

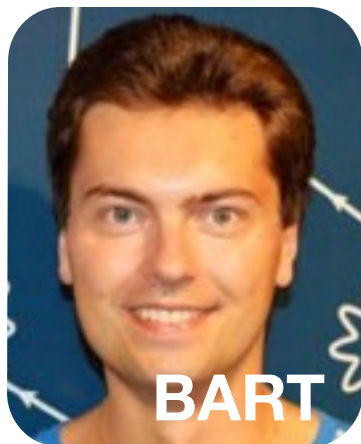
PROTOPHOBIC ^8Be TRANSITION EVIDENCE FOR A NEW 17 MEV BOSON

Flip Tanedo
UCI

arXiv:1604.07411 & work in progress
SLAC **Dark Sectors** 2016 (28 — 30 April)

with

Jonathan Feng, Bart Fornal, Susan Gardner, Iftah Galon, Jordan Smolinsky, & Tim Tait



A 6.8σ nuclear transition anomaly

PRL **116**, 042501 (2016)

PHYSICAL REVIEW LETTERS

week ending
29 JANUARY 2016

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

A. J. Krasznahorkay,^{*} 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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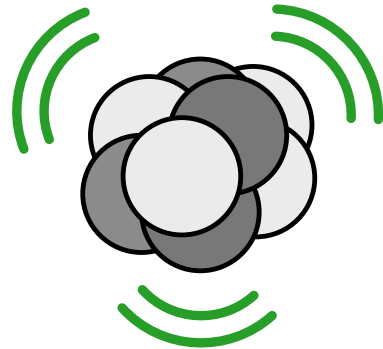
(Received 7 April 2015)

not have a nuclear physics related origin.

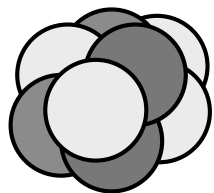
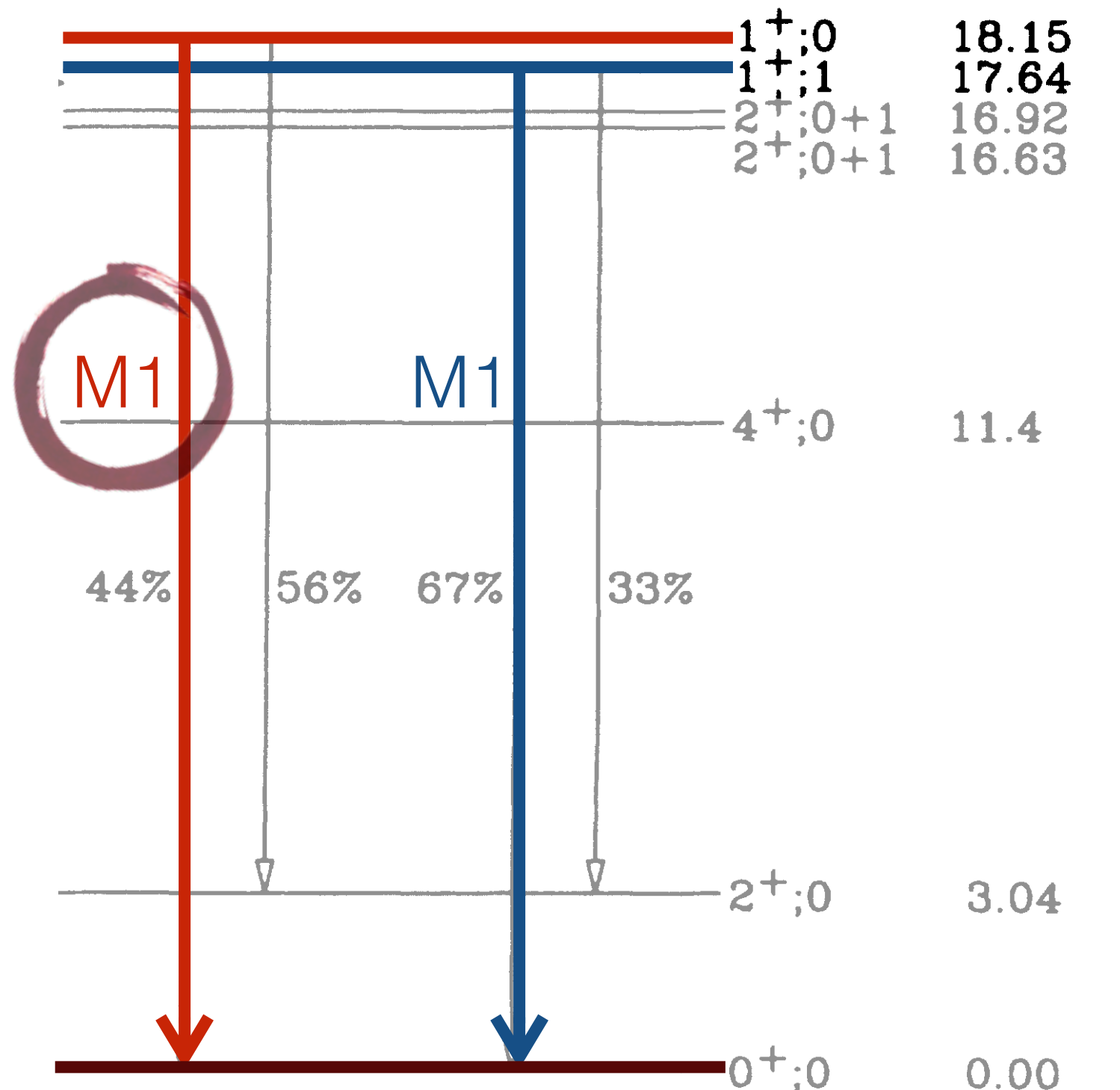
The deviation observed at the bombarding energy of $E_p = 1.10$ MeV and at $\Theta \approx 140^\circ$ has a significance of 6.8 standard deviations, corresponding to a background fluctuation probability of 5.6×10^{-12} . On resonance, the $M1$ contribution should be even larger, so the background

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 ^8Be . 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 $16.70 \pm 0.35(\text{stat}) \pm 0.5(\text{syst})$ MeV/ c^2 and $J^\pi = 1^+$ was created.

8-Beryllium Levels



many other states not shown

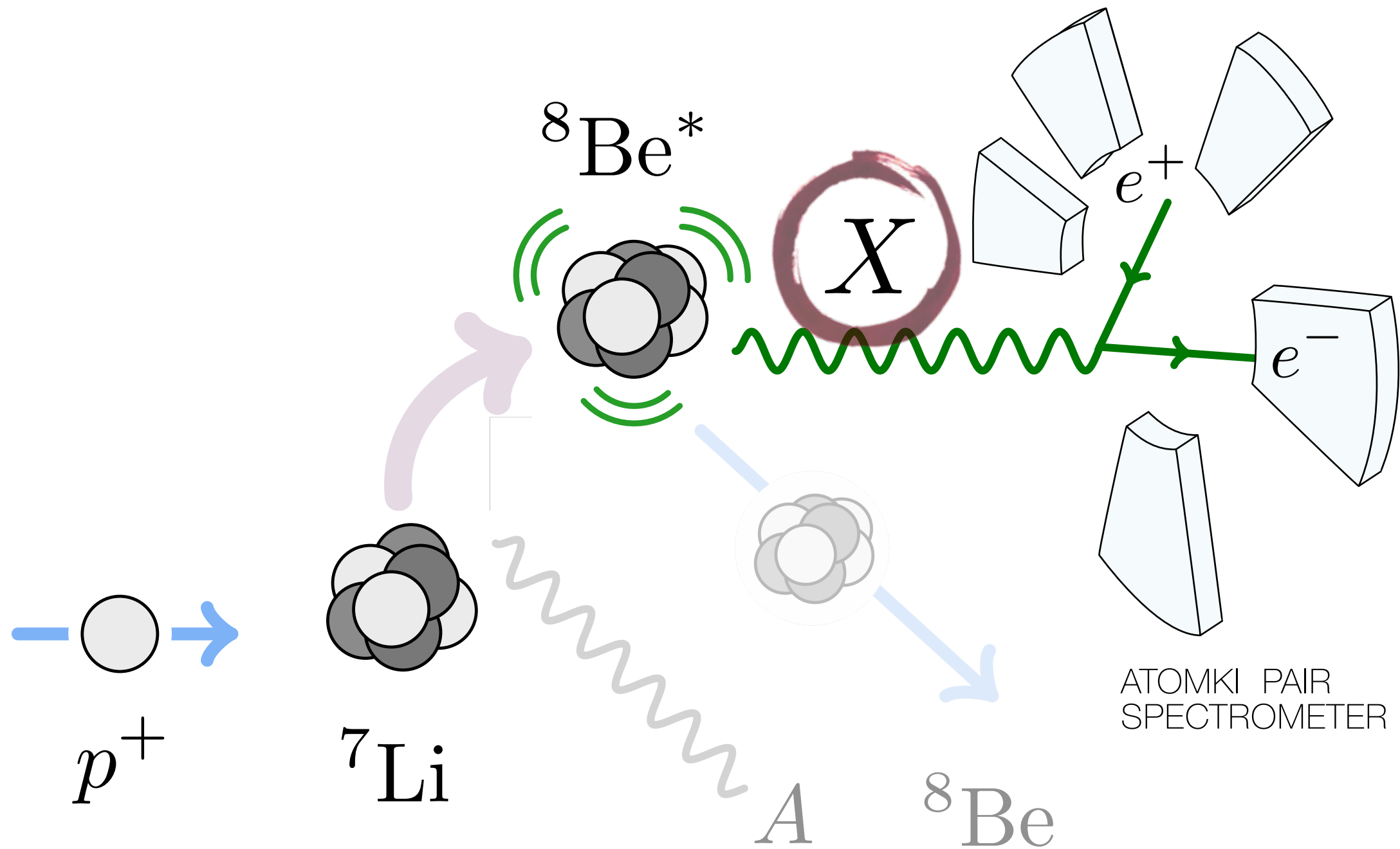


Savage et al. Phys. Rev. D37 (1987) 1134

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EVIDENCE FOR A 17 MEV NEW BOSON

