Search for He-η bound states with the WASA-at-COSY facility

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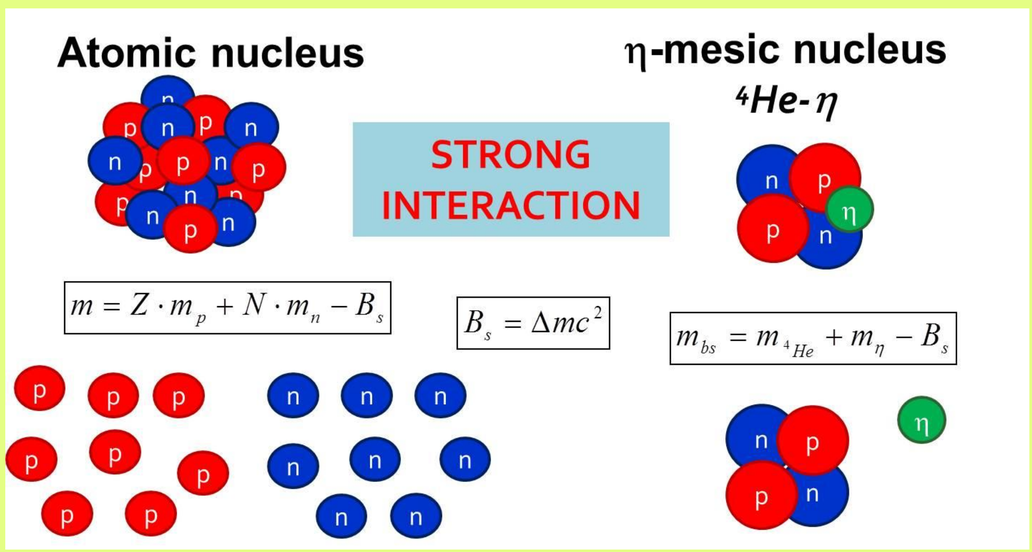
1. Introduction

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].

2. η-mesic bound state (^{4}He-η)

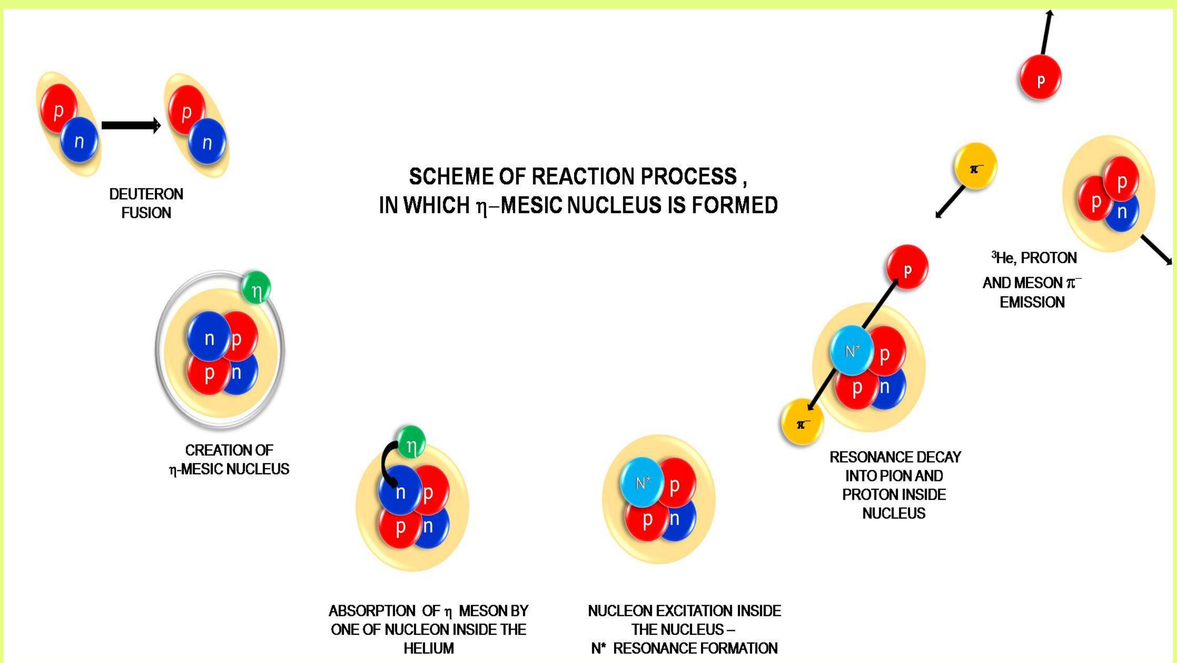
analogy to atomic nucleus



Conditions for the existence of eta-mesic nuclei ⇨ $\mathrm{Re}\,a_{\eta-nucleus} < 0$ and $|\mathrm{Re}\,a_{\eta-nucleus}| > |\mathrm{Im}\,a_{\eta-nucleus}|$

