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Experimental investigation of $dp \to ppn$ reaction at intermediate energies at Nuclotron

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Abstract. There are still discrepancies between theory and experimental data in the polarisation observables of $dp \to ppn$ reaction in the low and intermediate energies, despite of significant process in the development of theoretical models which include three and more nucleon forces and relativistic effects. The data of $dp \to ppn$ reaction have been accumulated at 300, 400 and 500 MeV in the Nuclotron (Dubna, Russia) and partially processed for some kinematic configurations including few in which possible relativistic effects can appear. Kinematic simulation in the framework of ROOT and GEANT4 package have been performed before data processing. Part of the preliminary results are obtained in the form of energy deposit correlations of the two arms working in coincidence and few in the form of kinematic S curve.

1 Introduction

Relative smallness of the typical energies involved in the nuclear reactions in which protons and deuterons take part leads us firstly to non-relativistic Schrödinger equation that includes only the nucleon-nucleon (NN) potentials as a starting point. It is known that the data obtained from the NN scattering at low and intermediate energies (up to 350 MeV) can be described with high precision using the NN potentials only (e. g. CD-Bonn [1]). Modern NN potentials, however, underestimate the binding energies of the three-nucleon systems by about 0.5-1 MeV [2] and also do not reproduce the dp breakup and dp elastic scattering data.

The dp breakup reaction investigation at low and intermediate energies is very interesting. Quality of NN potentials in presence of third nucleon can be tested and the reaction has rich phase space. The effects from Coulomb interaction, relativistic effects and three nucleon forces ($3NF$) can be investigated in various regions of phase space. To get complementary information about the reaction mechanism and the structure of the objects involved in the dp breakup reaction the data accumulation

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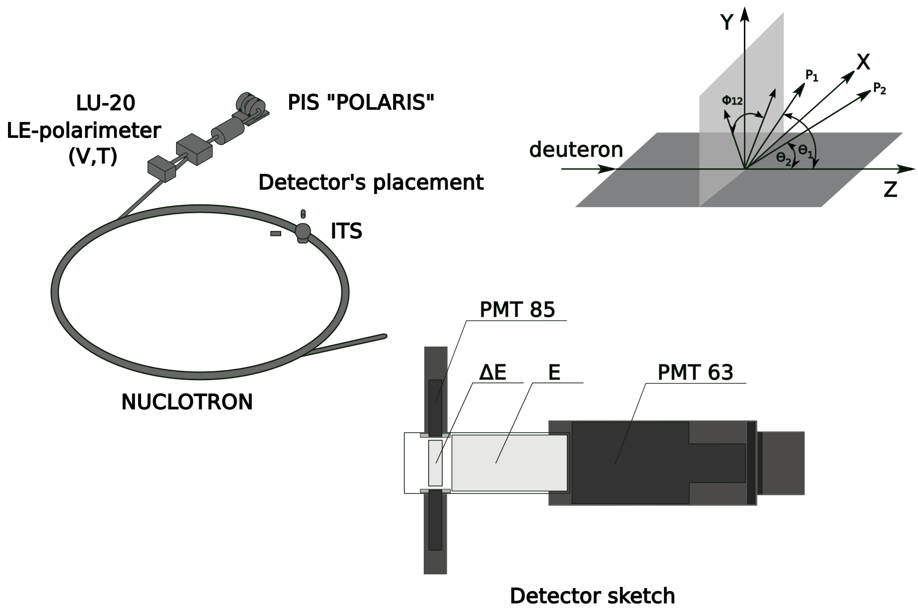

Figure 1. Nuclotron accelerator with sketched view of ΔE-E detector and angle description in case of *dp* reaction.

for the large region of the phase space is very desirable. It has been shown, that theoretical calculations based on Chiral Perturbation Theory, can satisfactorily describe data obtained for energies up to 100 MeV/nucleon. The worst situation is above 100 MeV/nucleon. Thus it is necessary to look for new types of these potentials or even for potentials involving more than three nucleons.

2 Experiment

The goal of the DSS experimental program is to obtain the information about two and three nucleon forces, including their spin dependent parts from *dp*-elastic scattering at the energies between 300 – 2000 MeV and *dp*-breakup with registration of two protons at deuteron energies of 300 – 500 MeV.

