

# Experimental overview on X17

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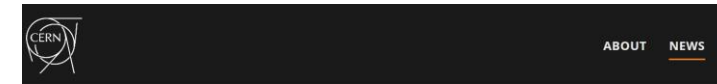


Workshop on Multi-front  
Exotic phenomena in Particle  
and Astrophysics (MEPA 2023)

19-22 October 2023

Hefei

University of Science and Technology of China



News · News · Topic: Physics

Voir en français

## The plot thickens for a hypothetical "X17" particle

Additional evidence of an unknown particle from a Hungarian lab gives a new impetus to NA64 searches

27 NOVEMBER, 2019 | By Ana Lopes



**CERN COURIER** Reporting on international high-energy physics

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SEARCHES FOR NEW PHYSICS | NEWS

### Rekindled Atomki anomaly merits closer scrutiny

20 December 2019



## Observation of Anomalous Internal Pair Creation in $^8\text{Be}$ : A Possible Indication of a Light, Neutral Boson

A. J. Krasznahorkay,<sup>\*</sup> M. Csatlós, L. Csige, Z. Gácsi, J. Gulyás, M. Hunyadi, I. Kuti, B. M. Nyakó, L. Stuhl, J. Timár, T. G. Tornyi, and Zs. Vajta

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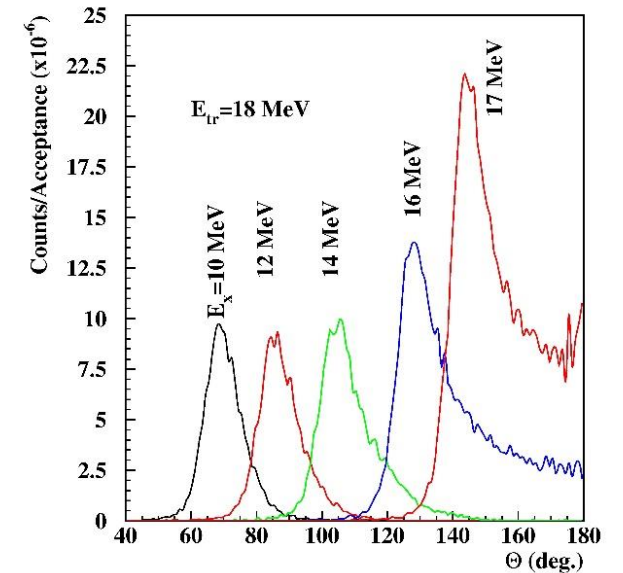
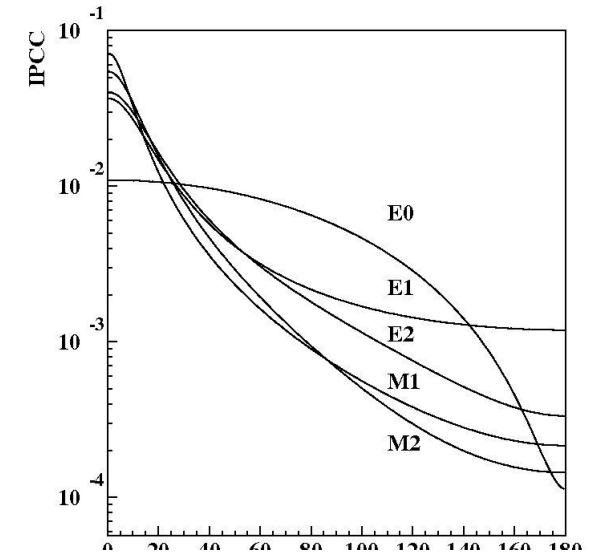
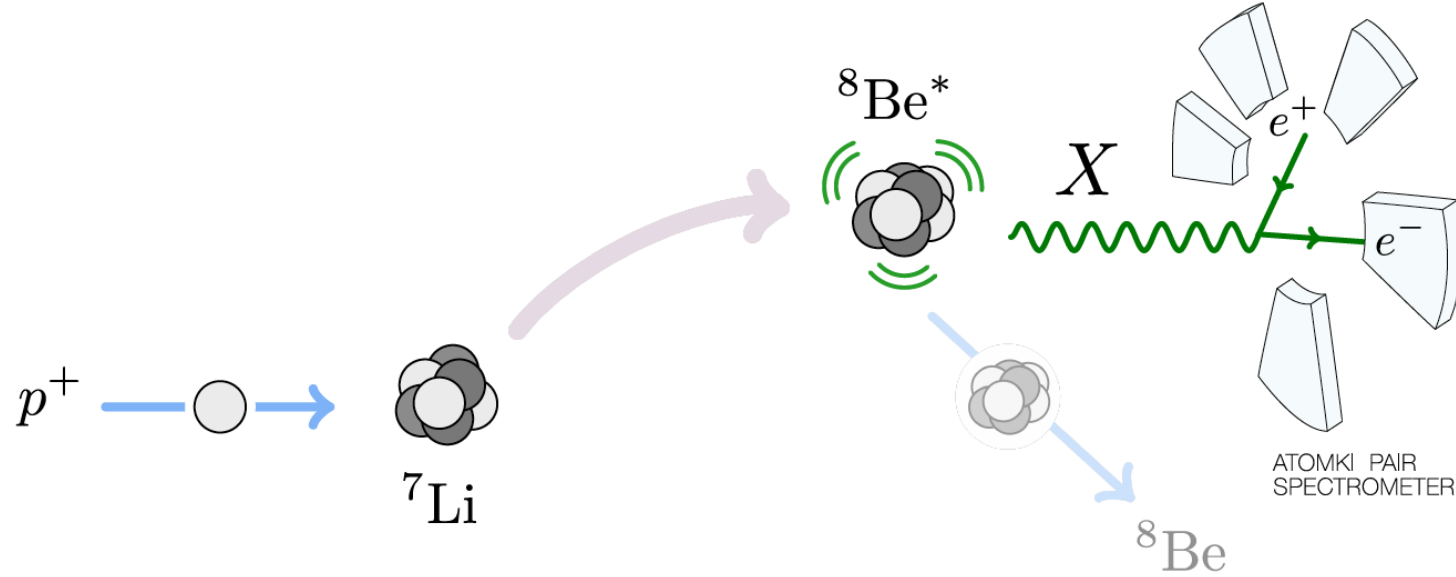
*CERN, CH-1211 Geneva 23, Switzerland and Institute for Nuclear Research, Hungarian Academy of Sciences (MTA Atomki), P.O. Box 51, H-4001 Debrecen, Hungary*

(Received 7 April 2015; published 26 January 2016)

Electron-positron angular correlations were measured for the isovector magnetic dipole 17.6 MeV ( $J^\pi = 1^+, T = 1$ ) state  $\rightarrow$  ground state ( $J^\pi = 0^+, T = 0$ ) and the isoscalar magnetic dipole 18.15 MeV ( $J^\pi = 1^+, T = 0$ ) state  $\rightarrow$  ground state transitions in  $^8\text{Be}$ . Significant enhancement relative to the internal pair creation was observed at large angles in the angular correlation for the isoscalar transition with a confidence level of  $> 5\sigma$ . This observation could possibly be due to nuclear reaction interference effects or might indicate that, in an intermediate step, a neutral isoscalar particle with a mass of  $16.70 \pm 0.35(\text{stat}) \pm 0.5(\text{syst}) \text{ MeV}/c^2$  and  $J^\pi = 1^+$  was created.

