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ДОКЛАДЫ РАППОРТЕРОВ RAPPORTEURS' REVIEWS

E 1804

STRANGE PARTICLES RESONANCES
(Experimental)

Rapporteur R. Armenteros

Secretaries:
G. Kopylov
V. Anisovitch
B. Geshkenbein

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This publication is of a preliminary character. To facilitate the rapid appearance of Reports, they are printed in the form as presented by Rapporteurs.

Introduction

In this talk I will present a simple summary-together with a few comments - of the experimental facts concerning resonances with a strangeness different from zero. There are two reasons why my talk is going to be very matter of fact: the first is that I lack both the knowledge and the imagination to talk either about the wider implications of the work or about the way experiments should be directed in the future to obtain better and more meaningful information. The second is that the parallel sessions have been much too short and it has not been possible to present adequately the results of different groups.

The talk will be divided into two sections. In the first, resonances involving a K-meson and n pions (n will only go up to three!) will be reported. In the second, hyperon resonances will be considered.

The table you see exposed does not intend to replace the well-known one from Berkeley. Its usefulness is limited to this talk and I will use it to summarize with suitable indications what, in my opinion, is the present status in our knowledge of the main properties of the resonances.

κ (730) This $(K\pi)$-resonance was reported long ago in $\pi^- p$ (1) collisions between 1.5 - 2.4 GeV/c and in $K^- p$ collisions(2) between 1.0 - 1.7 GeV/c. Its existence has never been really well established.

At this Conference a CERN group(3) presented new evidence which, taken together with the older one and with recent information both from Dubna(4) and Brookhaven(5), makes it very difficult not to believe in the existence of the kappa-meson. The CERN evidence comes from the study of the channels:

$$K^+p \longrightarrow pK^{\overset{0}{+}}\pi^+\pi^-\pi^{\overset{+}{0}} \qquad \text{of 3 GeV/c } K^+. \qquad (1)$$

The predominant intermediate state of (1) is

$$K^{*+}N^{*++}\pi^-,$$

which accounts for 50% of the events.

In fig. 1 the different $(K\pi)$ charged combinations with $I_3 = 1/2$ are shown. Besides production of the normal K^* (888), enhancements are seen in the 3 charged modes in the neighbourhood of 730 MeV. The hatched histogram is the contribution of events with N^*. Contrary to the K^*(888), the kappa does not seem to be produced in association with the N^*. Indeed, if N^* events are removed, the 730 MeV remains almost intact and corresponds to an excess above background with a 3 standard deviation significance.

The mass and width quoted in the most accurate Berkeley result(2) were:

$$M_{\kappa} = (723 \pm 3)\ \text{MeV}, \quad \Gamma \leqslant 12\ \text{MeV}$$

In the present experiment the width appears appreciably larger, but no detailed study of it has been presented.

The isospin is most likely 1/2; the main arguments(1,3) against $I = 3/2$ being the absence of an enhancement in the $(K^0\pi^-)$ system

The spin-parity are, of course, not known.

An interesting observation(3) is that the branching ratio

$$\frac{K^* \to \kappa + \pi}{K^* \to K + \pi} \leqslant 0.01$$

$K^*(888)$ Nothing new to report on this well established $(K\pi)$ P-state.

I pass on now to the tricky subject of $(K\pi\pi)$ resonances: three have been proposed at this Conference and a fourth one briefly mentioned.

$(K\pi\pi)$ - (1175)

Fig. 2 shows the $(K\pi\pi)$ mass distribution observed by Wangler et al.(6) in π^-p-collisions at 3.0 GeV/c. The final states studied are $\Lambda^0 K^{\overset{+}{0}} \pi^{\overset{0}{+}} \pi^-$, $\Sigma^0 K^0 \pi^+ \pi^-$, $\Sigma^- \pi^+ K^{\overset{+}{0}} \pi^{\overset{-}{0}}$. All $(K\pi\pi)$ combinations plotted are in the $I_3 = \pm 1/2$ state. An enhancement is observed in the 50 MeV interval centered at 1175 MeV; the effect is most pronounced in events containing a Λ^0 ; although 17 of the 24 Λ^0 events in this interval correspond also to production of $Y_1^*(1385)$ the authors have not been able to find an obvious explanation as to how the Y^* could lead to the observed $(K\pi\pi)$ peak.

Other characteristics of the peak are:

1) $\Gamma = (40 \pm 15)$ MeV

2) Isospin 1/2 or 3/2 bedause of its production:

$$\pi^- p \rightarrow \Lambda^0 + (K\pi\pi)$$

3) There is no positive evidence that it decays into $K^*\pi$.

m At this Conference, Miller et al(7) presented results on the same channels with much improved statistics. The π^- momentum was slightly above 3.0 GeV/c their $(K\pi\pi)$-spectrum is shown on fig.3. $(K\pi\pi)$ peaks appear and disappear as the energy is changed and this makes them suspect to the authors. One thing is clear, however; with much improved statistics this group does not confirm the Wisconsin result at 1175 MeV, which is therefore most likely a statistical fluctuation - fairly big but not out of the question.

C^0 $(K\pi\pi)$ - 1215

Two groups, one from Columbia-Rutgers$^{(8)}$ and another one from CERN-Collège de France$^{(9)}$ have presented results concerning the annihilation at rest ($\bar{P}P \rightarrow K\bar{K}\pi\pi$) with at least one $K^0(\bar{K}^0)$ decaying via $K_1^0 \rightarrow \pi^+\pi^-$. As you may remember, from a study of the channel $\bar{p}p \rightarrow K_1^0 K_1^0 \pi^+\pi^-$ the CERN-Collège de France group$^{(10)}$ proposed the existence of a $(K\pi\pi)$ resonant state, which they called C^0, and which decayed mainly into $K + \rho$. This evidence is reproduced in fig. 4, where the two $(K\pi\pi)$ combinations are plotted in the form of a mass-squared histogram. A satisfactory fit to the histogram is obtained under the conditions specified in the fig. 4.

Plano, reporting the Columbia-Rutgers results, showed that, while the $C^0 \rightarrow K\rho$ assumption describes reasonably well the $(K\pi\pi)$ mass-distribution in the $K_1^0K_1^0\pi^+\pi^-$-channel, the other four-body channels cannot be reproduced in the same way. This does not, I believe, represent disagreement between the two sets of data. The reason for this belief may be obvious after I describe briefly the more detailed analysis made by the CERN-Collège de France group.

At the Conference this group have presented their complete data on the other two 4-body channels

$$\begin{aligned} \bar{p}p &\rightarrow K_1^0K_2^0\pi^+\pi^- \\ &\rightarrow K_1^0K^\pm\pi^\mp\pi^0 . \end{aligned}$$

The results are: the three $K\pi\pi$ mass-squared distributions with total charge zero: $K_1^0\pi^+\pi^-$, $K_2^0\pi^+\pi^-$, $K^\pm\pi^\mp\pi^0$ show very much the same aspect of the original $M^2(K_1^0\pi^+\pi^-)$ - distribution. This is illustrated in figure 5. This is not true of the charged combination ($K_1^0\pi^\pm\pi^0$), which shows a strong peaking at around $M\,(K\pi\pi) \sim 1320$ MeV.

Statistically, the C^0- enhancement is without reproach in the neutral combinations.

Data on the decay channels of the C^0 are as follows:

	$K^*\pi$	$K\rho$	
$K_1^0\ K_1^0\pi^+\pi^-$	80	450	events
$K_1^0\ K_2^0\pi^+\pi^-$	640	0	events
$K_1^0\ K^\pm\pi^\mp\pi^0$	200	370	events

Table 1.

These numbers were obtained from a direct counting of events above the estimated background in the corresponding C^0 decay Dalitz-plots.

The results of the above table entail different $M^2(\pi\pi)$ distributions in the different channels – one of the results presented by Plano when showing the inconsistency of all this data with $C^0 \to K\rho$. The CERN-Collège de France data explain this inconsistendy by showing that the C^0 decays also via $K^*\pi$ frequently. An important question is to establish the relative frequencies of the two modes. There are difficulties in doing so which become apparent when this group attempts to establish the quantum numbers of the C. Thus, the isospin (1/2 or 3/2) can, in principle, be established by determining the C^0 branching ratio, B.R. into neutral and charged K^* in ($K^\pm\pi^\mp\pi^0$), say. We should have $B.R. = \frac{(K^{*0}),\,\pi^0}{(K^{*\pm}),\,\pi^\mp}$ equal to 1 if $I_c = 1/2$ or 4 if $I_c = 3/2$. Experimentally one observes 0.9, which argues in favour of $I_c = 1/2$.

However, for ($K\rho$) decay modes, we should have

$$B.R. = \frac{(\pi^\mp\pi^0),\ K^\pm}{(\pi^+\pi^-),\ K_1^0} = \begin{cases} 2 & \text{if } I_c = 1/2\ ; \\ 0.5 & \text{if } I_c = 3/2\ ; \end{cases}$$

experimentally one observes 0.82. This number, which has a small statistical error, disagrees with either isospin assignment.

In the same way, the angular distributions cannot be simply explained. Thus the decay angular distribution of the $C \to K^{*}\pi$ mode in $K_1^0 K_2^0 \pi^+ \pi^-$ appears as shown in the fig. 6. A strong interference effect is manifested for $0.1 < \cos\theta < 0.6$. This, the authors know, is due to K^{*} formation between the K not in the resonance and one of the pions.

The conclusion I would draw is: a proper analysis to establish the quantum numbers of the C and thus the reality of the C itself cannot be done until the interference effects are understood quantitatively - at the moment they are only known qualitatively. That this is going to be difficult in the annihilation of antiprotons at rest can be further emphasized if we notice that the C does not travel very far before decaying: ~ 0.5 fermi, i.e. while still well within the annihilation volume.

($K\pi\pi$)-1270

This comes from the study of $\bar{p}p$ annihilations at 3.0 GeV/c by CERN-Ecole Polytechnique - Imperial College group(11). The relevant channel is $\bar{p}p \to K^0 K^{\pm} \pi^{\mp} \pi^+ \pi^- \pi^0$.

This is an obviously complicated channel in which ω^0, ρ and $K^{*}(888)$ resonances are significantly produced. Effective ($K\pi\pi$) masses with $I_3 = \pm 1/2$ can be obtained in 8 possible ways; for $I_3 = \pm 3/2$ the number of combinations is reduced to 4. The consequence is that at the present level of statistics there is very little chance of seeing anything in the $I_3 = \pm 1/2$ channel that is not produced extremely abundantly and/or has not a very narrow width. In the $I_3 = \pm 3/2$ case the difficulties are much diminished, in particular if supplementary conditions are imposed to the ($K\pi\pi$)

distribution. In fig. 7, the $(K\pi\pi)$ mass-distribution is shown for the $I_3 = \pm 3/2$ combinations that contain one $K^*(888)$. A slightly over 3 standard deviation enhancement at a mass of 1270 MeV is seen. The enhancement is shown not to be a consequence of the K^* condition and can further be sharpened if events showing ρ or ω° production are eliminated. In the same way a possible $K\rho$ decay has been looked for; the result is shown in the hatched histogram, where a small excess of events - by itself statistically not significant- is found. The $(K^*\pi)$ and $(K\rho)$ distributions have been added up and show a four standard deviation effect.

