# The DRIFT Directional Dark Matter Detector

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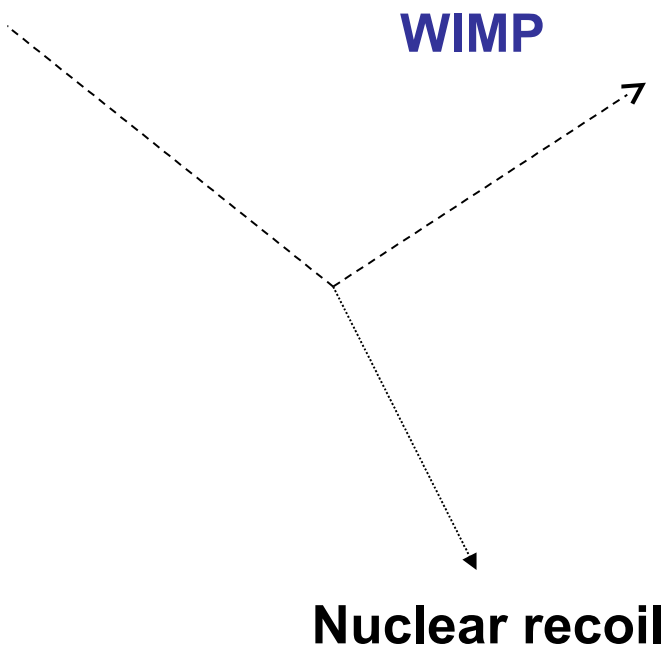
For the DRIFT Collaboration
TAUP
Sept 11 2013

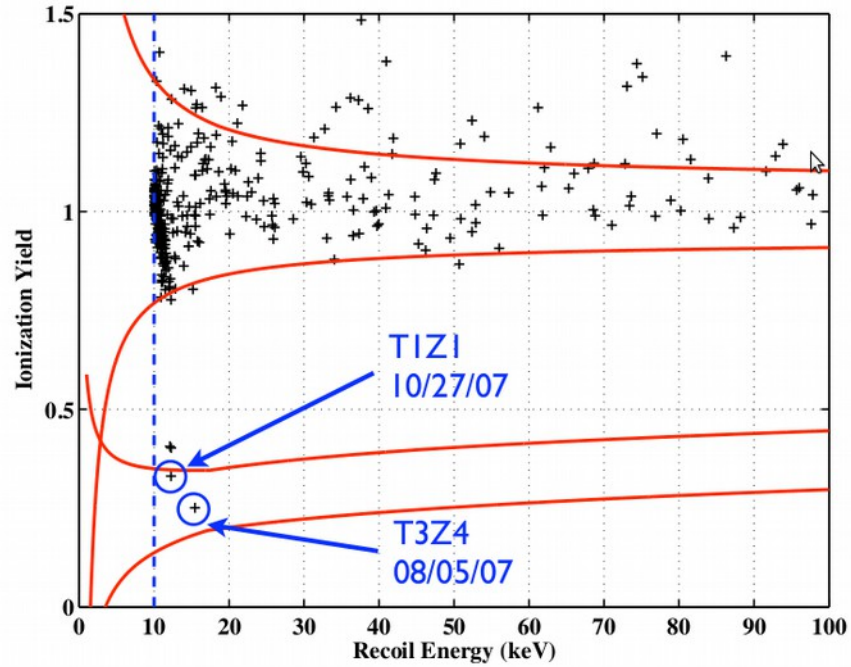
# Dark Matter Overview

- Looking for WIMP-Nucleus interaction
- Energy is deposited in detector
  - Scintillation
  - Ionization
  - Heat/Phonons



# Dark Matter Signatures

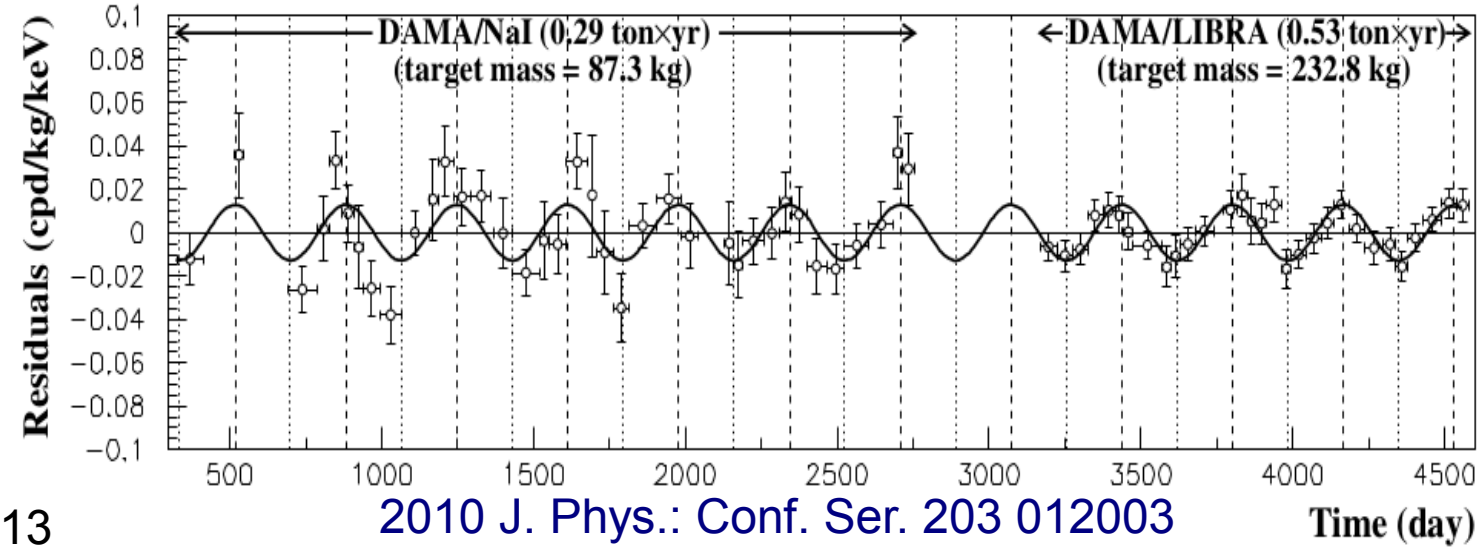
- Signals above background




2-6 keV

Cooley, SLAC, Dec. 17, 2009

- Annual Modulation

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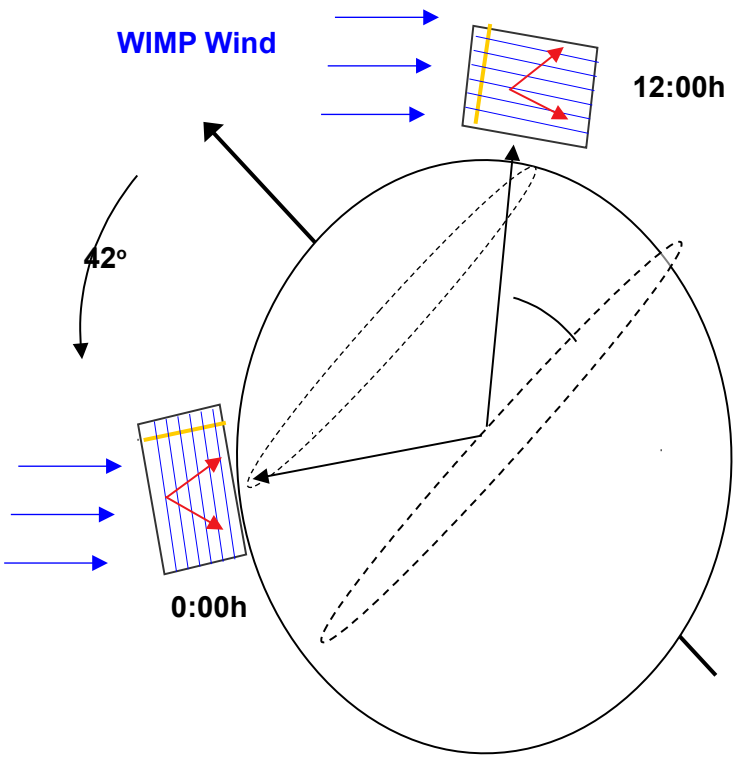
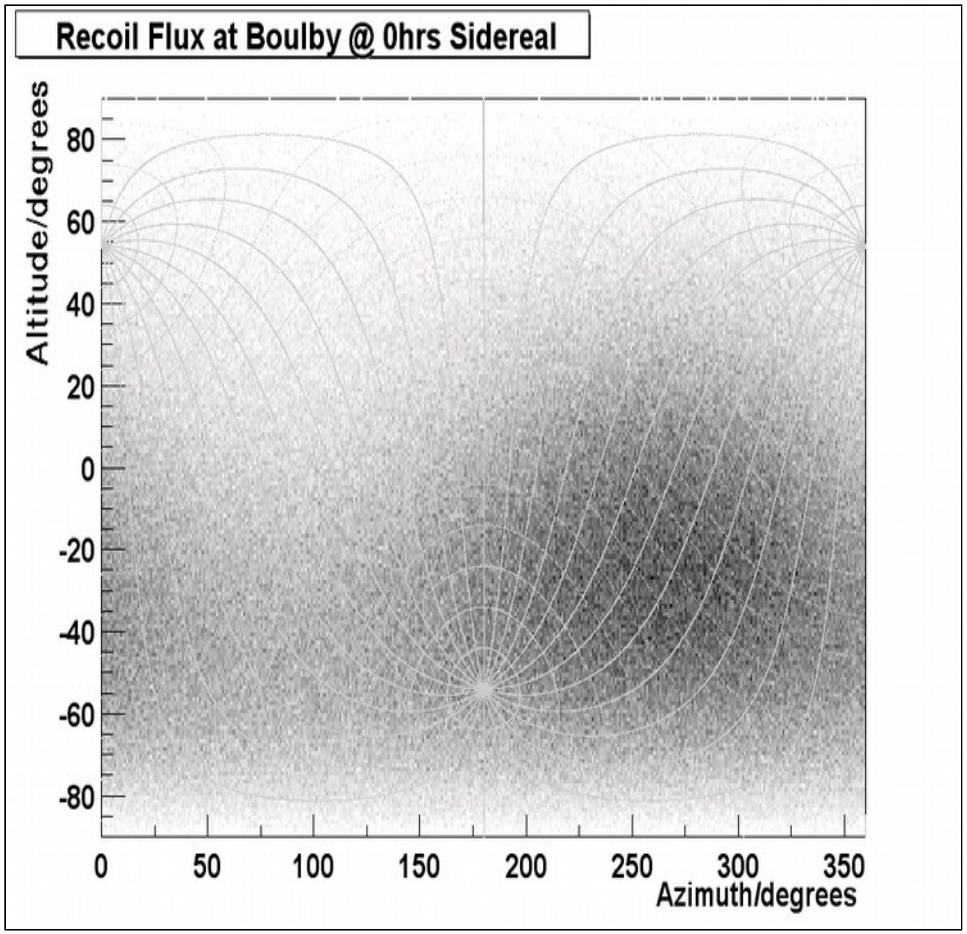
2010 J. Phys.: Conf. Ser. 203 012003

