

# X17 at ATOMKI

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## 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



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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. Tornyai, and Zs. Vajta

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(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**





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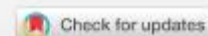
Feature Articles

# A New Particle is Being Born in ATOMKI that Could Make a Connection to Dark Matter

Attila J. Krasznahorkay ✉, Attila Krasznahorkay, Margit Csatlós, Lóránt Csige &amp; János Tímár

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## A New Particle is Being Born in ATOMKI that Could Make a Connection to Dark Matter

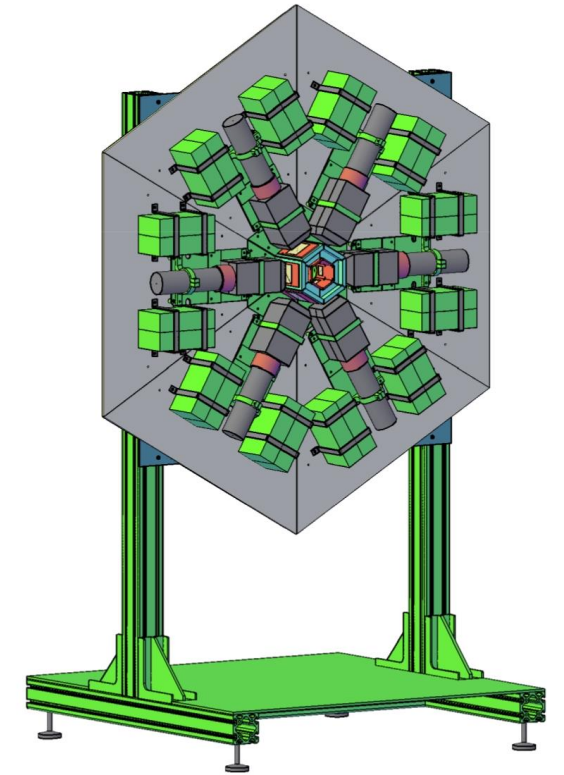
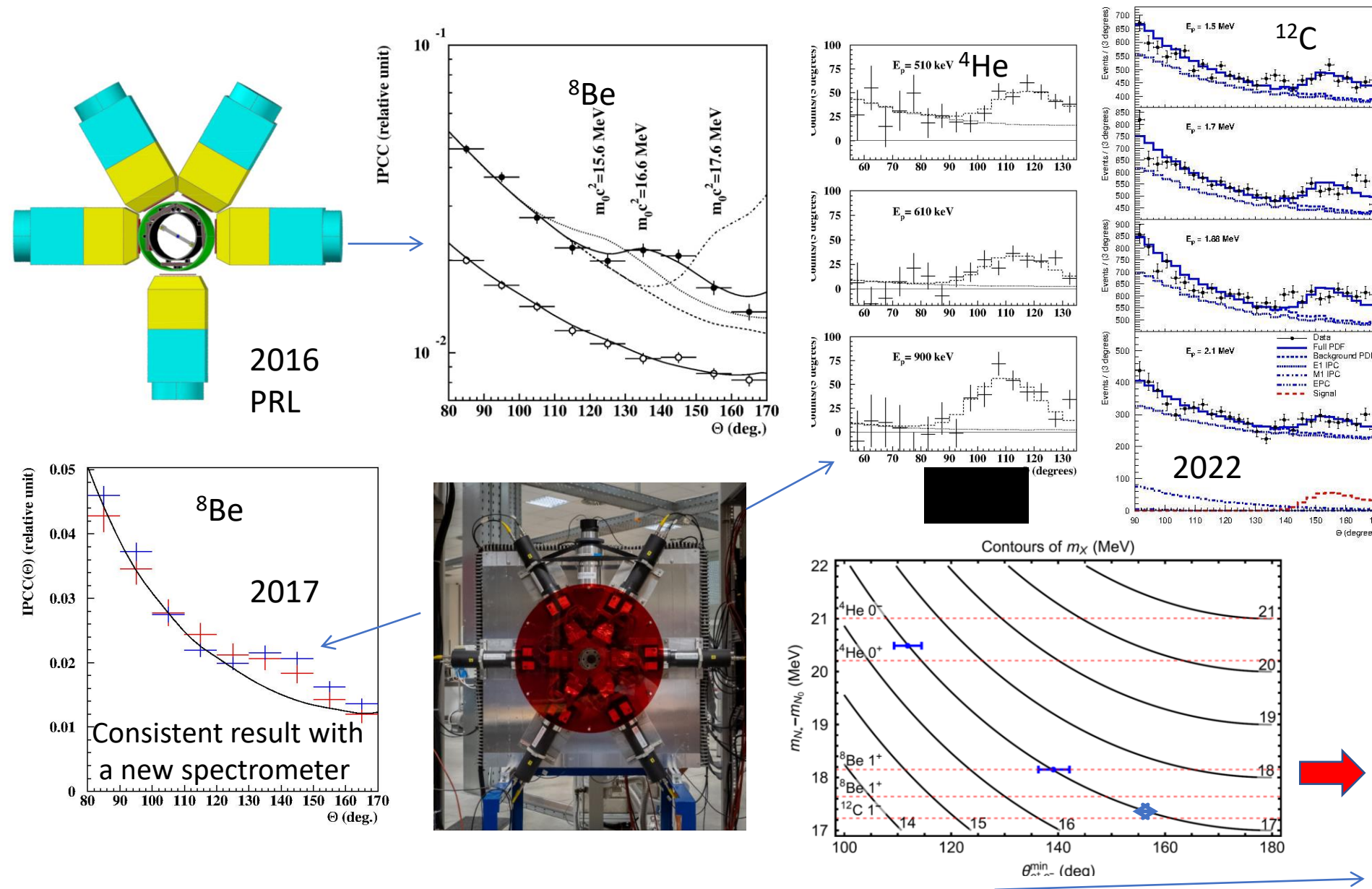
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# Previous experimental results



The newest version of the spectrometer

- Kinematical evidence for the X17 particle
- Vector character of X17 is supported
- Ejected with  $L=1$  in  $^8\text{Be}$

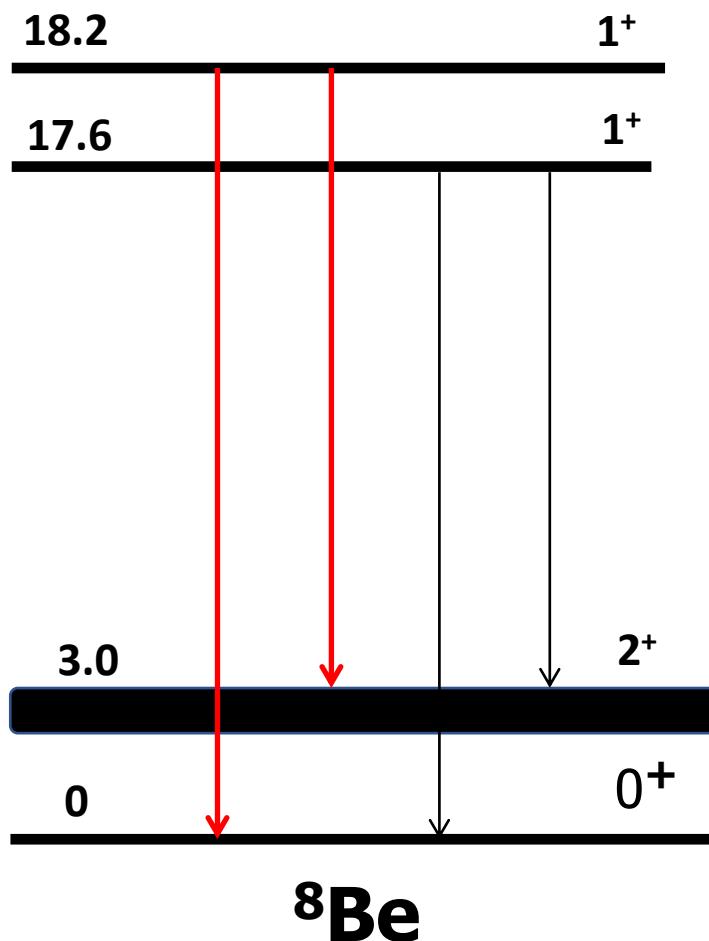
# On the acceptance of the spectrometers

**The following facts give us confidence about the reliability of the experimental results:**

- Good agreement between the experimental and simulated acceptances,
- Good agreement between experimental and simulated IPCC values for  $^{16}\text{O}$ ,  $^{28}\text{Si}$ ,  $^8\text{Be}$  17.6 MeV and 15.1 MeV transitions for large angular ranges,
- Consistent experimental results with 6, 5, and 2 telescopes,
- Good agreement between experimental and simulated IPCC values for asymmetric energy distributions of the  $e^+e^-$  pairs,

