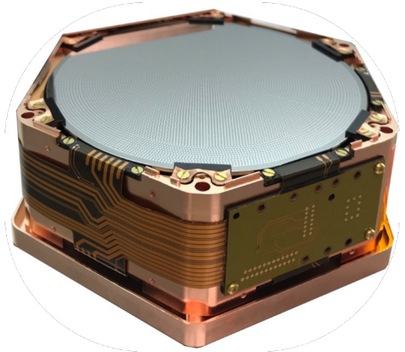
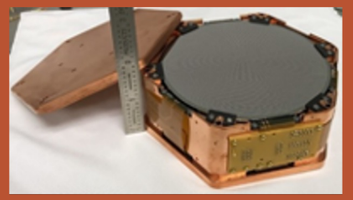
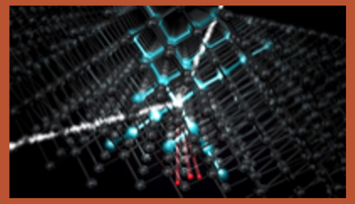
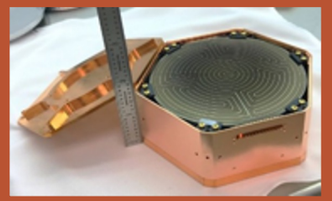


SuperCDMS SNOLAB
July 2024 EAC Review

Andy Kubik
SNOLAB Group PI
July 31, 2024

SuperCDMS Representatives

- ***Andy Kubik*** **PI of SNOLAB group**
- ***Richard Partridge*** **I&I Manager**
- *Tarek Saab* Spokesperson & Deputy Operations Manager
- *Miriam Diamond* Collaboration Council & Board Chair
- *Pekka Sinervo* Operations Shift Planner & Shipping Coordinator
- *Rob Cameron* Operations Manager
- *Joel Sander* Operations Scientist
- *Wolfgang Rau* Deputy Operations Manager

The SuperCDMS Collaboration

2024 Collab Mtg at SNOLAB

>130 scientists at 28 institutions & 6 Countries, including 3 US national labs and 2 Canadian labs

SUPER CDMS Cryogenic Dark Matter Search

Collaboration Updates

- Two new members recently joined the SuperCDMS team:
  - Hogan Nguyen, Fermi Senior Staff Scientist
    - Hogan is supporting the NEXUS DD generator / Yield measurement effort
  - Melina Ralph, SNOLAB
    - Providing support for shipping, storage of components on the surface and transport underground.

SuperCDMS Detector Technology

HV Detector

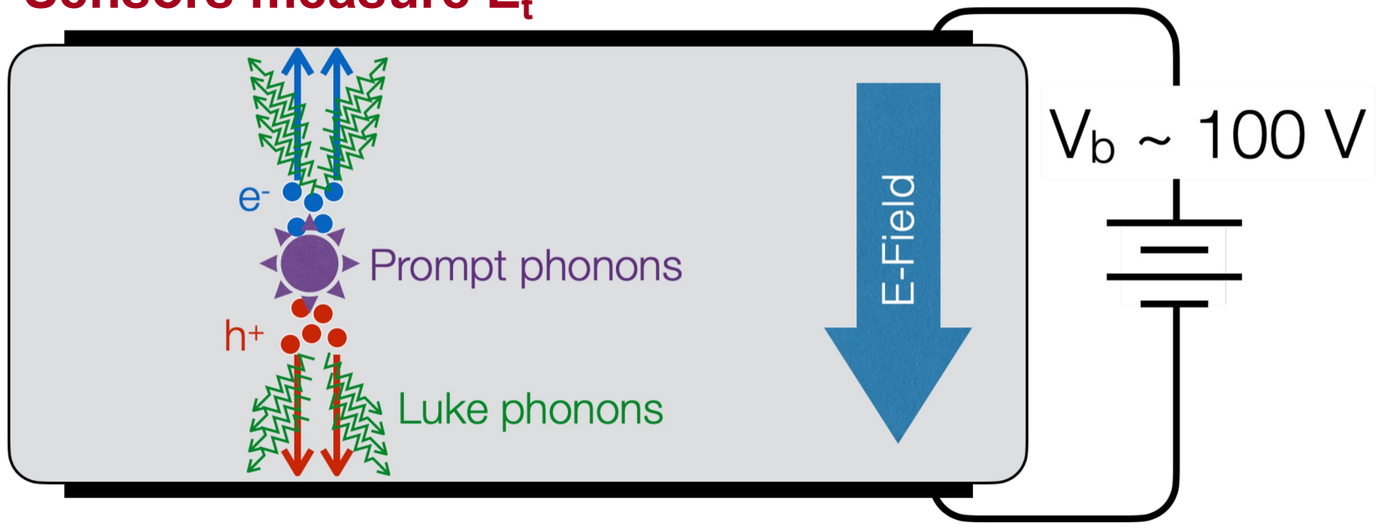
- Drifting electrons/holes across a potential (Vb) generates a large number of Luke phonons.
- Enables very low thresholds!
- No event-by-event Nuclear vs Electron Recoil discrimination
- Primary driver of science potential

iZIP Detector

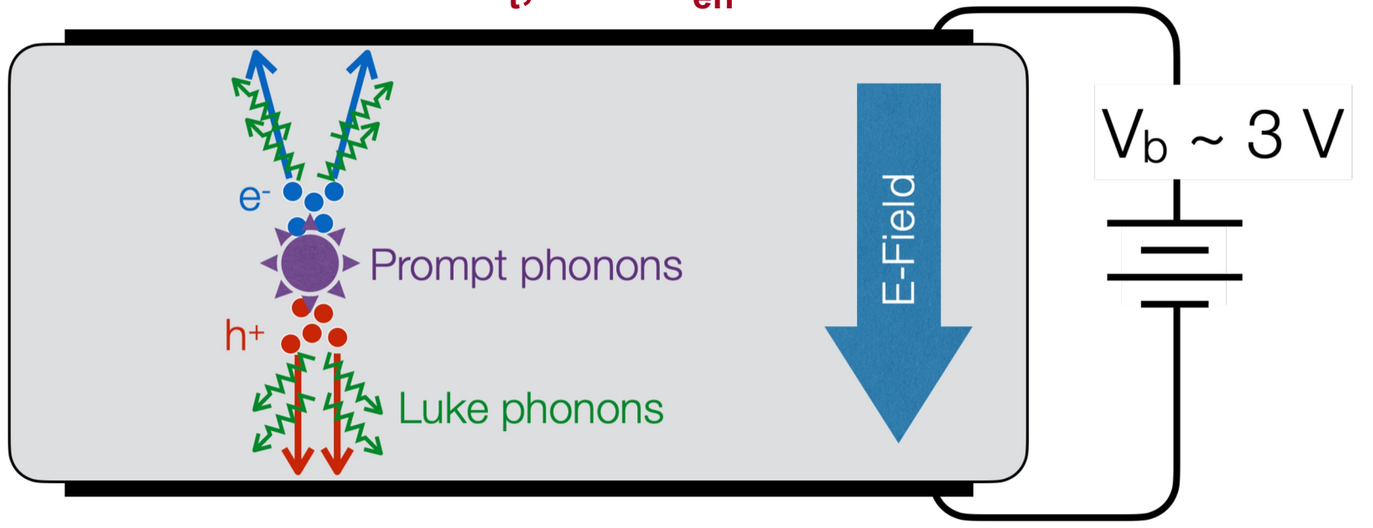
- Low background
- Phonon and ionization signals allow for discrimination between Nuclear and Electron Recoil events
- Effective characterization of bkg environment
  → Increases HV sensitivity by enabling a profile likelihood analysis

