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

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Abstract:

We propose to measure total and differential cross sections of the reaction $dd \to {}^4\mathrm{He}\,\eta$ close to threshold. Data on the total cross section are available up to $Q \approx 6$ MeV ($p_{\eta,c.m.} \approx$ 90 MeV/c) measured at SATURNE [13, 14]. Since angular distributions have not yet been measured, the extraction of reaction amplitudes and scattering length are based on the assumption of an isotropic c.m. distribution. The forward detection system of ANKE is well suited to identify the ^{4}He and reconstruct their momenta, providing a full azimuthal acceptance up to $p_{\eta,c.m.} = 300$ MeV/c. In total, it is planned to take data at three or four different energies. Since the detailed planning will be based on the first results, we ask for an initial beam time of one week at a deuteron momentum of 2.345 GeV/c ($p_{\eta,c.m.} = 55$ MeV/c).

Contents

1 Introduction

In January 2001, a first regular deuteron beam time has been delivered with great success [3, 4]. The deuteron beam was of the same quality as for protons and the intensity was even larger. $2 \cdot 10^{11}$ deuterons without cooling and about $5 \cdot 10^{10}$ cooled deuterons have been stored in COSY. This opens new fields for future research and additional beam times are already scheduled [5].

This proposal focuses on the reaction $\mathrm{dd} \to {}^4\mathrm{He}\eta$ close to the production threshold. As discussed below, only few data on the total cross section are available. The situation is different from $\mathrm{pd} \to {}^3\mathrm{He}\eta$, which has been studied more extensively. Therefore, a comparative analysis of these two reactions and theoretical interpretations rely on various assumptions on the differential distributions. In combination with the deuteron option of COSY, the ANKE spectrometer is well suited for more detailed investigations in the dd channel. The aim of this experiment is to provide information about the emergence of p and higher partial waves and to add new data for $Q > 6$ MeV.

As a further opportunity, the experiment will allow investigations of the background conditions and specific detector properties for future measurements exploiting the deuteron beam. This is of importance, because this experiment will be the first one using a deuteron beam at ANKE. Consequently, nothing is known about the global experimental environment in this case and subsequent proposals will gain from the achieved data. For the photon detector, for example, - in combination with ANKE - it is proposed to measure charge symmetry breaking in the reaction $\mathrm{dd} \to {}^4\mathrm{He}\pi^0$ at η-production threshold, i.e. very close to the beam momentum used here [6]. Requiring an α particle in the ANKE forward detector, the main trigger will be very similar for both experiments. The cross section for this reaction is quite low ($\sigma_{\mathrm{tot}} \leq 4.4$ pb/sr estimated) and, consequently, the total beam time foreseen is 9 weeks. Therefore, the experimental conditions should be known well in advance, in order to use the COSY beam as efficiently as possible.

2 Physics case

The renaissance of interest in η-production over the last 10 years started with the measurement at the SATURNE SPESIV spectrometer of the cross section and deuteron tensor analysing power for the $\tilde{\mathrm{d}}\mathrm{p} \to {}^3\mathrm{He}\eta$ reaction near threshold, which identified the η through a missing mass technique [1]. A summary of these and other available experimental data on coherent η production in pd and dd collisions is to be found in table 1. The SPESIV results were confirmed and extended in much more detailed measurements up to $Q \approx 6$ MeV at SPESII [2]. There is, nevertheless, a significant uncertainty in very-near-threshold points of both this and the earlier experiment due to energy losses in the target. This is an inherent problem for external targets with windows. The angular distributions obtained show only very small deviations from isotropy and limits on the slopes were derived.

By $Q \approx 50$ MeV a marked anisotropy sets in [8] and a study of how this develops was carried out at TSL, where the missing-mass technique was verified through the detection in

