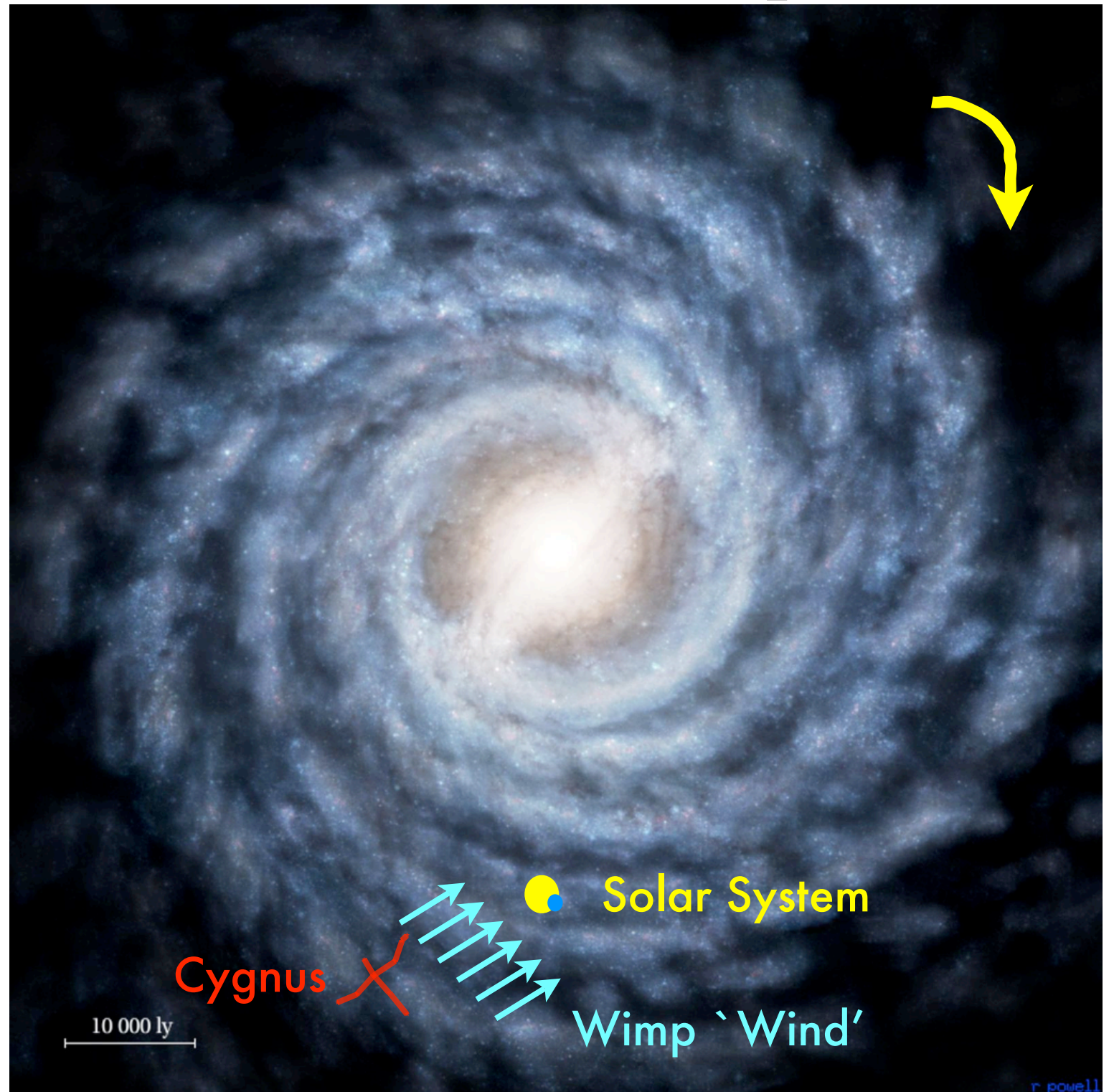


DMTPC: A Directional Dark Matter Experiment

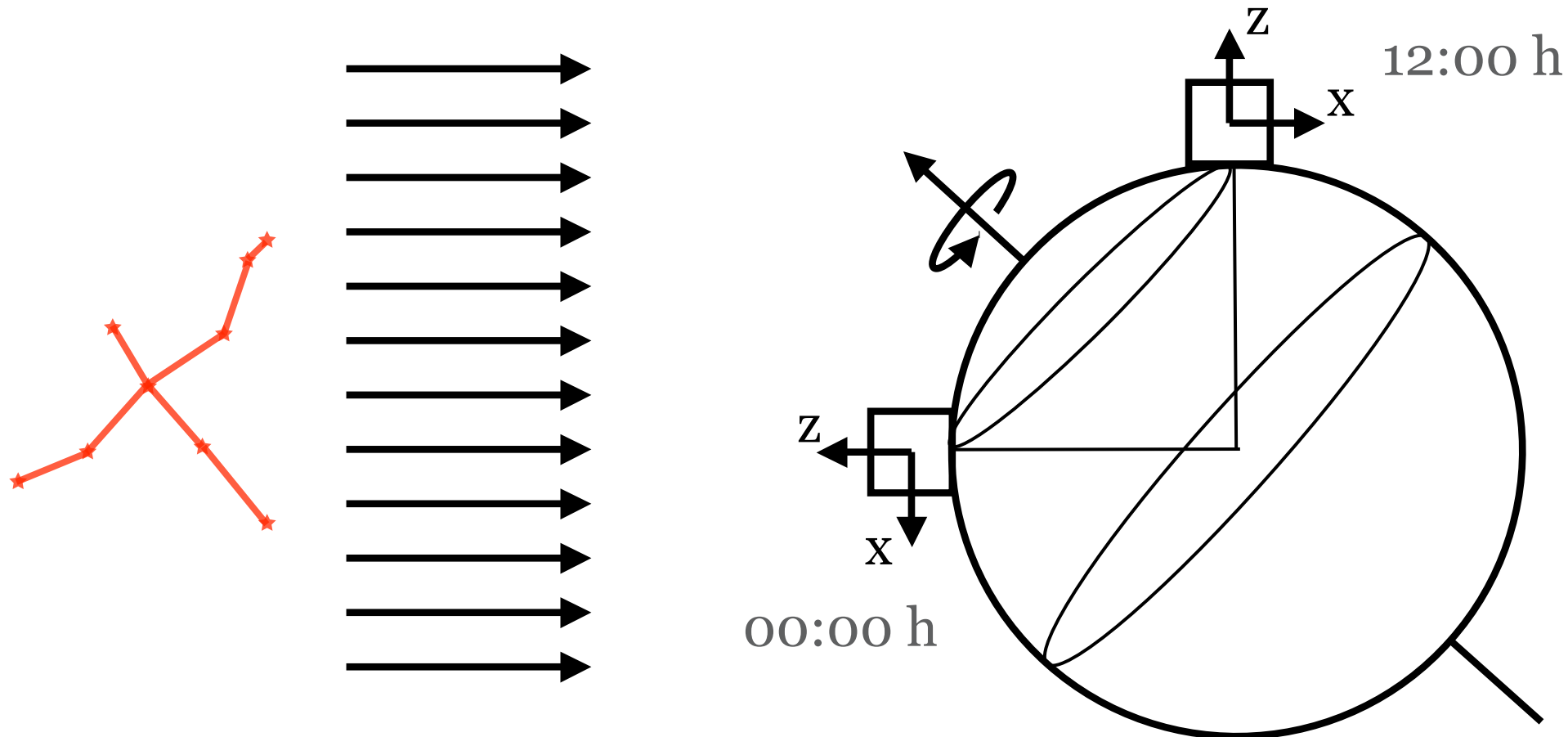
Asher Kaboth

Why Directionality?

Dark Matter Halo



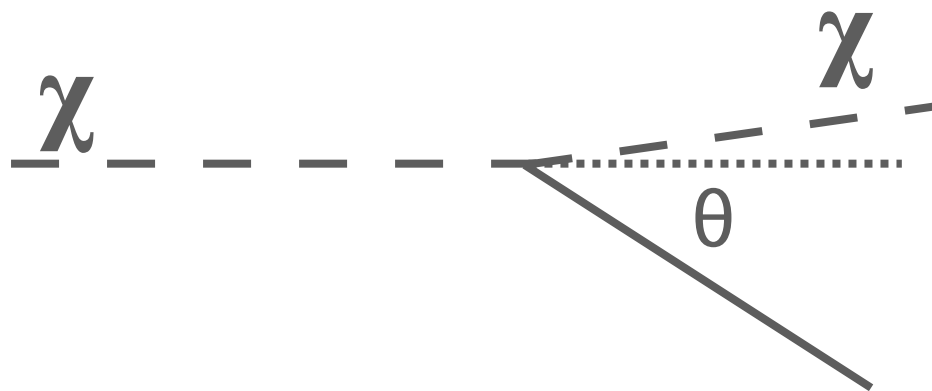
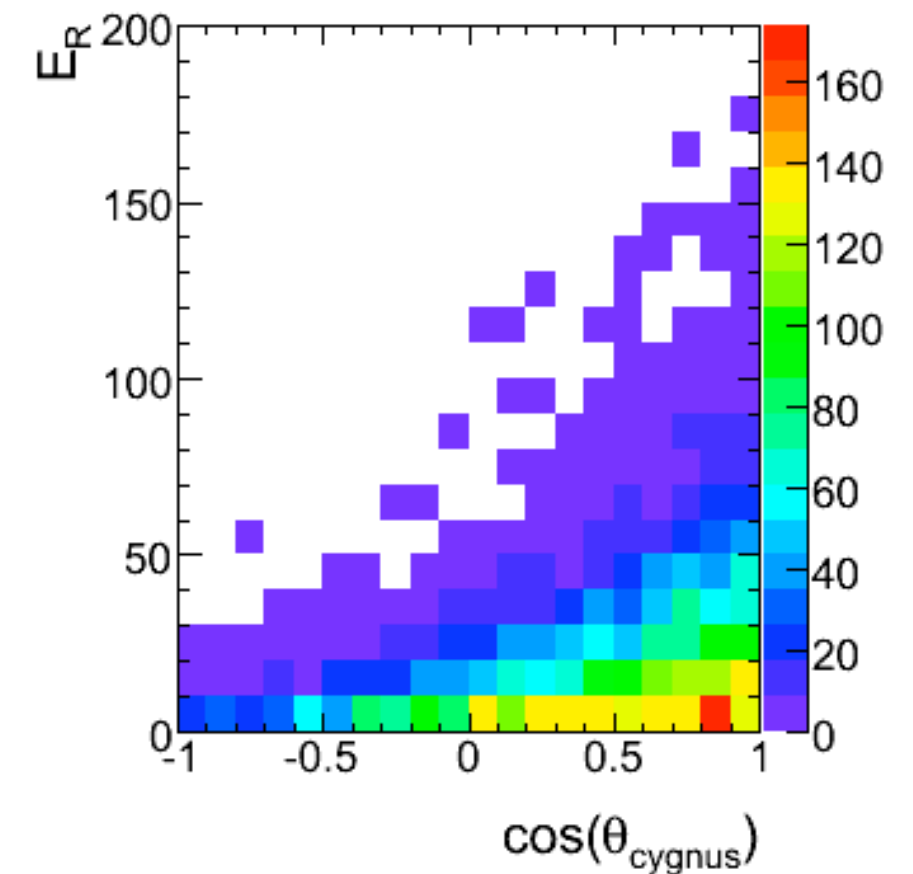
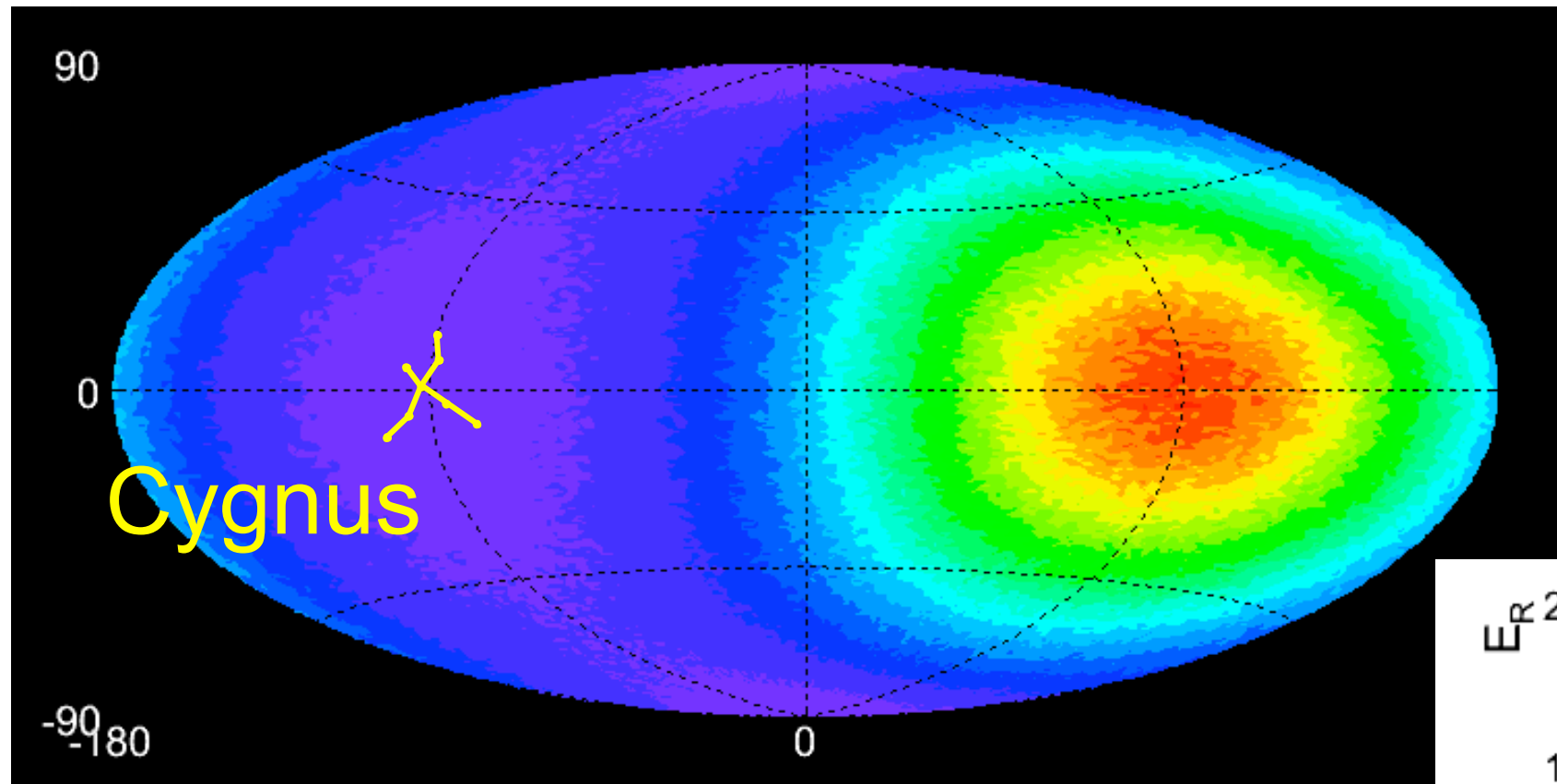
Signal Modulation