# Dark Matter Signatures

- Sidereal Modulation

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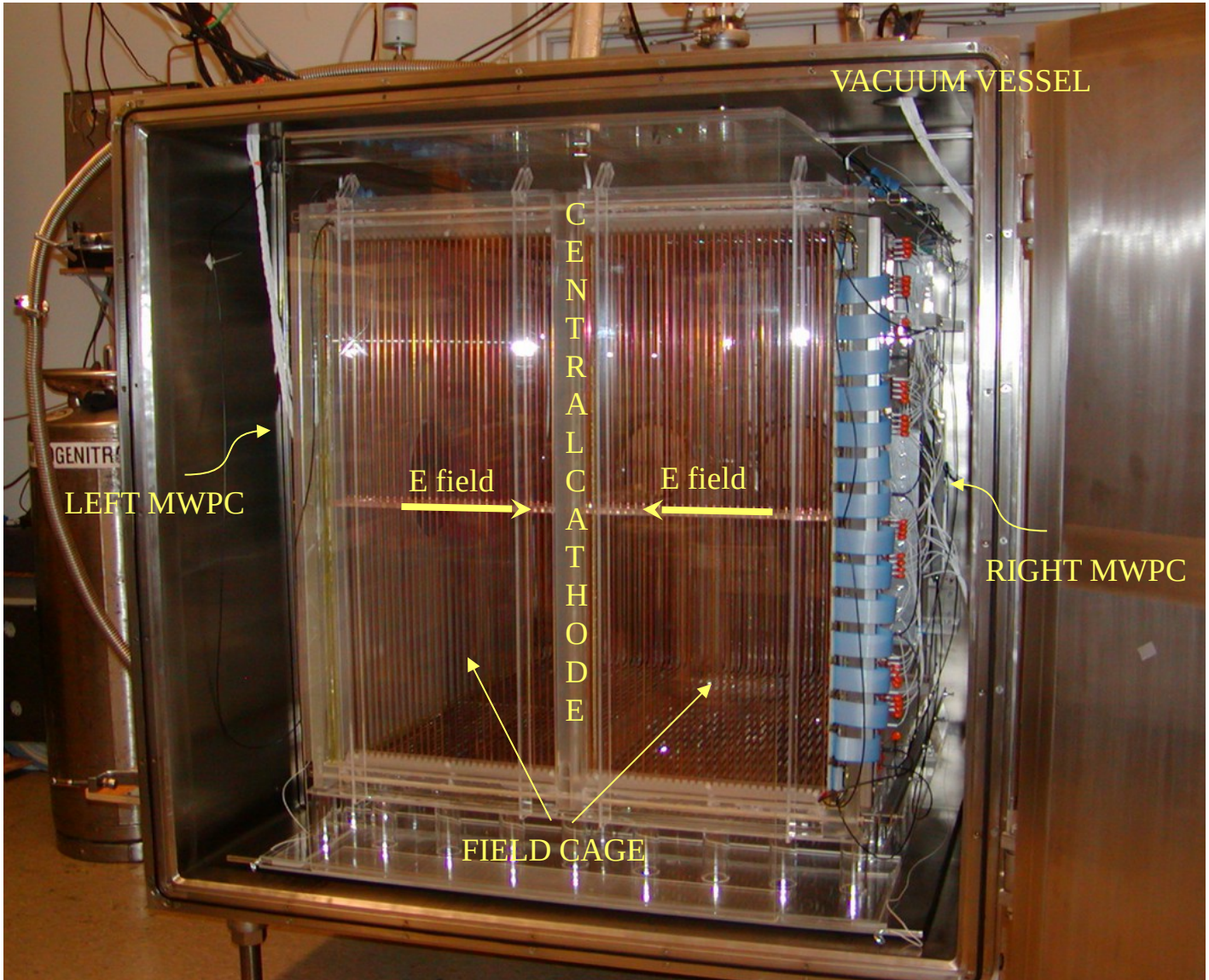
# DRIFT-II

- Low-Pressure (40 Torr) TPC

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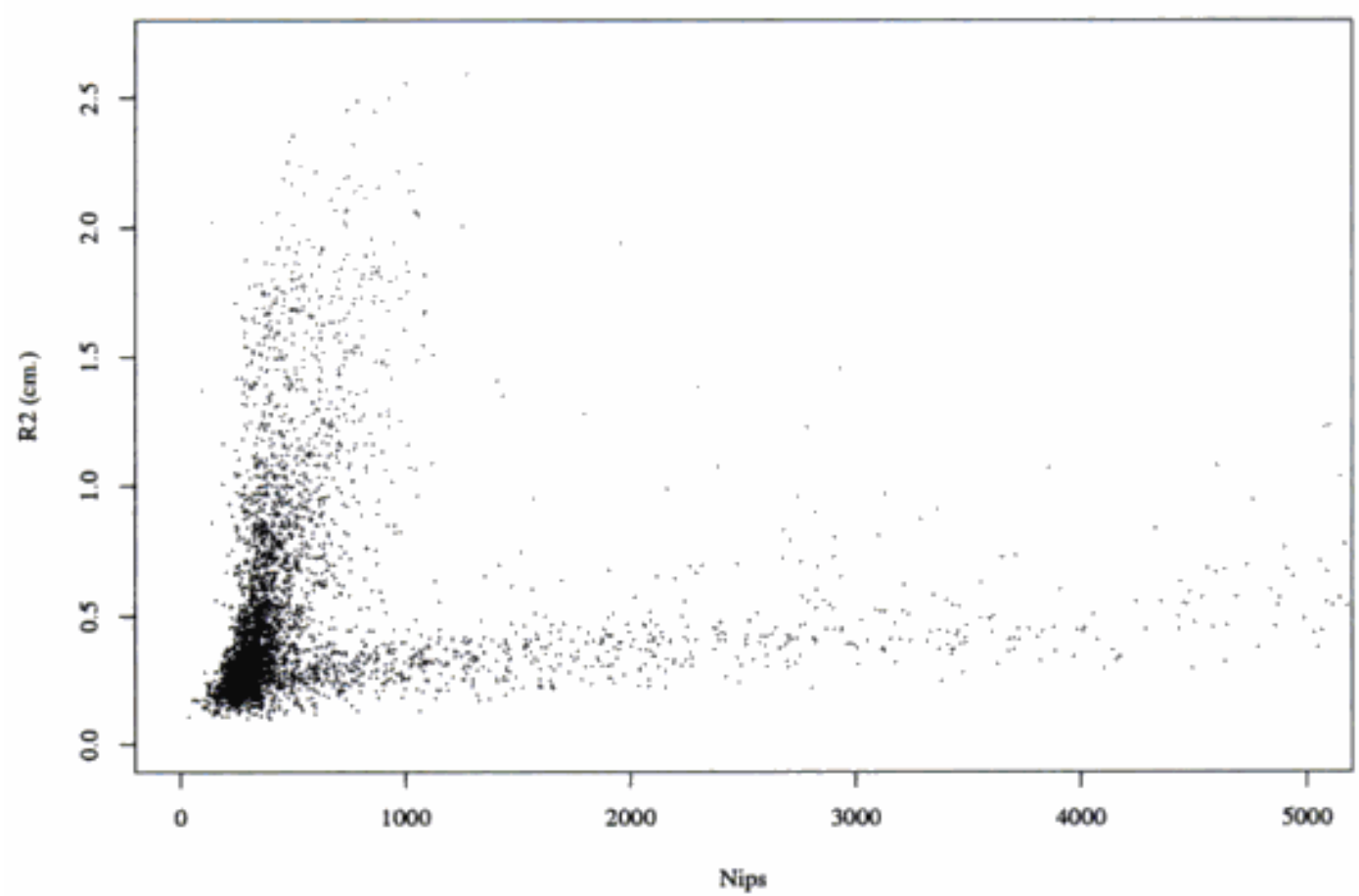
# DRIFT

- Spin-Dependent Sensitivity (10 Torr $CF_4$)
- Negative Ion (30 Torr $CS_2$) drift
  - Reduce maximum diffusion to ~0.7mm
- “Long” tracks
  - Recoil ~1 mm
  - Alpha ~ 100s of mm
  - Range vs. Energy Discrimination

