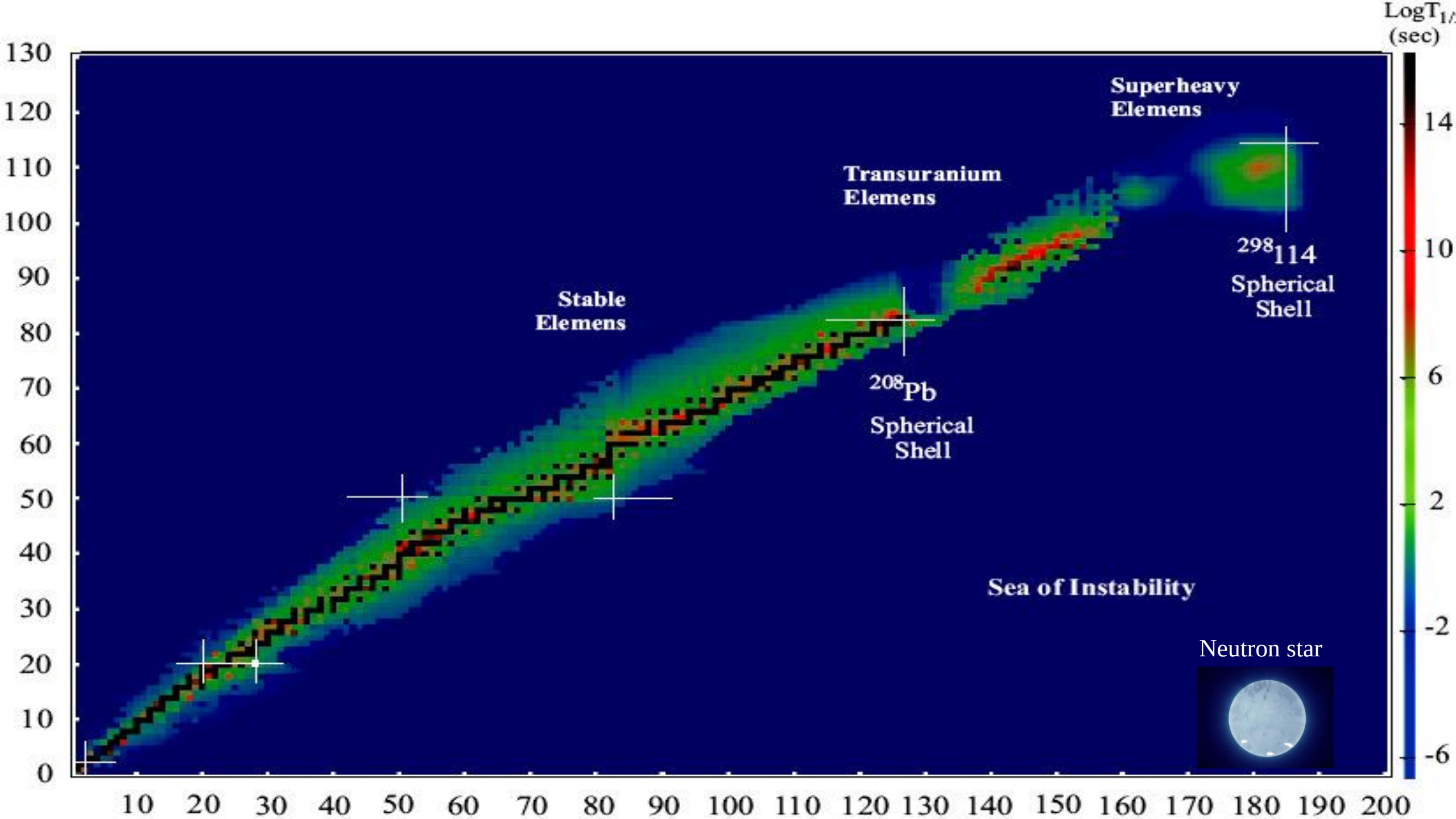
Search for ^{7}H at ACCULINNA-2

Ivan Muzalevskii

for ACCULINNA-2 collaboration

AYSS, 2020


Log$T_{1/2}$ (sec)
14
10
6
2
-2
-6
Superheavy Elemens
Transuranium Elemens
Stable Elemens
^{298}114
Spherical Shell
^{208}Pb
Spherical Shell
Sea of Instability
Neutron star
130
120
110
100
90
80
70
60
50
40
30
20
10
0
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

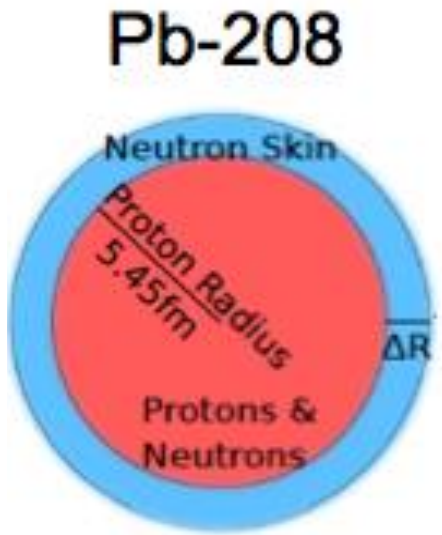
Exotic nuclei

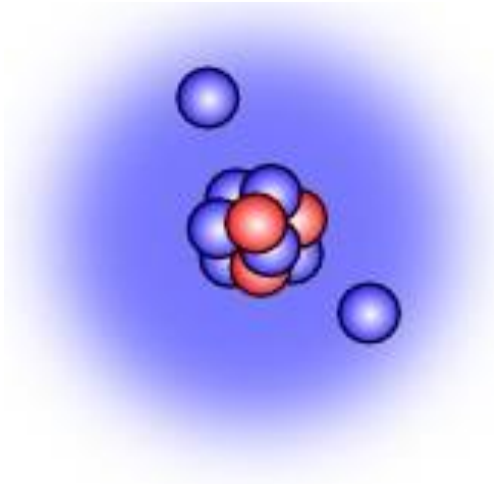
- **Unique phenomena**

–Halos and skins

–New types of excitation and radioactivity

–Appearance of new magic numbers etc.





