# CUTE

## A Cryogenic Underground TEst facility for SuperCDMS

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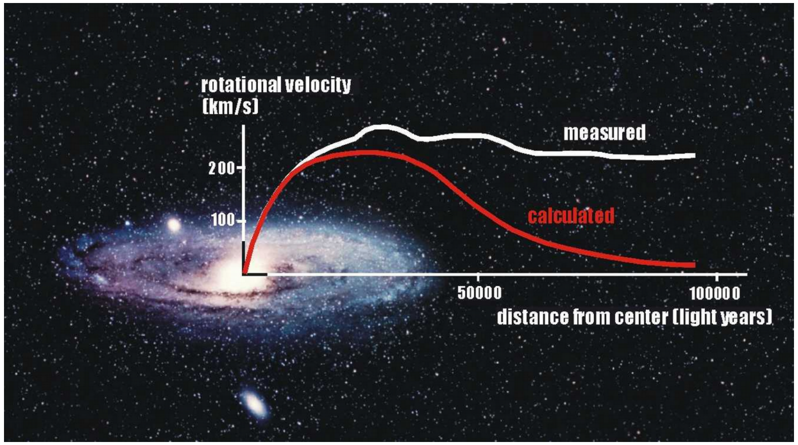
# Outline

- Dark matter
- SuperCDMS
- CUTE facility
- Backgrounds
- Status update

# Introduction

- Astronomical and cosmological observations suggest dark matter composes 85% of all matter in the universe

Credit: O. Lopez-Cruz
I. K. Shelton

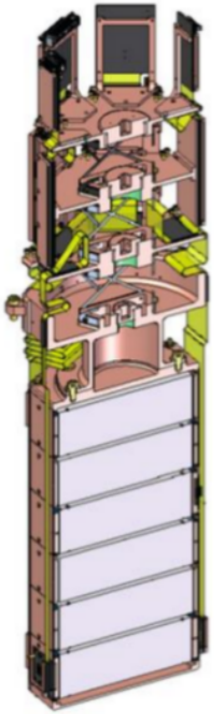



Credit: cdms.phy.queensu.ca

Credit: NASA, CXC, Cfa, et al.

