
SuperCDMS Update

Miriam Diamond, University of Toronto
(for the SuperCDMS Collaboration)

SEF Meeting

Feb 11 2026

Toronto, ON





THE SUPERCDMS COLLABORATION

2025 SUMMER COLLABORATION MEETING AT UNIVERSITY OF SOUTH DAKOTA

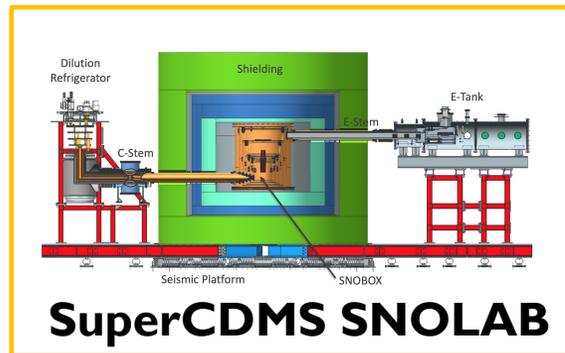
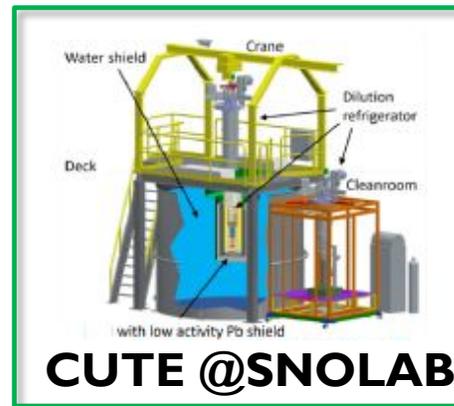
> 130 SCIENTISTS AT 28 INSTITUTIONS, 6 COUNTRIES



Multiple test facilities, channels, and R&D programs provide science leading to SuperCDMS SNOLAB

Surface R&D Facilities

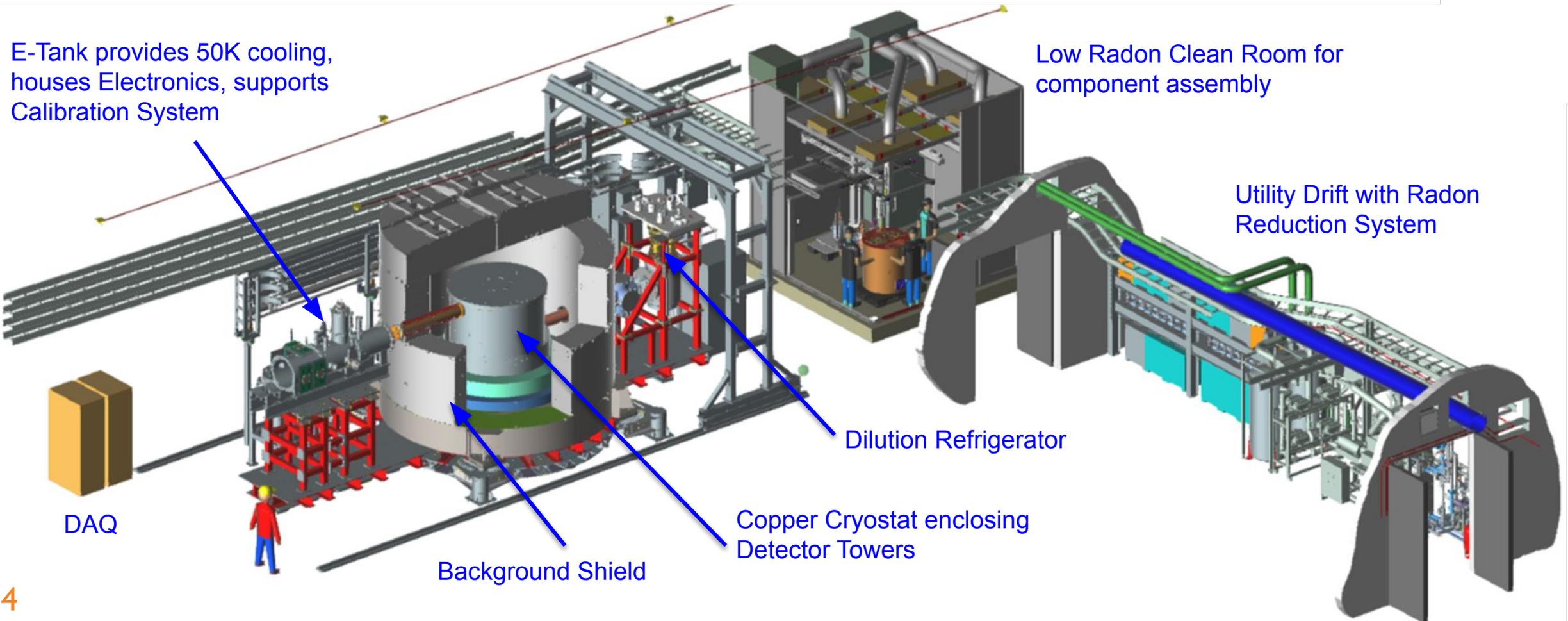
Lower Backgrounds, Larger Exposure



Operational

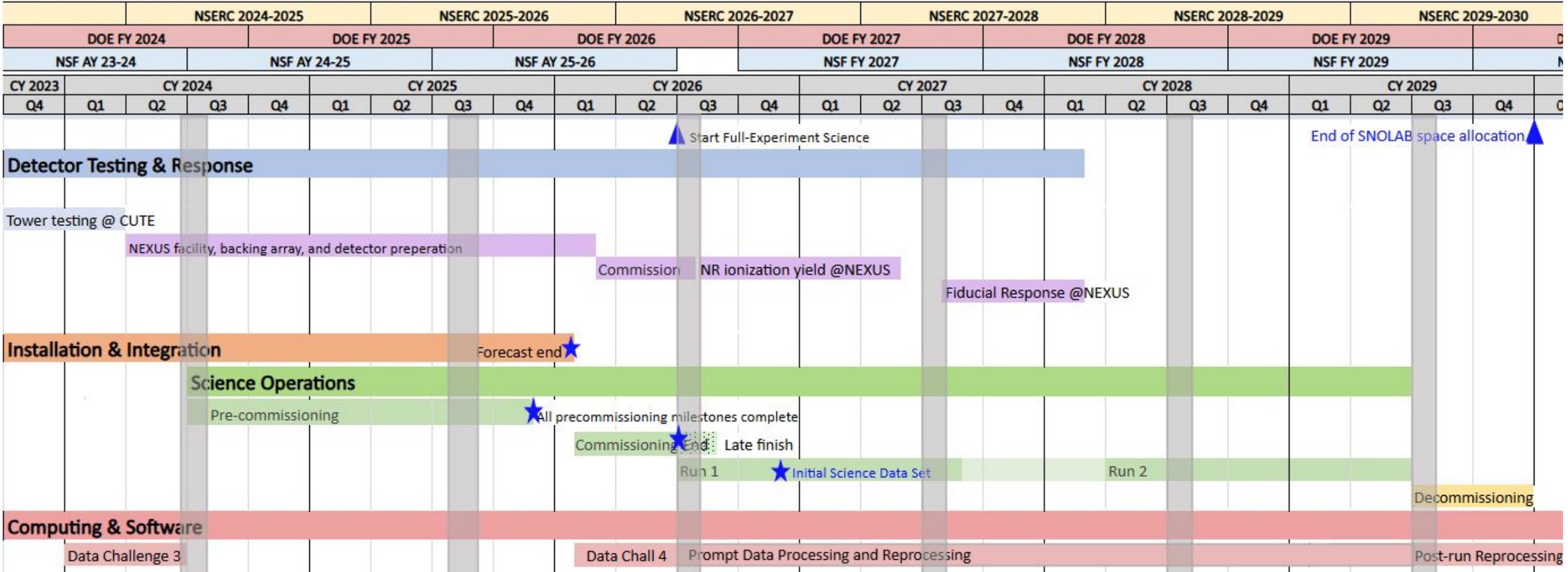
Commissioning

SuperCDMS SNOLAB experiment layout in Ladder Lab



Multi-pronged approach: Test facility results help us maximize discovery reach of SNOLAB experiment

2026 Jan 19 Update for I&I delays and add ops-precommissioning milestones met.



Outline

- SuperCDMS strategy & science goals
- SuperCDMS SNOLAB Installation & Integration: just completed
- SuperCDMS SNOLAB Commissioning: just began
- Recent publications & in-progress analyses from Test Facilities



SuperCDMS strategy: 2 detector types, 2 target materials perform complementary functions

Type

Germanium

Silicon

HV

Lowest threshold for low mass DM
Larger exposure, no ^{32}Si background

Lowest threshold for low mass DM
Sensitive to lowest DM masses

iZIP

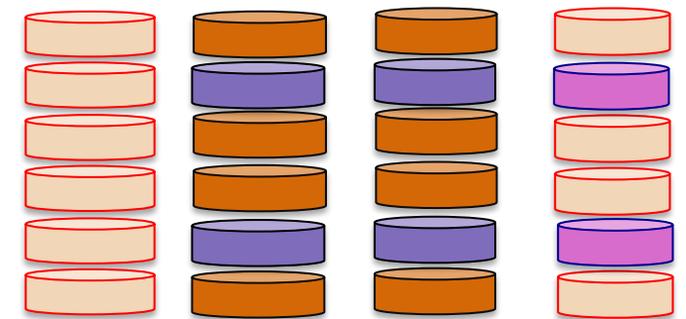
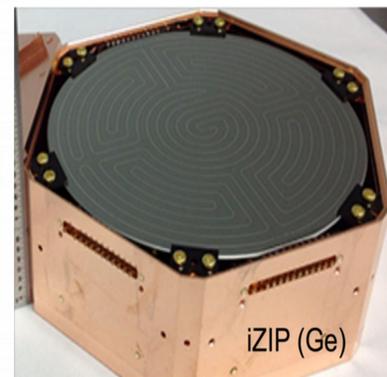
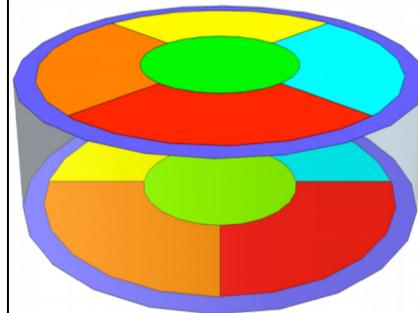
Nuclear Recoil Discrimination
Ge background analyses, ^8B ν -scatter