The *dp* breakup reaction is investigated at intermediate energies from 300 – 500 MeV of deuteron energy with eight $\Delta E - E$ scintillation detectors [3] (see Fig. 1) with PMT85 and PMT63 photomultiplier tubes. Special setup of the detectors has been chosen in the experiment performed at 2014 to follow inverse kinematics of the reaction in which relativistic effects can play a role [4]. Deuterons were accelerated up to required energy by Nuclotron (see Fig. 1). Polyethylene and carbon targets enclosed in a spherical hull of Internal Target Station (ITS) were used. Definition of mean angles of the detector placement with respect to the target is shown in Fig. 1. Solid angle of each of detector is 4.6°.

The kinematic variable S corresponds to the arc-length along the kinematic curve with zero point chosen at the minimal value of deposited energy in the second arm. Calculated kinematic S-curve with energy step of 5 MeV in case of *dp* breakup reaction for the detector arms placed at angles of $\Theta_1 = 35.0°$, $\Theta_2 = 43.0°$ and $\Phi_{12} = 180°$ at deuteron energy of 400 MeV is shown on the left panel in Fig. 2. The S is increasing in anti-clockwise direction. The number of breakup events in an interval $S - \Delta S/2$, and $S + \Delta S/2$ was obtained by projecting the events on a line perpendicular to the

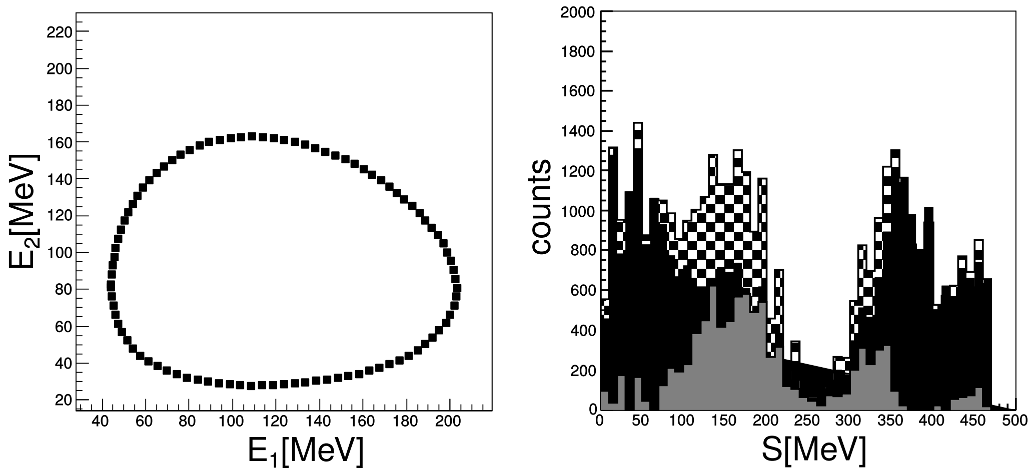

Figure 2. Left panel - calculated kinematic S-curve with energy step of 5 MeV in case of dp breakup reaction for the detector arms placed at angles of $\Theta_1 = 35.0°$, $\Theta_2 = 43.0°$ and $\Phi_{12} = 180°$ at deuteron energy of 400 MeV. Right panel - checked, black and grey histograms represent preliminary results of S distribution obtained on polyethylene, carbon and subtracted (dp) one (see text) for the same kinematic condition as for left the panel is used.

S-curve. Preliminary result for energy step $\Delta S = 5$ MeV and for the arm's polar angles of $\Theta_1 = 35°$, $\Theta_2 = 43°$ and azimuthal angle between them $\Phi_{12} = 180°$ for polyethylene (checked spectra), carbon (black spectra) and subtracted (grey spectra) at deuteron energy of 400 MeV is presented on the right panel in Fig. 2. Subtracted spectra is obtained by subtracting carbon content from polyethylene one. Carbon normalization was performed on the parts of polyethylene spectra where only carbon content is assumed.

3 Conclusion

Preliminary results of S distributions were obtained for some detector configuration at deuteron energy of 400 MeV. S distribution for particular detector configuration, $\Theta_1 = 35.0°$, $\Theta_2 = 43.0°$ and $\Phi_{12} = 180°$, is presented.

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References

[1] R. Machleidt *et al.*, Phys. Rev. C **53** 1483 (1996)
[2] A. Nogga *et al.*, Phys. Lett. B **409** 19 (1997)
[3] S. M. Piyadin *et al.*, Physics of Particles and Nuclei Letters **8** 107 (2011)
[4] H. Witala *et al.*, Few-Body Syst. **49** 61 (2011)