Light **D**ark **M**atter e**X**periment

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on behalf of the **LDMX** Collaboration

TeVPA 2017
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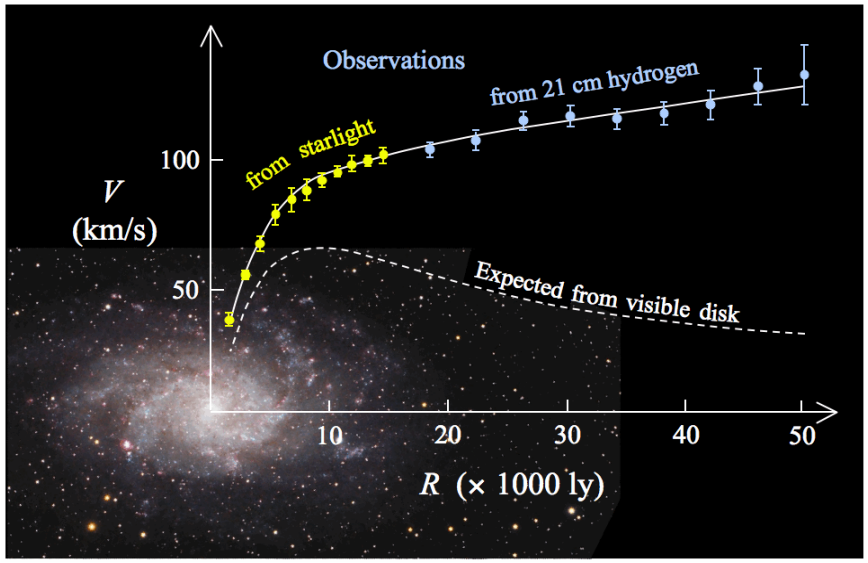
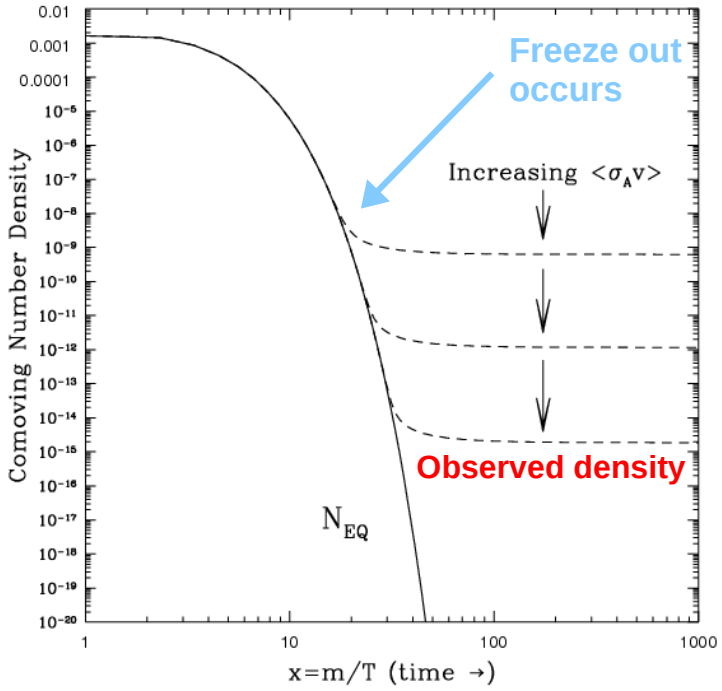
A Thermal Relic

Plentiful evidence for dark matter!

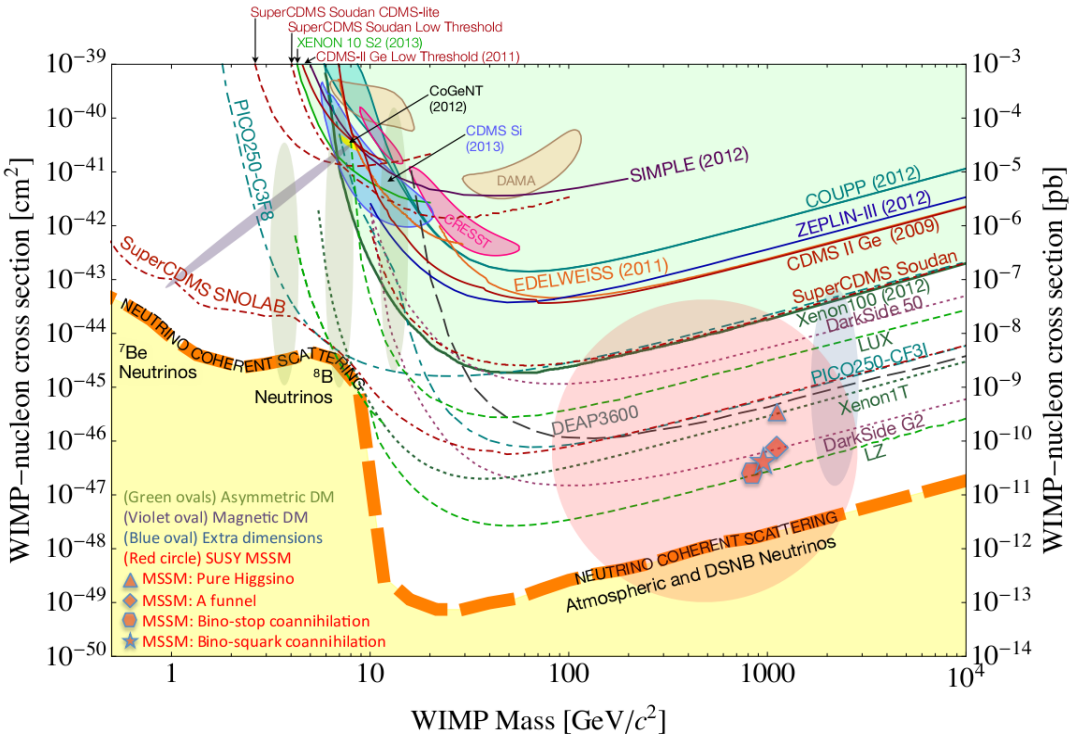


- Assuming DM has thermal origin
  - Constrains viable mass window
  - Sets minimum annihilation cross section



