UNIVERSITY OF TORONTO

SUPER CDMS
Cryogenic Dark Matter Search

The SuperCDMS SNOLAB Experiment

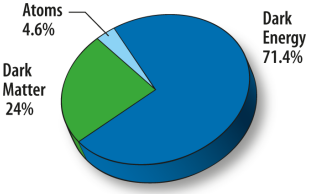
CAP congress, Fredericton, NB

Birgit Zatschler
on behalf of the SuperCDMS collaboration

22nd June 2023

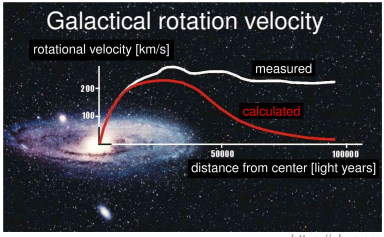
Introduction to Dark Matter

- Strong evidence for DM exist within the universe.
- There is five times more DM than normal matter.



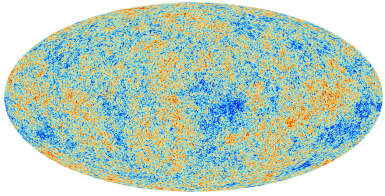
Composition of the universe

https://wmap.gsfc.nasa.gov

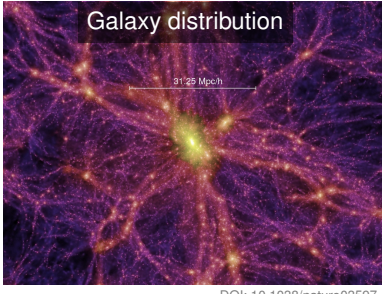


https://phys.org

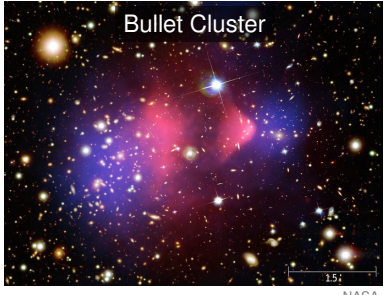
Cosmic microwave background



ESA and the Planck Collaboration

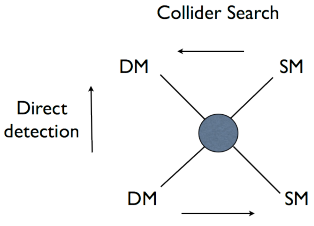


DOI: 10.1038/nature03597

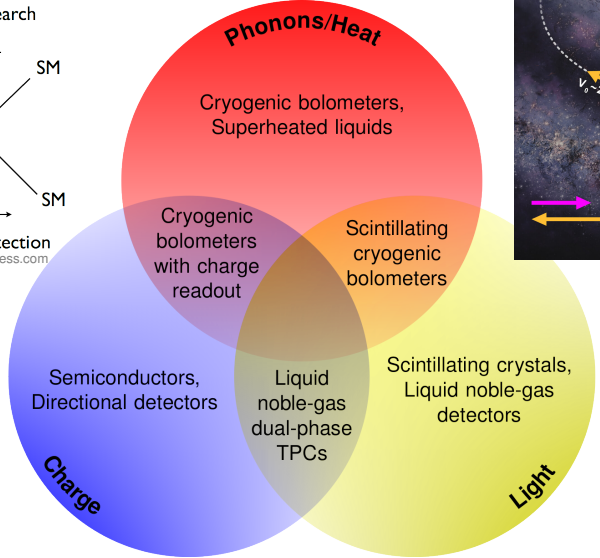


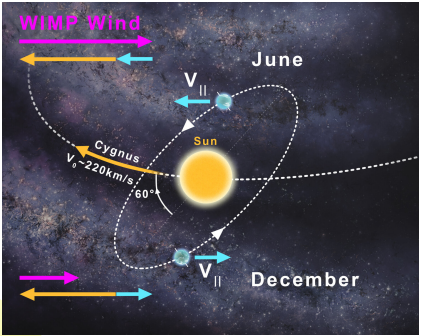
NASA

Detection methods



▲ Ways to search for DM





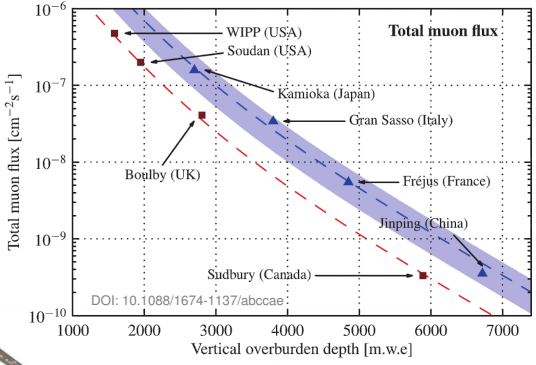
