The SuperCDMS experiment at SNOLAB

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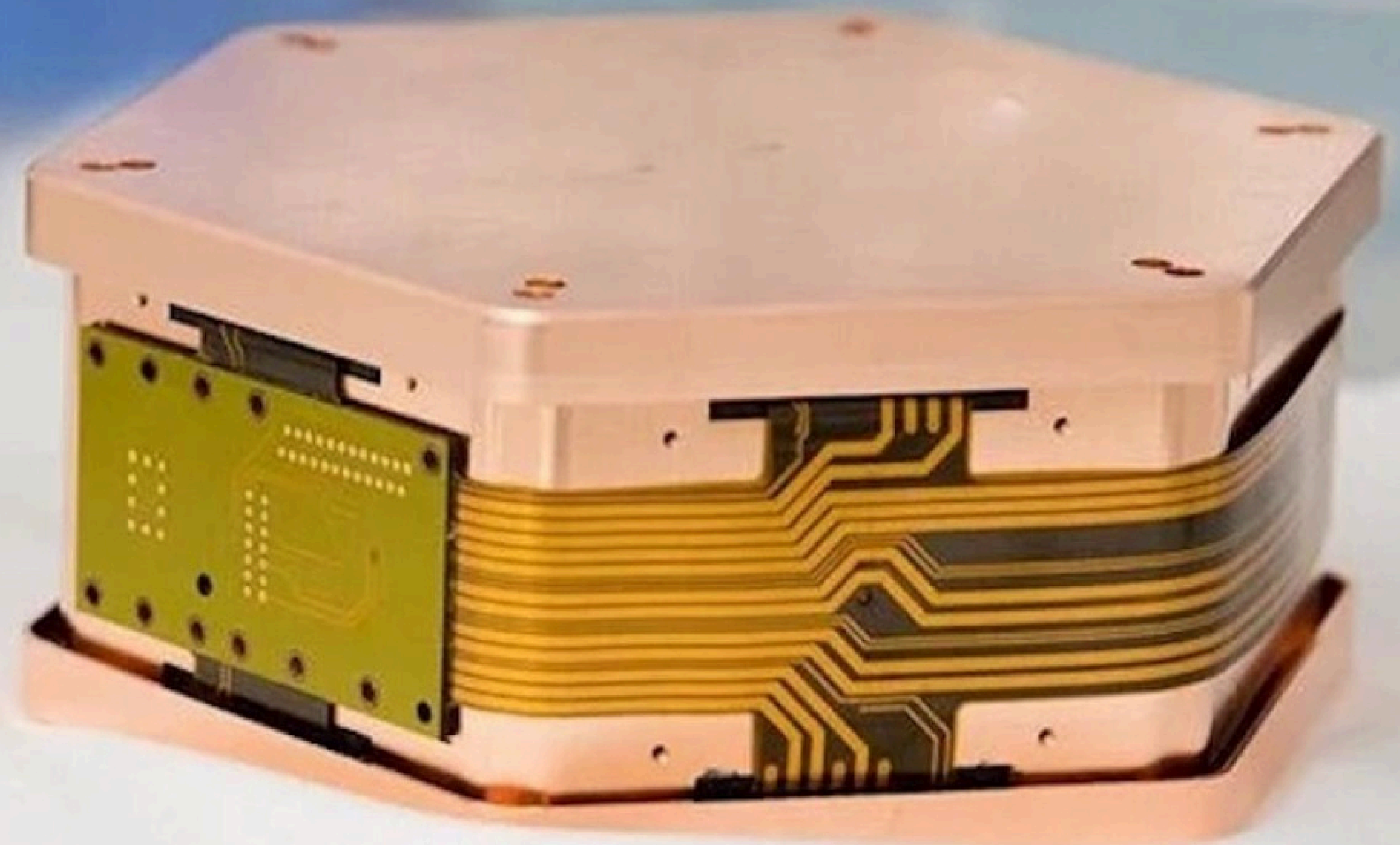
07/23/2024
TRIUMF Science Week 2024



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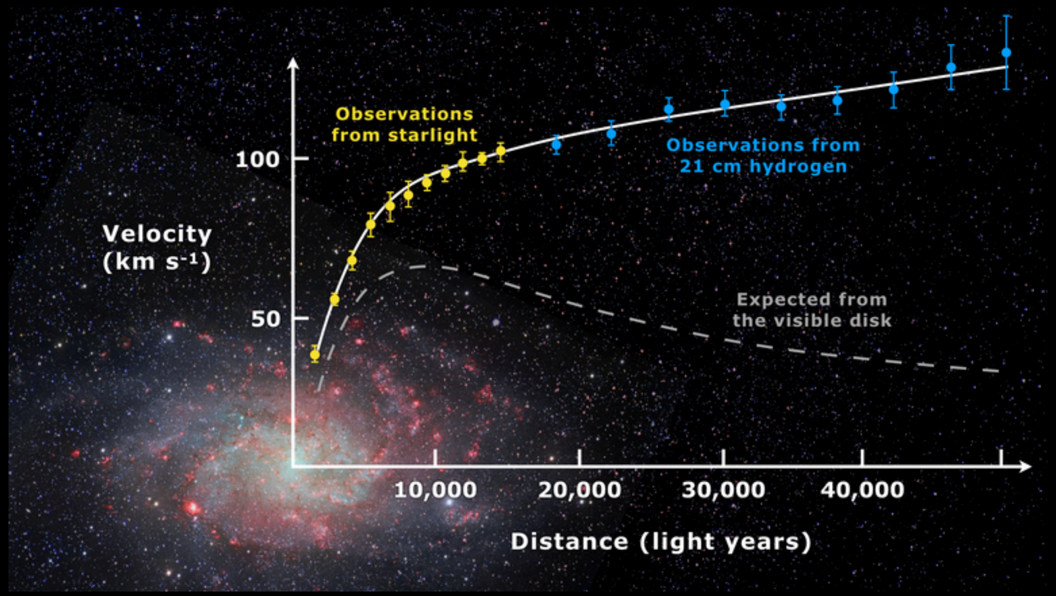
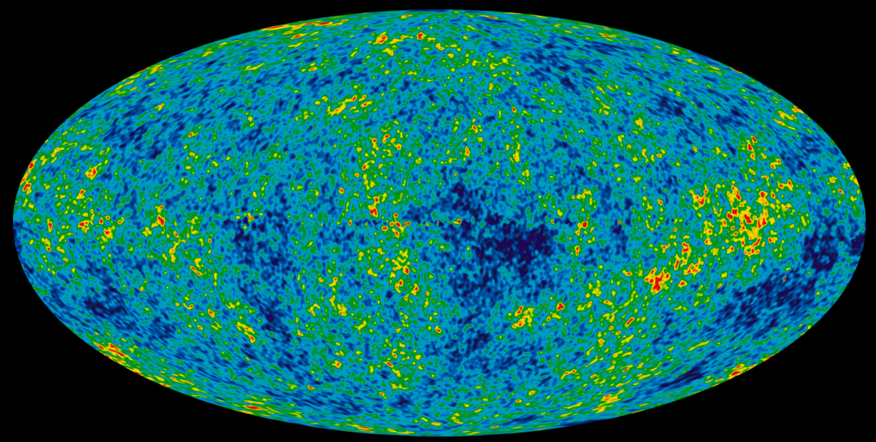
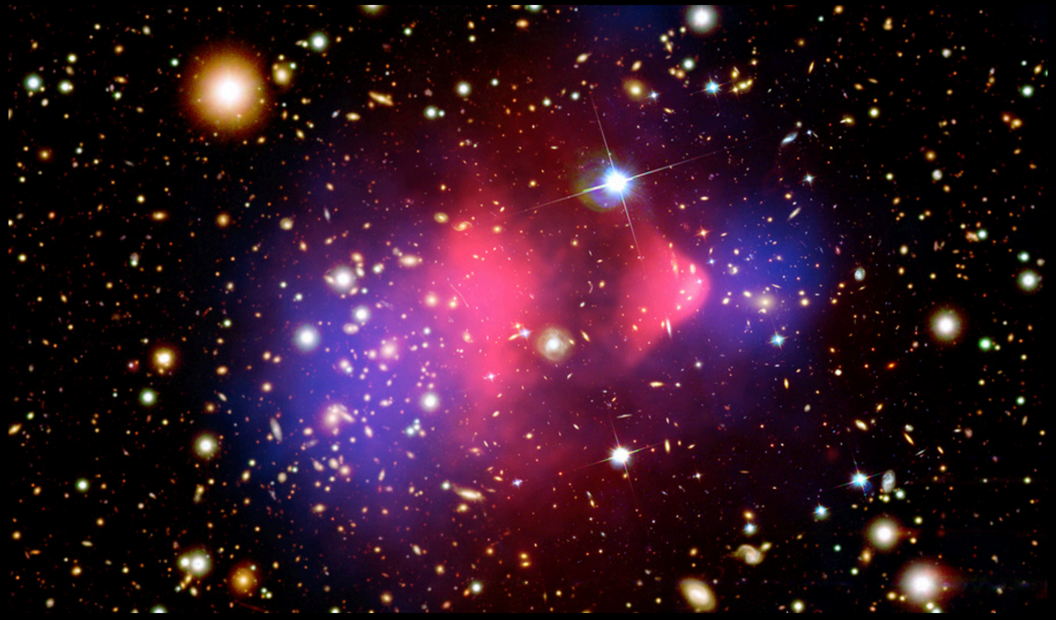
Evidence for Dark Matter and its properties