The best mass and width estimates are:

$M = (1270 \pm 20)$ MeV

$\Gamma = (60 \pm 20)$ MeV

$I = 3/2$

$$\text{B.R.} = \frac{K^*\pi}{K\rho} = \sim 3$$

The authors note that phase space favours the $K^*\pi$ mode by a factor of 2.6 over the $K\rho$ mode.

The K^+ group from CERN(12) have reported results which are again not of overwhelming statistical significance. They come from the distribution of $(K^+\pi^-\pi^{\circ})$ effective masses in the reaction

$$K^+p \longrightarrow K^+p\,\pi^+\pi^-\pi^{\circ} \quad \text{at } 3\text{ GeV/c}$$

A 3 standard deviation enhancement is obtained when the following two conditions are imposed:

a) one of the $(K\pi)$ mass combinations must correspond to that of the K^*;

b) one of the $(p\pi^+)$ mass combinations must correspond to that of the N^* (1.238).

The two conditions are said not to deform phase space in such a way as to produce a fortuitous enhancement.

The isospin agrees with $I = 3/2$ and not with $I = 1/2$. This comes from a comparison of the magnitude of the enhancement in the channel above and in

$$K^+p \rightarrow K^0 p \pi^+ \pi^- \pi^-$$

Let us conclude that although the statistical significance in each of those two experiments is not very high, the presence of a ($K\pi\pi$) effect in $T_z = 3/2$ at the same mass in two very different production channels cannot be lightly diseregarded.

($K\pi\pi\pi$) 1630 Belyakov et al(13) have reported from their 7.5 GeV/c π^- pictures taken in the Dubna 24 liter propane chamber the possible existence of a peak at a mass of 1630 MeV in the four-body system $K\pi\pi\pi$.

The effect was studied mainly in the $K^0\pi^-\pi^-\pi^+$ channel (with charge $Q = -1$). The evidence is presented in fig. 8.

In the center histogram an attempt was made to fit the data to a calculated curve taking in account the known $N_{33}, \eta, \omega, K^*,$... productions. In the top histogram a Monte Carlo histogram is shown in thin lines. The peak between 1600 and 1800 stands out above these curves.

The observation of K^{*+} decay in this band suggests $T_z = -3/2$ for the possible resonance.

It is my feeling that further statistics will be needed to establish firmly the existence of this possible resonance.

K^+K^+ enhancement

The CERN K^+ group(14) have presented results on the reac-

tion $K^+p \rightarrow KKY$ (133 events)
at incident K^+ momenta of 3.0 and 3.5 GeV/c.

The (KK) - mass spectrum is shown in fig. 9 together with a smooth curve representing normalized phase-space. An important bump is seen in the mass-range 1200-1350 MeV. Its statistical significance is difficult to evaluate; if the background is correctly represented by the phase-space curve as drawn in the figure, the peak corresponds to about a 3 standard deviation effect.

More details about this state are in the process of being studied but are not yet available. It is known, however, that the KY mass-spectra do not present any significant structure.

In the four-body processes:

$$K^+ + p \rightarrow K^+ K^+ \Lambda^\circ \pi^\circ$$
$$K^+ K^0 \Lambda^\circ \pi^+ \quad \text{(95 events)}$$

no enhancement in KK masses at $\sim$1275 MeV is observed. There is, however, abundant production of $K^*(888)$, $N^*(1688)$ and Y_1^* (1385).

II.

We consider now hyperon resonances.

Y_1^* (1385). This is the very familiar $\Lambda\pi$ - and hence I = 1 - resonance. No new evidence about its spin and parity has been presented at the Conference but for the sake of completeness it is worthwhile to summarize the latest information. Published results from Berkeley(15a) and CERN(16) agree on a likely $3/2^+$ assignment but a $5/2^-$ solution is not excluded by the data.

The data have one drawback: the Y^* longitudinal decay distributions show significant asymmetries indicating the presence of interference effects. It is not clear to me how much these effects - which are not taken into account in the analysis - can modify the conclusions.

An extension of the analysis to appreciably different energies is necessary before one is completely satisfied with the $3/2^+$ values. An effort has been made recently by Shafer(15b), in Berkeley, who has studied Y^*'s produced at seven K^- momenta between 1.1 and 1.7 Gev/c. At two momenta a slight discrimination against $5/2^-$ was obtained, while the $3/2^+$ solution was acceptable everywhere.

No new information on the $(\Sigma\pi)$ decay mode is available and the ratio $\frac{\Sigma\pi}{\Lambda\pi} = (4 \pm 4)\%$ as before.

Y_0^* (1405). This is a $(\Sigma\pi)^0$ resonance with $I = 0$ since it has never been seen in the charged mode. It is frequently seen both in K^-p, π^-p and even in $p\bar{p}$ -collisions but never sufficiently strongly or cleanly to permit a spin-parity determination.

An interesting fact is that the possible decay mode $(\Lambda\pi\pi)$ occurs, if at all, with a frequency smaller than 1% of the $(\Sigma\pi)$ mode.

Y_0^* (1520). Its intrinsic properties were established in the very complete work by Ferro-Luzzi, Tripp and Watson(17) and there is nothing to add or change to their results.

Ξ^* (1530) To my knowledge(*) there is nothing new on the spin-parity analysis of the Ξ^* (1530) since the results published by the U.C.L.A. group(18). Their simplest assigment was $3/2^+$, but higher spins and a different parity could not be ruled out. In the analysis the assumption was made that the spin-parity of the Ξ -particle are 1/2 - an assumption which has not yet been verified experimentally.

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[*] footnote. A paper on the Ξ^* (1530) spin and parity was submitted to the Conference by I. Button-Shafer, J.S. Lindsey and G. Smith (U.C.R.L. 11436). Unfortunately, it escaped my notice. The odds in favour of the $3/2^+$ hypothesis are slightly better than those given in ref. 18.

Y_1^* (1660), Y^*(1765), Y^{*-}(1815).

I do not think it makes much sense discussing one by one these three possible resonances without having had first a look at the general behaviour of K^-p total and elastic cross-sections in the corresponding energy interval. The data are not very abundant or precise as can be seen in fig. 10. A broad and unsymmetric peak appears in both cross-sections at a mass of 1815 MeV and with a total width 140 MeV. The data for K^-n is even poorer but of sufficient accuracy to show that if the K^-p bump is attributed to one single resonance this resonance must have isospin equal to zero. But do we have to do with only one resonance?

Tripp and coworkers(19) at Berkeley last year investigated the reaction

$$K^- n \rightarrow K^- \pi^- p$$

at 1.51 GeV/c and observed the K^-p effective mass-distribution shown of fig. 11. Abundant Y^* (1520) is observed, but also a statistically significant enhancement is seen centered at 1765 MeV and with a width ~60 MeV. A single 1815 MeV enhancement would be expected to behave as indicated by the dotted line. Tripp et al. give then arguments to show why this peak cannot be due to a displaced 1815; they look at the available data on cross -sections and angular distributions and suggest that the data can be best explained by splitting the large 1815 peak into two: one at 1765 MeV (Γ~60 MeV) and another at 1815 MeV (Γ~ 70 MeV). The behaviour of the charge-exchange cross-sections would indicate different isospin for the two states (0 and 1); the complexity of the elastic angular distributions would tend to support the same $J = 5/2$ but different parities for the two states.

The question of which isospin and which parity belongs to each state cannot be decided from the present data.

We now turn to the Y_1^* (1660) resonance. Note that to a mass of 1765 MeV corresponds a K^- momentum of 940 MeV/c while to 1815 corresponds a K^- momentum of 1045 MeV/c. The resonance at 1660 MeV corresponds to P_{K^-}= 715 MeV/c. It is weakly excited and its elasticity is small so that neither the total nor the elastic cross-sections show its presence with the present level of statistical accuracy.

This Y_1^* (1660) state was first seen as effective-mass enhancements in the final states of both $\pi^- p$ (20) and K^-p(21) collisions. The original (K^-p) results are shown in fig. 12.

The general comment I would make is that taken separately, none of the mass-combinations considered can by itself prove the existence of an effect. It is only the persistence of the deviations at roughly the same mass-value that makes one believe in the existence of a Y^*(1660) resonance. The same considerations apply to the π^-p-experiment, which first showed the existence of the 1660. Different experiments have since confirmed the Y^*(1660) but to the best of my knowledge the confirmation has been essentially in the ($\Sigma\pi$)-decay channel.

Attempts to measure the spin and parity of the state were made by Bastien and Berge(22) - who concluded that the spin was $\geq 3/2$ - and by Taher-Zadeh et al(23) at UCLA - who, with very restrictive assumptions, favoured a $3/2^+$ assignment. These results were obtained in a study of the variation in the angular distribution and angle of polarization of the Λ^0 in the reaction

$$K^- N \rightarrow \Lambda \pi$$

as the c.m. total energy is made to vary cross the 1660 MeV mass-region.

Results presented at this conference by Berley et al.(24) from Brookhaven, because of their better statistics and increased number of energy intervals studied, supersede the previous results on the channel

$$K^- N \rightarrow \Lambda \pi .$$

Berley at al have studied the reaction

$$K^- p \rightarrow \Lambda \pi^\circ \qquad (C)$$

at 7 energy intervals comprised between equivalent masses from 1620 to 1720 MeV.

The angular distribution and the polarization angle of the Λ° in this reaction were fitted to Legendre series of the form

$$4K^2 \frac{d\sigma}{d\Omega} = \sum_\ell A_\ell P_\ell (x) .$$

and the

$$4K^2 \alpha_\Lambda \frac{d\sigma}{d\Omega} = \sum_\ell B_\ell P_\ell^1 (y),$$

where $x = \vec{p}_{K^-} \cdot \vec{p}_{\pi^\circ}$ and $y \doteq \vec{P}_{proton} \cdot (\vec{P}_{K^-} x \vec{P}_{\pi^\circ})$, K is the wave number and α_Λ was taken as -0.67.

