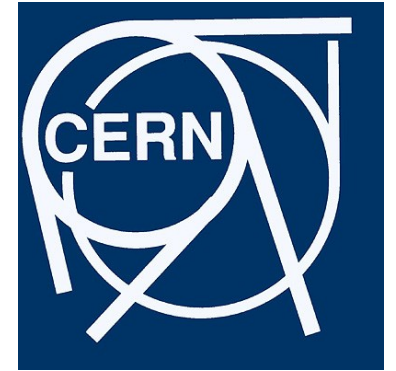


On a new light-particle candidate for Dark Matter observed in high-energy nuclear transitions



Attila Krasznahorkay

Inst. for Nucl. Res., Hung. Acad. of Sci.
(MTA-Atomki)



4 main divisions:

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

Size: 100 scientists, 100 other staff

www.atomki.mta.hu

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



About this Attention Score

In the top 5% of all research outputs scored by Altmetric

- Mentioned by**
- 55 news outlets
 - 19 blogs
 - 89 tweeters
 - 6 Facebook pages

SUMMARY News Blogs Twitter Facebook Go

Title	Observation of Anomalous Internal Pair Creation in ^8Be
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 dipole transition in ^8Be . The data show a clear deviation from the expected behavior, which is consistent with the existence of a new, light boson only 34 times heavier than the electron.

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 ^8Be Nuclear Transitions

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Phys. Rev. Lett. 117, 071803

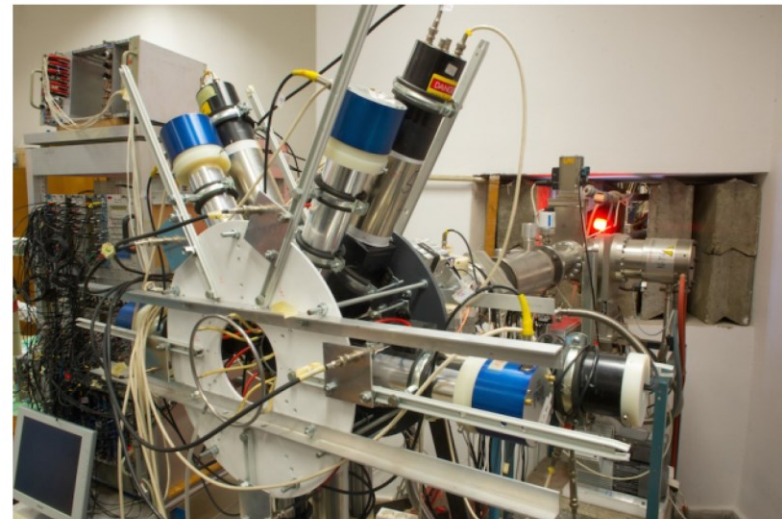
The Atomki anomaly → signals for a new 17 MeV boson → gauge boson of a new fundamental force of Nature

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



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

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 arXiv². 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.

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 Boudan Witsekowski, a physicist



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

Searching for new physics and Dark Matter

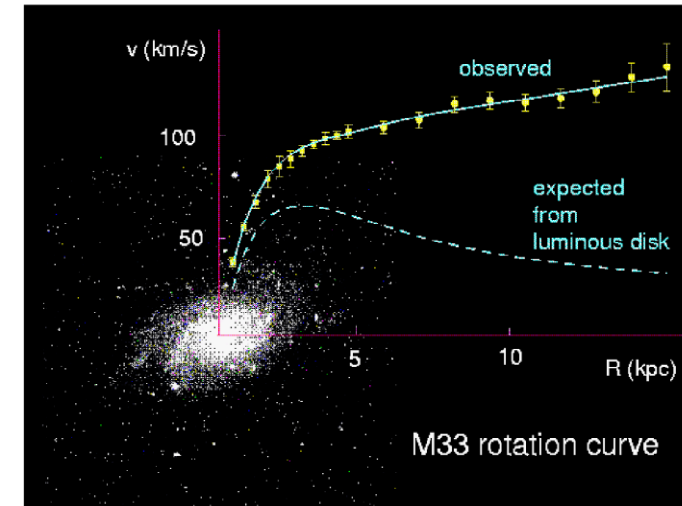
Should not have to defend this too much...

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.

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 \rightarrow)
- 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.



Census in the Universe

Stars and galaxies: 0.5 %

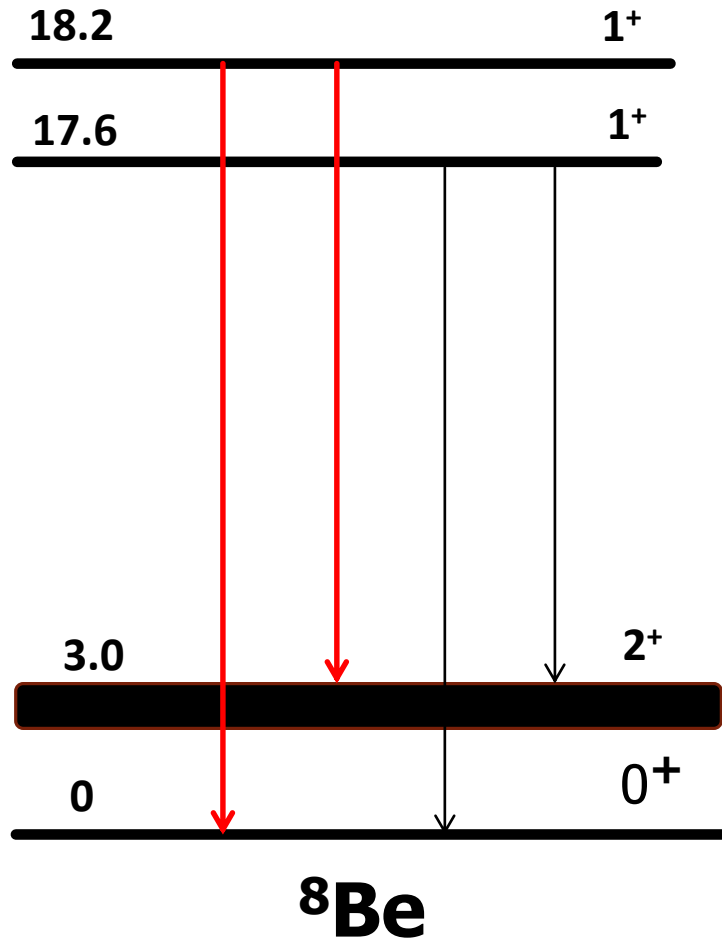
Visible matter: 5 %

Dark matter: ≈ 30 %

Dark energy: ≈ 65 %

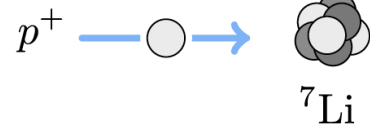
The creation and decay of $^8\text{Be}^*$

