



SEARCHING FOR LIGHT DARK MATTER WITH THE PADME EXPERIMENT

I.Oceano on behalf of PADME collaboration Workshop on the Standard Model and Beyond



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Sept. 1st, 2021



PHYSICAL MOTIVATIONS

DARK MATTER EVIDENCES

- Galactic rotation curves
- Galaxy clusters & GR lensing
- Bullet Cluster
- Velocity dispersions of galaxies
- Cosmic Microwave Background
- Baryon Acoustic Oscillations
- Type la supernovae distance measurements
- Big Bang Nucleosynthesis (BBN)
- Structure formation





A NEW GAUGE BOSON

Candidates challenged by LHC and direct detection experiments



Weak interaction with SM throughout ϵ

$$L_{mix} = -\frac{\epsilon}{2} F^{QED}_{\mu\nu} F^{\mu\nu}_{dark}$$

Introduction of a new Gauge symmetry $U_D(1)$

$$L \sim g' q_f \bar{\psi}_f \gamma^\mu \psi_f A'_\mu$$

- New massive Gauge Boson A' : dark photon
 - U(1) breaking mechanism
 - Higgs like mass for A' → dark
 Higgs existence needed
 - Stuckelberg mechanism → The only new light state remains A'

Dark Secto SM

Kinetic mixing coefficient

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A' DECAY MODES MEV-GEV SCALE



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[1]10.1007/978-3-030-62519-1 [2]10.1088/1361-6471/ab4cd2

VISIBLE AND INVISIBLE LIMITS









THE PADME EXPERIMENT







PADME DARK PHOTON SEARCH





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SIGNATURES



• If
$$E_{beam} = 550 \text{ MeV}$$
, $\sigma(e^+e^- \rightarrow \gamma\gamma) = 1.55 \text{ mb}$

•
$$e^+e^- \rightarrow \gamma\gamma\gamma$$

Symmetry lost

If
$$E_{beam} = 550 \text{ MeV}$$
, $\sigma(e^+e^- \rightarrow \gamma\gamma\gamma) = 7.5 \times 10^{-2} \text{ mb}$





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PADME DATA TAKING



SM PROCESSES IN PADME

$$e^+N \rightarrow e^+N\gamma$$

Bremsstrahlung positron profile on PVeto estimated by subtracting data with target and without target in data and MC compared to analytical formula (PDG)





Annihilation spectrum in the main calorimeter for a standard run configuration (red) and in a special one (black). The improvements on the beam line and in the ECAL reconstruction allow to have a negligible background

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FUTURE SEARCH IN PADME



ALP

Axion Like Particle





 $e^+e^- \rightarrow \gamma \alpha$

 Possible pseudo-scalar spin-0 mediator between the Standard Model and the Dark Sector

PADME accessible final states



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[1]arXiv:2012.04754

DARK HIGGS



PROTOPHOBIC X BOSON



CONCLUSION

- PADME is a fixed-target, missing-mass experiment to look for low-mass dark photons
- Model-independent (kinetic mixing)
 - Several dark sector candidates are potentially accessible at PADME
 - RUN I and RUN II acquired. The upgrade of the beam line in Run II helped to reduce the beam background.
 - PADME collected 5.58×10^{12} POT , about half of the planned statistics, during the pandemics
 - Run II data analysis on SM physics

Interesting by itself and a step towards the invisible dark photon analysis
New runs are planned to test other DM hypotheses!