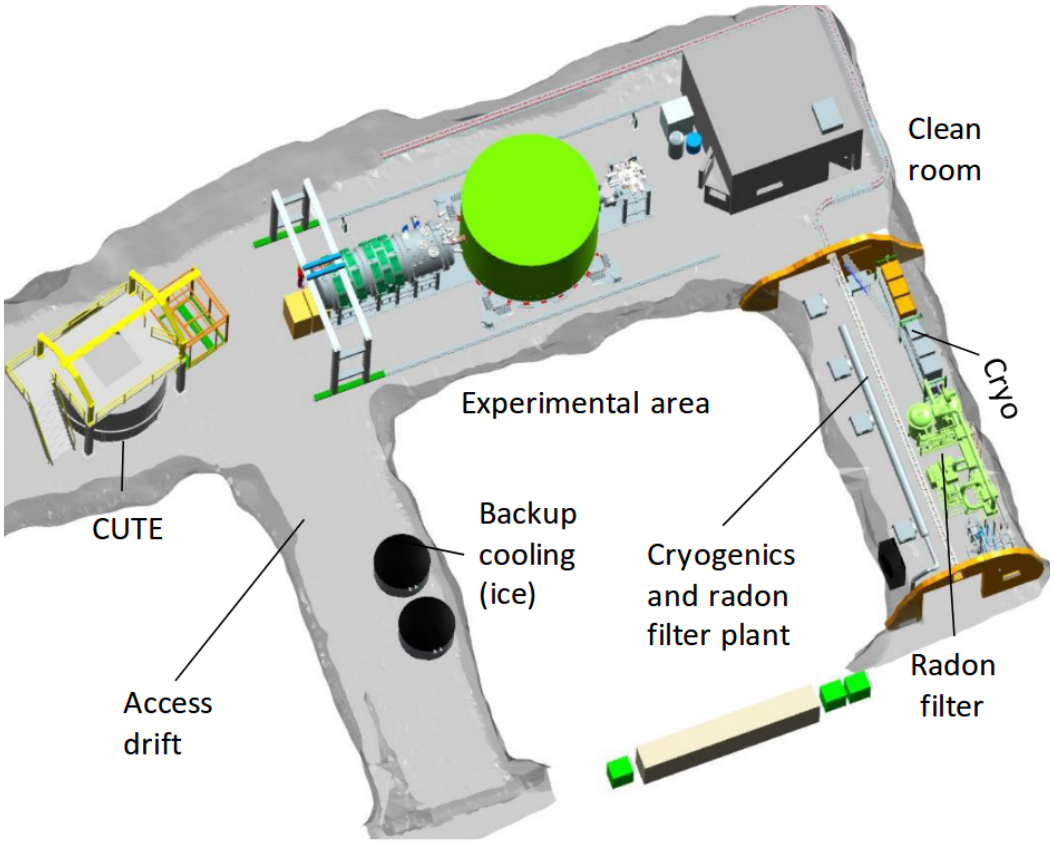
# SuperCDMS

- The Cryogenic Dark Matter Search has been a long running effort to directly observe the interaction of a dark matter particle in a detector
- SuperCDMS is preparing for the next phase of the experiment, SuperCDMS SNOLAB
- Cryogenic semiconductor (Ge/Si) detectors are operated at ~30 mK to measure energy deposited in the form of ionization and phonons



# SuperCDMS SNOLAB

- SNOLAB is located ~2 km underground to shield from cosmic rays
- Installation of SuperCDMS SNOLAB infrastructure will begin this year and will take about two years
- CUTE will share the ladder lab cavern in SNOLAB with SuperCDMS and will go underground in the summer of 2018