Josephides J 2019 WIMP Wind Infographic

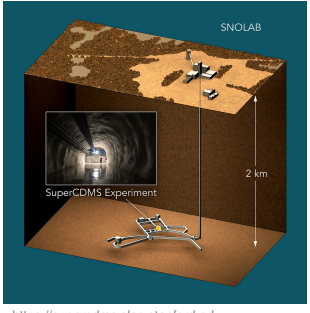
▲ Solar system moving through galactical DM halo

◄ Direct DM detection channels

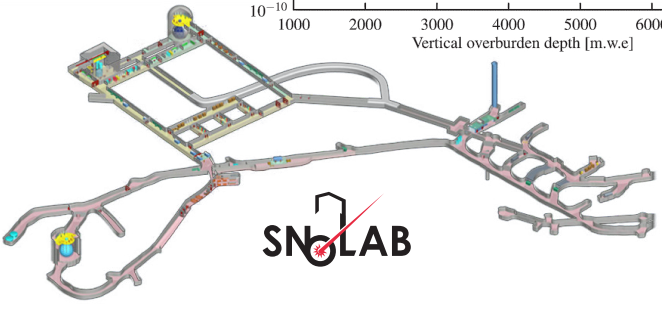
SNOLAB underground facility

- Located in Sudbury, Canada, inside an active mine.
- Rock overburden of 2 km shields from cosmic radiation.
- Muon flux reduced by a factor of 50 million.
- Hosting DM and neutrino experiments in need of low background environment.





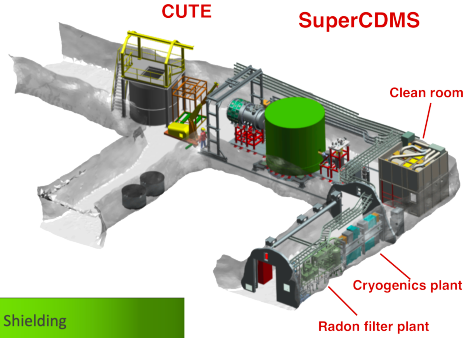
https://supercdms.slac.stanford.edu

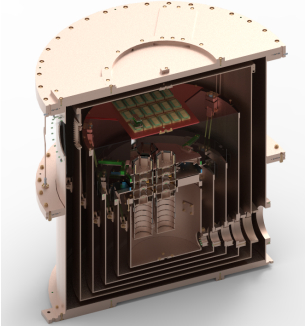


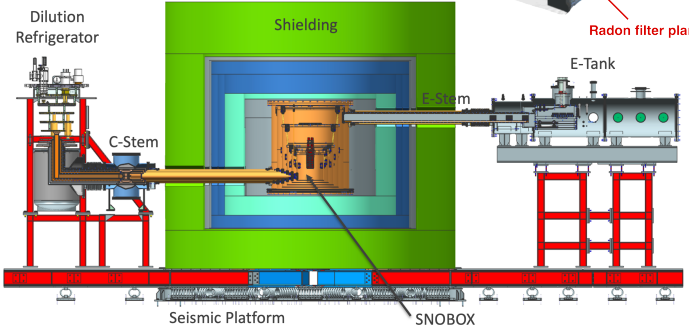
https://www.snolab.ca

SuperCDMS experiment at SNOLAB

- The **Super C**roygenic **D**ark **M**atter **S**earch experiment is aiming for direct detection of DM interactions with Standard Model matter.
- Operating 18 Ge and 6 Si detectors in cryogenic conditions following a complementary approach.
- Commissioning is planned for 2024.



