Confirmation the existence of the X17 particle

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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

In the downtown of Debrecen, www.atomki.mta.hu

Observation of Anomalous Internal Pair Creation in

Overview of attention for article published in Physical Review Letters, January 2016

SUMMARY | News | Blogs | Twitter | Facebook | Goo

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 dipol (J^{... [show]

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about how the information was compiled.

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

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

Jonathan L. Feng,[1] Bartosz Fornal,[1] Iftah Galon,[1] Susan Gardner,[1,2] Jordan Smolinsky,[1] Tim M. P. Tait,[1] and Philip Tanedo[1]

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Phys. Rev. Lett. 117, 071803

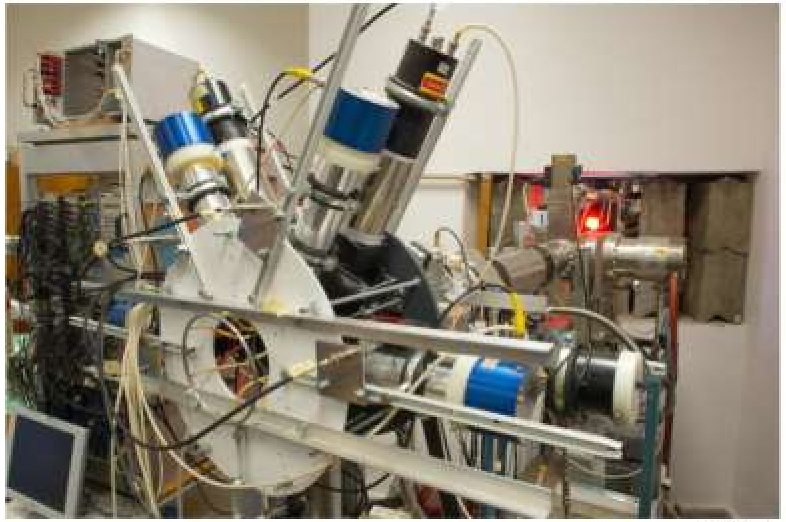
NATURE | NEWS

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.

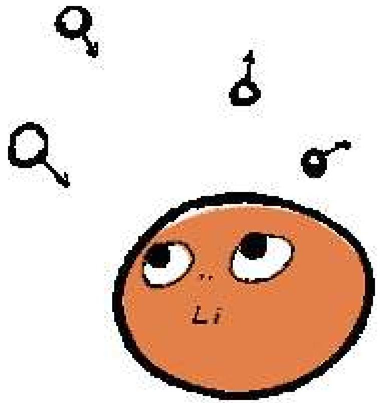
Attila Krasznahorkay at the Hungarian Academy of Sciences's Institute for Nuclear Research in Debrecen, Hungary, and his colleagues reported their surprising result in 2015 on the arXiv preprint server, and this January in the journal *Physical Review Letters*[1]. But the report – which posited the existence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

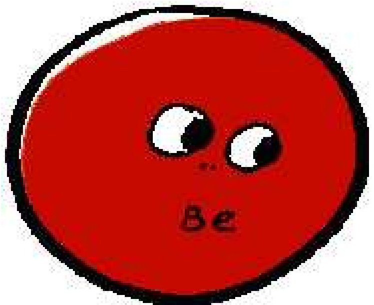
Then, on 25 April, a group of US theoretical physicists brought the finding to wider attention by publishing its own analysis of the result on arXiv[2]. The theorists showed that the data didn't conflict with any previous experiments – and concluded that it could be evidence for a fifth fundamental force.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

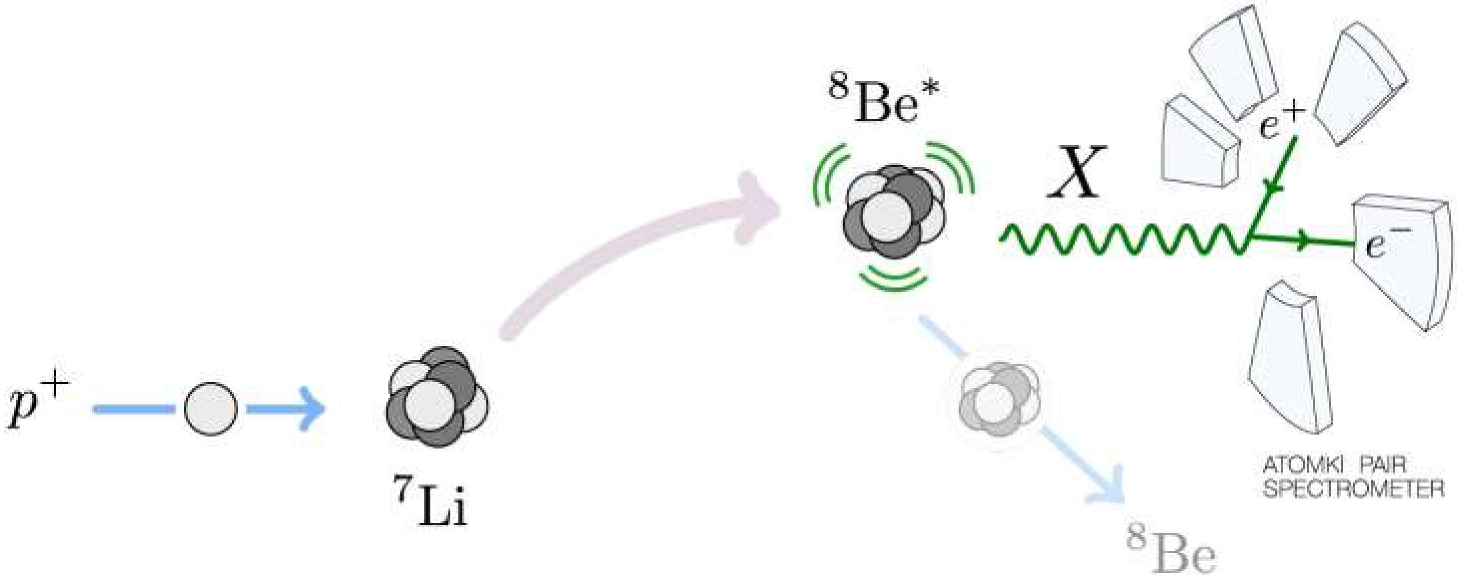
Dark matter may feel a "dark force" that the rest of the Universe does not

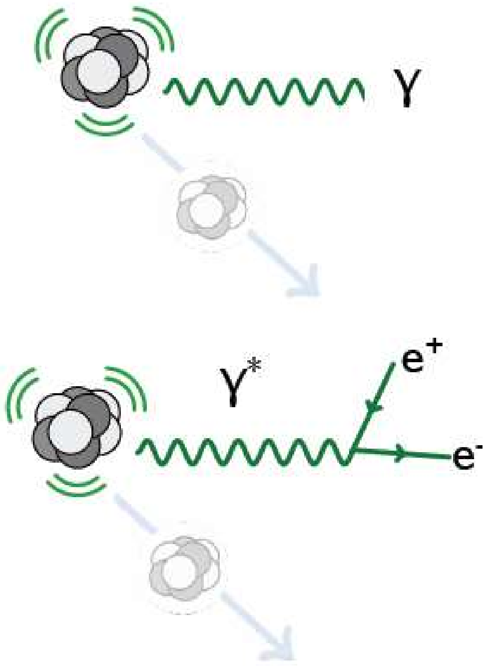
Four days later, two of Feng's colleagues discussed the finding at a workshop at the SLAC National Accelerator Laboratory in Menlo Park, California. Researchers there were sceptical but excited about the idea, says Bogdan Wojtsekhowski, a physicist at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. "Many participants in the workshop are thinking about different ways to check it," he says. Groups in Europe and the United States say that they should be able to confirm or rebut the Hungarian experimental results within about a year.

The creation and decay of ^{8}Be*





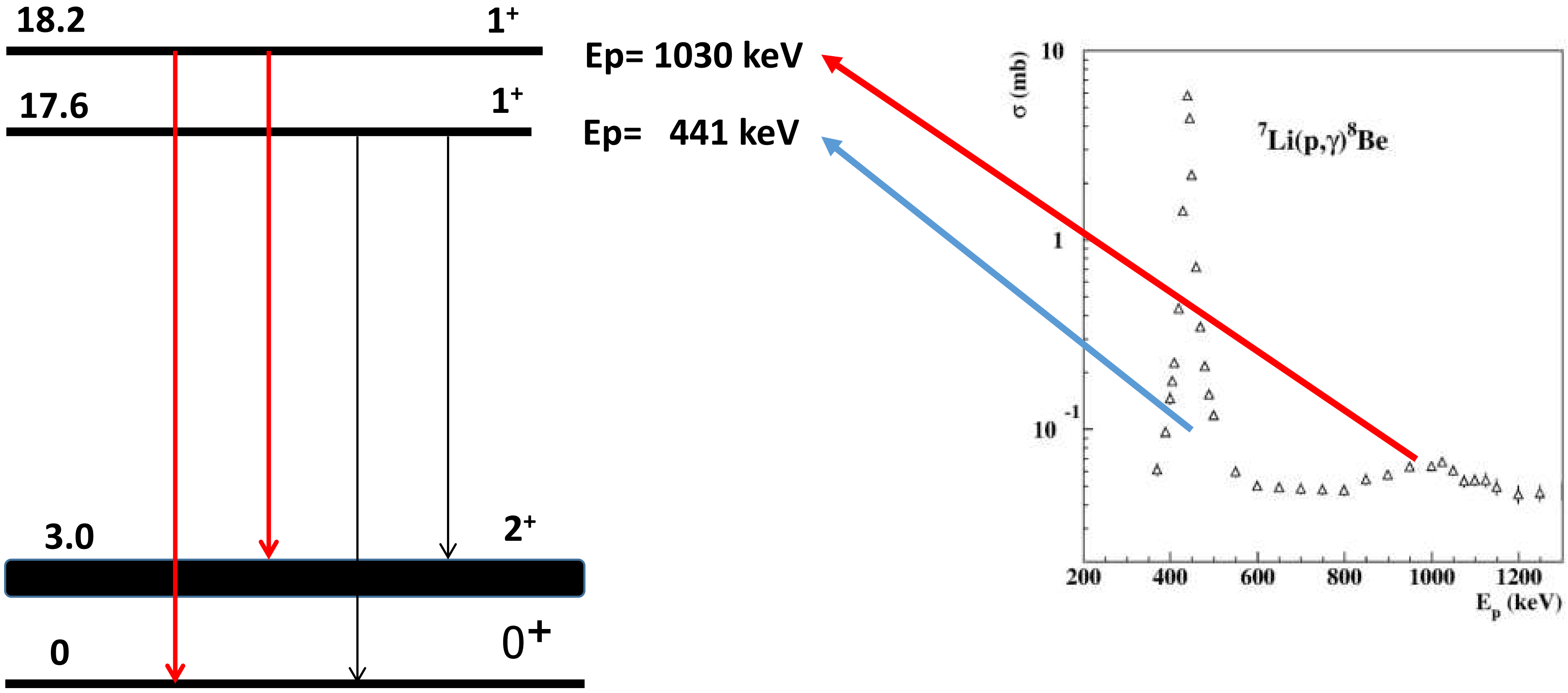




- Proton decay: B(p + ^{7}Li) ≈ 100%
- γ-decay: B(^{8}Be + γ) ≈ 1.5 x 10^{-5}
- Internal pair creation: B(^{8}Be + e^{+} e^{-}) ≈ 5.5 x 10^{-8}
- Ejection of a new particle: B(^{8}Be + X) ≈ 5.5 x 10^{-10}