Observable	Beam energy (MeV)	Q (MeV)	Comment	Ref.
$\mathrm{pd} \to {}^3\mathbf{He}\eta$				
$\mathrm{d}\sigma/\mathrm{d}\Omega$ & t_{20} $\theta_\eta \approx 0°$ & $180°$	$891.3 \leq T_p \leq 902$ MeV	$0.05 \leq Q \leq 6.1$	4 energies $\vec{d}$ beam	[1]
$\mathrm{d}\sigma/\mathrm{d}\Omega$	$891.35 \leq T_p \leq 902.15$	$0.12 \leq Q \leq 6.2$	8 energies angular slope limit	[2]
$\mathrm{d}\sigma/\mathrm{d}\Omega$ $\theta_\eta \approx 180°$	$920 \leq T_p \leq 2300$	$16 \leq Q \leq 712$	16 energies 2-3 angles	[7]
$\mathrm{d}\sigma/\mathrm{d}\Omega$ $14° \leq \theta_\eta \leq 123°$	980	49	11 angles	[8]
$\mathrm{d}\sigma/\mathrm{d}\Omega$ $\theta_\eta \approx 180°$	$1026 \leq T_p \leq 1190$	$75 \leq Q \leq 163$	4 energies 4 angles/1048 MeV d beam	[9]
$\mathrm{d}\sigma/\mathrm{d}\Omega$ $55° \leq \theta_\eta \leq 171.7°$	1450	299	11 angles	[10]
$\mathrm{d}\sigma/\mathrm{d}\Omega$ $36° \leq \theta_\eta \leq 139°$	930, 965 1037, 1100	21.6, 41.1 80.6, 114.8	≈ 25 angles per energy	[11]
$\mathrm{d}\sigma/\mathrm{d}\Omega$	$896.5 \leq T_p \leq 963$	$3 \leq Q \leq 40$		[12]
$\mathrm{dd} \to {}^4\mathbf{He}\eta$				
σ_T	$1120.5 \leq T_d \leq 1123.3$	$0.3 \leq Q \leq 1.5$	4 energies	[13]
σ_T	$1120.2 \leq T_d \leq 1139.0$	$0.1 \leq Q \leq 8.4$	6 energies $\vec{d}$ beam	[14]

Table 1: Summary of experimental data of η production on the deuteron. Energy scales quoted in terms of Q or p^*_η were converted to beam energies using $m_\eta = 547.3$ MeV/c^2. Note that the energy scales for SATURNE results published prior to those of ref. [1] were incorrect by a few MeV.

coincidence of photons from the η-decay [11]. The striking point to notice about the TSL data shown in Fig. 1 is that the cross sections are maximal for $\cos\theta_\eta \approx +0.5$ rather than in the forward direction. The other data shown on the figures can cast no light on this feature. Much more information is available on the distributions in the backward hemisphere and the systematic study of the cross section for $\theta_\eta \approx 180°$ is very valuable [7].

The near-threshold data [1, 2] are remarkable for both their strength and energy variation. To quantify this, define a spin-averaged amplitude squared in terms of the unpolarised cm cross section through

$$|f|^2 = \frac{p_d}{p_\eta}\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}(\mathrm{pd} \to {}^3\mathrm{He}\eta)\,, \tag{1}$$

where p_d and p_η are the initial and final cm momenta respectively. The threshold value of $|f|^2$ for η production is as big as that for π production at its threshold, despite the much larger momentum transfer. Furthermore, while remaining essentially isotropic, it is seen from Fig. 2 that $|f|^2$ falls by over a factor of three from threshold up to $p_\eta \approx 0.35$ fm^{-1} [2]. As this corresponds to the change of only a few MeV in the incident beam energy, it must be associated with an interaction between the η and the ^{3}He in the final state [15].

