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IN FAVOUR OF ISOSPIN
5/2 ISOBARS

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A b s t r a c t

The experimental data extracted from the analysis of the reactions

$\pi^- p \to n \pi^+ \pi^+ \pi^- \pi^-$ 4922 events (1)

$\pi^- p \to p \pi^+ \pi^- \pi^- \pi^0$ 7368 events (2)

$\pi^- p \to p \pi^+ \pi^- \pi^-$ 7056 events (3)

at 4,5 GeV/c are presented, which show an evidence for the existence of an isospin 5/2 isobars.

А.Ф.Нилов, А.Б.Кайдалов, Г.С.Ломкаци, В.Т.Смолянкин
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The problem of existens of exotic resonances - bosons which cannot be formed from quarks-antiquark ($q\bar{q}$) and baryons that consist of more than three quarks is of great interest. Different theoretical approaches [1-8] predict existance of such exotic states. Manyquark resonances arise in bag models and dual unitary models [5-7]. Exotic baryonic resonances, which appear in these models are comparatively heavy (M > 2 GeV) and have small width [5-7]. It has been shown in ref. [8] that, the analysis of the despersion sum rules points out to the existence of the baryonic resonance family E_I, with isotopic spins I $\geqslant$ 5/2. The lightes member of this family has the quantum numbers $J^P I = 5/2^+ \; 5/2$ and rather small mass M = (1.4 ÷ 1.7) GeV.

The most suitable for an experimental search of the E_I resonances is the backward production of these resonances - i.e. the reactions of the type $\pi^+ p \to (p\pi^+\pi^+)\pi^- \to E^{+++}_{5/2}\pi^-$ and $\pi^- p \to (n\pi^-\pi^-)\pi^+\pi^+ \to E^{--}_{5/2}\pi^+\pi^+$, where $p\pi^+\pi^+$ and $n\pi^-\pi^-$ are fast in the overall c.m.system.

The experimental data on multiple pion production in πK, KN and NN collisions do not contradict to the possibility of I = 5/2 baryonic resonances production with cross sections about 10 μb. In [9] the review of experimental situation up to 1972 is given. Recently a bump in the spectrum of $p\pi^+\pi^+$ and $n\pi^-\pi^-$ effective masses at M = 1.44 GeV produced in the reaction $np \to n\pi^-\pi^- p\pi^+\pi^+$ at 5.1 GeV/c has been observed [10].

In the present paper we wish to report on a possible production of exotic baryonic resonances with I = 5/2 and some evidence for an exotic baryon exchange in the t-channel in $\pi^- p$ interactions leading to four charge particles in the final state.

The investigation was performed, using the events obtained in the .5 m hydrogen bubble chamber exposed in the beam of π^- mesons at 4.5 GeV/c and related to one of the reactions

$\pi^- p \to n \pi^+ \pi^+ \pi^- \pi^-$	4922 events	(1)
$\pi^- p \to p \pi^+ \pi^- \pi^- \pi^0$	73[illegible]8 events	(2)
$\pi^- p \to p \pi^+ \pi^- \pi^-$	7056 events	(3)

The investigation of the longitudinal momentum distributions for particles in the reaction (1) has revealed a substantial number of events (1903) with large $P_{\parallel}$ of $n\pi^-$ pair [11]. This fact can be explained if one assumes the existance of the production mechanism mediated by the Δ, N Regge-pole exchange corresponding to the diagrams

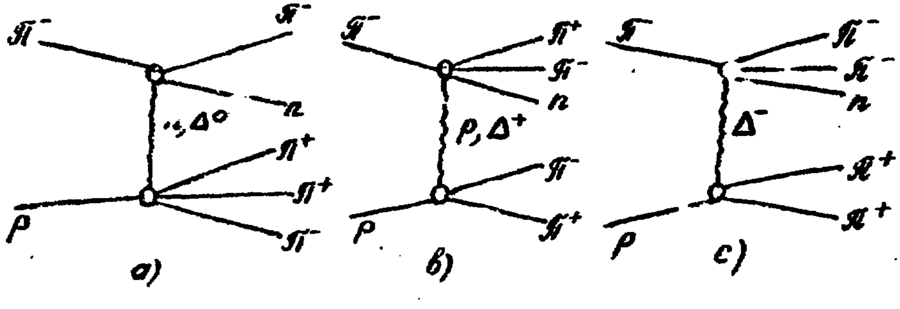

Fig. 1

Regge diagrams with the N, Δ exchange in the reaction (1)

The most interesting for our purpose is the diagram of fig. 1c because this mechanism can lead to production of the isobar with isospin 5/2.