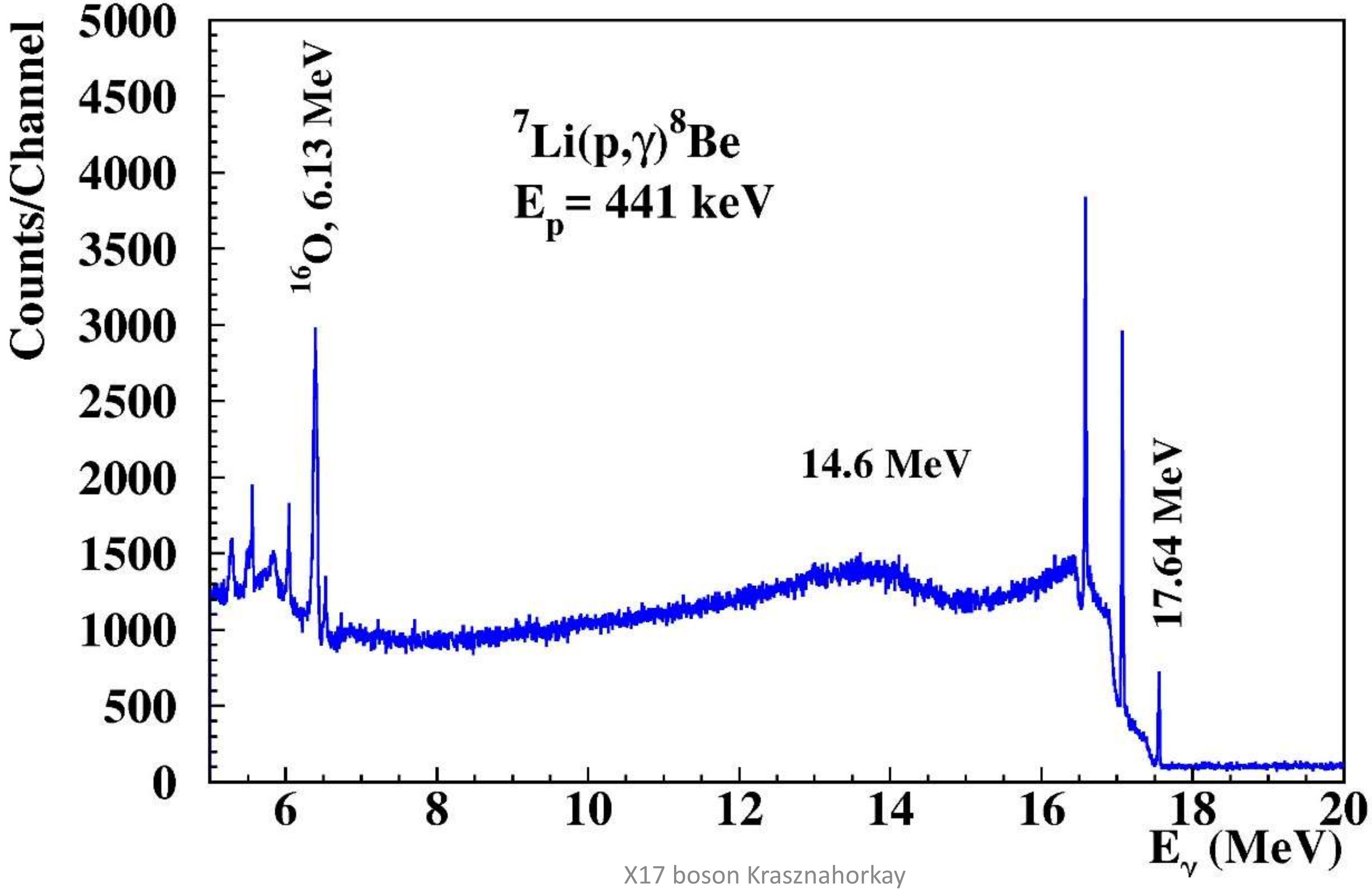
Study the ^{8}Be M1 transitions

Excitation with the
$^7Li(p,\gamma)^8Be$ reaction



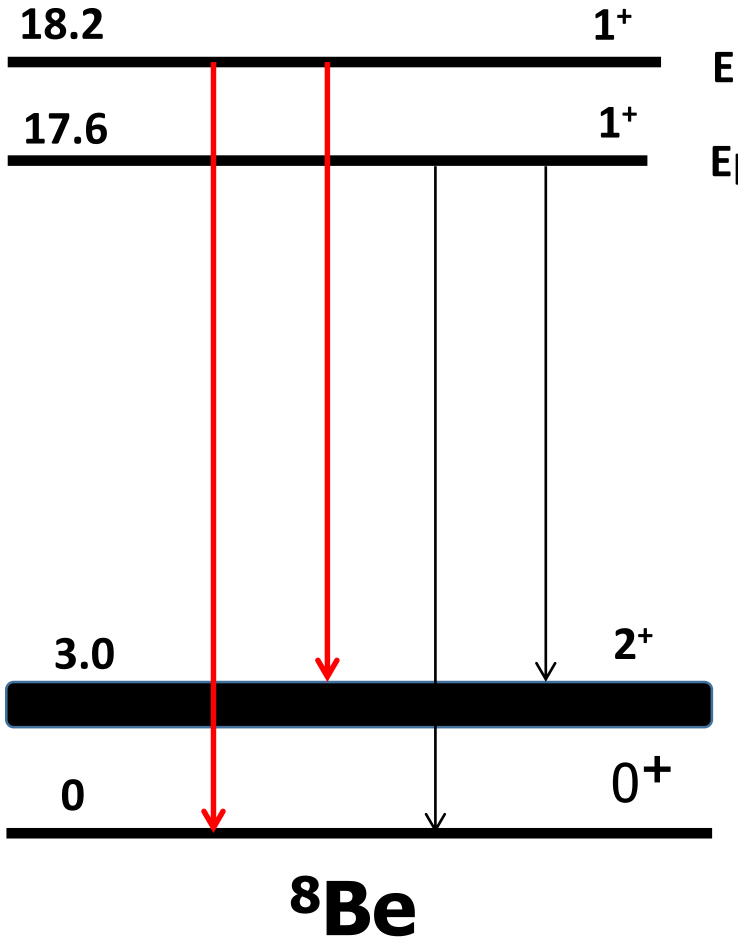
^{8}Be

γ-ray spectrum measured with a 100% HpGe detector



Study the ^{8}Be M1 transitions

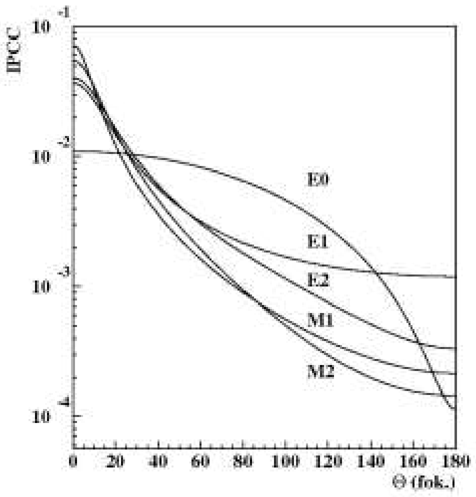
Excitation with the
^{7}Li(p,γ)^{8}Be reaction



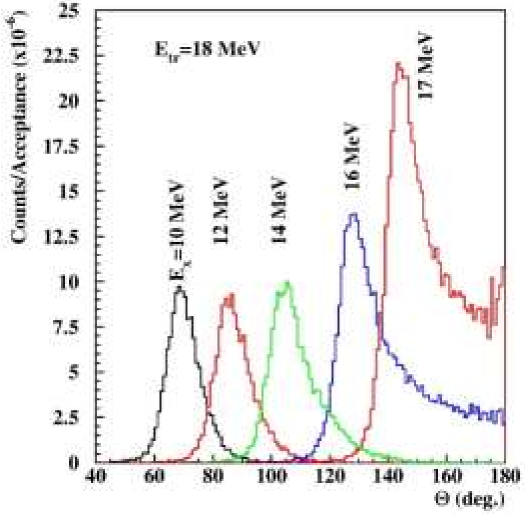
Ep= 1030 keV

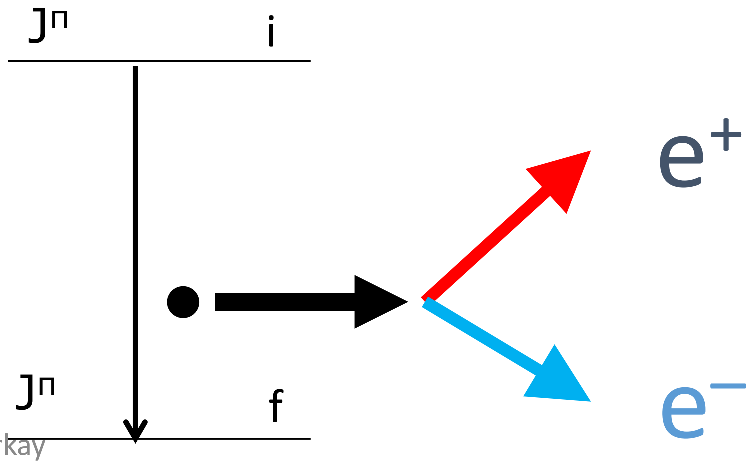
Ep=   441 keV

Background

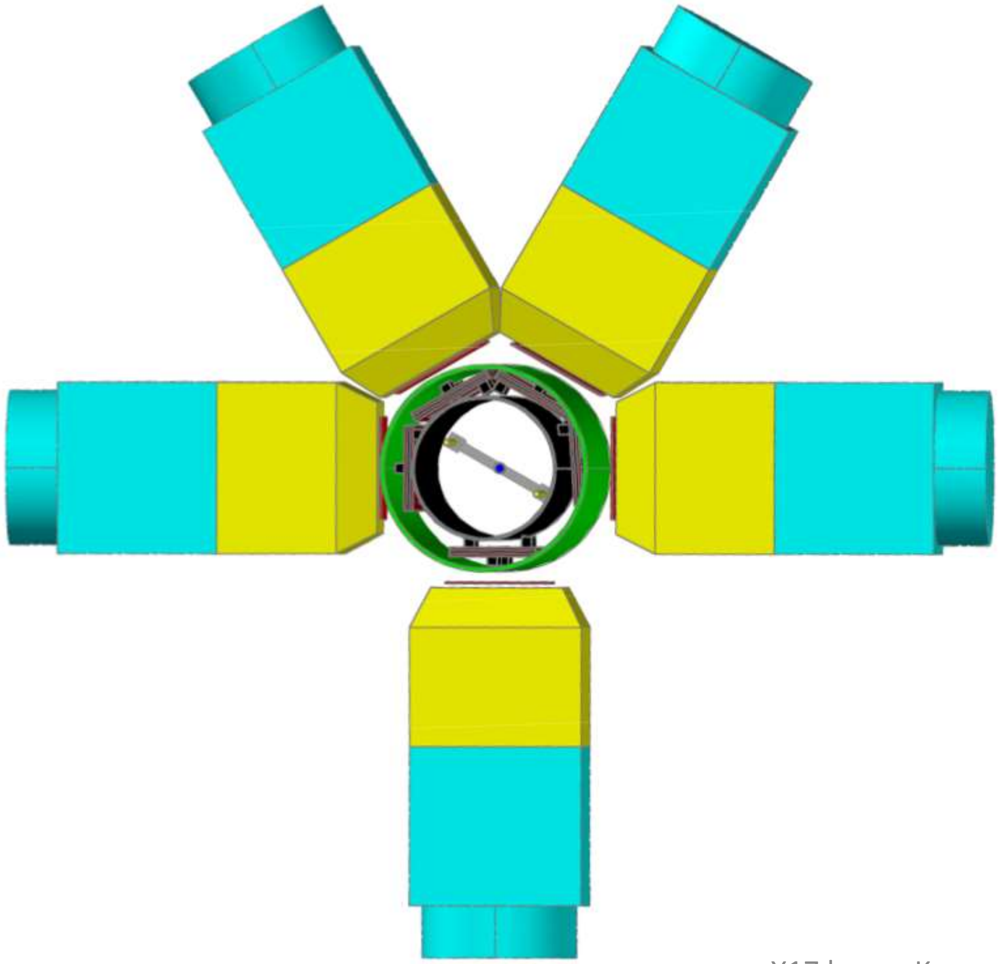


Signature



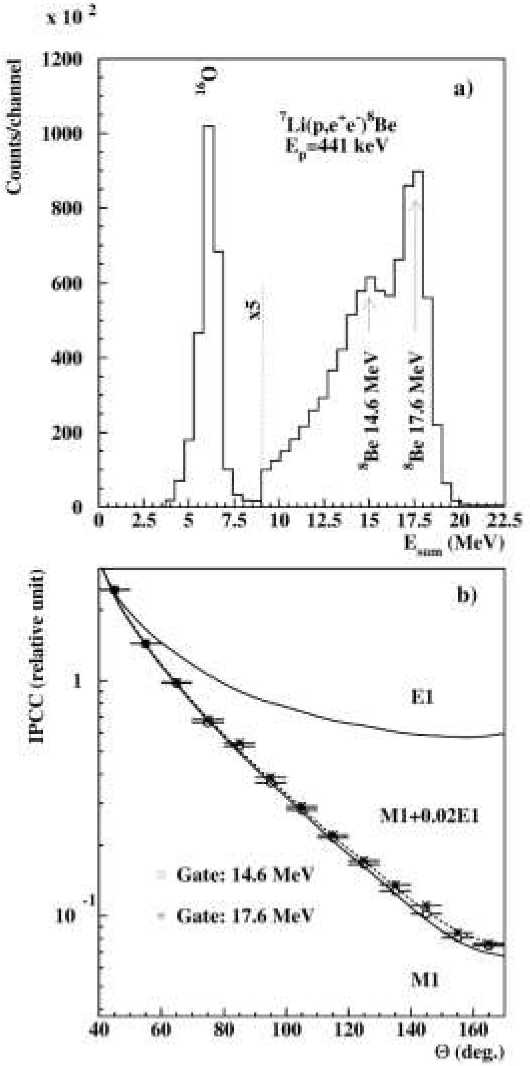


Geometrical arrangement of the scintillator telescopes (NIM, A808 (2016) 21)

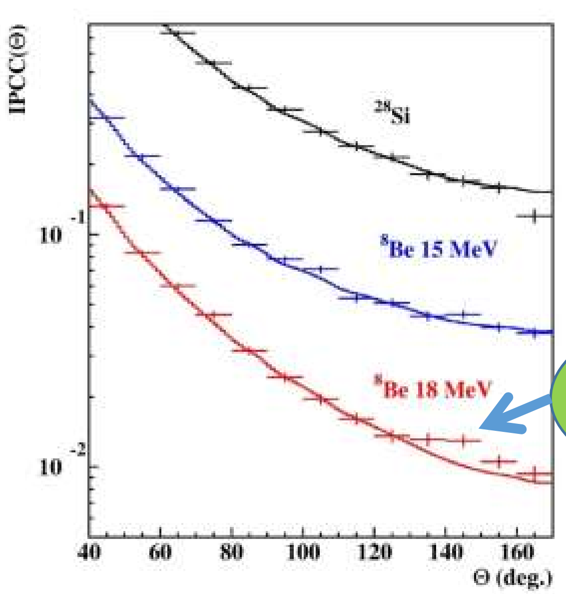


Results

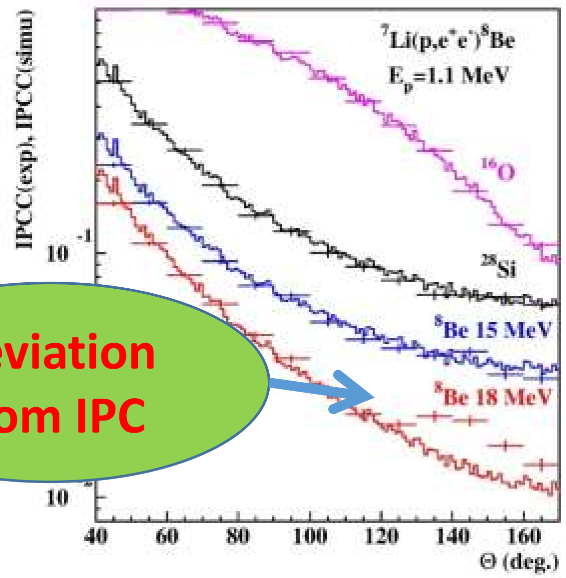
e$^+$ - e$^-$ sum energy spectra and angular correlations



