Status and updates from SuperCDMS SNOLAB

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Les Rencontres de Physique de la Vallée d’Aoste

2026/03/02

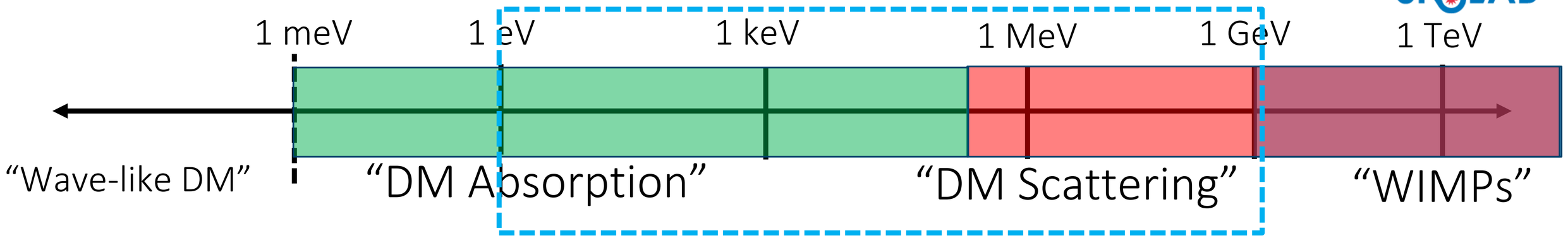
Outline

- SuperCDMS at SNOLAB
- HVeV program

SuperCDMS Collaboration

(+100 members, 27 institutions)

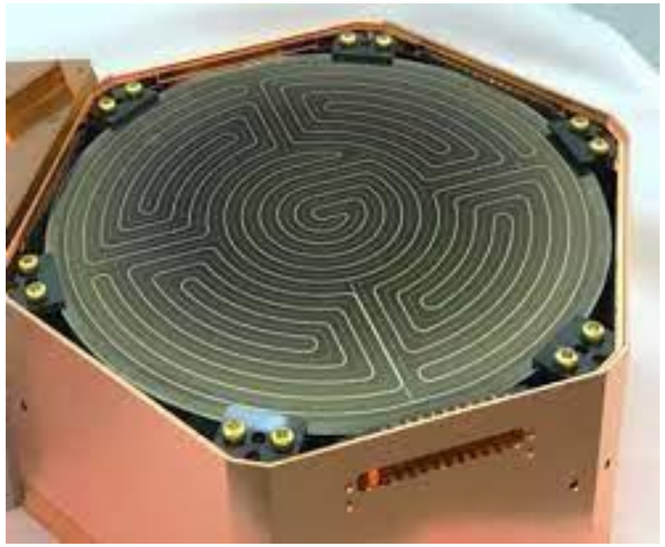
SuperCDMS Objectives



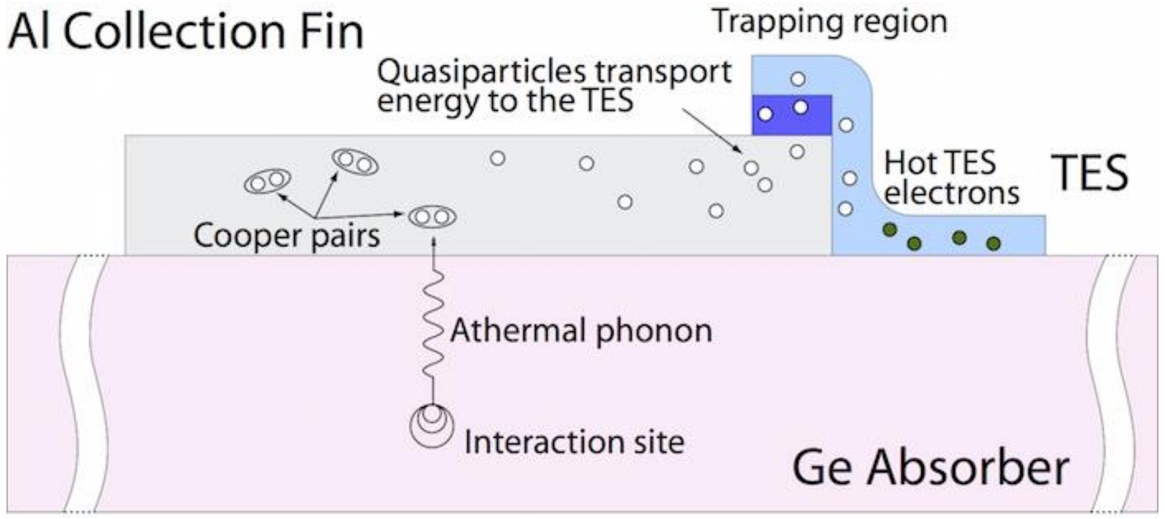
- Nucleon coupling: 0.05 – 5 GeV/c^2
- Dark photon-coupled light dark matter: 1 – 100 MeV/c^2
- Dark photon absorption : 1 – 100 eV/ c^2
- Axion-like particles absorption: 1 – 100 eV/ c^2

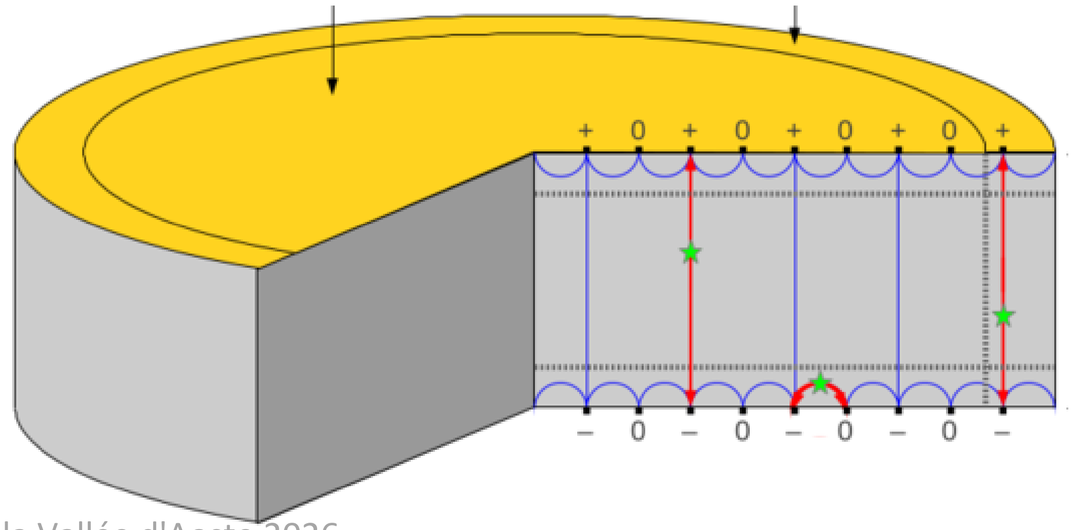
Adapted From: https://indico.cern.ch/event/1188759/contributions/5044015/

SuperCDMS Detectors

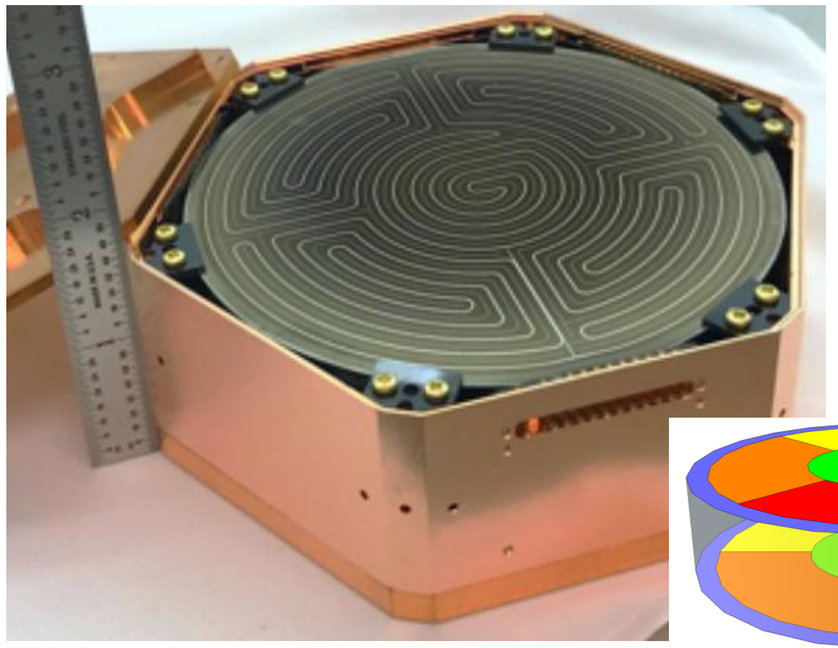


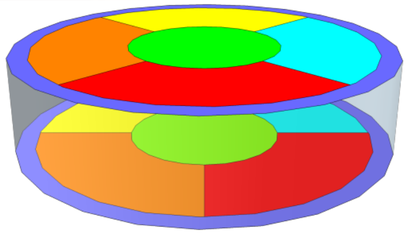
- Upgrade from CDMS and SuperCDMS Soudan (bigger and higher purity)
- Si(0.6 kg)/Ge (1.4 kg) cryogenic detectors
- Measure of **heat (phonon)** and **ionization**
- Heat is measured through Quasi-particle trap assisted electrothermal Feedback Transition Edge sensors (TES)
- Charge is measured through interleaved electrodes



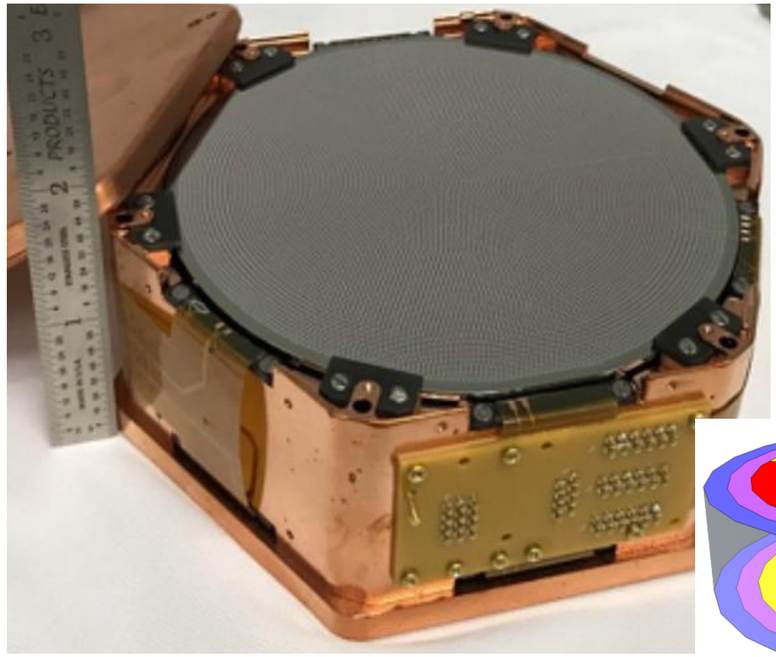


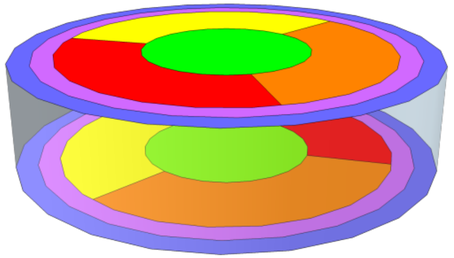
iZIP and HV SuperCDMS Detectors





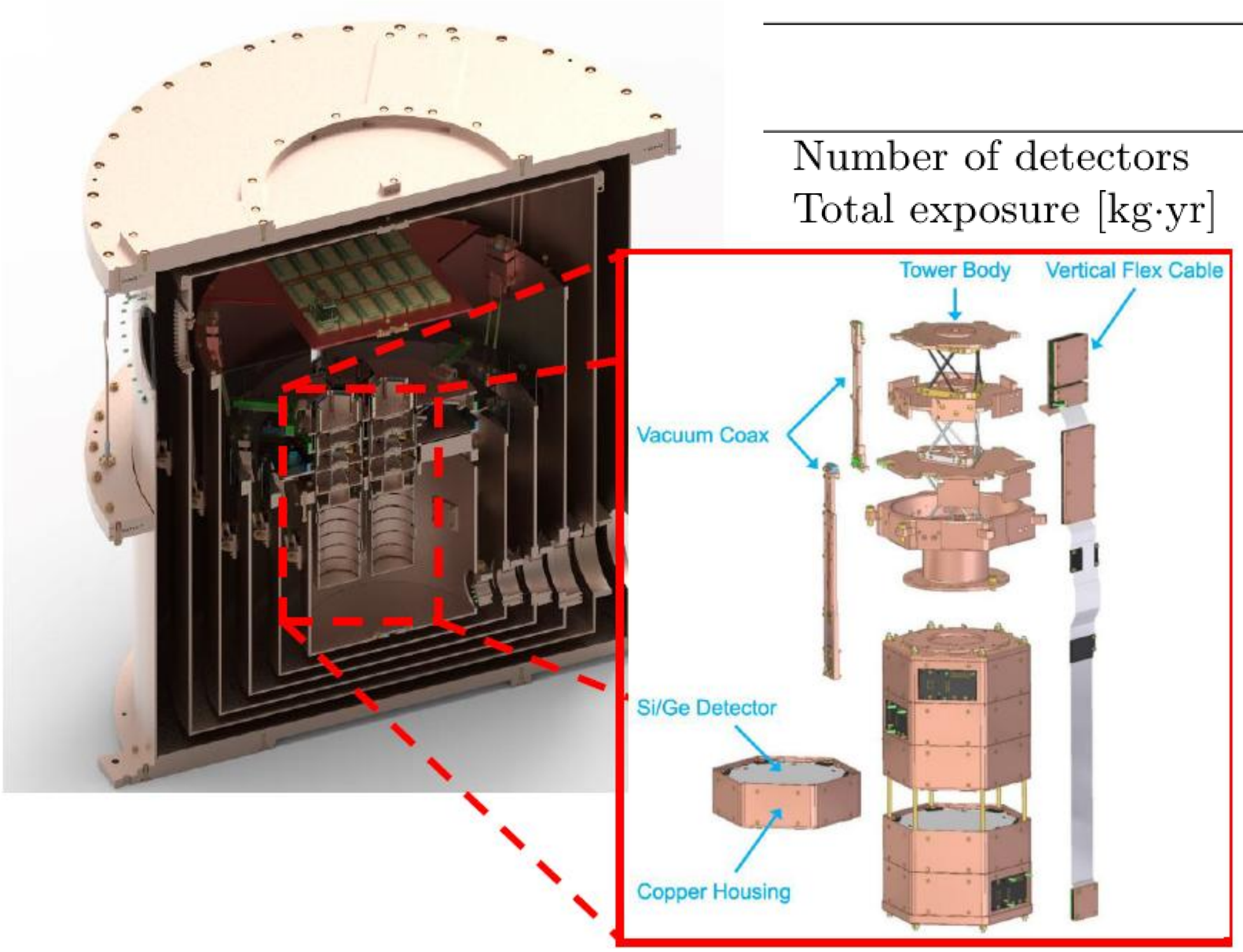
- iZIP (interleaved Z-sensitive Ionization and Phonon detector)
- 12 phonon, 4 charge channels
- Phonon and ionization channel allow for particle discrimination ER vs. NR



