# The X17 anomaly: status and prospect

Enrico Nardi

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

KBFI NICPB
HEP Group

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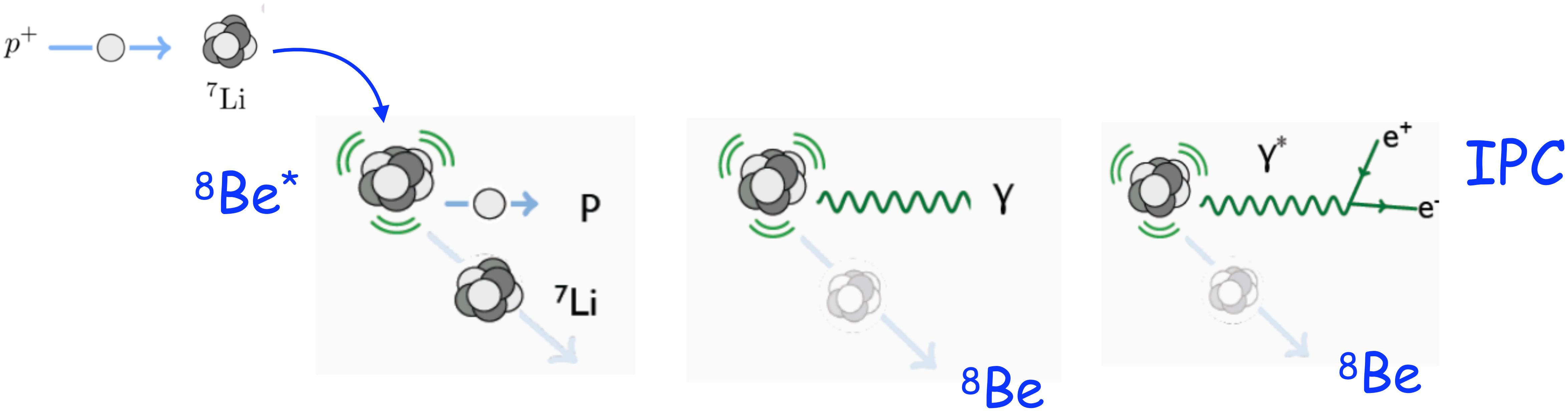


$^{8}Be^{*}$ -> p + $^{7}Li$ (mostly)

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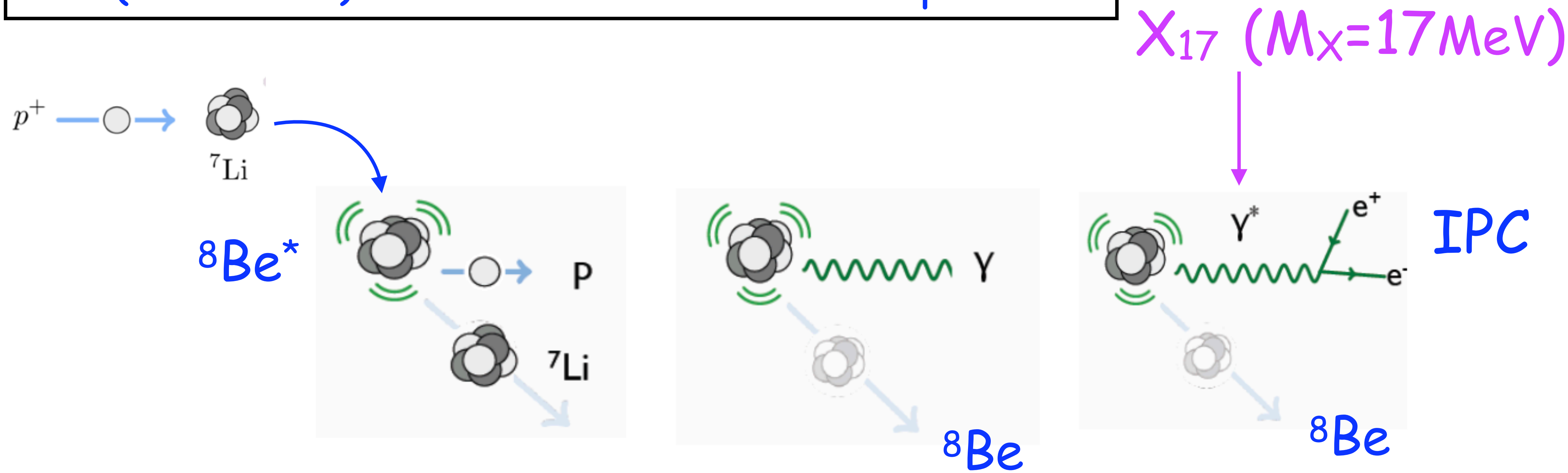


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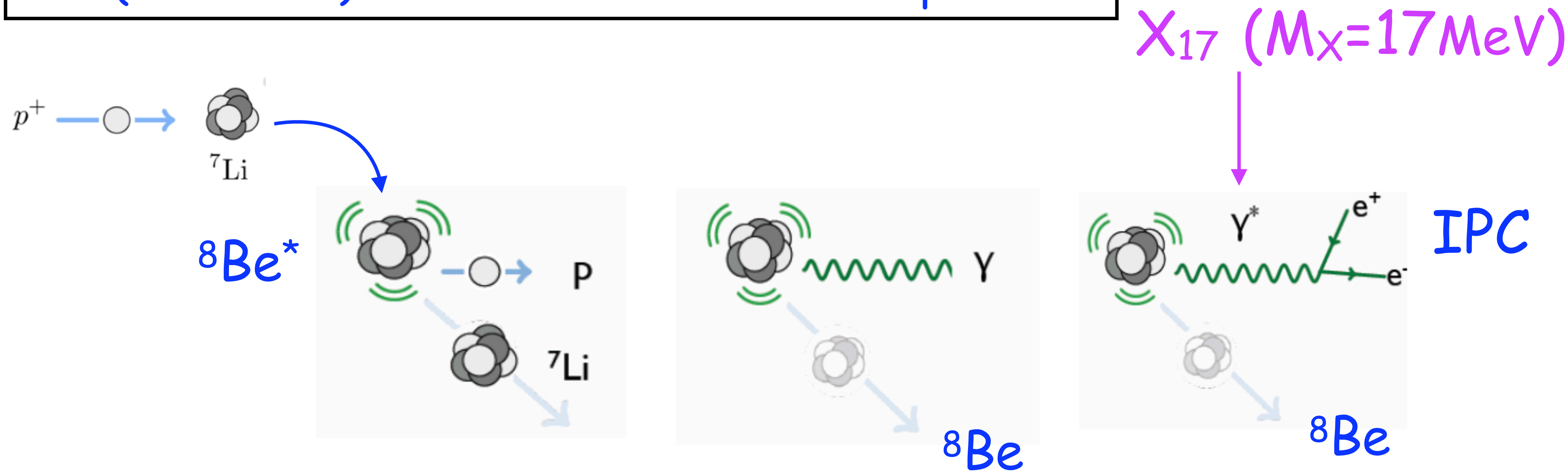


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ATOMKI Anomaly:
first observed in $^{8}$Be
Nuclear Transitions (2015)

=>

$^{8}Be^{*} \rightarrow {}^{8}Be + X_{17}$ (θ~ 140°)

$\quad \hookrightarrow e^+e^-$ ($B_X = 6 \times 10^{-6}\, B_\gamma$)

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- 2022: Confirmation of $e^+e^-$ excess in $^{12}C^*$(17.2 MeV) -> g.s. at large angles [~ 155° - 160° ] [A.J. Krasznahorkay, e-Print: 2209.10795 [nucl-ex], rev. v2 Nov. 2,2022]

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- August 2023: "Ab initio investigation of the $^{7}Li(p,e^{+}e^{-})^{8}Be$ process and the $X_{17}$"
  Conclusion: The bump cannot be explained by SM processes [e-Print: 2308.13751 nucl-th]

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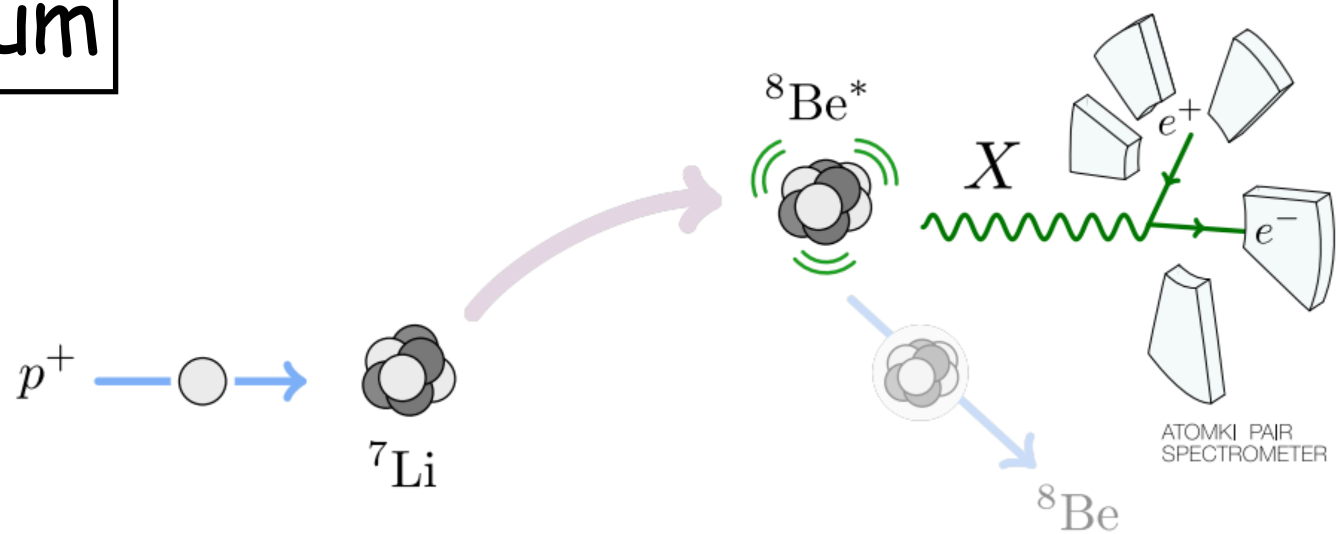
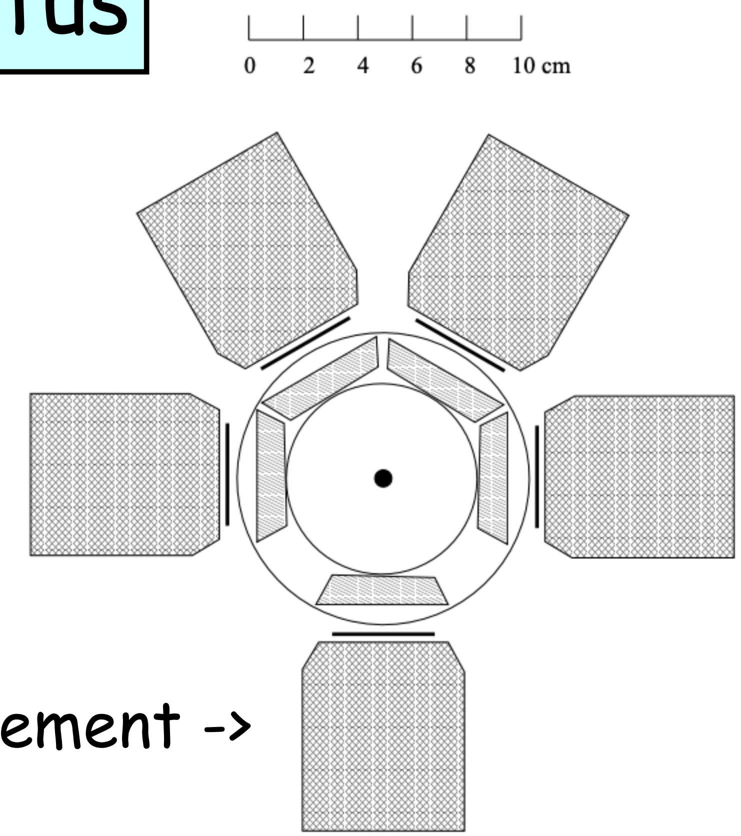



Feng+, 1608.0359

Five telescopes arrangement ->



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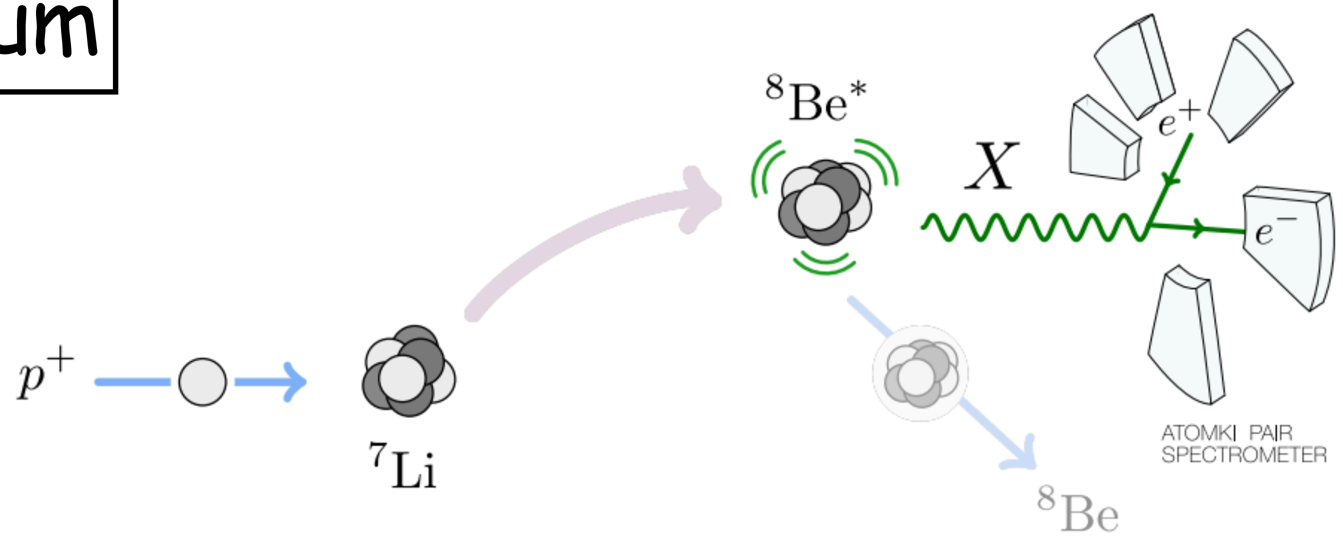


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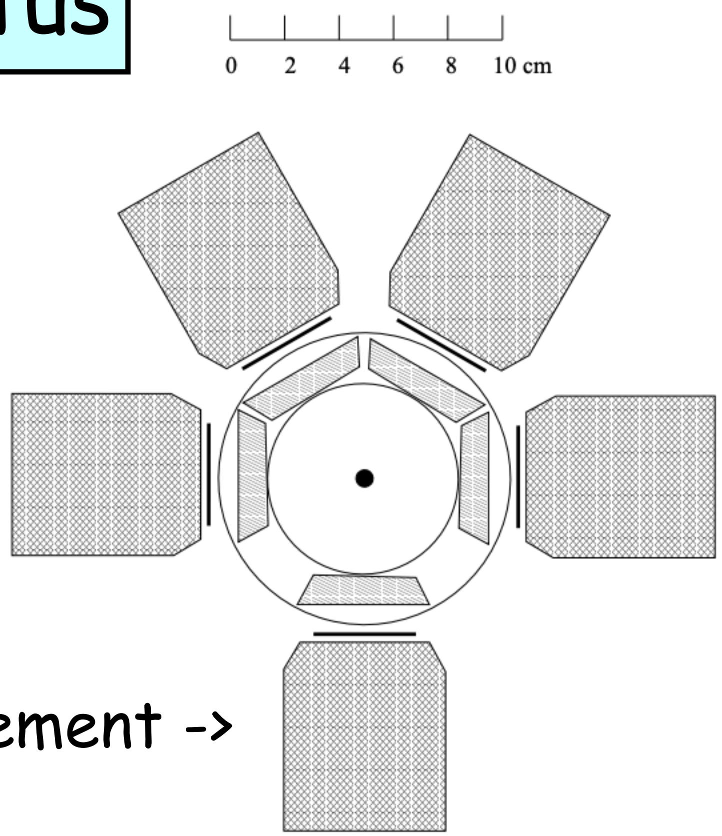


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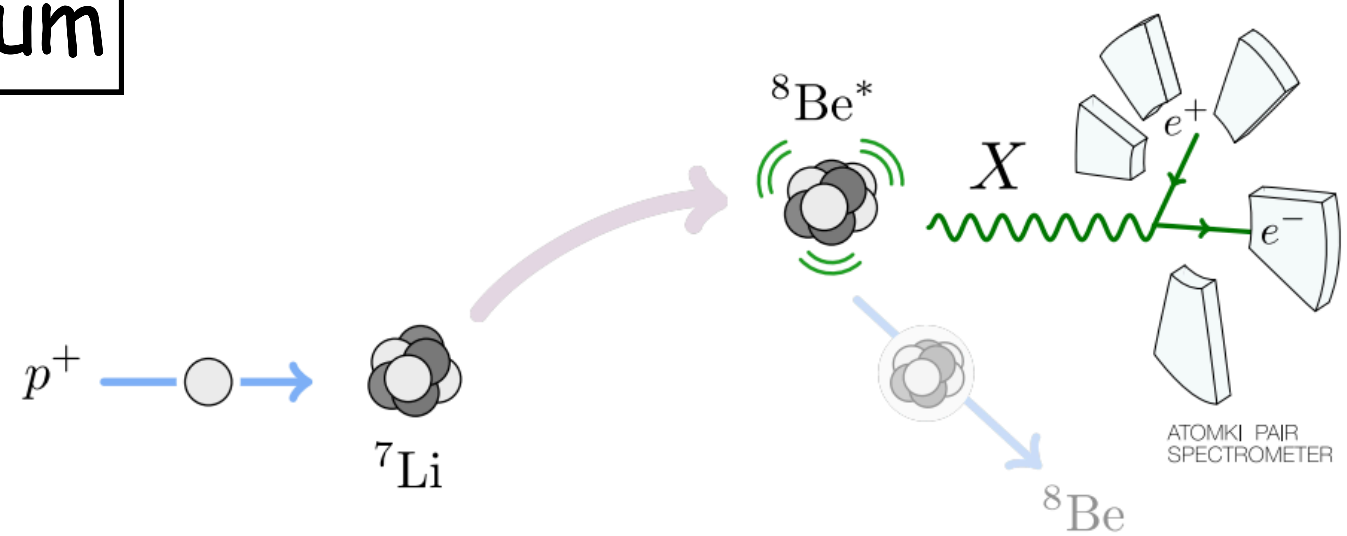


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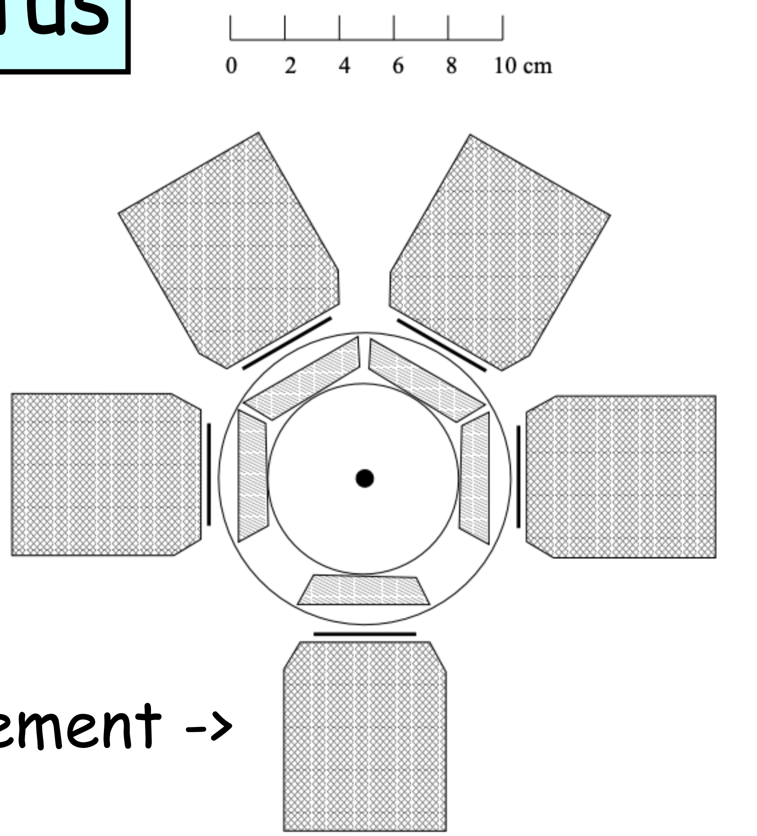


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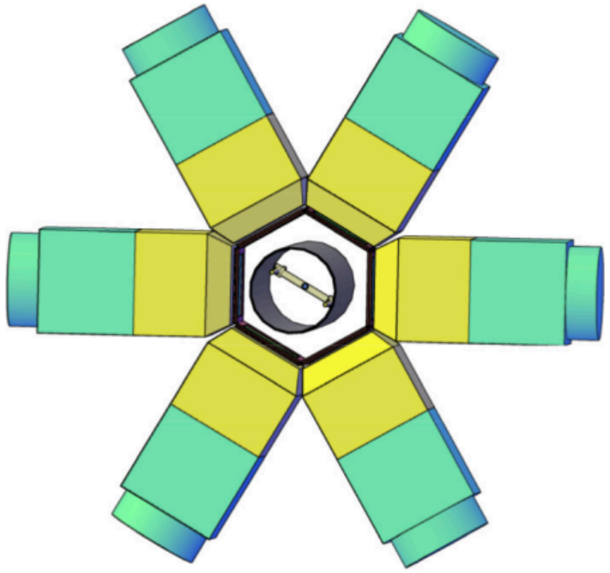

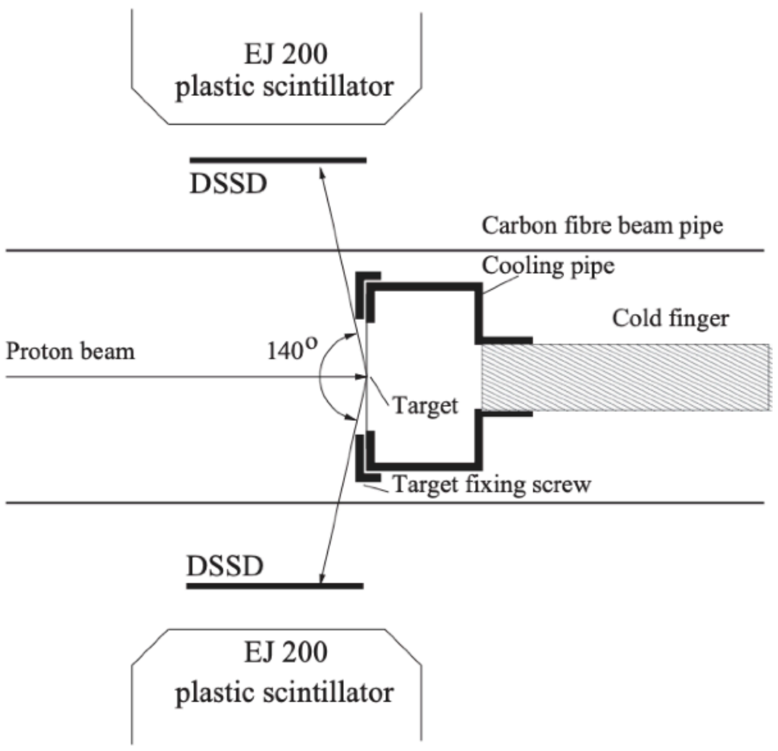

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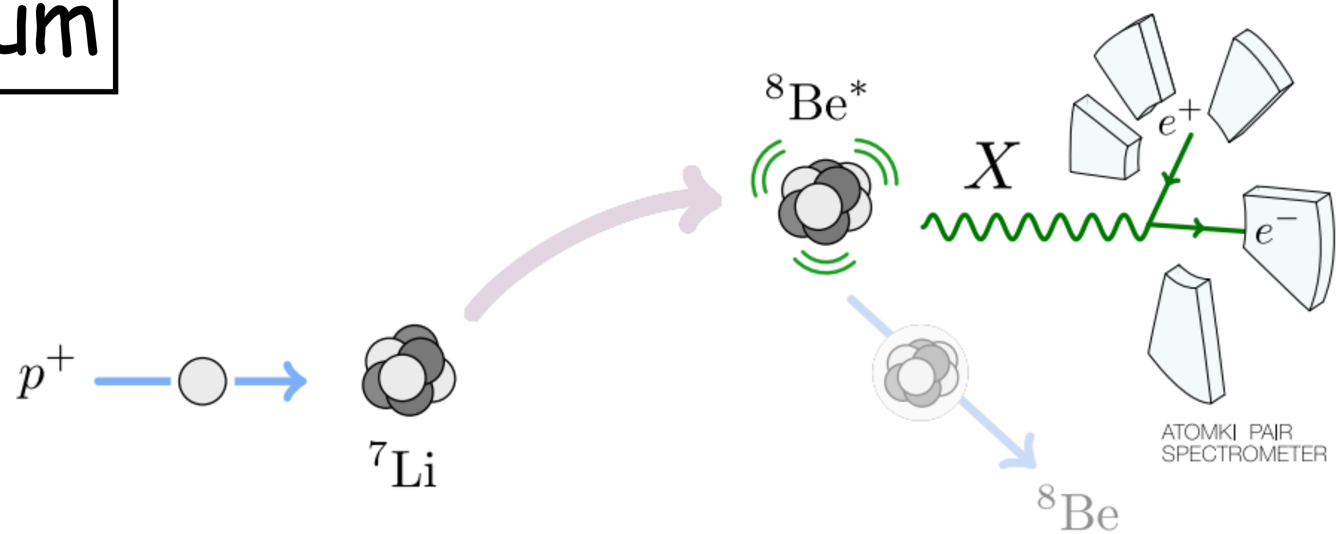


