Future: dark sectors

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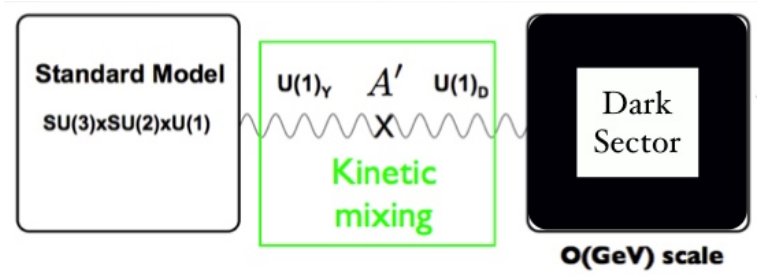
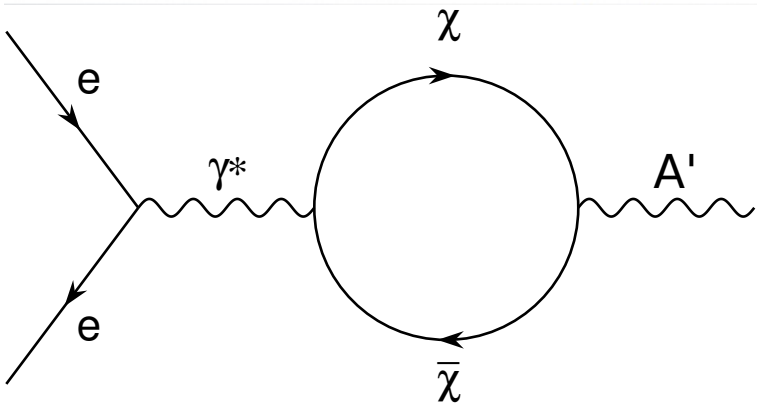
Why dark sectors?

- Standard Model is mostly complete: what's next?
- 10 years ago we thought we knew:
  - Find the Higgs
  - Find WIMP dark matter
  - Find supersymmetry
- Now it feels like we are 1 for 3 and we're missing something big
- Good time for small experiments making big bets
  - Axions
  - Light dark matter
  - Dark sectors

What is the dark photon?

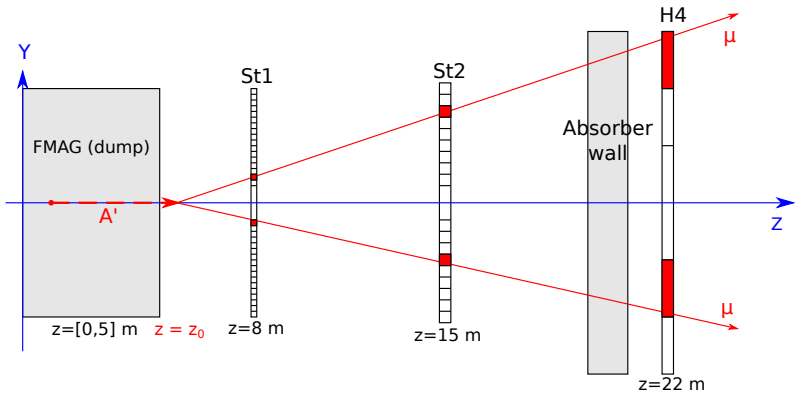
- "Dark sector" emerging as a picture of dark matter that is compatible with light dark matter, and allows for self-scattering, collisional excitation, annihilation
  - Standard Model forces don't couple to the dark sector, dark forces don't couple to Standard Model matter
  - "Portals" create weak effective couplings between the sectors
- Dark photon: dark mediator is a massive $U(1)$ boson ("vector portal") with weak effective coupling to electric charge
  - Minimal model that says nothing about the structure of the dark sector

