Status of the analysis of the $pn \to d\eta'$ reaction measured using the COSY-11 facility

Barbara Rejdych and Paweł Moskal for the COSY-11 Collaboration

M. Smoluchowski Institute of Physics, Jagiellonian University, PL-30-059 Cracow, Poland
Institute of Nuclear Physics, Research Centre Jülich, 52425 Jülich, Germany

Abstract. We present the experimental method and the status of the analysis of the quasi-free $pn \to d\eta'$ reaction measured by means of the COSY-11 detection system.

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INTRODUCTION

One of the research fields of the COSY–11 collaboration is the investigation of the η' meson production in nucleon-nucleon collisions which aim at the explanation of the reaction mechanism and the unknown interaction between the η' meson and the proton. In previous experiments we have determined the close-to-threshold excitation function for the $pp \to pp\eta'$ reaction, however it was not possible to determine the mechanism responsible for the η' meson production based on this reaction channel only [1, 2, 3]. Therefore, in order to put constraints on the theoretical models [4] and in consequence to learn more about the peculiar structure of the η' meson [5] we began investigations aiming at the determination of the dependence of the η' meson production on the isospin of the interacting nucleons. In the experiment carried out in August 2004 we have measured the near threshold excitation function for the quasi-free $pn \to pn\eta'$ reaction [6], and in February 2006 we have extended our study to a pure isospin zero state of the interacting nucleons by the measurement of the quasi-free $pn \to d\eta'$ reaction. The experiment was conducted using deuteron cluster-jet target [7, 8] and the COSY proton beam with a momentum of 3.365 GeV/c [9, 10].

The identification of the $pn \to d\eta'$ reaction is based on the determination of the four-momentum vectors of the outgoing deuteron and the spectator proton, whereas the η' meson is identified via the missing mass technique. The momentum of the interacting neutron is deduced from the momentum of the spectator proton under the assumption that the spectator was on its mass shell at the moment of the collision and left undisturbed the reaction region.

The considered $pd \to p_{sp}d\eta'$ reaction may be symbolically presented as:

$$p \begin{pmatrix} n \\ p \end{pmatrix} \begin{matrix} \to d\eta' \\ \quad p_{sp} \end{matrix}$$

where p_{sp} denotes the proton from the deuteron regarded as a spectator which is assumed not to interact with other particles.

MEASUREMENT AT THE COSY-11 FACILITY

A schematic view of the COSY-11 facility is presented in figure 1. For the registration of the $pd \rightarrow p_{sp} d \eta'$ reaction the spectator detector Si_{spec}, the drift chamber D4, and the scintillator hodoscope S^{D4} were used. The silicon pad counter consists of four modules each divided into six groups of three close laying strips [11] (see fig. 2). The modules are double-layered and each comprises eighteen silicon pads in the front layer (which is the plane closer to the beam) and six pads in the back layer. Two layers of the detector permit to measure the kinetic energy of the proton from 0.5 to 9 MeV and to distinguish the spectator protons from the fast particles based on the relation between the energy deposited in the first and the second detection plane. In the case of the

