 HBC - 11.2PI-P, RHO 2PI 5/70*
 M
 M AVG 1700.7 13.6 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)
 (SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 1700.7 ± 13.6
 ERROR SCALED BY 2.6



Experiment	CHI/S
CASO 70 HBC	0.0
BARTSCH 70 HBC	1.0
BARNHAM 70 HBC	25.9
ANDERSON 69 MMS	
ADERHOLZ 69 HBC	0.5
BALTAY 68 HBC	1.6
DANYSZ 67 HBC	5.4
Total	34.4

(CONLEV = 0.000)

OMEGA PI DECAYS
 M 1654. 24. BARNHAM 70 HBC + 10 K+ P, OMEGA PI 6/70*
 M (1630.) (11.0) CASO 70 HBC - 11.2PI-P, PI OMEG 5/70*

38 WIDTH (MEV)

M (30.) OR LESS LEVRAT 66 MMS - 7-12 PI- P 7/67
 M R2 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
 W R 80 (140.) (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 RHO BAND
 W 100. 35. BALTAY 68 HBC + 7. 8.5 PI+ P 6/68
 W C (120.0) CASO 68 HBC - 11.0 PI-P, 4PI 6/68
 W C (100.0) CASO 68 HBC - 11.0PI-P, RHO 2PI 6/68
 W C CASO 68 SUPERSEDED BY CASO 70
 W J (90.0) (20.0) JOHNSTON 68 HBC - 7.0 PI- P 6/68
 W J NOT SEPARATED FROM 2 PI DECAY
 M 112.0 60.0 ADERHOLZ 69 HBC + 8 PI+ P, KKBAR PI 8/69
 M (195.0) ANDERSON 69 MMS - 16 PI- P, BACKW 8/69
 M 72. 29. 20. BARNHAM 70 HBC + 10 K+ P, RHO PIP 6/70*
 M 160.0 40.0 BARTSCH 70 HBC + 8 PI+ P, 4 PI 5/70*
 M (160.0) CASO 70 HBC - 11.2PI-P, RHO 2PI 5/70*
 M

OMEGA PI DECAYS
 M 130. 73. 43. BARNHAM 70 HBC + 10 K+ P, OMEGA PI 6/70*
 M (60.0) CASO 70 HBC - 11.2PI-P, PI CMEG 5/70*

38 RHO(1710) PARTIAL DECAY MODES

Mode	Decay Masses
P1 RHO(1710) INTO 4 PI	139+ 139+ 139+ 139
P2 RHO(1710) INTO A2 PI	139+1300
P3 RHO(1710) INTO OMEGA PI	139+ 783
P4 RHO(1710) INTO PHI PI	1018+ 139
P5 RHO(1710) INTO 2 RHO	765+ 765

38 RHO(1710) BRANCHING RATIOS

R1 R2 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
 R1 (0.42)/ 0.56 / 0.01 FOCACCI 66 MMS - 10/66

R2 RHO(1710)+- INTO (PI+- A20)/(ALL PI+- PI+ PI- P10)
 R2 (WITH A20 INTO (PI+ PI- P10))
 R2 0.40 0.20 BALTAY 68 HBC + 7, 8.5 PI+P 6/68

R2 NOT SEEN JOHNSTON 68 HBC - 7 PI- P 6/68

R3 RHO(1710)+- INTO (PI OMEGA)/(ALL PI+- PI+ PI- P10)
 R3 (WITH OMEGA INTO (PI+ PI- P10))
 R3 0.25 0.10 BALTAY 68 HBC + 7-8.5 PI+P 5/68
 R3 .25 0.10 JOHNSTON 68 HBC - 7.0 PI- P 6/68
 R3
 R3 AVG 0.250 0.071 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4 RHO(1710)+- INTO (PI PHI)/(ALL PI+- PI+ PI- P10)
 R4 (0.11) OR LESS BALTAY 68 HBC + 7, 8.5 PI+P 6/68

R5 RHO(1710)+- INTO (RHO 2PI)/(ALL 4PI)
 R5 CONSISTENT WITH 1. CASO 68 HBC - 11 PI- P 6/68
 R5 SEEN VETLITSKY 69 HBC 04.7-5.7 PI- P 6/70*

R6 RHO(1710)+- INTO (RHO+- RHO0)/(ALL RHO 2PI)
 R6 0.18 0.16 CASO 68 HBC - 11 PI- P 6/68

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

R7 RH0(1710) INTO (2 RHG) / (ALL 4PI)
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 SEEN JOHNSTON 68 HBC - 7 PI-P 6/68

R8 RH0(1710)+ INTO (PI+- 2PI+ 2PI- P10)/(ALL PI+- PI+ PI- P10)
P8 (0.15) OR LESS BALTAY 68 HBC + 7,8.5 PI+ P 6/68

R9 RH0(1710)+ INTO (PI+- P10) / (ALL PI+- PI+ PI- P10)
R9 0 (0.98) OR LESS BALTAY 68 HBC + 7-8.5 PI+ P 6/68
R9 0 USING DATA OF DEUTSCHMANN 65 ON PI+P TO PI+ P10 P 6/68

REFERENCES FOR RH0(1710)
M. DEUTSCHMANN ET AL (AACHEN+BERLIN+CERN)
CERN MISSING MASS SPECTROMETER GROUP (CERN)
CERN MISSING MASS SPECTROMETER GROUP (CERN)

R(1750) 39 R(1750) I=1
THIS ENTRY CONTAINS I=1 PEAKS AND THE R3 PEAK
NOT A FIRMLY ESTABLISHED RESONANCE - OMITTED FROM TABLE

39 R(1750) MASS(MEV)
M 1748. 16. DUBAL 67 MMS - 7,11.5,12 PI- P 7/67
M F (1740.) FRENCH 67 HBC (K0 K+-) 3-4 PBAR P 7/67
M F SEE FIG. 9 OF FRENCH 67

39 R(1750) WIDTH (MEV)
W (138.) OR LESS LEVRAT 66 MMS - 7,12 PI- P 7/67
W F (120.) APPROX. FRENCH 67 HBC (K0 K+-) 3-4 PBAR P 11/69
W F ABOVE VALUE ESTIMATED FROM FIG. 9 OF FRENCH 67

39 R(1750) BRANCHING RATIOS
R3 R3 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R3 C (0.14)/ 0.80 / 0.05 FOCACCI 66 MMS - 10/66
R3 C FRACTION INTO ONE CHARGED PROB. LARGER THAN GIVEN ABOVE.
R3 C CF. DUBAL 67

REFERENCES FOR R(1750)
FOCACCI 66 PRL 17 890 CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT 66 PL 22 714 CERN MISSING MASS SPECTROMETER GROUP (CERN)
DUBAL 67 NP B3 435 CERN MISSING MASS SPECTROMETER GROUP (CERN)
FRENCH 67 NC 52A 442 *KINSON+MCDONALD+RIDDIFORD+ (CERN+BIRM)

eta_L, I=0 (1830) -> 4pi, K* K-bar
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.

42 MASS (MEV)
M 110 1832. 6. DANYSZ 67 HBC 0 SEE NOTE R BELOW 5/67
M P SEEN IN 2.5-3. PBAR P. 2PI+2PI-, WITH 0,1,2 PI+PI- PAIRS
M R IN RHO 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 K 1820. 12. FRENCH 67 HBC 0 SEE NOTE K BELOW 7/67
M K SEEN IN 3.-3.6 PBAR P TO (KS KO P10...). G PARITY UNKNOWN
M M AVG 1829.6 5.4 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

42 WIDTH (MEV)
W 110 42. 11. DANYSZ 67 HBC 0 SEE 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 RHO BAND
W M (130.0) OR LESS DUBAL 67 MMS - 7,11.5,12 PI- P 6/68
W M MISSING MASS R4 PEAK, FINAL STATE UNKNOWN
W K 50. 23. FRENCH 67 HBC 0 SEE NOTE K BELOW 7/67
W K SEEN IN 3.-3.6 PBAR P TO (KS KO P10...). G PARITY UNKNOWN
W M AVG 43.5 9.9 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

42 PARTIAL DECAY MODES
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

REFERENCES
DANYSZ 67 PL 248 309 *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)

phi_L, I=0 (1830) -> 5pi, K* K-bar
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.

43 MASS (MEV)
M 0 (1848.) (11.) DANYSZ 67 HBC 0 3,3.6 PBAR P 7/67
M 0 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 P10...) 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

43 WIDTH (MEV)
W 0 (67.) (27.) DANYSZ 67 HBC 0 3,3.6 PBAR P 7/67
W 0 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 P10...) MODE (G-PARITY UNKNOWN)
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

43 PARTIAL DECAY MODES
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

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)

S(1930) REGION
31 S(1930, JPG=) I=1 OR 2
THIS ENTRY CONTAINS, BESIDES THE S(1930) SEEN BY
CHIKOVANI 66 WITH A MMS, VARIOUS OTHER PEAKS NEARBY.
FOR REVIEWS, SEE MONTANET 69, BARISH TO
OMITTED FROM TABLE.

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+ P10 6/68
M (1945.0) CLINE 68 HRC -3.-7 PB P ELAST 9/68
M (1925.0) CLINE 68 HRC -3.-7 PB P ELAST 9/68
M 1973.0 15.0 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 1946.4 17.2 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
(SEE IDEOGRAM BELOW)

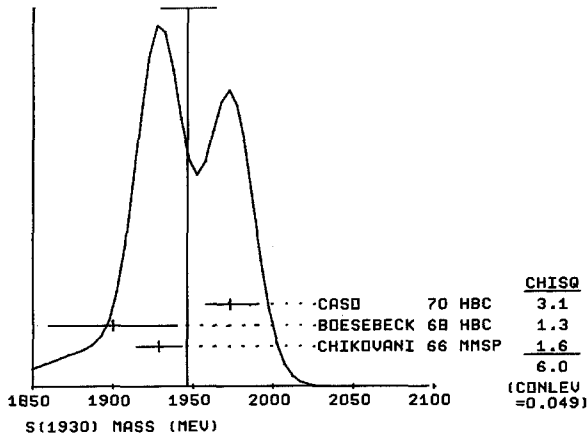
31 S(1930) WIDTH (MEV)
W (35.0) OR LESS CHIKOVANI 66 MMSP - 12.0 PI-P 8/66
W 216. 105. BOESEBECK 68 HBC + 8 PI+ P, PI+ P10 6/68
W (22.0) CLINE 68 HRC -3.-7 PB P ELAST 9/68
W (10.0) CLINE 68 HRC -3.-7 PB P ELAST 9/68
W (180.0) CASO 70 HBC - 11.2PI- P, NOTE C 5/70+
W C SEEN IN RHO- PI+ PI- (OMEGA AND ETA ANTISELECTED IN 4 PI SYSTEM) 5/70+

31 0(SIGMA)/D(T) (MICROBARN/(GEV/C)**2)
CS 35.0 12.0 FOCACCI 66 MMS .22 LTE T LTE .36 9/66

REFERENCES FOR S(1930)
CHIKOVANI 66 PL 22 233 CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI 66 PRL 17 890 CERN MISSING MASS SPECTROMETER GROUP (CERN)
BOESEBECK 68 NP B 4 501 BOESEBECK, DEUTSCHMANN, (AACHEN+BERLIN+CERN)
CLINE 68 PRL 21 1268 *ENGLISH+REEDER, TERRELL, TWITY (LWISONSIN)
MONTANET 69 LUND CONF. ON ELEM. PARTICLES, P. 189 (CERN)
BARISH TO PROC. PHILA. CONF. BARISH, SEE ALSO TALK BY D. MILLER (CALTECH)
CASO 70 LNC 3 707 *CORDS, COSTA, DARD, GEND, DESY, HAM, MILA, SACL

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 1946.4 ± 17.2
ERROR SCALED BY 1.7



**$\rho(\sim 2100)$
REGION**

51 RHO (2100, JPC= +) I=1
NICHOLSON 69 SUGGEST I_G=1+, J_P=3- FROM ANALYSIS OF DIFFERENTIAL CROSS-SECTIONS FOR PBAR PI -- 2P1. OMITTED FROM TABLE.

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, 2P1 9/69

**$\rho(\sim 2100)$
REGION**

51 RHO (2100) WIDTH (MEV)			
W	(150.0)		ANDERSON 69 MMS - 16 PI- P, BACKW 8/69
W	N	(1249.)	NICHOLSON 69 CNTR 0 .7-2.4 PB P, 2P1 9/69
W	N		THE WIDTH INCLUDES RESOLUTION.

REFERENCES FOR RHO(2100)

ANDERSON 69 PRL 22 1390 +COLLINS, BLIEDEN+ (BNL+CARN)
NICHOLSON 69 PRL 23 603 NICHOLSON, BARISH, DELORME, + (CALT+ROCH+BNL)

**T(2200)
REGION**

32 T(2200, JPC=) 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.

32 T(2200) MASS (MEV)			
M	2195.0	15.0	CHIKOVANI 66 MMSP - 12.0 PI-P 8/66
M	B	(2190.)	(5.) ABRAMS 67 CNTR S CHANNEL NBAR N 7/67
M	B		SEEN AS BUMP IN I=1 STATE. WIDTH MUCH LARGER THAN IN THE MMS EXPT. SEE ALSO COOPER 68
M	B		BRICMAN (69) SEES NO BUMP, SPIN LESS THAN 5 IS SO EXCLUDED
M	A	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	K	2190.0	CLAYTON 67 HBC + 2.5 PBAR, A2+OMEGA 10/67
M	K	(2190.0)	KALBFLEIS 69 HBC 0 S-CHANNEL PBAR P 7/69
M	K		SEEN IN PBAR P TO RHO RHO PI0. I _G =1-
M	C	2207.0	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	AVG	2197.0	6.7 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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	K	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 PBAR P 7/69
W	K		SEEN IN PBAR P TO RHO RHO PI0. I _G =1-
W	C	(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*

32 D(SIGMA)/D(T) (MICROBARN/(GEV/C)**2)			
CS	29.0	10.0	FOCACCI 66 MMS +22 LTE T LTE +36 9/66

32 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON			
CS	(6.)		ABRAMS 67 CNTR S CHANNEL NBAR N 7/67
CS	K	(0.5)	(0.1) KALBFLEIS 69 HBC 0 7/69
CS	K		PBAR P TO RHO RHO PI0 7/69

REFERENCES FOR T(2200)
CHIKOVANI 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)
ALLES-BO 67 NC 50 A 776 ALLES-BORELLI, FRENCH, FRISK, + (CERN+BNL)G-
CLAYTON 67 HEIDBG.CONF.P.57 +MASON, MUIRHEAD, FILIPPAS+ (LIVPOOL+ATHENS)
COOPER 68 PRL 20 1059 +HYMAN, MANNER, MUSGRAVE, VOJVODIC (ANL)
BRICMAN 69 PL 29 8 451 +FERRO-LUZZI, BIZARD, + (CERN+CAEN+SACL)
CASO 69 NC 62 A 755 +CONTE, BENZI, + (GENO+DESY+HAMB+MILA+SACL)
KALBFLEI 69 PL 29 8 259 G.KALBFLEISCH, R. STRAND, V. VANDERBURG (BNL)
MONTANET 69 LUND CONF.ON ELEM.PARTICLES, P.189 (CERN)
CASO 70 LHC +CONTE, TOMASINI, CORDS+(GENO+HAMB+MILA+SACL)
ALSO CASO 69
KALBFLEI 70 G.KALBFLEISCH AND D.MILLER REVUES (BNL)

 **$\rho(\sim 2275)$
REGION**
52 RHO (2275, JPC= +) I=1
NICHOLSON 69 SUGGEST I_G=1+, J_P=5- FROM ANALYSIS OF DIFFERENTIAL CROSS-SECTIONS FOR PBAR PI -- 2P1. OMITTED FROM TABLE.

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, 2P1 9/69

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, 2P1 9/69
W	N		THE WIDTH INCLUDES RESOLUTION.

REFERENCES FOR RHO(2275)
ANDERSON 69 PRL 22 1390 +COLLINS, BLIEDEN+ (BNL+CARN)
NICHOLSON 69 PRL 23 603 NICHOLSON, BARISH, DELORME, + (CALT+ROCH+BNL)

 **$N\bar{N}_1(2345)$
REGION**
58 N NBAR (2345) I=1
OMITTED FROM TABLE

58 MASS			
M	B	(2345.)	(10.) ABRAMS 67 CNTR S CHANNEL NBAR N 7/67
M	B		SEEN AS BUMP IN I=1 STATE. WIDTH MUCH LARGER THAN IN MMS EXPT.

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.

58 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON			
CS	(3.)		ABRAMS 67 CNTR S CHANNEL NBAR N 7/67

REFERENCES FOR N NBAR (2345)
ABRAMS 67 PRL 18 1209 +COOL+GIACOMELLI+KYCIA+LEONTIC+LI+ (BNL)

**U(2375)
REGION**
33 U(2375) C=-1, I=1, SO G=+1

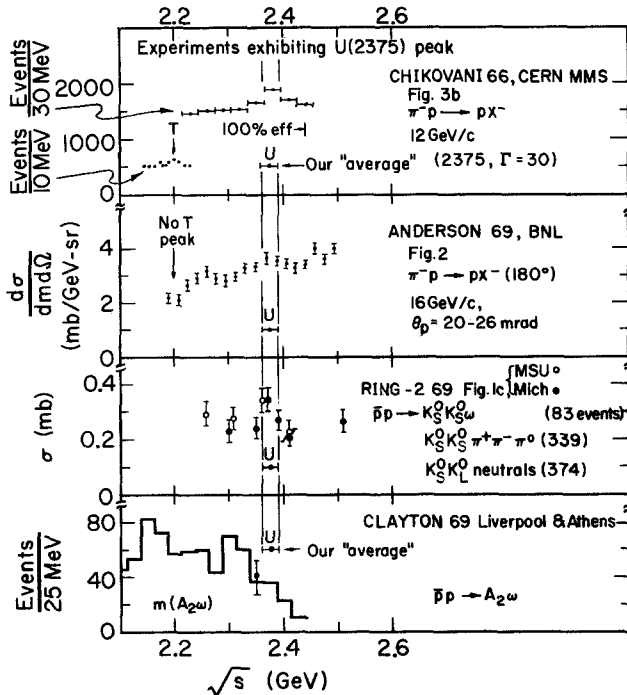
The CERN Missing-Mass Spectrometer group have reported narrow peaks above 1700 MeV called R, S, T, U, and X⁻. All except U(2375) are still omitted from the Meson Table because the supporting evidence is either insufficient or, in the R, S, and T regions, suggests more than one resonance. See the Lund Conference Report of MONTANET 69, and SMITH 70 (Phila.)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

However, the evidence supporting the original, narrow ($\Gamma \lesssim 30$ MeV) $U(2375)$ seems sufficiently consistent so that we have included it in the table. This evidence is presented in the figure below. Since it was drawn (Jan. 1970) OH 70 have published evidence for the mode $\bar{K}K^*\pi\pi$, and state that the evidence for the $\bar{K}K\omega$ mode compiled by RING-2 70 is weakened.

There is also a peak in the $I = 1$ $\sigma(\bar{p}p)$ reported by ABRAMS 67, but it is 140 MeV wide and is not drawn.

We thank the University of Michigan and Michigan State University HBC groups for informing us as to their combined events ($\bar{p}p \rightarrow K_S K_S \omega, K_S K_S \pi^+ \pi^- \pi^0, K_S K_L + \text{neutrals}$).



33 U(2375) MASS (MEV)						
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

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)			

ANDERSON	69 PRL 22	1390	+BLESER, BIRNBAUM, EDELSTEIN,+ (BNL+CERN)			
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)			
RING1	69 MICH PREPRINT		+CHAPMAN, CHURCH, LYS, MURPHY, VANDERVELD(ANNA)			
RING2	69		JOINT PREPRINT COMBINES RING1 AND OH 70			
OH	70 PRL 24	1257	+PARKER, EASTMAN, SMITH, SPRAFKA, MA (MICHIGAN)			
SMITH	70		G.A. SMITH (MSU)			

41 $\bar{N}N_{I=0}$ (2380)						
M	2380.	10.	ABRAMS	67 CNTR	S CHANNEL NBAR N	7/67
EVIDENCE FOR RESONANCE PRELIMINARY. OMITTED FROM TABLE.						

41 MASS						
M	2380.	10.	ABRAMS	67 CNTR	S CHANNEL NBAR N	7/67
41 WIDTH						
W	(140.)		ABRAMS	67 CNTR	S CHANNEL NBAR N	7/67

41 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON						
CS	(2.)		ABRAMS	67 CNTR		7/67

REFERENCES FOR N NBAR (2380)						
ABRAMS	67 PRL 18	1209	+COOL+GIACOMELLI+KYCIA+LEONTIC+LI+ (BNL)			
BRICMAN	69 PL 29 B	451	+FERRO-LUZZI, BIZARD,+ (CERN+CAEN+SACL)			

46 $X^-(2500)$						
M	2500.0	32.0	ANDERSON	69 MMS	- 16 PI- P, BACKW9	8/69
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+CERN)			

$X^-(2620)$ through $X^-(3535)$

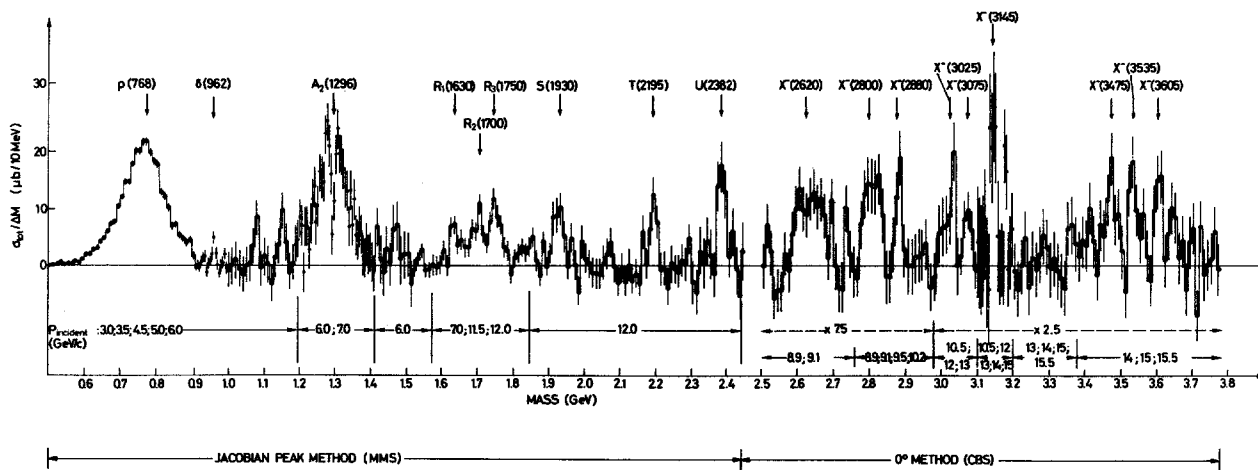
The figure on the next page shows the X^- spectrum, as studied with the CERN Boson Spectrometer. The background is not shown but is about ten times as large as the signal. Uncertainties in where to draw this background make it extremely difficult to measure the width of these peaks, or to judge their statistical significance. The data come from BAUD 70.

33 U(2375) MASS (MEV)						
M	2382.0	24.0	CHIKOVANI	66 MMS	- 12.0 PI-P	8/66
W	(2380.0)	(10.0)	CLAYTON	67 HBC	+ 2.5PBAR, A2+OMEGA	11/69
NOTES NOT AGREE WITH OTHER EXPTS COMPILED IN FIGURE						
M	2370.	17.	ANDERSON	69 ASPK	- 16 PI- BKSCAT	11/69
M	2370.0	10.0	RING	69 HBC	0 S-CHANNEL PBARP	11/69
M	2360.0	25.0	OH	70 HDBC	-OPBAR(P,N), K*K2PI	5/70*
AVG	2370.3	7.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

33 U(2375) WIDTH (MEV)						
W	(30.0)	OR LESS	CHIKOVANI	66 MMS	- 12.0 PI-P	8/66
W	(57.)		ANDERSON	69 ASPK	- 16 PI- BKSCAT	11/69
W	(40.0)	OR LESS	RING	69 HBC	0 S-CHANNEL PBARP	11/69
W	(60.0) OR LESS		OH	70 HDBC	-OPBAR(P,N), K*K2PI	5/70*

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

BOSON MASS-SPECTRUM IN $\pi^-p \rightarrow p(\text{BOSON})^-$, CERN 1965-70



From Baud et al. paper, presented by G. Damgaard, Proceedings 1970 Philadelphia Conference.

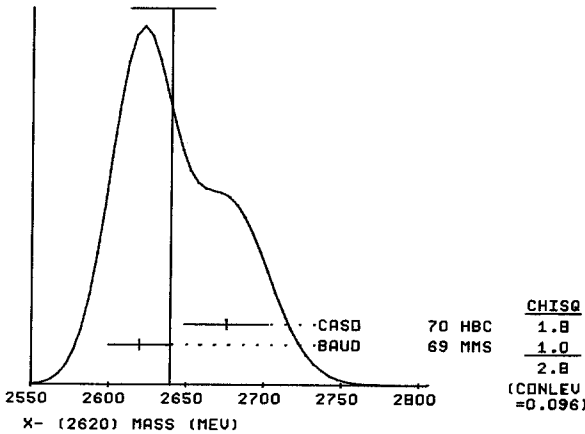
X⁻(2620)

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		2639.8	26.8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)				
M		(SEE IDEOGRAM BELOW)						

WEIGHTED AVERAGE = 2639.8 ± 26.8
ERROR SCALED BY 1.7



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*

REFERENCES FOR X-(2620)

BAUD 69 PL 308 129 +BENZ,BOSNJAKOVIC,BOTTERILL,KIENZLE,+(CERN)
CASO 70 LNC +CONTE,TOMASINI,CORDS+(GENO+HAMB+MILA+SACL)

X⁻(2800)

49 X- (2800, JPG=) I=1 OR 2
OMITTED FROM TABLE

49 X- (2800) MASS (MEV)

M	640	2800.	20.	BAUD	69 MMS	- 8.-10. PI- P	9/69
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49 X- (2800) WIDTH (MEV)

W	640	46.	10.	BAUD	69 MMS	- 8.-10. PI- P	9/69
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REFERENCES FOR X-(2800)

BAUD 69 PL 308 129 +BENZ,BOSNJAKOVIC,BOTTERILL,KIENZLE,+(CERN)

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 308 129 +BENZ,BOSNJAKOVIC,BOTTERILL,KIENZLE,+(CERN)

X⁻(3030)

53 X- (3030, JPG=) I=1 OR 2
OMITTED FROM TABLE

53 X- (3030) MASS (MEV)

M	3035.0	25.0	ALEXANDER	70 HBC	7. PBAR P,7 PI	5/70*
M	3025.0	20.0	BAUD	70 MMS	- 10.5-13 PI- P	5/70*
M	AVG	3028.9	15.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

53 X- (3030) WIDTH (MEV)
W 200.0 60.0 ALEXANDER 70 HBC 7. PBAR P,7 PI 5/70*
(25.0) APPROX. BAUD 70 MMS - 10.5-13 PI- P 5/70*

REFERENCES FOR X-(3030)
ALEXANDER 70 TAUP-133-70 +BAR-NIR,DAGAN,GIDAL,GRUNHAUS+ (TEL-AVIV)
BAUD 70 PL 31 B 549 +BENZ,BOSNJAKOVIC,BOTTERILL,DAMGAARD+(CERN)

X-(3075)

54 X- (3075, JPC=) 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 +BENZ,BOSNJAKOVIC,BOTTERILL,DAMGAARD+(CERN)

X-(3145)

55 X- (3145, JPC=) 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 +BENZ,BOSNJAKOVIC,BOTTERILL,DAMGAARD+(CERN)

X-(3475)

56 X- (3475, JPC=) 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 +BENZ,BOSNJAKOVIC,BOTTERILL,DAMGAARD+(CERN)

X-(3535)

X- (3535, JPC=) 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 +BENZ,BOSNJAKOVIC,BOTTERILL,DAMGAARD+(CERN)

K MESON (JP=0-) I=1/2
SEE LISTINGS OF STABLE PARTICLES

K(725)

17 KAPPA (725,JP=) I=1/2

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
FOR A COMPILATION, SEE APPENDIX A OF JAN 67 EDITION
(RMP 39, 1) OF THIS DATA SUMMARY.

K*(892)

18 K* (892,JP =1-) I=1/2

18 K* (892) MASS (MEV)

Table with columns: CHARGED ONLY, THIS IS WHAT APPEARS ON MESON TABLE, and various particle names and values.

MIXED-- CHARGED AND NEUTRAL. NOT TABULATED

Table with columns: MIXED-- CHARGED AND NEUTRAL, NOT TABULATED, and various particle names and values.

NEUTRAL ONLY, BUT WE DONT USE THIS FOR MASS DIFF. - SEE TYPED NOTE

Table with columns: NEUTRAL ONLY, BUT WE DONT USE THIS FOR MASS DIFF. - SEE TYPED NOTE, and various particle names and values.

18 K*(0) - K*(+-) MASS DIFF. (MEV)

Table with columns: 18 K*(0) - K*(+-) MASS DIFF. (MEV), and various particle names and values.

18 K* (892) WIDTH (MEV)

W CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE

Table with columns: W CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE, and various particle names and values.

Note on K^* Masses and Mass Differences

This note is divided into two discussions:

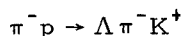
- I. Basic difficulties in determining the mass difference because of interferences and biases.
- II. Impossibly small errors reported by some experiments. We have increased some errors that violate the laws of statistics, and scaled up some errors that are inconsistent; but we warn that most of the errors in our data cards are inconsistent. One cannot then obtain a K^* mass difference by calculating an average mass for K^{*0} and for $K^{*\pm}$ and just subtracting the two.

I. BASIC DIFFICULTIES

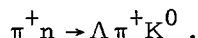
There are two difficulties in measuring a mass difference $m(K^{*0}) - m(K^{*\pm})$ of ~ 7 MeV when the half-width $\Gamma/2$ of the K^* is 25 MeV:

- 1) Interference between the resonant amplitude and background can in general shift the peak in the mass spectrum by some fraction of $\Gamma/2$.
- 2) 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.

Some reactions (symmetric under reflection of I_z) are immune to the first difficulty. Thus compare the mass of K^{*0} produced in



with the mass of K^{*+} in the I_z -reflected reaction



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.

II. IMPOSSIBLY SMALL ERRORS

Consider a sample of N events, with their invariant masses m distributed as an S-wave Breit-Wigner resonance:

$$\text{i. e., } P(\epsilon - \epsilon_R) = \frac{1/\pi}{(\epsilon - \epsilon_R)^2 + 1}, \quad (1)$$

where $\epsilon = \frac{m}{\Gamma/2}$, $\epsilon_R = \frac{m_R}{\Gamma/2}$. One can then show that the minimum possible error on the determination of the central value ϵ_R is

$$\delta_{\min}(\epsilon_R) = \pm \sqrt{\frac{2}{N}}, \text{ i. e., } \delta_{\min}(m_R) = \pm \sqrt{\frac{2}{N}} \frac{\Gamma}{2}. \quad (2)$$

This lower limit assumes no background events. In practice, with background, the error will be larger, by another factor $\alpha \approx \sqrt{2}$.

We illustrate errors with small and large backgrounds with a table summarizing the recent experiment ("Unsplit K^* 's") by DAVIS 69.

 Mass Errors δm of DAVIS 69

- Sample with 5% background/signal at peak.
 Events: $K^*(892)$, 10 700 events in resonance, $\frac{\Gamma}{2} \approx 25$ MeV.
 Lower limit from Eq. (2), $\delta_{\min}(m) = \sqrt{\frac{2}{N}} \frac{\Gamma}{2} = \pm 0.35$ MeV.
 Their likelihood fit yields two sorts of errors:
 - $\delta_1(m)$. Ignore correlations, i. e., keep all the parameters (background, width, etc.) fixed, vary m only:
 $\delta_1(m) = \pm 0.41$, $\delta_1(m)/\delta_{\min}(m) = 1.16$.
 - $\delta_2(m)$. As m is varied, reoptimize other parameters.
 $\delta_2(m) = \pm 0.53$, $\delta_2(m)/\delta_{\min}(m) = 1.5$.
 DAVIS 69 mention $\delta_2 = 0.53$, but to hedge against systematic effects, they quote $\delta_3 = 2$ MeV. We punch 2 MeV.
- Sample with 50% background/signal at peak.
 Events: $K^*(1420)$, 2200 events in resonance, $\frac{\Gamma}{2} = 50$ MeV.
 $\delta_{\min}(m) = 1.6$ MeV,
 $\delta_1(m)$ $= \pm 2.2$ MeV, $\delta_1(m)/\delta_{\min}(m) = 1.4$,
 $\delta_2(m)$ $= \pm 2.6$ MeV, $\delta_2(m)/\delta_{\min}(m) = 1.6$.

 Width Errors $\delta\Gamma$ of DAVIS 69

For width, the equivalent of Eq. (2) is $\delta_{\min}(\Gamma) = \pm \sqrt{\frac{8/3}{N}} \frac{\Gamma}{2} = 1.15 \delta_{\min}(m)$.
 For convenience we neglect the factor 1.15 and use $\delta_{\min}(\Gamma) \approx \delta_{\min}(m)$.

- 5% background, $K^*(892)$:
 $\delta_2(\Gamma) = \pm 1.6$ MeV, $\delta_2(\Gamma)/\delta_{\min}(m) = \frac{1.6}{0.35} = 4.6$.
- 50% background, $K^*(1420)$:
 $\delta_2(\Gamma) = \pm 10$ MeV, $\delta_2(\Gamma)/\delta_{\min}(m) = \frac{10}{1.6} = 6.25$.

We note that $\delta_2(m)/\delta_{\min}(m)$ does not change rapidly with background (1.5 at 5%, 1.6 at 50% and hence conclude that it is hard to believe an error with $\delta_2/\delta_{\min} < 1.4 = \sqrt{2}$. We chose $\sqrt{2}$ because together with Eq. (2) it leads to the simple "realistic" result

$$\delta(m) > \sqrt{2} \sqrt{\frac{2}{N}} \frac{\Gamma}{2} = \frac{\Gamma}{\sqrt{N}}. \quad (3)$$

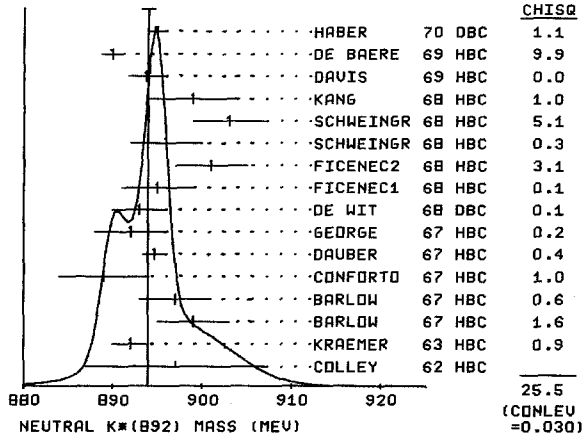
We conclude that for a sensitive subtraction like $m(K^{*0}) - m(K^{*\pm})$, the experiments as listed are useless, and we must either re-evaluate them all or concentrate on those two experiments that explicitly quote a mass difference. For a detailed discussion of how they have actually treated those experiments, we refer to the January 1970 edition of this note.

The table above also allows us to concoct a criterion for "realistic" errors in width $\delta(\Gamma)$. We average the 5% and 50% background results (to give $\delta(\Gamma)/\delta_{\min}(m)$ of 5 to 6) and express the result in terms of Γ , in the style of Eq. (3). We then get the "realistic" test for widths:

$$\delta\Gamma > 4 \frac{\Gamma}{\sqrt{N}}$$

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 893.93 ± 0.73
ERROR SCALED BY 1.3



CHISQ

HABER	70 DBC	1.1
DE BAERE	69 HBC	9.9
DAVIS	69 HBC	0.0
KANG	68 HBC	1.0
SCHWEINGR	68 HBC	5.1
SCHWEINGR	68 HBC	0.3
FICENEC2	68 HBC	3.1
FICENEC1	68 HBC	0.1
DE WIT	68 DBC	0.1
GEORGE	67 HBC	0.2
DAUBER	67 HBC	0.4
CONFORTO	67 HBC	1.0
BARLOW	67 HBC	0.6
BARLOW	67 HBC	1.6
KRAEMER	63 HBC	0.9
COLLEY	62 HBC	

25.5
(CONLEV
=0.030)

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	(43.)		CONFORTO	67 HBC	← 0.1 PBAR P	9/67	
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- PIK-PI0	2/69	
W	48.0	9.0	FICENEC2	68 HBC	← 2.7 K- PIK(PI-)	2/69	
W	52.0	8.0	KANG	68 HBC	← 4.6 K-P	7/69	
W	(27.0)	(8.0)	ERWIN	69 HBC	← 3.5 K+ P	9/69	
W	53.	3.	FRIEDMAN	69 HBC	← 2.1 K-P (3BDY)	9/69	
W	49.	4.	FRIEDMAN	69 HBC	← 2.45 K-P (3BDY)	9/69	
W	46.	2.	FRIEDMAN	69 HBC	← 2.6 K-P (3BDY)	9/69	
W	49.	3.	FRIEDMAN	69 HBC	← 2.7 K-P (3BDY)	9/69	
W	50.	7.	LIND	69 HBC	← 9. K+ P	5/70*	
W	AVG	48.98	0.92	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			
W	MIXED-- CHARGED AND NEUTRAL. NOT TABULATED						
W	200	60.0	5.0	ALEXANDER	62 HBC	+ 0 2.2 PI-P	
W		51.8	3.5	FERRO-LUZ	65 HBC	+ 0 3.0 K+P	6/66
W	(40.0)			WANGLER	65 HBC	+ 0 3.0 PI-P	6/66
W	60.	10.		FRENCH	67 HBC	+0 3-4 PBAR P	6/67
W	AVG	54.9	2.8	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	150 (50.0)			SMITH	63 HBC	0 2.3 PI-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	(43.)			CONFORTO	67 HBC	0 0.1 PBAR P	9/67
W	44.	4.		DAUBER	67 HBC	0 2.0 K-P	12/66
W	58.	2.		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- PIK-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/SORT(N). SEE TYPED NOTE.			HABER	70 DBC	0 3. K-N	11/69
W	4000	54.0	3.0				5/70*
W	AVG	52.2	1.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

18 K* (892) PARTIAL DECAY MODES

P1	K*(892) INTO K PI	DECAY MASSES
P2	K*(892) INTO (K PI PI)	493+ 139+ 139

19 K* (892) BRANCHING RATIOS

R1	K*(892) INTO (K PI PI)/(K PI)	
R1	0 (0.002) OR LESS	WOJCIK12 64 HBC - 1.7 K-P

REFERENCES FOR K*(892)

ALSTON 61 PRL 6 300 ALSTON,ALVAREZ,EBERHARD,GOOD,GRAZIANO+(LRL)
ALEXANDER 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)
GOLDHABER 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)

WOJCIK1 64 PR 135 B 484 STANLEY G WOJCIK (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+IOR+LIVERPOOL)	
BOMSE	67 PR 158 1298	+BORENSTEIN+COLE+GILLESPIE+ (JOHN HOPKINS)	
CONFORTO	67 NP 83 469	+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+MC DONALD+IDDIFORD+ (CERN+IOWA)	
GEORGE	67 NC 49A 9	+GOLDSCHMIDT-CLERMONT+HENRI+ (CERN+BRUX)	
SALLSTROM	67 NC 49A 348	SALLSTROM+GTTER+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, GCRDON, TROWER	(ILLINOIS)
KANG	68 PR 176 1587	Y.W.KANG	(IOWA)
SCHWEINGR	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 UCPL-18860	J.FRIEDMAN,PH.D. THESIS	(LRL)
JUMBLA	69 PR 184 1461	+LEACOCK,RHODE,KCELMAN,LIBBY,+ (AMES+COLO)	
LIND	69 NP B 14 1	+ALEXANDER,FIRESTONE,FU,GOLDHABER	(LRL)
ATHEPTON	70 NP B 16 416	+FRANEK,FRENCH,FRISK,BEDNAR+	(CERN+PRAG)

HABER 70 NP B 17 289 +SHAPIRA,ALEXANDER+ (REHO+SACL+BGNA+EPDL)

K_N (1080-1260)
→ Kπ

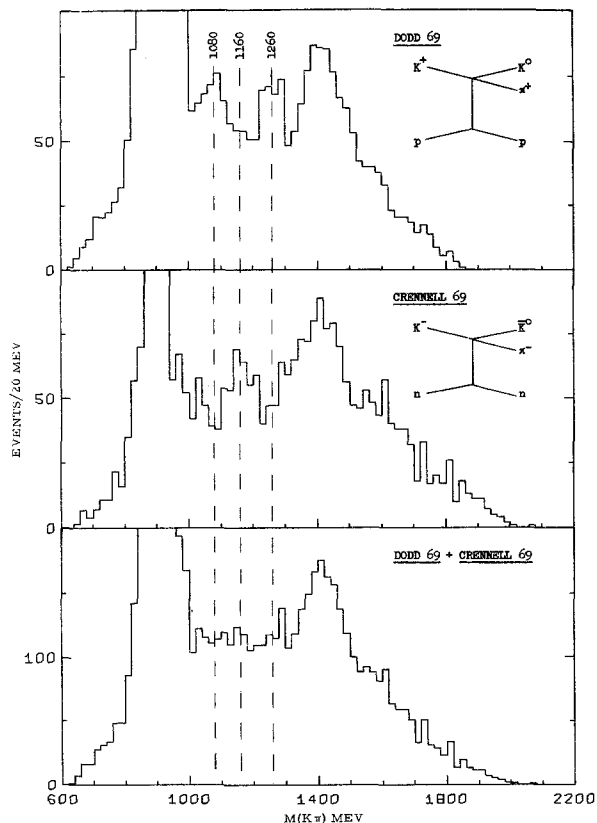
19 KN(1080-1260)
OMITTED FROM TABLE.