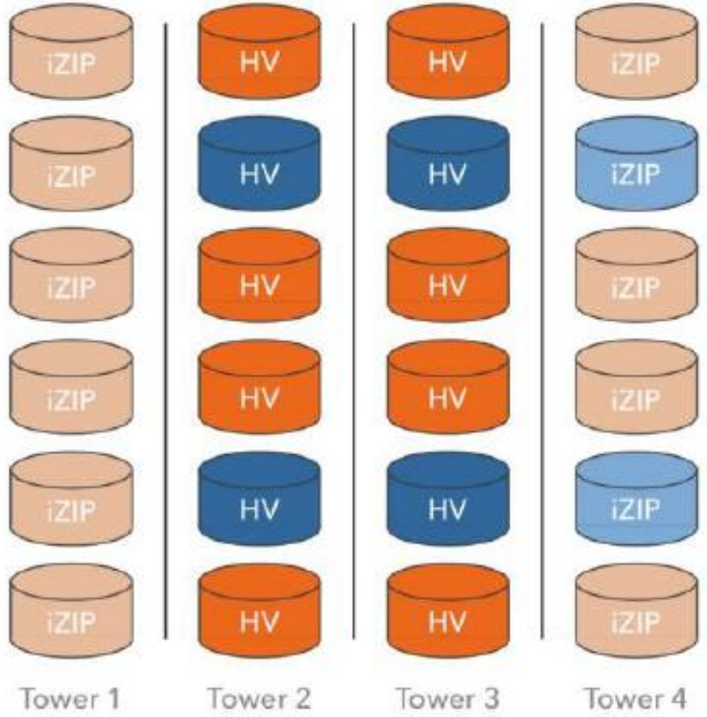


- HV (High Voltage detector)
- 12 phonon channels
- 100 V across the detector to exploit the Neganov-Trofimov-Luke (NTL) Effect

iZIP and HV SuperCDMS Detectors

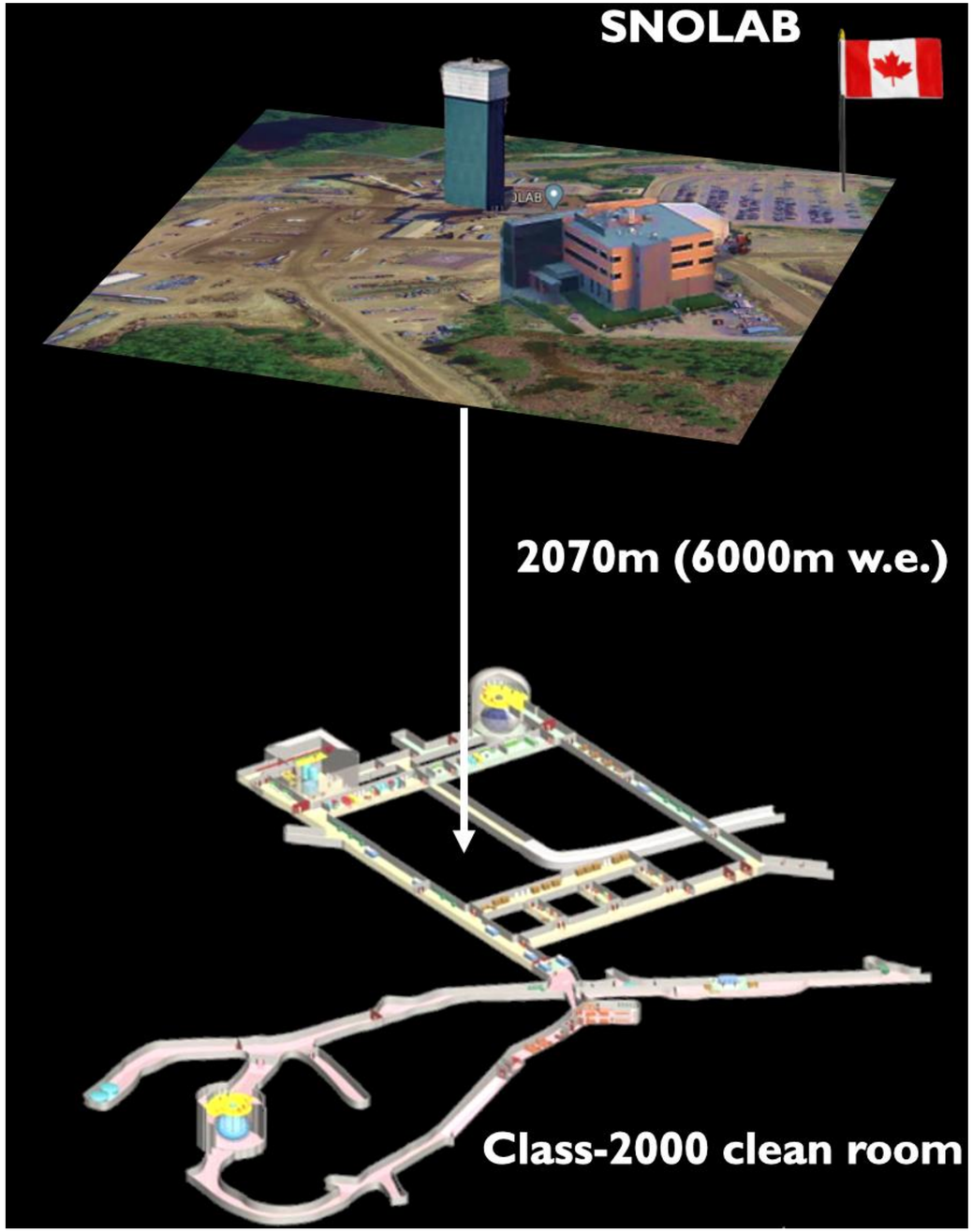


	iZIP		HV	
	Ge	Si	Ge	Si
Number of detectors	10	2	8	4
Total exposure [kg·yr]	45	3.9	36	7.8

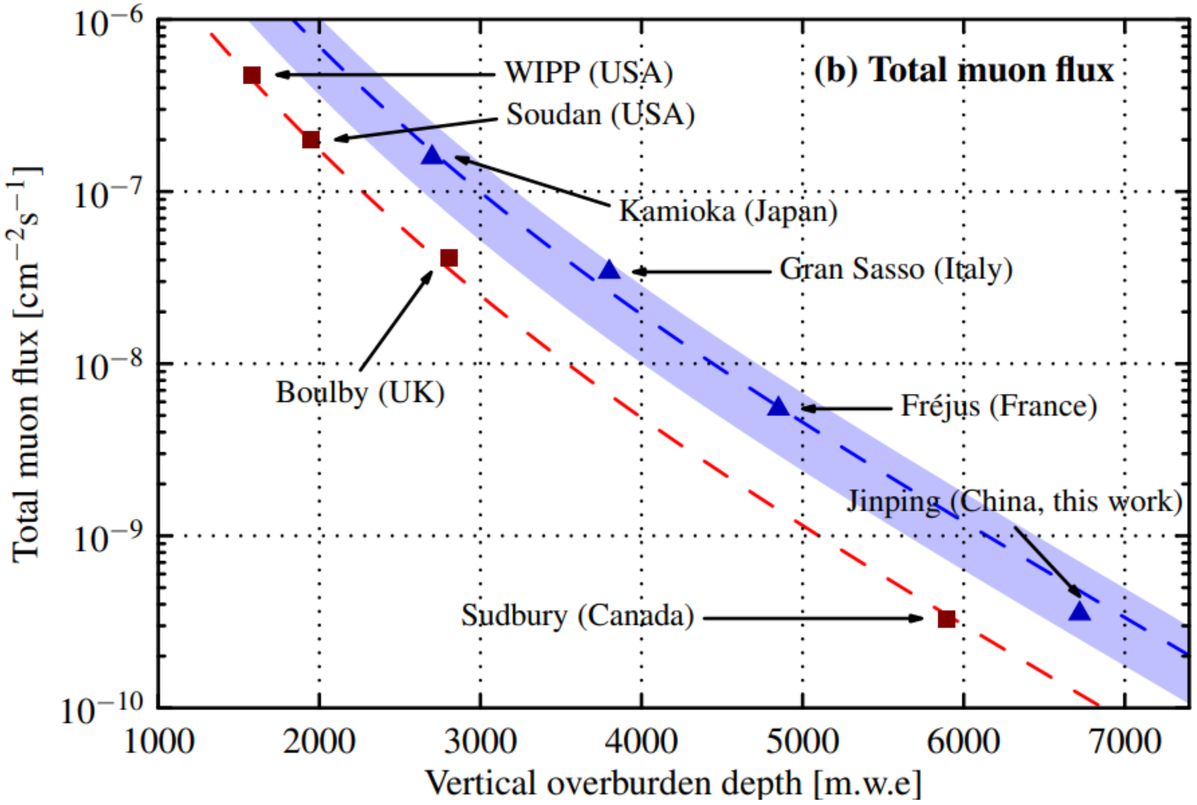


SNOLAB

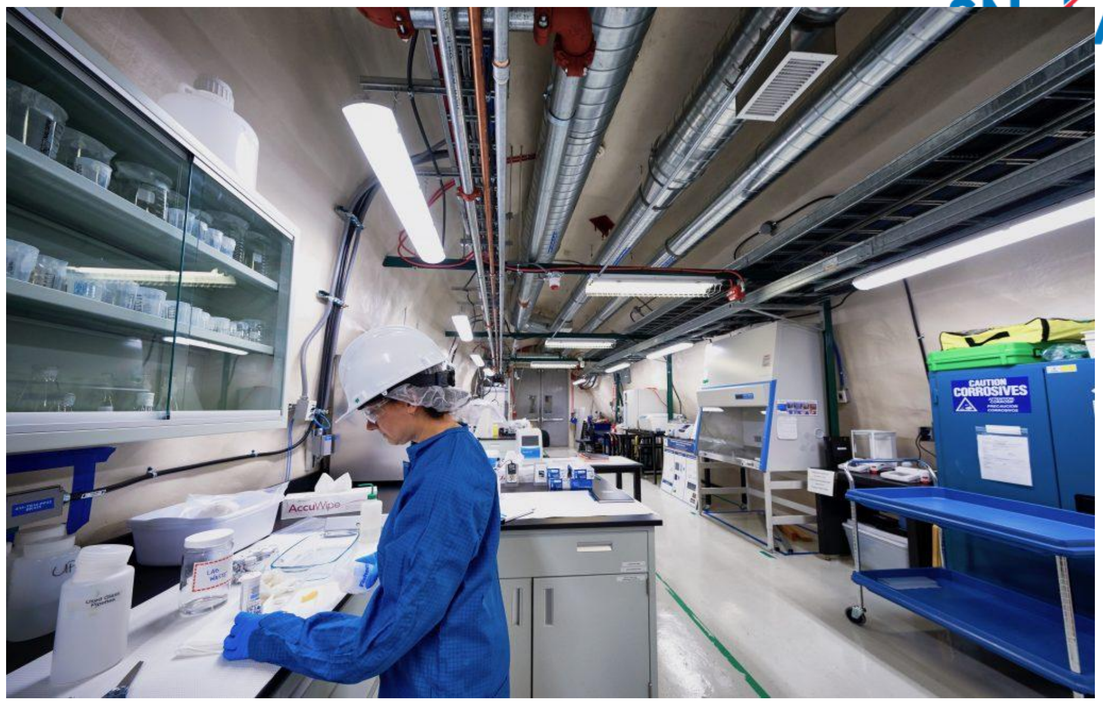
- SNOLAB is located at the Vale-Creighton mine just outside Sudbury
- On the traditional territory of the Robinson-Huron Treaty of 1850
- It is 2 km deep and operates as a class-2000 clean room
- Host to numerous particle physics experiments



Advantage at SNOLAB

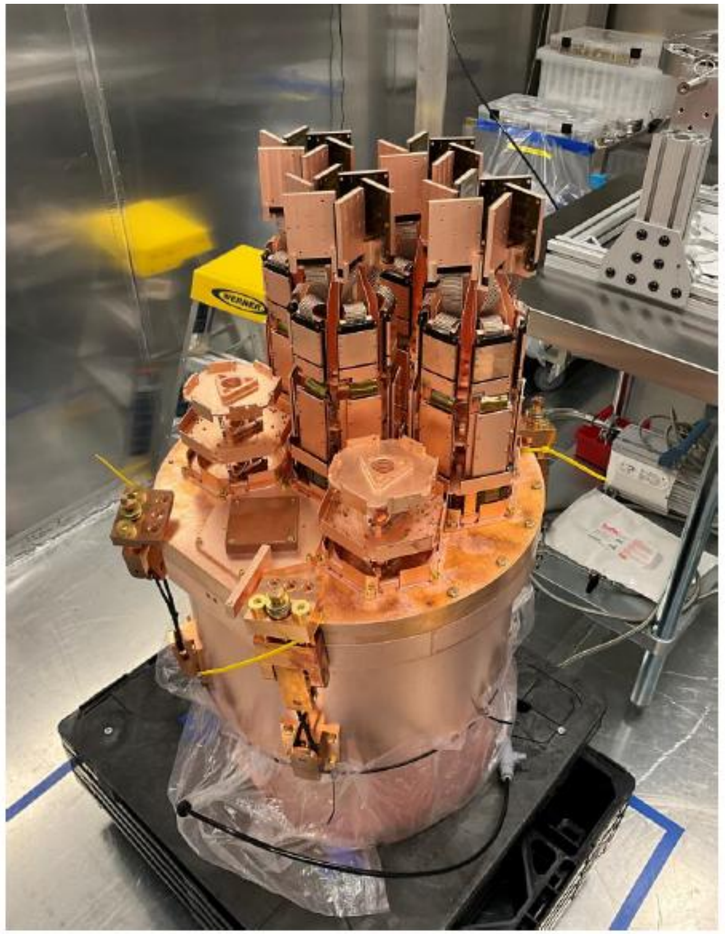


https://arxiv.org/pdf/2007.15925.pdf



- One of the lowest muon flux in the world
- Class-2000 clean-room
- <2000 particle >0.5µm in diameter per cubic feet
- SuperCDMS additionally employs a class-100 cleanroom