Nuclear Recoil Discrimination
Si background analyses, ^8B ν -scatter

HV detector

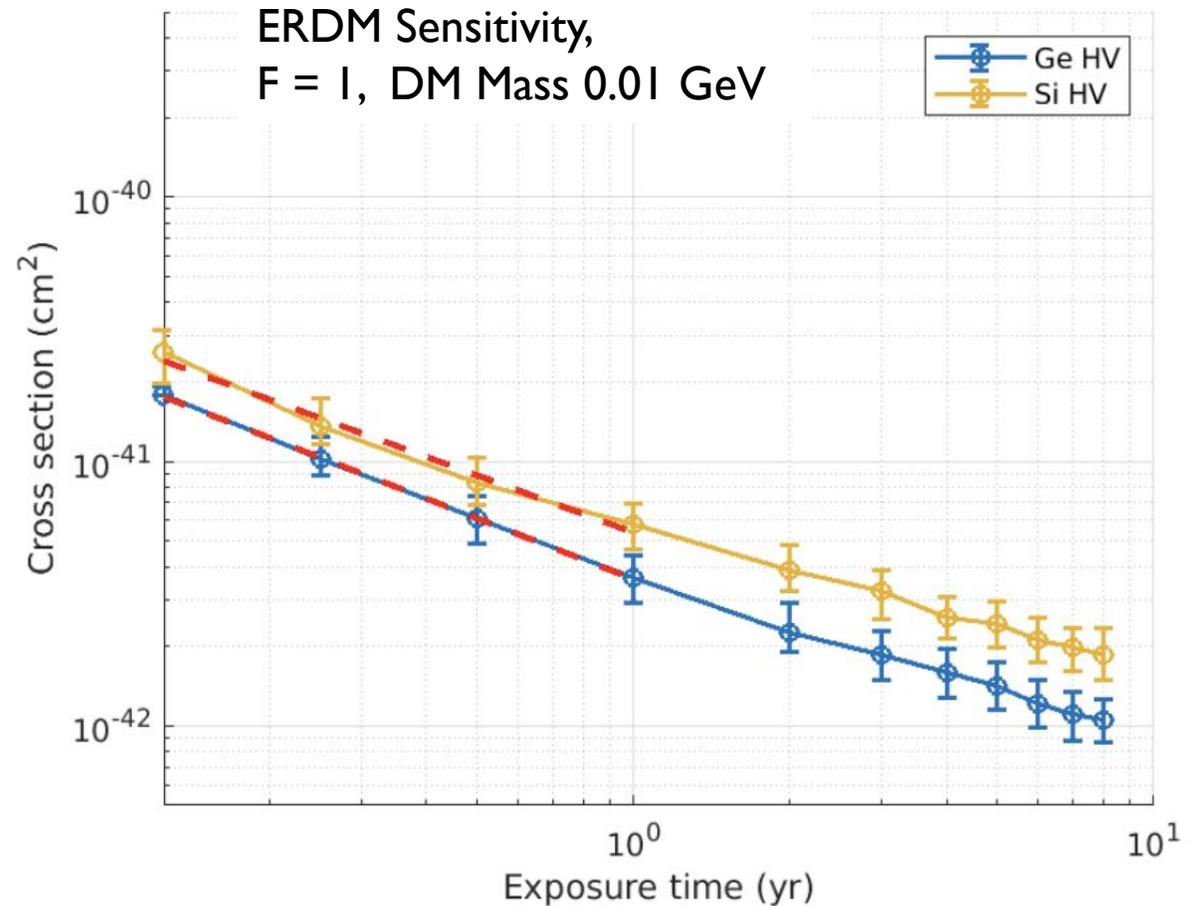
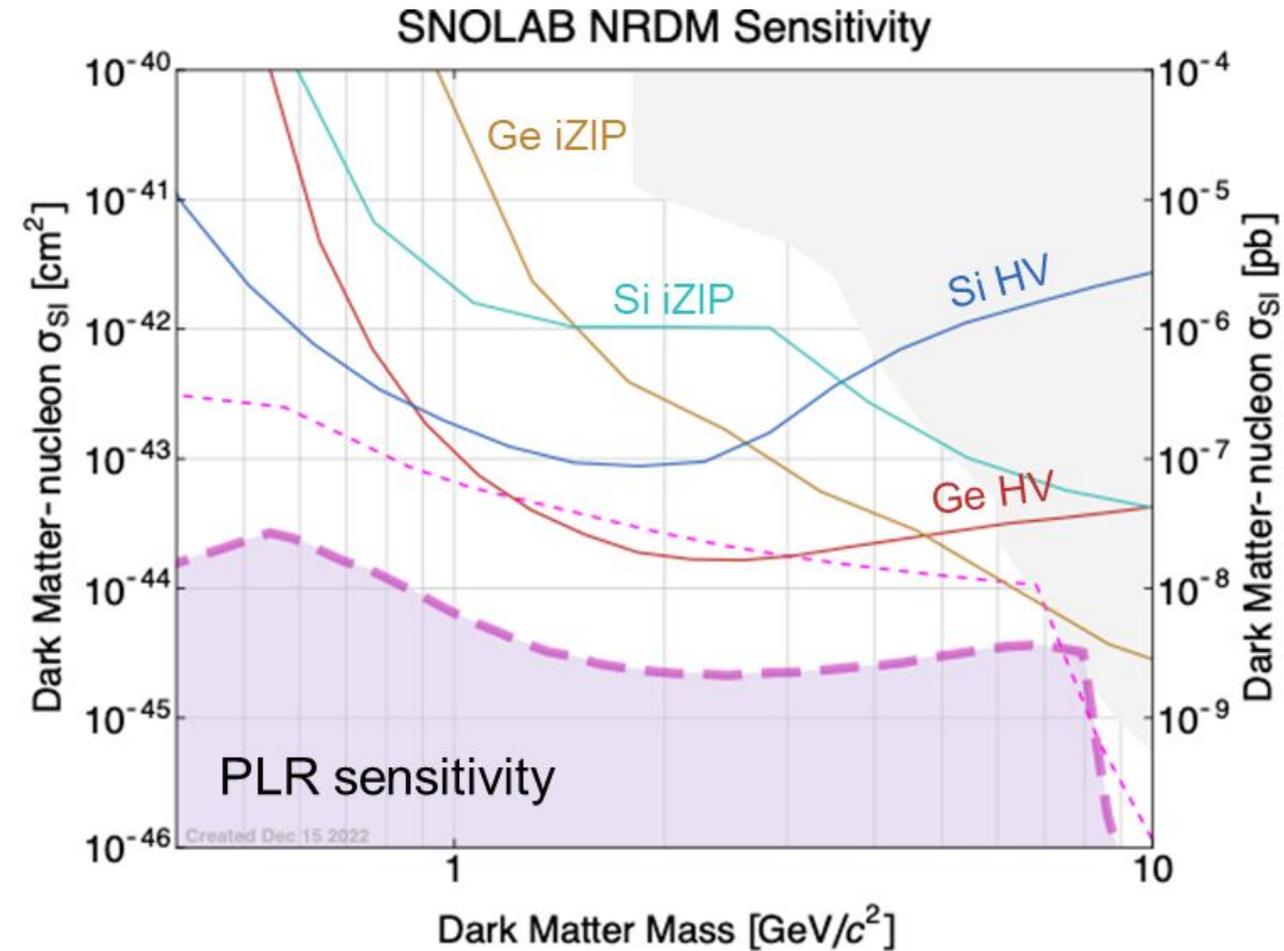


iZIP detector



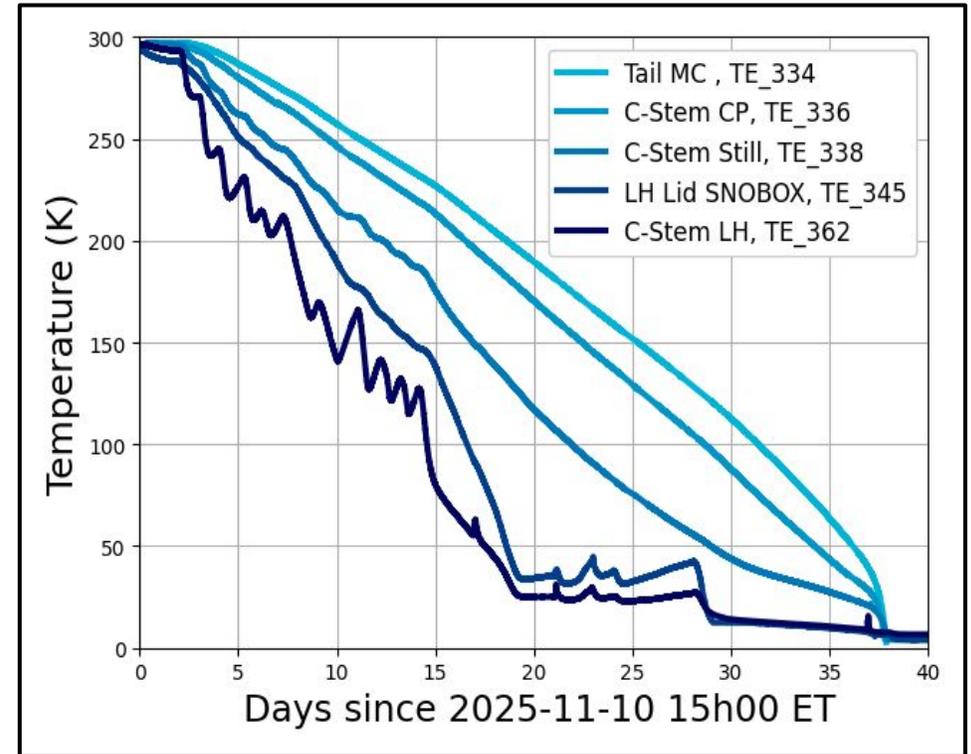
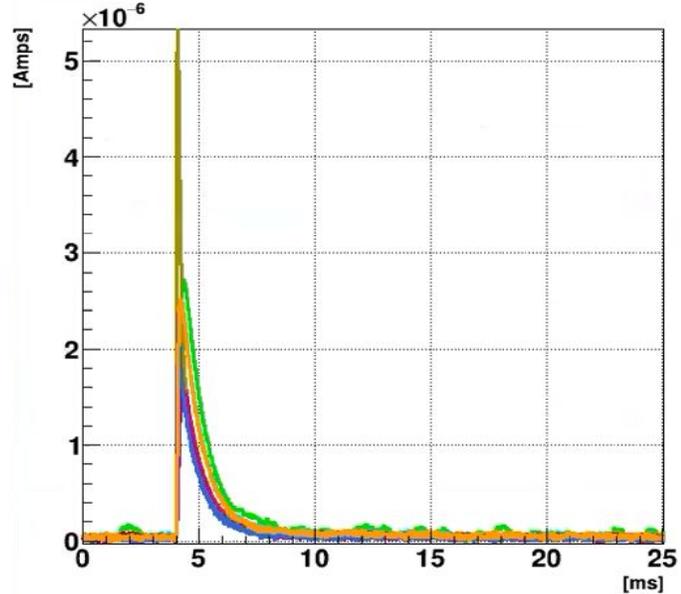
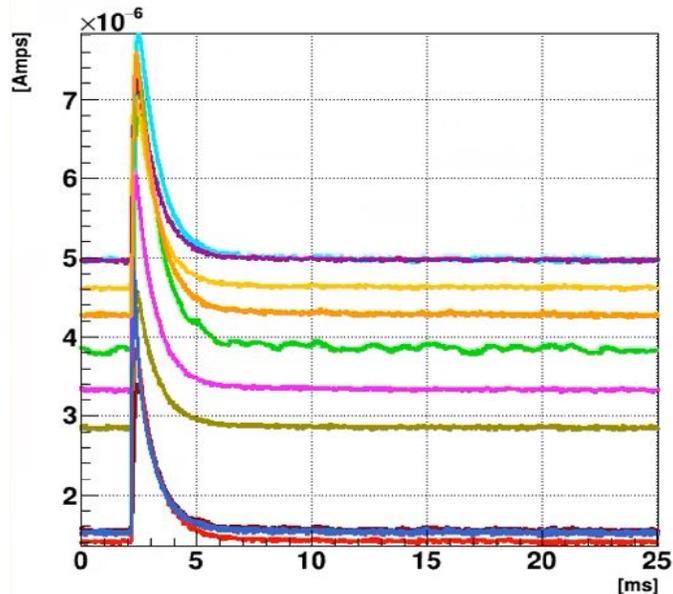
Tower 1: 6 Ge iZIP
Tower 2: 4 Ge HV, 2 Si HV
Tower 3: 4 Ge HV, 2 Si HV
Tower 4: 4 Ge iZIP, 2 Si iZIP

SuperCDMS goals: Coverage of low-mass WIMP region + sensitivity to electron-recoiling DM



SuperCDMS SNOLAB “Installation & Integration” just finished!

- 11/10: Cooldown started
- 12/14: Reached < 70K
- 12/18: Reached < 4K
- 1/9: Condensing LHe
- 1/13: Base temp first reached
- 1/29: First pulses from superconducting TESs! End of I&I