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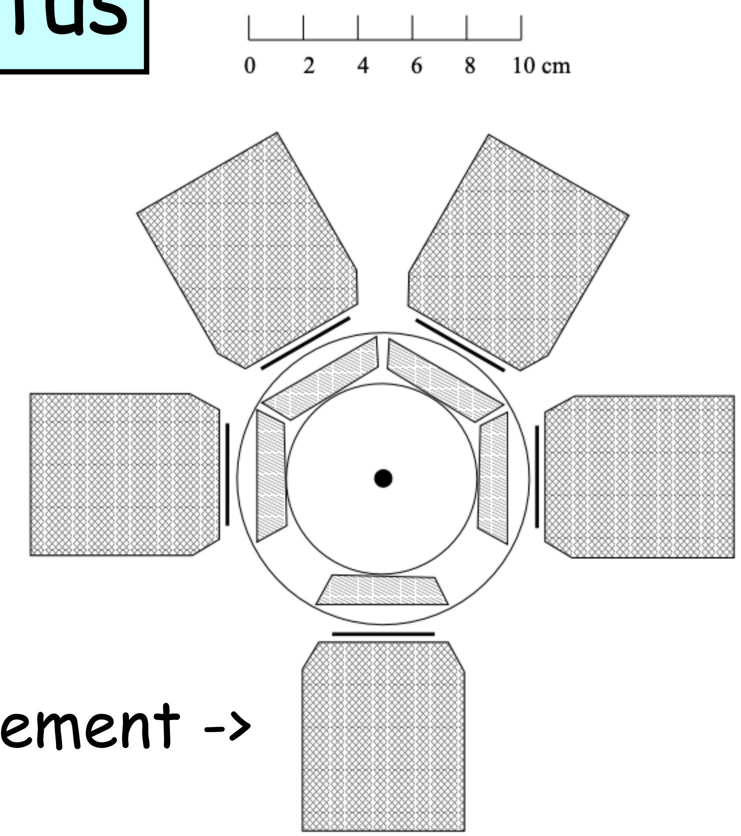


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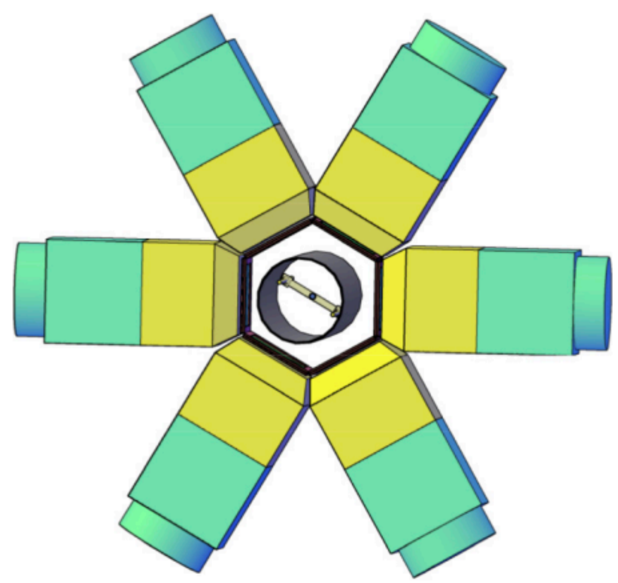

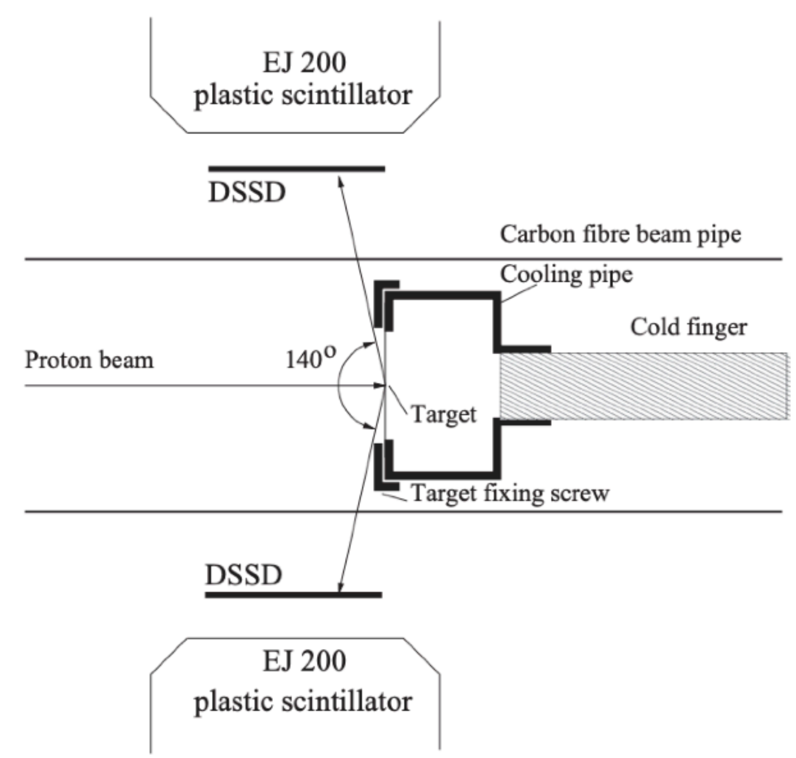


<u>Atomki $e^+e^-$ pairs measurements:</u>

1. energy-sum/diff spectrum $E_\pm = E_{e+} \pm E_{e-}$
2. $e^+e^-$ angular correlations $\theta$

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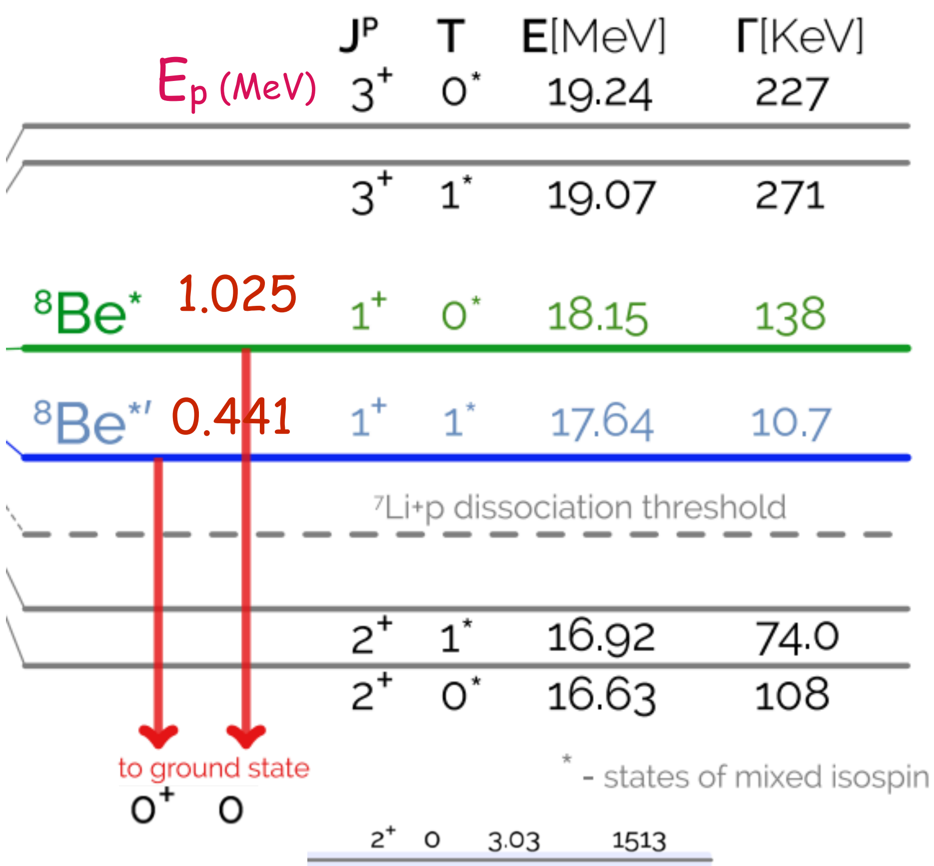
Resonant transition $p + {}^7Li \to {}^8Be^* \to \ldots$



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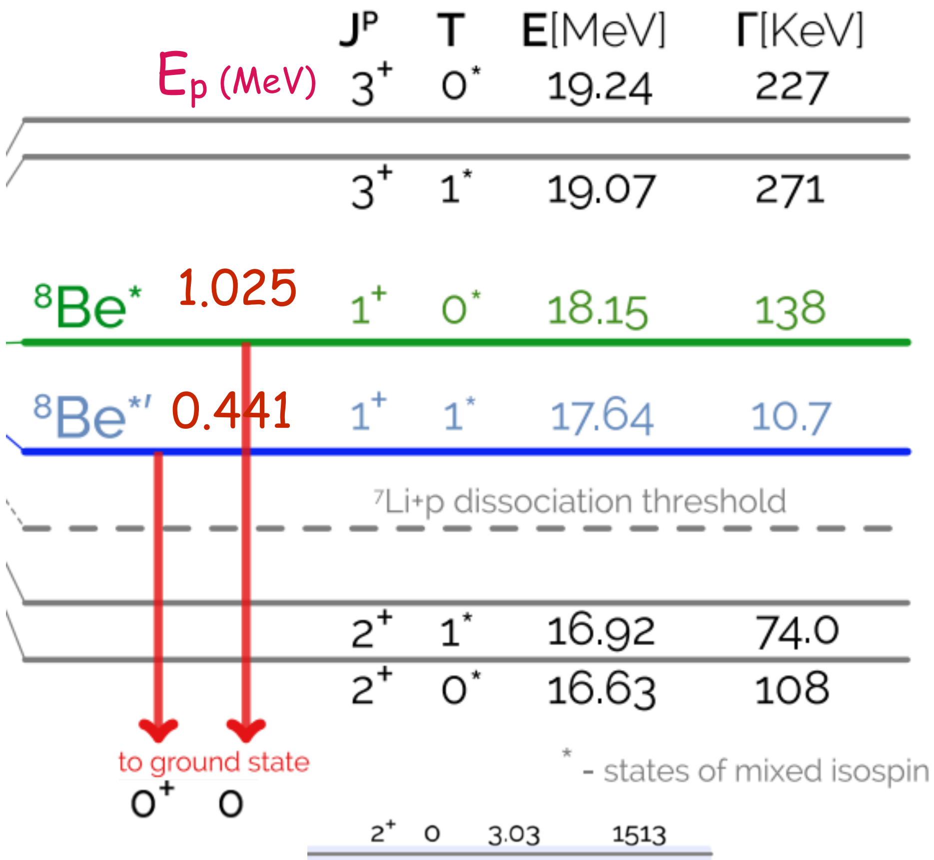


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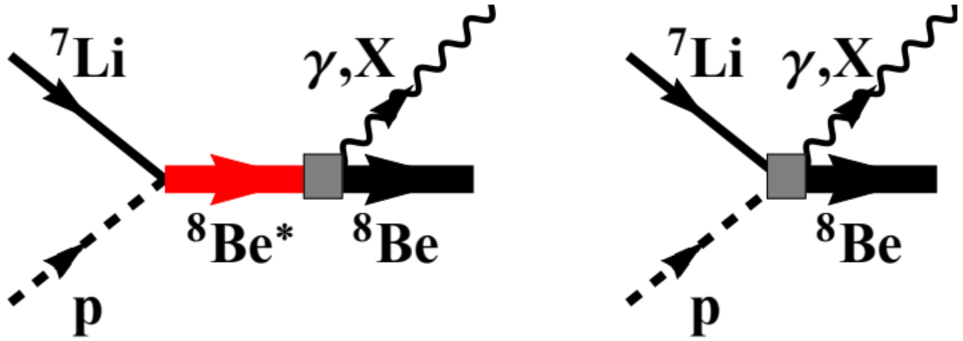
Radiative capt. $p + {}^7Li \rightarrow {}^8Be + \gamma$




M1 resonant transition - E1 direct p capture (valid also for a Vector $X_{17}$)

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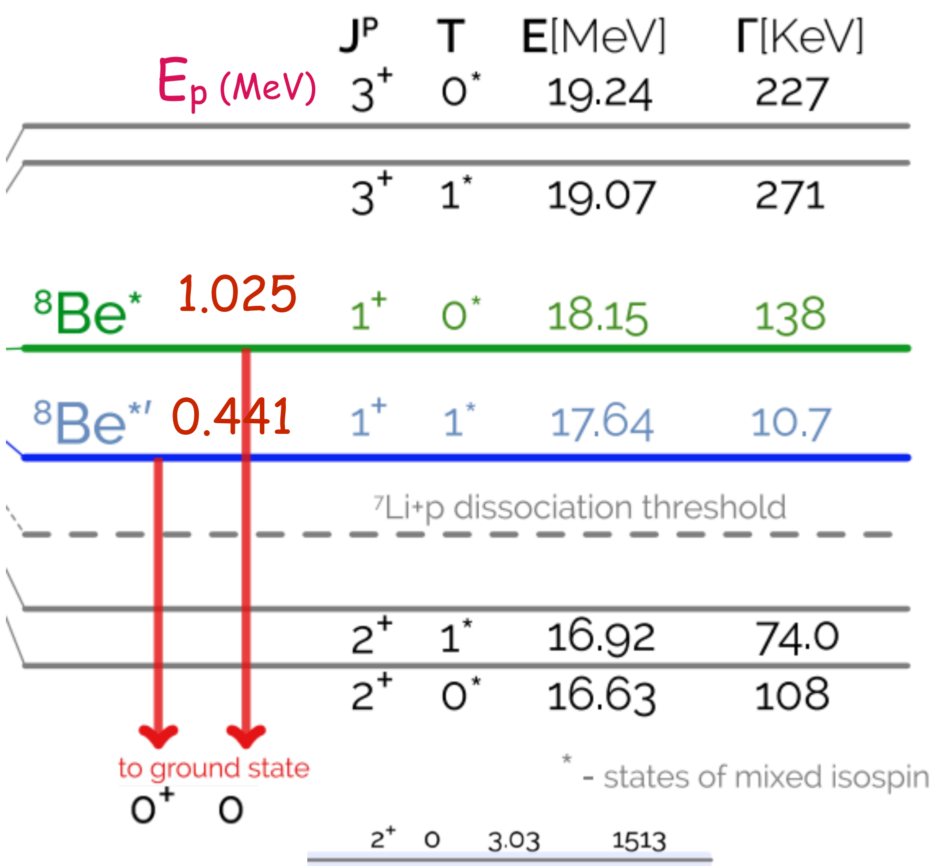


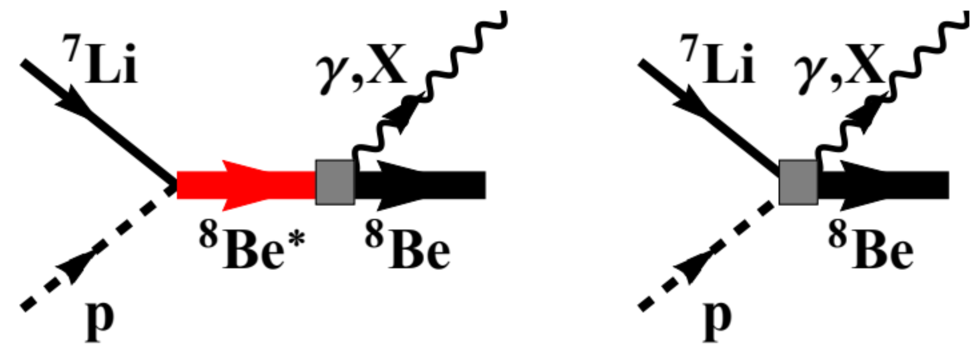


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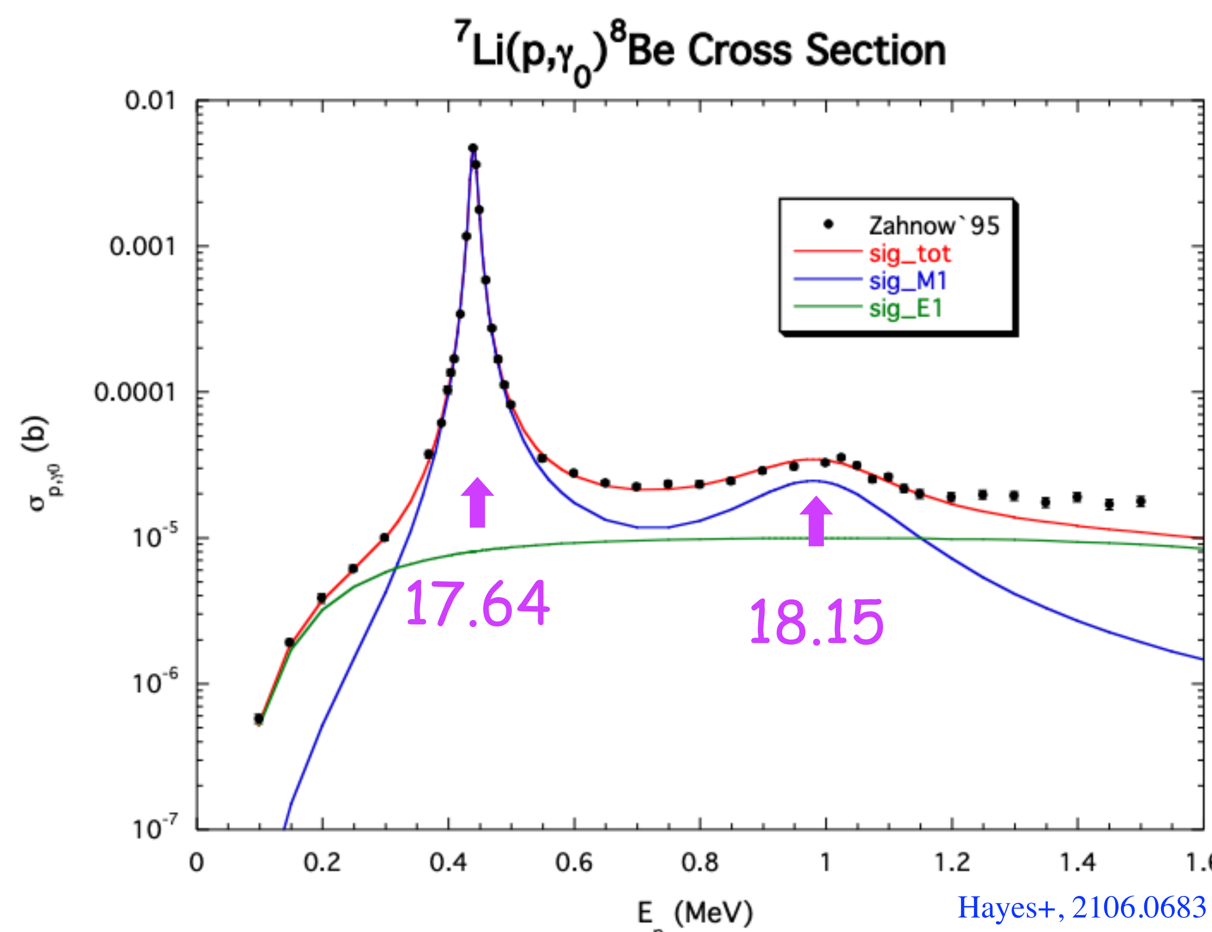

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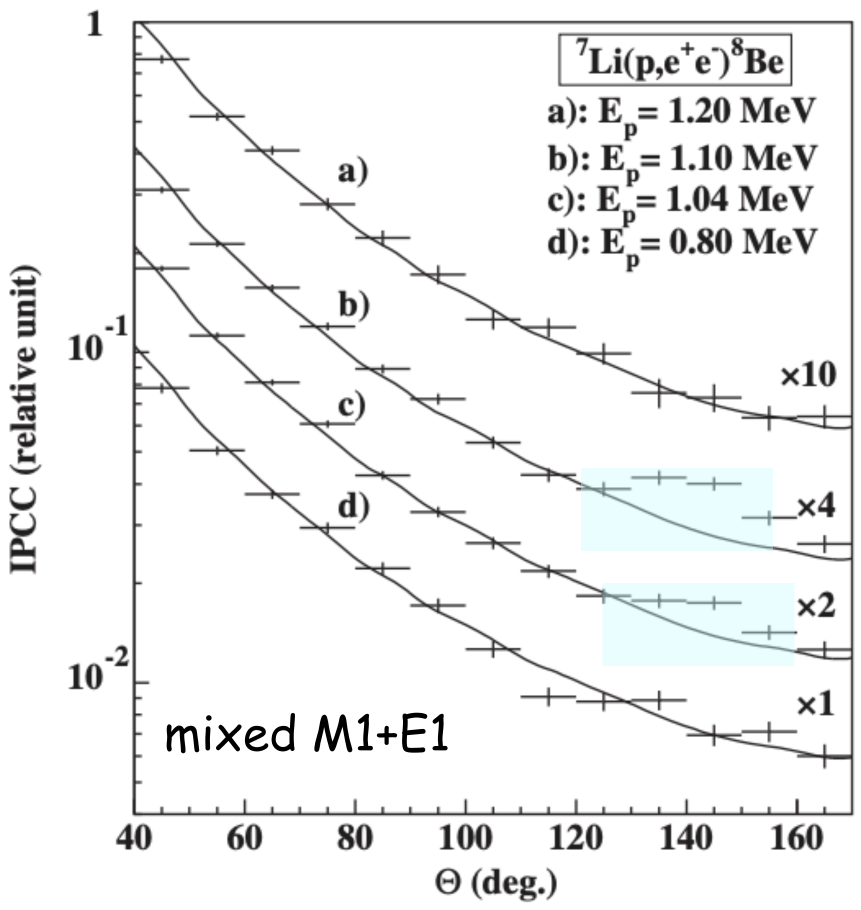


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Energy gate: $E_{\pm} > 18$ MeV

