The Heavy Photon Search Experiment at Jefferson Laboratory

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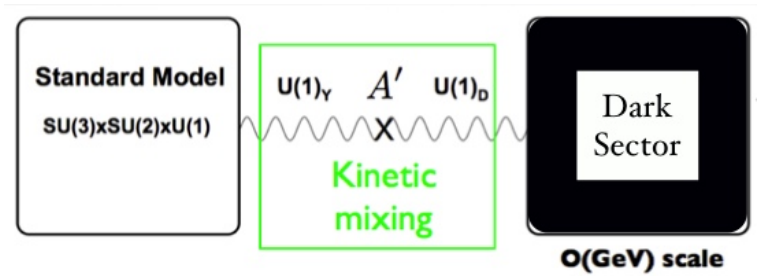
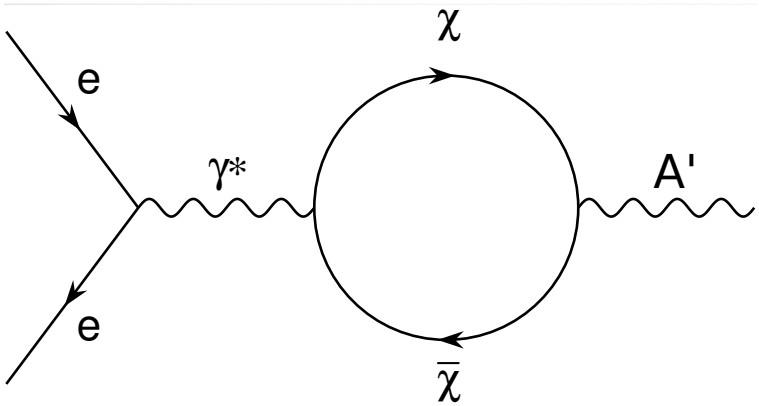
on behalf of the HPS Collaboration

U.S. DEPARTMENT OF ENERGY
Office of Science

What is the heavy photon?

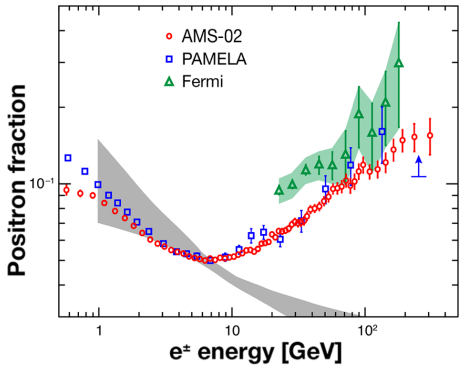
- A new massive $U(1)$ boson with no (direct) coupling to SM
  - Kinetic mixing with the photon $\rightarrow$ weak coupling to electric charge [Holdom 1986]
- If it couples to dark matter, could serve as "portal" to the dark sector
- Two relevant parameters: mass $m_{A'}$, relative coupling strength α'/α

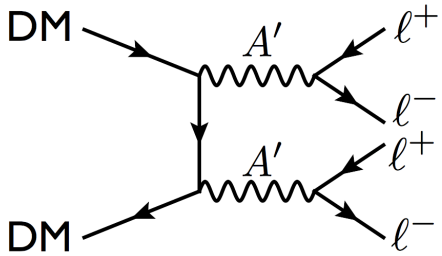




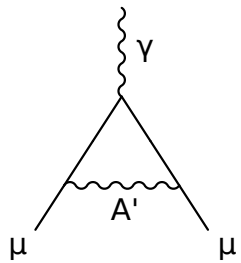
Why do we care?

