INSTITUTE FOR THEORETICAL AND EXPERIMENTAL PHYSICS

ITEP - 38

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A B S T R A C T

An observation of the reaction $\pi^- + d \to p + \Delta^-(1236)$ (Δ^- - backward) at 1.68 Gev/c is reported. Cross-section is estimated. $\frac{d\sigma}{du} = (241 \pm 87)$ $\mu b/(\text{Gev/c})^2$ for the momentum transfer squared $u = 0.161(\text{Gev/c})^2$. The results are compared with theoretical calculations for triangular mechanism of the reaction.

The study of nuclear reactions at high energies gives extensive information about the nuclei and elementary particles [I,2,3]. Among the direct reactions the so called pole mechanism has been comprehensively studied both theoretically and experimentally [3] (corresponding diagram see on Fig.Ia). It has been found to have some application limits (e.g. small momentum transfer to residual nuclei Z'). It is natural to assume that beyond the limits a contribution of rescattering on the residual nuclei Z' increases. The simplest diagram with the rescattering process is the triangular one (Fig.Ib). The extraction of this mechanism, however, has some difficulties because of lack of the specific features in kinematic distributions of the products of the reactions. But when C and Z' produce a resonant state the identification of the triangular mechanism facilitates. In particular the reaction with large momentum transfer to one of the deuterons nucleon is convenient for study of the triangular mechanism

$$\pi^- + d \rightarrow p + \Delta^- (I236) \quad (\text{backward } \Delta^-) \qquad (I).$$

In ref. [4] theoretical investigation of reaction (I) on the base of triangular mechanism (Fig.Ic) has been undertaken.

It should be mentioned that the authors of ref. [5] pointed out that the study of the reaction (I) gives the information about the admixture of the Δ-wave function in deuteron ($d \rightarrow \Delta\Delta$). See diagram on Fig.Id.

In general the role of the Δ wave function in nuclei is now widely discussed in connection with different aspects of relativistic nuclear physics.

We have search for the reaction (I) at I,68 GeV/c. The experiment was performed on 3-meter magnet spectrometer ITEP ref. [9]. Longitudinal cut of the spectrometer is shown in Fig.2. There is a liquid deuterium target surrounded by the spark chambers at the entrance of the spectrometer. The ПИК chambers detect the beam particle and the backward going products. The four ИКГ chambers (Fig.3) are used for side detection of charged particles, and БИК for detection of forward going ones. The trigger system is of the ref.[7] type.The missing mass method has been used for study of the reaction (I). In Fig.4 the missing mass (to the fast proton) spectrum (M_x^2) is plotted, here the assumption that the target particle is nucleon has been made. Protons were registered in the laboratory angle region nearby 0^o. At $M_x^2 \simeq 0$ quasielastic backward scattering peak is observed. Missing mass squared(M_{xd}^2), calculated when the target particle is assumed to be deuteron is connected with M_x^2 through the equation

$$M_{xd}^2 = 2M_x^2 + 2m_N^2 - U. \qquad (2)$$

Here m_N-mass of nucleon, U - squared momentum transfer from π^- to proton.($m_d=2m_N$ is assumed). At P_{π^-}= I.68 Gev/c, U_{max}= 0.2(Gev/c)^2, using equation (2) one can see that expected peak position from the reaction(I) is approximatly the same as from backward $\pi^- p$ quasi - elastic scattering. $\pi^- p$ quasielastic scattering background has been diminished through the selection of the events when secondary π^- meson flies out to the forward semisphere in laboratory system. As shown in ref.[4] the background can be neglected if such a selection is used. The result of this selection is plotted in Fig. 5 and a part of this spectrum when π^--meson flies out to small forward cone is displayed in Fig. 9 . Secondary π -meson was not required to have the same vertex as fast proton. Therefore the rescattering of π^- from the backward $\pi^- p$ quasielastic scattering when product of the reaction flies out forward can contribute to the observed bump in the region of $M_x^2 \simeq 0$. The estimation of the effect shows, however,that this contribution does not exceed several percent. Another type of background turns out to be more essential. It happens when "quasielastic" π^--meson is not registered by ИКГ and ПИК spark chambers but secondary particle from an accidental interaction in target is detected.

To diminish this background search for track intersection point of the projectile, proton and secondary side-direction particle has been performed. The requirement was the following: track of the secondary π^--meson must go off the vertex, defined by the intersection of the projectile track and recoil proton one. But the diminution factor is comparebly small(~ 5) because of small angles from the reaction (I).