The resulting A_ℓ and B_ℓ coefficients are shown in fig. 13. The following remarks can be made: the term A_0 - proportional to the product of K^2 by the total cross-section - is nearly constant thus the resonant effect is small compared to the background. Interference between a very small resonant amplitude and the background can, nevertheless, lead to rapid variations in the angular distributions as the energy changes. This may be the reason for the observed changes in some of the coefficients. An attempt has been made to fit the observations with a single resonant term of unknown strength and represented by a B.W. function with $M^* = 1660$ MeV, $\Gamma = 60$ MeV and background amplitudes which vary linearly with the momentum. S,P and D waves with arbitrary phases have been considered for the background and also, alternatively, for the resonant state. A minimum χ^2-fit to the data was made with the following results: a) the assumption that there is no resonant amplitude gives an extremely poor fit to the data. This, as the authors emphasize, does not prove that a resonant amplitude exists since it could also mean that the wrong assumptions have been made about the behaviour of the background.

b) a reasonable fit to the data is obtained with a $D_{3/2}$ resonant amplitude but not with $S_{1/2}$, $P_{3/2}$ or $D_{5/2}$. The $D_{3/2}$ and $P_{3/2}$ solutions are shown in the figure and illustrate the results of the fit.

This group have also studied the channel

$$K^- p \rightarrow \Lambda^0 \pi^+ \pi^-$$

in the same momentum interval and conclude that it is dominated by

$$K^- p \rightarrow Y_1^* (1385) + \pi .$$

The observed population of the Dalitz plot leads them to the conclusion that in the 1660 mass region this reaction is dominated by the $D_{3/2}$, $I = 1$ state. That the Y^* (1660) occurs as an intermediate state cannot again be established.

How can the situation be summarized? It is clearly very reminiscent of what happens in the (πN) resonances as soon as we get away from the (33) resonance - whose equivalent in the Y^* case is, of course, the Y^* (1520). Piecemeal investigation of the enhancements is likely to be misleading and not very fruitful. The possible resonances are too close together for their interference effects to be ignored. As Ticho and coworkers pointed out in their original publication$^{(23)}$, and this much seems to be confirmed by the Brookhaven data, there are indications of presence of new processes (1765?) not far from the expected position of the

1660 . Recently photographs have been taken both in Berkeley and at CERN to extend up to 1.2 GeV/c (i.e. 1890 MeV in mass) investigations similar to the one just described. I think it will be better to wait for their results before too much is made out of the present data.

$\Lambda^{\circ}\eta^{\circ}$ (1680). This enhancement comes from the study of production in a 24 l. propane chamber exposed to a 7-8 GeV/c π^{-}-beam at Dubna$^{(25)}$. A total of 134 Λ° events associated with only one gamma ray were observed. The experimental evidence is shown in fig. 14, where the $\Lambda\gamma$ effective mass-squared has been plotted. Two peaks corresponding to masses of 1180 and 1340 MeV are seen. The first is attributed to Σ° production, while the second one cannot be reproduced from the kinematics of a hyperon resonance ($Y^{*}(1385)$ or Y_1^{*} (1660)). In view of this, the authors take up a suggestion made by Ioffe$^{(26)}$ in connection with the behaviour of the $K^{-}p \rightarrow \Lambda^{\circ} + \eta^{\circ}$ cross-section near threshold. The suggestion is that this behaviour may be explained by a $\Lambda^{\circ}\eta^{\circ}$ resonance with a mass ~1680 MeV and a width $\Gamma < 20$ MeV.

On the assumption that the observed enhancement in the mass-squared spectrum between 1.7 - 2.0 GeV^{2} is due to a process

$$A \rightarrow \Lambda^{o} + \underset{\hookrightarrow \gamma + \gamma}{C}$$

the separate masses of A and C were calculated with the result A = 1660 MeV and C = 459 MeV - (no errors are quoted) - in agreement with the model. A check is obtained from the shape of the γ-ray spectrum in the laboratory system. The shape and the central value are in good agreement with that expected from the η°-decay. The isospin of the resonance should be zero; the spin 1/2 (S-state, since it is so close to the $\Lambda\eta$-threshold) and the parity negative.$^{(26)}$

$\Xi^*_{1/2}(1820)$. Indications that a new baryonic resonance with strangeness minus 2 ($S = -2$) and a mass ∼1820 MeV may exist were recently published at Berkeley (27). Two independent contributions have been presented at this Conference: one from Berkeley(28) and the other from the Ecole Polytechnique-Saclay (Paris) collaboration(29). The reaction channels of negative kaons on protons first examined by the two groups (Berkeley at K^- momenta from 2.4 to 2.7 GeV/c, Paris at 3.0 GeV/c) are:

	Berkeley	Paris
$\pi^+\pi^- K^+ \Xi^-$	41	26
$K^0 \Xi^0 \pi^+\pi^-$	26	Not included
$K^0 \Xi^- \pi^+ \pi^0$	45	41

There is very strong production of $\Xi^*_{1/2}(1530)$ in the above channels. By suitably defining a range of $(\Xi\pi)$ masses, events are then divided into those showing Ξ^* production and those not showing it. A Dalitz plot of the final state $\Xi^* K \pi$ is then drawn with the result shown on fig. 15 for the Berkeley events. Projection onto the $M^2(K\pi)$ and $M^2(\Xi^*\pi)$ axes shows clearly the presence of the $K^*(888)$ and an accumulation of $M^2(\Xi^*\pi)$ masses in the region 3.1 - 3.6 GeV^2. This $(\Xi^*\pi)$ accumulation appears, however, to be strongly correlated with the $K^*(888)$ as can be seen when the K^* events are subtracted from the $(\Xi^*\pi)$ distribution. As indicated by the clear part of the histogram no significant effect remains after the subtraction. For the non $\Xi^*(1530)$ Berkeley events, a plot of $I_3 = \pm 1/2$ $(K\pi)$ combinations versus $(\Xi\pi\pi)$ combinations shows a broad and statistically not very significant enhancement in the neighbourhood of $M(\Xi\pi\pi) \sim 1820$ MeV. In the three body final states $\Xi^-\pi^{\overset{+}{0}}K^{\overset{0}{+}}$, $\Sigma^- K^{\overset{+}{0}} \overline{K^{\overset{+}{0}}}$ Berkeley see again the same feeble and broad enhancements in the combinations $(\Xi\pi)$ and $(\Sigma\bar{K})$. This is seen in fig. 16. Here the histogram of masses $(\Lambda K^o + \Lambda\bar{K}^o + \Lambda K^-)$ is also shown for the channels $\Lambda K\bar{K}$ after subtraction of the ϕ events.

Note that in this histogram the two indistinguishable combinations ΛK^o, $\Lambda\bar{K}^o$ have been plotted and added to the ΛK^- distribution. Since the latter (ΛK^-) does not show any peaking but a displacement to the high end of the phase-space spectrum, the peaking comes essentially from the $(\Lambda K^o + \Lambda\bar{K}^o)$ combinations.

The Paris data were interpreted negatively as far as the enhancement at 1820 is concerned in the decay modes $\Xi\pi$, $\Xi^*\pi$ and $\Xi\pi\pi$ but a 2.5 standard deviation effect in the mass interval 1.80 - 1.85 GeV is seen in the $(\Lambda K^o + \Lambda\bar{K}^o)$ mass-histogram in the channel $K^-p \rightarrow \Lambda K^o\bar{K}^o$ after the ϕ events have been removed. This is seen in fig. 17. A feature which may be of interest is the fact that the peak seems to be connected with a backwards angular distribution of the 1820 system in the c.m. of the colliding particles.

Examination of the ΛK^- and ΛK^+ effective mass distributions in ΛK^+K^- - again after elimination of the ϕ^o events - shows a small enhancement in the ΛK^-- system and a hole in the (ΛK^+) system in the interval 1.80 - 1.85 GeV. Adding the ΛK^- histogram to the previous $(\Lambda K^o + \Lambda\bar{K}^o)$ histogram, the Paris group obtain the total histogram shown in fig. 18.

A fair summary of the two experiments is, I believe, the following: $\Xi^*\pi$, $\Xi\pi\pi$ and $\Xi\pi$ effective masses appear to be displaced towards the high end of phase space. This trend cannot be directly attributed to the existence of a resonant state.

Nevertheless the unresolved mass-distribution $\Lambda K^0 + \Lambda \bar{K}^0$ shows a peaking at a mass-value of ~1820 MeV in both experiments. Whether the strangeness is 0 or -2 cannot be firmly established since the evidence from the ΛK^- system is inconclusive: in the Paris experiment the significance of the $\Lambda \bar{K}^0 (\Lambda K^0)$ peak is enhanced while the Berkeley $\Lambda \bar{K}^0 (\Lambda K^0)$ distribution is smeared out by addition of the ΛK^- effective masses. The apparent non-existence of an N^* at ~ 1820 MeV would favour the $S = -2$ possibility.

Isospin of the eventual resonance is $I = 1/2$.

If one assumes now that the effedt is real, the branching ratios quoted by the two groups are:

$\Xi^*\pi$	$\Xi\pi\pi$	$\Xi\pi$	$\Lambda\bar{K}$	$\Sigma\bar{K}$	
1.25	0.30	0.25	1	0.04	(Berkeley)
<0.5	<0.5	<0.1	1	?	(Ecole Polytechnique - Saclay)

Expect perhaps for the mode ($\Xi\pi$), at the present level of statistics, the results are not really in disagreement. Certainly more data are required before one is satisfied that this state does really exist.

Although results have not been presented at this Conference, it is worth nothing that at the Siena Conference(30) the European groups working with a heavy liquid chamber with 3.5 BeV/c K^- presented evidence for a $I_3 = 1/2$ enhancement in the $(\Xi^-\pi^{\overset{+}{0}})$ mass-region between 1700 and 1800 MeV. Whether this is the same enhancement or not is not quite clear at present.

This written report is almost a word by word reproduction of what I actually said at the Conference. To accelerate publication I have preferred not to revise or to embellish it. My apologies to those authors whose results might have been more fairly interpreted had I yet had another look at them.

Many people have helped me in one way or another to prepare this report. In particular Dr. G.I. Kopylov and the other session secretaries have to be thanked for all the kind and efficient help they have given me.

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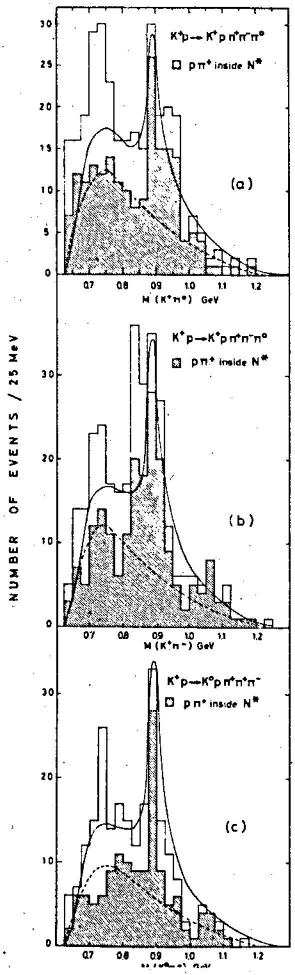


Fig. 1 M(Kπ) spectra in the reaction $K^+p \rightarrow pK^{\overset{0}{+}}\pi^+\pi^-\pi^{\overset{+}{0}}$ at 3.0 GeV/c showing production of K^* (888) and $\varkappa$ in the three charge combinations (Ref. 3).