HV and iZIP provide complementary functionality

Sensors measure E_t



Sensors measure E_t, and n_{eh}

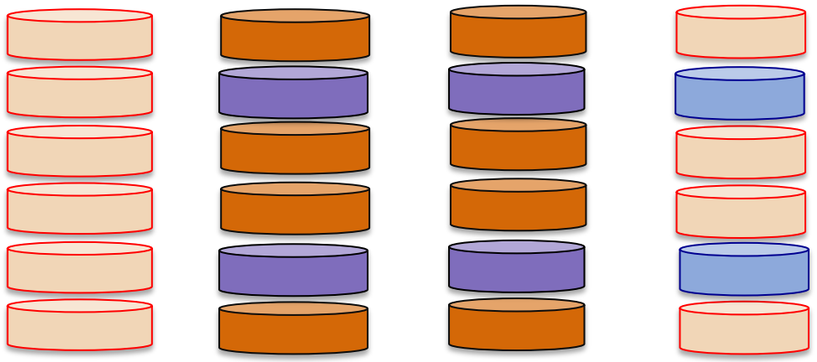


SuperCDMS Detector Technology

Payload Information

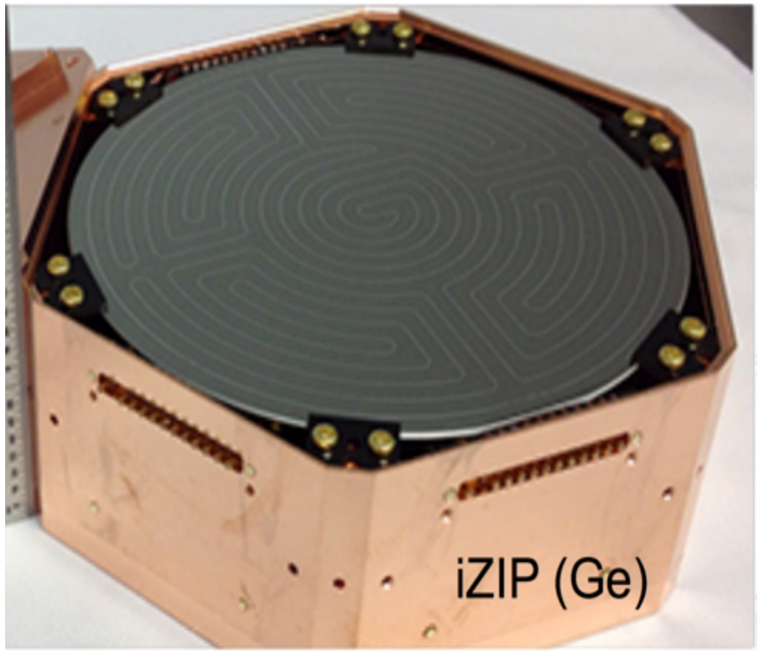
- Four detector towers each consisting of 6 detectors
- Two HV detector towers
- Two iZIP detectors towers
- Employ 1.5kg Ge HV and iZIP detectors
- Employ 0.6kg Si HV and iZIP detectors

Initial 4-tower payload

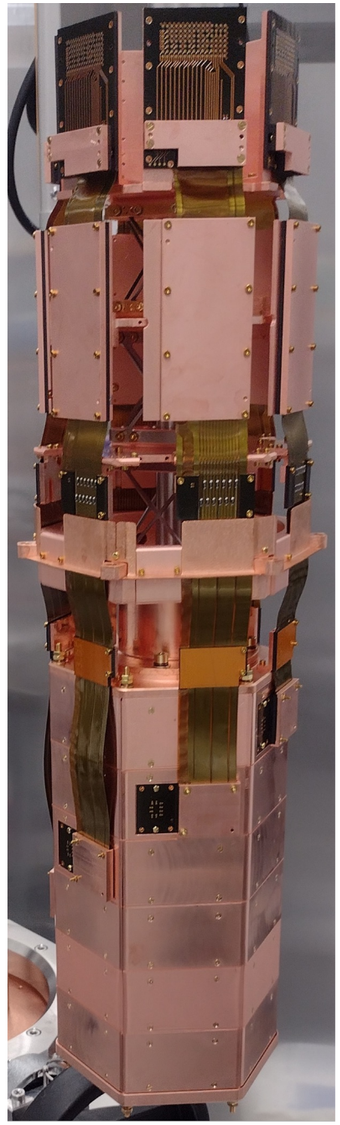


Tower 1	Tower 2	Tower 3	Tower 4
6 Ge iZIPs	4 Ge HV 2 Si HV	4 Ge HV 2 Si HV	4 Ge iZIPs 2 Si iZIPs