4

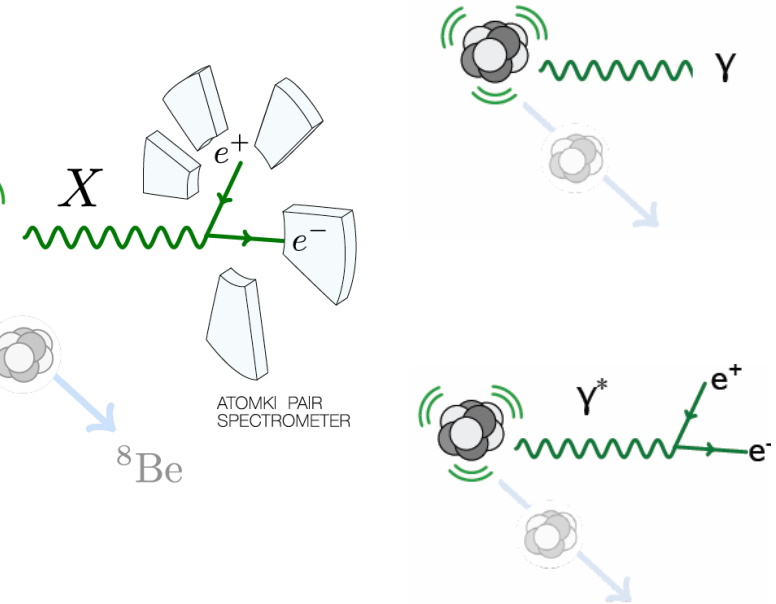


$E_p = 1030 \text{ keV}$

$E_p = 441 \text{ keV}$



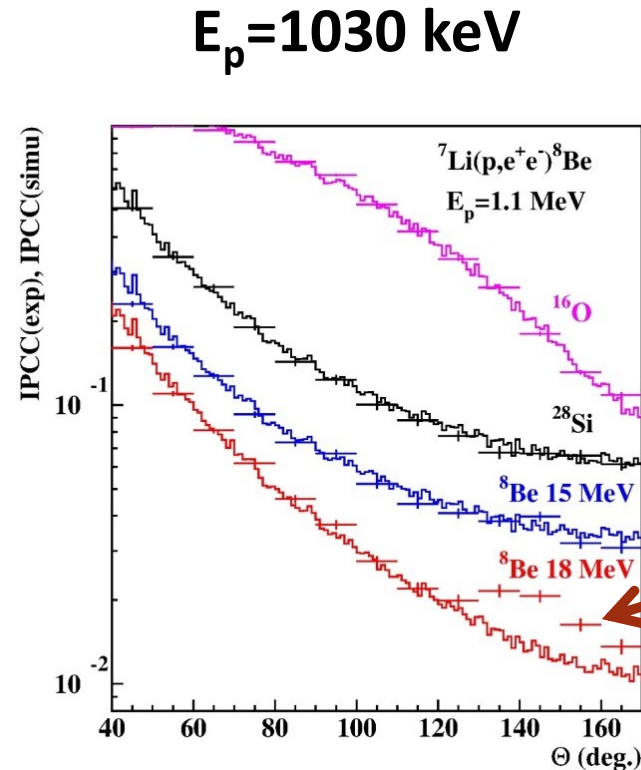
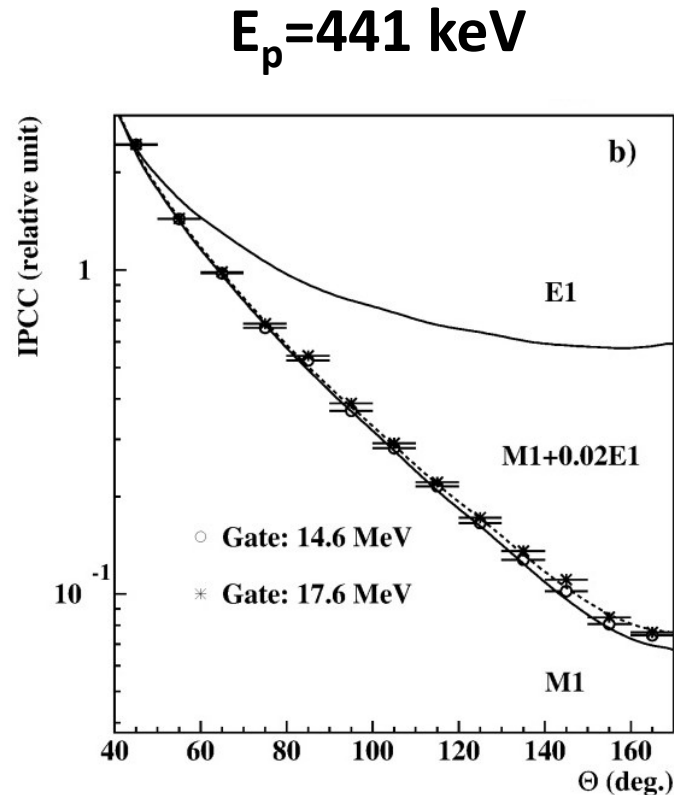
$^8\text{Be}^*$