From a study of $K^+ p \rightarrow K\pi \Delta^{++}$, TRIPPE 68 find that the $I = 1/2$ S-wave phase shift increases smoothly from threshold and reaches about 90 deg in the region 1100 to 1200 MeV. If interpreted as a resonance the width is about 400 MeV. However, there is no convincing evidence that the S-wave phase shift continues past 90 deg above 1100 to 1200 MeV (SCHLEIN 69).

On the other hand, Fu, Firestone, Goldhaber and Trilling [Nucl. Phys. B18, 93 (1970)] show that OPE is valid only up to $|t| = 0.1$ (GeV/c)². TRIPPE 68 base their analysis on the assumption that OPE is valid up to $|t| = 0.5$ (GeV/c)², and so their conclusion may turn out to need revision.

By compiling ~ 500 $K^+ p \rightarrow K_S^+ \pi^+$ events produced between 3 and 3.5 GeV/c, DODD 69 see an excess of $K\pi$ events at 1080 MeV and a 4.6-standard deviation peak at 1260 MeV with $\Gamma \approx 70$ MeV; however, CRENNELL 69 have 3000 $K^- n \rightarrow K_S^- \pi^-$ produced at 3.9 GeV/c and see a 5-standard deviation peak in between, at $M = 1160$, $\Gamma = 90$. These effects tend to cancel, as shown in the separate and combined histograms below. Can one reasonably compare

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.



these two histograms, for which both the energies and the reactions are somewhat different? If the two spectra had been similar, one would take them to be positive evidence for resonances. To this extent, then, it is always reasonable to compare similar spectra, and to be slightly discouraged if they are dissimilar. Further, if DODD 69 base their claim on agreement between spectra at 3.0 and 3.5 GeV/c one might hope for agreement between 3.5 and 3.9.

The other difference between these experiments is that one is $K^+ p \rightarrow \pi^+ p K^0$, the other $K^- n \rightarrow \pi^- n \bar{K}^0$. Their t-channel diagrams are sketched above each histogram. The two upper vertices are charge conjugate (hence similar), but the first experiment is subject to a $K^0 p$ final-state interference, the second to a different $\bar{K}^0 n$ interference. These could perhaps explain a difference in the spectra.

REFERENCES FOR KN(1080-1260)
DE BAERE 67 NC 51 A 401 +DEBAISIEUX,GOLDSCHMIDT-CLERM.+ (CERN+BRUX)
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)

$K_{A,I=3/2}(1175)$ 24 KA 3/2 (1175,JP=) I = 3/2
EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
FOR A DISCUSSION SEE ROSENFELD 68.

REFERENCES FOR KA3/2(1175)
WANGLER 64 PL 9 71 T P HANGLER,A R ERWIN,W D WALKER (WISCONS)
MILLER 65 PL 15 74 MILLER,KOVACS,MCELWAIN,PALFREY + (PURDUE)
ROSENFEL 68 PROC. PHILA. CONF ON MESON SPECTROSCOPY. P. 455. UCRL 18266
DODD 69 PR 177 1991 +JOLDERSMA, PALMER, SAMIOS (BNL)

$K_{A,I=3/2}(1265)$ 25 KA 3/2 (1265,JP=) I = 3/2
EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
FOR A DISCUSSION SEE ROSENFELD 68.

REFERENCES FOR K*3/2 (1265)
FRENCH 67 NC 52A 442 +KINSON+MC DONALD+RIDDFORD+ (CERN+BIRM)
ROSENFEL 68 PROC. PHILA. CONF ON MESON SPECTROSCOPY. P. 455. UCRL 18266

Q REGION, $K\pi\pi(1240-1400)$

There is a peak in the $K^* \pi$ spectrum centered at about 1300 MeV, or just about 270 MeV above $K^* \pi$ threshold. The $Q(\rightarrow K^* \pi)$ is then the hypercharge = 1 analog of the $A_1(\rightarrow \rho \pi)$, and its interpretation as resonance vs threshold enhancement is ambiguous. (For more discussion see text Sect. III and the note on "A1, A3, Q, L," just before the A1 in these listings.)

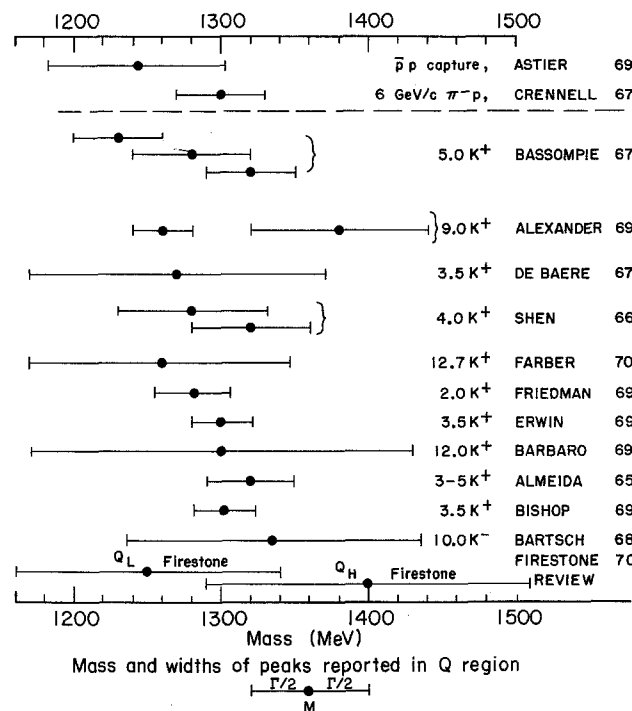
However, in the case of the Q region, there are two additional complications:

- 1) At some energies there is evidence for two separate peaks.
- 2) The $K_{A,I=3/2}^*(1240)$ or "C" meson, with width only 120 MeV, seems to be produced nondiffractively in $\bar{p}p$ capture at rest.

The figure shows M and Γ for all peaks reported in this region. We list first the results of the $\bar{p}p$ production of the "C", and the $\pi^- p \rightarrow \Lambda Q^0$ experiment, so as to separate them from the conventional diffractive experiments $K^\pm p \rightarrow Q^\pm p$. These remaining Q reports are ordered by increasing mass. (This is a change since our last edition, where we tried to group the peaks into several different subpeaks.) In

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

the list of widths and branching ratios, the mass of the related peaks is also given, to avoid confusion. Naturally no averaging is done.



General Comments

In all reported experiments, spin-parity 1^+ is favored although 2^- is not yet ruled out. $K^* \pi$ is the dominant decay mode. While there is K_p and interference between $K^* \pi$ and K_p , there is no evidence for other decay modes. From the coherent production of Q in $K^- d$ experiments, $I = 1/2$ is established.

Several experiments have reported the success of fitting Q production by a Reggeized Deck model between 5 to 7 GeV/c (e.g., CHUNG 69, CHIEN 69, and WERNER 69). It is remarkable that the model fits all the angular and mass distributions although the fit to Q mass peak is not quite as sharp as the data. This model seems to fail at higher energies.

Recently FIRESTONE 70 reviewed all $K^{\pm p}$ experiments from 2.5 to 13 GeV/c and concluded:

1) The Q peak does not have a simple Breit-Wigner shape.

2) The Q peak in the $K\pi\pi$ mass distribution can be fitted to two Breit-Wigner shapes (5-parameter fit) at all energies with reasonable χ^2 . (No attempt was made to fit distributions other than the mass.)

3) The Reggeized Deck model fits experiments around 7 GeV/c very well, while the double Breit-Wigner fits higher-energy experiments. At high energies, the Q is consistent with two peaks with $M = 1250 \pm 4$, $\Gamma = 182 \pm 9$ MeV; and $M = 1400 \pm 6$, $\Gamma = 220 \pm 14$ MeV.

28 KA(1240-1400) I=1/2

28 KA(1240-1400) MASS (MEV)

M	PRODUCED BY BEAMS OTHER THAN K MESONS				
M	1242.0	9.0	10.0	ASTIER 69 HBC	0 PBAR P
M	A THIS IS THE C MESON.				9/69
M	A ERRORS OF ASTIER 69 ARE STATISTICAL. TRUE UNCERTAINTY IS LARGER				
M	45(1300.1)			CRENNELL 67 HBC	0.6 PI- P
M					7/67
M	PRODUCED BY K BEAMS				
M	M=1230.0	15.0		BASSOMPIE 67 HBC	+ 5. K+ P
M	M=1260.0	10.0		ALEXANDER 69 HBC	9.0 K+ P
M	M=1260.0	20.0		FARBER 70 HBC	+ 12.7 K+ P
M	M=1270.0	APPROX.		DE BAERE 67 HBC	+ 3.5 K+ P
M	M=1280.0	25.0		SHEN 66 HBC	+ 0 4.6 K+P,5 BODY
M	M=1280.0	10.0		BASSOMPIE 67 HBC	+ 5. K+ P
M	M=1280.0	20.0		BERLINGHIERI 67 HBC	+ 12.7 K+ P
M	M=1281.0	7.0		FRIEDMAN 69 HBC	- 2.6+2.7 K- P
M	M=1300.0	10.0		ERWIN 69 HBC	0 3.5 K+P(K* PI)
M	M=1301.0	10.0		BISHOP 69 HBC	+ 3.5 K+P(K* PI)
M	M=1300.0	APPROX.		BARBARO 69 HBC	+ 12. K+ P (K 2PI)
M	M=1320.0	25.0		ALMEIDA 65 HBC	+ 3.5 K+ P
M	M=1320.0	10.0		SHEN 66 HBC	+ 4.6 K+ P
M	M=1320.0	15.0		BASSOMPIE 67 HBC	+ 5. K+ P
M	M=1325.0	6.0		BARTSCH 68 HBC	10. K-P,K 2PI
M	M=1335.0	6.0		BARTSCH 68 HBC	10. K-P,K NPI
M	M=1380.0	20.0		ALEXANDER 69 HBC	9.0 K+ P
M	M=1380.0	20.0		ALEXANDER 69 HBC	9.0 K+ P
M	M=1295.7	9.8		AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.5)	

28 KA(1240-1400) WIDTH (MEV)

W	PRODUCED BY BEAMS OTHER THAN K MESONS					
W	1270.0	25.0		ASTIER 69 HBC	0 PBAR P	
W	A ERRORS OF ASTIER 69 ARE STATISTICAL. TRUE UNCERTAINTY IS LARGER				9/69	
W	45 (160.1)			CRENNELL 67 HBC	0.6 PI- P	
W					7/67	
W	PRODUCED BY K BEAMS					
W	M=1230	60.0	20.0	BASSOMPIE 67 HBC	+ 5. K+ P	
W	M=1260	40.0	10.0	ALEXANDER 69 HBC	9.0 K+ P	
W	M=1260	180.0	28.0	FARBER 70 HBC	+ 12.7 K+ P	
W	M=1270 APPROX.	1200.1	APPROX.	DE BAERE 67 HBC	+ 3.5 K+ P	
W	M=1280	100.0	20.0	SHEN 66 HBC	+ 0 4.6 K+P,5 BODY	
W	M=1280	35	80.0	20.0	BASSOMPIE 67 HBC	+ 5. K+ P
W	M=1280	130.0	15.0	BERLINGHIERI 67 HBC	+ 12.7 K+ P	
W	M=1281	51.0	22.0	FRIEDMAN 69 HBC	- 2.6+2.7 K- P	
W	M=1300	21	40.0	15.0	ERWIN 69 HBC	0 3.5 K+P(K* PI)
W	M=1301	45	40.0	10.0	BISHOP 69 HBC	+ 3.5 K+P(K* PI)
W	M=1300 APPROX.	250.0	APPROX.	BARBARO 69 HBC	+ 12. K+ P (K 2PI)	
W	M=1320	60.0	20.0	ALMEIDA 65 HBC	+ 3.5 K+P	
W	M=1320	70	80.0	20.0	SHEN 66 HBC	+ 4.6 K+P
W	M=1320	60.0	20.0	BASSOMPIE 67 HBC	+ 5. K+ P	
W	M=1325	186.0	15.0	6.0	BARTSCH 68 HBC	10. K- P,K 2PI
W	A SEE NOTE UNDER MASS ABOVE					
W	M=1380	196.0	16.0	6.0	BARTSCH 68 HBC	10. K- P,K NPI
W	M=1380	120.0	20.0	ALEXANDER 69 HBC	9.0 K+ P	
W	M=1380	79.1	12.9			
W	AVG			AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.1)		

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

28 KA(1240-1400) PARTIAL DECAY MODES

		DECAY MASSES
P1	KA(1240-1400) INTO K*(890) PI	493+ 139+ 139
P2	KA(1240-1400) INTO K PHO	493+ 139+ 139
P3	KA(1240-1400) INTO K PI	493+ 139+ 139
P4	KA(1240-1400) INTO K ETA	493+ 139+ 139
P5	KA(1240-1400) INTO K OMEGA	493+ 139+ 139
P6	KA(1240-1400) INTO K PI PI	493+ 139+ 139

28 KA(1240-1400) BRANCHING RATIOS

PRODUCED BY BEAMS OTHER THAN K MESONS

R1	KA(1240) INTO (K RHO)/TOTAL	(UNITS OF 10**--2)		
R1	75.0	10.0	ARMENTERO 64 HBC	0.0 PBAR P 6/66
R2	KA(1240) INTO (K* PI)/TOTAL	(UNITS OF 10**--2)		
R2	25.0	10.0	ARMENTERO 64 HBC	0.0 PBAR P 6/66

PRODUCED BY K BEAMS

R9	KA(1300) INTO (K+ PI-) / (K+O P10+ PI-)			
R9	(0.2) OR LESS (CL=.90)	CRENNELL 67 HBC	0.6 0.0 PI-P	7/67
R10	KA(1300) INTO (KO PI+ PI- P10) / (K+O P10+ PI-)			
R10	(0.1) OR LESS (CL=.90)	CRENNELL 67 HBC	0.6 0.0 PI-P	7/67

PRODUCED BY K BEAMS

R1	KA(1280 PEAK) INTO (K PI) / (K*(890) PI)			
R1	(0.8) OR LESS	SHEN 66 HBC	4.6 K+P, 5 BODY	11/67
R1	KA(1320 PEAK) INTO K*(890) PI AND K RHO (OVERLAPPING BANDS)			
R1	(1.0)	SHEN 66 HBC +	4.6 K+P	8/66

REFERENCES FOR KA(1240-1400)

PRODUCED BY BEAMS OTHER THAN K MESONS

ARMENTERO 64 DUBNA CONF 1 577 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 8 10 65 +MARÉCHAL, MONTANET, + (CDF+CEBN+TPNP+LVP) JJP

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, GOLDBABERS, TRILLING (LRL)

ALSO 66 (PRIVATE COMMUN) GERSON GOLDBABER (LRL)

RASSOMPI 67 PL 26B 30 BASSOMPIERRE, GOLOSCHMIDT + (CERN+BRUX+BIRM) JJP

BERLINGHI 67 PRL 18 1087 BERLINGHIERI + FARBBER + FERREL + FORMAN (ROCH) JJP

DE BAERE 67 NC 49 376 +DEBAISIEUX + FAST + FILIPPAS + (CERN+BRUX)

AND PRIVATE COMMUNICATION BY R. JONGEJANS

BAPTSCH 68 NP 88 9 +COCCONI, + (AACH+BERL+CERN+LOIC+IHAW)

BOMSE 68 PRL 20 1519 +BORENSTEIN, CALLAHAN, COLE, COX, + (JOHNHOPK) 1+

DENEGRAT 68 PRL 20 1194 +CALLAHAN + ETTLINGER + GILLESPIE + (JOHNHOPK) 1+

ALEXAMPE 69 NP 8 13 503 G. ALEXANDER, FIRESTONE, GOLDBABER, + (LRL)

ANDREWS 69 PRL 22 731 +LACH, LUDLAM, SANDWESS, BERGER, + (YALE+LRL)

BARBARO 69 PRL 22 1207 BARBARO, GALTIERI, DAVIS, FLATTE, + (LRL)

COLLEY 69 NC A 59 519 +EASTWOOD, + (BIRM+GLAS+LOIC+MPIM+DXF+RHEL)

WERNER 69 PR 188 2023 +AMMAR, DAVIS, KROPAC, YARGER, CHO, + (NMS+ANL) 1+

BISHOP 69 NP 8 9 403 +GOSHAW, ERWIN, WALKER (WISC) (WISC)

SRWIN 69 NP 8 9 364 +WALKER, GOSHAW, WEINBERG (WISC+PRIN+VAND)

FRIEDMAN 69 UCRL-18860 J. FRIEDMAN, PH.D. THESIS (LRL)

CHEN 69 PL 20B 493 +MALAMUD, MELLEMA, RUDNICK, SCHLEIN + (UCLA)

CHUNG 69 PR 182 1443 +EISNER + BAL + LUERS (BNL)

WERNER 69 PR 188 2023 +AMMAR, DAVIS, KROPAC, YARGER, CHO, + (NMS+ANL)

BOWLER 70 PL 31 B 318 M.G. BOWLER (LOXFORD)

FIRESTONE 70 PROC. PHILA. CONF. A. FIRESTONE REVIEW (LRL)

$K_N(1420)$
or **K^{**}**

22 KN (1420, JP=2+) I=1/2
JP = 3- IS UNLIKELY BUT NOT YET COMPLETELY RULED OUT.

22 KN(1420) MASS (MEV)

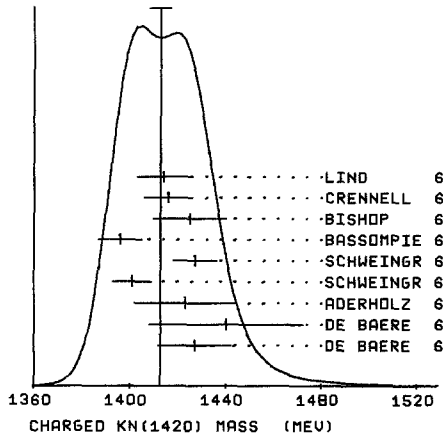
FOR DIFFICULTIES IN MEASURING MASS DIFFERENCE, SEE TYPED NOTE UNDER K*

CHARGED ONLY, WITH FINAL STATE K PI

M	1427.0	15.0	DE BAERE 67 HBC	+ 3.5 K+P (KO PI+)	10/66
M	1440.0	24.0	DE BAERE 67 HBC	+ 3.5 K+P (K+ P10)	10/66
M	1423.0	21.0	ADERHOLZ 68 HBC	- 10 K- P (K PI)	6/68
M	1401.0	8.0	SCHWEINGR 68 HBC	- 4.1 K- P (K PI)	9/67
M	1427.0	9.0	SCHWEINGR 68 HBC	- 5.5 K- P (K PI)	9/67
M B	125 1396.		RASSOMPIE 69 HBC	+ 5 K+P (K PI)	11/69

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- (KOPI-)	7/69
M	1414.0	11.0	LIND 69 HBC	+ 9.0 K+ P (KO PI+)	9/69
M	AVG	1412.7	4.4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)	(SEE IDEOGRAM BELOW)

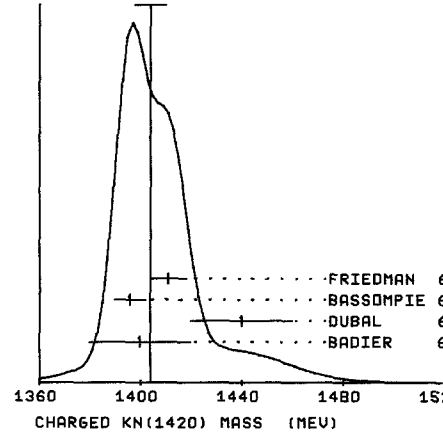
WEIGHTED AVERAGE = 1412.7 ± 4.4
ERROR SCALED BY 1.2



CHARGED ONLY, WITH OTHER FINAL STATES

M	1400.0	20.0	BADIER 65 HBC	- 3.0 K- P (K*PI)	10/66
M	20 1440.0	20.0	DUBAL 68 HMS	- 11.5 K- P	6/68
M B	240 1396.	6.	RASSOMPIE 69 HBC	+ 5 K+P (K 2PI)	11/69
M	1411.0	7.0	FRIEDMAN 69 HBC	- 2.7 K- P (K 2PI)	9/69
M	AVG	1404.0	6.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)	(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 1404.0 ± 6.2
ERROR SCALED BY 1.4



CHARGED AND NEUTRAL

M	1404.0	15.0	FOCARDI 65 HBC	- 0.3 K- P (K PI)	10/66
M	1390.0	6.0	SHEN 66 HBC	+ 4.6 K+ P (K PI)	10/66
M	1430.0	10.0	SHEN 66 HBC	+ 0 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	GOLDBABER 67 HBC	- 9.0 K+ P (K 2PI)	10/67
M	AVG	1421.2	4.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	

NEUTRAL ONLY

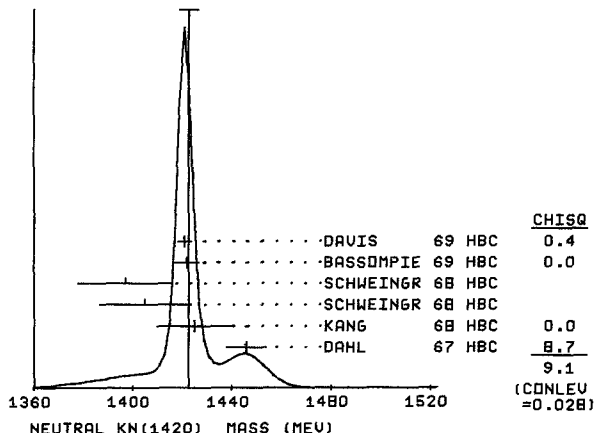
M	(1440.)		CRENNELL 67 HBC	0.6 PI- P (K 2PI)	7/67
M	1446.0	7.9	DAHL 67 HBC	0 4.0 PI- P (KPI)	10/66
M	1425.0	15.0	KANG 68 HBC	0 4.0 K- P	7/69
M	1405.0	18.0	SCHWEINGR 68 HBC	0 4.1 K- P (K PI)	9/67
M	1397.0	19.0	SCHWEINGR 68 HBC	0 5.5 K- P (K PI)	9/67
M B	420 1422.	5.	BASSOMPIE 69 HBC	0 5 K+P (K PI)	11/69
M B	BASSOMP.	ERRORS ENLARGED BY US TO	GAMMA/SORT(IN).	SEE K* TYPED NOTE.	11/69
M	2200 1421.1	2.6	DAVIS 69 HBC	0 12.0 K+ P (K*PI-)	9/69
M	AVG	1422.7	3.8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)	(SEE IDEOGRAM BELOW)

CHISO
0.0
0.1
0.7
3.4
2.5
0.2
0.7
0.9
10.8
(CONLEV = 0.215)

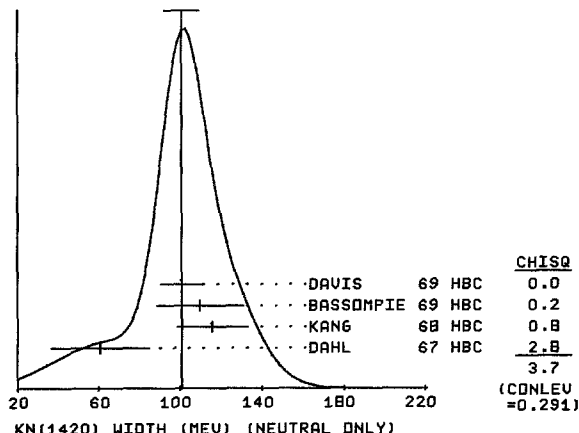
CHISO
1.0
1.8
3.2
0.0
6.1
(CONLEV = 0.109)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 1422.7 ± 3.8
ERROR SCALED BY 1.7



WEIGHTED AVERAGE = 101.2 ± 8.4
ERROR SCALED BY 1.1

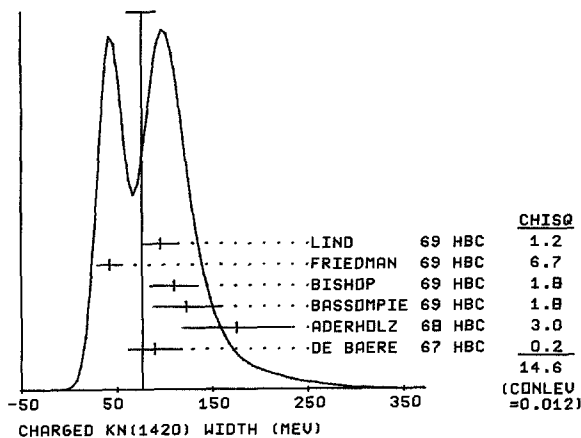


22 KN(1420) WIDTH (MEV)

W	CHARGED ONLY, WITH FINAL STATE K PI	DE BAERE 67 HBC + 3.5 K+ P	10/66
W	90.0 28.0	ADERHOLZ 68 HBC - 10 K- P (K PI)	6/68
W	175. 57. 0	BASSOMPIE 69 HBC + 5 K+ P (K PI)	11/69
W	125. 35. 0	BISHOP 69 HBC + 3.5 K+ P	9/69
B	125. 25.0	FRIEDMAN 69 HBC - 2.7 K- P (K 2PI)	9/69
W	110.0 25.0	LIND 69 HBC + 9. K+ P	5/70*
W	43. 13. 0		
W	96. 18. 0		
W	76.6 15.0	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)	
W	AVG	76.6 ± 15.0	

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 76.6 ± 15.0
ERROR SCALED BY 1.7



W	CHARGED ONLY, WITH OTHER FINAL STATES	BADIER 65 HBC - 3.0 K- P	6/66
W	105.0 30.0	BASSOMPIE 69 HBC + 5 K+ P (K 2PI)	11/69
W	240 110. 25. 0		
W	108.0 19.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	
W	AVG	108.0 ± 19.2	
W	CHARGED AND NEUTRAL	FOCARDI 65 HBC - 0 3.0 K- P (K PI)	8/66
W	92.0 14.0	SHEN 66 HBC + 04.6 K+ P	7/69
W	75.0 25.0	BASSANO 67 HBC - 0 4.6, 5.0 K- P	10/67
W	65.0 20.0	GOLDBERGER 67 HBC 9.0 K+ P (K 2PI)	10/67
W	80.0 20.0	SCHWEINGR 68 HBC - 0 4.1+5.5 K- P	9/67
W	107.0 20.0		
W	85.9 8.4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)	
W	AVG	85.9 ± 8.4	
W	NEUTRAL ONLY	DAHL 67 HBC 0 3.8-4.2 PI- P	9/66
W	61.0 24.0	KANG 68 HBC 0 4.6 K- P	7/69
W	116.0 17.0	BASSOMPIE 69 HBC 0 5 K+ P (K PI)	11/69
W	420 110. 21. 0		
W	2200 101. 10. 0	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)	
W	AVG	101.2 ± 8.4	

(SEE IDEOGRAM BELOW)

22 KN (1420) PARTIAL DECAY MODES

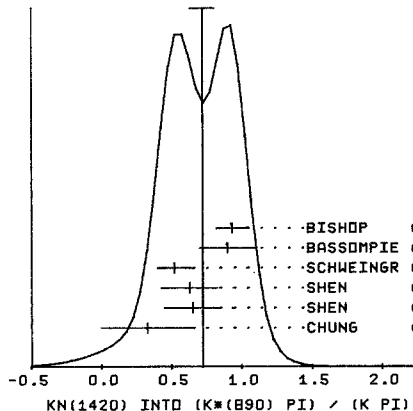
PI	KN(1420) INTO K PI	DECAY MASSES
P1	KN(1420) INTO K*(890) PI	493+ 139
P2	KN(1420) INTO K RHO	892+ 139
P3	KN(1420) INTO K OMEGA	493+ 765
P4	KN(1420) INTO K OMEGA	493+ 783
P5	KN(1420) INTO K ETA	493+ 548

22 KN(1420) BRANCHING RATIOS

R1	KN(1420) INTO (K PI)/TOTAL			
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 OBTAIN IT MERELY BY SUBTRACTING FROM UNITY THEIR MEASUREMENTS OF OTHER RATIOS.			
R1 R	0.492 0.034	VALUE FROM CONSTRAINED FIT		
R2	KN(1420) INTO (K*(890) PI) / TOTAL			
R2 R	.41 0.14	BADIER 65 HBC	3.0 K- P	6/66
R2 R	0.47 0.10	BASSANO 67 HBC	4.6, 5.0 K- P	10/67
R2 R	0.450 0.081	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		
R2 R	0.363 0.031	VALUE FROM CONSTRAINED FIT		
R3	KN(1420) INTO (K RHO)/TOTAL			
R3 R	0.14 0.05	BADIER 65 HBC	3.0 K- P	6/66
R3 R	0.14 0.10	BASSANO 67 HBC	0 4.6, 5.0 K- P	10/67
R3 R	0.140 0.045	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		
R3 R	0.080 0.035	VALUE FROM CONSTRAINED FIT		
R4	KN(1420) INTO (K OMEGA)/TOTAL			
R4 R	0.07 0.04	BADIER 65 HBC	3.0 K- P	6/66
R4 R	0.042 0.013	VALUE FROM CONSTRAINED FIT		
R5	KN(1420) INTO (K ETA)/TOTAL			
R5 R	0.02 0.02	BADIER 65 HBC	3.0 K- P	6/66
R5 R	0.022 0.013	VALUE FROM CONSTRAINED FIT		
R6	KN(1420) INTO (K*(890) PI) / (K PI)			
R6 R	0.33 0.33	CHUNG 65 HBC	+ 0 3.9-4.2 PI- P	8/66
R6 R	0.65 0.20	SHEN 66 HBC	0 4* PRODUCED	10/66
R6 R	0.63 0.20	SHEN 66 HBC	+ NO N* PRODUCED	10/66
R6 R	0.52 0.12	SCHWEINGR 68 HBC	0 4.1+5.5 K- P	10/67
R6 R	0.9 0.2	BASSOMPIE 69 HBC	+ 0 5 K+ P	9/69
R6 R	0.93 0.11	BISHOP 69 HBC	3.5 K+ P	9/69
R6 R	0.722 0.087	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)		
R6 R	0.738 0.099	VALUE FROM CONSTRAINED FIT (SEE IDEOGRAM BELOW)		
R7	KN(1420) INTO (K OMEGA) / (K PI)			
R7 R	(0.08) OR LESS	SHEN 66 HBC	4.6 K+ P	8/66
R7 R	(0.2) OR LESS	BASSOMPIE 69 HBC	+ 5 K+ P	9/69
R7 R	0.13 0.07	BASSOMPIE 69 HBC	0 5 K+ P	9/69
R7 R	0.086 0.029	VALUE FROM CONSTRAINED FIT		
R8	KN(1420) INTO (K RHO) / (K PI)			
R8 R	(0.09) OR LESS	CHUNG 65 HBC	+ 0 3.9-4.2 PI- P	8/66
R8 R	0.26 0.16	SCHWEINGR 68 HBC	0 4.1+5.5 K- P	10/67
R8 R	(0.2) OR LESS	BASSOMPIE 69 HBC	+ 5 K+ P	9/69
R8 R	(0.3) OR LESS	BASSOMPIE 69 HBC	0 5 K+ P	9/69
R8 R	0.11 0.06	BISHOP 69 HBC	3.5 K+ P	9/69
R8 R	0.128 0.056	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		
R8 R	0.163 0.076	VALUE FROM CONSTRAINED FIT		
R9	KN(1420) INTO (K RHO) / (K*(890) PI)			
R9 R	(0.39) OR LESS	BASSOMPIE 67 HBC	+ 5. K+ P	9/67
R9 R	(0.40) OR LESS (CL=90)	FIELD 67 HBC	- 3.8 K- P	6/67
R9 R	0.22 0.11	VALUE FROM CONSTRAINED FIT		

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 0.722 ± 0.087
ERROR SCALED BY 1.3



Author	CHI/DOF
BISHOP 69 HBC	3.6
BASSOMPIE 69 HBC	0.8
SCHWEINGR 68 HBC	2.8
SHEN 66 HBC	0.2
SHEN 66 HBC	0.1
CHUNG 65 HBC	1.4
	9.0
(CONLEU = 0.111)	

Author	Mode	Value	CHI/DOF
R10	KN(1420) INTO (K OMEGA) / (K*(B90) PI)	0.10 ± 0.04	67 HBC - 3.8 K- P
R10	FIELD		
R10 FIT	VALUE FROM CONSTRAINED FIT	0.116 ± 0.038	
R11	KN(1420) INTO (K ETA) / (K*(B90) PI)	0.07 ± 0.04	67 HBC - 3.8 K- P
R11	FIELD		
R11 FIT	VALUE FROM CONSTRAINED FIT	0.062 ± 0.036	
R12	KN(1420) INTO (K LTA) / (K PI)		
R12	(0.025)ER LESS	BASSOMPIE 69 HBC	5.0 K+ P
R12	(0.02) OR LESS	BISHOP 69 HBC	3.5 K+ P
R12 FIT	VALUE FROM CONSTRAINED FIT	0.046 ± 0.027	

Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i^2 \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \delta P_j)$.

	P 1	P 2	P 3	P 4	P 5
P 1	.492+-0.034				
P 2	-.530	.363+-0.031			
P 3	-.367	-.417	.080+-0.035		
P 4	-.361	-.207	-.126	.042+-0.013	
P 5	-.086	-.169	-.043	-.051	.022+-0.016

REFERENCES FOR KN(1420)

BADIER 65 PL 19 612	BADIER,DEHOUILLIN,GOLDBERG+ (EP+SACLAY+ZEEMAN)
CHUNG 65 PRL 15 325	+DAHL,HARDY,HUSS,JACOBS,KIRZ,WILLER (LRL)
FOCARDI 65 PL 16 351	FOCARDI,INGUZZI,RANZI,SERRA+ (BOLOGNA+GEN)
SHEN 66 PRL 17 726	+BUTTERWORTH,FU,GOLDHABERS,TRILLING (LRL)
ALSO 66 (PRIVATE COMMUN)	GERSON,GOLDBER
BASSAND 67 PRL 19 968	+GOLDBERG,GOD,BARNES,LEITNER+(BNL+SYRACUSE)
BASSOMPIE 67 PL 268 30	BASSOMPIERE,GOLDSCHMIDT+ (CERN+BRUX+BIRM)JP
CRENNELL 67 PRL 19 46	+KALBFLEISCH,LAI,SCARR,SCHUMANN (BNL)
DAHL 67 PR 163 1377	HARDY,HUSS+IRZ,MILLER (LRL)
ALSO 65 PRL 14 401	HARDY,CHUNG,DAHL,HUSS,KIRZ,WILLER (LRL)
DE BAERE 67 NC 51 A 401	+GOLDSCHMIDT-CLERMONT,HENRI+ (BRUX+CERN)
FIELD 67 PL 248 638	+HENDRICKS+PICCIONI+YAGER (LAJOLLA)
GOLDBAHE 67 PRL 19 972	G.GOLDBAHER,FIRESTONE,SHEN (LRL)
ADERHOLZ 68 NP B 5 567	+DEUTSCHMANN+ (AACH+BERL+CERN+I.C.+VIENNA)
ALSO 65 PL 22 357	BARTSCH,DEUTSCHMANN,MORRISON+ (ABRCLIC)VI
ANTICH 68 PRL 21 1842	+CALLAHAN,CARSON,COX,DENEGR1,+ (JHUP)
DUBAL 68 THESIS 1456	L.DUBAL (GENEVE)
KANG 68 PR 176 1597	Y.K.KANG (IOWA)
SCHWEINGR 68 PR 166 1317	SCHWEINGRUBER,DERRICK,FIELDS,AMMAR+(ANL+NNI)
ALSO 57 THESIS	F.L.SCHWEINGRUBER (NORTHWESTERN,EVANSTON)
BASSOMPIE 69 NP B13 189	BASSOMPIERE,GOLDSCHMIDT-CLERM.+ (CERN+BRUX) JP
BISHOP 69 NP B 9 403	+GOSHAN,ERWIN,WALKER (MISC)
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)
SUPPRESSED BY BASSOMPIERE 69	
FRIEDMAN 69 UCRL-18860	J.FRIEDMAN,PH.D. THESIS (LRL)
LIND 69 NP B 14 1	+ALEXANDER,FIRESTONE,FU,GOLDBAHER (LRL) JP

KN(1660)

27 KN (1660, JP=) I = 1/2

EVIDENCE NOT COMPELLING, OMITTED FROM TABLE

27 KN (1660) MASS (MEV)

Author	Mode	Value	CHI/DOF
M	(1660.0)	CARMONY 67 HBC	- 3.8 K-P, OMEGA K 11/67
M	1660.0	JOBES 67 HBC	+ 5. K+ P 11/67
M	J	CLAIMED BY JOBES IN (K PI), (K*(B90) PI), AND (KN(1420) PI)	
M	J	MODES. JOBES 67 SEES THE K PI BUMP MOSTLY IN INTERFERENCE WITH N*(1236).	

27 KN (1660) WIDTH (MEV)

Author	Mode	Value	CHI/DOF
W	60.0	20.0	JOBES 67 HBC + 5. K+ P 11/67

27 KN (1660) PARTIAL DECAY MODES

Mode	Value
P1 KN*(1660) INTO K PI	493+ 139
P2 KN*(1660) INTO K PI PI	493+ 139+ 139
P3 KN*(1660) INTO K*(B90) PI	892+ 139
P4 KN*(1660) INTO KN*(1430) PI	1409+ 139

REFERENCES FOR KN(1660)

CARMONY 67 PRL 18 615	D.CARMONY,T.HENDRICKS,L.LANDER (LA JOLLA)
JOBES 67 PL 268 49	+BASSOMPIERE,DE BAERE + (BIRM+CERN+BRUX)

KA(1775)
or L

23 KA (1775, JP=) I = 1/2

This peak is seen in all high-energy (>7 GeV/c) K^+p and K^-d experiments, with a dominant decay mode into $K_N(1420) \pi$, 215 MeV above that threshold. As discussed in Section III of the text and in the note on A1, A3, Q, and L, just before A1 in these listings, there is at present no way to distinguish between a resonant interpretation, a kinematic explanation, or both--i.e., a narrow peak on a broad background.