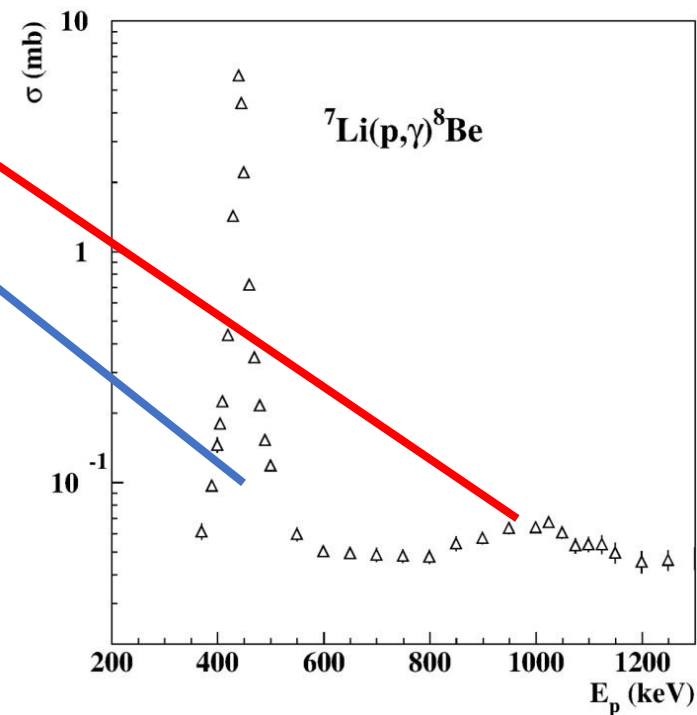
# Study of the $^8\text{Be}$ M1 transitions

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



$E_p = 1030 \text{ keV}$

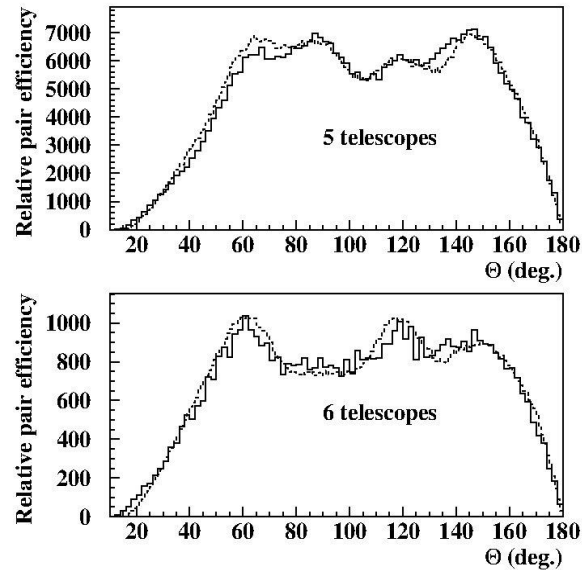
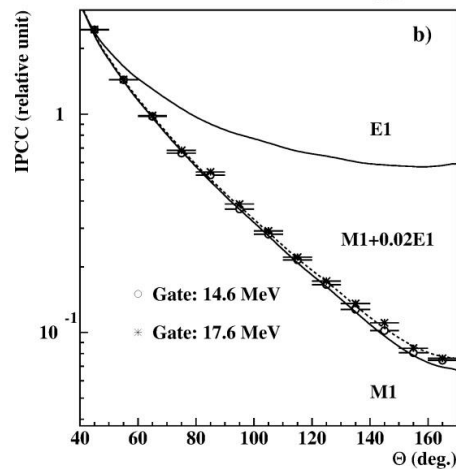
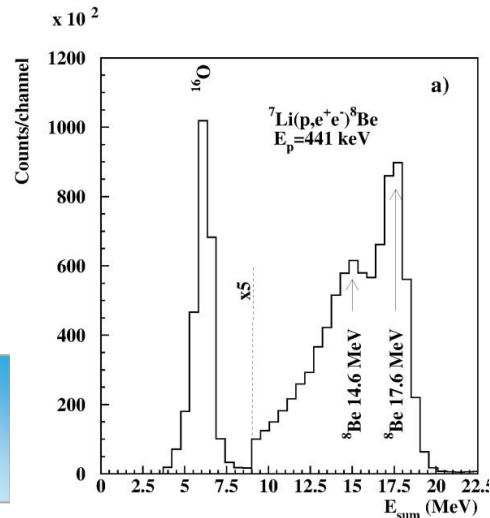
$E_p = 441 \text{ keV}$





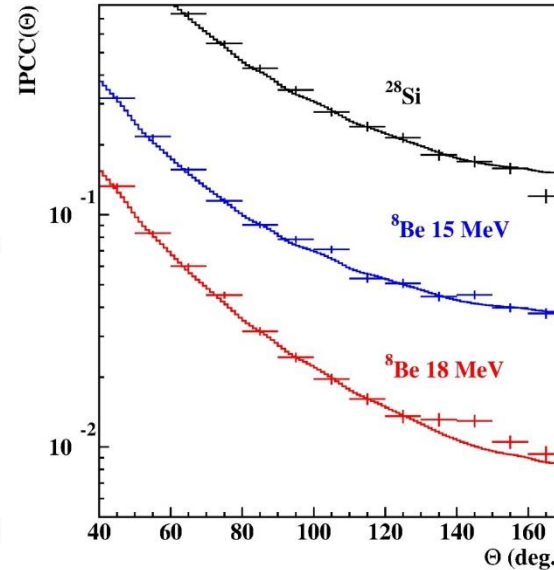
# $e^+e^-$ energy-sum spectra and angular correlations

$^8\text{Be}$



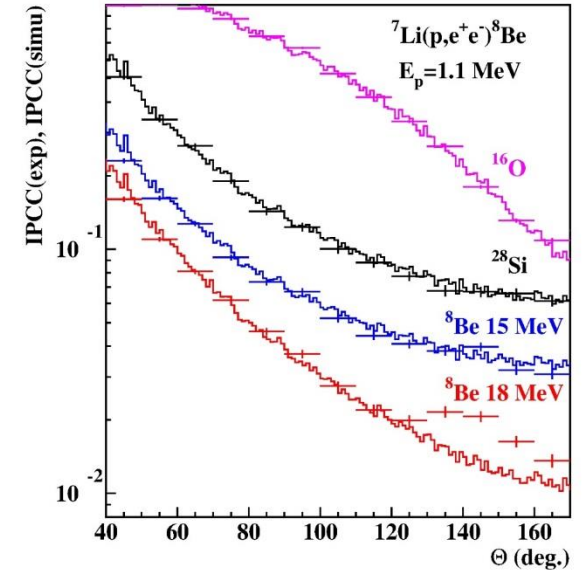
Acceptances for different detector configurations

$E_p=1.04\text{ MeV}$

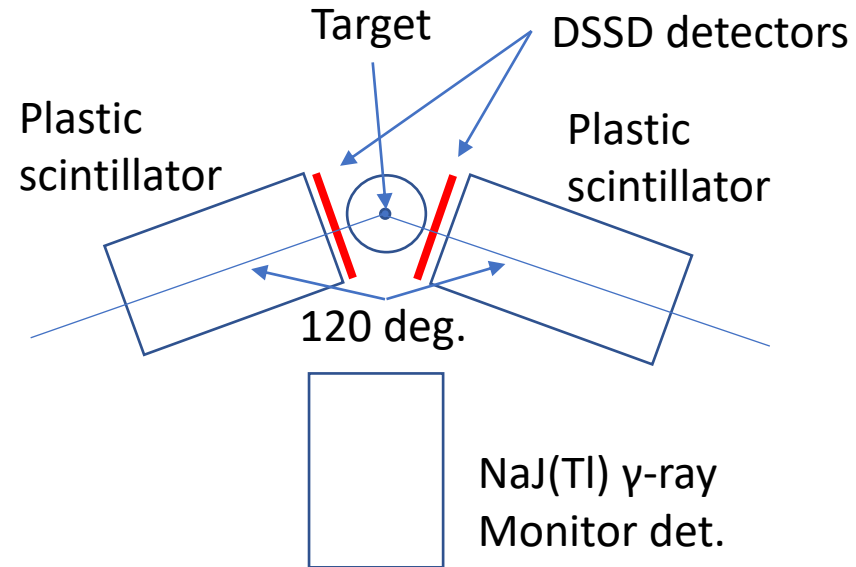


Angular correlations measured from the decay of the  $E_x=18.2\text{ MeV}$  resonance