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

Results

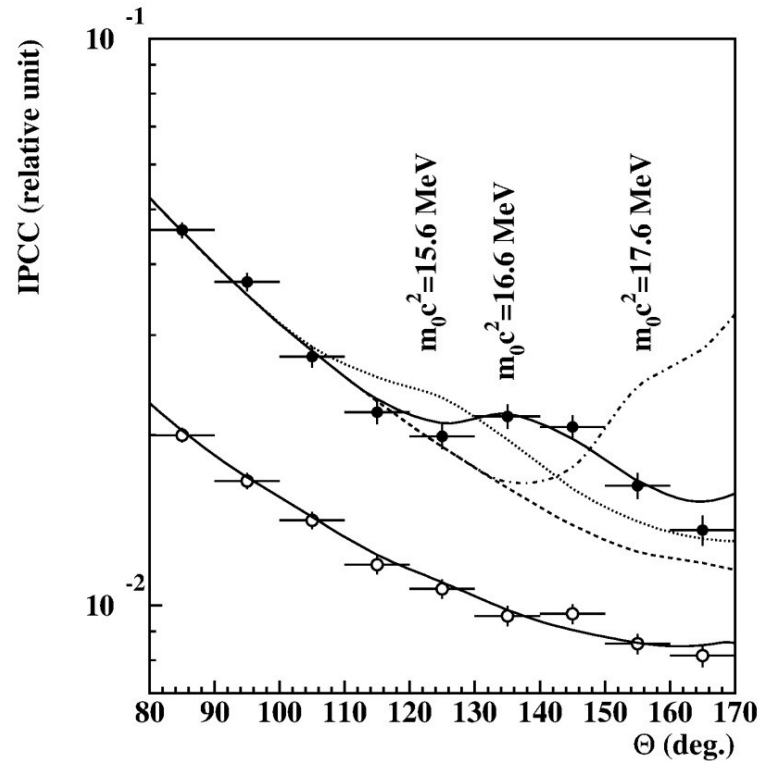
$e^+ - e^-$ sum energy spectra and angular correlations



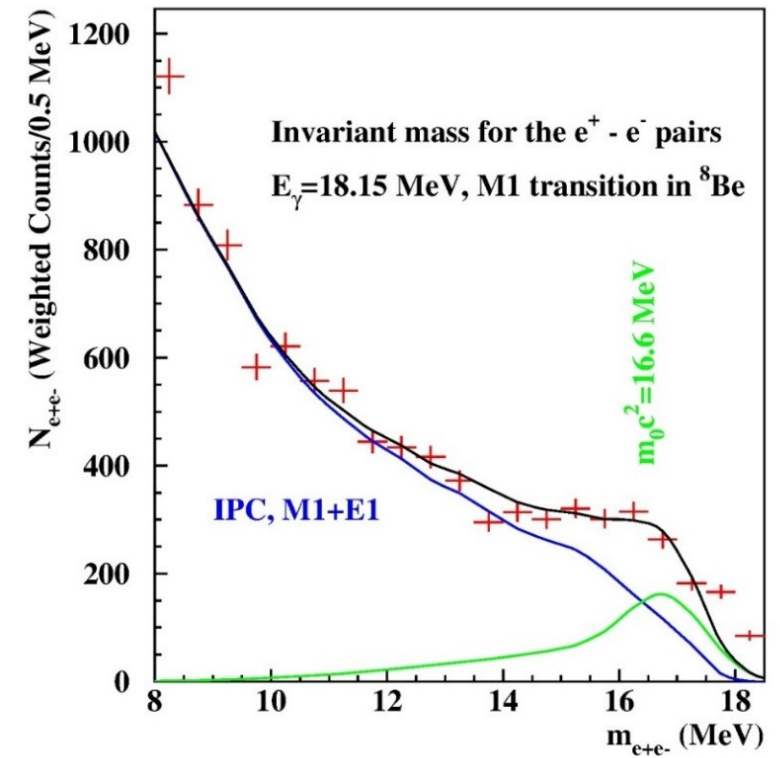
Deviation
from IPC

- 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 ${}^7\text{Li}(p, e^+e^-)$ reaction at $E_p = 1.10$ MeV with $-0.5 < \gamma < 0.5$ (closed circles) and $|\gamma| > 0.5$ (open circles), where $\gamma = (E_1 - E_2)/(E_1 + E_2)$.



Invariant mass distribution plot for the electron-positron pairs

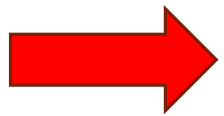
Introduction of the protophobic fifth force (J. Feng et al. PRL 117, 071803, (2016))

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



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

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



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

R \approx 12 fm

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

IPC:

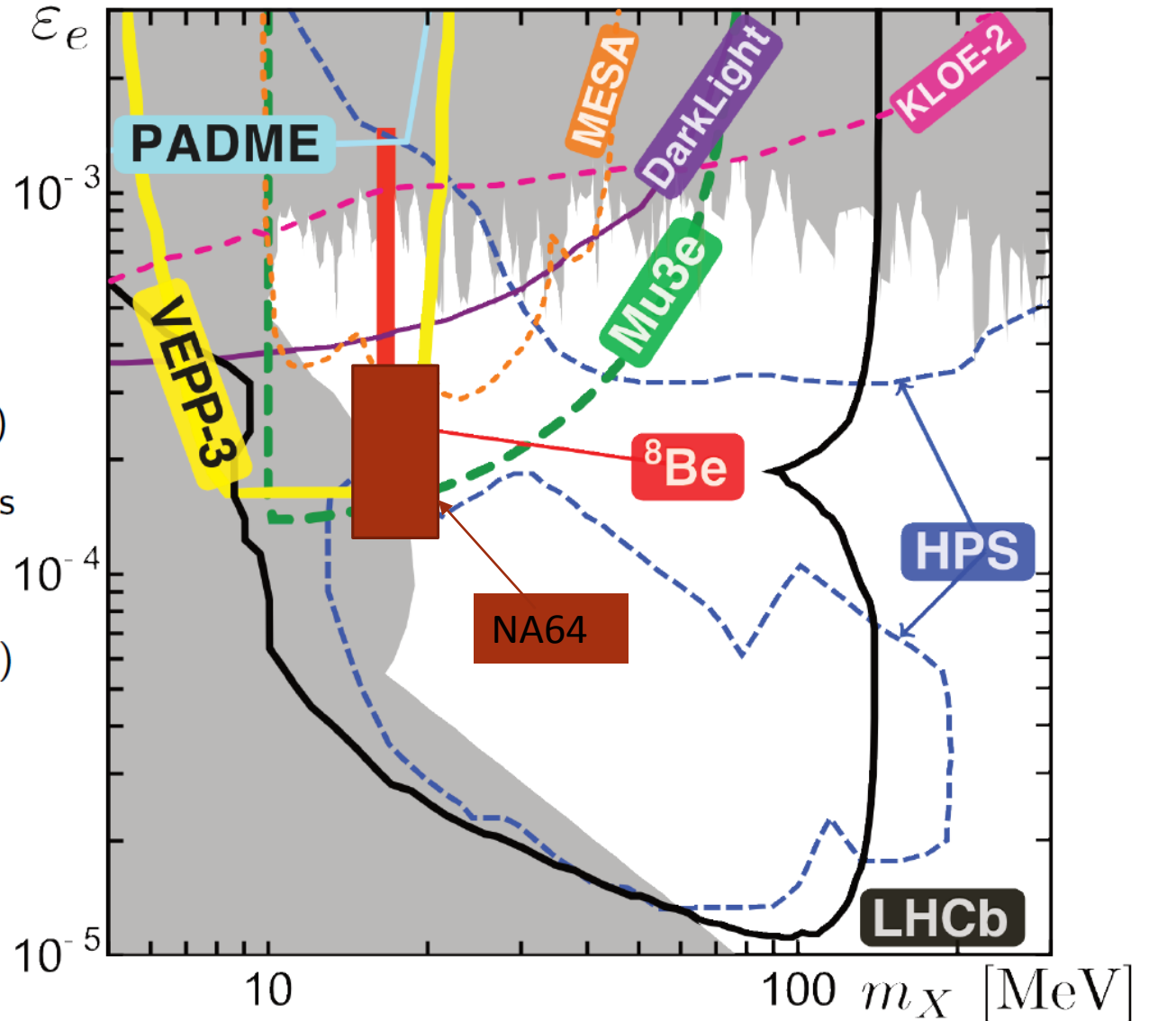
- verify ^8Be
- ^{10}B : 19.3 MeV
- ^{10}Be : 17.79 MeV