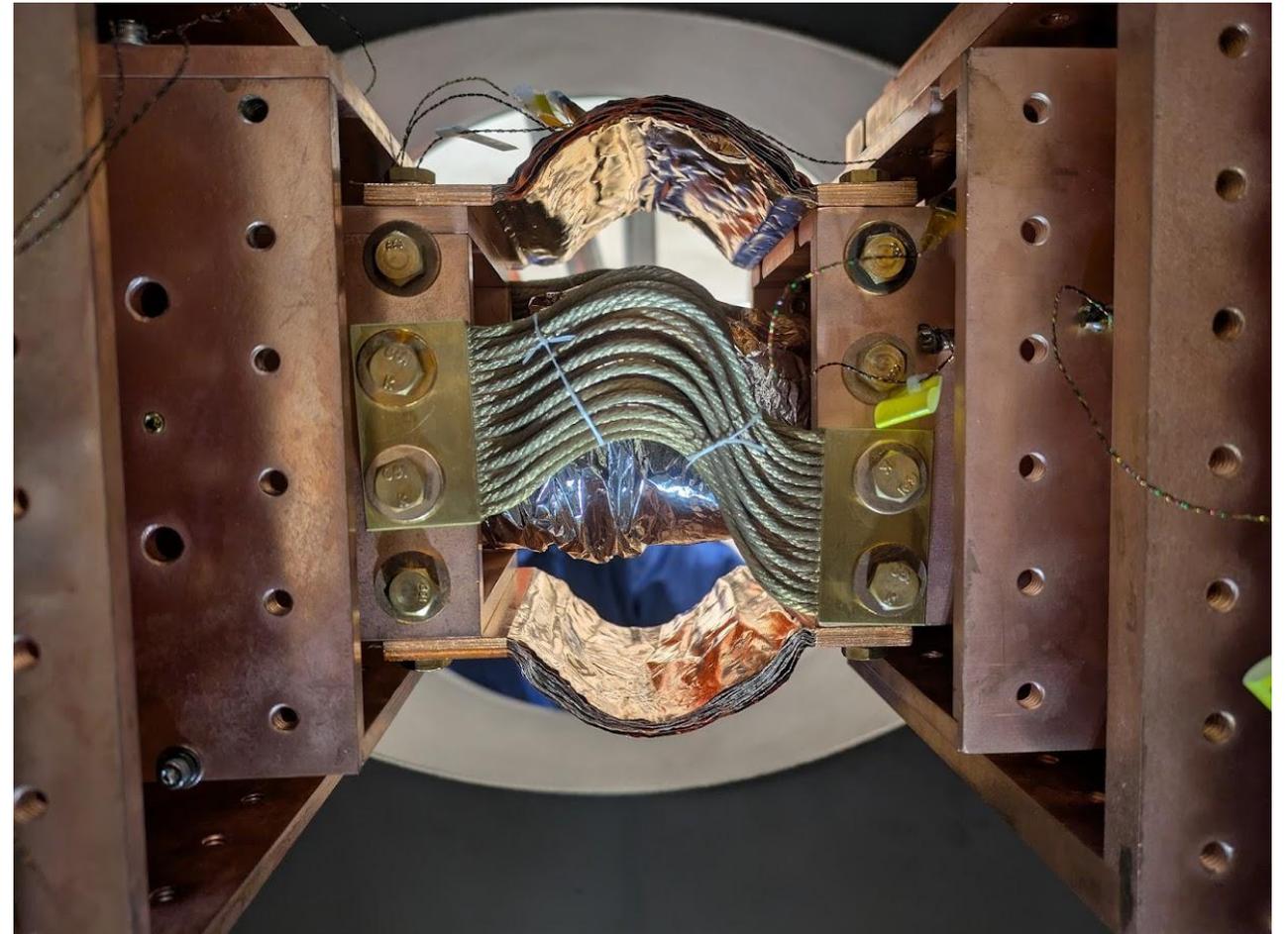


Detectors currently operating at 35-40 mK

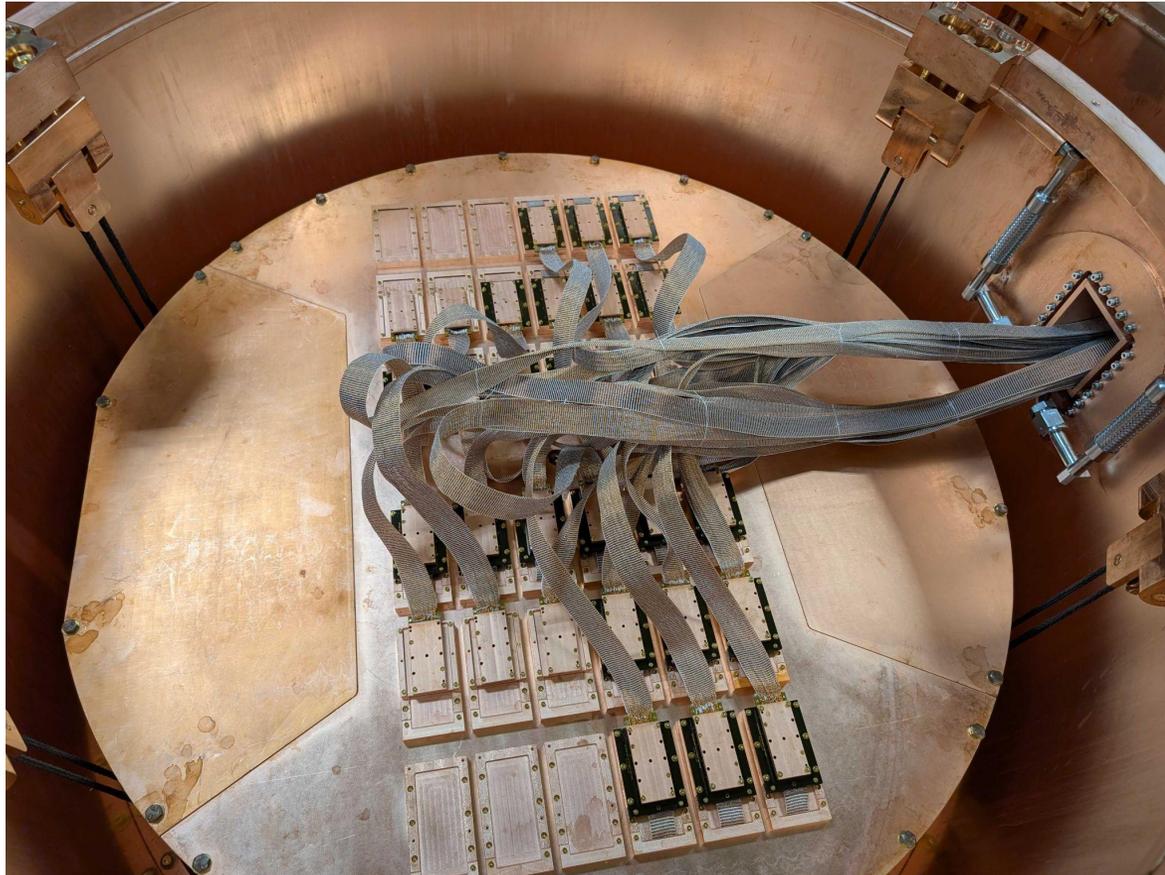
Dilution Refrigerator (DR) with cryogenic tails, just prior to its installation



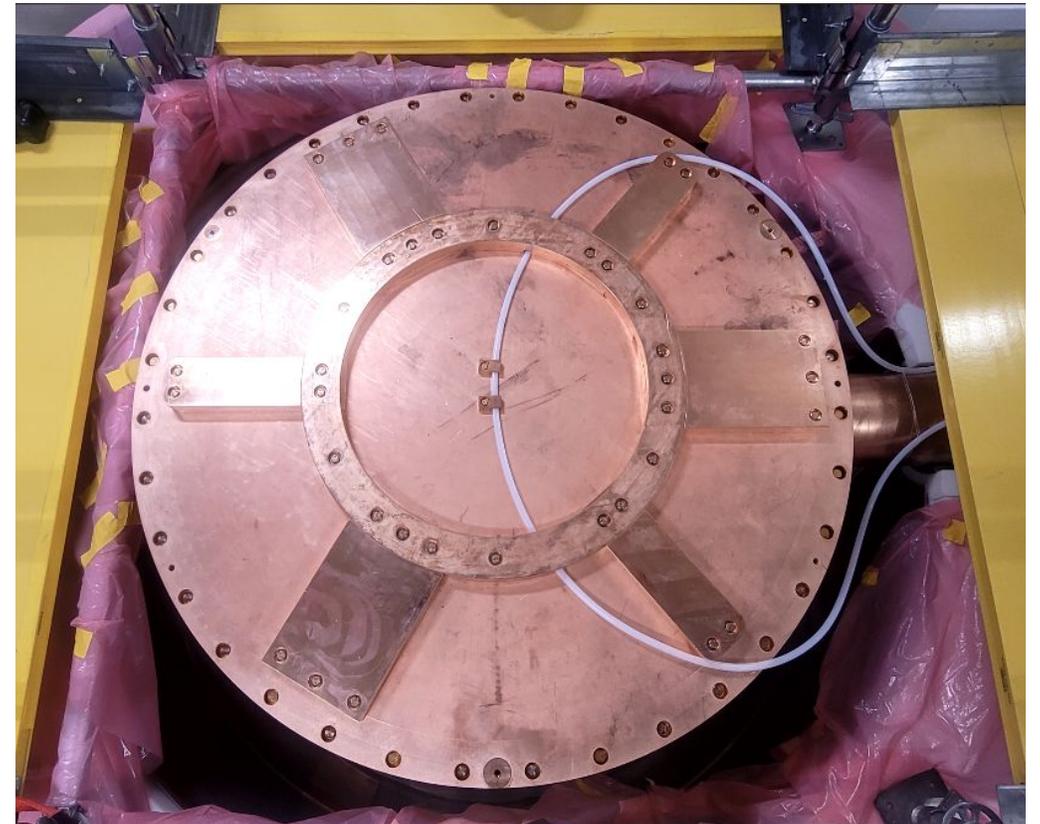
Thermal straps providing thermal connection from the DR to cryostat (Cold Plate thermal stage shown)



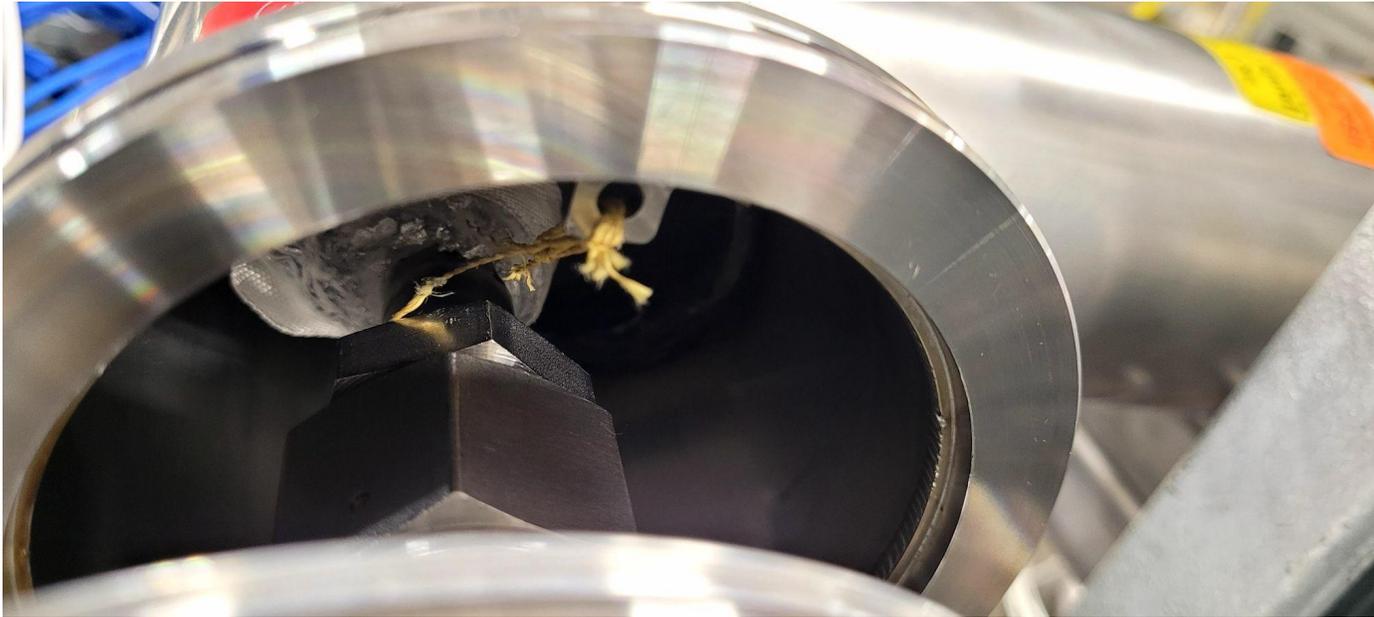
Cables connecting the detectors to E-Tank vacuum feedthroughs & readout electronics boards



Closed cryostat, with nylon guide tube for deploying Ba calibration source



There's a small leak in the 50K He cooling line, in "bayonet" connecting 50K cooler to E-Tank



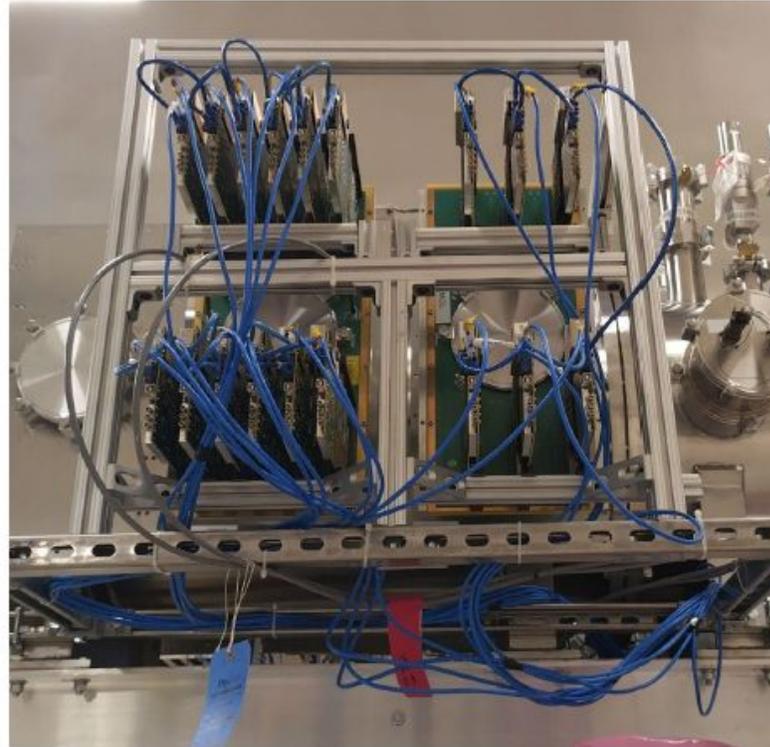
Temporary vacuum pumping setup out-pumps the bayonet leak, until bayonet can be replaced in a few months



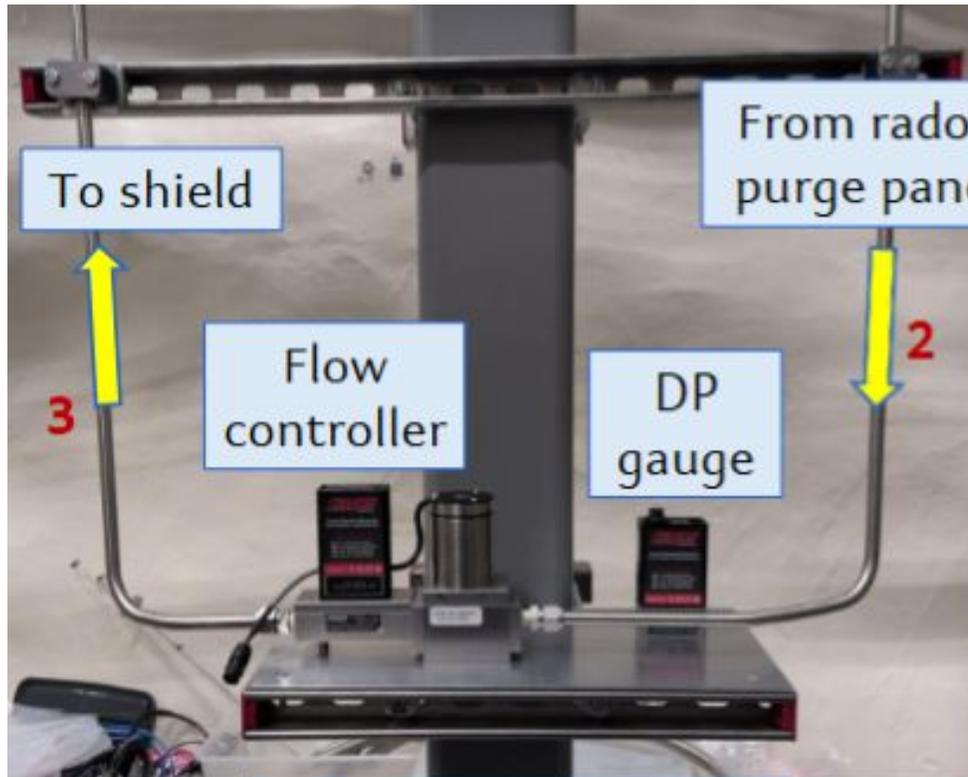
Installing top section of μ -metal shield to protect detectors from Earth's magnetic field