Figures 2 and 3 show the $n\pi^-$ and $n\pi^-\pi^-$ invariant mass spectra for events produced in the reaction (1) with large $P_{\parallel}$ of $n\pi^-$ pair. The peak, corresponding to the isobar $\Delta^-_{3/2\ 3/2}$ (1232) is distinctly visible. The mass spectrum of the $n\pi^-\pi^-$ combinations (fig.3) as well as the total $n\pi^-\pi^-$ spectrum is smooth and do not show any anomalies. The effective mass spectrum of the $n\pi^-\pi^-$ system for the events of the reaction (1) satisfying the additional selection criterion that the invariant $n\pi^-$ system mass is in the interval of Δ^- isobar ($1.10 \leq M_{n\pi^-} \leq 1.38$ GeV) is shown in fig. 4. It can be seen that this spectrum is not regular. It should be noted that in the total $n\pi^-\pi^-$ spectrum we as authors of other works don't seen any irregularities. In order to demonstrate that the irregularities in the spectrum of the fig. 4 are not coused by our selection criteria we have plotted in figures 5,6,7 the effective mass spectra of the $\Delta^-\pi^+$, $n\pi^+$ and $n\pi^+\pi^+$ systems with the same selection criteria as mentioned above. It can be seen from figures 5 and 7 that, in contrast to the distribution of fig. 4, these spectra are smooth and show only insignifican statistical fluctuations. Thus the presence of the significant irregularities on the effective mass spectrum of the $\Delta^-\pi^-$ system cannot be explained by kinematic reflactions. We have tried to fit the distribution in fig. 4 by the statistical phase-space curve (dotted line). The agreement between the calculated and the experimental dis-