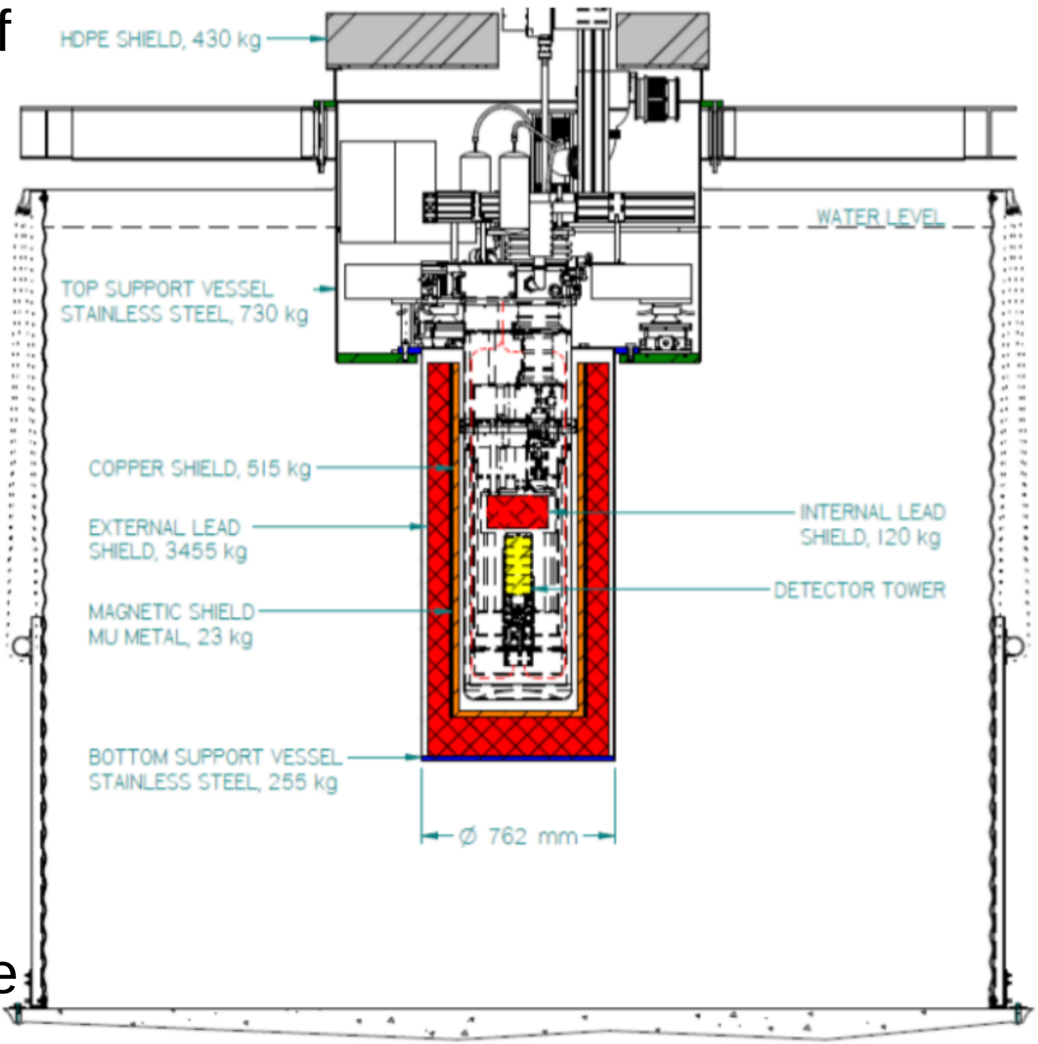


# CUTE Motivation

- The installation of CUTE prior to SuperCDMS SNOLAB allows for preliminary tests to ensure everything is in working order
- Tests can be performed in a lower background environment than is available in surface facilities
- Detector characterization can be done to understand the intrinsic backgrounds and noise issues, while avoiding cosmogenic activation
- Early dark matter search data may be obtained with backgrounds comparable to that of SuperCDMS Soudan, but with lower threshold detectors

# CUTE Shielding

- Cryostat with base temperature of 15 mK located inside the drywell of a water tank
- Approximately 1.5 m of water reduces external neutron and gamma flux
- 10-15 cm of low activity Pb reduces residual gammas
- The gap from the top is closed off by 20 cm of PE and 15 cm of internal Pb
- Internal Cu shields block IR photons, which contribute to noise



# Backgrounds

- Estimated overall background for Ge detectors in CUTE: $\lesssim$ 3 evts/kg/day/keV

