LDMX

A Light Dark Matter eXperiment

Nhan Tran, Fermilab

Hidden Sectors at Fermilab
September 4, 2019

Caltech
Fermilab
SLAC NATIONAL ACCELERATOR LABORATORY
UCSB UNIVERSITY OF CALIFORNIA SANTA BARBARA
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OUTLINE

Missing momentum technique

Physics reach for DM milestones

The LDMX detector

And where Fermilab fits in

More Physics!

Strongly interacting DM, millicharged particles, etc

Measurements for the neutrino program

https://arxiv.org/abs/1808.05219

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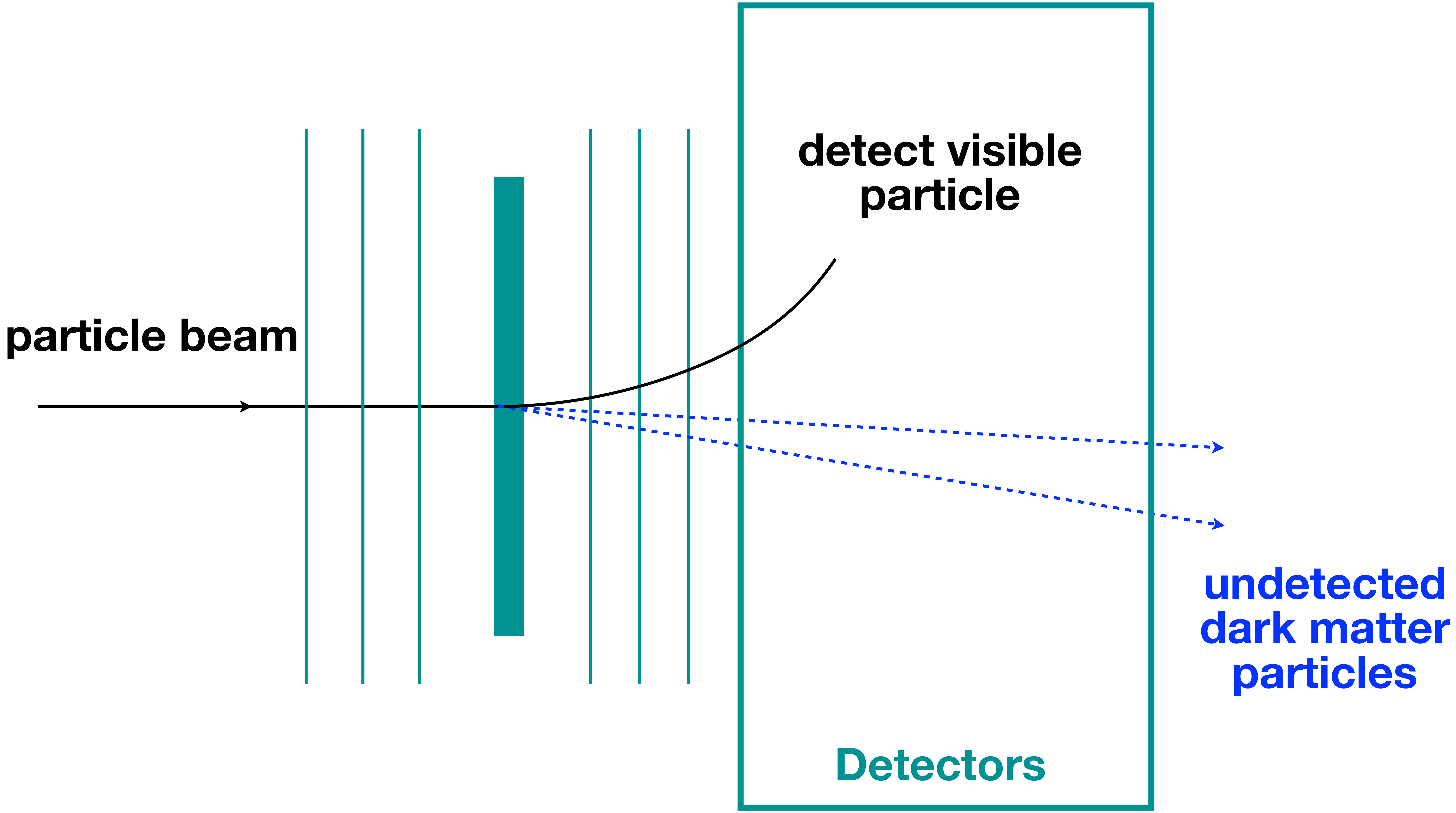
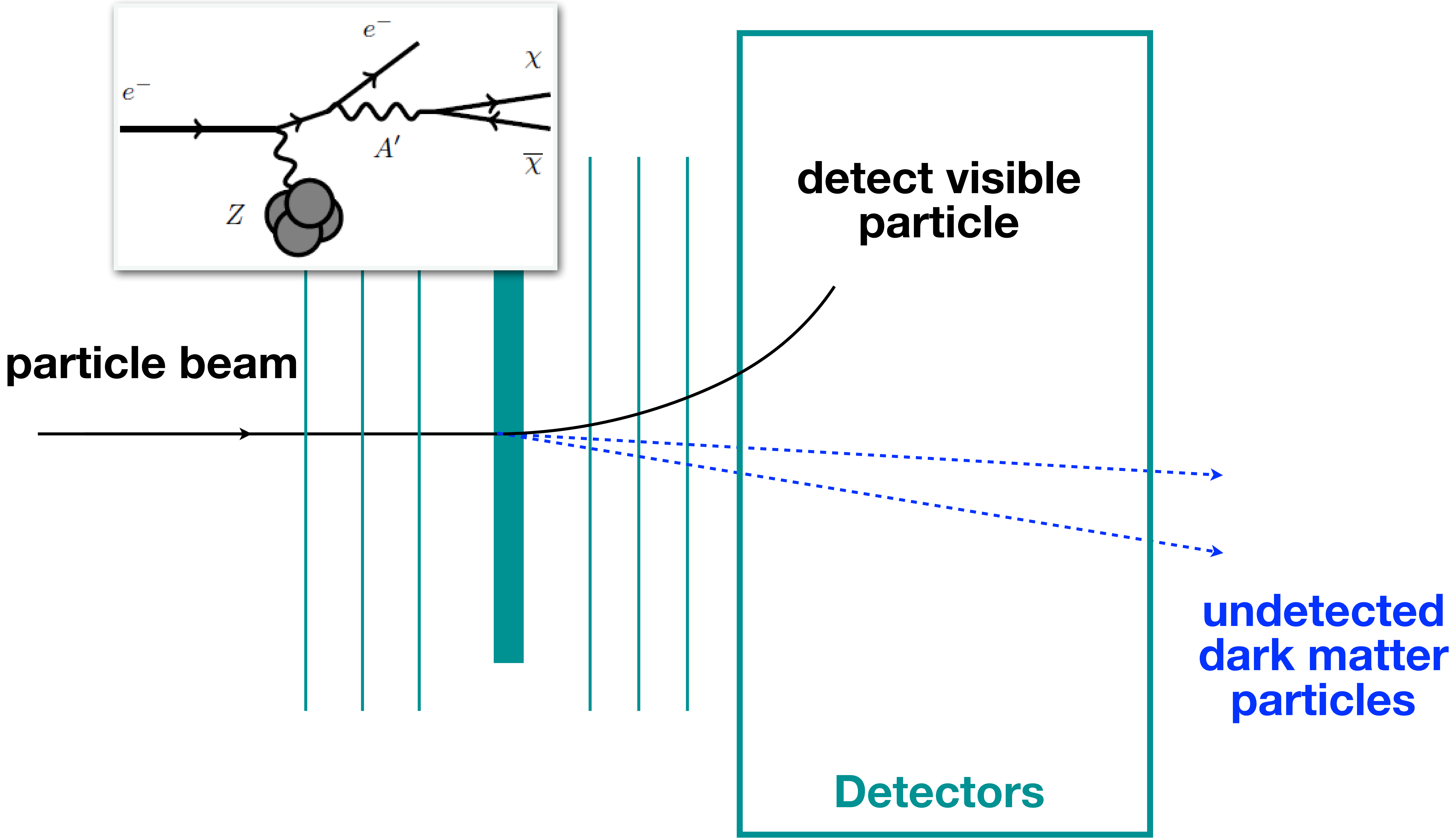
MISSING MOMENTUM



Sensitivity ~ ε^2 : compared to beam dumps which scale as ε^4

MISSING MOMENTUM



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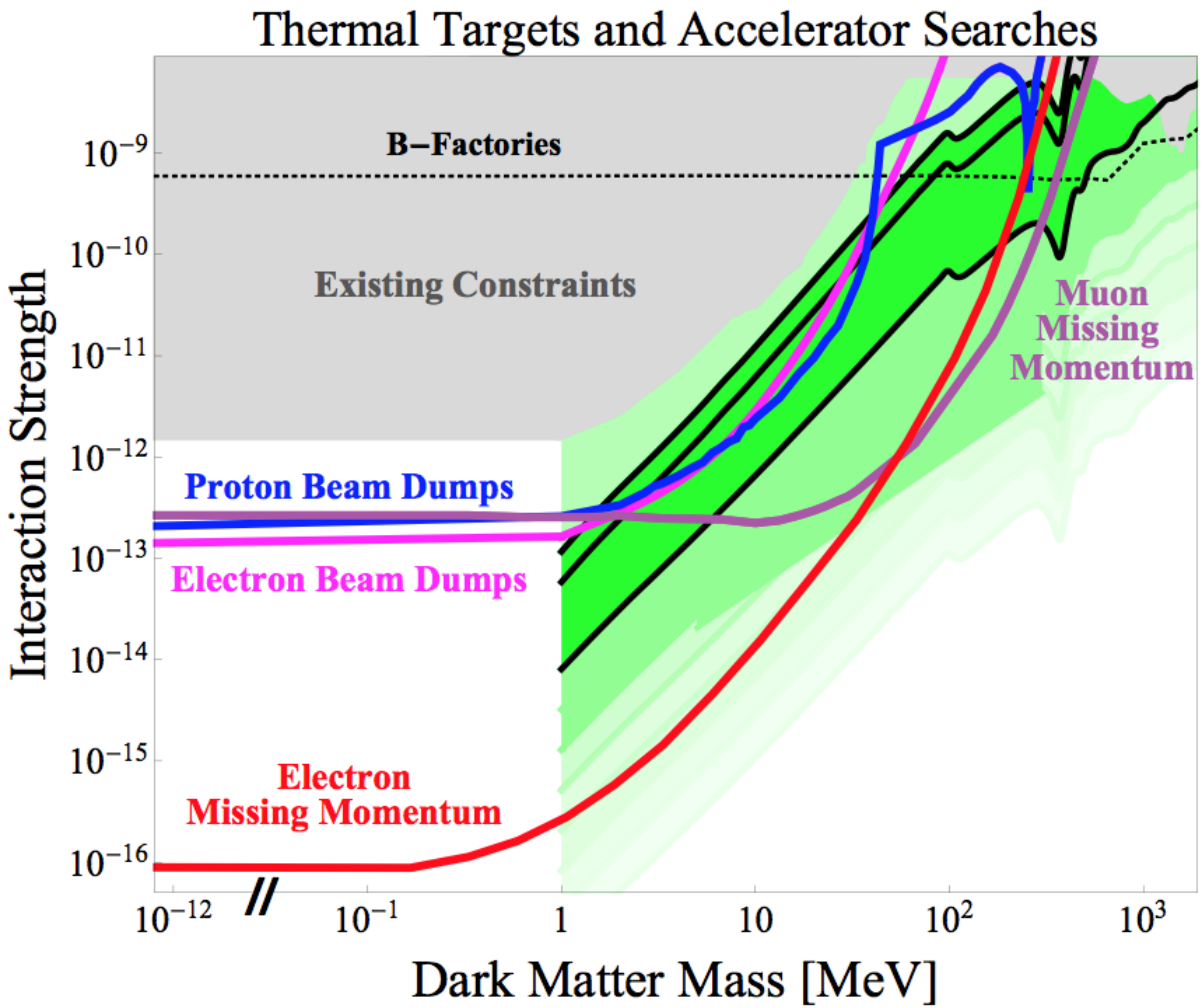
NEW OPPORTUNITIES IN DARK MATTER!