More Exp:

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

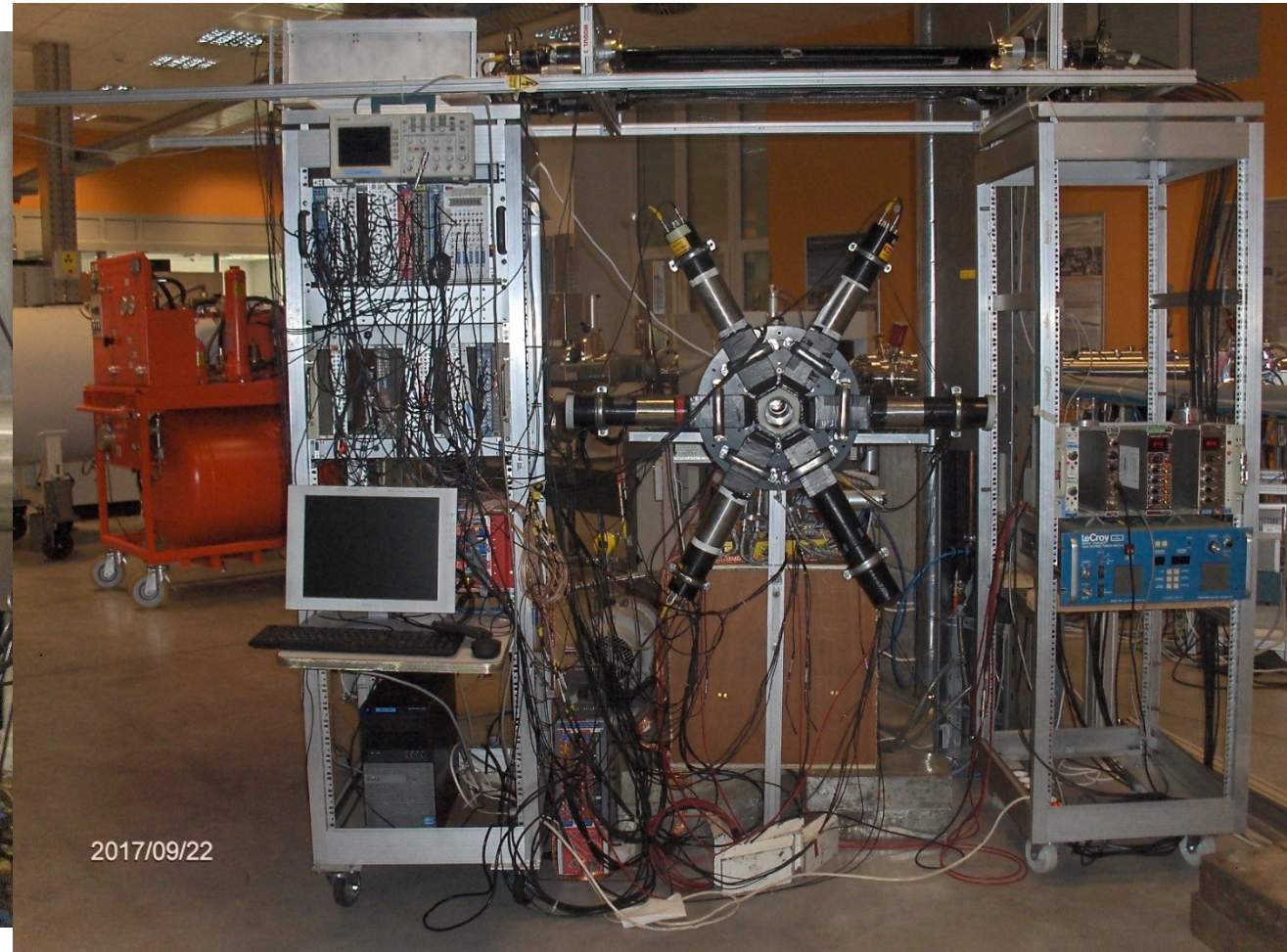
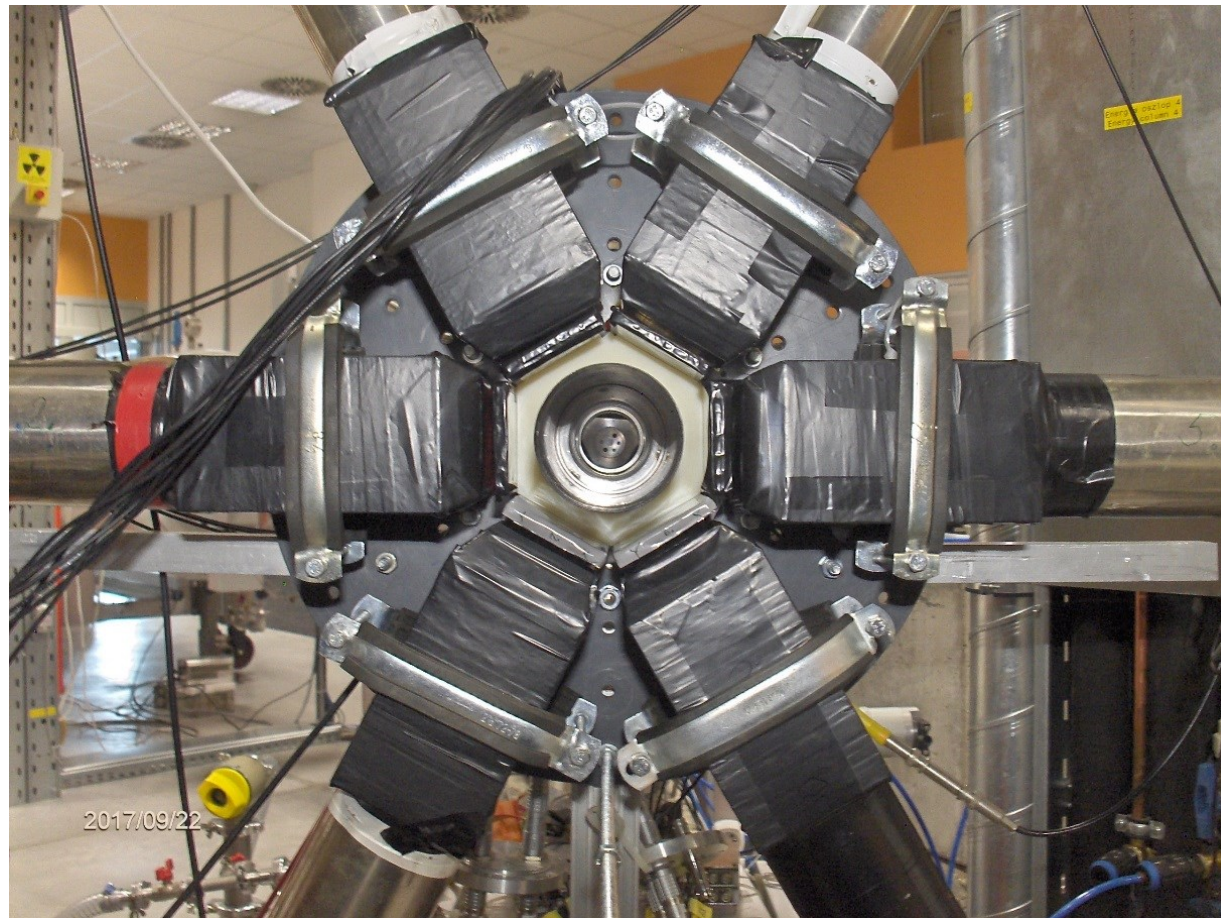
Prob UV

