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CUTE

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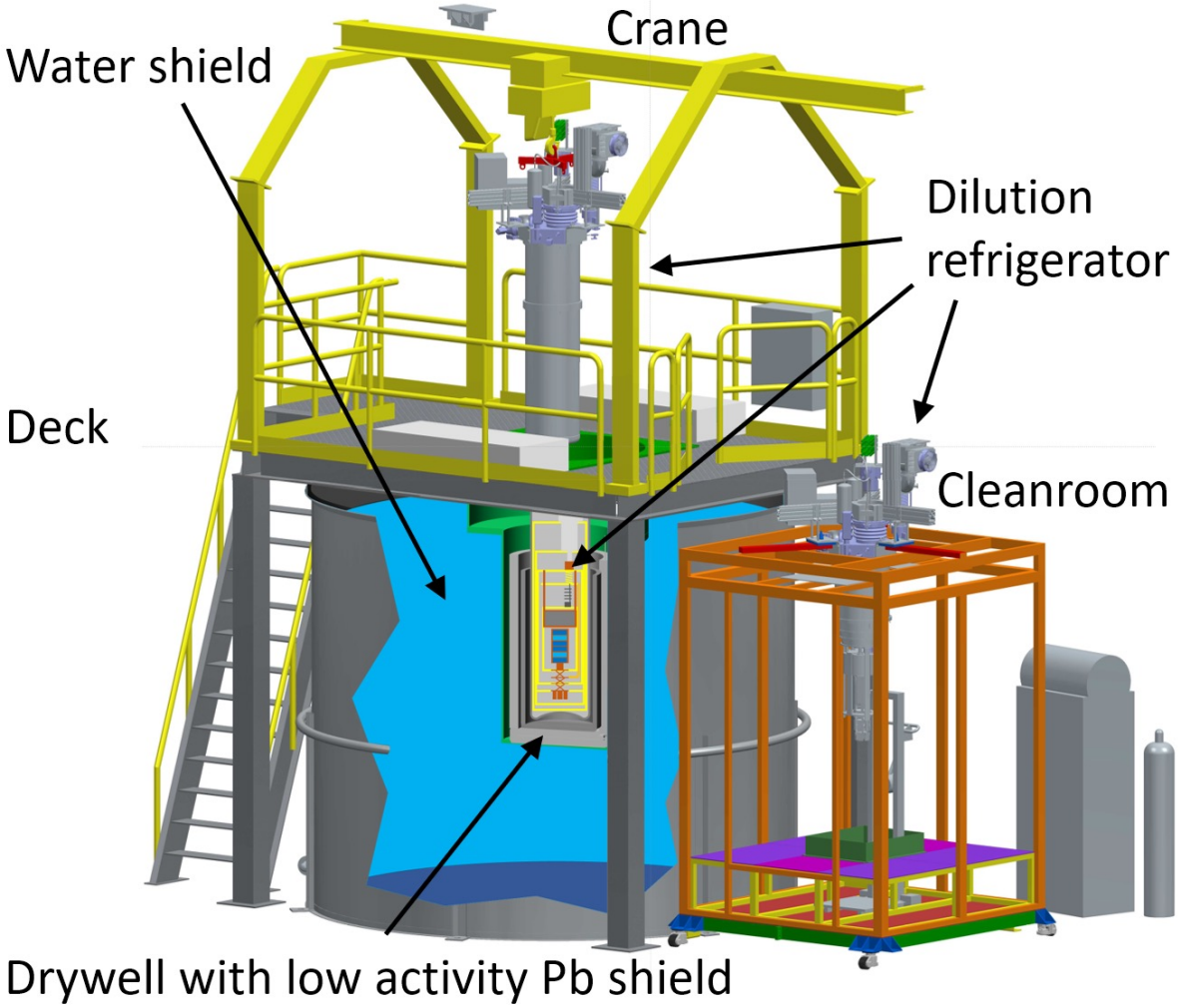
Experiment Overview



CUTE: a **C**ryogenic **U**nderground **TE**st facility

Developed for testing SuperCDMS detectors

Main features:

- Operational temperature < 15 mK
- Low background (few γs/keV/kg/day; $\mathcal{O}$(1 n/day/kg))
- Magnetic shielding (~1/50 Earth field)
- Vibration isolation
- Calibration sources (gamma, neutron)
- Low-radon cleanroom space to change payload
- Full remote operations up to ~2 months

Future of the facility:

After testing of SuperCDMS detectors is completed CUTE becomes a SNOLAB user facility.