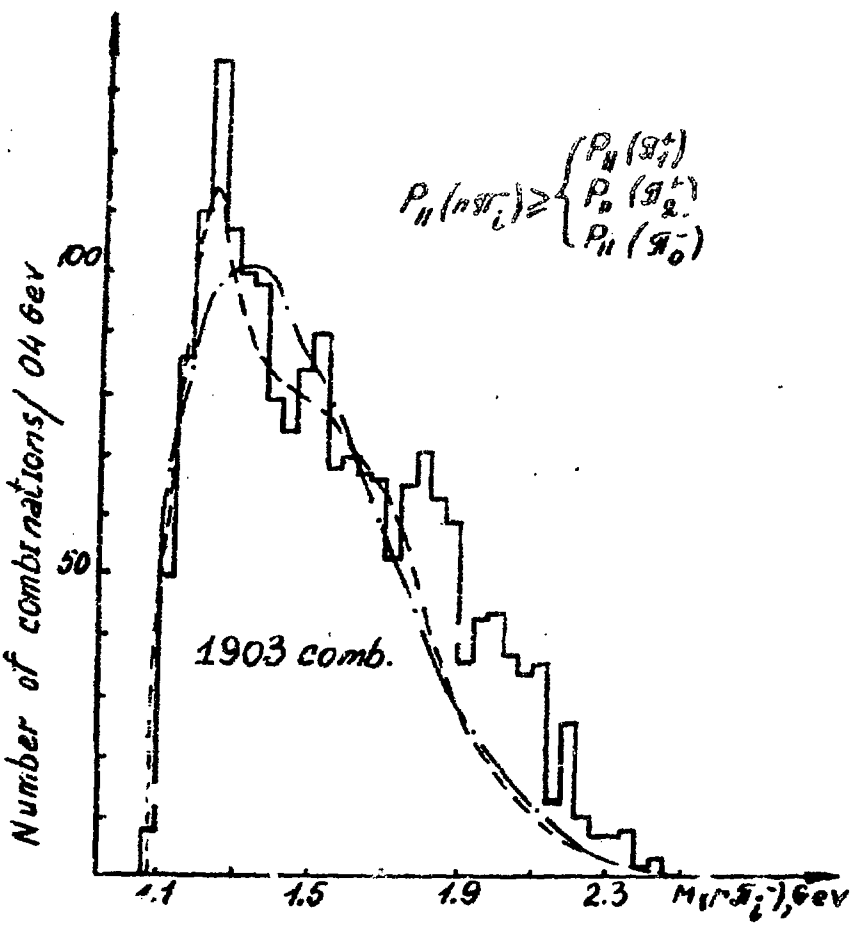

Fig. 2. The $(n\pi_i^-)$ effective mass distribution of the reaction (1) for the events satisfying the selection criterion $P_{\parallel}(n\pi_i^-) \geq P_{\parallel}(\pi^+_1); P_{\parallel}(\pi_2^+); P_{\parallel}(\pi_0^-)$.

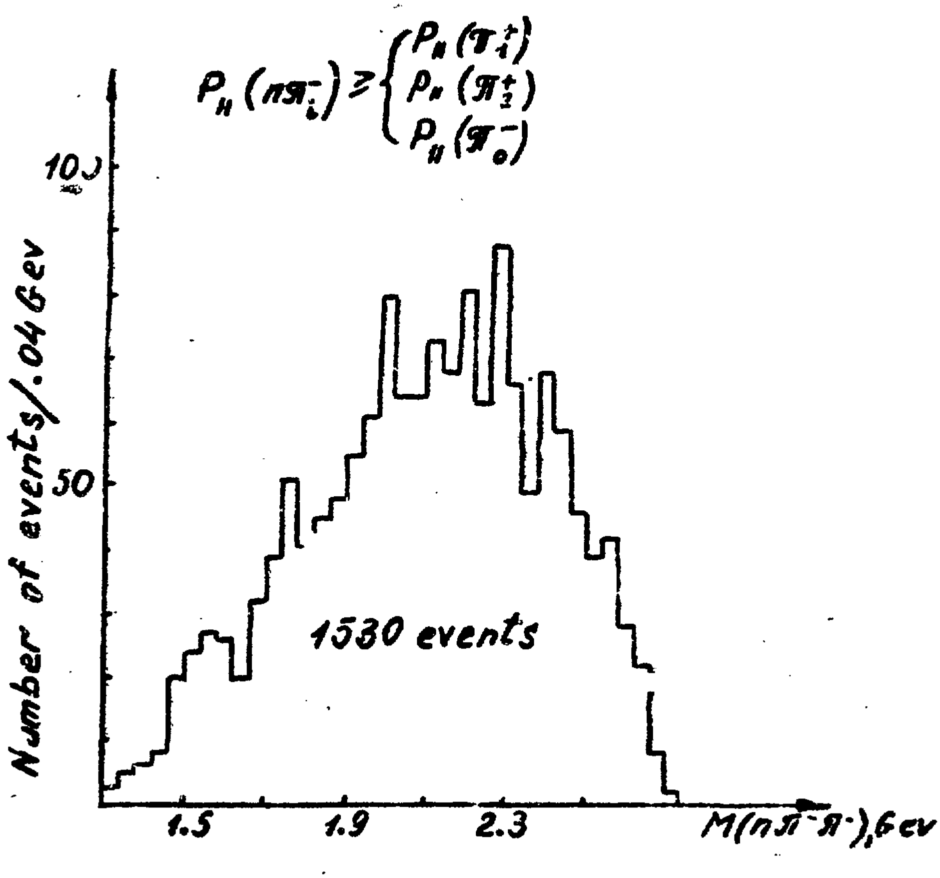

Fig. 3. The $(n\ \pi^-\pi^-)$ effective mass distribution of the reaction (1) for the evencs satisfying the same selection criterion as on fig. 2.