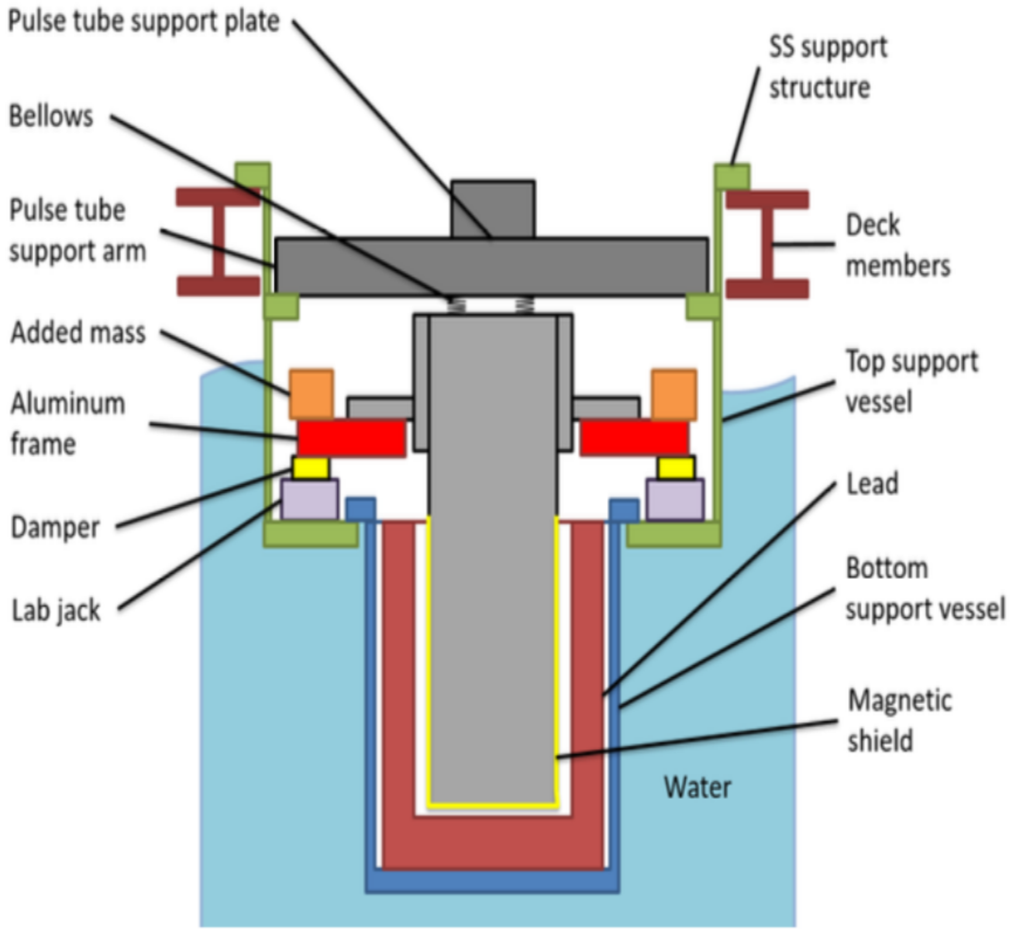
**Main Background Contributions**

| **Material** | **Background** (evts/kg/day/keV) |
|---|---|
| External background (lab walls, etc.) | 1.1 |
| External Pb shielding | 0.7 |
| Stainless steel vacuum can | 0.6 |
| Internal backgrounds (cryostat cans, etc.) | 0.5 |
| Cosmogenic activation ($^{3}$H, etc.) | <0.1 (SNOLAB)<br>~0.5 (early detectors) |
| $^{32}$Si (in silicon detectors) | 0.7 |
| Detector housing | <0.1 |