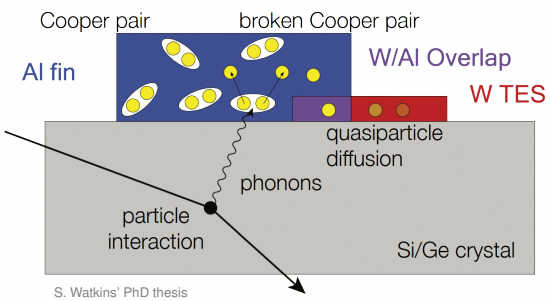




Measuring phonons with QETs

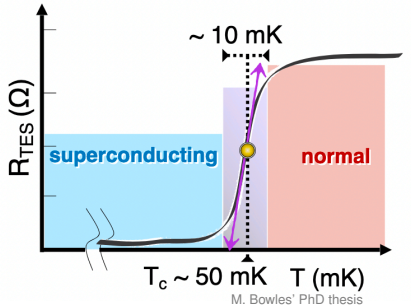
- Energy deposition in detector crystal creates charges and prompt phonons.
- Drifting charges create additional phonons via NTL (Neganov-Trofimov-Luke) effect.
- Phonons are measured by QETs (Quasiparticle trap assisted Electrothermal feedback Transition edge sensors).

QET working principle



S. Watkins' PhD thesis

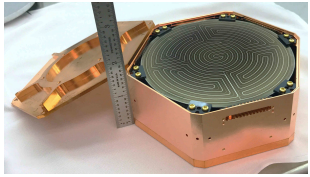
TES resistance curve



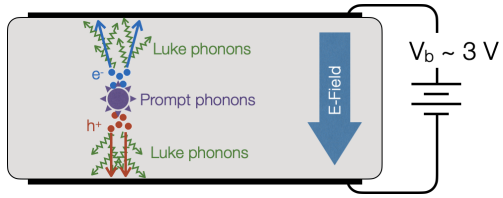
M. Bowles' PhD thesis

Detector technology

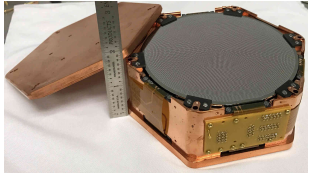
iZIP (interleaved Z-sensitive Ionization and Phonon) detectors



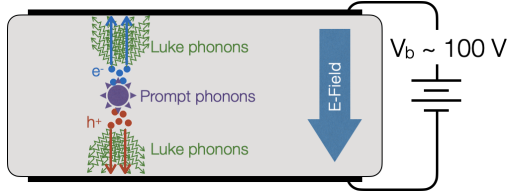
- Measure charge and phonons.
- Discrimination between nuclear recoil (NR) and electron recoil (ER).



HV (High Voltage) detectors

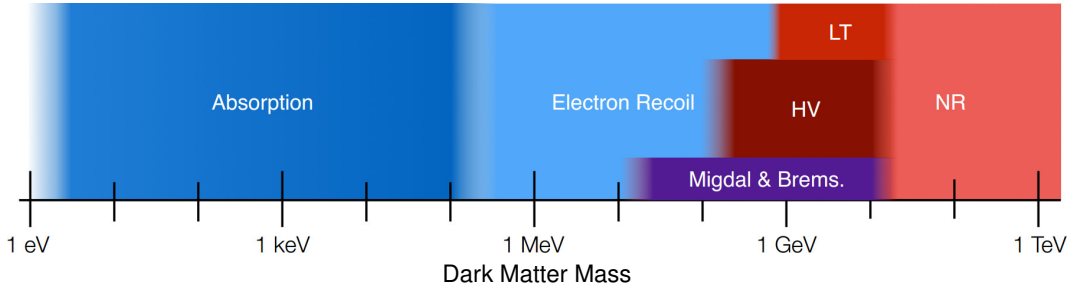


- Amplified NTL phonon production.
- Better energy resolution and lower threshold.

