The POKERINO prototype

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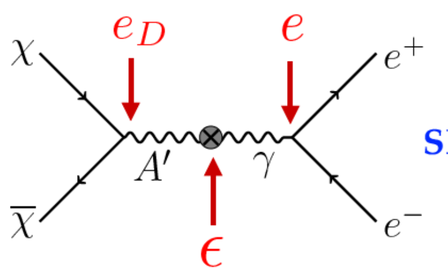
Università di Genova — INFN Genova — POKER (POsitron resonant annihilation into darK matter) — erc European Research Council, Established by the European Commission

Light Dark Matter

- Cosmological and astrophysical observations suggest the existence of Dark Matter but do not solve the puzzle of its microscopic nature.
- The **"Light Dark Matter"** model predicts the existence of new sub-GeV particles, coupled to SM states through a new massive vector boson (Dark Photon/A').

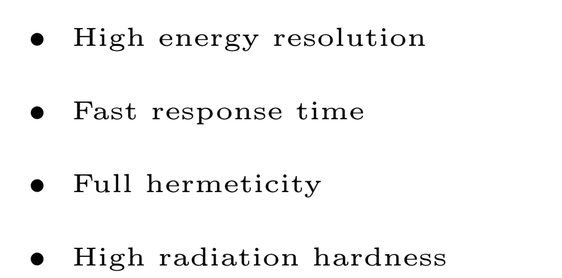
$\alpha_D \equiv \frac{e_D^2}{4\pi}$ **DM** — **SM** $\alpha \equiv \frac{e^2}{4\pi}$



The Missing Energy Technique

Accelerator-based experiments are uniquely suited to explore the Light Dark Matter hypothesis: high intensity / high energy.

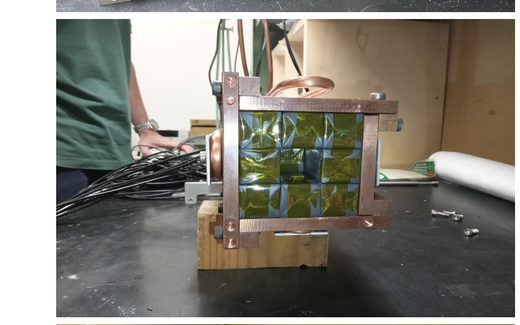
LDM particles can be produced by the beam interaction with a thick target, leaving it without depositing energy.
$\longrightarrow$ **Missing energy measurement**



- **Setup:** e^-/e^+ beam impinging on a thick active target.
- **ECAL:** measures the energy deposited by each particle. $E_{Miss} \equiv E_{Beam} - E_{Dep}$
- **HCAL:** Hermetic veto system.
- **Beam Current:** limited to $\sim$ 1 MHz to reduce pile-up.

Resonant e^+e^- annihilation:

- Closed kinematics: $P_\chi + P_{\overline{\chi}} = P_{e+} + P_{e-}$
- Breit-Wigner like cross section: $M_{A'} = \sqrt{2 m_e E_{e+}}$



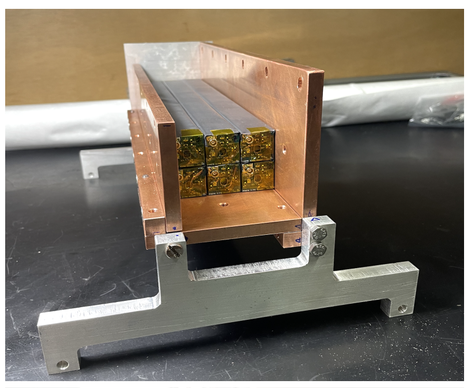
The POKERINO prototype

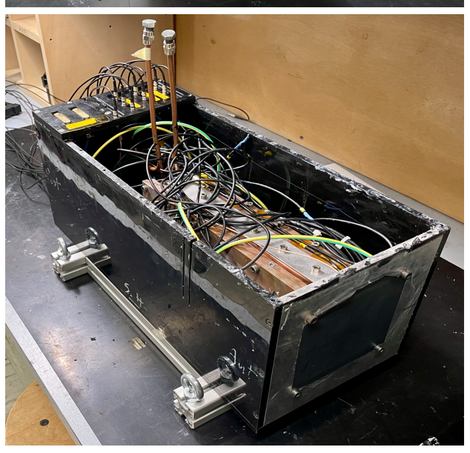
POKER-ECAL requirements:

- High energy resolution
- Fast response time
- Full hermeticity
- High radiation hardness

POKERINO:

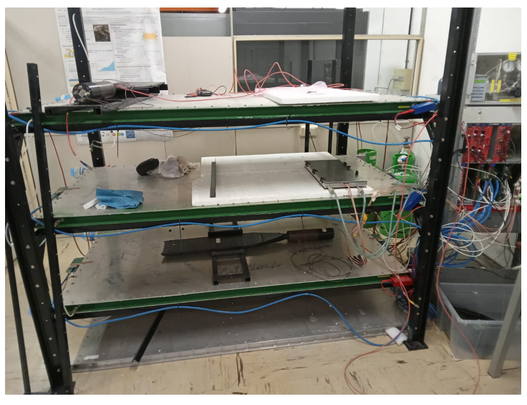
- 3x3 matrix of **$PbWO_4$ crystals** (2x2x25 cm^3) from CRYTUR
- Board with 4 **SiPMs** (Hamamatsu S14360-6010, 10 μm pixel size) glued on each crystal
- Reflective VM2000 and black Tedlar wrapping
- Copper mechanical structure and pipes linked to an outer cooling system
- External light-tight black box