Ep=1.04 MeV



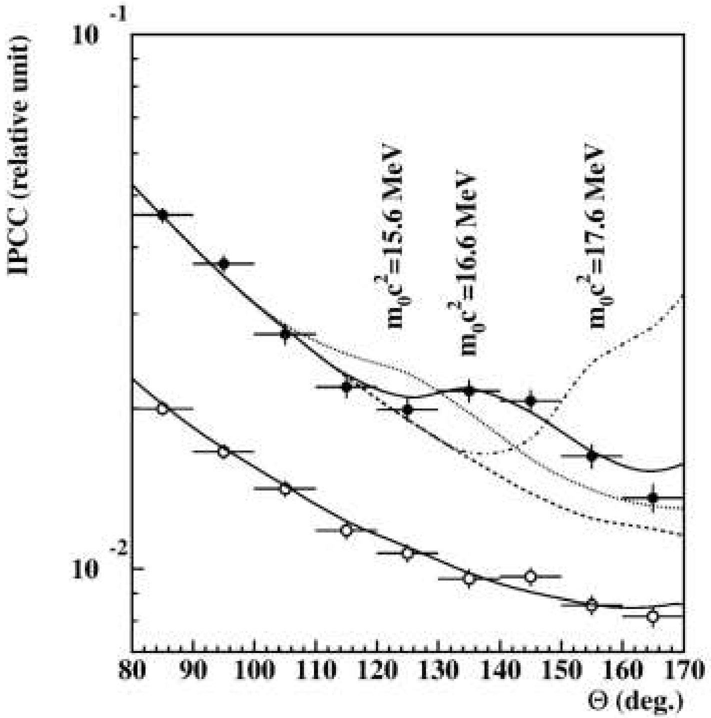
Ep=1.10 MeV

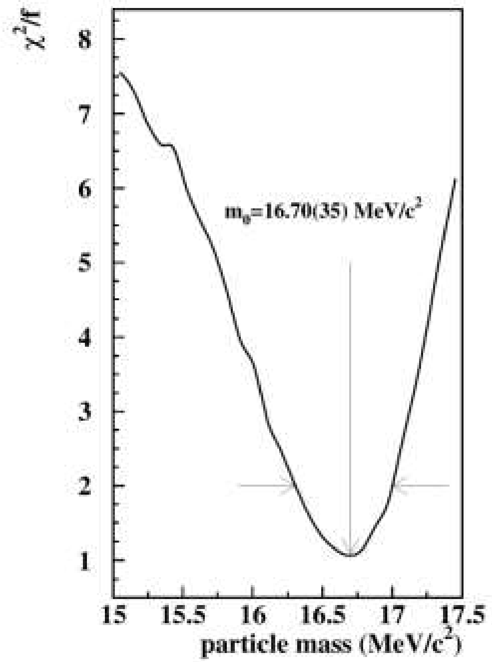


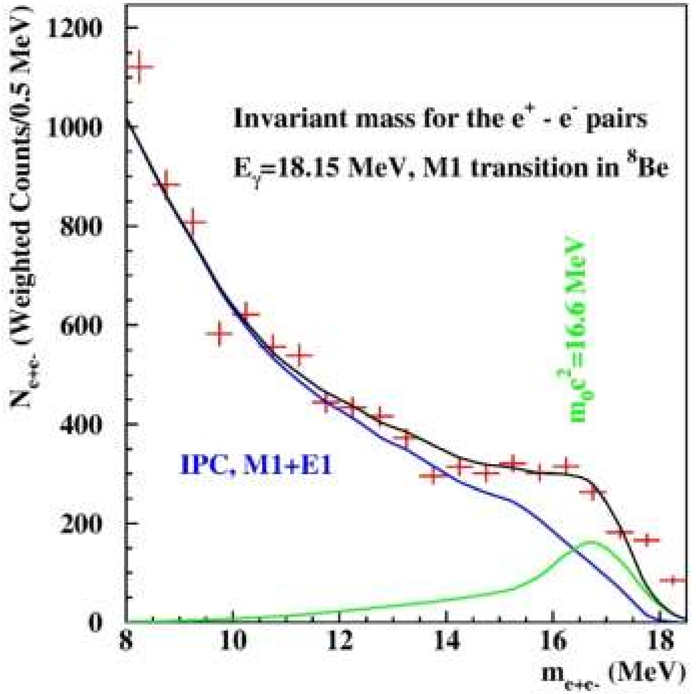
Deviation from IPC

- **Can it be some artificial effect caused by γ-rays?**
- **Can it be some nuclear physics effect?**
- **…**

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







Experimental angular e^+e^- pair correlations measured in the ^{7}Li(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).

Determination of the mass of the new particle by the X^2/f method

$$m^2 \approx (1-y^2)E^2\sin(\Theta/2)$$

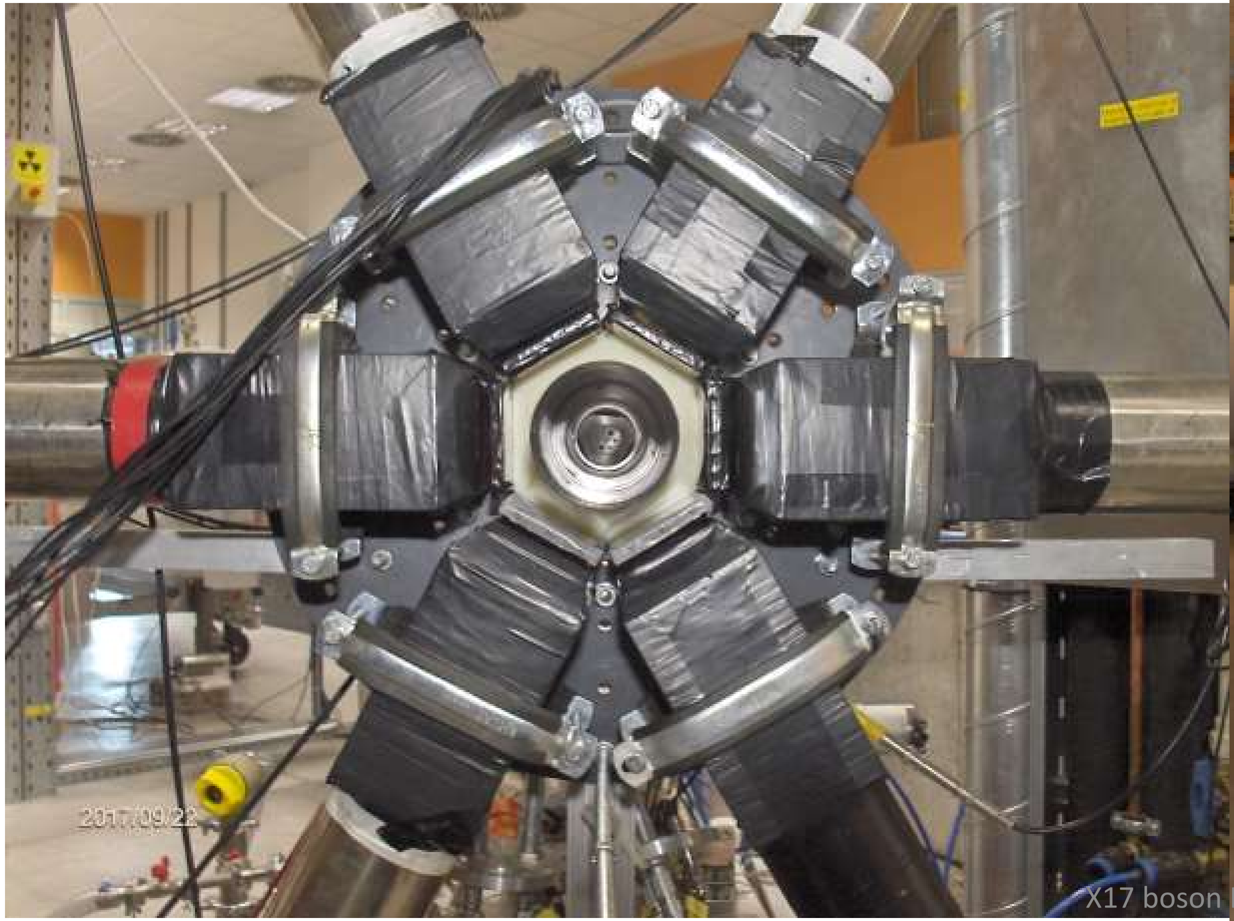
$$Y = \frac{E_+ - E_-}{E_+ + E_-}$$

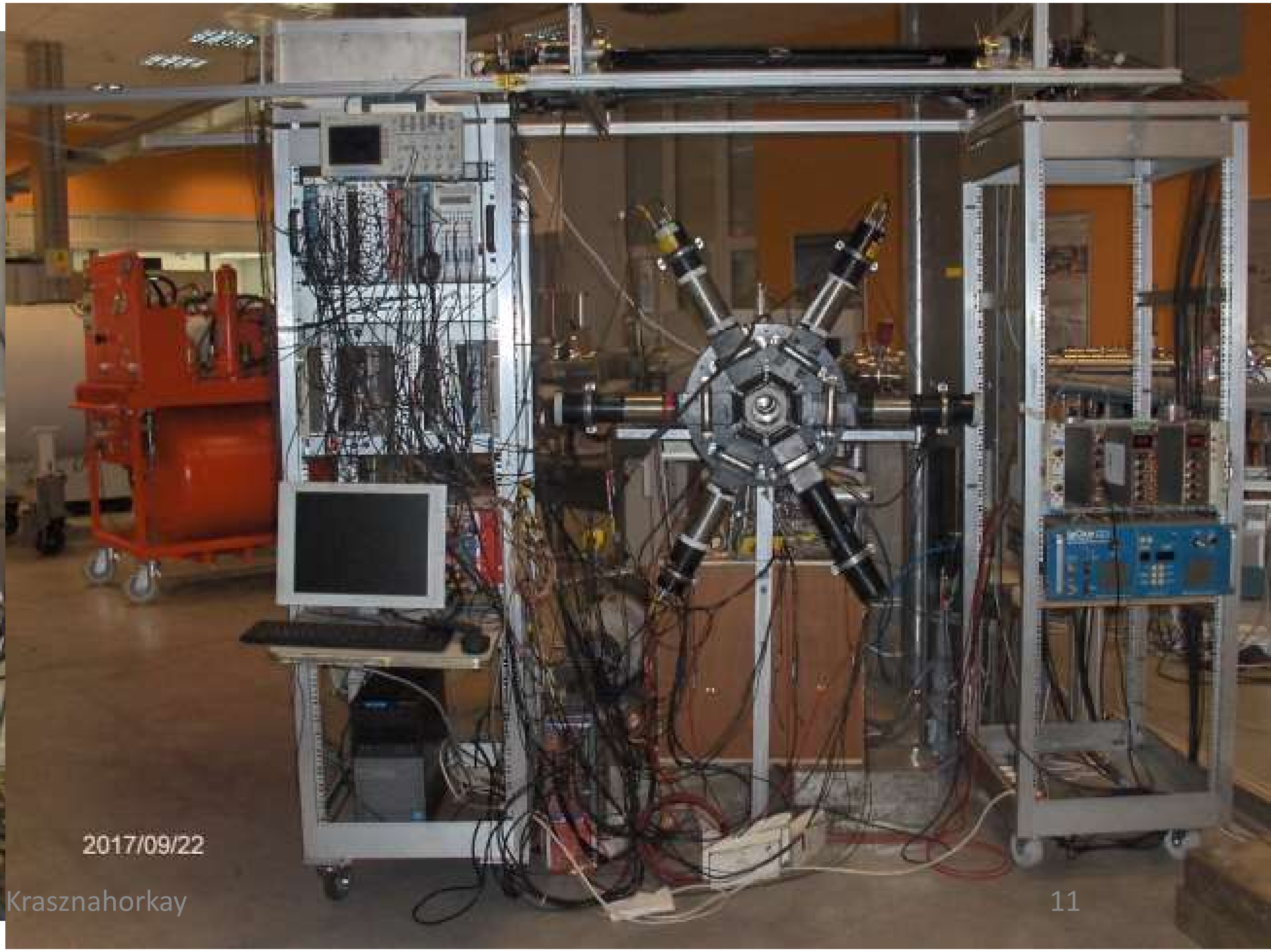
Repeating the experiments at a new Medium-Current Tandetron Accelerator in Atomki

Main specifications:

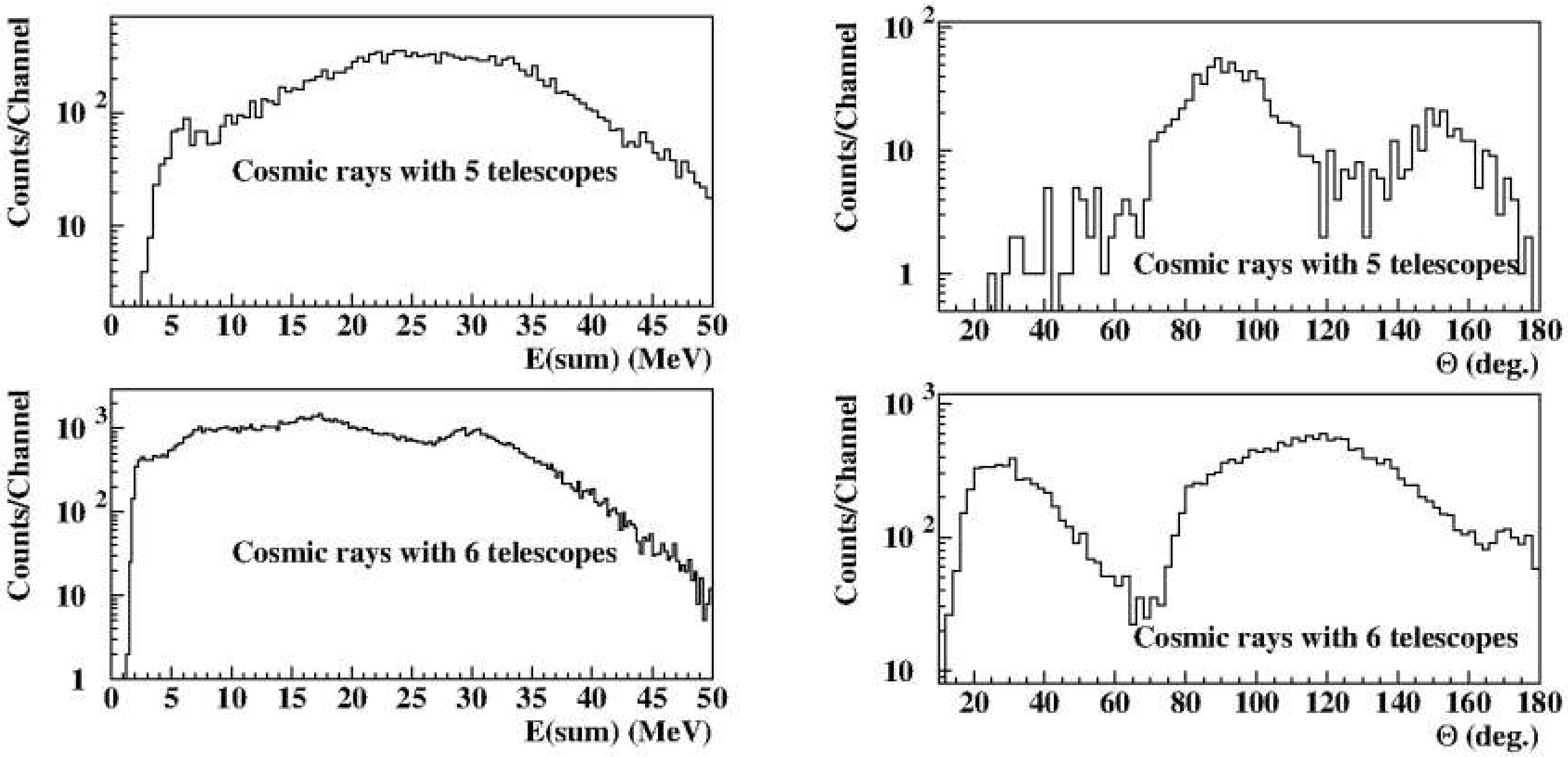
- TV ripple: 25 V_{RMS}, TV stability: 200 V (GVM), 30 V (SLITS)
- Beam current capability at 2 MV: 200 μA proton, 40 μA He