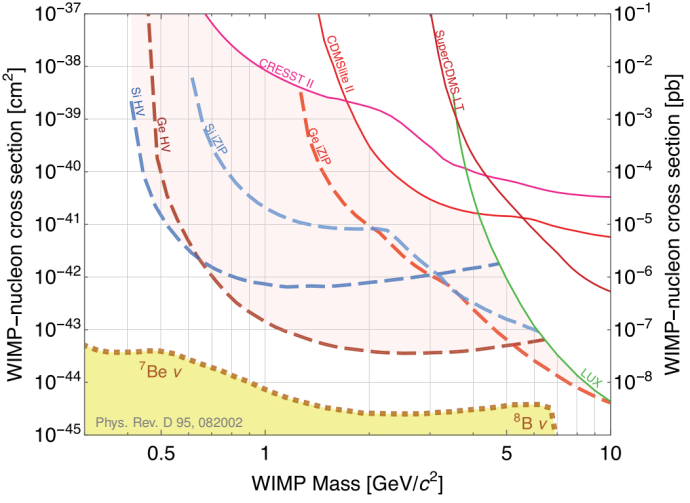


Dark matter search ranges

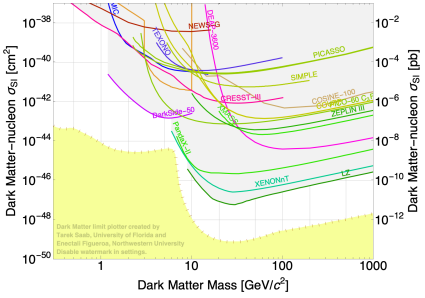
Absorption (Dark Photon, ALP):	$\sim$ 1 eV - 0.5 MeV	peak search (HV)
Electron Recoil:	$\sim$ 0.5 MeV - 10 GeV	no NR/ER discrim. (HV)
Migdal & Bremsstrahlung:	$\sim$ 0.01 - 10 GeV	no NR/ER discrim. (HV + iZIP)
HV Detectors:	$\sim$ 0.5 - 10 GeV	no NR/ER discrim. (HV)
Low Threshold (LT):	$\gtrsim$ 1 GeV	limited NR/ER discrim. (iZIP)
Traditional Nuclear Recoil:	$\gtrsim$ 5 GeV	full NR/ER discrim. (iZIP)



