Near threshold η production in $dd \to {}^4He\eta$

S.Dymov[3], V.Hejny[1], V.Komarov[3], A.Kulikov[3], A.Magiera[2], R.Schleichert[1], H.Ströher[1], C.Wilkin[4], A.Wrońska[1,2]

for the ANKE collaboration

[1]Forschungszentrum Jülich, Institut für Kernphysik, 52425 Jülich, Germany
[2]Institute of Physics, Jagiellonian University, 30059 Cracow, Poland
[3]Joint Institute of Nuclear Research, 141980 Dubna, Russia
[4]University College London, London, WC1E 6BT, UK

Spokesperson: A.Wrońska*

25th March 2003

*EMail: A.Wronska@fz-juelich.de

Abstract:

We ask for allocation of one week of beam time in autumn 2003 to study the reaction dd $\rightarrow {}^4\mathrm{He}\eta$ at $p_d = 2.4$ GeV/c and 2.5GeV/c in order to extract total and differential cross sections. The experimental program was presented as proposal #107 at PAC session #24 and in total two weeks of beam time have been granted. The first week was taken beginning of this year and used to take data at three excess energies close to threshold: -2.0 MeV, 3.2 MeV and 8.3 MeV. The course of the measurement as well as the current status of the analysis are presented here.

1 Recent beam time in January 2003

End of January 2003 the first part of the experimental program was conducted. Following the schedule presented in the proposal [1] measurements at beam momenta of 2.330 GeV/c, 2.345 GeV/c and 2.360 GeV/c (corresponding to Q values of -2 MeV, 3.2 MeV and 8.3 MeV, respectively) have been performed. While the main focus was set on the beam momentum of 2.345 GeV/c, the other two momenta were meant as auxiliary measurements: one below threshold for background studies and one at higher energies to ensure a positive Q-value taking into account the uncertainty of the beam momentum defined by COSY.

The overall experimental conditions were rather satisfactory. Due to a very good and stable deuteron beam provided by COSY and a stable and dense deuteron cluster-jet target, the average luminosity of $4 \cdot 10^{30}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ we aimed at could be reached. In addition, the restrictive trigger resulted in a relatively low rate and, consequently, in a small dead time. Also the track-reconstruction efficiency - due to the use of a different tracking detector [2] - was higher than assumed in the proposal. Therefore, the statistics might be sufficient to produce differential cross sections even at the highest beam momentum.

We have to emphasize that the one-night run for calibration measurement we got during the machine-development week prior to our beam time was very helpful for understanding the experimental conditions for this first deuteron beam time at ANKE. In particular, it allowed to study the background from break-up of beam deuterons and, thus, to prepare an improved setup for a much cleaner ^{4}He identification.

2 Status of the analysis

Since the experiment was carried out only recently, in the first approach only clean events were taken for analysis. Here, a "clean event" was defined by demanding a single-counter response in each of the three layers of the forward hodoscope with energy losses above certain thresholds. In addition, the reconstruction of a single track was requested. For further analysis combined ΔE-momentum cuts for each layer were applied to select the ^{4}He.

Q value [MeV]	# of clean events	# of ^{4}He	# of η
-2.0	13, 834, 763	158, 000	-
3.2	70, 538, 482	763, 000	17, 500
8.3	18, 153, 050	205, 500	7, 600

Table 1: Data on dd $\rightarrow$ ^{4}Heη collected in the measurement Jan/Feb 2003.

Due to the limited time the figures and numbers presented here have been obtained with only a rough energy loss calibration. Also not all possibilities to refine the momentum reconstruction have been exploited yet. Therefore, the spectra still contain a considerable background from misidentified protons. We expect to reduce this in further analysis. The

numbers of the dd $\rightarrow$ ^{4}Heη events have been obtained by integration of the preliminary missing mass spectra. The collected statistics is summarized in table 1.

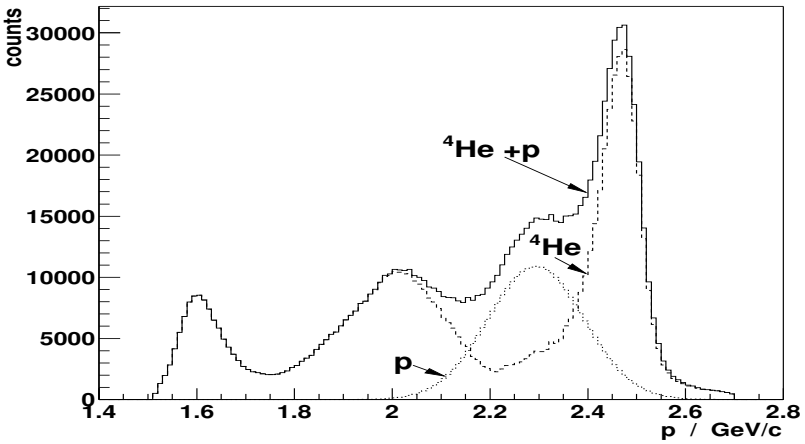

Figure 1: Momentum spectrum of the detected ^{4}He particles for $p_d = 2.345$ GeV/c. The dotted line represents the contribution of break-up protons obtained by extrapolation of the momentum distribution at higher energy losses. The resulting spectrum, plotted with a dashed line, reveals the expected shape [3, 4, 5].

As an example, for one beam energy the momentum distribution of the detected ^{4}He particles is shown in fig. 1. The clean spectrum, obtained by subtraction of the proton background, reveals the expected three-peak structure. The ^{4}He particles associated with η production contribute to the central peak.