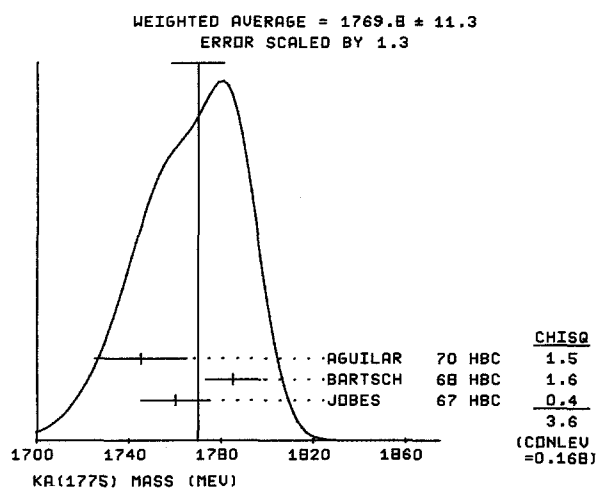
The cleanest L peak is seen produced coherently in the K^-d experiment of DENEGR1 68. Two K^-p experiments report narrow peaks in the $K\pi\pi$ mass spectrum from $K^-p \rightarrow \bar{K}\pi\pi p$, but only after difficult subtraction of high backgrounds. (BARTSCH 68 had ~3500 events; AGUILAR 70 have ~3200).

A high-statistics K^+p experiment (BARBARO-GALTIERI 69, 27 000 events) and a recent compilation [CHIEN 70; 65 000 $K^+p \rightarrow K^+\pi^+\pi^-p$ events with $P(\text{beam}) > 7 \text{ GeV}/c$] show that all the K^+p experiments have a broad (250 to 400 MeV) peak at 1775 MeV in the $K\pi\pi$ system, with $K_N(1420)$ as the dominant mode. There may be some direct 3-body $K\pi\pi$, but more detailed analysis on each experiment is needed to calculate the exact amount. There is no evidence for $K\omega$, $K\phi$, Kf , $K^*\pi$, and $K\rho$ modes.

The I-spin is 1/2, and $J = 1^-$ or 2^+ are favored. In summary, there are differences between K^+ and K^- experiments, and some higher-statistics K^-p and K^-d experiments are needed.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

23 KA (1775) MASS (MEV)					
M	20(1780.)		BERLINGHI 67 HBC	+ 12.7 K+P	7/67
M	1740.0	15.0	JOBES 67 HBC	+ 5. K+ P	11/67
M	1785.0	12.0	BARTSCH 68 HBC	10.0 K- P	9/69
M	1745.0	20.0	AGUILAR 70 HBC	-4.6, K- P	6/70*
M	.....	.....	
M	AVG	1769.8	11.3	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3) (SEE IDEOGRAM BELOW)	



23 KA (1775) 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	127.0	43.0	BARTSCH 68 HBC	10.0 K- P	9/69
W	100.0	50.0	AGUILAR 70 HBC	-4.6, K- P	6/70*
W	.....	.....	
W	AVG	75.2	18.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)	

23 KA (1775) PARTIAL DECAY MODES			
P5	KA	INTO K PI PI	497+ 134+ 134
P6	KA	INTO K*(1420) PI	134+1409

23 KA (1775) BRANCHING RATIOS	

REFERENCES FOR KA(1775)	
BERLINGHI 67 PRL 18 1087	BERLINGHIERI+FARBER+FERBEL+FORMAN+ (ROCH)I
JOBES 67 PL 268 49	+BASSOMPIERRE, DE BAERE + (BIRM+CERN+BRUX)
DENEGRI 68 PRL 20 1194	+CALLAHAN+ETTLINGER+GILLESPIE+ (JOHNSHOP)
BARTSCH 68 NP 88 9	+COCCONI,+ (AACH+BERL+GEN+LOIC+THAW)
ANDREWS 69 PRL 22 731	+LACH, LUDLAM, SANDWEISS, BERGER,+ (YALE+LRL)
BARBARO1 69 PRL 22 1207	BARBARO-GALTIERI, DAVIS, FLATTE,+ (LRL)
BARBARO2 69 LUND PAPER 89	SAME AUTHORS AS ABOVE - DATA DOUBLED (LRL)
COLLEY 69 NC A 59 519	+EASTWOOD,+ (BIRM+GLAS+LOIC+MPIIM+OXF+RHEL)
AGUILAR 70 BNL 14388-R	+BARNES, BASSANO, CHUNG, EISNER, FLAMINIO+ (BNL)
CHIEN 70 PROC. PHILA. CONF	C. Y. CHIEN (JOHNS HOPKINS)

K*(2240) 40 K* (2240, JP=) I=1/2
 ENHANCEMENT SEEN IN (ANTIHYPERON+NUCLEON) MASS.
 EVIDENCE NOT COMPELLING, OMITTED FROM TABLE.

40 K* (2240) MASS (MEV)			
M	15 2240.	20.	ALEXANDER 68 HBC + 0 9 K+P, YBAR+N+.. 6/68

40 K* (2240) WIDTH (MEV)			
W	15 70.	20.	ALEXANDER 68 HBC + 0 9 K+P, YBAR+N+.. 6/68

REFERENCES FOR K*(2240)	
ALEXANDE 68 PRL 20 755	ALEXANDER, FIRESTONE, GOLDBABER, SHEN (LRL)

Note on N's and Δ 's

There are now complete phase-shift analyses from four different groups: The Saclay-group (referred to as BAREYRE 68 and AYED 70), the Berkeley group (JOHNSON 67), the Glasgow group (DAVIES 68), and the CERN group.

The CERN group has performed two phase-shift analyses, using different methods. The CERN I solution is published as DONNACHIE-1 68 for both I spin 1/2 and 3/2. Their figures contain two sorts of results:

1. "Experimental Phase Shifts." i. e., partial-wave amplitudes at each energy at which they used experimental input. These are plotted as, η and δ at each energy, but not as Argand plots.
2. "Theoretical Fits" using smooth functions based on dispersion-relation theory. These are plotted both as smooth curves of η and δ vs energy, and as Argand plots. Brody et al.¹ have recently criticized the "Theoretical Fits" because it turns out that although the "experimental" amplitudes describe the data as well as (or better than) any other available set, the theoretical fits for some rapidly varying partial waves are too smooth. Because they are so convenient to draw and to remember, we continue to present these smooth Argand plots, having warned the reader of their limitations.

The new solution, CERN II,² covers I = 3/2 only, and has been published only as Argand plots of "experimental" amplitudes.

The most recent and extensive analysis comes from the Saclay group (AYED 70); it extends up to a mass of 2.5 GeV. Only the Argand diagrams are available for the moment; values of mass, width, and elasticity of resonances obtained from an energy-dependent fit to the amplitudes should be published soon. We reproduce here, in Figs. 1, 2, 3, most of the available Argand diagrams. The Berkeley diagrams, from which the authors do not yet quote resonance parameters, are reproduced here only for I = 1/2 partial waves.³ Table I is a summary of all the states claimed by the various groups with our evaluation of their significance. We have included in the Baryon Table only states listed as "good" or "fair."

Spread Around 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. We now have complete phase-shift analyses from four different groups, but we are quite far from having reliable masses and widths derived therefrom.

The problem is that the errors on the phase shifts are quite large and it is thus difficult to draw smooth curves on the Argand diagrams. In addition, except for the Glasgow solutions, where an energy-dependent fit to the data and phase shifts is done, the resonance parameters are just the result of an "eyeball" fit with the use of different methods. As a result, different authors using the same phase shifts often estimate different values of M , Γ , x . This is the case for the CERN I solution, from which three sets of parameters have been reported. In order to make the reader aware of this problem we report here a table, Table II, with all the different values for M , Γ , x . On the main table of Baryon Resonances we decided not to quote a value with an error, but to quote a range of masses and widths in order to point out the large indeterminacy of these parameters. So the P_{11}^+ will be $M = 1435$ to 1505 MeV, $\Gamma = 200$ to 400 MeV, etc.

Footnotes and References

1. A. D. Brody, D. W. G. S. Leith, B. G. Levi, B. C. Shen, D. Herndon, R. Longacre, L. Price, A. H. Rosenfeld, and P. Söding, Phys. Rev. Letters 22, 1401 (1969).
2. The CERN II Argand plots have been reported by A. Donnachie, 14th International Conference on High Energy Physics, Vienna, 1968, p. 139.
3. For the complete set of Argand plots including speed versus energy, see UCRL-20030 πN (February 1970) by D. J. Herndon, A. Barbaro-Galtieri, A. H. Rosenfeld. The AYED 70 solutions are not included, since they were not available at the time.

84 Table I. Our evaluation of the status of all N and Δ resonances as seen in partial-wave analyses. D = definite, Pr = probable, Po = possible, A = ambiguous, No = not present. Notice that in the Glasgow fits the resonance hypothesis is built into the fit, so only the symbols D or No apply, except for one Pr at the upper end.

	f					Our evaluation	ηn	KΛ	KΣ	πΔ	ρN	γN
	Berkeley	CERN I	Saclay	Glasgow	RBD ^a								CERN II
P ₁₁ ⁱ (1470)	D	D	D	D		Good						
D ₁₃ ⁱ (1520)	D	D	D	D		Good				D		D
S ₁₁ ⁱ (1535)	D	D	D	D		Good	D					D
D ₁₃ ⁱⁱ (1700)	Po	Po	Po	No		Poor						
D ₁₅ ⁱ (1670)	D	D	D	D		Good				D		
F ₁₅ ⁱ (1688)	D	D	D	D		Good				D		D
S ₁₁ ⁱⁱ (1700)	D	D	D	D		Good	Po	D				D
P ₁₁ ⁱⁱ (1780)	Pr	Pr	Pr	D		Fair	Po	D				D
P ₁₃ ⁱ (1860)	A ^c	A	A ^c	Pr	Pr	Fair						
F ₁₇ ⁱ (1990)	c	Pr	A	e	D	Fair						
D ₁₃ ⁱⁱⁱ (2040)	c	Pr	Po	c	D	Fair						
G ₁₇ ⁱ (2190)	c	D	D	c	Pr	Good						
P ₃₃ ⁱ (1236)						Good						D
S ₃₁ ⁱⁱ (1650)	D	D	D	D	D	Good				Po ^b		
P ₃₃ ⁱⁱ (1690)	Po	A	Po ^g	No	A	Poor				Po ^b		
D ₃₃ ⁱ (1670)	A	D	D	D	D	Fair				Po ^b		
F ₃₅ ⁱ (1890)	Pr	Pr	Pr	D	Pr	Fair						
P ₃₁ ⁱ (1910)	Pr ^c	Pr	D	D	D	Fair			Po			
D ₃₅ ⁱ (1960)	c	A	No	c	Po	A			Po			
F ₃₇ ⁱ (1950)	D	D	D	D	D	Good			Po	D	D	D
P ₃₃ ⁱⁱⁱ (2160)	Po ^c	Po	No	c	d	Poor						

^aRBD = LEA 69 (Lea et al., Ruth, Bristol, Daresbury).

^bFor these references see DONNACHIE-2, the latter part of the article.

^cThis state is very close to or beyond their highest energy.

^dWe can't say anything.

^eGlasgow A has a G₁₇ state, Glasgow B may have an F₁₇. However, this region is very close to their highest energy.

^fEvaluation based on new analysis (AYED 69).

^gAround 1900 MeV, however.

PARTIAL-WAVE AMPLITUDES FOR CERN I, CERN II, AND BERKELEY SOLUTIONS.

(Arrows point to approximate resonance positions.)

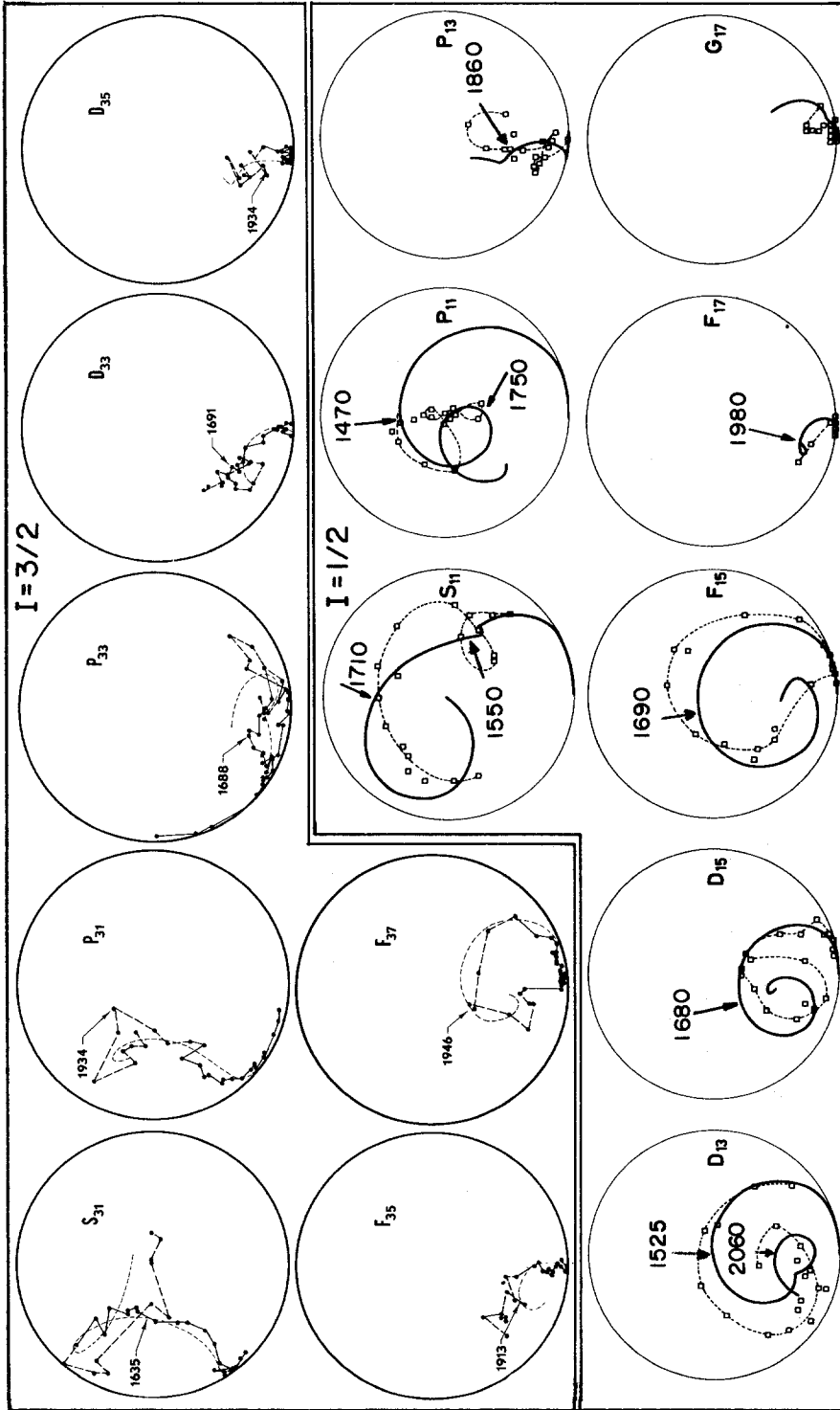


Fig. 4. Results of the phase-shift analyses of the CERN and Berkeley groups. The CERN I results are the smooth curves (dashed in the $I = 3/2$ diagrams). This analysis used dispersion relations to join and smooth the solutions found at different energies. The arrows in the $I = 1/2$ diagrams indicate approximate resonance positions; they have been drawn by us. The CERN II solution is shown (as a dot-dash line) only for the $I = 3/2$ amplitudes since the $I = 1/2$ are not available. The arrows have been drawn by the authors. The Berkeley solution is shown only for the $I = 1/2$ state (as empty squares joined by dashes)

PARTIAL WAVE AMPLITUDES OBTAINED BY THE GLASGOW GROUP

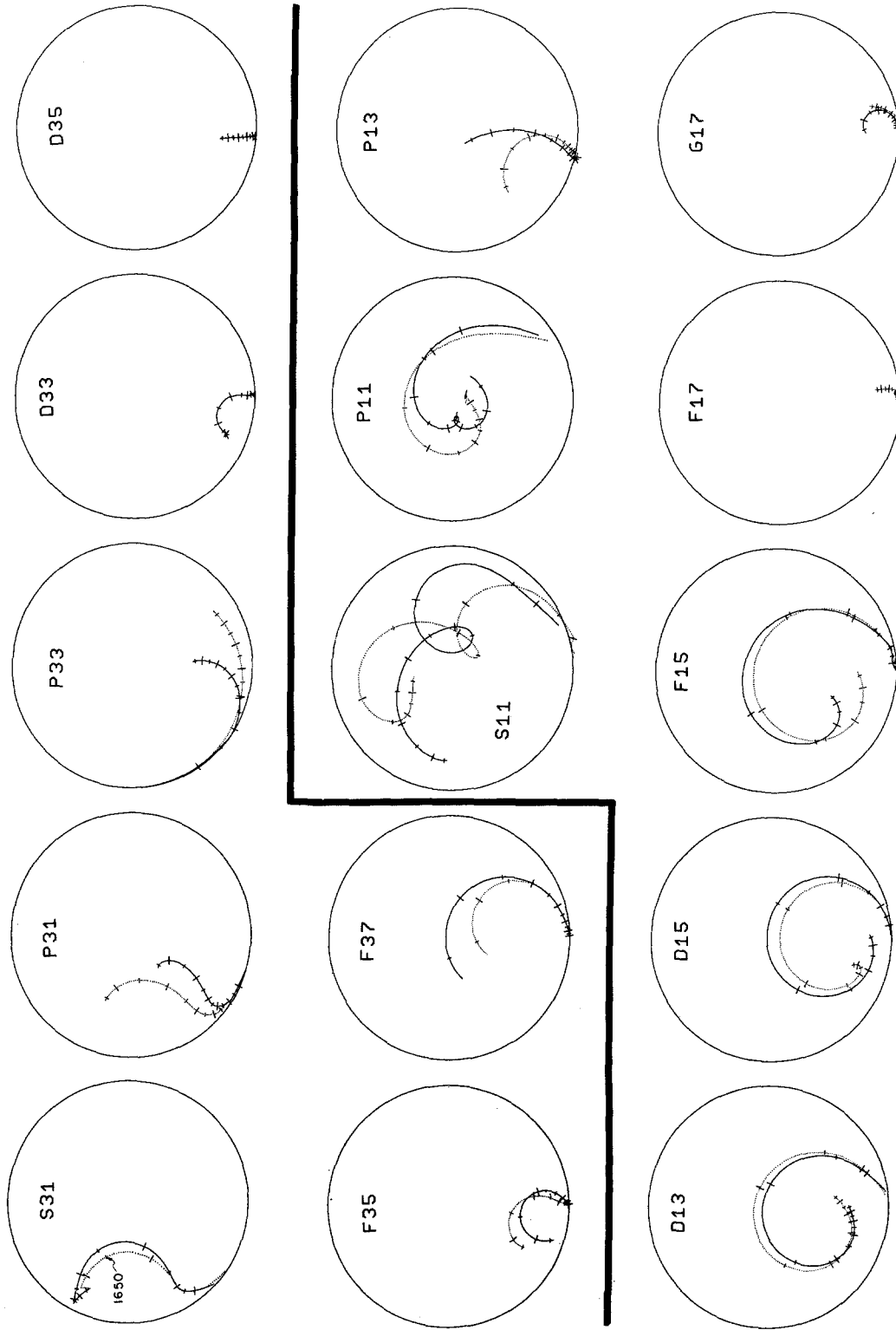


Fig. 2. Partial wave analysis results of DAVIES 68. The curves plotted here are the results of the energy-dependent analysis. DAVIES A (solid curves) is obtained by starting from the set of phase shifts best solution of the Glasgow group. DAVIES B (dashed curves) is obtained by starting from the CERN 1 phase shifts. DAVIES B is not shown when it is very close to DAVIES A. Scale marks are shown every 50 MeV. The first large mark is at $M = 1400$ MeV, the last large mark at $M = 1900$ MeV.

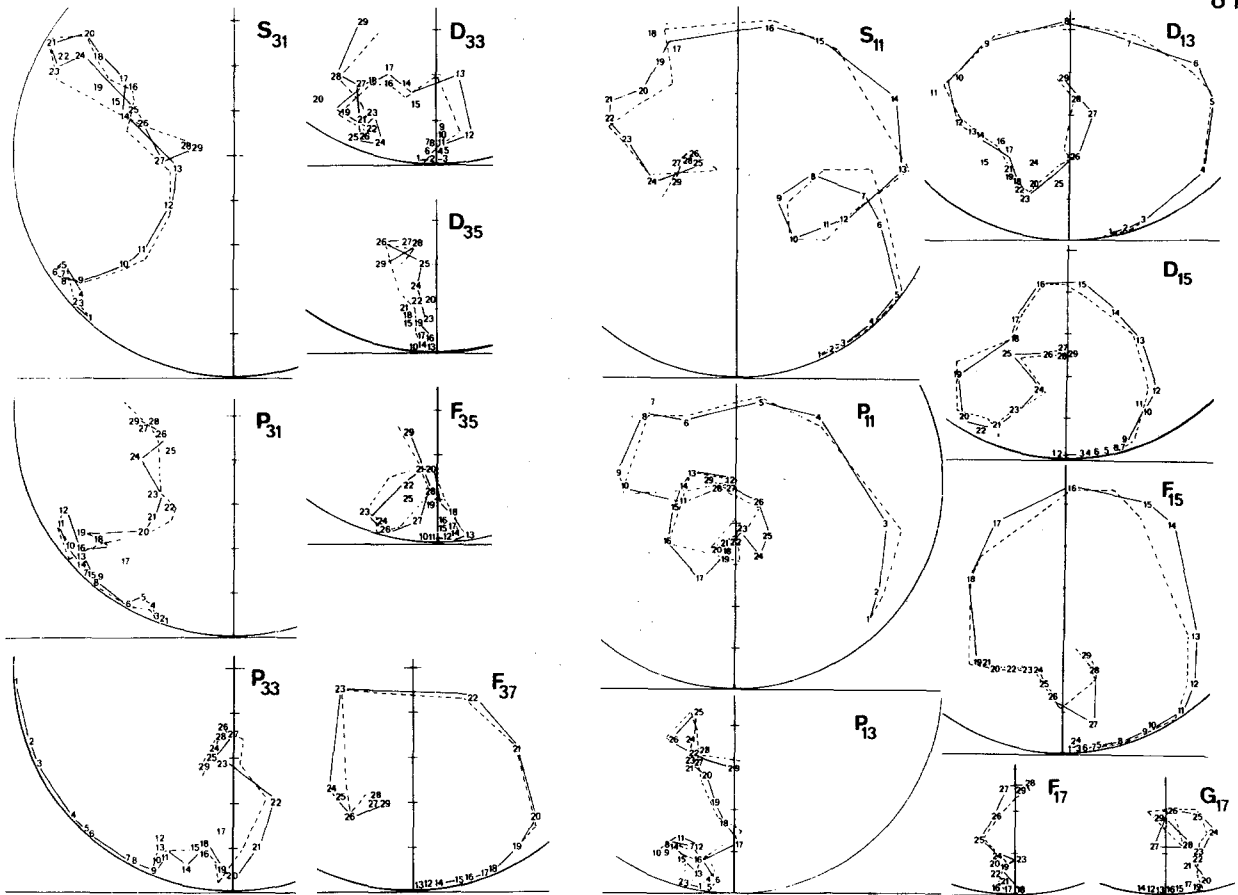


Fig. 3. New Saclay phase-shift analysis results (AYED 70). The full and dashed lines connect points of "minimal path" and "minimal surface," respectively.

Table II. Resonance parameters for N^* and Δ from phase-shift analyses, as listed by their authors. The $P_{33}(1236)$ is not included because the analyses listed start at higher energy.

BAREYRE 68 uses two methods to find resonance parameters; 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 quotes only one method, usually where the absorption is maximum, but three different sets of values have been given. The Glasgow group (DAVIES 68) uses Breit-Wigner parameterization; 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. We report in the M column our evaluation of the status of this resonance as judged on the published Argand plots. Symbols are the same as on Table I.

The "Ind. Ext. Error" written below the average is the "external error" of the individual values, i. e., $\langle \delta x_i \rangle = \sqrt{\frac{1}{N} \sum_1^N (x_i - \bar{x})^2}$. The error \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.

Table II. (see caption on preceding page)

I = 1/2 States					Method M Γ x				
• P'11 (1470)					• P'11 (1780)				
1	Bareyre	68	σ	1470	1	Bareyre	68	σ	Pr
2	Bareyre	68	Speed	1505	2	Bareyre	68	Speed	Pr
3	Berkeley	67		D	3	Berkeley	67		Pr
4	Donnachie-1	68	Abs.	1466	4	Donnachie-1	68	Abs.	1751
5	Donnachie-2	68	Abs.	1470	5	Donnachie-2	68	Abs.	1750
6	Kirsopp	68	Abs.	1466	6	Kirsopp	68	Abs.	1860
7	Glasgow	68	A	1462	7	Glasgow	68	A	1770
8	Glasgow	68	B	1436	8	Glasgow	68	B	(1867)
Average				1468	Average				1783
\pm Ind. ext. error				± 19	\pm Ind. ext. error				± 45
• D'13 (1520)					• P'13 (1860)				
1	Bareyre	68	σ	1510	1	Bareyre	68	σ	A ^b
2	Bareyre	68	Speed	1515	2	Bareyre	68	Speed	A ^b
3	Berkeley	67		1526 ^a	3	Berkeley	67		A ^b
4	Donnachie-1	68	Abs.	1541	4	Donnachie-1	68	Abs.	1863
5	Donnachie-2	68	Abs.	1520	5	Donnachie-2	68	Abs.	1860
6	Kirsopp	68	Abs.	1526	6	Kirsopp	68	Abs.	1900
7	Glasgow	68	A	1512	7	Glasgow	68	A	1844
8	Glasgow	68	B	1512	8	Glasgow	68	B	1854
Average				1520	9	Lea	69		1860
\pm Ind. ext. error				± 10	Average				1864
• S'11 (1535)					• F'17 (1990)				
1	Bareyre	68	σ	1535	1	Bareyre	68	σ	b
2	Bareyre	68	Speed	1515	2	Bareyre	68	Speed	b
3	Berkeley	67		1548 ^a	3	Berkeley	67		b
4	Donnachie-1	68	Abs.	1591	4	Donnachie-1	68	Abs.	1983
5	Donnachie-2	68	Abs.	1550	5	Donnachie-2	68	Abs.	—
6	Kirsopp	68	Abs.	1540	6	Kirsopp	68	Abs.	1995
7	Glasgow	68	A	1502	7	Glasgow	68	A	c
8	Glasgow	68	B	1499	8	Glasgow	68	B	c
Average				1535	9	Lea	69		-2000
\pm Ind. ext. error				± 28	Average				1989
• D'13 (1700)					• D''13 (2040)				
1	Bareyre	68	σ	Po	1	Bareyre	68	σ	b
2	Bareyre	68	Speed	Po	2	Bareyre	68	Speed	b
3	Berkeley	67		Po	3	Berkeley	67		b
4	Donnachie-1	68	Abs.	—	4	Donnachie-1	68	Abs.	2057
5	Donnachie-2	68	Abs.	1730	5	Donnachie-2	68	Abs.	2030
6	Kirsopp	68	Abs.	1680	6	Kirsopp	68	Abs.	2040
7	Glasgow	68	A	No	7	Glasgow	68	A	b
8	Glasgow	68	B	No	8	Glasgow	68	B	b
Average				1705	9	Lea	69		2030
\pm Ind. ext. error				± 25	Average				2039
• D15 (1670)					• C17 (2190)				
1	Bareyre	68	σ	1680	1	Bareyre	68	σ	b
2	Bareyre	68	Speed	1655	2	Bareyre	68	Speed	b
3	Berkeley	67		D	3	Berkeley	67		b
4	Donnachie-1	68	Abs.	1678	4	Donnachie-1	68	Abs.	2265
5	Donnachie-2	68	Abs.	1680	5	Donnachie-2	68	Abs.	2190
6	Kirsopp	68	Abs.	1678	6	Kirsopp	68	Abs.	2265
7	Glasgow	68	A	1669	7	Glasgow	68	A	(1906) ^c
8	Glasgow	68	B	1667	8	Glasgow	68	B	c
Average				1672	9	Lea	69		-2000
\pm Ind. ext. error				± 10	Average				2180
• F15 (1688)					• S31 (1650)				
1	Bareyre	68	σ	1690	1	Bareyre	68	σ	b
2	Bareyre	68	Speed	1680	2	Bareyre	68	Speed	b
3	Berkeley	67		1692 ^a	3	Berkeley	67		Po ^b
4	Donnachie-1	68	Abs.	1687	4	Donnachie-1	68	Abs.	1695
5	Donnachie-2	68	Abs.	1690	5	Donnachie-2	68	Abs.	1650
6	Kirsopp	68	Abs.	1692	6	Kirsopp	68	Abs.	D
7	Glasgow	68	A	1685	7	Glasgow	68	A	b
8	Glasgow	68	B	1684	8	Glasgow	68	B	b
Average				1688	Average				2160
\pm Ind. ext. error				± 4	\pm Ind. ext. error				± 260
• S'11 (1700)					• P'33 (1690)				
1	Bareyre	68	σ	1710	1	Bareyre	68	σ	A
2	Bareyre	68	Speed	1665	2	Bareyre	68	Speed	A
3	Berkeley	67		1709 ^a	3	Berkeley	67		Po
4	Donnachie-1	68	Abs.	—	4	Donnachie-1	68	Abs.	1688
5	Donnachie-2	68	Abs.	1710	5	Donnachie-2	68	Abs.	1640
6	Kirsopp	68	Abs.	1709	6	Kirsopp	68	Abs.	1635
7	Glasgow	68	A	1766	7	Glasgow	68	A	1670
8	Glasgow	68	B	1671	8	Glasgow	68	B	1623
Average				1706	Average				1650
\pm Ind. ext. error				± 31	\pm Ind. ext. error				± 23
• D33 (1670)					• F35 (1890)				
1	Bareyre	68	σ	Po	1	Bareyre	68	σ	Po
2	Bareyre	68	Speed	Po	2	Bareyre	68	Speed	Po
3	Berkeley	67		A	3	Berkeley	67		Pr
4	Donnachie-1	68	Abs.	1691	4	Donnachie-1	68	Abs.	1913
5	Donnachie-2	68	Abs.	1690	5	Donnachie-2	68	Abs.	1910
6	Kirsopp	68	Abs.	1690	6	Kirsopp	68	Abs.	1910
7	Glasgow	68	A	1649	7	Glasgow	68	A	1841
8	Glasgow	68	B	1650	8	Glasgow	68	B	1852
Average				1674	Average				1885
\pm Ind. ext. error				± 20	\pm Ind. ext. error				± 32
• P31 (1910)					• D35 (1960)				
1	Bareyre	68	σ	A ^b	1	Bareyre	68	σ	A ^b
2	Bareyre	68	Speed	A ^b	2	Bareyre	68	Speed	A ^b
3	Berkeley	67		P ^b	3	Berkeley	67		b
4	Donnachie-1	68	Abs.	1934	4	Donnachie-1	68	Abs.	1954
5	Donnachie-2	68	Abs.	1930	5	Donnachie-2	68	Abs.	—
6	Kirsopp	68	Abs.	1930	6	Kirsopp	68	Abs.	1970
7	Glasgow	68	A	1914	7	Glasgow	68	A	b
8	Glasgow	68	B	1834	8	Glasgow	68	B	b
Average				1908	9	Lea	69		1950
\pm Ind. ext. error				± 38	Average				1958
• F37 (1950)					• P''33 (2160)				
1	Bareyre	68	σ	1975	1	Bareyre	68	σ	b
2	Bareyre	68	Speed	1980	2	Bareyre	68	Speed	b
3	Berkeley	67		D	3	Berkeley	67		Po ^b
4	Donnachie-1	68	Abs.	1946	4	Donnachie-1	68	Abs.	2160
5	Donnachie-2	68	Abs.	1950	5	Donnachie-2	68	Abs.	2160
6	Kirsopp	68	Abs.	1946	6	Kirsopp	68	Abs.	2160
7	Glasgow	68	A	1935	7	Glasgow	68	A	b
8	Glasgow	68	B	1935	8	Glasgow	68	B	b
Average				1952	Average				2160
\pm Ind. ext. error				± 19	\pm Ind. ext. error				± 260

() Values in parentheses have not been used in the averages.

^aValues quoted by Lovelace, rapporteur talk at Heidelberg Conference (1967), p. 109.

^bThis state is very close to or beyond their highest energy.

^cGlasgow A has a C₁₇ state at this mass, Glasgow B may have an F₁₇ and a G₁₇; however, this energy region is very close to their highest energy.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

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

[p] 16 PROTON (938, J=1/2) I=1/2
SEE LISTINGS OF STABLE PARTICLES

[n] 17 NEUTRON (939, J=1/2) I=1/2
SEE LISTINGS OF STABLE PARTICLES

[N(1470)] 61 N*1/2(1470, JP=1/2+) I=1/2 [P'1]
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE
PRECEDING N*1/2(1470).

THE MASS AND WIDTH ARE BEST DETERMINED FROM PHASE-SHIFT ANALYSES. WE
LIST PRODUCTION EXPERIMENTS SEPARATELY--SEE BELOW.

Table with columns: M, (1380-0), (1370-0), (1470-0), (1436-0), (1505-0), (1462-0), (1436-0), (1466-0), (1470-0), (1466-0). Rows include ROPER, BRANSEN, BAREYRE, DAVIES, DONNACH1, DONNACH2, KIRSOPP.

Table with columns: W, (255-0), (205-0), (391-), (224-), (211-0), (211-), (210-). Rows include BAREYRE, DAVIES, DONNACH1, DONNACH2, KIRSOPP.

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

Table with columns: P1, N*1/2(1470) INTO PI N, N*1/2(1470) INTO N SIGMA (SIGMA MESON), N*1/2(1470) INTO N*3/2(1236) PI, N*1/2(1470) INTO N PI PI, N*1/2(1470) INTO GAMMA N. Rows include 139+ 938, 938+ 410, 1236+ 139, 938+ 139+ 139, 0+ 938.

Table with columns: R1, N*1/2(1470) INTO (PI N)/TOTAL, (P1)/TOTAL. Rows include (0.68), (0.49), (0.46), (0.58), (0.66), (0.66).

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

Table with columns: R1, (0.67), (0.58), (0.22), (0.03), (0.20), (0.20), (0.20). Rows include SAKON, MORGAN, DONNACH2, KIRSOPP.

A AND B CORRESPOND TO THE 2 BEST SOLUTIONS. ANALYSIS IS DONE ON THREE
BODY DECAYS, ASSUMING ONLY P1, P2 AND P3 DECAYS PRESENT.

Table with columns: R2, N*1/2(1470) INTO (N SIGMA)/TOTAL, (P2)/TOTAL. Rows include (0.22), (0.03), (0.20), (0.20).

A AND B CORRESPOND TO THE 2 BEST SOLUTIONS. SEE NOTE IN R1.

Table with columns: R3, N*1/2(1470) INTO (N*3/2(1236) PI)/TOTAL, (P3)/TOTAL. Rows include (0.22), (0.03), (0.20), (0.20).

A AND B CORRESPOND TO THE 2 BEST SOLUTIONS. SEE NOTE IN R1.

Table with columns: R4, N*1/2(1470) INTO (GAMMA N)/(PI N), (P5)/(P1). Rows include (0.22), (0.03), (0.20), (0.20).

SOME INDICATION LDOI-RIZZ 70 DBC GAM-N TO PI-P 7/70*

REFERENCES -- N*1/2(1470)

Table with columns: ROPER, BRANSEN, THURNAUER, NAMYSLOW, ROSENFEL, BAREYRE, DAVIES, DONNACH1, DONNACH2, KIRSOPP, MORGAN, LDOI-RIZ, SAKON. Rows include LD ROPER, RM WRIGHT, BY FELD, +DODNELL, MOORHOUSE, P G THURNAUER, NAMYSLOW, RAZMI, ROBERTS, A H ROSENFELD, P SODING, P BAREYRE, C BRICMAN, G VILLET, A DAVIES, R MOORHOUSE, A DONNACHIE, R G KIRSOPP, C LOVELACE, DONNACHIE, RAPPOURTEUR, S TALK, R G KIRSOPP, D MORGAN, +FIORE, PIAZZA, ... (PAVIA+ROMA+GENA+NAPOLI), SAKON, MULVEY, CHINDWSKY, (OXF+LRL).

PAPERS NOT REFERRED TO IN DATA CARDS.

Table with columns: BAREYRE, DAVIES, DALITZ, JOHNSON. Rows include +BRICMAN, VALLADAS, VILLET, +BRICMAN, STIRLING, VILLET, R H DALITZ, R G MOORHOUSE, C H JOHNSON.

DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 PL 218 598 L RESNICK (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1
BERARDO 70 PRL 24 419 +HADDOCK, NEFKENS, ... PARSONS... (UCLA+LRL)

THE FOLLOWING ARE THEORETICAL PAPERS CONCERNING THE N*1/2(1470) --
RESNICK 66 PR 150 1292 +BAREYRE, VILLET (SACLAY)
SCHWARZ 66 PR 152 1325 J H SCHWARZ (NIELS BOHR)
BALL 67 PR 155 1725 JS BALL, GL SHAW, DY WONG (LRL)
GOLDBERG 67 PR 154 1558 H GOLDBERG (UCLA,UCI,UCSD) (GORNELL)

1470 MEV REGION - PRODUCTION EXPERIMENTS

61 N*(1470) PROD. EXP.

IT IS NOT CLEAR THAT THE BUMP SEEN IN PRODUCTION EXPERIMENTS AT LOW INVARIANT MASS CORRESPONDS TO THE P11 RESONANT STATE. DIFFRACTION SCATTERING SEEMS TO BE THE DOMINANT FEATURE IN THIS MASS REGION--SEE GELLERT 66, WALKER 68 AND CLEGG 69 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 A BUMP IN THE PPII MASS PLOT. TAN 68, SHAPIRA 68 SEE A BUMP IN PI P - PRODUCTION OF THIS STATE IN GAMMA-P DR GAMMA-D IS VERY SMALL--SEE ALBERTI 68.

Table with columns: M, (1425-), (1400-), (1430-), (1400-), (1405-), (1410-), (1400-), (1450-), (1420-), (1400-), M S 175(1446-), (11-), M S TAN 68, SHAPIRA 68 ARE ONLY PRODUCTION EXPERIMENT TO SEE PI P DECAY, M S (1390-), (120-), M 120(1443-), (15-). Rows include APPROX, COCCONI, ANKENBRAN, BELLETTIN, ANDERSON, FOLEY, ALMEIDA, BELL, SHAPIRA, SHAPIRA, RHODE.

Table with columns: W, (100-), (100-), (150-), (100-), (100-), (100-). Rows include BELL, SHAPIRA, TAN, RHODE.

Table with columns: R1, N*1/2(1470) INTO (PI P)/TOTAL, (P1)/TOTAL, PRODUC. EXPER., R2, N*1/2(1470) INTO (N*3/2(1236) PI)/TOTAL, PRODUC. EXPER., R3, N*1/2(1470) INTO (GAMMA N)/(PI N), (P5)/(P1). Rows include (0.66), TAN, 68 HBC, PP TO PIP, 6.1, 10/69; LAMSA, 68 HBC, PI-P 8 BEV/C, 11/68; JESPERSEN, 68 HBC, PP 22 BEV/C, 11/68.

REFERENCES --N*1/2(1470)-- PROD. EXP.

Table with columns: COCCONI, ADELMAN, ANKENBRA, BELLETTIN, ANDERSON, BLAIR, GELLERT, FOLEY, ALBERTI, ALMEIDA, BELL, CLEGG, JESPERSE, LAMSA, SHAPIRA, TAN, WALKER, RHODE. Rows include +LILLETHUN, SCANLON, STAHL BRANDT, + (CERN), S L ADELMAN, PRL 14 1043, ANKENBRANDT, CLOYDE, COOK, KEFFE, KERTH, + (LRL), BELLETTINI, COCCONI, OIDDENS + (CERN), +BLESER, COLLINS, FUJII, + (BNL, CARL), +TAYLOR, CHAPMAN, + THARWELL, QUEENMAR, (RHE), +SMITH, VOJCIK, COLTON, SCHLEIN + (LRL, UCLA), +JONES, LINDENBAUM, LOVE, OZAKI + (BNL), +APPEL, BUONITTI, CHEN, DUNNING, GOITEIN + (HARV), +RUSHBROOKE, SCHARENQUIVEL + (CAVE, DESY), +KRENELL, HODGK, KARSHON, LAI + (BNL, CCNY), A B CLEGG, (LANC), JESPERSEN, KANG, KERMAN + (IOWA STATE), +CASON, BISWAS, DERADD, GROVES, + (NOTRE DAME), +BENARY, EISENBERG, RONAT, YAFFE + (RHOD), TAN, PERL, MARTIN, CHINOWSKY + (SACLAY+LRL+UCI), WALKER 68 PRL 20 133 +THOMPSON, ROBERTSON, OH, LEE, HARTUNG, + (WISC), RHODE 69 PR 187 1844, RHODE, LEACOCK, KERMAN, JESPERSEN, + (AMES).