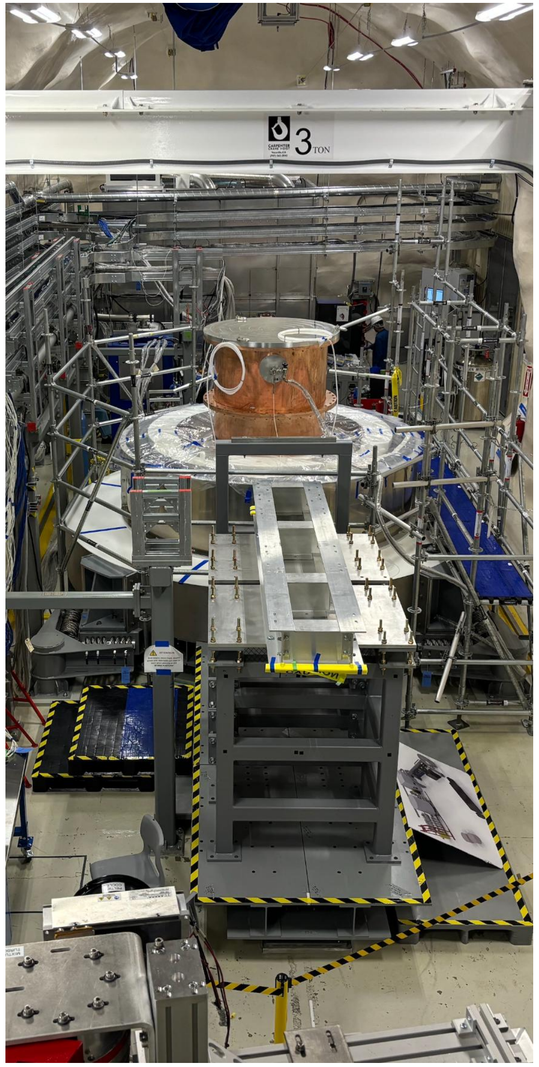
The building process



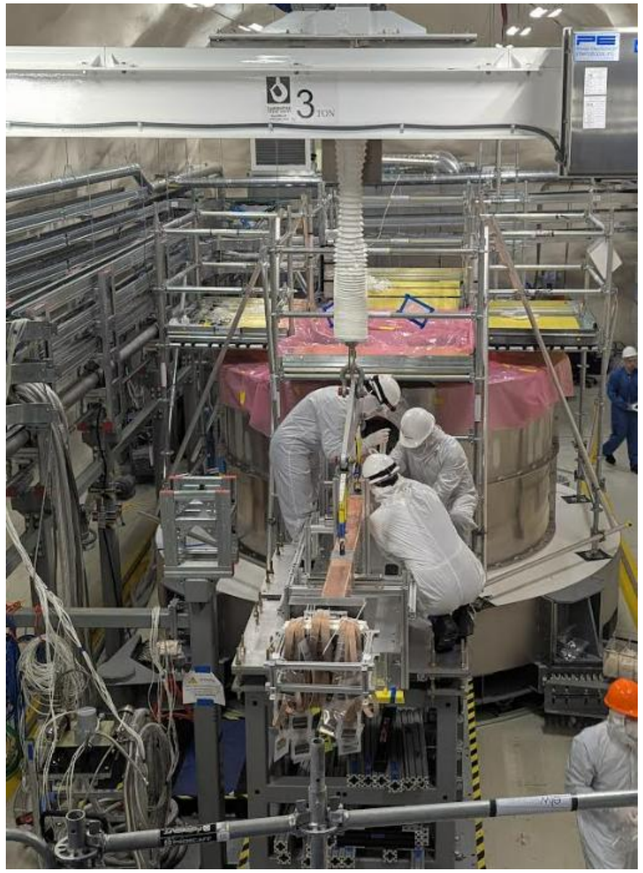
Current Construction

2022

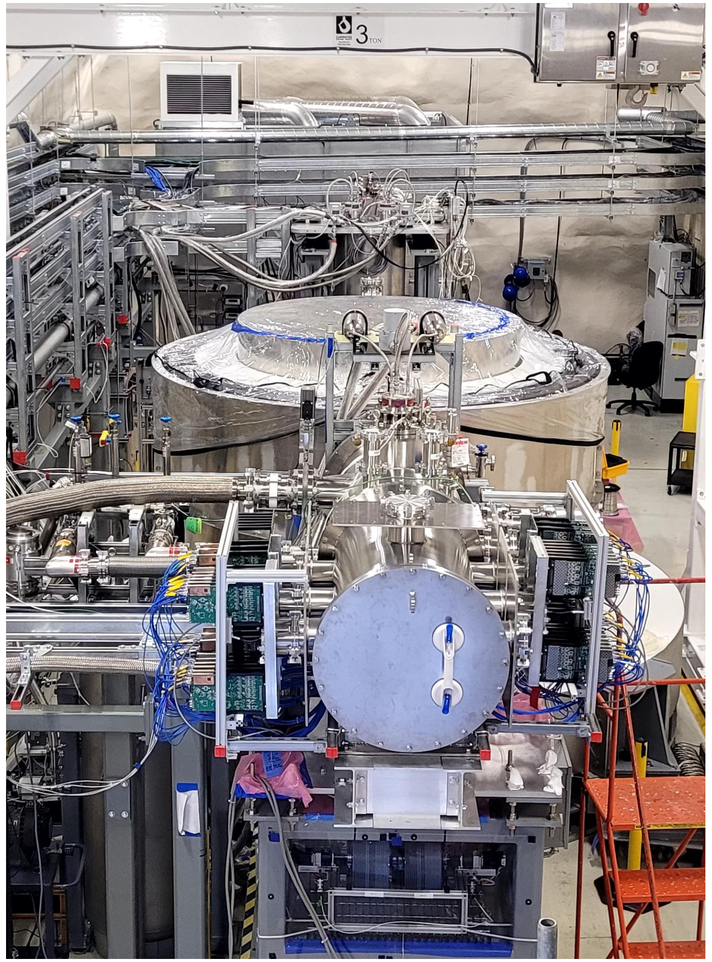
2024



May 2025

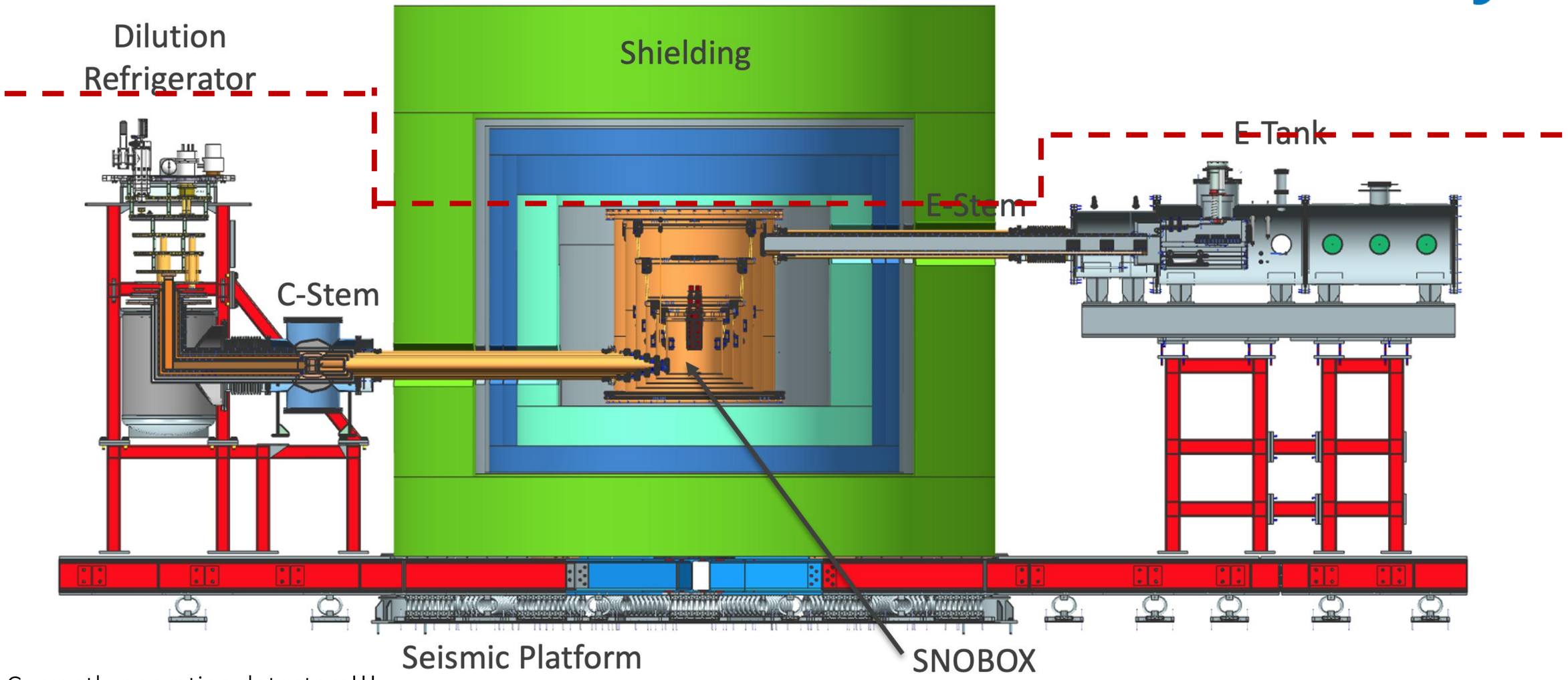


Feb. 2026



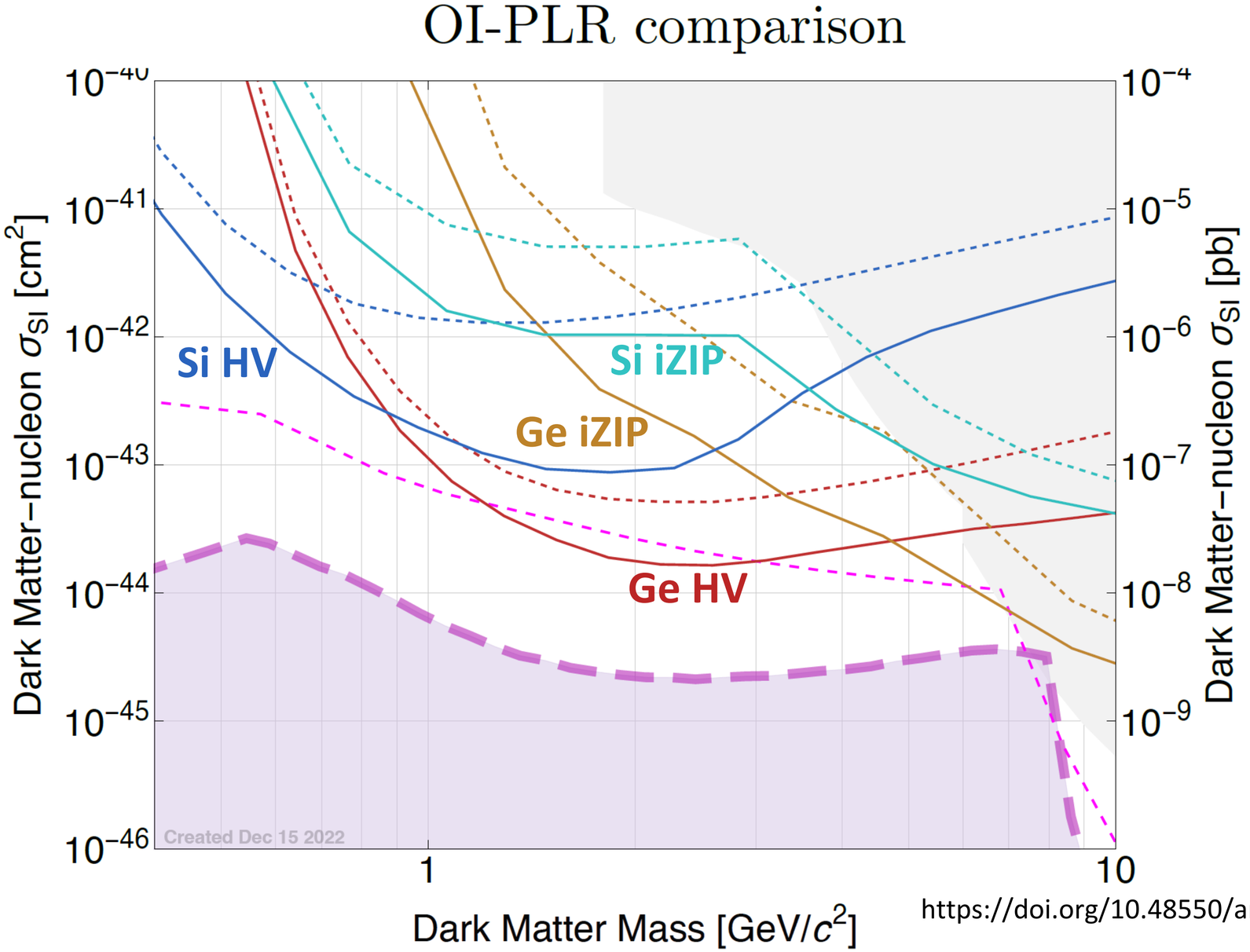
First cooldown and commissioning began this, Winter!!!