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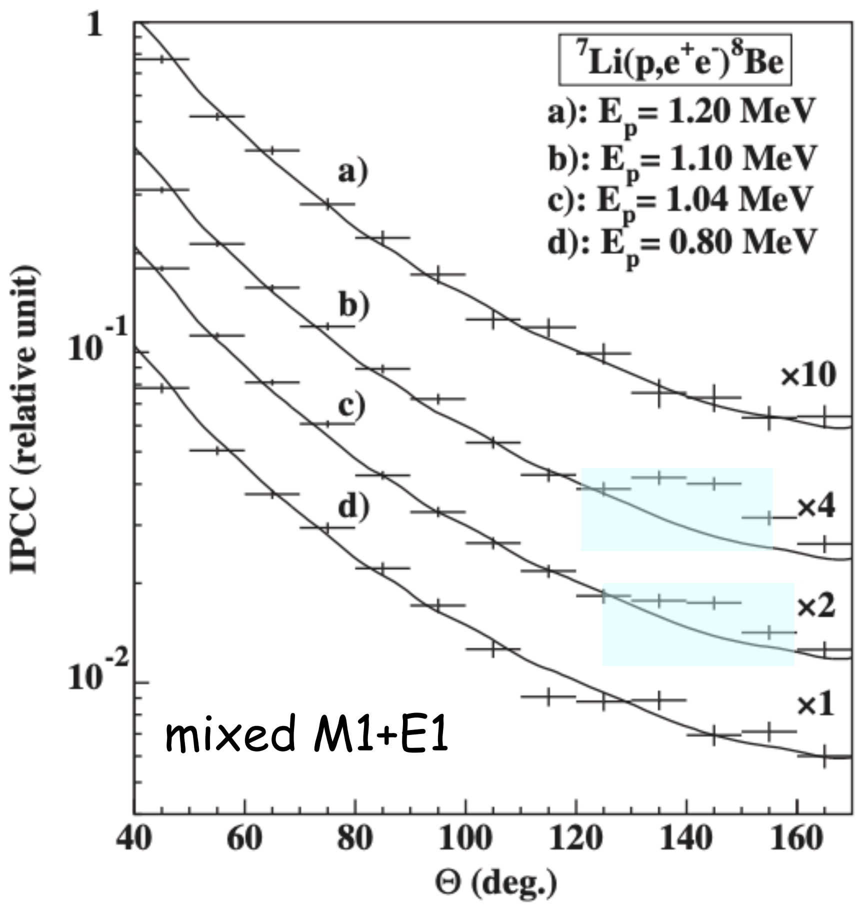


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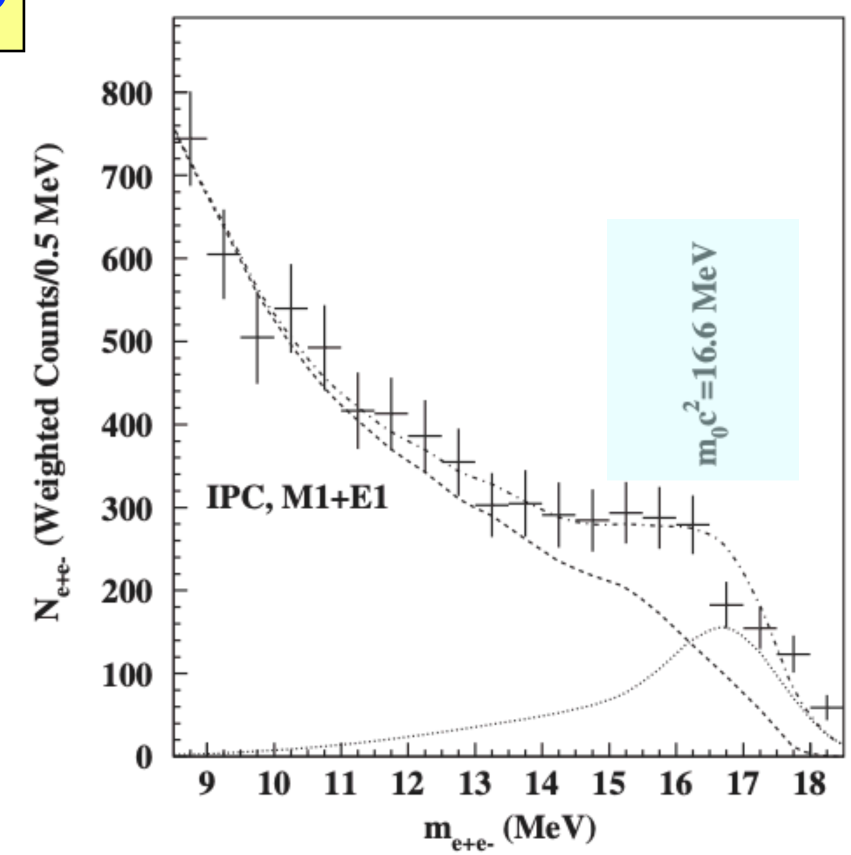
Invariant mass distribution



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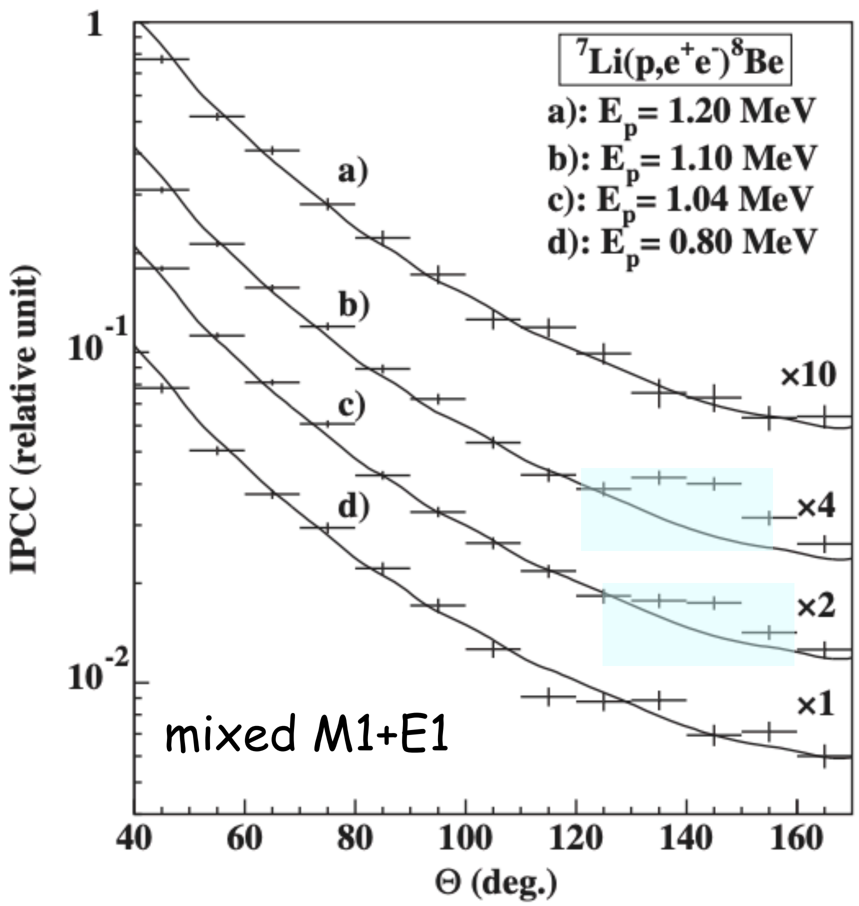


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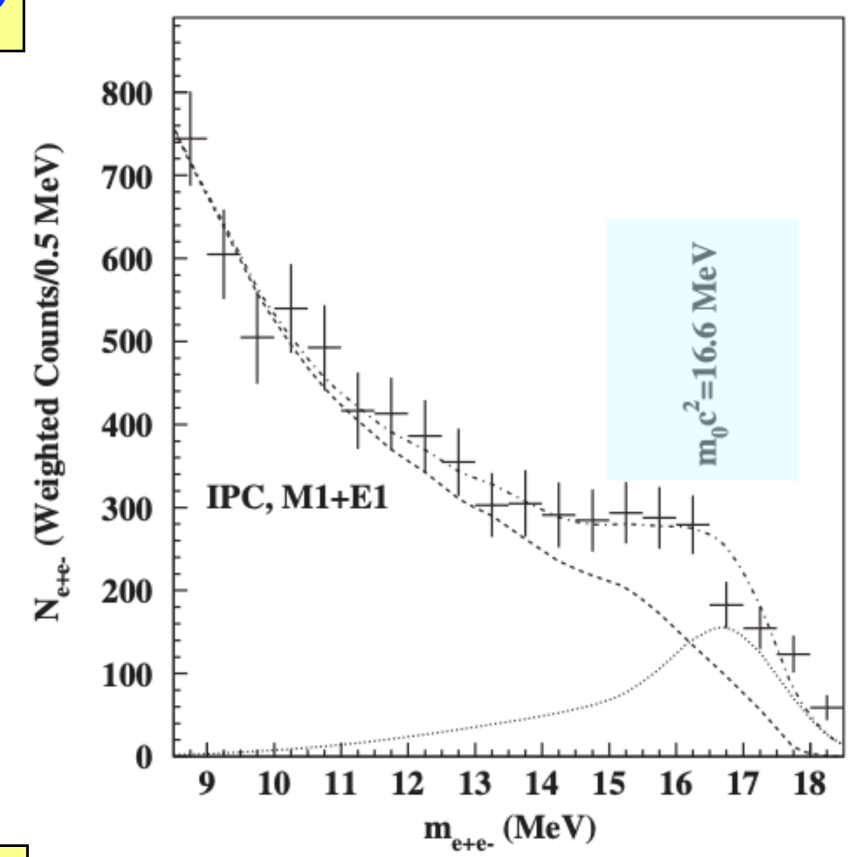

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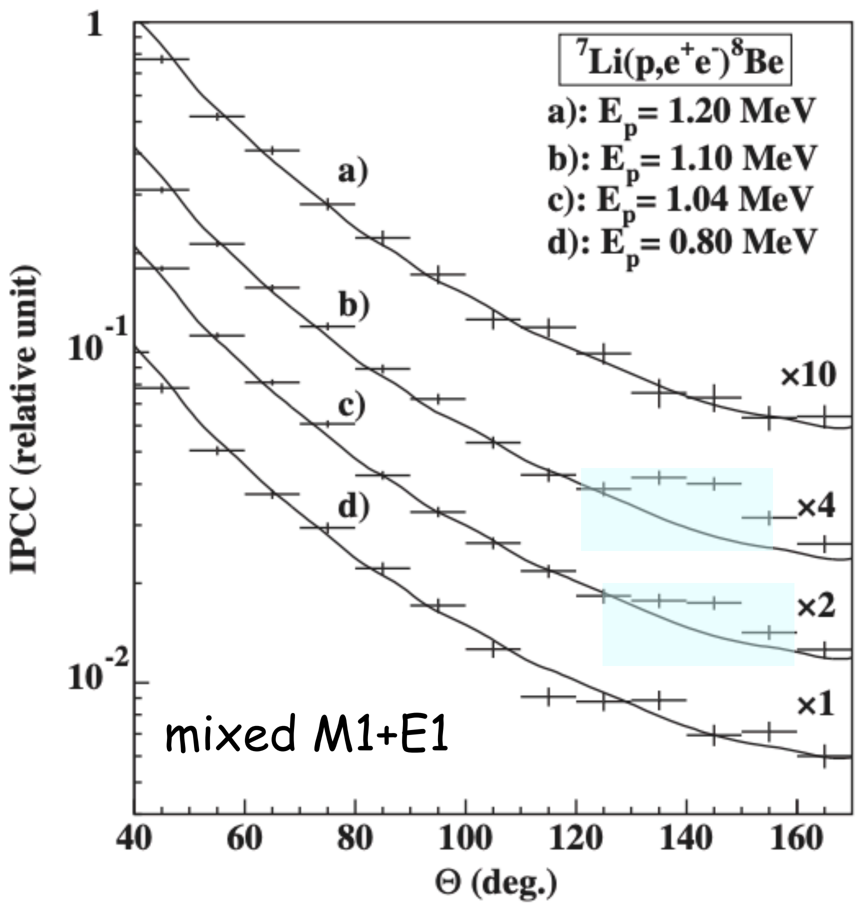


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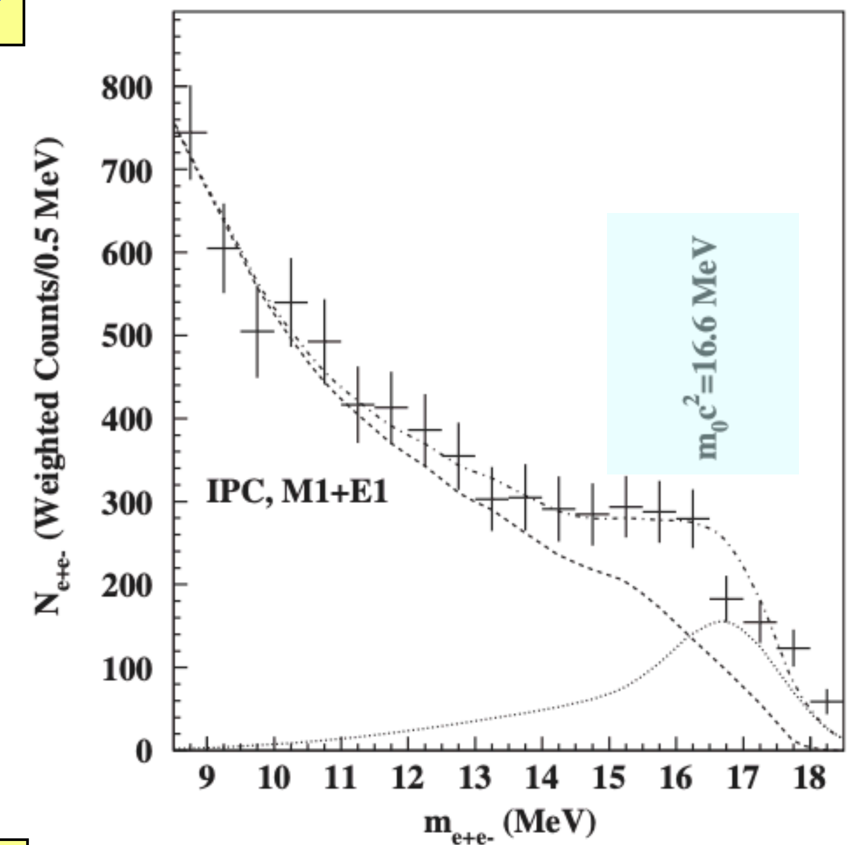
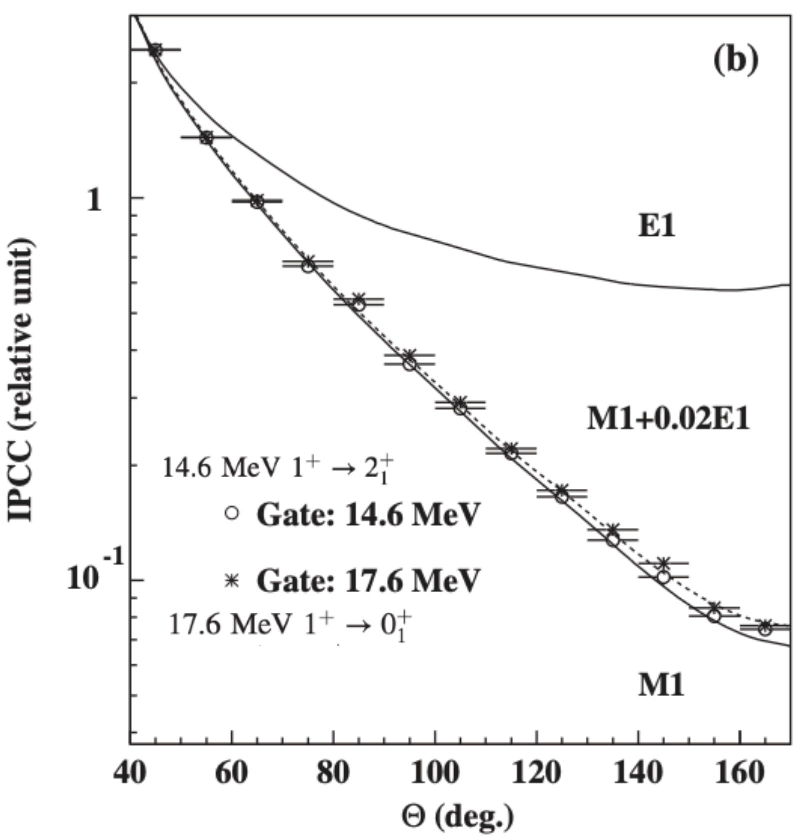



## $^8$Be*(17.64MeV) Iso-V




The contribution of the direct capture depends on the target thickness if the energy loss of the beam in the target is larger than the width of the resonance. The dashed simulated curve in Fig. 1(b) is obtained by fitting a small (2.0%) $E1$ contribution to the dominant $M1$ one, which describes the experimental data reasonably well.

# One important theoretical input [Feng+, PRL 1604.07411 [hep-ph]; PRD 1608.03591 [hep-ph]]

As noted above, the decay $^8\text{Be}^{*\prime} \to {}^8\text{Be}\,X$ is not seen. The protophobic gauge boson can mediate isovector transitions, so there is no dynamical suppression of this decay. However, its mass is near the 17.64 MeV threshold, so the decay is kinematically suppressed. For $m_X = 17.0\ (17.4)$ MeV, the $|\vec{p}_X|^3/|\vec{p}_\gamma|^3$ phase space suppression factor is 2.3 (5.2) times more severe for the $^8\text{Be}^{*\prime}$ decay than for the $^8\text{Be}^*$ decay. In particular,

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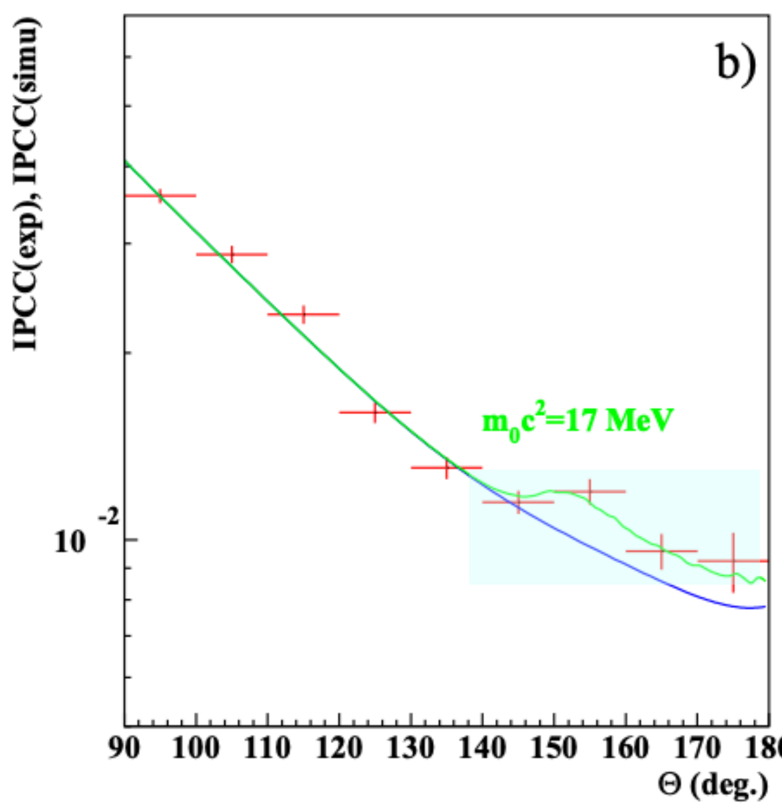
**Bump location:**
150° (17.64 MeV) vs.
140° (18.15 MeV)

Messina symposium (Oct 2016)

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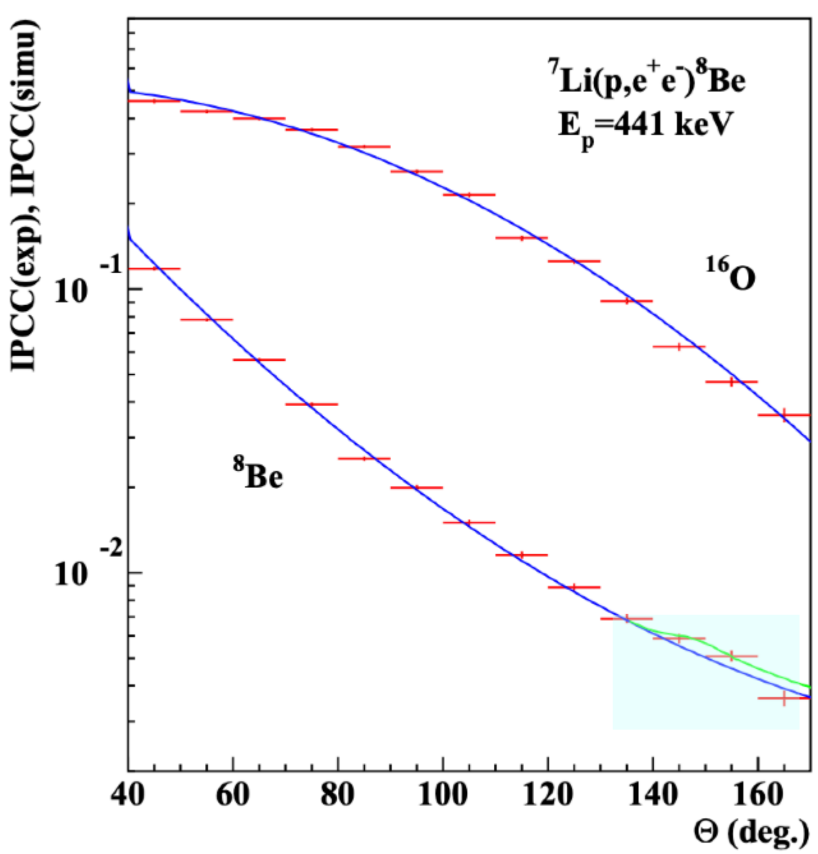

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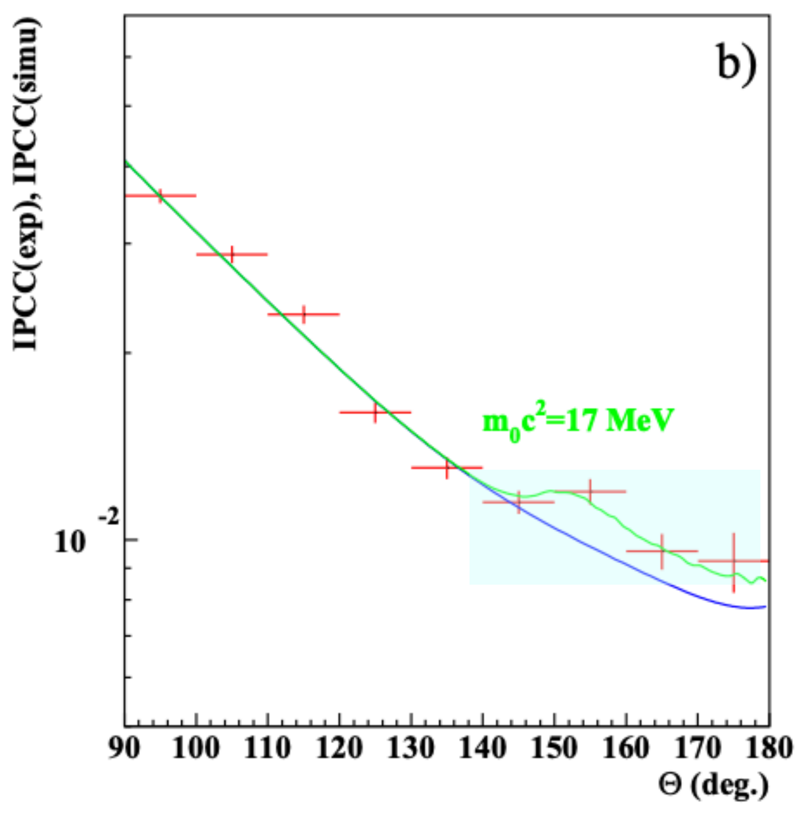