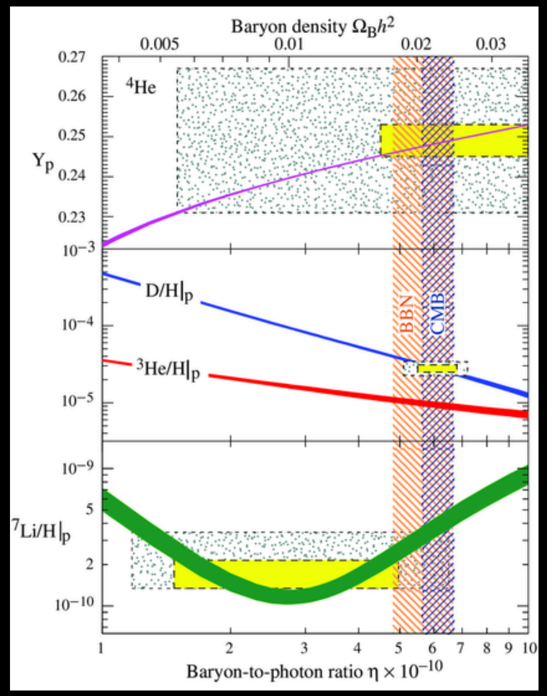
discrepancy in galatic rotational curve



Cosmic Microwave Background



the Bullet cluster

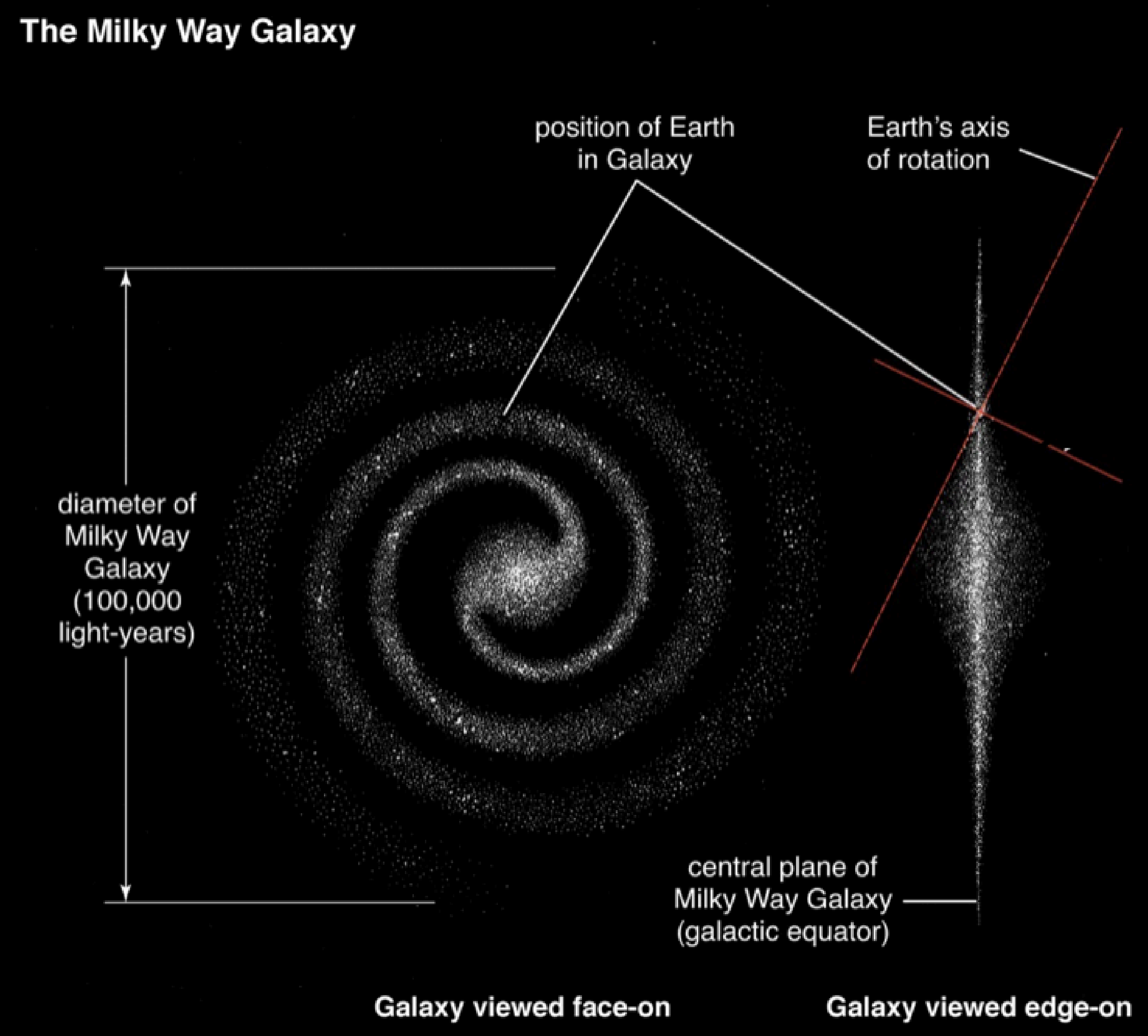


Big Bang Nucleosynthesis

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

In fact, we can assume some more...

Standard Halo Model



- **Local velocity (velocity of Dark Matter at the Earth)**

  $\sim 10^{-3}\,c$

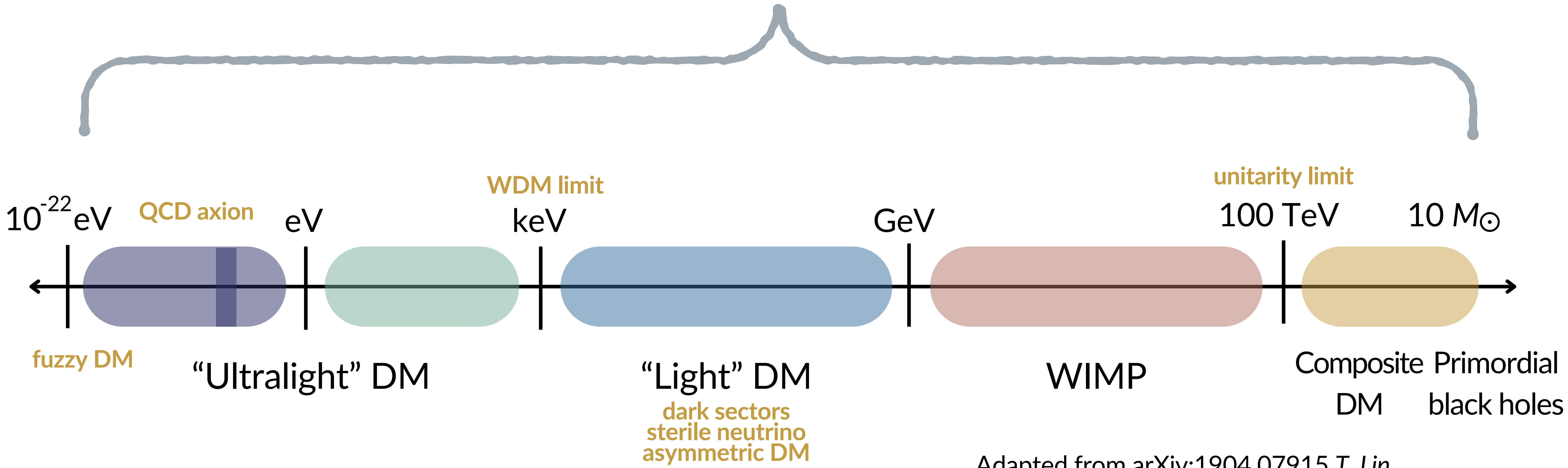
- **Local density (density of Dark Matter at the Earth)**

