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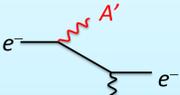
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The Dark Photon

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 ee . For this reason it is often called «dark photon».

A' production

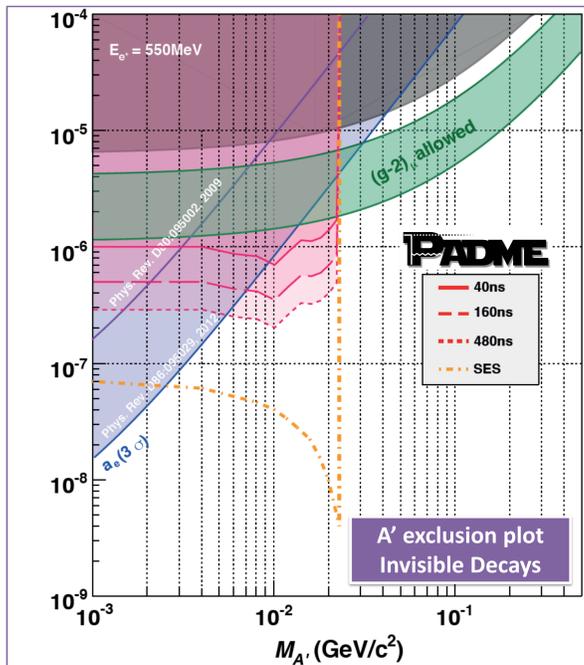
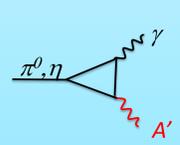
Bremsstrahlung



Annihilation



Meson decay



The PADME Experiment

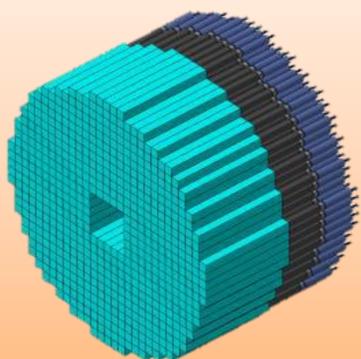
PADME (Positron Annihilation into Dark Mediator Experiment), approved by INFN in 2015, will look for invisible A' decays using the Beam Test Facility (BTF) line of the Linear Accelerator at the INFN Frascati National Laboratory (LNF).

A 550 MeV e^+ beam will impinge on a thin (100 μ m) diamond target: the experiment will detect the production of dark photons by measuring the missing mass of the $e^+e^- \rightarrow A'\gamma$ final state.

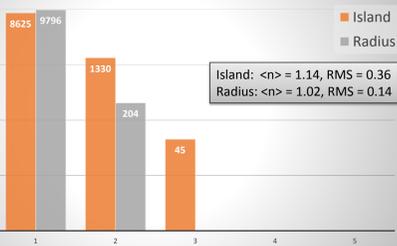
The experiment is currently under construction and will begin data taking in 2018.

The Electromagnetic Calorimeter

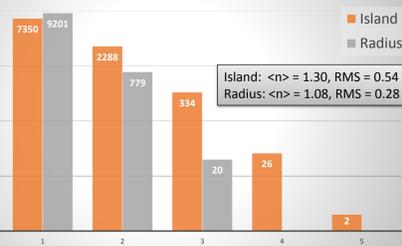
- Measure energy/angle of the recoil photon
- Veto multiple photons events
- 616 BGO crystals recovered from the L3 EM endcap
- Crystals reshaped to 2.1 x 2.1 x 23.0 cm³
- \varnothing 19 mm PMT readout
- Roughly circular arrangement with square hole
- Angular coverage: \sim 20-93 mrad
- Energy resolution: $<$ 2%/VE
- Spatial resolution: \leq 5 mm
- Time resolution: \approx 500 ps