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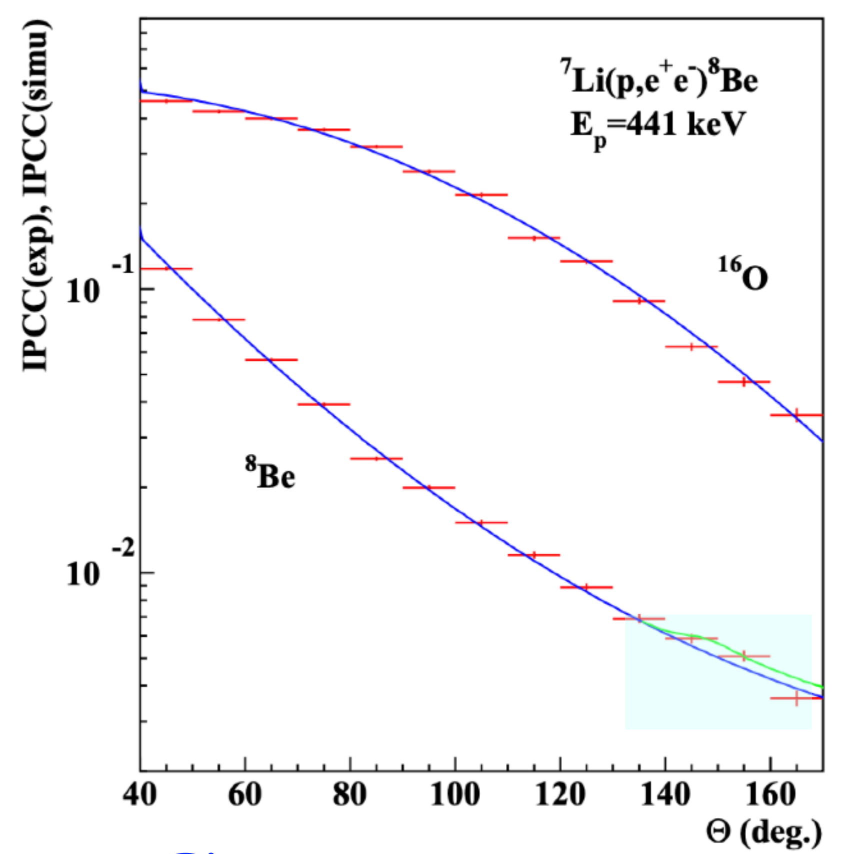



## Axial vector boson

Calculation of relevant Nucl. Matrix Elements:

Kozaczuk+, PRD 1612.01525 [hep-ph]

the ${}^8\mathrm{Be}^{*\prime} \to {}^8\mathrm{Be}+X$ transition rate can be suppressed relative to that of the ${}^8\mathrm{Be}^{*} \to {}^8\mathrm{Be}+X$ mode for an axial vector. This effect is dynamical,

# $^8$Be anomaly: Standard Model explanations ?

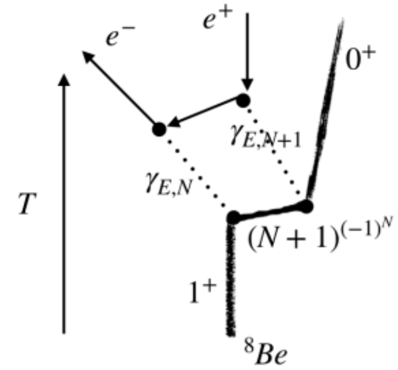
## Zhang & Miller PLB, arXiv:1703.04588 [nucl-th]

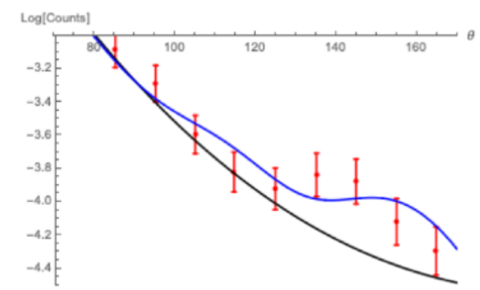
Interferences between different multipoles. Possibility of using the nuclear transition form factor to explain the anomaly

We find that the model improvements are not able to explain the anomaly.

## Koch, NPB, arXiv:2003.05722 [hep-ph]

Hypothesises nuclear chain reaction and conversion of two resulting highly energetic γs into an electron–positron pair.




The kinematics fits perfectly the experimental result. No explanation for the isospin structure can be given. The process does not give a satisfying explanation of X17.

## Kálmán & Keszthelyi EPJA, arXiv:2005.10643 [nucl-th]

Higher order processes, in which strong and electromagnetic interactions are coupled and govern jointly the system from the definite initial state to the definite final one [Analyzed $^8$Be and (qualitatively) also $^4$He]

Enhancement can be generated by higher order processes. Lower energy nucl. transitions can cause peaked angle dependence in angular correlations.

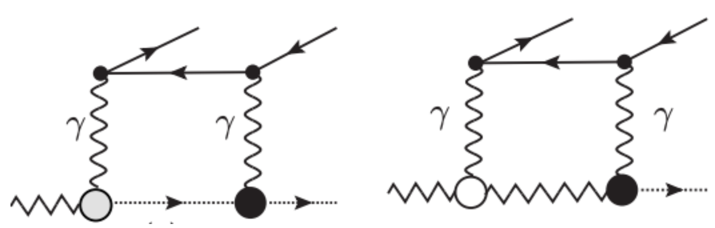
## Zhang & Miller PLB, arXiv:2008.11288 [hep-ph]

Derived isospin relation between photon and (protophobic) X couplings to nucleons. X production dominated by direct transitions with a smooth energy dependence occurring for all proton beam energies above threshold

X bremsstrahlung occurs at all beam energies above threshold. The enhancement should have been seen at all four Atomki p-energies. The explanation of the anomaly in terms of protophobic vector boson cannot be correct.

## Aleksejevs+, arXiv:2102.01127 [nucl-th]

Full second-order calculation of $^8Be^* \rightarrow {}^8Be\, e^+e^-$ process: interferences second-order corrections and the interference terms to the Born-level decay amplitudes




The observed $^8$Be experimental structure can be reproduced within the Standard Model.

## Hayes+, arXiv:2106.06834 [nucl-th]

Study of $e^+e^-$ angular distributions for nuclear decay for several multipoles M1,E1 dominate, but the ratio of M1 to E1 strength strong function of energy (Atomki: M1/E1 assumed constant over the energy region Ep = 0:8-1:2 MeV)

The evidence of a new particle emitted from the 18.15 MeV resonance in $^8$Be seems to be strongly dependent on the assumptions about the nuclear structure of this resonance. Atomki surplus events at large angles could be an artefact of the Atomki analysis nuclear structure assumptions.

The past week: [August 29, 2023] arXiv:2308.13751 appeared....

# ***Ab initio*** **investigation of the** $^{7}\mathrm{Li}(p, e^+e^-)^{8}\mathrm{Be}$ **process and the X17 boson**

P. Gysbers[1,2], P. Navrátil[1], K. Kravvaris[3], G. Hupin[4], S. Quaglioni[3]

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Validation: Our results are to a large extent in line with the ATOMKI Standard Model background, i.e., the $e^{+}e^{-}$ angular correlations without the anomalous bump at 140°

The bump at 140° seen in the data, if real, cannot be explained by a Standard Model electromagnetic process.

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Scalar: $J^P = 1^+(^8Be^*) \to 0^+(^8Be)\ 0^+(X_{17})$ => $L=1$; $P = +1 = (-1)^L$

Vector with no definite parity (Z'): APV constraints

$U(1)_{B-L}$ vector boson: $\nu$-e scattering ($g_{B-L} \lesssim 10^{-5}$)

Kinetically mixed V': $g_f = \varepsilon Q_f$ NA48/2 limit $\pi^0 \to X\,\gamma$

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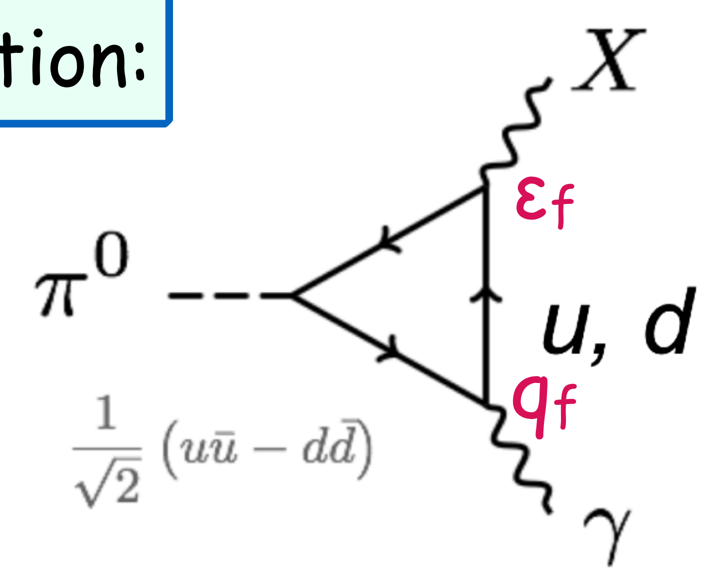
$\pi^0 \to X\gamma$ : $|2\varepsilon_u + \varepsilon_d| <$ 8 x $10^{-4}$ (NA48/2)



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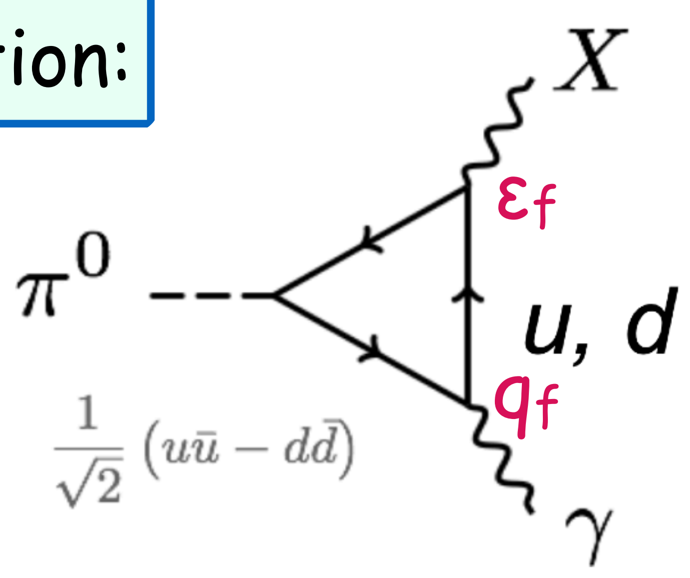
$B_X/B_\gamma \propto (\varepsilon_p+\varepsilon_n)^2 (p_X/p_\gamma)^3 \approx 6 \times 10^{-6}$ (Atomki)

=> $|\varepsilon_u + \varepsilon_d| \approx 4 \times 10^{-3}$




$\varepsilon_d \approx -2\ \varepsilon_u$ (±10%) ==> $\varepsilon_p = 2\varepsilon_u + \varepsilon_d \approx 0$; $\varepsilon_n = 2\varepsilon_d + \varepsilon_u \approx 1.2 \times 10^{-2}$

[Feng+, 1608.0359 [hep-ph] (Aug. 2016)]

For protophobic vector, $^8$Be data can be explained with:

$\varepsilon_u = -\varepsilon_n/3 \approx \pm\, 3.7 \times 10^{-3}$; $\varepsilon_d = 2\varepsilon_n/3 \approx \mp\, 7.4 \times 10^{-3}$; $|\varepsilon_e| \in [2,14] \times 10^{-4}$

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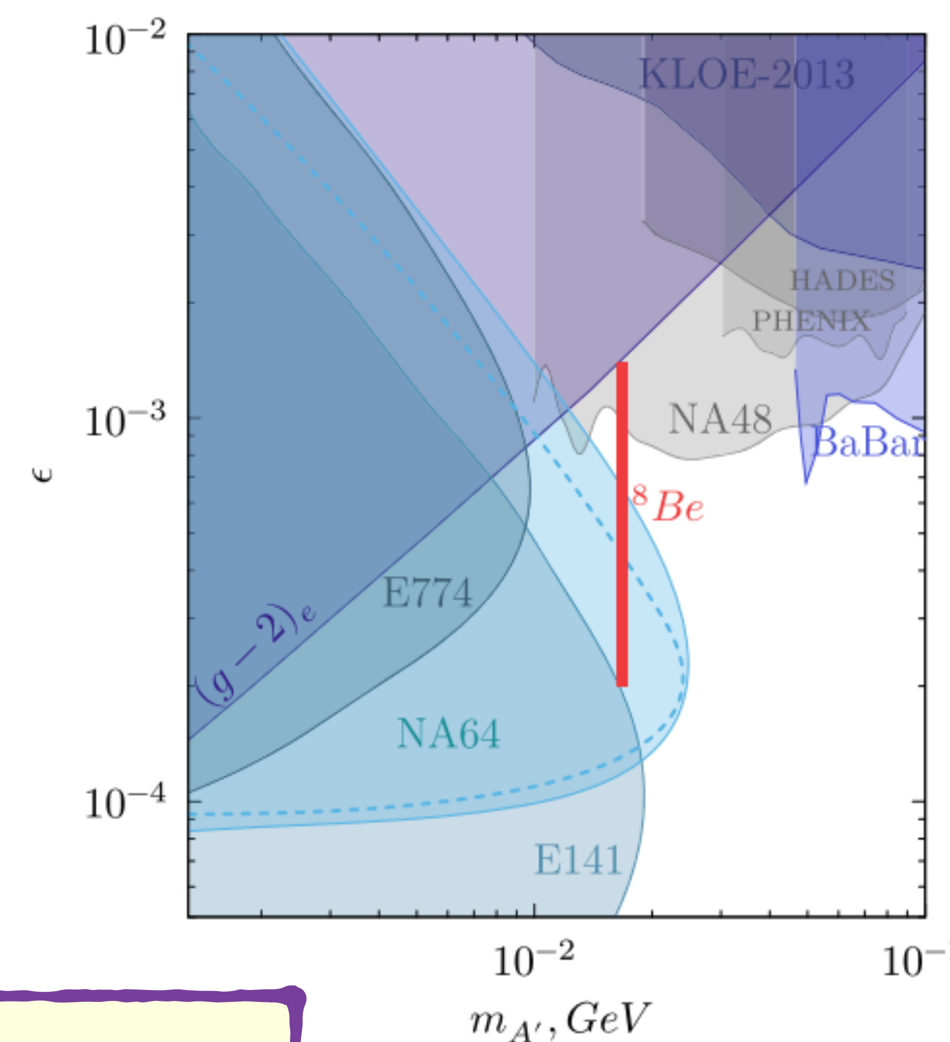
## Current limits on X17

[NA64@ CERN, 1912.11389 [hep-ex] (Dec. 2019)]

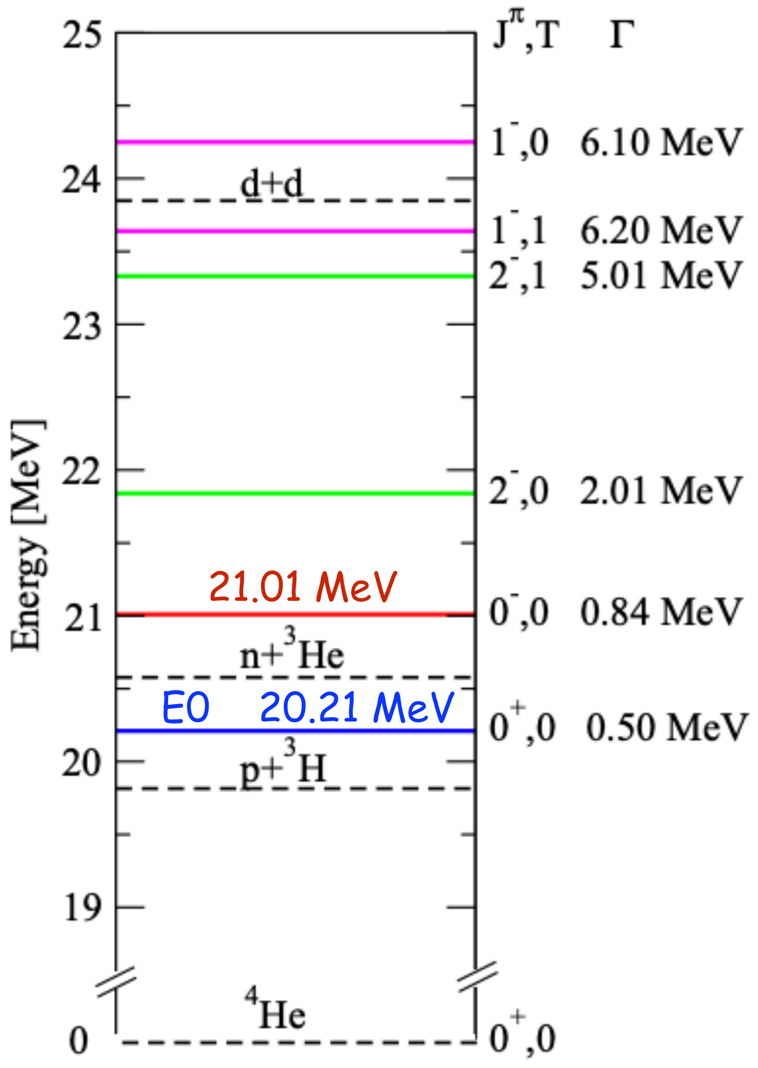
The X17 boson could be produced in the bremsstrahlung reaction $e^- Z \rightarrow e^- Z\, X$ by a high energy beam (150 GeV) of electrons incident on the active target in the NA64 experiment, and observed through its decay $X \rightarrow e^+e^-$




$|\varepsilon_e| \notin [2.0,6.8] \times 10^{-4}$ for $M_X$ =16.7 MeV

In the meanwhile: $M_X$ ($^{8}$Be) = (17.1 ± 0.16) MeV

# Helium 4 nuclear transitions



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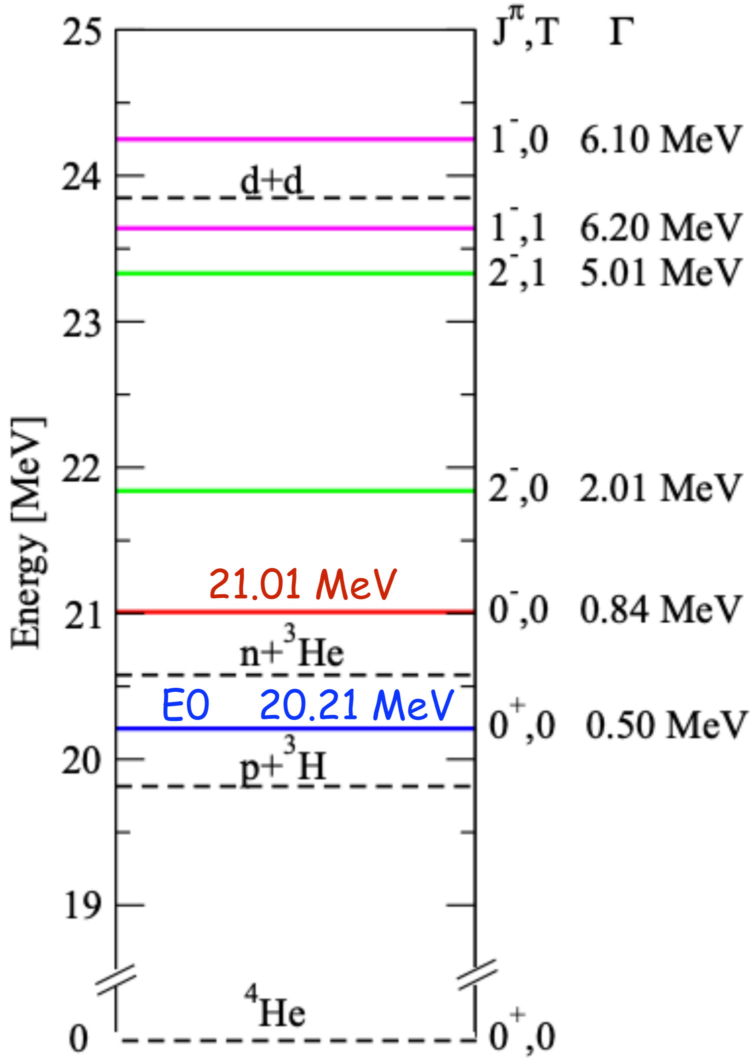
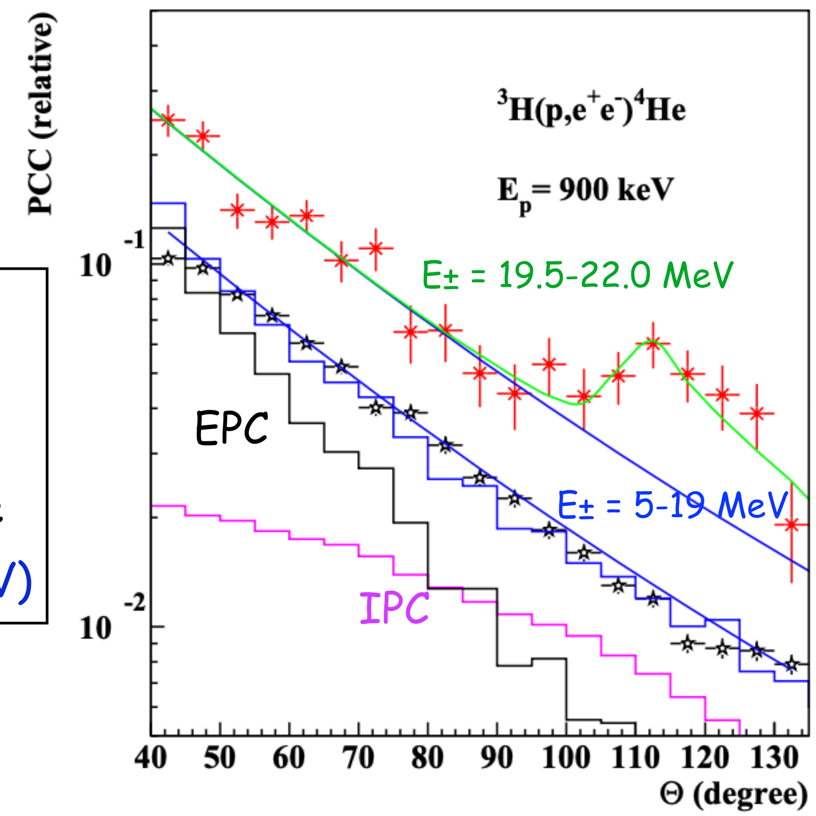
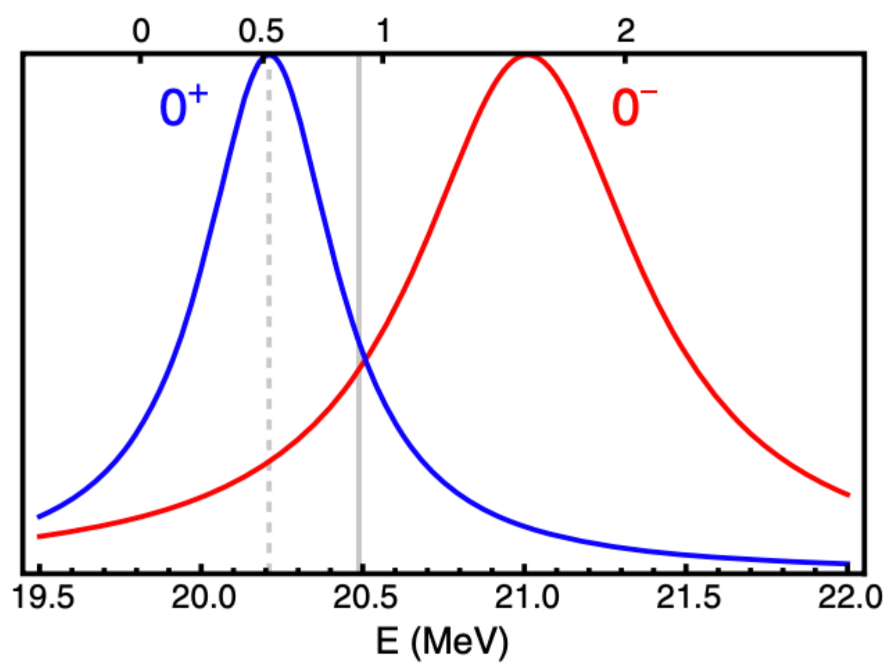



arXiv:1910.10459 [nucl-ex] $E_p$=900 keV
(below E(p,n) = 1.018 keV threshold)
excites the $^4$He nucleus to E*=20.49 MeV
and populates the second $^4$He excited state
$0^-$(21.01 MeV) overlapped with $0^+$(20.21 MeV)



