Final results of the first $dd \to {}^4He\,\eta$ measurement at ANKE[a]

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In 2003 the ANKE collaboration performed measurements of the $dd \to {}^4He\,\eta$ reaction close to threshold [1] in two weeks of beam time, in January and November. The analysis of the first data set, *i.e.* that taken at the excess energies of -2.6 MeV, $+2.6$ MeV and $+7.7$ MeV, has been finalised. The details can be found in refs. [2, 3] and only the main results are summarised here.

Tracks and momenta of ${}^4He$ were reconstructed from signals in the multiwire drift chambers, while energy losses and time-of-flights were measured using the three–layer scintillation hodoscope. A set of two–dimensional cuts was exploited in order to select ${}^4He$ particles: three ΔE–p cuts and two ΔT–p cuts (signals from the 1st layer provided a reference time). The number of events with an η meson accompanying the ${}^4He$ particle was determined by studying the missing–mass spectra in individual angular bins. The shape of the background beneath the η peaks was deduced from analogous spectra obtained below threshold. The absolute normalisation was deduced by comparing the interpolated inclusive ${}^4He$ production data of ref. [4] with the yields observed in our experiment. This normalisation was confirmed through the analysis of another observed process, the $dd \to {}^3He\,n$ yields being compared to the data of ref. [5]. The total cross sections obtained were

$$\sigma_1 = \left(13.1 \pm 0.7_{\rm stat} \pm 1.8_{\rm syst}\right)\ \text{nb} \quad \text{at} \quad Q_1 = 2.6\,\text{MeV}\,,$$
$$\sigma_2 = \left(16.4 \pm 1.0_{\rm stat} \pm 2.1_{\rm syst}\right)\ \text{nb} \quad \text{at} \quad Q_2 = 7.7\,\text{MeV}\,.$$

Fig. 1 is a graphical representation of our results and those of previous experiments [6, 7]. However, the SPESIV results [6] cover only lower excess energies and those of SPESIII were obtained with a polarised deuteron beam of helicity $m = \pm 1$. The latter can only be compared to our cross sections after making certain assumptions on the partial wave composition of the reaction amplitude. These can only be verified through the determination of angular distributions and deuteron tensor analysing powers.

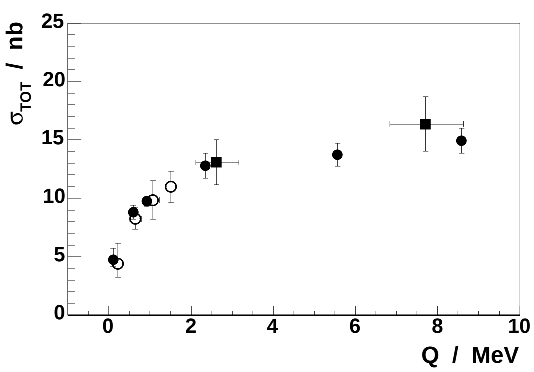

Fig. 1: Our results (squares) compared to the data on the $dd \to {}^4He\,\eta$ total cross section obtained at Saclay ([6] – open circles, [7] – full circles, data obtained with polarised beam).

Fig. 2 presents the angular distributions of the η meson from the $dd \to {}^4He\,\eta$ reaction measured in our experiment. Statistical errors are attached to the data points and the systematic errors, obtained by varying the analysis conditions within their uncertainties, are shown as histograms. Solid lines represent a constant and quadratic fits for the lower and higher excess energy, respectively. The two types of errors were added in quadrature for fitting purposes.

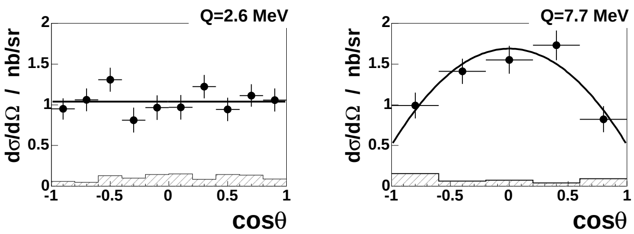

Fig. 2: Angular distributions of the η meson produced in the $dd \to {}^4He\,\eta$ reaction at the two excess energies investigated in the January beam time. Error bars represent statistical errors and the systematic ones are drawn as histograms.

While consistent with isotropy at the lower energy, *i.e.* with s-wave production, the angular distribution at the higher energy reveals a strong anisotropy, indicating the onset of higher partial waves. This result brings into question the scaling used in ref. [7] to obtain the unpolarised cross section from the polarised one.

The possibility of higher partial waves influences also the determination of the s–wave $\eta\alpha$ scattering length, which is a key quantity in studying the $\eta\alpha$ quasi–bound state hypothesis. This requires the s-wave production to be isolated. However, as we showed in ref. [3], the knowledge of the angular distributions alone is insufficient to decompose unambiguously the reaction amplitude into partial waves. For this purpose one needs also polarisation observables. Our experiment has shown, at which energies such measurements should be started. An experiment performed in autumn 2003 by the GEM collaboration [8] is designed to provide such deuteron analysing powers.

The data collected in the November run at $Q = 22$ MeV and $Q = 43$ MeV are still under analysis. Due to the smaller statistics, we will probably extract only total cross sections at these energies.

References:

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