On a new light-particle candidate for Dark Matter observed in high-energy nuclear transitions

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- Nuclear Physics Division
- Atomic Physics Division
- Applied Physics Division

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Observation of Anomalous Pair Creation in ^{8}Be: A Possible Indication of a Light Neutral Boson

624

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Title	Observation of Anomalous Internal Pair Creation in <span class
Published in	Physical Review Letters, January 2016
DOI	10.1103/physrevlett.116.042501
Pubmed ID	26871324
Authors	A. J. Krasznahorkay, M. Csatlós, L. Csige, Z. Gácsi, J. Gulyás, M. Hunyadi, T. J. Ketel, A...
Abstract	Electron-positron angular correlations were measured for the isovector magnetic dipo (J^{... [show]

TWITTER DEMOGRAPHICS | MENDELEY READERS

The data shown below were collected from the profiles of **89** tweeters who shared

about how the information was compiled.

Evidence for a Protophobic Fifth Force from ^{8}Be Nuclear Transitions

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Jordan Smolinsky,[1] Tim M. P. Tait,[1] and Philip Tanedo[1]

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Phys. Rev. Lett. 117, 071803

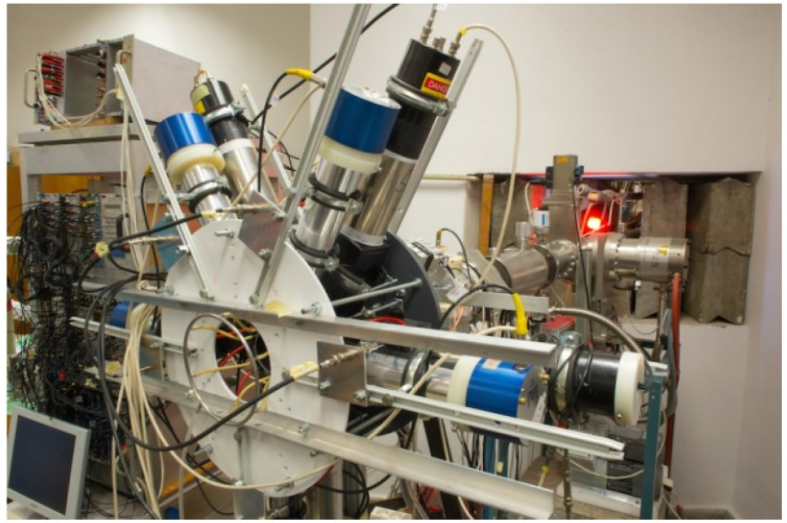
NATURE | NEWS

Has a Hungarian physics lab found a fifth force of nature?

Radioactive decay anomaly could imply a new fundamental force, theorists say.

Edwin Cartlidge

25 May 2016



MTA-Atomki

Physicists at the Institute for Nuclear Research in Debrecen, Hungary, say this apparatus — an electron-positron spectrometer — has found evidence for a new particle.

Print

A laboratory experiment in Hungary has spotted an anomaly in radioactive decay that could be the signature of a previously unknown fifth fundamental force of nature, physicists say – if the finding holds up.

Attila Krasznahorkay at the Hungarian Academy of Sciences's Institute for Nuclear Research in Debrecen, Hungary, and his colleagues reported their surprising result in 2015 on the arXiv preprint server, and this January in the journal *Physical Review Letters*[1]. But the report – which posited the existence of a new, light boson only 34 times heavier than the electron – was largely overlooked.

Then, on 25 April, a group of US theoretical physicists brought the finding to wider attention by publishing its own analysis of the result on arXiv[2]. The theorists showed that the data didn't conflict with any previous experiments – and concluded that it could be evidence for a fifth fundamental force. "We brought it out from relative obscurity," says Jonathan Feng, at the University of California, Irvine, the lead author of the arXiv report.

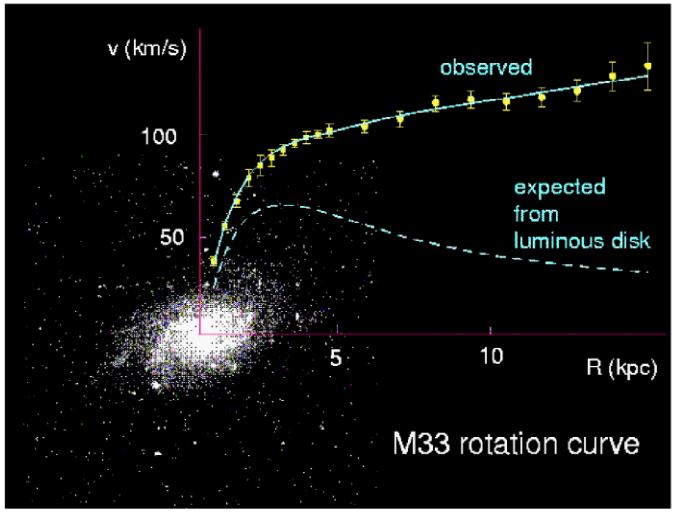
Dark matter may feel a "dark force" that the rest of the Universe does not

Four days later, two of Feng's colleagues discussed the finding at a workshop at the SLAC National Accelerator Laboratory in Menlo Park, California. Researchers there were sceptical but excited about the idea, says Bogdan Wojtsekhowski, a physicist

The Atomki anomaly → signals for a new 17 MeV boson → gauge boson of a new fundamental force of Nature

Searching for new physics and Dark Matter
Should not have to defend this too much…

It is well known that the Standard Model is not complete and many of the theories that seek to extend it, predict new phenomena that may be accessible in low-energy settings.



Census in the Universe

Stars and galaxies: 0.5 %

Visible matter: 5 %

Dark matter: ≈ 30 %

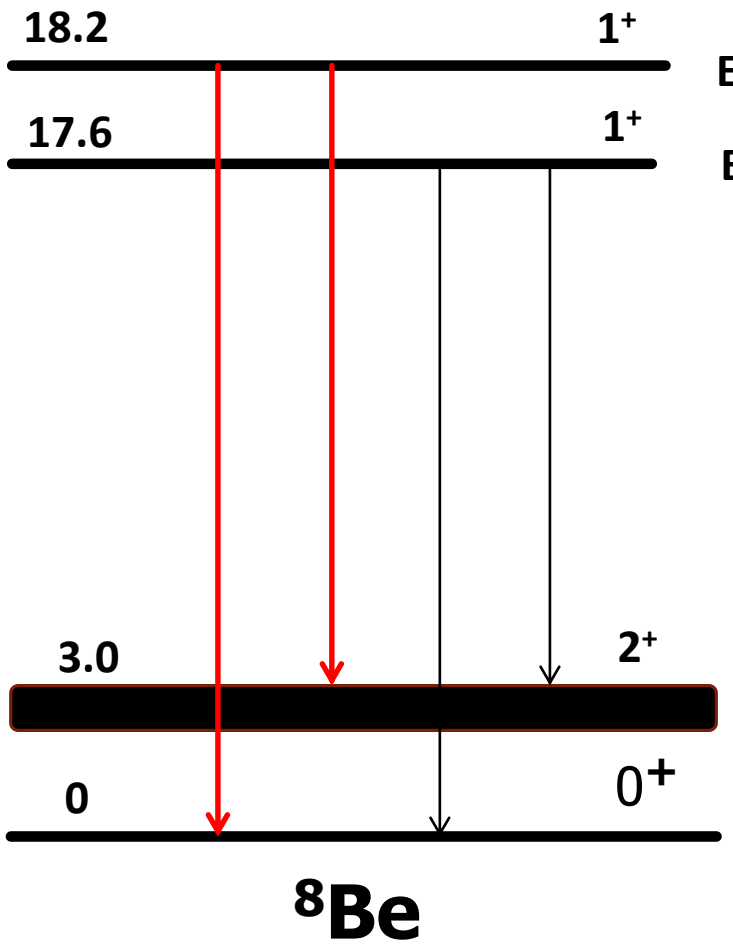
Dark energy: ≈ 65 %

Fertile ground:

