Measurement of the reaction dd $\to$ ^{4}Heη close to threshold at ANKE[a]

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During the last years the question whether the ηN interaction allows the formation of η-nucleus bound states has been widely discussed. One indication favoring these types of models is the strong threshold enhancement of the production amplitudes in the reactions dd $\to$ ^{4}Heη and pd $\to$ ^{3}Heη. Since the existing data do not provide precise information on differential cross sections, in both cases it has to be assumed that close to threshold ($p_\eta^{\mathrm{cm}} < 100\,\mathrm{MeV/c}$) only s-wave contributes. For pd $\to$ ^{3}Heη angular distributions have been measured and limits on the slope compatible with s-wave have been extracted [1]. However, the total cross sections are not consistent with other data sets with respect to the shape and absolute normalization of the excitation function [2]. For dd $\to$ ^{4}Heη only data on total cross sections are available [3, 4]. In addition, data for higher Q values are missing, which could provide some information on the onset of the p-wave and, thus, be used to study the production mechanism.

The experimental program at ANKE for dd $\to$ ^{4}Heη covers the two latter aspects. In 2003, two periods of beam time have been taken: the first one in January measuring at beam momenta of 2.330 GeV/c, 2.343 GeV/c and 2.358 GeV/c (corresponding to excess energies of $Q =$ -2 MeV, 2.5 MeV and 7.5 MeV, respectively) and the second in November at 2.4 GeV/c and 2.46 GeV/c ($Q = 22$ MeV, 43 MeV).

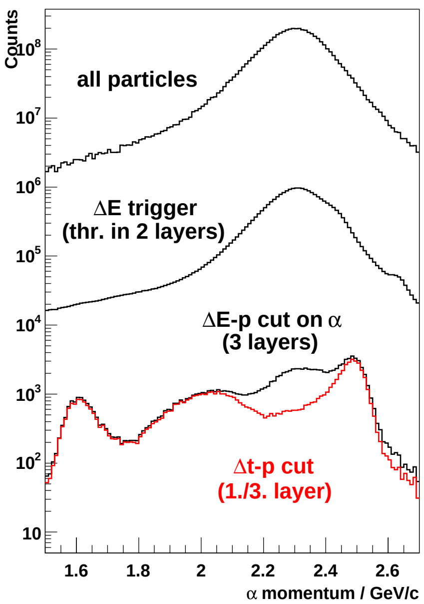

Fig. 1: ^{4}He identification by means of energy-loss (ΔE) and time-of-flight (Δt) versus momentum (p) cuts in three scintillation layers. The final spectrum (lowest curve) is nearly background free.

For the run in January the multi-wire proportional chambers of the ANKE forward system have been replaced by a set of drift chambers [5] previously used at COSY-11 and GEM [6]. In addition, the two hodoscope layers were supplemented by one of the so-called sidewall hodoscope layers in order to improve the particle discrimination by energy loss. To illustrate the identification capabilities for ^{4}He Fig. 1 shows the momentum spectrum of the particles selected at various trigger/analysis stages. The full distribution (taken with minimum bias trigger) is dominated by protons with half the beam momentum originating mainly from any quasi-free reaction on the neutron of the beam deuteron. The main trigger (for data taking) was supplied by analog integrators setting a threshold for the sum of charge from the upper and lower photomultiplier of each counter of the forward hodoscope. This reduces the trigger rate to a level that could be handled by the data acquisition. Further reduction of the background was done off-line by applying two-dimensional cuts in $\Delta E - p$ and $\Delta t - p$ for the individual layers. Finally a reduction factor of 10^5 was achieved. The resulting inclusive momentum spectrum for ^{4}He
(Fig. 1, lowest curve) reveals the structure as measured earlier [7]. In Fig. 2 the missing mass spectra for the two beam momenta above threshold are presented. The two upper figures show the measured spectra together with the estimated background from the data set taken below threshold (shaded area). This estimation was done (i) by doing an event-by-event transformation with respect to the maximum ^{4}He momentum in the c.m. system to match the kinematics and phase space and (ii) by normalizing the spectra with respect to luminosity and acceptance in the peak region. The latter was done by adjusting the height in the transverse-momentum spectrum outside the region for η production. The lower figures show the background-subtracted and fitted signal. The width is in agreement with the expectation based on simulations. Final cross sections and angular distributions will be available within the next few months. The analysis of the run in November 2003 has just started.

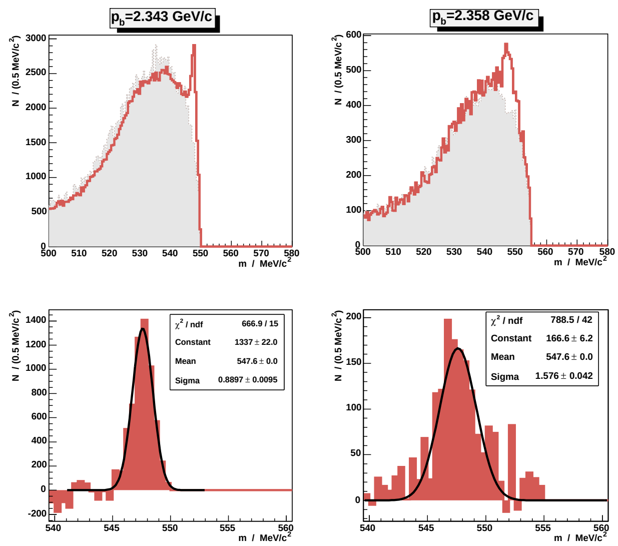

Fig. 2: Missing mass spectra for $p_d = 2.343\mathrm{GeV/c}$ (left) and $p_d = 2.358\mathrm{GeV/c}$ (right). The In the lower figures the background (shaded areas in in the upper plots) are subtracted.

References:

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[a] supported by EU

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