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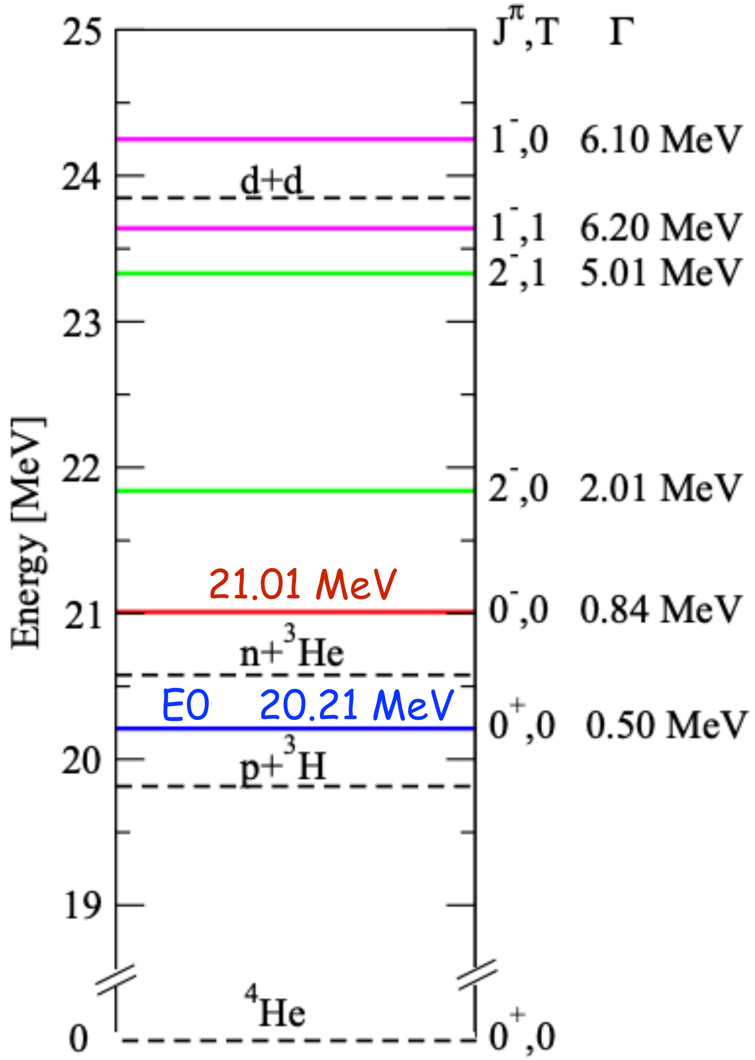


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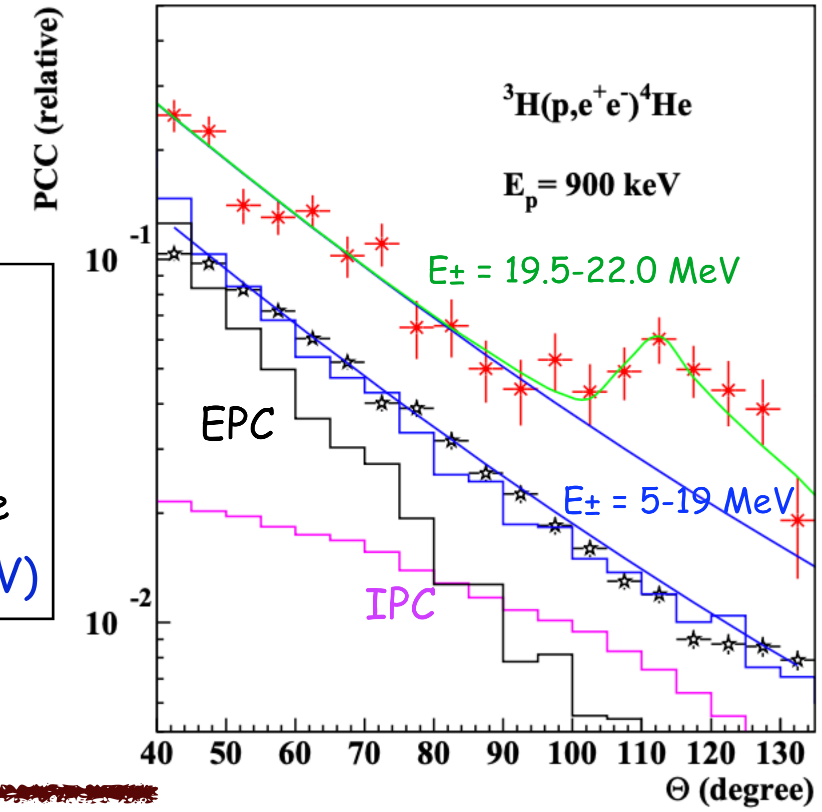


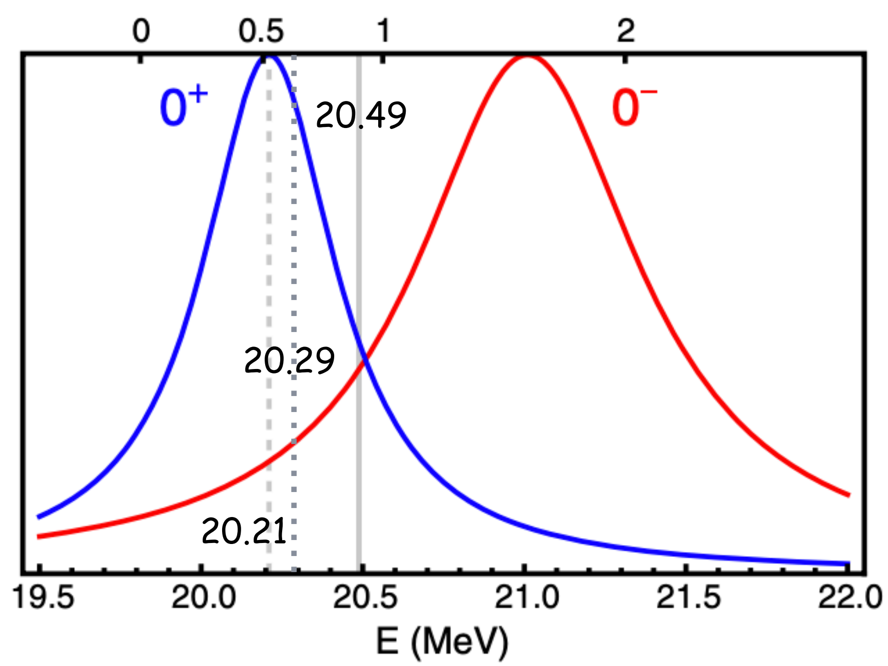


PRC (2021) [arXiv:2104.1075 [nucl-ex]]
$E_p$ = 510, 610, 900 keV to induce direct
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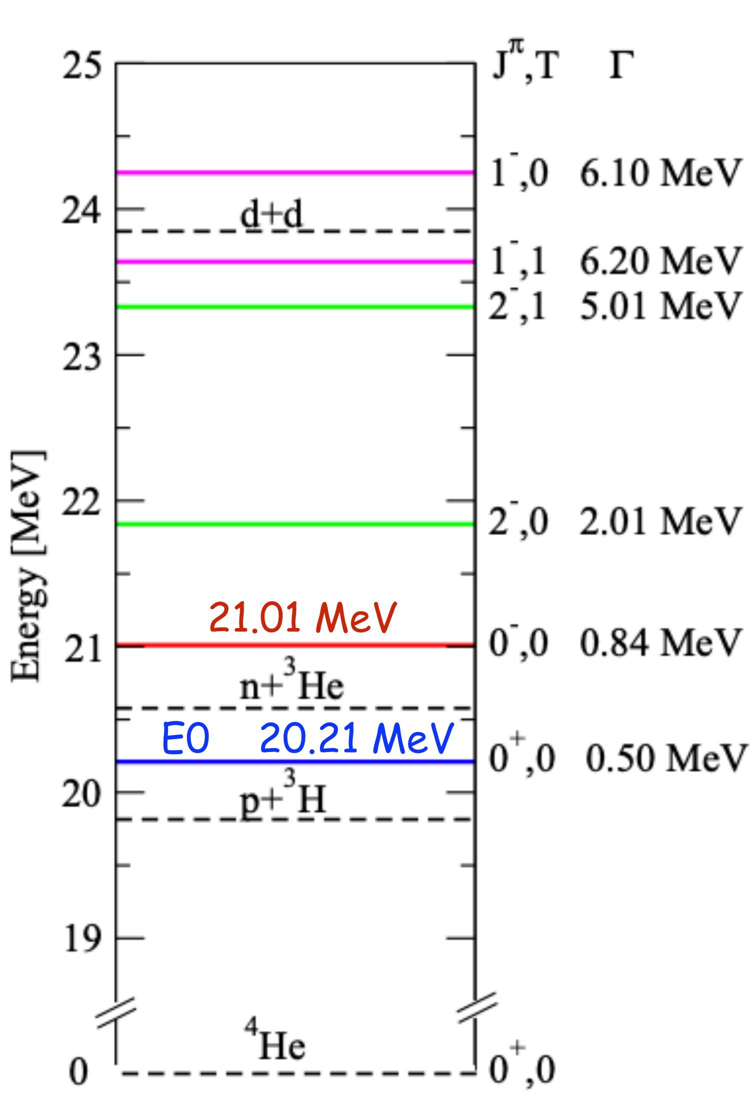


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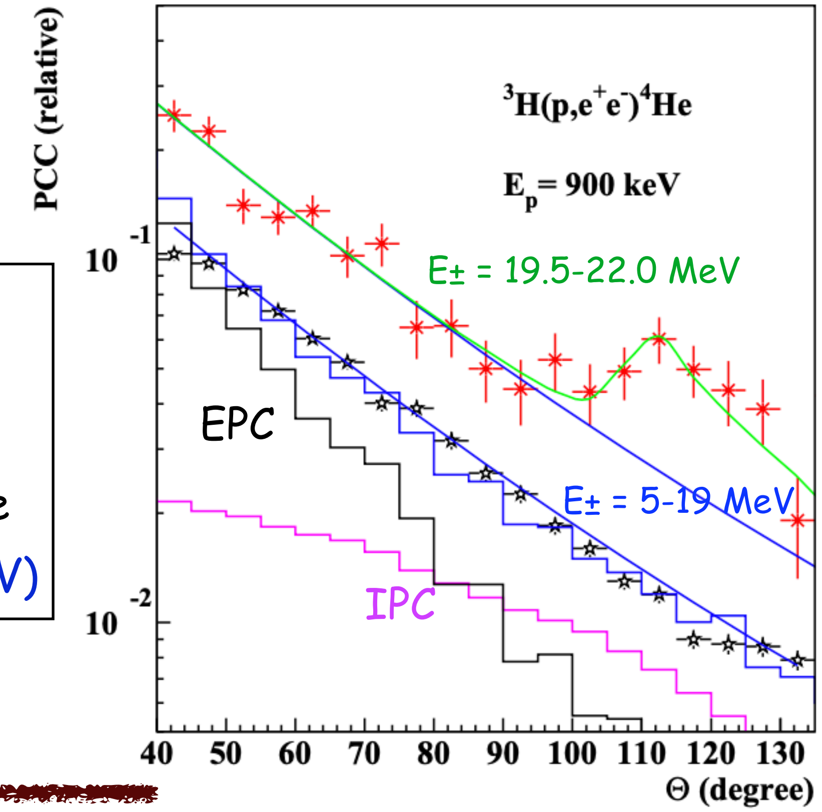


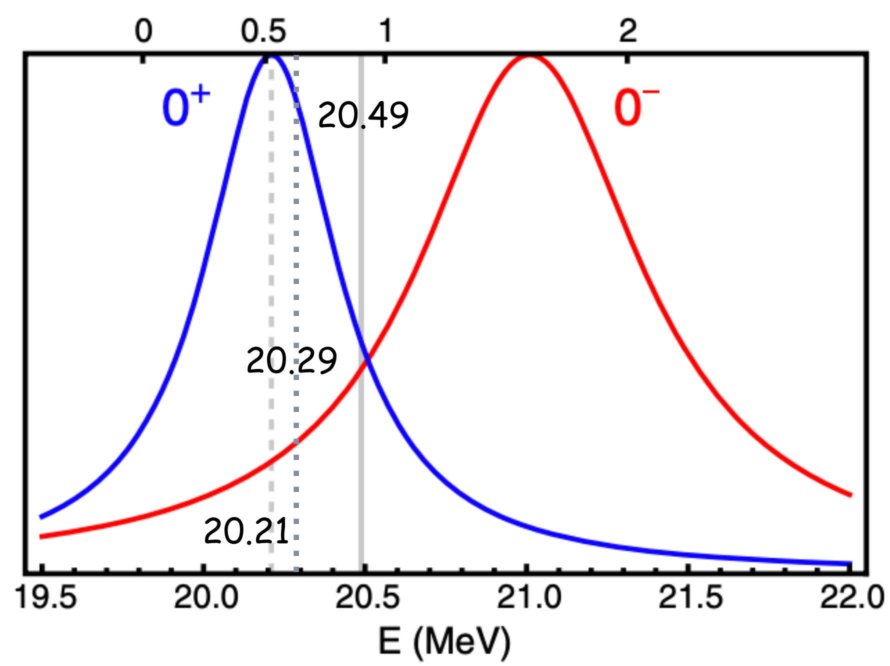


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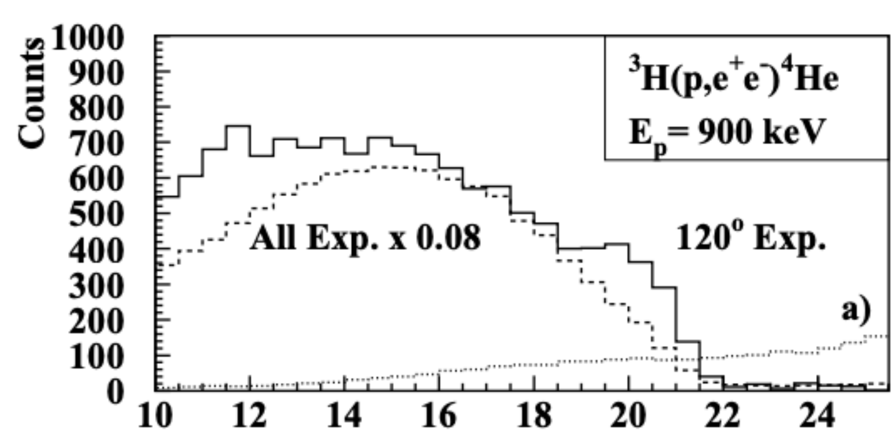


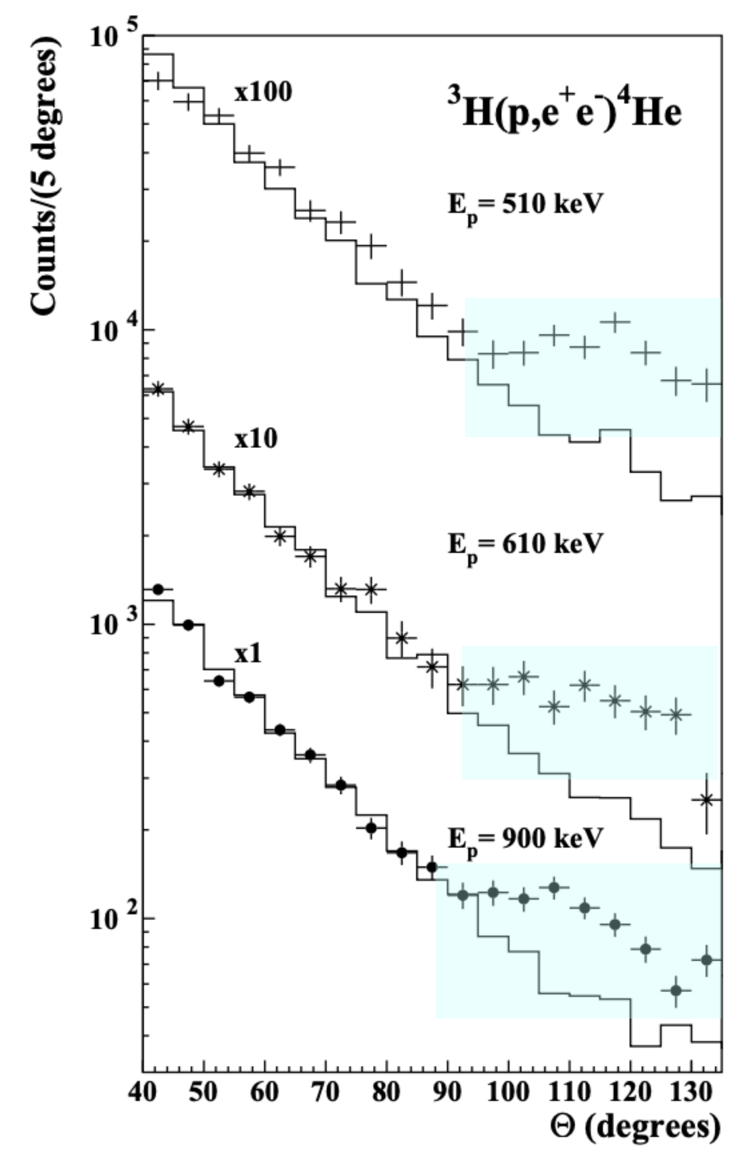

# $^4He$ anomaly: Standard Model explanations ?

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Viviani+, PRD 2104.04808 [nucl-th]. Thorough calculation for $^4$He, comprehensive of NP

## The X17 boson and the $^3$H(p,e$^+$e$^-$)$^4$He and $^3$He(n,e$^+$e$^-$)$^4$He processes: a theoretical analysis

- Analysis of the process in the standard theory (ab initio nuclear physics. calculation)
- Study of how the exchange of $X_{17}$(V,A,S,P) would impact such a process
- Beyond the resonance-saturation approach (justified for $^8$Be but not for $^4$He)
- Detailed study of the behaviour of the (V,A,S,P) induced angular correlations

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- Detailed study of the behaviour of the (V,A,S,P) induced angular correlations

## Main results:

- The predicted cross sections are monotonically decreasing as function of the $e^+e^-$ opening angle.
- In the SM: Absence of any resonance-like structure
- Measurements at $\theta_{vp} \neq 90^o$ can discriminate X=V,A,S,P

# $^{8}Be$ vs. $^{4}He$: kinematic consistency [Feng+, PRD 2006.01151 [hep-ph]]

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The theor. values are: $\theta^{min}_{\pm}$ = 112° [$^4$He(20.49)]; 139°[$^8$Be(18.15)]; 161° [$^{12}$C(17.23)].

[Exact for spin 0, approximate for spin 1]

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[Exact for spin 0, approximate for spin 1]

$^4$He: $M_X$ = 16.94 ± 0.24, θ ~ 115°
$^8$Be: $M_X$ = 17.01 ± 0.16, θ ~ 140° [θ(17.64 MeV)~150°]
$^{12}$C: $M_X$ broadly consistent, θ ~ 160° [prediction]

| $N_*$ | $J_*^{P_*}$ | $T_*$ | $\Gamma_{N_*}$ [keV] | $B(N_* \to N_0\gamma)$ |
|---|---|---|---|---|
| $^8$Be(18.15) | $1^+$ | 0 | 138 | $1.4 \times 10^{-5}$ |
| $^8$Be(17.64) | $1^+$ | 1 | 10.7 | $1.4 \times 10^{-3}$ |
| $^{12}$C(17.23) | $1^-$ | 1 | 1150 | $3.8 \times 10^{-5}$ |
| $^4$He(21.01) | $0^-$ | 0 | 840 | 0 |
| $^4$He(20.21) | $0^+$ | 0 | 500 | $6.6 \times 10^{-10}$ (E0) |
| ($^8$Be, $^{12}$C, $^4$He)$_{gs}$ | $0^+$ | 0 | | |

# $^8$Be vs. $^4$He: kinematic consistency [Feng+, PRD 2006.01151 [hep-ph]]

For $M_X$=17MeV and uniform distrib. in cos φ ($e^{\pm}$ axis vs. $v_X$) the Lab. opening angle distributions will be strongly peaked near their minimal values (when $e^{\pm}$ axis ⊥ $v_X$)

The theor. values are: $\theta^{min}_{\pm}$ = 112° [$^4$He(20.49)]; 139°[$^8$Be(18.15)]; 161° [$^{12}$C(17.23)].

