SUPERCDMS SNOLAB

A SNAPSHOT OF THE DARK MATTER EXPERIMENT

Presented at the Lake Louise Winter Institute

19^{th} – 24^{th} February, 2023

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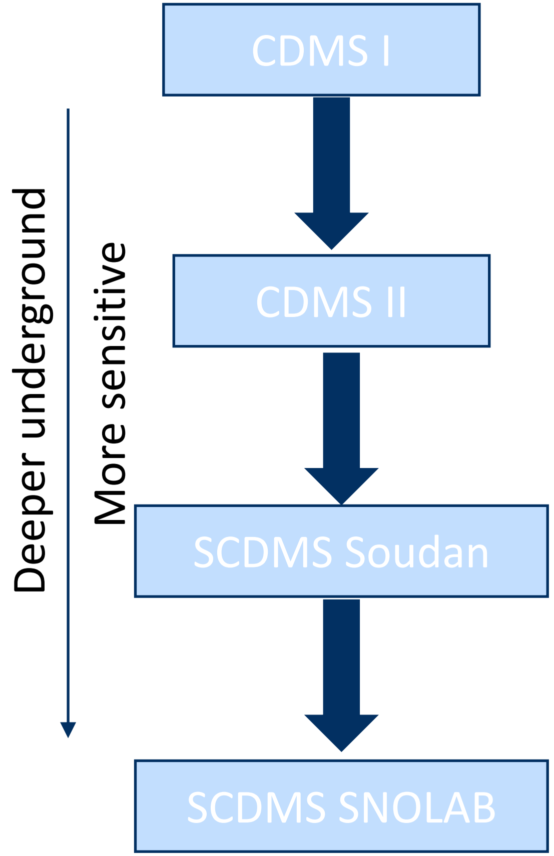
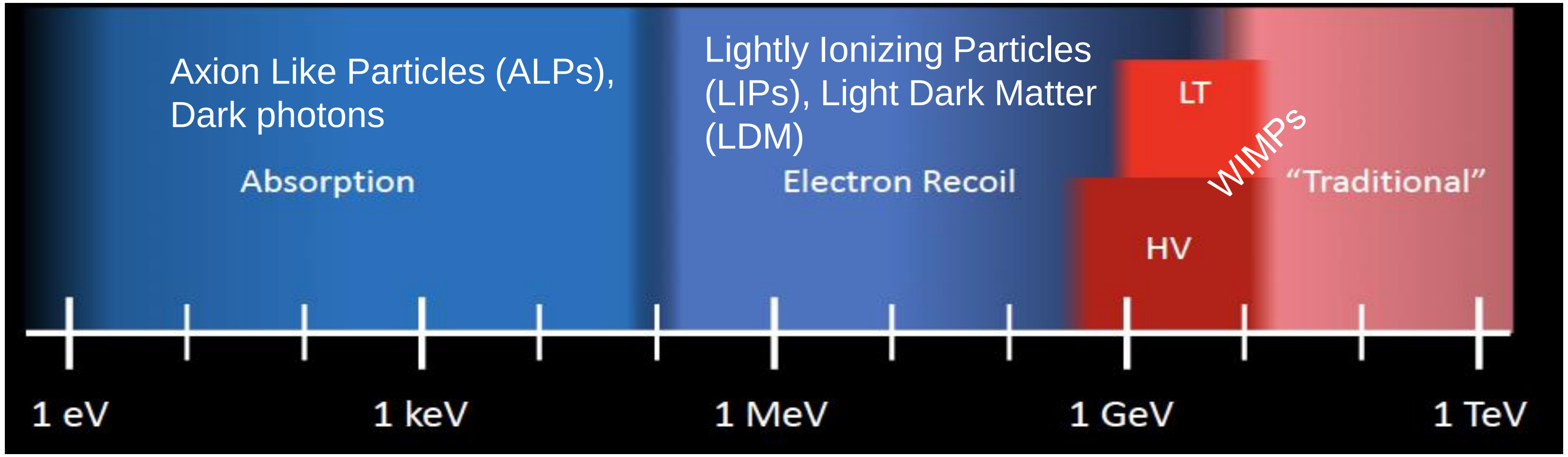
on behalf of the SuperCDMS collaboration

OVERVIEW

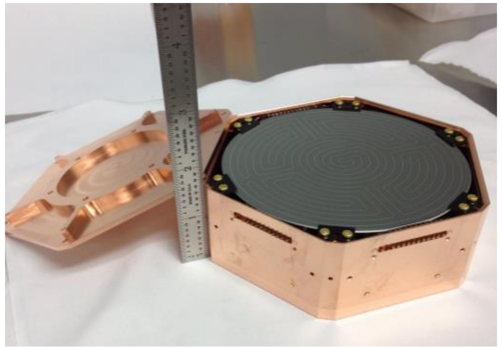
- ✓ Many theories motivate DM searches at lower energy scales (< 10 GeV)
  - ✓ Asymmetric DM that could explain matter antimatter asymmetry
  - ✓ Hidden sector DM with weak couplings to SM matter
  - ✓ Axions and Axion-Like Particles



