

HVeV Run 5

The Latest Generation of High-Voltage, Electronvolt-Scale
Cryogenic Silicon Calorimeters in the Search for Dark Matter

Mason Buchanan
on behalf of SuperCDMS

University of Toronto

28 July 2026

Overview

- 1 Background
- 2 Experiment
- 3 Analysis

Background





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 - Uses Si and Ge HV (High Voltage, phonon) and iZIP (phonon + ionization) detectors



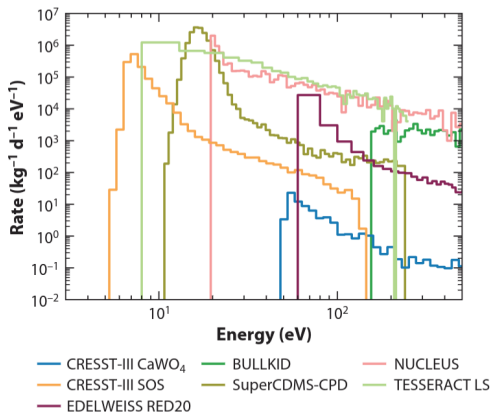
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 - Ideal for finely probing background

Unknown Backgrounds: The Low-Energy Excess

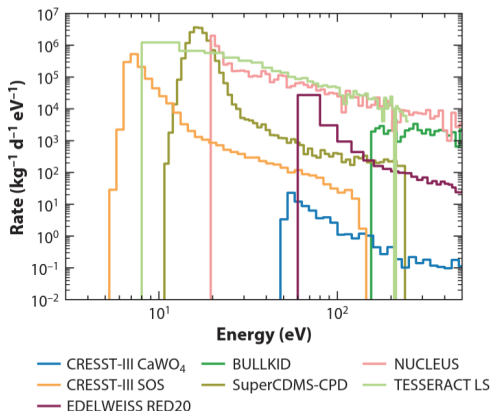
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Baxter, Essig, et al. 2025

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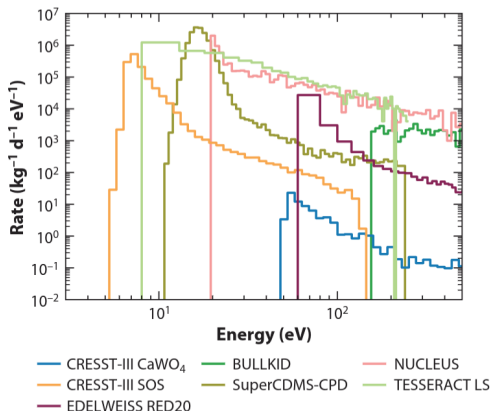
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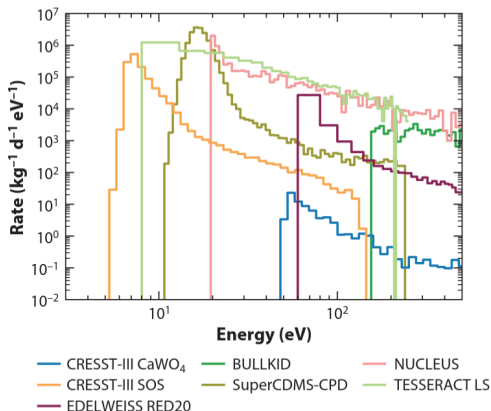
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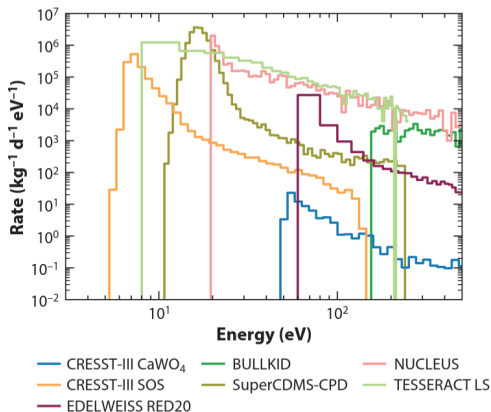
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- Low-mass experiments are seeing unknown backgrounds
- Rate and energy vary, but usually visible around 100 eV and below
 - Thus dubbed “low-energy excess” (LEE)
- Appears non-ionizing (EDELWEISS 2023)
- Decreases with time after cooldown; very unlikely dark matter



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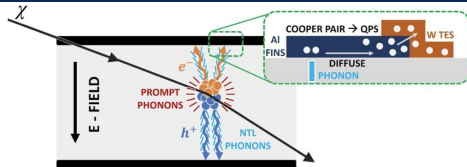