Experiment & interpretation

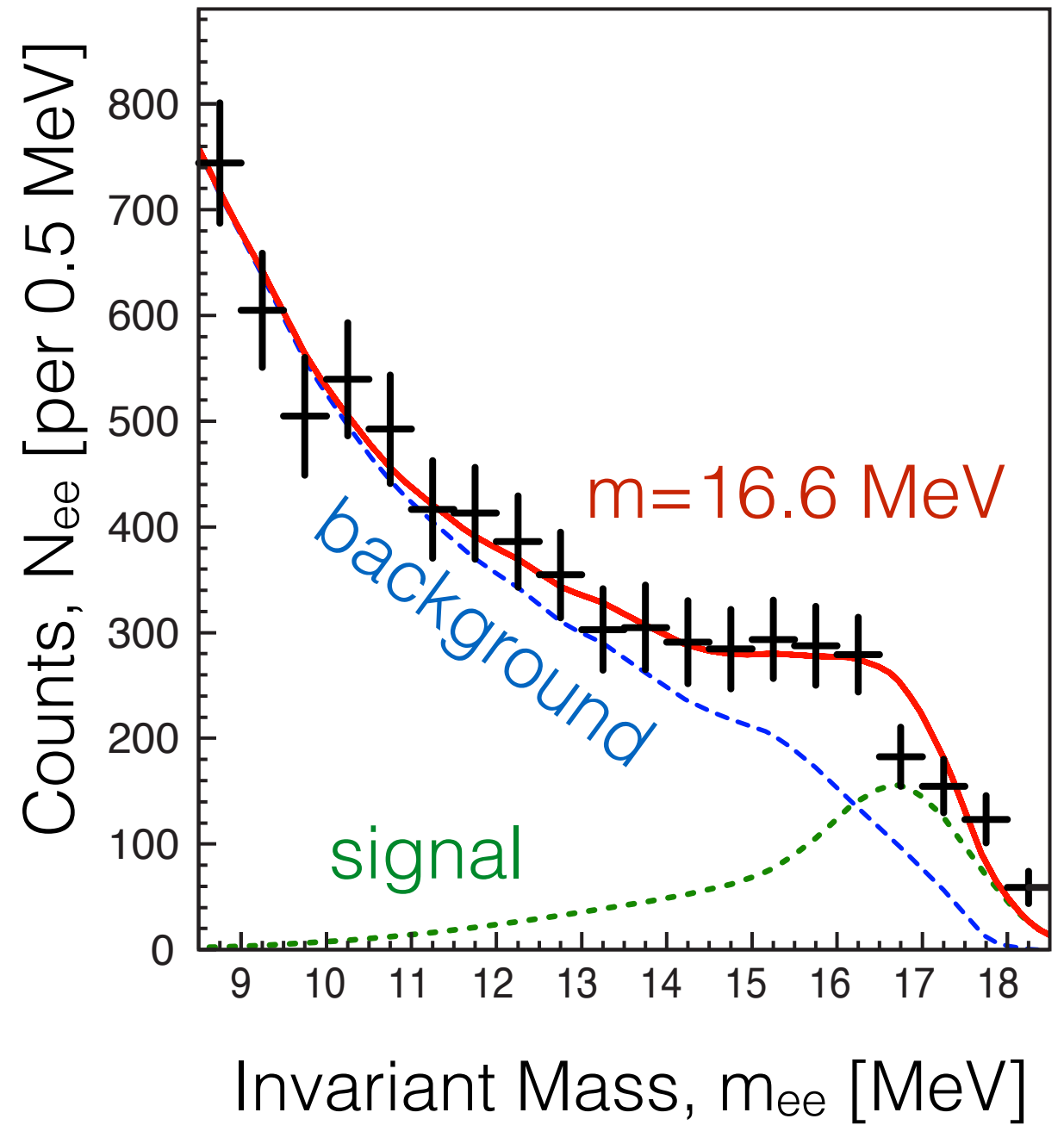
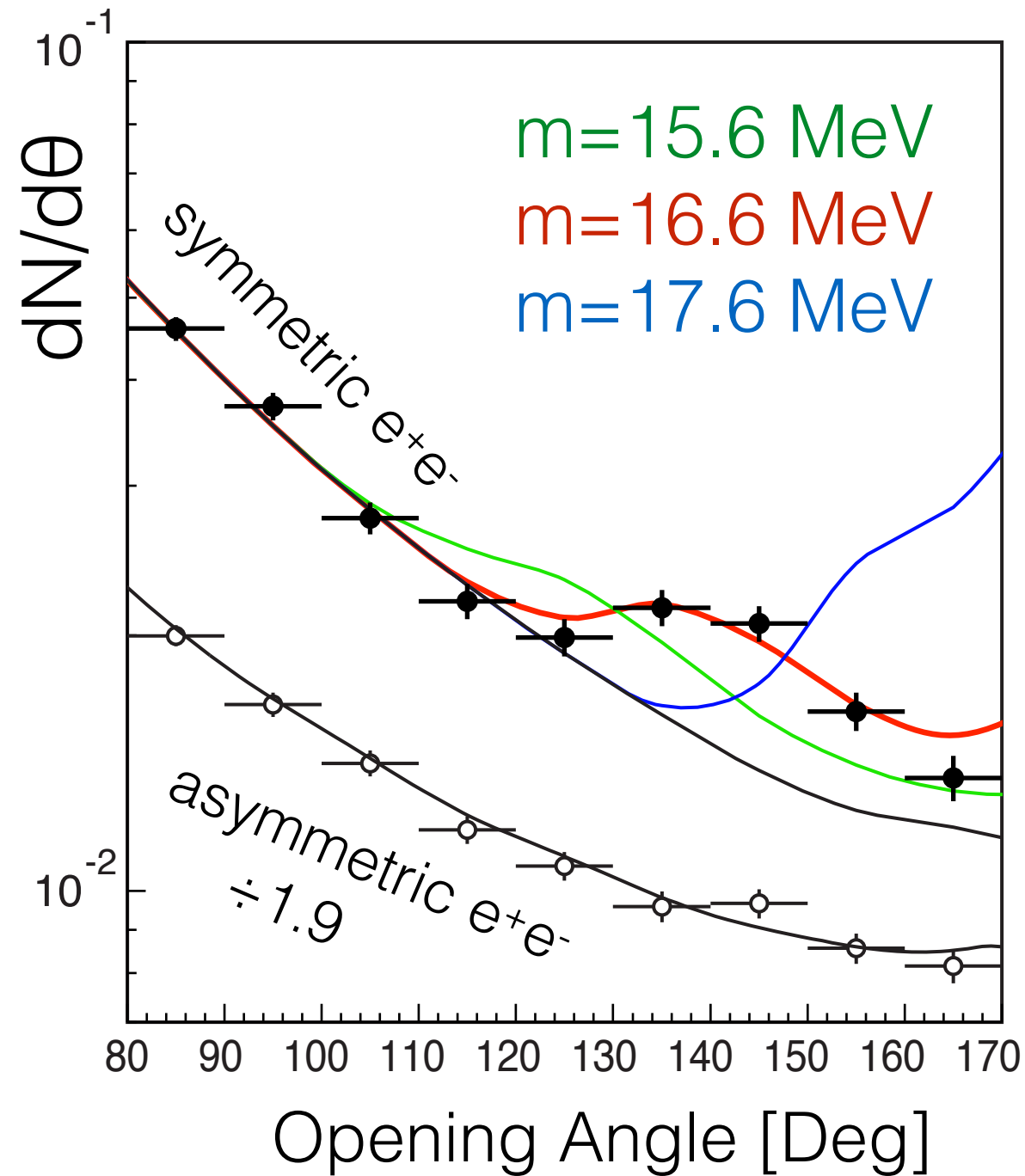


FT, based on Gulyás et al. (1504.00489)

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EVIDENCE FOR A 17 MEV NEW BOSON

A 6.8σ anomaly: two measurements



Sanity Checks

1. **Bump**, not monotonically decreasing background
2. **Opening angle** and **invariant mass** agree (17 MeV)
3. **Bump disappears off resonance**
not interference with other decays
4. **Bump disappears for asymmetric energies**
consistent with kinematics for on-shell particle
5. Large energy splitting, **wouldn't see in other nuclei**