*Most internal backgrounds due to $^{210}$Pb

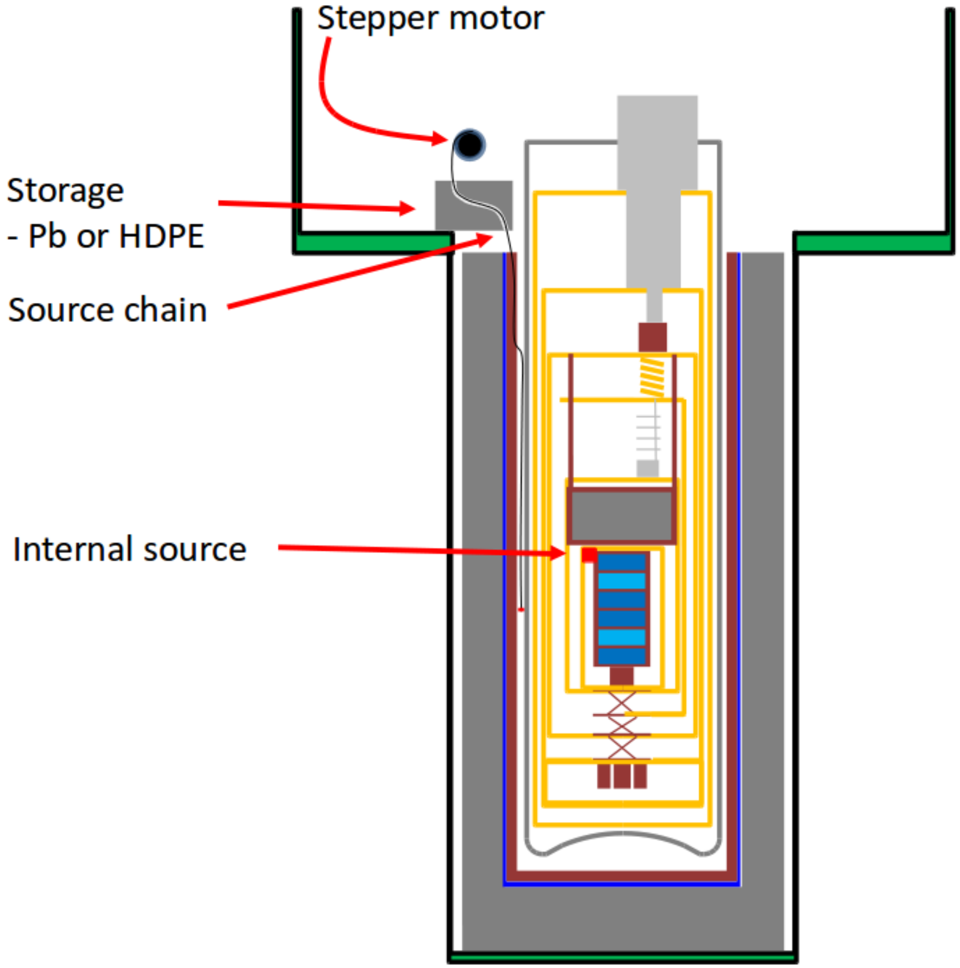
# Suspension System

- The pulse tube cooler (PTC) is a source of vibrations
- Cryocooler induced microphonic noise has limited SuperCDMS in the past
- PTC mounted on seperate plate with soft coupling (bellow) to cryostat to minimize vibrations
- The bellow makes the system sensitive to pressure fluctuations in the lab, so an active system tracks and controls the position of the cryostat



# Calibration

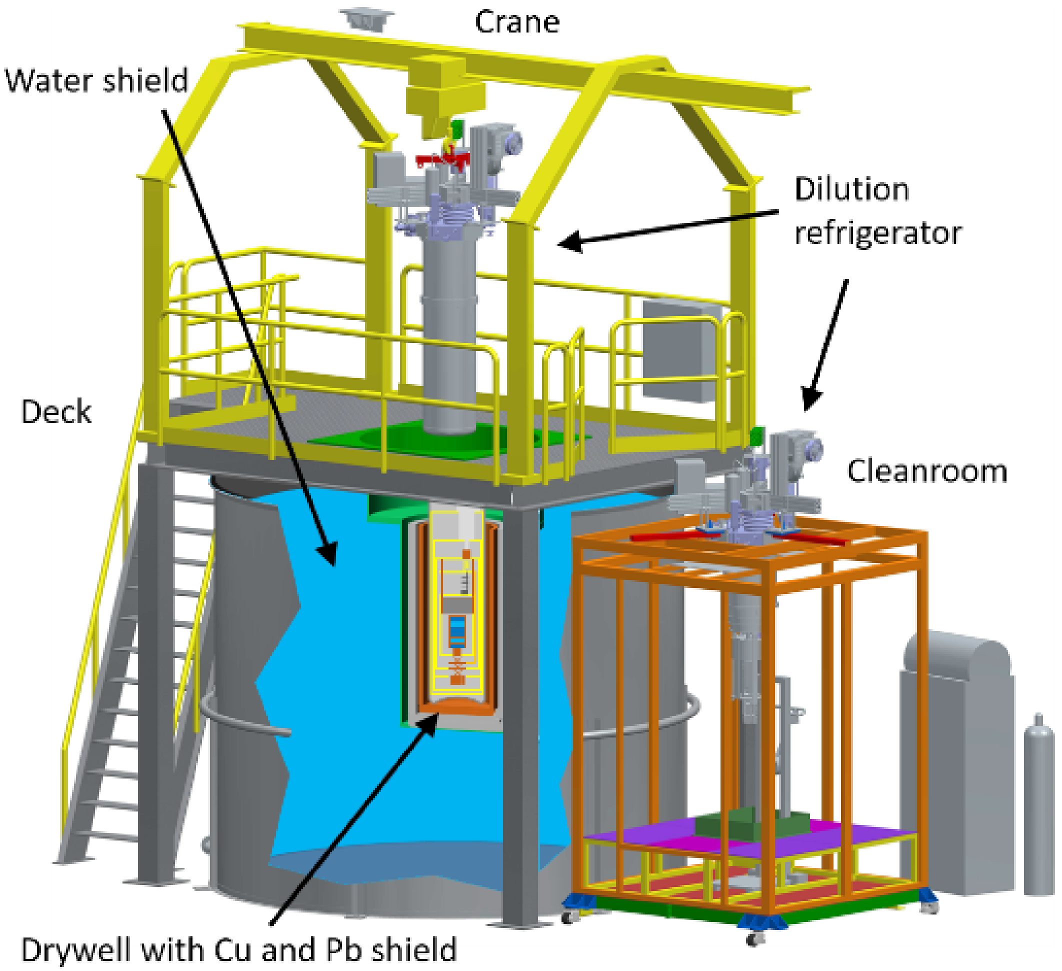
- Radioactive sources are used to calibrate the energy scale, monitor stability, and characterize interaction types
- Sources ($^{133}$Ba for gammas, $^{252}$Cf for neutrons) are moved remotely from shielded storage to the measurement position
- A low energy gamma source ($^{241}$Am) can be mounted in the cryostat