Readout electronics cards mounted to the E-Tank vacuum feedthrough

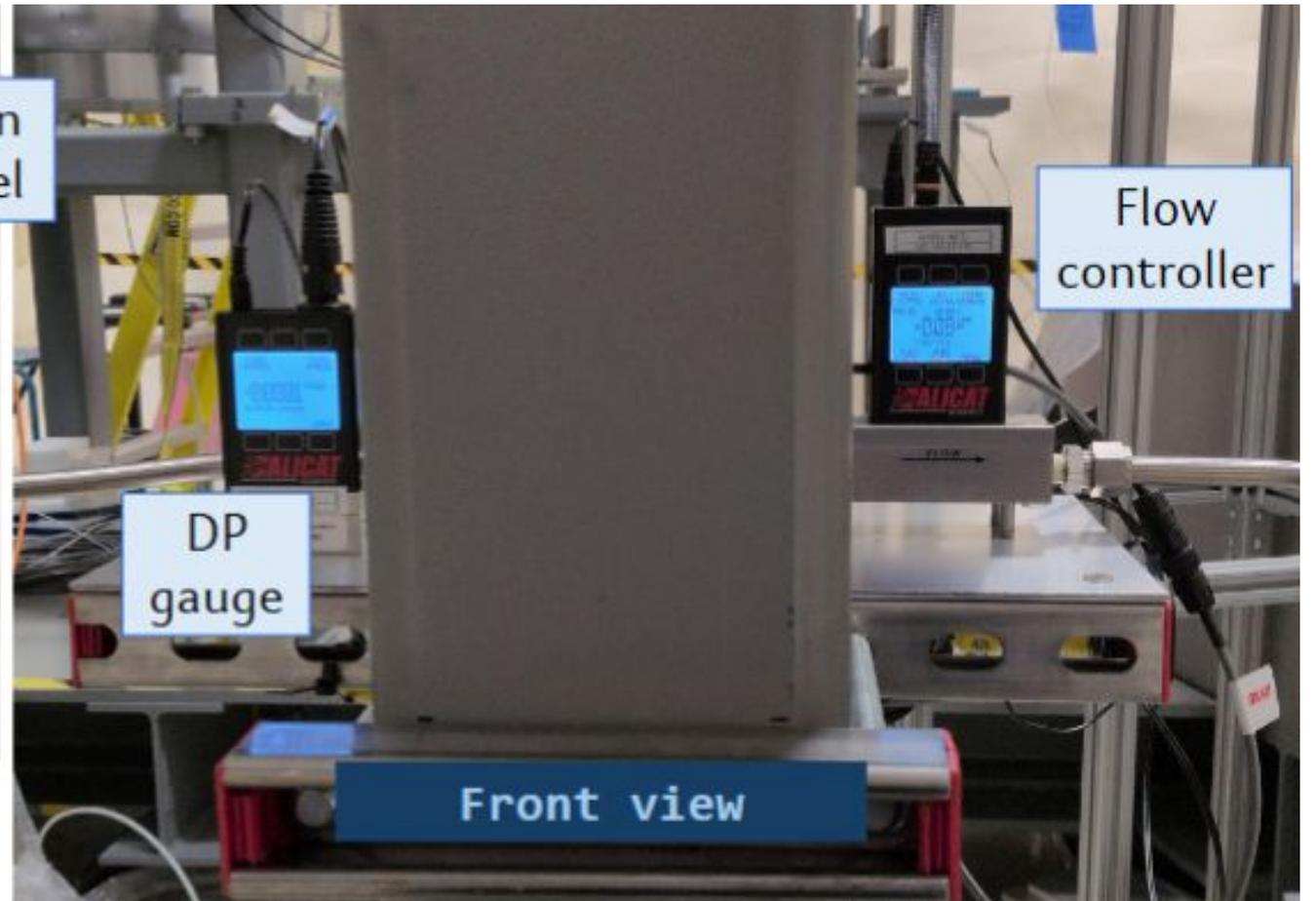
Installing heaters to offset radiative cooling



Radon purge subsystem: differential pressure gauge + flow controller

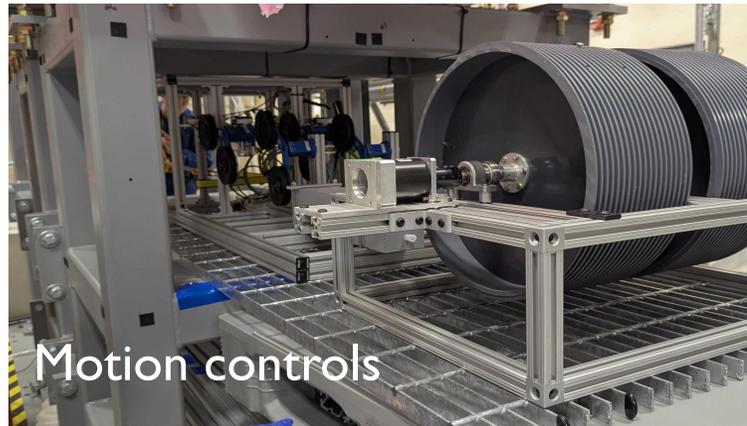


Back view

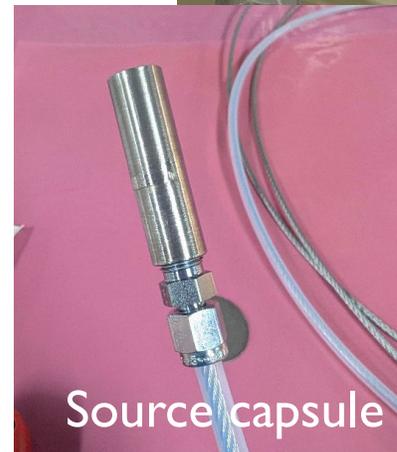
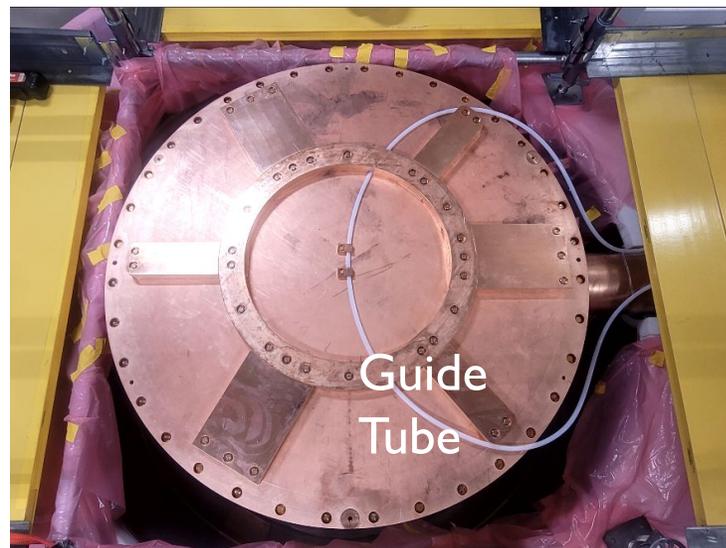
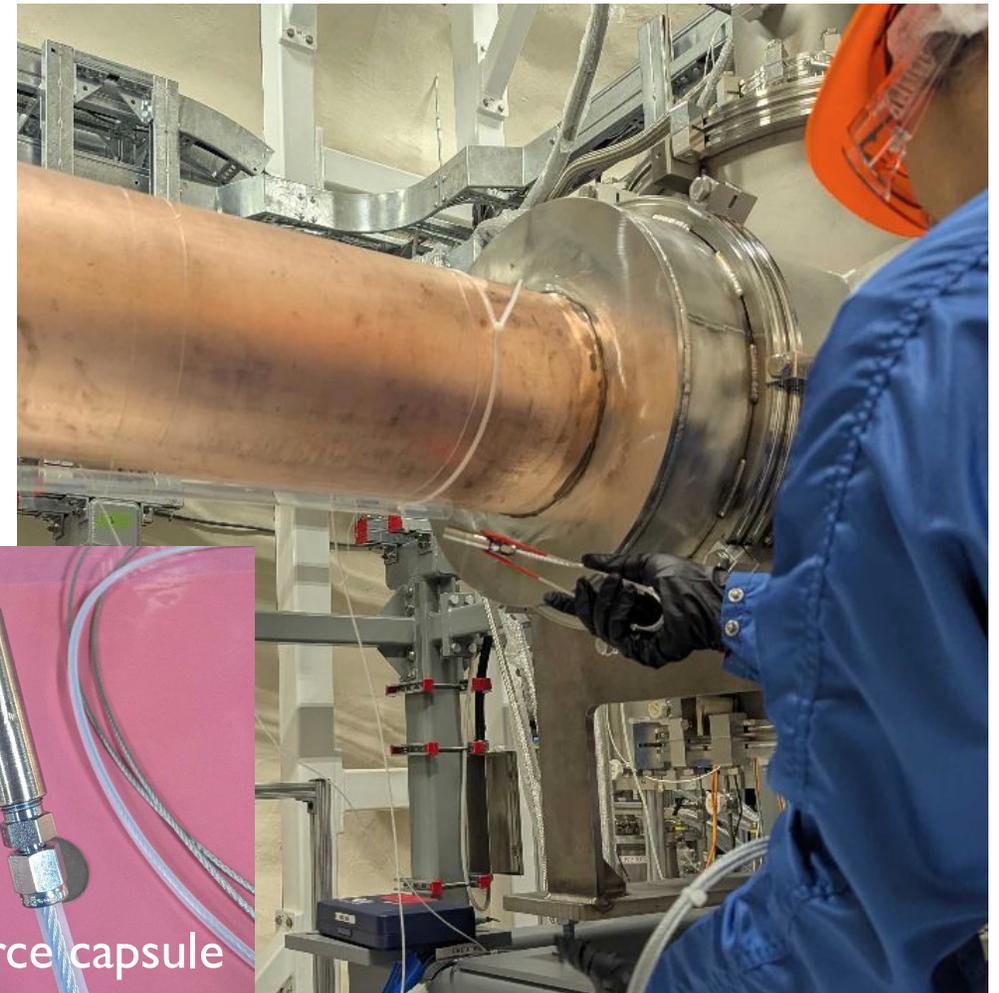


Front view

Automatic system for deploying gamma calibration system: Ba sources on steel cable driven by stepper motor, goes along E-stem and across top & bottom of cryostat



Neutron calibration system: encapsulated Cf sources attached to flexible “wands” inserted into shield manually, with guide tubes running along C-stem and E-stem



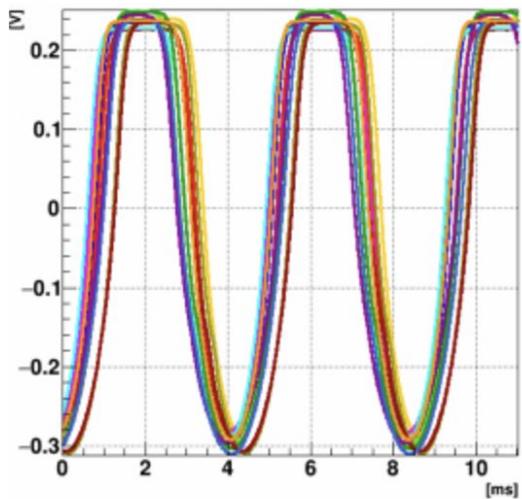
SuperCDMS SNOLAB Commissioning just began!

- Known issues requiring troubleshooting: higher temperatures in some parts of DR than desired, electrical grounding / ground-loops
- Planned Campaigns: detector characterization, optimization, trigger setup, calibration source deployment, activation, neutralization, noise-hunting
- Careful remote monitoring as we validate safety and alarm systems
- Some installation items deferred to preserve access during early Commissioning
 - Upper section and lid of lead/poly shielding wall
 - Radon purge system, upper section of radon barrier
 - Water tank background shield
- Some repair / backup / modifications will happen during Commissioning
 - Replacement of 50K cooler bayonet
 - Modification of Detector Control & Readout Cards to address charge readout oscillations
 - Ice-tank chilled water backup
 - Additional electronics filtering

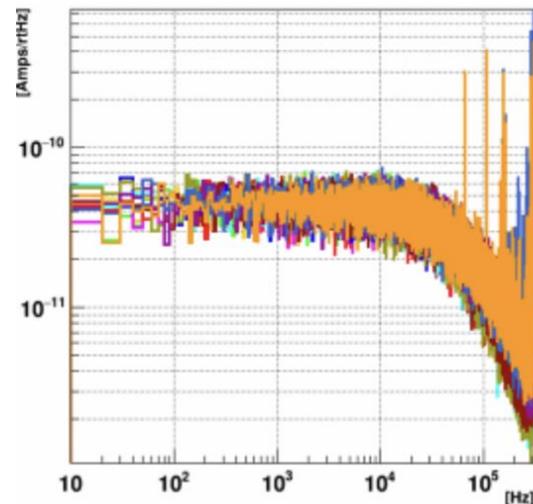
Preliminary results/highlights from Jan 2026 “first commissioning campaign”, overlapping with end of I&

- SQUID testing and characterization performed at 4K: >99% operational
- ~80% of TESs were superconducting within 2 days of condensing, despite not being at base temp yet
- Several detectors measuring large (~10 - 20 mOhm) parasitic resistances, probably due to higher-than-expected “4K still” temp