Not a dark Higgs

ANGULAR MOMENTUM

$$\ell = 1$$

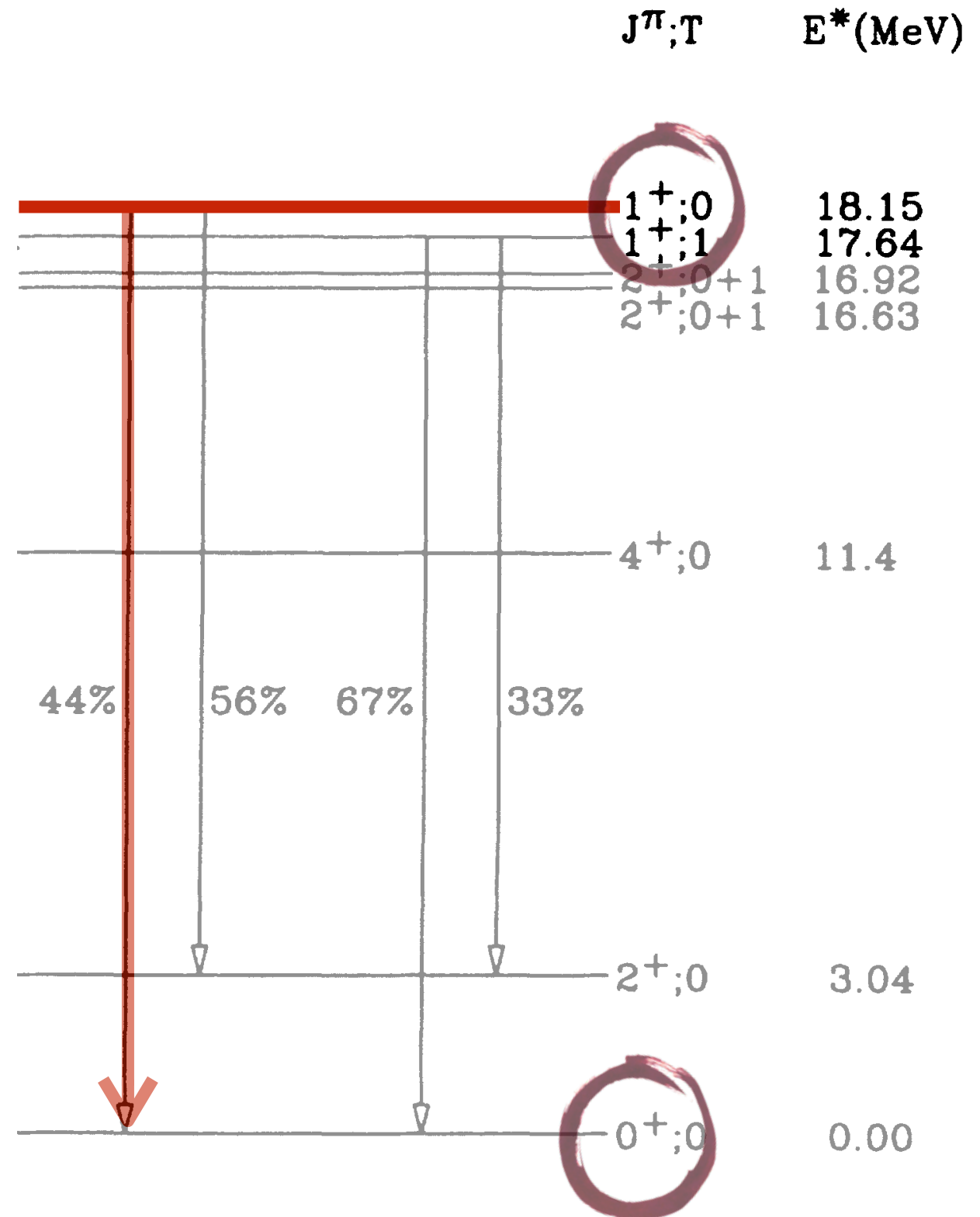
PARITY

$$P = (-)^{\ell} P_{\text{Be}} P_X$$

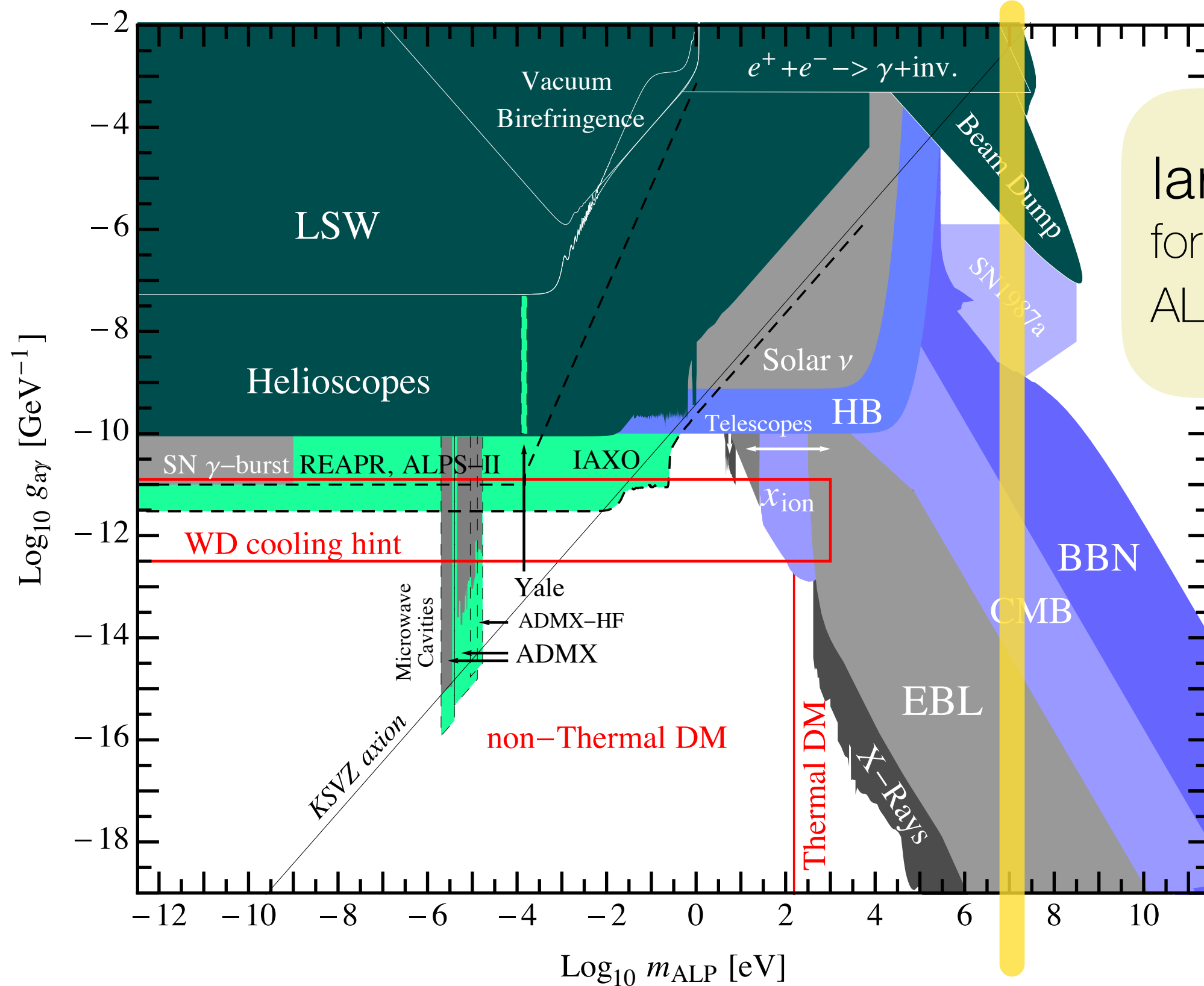
- + +

Decay is **forbidden**

up to parity violation



Not an axion-like particle



largely ruled out
for many decades in
ALP- γ couplings

See also:
1512.03069

Hewett et al. "Fundamental Physics at the Intensity Frontier" 1205.2671

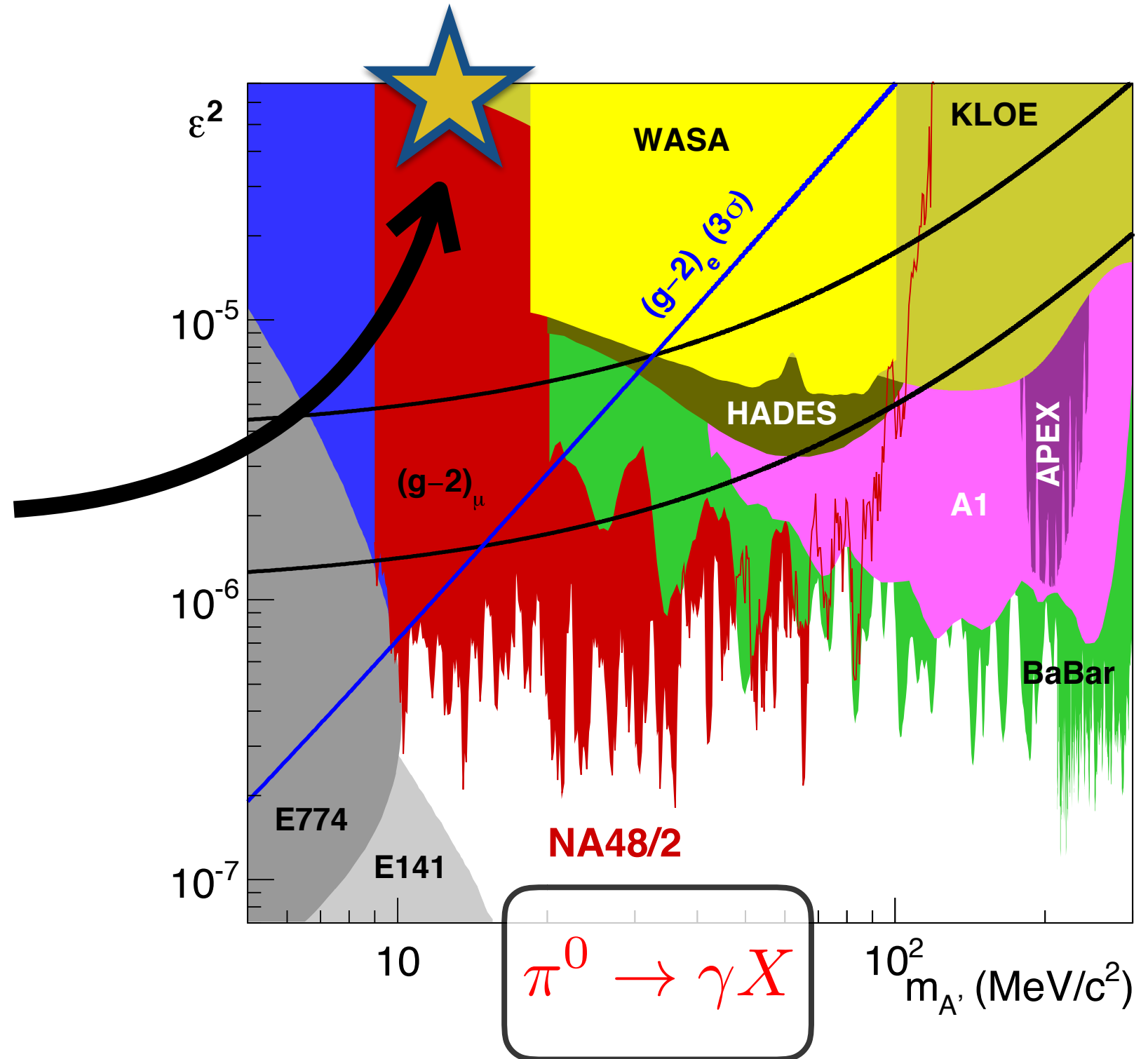
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EVIDENCE FOR A 17 MEV NEW BOSON