- ATLAS, CMS

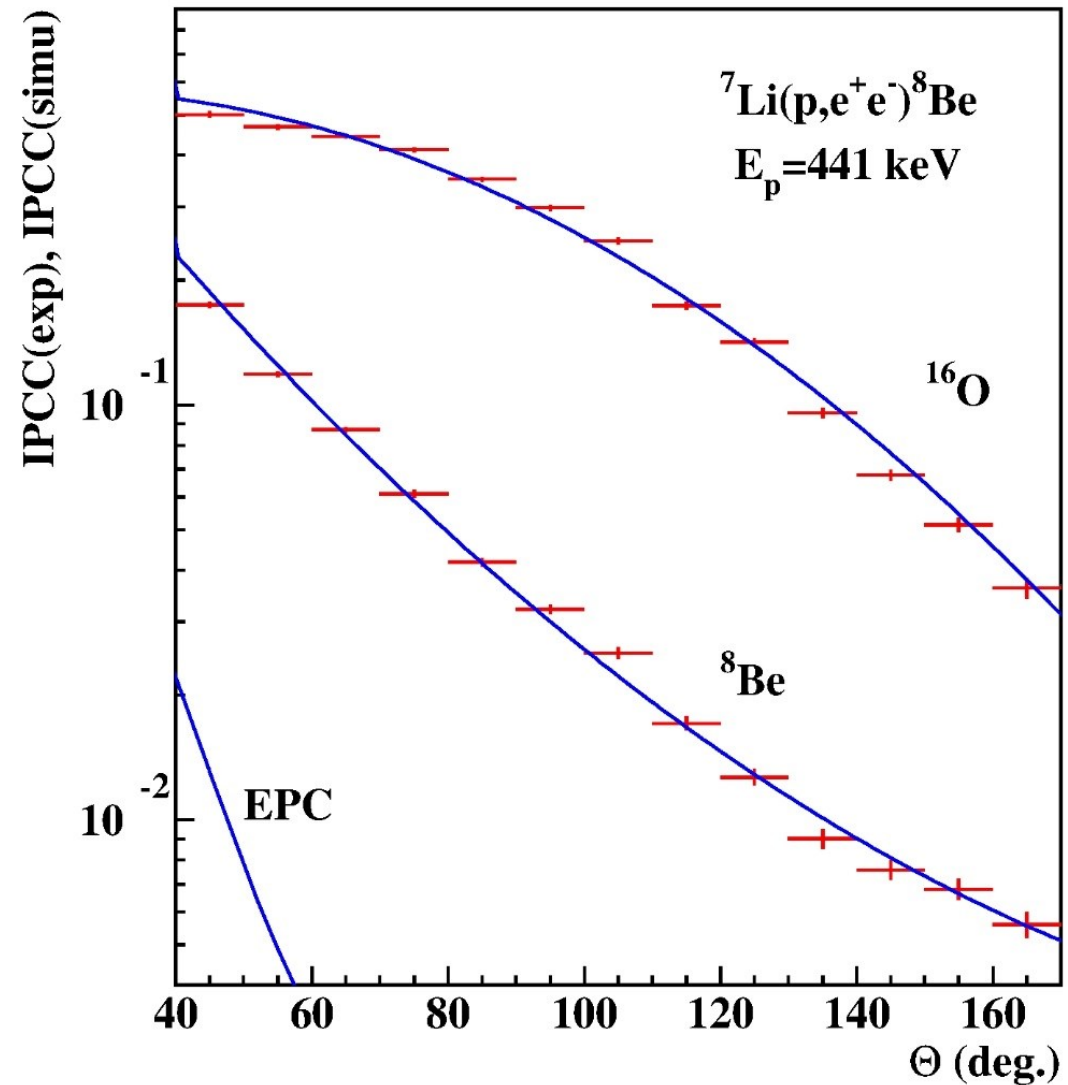


Repeating the experiments at a new Medium-Current Tandetron Accelerator System in Atomki Debrecen