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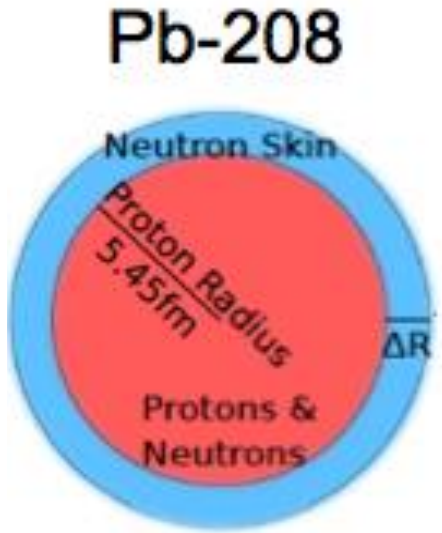
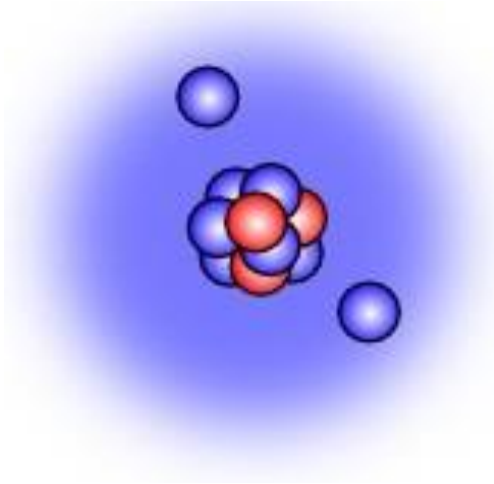
- **Light exotic nuclei**

–**Easy approach for structure studies**

–Effective way to **test** modern theoretical models





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- **Unique phenomena**

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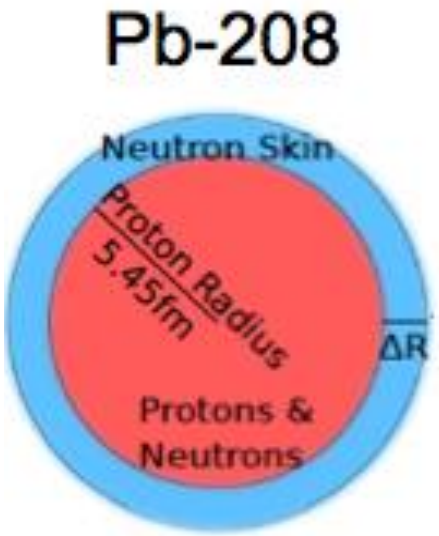
- **^{7}H uniqueness:**

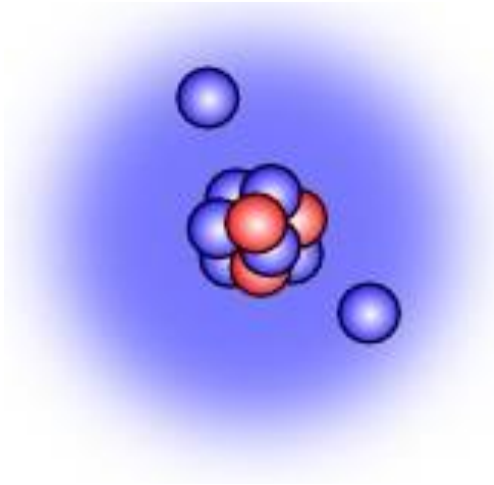
–Lifetime < 10^{-12} s

–Z/M = 1/7

–5-body decay expected

–Candidate for 4-neutron radioactivity

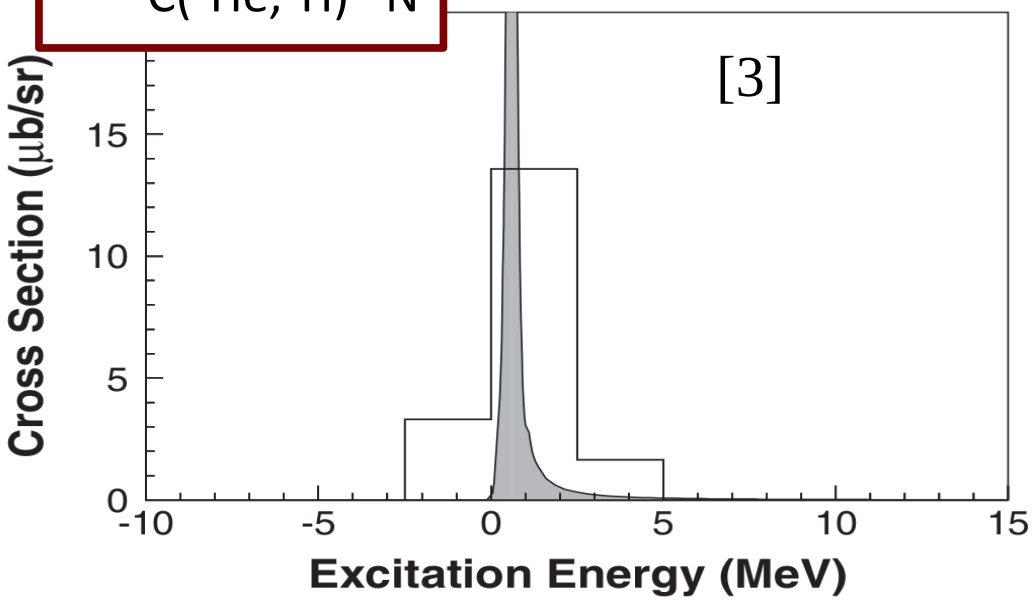




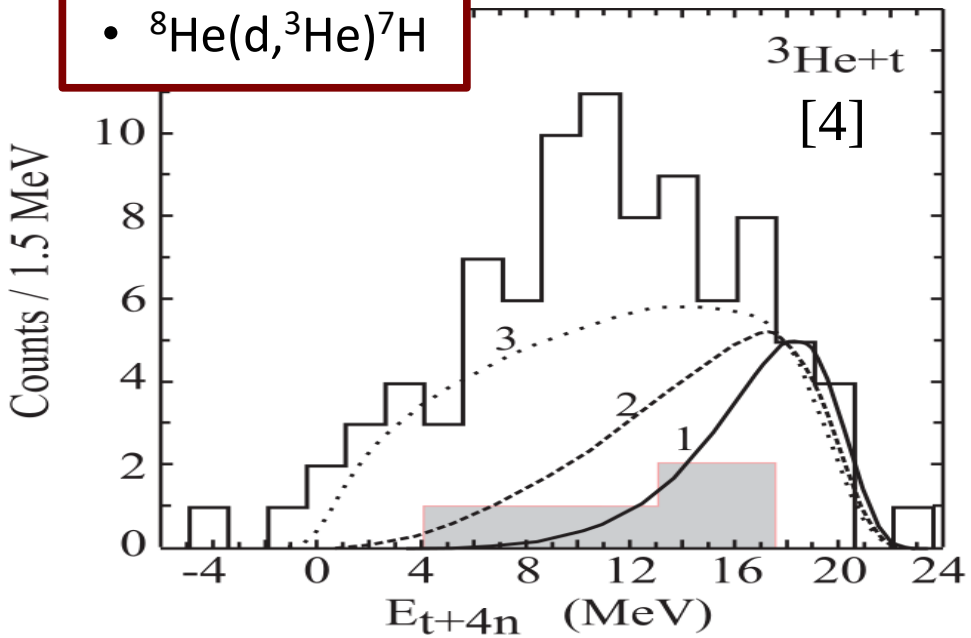
History

- Existence suggested in 1960 [1]
- Indication in three experimental works [2,3,4]