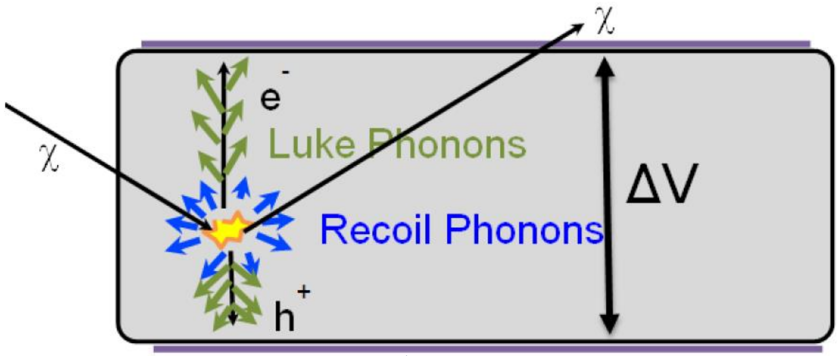
SuperCDMS SNOLAB searches for dark matter across a spectrum of candidates using different detection channels

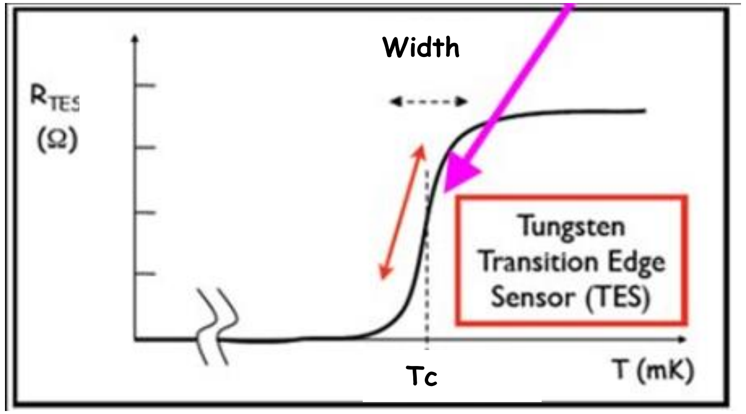


HOW DO WE FIND DARK MATTER?



Prototype iZIP detector





Phonon signal collected via Tungsten TES sensors; charge signals collected at electrodes

ΔV < 10 V

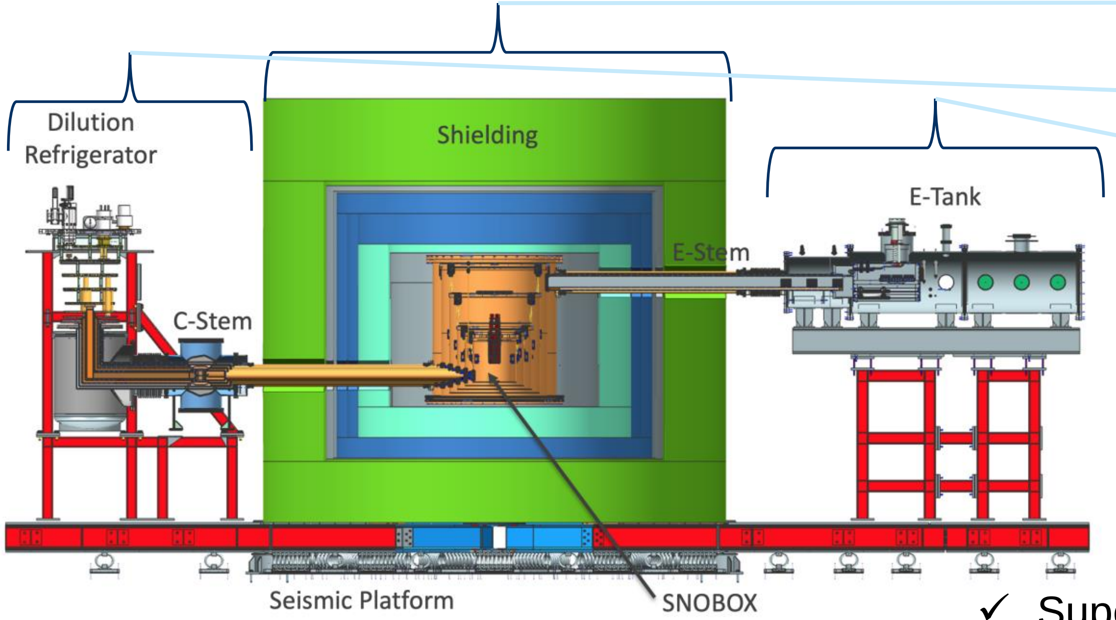
- ✓ Recoil/prompt phonons dominate for nuclear recoils
- ✓ Readout 12 phonon + 4 charge channels
- ✓ Low background detectors (event by event ER/NR discrimination) : **iZIP**
- ✓ Threshold of 133 eV_{pt} (231 eV_{pt})* in Si (Ge)
- ✓ Resolution of 19 eV_{pt} (33 eV_{pt})* in Si (Ge)

