The quasi-free reaction $p + d \rightarrow d + \eta + p_{sp}$ close to threshold at ANKE*

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Recently the reaction $p + d \rightarrow d + \eta + p_{sp}$ was measured near the production threshold at ANKE in order to extract total and differential cross sections [1]. Based on these information the dη scattering length $a_{d\eta}$ will be measured which will shed new light on the examination of mesic nuclei.
For this purpose two beam momenta ($p_{beam} = 2.09$ GeV/c and $p_{beam} = 2.25$ GeV/c) have been used. The deuteron target is used as an effective neutron target with a spectator proton. Because of the Fermi-motion of the nucleons inside the target-deuteron these data allow to investigate the cross section in an excess energy range from 0 MeV up to 100 MeV.
As the reconstruction of the η meson in this reaction will be achieved via the missing mass method, it is important to clearly identify the spectator proton in the Silicon Tracking Telescopes (STT) and the deuteron in the ANKE Forward system (Fd).
A particle hit in the Fd detector is selected using energy loss (ΔE) versus momentum (p) plots. In the case of the deuteron this task is very challenging because the proton and deuteron bands are located very close together (Fig. 1 (left)). This can also be seen in the projection of $\Delta E \cdot \beta^2$ (Fig. 1 (right)) with the relativistic velocity β. In this case there is a huge proton peak with a small deuteron shoulder at the right tail so that a clean deuteron identification is difficult. To improve the situation two complementary methods are applied.
If one investigates the energy loss in a Fd counter as a function of the y-momentum of the detected particle it is obvious that the energy loss is not constant (Fig. 2). This is caused by two effects. First, the particle has to pass a larger distance in the hodoscope if the y-momentum is higher. Secondly, there are two energy loss measurements for each counter of the Fd system, one at the top and one at the bottom and they have to be calibrated accordingly. The energy loss in each counter can be described by a second order polynomial. After the correction with this function the energy loss is independent of the y-momentum and the proton and the deuteron bands are significantly narrower.

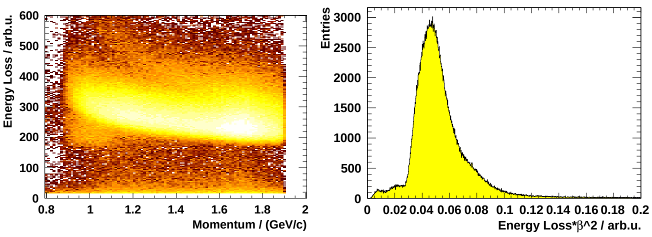

Fig. 1: Energy loss versus momentum (left) in the Fd system before applying cuts on the time-of-flight and before correcting for the y-momentum. A broad proton band and a deuteron band on top of it is visible. Associated $\Delta E \cdot \beta^2$-spectrum (right) with a dominating proton peak and a small deuteron shoulder on the right hand tail.

Additionally, a special trigger, combining the Positive (Pd) and the Fd system, was used during the beam time. By de-

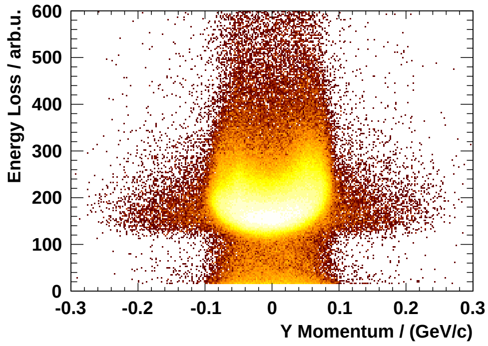

Fig. 2: Energy loss versus the y-momentum of the measured particles in one counter of the Forward system.

tecting a π^+ in the Pd detector, which can be identified easily via the low energy loss compared to protons, and another particle in the Fd system, one can compute the Time-of-Flight (ToF) difference of these two particles and distinguish between protons and deuterons in the Fd detector. The results of this method are shown in Fig. 3. A deuteron band in the ΔE-vs-p-spectrum is clearly visible (left) and enables a separation in the $\Delta E \cdot \beta^2$-spectrum (right), where a deuteron peak can be identified so that deuterons can be selected by cutting on this peak [2].
The cut parameters, obtained in this way, can be used for the following analysis and will allow to reduce the proton background in the reaction $p + d \rightarrow d + \eta + p_{sp}$ drastically. The further analysis of the data is in progress with the next step being the identification and reconstruction of the spectator protons in the Silicon Tracking Telescopes.

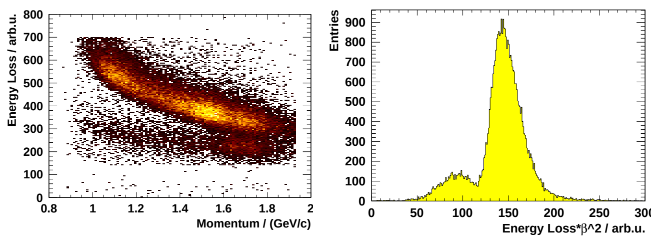

Fig. 3: Energy loss versus momentum (left) in the Fd system after applying ToF-cuts. The deuterons (upper band) are clearly visible while the protons are suppressed. $\Delta E \cdot \beta^2$-spectrum (right) in the Fd system with ToF-cuts resulting in a clean deuteron peak with a few remaining protons at the left hand tail.

References:

[1] A. Khoukaz et al, Measurement of the quasi-free $pn \rightarrow d\eta$ cross section at ANKE, 2012 , http://www2.fz-juelich.de/ikp/anke/en/proposals.shtml

[2] M. Rump, bachelor thesis, 2013, Westfälische Wilhelms-Universität Münster

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