EPJ Web of Conferences **130**, 03008 (2016)
DOI: 10.1051/epjconf/201613003008
MESON 2016

Near threshold production of η-mesons in proton neutron collisions at ANKE

Daniel Schröer[1,⋆], Christopher Fritzsch[1], Alfons Khoukaz[1], and Marcel Rump[1]
for the ANKE Collaboration

[1] *Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Germany*

Abstract. The interaction between hadrons and η-mesons is an intensively studied topic. Due to its stength it might lead to the formation of η-mesic nuclei. In order to study the characteristics of this interaction a measurement of the reaction $p + d \to d + \eta + p_{\mathrm{sp}}$ has been performed at the ANKE spectrometer at the COSY accelerator of the Forschungszentrum Jülich. The two different beam momenta ($p_1 = 2.09\,\mathrm{GeV/c}$ and $p_2 = 2.25\,\mathrm{GeV/c}$) in combination with the Fermi motion inside the target deuteron grant access to the determination of total and differential cross sections in an excess energy range from threshold up to $Q = 90\,\mathrm{MeV}$. While the course of the total cross section, especially near threshold, will allow to extract the scattering length $a_{\mathrm{d}\eta}$ via an s-wave final state interaction ansatz, the differential cross sections permit to verify the legitimacy of the s-wave assumption.

1 Introduction

The ANKE spectrometer [1] at the accelerator facility COSY is very well suited for the production of light mesons. Particularly the interaction of η-mesons with hadrons is of special concern, as this might lead to the formation of η-mesic nuclei [2]. To search for such η-mesic nuclei there are principally two possibilities. The first way is to look for a decay signal below the production threshold. In this case the η-mesic nucleus would decay e.g. into a nucleus and a pion, which would influence the cross section of pion production, but up to now no clear sign has been encountered yet. The second approach is to examine the production above threshold, where a pole near threshold could cause a steeper rise in the cross section than expected from pure phase space behaviour.

The difference between pure phase space behaviour and the final state interaction ("FSI") effect for a two-particle final state can be described by an s-wave FSI-Ansatz

$$\frac{p_i}{p_f} \cdot \frac{d\sigma}{d\Omega} = |f|^2 = |f_s \cdot \mathrm{FSI}|^2 \tag{1}$$

with f_s being a constant production amplitude

$$\mathrm{FSI} = \frac{1}{1 - i \cdot a \cdot p_f + \frac{1}{2} r_0 a p_f^2} = \frac{1}{(1 - p_f/p_a)(1 - p_f/p_b)}, \tag{2}$$

⋆e-mail: d_schr13@uni-muenster.de

with p_f (p_i) being the final (initial) state momentum, a the scattering length and r_0 the effective range.

Investigations of the reaction $d + p \rightarrow {}^3He + \eta$ have shown a steep rise close to the threshold which could be described by a pole at $|Q_0| \approx 0.3$ MeV [3]. As the sign of this pole is not determined, further studies have to be undertaken. For this purpose the reaction $p + d \rightarrow d + \eta + p_{\mathrm{sp}}$ has been measured at ANKE.

2 The reaction $p + n \rightarrow d + \eta$

To measure the reaction $p+n \rightarrow d+\eta$ COSY provided a proton beam with momenta $p_1 = 2.09$ GeV/c and $p_2 = 2.25$ GeV/c while the cluster-jet target at ANKE produced a stream of deuterons, which served as an effective neutron target with the proton being a spectator particle. This combination allows to investigate the cross section and thence the FSI in an excess energy range from threshold up to $Q = 90$ MeV. The impact of the FSI is strongest in the vicinity of the threshold so that it is essential to extract a clean signal at low Q-values.

The reaction is identified via the missing mass method. For this purpose both the deuteron and proton have to be reconstructed. Two Silicon Tracking Telescopes ("STT"), placed near the interaction point, are used for the detection of the spectator proton while the deuteron is observed in the Forward system ("Fd") (Fig. 1). As there is a huge proton background, great emphasis was placed on the clean separation between protons and deuterons [4]. Since near threshold the peak in the missing