  $\sim 0.3\ \mathrm{GeV}/c^2/\mathrm{cm}^3$

  roughly $10^{-28}\ \mathrm{kg/cm}^3$

Dark Matter Mass

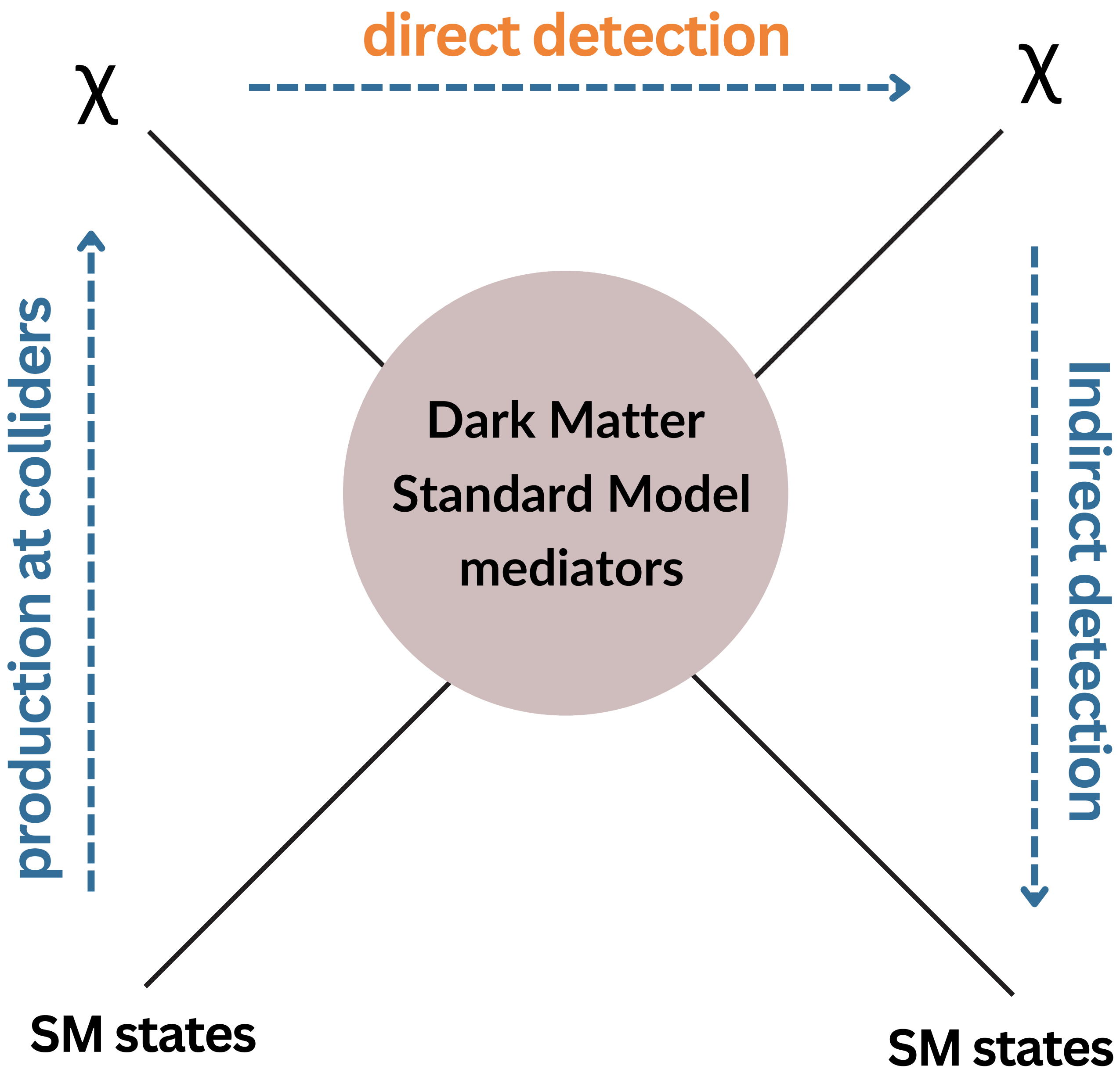
spanning across ~88 orders of magnitude



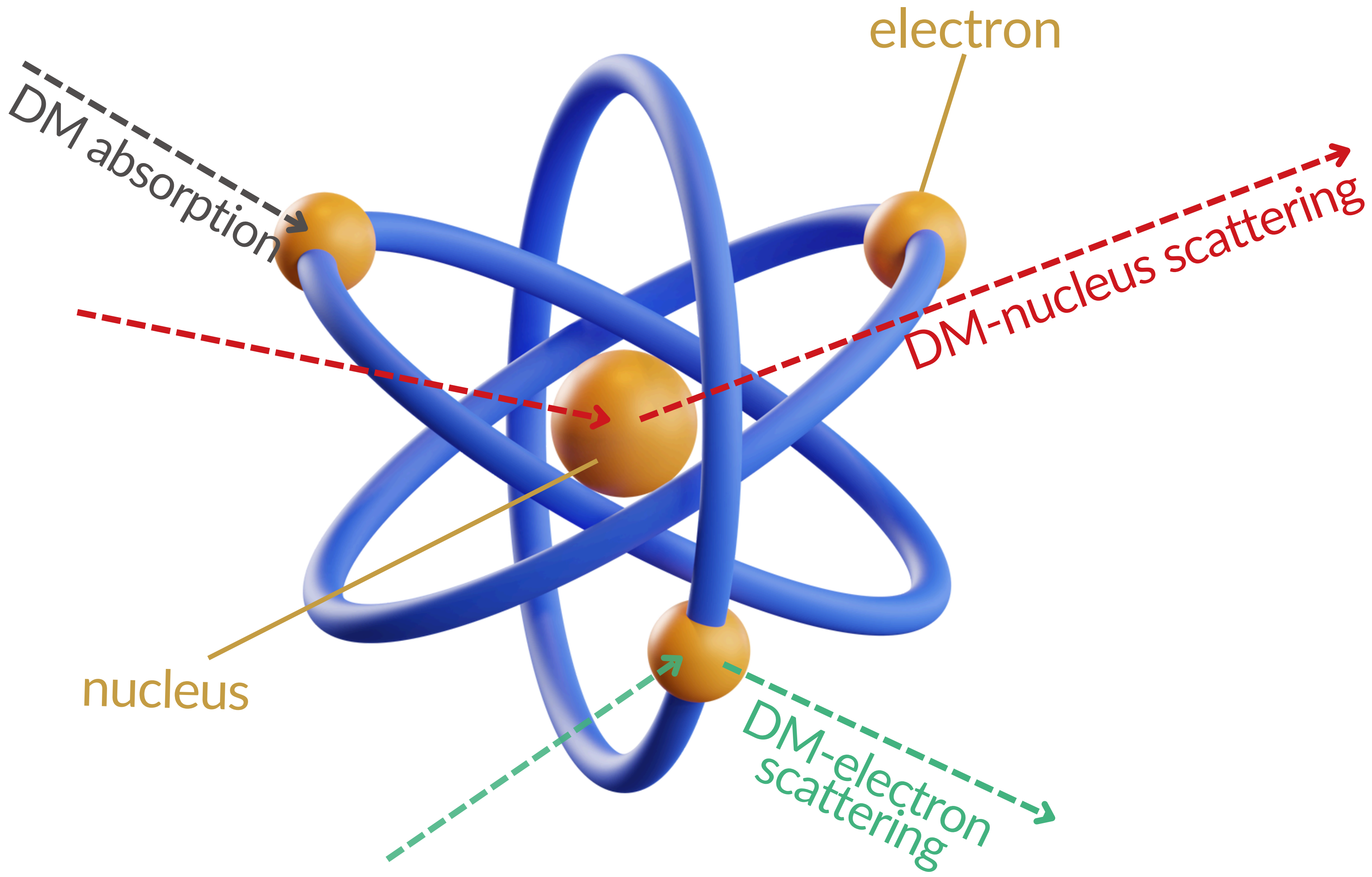
Adapted from arXiv:1904.07915 *T. Lin*

Make it, Break it, or Shake it

DarkLight@TRIUMF



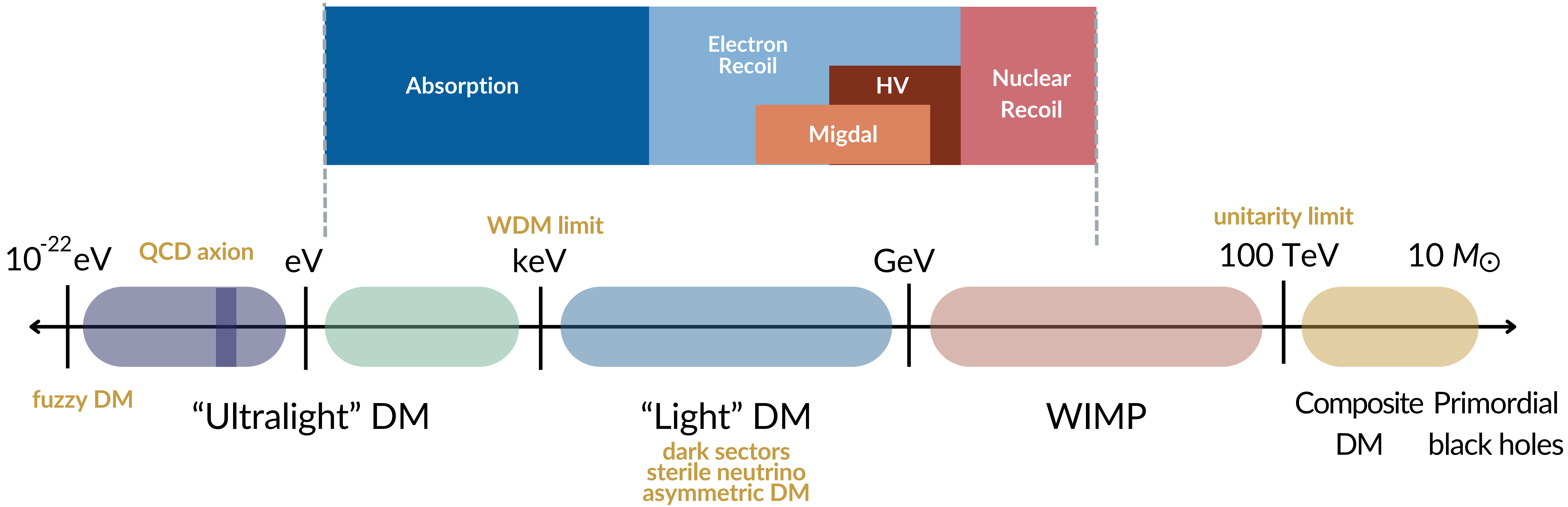
Typical Schemes for DM Direct Search



- **DM-nucleus scattering**
  - typically sensitive to >GeV dark matter if assuming elastic interaction
- **DM-electron scattering**
  - inelastic process allowing full energy deposition
  - suitable for <GeV dark matter search
- **DM absorption**
  - Clear spectral line feature
  - mass sensitivity limited by threshold

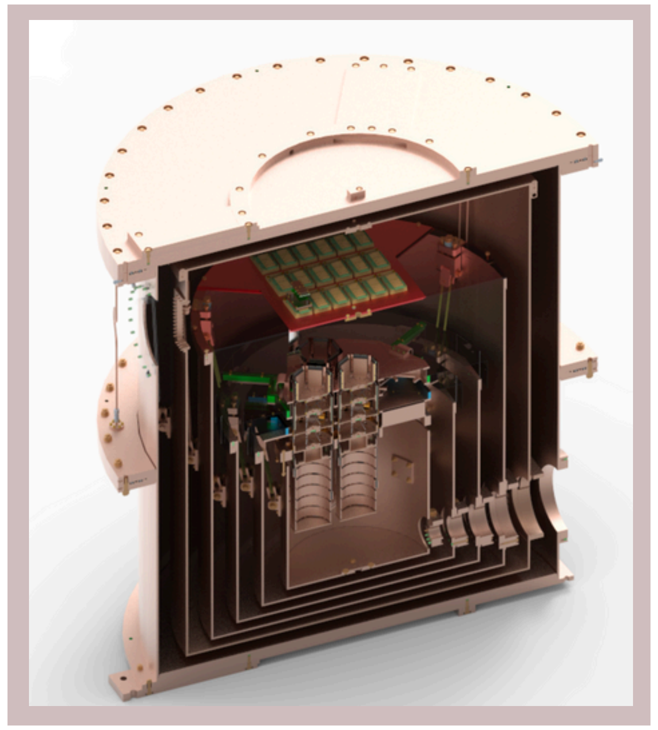
SuperCDMS as a Dark Matter Experiment

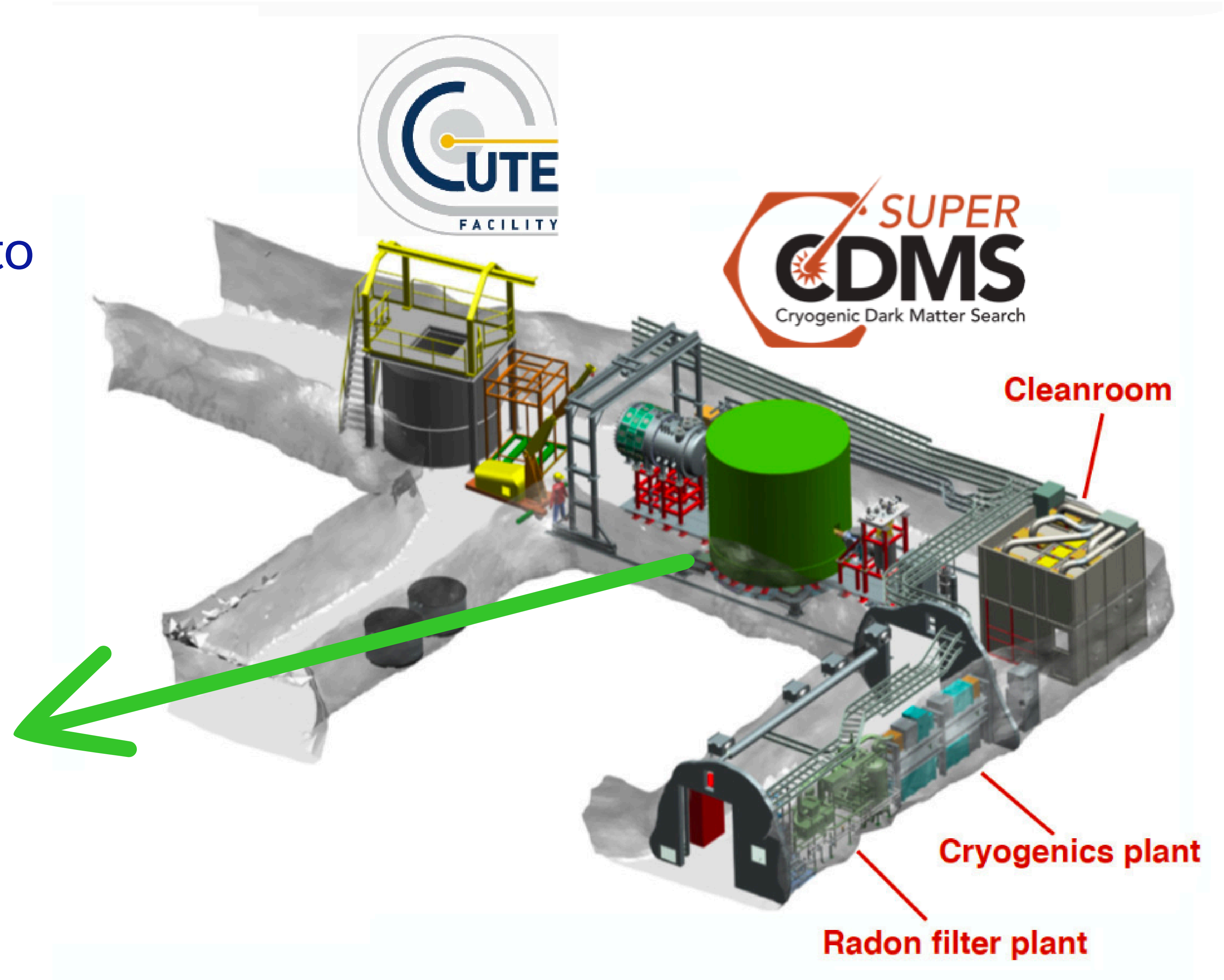
SuperCDMS SNOLAB is sensitive to various dark matter models across **10 orders of magnitude**!



