

The SuperCDMS SNOLAB Experiment

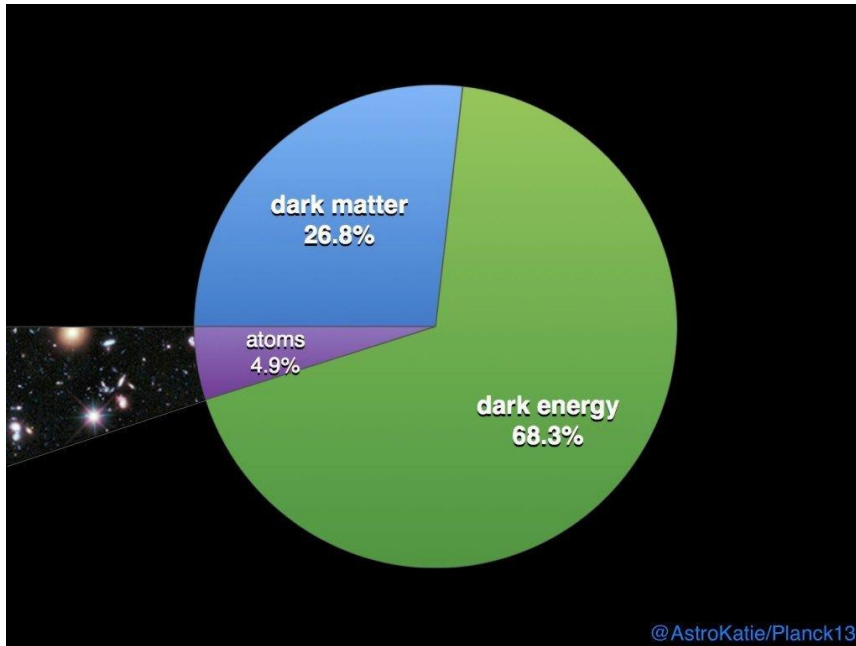


Aditi Pradeep

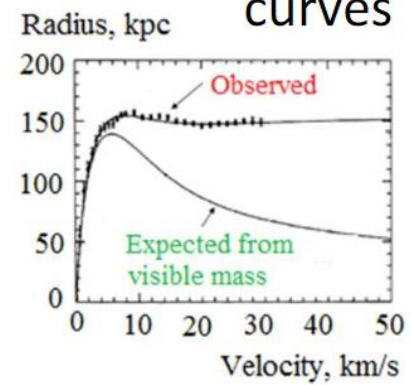
University of British Columbia /
TRIUMF

The million dollar question...

What is dark matter?