- Light, Weakly Interacting DM, the dark photon concept (γ-like vector particles)
- Pseudoscalar, Axion Like Particles (ALP) (axion search in nuclear transitions 1978 →)
- Z^0-like particles

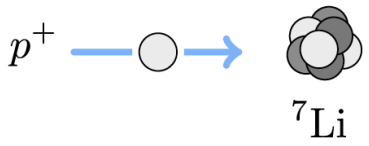
In our present work we are actually using the same method, which was introduced for the axion search, but using higher energy transitions and searching for somewhat heavier particles.

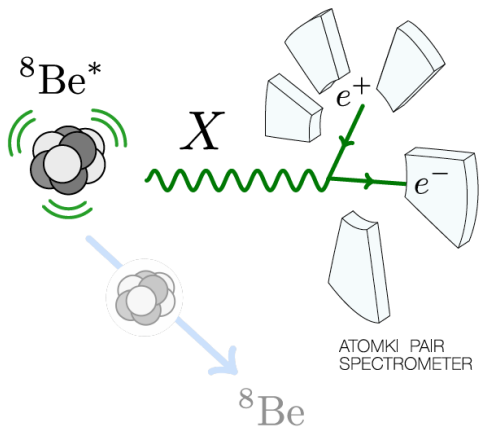
The creation and decay of $^{8}Be^{*}$

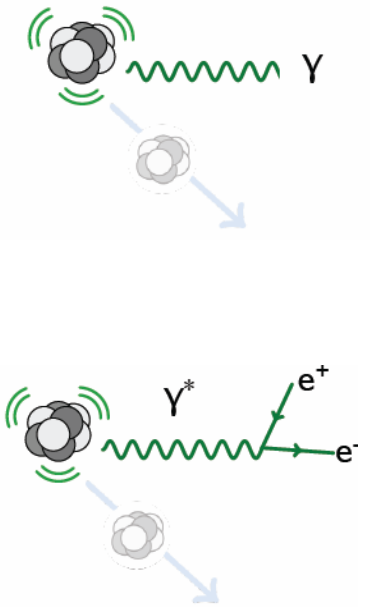


Ep= 1030 keV

Ep= 441 keV





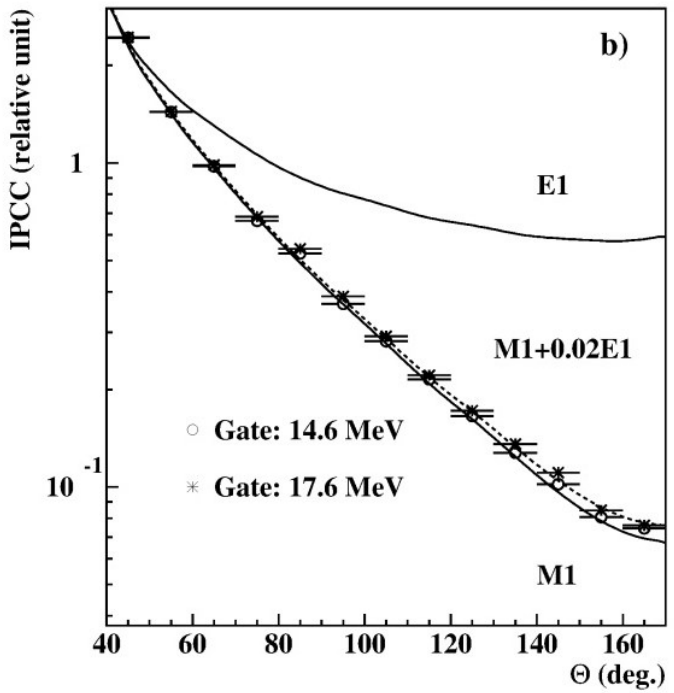


- Proton decay: B(p + ^{7}Li) ≈ 100%
- γ-decay: B(^{8}Be + γ) ≈ 1.5 x 10^{-5}
- Internal pair creation: B(^{8}Be + e^{+} e^{-}) ≈ 5.5 x 10^{-8}
- Ejection of a new particle: B(^{8}Be + X) ≈ 5.5 x 10^{-10}