Not your mother's dark photon

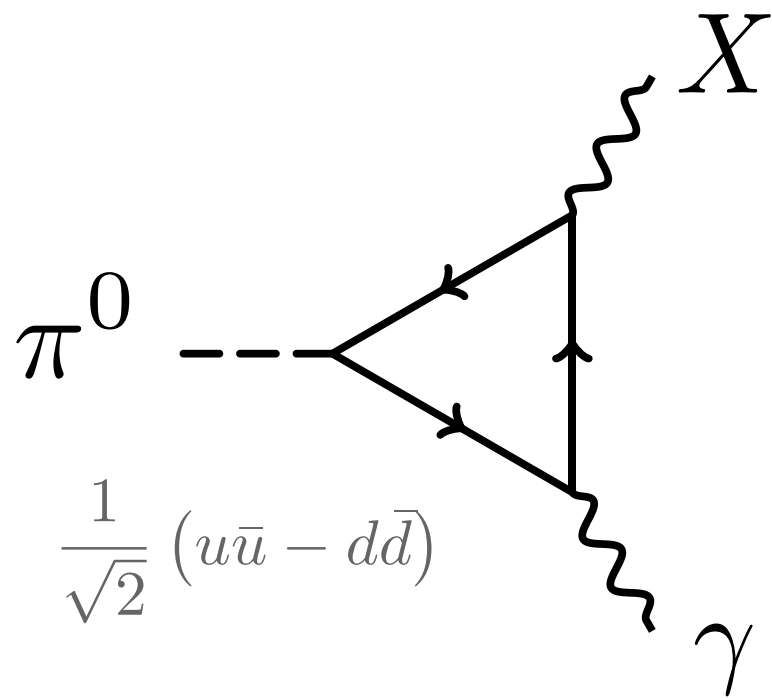
$$\varepsilon \approx 0.011$$

Proposal: **separate**
 u , d and e couplings



π^0 -phobia = p^+ -phobia

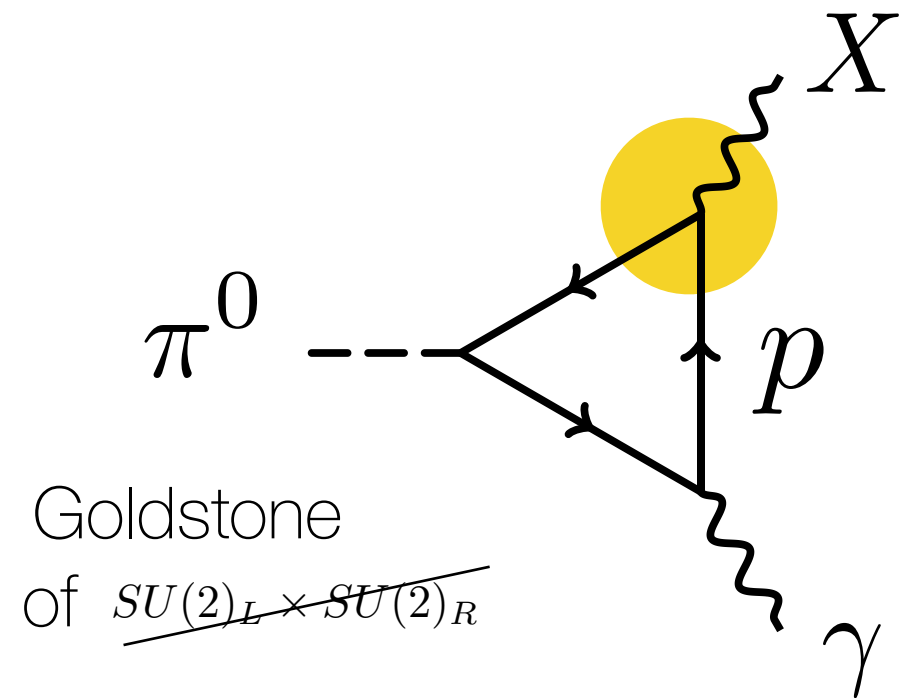
To avoid **NA46/2**, prohibit π^0 decay to $X\gamma$



FROM QUARK CONTENT

$$Q_u Q'_u - Q_d Q'_d = 0$$

$$Q'_d = -2Q'_u$$



FROM CHIRAL PERT. THEORY

$$N = \begin{pmatrix} p \\ n \end{pmatrix}$$

For spin-1-

Production and Decay

$$\frac{\text{Br}({}^8\text{Be}^* \rightarrow {}^8\text{Be } X)}{\text{Br}({}^8\text{Be}^* \rightarrow {}^8\text{Be } \gamma)} = \overset{\text{PRODUCTION}}{\underbrace{(\cancel{\varepsilon_p} + \varepsilon_n)^2}} \overset{0.03}{\frac{|\vec{p}_X|^3}{|\vec{p}_\gamma|^3}} \approx 5.6 \times 10^{-6}$$