**The ATOMKI anomaly  $\rightarrow$  signals for a new 17 MeV boson  $\rightarrow$   
gauge boson of a new fundamental force of nature**

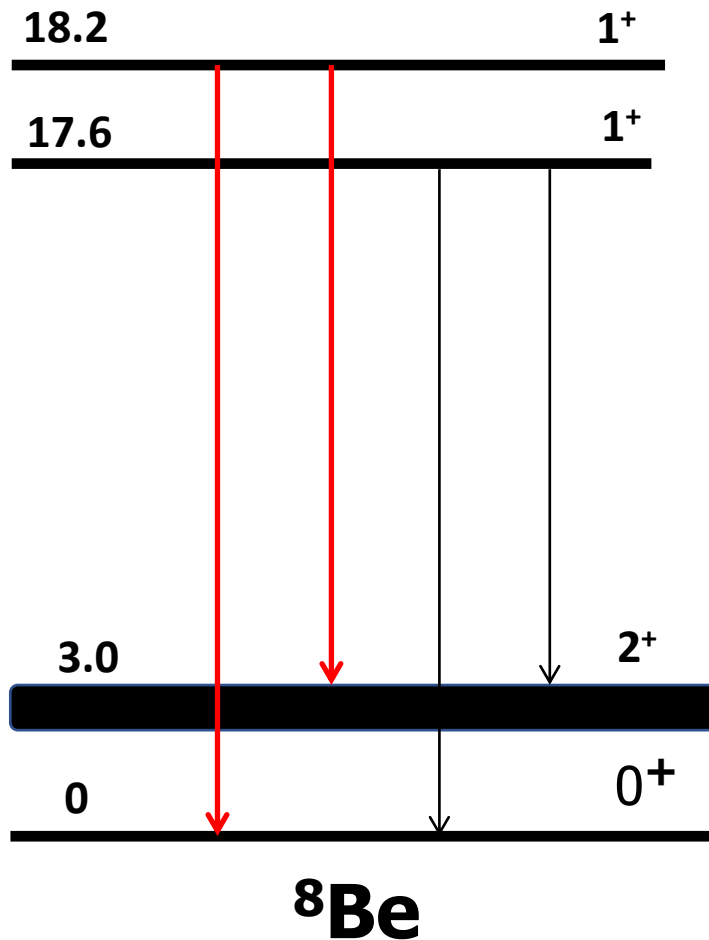
# Creation and decay of $^8\text{Be}^*$



- Decay with  $2\alpha$  emission:  $\approx 100\%$
- With  $\gamma$ -radiation:  $B(^8\text{Be} + \gamma) \approx 1.5 \times 10^{-5}$
- With internal pair creation:  $B(^8\text{Be} + e^+ e^-) \approx 5.5 \times 10^{-8}$
- Smooth, gradually decreasing angular correlation
- Creating a dark photon:  $B(^8\text{Be} + X) \approx 5.5 \times 10^{-10}$
- finding a peak on the curve

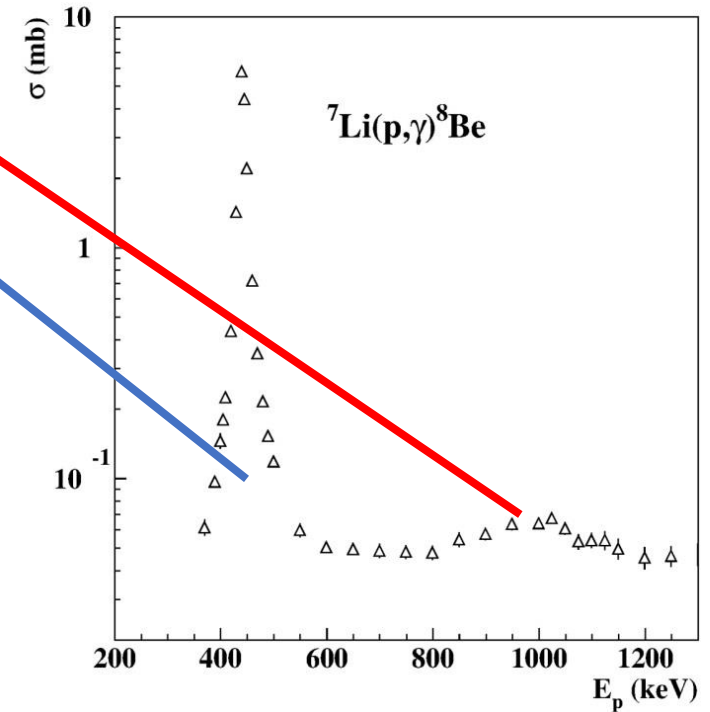
# Study of the $^8\text{Be}$ M1 transitions