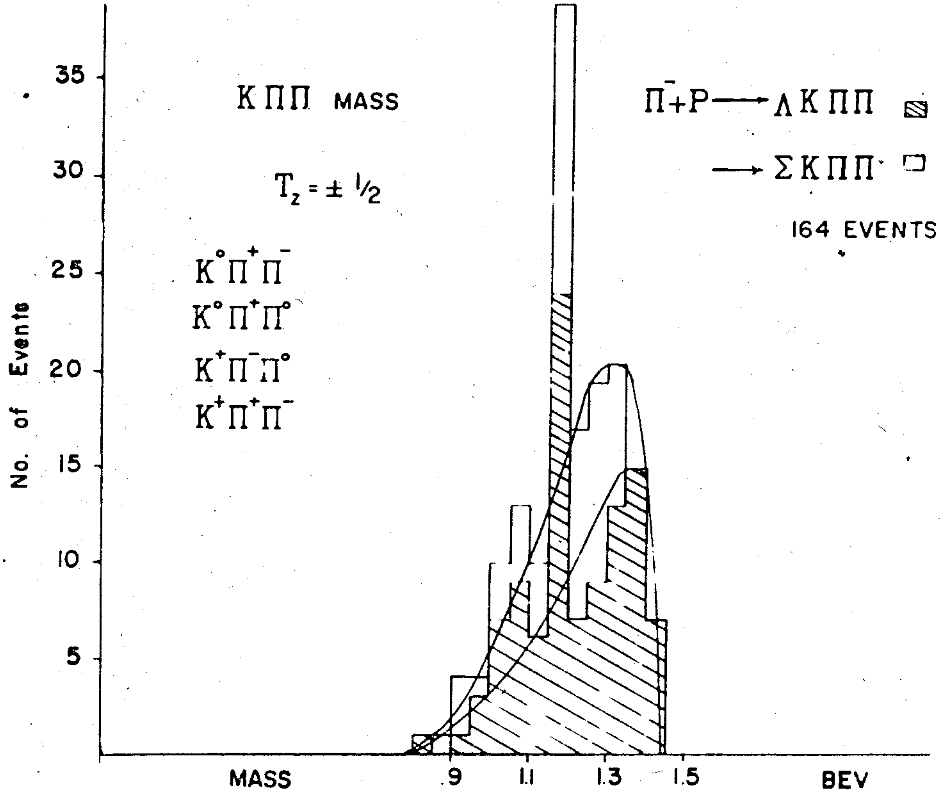


Fig. 2 Evidence of Wangler et al(6) for a $(K\pi\pi)$ enhancement at 1175 MeV in π^-p-collisions at 3.0 GeV/c.

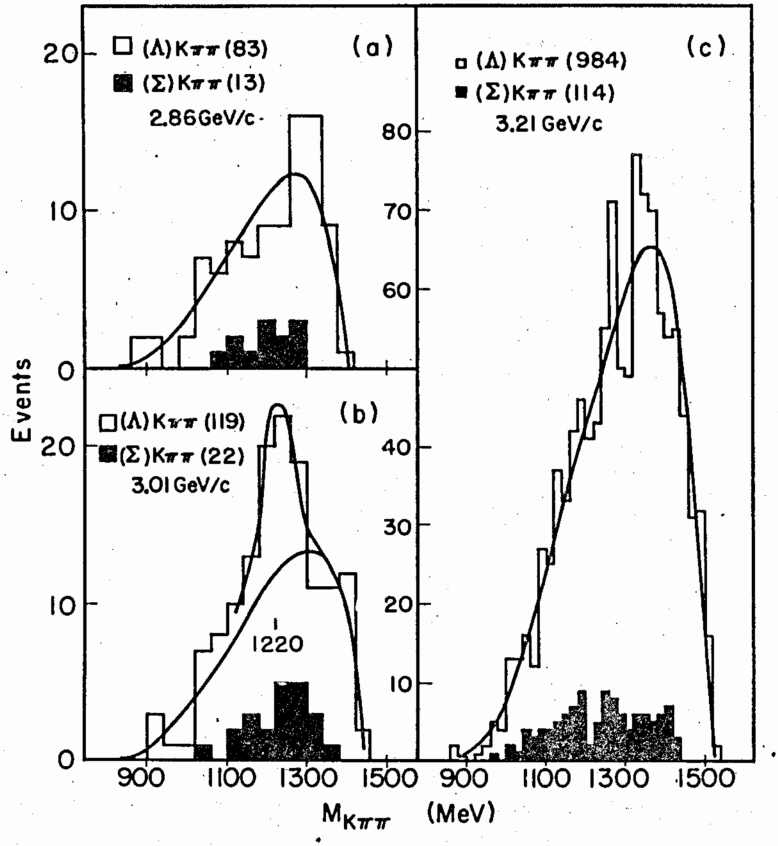


Fig. 3 (Kππ) effective masses in $\pi^- p \to \Lambda(\Sigma) K\pi\pi$ from ref.(7)

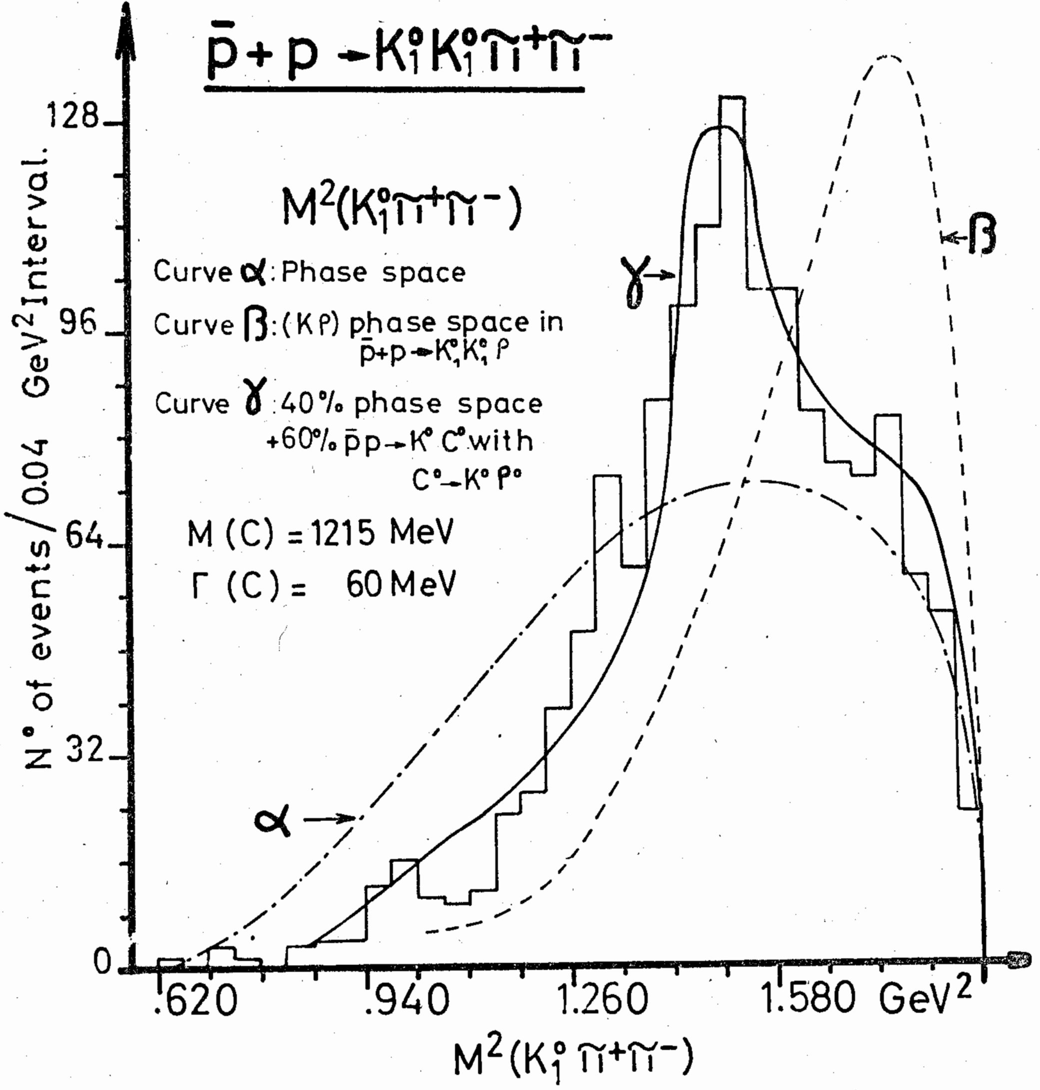


Fig. 4 $M^2(K_1^0\pi^+\pi^-)$ in $\bar{p}p \to K_1^0 K_1^0 \pi^+\pi^-$ at rest(10).