# Background Rejection

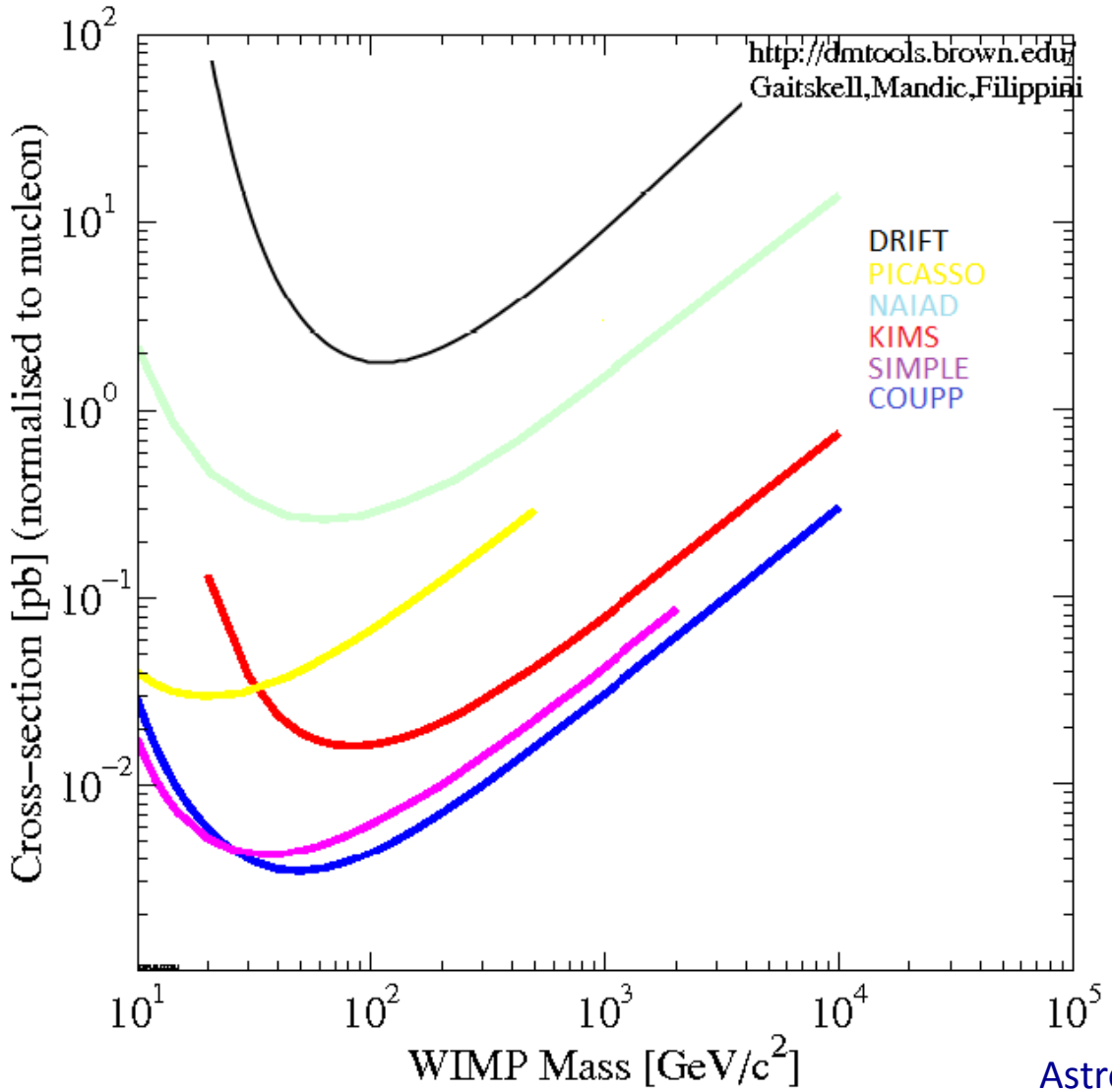
- Track Length provides Alpha and Gamma discrimination




Snowden-Ifft et al., IDM2000

# DRIFT

- Competitive with non-directional detectors

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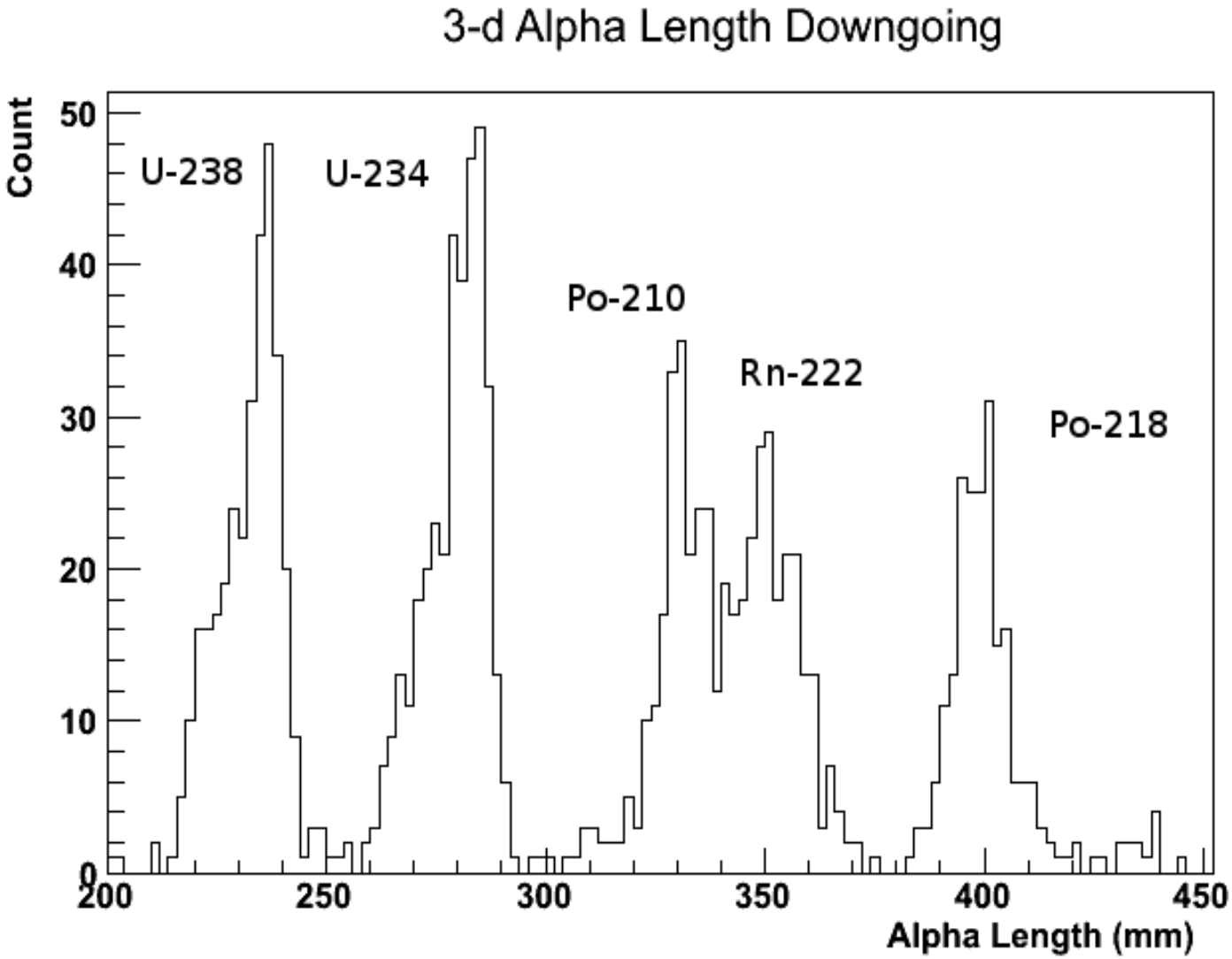
AstroPle, **35**, (2012) 397.

# Background Reduction

- Limit-setting run had 130 events/day
- Backgrounds primarily from Alpha decays on cathode
- Background rate reduced to ~1/day (preliminary)
- On-going background reduction efforts:
  - Reduce $^{222}$Rn
  - Transparent Cathode
  - Z-Fiducialization

# DRIFT Contamination ID

- Alpha Spectrometry identifies radioactive isotopes

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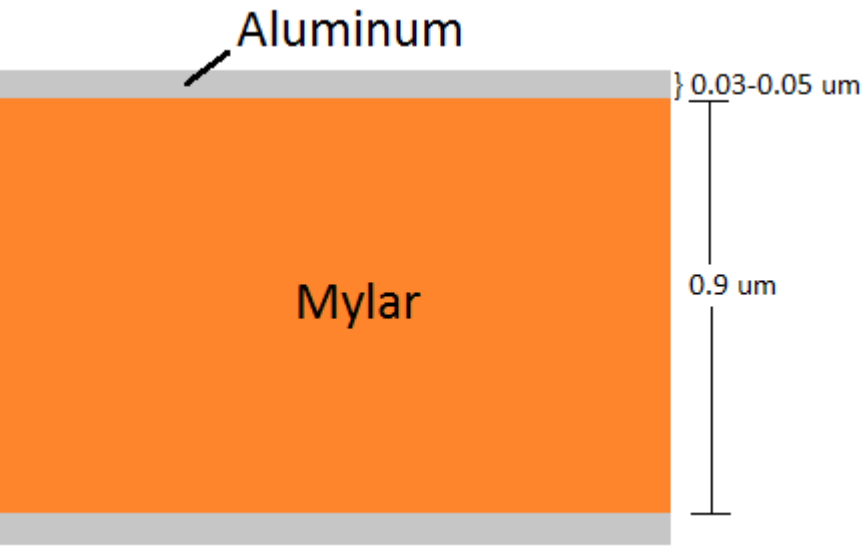
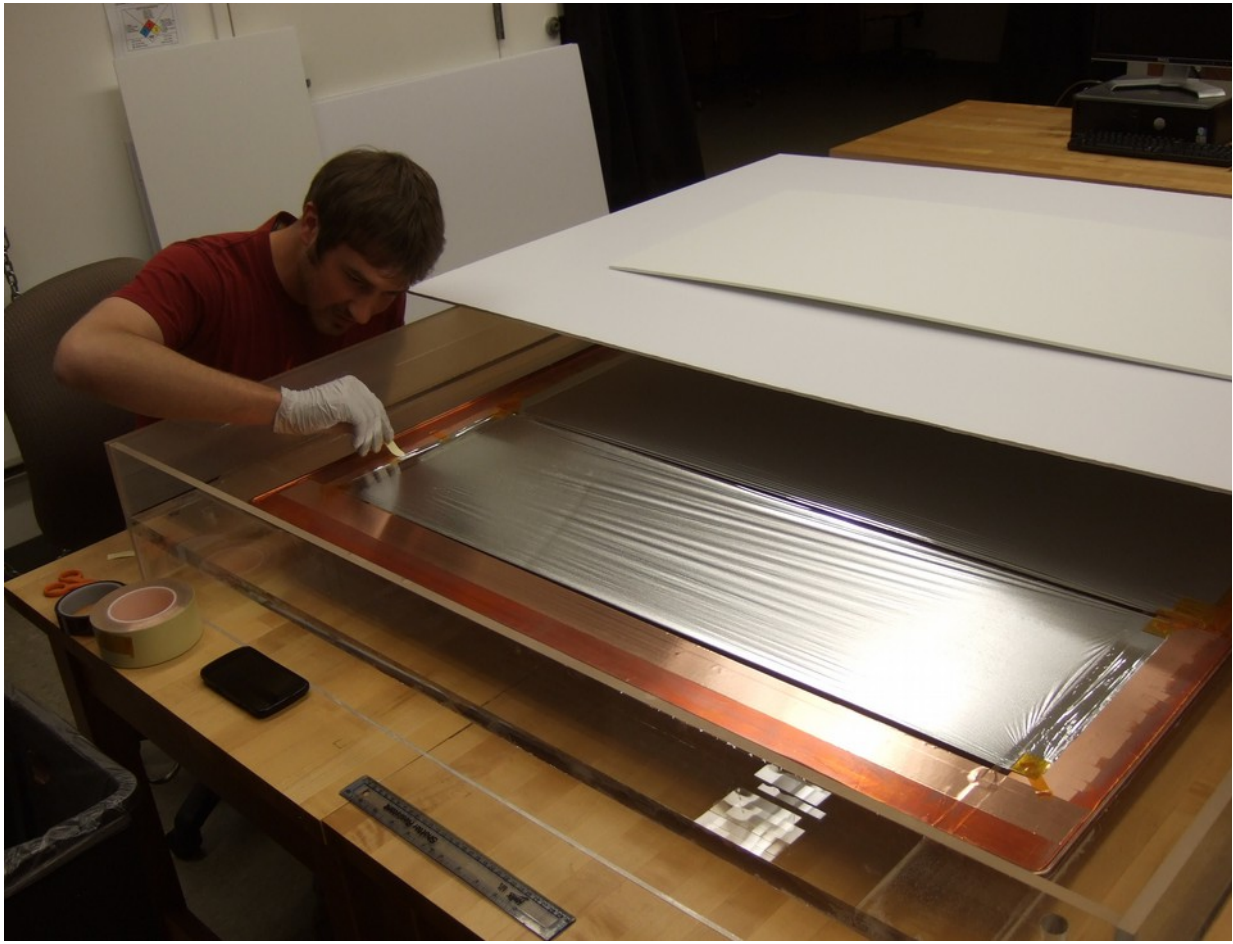
# DRIFT Contamination ID