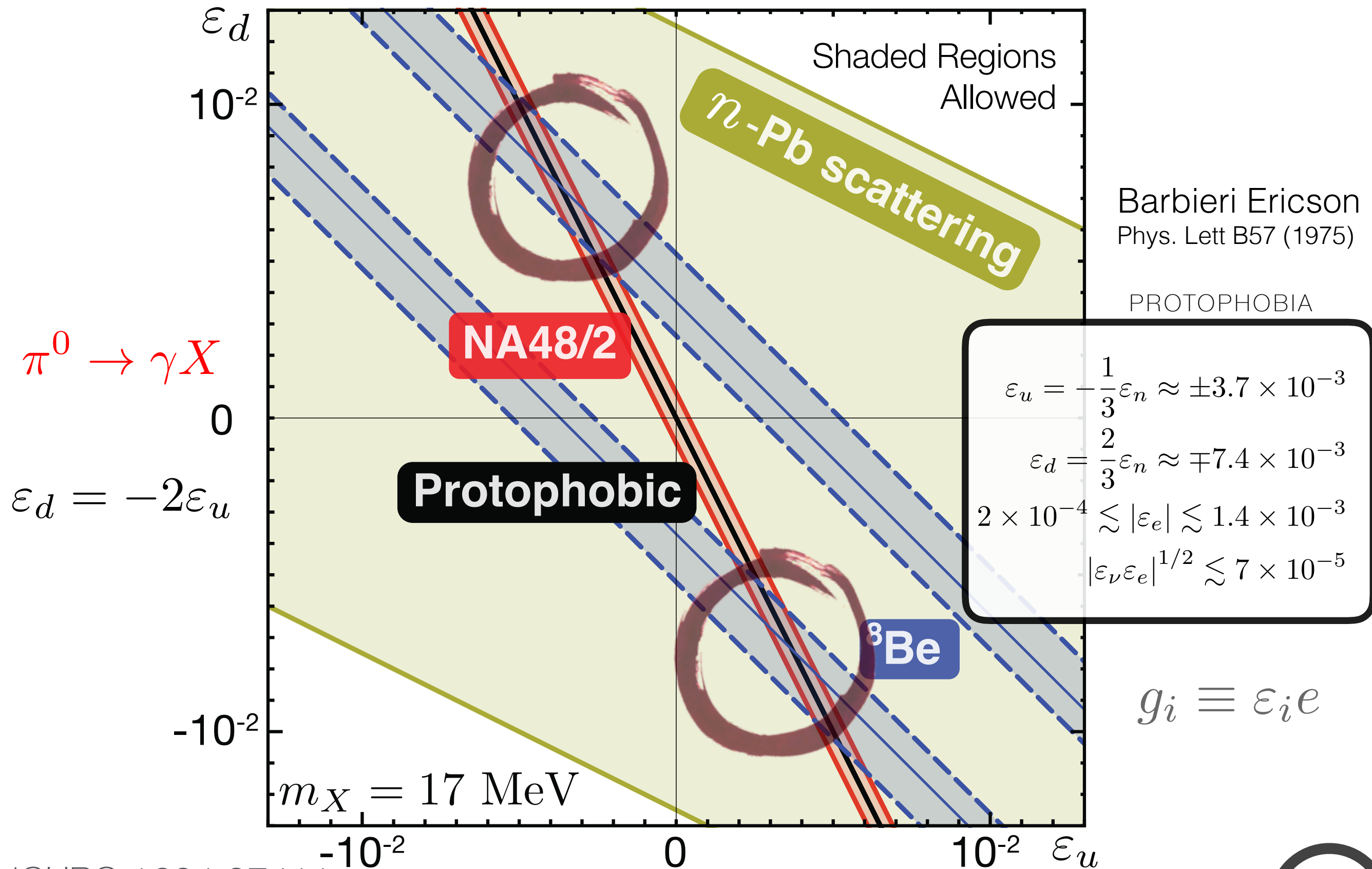
DECAY

$$\varepsilon_e \gtrsim 1.4 \times 10^{-5}$$

“Dark photon” with
separate couplings

$$g_i \equiv \varepsilon_i e$$

Production (quark) couplings



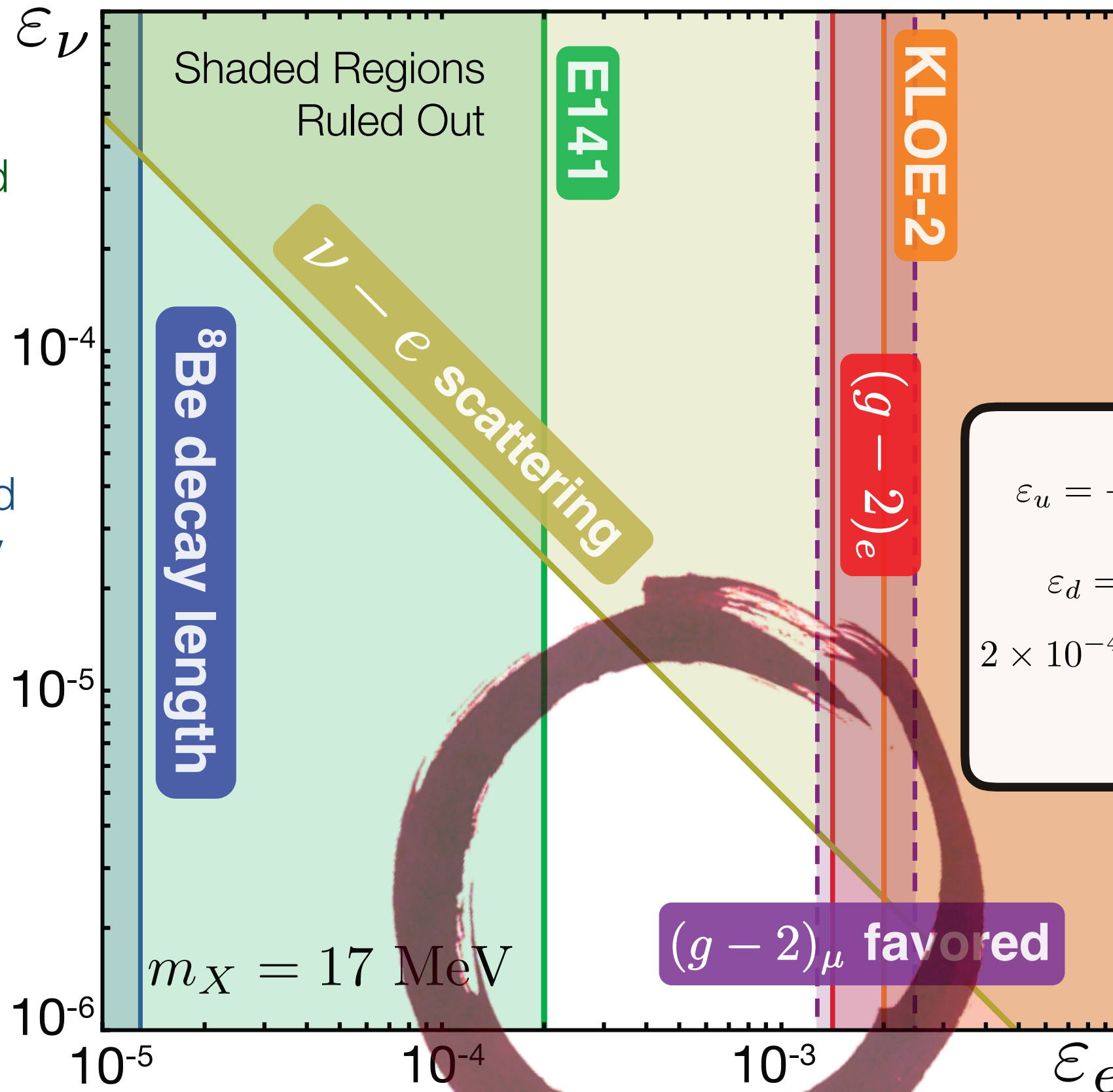
Decay (lepton) couplings

E141

Lower bound
on ε_e : decay
inside dump

^8Be

Lower bound
on ε_e : decay
in detector



KLOE-2

$e^+e^- \rightarrow \gamma X$

PROTOPHOBIA

$$\varepsilon_u = -\frac{1}{3}\varepsilon_n \approx \pm 3.7 \times 10^{-3}$$

$$\varepsilon_d = \frac{2}{3}\varepsilon_n \approx \mp 7.4 \times 10^{-3}$$

$$2 \times 10^{-4} \lesssim |\varepsilon_e| \lesssim 1.4 \times 10^{-3}$$

$$|\varepsilon_\nu \varepsilon_e|^{1/2} \lesssim 7 \times 10^{-5}$$

Future experiments

See also: reach
from SeaQuest

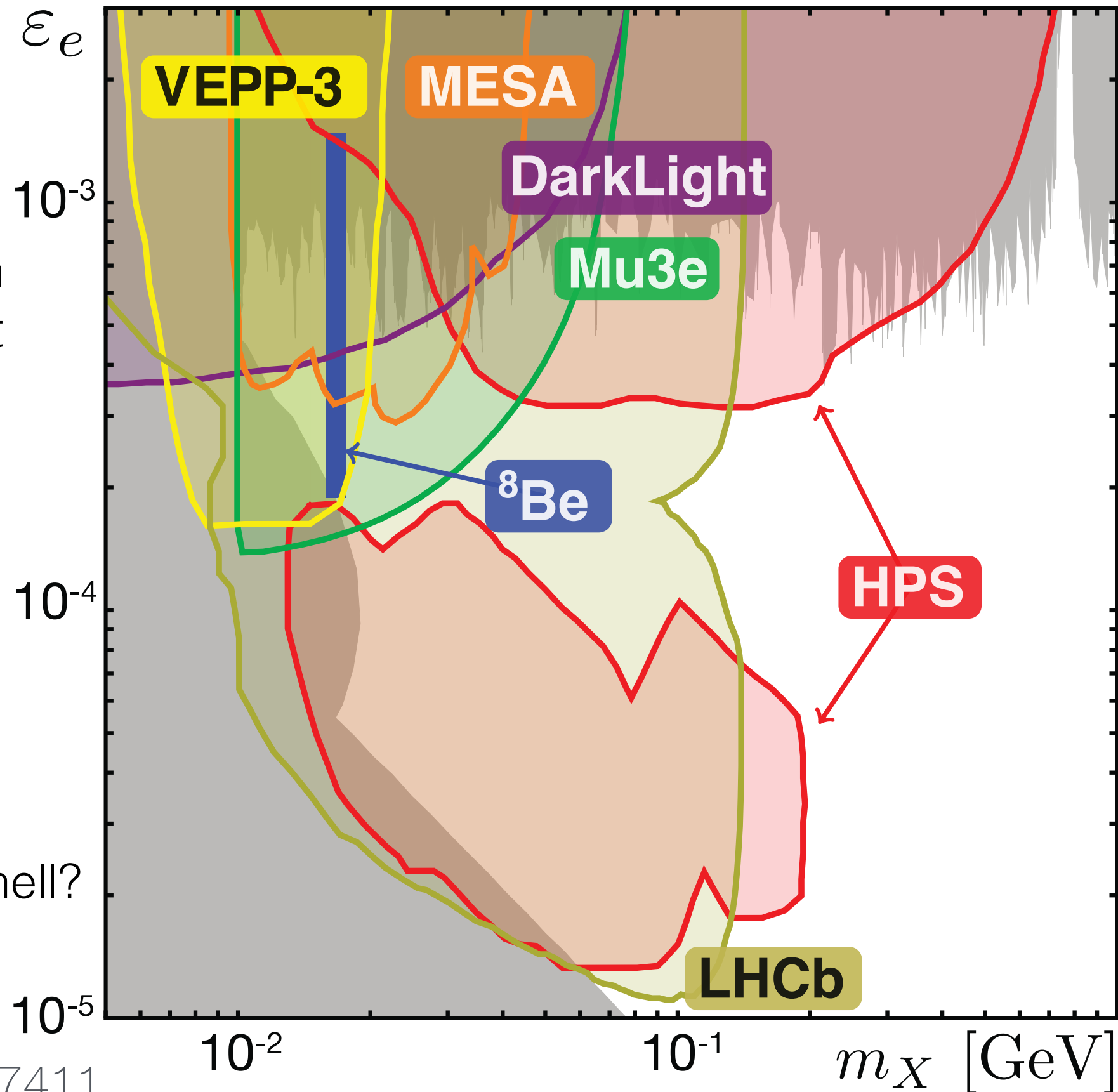


this session

MMAPS @ Cornell?

UCI IPC 1604.07411

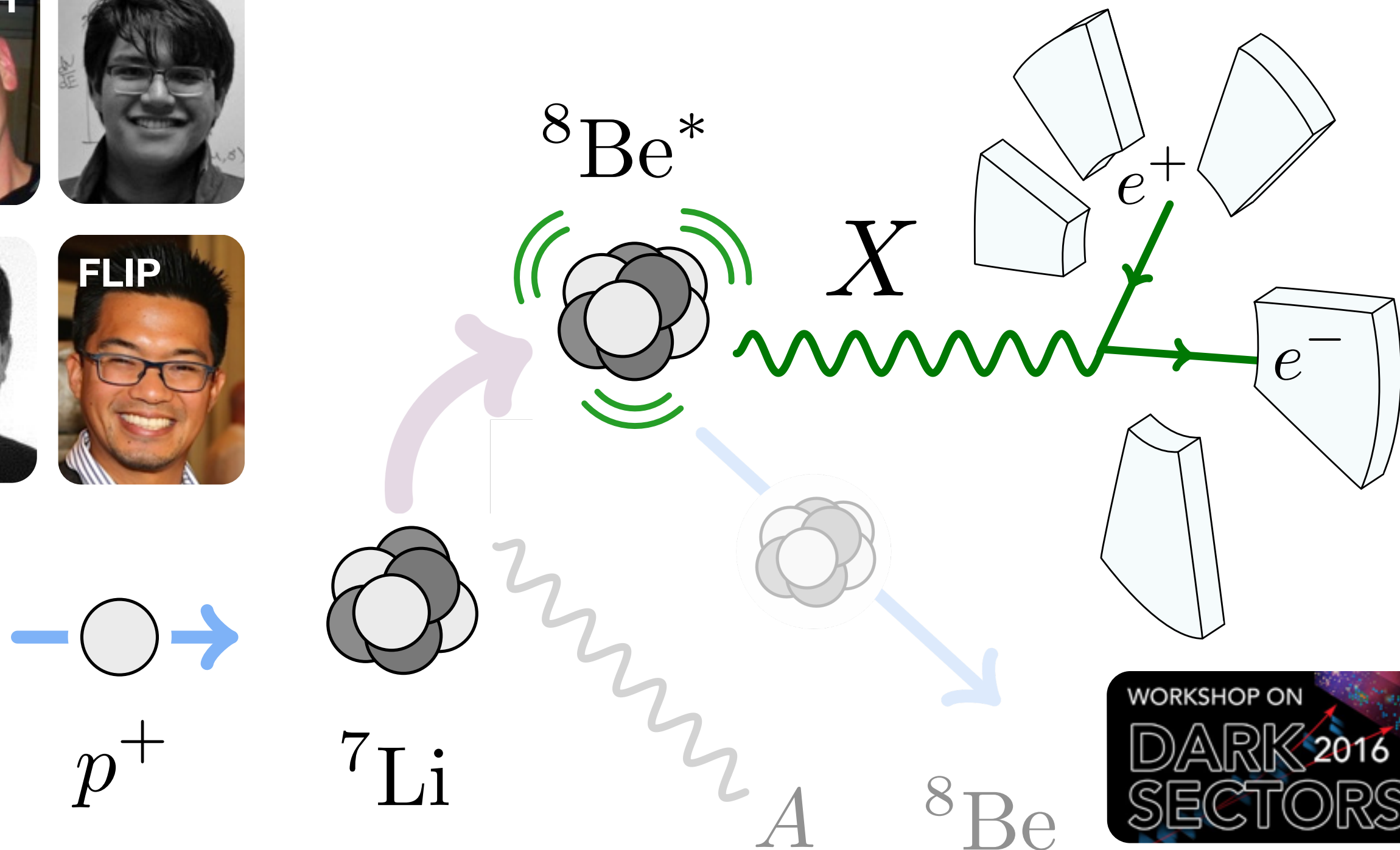
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EVIDENCE FOR A 17 MEV NEW BOSON