SuperCDMS projected sensitivity

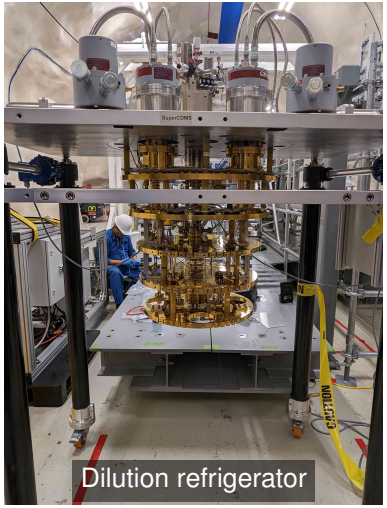


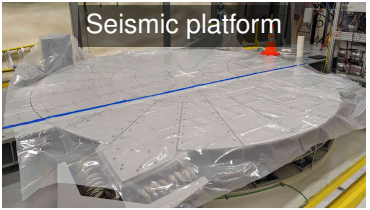
Dark Matter Limit Plotter

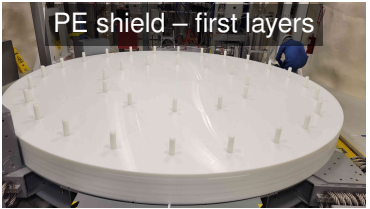


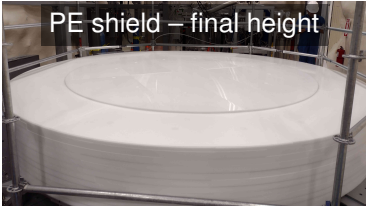
- Plot limits and projections of various experiments and DM channels: NR, ER, Dark Photon, Axion.
- Download: dark-matter-limit-plotter
- Submit your data to be added!

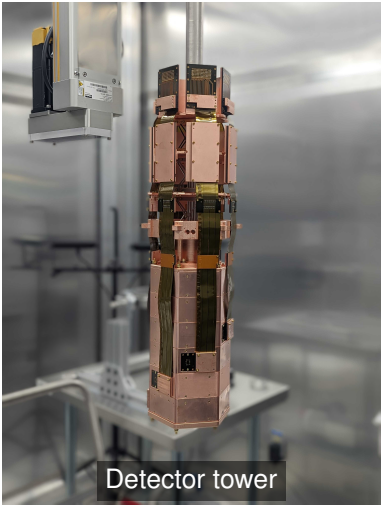
Construction Status











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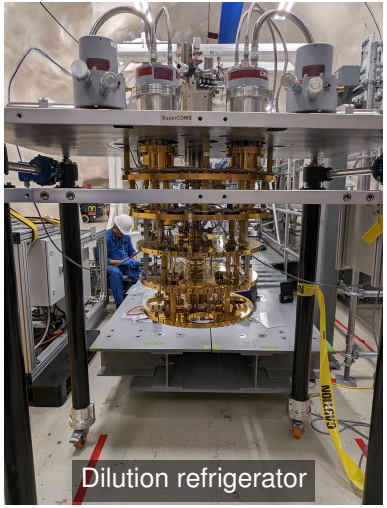
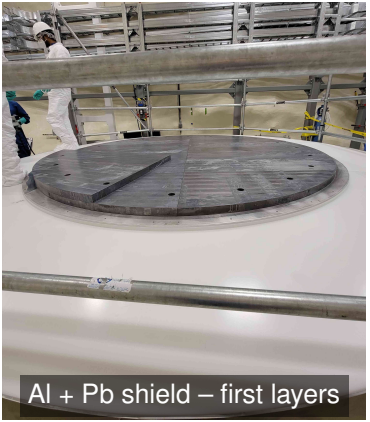
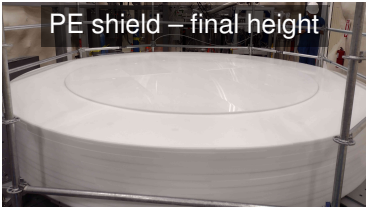
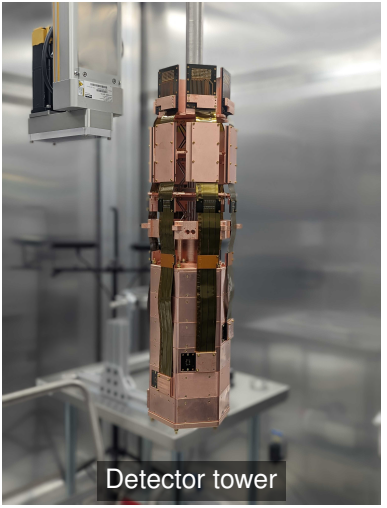




