Identification of the quasi-free reaction $\mathbf{p + d \to d + \eta + p_{sp}}$ *

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In order to further investigate the η-nucleus final state interaction (FSI) and the question on η-mesic nuclei the reaction $p + d \to d + \eta + p_{sp}$ was measured at the ANKE spectrometer. The deuteron acts in this case as an effective neutron target with the proton being a spectator particle. By using two different beam momenta, $p_{beam} = 2.09\,$GeV/c and $p_{beam} = 2.25\,$GeV/c, the Fermi motion inside the target allows to extract total and differential cross sections in a region from threshold up to an excess energy of Q=100 MeV.
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 cnter of mass final/initial state momentum and f the production amplitude. Assuming there are no higher partial waves than s-wave, this amplitude can be separated in a constant term f_{prod} and a term describing the final state interaction between deuteron and η meson

$$\mathrm{FSI} = \frac{1}{1 - iap_f} \tag{2}$$

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 resolve the first deviation from a flat scattering angle distribution in $\cos\vartheta$.

To achieve all of this precise measurement and identification of the deuteron and the spectator proton has to be ensured.
The proton is detected in one of two Silicon Tracking Telescopes ("STT") [2]. One STT, consisting of three layers of silicon, is placed at each side of the target in a distance of 2.8 cm.

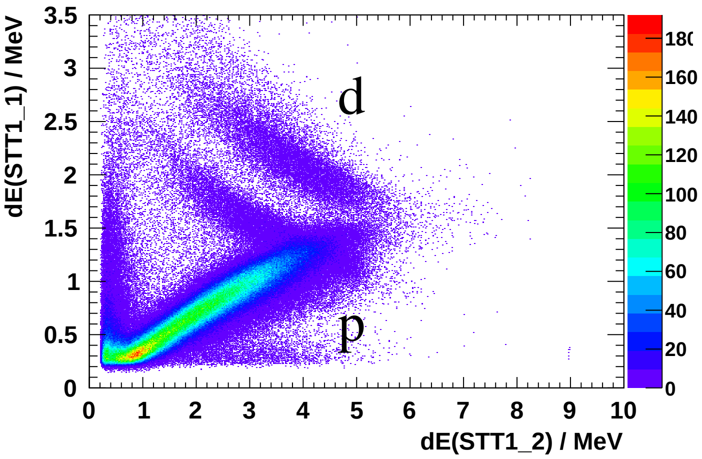

Fig. 1: Energy loss in the first layer as a function of the energy loss in the second layer in one of the two STTs for one run. Well separated proton and deuteron bands can be seen.

Here one hit is demanded in the first two STT layers. This request results in an energy range for the spectator particles from 2.5 MeV up to 8 MeV which assures that observed protons originate only from spectator reactions. The separation of protons and deuterons, mainly from elastic scattering, is obtained by comparing the energy losses in the first to layers, where clean deuteron and proton bands are visible (Fig. 1).

The identification of the deuterons is more challenging due to a huge proton background. It is detected in the ANKE Forward System ("Fd system") and selected via the energy loss information in the scintillator hodoscopes. As the energy loss of deuterons and protons is very similar in this momentum region the determination of cut values is demanding.
For this reason a special trigger was used during the beam time slecting events with a particle in the Fd system and a pion in the positive system. By applying cuts on the Time-of-Flight difference between the pions and the particle in the Fd system the proton background can be suppressed, so that the deuteron band becomes visible.This technique allows a precise determination of energy loss cuts for the deuteron.

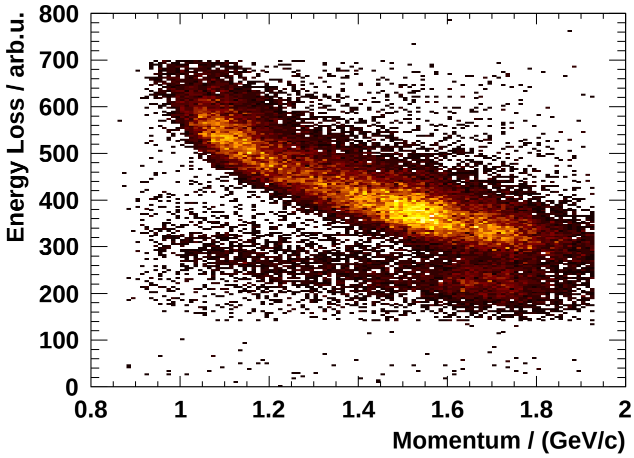

Fig. 2: Energy loss versus momentum in the Fd system after applying ToF cuts on the reaction $p + d \to d + \pi^+ + n_{sp}$. The deuterons (upper band) are clearly visible while the protons (lower band) are suppressed.

With both particles, proton and deuteron, the reaction $p + d \to d + \eta + p_{sp}$ can be identified via the missing mass and first results on the cross section will be available soon.

References:

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