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

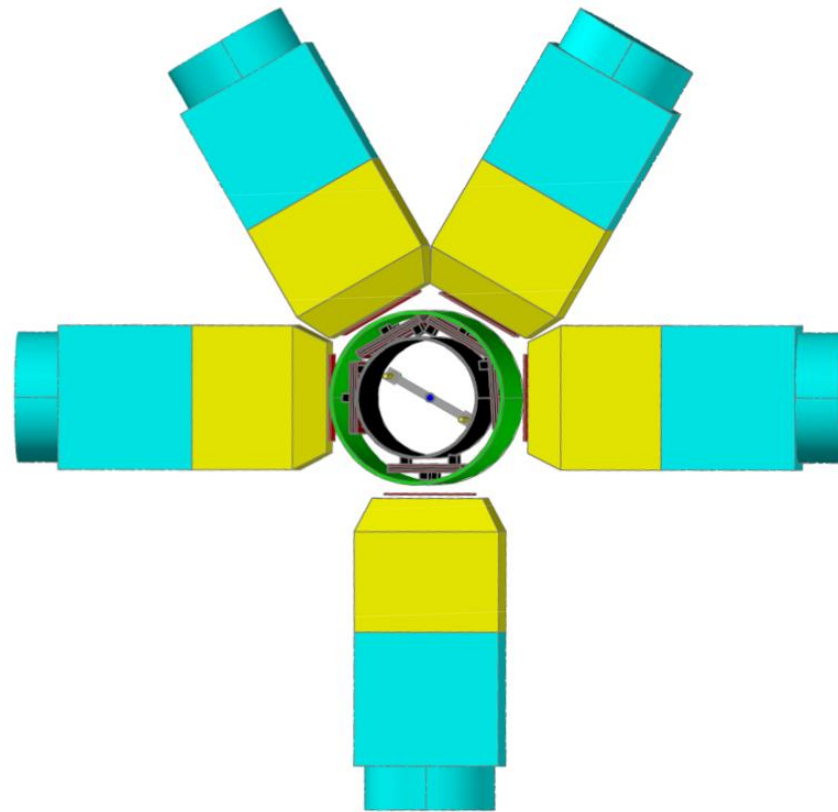


$E_p = 1030$  keV

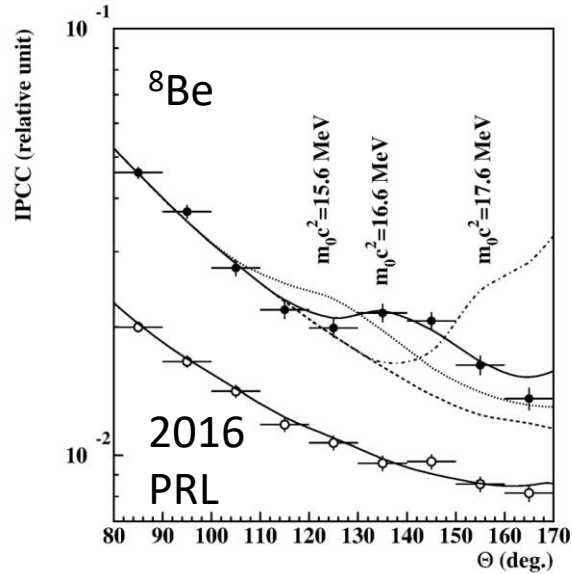
$E_p = 441$  keV



An  $e^+ - e^-$  spectrometer constructed by using Multi Wire Proportional (gas filled) detectors and plastic scintillator telescopes

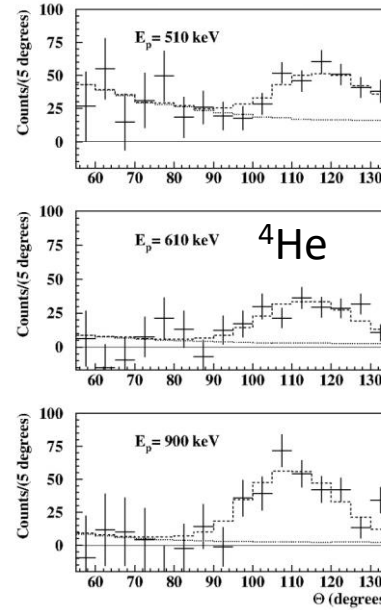


# Experimental results

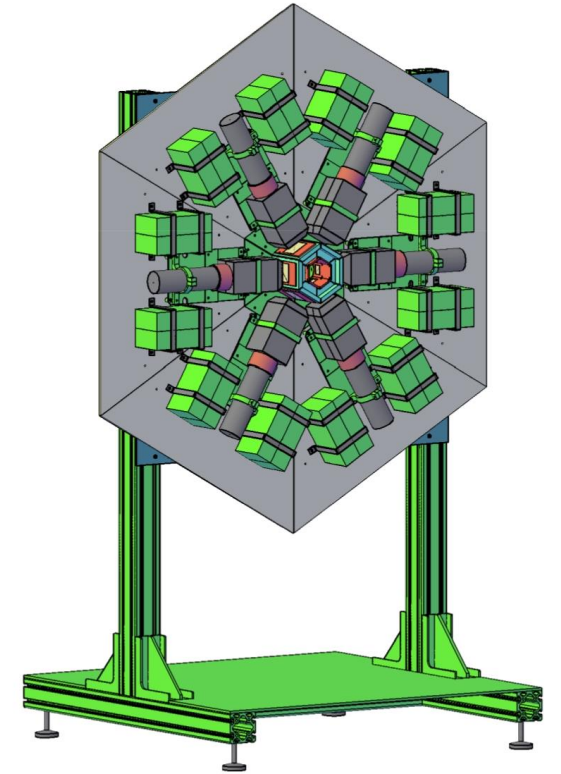
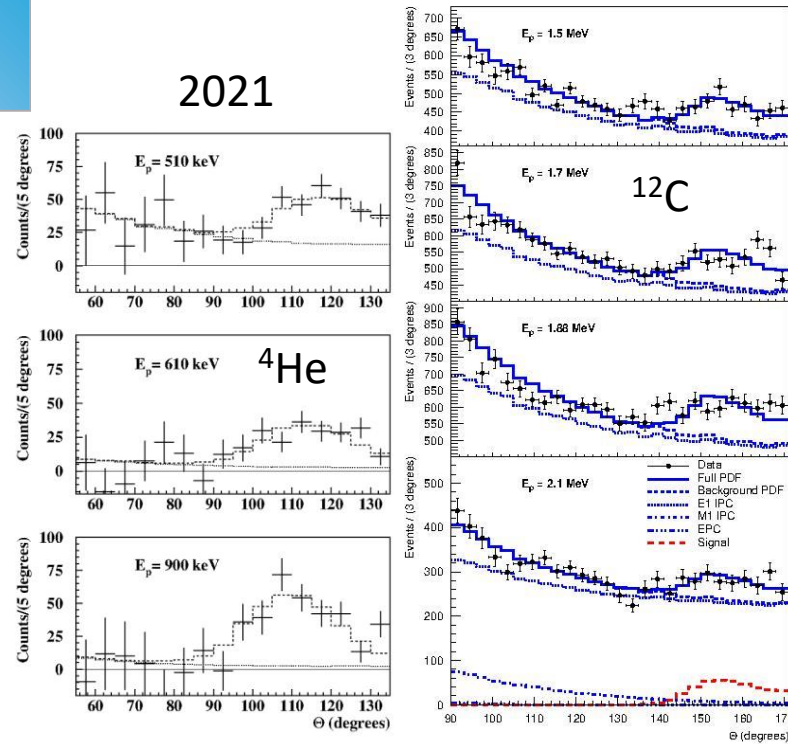