- Using resulting sensitivity for dark matter search that could also be used to probe LEE

Experiment

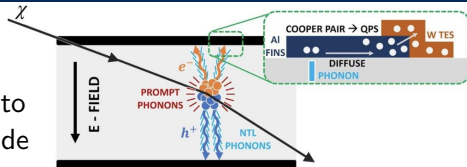
The SiO₂ HVeV Detector

- Interactions in crystal knock loose electron-hole pairs



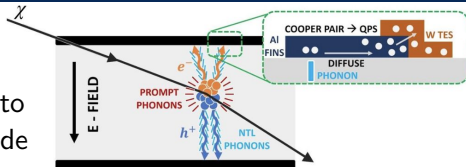
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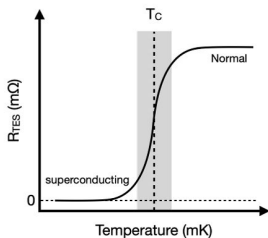
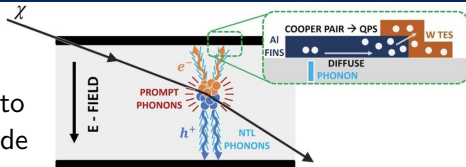
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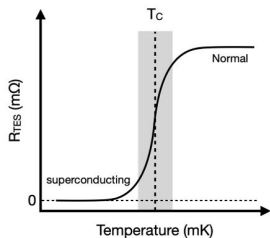
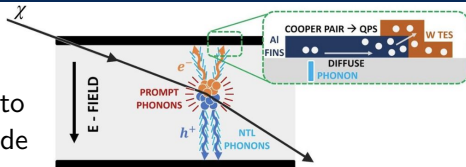
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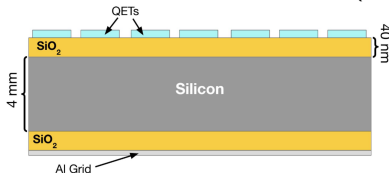
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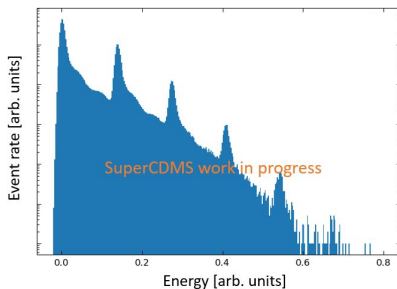
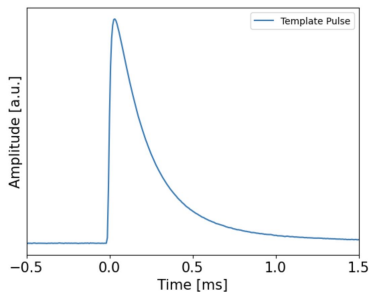
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- New SiO₂ layer hoping to reduce charges tunneling from Al into crystal (“leakage”)

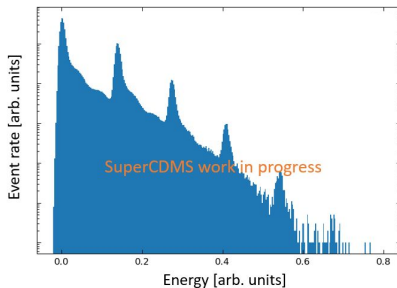
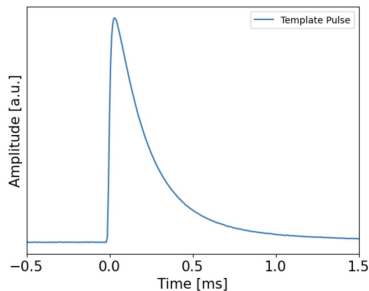


