CUTE – A low background facility for testing cryogenic detectors

Serge Nagorny

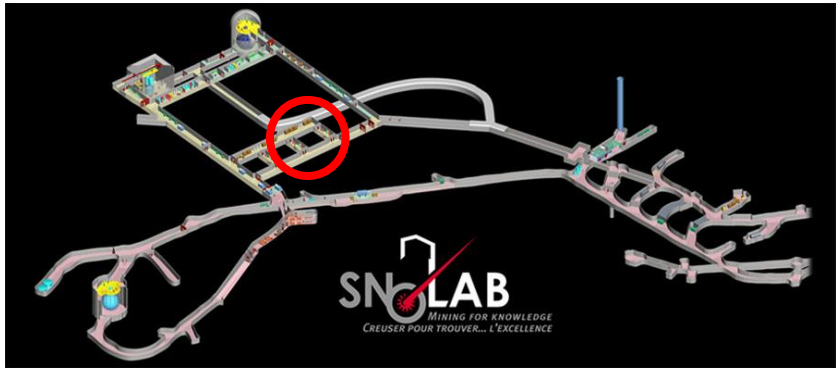
on behalf of the CUTE collaboration

April 26th, 2019

Motivation

- Provide a moderate size (10 kg detector) handy (few days turnover) well-shielded cryogenics (20 mK) infrastructure for rare event physics
  - Test and validation of entire SuperCDMS detector tower (6 detector + electronics)
  - Measurements in a low background environment avoiding cosmogenic activation of detector's material (^{3}H, ^{32}Si, etc.)
  - Complete SuperCDMS detector characterization to understand its intrinsic background and noise issues
  - Confirmation of screening program and handling procedures
  - Early science run for dark matter search can be performed thanks to low-background environment and low-energy threshold of SuperCDMS detectors
- Testing of various type cryogenic detectors