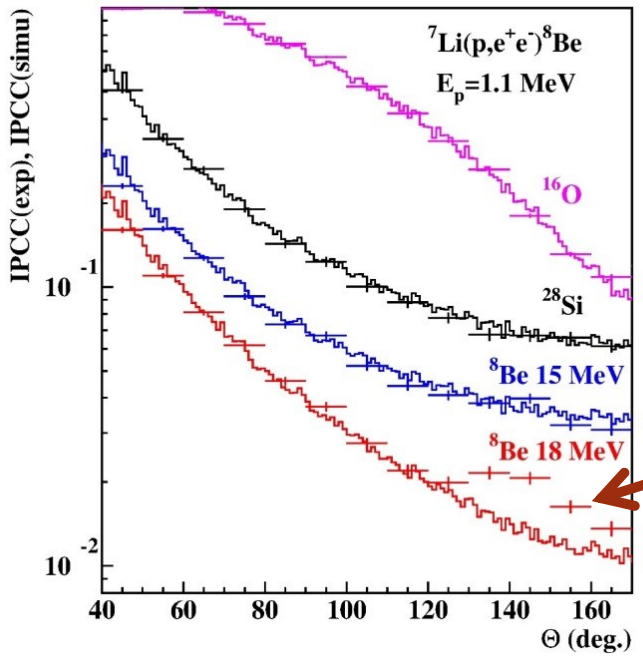
Results

e^+ - e^- sum energy spectra and angular correlations

E_p=441 keV



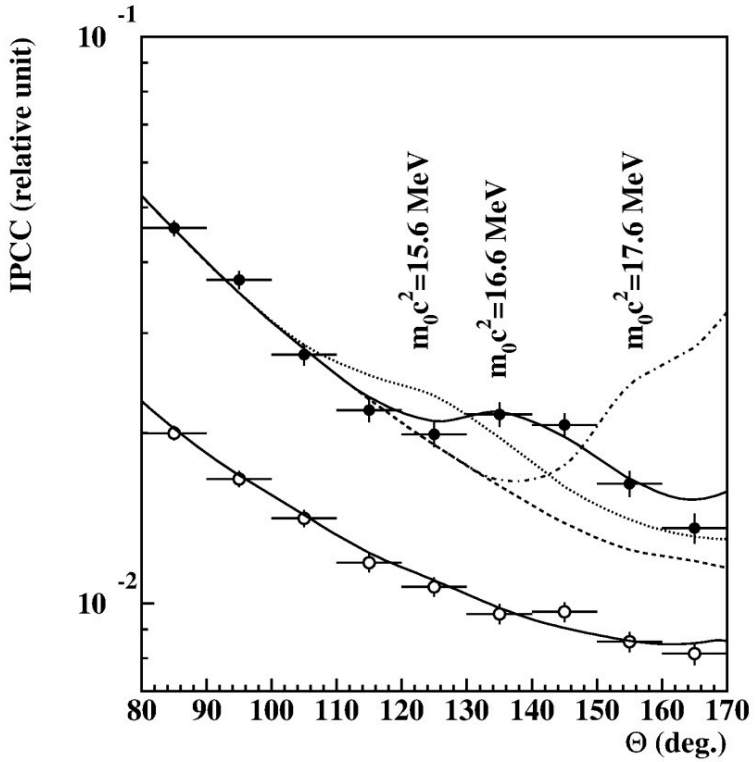
E_p=1030 keV



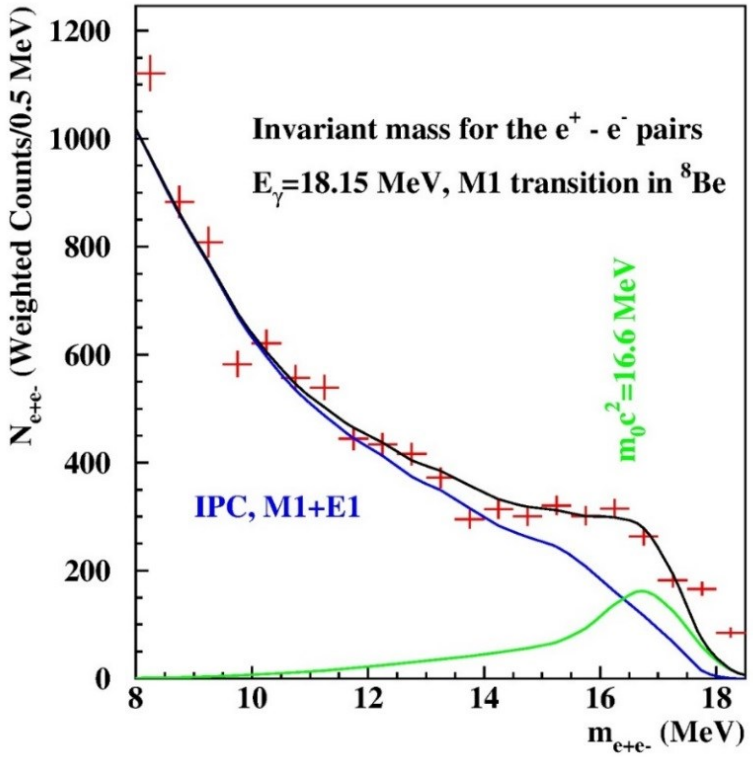
Deviation from IPC

- **Can it be some artificial effect caused by γ-rays?**
- **Can it be some nuclear physics effect? No.**
  X. Zang, G. Miller, Phys. Lett. B 773 (2017) 159.

How can we understand the peak like deviation? Fitting the angular correlations



Experimental angular e^+e^- pair correlations measured in the $^7Li(p,e^+e^-)$ reaction at Ep=1.10 MeV with -0.5< y <0.5 (closed circles) and |y|>0.5 (open circles), where y=(E1-E2)/(E1+E2).



Invariant mass distribution plot for the electron-positron pairs

Introduction of the protophobic fifth force
(J. Feng et al.PRL 117, 071803, (2016))

Branching ratio: $$\frac{B(^8\mathrm{Be}^* \to {}^8\mathrm{Be}\, X)}{B(^8\mathrm{Be}^* \to {}^8\mathrm{Be}\,\gamma)} = (\varepsilon_p + \varepsilon_n)^2 \frac{|\vec{p}_X|^3}{|\vec{p}_\gamma|^3} \approx 5.6 \times 10^{-6}$$

$$\Rightarrow \quad |\varepsilon_p + \varepsilon_n| \approx 0.011$$

Pion decay: $$|2\varepsilon_u + \varepsilon_d| < \varepsilon_{\max} = 8 \times 10^{-4}$$

$$\Rightarrow \quad -2.3 < \frac{\varepsilon_d}{\varepsilon_u} < -1.8\,, \quad -0.067 < \frac{\varepsilon_p}{\varepsilon_n} < 0.078$$

R≈12 fm

Promising Outlook (It will take several years to get results…)

Purdue Univ., USA
Hanoi, Vietnam
Orsay, France
Canberra, Australia

IPC:

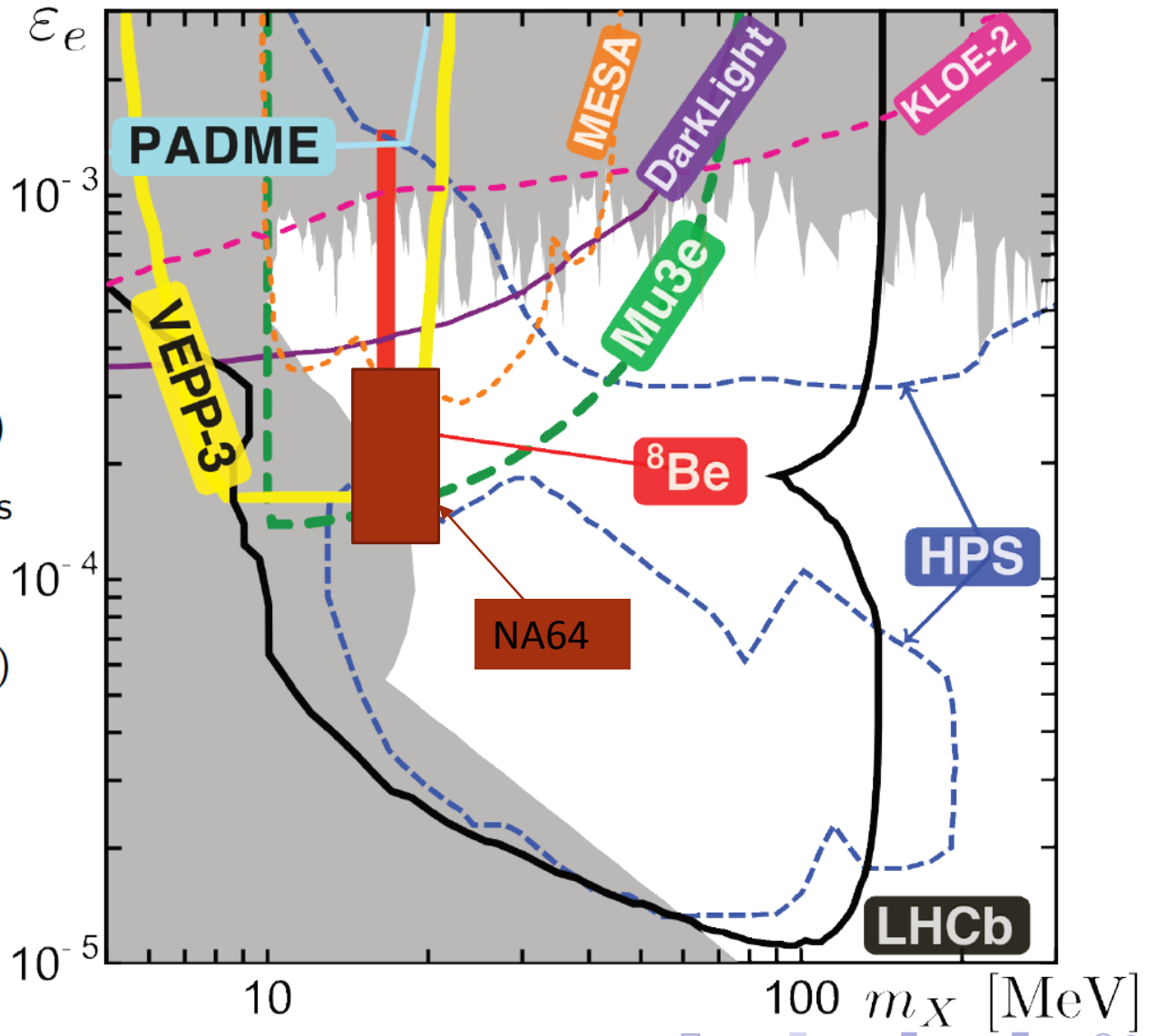
- verify ^{8}Be
- ^{10}B : 19.3 MeV
- ^{10}Be : 17.79 MeV

