Performance of the charged particle detectors of the PADME experiment

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The role of the veto system

PADME[1] (Positron Annihilation into Dark Matter Experiment) searches a hypothetical dark photon $A'$ produced in the annihilation between a positron and a beam with an electron from a thin diamond target. The PADME experiment employs the missing mass method so the dark photon mass can be calculated:

$$m_{A'}^2 = (P_{\text{beam}} + P_e - P_y)^2$$

PADME is sensitive to the values of $A'$ mass up to 23.7 MeV/c^2 and mixing parameter $\sigma > 10^{-6}$ for 4x10^{11} Positrons On Target (POT).

Veto system parameters

- Aluminum support structure to hold an array of 96(16) scintillating bars for PV and EV (HEP) together with the FE boards
- Scintillating bars are parallel to the magnetic field direction and rotated around their longitudinal axis by 0.1 rad to minimize geometrical inefficiencies
- Hamamatsu 13360 FEE channel includes a transimpedance amplifier (gain=4), HV regulation, module voltage and current monitor, Ona FE board serves 4 channels
- GAIN=10^3–10^4
- FEE operates in vacuum
- Signals will be digitalized by CAEN V1742

Silicon photo-multiplier SiPM

- Front end electronics (FEE)
- Able to work inside vacuum
- Sustain stationary magnetic field of 0.6 T
- Low operating Voltage
- Substrate

Silicon photo-multiplier SiPM

**SCINTILLATORS**

- Polyethylene-based scintillating plastic bars with 1.5% POP (Polyethylene Octylphenyl) producing a well-defined light pulse

**OPTICAL FIBERS**

- BCF-92 optical fibers housed in a longitudinal groove of cross section 1.6 x 1.6 mm^2
- BCF-92:
  - light attenuation length is > 3.5 m
  - maximum absorption at 400 nm, matching POP emission
  - maximum emission at 492 nm (Wave Length Shifter)

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The assembly of the vetoes in the experiment

96–95 scintillating bars act as PVeto and EVeto system of the experiment. Readout from both sides only for HEVeto (16 bars).

Signal Reconstruction

- Pulse height distribution of one Channel for each Veto, with BTF Trigger (49 Hz)
- 100 kEvents reconstructed

Veto system prototype and beam test

- 16 bars cut at the desired length (of approximately 180 mm to fit into the dipole magnet clearance) and covered with a chemical reflector; 4 counters served by each board (in green in Fig. A)
- Support holding scintillators and FE boards assures thermal coupling to the vacuum vessel
- WS fibers of type BCF-92; some of them glued with Eilen ES-500 epoxy cement
- Optical contacts improved with Saint-Gobain BC-630 silicone optical grease
- Support holding: S12573 Hamamatsu used for the first prototype, noisy than the 13360

A prototype of the first version of the HEP detector of PADME was tested in April 2017 [3].

Veto system prototype and beam test

- Beam test performed in order to evaluate the performance of different scintillators species, with different readouts.
- Best performance (<1 ns) for scintillators with glued fibers.

Preliminary Results

- Difference in time between PVeto and one of the center crystals of the SAC (small angle calorimeter, placed just behind the ECAL hole).
- In agreement with time requirement

References


15th IPRD19
14-17 October 2019 - Siena, Italy