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

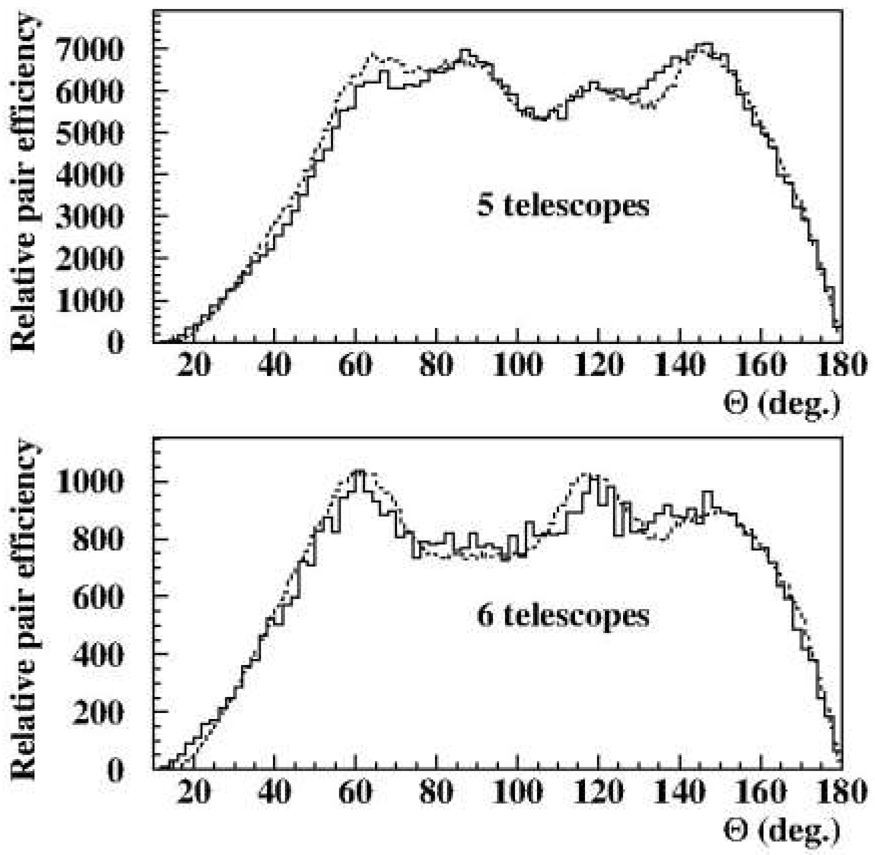




Background from cosmic rays in the setups with 5 and 6 telescopes

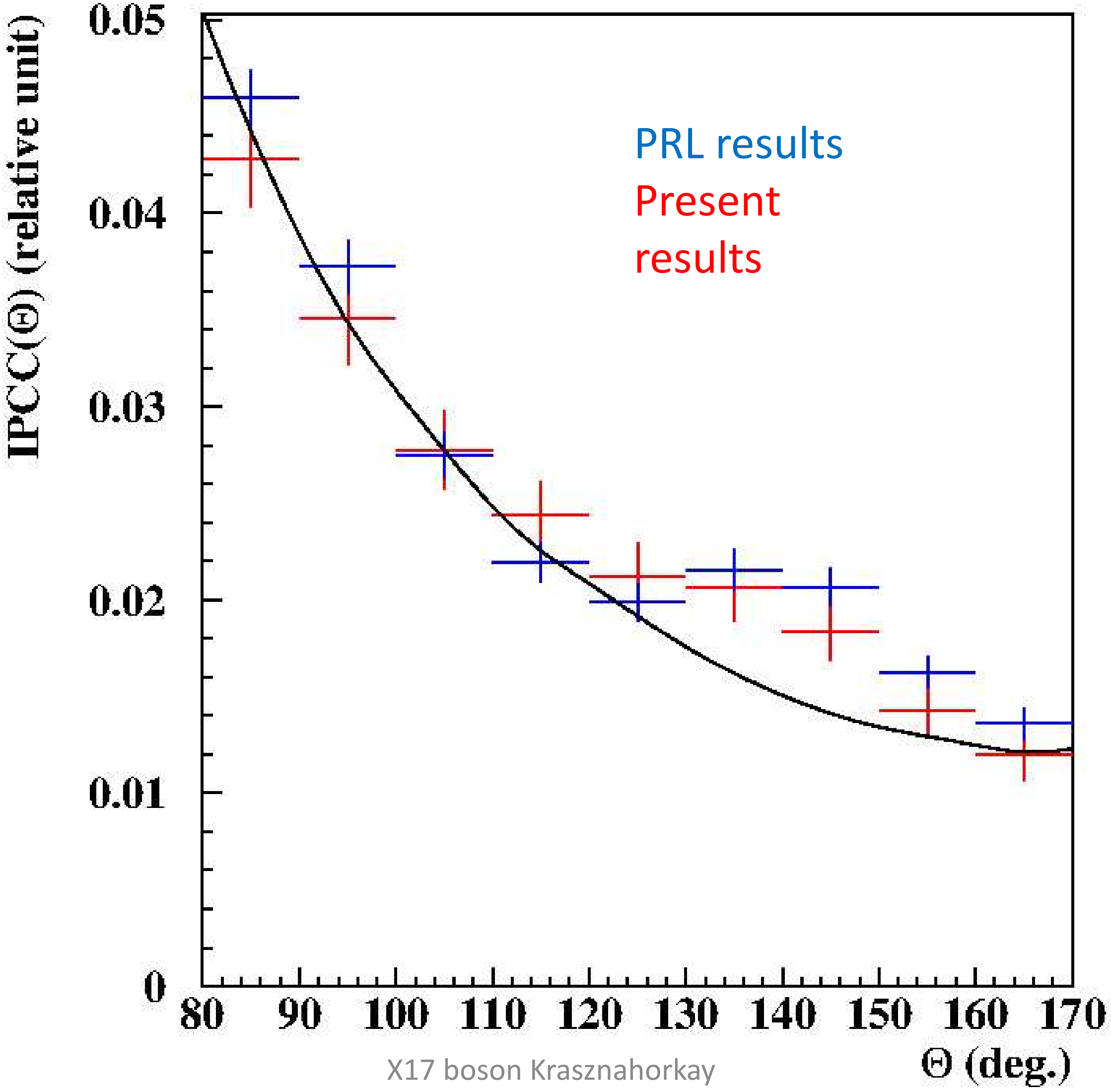


Efficiency curves for the setups with 5 and 6 telescopes

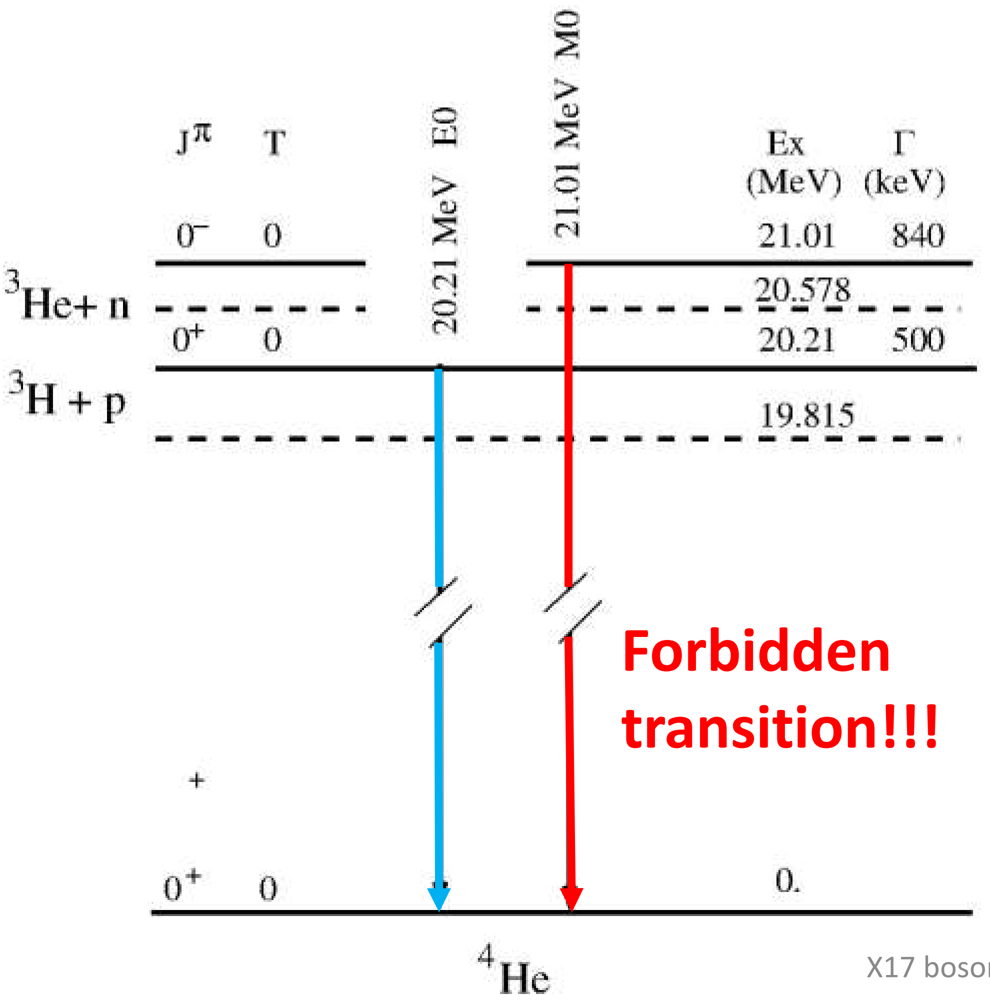


The results of the present experiment can be considered independent from the one we published in PRL in 2016.

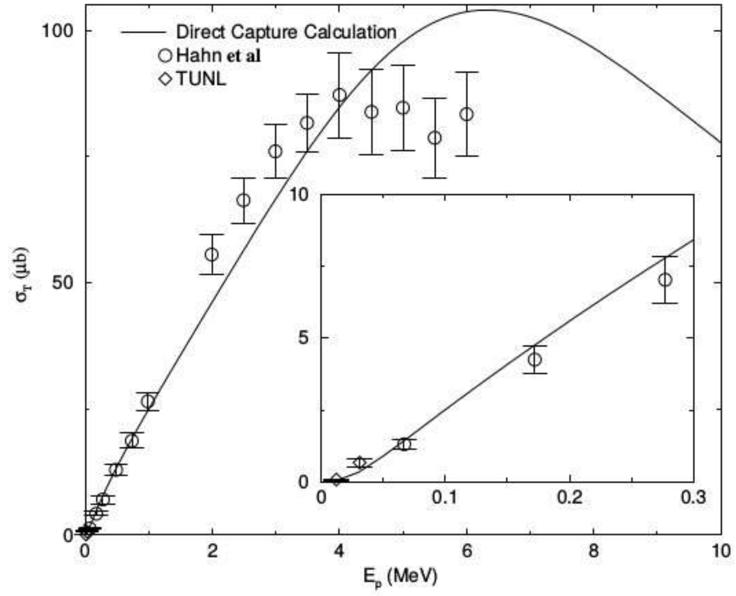
Recent (preliminary) results for the 18.15 MeV transition



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

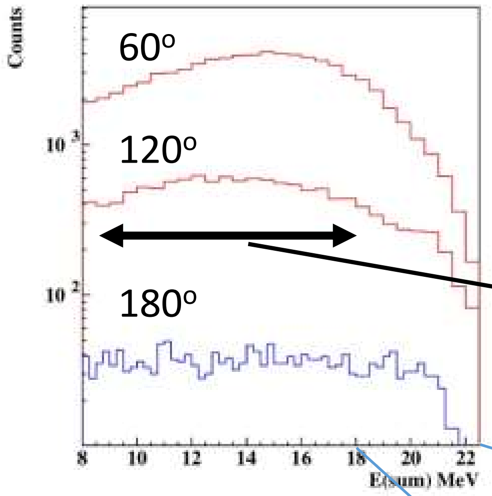


Forbidden transition!!!

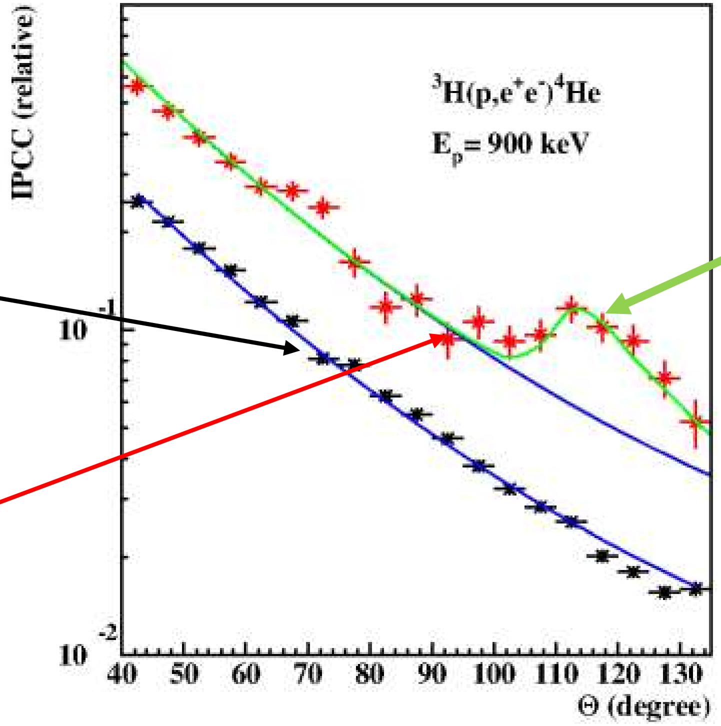


γ-ray production with direct proton capture. The main source of background produced by external pair creation on the backing of the target and on the other surrounding materials. **GEANT simulations.**

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



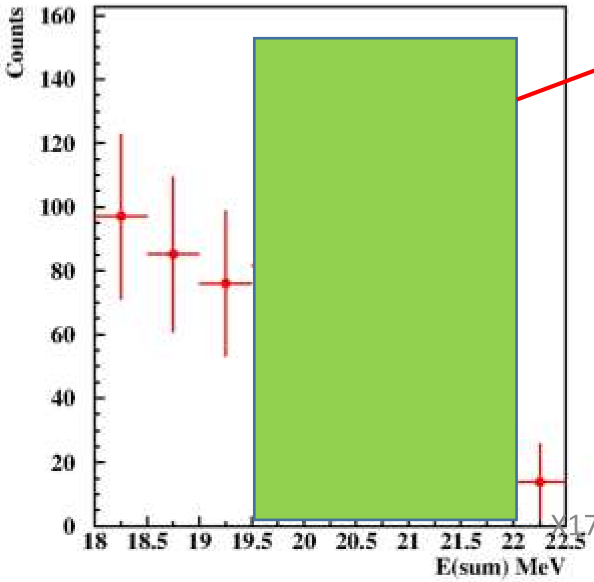
Measured e^+e^- sum-energy spectra for different detector combinations.