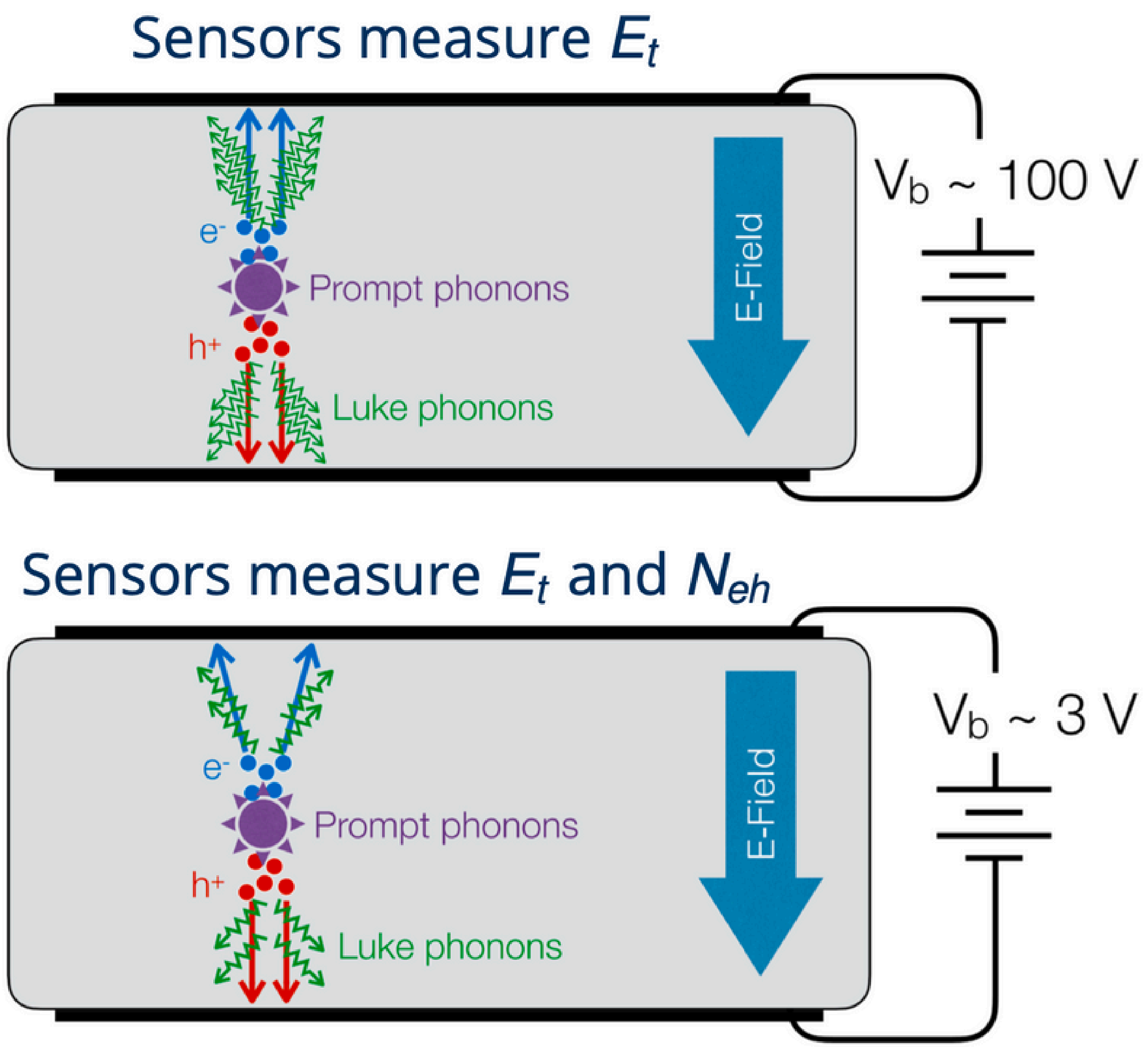
SuperCDMS SNOLAB Experiment

- US Generation 2 Dark Matter Experiment
- 2km underground in Sudbury, Canada
- Germanium and Silicon crystals cooled down to ~10 mK to be sensitive to minute dark matter signals





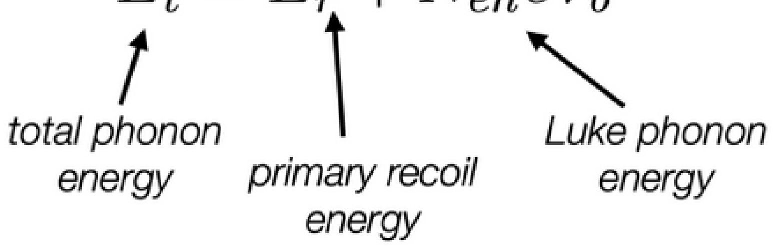
SuperCDMS SNOLAB Detector Technology



Two different detector configurations

- **HV detectors -> low threshold**
  - NTL effect to reach lower threshold
  - highest science reach

$$E_t = E_r + N_{eh} e V_b$$

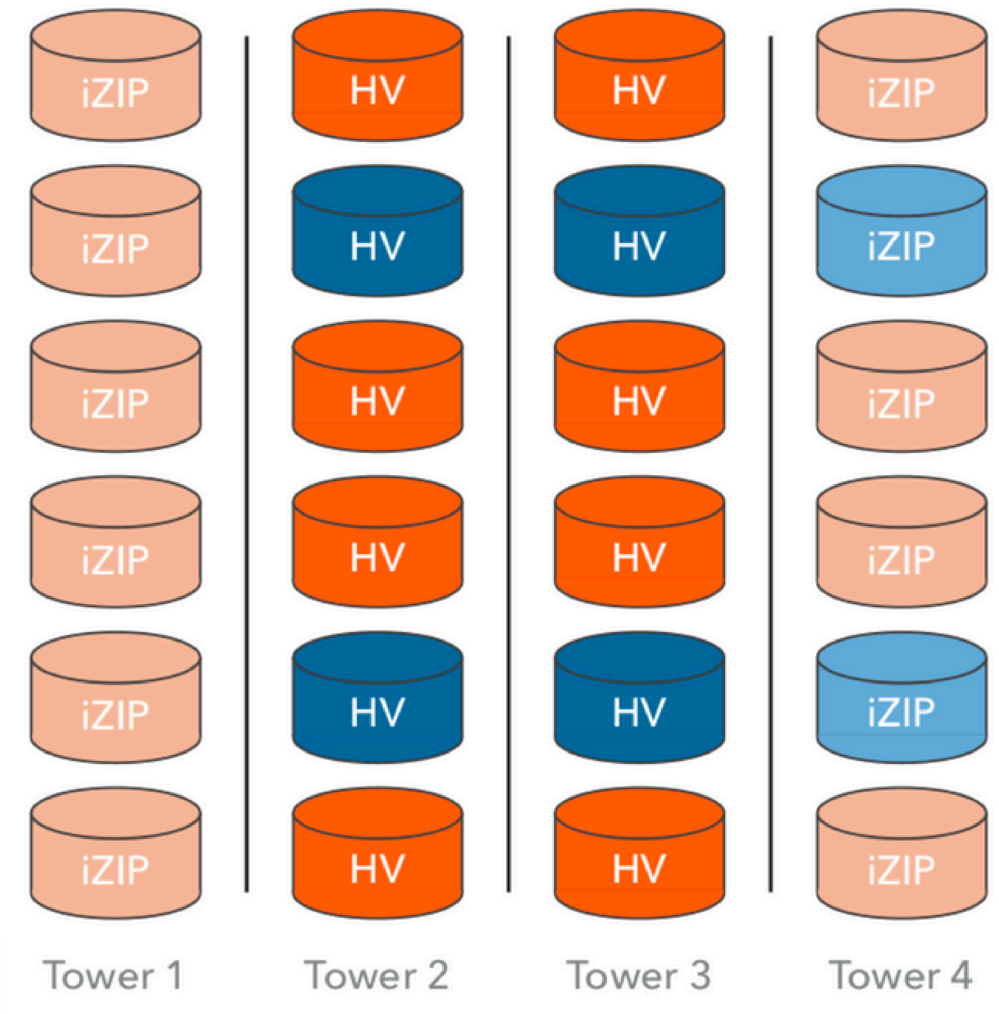


- **iZIP detectors -> low background**
  - ionization-based NR/ER background discrimination
  - higher dynamic range
  - radioactive background measurements