$$\frac{dR}{dE d\cos\gamma} \propto \exp \left[- \left(\frac{(v_E + v_\odot) \cos\gamma - v_{min}}{v_{halo}} \right)^2 \right]$$

Spergel, Phys.Rev. D37 (1988) 1353

Dark Matter Recoils



DMTPC Collaboration

Boston University

S. Ahlen (PI) , A. Inglis, H. Tomita

Brandeis University

A. Dushkin, S. Goyal, F. Golub, B. N. Skvorodnev, H. Wellenstein (PI)

Massachusetts Institute of Technology

P. Fisher (PI), G. Sciolla, R. Yamamoto, D. Dujmic, R. Vanderspek,
J. Battat, J. Monroe, S. Henderson, A. Kaboth, J. Lopez, T. Caldwell,
A. Lee, T. Sahin, I. Wolfe, H. Yegorian

Detector Papers

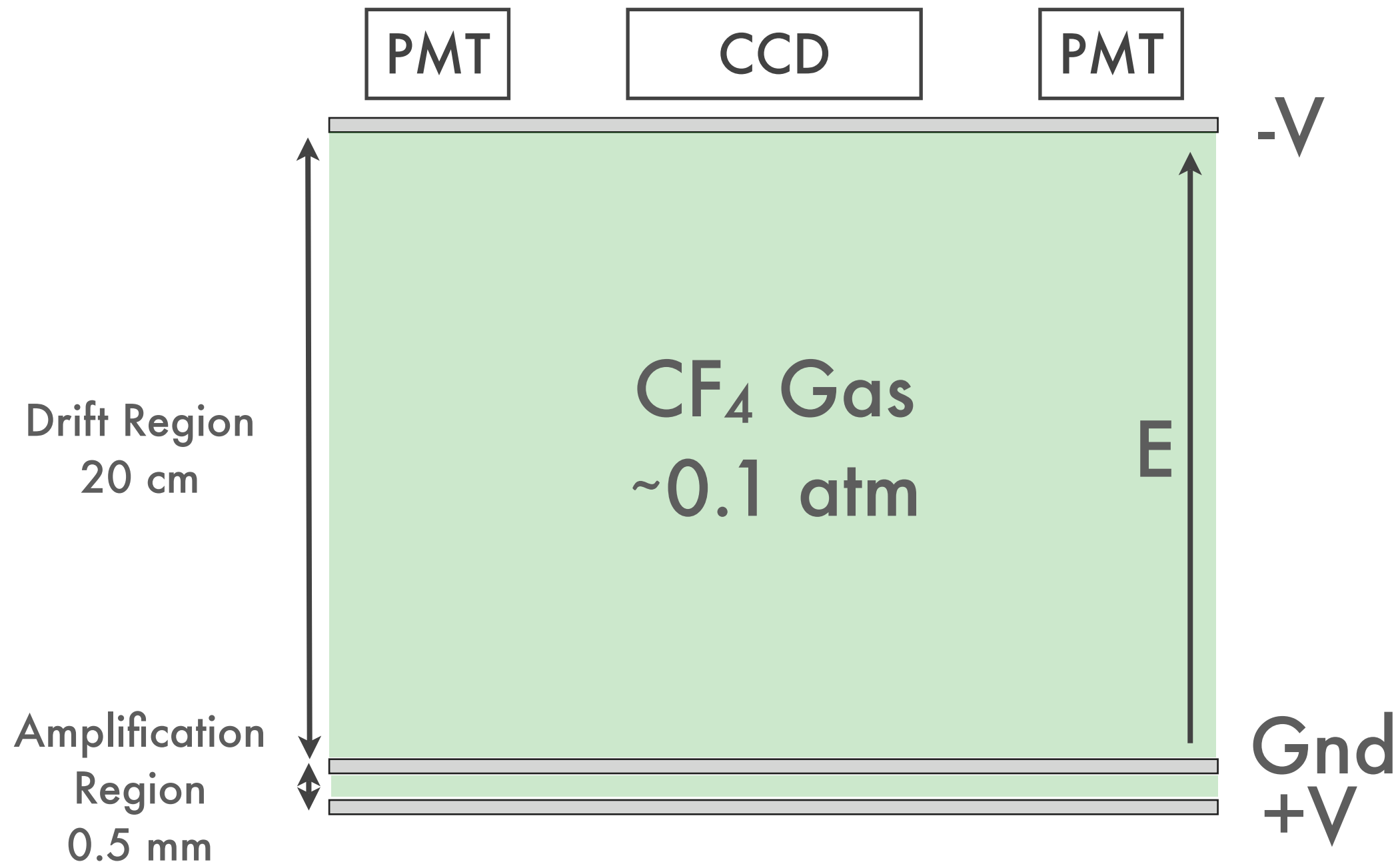
D. Dujmic et al. [DMTPC] NIMA 584 (2007)

A. Kaboth et al. [DMTPC] NIMA 592 (2008)

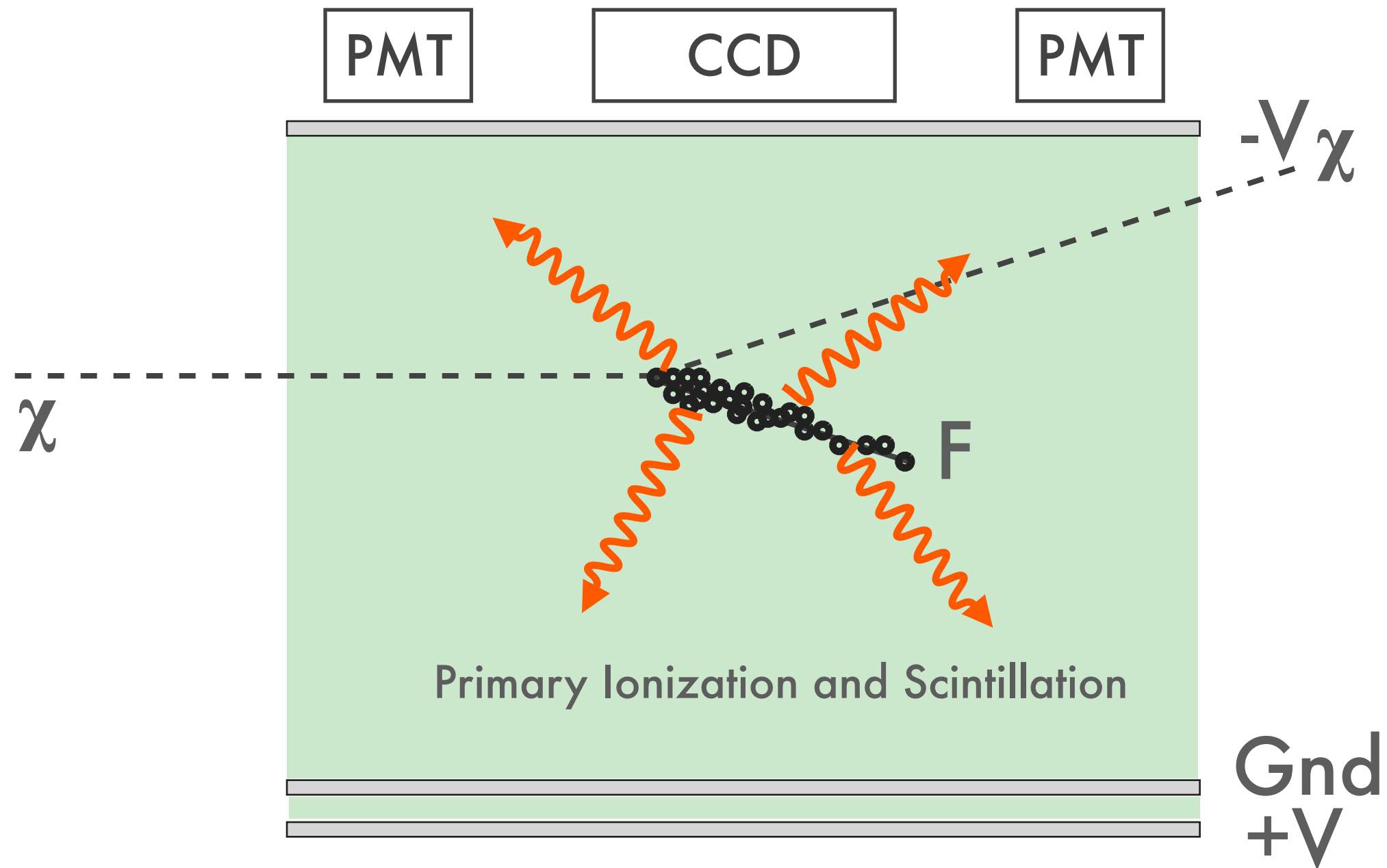
D. Dujmic et al. [DMTPC] Astropart. Phys 30 (2008)

