Identification of deuterons in $p + d \to d + X$ reactions *

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The interaction between η mesons and hadrons is an intensively investigated topic. In order to get further insights and to study the production mechanism of η mesons a measurement of the reaction pd → dηp$_{sp}$ near threshold has been performed at ANKE [1]. Here the deuteron acts as an effective neutron target while the proton is handled as a spectator particle. The Fermi motion of these particles combined with the two different beam momenta (p_1 = 2.09 GeV/c and p_2 = 2.25 GeV/c) allow to study the reaction on a wide excess energy range from threshold up to 90 MeV.

The reconstruction of the η mesons will be accomplished via the missing mass method. Therefore clearly identifying the proton and the deuteron is an essential part of the procedure. The spectator protons are detected in one of two Silicon Tracking Telescopes ("STT") [2] and can be selected with an almost negligible background from, e.g., deuterons [3].
Contrary, due to a dominant proton background, the identification of the deuterons in the ANKE Forward system (Fd) via the energy loss is more challenging. In ΔE-p spectra the proton and deuteron bands are located very close to each other (Fig. 1 (left)). This is also shown in the projection $\Delta E \cdot \beta^2$ (Fig. 1 (right)) with the relativistic velocity β, where the deuterons appear as a small shoulder on the right tail of the dominant proton peak. As a first step the energy loss in each Fd counter was then calibrated based on Monte Carlo simulations.

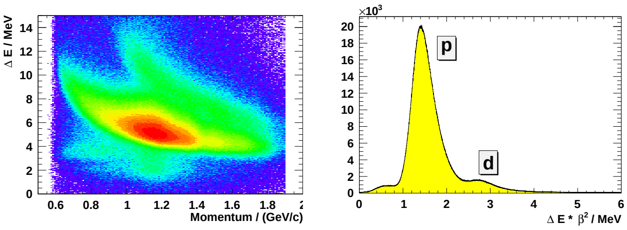

Fig. 1: Left: Energy loss ΔE versus momentum p in the Fd system. The proton band and a deuteron band on top of it are clearly visible. Right: $\Delta E \cdot \beta^2$-spectrum (right) with a dominant proton peak and a small deuteron shoulder on the right-hand side.

In order to allow careful studies on particle identification, an additional trigger was installed during the beam time, combining the Positive detector system (Pd) and the Fd system. By simultaneously detecting a π^+ in the Pd system and another particle in the Fd system one can distinguish protons from deuterons by comparing the Time-of-Flight (ToF) difference between these two particles. The π^+ can be easily identified because of its low energy loss compared to protons. Due to the significant ToF difference the deuteron and proton bands are clearly separated as shown in Fig. 2.
By applying an optimized cut in Fig.2 it is possible to investigate $\Delta E \cdot \beta^2$ spectra individually for deuterons and protons, as can be seen in Fig.3. With this information final

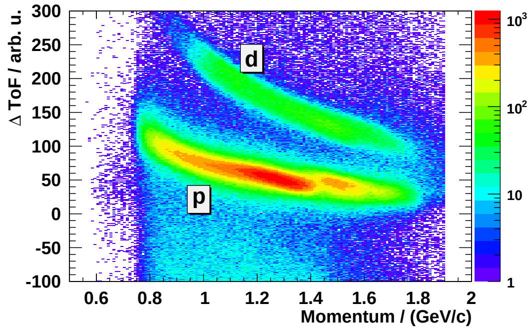

Fig. 2: Time-of-Flight (ToF) difference of the π^+ hit and another particle detected in the Fd system versus the momentum of this particle for one combination of Fd and Pd counter elements. The deuteron band is clearly separated from the proton band.

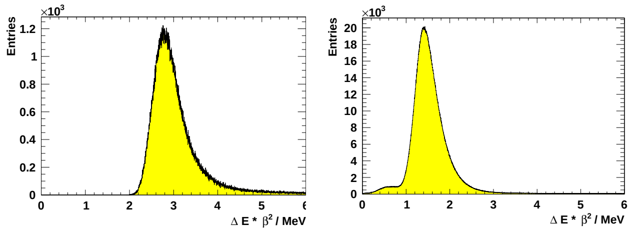

Fig. 3: Left: $\Delta E \cdot \beta^2$-spectrum of the extracted deuteron signal by applying the Time-of-Flight method. Right: Remaining proton background.

cuts will be identified to reduce the proton background in the reaction pd → dηp$_{sp}$ drastically.
Moreover, this method can also be used to identify other reactions that can be studied with the same dataset, e.g. pd → d$\pi^+\pi^-$p$_{sp}$. The wide excess energy range allows to study the low and high-mass enhancement in isoscalar $M_{\pi\pi}$ spectra corresponding to the ABC effect as well as total and differential cross sections [4]. The analysis of this reaction is in progress and first results will be available soon.

References:

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