Missing Mass A-Prime Search: MMAPS at Cornell

1 Quick Summary

1. Name and Location: MMAPS, Cornell
2. Collaboration: Cornell, U-MInn, CMU. Approx 6 senior members + a flock of undergrads. No grad students or postdocs.
3. Primary physics goal: detect and measure mass of A', with invisible decay channels.
4. Experimental approach:
   $e^+e^- \to \gamma A'$ with missing mass reconstruction.
   $5.3\,\mathrm{G}eV$ positron beam on fixed target.
   CsI calorimeter for normal photon measurement.
   Charged particle tagging/veto.
   Continuous *in situ* calibration/monitoring.
5. Projected Future Results:
   Data set: 1×10^{17} e^+ on target.
   Mass range: $\sim 20\,\mathrm{MeV} < m'_A < 72\,\mathrm{MeV}$
   Sensitivity: $\varepsilon^2 > 1 \times 10^{-8}$.
6. Plots: shown below
7. Future plans:
   Grow collaboration.
   Restructure funding plan. Get funding.
   2 years to build, 2 years to commission and run.

2 Discussion

The fundamental principle of MMAPS is to produce dark photons in $e^+e^- \to \gamma A'$ reactions and measure the γ energy and direction, inferring the A' mass by missing mass reconstruction. The method is inclusive, ie independent of the A' decay mode, and thus is sensitive to invisible decay modes such as $A' \to \chi\chi$, as well as partially invisible modes such as $A' \to \chi\chi e^+e^-$. Any signal will appear as a small bump on a large, smooth background in the missing-mass distribution.

A $5.3\,\mathrm{G}eV$ pulsed positron beam of average current $1.4{\times}10^{10}e^+$/sec is extracted in a slow spill from the Cornell synchrotron and directed to a solid fixed target. In $\times 10^7$ seconds of operation the experiment will receive 1×10^{17} positrons on target. Operation is fully parasitic, with beam extraction and delivery taking place between top-offs of the CESR storage ring for the x-ray program; in this mode the dark photon operation is transparent to the primary lab program, and the duty factor for MMAPS beam is expected to be around 75%.

The detector, shown in Fig. 1, consists of calorimeter wall comprising 700 CsI crystals covering a forward angular range of $2-5\,\mathrm{deg}$ in the lab frame. A dipole magnet immediately after the target sweeps most charged particles out of the calorimeter acceptance, and a MIP detector in front of the calorimeter vetos any residual charged flux. The missing mass resolution varies from $6\,\mathrm{M}eV$ at $m'_A = 20\,\mathrm{MeV}$ to $1\,\mathrm{M}eV$ at $m'_A = 72\,\mathrm{MeV}$.

Dominant backgrounds are $e^+e^- \to \gamma e^+e^-$, $e^+e^- \to \gamma\gamma$, and $e^+e^- \to \gamma\gamma\gamma$. The detector has been modelled with Geant4, with backgrounds generated by MadGraph. The projected 5-sigma exclusion plot shown in Fig. 2 is based on simulated yields of signal and background.

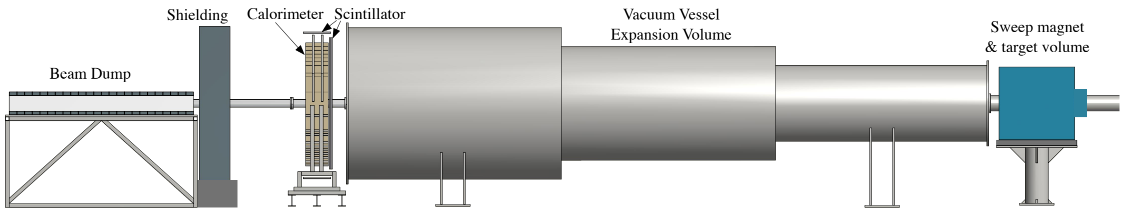

Figure 1: MMAPS beam and detector configuration.

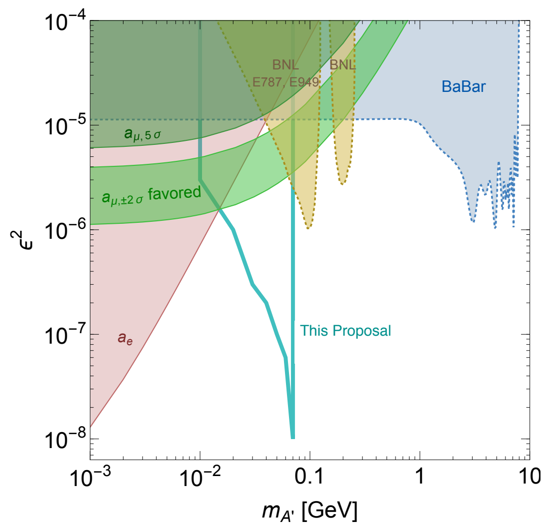

Figure 2: MMAPS projected exclusion: 5σ, 10^{17} e^+ on target.