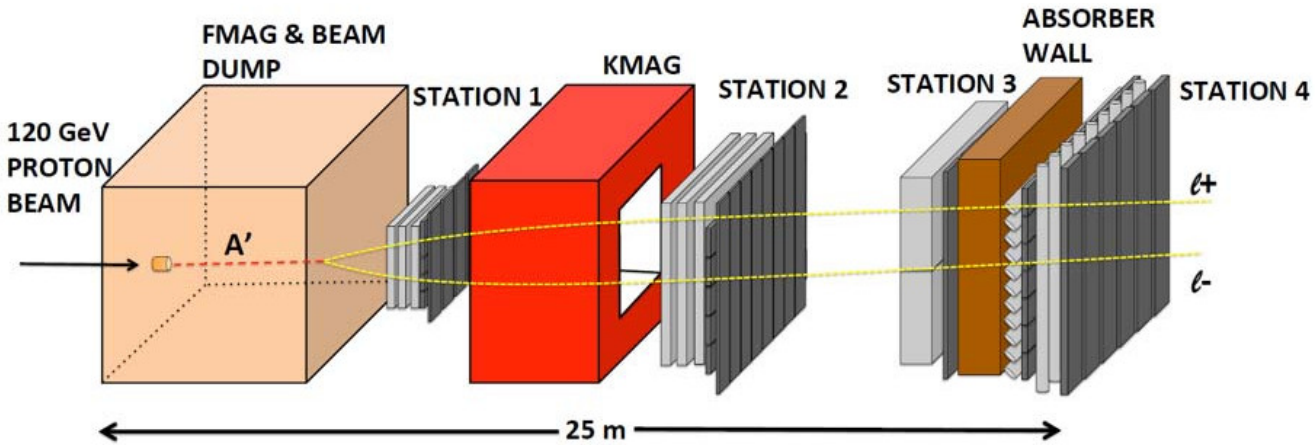




SeaQuest search for dark photons

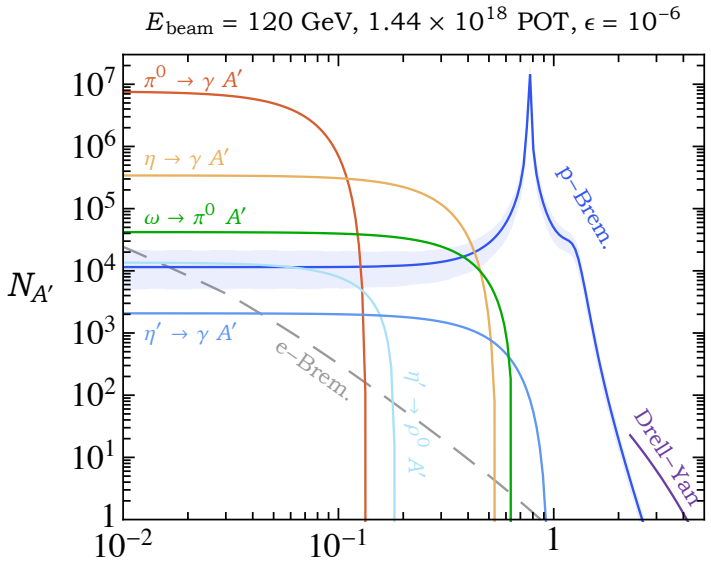
- Identify dark photons that travel through the dump before dimuon decay

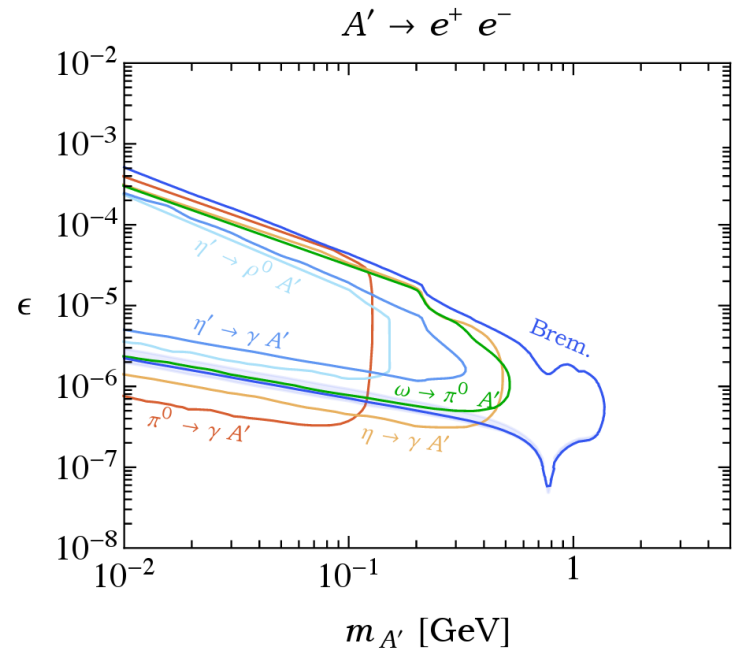




Why SeaQuest?