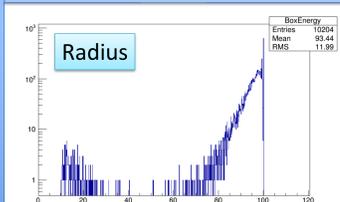
Number of Clusters @100 MeV



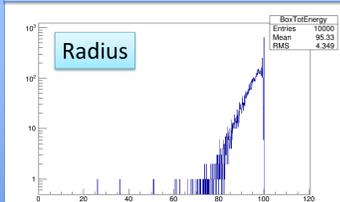
Number of Clusters @400 MeV



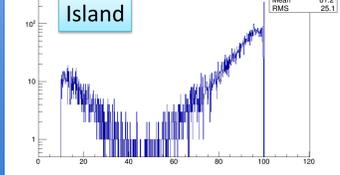
100 MeV - Single cluster energy distribution



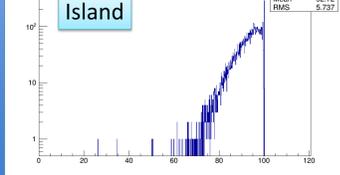
100 MeV - Total energy distribution



100 MeV - Single cluster energy distribution

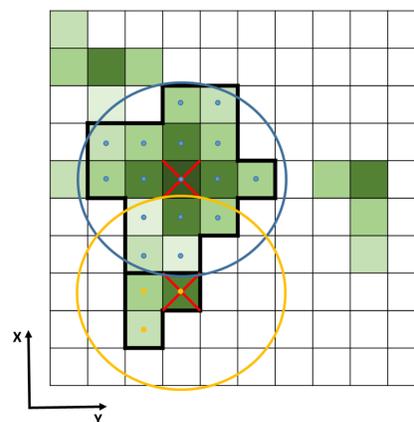
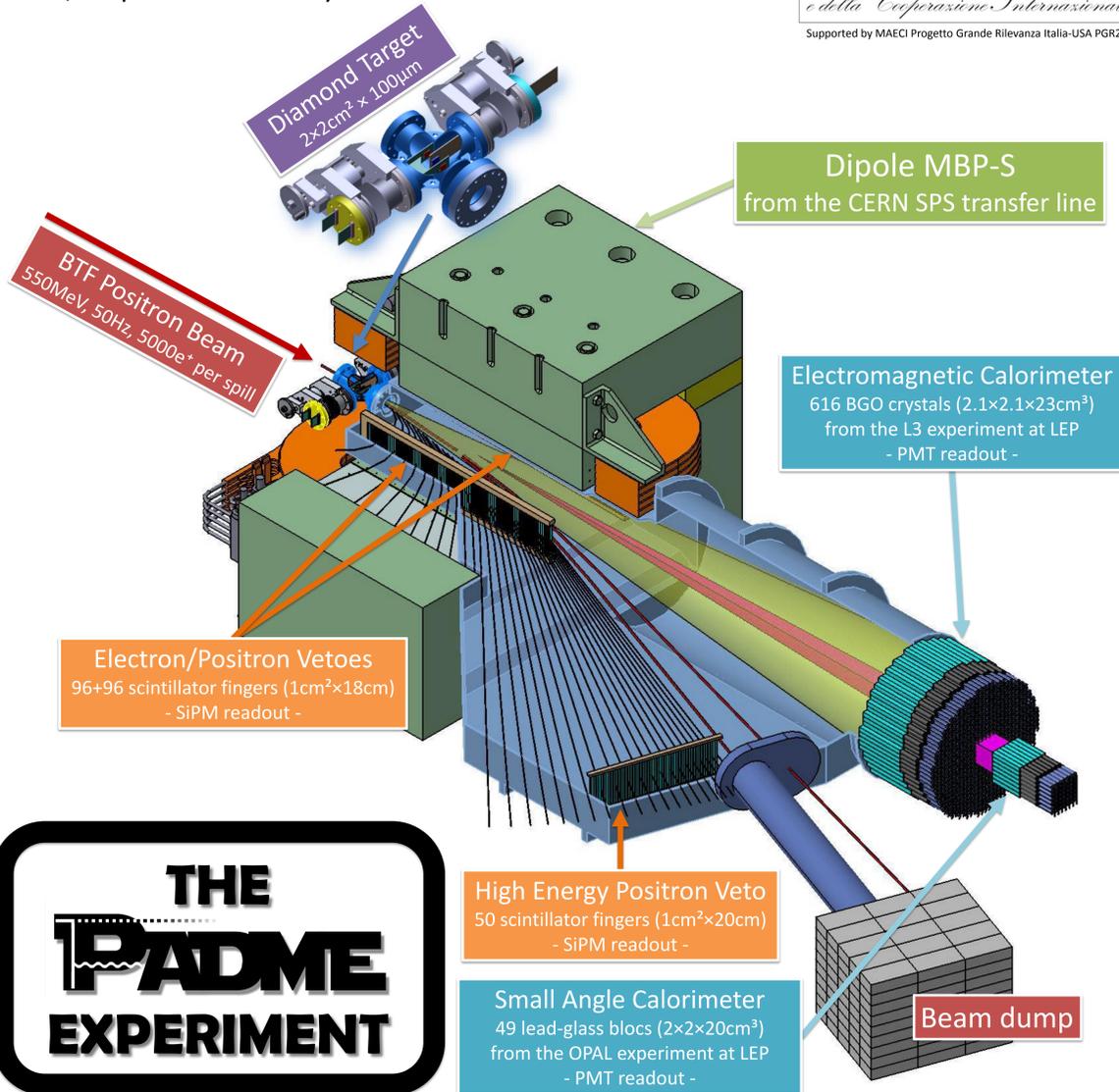