END PRODUCTION EXPERIMENTS

[N(1520)] 62 N*1/2(1520, JP=3/2-) I=1/2 [D13]
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE
PRECEDING N*1/2(1470).

Table with columns: M, (1536-0), (1530-0), (1510-0), (1515-0), (1515-0), (1520-), (1520-), (1520-), (1512-0), (1512-0). Rows include ROPER, BRANSEN, BAREYRE, DAVIES, DONNACH1, DONNACH2, KIRSOPP, DAVIES.

Table with columns: W, (125-0), (110-0), (114-0), (114-), (114-), (106-0), (125-0). Rows include BAREYRE, DAVIES, DONNACH1, DONNACH2, KIRSOPP, DAVIES.

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Table with columns for ID, Nucleus, Decay Mode, and Decay Masses. Includes entries for 62 N*1/2(1520) PARTIAL DECAY MODES.

Table with columns for ID, Nucleus, Branching Ratios, and Decay Masses. Includes entries for 62 N*1/2(1520) BRANCHING RATIOS.

ALMOST THE ENTIRE INELASTICITY IS IN W PI PI (ONLY N ETA COULD COMPETE, AND IT DOESN'T). THE N PI PI SEEMS TO BE MAINLY N*3/2(1236) PI, IN BOTH S AND O WAVES.

Table with columns for ID, Nucleus, Branching Ratios, and Decay Masses. Includes entries for 62 N*1/2(1520) INTO (N*3/2(1236) PI)/TOTAL.

Table with columns for ID, Nucleus, Branching Ratios, and Decay Masses. Includes entries for 62 N*1/2(1520) INTO (N*3/2(1236) PI)/(IN PI PI).

Table with columns for ID, Nucleus, Branching Ratios, and Decay Masses. Includes entries for 62 N*1/2(1520) INTO (N*3/2(1236) PI) / TOTAL.

Table with columns for ID, Nucleus, Branching Ratios, and Decay Masses. Includes entries for 62 N*1/2(1520) INTO (N*3/2(1236) PI) / TOTAL.

REFERENCES -- N*1/2(1520)

SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

Table of references for N*1/2(1520) including authors like BRANDSEN, ROPER, THURNAUE, KIRZ, etc.

PAPERS NOT REFERRED TO IN DATA CARDS.

Table of references for N*1/2(1520) including authors like KIRZ, BAREYRE, CRUICH, etc.

N(1535)

63 N*1/2(1535, JP=1/2-) I=1/2 S'11

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N*1/2(1470).

Table with columns for ID, Nucleus, Mass (MEV), and Decay Masses. Includes entries for 63 N*1/2(1535) MASS (MEV).

Table with columns for ID, Nucleus, Mass (MEV), and Decay Masses. Includes entries for 63 N*1/2(1535) MASS (MEV).

63 N*1/2(1535) WIDTH (MEV)

Table with columns for ID, Nucleus, Width (MEV), and Decay Masses. Includes entries for 63 N*1/2(1535) WIDTH (MEV).

Table with columns for ID, Nucleus, Decay Mode, and Decay Masses. Includes entries for 63 N*1/2(1535) PARTIAL DECAY MODES.

Table with columns for ID, Nucleus, Branching Ratios, and Decay Masses. Includes entries for 63 N*1/2(1535) BRANCHING RATIOS.

Table with columns for ID, Nucleus, Branching Ratios, and Decay Masses. Includes entries for 63 N*1/2(1535) BRANCHING RATIOS.

Table with columns for ID, Nucleus, Branching Ratios, and Decay Masses. Includes entries for 63 N*1/2(1535) BRANCHING RATIOS.

REFERENCES -- N*1/2(1535)

Table of references for N*1/2(1535) including authors like HENDRY, MICHAEL, UCHIYAMA, etc.

PAPERS NOT REFERRED TO IN DATA CARDS.

Table of references for N*1/2(1535) including authors like BRANDSEN, BAREYRE, etc.

THERE IS GETTING TO BE A WHOLE LITERATURE ON THE REACTIONS PI- P TO ETA N AND GAMMA P TO ETA P NEAR THRESHOLD AND THEIR CONNECTION WITH THE BEHAVIOR OF THE S11 AMPLITUDE AS DETERMINED IN PI P PHASE-SHIFT ANALYSIS. THE READER IS INVITED TO PERUSE THE FOLLOWING RATHER INDIGESTIBLE COLLECTION. FURTHER REFERENCES MAY BE FOUND IN THESE.

Table of references for N*1/2(1535) including authors like BULOS, RICHARDS, JONES, etc.

1520 MEV REGION - PRODUCTION EXPERIMENTS

Table with columns for ID, Nucleus, Production Experiments, and Decay Masses. Includes entries for 8 N*1(520) PRODUCTION EXPERIMENTS.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

***** REFERENCES -N*(1520)- PROD. EXP. *****

A-BOPPELL 67 NC 47 232 ALLES-BORELLI,FRENCH,FRISK,MICHELOJA (CERN)
ALEXANDE 67 PR 154 1284 ALEXANDER,BENARY,CZAPEK,+ WEIZMANN(CERN)
BASSOMPI 67 PL 258 440 BASSOMPIERRE,+ (CERN,BRUXELLES)
LEE 67 PR 159 1156 +MOEBS,ROE,SINCLAIR,VANDER VELDE (MICH)

END PRODUCTION EXPERIMENTS

N(1670)

64 N*1/2(1670, JP=5/2-) I=1/2 D15
FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

64 N*1/2(1670) MASS (MEV)

Table with columns for mass measurements, including entries for BRANSDEN, DUKE, BAREYRE, KIRSOPP, DONNACHI, and DAVIES with associated RVUE and analysis types.

64 N*1/2(1670) WIDTH (MEV)

Table with columns for width measurements, including entries for BAREYRE, DONNACHI, KIRSOPP, and DAVIES with associated RVUE and analysis types.

64 N*1/2(1670) PARTIAL DECAY MODES

Table listing partial decay modes for N(1670) into various particles like PI N, N ETA, LAMBDA K, and N PI PI.

64 N*1/2(1670) BRANCHING RATIOS

Table showing branching ratios for N(1670) into (PI N)/TOTAL, (PI2)/TOTAL, (PI3)/TOTAL, and (PI4)/TOTAL.

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

Table showing branching ratios for N(1670) into (N*3/2 PI)/TOTAL, (N*3/2 PI2)/TOTAL, and (N*3/2 PI3)/TOTAL.

SEE NOTE PRECEDING THE N*1/2(1688) INELASTIC DECAY MODE MEASUREMENTS.

REFERENCES -- N*1/2(1670)

BRANSDEN 65 PL 19 420 +DODNELL, 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

PAPER 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)

NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

N(1688)

65 N*1/2(1688, JP=5/2+) I=1/2 F15

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*1/2(1470).

65 N*1/2(1688) MASS (MEV)

Table with columns for mass measurements, including entries for BRANSDEN, DUKE, BAREYRE, KIRSOPP, DONNACHI, and DAVIES with associated RVUE and analysis types.

65 N*1/2(1688) WIDTH (MEV)

Table with columns for width measurements, including entries for BAREYRE, DONNACHI, KIRSOPP, and DAVIES with associated RVUE and analysis types.

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

65 N*1/2(1688) PARTIAL DECAY MODES

Table listing partial decay modes for N(1688) into various particles like PI N, N ETA, LAMBDA K, and N PI PI.

65 N*1/2(1688) BRANCHING RATIOS

Table showing branching ratios for N(1688) into (PI N)/TOTAL, (PI2)/TOTAL, (PI3)/TOTAL, and (PI4)/TOTAL.

MORE INFORMATIONS ON THE INELASTIC DECAY MODES OF THE 1690 MEV
BUMP, AS SEEN IN PRODUCTION EXPERIMENTS, MAY BE FOUND BELOW

Table showing branching ratios for N(1688) into (N*3/2 PI)/TOTAL, (N*3/2 PI2)/TOTAL, and (N*3/2 PI3)/TOTAL.

REFERENCES -- N*1/2(1688)

SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

BRANSDEN 65 PL 19 420 +DODNELL, MOORHOUSE (DURHAM,RTHFD)IJP
HEUSCH 66 PRL 17 1019 C A HEUSCH, C Y PRESCOTT, R F DASHER (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

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,PAOVA,WEIZMANN)
DERADO 65 ATHENS CONF 244 +KENNEY,LAMSA + (NOTRE DAME,KENTUCKY)
MERLO 66 P ROY SOC 289 448 J P MERLO, G VALLADAS (SACLAY)

NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

N(1700)

66 N*1/2(1700, JP=1/2-1) I=1/2
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N*1/2(1470).

S11

Table with columns for mass (MEV), author, and resonance parameters for N*1/2(1700). Includes entries for BRANDSEN, MICHAEL, BAREYRE, etc.

Table with columns for width (MEV), author, and resonance parameters for N*1/2(1700). Includes entries for MICHAEL, BAREYRE, DAVIES, etc.

Table with columns for partial decay modes, author, and decay masses for N*1/2(1700). Includes entries for INTO PI N, INTO N ETA, etc.

Table with columns for branching ratios, author, and resonance parameters for N*1/2(1700). Includes entries for INTO (PI N)/TOTAL, APPROX, etc.

Table with columns for branching ratios, author, and resonance parameters for N*1/2(1700). Includes entries for INTO (LAMBDA K)/(PI N)/TOTAL, etc.

Table with columns for branching ratios, author, and resonance parameters for N*1/2(1700). Includes entries for INTO (LAMBDA K)/(PI N)/TOTAL, APPROX, etc.

Table with columns for branching ratios, author, and resonance parameters for N*1/2(1700). Includes entries for INTO (LAMBDA K)/(PI N)/TOTAL, APPROX, etc.

***** REFERENCES -- N*1/2(1700) *****

BRANDSEN 65 PL 19 420 +DODDNEILL, MOORHOUSE (DURHAM, RTHFD) JIP
MICHAEL 66 PL 21 93 C MICHAEL (OXF)
BAREYRE 68 PR 165 1731 P BAREYRE, C BRICMAN, G VILLET (SACLAY) JIP

PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE 65 PL 18 342 + BRICMAN, STIRLING, VILLET (SACLAY) JIP
JOHNSON 67 UCRL-17683 THESIS C H JOHNSON (LRL)
DEANS 69 PRL 177 2623 S R DEANS (FLORIDA)

***** REFERENCES -- N*1/2(1700) *****

N(1700)

18 N*1/2(1700, JP=3/2-) I=1/2
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N*1/2(1470).

D13

Table with columns for mass (MEV), author, and resonance parameters for N*1/2(1700). Includes entries for KIRSOPP, DONNACHZ, etc.

Table with columns for width (MEV), author, and resonance parameters for N*1/2(1700). Includes entries for KIRSOPP, DONNACHZ, etc.

Table with columns for partial decay modes, author, and decay masses for N*1/2(1700). Includes entries for INTO PI N, etc.

***** REFERENCES -- N*1/2(1700) *****

DONNACHZ 68 VIENNA 139 DONNACHIE RAPPORTEUR.S TALK (GLAS)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)

***** REFERENCES -- N*1/2(1700) *****

1700 MEV REGION - PRODUCTION EXPERIMENTS

20 N*(1700) PRODUCTION EXPERIMENTS

PARTIAL WAVE ANALYSIS REQUIRES AT LEAST FOUR STATES IN THE 1670 TO 1780 REGION (D13, F15, S11, P11). OBVIOUSLY DIFFERENT EXPERIMENTS ARE SEEING DIFFERENT STATES. NO EFFORT WAS MADE TO SEPARATE THESE EXPERIMENTS ACCORDING TO JP, SINCE NONE OF THEM IS FIRMLY ESTABLISHED. WE LIST ALL THE INFORMATION HERE, BUT WE HAVE NOT USED IT IN THE BARYON TABLE.

Table with columns for mass (MEV), author, and resonance parameters for 20 N*(1700) production experiments. Includes entries for A-BORELLI, GALLOWAY, etc.

20 N*(1700) WIDTH (MEV)

Table with columns for width (MEV), author, and resonance parameters for 20 N*(1700) width experiments. Includes entries for A-BORELLI, ALMEIDA, etc.

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

20 N*(1700) BRANCHING RATIOS

Table with columns for branching ratios, author, and resonance parameters for 20 N*(1700) branching ratios. Includes entries for INTO (PI N)/(PI N+PI P), etc.

Table with columns for branching ratios, author, and resonance parameters for 20 N*(1700) branching ratios. Includes entries for INTO (LAMBDA K)/(PI N+PI P), etc.

Table with columns for branching ratios, author, and resonance parameters for 20 N*(1700) branching ratios. Includes entries for INTO (LAMBDA K)/(PI N+PI P), etc.

Table with columns for branching ratios, author, and resonance parameters for 20 N*(1700) branching ratios. Includes entries for INTO (LAMBDA K)/(PI N+PI P), etc.

Table with columns for branching ratios, author, and resonance parameters for 20 N*(1700) branching ratios. Includes entries for INTO (LAMBDA K)/(PI N+PI P), etc.

Table with columns for branching ratios, author, and resonance parameters for 20 N*(1700) branching ratios. Includes entries for INTO (LAMBDA K)/(PI N+PI P), etc.

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

***** REFERENCES -- N* IN PRODUCT EXPERIMENTS *****

KRAEMER 64 PR 136 8496 +MADANSKY, + (J HOPKINS, N WESTERN, WOODSTOCK) I
ALEXANDER 67 PR 154 1284 ALEXANDER, BENARY, CZAPEK, + (WEIZMANN (CERN))
A-BORELLI 67 NC 47 232 ALLES-BORELLI, FRENCH, FRISK, MICHEJDA (CERN)

ALMEIDA 68 PR 174 1638 +RUSHBROOKE, + (CAVNDISH, DESY (CERN))
CHINDOSK 68 PR 165 1466 CHINDOSKY, KINSEY, KLEIN, + (LRL, SLAC)
KAYAS 68 NP 85 169 +GUYADER, SENE, YIOU, ALITTI, + (ORSAY, SACLAY)

PAPERS NOT REFERRED TO IN DATA CARDS

MERLO 66 P ROY SOC 289 489 J P MERLO, G VALLADA (SACLAY)

***** REFERENCES -- N* IN PRODUCT EXPERIMENTS *****

END PRODUCTION EXPERIMENTS

***** REFERENCES -- N* IN PRODUCT EXPERIMENTS *****

N(1780)

14 N*1/2(1780, JP=1/2+) I=1/2
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N*1/2(1470).

P11

Table with columns for mass (MEV), author, and resonance parameters for N*1/2(1780). Includes entries for DONNACHZ, KIRSOPP, etc.

Table with columns for width (MEV), author, and resonance parameters for N*1/2(1780). Includes entries for DONNACHZ, KIRSOPP, etc.

Table with columns for partial decay modes, author, and decay masses for N*1/2(1780). Includes entries for INTO PI N, etc.

***** REFERENCES -- N*1/2(1780) *****

DONNACHZ 68 VIENNA 139 DONNACHIE RAPPORTEUR.S TALK (GLAS)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)

***** REFERENCES -- N*1/2(1780) *****

BARYONS

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

REFERENCES -- N*1/2(1780)

Table listing references for N(1860) with columns for mass (M), width (W), and various decay modes and branching ratios.

PAPERS NOT REFERRED TO IN DATA CARDS
DEANS 69 PRL 177 2623 S R DEANS (FLORIDA)
DONNACHI 69 NP 108 433 A DONNACHIE, R G KIRSOPP (GLAS+EDIN)
AYED 70 PL 318 598 +BAREYRE-VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

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Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1860).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

PAPERS NOT REFERRED TO IN DATA CARDS
DEANS 69 PRL 177 2623 S R DEANS (FLORIDA)
DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 PL 318 598 +BAREYRE-VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N*1/2(1470).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

REFERENCES -- N*1/2(1780)

Table listing references for N(1990) with columns for mass (M), width (W), and various decay modes and branching ratios.

PAPERS NOT REFERRED TO IN DATA CARDS
DEANS 69 PRL 177 2623 S R DEANS (FLORIDA)
DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 PL 318 598 +BAREYRE-VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

Table with columns for mass (M), width (W), and various decay modes and branching ratios for N(1990).

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

PAPERS NOT REFERRED TO IN DATA CARDS

DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 PL 318 598 +BARREYRE,VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

N(2190)

G17

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE PRECEDING N*1/2(1470).

71 N*1/2(2190) MASS (MEV)

Table with columns M, (2190.0), DIDDENS 63 CNTR, PI+- P TOTAL, HOHLER 64 RVUE, DATA + DISP REL, YOKOSAWA 66 CNTR, PI- P DSIG + PDL, DONNACHI 68 RVUE, PHASE-SHIFT ANAL, DONNACH2 68 RVUE, PHAS.SHIFT-CERN1, KIRSOPP 68 RVUE, PHASE SHIF ANAL, KIRSOPP 68 RVUE, PHASE SHIF ANAL, LEA 69 CNTR, PI-P ELASTIC.

71 N*1/2(2190) WIDTH (MEV)

Table with columns W, (200.0), DIDDENS 63 CNTR, HOHLER 64 RVUE, YOKOSAWA 66 CNTR, DONNACHI 68 RVUE, DONNACH2 68 RVUE, KIRSOPP 68 RVUE, LEA 69 CNTR.

SEE THE NOTES ACCOMPANYING THE MASSES QUOTED. P EY

71 N*1/2(2190) PARTIAL DECAY MODES

Table with columns P1, N*1/2(2190) INTO PI N, 139+ 938, P2, N*1/2(2190) INTO LAMBDA K, 1115+ 497, P3, N*1/2(2190) INTO N PI PI, 938+ 139+ 139.

71 N*1/2(2190) BRANCHING RATIOS

Table with columns R1, N*1/2(2190) INTO (PI N)/TOTAL, (PI1)/TOTAL, R1 ONLY (J+1/2)*(PI N/TOTAL) MEASURED FOR THIS STATE, R1 0, (0.33) APPROX, DIDDENS 63 CNTR, YOKOSAWA 66 CNTR, DONNACHI 68 RVUE, DONNACH2 68 RVUE, KIRSOPP 68 RVUE.

REFERENCES -- N*1/2(2190)

DIDDENS 63 PRL 10 262 +JENKINS, KYCIA, RILEY (BNL) I
HOHLER 64 PL 12 149 G HOHLER, J GIESECKE (KARLSRUHE) I
YOKOSAWA 66 PRL 16 174 +SUNA,HILL,ESTERLING, BOOTH (ARG,CHI) JP
DONNACHI 68 PL 260 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)JP
DONNACH2 68 VIENNA 139 DONNACHIE RAPPORTEUR.S TALK (GLAS)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
LEA 69 PL 298 584 LEA,DADES,WARD,COWAN,+ (RHEL,BRISTOL,DARE)

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN DATA CARDS.

CARRGLL 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 (MISC) P
BUSZA 67 NC 52A 331 +DAVIS,DUFF,HEYMAN,+ (UNICOL,WESTFIELD)

PAPERS NOT REFERRED TO IN DATA CARDS

AYED 70 PL 318 598 +BARREYRE,VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

M > 2200 MEV - PRODUCTION AND TOTAL EXPERIMENTS

N(2650)

72 N*1/2(2650, JP= -) I=1/2

72 N*1/2(2650) MASS (MEV)

Table with columns M, (2700.0), ALVAREZ 64 CNTR, PI PHOTOPROD, WAHLIG 64 DSPK 0, PI-P CH EX, HOHLER 64 RVUE, DATA + DISP REL, CITRON 66 CNTR, PI+- P TOTAL, BARGER 66 FIT, TOTAL + CH EX.

72 N*1/2(2650) WIDTH (MEV)

Table with columns W, (100.0), ALVAREZ 64 CNTR, HOHLER 64 RVUE, CITRON 66 CNTR, BARGER 66 FIT, TOTAL + CH EX.

72 N*1/2(2650) PARTIAL DECAY MODES

Table with columns P1, N*1/2(2650) INTO PI N, 139+ 938, P2, N*1/2(2650) INTO LAMBDA K, 1115+ 497, P3, N*1/2(2650) INTO N PI PI, 938+ 139+ 139.

72 N*1/2(2650) BRANCHING RATIOS

Table with columns R1, N*1/2(2650) INTO (PI N)/TOTAL, (IPI)/TOTAL, R1 ONLY (J+1/2)*(PI N/TOTAL) MEASURED FOR THIS STATE, CITRON 66 CNTR, TOTAL CROSS-SEC., BARGER 66 RVUE, TOTAL + CH EX., BARGER 67 RVUE, USES KORMANYOS67, BARGER 67 RVUE, USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREE, BARGER 67 RVUE, USES KORMANYOS67, BARGER 67 RVUE, USES KORMANYOS67, BARGER 67 RVUE, USES KORMANYOS67, BARGER 67 RVUE, USES KORMANYOS67.

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 (MISC) P
BARGER 67 PR 155 1792 V BARGER, D CLINE (MISC) P
DIKMEN 67 PRL 18 798 F N DIKMEN (MICH)
KORMANYO 67 PR 164 1661 KORMANYOS, KRISCH, OFALLON,+ (MICH,ARG) P
DOLEN 68 PR 166 1768 R DOLEN, D HORN, C SCHMID (CAL TECH)

PAPER NOT REFERRED TO IN DATA CARDS.

BAACKE 67 NC 51A 761 J BAACKE, M VVERT (KARLSRUHE,ORSAY)J-L
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.

N(3030)

73 N*1/2(3030, JP=) I=1/2

73 N*1/2(3030) MASS (MEV)

Table with columns M, (3080.0), HOHLER 64 RVUE, DATA + DISP REL, CITRON 66 CNTR, PI+- P TOTAL.

73 N*1/2(3030) WIDTH (MEV)

Table with columns W, (400.0), CITRON 66 CNTR.

73 N*1/2(3030) PARTIAL DECAY MODES

Table with columns P1, N*1/2(3030) INTO PI N, 139+ 938, P2, N*1/2(3030) INTO N PI PI, 938+ 139+ 139.

73 N*1/2(3030) BRANCHING RATIOS

Table with columns R1, N*1/2(3030) INTO (PI N)/TOTAL, (PI1)/TOTAL, R1 ONLY (J+1/2)*(PI N/TOTAL) MEASURED FOR THIS STATE, CITRON 66 CNTR, TOTAL CROSS-SEC., BARGER 66 RVUE, TOTAL + CH EX., BARGER 67 CNTR, USES KORMANYOS66, BARGER 67 CNTR, USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREE, BARGER 67 CNTR, USES KORMANYOS67, BARGER 67 RVUE, USES KORMANYOS67, BARGER 67 RVUE, USES KORMANYOS67.

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 (MISC) P
DIKMEN 67 PR 155 1792 V BARGER, D CLINE (MISC) P
KORMANYO 67 PR 164 1661 KORMANYOS, KRISCH, OFALLON,+ (MICH,ARG) P
DOLEN 68 PR 166 1768 R DOLEN, D HORN, C SCHMID (CAL TECH)

N2(3245)

74 N* (3245, JP= +)

EXISTENCE NOT CONCLUSIVELY ESTABLISHED. I-SPIN NOT DETERMINED, BUT THE NARROW WIDTH INCLUDES IDENTIFICATION WITH THE N*3/2(3230). OMITTED FROM TABLE.

74 N* /2(3245) MASS (MEV)

Table with columns M, 3245.0, 10.0, KORMANYOS 67 CNTR, PI-P 180 DEG EL.

74 N* /2(3245) WIDTH (MEV)

Table with columns W, (35.0), OR LESS, KORMANYOS 67 CNTR.

74 N* /2(3245) PARTIAL DECAY MODES

Table with columns P1, N* /2(3245) INTO PI N, 139+ 938.

74 N* /2(3245) BRANCHING RATIOS

Table with columns R1, J IS NOT KNOWN. FOLLOWING IS (J+1/2)*(PI N)/TOTAL, KORMANYOS 67 CNTR.

REFERENCES -- N* /2(3245)

KORMANYO 67 PR 164 1661 KORMANYOS, KRISCH, OFALLON,+ (MICH,ARG) P

N(3690)

75 N*1/2(3690, JP=) I=1/2

A BUMP SEEN IN THE INVARIANT MASS OF A VERY COMPLICATED STATE (N * SEVEN PIS), SO AS EVIDENCE FOR A NEW RESONANCE IT IS NOT CONCLUSIVE. NOT INCLUDED IN TABLE.

75 N*1/2(3690) MASS (MEV)

Table with columns M, 3690.0, 10.0, BARTKE 67 HBC + PI+P 8 PRONGS.

75 N*1/2(3690) WIDTH (MEV)

Table with columns W, 50.0, 30.0, BARTKE 67 HBC +.

75 N*1/2(3690) PARTIAL DECAY MODES

Table with columns P1, N*1/2(3690) INTO N + 7 PIS, 2250.

REFERENCES -- N*1/2(3690)

BARTKE 67 PL 248 118 +CZYVIEWSKI,DANYSZ,+ (CRACOV,ORSAY) I

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Np (3755) 76 N* /2(3755, JP=)
A SMALL PEAK IN THE (P P PBAR) INVARIANT MASS FROM
0.4 BEV/C PI+ P TO PI+ 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 PLAND, J B WHITTAKER (RUTGERS)

END PRODUCTION EXPERIMENTS

A(1236) 33 N*3/2(1236, JP=3/2+) I=3/2 P'33
33 N*3/2(1236) MASS (MEV)
M (1234.) ROPER 65 DPWA O++ PHASE SHIFT AN.
33 N*3/2(1236) WIDTH (MEV)
W (120.) ROPER 65 DPWA O++ PHASE SHIFT AN.
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+2000+ 139
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

REFERENCES -- N*3/2(1236)
ROPER 65 PR 138 8190 L D ROPER, R M WRIGHT, B T FELD (LRL+MIT)JIP
FOR EXTENSIVE REFERENCES TO DATA AND PHASE-SHIFT ANALYSES TILL 1965,
SEE ROPER 65, ESPECIALLY APPENDIX II.

A(1236) PRODUCTION EXPERIMENTS
81 N*3/2(1236) MASS (MEV)
M++ 1236.0 0.55 OLSSON 65 RVUE ++ TOTAL-SIGMA DATA
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(INN) PI
M++ (1235.0) DEANS 66 RVUE ++ PI+P TOTAL
M++ (1224.0) (2.0) HABER 70 DBC K-D TO 4 BOD(P)
MO 1236.45 0.65 OLSSON 65 RVUE 0
M- (1241.3) (5.1) GIDAL 66 DBC - 7/66
7/70*
81 N*(0) - N*(++) MASS DIFFERENCE (MEV)
D R (0.45) (0.85) OLSSON 65 RVUE
D R REDUNDANT WITH DATA IN MASS LISTING.
81 N*(-) - N*(++) MASS DIFFERENCE (MEV)
D 7.9 6.8 GIDAL 66 DBC
81 N*3/2(1236) WIDTH (MEV)
M++ 120.0 2.0 OLSSON 65 RVUE ++
M++ (125.0) (30.0) FERRO-LUZ 65 HBC ++
M++ (124.0) (14.0) GIDAL 66 DBC ++
M++ (121.0) DEANS 66 RVUE ++
M++ (120.0) (8.0) HABER 70 DBC K-D TO 4 BOD(P)
MO 119.6 2.4 OLSSON 65 RVUE 0
M- (149.0) (19.0) GIDAL 66 DBC - 7/66

REFERENCES -- N*3/2(1236) PROD. EXPERIMENTS
OLSSON 65 PRL 14 118 M G OLSSON (WISC)
FERRO-LU 65 NC 36 1101 FERRO-LUZZI, GEORGE, + (CERN)
DALITZ 66 PR 146 1180 DALITZ, SUTHERLAND (OXFORD)
DEANS 66 PREPRINT S R DEANS, W G HOLLADAY (VANDERBILT)
GIDAL 66 PR 141 1261 G GIDAL, A KERMAN, S KEM (LRL)
HABER 70 NP 178 289 +SHAPIRA, MERRILL, MONARI++ (SABRE COLL)

A(1650) 82 N*3/2(1650, JP=1/2-) I=3/2 S31
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE
PRECEDING N*1/2(1470).
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 2 (1650.0) 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 68 RVUE P-S ANAL SOL A 8/69
M 5 (1623.0) DAVIES 68 RVUE P-S ANAL SOL B 8/69
M 5 SOL B IS E_0 FIT TO SAME DATA START FROM CERN I EXPER. (DONNACHI 68)
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 5/68
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 68 RVUE P-S ANAL SOL A 8/69
W 5 (140.0) DAVIES 68 RVUE P-S ANAL SOL B 8/69
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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
82 N*3/2(1650) BRANCHING RATIOS
R1 N*3/2(1650) INTO (PI N)/TOTAL (P1)/TOTAL
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 68 RVUE P-S ANAL SOL A 8/69
R1 5 (0.25) DAVIES 68 RVUE P-S ANAL SOL B 8/69

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)JIP
DONNACHI 68 PL 268 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)I
DONNACH2 68 VIENNA 139 DONNACHIE RAPORTEUR.S TALK (GLAS)
DAVIES 68 VIENNA CONF. A DAVIES+R MCCRHOUSE (GLAS)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
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 66 PR 134 81062 +DEVLIN, HAGGE+LONGO, MOYER, WOOD (LRL) I
BAREYRE 65 PL 18 342 + BRICMAN, STIRLING, VILLET (SACLAY)JIP
JOHNSON 67 UCL-17683 THESIS C H JOHNSON (LRL)
DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 PL 318 598 +BAREYRE, VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1
BOWLER 70 NP 178 331 +CASHMORE (U. OXFORD)

A(1670) 10 N*3/2(1670, JP=3/2-) I=3/2 D33
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE
PRECEDING N*1/2(1470).
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 68 RVUE P-S ANAL SOL A 8/69
M 5 (1650.0) DAVIES 68 RVUE P-S ANAL SOL B 8/69
M 5 SOL B IS E_0 FIT TO SAME DATA START FROM CERN I EXPER. (DONNACHI 68)
10 N*3/2(1670) WIDTH (MEV)
W 3 (269.0) DONNACHI 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 68 RVUE SOL A 8/69
W 5 (174.0) DAVIES 68 RVUE SOL B 8/69
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
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
10 N*3/2(1670) BRANCHING RATIOS
R1 N*3/2(1670) INTO (PI N)/TOTAL (P1)/TOTAL
R1 3 (0.14) DONNACHI 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 68 RVUE SOL A 8/69
R1 5 (0.13) DAVIES 68 RVUE SOL B 8/69
R2 N*3/2(1670) INTO (K SIGMA)/TOTAL (P3)/TOTAL
R2 1 LESS THAN 0.0002 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.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

REFERENCES -- N*3/2(1670)

DAVIES 68 VIENNA CONF. A DAVIES, R MOORHOUSE (GLAS)
DONNACHI 68 PL 268 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (ICERN)JIP
DONNACH2 68 VIENNA 139 DONNACHIE RAPPOURTEUR.S TALK (GLAS)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
FEUERBAC 70 NP 168 85 FEUERBACHER+HOLLADAY (VANDERBILT)

PAPERS NOT REFERRED TO IN DATA CARDS

DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 PL 318 598 +BAREYRE,VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1
BOWLER 70 NP 178 331 +CASHMORE (U. OXFORD)

Delta(1690)

F33

19 N*3/2(1690,JP=3/2+) I=3/2
FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE PRECEDING N*1/2(1470).

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
3 WHERE MAX. ABSORPTION IS --DONNACHI, 2 ,KIRSOPP EYEBALL FIT CERN 1 10/69

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

19 N*3/2(1690) PARTIAL DECAY MODES
P1 N*3/2(1690) INTO PI N DECAY MASSES 139+ 938
P2 N*3/2(1690) INTO K SIGMA 493+1189

19 N*3/2(1690) BRANCHING RATIOS
R1 N*3/2(1690) INTO (PI N)/TOTAL (P1)/TOTAL
R1 3 (.101) DONNACH2 68 RVUE PHAS.SHIFT-CERN1 10/69
R1 3 (.08) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69

R2 N*3/2(1690) INTO (K SIGMA)/TOTAL (P2)/TOTAL
R2 1 LESS THAN 0.0002 FEUERBACH TO RVUE PI P TO K+ SIG+ 7/70+
1 ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
1 MODEL USED MAY DOUBLE COUNT.

REFERENCES -- N*3/2(1690)

DONNACH2 68 VIENNA 139 DONNACHIE RAPPOURTEUR.S TALK (GLAS)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
FEUERBAC 70 NP 168 85 FEUERBACHER+HOLLADAY (VANDERBILT)

PAPERS NOT REFERRED TO IN DATA CARDS

AYED 70 PL 318 598 +BAREYRE,VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1
BOWLER 70 NP 178 331 +CASHMORE (U. OXFORD)

Delta(1890)

F35

11 N*3/2(1890,JP=5/2+) I=3/2
FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE PRECEDING N*1/2(1470).

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
3 WHERE MAX. ABSORPTION IS --DONNACHI, 2 ,KIRSOPP EYEBALL FIT CERN 1 10/69
M 4 (1841.0) DAVIES 68 RVUE P-S ANAL SOL A 8/69
M 5 (1852.0) DAVIES 68 RVUE P-S ANAL SOL B 8/69
5 SOL B IS E-D FIT TO SAME DATA START FROM CERN 1 EXPER. (DONNACHI 68)

11 N*3/2(1890) WIDTH (MEV)
W 3 (350.0) DONNACH1 68 RVUE
W 3 (350.1) DONNACH2 68 RVUE PHAS.SHIFT-CERN1 10/69
W 3 (380.) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
W 4 (136.0) DAVIES 68 RVUE SOL A 8/69
W 5 (150.0) DAVIES 68 RVUE SOL B 8/69
SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)

11 N*3/2(1890) PARTIAL DECAY MODES
P1 N*3/2(1890) INTO PI N DECAY MASSES 139+ 938
P2 N*3/2(1890) INTO N PI PI 938+ 139+ 139
P3 N*3/2(1890) INTO K SIGMA 493+1189

11 N*3/2(1890) BRANCHING RATIOS
R1 N*3/2(1890) INTO (PI N)/TOTAL (P1)/TOTAL
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 68 RVUE SOL A 8/69
R1 5 (0.19) DAVIES 68 RVUE SOL B 8/69

R2 N*3/2(1890) INTO (K SIGMA)/TOTAL (P3)/TOTAL
R2 1 LESS THAN 0.008 FEUERBACH TO RVUE PI P TO K+ SIG+ 7/70+
1 ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
1 MODEL USED MAY DOUBLE COUNT.

REFERENCES -- N*3/2(1890)

DAVIES 68 VIENNA CONF. A DAVIES, R MOORHOUSE (GLAS)
DONNACHI 68 PL 268 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (ICERN)JIP
DONNACH2 68 VIENNA 139 DONNACHIE RAPPOURTEUR.S TALK (GLAS)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
FEUERBAC 70 NP 168 85 FEUERBACHER+HOLLADAY (VANDERBILT)

PAPERS NOT REFERRED TO IN DATA CARDS

AYED 70 PL 318 598 +BAREYRE,VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

Delta(1910)

P31

12 N*3/2(1910,JP=1/2+) I=3/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE PRECEDING N*1/2(1470).

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
3 WHERE MAX. ABSORPTION IS --DONNACHI, 2 ,KIRSOPP EYEBALL FIT CERN 1 10/69
M 4 (1914.0) DAVIES 68 RVUE P-S ANAL SOL A 8/69
M 5 (1834.0) DAVIES 68 RVUE P-S ANAL SOL B 8/69
5 SOL B IS E-D FIT TO SAME DATA START FROM CERN 1 EXPER. (DONNACHI 68)

12 N*3/2(1910) WIDTH (MEV)
W 3 (339.0) DONNACH1 68 RVUE 8/69
W 3 (339.1) DONNACH2 68 RVUE PHAS.SHIFT-CERN1 10/69
W 3 (425.1) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
W 4 (290.1) DAVIES 68 RVUE SOL A 8/69
W 5 (231.0) DAVIES 68 RVUE SOL B 8/69
SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)

12 N*3/2(1910) PARTIAL DECAY MODES
P1 N*3/2(1910) INTO PI N DECAY MASSES 139+ 938
P2 N*3/2(1910) INTO N PI PI 938+ 139+ 139
P3 N*3/2(1910) INTO K SIGMA 493+1189

12 N*3/2(1910) BRANCHING RATIOS
R1 N*3/2(1910) INTO (PI N)/TOTAL (P1)/TOTAL
R1 3 (0.30) DONNACH1 68 RVUE 8/69
R1 3 (1.30) DONNACH2 68 RVUE PHAS.SHIFT-CERN1 10/69
R1 3 (1.25) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
R1 4 (0.18) DAVIES 68 RVUE SOL A 8/69
R1 5 (0.24) DAVIES 68 RVUE SOL B 8/69

R2 N*3/2(1910) INTO (K SIGMA)/TOTAL (P3)/TOTAL
R2 1 LESS THAN 0.008 FEUERBACH TO RVUE PI P TO K+ SIG+ 7/70+
1 ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
1 MODEL USED MAY DOUBLE COUNT.

REFERENCES -- N*3/2(1910)

DAVIES 68 VIENNA CONF. A DAVIES, R MOORHOUSE (GLAS)
DONNACHI 68 PL 268 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (ICERN)JIP
DONNACH2 68 VIENNA 139 DONNACHIE RAPPOURTEUR.S TALK (GLAS)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
FEUERBAC 70 NP 168 85 FEUERBACHER+HOLLADAY (VANDERBILT)

PAPERS NOT REFERRED TO IN DATA CARDS

CARYANN 65 PR 138 8433 CARAYANNOPOULOS,TAUFEST,WILLMANN (PURD)
A PARTIAL WAVE ANALYSIS OF PI+P TO SIGMA+ K+ (SACLAY)
AYED 70 PL 318 598 +BAREYRE,VILLET (SACLAY)
NEW ANALYSIS--RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

Delta(1950)

F37

83 N*3/2(1950,JP=7/2+) I=3/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE PRECEDING N*1/2(1470).

83 N*3/2(1950) MASS (MEV)
M 3 (1920.0) DUKE 65 CNTR PI-P EL + POL 6/68
M 3 (1950.0) APPROX YOKOSAWA 66 CNTR PI- P DSIG + POL 7/66
M 1 (1975.0) BAREYRE 68 RVUE PHASE-SHIFT ANAL 11/67
2 IS GREATEST - EYEBALL FIT
M 2 (1980.0) BAREYRE 68 RVUE PHASE-SHIFT ANAL 11/67
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 (1946.1) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
3 WHERE MAX. ABSORPTION IS --DONNACHI, 2 ,KIRSOPP EYEBALL FIT CERN 1 10/69
M 4 (1935.0) DAVIES 68 RVUE P-S ANAL SOL A 8/69
M 5 (1935.0) DAVIES 68 RVUE P-S ANAL SOL B 8/69
5 SOL B IS A FIT TO DONNACHIE 68 SOLUTION

83 N*3/2(1950) WIDTH (MEV)
W 3 (170.0) DUKE 65 CNTR 7/66
W 3 (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 68 RVUE SOL A 8/69
W 5 (212.0) DAVIES 68 RVUE SOL B 8/69
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

83 N*3/2(1950) PARTIAL DECAY MODES
P1 N*3/2(1950) INTO PI N DECAY MASSES 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

83 N*3/2(1950) BRANCHING RATIOS
R1 N*3/2(1950) INTO (PI N)/TOTAL (P1)/TOTAL
R1 1 (0.41) DUKE 65 CNTR 7/66
R1 1 (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

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

R: 3 (.39) DONNACH2 68 RVUE PHAS.SHIFT-CERNI 10/69
R: 3 (.39) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
R: 4 (0.51) DAVIES 68 RVUE SOL A 8/69
R: 5 (0.31) DAVIES 68 RVUE SOL B 8/69
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
R: N*3/2(1950) INTO (SIGMA K)(PI N)/TOTAL**2 (P2*PI1)/TOTAL**2
R: SEEN BORREANI 68 HBC PI+P 1.35-1.68 10/69
R: 1 (0.004) (0.008) FEUERBACH 70 RVUE PI P TO K+ SIG+ 7/70*
1 ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
1 MODEL USED MAY DOUBLE COUNT.
R: N*3/2(1950) INTO (D(1236) PI)*(PI N)/TOTAL**2 (P3*PI1)/TOTAL**2
R: 0.23 0.04 FUNG 68 HBC ++ PI+P TO PI+PI0 P 11/68

MORE INFORMATIONS ON INELASTIC DECAY MODES OF RUMPS, SEEN IN PRODUCTION EXPERIMENTS AROUND 1950 MEV, MAY BE FOUND IN THE NEXT ENTRY

REFERENCES -- N*3/2(1950)

DUKE 65 PRL 15 468 +JONES,KEMP,MURPHY,PRENTICE, + (RTHFD,DXFI)JP
YKOSAWA 66 PRL 16 714 +SUWA, HILL, ESTERLING, BOUTH (ARG,CHI)JP
BAREYRE 68 PR 165 1731 P BAREYRE, C BRICMAN, G VILLET (SACLAY)JP
BORREANI 68 UCRL 18350 BORREANI, KALMUS (LRL)
DAVIES 68 VIENNA CONF. A DAVIES, R MDRHOUSE (GLAS)
DONNACHI 68 PL 268 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)JP
DONNACH2 68 VIENNA 139 DONNACHIE RAPPORTEUR-S TALK (GLAS)
FUNG 68 VIENNA CONF. FUNG, KERMAN, KALMUS, BIRGE (RIVERSIDE, LRL)
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
FEUERBAC 70 NP 168 85 FEUERBACHER+HOLLADAY (VANDERBILT)

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 (IMPCOLI)JP
HOHLER 64 PL 12 149 G HOHLER, J GIESECKE (KARLSRUHE) I
HELLAND 64 PR 134 81062 +DEVLIN,HAGGE, LONGO, MOYER, WOOD (LRL) IJ
HOLLADAY 65 PR 139 81348 W G HOLLADAY (VANDERBILT)
JOHNSON 67 UCRL-17683 THESIS C H JOHNSON (LRL)
DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)
AYED 70 PL 318 598 +BAREYRE+WILLET (SACLAY)

NEW ANALYSIS-RESONANCE PARAMETERS NOT YET AVAILABLE. SEE FIG 3 + TABLE 1

Delta(1960) 13 N*3/2(1960, JP=5/2-) I=3/2 D35
FOR DISCUSSION CONCERNING RESONANT PARAMETERS, SEE NOTE PRECEDING N*1/2(1470).