A set of tests gave the accuracy of this procedure $\sim$ 3cm and proved the confidence of background suppression. One of these tests was as follows: events when a charged particle-product of the reaction (3) goes forward were selected.

$$\pi^- + P \rightarrow P + X \qquad (3)$$

Statistics at I.68 Gev/c on hydrogen target have been used. The result of application of track intersection criterion is illustrated by Fig. 7.

It should be mentioned that the contribution of events of the reaction with two and more π -mesons to the region $M_X^2 \simeq 0$ is extremely small. It results in the calculations based on the pole mechanism and experimental distributions of events with two secondary π -mesons.

Histogram obtained with the application of track intersection criterion is plotted in Fig. IO. There is a bump in the mass region of $M_X^2 \simeq 0$ wich may be identified as the reaction (I), if one subtracts small amount of background events. Nevertheless the identification of the observed bump in the region of $M_X^2 \simeq 0$ ($M_{X\alpha}^2 \simeq m_{\Delta^-}^2$ (I236)) as Δ^- production in the reaction (I) can not be quite confident. The explanation lies in the lack of information about the behaviour of missing mass spectrum at $M_X^2 > 0.I$ (Gev)^2 for the reaction with one final state π^--meson. This remark yet, can not influence on the upper limit for the cross section of the reaction

(I). Breit-Wigner term for Δ^- and incoherent statistical background for two π-meson production were fitted to the observed spectrum using efficiency and resolution of the apparatus. The normalization of the mass scale was made with the help of peak of backward quasielastic scattering, which is shown in Fig.6. The optimal parameters (χ^2 probability = 20%) are $M^2_{\pi d}$=1.59 (Gev)^2 and $M\Gamma$ = 0.12 (Gev)^2. χ^2-probability only slitely changes if we use commonly accepted values for Δ-isobar ($M^2_{\pi d}$=1.53 (Gev)^2, $M\Gamma$=0.14 (Gev)^2). The cross section have been corrected for μ, e-contamination in the beam, particle absorption in the material of the apparatus, absorption in deuterium, background of empty target. We have also used correction coefficients for the selection of the secondary π^--mesons flying off to forward semisphere (2.65±0.35), detection efficiency of the secondary π^--mesons (2±0.4), background of accidental coincidence (0.8±0.1), track intersection criterion (1.2±0.15).

The measured differential cross section of Δ^--production is equal to $d\sigma/du$=(241±87) μb/(Gev/c)^2 for the momentum transfer squared u=(0.181±0.015)(Gev/c)^2 or corresponding angular interval $-1 \leq \cos\theta^* \leq -0.98$.

In ref.[4] correlation between differential cross section for the reaction (I) and cross section for π^-P-backward elastic scattering is received

$$\left(\frac{d\sigma_{\Delta^-}}{du}\right)_{180^\circ} = F(u)\cdot\left(\frac{d\sigma_{el}}{du}\right)_{180^\circ}. \qquad (4)$$

Here $F(u)$ is a function of momentum transfer. The cross section of π^-P-backward elastic scattering at P_{π^-}= 1.[illegible] Gev/c and u = 0.1[illegible] (Gev/c)^2 according to ref. [8,9] is found to be $d\sigma_{el}/du$=(980±60) μb/(Gev/c)^2. The calculated value of the differential cross section for the reaction (I) according to (4) turns out to be

$d\sigma_{\Delta^-}/du$=(from 338 to 530) μb/(Gev/c)^2. This value depends on the type of nucleon wave function in deuteron. Apparently, there is a satisfactory agreement between theoretical calculations based on triangular mechanism and experimental estimation of the cross section for the reaction (I).

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Figure Captions

Fig. I. Diagrams for various mechanisms of the elementary particle interaction with nuclei.

Fig. 2. Long itudinal cut of the spectrometer. БИК$_1$-БИК$_2$-large spark chambers inside the magnet. ИКГ - spark chambers around the target. ПИК$_1$-ПИК$_2$-beam chambers. ЩС - slot for the scintillation counters installation.

Fig. 3 Lay out of ИКГ chambers and mirrors. Arrows are the optical rays.

Fig. 4. M_x^2 distribution for the reaction $\pi^- + d \to p + x^-$. Target particle in M_x^2 calculation is assumed to be nucleon. All Fig. display the part of the distribution limitted by $M_x^2 = 0.4\ (Gev)^2$.

Fig. 5 M_x^2 distribution for the reaction $\pi^- + d \to p + x^-$. Events selection with one (in addition to proton) charged particle in the forward semisphere is performed.