Consistent result were obtained with the new spectrometer

2021



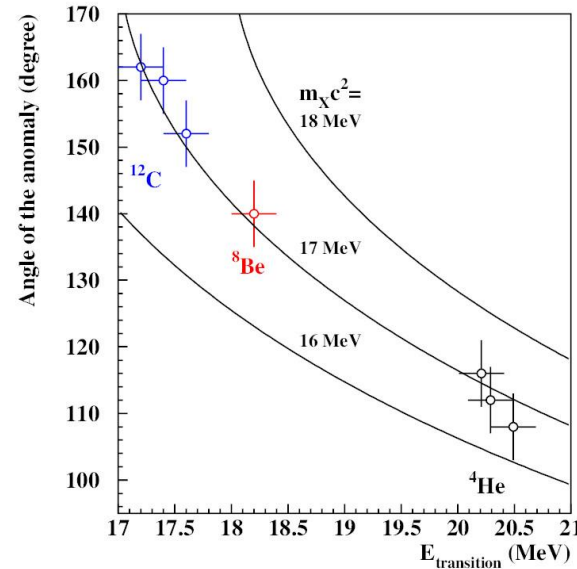
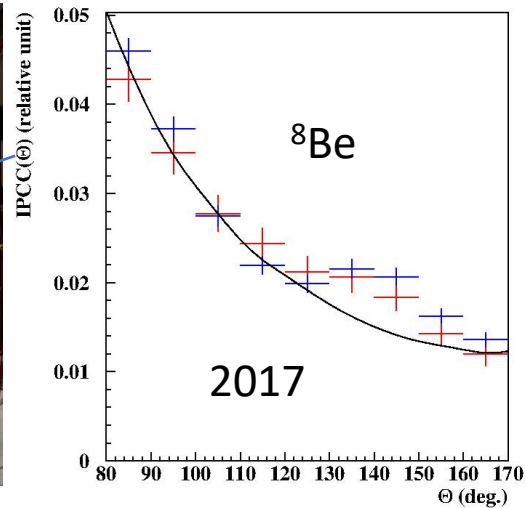
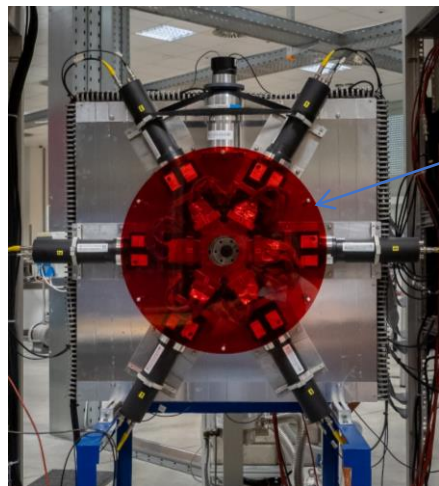
2022



The newest version of the spectrometer



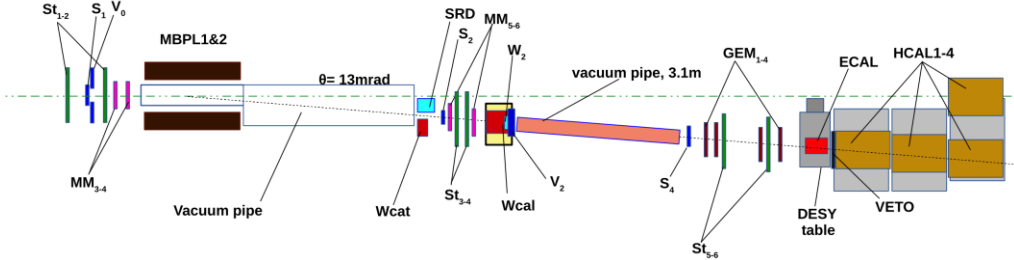
- Kinematical evidence for the X17 particle
- Vector character of X17 is supported.



# Particle and nuclear physics experiments searching for the X17 particle

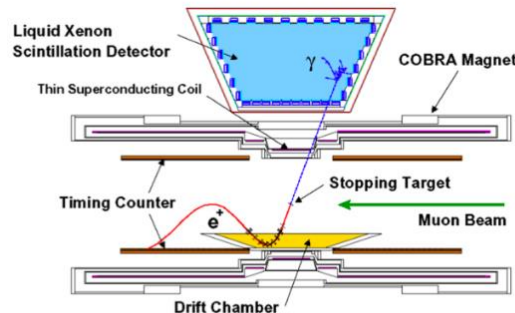
The  $^8\text{Be}$  excess and search for the  $X \rightarrow e^+e^-$  decay of a new light boson with NA64 (CERN)

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

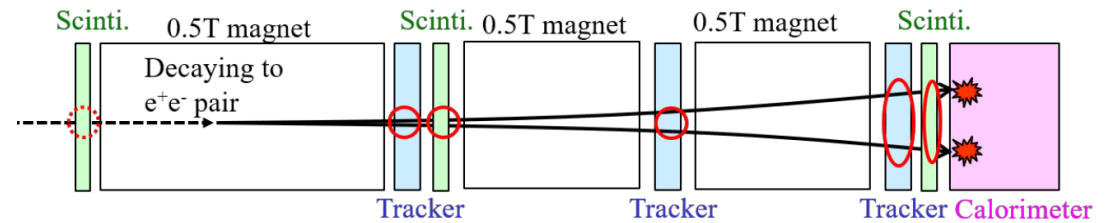


Phys. Rev. Lett. **125**, 081801 (2020)

Search for the X(17) particle in the  $^7\text{Li}(p, e^+e^-)^8\text{Be}$  reaction with the MEG II detector (PSI, Willigen, Switzerland)



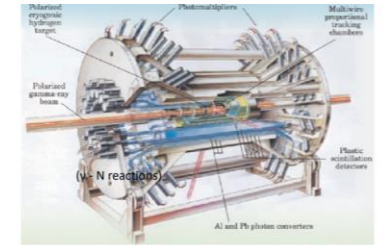
## Forward Search Experiment (FASER)



CERN's newest experiment, is now running in the LHC tunnel. FASER is designed to study the interactions of light and weakly interacting particles.

