First Installation of a SuperCDMS detector at SNOLAB
Prototype HV Ge into CUTE

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Mission:
Vastly improve dark matter-nucleon scattering sensitivity for masses below 10 GeV/c²

- Funded 2016 (DOE, NSF, CFI)

Goal:
Reach for the neutrino floor
SuperCDMS detector technology

QET – Quasi-particle trap assisted Electrothermal feedback Transition edge sensor

- Energy deposited in kg-scale detector concentrated on mg-scale sensors
- 5-10 eV resolution for athermal phonons
SuperCDMS detector technology

2 flavours
- iZIP: independent charge readout
- HV: new optimized phonon resolution

2 materials
- Si
  - Lower mass sensitivity
- Ge
  - Larger exposure
Optimizing QETs

vs. previous SuperCDMS Soudan

- Lower Tc
  - Resolution scales as $T_c^3$
  - $(40 \text{ mK}/90 \text{ mK})^3 = 0.05$

- Optimize geometry
  - More overlap between Al and W
  - Optimization for lower $T_c$

- Eliminate charge readout (HV)
Ionization in HV mode

Athermal (high-frequency) phonons produced by

- Heavy ion stopping
- Neganov-Trofimov-Luke (NTL) effect
  - Energy released from charge drifted across the potential of the crystal.

\[ E_{\text{phonon}} = E_{\text{recoil}} + V \times n_{eh} \]
Demonstrated sensitivity

Testing with g-sized detectors

- Electron/hole counting
- Leading DM-electron coupling limits from a run on surface.

\[ E_{\text{phonon}} = E_{\text{recoil}} + V \times n_{\text{eh}} \]
SuperCDMS SNOLAB backgrounds

- Electron recoils (for which HV detectors are sensitive)
  - $^3\text{H}$, $^{60}\text{Co}$ from cosmogenic activation
  - $^{32}\text{Si}$ from atmospheric deposition
  - Background energy differential rate reduced by ER/NR energy scale ratio
- Radon deposition
- Neutrons, cosmic rays, neutrinos
  - Minimized by shielding and siting at SNOLAB.
SuperCDMS SNOLAB facility

A campus for cryogenic dark matter detectors.

- 6800 m.w.e. overburden
- Capacity for 31 towers (4 initially)
- $\nu$-dominated NR bg
- O(0.1) dru $\gamma$ background
- 15 mK base temperature
A campus for cryogenic dark matter detectors

- Low-radon clean-room
- Collaborating with Cryogenic Underground TEst facility (CUTE)
  - Rapid-turn around detector testing
  - First data from SuperCDMS SNOLAB towers.
Installation ramping up

Last week:
Ge HV prototype operated at CUTE
Radon filter system installation
- Power, water, crane rails - installed
- Cleanroom, shield, fridge, cryostat - this fall
- Detector installation - next spring/summer
- Initial run - early 2021
Understanding ~eV energy depositions

- Discretisation
- Binding energies
- Nuclear recoil energy calibration
  - IMPACT@TUNL beam last month →
  - NEXUS@FNAL in installation
- Lessons from other fields
  - e.g. production of plasmons (E. Michaud, CAP 2019 @ SFU)
One giant leap in sensitivity at SNOLAB

An underground cryogenic campus
- Commissioning next year
- First HV publication in 2022

Ongoing efforts
- Comprehensive prototyping
- Off-site calibrations
- Backgrounds mitigation
- Opportunistic DM searches
GeV-scale dark matter models

Dark U(1) sector
- Simplest new symmetry for BSM physics
- Dark matter mass weakly constrained (10 keV – 100 TeV)

Asymmetric DM
- Number density related to baryons
  - Mass of 2 or 6 GeV/c$^2$ likely if baryon number is conserved in dark sector
SuperCDMS detector technology

QET

- meV phonons break Cooper pairs in superconduction Al
- Quasi-particles (broken pairs) migrate to tungsten sensor
- Resistance of voltage-biased sensor rapidly increases
Detector fabrication

- 24 detectors to be deployed in 4 towers.
- First 6 detectors (Ge iZIP) fabricated
- Fabrication underway for following 6 HV detectors with low-cosmogenic exposure
- Prototype testing underway at CUTE
SuperCDMS Soudan & CDMSlite

Retrofitted an iZIP detector for high bias-voltage application.

- Reduced threshold from ~200 eV to 56 eVee.
- Motivated strategy for optimized HV design
High voltage eV-scale (HVeV) results