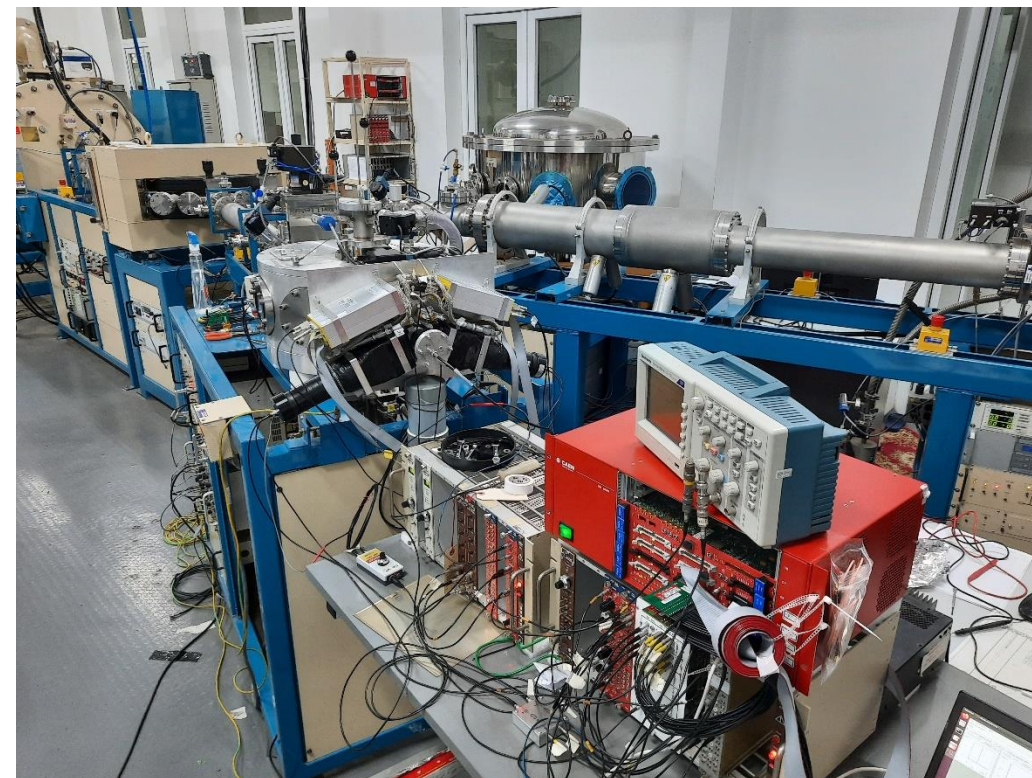
$E_p=1.10\text{ MeV}$



# Experiments started at Hanoi University of Science (HUS) to search for dark matter in 2022







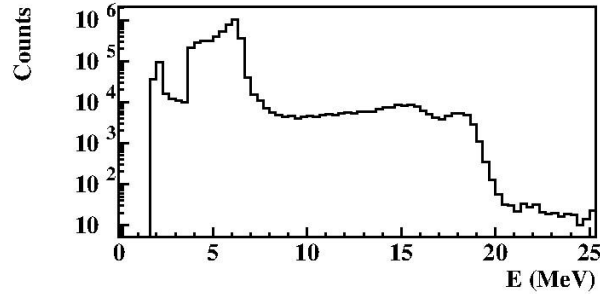
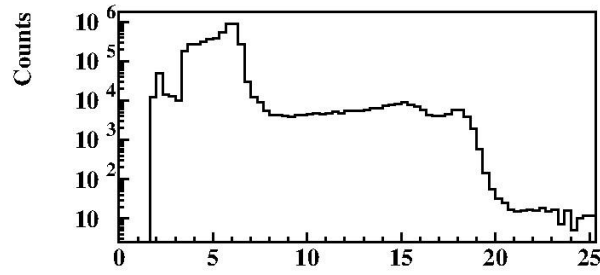
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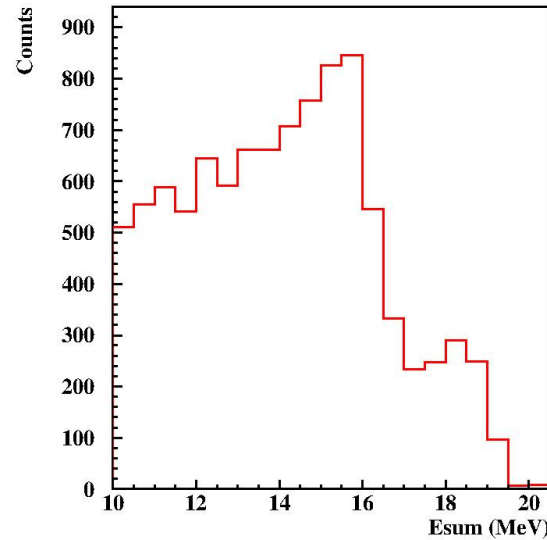
Công nghệ 360 (2022) - Số 18



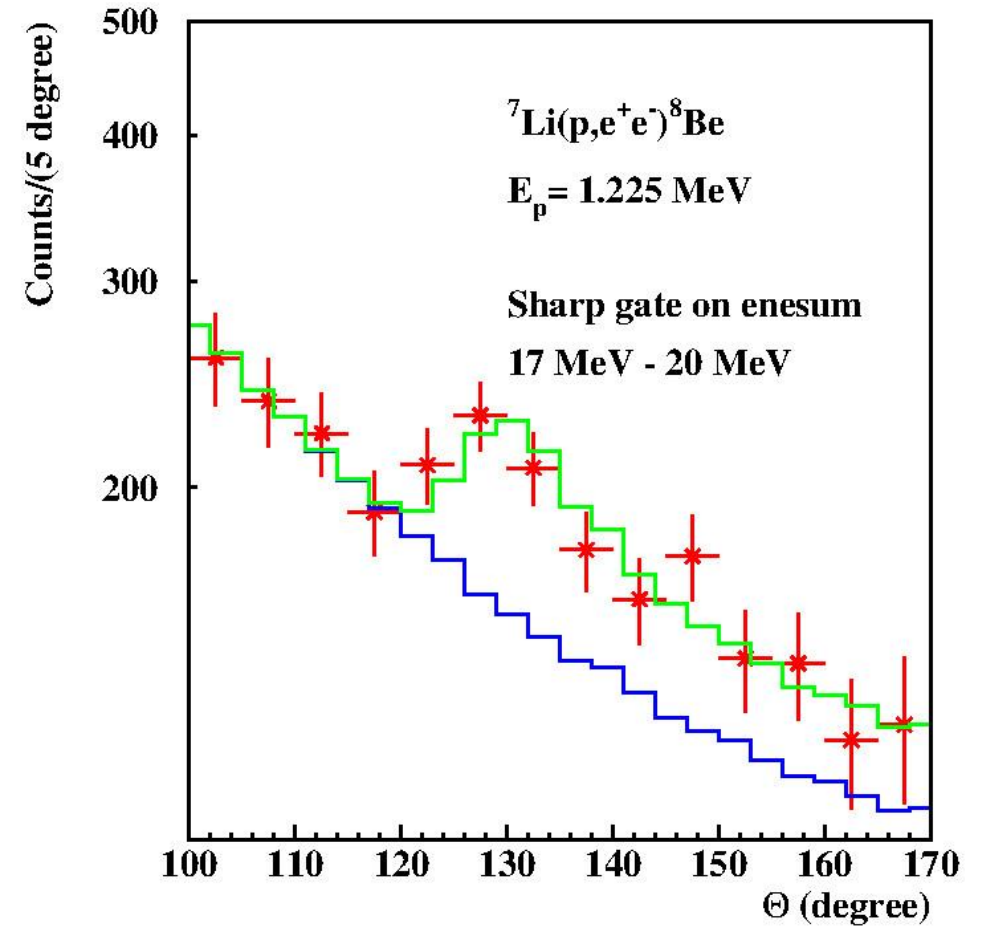
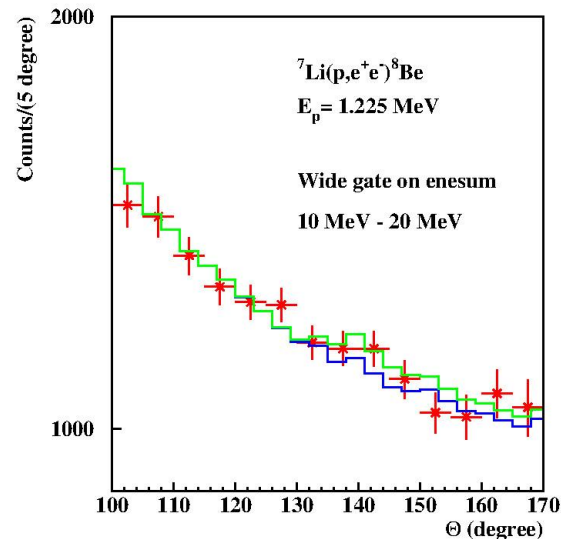
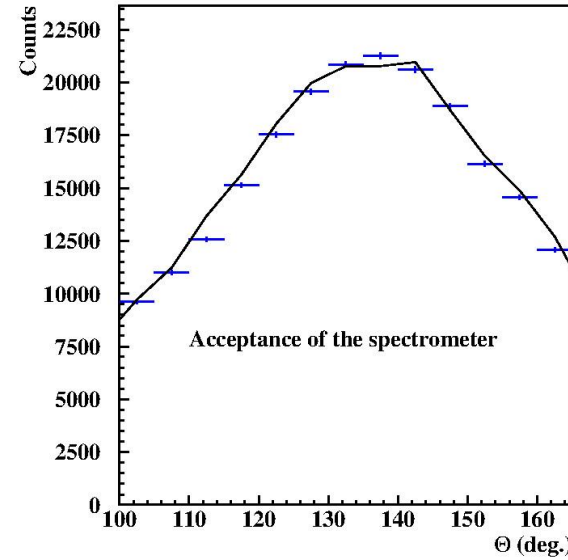
# Preliminary results of the $^8\text{Be}$ experiment performed at HUS