- Thin-Film Cathode



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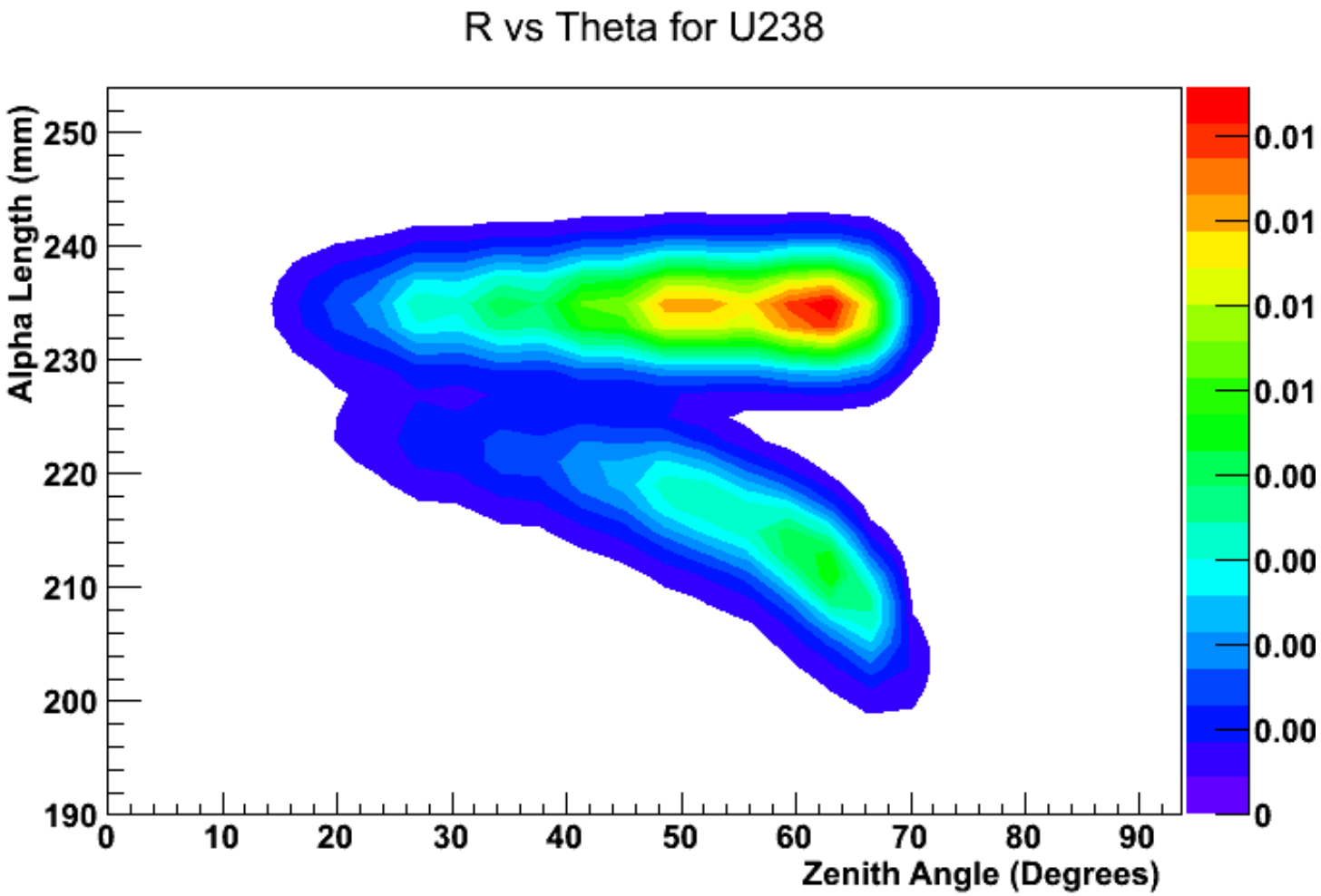
# DRIFT Contamination ID

- Model distribution for U in Al

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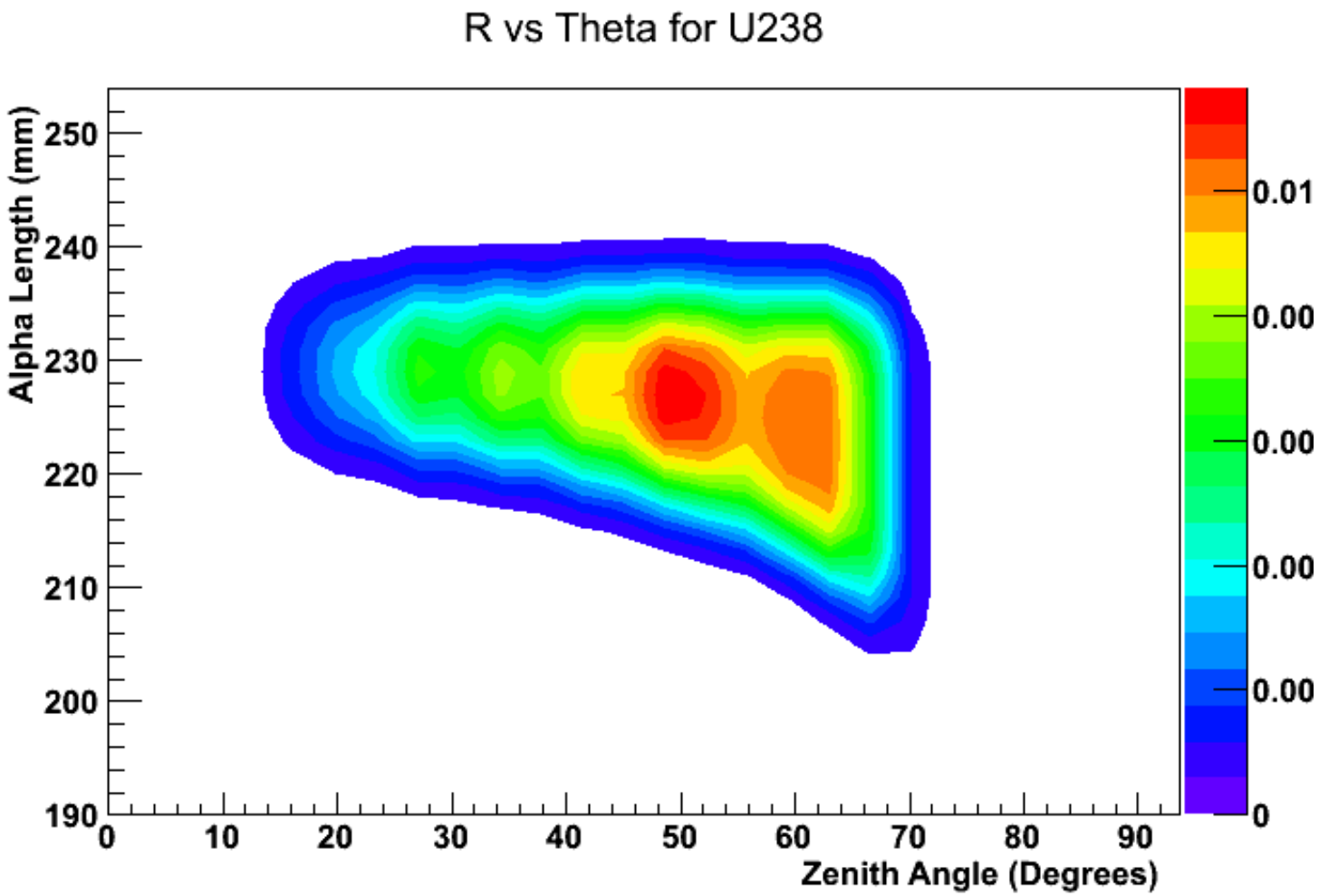
Thanks to SRIM-2008

