Optimal conditions for quasi-free $pn \to pn\eta(\eta')$ measurements at COSY–11 facility

R. Czyżykiewicz[1] and P. Moskal for the COSY–11 collaboration

As a first step towards a study of the $pn \to pn\eta'$ reaction, and as a general commissioning of the extended COSY-11 facility to investigate quasi-free $pn \to pnX$ reactions, we have performed a measurement of the $pn \to pn\eta$ reaction at a beam momentum of 2.075 GeV/c. The experiment, carried out in June 2002, had been preceded by the installation of a spectator and a neutron detectors [1], and by a series of thorough simulations performed in order to determine the best conditions for measuring quasi-free $pn \to pn\eta$ and $pn \to pn\eta'$ reactions. Calculations have been performed by a dedicated fast-simulation programme which enabled us to elaborate more than 100 of various detector configurations each for 30 different beam momenta with 10^7 events generated for each settings [2].

Results of the search for the optimum beam momenta for the $pn \to pn\eta(\eta')$ reactions are presented in figure 1. In the calculations the beam momentum has been scanned in 10 MeV/c steps. The optimum value for a quasi-free $pn \to pn\eta$ reaction was found to be $p_{beam}^{pn\to pn\eta} = 2075 \pm 5$MeV/c, whereas for the $pn \to pn\eta'$ reaction it amounts to $p_{beam}^{pn\to pn\eta'} = 3340 \pm 5$MeV/c.

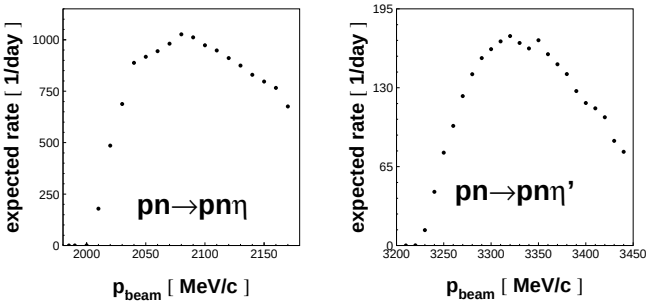

Fig. 1: Expected number of $pn \to pn\eta$ reactions (**left**) and $pn \to pn\eta'$ reactions (**right**) to be registered within one day of measurements as a function of a beam momentum. The neutron detector was placed at a distance of 730 cm, whereas the spectator detector's position was set to be $z_{SD} = -3.0$ cm and -2.2 cm for η and η' production, respectively. For notation see reference [2]

Figure 2 depicts the optimization of the spectator detector's position. The calculations have been performed varying – with a 2 mm step – the distance between the target and the detector [2]. For each point from figure 2 the missing mass width has been calculated. The established mass resolution together with magnitude and slope of the expected rate have been used as a criterion in seeking for optimum beam/detector settings. It was found that the optimal positions of the spectator detector for $pn \to pn\eta(\eta')$ reactions are $z_{SD}^{pn\to pn\eta} = -2.6 \pm 0.1$ cm and $z_{SD}^{pn\to pn\eta'} = -2.8 \pm 0.1$ cm respectively.

Two different configurations [2] of 24 detection modules of the neutron detector (optimised for two possible positions) were under investigation in terms of the missing mass resolution and the expected rate. A 3×8 arrangement [2] at a distance of 430 cm from the target gave a slightly better rate (factor of 1.4) compared with a 5×5 configuration at 730 cm (see fig. 3), however, the latter arrangement led to a slightly better missing mass resolution and this configuration was chosen for the measurements.

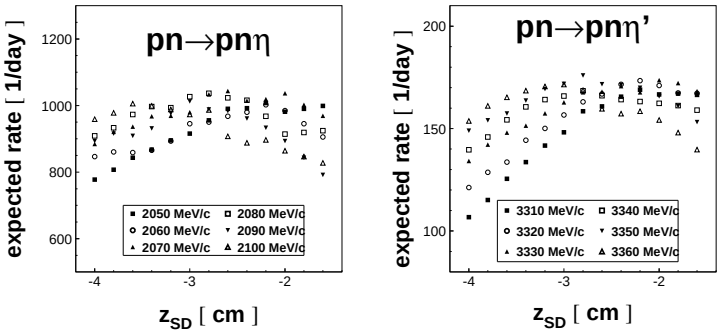

Fig. 2: Expected number of $pn \to pn\eta$ (**left**) and $pn \to pn\eta'$ reactions (**right**) as a function of the beam momentum and spectator detectors position along the beam axis.

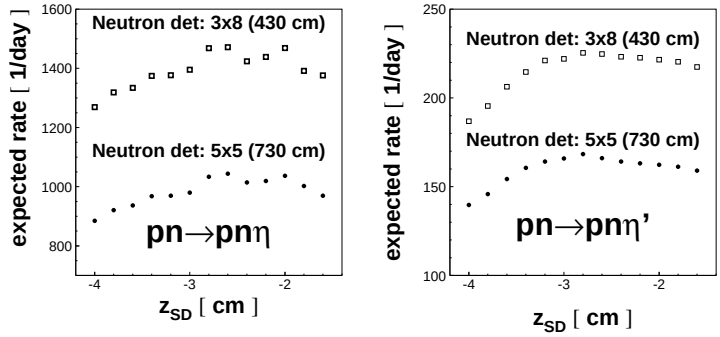

Fig. 3: Expected rate for $pn \to pn\eta$ (**left**) (at 2070 MeV/c) and $pn \to pn\eta'$ reactions (**right**) (at 3340 MeV/c) for two different positions and configurations of the neutron detector.

The spectra of the expected missing mass distributions for both considered reactions are presented in fig. 4. For the optimal conditions (previously described), in the case of η production, the width of the missing mass spectrum was found to be 6.0 ± 0.5 MeV (FWHM), whereas in the case of η' a value of 7.0 ± 0.5 MeV (FWHM) is expected.

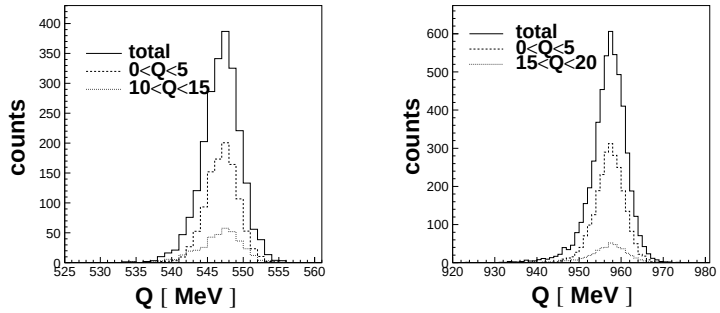

Fig. 4: Missing mass distribution as reconstructed from Monte-Carlo simulations at the optimum experimental conditions for the $pn \to pn\eta$ – (**left**) and the $pn \to pn\eta'$ reaction (**right**). Dashed and dotted lines indicate result for various ranges of excess energy.

References:

[1] M. Janusz et al., contribution in this report.
[2] R. Czyżykiewicz, Diploma thesis 2002, Jül-4017 in press.

[1] Institute of Physics, Jagellonian University, Cracow, Poland