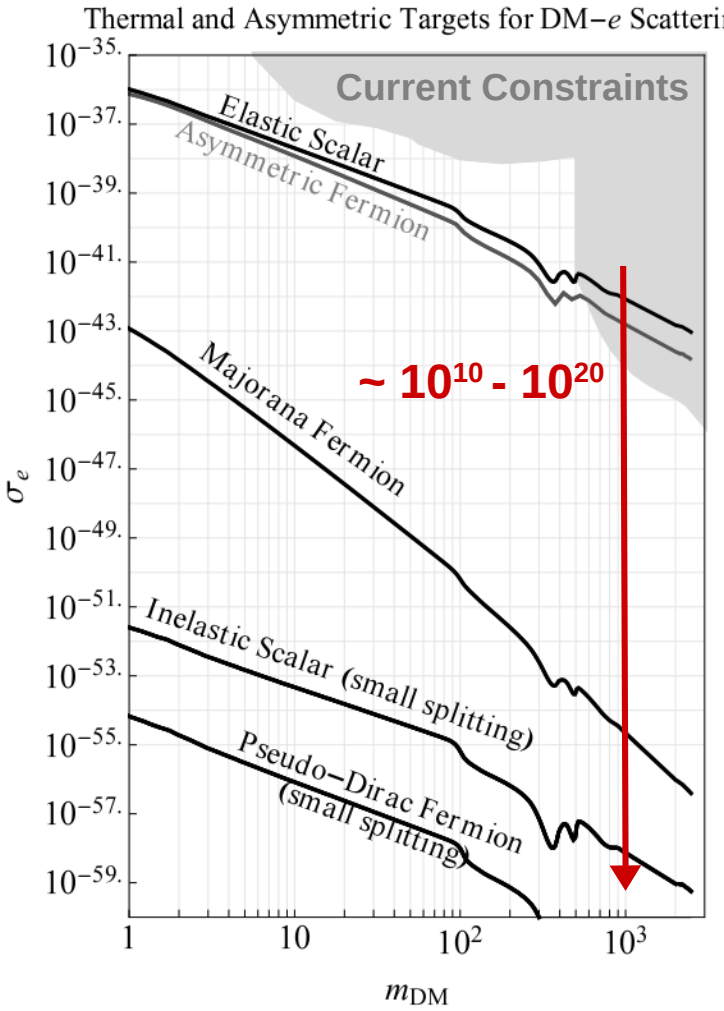
Looking for Light Dark Matter

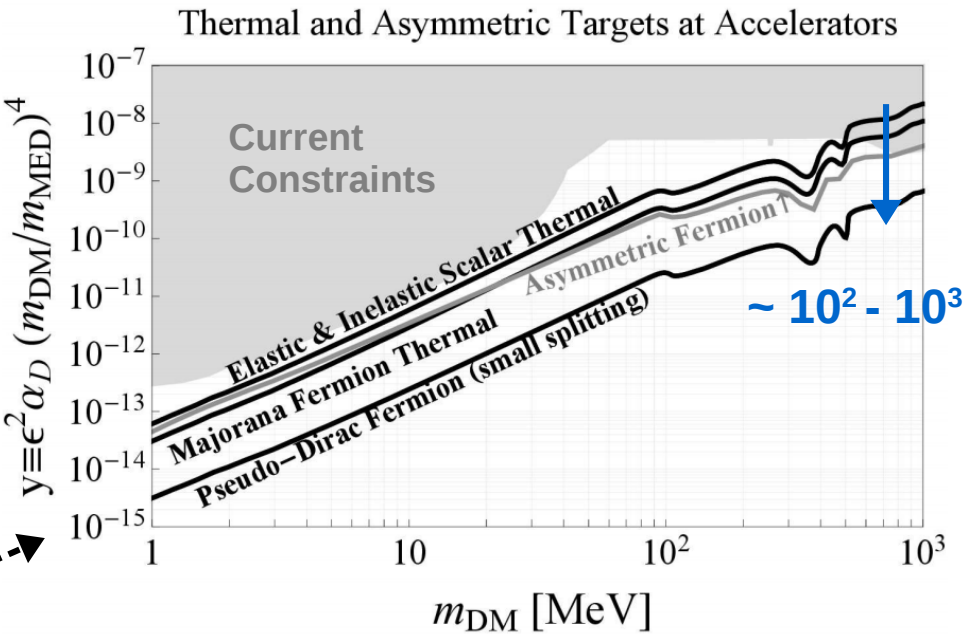
Amazing direct detection work has been done to explore WIMP phase space!



- LDM regime largely unexplored, well motivated
  - However, SM forces cannot give observed matter density
    - New, light forces must be present
    - Vector mediator (**dark photon**) a simple, but predictive model

Reaching LDM Thermal Targets





Significant velocity dependence for direct detection cross section leaves some targets out of reach

Relativistic nature of accelerators wipes out velocity dependence

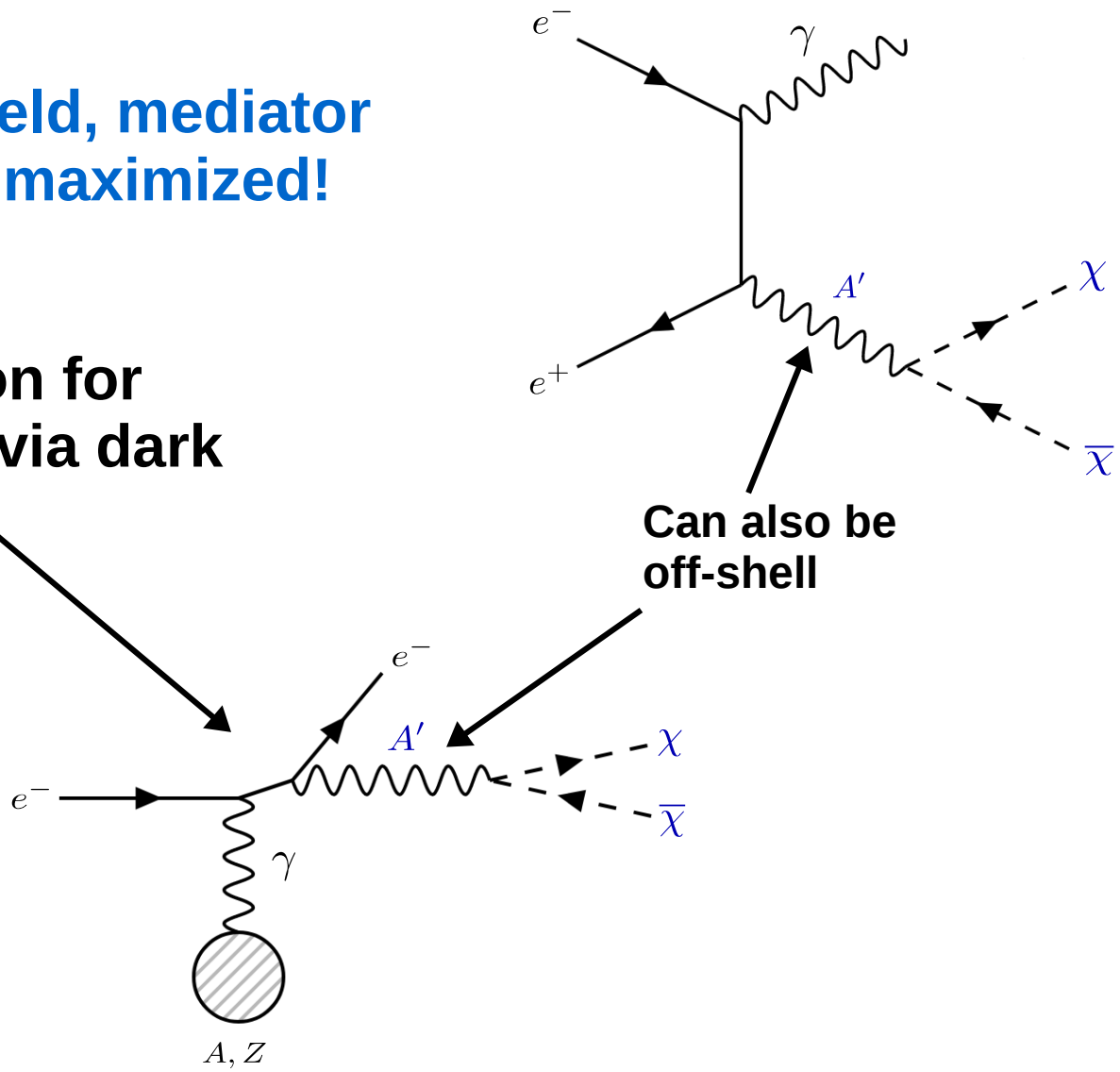
Thermal targets are within reach!

LDM Accelerator Searches

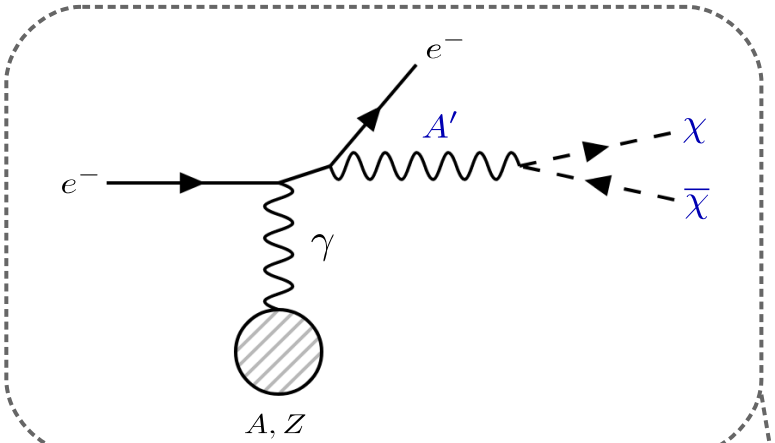
To maximize LDM yield, mediator production must be maximized!