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

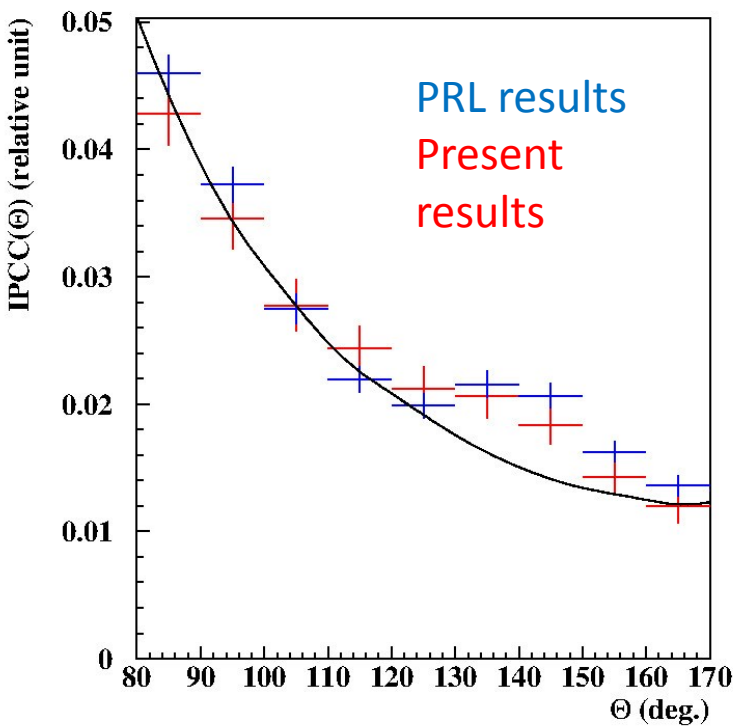


Recent results for the 17.6 MeV transition



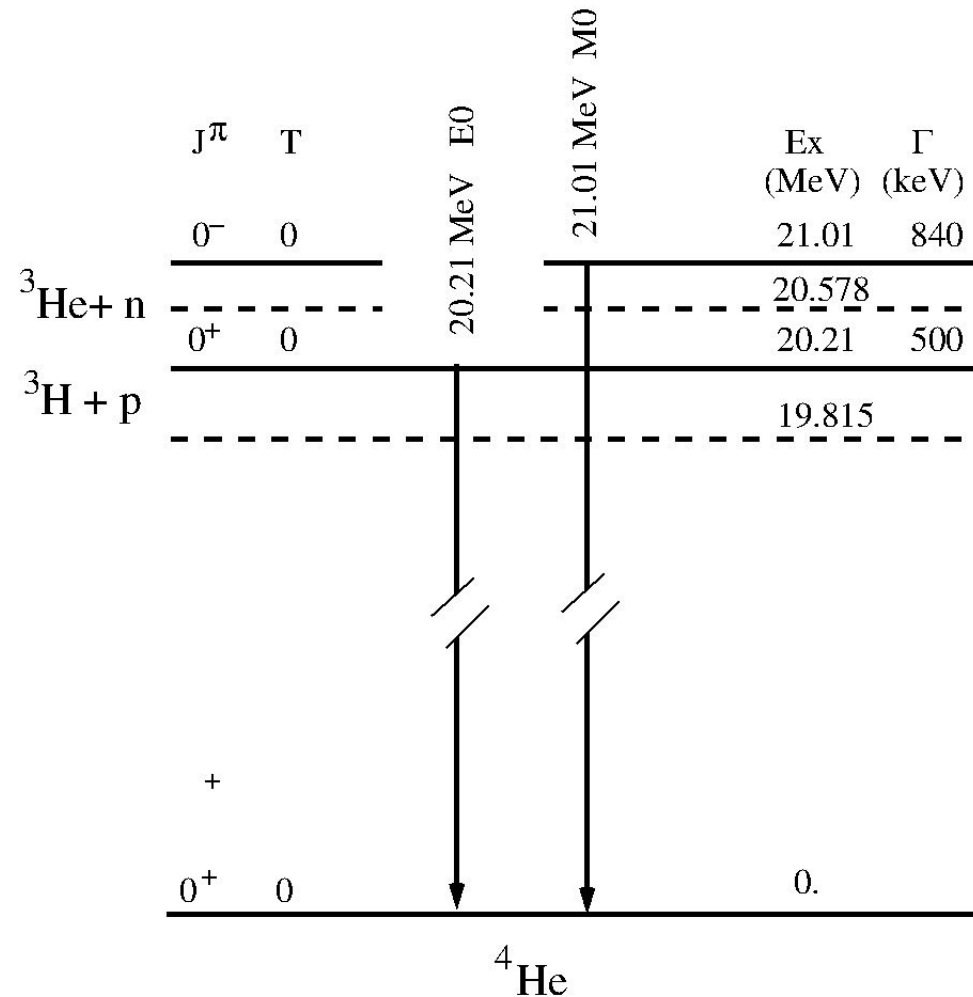
Comparison of results for the 18.15 MeV transition