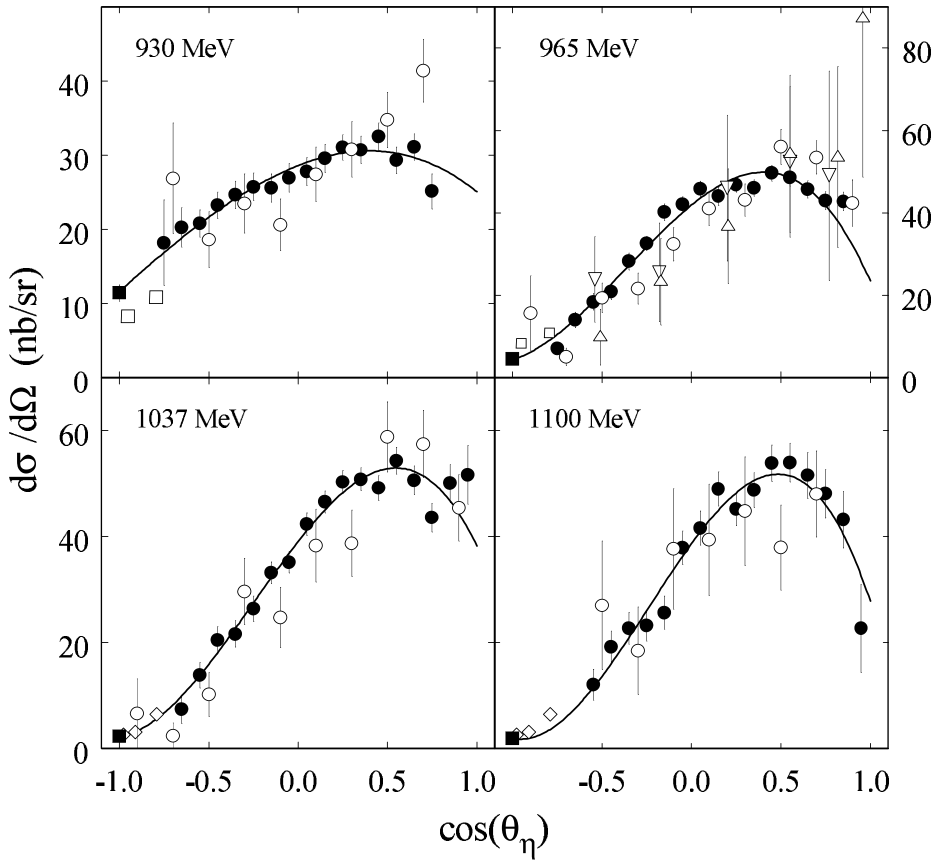

Figure 1: Differential cross sections for the pd $\to$ ^{3}Heη reaction at four beam energies. The full and empty circles represent CELSIUS data [11] taken with only the ^{3}He detected and with the ^{3}He and two photons detected in coincidence, respectively. The points in the backward direction (full squares) come from an interpolation of the Saclay SPESIV results [7]. The curves represent third order polynomial fits in $\cos\theta_\eta$. The open squares shown on the 930 and 965 MeV graphs and the diamonds on the 1037 and 1100 graphs were taken from the SPESIV results at 950 and 1050 MeV respectively [7]. The triangles on the 965 MeV graph are the GEM points [8] scaled by an empirical factor of 0.71.

Parametrising the final state interaction by an *S*–wave scattering length formula,

$$f = \frac{f_B}{1 - iap_\eta}\,, \tag{2}$$

where f_B is slowly varying, the best fit is obtained with a scattering length [2]

$$a = -\lim_{p_\eta \to 0}(\tan\delta/p_\eta) = \pm(3.8 \pm 0.6) - i(1.6 \pm 1.1)\ \text{fm}\,. \tag{3}$$

It should be noted that the data are insensitive to the sign of the real part of the scattering length. The error bars may have been underestimated significantly because those on the real and imaginary parts are strongly coupled in the fit.

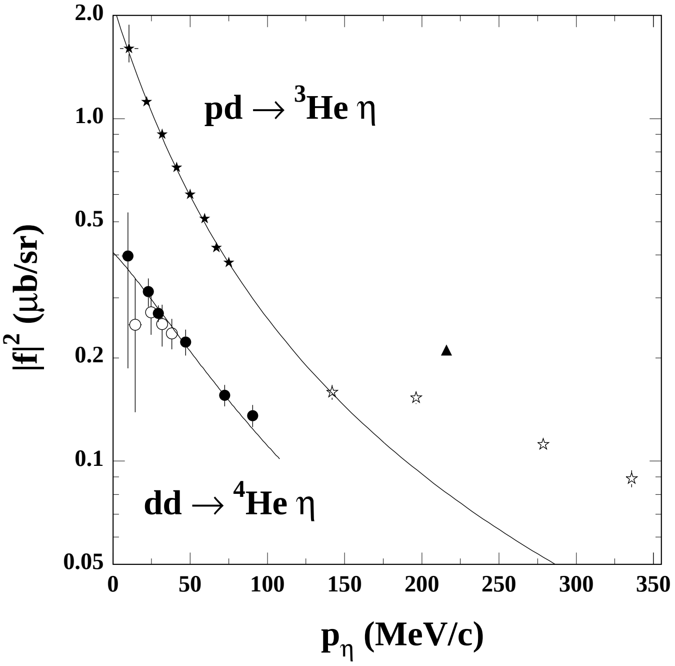

Figure 2: Amplitudes squared of the pd $\to$ ^{3}Heη reaction averaged over spin and angle as a function of the cm η momentum. Full and empty stars represent the results from SPESII [2] and TSL [11], respectively. The GEM point [8] (closed triangle) lies well above the trend of the other data. The Saclay data from the corresponding dd $\to$ ^{4}Heη reaction, shown as open [13] and closed circles [14], have been scaled up by a factor of 10 for display purposes, though mention of this fact was overlooked in the original article [14]. The curves, taken from Ref. [14], follow from a combined *s*-wave optical model fit to near-threshold data from both reactions.

Such a large scattering length raises the question of whether the η meson can form quasi-bound states with nuclei much lighter than those originally suggested [16]. Direct searches for η-meson quasi-bound states in $^{16}\mathrm{O}(\pi^+,p)X$ and $^{16}\mathrm{O}(\pi^+,\pi 2p)X'$ [17, 18] have proved rather inconclusive.