Largest cross section for production realized via dark bremsstrahlung

$$\sigma \propto \frac{Z^2 \epsilon^2}{m_{\mathrm{A}'}^2}$$

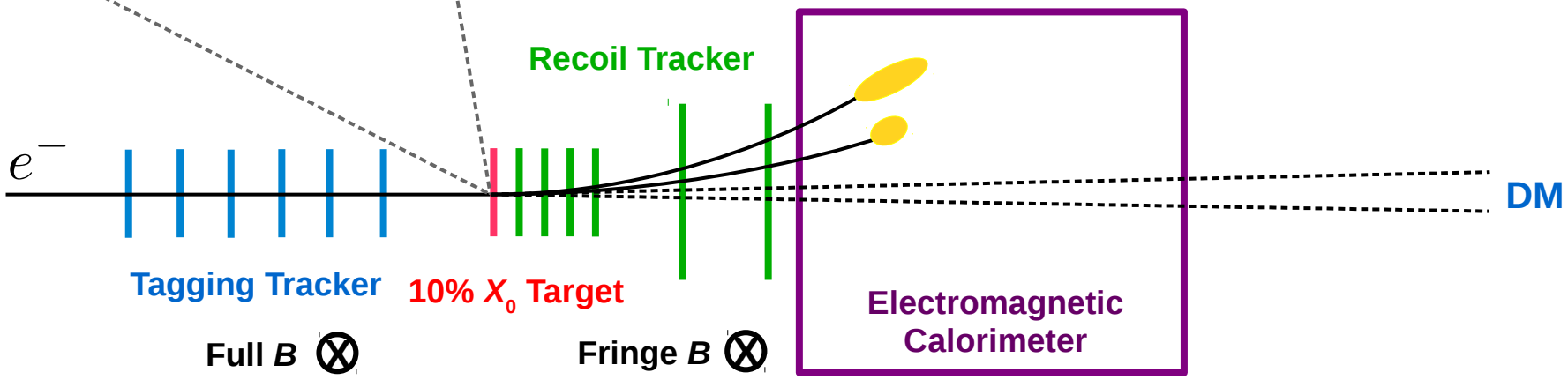


The Light Dark Matter eXperiment LDMX

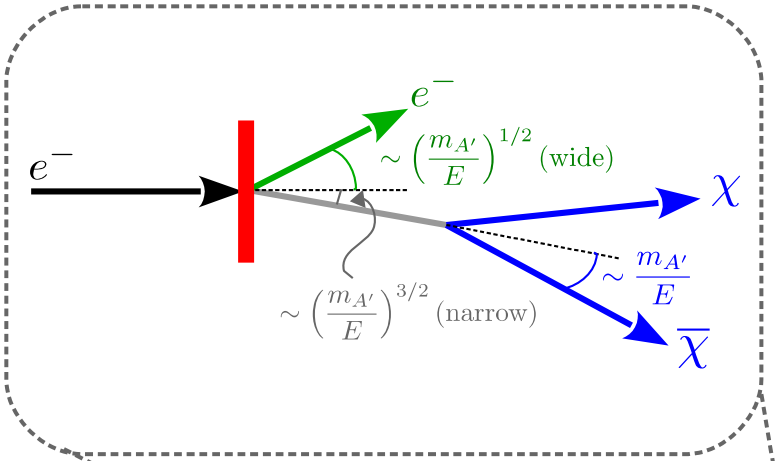


LDMX is an electron fixed-target, missing momentum experiment

With 10^{16} electrons on target, LDMX can probe thermal targets over the MeV-GeV range

