The X_{17} resonant research at PADME

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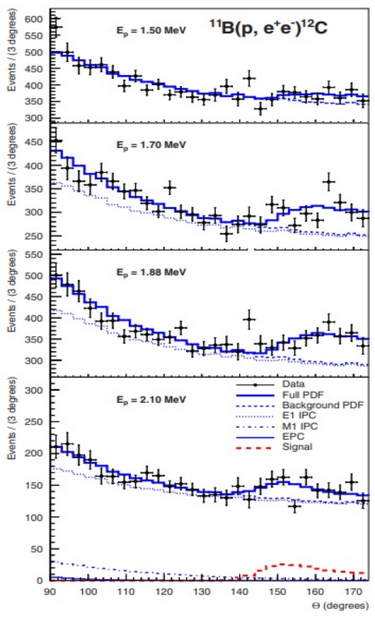
The X_{17} anomaly

Anomaly in the angular correlation of e^+e^- pairs emitted via Internal Pair Creation (ATOMKI anomaly) in ^8Be, ^4He and ^{12}C nuclear transitions [1].
Main properties of the hypothetical new particle:



- $m_{X_{17}} \simeq 17\ \mathrm{MeV}$
- $\frac{\sigma(e^+e^-\to X_{17})}{\sigma(e^+e^-\to\gamma\gamma)} \simeq 5\times10^{-6}$
- $\Gamma_V \simeq 0.5 \left(\frac{g_V}{0.001}\right)^2$ eV for the vector case

$J_* = L \oplus J_0 \oplus J_X$ and $P_* = (-1)^L P_0 P_X$ to identify the nature of the particle [2]

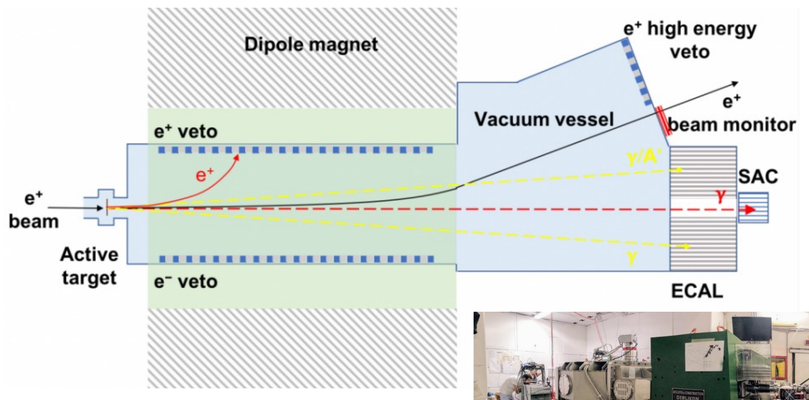
N_*	J^P_*	Scalar X17	Pseudoscalar X17	Vector X17	Axial Vector X17
^{8}Be(18.15)	1^+	✗	✓	✓	✓
^{12}C(17.23)	1^-	✓	✗	✓	✓
^{4}He(21.01)	0^-	✗	✓	✗	✓
^{4}He(20.21)	0^+	✓	✗	✓	✗

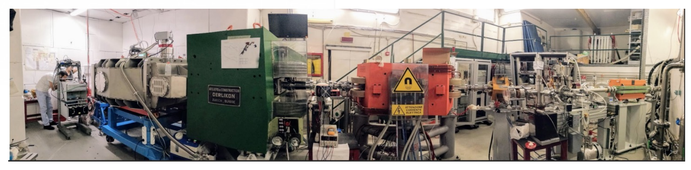
^{12}C Last results

PADME experiment

The Positron Annihilation into Dark Matter Experiment @LNF searched A' in the $e^+e^- \to \gamma A'$ process during Run I and II

- e^+-beam ($E < 550$ MeV) on 100μm diamond target
- Dipole B-field bends out un-interacting beam and charged particles
- Electromagnetic Calorimeter (ECal) to measure photons
- Small Angle Calorimeter (SAC) Bremm. rejection behind ECal hole
- Charged particle vetoes of plastic scintillator bars