# CUTE Facility

Cryogenic Underground TEst facility

- Detector towers are changed in a low radon, low particle count cleanroom next to the tank
- Cleanroom will share radon filter system with SuperCDMS when operational
- A monorail crane moves the dilution refrigerator between the cleanroom and the drywell



# Status of CUTE

Cryogenic Underground TEst facility

- CUTE cryostat at Queen's to test cryogenic performance
- Detector implementation: all parts designed and material ordered
- Calibration system design is 80% complete
- Water tank, crane, and platform installed underground at SNOLAB
- Cleanroom under construction by vendor
- Completion and comissioning of underground facility takes place in summer of 2018

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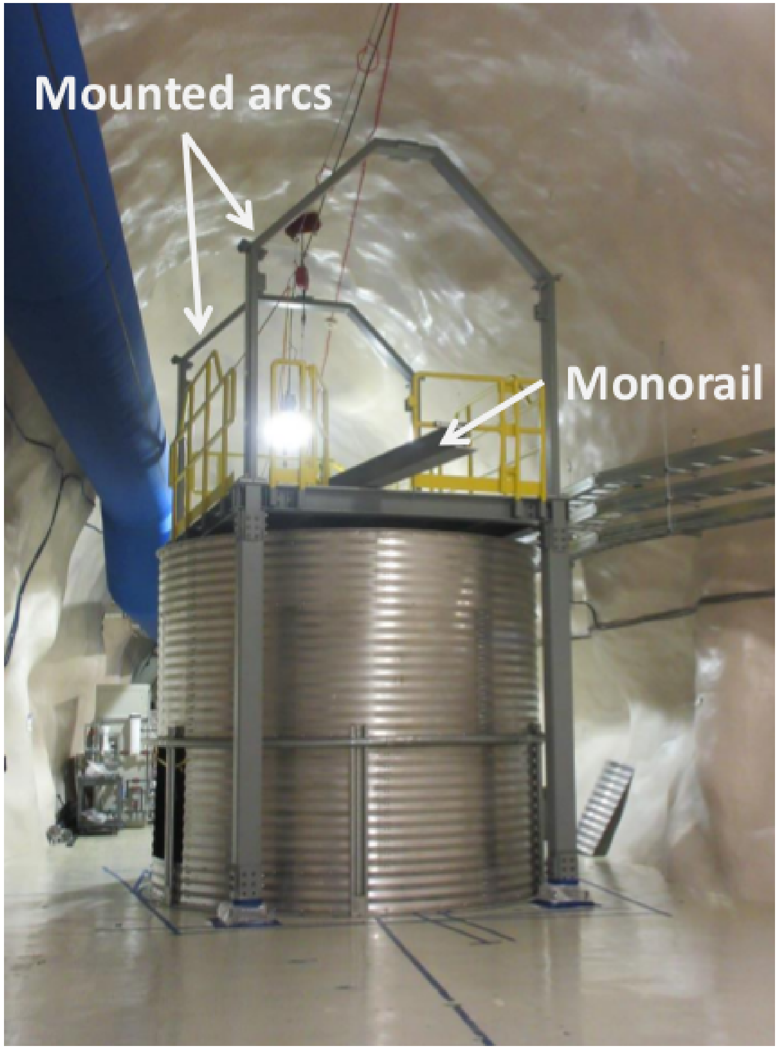