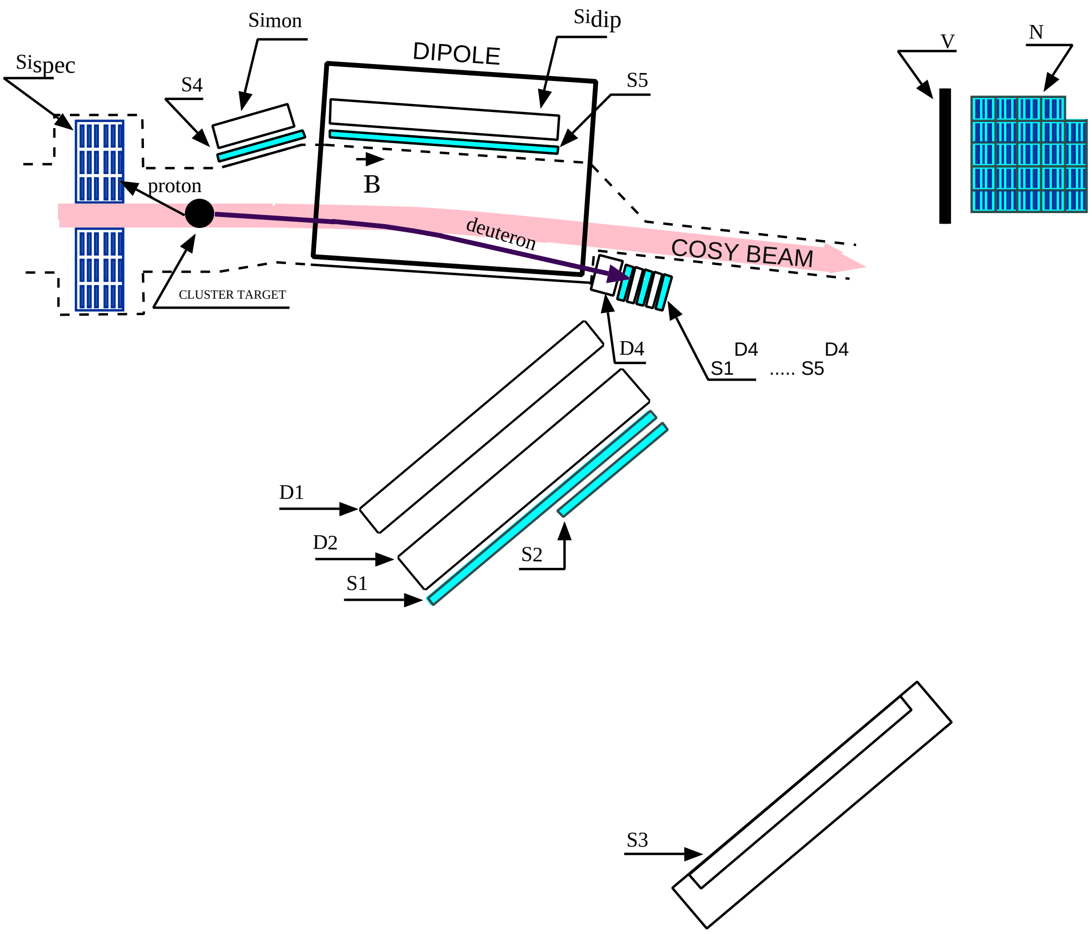

FIGURE 1. Schematic view of COSY-11 detection setup [12, 13]. D1, D2, and D4 denote the drift chambers; S1, S2, S3, S4, S5, $S1^{D4}$ ... $S5^{D4}$ and V stand for the scintillation detectors; N is the neutron detector and Si_{mon}, Si_{spec} and Si_{dip} are silicon strip detectors to detect elastically scattered protons, spectator protons and negatively charged particles, respectively.

$pn \rightarrow d\eta'$ reaction at threshold the outgoing deuteron possesses about 2/3 of the beam momentum, and consequently it is relatively weakly deflected by the magnetic field of the COSY-11 dipole. However, due to the Fermi motion of the interacting neutron, the excess energy as well as the direction of the reaction center-of-mass velocity varies from event to event, enabling a significant fraction of deuterons to leave the dipole through a small window (see fig. 1), where they are registered by means of the drift chamber D4 and the scintillation hodoscope S^{D4}. The latter build out of five independent detection layers each of 5 mm thickness (see fig. 3). The ionization power of deuterons is only 30% larger than that of protons in the relevant momentum range (2.2GeV/c), but the energy resolution of the detectors (25% FWHM) allows for an efficient separation of signals from protons and deuterons. In the off-line analysis the energy loss in these five