### The Montreal X-17 Project

- Use parts of the DAPHNE experiment (Saclay/Mainz\*)
- Tracking MWPC chamber & 16 scintillators (NE102A)
- Scints & MWPC from U. Mainz → now @ Montreal
- Phototubes and some ADC/TDC's borrowed from TRIUMF

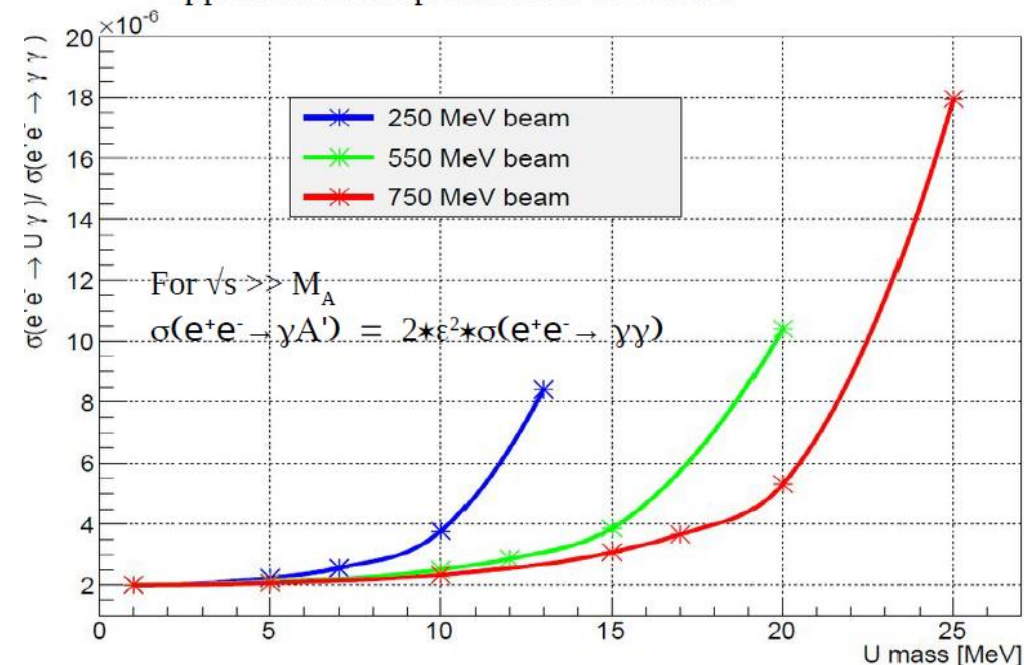


\*Many thanks to L. Doria & U. Mainz!

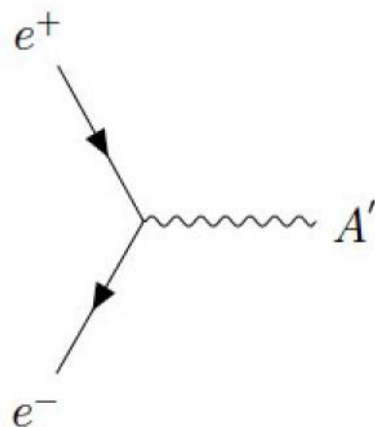
Ariel workshop, Vancouver

# X17 @ PADME strategy

Cross section enhancement with the approach of the production threshold



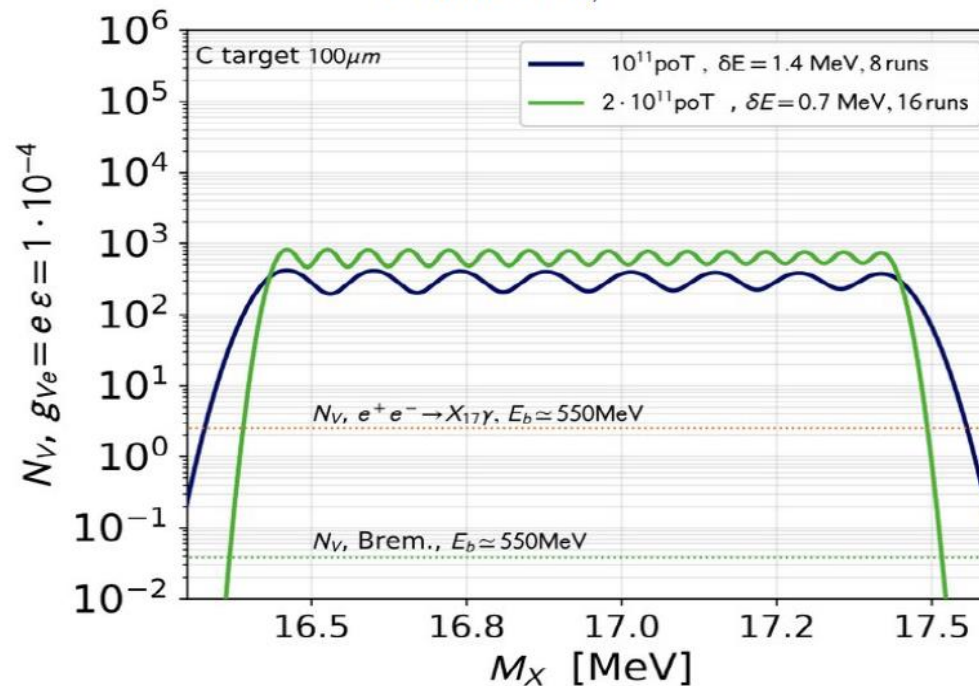
- Resonant production of X17
- energy at resonance: ~283 MeV: scan
- Need to measure the final state to reconstruct the invariant mass
  - Or change in cross section



$$\sigma_{\text{res}}(E_e) = \sigma_{\text{peak}} \frac{\Gamma_{A'}^2/4}{(\sqrt{s} - m_{A'})^2 + \Gamma_{A'}^2/4}$$

$$\sigma_{\text{peak}} = 12\pi/m_{A'}^2 \quad \Gamma_{A'} = \frac{1}{3}m_{A'}\epsilon^2\alpha$$

L. Darmé et. al.,





Shedding light on X17: community report:

Eur. Phys. J. C (2023) 83:230

<https://doi.org/10.1140/epjc/s10052-023-11271-x>

$^8\text{Be}$  and more recently  $^4\text{He}$  and  $^{12}\text{C}$  anomalies constitute an open question in nuclear and low energy particle physics. Independent confirmation will be very welcome in strengthening the ATOMKI observation, and possibly confirming the particle-like explanation of the anomalous angular distributions observed so far.

Several experimental efforts are ongoing in different international laboratories in order to reproduce the observation using the same or similar techniques. Future initiatives are proposing alternative approaches based on different production mechanisms.