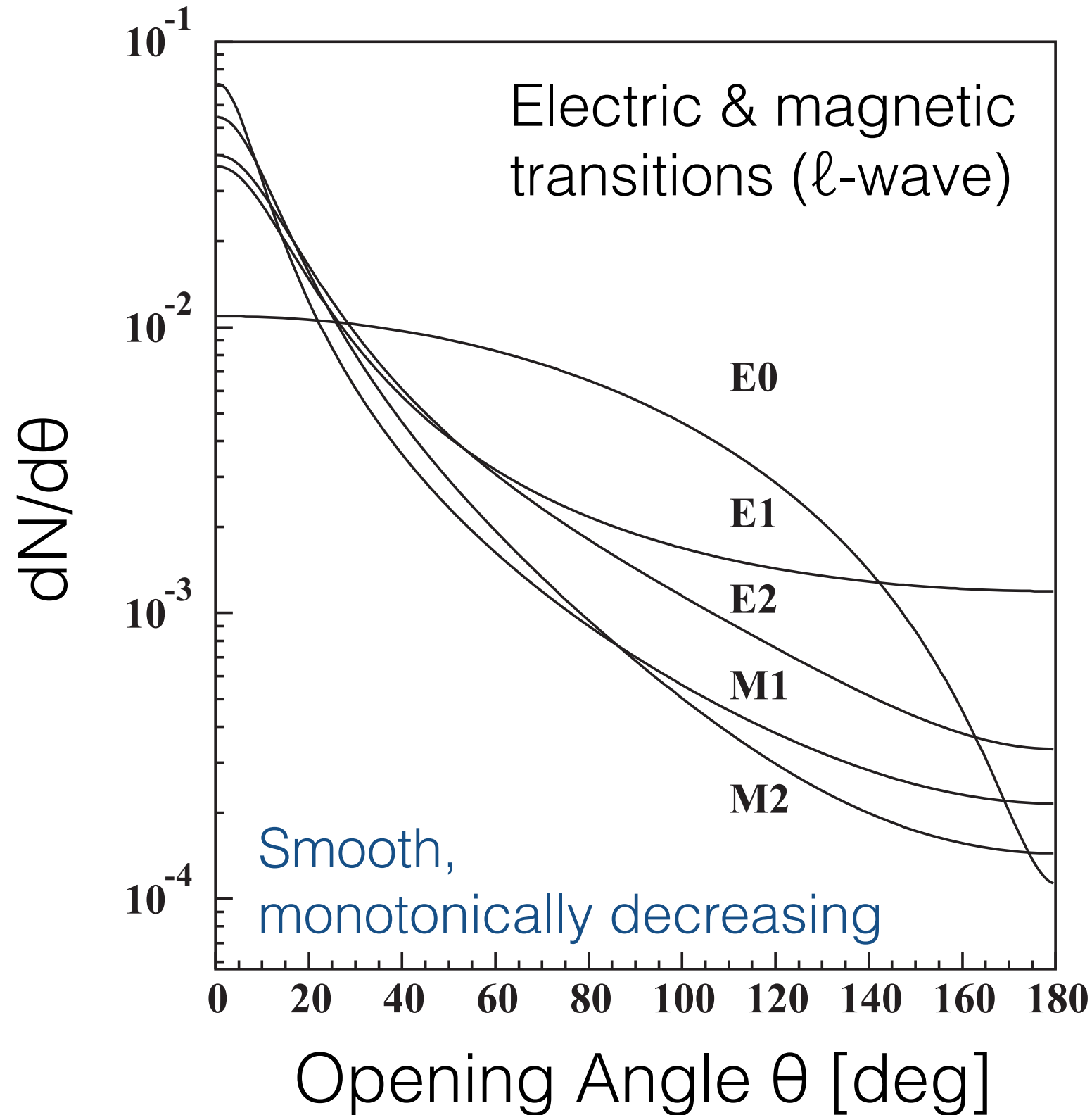


UCI IPC

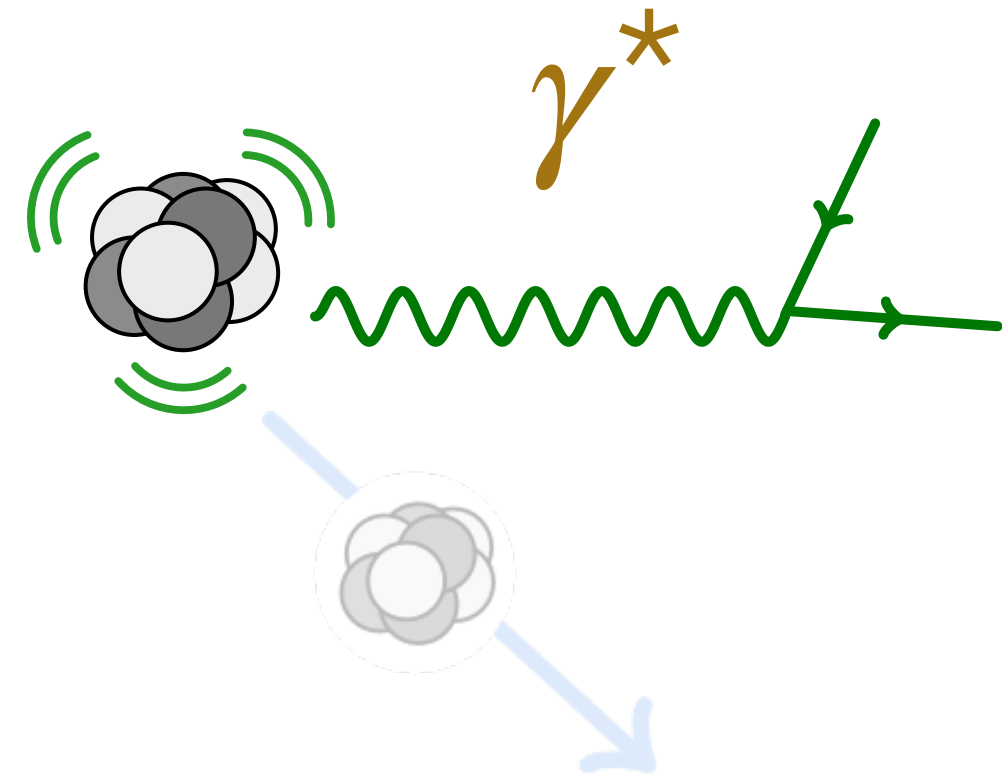


Extra Slides

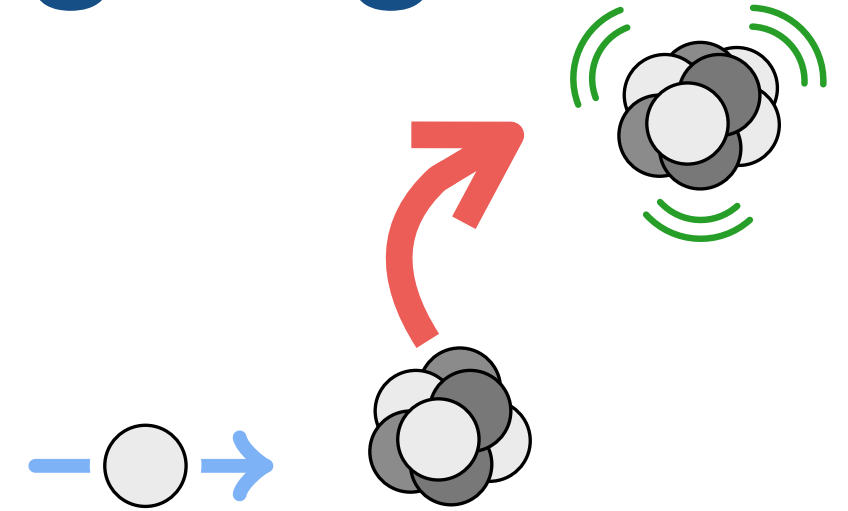
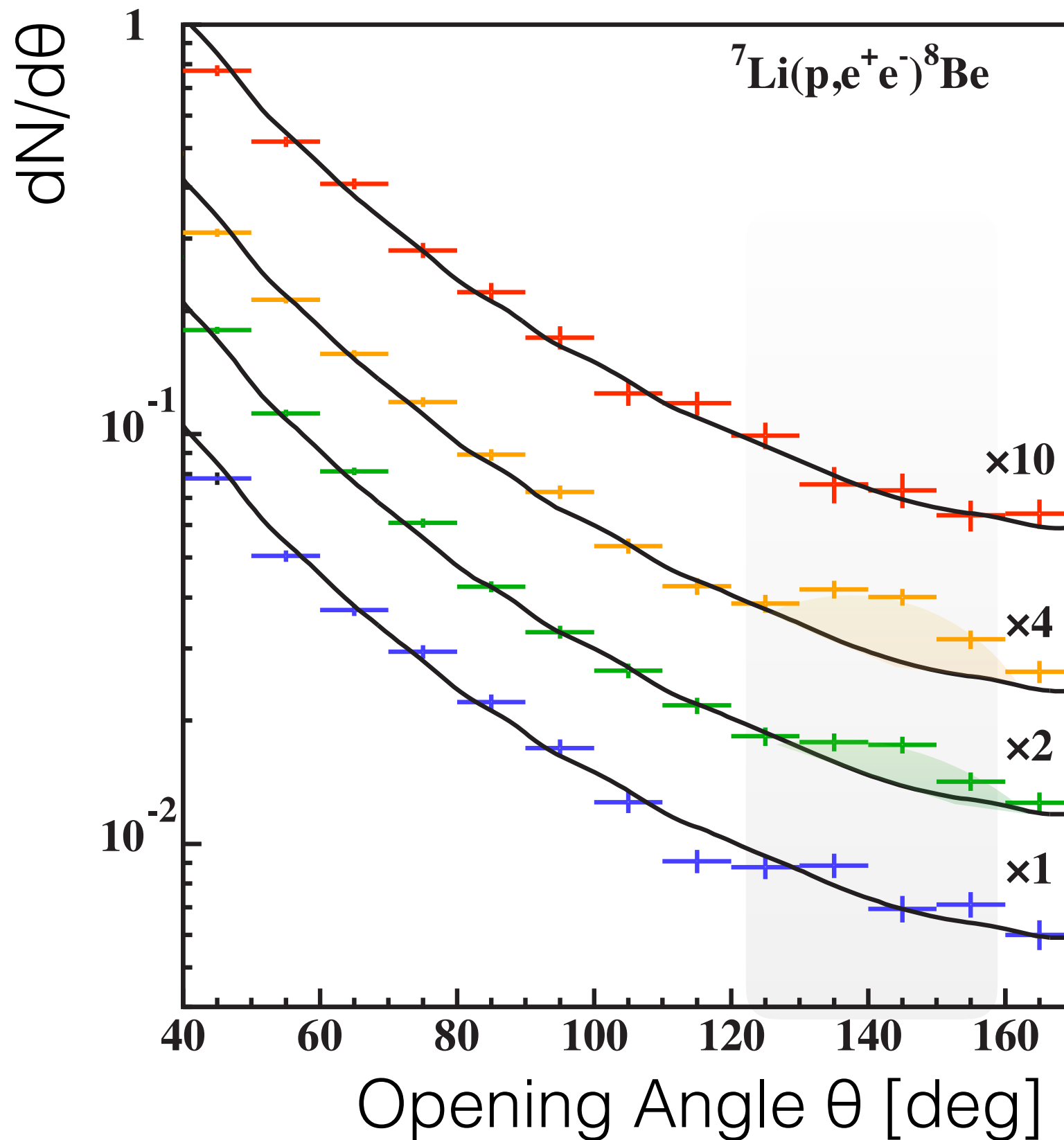
Internal Pair Conversion