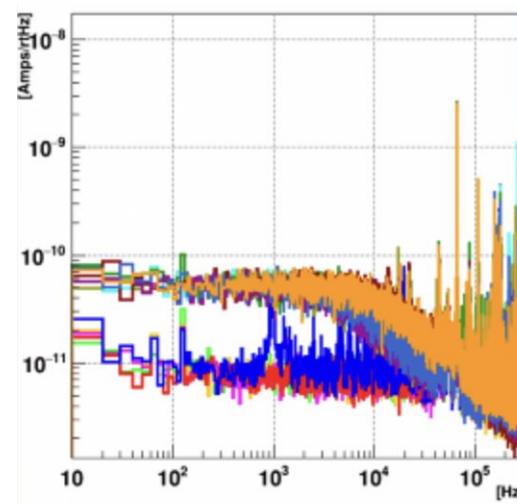
SQUID oscillations



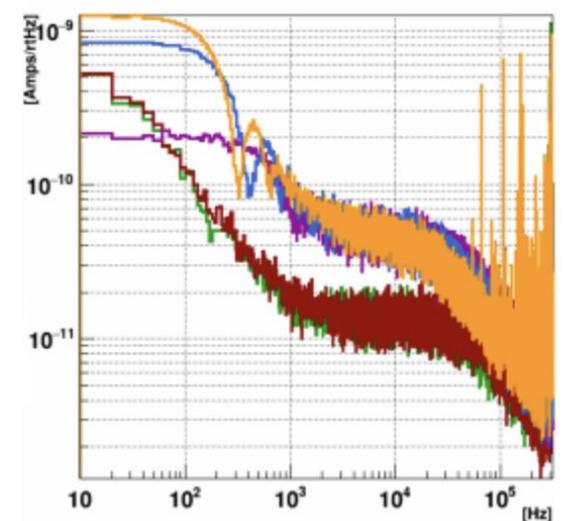
Superconducting (SC) noise



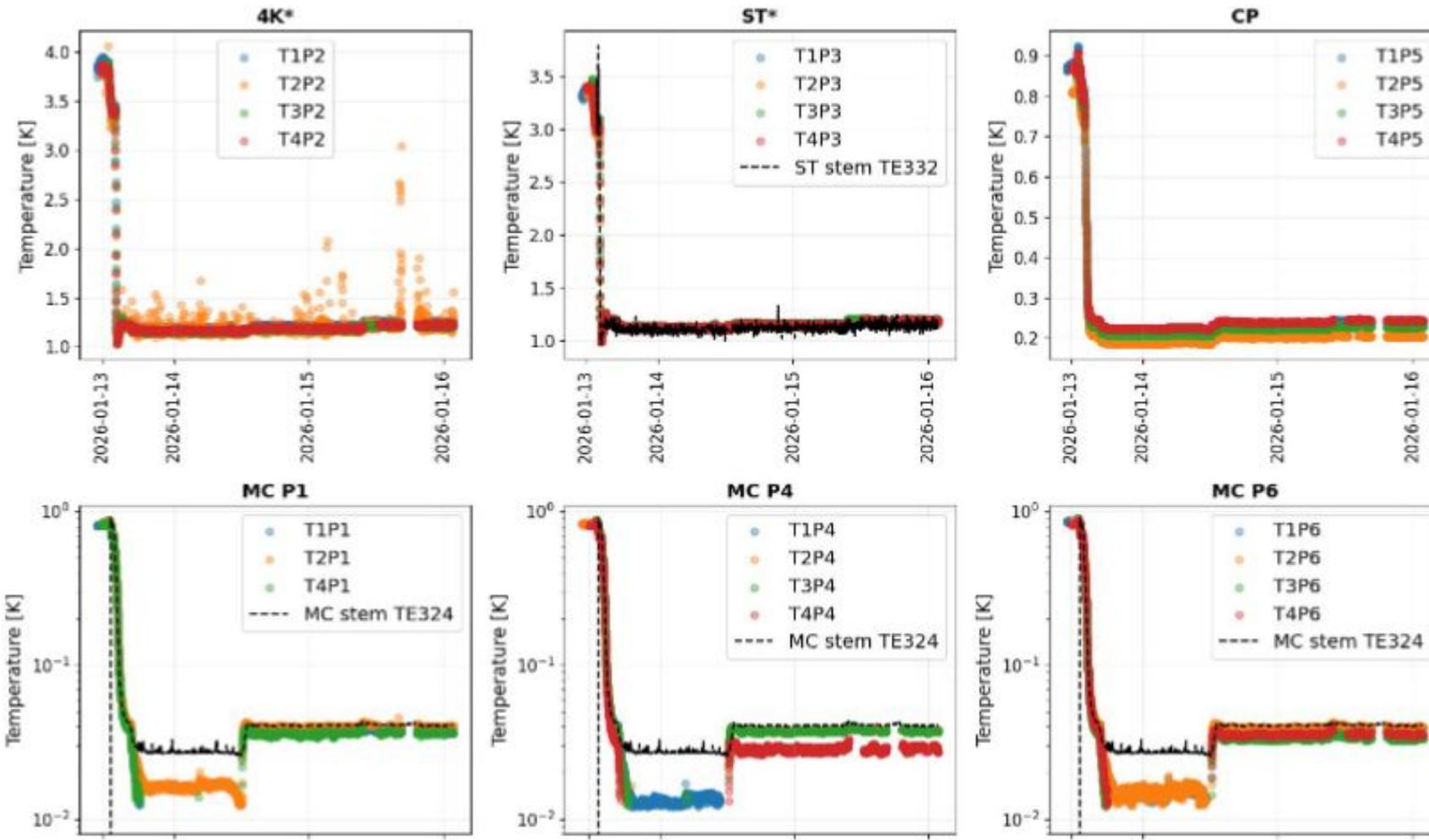
Noise with 50% SC, 50% Normal



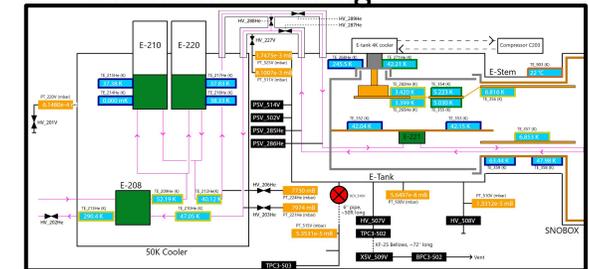
Transition noise with some pulses



Thermometry on detector towers, with readout through DAQ, enabled remote monitoring of condensing



Online monitoring interface



Detector operation UI

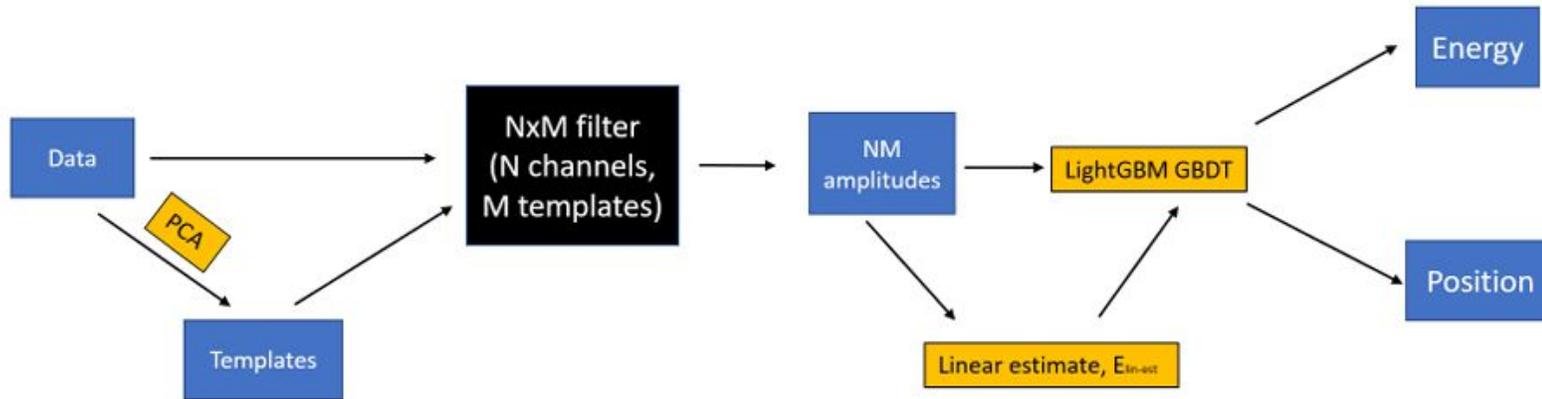
The screenshot shows the Detector operation UI, which includes a dashboard with various controls and status indicators. Key features include:

- Navigation:** Log, Dashboard, Run Control, Detector, Detector Testing, Trigger, LED Flash, ZAP, General, ODB, Help.
- Status:** Sequencer is off, Run stopped, Not write to data, Update - gray Sequencer/Run boxes, Midas Messages, Detector, Trigger, & Detector Testing data every 10 sec, Last updated: 9:15:11 AM, v5.8.16, Power Over Ethernet: POE1, POE2, & SDBCS, Resync DCRCS.
- Settings:** Open Save Settings Interface, Open Load Settings Interface.
- Channels:** Phonon Channel, Charge Channels, High Voltage, Diagram view, Table view.
- Side Panels:** Side 1 (Top), Side 2 (Bottom), Side 1 (Top), Side 2 (Bottom).
- Ge HV circuit diagram:** G165 TES0, TES1, TES2, TES3, TES4, TES5, TES6, TES7, TES8, TES9, TES10, TES11, TES12, TES13, TES14, TES15, TES16, TES17, TES18, TES19, TES20, TES21, TES22, TES23, TES24, TES25, TES26, TES27, TES28, TES29, TES30, TES31, TES32, TES33, TES34, TES35, TES36, TES37, TES38, TES39, TES40, TES41, TES42, TES43, TES44, TES45, TES46, TES47, TES48, TES49, TES50, TES51, TES52, TES53, TES54, TES55, TES56, TES57, TES58, TES59, TES60, TES61, TES62, TES63, TES64, TES65, TES66, TES67, TES68, TES69, TES70, TES71, TES72, TES73, TES74, TES75, TES76, TES77, TES78, TES79, TES80, TES81, TES82, TES83, TES84, TES85, TES86, TES87, TES88, TES89, TES90, TES91, TES92, TES93, TES94, TES95, TES96, TES97, TES98, TES99, TES100, TES101, TES102, TES103, TES104, TES105, TES106, TES107, TES108, TES109, TES110, TES111, TES112, TES113, TES114, TES115, TES116, TES117, TES118, TES119, TES120, TES121, TES122, TES123, TES124, TES125, TES126, TES127, TES128, TES129, TES130, TES131, TES132, TES133, 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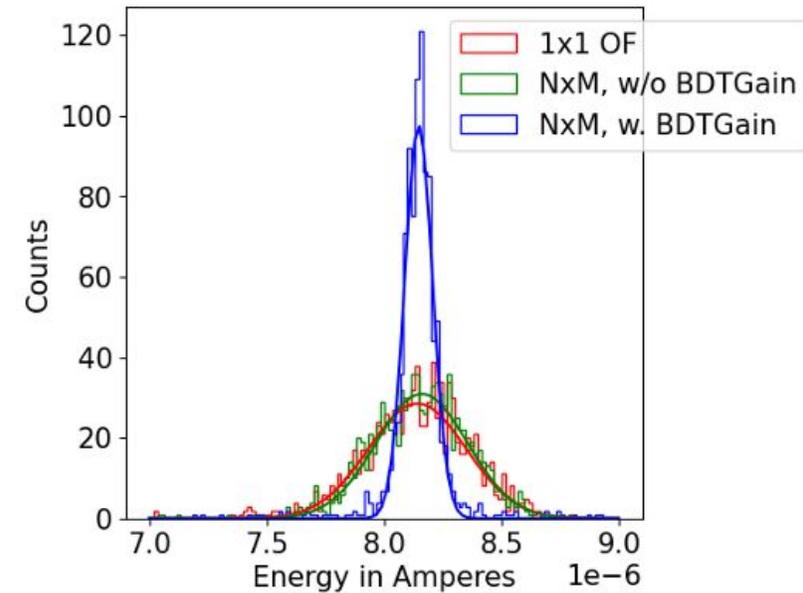
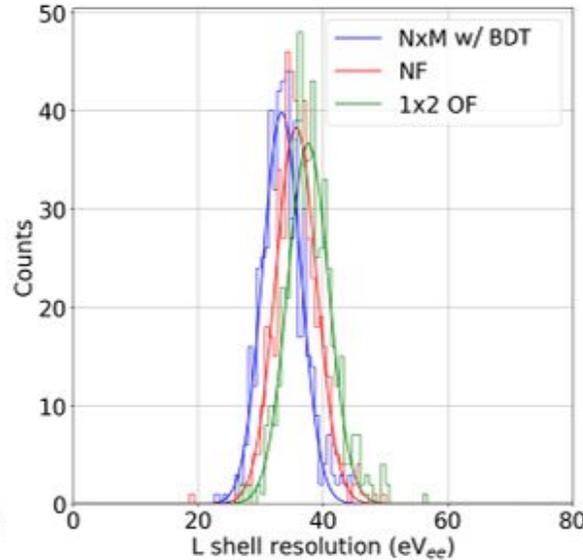
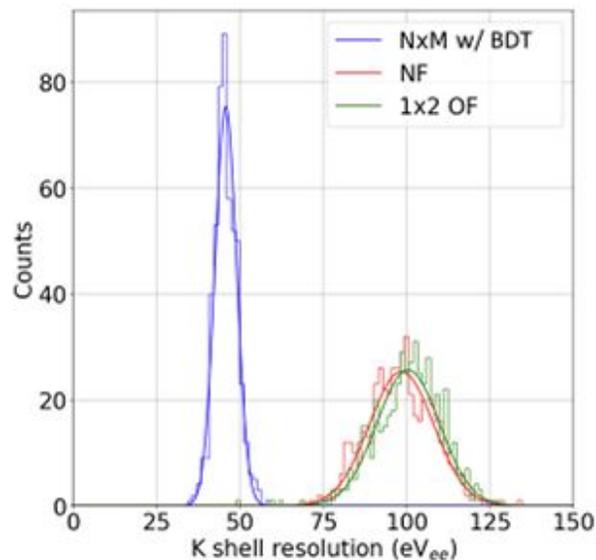
Recent & upcoming SuperCDMS publications: exciting test facility analyses & results

- Event reconstruction: Multi-channel, multi-template, using machine learning [arXiv:2508.20090](#), submitted to NIM A (Jan 2026)
- HVeV Run 4 @NEXUS test facility
 - Si detector calibration using Compton steps: Energy signatures at $\sim 100\text{eV } E_{ee}$ (L shell steps), $\sim 2\text{keV } E_{ee}$ (K shell step) [arXiv:2508.02402](#), Phys. Rev. D 112, 092014 (Nov 2025)
 - ERDM search: re-designed detector holder eliminated luminescence background from PCBs [arXiv:2509.03608](#), accepted for publication in PRD (Jan 2026)
- HV Tower test @CUTE: internal analyses underway (noise modeling, background rates, calibrations, etc.)
- HVeV Run 5 @CUTE
 - Device performance characterization: sub-eV energy resolution and single charge sensitivity [arXiv:2601.16307](#) (Jan 2026)
 - ERDM search: analysis in final stages
- HVeV 2mm 2-channel Prototype Run @NEXUS: data-taking just completed