[Exact for spin 0, approximate for spin 1]

$^4$He: $M_X$ = 16.94 ± 0.24, θ ~ 115°

$^8$Be: $M_X$ = 17.01 ± 0.16, θ ~ 140° [θ(17.64 MeV)~150°]

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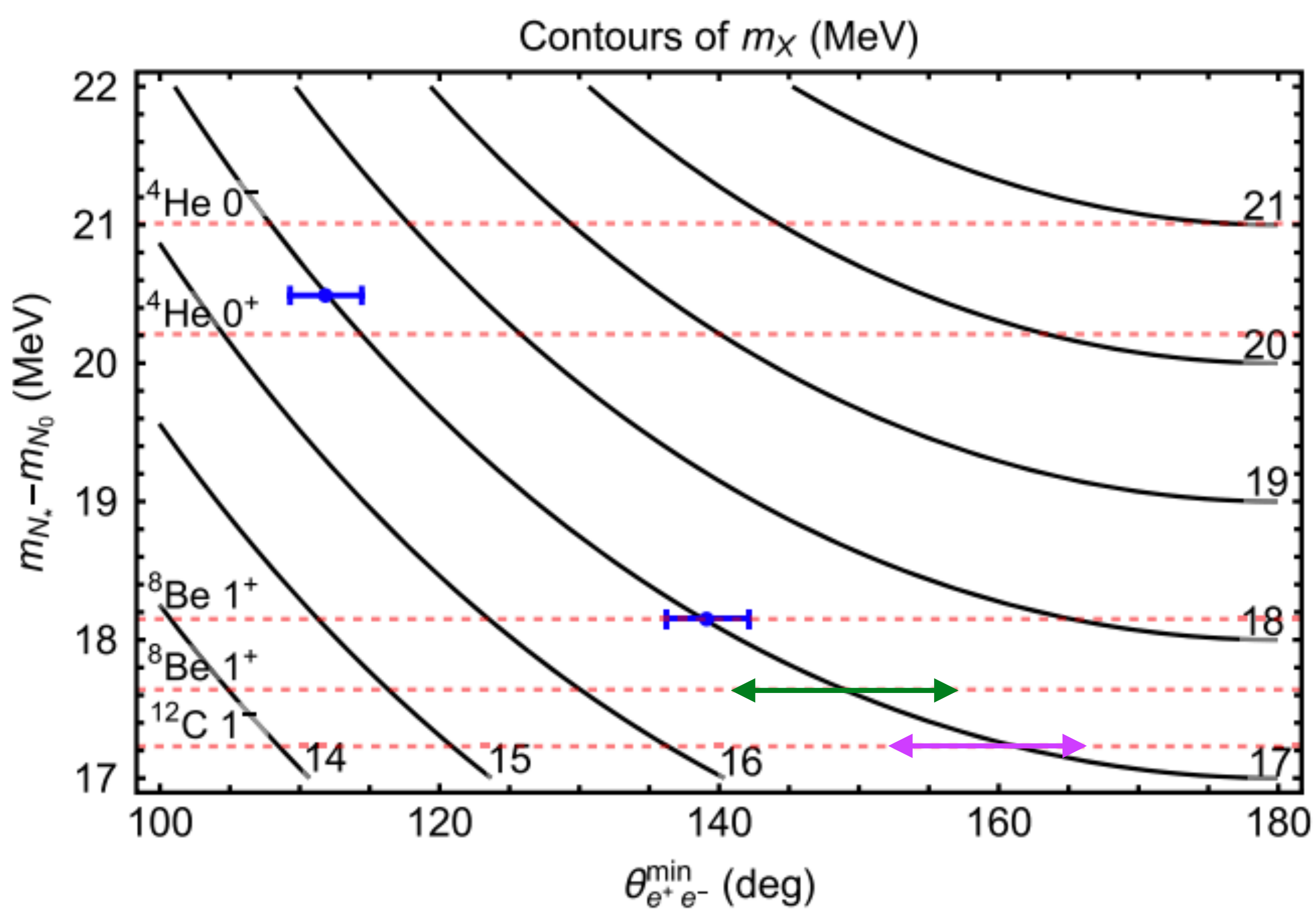

# Preliminary results for $^{12}C$

Nuclear reaction: $p + {}^{11}B \longrightarrow {}^{12}C^*(17.23\ \text{MeV}) \longrightarrow {}^{12}C + e^+e^-$

$E_p = 2.25$ MeV $\quad J^P({}^{12}C^*) = 1^-$

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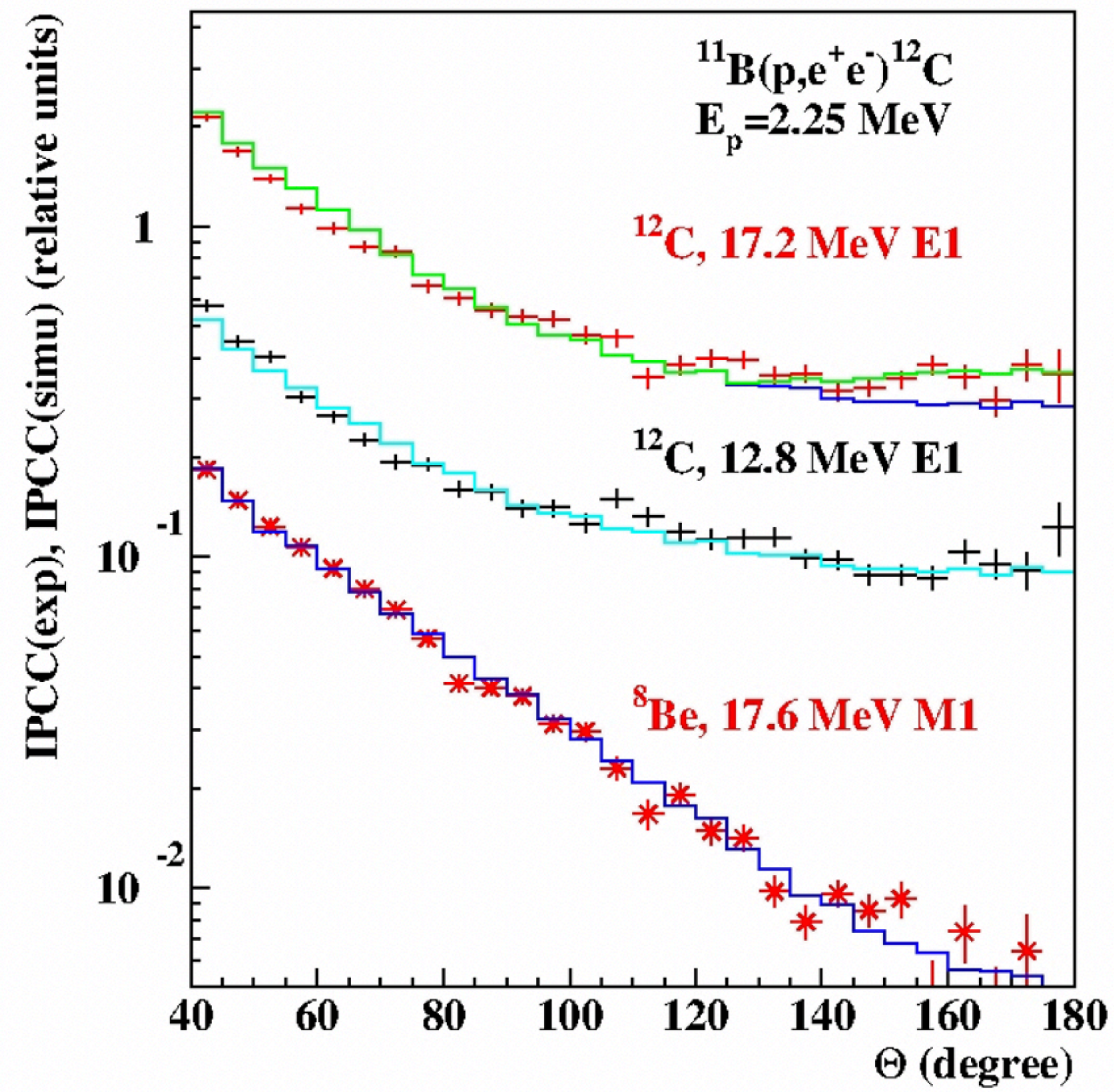
A. Krasznahorkay
"Shedding light on X17 Workshop
Rome, September 6-8, 2021



# September 2022: Results for $^{12}C$ arXiv:2209.10795 [nucl-ex]

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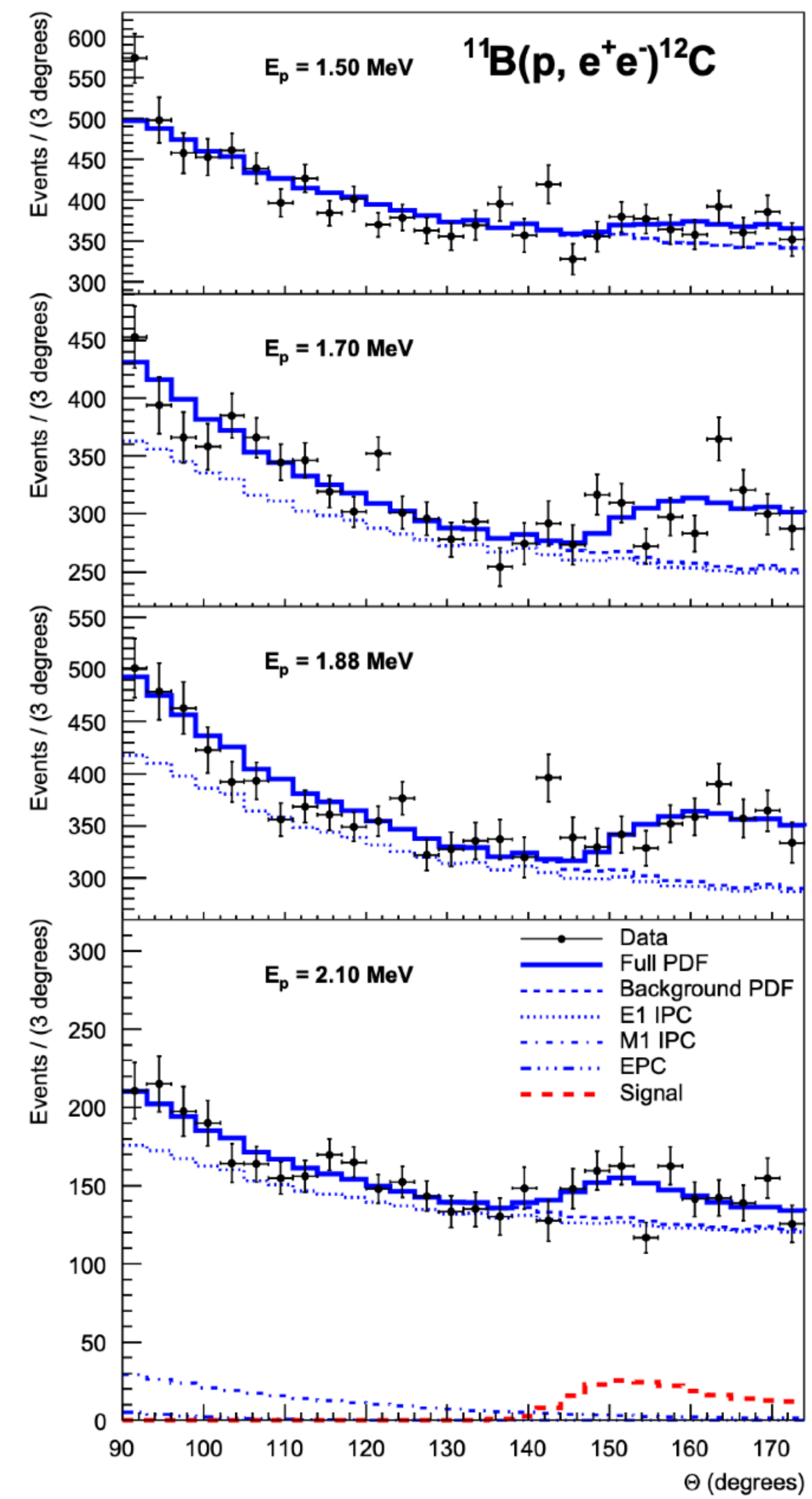
$E_p = 2.25$ MeV $\quad J^P({}^{12}C^*) = 1^-$

| $E_p$ | $B_x$ | Mass | Confidence |
|---|---|---|---|
| (MeV) | $\times 10^{-6}$ | (MeV/$c^2$) | |
| 1.50 | 1.1(6) | 16.81(15) | $3\sigma$ |
| 1.70 | 3.3(7) | 16.93(8) | $7\sigma$ |
| 1.88 | 3.9(7) | 17.13(10) | $8\sigma$ |
| 2.10 | 4.9(21) | 17.06(10) | $3\sigma$ |
| Averages | 3.6(3) | 17.03(11) | |
| Previous [14] | 5.8 | 16.70(30) | |
| Previous [28] | 5.1 | 16.94(12) | |




$M_X = 17.03 \pm 0.11 \pm 0.20$ MeV & $B_X$ are consistent with the same $X_{17}$ particle suggested by the $^8$Be and $^4$He anomalies

# $^8$Be vs. $^4$He: dynamical consistency [Feng+, PRD 2006.01151 [hep-ph]]

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## Allowed nuclear transitions and $X_{17}$ mediators

| $N_*$ | $J_*^{P_*}$ | Scalar $X$ | Pseudoscalar $X$ | Vector $X$ | Axial Vector $X$ |
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Selection rules:

$J^* = L \oplus J_X$

$P^* = (-1)^L P_X$

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$$\frac{\Gamma_X^{\rm Be}}{\Gamma_\gamma^{\rm Be}} \equiv \frac{\Gamma(^8{\rm Be}^* \to {}^8{\rm Be} + X)}{\Gamma(^8{\rm Be}^* \to {}^8{\rm Be} + \gamma)} \simeq 6 \times 10^{-6} \qquad {}^8{\rm Be}^*(18.15)$$

$$\frac{\Gamma_X^{\rm He}}{\Gamma_\pm^{\rm He}} \equiv \frac{\Gamma(^4{\rm He}' \to {}^4{\rm He} + X)}{\Gamma(^4{\rm He}^* \to {}^4{\rm He}\ e^+e^-)} \simeq 4 \times 10^{-5} \qquad {}^4{\rm He}'(20.49),\ {}^4{\rm He}^*(20.21)$$

Are these branchings consistent with a single set of $X_{17}$ couplings ?

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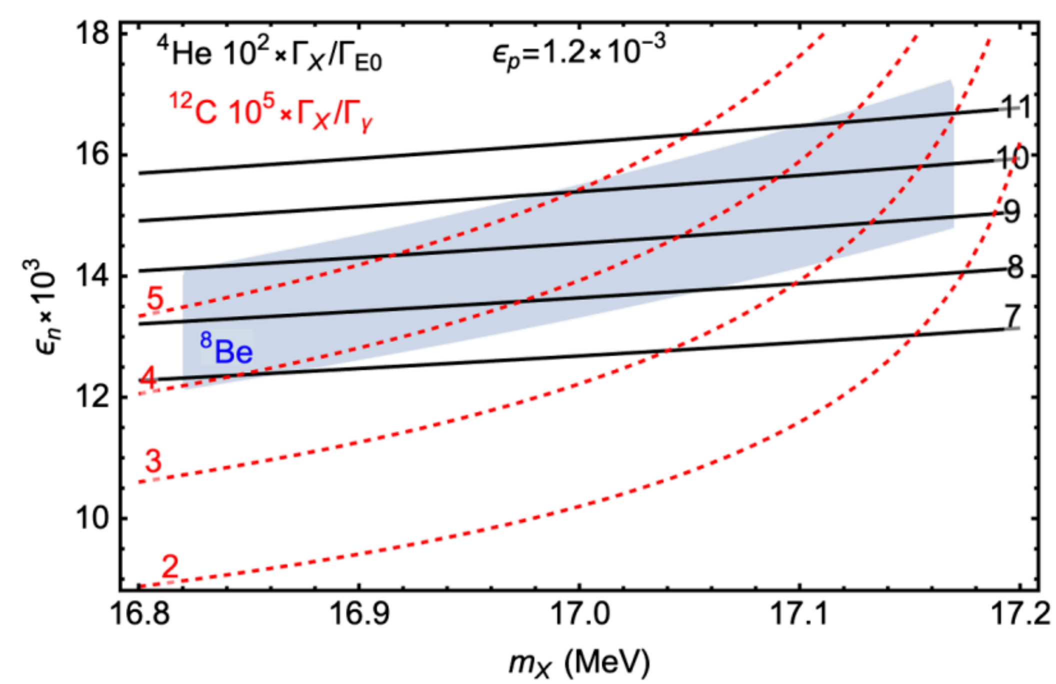

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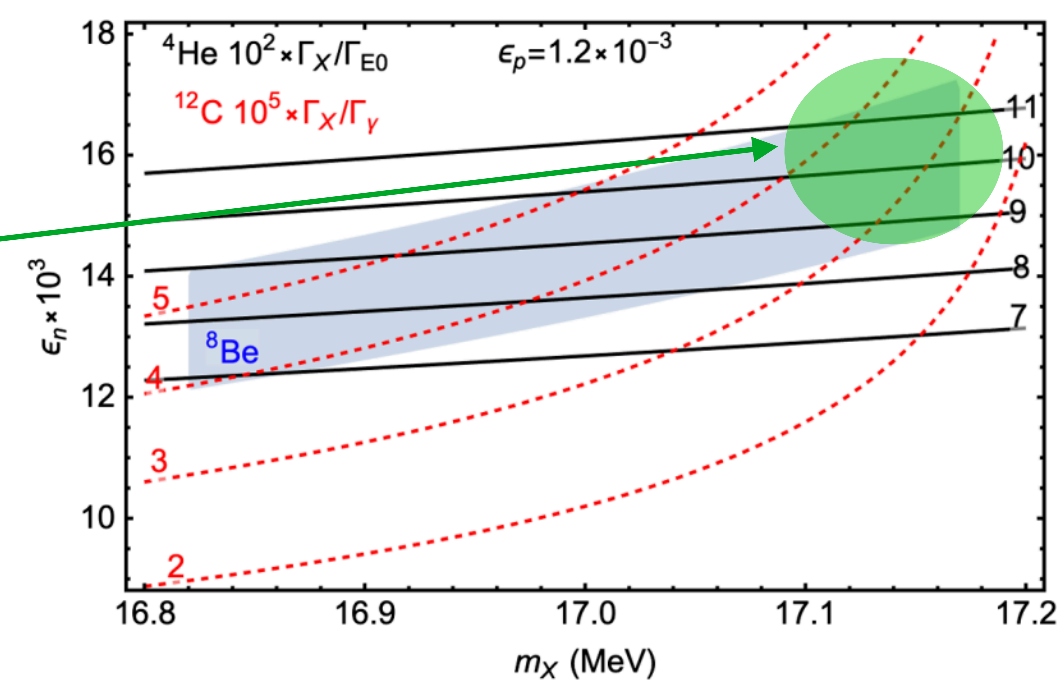
Protophobic Vector: $^8$Be - $^4$He - $^{12}$C dynamical consistency region

Axial vector: might also explain $^8$Be - $^4$He - $^{12}$C consistency

(See Barducci & Toni, arXiv:2212.06453)



Taking a look at $^{12}C$ excited levels:

"Experimental study of the $^{11}B(p,3\alpha)$ reaction at $E_p$=0.5-2.7 MeV"

O. S. Kirsebom et al. [e-Print: 2005.07825]

| $\hat{E}_x$ (MeV) | $\Gamma$ (keV) | $\Gamma_p$ (keV) | $J^\pi$ | $T$ |
|---|---|---|---|---|
| 16.62(5) | 280(28) | 150 | $2^-$ | 1 |
| 17.23 | 1150 | 1000 | $1^-$ | 1 |
| 17.768 | 96(5) | 76 | $0^+$ | 1 |
| 18.13 | 600(100) | - | $(1^+)$ | (0) |
| 18.16(7) | 240(50) | - | $(2^-)$ | (0) |
| 18.35(5) | 350(50) | 68 | $3^-$ | 1 |
| 18.35(5) | 350(50) | - | $2^-, 2^+$ | $0+1$ |
| (18.39) | 42 | 33 | $0^-$ | (1) |

$^{12}C$ Results:
Scalar
Vector
Axial vector

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With the Atomki 2 mg/cm2 thick $^{11}$B target the energy loss in the target (about 300 keV), is too large.
Plans to make a thinner target (0.2 mg/cm2, 30 keV energy loss) possibly during next months (private comm.)

# Summarising:

- All the three anomalies $\gtrsim$ 6 $\sigma$, not a statistical fluctuation
- Bumps, not general excesses. Not a single bin or a last bin effect
- By Introducing a new particle, remarkable improvement of the fits
- SM explanation strongly disfavoured $^{8}$Be [Zhang+, (2017)]; $^{4}$He [Viviani+, (2021)]
- $^{8}$Be - $^{4}$He - $^{12}$C anomalies kinematically & dynamically consistent for V (and A) (see Barducci & Toni, arXiv:2212.06453)
- For $^{12}$C the effect was predicted, and confirmed by experimental data

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Indeed PADME@LNF has the capability to provide a truly extraordinary evidence for the X17 !

# Experimental perspective: Mostly Nuclear Physics

MEGII @ PSI: (search for CLFV $\mu^+ \to e^+ \gamma$)

$^8$Be: CW accelerator $E_p$ = 1.1 MeV, MEGII spectrometer, $Li_2O$ target

Engineering run during main HIPA 2022 shutdown (Jan/Feb 2022)

Physics run: Feb 2023 (Processing - Based on ATOMKI BR, O(400) $X_{17}$ expected)

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U. Montreal: Tandem Van de Graaff $E_p \in$ 0.4-1.0 MeV: $^8$Be$^*$(18.15MeV)

Data Taking should take place in early 2023 [arXiv:2211.11900 [physics.ins-det]]

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LUNA-MV @ LNGS: high intensity proton beam and very low background

$^4$He via $^3$H(p,$e^+e^-$)$^4$He reaction. (RICH detector under study)

Measurements: 2024-5 (LoI in preparation)

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n_ToF @ CERN: pulsed neutron beam in a wide energy range. $^4$He via

$^3$He(n,$e^+e^-$)$^4$He. Measurements: 2023-24 (CERN LoI approved CERN-INTC-2021-041 / INTC-I-233 )

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AN2000 @ LNL (INFN): Focus on $^8$Be and, possibly, $^{12}$C cases (timescale ?)

---

E12-21-003@JLAB: Brem/Bump: 3.3GeV CW $e^- + Ta \to e^- + Ta + X_{17} (\to e^+e^-)$

($M_X$ ~ 3-60MeV) "Ready to run" [arXiv:2301.08768 [nucl-ex]] Probably no beam before 2025

# Validation/confutation from a particle physics experiment

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PHYSICAL REVIEW D **97,** 095004 (2018)

**Resonant production of dark photons in positron beam dump experiments**

Enrico Nardi,[1,*] Cristian D. R. Carvajal,[2] Anish Ghoshal,[1,3] Davide Meloni,[3,4] and Mauro Raggi[5]

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$\sqrt{s} \sim$ 12.5 - 22.5 MeV

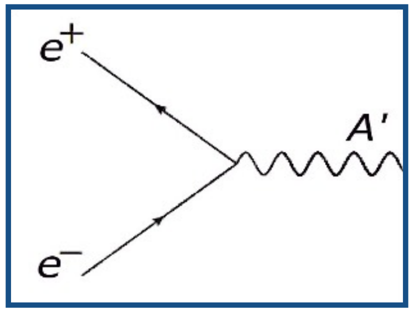
$M_X$=17 MeV $E_+$=285 MeV

$$\sigma_{\rm res} = \sigma_{\rm peak} \frac{\Gamma_X}{2m_X} \delta\left(1 - \frac{\sqrt{s}}{M_X}\right)$$

$$\Gamma_X = 0.05 \left(\frac{\epsilon}{10^{-3}}\right)^2 \mathrm{eV}$$

$$\sigma_{\rm peak} \sim 50\mathrm{b}$$

"Huge" cross section !