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

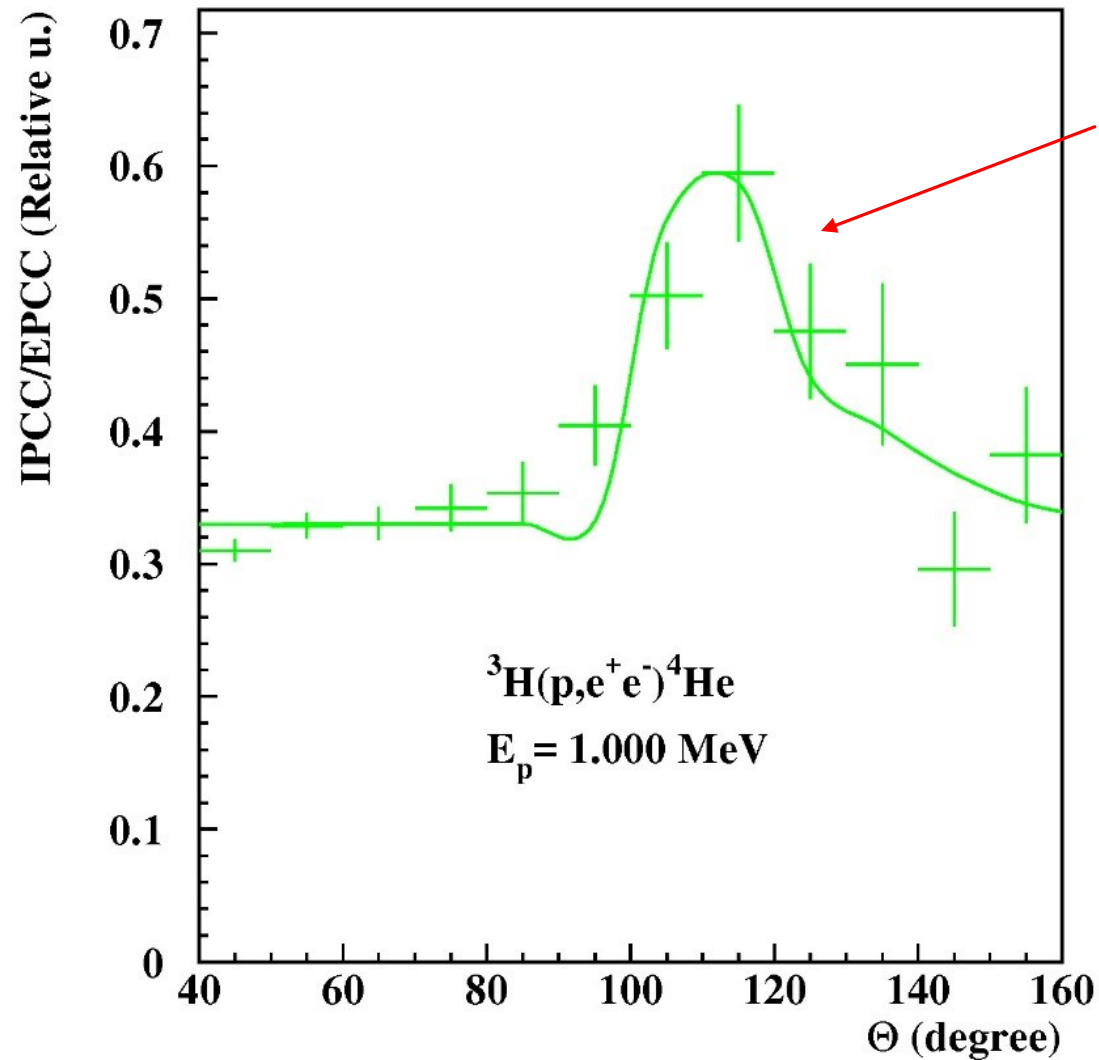


	Exp1	Exp2	Average
$m_0c^2(MeV)$	16.86(6)	17.17(7)	17.01(16)
B_x	$6.8(10) \times 10^{-6}$	$4.7(21) \times 10^{-6}$	$6(1) \times 10^{-6}$
Significance	7.37σ	4.90σ	

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



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



$M_0c^2 = 16.6 \text{ MeV}$

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 ^8Be Nuclear Transitions

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(Received 3 May 2016; published 11 August 2016)



PUBLISHED FOR SISSA BY SPRINGER

RECEIVED: September 23, 2016

REVISED: October 24, 2016

ACCEPTED: October 28, 2016

PUBLISHED: November 8, 2016

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

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.

^4He experiments in Debrecen, and in Garching

The $^3\text{H}(p,\gamma\gamma)^4\text{He}$ experiment in Debrecen

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

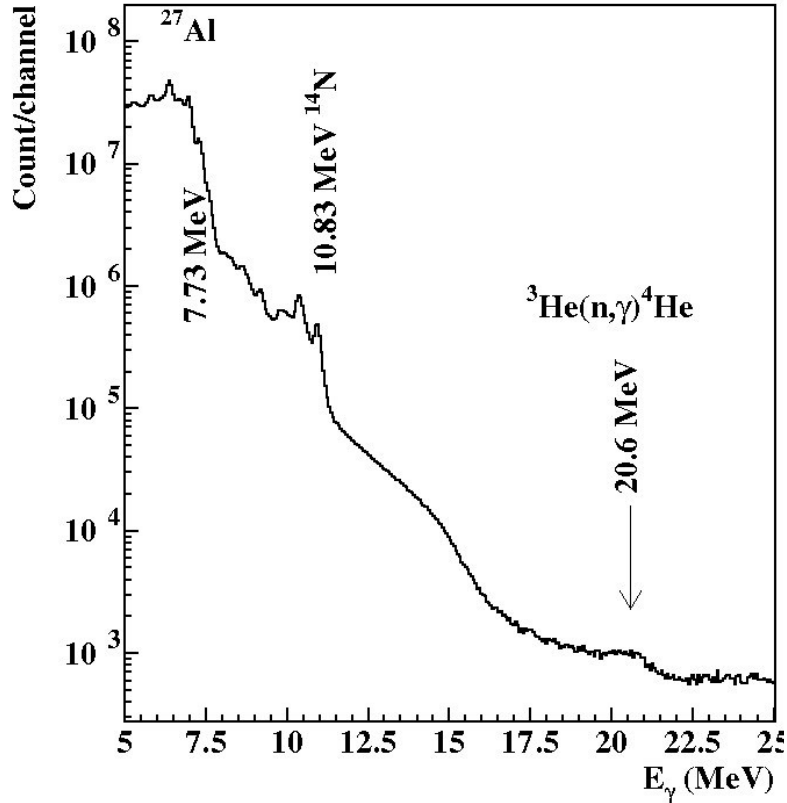
The $^3\text{He}(n,\gamma\gamma)^4\text{He}$ experiment in Garching