T. Caldwell et al. [DMTPC] arXiv:0905.2549 (2009)

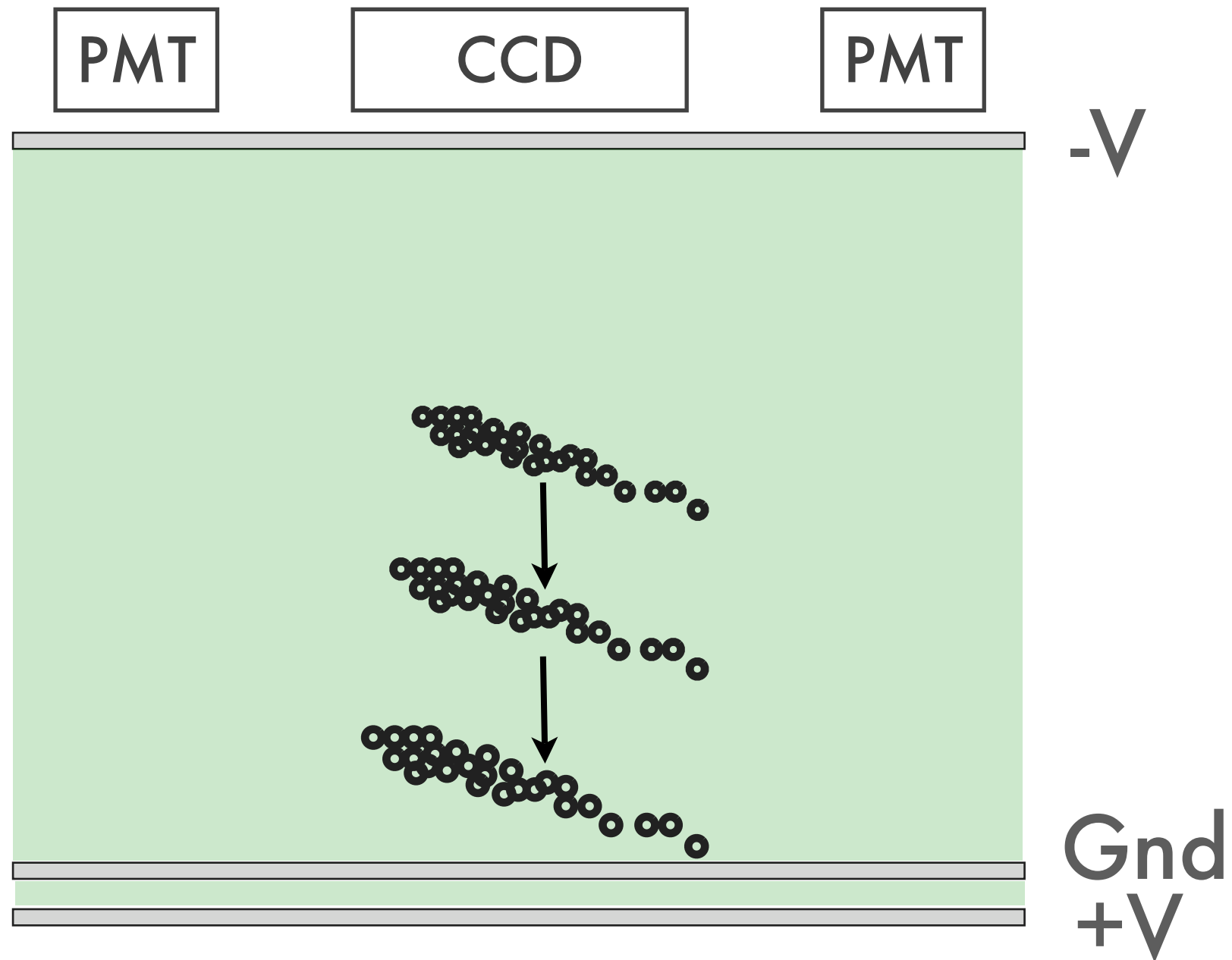
Detector Concept



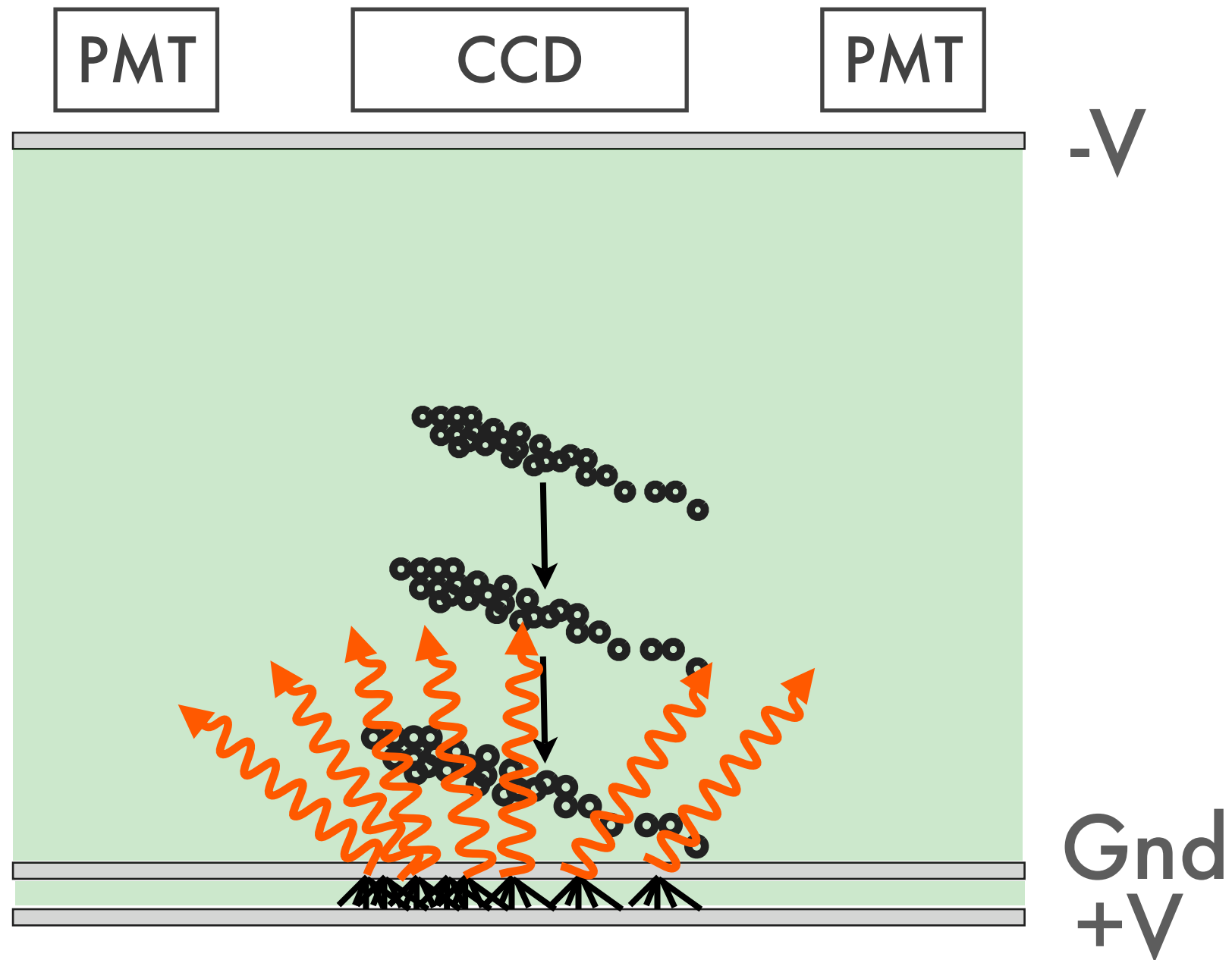
Detector Concept



Detector Concept



Detector Concept



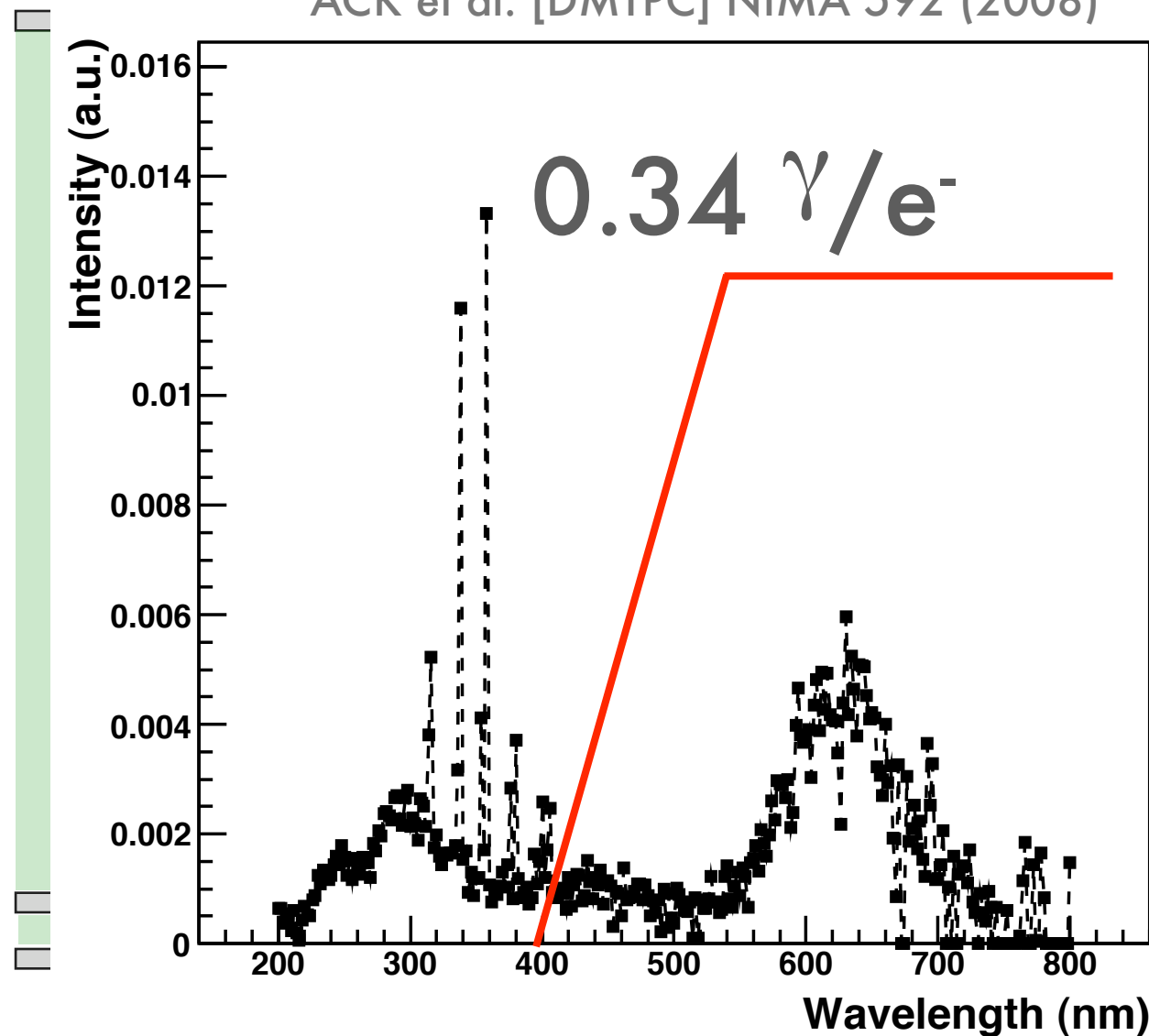
Detector Concept

DMT

CCD

DMT

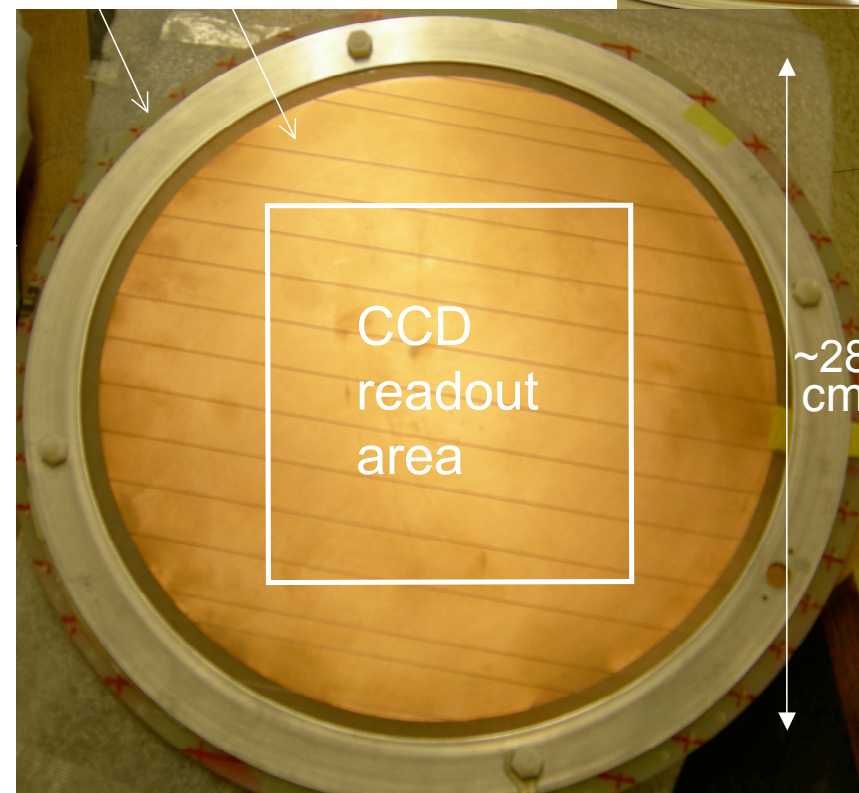
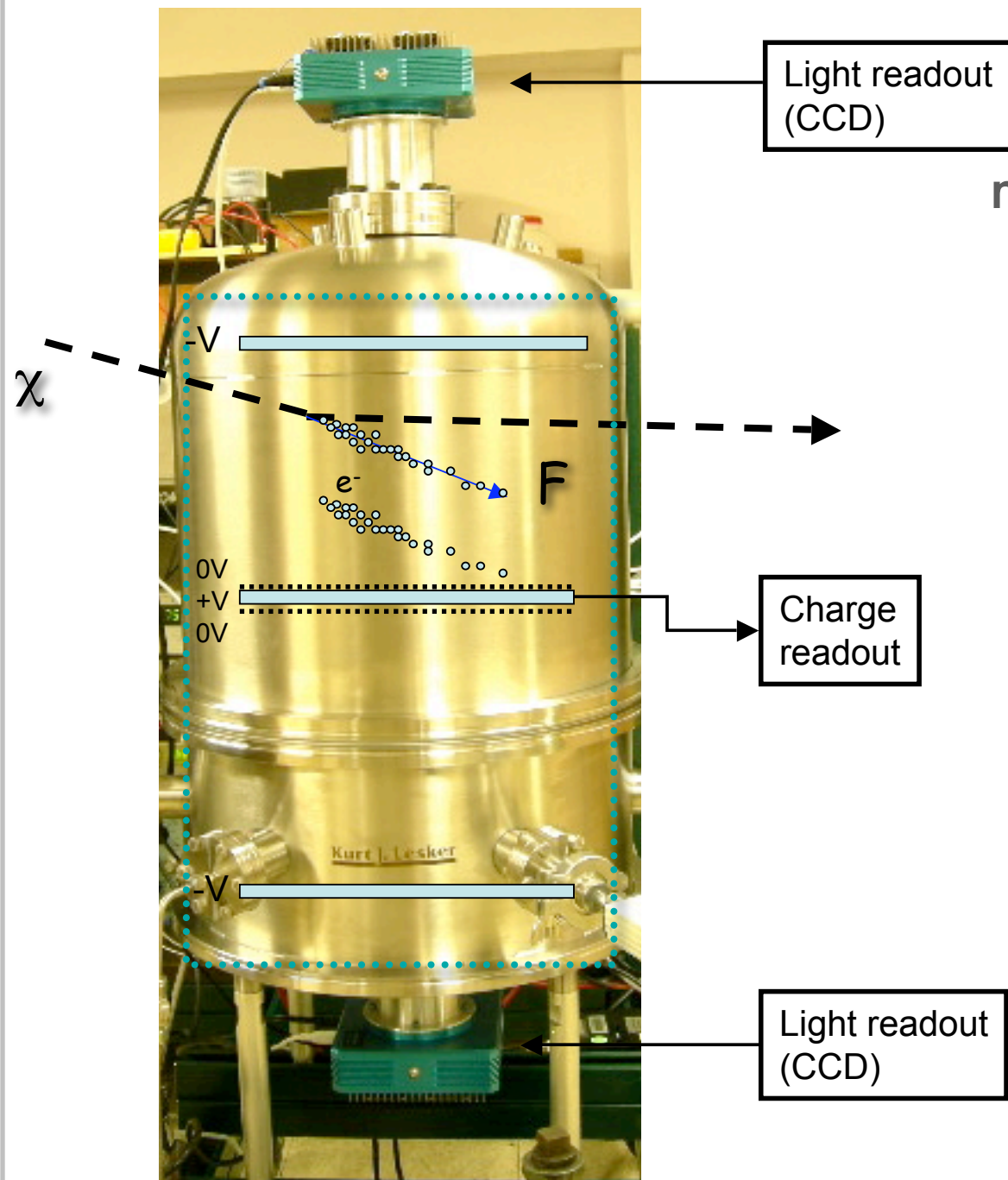
ACK et al. [DMTPC] NIMA 592 (2008)



