Development of the COSY-11 simulation program for the study of the $dp \to dp\eta$ reaction

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The deuteron-η interaction is of the special interest due to the possible existence of the η-nucleus bound or quasi-bound states predicted by Ueda [1]. The η meson production near threshold in the three nucleon system is much less explored as compared to the two nucleon system [2]. For the $dp \to dp\eta$ reaction near threshold only total cross section data exist for two excess energies Q = 1.5 $\pm$ 0.6 and 3.8 $\pm$ 0.6 MeV measured with the spectrometer SPESIII at the SATURNE accelerator [3]. The energy dependence of the total cross section for this reaction is expected to be very sensitive to the $d-\eta$ interaction since even much weaker $p-\eta$ interaction significantly modifies the shape of the excitation function as observed in the $pp \to pp\eta$ reaction [4]. The aim of the experiment performed by the COSY-11 collaboration is the determination of the $d-\eta$ interaction and study of the η production mechanism in the $dp \to dp\eta$ reaction. The experiment was carried out with the internal deuteron beam of the COSY accelerator scattered on the proton target of the cluster jet type. In the case of the $dp \to dp\eta$ reaction at the threshold the outgoing deuterons have about two times larger momentum than the outgoing protons and, consequently, their deflection in the magnetic field of the COSY-11 dipole magnet is two times smaller. They leave the COSY-11 vacuum chamber through 10 cm wide and 5.6 cm high forward window as shown in figure 1.

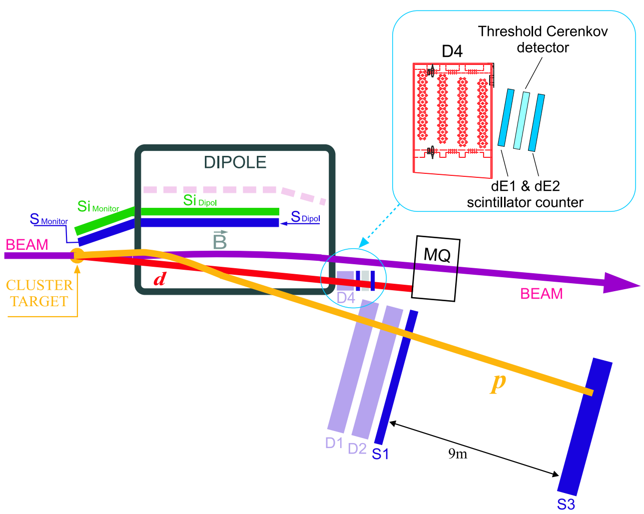

Fig. 1: Detection setup of the COSY-11 experiment [5]. Protons are measured in the drift chambers D1, D2, as well as in the scintillator hodoscopes S1, and S3. For the deuterons, small drift chamber D4, two scintillators dE1, dE2 and Cerenkov threshold counter were installed.

Protons are registered in the standard COSY-11 drift chambers D1, D2, as well as in the scintillator hodoscopes S1 and S3. In the previous year we conducted a measurement of the $pd \to pd\eta$ reaction at four values of excess energies [6] and also performed the first step of the data analysis showing a clear separations of protons, deuterons and ^3He nuclei registered. We also reported a clear signals for the quasi-free $pp \to pp$ and $pp \to d\pi^+$ reactions used for the determination of the luminosity. At present we are at the last stage of accomplishing the programme for the analysis of the $dp \to dp\eta$ events. A corresponding computing procedure necessary for the track reconstruction, and the geometry of the hexagonal drift chamber, are being implemented into the complex computer programme enabling the simulation and analysis of the reactions measured. For the registration of deuterons from the $pd \to pd\eta$ reaction a small drift chamber D4 with two scintillators dE1, dE2 and Cerenkov threshold counter were installed in the space between the dipole exit window and the quadrupole magnet MQ. The chamber D4 has a box shape with dimensions of 13 cm x 18 cm x 18 cm. It consists of seven detection planes: four planes with 10.4 cm vertical wires separated by three planes with 12.70 cm horizontal wires. Each detection plane contains hexagonal cells with the width of 1.1 cm. The distance between adjacent planes is 1.65 cm. Two projections of the drift chamber D4 are shown in figure 2.

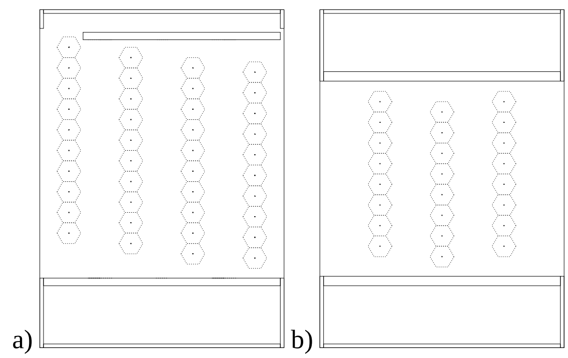

Fig. 2: (a) Top view of the D4 drift chamber showing four identical detection planes, containing 10 cells with vertical wires. (b) Side view presenting three planes containing 8 cells of horizontal wires, each.

The chamber allows for the three dimensional particle tracks reconstruction. The particles momenta are determined by tracing their trajectories in the magnetic field of the dipole magnet back to the target position. Behind the drift chamber D4 two 5 mm thick scintillators dE1 and dE2 are placed. Their signals (if in coincidence) are used as a trigger for the D4 detector readout and as a stop signal for the time–of–flight measurement on the 2 m path from the target. The time of the reaction at the target is derived from measurement of the velocity of the associated particle registered in the scintillator hodoscopes S1 and S3 and from the time measured by the S1 detector. Such a solution enables the particles identification. In order to reduce the proton background a 2 cm plexi glass threshold Cerenkov detector is used. Further improvement of the particle identification is done by taking into account the energy losses in the scintillators. Data analysis is in progress.

References:

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