**Investigation of the $^3$He $\eta$ Final State in dp-Reactions at ANKE***

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The existence of $\eta$-mesic nuclei is still an open issue of research. To investigate the possibility of the formation of such bound systems, production measurements with one $\eta$ meson and one light nucleus in the final state are of great interest. By studying the final state interaction at low excess energies, information about the scattering length of the $\eta$-nucleus system can be gained. The latter one is closely related to the properties of such a possible bound state and has to be determined with high precision. The available data sets in the close vicinity of the threshold expose discrepancies, which currently forbid the extraction of scattering length information with sufficient precision [1].

Therefore, the reaction d+p$\rightarrow$$^3$He+$\eta$ has been investigated at the ANKE spectrometer using a continuously ramped accelerator beam at excess energies ranging from below threshold at Q = -4 MeV up to Q = +12 MeV. Additionally, data at excess energies of Q = 20, 40 and 60 MeV have been recorded in order to determine total cross sections and to investigate contributions from higher partial waves [2].

For the analysis of the continuous ramp all data was sorted by the time information in the ramp. A twelve seconds wide interval with an average excess energy Q = 11.35 MeV was picked out to be presented in this report. The resulting width of the excess energy interval is 0.70 MeV.

To search for the events of the reaction channel of interest the $^3$He nuclei are selected using the ANKE forward detector. The production of $\eta$-mesons is identified via the missing mass technique. For the reconstruction of the momenta via the magnetic spectrometer the information of the three drift- and multi-wire proportional chambers are used.

The particle identification is achieved by an energy loss versus momentum plot ($\Delta$E/p) for three segmented scintillation walls, two of the forward system and an additional side wall frame of the positive detector placed behind the forward system. A simultaneous cut on the expected region for $^3$He nuclei in the ($\Delta$E/p) plot in the three scintillation walls allows for a clear identification of the $^3$He band. In figure 1b) and c) this plot including the cut is presented for the first and second forward scintillation wall. In the region of 2.6 GeV/c events of the $^3$He $\eta$-production are visible, at 3.2 GeV/c a maximum resulting from events of the two pion production and at 3.4 GeV/c from $^3$He $\pi^0$ can be observed.

The reactions can be identified by plotting the transversal versus the longitudinal reconstructed center of mass (CMS) momenta as shown in figure 1a). For a reaction with two particles in the exit channel one expects a momentum ellipse with a fixed radius. The calculated momentum ellipses of the channels $^3$He $\eta$ and $^3$He $\pi^0$ and the kinematical limit for the two pion production are sketched in the plot. Due to the fact that the density of events on an ellipse for events distributed according to phase space is proportional to the transversal momentum, the plot was filled with the reciprocal value of the transversal momentum as an event weight.

In the near threshold region the CMS-momenta of the $^3$He nuclei are small. Due to this fact the scattering angles $\vartheta^{LS}$ for the $^3$He nuclei after the Lorentz transformation into the laboratory system are small and all $^3$He nuclei of the reaction channel of interest are in the geometrical acceptance of the

