

A PROBE FOR DARK SECTOR MEDIATORS WITH A PROTON BEAM

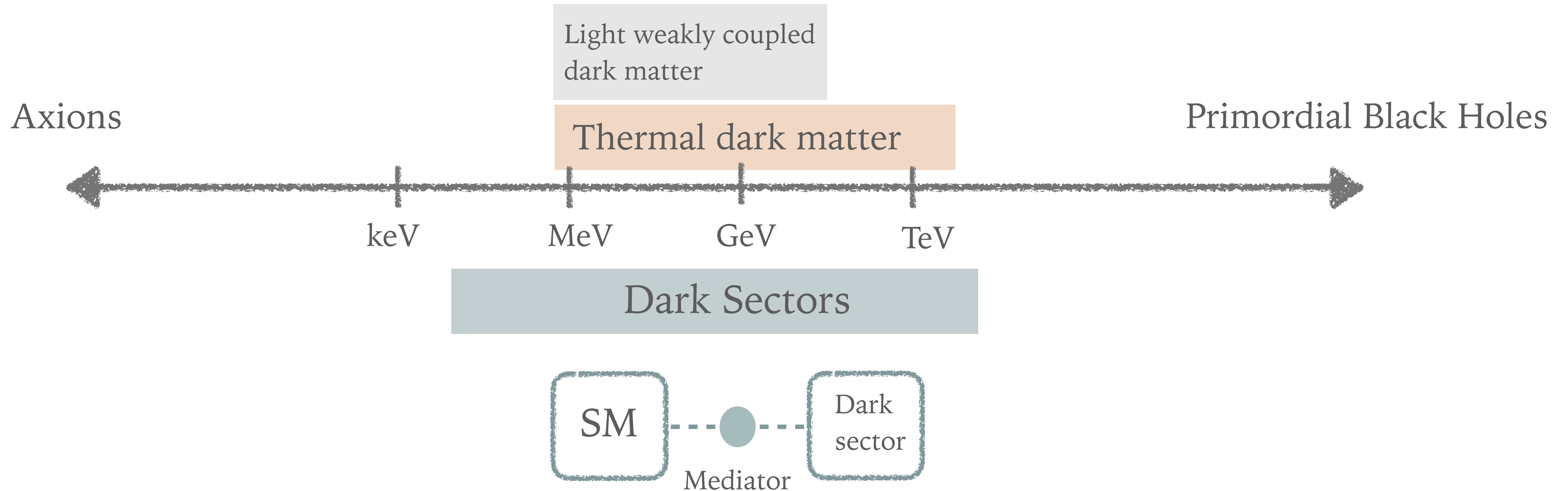


*Cristina Mantilla Suarez (FNAL)
for the DarkQuest collaboration*

*PHENO 2021
24 May 2021*

- DarkQuest is a unique proposal to upgrade existing detectors (SpinQuest @ FNAL) and greatly extend the mass reach of the search for visible-decaying dark sectors.
- I will talk about the expected sensitivity, upgrade plans and ongoing simulation studies.

DARK SECTORS AND LIGHT DARK MATTER



Big opportunity to probe dark sectors in MeV-GeV regime with high-intensity accelerators and fixed-target experiments

WHY DARKQUEST?

For χ prod.: $m_{\text{med}} > 2m_\chi$

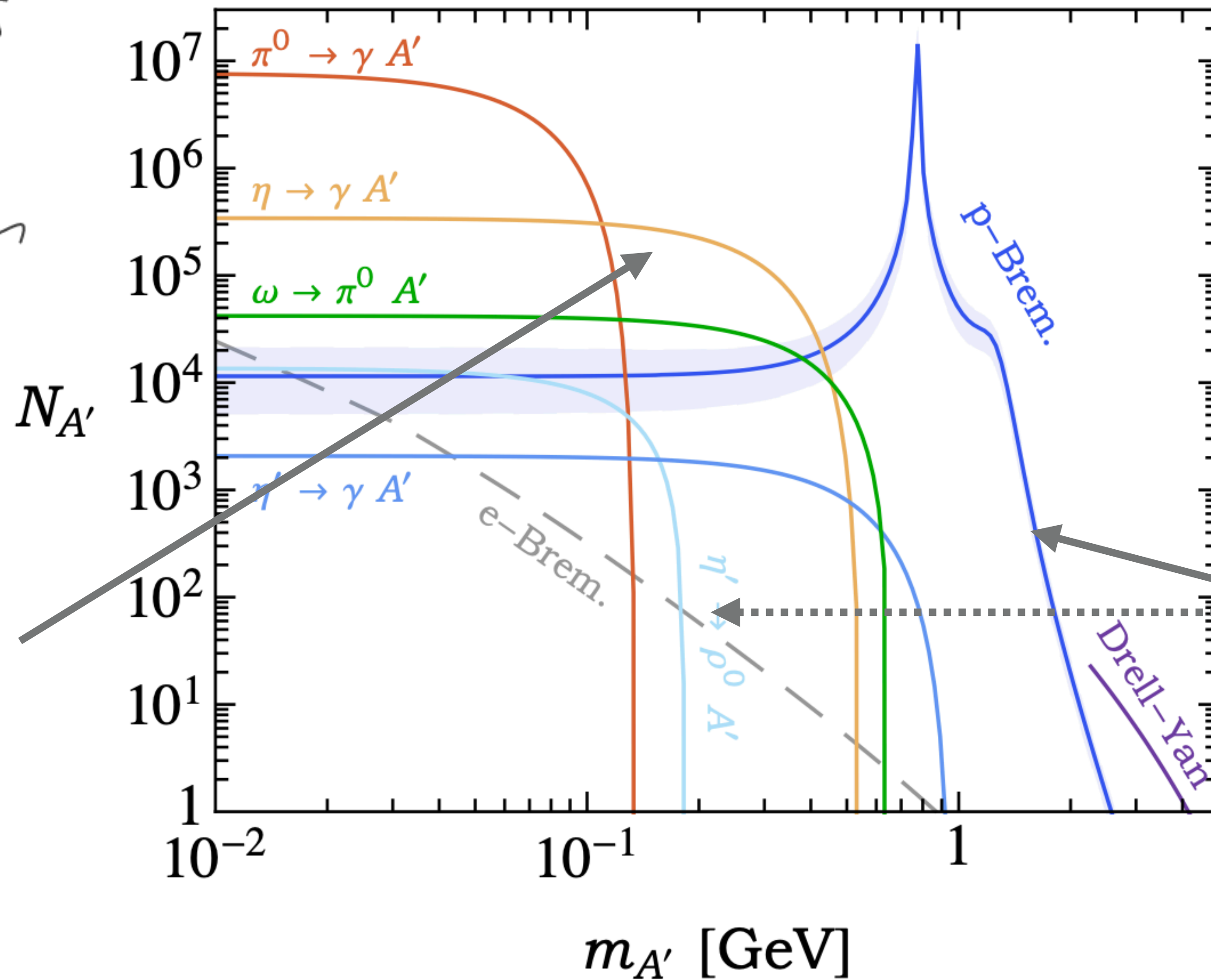
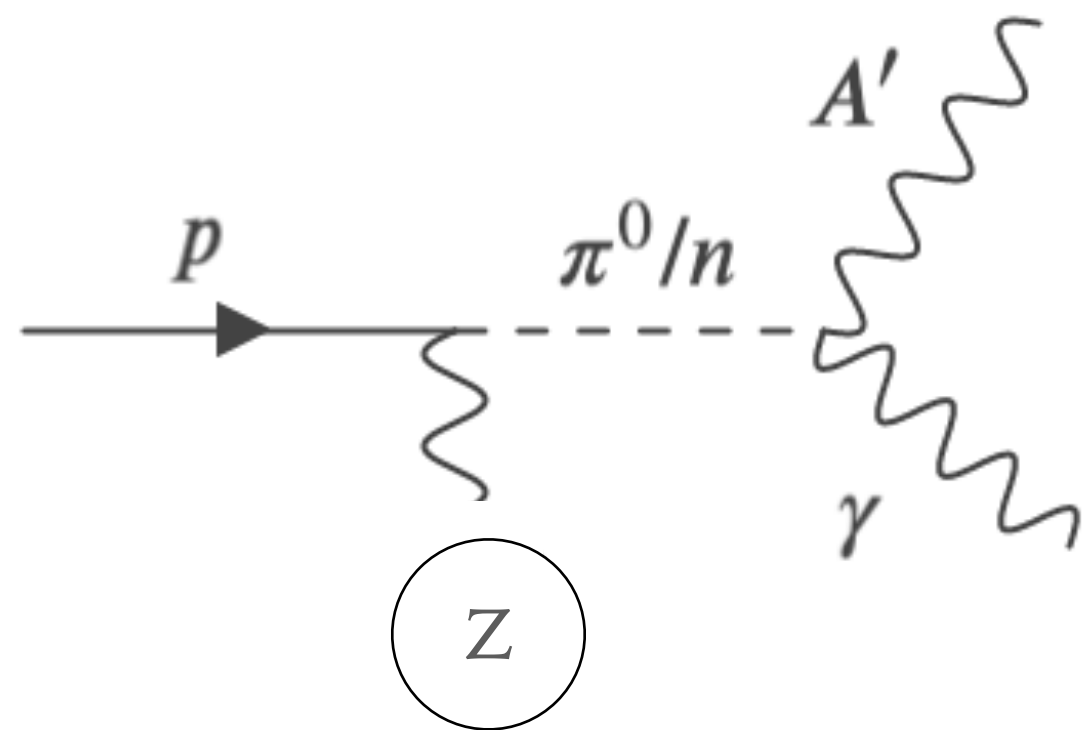