More Exp:

- TUNL (HIGS facility γ *Nuc*)
- TREK@JPARC: K^+ Decays
- SHIP
- SeaQuest (Gardner & Holt)
- VdG UK
- BESIII (arXiv:1607.03970)

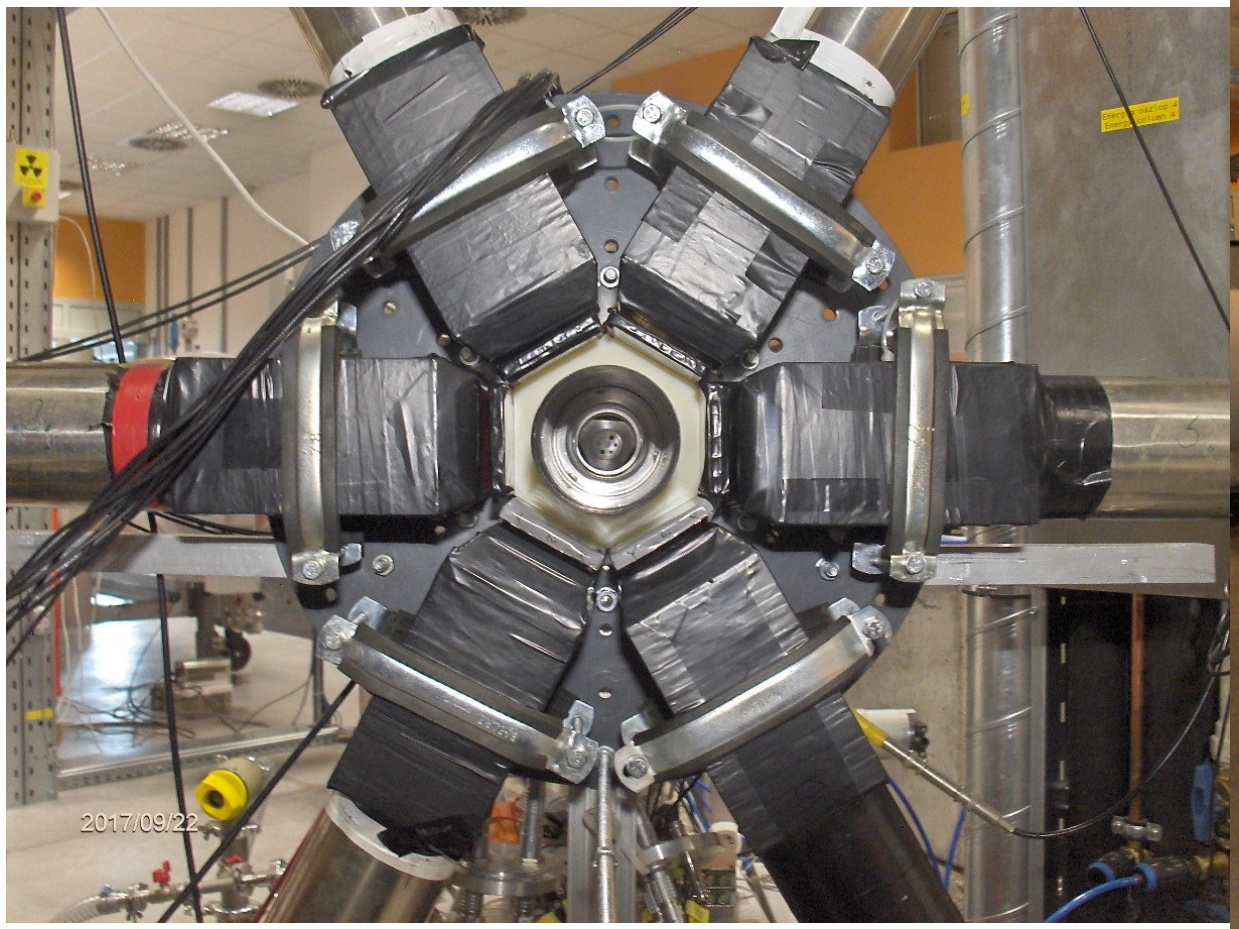
Prob UV