Evidence for the quasi-bound-state hypothesis is provided by the near-threshold data on dd $\to$ ^{4}Heη [13, 14], which show that the amplitude varies much less with p_η than for the analogous ^{3}He case. Independent of any details of η–nucleus scattering schemes, the $\eta\,^4$He system is expected to be more bound than $\eta\,^3$He due to the smaller radius of the ^{4}He nucleus and the presence of one extra nucleon. This implies that in any scattering length fit

$$\left|Re\left\{1/a\left(\eta\,^4\mathrm{He}\right)\right\}\right| > \left|Re\left\{1/a\left(\eta\,^3\mathrm{He}\right)\right\}\right| . \qquad (4)$$

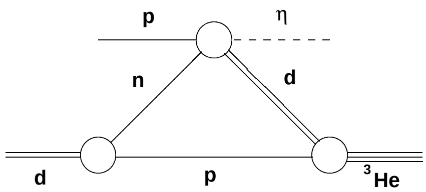

Figure 3: Spectator model for the pd $\to$ ^{3}Heη reaction.

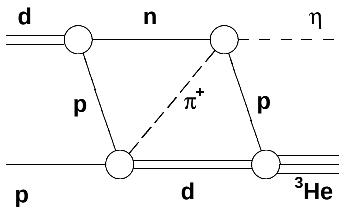

Figure 4: Two-step model for the pd $\to$ ^{3}Heη reaction. There is also a contribution from an intermediate π^0.

This, together with the relative slope statement, fixes the sign of $Re\left\{1/a(\eta\,^4\mathrm{He})\right\}$, which in turn resolves the sign ambiguity in $Re(a)$. The result suggests that there is indeed a quasi-bound state in the case of $\eta\,^4$He [14].

If we assume a simple one-body optical potential [14] with the same effective ηN input in the two cases, a combined fit to the ^{3}He and ^{4}He Saclay data yields

$$\begin{aligned} a(\eta\,^3\mathrm{He}) &\approx (2.3-3.2i)\,\mathrm{fm}\,, \\ a(\eta\,^4\mathrm{He}) &\approx (2.2-1.1i)\,\mathrm{fm}\,. \end{aligned} \tag{5}$$

Both these correspond to the η being in a quasi-bound state with respect to the helium isotope. The conclusion in the ^{3}He case is somewhat model-dependent, and other multiple scattering schemes might give different answers.

The results of the fits are shown in Fig. 2. It is interesting to note that when the pd $\to$ ^{3}Heη predictions are continued in p_η, they pass just below the lowest point of the TSL data [11]. At higher values of p_η the experimental points lie much further above the curve. This is as expected, because the strong angular dependence apparent in Fig. 1 is an indication of the presence of p and higher waves.

If the $\eta\,^{\{3,4\}}$He systems possess quasi-bound states then their properties should be largely independent of how they are produced but there is, as yet, relatively little extra information. Attempts to measure p^{3}H$\to$ ^{4}Heη were thwarted by problems with the tritium target [19]. The data on $\pi^-\,^3$He$\to$ ^{3}Hη [20] only start at $p_\eta \approx 0.5$ fm^{-1} and so are insensitive to any steep slope associated with a final state interaction. Due to spin-parity considerations, the s-wave photoproduction amplitude for γ^4He$\to$ ^{4}Heη vanishes and, indeed, experiments with the TAPS spectrometer at Mainz [21] found only an upper limit on the cross section close to threshold. However, the group is now analysing data on γ^3He$\to$ ^{3}Heη where the s-wave is not forbidden by selection rules and where a FSI signal might be seen.

Although FSI might describe the strong energy dependence of η production, it does not explain the overall strength of the reaction. Because of the very large momentum transfer models, such as that of Fig. 3 where there is a spectator nucleon, underpredict the pd $\to$ ^{3}Heη cross section [22, 23]. A contribution is required where all three final nucleons are involved in the reaction mechanism.

Kilian and Nann [24] showed that the threshold kinematics for pd $\to$ ^{3}Heη are *magic*. The momentum of the final η in the laboratory is essentially the same as that obtained from the sequential physical processes $pp \to d\pi^+$ followed by $\pi^+ n \to p\eta$, when there is no relative momentum between the final pd pair and all Fermi momenta have been neglected. In such cases the final proton and deuteron are likely to *stick* to form a ^{3}He nucleus. An order-of-magnitude estimate of the cross section could be achieved in a classical Monte Carlo simulation of this two-step scenario. It has been claimed by many authors [25] that contributions from such virtual pion beams are also important for η (and kaon) production in inclusive proton-nucleus and nucleus-nucleus collisions.

The boost to the $pd \to {}^3\mathrm{He}\eta$ cross section coming from the magic kinematics has been confirmed in a quantum mechanical evaluation of the amplitude corresponding to Fig. 4 [26]. This gives a much more realistic estimate of the pd *sticking factor* to form the final ^{3}He and also includes contributions where the intermediate pion is off its mass shell. Using experimentally determined (on-shell) $pp \to d\pi^+$ and $\pi^+ n \to p\eta$ amplitudes, the predicted near-threshold amplitude is still about a factor of $N \approx 2.4$ lower than experiment [13, 14]. This could be due to approximations in the calculations which underestimate the effects of the $\eta\,^3$He fsi, or the neglect of two-step contributions where there is an intermediate d^* (a $^1S_0$ state) rather than a deuteron in Fig. 4. Alternatively there might be constructive interference with a small two-body term as in Fig. 3

Even with non-classical contributions, the cross section predicted by the two-step model is still largest when the intermediate pion is closest to its mass shell. Away from threshold this is for $\cos\theta_\eta \approx -0.3$, which is far from the observed $+0.5$ [11]. This might be changed by a positive interference with the spectator term of Fig. 3, which is strongly peaked in the forward direction. A fully microscopic model [22] would then be needed in order to establish the relative phase between the two contributions.