Energy summing in  
det1 and in det2

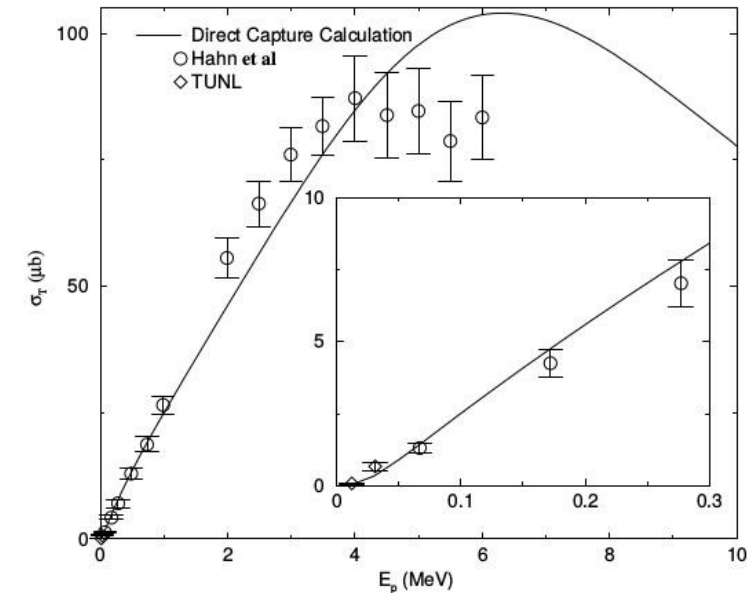
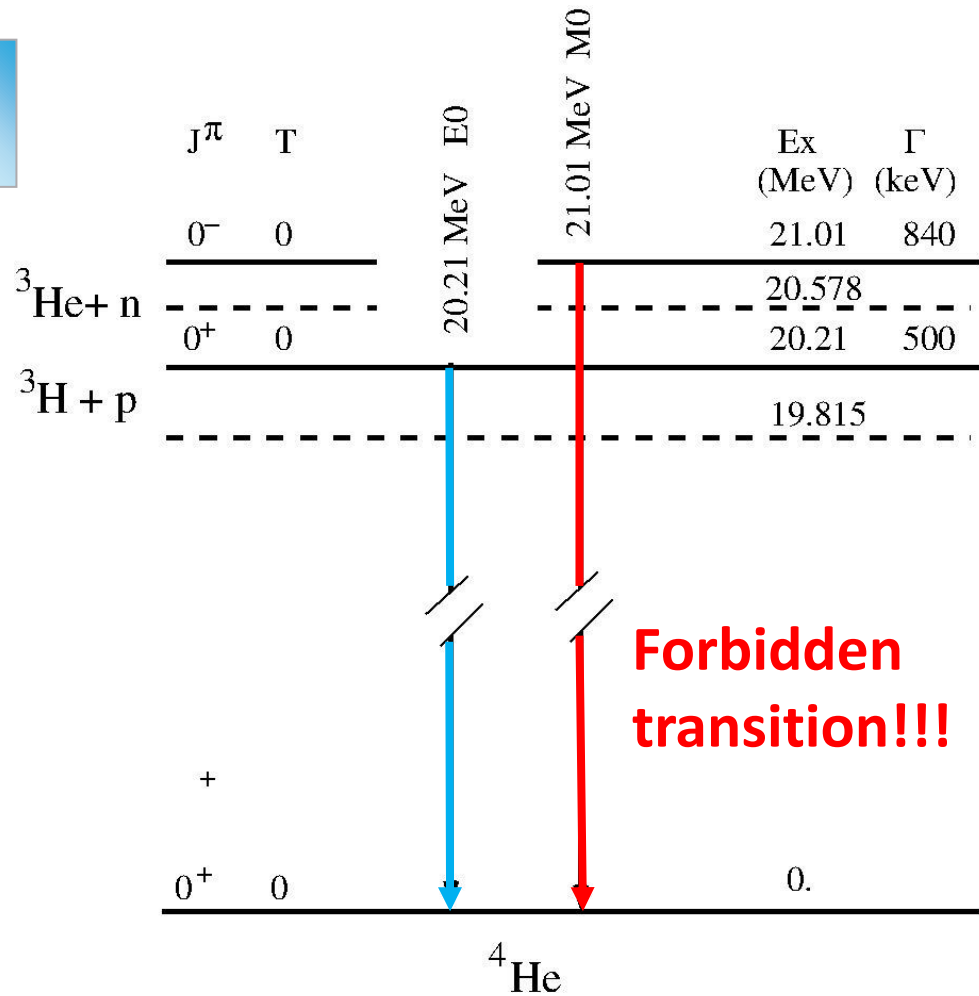


Energy sum spectrum



# Study of the 21 MeV M0 transition in $^4\text{He}$ excited by the $^3\text{H}+p$ reaction

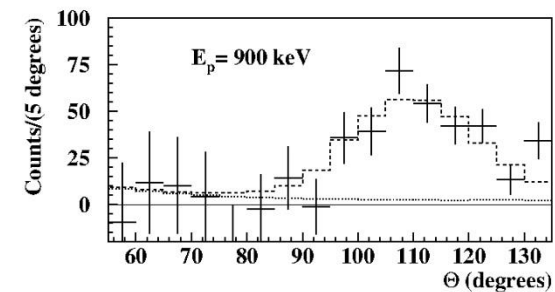
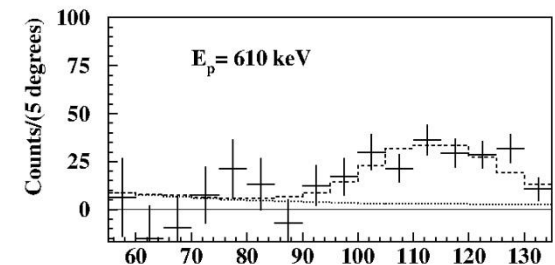
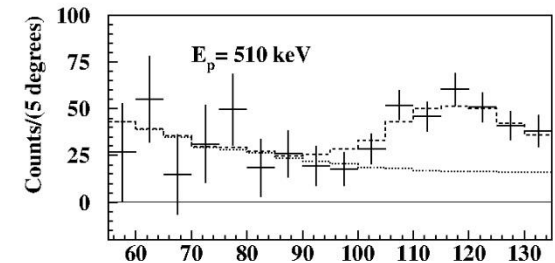
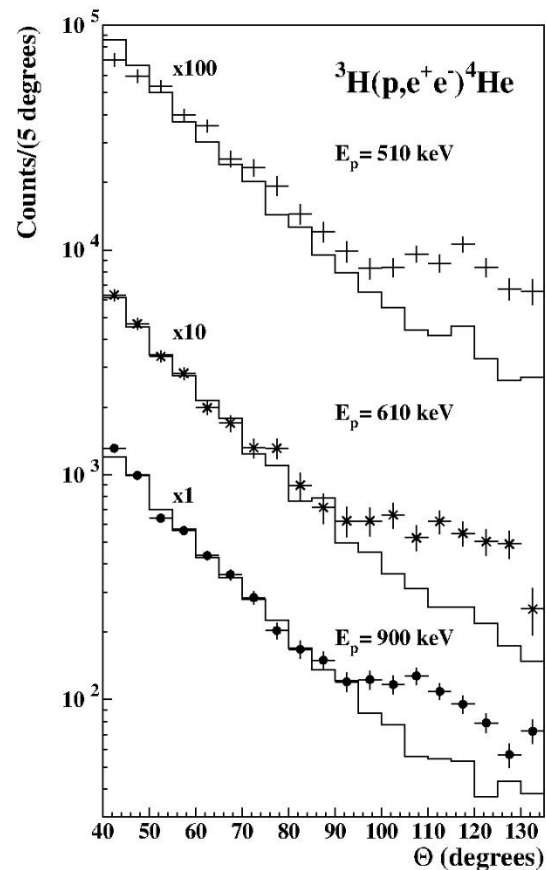
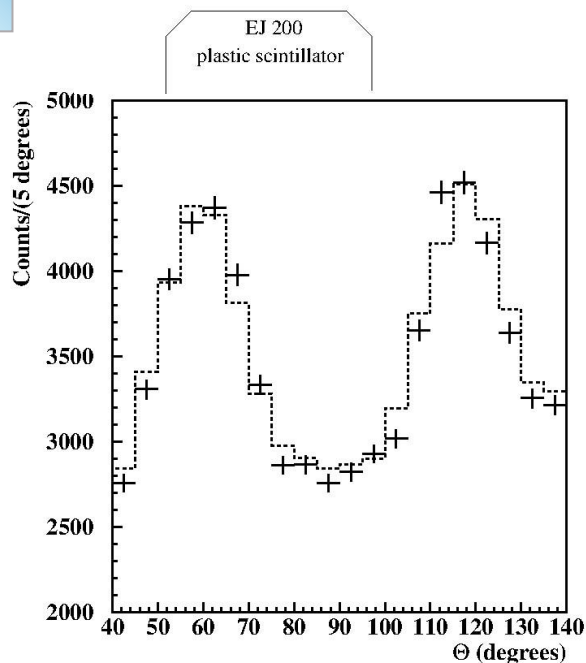
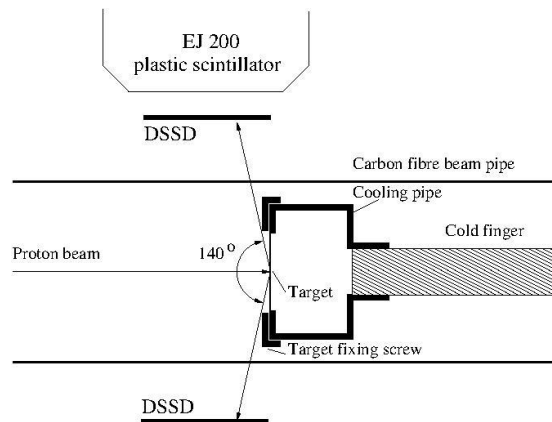
$^4\text{He}$



$\gamma$ -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 obtained for $^4\text{He}$

