Evaluation of clustering algorithms at the <1 GeV energy scale for the electromagnetic calorimeter of the PADME experiment

Emanuele Leonardi¹, Gabriele Piperno², Mauro Raggi¹,³
¹INFN Roma, ²INFN LNF, ³Sapienza University of Rome

The PADME Experiment
PADME (Positron Annihilation into Dark Mediator Experiment), approved by INFN in 2015, will look for invisible A' decays using the Beam Test Facility (BTF) line of the Linear Accelerator at the INFN Frascati National Laboratory (LNF).

A 550 MeV e+ beam will impinge on a thin (100μm) diamond target: the experiment will detect the production of dark photons by measuring the missing mass of the e⁺→A'/γ' final state. The experiment is currently under construction and will begin data taking in 2018.

The Electromagnetic Calorimeter
- Measure energy/angle of the recoil photon
- Veto multiple photons events
- 616 BGO crystals recovered from the L3 EM endcap
- Crystals resheared to 2.1 x 2.1 x 23.0 cm³
- Ø 19 mm PMT readout
- Roughly circular arrangement with square hole
- Angular coverage ~ 20-93 mrad
- Energy resolution: < 2%/VE
- Spatial resolution: ≤ 5 mm
- Time resolution: ~ 500 ps

The PADME Algorithm
1. Create list of crystals with non-zero energy.
2. Sort list by decreasing energy.
3. Tag all crystals as not used.
4. Find the first not used crystal in the sorted list: this is the cluster seed.
5. If none are found, the algorithm terminates.
6. Create cluster.
7. Attach seed to cluster.
8. Tag seed crystal as used.
9. Attach all crystals (i.e. adjacent) to center of seed and
   a. If none are found, the algorithm terminates.
   b. If list is incomplete: go to point 4.

Conclusions
- The optimization of the clustering strategy in the PADME electromagnetic calorimeter is of primary importance to the reconstruction of the missing mass in the e⁺e⁻→A'/γ' process.
- Two different algorithms are currently being evaluated: PADME Radius and PADME Island.
- The characteristics of these algorithms are significantly different and must be tested in all the relevant experimental scenarios (single γ, multiple γ) in terms of energy, spatial, and time resolution.
- These algorithms are now available in the general PADME software framework and are being tested both on real data from testbeams and on MC events.

REFERENCES
- PADME Experiment Home Page: http://www.lnf.infn.it/acceleratori/padme/

The Dark Photon
A possible solution to the Dark Matter problem is the hypothesis that it interacts with the SM gauge fields only via “portals” which link our world to the “dark” world. The simplest model postulates the existence of a U(1) symmetry with its corresponding A' vector boson: SM particles are neutral under this symmetry, so that this field, thanks to the possible mixing with the photon, would couple to the SM only with an effective charge e'. For this reason it is often called «dark photon».

The Electromagnetic Calorimeter 616 BGO crystals (2 x 2 x 23 cm³) from the L3 experiment at LEP – PMT readout.

Small Angle Calorimeter 20 cm³ readout.

Beam dump

Electromagnetic Calorimeter 49 lead glass blocks (2 x 2 x 20 cm³) from the D0L experiment at LEP – PMT readout.

Electron/Positron Vetoes
50 SiPM readout.

High energy Positron Veto (65 scintillator fingers 1cm² x 28cm)

Beam dump

SMASS:

Electromagnetic Calorimeter 616 BGO crystals (2 x 2 x 23 cm³) from the L3 experiment at LEP – PMT readout.

Small Angle Calorimeter 20 cm³ readout.

Beam dump

Electron/Positron Vetoes
50 SiPM readout.

High energy Positron Veto (65 scintillator fingers 1cm² x 28cm)

Beam dump