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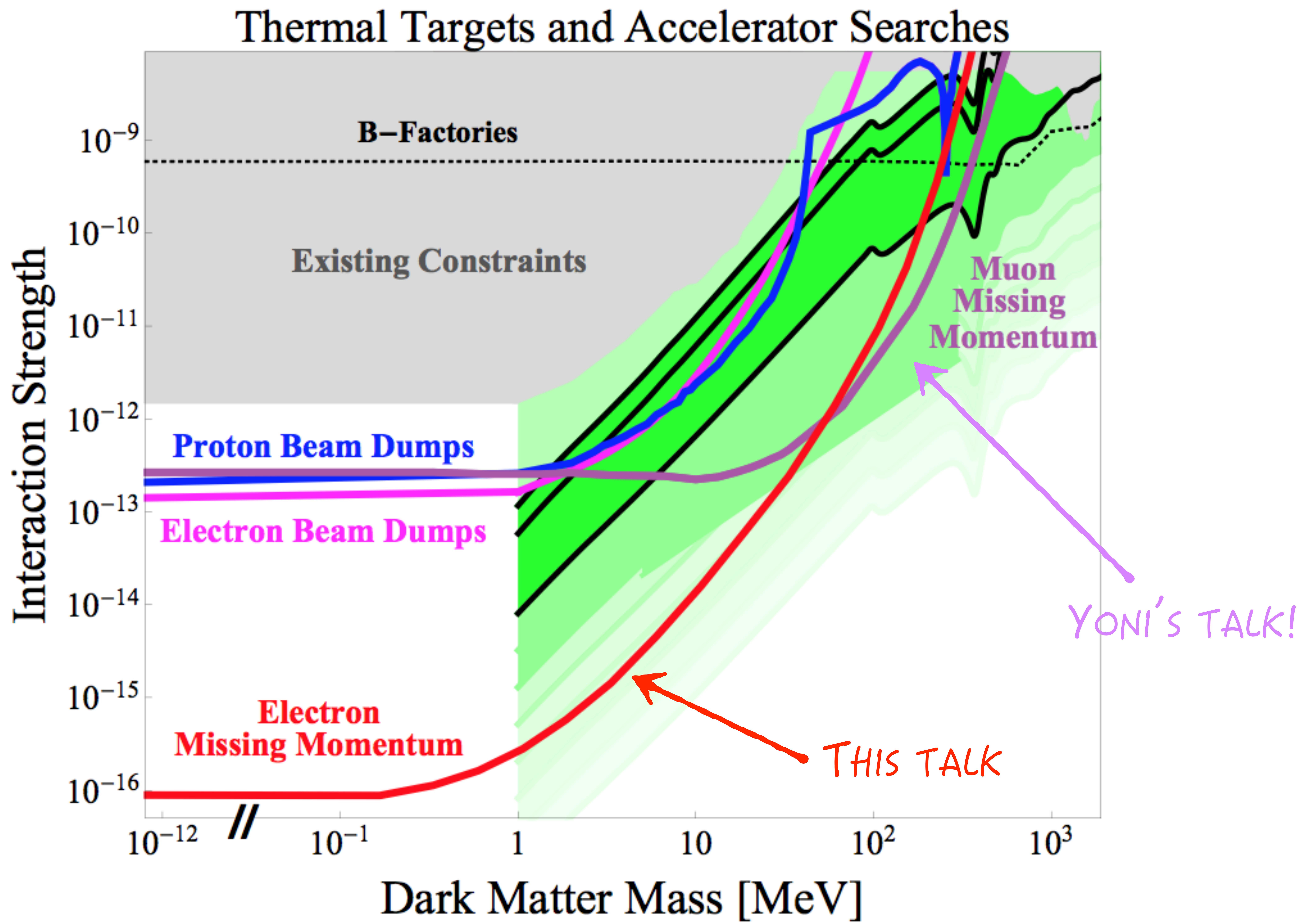


Beam Requirements

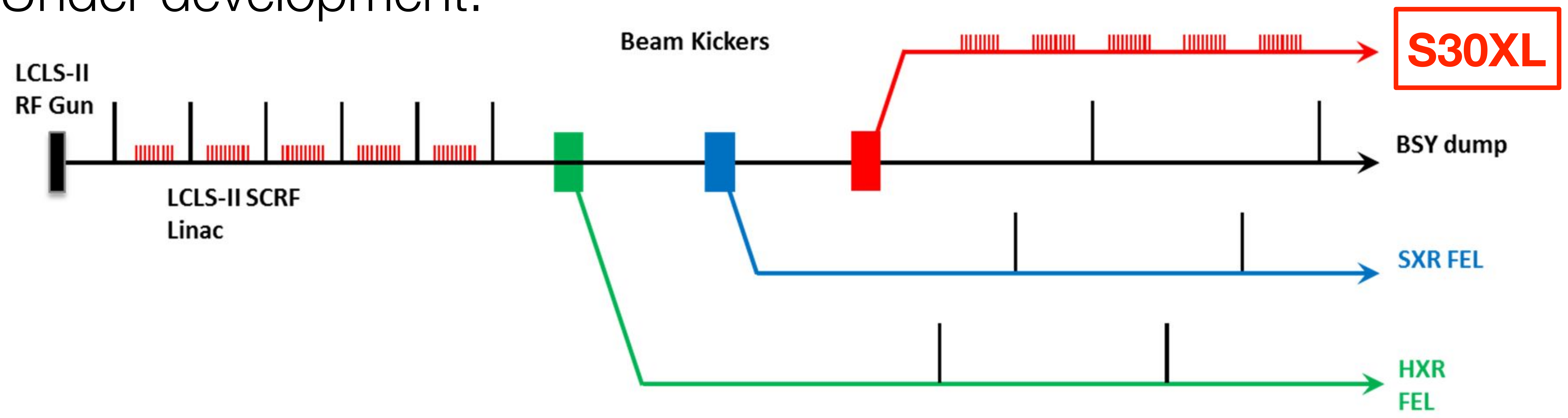
Low current, high repetition rate

Incoming beams of O(1) electron that can be individually tracked and identified

Beam rates (1×10^{14} - 1×10^{16} Electrons on Target):

- To achieve thermal milestones, in O(few years), need beam frequencies of ~50 MHz

Under development:



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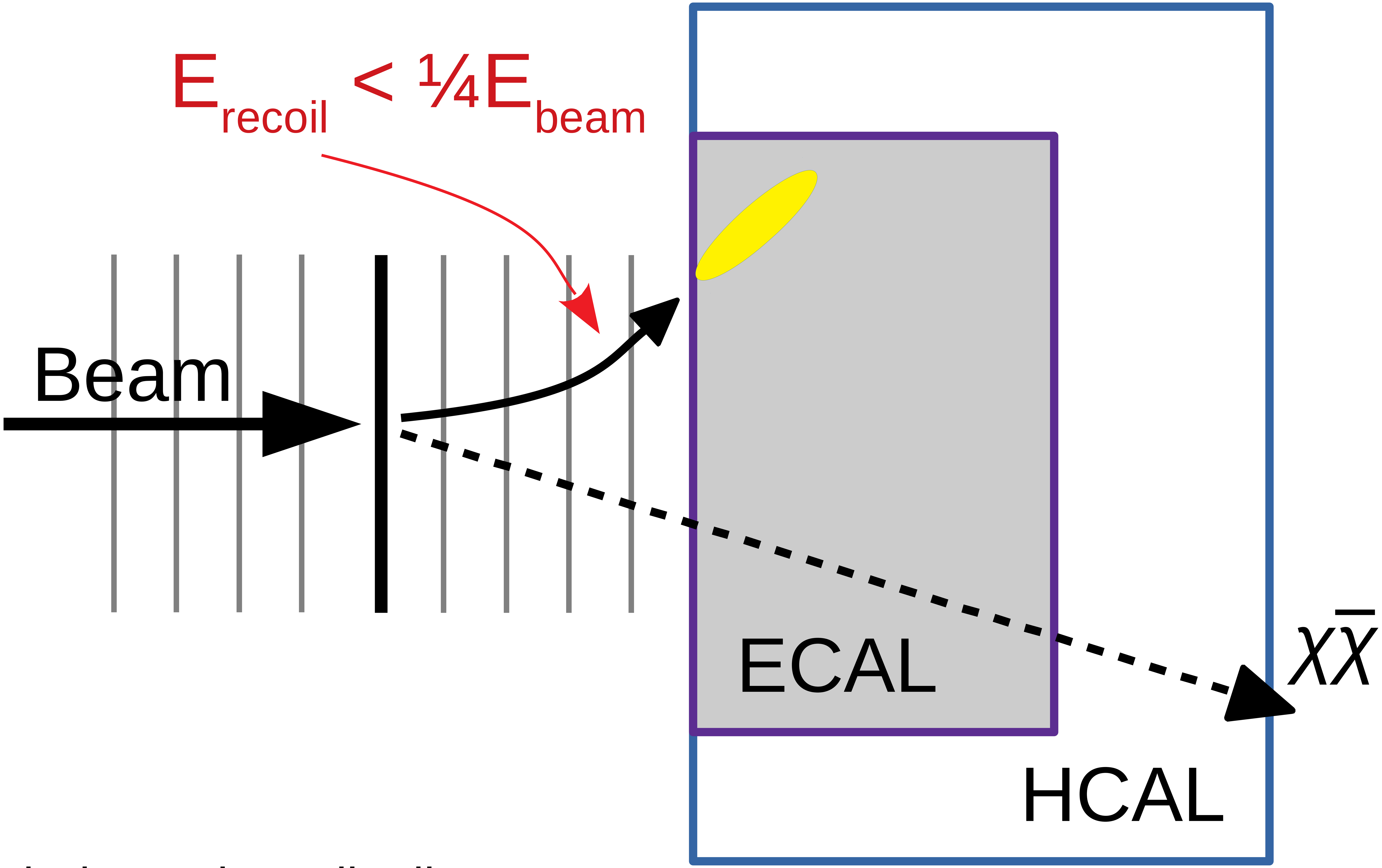
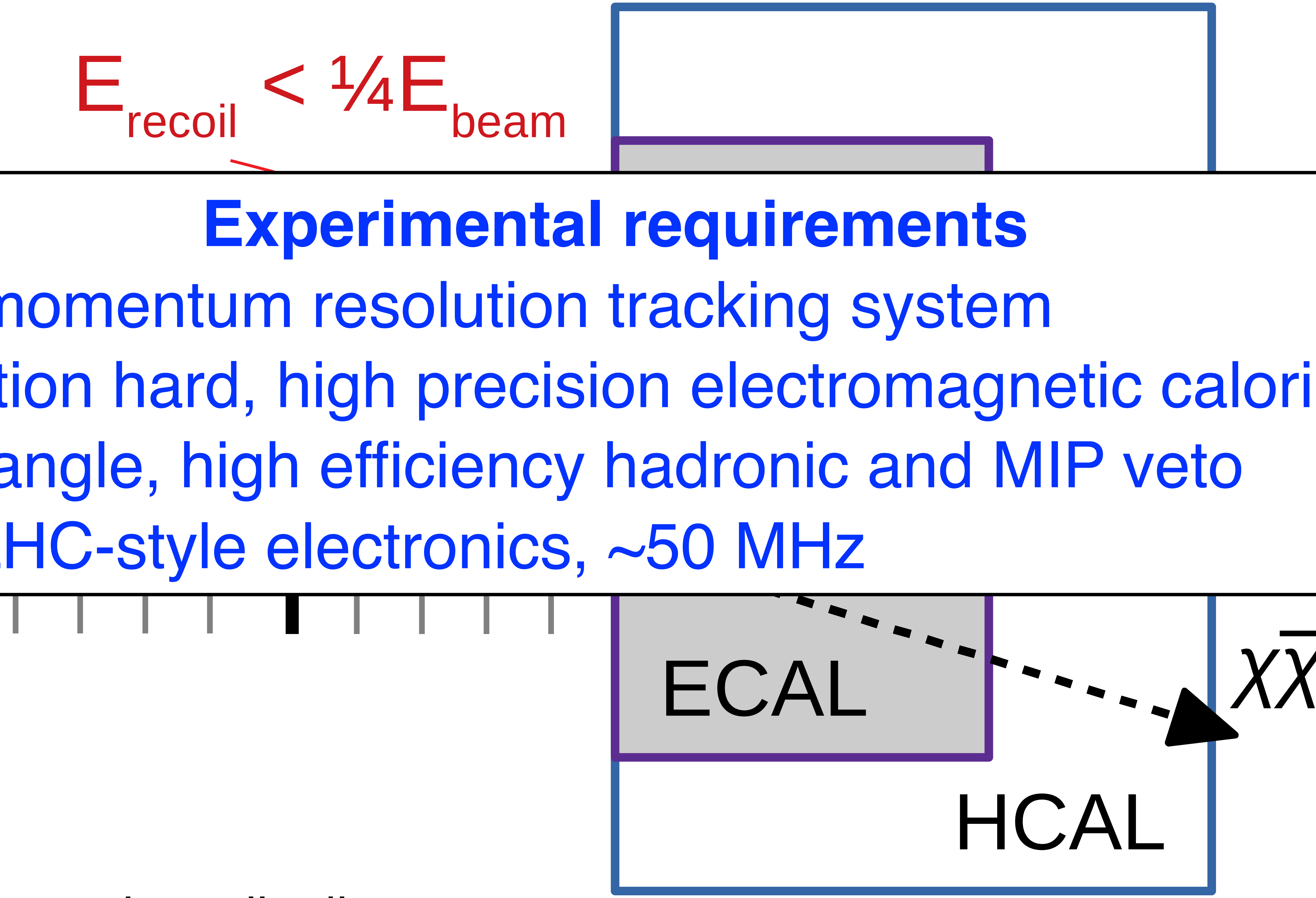
ELECTRON MISSING MOMENTUM



To reach thermal recall milestones,
need $O(1\times10^{16}$ EoT)
→ Several years, few electrons every 25 ns

Electron Missing Momentum



Experimental requirements

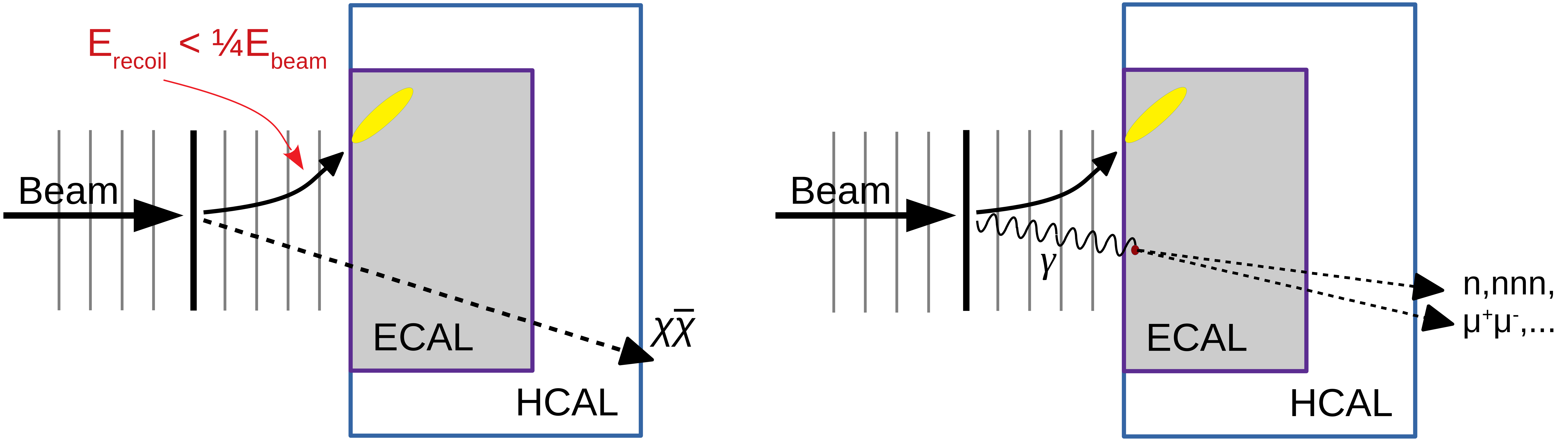
- » High momentum resolution tracking system
- » Radiation hard, high precision electromagnetic calorimeter
- » Wide angle, high efficiency hadronic and MIP veto
- » Fast LHC-style electronics, ~50 MHz

To reach thermal recall milestones,
need $O(1\times10^{16}$ EoT$)$
→ Several years, few electrons every 25 ns

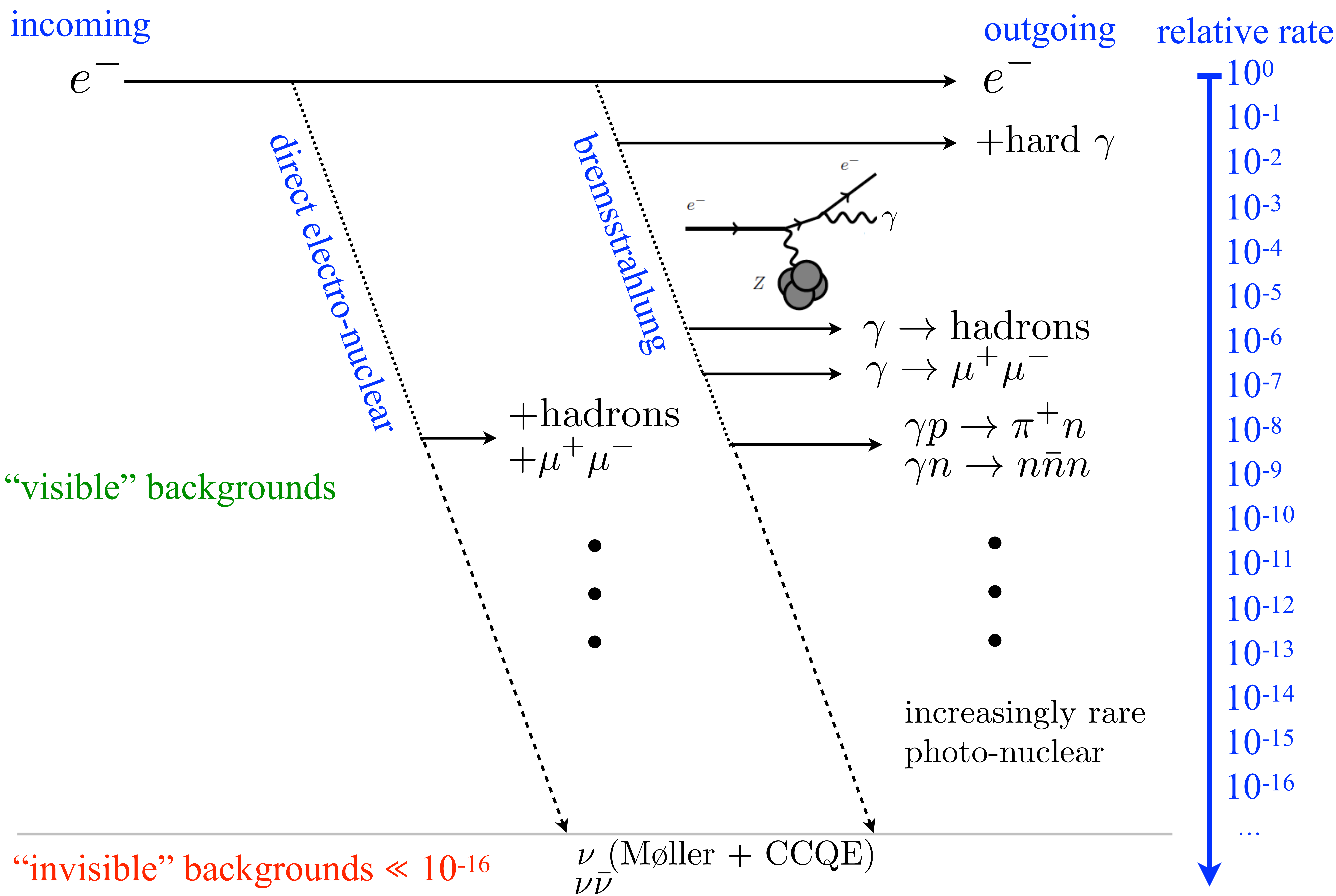
LDMX

Detector technology synergies:
Tracker: HPS/CMS
ECal: CMS HGCal
HCal/Trigger Scintillator: CMS/mu2e

