Search for ^{4}He-η bound states in dd->^{3}He p π^- and dd->^{3}He n π^0 reactions with the WASA-at-COSY facility

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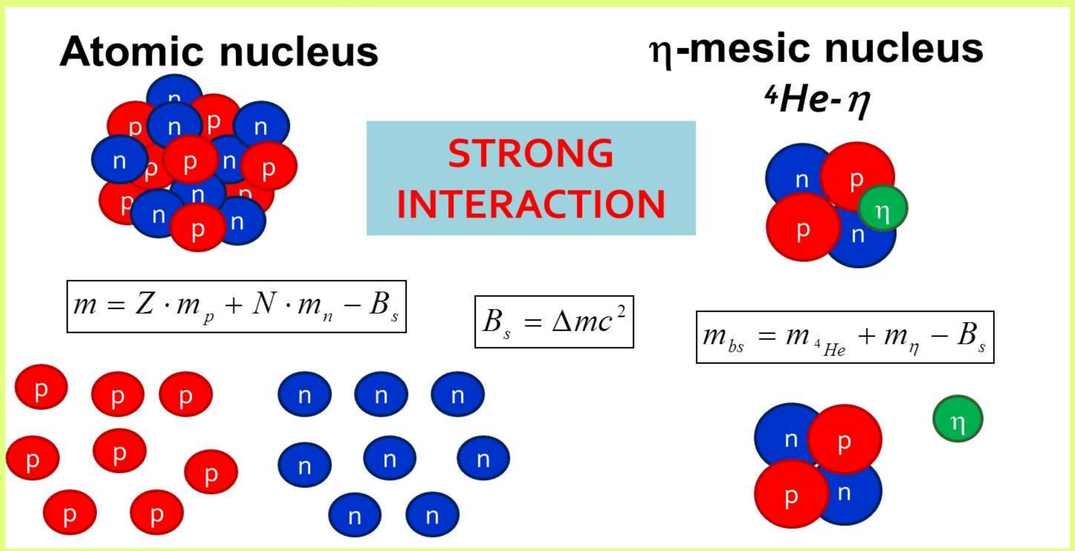
1. Introduction

The existence of **η-mesic nuclei** in which the η meson is bound in a nucleus with the strong interaction was postulated already in 1986 [1] but it has not been yet experimentally confirmed. The discovery of this new kind of an exotic nuclear matter would be very important as it might allow for a better understanding of the η meson structure and its interaction with nucleons [2,3]. The search for **η-mesic helium (^{4}He-η)** is carried out with high statistics and high acceptance with the **WASA detector**, installed at the cooler synchrotron COSY in the Research Center Jülich [4,5,6].

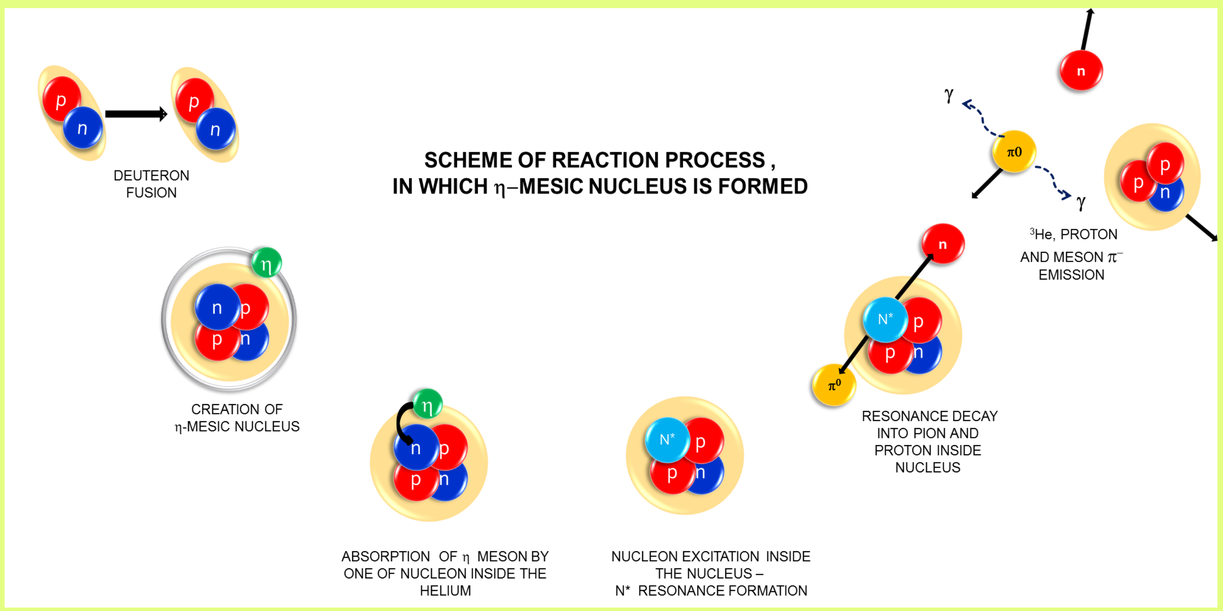
2. η-mesic bound state (^{4}He-η)