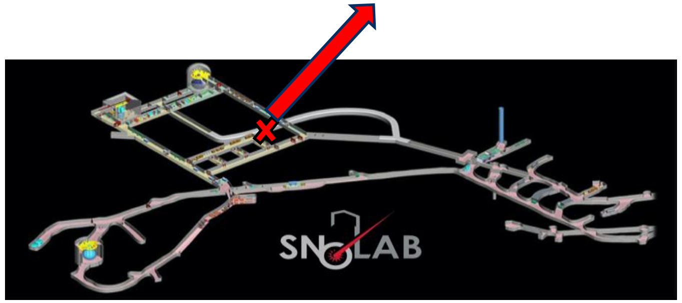
ΔV >10 V

- ✓ Luke phonons dominate
- ✓ Readout 12 phonon channels
- ✓ Low threshold detectors: **HV**
- ✓ Threshold of 91 eV_{pt} (238 eV_{pt})* in Si (Ge)
- ✓ Resolution of 13 eV_{pt} (34 eV_{pt})* in Si (Ge)

* Refer arXiv:2203.08463

SUPERCDMS @ SNOLAB





Low Radon cleanroom

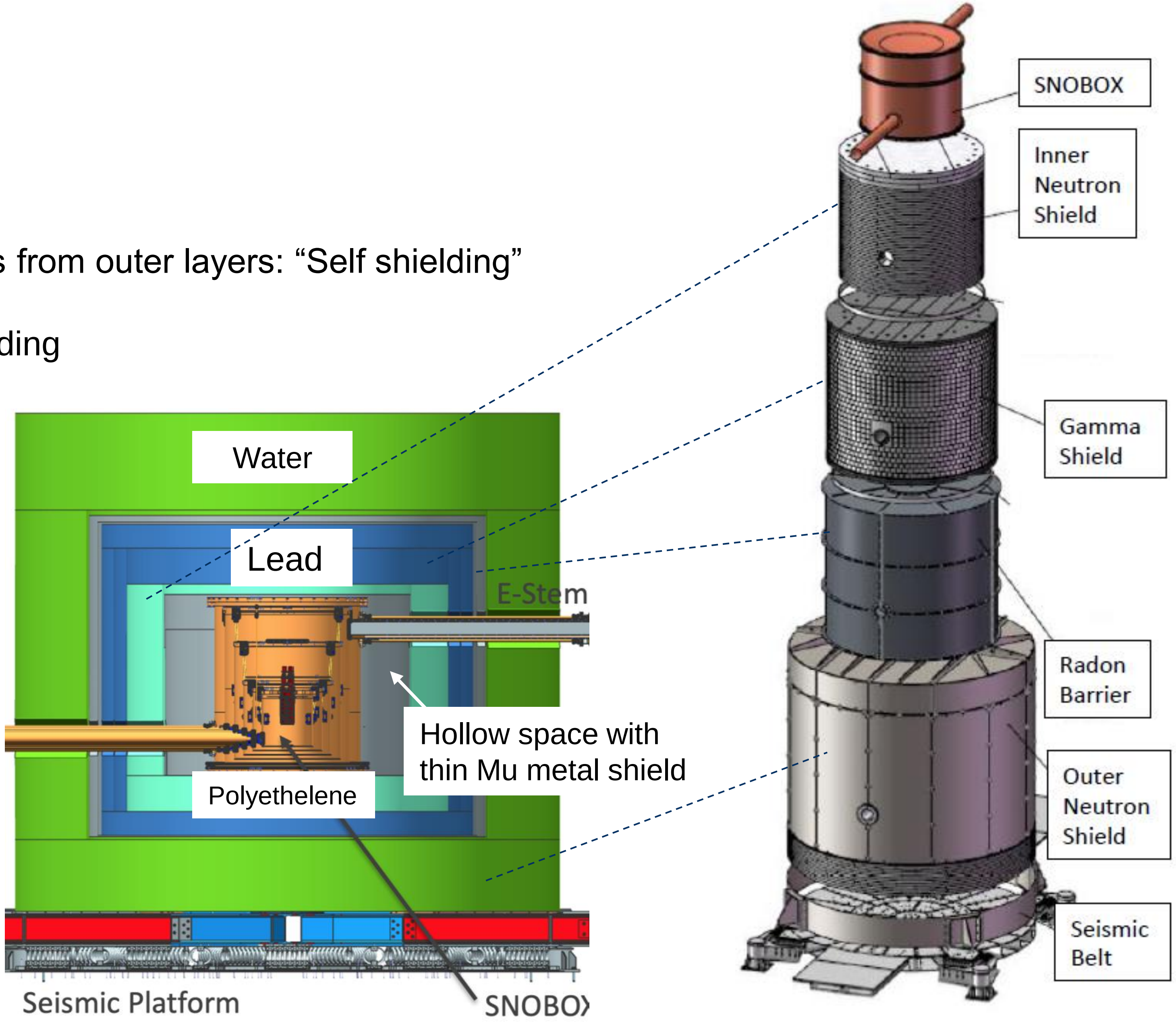
Seismic platform

- ✓ SuperCDMS SNOLAB is under construction in SNOLAB, the deepest underground clean lab in North America
- ✓ SNOLAB provides 2 km natural rock overburden
- ✓ Commissioning to begin this year!