HV and iZIP provide complementary functionality

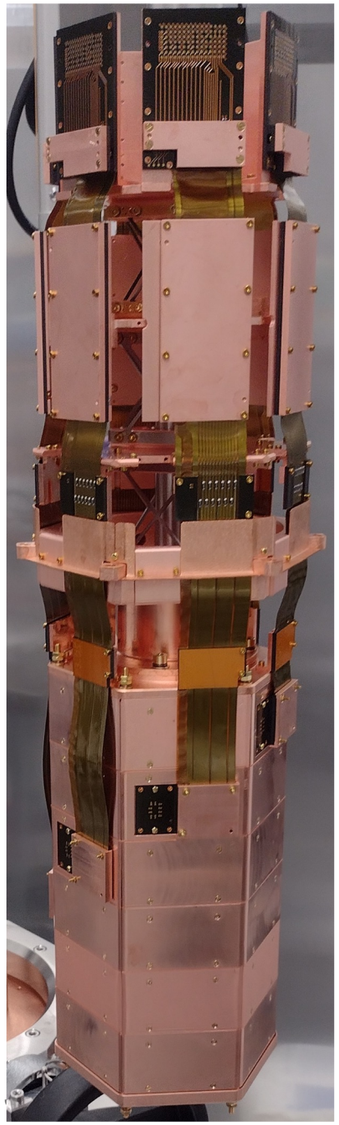


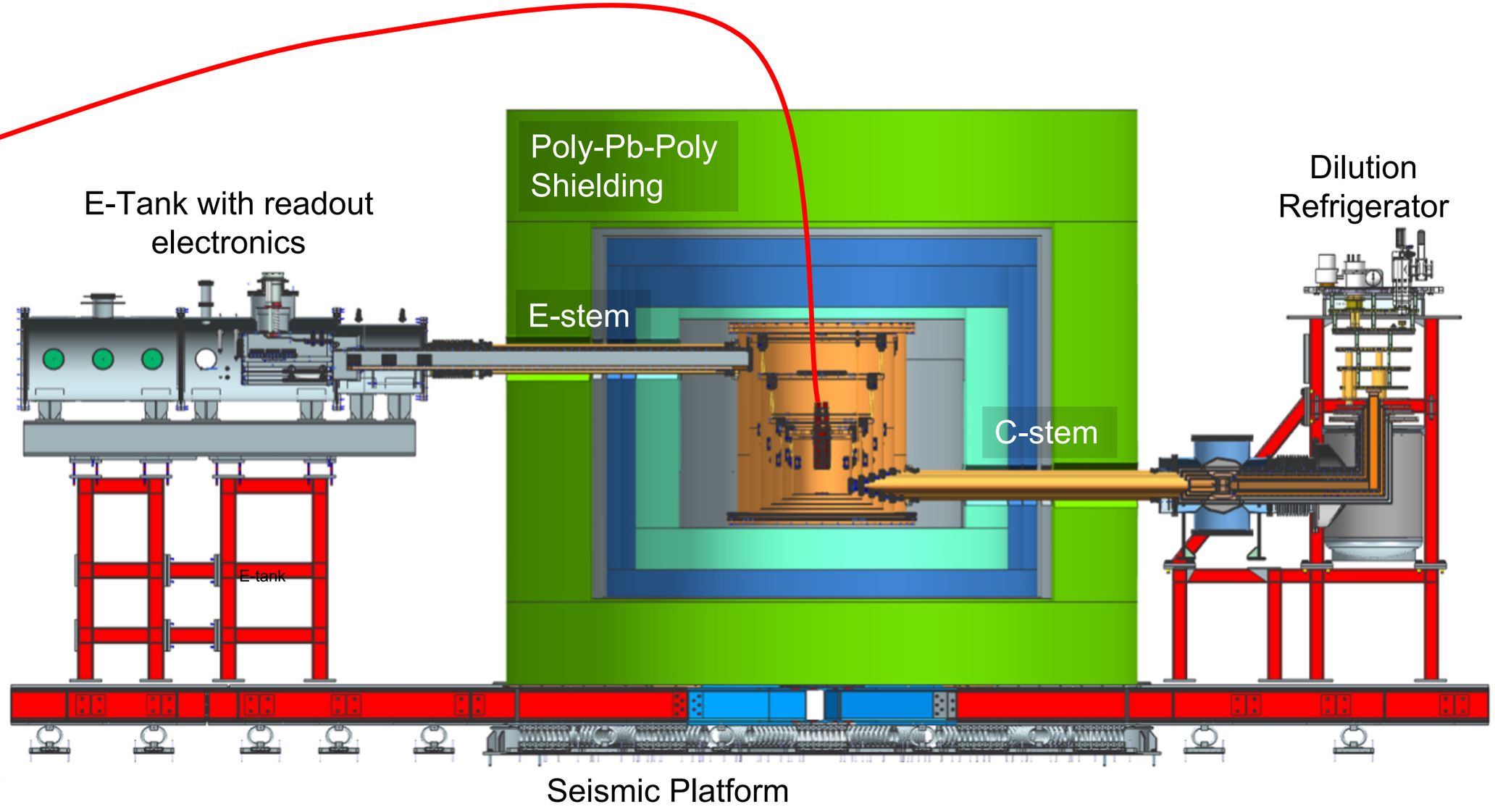
Detector Tower



SuperCDMS Shielding and Cryogenics

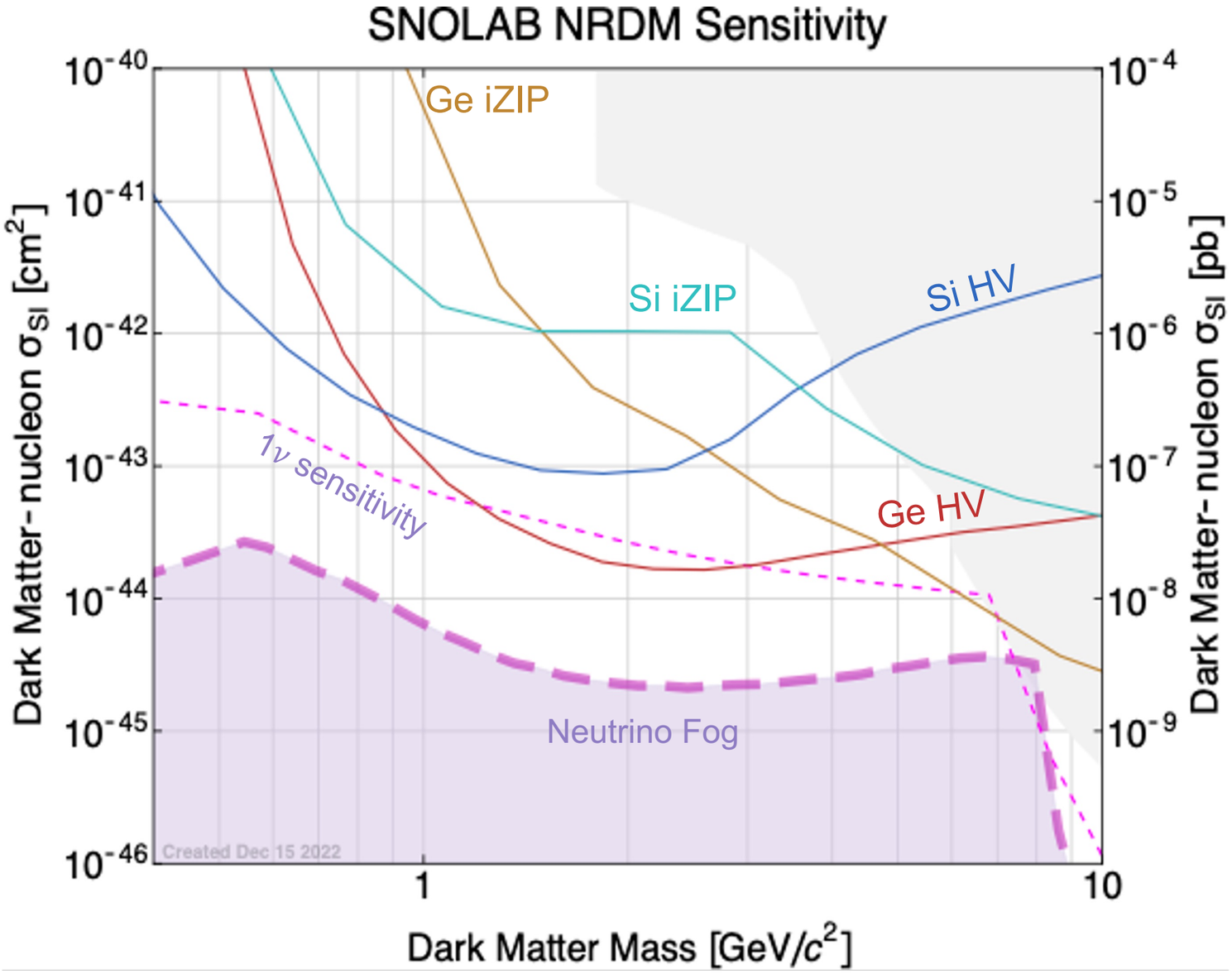
Detector Tower





Science Strategy: Complementary Targets and Functionality

2 technologies and 2 target materials cover the low-mass NRDM region, and provide sensitivity to electron-recoiling DM

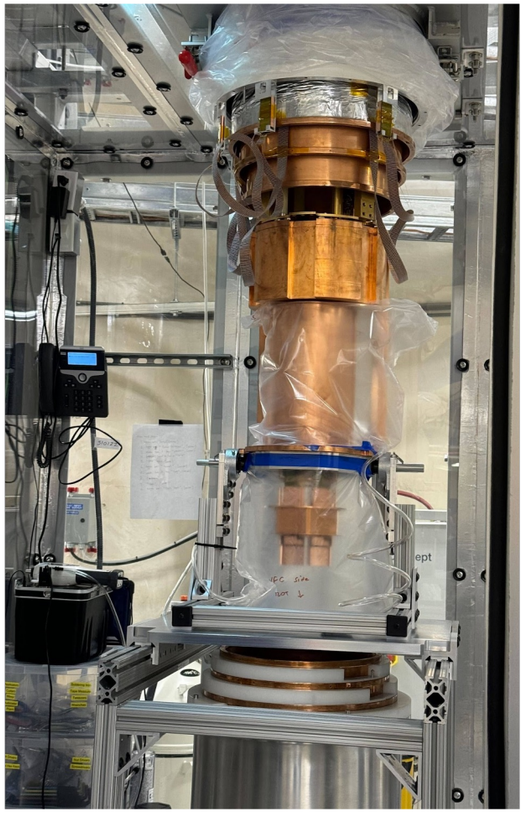


CUTE Tower 3 Run

- An HV Tower (Tower 3) was tested in CUTE from mid-October 2023 to mid-March 2024
- Highly efficient campaign with 90% of data runs deemed usable for analysis
- Accumulated data was used to conduct
  - Investigation of noise sources
  - Detector neutralization studies
  - Detector calibration measurements
  - Low-background exposure

Exposure [detector-days]	0V			HV		
	Background	Ba Calib	Cf	Background	Ba Calib	Cf
Silicon	24.2/21.7	29.1/27.4	–	20.6/18.6	29.4/22.0	–
Germanium	20.2/16.8	34.9/31.7	0.6/0.15	44.2/43.5.6	4.7/7.6	0.3/0.29

Background data include the data acquired with the activated Ge detectors.
The first / second exposure value corresponds to the total amount of data acquired / data of sufficient quality to be used for analysis.

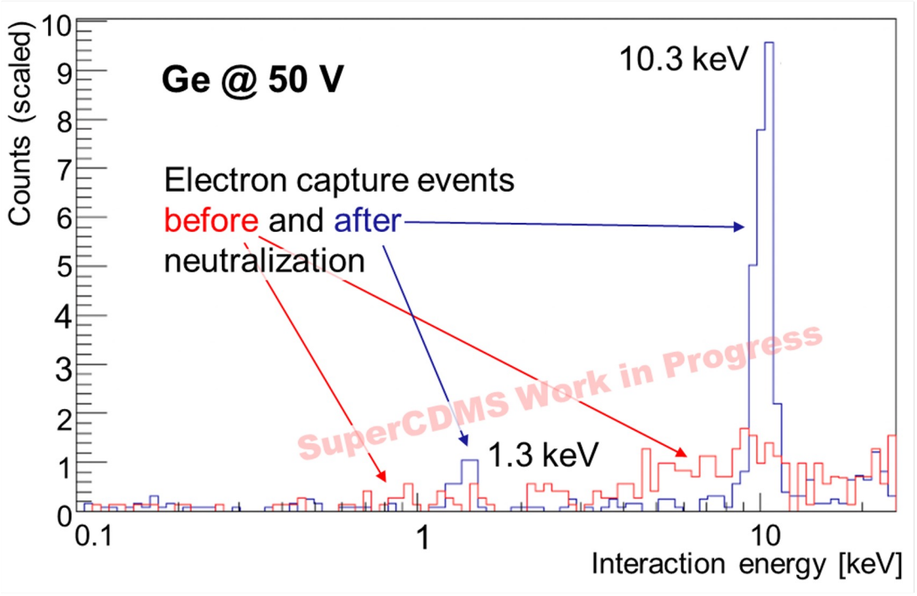


Tower 3 Installed in CUTE

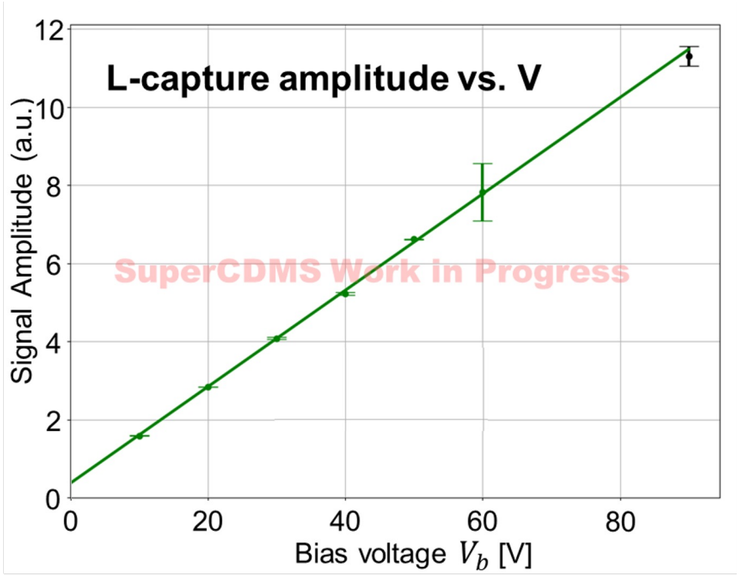
Highlights from CUTE Tower 3 Run

- Achieved all major testing goals and made substantial progress understanding several aspects of detector commissioning; reduced key commissioning risks.