- $^{12}C(^{8}He,^{7}H)^{13}N$



- $^{8}He(d,^{3}He)^{7}H$



[1] Ya.B. Zel'dovich Zh. Eksp. Teor. Fiz. 38 1123 (1960)
[2] A. A. Korsheninnikov et al., Phys. Rev. Lett. 90, 082501 (2003);
[3] M. Caamaño et al., Phys. Rev. Lett. 99, 062502 (2007);
[4] E . Yu. Nikolskii et al., Phys. Rev. C 81 064606 (2010);

Only the limits estimation of the lifetime, ground state energy and the cross section, as well as the existence of obvious contradictions in the results with **[3]** make ^{7}H problem open

Experimental idea

ACCULINNA-2

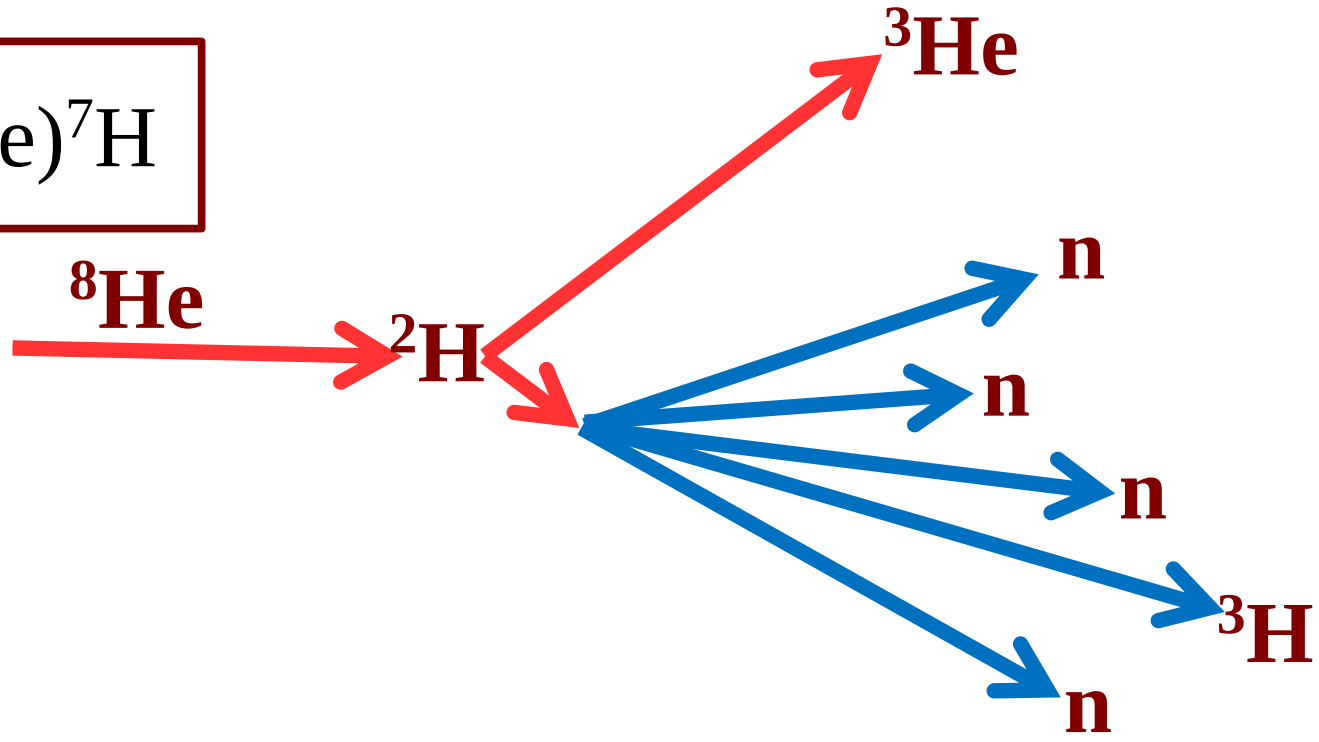
26 AMeV ^{8}He beam, :

~10^{5} pps,

~26 AMeV,

~90% purity

^{2}H(^{8}He,^{3}He)^{7}H



coincidences of ^{3}He-^{3}H considered as ^{7}H events

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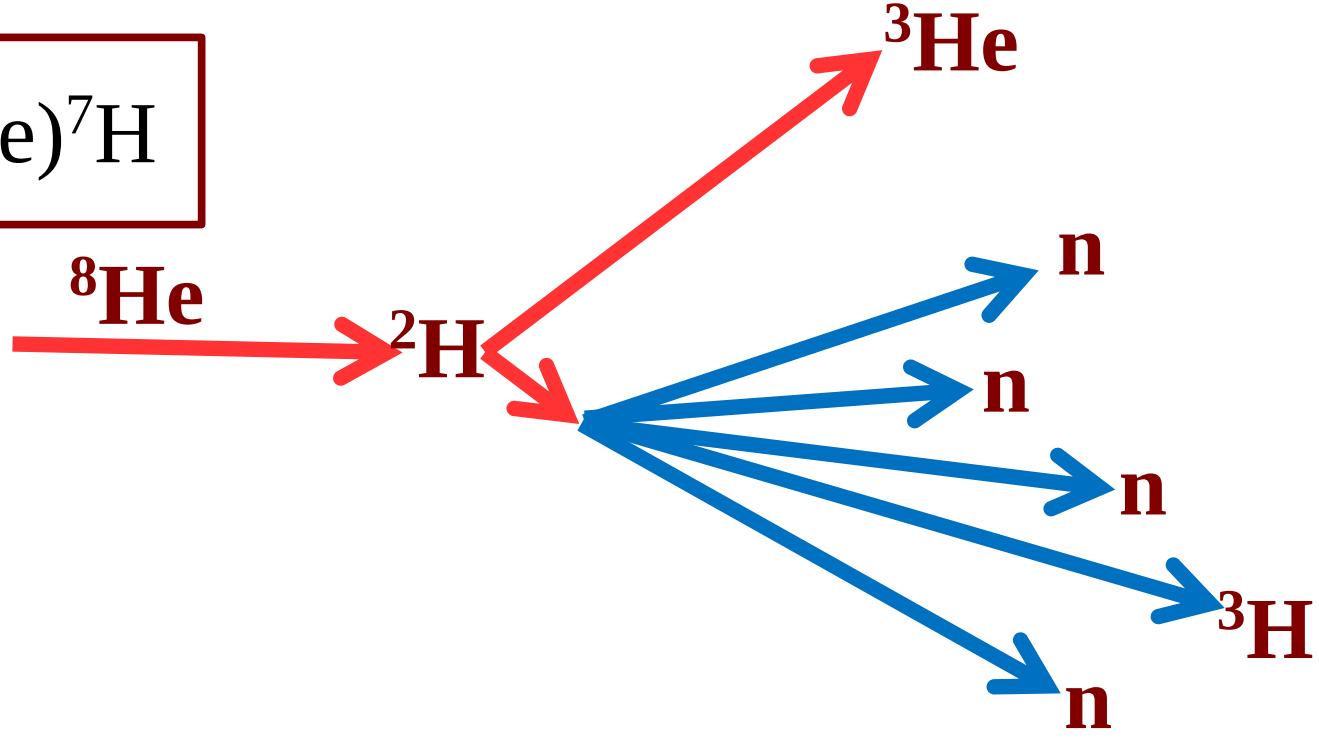


coincidences of ^{3}He-^{3}H considered as ^{7}H events

Missing mass method:

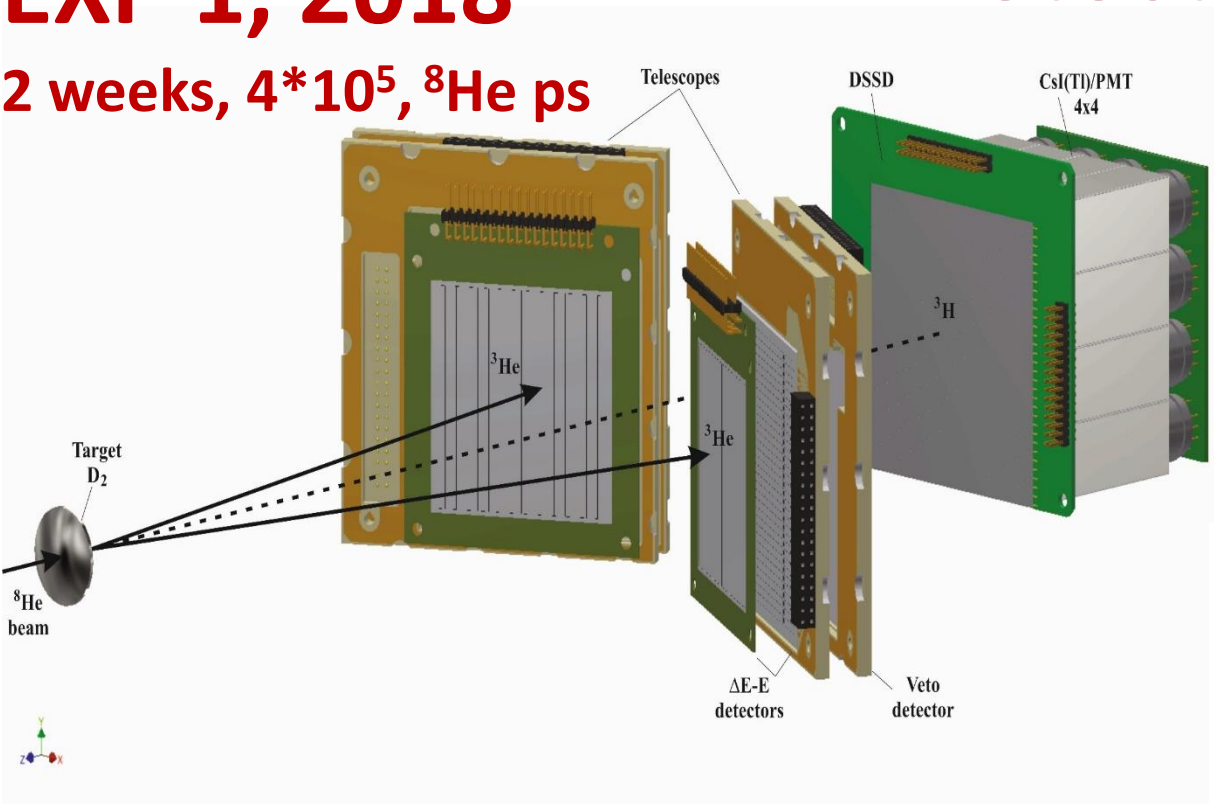
$$\vec{p}_{8He} + \vec{p}_{2H} \rightarrow \vec{p}_{3He} + \vec{p}_{7H}$$

$$|M_{7H}| = \sqrt{\vec{p}_{8He} + \vec{p}_{2H} - \vec{p}_{3He}}$$

Detector system

EXP 1, 2018

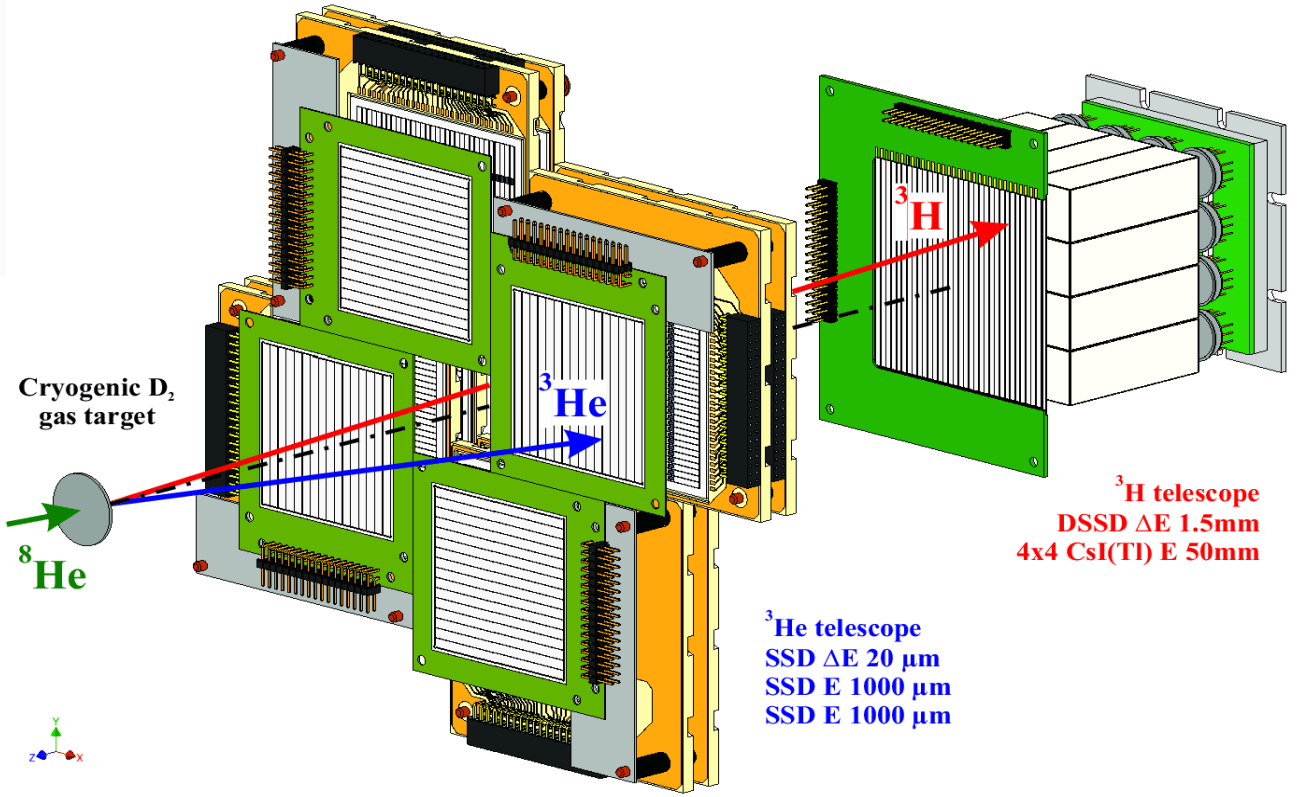
2 weeks, 4*10^5, ^{8}He ps



- Energy resolution for the ^{7}H missing mass ~1.1 MeV
- Efficiency of ^{3}He-^{3}H coincidence ~65%
- Key advantage: ^{3}H detection with angular resolution ~ 0.5 deg, energy resolution 2%