SuperCDMS Experimental Setup



- Currently operating detectors!!!
- Commissioning ~8 months: Detector characterization, calibration, activation
- Cooldown to operating temperature took > 60 days

SuperCDMS NRDM Sensitivity



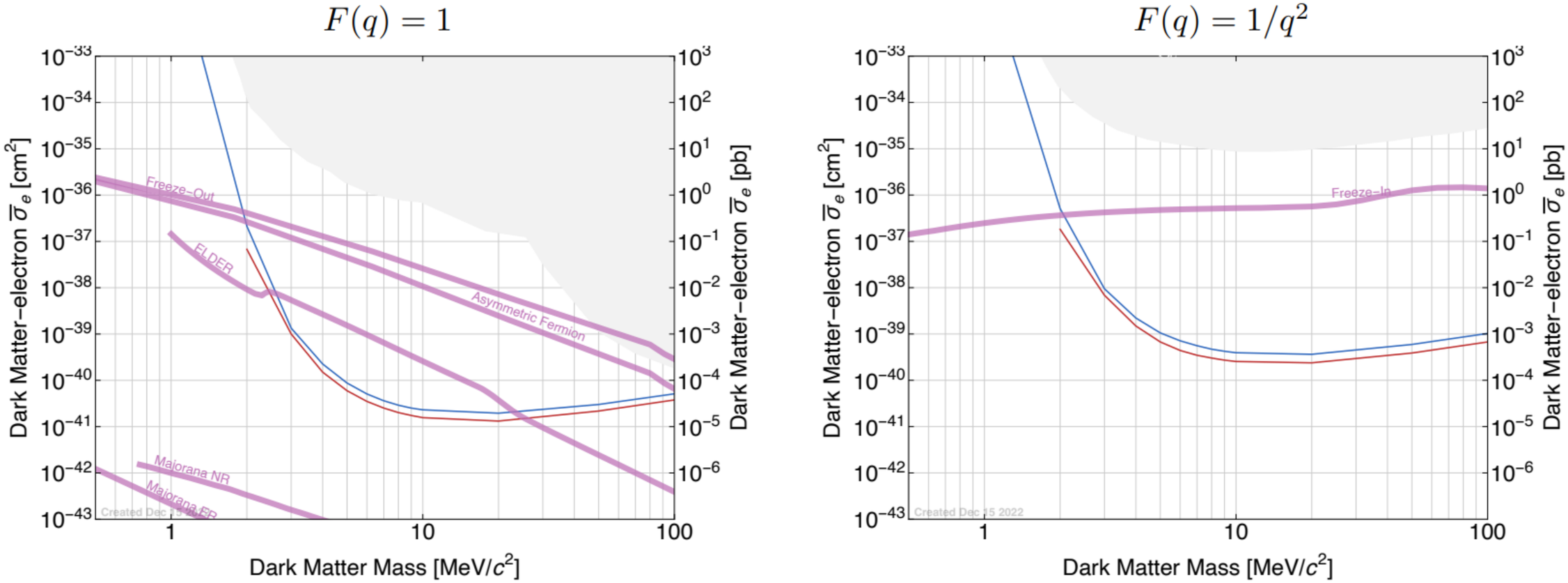
- 90% C.L. exclusion sensitivity using the optimal interval (dashed) and profile likelihood ratio (solid)
- Uses current estimate for detector performance and backgrounds
  - 4-year exposure

	iZIP		HV	
	Ge	Si	Ge	Si
Number of detectors	10	2	8	4
Total exposure [kg·yr]	45	3.9	36	7.8
Phonon resolution [eV]	33	19	34	13
Ionization resolution [eV$_{ee}$]	160	180	–	–
Voltage Bias ($V_+ - V_-$) [V]	6	8	100	100

https://doi.org/10.48550/arXiv.2203.08463

DM-electron scattering sensitivity

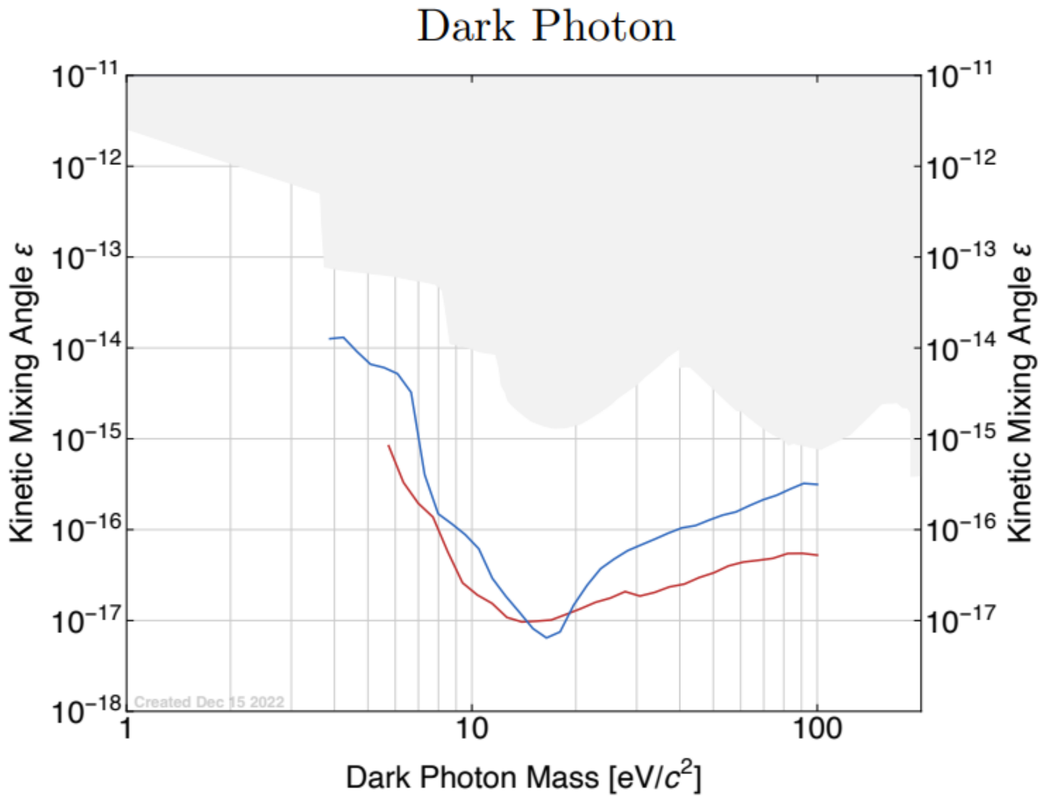
- SuperCDMS can probe electron scattering from photon coupled light DM (O(MeV)). Si = blue, Ge = Red

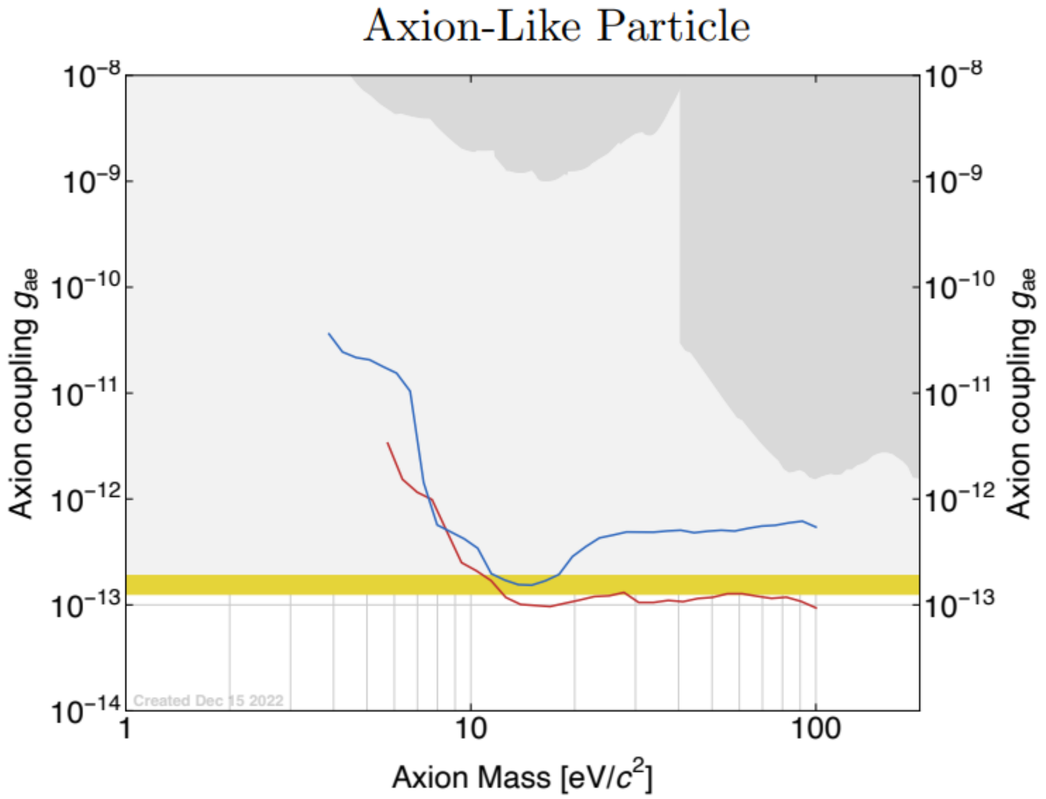


https://doi.org/10.48550/arXiv.2203.08463

Absorption Sensitivity

- SuperCDMS can probe even further by looking for dark photon (O(eV)) absorption (peak) or axion-like particle absorption (O(eV)). Si = blue Ge = Red