# Observation of the X17 anomaly in the decay of the Giant Dipole Resonance

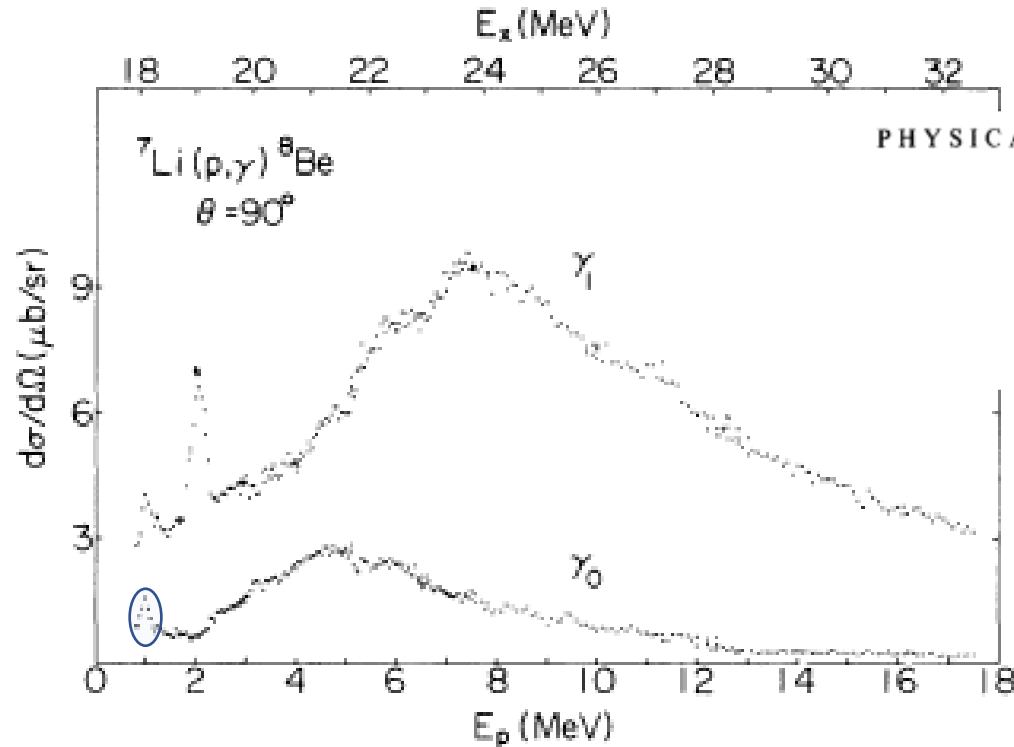
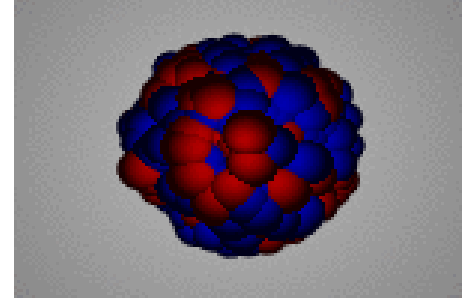


FIG. 3. The yield functions for the  $\gamma_0$  and  $\gamma_1$  transitions obtained at  $90^\circ$ , which show the broad giant resonances built on the ground state and the first excited state of  ${}^8\text{Be}$ .

PHYSICAL REVIEW C

VOLUME 14, NUMBER 1

Giant  $E1$  resonances in  ${}^8\text{Be}$  from the reaction  ${}^7\text{Li}(p, \gamma){}^8\text{Be}^\dagger$

G. A. Fisher,\* P. Paul,† F. Riess,§ and S. S. Hanna

Department of Physics, Stanford University, Stanford, California 94305

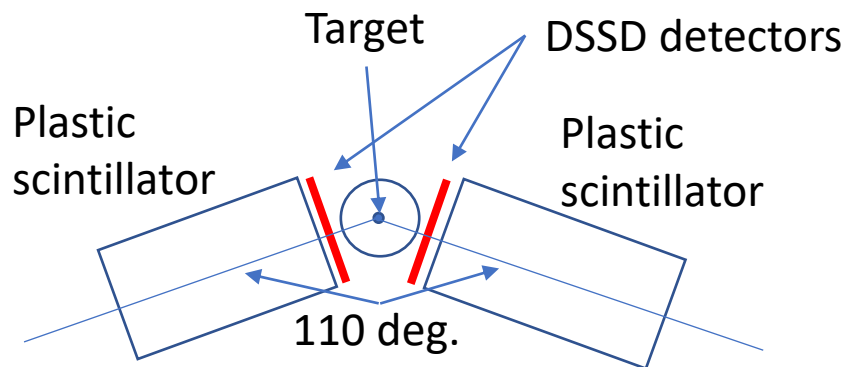
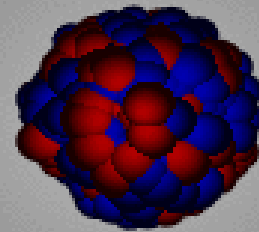
(Received 21 January 1976)