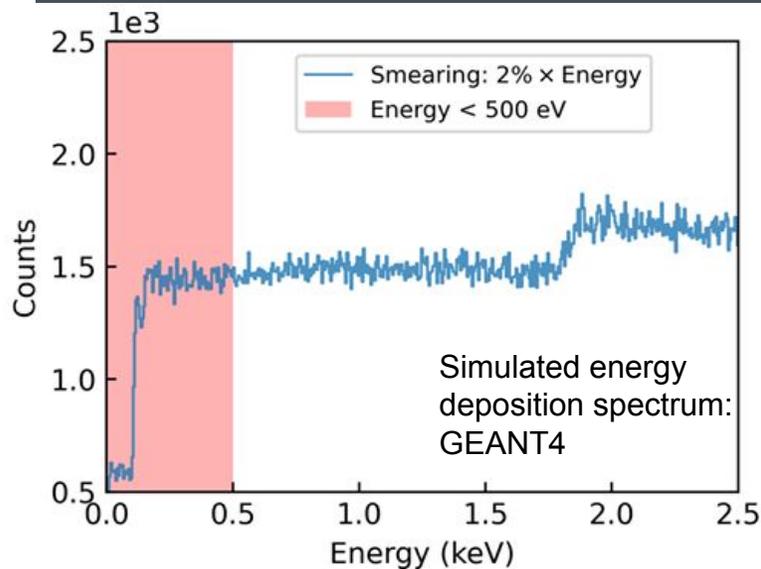
Event reconstruction: “N channels x M templates” Optimal Filter with machine-learning boost, validated on old CDMSlite data



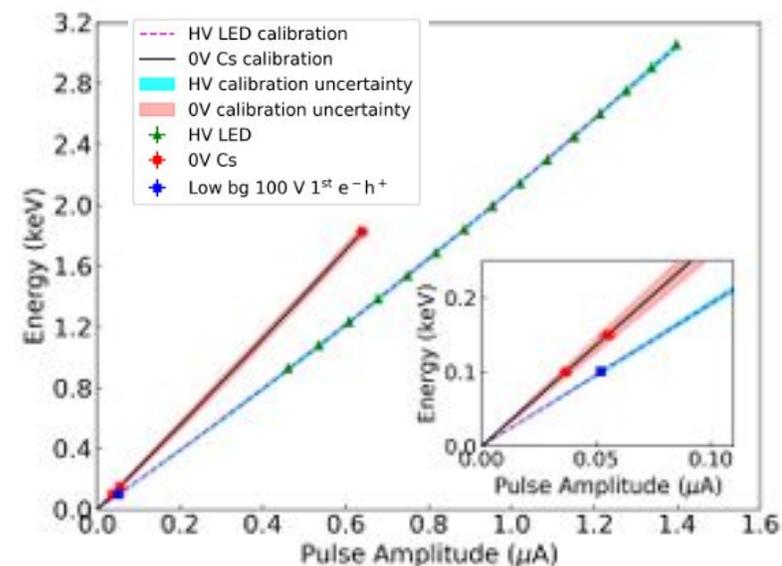
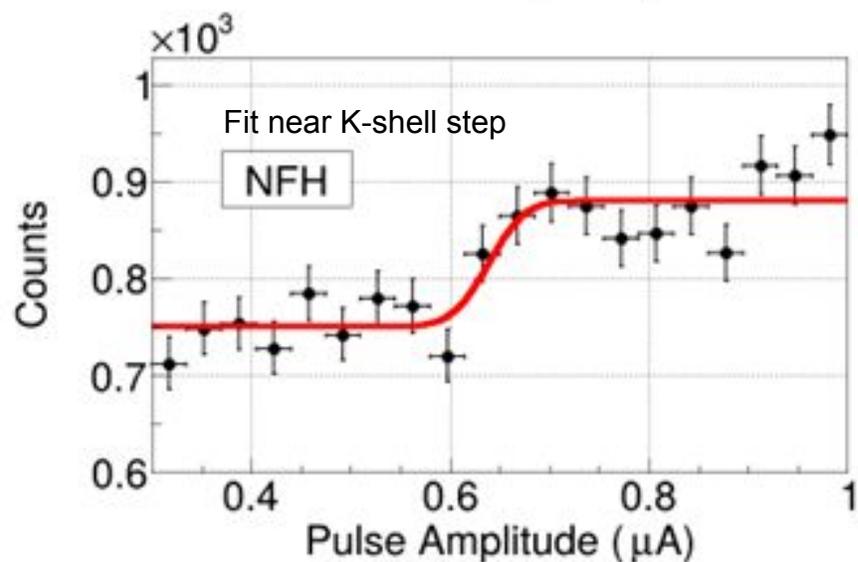
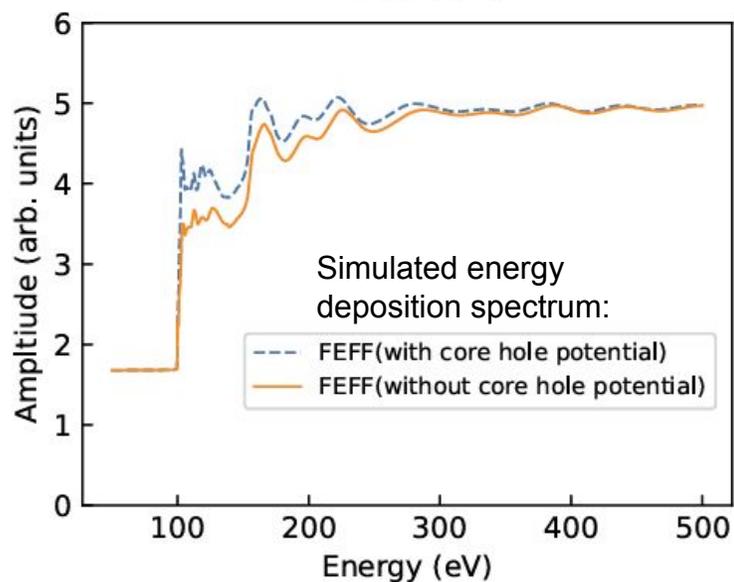
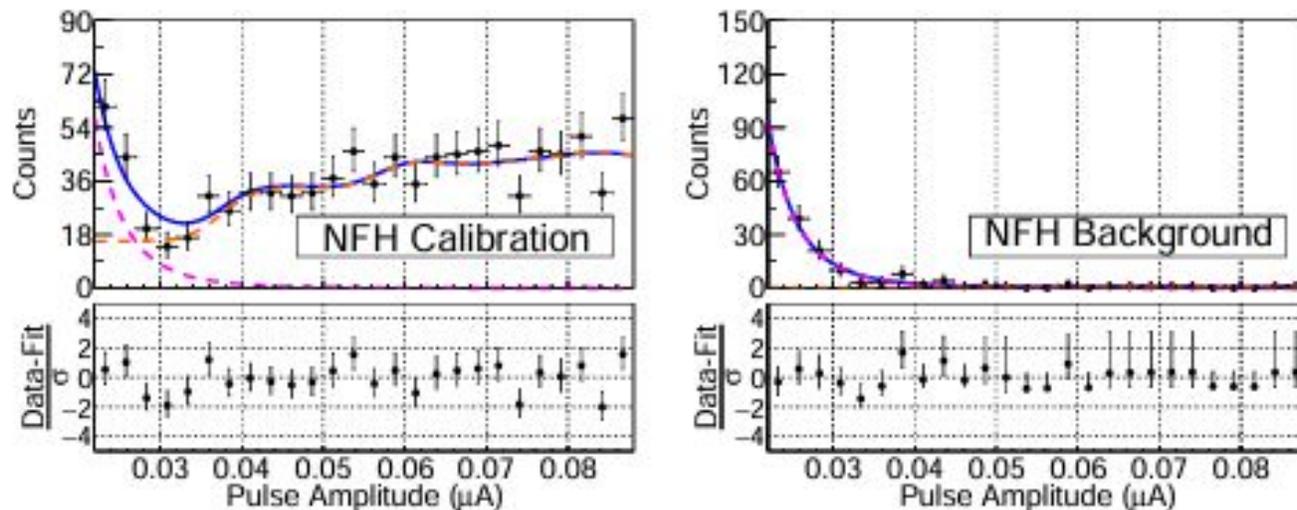
Goal: accounting for correlated noise between channels and for position-dependent variations in pulse shape



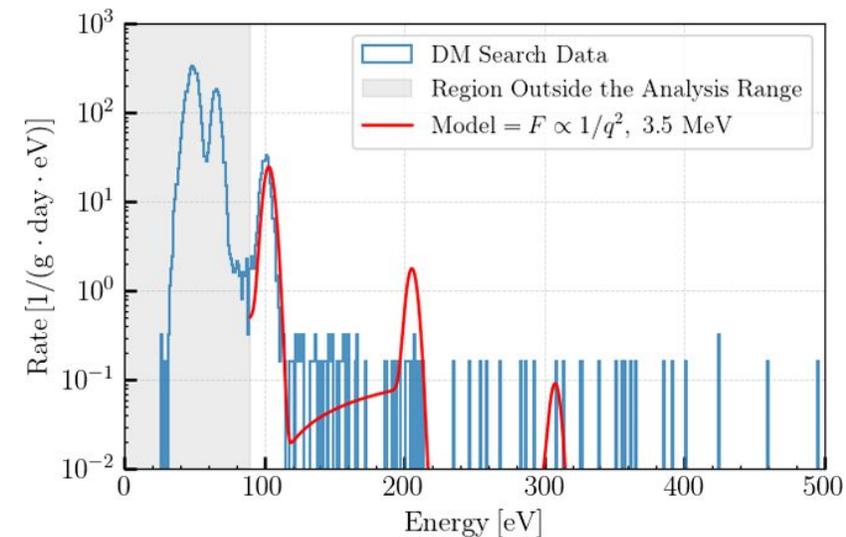
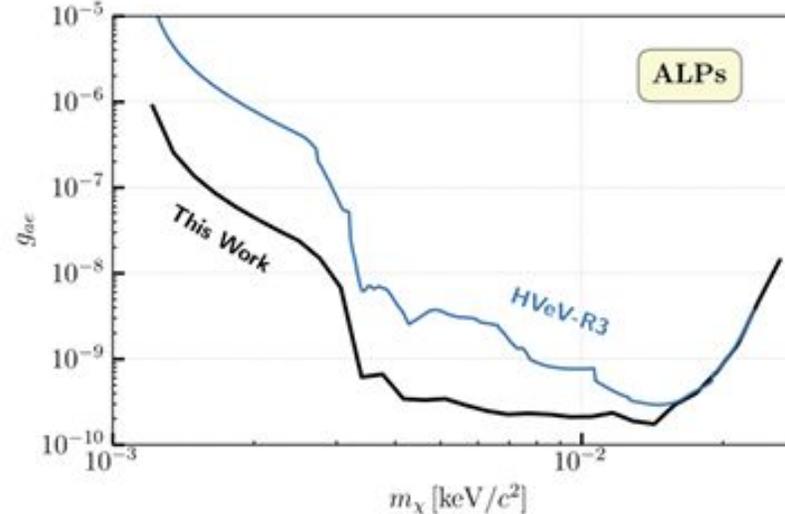
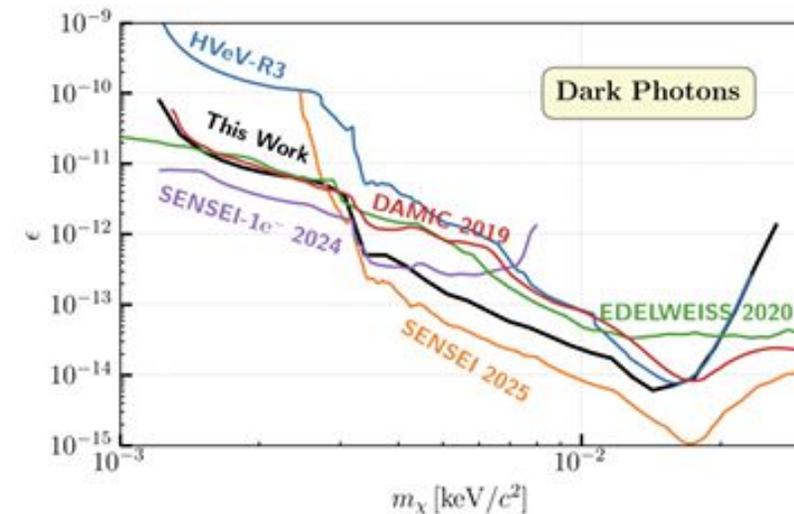
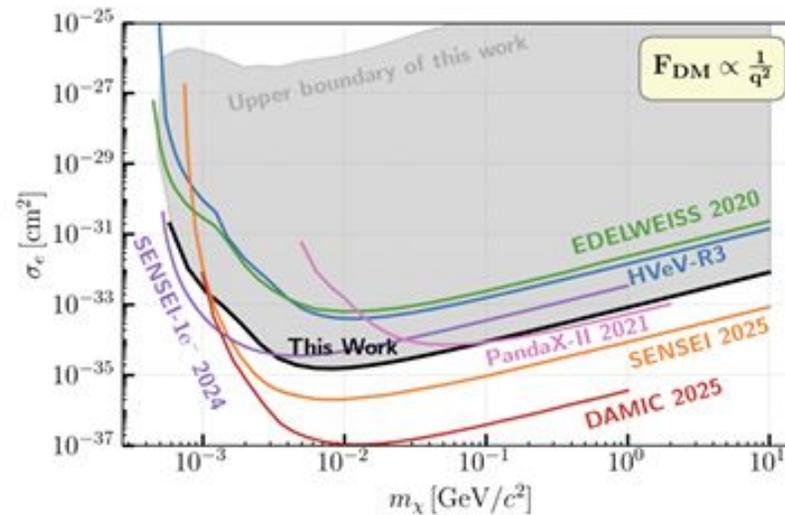
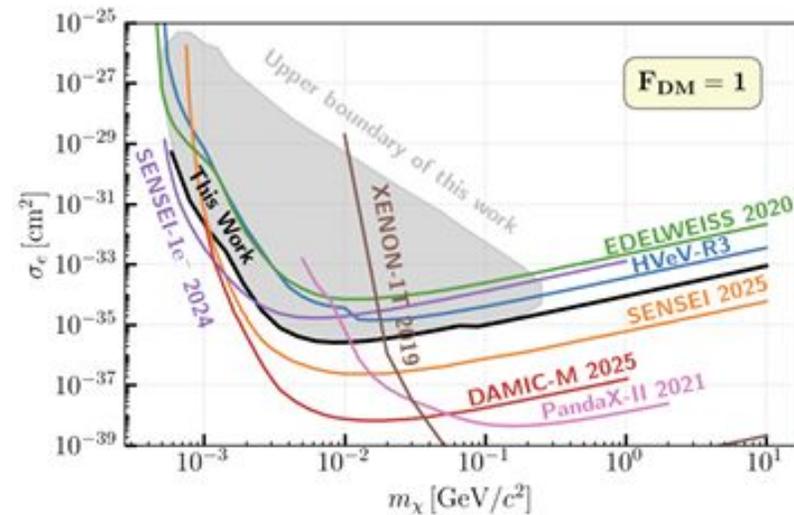
HVeV Run 4 @NEXUS: Si calibration using Compton steps