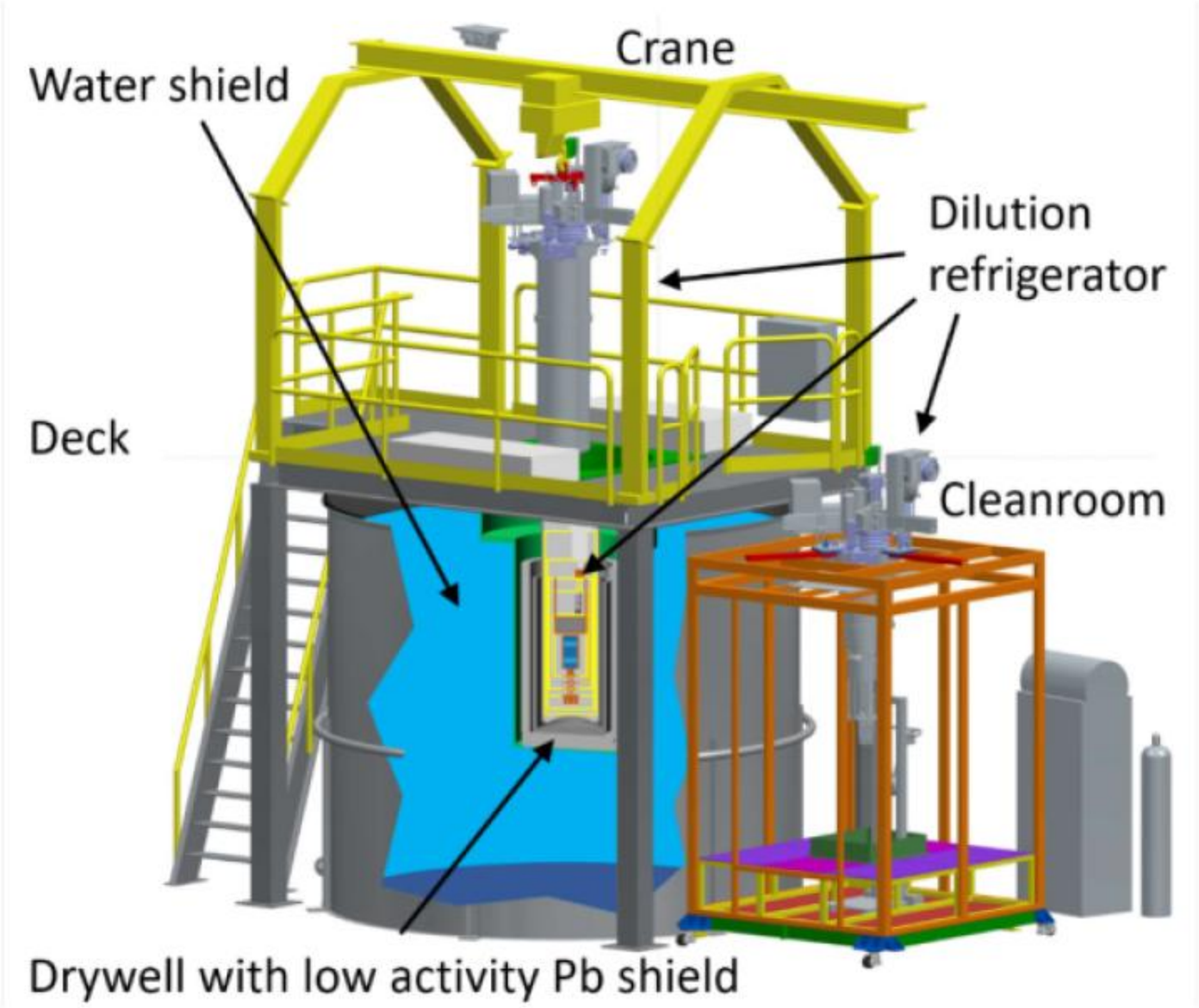




https://doi.org/10.48550/arXiv.2203.08463

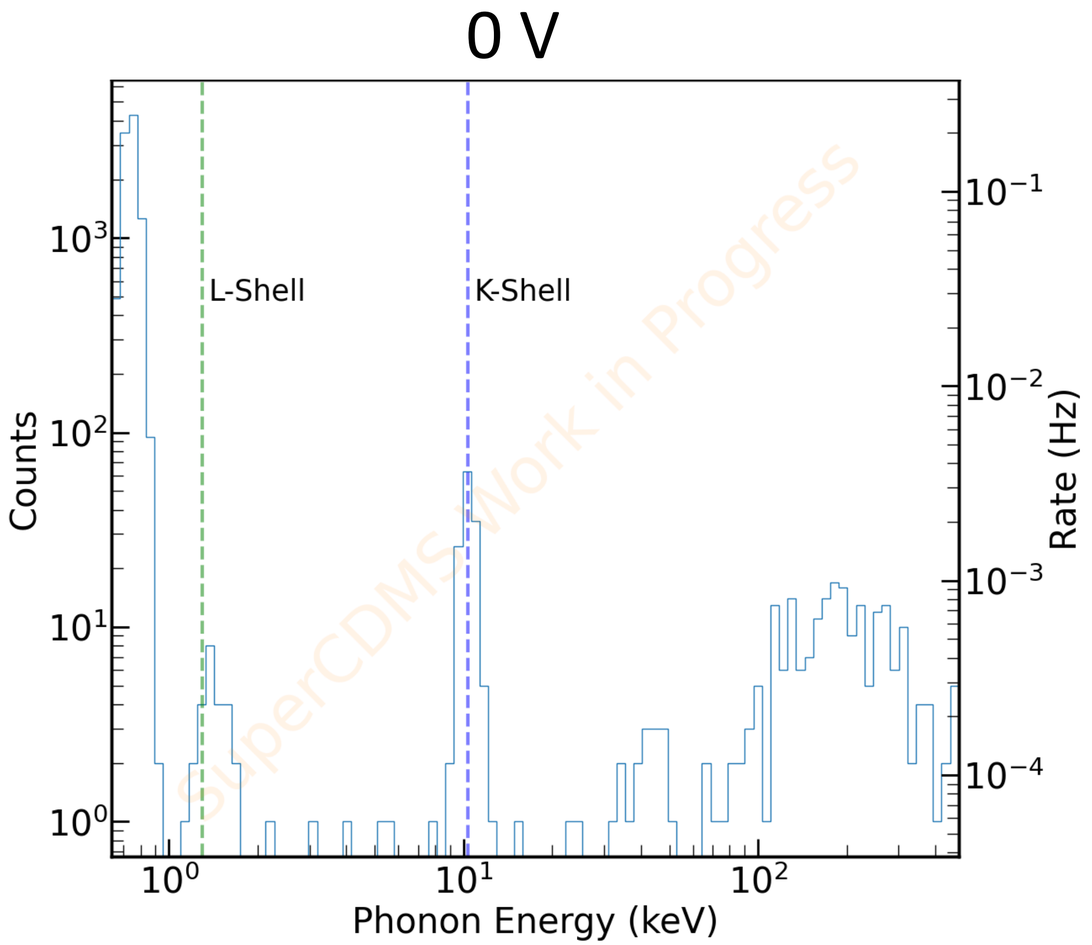
SuperCDMS Detector Testing

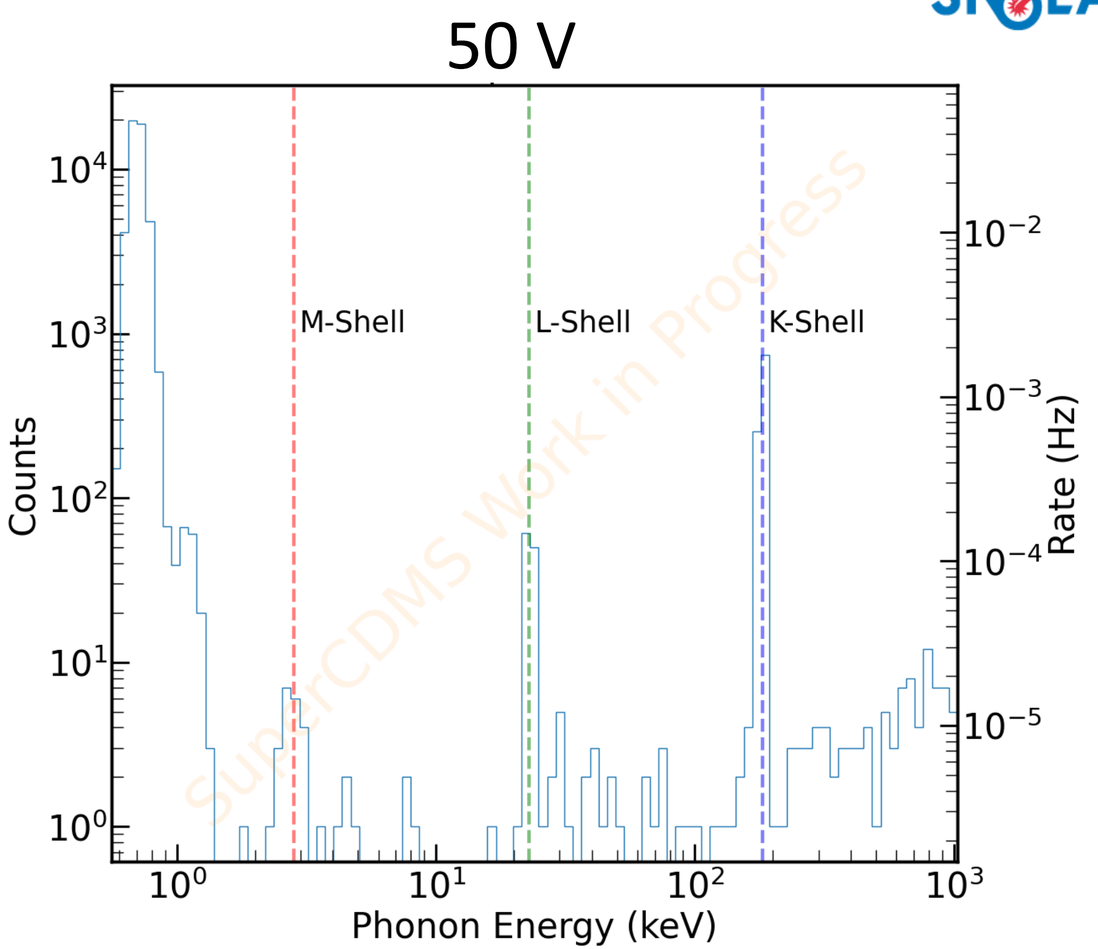
Testing at the CUTE Facility



- Cryogenic Underground TEsting Facility
- One full SuperCDMS HV tower (6 detectors) was placed into CUTE and operated for ~6 months
- Allowed for detector characterization (SQUIDs, Tc etc.),Noise modelling, calibration, Pulse shape characterization, data pipeline testing, HV operation and more

Ge Detector Calibration I





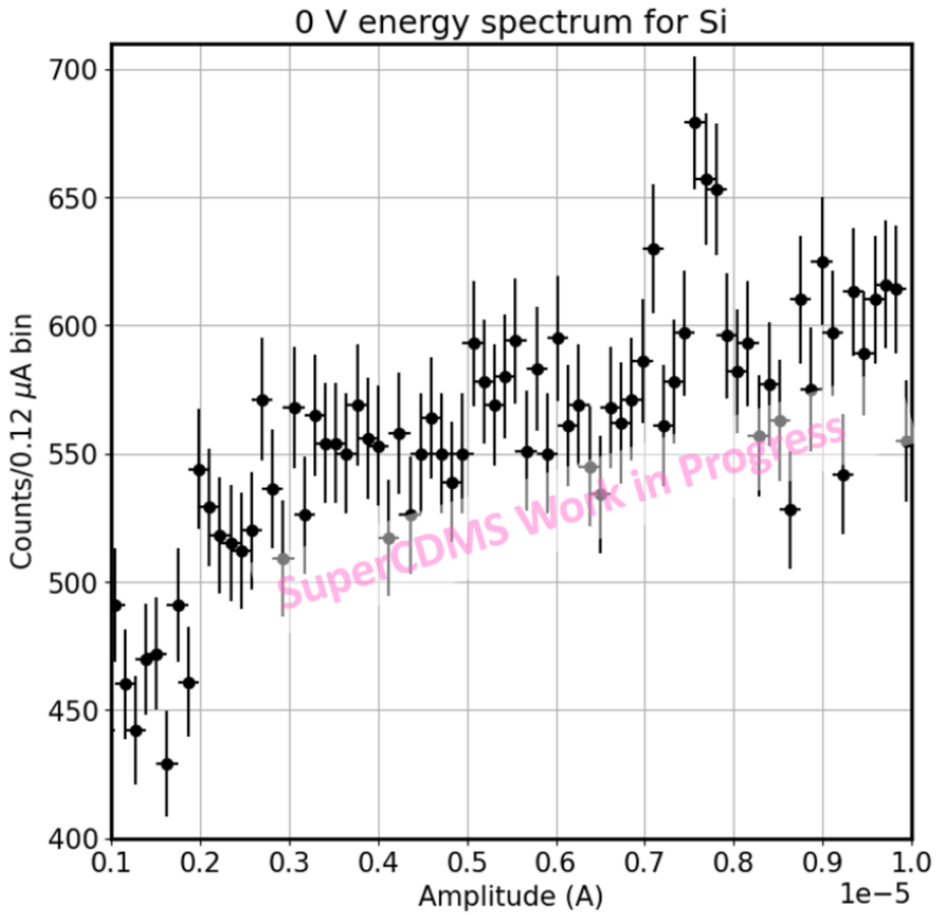
- Cf-252 neutron capture on Ge-70 -> leads to EC of Ge-71
- K-shell: 10.37 keV, L-Shell: 1.3 keV and M-shell: 0.16 keV

Ge Detector Calibration II

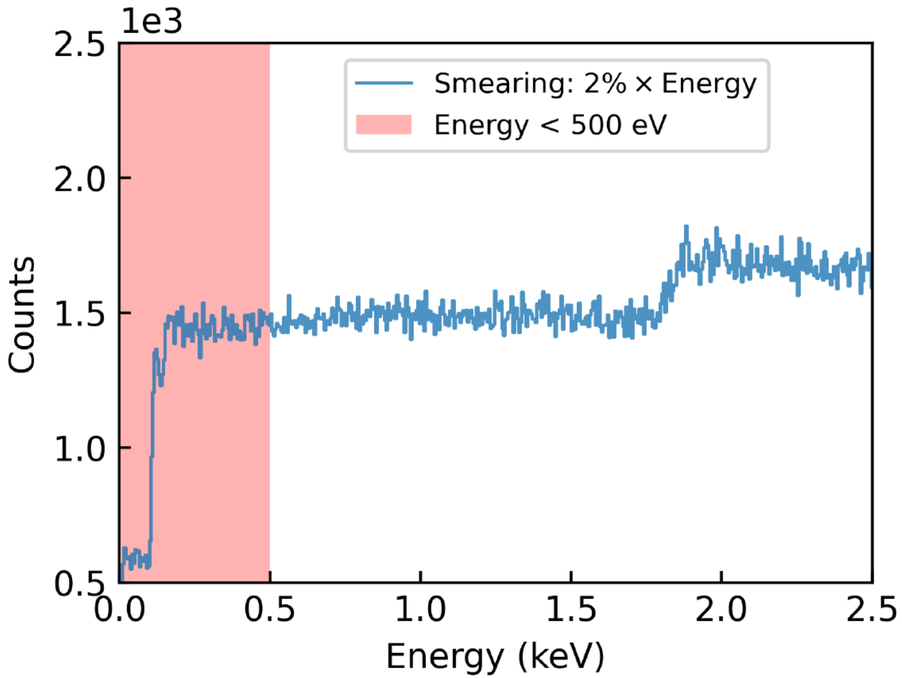
Summary of the measured baseline resolutions in total phonon energy units; SuperCDMS Work in Progress Results	
Detector/Voltage	**Best Measured Baseline Resolution (eV)**
Z1@0V	84.6 ± 0.7
Z3@0V	73.2 ± 1.0
Z6@0V	167 ± 14.0

- Improvements expected when operated in final setup
- Z6 is underperforming and not representative of SNOLAB detectors

Si Detector Calibration



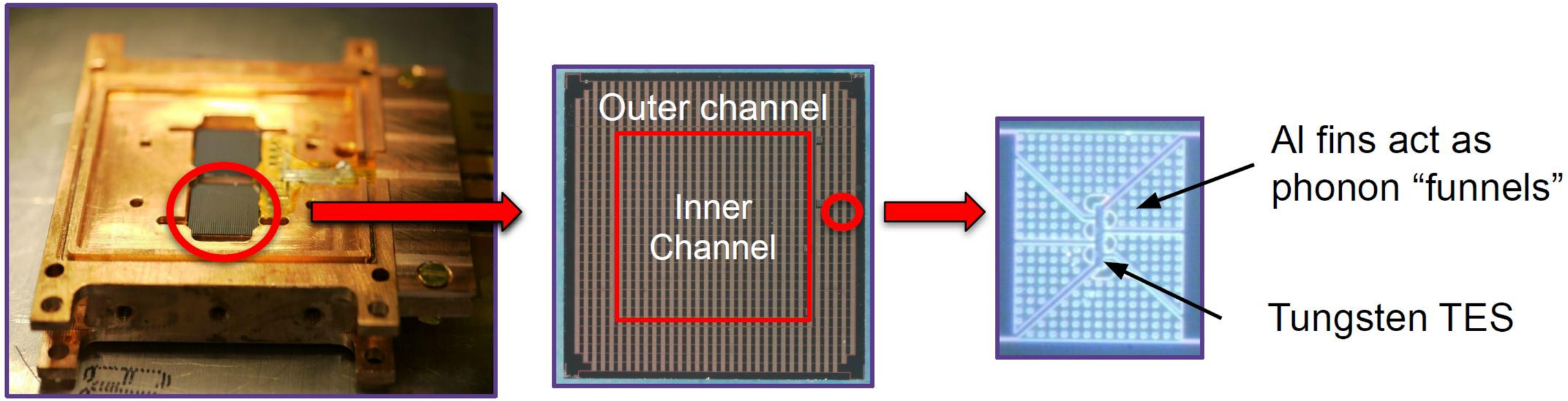
- Compton scattering will produce visible "steps" at K, L and M shell energy levels
- K-Shell: 1.8 keV
- Cu fluorescence peak ~8.1 keV