# DRIFT Contamination ID

- Model distribution for U in Mylar

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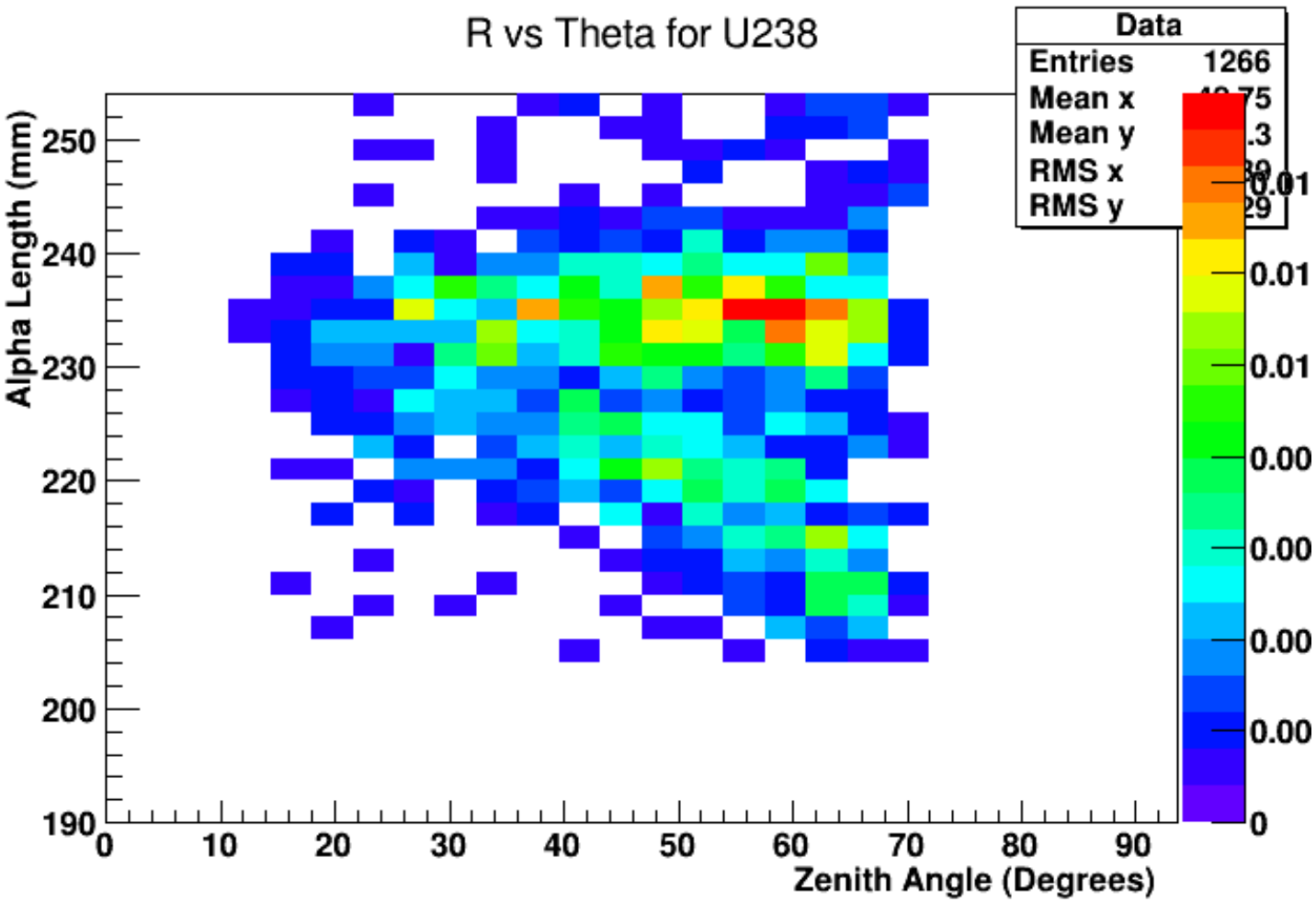
Thanks to SRIM-2008

# DRIFT Contamination ID

- Distribution from Data

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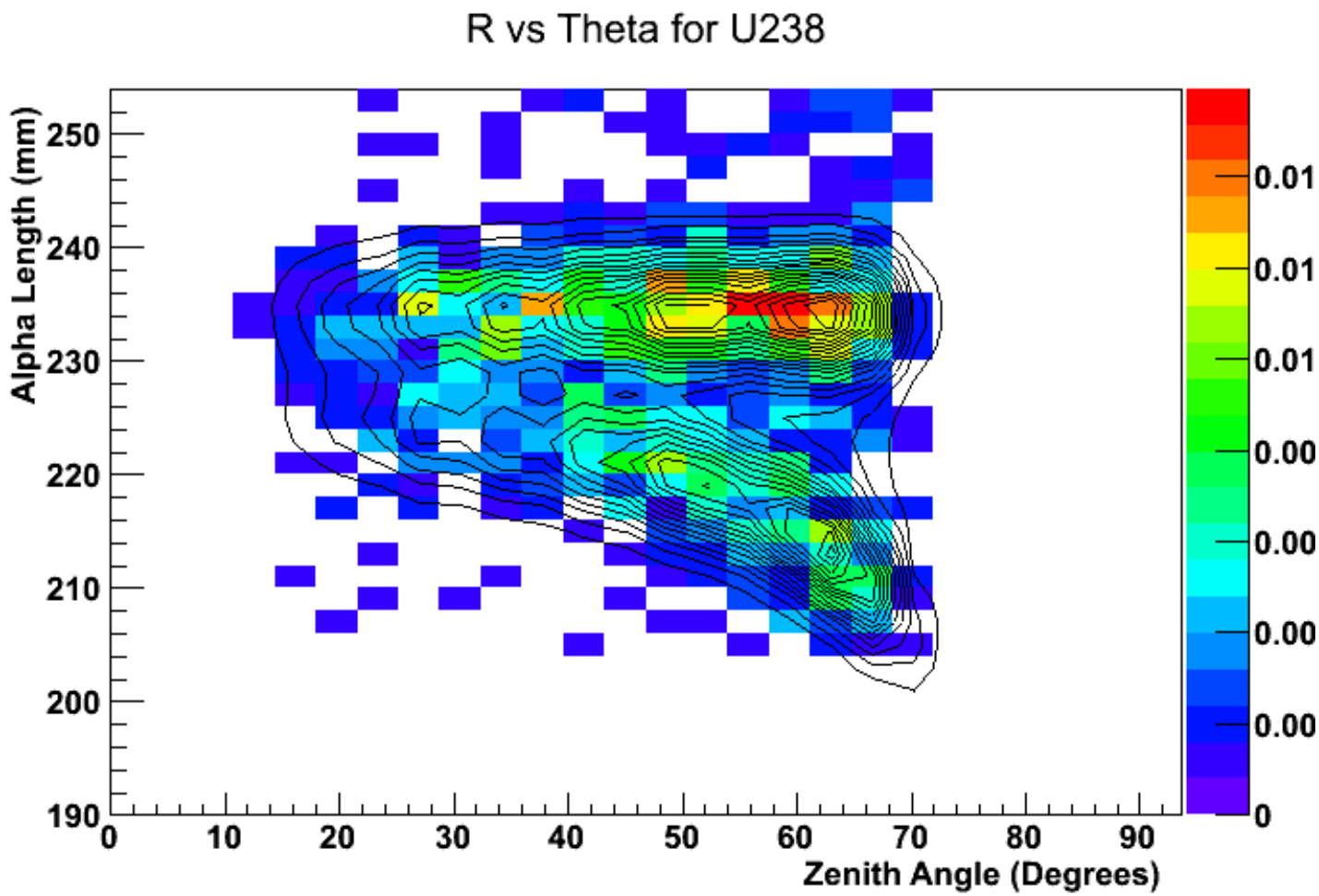
# DRIFT Contamination ID

- Data & Model (90% U from Al; 10% from Mylar)

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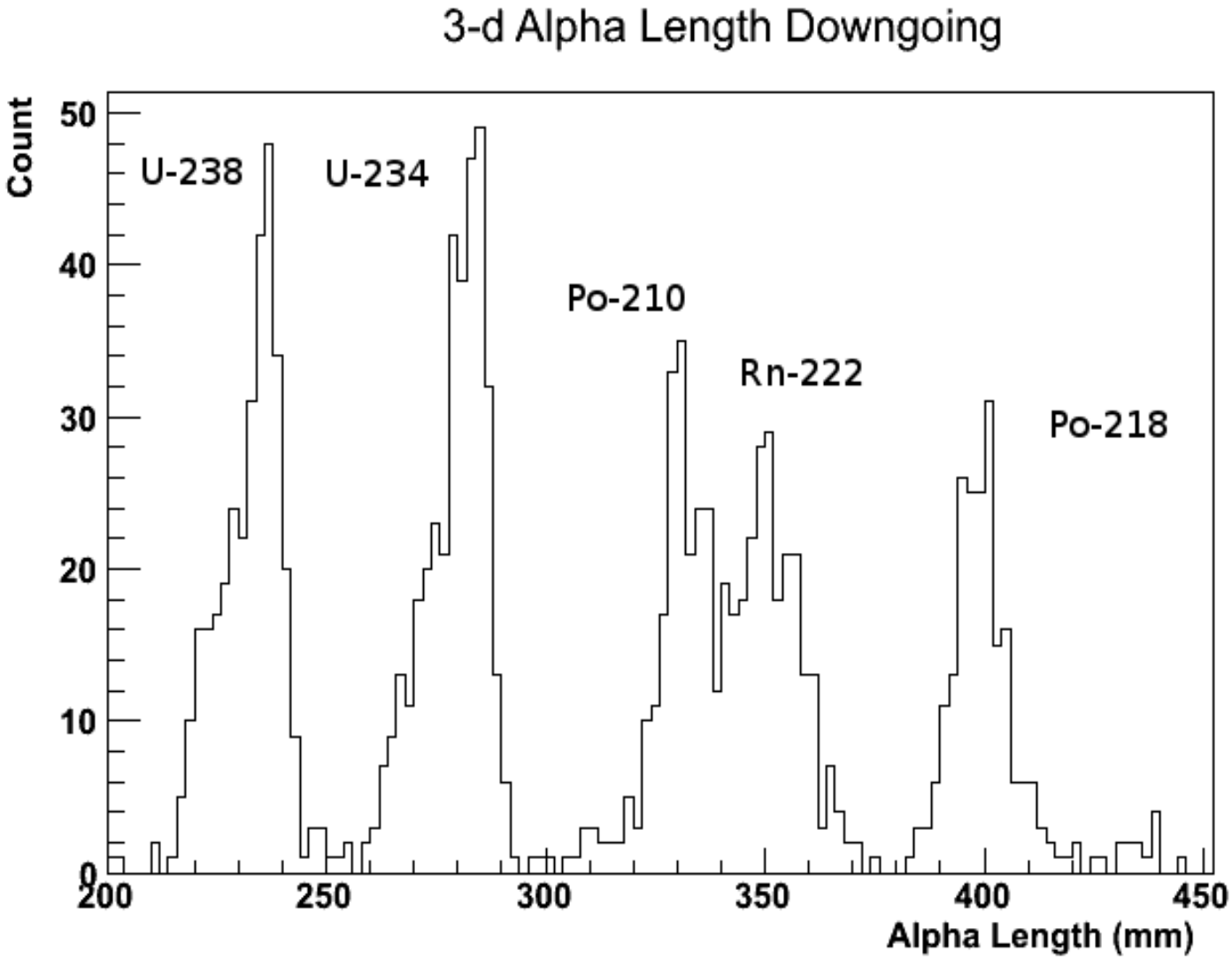
# DRIFT Contamination ID