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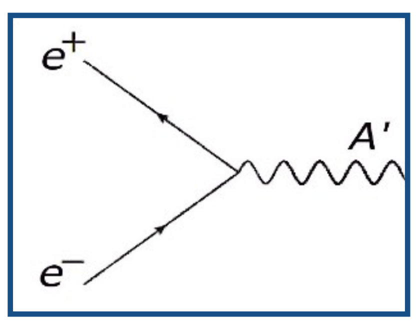
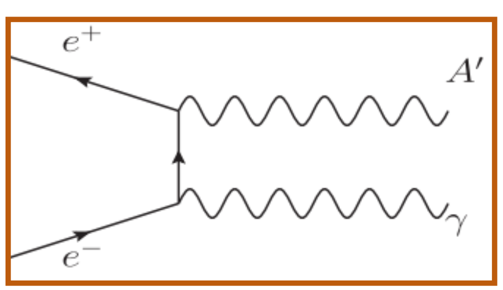
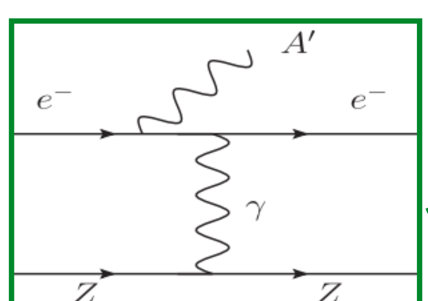
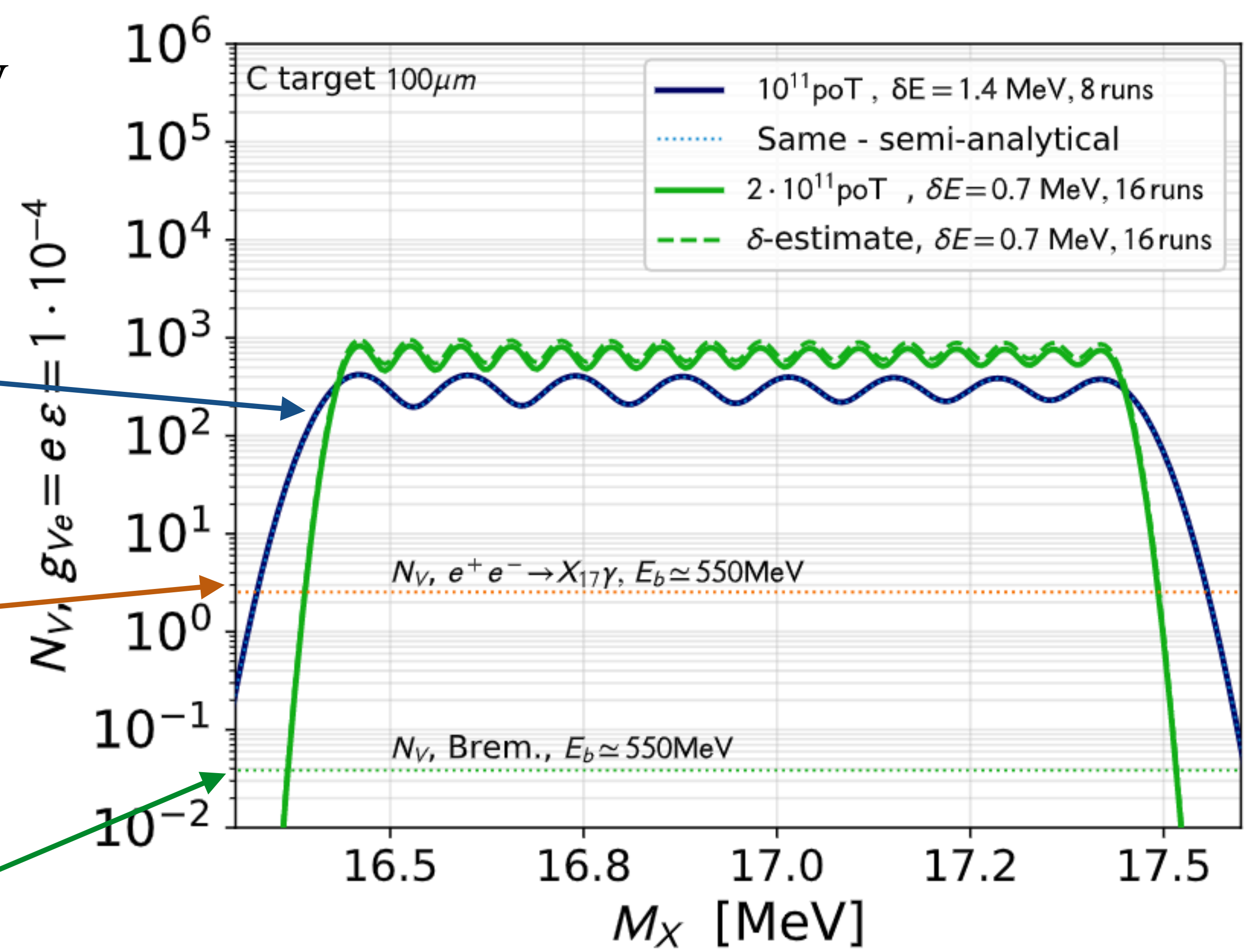


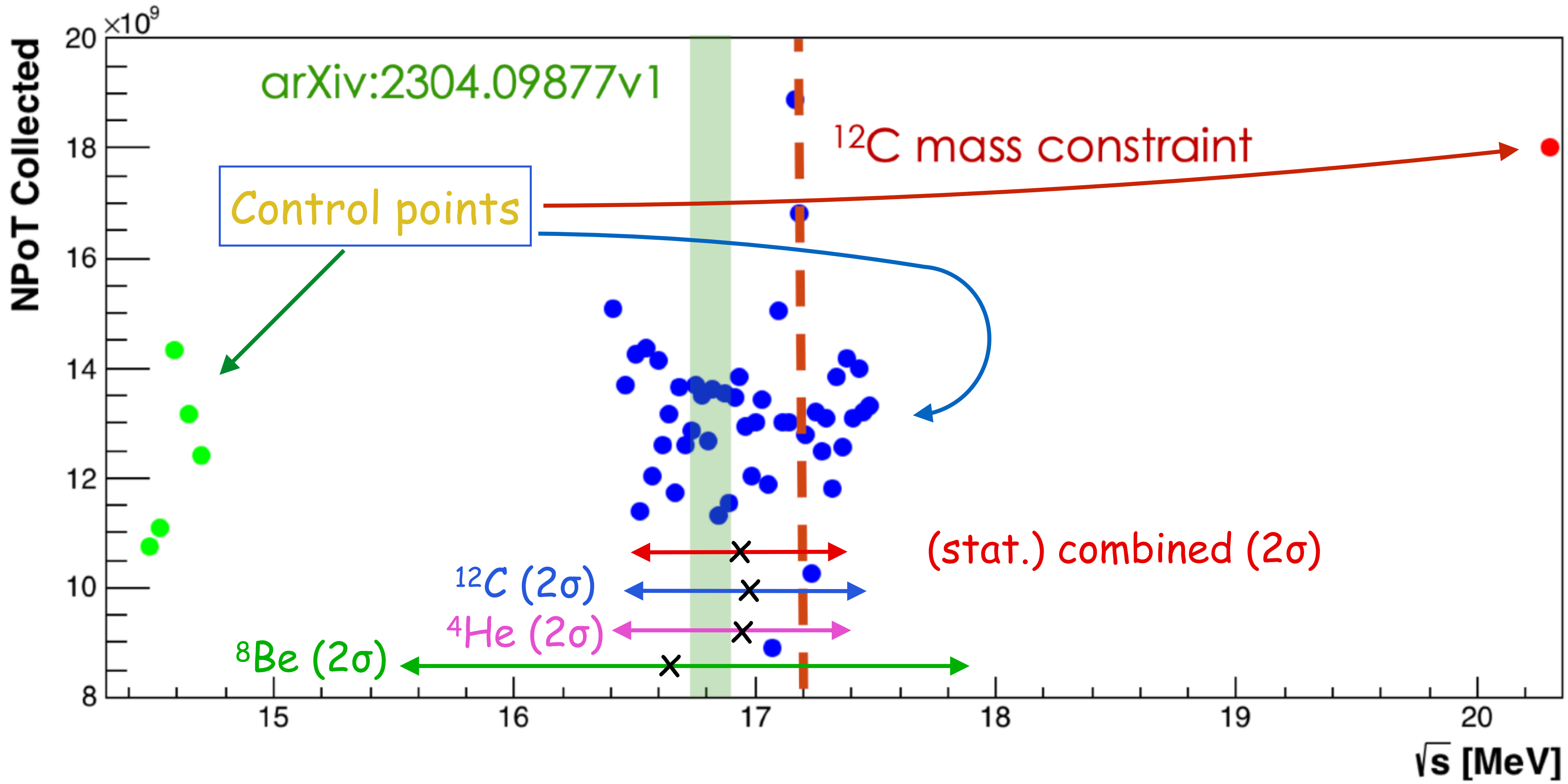



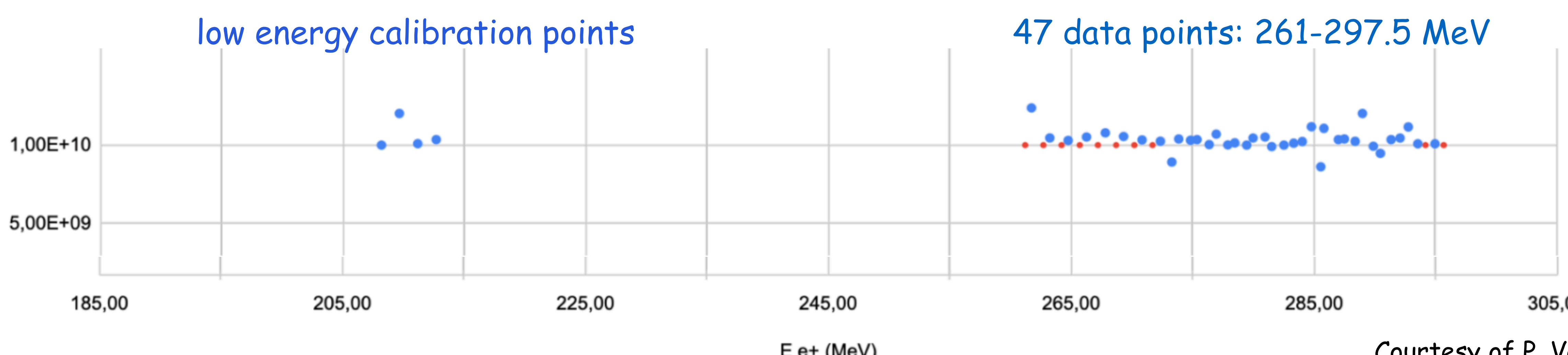



# Resonant search for the X17 boson at PADME

## Final status of data taking (23 Dec 2022)




Courtesy of P. Valente

# Resonant X17 search at PADME: EXCLUSION

- E. Nardi, C. Carvajal, A. Ghoshal, D. Meloni, M. Raggi PRD97 095004 (2018)
- L. Darme, M. Mancini, E. Nardi, M. Raggi arXiv:2209.09261 [hep-ph]

- Our exp. colleagues have been collecting data at $E_{beam} \sim 290$MeV
- Control of beam parameters was excellent, better than we expected
- Our projections indicate that the spin-1 $X_{17}$ can be fully tested
- Spin-0 pseudoscalar only partially (but a $0^-$ particle is $^{12}C$ disfavoured)

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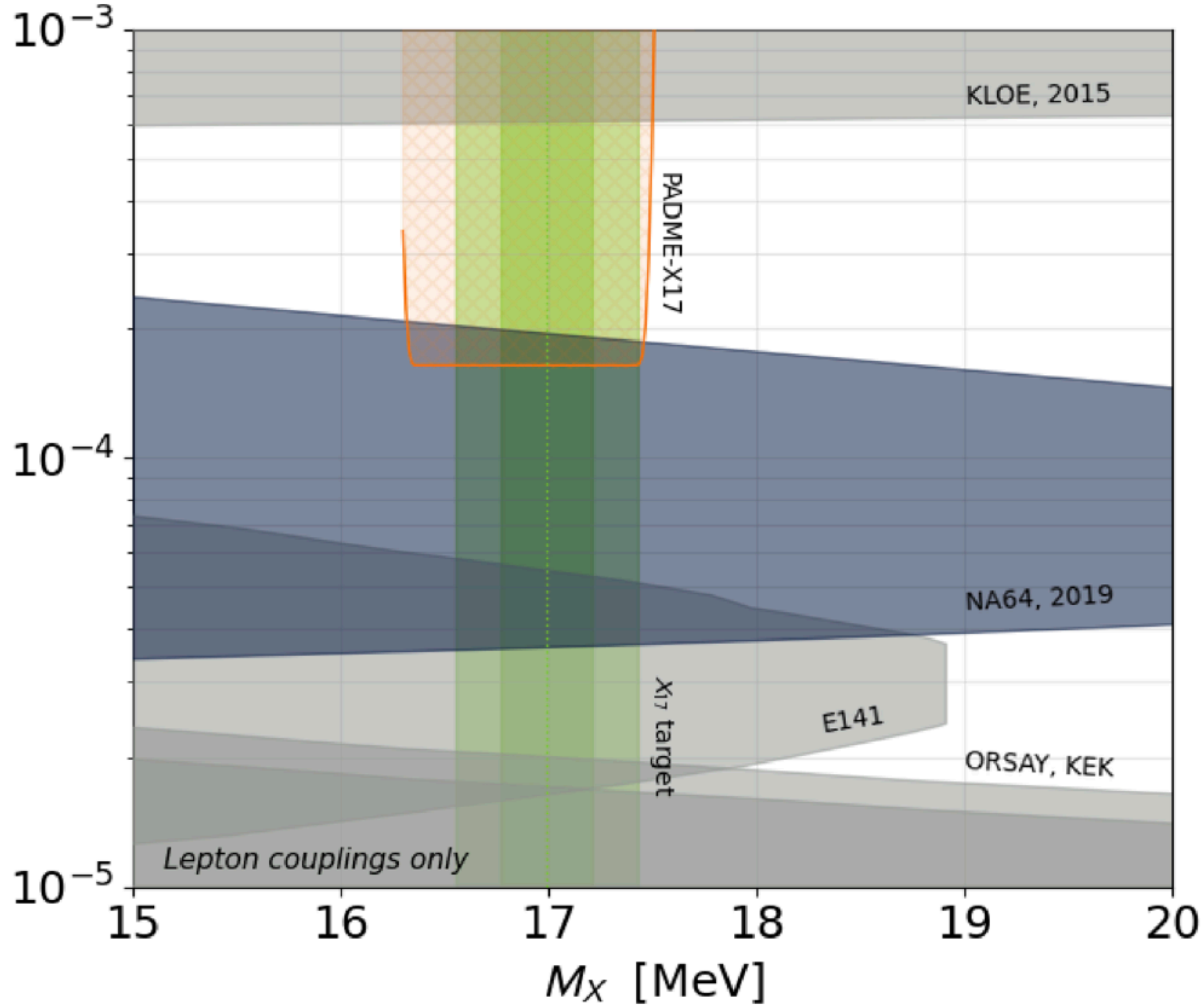
Vector




Courtesy of L. Darmé

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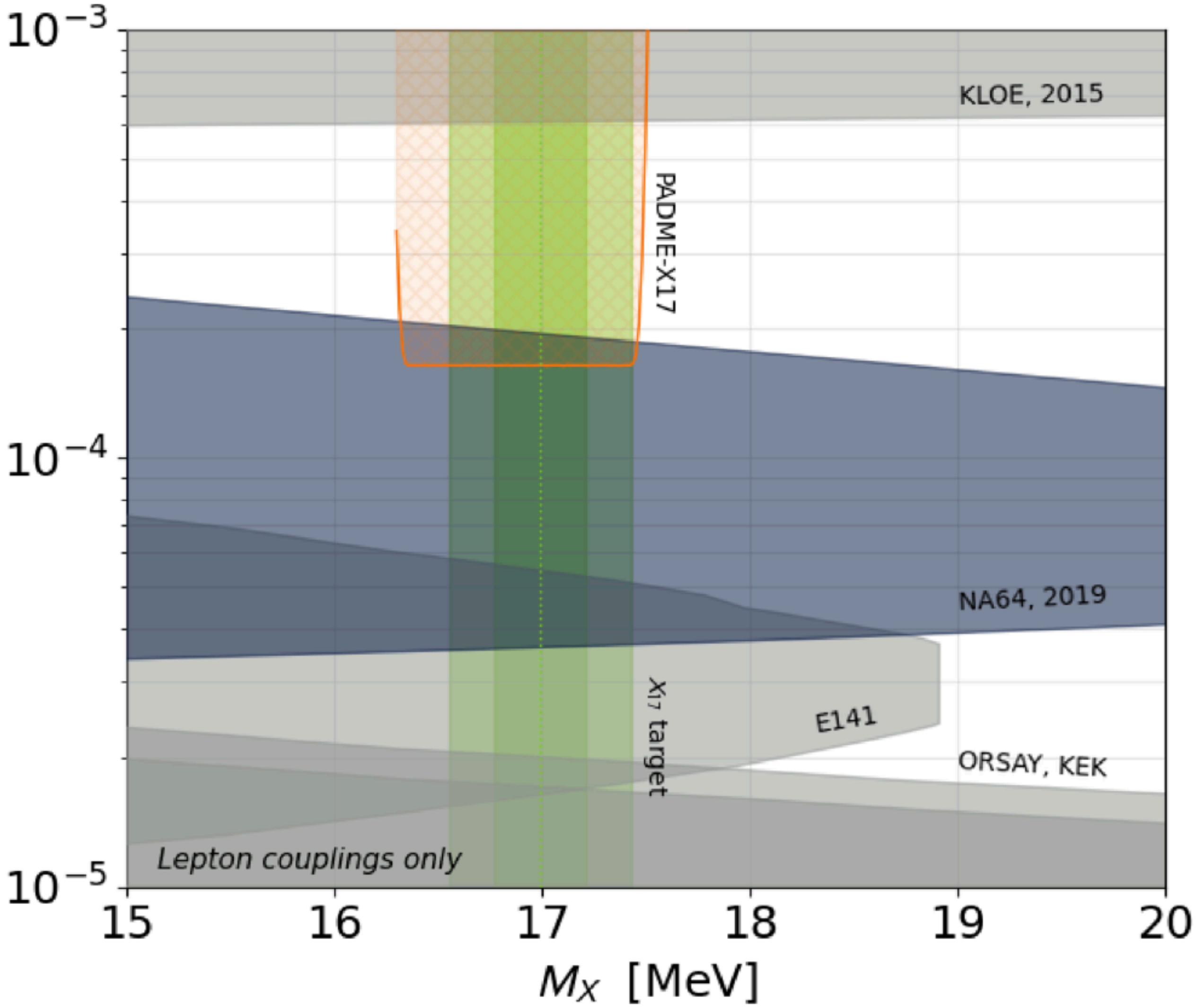
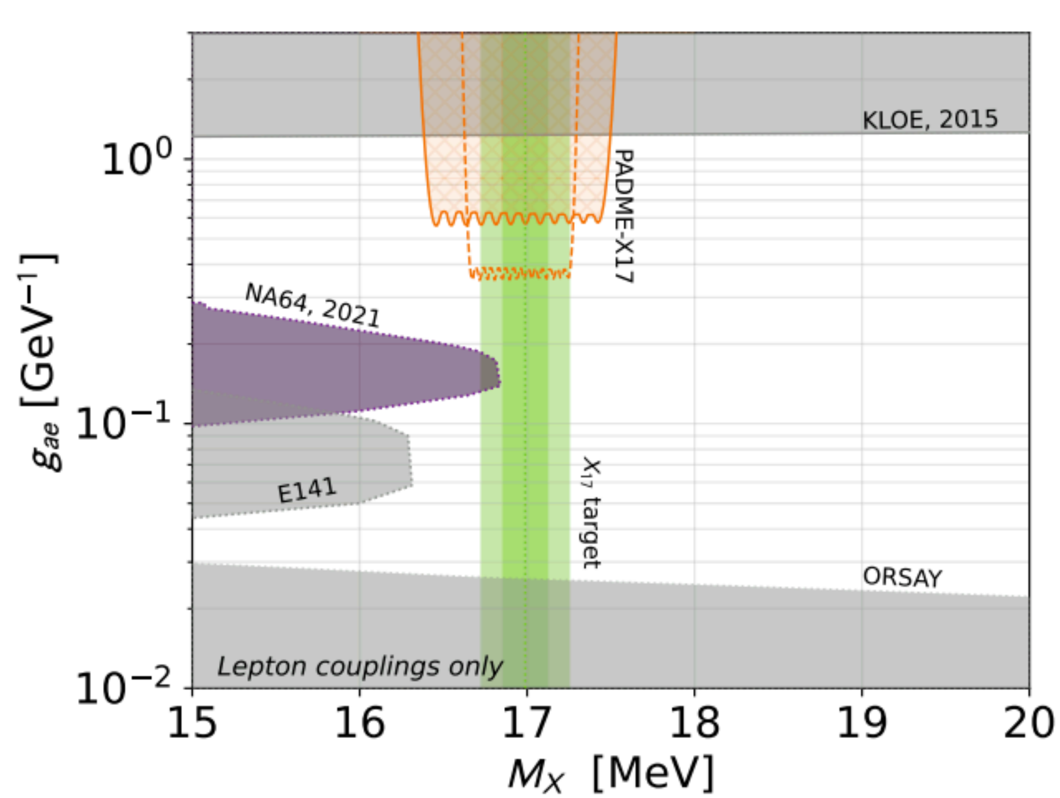



Pseudoscalar

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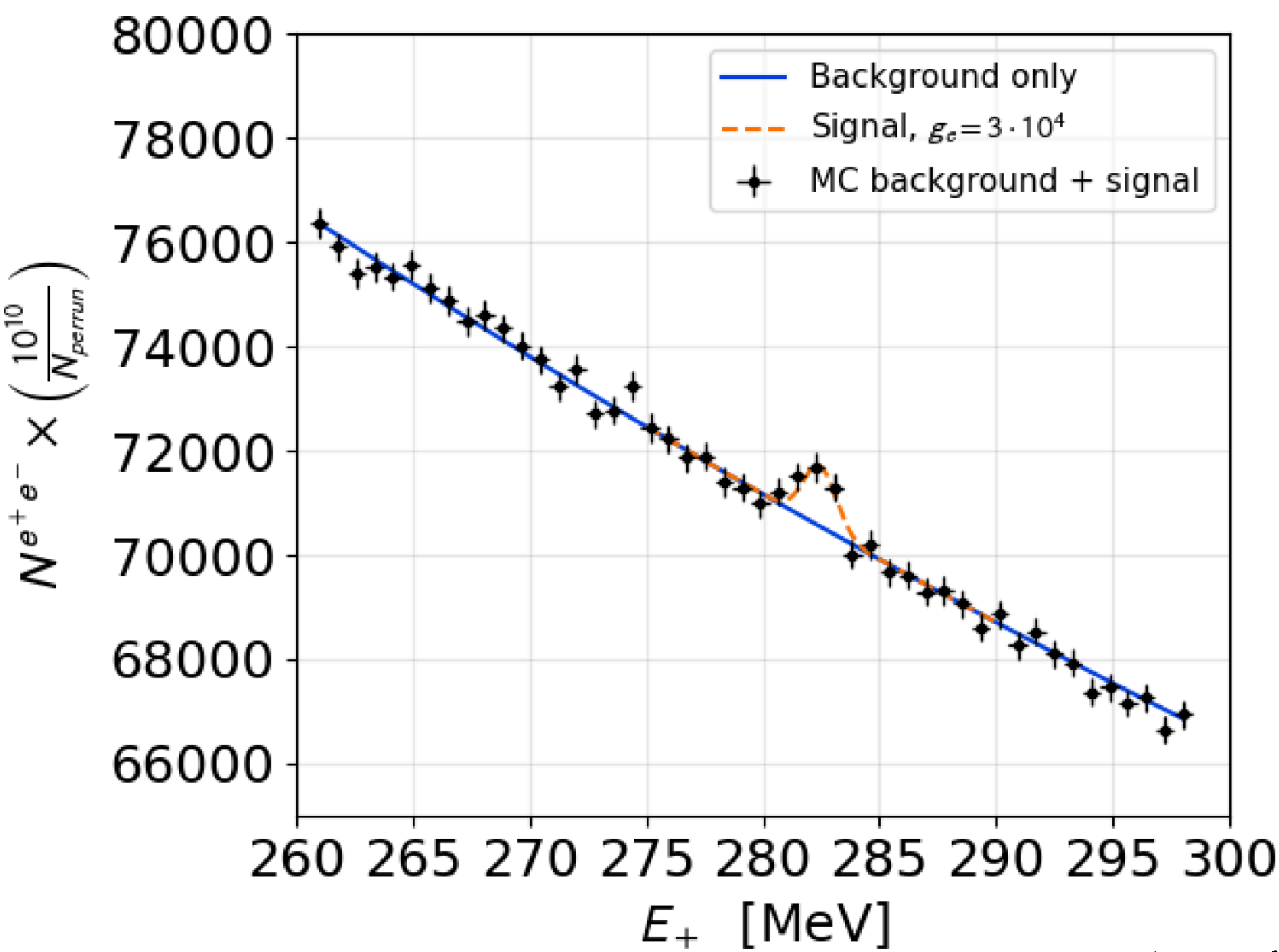


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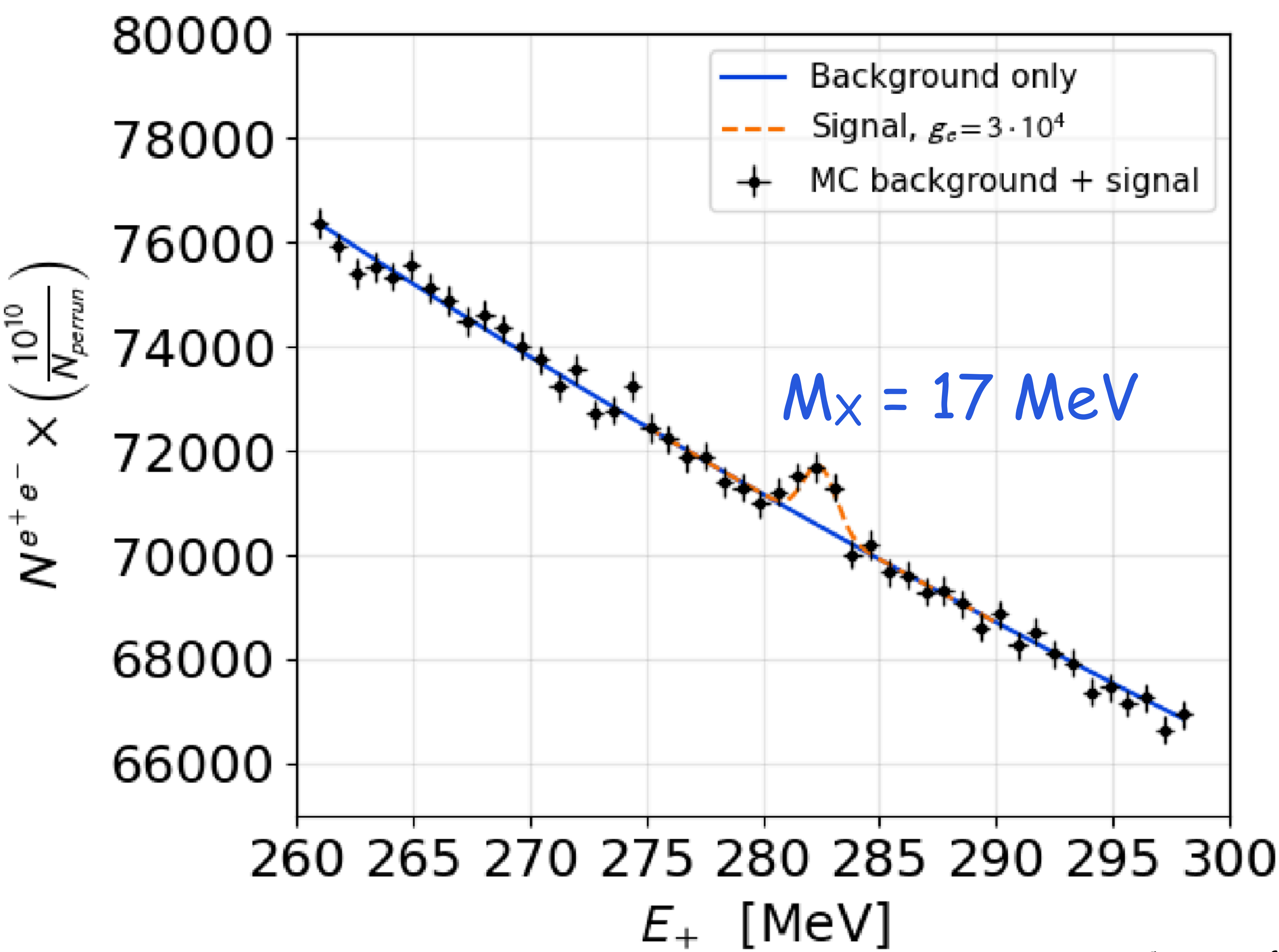


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# Conclusions

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- Statistical evidence is very strong (~ 7σ for each nucleus)
- Explanations via higher order nuclear effects, interferences, higher multipoles contributions, are theoretically (strongly) disfavoured…
- Present data from a single experiment. (see, however, Hanoi, 22/08) Additional independent validations are needed.
- Intense effort for new Nucl. Phys. experiments is ongoing. First results expected not earlier than 2024.
- Being of a completely different nature, a particle physics experiment like PADME can be decisive to validate/disprove the $X_{17}$ hypothesis.

