Production of η-mesons in pn-collisions at ANKE *

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To study the possible formation of η-mesic nuclei the production of η-mesons was measured at ANKE via the quasi-free reaction $p + d \rightarrow d + \eta + p_{sp}$. In this case the deuteron is used as an effective neutron target while the proton acts as a spectator particle. Two different beam momenta ($p_1 = 2.09$ GeV/c and $p_2 = 2.25$ GeV/c) in combination with the Fermi motion inside the target deuteron allow to obtain total and differential cross sections in a region from threshold up to an excess energy of Q = 90 MeV (Fig. 1).
The course of the cross section, especially near threshold, will give access to information about the final state interaction ("FSI") between the η-meson and the deuteron.

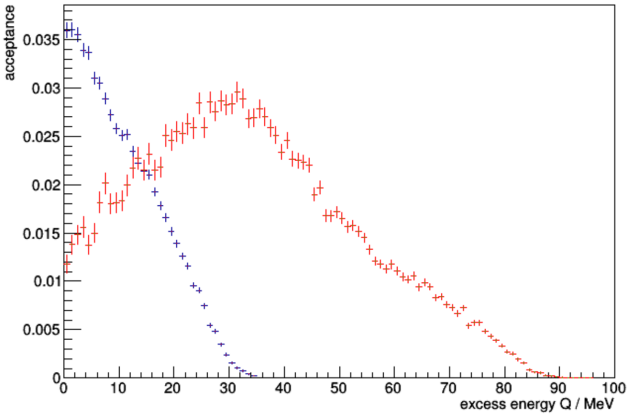

Fig. 1: Acceptance of the reaction $p + n \rightarrow d + \eta$ in blue for $p_1 = 2.09$ GeV/c and in red for $p_2 = 2.25$ GeV/c

For this two particle final state the cross section can be written as

$$\frac{d\sigma}{d\Omega} = \frac{p_f}{p_i} \cdot |f(\vartheta)|^2, \tag{1}$$

with the final/initial state momentum being p_f/p_i and the production amplitude f. This amplitude can be splitted into an energy independent amplitude f_{prod} and the final state interaction term FSI. It can then be rewritten as

$$|f(\vartheta)|^2 = |f_{\text{prod}}|^2 \cdot |\text{FSI}|^2 = \frac{|f_{\text{prod}}|^2}{|1 - iap_f|^2} \tag{2}$$

with the complex scattering length a, which describes the strength of the dη final state interaction [1]. Different to the final state interaction, which could vary strongly at threshold, the production amplitude is expected to expose only a weak energy dependence.
The identification of this reaction is achieved via the Missing Mass method. In order to do so, two particles in the final state have to be measured. The deuteron is detected in the forward system and identified by the energy loss [2] while the spectator proton in registered in one of two Silicon Tracking Telescopes.
To substract the multi-pion background, a method developed by the SPESIII Collaboration [3] is used [4] and the result is shown in Fig.2. The resulting count rates have to be corrected

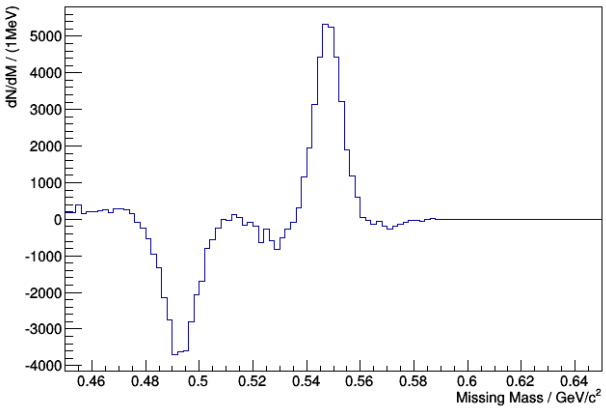

Fig. 2: Difference between the missing mass spectra for both beam momenta. The right, positive peak corresponds to the first beam energy, while the left, negative peaks is a result of the substraction of the events of the second beam energy.

for acceptance and Fermi motion inside the target deuteron as the latter causes different effective luminosities for every Q value. A preliminary analysis with unnormalized cross sections are shown in Fig.3. A fit to the data using Eq. 1 and 2 already describes the data nicely. However, in the final analysis further effects like finite beam energy smearing have to be considered. This is currently in progress.

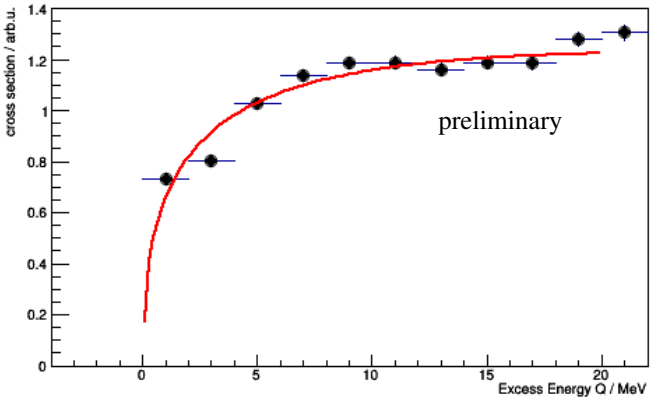

Fig. 3: Preliminary cross section of the reaction $p + n \rightarrow d + \eta$. In red the fit with Eq. 1 and 2 is shown.

In total, approximately 100k events of the reaction $p + n \rightarrow d + \eta$ have been gathered in agreement with expected count rates [5]. A preliminary scattering length could be determined via the course of the total cross section but the differential cross sections will be investigated to determine the limit for the s-wave FSI-ansatz. Additionally the calculation of the luminosity via elastic scattering is on its way to allow to value the total cross section.

References:

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