First Glimpses of the SuperCDMS High Voltage Detectors
Dark Matter Properties

- Dark
- Stable
- Non-baryonic
- Not “hot”
- ~25% of the total universe mass
Dark Matter Mass

spanning across ~88 orders of magnitude

- $10^{-22}$ eV: QCD axion
- eV: "Ultralight" DM
- keV: "Light" DM (dark sectors, sterile neutrino, asymmetric DM)
- GeV: WIMP
- 100 TeV: Composite DM
- $10^2$ M☉: Primordial black holes
SuperCDMS as a Dark Matter Experiment

SuperCDMS SNOLAB is sensitive to various dark matter models across 10 orders of magnitude!

- Absorption
- Electron Recoil
- HV
- NR

Unitarity limit
- $10^{-22}$ eV: QCD axion
- eV: fuzzy DM
- keV: "Ultralight" DM
- eV: "Light" DM, dark sectors, sterile neutrino, asymmetric DM
- GeV: WIMP
- 100 TeV: Composite DM
- $10 M⊙$: Primordial black holes
SuperCDMS SNOLAB Experiment

- 2 km underground in Sudbury, Canada
- Tower (stacks of 6 detectors) mounted inside a cryostat, which is surrounded by shielding to minimize background
- Germanium and Silicon crystals cooled down to ~10 mK to be sensitive to minute dark matter signals
SuperCDMS SNOLAB Detector Technology

Athermal phonon detectors

- Only partial energy is measured
- To first order decoupled from crystal heat capacity
- Fast pulses compared to thermal measurement
- Signal is position dependent
- Al fins as phonon collectors which enable large coverage area

Superconducting

Normal

Resistance [mΩ]

Temperature [mK]

TES: Transition Edge Sensor
SOMETHING CALLED "SINGLE-SHOT" TEST, WHERE THE MC/ST TEMPS ARE HELD ROUGHLY THE SAME, BUT THE 4K/60K TEMPS INCREASES

WHAT WE OBSERVE IS THAT

SuperCDMS SNOLAB Detector Technology

Two different detector configurations

- **HV detectors -> low threshold**
  - Luke effect can amplify phonon signals under E field to lower detection threshold
  - highest science reach

  \[ E_t = E_r + N_{ch} eV_b \]

- **iZIP detectors -> low background**
  - ionization-based NR/ER background discrimination
  - higher dynamic range
  - radioactive background measurements
SOMETHING CALLED "SINGLE-SHOT" TEST, WHERE THE MC/ST TEMPS ARE HELD ROUGHLY THE SAME, BUT THE 4K/60K TEMPS INCREASES WHAT WE OBSERVE IS THAT
A major milestone of the experiment:

A SuperCDMS SNOLAB High Voltage tower operated in an underground, low background environment.
Tower Testing at CUTE: Statistics

151 days covering 4 thermal cycles

Total data volume: 400 detector days

~2 month of calibration data

~2 weeks of low background data

Example pulses from a Silicon detector operated at 100V

+/-50V, low-pass filter on
Tower Testing at CUTE: Ge Detector Calibration

- Irradiating Ge with neutrons produces $^{71}\text{Ge}$ (11.4 days half-life)
- The activation lines from $^{71}\text{Ge}$ electron captures are:
  - 10 keV, 1.3 keV, 160 eV
- From Dec. 16 to Dec. 21, ~90 hours of Ge detector calibration dataset was taken
Tower Testing at CUTE: Si Detector Calibration

- ~90 hrs of Ba source data for Si detector operated at 0V.

- Characteristic steps in energy spectrum caused by the binding energy of shell electrons can be used to calibrate the Si detector.

- Demonstrating the calibration method for the Si detector was one of the most important goals for CUTE tower testing.
1. Direct detection of dark matter is one of the most promising methods we have to investigate BSM physics.

2. SuperCDMS SNOLAB is sensitive to a variety of dark matter models ranging over 10 orders of magnitude in dark matter mass.

3. SuperCDMS High Voltage tower at CUTE marks the first time these detectors are operated in an underground, low background environment.

4. Preliminary results indicate great potentials with these detectors, enabling us to explore exciting science in the coming months and beyond.