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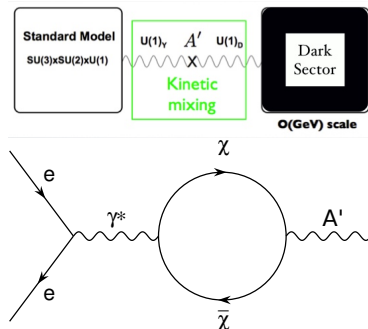
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Searching for Dark Photons with the SeaQuest Spectrometer

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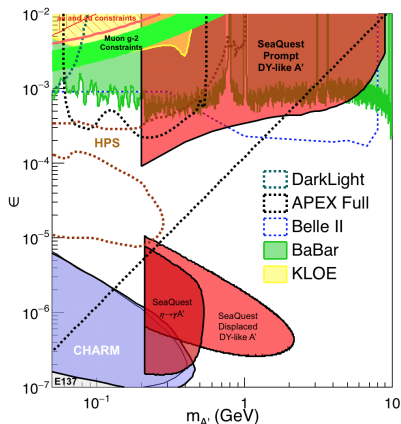
What is the dark photon?

- “Dark sector” emerging as a picture of dark matter that is compatible with light dark matter, and allows for self-scattering, collisional excitation, annihilation
 - ▶ Standard Model forces don’t couple to the dark sector, dark forces don’t couple to Standard Model matter
 - ▶ “Portals” create weak effective couplings between the sectors
- Vector portal: dark mediator is a massive $U(1)$ boson (heavy photon)
 - ▶ Kinetic mixing with the photon \rightarrow weak coupling to electric charge



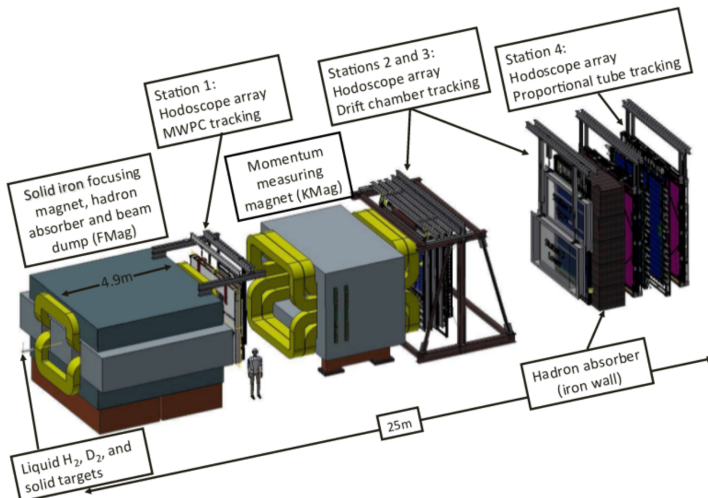
Parameter space

- Mass hierarchy: dark photon decays visibly if $m_{A'} < 2m_\chi$, invisibly if $m_{A'} > 2m_\chi$
 - ▶ SeaQuest is sensitive to visible decays
- Two relevant parameters: mass $m_{A'}$, coupling strength $\epsilon = \sqrt{\alpha'/\alpha}$
 - ▶ Coupling strength governs production from, and decay to, Standard Model matter
 - ▶ Favored region is $m_{A'}$ MeV—GeV, $\epsilon > 10^{-6}$



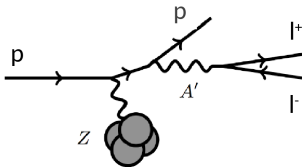
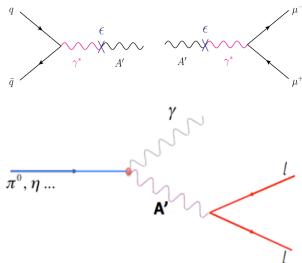
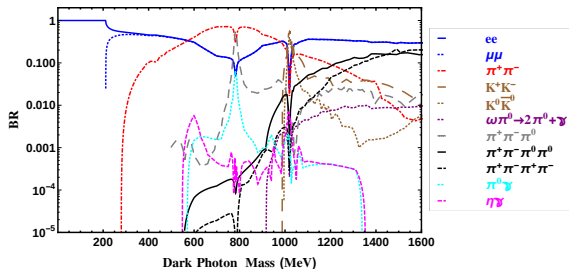
The SeaQuest facility

- Fixed target muon spectrometer, Fermilab 120 GeV proton beam
- Measurement of the nucleon sea quark distribution using Drell-Yan
- Parasitic searches for dark photons approved 2015