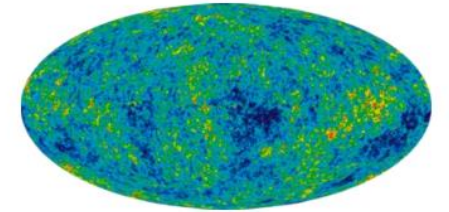
Galaxy rotation curves



Gravitational lensing

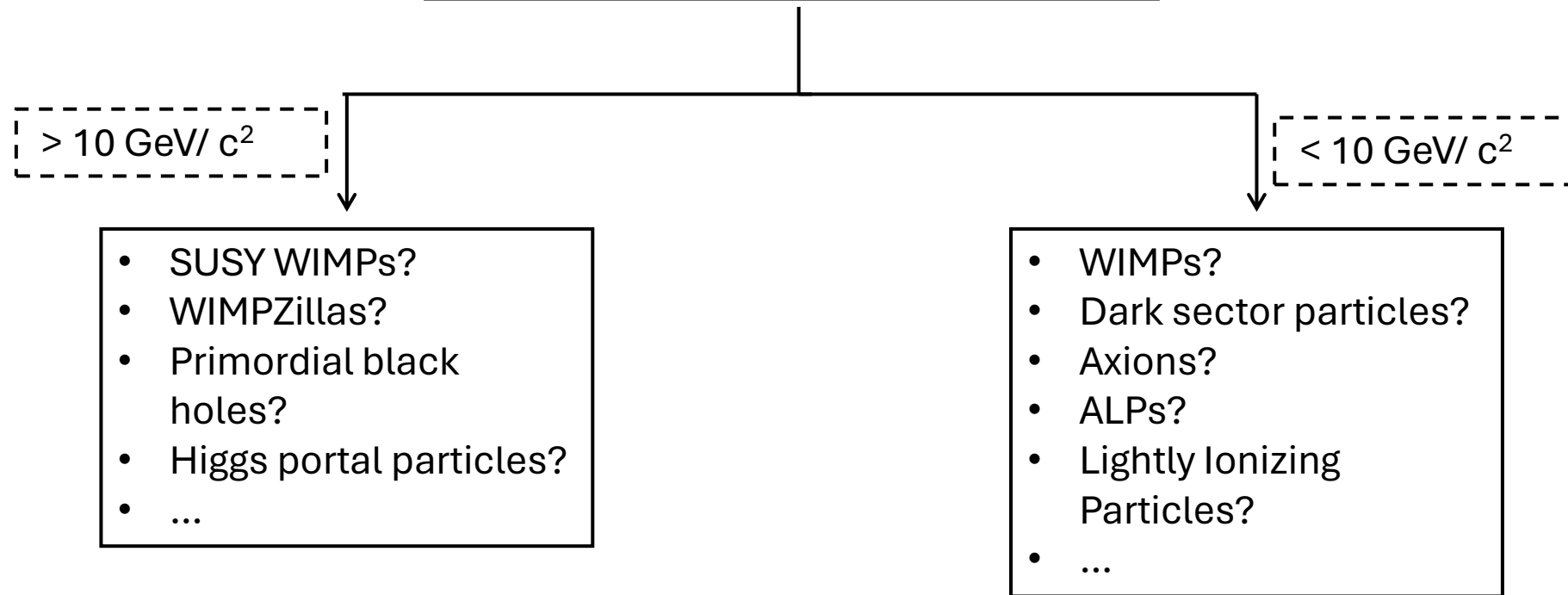


Anisotropy of CMB

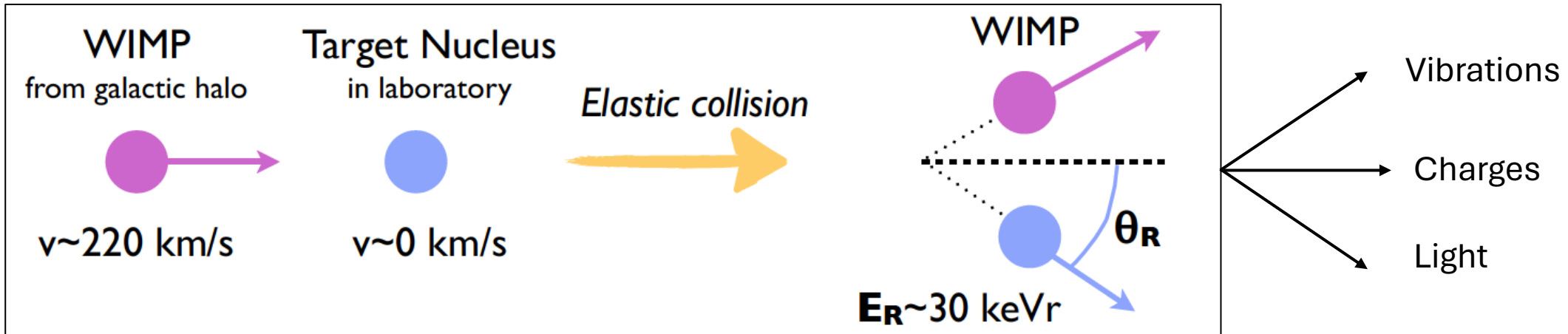
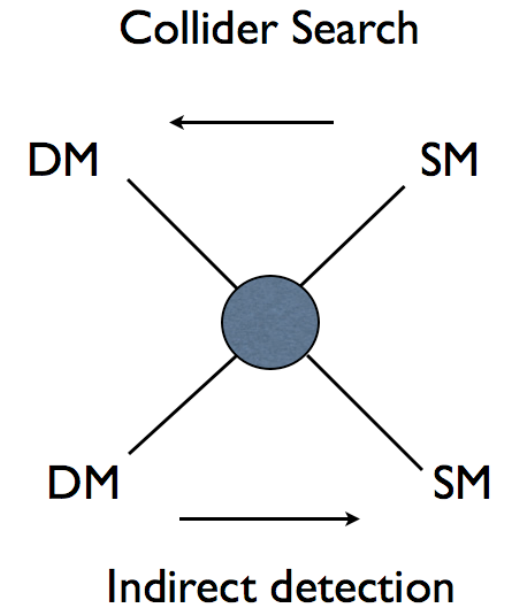
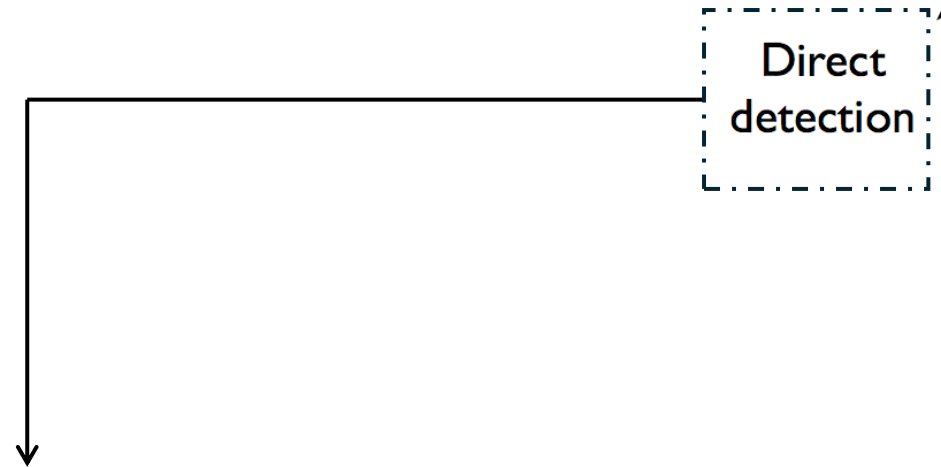


The million dollar question...

What is dark matter?