A proton beam will yield *higher effective luminosities* than a lepton beam and DarkQuest's (existing) short baseline (5 m) makes it *unique for LLP searches* ($z_{\text{displaced}}$: 5 -10m)

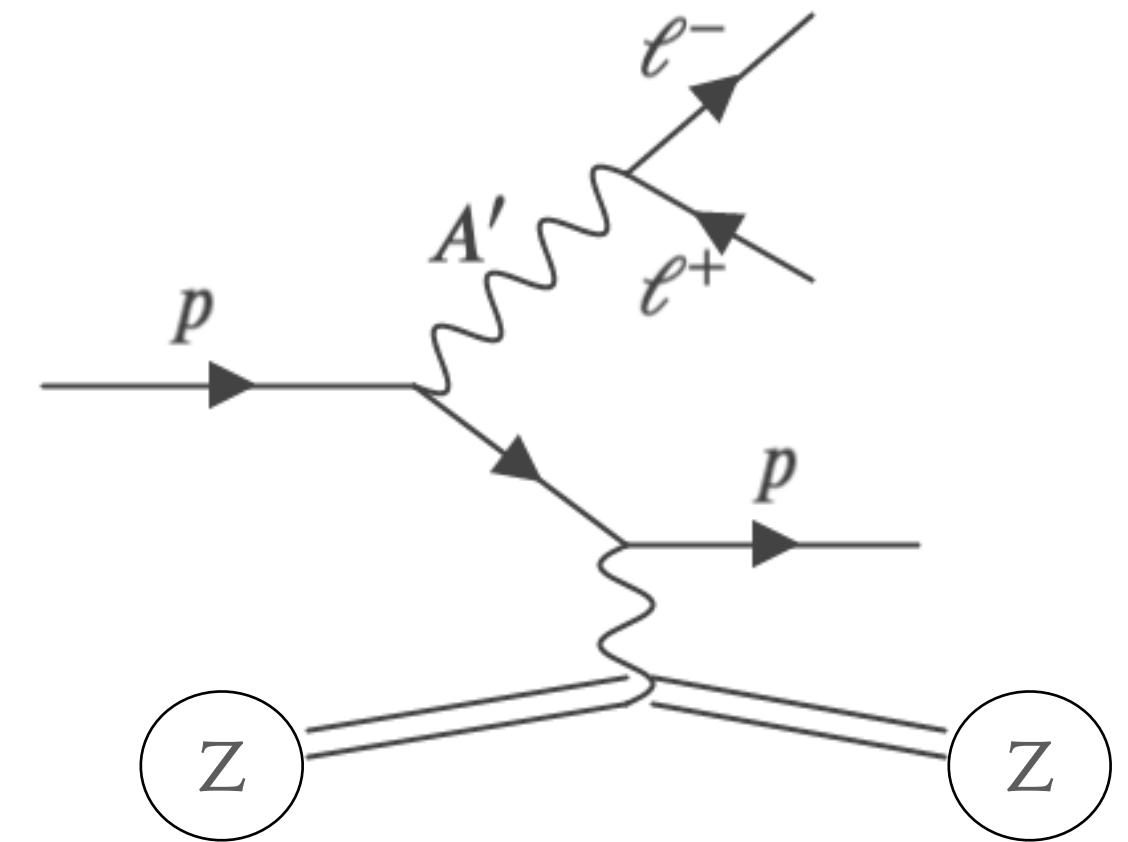
AN EXAMPLE: A' PRODUCTION IN PROTON BEAMS

Berlin, Gori, et. al. (2018)

$E_{\text{beam}} = 120 \text{ GeV}, 1.44 \times 10^{18} \text{ POT}, \epsilon = 10^{-6}$



Large production of light mesons



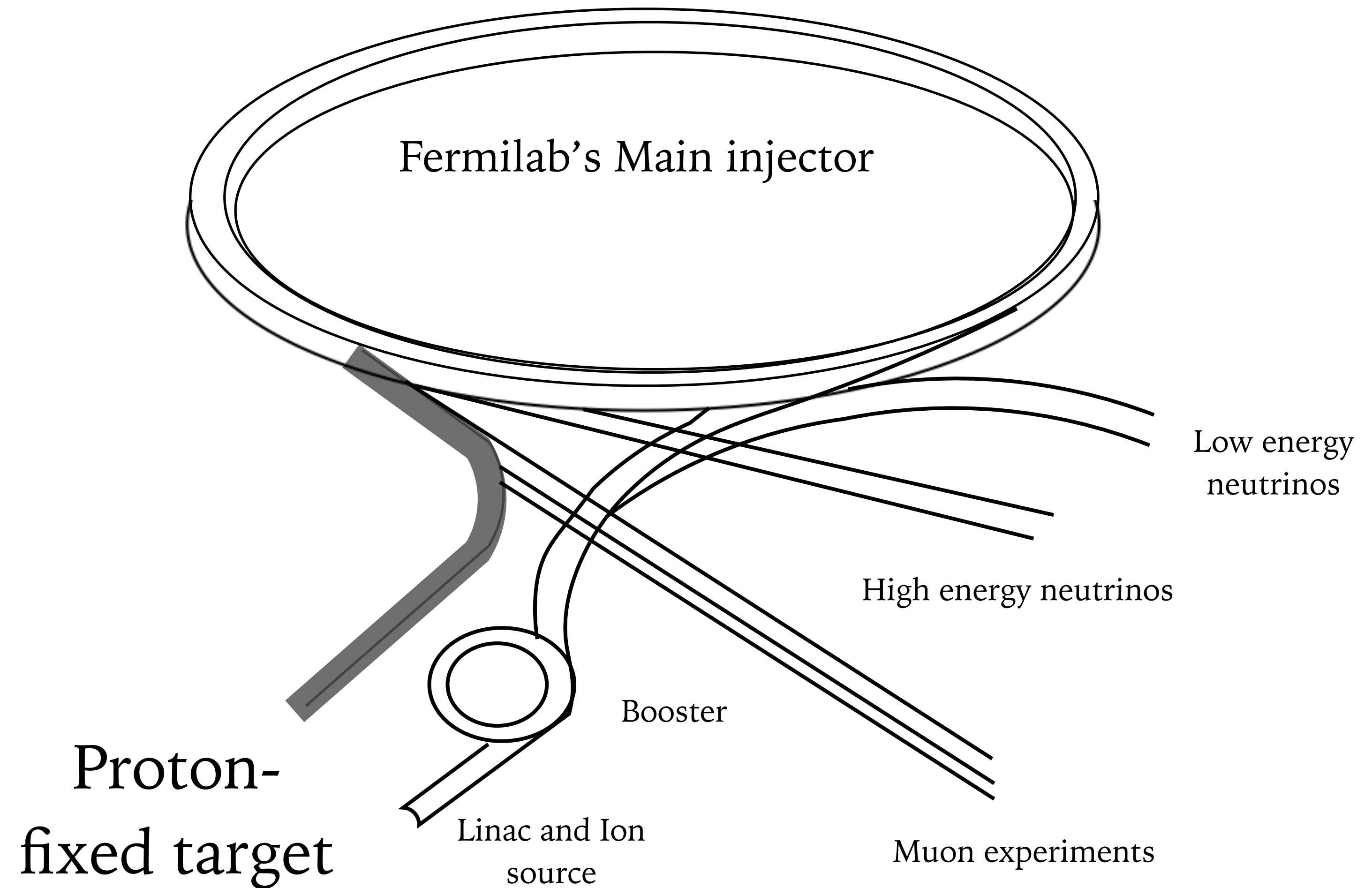
Proton Bremsstrahlung is enhanced by α_s/α_{EM}

