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ASYMMETRY IN THE ANGULAR DISTRIBUTIONS OF SPECTATOR-NUCLEONS

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The data we report here have been obtained in an exposure of the 1 m hydrogen bubble chamber to a deuteron beam of 3.33 GeV/c momentum /1/. The aim of the present paper is to show that the observed substantial deviations from isotropy in the angular distribution of spectator-nucleons * do not contradict the spectator model. The following reactions are considered:

$$dp \to p_s p p \pi^-, \qquad (1)$$

$$dp \to p_s p n \pi^+ \pi^-, \qquad (2)$$

$$dp \to n_s d_f \pi^+. \qquad (3)$$

The symbol d_f in the reaction (3) refers to a sample with deuteron momentum larger than that of the neutron in the deuteron rest system. It has been shown previously /2/ that these events correspond to the proton exchange leading to the deuteron formation whereas a neutron behaves like a spectator.

Figure 1 shows that the momentum distribution of spectators in the reactions studied is satisfactorily described by the Hulten deuteron wave function. In the case of reaction (1) the parameter β has been obtained from the fitting procedure.

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* By definition the spectator is considered as the slowest nucleon in the deuteron rest frame.

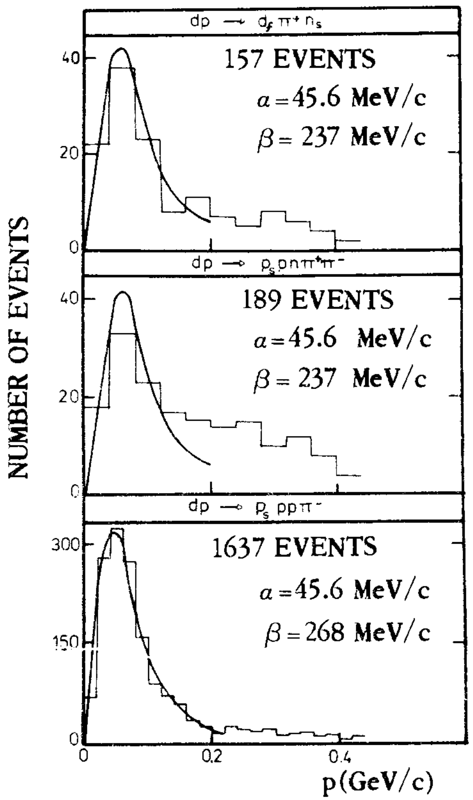

Fig. 1. The momentum distribution of spectator-nucleons.

Assuming that in the unpolarized nucleus the Fermi momentum distribution is isotropic, the spectator angular distribution can be written as

$$\frac{d\sigma}{d(\cos\Theta_s)} = \int_0^p p_s^2\, |\Phi(p_s)|^2 \sigma(s)\, F(p_s, p_b, \cos\Theta_s)\, dp_s\,, \qquad (4)$$

where $\Phi(p_s)$ is the deuteron wave function, s is the total energy squared in the nucleon-nucleon c.m.s., $\sigma(s)$ is the energy-dependent cross section for the corresponding nucleon-nucleon reaction and

$$F(p_s, p_b, \cos\Theta_s) = \frac{1}{m_s m_b}\left[(E_b E_s + p_b p_s \cos\Theta_s)^2 - m_b^2 m_s^2\right]^{1/2}$$

is the flux-factor /3/.

Figure 2 shows the angular distribution of spectators with momentum below 200 *MeV/c* for channels (1)-(3) which were identified in practice unambiguously. The significant asymmetry of different sign is observed in the angular distributions. Curves 1, 2 and 3 refer to the calculated angular distributions taking into account only the flux-factor and $\sigma(s)$, only the flux-factor, and only $\sigma(s)$, respectively. The Hulthen wave function and $\sigma(s)$ shown in fig. 3 were used in the calculations. It is seen that curves 1 and 3 reveal the basic behaviour of the experimental angular distributions. The corresponding experimental and calculated asymmetry values are