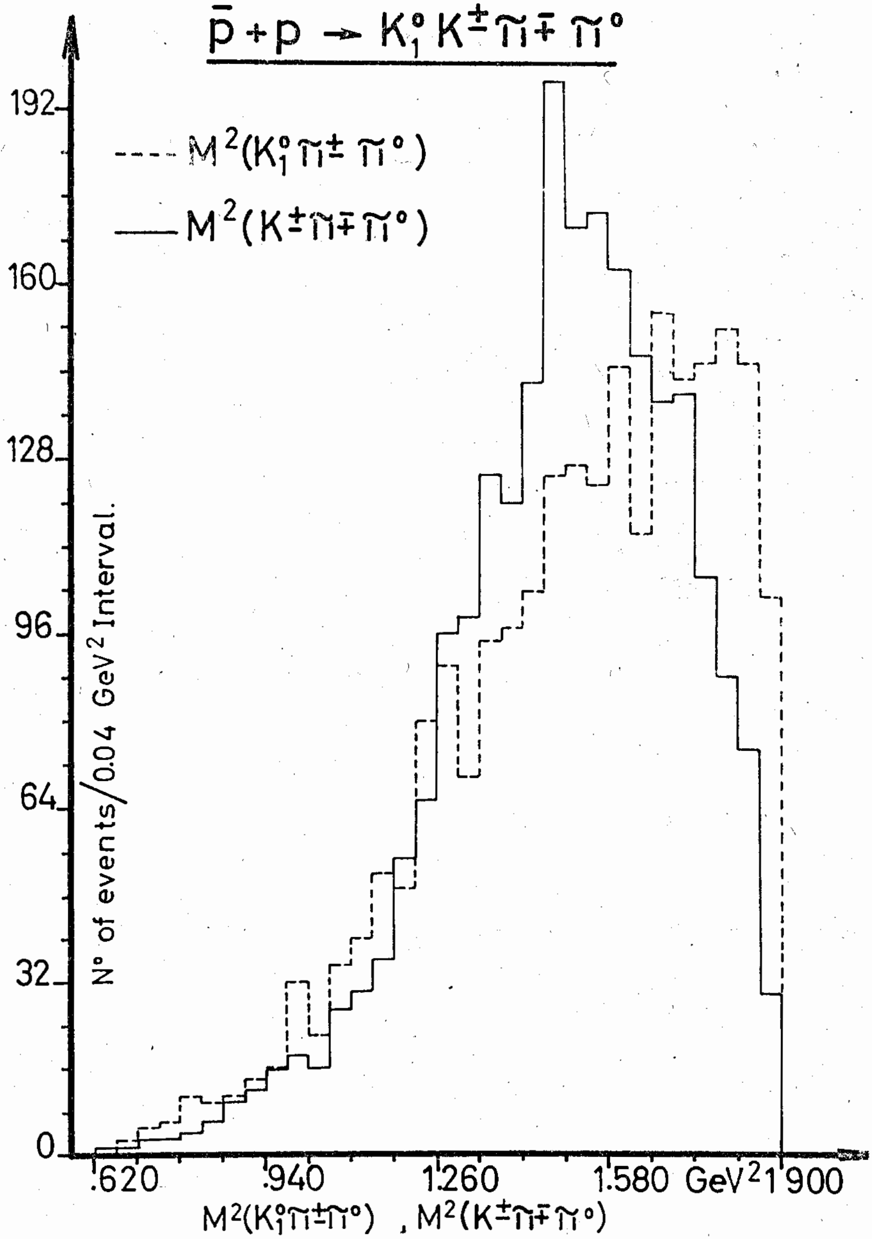


Fig. 5 The $M^2(K_1^0 \pi^+ \pi^-)$ and $M^2(K^{\pm} \pi^{\mp} \pi^0)$ in the channel $\bar{p}p \rightarrow K_1^0 K^{\pm} \pi^{\mp} \pi^0$ from the CERN-Collège de France experiment(9).

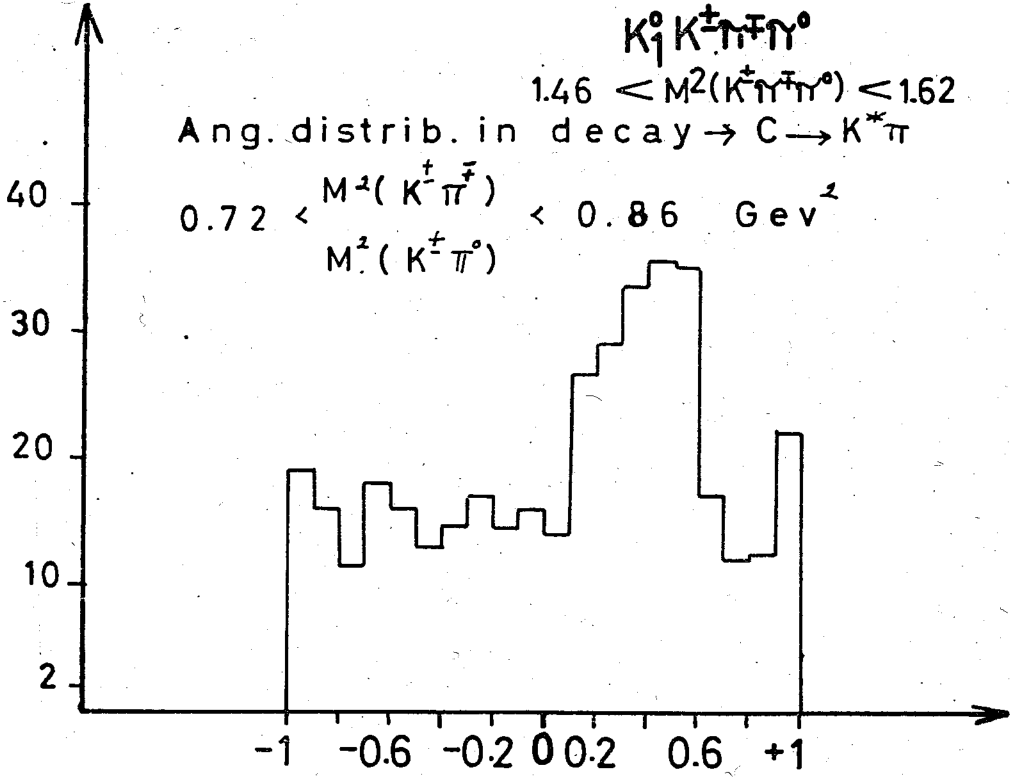


Fig. 6. Angular distribution in decay $C \rightarrow K^* \pi$. The $C^{\pm}$ is defined by $1.46 \leqslant M^2(K^{\pm}\pi^{\mp}\pi^0) \leqslant 1.62$ GeV^2 (Ref. 9).

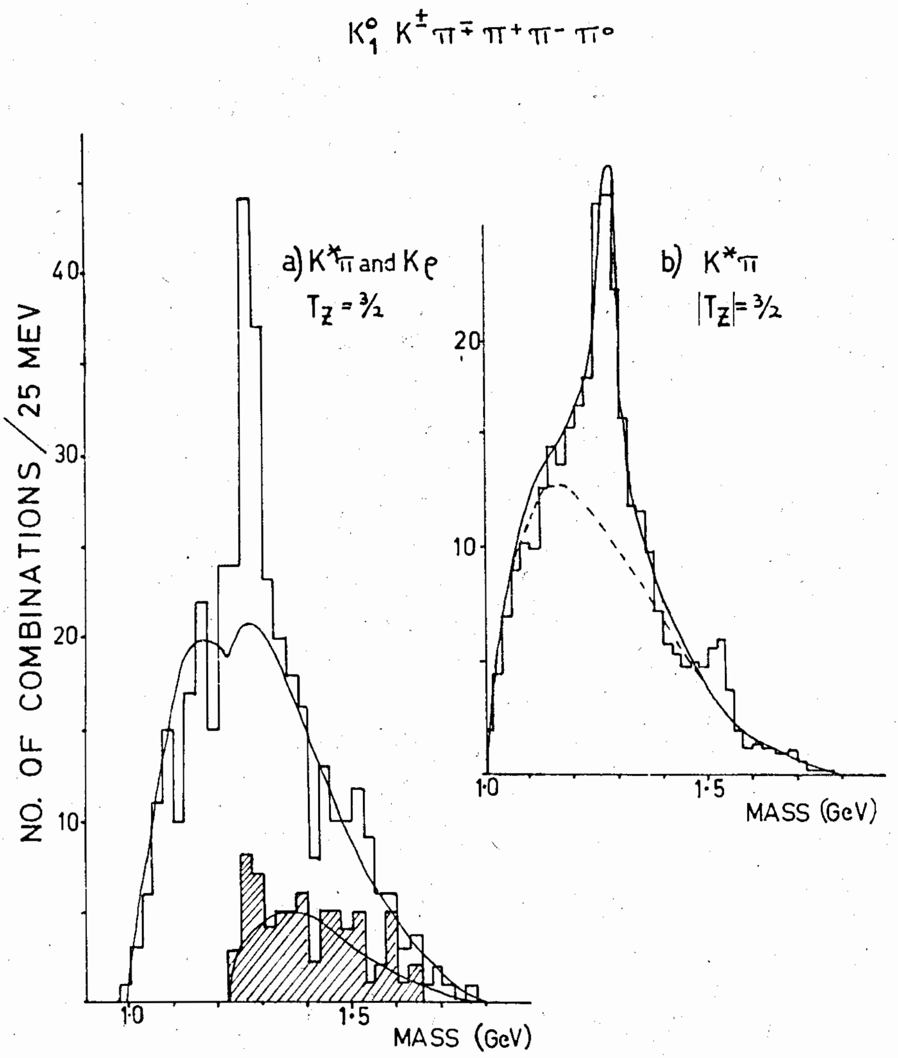


Fig. 7. $|I_3| = 3/2$ (Kππ) mass histogram in the reaction $\bar{p}p \to K_1^0 K^{\pm} \pi^{\mp} \pi^+ \pi^- \pi^0$ at 3.0 GeV/c (From ref. 11).

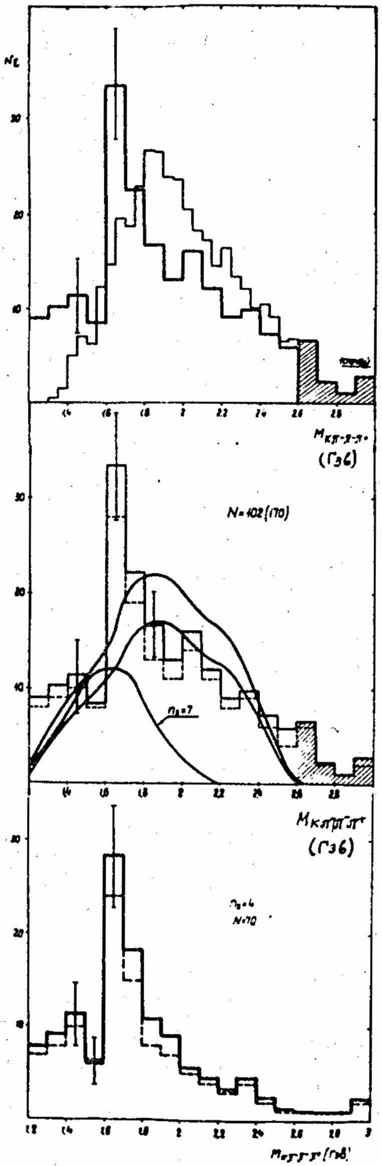


Fig. 8. Evidence for an enhancement $(K^0\pi^-\pi^-\pi^+)$ at 1660 MeV in reactions $\pi^-p\rightarrow\Lambda(\Sigma)K^0(n)\,\pi^{\pm}(m)\,\pi^0$ at 7 GeV/c (Ref. 13).

