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Experimental and simulated dp breakup reaction data at 300, 400 and 500 MeV

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Abstract. dp breakup reaction occupies large phase space. Two and three nucleon forces and relativistic effects can be investigated under various detector configuration. The results of simulation of dp breakup reaction in energy region from 300 to 500 MeV are presented. Preliminary results obtained at 300, 400 and 500 MeV of deuteron energy at some detector configurations at Nuclotron as well as future plans in investigation of relativistic effects are discussed.

1 Introduction

Experiments (e.g. [1–3]) performed during last two decades clearly indicate the importance of the three nucleon forces in description of binding energies of light nuclei, polarisation observables and scattering experiments with at least three nucleons involved in the reaction. The importance of relativistic effects under specific detector configurations (e.g. space star) have been also observed. In order to perform deeper theoretical study more data which cover large angular and energy range are needed.

2 Simulation and experiment

The $dp \rightarrow ppn$ breakup reaction at deuteron energies of 300, 400 and 500 MeV is investigated by ROOT and GEANT4 simulations and results are compared with obtained experimental data. The aim of the deuteron spin structure (DSS) project is to investigate NN and 3N correlations at intermediate energies. Also, relativistic effects can appear under specific kinematic conditions. Two targets are made from polyethylene and carbon. They are enclosed in spherical hull made from stainless steel with an external diameter of 160 mm and a thickness of 0.5 mm. In experiment eight $\Delta E - E$ scintillation detectors were used and they were placed around the target. Both scintillators are equipped with

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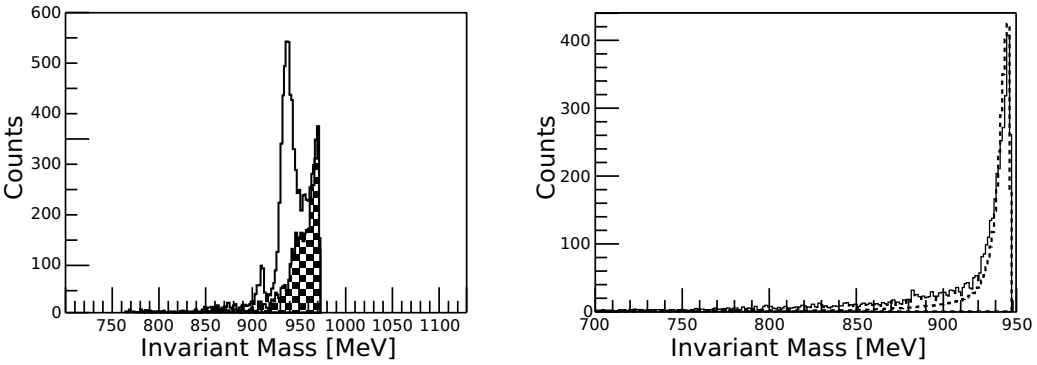

Figure 1. Left panel - simulated invariant mass spectra of two protons obtained on polyethylene (clear histogram) and carbon (checked histogram) targets for the detector arms placed at azimuthal angles of 25.2° (±2.3°) and 43.9° (±2.3°) and lying in the same plane as deuteron beam at energy of 300 MeV. Right panel - simulated (dashed line) and experimental (solid one) plots of the invariant mass spectra of two protons obtained on polyethylene target for the detector arms placed at the same azimuthal angle of 43.2° (±2.3°) and lying in the same plane as deuteron beam at energy of 500 MeV.

photomultiplier tubes (PMT) and have lenght of 1 cm and 20 cm, respectively. Each detector covers solid angle of 4.6°. The details of the ΔE–E detector construction can be found in [4]. To calibrate the detectors a linear dependence of deposited energy on obtained amplitude for all detectors have been assumed. Also, another relevant assumption is that the energy deposit in ΔE and E detectors at the same incoming proton energy has to be the same. Calibration coefficients have been obtained by fitting the system of equations in which obtained detector amplitudes and known energies of protons and deuterons obtained from kinematic simulations performed for dp elastic reaction and pp quasi elastic one were used. Invariant mass distributions of two charged particles assuming that these two particles are protons are shown in figure 1. In the left panel there are depicted simulated invariant mass spectra of two protons obtained on polyethylene and carbon (checked histogram) targets for the detector arms placed at azimuthal angles of 25.2° (±2.3°) and 43.9° (±2.3°) and lying in the same plane as deuteron beam at energy of 300 MeV. Peak around 940 MeV on polyethylene spectra contains events from $dp \rightarrow ppn$ breakup reaction. Small peak in the polyethylene spectra represents dp elastic events. Carbon spectra is normalised to polyethylene one in regions where only carbon content is expected. Normalization can be difficult to perform when carbon content only region is very narrow. In the right panel the simulated (dashed line) and experimental (solid one) plots of the invariant mass spectra of two protons obtained on polyethylene target for the detector arms placed at the same azimuthal angle of 43.2° (±2.3°) and lying in the same plane as deuteron beam at energy of 500 MeV are shown. GEANT4 simulated spectra is multiplied by a constant in order to make the comparison of the experimental data and the simulated data easier. The simulated spectra is in a good agreement with simulated one. A QBBC physics list which contains binary cascade model is used by GEANT4. GEANT4 simulations using Liege model have been performed at the same detector configurations as in case of QBBC physics list. There have been found large differences in yields between these two models at some detector configurations. Liege model at the time of simulations was in experimental stage, thus in next we will use only the results which are obtained using QBBC physics list only. For more information about simulations see [5, 6].

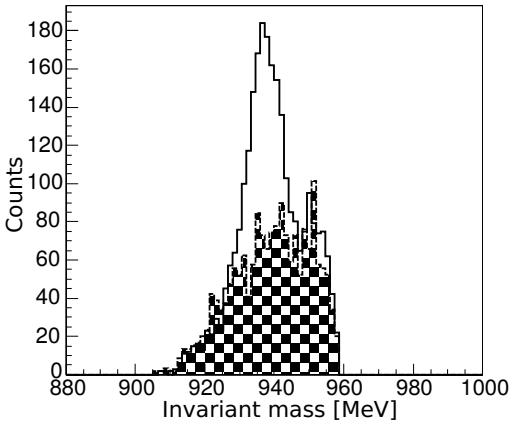

Figure 2. Invariant mass spectra obtained on polyethylene and carbon (checked histogram) targets for detector arms both placed at azimuthal angles of 37° (±2.3°) and lying in the same plane as deuteron beam at energy of 300 MeV.

ROOT kinematic simulation have been performed to find region (locus) where $dp \rightarrow ppn$ events are placed. In figure 2 invariant mass spectra obtained on polyethylene and carbon (checked histogram) targets with cut on locus (from ROOT kinematic simulation) for detector arms both placed at azimuthal angles of 37° (±2.3°) and lying in the same plane as deuteron beam at energy of 300 MeV are shown. One can see clear peak on polyethylene spectra. Again, $dp \rightarrow ppn$ breakup events can be obtained subtracting carbon spectra from polyethylene one.

3 Conclusion

The results obtained from GEANT4 and ROOT simulations have been used in investigation of $dp \rightarrow ppn$ breakup reaction. Selected experimental invariant mass spectra at deuteron energies of 300 and 500 MeV at some detector configurations are presented and those obtained at 500 MeV are compared with result of simulation. We have also accumulated data at detector configuration for which relativistic effects can occur at deuteron energies of 300, 400 and 500 MeV.

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