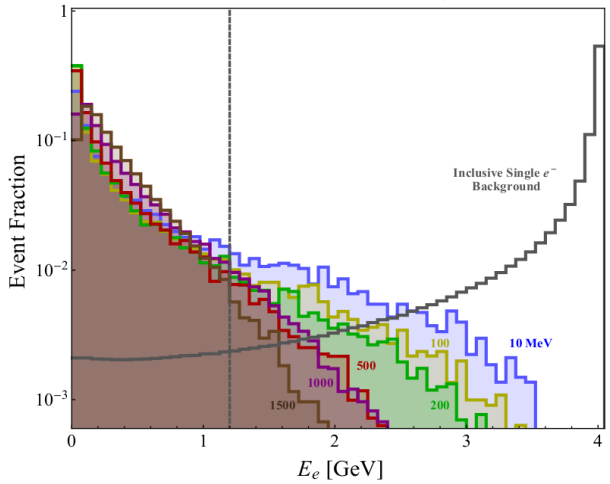


Dark Bremsstrahlung

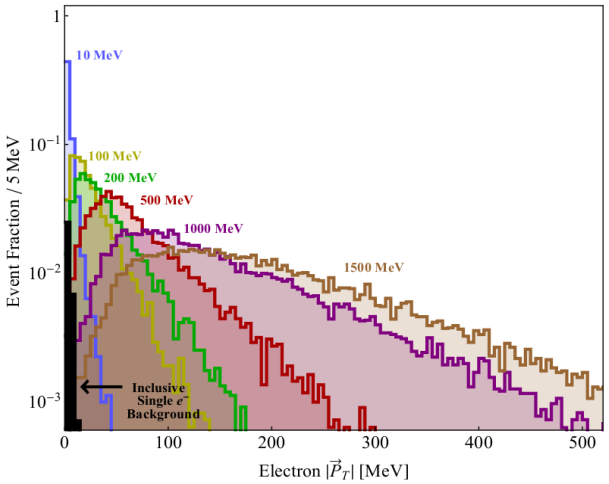


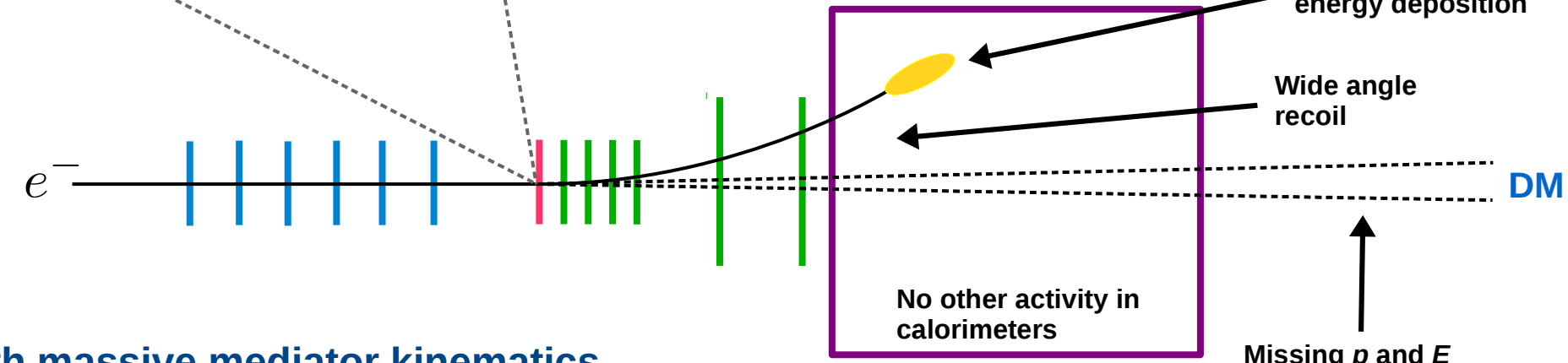
Kinematics

Recoil Energy Distribution



Recoil p_T Distribution

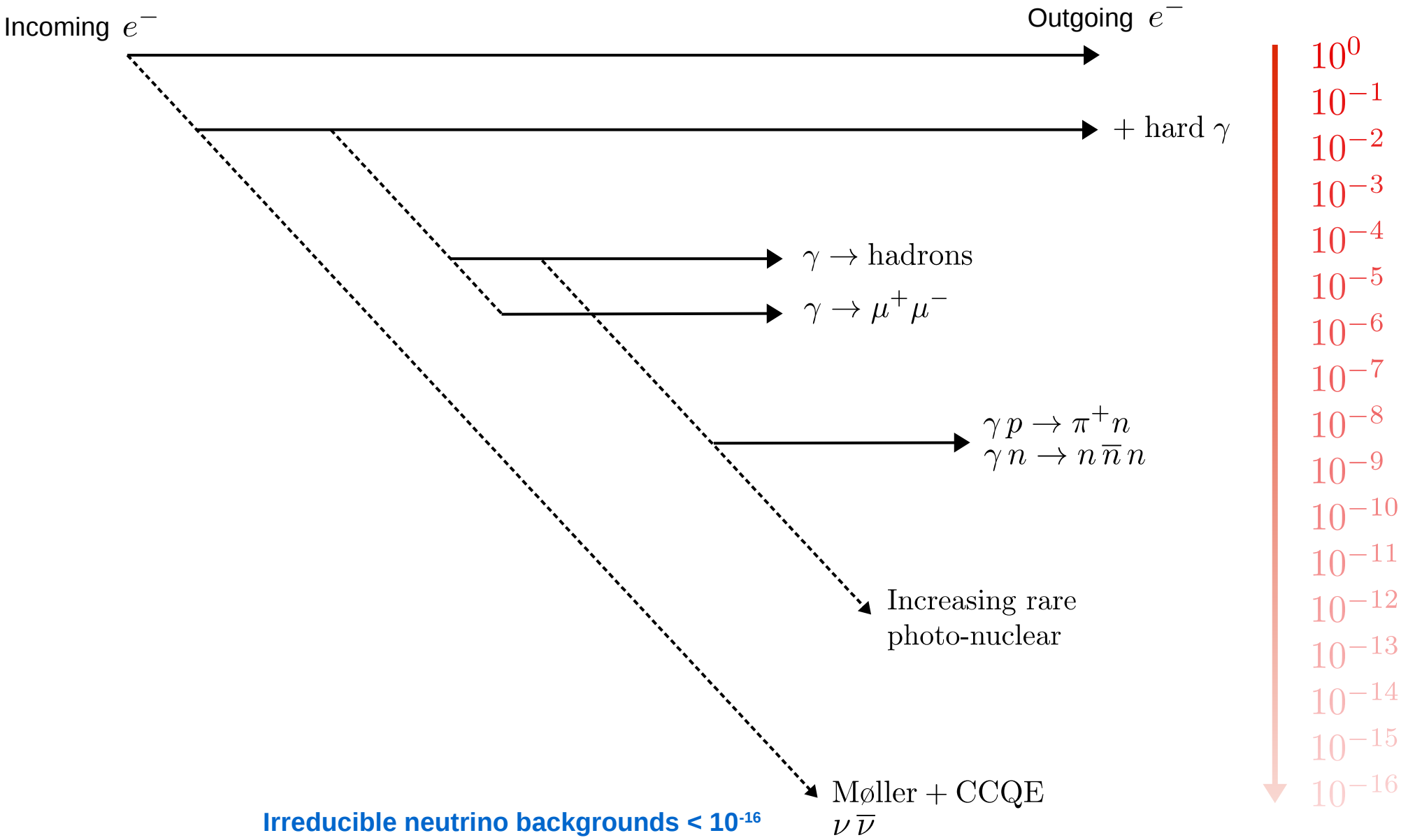




With massive mediator kinematics quite different from SM bremsstrahlung

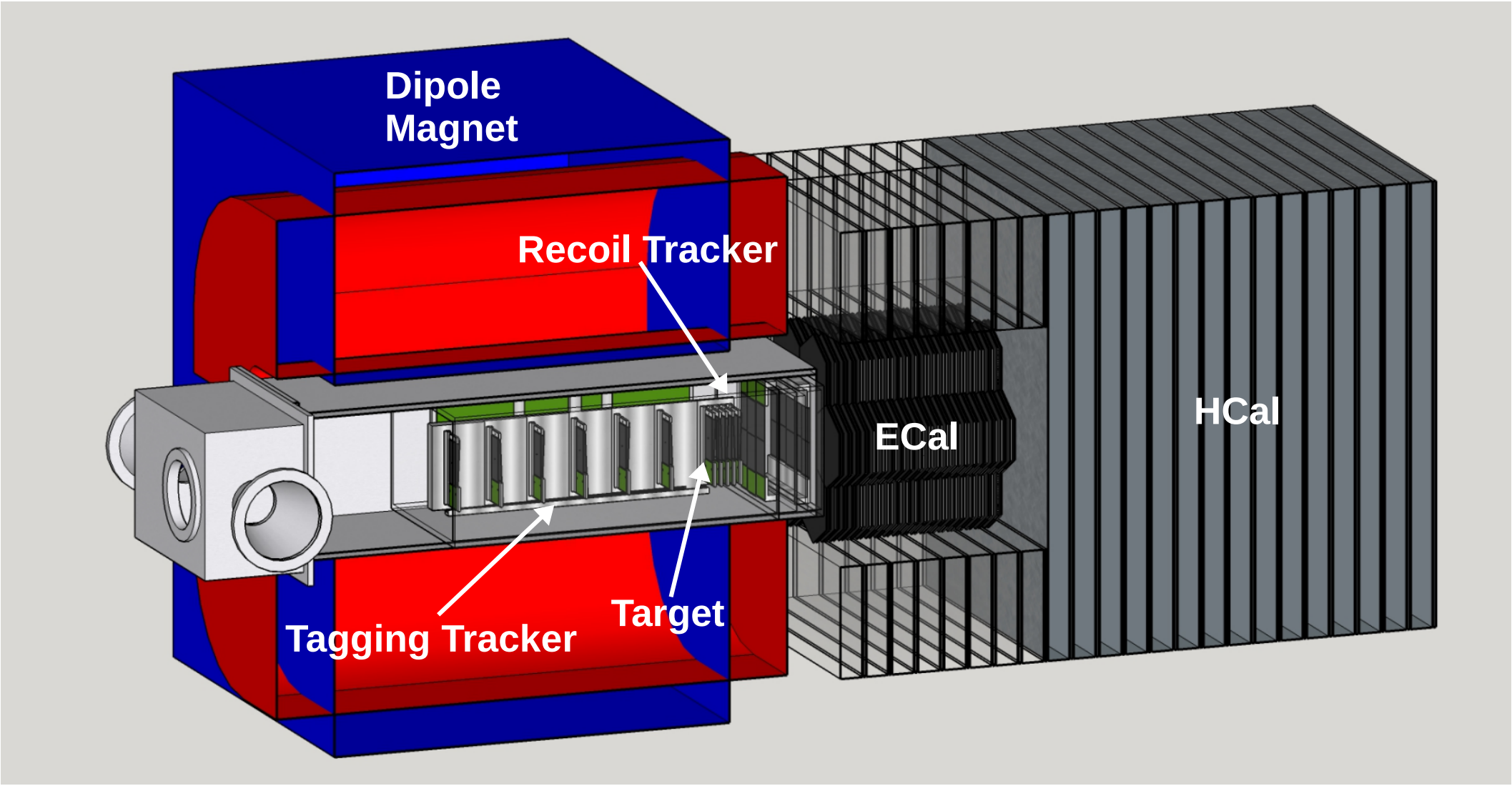
Signal

Backgrounds

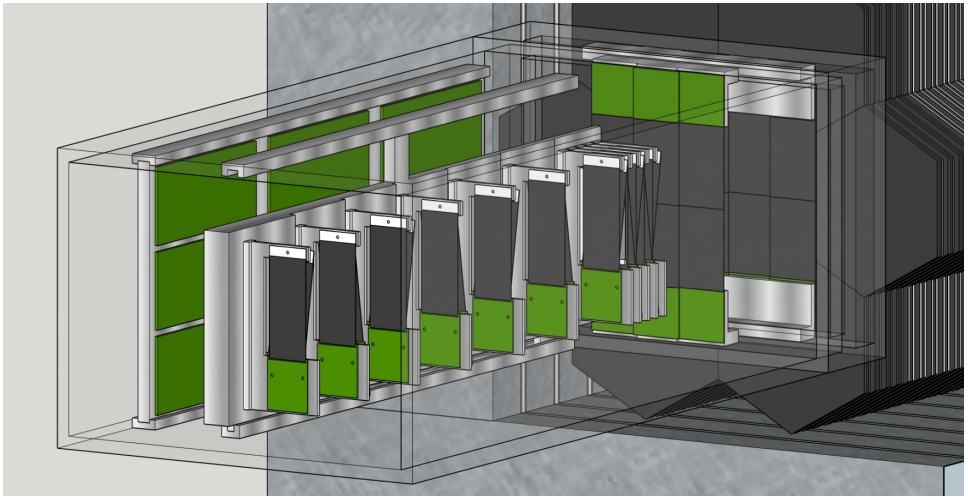


Irreducible neutrino backgrounds < 10^{-16}

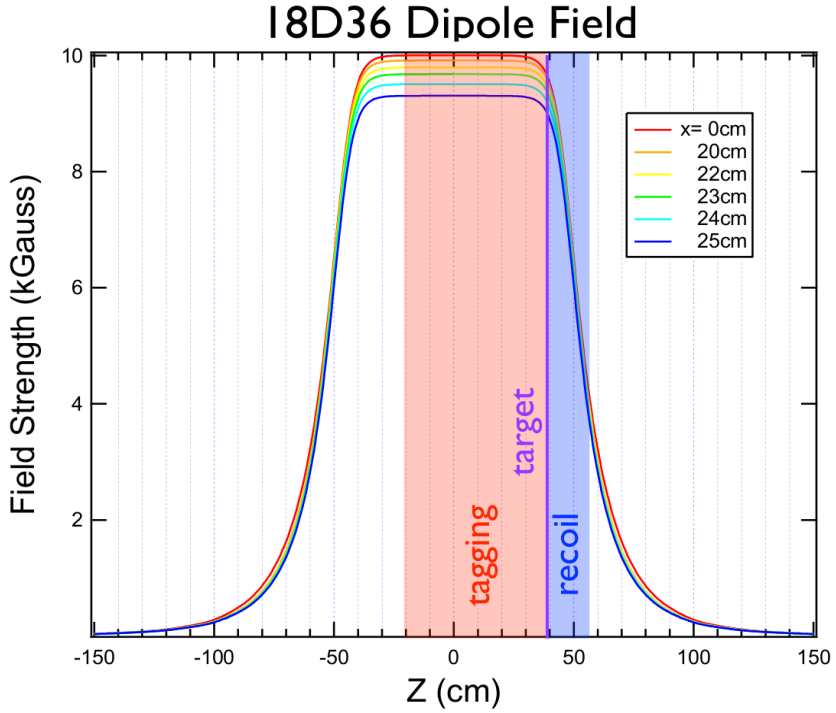
The Detector



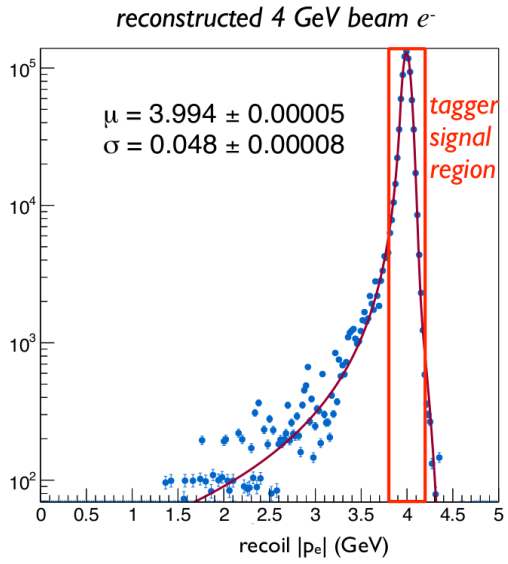