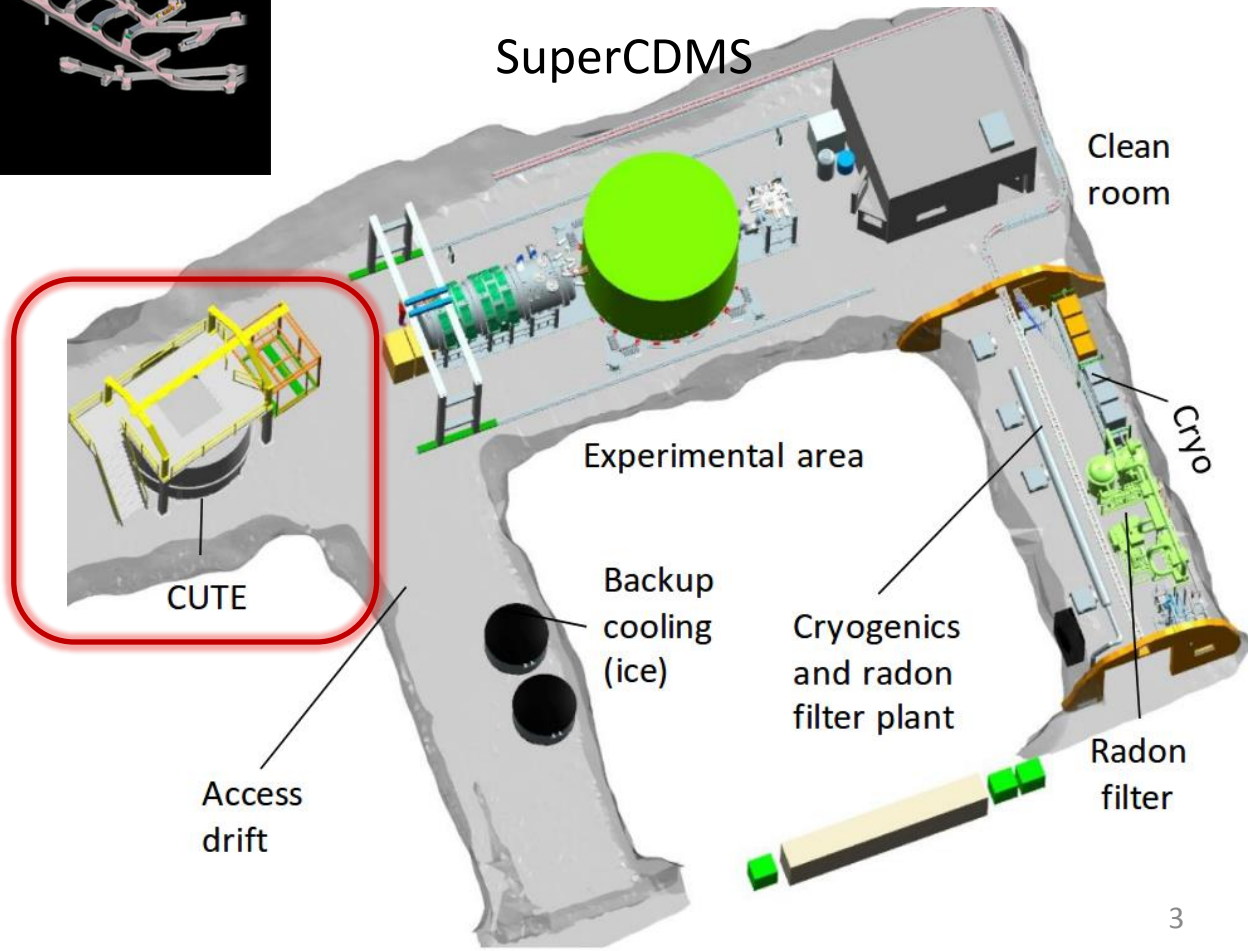
CUTE location at SNOLAB



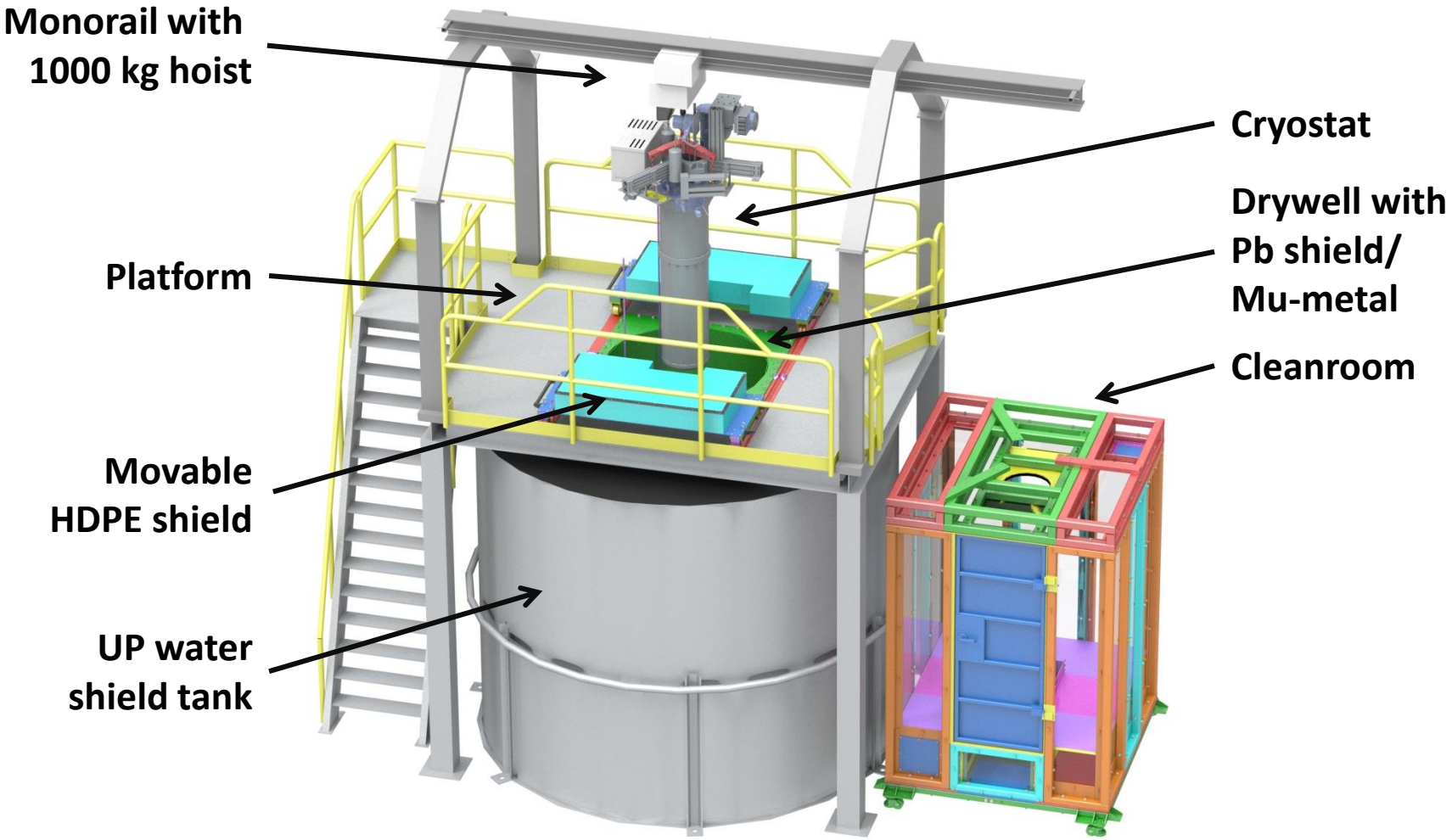
2 km deep

Strong cosmic ray flux suppression

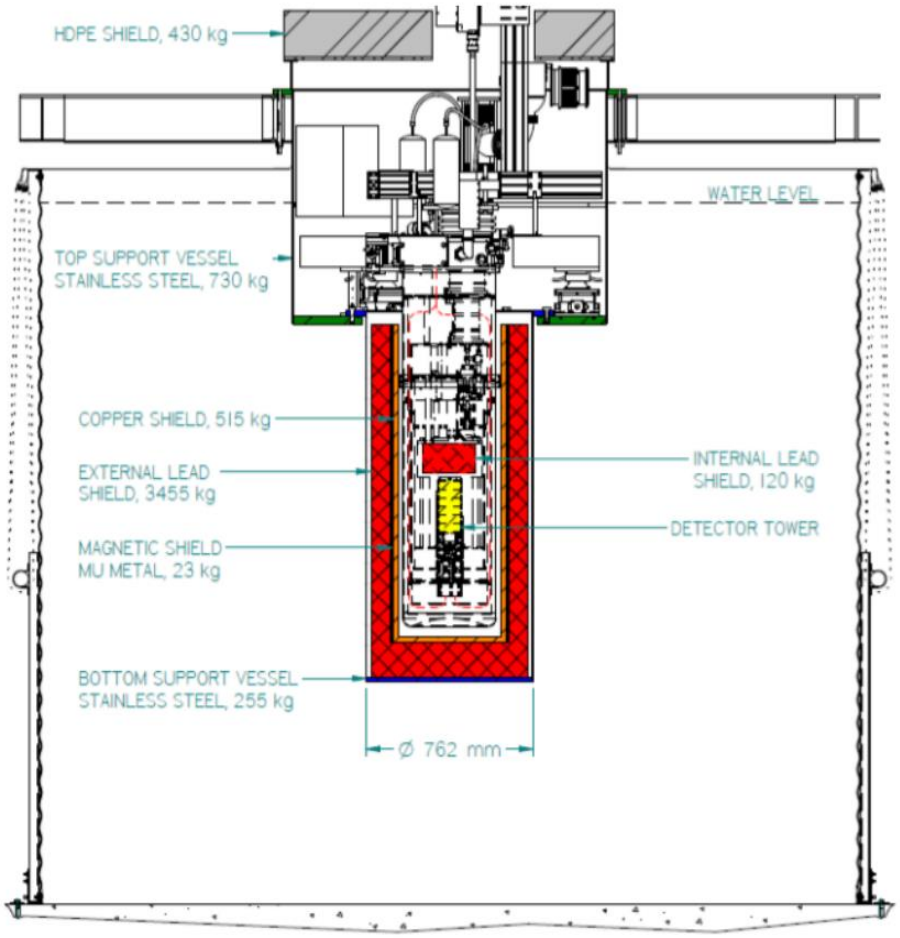
Cleanroom environment