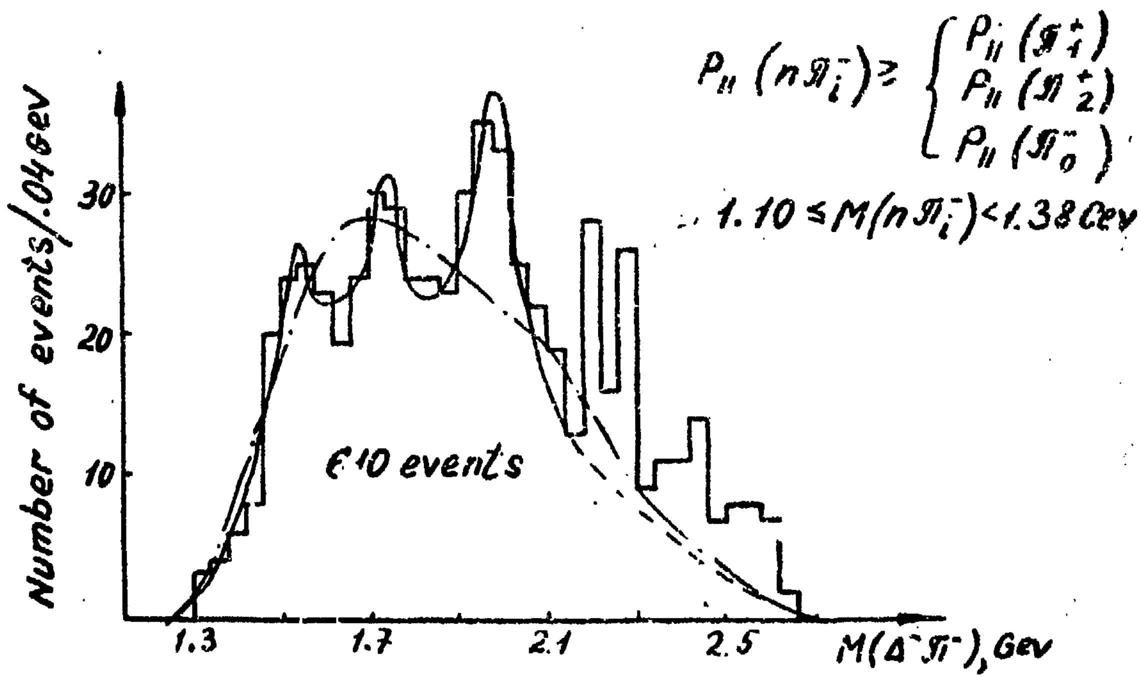

Fig. 4. Tl › $(n\ \pi^-\ \pi^-)$ effective mass distribution of tl › reaction (1) for the events satisfy'ng the selection criteria

1) $P_{\parallel}(n\pi_i^-) \geq P_{\parallel}(\pi_1^+);\ P_{\parallel}(\pi_2^+);\ P_{\parallel}(\pi_0^-)$.

2) $1,10 \leq M(n\pi_i^-) \leq 1.38$ GeV.