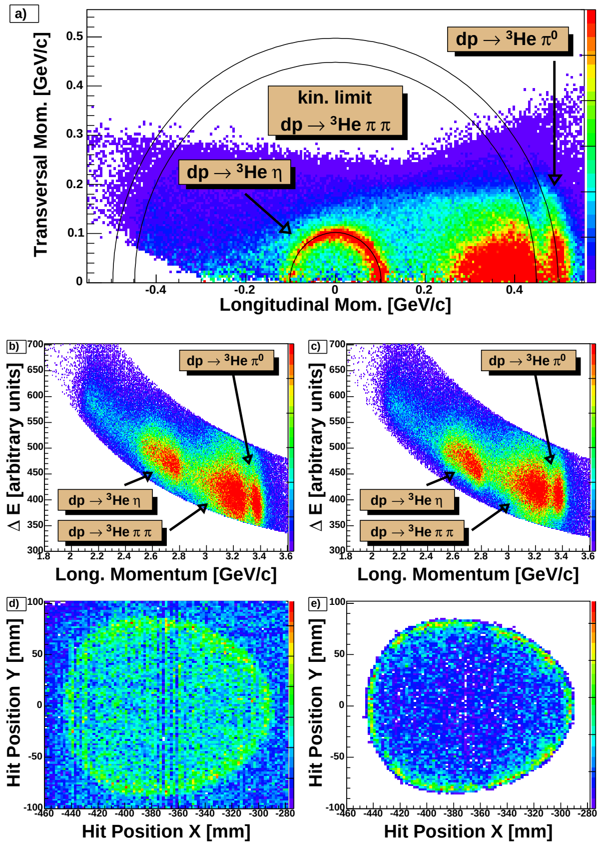


Fig. 1: Preliminary results of the analysis at an average excess energy of Q = 11.35 MeV (timing interval 265 s to 277 s of the continuous ramp)
a) $^3$He momentum plot to identify CMS momentum ellipses (filled with the reciprocal value of the transversal momentum as event weight).
b), c) ($\Delta$E/p) plot for the first and second scintillation walls (pre-cut on both walls).
d), e) Hit Position of $^3$He nuclei in the drift chamber system for data (left hand side) and simulations (right hand side) of the reaction d+p$\rightarrow$$^3$He+$\eta$.

wire chambers of the forward system. For this reason the dp kinematic was used for the beamtime, leading to a full geometrical acceptance in the wire chambers up to an excess energy of 20 MeV. The result is a characteristic image of the hit position in all chambers. In figure 1d) and e) a plot of the hit position of $^3$He nuclei in ANKE coordinates for the measured data and for Geant4 simulations is shown.

The identification of the $\eta$ events is done using the missing mass distribution shown in figure 2a). The challenge of the extraction of the $\eta$ peak from the background near the kinematical limit can impressively be met by using subthreshold data as it was done in [3]. The background reactions, namely the multi pion production and misidentified protons from breakup reactions, have a high excess energy and vary only slowly with the excess energy for the $\eta$-production. Subthreshold data of the continuous ramp analysed with the same kinematical conditions as the analysed data are expected to

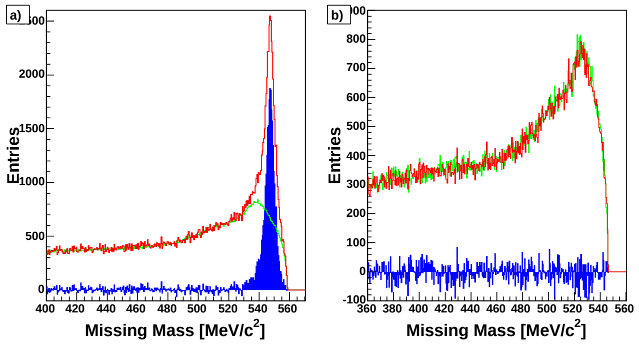


Fig. 2: a) Preliminary missing mass distribution (red line) at an excess energy of Q = 11.35 MeV, the scaled background description (green line) using subthreshold data of the first eighty seconds of the ramp and the background subtracted distribution resulting in a clean η peak (filled histogram).
b) Comparison of the data of the time interval 0 s < t < 10 s of the continuous ramp (Q = -4.4 MeV, green line) with the one of 70 s < t < 80 s (Q = -0.3 MeV, red line) and the difference (blue filled histogram). All events were analysed assuming the same beam momentum.

