Investigation of the mechanism of the η meson production via the measurement of the $\vec{p}p \to pp\eta$ reaction

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There is a general consensus in theory that in NN collisions the η meson is being produced in a two-step process, where in the first stage pseudoscalar or vector mesons excites the S_{11} resonance which subsequently decays into the N η pair as presented in figure 1a. The $S_{11}(1535)$ resonance seems to play an important role as an intermediate state since it has a large width, covering the threshold energy for the $pp \to pp\eta$ reaction, and couples strongly to the Nη system with the branching ratio corresponding to 30-55 % [1].

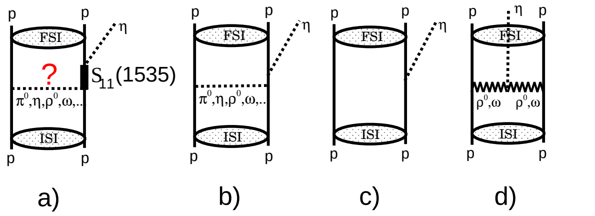

Fig. 1: Possible mechanisms of η meson production in NN collisions: (a) resonant current, (b) nucleonic currents, (c) direct production, (d) mesonic currents.

However, there are some ambiguities regarding the particular contributions from the individual mesons which are exchanged between nucleons. While the references [2, 3] the largest contribution is a virtual ρ meson exchange, the authors of [4] predict the highest amplitude for the π meson exchange. As shown in [5] the shape and the magnitude of the excitation curve close to threshold can be well reproduced by assuming π and η coupling to S_{11}. The interference between these two amplitudes was found to be destructive [5]. Astonishingly, the authors of the reference [6] found similar contributions from ρ and π mesons ($|M_\rho| \approx 1.5|M_\pi| \approx 2.1|M_\eta|$, close to threshold). They also claim that exchanges of mesons like σ, δ and ω are of less importance. More surprisingly, Vetter and colaborators [7] report almost the same contribution from ρ and ω mesons being the main contributions to the production amplitude. It is worth to mention that apart from the resonance currents different models take into account the production via some other mechanisms like nucleonic currents [6, 8, 9, 10] (figure 1b), direct production [8, 9] (figure 1c) or mesonic currents [10] (figure 1f). In ref [8] the main contribution to the η production amplitude results not from the S_{11} excitation, but strongly depends on the shorter range part of the nucleonic currents. There have also been trials to explain the η production mechanism on the basis of instanton models for QCD vacuum [11, 12].

In summary: a variety of models based on different assumptions concerning the mechanism of η production, show rather good agreement with existing data on close-to-threshold total cross sections for the $pp \to pp\eta$ reaction. The excitation function for the $pp \to pp\eta$ process can be equally likely decribed by the intermediate excitation of S_{11} via either pseudoscalar or vector mesons [10]. This implicates that more limitations have to be added to the models in order to extract the way the η meson is really being created. One solution would be a verification of the polarisation observables in terms of different models. At present there exist two models that predict the energy dependence of the proton analysing power for the $\vec{p}p \to pp\eta$ reaction [3, 10]. There are significant differences between the predictions visible in both: relative sign and the magnitude of the proton analysing power. Measurements of this observable might therefore serve in establishing the valid mechanism of η meson production.

So far measurements of the proton analysing power for the $\vec{p}p \to pp\eta$ reaction at three different excess energies: Q = 40 MeV (January '01), Q = 37 MeV (September '02) and Q = 10 MeV (April '03). The data taken during the tentative run have been analysed and published [13], whereas the data from the last two runs are being analysed. A preliminary missing mass spectrum for events with two identified protons in the exit channel, as obtained during the whole April '03 measurement is presented in figure 2. The red-dashed line is a preliminary estimated background which may be a subject to change and should be treated as a line to guide the eyes.

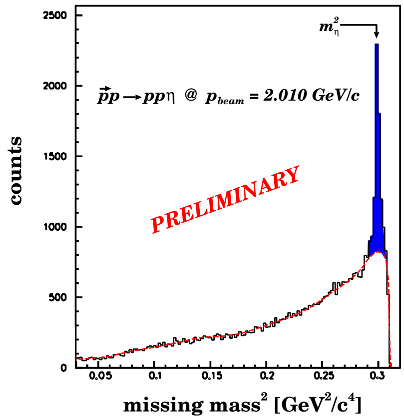

Fig. 2: Preliminary results of the missing mass spectrum as obtained during the April/May '03 run.

There are about 4000 η mesons in the peak above the background line. The polarisation of the proton beam has significantly increased from 50 % (January '01) up to 75 % (April '03). The luminosity integrated over the whole April's measurements exceeds by a factor of 1.5 the one from the measurement in 2001. All this facts together encourage us to predict that the accuracy of the last measurement should be about two times better than the one obtained in 2001.

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