PROTON BEAM SETUP

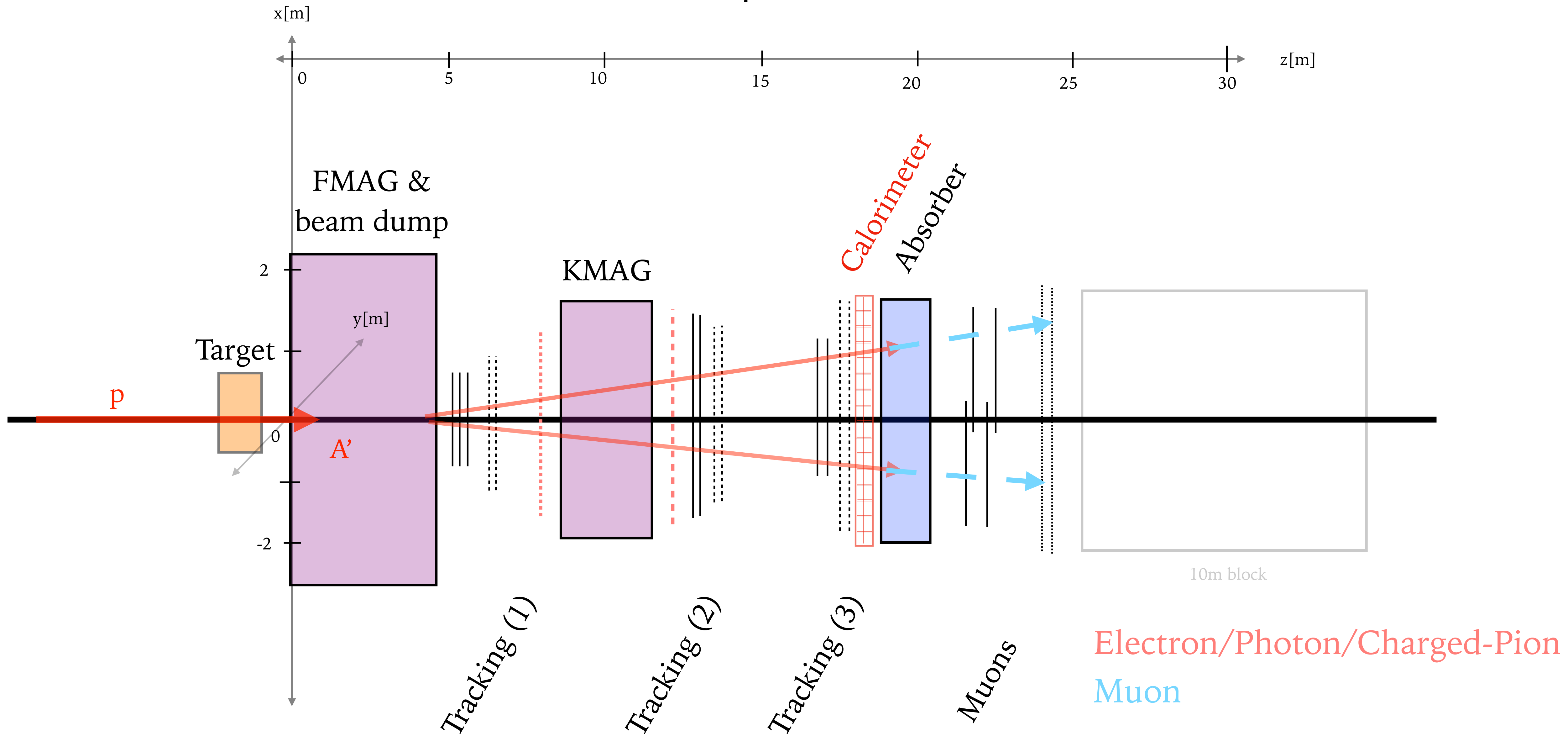
120 GeV proton beam: max. intensity of $1e13$ protons/ 4s. spill and beam spot $\sim 6-7$ mm

RF frequency: 53 MHz

Expected luminosity: $1e18$ Protons on Target (POT) in 2023-2025 and $1e20$ (>2025)