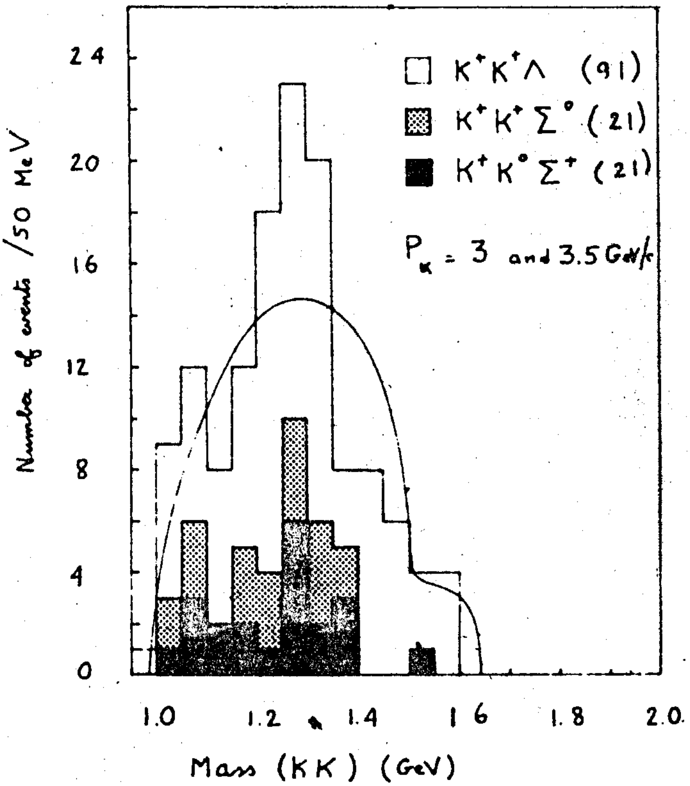


Fig. 9 The distribution of $M(K^+K^+)$ in the reaction $K^+p \rightarrow K^+K^+\Lambda$ at 3.0 GeV/c.

The smooth curve represents phase space normalized to the total number of events (Reference 14).

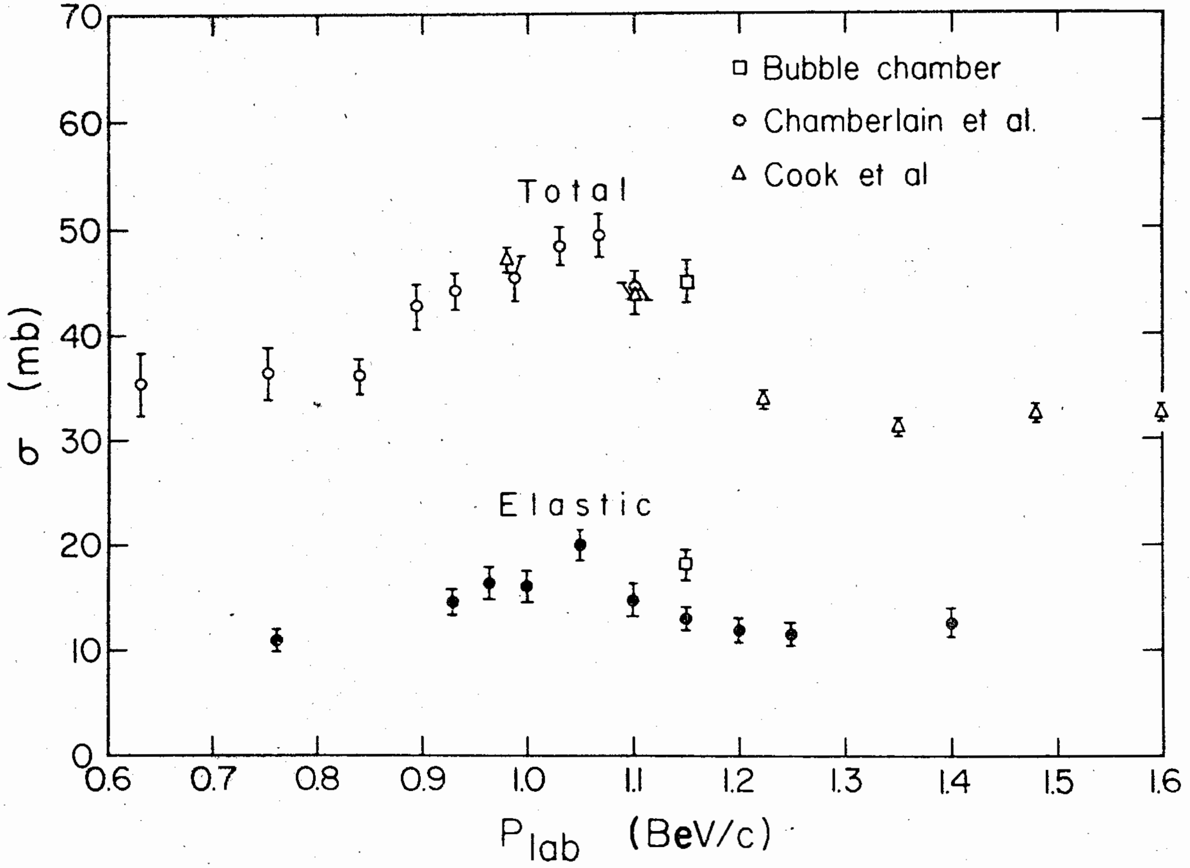


Fig. 10 A summary of (K^-p) total and elastic cross-sections from 0.6 to 1.5 GeV/c.

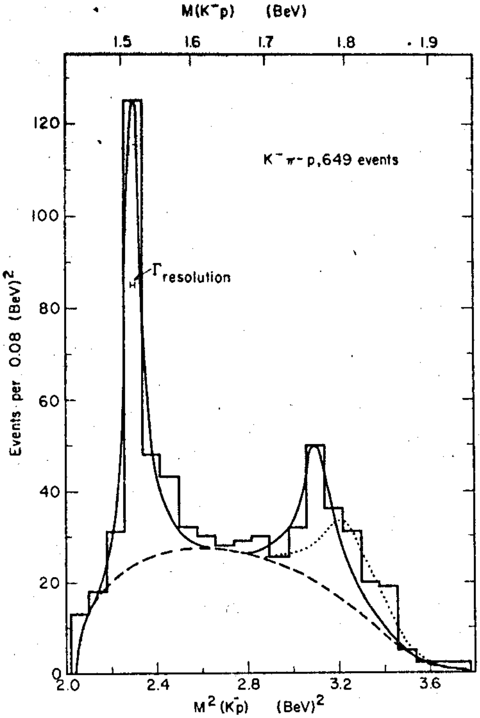


Fig. 11 The $M^2(Kp)$ – distribution obtained by Barbaro-Galtieri et al(19) in $K^- n \rightarrow K^- p \pi^-$ at 1.5 GeV/c. Besides production of the $Y_0^*(1520)$ an enhancement is seen corresponding to a mass of 1765 MeV.

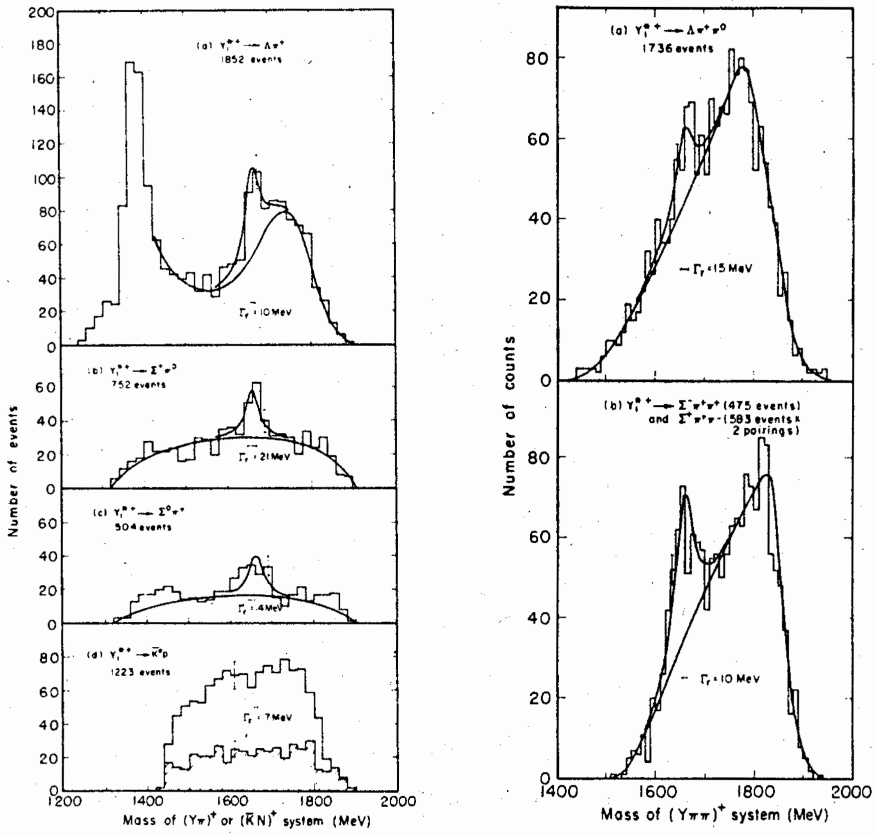


Fig.12 Different ($Y\pi$) and ($Y\pi\pi$) mass-distributions observed by Alvarez et al(21) in K^-p collisions at 4,5 GeV/c

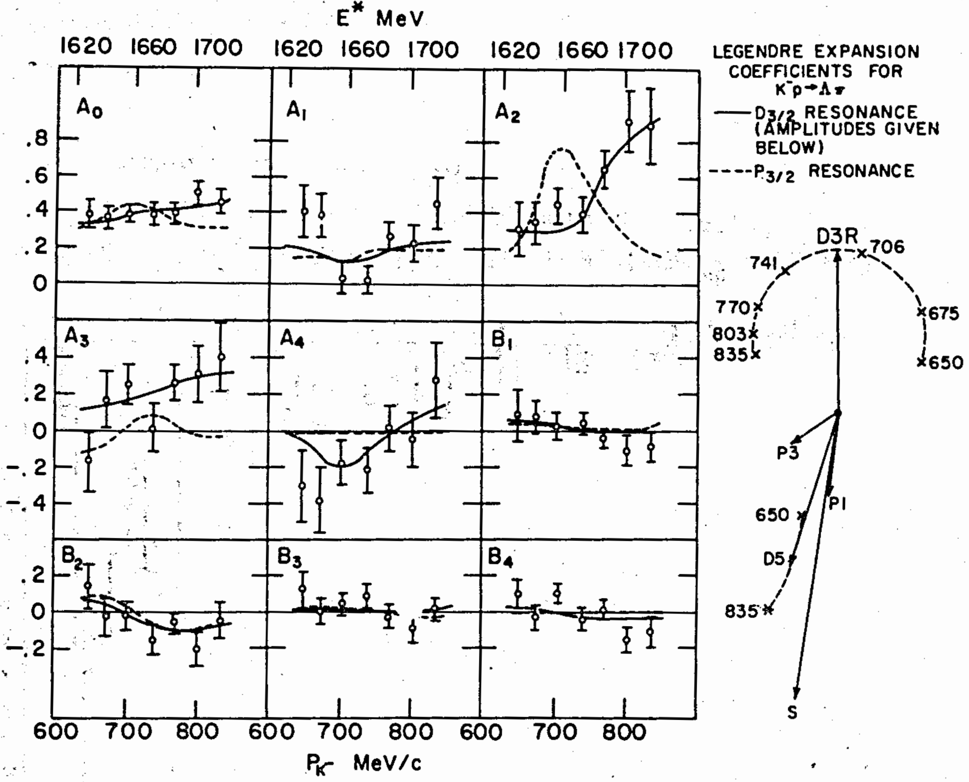


Fig.13 Coefficients for Legendre polynomial expansion for the cross-section and polarization of the Λ^0 in $K^-p \to \Lambda\pi^0$. The curves show the result of fits in terms of background and $D_{3/2}$ ($P_{3/2}$) resonance amplitude. The amplitude vectors for the best solution are also shown (Ref.24).