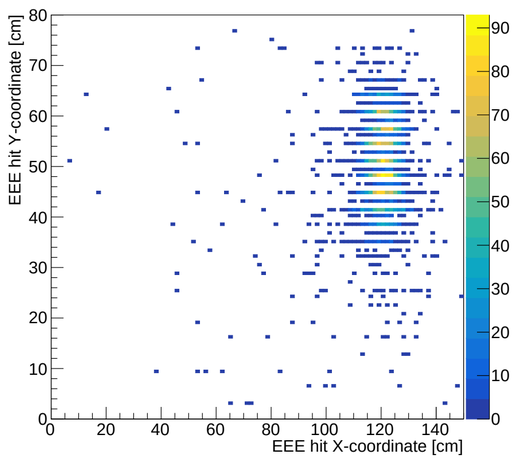


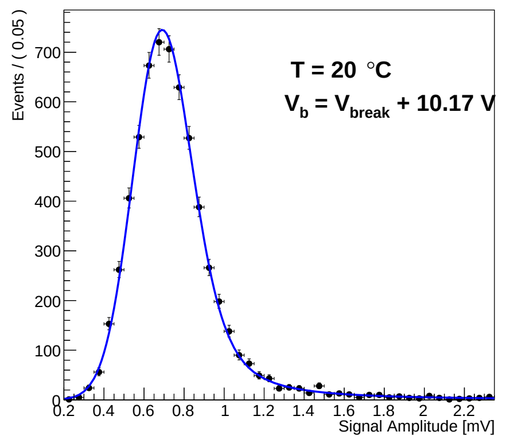


Characterisation with cosmic rays

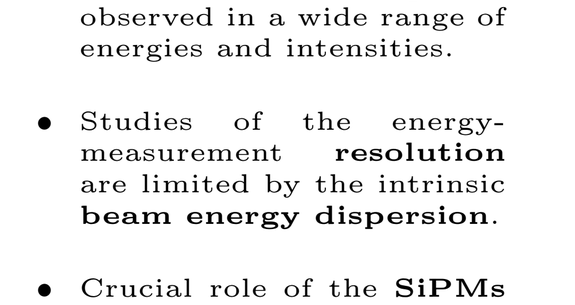
- POKERINO characterisation with the Extreme Energy Events (EEE) **cosmic-ray telescope** in Genova
- Cosmic-ray vertical track selection on wide surface
- POKERINO response agrees with preliminary tests and Monte Carlo simulations







Test Beam @CERN-SPS-H8



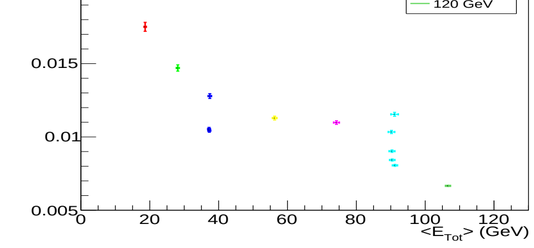
July 2023: a week of measurements at the H8 beamline of the CERN Super Proton Synchrotron (SPS).

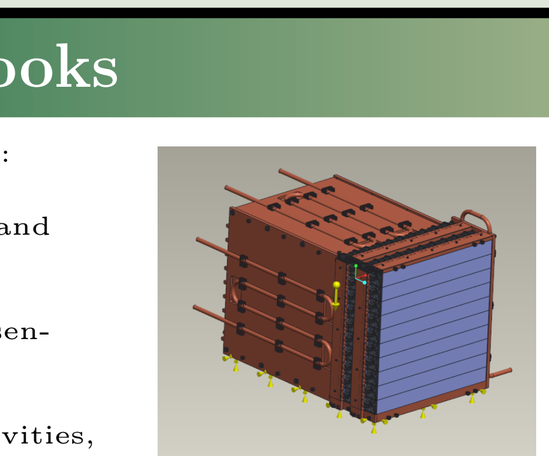
Performed measurements:

- **Pre-calibration** runs with a 180 GeV **muon** beams.
- Cell-by-cell **energy scan** with **positron** beams between 10 GeV and 120 GeV.
- **Higher intensity** runs with $\sim$180 GeV **proton** beams.

Studies and results:

- **Linear detector response** observed in a wide range of energies and intensities.
- Studies of the energy-measurement **resolution** are limited by the intrinsic **beam energy dispersion**.
- Crucial role of the **SiPMs heating**.





Outlooks

Upgrades for the 2024 test @SPS-H6:

- **Tracking system:** impact point and momentum measurements.
- **SiPM boards upgrade:** PT100 sensors directly mounted on them.

For more details about POKER activities, check out A. Marini's poster on Thursday.