The PADME experiment at DAΦNE Linac

M. Raggi, Sapienza Università di Roma

Abstract

1 Introduction

In the most general dark sector scenario with other particles lighter than A' the so called "invisible" A' decays are allowed. Since the decay products are non-Standard Model particles they could be neutral under the SM interactions and easily escape detection. Given the small coupling of the DP to visible SM objects, which makes the visible rates suppressed by ϵ^2, it is not hard to imagine a situation where the invisible decay dominate, the visible rate is small and the previous searches are weakened. There are few studies on the searches of a A' decaying into dark sector particles and the sensitivities sometimes rely on the assumption that the dark decay products constitute the dark matter, and are in several cases model dependent.

2 PADME experimental approach

The aim of the PADME experiment is to detect the non Standard Model process $e^+e^- \rightarrow \gamma + \textit{nothing}$, nothing being any possible candidate exotic particle (A', ALPs, etc.) coupling to electrons. The experiment is equipped with photons and charged particle detectors, to suppress as much as possible standard model QED background, and with a calorimeter to measure the recoil photon 4-momentum.

The experiment is composed of a thin (50-100μm) active diamond target, to measure the average position and the intensity of the beam during a single bunch, a set of charged particle veto detectors immersed in the field of a dipole magnet, to detect the positron losing their energy due to radiation, and an electromagnetic calorimeter to measure/veto final state photons. The apparatus is inserted into a vacuum chamber, to minimize the unwanted interactions of primary and secondary particles that might generate extra photons. The rate in the central part of the calorimeter is too high due to Bremsstrahlung photons. For this reason the calorimeter has a hole covered by a faster photon detector, the Small Angle Calorimeter (SAC). Detailed experiment layout is shown in Fig. 1.

The PADME sensitivity to A' invisible decays has been estimated by using a full GEANT4 Monte Carlo simulation for 550 MeV e^+ on target collisions accumulated in $3.15 \cdot 10^7$ s with 50 bunches of 200 ns, each containing 20000 positrons. The resulting sensitivity is shown in Fig.2 selection and background studies are described in more details in[3][4].

3 Expected physics reach

The main goal of the PADME experiment is to search for dark photons decaying into dark matter particles by measuring the missing mass in the process $e^+e^- \rightarrow \gamma A'$ in the region of mass below 24 MeV. A competitive sensitivity is also expected for the process $e^+e^- \rightarrow \gamma A'$

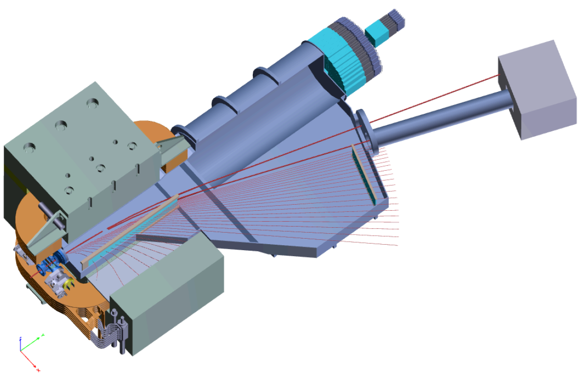

Figure 1: Layout of the PADME experiment. Beam entering from left to right.

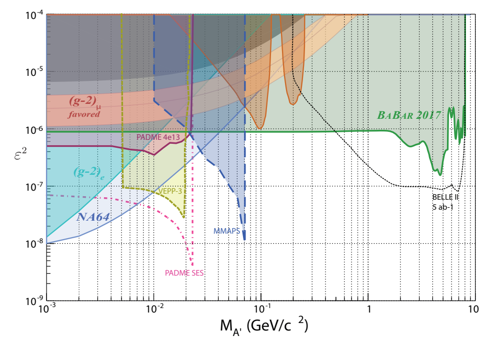

Figure 2: Expected PADME exclusion in the invisible channel with a 550MeV positron beam.

$A' \rightarrow e^+e^-$ by adding the request of two opposite sign in time tracks in the charged particles veto. No studies have been performed so far on the PADME sensitivity to visible decaying A' produced by bremsstrahlung $e^+N \rightarrow e^+N + A'$ which could extend the region explored by PADME to A' mass above the 24 MeV limit. The possibility of searching for ALPs produced in ALP-strahlung processes and decaying into $\gamma\gamma$ pairs has been recently pointed out and dedicated sensitivity studies are planned. In non minimal dark sector scenario dark Higgs h' might be produced in association to dark photon in the Higgs-strahlung channel $e^+e^- \rightarrow A'h'$. The decay mode of the h' depends on its mass, and in particular if $M_{h'} > 2M_{A'}$ it decays to pairs of dark photons. The dominant final state at the energy of interest for PADME will be then $3(e^+e^-)$, which could be identified by selecting 6 in time opposite charged tracks in the PADME charged veto system.

4 Future plans

The PADME collaboration is at present composed of 6 institutions Laboratori Nazionali di Frascati, Roma La Sapienza, Lecce, University of Sofia, Atomiki Laboratory, and Cornell University, with more than 40 physicists involved. The PADME experiment has been approved and financed by INFN with 1.35 Meuro, and is currently under construction at INFN Laboratori Nazionali di Frascati. The collaboration aims at assemble the detector by the end of 2017 and will have a first physics run lasting 6 month during 2018. The DAΦNE linac bunch length has been improved to ∼4 times thus allowing PADME to collect $1 \cdot 10^{13}$ positrons on target by the end of 2018. After the first phase at LNF of 1-2 years the PADME experiment sensitivity will be limited by the LINAC luminosity. For this reason a fruitful collaboration has been established with the MMAPS Cornell project to study the possibility of moving PADME at the Cornell CESR accelerator profiting of a 10000 higher luminosity and a 12 times higher energy.

References

[1] J. Alexander *et al.*, arXiv:1608.08632 [hep-ph].

[2] M. Raggi and V. Kozhuharov, Riv. Nuovo Cim. **38**, no. 10, 449 (2015). doi:10.1393/ncr/i2015-10117-9

[3] M. Raggi and V. Kozhuharov, Adv. High Energy Phys. **2014**, 959802 (2014)

[4] M. Raggi, V. Kozhuharov and P. Valente, arXiv:1501.01867 [hep-ex].

[5] P. Valente *et al.*, arXiv:1603.05651 [physics.acc-ph].