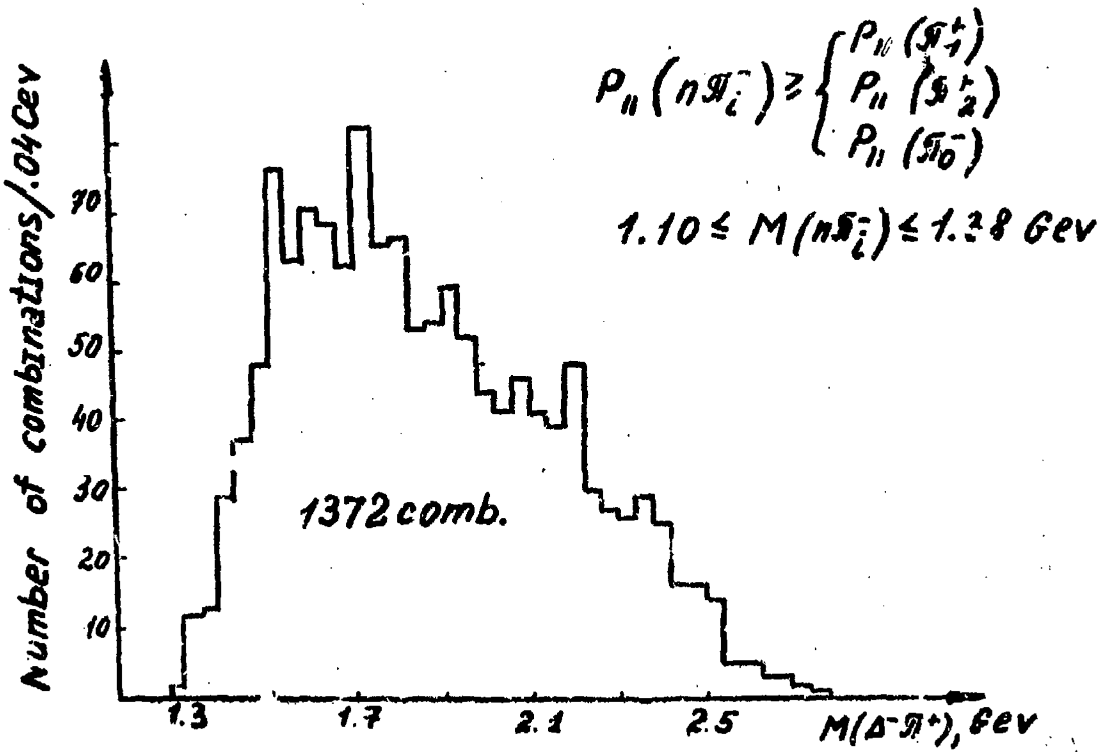

Fig. 5. The $(n\pi^+\pi_i^-)$ effec ive mass distribution of the reaction (1) with the same selection criteria as on fig. 4.

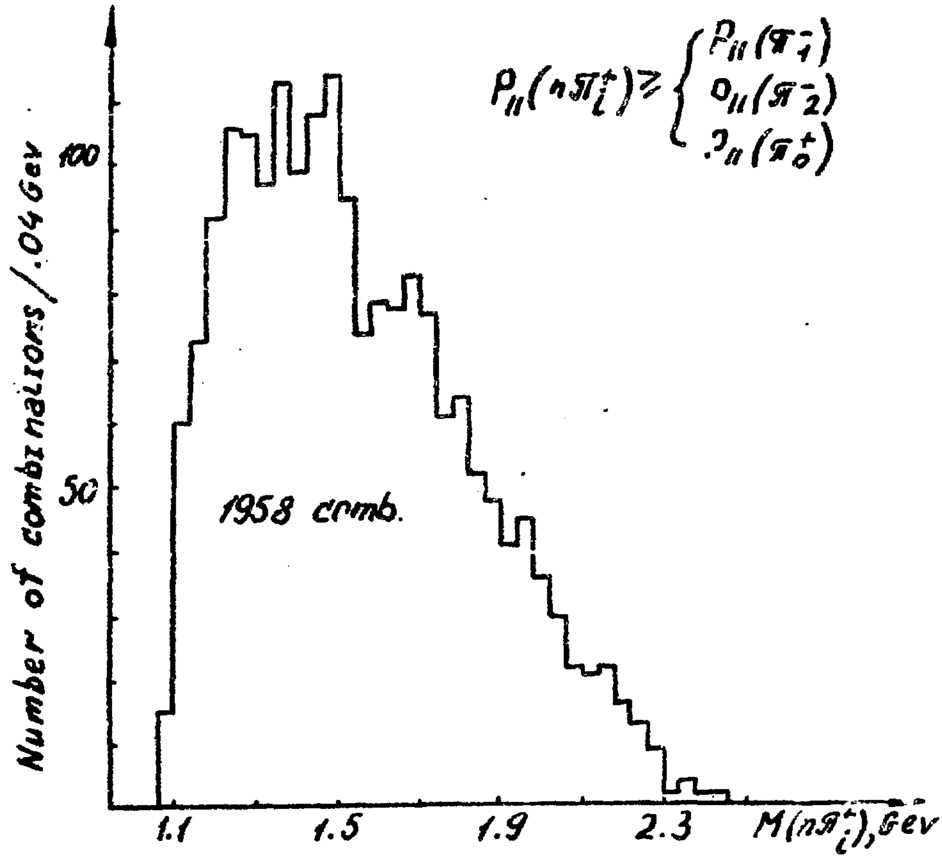

Fig. 6. The $(n\pi_i^+)$ effective mass distribution of the reaction (1) for the events satisfying the selection criterion

$$P_{\parallel}(n\pi_i^+) \geq P_{\parallel}(\pi_1^-);\ P_{\parallel}(\pi_2^-);\ P_{\parallel}(\pi_0^+)$$