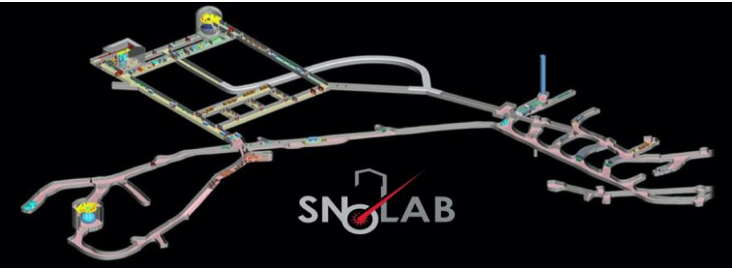


Dark matter in a lab



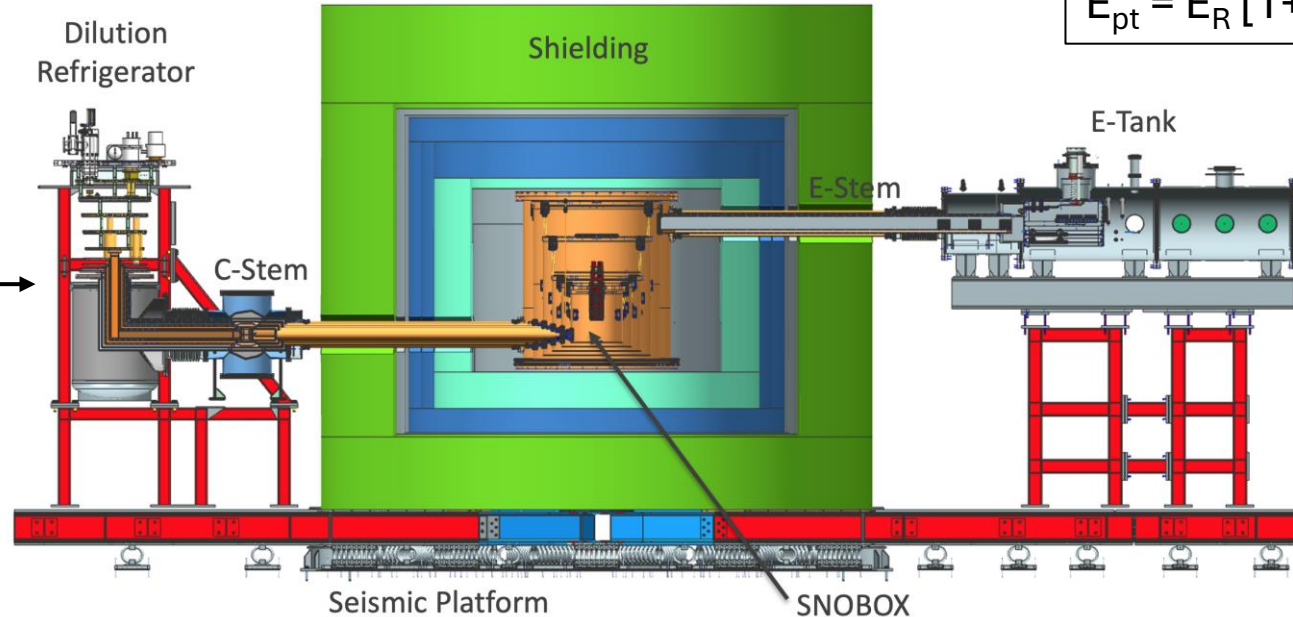
Dark matter in a lab

The lab

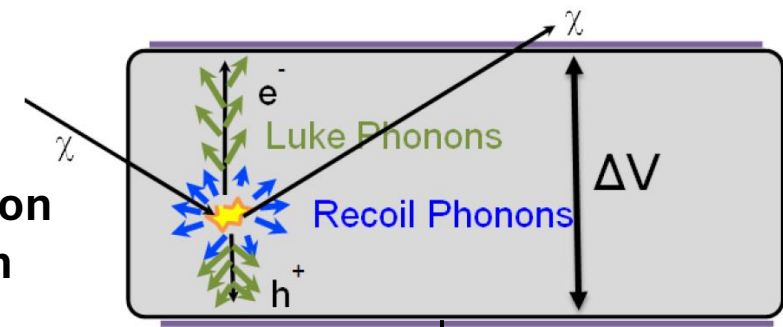


The experiment SuperCDMS SNOLAB

- Initial 4 tower payload – 2 HV, 2 iZIP
- 24 cryogenic Si and Ge detectors
- Encased in SNOBOX and shielding
- Cooled with dilution fridge
- Vibrationally isolated



