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The PADME experiment

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Summary. — The PADME experiment, hosted at the Laboratori Nazionali di Frascati, will search for a Dark Photon that decays in invisible channels with a mass up to 23.7 MeV and coupling constant down to 10^{-3}.

1. – Introduction

Since first cosmological evidences, the Dark Matter (DM) direct detection remains an open issue. This puzzle can be solved hypothesizing that the DM does not directly interact with the Standard Model (SM) gauge fields, but only by means of "portals" that connect our world with this dark sector. The simplest model adds a U(1) symmetry and its corresponding vector boson A' [1]: SM particles are neutral under this symmetry, while the new field, thanks to the possible mixing with the photon, could couple to SM with an effective charge εe and for this reason is often called Dark Photon (DP).

Recently it has been noted that an A' with mass in the range 1 MeV to 1 GeV and constant $\varepsilon \approx 10^{-3}$ can explain the discrepancy between theory and experiment on the muon anomalous magnetic moment $(g-2)_\mu$ [2].

2. – The experiment

Approved by the INFN at the end of 2015, PADME will search for DP that decays into invisible channels (DM or long lived A' independently of the decay products nature) [3,4]. The experiment is designed to detect as missing energy the A' produced in the reaction $e^+e^- \to A'\gamma$, where e^+, provided by the LNF linac, is incident on a fixed target. Since the initial state kinematic is known ($\vec{P}_{e^-}$ and $\vec{P}_{beam}$ for the e^- and the e^+, respectively), the A' invariant mass can be determined measuring the photon in the final state ($\vec{P}_\gamma$):

$$M^2_{miss} = \left(\vec{P}_{e^-} + \vec{P}_{beam} - \vec{P}_\gamma\right)^2,$$

where $\vec{P}_{e^-} = \vec{0}$ and $\vec{P}_{beam}$ has the nominal value of 550 MeV along the z-axis.

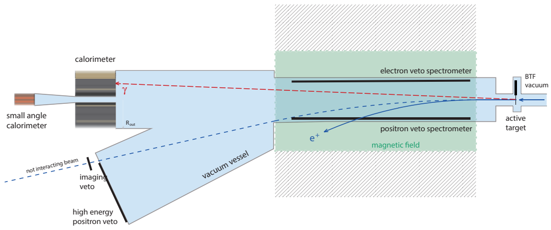

Fig. 1. – PADME detector layout. The distance between the target and the calorimeter (which has a radius of 29 cm) is 3 m, while the small angle calorimeter is a square of 14 cm side.

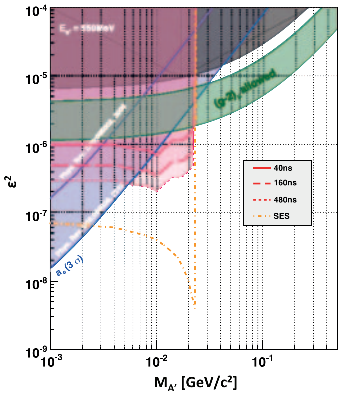

Fig. 2. – PADME sensitivity for different bunch lengths and in absence of background (SES) at the nominal beam energy of 550 MeV.

Figure 1 shows the experiment layout. The detector consists in an active target (diamond with graphitic strips to determine the beam position), a MBP-S dipole, that deflects the exaust beam and direct the e^+ that lost energy (the majority for bremsstrahlung) towards the vetoes, an electromagnetic calorimeter (616 $2 \times 2 \times 22\,\text{cm}^3$ bismuth germanate crystals, energy resolution $\sim \frac{(1-2)\%}{\sqrt{E}}$), that measures energy and angle of the produced γ, with a central opening to let bremsstrahlung radiation to pass, which is then identified by the small-angle calorimeter (49 $2 \times 2 \times 20\,\text{cm}^3$ SF57 lead glasses for Cherenkov light).

Main backgrounds to be reduced with the detector geometry are the $e^+\,e^-$ annihilation into 2 or 3γ and the bremsstrahlung, while the pile-up, being connected to the bunch density, will be the most important limiting factor to the PADME sensitivity.

The collaboration aims to build the detector by the end of 2017 and to collect 10^{13} 550 MeV positrons on target by the end of 2018, reaching a sensitivity on the DP coupling constant to the SM charge ε of $\sim 10^{-3}$ and a DP mass up to 23.7 MeV (see fig. 2).

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