Fig. 6. Missing mass squared spectrum for the reaction $\pi^- + p \to p + x^-$. Events selection is the same as in Fig5.

Fig. 7 The same as in Fig. 6 with the application of the track intersection criterion.

Fig. 8. M_x^2 distribution in the reaction $\pi^- + d \to p + x^-$ for the events with one(in addition to projectile)charged particle in ПИКchamber (see Fig. 2).

Fig. 9. M_x^2 distribution in the reaction [illegible] $p + x^-$. Events selection with the charged particle (in addition to proton) in БИКchambers is performed.

Fig. IO. The same as in Fig. 5 with the application of track intersection criterion.

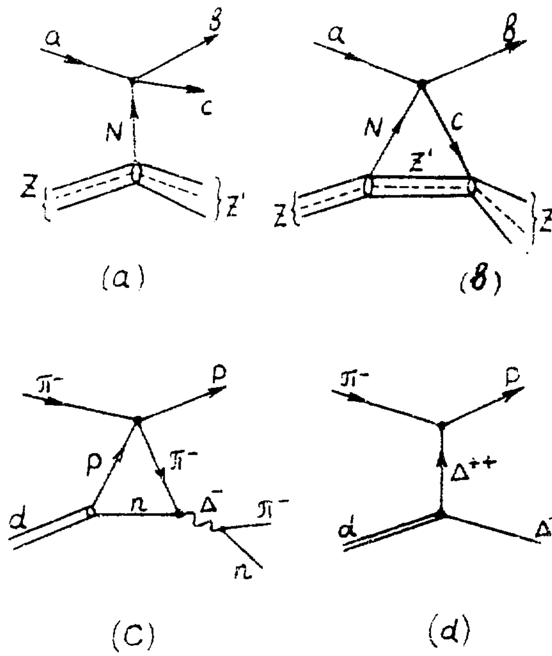
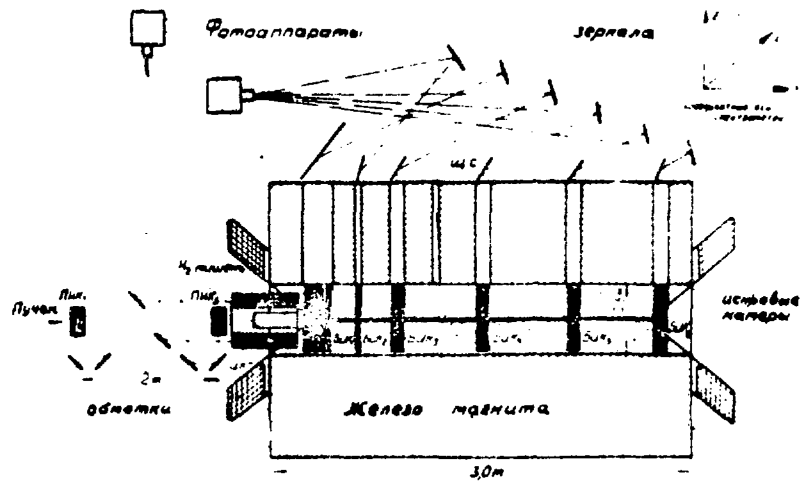


Fig. 1



Фотоаппараты
зеркала
искровые камеры
Пучок
Железо магнита
3,0m

Fig 2

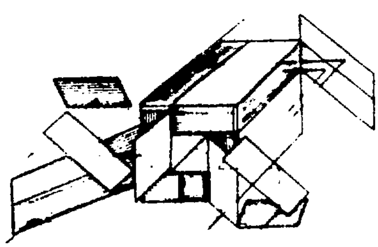


Fig 3

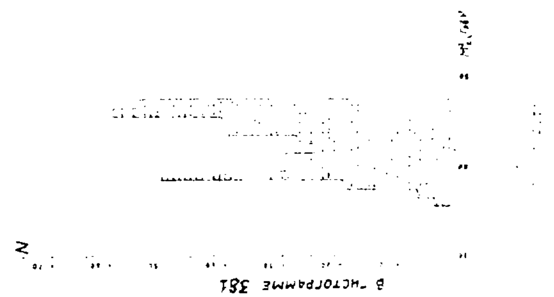
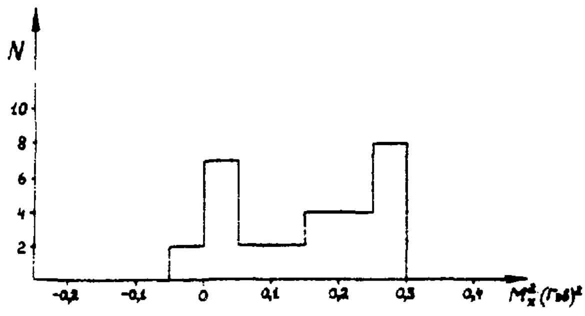