analogy to atomic nucleus



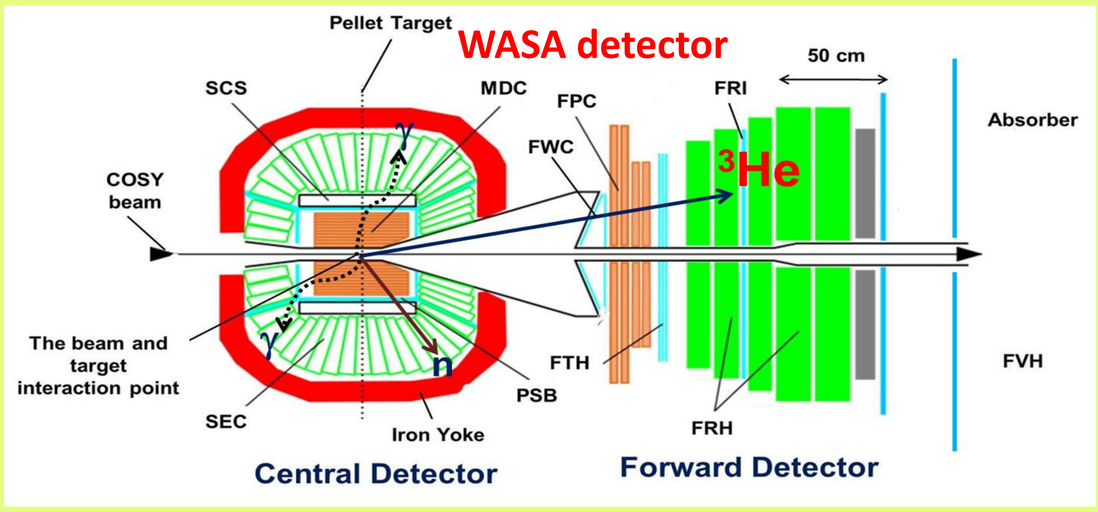
3. Production of ^{4}He-η in dd collision

$$dd \rightarrow \left({}^4He-\eta\right)_{bs} \rightarrow {}^3He\ p\ \pi^-$$
$$dd \rightarrow \left({}^4He-\eta\right)_{bs} \rightarrow {}^3He\ n\ \pi^0 \rightarrow {}^3He\ n\ \gamma\ \gamma$$



(^{4}He-η) bound state existence manifested by resonant-like structure below **η** production threshold

4. Experiment (No. 186.2)



Beamtime: Nov/Dec 2010
Measurement: beam momentum ramped from **2.127GeV/c** to **2.422GeV/c**, corresponding to the range of the excess energy **Q∈(-70,30)MeV, T=154h, A=53%**

5. Data analysis

2008: dd->^{3}He p π^-

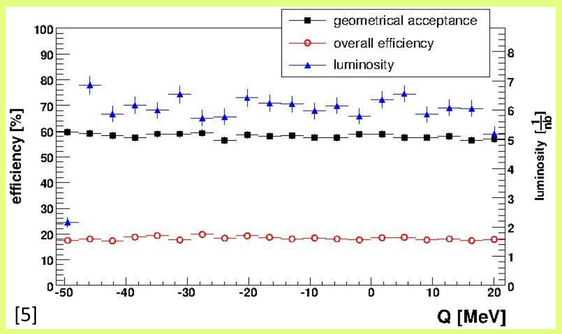


Fig.1. Geometrical acceptance (full squares), overall efficiency (open circles) and luminosity (full triangles) as a function of the excess energy. The right axis of coordinates denotes the luminosity.