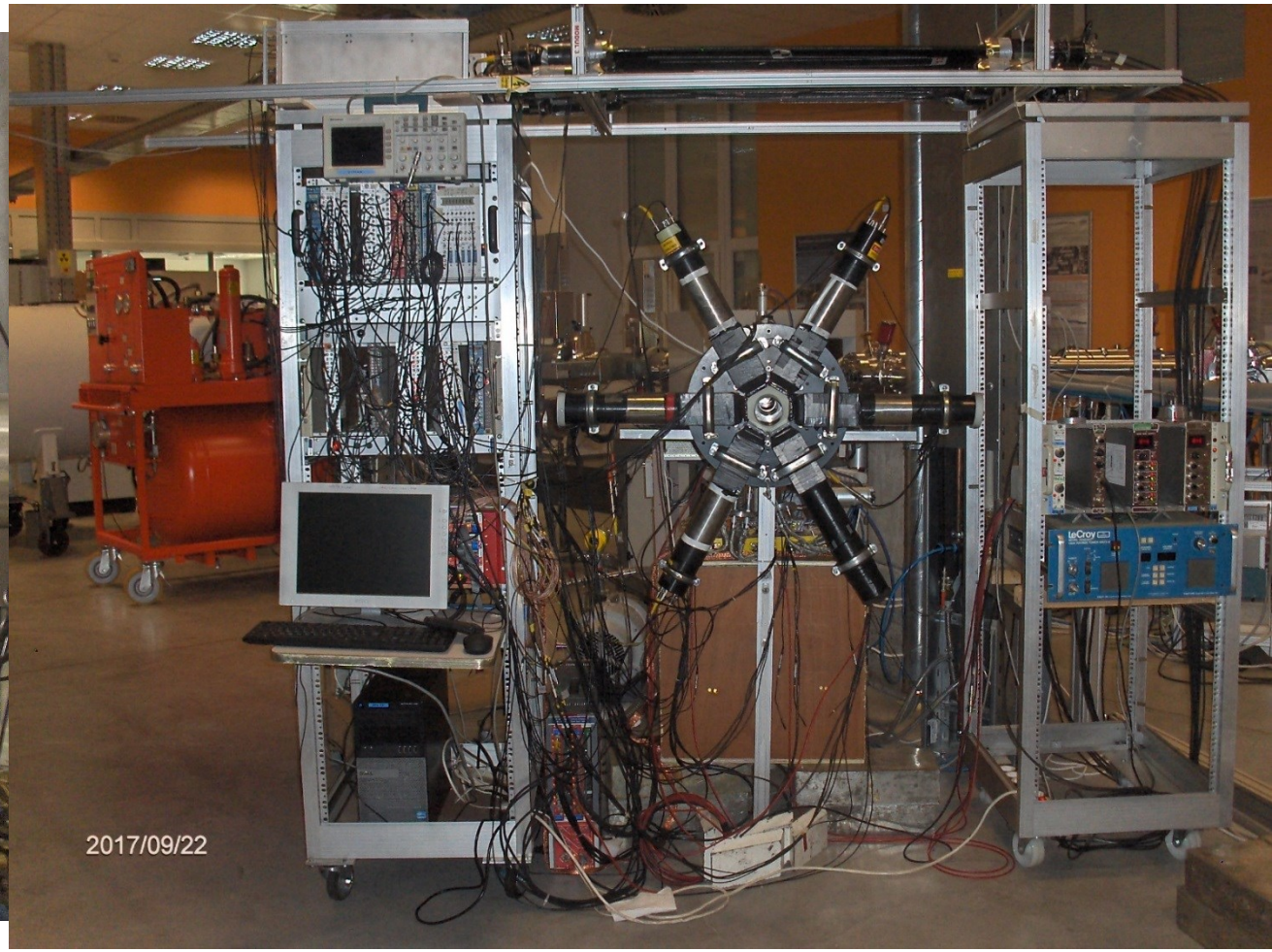
- ATLAS, CMS



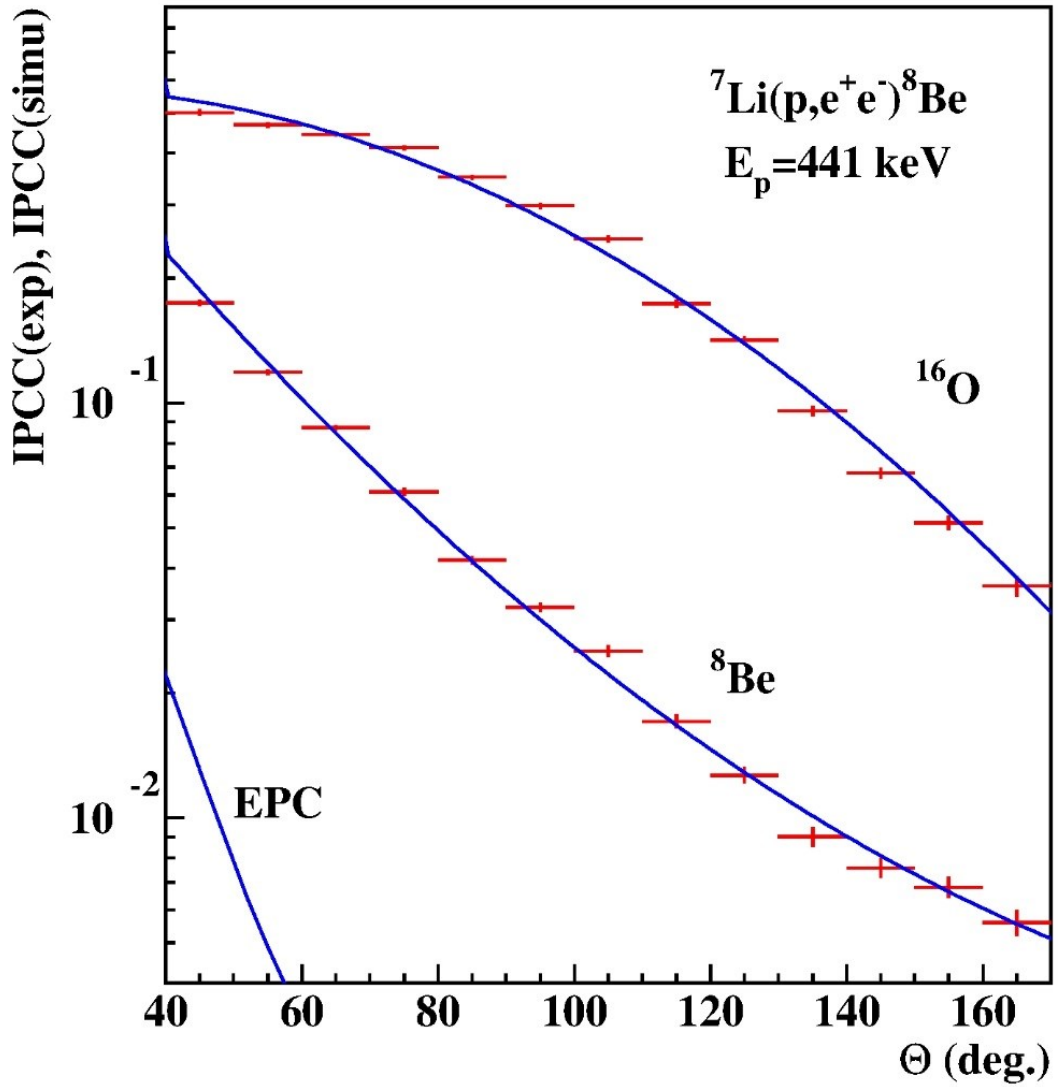
Repeating the experiments at a new Medium-Current Tandetron Accelerator System in Atomki Debrecen