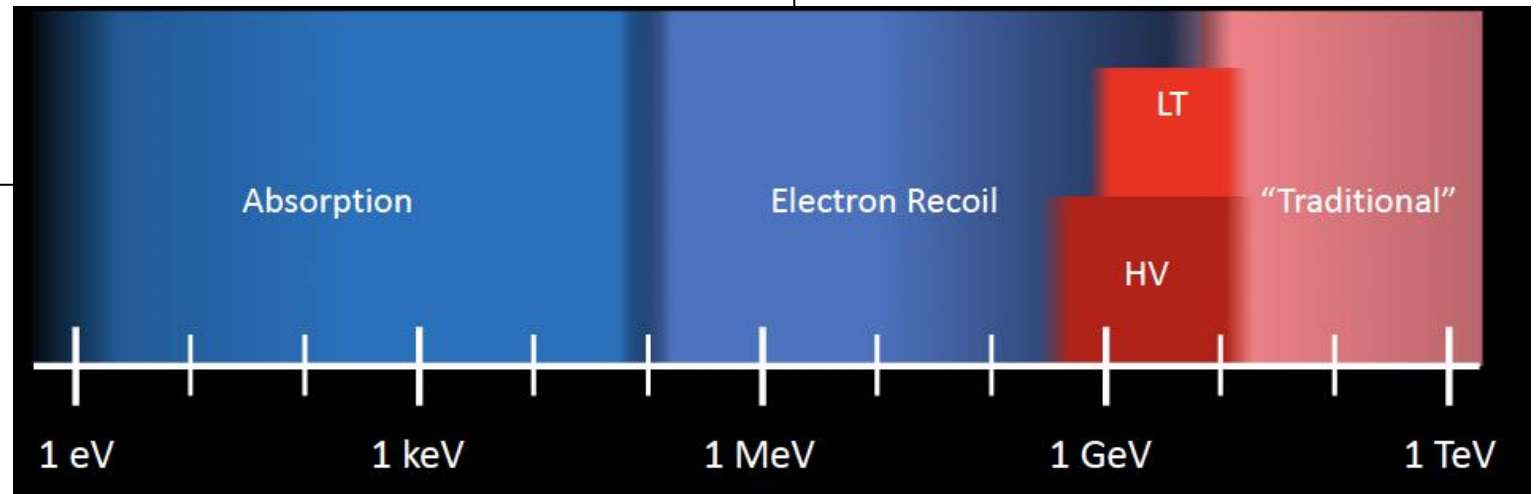
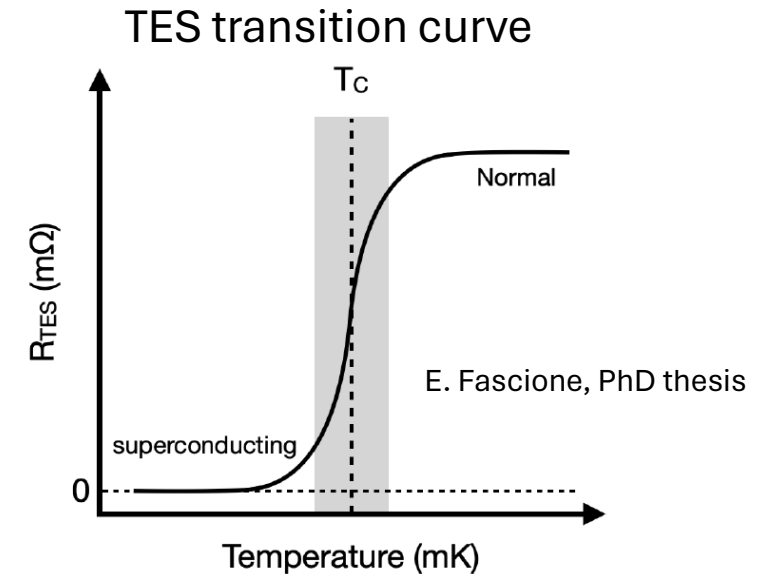
The detection mechanism



Phonons and Ionization.
Although sometimes only an amplified phonon signal is collected by accelerating charges via NTL effect:
 $E_{pt} = E_R [1 + Y(E_R)eV/\epsilon]$