- Alpha Spectrometry identifies radioactive isotopes

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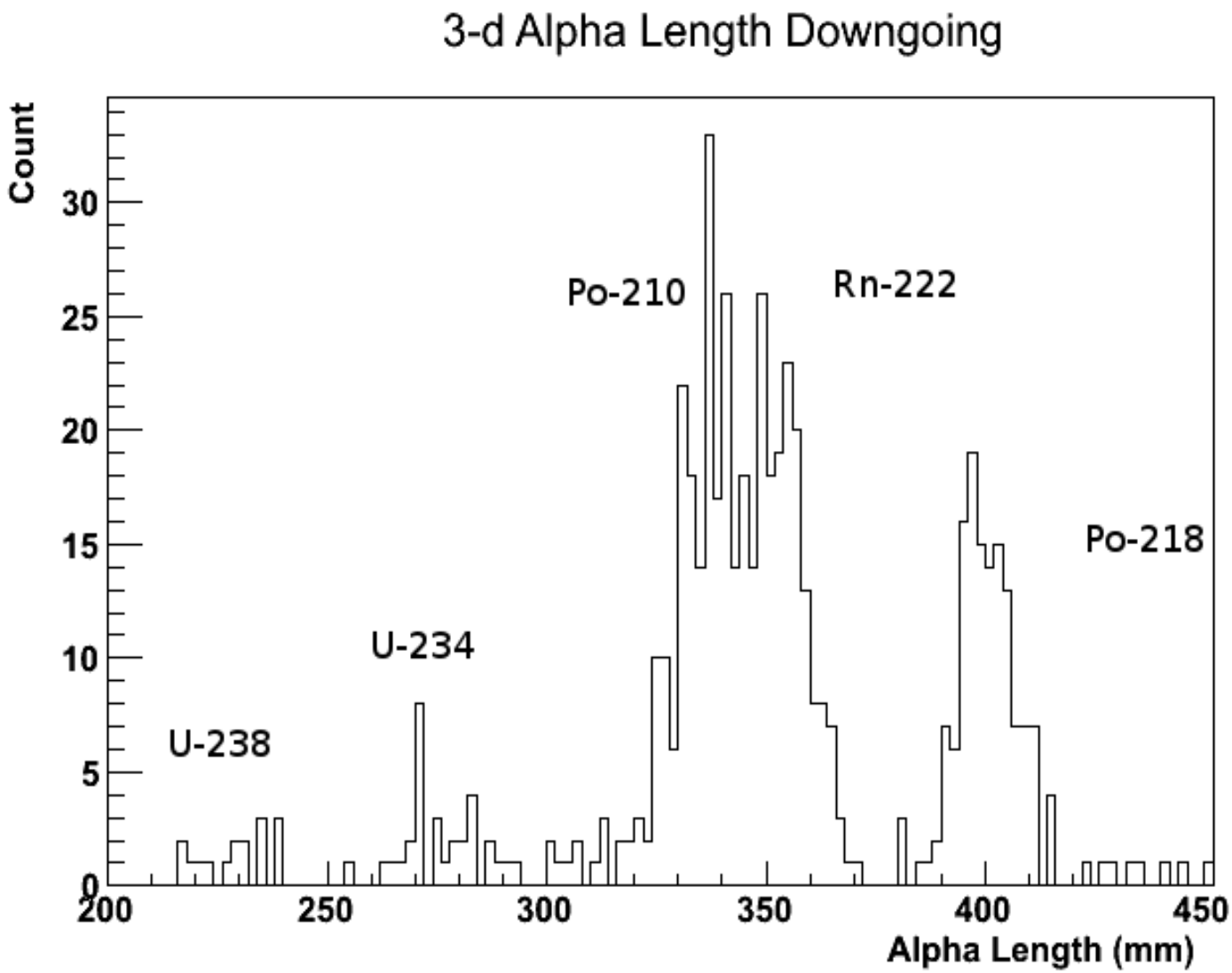
# DRIFT Contamination ID

- Identification leads to Reduction

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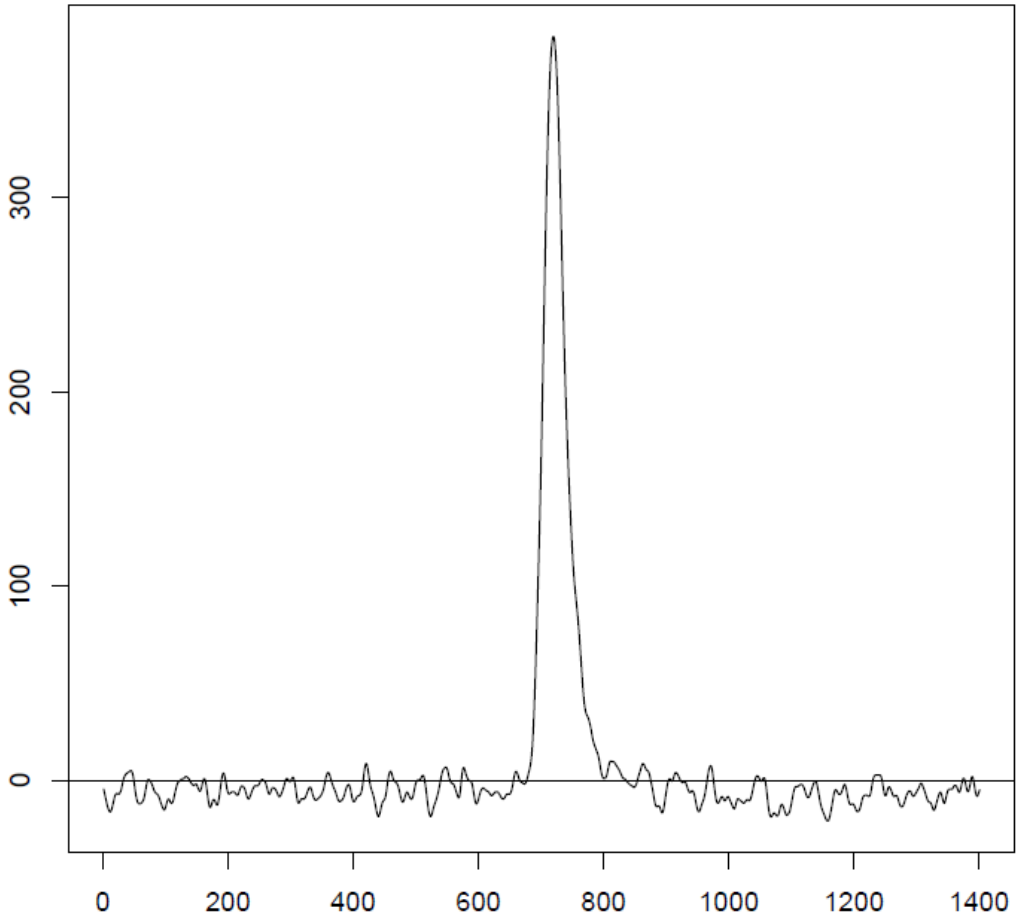
# DRIFT Contamination Reduction

- Preliminary!
- Significant contamination reduction
- Excellent sensitivity

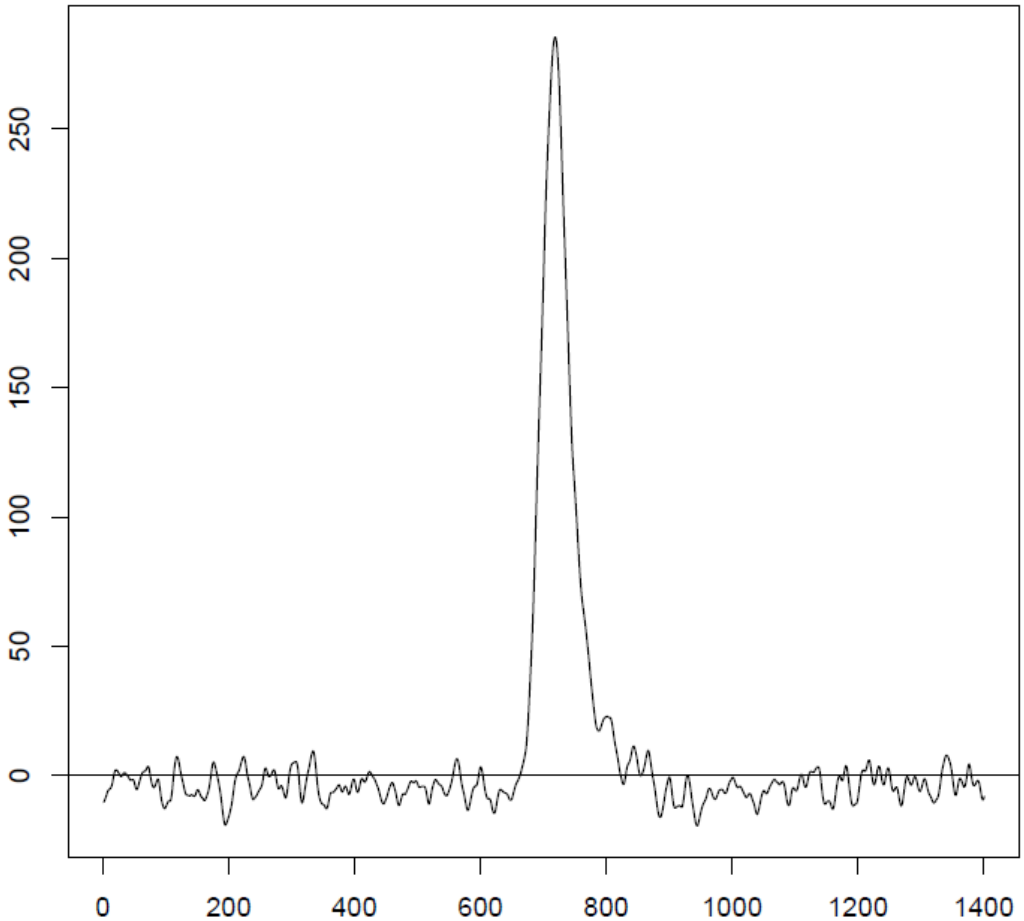
| Isotope | Dirty | Clean |
|---|---|---|
| $^{234}\mathrm{U}$ | $14 \pm 1.2\mathrm{ppt}$ | $2.5 \pm 0.24\mathrm{ppt}$ |
| $^{238}\mathrm{U}$ | $284 \pm 22\mathrm{ppb}$ | $20 \pm 2.4\mathrm{ppb}$ |

# Backgrounds from the Cathode

- Can you tell the difference?




