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Submitted to International Seminar on Interactions of High Energy Particles with Nuclei. Moscow 1973.

The reaction $dp \to ppn$ has been studied with the help of the JINR Im hydrogen bubble chamber exposed in the 3.33 ± 0.08 Gev/c deuteron beam.

The use of the deuteron beam provides small losses of the spectators due to favourable conditions of their observation. The contamination of other reactions is negligible [I,2].

In this paper we analyse the experimental data on the investigation of the mechanism of dp interactions from the point of view of the validity of the pole approximation to the nucleon-nuclei interactions considered in refs. [3,4,5]

In these refs. it was pointed out that in the region $0 \le q^2 \le 2M\varepsilon$ one could expect the validity of the pole diagram shown in fig.I. Here: q is the momentum of the recoil nucleus, i.e. the momentum of the spectator nucleon in the deuteron rest frame in our case; M is the reduced mass of the nucleus decay products (in our case - the reduced mass of two nucleons); ε is the deuteron binding energy.

The range of q in which the pole approximation can be considered to be valid may be defined by an estimate of the upper limit of q from the inequality and is found to be $q \le 45$ Mev/c.

The spectator was defined as the slowest nucleon in the d-system. The momentum distribution of the spectators is presented in fig.2. The solid line corresponds to the solution of the Schrödinger equation with the Hülten potential that in the momentum representation can be written as:

$$\Psi(\kappa) = \sqrt{\frac{2}{\pi}} \left[\frac{1}{\alpha^2+\kappa^2} - \frac{1}{(\alpha+\mu)^2+\kappa^2} \right].$$

When fitting α and μ were taken as parameters, and the spectrum was cut at 200 Mev/c. The results of fitting gave the parameters:

α = 52.9 ± I.5 Mev/c

μ = I87.4 ± I7.7 Mev/c

(χ^2 = I9.8 at n = I8 degrees of freedom). Besides, the fitting at the fixed α = 45.9 Mev/c gave μ = 3II.9 ± 20.8 Mev/c (χ^2 = 54.2, n = I9).

All other spectator momentum distributions are plotted in 40 Mev/c bins.

Fig.3 presents the angular distributions of the spectators in the d-system for six momentum intervals. The interval limits are shown. The same figure gives the summary distribution having a small asymmetry in the direction of the proton motion before the collision.

As in the discussed diagram the nucleon stands for the particle connecting the vertices of the deuteron virtual decay and quasi-elastic scattering, the criteria necessary for factorization of the process amplitude are fulfilled. It means that in the region of the pole approximation one can expect an isotropic distribution over the Treiman-Yang angle:

$$\Phi = \arccos \frac{[\vec{P}_0 \times \vec{P}_{sp}] \cdot [\vec{P}_1 \times \vec{P}_2]}{|\vec{P}_0 \times \vec{P}_{sp}| \cdot |\vec{P}_1 \times \vec{P}_2|},$$

where P_o is the momentum of the incident deuteron;

P_{sp} is the momentum of the spectator nucleon;

$P_{I,2}$ are the momenta of two other nucleons.

When the proton is a spectator P_I always refers to the neutron and the angle is uniquely defined in the interval of 0^o - $I80^o$.

Fig.4 presents the distributions over the Treiman-Yang angle for the events with the spectator proton for various spectator momentum intervals as well as the summary distribution. The asymmetry coefficient $A = \frac{N(0^\circ \div 90^\circ) - N(90^\circ \div 180^\circ)}{N(0^\circ \div 90^\circ) + N(90^\circ \div 180^\circ)}$ is presented in the same figure.

One can see that the asymmetry systematically increases with increasing the spectator momentum. The isotropy is observed only for low spectator momenta.

In order to check the dependence of the asymmetry on the 4-momentum transfer squared in quasi-elastic scattering, the Treiman-Yang angle distributions were plotted for the events with $/t_I/ < 0.2\ (Gev/c)^2$ (fig.5). The definition of t_I is given below. Such a cut leads to an essential increase of the asymmetry. Fig.6 presents the dependence of the asymmetry coefficient on the spectator momentum for both the cases. The picture clearly shows that the whole asymmetry is related to the events with low (in any case less than $0.2\ (Gev/c)^2$) 4-momentum transfer in quasi-elastic scattering. In fact, the distributions for the events with $/t/ > 0.2(Gev/c)^2$ turned out to be isotropic.

