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ISOSPIN DEPENDENCE OF THE η' MESON PRODUCTION IN NUCLEON-NUCLEON COLLISIONS

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Abstract

Using the COSY-11 detection setup we intend to determine the excitation function of the total cross section for the $pn \to pn\eta'$ reaction near the kinematical threshold. The comparison of the $pp \to pp\eta'$ and $pn \to pn\eta'$ total cross sections will allow to learn about the production mechanism of the eta-prime meson in nucleon–nucleon collisions and to investigate aspects of the gluonium component of the η' meson. A method of the measurement and preliminary results are presented in this report.

1 Introduction

Despite the fact that the η' meson was observed forty years ago, there is not much known about the relative contribution of the possible reaction mechanisms of the production of this meson. It is expected that the η' meson can be created through heavy meson exchange, through the excitation of an intermediate resonance or via emission from the virtual meson [1]. It is also possible that η' meson is produced from excited glue in the interaction region of the colliding nucleons, which couple to the η' meson directly via its gluonic component or through its SU(3)-flavour-singlet admixture [2, 3]. As suggested in reference [4], η' production via the colour-singlet object does not depend on the total isospin of the colliding nucleons and should lead to the same production amplitude for the η' in the $pn \to pn\eta'$ and $pp \to pp\eta'$ reactions. In case of the η meson, the ratio of the total cross sections for the reactions $pn \to pn\eta'$ and $pp \to pp\eta'$ was determined to be $R_\eta = 6.5$ [5], what suggest the dominance of isovector meson exchange in the η production in nucleon-nucleon collisions. Since the quark structure of η and η' mesons is very similar, in case of the dominant isovector meson exchange – by the

analogy to the η meson production – we can expect that the ratio $R_{\eta'}$ should also be about 6.5. If however η' meson is produced via its flavour-blind gluonium component from the colour-singlet glue excited in the interaction region the ratio should approach unity after corrections for the initial and final state interactions. The close–to–threshold excitation function for the $pp \to pp\eta'$ reaction has already been determined [6–10], whereas the total cross section for the η' meson production in the proton-neutron interaction is still unknown.

2 Measurement of the $pn \to pn\eta'$ reaction

In August 2004 –for the first time– using the COSY–11 facility [**?**,12] we have conducted a measurement of the η' meson production in the proton-neutron collision. A quasi-free proton-neutron reactions were induced by a proton beam impinging on a deuteron target. The experiment is based on the reg-

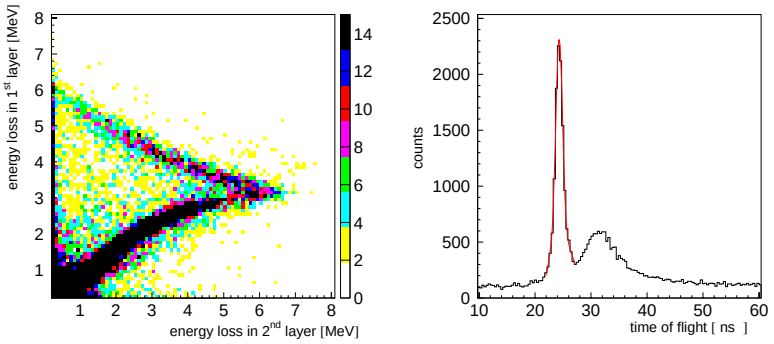

Figure 1: Energy losses in the first layer versus the second layer as measured at COSY–11 with a deuteron target and a proton beam with momentum of 3.35 GeV/c (left). Time–of–flight determined between the target and the neutron detector (right).

istration of all outgoing nucleons from the $pd \to p_{sp}pnX$ reaction. Protons are measured in two drift chambers and scintillator detectors [13], neutrons are registered in the neutral particle detector [14]. Protons considered as a spectators are measured by the dedicated silicon-pad detector [15, 16]. Figure 1 (left) shows energy losses in the 1^{th} layer of the spectator detector versus 2^{nd} layer. Slow spectator protons are stopped in the first layer of the detector whereas fast particles cross both detection layers. The total

energy available for the quasi-free proton-neutron reaction can be calculated for each event from the vector of the momenta of the spectator and beam protons, assuming that the spectator spectator does not take part in the reactions and escapes untouched carrying the Fermi momentum possessed at the time of the reaction. The absolute momentum of neutrons is determined from the time-of-flight between the target and the neutron detector. Figure1(right) presents the time-of-flight distribution – for neutral particles – measured between the target and the neutral particle detector. A clear signal originating from the gamma rays is seen over a broad enhancement from neutrons. This histogram shows that discrimination between signals originating from neutrons and gamma quanta can be done by a cut on the time of flight. Application of the missing mass technique allows to identify events with the creation of the meson under investigation. However, due to the smaller efficiency and lower resolution for the registration of the quasi-free $pn \rightarrow pn\ meson$ reaction in comparison to the measurements of the proton-proton reactions, the elaboration of the data encounters problems of low statistic. However one can determine the number of registered $pn \rightarrow pn\eta'$ events from the multi-pion background by comparison of the missing mass distributions for the negative values of Q, when only pions may be created, and for Q values larger than 0 [17]. The evaluation of the background is in progress.

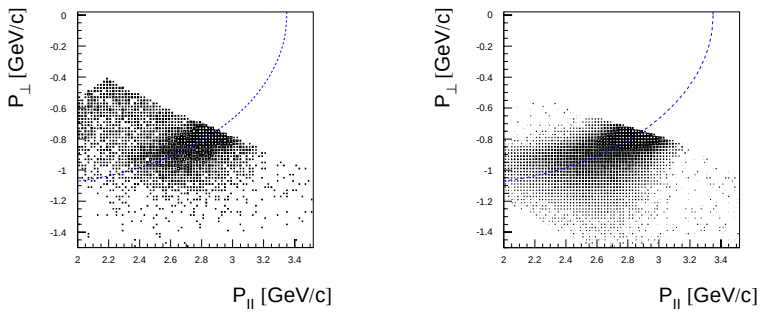

Figure 2: Parallel versus transversal momentum component of the reconstructed fast proton momentum as obtained in the experiment (left) and in the simulation (right).

The luminosity will be established from the number of the quasi-free proton-proton elastic scattering events employing the method described in

the [18]. Figure 2 shows parallel versus transversal component of the reconstructed momentum of the forward scattered proton. Events corresponding to the elastic scattered protons are seen near the kinematical ellipse, which is marked as a solid line. The comparison of the experimental and simulated distributions will enable to determine the value of the integrated luminosity [18].

Acknowledgments

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