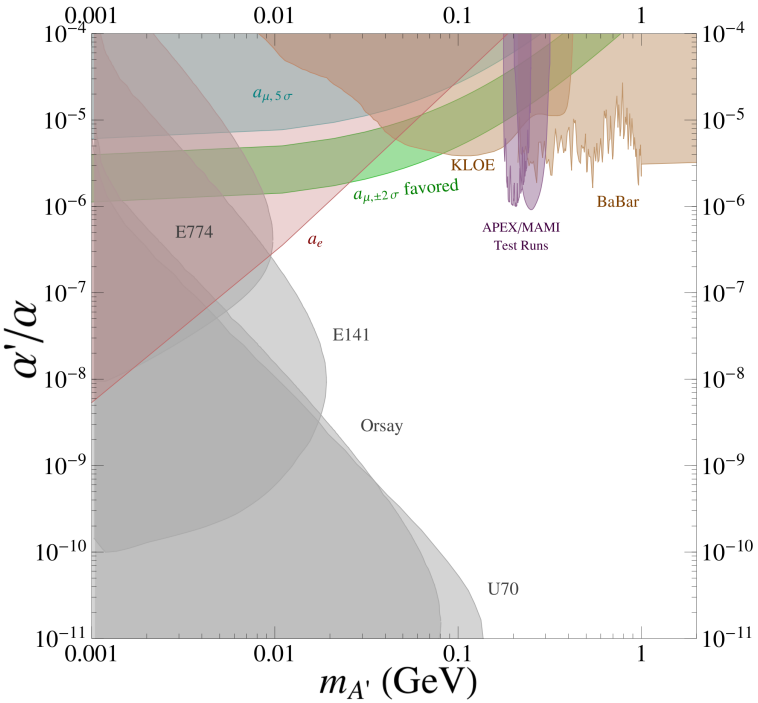
- PAMELA, Fermi, AMS find cosmic ray e^+ excess
  - DM annihilation? Can't be direct (no $\bar{p}$ excess), but consistent with sub-GeV $m_{A'}$





- Muon g-2 deviates from SM predictions
  - Can be explained by A'