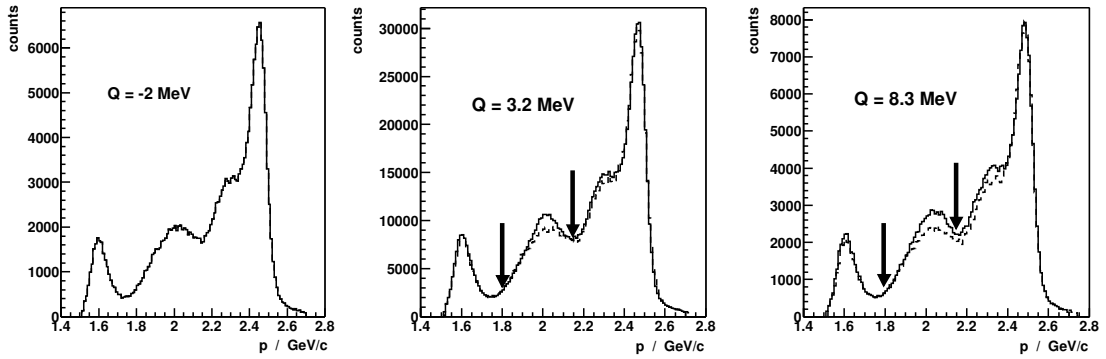

Figure 2: Momentum distributions of the ^{4}He particles for all measured energies. The data measured below threshold are kinematically scaled to the higher energies and plotted with a dashed line. Arrows indicate the momentum range of events from which the missing mass spectra were constructed.

Fig. 2 shows the momentum distributions for all three beam momenta. For each of the two energies above threshold the distribution below threshold was scaled kinematically and plotted on top. Enhancements due to η production are clearly visible in the momentum range of interest. In the momentum region, where the background protons are located, slight discrepancies between the data and the extrapolated background can be observed. These protons have different kinematics and, thus, the kinematical scaling fails.

Those events, which are located in the momentum spectra between the two arrows, served as input for the missing mass spectra (signal and background). The results showing a signal at the η mass are presented in fig. 3.

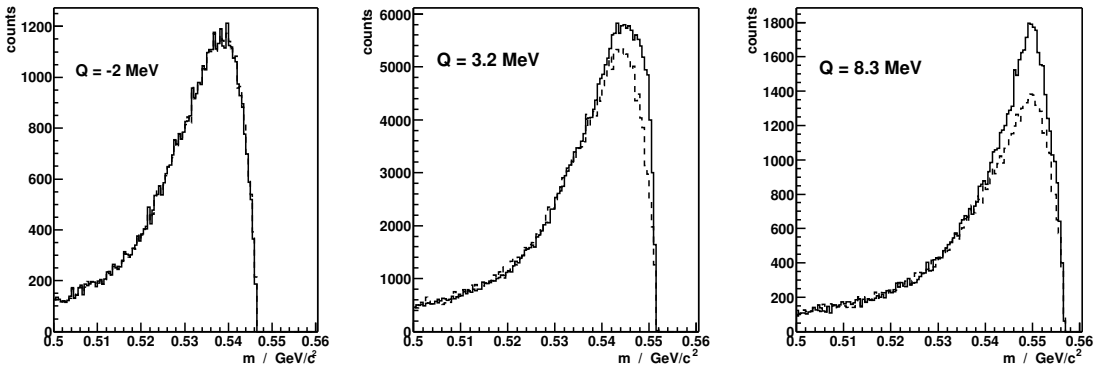

Figure 3: Missing mass spectra for events indicated in fig. 2. For the data taken above threshold enhancements around the η mass can be observed. A more refined momentum reconstruction should improve the momentum resolution and, thus, the missing mass resolution.

3 Beam time request

The preliminary results of the ongoing analysis proved our ability to measure the reaction dd $\rightarrow$ ^{4}Heη at ANKE. Although the recent data taken at 2.330, 2.345 and 2.360 GeV/c require a further, more elaborated analysis (e.g. precise energy loss calibration, better momentum reconstruction, etc.) the available results show that the identification of the reaction dd $\rightarrow$ ^{4}Heη is well possible.

Therefore, we would like to go on studying this reaction as described in the proposal. We request the allocation of the remaining week of beam time, which has been granted by PAC #24, during the next beam time period. Following the schedule presented in the original proposal, we will measure total cross section and angular distribution at a beam momentum of 2.4 GeV/c (corresponding to Q = 22 MeV) in order to study the onset of higher partial waves. If the experimental conditions turn out to be as excellent as in the recent beam time, we will be able to measure at another beam momentum. In this case we will choose 2.5 GeV/c (Q = 57 GeV/c). The request is summarized below.

Duration of beam time:	1 week
Deuterons in COSY:	$> 5 \cdot 10^{10}$
Beam momentum:	2.4 GeV/c, (2.5 GeV/c)
Absolute precision:	10^{-3}
Momentum spread:	$\leq 5 \cdot 10^{-4}$

This measurement will complete the total beam time granted for the proposal #107.

References

[1] COSY Proposal 107: "Near threshold η production in dd $\rightarrow$ ^{4}Heη", Spokesperson A.Wrońska, 2002.

[2] A. Wrońska et al., IKP Annual Report 2002: "Test of drift chambers at ANKE".

[3] R. Frascaria et al., Phys. Rev. C **50** (1994) R537.

[4] N. Willis et al., Phys. Lett. **B406** (1997) 143.

[5] J. Banaigs et al., Nucl. Phys. **B105** (1976) 52.