PADME experiment status

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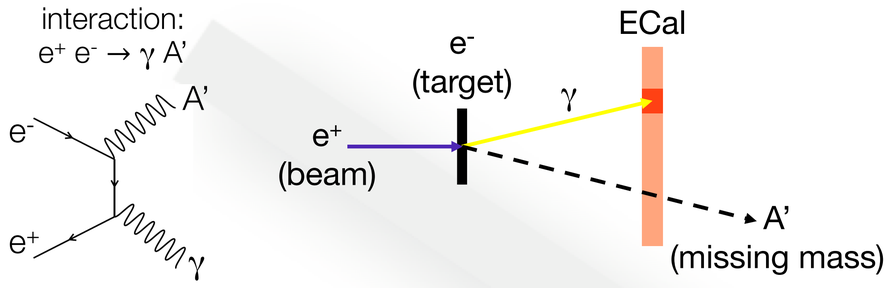
ABSTRACT

The difficulty in the Dark Matter (DM) detection can be solved under the hypothesis that this interacts with the Standard Model (SM) gauge fields only by means of "portals", which connect our world with this dark sector. The simplest model only adds a new U(1) symmetry with its vector boson A', called Dark Photon (DP): SM particles are neutral under this symmetry, while A' can mix with the photon and couple to SM particles with an effective charge εe, with ε coupling constant and e electric charge.
Depending on the model, the DP could explain not only DM, but also the discrepancy between theory and experimental results on the muon (g-2) and the ^{8}Be anomaly.
PADME (Positron Annihilation into Dark Matter Experiment), hosed at Laboratori Nazionali di Frascati (Rome, IT), is dedicated to the search of an A' that decays in DM particles.

THE WORKING PRINCIPLE

PADME is designed to search for A' produced in e^+/e^- annihilations, looking for missing mass (→ invisible decay) in a kinematically constrained condition.



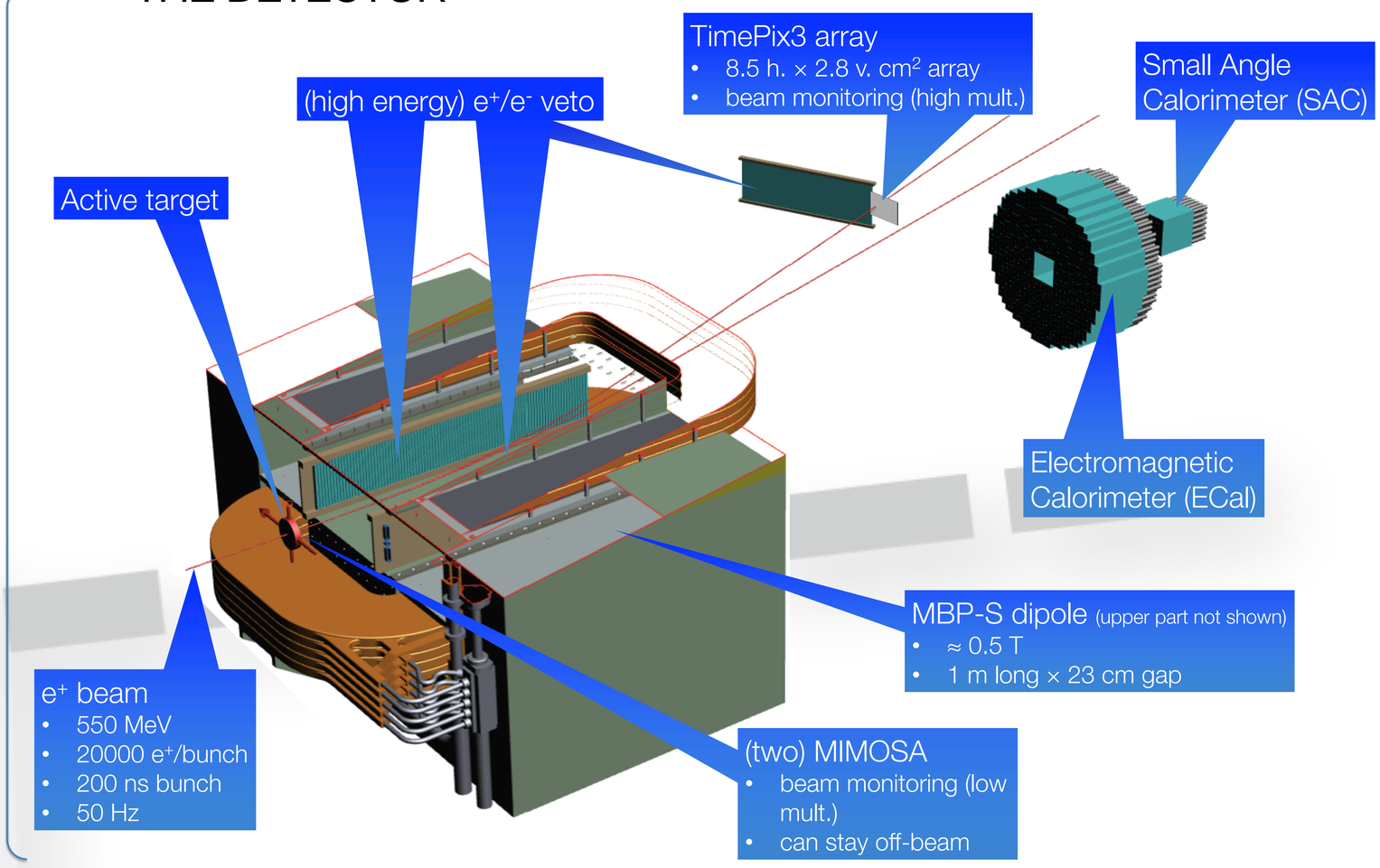
- known beam energy and position
- measured photon energy and position