SIGNALS AND BACKGROUNDS



BACKGROUNDS



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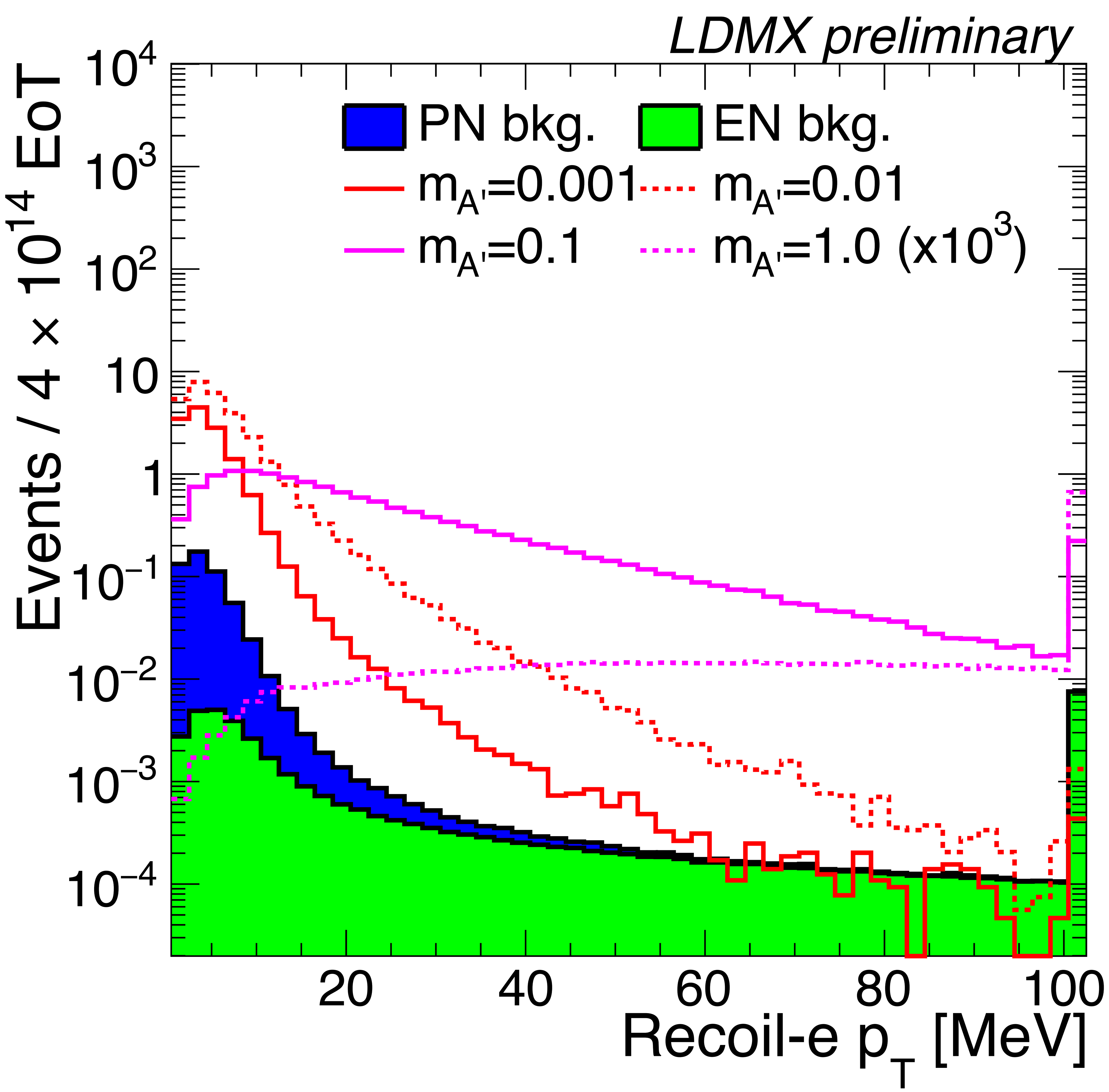

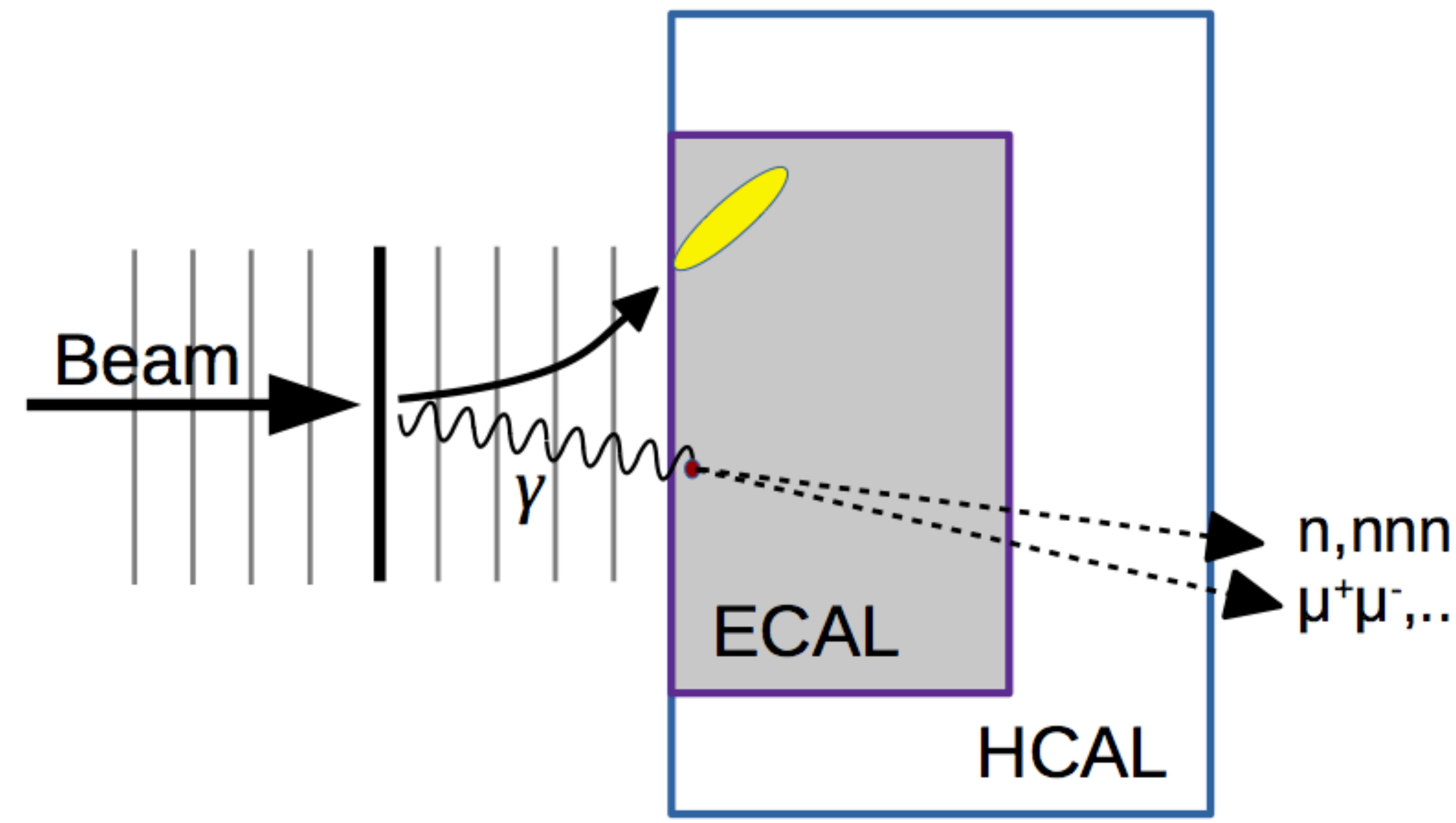

Tracker:

Good resolution for charged tracks
Granularity for track multiplicity

ECal:

Granularity for EM vs Had shower profile
MIP tracking for pions and kaons

HCal:

Deep, high light yield HCal for detecting neutrons and MIPs

LDMX and Fermilab

Scientific and technological expertise for missing momentum program has **strong synergy with Fermilab capabilities**

Intellectual leadership in this physics program

Originators and drivers of the LDMX physics program

Drivers of the LDMX experimental concept;

simulation studies and calorimeter/electronics expertise

LDMX detector synergy - current involvement

HCal employs mu2e scintillator fabricated in Fermilab Scintillator Fabrication Facility and electronics from mu2e cosmic ray veto

Target scintillator deploys CMS HCal electronics

Trigger/DAQ leadership from Fermilab/CMS expertise

Missing momentum with muons (Yoni's talk)

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More physics

A complete physics case for hidden sectors at LDMX

https://arxiv.org/abs/1807.01730

Dark Matter, Millicharges, Axion and Scalar Particles, Gauge Bosons, and Other New Physics with LDMX

Asher Berlin,[1] Nikita Blinov,[1] Gordan Krnjaic,[2] Philip Schuster,[1] and Natalia Toro[1]