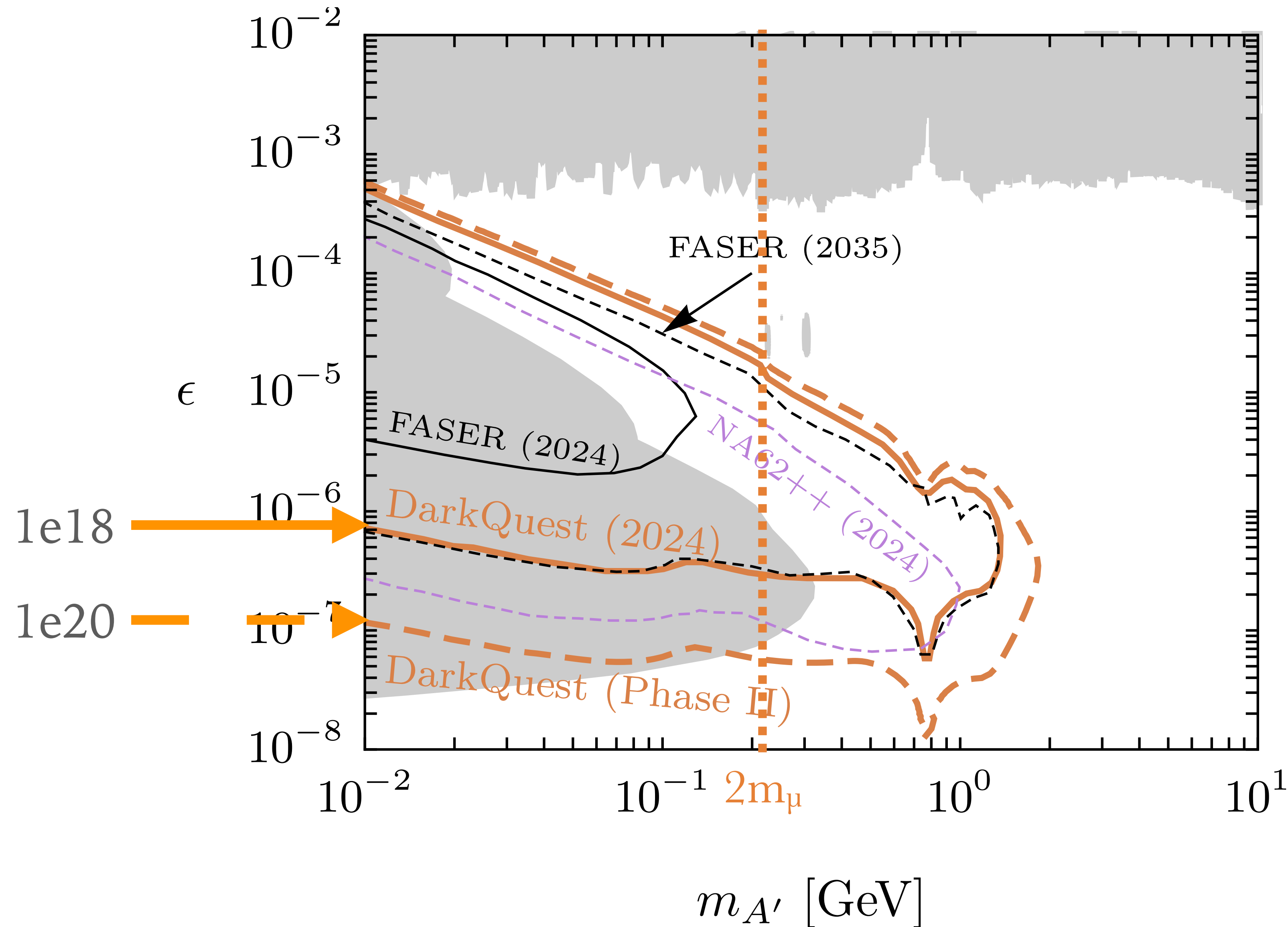


~ 25m Spectrometer

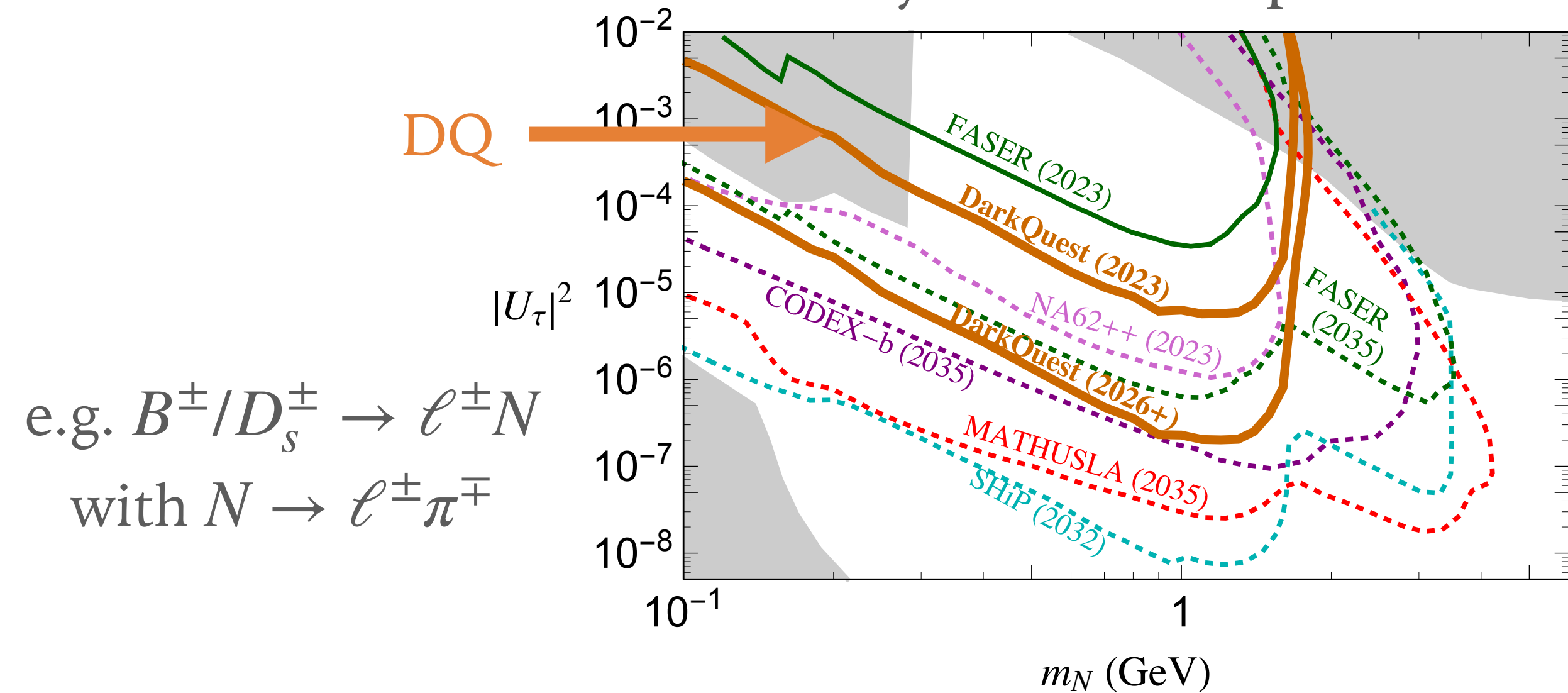


A' TO DI-LEPTONS REACH FROM PHENO STUDIES

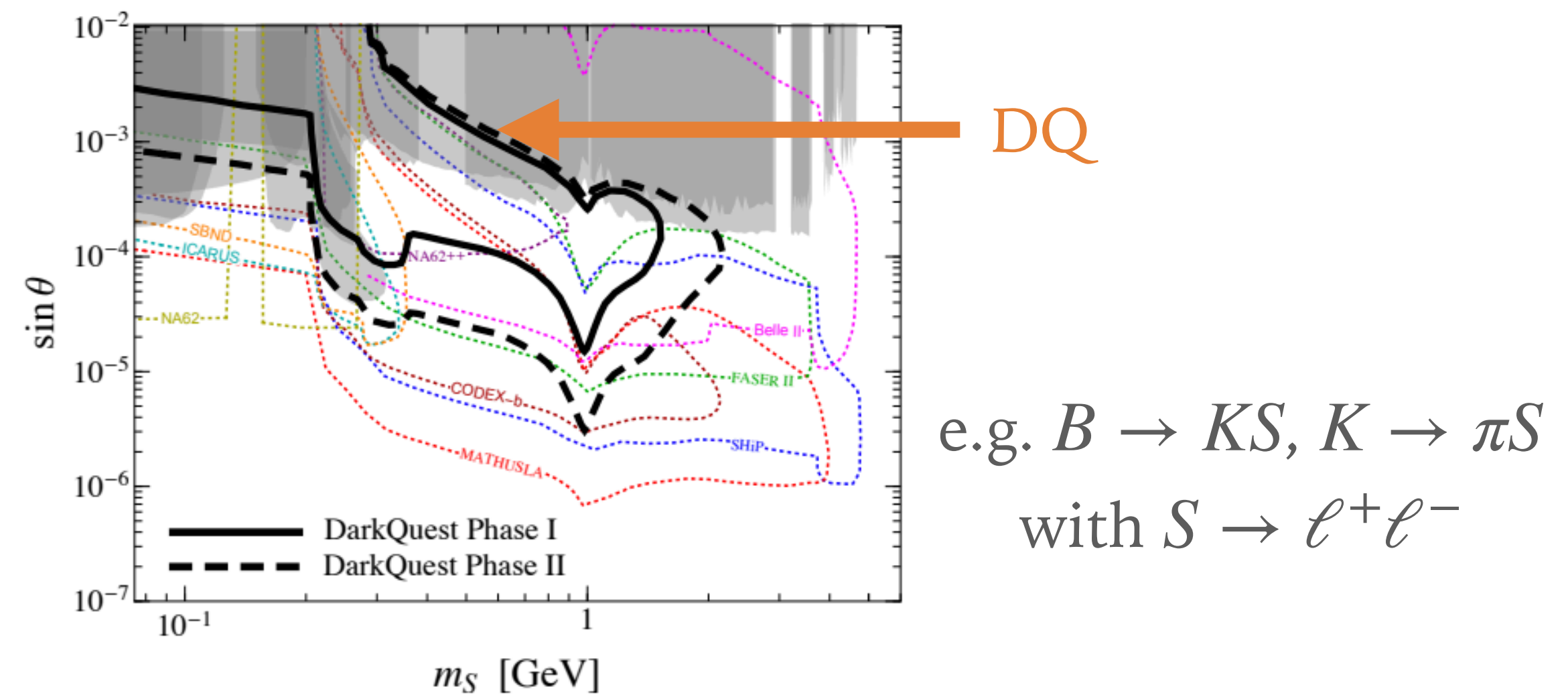
Berlin, Gori, et. al. (2018)
and N. Blinov