Nuclear Recoil from Neutron




RPR Background

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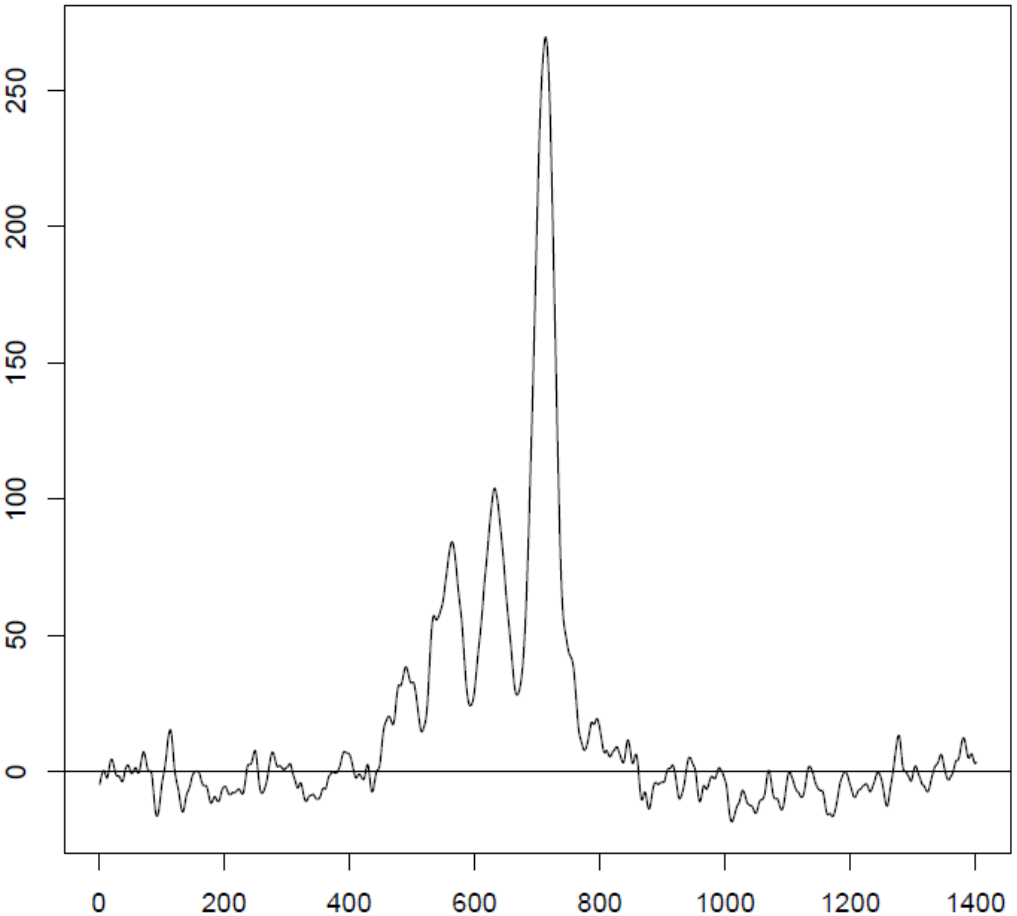
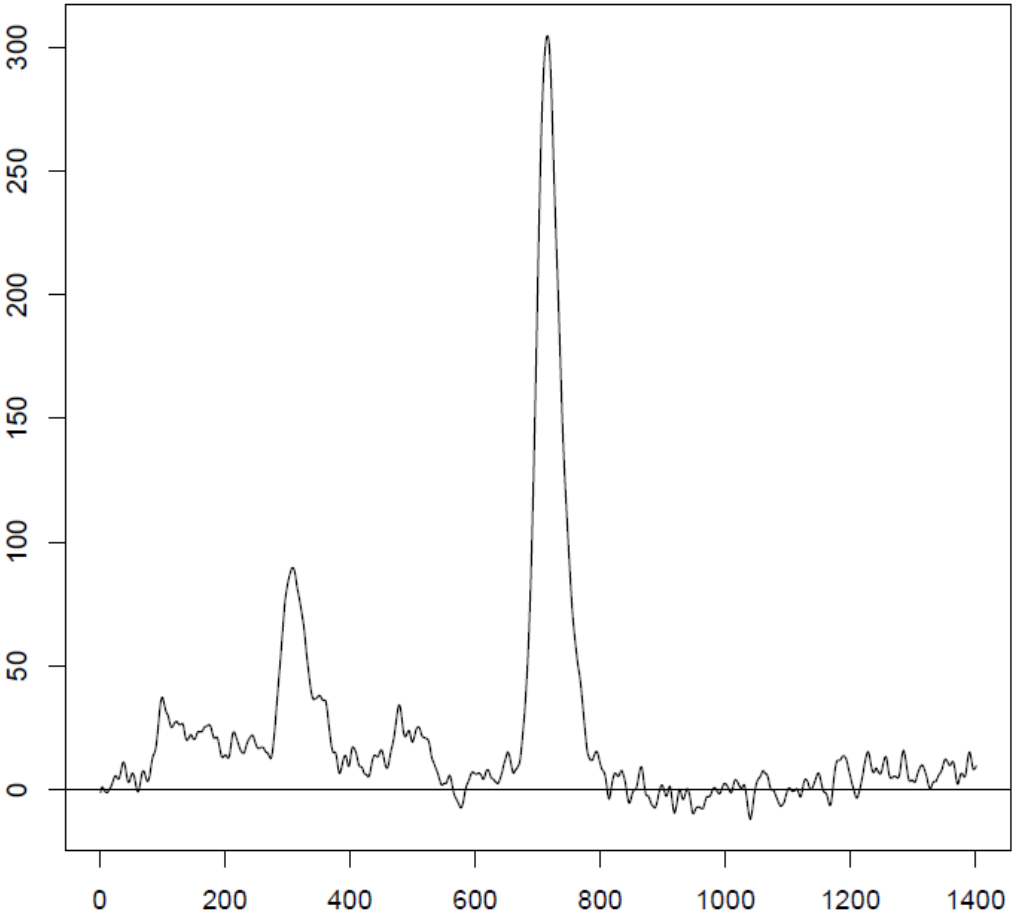
# Z-Fiducialization

- Addition of O2 introduces minority carriers arXiv:1308.0354
  - Different drift speeds allow for z-localisation




Nuclear Recoil from Neutron




RPR Background

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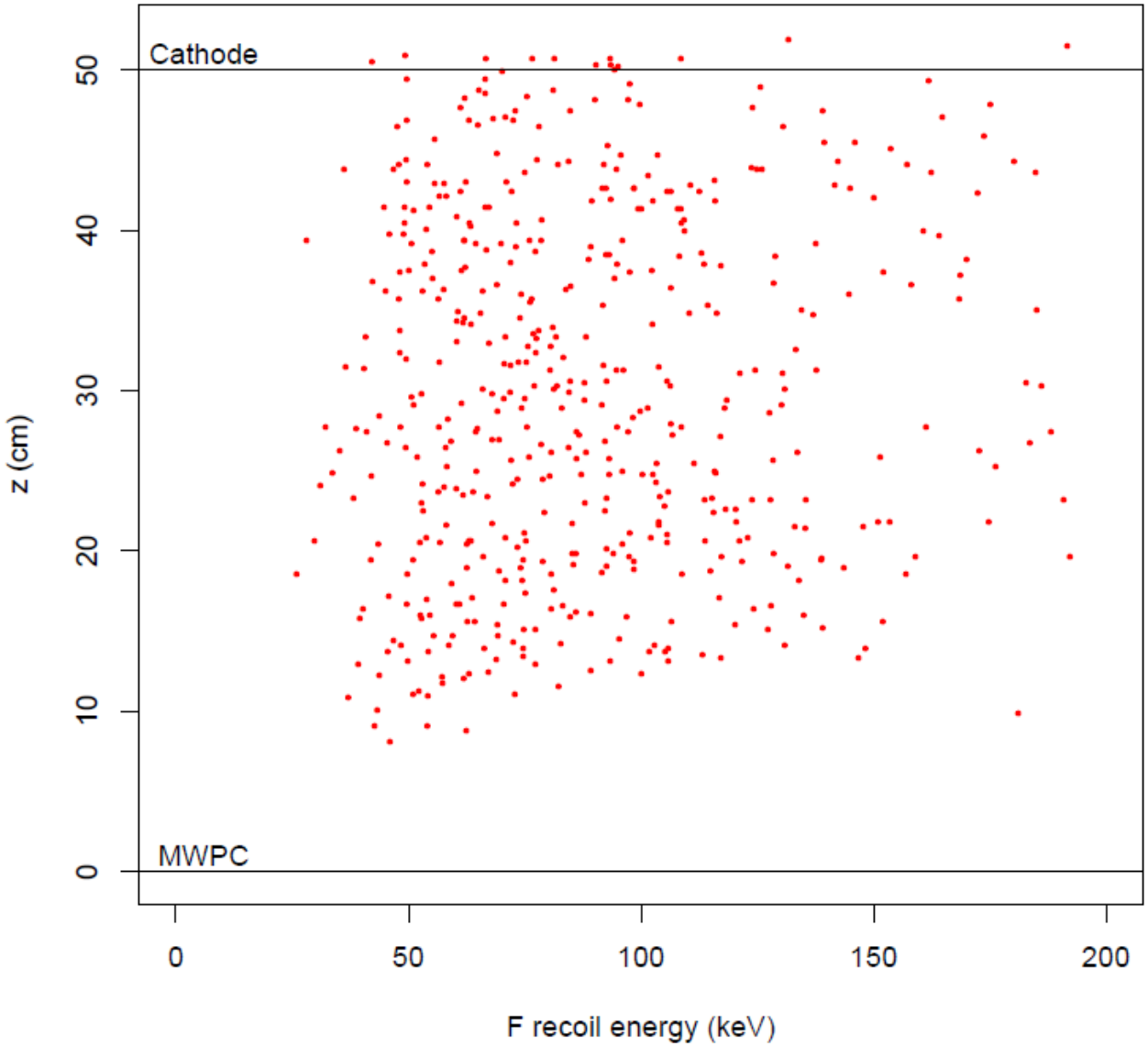
# Z-Fiducialization