General view of the CUTE facility

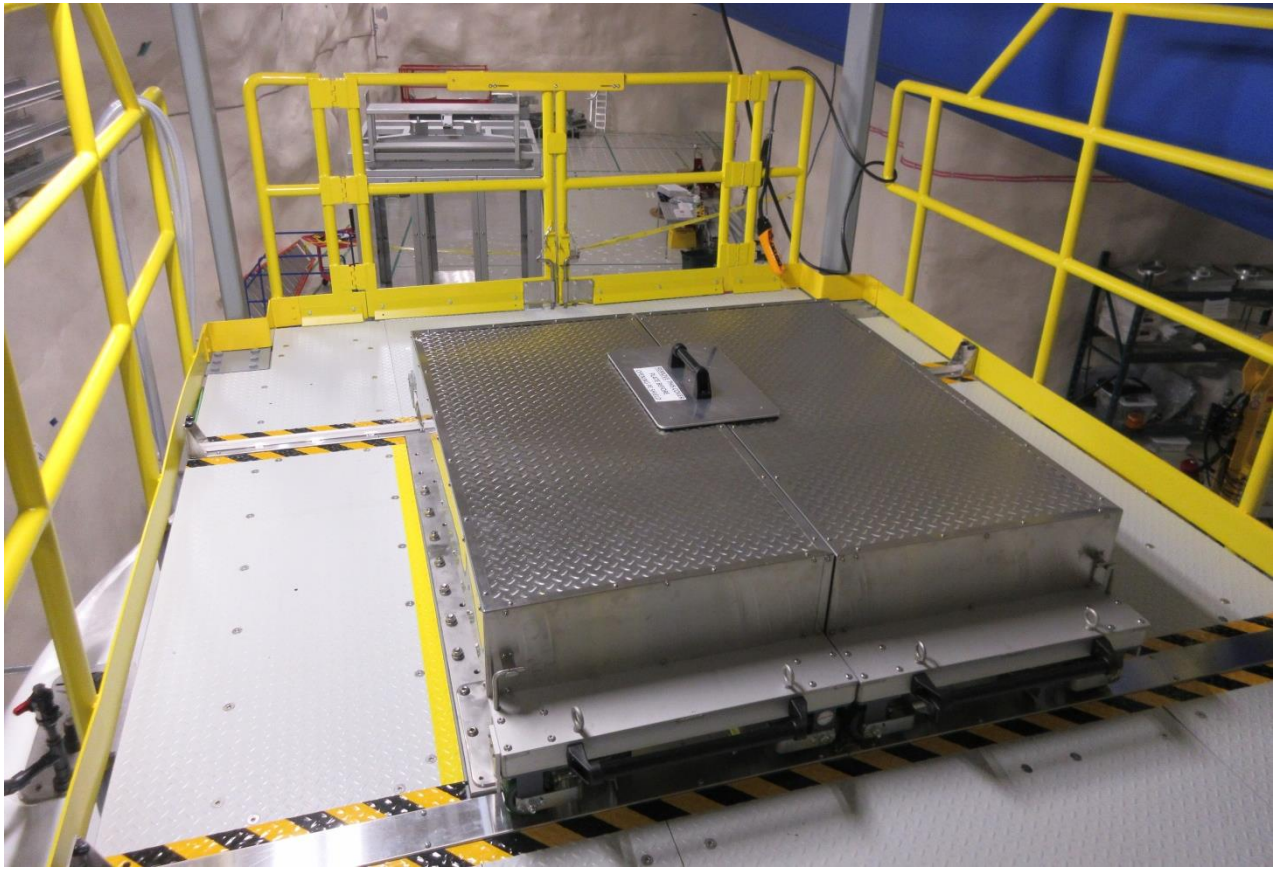


Shielding in the CUTE facility



- Cryostat placed inside the drywell of a water tank
- 1.5 m of water layer at side and 1.0 m at bottom reduces external neutron and gamma flux
- 11-15 cm of low activity Pb reduces residual gammas
- The gap from the top is closed off by 20 cm of HDPE and 15 cm of Pb inside cryostat
- Internal Cu shields block IR photons, which contribute to detector noise