The new e^+e^- pair spectrometer with six telescopes equipped with Si DSSD's



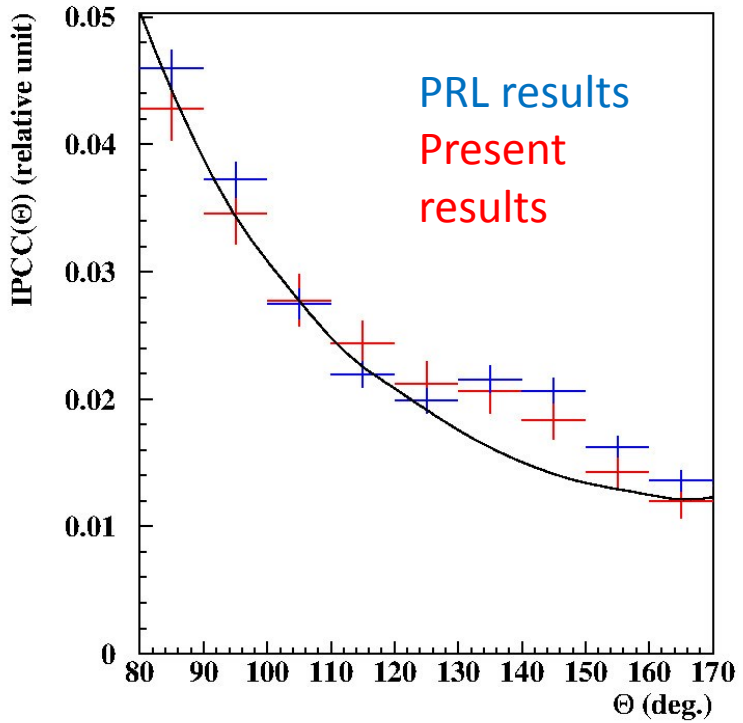


Recent results for the 17.6 MeV transition



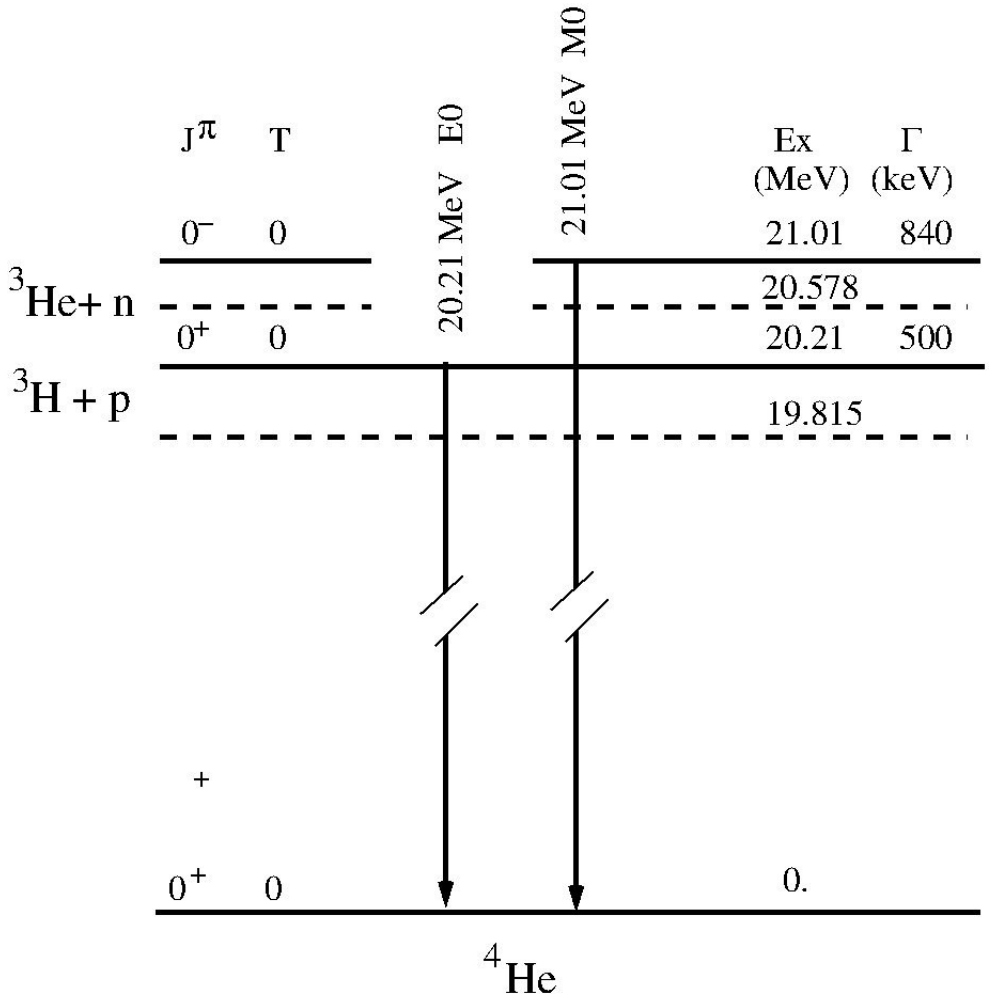
Comparison of results for the 18.15 MeV transition

Journal of Physics: Conf. Series **1056** (2018) 012028

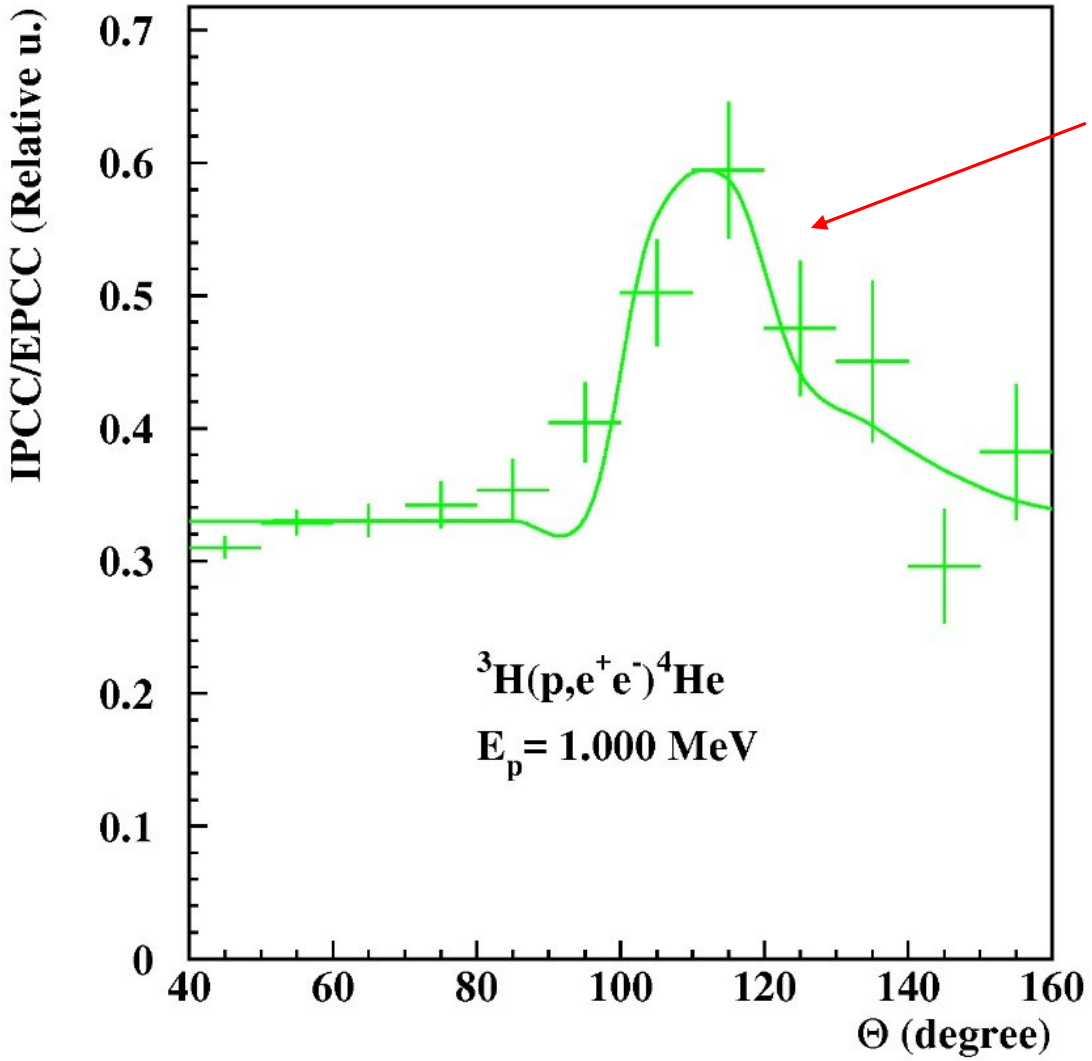


	Exp1	Exp2	Average
$m_0c^2(MeV)$	16.86(6)	17.17(7)	17.01(16)
B_x	$6.8(10) \times 10^{-6}$	$4.7(21) \times 10^{-6}$	$6(1) \times 10^{-6}$
Significance	7.37σ	4.90σ	

Study of the 21 MeV M0 transition in ^{4}He excited by ^{3}He+n, and t+p reactions



Results for the e^+e^- decay measured in Debrecen



M_0c^2= 16.6 MeV

Measured e^+e^- pair correlation divided by the simulated pair creation.