Simultaneous fit of datasets for L-steps: Compton + LEE

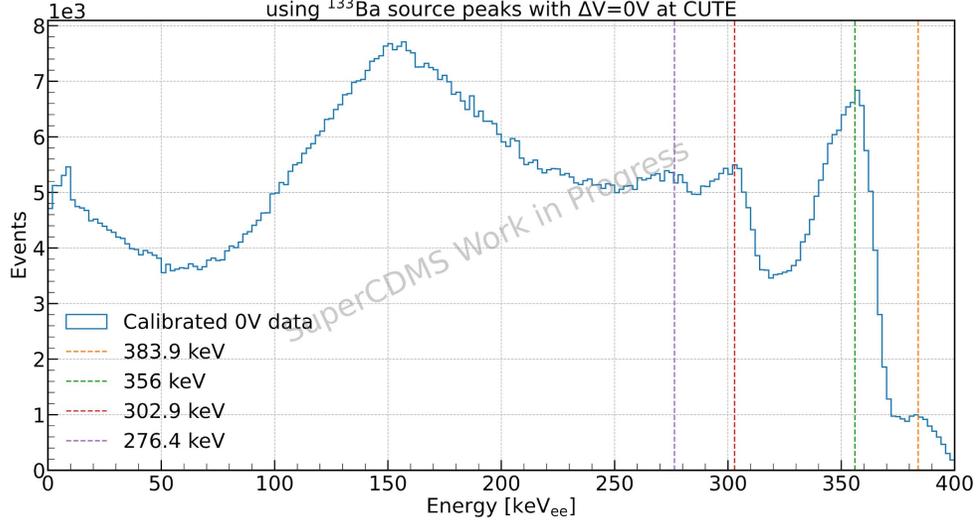


HVeV Run 4 @NEXUS: ERDM searches

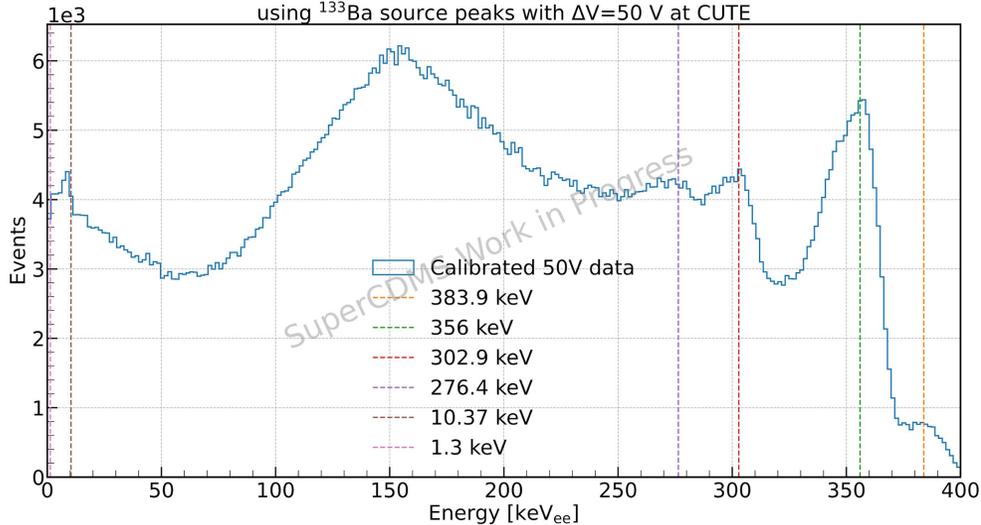


HV Tower test at CUTE: Ge Calibration results

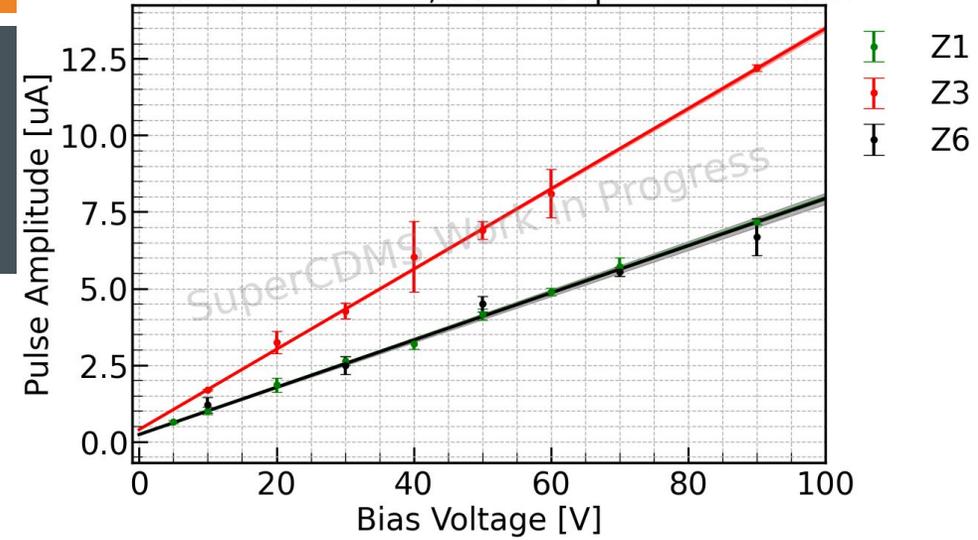
Calibration of tower 3 detector 1 at high energies using ^{133}Ba source peaks with $\Delta V=0\text{V}$ at CUTE



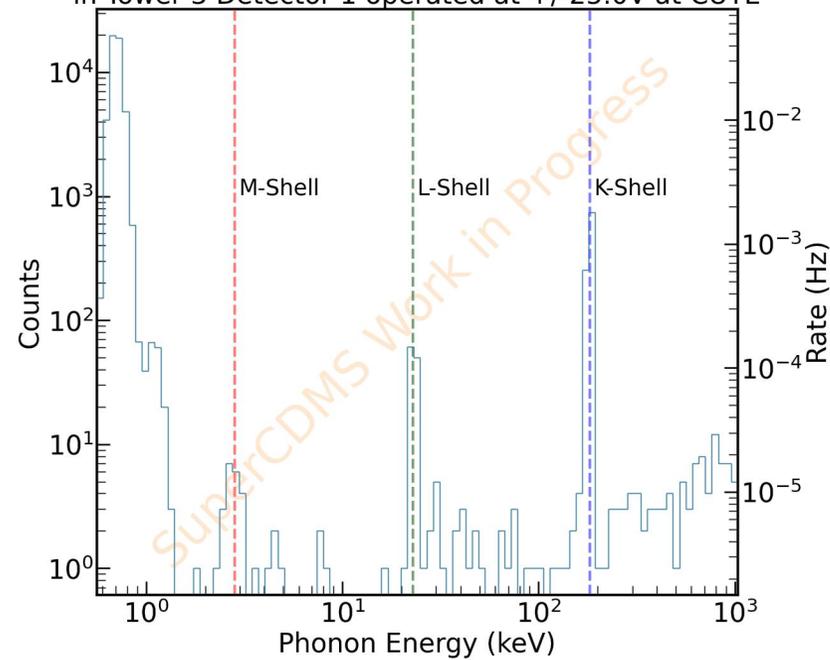
Calibration of tower 3 detector 1 at high energies using ^{133}Ba source peaks with $\Delta V=50\text{V}$ at CUTE



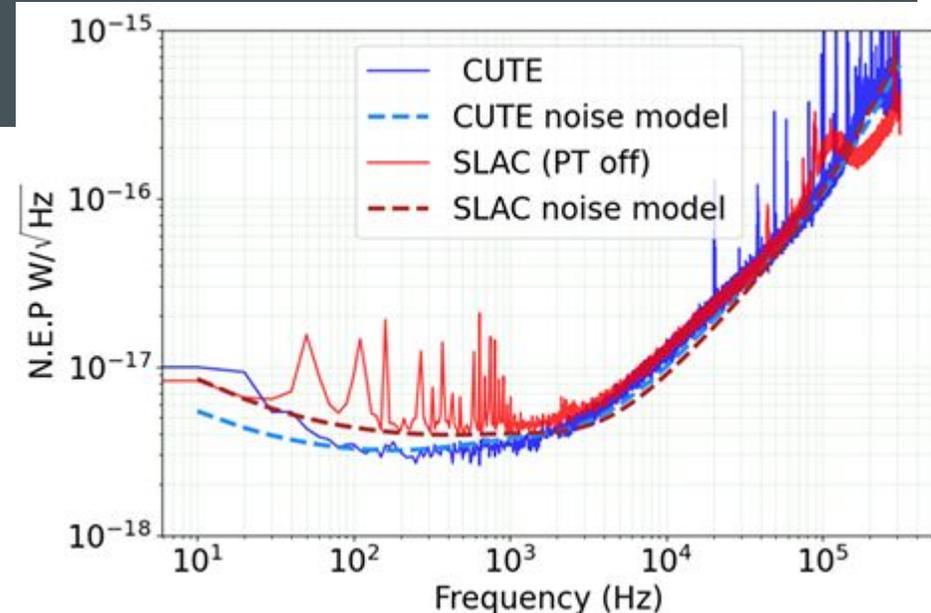
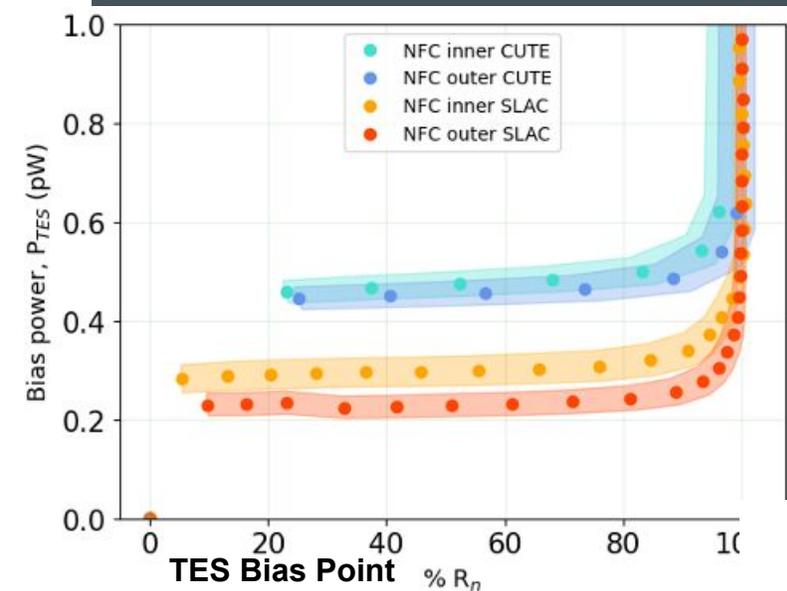
The L Shell peak position as a function of voltage
Tower 3 Detectors 1, 3 and 6 operated at CUTE