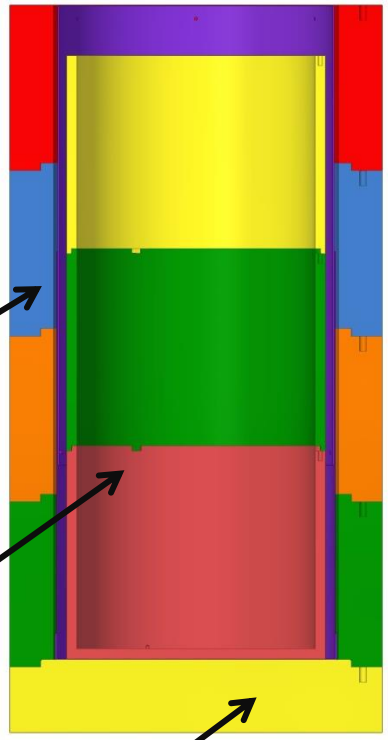
PE shielding



Installed

Fully functional, tested during Pb shield installation, Jan 2019

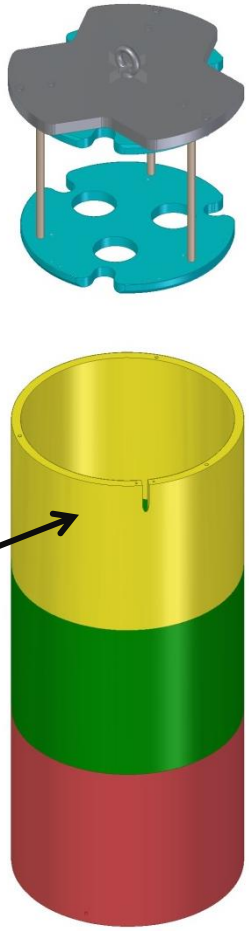
Lead shielding



9 cm
outer layer

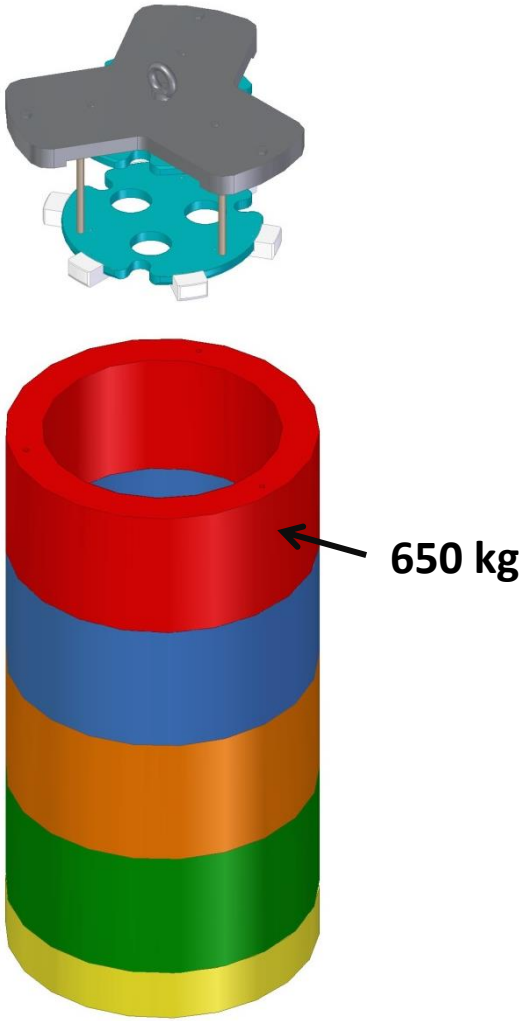
2 cm
inner layer

13 cm
outer layer



140 kg

Pb inner layer
< 3 Bq/kg

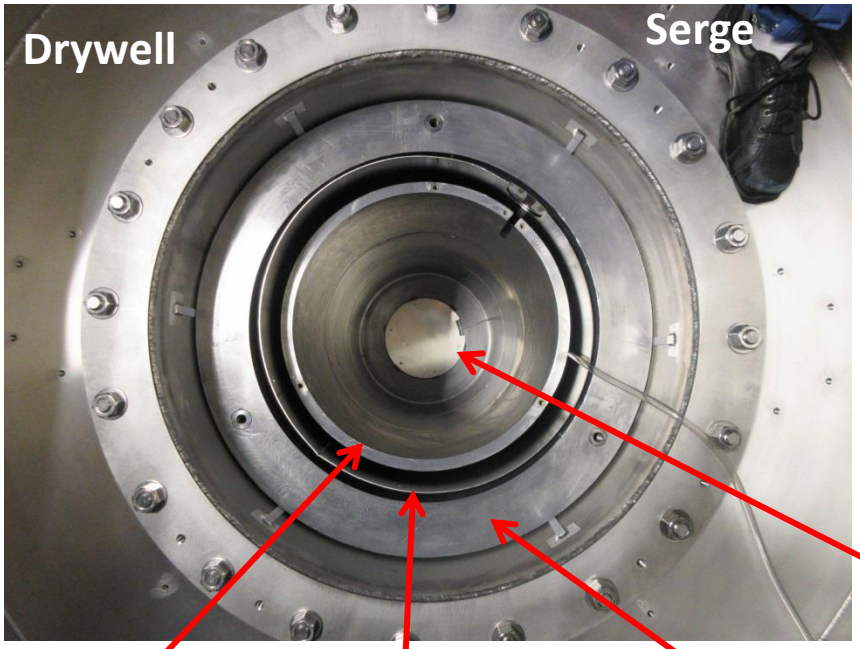


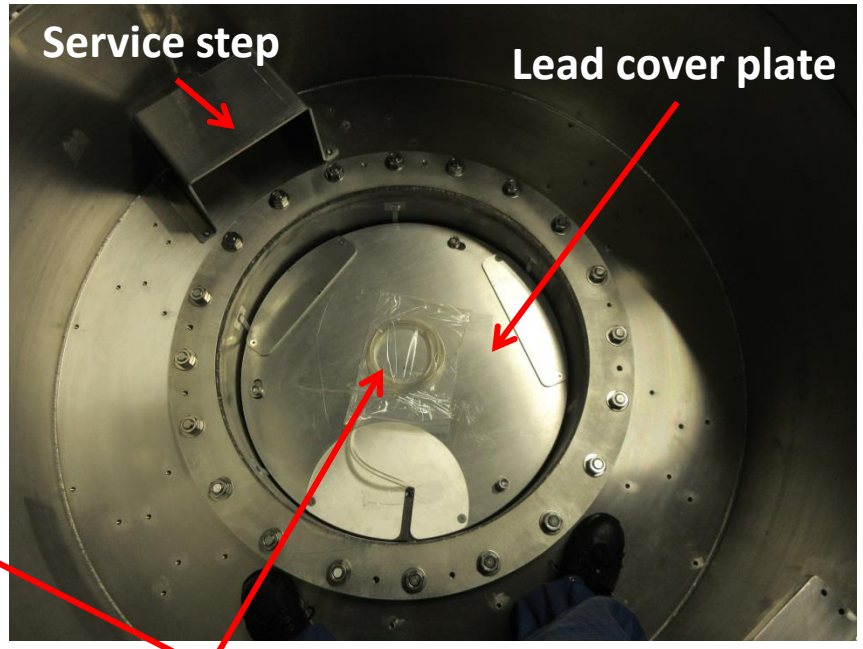
650 kg

Pb outer layer
< 30 Bq/kg

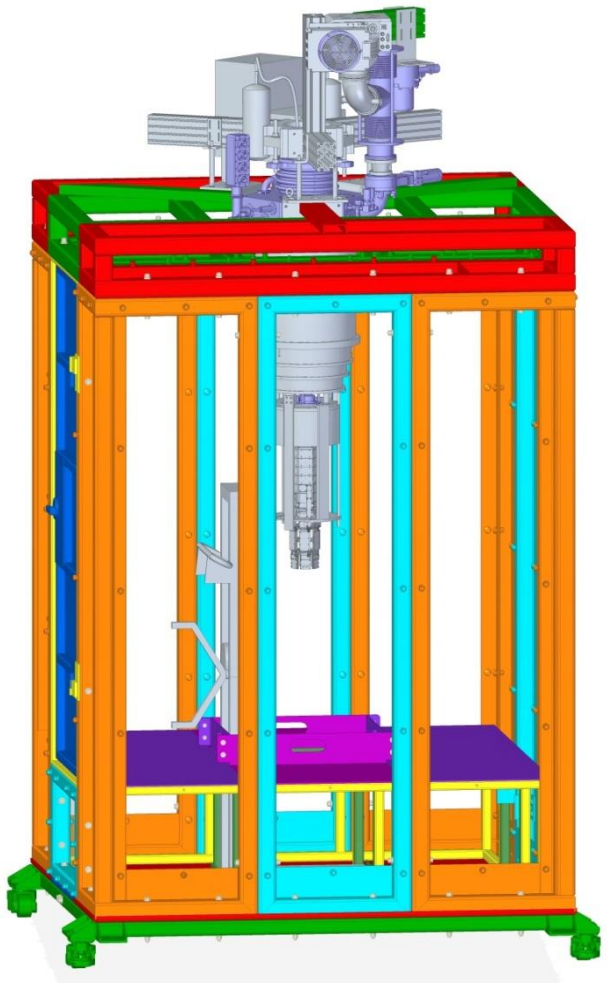
Lead shielding

Installed @ Jan 25th, 2019