How can we choose between the different interpretations?

PRL 117, 071803 (2016) PHYSICAL REVIEW LETTERS week ending 12 AUGUST 2016

Protophobic Fifth-Force Interpretation of the Observed Anomaly in ^{8}Be Nuclear Transitions

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Possible explanation of the electron positron anomaly at 17 MeV in ^8Be transitions through a light pseudoscalar

Ulrich Ellwanger[a,b] and Stefano Moretti[b]

Vector (1^+) or pseudoscalar (0^-) particle?

If vector particle, then $\gamma\gamma$ emission is forbidden (Landau-Yang theorem).

If pseudoscalar then it can decay by $\gamma\gamma$ emission.

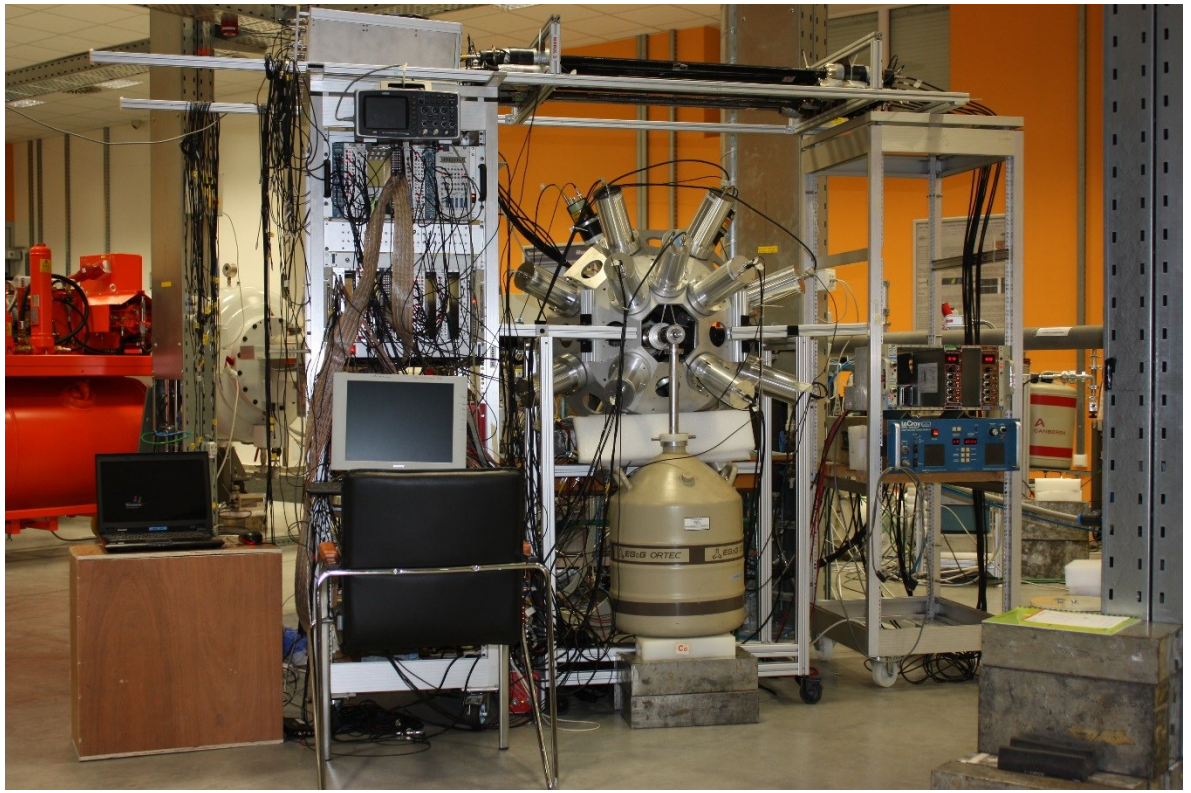
^{4}He experiments in Debrecen, and in Garching

The ^{3}H(p,γγ)^{4}He experiment in Debrecen

Cooled (LN_2), ^{3}H absorbed in Ti (3 mg/cm2) on a 0.4 mm thick Mo disc (target for neutron generator)

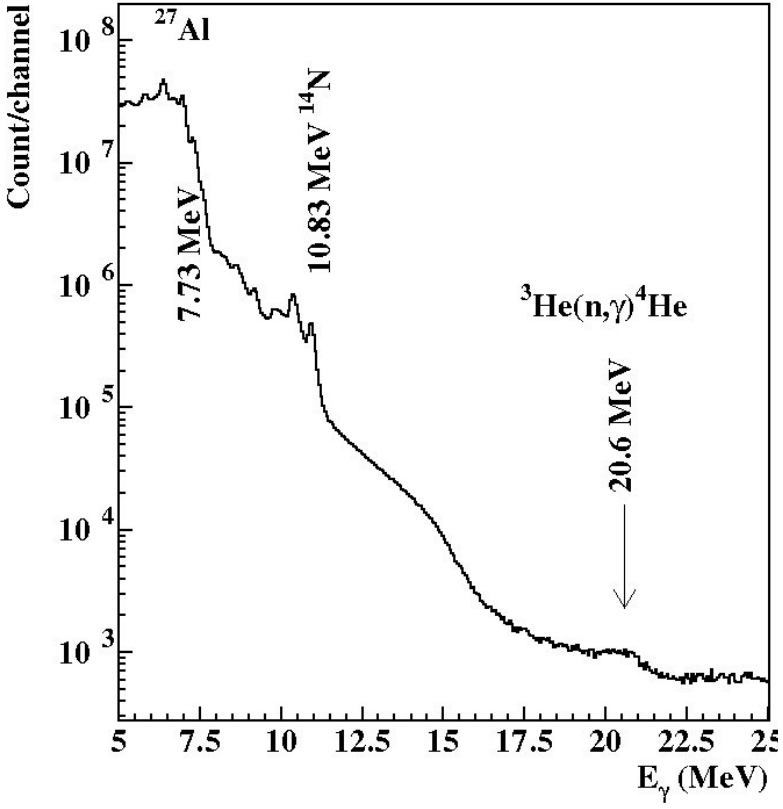
The ^{3}He(n,γγ)^{4}He experiment in Garching

FRM II High Flux Reactor (10^{10} cold n/cm2), pressurized 3He target.