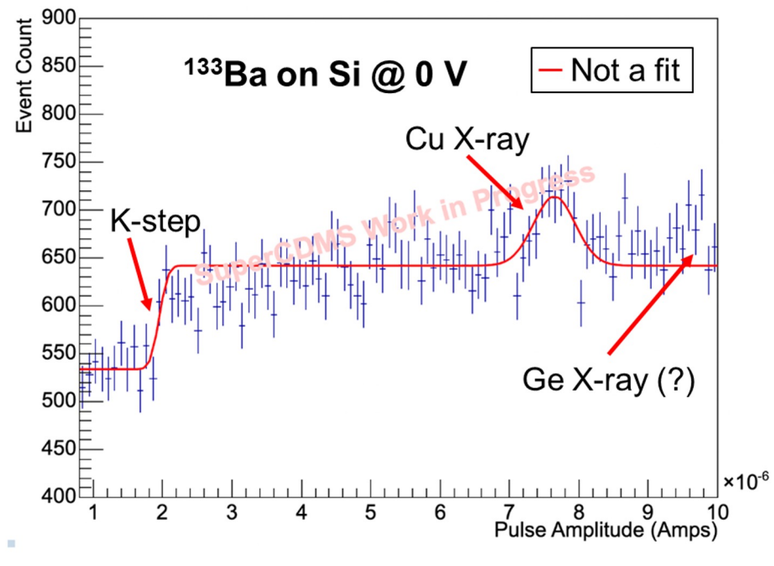
Established Neutralization Procedure for HV Detectors



Demonstrated High-Voltage Operations & Luke-gain Linearity



Demonstrated Low-Energy Si Detector Calibration using Compton Steps



Key takeaways from CUTE Tower 3 Run

- Tower 3 functionality characterized:
  - Reference for detector parameters (SQUIDs, TESs, etc.) → baselines expectations for commissioning
- Performed dedicated noise characterization campaign:
  - Identified key sources of noise → mitigations underway in advance of commissioning
- Demonstrated neutralization for HV detectors:
  - Rapid procedure identified → reduces commissioning time & informs detailed procedures
- Established high-voltage operating procedures:
  - Monitoring, ramp-up, breakdown recovery → does not need to be developed during commissioning
- Demonstrated low-energy calibration methods:
  - Especially important for Si HV detectors → substantially mitigates a key commissioning risk
- Exercised shift model, communication, monitoring methods:
  - Identified need for more trained operators & to expand automated monitoring → informs shift model

Ongoing CUTE Tower 3 Run Work

- The data analysis is still in a developing stage and we expect to produce several additional findings.
  - Test new data processing methods and establish a salting scheme for data blinding
  - Determination of detector specific fiducial cuts and their respective efficiencies
  - Measurement of background event rate at CUTE

- We expect the analysis work and the development of new tools and methods to continue during the SuperCDMS installation and commissioning period

Collaboration Health and EDI

- Collaboration maintains an external and internal facing effort aimed at EDI effort
  - The **external effort** consists of public statements posted at the collaboration's public website (https://supercdms.slac.stanford.edu/diversity-openness) describing the collaboration's formal position on Code of Conduct and EDI related matters
    - The Code of Conduct includes a written process through which the Executive Committee can address any allegation of a Code of Conduct violation.
  - The **internal effort** consists of providing (to all collaboration members)
    - Ombudsperson and Safe People serve as a non-threatening option to help members of the collaboration navigate a difficult situation while retaining privacy, protection from retaliation, and preventing a situation from worsening. They offer an informal path to resolve a situation.
    - Conducting an annual (anonymous) "Climate" survey.

      The Ombuds/Safe People are preparing to issue the 5th annual collaboration survey on environmental professionalism and inclusivity in the next month.

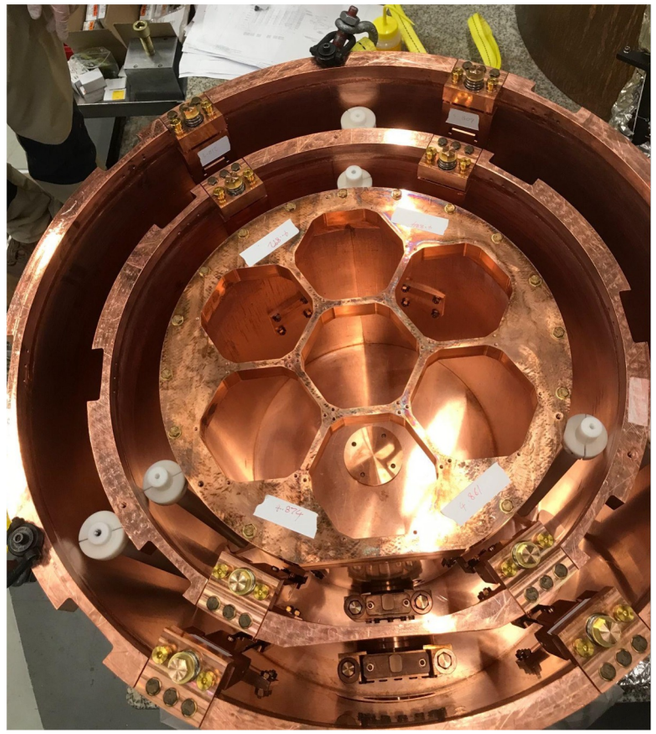
      One Safe Person departed the collaboration. Identified a likely replacement that will maintain the broad diversity of the group including breadth of geographic perspectives.

Installation Schedule Milestones as of Feb 2024

Task Name	Baseline Early Finish	Baseline Late Finish	Forecast/ Actual	Variance	Status
Dilution refrigerator stand-alone test	7/20/2023	8/3/2023	*7/20/2023*	*14*	Completed
Readout cables fabricated and tested	9/25/2023	10/10/2023	*10/13/2023*	*-3*	Completed
HAZOP review completed	10/3/2023	10/18/2023	*9/13/2023*	*35*	Completed
Tower 1 Bluefors testing complete	10/23/2023	11/15/2023	*11/6/2023*	*9*	Completed
Tower 3 installed in CUTE	10/24/2023	11/17/2023	*10/12/2023*	*36*	Completed
OVC chamber received at SNOLAB	10/30/2023	11/27/2023	4/24/2024	-149	Not Completed
IR Shields fabricated	11/9/2023	12/13/2023	2/14/2024	-63	Not Completed
IRR3B review completed	11/15/2023	12/19/2023	*11/13/2023*	*36*	Completed
Preassembly completed	11/21/2023	1/10/2024	3/19/2024	-69	Not Completed
All towers shipped to SNOLAB with successful acceptance testing	11/27/2023	1/18/2024	2/16/2024	-29	Not Completed
Mu-metal shield base installed	12/13/2023	2/13/2024	2/29/2024	-16	Not Completed
CUTE tower testing completed	1/10/2024	3/6/2024	2/16/2024	19	Not Completed
Remaining Chambers+Stems Received at SNOLAB	1/16/2024	3/14/2024	6/6/2024	-84	Not Completed
Full complement of DCRC boards underground	1/22/2024	3/22/2024	4/2/2024	-11	Not Completed
IRR4 review completed	2/6/2024	4/17/2024	3/7/2024	41	Not Completed
Etching and passivation completed	2/21/2024	5/8/2024	7/11/2024	-64	Not Completed
OVC chamber and C-Stem installed	2/29/2024	5/22/2024	9/30/2024	-131	Not Completed
IRR4 review completed	3/14/2024	6/12/2024	7/25/2024	-43	Not Completed

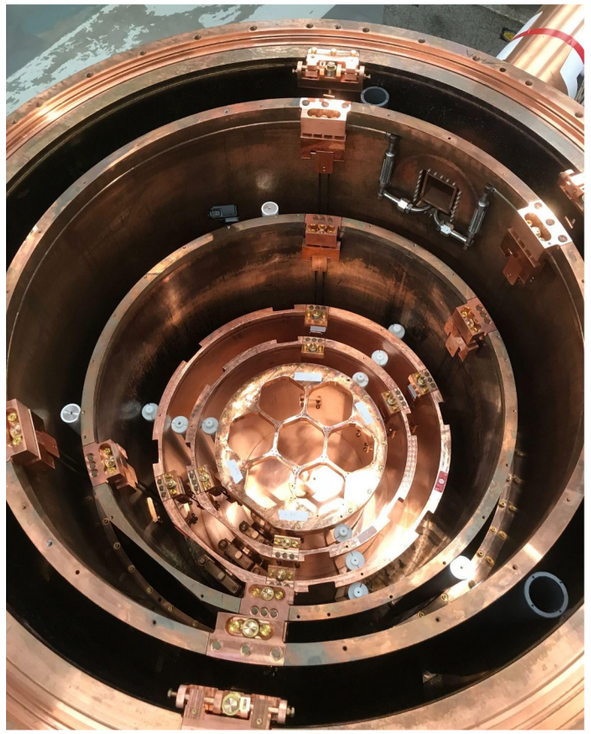
Successful pre-assembly of Inner Chambers

Pre-assembled chamber, hanger brackets, clamps and tower lid
Verified hanger clamp location



