Simulations of the dd $\to \alpha\eta$ reaction at ANKE

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Deuteron acceleration in COSY has been achieved successfully during the year 2000. The tests showed that both quality and intensity of the deuteron beam were similar to the proton case [1]. This opens new fields for research at COSY, among others investigation of η-meson production in the dd $\to \alpha\eta$ reaction. So far only near-threshold data for the total cross section of this reaction are available [2, 3], information on angular distributions and data for higher Q values are missing (see Fig. 1). Currently used values for the α-η scattering length - crucial e.g. in the discussion about η-nucleus bound states - were extracted under the assumption of pure S-wave production. The goal of the proposed investigation is to study the contribution of higher partial waves in the near threshold region and, in particular, to determine the energy, at which the P-wave channel opens (c.m. angular distribution becomes anisotropic). Thus, this measurement will test the validity of the S-wave approximation.

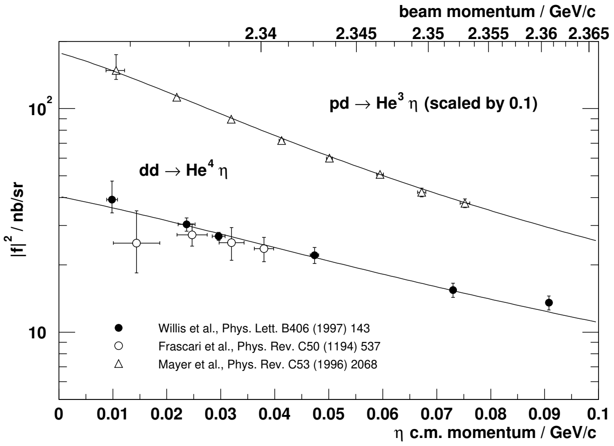

Fig. 1: Extracted reaction amplitudes for pd $\to {}^3$Heη and dd $\to {}^4$Heη. The curves taken from [3] follow from a combined S wave optical model fit. In case of pd $\to {}^3$Heη, new data show a deviation from this fit starting at $p_{\eta,\mathrm{c.m.}} \approx 0.15\mathrm{GeV/c}$ [4]

To check the feasibility of such a measurement using the ANKE detection system, Monte Carlo simulations have been carried out. For a beam momentum of 2.35 GeV/c ($p_{\mathrm{d,thr.}} = 2.335\mathrm{GeV/c}$) a total cross section of 13.5 nb and a luminosity of $5 \cdot 10^{30}$ cm^{-2}s^{-1} (deuterium-cluster-jet target) were assumed. The background, which is considered to be mainly 2-pion production ($\sigma_{tot} \approx 2\mu$b), was generated on the basis of parameterised data from [5]. Only the α particle will be detected in ANKE, the η will be reconstructed by a missing-mass analysis.

Figure 2 presents the results containing statistics for 2 days of beam time expected under the conditions listed above. In the left picture the η peak in the missing-mass spectrum is clearly visible on top of the background. Thus, the resolution of the forward multiwire chambers is sufficient to identify the η meson in the proposed measurement. The right picture, showing the transverse momentum distribution of the produced α-particles with a cut on the η missing mass, will serve for the η c.m.-momentum determination independent from the beam momentum information provided by COSY. Using ANKE a resolution of $\Delta p_{\eta,\mathrm{c.m.}} \approx \pm 5$ MeV/c can be achieved. This corresponds to an uncertainty of the beam momentum of $\Delta p_{\mathrm{d}}/p_{\mathrm{d}} \approx \pm 1 \cdot 10^{-3}$.

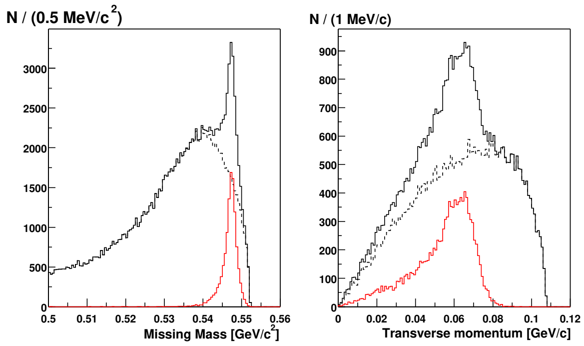

Fig. 2: Results of the simulations for dd $\to \alpha\eta$ at a beam momentum of 2.35 GeV/c. Left:missing mass spectrum; right: transverse momentum distribution with a cut on missing mass ($m > 0.54$ GeV/c). The dotted histogram indicates the signal, the dashed one shows the background from 2-pion production.

At the investigated beam momentum all α-particles from the reaction dd $\to \alpha\eta$ can be detected in the forward detector of ANKE. The hardware trigger will be based on the forward hodoscope response. Since the mean energy losses of α's in the hodoscope 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. In off-line analysis events with an α-particle in the exit channel will be selected by a combined energy loss - momentum cut. The reaction dd $\to \alpha\eta$ will be identified - as shown above - by the missing-mass method.

The discussed method of the dd $\to \alpha\eta$ measurement at ANKE does not require the installation of any additional detectors. However, such a possibility has been taken into consideration as well. Namely, it is possible to take advantage of the near-target vertex detector which is going to be constructed. As the final setup of this detector has not been fixed yet, several different, preliminary layouts were checked, that could be built and installed on a short time scale. In the optimal setup (4 silicon detectors, 5cm$\times$6cm each), demanding an α in the forward detectors together with no other charged particle in ANKE or the vertex detector, this would lead to a further background supression: the signal-to-background ratio would improve by a factor of 1.5.

In view of the presented results we decided to apply for a beam time in the second half of 2002. The proposal will be submitted for the PAC meeting April 2002.

References:

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