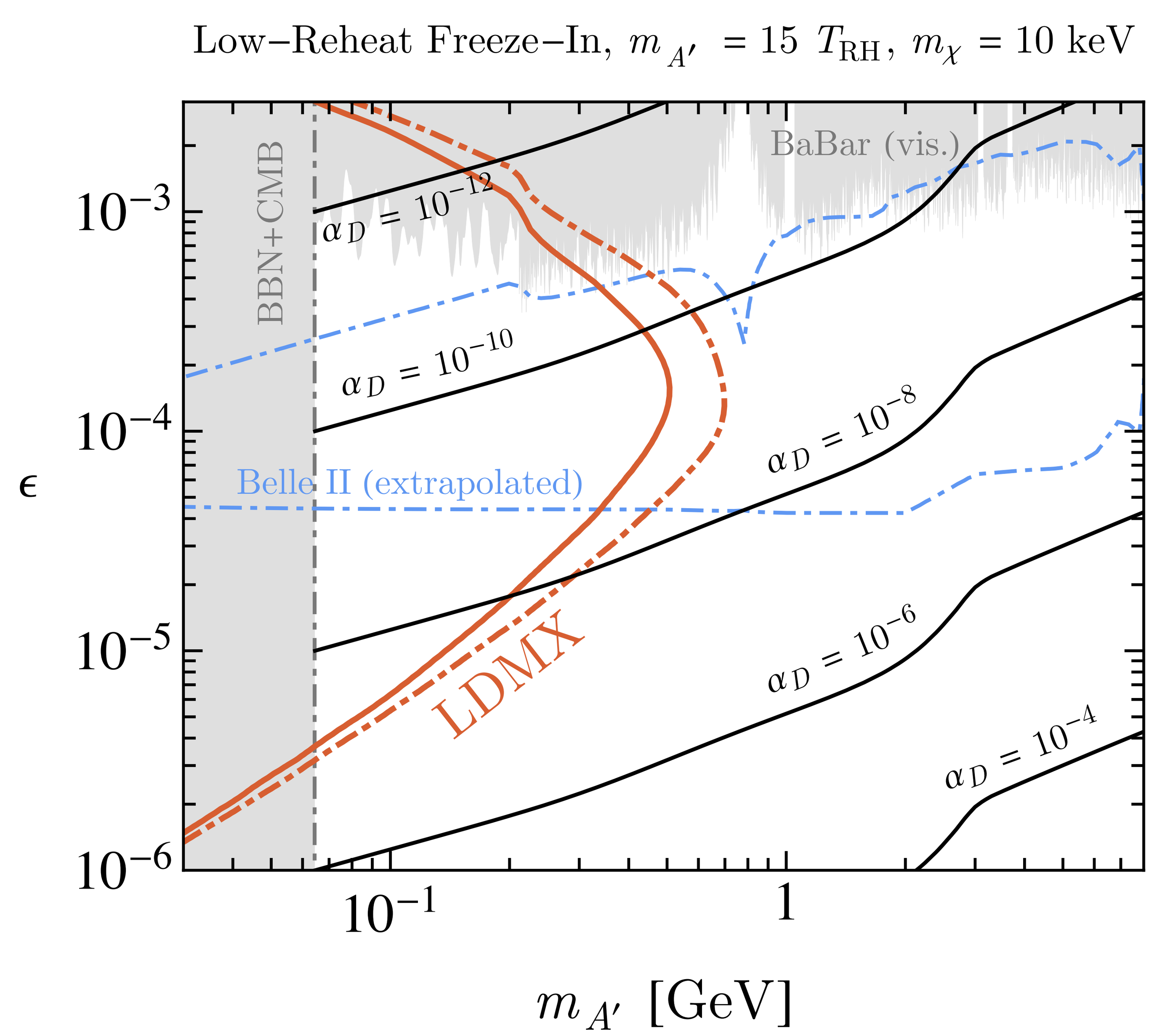
[1]*SLAC National Accelerator Laboratory, Menlo Park, CA 94025, USA*

[2]*Fermi National Accelerator Laboratory, Batavia, IL 60510, USA*

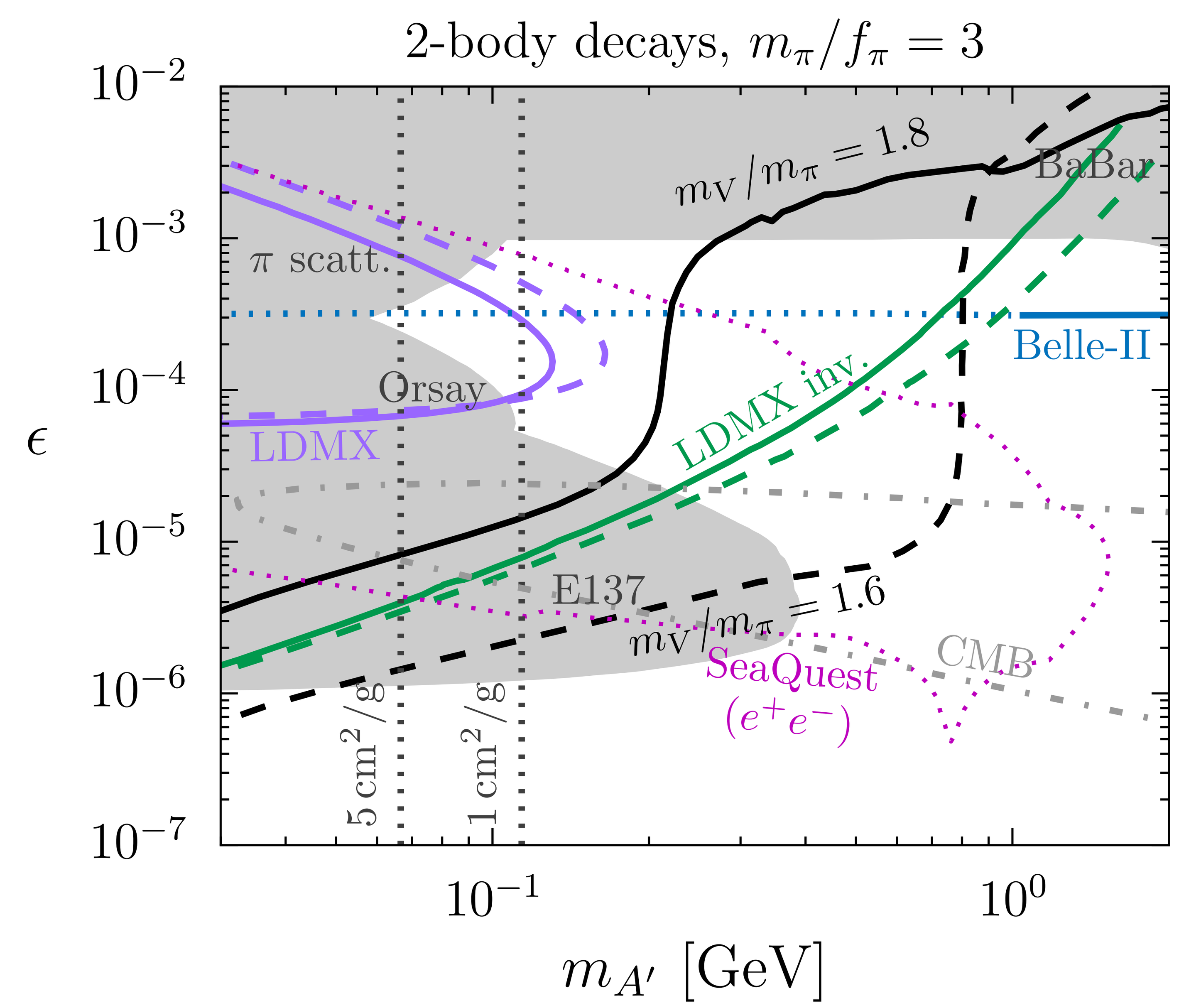
(Dated: July 6, 2018)