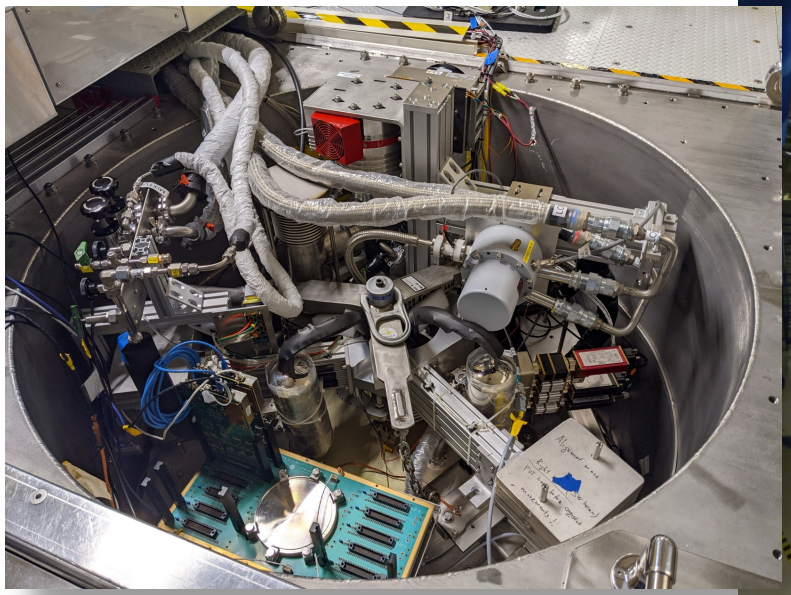
Upcoming projects:

- Small scale cryogenic detectors (spring/summer 2024)
- Cryogenic qbits (fall 2024 into 2025)

Experiment Overview

CUTE

Drywell with cryostat installed (top view)



Moving the refrigerator

Payload installation

New Science Developments

Cryogenic detectors

- A range of projects are developing new cryogenic detectors for rare event searches; for example
  - TESSERACT: TES (Transition-Edge Sensor) based, very low threshold, DM search
  - BULLKID: MKID (Multiplexed Kinetic Inductance Detector), pixelated, DM search, CEνNS
  - MAGNETO-DM: MMC (Metallic Magnetic Calorimeter), various targets, DM search
- New project will need to demonstrate low-background performance

Quantum Technologies

- Cryogenic Qubit performance impacted by radiation background
- Sensitivity to radiation may turn them into valid low-energy particle detectors
- Quantum Device Workshop, January 2024 @ SNOLAB – exploring synergies
  - Sparked interest in UK-Canada collaboration focused on fundamental physics; test cryostat proposed for Boulby lab in the UK
  - Potential new collaboration on cryogenic devices between TRIUMF and Sherbrook

Collaboration Health

"Provide any update and status of efforts to maintain an equitable, diverse, and inclusive culture within your collaborative activities. "

- CUTE is a SNOLAB facility and the user team has been SuperCDMS
- Accordingly, the efforts to achieve or maintain an equitable, diverse and inclusive culture affecting CUTE and governing our interactions with the lab and the present users are those by SNOLAB and SuperCDMS
- In the future, we plan to adopt the SNOLAB policies regarding EDI and will request the users to do so as well

Schedule Impacts & Milestones

Since PMP 2023: *SuperCDMS Tower Testing*

Detailed timeline:

- September: Tower installation rehearsal + (internal) Installation Readiness Review
- Early October: Cable installation; last preparations
- October 11-18: Tower installation and preparations for cooldown
- October 19: start of cooldown
- October 23: start of detector testing

Delays (2.5 weeks total):

- Thermal connection between two layers made detector operation difficult:
  $\rightarrow$ Warm up on October 27; fix issue and cool back down; resume testing on November 11
- Power and compressed air instabilities early December
  $\rightarrow$ Partial warmup on December 9; resume testing on December 11

Schedule Impacts & Milestones

Upcoming

Anticipated timeline for experiments:

- End of SuperCDMS Tower Testing: early March
- Installation of HVeV detectors (gram-scale Si detectors with HV bias and eV-scale resolution): mid-March
- End of HVeV operation: before PMP 2024
- Start of installation for Qubit project: October 2024

Anticipated facility upgrades: installation of neutron source delivery system (before or after HVeV project)

Delays:

- Transition from SuperCDMS Tower testing to HVeV project originally scheduled for January 2024
  Delay benefits both SuperCDMS (more testing time) and HVeV project (more time for preparations)
- End of HVeV project may be postponed until after PMP

Opportunities:

- Possible open window in summer/early fall; discussions about beneficial use of this time are ongoing

Challenges

Fundamental challenge:

R&D and testing outcomes are very difficult to predict – uncertain timeline, e.g.

- Some sources of noise difficult to eliminate or address
- Issues with operational details of SuperCDMS readout electronics led to slower testing program
- Detector conditioning (‘neutralization’) more difficult to assess than expected

General issues:

- Power / compressed air / cooling instability – working on improving our independence

Access and personnel

- Expected PMP may affect our operations plan
- General shortage of experienced personnel slows us down (both for facility and experiments)
- Presently CUTE has significant support from the user team; will need to become indpendnet over the next half year.

Outlook: presently no user after Qubit project

Experiment Status

Recent accomplishments with the facility: very successful SuperCDMS tower testing

First operation of new SuperCDMS detectors under “real live” conditions:

- Operation in low-background environment
- Extended operation with HV, accumulating quality data
- Calibration for both Ge and Si detectors (0 V and HV)
- Full performance assessment
- Detector conditioning (“neutralization”)

Key ingredient for effective and efficient use of facility:

- Extremely dedicated core operations and analysis team
- Very quick feedback on data quality and first-pass analysis (enabled quick and efficient adaptation of test plan)
- Availability of on-site personnel to test configuration changes
- Close monitoring of facility performance and service availability (power, compressed air, cooling water)

Experiment Status

Upcoming: testing of g-scale Si detectors with single eh-pair resolution

- Detectors developed in the context of SuperCDMS
- Upcoming test is not directly related to main SuperCDMS program
- Will use SuperCDMS warm readout electronics and DAQ
- New wiring solution to minimize cross talk
- Very careful planning to minimize IR radiation on detectors
- New mechanical components inside fridge for mounting of electronics
- Payload includes detectors tested before in higher-background environment and new detectors
- New detectors have lower threshold and new contact design to reduce leakage current
- Main goals
  - Assess effectiveness of new detector design
  - Distinguish between different sources of leakage current (contact design, IR, background radiation)

Future: testing of Qubits under low-background conditions

- Funding secured
- Planning for facility modifications (wiring, device mounting etc.) has started

Conclusions

Facility

- CUTE provides low-background low-vibration environment
- Recent publication of technical paper describing facility (Frontiers in Physics 11:1319879 (2024)
- Upgrades planned: installation of neutron-source delivery system
- Transitioning from single-use (SuperCDMS) to multi-user facility

Experiments

- About to conclude SuperCDMS detector testing – very successful operation since last fall
- Upcoming HVeV project: first step of CUTE towards a user facility
- Interesting program lined up for the next ~1.5 years
- OPEN FOR PROPOSALS for new projects!!!