Fig 5

Fig 4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M_x^2 (Гэв)²

Fig. 6

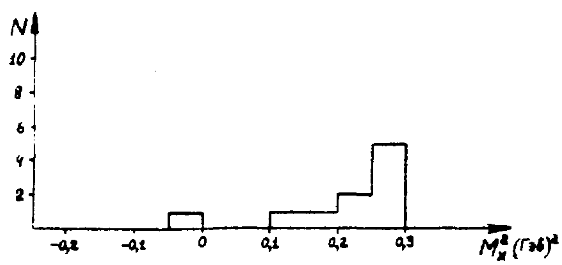
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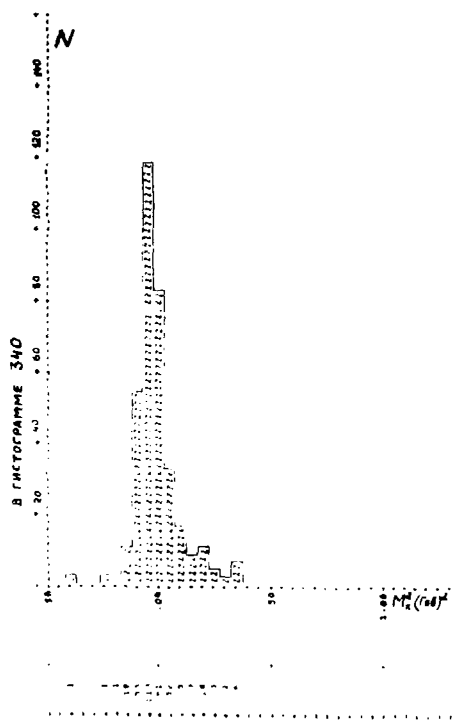
Fig. 7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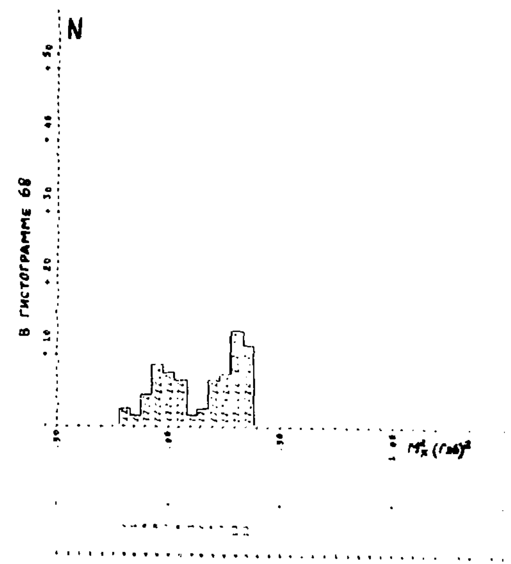
M_x^2 (Гэв)^2

Fig. 8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M_x^2 (Гэв)^2

Fig. 9

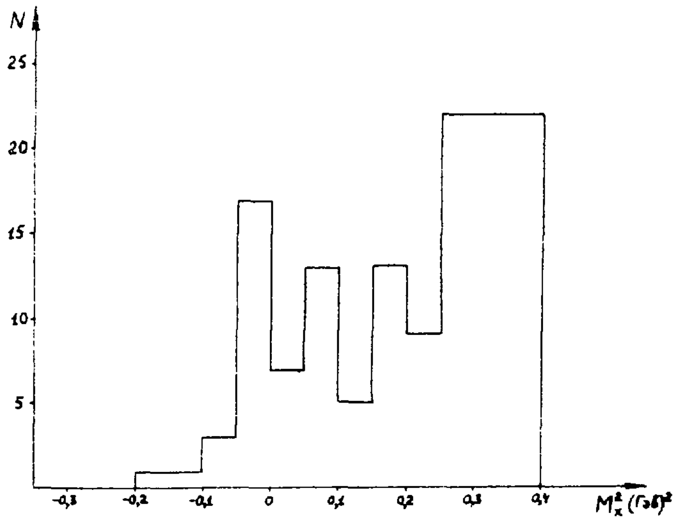

Fig 10

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