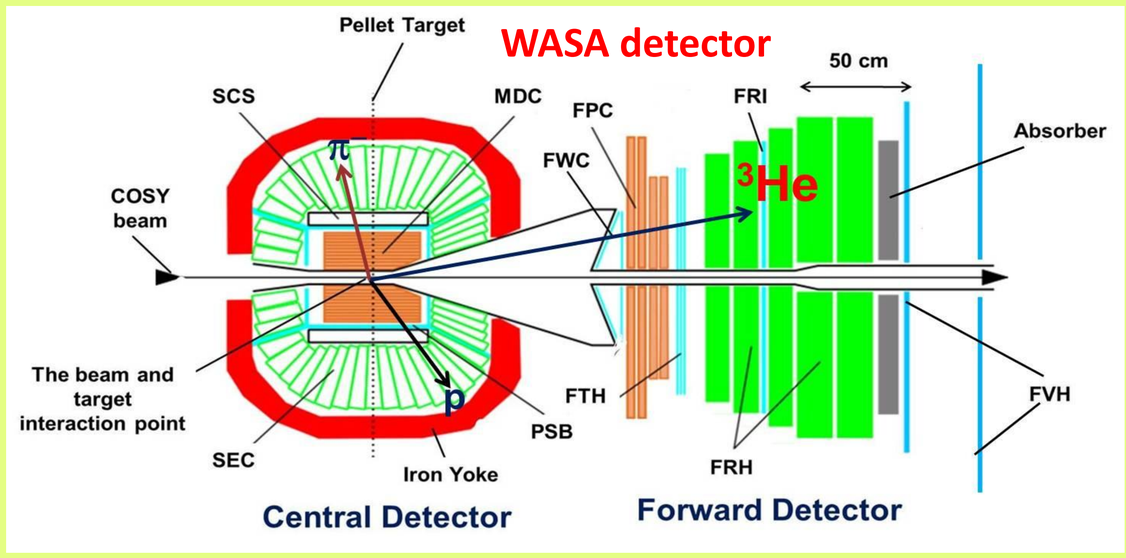
3. Production of ^{4}He-η in dd collision

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



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

4. Experiment (No. 186.2)



Beamtime: Nov 26 - Dec 13, 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%, L=1.5·10^{31} 1/cm^2·s

more than **40 times higher** statistics were collected than in experiment carried out in 2008

5. Data analysis

Luminosity determination based on the **dd->^{3}Hen** reaction:

$$L = \sum_i \frac{\frac{dN}{d\Omega}(\cos\theta, p_i)}{\frac{d\sigma}{d\Omega}(\cos\theta, p_i) \cdot \varepsilon(\cos\theta, p_i)}$$

$\frac{d\sigma}{d\Omega}$-differential cross section
ε-reconstruction efficiency from MC
N- number of **dd->^{3}Hen** events

average luminosity
L=1.5·10^{31} 1/cm^2·s

PRELIMINARY! 2010

PRELIMINARY! 2008

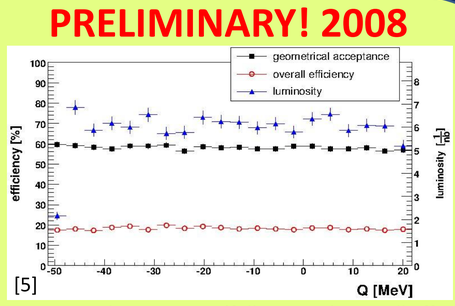


Fig.1. Geometrical acceptance (full squares), overall efficiency (open circles) and luminosity (full triangles) as a function of the excess energy. The right axis of coordinates denotes the luminosity.

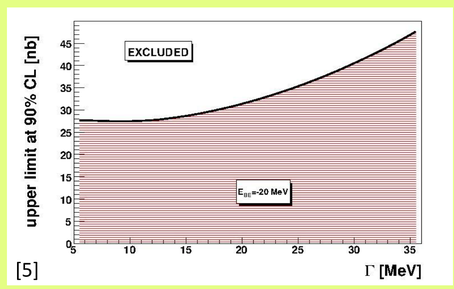


Fig.2. Upper limit at 90% confidence level of the cross-section for formation of the (^{4}He-η) bound state and its decay via the dd->^{3}He p π^- reaction as a function of the width of the bound state. The binding energy was set to E_{BE}=-20MeV.

6. References

[1] Q. Haider, L.C. Liu, Phys. Lett. B 172 (1986) 257.
[2] T. Inoue, E. Oset, Nucl. Phys. A 710 (2002) 354.
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[4] M. Skurzok, P. Moskal, W. Krzemien, Prog. Part. Nucl. Phys. 67, 445 (2012).
[5] W. Krzemień, Ph.D. Thesis, Jagiellonian University 2011, *arXiv: 1202.5794*.

INNOWACYJNA GOSPODARKA
NARODOWA STRATEGIA SPÓJNOŚCI
UNIWERSYTET JAGIELLOŃSKI W KRAKOWIE
FNP Fundacja na rzecz Nauki Polskiej
UNIA EUROPEJSKA EUROPEJSKI FUNDUSZ ROZWOJU REGIONALNEGO

Supported by FFE grants of Research Center Juelich and Polish National Science Centre (0320/B/H03/2011/40, 2011/01/B/ST2/00431)