Nonresonant $\pi^+\eta$ production in the reaction $\mathbf{pp \to dX}$ at $p_{\mathbf{lab}} = \mathbf{2.5 \div 3.8}$ GeV/c*

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An experiment on a_0^+-meson production in the reaction $pp \to da_0^+$ (1) decaying into $\pi^+\eta$ and $K^+\bar{K}^0$ is in preparation for the ANKE spectrometer [1]. In this report we present the results of our analyses of possible background from nonresonant $\pi^+\eta$ production in the reaction $pp \to d\pi^+\eta$ (2).

A rough estimate of the total cross section for the reaction $pp \to pn\pi^+\eta$ (3) can be obtained as follows: The ratio of η/π^0 production in pp- collisions is approximately $R = \sigma(pp\eta)/\sigma(pp\pi^0) \simeq 1/15 \div 1/20$ at 3.4 GeV/c. We assume that $\sigma(pn\eta\pi^+) = R \cdot \sigma(pn\pi^0\pi^+)$. Taking $\sigma(pn\pi^0\pi^+) \simeq 4$ mb we find that $\sigma(pn\eta\pi^+) \simeq 200 \div 250$ μb. The probability that the final p and n fuse into a deuteron was calculated using the coalescense model and found to be $\simeq 0.02$. This gives $\sigma(d\eta\pi^+) \simeq 0.02 \cdot \sigma(pn\pi^+\eta) \simeq 4 \div 5$ μb. However, this estimate is rather crude because it does not take into account spin-parity conservation arguments. As a matter of fact, the final system in reaction (2) cannot be in S-wave. Thus, near threshold the main contribution comes from the $d - (\pi^+\eta)$ P-wave.

A more realistic estimates can be obtained from the amplitude which is described by the diagram shown on the left side of Fig.1, where the η- and π-mesons are produced through one-pion exchange. The dominant intermediate state are the $\Delta(1232)$ (in the amplitude $\pi N \to \pi N$) and the $N^\star(1535)$ resonances (in the amplitude $\pi N \to \eta N$).

In [2] it was demonstrated that in the case of the reaction $pp \to N\Delta(1232)$ the pion-exchange amplitude is dominant. We analyzed this amplitude in order to fix the parameters for the $\Delta N\pi$ vertex. For a virtual pion in each vertex we introduce a form factor of monopole type with a cutoff parameter $\Lambda_\pi = 1 \div 1.3$ GeV/c. For the $\Delta N\pi$ vertex we also take into account the so-called barrier-penetration factor

$$F(|\mathbf{q}_{\pi N}|) = \frac{|\mathbf{q}_R|^2 + \kappa^2}{|\mathbf{q}_{\pi N}|^2 + \kappa^2}$$

which takes into account the dependence of the $\Delta\pi N$ coupling constant on the deviation of the relative pion-nucleon momentum $|\mathbf{q}_{\pi N}|$ in the Δ-isobar rest frame from the resonant value $|\mathbf{q}_R| = 0.227$ GeV/c. Using $\Lambda_{\pi NN} = 1$ GeV/c and $\kappa = 0.3$ GeV/c we obtain the $pp \to n\Delta^{++}$ cross section $\sigma_{pp\to n\Delta^{++}} \simeq$ 15 mb at $T_{\rm lab} = 0.8$ GeV which is in reasonable agreement with the value of 13.4 mb found in [2]. The $\pi N \to \eta N$ S-wave amplitude (which includes also the N(1535) contribution) was taken as in [3].

The result for the nonresonant contribution to the $pp \to d\pi^+\eta$ cross section as a function of the proton laboratory momentum is presented by the dashed curve 2a on the right side of Fig.1. To demonstrate the sensitivity of our prediction to the choice of the pion cut-off parameter we changed $\Lambda_{\pi NN}$ from 1 GeV/c to 1.3 GeV/c and obtained the dashed curve 2b. The solid curve shows the a_0 contribution to the $pp \to d\pi^+\eta$ cross section which was calculated using the $pp \to da_0^+$ total cross section from [4] multiplied by the factor 0.8 (branching ratio for the $\pi\eta$ decay mode of a_0). For the maximum energy at COSY $T_{\rm lab} = 2.6$ GeV ($p_{\rm lab} = 3.41$ GeV/c) the total cross section of the nonresonant $\pi^+\eta$ production can be estimated as $1.6 \div 3.3$ μb while the resonant contribution to the $pp \to da_0^+(\to \eta\pi^+)$ cross section at this energy is predicted to be ~ 1 μb. Our calculations of the $\pi^+\eta$ continuum background gives a much smaller cross section as compared with an estimate of [5]. This means that when the events from the reaction $pp \to d\pi^+\eta$ are selected, one can expect that a comparatively narrow a_0 contribution can be separated from the $\pi^+\eta$ continuum on missing-mass or Dalitz-plot distributions.

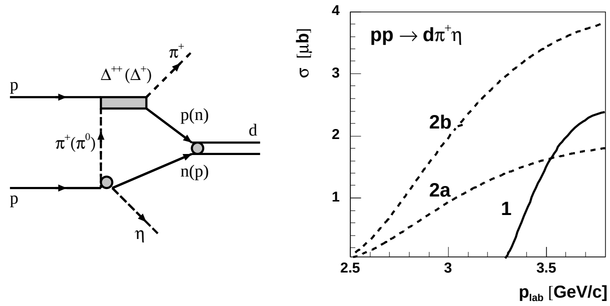

Figure 1: Left side: diagram describing the nonresonant $\pi^+\eta$ production in reaction (2); right side: total cross sections of reactions (1) (solid curve) and (2) (dashed curves) as functions of $p_{\rm lab}$.

References:

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