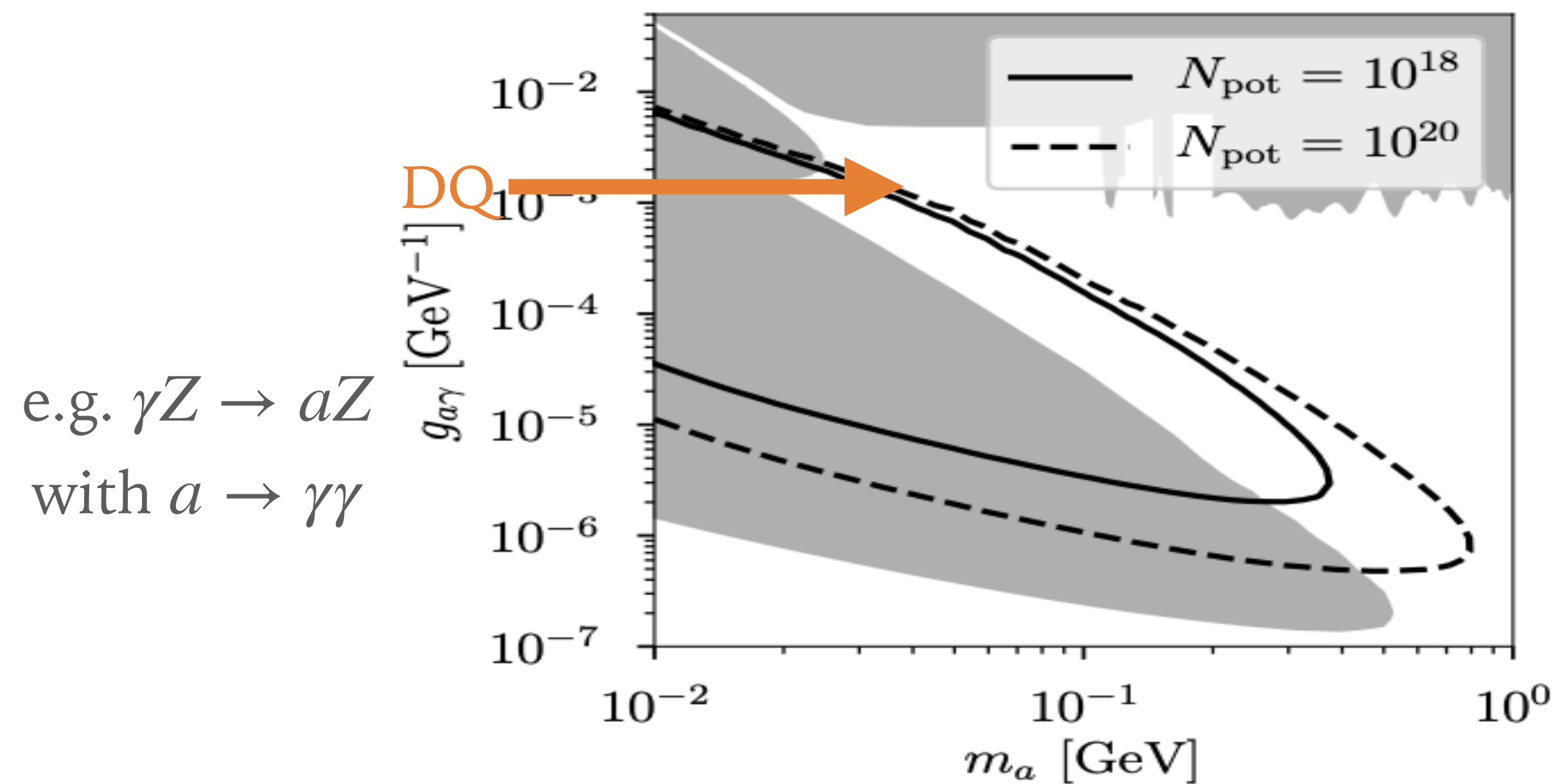
Heavy Neutral Leptons



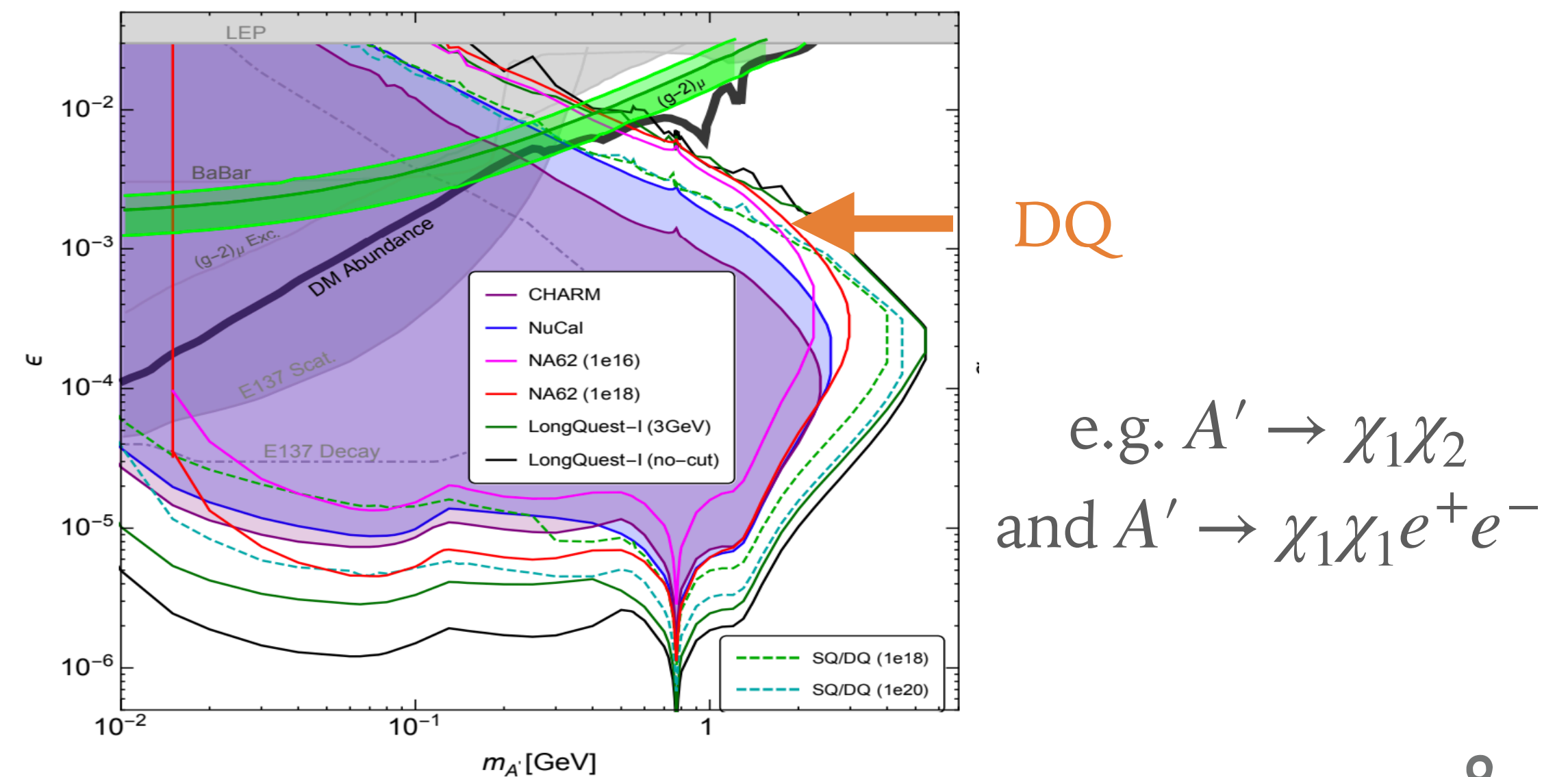
Dark Scalars



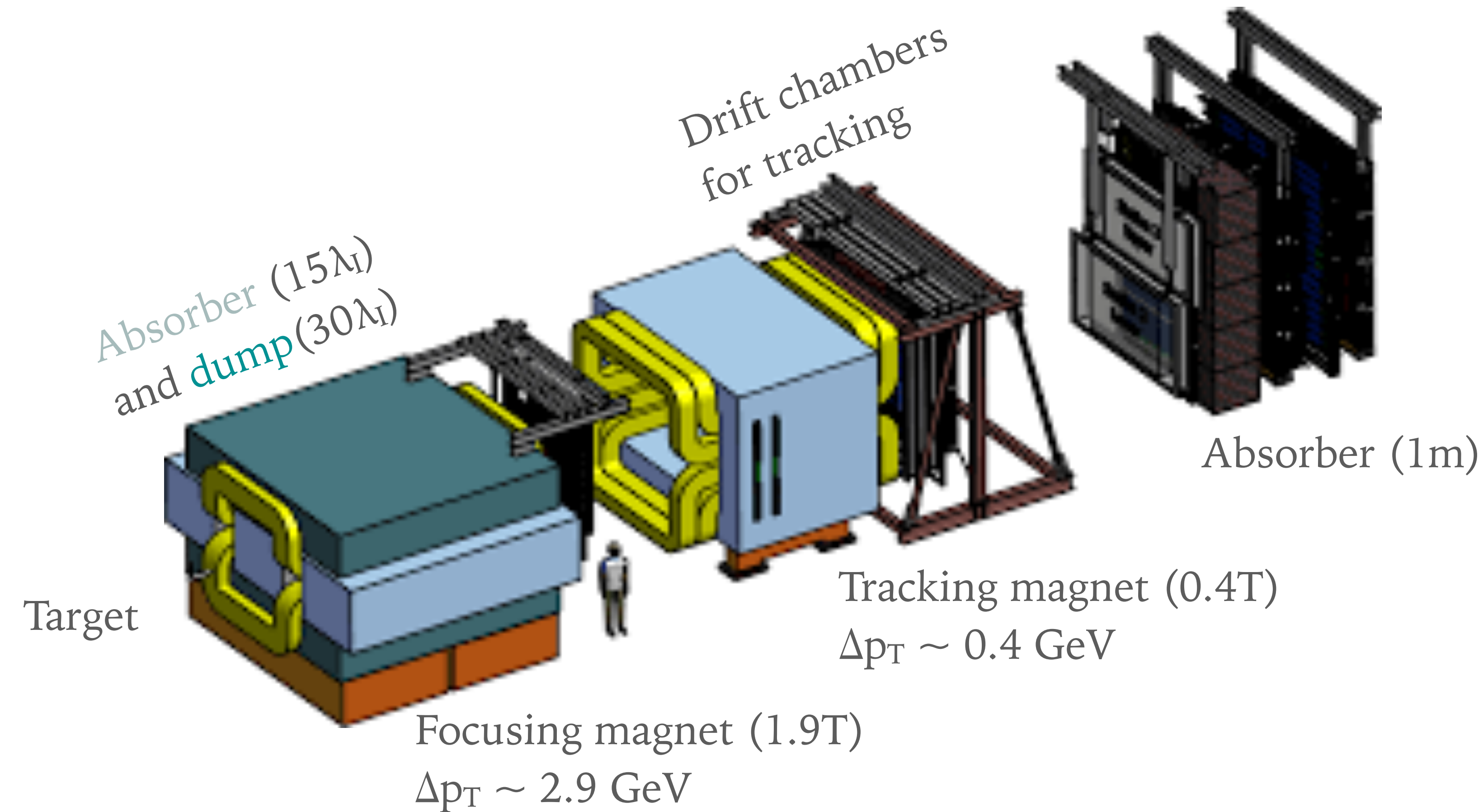
Axion-like particles



