High statistics measurement of the $pp \to pp\eta$ reaction at COSY-11

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Investigations of the η meson production via the $pp \to pp\eta$ reaction addresses the question of the strength of the proton-η interaction at low relative momenta of the reaction particles. In the frame of the optic potential model this interaction can be expressed in terms of phase shifts, which in turn are described by the scattering length $a_{\eta N}$ and the effective range of the potential. Usually the $a_{\eta N}$ is defined as a complex quantity, with the imaginary part accounting for the $\eta N \to \pi N$ process. The real part of the scattering length is a direct measure for the formation – or non-formation – of an η-nuclear quasi-bound state [1]. At present this very interesting issue whether the attractive interaction between η-nucleon and nucleon-nucleon pairs is strong enough to form a quasi-bound ηNN state remains open. Encouraging results indicate [2] that a three-body ηNN resonant state, which may be formed close to the ηd threshold, may evolve into a quasi-bound state for $\mathrm{Re}(a_{\eta N}) \geq 0.733$ fm. Similarly, the close to threshold enhancement of the total cross section of the $pp \to pp\eta$ [3] reaction was interpreted as being either a Borromean (quasi-bound) – or a resonance ηpp state [4], provided that $\mathrm{Re}(a_{\eta N}) \geq 0.7$ fm. Contrary, recent calculations performed within a three-body formalism indicate [5] that a formation of a three-body ηNN resonance state is rather not possible independently of the ηN scattering parameters. Moreover, the authors of reference [6] exclude also the possibility of the existence of an ηNN quasi-bound state. However, results of both calculations [5, 6], although performed within a three-body formalism, used the assumption of a separability of the two-body ηN and NN interactions, and hence the new quality in the three-body ηNN-interaction is not excluded and deserves experimental investigations.

The COSY-11 collaboration performed a high statistics measurement of the $pp \to pp\eta$ reaction at an excess energy of Q = 16 MeV. The determination of the four-momentum vectors for both outgoing protons of each registered event gives the complete information of the ηpp-system allowing for the investigations of the ηp and ηpp interactions. The analysis of the Dalitz-plot aims for the extraction of the still not well established value of the η-proton scattering length. The analysis of the data is still in progress.

At present the data were corrected for the mean beam momentum changes (see Fig. 1) during the 10 days of data taking. The missing mass distribution, shown in Figure 2, will further be corrected for effects of the time dependent relative shifts between the beam and the target using the method described in reference [7]. After this is done the Dalitz- and t-plot analysis will be performed. The t-plot will show an enhancement at the four-momentum square which corresponds to the mass of the particle exchanged between the interacting protons during the $pp \to pp\eta$ reaction.

For the calculation of the differential acceptance of the detector system – needed to correct for the Dalitz- and t-plots – we will take advantage of the results of the angular distributions of the ejectile plane measured by the TOF collaboration [8].

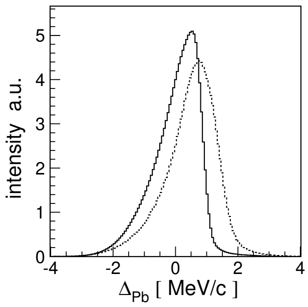

Figure 1: The dashed curve denotes the difference of the measured proton beam momentum distribution from its nominal value of 2.027 GeV averaged over the 10 days of the COSY running. The solid line shows the beam momentum distribution after the correction for the mean value of the beam momentum, determined in each 10 second intervals, was applied.

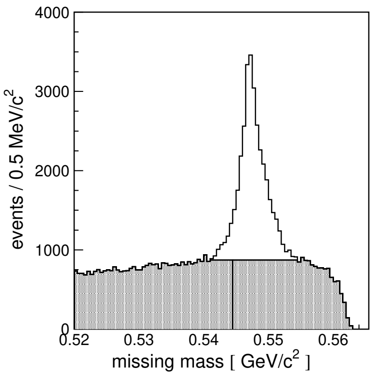

Figure 2: Missing mass distribution for the $pp \to ppX$ reaction determined by means of the COSY-11 detection system at a beam momentum of 2.027 GeV. A shaded area depicts the missing mass spectrum originating from the multi pion production. In order to guide the eye below the signal from the η meson production, the multi pion distribution is approximated by a straight line.

References:

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