# Anomalies observed in nuclear transitions indicate the existence of a new particle with mass of 17 MeV/c<sup>2</sup>



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### 3 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

#### Leitmotif of my present talk:

In an age of giant accelerators, of complex experiments and of mystifying theories it is a pleasure to report on some simple experiments, made with simple equipment and having a simple interpretation

**Robert Hofstadter (Nobel, 1961)** 



### **Dark Forces at Accelerators Workshop**

INFN – Laboratori Nazionali di Frascati 16<sup>th</sup> -19<sup>th</sup> October, 2012



Search for a light neutral boson in nuclear transitions Attila Krasznahorkay, F.W.N. de Boer, M. Csatlós, L. Csige, Z. Gácsi, J. Gulyás, M. Hunyadi, T.J. Ketel, A. Krasznahorkay Jr., R.G. Lovas, B.M. Nyakó, L. Stuhl, T. Tornyi, J. Van Klinken

The boson showed up with  $\approx 3\sigma$  confidence  $\rightarrow$  inspiration for further more precise experiments !!!



#### Observation of Anomalous Internal Pair Creation in <sup>8</sup>Be: A Possible Indication of a Light, Neutral Boson

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Electron-positron angular correlations were measured for the isovector magnetic dipole 17.6 MeV

### ~200 citations, <sup>8</sup>Be anomaly, X17 boson

### Study the <sup>8</sup>Be M1 transitions

### Excitation with the <sup>7</sup>Li(p,γ)<sup>8</sup>Be reaction



### Internal pair creation and particle decay



Signature



### Experiments with a new e<sup>+</sup>e<sup>-</sup> spectrometer (NIM, A808 (2016) 21)

X17 boson Krasznahorkav

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





### **Results** e<sup>+</sup> - e<sup>-</sup> sum energy spectra and angular correlations



Θ (deg.)

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



Experimental angular  $e^+e^-$  pair correlations measured in the <sup>7</sup>Li(p,e<sup>+</sup>e<sup>-</sup>) 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<sup>2</sup>/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<sub>RMS</sub>, TV stability: 200 V (GVM), 30 V (SLITS)
- Beam current capability at 2 MV: 200 μA proton, 40 μA He



### The new e<sup>+</sup>e<sup>-</sup> 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

Relative numbers! The absolute efficiency for 6 detectors is certainly larger!



The results of the present experiment can be considered independent from the one we published in PRL in 2016. X17 boson Krasznahorkay 13

### Recent results for the 18.15 MeV transition



### Study of the 21 MeV M0 transition in <sup>4</sup>He excited by <sup>3</sup>H+p, and <sup>3</sup>He+n reactions







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<sup>+</sup>e<sup>-</sup> decay measured in Debrecen**



### On the partial width ( $\Gamma_X$ ) of the X17 particle



$$\Gamma_X / \Gamma_{E0} = \left(\frac{\sigma(x17)}{\sigma(E0)}\right)_{exp.} \left(\frac{\sigma(0^+)}{\sigma(0^-)}\right)_{th.}$$
$$\left(\frac{\sigma(x17)}{\sigma(E0)}\right)_{exp.} = 0.20$$
$$\left(\frac{\sigma(0^+)}{\sigma(0^-)}\right)_{th.} = \frac{\Gamma_{tot}(0^+)}{\Gamma_{tot}(0^-)} = 0.59$$
Since:  $\Gamma_{E0} = 3.3 \times 10^{-4} \quad \Rightarrow \Gamma_X = 3.9 \times 10^{-5} \text{ eV}$ 

In <sup>8</sup>Be it was:  $\Gamma_X = \Gamma_\gamma x B_x = 1.9x6x10^{-6} \text{ eV} = 1.2x10^{-5} \text{ eV}$ (role of the phase space correction factor)<sup>7</sup>

### **Details of the fit performed by RooFit**



### **Invariant mass distribution**



### Conclusion

- The <sup>8</sup>Be anomaly has been reproduced with an upgraded 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 <sup>4</sup>He in a 21.01 MeV  $0^- \rightarrow 0^+$  transition at a correspondingly smaller angle. The significance of the peak is 7.2  $\sigma$ .
- We are planning to study the γγ-decay of X17 to determine their spin.
- Promising outlook.

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### To <sup>8</sup>Be continued...

## Thank you very much for your attention