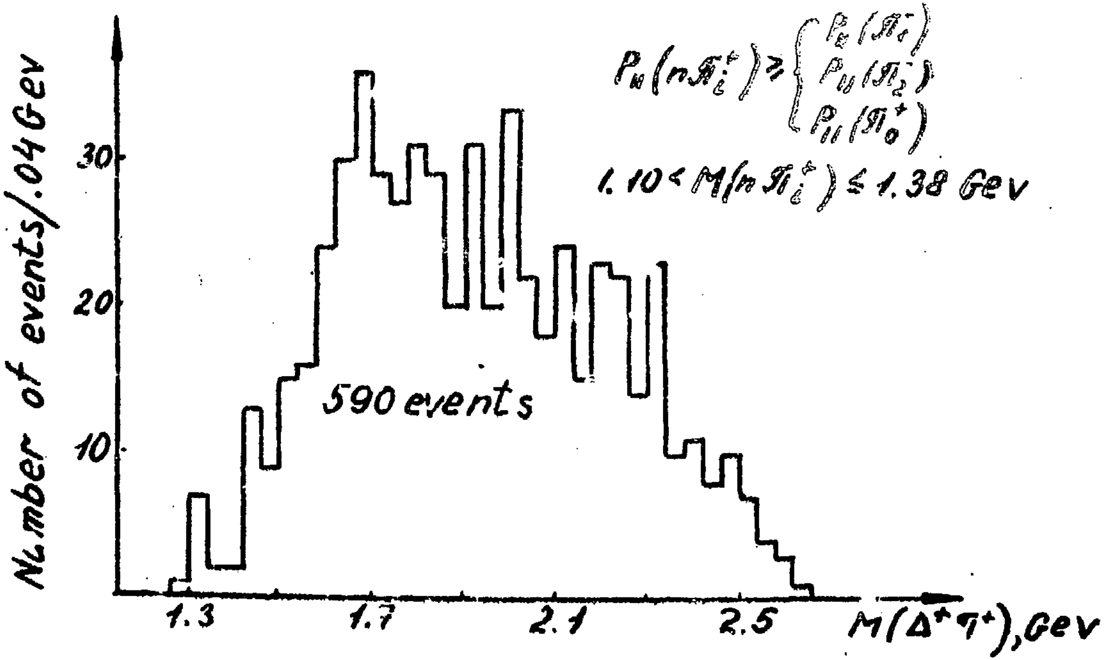

Fig. 7. The $(n\pi^+\pi^+)$ effective mass distribution of the reaction ( ) for the events satisfying the selection criteria

1) $P_{\parallel}(n\pi_i^+) \geq P_{\parallel}(\pi_1^-); P_{\parallel}(\pi_2^-); P_{\parallel}(\pi_0^+)$.

2) $1.10 \leq M(n\pi_i^+) \leq 1.38$ GeV

stributions is unsatisfactory. Let us note that it is difficult to describe simultaneously the "light" and "heavy" parts of the spectrum. For this reason we have picked out a region of small masses (1.3 ÷ 2.14 GeV) and made an attempt to fit it separately, assuming that the enhancements at masses 1.52; 1.74; 1.98 GeV are due to the $E_{5/2}$ isobars. The fitting was made with the sum of modified statistical phase-space volume and three Breit-Wigner functions (22 points, 10 parameters). The modification takes into account the experimental dependence of the distributions at four-momentum transferred from incident pion to $n\pi$ system. This dependence was taken in the form $Ae^{-Bu'}$ ($u' = t - u_{min}$). The coefficients A and B were defined while fitting u' dependence of the distributions (A = 122 ev, B = 1.22 (GeV/c)^2). The solid line on fig. 4 represents the result of the fitting.