The cross section for the $dd \to {}^4\mathrm{He}\eta$ reaction is almost two orders of magnitude smaller than that for $pd \to {}^3\mathrm{He}\eta$ and the threshold behaviour is reproduced in a two-step model as the sequential $dp \to {}^3\mathrm{He}\pi^0$ followed by $\pi^0 n \to n\eta$ processes [27]. No measurements have yet been carried out on angular distributions which would allow one to see the onset of higher partial waves. These will be very different from the $pd \to {}^3\mathrm{He}\eta$ case because of the symmetry in the entrance channel. There are also no data at higher energies than those shown in the figure, which are all below $Q = 8.4$ MeV. It is the aim of the present proposal to continue these data to higher energies and measure also the differential cross section with the hope of testing the two-step model and establishing further the parameters of the low energy $\eta\,^4$He system.

3 Experimental conditions

It is proposed to measure $dd \to {}^4\mathrm{He}\eta$ using the existing ANKE set-up. Up to a Q-value of 6.6 MeV *all* ^{4}He ejectiles from this reaction can be detected in the forward detector of ANKE (see Fig. 5). The corresponding η mesons will be reconstructed through a missing-mass analysis.

The published SATURNE data were taken very close to threshold and are extremely precise in their determination of Q. To reproduce these data with the same quality, either the absolute value of the COSY beam momentum has to be fixed to $\Delta p_d/p_d < 5\cdot 10^{-5}$ or the

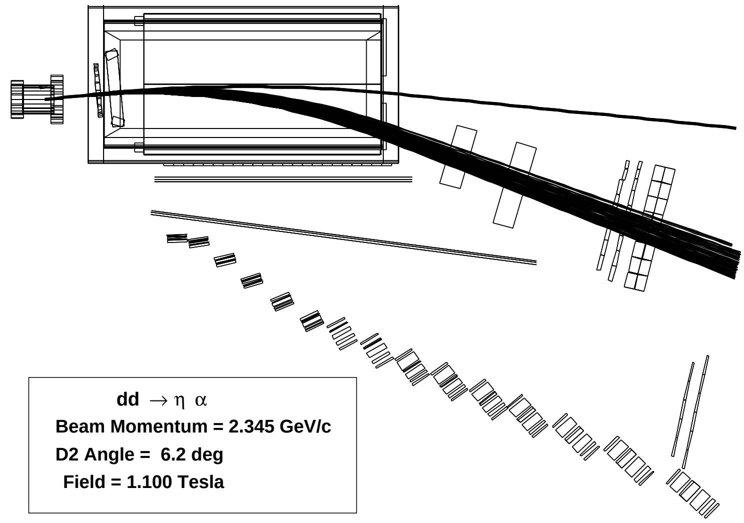

Figure 5: Schematic setup of ANKE detector. For the proposed experiment only the forward detection system is used. For a beam momentum of 2.345 GeV/c ($Q \approx$ 3MeV) the tracks of ^{4}He originating from dd $\to$ ^{4}Heη are shown. At this energy all tracks are in the acceptance of the forward detector.

momentum of the produced ^{4}He has to be determined with a precision of $\Delta p/p \approx 1 \cdot 10^{-3}$ in the forward detection system of ANKE. Neither of these can be achieved with the current set-up.

However, the aim of this proposal is to measure angular distributions and to extend the existing data set to higher energies. For this purpose, the capability to identify the η-meson well with an appropriately large acceptance is more important than a precise determination of the value of Q. It is therefore proposed to use the information of beam momentum from COSY for this purpose (providing an absolute precision of 10^{-3} and a width of $< 5 \cdot 10^{-4}$); the ANKE system will primarily be used to identify the reaction channel.

The kinematical situation near threshold is shown in Fig. 6. The value of $p_{\eta,\mathrm{c.m.}}$ is fixed by the beam momentum with a precision of ± 7 MeV/c. In addition, this can be checked with ANKE by using the transverse momentum of the detected ^{4}He particles. Due to the two-body kinematics, the upper limit of this distribution also gives the value of $p_{\eta,\mathrm{c.m.}}$. The resolution will be comparable to the one achieved from the beam information. Fig. 7 shows the momentum resolution of the forward detection system for the transverse and longitudinal component together with the experimental resolution of $\theta_{\eta,\mathrm{c.m.}}$. The distribution for the η transverse momentum is given in Fig. 8. The included background, which is considered to be mainly 2π production ($\sigma_{\mathrm{tot}} \approx 2\ \mu$b), was generated on the basis of parameterised data taken from [28].