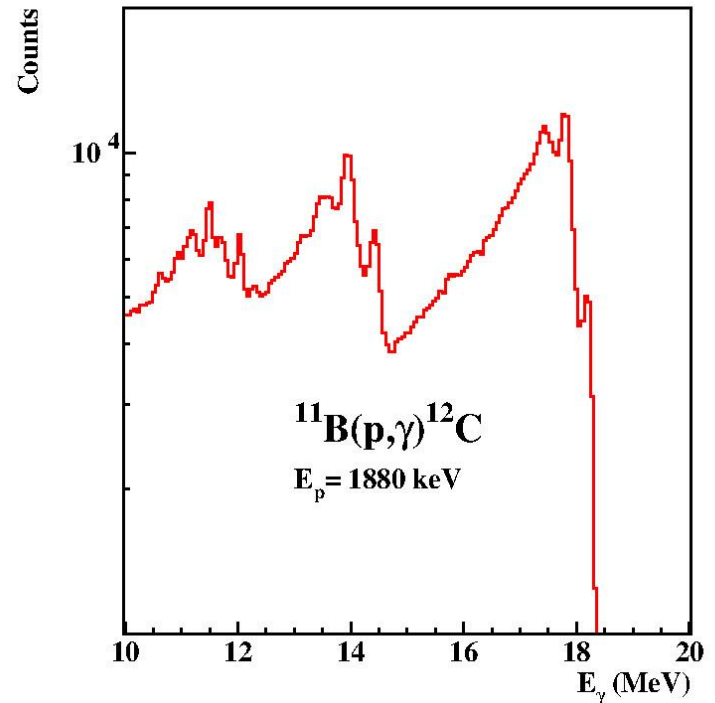
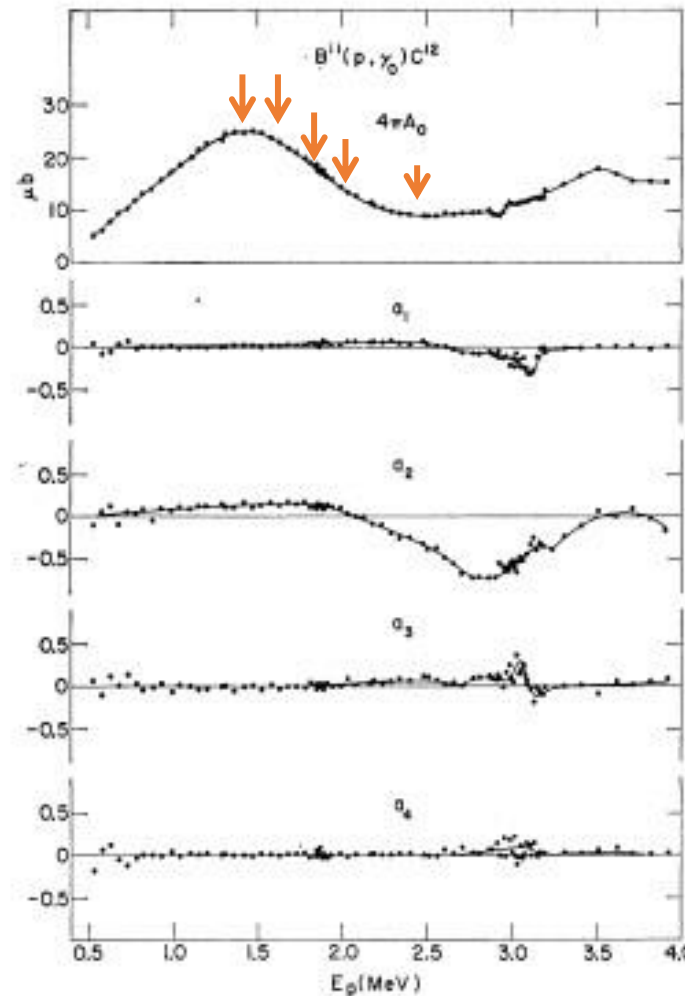
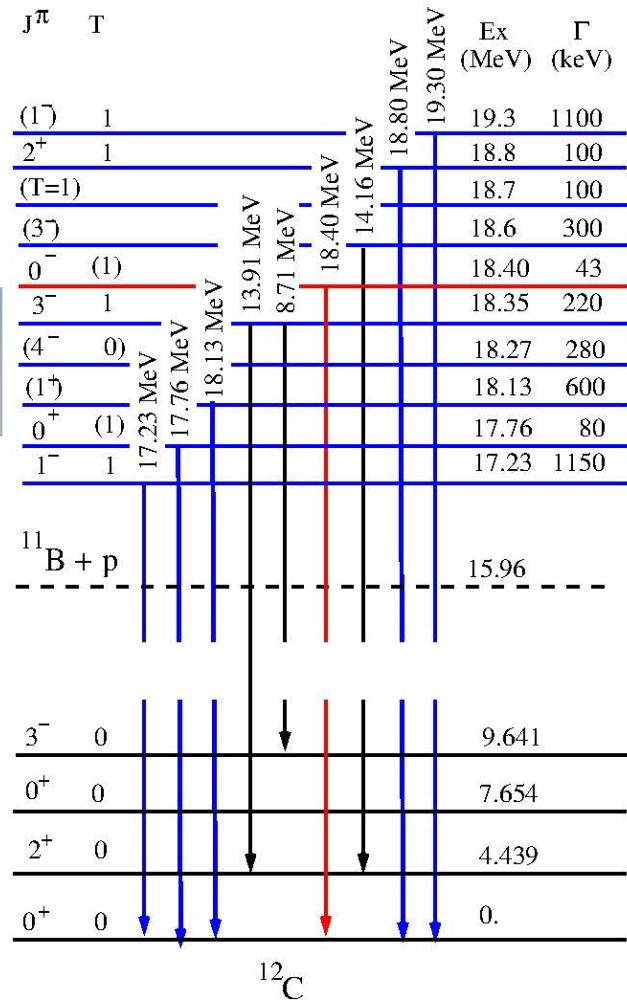
$^4\text{He}$





# Search for X17 in the decay of the 17.23 MeV $1^-$ resonance in the $^{11}\text{B}(p,e^+e^-)^{12}\text{C}$ reaction

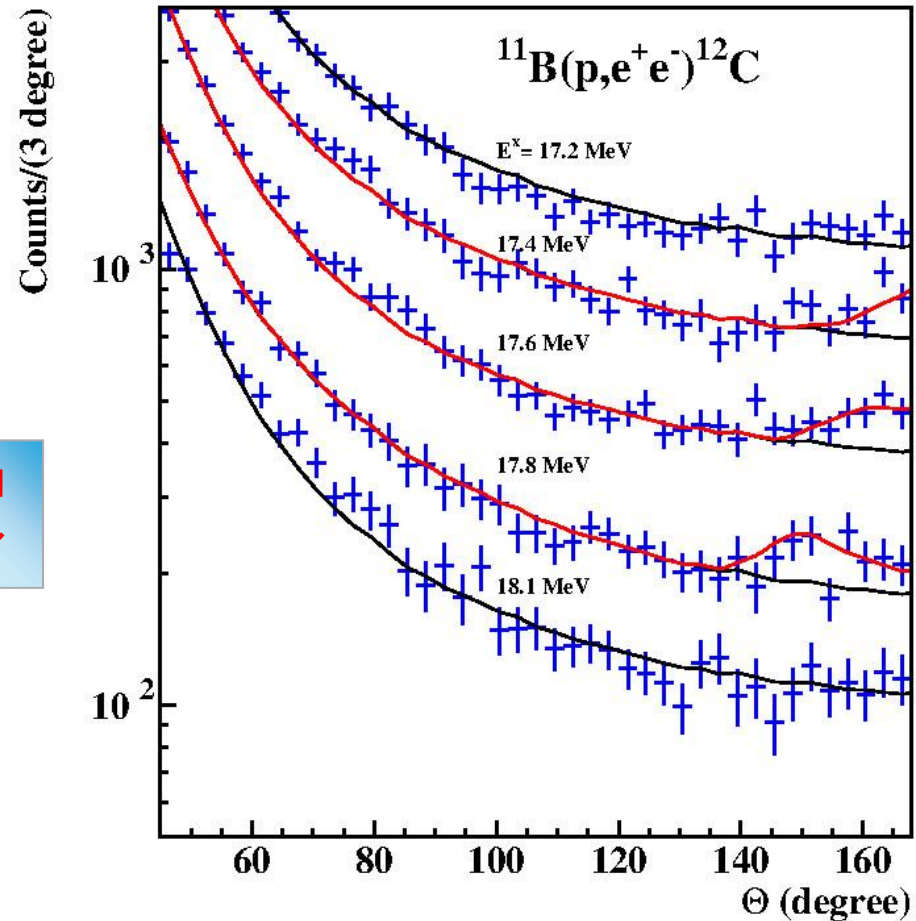
$^{12}\text{C}$



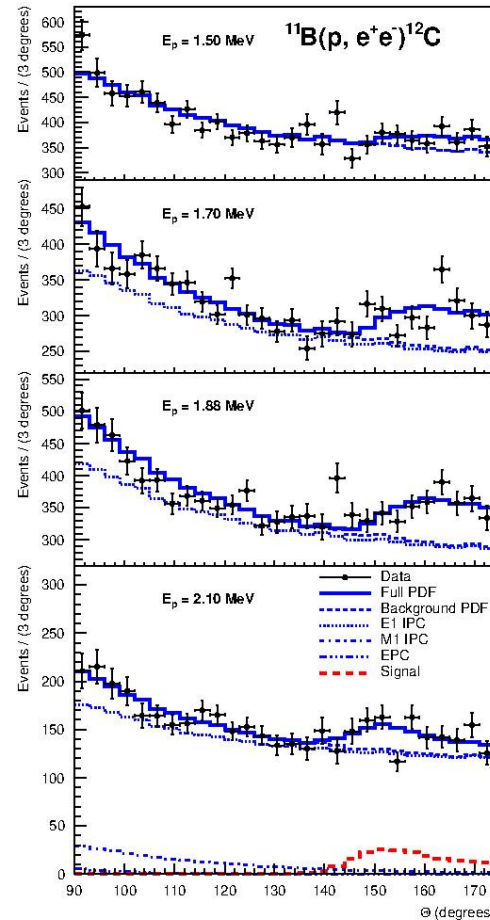
$\gamma$ -ray spectrum taken with a 3"x3" LaBr<sub>3</sub> detector.