Data from an HVeV Experiment



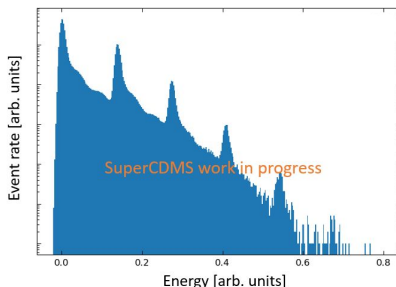
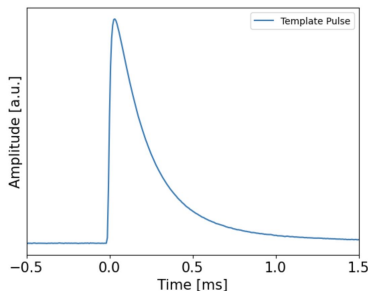
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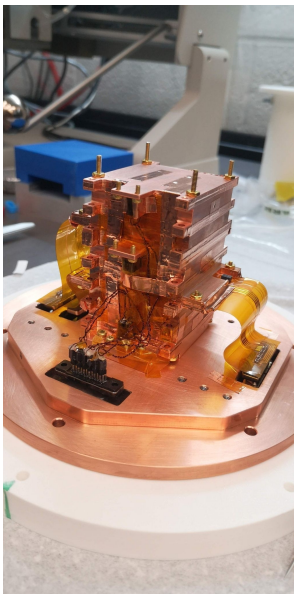
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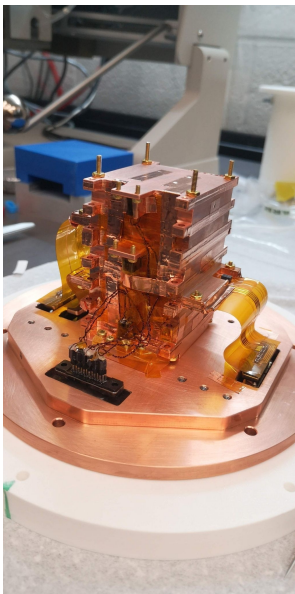
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- Energies are distributed in peaks per number of e-h pairs created

Data Collection



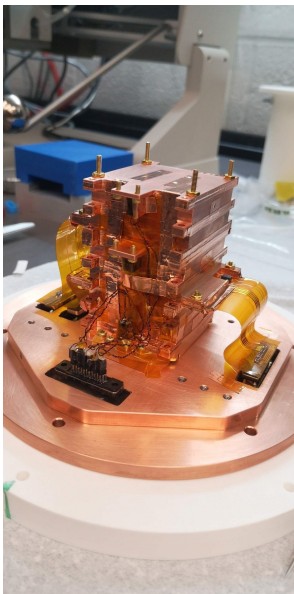
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- About 13 days of blinded dark matter search data, broken into 12-hour series

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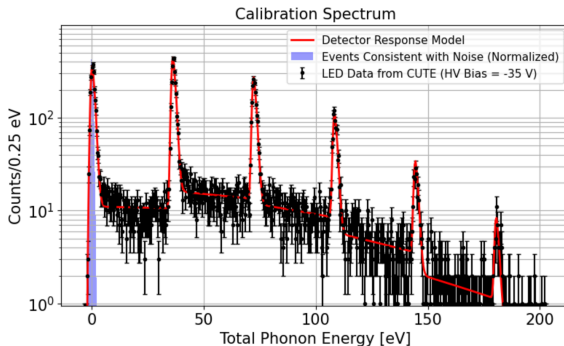
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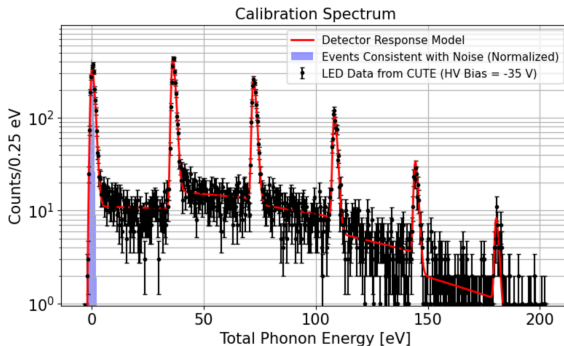
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 - Template produced by averaging pulses in 1 e-h peak

Calibration



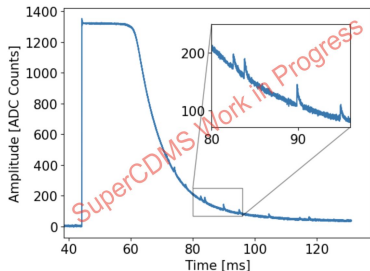
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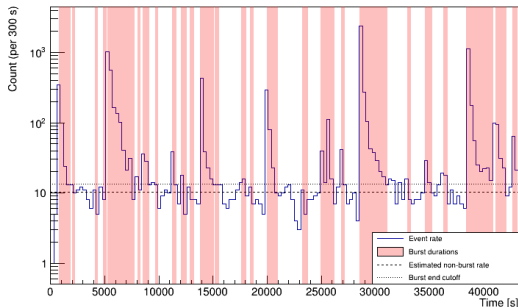
- Calibrated detector using LED flashes of known wavelength
- Also measured width of energy distribution of random triggers to calculate resolution of **0.589 ± 0.005 eV** (Kennard et al. 2026)