Assemblying the last tower at SLAC summer 2022

SuperCDMS SNOLAB Detector Technology

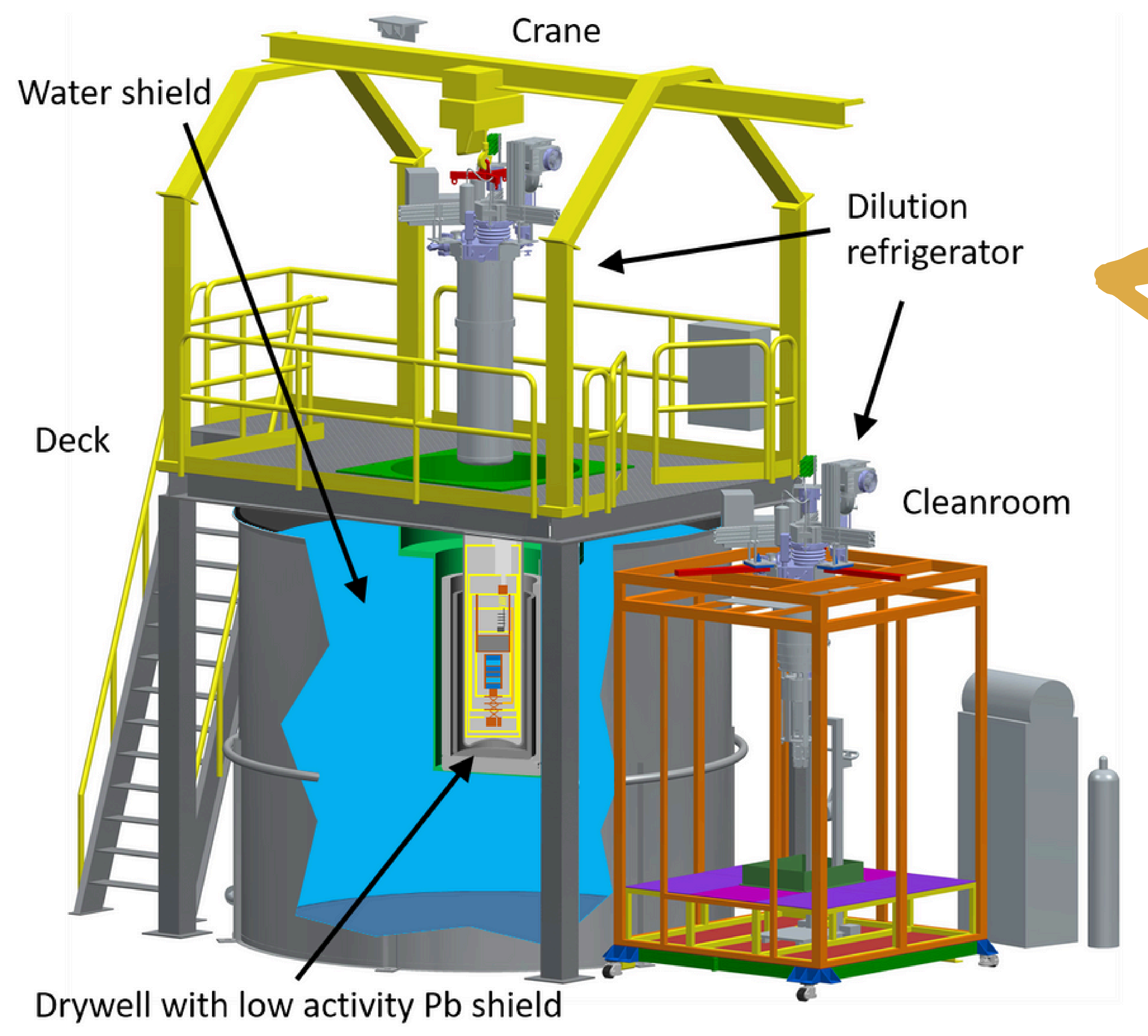
24 detectors were assembled in 4 towers at SLAC, and arrived at SNOLAB underground in 2023.

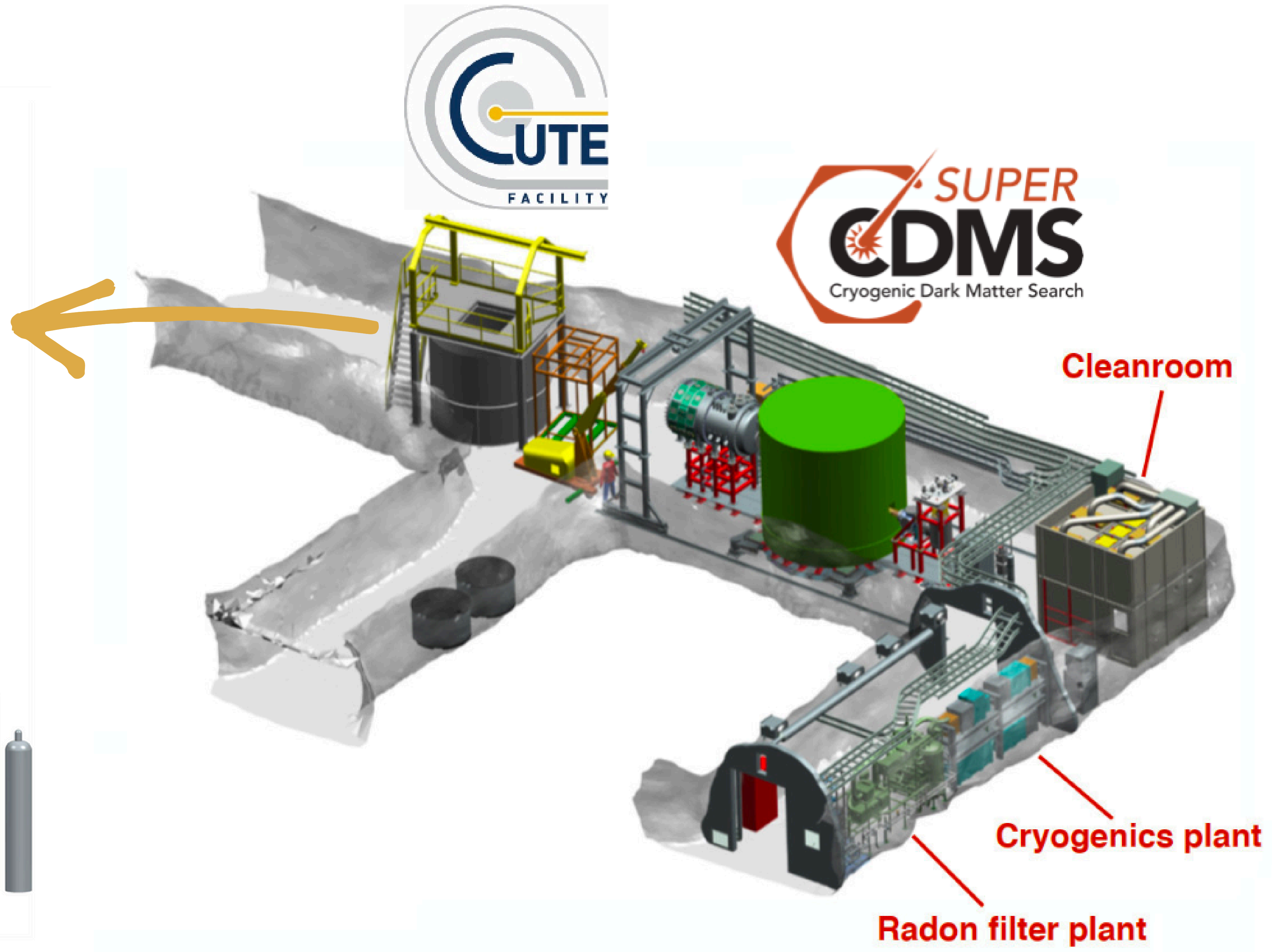


Ge: 1.4 kg

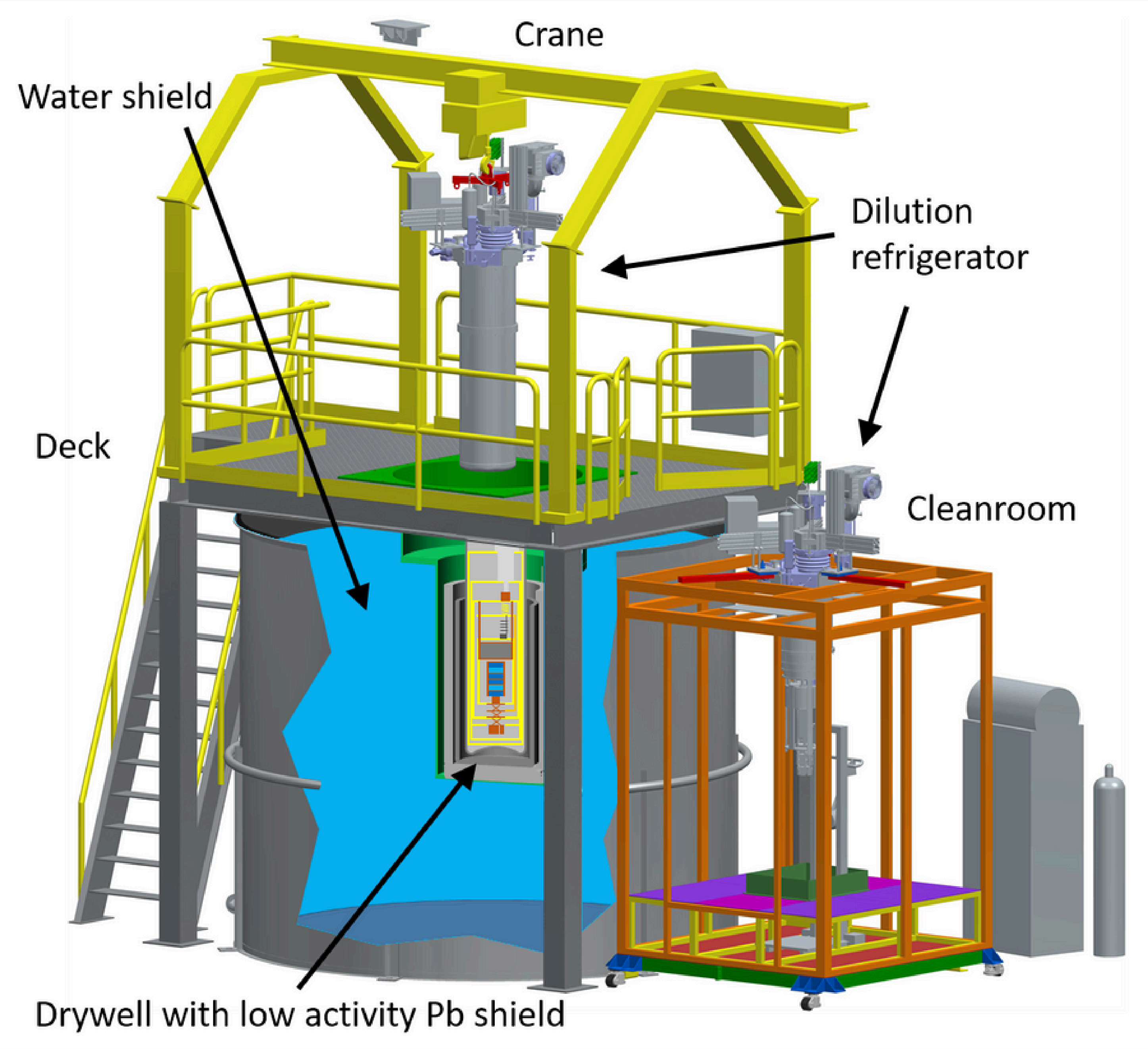
Si: 0.6 kg

Cryogenic Underground TEst Facility





Cryogenic Underground TEst Facility



- CUTE is a unique deep underground, low background cryogenic test facility
  - Background level ~10 DRU
  - Suspension system to reduce vibration
- Efficient turnaround of cryogenic device testing

