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The investigation on the dark sector at the PADME experiment

Paola Gianotti[1] for the PADME collaboration

[1] Laboratori Nazionali di Frascati dell'INFN
Via E. Fermi, 40 – 00044 Frascati

Summary

The PADME experiment [1], at the Laboratori Nazionali di Frascati (LNF) of INFN, is designed to be sensitive to the production of a low mass gauge boson A' of a new U(1) symmetry holding for dark particles [2]. The DAΦNE Beam-Test Facility of LNF [3] is providing a high intensity, mono-energetic positron beam impacting on a low Z target to provide e^+e^- annihilations, where the dark photon can be produced along with an ordinary photon. Simulation studies predict a sensitivity on the interaction strength (ε^2 parameter) down to 10^{-6}, in the mass region 1 MeV<$M_{A'}$<23.7 MeV, for one year of data taking with a 550 MeV beam. In 2018 the first run will take place, and early data will give the opportunity to compare the detector performance with the design requirements. Right now, an intense activity is taking place to install and commission the PADME experimental apparatus on site.

The PADME technique

The main goal of the PADME experiment is to search for dark photons produced by the annihilation of a positron beam with the electrons at rest in a thin active diamond target.

- Beam 5000 e^+/bunch;
- E = 550 MeV;
- δE/E ~ 1%;
- Repetition rate 50 Hz.

The expected final state is a single photon and nothing else. The ECAL measures accurately the energy and the angle of the photon emitted with the dark photon, in order to allow evaluating the missing mass according to the formula:

$$M^2_{miss} = (P_{e^-} + P_{e^+} - P_\gamma)^2$$

The strategy for the A' identification rely on the possibility to efficiently reject the background that is mainly represented by Bremsstrahlung photons. Most of 2γ or 3γ events are rejected by requiring only one cluster in the ECAL. The reconstructed cluster should fall inside a fiducial window to improve the resolution on the missing mass reducing the energy leakage in the ECAL. By selecting a cluster energy interval optimised for the A' mass hypothesis, Bremsstrahlung ($E_\gamma > E_{min}$) and pile-up ($E_\gamma < E_{max}$) can be efficiently reduced. A charged particle veto system, located inside the vacuum tank, should not have in-time signals with the ECAL (within 2 ns). Finally, there should be no clusters in the SAC, with energy above 50 MeV. This last requirement removes most of the residual 3γ events, when only one falls inside the ECAL acceptance.