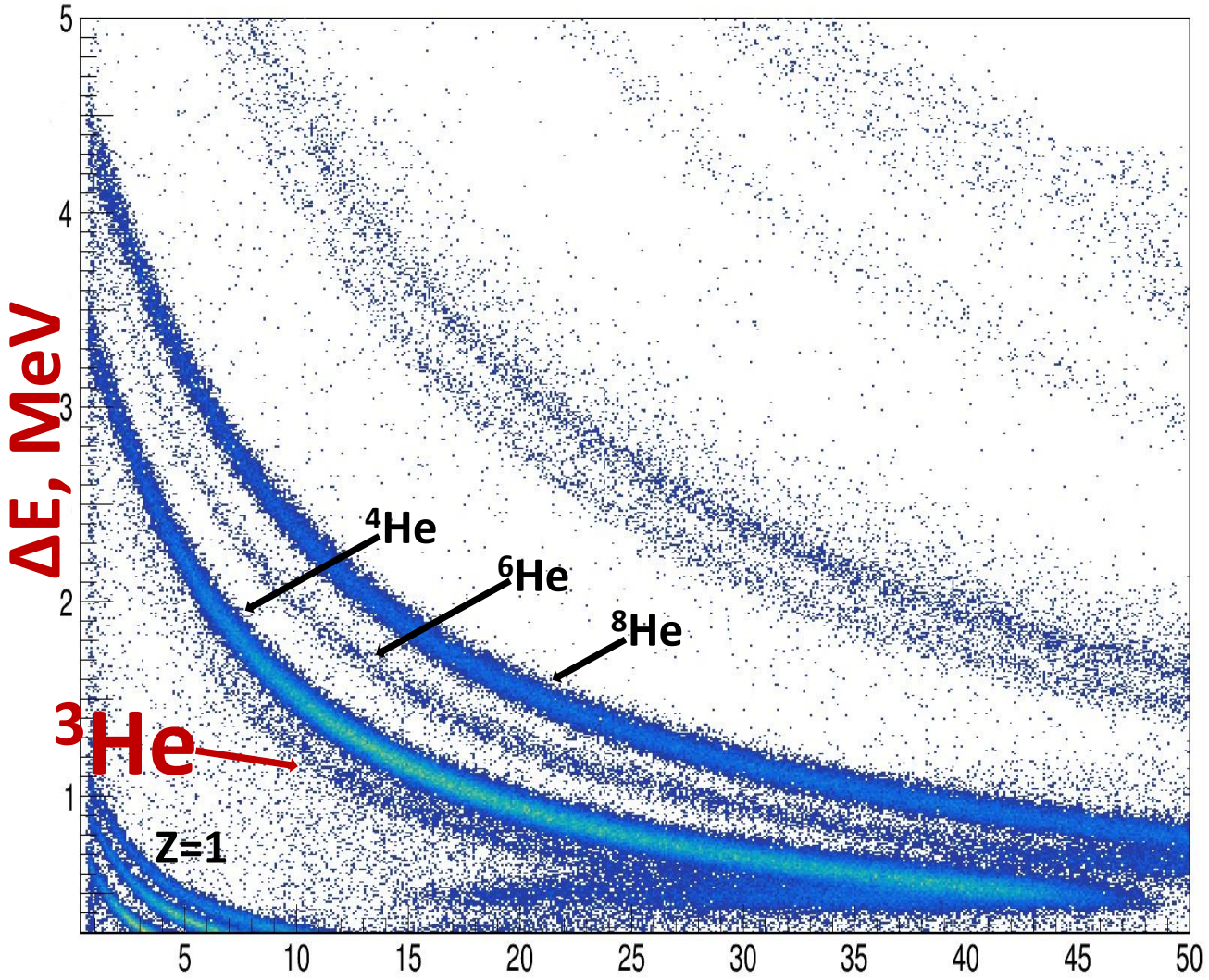
EXP 2 , 2019

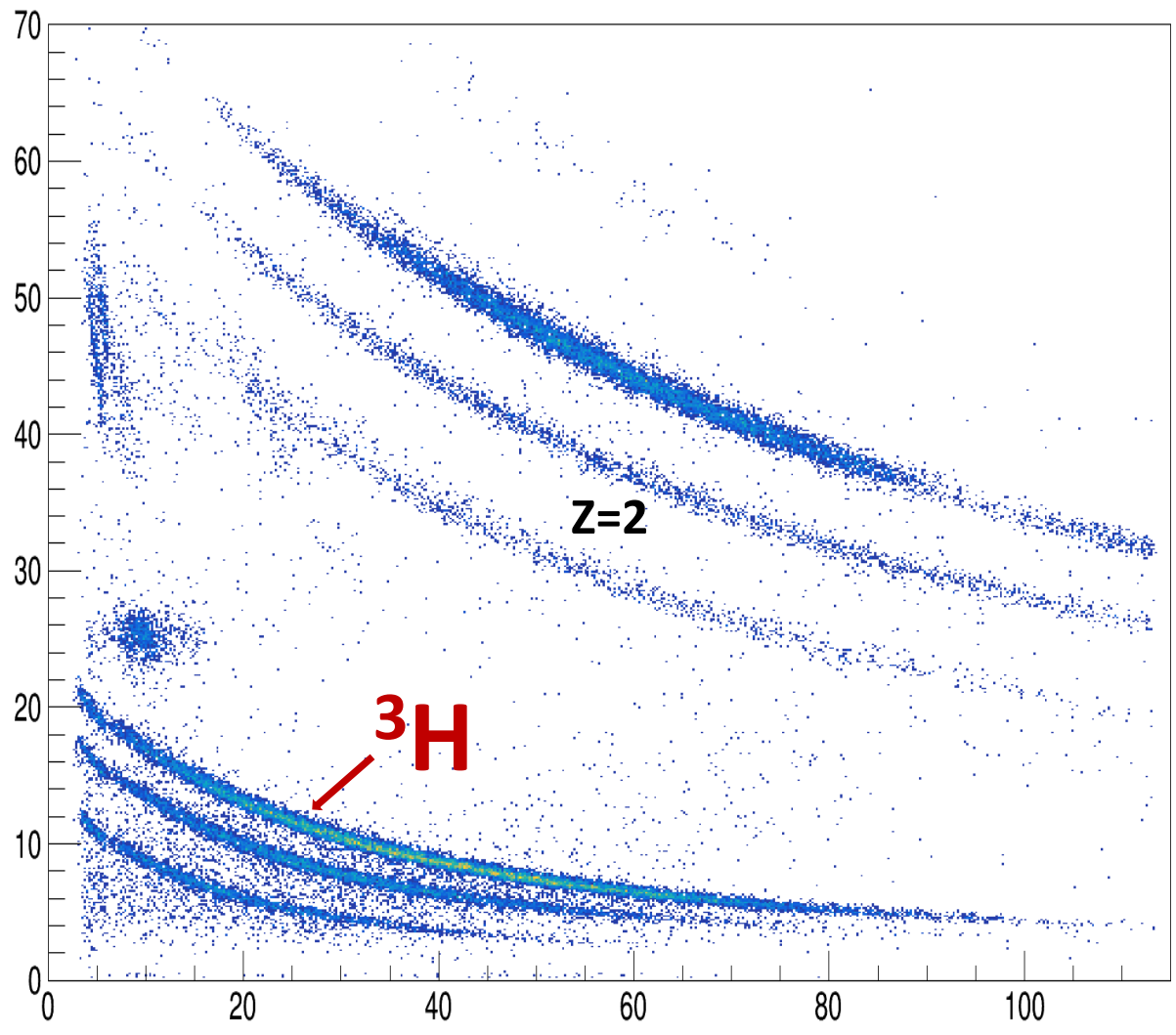
3 weeks, 3*10^5, ^{8}He ps



Particle identification

$^{2}H(^{8}He,^{3}He)^{7}H$, $^{7}H \rightarrow {}^{3}H+4n$, coincidences of ^{3}He-^{3}H considered as ^{7}H events