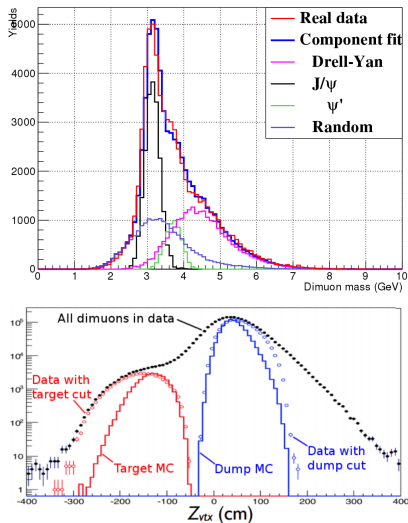
Production and signatures at SeaQuest

- Three dominant production mechanisms: Drell-Yan, meson decay, proton bremsstrahlung
- Branching fraction to $\mu^+\mu^-$ is significant at all $m_{A'} > 2m_\mu$; decay length depends on ϵ
- Two signatures: mass resonance and (at small ϵ) displaced vertices



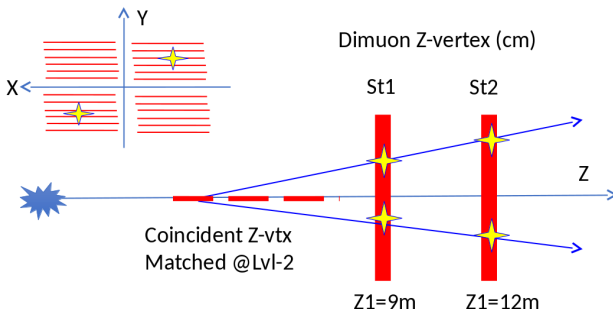
SeaQuest searches for dark photons

- Prompt dark photons (large ϵ): look for a mass bump above the smooth Drell-Yan background
- Non-prompt dark photons (small ϵ): look for dimuon vertices deep inside the beam dump
- Non-prompt search requires a new trigger for low-mass displaced vertices, which was commissioned this year



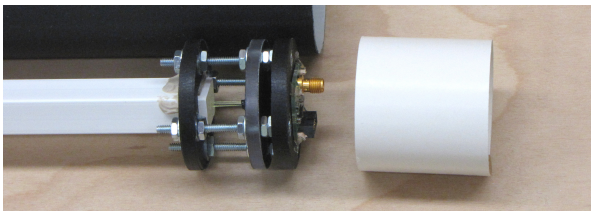
Displaced vertex trigger

- Two stations of fine-grained scintillator hodoscopes measure track Y
- FPGA trigger extrapolates tracks to the beam plane and fires on pairs of tracks with matching Z



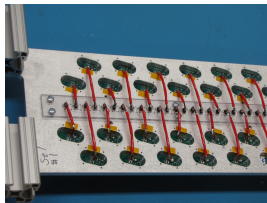
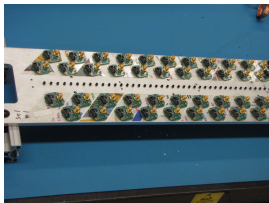
Trigger hodoscopes

- Extruded scintillator bars detect charged particles, wavelength-shifting fibers collect light and transport it to SiPMs
- Station 1: four boxes, 80 1×1 cm bars each
- Station 2: four boxes, 50 2×2 cm bars each



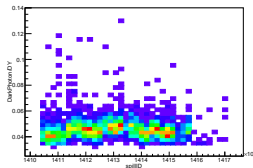
Readout and services

- Postage-stamp preamps read out the SiPMs and send signals to discriminators
- Power supplies provide independent control of every SiPM bias voltage
- Trigger decision made using CAEN V1495 FPGA boards



Installation and commissioning

- Trigger hodoscopes installed on the SeaQuest beamline this spring
- Detectors and trigger electronics tested and timed in
- Displaced vertex trigger rate is $\sim 5\%$ of the SeaQuest Drell-Yan trigger, acceptable for parasitic running
- 5 days of good data taken with the displaced vertex trigger before accelerator shutdown



Schedule and prospects

- This year's commissioning data is sufficient to understand the real backgrounds and sensitivity of the displaced vertex search
 - ▶ Expect updated reach estimates before next fall
 - ▶ Some physics reach may be possible with this data
- SeaQuest will run with polarized target (E1039) in 2018 and 2019: dark photon search will run parasitically
- Possible PID upgrade (using recycled PHENIX EMCal) may add sensitivity to dielectron decay channel