The parameters of these possible exotic resonances are given in the table 1.

Table 1

M (GeV)	1.52±0.03	1.74±0.01	1.99±0.02
Γ (GeV)	0.08±0.07	$0.03^{+0.15}_{-0.03}$	0.12±0.06
σ (μb)	5 ± 3	5 ± 5	22 ± 5

To check the validity of the fitting of the experimental distributions we have described the $n\pi^-$ effective mass distribution using the same parameters. The description is good in the mass interval up to 1.7 GeV (dotted line on fig. 2).

In order to investigate an exotic exchange in the reactions (2) and (3) we have searched for Δ^{++} (1232) production in the upper vertex of diagrams (fig.8).

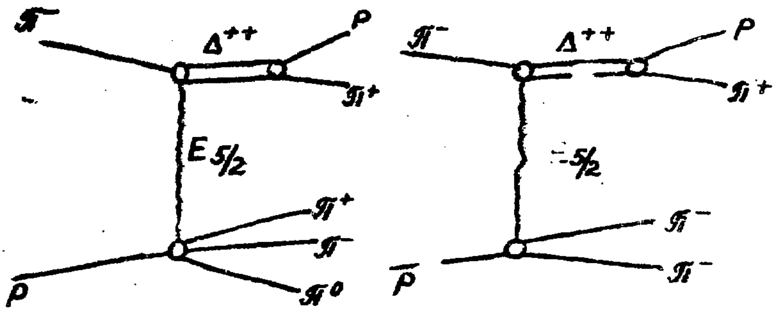

Fig. 8.

Diagrams with $E_{5/2}$ exchange in the reaction (2) and (3)

In this case the longitudinal momentum of the $p\pi^+$ pair is more than the momenta of other pions. Such process corresponds to the exotic exchange with I = 5/2 (for example E_{55} isobar) in the t-channel. The $p\pi^+$ effective mass spectrum in both channels (2) and (3) indicates to the substantial production of the Δ^{++} (1232) isobar (fig. 9.). This observation serve as an indirect evidence in favour of the existance of $E_{5/2}$ isobars.