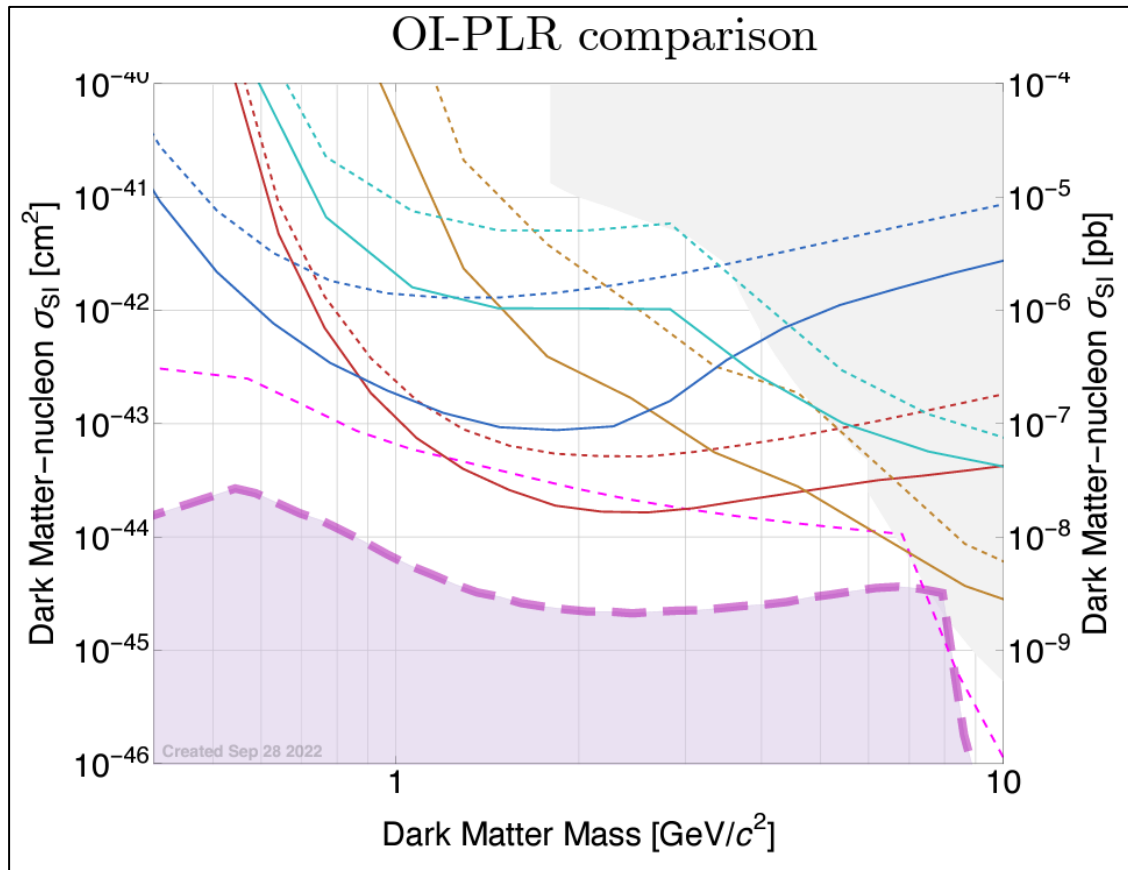
A broadband dark matter search

- Two detection schemes:
 - Ionization + phonon (iZIP detectors; $V < 10$ V)
 - (Amplified) phonon only (HV detectors; $V > 10$ V)
- HV detectors = lower threshold; iZIP detectors = excellent nuclear recoil – electron recoil discrimination
- Transition Edge Sensor (TES) readout for phonons; ionization readout with HEMTs
- Threshold $O(100\text{'s eV}_t)^*$
- Resolution $O(10\text{'s eV}_t)^*$



* Refer [arXiv:2203.08463](https://arxiv.org/abs/2203.08463)

A broadband dark matter search



Comparison of expected NRDM sensitivity for SCDMS SNOLAB between OI¹ (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.

¹ Refer <https://arxiv.org/abs/physics/0203002>

* Refer [arXiv:2203.08463](https://arxiv.org/abs/2203.08463)

Building an experiment: Current status



✓ Fridge commissioning 2023



✓ Detector tower testing @CUTE 2023-2024



✓ DAQ installation 2021



✓ Shield base installation 2023

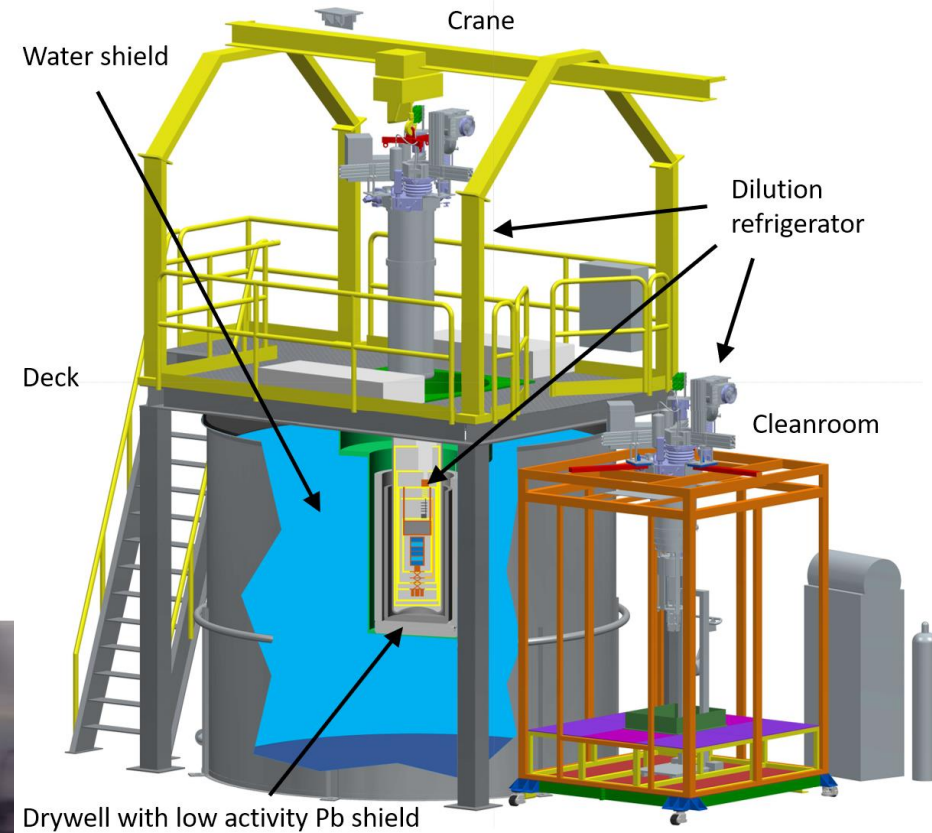
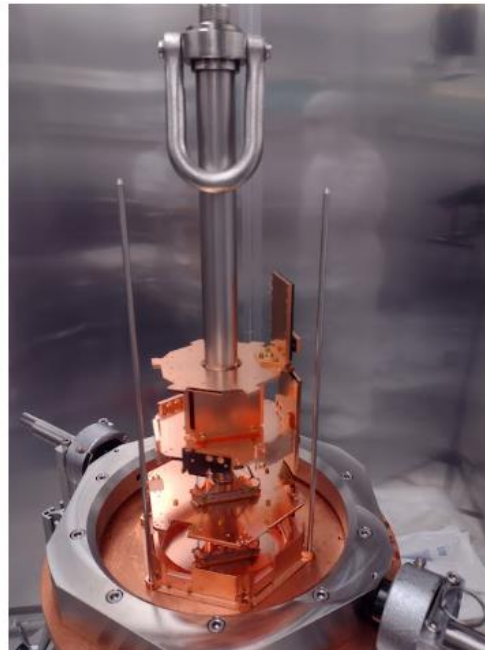