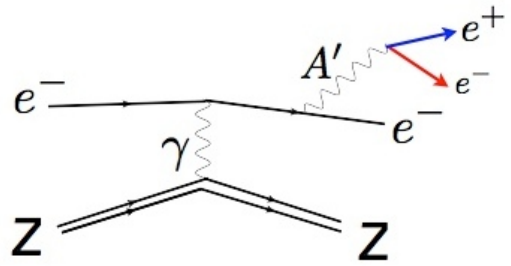


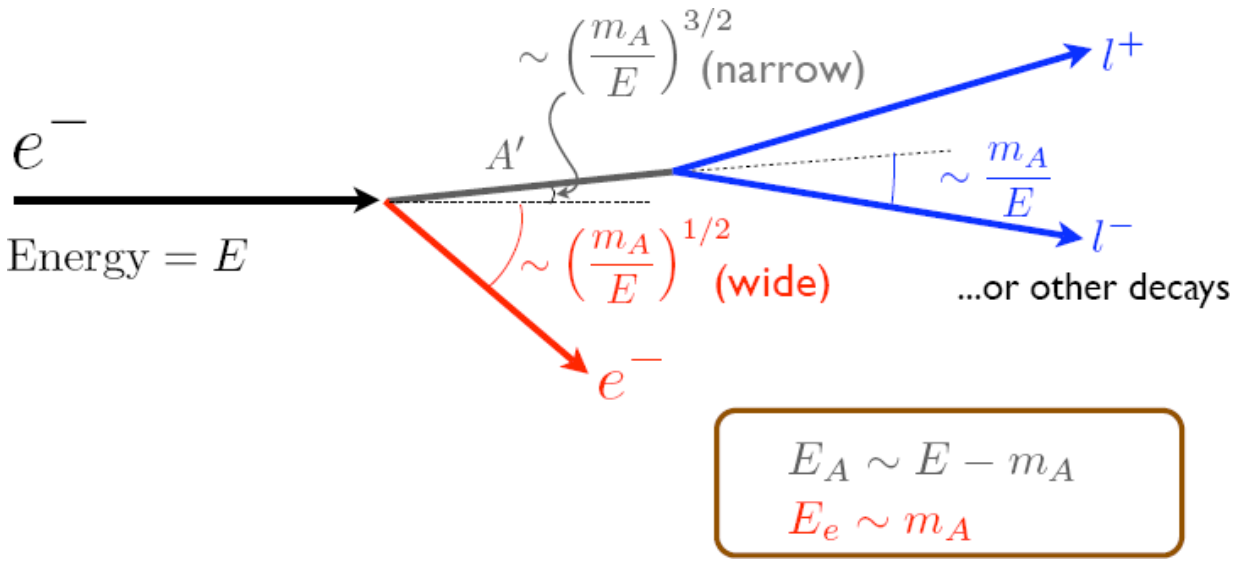


- Many current searches! See Tuesday talk by John Jaros

Producing heavy photons

- Similar to bremsstrahlung: e^- (1.1, 2.2 and 6.6 GeV) on high-Z fixed target

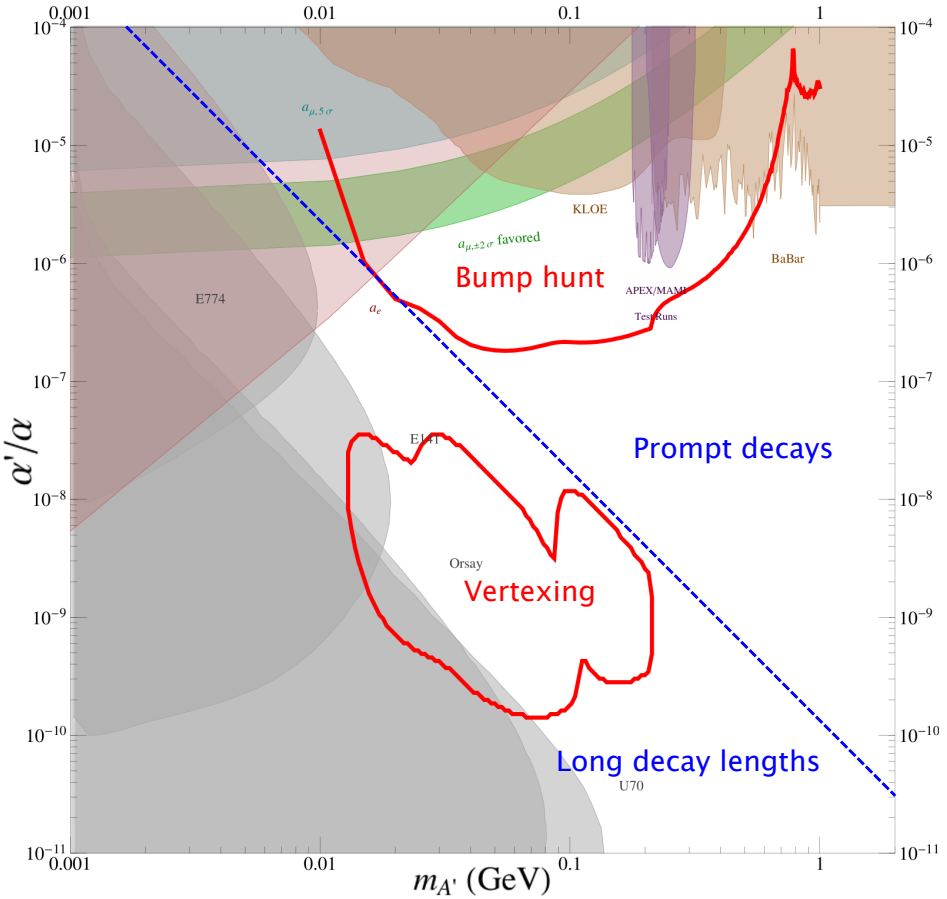




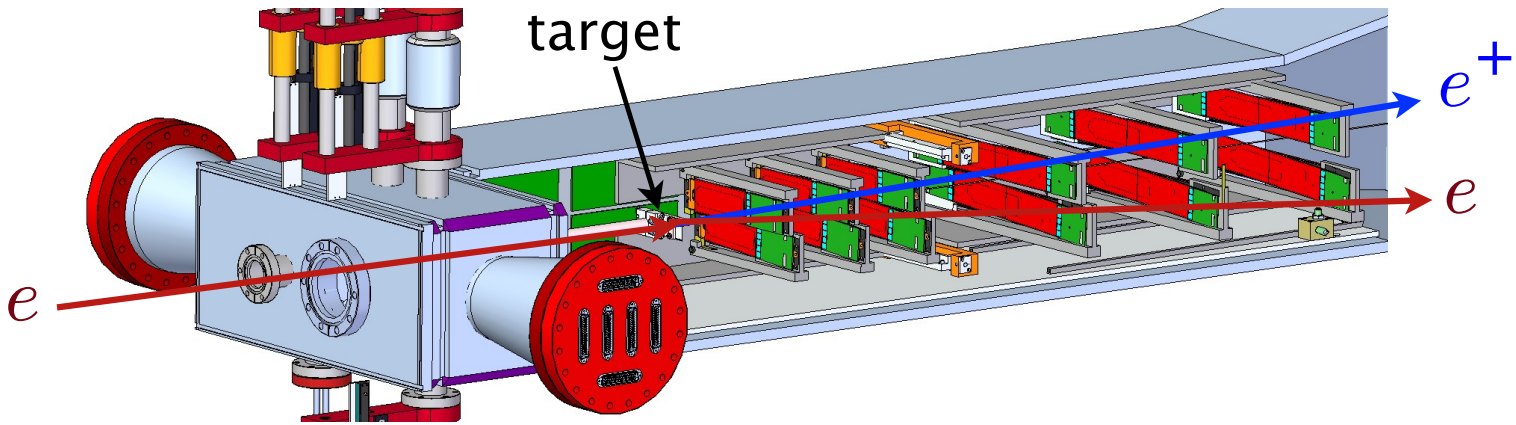
- A' carries most of incident e^- energy (unlike γ bremsstrahlung)
- Pairs from A' decay are produced along beam with some decay length and small opening angle