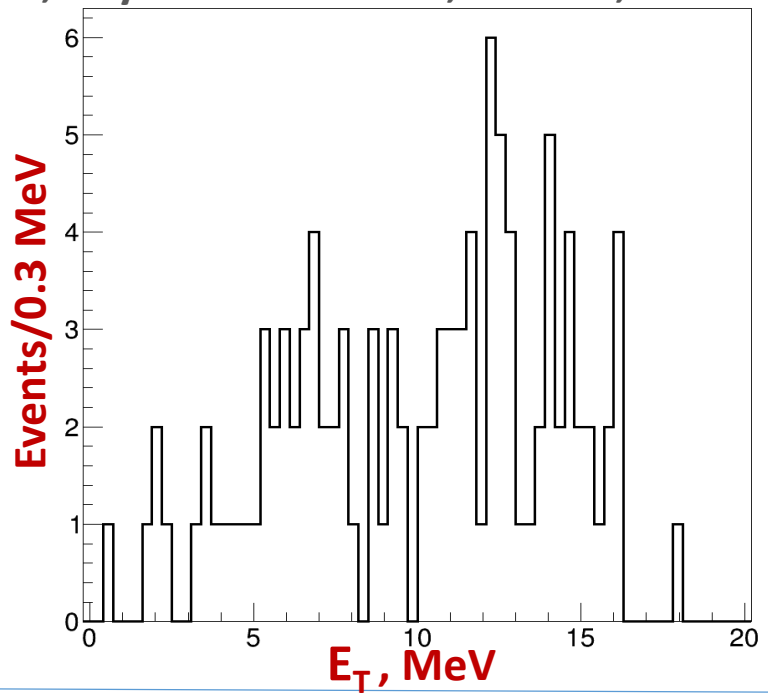




A.A.Bezbakh et al., Phys. Rev. Lett. 124, 022502, 2020.

EXP 1,

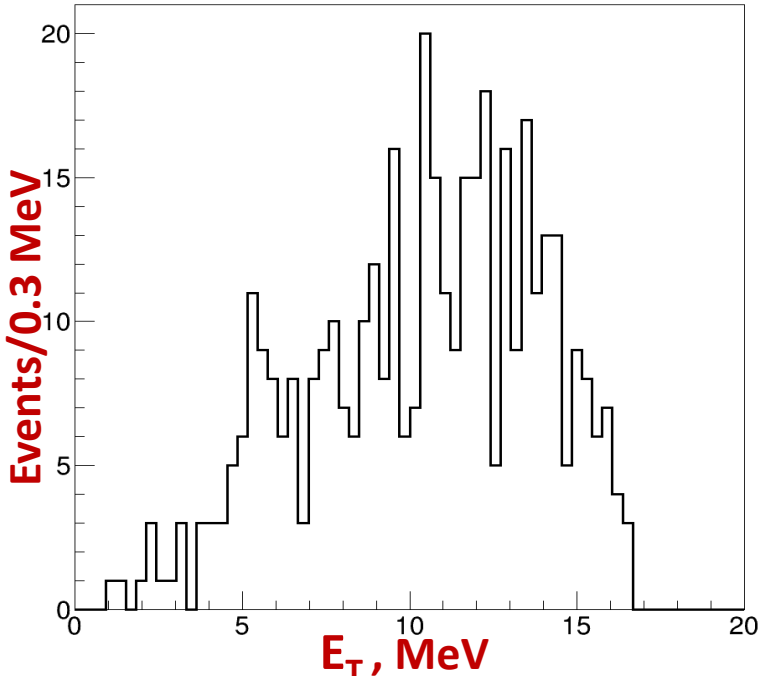
107 ^{7}H events



EXP 2,

processing

404 ^{7}H events



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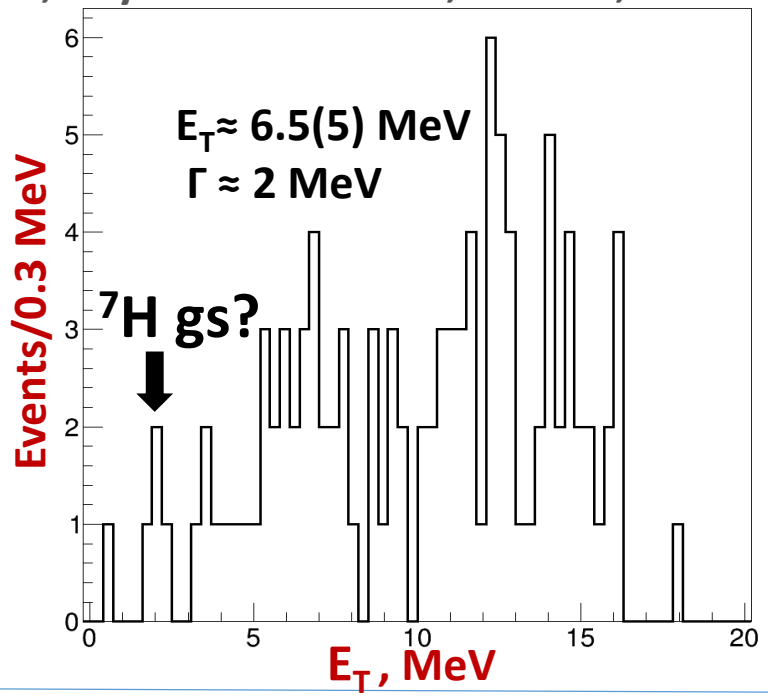