In order to obtain the quasi-elastic scattering differential cross sections (the right-side vertex of the diagram in fig.I), the distribution of the 4-momentum transfer squared t from the target-proton to the nucleon products of quasi-elastic scattering collisions was plotted. In particular, for the pp quasi-elastic scattering we expected to obtain a symmetric picture similar to the elastic scattering of free nucleons. However, the peak at large /t/ is badly smeared out (see fig.7a).

A symmetric distribution over the 4-momentum transfer squared from the incident deuteron nucleon of momentum ($\frac{m_N}{m_d}\vec{P}_0$) to the decay nucleons for the quasi-elastic scattering is observed.

Fig.8 presents the distributions of the 4-momentum transfer squared from the target to the protons – products of quasi-elastic interactions for various spectator momentum intervals.

One can see that the peak width at large /t/ systematically increases with increasing the spectator momentum.

The totality of data on the differential cross sections indicates that when considering the interaction it is necessary to take into account the Fermi motion.

The differential cross sections for various spectator momentum ranges in the region of comparatively small t are presented in fig.9. The solid line for the summary distribution has been calculated in the frame of the Glauber model using the "closure approximation" omitting the spin effects. The deuteron formfactor was taken to be equal to $S(q) = \exp(-33q^2)$; and the nucleon-nucleon scattering amplitude was of the form:

$$f_{pN} = A_N (i + \alpha_N) \exp(\tfrac{1}{2} b_N t),$$ where

A_n^2 = IIO mb(Gev/c)$^{-2}$, $\alpha_n = 0.36$, $b_n = 6.0$ (Gev/c)$^{-2}$.

A_p^2 = I47 mb(Gev/c)$^{-2}$, $\alpha_p = 0.0$, $b_p = 6.6$ (Gev/c)$^{-2}$.

The curve was not normalized to the experimental data. The calculation agrees well with the measurements in the region /t/ = 0.I ÷ 0.4 (Gev/c)^2.

C O N C L U S I O N

I. The fitted parameters have been obtained when describing the momentum distribution of the spectators from the reaction dp → ppn by the Hülten potential.

2. It is shown that the Treiman-Yang angle asymmetry is related only to small 4-momentum transfers in quasi-elastic scattering.

3. The differential cross section of the reaction in the range /t/ = 0.I ÷ 0.4 (Gev/c)^2 agrees with the Glauber theory.

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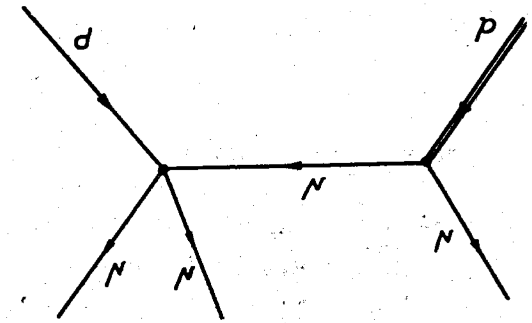

Fig.I Pole diagram.

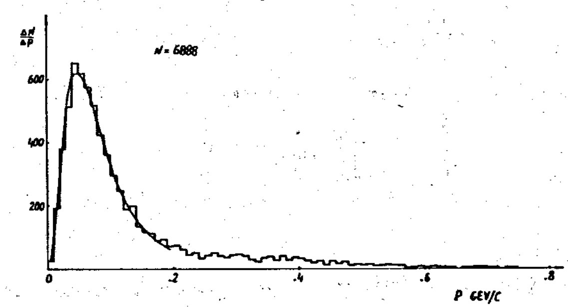

Fig.2 Momentum distributions of spectator nucleons in the deuteron rest frame.

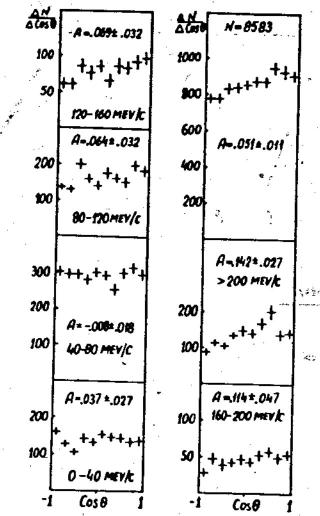

Fig.3 Angular distributions of spectator nucleons in the deuteron frame.

