

## The quasi-free $pn \rightarrow pn\eta'$ reaction at the COSY-11 facility

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Investigations of the  $\eta'$  meson production in  $NN$  collisions are of great interest due to several reasons. First of all, the mass of the  $\eta'$  does not fit into the SU(3) scheme. This discrepancy reflects the still unknown structure of this meson. The production mechanism of the  $\eta'$  meson in collisions of nucleons also is yet unexplained. The establishment of the unknown coupling constant  $g_{NN\eta'}$  is another motivation for studies of the  $\eta'$  production close-to-threshold. A further interesting issue is the unknown proton- $\eta'$  interaction which has been tentatively investigated by the COSY-11 group [1], however, for a more quantitative understanding the analysis of the Dalitz plot is required, which will be possible due to recently performed high-statistics measurements of the  $pp \rightarrow pp\eta'$  reaction [2].

Since the close-to-threshold production of  $\eta'$  meson in  $NN$  collisions requires a large momentum transfer between the nucleons and occur at distances in the order of  $\sim 0.3$  fm, the quark-gluon degrees of freedom may play a significant role in the production dynamics of this meson. Therefore, additionally to the mechanisms associated with meson exchanges it is possible that the  $\eta'$  meson is created from excited glue in the interaction region of the colliding nucleons [3, 4], which couple to the  $\eta'$  meson directly via its gluonic component or through its SU(3)-flavour-singlet admixture. The production through the colour-singlet object as suggested in reference [3] is isospin independent and should lead to the same production yield of the  $\eta'$  meson in the  $pn \rightarrow pn\eta'$  and  $pp \rightarrow pp\eta'$  reactions disregarding the final and initial state interaction between the nucleons.

Measurements of the ratio of the total cross sections for the reactions  $pn \rightarrow pn\eta$  and  $pp \rightarrow pp\eta$  ( $R_\eta = \frac{\sigma(pn \rightarrow pn\eta)}{\sigma(pp \rightarrow pp\eta)}$ ), which was determined to be  $R_\eta \approx 6.5$  in the excess energy range between 16 MeV and 109 MeV [6] allowed to suspect the dominance of the isovector meson ( $\pi$  and  $\rho$ ) exchange in the creation of  $\eta$  in nucleon-nucleon collisions [5, 6].

Similar studies concerning the determination of the  $R_{\eta'} = \frac{\sigma(pn \rightarrow pn\eta')}{\sigma(pp \rightarrow pp\eta')}$  ratio are expected to give an answer to the question of the production mechanism of the  $\eta'$  meson. A value of  $R_{\eta'} = 1$  (disregarding the initial and final state interactions) is expected for the extreme scenario in which the  $\eta'$  meson is created via its gluonic component, which does not distinguish between the flavours. A  $R_{\eta'}$  value different than unity may be an indication of the presence of some other production mechanisms, e.g. the isovector meson exchange. The cross sections for  $\eta'$  at different close-to-threshold excess energies has already been determined [1], whereas those for the  $I = 0$  isospin channel are still unknown. Measurements of the latter has been proposed by the COSY-11 collaboration [7] and the beamtime of three weeks has been granted and scheduled for August '04. The investigations will be performed at the COSY-11 facility (for the detailed description of the method of measurement see [7, 8] and references therein).

As a prove of ability of the COSY-11 facility to register quasi-free  $pn \rightarrow pnX$  reactions, we present spectra obtained during the measurement of the  $pn \rightarrow pn\eta$  reaction at a beam momentum of 2.075 GeV/c [8]. Figure 1 shows the excess energy distribution for the quasi-free  $pn \rightarrow pnX$  reaction. The tail in the region of negative  $Q$  values results from multi-

pion production. For positive values of  $Q$  it is principally impossible to differentiate between multi-pion and  $\eta$  meson production on an event-by-event basis. However, on a statis-

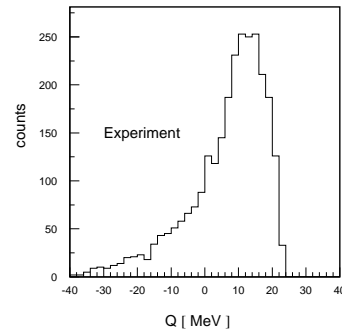


Fig. 1: Distribution of the excess energy  $Q$  for the quasi-free  $pn \rightarrow pnX$  reaction, determined with respect to the  $pn\eta$  threshold as obtained during the June '02 run.

tical basis the  $pn \rightarrow pn\eta$  events can be distinguished from the multi-pion background by comparing the missing mass distributions for negative and positive  $Q$  values, as shown in figure 2a.

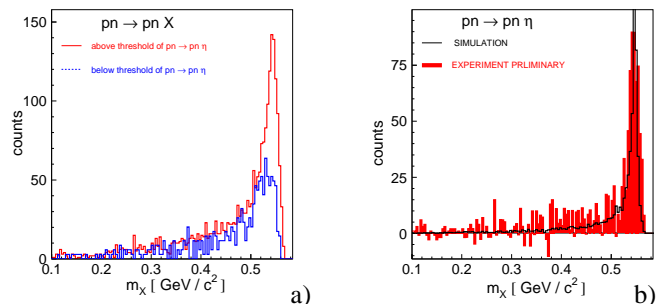


Fig. 2: Missing mass spectra as obtained during the June '02 run: (a) Event distribution for  $Q < 0$  (blue line) and for  $Q > 0$  (red line), (b) Difference between number of events above and below threshold for the  $pn \rightarrow pn\eta$  reaction. The black line corresponds to the Monte-Carlo simulation.

By identifying events for which  $Q < 0$  with the multi-pion production exclusively and subtracting their missing mass distribution from those for which  $Q > 0$ , we are able to derive the missing mass spectrum corresponding to the  $pn \rightarrow pn\eta$  events as presented in figure 2b.

### References:

- [1] P. Moskal et al., Phys. Lett. **B 474** (2000) 416.
- [2] J. Przerwa et al., contribution in this report.
- [3] S. D. Bass, Phys. Lett. **B 463** (1999) 286.
- [4] S. D. Bass, e-Print Archive: hep-ph/0006348.
- [5] G. Faldt, T. Johansson, C. Wilkin, Phys. Scripta **T 99** (2002) 146.
- [6] H. Calén et al., Phys. Rev. **C 58** (1998) 2667.
- [7] P. Moskal et al, COSY Proposal No. 133 (2003).
- [8] P. Moskal et al., e-Print Archive: nucl-ex/0311003.

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