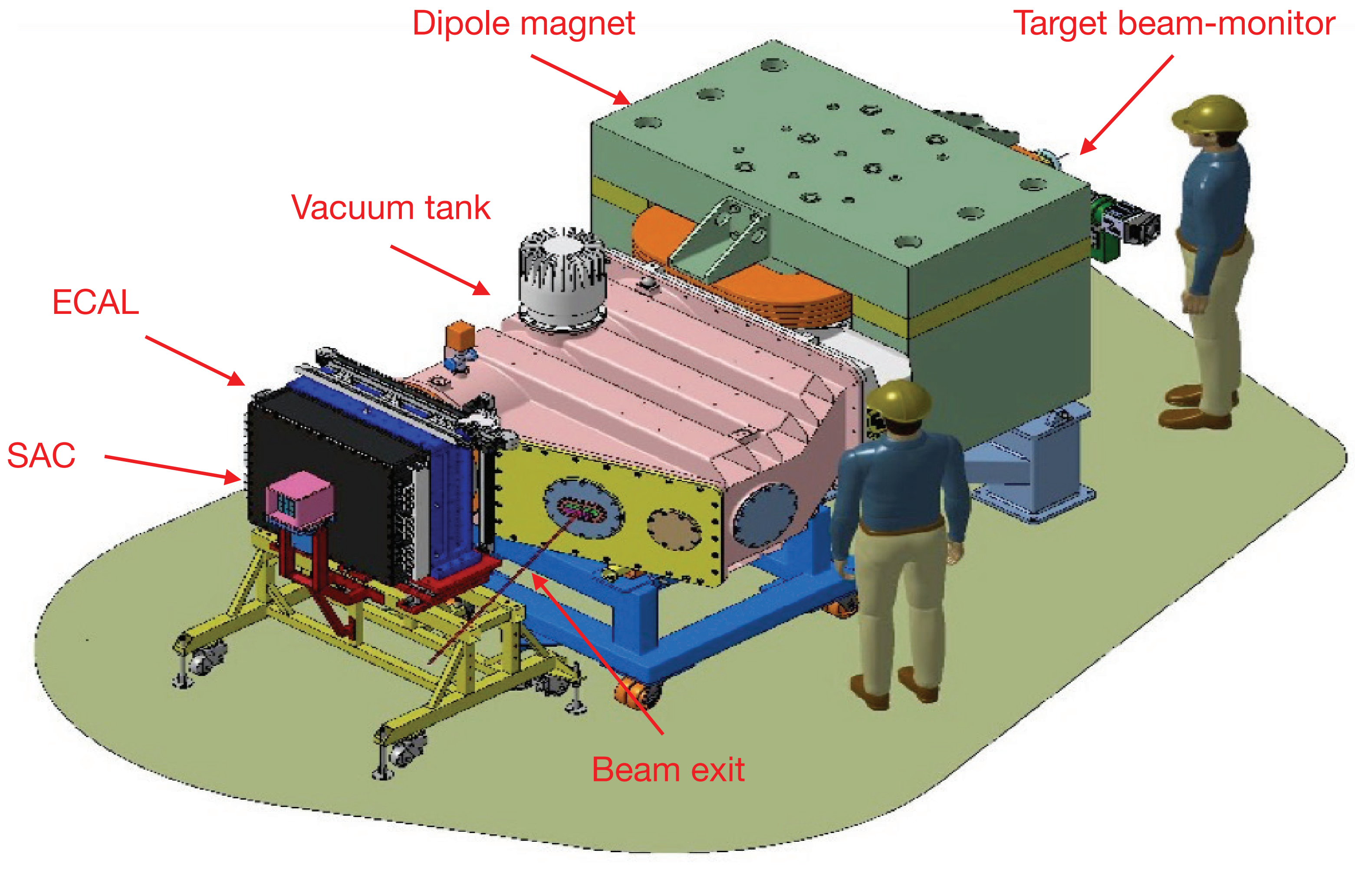


FIGURE 2. *THE PADME DETECTOR*

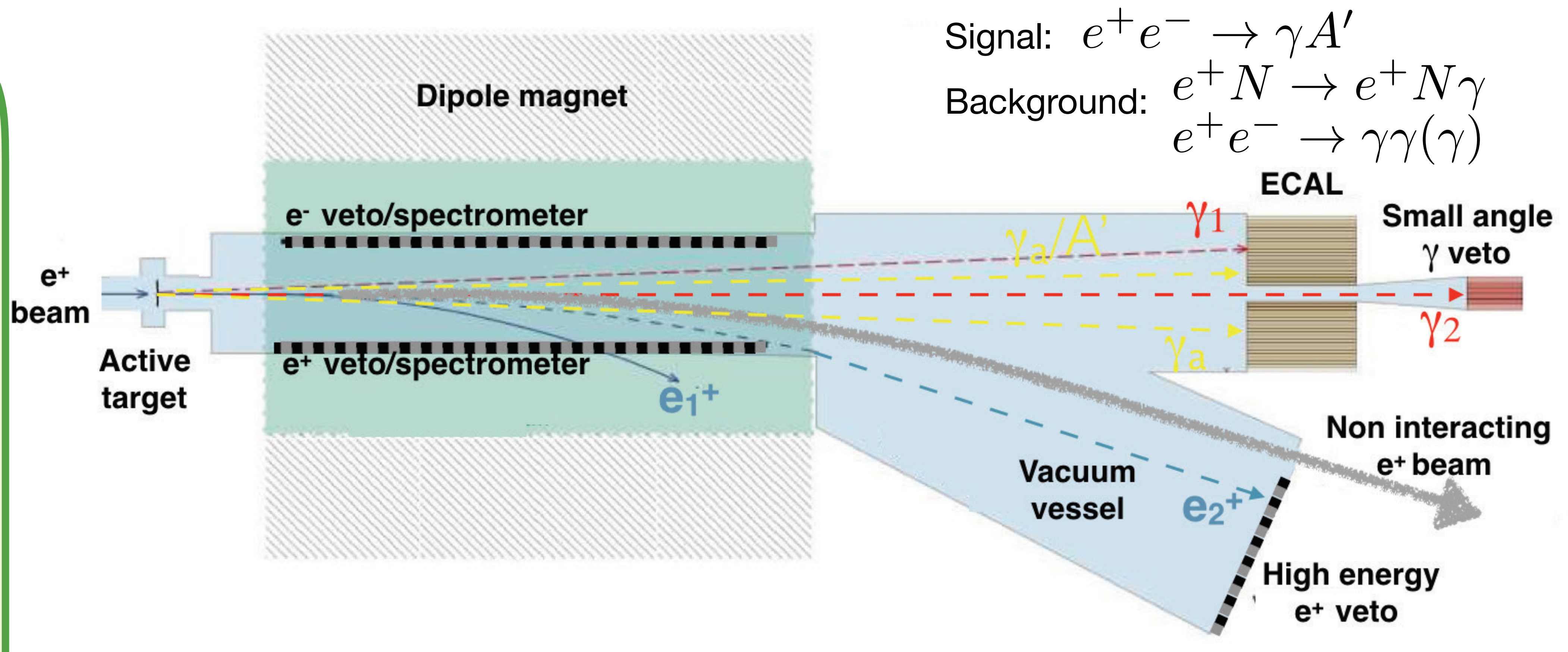
Sensitivity

PADME can explore, in a model-independent way, the region down to $\varepsilon^2 \approx 10^{-6}$ for masses of the A'≤ 23.7 MeV. The expected exclusion region is reported in figure 3 for two different scenarios of POT: 10^{13} and 4×10^{13} . The corresponding running times will depend on the positron bunch length and on the global efficiency that here is assumed 60%.

Contact information

paola.gianotti@lnf.infn.it

More information are available
http://www.lnf.infn.it/acceleratori/padme/



Signal: $e^+e^- \rightarrow \gamma A'$
Background: $e^+N \rightarrow e^+N\gamma$
$e^+e^- \rightarrow \gamma\gamma(\gamma)$

FIGURE 1. *OVERVIEW OF THE PADME EXPERIMENT*

The PADME detector

Under construction at the Laboratori Nazionali di Frascati of INFN, the PADME detector consists of:

- a **thin (50-100 μm) active diamond target,** to measure the average position of the beam;
- a **dipole magnet**, to deflect the primary positron beam out of the calorimeter acceptance and to convey any charged particle from interactions in the target toward the charged particle veto detectors;
- a **charged particles veto**, to reject Bremsstrahlung background;
- a **vacuum chamber**, to minimise the unwanted interactions of primary and secondary particles;
- a high resolution **electromagnetic calorimeter** of BGO crystals (ECAL), to measure precisely the energy and the angle of the photon emitted with the dark photon;
- a **small angle calorimeter** made of fast PbF_2 crystals (SAC) to veto forward emitted photons.