Simulation for m_0c^2= 17.0 MeV

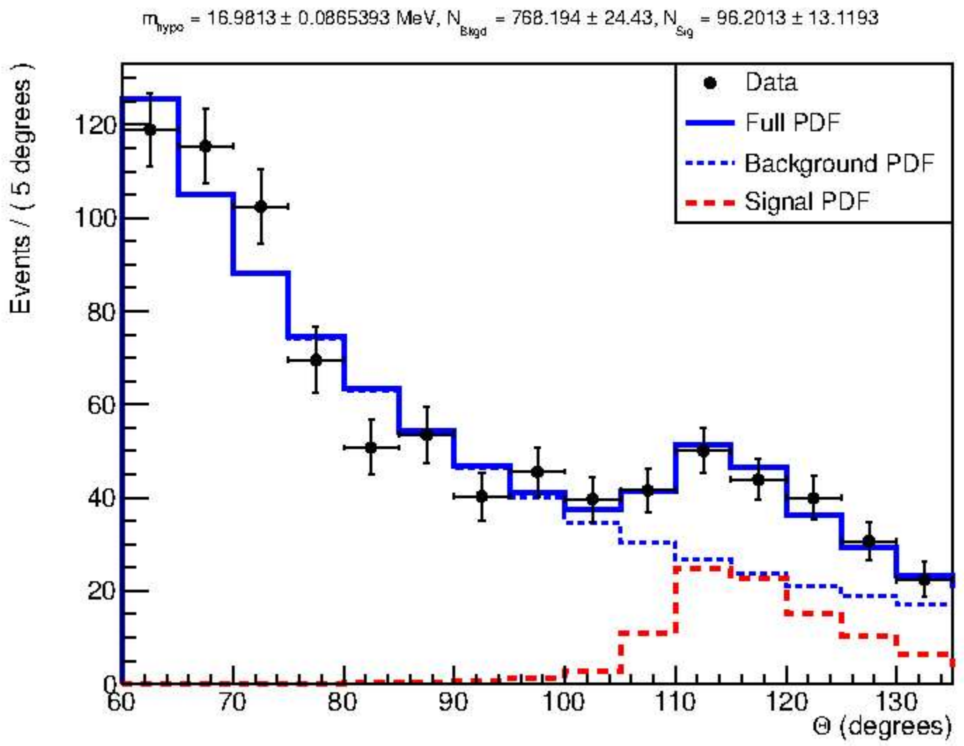
Significance: 7.6 σ

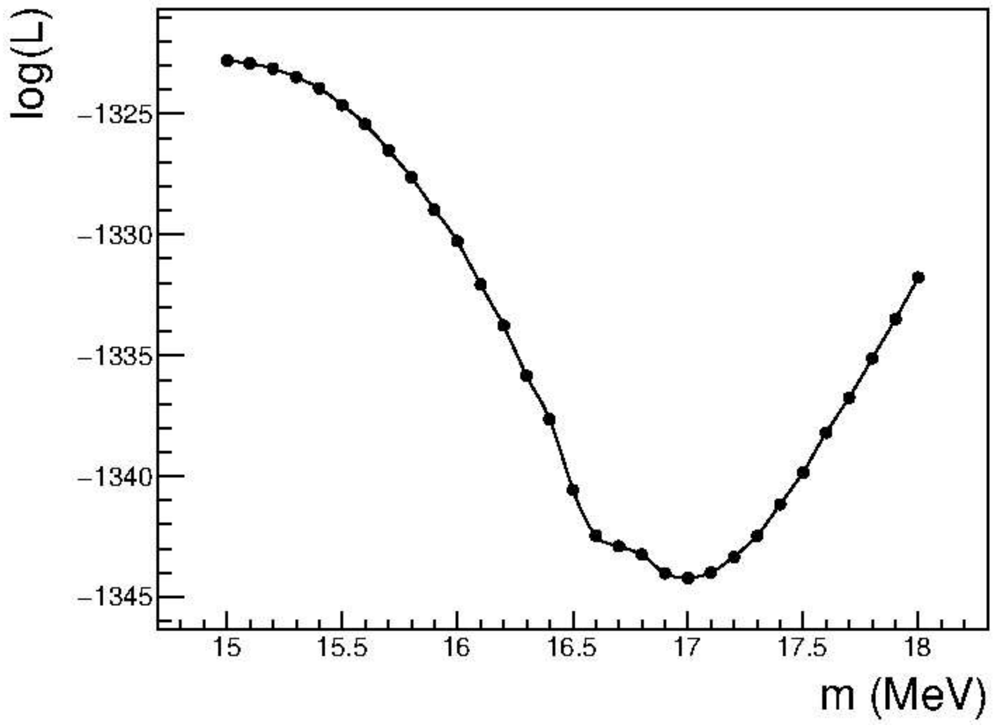
Difference between spectra measured at 120° and 60°.



Measured (gated) e^+e^- pair correlation for the full energy pairs.

Details of the fit performed by RooFit

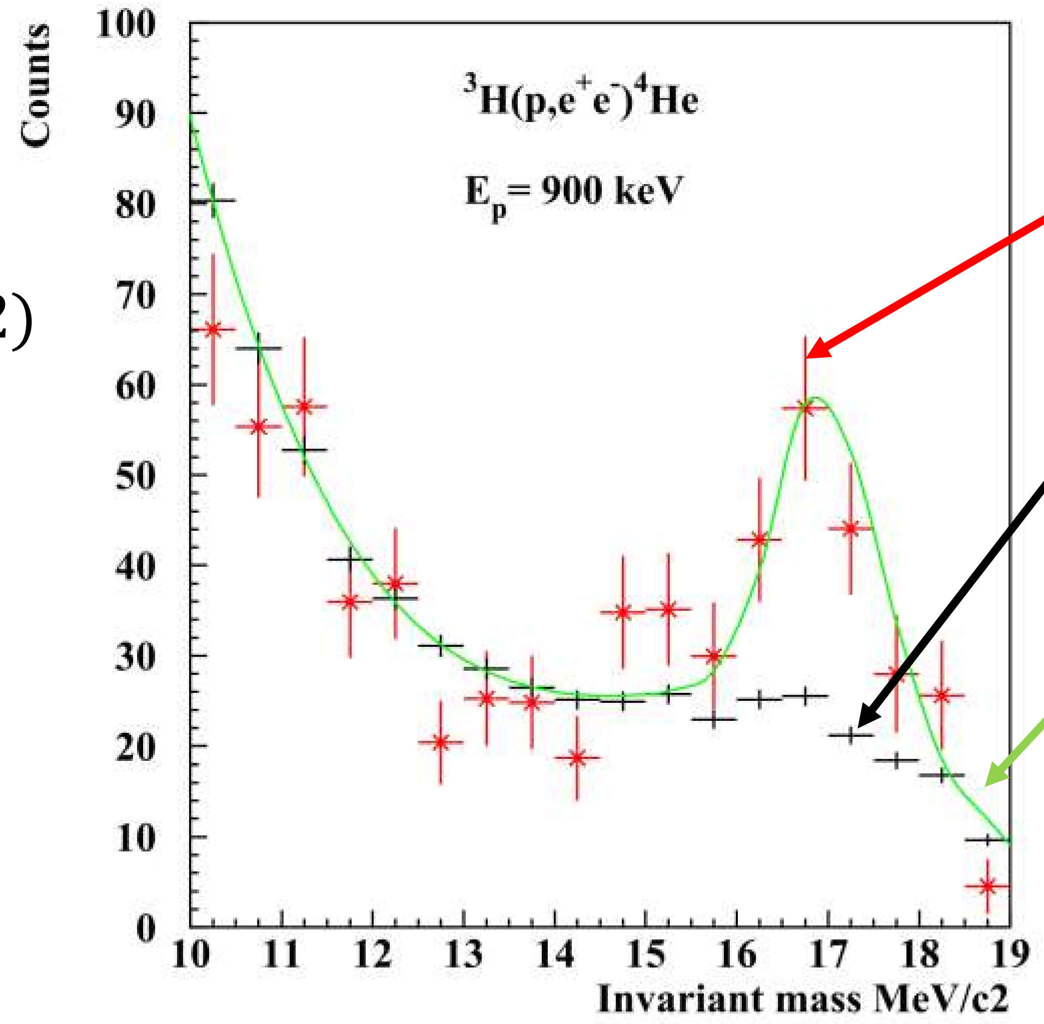




Invariant mass distribution

$$mc^2=\sqrt{(1-y^2)}E\sin(\Theta/2)$$

$$y=\frac{E_+ - E_-}{E_+ + E_-}$$



Gated invariant mass distr. for full energy pairs.

Gated invariant mass distr. for external pairs.

Simulated result for m_0c^2= 17.0 MeV

Study the $\gamma\gamma$-decay of X(17) in ^{4}He

- Vector particle (1+) or axialvector (0-)? If axialvector than it can decay by $\gamma\gamma$ emission.

- $\gamma\gamma$-decay only known in a special case: $0^{+} \rightarrow 0^{+}$ (^{90}Zr, ^{40}Ca, ^{16}O) ^{4}He
- *J. Schirmer et al., PRL 53, 1897 (1984)*
- *J. Kramp et al., NPA 474, 412 (1987)*
- Walz, N. Pietrala et al., Competitive Double-Gamma (Decay *Nature* **526**, 406 (2015)

$$\cos(\Theta) = 1 - \frac{m_x^2}{2E_1E_2}$$

Study the angular correlation with state of the art 3”x3” $LaBr_3$ detectors!

Promising outlook

A NEW EXPERIMENT SEARCHING FOR DARK MATTER AT CERN ...

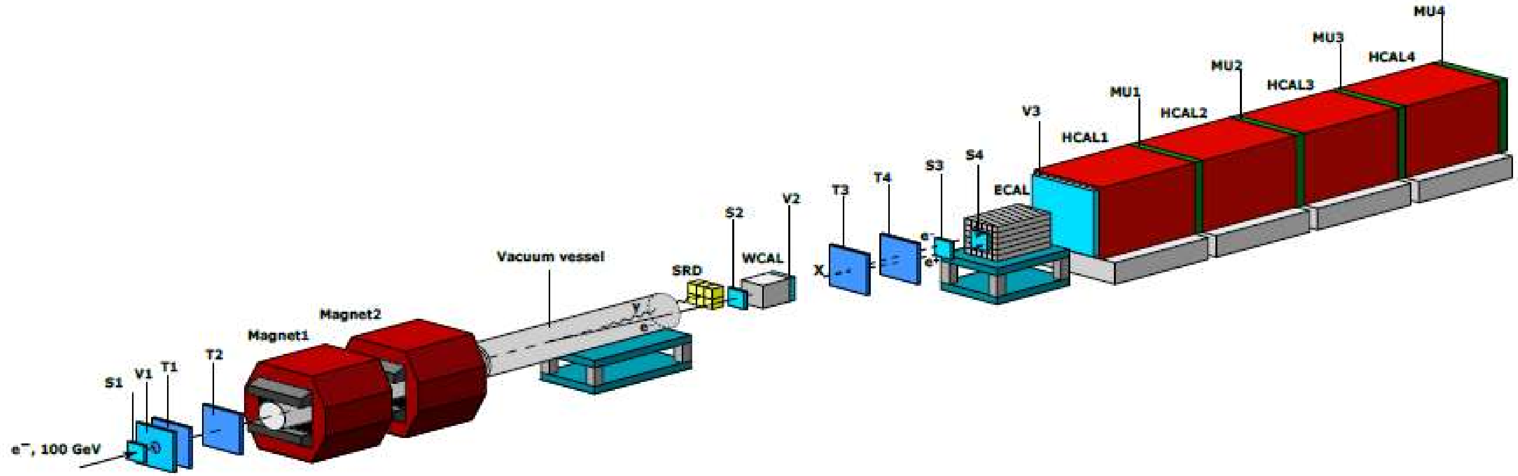
The Dark Sector Experiment

NA64 Analysis Note

The ^{8}Be excess and search for the $X \to e^+e^-$ decay of a new light boson with NA64

NA64-17-02-v2
March 20, 2017

S.V. Donskov, S.N. Gninenko, M.M. Kirsanov, D.V. Kirpichnkov



https://www.youtube.com/watch?v=J1P5r3IvVrM

Search for a new $X(16.7)$ boson and dark photons in the NA64 experiment at CERN

D. Banerjee,[4] V. E. Burtsev,[11] A. G. Chumakov,[11] D. Cooke,[13] P. Crivelli,[13] E. Depero,[13] A. V. Dermenev,[5] S. V. Donskov,[10] R. R. Dusaev,[11] T. Enik,[2] N. Charitonidis,[3] A. Feshchenko,[2] V. N. Frolov,[2] A. Gardikiotis,[9] S. G. Gerassimov,[6,8] S. N. Gninenko**,[5] M. Hösgen,[1] M. Jeckel,[3] A. E. Karneyeu,[5] G. Kekelidze,[2] B. Ketzer,[1] D. V. Kirpichnikov,[5] M. M. Kirsanov,[5] I. V. Konorov,[6,8] S. G. Kovalenko,[12] V. A. Kramarenko,[2,7] L. V. Kravchuk,[5] N. V. Krasnikov,[5] S. V. Kuleshov,[12] V. E. Lyubovitskij,[11,12] V. Lysan,[2] V. A. Matveev,[2] Yu. V. Mikhailov,[10] D. V. Peshekhonov,[2] V. A. Polyakov,[10] B. Radics,[13] R. Rojas,[12] A. Rubbia,[13] V. D. Samoylenko,[10] V. O. Tikhomirov,[6] D. A. Tlisov,[5] A. N. Toropin,[5] A. Yu. Trifonov,[11] B. I. Vasilishin,[11] G. Vasquez Arenas,[12] P. V. Volkov,[2,7] V. Volkov,[7] and P. Ulloa[12]

(The NA64 Collaboration)

[1] *Universität Bonn, Helmholtz-Institut für Strahlen-und Kernphysik, 53115 Bonn, Germany*
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[10] *State Scientific Center of the Russian Federation Institute for High Energy Physics of National Research Center 'Kurchatov Institute' (IHEP), 142281 Protvino, Russia*
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[12] *Universidad Técnica Federico Santa María, 2390123 Valparaíso, Chile*
[13] *ETH Zürich, Institute for Particle Physics and Astrophysics, CH-8093 Zürich, Switzerland*

(Dated: March 22, 2018)

We report the first results on a direct search for a new 16.7 MeV boson (X) which could explain the anomalous excess of e^+e^- pairs observed in the excited ^{8}Be* nucleus decays. Due to its coupling to electrons, the X could be produced in the bremsstrahlung reaction $e^- Z \to e^- ZX$ by a 100 GeV e^- beam incident on an active target in the NA64 experiment at the CERN SPS and observed through the subsequent decay into a e^+e^- pair. With 5.4×10^{10} electrons on target no evidence for such decays was found, allowing to set first limits on the $X-e^-$ coupling in the range $1.3\times10^{-4} \lesssim \epsilon_e \lesssim 4.2\times10^{-4}$ excluding part of the allowed parameter space. We also set new bounds on the mixing strength of photons with dark photons (A') from non-observation of the decay $A' \to e^+e^-$ of the bremsstrahlung A' with a mass $\lesssim$ 23 MeV.