✓ SNOBOX & eTank testing in progress 2024

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Tower testing at CUTE facility

- 1 HV tower payload: 4 Ge, 2 Si detectors
- 5-month international effort
- First time testing in a low bg environment

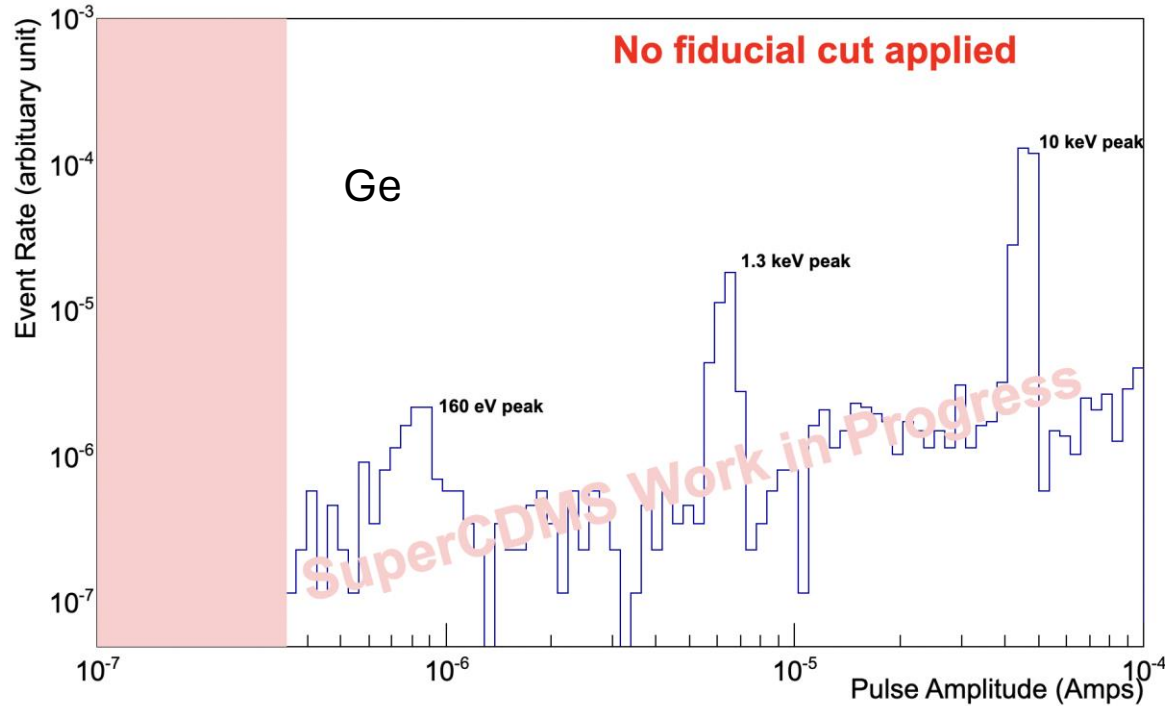


Several analysis efforts in progress

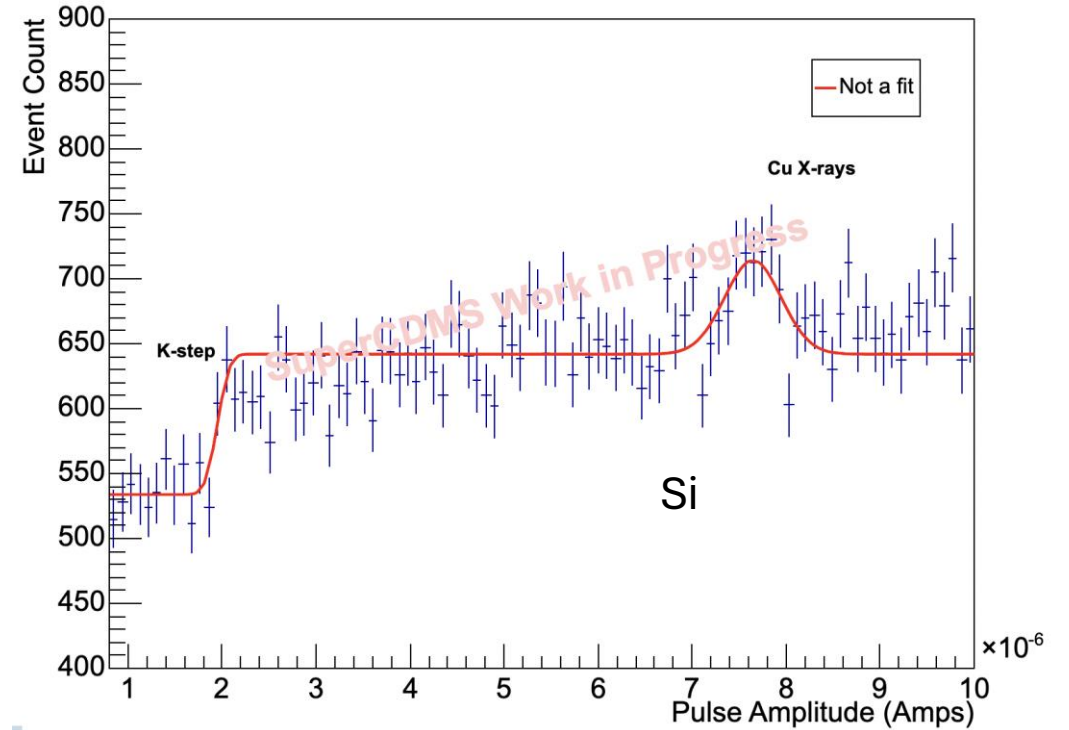
- ✓ Detector calibration
- ✓ Noise modelling
- ✓ Background rates
- ✓ Phonon signal amplification with NTL effect
- ✓ Sensitivity estimation
- ✓ Potential dark matter search

A sneak peak into our data...

Ge activation peaks in Tower 3 Detector 3 +/-25V (preliminary data quality cuts)



Ba calibration for Tower 3 Detector 2 at 0V (preliminary data quality cuts)



✓ Demonstrated calibration capability for Ge and Si detector types

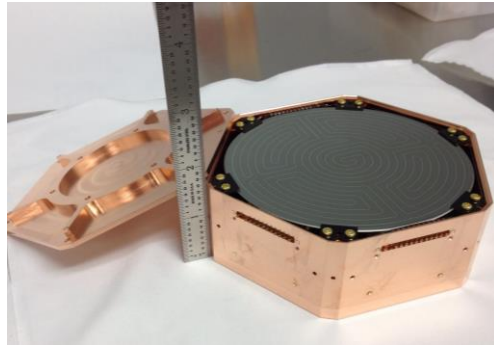
