The calorimeters of the PADME experiment

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Summary

The PADME experiment [1] will be held at Laboratori Nazionali di Frascati (LNF) of INFN to explore the coupling between ordinary and dark matter (DM). This will be done by detecting the Standard Model (SM) photons produced in the reaction $e^+e^- \rightarrow \gamma A'$ [2]. The measurement of the 4-momentum of the SM photon allows to reconstruct the missing mass spectrum of the process, where the dark photon A' could appear as a peak. Positrons accelerated by the LNF's LINAC at 550 MeV collide with a diamond target, possibly producing γ and A', with $M_{A'} \leq 23.7$ MeV. The Electromagnetic Calorimeter (ECAL), made of 616 21×21×230 mm^3 BGO crystals, is devoted to the γ detection and measurement. The scintillating units composing ECAL are arranged in a cylindrical structure with a central hole. This allows the passage of Bremsstrahlung photons, that otherwise would over-trigger the calorimeter. These photons are then detected by a faster calorimeter (time resolution ~ 90 ps), the Small Angle Calorimeter (SAC), made of 25 30×30×140 mm^3 PbF_2 crystals. The two calorimeters are presently under construction. In this work are presented the results obtained with prototypes tested during test beams performed at the Beam Test Facility (BTF) of LNF to evaluate the performance of the calorimeter's units.

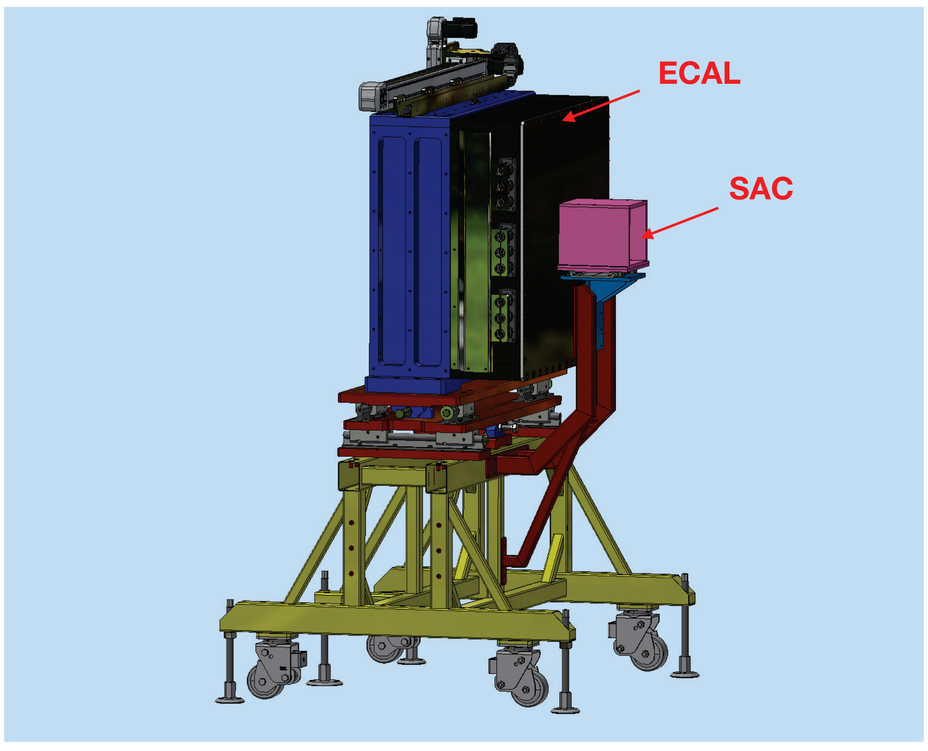

FIGURE 1. *ARRANGEMENT OF THE PADME CALORIMETER SYSTEM*

The PADME calorimeter system

In order to efficiently detect and measure the photons produced in the reaction $e^+e^- \rightarrow \gamma A'$ the PADME apparatus is equipped with the following detectors:

- **ECAL**. It consists of 616 bismuth germanate (BGO) crystals of dimensions 21×21×230 mm^3 disposed in a cylindrical array of 60 cm diameter placed roughly 3 m downstream the interaction target. This arrangement provides an angular coverage (20, 95) mrad. ECAL foresees a central squared hole, five crystals wide, to let the Bremsstrahlung radiation to pass and to be vetoed by a faster small angle calorimeter placed behind it; this is necessary since the BGO has a long scintillating light decay time (~300 ns) and would be continuously "blinded" by this radiation. Each ECAL crystal is coupled to an HZC XP1911 photomultiplier. The expected energy resolution is ≈ 2%/√E, measured with a detector prototype irradiated with BTF electron beams of different energies [3].
- **SAC.** Made of 25 lead difluoride (PbF_2) elements of dimensions 30×30×140 mm^3 it has to veto Bremsstrahlung photons in the angular range (0, 20) mrad. Being based on Cherenkov counters coupled to fast Hamamatsu R13748 photomultipliers, it has a short dead time of ~ 3 ns and it is able to stand event rates 10 times higher than the BGO. The measured time resolution of this detector is < 90 ps.