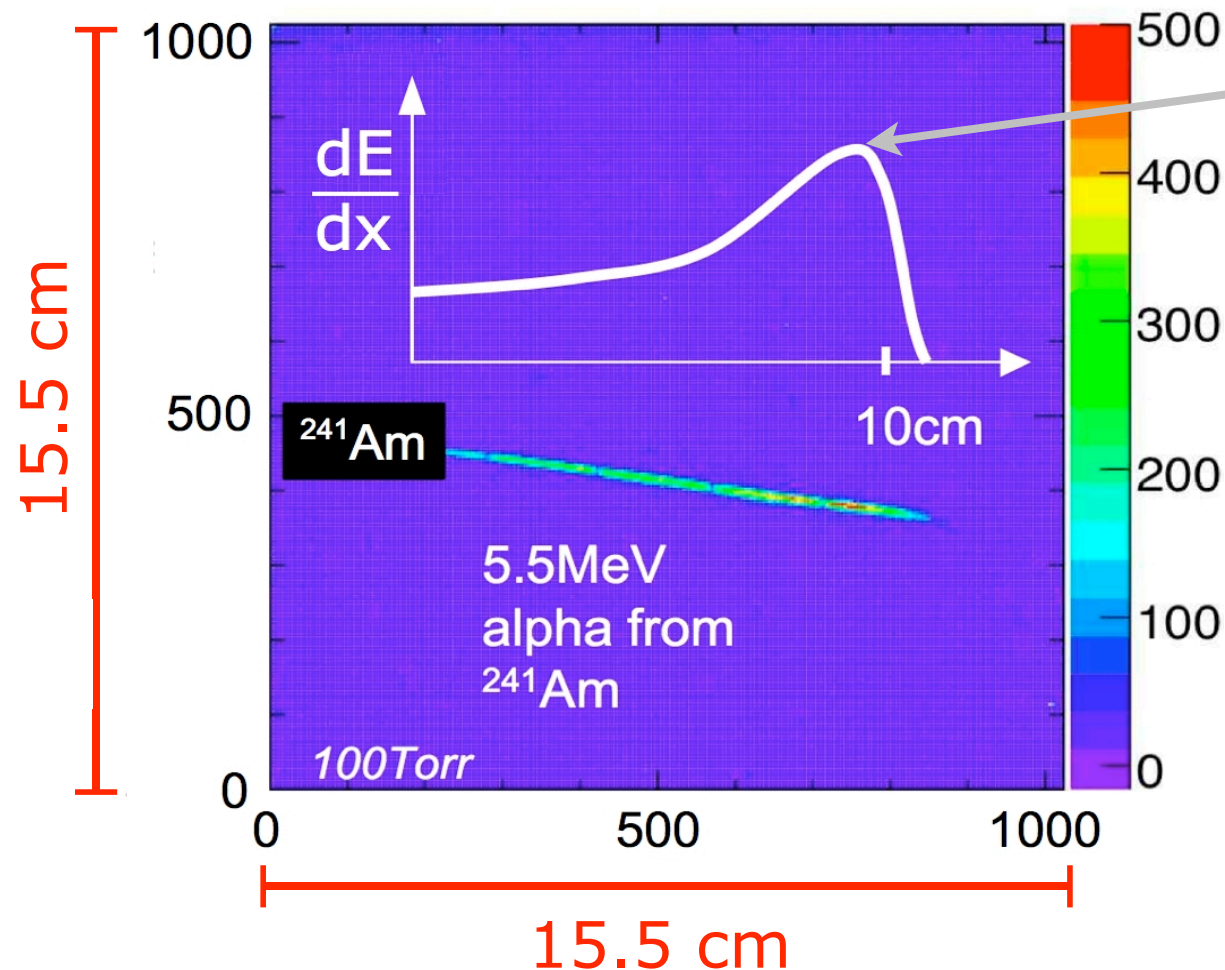
$-V$

Gnd
 $+V$

Prototype Detector

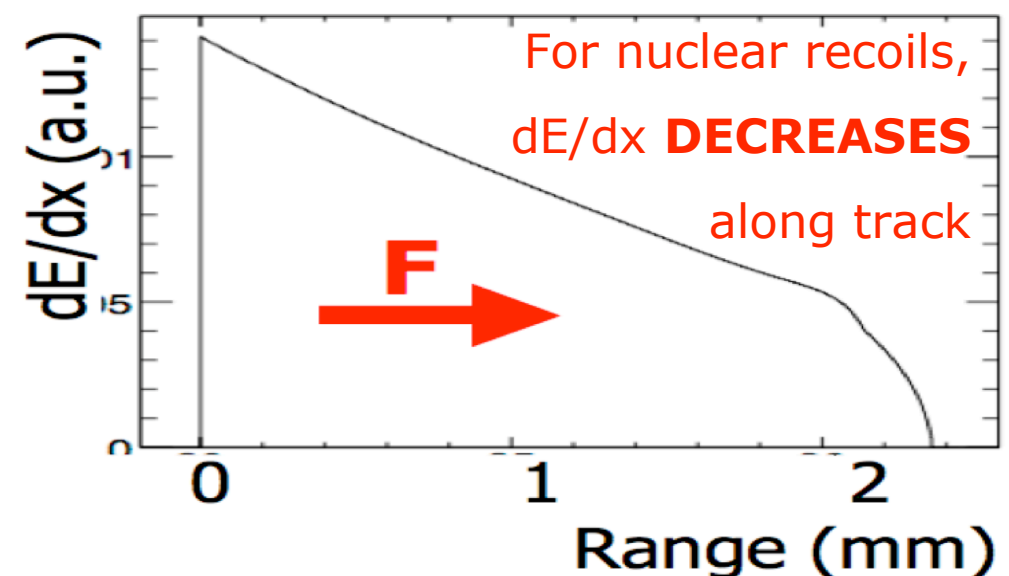


Directionality

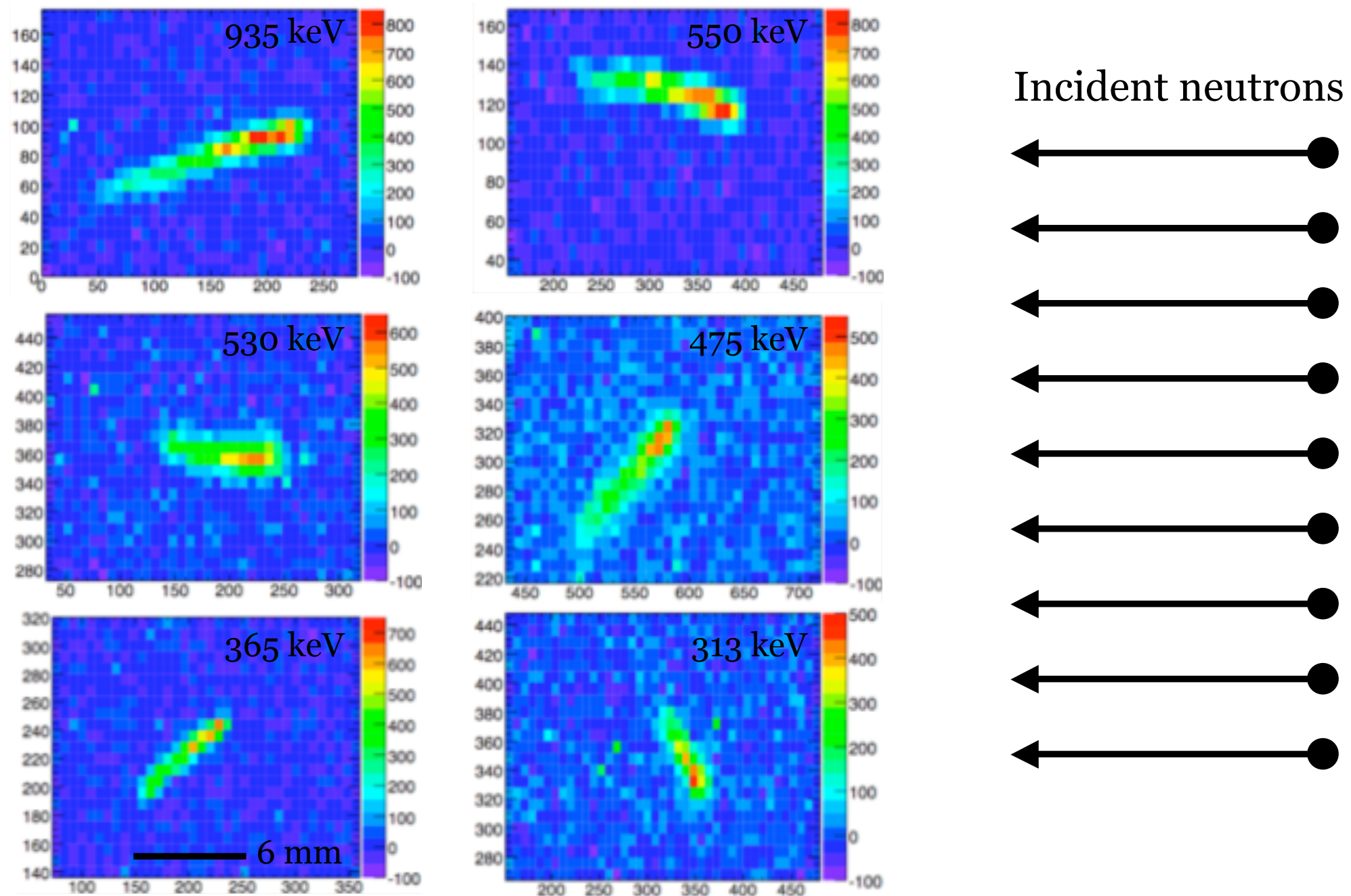


Angle and sense
are given by
knowledge of the
energy deposition

Total energy is given
by amount of light
deposited

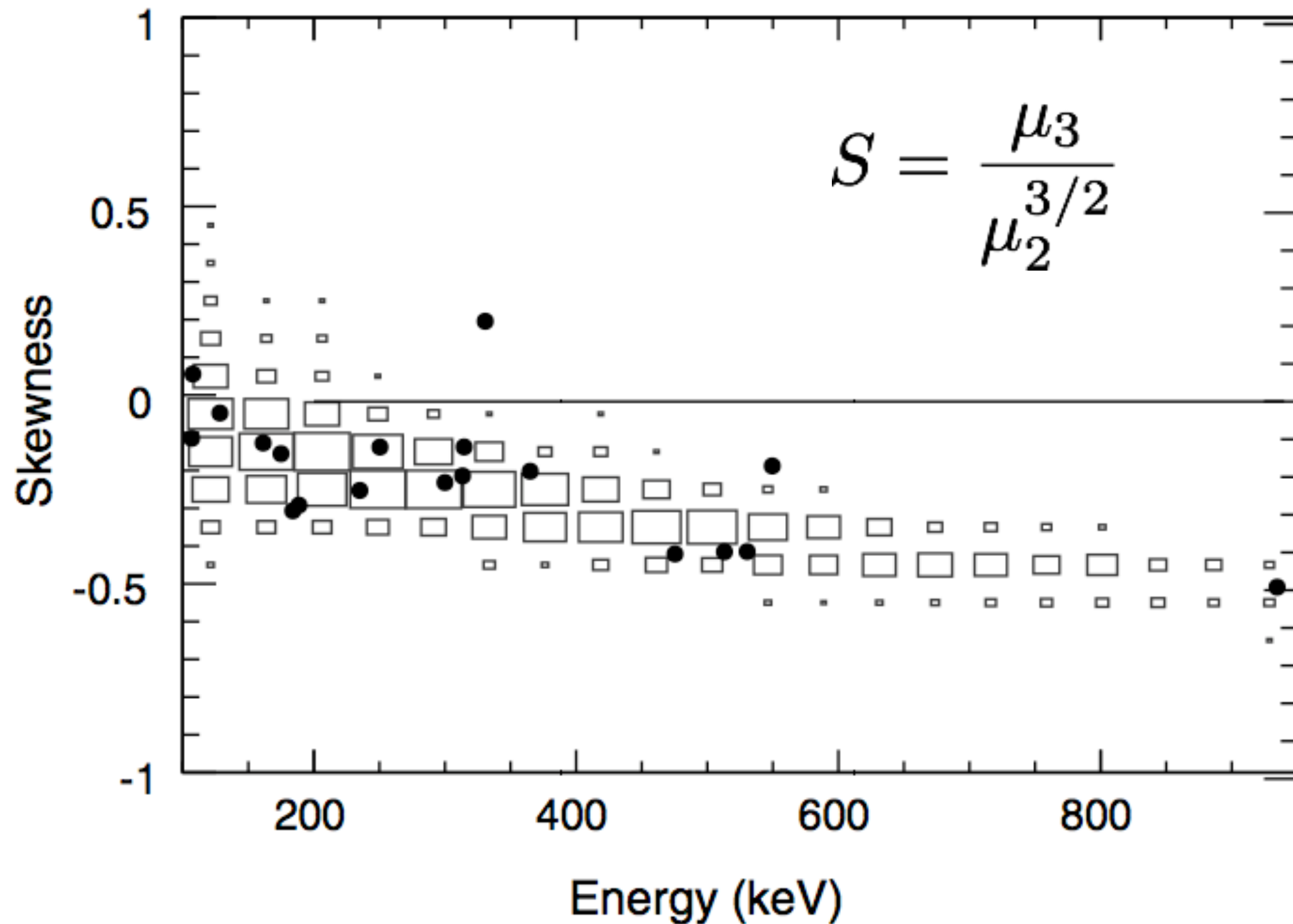


Nuclear Head-Tail