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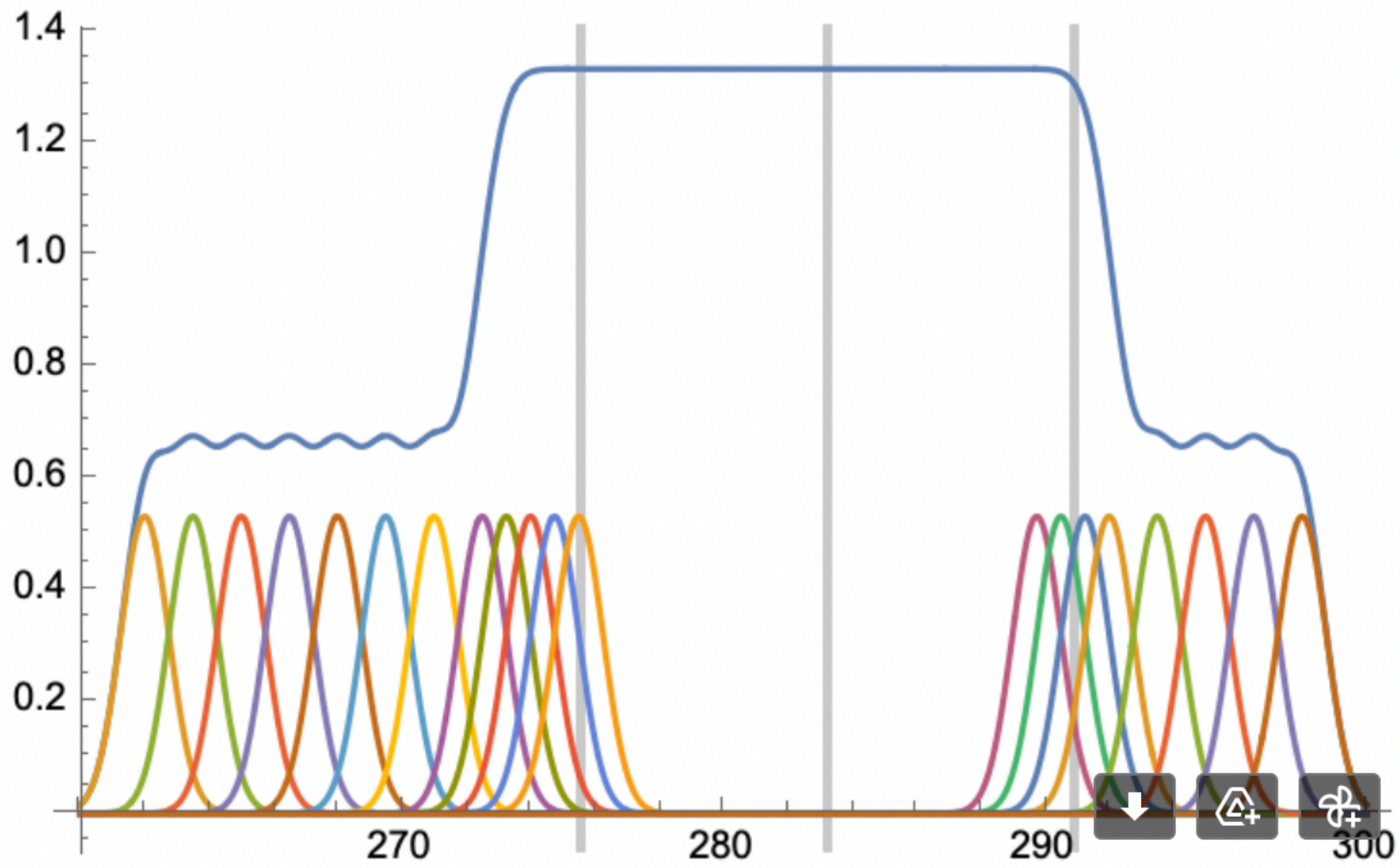
Acknowlegments:

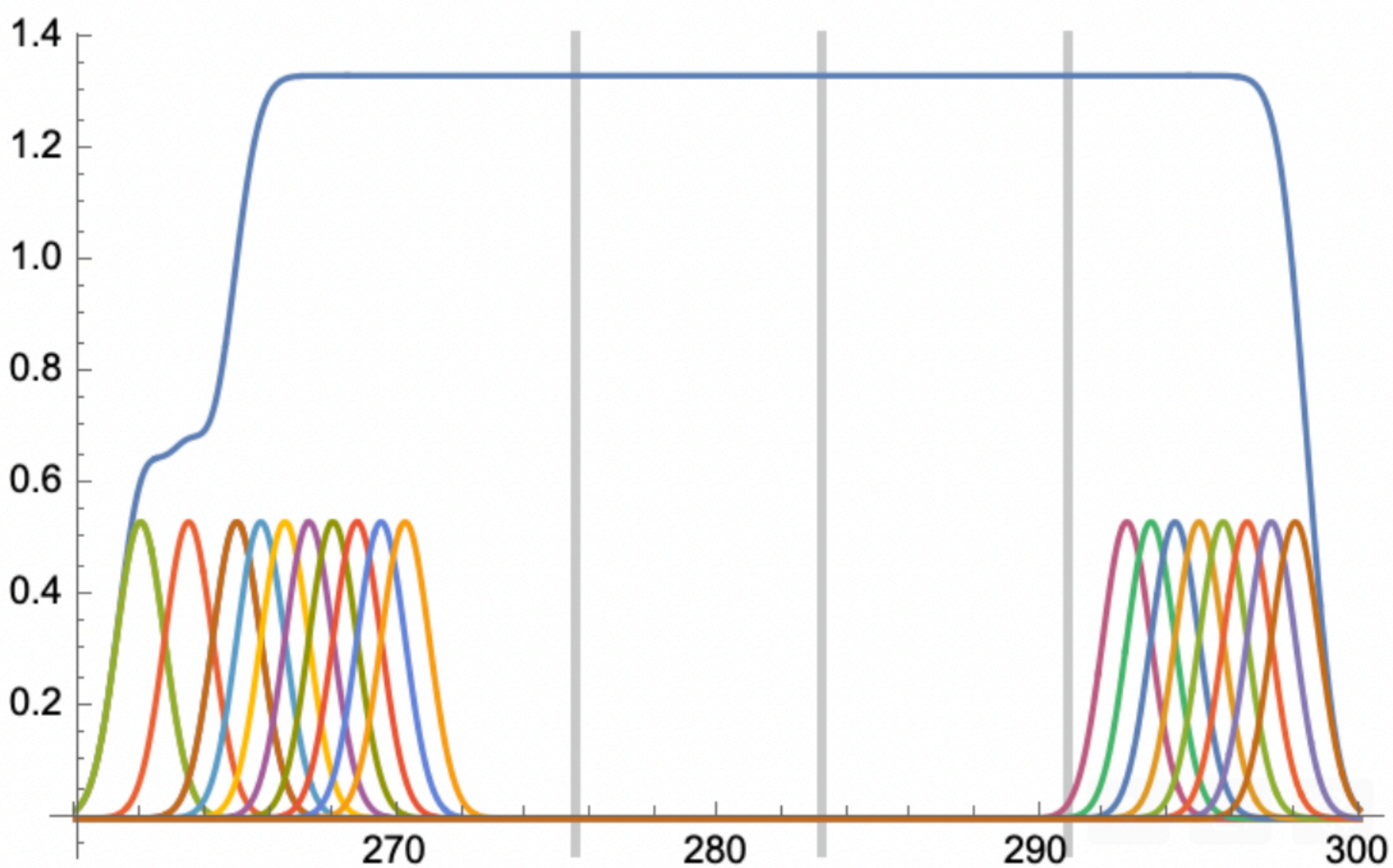
Luc Darmé (IP2I, Lyon. Previously Cabibbo fellow @ LNF)

Paolo Valente, Mauro Raggi & the PADME team

Luca Foggetta & the BTF team



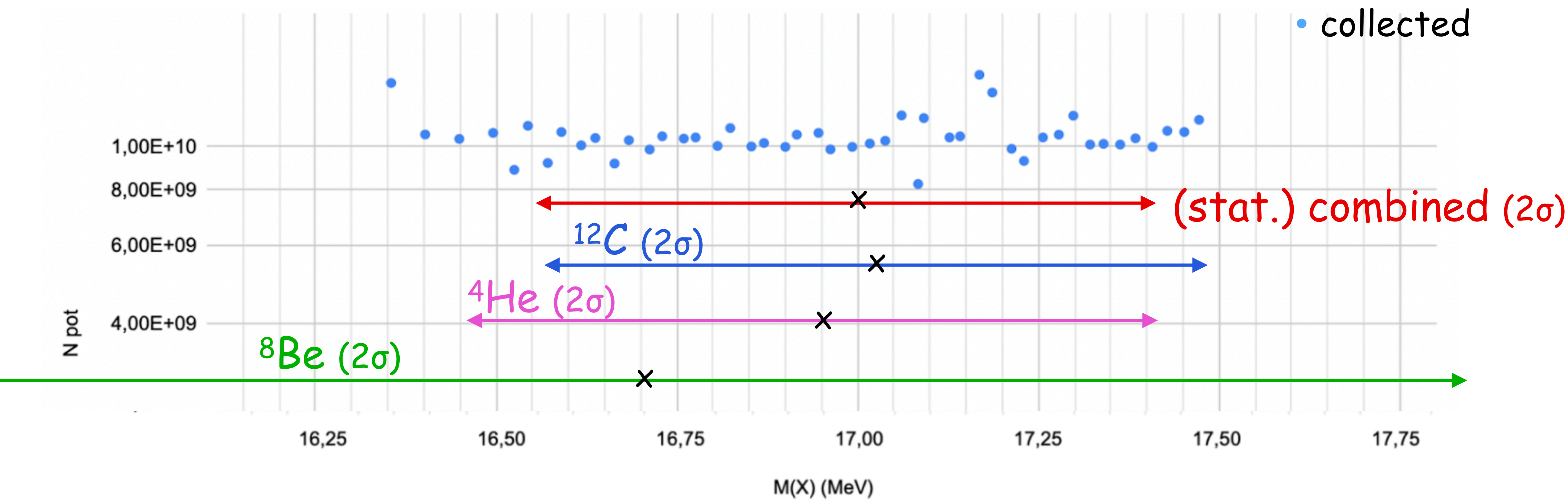

38 points
15 Dec. 2022

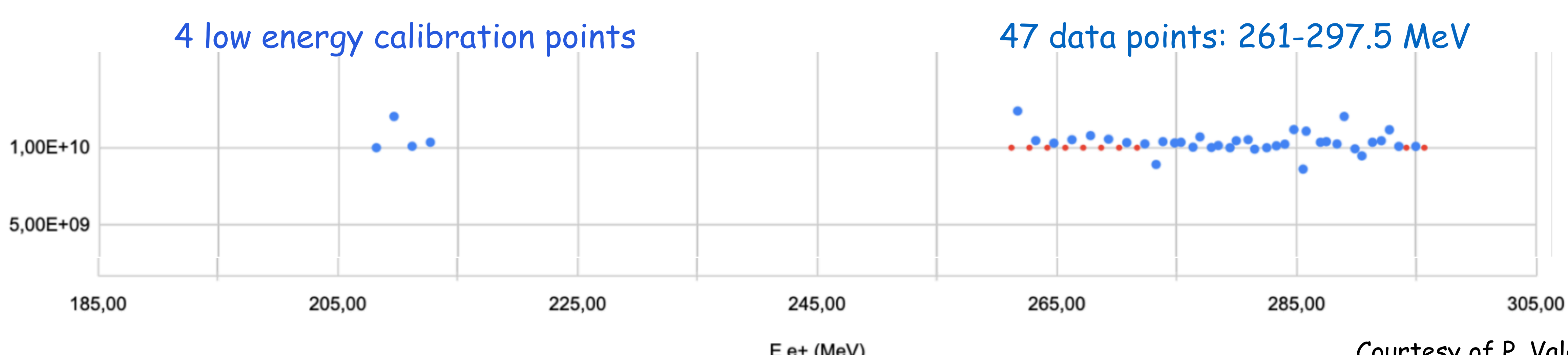



38+9 points
23 Dec. 2022

# Resonant search for the X17 boson at PADME

# Final status of data taking (23 Dec 2022)




Courtesy of P. Valente

# LKB 2020 result from $^{87}$Rb recoil velocity

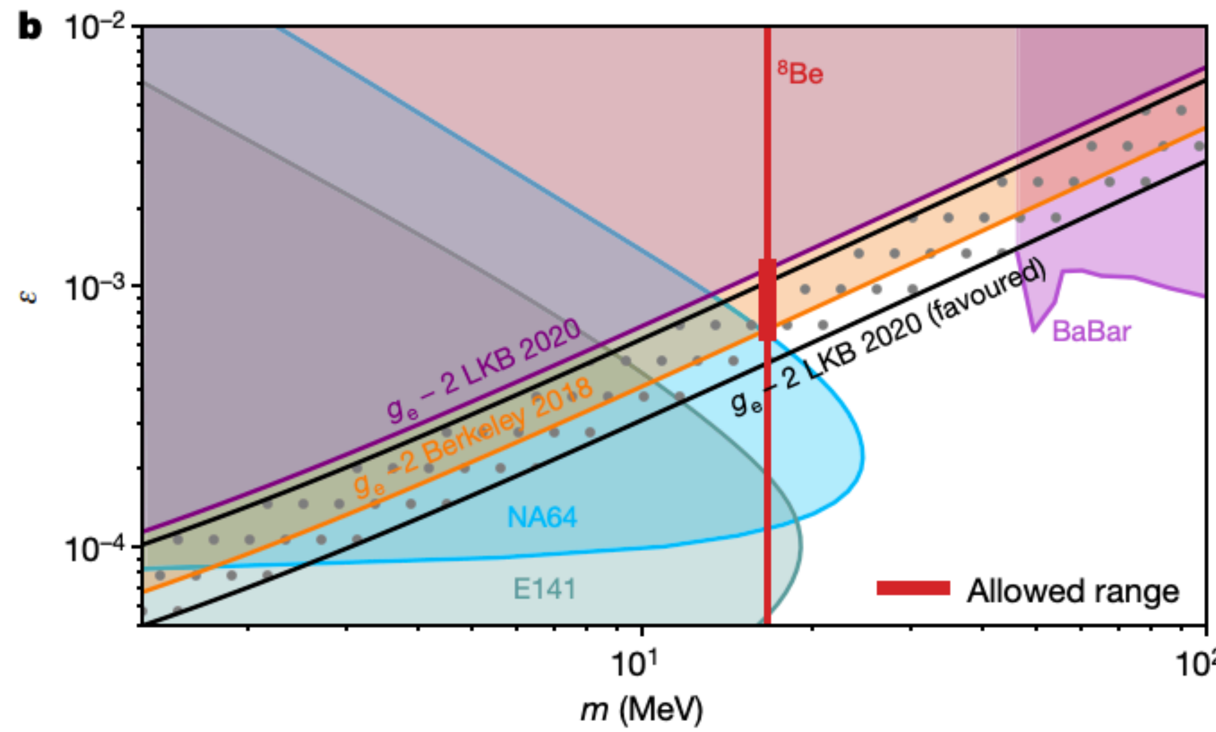
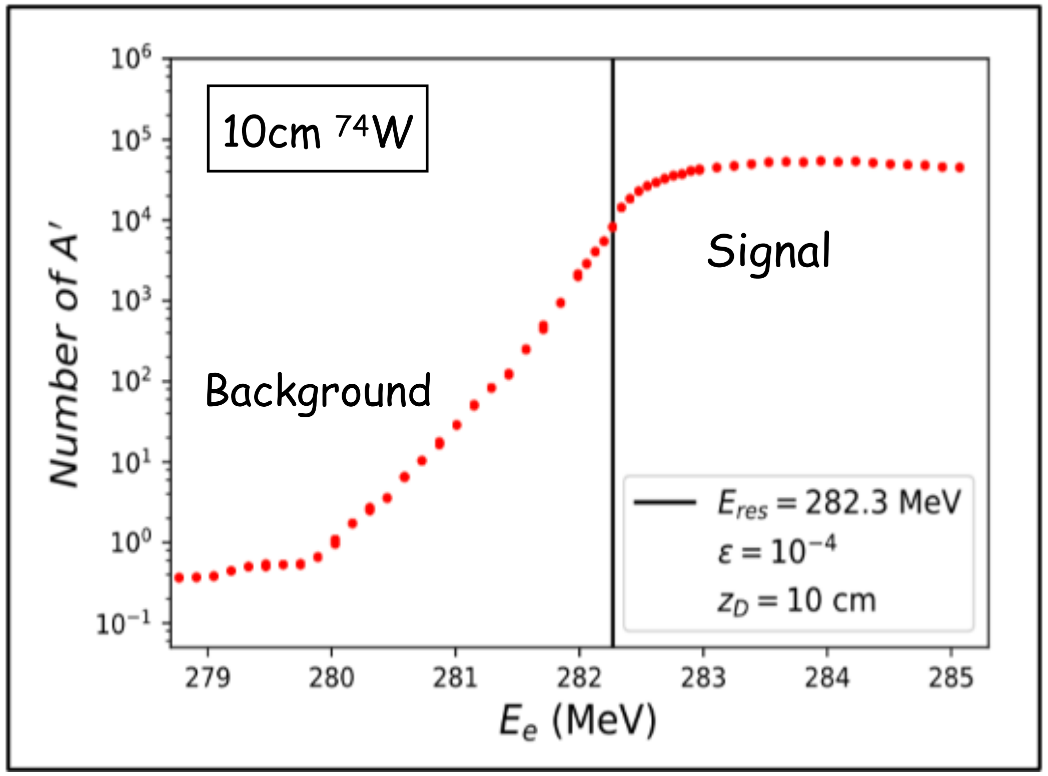



**Fig. 4 | Impact on the test of the standard-model prediction of $a_e$ and limits on hypothetical $X$ boson. a**, Summary of contributions to the relative uncertainty on $\delta a_e$. The horizontal green line corresponds to the $\delta a_e$ value obtained by taking into account the muon magnetic moment discrepancy and using a naive scaling model. Previous data from ref. [9] (Harvard 2008), ref. [18] (LKB 2011), ref. [3] (Berkeley 2018), ref. [13] (Atomic Mass Evaluation, AME 2016), ref. [14] (Max-Planck-Institut für Kernphysik, MPIK 2014) and ref. [2] (RIKEN 2019). Also shown are the 10th-order and hadronic contributions in the calculation of the electron moment anomaly. **b**, Exclusion area in ($\varepsilon$, $m_X$) space for the $X$ boson. The grey, blue and light purple regions are ruled out by the E141[31], NA64[32] and BaBar[35] experiments, respectively. A test based on the magnetic moment of the electron rules out the orange region when using the Berkeley measurement[3] and the purple region when using the present result. Disregarding the Berkeley measurement, the remaining allowed range at 16.7 MeV is depicted by the thick red line. The zone favoured by $\delta a_e > 0$, as deduced from this work, is shown by grey dots.

# Several other advantages, as e.g. measurement of background

- $E_{beam}$ below/above resonance
- Shoot with an $e^-$ beam



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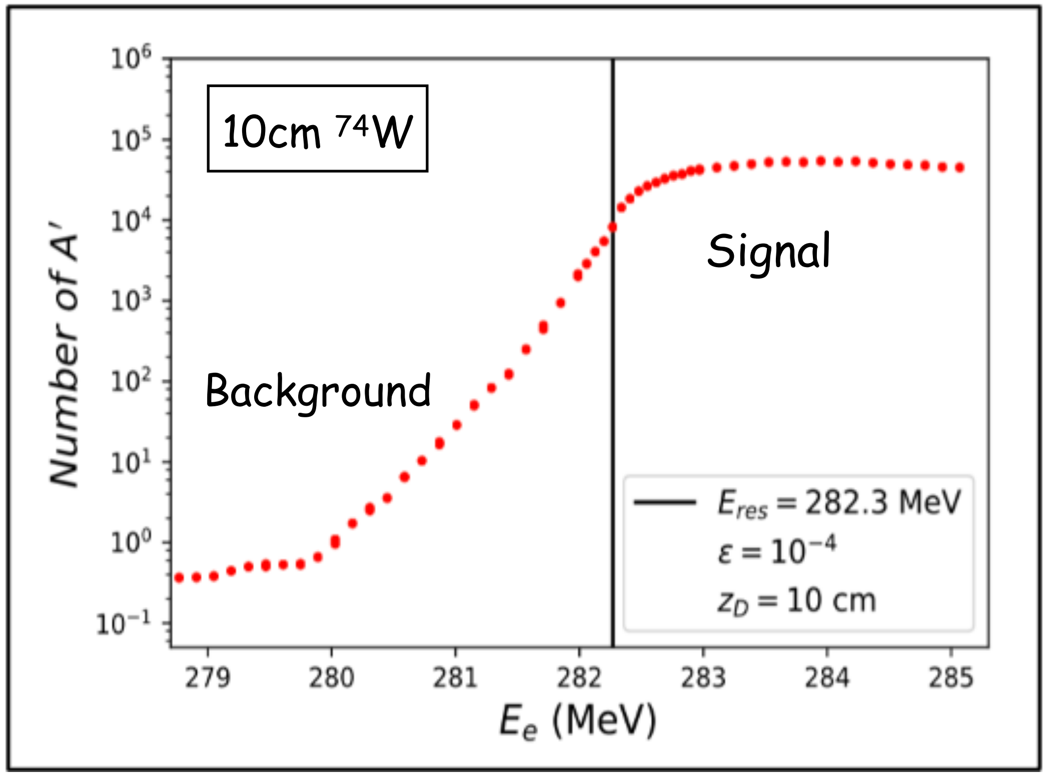


- Although not optimal for X —> $e^+e^-$ detection/reconstruction (conceived for $e^+ e^-$ —> $\gamma$ $X_{invis.}$) the existing PADME detector can be used (with minor upgrades)
- Beam tests at 280-290 MeV will be performed soon (weeks)
- Physics run most probably only after the summer 😠