Nuclear de-excitation
by off-shell photon



A 6.8σ anomaly: opening angle



PROTON ENERGY

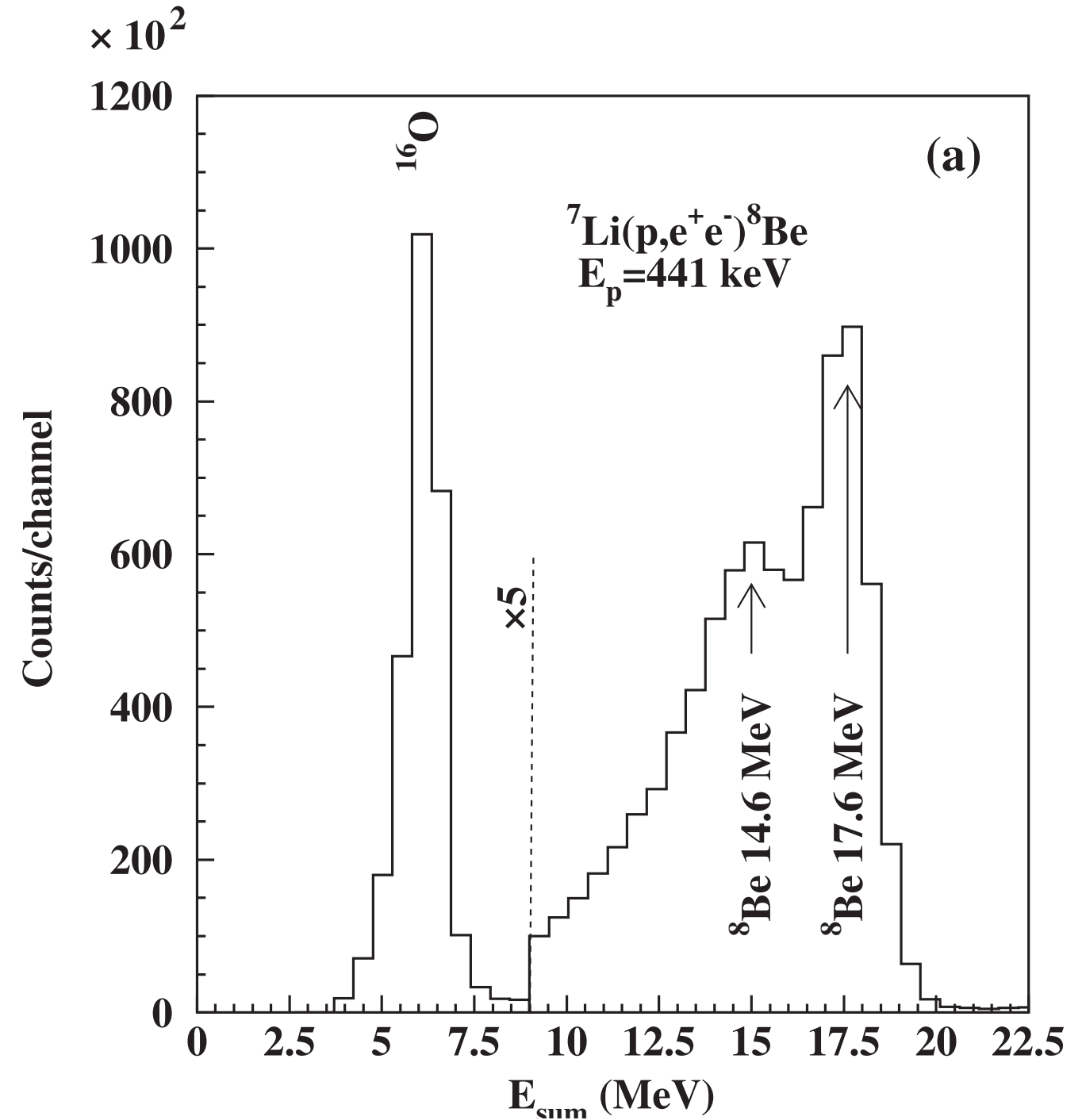
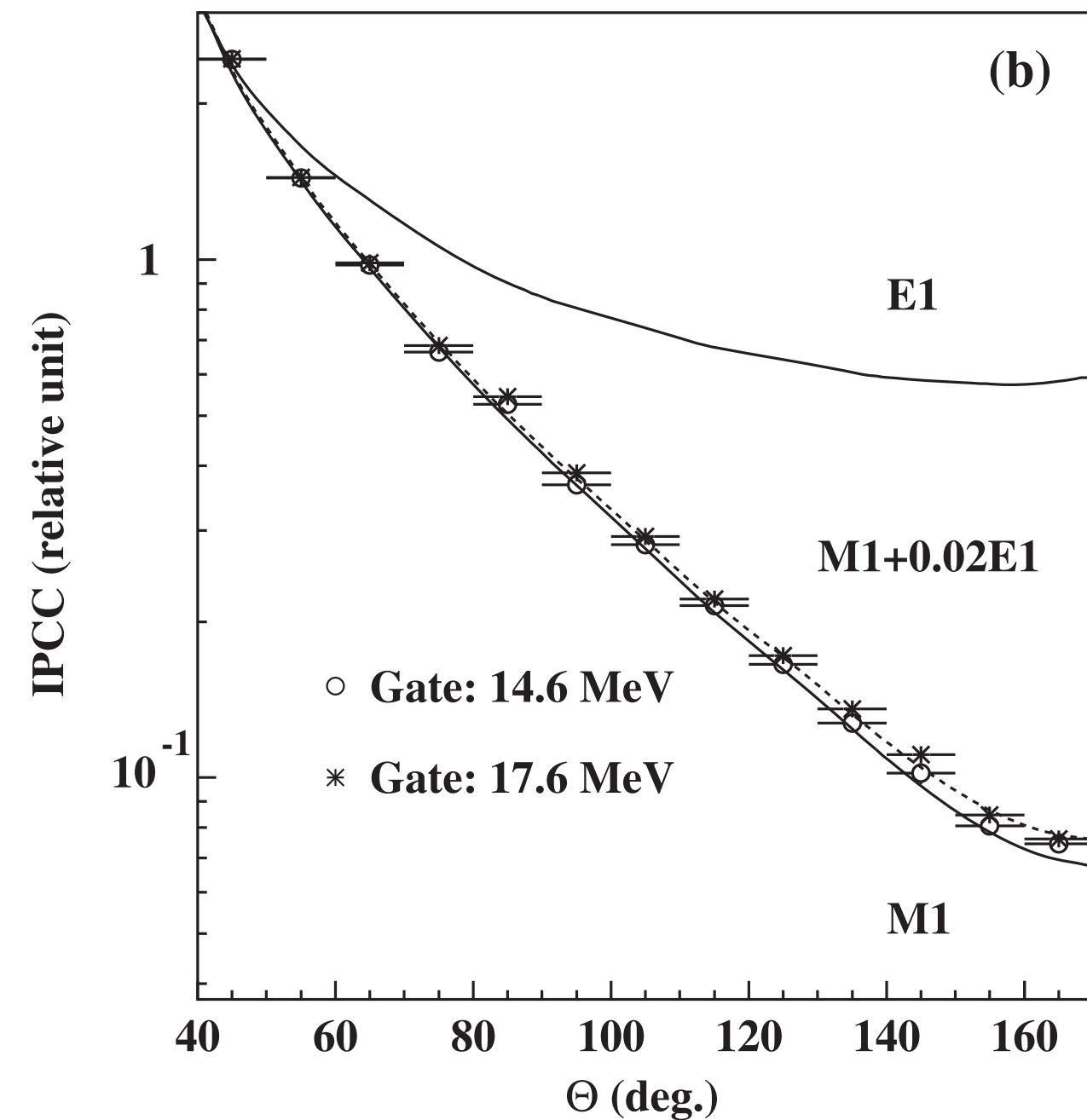
$E_p = 1.20 \text{ MeV}$