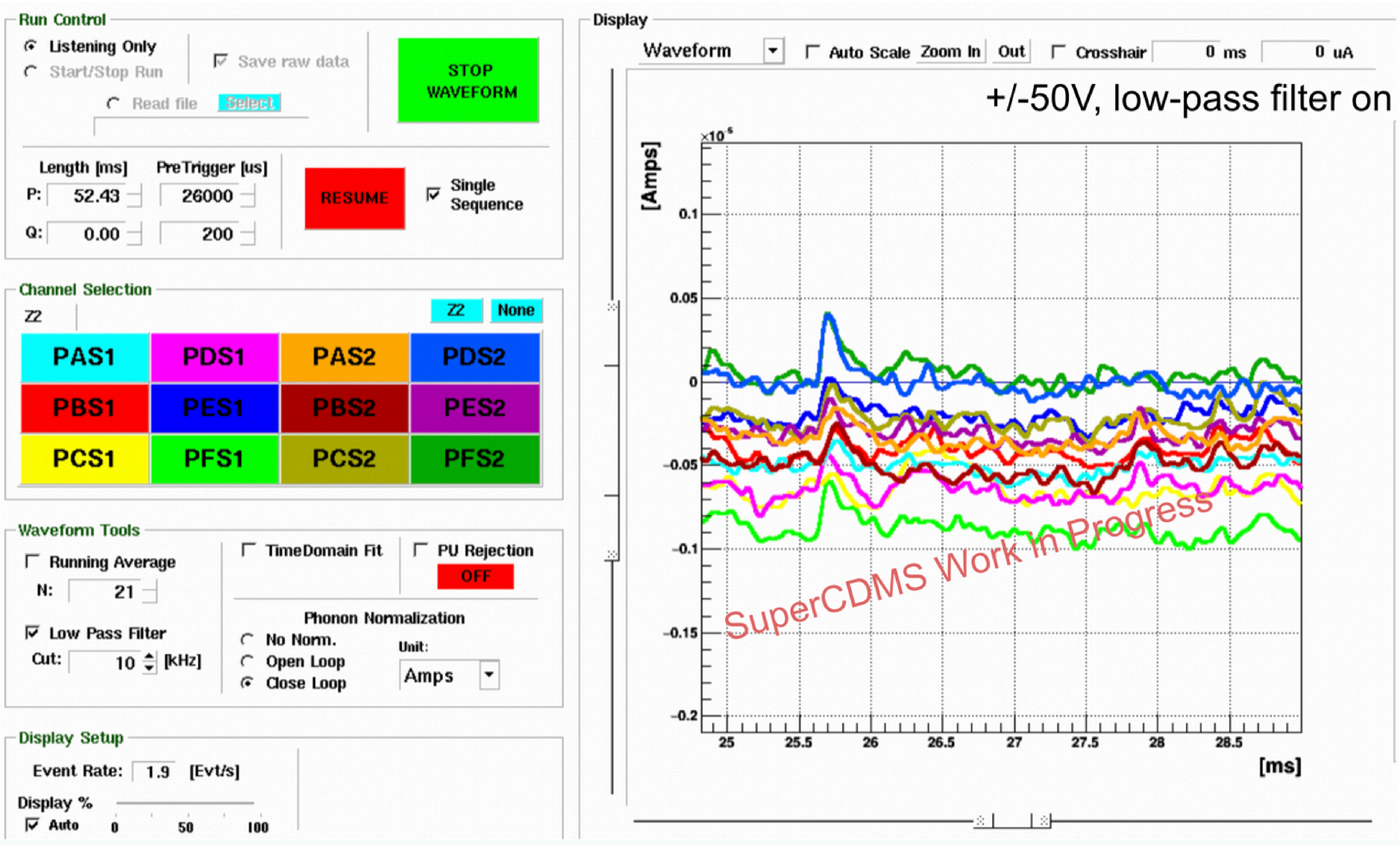
Tower testing at CUTE

- A significant milestone for the experiment
    - First underground, low background environment testing of the new generation SuperCDMS detectors

- The TRIUMF/UBC group played a leading role in the 5-month long tower testing efforts

TRIUMF/UBC group standing on top of CUTE

Tower Testing at CUTE: First Raw Pulses

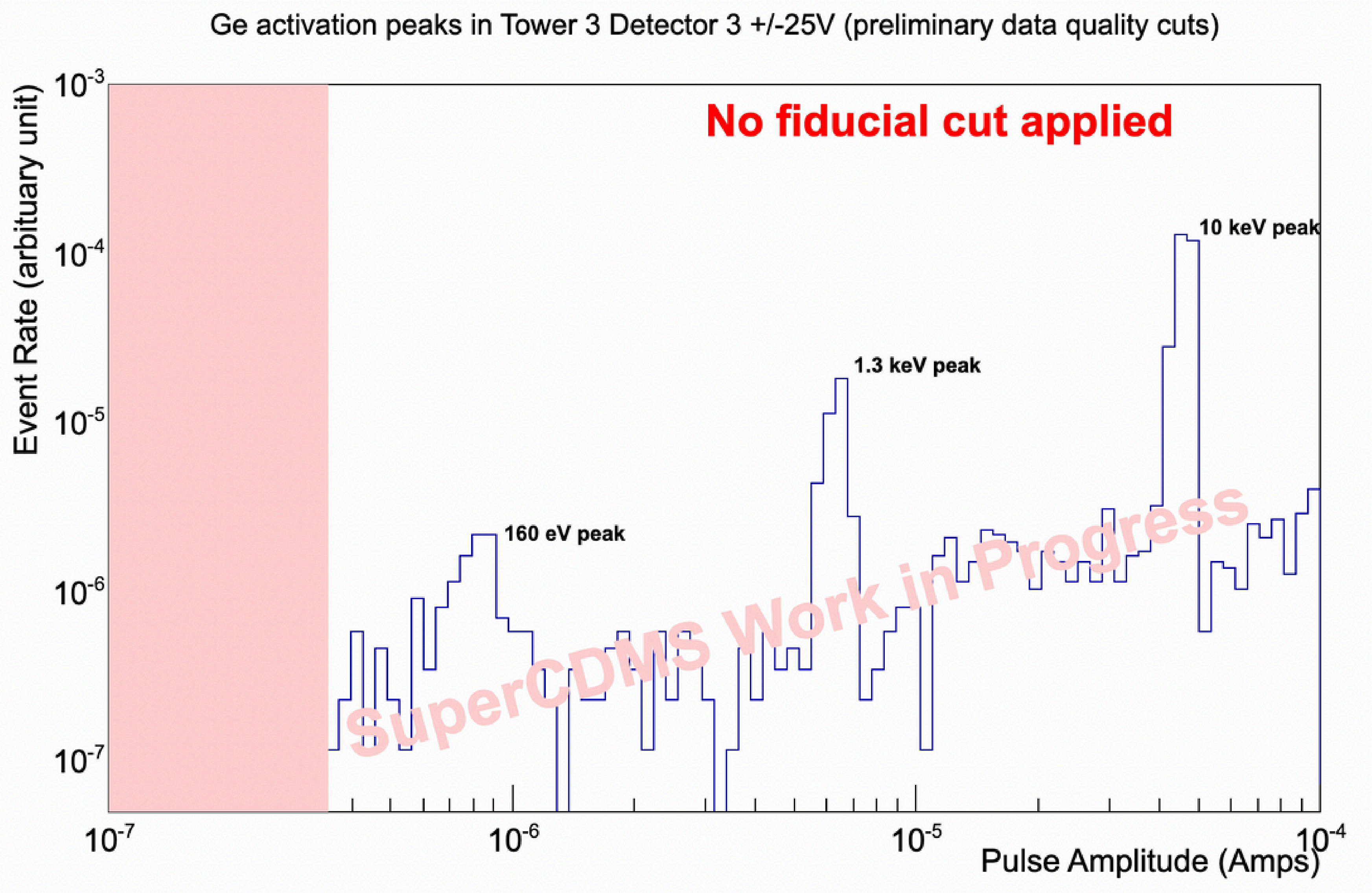


At use is the SuperCDMS DAQ, developed at TRIUMF based on the MIDAS system

Tower Testing at CUTE: Ge Detector Calibration

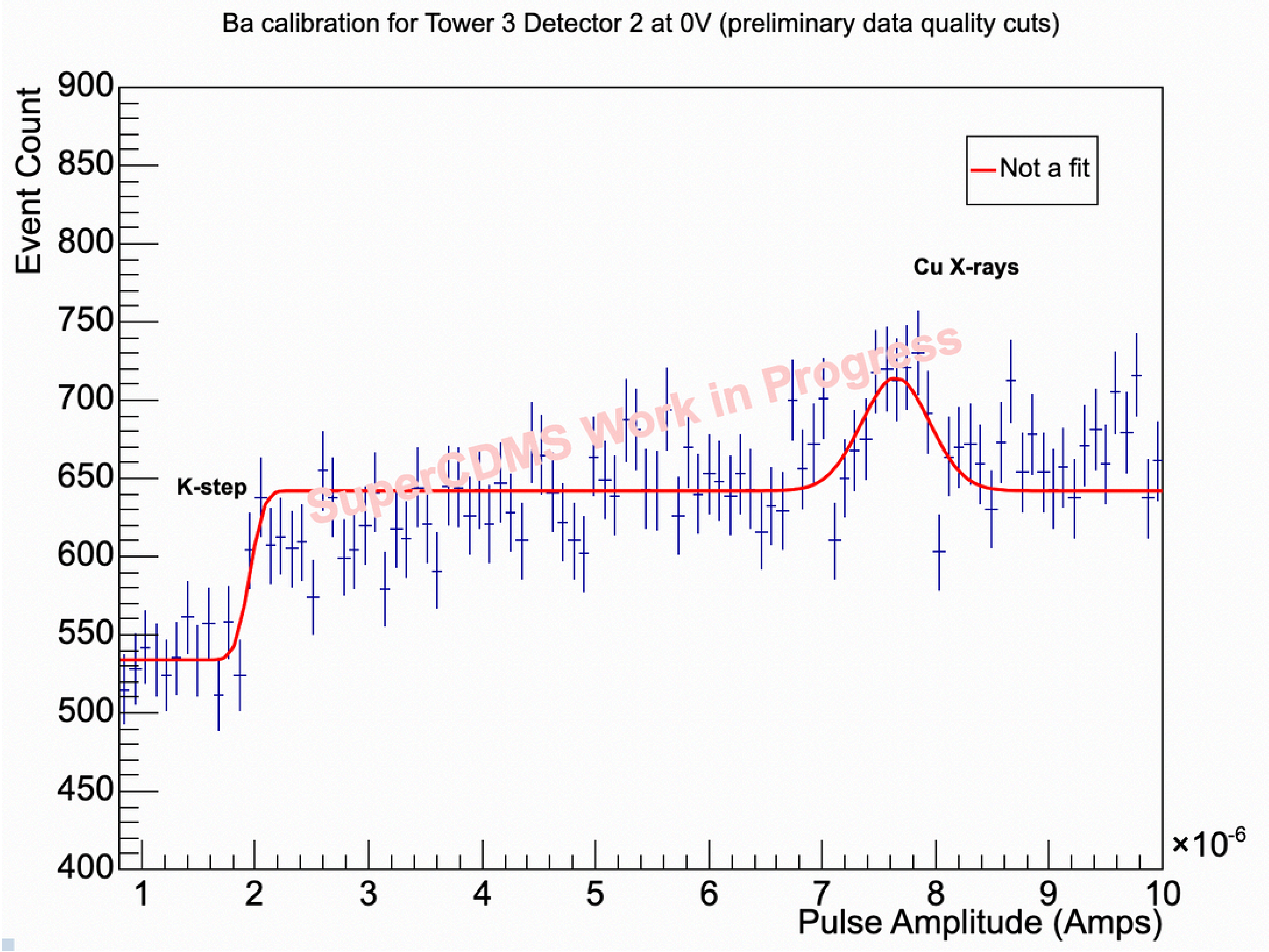
- The activation lines from ^{71}Ge electron captures are:
  — 10 keV, 1.3 keV, 160 eV