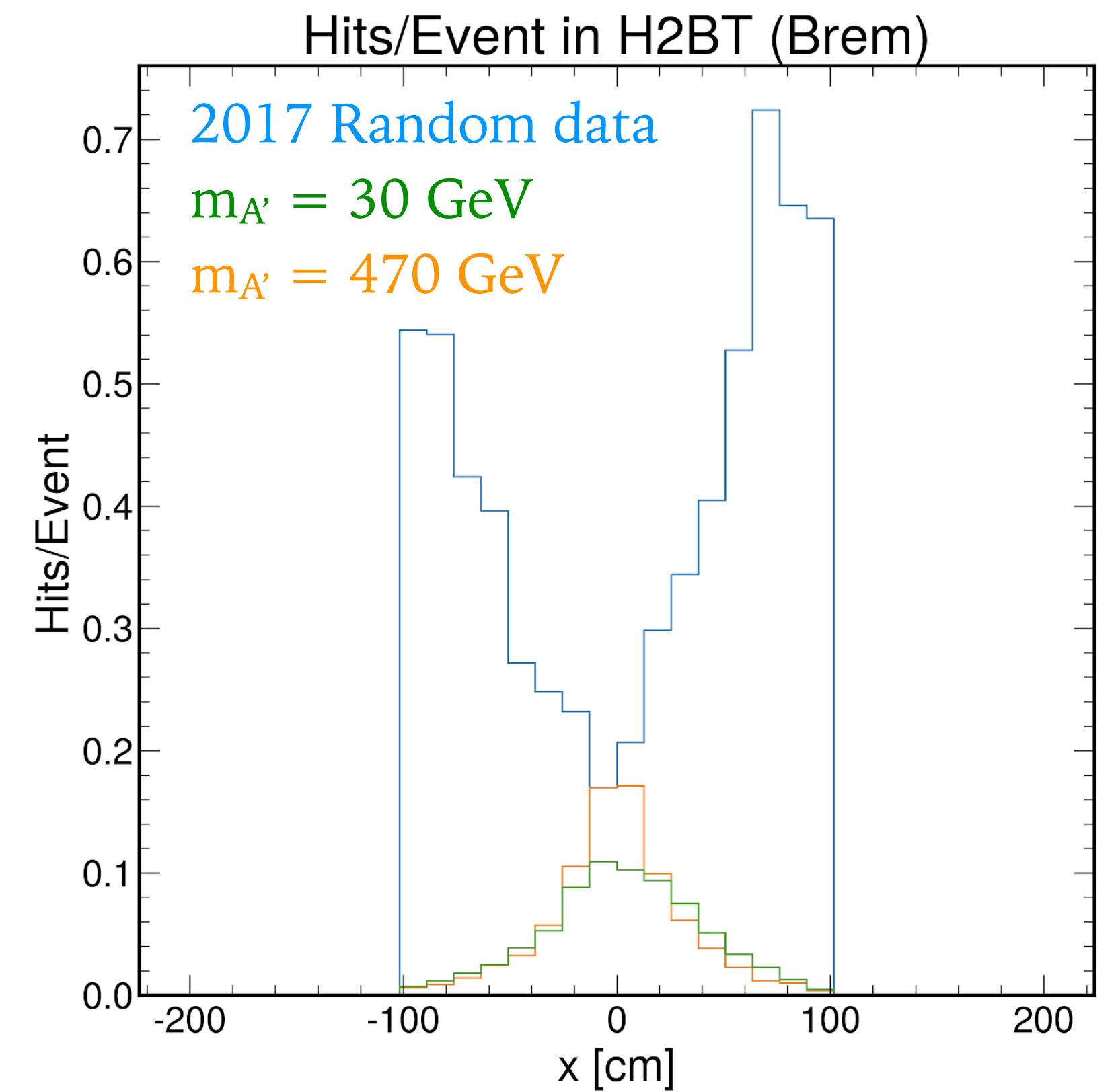
Fermionic Inelastic Dark Matter



EXISTING SPECTROMETER COMPONENTS

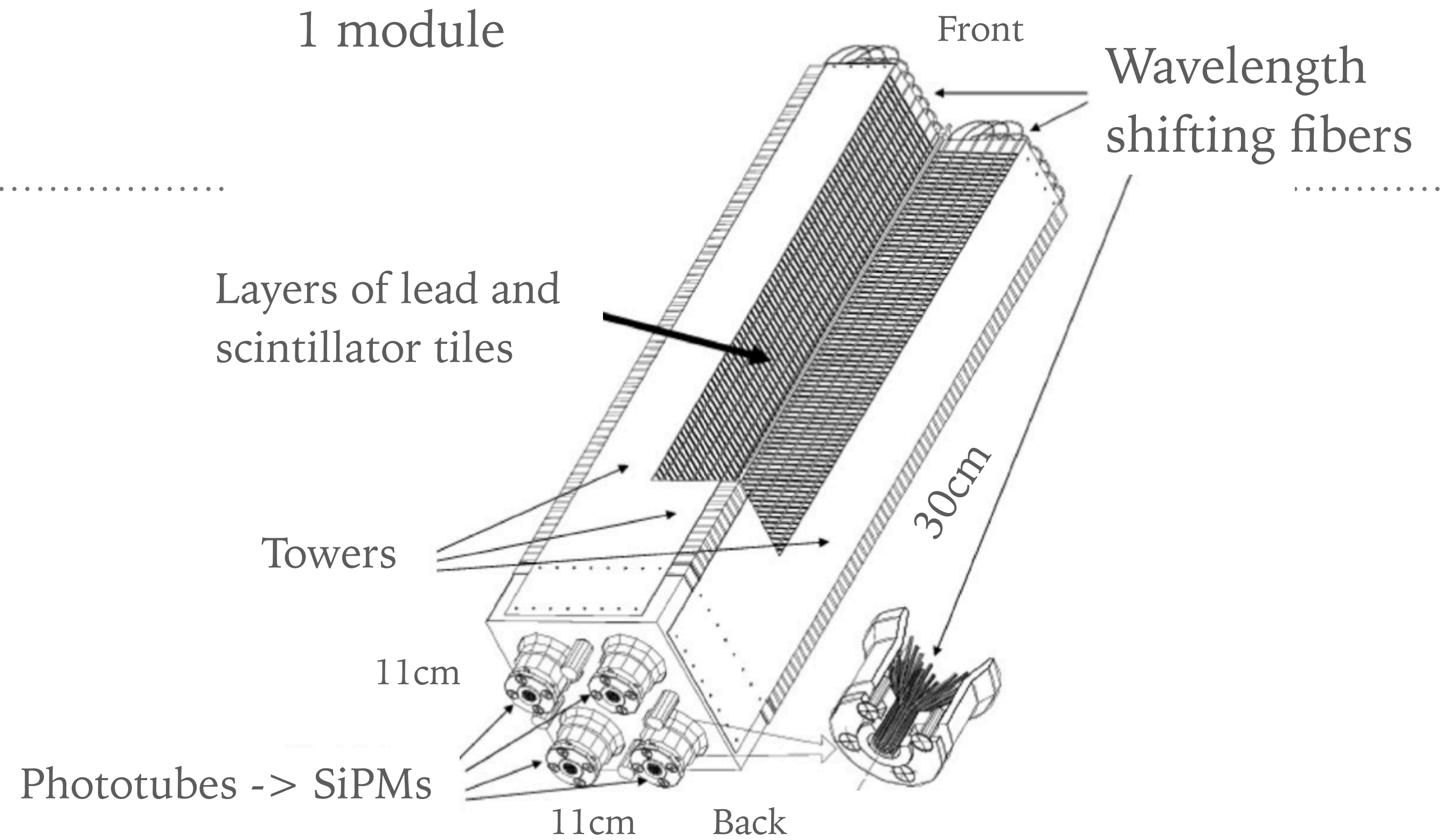


High-momentum signal
focused near beam line