$$m^2_{Miss} = \left(\boldsymbol{P}_{beam} + \boldsymbol{P}_{e^-} - \boldsymbol{P}_{\gamma}\right)^2$$

A' experimental signature
Single γ in the calorimeter and nothing in the other detector components.

- Minimal model dependent assumptions: A' couples to leptons
- Can set limits on coupling of any new light particle that can be produced in e^+/e^- annihilation: DP, ALPs, Dark Higgs

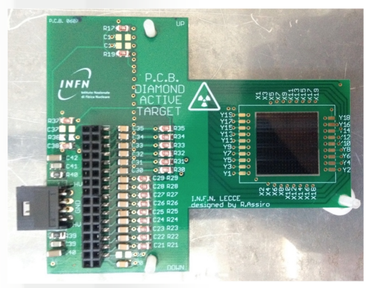
THE DETECTOR

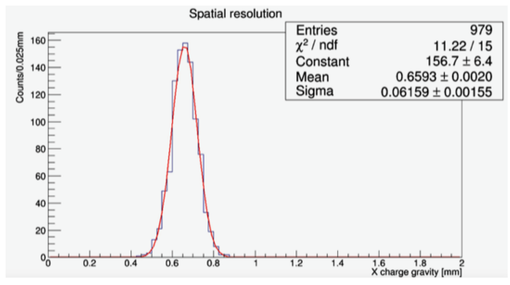


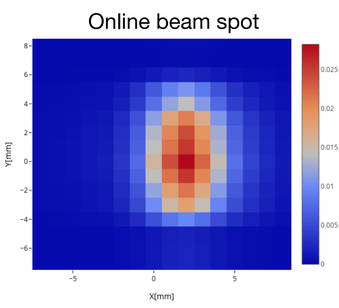
DETECTOR STATUS

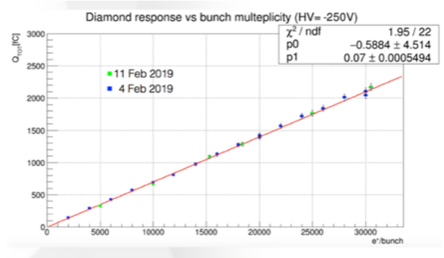
Active target

- Diamond (low Z, reduced Brems.)
- Dim.: 20×20×0.1 mm³
- 19 (x) × 19 (y) active graphitic strips (1 mm pitch, 0.15 mm interstrip, electric resistance ~2.5kΩ)
- 16 h.×16 v. strips are read
- In vacuum w/ movement system