MC + CP + ST Chamber with temporary bumpers

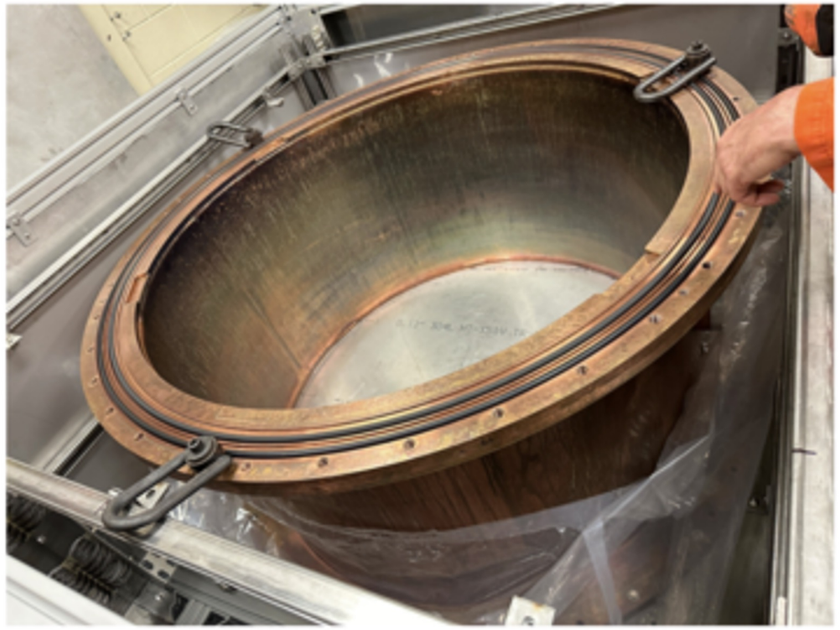
MC + CP + ST + LH Chamber

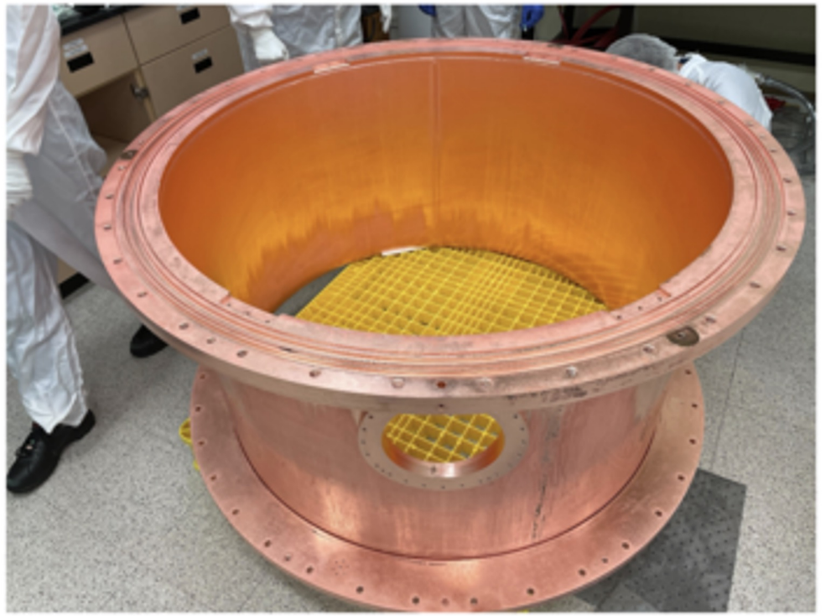


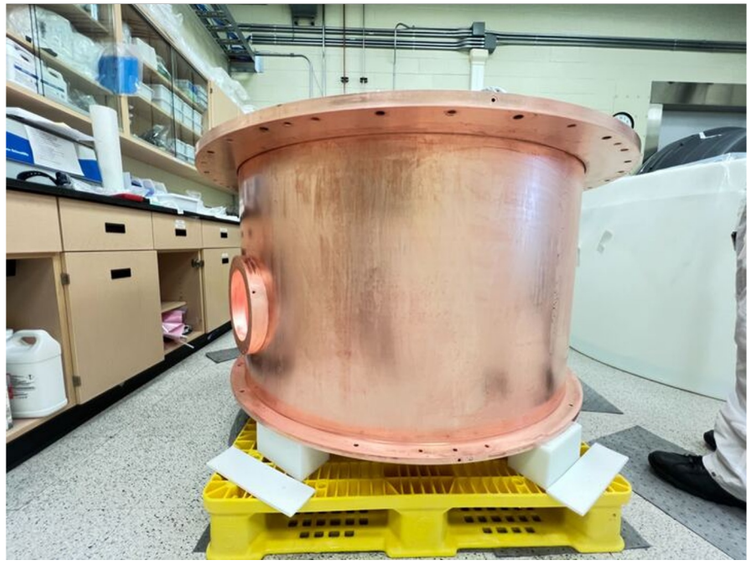
Inner Chambers installed into Shield/OVC Chambers

Pre-assembly was invaluable to develop tooling and procedures to ensure success underground

OVC Cleaning complete!

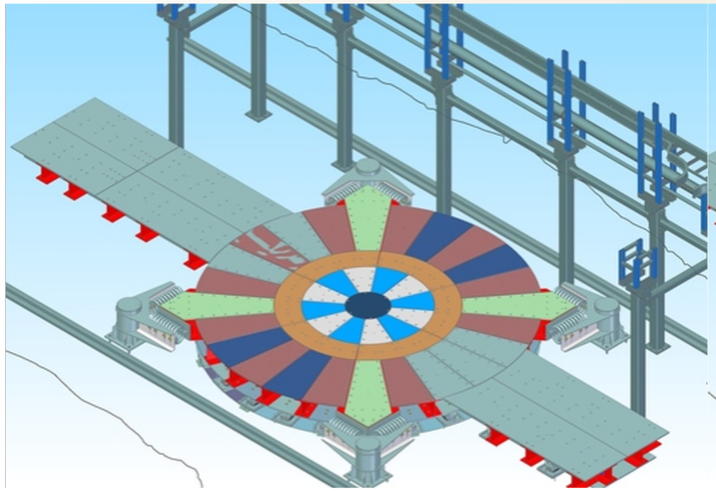




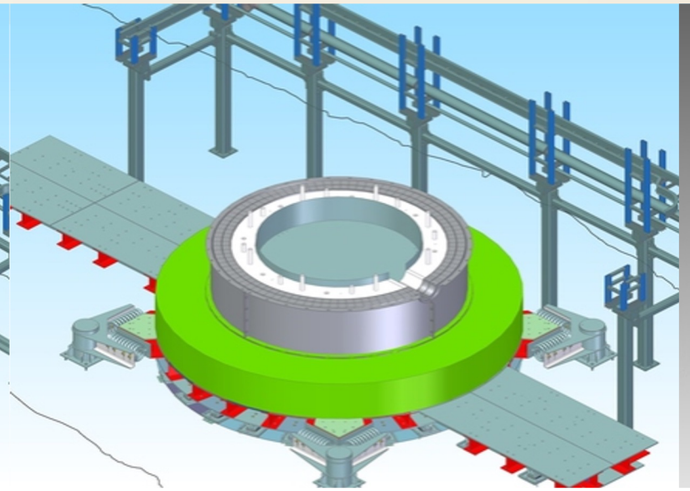


- Developed tooling to etch/passivate OVC Stems
  - Completed on schedule on end of May 2024.
- Will be shipped underground after end of PMP

