Investigation of the η'-proton interaction at the COSY-11 and WASA@COSY facilities

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During 2004 the COSY-11 collaboration has published results on the $pp \to pp\eta$ reaction at the excess energy of $Q = 15.5\ MeV$ [1]. Especially interesting is the structure determined for the proton-proton invariant mass distributions which reveals a statistically significant enhancement at large proton-proton momenta. The structure could be due to the η-proton interaction, but a firm explanation remains at present a challenge for the theory since it requires a rigorous three-body approach to the system with complex potentials.

On the experimental side it is natural to ask whether the enhancement will also appear in the case of the production of other mesons. Specifically interesting in that context are the π^0 and η' mesons, the SU(3) flavour neutral partners of the η meson. We have chosen for the comparison the η' meson mainly because its interaction with nucleons is still quantitatively not established, and thus the observation of a signal originating from the proton-η' interaction would be already exciting in itself. Secondly, because the η' meson is much heavier than the pion and the relevant angular momenta in the ppη' system are expected to be zero at Q = 15.5 MeV, at this energy the $pp\pi^0$ system has significant contribution from higher partial waves [2].

At a beam momentum of 3.257 GeV/c, corresponding to an excess energy of Q = 15.5 MeV, the $pp \to pp\eta'$ reaction was measured with rather high statistics by the COSY-11 collaboration. The investigations were performed at exactly the same excess energy as those for the $pp \to pp\eta$ reaction in order to permit a direct comparison between the results for η and η' mesons and hence to facilitate drawing less model dependent conclusions. The data are presently analyzed and the overall number of registered $pp \to pp\eta'$ events amounts to about 13000 [3]. Due to the missing mass technique used, it is impossible to identify univocally the studied reaction on the event-by-event basis. The experimentally determined ratio of the signal to the unavoidable multi-pion background amounts to about $\approx$0.25 [3]. Nevertheless, the achieved statistics will allow for the reduction of the multi-pion background in one-dimensional differential spectra and we will see whether these spectra will reveal some remarkable signals. Yet, the full information of the mutual interaction between ejectiles is excessible from the two-dimensional Dalitz plot. Unfortunately, the present COSY-11 data do not permit for its background-free determination without the loss of the required accuracy. A qualitative improvement of the data basis can only be made if additionally to the registration of outgoing baryons the gamma quanta from the decay of the meson will be detected. This would allow to obtain multi-dimensional differential distributions free of (or at least with drastically reduced) multi-pion background. Needless to say that the more particles are registered in coincidence the more crucial becomes the detection acceptance. Therefore, a scan of the phase space of the reactions characterized by 1 μb cross section is feasible only at a detector facility possessing an acceptance close to 4π. For such studies the WASA detector will be well suited after it is installed at COSY [4]. We intend to use this detector for the determination of a background free Dalitz plot and to begin we have performed simulation studies in order to estimate the acceptance of the WASA detector for the $pp \to pp\eta'$ reaction. Figure 1(left) shows a two protons invariant mass spectrum for all simulated events and in figure 1(right) the corresponding spectrum is extracted only for those events for which two protons were reconstructed. The acceptance given in figure 2 is a ratio of the spectra from figure 1(right) and figure 1(left) for every bin of invariant mass. Here only the decay channel $\eta' \to \gamma\gamma$ was taken into account at the present condition of the WASA detector. However, for the η' meson identifications, one can use further decay sequences as e.g. $\eta' \to \pi^0\pi^0 \to 6\gamma$ [5]. The spectra indicate that with the present forward detector and reconstruction algorithms the effciency of the protons reconstruction from the $pp \to pp\eta'$ reaction is not high and both the modifications of forward detector (FD), which will improve track coordinate measurements, energy measurements and particle identification for the higher energies, as well as the development of the reconstruction procedures suitable for protons with kinetic energy up to at least 500 MeV, are needed.

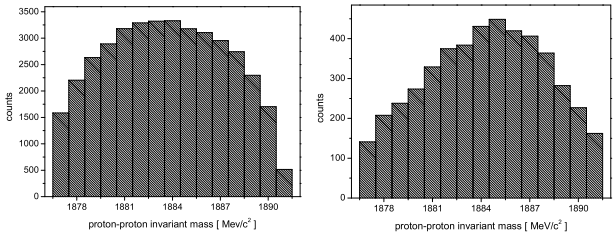

Fig. 1: Proton-proton invariant mass spectra. (left) generated, (right) reconstructed from signals in the detector. For the reconstruction noly events with the invarian mass of the $\gamma\gamma$ system larger than 800 MeV were taken into account.

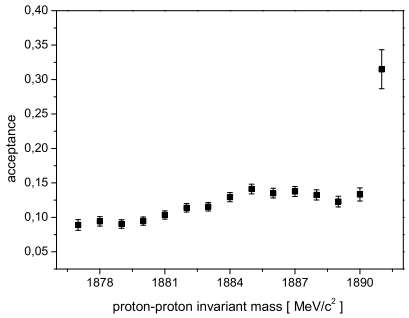

Fig. 2: Ratio of the spectra from figure 1. (see text)

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