13 N*3/2(1960) MASS (MEV)

M 3 (1954.0) DONNACHI 68 RVUE PHASE-SHIFT ANAL 6/68
M 3 (1970.) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69
M 3 (1950.0) APPROX LEA 69 CNTR PI-P ELASTIC 8/69
WHERE MAX. ABSORPTION IS -DONNACHI, 2, KIRSOPP EYEBALL FIT CERN 1 10/69

13 N*3/2(1960) WIDTH (MEV)

W 3 (311.00) DONNACHI 68 RVUE 8/69
W 3 (400.) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69

13 N*3/2(1960) PARTIAL DECAY MODES

P1 N*3/2(1960) INTO PI N DECAY MASSES 139+ 938
P2 N*3/2(1960) INTO K SIGMA 493+1189

13 N*3/2(1960) BRANCHING RATIOS

R1 N*3/2(1960) INTO (PI N)/TOTAL (P1)/TOTAL
R1 3 (.154) DONNACHI 68 RVUE PHASE SHIFT ANA. 10/69
R1 3 (.12) KIRSOPP 68 RVUE PHASE SHIFT ANAL 10/69

R2 N*3/2(1960) INTO (K SIGMA)/TOTAL (P2)/TOTAL
R2 1 (0.013) (0.01) FEUERBACH 70 RVUE PI P TO K+ SIG+ 7/70*
1 ASSUME MASS, WIDTH, X(ELAST) OF DONNACHIE 68
1 MODEL USED MAY DOUBLE COUNT.

REFERENCES -- N*3/2(1960)

DONNACHI 68 PL 268 161 A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)JP
KIRSOPP 68 THESIS R G KIRSOPP (EDIN)
LEA 69 PL 298 584 LEA, DADES+WARD, COWAN, + (RHEL, BRISTOL, DAR)
FEUERBAC 70 NP 168 85 FEUERBACHER+HOLLADAY (VANDERBILT)

PAPERS NOT REFERRED TO IN DATA CARDS

DONNACHI 69 NP 108 433 A DONNACHIE, R KIRSOPP (GLAS+EDIN)

1950 MEV REGION - PRODUCTION AND sigma TOTAL EXPERIMENTS

70 N* (1950) PROD. EXP.

M (1922.0) APPROX COOL 56 CNTR PI+ P TOTAL 7/66
M (1912.0) (15.0) BRISSON 61 CNTR PI+ P TOTAL 7/66
M (1900.0) (9.0) DEVLIN 65 CNTR PI+ P TOTAL
M (2089.0) (12.0) YOON 67 HBC + 3 BEV/C PI-P 8/67
N THIS BUMP IS NOT SEEN BY CHUNG 68 AT 3.2 BEV/C

70 N* (1950) WIDTH (MEV)

W (256.0) (139.0) DEVLIN 65 CNTR
W 40.0 20.0 YOON 67 HBC + 8/67

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 3P1) N 11/68
R3 SEEN BOGGILD 70 HBC PP TO N3PI(INTRL) 6/70*
R4 N* (1950) INTO (PI N)/(N*3/2(1236) PI) PROD. EXP.
R4 LESS THAN 0.55 LEE 67 HBC PI-P 3.63 BEV/C 11/67
R5 N* (1950) INTO ((PI N)+(NEUTRON PI+ PI+1)/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 3P1) N 11/68
THIS INCLUDES CORRECTION FOR UNSEEN DECAY (1/SPIN FACTOR 5/3).

COOL 56 PR 103 1082 R COOL, D PICCIONI, D CLARK (BNL) I
BRISSON 61 NC 19 210 +DETOUF, 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 +MOERS, ROE, SINCLAIR, VANDER VELDE (MICH)
YOON 67 PL 248 307 +BERENYI, KEV, 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 268 334 K F GALLOWAY (INDIANA) I
BOGGILD 70 NP B16 503 +KOREA-AHO+JACOBSEN+ (COP+HELS+OSLO+STOCK)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

P1 0 (0.163) DIKMEN 67 FIT ASSUMING J=11/2 11/67
0 USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1 (0.06) KORMANYOS 67 CNTR ASSUMING J=11/2 11/67

P2 N*3/2(2420) INTO (PI N)/(NEUTRON PI+P)/(TOTAL**2) (PI**4)/(TOTAL**2)
R2 0.0195 0.0048 GALLOWAY 68 RVUE 6/68

REFERENCES -- N*3/2(2420)

DIOBENS 63 PRL 10 262 +JENKINS, KYCIA, RILEY (BNL) I
ALVAPEZ 64 PRL 12 710 +BAR-YAM, KERN, LUCKEY, OSBORNE, + (MIT, ICSA)
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) P

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
DOLEN 68 PR 166 1768 R DOLEN, D HORN, C SCHMID (CAL TECH)
GALLOWAY 68 PL 268 334 K F GALLOWAY (INDIANA) I

PAPERS NOT REFERRED TO IN DATA CARDS.

DOBROWOL 67 PL 248 203 DOBROWOLSKI, GUSKOV, LIKHACHEV, + (DUBNA) P
BELLAMY 67 PRL 19 476 +BUCKLEY, DOBSON, + (WESTFIELD, UNICOL) JP
BAACKE 67 NC 51A 761 J BAACKE, M YVERT (KARLSRUHE, ORSAY) J-L
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.

Delta(2850) 85 N*3/2(2850, JP= +) I=3/2
85 N*3/2(2850) MASS (MEV)

M (2700.0) APPROX WAHLIG 64 GSPK 0 PI-P CH EX 6/70*
M (2870.0) HOHLER 64 RVUE DATA + DISP REL 7/70*
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

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

85 N*3/2(2850) PARTIAL DECAY MODES

P1 N*3/2(2850) INTO PI N DECAY MASSES 139+ 938
P2 N*3/2(2850) INTO P PI PI 938+ 139+ 139
P3 N*3/2(2850) INTO N PI PI 938+ 139+ 139

85 N*3/2(2850) BRANCHING RATIOS

R1 N*3/2(2850) INTO (PI N)/TOTAL (PI)/TOTAL
R1 ONLY (J+1/2)^(PI N)/TOTAL MEASURED FOR THIS STATE
P1 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 KORMANYOS 66 11/67
B USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREE
B FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1 D (0.49) DIKMEN 67 RVUE USES KORMANYOS 67 11/67
D USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1 (0.39) DOBROWOLSKI 67 CNTR PI+P AT 180 DEG. 11/67
R1 (0.39) DOBROWOLSKI 67 CNTR PI+P AT 180 DEG.

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-DZINOWSKA, DANYSZ, + (WARSAW)
BARGER 66 PR 151 1123 V BARGER, M OLSSON (WISC) P

BARGER 67 PR 155 1792 V BARGER, D CLINE (WISC) P
DIKMEN 67 PRL 18 798 F N DIKMEN (MICH)
DOBROWOL 67 PL 248 203 DOBROWOLSKI, GUSKOV, LIKHACHEV, + (DUBNA) P
KORMANYO 67 PR 164 1661 KORMANYOS, KRISCH, OFALLON, + (MICH, ARG) P
DOLEN 68 PR 166 1768 R DOLEN, D HORN, C SCHMID (CAL TECH)

PAPERS NOT REFERRED TO IN DATA CARDS.

BAACKE 67 NC 51A 761 J BAACKE, M YVERT (KARLSRUHE, ORSAY) J-L
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.

Delta(3230) 86 N*3/2(3230, JP=) I=3/2
86 N*3/2(3230) MASS (MEV)

M (3230.0) CITRON 66 CNTR PI+ P TOTAL 7/66

86 N*3/2(3230) WIDTH (MEV)
W (440.0) CITRON 66 CNTR 7/66

86 N*3/2(3230) PARTIAL DECAY MODES

P1 N*3/2(3230) INTO PI N DECAY MASSES 139+ 938
P2 N*3/2(3230) INTO N PI PI 938+ 139+ 139

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 CROSS-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 KORMANYOS 66 11/67
R1 B USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREE
R1 B FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1 D (0.25) DIKMEN 67 RVUE USES KORMANYOS 67 11/67
D USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES

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 PR 18 798 F N DIKMEN (MICH)
KORMANYO 67 PR 164 1661 KORMANYOS, KRISCH, OFALLON, + (MICH, ARG) P
DOLEN 68 PR 166 1768 R DOLEN, D HORN, C SCHMID (CAL TECH)

END PRODUCTION EXPERIMENTS

EXOTIC NUCLEONS 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, I, 9 GEV/C 7/70*

REFERENCES -- EXOTIC NUCLEONS

BANNER 70 NP B15 205 +CHEZE, HAMEL, TEIGER, ZACCONE + (SACLAY)

Z0(1780) 95 Z*0(1780, JP=1/2) I=0
95 Z*0(1780) MASS (MEV)

M ABOUT 1780.0 ABRAMS 69 RVUE K+ P, D TOTAL 6/70*

M D SEEN DOWELL 70 RVUE 7/70*

M D SEE ALSO DISCUSSION OF LYNCH 70

95 Z*0(1780) WIDTH (MEV)

W ABOUT 565.0 ABRAMS 69 RVUE K+ P, D TOTAL 6/70*

95 Z*0(1780) PARTIAL DECAY MODES

PI Z*0(1780) INTO K N DECAY MASSES 493+ 939

95 Z*0(1780) BRANCHING RATIOS

R1 Z*0(1780) INTO (K N)/TOTAL (PI)/TOTAL
R1 ABOUT 0.95 ABRAMS 69 RVUE K+ P, D TOTAL 6/70*

REFERENCES -- Z*0(1780)

SEE REFERENCES FOR THE Z*1(1900)

Z0(1865) 96 Z*0(1865, JP=) I=0
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

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

96 Z*0(1865) PARTIAL DECAY MODES

P1 Z*0(1865) INTO K N DECAY MASSES 493+ 939

P2 Z*0(1865) INTO N K*(890) 938+ 892

96 Z*0(1865) BRANCHING RATIOS

R1 Z*0(1865) INTO (K N)/TOTAL (PI)/TOTAL
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

REFERENCES -- Z*0(1865)

SEE REFERENCES FOR THE Z*1(1900)

Z1(1900) 97 Z*1(1900, JP=) I=1

SEE THE MINI-REVIEW ON Z*5 IN FRONT OF THE Z*0(1780) LISTING. SEE ALSO THE REVIEWS IN PREVIOUS EDITIONS OF THIS COMPILATION.

97 Z*1(1900) MASS (MEV)

M (1900.0) (10.0) KYCIA 67 CNTR ++ K+P TOTAL 8/67

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 THROUGH AYED TO 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 IN THE AMPLITUDES RESULTING FROM THE ANALYSIS

M (1959.0) ERNE 70 IPWA P13 6/70*

M (1880.0) (90.0) KATO 70 IPWA P13 IN SOLN I 6/70*

M (1950.) (100.) KATO 70 IPWA SOL. III 7/70*

Note on Possible Z_0^* 's

Although much work has been done on the strangeness +1 reactions during the past year, 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 recently 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 ($M \sim 1865$ MeV) has a companion at about 0.8 GeV/c ($M \sim 1780$ 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. (The elastic cross section has not been independently measured.)

The Z_0^* (1780) in the listings below is the result of fitting the elastic peak with a Breit-Wigner resonance form. The width is anomalously large, 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.

Phase shift analyses of the elastic scattering data in the I = 0 state have been done only up to 810 MeV/c; ¹ therefore it is not clear whether the structure (either double-peaked or not) is associated with a definite resonance-like structure in one or more partial waves.

(b) I = 1 System. New K^+p data has been reported by REBKA 70 from 1.54 to 1.71 GeV/c and by BARBER 70 from 1.4 to 2.3 GeV/c. As for new analyses at the Duke Conference on Hyperons, a total of nine partial-wave analyses were presented. Each of these analyses gets more than one solution to choose from, which indicates that the data are not good enough to eliminate some of the possibilities. Certainly new data and the simultaneous analysis of elastic and inelastic channels (copious inelastic data is 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 the various 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 claimed by REBKA 70, KATO 70, ERNE 70, and BGRT 70; the results of the other five 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. For this reason they claim one is not obliged to invoke a resonance.

BENNETT 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.

BARBER 70 include the new data up to 2.3 GeV/c. Their preferred solution is shown in Fig. 3 and shows no structure in the speed. They also report a second solution which resembles the Argonne solution I (KATO 70 and Fig. 3) below 1.8 GeV/c.

HALL 70 have presented an analysis that includes the elastic and inelastic data. The analysis was done at three momenta, and the P_{13} amplitude of their best solution is shown in Fig. 3. Here again the errors are really too large to detect any possible Breit-Wigner behavior.

The S_{11} amplitude. It should be mentioned that AYED 70 find a solution with the P_{13} negative and moving clockwise, and the S_{11} positive and moving counter clockwise. In this solution the S wave is essentially zero below 520 MeV/c, and a negative P_{11} wave rather than S wave would fit the angular distributions at low energy. The trouble with this solution is that the P_{11} phase shifts do not show the q^3 dependence at low energy as required from a P wave. CARRERAS 70 report an attractive S wave at low energy. This is in contradiction with the constructive

interference between the elastic and Coulomb scattering suggested by the data. CARRERAS-1 70 mention the possibility that S and P_{11} waves contribute equally at low energy (below 300 MeV/c). This is also contradicted by the data, which do not show the required SP interference term. See GOLDHABER 70 for more discussions on the sign of the S_{11} .

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 (≈ 0.2) and it decays mainly into $K\Delta$. But a definite conclusion has yet to be made and awaits much more data.

One more comment on exotic resonances is that, as pointed out in 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. So in conclusion, the existence of exotic resonances, as of the Duke Conference (April 1970), is still an open question.

Conclusions. The existence of exotic resonances, as of the Duke Conference (April 70) 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 peak is seen.
- 2) The fit to the data should extend over a very wide region, down to threshold and up to 2 GeV/c as already done by ERNE 70, BARBER 70, and AYED 70.
- 3) Simultaneous study of elastic and inelastic channels should certainly help.
- 4) More emphasis on the speed plot.²
- 5) For the $I = 0$ states it would be very useful, however difficult it may be, to measure the elastic cross section.

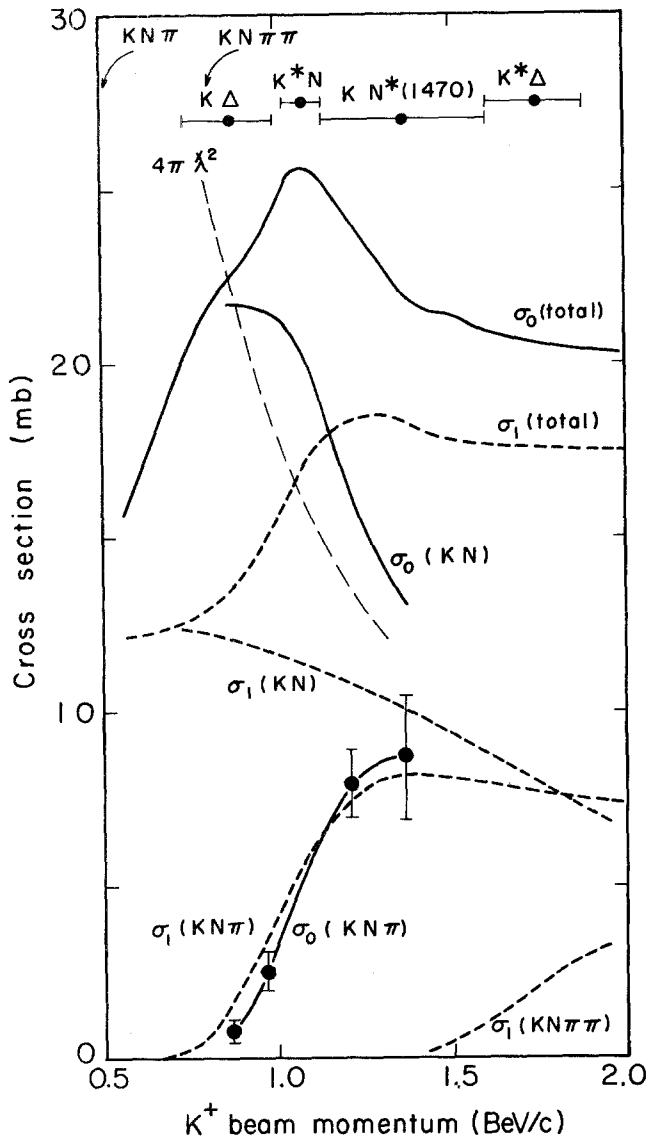


Fig. 1.

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.

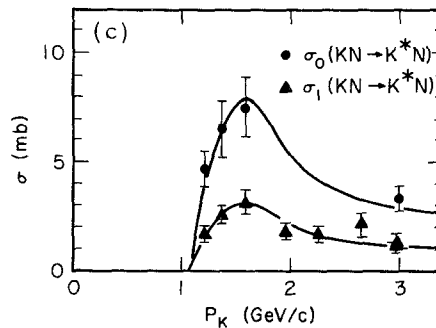
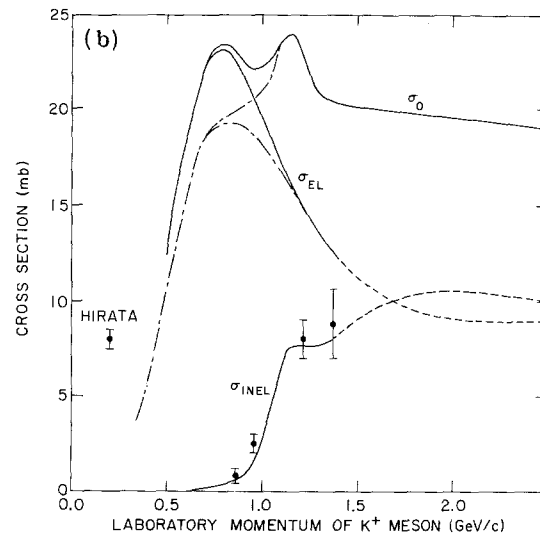
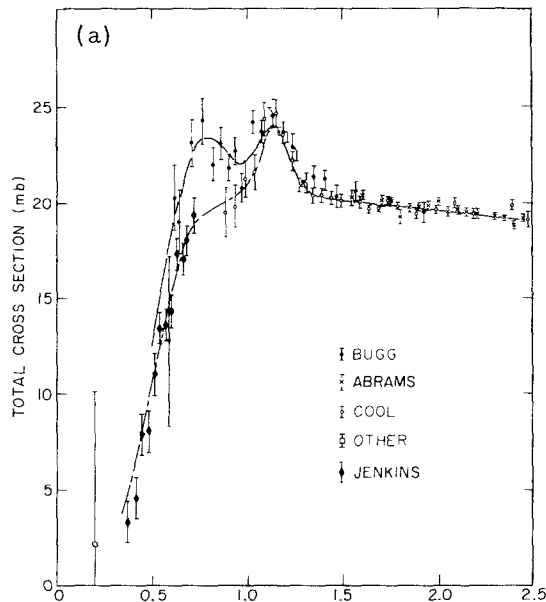


Fig. 2.

(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.

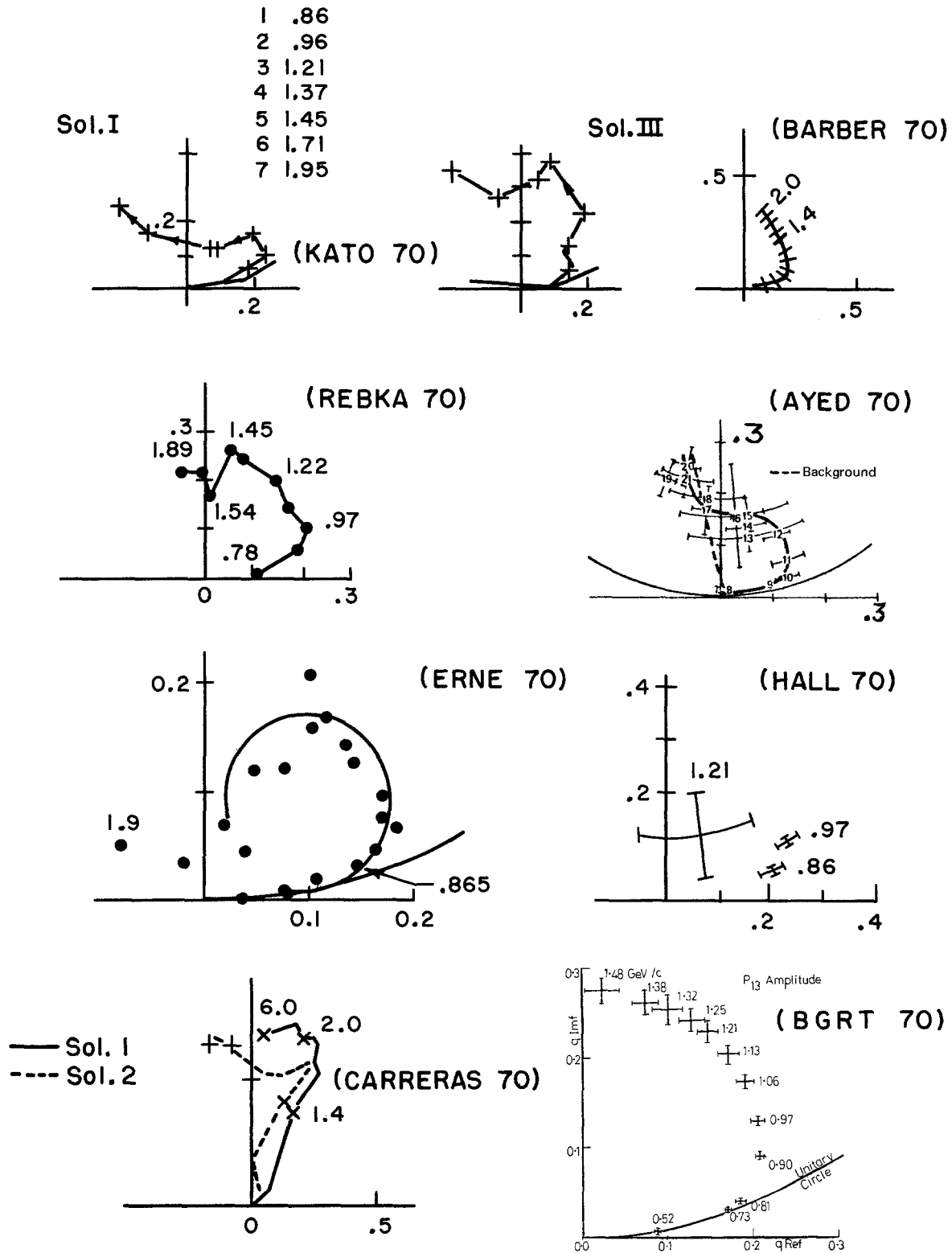


Fig. 3. Argand plots for the P_{13} partial wave as obtained in partial-wave analyses performed by the authors indicated.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

References

- 1. V. J. Stenger, W. E. Slater, D. H. Stork, H. K. Ticho, G. Goldhaber, and S. Goldhaber, Phys. Rev. 134, B1111 (1964).
2. See the January 1970 edition of the Review of Particle Properties for some earlier speed plots and definitions.

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 (CERN,BRUXELLES)
HALL 69 UCRL-19231 HALL, BLAND, GOLDBERGER, TRILLING (BNL)
LEA 69 LUND PAPER 362 LEA,MARTIN,OADES (RHCL+UCL)

18 LAMBDA (1115,JP=1/2+) I=0
SEE LISTINGS OF STABLE PARTICLES

87 Y*(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 SPECTRUM IN THREE PI- PROPANE EXPERIMENTS (YUNG-CHANG 64, BUBELEV 67, AND BOZOKI 68). IN THE FIRST TWO, THIS WAS TAKEN AS INDIRECT EVIDENCE FOR THE Y*(1670) DECAYING TO LAMBDA ETA, WITH THE ETA DECAYING TO TWO GAMMAS. IN THE THIRD EXPERIMENT THIS INTERPRETATION HAS BEEN RULED OUT. BOZOKI 68 MENTION THE POSSIBILITY OF THERE BEING A Y*(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* NEAR THE LAMBDA OR SIGMA MASS WAS MADE BY TAN 69. NONE WAS FOUND.

REFERENCES -- Y*(1330)
Y-CHANG 64 DUBNA CONF I 615 YUNG-CHANG, IN, KLANITSKAYA, + (DUBNA)
BUBELEV 67 PL 248 246 +CHADRAA, CHUVILO, + (JINR,BUCHAREST,CERN)
DAHL 67 PR 163 1377 DAHL, HARDY, HESS, KIRZ, MILLER (LRL)
BOZOKI 68 PL 288 360 +FENYVES, GEMESY, + (BUDAPEST,DUBNA)
TAN 69 PRL 23 101 T H TAN (SLAC)

37 Y*(1405, JP=1/2-) I=0 S01

THIS RESONANCE CAN BE IDENTIFIED WITH THE VIRTUAL BOUND STATE IN THE KBAR-N SYSTEM FOUND IN THE ANALYSIS OF LOW ENERGY K-P INTERACTION. WE LIST SUCH EXPERIMENTS SEPARATELY BELOW. WE USE ONLY PRODUCTION EXPERIMENTS FOR AVERAGING OF MASSES AND WIDTHS -

Table with columns: M, (1405.0), ALSTON 61 HBC, K-P 1.15 BEV/C, ALEXANDER 62 HBC, PI-P 2.1 BEV/C, (1405.0), ALSTON 62 HBC, K-P 1.2-2.5 BEV/C, 1400.0, 24.0, MUSGRAVE 65 HBC, PARAR P 3-4 BEV/C, (1382.0), (8.0), ENGLER 65 HBC, PI-P, PI+D 1.68, 67 1400.0, 5.0, BIRMINGHAM 66 HBC, 3.5 K-P, 120 1405.0, 5.0, GALTIERI 68 HBC, K-D 2.1-2.7BEV/C

Table with columns: W, (20.0), ALSTON 61 HBC, 7/66, W, 35.0, ALEXANDER 62 HBC, W, (50.0), ALSTON 62 HBC, W, 60.0, MUSGRAVE 65 HBC, W, (89.0), (20.0), ENGLER 65 HBC, W, 67 50.0, 10.0, BIRMINGHAM 66 HBC, 3.5 K-P, W, 120 35.0, 8.0, GALTIERI 68 HBC, K-D 2.1-2.7BEV/C, W, AVG, 38.1, 3.9, AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0), 6/68

37 Y*(1405) PARTIAL DECAY MODES

PI Y*(1405) INTO SIGMA PI DECAY MASSES 1197+ 139

REFERENCES -- Y*(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, + (BIRMINGHAM,CERN,EP,IMPCOL,SACLAY)
ENGLER 65 PRL 15 224 +FISK, KRAEMER, MELTZER, HESTGARD, + (CERN,BNL) IJ

BIRMINGHAM 66 PR 152 1148 BIRMINGHAM, GLASGOW, I.C., OXFORD, RUTHERFORD
GALTIERI 68 PRL 21 573 BARBARO-GALTIERI, CHADWICK + (LRL, SLAC)

Table with columns: W, (260.0), (50.0), KYCIA 67 CNTR ++, 8/67, W, 1, (520.0), AYEED 70 IPWA, K+P, 6/70*

97 Z*(1900) PARTIAL DECAY MODES

Table with columns: P1, Z*(1900) INTO K N, 493+ 938, DECAY MASSES, P2, Z*(1900) INTO N*3/2(1236) K, 1236+ 493

97 Z*(1900) BRANCHING RATIOS

Table with columns: R1, Z*(1900) INTO (K N)/TOTAL, (PI)/TOTAL, R1, 0.25, 0.06, CARTER 67 THEO, DISPERSION REL., 8/67, R1, 1, (0.16), AYEED 70 IPWA, K+P, 6/70*

SEE NOTES ACCOMPANYING THE MASSES QUOTED.

Table with columns: R2, Z*(1900) INTO K N*3/2(1236), (P2), R2, MAIN INELASTIC DECAY, BLAND 67 HBC ++, 8/67

Z* CROSS SECTION LIMITS (MICROBARN)

SEE MINIREVIEW PRECEDING Z*0

Table with columns: 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

REFERENCES -- Z*(1900)

TOTAL-CROSS-SECTION EXPERIMENTS ---
COOL 66 PRL 17 102 +GIACOMELLI, KYCIA, LEONTIC, LI, LUNDRY, + (BNL) I
--- SLIGHTLY REVISED RESULTS FROM KYCIA 67 REPLACE COOL 66 ---
KYCIA 67 PRIVATE COMM. T F KYCIA (BNL) I
ABRAMS 67 PRL 19 259 +COOL, GIACOMELLI, KYCIA, LEONTIC, LI, + (BNL) I
BUGG 68 PR 168 1466 +GILMORE, KNIGHT, + (RTHFD, BRGMHM, CVNSH) I
ABRAMS 69 PL 308 564 +COOL, GIACOMELLI, KYCIA, LI, MICHAEL (BNL) IJ
BOWEN 70 DUKE 3 R L COOL (BNL)
COOL 70 DUKE 47 J.D. DOWELL (BIRM)
DOWELL 70 DUKE 53 G LYNCH (REVIEWER OF CR.SEC. DATA) (LRL)
LYNCH 70 DUKE 9

DISPERSION-RELATION CALCULATION USING TOTAL-CROSS-SECTION DATA ---
CARTER 67 PRL 18 801 A A CARTER (CAVENDISH)
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)

A REGGE-POLE ANALYSIS EXTENDED TO LOW ENERGIES --
CARRERAS 70 NP B19 349 B CARRERAS, A DONNACHIE (DARESBURY, MANCH)

EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS ---
BLAND 67 PRL 18 1077 +BOWLER, BROWN, GOS, GOLDBERGER, SEEGER, + (LRL)
BLAND 68 UCRL-18131 THESIS R W BLAND (LRL)
HIRATA 68 PRL 21 1485 HIRATA, MOHL, GOLDBERGER, TRILLING (LRL)
BLAND 69 NP B13 595 +BOWLER, BROWN, KADYK, GOLDBERGER, + (LRL)
BLAND 70 NP B18 537 +BOWLER, BROWN, GOLDBERGER, (LRL)
--- BLAND 69 AND BLAND 70 REPLACE BLAND 67 AND BLAND 68.
HIRATA 70 DUKE 429 +GOLDBERGER, SEEGER, TRILLING+MOHL (LRL)

THE MAIN K+P ELASTIC SCATTERING AND POLARIZATION EXPERIMENTS ---
CARPOLL 68 PRL 21 1282 +FISCHER, LUNDRY, PHILLIPS, + (BNL+ROCH)
ANDERS-1 69 PL 288 511 ANDERSSON, DAUM, ERNE, LAGNAUX, + (CERN)
ASBURY 69 PRL 23 194 +DOWELL, KATO, LUNDQUIST, NOVEY, + (ARG, MO)
BLAND 69 PL 298 618 R W BLAND, G GOLDBERGER, G H TRILLING (LRL)

THE LATEST PHASE-SHIFT ANALYSIS.

Table with columns: ANDERS-2 69 PL 308 56, ANDERSSON, DAUM, ERNE, LAGNAUX, + (CERN), AYEED 70 CERN-SACLAY (P) +BARBYRE, FELTESSE+WILLET (CERN-SACLAY) IJP, BARBER 70 DUKE 453 +BROMME+...+MONNA+LEA (UCL+RHCL), BARNETT 70 DUKE 443 +GOLDMAN, LAASANEN, STEINBERG (MARYLAND) IJP, BGRT 70 DUKE 457 BOLOGNA, GLASGOW, ROME, TRIESTE COLLABORAT., CARRERA1 70 DUKE 447 +DONNACHIE+KIRSOPP (DARE+MCHS+U.EDINBURG), ERNE 70 DUKE 375 +SENS, MAGNER (CERN) IJP, HALL 70 DUKE 435 +BLAND, GOLDBERGER, TRILLING (LRL), KATO 70 PL 24 615 +KOEHLER, NOVEY, YOKOSAWA, + (ARG, NWES) IJP, GIACOMEL 70 PREPRINT +GIACOMELLI, GRIFFITHS+ (BONN+GLAS+ROMA+TRST), REBAK 70 PL 24 160 +ROTHBERG, ETKINS, GLODIS, + (YALE) IJP

The number of known or suspected Y^* states has increased considerably in the last year or two, following closely a similar increase in the number of N^* states.¹ Just as the recently discovered N^* 's are only weakly coupled in the $\pi N \rightarrow \pi N$ reaction, so also are the recently discovered Y^* 's only weakly coupled in the $\bar{K}N \rightarrow \bar{K}N$, $\bar{K}N \rightarrow \Lambda\pi$, and $\bar{K}N \rightarrow \Sigma\pi$ 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 usually 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 lie in the resonances in the 1600- to 1700-MeV. See the mini-review on $\Sigma(1620)$ and $\Sigma(1660)$ inserted in the listings. A good review is given by MILLER 70.²

Formation experiments. Partial-wave analyses have been performed on $\bar{K}N$, $\Lambda\pi$, $\Sigma\pi$ and ΞK 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 parameters for the two fits. Not surprisingly sometimes neither fit is very good, nor is the choice between them always clear. Errors given by the fitting programs from this kind of analysis tend to be small, for they are usually only the statistical errors and don't reflect the quite possibly large systematic errors that result from the restrictive parametrization forced on the amplitudes. See next page for further discussion.

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 $K^- p \rightarrow \Lambda\pi$ 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 $K^- p \rightarrow \Sigma\pi$. 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.

Partial-wave analyses above 1.1 GeV/c.

One of us³ 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. Table I, taken from Ref. 3, shows the resonances included in the fits; the other partial waves were parametrized as background amplitudes with the indicated number of parameters. The three partial waves where agreement was found were D_{15} , F_{15} , F_{17} .

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. For the $\Sigma\pi$ channel, where two I-spin states are present, the interference terms certainly help to reduce the number of possible solutions. Table II, again taken from Ref. 3, is a summary of the states claimed above 1.1 GeV/c where, in view of the above difficulties, most of the new states have

been classified "wait." The signs of the amplitudes at resonance follow the convention advocated by Levi-Setti.¹ 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, as discussed earlier, 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 are certainly a better estimate of the uncertainties than the statistical errors. One clear example of how little meaning the quoted errors have is given by the elasticity R_1 of the $\Lambda(1690) D_{03}$. Here the quoted values range from 0.18 ± 0.02 to 0.34 ± 0.02 and, since the same data were used in the analyses, puts us in the uncomfortable situation of having to decide on a value!

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 $\Sigma(1915)$]. These errors are probably more realistic. In conclusion, we chose not to give errors on masses and widths determined in partial-wave analyses, but, whenever necessary, we give a range of values.

Table III 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

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

TABLE III

STATUS OF THE Y* RESONANCES. THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE.

Table with columns: PARTICLE, LIJ, OVERALL STATUS, TOTAL* CR. SEC., KBAR N, LAM PI, SIG PI, OTHER CHANNELS. Lists various baryon resonances like LAM(1330), SIG(1385) P13, etc.

*** 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.

A(1405) EXTRAPOLATION BELOW THRESHOLD

SEE NOTE IN Y*0(1405) PRODUCTION EXPERIMENTS - THE DIFFICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ ET AL.

Table with columns: M, N, W, N, W, N, W, N, W, N, W. Lists mass and width data for A(1405) resonance.

REFERENCES -- Y*0(1405) FROM EXTRAPOLATIONS

Table listing references for A(1405) from extrapolations, including authors like J K KIM, G S ABRAMS, etc.

PAPERS NOT REFERRED TO IN DATA CARDS.

Table listing papers not referred to in data cards, including authors like G S ABRAMS, B SECHI-ZORN, etc.

END -EXTRAPOLATION BELOW THRESHOLD-

A(1520)

D03

38 Y*0(1520, JP=3/2-) I=0
PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL WITH EACH OTHER, THEREFORE THEY HAVE NOT BEEN SEPARATED FOR THIS PARTICLE

Table with columns: M, N, W, N, W, N, W, N, W, N, W. Lists mass and width data for A(1520) resonance.

Table with columns: W, N, W, N, W, N, W, N, W, N, W. Lists width data for A(1520) resonance.

Table with columns: P1, P2, P3, P4, P5, P6, P7. Lists partial decay modes for A(1520) resonance.

Table with columns: W1, W1 O, W2, W2 O. Lists partial widths for A(1520) resonance.

Table with columns: R1, R1 O, R1, R1 O, R1, R1 O, R1, R1 O, R1, R1 O. Lists branching ratios for A(1520) resonance.

Table with columns: R2, R2 O, R2, R2 O, R2, R2 O, R2, R2 O, R2, R2 O. Lists branching ratios for A(1520) resonance.

Table with columns: R3, R3 O, R3, R3 O, R3, R3 O, R3, R3 O, R3, R3 O. Lists branching ratios for A(1520) resonance.

Table with columns: R4, R4 O, R4, R4 O, R4, R4 O, R4, R4 O, R4, R4 O. Lists branching ratios for A(1520) resonance.

Table with columns: R5, R5 O, R5, R5 O, R5, R5 O, R5, R5 O, R5, R5 O. Lists branching ratios for A(1520) resonance.

Table with columns: R6, R6 O, R6, R6 O, R6, R6 O, R6, R6 O, R6, R6 O. Lists branching ratios for A(1520) resonance.

Table with columns: R7, R7 O, R7, R7 O, R7, R7 O, R7, R7 O, R7, R7 O. Lists branching ratios for A(1520) resonance.

Table with columns: R8, R8 O, R8, R8 O, R8, R8 O, R8, R8 O, R8, R8 O. Lists branching ratios for A(1520) resonance.