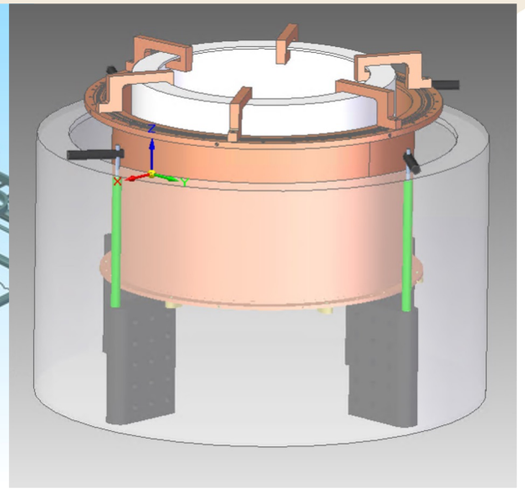
Completed Installation Activities



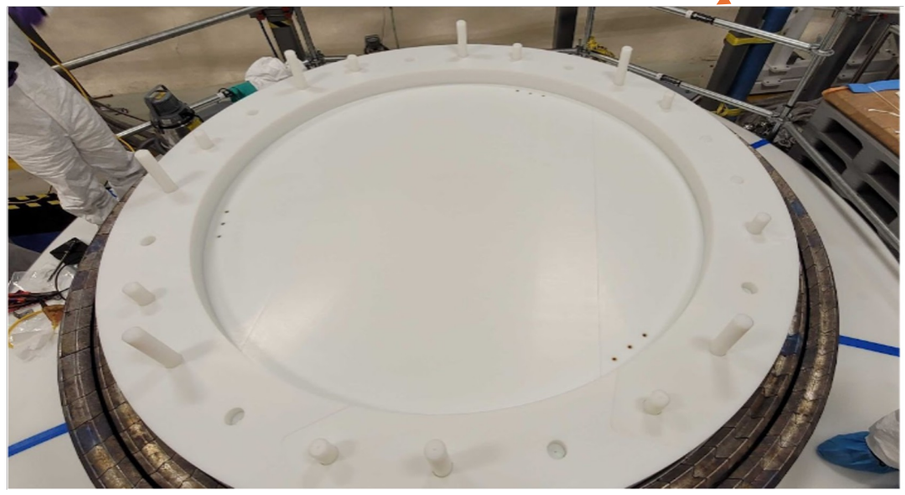
Install Seismic Platform, Cable Trays

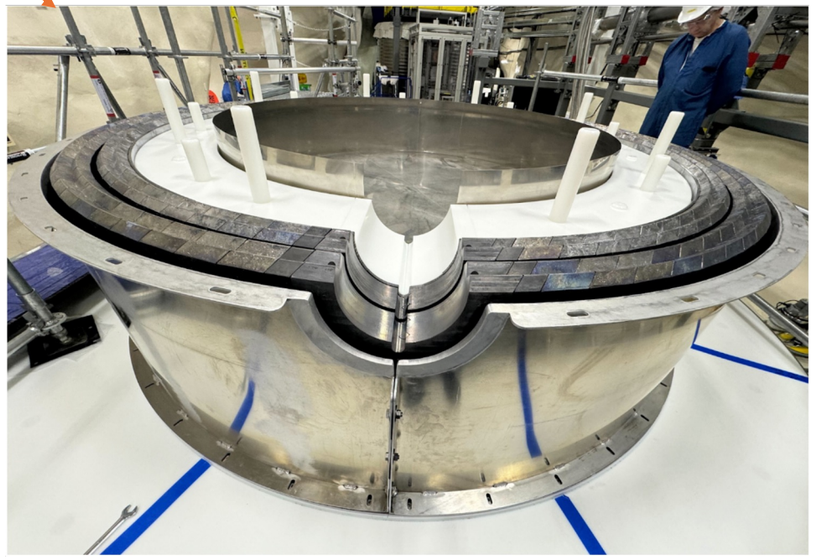


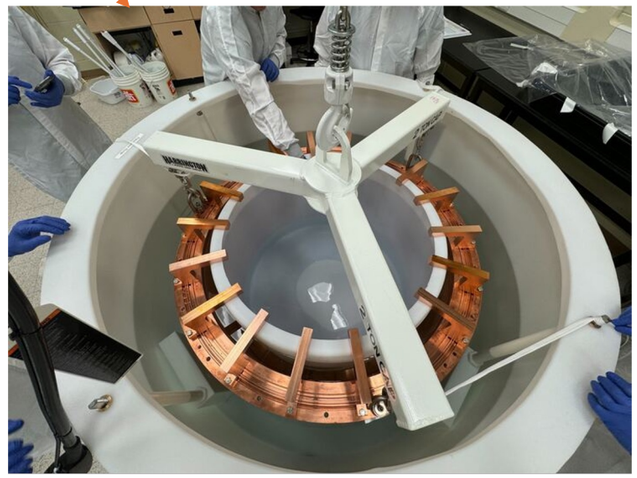
Build Shield up to C-Stem



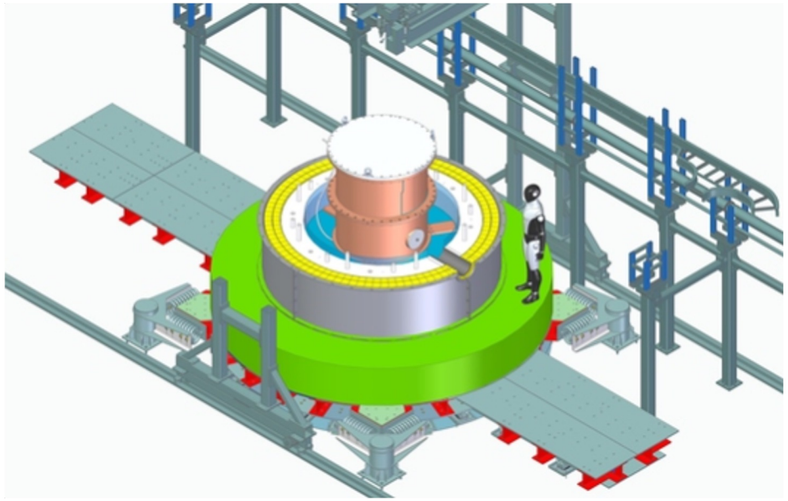
Copper etching/passivation





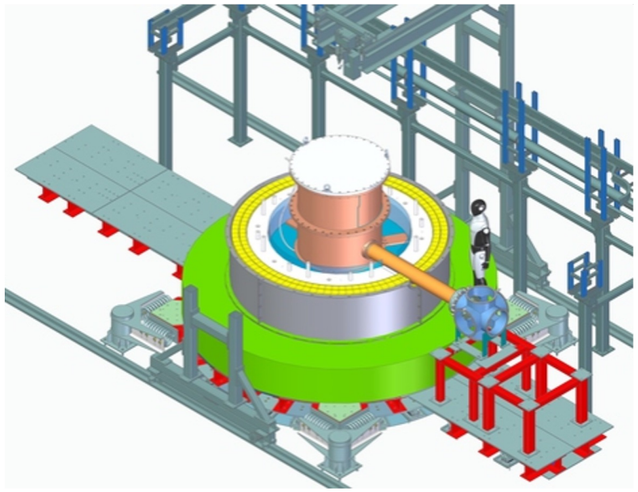


Upcoming Installation Activities



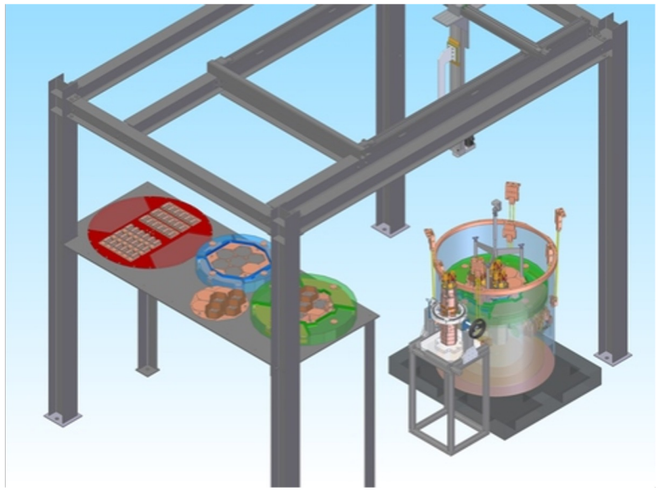
Install OVC Chamber, perform metrology, custom machine C-Stem Lead Insert

Upcoming Installation Activities



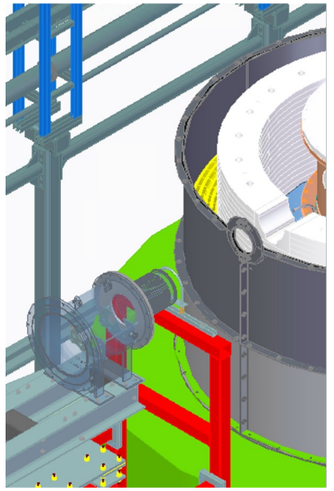
Install DR Frames, Cross, OVC C-Stem

Upcoming Installation Activities



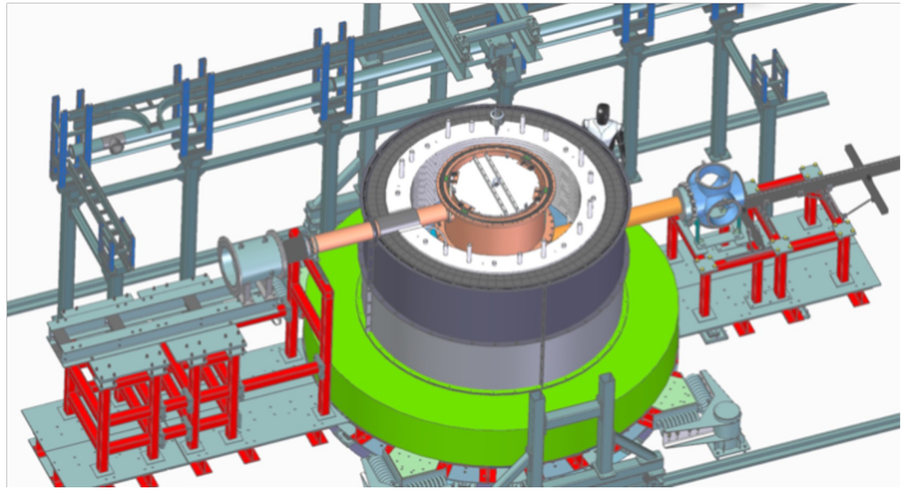
Assemble LH-ST-CP-MC Cans, move to Clean Room for Tower Assembly