The PADME Run III

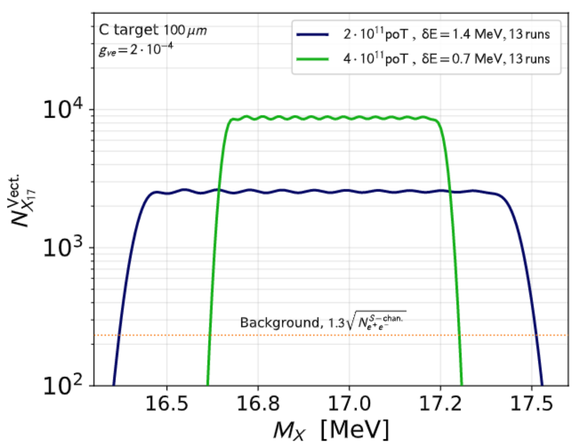
Production mechanism

Resonant annihilation: $e^+e^- \to X_{17}$ and search for visible decays into e^+e^-

$$\sigma_{res}(\sqrt{s}) = \frac{12\pi}{m_{X_{17}}^2} \frac{\Gamma_{X_{17}}^2/4}{\left(\sqrt{s} - m_{X_{17}}\right)^2 + \Gamma_{X_{17}}^2/4}$$

@PADME $\sqrt{s} = \sqrt{2m_e E_{beam}}$ and $\sigma_{res}(\sqrt{s})$ increases if $\sqrt{s} = m_{X_{17}}$

→ invariant mass scan procedure [4,5]



g_{V_e} vector-electron coupling

Gaussian beam spread → σ_E beam energy spread

$$N^{perPoT}_{X_{17}} \simeq \frac{g^2_{V_e}}{2m_e} \ell_{tar} \frac{N_A \rho Z}{A} f\left(\frac{m^2_{X_{17}}}{2m_e}, E_{beam}\right)$$

Main SM background processes: Bhabha scattering & $\gamma\gamma$-production → Improvements of experimental setup

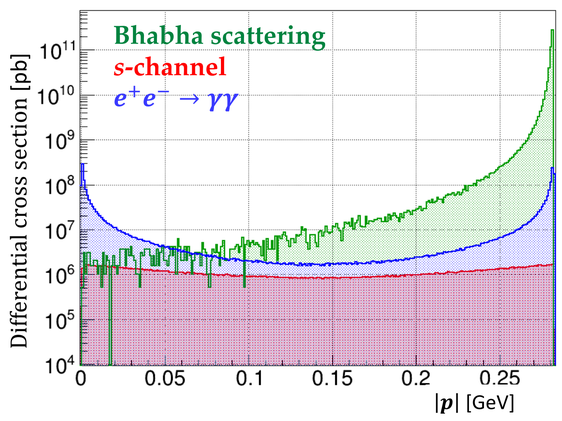
Analysis strategy

Fixed target experiment: *s*- and *t*- channel kinematics can be distinguished

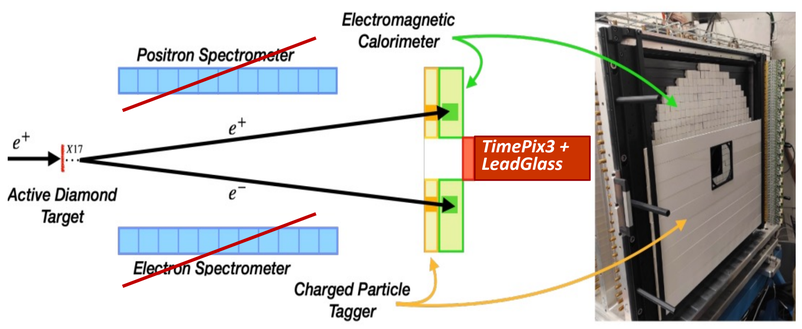
→ X_{17} resonant production has same acceptance of Bhabha *s*-channel

→ Full Bhabha scattering strongly boosted in forward direction

→ Set of cuts selecting events in central region where background is comparable to the signal



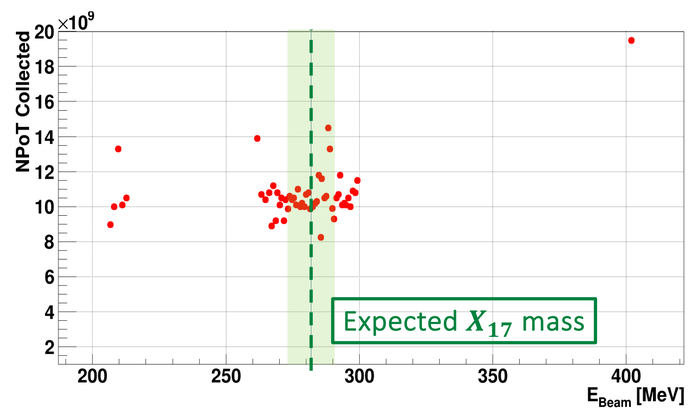
Run III experimental setup:
B-field off to detect final state particles with ECal and ETagger