- Measurements from Neutron runs

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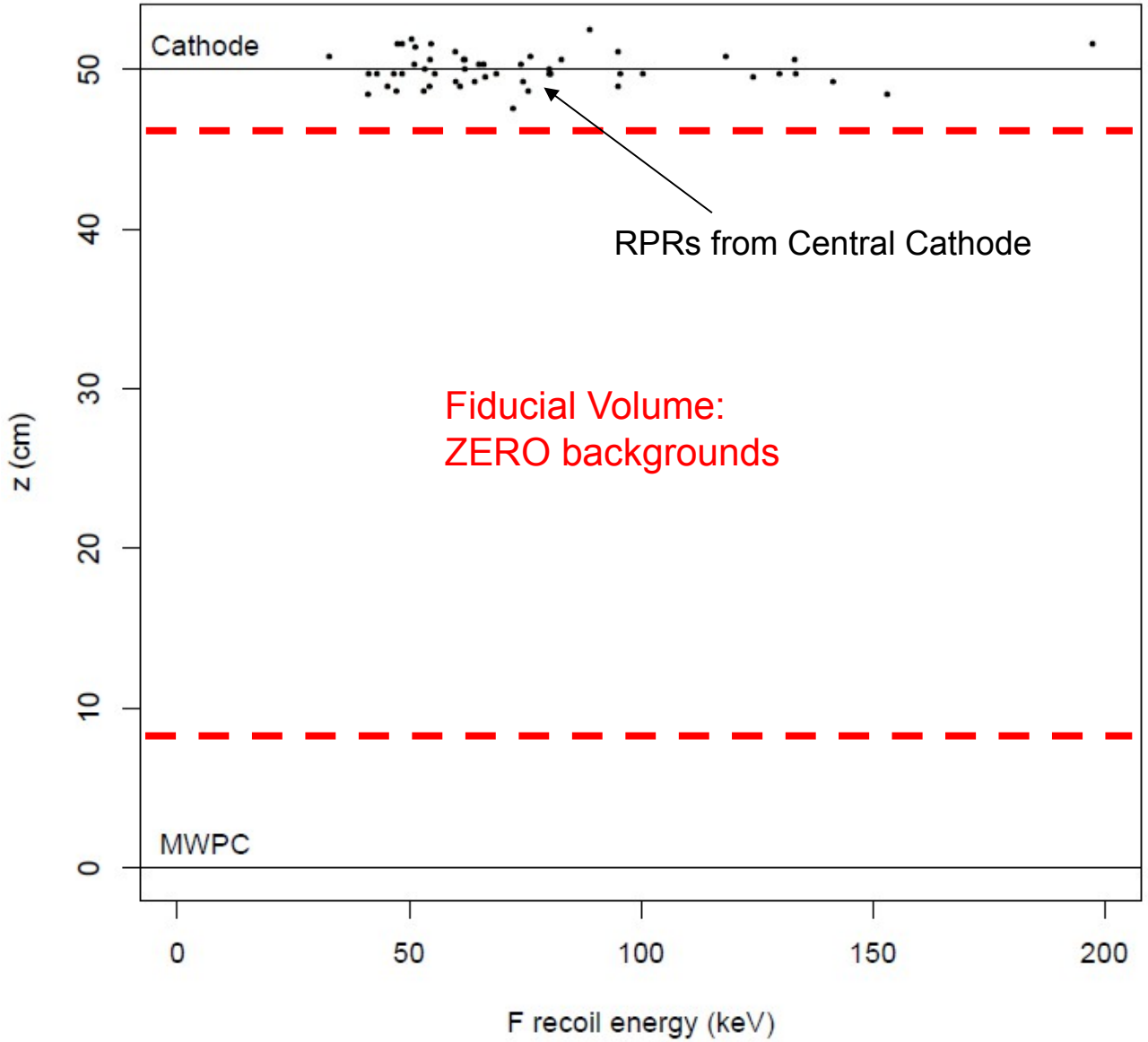
# Z-Fiducialization

- Preliminary Data from underground dark matter runs

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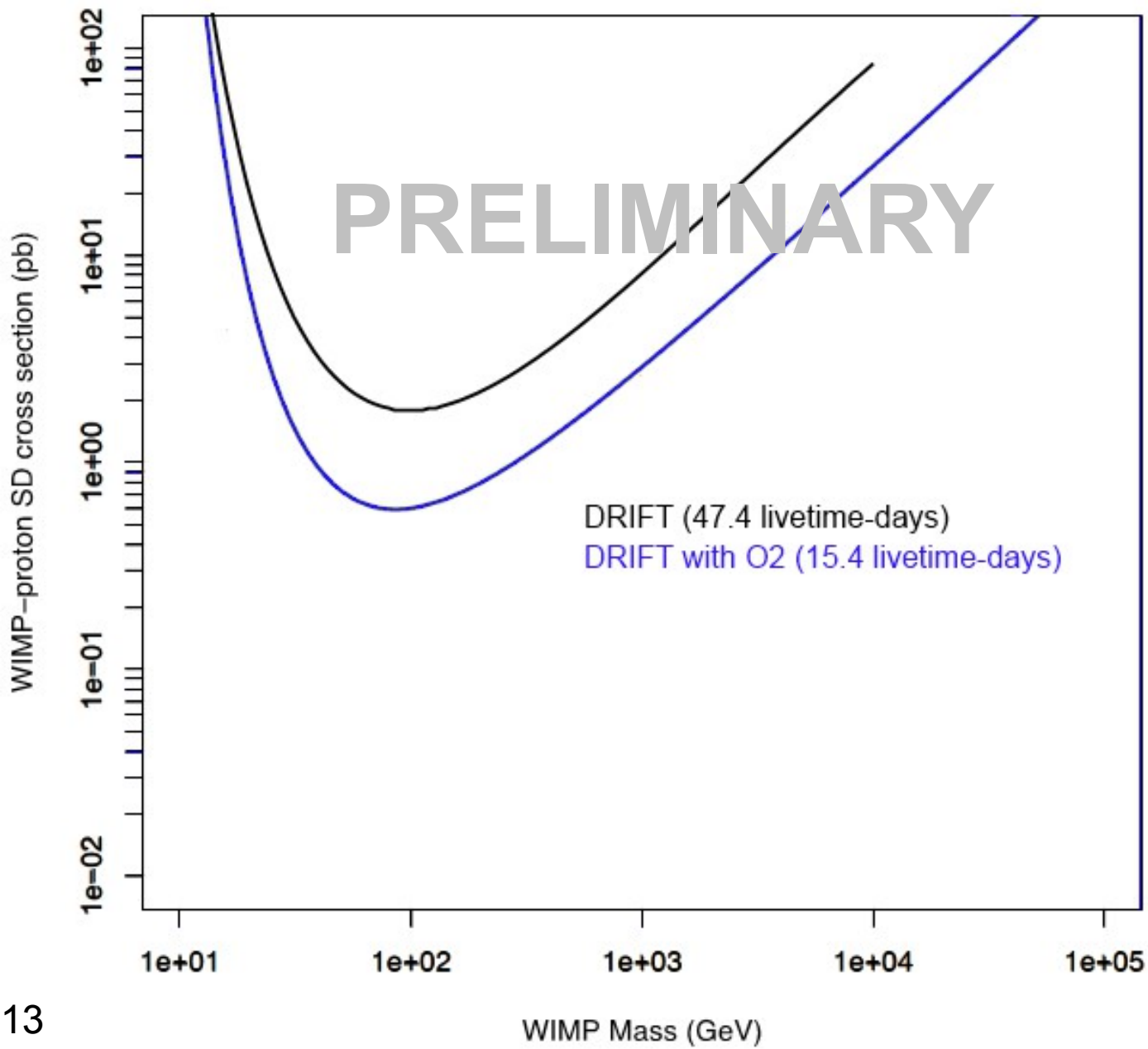
# Improved Sensitivity!

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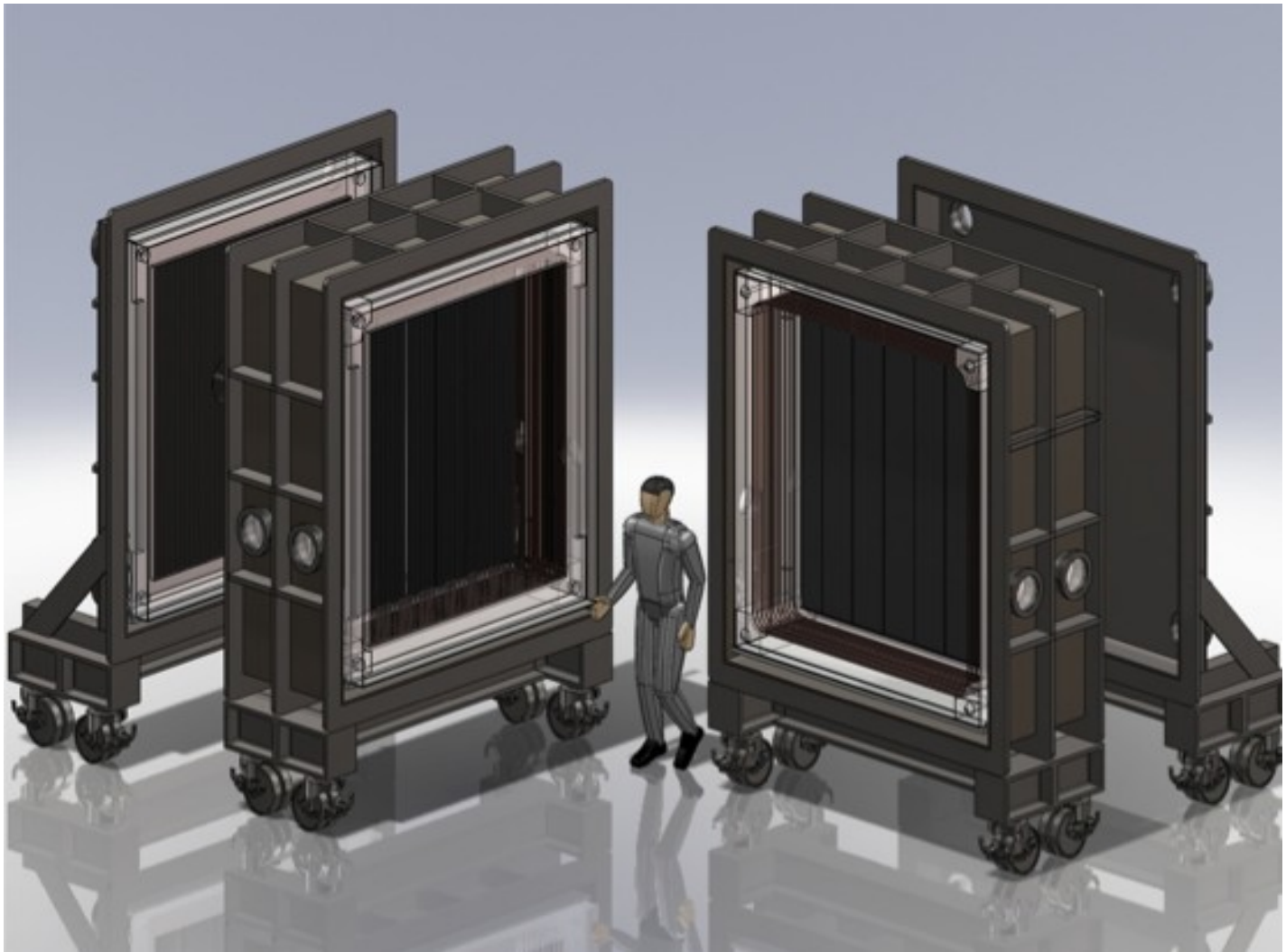
# DRIFT-III

- Proposed 8 $m^3$ DRIFT-III.1 Detector
  - Extendable to 24 $m^3$ module



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# Summary

- Directionality provides “Smoking Gun” WIMP signal
- Excellent radioactive contaminant identification
- Preliminary: Background-free dark matter runs!
  - 10-fold increase in sensitivity
  - DRIFT-II now volume-limited
- Engineering toward scale-up for DRIFT-III
  - Second DRIFT-II module under construction