Identification of the reaction $\mathbf{p + d \rightarrow d + \eta + p_{sp}}$ *

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The reaction $\mathrm{p + d \rightarrow d + \eta + p_{sp}}$ was measured at the ANKE spectrometer to study the η-nucleus final state interaction (FSI) and to further investigate the question on the possible existence of η-mesic nuclei. Here, the deuteron is used as an effective neutron target with the proton being a spectator particle. The combination of the Fermi motion inside the target with two different beam momenta, $p_1 = 2.09$ GeV/c and $p_2 = 2.25$ GeV/c, allows to extract total and differential cross sections in a region from threshold up to an excess energy of Q = 90 MeV.

For the two-particle $\mathrm{p + n \rightarrow d + \eta}$reaction the cross section can be written as

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

with p_f and p_i being the center of mass final/initial state momentum and f the production amplitude. As long as there are no higher partial waves than s-wave, f can be rewritten as a constant term f_{prod} and a term describing the final state interaction between deuteron and η meson

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

with the complex scattering length a [1].To pin down the range in which this ansatz is valid the onset of higher partial waves has to be identified. Therefore differential cross sections will be determined to identify contributions different from pure s-wave.

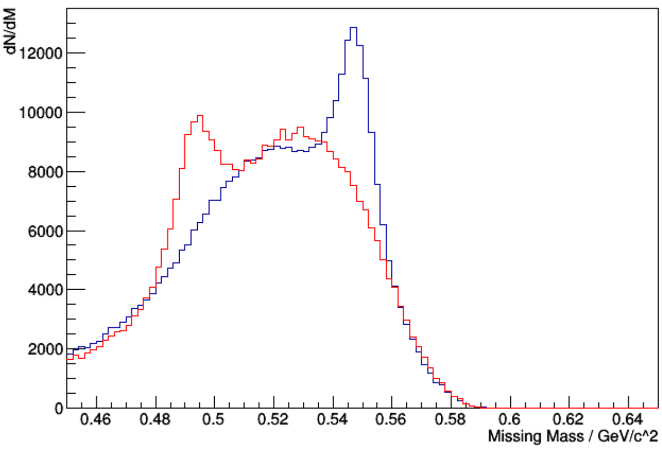

Fig. 1: Missing Mass for both used beam momenta ($p_1 = 2.09$ GeV/c in black and shifted for $p_2 = 2.25$ GeV/c in red) in an excess energy range from 0 MeV up to 5 MeV

As the influence of the FSI term is best seen near the production threshold, it is mandatory to extract a clean signal in its vicinity. To identify the reaction the missing mass technique is used with the spectator proton being detected in one of two Silicon Tracking Telescops ("STT") and the deuteron in the ANKE Forward System ("Fd system"). Due to the huge proton background in the Fd system, great importance was set on the clean separation of the protons and deuterons [2].

As the peak of the η meson is close to the kinematic limit near the threshold a creative solution for background description is necessary.
An elegant way to substract the multi-pion background was developed by the SPESIII Collaboration [3]. The data taken at the second beam energy are analysed as if they were taken at the other energy. By doing this the kinematic limits of both data sets are identical, but the peaks of the investigated reaction are shifted (Fig. 1).

The substraction of these two spectra results in a peak and a dip for the shifted data set (Fig. 2).

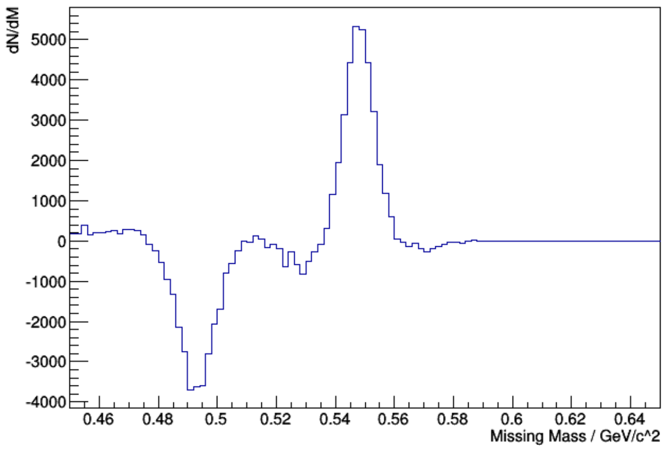

Fig. 2: Difference between the missing mass spectra for both beam momenta in an excess energy range from 0 MeV up to 5 MeV

This allows for a clean and model independent identification of the reaction $\mathrm{p+d \rightarrow d+\eta+p_{sp}}$ near threshold. First calculations show that the data are in agreement with the expected count rates. The further analysis of the data is in progress and results on the cross section will be available soon.

References:

[1] C. Wilkin et al., Phys. Lett. B 654, 92-96, 2007
[2] M. Rump et al., Annual report (2015)
[3] F. Hibou et al., Phys. Rev. Lett. 83, (1999) 492.

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