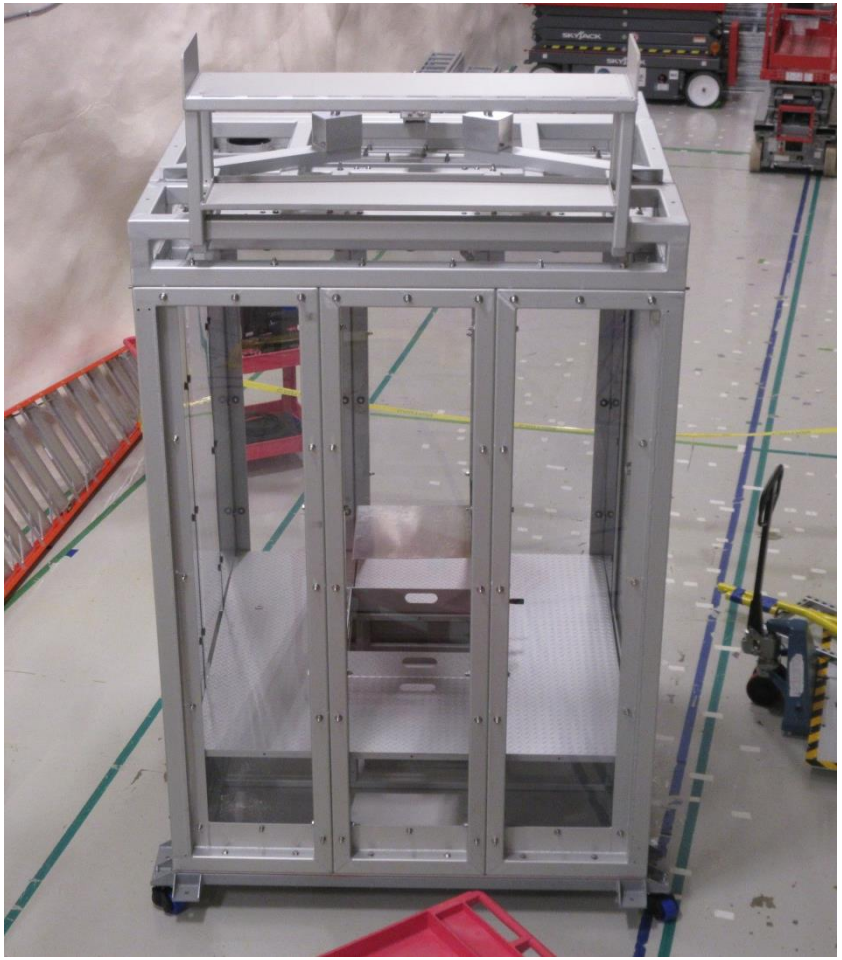


Cleanroom



- Space for two operators
- Aluminum structure with LEXAN panels
- Resistant to seismic events
- Movable
- Lifting device for cryostat cans
- Low Rn air supply (< 3 Bq/m^3)
- Later SuperCDMS Rn-filter system (< 0.1 Bq/m^3) will be used
- Crane moves cryostat between cleanroom and drywell

Cleanroom status @ Apr 26st, 2019



- **95% installation accomplishment**

To be completed:

- Connection to compressed air line
- HEPA filter in air supply line
- Sealing with Al-tape