“Bursts”

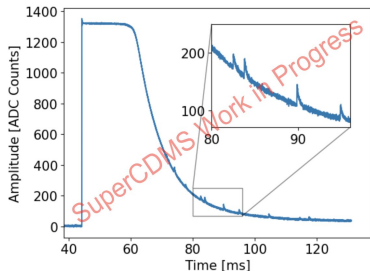


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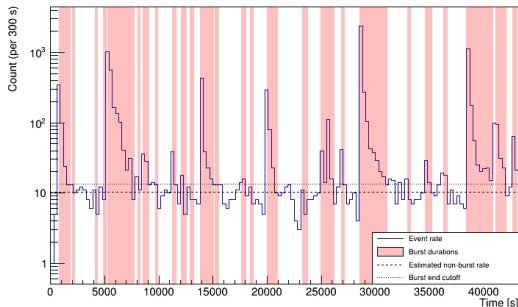
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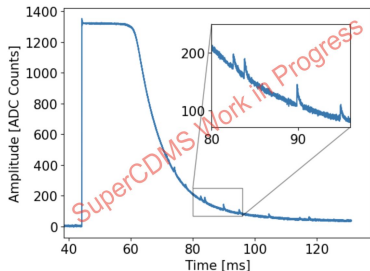
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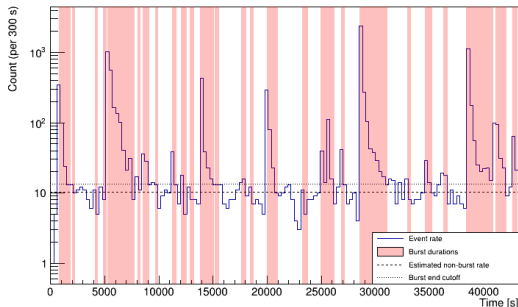
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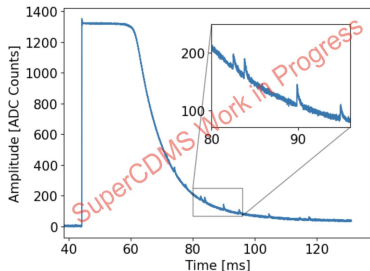
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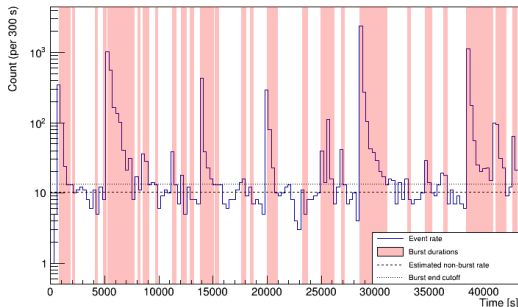
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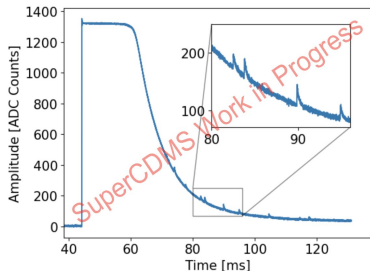
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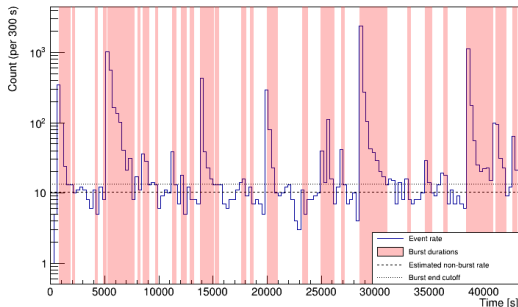
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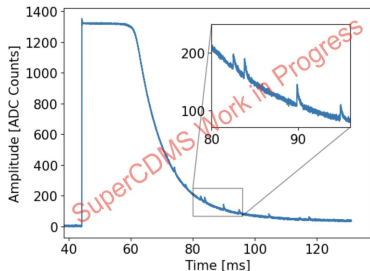
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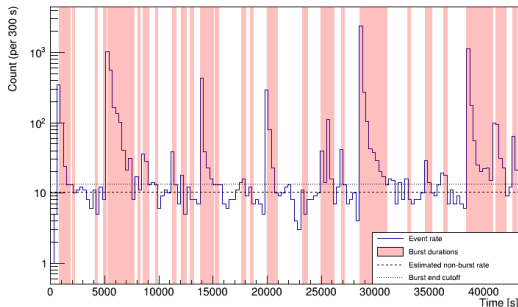
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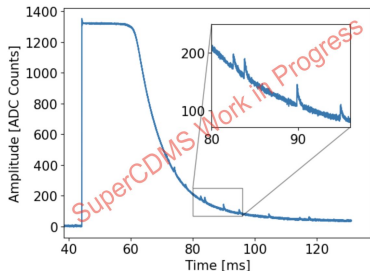
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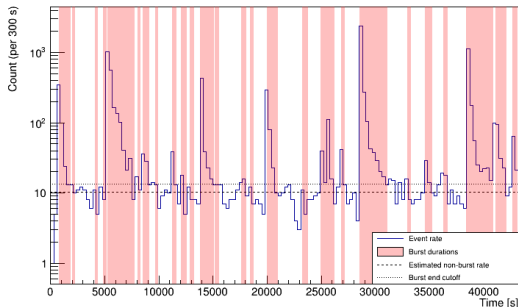
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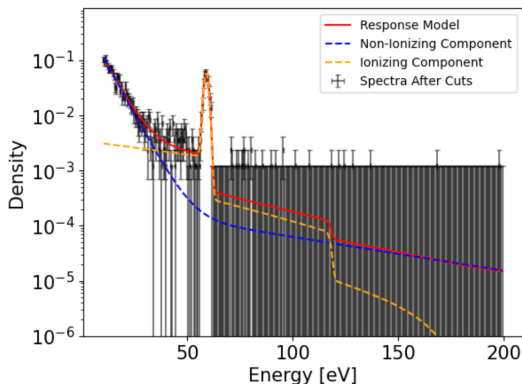
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- Cause is subject of ongoing investigation