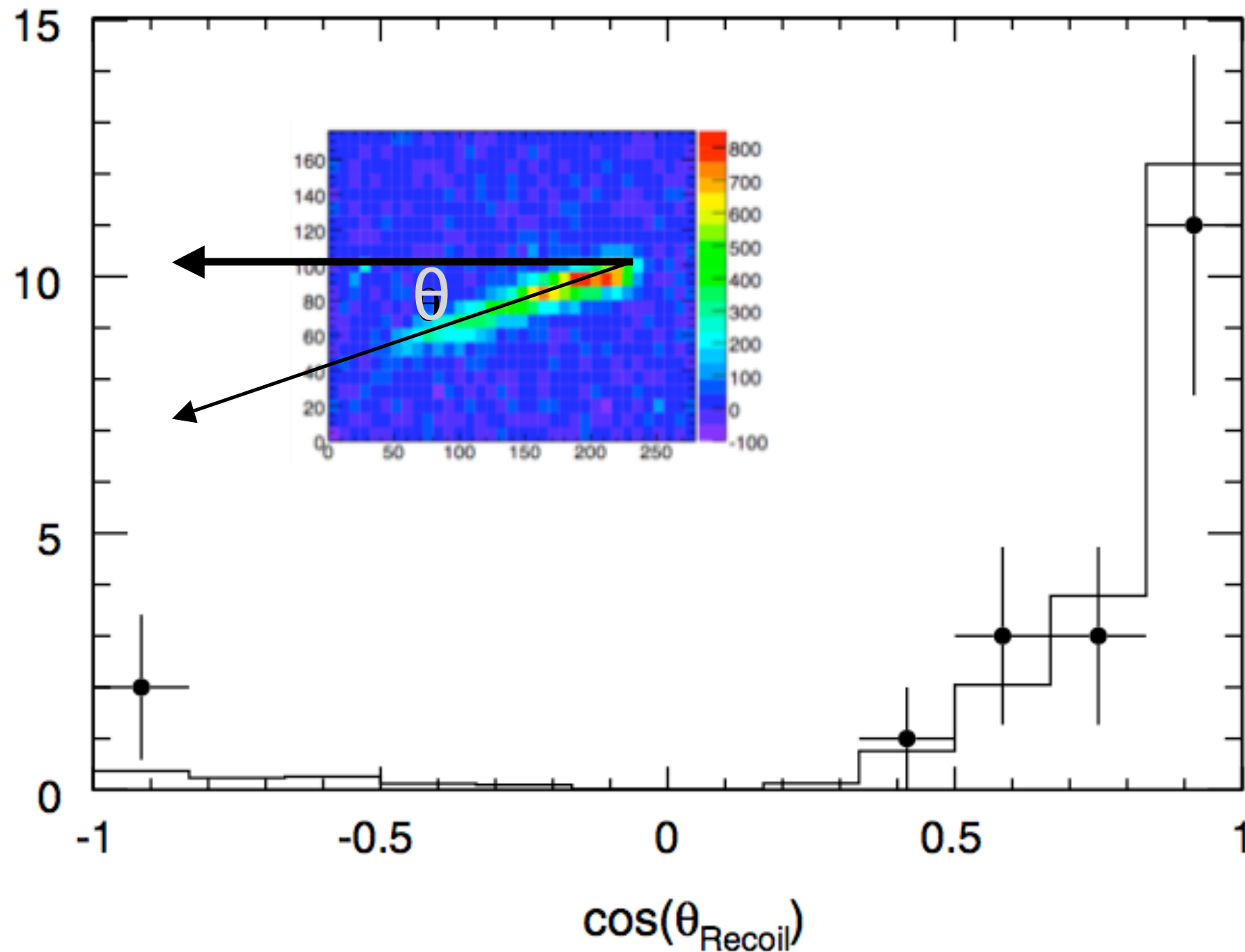


Dujmic et al. Astropart. Phys. 30 (2008) arXiv:0804.4827

Skewness



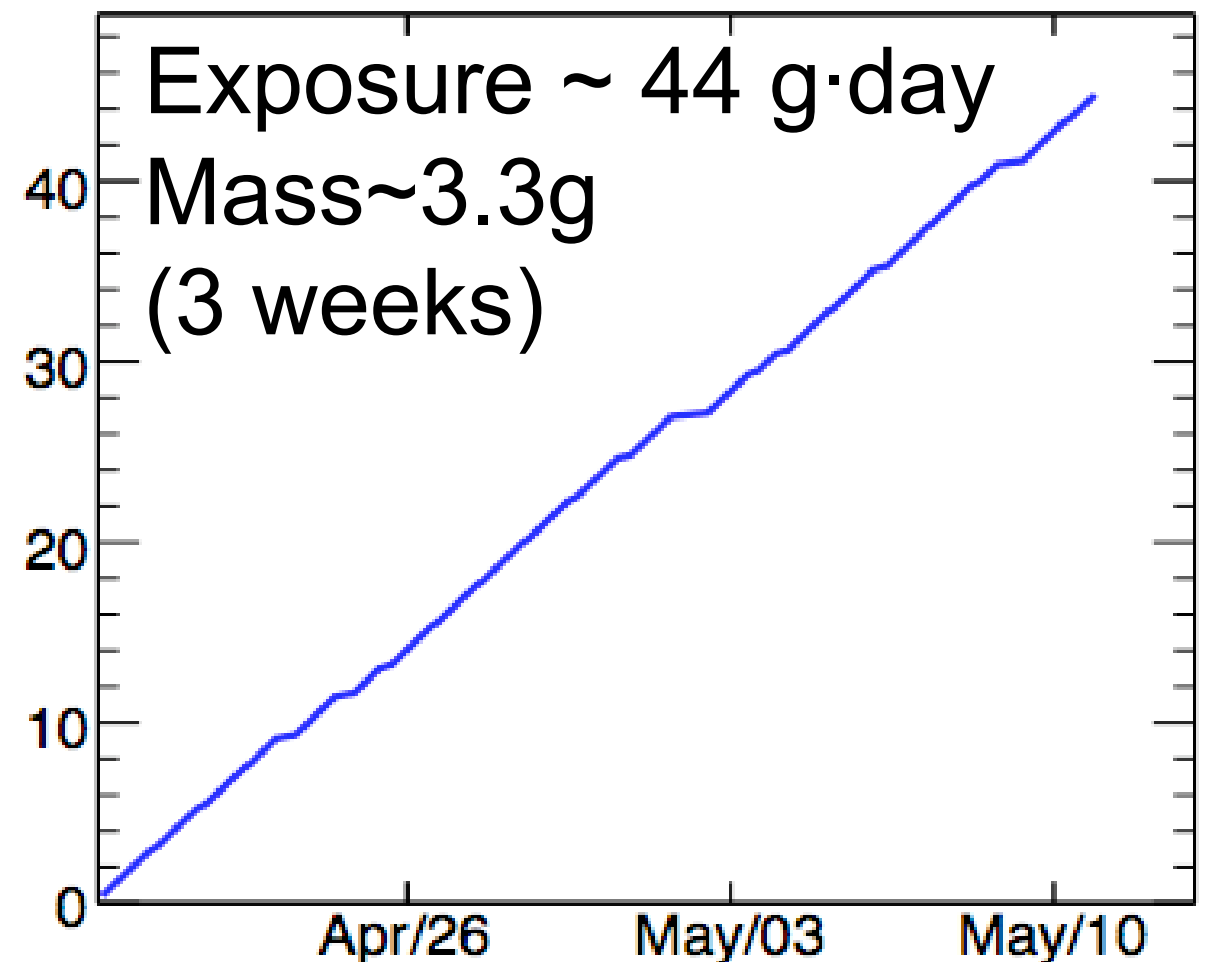
Recoil Distribution



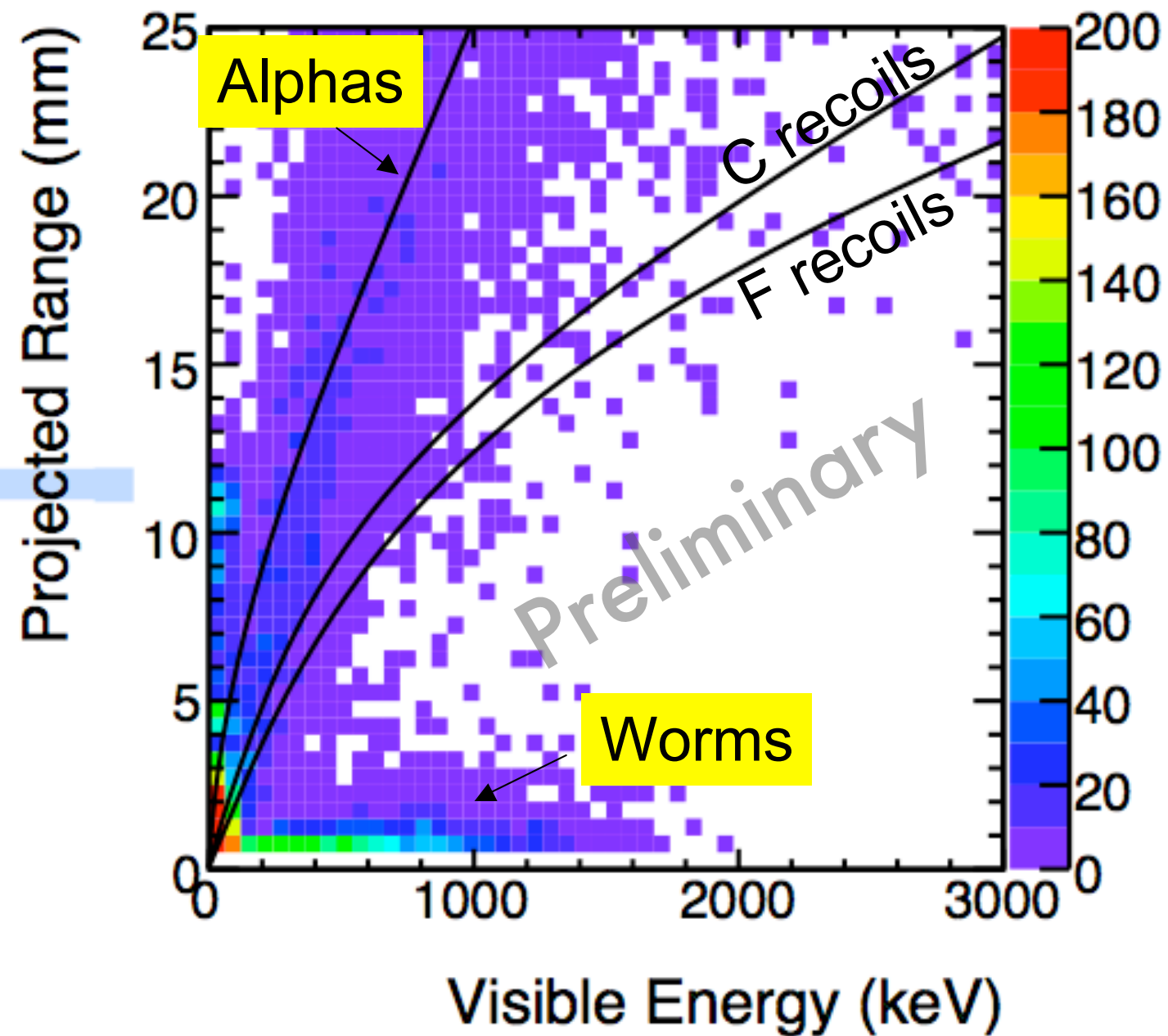
Surface Background Run

- Basement lab at MIT
- Triggerless, remote operation
- 5s CCD exposures
- Refill gas every 24 hours
- 70% live time
- 1% gain stability