EMCAL UPGRADE TASKS

2 existing EMCAL sectors @ BNL:
1296 readout ch./sector



Ongoing and future tasks:

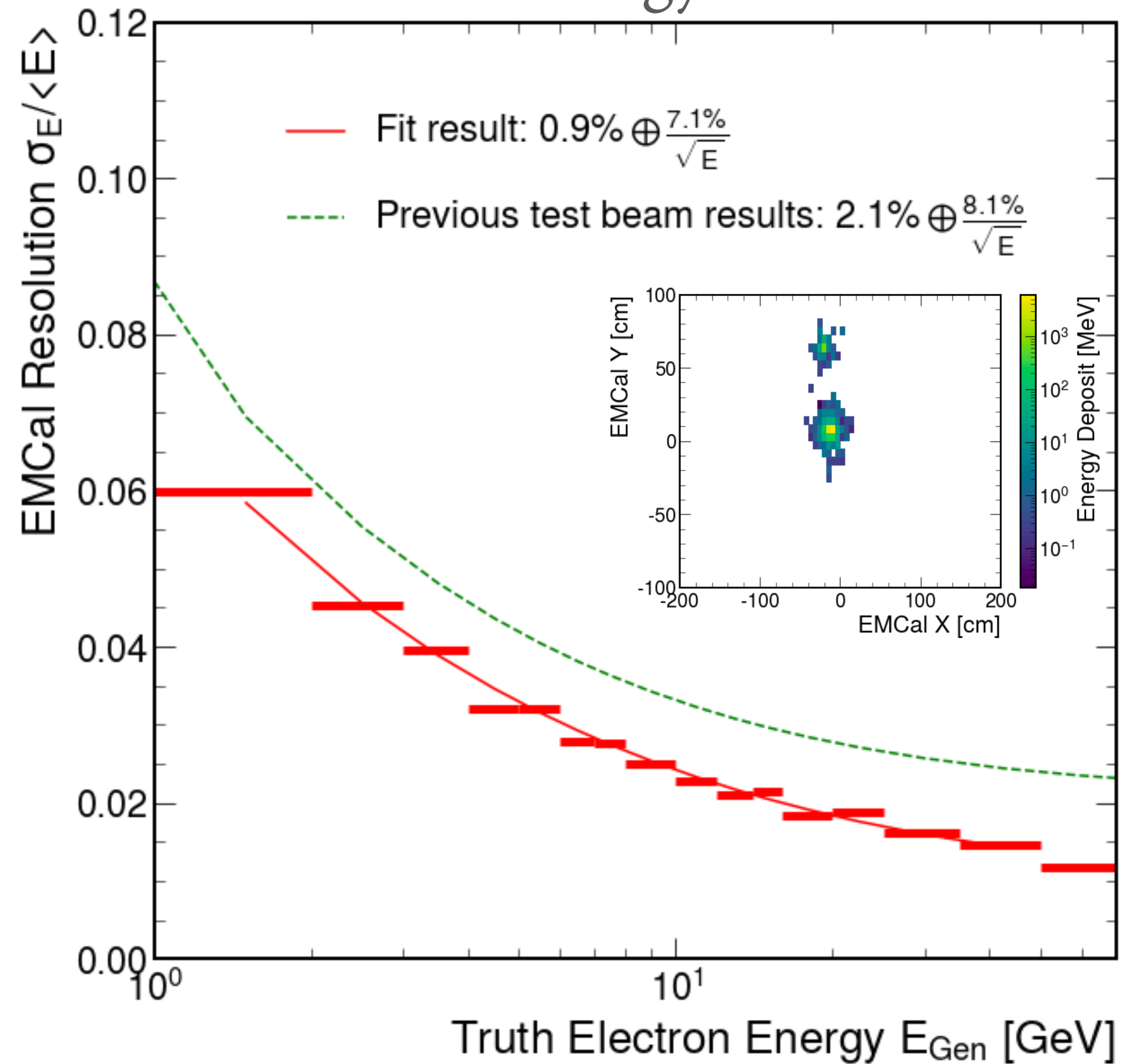
Update from PMT to SiPMs (ADC+TDC)