The missing-mass spectrum in Fig. 8 represents a statistics of 1250 valid events (estimated for one angular bin after one week of beam time). The η peak is clearly visible and - using the transverse momentum information in addition - the background can be subtracted consistently.

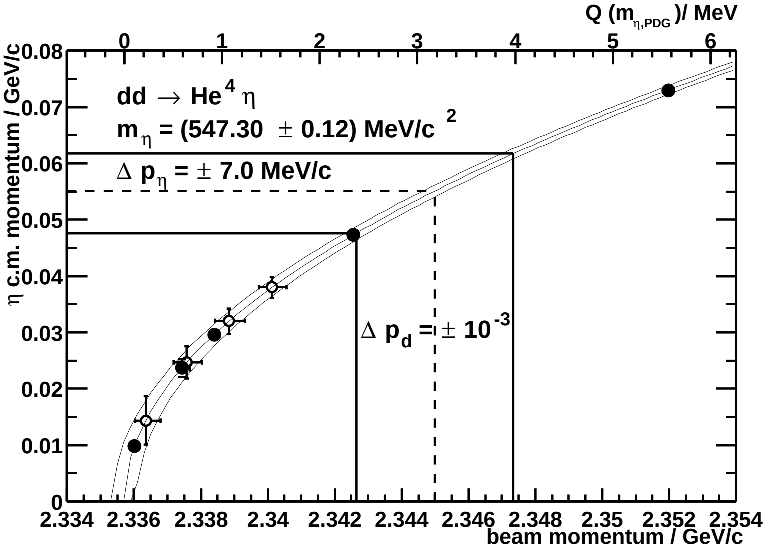

Figure 6: Kinematics of the dd → ^{4}Heη reaction. The relation between beam momentum, $p_{\eta,\mathrm{c.m.}}$ and Q-value is shown for different η masses. The points correspond to the data from [13, 14] and the error bars represent the precision in beam momentum and $p_{\eta,\mathrm{c.m.}}$, respectively. For a given beam momentum of 2.345 GeV/c, absolutely determined to 10^{-3}, the resulting variation in $p_{\eta,\mathrm{c.m.}}$ is indicated.

For the absolute normalisation of the cross section, inclusive data for dd → ^{4}He X from [28] taken at various energies and angles will be used .

4 Trigger

The hardware trigger will be based on energy loss in the two hodoscope layers of the forward detection system. Since the mean energy losses of α particles in a single hodoscope layer are 8 times larger than those of protons and 4 times larger than those of deuterons of the same rigidity, high threshold settings will reduce the trigger rate to a level, which can be handled by the ANKE DAQ. Contributions from lighter particles due to high energy tails will be suppressed further by a coincidence between both layers.

In the off-line analysis, events with an α particle in the exit channel will be selected by a combined energy loss - rigidity cut. Using rigidity bins of 50 MeV, ^{3}He and ^{4}He are separated by 8 times FWHM of the energy-loss peaks.

With this trigger all events of type dd → ^{4}He X will be written to tape. This will, in addition, enable inclusive measurements of other channels such as dd → ^{4}He$\pi^+\pi^-$. As an option, we consider installation of a more extended version of the spectator/vertex set-up in the target chamber to study charged pion detection with these detectors and to check whether this type of reaction could be measured with ANKE. This can also be used to reduce the background from this channel to η production by about a factor of 1.5. While