Upcoming Installation Activities



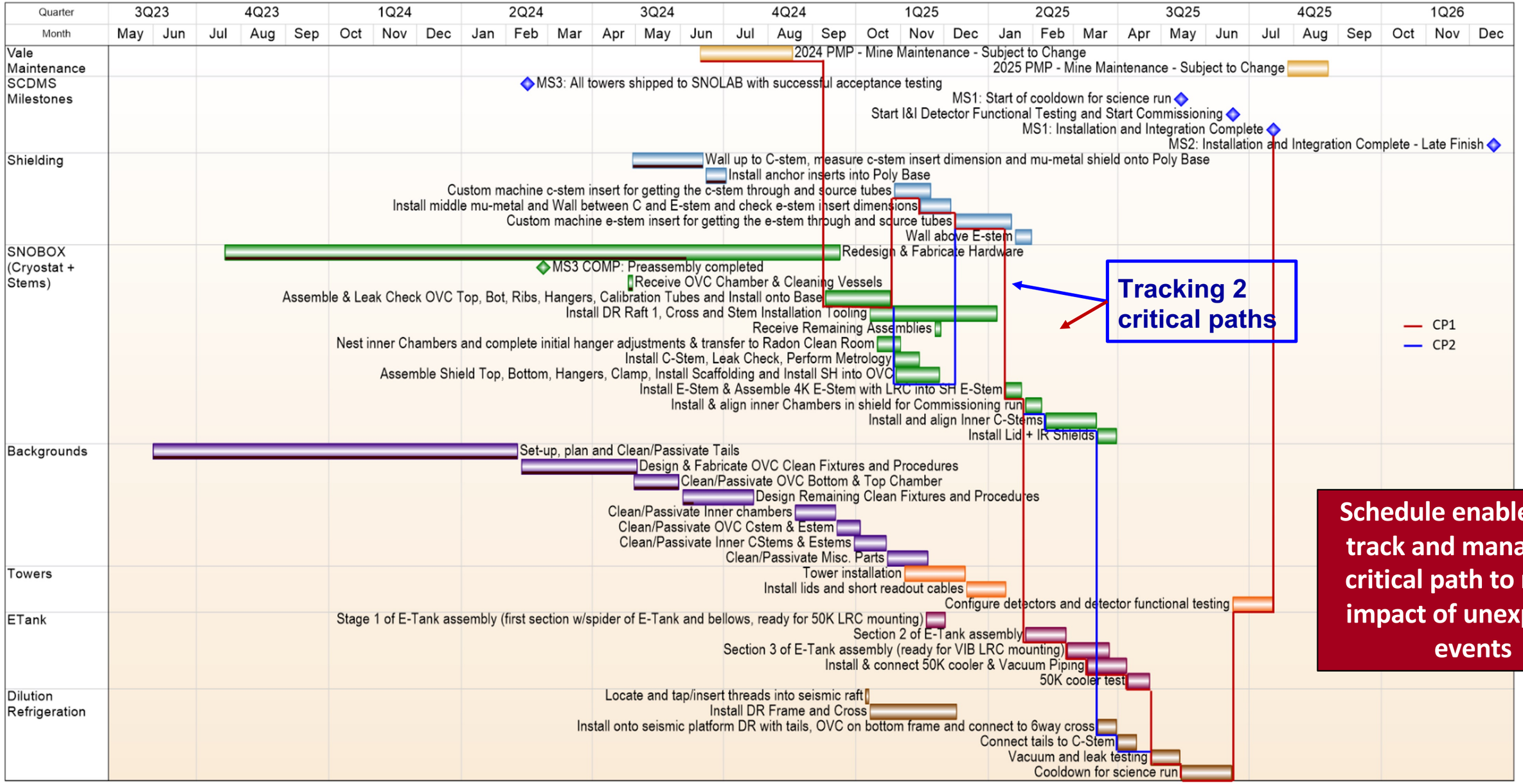
Install Etank Section 1 and bellows

Upcoming Installation Activities



Install Shield Chamber, Build Shield up to Estem, install Estem and insert Estem lead collar

Installation Schedule



Schedule enables us to track and manage the critical path to reduce impact of unexpected events

Installation Schedule Milestones

Task Name	Baseline Early Finish	Baseline Late Finish	Forecast/ Actual	Variance	Status
Dilution refrigerator stand-alone test	7/20/2023	8/3/2023	*7/20/2023*	*14*	Completed
HAZOP review completed	10/3/2023	10/18/2023	*9/13/2023*	*35*	Completed
Tower 3 installed in CUTE	10/24/2023	11/17/2023	*10/12/2023*	*36*	Completed
Readout cables fabricated and tested	9/25/2023	10/10/2023	*10/13/2023*	*-3*	Completed
Tower 1 Bluefors testing complete	10/23/2023	11/15/2023	*11/6/2023*	*9*	Completed
IRR3B review completed	11/15/2023	12/19/2023	*11/13/2023*	*36*	Completed
IR Shields fabricated	11/9/2023	12/13/2023	*2/16/2024*	*-65*	Completed
All towers shipped to SNOLAB with successful acceptance testing	11/27/2023	1/18/2024	*2/16/2024*	*-29*	Completed
CUTE tower testing completed	1/10/2024	3/6/2024	*2/16/2024*	*19*	Completed
Preassembly completed	11/21/2023	1/10/2024	*2/27/2024*	*-48*	Completed
Thermal Instrumentation Package fabricated	4/12/2024	9/24/2024	*3/1/2024*	*207*	Completed
IRR 4 (was IRR3C) review completed	2/6/2024	4/17/2024	*3/27/2024*	*21*	Completed
Mu-metal shield base installed	12/13/2023	2/13/2024	*4/23/2024*	*-70*	Completed
OVC chamber received at SNOLAB	10/30/2023	11/27/2023	*4/29/2024*	*-154*	Completed
IRR5 (was IRR4) review completed	3/14/2024	6/12/2024	8/28/2024	-77	Not Complete
Remaining Chambers+Stems Received at SNOLAB	1/16/2024	3/14/2024	9/27/2024	-197	Not Complete
Inner Chambers Assembled and Ready for Tower Integration	3/26/2024	6/27/2024	11/1/2024	-127	Not Complete
OVC chamber and C-Stem installed	2/29/2024	5/22/2024	11/14/2024	-176	Not Complete
E-Tank frame installed	5/8/2024	10/31/2024	11/18/2024	-18	Not Complete
Etching and passivation completed	2/21/2024	5/8/2024	11/20/2024	-196	Not Complete

Task Name	Baseline Early Finish	Baseline Late Finish	Forecast/ Actual	Variance	Status
Lid test assembly with operations tower completed	5/27/2024	11/27/2024	11/20/2024	7	Not Complete
Full complement of DCRC boards underground	1/22/2024	3/22/2024	12/4/2024	-257	Not Complete
Dilution refrigerator system test completed	10/31/2024	5/1/2025	12/5/2024	147	Not Complete
Towers and lids installed in inner cans for science run	6/24/2024	1/22/2025	1/13/2025	9	Not Complete
Completion of shield wall	9/4/2024	2/4/2025	1/31/2025	4	Not Complete
DR ready for installation with cryostat	11/29/2024	6/13/2025	2/11/2025	122	Not Complete
Long readout cables installed in Cryostat / E-Tank	10/21/2024	4/11/2025	3/24/2025	18	Not Complete
E-Tank installation completed	10/4/2024	3/24/2025	3/26/2025	-2	Not Complete
Certification of encapsulated californium source	1/15/2025	10/2/2025	3/31/2025	185	Not Complete
50K cooler installed	11/4/2024	5/6/2025	4/23/2025	13	Not Complete
Readout cables connected for science run	11/26/2024	6/6/2025	4/30/2025	37	Not Complete
Readout electronics ready for commissioning	2/7/2025	11/16/2025	5/7/2025	193	Not Complete
Cryostat Cstem & Estems installed and aligned	10/30/2024	4/30/2025	5/14/2025	-14	Not Complete
Start of cooldown for science run	1/13/2025	9/26/2025	5/15/2025	134	Not Complete
Calibration system installed and tested	2/4/2025	10/3/2025	6/26/2025	99	Not Complete
IRR8 (formerly GW3) ORR review completed	1/10/2025	9/26/2025	7/11/2025	77	Not Complete
Water tanks installed, shield complete	2/24/2025	11/27/2025	7/17/2025	133	Not Complete
Installation and Integration Complete	3/10/2025	12/18/2025	7/18/2025	153	Not Complete

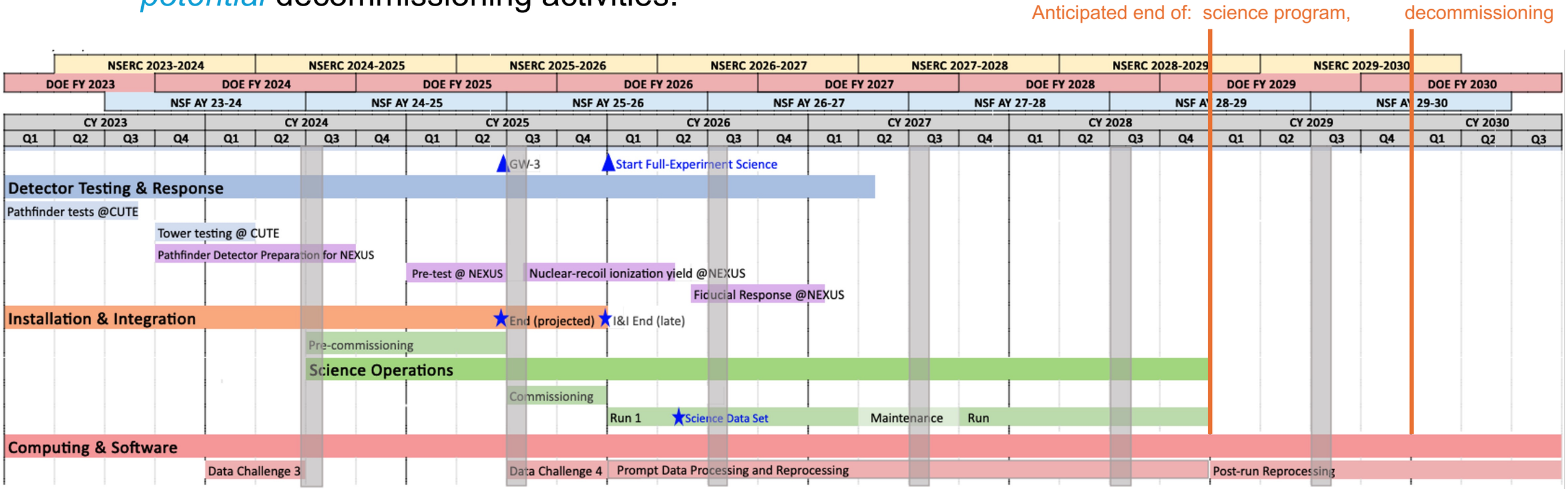
Working to ensure installation activities and transitions to commissioning/ science operations happen on schedule

Schedule Impacts

- Transportation of the cleaned OVC chamber was planned June 5th, but has been delayed until after end of PMP, with a current expectation of August 19th
  - This impacts several downstream activities.
  - A reorganization of the remaining tasks, guided by the Installation Schedule, forecast a net overall delay of 1 month for the end of installation: from 6/30/2025 to 7/18/2025.