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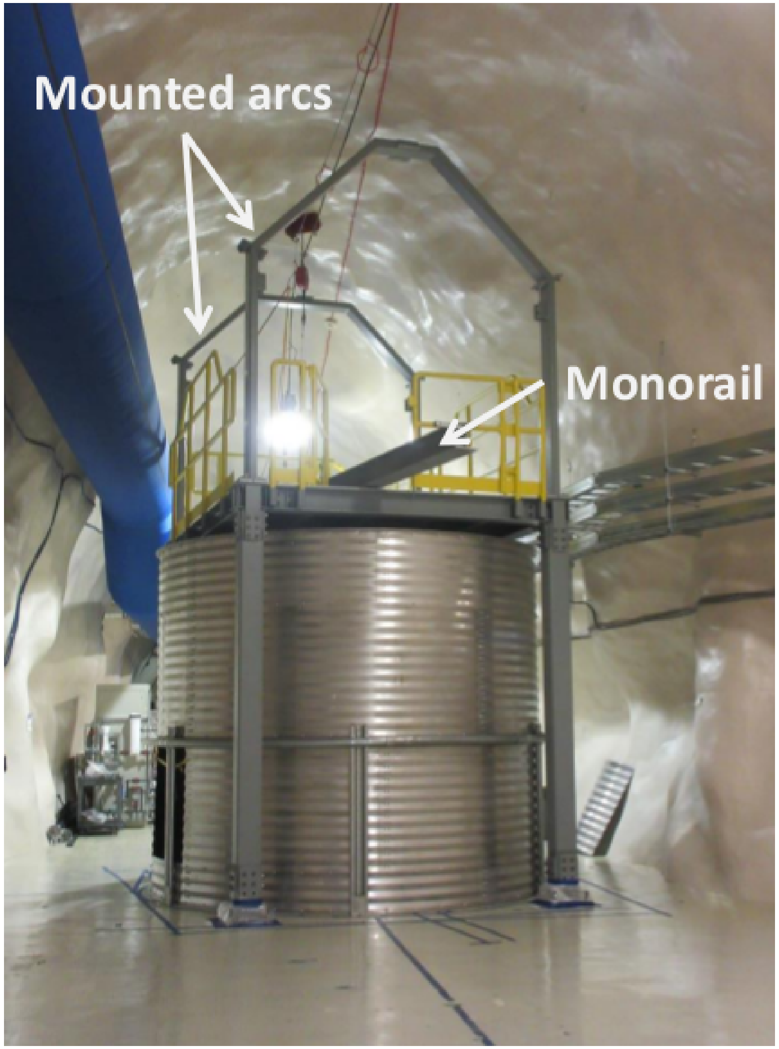

# Conclusion

- CUTE provides a low background environment for testing/characterization of SuperCDMS detectors, and studying backgrounds prior to full deployment of SuperCDMS SNOLAB
- Early dark matter search data may be obtained if background goals are met and if the timeline is met
- Facility should be operational in the summer/fall of 2018

# Thank You