https://arxiv.org/abs/2508.02402

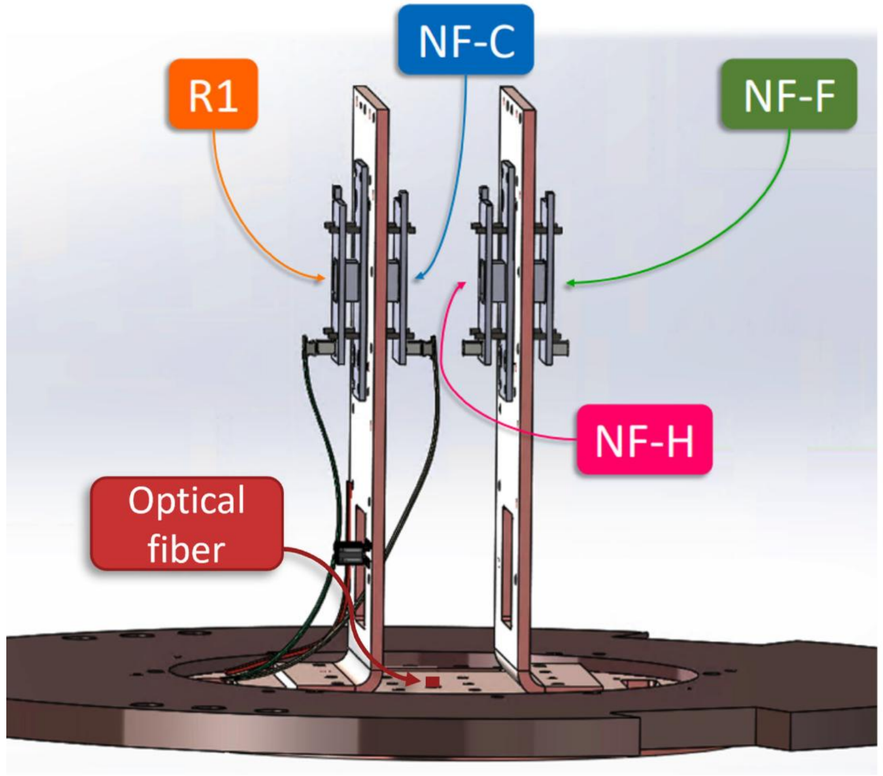
SuperCDMS HVeV Program

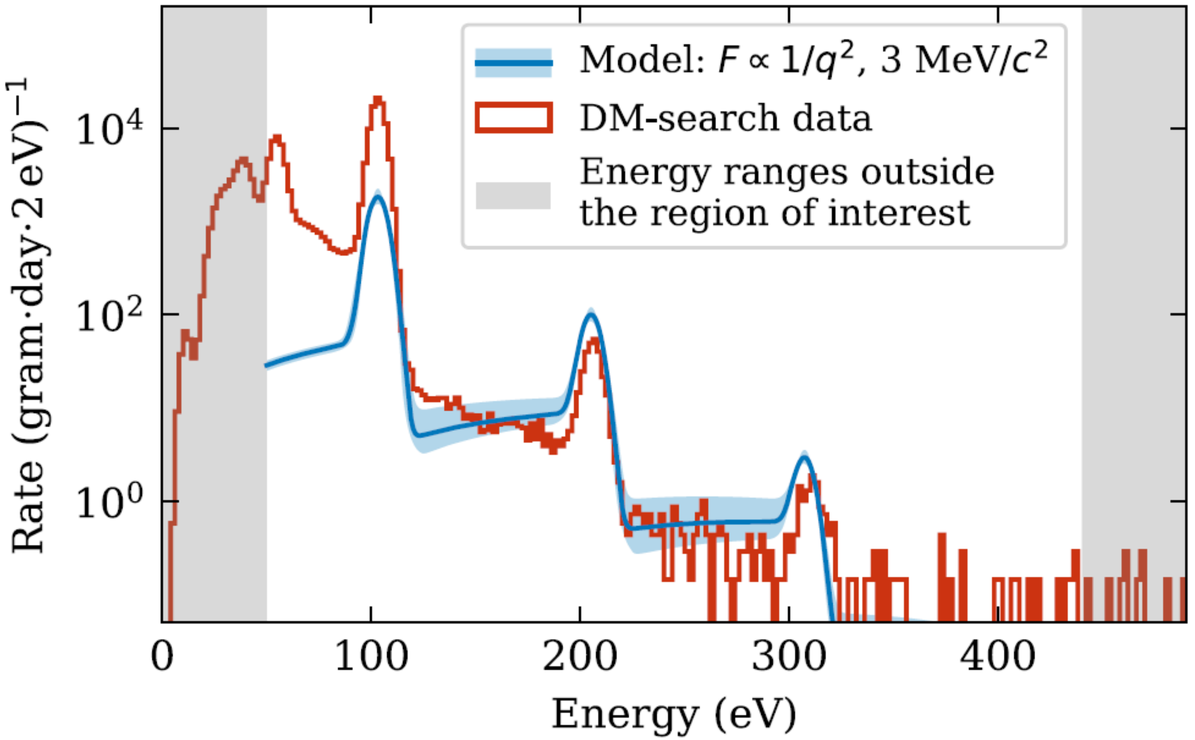
SuperCDMS- HVeV Program



- Gram-scale detectors aimed at achieving eV energy resolution
- Si: 10x10x4 mm^3
- Two channels (inner and outer), similar technology to SuperCDMS detectors
- Background studies, Low-mass dark matter searches

HVeV Run-3

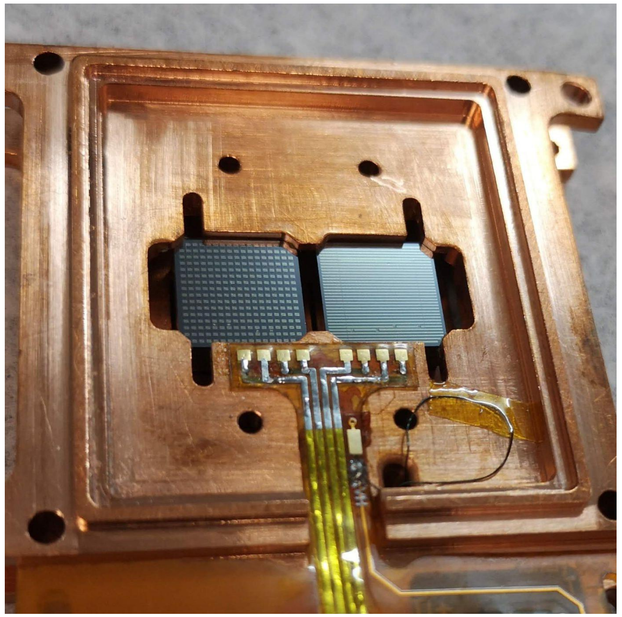


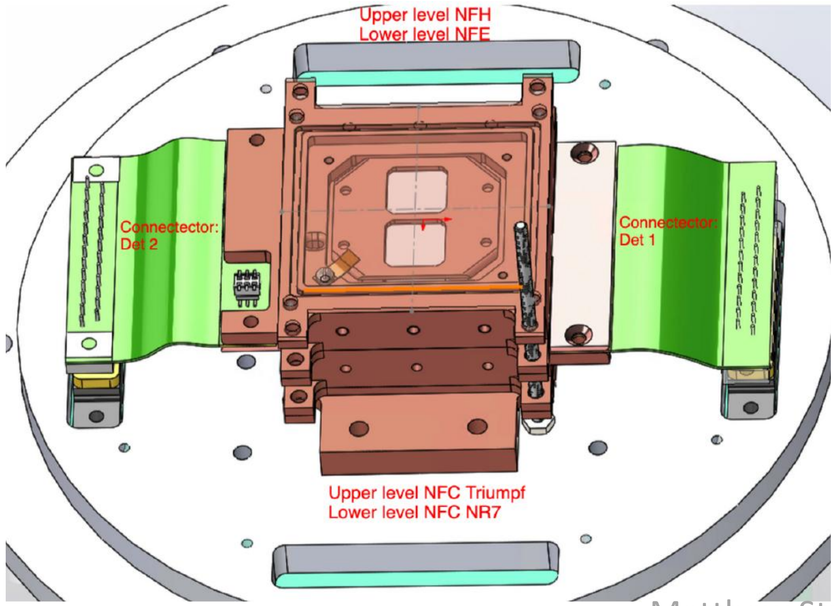


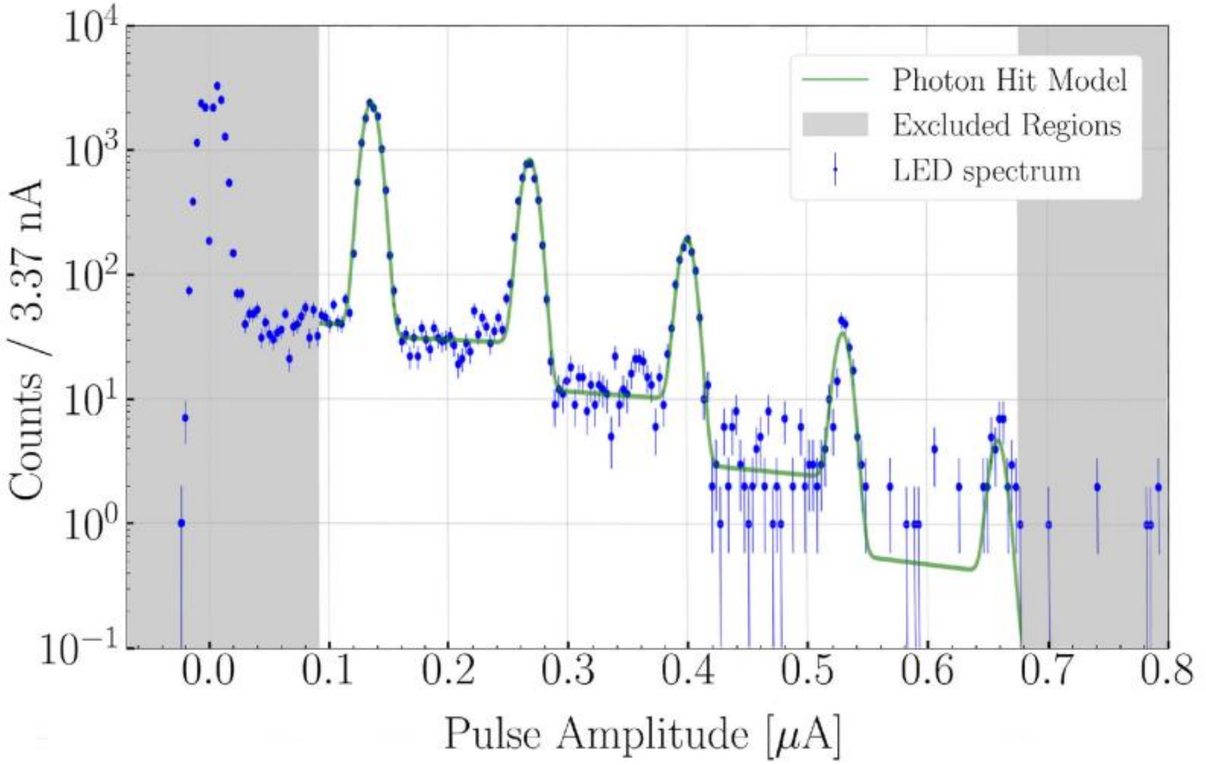
- First underground Dark Matter search using the NEXUS facility
- Achieved a 3.03 eV baseline resolution, w/ 100V applied
- Optical fiber allows for detector calibration
- Burst events present in data due to luminescence of the PCB