Tracking System

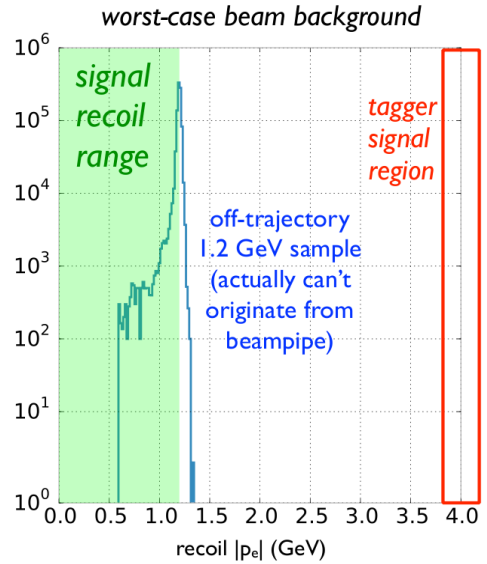


- **Tagging Tracker**
  - **Objective:** Verify incoming electron has beam energy and **veto** otherwise
- **Recoil Tracker**
  - **Objective:** Identify low-momentum, recoiling electrons



Designed with experience from HPS

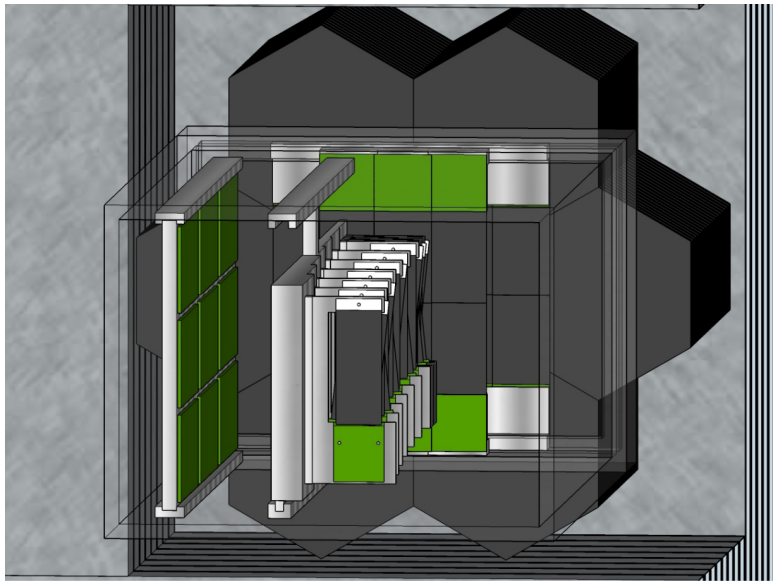


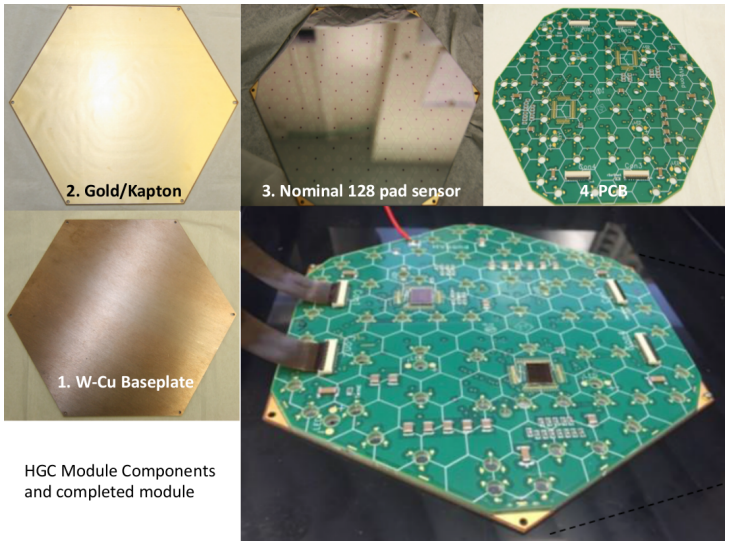


Electromagnetic Calorimeter

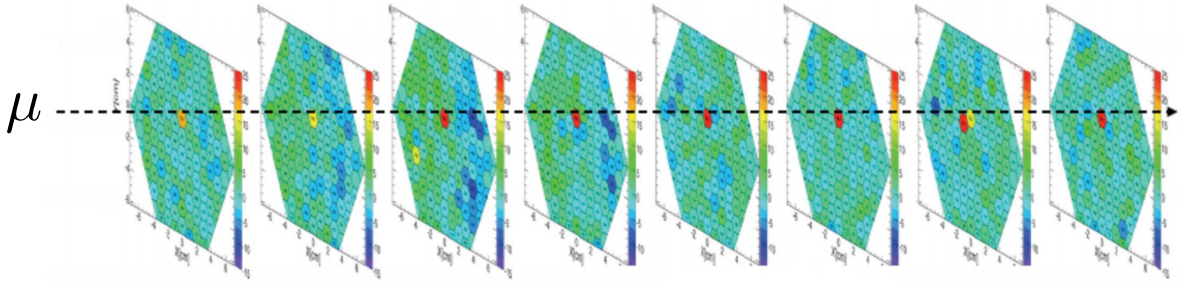
- **Objective:** Make high speed energy measurements with excellent resolution and radiation hardness

