Upper limit of the total cross section for the $pn \to pn\eta'$ reaction

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In this report we present first results on the measurement of the $pn \to pn\eta'$ reaction.

The main goal of this experiment was the determination of the excitation function for the quasi-free $pn \to pn\eta'$ reaction near the kinematical threshold. The motivation was the comparison of the $pp \to pp\eta'$ and $pn \to pn\eta'$ total cross sections in order to learn about the production mechanism of the η' meson in the channels of isospin $I = 1$ and $I = 0$ and to investigate aspects of the gluonium component of the η' meson.

The experiment has been performed at the cooler synchrotron COSY by means of the COSY–11 detector system. For the purpose of this experiment the standard COSY–11 detector setup was extended by a neutral particle and spectator detectors. The quasi-free $pn \to pn\eta'$ reaction has been induced by a proton beam with a momentum of 3.35 GeV/c in a deuteron target. All outgoing nucleons have been registered by the COSY–11 detectors, whereas for the η' meson identification the missing mass technique was applied. The energy dependence of the cross section was extracted exploiting the Fermi momenta of nucleons inside the deuteron.

Although the integrated lumonosity was by a factor of 50 larger than in the experiments with the η meson, due to the low statistics and very low signal-to-background ratio, the signal from η' mesons created in the proton-neutron collision is statistically insignificant. Therefore, we can only estimate an upper limit for the η' meson production in the $pn \to pn\eta'$ reaction [1]. The luminosity of $L = 4.77\ pb^{-1} \pm 0.06\ pb^{-1}$ was established from the number of quasi-free proton-proton scattering events applying the method described in a dedicated article [2]. The acceptance of the detector setup and efficiency was determined based on Monte Carlo studies.
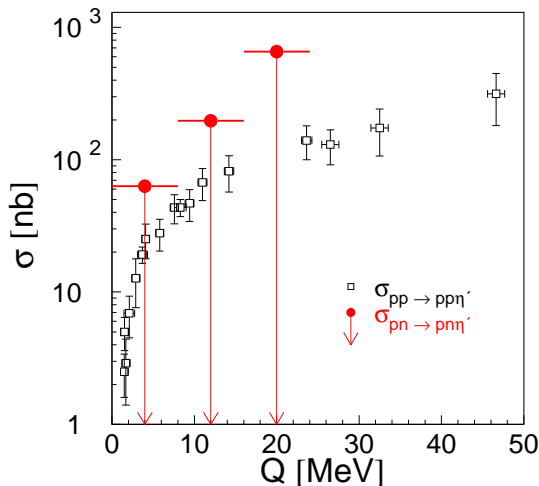

Fig. 1: Total cross sections for the $pp \to pp\eta'$ reaction as a function of the excess energy (open squares). Upper limit for the total cross section for the $pn \to pn\eta'$ reaction as a function of the excess energy (dots).

The result is shown in Figure 1. The horizontal bars in Figure 1 represents the intervals of the excess energy, for which the upper limit of the total cross section was calculated. Figure 2 presents the upper limit of the ratio $R_{\eta'} = \sigma(pn \to pn\eta')/\sigma(pp \to pp\eta')$ of the total cross section for the $pn \to pn\eta'$ and $pp \to pp\eta'$ reaction as a func-

tion of the excess energy (dots). The corresponding ratios for the η meson are also shown as open squares. For the η meson, the value of R_η is ≈ 6.5 at excess energies larger than ~ 16 MeV [3] which suggests the dominance of isovector meson exchange in the production mechanism. The decrease of R_η close to the threshold [5] may be explained by the different energy dependence of the proton-proton and proton-neutron final state interactions [4].
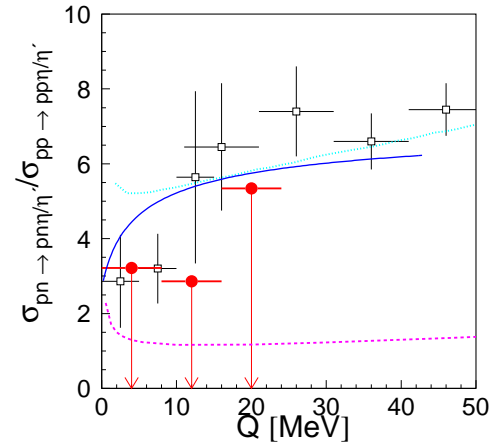

Fig. 2: Upper limit of the ratio $(R_{\eta'})$ of the total cross sections for the $pn \to pn\eta'$ and $pp \to pp\eta'$ reactions (dots) in comparison with the ratio (R_η) determined for the η meson (open squares). The superimposed line indicates a result of the fit to the R_η data taking into account the final state interaction of nucleons [5]. The dashed line represents results of calculations from [6]. The dotted line shows the $(R_{\eta'})$ ratio value assuming that the production of the η' meson proceeds in the same way as the production of the η meson [7].

For the η' meson the upper limit of the ratio for the excess energy range $[0, 8]$ MeV is nearly equal to values of the ratio obtained for the η meson, whereas for larger excess energy ranges $[8, 16]$ MeV and $[16, 24]$ MeV the upper limits of the ratio are lower by about one standard deviation each. This result allows to conclude that the meson η' is not dominantly created via the excitation of the $S_{11}(1535)$ resonance and gives a weak indication for a greater role for singlet currents in the η' production process. Possible explanations include a significant role for OZI violating gluonic excitation [8] or a larger role for isoscalar exchange between the two nucleons. However, to confirm this interesting observation further experimental investigations with improved statistics are required.

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