Table with columns: R9, R9 O, R9, R9 O, R9, R9 O, R9, R9 O, R9, R9 O. Lists branching ratios for A(1520) resonance.

Fitted Partial Decay Mode Branching Fractions

Diagonal elements are P_i ± delta P_i; delta P_i = sqrt($\langle \delta P_i \delta P_i \rangle$). Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \delta P_j)$.

Table with columns: P 1, P 2, P 3, P 4, P 5, P 6. Lists fitted partial decay mode branching fractions.

REFERENCES -- Y*0(1520)

Table listing references for A(1520) resonance, including authors like M B WATSON, M FERRO-LUZZI, etc.

Table I. Results of partial-wave analyses in the $\Lambda\pi$ channel. In the second column $N = 50$ means that 50 parameters were used in the overall fit. In the first row to the right, N_{par} indicates how many parameters were used for that partial wave. R(4) means that the resonant amplitude included four parameters (M, Γ , $|t|, \theta$).

		N_{par}	P_{11}	P_{13}	D_{13}	F_{15}	F_{17}	G_{17}	G_{19}^d
^a SMART 66	$\Lambda\pi^-, \Lambda\pi^0$	N_{par}	4+R(4)	6	6	4+R(4)	R(4)	3	3
	.75-1.9 GeV/c	M	1882±40			1902±11	2032±6		
	N=50	Γ	222±150			52±25	160±16		
	$\chi^2/DF=418/390$	t	-.11±.03			-.08±.02	.21±.01		
BERTHON 70	$\Lambda\pi^0$	N_{par}	4	8	4	8+R(4)	R(3)	4	---
	1.134-1.84 GeV/c	M				1910±20	2030±10		
	N=39	Γ				60±20	165±15		
	$\chi^2/DF=319/295$	t				-.10±.02	.20±.02		
^b COX 70	$\Lambda\pi^-$	N_{par}	6	3+R(3)	3	3+R(3)	R(3)	3	3
	1.18 -1.71 GeV/c	M		^b 2100±20		1903±10	2027±6		
	N=40	Γ		87±20		77±27	158±16		
	$\chi^2/DF=258/199$	t		-.16±.03		-.09±.02	.19±.01		
^b LITCHFIELD 70	$\Lambda\pi^-, \Lambda\pi^0$	N_{par}	5+R(3)	4+R(3)	4+R(3)	5+R(3)	R	7	---
	1.0 -1.85 GeV/c	M	1920±30	2070±30	1940±30	1895±10	2022±4		
	N=54	Γ	170±40	250±40	280±40	70±15	170±15		
	$\chi^2/DF=705/636$	t	-.14±.03	-.09±.03	-.14±.03	-.070±.015	.200±.008		
^e This paper	$\Lambda\pi^0$	N_{par}	4+R(4)	4	R(4)	4+R(4)	R(3)	R(3)	R(1)
	1.0 -1.85 GeV/c	M	1950±50		1940±50	1905±30	2040±15	2060±20	[2250]
	N=38	Γ	200±50		200±50	70±20	145±15	70±30	[140]
	$\chi^2/DF=299/245$	t	-.09±.04		-.12±.04	-.11±.03	.16±.03	-.07±.02	-.18

^aThe F_{15} state $\Sigma(1765)$ was also included in the analysis; the following parameters were found: $M = 1775\pm 7$, $\Gamma = 146\pm 9$, $t = -.266\pm .017$.

^bParameters reported here are the ones of fit 13, except for the P_{13} where mass and errors have been estimated by us, examining the various fits reported by the authors. The other errors are only statistical.

^cThe results quoted are the ones from fit A.

^d $\Sigma(2250)$, G_{19} is really outside the range of most analysis, but its lower tail can be included instead of a G_{19} background.

^eQuantities in square brackets have been kept fixed. See text for a fit from .61 to 1.85 GeV/c.

are more familiar with.

References

1. For a recent review of Y^* resonances see R. Levi-Setti, rapporteur talk at the Lund International Conference on Particle Physics (Lund, June 1969), p. 339.
2. D. H. Miller, in Proceedings of the Duke Conference on Hyperon Resonances (1970), p. 229.
3. A. Barbaro-Galtieri, in Proceedings of the Duke Conference on Hyperon Resonances (1970), p. 173.

Table II. Summary of the results obtained for the 11 states discussed in this paper. M and Γ are expressed in MeV. For the $\bar{K}N$, κ , the elasticity, is listed. For the other channels the quantity listed is t , the amplitude at resonance ($t = \sqrt{\kappa \bar{\kappa}}$). The last column is this author's rating for the resonance.

		M	Γ	$\bar{K}N$ κ	$\Lambda\pi$ t	$\Sigma\pi$ t	ΞK t	Status
$\Lambda(1870)$	$F_{07}^?$	1870	40	.10				Poor
$\Lambda(2015)$	F_{07}	2020	160			-.15		Wait
$\Lambda(2040)$	D_{03}	2010	130			-.20 (?) ^a		Wait
$\Lambda(2100)$	G_{07}	2100	60-145	.29		.06 seen ^b		Good
$\Sigma(1900)$	P_{11}	~1900	200		-.11			Poor
$\Sigma(1915)$	F_{15}	1905	60	.10	-.09	-.09 .008		Fair
$\Sigma(1940)$	D_{13}	1940	200		-.13	-.12 (?) ^a		Wait
$\Sigma(2020)$	F_{17}	2020	100-170	.1-.25	.19	-.05 .023		Good
$\Sigma(2070)$	P_{13}	~2100	87-250		-.12			Poor
$\Sigma(2120)$	G_{17}	~2100	~100		-.07	.13		Wait
^c $\Sigma(2250)$	$G_{19}^?$	2040	~160	.05 (-.18) ^c		(.07) ^c		Fair

a. The analysis of BURGUN 68 suggests a $J = 3/2$ state with either I-spin in this mass region.
 b. The two analysis of the ΞK channel do not agree on this value (see BURGUN 68 and MULLER 69).
 c. This state is really outside the region where the analyses have been done. Here it has been assumed to be a G_{19} state, as suggested by the analysis of DAUBER 66.

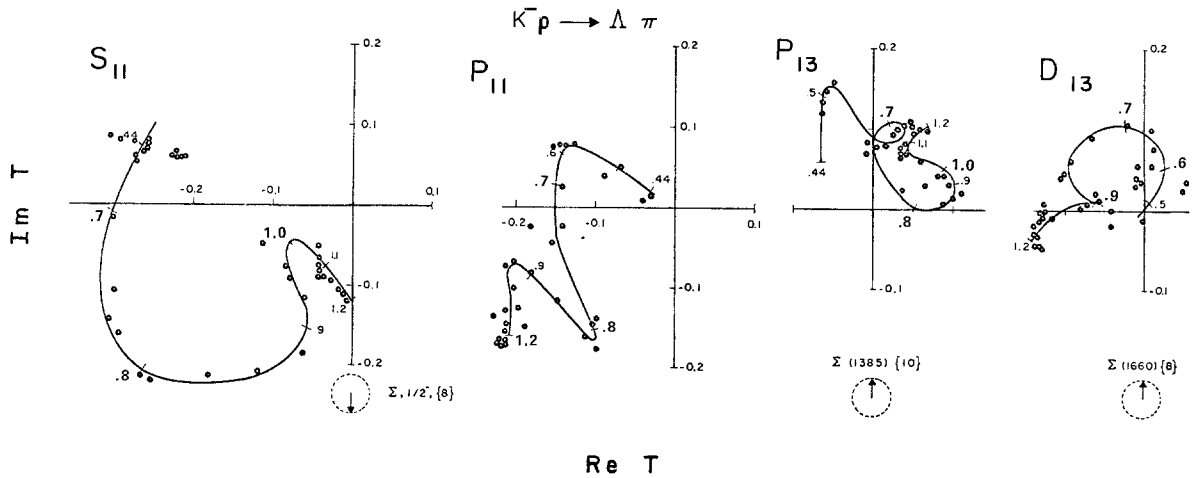


Fig. 1. Partial-wave amplitudes for the reaction $K^- p \rightarrow \Lambda \pi$ as determined in the energy-independent analysis of ARMENTEROS 69. The K^- laboratory momenta are indicated. The arrows in a circle, drawn in the lower part of the imaginary axes, fix the sign convention used. See LEVISETTI 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)].

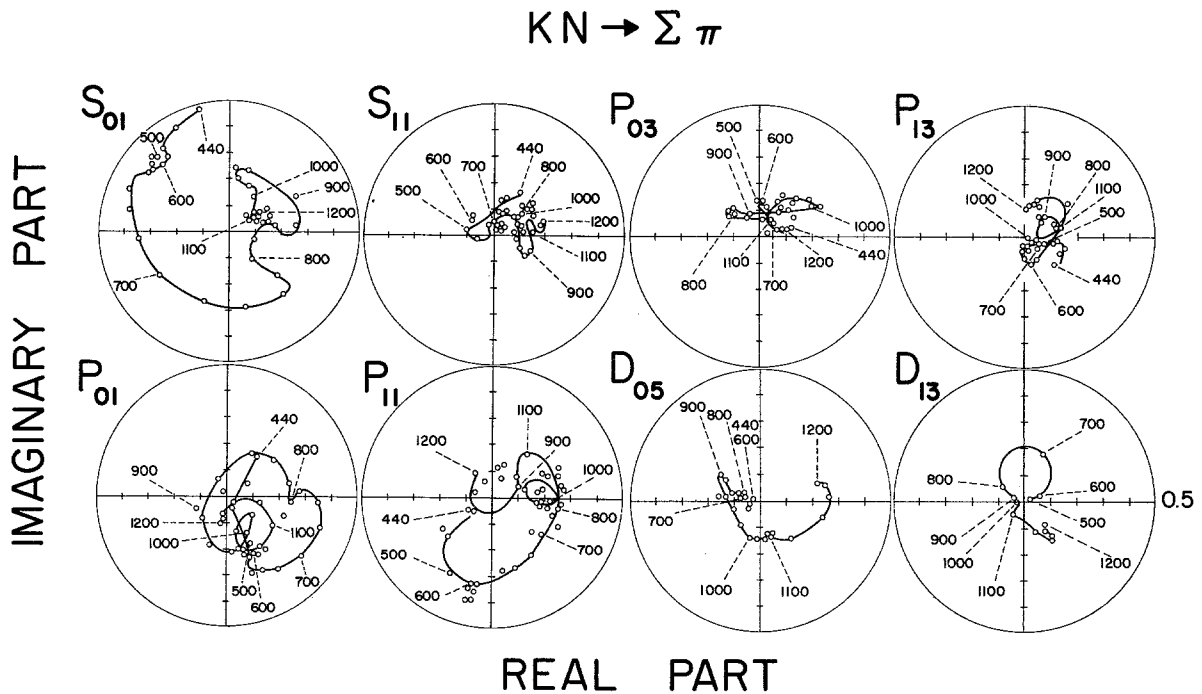


Fig. 2. Partial-wave amplitudes for the reaction $K^- p \rightarrow \Sigma \pi$ as determined in the energy-independent analysis of ARMENTEROS 70. The K^- laboratory momenta are indicated. Here again the sign convention follows LEVI SETTI 69.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

A(1670)

S01

40 Y*0(1670, JP=1/2-1) 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)).

Table with columns for mass (MEV), width (MEV), and various resonance parameters like BERTANZA, ARMENT-1, etc.

Table with columns for width (MEV) and resonance parameters like BERTANZA, ARMENT-1, etc.

Table with columns for partial decay modes and decay masses.

Table with columns for branching ratios and resonance parameters like BERTANZA, ARMENT-1, etc.

Table with columns for branching ratios and resonance parameters like BERTANZA, ARMENT-1, etc.

REFERENCES -- Y*0(1670)
BERLEY 65 PRL 15 641
BIRMINGHAM 66 PR 152 1148
ARMENT-1 68 NP 88 195
ARMENT-2 68 NP 88 223
ARMENT-3 69 LUND PAPER 229
ARMENT-3 69 LUND PAPER 339
ARMENT-4 69 NP 814 91
CONFORTO 70 EFT 70-281 SUB NP1
GALTIERI 70 DUKE 173

A(1690)

D03

55 Y*0(1690, JP=3/2-1) I=0
SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.
THIS RESONANCE IS WELL ESTABLISHED.

Table with columns for mass (MEV), width (MEV), and various resonance parameters like BUGG, ARMENT-1, etc.

55 Y*0(1690) WIDTH (MEV)

Table with columns for width (MEV) and resonance parameters like ARMENT-1, ARMENT-3, etc.

55 Y*0(1690) PARTIAL DECAY MODES

Table with columns for partial decay modes and decay masses.

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.

Table with columns for branching ratios and resonance parameters like BUGG, ARMENT-1, etc.

Table with columns for branching ratios and resonance parameters like ARMENT-1, ARMENT-3, etc.

Table with columns for branching ratios and resonance parameters like ARMENT-1, ARMENT-3, etc.

Table with columns for branching ratios and resonance parameters like ARMENT-1, ARMENT-3, etc.

REFERENCES -- Y*0(1690)
DAVIES 67 PRL 18 62
ARMENT-1 68 NP 88 195
ARMENT-2 68 NP 88 216
ARMENT-3 68 NP 88 223
BARTLEY 68 PRL 21 1111
BUGG 68 PR 168 1466
CONFORTO 68 NP 88 265
ARMENT-4 69 NP 814 91
BERTANZA 69 PR 177 2036
BERLEY 69 PL 308 430
CONFORTO 70 EFT 70-281 SUB NP1
GALTIERI 70 DUKE 173

A(1750)

P01

77 Y*0(1750, JP=1/2-1) I=0
SEE THE MINI-REVUE 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 PO1 AMPLITUDE WHEN IT WAS PARAMETERIZED AS A TWO-STRAIGHT-LINE BACKGROUND.

THERE IS ALSO SOME EVIDENCE FOR A PO1 STATE IN THE SIGMA PI CHANNEL (GALTIERI 69 AND ARMENTEROS 70). ALTHOUGH THE PARAMETERS AS DETERMINED IN THE TWO CHANNELS ARE QUITE DIFFERENT, IN NEITHER CASE ARE THEY AT ALL WELL DETERMINED, AND WE TENTATIVELY LIST THE EFFECTS TOGETHER.

77 Y*0(1750) MASS (MEV)

Table with columns for mass (MEV) and resonance parameters like ARMENTEROS, GALTIERI, etc.

77 Y*0(1750) WIDTH (MEV)

Table with columns for width (MEV) and resonance parameters like ARMENTEROS, GALTIERI, etc.

77 Y*0(1750) PARTIAL DECAY MODES

Table with columns for partial decay modes and decay masses.

77 Y*0(1750) BRANCHING RATIOS

Table with columns for branching ratios and resonance parameters like ARMENTEROS, GALTIERI, etc.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

R2 Y*0(1750) INTO (KBAR N)*(SIGMA PI)/TOTAL**2 (P1*P2)/TOTAL**2
1+0.040 ARMENTERO 70 HBC 0 SIGMA PI 6/70*
R2 +0.017 0.008 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
WHERE EXPLICIT, THE SIGN FOLLOWS LEVI-SETTI'S CONVENTION

REFERENCES -- Y*0(1750)
ARMENTERO 68 NP 88 195 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLA)YIJP
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP
ARMENTERO 70 DUKE 123 ARMENTEROS, BAILLON, + (CERN,HEIDEL)IJP

F(1815) 39 Y*0(1815, JP=5/2+) I=0 F05
SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THIS RESONANCE IS AS WELL ESTABLISHED AS ANY Y*, AL-
THOUGH SOME OF THE LESSER BRANCHING RATIOS NEED TO BE
REVISITED. DETERMINED. WE OMIT A FEW EARLY RESULTS (SEE
AN EARLIER EDITION FOR THEM), THROUGH THE REFERENCES ARE RETAINED. THE
QUOTED ERRORS ARE JUST STATISTICAL, AND DONT INCLUDE SYSTEMATIC EF-
FECTS, THUS ERRORS ARE UNDERESTIMATED. ERROR QUOTED IN GALTIERI 70 INCLUDES
VARIATION OF THE F05 PARAMETERS WHEN OTHER PARTIAL WAVES ARE
PARAMETERIZED IN DIFFERENT WAYS.

39 Y*0(1815) MASS (MEV)
M 1813.0 2.0 ARMENT-1 67 HBC 0 K-P TO SIGMA PI 8/67
M 1816.0 4.0 BELL 67 HDHC 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 1819.0 4.0 BUGG 68 CNTR 0 K-P, D TOTAL 6/68
M N 1816.0 2.0 CONFORTO 68 HBC 0 ELASTIC, CH EXCH 11/68
M N THESE TWO ANALYZE ESSENTIALLY THE SAME DATA IN DIFFERENT WAYS.
M P (1825.0) (1.0) BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*
M P THE ERROR IS ONLY STATISTICAL AND IS DOUBTFUL TOO SMALL.
M N 1816.0 2.0 CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
M 1820.0 10.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
M
M
M AVG 1816.20 0.94 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
FACTS. THE MEASUREMENTS OF R2 DO NOT AGREE (S=6.9) PROBABLY BECAUSE
ERRORS ARE UNDERESTIMATED. ERROR QUOTED IN GALTIERI 70 INCLUDES
VARIATION OF THE F05 PARAMETERS WHEN OTHER PARTIAL WAVES ARE
PARAMETERIZED IN DIFFERENT WAYS.

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 HDHC 0 11/67
W N 71.0 4.0 ARMENT-3 68 HBC 0 SEE NOTE N ABOVE 11/68
W 75.0 7.0 BUGG 68 CNTR 0 6/68
W N 72.0 7.0 CONFORTO 68 HBC 0 SEE NOTE N ABOVE 11/68
W 80.0 6.0 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*
W 100.0 20.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
W SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.
W 90.0 4.0 CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
W
W
W AVG 78.9 3.4 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

39 Y*0(1815) PARTIAL DECAY MODES
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 LAMBDA PI PI 1115+ 139+ 139
P5 Y*0(1815) INTO SIGMA PI PI 1192+ 139+ 139

39 Y*0(1815) BRANCHING RATIOS
R1 Y*0(1815) INTO (KBAR N)/TOTAL (P1)/TOTAL
R1 N 0.62 0.02 ARMENT-3 68 HBC 0 SEE NOTE N ABOVE 11/68
R1 0.72 0.02 BUGG 68 CNTR 0 6/68
R1 N 0.65 0.01 CONFORTO 68 HBC 0 SEE NOTE N ABOVE 11/68
R1 0.65 0.02 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*
R1 0.63 0.01 CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
R1
R1 AVG 0.6390 0.0066 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1 FIT 0.6389 0.0063 VALUE FROM CONSTRAINED FIT

R2 Y*0(1815) INTO (KBAR N)*(SIGMA PI)/TOTAL**2 (P1*P2)/TOTAL**2
R2 0.029 0.0054 ARMENT-1 67 HBC 0 8/67
R2 0.054 0.012 BELL 67 HDHC 0 11/67
R2 0.068 0.016 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
R2
R2 AVG 0.0696 0.0048 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
WHERE EXPLICIT, THE SIGN FOLLOWS LEVI-SETTI'S CONVENTION
R2 FIT 0.0696 0.0047 VALUE FROM CONSTRAINED FIT

R3 Y*0(1815) INTO (KBAR N)*Y*1(1385) PI/TOTAL**2 (P1*P3)/TOTAL**2
R3 0.09 0.03 ARMENT-2 67 HBC 0 K-P TO LAM PI PI 9/69
R3
R3 FIT 0.108 0.022 VALUE FROM CONSTRAINED FIT

R4 Y*0(1815) INTO (Y*1(1385) PI)/TOTAL (P3)/TOTAL
R4 0.20 0.05 BIRGE 65 HBC 0 K-P TO LAM PI PI 7/66
R4
R4 FIT 0.169 0.034 VALUE FROM CONSTRAINED FIT

R5 Y*0(1815) INTO (SIGMA PI PI)/TOTAL (P5)/TOTAL
R5 P NO CLEAR SIGNAL ARMENT-4 68 HDHC 0 K-N TO SIG PI PI 11/68
R5 P THERE IS A SUGGESTION OF A BUMP, ENOUGH TO BE CONSISTENT WITH
K5 WHAT IS EXPECTED FROM SIGMA PI DECAY OF THE Y*1(1385) -- ABOUT 0.02.
R5

Fitted Partial Decay Mode Branching Fractions
Diagonal elements are Fij = delta Pij; delta Pij = sqrt(<delta Pij delta Pij>). Off-diagonal elements are
correlation coefficients = <delta Pij delta Pkj> / (delta Pij delta Pkj).
P 1 .639+-0.006
P 2 -.145 .109+-0.007
P 3 -.030 .004 .169+-0.034
P 4 -.119 -.189 -.967 .084+-0.035

REFERENCES -- Y*0(1815)
BIRGE 65 ATHENS CONF 296 +ELY,KALMUS,KERNAN,LOUIE,SAHOURIA, + (LRL)IJP
ARMENT-1 67 PL 248 198 ARMENTEROS, F LUZZI, + (CERN,HEIDEL,SACLA)YIJP
ARMENT-2 67 ZEIT PHYS 202 486 ARMENTEROS, F LUZZI, + (CERN,HEIDEL,SACLA)YIJP
BELL 67 PRL 19 936 R B BELL (LRL)IJP
ARMENT-3 68 NP 88 195 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLA)YIJP
ARMENT-4 68 NP 88 216 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLA) I
BUGG 68 PR 168 1466 +GILMORE, KNIGHT, + (RHEL+BIRM+CAVE) I
CONFORTO 68 NP 88 265 +HARMSEN, LASINSKI, + (CHICAGO,HEIDEL)IJP
BRICMAN 70 PL 318 152 +FERRO LUZZI, FERREAU, + (CERN,CAEN,SACLA)
CONFORTO 70 EFF 70-28(SUB NP) +HARMSEN,LASINSKI** (LEFI)HEID)IJP
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP

PAPERS NOT REFERRED TO IN DATA CARDS.

CHAMBERL 62 PR 125 1696 CHAMBERLAIN,GROVE,KEEFE,KERTH, + (LRL) I
GALTIERI 63 PL 6 296 A BARBARO-GALTIERI, A HUSSAIN,RO TRIPP (LRL)IJP
SODICKSD 64 PR 133 8757 SODICKSON,MANNELLI,FRISCH,WAHLIG MITT(BNL) J
HOLLEY 65 UCRL-16274 THESIS W R HOLLEY (LRL) J
BIRMINGHAM 66 PR 152 1148 BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
GELFAND 66 PRL 17 1224 +HARMSEN,LEVI-SETTI,PREDAZZI* (EFINS,ARGON)
ARMENTER 67 NP 83 592 ARMENTEROS,FERRO-LUZZI* (CERN,HEID,SACLA) IJP
LASINSKI 68 PR 163 1792 LASINSKI, LEVI SETTI, PREDAZZI (CHICAGO) JP

D05 56 Y*0(1830, JP=5/2-) I=0
SEE THE MINI-REVUE 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.

56 Y*0(1830) MASS (MEV)
M A (1827.0) (3.0) ARMENTERO 67 HBC 0 K-P TO SIGMA PI 8/67
M A (1827.0) (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 N (1840.0) (5.0) CONFORTO 68 HBC 0 ELASTIC, CH EXCH 11/68
M N THESE ANALYZE ESSENTIALLY THE SAME DATA IN DIFFERENT WAYS.
M A NOT AVERAGED, AS FOR CARDS WITH NOTE N, BECAUSE SYSTEMATIC ERRORS,
M A DUE TO THE PARTICULAR PARAMETERIZATION USED, CAN BE LARGE
M C (1840.0) 15.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
M C (1831.0) (5.0) CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
M C CONFORTO 70 IS A NEW FIT, USING IMPROVED KBAR N DATA.

56 Y*0(1830) WIDTH (MEV)
W A (175.0) (9.0) ARMENTERO 67 HBC 0 8/67
W A (74.0) (18.0) BELL 67 HBC 0 8/67
W N (123.0) (32.0) ARMENTERO 68 HBC 0 SEE NOTE N ABOVE 11/68
W N (66.0) (25.0) CONFORTO 68 HBC 0 SEE NOTE N ABOVE 11/68
W 140.0 35.0 CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
W 150.0 30.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
W
W
W AVG 145.8 22.8 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

56 Y*0(1830) PARTIAL DECAY MODES
P1 Y*0(1830) INTO KBAR N 497+ 939
P2 Y*0(1830) INTO SIGMA PI 1189+ 139

56 Y*0(1830) BRANCHING RATIOS
R1 Y*0(1830) INTO (KBAR N)/TOTAL (P1)/TOTAL
R1 N 0.09 0.01 ARMENTERO 68 HBC 0 SEE NOTE N ABOVE 11/68
R1 N 0.10 0.01 CONFORTO 68 HBC 0 SEE NOTE N ABOVE 11/68
R1 0.05 0.02 CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
R1
R1 AVG 0.090 0.011 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

R2 Y*0(1830) INTO (KBAR N)*(SIGMA PI)/TOTAL**2 (P1*P2)/TOTAL**2
R2 -0.0225 0.0060 ARMENTERO 67 HBC 0 8/67
R2 0.0374 0.0033 BELL 67 HBC 0 11/67
R2 0.026 0.010 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
R2

REFERENCES -- Y*0(1830)
ARMENTER 67 PL 248 198 ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLA)YIJP
BELL 67 PRL 19 936 R B BELL (LRL)IJP
ARMENTER 68 NP 88 195 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLA)YIJP
CONFORTO 68 NP 88 265 +HARMSEN, LASINSKI, + (CHICAGO,HEIDEL)IJP
CONFORTO 70 EFF 70-28(SUB NP) +HARMSEN,LASINSKI** (LEFI)HEID)IJP
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP

F(1860) 60 Y*0(1860, JP= +) I=0
SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THE STATUS OF THIS RESONANCE -- OR THESE RESONANCES --
IS CONFUSED. AN F07 RESONANCE WAS FIRST SUGGESTED IN
THE PHASE-SHIFT ANALYSIS OF KBAR N DATA BY ARMENTEROS
67. IN ADDITION, THE ISOSPIN-0 TOTAL CROSS SECTION HAS A SHOULDER ON
THE HIGH SIDE OF THE Y*0(1815) THAT IS COMPATIBLE WITH SUCH A STATE
(BUGG 68). THE ARMENTEROS 68 AND CONFORTO 68 ANALYSES OF IMPROVED
KBAR N DATA INCLUDED THE F07 STATE. HOWEVER IN THE CONFORTO 69 ANALY-
SIS OF ESSENTIALLY THE SAME DATA, THE F07 RESONANCE IS OMITTED AND A
NEW P03 RESONANCE IS SUGGESTED. THE QUANTITY (J+1/2)X FOR EITHER RE-
SONANCE ALONE IS ABOUT EQUAL TO THE VALUE GIVEN BY THE TOTAL-CROSS-
SECTION EXPERIMENT. WE TENTATIVELY GROUP THE TWO EFFECTS TOGETHER.

IF THERE IS INDEED A SPIN 7/2 Y* AT THIS MASS, IT LIES ABOVE ANY
PREVIOUSLY KNOWN Y* TRAJECTORY.

60 Y*0(1860) MASS (MEV)
M A (1870.0) (5.0) BUGG 68 CNTR 0 K-P TOTAL 7/68
M A DUE TO THE PARTICULAR PARAMETERIZATION USED, ERROR CAN BE LARGE
M N F07 1865.0 2.0 ARMENTERO 68 HBC 0 ELASTIC, CH EXCH 11/68
M N F07 1865.0 2.0 CONFORTO 68 HBC 0 ELASTIC, CH EXCH 11/68
M N THESE ANALYZE ESSENTIALLY THE SAME DATA IN DIFFERENT WAYS. THE
M C P03 1883.0 10.0 CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
M C CONFORTO 70 IS A NEW FIT, USING IMPROVED KBAR N DATA
M N F07 1877.0 6.0 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*
M N PARTIAL WAVE THOUGHT TO BE RESONATING IN EACH CASE IS INDICATED.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

60 Y*0(1860) WIDTH (MEV)
W A (40.0) (10.0) BUGG 6R CNTR 0 7/68
W N F07 39.0 7.0 ARMENTERO 68 HBC 0 SEE NOTE N ABOVE 11/68
W N F07 49.0 9.0 CONFORTO 68 HBC 0 SEE NOTE N ABOVE 11/68
W C P03 80.0 20.0 CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
W F07 24.0 15.0 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*

60 Y*0(1860) PARTIAL DECAY MODES
P1 Y*0(1860) INTO KBAR N 497+ 939
P2 Y*0(1860) INTO SIGMA PI 1197+ 139

60 Y*0(1860) BRANCHING RATIOS
R1 Y*0(1860) INTO (KBAR N)/TOTAL (P1)/TOTAL
R1 N F07 0.12 0.02 ARMENTERO 68 HBC 0 SEE NOTE N ABOVE 11/68
R1 N F07 0.10 0.04 CONFORTO 68 HBC 0 SEE NOTE N ABOVE 11/68
R1 N P03 0.25 0.03 CONFORTO 70 HBC 0 K-P,ELAST,CEX 6/70*
R1 F07 0.07 0.02 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*

60 Y*0(1860) INTO SIGMA PI (P2)
R2 P PROBABLY SEEN GALTIERI 68 HBC 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).

REFERENCES -- Y*0(1860)
ARMENTERO 57 NP B3 592 ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
-- ARMENTEROS 67 IS REPLACED BY ARMENTEROS 68 AND CONFORTO 68.
ARMENTERO 68 NP B8 195 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BUGG 68 PR 168 1466 +GILMORE, KNIGHT, + (RTHFRD,BRMNGHM,CVNDSH) I
CONFORTO 68 NP B8 265 +HARMSSEN, LASINSKI, + (CHICAGO,HEIDEL)IJP
GALTIERI 68 PRL 21 573 BARBARO-GALTIERI, MATISON, + (LRL,SLAC)
LEVISETT 69 LUND 339 R.LEVI SETTI (RAPPORTEUR) (EFINS)
CONFORTO 70 EPI 70-28(SUB NP) +HARMSSEN-LASINSKI++ (EF+HEIDI)IJP
BRICMAN 70 PL 318 152 +FERRO LUZZI, PERREAU, + (CERN,CAEN,SACLAY)

REFERENCES -- Y*0(2100)
WOHL 66 AND DAUM 68 FIND JP=7/2-1
SEE THE MINI-REVIEW AT START OF Y* LISTING

60 Y*0(2100) MASS (MEV)
M B (2120.0) (10.0) WOHL 66 HBC K-P CH EX 7/66
M B 2080. 10.0 BURGUN 68 HBC OK-P TO XI-K (B) 10/69
M 2110.0 20.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

60 Y*0(2100) PARTIAL DECAY MODES
P1 Y*0(2100) INTO KBAR N 497+ 939
P2 Y*0(2100) INTO SIGMA PI 1197+ 139
P3 Y*0(2100) INTO LAMBDA OMEGA 1115+ 548
P4 Y*0(2100) INTO XI K 1321+ 497
P5 Y*0(2100) INTO LAMBDA OMEGA 1115+ 783
P6 Y*0(2100) INTO KBAR N PI 497+ 939+ 139

60 Y*0(2100) BRANCHING RATIOS
R1 Y*0(2100) INTO (KBAR N)/TOTAL (P1)/TOTAL
R1 (0.25) WOHL 66 HBC K-P,ELA. TOT,PWA 7/66
R1 (1.33) DAUM 68 CNTR 6/70*
R2 Y*0(2100) INTO (SIG PI)*(KBAR N)/TOTAL**2 (P2)*(P1)/TOTAL**2
R2 0.0036 0.0036 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

60 Y*0(2100) INTO (LAMBDA ETA)*(KBAR N)/TOTAL**2 (P3)*(P1)/TOTAL**2
R3 (0.0087) OR LESS FLATTE 2 67 HBC K-P TO LAM ETA 6/68
R4 Y*0(2100) INTO (XI K)*(KBAR N)/TOTAL**2 (P4)*(P1)/TOTAL**2
R4 (0.0023) TRIPP 67 RVUE 8/67
R4 B .0011 .0002 BURGUN 68 HBC K-P TO XI K 11/68
R4 .00001 MULLER 69 HBC 0 XI K ,EDPWA 7/70*

60 Y*0(2100) INTO (LAMBDA OMEGA)/TOTAL (P5)/TOTAL
R5 (0.1) OR LESS FLATTE 1 67 HBC 8/67
REFERENCES -- Y*0(2100)
WOHL 66 PRL 17 107 C G WOHL, F T SOLMITZ, M L STEVENSON (LRL)IJP
FLATTE 1 67 PR 155 1517 S M FLATTE (LRL)
TRIPP 67 NP B3 10 + LEITH, + (LRL,SLAC,CERN,HEIDEL,SACLAY) (LRL)
FLATTE 2 67 PR 163 1441 S M FLATTE, C G WOHL (LRL)
DAUM 68 NP B7 19 +ERNE, LAGNAUX, SENS, STEUER, UDDO (CERN)IJP
BURGUN 68 NP B8 447 +MEYER, PAULI, + (SACLAY,COLFRANCE,RTFD) (LRL)
MULLER 69 THESIS,UCRL 19372 R A MULLER (LRL)
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP

REFERENCES -- Y*0(2010) -- D03 --
GALTIERI 70 DUKE 173 A. BARBARO-GALTIERI (LRL)IJP

60 Y*0(2010) MASS (MEV)
M 2010. 30. GALTIERI 70 HBC 0 SIG PI , EDPWA 7/70*

60 Y*0(2010) WIDTH (MEV)
W 130. 50. GALTIERI 70 HBC 0 SIG PI , EDPWA 7/70*

60 Y*0(2010) PARTIAL DECAY MODES
P1 Y*0(2010) INTO KBAR N 497+ 939
P2 Y*0(2010) INTO SIGMA PI 1197+ 139

60 Y*0(2010) BRANCHING RATIOS
R1 Y*0(2010) INTO (KBAR N)*(SIG PI)/TOTAL**2 (P1*P2)/TOTAL**2
R1 .040 .016 GALTIERI 70 HBC SIG PI , EDPWA 7/70*

REFERENCES -- Y*0(2015)
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP

60 Y*0(2015) MASS (MEV)
H 2020.0 20.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

60 Y*0(2015) WIDTH (MEV)
W 160.0 30.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

60 Y*0(2015) PARTIAL DECAY RATES
P1 Y*0(2015) INTO KBAR N 497+ 939
P2 Y*0(2015) INTO SIGMA PI 1197+ 139

60 Y*0(2015) BRANCHING RATIOS
R1 Y*0(2015) INTO (SIG PI)*(KBAR N)/TOTAL**2 (P2*P1)/TOTAL**2
R1 0.022 0.006 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

REFERENCES --Y*0(2100)
WOHL 66 PRL 17 166 +COOPER, FRENCH, KINSON, + (CERN,SACLAY)
COOL 66 PRL 16 1228 +GIACOMELLI, KYCIA, LEONTIC, LI, LUNDBY, + (BNL) I
-- SLIGHTLY REVISED RESULTS FROM KYCIA 67 REPLACE COOL 66 --
KYCIA 67 PRIVATE COMM. T F KYCIA (BNL) I
BUGG 68 PR 168 1466 +GILMORE, KNIGHT, + (RTHFRD,BRMNGHM,CVNDSH) I
BRICMAN 70 PL 318 152 +FERRO LUZZI, PERREAU, + (CERN,CAEN,SACLAY)

A(2100) 41 Y*0(2100, JP=7/2-1) I=0 G07
WOHL 66 AND DAUM 68 FIND JP=7/2-1.
SEE THE MINI-REVIEW AT START OF Y* LISTING

41 Y*0(2100) MASS (MEV)
M B (2120.0) (10.0) WOHL 66 HBC K-P CH EX 7/66
M B 2080. 10.0 BURGUN 68 HBC OK-P TO XI-K (B) 10/69
M 2110.0 20.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

-- B A RESONANCE-LIKE EFFECT IS SEEN IN THIS REGION IN THE REACTION
K-P TO XI K, BUT A PERHAPS MORE LIKELY EXPLANATION OF THE DATA IS
IN TERMS OF A SO FAR OTHERWISE UNOBSERVED RESONANCE HAVING SPIN
LESS THAN 7/2. THE SITUATION REMAINS TO BE CLARIFIED.

41 Y*0(2100) WIDTH (MEV)
W B (145.0) (10.0) WOHL 66 HBC 66 HBC 7/66
W B 80. 10.0 BURGUN 68 HBC OK-P TO XI-K (B) 10/69
W (60.0) (25.0) GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

41 Y*0(2100) PARTIAL DECAY MODES
P1 Y*0(2100) INTO KBAR N 497+ 939
P2 Y*0(2100) INTO SIGMA PI 1197+ 139
P3 Y*0(2100) INTO LAMBDA ETA 1115+ 548
P4 Y*0(2100) INTO XI K 1321+ 497
P5 Y*0(2100) INTO LAMBDA OMEGA 1115+ 783
P6 Y*0(2100) INTO KBAR N PI 497+ 939+ 139

41 Y*0(2100) BRANCHING RATIOS
R1 Y*0(2100) INTO (KBAR N)/TOTAL (P1)/TOTAL
R1 (0.25) WOHL 66 HBC K-P,ELA. TOT,PWA 7/66
R1 (1.33) DAUM 68 CNTR 6/70*

41 Y*0(2100) INTO (SIG PI)*(KBAR N)/TOTAL**2 (P2)*(P1)/TOTAL**2
R2 0.0036 0.0036 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

41 Y*0(2100) INTO (LAMBDA ETA)*(KBAR N)/TOTAL**2 (P3)*(P1)/TOTAL**2
R3 (0.0087) OR LESS FLATTE 2 67 HBC K-P TO LAM ETA 6/68
R4 Y*0(2100) INTO (XI K)*(KBAR N)/TOTAL**2 (P4)*(P1)/TOTAL**2
R4 (0.0023) TRIPP 67 RVUE 8/67
R4 B .0011 .0002 BURGUN 68 HBC K-P TO XI K 11/68
R4 .00001 MULLER 69 HBC 0 XI K ,EDPWA 7/70*

41 Y*0(2100) INTO (LAMBDA OMEGA)/TOTAL (P5)/TOTAL
R5 (0.1) OR LESS FLATTE 1 67 HBC 8/67
REFERENCES -- Y*0(2100)
WOHL 66 PRL 17 107 C G WOHL, F T SOLMITZ, M L STEVENSON (LRL)IJP
FLATTE 1 67 PR 155 1517 S M FLATTE (LRL)
TRIPP 67 NP B3 10 + LEITH, + (LRL,SLAC,CERN,HEIDEL,SACLAY) (LRL)
FLATTE 2 67 PR 163 1441 S M FLATTE, C G WOHL (LRL)
DAUM 68 NP B7 19 +ERNE, LAGNAUX, SENS, STEUER, UDDO (CERN)IJP
BURGUN 68 NP B8 447 +MEYER, PAULI, + (SACLAY,COLFRANCE,RTFD) (LRL)
MULLER 69 THESIS,UCRL 19372 R A MULLER (LRL)
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP

REFERENCES -- Y*0(2100)
WOHL 66 PRL 17 107 C G WOHL, F T SOLMITZ, M L STEVENSON (LRL)IJP
FLATTE 1 67 PR 155 1517 S M FLATTE (LRL)
TRIPP 67 NP B3 10 + LEITH, + (LRL,SLAC,CERN,HEIDEL,SACLAY) (LRL)
FLATTE 2 67 PR 163 1441 S M FLATTE, C G WOHL (LRL)
DAUM 68 NP B7 19 +ERNE, LAGNAUX, SENS, STEUER, UDDO (CERN)IJP
BURGUN 68 NP B8 447 +MEYER, PAULI, + (SACLAY,COLFRANCE,RTFD) (LRL)
MULLER 69 THESIS,UCRL 19372 R A MULLER (LRL)
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP

M > 2100 MEV - PRODUCTION AND TOTAL EXPERIMENTS

25 Y*0(2100) PRD. EXPR.
SEE THE MINI-REVIEW AT START OF Y* LISTING
THE BUMP SEEN AT THIS MASS IN TOTAL CROSS SECTION EXPE.
CONTAINS BOTH THE G07 AND F07 STATES ABOVE-

25 Y*0(2100) MASS (MEV) -PRD. EXP.
M (2097.0) (6.0) BOCK 65 HBC PRAR P S-T REV/C 7/66
M 2103.0 10.0 KYCIA 67 CNTR K-P, D TOTAL 8/67
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*

25 Y*0(2100) WIDTH (MEV) -PRD. EXP.
W (24.0) (14.0) (24.0) BOCK 65 HBC INTO KBAR N (PI) 7/66
W 143.0 10.0 KYCIA 67 CNTR 8/67
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*

25 Y*0(2100) BRANCHING RATIOS -PRD. EXP.
R1 Y*0(2100) INTO (KBAR N)/TOTAL PRD. EXP.
R1 0.333 0.013 KYCIA 67 CNTR 8/67
R1 (0.305) BUGG 68 CNTR 6/68
R1 0.24 0.02 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*

25 Y*0(2100) INTO (KBAR N PI)/TOTAL PRD. EXP.
R2 SEEN BOCK 65 HBC
REFERENCES --Y*0(2100)
WOHL 66 PRL 17 166 +COOPER, FRENCH, KINSON, + (CERN,SACLAY)
COOL 66 PRL 16 1228 +GIACOMELLI, KYCIA, LEONTIC, LI, LUNDBY, + (BNL) I
-- SLIGHTLY REVISED RESULTS FROM KYCIA 67 REPLACE COOL 66 --
KYCIA 67 PRIVATE COMM. T F KYCIA (BNL) I
BUGG 68 PR 168 1466 +GILMORE, KNIGHT, + (RTHFRD,BRMNGHM,CVNDSH) I
BRICMAN 70 PL 318 152 +FERRO LUZZI, PERREAU, + (CERN,CAEN,SACLAY)

A(2010)

D03

A(2015)

F07

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

A(2350)

42 Y*0(2350, JP=) I=0
SEE THE MINI-REVIEW AT START OF Y* LISTING
DAUM 68 FAVORS JP=7/2- OR 9/2+
42 Y*0(2350) MASS (MEV)
M 2352.0 11.0 KYCIA 67 CNTR K-P, D TOTAL 8/67
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*

42 Y*0(2350) WIDTH (MEV)
W 210.0 50.0 KYCIA 67 CNTR 8/67
W 140.0 20.0 BUGG 68 CNTR 6/68
W 324.0 30.0 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*

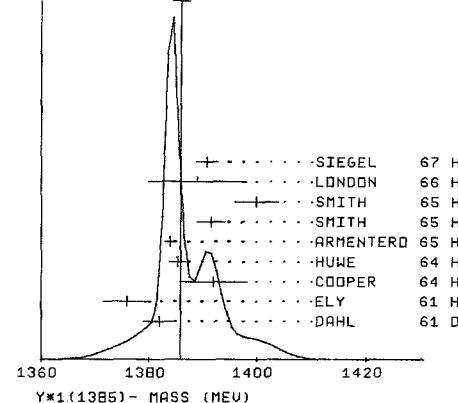
42 Y*0(2350) PARTIAL DECAY MODES
PI Y*0(2350) INTO KBAR N DECAY MASSES 497+ 939
42 Y*0(2350) BRANCHING RATIOS
R1 Y*0(2350) INTO (KBAR N)/TOTAL (PI1)/TOTAL
J IS NOT KNOWN. FOLLOWING IS IJ+1/2I+(KBAR N)/TOTAL

43 Y*(1385, JP=3/2+) I=1 P13
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 EFFECTS THAT CHANGE WITH PRODUCTION MECHANISM AND BEAM MOMENTUM.

