Study of the reaction of the quasielastic backward $\pi^- p$ scattering by a deuteron at 3.63 GeV/c

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We investigated the quasielastic backward $\pi^- p$ scattering by a deuteron at 3.63 GeV/c. Using the distributions with respect to the momentum and the cosine of the polar angle of the recoil neutron and the Treiman–Yang angle, we show that the process is described in the pole approximation.

We investigated the reaction of the backward ($\langle t\rangle \sim 6$ (GeV/c)^2) quasielastic $\pi^- p$ scattering by a deuteron at the momentum 3.63 GeV/c. In the chosen region of the kinematic variables, there are no experimental data on the reaction mechanism, which was investigated in detail for slower initial energies and smaller momentum transfers from the primary meson to the proton.[1,2]

The study is based on analysis of photographs obtained with the aid of the 1.5-meter large-aperture track spectrometer,[3] in the spark chamber of which was placed a solid-deuterium target 15 cm long (3 g/cm^2). The protons from the investigated reaction, emitted forward, were registered with a hodoscope of scintillation counters, while the pions scattered backward in the angle range 120–180° were registered by a counter placed inside a spark chamber, which operated by coincidence of the pulses from the rear counter and one of the hodoscope channels. A total of 2.5×10^8 negative pions were passed through the apparatus.

We selected on the photographs the two-prong events of appropriate topology. They were measured with the PUOS instruments; the momenta and the angles of particles were calculated in accordance with the ASPIK program.[4]

For the subsequent analysis we selected cases in which the particle emitted forward had a momentum larger than 3500 MeV/c, and the error of its measurement was less than 160 MeV/c, while the particle moving backward at a momentum larger than 200 MeV/c.

Figure 1 shows the distribution of the number of events with respect to the square of the missing mass to the measured proton and pion in the reaction $\pi D \to p\pi\chi$, when the missing momentum is $q_x < 150$ MeV/c. It is seen from the distribution that the missing particle is a neutron.

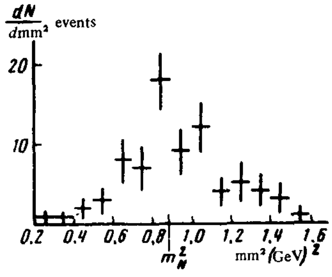

FIG. 1. Distribution of the number of events with respect to the square of the proton and pion missing mass.

All the events selected in accordance with the foregoing criteria were passed through the *balance* program and the parameters of the particles were balanced within the framework of the $\pi D \to p\pi n$ hypothesis.

After the balance, we retained the cases with $\chi^2 < 3$ (with one degree of freedom). Figure 2 shows the distributions of these cases with respect to the kinematic variables that are most sensitive to the mechanism of the reaction,[5] namely the momentum transferred to the neutron (Fig. 2a), the Treiman-Yang angle (Fig. 2b), and the polar angle of the recoil neutron (Fig. 2c). All the distributions were corrected for the geometric efficiency of the installation, which amounted to 15% and varied little in the measured range of kinematic variables. For the final analysis we were left with 69 cases.

The distribution of the events of the $\pi D \to p\pi n$ reaction with respect to the momentum transferred to the neutron (Fig. 2a) has a maximum in the small-momentum region; this maximum is typical of the pole mechanism. The solid curve represents the spectrum calculated in

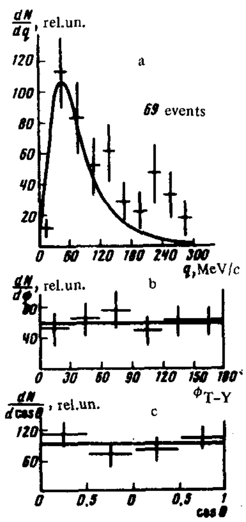

FIG. 2. a) Spectrum of recoil-neutron momenta. Solid curve—calculation in the pole approximation. b) Dependence of the number of events on the Treimann-Yang angle; straight line—prediction of pole model, $\chi^2 = 2.2$ at $n = 5$. c) Dependence of the number of events on the cosine of the polar angle of the recoil neutron (relative to the direction of the primary pion momentum); straight line—prediction of the pole model, $\chi^2 = 2.6$ at $n = 3$.

the pole approximation with the Hulthén wave function of the deuteron. The curve is normalized in the region $q < 120$ MeV/c. It approximates well the experimental points. A certain excess of the number of events with $q > 210$ MeV/c may be connected with processes that are not described by the pole diagram, but this is most readily a background from other reactions.

An additional confirmation of the decisive contribution of the pole mechanism at small momentum transfers may be the distributions in Figs. 2b and 2c, which represent cases with $q < 210$ MeV/c. We see that the experimental points are well described by the isotropic distributions predicted in the pole model. The asymmetry coefficient in the distribution with respect to the Treimann-Yang angle

$$\left(P = \frac{N_1(0 \div 90°) - N_2(90 \div 180°)}{N_1 + N_2} \right)$$

is equal to $P = 0.06 \pm 0.06$.

We calculated n_{eff}, defined by

$$n_{eff} = \frac{\iint \frac{d^2\sigma_{quasiel}}{du\,dq}\,du\,dq}{\int \frac{d\sigma_{el}}{du}\,du}$$

The integration was carried out with respect to u (the square of the 4-momentum transfer from the pion to the proton) in the range 0.1 to -0.175 (GeV/c)^2, as determined by the geometry of the setup, and with respect to q up to 120 MeV/c.

The data on elastic $\pi^- p$ scattering were taken from[6]. The value of n_{eff} turned out to be 0.78 ± 0.16. The error of n_{eff} includes not only the statistical uncertainty, but also the errors of the elastic cross sections and of all the corrections. The value of n_{eff} in the same range of q, calculated in the pole approximation with the Hulthén wave function of the deuteron, is 0.82. It agrees well with the value of n_{eff} measured in[1] under essentially different kinematic conditions.

The results indicate that at large t the pole diagram predominates in the region of small q.

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