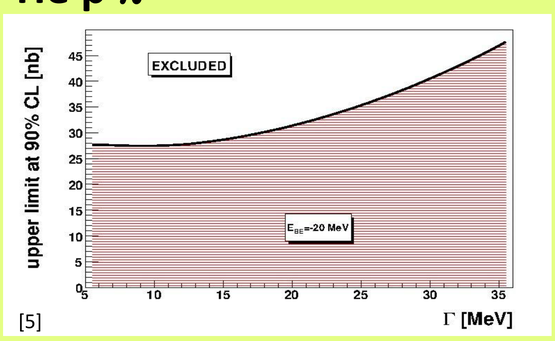


Fig.2. Upper limit at 90% confidence level of the cross-section for formation of the (^{4}He-η) bound state and its decay via the dd->^{3}He p π^- reaction as a function of the width of the bound state. The binding energy was set to E_{BE}=-20MeV.

2010: dd->^{3}He n π^0

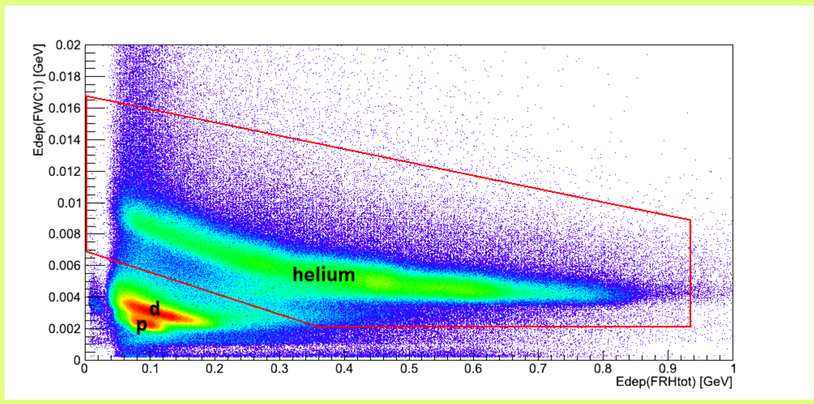


Fig.3. The ^{3}He outgoing in considered reaction is identified in Forward Detector based on ΔE-E method. The helium is disentangled from other charged particles (deuterons, protons, pions) using cut in the spectrum of energy deposited in first layer of Forward Window Counter (FWC1) versus energy deposited in Forward Range Hodoscope (FRH_{to}): Edep(FWC1) vs Edep(FRH_{tot}). Applied cut is marked with red colour.

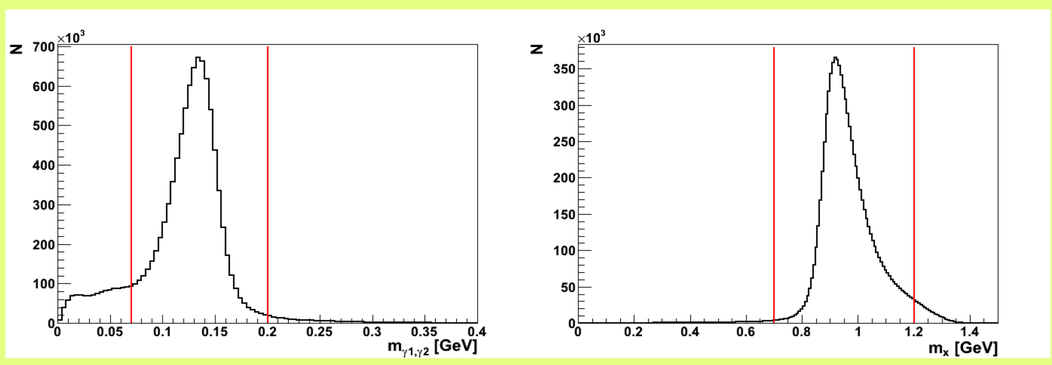


Fig.4. The neutral pion π^0 is reconstructed in the Central Detector from the invariant mass of two gamma quanta originating from its decay (left panel) while the neutron four-momentum was calculated using the missing mass technique (right panel). The cuts applied in analysis are marked with red lines.

6. References

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