Search channels

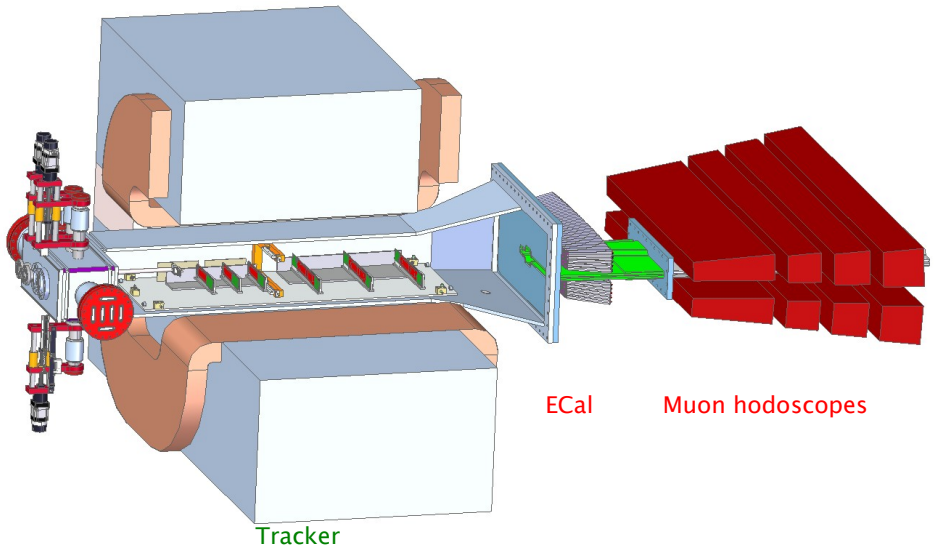
- Bump hunt: look for a peak in pair invariant mass
  - A' decays compete with QED tridents; mass resolution ($\sim$MeV) is key
- Vertexing: look for pairs originating downstream of the target
  - Requires a tracker close to the target for $\sim$mm vertex resolution
- HPS probes a large unexplored region of the parameter space