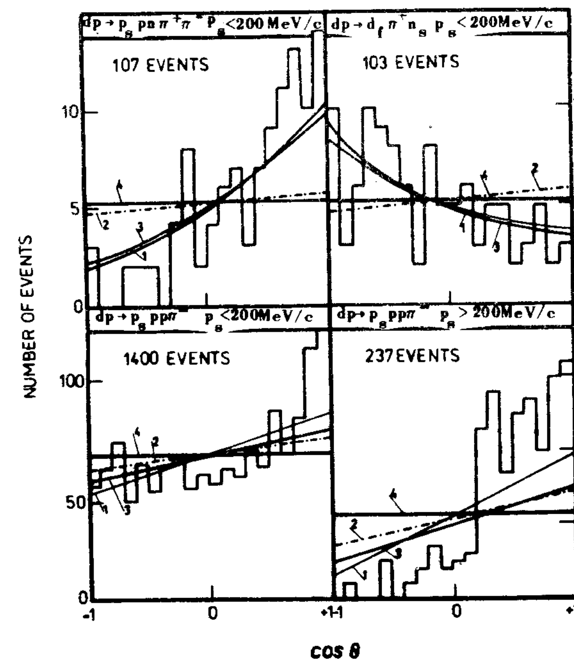

Fig. 2. The angular distribution of spectator-nucleons.

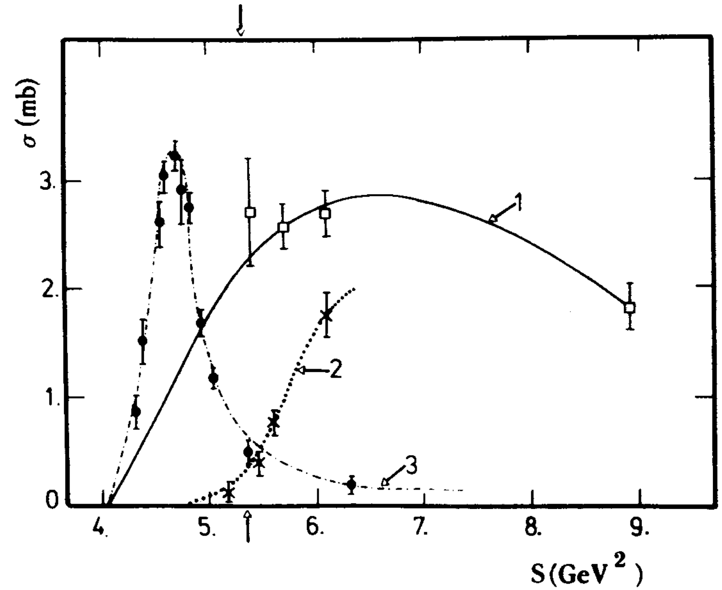

Fig. 3. The energy dependence of the cross sections for channels (1)-(3). (Points ⧫ are taken from paper [5]*, the remainder from compilation* [6]*).*

presented in the table. It is seen from the table that the flux-factor contribution amounts about 4-5% only, and the $\sigma(s)$ dependence plays a main role [5,6] since at our energy the nucleon-nucleon cross section is strongly energy-dependent (see fig. 3 where the arrow shows our total c.m.s. energy with a target-nucleon to be at rest). The cross sections for channels (1) and (2) grow with energy whereas for channel (3) $\sigma(s)$ decreases leading to the asymmetry of opposite sign as compared with (1) and (2). For spectators with momentum above 200 *MeV/c* the agreement between the calculated angular distributions and the experiment deteriorates (see fig. 2 where the angular distribution for $p_s >$ 200 *MeV/c* events from 4C $dp \to p_s pp\pi^-$ channel is presented). It is well-known, however, that the Hulthen and other sophisticated deuteron wave functions are not valid above 200 *MeV/c*. This is mainly due to growing relative contribution of non-spectator effects to the high momentum tail of the slowest nucleon.

Table

Reaction	Asymmetry $A = \frac{F-B}{F+B}$ Experimental	Calculated with (4)	Calculated with (4) without flux-factor	Calculated with (4) without $\sigma(s)$
$dp \to p_s pp\pi^-$	0.13 ± 0.03	0.12	0.07	0.044
$dp \to p_s pn\pi^+\pi^-$	0.57 ± 0.08	0.39	0.35	0.044
$dp \to d_f n_s \pi^+$	−0.26 ± 0.09	−0.21	−0.25	0.044

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