Hardware based on CMS forward calorimeter upgrade

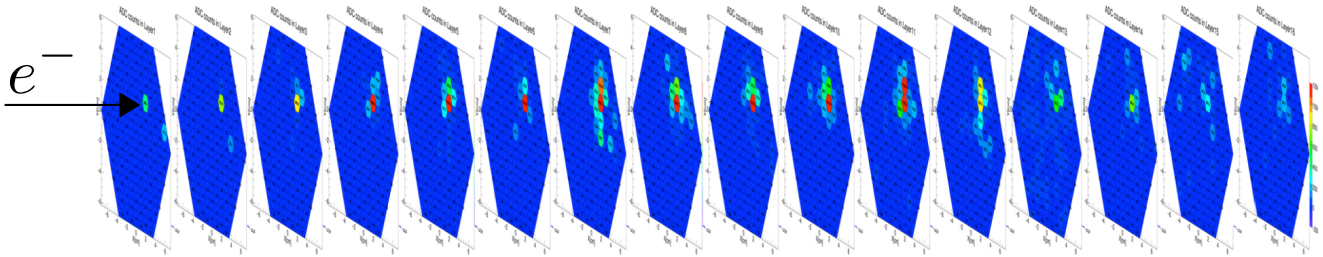




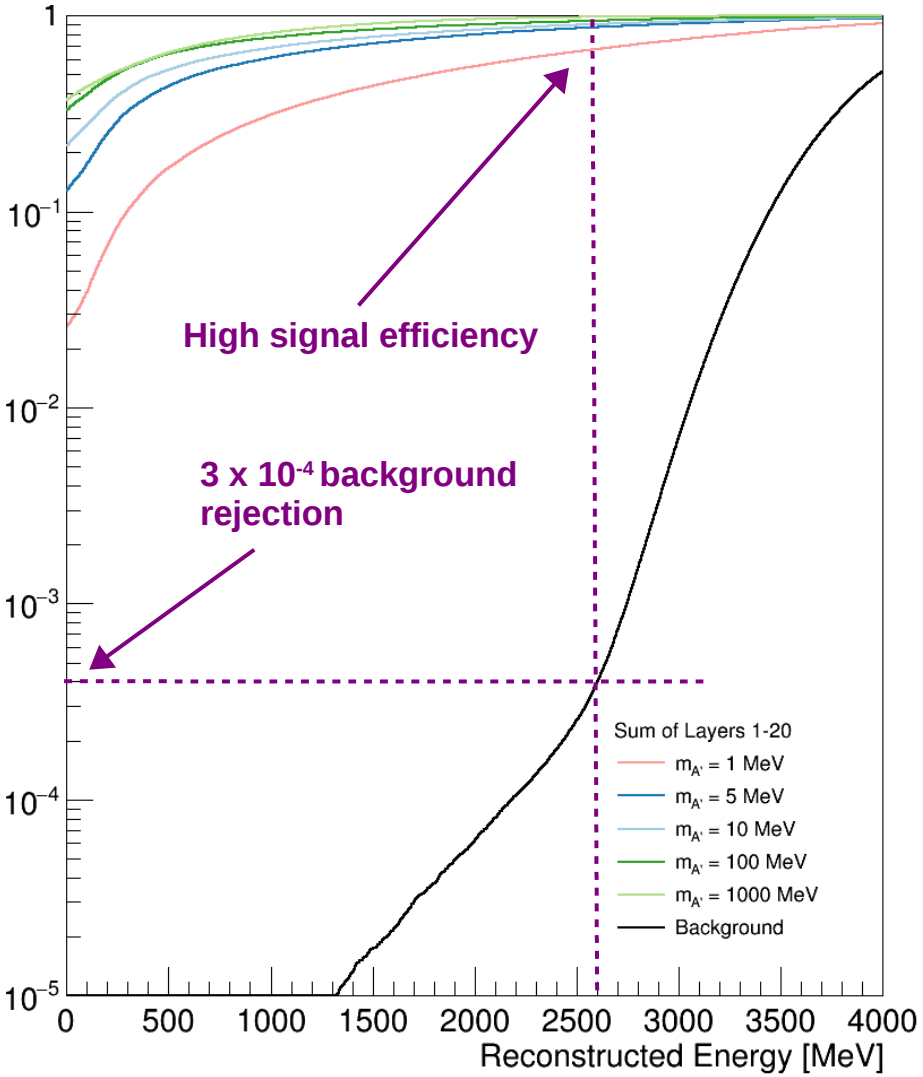
HGC Module Components and completed module



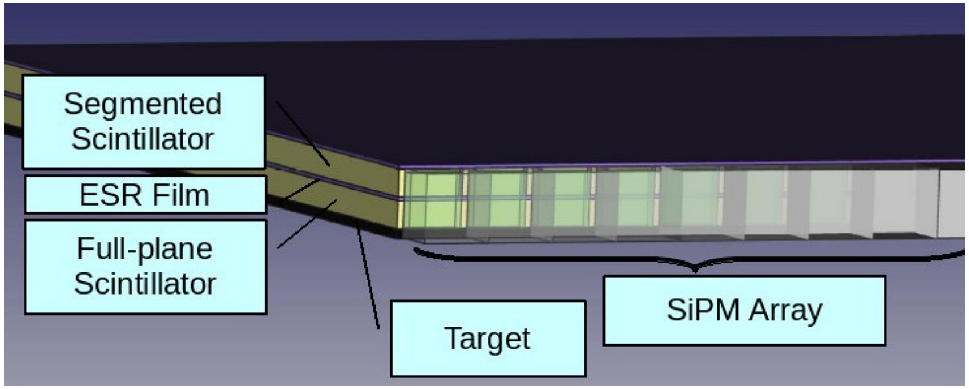
CERN/FNAL Testbeam



Trigger



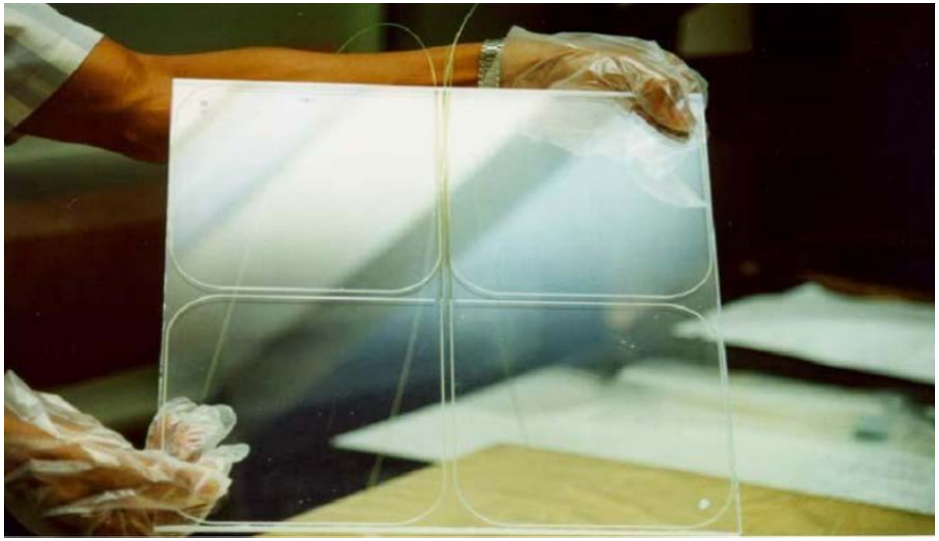
- **Primary physics trigger**
  - Total energy deposition in the first 20 layers of the ECal
  - **Trigger on low energy!**
  - Reduce beam particle rate from **46 MHz** to **4 kHz**