- Most fixed-target dark photon experiments have thin targets or thick beam dumps (100s of meters)
- SeaQuest has:
  - Thin dump, just thick enough to absorb beam backgrounds
  - High beam energy (boosts the A', so $\gamma c\tau$ gets through the dump)
  - Proton beam: many production channels and wide mass coverage
- Strong support from theory groups for a broad dark sectors program at SeaQuest



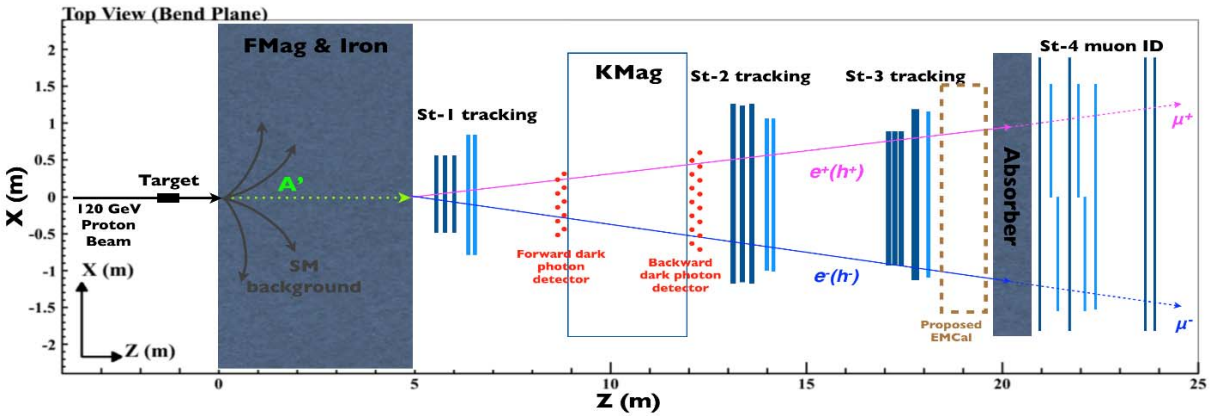


Displaced dimuon parasitic run (current commitment)

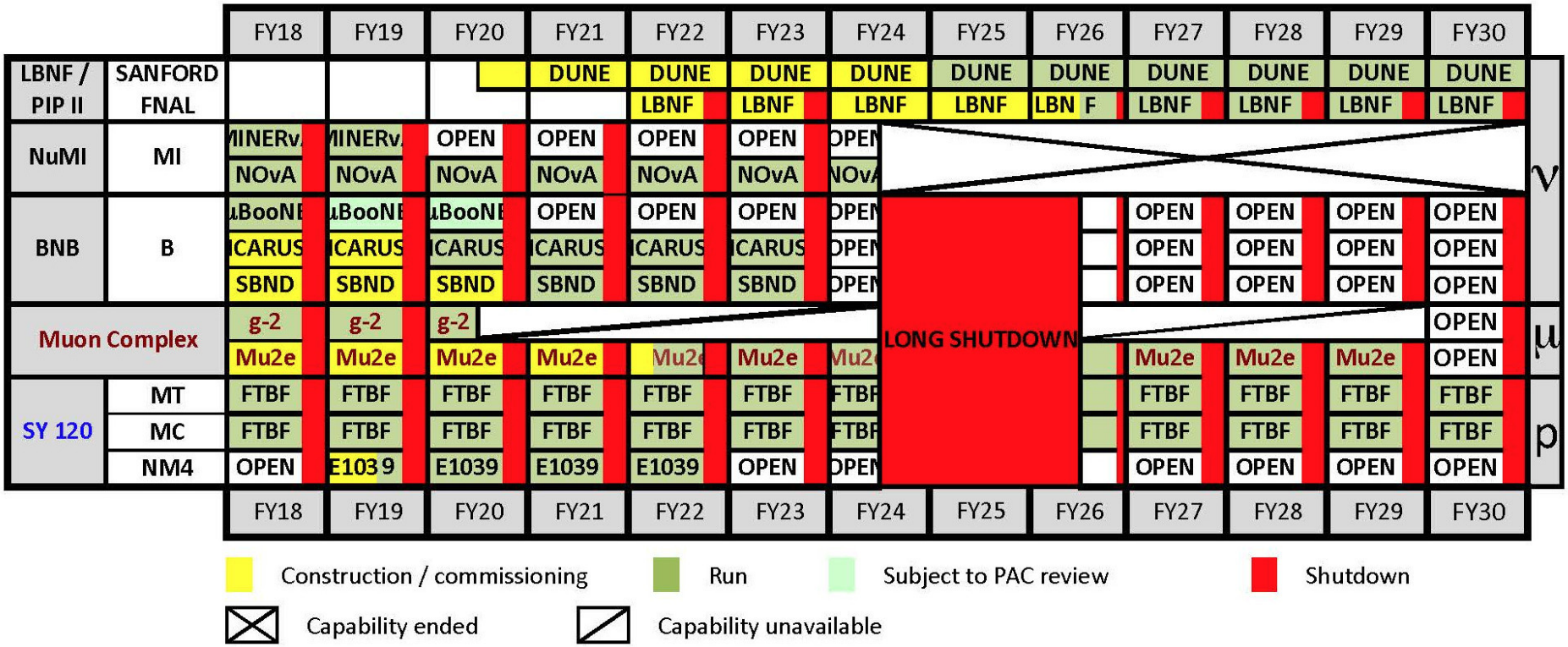
- Dimuon trigger is already commissioned, ready to go
- Run dimuon dark photon search during E1039 commissioning and running
- Analysis should get a result quickly
  - Efficiency and signal model are ready
  - Shoot for initial result (from first year's data) late 2019/early 2020
- 2019–2021: 0.5 postdoc