give a good description of the background behaviour.
The data of the choosen excess energy interval and the subthreshold data were analysed with an expected fixed beam momentum of 3.1865 GeV/c corresponding to the average excess energy Q = 11.35 MeV. The reconstructed $^3$He momenta were scaled to the same conditions. In figure 2a) the red line shows the resulting missing mass distribution of the data at Q = 11.35 MeV and the green one of the subthreshold data scaled to the red line. The difference, plotted as the filled histogram, corresponds to pure η production.
A check of the method to describe the background is possible by the comparison of the data of the time interval 0 s < t < 10 s corresponding to an average excess energy Q = -4.4 MeV (green line) with the one of 70 s < t < 80 s near threshold at Q = -0.3 MeV (red line) in figure 2b). The difference of the scaled curves (blue filled histogram) vanish, therefore the shape of the background does not vary within the first eighty seconds of the ramp. Thus it can be assumed that this behaviour does not change for the following 180 seconds.
To get angular distributions for the emitted $^3$He nuclei in the CMS, the missing mass technique is used for different $\cos(\vartheta)^{CMS}$ bins. The background description method is similar and preliminary results are plotted in figure 3.
The resolution of the momentum reconstruction for the $^3$He nuclei limits the possible binning for angular spectra. A $\cos(\vartheta)^{CMS}$ dependent analysis of the width of the CMS momentum peak for the η-production can be used to determine the transversal and longitudinal resolution.
The current results of the analysis show that the goals of the proposal [2], the investigation of the near threshold region up to intermediate excess energys and extraction of angular distributions, can be realised with complete satisfaction. A data sample with low statistical and systematical errors will help to extract information about the scattering length with high precision and will contibute to the open question about the existence of η-mesic $^3$He nuclei.

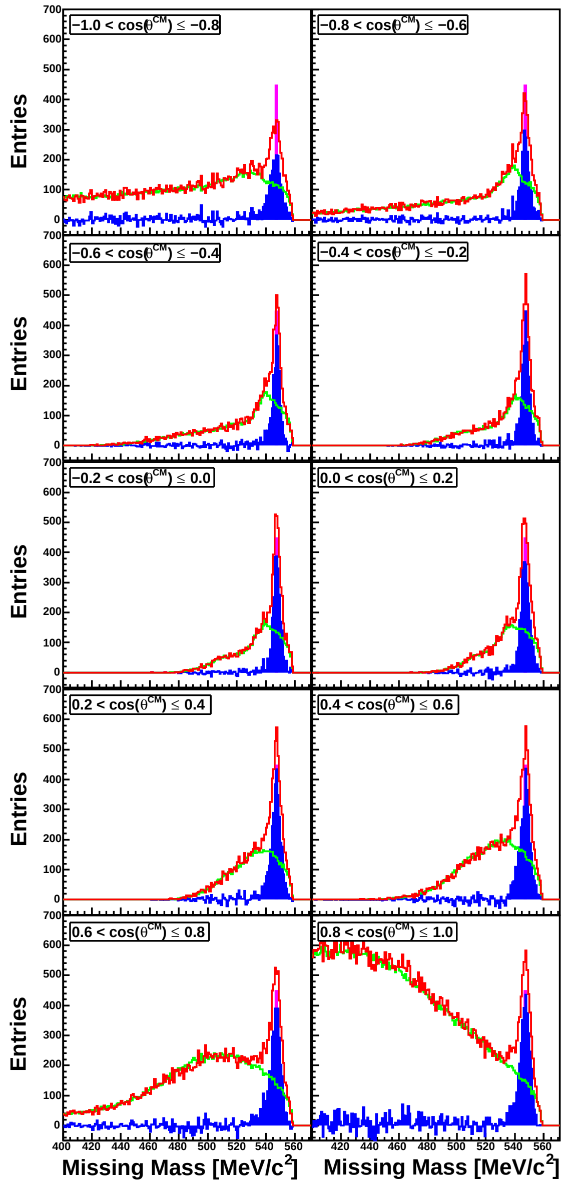


Fig. 3: Preliminary missing mass plots (red line) in $\cos(\vartheta)$ dependence to extract an angular distribution at an excess energy of Q = 11.35 MeV. The background description (green line) and the subtracted η signal (blue filled histogram) are added.

**References:**


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