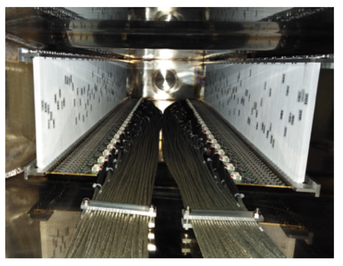


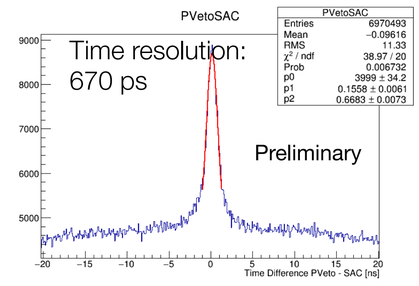
(High energy) e^+/e^- veto

- 96 (e^- veto) + 90 (e^+ veto) + 16 (HEP veto) 1.1×1×17.8 cm³ scintillating plastic bars w/ WS glued ($\tau_{signal\ TOT}$ = 70-100 ns)
- In vacuum and magnetic field (no HEP veto)
- Sampling: 2.5 GS/s, 1024 samples
- SiPM: Hamamatsu S13360 3x3 mm² 25 μm cell
- Custom FEE w/ differential output

From test results:
- >99% eff. using 500 MeV e^+

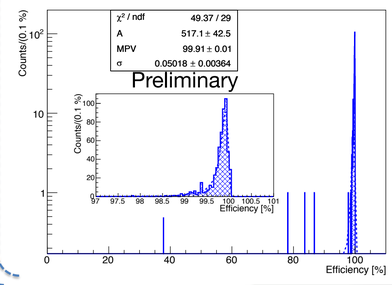
During data taking:
- no dead channel
- (HEP) SiPM temp.: (32-35 °C) 40-43 °C



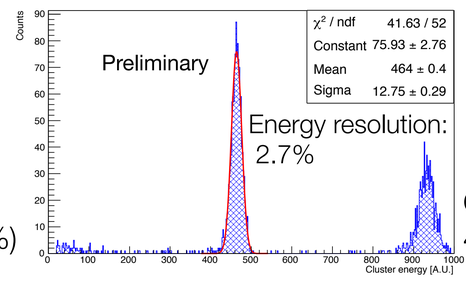


Electromagnetic Calorimeter

- 616 2.1×2.1×23 cm³ scintillating BGO (τ_{decay} = 300 ns)
- Radius ≈ 29 cm, length = 20.5 X_0
- Tedlar between crystals (no honeycomb structure) to reduce light crosstalk
- 3.45 m from the target → angular coverage: [15,84] mrad
- PMT: HZC XP1911
- Central hole (10.5×10.5 cm²) for Brems. to SAC (faster)
- Sampling: 1GS/s, 1024 samples
- W/ current gain (15.3 pC/MeV) Scint. Units (SUs) see γ w/ E_γ < 511 keV

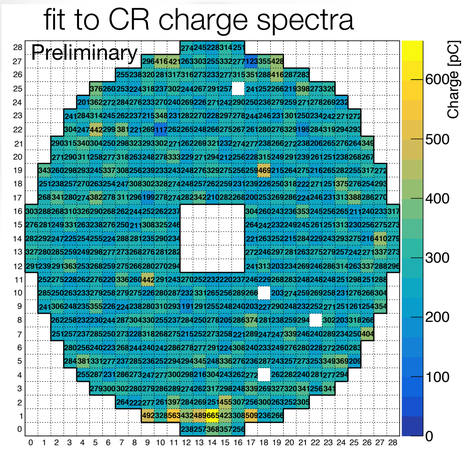


SUs efficiency w/ CRs (> 99%)



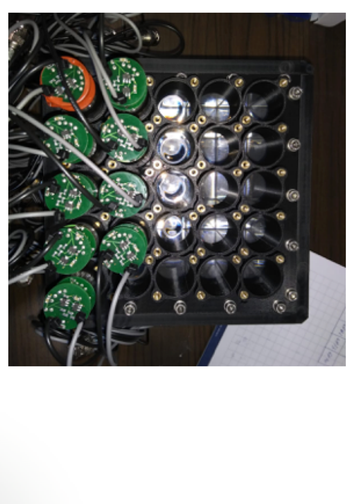
Cluster energy from single 490 MeV e^+ in ECal

