Simulations for production of mesons via quasi-free proton-neutron scattering at the WASA 4π-detector.

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Part of the physics program of the COSY-11 collaboration concerns the study of the production of η and η' mesons in collisions of nucleons. Measurement of the excitation functions of the $pp \to pp\eta$ and $pp \to pp\eta'$ reactions were completed and at present we extend our investigations to one-dimensional differential distributions [1, 2]. In parallel we also explore the spin and isospin degrees of freedom in the creation of the mentioned mesons. To perform such a study we extended the COSY-11 detection set-up by a neutron – [3] and a spectator detector [4]. First successful measurements of the $pn \to pn\eta$ and $\vec{p}p \to pp\eta$ reactions have proven the feasibility to study the quasi-free $pn \to pnX$ reactions as well as polarisation observables using the newly accomplished experimental set-up [5, 6]. Though COSY-11 possesses unprecedented precision for the determination of the momentum of the charged ejectiles its rather modest acceptance led us to consider whether the discussed studies could be continued more efficiently with the WASA detector when it will be installed at the cooler synchrotron COSY [7]. As a first step in January 2004 the COSY-11 collaboration presented two Letters of Intent [8, 9] describing the general physics motivations and advantages of continuing the studies by means of the 4π detector. However, detailed estimations of possible advantages and/or disadvantages require quantitative simulations of the response of the WASA detector to the investigated reactions. For this purpose we began to perform simulations of the $pp \to pp\eta'$ reaction, and also of the quasi-free processes like $pn \to pn\eta'$ and $pn \to pn\eta$. Results of the very first studies are presented in two separated reports [10, 11]. For the calculations we have applied one of the two simulation packages used by the WASA collaboration, assuming temporarily the arrangement of the WASA detector components as presently in operation at CELSIUS [12]. The computation package chosen is based on the GEANT simulations program and the dedicated software package ODIN (Onlie/Offline Data INspection) for the analysis of data and the WASA-experiment control [13]. It is written in the languages Fortran and C and the whole project is maintained using the Microsoft Developer Studio. This program was previously optimized for the analysis of the $pp \to pp\pi^0$ [14], $pd \to {}^3He\eta$ [15] and $pd \to pd\eta$ [16] reactions. Thus, as a very first exercise we have extended it to enable the simulations and analysis of the quasi-free processes like $pd \to pn\eta p_{sp}$, where p_{sp} denotes the spectator proton and implemented procedures for the calculations of the excess energy of the $pn \to pn\eta$ process according to the method described in references [17, 18]. As a first task we checked to what extent the accuracy obtained in the measurements of the quasi-free $pn \to pn\eta$ reaction performed by the PROMICE/WASA collaboration is due to the approximation used in the calculation of the excess energy and to what extent it is due to the experimental resolution of the detection set-up. For calculating the excess energy it is assumed that the transverse components of the Fermi momentum of the target nucleon are zero. Figure 1 demonstrates the spectrum obtained for the difference between the real excess energy and the one determined under this supposition. The distribution indicates that using this approximation one overestimates the real excess energy - on the average - by a few MeV. This is, however, less than the experimental resolution which amounts to about 8 MeV [17].

Further studies, aiming at the precise comparison between the COSY-11 and WASA facilities in view of the experimental resolution for the invariant mass determination, excess energy and acceptance are in progress.

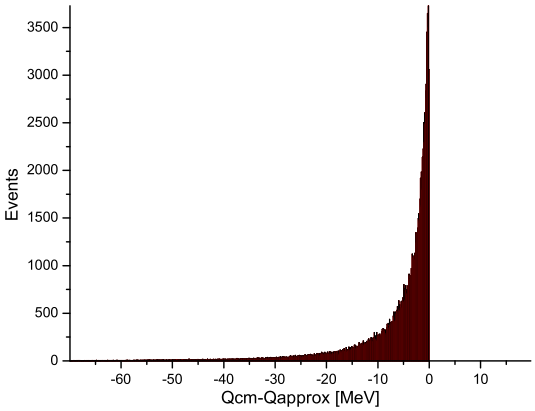

Fig. 1: Distribution of the difference between the real and approximated excess energy of the quasi-free $pn \to pn\eta$ reaction simulated for the $pd \to pn\eta p_{sp}$ process at the proton beam momentum of 2.075 GeV/c. For details see text.

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