Summary

- SuperCDMS SNOLAB is a broadband direct detection experiment under construction at SNOLAB
- Rapidly ramping up to commissioning phase
- Detector towers tested at CUTE facility in SNOLAB
- Several analyses in progress to better understand our detectors
- Expecting early science results later this year

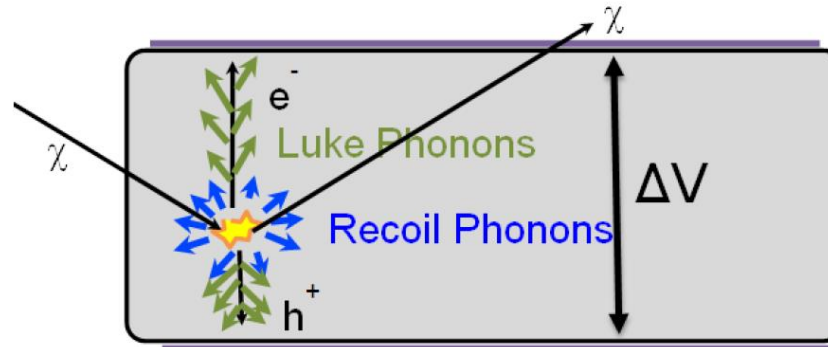
Thank you!

Backup slides

SCDMS DARK MATTER DETECTION

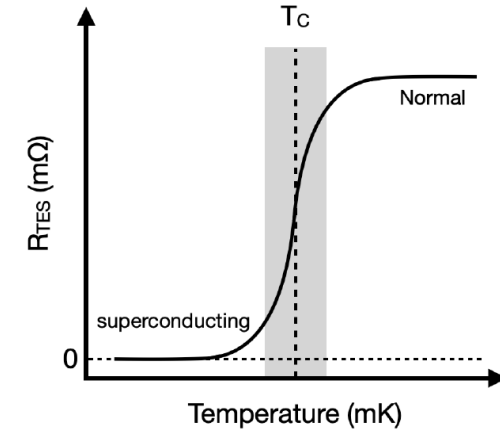


Prototype iZIP detector



$\Delta V < 10 \text{ V}$

$\Delta V > 10 \text{ V}$



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

- ✓ 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 $133 \text{ eV}_{\text{pt}}$ ($231 \text{ eV}_{\text{pt}}$)* in Si (Ge)
- ✓ Resolution of $19 \text{ eV}_{\text{pt}}$ ($33 \text{ eV}_{\text{pt}}$)* in Si (Ge)