SHIELDING

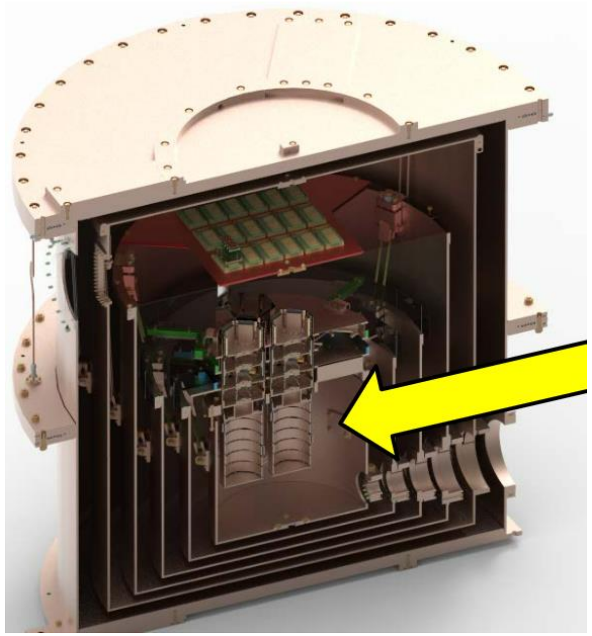
- ✓ Several layers of nested shielding
- ✓ Inner layers attenuate by-products from outer layers: “Self shielding”
- ✓ Mu metal provides magnetic shielding

Completely assembled Lead shield



DILUTION FRIDGE & SNOBOX

- ✓ Commercial dilution fridge that cools to temperatures of order ~ 10 mK
- ✓ SNOBOX contains 7 nested Cu cans for staged cooling
- ✓ Innermost can houses detector towers!



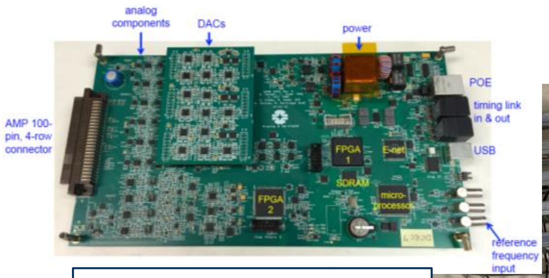
SCDMS SNOLAB SNOBOX

Inside the SCDMS fridge

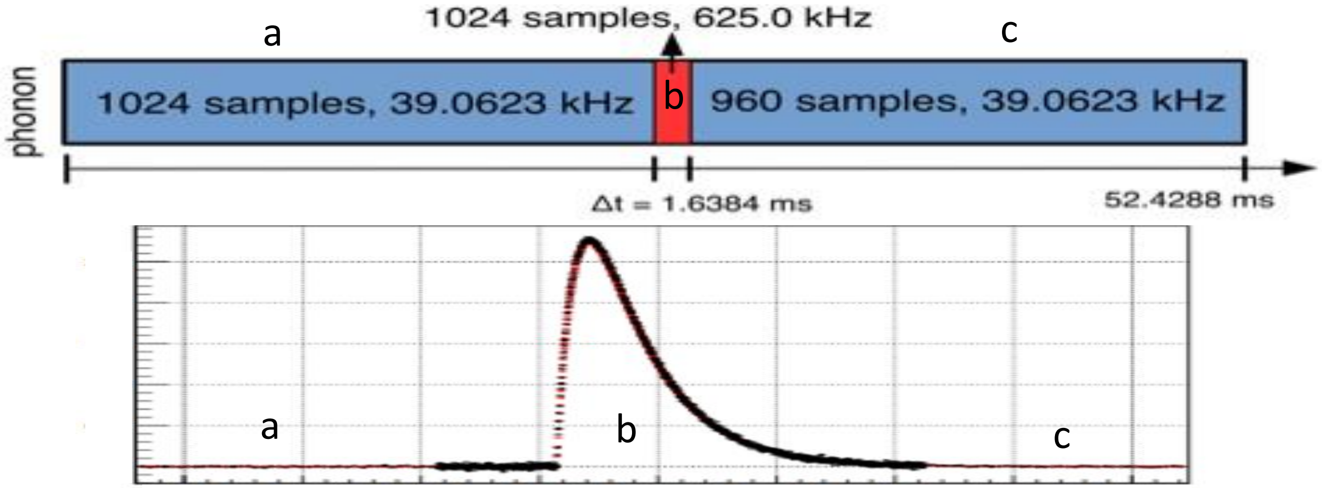
The fridge has arrived at SNOLAB and will be installed soon. SCDMS gas handling system (blue box on the left with buttons) also currently at SNOLAB.