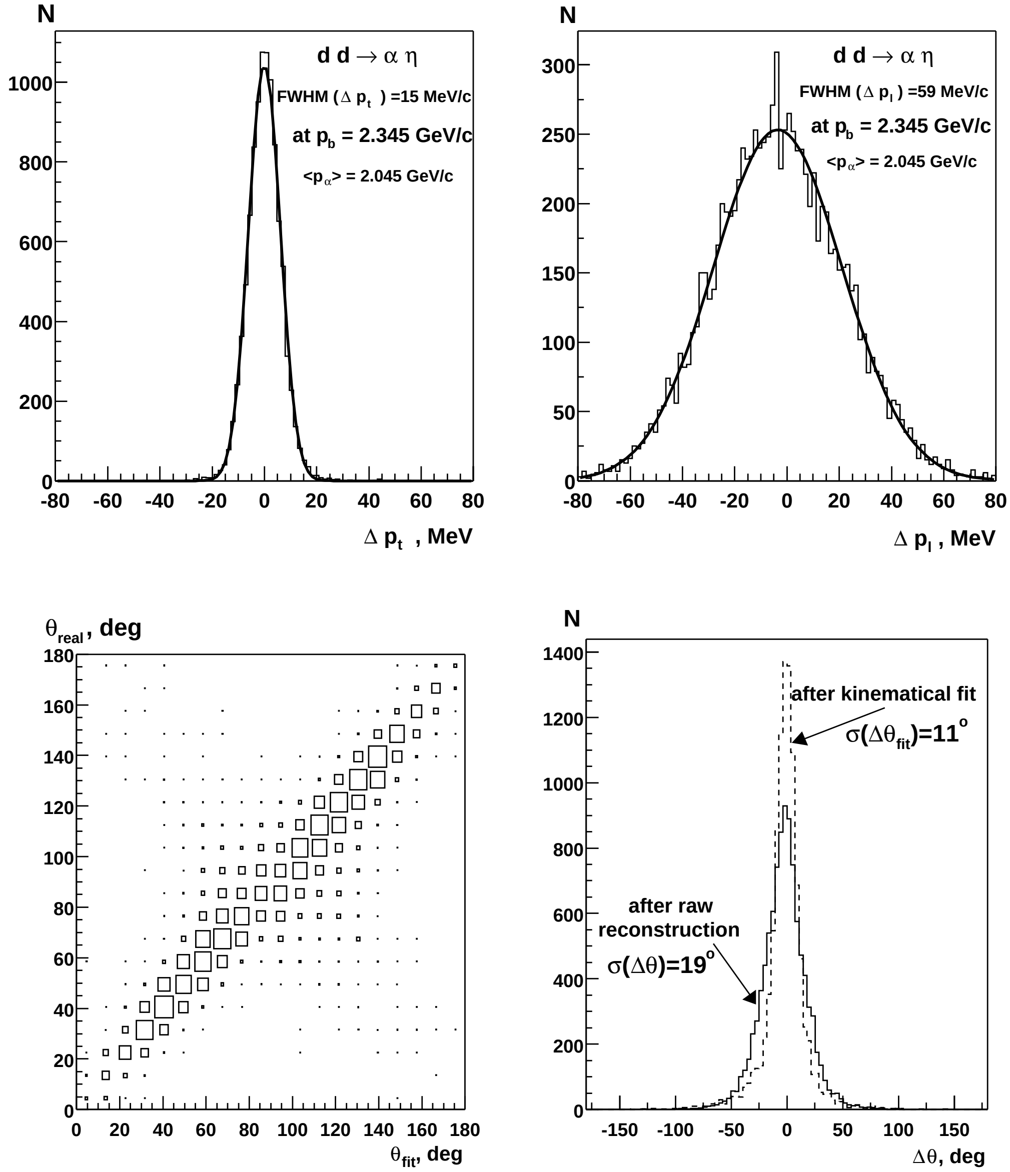

Figure 7: Upper figures: momentum resolution of the ANKE forward detector (transverse and longitudinal, respectively) for ^{4}He from the reaction dd $\rightarrow$ ^{4}Heη at 2.345 GeV/c. The transverse component can be determined much more precisely than the longitudinal one. Together with the fixed total c.m. momentum, this can be exploited by using a kinematic fitting procedure. Lower figures: simulated resolution of $\theta_{\eta,\mathrm{c.m.}}$. The left plot shows the correlation between the real value and the measured one, the right one gives the resolution of θ_{cm} with and without a kinematic fit.

this will not substantially improve the identification of η mesons, it will help in the study of systematic errors.

5 Experimental programme and beam time estimates

As indicated in Fig. 6, it is proposed to start at a beam momentum of $p_\mathrm{d} = 2.345$ GeV/c. If the angular distribution show contributions from higher partial waves, one energy above and one below will be measured in subsequent beam times. Otherwise, the further programme will concentrate on the development of partial waves at higher momenta, e.g. at 2.4 GeV/c and 2.5 GeV/c, measuring total and angular differential cross sections. However, the final request can only be made after analysing the first data.

Based on a total cross section of $\sigma_\mathrm{tot} = 13$ nb at beam momentum 2.345 GeV/c, an average luminosity of $4 \cdot 10^{30}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ (deuterium-cluster-jet target with a thickness of $5 \cdot 10^{13}\mathrm{cm}^{-2}$ and $5 \cdot 10^{10}$ cooled particles in COSY), a DAQ dead-time of 20% and a track reconstruction efficiency of 70% for the forward chambers, a data rate of 95 detected $^4\mathrm{He}\eta$ events/hour is assumed. The proposed 2-body reaction has a strong position-$\theta_\mathrm{c.m.}$ correlation in the forward detection chambers and is, therefore, very sensitive to inhomogeneities in the chamber efficiencies. The angular distribution at these energies is a function of $\cos^2\theta_\mathrm{c.m.}$ and, therefore, has a forward-backward symmetry. This feature will be used to exclude such systematic effects. Thus, taking into account a measured angular distribution with 2 times 4 bins (forward/backward) and 1000 events/bin (to allow a clean background subtraction), 4 days of beam time are needed. In addition, we propose to measure 2 days at one energy below threshold (e.g. 2.33 GeV/c) to determine the background from multi-