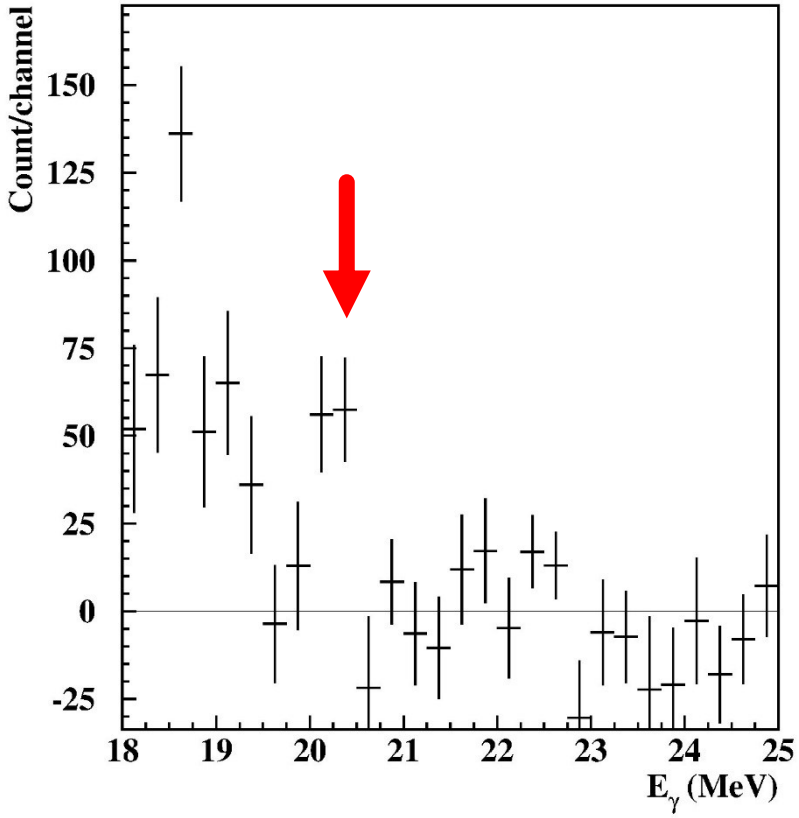


γ-spectrometer with twelve, 3”x3” and two 3.5”x6” LaBr3 detectors

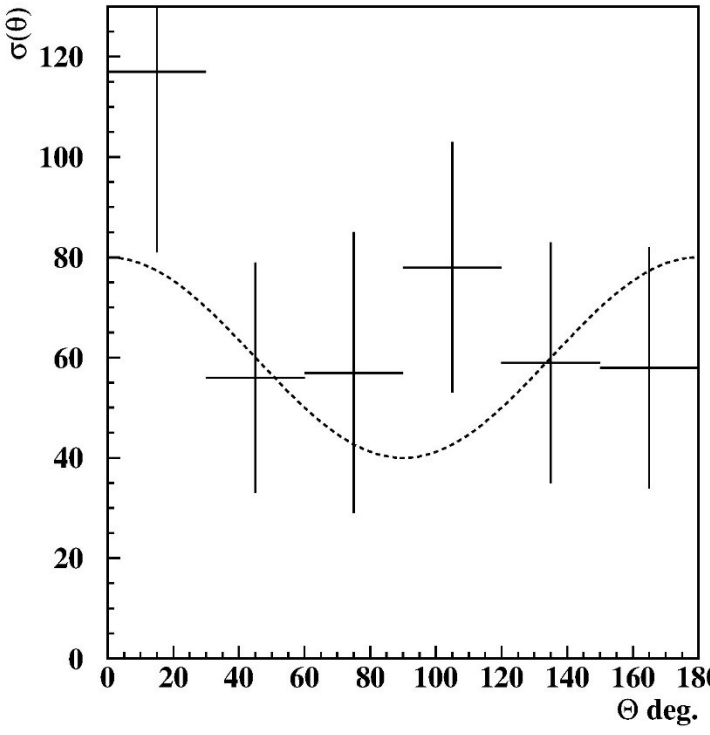
The first preliminary results



A typical singles γ-ray spectrum



Typical sum-energy spectra for coincident detectors

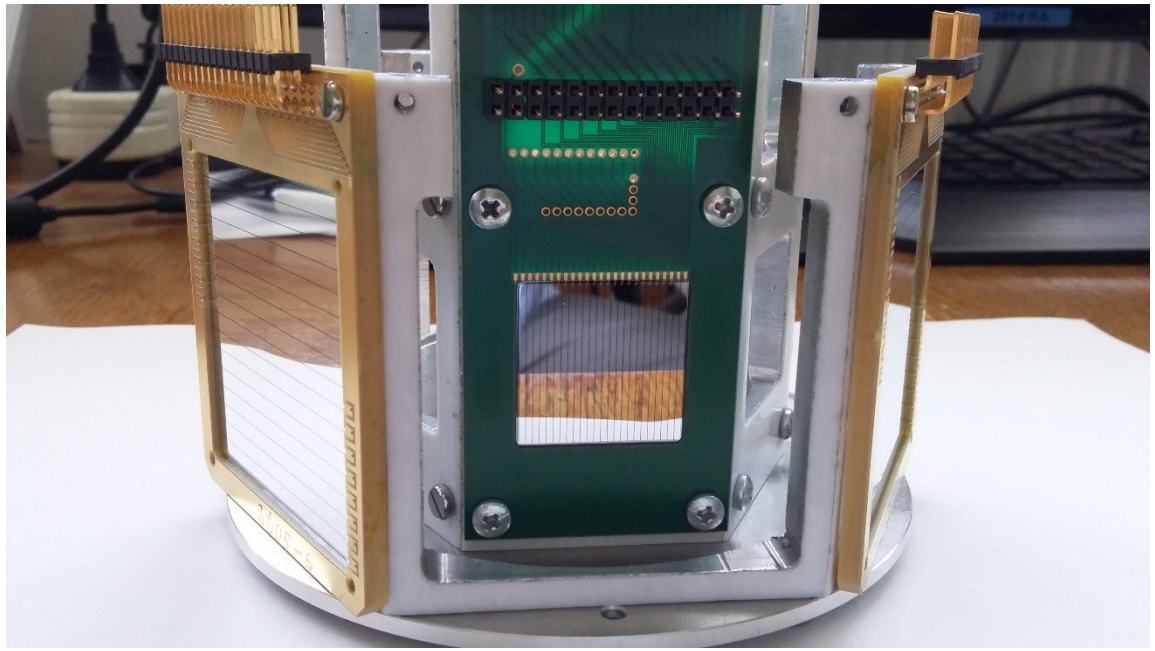


Preliminary γγ-angular correlation

Conclusion

- The ^{8}Be anomaly could be reproduced with an independent spectrometer.
- The effect can not be explained within nuclear physics.
- The anomaly can be successfully described by a new particle called (X17).
- The effect of X(17) was observed also in ^{4}He in a 20.6 MeV $0^{-} \rightarrow 0^{+}$ transition at a correspondingly smaller angle.
- The γγ-decay of X17 was studied. We are planning further experiments.

To ^{8}Be continued…



Thank you very much for your attention