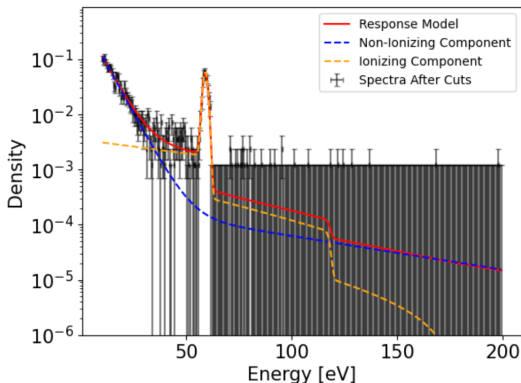


Background Model



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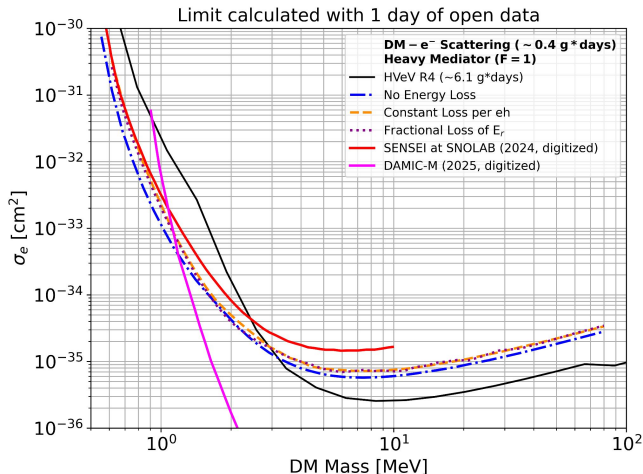


- Non-ionizing component (incl. LEE) is modelled by double-Poisson function constrained by 0 V data
- Ionizing component (leakage and bursts) is modelled by crystal response with bulk and surface trapping and impact ionization (Wilson, Zaytsev et al. 2024)
 - Usual gamma/neutron backgrounds subdominant

- Utilizes profile likelihood ratio
 - Scans possible DM cross section values, producing test statistic that compares likelihood for each cross section to the likelihood of most likely cross section