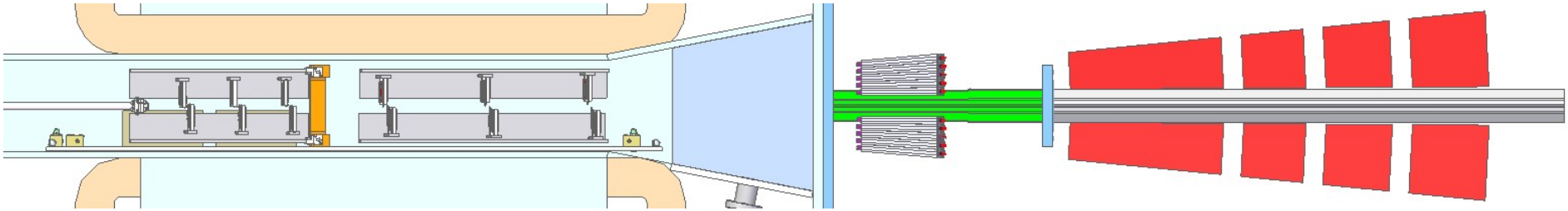
The HPS detector



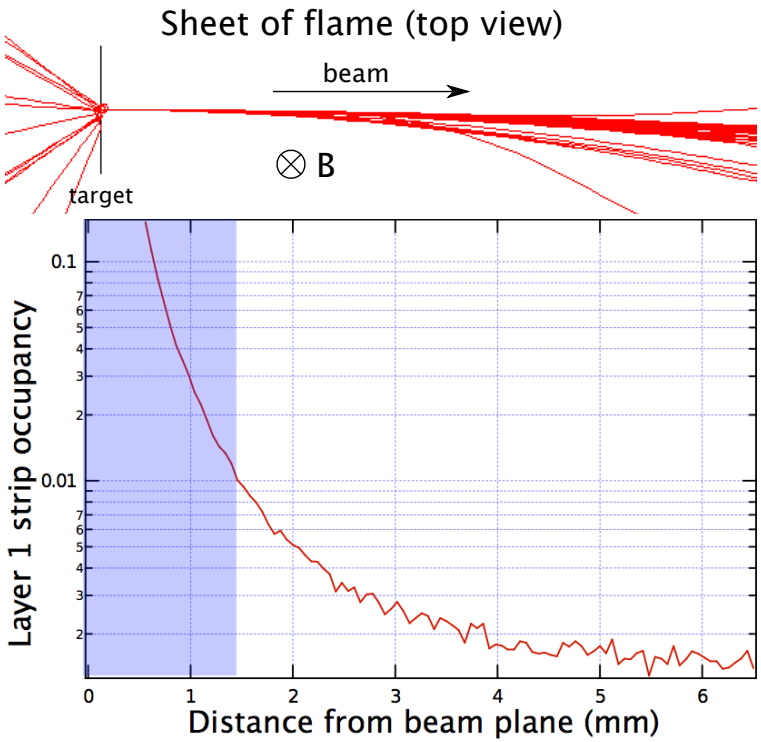
- Thin (0.125% or 0.25% X_0) tungsten target
- Silicon microstrip tracker in vertical B-field for measurement
- $PbWO_4$ calorimeter and scintillator hodoscopes for trigger



Killing backgrounds . . . in space

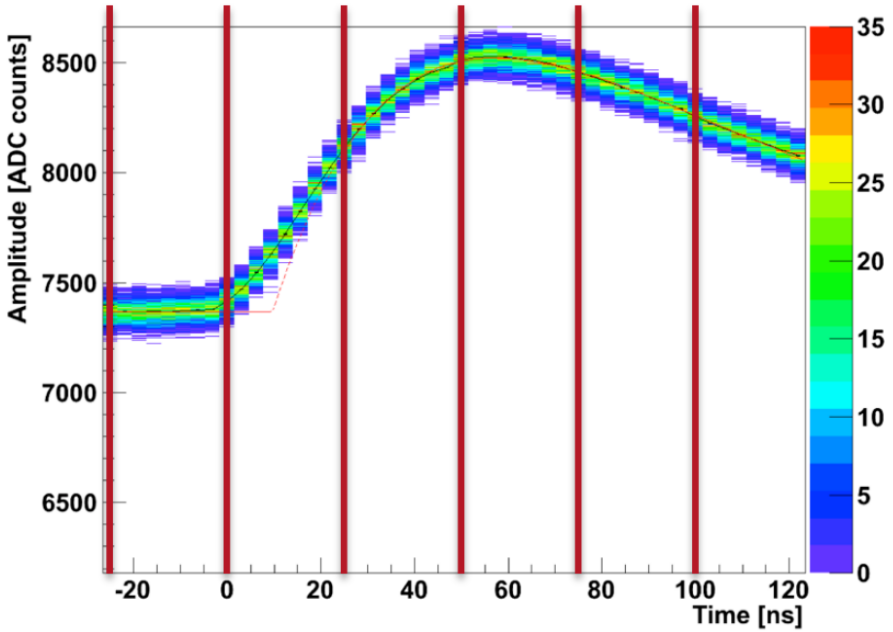


- Main detector background is electrons scattered in the target and bent by the tracking field: “sheet of flame”
- Vacuum transport for primary+scattered beam through entire detector
- All detectors split ± 15 mrad above and below beam plane
  - Active region of tracker layer 1 is 1.5 mm from beam



Killing backgrounds . . . in time

- CEBAF at JLab: continuous beam (499 MHz rep rate and 100% duty cycle)
- Use time resolution to reject out-of-time hits
  - Tracker readout: APV25 (CMS) with 24 ns sampling period (2 ns resolution after time reconstruction)
  - ECal and muon system readout: FADC250 (JLab) with 4 ns sampling period



Fit CR-RC pulse shape to determine t_0

2012 test run and beyond

- Built and ran a test version of the tracker and the full ECal in a parasitic run with a photon beam
- Demonstrated key challenges:
  - verified MC treatment of multiple Coulomb scattering
  - multi-kHz trigger and readout
  - tracker hit time reconstruction
- On track for full run when CEBAF resumes operation after 12 GeV upgrade — late 2014