DATA ACQUISITION & PROCESSING

- ✓ E-Tank houses DAQ electronics
- ✓ Detector Control and Readout Cards (DCRCs) read out data from detectors (throughput of ~5 MB/sec)
- ✓ DAQ is limited by bandwidth of electronics; data will be **<u>hybrid sampled</u>**
- ✓ Advanced processing algorithms developed and deployed
- ✓ Massive computing effort: 100 TB/yr of anticipated raw data



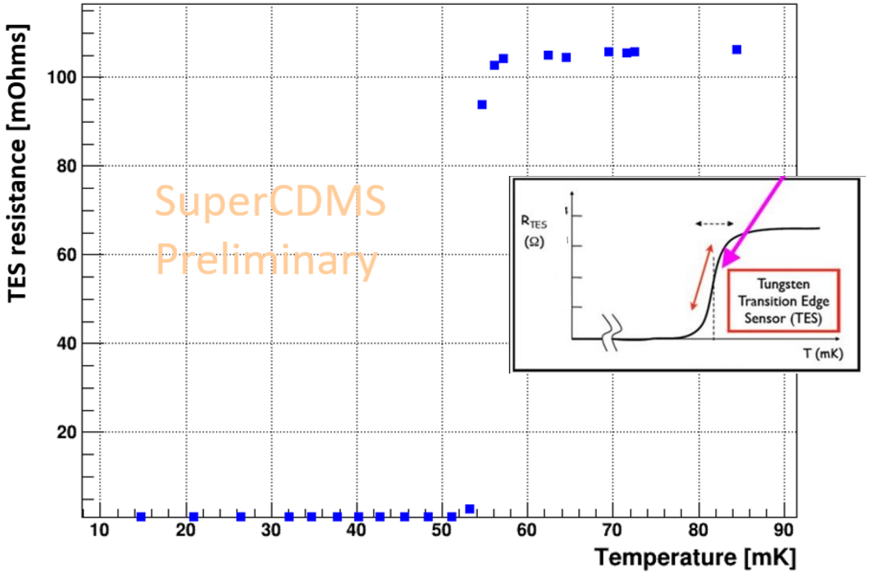
A single DCRC board

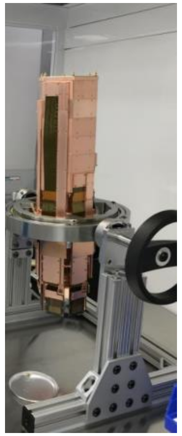


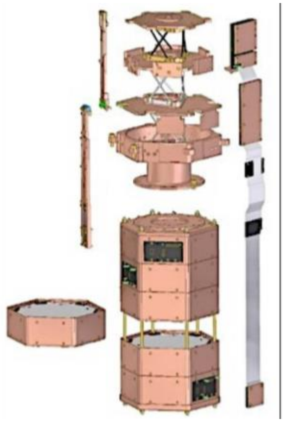
All 36 DCRCs for SCDMS SNOLAB and other DAQ hardware installed at SNOLAB

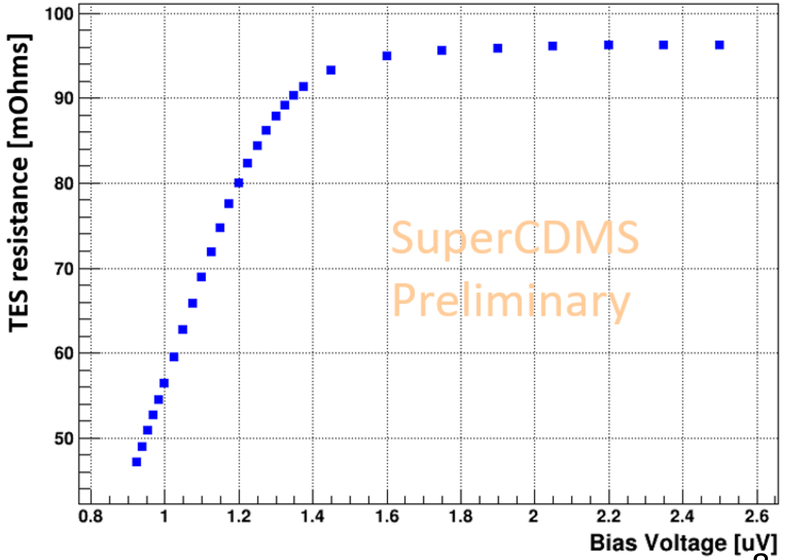
TOWER TESTING: SLAC

- ✓ 4 detector towers: 2 iZIP (T1 & T4) + 2 HV (T2 & T3) towers
- ✓ Detector composition: [6 Ge] (T1) + [4 Ge, 2 Si] (T2, T3, T4)
- ✓ **All towers were tested successfully for basic functionality at SLAC**
- ✓ **Crystal properties measured (T_c , resistances) indicate optimal sensitivity & thresholds**
- ✓ Limitations: surface testing with single layer of Cu shielding- high background & event rates; source-less testing, i.e., no energy scale estimate (yet!)
- ✓ More testing at CUTE!