FIGURE 2. *ECAL MECHANICAL STRUCTURE*

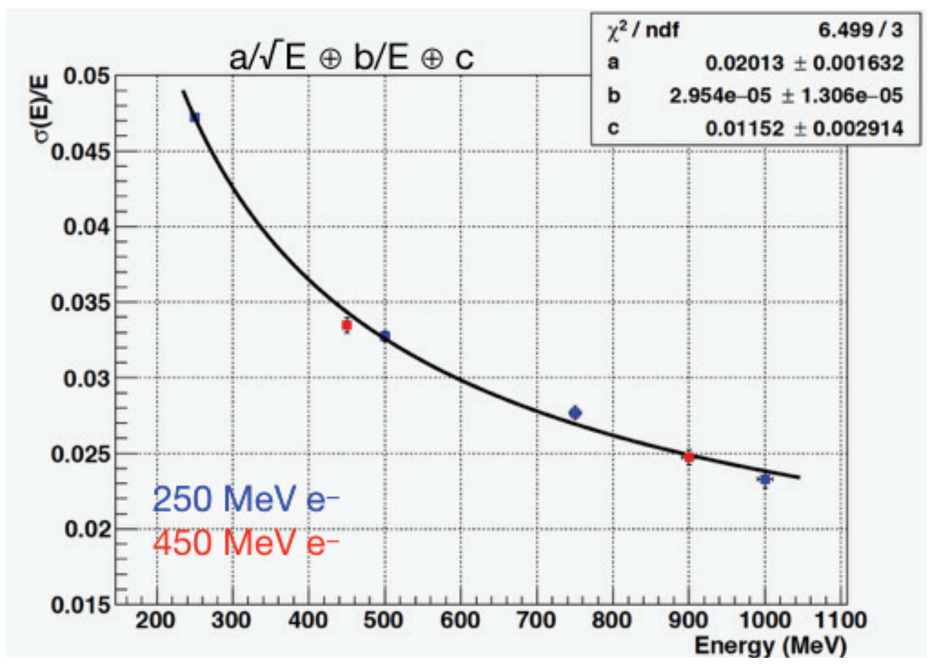

FIGURE 4. *ENERGY RESOLUTION MEASURED WITH ECAL PROTOTYPE EXPOSED TO BTF ELECTRON BEAMS OF DIFFERENT ENERGIES*

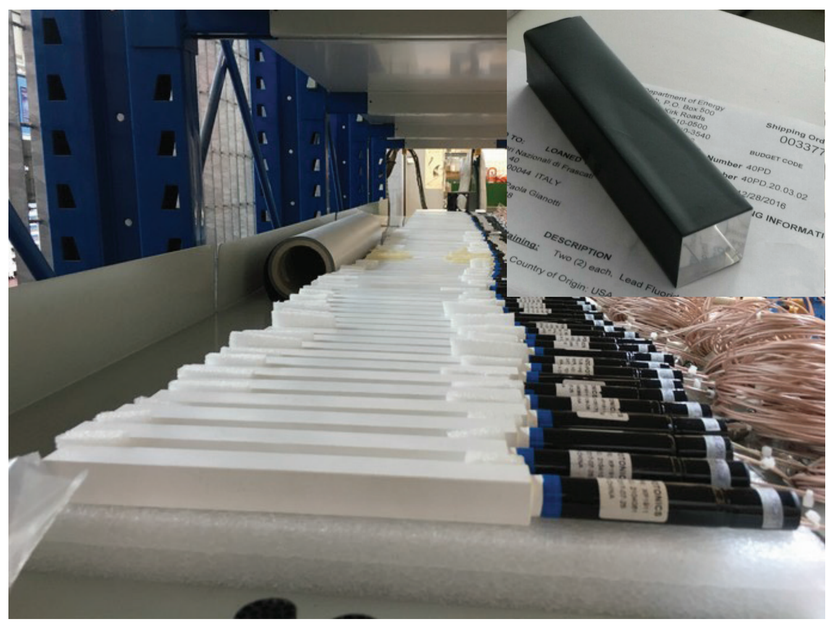

FIGURE 3. *SCINTILLATING UNITS OF THE PADME ECAL. IN THE INSET ONE OF THE SAC CRYSTALS*

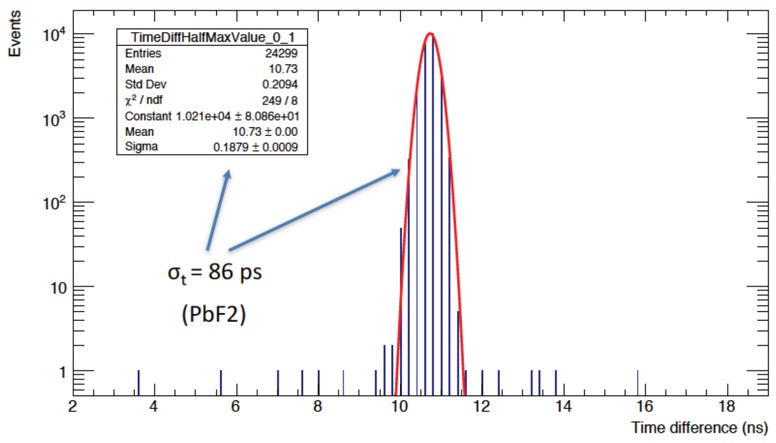

FIGURE 5. *TIME RESOLUTION MEASURED WITH SAC PROTOTYPE*

Status and perspective

All the element of the PADME calorimeter system are available at LNF. The final assembly in the BTF experimental hall will start next days. The commissioning of the experiment is foreseen to start beginning of July. For the data taking of the order of 10^{13} POT will be acquired.

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More information are available
http://www.lnf.infn.it/acceleratori/padme/

References

[1] M. Raggi e V. Kozhuharov, Adv. High Energy Phys. 2014 (2014) 959802.
[2] B. Holdom., Phys. Lett. B 166 (1986) 196.
[3] M. Raggi et al., Nucl. Instrum. Meth. A 862 (2017) 31.