Near threshold production mechanism of the η meson

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From precise measurements of the total cross sections of the η meson production in the $pp \to pp\eta$ reaction [1, 2, 3, 4, 5, 6, 7, 8] it was concluded that this process proceeds through the excitation of one of the protons to the $S_{11}(1535)$ state which subsequently deexcites via the emission of the η meson (see Fig. 1). In practice, within the meson exchange

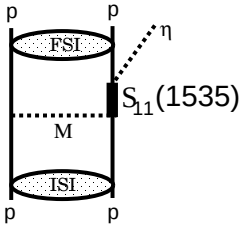

Fig. 1: The mechanism of the η meson production in nucleon-nucleon collisions. M denotes an intermediate pseudoscalar or vector meson, e.g. π, η, ω, ρ. ISI and FSI indicate initial and final state interaction between the nucleons.

picture, the excitation of the intermediate resonance can be induced by exchange of any of the pseudoscalar or vector ground state mesons between the nucleons. Based only on the excitation function it was, however, impossible to disentangle the contributions to the production process originating from the π, η, ω or ρ meson exchange.

More constraints to theoretical models [9, 10, 11, 12, 13, 14, 15, 16] have been deduced from the measurement of the isospin dependence of the total cross section by the WASA/PROMICE collaboration [17]. From the comparison of the η meson production in proton-proton and proton-neutron collisions it was inferred that the η meson is by a factor of twelve more copiously produced when the total isospin of the nucleons equals to zero with respect to the case when it equals to one. As a consequence only an isovector meson exchange is conceivable as being responsible for such a strong isospin dependence. It was a large step forward but still the relative contributions of the ρ and π mesons remained to be disentangled. For this purpose we have determined the analysing power for the $\vec{p}p \to pp\eta$ reaction since its theoretical value [11, 14] is sensitive to the assumption on the type of the meson being exchanged in order to excite one of the colliding nucleons to the $S_{11}(1535)$ state.

Measurements have been performed in the close-to-threshold region at beam momenta of p_{beam} = 2.010 and 2.085 GeV/c, corresponding to the excess energies of Q=10 and 36 MeV, respectively. The experimental method is presented elsewhere [18, 19], here we would only like to present the results of our measurements and the conclusions.

The values of analysing power determined for both excess energies are presented in Fig. 2. At the excess energy of Q = 36 MeV an insufficient statistics for the $\cos\theta_\eta \in (-1;-0.5)$ range resulted in an error larger than the allowed range of values and hence this point was omitted.

In order to verify the correctness of the models based on the dominance of the ρ or π meson exchanges, a χ^2 test has been performed [18, 19]. The reduced value of the χ^2 for the pseudoscalar meson exchange model was determined to be $\chi^2_{psc} = 0.54$, which corresponds to a significance level $\alpha_{psc} = 0.81$, whereas for the vector meson exchange model $\chi^2_{vec} = 2.76$, resulting in a significance level of $\alpha_{vec} = 0.006$. This result provides a strong evidence for the supposition that the production of the η mesons in nucleon-nucleon collision is dominated by the pion exchange.

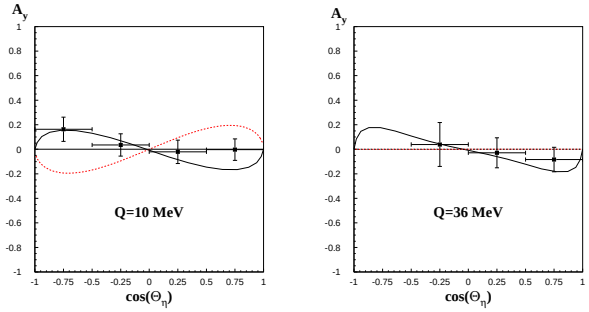

Fig. 2: Analysing powers for the $\vec{p}p \to pp\eta$ reaction as a function of the cosine of center-of-mass polar angle of the η meson for Q = 10 MeV (left panel) and Q = 36 MeV (right panel). Full lines are the predictions based on the pseudoscalar meson exchange model [14] whereas the dotted lines represent the results of the calculations based on the vector meson exchange [11]. In the right pannel the dotted line is consistent with zero. Error bars in this figure show the statistical uncertainties only.

One should, however, keep in mind that the interference in the exchange of both types of mesons are not excluded and should be studied theoretically and experimentally by the measurement of further spin observables.

It is also worth to mention that the analysing powers of the $\vec{p}p \to pp\eta$ reaction for both excess energies studied are consistent with zero within one standard deviation. This may suggest that the η meson is predominantly produced in the *s*-wave, an observation which is in agreement with the results of the analysing power measurements performed by the DISTO collaboration [20] where, interestingly, in the far-from-threshold energy region the A_y were found to be also consistent with zero within one standard deviation.

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