PACS numbers: 14.80.-j, 12.60.-i, 13.20.-v, 13.35.Hb

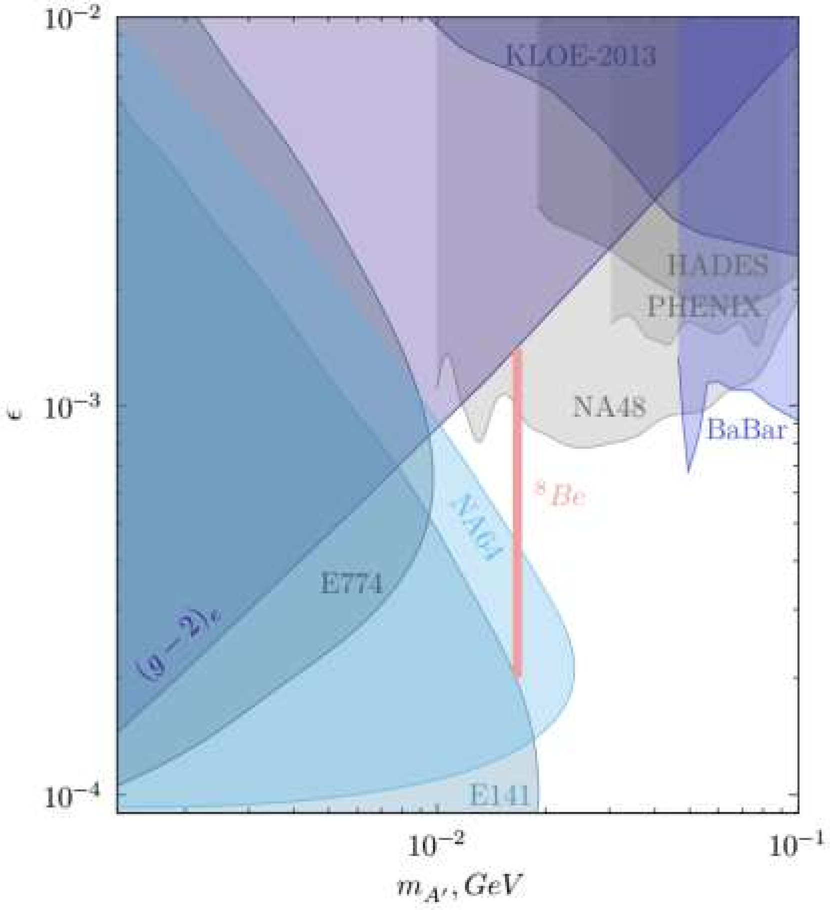


FIG. 3: The 90% C.L. exclusion areas in the $(m_X;\epsilon)$ plane from the NA64 experiment (blue area). For the mass of 16.7 MeV, the $X-e^-$ coupling region excluded by NA64 is $1.3\times10^{-4} < \epsilon_e < 4.2\times10^{-4}$. The full allowed range of ϵ_e explaining the ^{8}Be* anomaly, $2.0\times10^{-4} \lesssim \epsilon_e \lesssim 1.4\times10^{-3}$ [2, 3], is also shown (red area). The constraints on the mixing ϵ from the experiments E774 [24], E141 [21], BaBar [39], KLOE [44], HADES [46], PHENIX [47], NA48 [49], and bounds from the electron anomalous magnetic moment $(g-2)_e$ [67] are also shown.

Resonant production of X17 in positron beam dump experiments

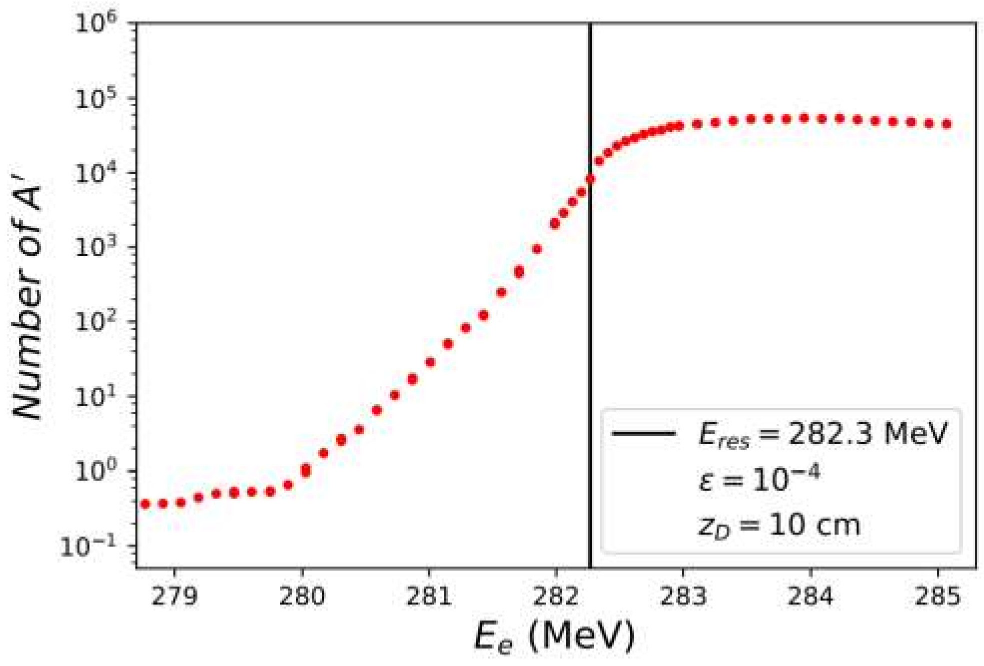
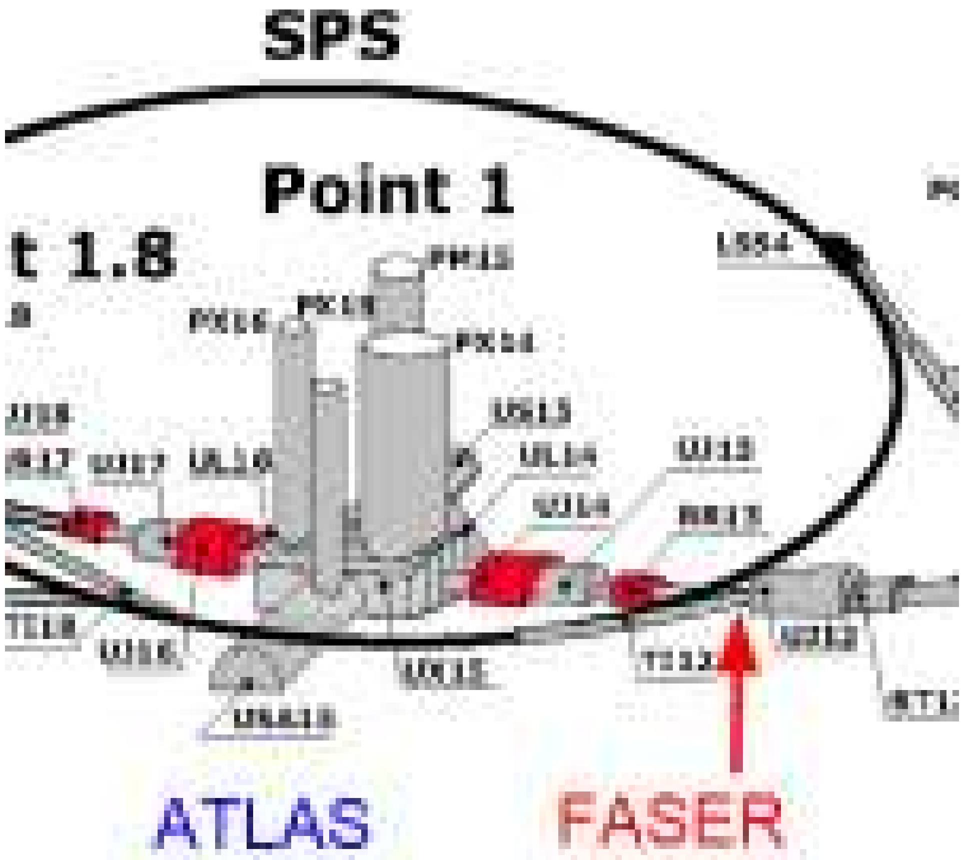


Figure 2. The number of DP decaying outside the dump as a function of the beam energy for $\epsilon = 10^{-4}$. The vertical line corresponds to the energy for resonant production of a 17 MeV DP. A dump length $z_D = 10$ cm and a background free measurement have been assumed.

PADME experiment in Frascati

It is running

ForwArd Search ExpeRiment (FASER) at the LHC



FASER can discover ALPs with masses $m_a \sim 10–400$ MeV

Exp. Starts at 2023.

A few other planned experiments to study X(17)

- **Mu3e** is a particle physics experiment at the Paul Scherrer Institute, searching for decays of anti-muons (*Mu*) to an electron and two positrons (*3e*).

- VEPP-3 is planned experiment in Vladivostok, Russia. They are planning to use intense positron beams.

- DarkLight is an experiment at the JLAB in USA using electron–proton collisions.

Conclusion

- The ^{8}Be anomaly has been 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 X17 was observed also in ^{4}He in a 20.6 MeV $0^- \rightarrow 0^+$ transition at a correspondingly smaller angle. The significance of the peak is 7.6 σ.
- We are planning to study the $\gamma\gamma$-decay of X17 to determine their spin.
- Promising outlook.

Acknowledgement

M. Csatlós, M. Ciemala, L. Csige, Z. Gácsi, J. Gulyás,
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A. Maj, Á. Nagy, N. Pietralla, Zs. Révay, N. Sas,
C. Stieghorst, B. Szihalmi, J. Timár, T. Tornyi,
B. Wasilewska

To ^{8}Be continued…

Thank you very much for your attention

Backup slides

Searching for new particles created in nuclear transitions has a very long history…

- The axion particle was proposed by Weinberg and by Wilczek as one mechanism for preserving CP invariance of strong interactions in the presence of instantons almost 40 years ago.

- The search for axions in nuclear transitions culminated in 1982.

- It turned out that nuclear transitions provide a useful laboratory to search for light particles which couple to quarks and/or gluons. The spin and parity of a particle emitted in nuclear decay can be constrained by an appropriate choice of the nuclear transition.

- The atomic nucleus can be considered as a femto-laboratory including probably all of the interactions in Nature. A real discovery machine like LHC, but at low energy.

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

$$\mathcal{L} = -\frac{1}{4}X_{\mu\nu}X^{\mu\nu} + \frac{1}{2}m_X^2 X_\mu X^\mu - X^\mu J_\mu ,$$

$$\varepsilon_p = 2\varepsilon_u + \varepsilon_d$$

$$\varepsilon_n = \varepsilon_u + 2\varepsilon_d$$

Branching ratio:

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

$$\Rightarrow \quad |\varepsilon_p + \varepsilon_n| \approx 0.011 \qquad |\varepsilon_u + \varepsilon_d| \approx 3.7 \times 10^{-3}$$

Pion decay constrain:

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

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

Promising Outlook

IPC:

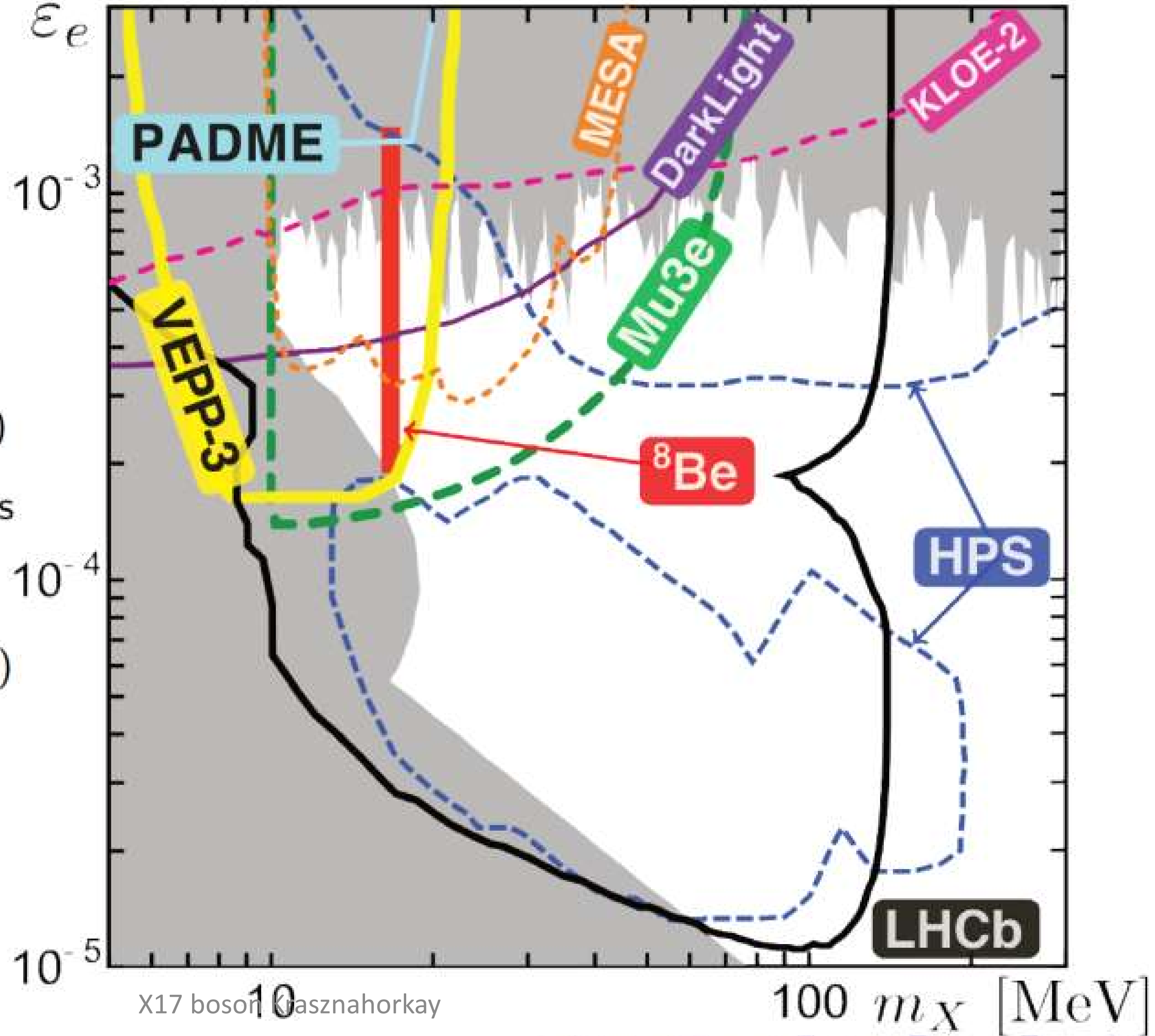
- verify ^{8}Be
- ^{10}B : 19.3 MeV
- ^{10}Be : 17.79 MeV

More Exp:

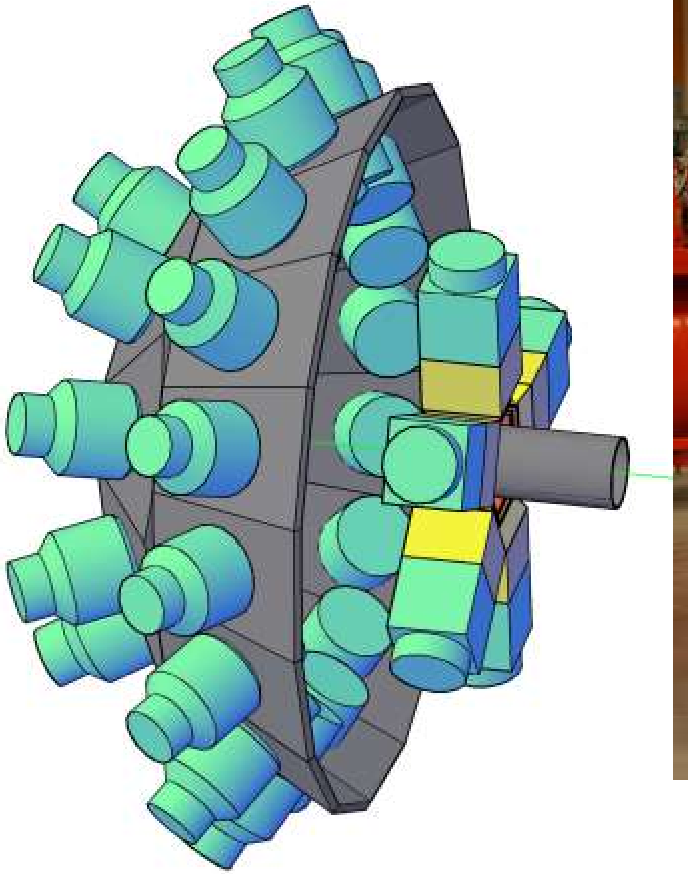
- TUNL (HIGS facility γ *Nuc*)
- TREK@JPARC: K^+ Decays
- SHIP
- SeaQuest (Gardner & Holt)
- VdG UK
- BESIII (arXiv:1607.03970)

Prob UV

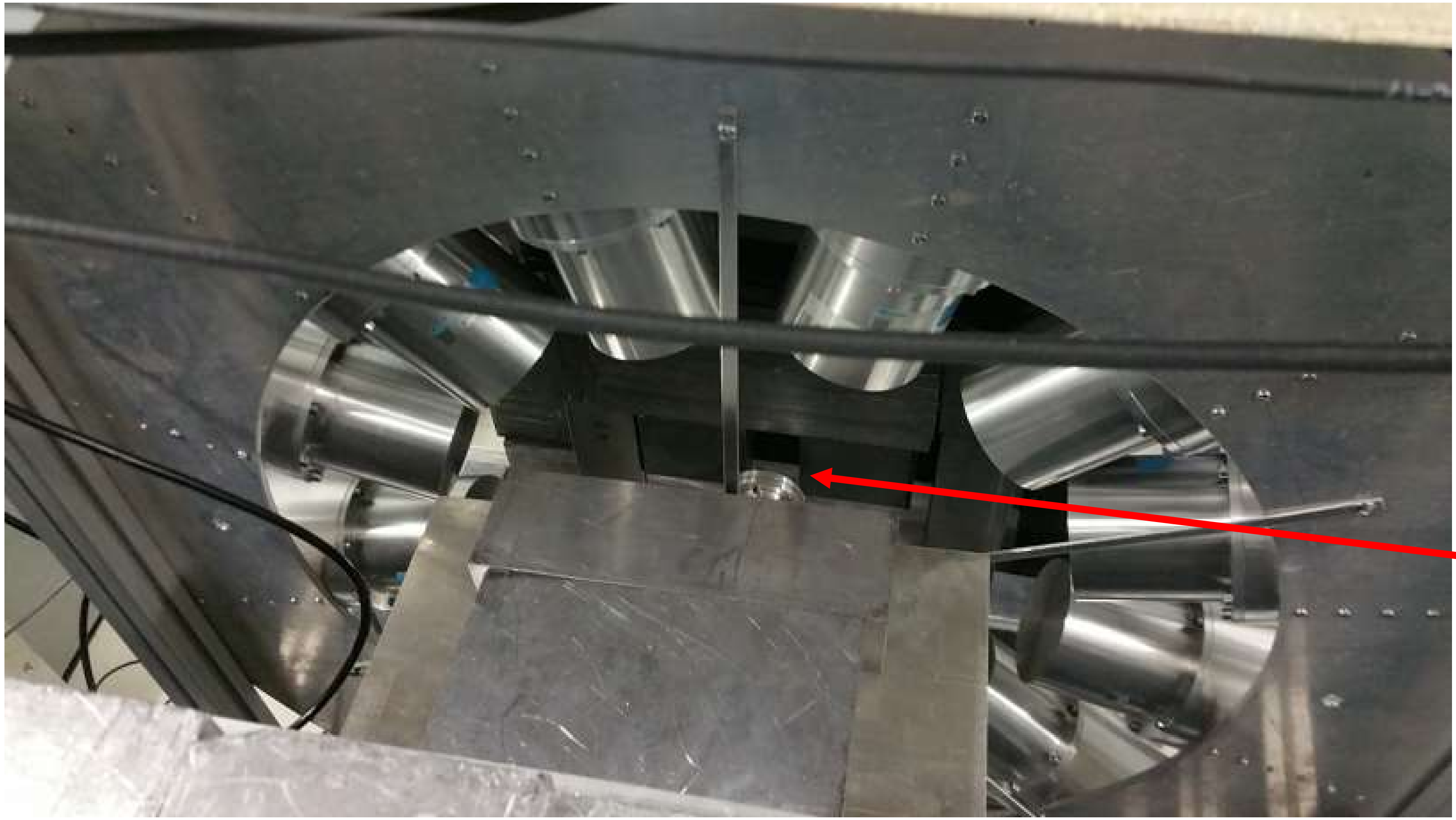
- ATLAS, CMS



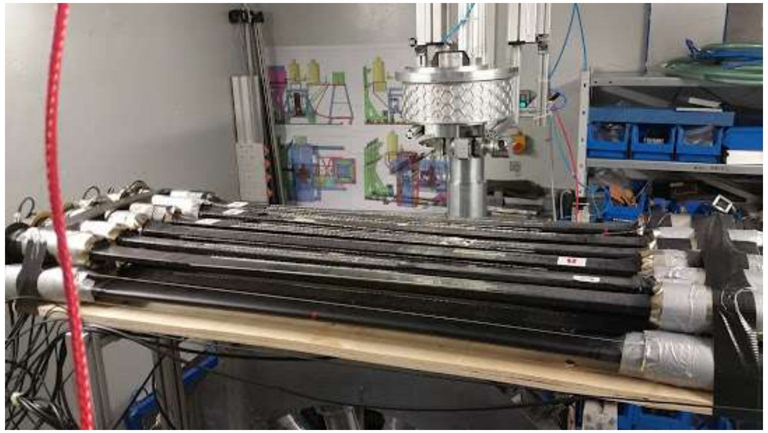
The experimental setup in Debrecen including both the e^+e^- and the γ-ray spectrometers

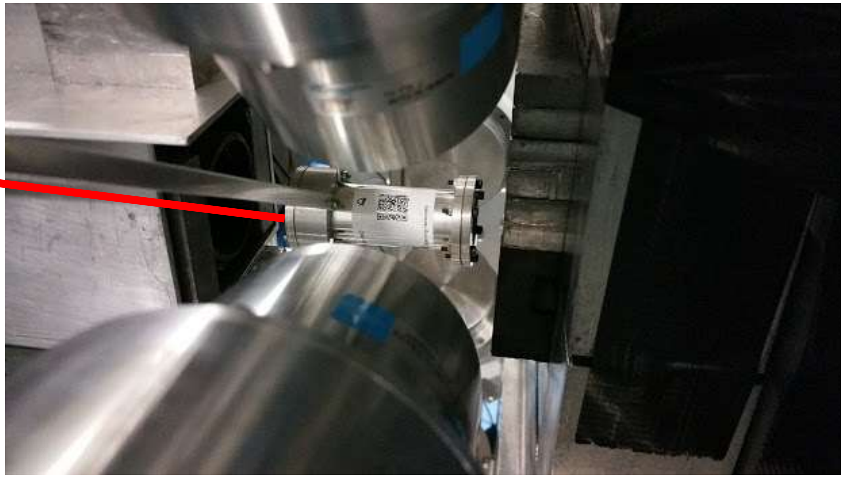


The $^{3}He(n,\gamma\gamma)^{4}He$ experiment in Garching with the FRM II High Flux Reactor (10^{10} cold n/cm2)



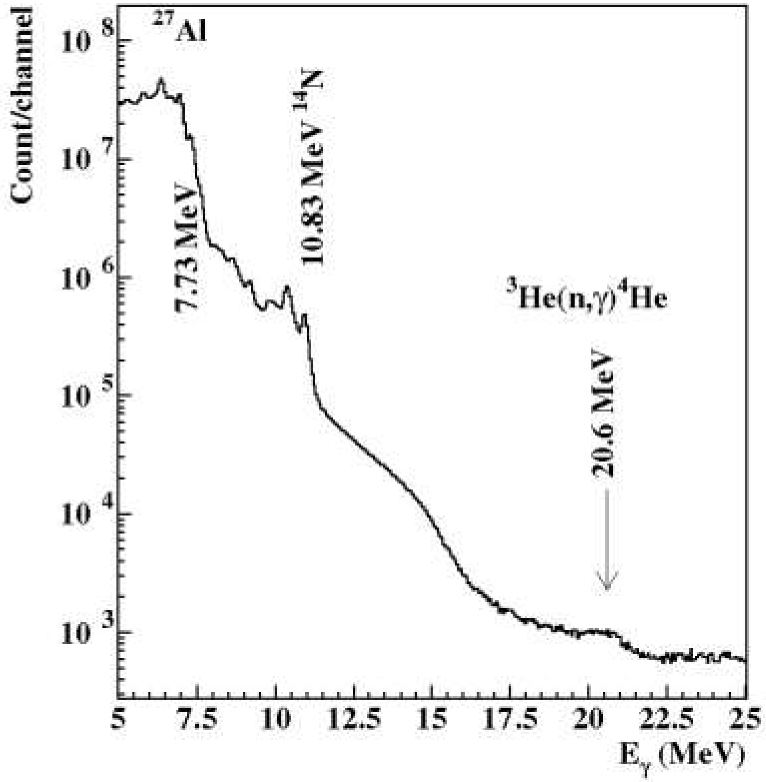
Coincidence γ-ray spectrometer with twelve 3"x3" LaBr3 detectors.
The angle between the detectors is 30 degree, and the detector plain
Is perpendicular to the beam.



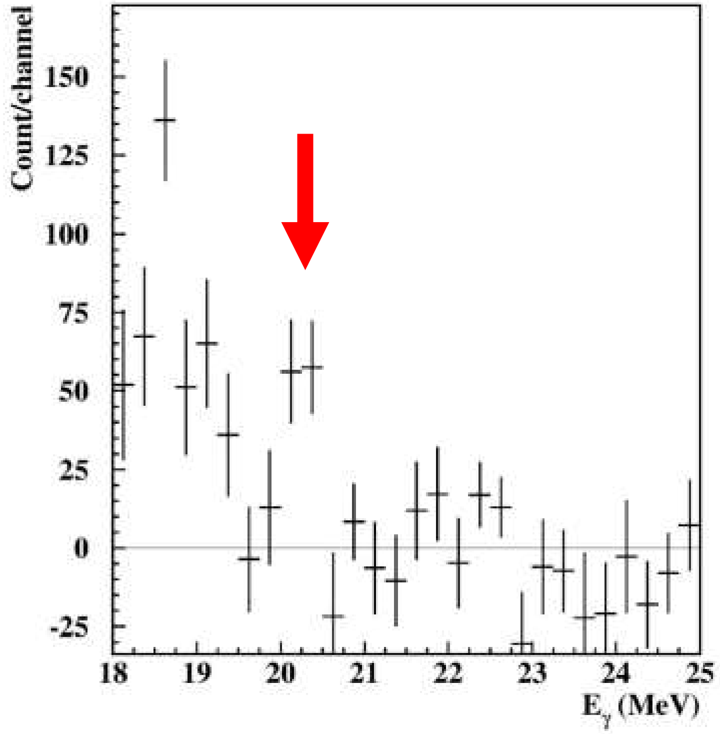


The pressurized (2 bar) ^{3}He target located in the middle of the spectrometer, and the active cosmic-ray shield (above).

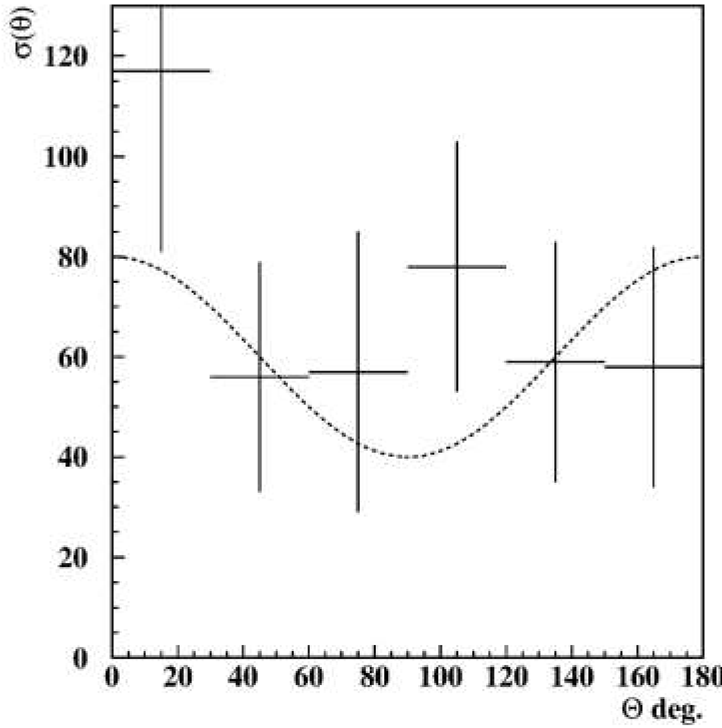
The first results obtained in Garching



A typical singles γ-ray spectrum



Typical sum-energy spectra for coincident detectors



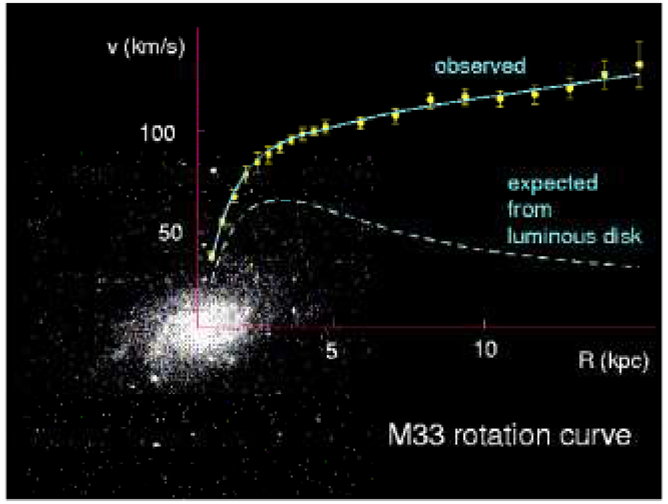
Preliminary γγ-angular correlation

The first motivation to search for the dark matter

In grammar school we learned that the movements of planets around the Sun can be interpreted precisely with the Newton's laws

Andromeda galaxies
Mass: 370 milliárd $M_{\odot}$
Distance: 2.5 million Light year

- Study of the rotational curves
- Dark matter should be introduced
- Modified Newtonian Dynamics ?