- From Dec. 16 to Dec. 21, we took ~90 hours of Ge detector calibration dataset



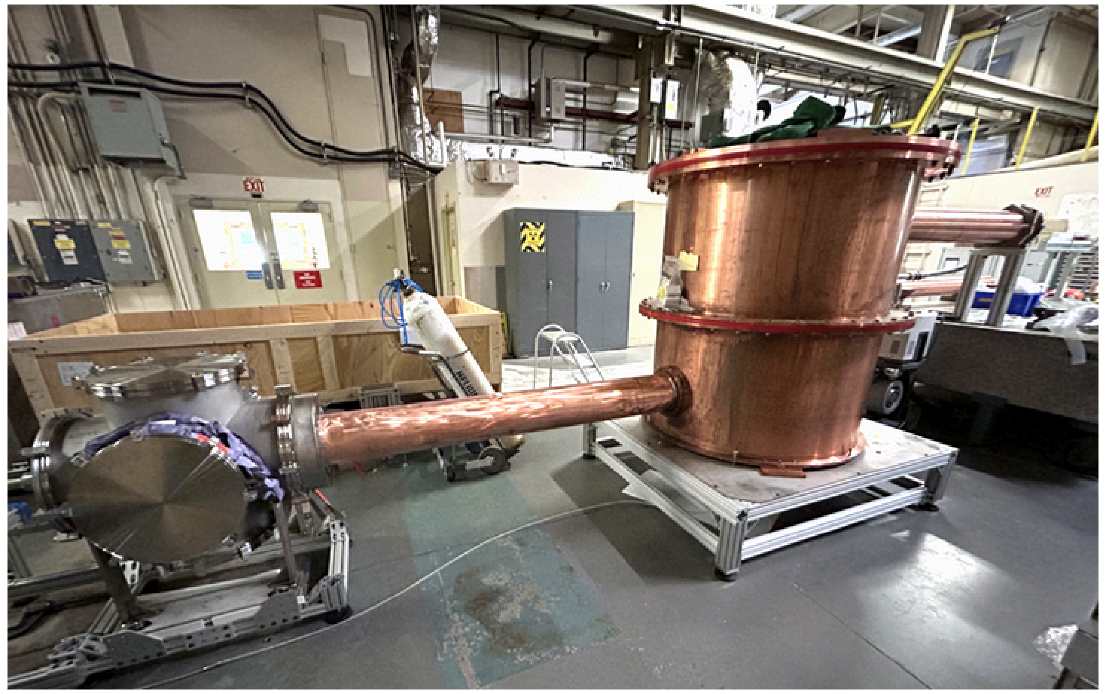
Tower Testing at CUTE: Si Detector Calibration

- On the other hand, Silicon detectors are much harder to calibrate due to lack of spectral lines
- Characteristic steps in energy spectrum caused by the binding energy of shell electrons can be used to calibrate the Si detector.
- **First proof-of-principle demonstration the calibration method for SuperCDMS Si detectors.**

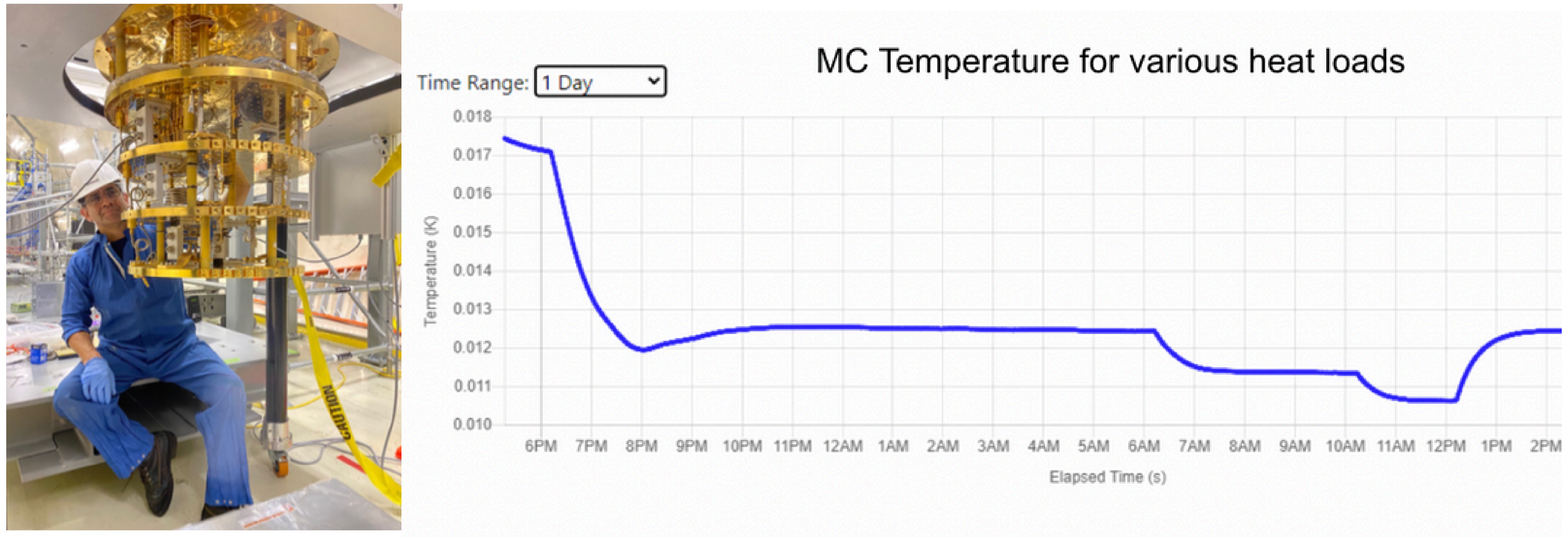


SuperCDMS Construction Progress during Last Year

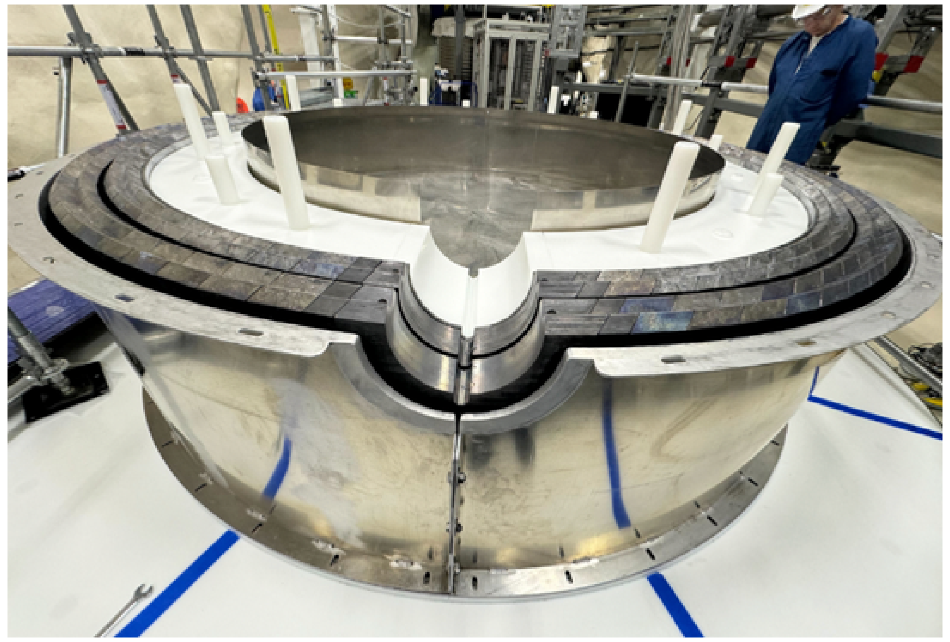
All four towers has been delievered underground at SNOLAB