100 MeV - Total energy distribution



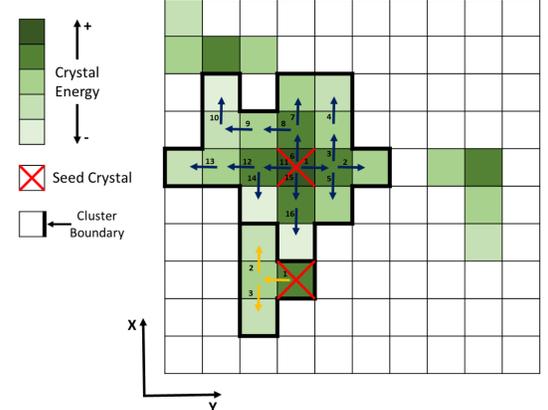
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- Raggi M, Kozhuharov V, Valente P. *The PADME experiment at LNF*. EPI Web of Conferences 96, 01025 (2015).
- PADME Experiment Home Page: <http://www.lnf.infn.it/acceleratori/padme/>
- Meschi E, Monteiro T, Seez C, Vikas P. *Electron reconstruction in the CMS Electromagnetic Calorimeter*. CMS Note 2001/034.



The PADME Radius 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**. If none are found, the algorithm terminates. **END**
5. Create **cluster**.
6. Attach **seed** to **cluster**.
7. Tag **seed** crystal as **used**.
8. Find all **not used** crystals with center within a given radius from center of **seed** and
 - a. Attach them to **cluster**.
 - b. Tag them as **used**.
9. **cluster** is complete: go to point 4.



The PADME Island 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**. If none are found, the algorithm terminates. **END**
5. Create **cluster**.
6. Attach **seed** to **cluster**.
7. Tag **seed** crystal as **used**.
8. Call **Expand_Cluster(cluster, seed)**
9. **cluster** is complete: go to point 4.

Expand_Cluster(cluster, current)

1. Loop over four **adjacent** crystals (above, below, right, and left) to **current** crystal, then **RETURN**
2. If **adjacent** is **not used** and its energy is below that of **current**:
 - a. Attach **adjacent** to **cluster**.
 - b. Tag **adjacent** crystal as **used**.
 - c. Call **Expand_Cluster(cluster, adjacent)**

Tunable parameters

- Both algorithms:
- Minimum energy to accept a crystal (now: 100 keV)
 - Minimum energy for cluster seed (now: 10 MeV)
- Radius algorithm only:
- Radius of circle around seed crystal (now: 5 cm)

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 $e^+e^- \rightarrow A'\gamma$ process.
- Two different algorithms are currently being evaluated: PADME Radius and PADME Island.
- The characteristics of these algorithm 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.