GDR

TRK sum rule

$$\int_{18}^{33} \sigma(E) dE = 60 \frac{NZ}{A} \text{ MeV mb}$$

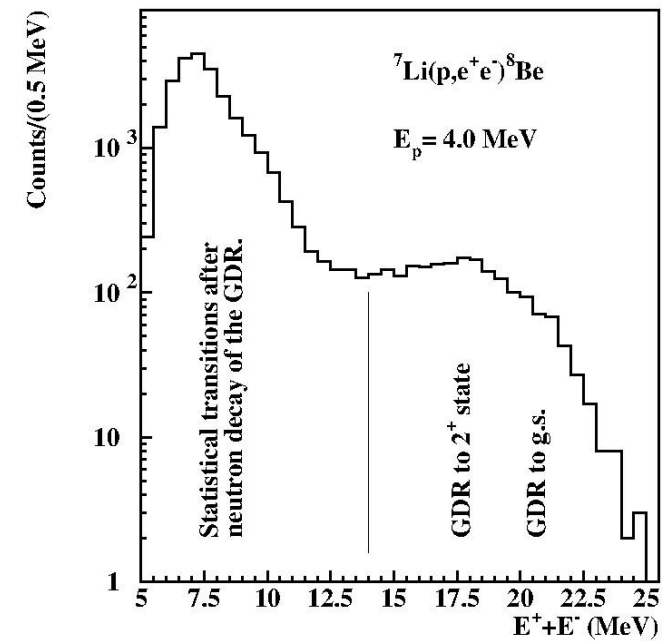
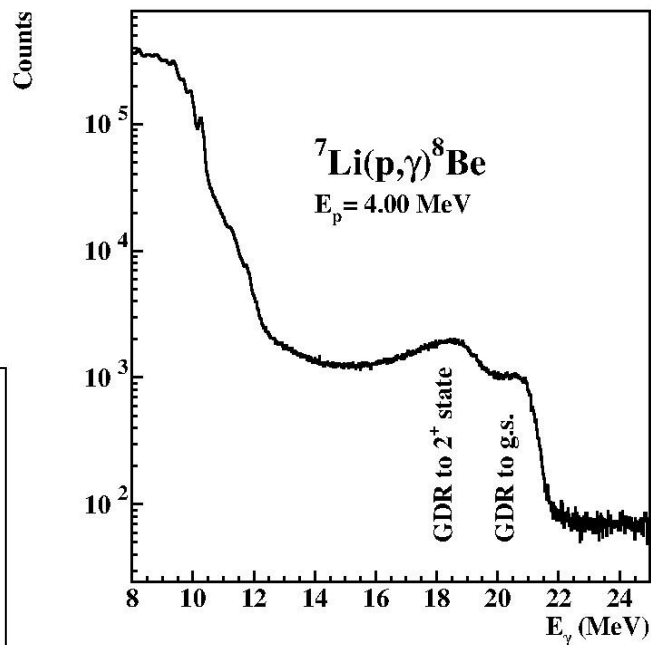
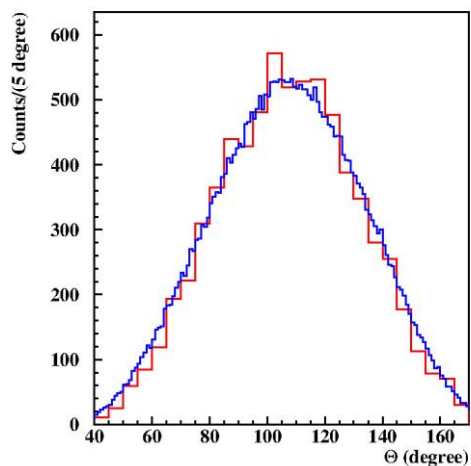
# A new $e^+e^-$ spectrometer, their acceptance, $\gamma$ -ray and energy-sum spectra



**GDR**

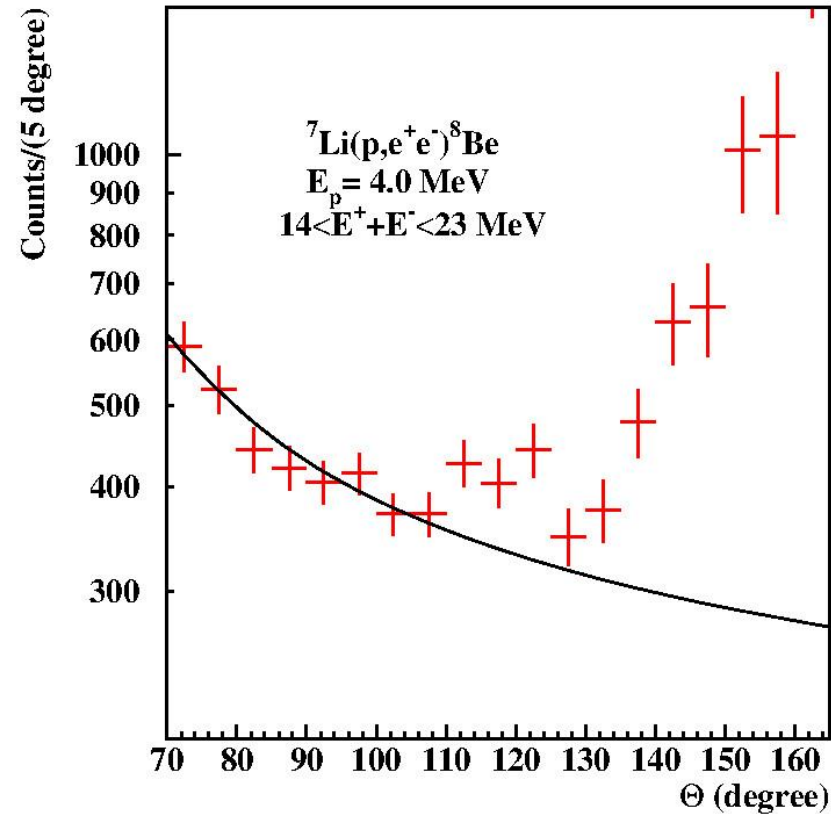
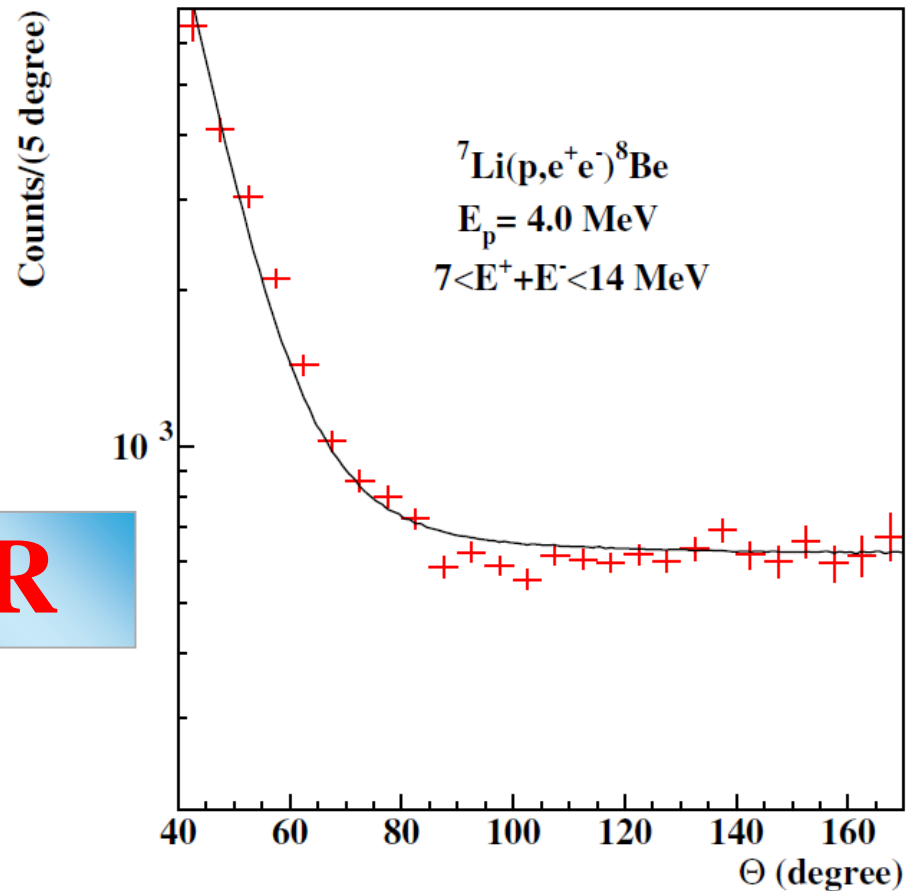
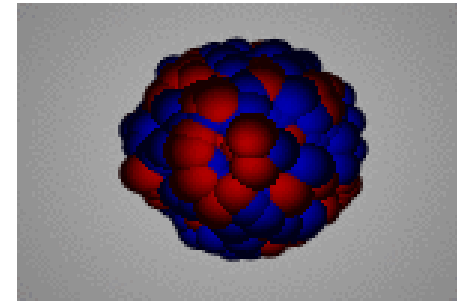