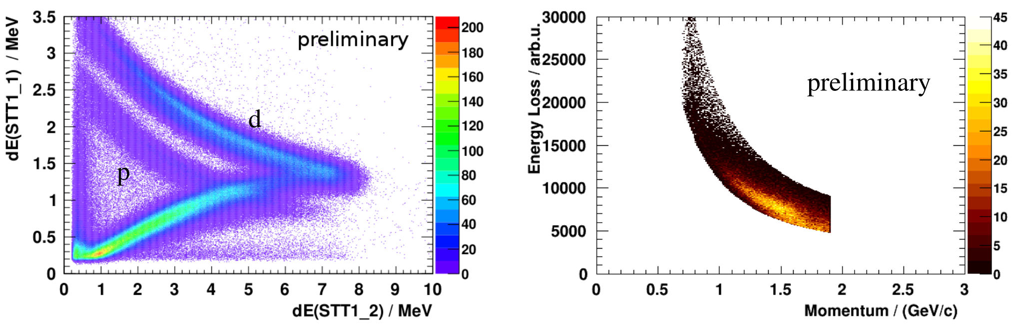

Figure 1. Left: Energy loss in first layer vs energy loss in second layer of one STT; right: Energy Loss in Fd Counter vs momentum of incident particle with cut on deuterons.

mass spectrum is close to the kinematical limit an elegant description of the multi-pion background is mandatory. For this goal the data taken at the second beam energy analyzed as if they happened at the the first one. This results in a shift of the recorded events so that the kinematical limits are at the same position, whereas the η-peaks are separated. If both spectra are scaled accordingly and subtracted a dip (peak) for the (un-)shifted data sets can be seen (Fig. 2).

The resulting count rates have to be corrected for acceptance and the Fermi motion inside the deuteron as the latter results in different effective luminosities for each Q value. Both has been achieved by executing Monte-Carlo simulations. The resulting, unnormalized cross sections are shown in Fig. 3. A fit with Eq. 1 shows a scattering length of $|a_{\mathrm{d}\eta}| \approx 1.2$ fm.

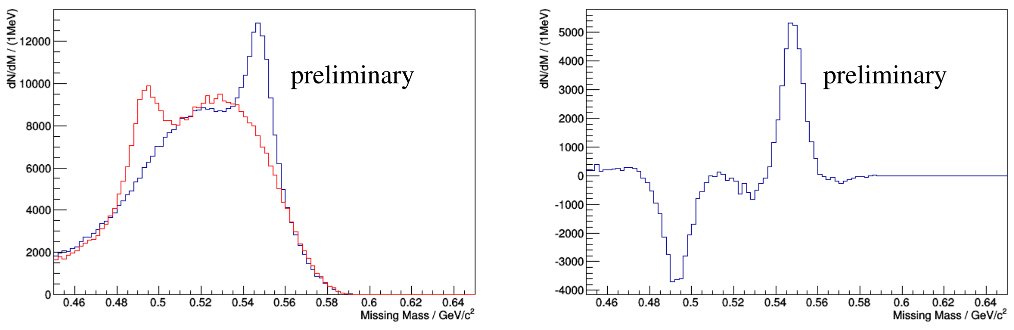

Figure 2. Left: Missing mass for both beam momenta (p_1 = 2.09 GeV/c in black and shifted for p_2 = 2.25 GeV/c in red); right: Difference between the missing mass spectra for both beam momenta.

3 Summary and outlook

Approximately 100k events of the reaction $p + n \to d + \eta$ have been gathered at ANKE. By detecting and reconstructing the deuteron and the spectator proton a clean signal can be seen in missing mass spectra. 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 is on its way to allow to value the total cross section.

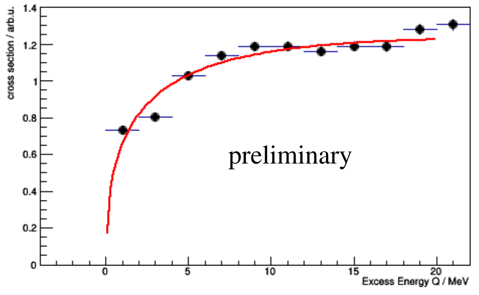

Figure 3. Cross section of the reaction $p + n \to d + \eta$. In red the fit with Eq. 1 is shown.

Acknowledgements

The support from COSY-FFE grants is kindly acknowledged.

References

[1] S. Barsov *et al.*, Nuclear Inst. and Methods in Physics Research A **462**, 364 - 381 (2001)
[2] Q. Haider and L.C. Liu, Phys. Lett. B **172**, 257 (1986)
[3] T. Mersmann *et al.*, Phys. Rev. Letters **98**, 242301 (2007)
[4] M. Rump, bachelor thesis, Westfälische Wilhelms-Universität Münster, Germany, 2013