$E_p = 1.10 \text{ MeV}$

$E_p = 1.04 \text{ MeV}$

$E_p = 0.80 \text{ MeV}$

Decays



Mixing with E1 transition

ATOMKI Pair Spectrometer



from A.J. Krasznahorkay; slideplayer.com/slide/6112261/

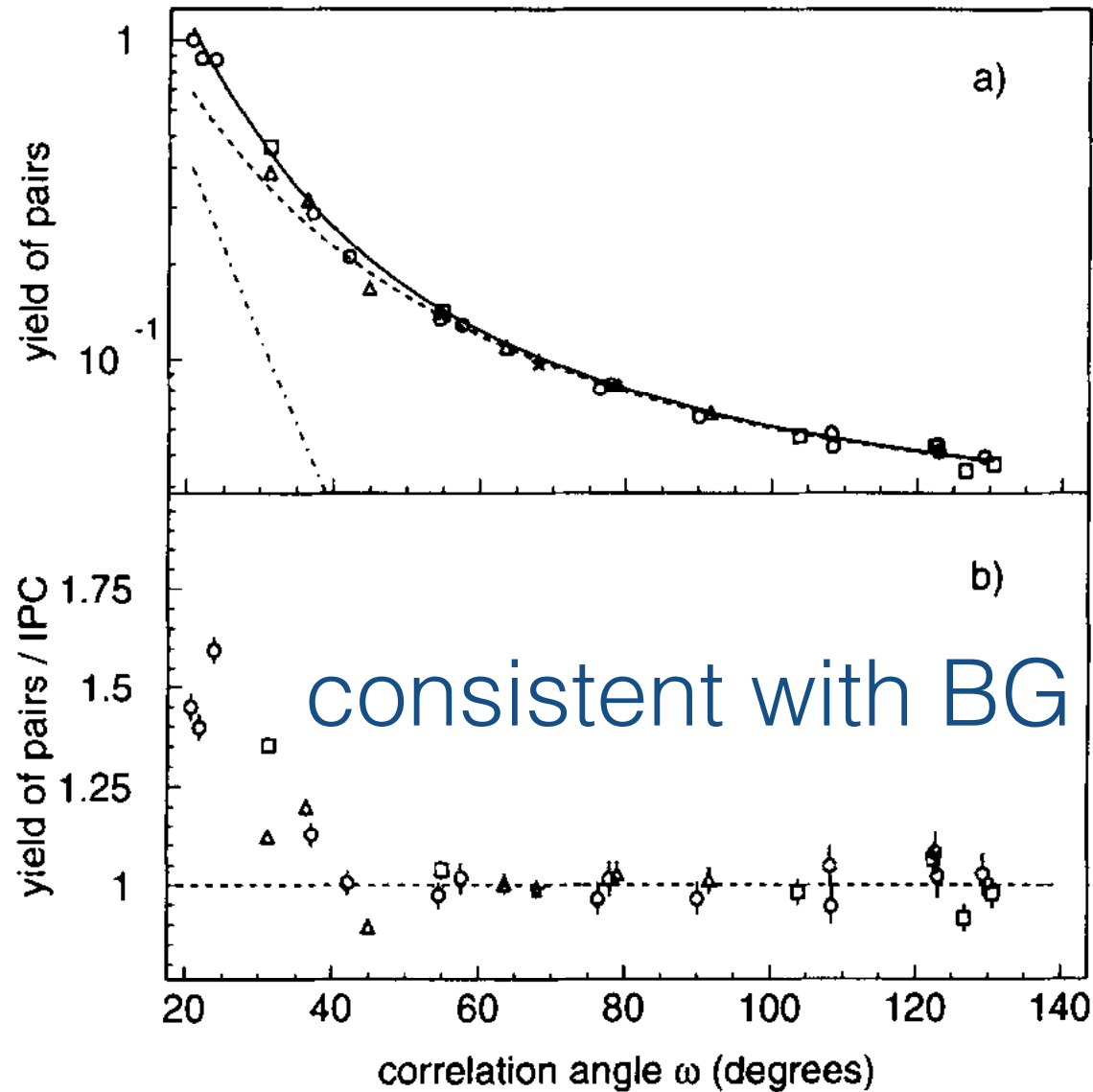
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EVIDENCE FOR A 17 MEV NEW BOSON

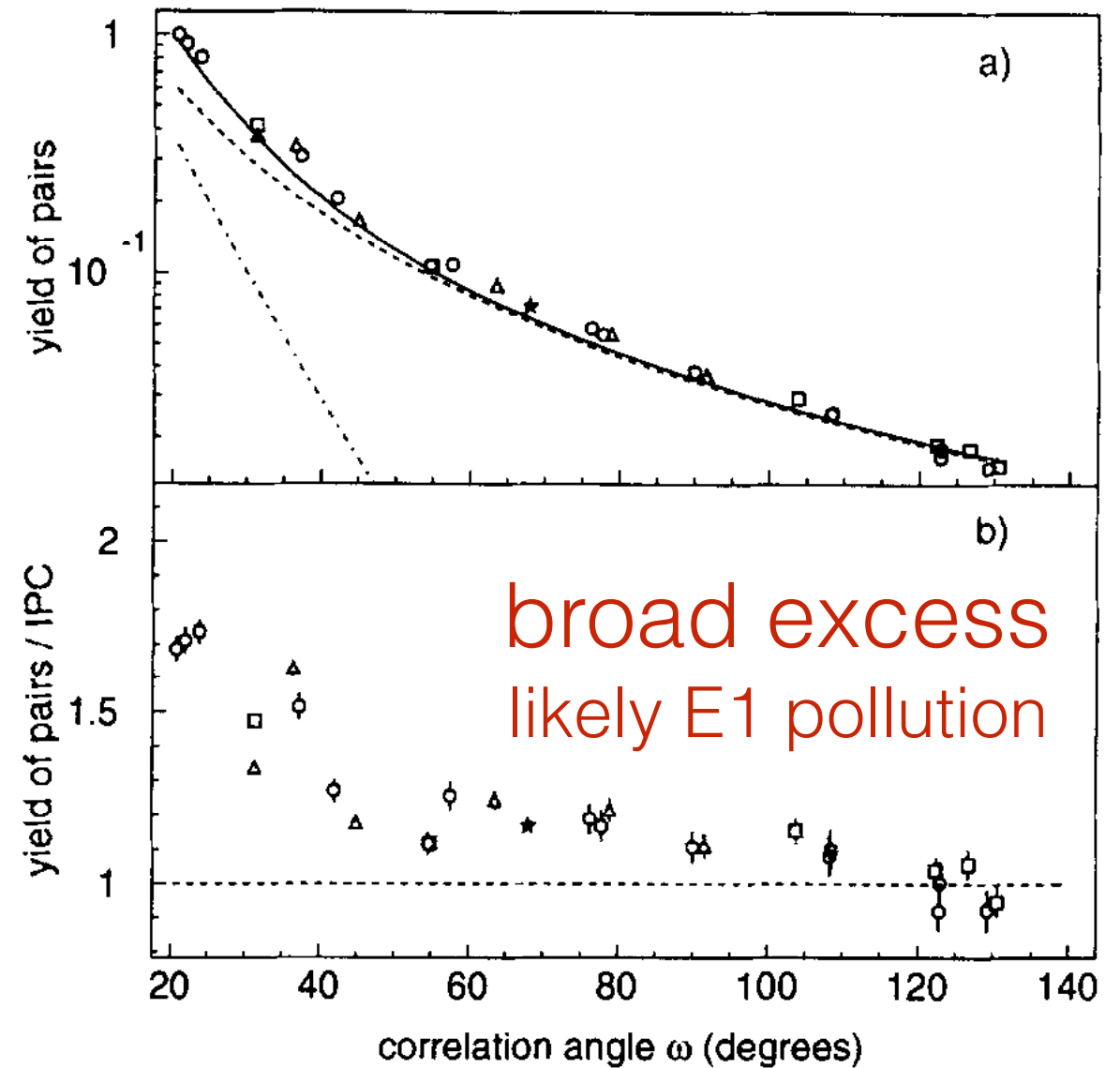
Significance

The deviation observed at the bombarding energy of $E_p = 1.10$ MeV and at $\Theta \approx 140^\circ$ has a significance of 6.8 standard deviations, corresponding to a background fluctuation probability of 5.6×10^{-12} . On resonance, the $M1$ contribution should be even larger, so the background should decrease faster than in other cases, which would make the deviation even larger and more significant.

Pre-History: Extinct ^8Be Anomaly



^{12}C E1 transition



^8Be (17.6 MeV) M1 transition
excluded by ATOMKI study