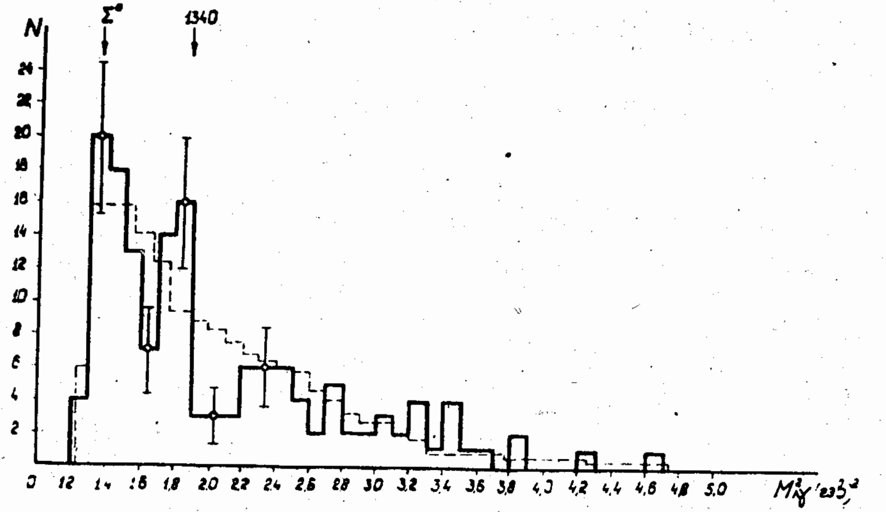


Fig.14 The M^2 ($\Lambda^\circ\gamma$) distribution obtained at Dubna(25). The peak at a mass ~1340 is explained in terms of a $(\Lambda^\circ\eta^\circ)$-enhancement at a mass = 1680 MeV.

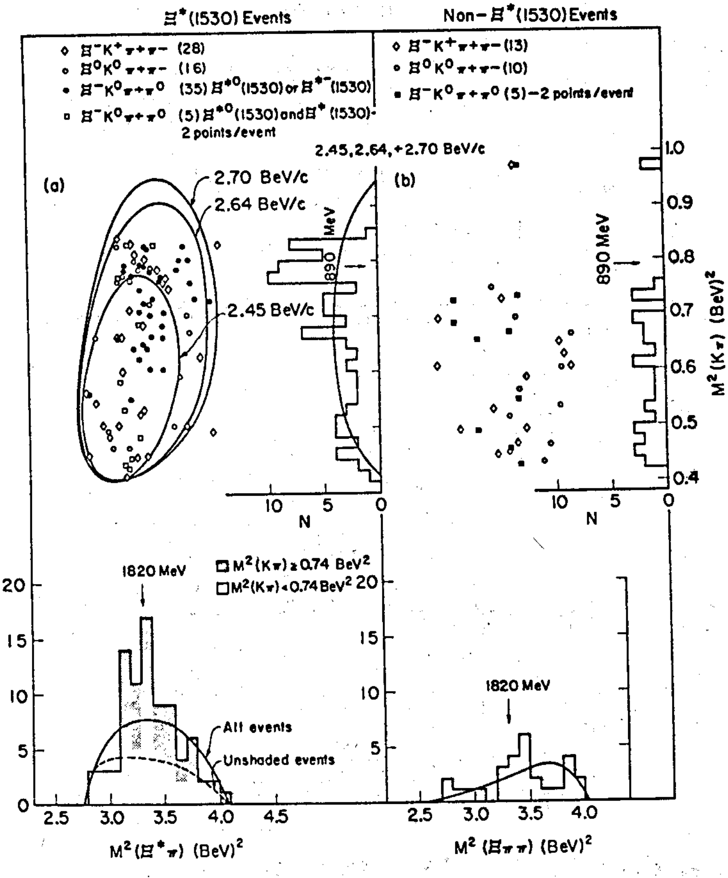


Fig.15 Dalitz-plot of the final state (Ξ π π K) for events containing a Ξ* (1530) (a) or not containing a Ξ* (1530) (Ref.28)

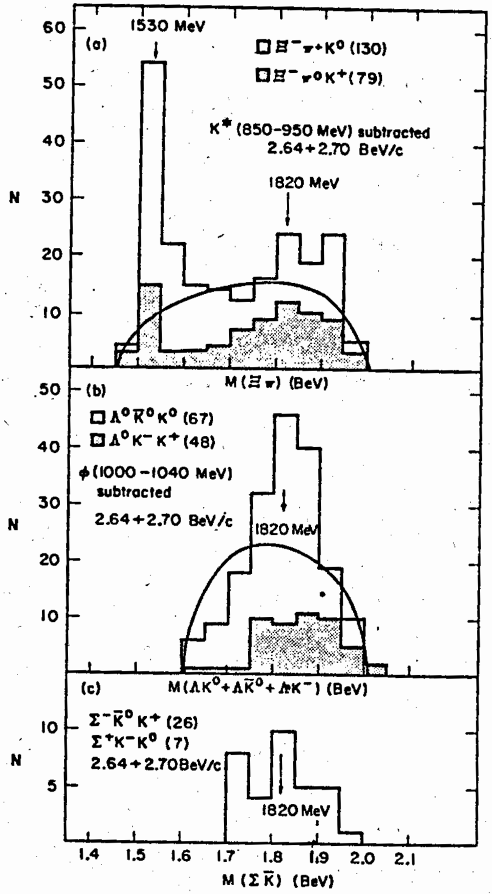
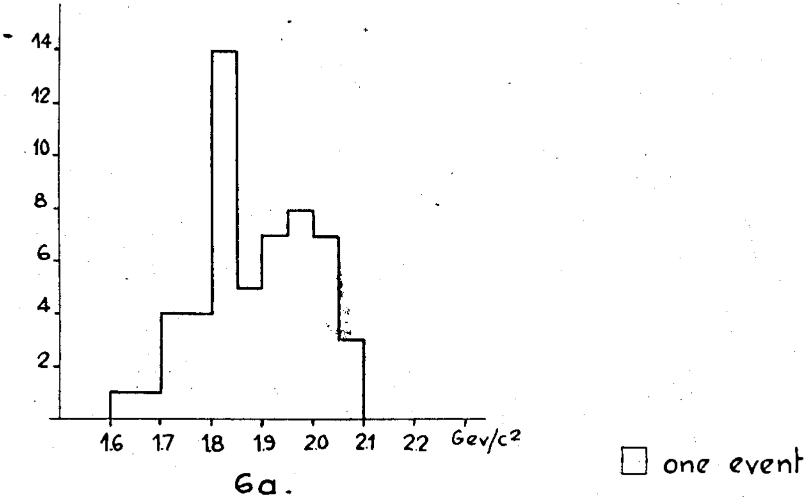


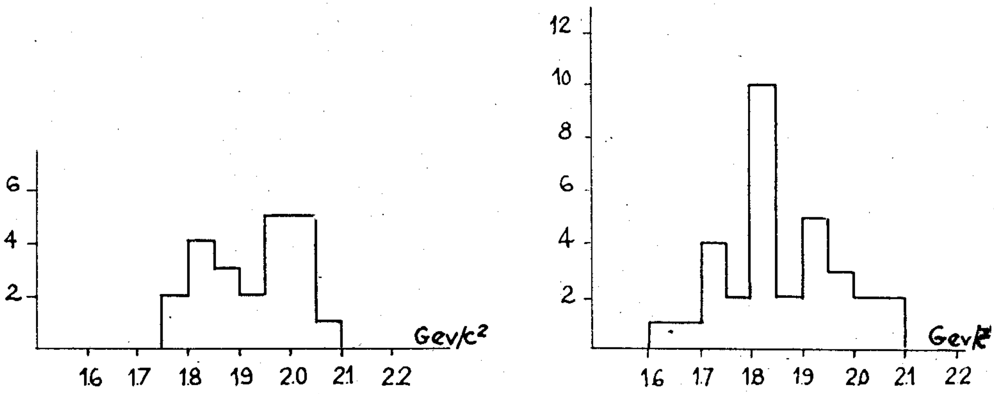
Fig.16 Effective ($\Xi\pi$), ($\Lambda K^{\circ}+\Lambda\overline{K^{\circ}}+\Lambda K^{-}$) and ($\Sigma\overline{K}$) masses showing enhancements in the neighbourhood of 1820 MeV (Ref.28)



6a.

$K^-p \to \Lambda^\circ K^\circ \bar{K}^\circ$

mass $\Lambda^\circ K^\circ$ or $\Lambda^\circ \bar{K}^\circ$
(φ° removed = 1010-1030)



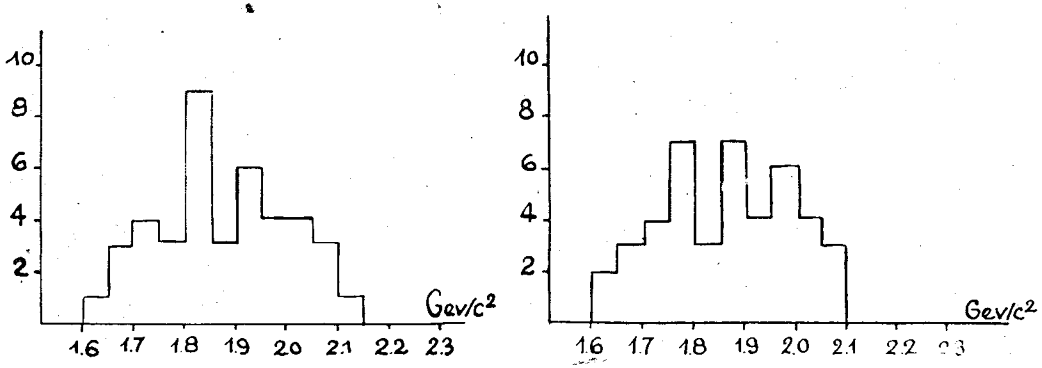
6b

mass of $(\Lambda^\circ K^\circ)$ or $(\Lambda^\circ \bar{K}^\circ)$ system
produced forwards in C.M.S

6c.

