Feasibility study of ^{3}H-η bound states production by means of the COSY-TOF facility

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Formation of η-mesic Tritium might be realized by quasi-free reactions as already successfully used at COSY to study meson production in quasi free proton-neutron collisions [1, 2]. Measurements of such reactions is possible for the external COSY-TOF detector, where the search for η-mesic Tritium can be carried out by the measurement of the excitation function of the $nd \to (^3\text{H-}\eta)_{bs} \to dp\pi^-$ reaction using a deuteron beam and tagging the nd reactions by measuring the spectator protons (p_{sp}) from the $dd \to p_{sp}nd \to p_{sp}(^3\text{H-}\eta)_{bs} \to p_{sp}dp\pi^-$ reaction, which is schematically schown in Fig. 1. The signal from $(^3\text{H-}\eta)_{bs}$ is expected below the threshold of the $nd \to {}^3\text{H-}\eta$ production [3].

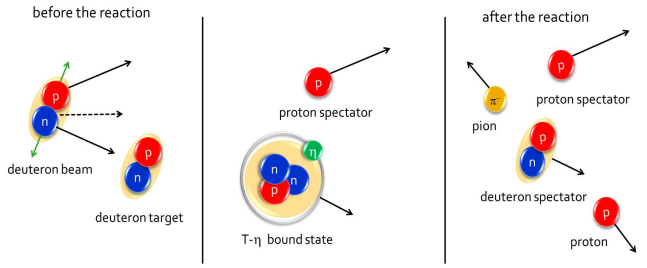

Fig. 1: Schematic picture of the quasi-free $dd \to p_{sp}nd \to p_{sp}(^3\text{H-}\eta)_{bs} \to p_{sp}dp\pi^-$ reaction. The Fermi momentum of the nucleons inside the deuteron is presented by the green arrows and the beam momentum by the dashed arrow. The figure is adapted from reference [4].

The systematic uncertainties in establishing the shape of the excitation functions are significantly reduced when using this method, because in the case of quasi-free reaction the energy scan (in the range of about 100 MeV) around the η meson production threshold can be achieved from the Fermi motion of the nucleons inside the deuteron beam at a fixed value of the beam momentum.

The feasibility of the measurement of the $(^3\text{H-}\eta)_{bs}$ bound states production via quasi-free reaction: $dd \to p_{sp}nd \to p_{sp}(^3\text{H-}\eta)_{bs} \to p_{sp}dp\pi^-$ with COSY-TOF detection setup is analised in Reference [4]. The effective detector acceptances as a function of the beam momentum were determined and are presented in Fig. 2 and Fig. 3. From the dependence shown in those figures it follows that the highest probability to register the quasi-free $dd \to p_{sp}(^3\text{H-}\eta)_{bs} \to p_{sp}dp\pi^-$ reaction is for the beam momentum p_{beam}=3.1 GeV/c corresponding to the $dd \to p_{sp}(p_F = 0)^3\text{H-}\eta$[1] reaction threshold whereas for beam momenta above and below the threshold the effective acceptance decreases. Thus, the measurement of quasi-free reaction products is the most efficient at the η meson production threshold.

[1] p_F−Fermi momentum of proton spectator inside beam deuteron.

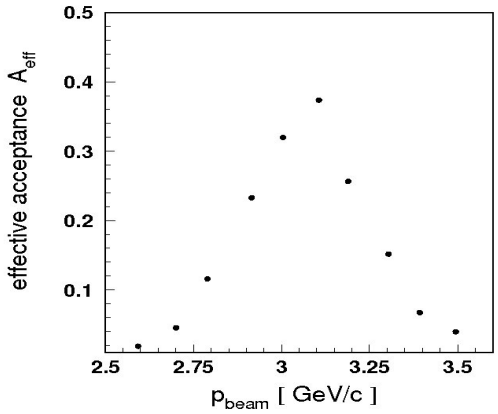

Fig. 2: Effective acceptance to register the quasi-free $dd \to p_{sp}(^3\text{H-}\eta)_{bs} \to p_{sp}dp\pi^-$ reaction near the η production threshold (Q∈(-60,20) MeV) as a function of the beam momentum.

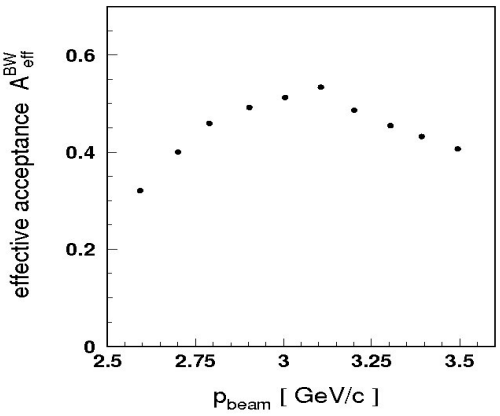

Fig. 3: Effective acceptance to register the quasi free $dd \to p_{sp}(^3\text{H-}\eta)_{bs} \to p_{sp}dp\pi^-$ reaction near the η production threshold (Q∈(-60,20) MeV) as a function of the beam momentum assuming a Breit-Wigner distribution of the squared invariant mass $\sqrt{s_{nd}}$ for the bound state width Γ=10MeV.

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References:

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