- Final cleaning

Will be completed within first week of May, 2019

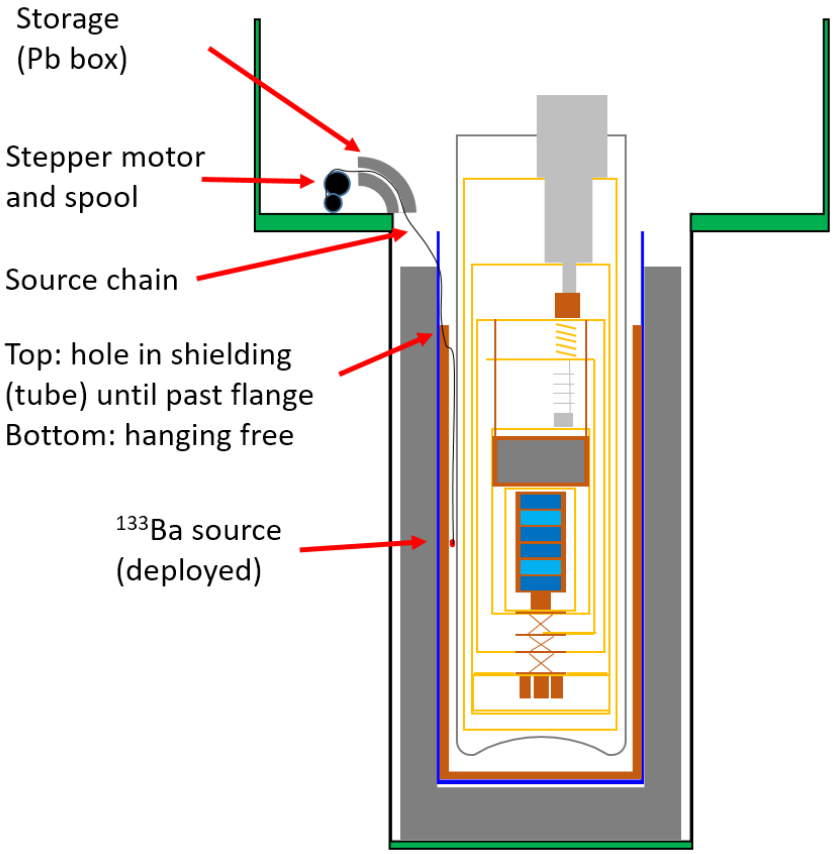
Installation Review, Part 3

(Feb 5th, 2019)

- Calibration system
- Suspension system
- Cryostat installation

All actions are planned to be completed by April 2019

Calibration system concept



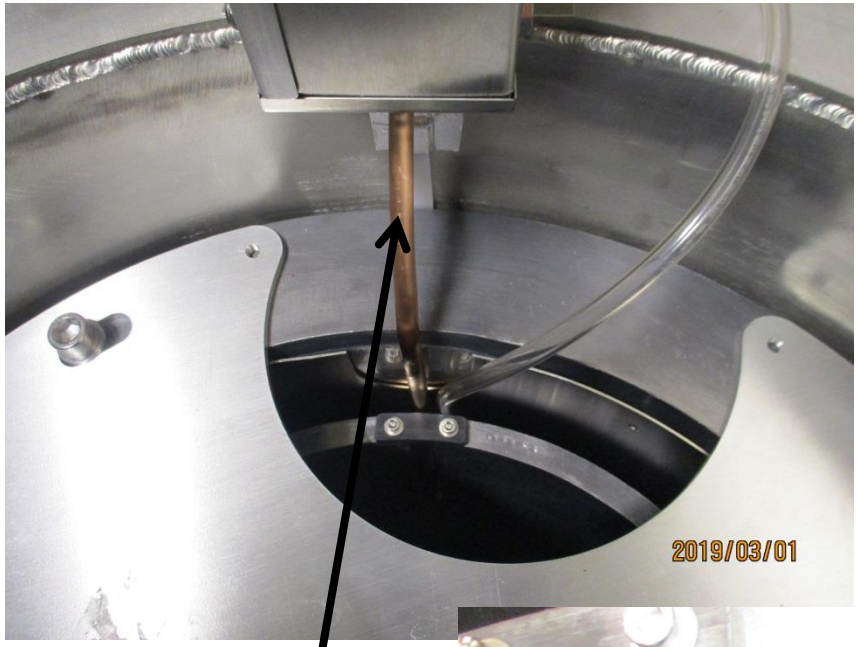
Different radioactive sources will be used to calibrate the energy scale and to monitor stability of detectors performance, as well for characterization of particle interaction types

