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

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Investigations of the η' meson production in NN collisions are of great interest due to several reasons. First of all, the mass of the η' does not fit into the SU(3) scheme. This discrepancy reflects the still unknown structure of this meson. The production mechanism of the η' 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 η' production close-to-threshold. a further interesting issue is the unknown proton-η' 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 $pp \to pp\eta'$ reaction [2].

Since the close-to-threshold production of η' 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 η' meson is created from excited glue in the interaction region of the colliding nucleons [3, 4], which couple to the η' 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 η' meson in the $pn \to pn\eta'$ and $pp \to pp\eta'$ reactions disregarding the final and initial state interaction between the nucleons.

Measurements of the ratio of the total cross sections for the reactions $pn \to pn\eta$ and $pp \to pp\eta$ ($R_\eta = \frac{\sigma(pn\to pn\eta)}{\sigma(pp\to pp\eta)}$), 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 (π and ρ) exchange in the creation of η in nucleon-nucleon collisions [5, 6].

Similar studies concerning the determination of the $R_{\eta'} = \frac{\sigma(pn\to pn\eta')}{\sigma(pp\to pp\eta')}$ ratio are expected to give an answer to the question of the production mechanism of the η' meson. A value of $R_{\eta'} = 1$ (disregarding the initial and final state interactions) is expected for the extreme scenario in which the η' 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 η' 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 $pn \to pnX$ reactions, we present spectra obtained during the measurement of the $pn \to pn\eta$ reaction at a beam momentum of 2.075 GeV/c [8]. Figure 1 shows the excess energy distribution for the quasi-free $pn \to pnX$ 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 η meson production on an event–by–event basis. However, on a statistical basis the $pn \to pn\eta$ enents can be distuinguished from the multi–pion background by comparing the missing mass distributions for negative and positive Q values, as shown in figure 2a.

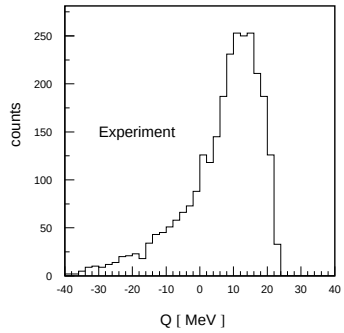

Fig. 1: Distribution of the excess energy Q for the quasi-free $pn \to pnX$ reaction, determined with respect to the $pn\eta$ threshold as obtained during the June '02 run.

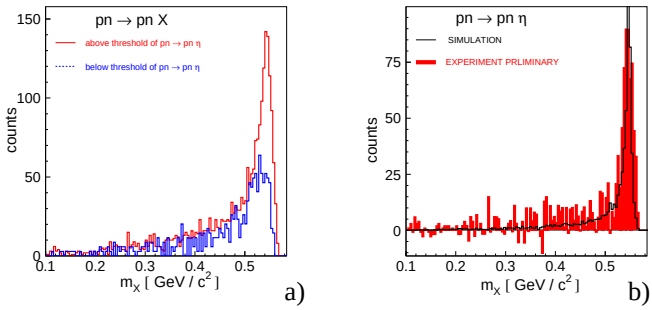

Fig. 2: Missing mass spectra as obtained during the June '02 run: (a) Event distribution for Q<0 (blue line) and for Q>0 (red line), (b) Difference between number of events above and below threshold for the $pn \to pn\eta$ reaction. The black line corresponds to the Monte-Carlo simulation.

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 $pn \to pn\eta$ events as presented in figure 2b.

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