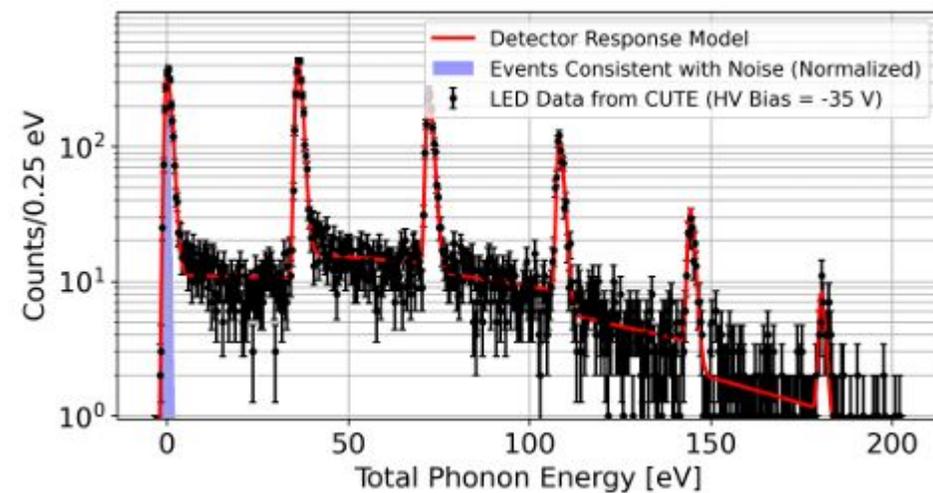
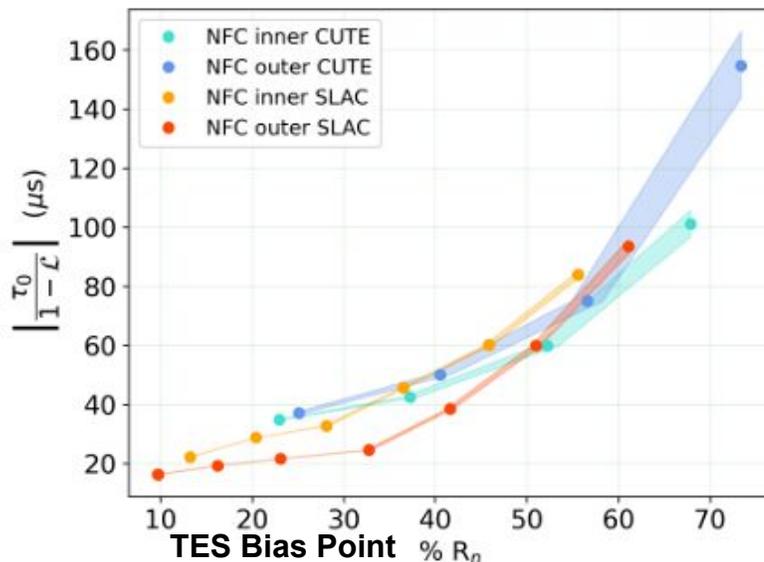
Calibrated Ge activation peaks in Tower 3 Detector 1 operated at $\pm 25.0\text{V}$ at CUTE



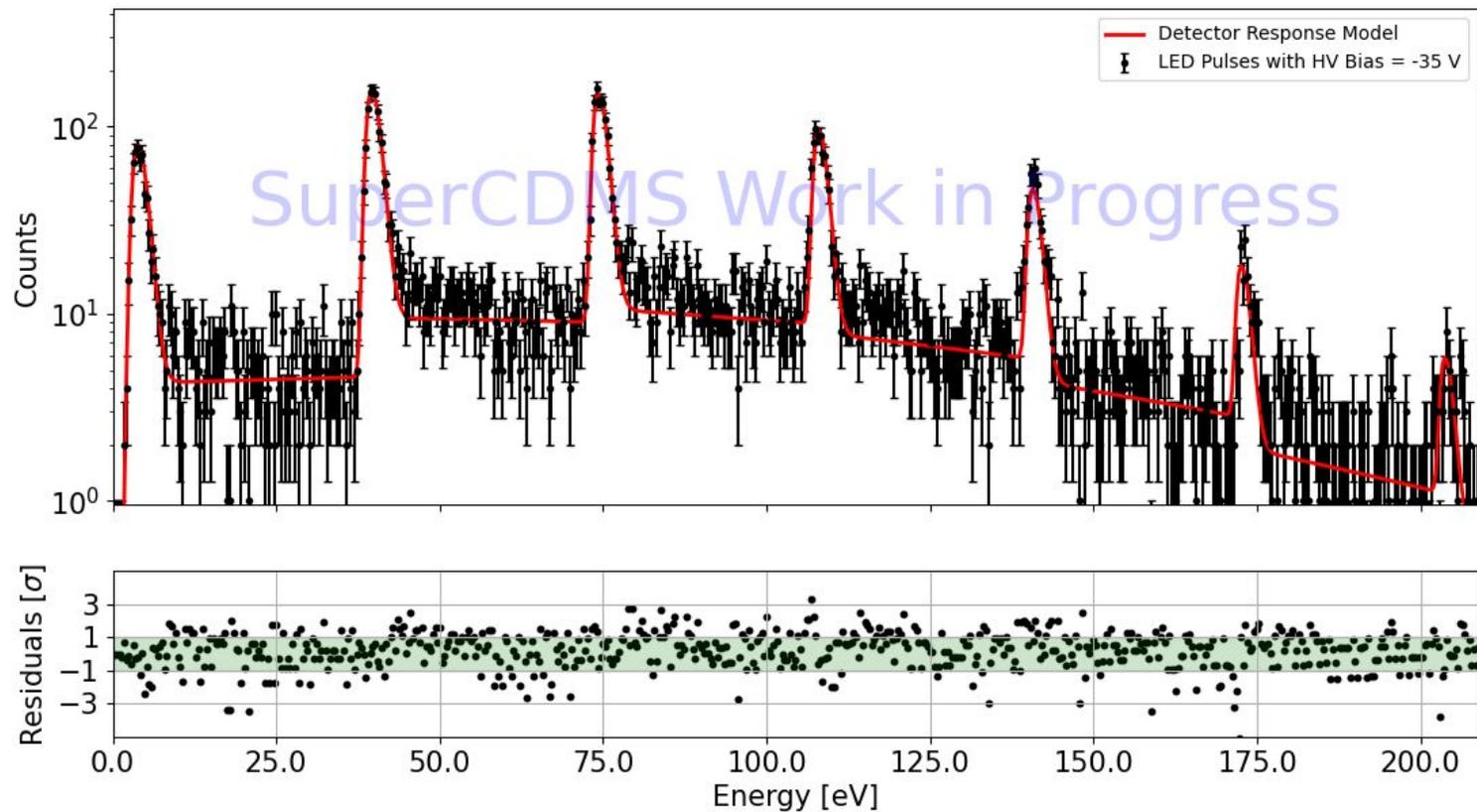
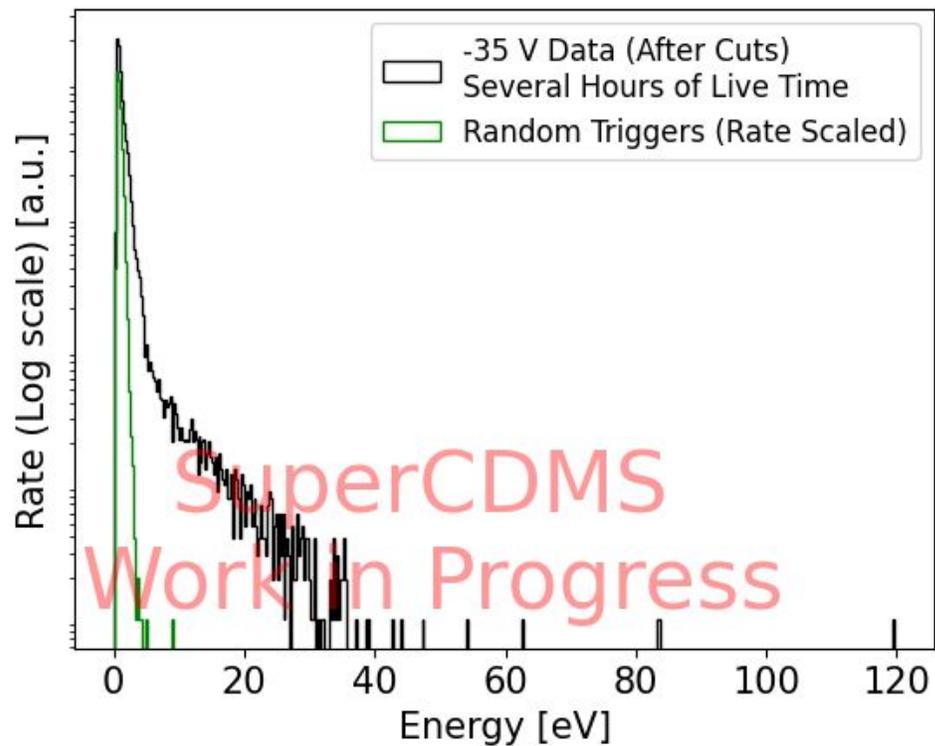
HVeV Run 5 @CUTE: device characterization, in comparison to run at SLAC surface facility



Description	Unit	SLAC	CUTE
Resolution	meV	900^{+22}_{-2}	612 ± 4
Charge trapping probability	%	10^{+2}_{-3}	27.1 ± 0.3
Impact ionization probability	%	7^{+3}_{-2}	1.2 ± 0.4
Surface trapping probability	%	29^{+1}_{-2}	18.5 ± 0.5
Collected photon energy	eV	$2.6^{+0.1}_{-0.2}$	1.23 ± 0.03
Linear calibration factor	$eV/\mu A$	290^{+2}_{-4}	340.6 ± 0.3
Second-order calibration factor	$eV/\mu A^2$	27^{+5}_{-4}	55.2 ± 0.4
Photon energy	eV	3.40	2.0468 ± 0.0002
Lost photon energy	eV	$0.8^{+0.2}_{-0.1}$	0.81 ± 0.03



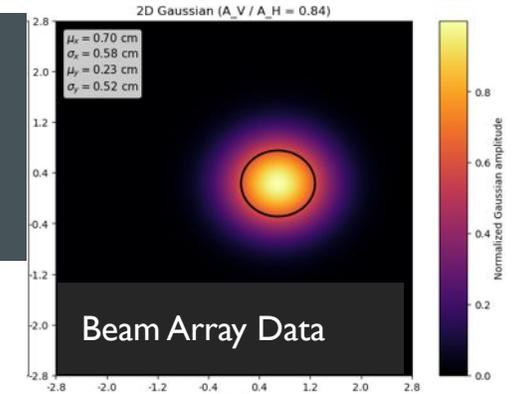
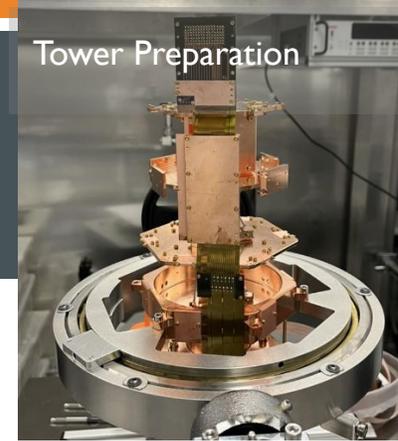
HVeV Run 5 @CUTE: analysis underway for ERDM search



NEXUS facility: preparation for Ge HV energy calibration campaigns

Single HV detector installed in a Tower at SNOLAB - Jan. 2026.

- Planning shipment to Fermilab and installation in NEXUS test stand



Backing Array at Northwestern:

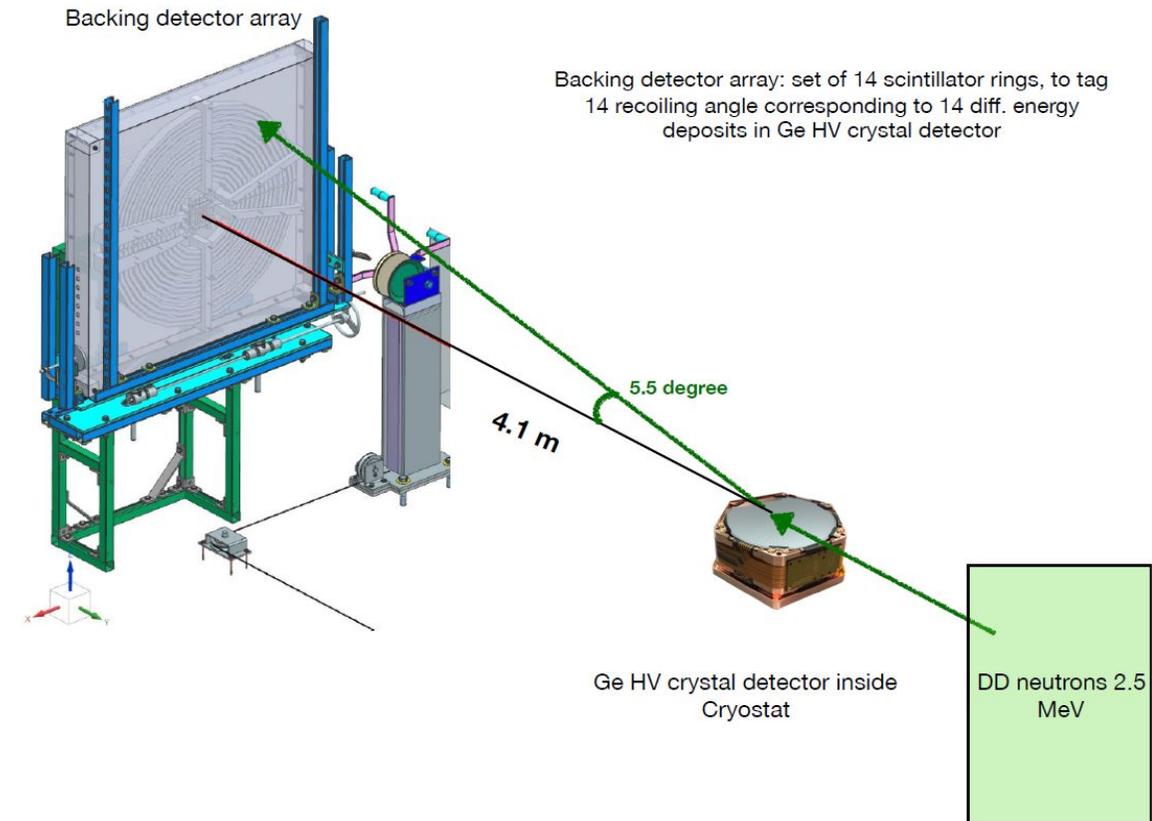
- *First data with beam array - Fall 2025*
- Integration of full array now complete
- Trigger settings need optimization

DD generator Commissioning:

- Operational since late 2024
- Electrical issues resolved Jan. 2026

Full integration underway:

- Check alignment of the DD generator.
- Installation of tower and backing array at NEXUS
- Commissioning in Spring



Conclusion ... Or, the Beginning!

- SuperCDMS SNOLAB commissioning over the next few months
- Stay tuned for first science-quality dataset by the end of the year!
- And we're still learning from test facility runs – about detector response, low-energy backgrounds, etc.

Thanks to SNOLAB for hugely valuable assistance in completing I&I !