43 Y*(1385) MASS (MEV)
M 141(1384.0) ALSTON 60 HBC +- K-P 1.15 BEV/C
M 381(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) COLLEY 62 HLBC 0- PI- PRP 2. BEV/C
M 106(1381.0) CURTIS 63 DSPK 0 PI-P 1.5 BEV/C
M (1392.0) MUSGRAVE 65 HBC +-OPBAR P 3-4 BEV/C 7/66
M (1389.0) BALTAY 65 HBC +- PBAR P 3.7 BEV/C 7/66

WEIGHTED AVERAGE = 1385.9 +/- 1.5
ERROR SCALED BY 2.2



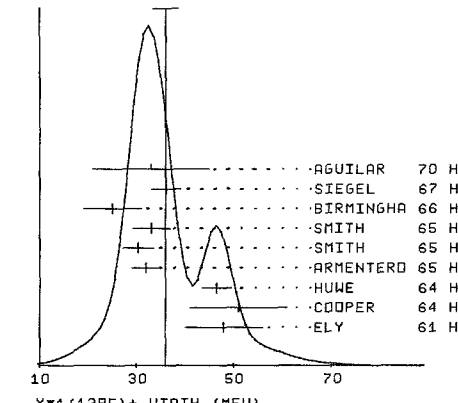
Y*(1385)- MASS (MEV)

43 Y*(1385) MASS DIFFERENCE (MEV)
D R (10.0) (4.2) ELY 61 HLBC +- K-P 1.11 BEV/C 8/66
D R (17.1) (7.1) COOPER 64 HBC 10/69
D R (4.3) (2.2) HUWE 64 HBC +- K-P 1.22 BEV/C 8/66

43 Y*(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) COLLEY 62 HLBC 0-
W (30.0) CURTIS 63 DSPK 0
W (38.0) MUSGRAVE 65 HBC +-0 7/66
W (26.0) BALTAY 65 HBC +- 7/66

WEIGHTED AVERAGE = 35.9 +/- 2.6
ERROR SCALED BY 1.9



Y*(1385)+ WIDTH (MEV)

W (40.0) DAHL 61 DBC -
W (86.0) ELY 61 HLBC -
W (88.0) COOPER 64 HBC -
W (62.0) HUWE 64 HBC -
W (38.0) ARMENTERO 65 HBC -
W (29.2) SMITH 65 HBC -
W (17.1) SMITH 65 HBC -
W (370) SIEGEL 67 HBC +- K-P AT 2.1 GEV/C 10/69

Sigma+

Sigma-

Sigma0

Sigma(1385)

CHISO
SIEGEL 67 HBC 5.8
LONDON 66 HBC
SMITH 65 HBC 12.1
SMITH 65 HBC 4.7
ARMENTERO 65 HBC 3.6
HUWE 64 HBC 0.2
COOPER 64 HBC 1.0
ELY 61 HLBC 5.1
DAHL 61 DBC 1.7
34.0
(CONLEV =0.000)

CHISO
AGUILAR 70 HBC
SIEGEL 67 HBC 0.0
BIRMINGHAM 66 HBC 3.3
SMITH 65 HBC 0.5
SMITH 65 HBC 3.3
ARMENTERO 65 HBC 1.7
HUWE 64 HBC 12.5
COOPER 64 HBC 2.3
ELY 61 HLBC 2.3
25.9
(CONLEV =0.001)

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 36.3 ± 6.3
ERRR SCALED BY 3.5

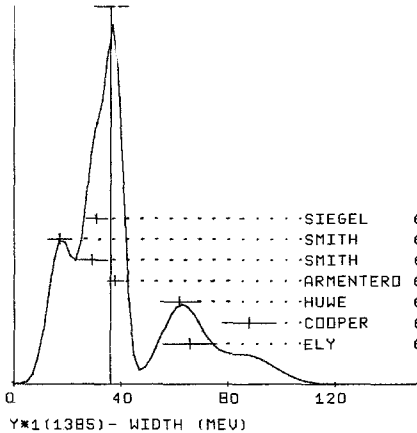


Table with 2 columns: Name and CHISO value. Includes SIEGEL (67 HBC, 1.7), SMITH (65 HBC, 18.9), ARMENTERO (65 HBC, 1.5), HUWE (64 HBC, 0.3), COOPER (64 HBC, 13.5), ELY (61 HLBC, 26.8), and a total of 71.7.

Table with 2 columns: Name and DECAY MASSES. Includes Y*1(1385) INTO LAMBDA PI (1115+ 139) and Y*1(1385) INTO SIGMA PI (1197+ 139). Also includes branching ratios for Y*1(1385) into (SIGMA PI)/(LAMBDA PI) and (P2)/(P1).

WEIGHTED AVERAGE = 0.101 ± 0.028
ERRR SCALED BY 1.4

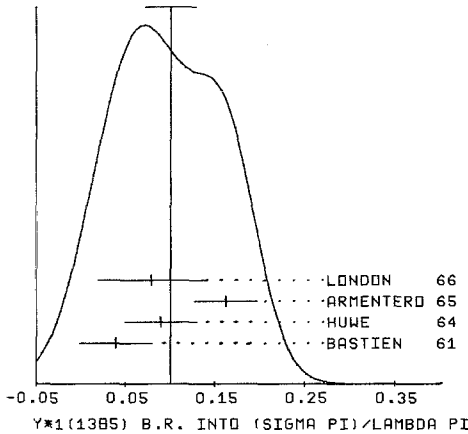


Table with 2 columns: Name and CHISO value. Includes LONDON (66 HBC, 0.1), ARMENTERO (65 HBC, 3.1), HUWE (64 HBC, 0.1), BASTIEN (61 HBC, 2.3), and a total of 5.7.

REFERENCES -- Y*1(1385) table listing various experiments and authors such as ALSTON, DAHL, MARTIN, BERGE, BASTIEN, ELY, ALSTON, COLLEY, CURTIS, COOPER, HUWE, MUSGRAVE, ARMENTER, BALTAY, SMITH, BIRMINGHAM, LONDON, SIEGEL, AGUILAR, ALVAREZ, EBERHARD, GOOD, GRAZIANO, HORWITZ, MILLER, MURRAY, WHITE, LEIPUNER, CHINOWSKY, SHEVELY, BASTIEN, DAHL, FERRO-LUZZI, KIRZ, P BASTIEN, M FERRO-LUZZI, A H ROSENFELD, FUNG, GIDAL, PAN, POMELL, WHITE, ALVAREZ, FERRO-LUZZI, ROSENFELD, GELFAND, NAUENBERG, COFFIN, MEYER, TERWILLIGER, FILTHUTH, FRIDMAN, MALAMUO, SANDWEISS, TAFT, CULWICK, KOPP, PETMEZAS, ARMENTEROS, SANDWEISS, TAFT, CULWICK, KOPP, L T SMITH, BIRMINGHAM, CLASGOW, OXFORD, RUTHERFORD, RAU, SAMIOS, YAMAMOTO, GOLDBERG, BNL, SYCR, BNL, SYR, BARNES, BASSANO, CHUNG, EISNER, BNL, SYR.

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN DATA CARDS.

SHAFER 64 PR 134 81372 J B SHAFER, D O HUWE (LRL) JP
MALAMUO 64 PL 10 145 E MALAMUO, P E SCHLEIN (CERN,UCLA) JP

M < 1500 MEV - PRODUCTION EXPERIMENTS

Σ(1440) 80 Y*1(1440, JP=) I=1
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-0 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.

REFERENCES -- Y*1(1440)

CLINE 68 PRL 21 1372 D CLINE, R LAUMANN, J MAPP (WISCONSIN) I
ALEXANDER 69 PRL 22 483 ALEXANDER, HALL, JEW, + (LRL,RIVERSIDE)

Σ(1480) 23 Y*1(1480, JP=) I=1
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.

23 Y*1(1480) MASS (MEV)

Table with 2 columns: Name and MASS (MEV). Includes YU-LI PAN 69 HBC + PI+P TO K PI LAM 9/69 and YU-LI PAN 69 HBC + PI+P TO K PI SIG 9/69.

23 Y*1(1480) WIDTH (MEV)

Table with 2 columns: Name and WIDTH (MEV). Includes YU-LI PAN 69 HBC + PI+P TO K PI LAM 9/69 and YU-LI PAN 69 HBC + PI+P TO K PI SIG 9/69.

23 Y*1(1480) PARTIAL DECAY MODES

Table with 2 columns: Name and PARTIAL DECAY MODES. Includes Y*1(1480) INTO KBAR N (497+ 939), Y*1(1480) INTO LAMBDA PI (1115+ 139), and Y*1(1480) INTO SIGMA PI (1189+ 139).

23 Y*1(1480) BRANCHING RATIOS

Table with 2 columns: Name and BRANCHING RATIOS. Includes Y*1(1480) INTO (SIGMA PI)/(LAMBDA PI) (P3)/(P2) 9/69 and Y*1(1480) INTO (PROTON KOBAR)/(LAMBDA PI) (P1)/(P2) 9/69.

REFERENCES -- Y*1(1480)

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)

Σ(1620) 79 Y*1(1620, JP=1/2+) I=1 P11
SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THE PARTIAL-WAVE ANALYSIS OF K- N TO SIGMA PI SUGGESTS SUCH A RESONANCE, BUT FURTHER EVIDENCE IS REQUIRED.

79 Y*1(1620) MASS (MEV)

Table with 2 columns: Name and MASS (MEV). Includes ARMENTERO 70 HDCC 0- K-N TO SIGMA PI 6/70*

79 Y*1(1620) WIDTH (MEV)

Table with 2 columns: Name and WIDTH (MEV). Includes ARMENTERO 70 HDCC 0- K-N TO SIGMA PI 6/70*

79 Y*1(1620) PARTIAL DECAY MODES

Table with 2 columns: Name and PARTIAL DECAY MODES. Includes Y*1(1620) INTO KBAR N (497+ 939) and Y*1(1620) INTO SIGMA PI (1197+ 139).

79 Y*1(1620) BRANCHING RATIOS

Table with 2 columns: Name and BRANCHING RATIOS. Includes Y*1(1620) INTO (KBAR N)/(SIGMA PI)/TOTAL**2 (P1*P2)/TOTAL**2 6/70*

REFERENCES -- Y*1(1620)

ARMENTER 70 DUKE CONF PAPER ARMENTEROS, BAILLON, + (CERN,HEIDEL)JP

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Note on $\Sigma(1620)$

This state was first suggested by the BNL-CCNY collaboration (CRENNELL 68) who presented evidence for it in the reaction $K^- n \rightarrow \Sigma(1620)^{\pm} \pi^{\mp} \pi^-$ with $\Sigma(1620)^{\pm}$ decaying into $\Lambda \pi^{\pm}$. Since then there have been conflicting reports about this state. 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^{*1} s) partial-wave analysis (ARMENTEROS 70) shows evidence for a P_{11} state at 1620 MeV in the $\Sigma\pi$ channel. They had previously reported evidence for this state in the $\Lambda\pi$ channel (ARMENTEROS 69) which they now disclaim. This is because of the fact that new data have been added at the low-energy end of their previous analysis (i.e., around the 1600-MeV region) and now the preferred solution shows structure at a higher mass, in the $\Lambda\pi$ channel.

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 Σ^0 from the production of $\Sigma(1670)$ decaying into $\Sigma^0 \pi^+$. CRENNELL 69 give counter arguments to show that this is not the case in their data and the controversy goes on. AMMANN 70 studied the same reaction at 4.5 GeV/c and report a state at 1640 MeV, again decaying only into $\Lambda\pi$ (no evidence seen in $\Sigma\pi$ or $\bar{K}N$ 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 $\Sigma(1620)$ we have to wait for more data and for a complete understanding of the entire mass region 1600 to 1700 MeV. The hope is that the determination of quantum numbers for each of these effects for each decay mode may eventually clarify the situation.

$\Sigma(1620)$ PRODUCTION EXPERIMENTS

SEE THE MINI-REVUE AT THE START OF THE Y^* LISTINGS,

THIS RESONANCE NEEDS CONFIRMATION. THE RESULTS OF CRENNELL 69 AT 3.0 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 $Y^*(1670)$. SEE MILLER 70 FOR A REVIEW OF THESE CONFLICTS.

THERE WAS AN INDICATION OF A $Y^*(1610)$ 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. HOWEVER 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.)

78 $Y^*(1620)$ MASS (MEV)							
M	N	(1616.0)	(8.0)	CRENNELL 68 DBC	+-	K-D 3.9 GEV/C	11/68
M	N	20 1618.0	3.0	BLUMENFELD 69 HBC	+	K-D LONG + PROTON	9/69
M	N	1619.0	8.0	CRENNELL 69 DBC	+-	K-N TO LAM 3 PI	9/69
M	N	1642.0	12.0	AMMANN 70 DBC		K-P 4.5 GEV/C	6/70*
M	N	1619.4	3.8	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)			

78 $Y^*(1620)$ WIDTH (MEV)							
W	N	(66.0)	(16.0)	CRENNELL 68 DBC	+-	SEE NOTE N ABOVE	11/68
W	N	20 30.0	10.0	BLUMENFELD 69 HBC	+		9/69
W	N	72.0	22.0	CRENNELL 69 DBC	+-		9/69
W	N	55.0	24.0	AMMANN 70 DBC		K-P 4.5 GEV/C	6/70*
W	N	41.3	12.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)			
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED							

78 $Y^*(1620)$ PARTIAL DECAY MODES							
P1		$Y^*(1620)$ INTO $\bar{K}B\bar{A}R N$				DECAY MASSES	
P2		$Y^*(1620)$ INTO $\Lambda B D A \pi$				497+ 939	
P3		$Y^*(1620)$ INTO $Y^*(1385) \pi$				1115+ 139	
P4		$Y^*(1620)$ INTO $\Lambda B D A \pi \pi$				1385+ 139	
P5		$Y^*(1620)$ INTO $\Sigma \pi \pi$				1115+ 139+ 139	
P6		$Y^*(1620)$ INTO $Y^*(1405) \pi$				1174+ 139	
						1405+ 139	

78 $Y^*(1620)$ BRANCHING RATIOS							
R1		$Y^*(1620)$ INTO $(\Lambda B D A \pi \pi) / (\Lambda B D A \pi)$				(P4)/(P3)	
R1		14 (2.5) APPROX		BLUMENFELD 69 HBC	+		
R2		$Y^*(1620)$ INTO $(\bar{K}B\bar{A}R N) / (\Lambda B D A \pi)$		CRENNELL 68 DBC	+	(P1)/(P2)	
R2		(0.0) (0.1)		AMMANN 70 DBC			6/70*
R3		$Y^*(1620)$ INTO $\Lambda B D A \pi$		CRENNELL 68 DBC	+-	(P2)	11/68
R3		LARGE					
R4		$Y^*(1620)$ INTO $(Y^*(1385) \pi) / (\Lambda B D A \pi)$		CRENNELL 68 DBC	+-	(P3)/(P2)	11/68
R4		(0.2) (0.1)		AMMANN 70 DBC			6/70*
R4		(0.31) (95 PC UPPER LIMIT)				K-P 4.5 GEV/C	
R5		(1.1) (95 PC UPPER LIMIT)		AMMANN 70 DBC		K-P 4.5 GEV/C	6/70*
R5		$Y^*(1620)$ INTO $(\Sigma \pi \pi) / (\Lambda B D A \pi)$				(P5)/(P2)	
R6		$Y^*(1620)$ INTO $(Y^*(1405) \pi) / (\Lambda B D A \pi)$		AMMANN 70 DBC		(P6)/(P2)	
R6		0.7 0.4				K-P 4.5 GEV/C	6/70*

REFERENCES -- $Y^*(1620)$

ARMENTEROS 68 NP 88 183
 CRENNELL 68 PRL 21 648
 BLUMENFELD 69 PL 298 58
 CRENNELL 69 LUND PAPER 183
 LEVISETT 69 LUND CONF
 TRIPP 69 UCRL 19361
 SABRE 70 NP 816 201
 AMMANN 70 PRL 24 327
 ARMENTEROS 70 DUKE 123
 MILLER 70 DUKE 229

ARMENTEROS, BAILLON + (CERN+HEID+SALAY)
 + DELANEY, FLAMINIO, KARSHON, + (BNL,CCNY) I
 BLUMENFELD, KALBFLEISCH (BNL) I
 + KARSHON, LAI, ONEIL, SCARR, + (BNL,CCNY) I
 ARE QUOTED IN LEVI SETTI 69.
 R LEVI SETTI (RAPPORTEUR) EFINS (LRL)
 R D TRIPP
 SABRE COLLAB. (SACL,AMST,BGNA,REHO,EPLD)
 + GARFINKEL, CARMONY, GUTAY, + (PURDUE,IND)
 ARMENTEROS, BAILLON + (CERN+HEID+SALAY)
 D H MILLER (REVIEW TALK) (PURDUE)

 END PRODUCTION EXPERIMENTS

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Note on Σ(1670)

Formation experiments show the presence of only one I = 1 state in this energy region with major decay modes into K̄N (9%), Λπ (10%), Σπ (40%) and a very small branching fraction into Σππ. 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 Σπ and Λ(1405)π]. The measured branching ratio R = Σπ/Σππ changes with the momentum transfer to the proton. This was first observed by EBERHARD 69 who suggested the existence of 2 Y₁* with the same mass and quantum numbers; one object with a large Σππ [mainly Λ(1405)π] decay mode produced peripherally, and another one with a large Σπ decay mode produced at larger angles. This observation has now been confirmed by AGUILAR-BENITEZ (70).

The other difficulty comes from the different Λπ/Σπ branching ratios reported by the various experiments. The possibility of a third Y₁* state with a large Λπ/Σπ 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 → Λπ⁺π⁻ and K⁻p → Σ⁰π⁺π⁻ that 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 note on Σ(1620).

Σ(1670)

D13

44 Y*(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-.

Table with columns for mass (MEV) and various decay channels like BERLEY 64 HBC, ARMENTER 68 HBC, etc.

Table with columns for width (MEV) and various decay channels like BERLEY 64 HBC, ARMENTER 68 HBC, etc.

Table with columns for partial decay modes and decay masses like INTO KBAR N, INTO LAMBDA PI, etc.

Table with columns for branching ratios and various decay channels like INTO (KBAR N)/TOTAL, INTO (SIGMA PI PI)/TOTAL, etc.

Table with columns for branching ratios and various decay channels like INTO (SIGMA PI PI)*(KBAR N)/TOTAL**2, INTO (Y*(1385)PI)*(KBAR N)/TOTAL**2, etc.

REFERENCES -- Y*(1670)
BERLEY 64 DUBNA CONF I 565 +CONNOLLY,HART,RAHM,STONEHILL, + (BNL)JP
ARMENTER 68 NP 88 195 ARMENTEROS,BAILLON + (CERN+HEID+SACLAY)JP

PAPERS NOT REFERRED TO IN DATA CARDS.
BASTIEN1 63 PRL 10 188 P L BASTIEN, J P BERGE (LRL) IJ
BASTIEN2 63 UCRL-10779 THESIS P L BASTIEN (LRL) IJ

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Σ(1670) PRODUCTION EXPERIMENTS

SEE NOTE PRECEDING Y*1(1670)
PROBABLY THERE ARE TWO STATES AT SAME MASS WITH SAME
QUANTUM NUMBERS, ONE DECAYING INTO SIGMA PI AND LAMBDA
PI, THE OTHER INTO Y*0(1405) PI. BRANCHING RATIOS NOT
DISENTANGLED YET, WE LIST THEM TOGETHER FOR NOW.

Table with columns for mass (MEV), production, and various experimental parameters for Σ(1670).

Table with columns for width (MEV), production, and various experimental parameters for Σ(1670).

Table with columns for branching ratios, production, and experimental parameters for Σ(1670).

Table with columns for width (MEV), production, and experimental parameters for Σ(1670).

Table with columns for width (MEV), production, and experimental parameters for Σ(1670).

Table with columns for width (MEV), production, and experimental parameters for Σ(1670).

Table with columns for width (MEV), production, and experimental parameters for Σ(1670).

44 Y*1(1670, JP=3/2-) I=1 D13

Table with columns for quantum number determination, JP, and experimental parameters for Σ(1670).

REFERENCES -- Y*1(1660) PROD. EXPERIMENTS

Table listing references for Y*1(1660) production experiments, including authors and publication details.

REFERENCE FOR QUANTUM NUMBERS

LEVEQUE 65 PL 18 69 + (SACLAY,EP,GLASGOW,IMPCOL,OXF,RTHF01 JP
LEE 66 PFL 17 45 Y Y LEE, D D REEDER, R W HARTUNG (WISC) JP

PAPERS NOT REFERRED TO IN DATA CARDS

EBERHARD 67 PR 163 1446 *PRIPSTEIN,SHIVELY,KRUSE,SWANSON (LRL,ILL)JP

Σ(1690)

58 Y*1(1690, JP=) I=1

SEE THE MINI-REVEU AT THE START OF THE Y* LISTINGS.

SEE NOTE PRECEDING Y*1(1660) LISTINGS, SEEN IN PRO.
EXPERIMENTS ONLY, MAIN DECAY MODE IS LAMBDA PI.

58 Y*1(1690) MASS (MEV)

Table with columns for mass (MEV), production, and various experimental parameters for Σ(1690).

58 Y*1(1690) WIDTH (MEV)

Table with columns for width (MEV), production, and various experimental parameters for Σ(1690).

58 Y*1(1690) PARTIAL DECAY MODES

Table with columns for partial decay modes, production, and experimental parameters for Σ(1690).

58 Y*1(1690) BRANCHING RATIOS

Table with columns for branching ratios, production, and experimental parameters for Σ(1690).

REFERENCES -- Y*1(1690)

Table listing references for Y*1(1690) production experiments, including authors and publication details.

PAPERS NOT REFERRED TO IN DATA CARDS

AGUILAR 70 PRL 25 58 AGUILAR-BENITEZ,BARNES,BASSANO+ (BNL+SYR)

END Y*1(1670) PRODUCTION EXPERIMENTS

Σ(1750)

57 Y*1(1750, JP=1/2-) I=1

S11

SEE THE MINI-REVEU AT THE START OF THE Y* LISTINGS.

THERE IS NOW EVIDENCE IN THREE CHANNELS FOR AN S11 RESONANCE NEAR THIS ENERGY. INTERPRETATION OF THE SIGMA ETA THRESHOLD BUMP ON ITS OWN MERITS IS NOT CONCLUSIVE (CLINE 67) -- MORE DATA ARE NEEDED. BUT BY ANALOGY WITH THE SIMILAR N ETA AND LAMBDA ETA THRESHOLD EFFECTS, WHICH ARE ALMOST CERTAINLY RESONANCES, IT SEEMS VERY LIKELY THAT THIS TOO IS A RESONANCE. SEE THE RAPPORTEUR TALKS OF FERRO LUZZI 66 AND MEYER 67 FOR DISCUSSIONS.

IN THE ENERGY-INDEPENDENT PARTIAL WAVE ANALYSIS OF K- N TO LAMBDA PI, THE S11 AMPLITUDE APPEARS TO RESONATE (ARMENTEROS 69). IN 1968 IT APPEARED TO RESONATE NEAR 1650 MEV (ARMENTEROS 68), AND WAS LISTED HEREIN AS A SEPARATE STATE. NOW IT HAS MOVED CLOSE ENOUGH TO THE OTHER EFFECTS TO BE TENTATIVELY LISTED WITH THEM, BUT THE SIZE OF THE CHANGE IN THE MASS SHOULD BE A HEALTHY WARNING THAT THE PARAMETERS GIVEN FOR RESONANCES IN LOWER PARTIAL WAVES FROM SUCH ANALYSES ARE SUBJECT TO LARGE CHANGE. (ARMENTEROS 70, FROM WHICH THE RESONANCE PARAMETERS ARE QUOTED, IS A SLIGHT UPDATING OF ARMENTEROS 69.)

THERE IS WEAKER EVIDENCE FOR THIS RESONANCE IN AN ENERGY-DEPENDENT PARTIAL-WAVE ANALYSIS OF ELASTIC AND CHARGE-EXCHANGE SCATTERING (CONFORTO 69). THE ERRORS GIVEN FOR THIS SHOULD NOT BE TAKEN SERIOUSLY. THEY ARE STATISTICAL ONLY, AND DO NOT REFLECT THE LARGE SYSTEMATIC ERRORS THAT CAN RESULT FROM THE RESTRICTIVE PARAMETRIZATION FORCED ON THE PARTIAL WAVES.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Table with columns for mass (MEV) and branching ratios for Y*(1765). Includes entries for NEAR SIGMA ETA THRESHOLD and ABOUT 1750.0.

Table with columns for width (MEV) and branching ratios for Y*(1765). Includes entries for ABOUT 50 and ABOUT 80.0.

Table with columns for partial decay modes and decay masses for Y*(1765). Includes entries for INTO KBAR N and INTO SIGMA PI.

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (KBAR N)/TOTAL and INTO (SIGMA PI)/(KBAR N).

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (KBAR N)*(SIGMA PI)/TOTAL**2.

REFERENCES -- Y*(1765)
FERRO-LU 66 BERKELEY CONF 133 M FERRO LUZZI (RAPPORTEUR) (CERN)
CLINE 67 PL 25B 41 CLINE, OLSSON (WISCONSIN)IJP
MEYER 67 HEIDELBERG C 117 J MEYER (RAPPORTEUR) (SACLAY)IJP

REFERENCES -- Y*(1765)
FERRO-LU 66 BERKELEY CONF 133 M FERRO LUZZI (RAPPORTEUR) (CERN)
CLINE 67 PL 25B 41 CLINE, OLSSON (WISCONSIN)IJP
MEYER 67 HEIDELBERG C 117 J MEYER (RAPPORTEUR) (SACLAY)IJP
ARMENTER 68 NP B8 183 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
CONFORTO 70 210-281(SUB NP) +HARMSEN+LASINSKI++ (CERN,HEIDEL,SACLAY)IJP
ARMENTER 70 DUKE 123 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP

Table with columns for mass (MEV) and branching ratios for Y*(1765). Includes entries for 1765.0 and 1755.0.

Table with columns for width (MEV) and branching ratios for Y*(1765). Includes entries for 10.0 and 20.0.

(SEE IDEOGRAM BELOW)
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

WEIGHTED AVERAGE = 113.5 ± 0.0
ERROR SCALED BY 2.9

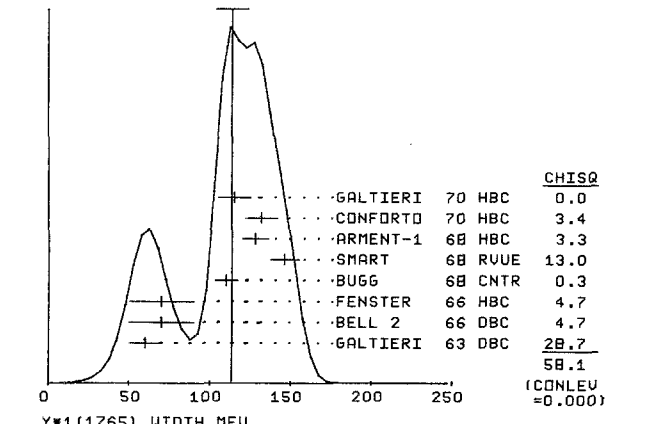


Table with columns for partial decay modes and decay masses for Y*(1765). Includes entries for INTO KBAR N and INTO SIGMA PI.

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (KBAR N)/TOTAL and INTO (SIGMA PI)/(KBAR N).

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (LAMBDA PI)*(KBAR N)/TOTAL**2.

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (LAMBDA PI)*(KBAR N)*(SIGMA PI)/TOTAL**2.

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (Y*(1520) PI)*(KBAR N)/TOTAL**2.

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (Y*(1385) PI)*(KBAR N)/TOTAL**2.

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (SIGMA PI)*(KBAR N)/TOTAL**2.

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (LAMBDA PI)/(KBAR N).

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (Y*(1520)/(KBAR N).

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (Y*(1385)/(KBAR N).

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (SIGMA PI)/(KBAR N).

Table with columns for branching ratios and decay masses for Y*(1765). Includes entries for INTO (SIGMA PI) PI)/TOTAL.

Fitted Partial Decay Mode Branching Fractions
Diagonal elements are P_i ± delta P_i; delta P_i = sqrt(<delta P_i^2>). Off-diagonal elements are correlation coefficients = <delta P_i delta P_j> / (delta P_i delta P_j).

Table showing fitted partial decay mode branching fractions. Columns are P 1 through P 6. Values range from -0.436 to 0.136.

REFERENCES -- Y*(1765)

GALTIERI 63 PL 6 296 A BARBARO-GALTIERI, A HUSSAIN, RD TRIPP (LRL)IJP
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)IJP
ARMENTEZ 67 ZEIT-PHYS.202,486 ARMENTEROS, FERRO-LUZZI+ (CERN,HEID,SACLAY)IJP
UHLIG 67 PR 155 1448 +CHARLTON,CONDON,GLASSER,YODH,+ (MD,USNR)I

REFERENCES -- Y*(1765)
GALTIERI 63 PL 6 296 A BARBARO-GALTIERI, A HUSSAIN, RD TRIPP (LRL)IJP
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)IJP
ARMENTEZ 67 ZEIT-PHYS.202,486 ARMENTEROS, FERRO-LUZZI+ (CERN,HEID,SACLAY)IJP
UHLIG 67 PR 155 1448 +CHARLTON,CONDON,GLASSER,YODH,+ (MD,USNR)I
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
CONFORTO 68 NP B8 265 +HARMSEN, LASINSKI, + (CHICAGO,HEIDEL)IJP
SIMS 68 PRL 21 1413 SIMS,ALBRIGHT,BARTLEY,HEER+ (FLC,TAFTS+BRAF)I
SMART 68 PR 169 1330 W N SMART (LRL)IJP
CONFORTO 70 EFI 70-28(SUB NP) +HARMSEN+LASINSKI++ (LEF+HEID)IJP
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Σ(1880)

67 Y*(1880, JP=1/2+) I=1
SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.
NEEDS CONFIRMATION. OMITTED FROM TABLE.
67 Y*(1880) MASS (MEV)
M N [1882.0] (40.0) SMART 68 RVUE 0- K-N TO LAMBDA PI 7/68
M ABOUT 1850.0 ARMENTERO 70 HBC 0- ELASTIC, CH EX 6/70*

F11

REFERENCES -- Y*(1915)
ARMENTERO 67 PL 24B 198 ARMENTEROS,FERRO-LUZZI+ (CERN,HEID,SACLAY)
ARMENTE1 67 NP 83 592 ARMENTEROS,FERRO-LUZZI+ (CERN,HEID,SACLAY)
CONFORTO 68 EFI 68-62 NP TBP. B.CONFORTO,HARMSSEN+BURKHARDT+ (EFINS+HEID)
SMART 68 PR 169 1330 W M SMART (LRL)
DAUM 68 NP 87 19 +ERNE,LAGNANU,SENS,STEVEUR,UDO (CERN)JP

DECAY MASSES
P1 Y*(1880) INTO KBAR N 497+ 939
P2 Y*(1880) INTO LAMBDA PI 1115+ 134

67 Y*(1880) BRANCHING RATIOS
R1 Y*(1880) INTO (KBAR N)/TOTAL (P1)/TOTAL
R1 ABOUT 0.2 ARMENTERO 70 HBC 0- ELASTIC, CH EX 6/70*

REFERENCES -- Y*(1880)
SMART 68 PR 169 1330 W M SMART (LRL)JP
ARMENTERO 70 DUKE CNF PAPER ARMENTEROS, BAILLON, + (CERN,HEIDEL)JP
LITCHFIE 70 RHEL RPP/H/66 P J LITCHFIELD (RHEL)JP
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)JP

Σ(1910)

46 Y*(1915, JP=5/2+) I=1
SEE THE MINI-REVIEW AT START OF Y* LISTING
FORMATION EXPERIMENTS PRESENT GOOD EVIDENCE FOR IT-
PRODUCTION EXPERIMENTS SEE A STATE AT THIS MASS, OF
UNKNOWN QUANTUM NUMBERS-- SEE LISTING OF PRODUCTION
EXPERIMENTS BELOW-
46 Y*(1915) MASS (MEV)

F15

46 Y*(1915) WIDTH (MEV)
W A (50.0) (20.0) ARMENTERI 67 HBC OK-P EL. +CH-EXC. 11/67
W A LACK OF DATA PREVENTS AUTHORS FROM DETERMINING UNAMBIG THIS AMPLITU. 11/67

DECAY MASSES
P1 Y*(1915) INTO KBAR N 497+ 939
P2 Y*(1915) INTO LAMBDA PI 1115+ 139
P3 Y*(1915) INTO SIGMA PI 1197+ 139

46 Y*(1915) BRANCHING RATIOS
R1 Y*(1915) INTO (KBAR N)/TOTAL (P1)/TOTAL
R1 A (0.12) (0.01) ARMENTERI 67 HBC 0 K-P EL. +CH-EXC. 11/67
R1 A LACK OF DATA PREVENTS AUTHORS FROM DETERMINING UNAMBIG THIS AMPLITU. 11/67

WHERE EXPLICIT, THE SIGN IS IN THE LEVI SETTI CONVENTION.
SEE THE NOTE AT THE START OF THE Y* LISTINGS.
R3 Y*(1915) INTO (SIGMA PI)*(KBAR N)/TOTAL**2 (P1*P3)/TOTAL**2
R3 A (0.00) (0.01) ARMENTERO 67 HBC K-P TO SIG+PI+ 11/67

1900 MEV REGION - PRODUCTION AND TOTAL EXPERIMENTS

29 Y*(1900) PRODUCTION EXPERIMENTS
THE QUANTUM NUMBERS OF THE EFFECT SEEN IN THESE EXPERIMENTS ARE NOT KNOWN -
29 Y*(1900) MASS (MEV) PROD. EXP.

M (1942.0) (19.0) BOCK 65 HBC PBAR P 5.7 BEV/C
M 1915.0 20.0 COOL 66 CNTR 0- K-P, D TOTAL 7/66
M 1905.0 5.0 BUGG 68 CNTR K-P, D TOTAL 11/66

29 Y*(1900) WIDTH (MEV) PROD. EXP.
W (36.0) (20.0) (36.0) BOCK 65 HBC 65 HBC 7/66
W (65.0) (0) COOL 66 CNTR 0- 11/66
W 60.0 10.0 BUGG 68 CNTR 11/66

29 Y*(1900) BRANCHING RATIOS PROD. EXP.
R1 Y*(1900) INTO (KBAR N)/TOTAL PRODUC. EXP.
R1 RATIOS CALCULATED ASSUMING J=5/2
R1 (0.103) COOL 66 CNTR ASSUMING J=5/2 7/66

REFERENCES -- Y*(1900)-- PROD. EXPERIMENTS
BOCK 65 PL 17 166 +COOPER,FRENCH,KINSON, + (CERN,SACLAY) I
COOL 66 PRL 16 1228 +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
KYCIA 67 PRIVATE COMM. T F KYCIA (BNL) I

Σ(1940)

D13

98 Y*(1940, JP=3/2-) I=1
THIS STATE IS SUGGESTED BY THE PARTIAL-WAVE ANALYSIS
OF K-N TO SIGMA PI AND TO LAMBDA PI. PERHAPS IT
IS ASSOCIATED WITH THE EFFECTS SEEN NEAR THIS MASS IN
PRODUCTION EXPERIMENTS.

98 Y*(1940) MASS (MEV)
M 1940.0 30.0 LITCHFIEL 70 RVUE K-N TO LAM PI 6/70*
M 1940.0 40.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

98 Y*(1940) WIDTH (MEV)
W 280.0 40.0 LITCHFIEL 70 RVUE K-N TO LAM PI 6/70*
W 200.0 50.0 GALTIERI 70 HBC 0 LAM PI,EDPWA 7/70*

98 Y*(1940) PARTIAL DECAY MODES
DECAY MASSES
P1 Y*(1940) INTO KBAR N 497+ 939
P2 Y*(1940) INTO LAMBDA PI 1115+ 139
P2 Y*(1940) INTO SIGMA PI

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

98 Y*1(1940) BRANCHING RATIOS
R1 Y*1(1940) INTO (KBAR N)*(LAMBDA PI)/TOTAL**2 (P1*P2)/TOTAL**2
R1 -0.0196 0.0084 LITCHFIEL 70 RVUE K- N TO LAM PI 6/70*
R1 -0.014 0.010 GALTIERI 70 HBC 0 LAM PI,EDPWA 7/70*

REFERENCES -- Y*1(1940)
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP
LITCHFIE 70 RHEL RPP/H/66 P J LITCHFIELD (RHEL)IJP

Sigma(2030)

47 Y*1(2030, JP=7/2+) I=1 F17
SEE THE MINI-REVIEW AT START OF Y* LISTING
WOHL 66, SMART 68, AND DAUM 68 FIND JP=7/2+.

47 Y*1(2030) MASS (MEV)
W (2030.0) (20.0) WOHL 66 HBC 0 K-P TO LAM PIO 7/66
M (2052.0) (5.0) SMART 68 RVUE K-N TO LAM PI 6/68
M N 2000.0 20.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

N LITCHFIELD 70 INCLUDES DATA USED BY WOHL, SMART, AND COX.