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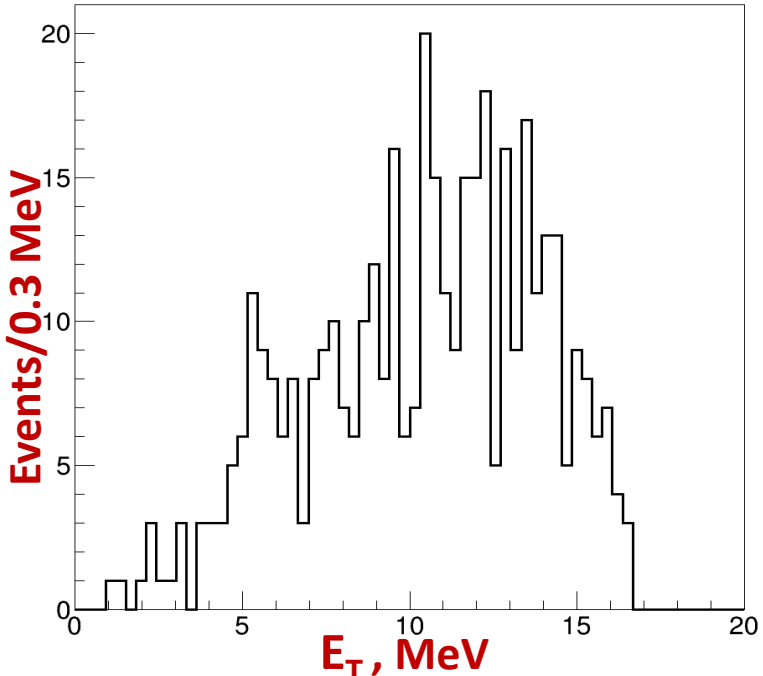

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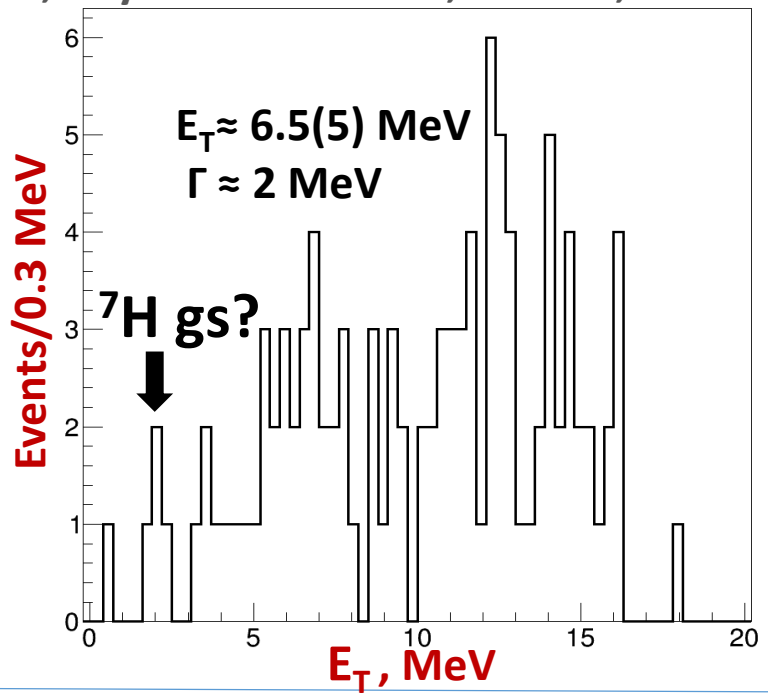

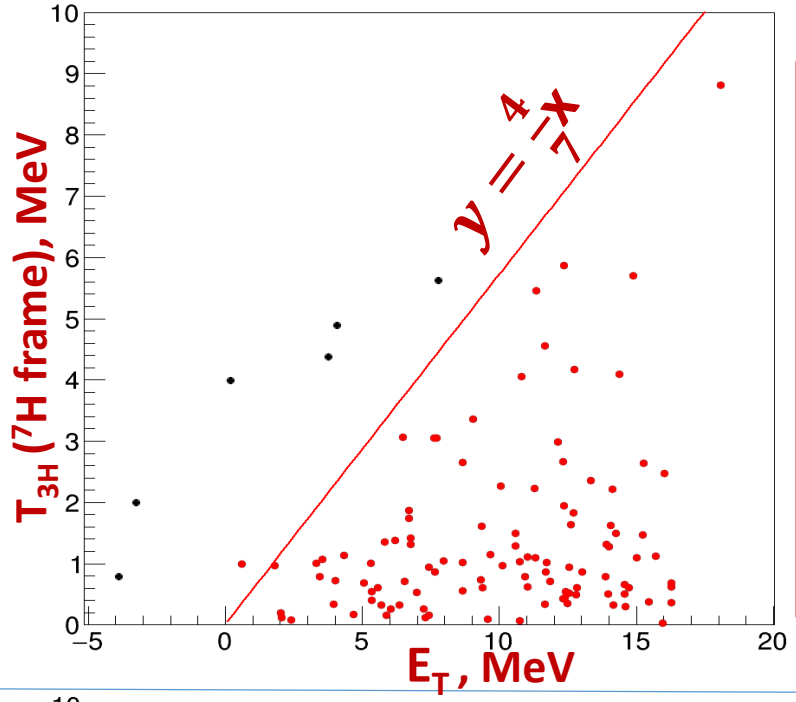

In the ^{7}H CMS frame:

$$\begin{cases} \vec{p}_{4n} = -\vec{p}_{3H} \\ T_{3H} + T_{4n} = ET \end{cases}$$