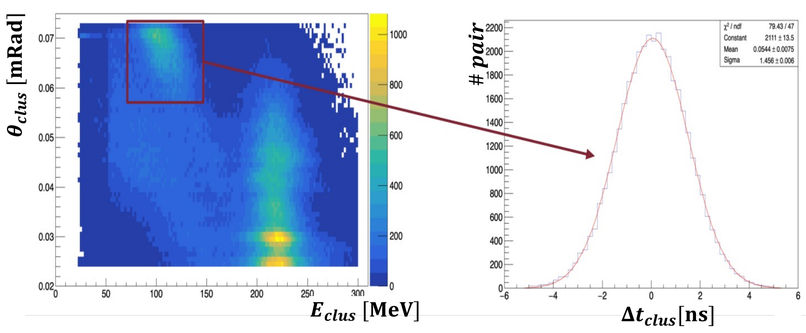


Collected data

Data taking lasted 3 months at the end of 2022

- Acquired luminosity $\sim 6\times10^{11}$ PoT:
- 47 points in $260 < E_{beam} < 300$ MeV with $\sigma_E \simeq 0.7$ MeV
- 5 points in $205 < E_{beam} < 212$ MeV
- 1 point at $E_{beam} = 402$ MeV





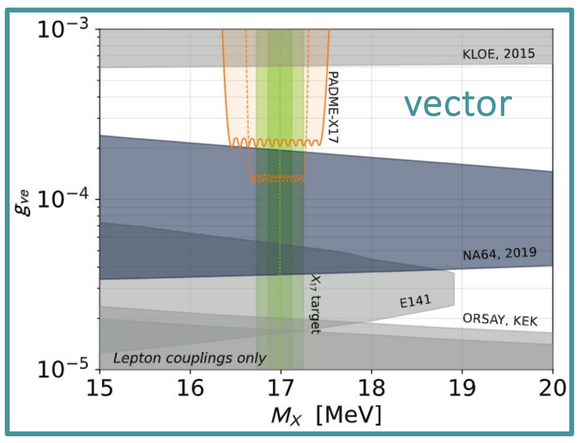
Out-of-resonance points:

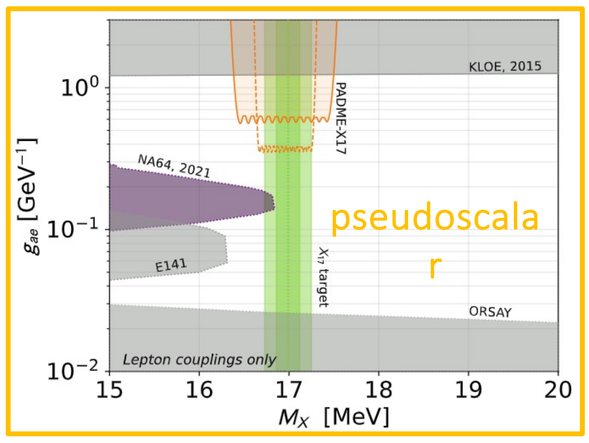
- Using kinematic relation between E_γ and θ_γ → very good signal to background separation
- Pure SM measurements
- Comparisons with data and PADME full MC [6]

Preliminary results and conclusions

The data analysis is in progress

- PADME will set stringent limits on both vector and pseudoscalar hypotheses [5]
- Measurements of cross sections of involved SM processes below 20 MeV will be performed





References

[1] A. J. Krasznahorkay et al, Phys. Rev. C, 106(6):L061601 (2022)
[2] J. Feng et al, Phys. Rev. D, 102(3):L036016 (2020)
[3] P. Albicocco et al, JINST, 17(08):P08032(2022)
[4] E. Nardi et al, Phys. Rev. D, 97(9):L095004 (2018)
[5] Darmè et al., Phys. Rev. D, 106:L115036(2022)
[6] F. Bossi et al, JHEP, 09:233 (2022)

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