EMCal upgrade for dielectron trigger

- One PHENIX EMCal sector: 2×4 m^2 wall of Pb-scintillator shashlyks
- Simple energy threshold can trigger on non-MIP particles
- Track matching enables electron ID (reject $K_L^0 \to \pi^{\pm} e^{\mp} \nu_e$ mis-ID background)
- Requires some spectrometer reconfiguration — must be installed after E1039 is done



SeaQuest after E1039



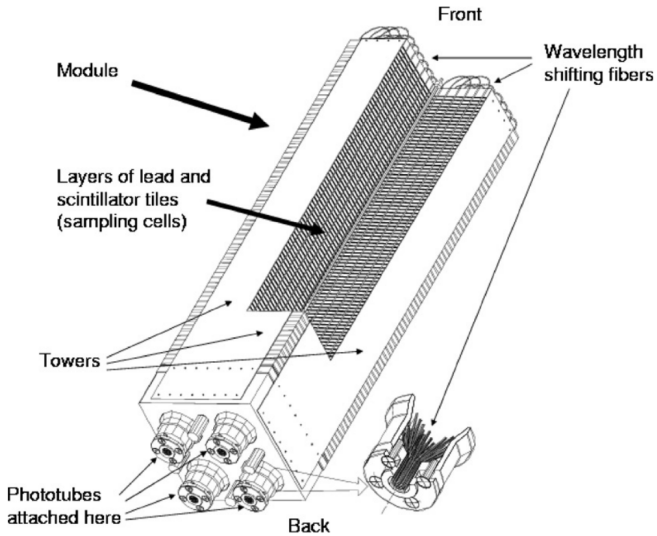
- NM4 is unscheduled after E1039: new NP program possible, or dedicated HEP dark sectors program?
- Dark photon searches can run in either scenario

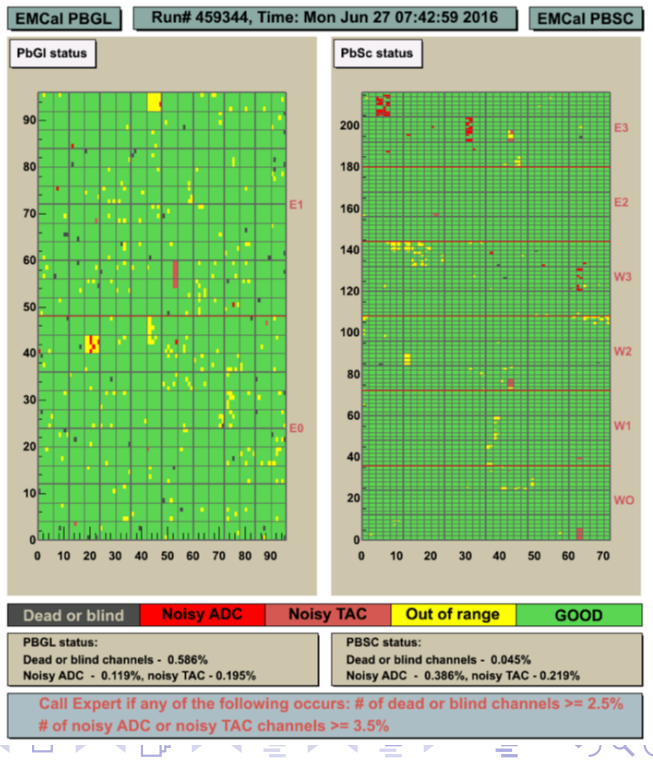
Planning EMCal upgrade

- Letter of Intent for EMCal
- Gather collaborators from the HEP world
- MC studies for full proposal
- Investigate hardware options
- 2020–2021: 0.5 staff, 1 postdoc

Executing EMCal upgrade

- The two best sectors have been transferred (on paper) to LANL
- We have the full PHENIX readout system; investigating whether it can be directly reused for SeaQuest
  - Time structure (10 MHz vs. 53 MHz) is the main concern, but pileup is negligible
  - Alternative: STAR is developing an SiPM-based readout system with the same modules
- 2021–2023: 1.5 staff, 2 postdoc, 1 engineer





The competition

- Expected before 2023 (left), proposed and 2023+ (right)
- LHCb triggerless readout 2021-23, NA62 beam-dump run 2023, FASER (proposed, early stages) 2021-2023
- SHiP proposed, earliest 2026