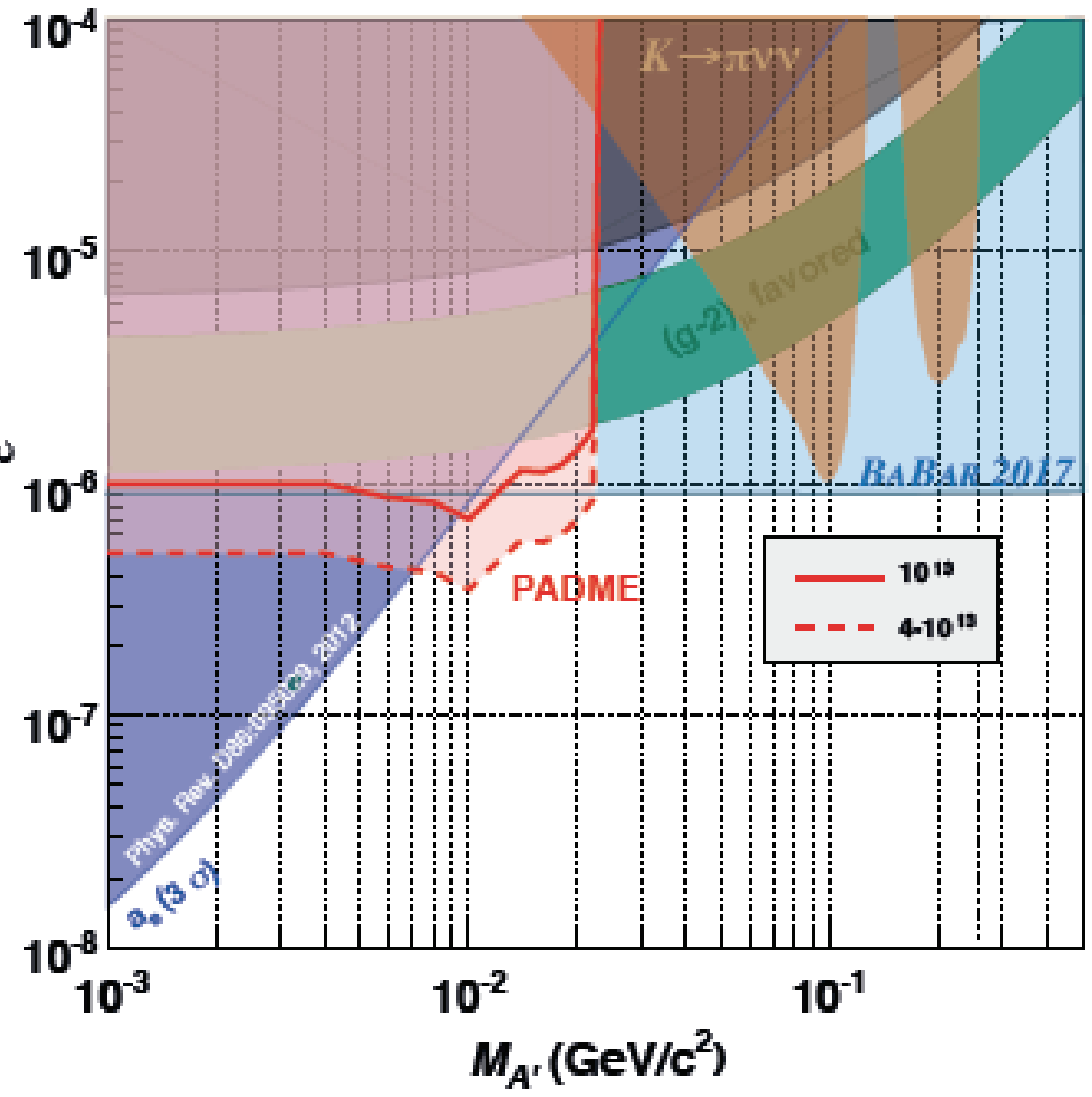


FIGURE 3. *PADME SENSITIVITY FOR DIFFERENT COLLECTED STATISTICS*

References

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[2] B. Holdom, Phys. Lett. B 166 (1986) 196.
[3] G. Mazzitelli et al., Nucl. Instrum. Meth. A 515, 524 (2003).