47 Y*1(2030) WIDTH (MEV)
W (170.0) (16.0) WOHL 66 HBC 0 7/66
W N (160.0) (16.0) SMART 68 RVUE INCLUDES WOHL 66 6/68
W 100.0 40.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*

47 Y*1(2030) PARTIAL DECAY MODES
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

47 Y*1(2030) BRANCHING RATIOS
R1 Y*1(2030) INTO (KBAR N)/TOTAL (P1)/TOTAL
R1 (0.25) (0.11) WOHL 66 HBC 0 K-P CH EX 7/66
R1 (.11) DAUM 68 CNTR K-P,ELA. TOT,PWA 7/70*

47 Y*1(2030) PARTIAL DECAY MODES
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

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)
BURSON 68 NP 88 447 +MEYER,PAULI,TALLINI + (SACL+CDF+RHEL)
DAUM 58 NP B7 19 +ERNE, LAGNAUX, SENS, STEUER, UDD (CERN)IJP
SMART 68 PR 169 1336 W M SMART (LRL)IJP
MULLER 69 THESIS,UCRL 19372 R A MULLER (LRL)
BERTHON 70 PREPRINT RPP/H/60 +RANGAN,VRANA,BUTTERWORT (CDF+RHEL+SCLAY)IJP
COX 70 NP 819 61 +ISLAM, COLLEY, + (BIRM,EDIN,GLAS,LOIC)IJP
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP
LITCHFIE 70 RHEL RPP/H/66 P J LITCHFIELD (RHEL)IJP

Sigma(2080)

88 Y*1(2080, JP=3/2+) I=1 P13
SEE THE MINI-REVIEW AT THE START OF THE Y* LISTINGS.
THIS STATE IS SUGGESTED IN THE PARTIAL-WAVE ANALYSES OF K- N TO LAMBDA PI, BUT NEEDS TO BE CONFIRMED.

88 Y*1(2080) MASS (MEV)
M N (2082.0) (4.0) COX 70 DBC - K-N TO LAM PI- 6/70*
M N 2070.0 30.0 LITCHFIEL 70 RVUE K- N TO LAM PI 6/70*
N LITCHFIELD 70 INCLUDES DATA USED BY COX 70.

88 Y*1(2080) WIDTH (MEV)
W N (87.0) (23.0) COX 70 DBC - K-N TO LAM PI- 6/70*
W N 750.0 40.0 LITCHFIEL 70 RVUE K- N TO LAM PI 6/70*

88 Y*1(2080) PARTIAL DECAY MODES
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) INTO (KBAR N)*(LAMBDA PI)/TOTAL**2 (P1*P2)/TOTAL**2
R1 N (-0.0256) (0.0096) COX 70 DBC - K-N TO LAM PI- 0 6/70*
R1 N -0.0081 0.0054 LITCHFIEL 70 RVUE K- N TO LAM PI 6/70*

REFERENCES -- Y*1(2080)
COX 70 NP 819 61 +ISLAM, COLLEY, + (BIRM,EDIN,GLAS,LOIC)IJP
LITCHFIE 70 RHEL RPP/H/66 P J LITCHFIELD (RHEL)IJP

Sigma(2130)

26 Y*1(2130, JP=7/2-) I=1 G17
SEE THE MINI-REVIEW AT START OF Y* LISTING

26 Y*1(2130) MASS (MEV)
M 2120.0 30.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
M 2060.0 20.0 GALTIERI 70 HBC 0 LAM PI,EDPWA 7/70*
M
M AVG 2078.5 27.7 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

26 Y*1(2130) WIDTH (MEV)
W 135.0 30.0 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
W 70.0 30.0 GALTIERI 70 HBC 0 LAM PI,EDPWA 7/70*
W
W AVG 102.5 32.5 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

26 Y*1(2130) PARTIAL DECAY MODES
P1 Y*1(2130) INTO KBAR N 497+ 939
P2 Y*1(2130) INTO SIGMA PI 1197+ 139

26 Y*1(2130) BRANCHING RATIOS
R1 Y*1(2130) INTO (SIG PI)*(KBAR N)/TOTAL**2 (P2*P1)/TOTAL**2
R1 0.017 0.005 GALTIERI 70 HBC 0 SIG PI,EDPWA 7/70*
R2 0.0049 0.003 GALTIERI 70 HBC 0 LAM PI,EDPWA 7/70*

REFERENCES -- Y*1(2130)
GALTIERI 70 DUKE 173 A. BARBARO GALTIERI (LRL)IJP

2100 MEV REGION - PRODUCTION AND TOTAL EXPERIMENTS

28 Y*1(2000) PRODUC. EXPER.
THE BUMP SEEN AT THIS MASS IN TOTAL CROSS SECTION EXPER. CONTAINS BOTH THE G07 AND F07 STATES ABOVE-

28 Y*1(2000) MASS (MEV) PROD. EXP.
M (2022.0) (20.0) BLANPIED 65 CNTR 0 GAMMA P TO K+ Y*
M 2026.0 19.0 KYCIA 67 CNTR K-P, D TOTAL 8/67
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*

28 Y*1(2000) WIDTH (MEV) PROD. EXP.
W (120.0) (20.0) BLANPIED 65 CNTR 0
W 120.0 7.0 KYCIA 67 CNTR 8/67
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*

28 Y*1(2000) BRANCHING RATIOS PROD. EXP.
R1 0.105 0.005 KYCIA 67 CNTR 8/67
R1 (0.131) BUGG 68 CNTR 6/68
R1 0.27 0.02 BRICMAN 70 CNTR 0 TOTAL AND CH EX 6/70*

REFERENCES --Y*1(2000)-- PROD. EXPERIMENTS
BLANPIED 65 PRL 14 741 +GREENBERG,HUGHES,KITCHING,LU,+ (YALE,CFA)
COOL 66 PRL 16 1228 +GIACOMELLI,KYCIA,LEONTIC,LILUNDBY,+ (BNL) I
-- SLIGHTLY REVISED RESULTS FROM KYCIA 67 REPLACE COOL 66 --
KYCIA 67 PRIVATE COMM. T F KYCIA (BNL) I
BUGG 68 PR 158 1445 +GILMORE,KNIGHT, + (RTHFD,BRMSHM,CVNSH) I
BRICMAN 70 PL 318 152 +FERRO LUZZI, PERREAU, + (CERN,CAEN,SACLAY)

Sigma(2250)

48 Y*1(2250, JP=) I=1
SEE THE MINI-REVIEW AT START OF Y* LISTING
BRICMAN 70 ASSUMES JP=7/2-, GALTIERI 70 ASSUMES JP=9/2

48 Y*1(2250) MASS (MEV)
M (2245.0) (16.0) BLANPIED 65 CNTR GAMMA P TO K+ Y*
M (2299.0) (16.0) BOCK 65 HBC PBAR P 5.7 BEV/C
M 2252.0 10.0 KYCIA 67 CNTR K-P, D TOTAL 8/67
M 2250.0 7.0 BUGG 68 CNTR K-P, D TOTAL 6/68
M 42 2280. 20. BARNES 69 HBC + K-P 3.9,5. GEV/C 10/69

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

Table with columns for particle name, mass, width, and experimental details. Includes entries for BRICMAN 70 CNTR 0 and AGUILAR 70 HBC + K-P 4 GEV/SIG.PI.

Table for Y*(2250) PARTIAL DECAY MODES, listing decay masses and branching ratios for various decay channels.

Table for Y*(2250) BRANCHING RATIOS, providing detailed branching ratios and references for various decay modes.

Table for Y*(2250) INTO (KBAR N)/(SIG PI) and Y*(2250) INTO (LAMBDA PI)/(SIG PI), listing experimental data and references.

REFERENCES -- Y*(2250)
BLANPIED 65 PRL 14 741
BOCK 65 PL 17 166
CDOL 66 PR 16 1228
...
DAUBER 66 PL 23 154

Σ(2455)

Table for Σ(2455) MASS (MEV), WIDTH (MEV), and PARTIAL DECAY MODES, listing experimental data and averages.

Table for Σ(2455) BRANCHING RATIOS, listing branching ratios and references for various decay channels.

REFERENCES -- Y*(2455)
ABRAMS 67 PRL 19 678
BUGG 68 PR 168 1466
GREENBER 68 PR 20 221
BRICMAN 70 PL 31B 152

Σ(2595)

Table for Σ(2595) MASS (MEV), WIDTH (MEV), and PARTIAL DECAY MODES, listing experimental data and averages.

REFERENCES -- Y*(2595)
ABRAMS 67 PRL 19 678
BRICMAN 70 PL 31B 152

Σ(3000)

Table for Σ(3000) MASS (MEV), PARTIAL DECAY MODES, listing experimental data and averages.

REFERENCES -- Y*(3000)
EHRlich 66 PR 152 1194
R EHRlich, W SELOVE, H YUTA (PENNBNL) I

EXOTIC HYPERONS CROSS SECTION LIMITS (MICROBARN)

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-PI0 7/70*
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-PI0 7/70*
CR A ABOVE LIMIT FOR MASS LT 2.3 GEV AND GAMMA LT 120 MEV- (2.7 GEV/C K-) 7/70*

Note on Σ States

The cross sections for these states are very low (< 50 μb); therefore, the statistics available are quite small.

As a general policy of this compilation we list all the reported results on a state in order to provide the reader with references for every claim of a peak or a branching ratio. What we report in the main tables is only what we judge relevant or significant.

In view of the low statistics available for Σ states we have lowered our significance test to 4 standard deviations.

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

As for $\Xi(1820)$, we have listed together every experiment giving results in this mass region. BMST 70 claim that more than one state is present here. It is not clear at the moment of what nature the complexity is. Figure 1 shows a plot of the measured masses and widths for each of the reported decay modes. We keep them together until a clear separation is achieved.

Table I is our evaluation of the evidence for the various Ξ states.

STATUS OF THE Ξ RESONANCES. THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE MAIN BARYON TABLE.

STATUS AS SEEN IN --							
PARTICLE	LIJ	OVERALL STATUS	XI PI	LAM K	SIG K	XI* PI	OTHER CHANNELS
$\Xi(1530)$	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 Ξ^- (1321, JP=1/2) I=1/2
SEE LISTINGS OF STABLE PARTICLES

Ξ^0

23 Ξ^0 (1314, JP=1/2) I=1/2
SEE LISTINGS OF STABLE PARTICLES

$\Xi(1530)$

49 $\Xi(1530)$ (1530, JP=3/2+) I=1/2 **P13**
THIS IS THE ONLY WELL-UNDERSTOOD Ξ .

49 $\Xi(1530)$ MASS (MEV)								
M	(1529.0)	(5.0)	PJERROU	62 HBC	0-	K-P 1.8 BEV/C		
M	(1532.0)	(2.0)	BADIER	64 HBC	0-	K-P 3 BEV/C		
M	1535.7	3.2	LONDON	66 HBC	-	K-P 2.24 BEV/C	7/66	
M	1528.7	1.1	LONDON	66 HBC	0		7/66	
49 $\Xi(1530)$ MASS DIFFERENCE (MEV)								
D	5.7	3.0	PJERROU	65 HBC	0-	K-P 1.8-1.95 B/C	7/66	
D	(7.0)	(4.0)	LONDON	66 HBC	0-		7/66	
REDUNDANT WITH DATA IN MASS LISTING.								
D	2.0	3.2	MERRILL	66 HBC	0-	K-P 1.7-2.7 BEV/C	7/66	
D	4.0	2.2	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
49 $\Xi(1530)$ WIDTH (MEV)								
M	7.0	2.0	SCHLEIN	63 HBC	0	K-P 1.8-1.95 B/C		
M	8.5	3.5	LONDON	66 HBC	0		7/66	
M	7.0	7.0	BERGE	66 HBC	0	K-P 1.5-1.7 BEV/C	7/66	
M	7.3	1.7	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)					
49 $\Xi(1530)$ PARTIAL DECAY MODES								
P1	$\Xi(1530)$ INTO Ξ PI			DECAY MASSES 1321+ 139				
OTHER STRONG DECAYS ARE FORBIDDEN BY ENERGY CONSERVATION.								

REFERENCES -- $\Xi(1530)$
PJERROU 62 PRL 9 114 +PRAWSE, SCHLEIN, SLATER, STORK, TICH0 (UCLA) I
SCHLEIN 63 PRL 11 167 +CARMONY, PJERROU, SLATER, STORK, TICH0 (UCLA) IJP
BADIER 64 DUBNA I 593 +DEMOULIN, GOLDBERG, + (EP, SACLAY, AMSTR) I
PJERROU 65 PRL 14 275 +SCHLEIN, SLATER, SMITH, STORK, TICH0 (UCLA)
LONDON 66 PR 143 1034 +RAU, SAMIOS, YAMAMOTO, GOLDBERG, + (BNL, SYCR) I
BERGE 66 PR 147 945 +EBERHARD, HUBBARD, MERRILL, B-SHAFER, + (LRL) I
MERRILL 66 UGRL-16435 THESIS D W MERRILL (LRL) JP
SHAFER 66 PR 142 883 BUTTON-SHAFER, LINDSEY, MURRAY, SMITH (LRL) JP
-- A SPIN-PARITY DETERMINATION.

$\Xi(1630)$

21 $\Xi(1630)$ (1630, JP=) I=1/2
SEE THE MINIREVIEW PRECEDING $\Xi(1530)$

21 $\Xi(1630)$ MASS (MEV)							
M	(1628.0)	(5.0)	APSELL	69 HBC	0	K-P 2.87 GEV/C	9/69
M	PROBABLY SEEN		BARTSCH	69 HBC	0	K-P 10 GEV/C	10/69
M	40 1635.	10.	BMST	70 HBC	0	INTO Ξ^- PI+	7/70
OLD VALUES, LATEST MASS AND WIDTH REPORTED IN BMST 70							
BARTSCH 69 SEE A BROAD ENHANCEMENT NEAR 1650 MEV - NOT CLEAR IF IT IS THE SAME PHENOMENA AS THE BMST 70 BUMP -							
21 $\Xi(1630)$ WIDTH (MEV)							
W	(15.0)	(5.0)	APSELL	69 HBC	0		9/69
W	40	57.	18.	BMST	70 HBC	0	
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED							

21 $\Xi(1630)$ PARTIAL DECAY MODES
P1 $\Xi(1630)$ INTO Ξ PI DECAY MASSES 1321+ 139
REFERENCES -- $\Xi(1630)$
APSELL 69 PRL 23 884 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
BARTSCH 69 PL 288 439 + (AACHEN, BERLIN, CERN, LONDON, VIENNA) I
BMST 70 DUKE 317 BRANDEIS+MARYLAND+SYRACUSE+TUFTS COLLAB.

$\Xi(1700)$

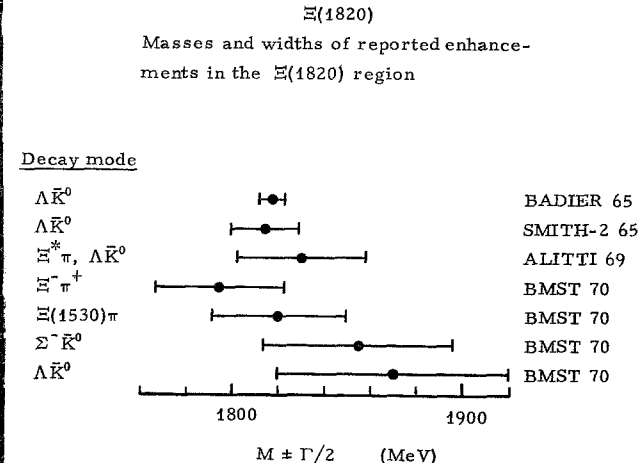
51 $\Xi(1700)$ (1700, JP=) I=1/2
SEE THE MINIREVIEW PRECEDING $\Xi(1530)$
THIS RESONANCE IS NO LONGER THOUGHT TO EXIST.

51 $\Xi(1700)$ MASS (MEV)							
M	(1705.0)		APPROX	SMITH	65 HBC	0-	K-P 2.1--7 BEV/C
51 $\Xi(1700)$ WIDTH (MEV)							
W	(20.0)		APPROX	SMITH	65 HBC	0-	
51 $\Xi(1700)$ PARTIAL DECAY MODES							
P1	$\Xi(1700)$ INTO Ξ PI			DECAY MASSES 1321+ 139			
P2	$\Xi(1700)$ INTO LAMBDA KBAR			1115+ 497			

REFERENCES -- $\Xi(1700)$
SMITH 65 ATHENS CONF 251 G A SMITH, J S LINDSEY (LRL) I

$\Xi(1820)$

50 $\Xi(1820)$ (1820, JP=) I=1/2
SEE THE MINIREVIEW PRECEDING $\Xi(1530)$
PROBABLY MORE THAN ONE STATE IS PRESENT IN THE 1800 TO 1900 MEV REGION UNTIL A CLEAR SEPARATION IS OBTAINED WE GROUP ALL THE DECAY MODES TOGETHER AND LIST THE REPORTED BRANCHING RATIOS.



See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

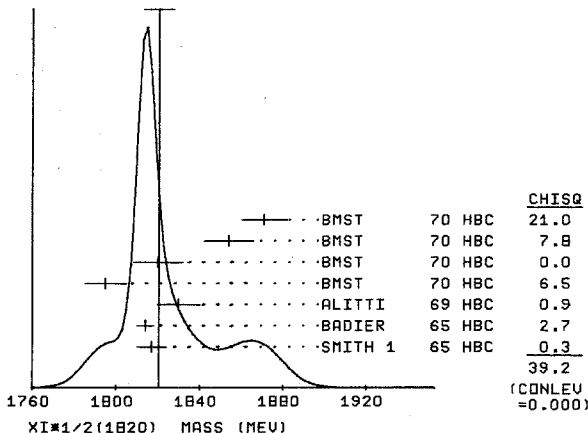
50 XI*1/2(1820) MASS (MEV)

M	(1770.0)		HALSTEINS	63 FBC	0-	K-FR 3.5 BEV/C	
M	1817.0	7.0	SMITH 1	65 HBC	0-	K-P 2.4-7 BEV/C	
M	1814.0	4.0	BADIER	65 HBC	0	K-P 3 BEV/C	
M	1830.0	19.0	ALITTI	69 HBC	-	K-P 3.9-5 BEV/C	9/69
M	(1801.0)	(13.0)	APSELL	69 HBC	0	XI PI	9/69
M	(1829.0)	(9.0)	APSELL	70 HBC	0-	XI(1530) PI	6/70*
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*

LATEST VALUES OF MASSES AND WIDTHS FROM THIS EXP. ARE IN BMST 70

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 1820.6 ± 7.2
ERROR SCALED BY 2.6



50 XI*1/2(1820) BRANCHING RATIOS

R1	XI*1/2(1820) INTO (LAMBDA KBAR)/TOTAL	(P1)/TOTAL	
R1	LARGE	BADIER 65 HBC	7/66
R1	LARGE	SMITH 2 65 HBC	7/66
R1	0.3	ALITTI 69 HBC	9/69
R2	XI*1/2(1820) INTO (XI PI)/TOTAL	(P2)/TOTAL	
R2	0.1	ALITTI 69 HBC	9/69
R3	XI*1/2(1820) INTO (SIGMA KBAR)/TOTAL	(P3)/TOTAL	
R3	(0.02) OR LESS	TRIPP 67 RVUE	8/67
R3	0.3	ALITTI 69 HBC	9/69
R4	XI*1/2(1820) INTO (XI*1/2(1530) PI)/TOTAL	(P4)/TOTAL	
R4	0.3	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	BADIER 65 HBC	7/66
R5	SMALL	SMITH 2 65 HBC	IF XI*1933 EXIST 7/66
R6	XI*1/2(1820) INTO (XI*1530) PI/(LAMBDA KBAR)	(P4)/(P1)	
R6	0.26	SMITH 1 65 HBC	
R6	SMALL	BADIER 65 HBC	7/66
R7	XI*1/2(1820) INTO (XI PI)/(LAMBDA KBAR)	(P5)/(P1)	
R7	(0.1) OR MORE	SMITH 1 65 HBC	
R7	SMALL	BADIER 65 HBC	7/66
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)/(XI(1530) PI)	(P5)/(P4)	
R9	0.3	0.5	APSELL 70 HBC 0 6/70*

REFERENCES -- XI*1/2(1820)

HALSTEIN 63 SIENA CONF 173 HALSTEINS ID., + BERGEN, CERN, EP, RTHF, UNICOL I
SMITH 1 65 PRL 14 25 + LINDSEY, BUTTON-SHAFER, MURRAY (LRL) JP
BADIER 65 PL 16 171 + DEMOULIN, GOLOBERG, + (EP, SACLAY, AMST) I
SMITH 2 65 ATHENS CONF 251 G A SMITH, J S LINDSEY (LRL)
TRIPP 67 NP 83 10 + LEITH, + (LRL, SLAC, CERN, HEIDEL, SACLAY)
MERRILL 68 PR 167 1202 D W MERRILL, J BUTTON-SHAFER (LRL)
-- WEAK EVIDENCE CONCERNING JP.

ALITTI 69 PRL 22 79 + BARNES, FLAMINIO, METZGER, + (BNL, SYRACUSE) I
DAUBER 69 PR 179 1262 + BERGE, HUBBARD, MERRILL, MULLER (LRL)
APSELL 69 PRL 23 884 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
APSELL 70 PRL 24 777 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
BMST 70 DUKE 317 BRANDEIS+MARYLAND+SYRACUSE+TUFTS COLLAB.

E(1930)

52 XI*1/2(1940, JP= 1 I=1/2
SEE THE MINIREVIEW PRECEDING XI*1/2(1530)

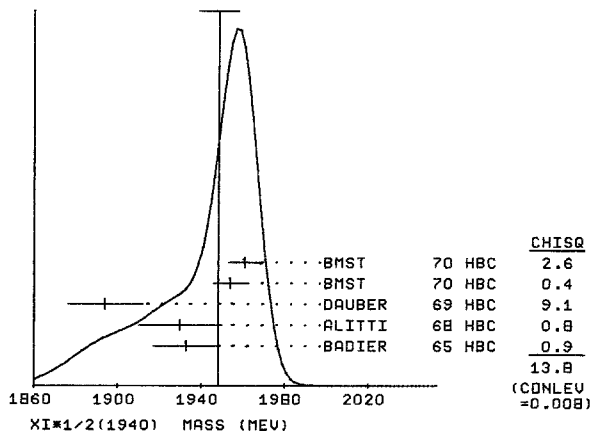
52 XI*1/2(1940) MASS (MEV)

M	35 1933.0	16.0	BADIER	65 HBC	0	K-P 3 BEV/C	
M	27 1930.0	20.0	ALITTI	68 HBC	0	K-P 4.6-5 BEV/C	11/68
M	66 1894.0	18.0	DAUBER	69 HBC	-	K-P 2.7 BEV/C	11/68
M	0 (1962.0)	(14.0)	APSELL	69 HBC	0	XI PI	9/69
M	0 (1964.0)	(10.0)	APSELL	70 HBC	0-	XI(1530) PI	6/70*
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*

LATEST VALUES OF MASSES AND WIDTHS FROM THIS EXP. ARE IN BMST 70

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 1948.2 ± 9.6
ERROR SCALED BY 1.9



52 XI*1/2(1940) WIDTH (MEV)

M	35 140.0	35.0	BADIER	65 HBC	0		
M	27 80.0	40.0	ALITTI	68 HBC	0		11/68
M	66 98.0	23.0	DAUBER	69 HBC	-		11/68
M	0 (147.0)	(55.0)	APSELL	69 HBC	0	XI PI	9/69
M	0 (60.0)	(39.0)	APSELL	69 HBC	0-	XI(1530) PI	6/70*
M	110 129.	30.	BMST	70 HBC	0	XI-PI+ (2.9 K-P)	7/70*
M	40 141.	35.	BMST	70 HBC		XI(1530) PI	7/70*

AVG 100.2 15.8 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

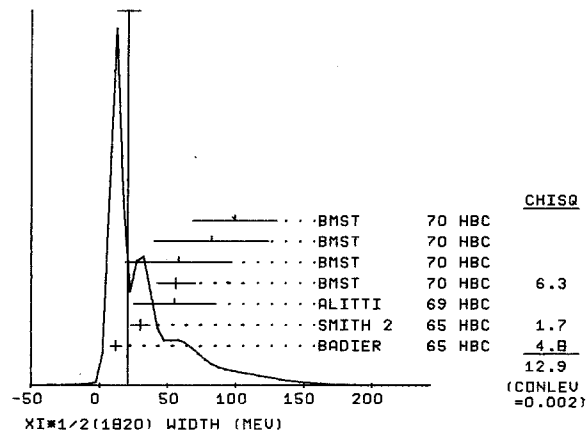
50 XI*1/2(1820) WIDTH (MEV)

M	(80.0)	OR LESS	HALSTEINS	63 FBC	0-		
M	12.0	4.0	BADIER	65 HBC	0		
M	30.0	7.0	SMITH 2	65 HBC	0-		
M	55.0	40.0	20.0	ALITTI	69 HBC	-	9/69
M	0 (78.0)	(33.0)	APSELL	69 HBC	0	XI PI	9/69
M	0 (52.0)	(34.0)	APSELL	70 HBC	0-	XI(1530) PI	6/70*
M	35 56.	14.	BMST	70 HBC	-	SIGMA- KOBAR	7/70*
M	65 58.	39.	BMST	70 HBC	0	LAMBDA KOBAR	7/70*
M	55 82.	42.	BMST	70 HBC		XI(1530) PI	7/70*
M	65 99.	31.	BMST	70 HBC		XI-PI+ (2.9 K-P)	7/70*

SEE NOTES ACCOMPANYING THE MASSES QUOTED

(SEE IDEOGRAM BELOW)

WEIGHTED AVERAGE = 20.8 ± 8.4
ERROR SCALED BY 2.5



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

See the illustrated key preceding the data card listings.
Data in parentheses have not been included in our averages.

52 XI*1/2(1940) PARTIAL DECAY MODES
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

52 XI*1/2(1940) BRANCHING RATIOS
R1 XI(1940) INTO XI PI (P1)
R1 SEEN BA0IER 65 HBC 0
R1 ALITTI 68 HBC 0 11/68
R1 SEEN DAUBER 69 HBC - 11/68

R2 XI(1940) INTO (XI PI)/(XI(1530) PI) (P1)/(P2)
R2 2.8 0.7 0.6 APSELL 70 HBC 0 6/70*
R3 XI(1940) INTO (XI PI PI)/(XI(1530) PI) (P3)/(P2)
R3 0.0 0.3 APSELL 70 HBC 0 6/70*

LOOKED FOR BUT NOT SEEN IN OTHER CHANNELS. SEE ALITTI 68.

REFERENCES -- XI*1/2(1940)

BADIER 65 PL 16 171 +DEMOLIN,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 69 PRL 23 884 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
APSELL 70 PRL 24 777 + (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
BMST 70 DUKE 317 BRANDEIS+MARYLAND+SYRACUSE+TUFTS COLLAB.

E(2030) 68 XI*1/2(2030, JP=) I=1/2
SEE THE MINIREVIEW PRECEDING XI*1/2(1530)
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 2058.0 17.0 BARTSCH 69 HBC K-P 10GEV/C 9/69
M
M AVG 2037.2 12.2 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

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 AVG 51.0 21.2 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

68 XI*1/2(2030) PARTIAL DECAY MODES
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

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 THRU 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

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)

E(2250) 22 XI* (2250, JP=)
SEE THE MINIREVIEW PRECEDING XI*1/2(1530)
THE EVIDENCE FOR THIS RESONANCE IS WEAK. IT IS SEEN
AS A BUMP OF NOT MUCH STATISTICAL SIGNIFICANCE IN
(LAMBDA KBAR PI), (SIGMA KBAR PI), AND (XI PI PI) IN-
VARIANT-MASS DISTRIBUTIONS.

22 XI* (2250) MASS (MEV)
M 2244.0 52.0 BARTSCH 69 HBC K-P 10 GEV/C 9/69
22 XI* (2250) WIDTH (MEV)
M 130.0 80.0 BARTSCH 69 HBC 9/69
22 XI* (2250) PARTIAL DECAY MODES

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)

E(2500) 99 XI*1/2(2500, JP=) I=1/2
SEE THE MINIREVIEW PRECEDING XI*1/2(1530)
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 2500.0 10.0 BARTSCH 69 HBC 0- K-P 10 GEV/C 9/69

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 AVG 79.5 38.0 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

99 XI*1/2(2500) PARTIAL DECAY MODES
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)

Omega 24 OMEGA - (1675, JP=3/2+) I=0
SEE LISTINGS OF STABLE PARTICLES

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 decays.

$\Gamma_{K_{\ell 3}^+} = \Gamma_{K_{e3}^+} + \Gamma_{K_{\mu 3}^+}$	$= (6.50 \pm .12) \times 10^6 \text{ sec}^{-1}$
$\Gamma_{K_{\tau}^+} - \Gamma_{K_{\tau}^+}$	$= (3.135 \pm .044) \times 10^6 \text{ sec}^{-1}$
$\Gamma_{K_{\mu 3}^+} / \Gamma_{K_{e3}^+}$	$= 0.656 \pm .023$
$\Gamma_{K_{\tau}^+} / \Gamma_{K_{\tau}^+}$	$= 3.28 \pm .09$
$\Gamma_{K_{\ell 3}^0} = \Gamma_{K_{e3}^0} + \Gamma_{K_{\mu 3}^0}$	$= (12.20 \pm .45) \times 10^6 \text{ sec}^{-1}$
$\Gamma_{K_{\mu 3}^0} / \Gamma_{K_{e3}^0}$	$= 0.689 \pm .028$
$\Gamma_{K^0(000)} / \Gamma_{K^0(+ - 0)}$	$= 1.703 \pm .075$

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

$$\Gamma_{K_{\ell 3}^0} / 2\Gamma_{K_{\ell 3}^+} = 1.012, \text{ a phase-space}$$

factor,² and

$$\Gamma_{K_{\mu 3}^0} / \Gamma_{K_{e3}^0} = \Gamma_{K_{\mu 3}^+} / \Gamma_{K_{e3}^+}$$

From Table I,

$$\Gamma_{K_{\ell 3}^0} / 2\Gamma_{K_{\ell 3}^+} = 0.94 \pm 0.04$$

$$\text{and } \frac{\Gamma_{K_{\mu 3}^0}}{\Gamma_{K_{e3}^0}} \left[\frac{\Gamma_{K_{\mu 3}^+}}{\Gamma_{K_{e3}^+}} \right]^{-1} = 1.05 \pm .06 .$$

These results seem to show a less than 2σ disagreement with the predictions, but the errors should be regarded with caution in view of the internal disagreements in the data. (Note the ideograms in the data listing for the charged K meson.)

2. Three-pion decays

We follow here the tests done by Mast et al.,³ based on the general analysis of K decays suggested by Zemach.⁴ Both decay rates and slopes (energy dependence of the Dalitz plot distributions) are used. The $\Delta I = 1/2$ rule gives the following predictions:

$$T_1 = \frac{2}{3} \frac{\Gamma_{K^0(000)}}{\phi_1} \left[\frac{\Gamma_{K^0(+ - 0)}}{\phi_2} \right]^{-1} = 1 ,$$

$$T_2 = \frac{1}{4} \frac{\Gamma_{K_{\tau}^+}}{\phi_3} \left[\frac{\Gamma_{K_{\tau}^+}}{\phi_4} \right]^{-1} = 1 ,$$

$$T_3 = \frac{1}{2} \frac{\Gamma_{K_{\tau}^+}}{\phi_3} \left[\frac{\Gamma_{K^0(+ - 0)}}{\phi_2} \right]^{-1} = 1 ,$$

$$T_4 = \frac{1}{2} g_{K_{\tau}^+} + g_{K_{\tau}^+} = 0 ,$$

where the ϕ_i are the phase space factors. Mast et al.³ have calculated these factors by use of a relativistic formulation and the masses 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	1.451
$\phi_2(+ - 0) =$	1.219	1.268	1.268
$\phi_3(++ -) =$	1.000	1.000	1.000
$\phi_4(+00) =$	1.247	1.184	1.155

The slopes for the various decays have not been tabulated in the Stable Particles Table. They are as follows:

$$\left. \begin{aligned} g_{K_{\tau}^+} &= -0.206 \pm 0.009 \\ g_{K_{\tau}^-} &= -0.194 \pm 0.007 \end{aligned} \right\} -0.198 \pm 0.006,$$

$$g_{K_{\tau^1}^+} = 0.511 \pm 0.018,$$

$$g_{K_L^0(+0)} = 0.400 \pm 0.033.$$

A difference in the τ^+ and τ^- slopes would be an indication of CP violation in this decay. Since no difference is present at this time, we average the two and use this value in T_4 .

Using the CNUDP and rates and slopes reported here we get:

$$\begin{aligned} T_1 &= 0.002 \pm 0.044, \\ T_2 &= 0.947 \pm 0.026, \\ T_3 &= 1.22 \pm 0.050, \\ T_4 &= 0.058 \pm 0.019. \end{aligned}$$

The three-pion final state can be in isospin states $I = 1, 2, 3$. T_1 and T_2 test the existence of isospin $I = 3$ in the final state and are consistent with no or very little $I = 3$. T_4 is related to the $I = 2$ amplitude in the final state and indicates, within three standard deviations, the presence of some $I = 2$. T_3 , finally, gives information on the $\Delta I = 3/2$ part of the $I = 1$ amplitude relative to the $\Delta I = 1/2$ part and seems to be the largest violation of all.

More information can be drawn by comparing the slopes; for this we refer the reader to the paper by Mast et al.³

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.
4. T. S. Mast, L. K. Gershwin, M. Alston-Garnjost, R. O. Bangert, 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).

Appendix II

A. SU(3) CLASSIFICATION OF BARYON RESONANCES

There are a few multiplets that have been studied and we report here the results. The relevant formulae are given below.

Mass Formulae

Decuplet	$\Delta - \Sigma = \Xi - \Xi^* = \Xi^* - \Omega$	GMO (1)	
Octet	$2(N + \Xi) = 3\Lambda + \Sigma$	GMO (2)	
Nonet	{	$\sin^2 \theta = \frac{\Lambda - M_8}{\Lambda - \Lambda'}$	Mixing angle† (3)
		$M_8 = \frac{2(N + \Xi) - \Sigma}{3}$	GMO (4)

Here GMO stands for the Gell-Mann-Okubo formula; the particle symbol indicates its mass. The formulae would be the same if squared masses were used. For the nonet case, Λ is the "mostly-octet" particle, Λ' is the "mostly-singlet" particle.

Decay Rates

In terms of a relativistically invariant matrix element T , the decay rate for two-body decay of a resonance of mass M_R is

$$\Gamma = \frac{|T|^2 R_2}{M_R}, \quad (5)$$

where $R_2 = k/M_R$ is the two-body phase space factor. Since the numerator is an invariant, and since Γ must transform as $1/E$, we introduce the denominator $1/M_R$ (see FEYNMAN 62).

For meson decays (see below) the rates are calculated according to Eq. (1); 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

$$\Gamma = \frac{|T|^2 k}{M_R} \text{ for baryons} \quad (5')$$

$$= \frac{|T|^2 k}{M_R^2} \text{ for mesons.} \quad (5'')$$

In Eqs. (6) and (7) below, $|T|^2$ is dimensionless, so we tidy up the dimensions by introducing a factor of mass M_N (or M_N^2 for mesons), where M_N is conventionally taken to be the nucleon mass.

$|T|^2$ contains centrifugal barrier factors, which we call B_ℓ . We then have

$$\left. \begin{array}{l} \text{Decuplet} \\ \text{Singlet} \end{array} \right\} \Gamma = (c_g)^2 B_\ell(k) \frac{M_N}{M_R} k \quad (6)$$

$$\text{Octet} \quad \Gamma = (c_D g_D + c_F g_F)^2 B_\ell(k) \frac{M_N}{M_R} k \quad (7)$$

$$\text{Nonets} \quad \left\{ \begin{array}{l} G_8 = \Lambda \cos \theta - \Lambda' \sin \theta \\ G_1 = \Lambda \sin \theta + \Lambda' \cos \theta \end{array} \right. \quad (8)$$

$$\text{with} \quad \left\{ \begin{array}{l} G_8 = c_D g_D + c_F g_F \\ G_1 = c_1 g_1 \end{array} \right. \quad (9)$$

Here B_ℓ are the centrifugal barrier factors given by Blatt-Weisskopf (1952), the c_i are the SU(3) coefficients with the sign convention adopted in this article [see long caption for the table of SU(3) isoscalar coefficients], M_N is the nucleon mass, M_R is the resonance mass for which Γ is calculated, k is the center-of-mass momentum for the channel being considered, g_i are the relevant couplings. For the case of singlet-octet mixing, formula (8) has to be used in conjunction with (6) and (7). G_8 and G_1 represent the couplings for the multiplet, and Λ and Λ' represent the couplings for the physical states.

The relation between g_D , g_F and the D (symmetric) and F (antisymmetric) couplings is as follows:

$$\frac{F}{D} = \sqrt{\frac{5}{3}} \frac{g_F}{g_D} \quad (10)$$

Table I shows the situation. We now discuss each multiplet in detail.

$\frac{1}{2}^-$ -Nonet (Baryon-Eta Resonances)

We report here the results of Tripp (1969). The mixing angle θ as well as the first F/D ratio have been calculated by using the Λ (1670) and Λ (1405) decay rates. 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 factor[§] for the $1/2^-$ octet has been used by Gell-Mann et al. (Gell-Mann, 1968). The second F/D ratio was calculated

by using the N(1535) decay rates. Using the mass formulae (3) and (4) with 19 deg mixing angle, the mass for the Ξ member of the octet falls at $M = 1818$ MeV (not observed).

$3/2^-$ Nonet

The mixing angle is from Levi Setti (1969), calculated by using the Λ (1690) and Λ (1520) decay rates. The F/D ratio is from Tripp (1968), taken to be the most likely value for the interception of the lines in the plot of g_F vs g_D for all the members of the octet. The mixing angle, calculated by using the mass formula and assuming Ξ (1820) to be a member of this multiplet, is 20 deg. The decay rates for Ξ (1820) are in agreement with the decay rates of the other members of the multiplet.

$5/2^-$ and $5/2^+$ Octets

The F/D ratio is taken from Tripp (1968), again as the intersection in the plot of g_F vs g_D for the decay rates measured (see Baryon Table).

$3/2^+$ and $7/2^+$ Decuplets

Tripp (1968) has calculated the value of g^2 for the various members of these decuplets. The value of g^2 should be common to all decays, but it appears to be significantly different.[‡]

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

$$4\hat{K} = 3\hat{\eta} + \hat{\pi} \quad (2')$$

The symbol \hat{K} was introduced by Glashow and Socolow[†] for the square of the \hat{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).

For mesons there are only three established nonets: 0^- , 1^- , and 2^+ , so it has been possible to crowd a small note about them at the bottom of the footnotes to the meson table.

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 pseudoscalar meson octet.

J^P	Octet members				Singlet	θ (degrees)	F/D	g_D^a	Ref
$1/2^-$	N' (1535)	Λ (1670)	Σ (1750)	Ξ (1818)?	Λ (1405)	19	-1.77 or -1.98	0.42 0.45	Tripp 1969
$3/2^-$	N(1530)	Λ (1690)	Σ (1670)	Ξ (1820)?	Λ (1520)	-18 ± 3^b	1.19	0.34	Tripp 1968
$5/2^-$	N(1670)	Λ (1830)	Σ (1765)				-0.13	0.77	Tripp 1968
$5/2^+$	N(1688)	Λ (1815)	Σ (1915)				1.06	0.56	Tripp 1968
Decuplet members					g_{10}^2				
$3/2^+$	Δ (1236)	Σ (1385)	Ξ (1530)	Ω^-	0.94 to 2.38				Tripp 1968†
$7/2^+$	Δ (1950)	Σ (2030)			0.25 to 0.97				Tripp 1968

a. Using formula (10) one can derive g_F . b. from Levi Setti 69.

Footnotes and References for SU(3) Classification

§ 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 and used first by Graham et al. (Graham 1967).

† Graham et al. have used additional factors § in Eq.(6) for the $3/2^+$ decuplet and found a better agreement between the couplings.

† 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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