Optimization of the spectator detector arrangement for the $pn \to pn\eta'$ measurements at COSY-11

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In order to investigate the quasi-free η' meson production the COSY-11 setup will be extended by the silicon pad counters used succesfully at the CELSIUS storage ring for tagging of the quasi-free $pn \to pn\pi^0$ and $pn \to d\pi^0$ reactions [1].

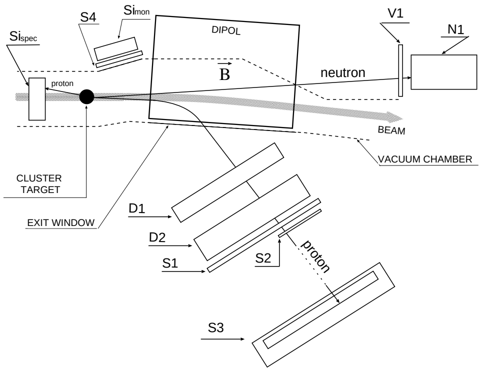

Fig. 1: Schematic view of the COSY-11 detection setup with the new spectator detector denoted as Si_{spec}.

In Figure 1 a shematic view of the COSY-11 facility together with a spectator counter is presented. The tagger shown in more detail in Figure 2 consists of four modules each divided into six groups of three close laying strips. The active area of a unit strip amouts to 20 mm x 5 mm.

The study of the $pn \to pn\eta'$ reaction will be realized by means of the COSY proton beam with a fixed momentum and by utilizing a deuteron cluster target as a source of neutrons. The spectator detecor will be used for tagging the quasi-free proton-neutron interaction and for the determination of the total energy available in the center of mass of the interacting nucleons, since this will vary from event to event due to the Fermi motion of the nucleons inside a deuteron. The excess energy of the ejectiles of the quasi-free $pn \to pn\eta'$ reaction will be determined indirectly by the measurement of the emission angle and the kinetic energy of the spectator proton which will allow to deduce the four-momentum vector of the neutron at the moment of the interaction.

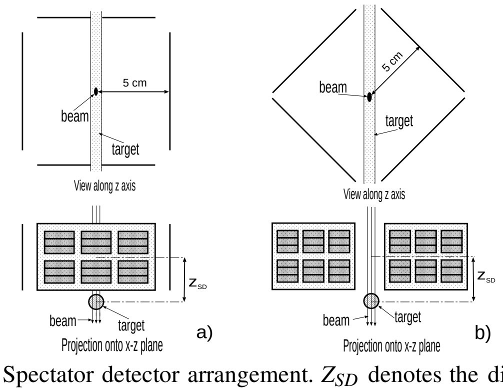

Fig. 2: Spectator detector arrangement. Z_{SD} denotes the distance (along the beam axis) between target and detector center. Simulations have been performed varying the parameter Z_{SD} but keeping the distance between the proton beam and the detector to be constant and equal to 5 cm. This is a compromise between the coverage of the solid angle, angular resolution for the measurement of the spectator proton and the technical needs for the installation.

At a given beam momentum the position of the spectator detector determines the maximum in the excess energy spectrum of the tagged $pn \to pn\eta'$ reactions. For example, installing the detector upstream the target as shown in Figure 1, the $pd \to p_{sp}pn\eta'$ event can be tagged only if the spectator proton is moving opposite to the beam proton, and hence the neutron inside the target deuteron is escaping the beam proton which results in the excess energy lower than it would be in the case with tagger being placed downstream the beam and the neutron moving against it. Due to the geometry of the standard COSY-11 setup the most appropriate excess energy range to be studied is between 0 MeV and 30 MeV. In order to find out an optimum position for the installation of the spectator detector which would give the maximum at this excess energy range a Monte-Carlo calculation have been performed varying a distance Z_{SD} along the beam axis between the target and the spectator counter.

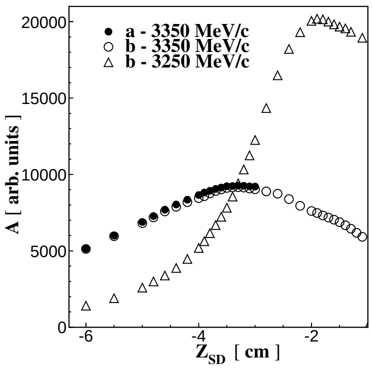

Fig. 3: Detection efficiency for the $pd \to p_{sp}pn\eta'$ reaction as a function of the Z_{SD} – distance measured along the beam axis between target and spectator detector. Circles (triangles) show calculations at P_{beam} = 3350 MeV/c (3250 MeV/c) for both configuration depicted in Figure 2 **a**(filled symbols) and **b**(open symbols). Neutron detector was placed 430 cm from the target and we assumed 0.2 cm and 0.4 cm standard deviations for the horizontal and vertical beam spread, respectively [2].

Figure 3 shows the fraction out of $5 \cdot 10^6$ generated $pd \to p_{sp}pn\eta'$ events which give signals in the detection system necessary to identify a quasi-free $pn \to pn\eta'$ reaction. The calculations have been performed for the two different detector configurations shown in Figure 2. It was found that at P_{beam} = 3350 MeV/c the maximum of the detection efficiency is obtained at Z_{SD} = -3.3 cm independently of the choice of a configuration. However, at the lower beam momentum of P_{beam} = 3250 MeV/c a maximum of the determined efficiency is about two times larger than this at P_{beam} = 3350 MeV/c. This preliminary results show that the detection efficiency for registering quasi-free $pn \to pn\eta'$ reaction depends strongly on both position of the spectator detector and momentum of the proton beam.

References:

[1] R. Bilger et al., Nucl. Instr. & Meth. **A 457** (2001) 64.
[2] P. Moskal et al., Nucl. Instr. & Meth. **A 466** (2001) 448.

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