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

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Measurement of the ^{4}He-η bound states is performed with unique precision with the WASA detector installed at the Cooler Synchrotron COSY. Signals of the η-mesic nuclei are searched for via studying the excitation function of specific decay channels of the ^{4}He-η system, formed in deuteron-deuteron collision [1]. The measurement is performed for beam momenta varying continously around the threshold. The beam ramping technique allows to reduce the systematic uncertainities. The existence of the bound system should manifest itself as a resonance-like structure in the excitation curve of eg. $dd \rightarrow (^4\text{He-}\eta)_{bs} \rightarrow {}^3\text{He}p\pi^-$ reaction below the $dd \rightarrow {}^4$He-η reaction threshold. This reaction is schematically presented in Fig. 1.

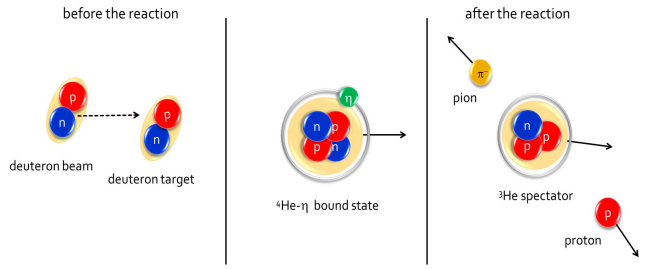

Fig. 1: Schematic picture of the $dd \rightarrow (^4\text{He-}\eta)_{bs} \rightarrow {}^3\text{He}p\pi^-$ reaction. Red and blue circles represent protons and neutrons respectively, further more π^- meson is depicted as yellow circle. The beam momentum is indicated by the dashed arrow [2].

During the experiment, in November 2010, two channels of the eta-mesic helium decay 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 the beam momentum ramping from 2.127GeV/c to 2.422GeV/c, corresponding to the range of excess energy Q$\in$(-70,30)MeV.

For both of reactions the geometrical acceptance of the detector as a function of the excess energy Q near the kinematical threshold for η meson production was determined in simulations [2]. It is presented in Fig. 2 for different bound state widths and AV18 model describing nucleon momentum distribution inside the ^4He nuclei. The detailed description of the simulations is presented in Ref. [2]. The acceptance is almost a constant function of the excess energy and its average value is about 53% and 50% for $dd \rightarrow (^4\text{He-}\eta)_{bs} \rightarrow {}^3\text{He}p\pi^-$ and $dd \rightarrow (^4\text{He-}\eta)_{bs} \rightarrow {}^3\text{He}n\pi^0 \rightarrow {}^3\text{He}n\gamma\gamma$, respectively. The high acceptance values allow high statistics measurements of these final states.

During the experiment, data were effectively taking for about 167 hours. However, because the cooling system of Superconducting Solenoid failed, the measurement with magnetic field was carried out for only 41 hours. The total integrated luminosity was estimated based on the trigger used for the elastic proton-proton scattering (trigger No. 17 assuming that 220kHz corresponds to L=$4{\cdot}10^{30} cm^{-2}s^{-1}$) and is equaled to about L=$8.5{\cdot}10^{30} cm^{-2}s^{-1}$. Taking into account the fact that there were two reactions measured, in total more than 40 times higher statistics were collected than in 2008. At present the data analysis is in progress. In optimistic case the statistics could be sufficient to observe a signal from the η-mesic helium and in the pesimistic scenario we will decrease the upper limit of the cross section for the ^{4}He-η bound state production by a factor of about six.

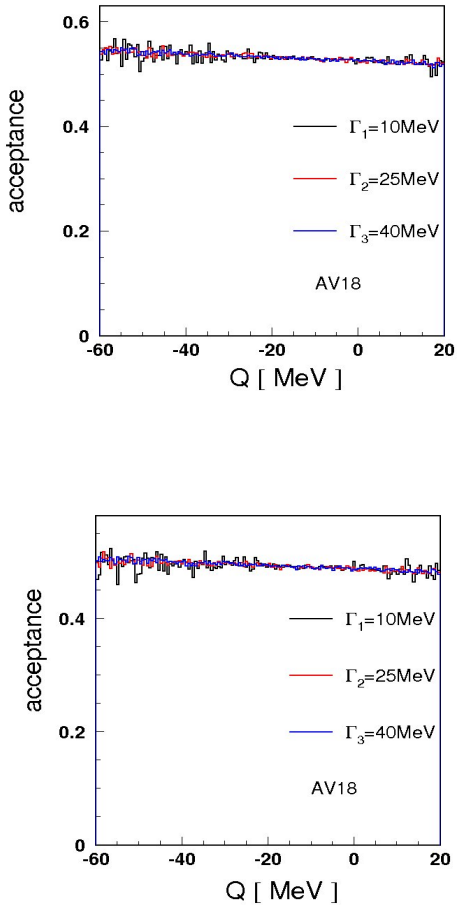

Fig. 2: Geometrical acceptances of the WASA-at-COSY detector for the $dd \rightarrow (^4\text{He-}\eta)_{bs} \rightarrow {}^3\text{He}p\pi^-$ (top) and $dd \rightarrow (^4\text{He-}\eta)_{bs} \rightarrow {}^3\text{He}n\pi^0 \rightarrow {}^3\text{He}n\gamma\gamma$ reaction (down). Acceptance is calculated for three different bound state width values and AV18 potencial model describing the momentum distribution of the nucleons inside ^{4}He.

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References:

[1] P. Moskal, *arXiv:0909.3979* (2009).
[2] M. Skurzok, *Diploma Thesis, Jagiellonian University of Cracow* (2010), Berichte des FZ-Jülich, Jül-4332 (2010), *arXiv:1009.5503* (2010).

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