LDMX BROAD PROGRAM

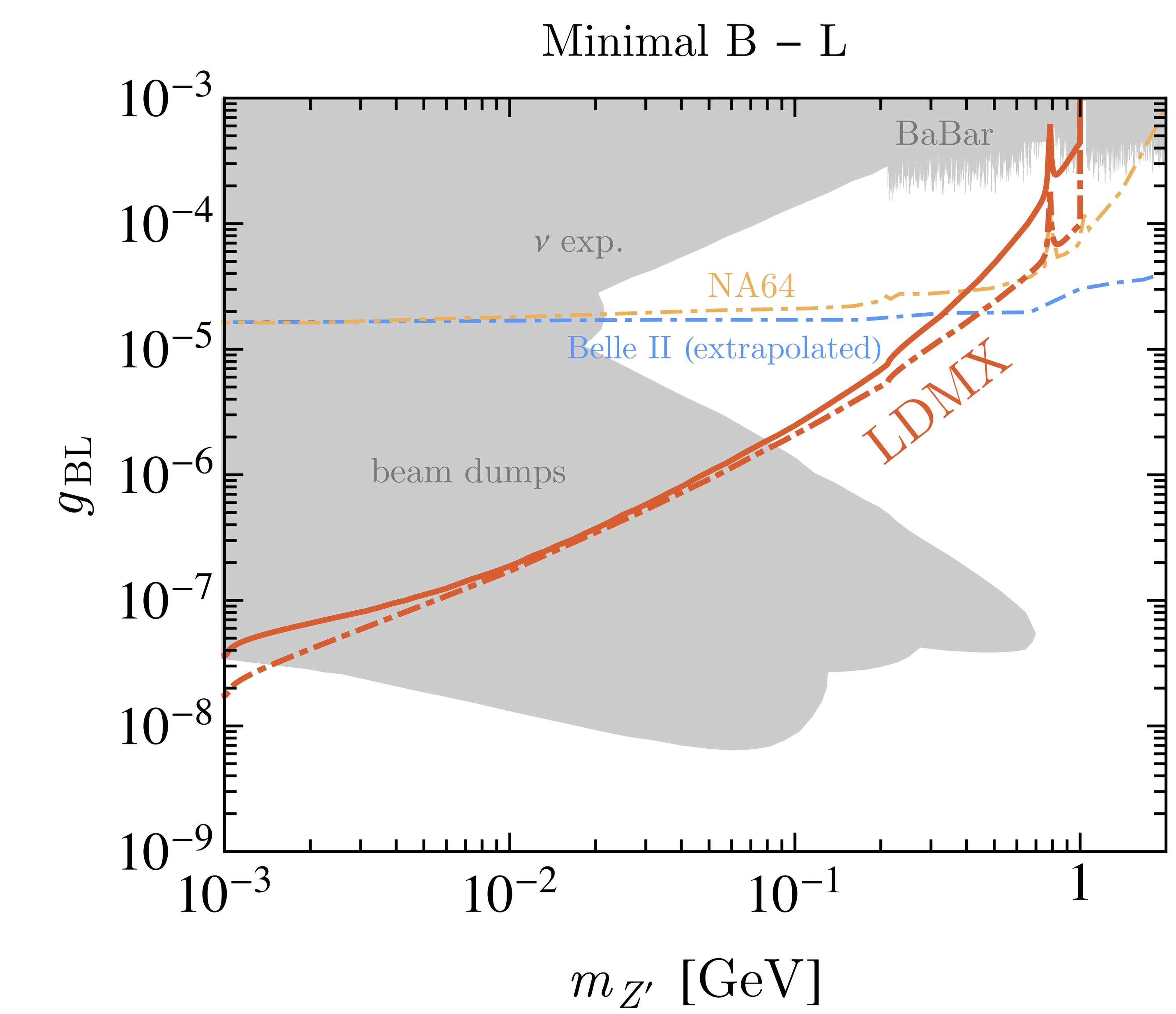
Freeze-in

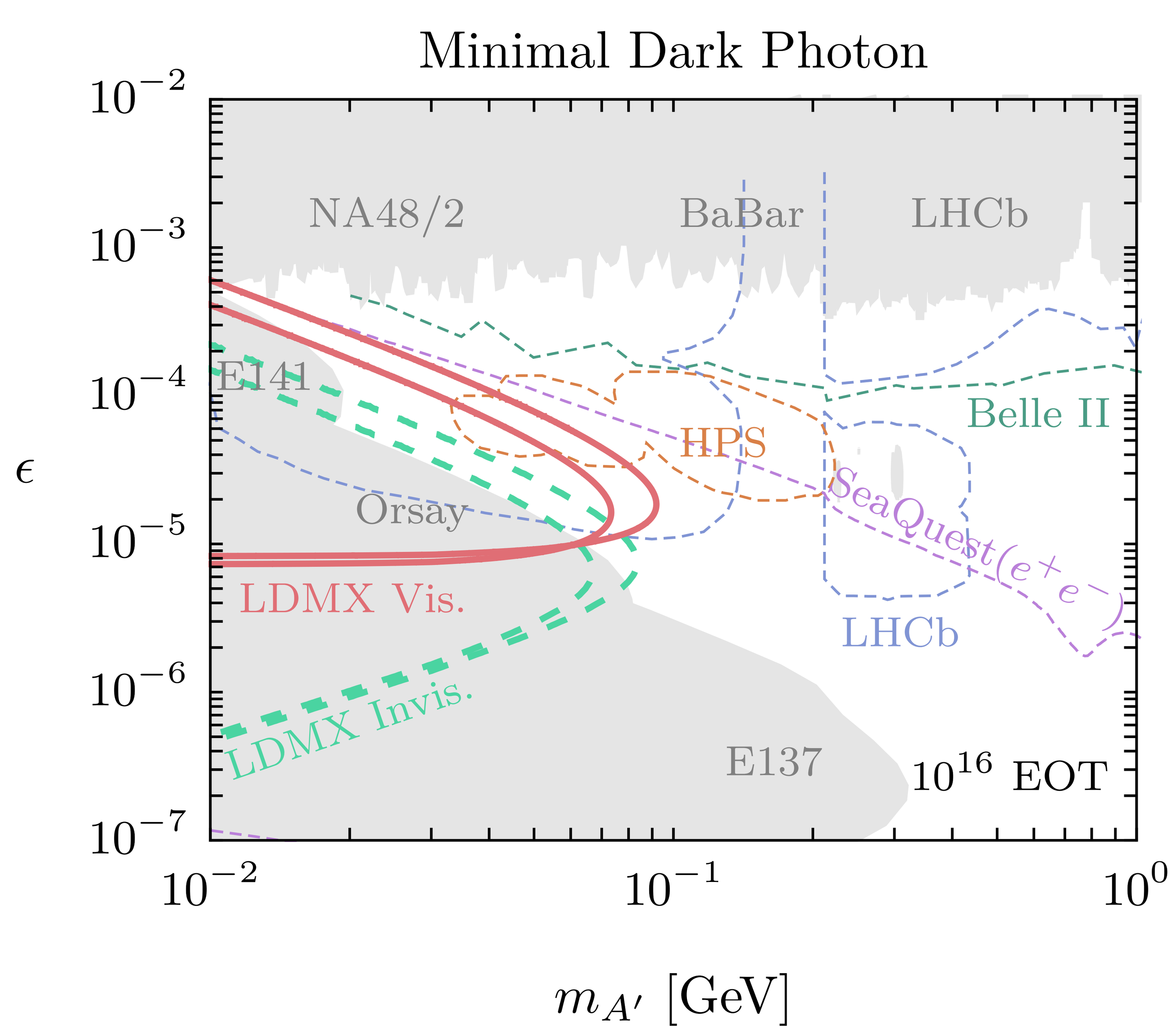


SIMPs

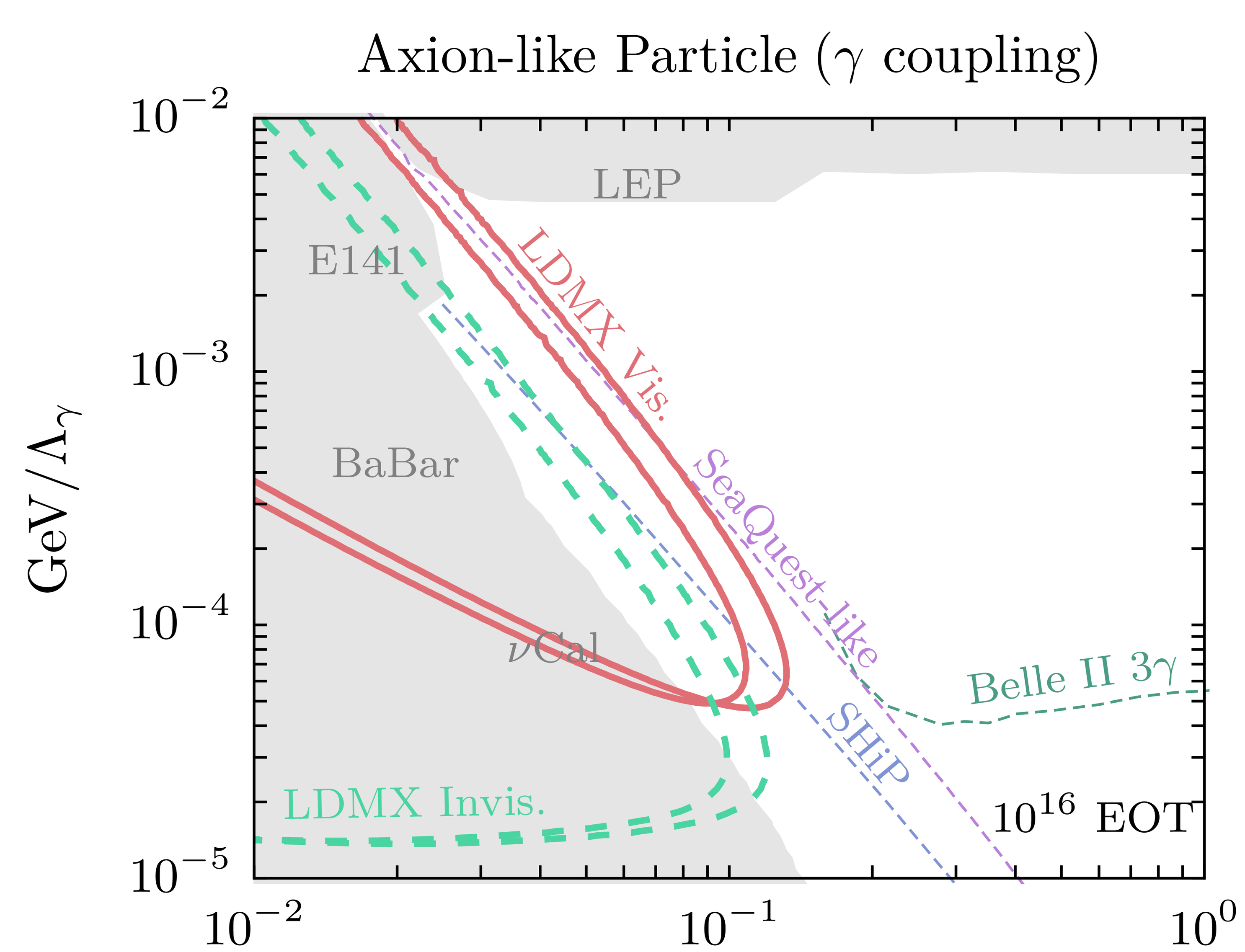


B-L to ν's

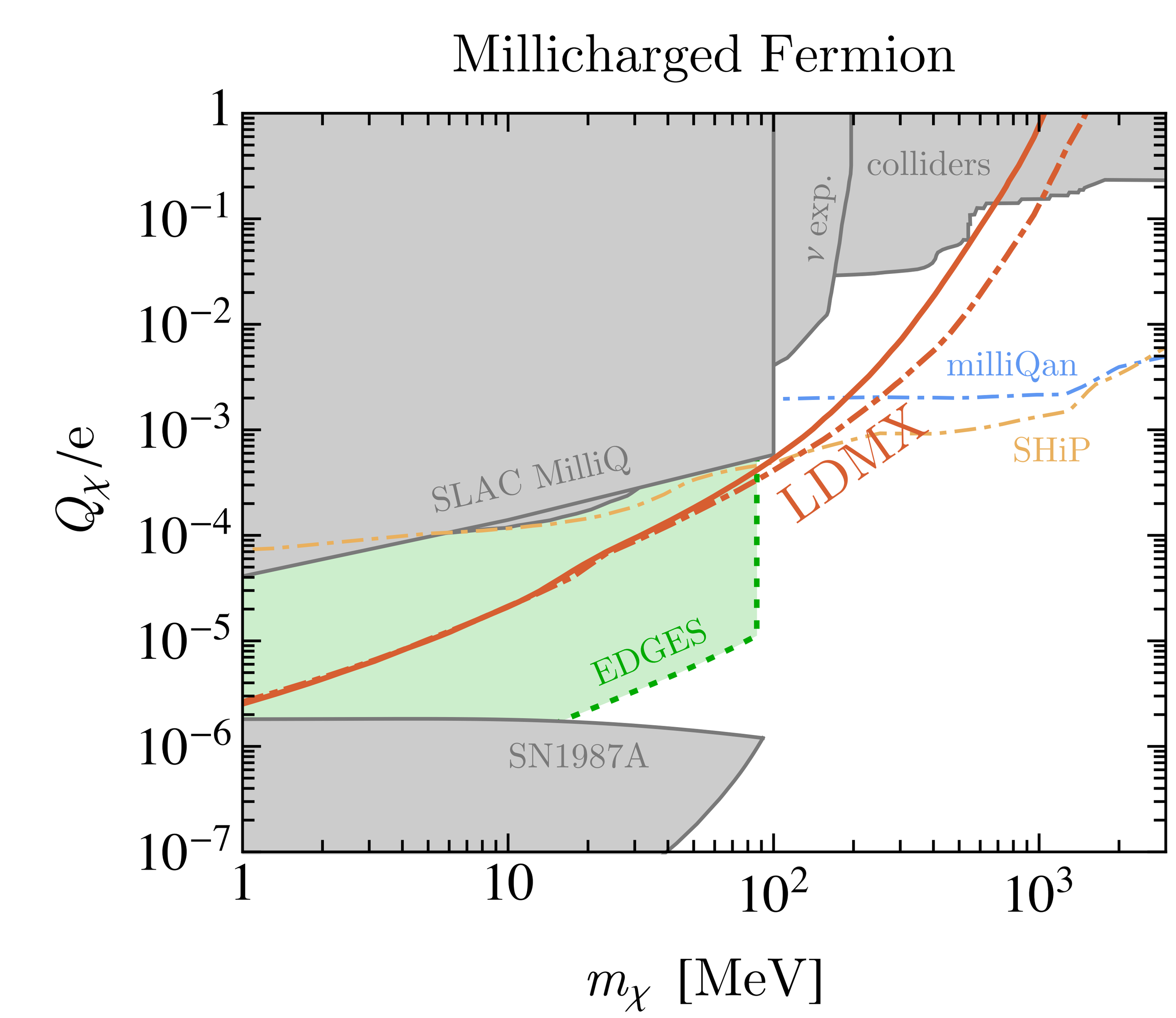




Dark Photon

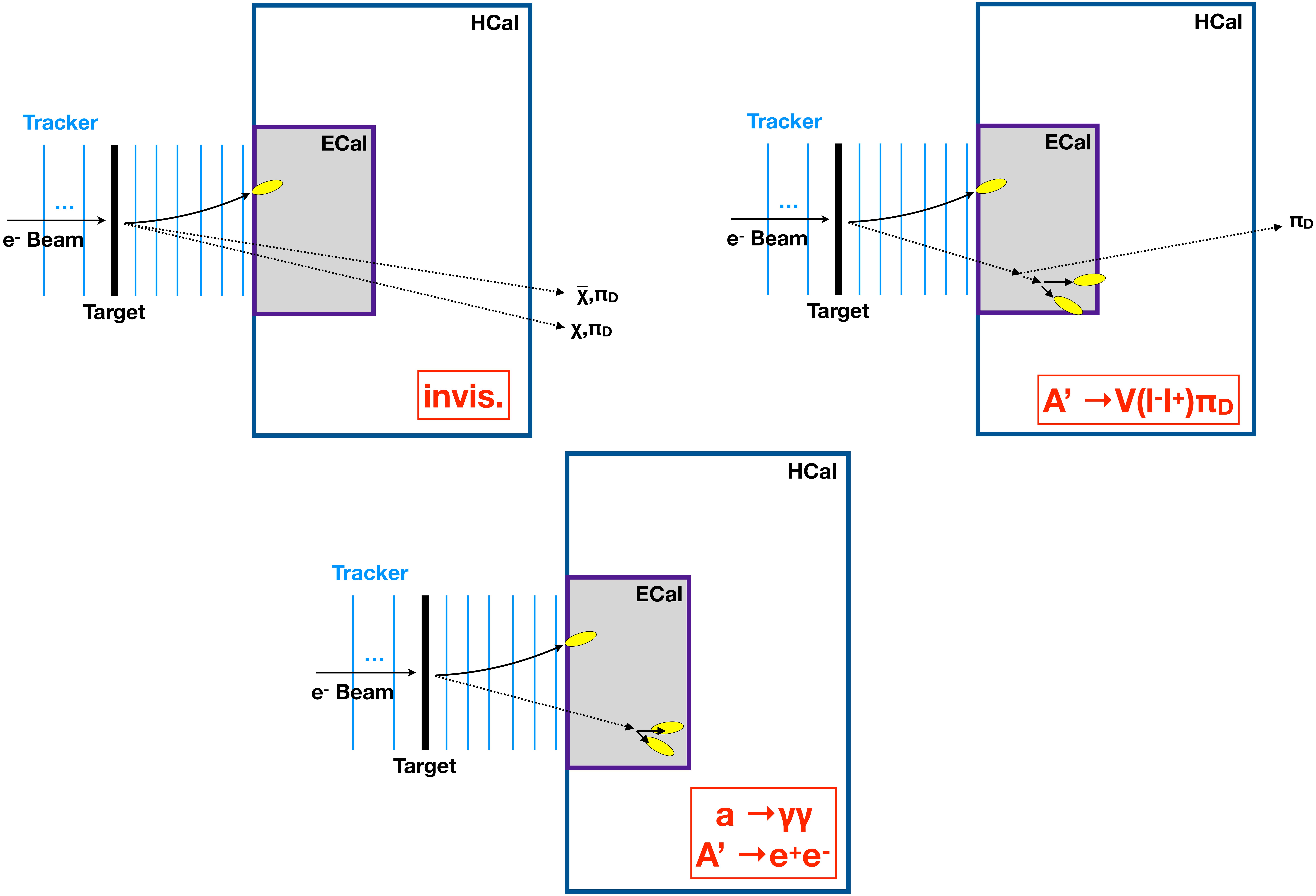


ALPs



Millicharged

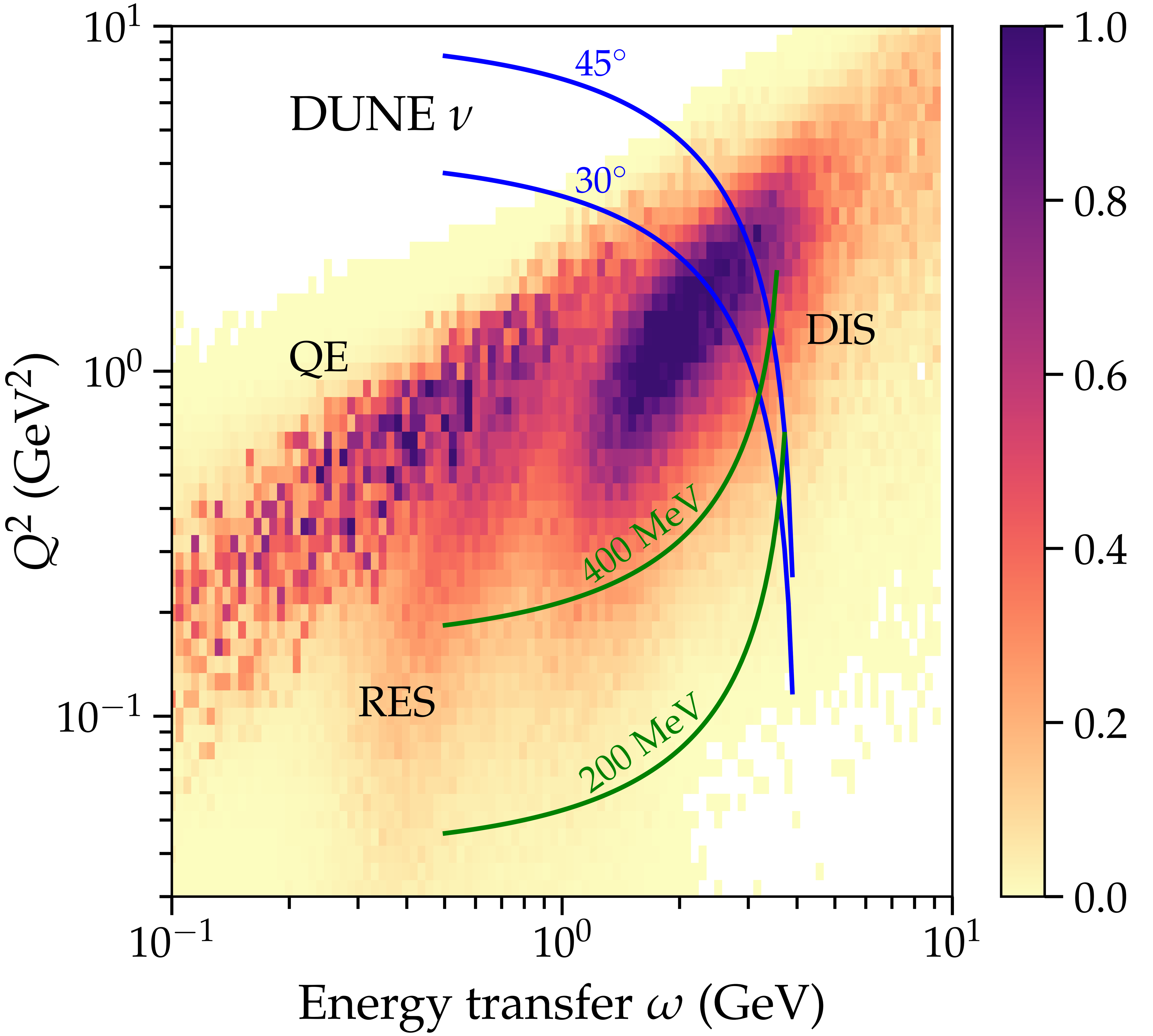
MORE LDMX SIGNATURES



LDMX AND NEUTRINO PROGRAM

Artur Ankowski, Alex Friedland, Shirley Li, O. Moreno, Philip Schuster, Natalia Toro, N.T
Work in progress

Modeling **ν-nucleon** very important for neutrino oscillation program
Measurements of **e-nucleon** provide valuable inputs for simulation