Design SiPM readout (e.g. from EMPHATIC experiment)

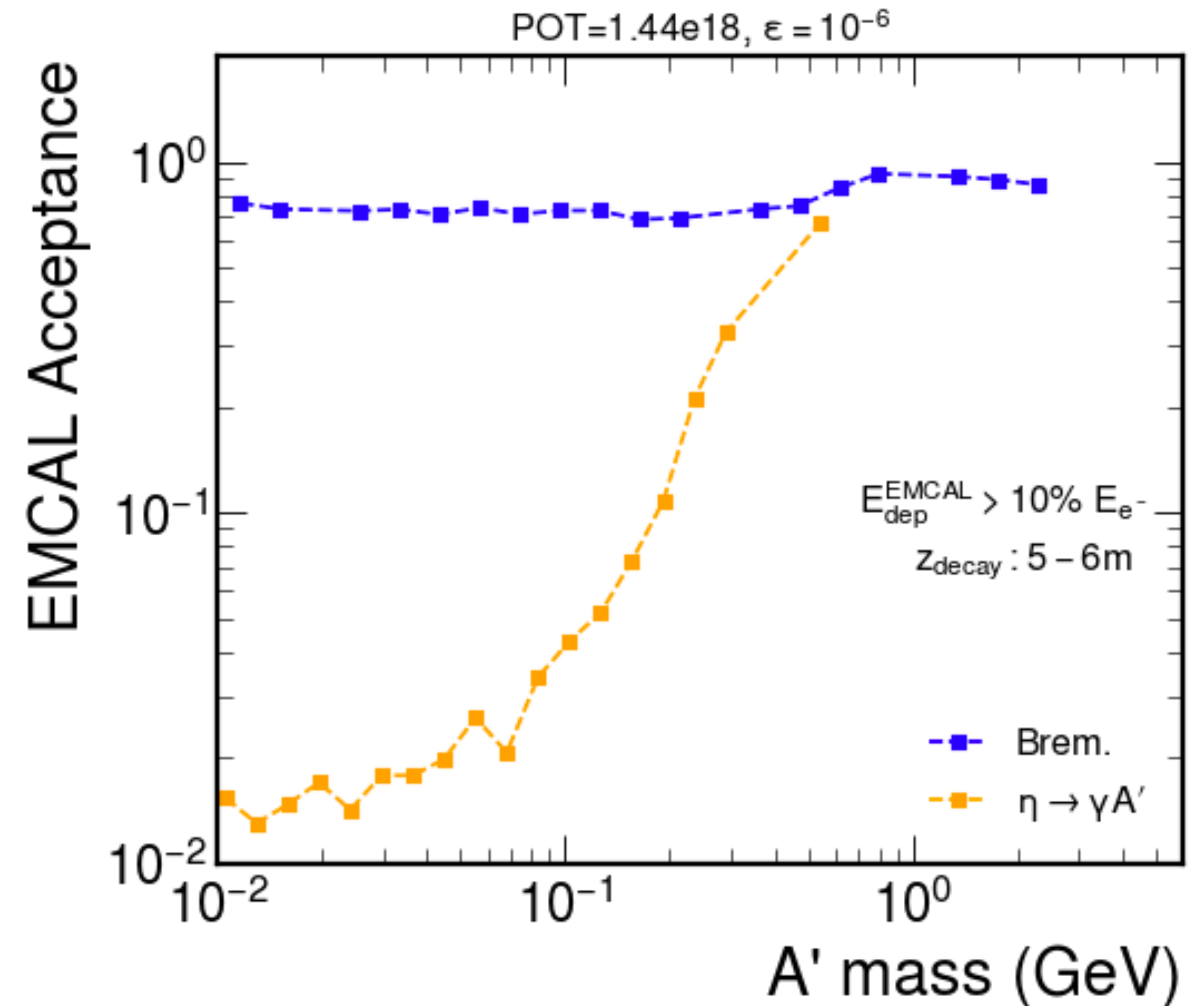
Integrate with current DAQ

FULL GEANT4 STUDIES

EMCAL energy resolution

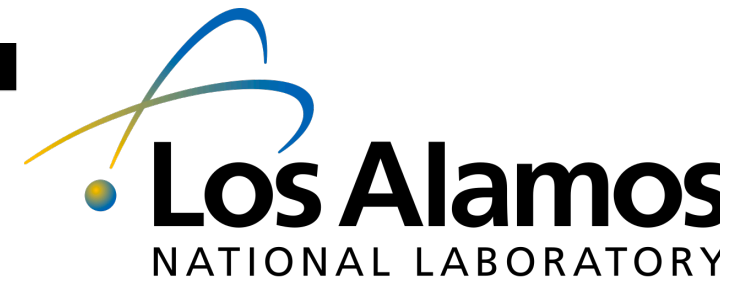


geometric acceptance (\sim pheno-predictions)



COLLABORATION

- Growing team of experimentalist and theorists (~ 1 year old)



Experimentalists:

BU: Zeynep Demiragli, David Sperka, Amitav Mitra
FNAL: Nhan Tran, Yongbin Feng, Cristina Mantilla Suarez
MIT: Phil Harris, Duc Hoang, Noah Paladino, Sergio Cuadra
LANL: Ming Liu, Kun Liu
JHU: Petar Maksimovic
SLAC: Tim Nelson, Omar Moreno

Theorists:

FNAL: Nikita Blinov, Yu-Dai Tsai
PITT: Brian Batell, Mudit Rai
NYU: Asher Berlin
UCSC: Stefania Gori

- Establishing strong connections with SpinQuest collaboration
- LongQuest proposes new far detector and further upgrades (PID, new dump and fast tracking) see Tsai et. al. (2021) - ongoing studies for Snowmass!
- We welcome new collaborators! Contact us: cmantill@fnal.gov, ntran@fnal.gov

SUMMARY

- DarkQuest offers a low cost ($\sim 500k$) opportunity to expand the mass reach for light dark sector mediators
- Plans for EMCAL upgrade that adds electron/photon channel
- Ongoing simulation studies: integration of EMCAL, displaced tracking, signal and background yields
- Planned Timeline: SpinQuest will run (Fall 2021-2022): parasitic run w. dimuons, and DarkQuest aims for Fall 2023-2025