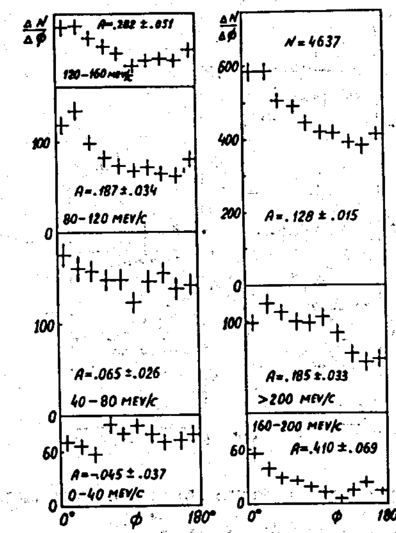

Fig.4 Treiman-Yang angle distributions for the events with the proton spectator.

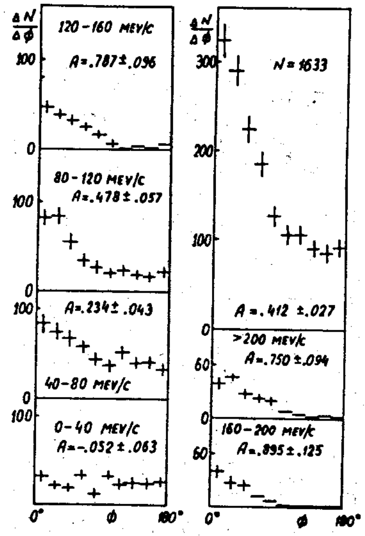

Fig.5 Treiman-Yang angle distributions for the events with the proton spectator at $/t_I/ < 0.2\ (Gev/c)^2$.

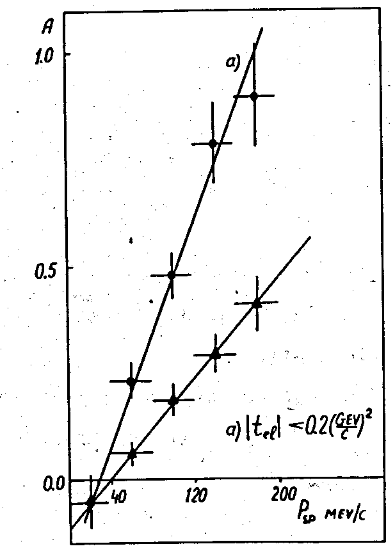

Fig.6 Asymmetry coefficient vs spectator momentum for the total data and for the events at $/t_I/ < 0.2(Gev/c)^2$ (proton spectator).

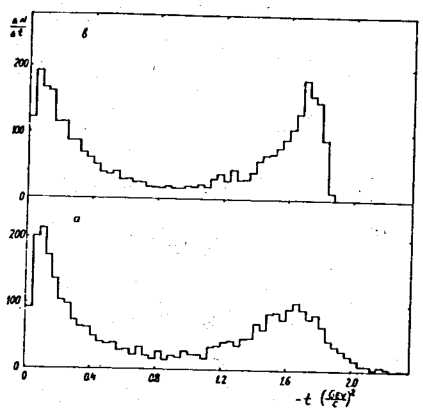

Fig.7 Distributions of the 4-momentum transfer squared

a) from the target proton to the products of quasi-elastic scattering t ;

b) from the nucleon momentum in the deuteron beam ($\frac{m_N}{m_d}\vec{P}_0$) to the products of quasi-elastic scattering t_I.

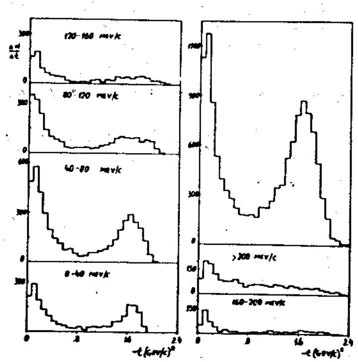

Fig.8 Distributions of the 4-momentum transfer squared from the target to the protons- - products of quasi-elastic interactions.

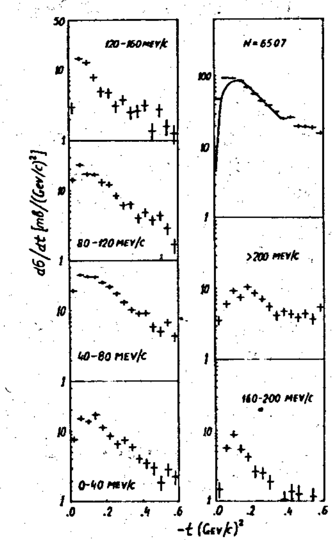

Fig.9 Differential cross sections for the reaction dp→ ppn. Solid line - the Glauber model.