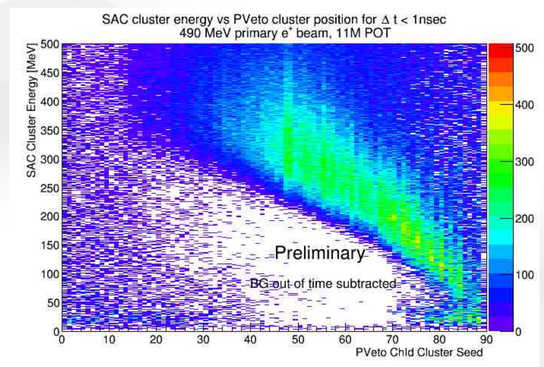
MPVs distribution of Landau fit to CR charge spectra



Small Angle Calorimeter

- 25 3×3×14 cm³ PbF_2 (Cherenkov → $\tau_{signal\ TOT}$ = 3-4 ns)
- 50 cm behind ECal
- Sampling: 2.5 GS/s, 1024 samples
- PMT: Hamamatsu R13478UV
- Angular coverage: [0,15] mrad

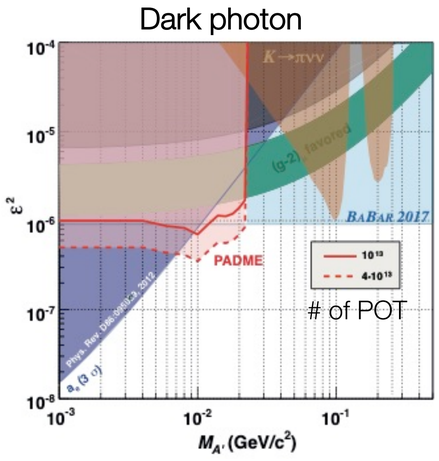




ANALYSIS STATUS

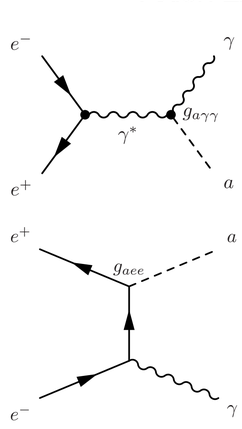
Sensitivity studies

Dark photon

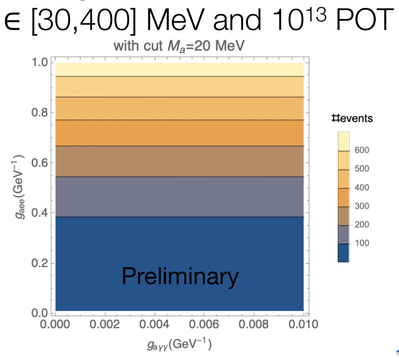


PADME DP sensitivity based on 2.5·10¹⁰ fully GEANT4 simulated 550 MeV e^+ on target events and extrapolated to 10¹³ POT

Axion Like Particles (ALPs)



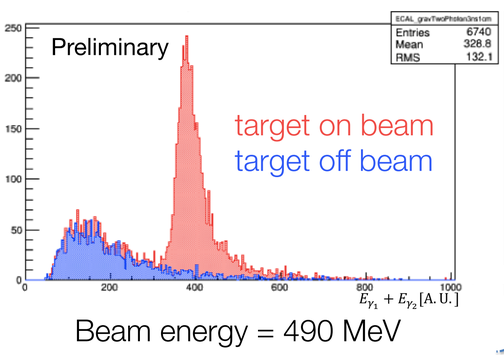
# of ALPs expected in PADME assuming the ECal acceptance, $E_\gamma \in [30,400]$ MeV and 10¹³ POT



Data analysis

First studies on γγ events, cuts:
- only couple of clusters in ECal (→ 2γ, 4γ, …)
- cluster couple charge centre of gravity in a 1×1 cm² square at ECal centre
- Δt < 1 ns to be coupled

~hours of data to reach ~% precision on $\sigma_{e^+e^-} \to \gamma\gamma$ (current results in this energy range have 20%)



Beam energy = 490 MeV