https://doi.org/10.1103/PhysRevD.111.012006

HVeV Run-4

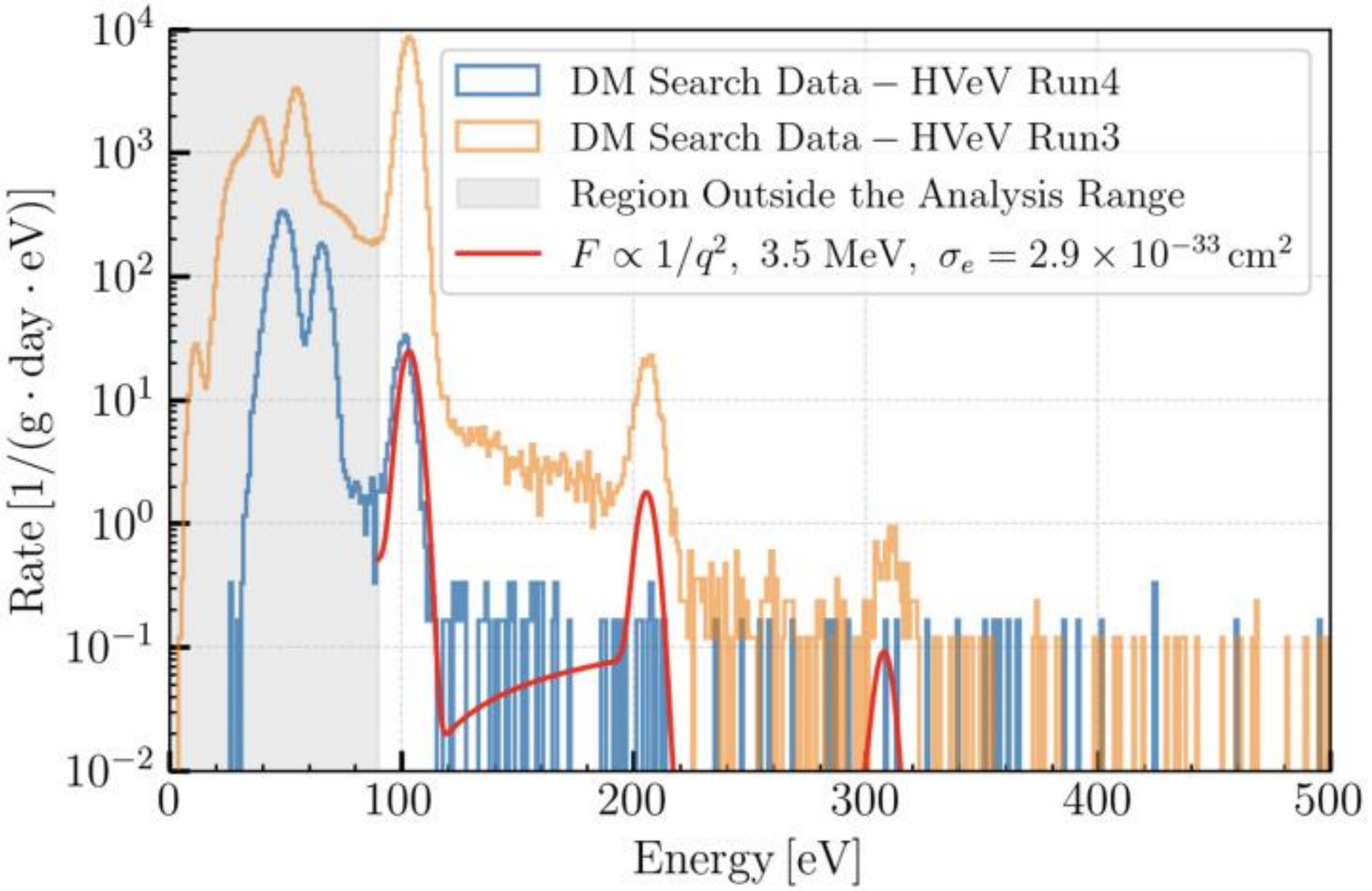






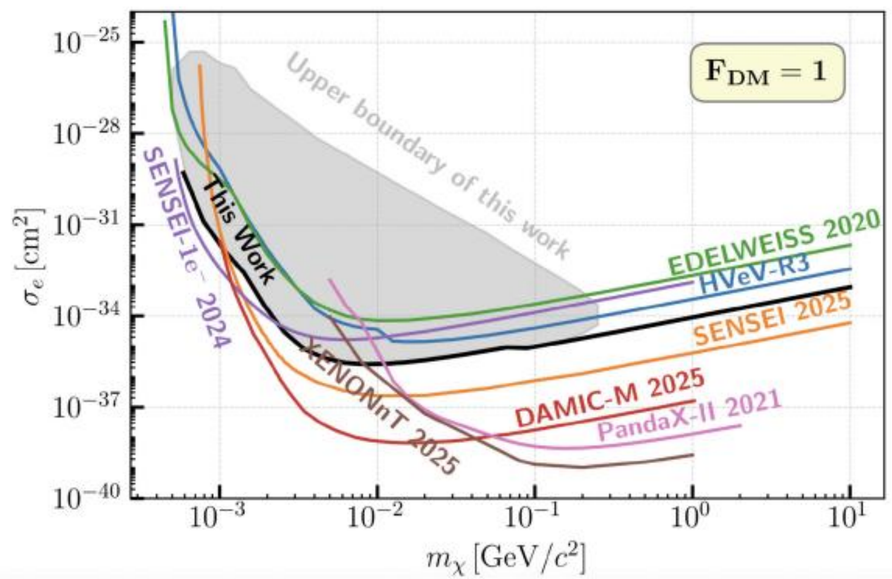
- Improved light-tight copper housing with individual LED for each detector
- Baseline Resolution: **3.2 +/- 0.1 eV**
- https://doi.org/10.1103/5lnp-6mng

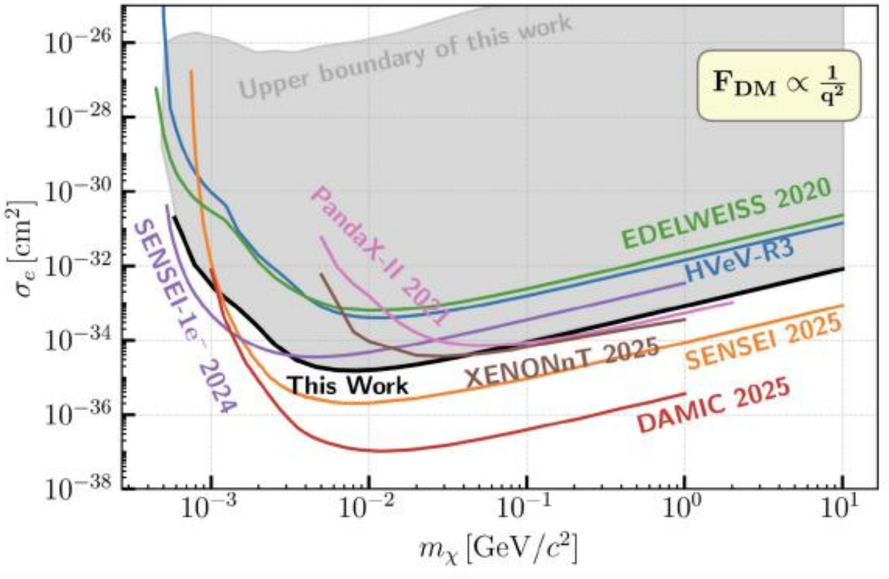
HVeV Run-4: Comparison

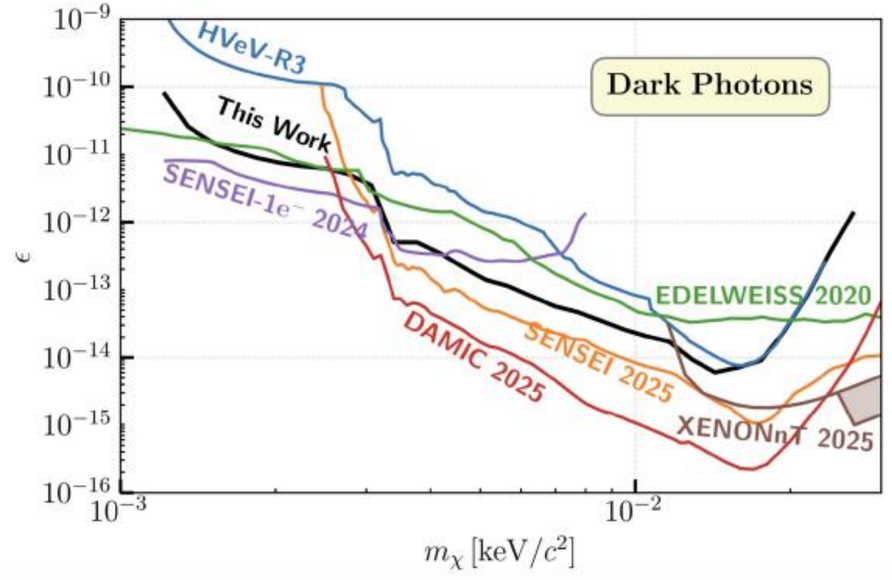


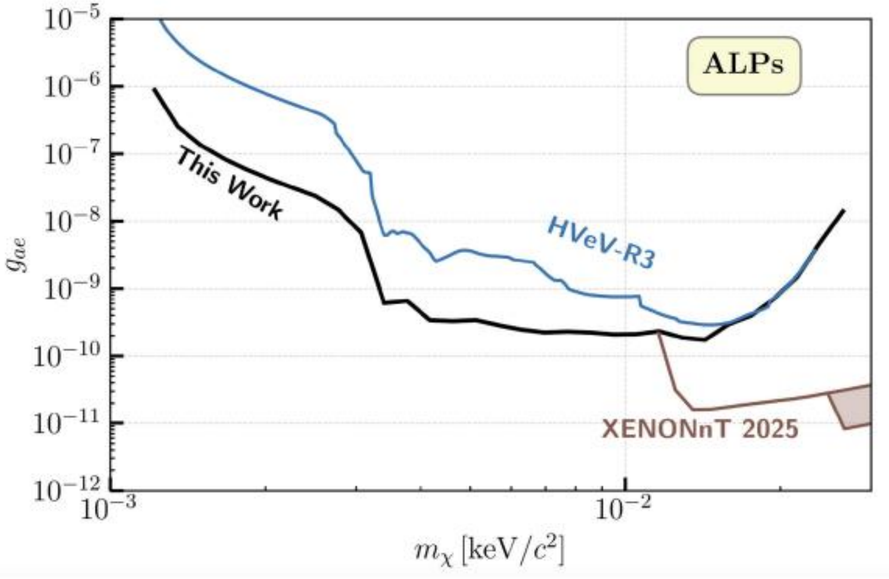
- Significant improvement in the background energy spectrum at the 2 and 3 eh level