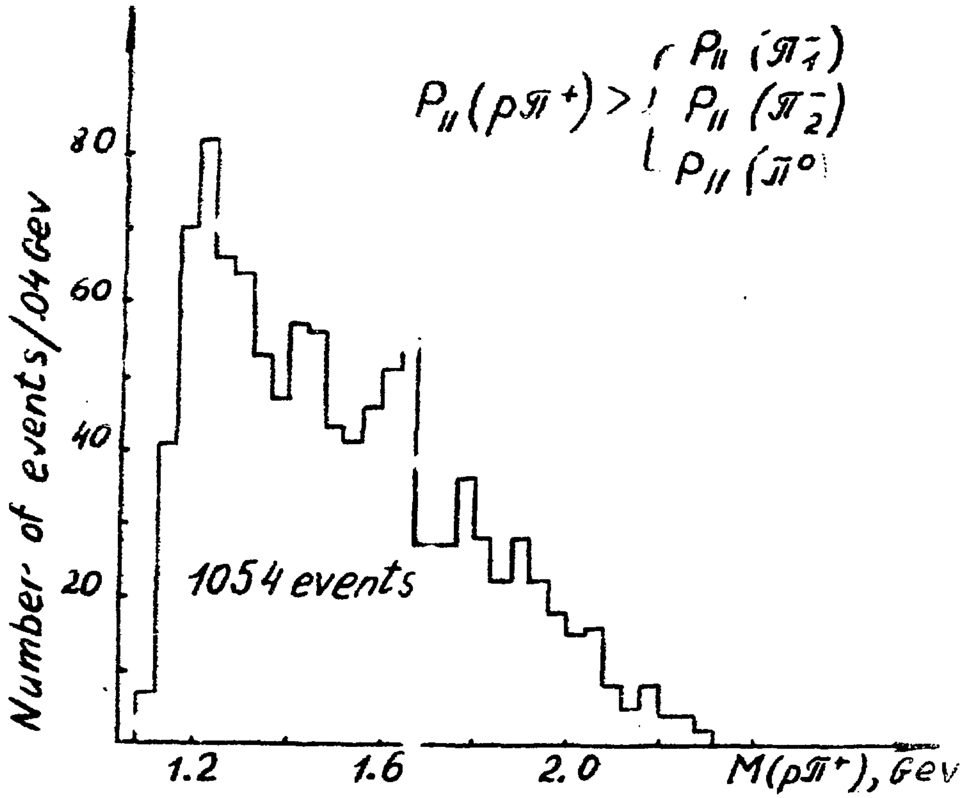

Fig. 9. The $(p\pi^+)$ effective mass distribution of the events from the reaction (2) satisfying the selection criterion $P_{\parallel}(p\pi^+) \geqslant P_{\parallel}(\pi_1^-); P_{\parallel}(\pi_2^-); P_{\parallel}(\pi^0)$

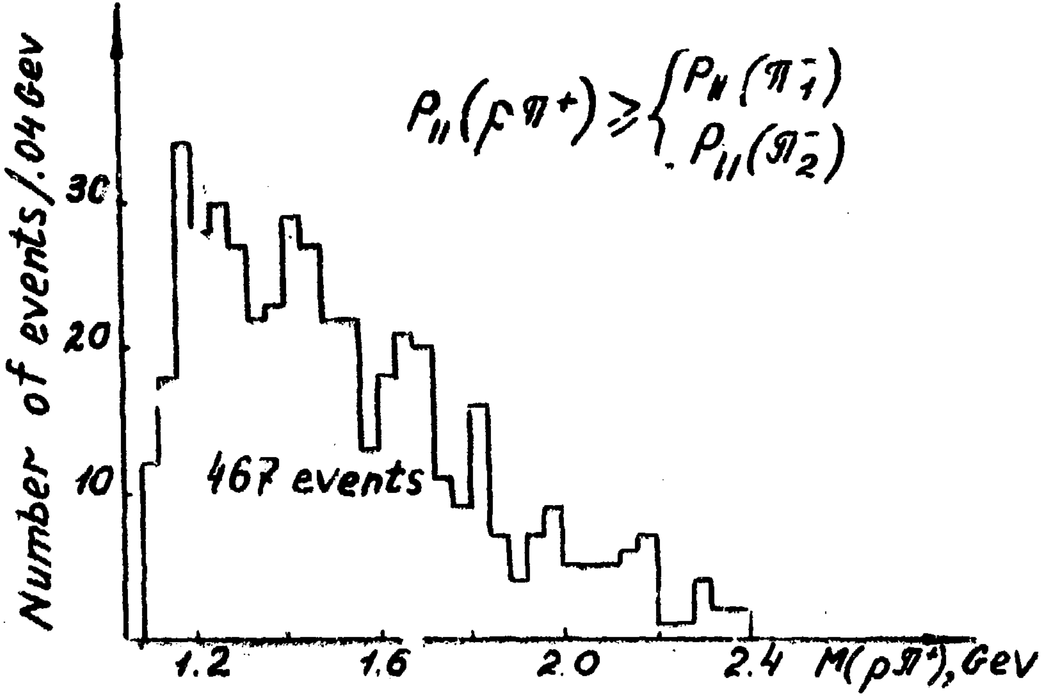

Fig. 10. The $(p\pi^+)$ effective mass distribution of the reaction (3) for the events satisfying the selection criterion $P_{\parallel}(p\pi^+) \geq P_{\parallel}(\pi_1^-); P_{\parallel}(\pi_2^-)$.

Conclusion

Our results point out that the isobars $E_{5/2}$ may be produced in the reaction (1) followary the diagram of fig.11

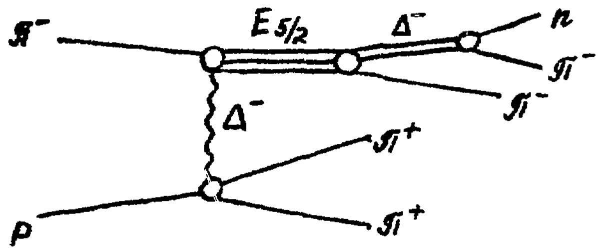

Fig. 11

This conclusion should be checked with higher statistics.

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