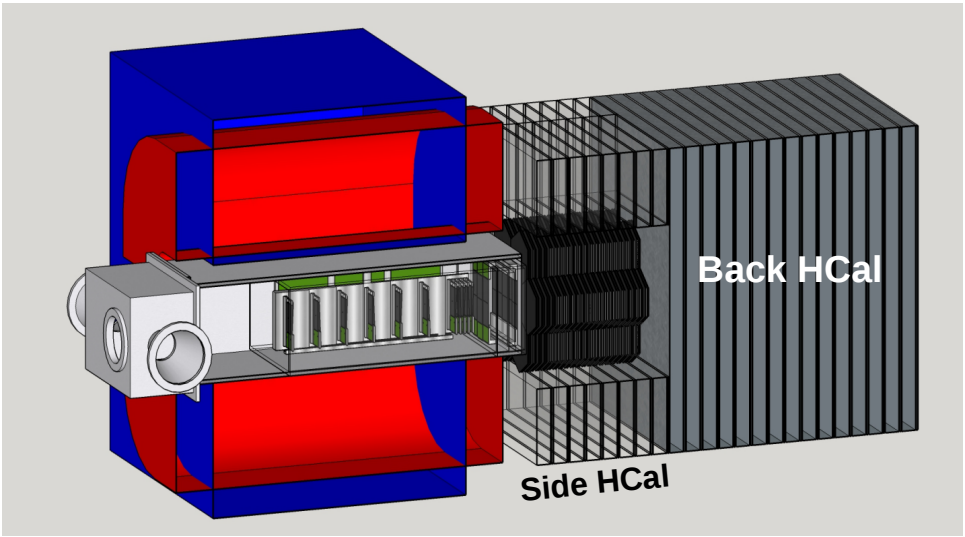


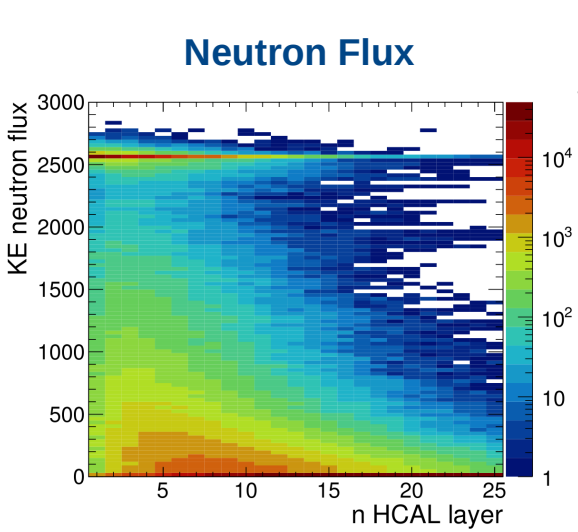
Hadronic Calorimeter

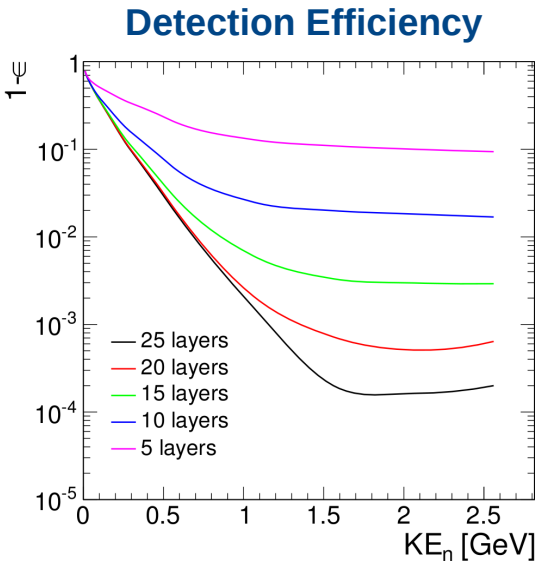
- **Objective:** Assist ECal in vetoing photonuclear