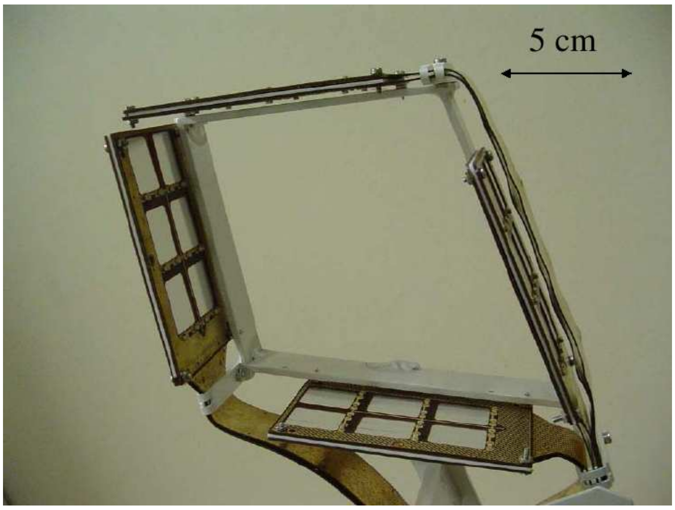

FIGURE 2. Photo of the the silicon pad counters used for the registration of spectator protons.

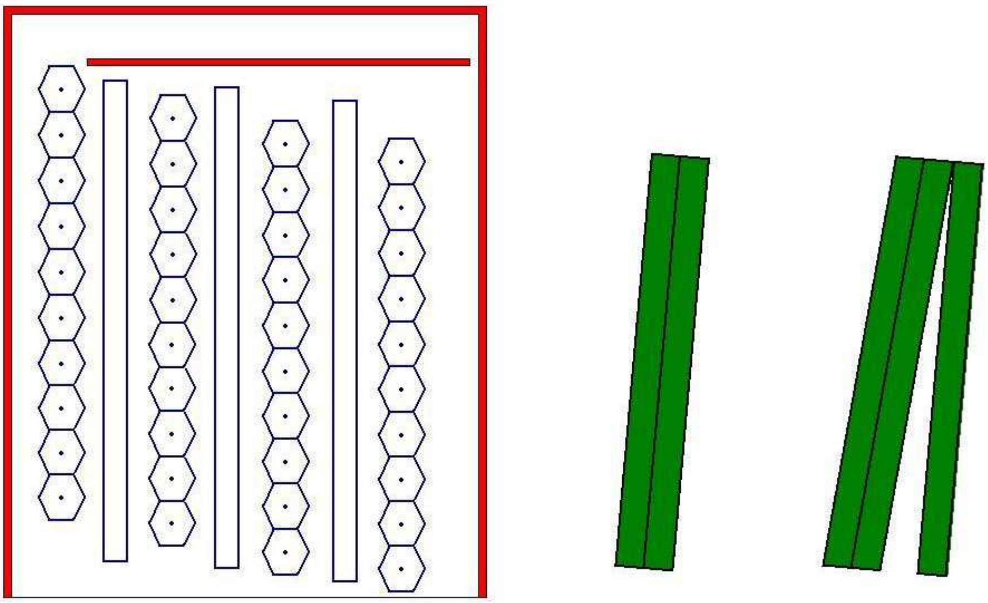

FIGURE 3. Top view of the drift chamber D4 and the scintillator hodoscope. In the chamber four detection planes containing 10 cells with vertical wires are visible [14, 15].

scintillators will be used for the seperation of deuterons from protons and pions. In order to decide for each event, whether the measured set of five independent ΔE values is due to deuteron or other particle, we will employ the Neyman-Pearson test. 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 [14] with the width of 1.1 cm. The distance between adjacent planes is 1.65 cm. The chamber allows for the three dimensional particles tracks reconstruction [14, 15]. The particles momenta are determined by tracing their trajectories in the magnetic field of the COSY dipole magnet back to the target position.

The luminosity will be established from the number of the quasi-free proton-proton elastic scattering events measured simultaneously with the main investigated reaction [16]. During the on-line analysis the integrated luminosity was roughly established to be 500 nb^{-1}. Assuming that the ratio of the cross section $pn \to d\eta'$ and $pp \to pp\eta'$ will be on the same order as already established ratio [17] for the $pn \to d\eta$ and $pp \to pp\eta$ reactions we expect to identify about 1000 $pn \to d\eta'$ events in the whole data sample. Presently the off-line analysis is in progress.

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