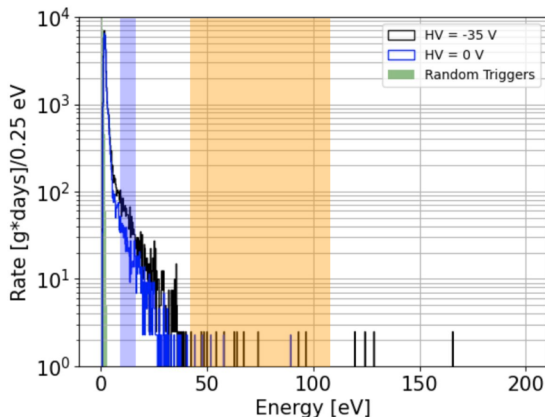
- Utilizes profile likelihood ratio
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- 90% confidence limit is calculated for each mass for each of four signal models
 - DM-e scattering with light mediator
 - DM-e scattering with heavy mediator
 - Dark photon
 - Axion-like particle (ALP)

One Limit from One Day of Data



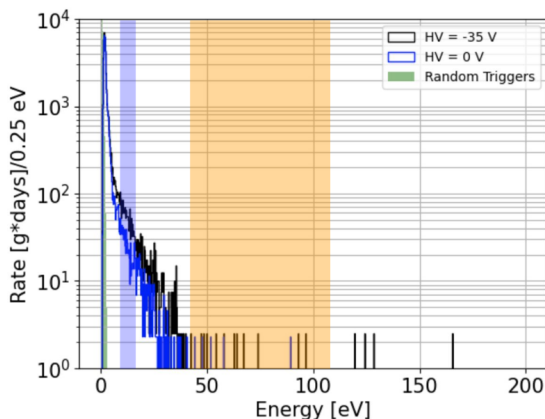
- Our most conservative limit:
World leading below $\sim 1.2 \text{ MeV}$

What About the LEE? — Ionization



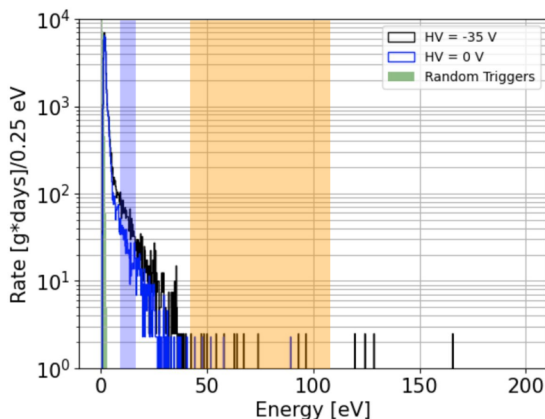
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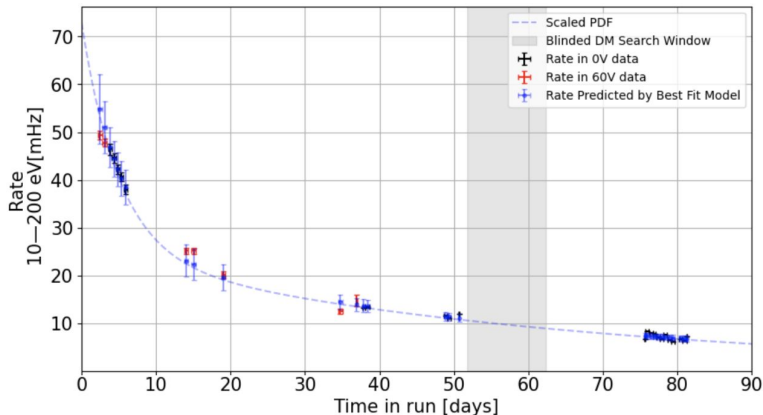
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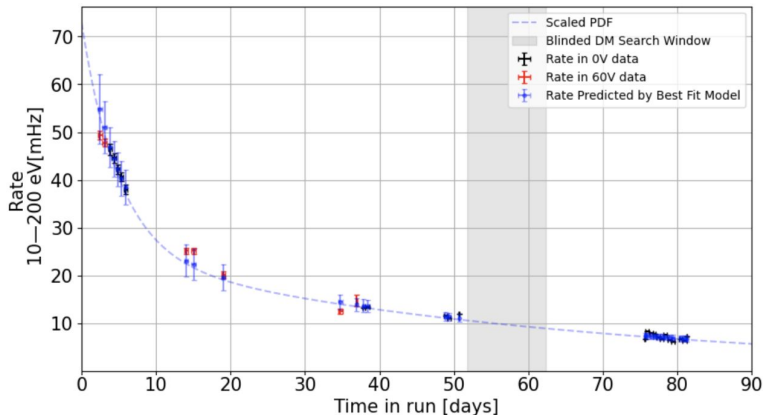
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- Corroboration of the LEE being non-ionizing

What About the LEE? — Rate Over Time



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Where We Go from Here

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