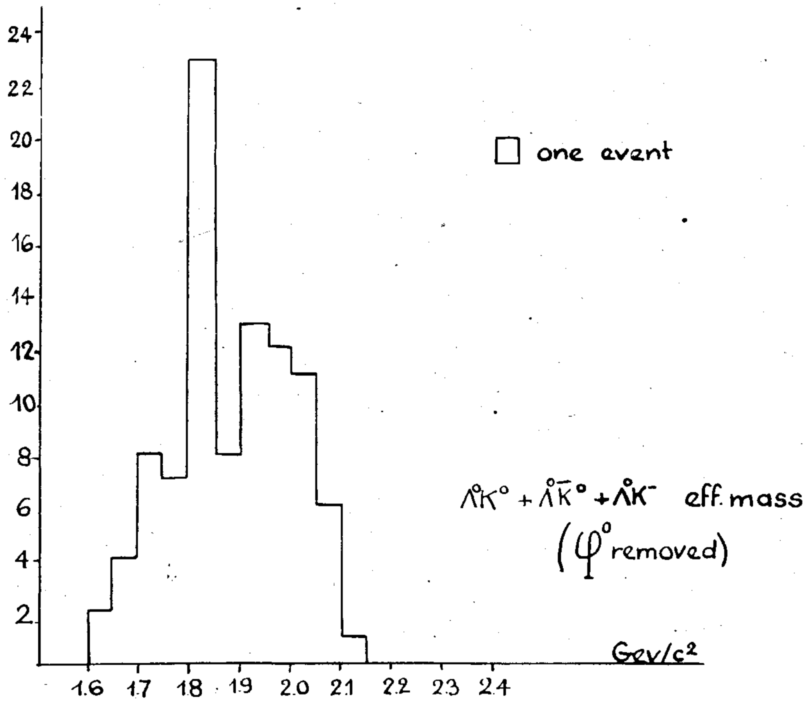
backwards

Fig.17 Histogram of effectives, masses $\Lambda^\circ K^\circ$ $(\Lambda^\circ \bar{K}^\circ)$ in $K^-p \to \Lambda^\circ K^\circ \bar{K}^\circ$ at 3.0 GeV/c after the ϕ -events have been removed$^{(29)}$. The bottom histograms show the same distributions for $\Lambda^\circ K^\circ$ $(\Lambda^\circ \bar{K}^\circ)$ systems produced forwards (backwards) in c.m. of collision.



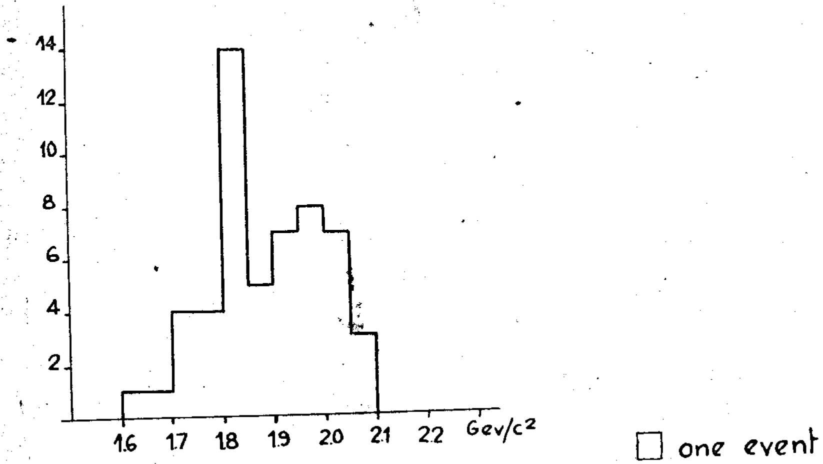
Λ^0K^- eff. mass (φ^0 removed)

Λ^0K^+ eff mass (φ^0 removed)

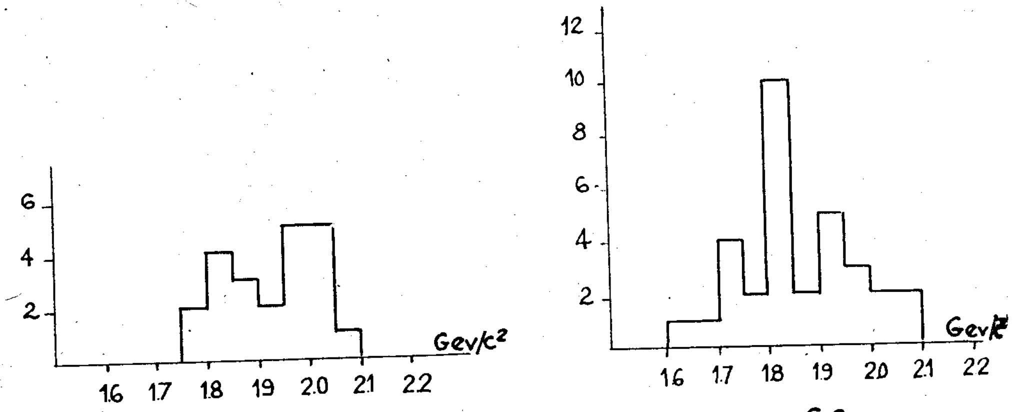


$\Lambda^0K^0 + \Lambda^0\bar{K}^0 + \Lambda^0K^-$ eff. mass (φ^0 removed)

Fig.18 Λ^0K^- (Λ^0K^+) effective-mass distribution in $K^-p\to\Lambda^0K^+K^-$ at 3.0 GeV/c after removing ϕ -events. The result of adding the (Λ^0K^-) distribution to that of fig.17 is shown in the lower histrogram (Reference 29).



6a.
$K^-p\to\Lambda^0K^0\bar{K}^0$
mass Λ^0K^0 or $\Lambda^0\bar{K}^0$
(φ^0 removed = 1010-1030)



6b

6c.

mass of (Λ^0K^0) or ($\Lambda^0\bar{K}^0$) system produced forwards in C.M.S

backwards

Fig.17 Histogram of effective~~s~~ masses Λ^0K^0 ($\Lambda^0\bar{K}^0$) in $K^-p\to\Lambda^0K^0\bar{K}^0$ at 3.0 GeV/c after the ϕ -events have been removed(29). The bottom histograms show the same distributions for Λ^0K^0 ($\Lambda^0\bar{K}^0$) systems produced forwards (backwards) in c.m. of collision.

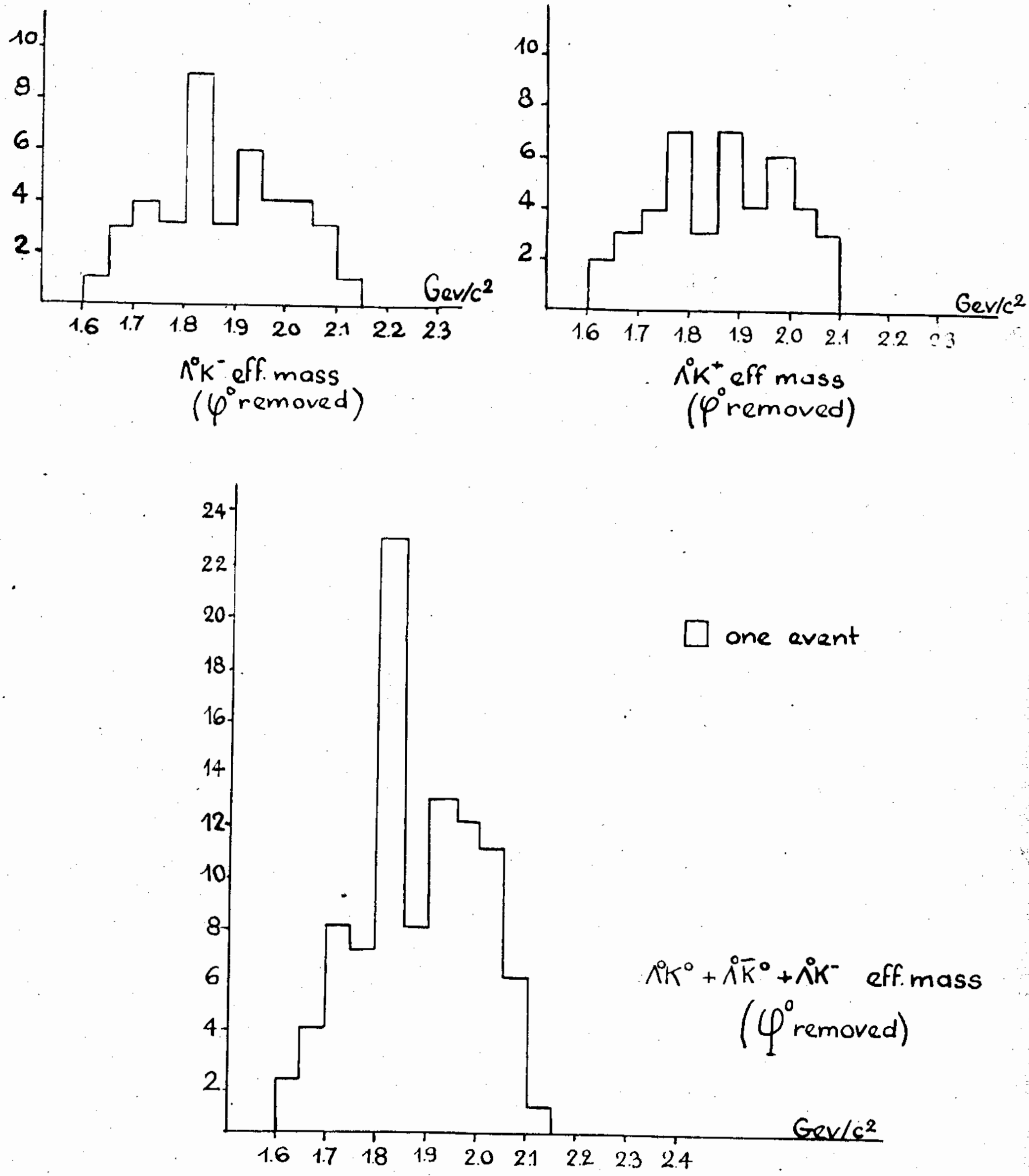


Fig.18 $\Lambda^0 K^-$ $(\Lambda^0 K^+)$ effective-mass distribution in $K^- p \rightarrow \Lambda^0 K^+ K^-$ at 3.0 GeV/c after removing ϕ -events. The result of adding the ($\Lambda^0 K^-$) distribution to that of fig.17 is shown in the lower histrogram (Reference 29).