Status of the search for $(^4\text{He-}\eta)_{bs}$ by means of the WASA-at-COSY facility

W. Krzemien[a], P. Moskal[a,b], M. Skurzok[a] for the WASA collaboration

In June 2008, the search for the ^{4}He-η bound state was performed by measuring the excitation function of the $dd \rightarrow {}^3\text{He}p\pi^-$ reaction near the η production threshold. During the experimental run the momentum of the deuteron beam was varied continuously within each acceleration cycle from 2.185 GeV/c to 2.400 GeV/c, crossing the kinematic threshold for the η production in the $dd \rightarrow {}^4\text{He}\eta$ reaction at 2.336 GeV/c. This range of beam momenta corresponds to a variation of ^{4}He-η excess energy from -51.4 MeV to 22 MeV. The integrated luminosity in the experiment was determined using the $dd \rightarrow {}^3\text{He}n$ reaction and equals 118±14 nb^{-1}. The relative normalization of the $dd \rightarrow {}^3\text{He}p\pi^-$ excitation function was based on quasi-elastic proton-proton scattering.

The excitation function was determined after applying cuts on the ^{3}He momentum distribution, the p and π^- kinetic energy distribution and the $p-\pi^-$ opening angle in the CM system [1]. The result is shown in Fig. 1. The excitation function does not show a structure which could be interpreted as a resonance originating from the decay of an η-mesic ^{4}He.

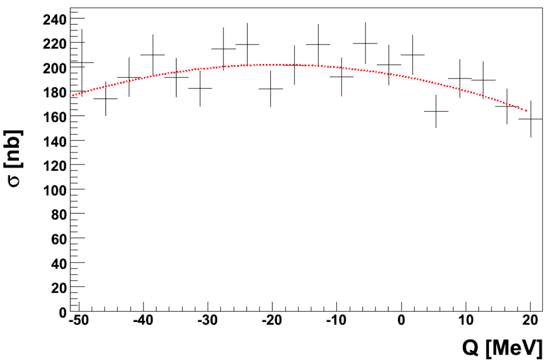

Fig. 1: Excitation function for the $dd \rightarrow {}^3\text{He}p\pi^-$ reaction obtained by normalizing number of events by corresponding integrated luminosities separately in individual excess energy intervals. The solid line represents a fit with second order polynomial.

In the experiment, in November 2010, two channels were measured: $dd \rightarrow (^4\text{He-}\eta)_{bs} \rightarrow {}^3\text{He}p\pi^-$ and $dd \rightarrow (^4\text{He-}\eta)_{bs} \rightarrow {}^3\text{He}n\pi^0 \rightarrow {}^3\text{He}n\gamma\gamma$. The measurement was performed with a beam momentum ramping from 2.127GeV/c to 2.422GeV/c, corresponding to the range of the excess energy Q∈(-70,30) MeV.

Luminosity is determined based on the $dd \rightarrow {}^3\text{He}n$ reaction in which, because of the binary character of the reaction, the helium ions can be easily separated from the helium originating from three- or four-body reactions.

Monte Carlo simulations for $dd \rightarrow {}^3\text{He}n$ reaction carried out with the cross section parametrization described in details in [2] show that outgoing ^{3}He is stopped in third and fourth FRH layer while neutron is going into Central Detector. It is schematically presented in Fig. 2.

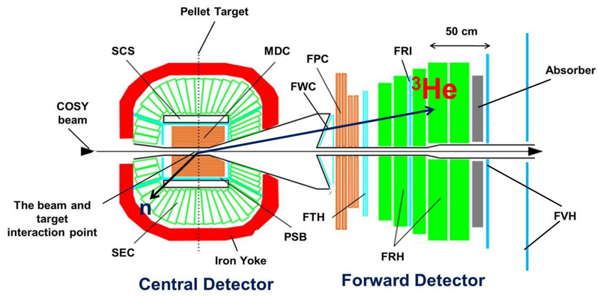

Fig. 2: Scheme of the WASA-at-COSY detection system with tagged $dd \rightarrow {}^3\text{He}n$ reaction. Helium is here registered in Forward Detector whereas neutron is going to Central Detector.

To disentangle the ^{3}He from all charged particles in FD a cut in the Edep(FRH1) vs Edep(FRH2) spectrum was applied (Fig. 3 left). In the next step of the analysis, helium stopped in FRH3 or in FRH4 (Fig. 3 right) was taken into account. Due to low neutron detection efficiency in CD, number of $dd \rightarrow {}^3\text{He}n$ events is determined from missing mass spectrum after cut rejecting three and four-body reactions.

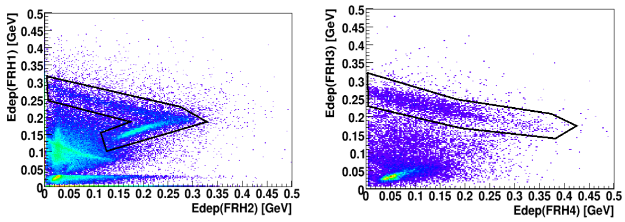

Fig. 3: Cuts: on energy deposited in FRH1 versus energy deposited in FRH2 (left) and on Edep(FRH3) vs. Edep(FRH4) spectrum (right).

The analysis is in progress. Taking into account the time of measurement, high acceptance for the reaction and integrated luminosity estimated based on registered quasi-elastic scattering reactions, we expect the number of $dd \rightarrow {}^3\text{He}n$ events in the order of 30 millions. This statistics is high enough to determine the luminosity as an function of beam momentum without using additional quasi-elastic reactions.

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References:

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[a] M. Smoluchowski Institute of Physics, Jagiellonian University, 30-059 Cracow, Poland

[b] IKP, Forschungszentrum Jülich, D-52425 Jülich, Germany