Study of the production of the (1236) isobar in the reaction $\pi^- + d \to p + \Delta^-$ (Δ^- backward) from 1.03 to 1.68 GeV/c

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Institute of Theoretical and Experimental Physics
(Submitted December 27, 1974)
ZhETF Pis. Red. **21**, No. 3, 201–205 (February 5, 1975)

We measured the differential cross section of the backward production of the Δ(1236) isobar in the reaction $\pi^- + d \to p + \Delta^-$ at four values of the momentum of the incident negative pions in the interval from 1.03 to 1.68 GeV/c. The measured cross sections are in satisfactory agreement with the calculations performed on the basis of the triangular reaction mechanism.

The investigation of reactions with large momentum transfers in the scattering of high-energy hadrons with nuclei explains not only the mechanism of these processes, but can also yield new information on the nuclear wave functions. In[1], to obtain data on the admixture of isobaric states in the deuteron wave function ($d \to \Delta\Delta$), it was proposed to measure the cross section of the reaction

$$\pi^- + d \to p + \Delta^- \tag{1}$$

with emission of a fast proton forward. On the other hand, the reaction (1) is described in[2], within the framework of the triangular mechanism. In this description, in contrast to[1], it is not proposed that a Δ isobar is present in the deuteron.

We investigated the reaction (1) at the following primary negative-pion momenta: 1.03, 1.25, 1.48, and 1.68 GeV/c.[1)] The experiment was performed with the three-meter magnetic spark spectrometer of our Institute.[4] The system for the master triggering at 1.68 GeV/c did not differ from that described earlier.[5,6] At low momenta, we used a system with time-of-flight separation of p, d, and π^+.

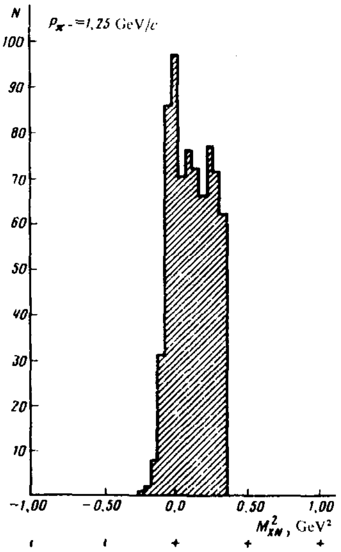

FIG. 1. Distribution with respect to M^2_{xN} in the reaction $\pi^- + d \to p + X^-$. It is assumed in the calculations that the target particle is a nucleon. The figure shows some of the distribution, bounded by $M^2_{xN} = 0.4$ (GeV)². The incident pion momentum is 1.25 GeV/c.

We used the missing-mass method to study the reaction (1). We measured the angle and momentum of the fast protons emitted forward (laboratory angle close to 0°) from the reaction

$$\pi^- + d \to p + X^- . \tag{2}$$

A particular case of this reaction is

$$\pi^- + p(n_s) \to p(n_s) + X^- , \tag{3}$$

where n_s is the spectator neutron.

The square of the proton missing mass in the reaction (2) (M^2_{xd}) is connected with the square of proton missing mass in the reaction (3) (M^2_{xN}) by the relation

$$M^2_{xd} = 2M^2_{xN} + 2m^2_N - U, \tag{4}$$

where m_N is the nucleon mass and U is the square of the momentum transferred from the π^- meson to the proton. Inasmuch as $U \approx 0.2$ (GeV/c)² at the investigated energies and at $M^2_{xN} \approx 0$, it is seen from relation (4) that the position of the expected peak in the missing-mass spectrum from the Δ (1236) isobar in the reaction (2) coincides approximately with the position of the peak from the quasielastic backward scattering in the reaction (3). For this reason, the main source of the background in the study of the reaction (1) is the quasielastic back-

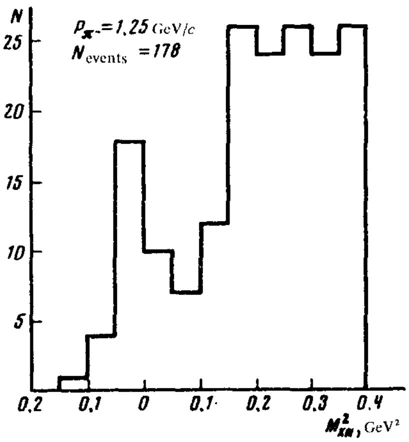

FIG. 2. Distribution with respect to M^2_{xN} in the reaction $\pi^- + d \to p + X^-$. The selection of the events with emission of a charged reaction product in the forward hemisphere and with a search for the vertex of the event. The pion momentum is 1.25 GeV/c.