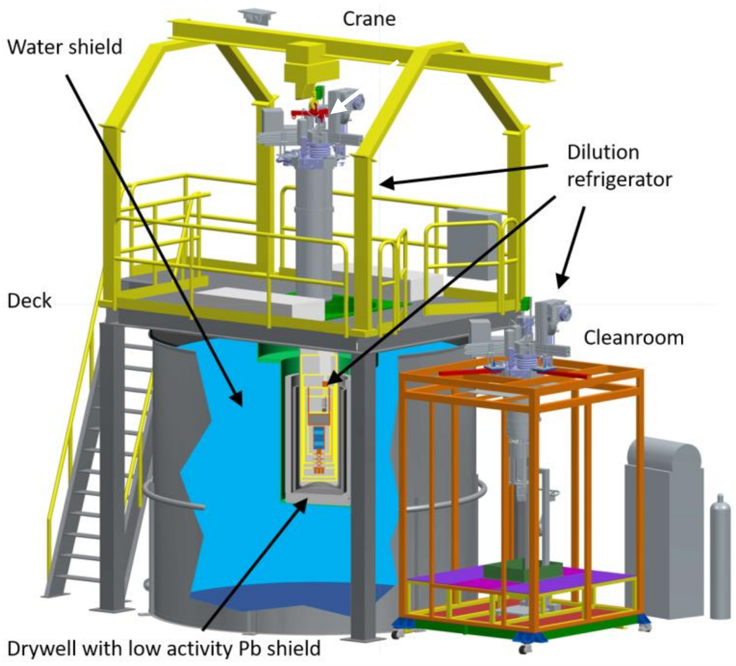


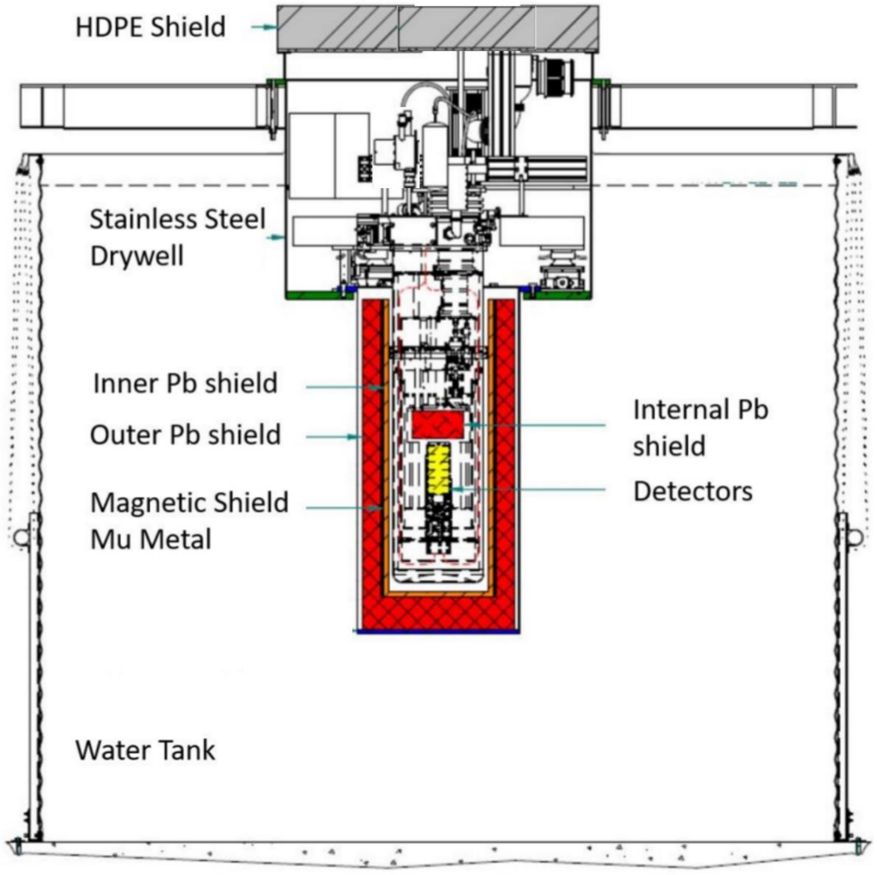


DETECTOR TESTING: CUTE

- ✓ Low bkgd testing of SCDMS detectors for early science
- ✓ Purging out potential software & hardware issues
- ✓ Several prototype and RnD devices already tested
- ✓ Tower testing & calibration to begin in a couple of months

