Investigation of the ^{3}Heη final state in polarized dp-collisions at ANKE

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Measurements at ANKE on the reaction $\mathrm{d} + \mathrm{p} \to {}^3\mathrm{He} + \eta$ close to the production threshold have yielded a rich and precise data set on total and differential cross sections [1]. The interpretation of these data indicated a very strong final state interaction (FSI) and the existence of a possible bound state of the ^{3}Heη system. With only unpolarised data, however, it is not possible to quantify possible contributions from the initial state such as angular momenta to the shape of the total cross section. In order to further investigate this situation, measurements with a polarized deuteron beam have been performed at ANKE covering the same excess energy range of Q = 0 MeV to 11 MeV.

Close to threshold there are two independent s-wave amplitudes for the $\vec{d} + \mathrm{p} \to {}^3\mathrm{He} + \eta$ reaction which can be thought of as spin-$\frac{3}{2}$ or spin-$\frac{1}{2}$ combinations of the dp spins coupled with L_{dp} = 1 to give the overall $J^P = \frac{1}{2}^-$ state. An alternative decomposition was given by Germond & Wilkin [3]

$$f = \bar{u}_{^3\mathrm{He}} \hat{p}_\mathrm{p} \cdot (A\vec{\epsilon}_\mathrm{d} + iB\vec{\epsilon}_\mathrm{d} \times \vec{\sigma}) u_\mathrm{p}. \qquad (1)$$

With these two amplitudes A and B the differential cross section can be expressed by:

$$\frac{d\sigma}{d\Omega} = \frac{1}{3}\frac{p_f}{p_i}\left[|A|^2 + 2\cdot|B|^2\right] \qquad (2)$$

From Eq. 2 it is obvious that, if the energy dependence of A and B differs from each other, which would indicate further effects than only final state interactions, the shape of the total cross section would be affected as well. In that case, the pure FSI ansatz presented in [1] would have to be expanded to account for the contributions from the different initial states. The moduli-squared of the two amplitudes A and B can be separated by the determination of the spherical tensor analysing power t_{20}:

$$t_{20} = \sqrt{2}\frac{|B|^2 - |A|^2}{|A|^2 + 2|B|^2} \qquad (3)$$

It can be shown that if A and B have the same energy dependence, which would be the case if the initial state does not influence the energy dependence of the excitation function, then t_{20} is expected to be independent of Q.

In order to determine t_{20} in collinear kinematics,

$$t_{20} = \frac{2\sqrt{2}}{p_{zz}} \cdot \left(\frac{\frac{d\sigma^0}{d\Omega}(\theta) - \frac{d\sigma^\uparrow}{d\Omega}(\theta)}{\frac{d\sigma^0}{d\Omega}(\theta)} \right) \qquad \theta = 0^\circ, 180^\circ, \quad (4)$$

the tensor polarization p_{zz} has to be known. For this purpose the *polarization export* was used where additional data below the η production threshold have been taken at a deuteron momentum $p_d = 2.435$ GeV/c. By the investigation of different reactions with known analysing powers it is possible to determine p_{zz}. One suitable reaction for the determination of p_{zz} is $\mathrm{d} + \mathrm{p} \to {}^3\mathrm{He} + \pi^0$ where the differential cross section for forward scattered ^{3}He particles depends only on p_{zz}:

$$\frac{d\sigma^\uparrow}{d\Omega}(\theta,\phi)/\frac{d\sigma^0}{d\Omega}(\phi) = 1 + \frac{1}{2}p_{zz}A_{yy} \qquad \theta = 0^\circ \qquad (5)$$

The diproton production $\mathrm{d} + \mathrm{p} \to (\mathrm{pp}) + \mathrm{n}$ is influenced by p_z and p_{zz}, though it was shown that the p_z part vanishes for small excitation energies of the diproton ($E_{pp} < 3$ MeV) [4].

$$\frac{d\sigma^\uparrow}{dt}(q,\phi)/\frac{d\sigma^0}{dt}(q) = 1 + \sqrt{3}p_z it_{11}(\theta)\cos\phi - \frac{1}{2\sqrt{2}}p_{zz}t_{20}(\theta) - \frac{\sqrt{3}}{2}p_{zz}t_{22}(\theta)\cos 2\phi \qquad (6)$$

After the determination of p_{zz}, missing mass spectra of $\mathrm{d} + \mathrm{p} \to {}^3\mathrm{He} + \eta$ are analysed to determine the ratio of differential cross section and by this t_{20}. Using the same background description as [1] yields clean signals of the η production (Fig. 1).

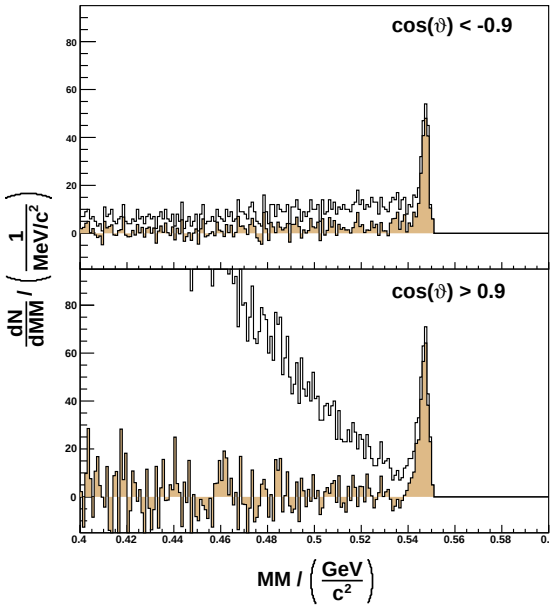

Fig. 1: Missing mass spectra for $\mathrm{d} + \mathrm{p} \to {}^3\mathrm{He} + \eta$ with the ^{3}He particles scattered in backward (upper frame) and in forward direction (lower frame).

The data on the ^{3}Heη production, which were obtained with a ramped COSY beam, are currently analysed for ten energy bins close to threshold with a bin width of 1 MeV each. To extract the tensor analysing power t_{20} for each of these energy bins, the ratio of the differential cross sections as well as the individual tensor polarizations p_{zz} are currently determined. Although still preliminary the t_{20} are found to be compatible with the data presented in [5]. Final results are expected to be available soon and will provide further information on the energy dependence of t_{20} in a broader excess energy range.

References:

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