# Anomalous internal pair creation observed in $^{12}\text{C}$ , which supports the X17 boson

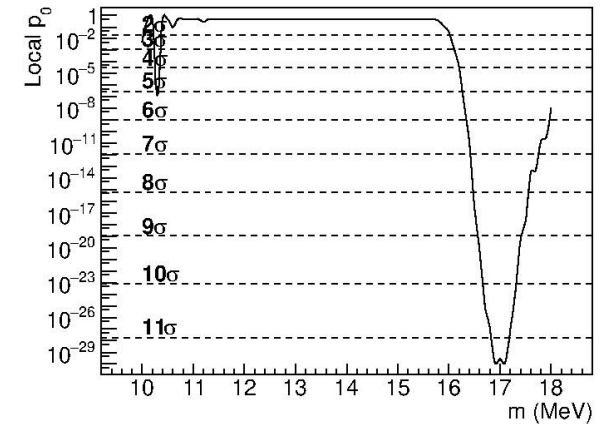
$^{12}\text{C}$



Angular correlations measured at different excitation energies



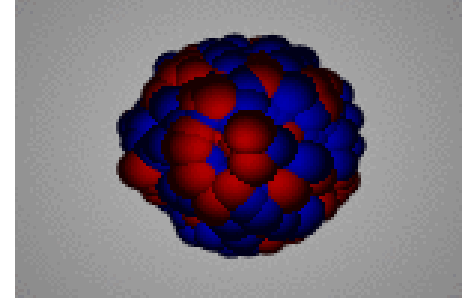
Fitting the experimental data with MC simulations



$$m_0c^2 = 17.0 \text{ MeV}$$

**Kinematical evidence for the X17 particle**

# Future plans: Extend the X17 research towards higher excitation energies



GDR

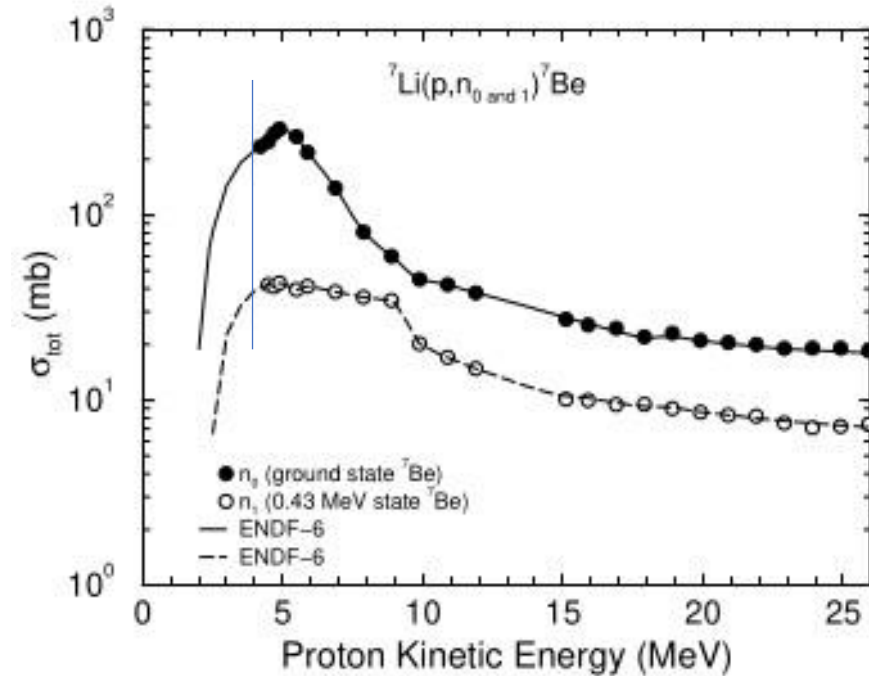
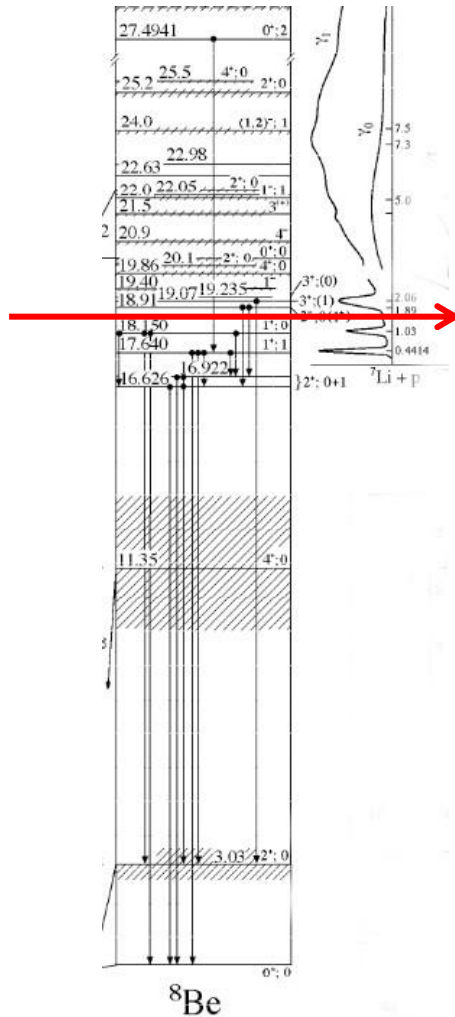
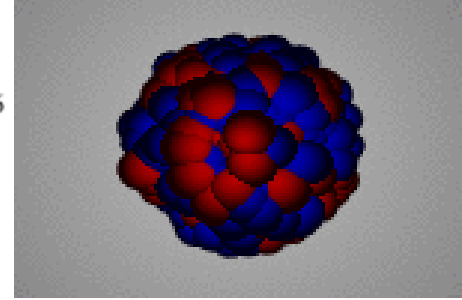


Figure 1: Measured total cross sections for the  $^7\text{Li}(p,n_0)^7\text{Be}$  and  $^7\text{Li}(p,n_1)^7\text{Be}$  reactions between 4 and 26 MeV [12] together with our evaluations in the ENDF-6 [19] format.



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

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

*Department of Physics, Stanford University, Stanford, California 94305*

(Received 21 January 1976)