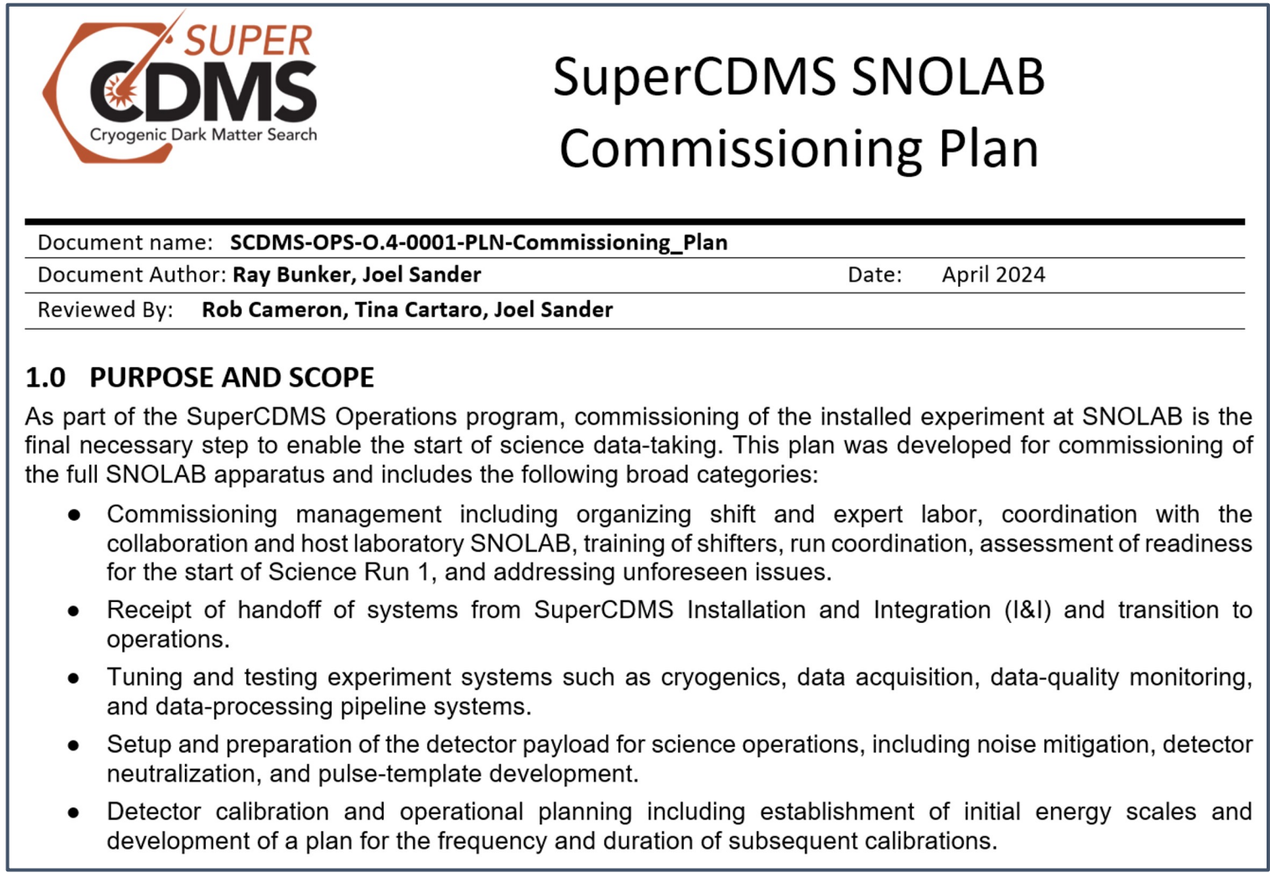
Request for Extension of SuperCDMS Space Allocation

- We would like to request from the EAC an extension of the currently allocated space through the end of CY2029
  - As the start of science operations is anticipated for early 2026, exte ding space allocation to end of CY2029 will allow for completion of the science program and *potential* decommissioning activities.



Preparation for Commissioning and Operations

- Commissioning plan being developed, in anticipation of transition from I&I
- Plan provides overall Commissioning framework
  1. Purpose & Scope
  2. Objectives
  3. Commissioning Team: management,
  4. shift types, expertise needs, training,
  5. communication, interfaces
  6. Transition from I&I
  7. Tasking & Criteria
  8. Controls & Monitoring
  9. Resources: infrastructure,
  10. SNOLAB support
  11. Hazards, Precautions, ES&H
  12. References



SUPER CDMS Cryogenic Dark Matter Search

SuperCDMS SNOLAB Commissioning Plan

Document name: **SCDMS-OPS-O.4-0001-PLN-Commissioning_Plan**

Document Author: **Ray Bunker, Joel Sander** Date: April 2024

Reviewed By: **Rob Cameron, Tina Cartaro, Joel Sander**

1.0 PURPOSE AND SCOPE

As part of the SuperCDMS Operations program, commissioning of the installed experiment at SNOLAB is the final necessary step to enable the start of science data-taking. This plan was developed for commissioning of the full SNOLAB apparatus and includes the following broad categories:

- Commissioning management including organizing shift and expert labor, coordination with the collaboration and host laboratory SNOLAB, training of shifters, run coordination, assessment of readiness for the start of Science Run 1, and addressing unforeseen issues.
- Receipt of handoff of systems from SuperCDMS Installation and Integration (I&I) and transition to operations.
- Tuning and testing experiment systems such as cryogenics, data acquisition, data-quality monitoring, and data-processing pipeline systems.
- Setup and preparation of the detector payload for science operations, including noise mitigation, detector neutralization, and pulse-template development.
- Detector calibration and operational planning including establishment of initial energy scales and development of a plan for the frequency and duration of subsequent calibrations.

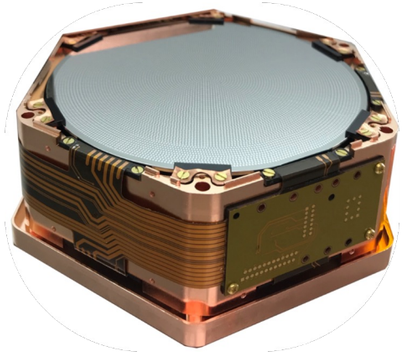
Preparation for Commissioning and Operations

- Science Operations plans & coordinates commissioning activities
  - Led by L2 Manager and L3 Commissioning Coordinator, L3 Run Coordinator
- Supported by broader Ops org:
  - Management, ES&H, shift planner
  - Site & hardware support
    (e.g., cryogenics, infrastructure)
  - Computing and software
    (e.g., data processing, storage)
  - Technical support (e.g., detectors, DAQ)
  - Tight coupling to Collaboration WGs
- Esp. Analysis, with objectives & tasks
  - explicitly included in commissioning plan
- Leadership of most technical subsystems carries forward from I&I to Operations
- *Shift model based on Tower Testing in CUTE experience*

Shift type	Notes
Data-taking & detector operations	Use DAQ to configure detectors and data-taking series; on-site & off-site; up to 24/7
Data quality & data handling	Use DQM and standardized analysis scripts to assess data quality; shepherd data transfer & processing; primarily off-site; several times daily
Analysis	Fast turnaround data analysis; primarily off-site; daily tasks at detector commissioning peak
Hardware monitoring	On-site & off-site monitoring of cryogenics system and SNOLAB infrastructure (chilled water, network, shield purge, etc.); up to 24/7 during commissioning
Expert	Shifts requiring specific expertise, including on-site shifts and off-site experts “on call”; up to 24/7

Conclusions

- We continue to receive great support from SNOLAB for our ongoing installation activities and have an open channel of communication with the lab
  - SuperCDMS receiving significant support in terms of staff effort and resources for OVC cleaning during the summer.
  - Hosted, and provided support organizational support, for summer 2024 collaboration meeting
  - Provided significant effort in the preparation for and representation at the recent (July 2024) DOE/NSF Operations Review
    - Overall was a successful review, thanks to contributions from a dedicated team at SNOLAB



SuperCDMS SNOLAB
July 2024 EAC Review

Andy Kubik
SNOLAB Group PI
July 31, 2024