$$T_{3H} \leq \frac{4}{7} E_T$$

EXP 2,

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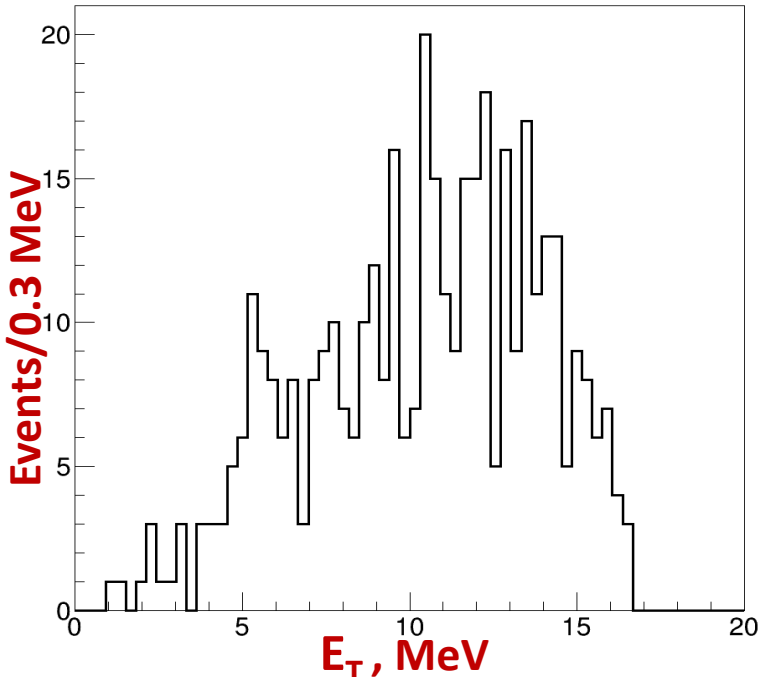
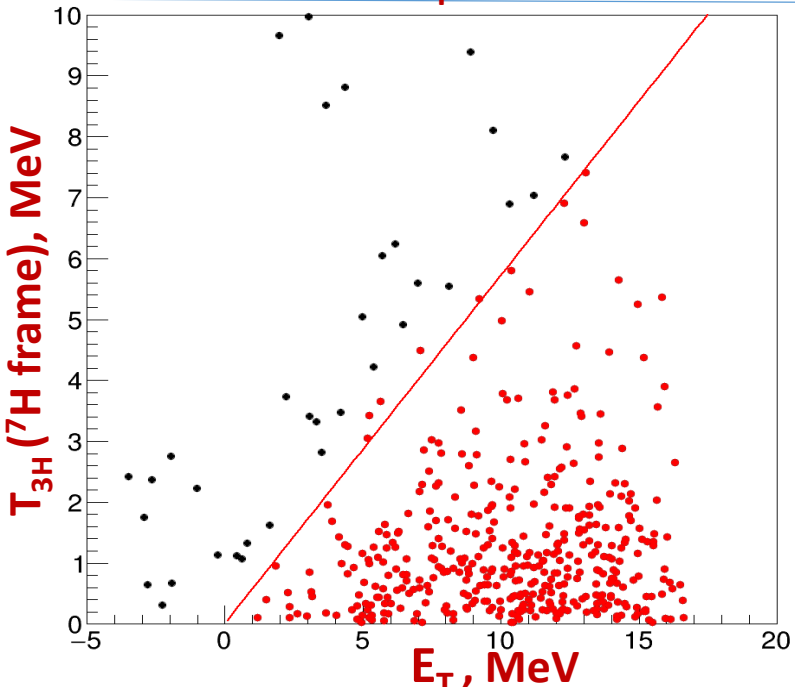


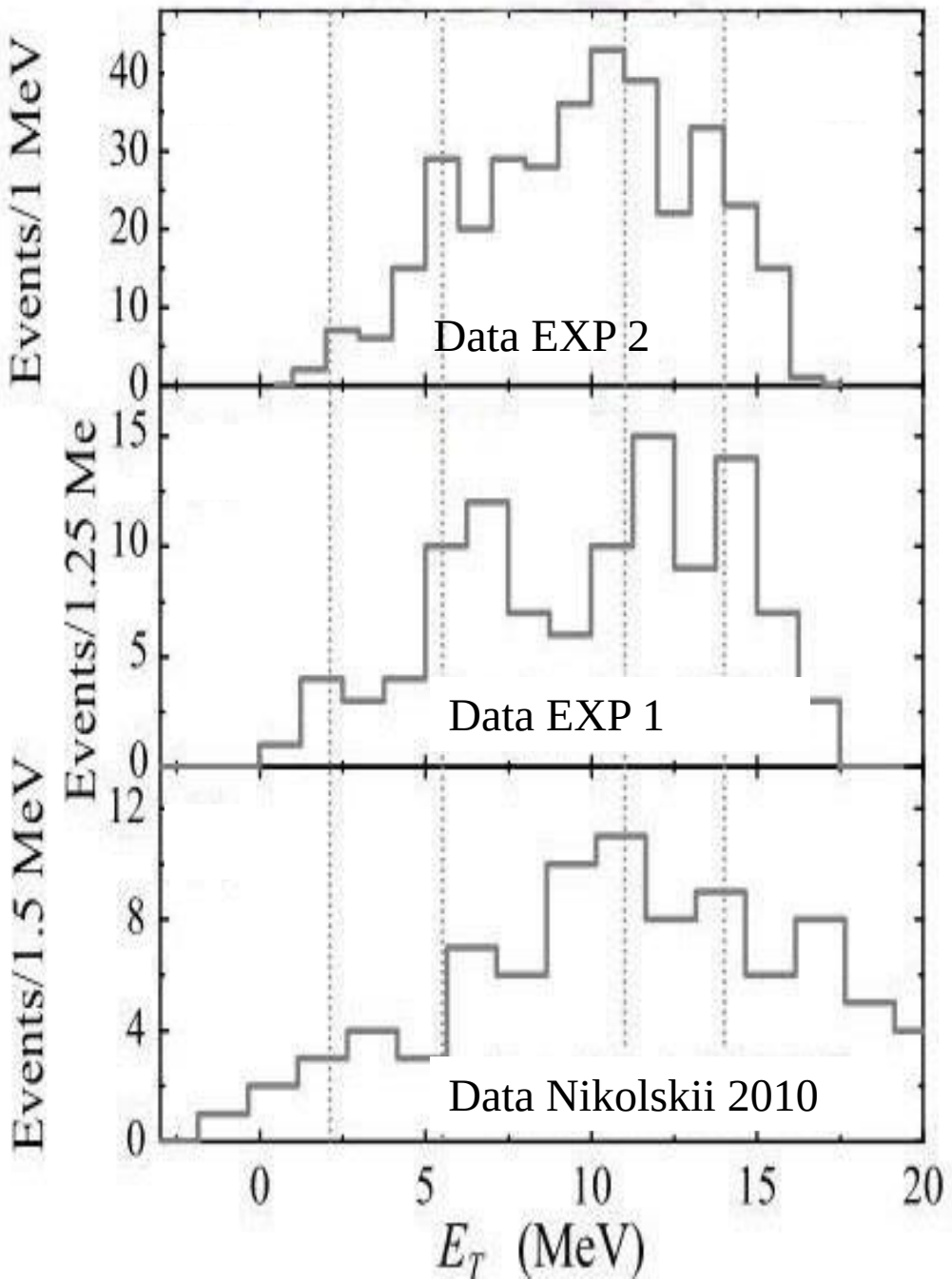


- **^{3}H detection:**

ΔT_{3H}(^{7}H CMS)≈ 0.3 MeV

- Reaction channel identification!

Results



- Obtained results are in good agreement with the previous experiments
- Triton detection improved the energy resolution, which allowed to found the first excitation level

Summary

- For the first time, the ^{7}H excited state is observed at $E_T \approx 6.5(5)$ MeV with $\Gamma=2.0(5)$ MeV. This state can be interpreted as unresolved 5/2+ and 3/2+ doublet, built upon the 2+ excitation of valence neutrons, or one of the doublet states
- Indications for the ^{7}H g.s. at $E_T = 2.0(5)$ MeV are found in the measured energy and angular distributions
- The measured c.m. population cross section of the presumed ^{7}H g.s. is about **10 μb/sr**, which clarifies why the previous searches for the ^{7}H g.s. required so much time and effort without bringing reliable assignments of such a remote isotope
- Analyse of the second experiment data is about to be finished. Submitting to PRC next year.
- The obtained results represent an important step towards resolving the ^{7}H problem and also demonstrate the high potential of the “newcomer” ACCULINNA-2 facility

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Thanks for attention