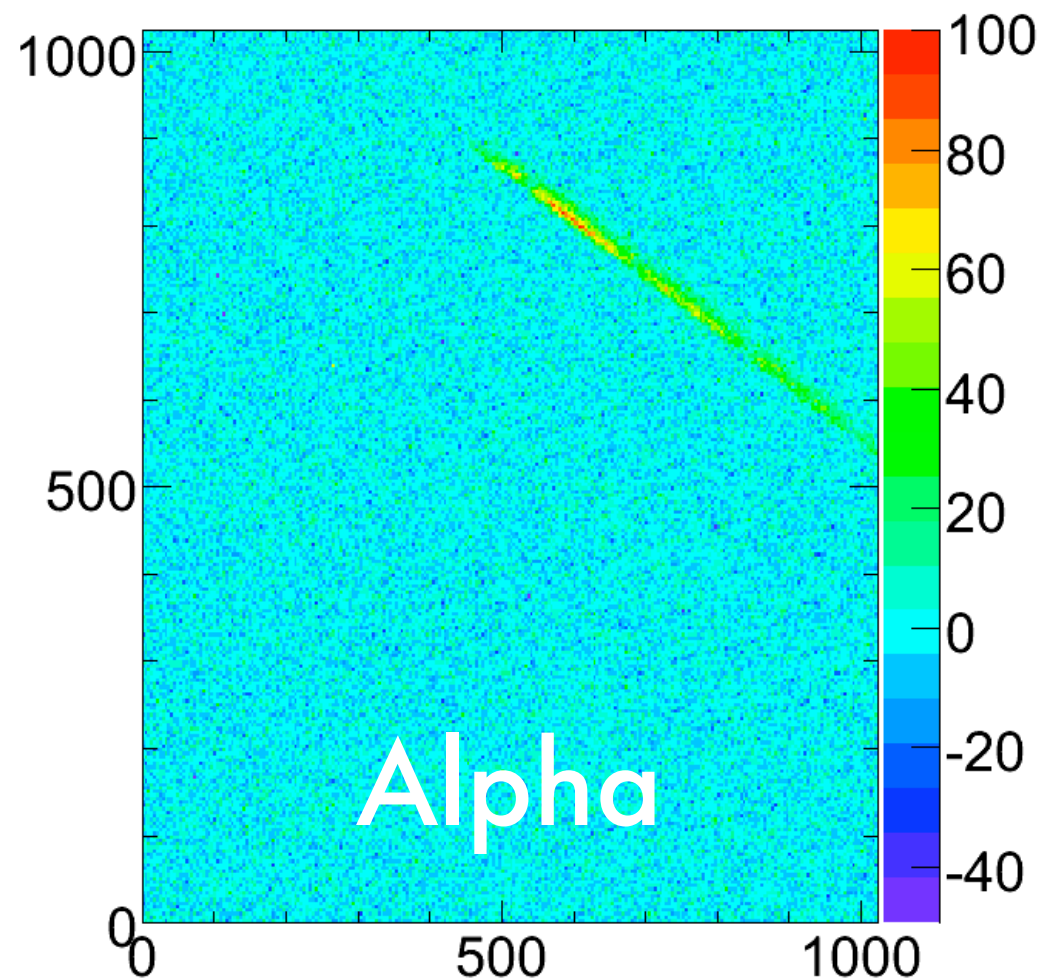
Exposure (g-day)



Data Without Cuts

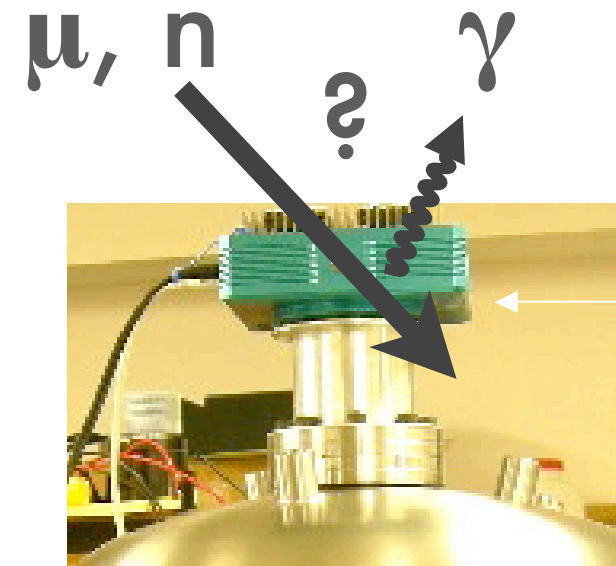
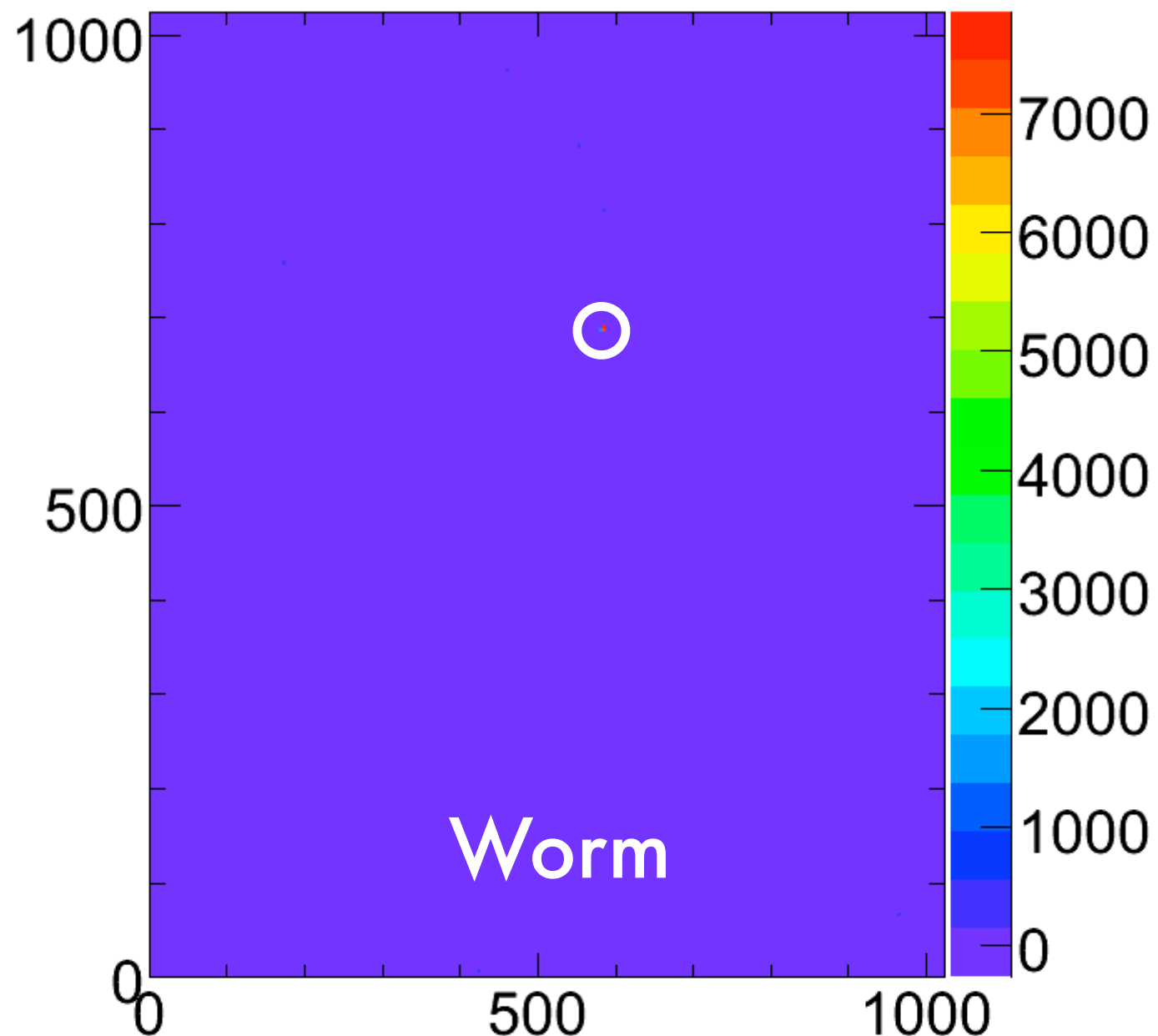


Alphas Background



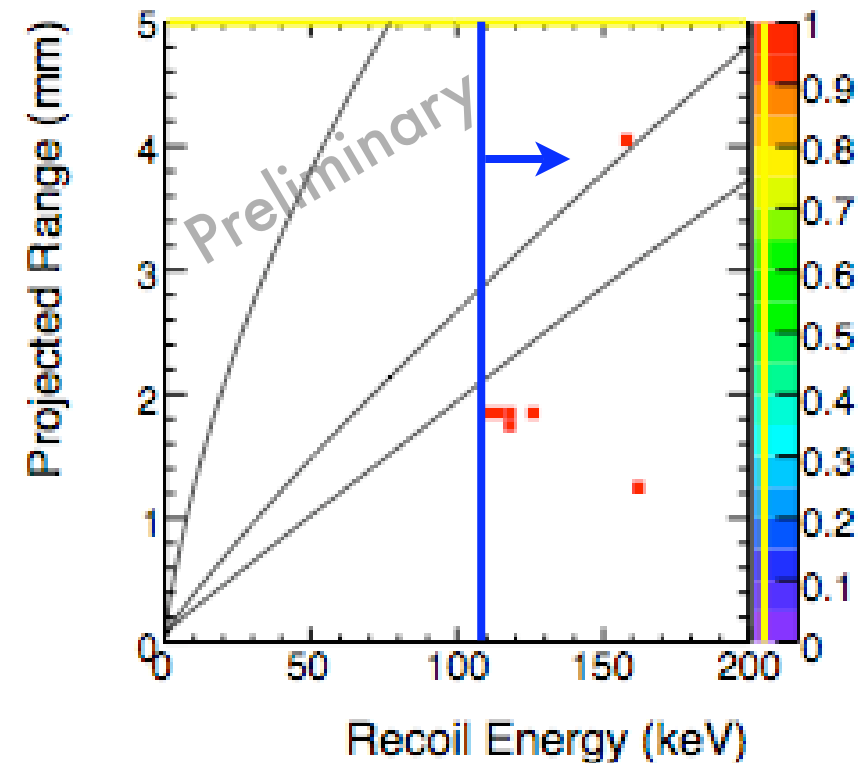
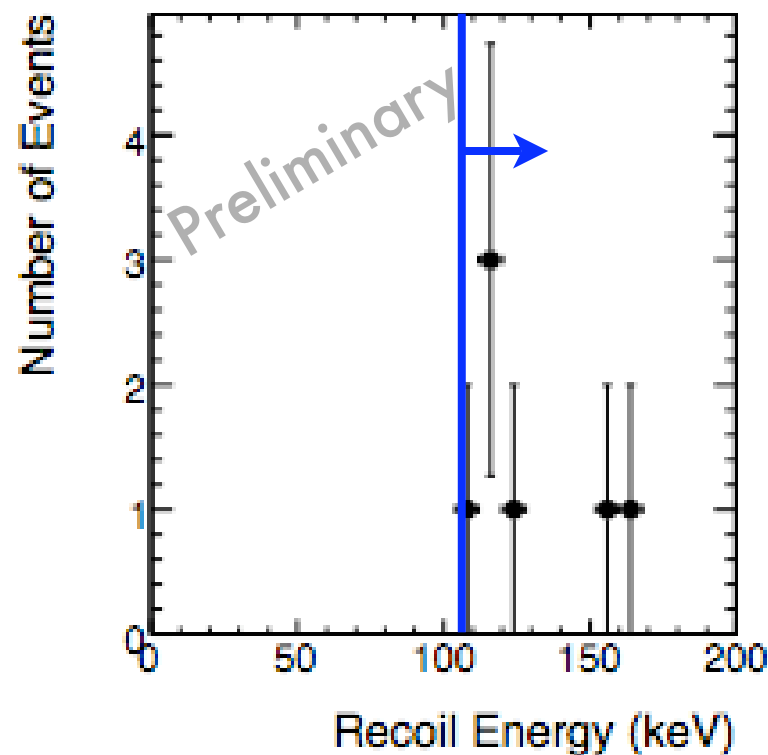
- From U, Th decays in materials
- Efficiently remove with edge cuts, range/energy
- Reduce with radiopure materials