Cryostat pre-assembly accomplished at SLAC

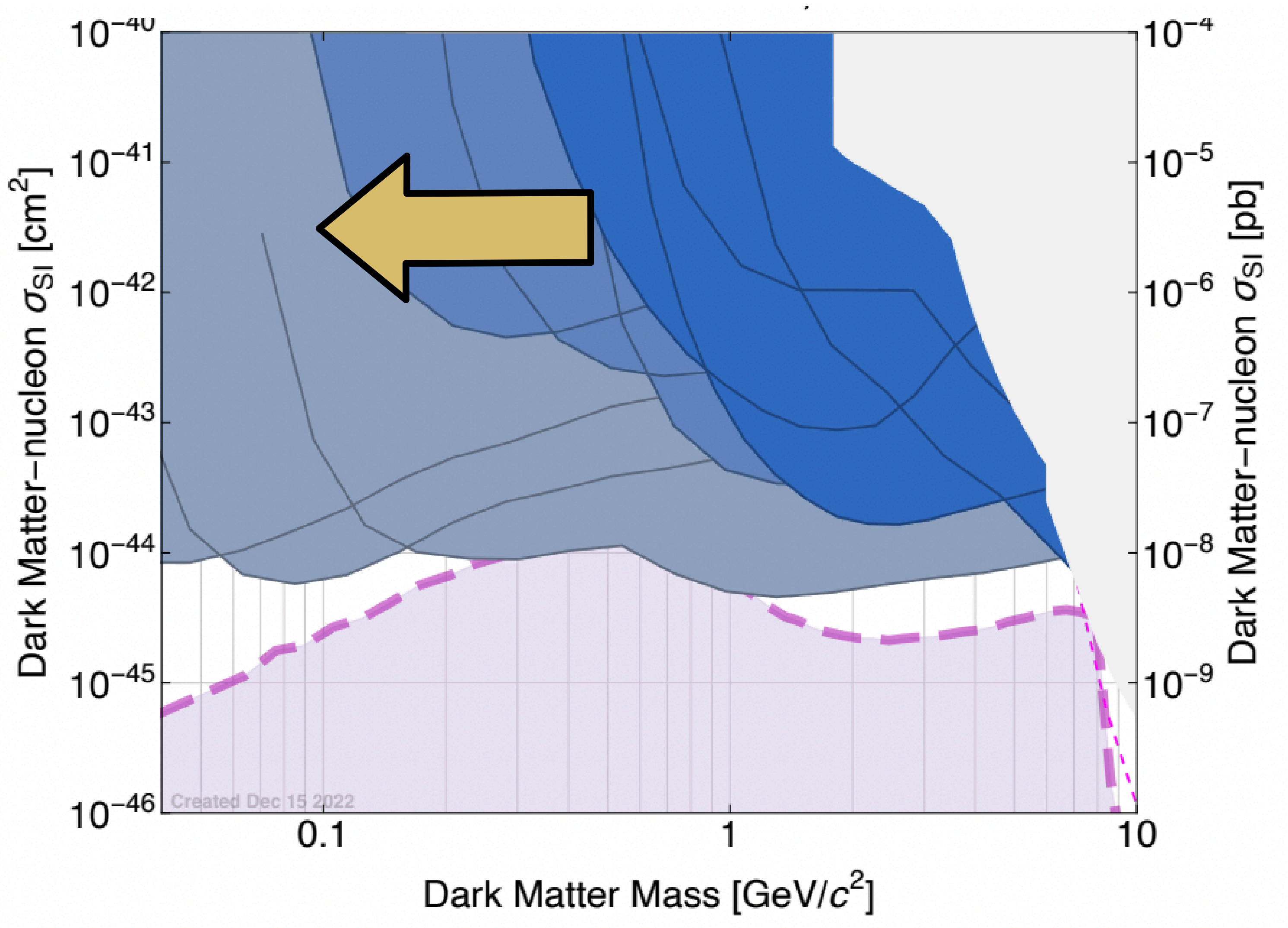


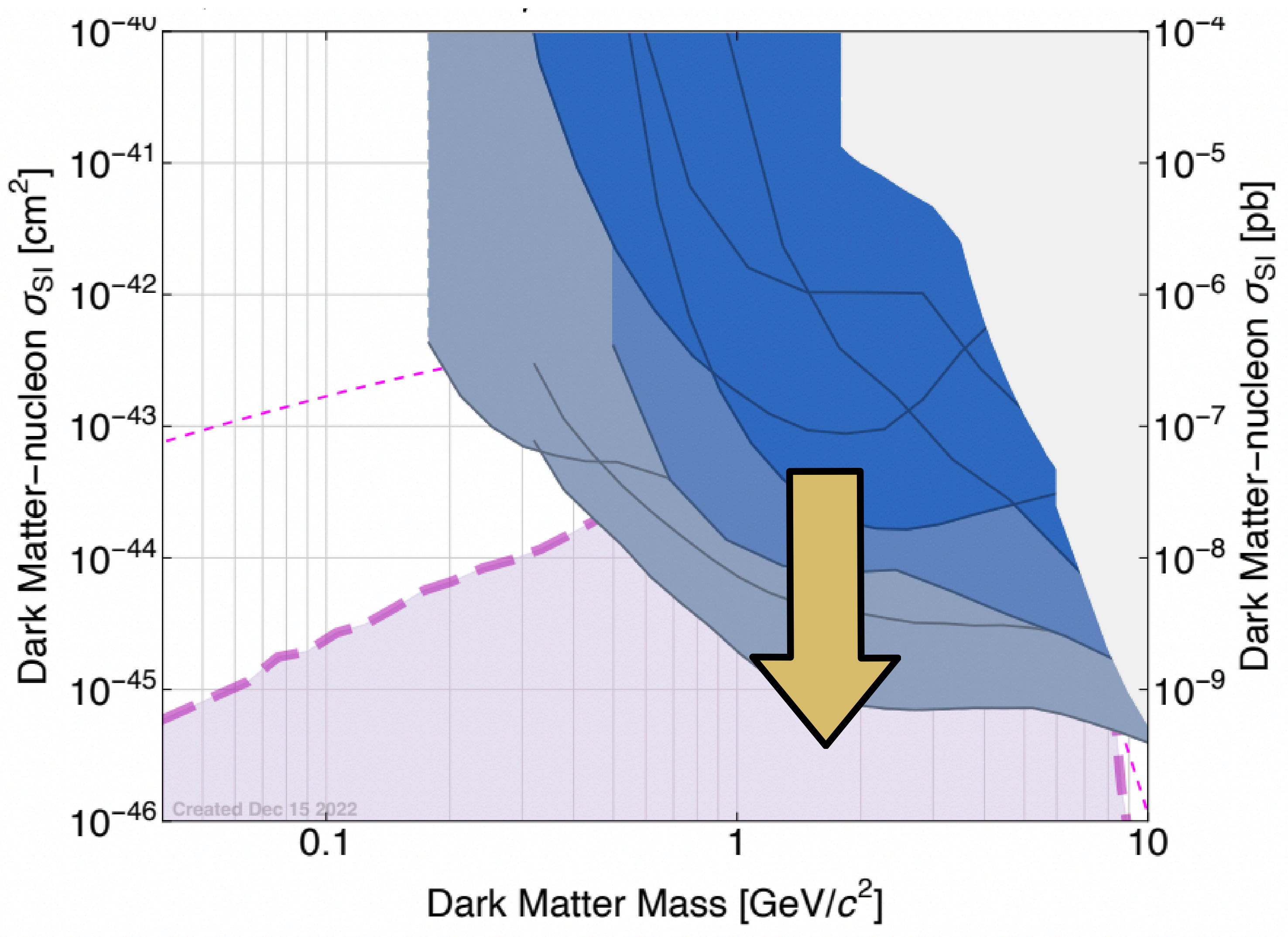
Standalone test of the dilution fridge demonstrated base temperature



Shield base installation completed

Science Reach of SuperCDMS SNOLAB

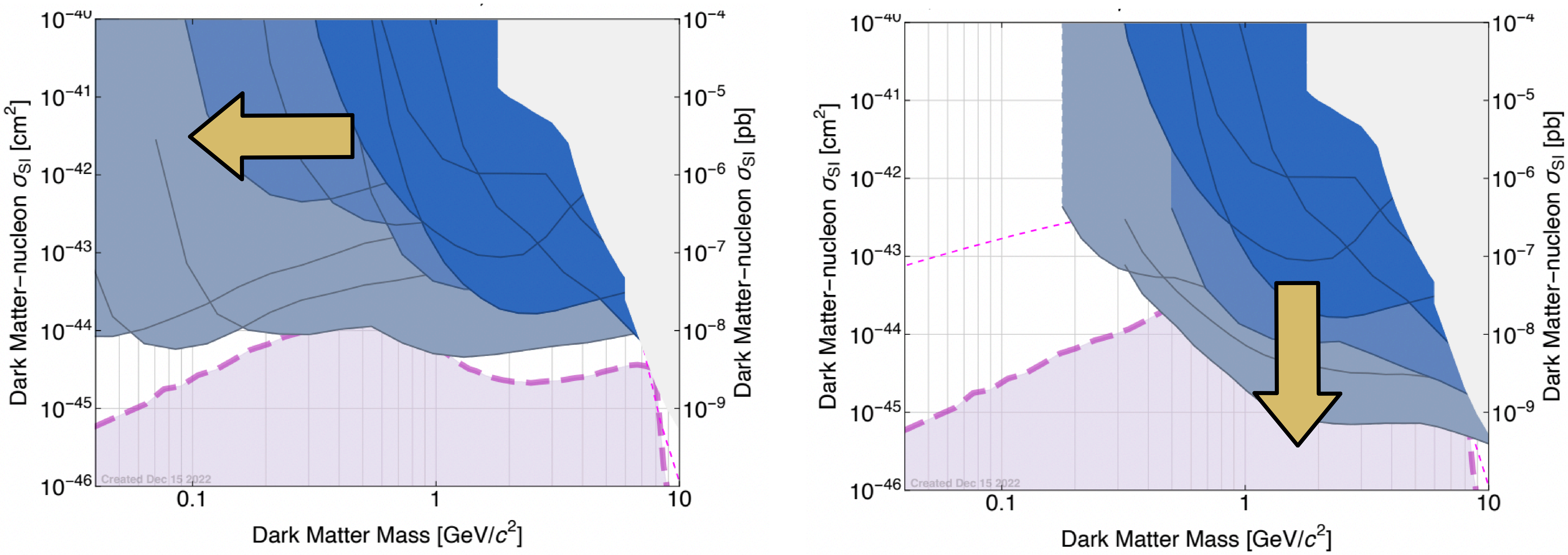




arXiv:2203.08463 *SuperCDMS Collaboration*

Dark blue: current experiment sensitivity
Lighter colors: improved science reach based on experience-guided technological advancement

Science Reach of SuperCDMS SNOLAB



arXiv:2203.08463 *SuperCDMS Collaboration*

Background level achieved at the SuperCDMS SNOLAB will not be limiting our dark matter sensitivity for the next decade or more.

CONCLUSIONS

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. We successfully ran one SuperCDMS High Voltage tower at CUTE last year, marking the first time these detectors are operated in an underground, low background environment.

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

5. Stay tuned!

thankyou


Francisco Ponce
Matt Wilson
Hanno Meyer zu Theen...
Mouli
Varchaswi Kashyap
Ruslan Podviianiuk
Sagar Sharma
Tina Cartaro
Richard Schnee
Kent May
Steven Yellin
Huanbo Sun
David MacFarlane
Rob Cameron
Vijay Iyer
David Santiago Pedreros
Sasha (A. Zaytsev)
sudipta (he/him/his)
Qubit & Quark
Silvia Scorza
Sukee (S. Dharani)
Wolfgang Rau
Belina von Krosigk (she...
Lauren Hsu
Kelsey, Michael H
SUPER CDMS
Cryogenic Dark Matter Search
Arts
science
UNIVERSITY OF TORONTO