Gravitational lensing

Dark galaxies

Census in the Universe
Stars and galaxies: 0.5 %
Visible matter: 5 %
Dark matter: ≈ 30 %
Dark energy: ≈ 65 %

What do we know and what we do not about the dark matter?

- We observe its gravitational effect on the visible stars. Their contribution to the mass of the Universe is huge (95%)
- We are searching diligently for the associated particles with more and more sensitive detectors.

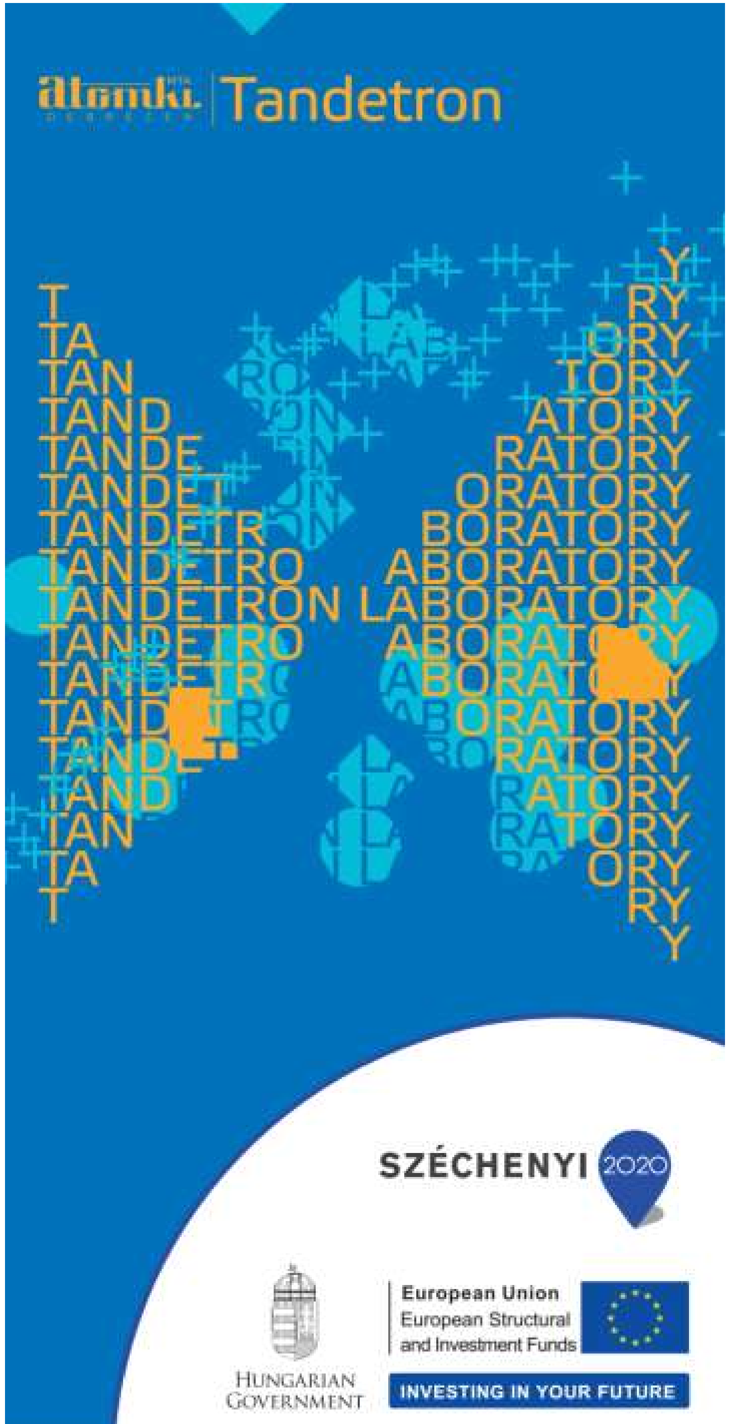
- What particle (s) are they consist of?
- What (new) interactions affect these particles?

- Very recently, a distant galaxy that appears completely devoid of dark matter has baffled astronomers: P. van Dokkum et al., Nature volume 555, 629 (29 March 2018). The general validity of Modified Newtonian Dynamics as an alternative to dark matter is now disproved, thus further supporting the idea of dark matter.

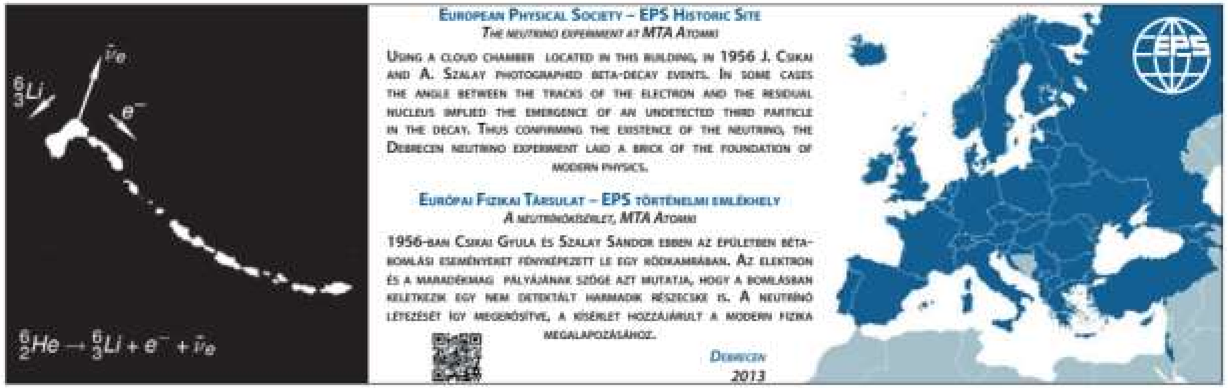
Searching from the basement to the attic already for 30 years, every corner with tremendous strength ...

- With state-of-the-art underground detectors,

with high-sensitivity spectrometers built in space



In the early years, as an example, the investigation of nuclear decay led to an indirect proof of the existence of the neutrino. Recently, this achievement was the basis for an award from the European Physical Society (EPS), which designated MTA Atomki as one of the Historic Sites in Europe.



FOREWORD

Physics Letters B 773 (2017) 159–165

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Physics Letters B

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Can nuclear physics explain the anomaly observed in the internal pair production in the Beryllium-8 nucleus?

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A R T I C L E   I N F O

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A B S T R A C T

Recently the experimentalists in Krasznahorkay (2016) [1] announced observing an unexpected enhancement of the e^{+}–e^{-} pair production signal in one of the ^{8}Be nuclear transitions. The subsequent studies have been focused on possible explanations based on introducing new types of particle. In this work, we improve the nuclear physics modeling of the reaction by studying the pair emission anisotropy and the interferences between different multipoles in an effective field theory inspired framework, and examine their possible relevance to the anomaly. The connection between the previously measured on-shell photon production and the pair production in the same nuclear transitions is established. These improvements, absent in the original experimental analysis, should be included in extracting new particle's properties from the experiment of this type. However, the improvements can not explain the anomaly. We then explore the nuclear transition form factor as a possible origin of the anomaly, and find the required form factor to be unrealistic for the ^{8}Be nucleus. The reduction of the anomaly's significance by simply rescaling our predicted event count is also investigated.

PHYSICAL REVIEW D **95,** 115024 (2017)

Light axial vector bosons, nuclear transitions, and the ^{8}Be anomaly

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New hidden particles could potentially be emitted and discovered in rare nuclear transitions. In this work, we investigate the production of hidden vector bosons with primarily axial couplings to light quarks in nuclear transitions, and we apply our results to the recent anomaly seen in ^{8}Be decays. The relevant matrix elements for $^{8}\mathrm{Be}^{*}(1^{+}) \to {}^{8}\mathrm{Be}(0^{+})$ transitions are calculated using *ab initio* methods with internucleon forces derived from chiral effective field theory and the in-medium similarity renormalization

free ultraviolet-complete theory that is consistent with current experimental data.

More generally, we also find that the Atomki measurements of the ^{8}Be system can provide the most sensitive model-independent probe of the interactions of a light vector with quarks. This motivates future searches for light vector bosons and other particles in rare nuclear transitions.

A viable QCD axion in the MeV mass range

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(Dated: October 12, 2017)

Most recently, the ATOMKI collaboration [102] has measured several ^{8}Be nuclear transitions via emission of e^+e^- pairs. The two relevant transitions for our discussion are the M1 de-excitations of the $J^P = 1^+$ isospin doublet states, namely, $^8\text{Be}^*(17.64)$ and $^8\text{Be}^*(18.15)$, to the $J^P = 0^+$ isospin singlet ground state, $^8\text{Be}(0)$:

$$^8\text{Be}^*(17.64) \to {}^8\text{Be}(0) \quad , \quad \Delta E = 17.64 \text{ MeV} \quad , \quad \Delta T \approx 1\,, \tag{5.36}$$

$$^8\text{Be}^*(18.15) \to {}^8\text{Be}(0) \quad , \quad \Delta E = 18.15 \text{ MeV} \quad , \quad \Delta T \approx 0\,. \tag{5.37}$$

The ATOMKI collaboration claimed a deviation in the e^+e^- spectrum of the $^8\text{Be}^*(18.15) \to {}^8\text{Be}(0)$ transition relative to the SM prediction of internal pair conversion ($\gamma^* \to e^+e^-$). According to [102], this deviation was consistent with the on-shell emission of a narrow resonance X of mass $m_X \approx (16.6 \pm 0.9)$ MeV promptly decaying to e^+e^-. The best fit for the relative de-excitation rate was $\Gamma_X/\Gamma_\gamma \approx 5.8 \times 10^{-6}$, with a statistical significance of $6.8\,\sigma$. Moreover, in the original publication [102], no excess was observed in the e^+e^- spectrum of the $^8\text{Be}^*(17.64) \to {}^8\text{Be}(0)$ transition. No error bars were quoted for either measurement, neither were upper bounds on emission rates of generic new particles, such as light vectors or pseudoscalars. Subsequent studies have attempted to understand these results via nuclear physics models [103], or via emission of a new light resonance [104–111].

Experimental searches for the X(17) boson

- **The ATLAS Collaboration** (ATLAS NOTE ATLAS-CONF-2016-042) presented results of a search for long-lived neutral particles decaying into collimated jets of light leptons and mesons, so-called "lepton-jets", using a sample of 3.4 fb^{-1} of proton-proton collisions data at a center-of-mass energy of $\sqrt{s}$=13 TeV collected during 2015 with the ATLAS detector at the LHC. Assuming conventional production cross section σ·BR to the dark sector of 5.0 pb for a 800 GeV heavy scalar boson, dark photon cτ is excluded in the range 0.6 mm <cτ< 63 mm for the Higgs → $2\gamma_d$+ X model and in the range 0.8 mm <cτ< 186 mm for the Higgs → $4\gamma_d$+ X model.

$$c\tau_{A'\to e^+e^-} \simeq 0.8\,\mathrm{mm}\left(\frac{10^{-4}}{\epsilon}\right)^2 \frac{10\,\mathrm{MeV}}{m_{A'}}$$

- $2\times10^{-4} < \varepsilon_e < 1{,}4\times10^{-3}$ esetén → 2.5 μm <cτ< 120 μm
- Our results are not affected.

The DarkLight experiment at JLAB

- The DarkLight experiment proposes to search for dark photon through complete reconstruction of the final states of electron–proton collisions. In order to accomplish this, the experiment requires a moderate-density target and a very high intensity, low energy electron beam.
- Projected reaches in mass and coupling for upcoming experiments near the Beryllium-8 anomaly. Note that these are taken in the fully protophobic limit, so the sensitivities of experiments that search for the dark photon through hadronic probes are heavily suppressed. The DarkLight projection marks the region where an anomaly yields a 5σ with 1 ab^{-1} of data, which is readily achievable with anticipated luminosities.

Searching for the X(17) in particle decays

- Araki et al, (Phys. Rev. D 95, 055006 (2017)) discussed the feasibility of detecting the gauge boson of the U(1) symmetry, which possesses a mass in the range between MeV and GeV, at the **Belle-II experiment**. They have found that the Belle-II experiment with the design luminosity can examine a part of the parameter region that evades the current experimental constraints and, at the same time, is favored by the observation of the muon anomalous magnetic moment.
- Rare leptonic kaon and pion decays $K^+(\pi^+) \rightarrow \mu^+\nu_\mu e^+e^-$ can also be used to probe a dark photon of mass O(10)MeV. Cheng-Wei Chiang (Physics Letters B 767 (2017) 289) evaluated the reach of future experiments for the dark photon with vectorial couplings to the standard model fermions except for the neutrinos, and show that a great portion of the preferred 16.7-MeV dark photon parameter space can be decisively probed.

Data mining and new projects

- Long-Bin Chen et al., (arXiv:1607.03970v2) discussed, the production of this yet-not-verified new boson in electron-positron collision, using BaBar, and the results are encouraging. The data collected at **BESIII and BaBar** turn out to be enough to perform a decisive analysis and hence give a definite answer to the existence of X(16.7).
- Marin Benito et al., (IOP Conf. Series: Journal of Physics: Conf. Series **800** (2017) 012031) discussed the prospects for the search of $K_S^0 \rightarrow \pi^+\pi^- e^+e^-$ at LHCb. **LHCb has proved to be very competitive in the search for such rare strange decays.** The feasibility of observing such K0 decay at LHCb is studied using simulated and real data. During the Run I of LHC (2012), the yield of events expected per fb^{-1} of pp collisions at $\sqrt{s}$= 8 TeV is found to be N_{Run1} =120+280-100. A dedicated trigger selection has been developed for the 2016 data-taking. A large signal yield, $N_{Upgrade}$= $(5\pm0.3)\cdot10^4$ per fb^{-1}, is expected in the LHC upgrade phase. Pseudo experiments have been run to assess the feasibility of discovering evidence for the observation of the signal already in the Run I data-set.

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Physics Letters B

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Probing a dark photon using rare leptonic kaon and pion decays

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ABSTRACT

Rare leptonic kaon and pion decays $K^+(\pi^+) \to \mu^+ \nu_\mu e^+ e^-$ can be used to probe a dark photon of mass $\mathcal{O}(10)$ MeV, with the background coming from the mediation of a virtual photon. This is most relevant for the 16.7-MeV dark photon proposed to explain a 6.8σ anomaly recently observed in ^{8}Be transitions by the Atomki Collaboration. We evaluate the reach of future experiments for the dark photon with vectorial couplings to the standard model fermions except for the neutrinos, and show that a great portion of the preferred 16.7-MeV dark photon parameter space can be decisively probed. We also show the use of angular distributions to further distinguish the signal from the background.