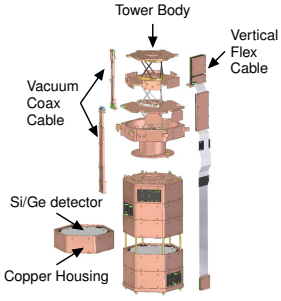




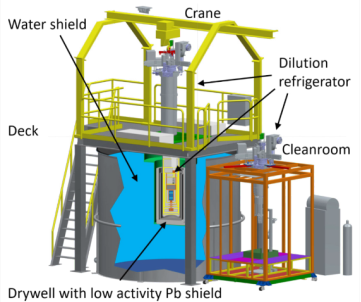
Tower testing at CUTE FACILITY

- The **C**ryogenic **U**nderground **TE**st facility is located in SNOLAB next to SuperCDMS.
- Close collaboration between CUTE and SuperCDMS.
- Plan to test one SuperCDMS HV tower hosting 4 Ge and 2 Si detectors this summer/fall.
- Possibility to achieve early science results.

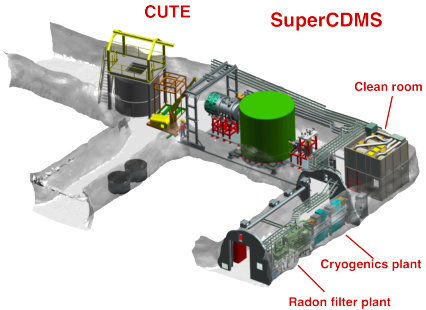
Detector tower



CUTE



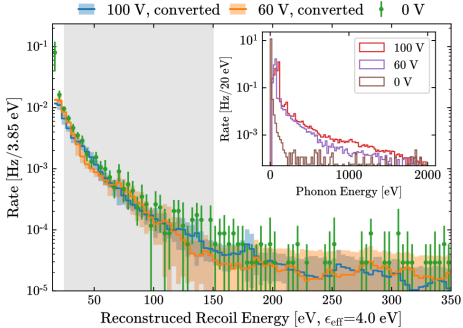
SNOLAB



Recent publications – SuperCDMS HVeV prototype detector

Investigation of low energy excess

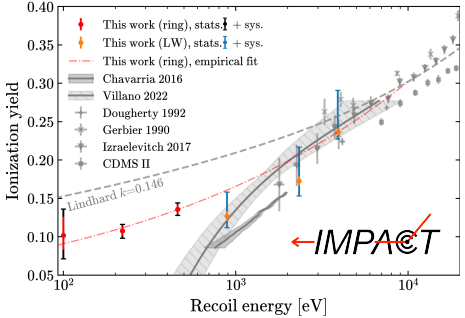
- Observed rate excess in low energy region.
- Hypothesis: luminescence photons could be created in PCB detector holder.
- Replaced PCB and analysis is underway.



Phys. Rev. D 105, 112006 (June 2022)

Nuclear recoil ionization yield in silicon

- Ionization yield is the ratio of charge carriers produced by NR and ER.
- Ionization yield measurements below 4 keV indicate significant deviation from Lindhard model.

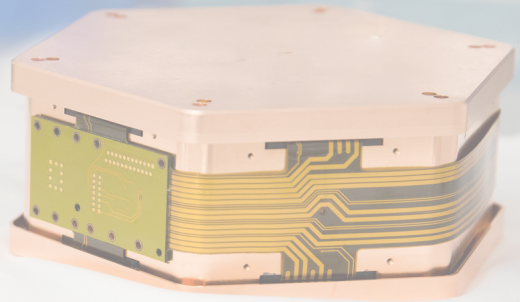


arXiv:2303.02196 (March 2023)

SuperCDMS also contributed to Snowmass 2021: arXiv:2203.08463

Summary & Outlook

- SuperCDMS is currently under construction at SNOLAB.
- Detector tower testing will be performed in CUTE in summer/fall 2023.
- Plan to begin commissioning in 2024.
- Complementary detector technologies and crystal materials allow:
  - a broadband DM search and
  - sensitivities down to unprecedented cross sections.



Flag icons from flaticon.com

SuperCDMS Collaboration

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