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

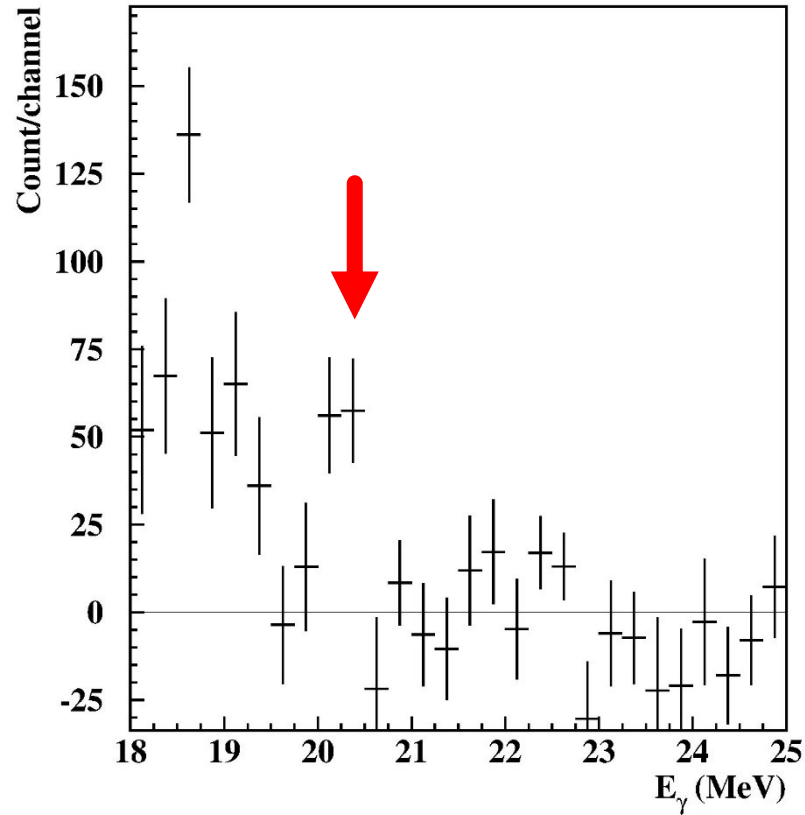


γ -spectrometer with twelve, 3"x3" and two 3.5"x6" LaBr₃ detectors

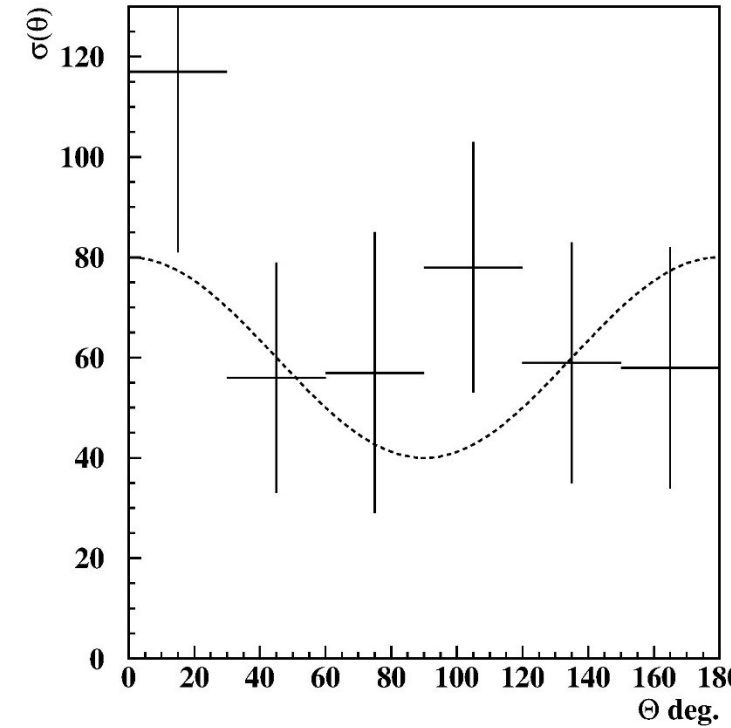
The first preliminary results



A typical singles γ -ray spectrum



Typical sum-energy spectra for coincident detectors



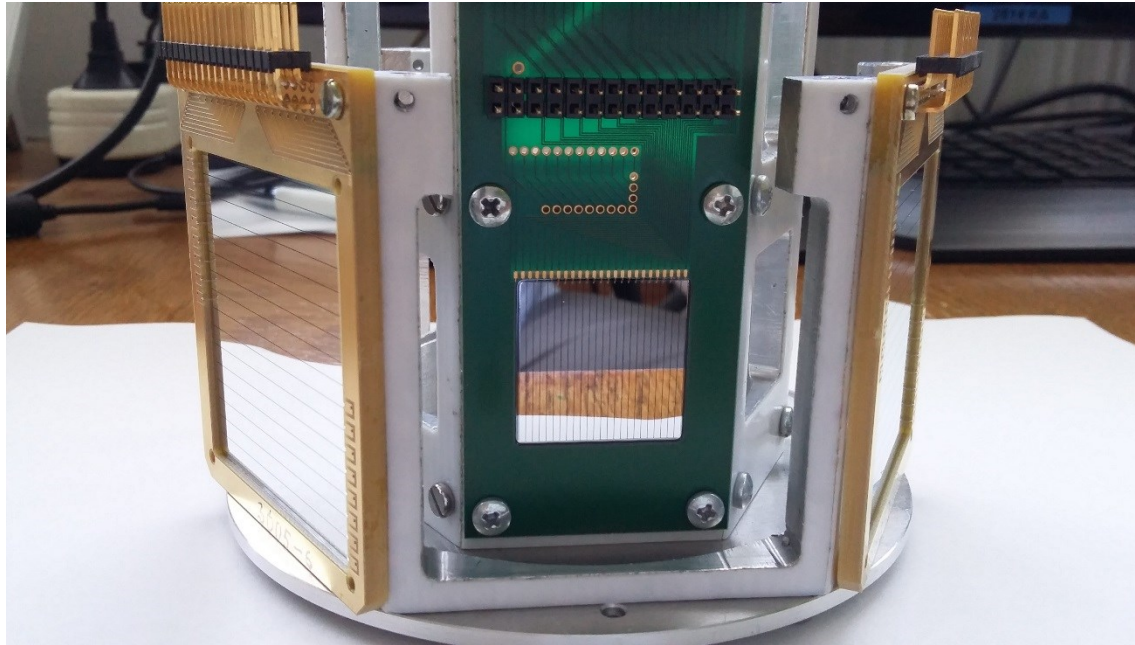
Preliminary $\gamma\gamma$ -angular correlation

Conclusion



- The ^8Be 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 ^4He in a 20.6 MeV $0^- \rightarrow 0^+$ transition at a correspondingly smaller angle.
- The $\gamma\gamma$ -decay of X17 was studied. We are planning further experiments.

To ^8Be continued...



Thank you very much for your
attention