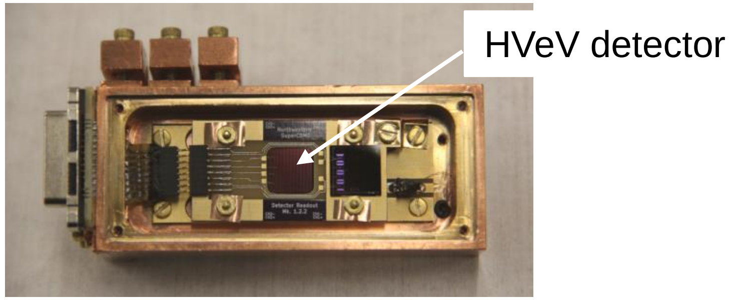
CUTE facility

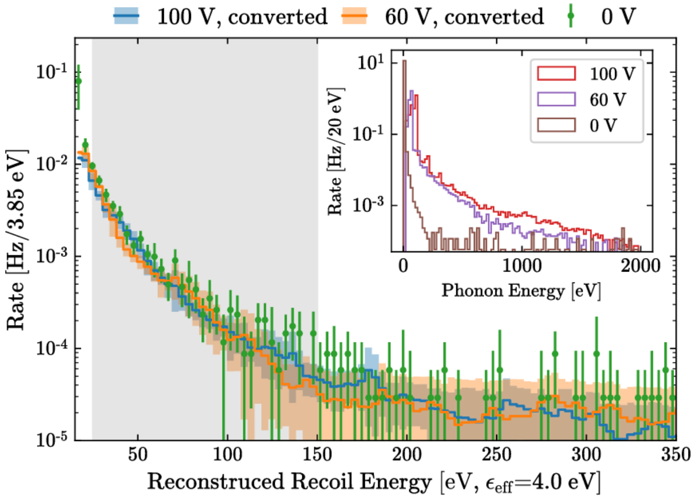


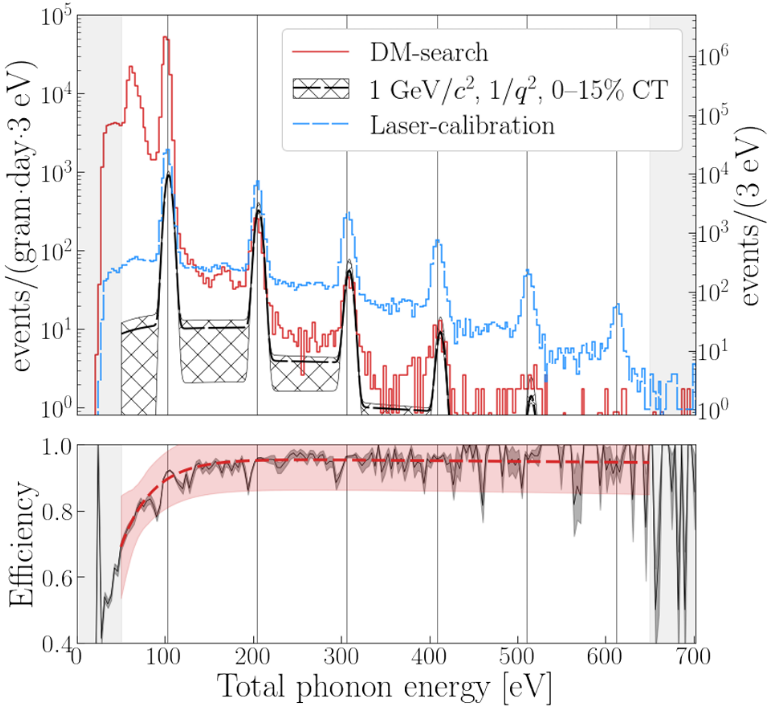


DETECTOR TESTING: NEXUS

- ✓ Testing gram-scale, low threshold devices
- ✓ HVeV devices have single e^-/h^+ pair resolution (~ 3eV)
- ✓ Observed low energy excess events similar to other experiments (but consistent with background)
- ✓ Relevant publications: Phys. Rev. D 105, 112006 (2022), Phys. Rev. D 102, 091101(R)