LaBr<sub>3</sub>  $\gamma$ -ray monitor



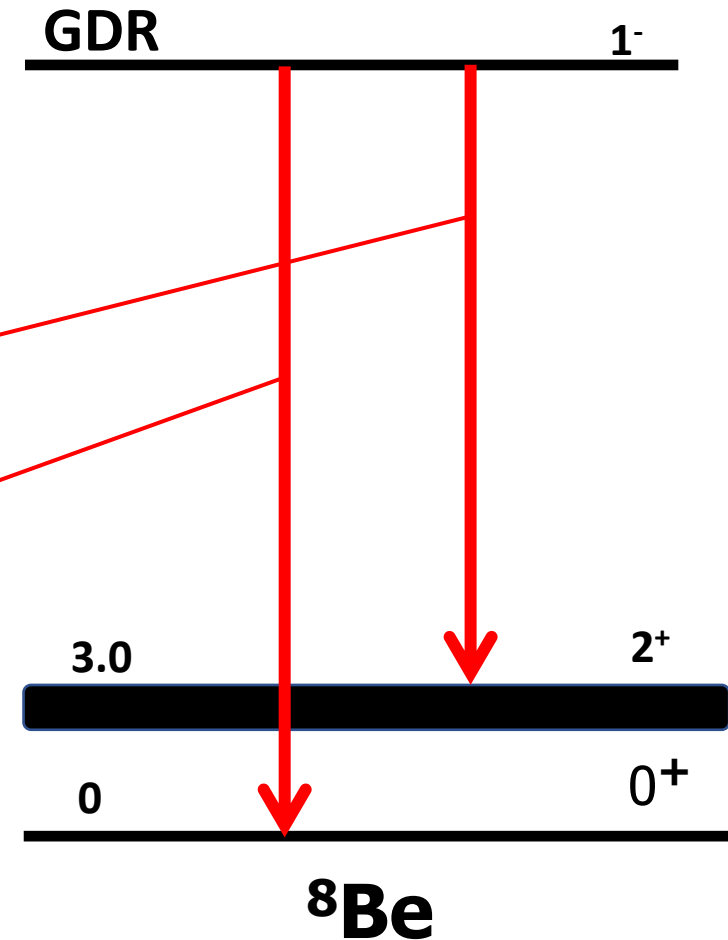
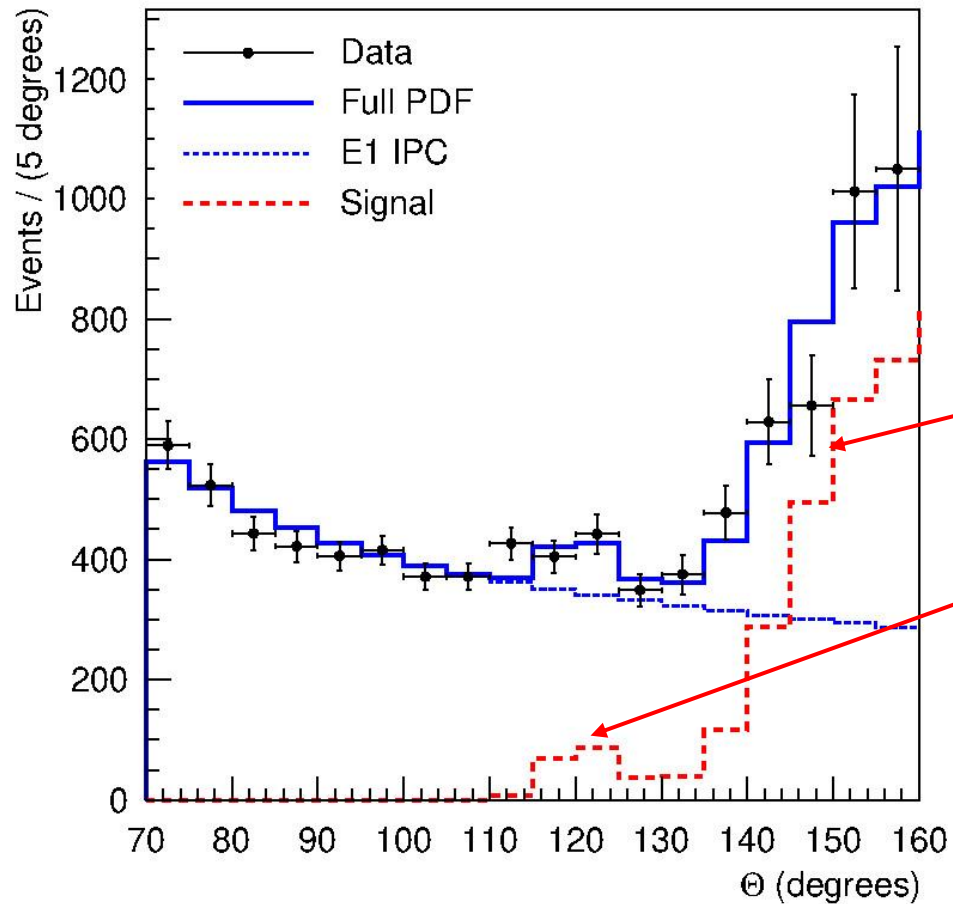
Energy-sum spectrum

# $e^+e^-$ angular correlations for the low-energy region, and for the GDR one



**GDR**

# Fitting the $e^+e^-$ angular correlation for the GDR region



$m_0c^2=17 \text{ MeV}$

# Conclusions:

- We have got kinematical evidence for the X17 particle
- Our recent experimental data supports the vector character of the X17 particle
- Very recently, at the 52nd International Symposium on Multiparticle Dynamics (Gyöngyös, 21-25 August 2023) *two groups are already reported on supporting experimental results.*

**Thank you very much for your kind attention**  
**To  $^8\text{Be}$  continued...**