HVeV Run-4: Results

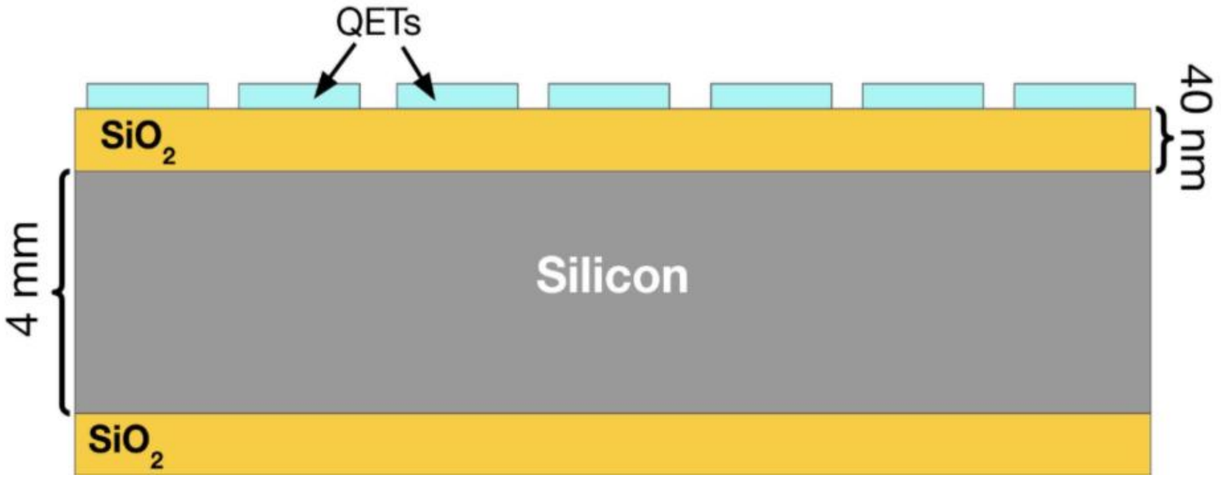


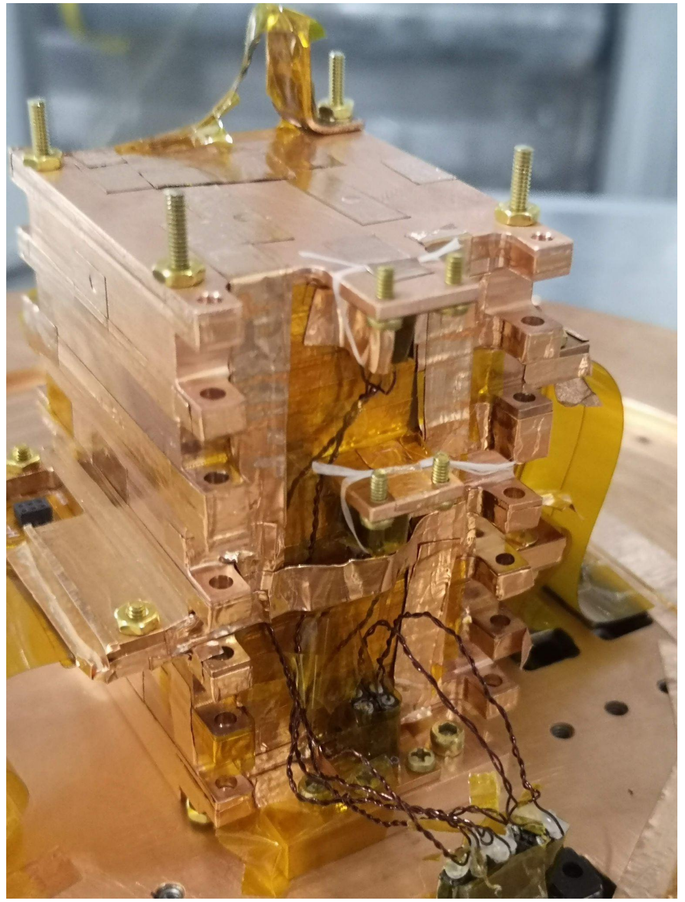






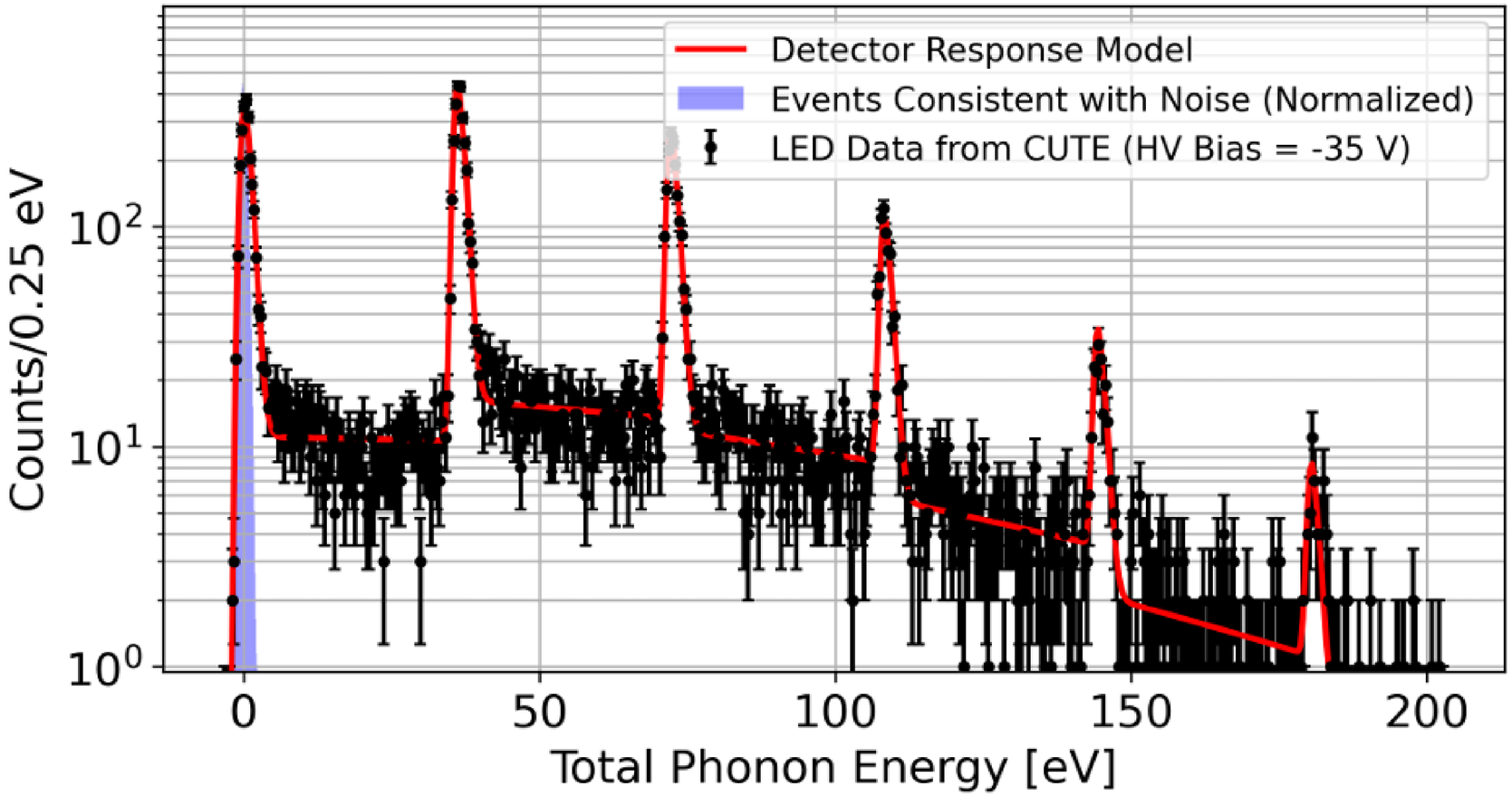
HVeV-Run 5





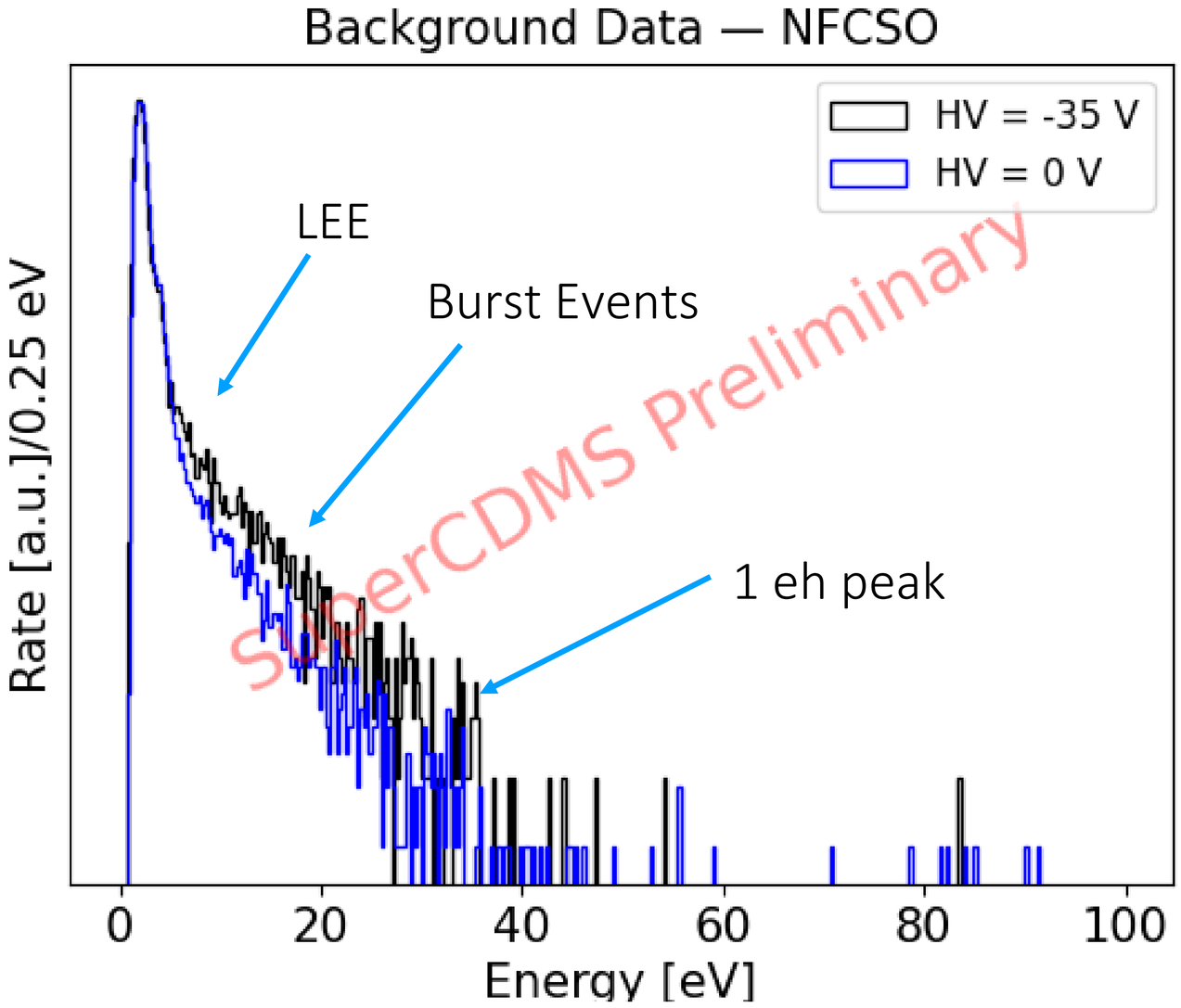
- Ran 6, 1g Si detectors capable of reaching 1 eV threshold at the CUTE facility
- Two new detectors with lower T_c (60 -> 45 mK) and SiO_2 layer to reduce leakage from QETs
- Detector tower was put into CUTE at the end of March, 2024 and ran until the end of September

HVeV – Run 5 Results



- HVeV achieved a baseline resolution 612 meV ± 4 meV
- https://doi.org/10.48550/arXiv.2601.16307

HVeV – Run 5 Results

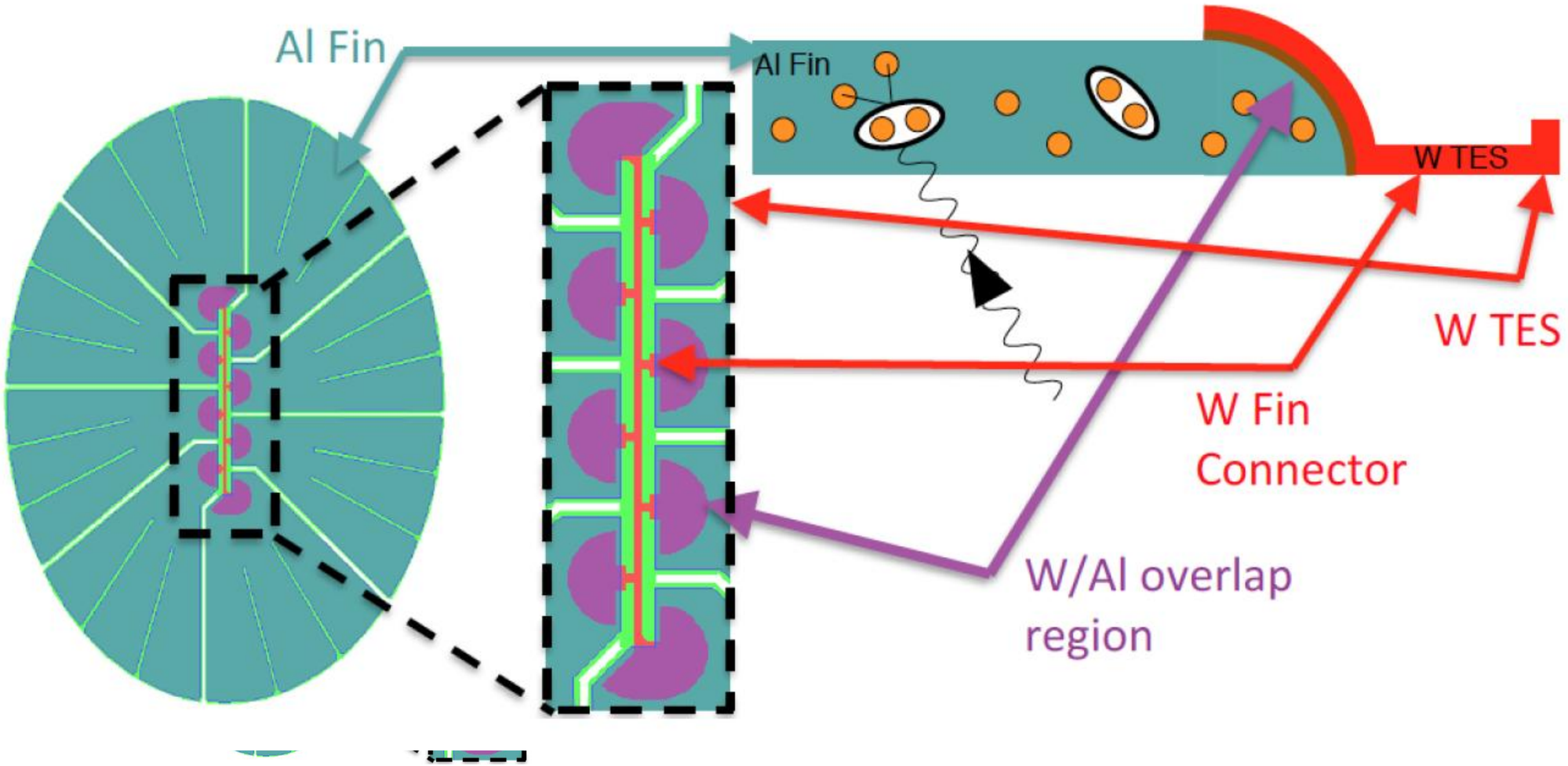


- Reduced 1eh rate compared to Run 3 and 4
- Took DM search data (-35V for 13 days of exposure)
- 90% of data is blinded
- DM result is coming very soon
- Allowed for studies of LEE

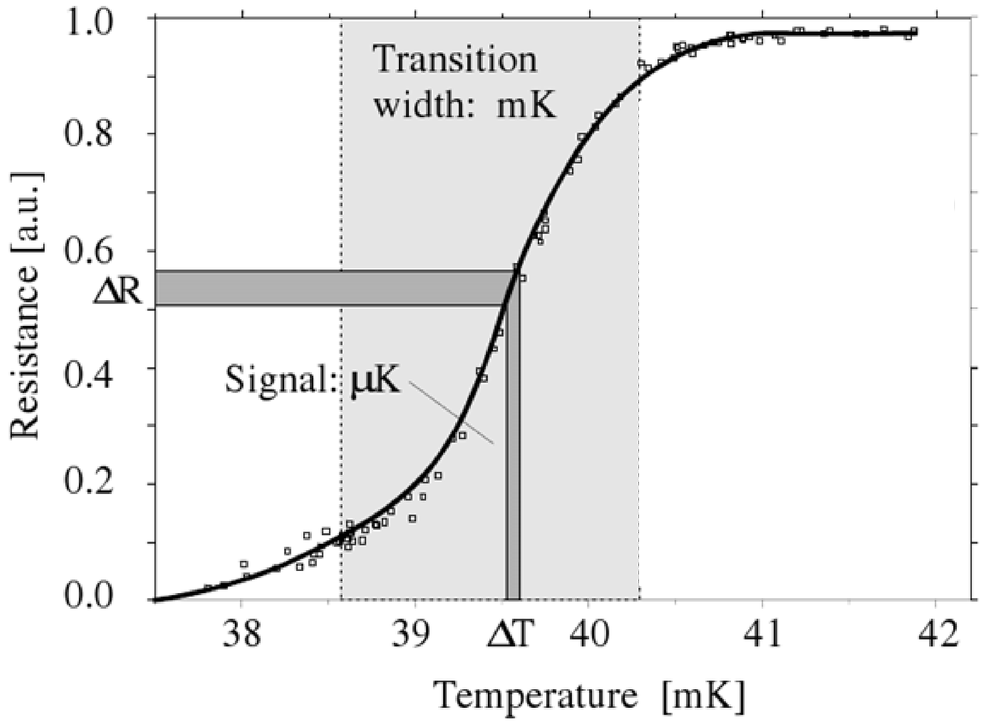
Conclusion

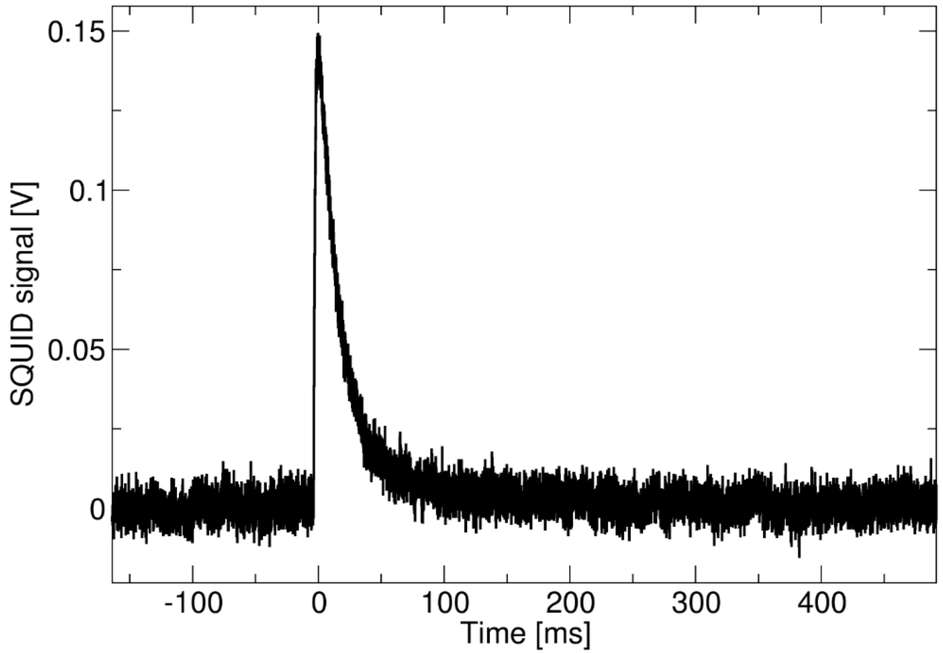
- SuperCDMS will push the boundaries of Sub-GeV dark matter searches at SNOLAB:
  - Commissioning has started, should finish by summer
  - This year we hope to start our first science run
- 30 kg of Si and Ge detectors. 4 towers with 6 detectors in each
- 12 iZIP and 12 HV detectors
- HVeV is a promising R&D program that has achieved incredible energy resolution: 612 meV

Extra Slides


Al Fin
Al Fin
W TES
W TES
W Fin
Connector
W/Al overlap
region

Transition Edge Sensors (TES)





- Deposition of energy → Lattice vibrations (**Phonons)** → Change of temperature → Change in resistance → Signal
- Critical temperature reduced from 90 mk (Soudan) to 40 mk.
- Resolution will scale T_c^3
- TES are widely used in the field of rare event searches