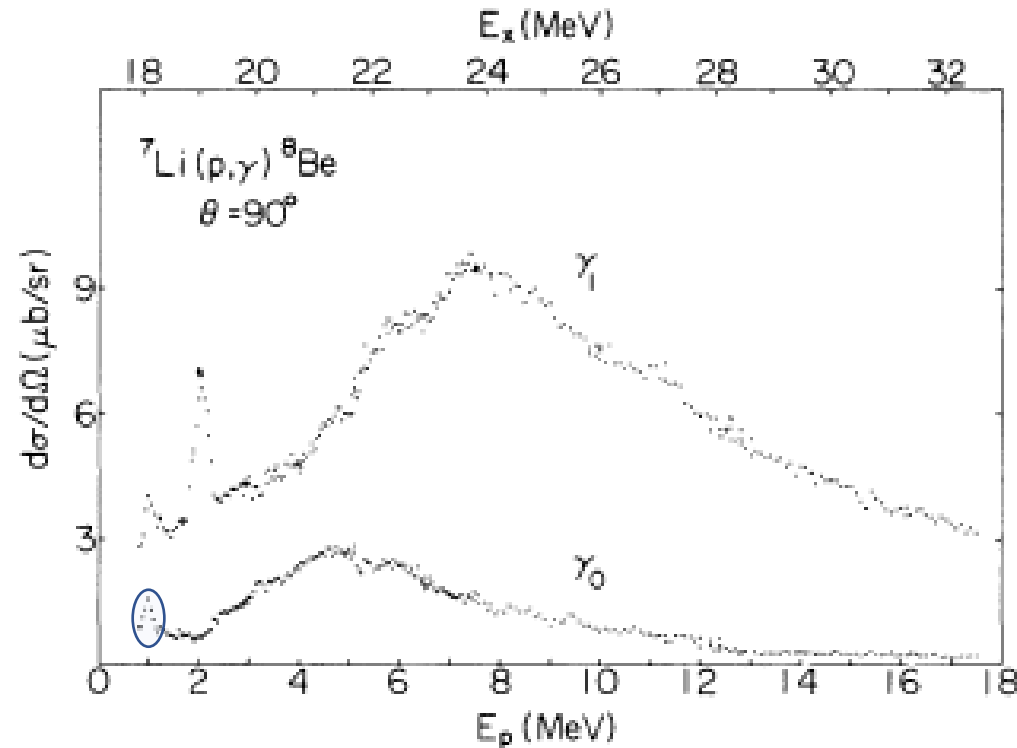


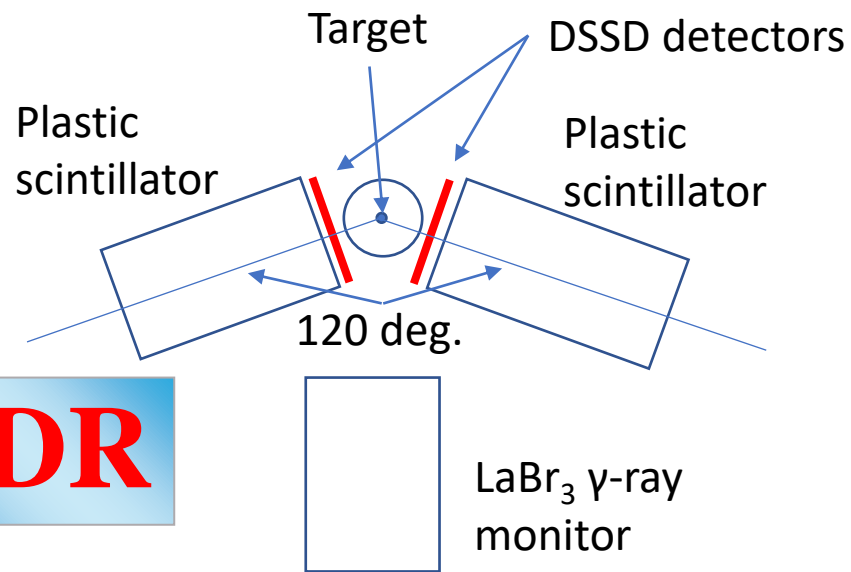
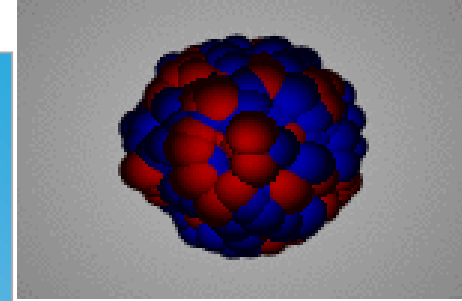
FIG. 3. The yield functions for the  $\gamma_0$  and  $\gamma_1$  transitions obtained at  $90^\circ$ , which show the broad giant resonances built on the ground state and the first excited state of  $^8\text{Be}$ .

TRK sum rule

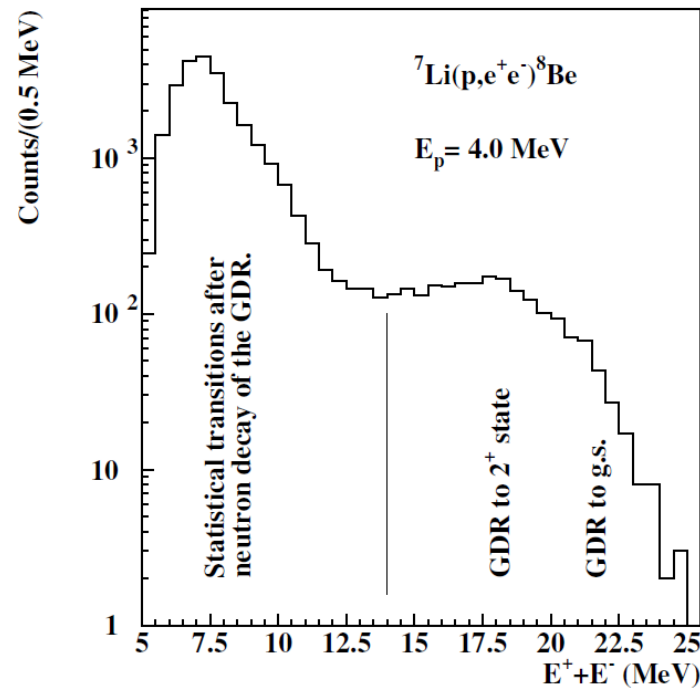
$$\int_{1.8}^{3.3} \sigma(E) dE = 60 \frac{NZ}{A} \text{ MeV mb}$$



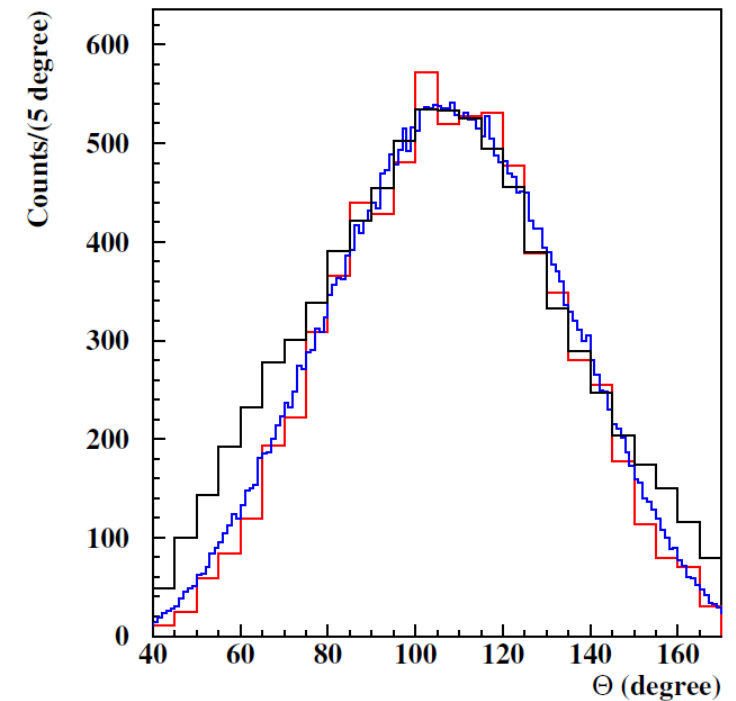
# A new $e^+e^-$ spectrometer, energy-sum spectrum and the acceptance of the spectrometer



**GDR**

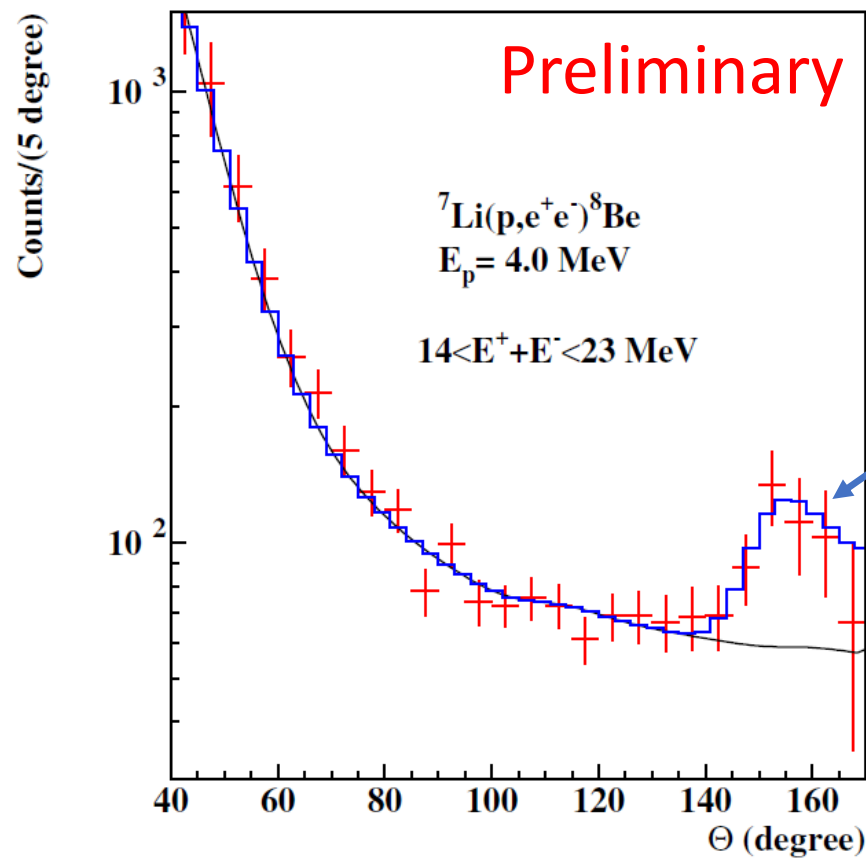
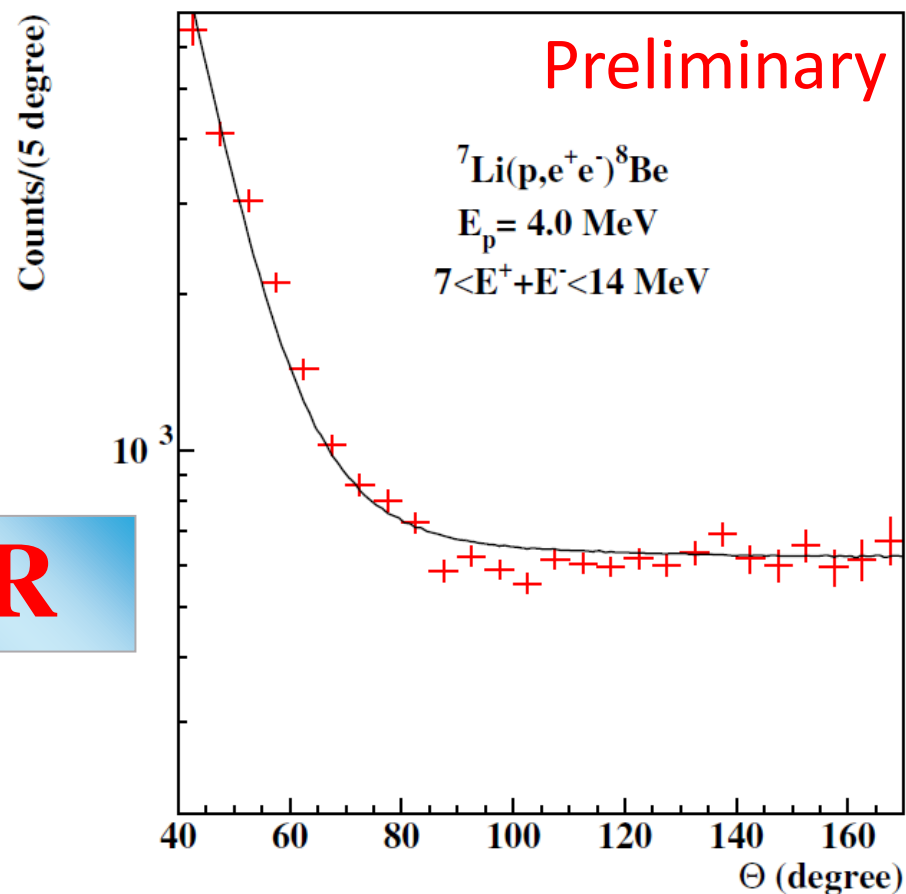
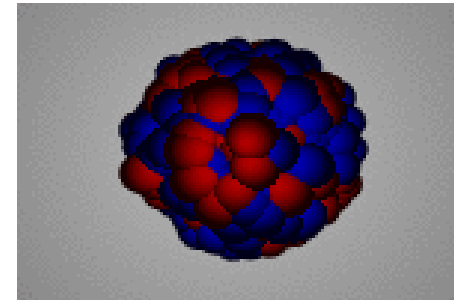