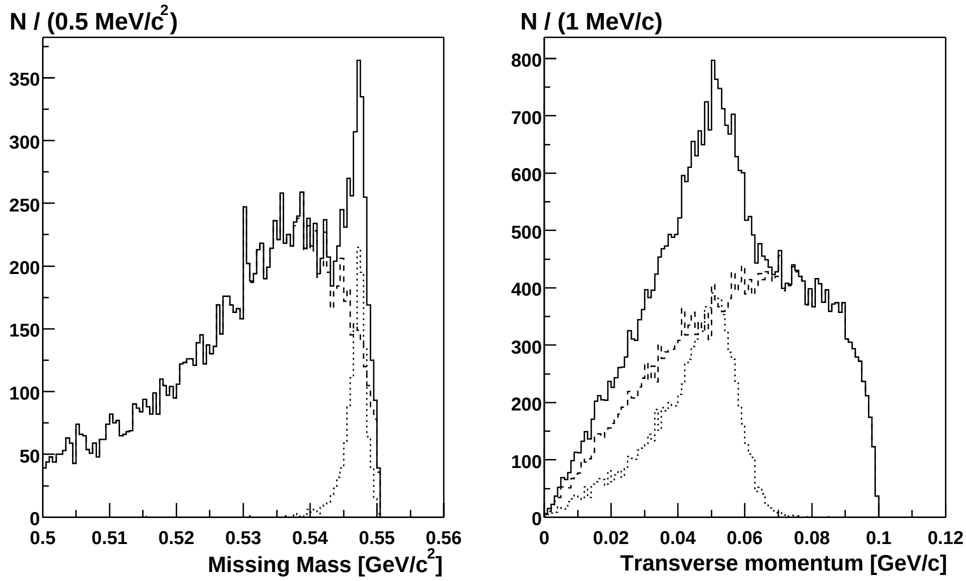

Figure 8: Results of the simulations for dd $\to \alpha\eta$ at a beam momentum of 2.345 GeV/c. Left: missing mass spectrum (with expected statistics for one angular bin); right: transverse momentum distribution with a cut on missing mass ($m > 0.54$ GeV/c) for the full statistics. The dotted histogram indicates the signal, the dashed one shows the background from 2-pion production.

pion production. Including time for trigger adjustment and necessary calibration runs, a total beam time of one week is estimated.

Presuming the same conditions, a conservative estimate for the other two near-threshold measurements gives one week per energy, too. However, after the analysis of the first data we can judge whether it is possible, for example, to skip the individual background measurements and to do both in one week. For higher energies the overall acceptance is lower due to cuts in polar angle. The actual value depends on the exact beam momentum to be measured. As an (reasonable) estimate one week per measurement is assumed here.

The tentative schedule is summarised in the following table:

beam momentum	primary observable	estimated beam time
2.330 GeV/c **2.345 GeV/c**	**background study** **angular distribution**	**1 week**
2.339 GeV/c 2.350 GeV/c	angular distribution angular distribution	1 week
2.4 GeV/c	total cross section angular distribution	1 week
(2.5 GeV/c	total cross section angular distribution	1 week)

From the Saclay experiments [13, 14] it is known that a tensor polarised deuteron beam could help to do a consistent subtraction of the multi-pion background. Although first tests using polarised deuterons in COSY are not done yet and will take place in summer, estimations on the intensity (based on the experience with protons) give a factor of 10 less than for the unpolarised beam. However, providing a reasonable intense beam (like the current unpolarised one) were available in future, this could increase data quality, although it would not shorten the total beam time. We are currently discussing the boundary conditions for using a polarised deuteron beam for these measurements (beam intensity, polarisation determination and monitoring). If COSY will provide deuteron polarisation, we would consider to continue the program in polarised mode. However, since this will be the first experiment with a deuteron beam for ANKE, to study the experimental conditions the initial beam time in any case should still be unpolarised.

6 Beam request

Following the discussion above, we request one week of deuteron beam time for the second half of 2002. The general beam parameters are:

Deuterons in COSY:	$5 \cdot 10^{10}$
Beam momentum:	2.345 GeV/c
Absolute precision:	10^{-3}
Momentum spread:	$\leq 5 \cdot 10^{-4}$

In order to achieve a $\Delta p/p$ as small as possible, a stochastically cooled beam is preferred, if the ongoing deuteron tests in COSY will show that this feasible for deuterons at this energy.

In addition, about 3 more weeks are needed to complete the program. A final schedule will be presented to the PAC after analysing the initial measurement.

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