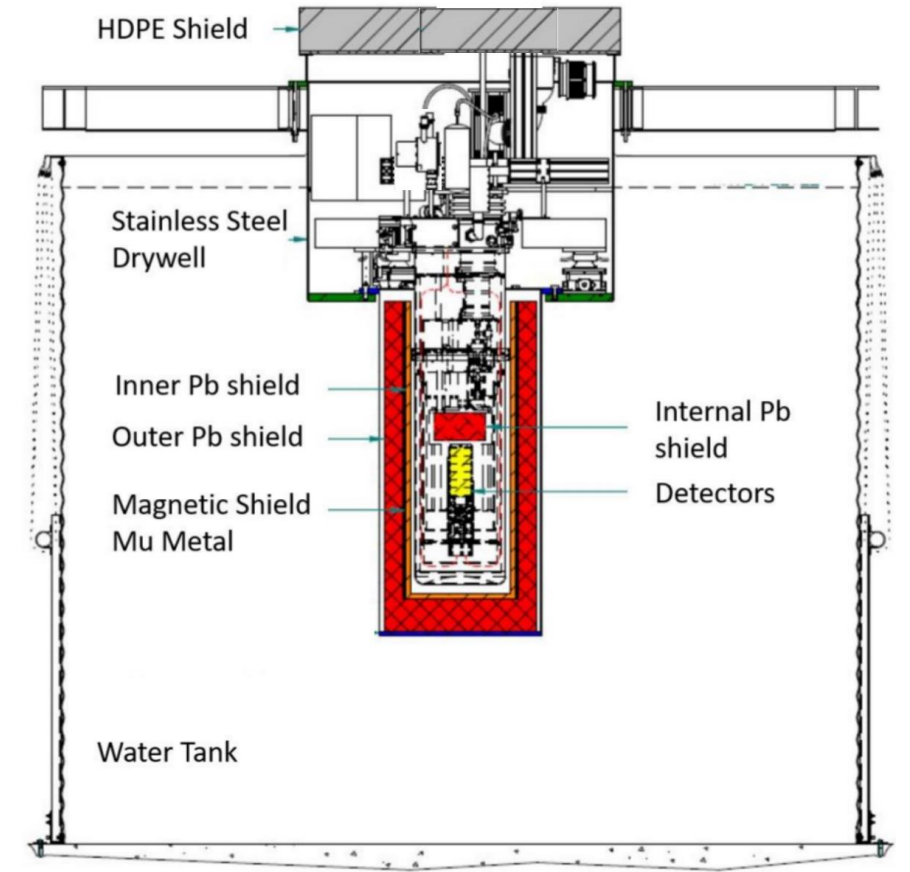
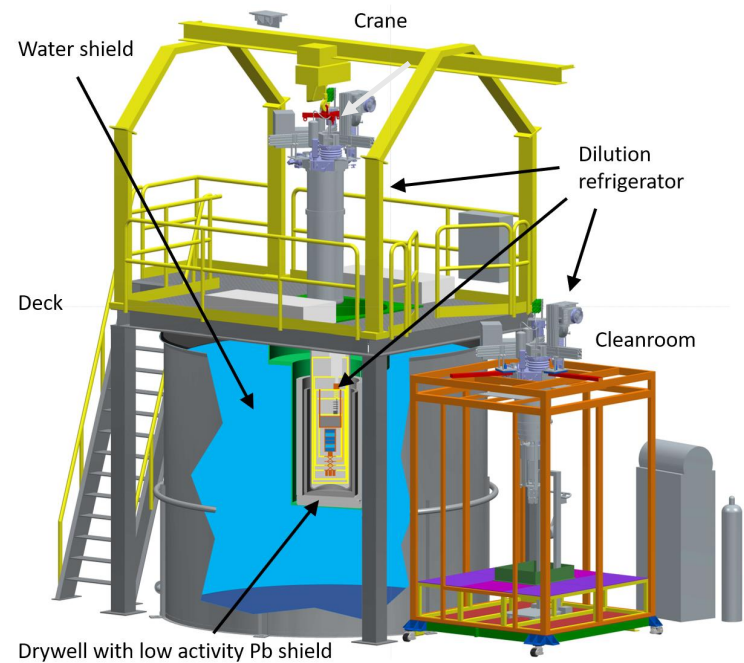
- ✓ Luke phonons dominate, $E_T = E_R \left(1 + Y(E_R) \frac{eV_b}{\epsilon_{eh}} \right)$
- ✓ Readout 12 phonon channels
- ✓ **Low threshold detectors: HV**
- ✓ Threshold of $91 \text{ eV}_{\text{pt}}$ ($238 \text{ eV}_{\text{pt}}$)* in Si (Ge)
- ✓ Resolution of $13 \text{ eV}_{\text{pt}}$ ($34 \text{ eV}_{\text{pt}}$)* in Si (Ge)

* Refer [arXiv:2203.08463](https://arxiv.org/abs/2203.08463)

DETECTOR TESTING: CUTE

- ✓ Low bkgd testing of SCDMS detectors for early science
- ✓ Debugging potential software & hardware issues
- ✓ Several prototype and RnD devices and SCDMS tower already tested

CUTE facility



Slide taken from [Lake Louise talk](#), also by the author.