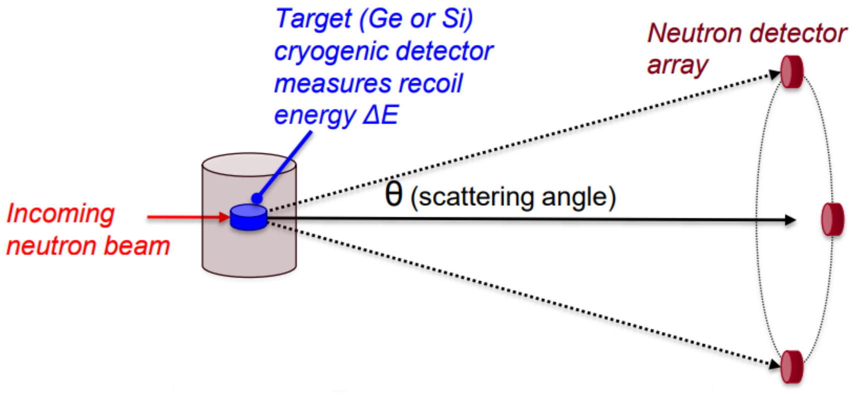


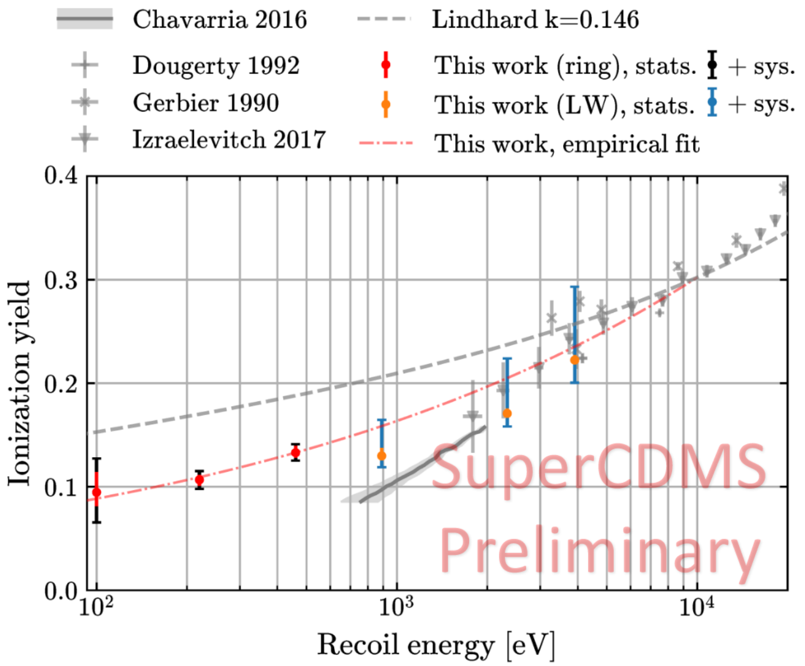




IONIZATION YIELD: IMPACT

- ✓ Ionization yield is instrumental to background discrimination in SCDMS
- ✓ Total phonon energy, $E_T = E_R\left(1 + Y(E_R)\frac{eV_b}{\epsilon_{eh}}\right)$, where, **$E_R$**: recoil energy, **Y**: yield, **V_b**: applied bias, **ε_{eh}**: average e^-/h^+ pair production energy
- ✓ Yield described by Lindhard theory. Deviations observed below 5 keV_{NR}
- ✓ IMPACT is a neutron scattering experiment to measure Y at low recoil energies
- ✓ **Look out for upcoming publication for Si ionization yield!**



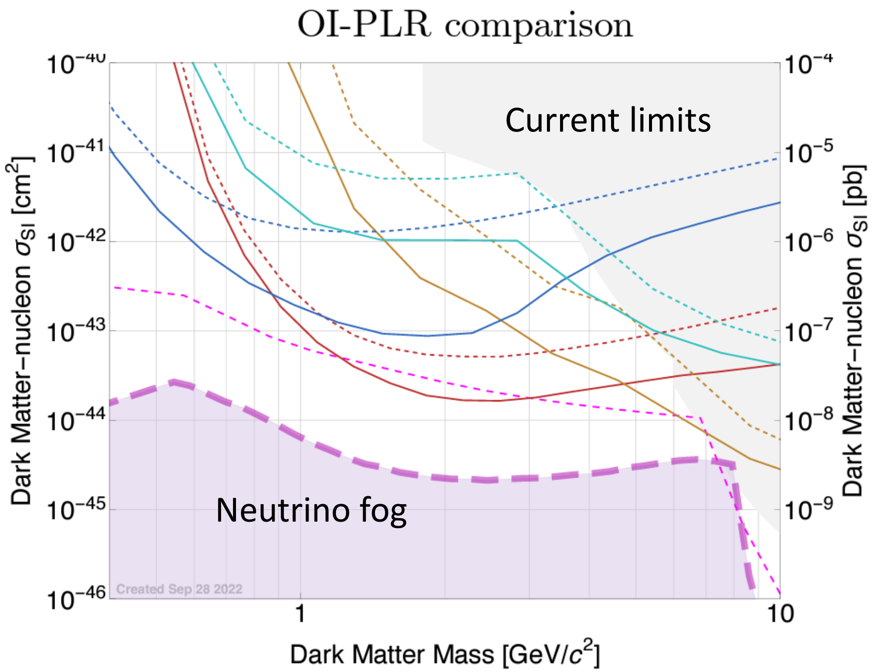


SCDMS SNOLAB SENSITIVITY

- ✓ SNOMASS paper: arXiv:2203.08463
- ✓ Current and future sensitivity of SCDMS SNOLAB experiment for NRDM, ERDM (ALPs, dark photons, LDMs)
- ✓ Several detector upgrade & bkgd scenarios considered

Other upcoming papers:

- ❖ EFT analysis of CDMSLite Run 2 data : arXiv:2205.11683
- ❖ Inelastic DM scattering analysis with CDMSLite Run 3



Comparison of expected NRDM sensitivity for SCDMS SNOLAB between OI (dashed) and Profile likelihood methods (solid)

Legend: Ge HV; Si HV; Ge iZIP; Si iZIP; "single neutrino" sensitivity, where one neutrino event can be expected on average;

We

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BACKUP SLIDES

DILUTION FRIDGE SCHEMATIC