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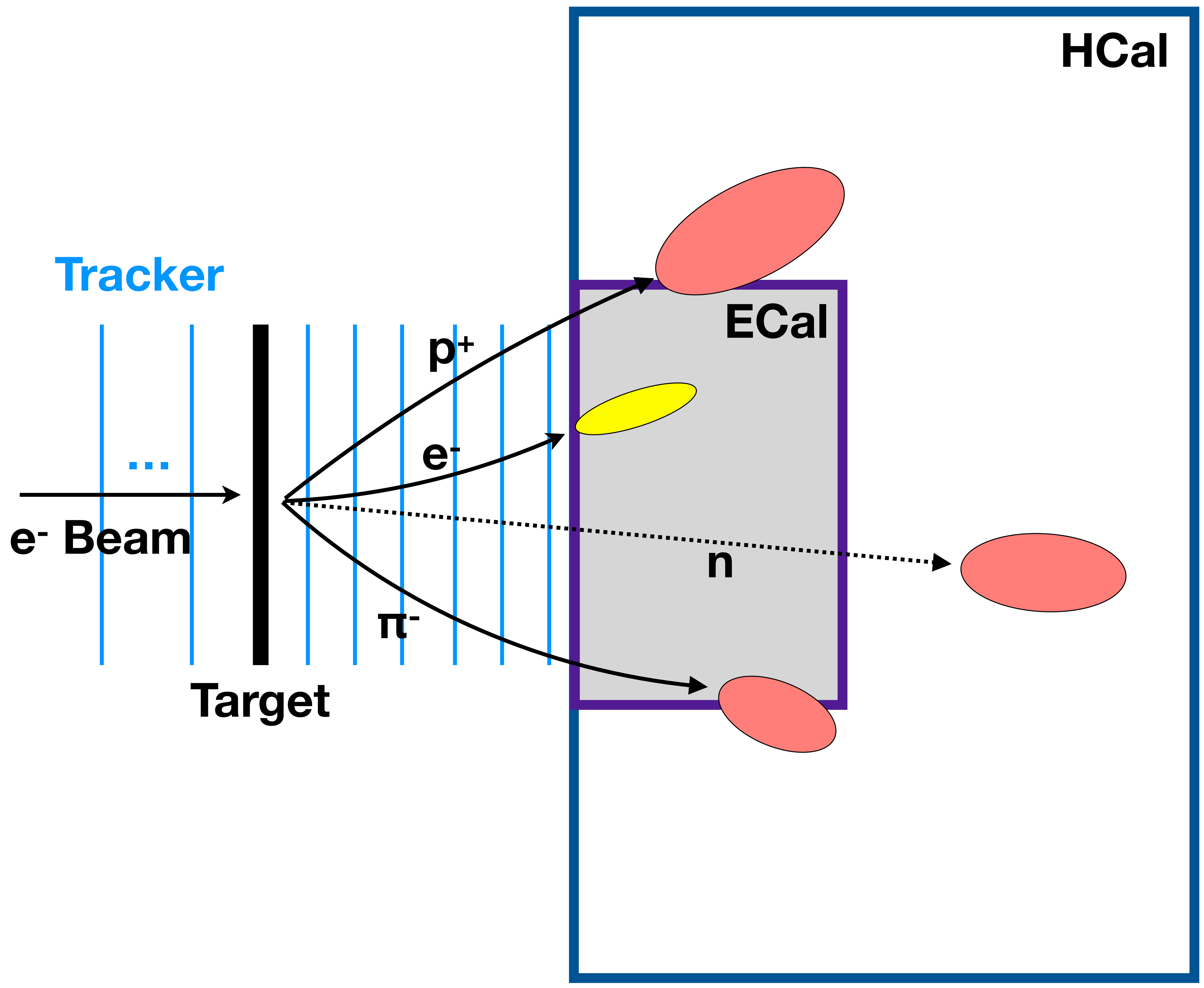

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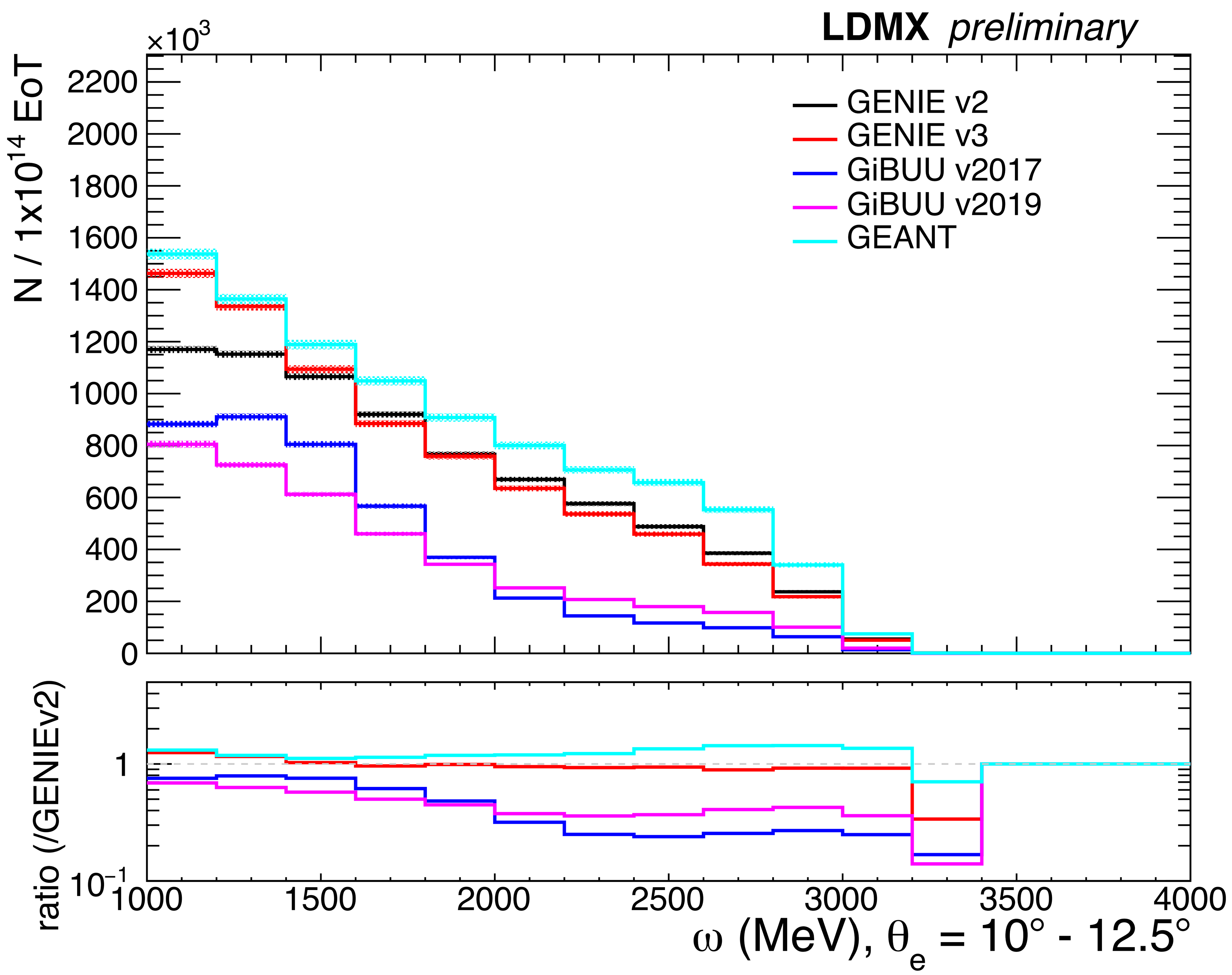
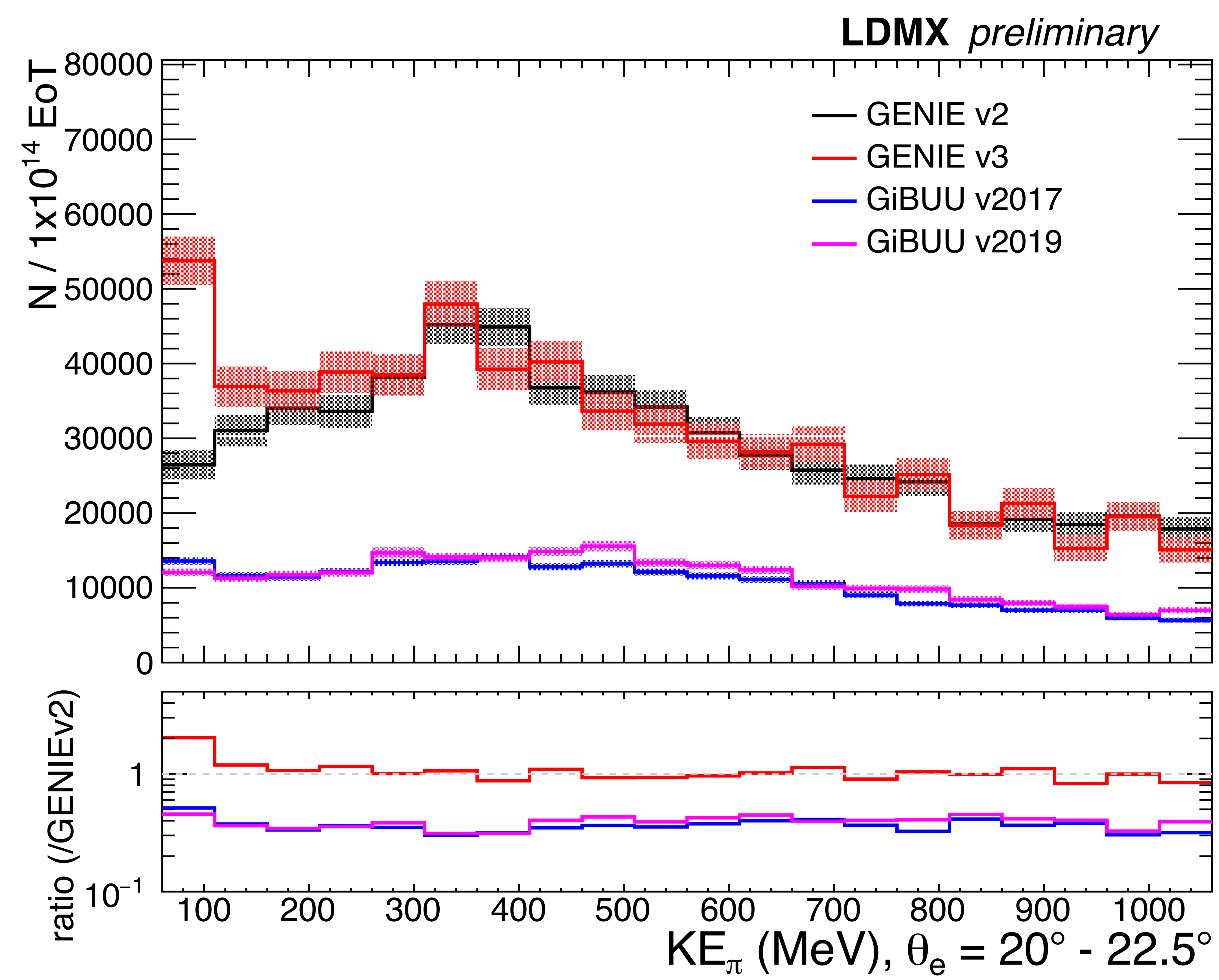


Electron energy transfer



Pion kinetic energy

SUMMARY AND OUTLOOK

Missing momentum a promising technique to reach thermal relic milestones for sub-GeV dark matter

LDMX is developed experimental concept demonstrating feasibility of **missing momentum technique**

- Fermilab plays crucial role in intellectual development of the physics program and the several of the detector subsystems

Strong **hidden sector** and **nuclear physics** program

- Millicharges, freeze-in, SIMPs, dark photon, ALPs, etc.
- Electron-nucleus scattering measurements synergistic with DUNE phase space