Worms



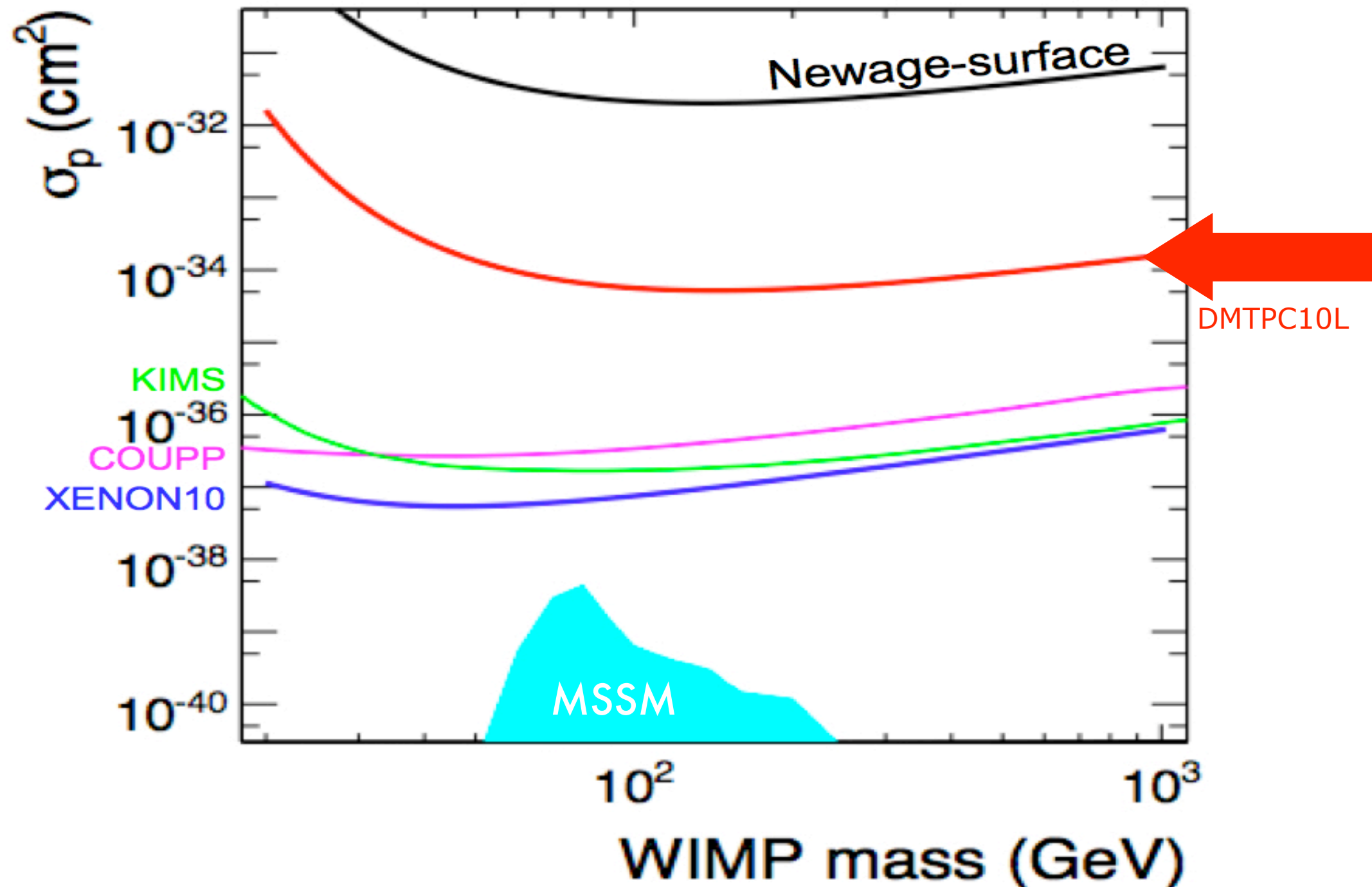
- CCD effect
- Remove most in software with energy density cut
- Reduce by going underground, new hardware

Preliminary Background Rate



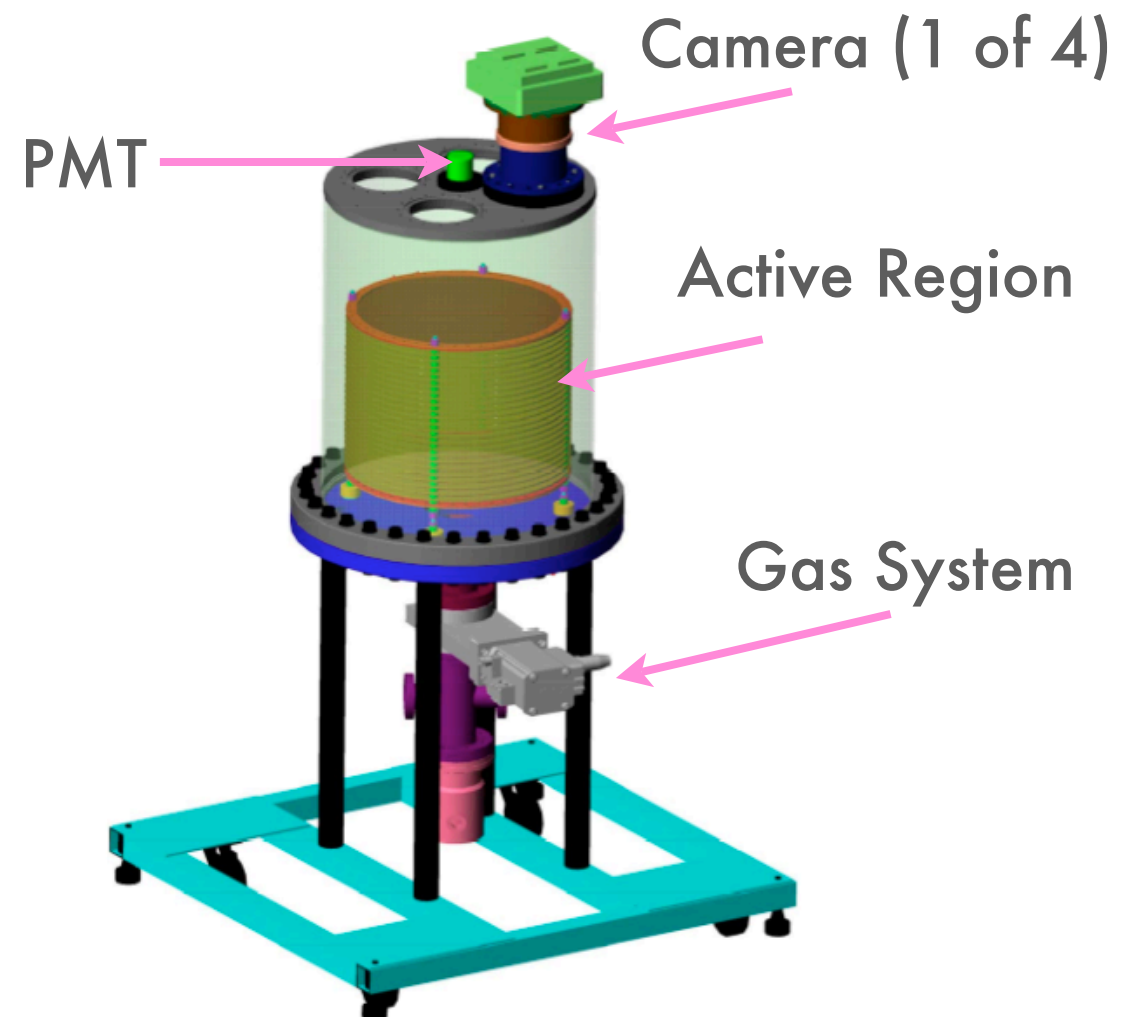
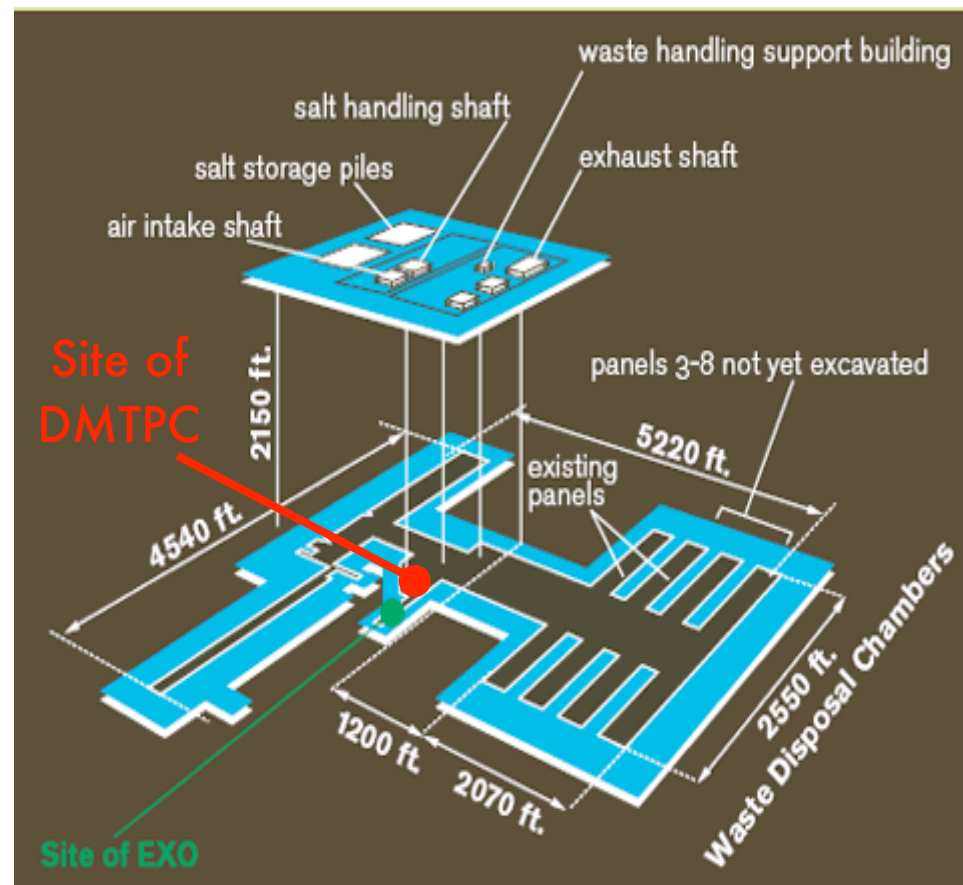
- Observe 7 recoil events in 110-200 keV range
- 10.8 day live-time
- 3.3 g detector mass