Energy-sum  
spectrum



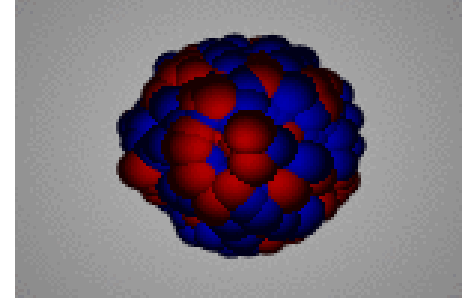
Red: Experimental acceptance (GDR energy range)  
Black: Experimental acceptance (statistical range)  
Blue: Simulated acceptance (GDR energy range)

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



$m_0 c^2 = 17 \text{ MeV}$

# Opening a new avenue for studying the X17 properties in GDR decay

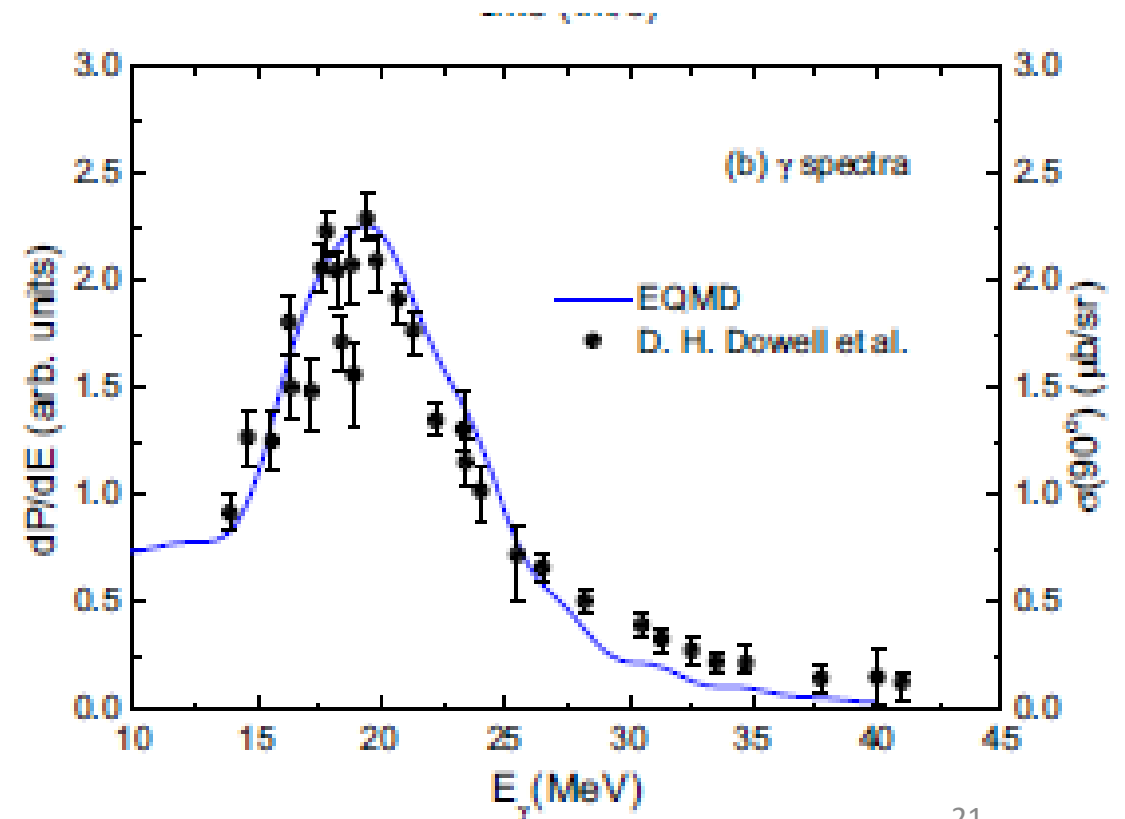
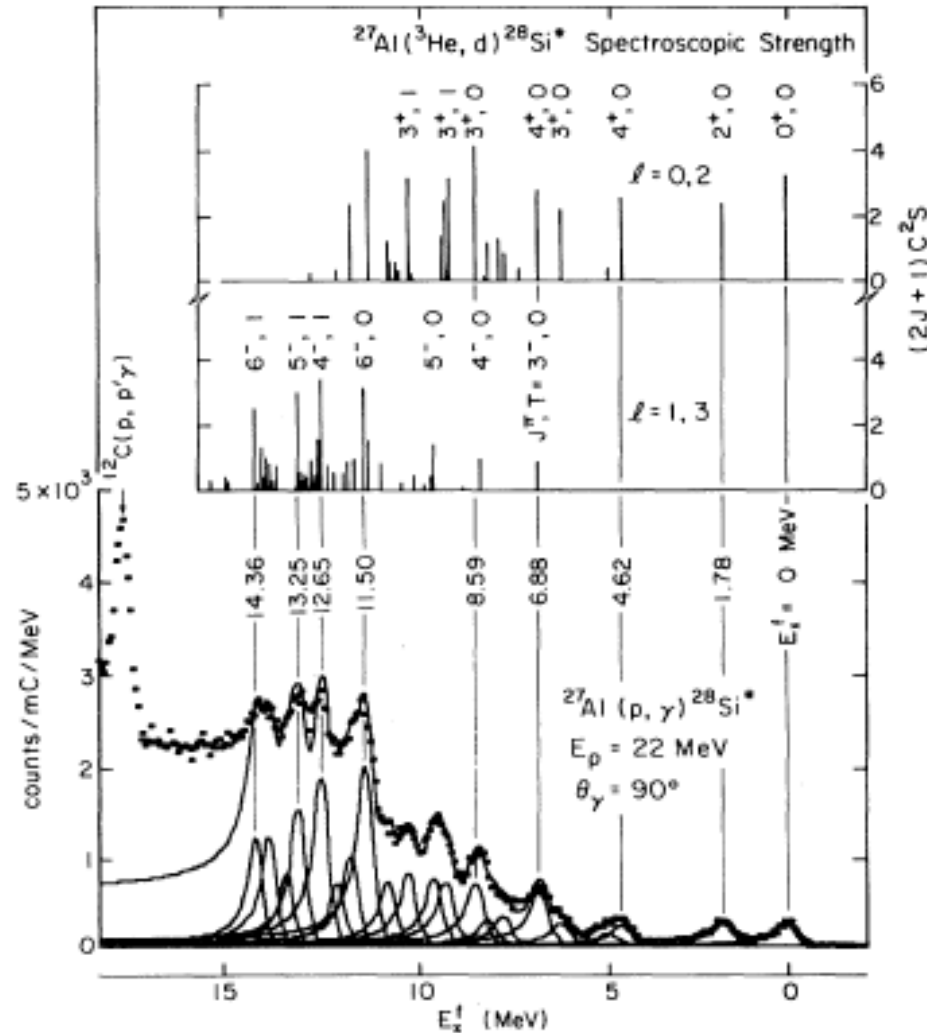


Target	Q(p, $\gamma$ )	Q(p,n)
$^9\text{Be}$	6.59	-1.85
$^{11}\text{B}$	15.96	-11.45
$^{13}\text{C}$	7.55	-1.419
$^{19}\text{F}$	12.84	-10.43
$^{23}\text{Na}$	11.69	-4.84
$^{25}\text{Mg}$	6.31	-5.06
$^{27}\text{Al}$	11.58	-5.59
$^{29}\text{Si}$	5.59	-5.72
$^{31}\text{P}$	8.86	-6.18
$^{33}\text{S}$	5.14	-6.36
$^{15}\text{N}$	12.12	-3.54
$^{39}\text{K}$	8.33	-7.30

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



# Coming experiments



# $\gamma$ -ray and $e^+e^-$ energy-sum spectra recorded at $E_p = 4$ MeV