Takes advantage of CMS Phase I upgrade

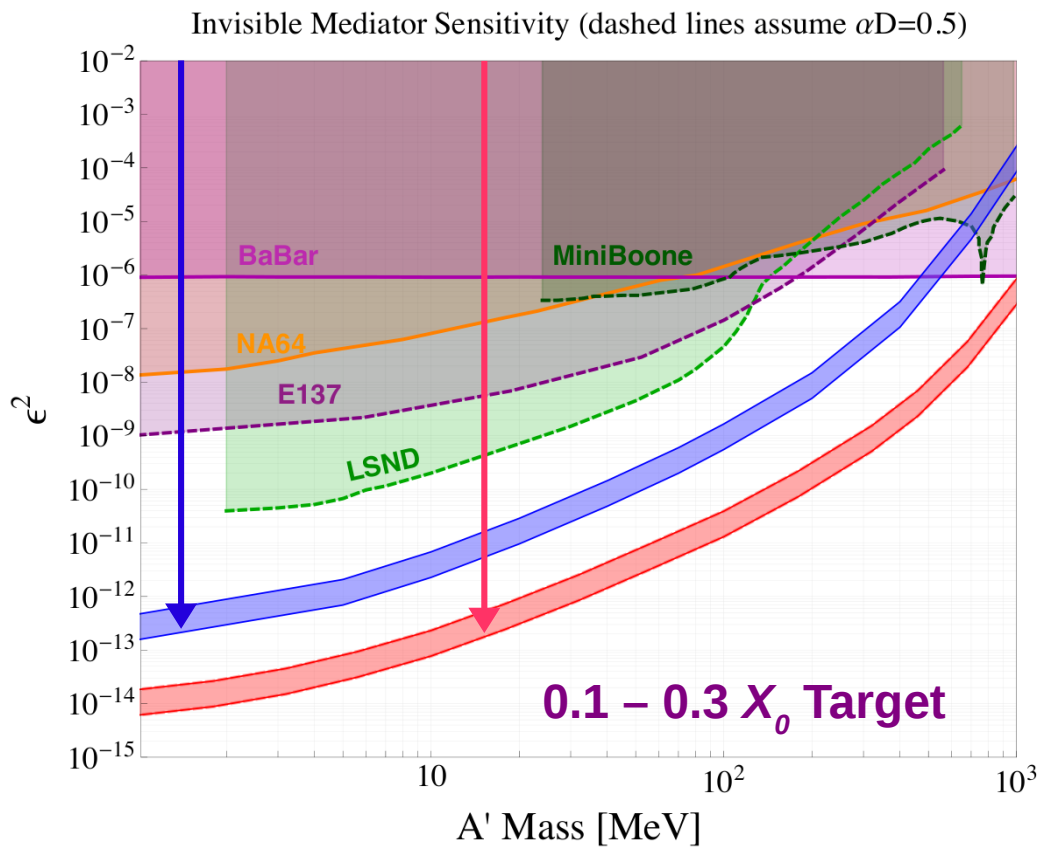


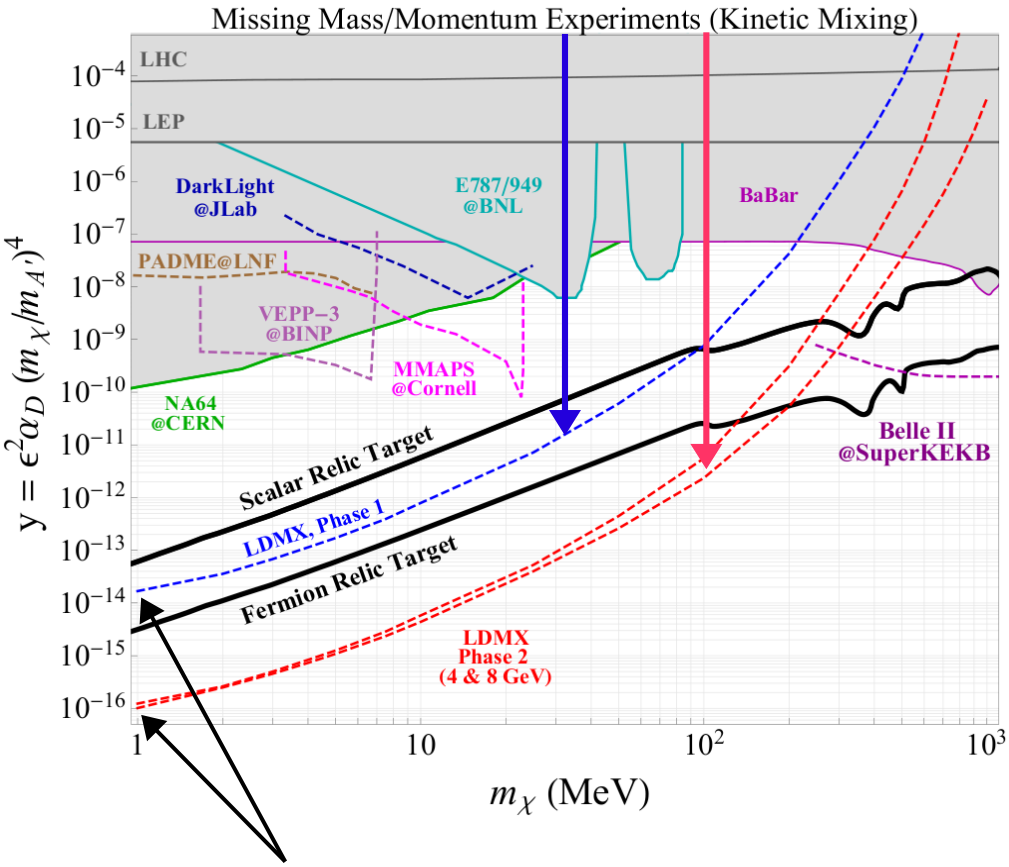






Physics Potential





LDMX Phase I:
10^{14} EOT @ 4 GeV

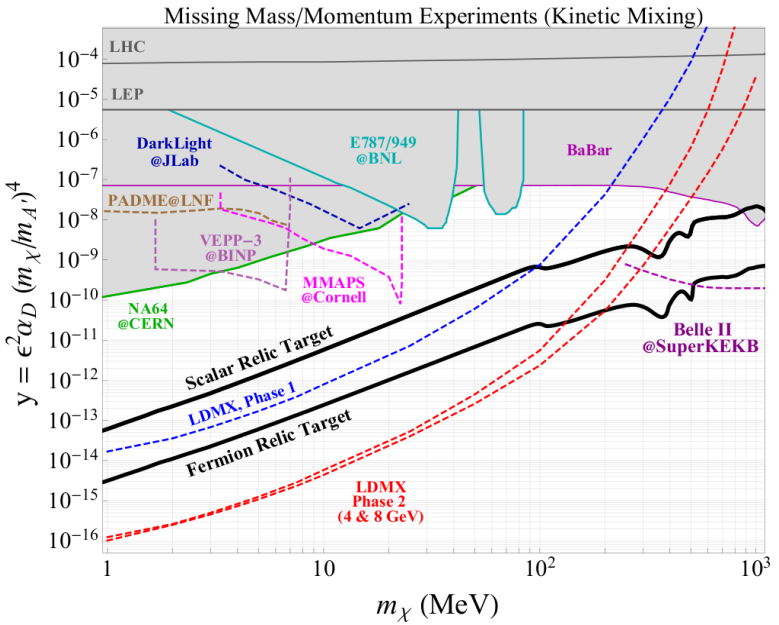
LDMX Phase II:
10^{16} EOT @ 8 GeV

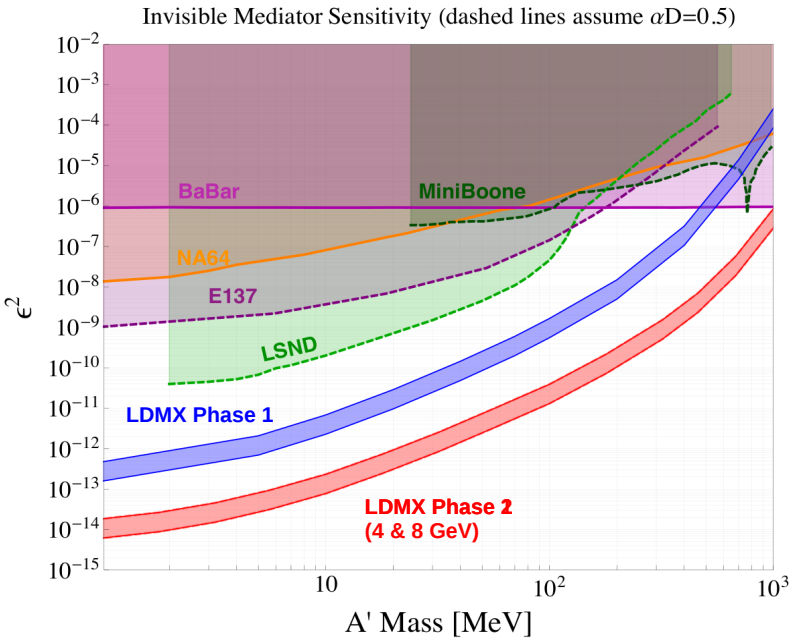
Sensitivity extends down to lower masses

Summary

- Accelerator-based experiments uniquely sensitive to sub-GeV range
  - Missing momentum technique has the best sensitivity
- **LDMX has broad sensitivity over sub-GeV mass range**

- **Other physics potential**
  - Displaced vertex from visibly decaying mediators
  - Displaced electron-positron showers that result from DM co-annihalation models
  - Dark Vectors decaying to neutrinos
  - Photonuclear and electronuclear measurements for neutrino scattering





The Collaboration

Bertrand Echenard, David Hitlin

Gordan Krnjaic, Nhan Tran, Andrew Whitbeck

Norman Graf, Jeremy McCormick, Takashi Maruyama, Omar Moreno, Tim Nelson, Philip Schuster, Natalia Toro

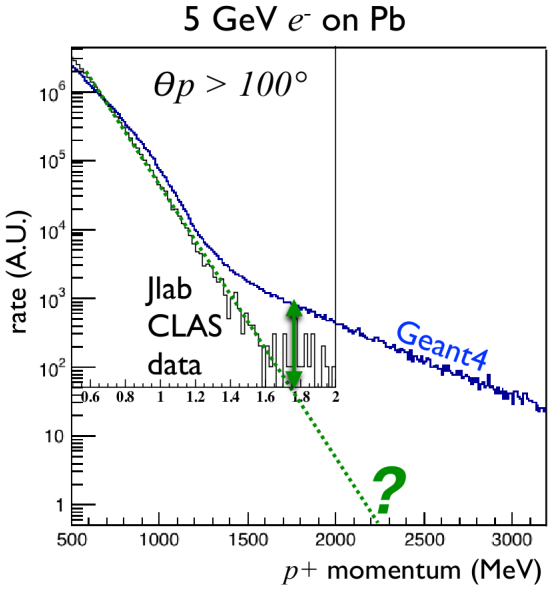
Owen Colegrove, Joe Incandela, Alex Patterson

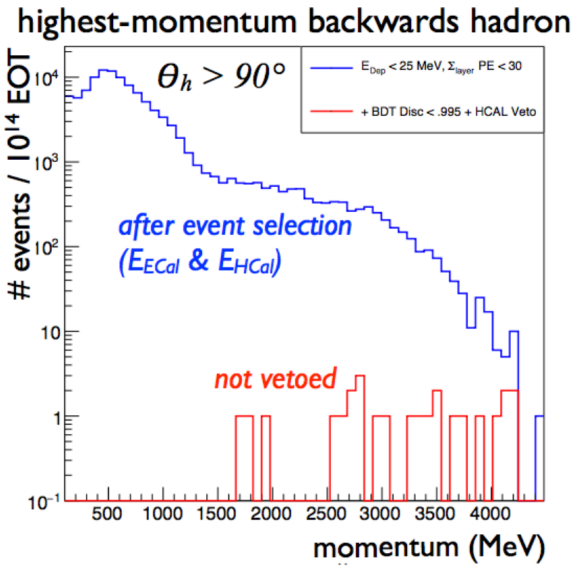
Josh Hiltbrand, Jeremy Mans, Reese Petersen

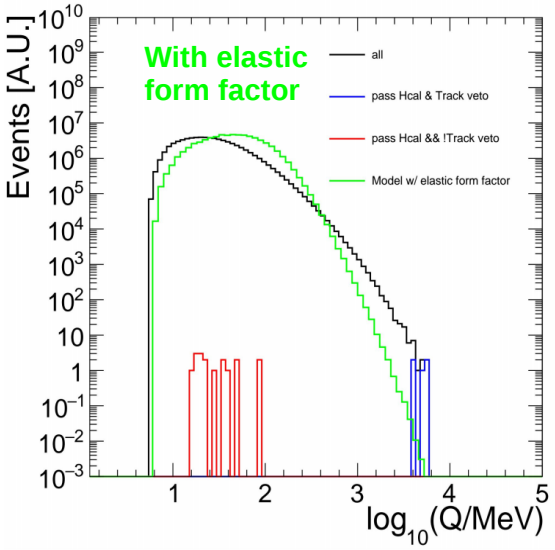
Robert Johnson

Backup

Dealing with Photons







- **Photonuclear events**
  - Currently able to reject on the order of a few x 10^{13} EOT
  - Investigating overproduction of exotic final state kinematics in Geant4
- **Extremely hard, backwards going hadrons**
  - Overproduced by perhaps orders of magnitude!
- **Muon conversion**
  - Can be treated similarly to photonuclear
  - Currently can veto all but a few in 10^{13} EOT
  - Looking at Geant4 form factor implementation