Expected Sensitivity



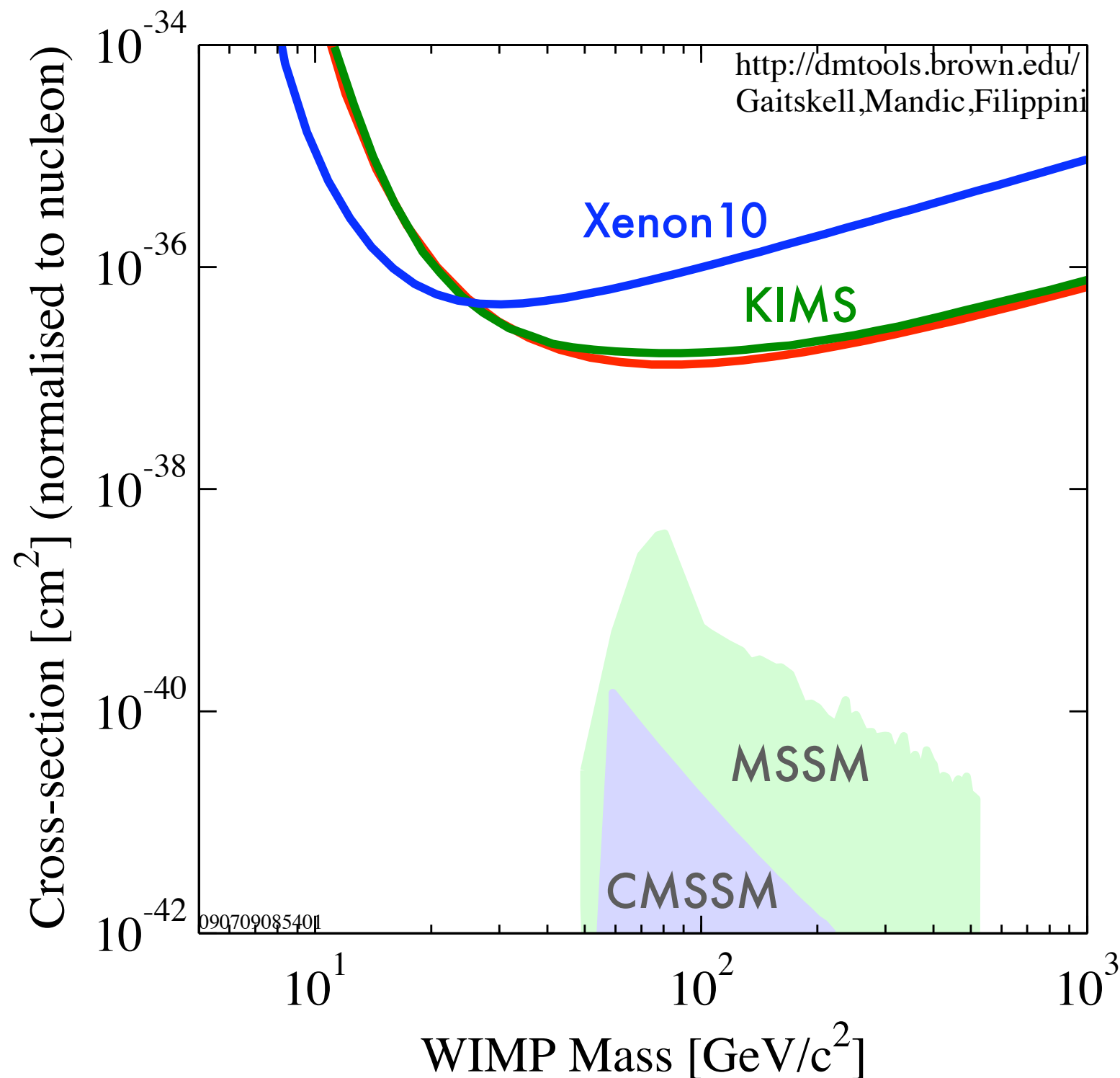
Going Underground

Waste Isolation Pilot Plant

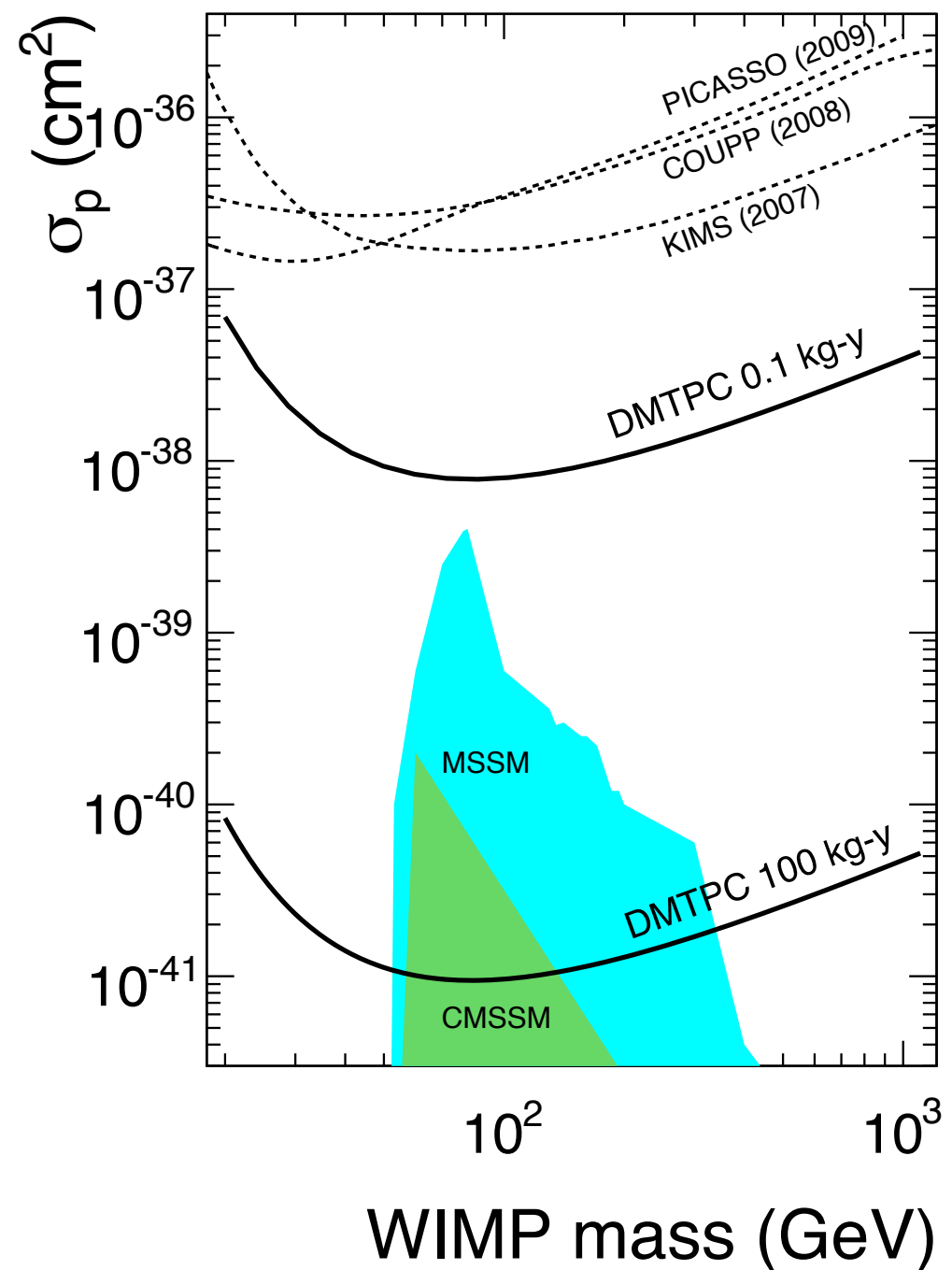
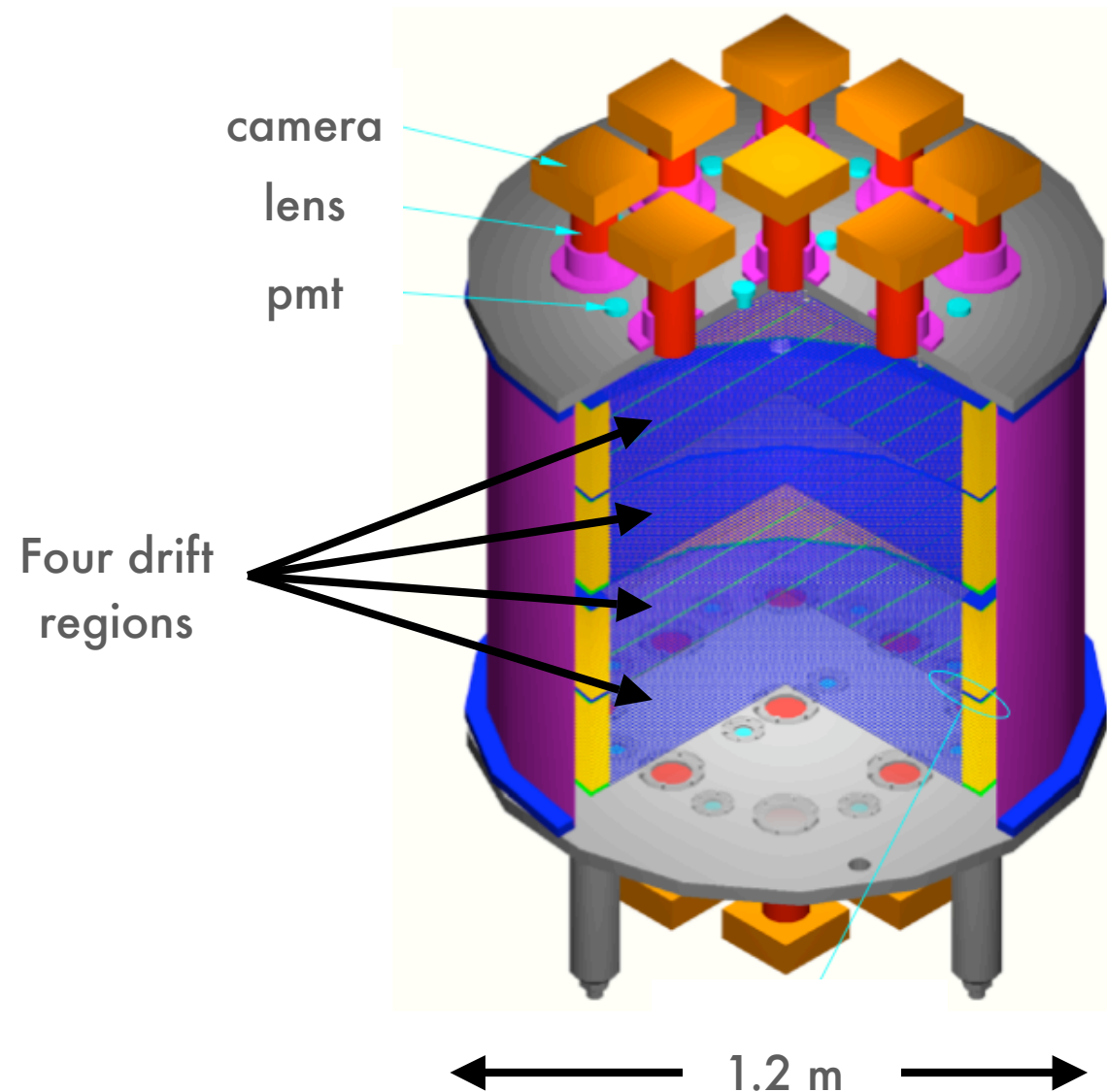


- New 10L detector with purer materials and four cameras
- ~1600 m.w.e passive shielding and active neutron monitoring
- Low radon contamination, $< 7 \text{ Bq/m}^3$

Projected Sensitivity

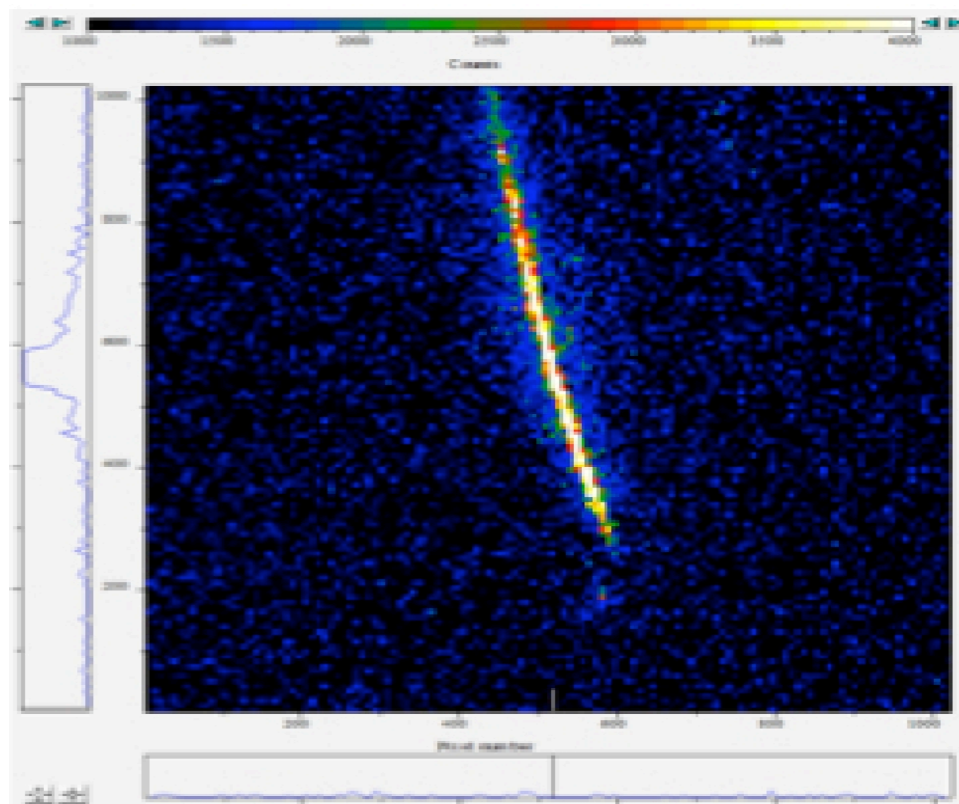


Scaling to 1 m³



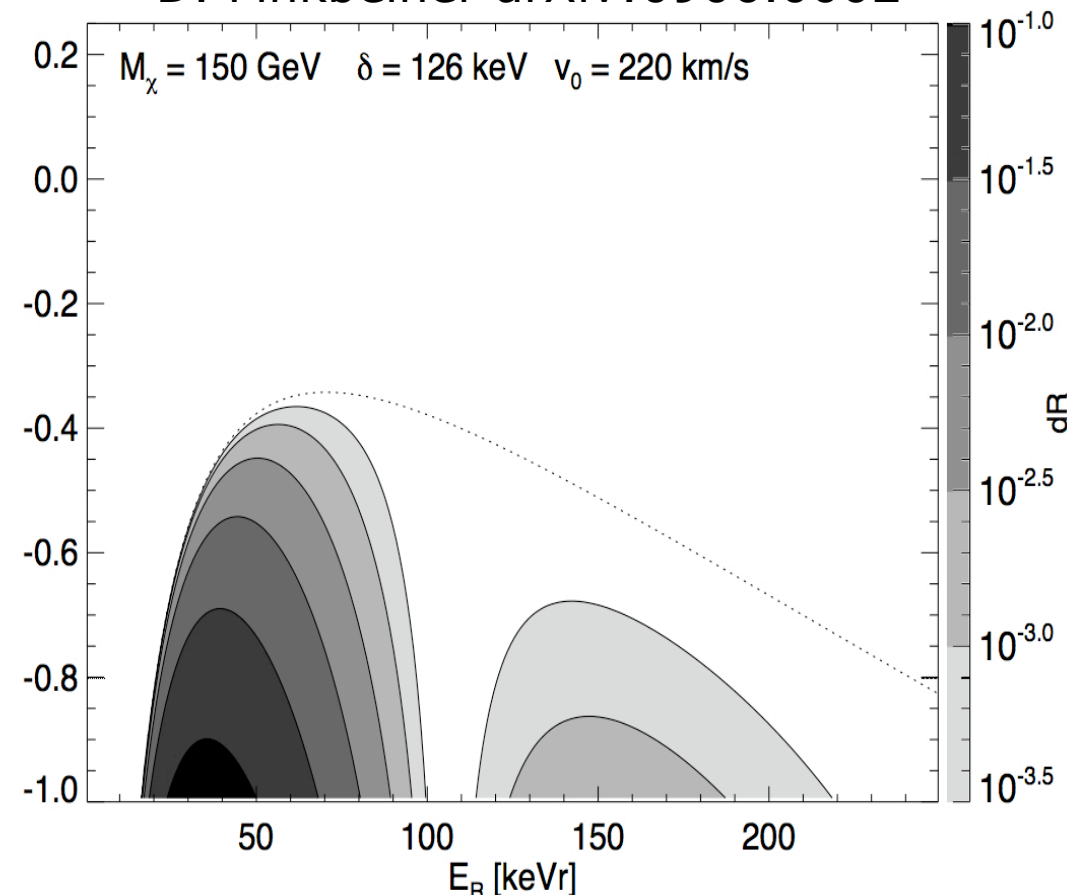
Ongoing and Future Work

- ◉ Use secondary detection (PMTs, charge readout) to improve reconstruction
- ◉ Different gas mixtures (e.g. Xe/CF₄ mixes)
- ◉ Incorporate inelastic dark matter models



(80torr Xe + 15torr CF₄)

D. Finkbeiner arXiv:0906.0002



Summary

- Demonstrated operation of a CCD-based gas detector with directional sensitivity
- Collected and analyzed surface run background data
- Plans for underground operation at WIPP