P, GeV/c	M^2_{xd}, GeV²	Confidence level	$d\sigma/dU$ μb/(GeV/c)²	U, (GeV/c)²
1.68	1.59	0.2	278 ± 105	0.16 – 0.2
1.48	1.57	0.3	705 ± 245	0.15 – 0.19
1.25	1.56	0.3	980 ± 320	0.18 – 0.22
1.03	1.56	0.6	1800 ± 720	0.22 – 0.26

ward $\pi^- p$ scattering. Figure 1 shows the spectrum of the proton missing masses (M^2_{xN}) at a π^{-1}-meson momentum 1.25 GeV/c. In the region $M^2_{xN} \approx 0$ one can clearly see the peak from the quasielastic $\pi^- p$ scattering.

To suppress the background from the quasielastic $\pi^- p$ scattering, we selected events in which the π^- meson produced in the reaction was emitted in the forward hemisphere (in the laboratory frame). As shown in[2], when this selection is made the background becomes negligibly small (~1%) in comparison with the expected yield of the reaction (1). The histogram obtained with this selection from the distribution in Fig. 1 is shown in Fig. 2. For other momenta, analogous distributions are obtained. The excess of cases in the region $M^2_{xN} \approx 0$, after subtracting a certain fraction of the background, is due, we believe, to the investigated reaction (1).

An analysis of the material on the reaction

$$\pi^- + p \to p + X^- \quad \text{at } 1.65 \text{ GeV}/c \tag{5}$$

has shown that with the used kinematic selection the contribution of the backward elastic scattering, of the rescattering of the π^- mesons (the products of the reaction in the target material) and of the random tracks to the investigated region of the spectrum is negligibly small.

The spectra observed after the selection were described with allowance for the efficiency and the resolution of the installation by means of the Breit-Wigner term for the Δ isobar and the incoherent statistical background production of two π mesons. The results of the description, and also the summary cross sections of the reaction (1) are listed in the table. The procedure for introducing corrections to the cross sections did not differ from that described in[3].

Comparison of the cross section measured at 1.03 GeV/c with the predictions of the pole model[1] yields for the admixture of the isobar states in the total wave function of the deuteron a value on the order of 2%. It must be borne in mind, however, that experiment (Fig. 3) does not confirm the energy dependence of the reaction predicted in[1], and it appears that the pole model cannot be used directly to determine the $d \to (\Delta\Delta)$ vertex.

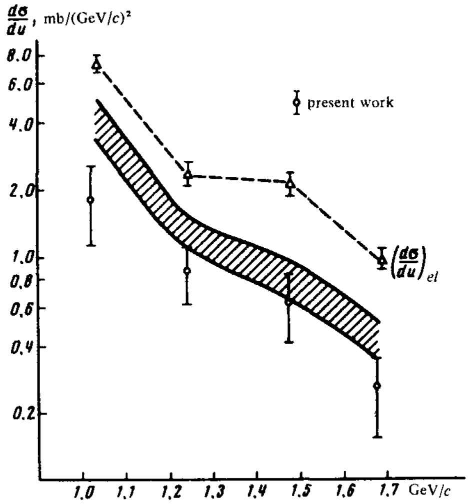

FIG. 3. Dependence of the differential cross section for the production of the (1236) isobar on the momentum of the π^- meson. Shaded region–calculation based on the triangular mechanism of the reaction. ▵–experimental values of the cross section of elastic $\pi^- p$ scattering backward from[7,8,9,10] with allowance for the angle subtended by the spectrometer. The values of $(d\sigma/du)_{el}$ and the calculated currents are joined for the sake of clarity by a freehand curve.

The shaded region in Fig. 3 shows the expected values of the differential cross section of reaction (1), calculated on the basis of the triangular mechanism[2] with accuracy to within the uncertainty in the choice of the correct form of the wave function of the deuteron. There is satisfactory agreement between the experimental values and the theoretical calculations. While the experimental points lie systematically below the calculated ones, the energy dependence of the cross section is similar in appearance.

The authors are grateful to V.V. Vladimirskiĭ, I.S. Shapiro, and V.A. Karmanov for useful discussions.

[1)]Preliminary results of the investigation at 1.68 GeV/c were reported by us earlier.[3]

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