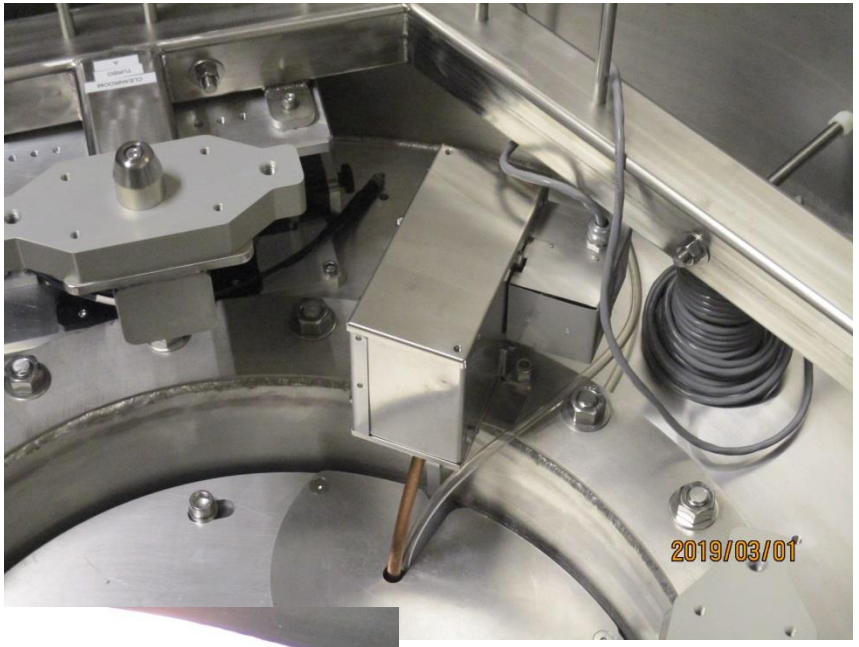
Gamma source: **^{133}Ba** *(this Installation stage)*

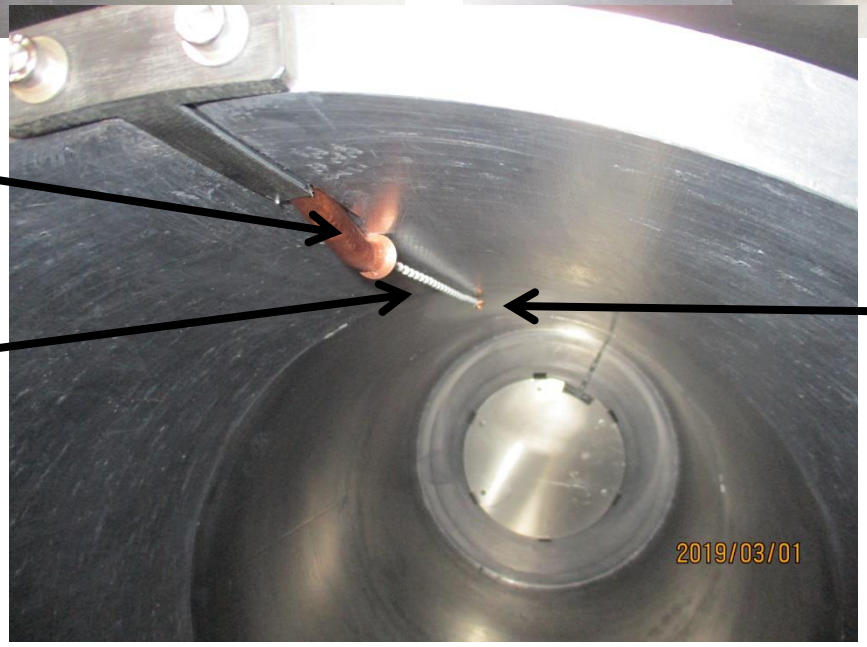
Neutrons source: **^{252}Cf** *(next step in a while)*

Sources will be remotely moved from shielded storage box to the measurement position

Calibration system status @ March 1st, 2019





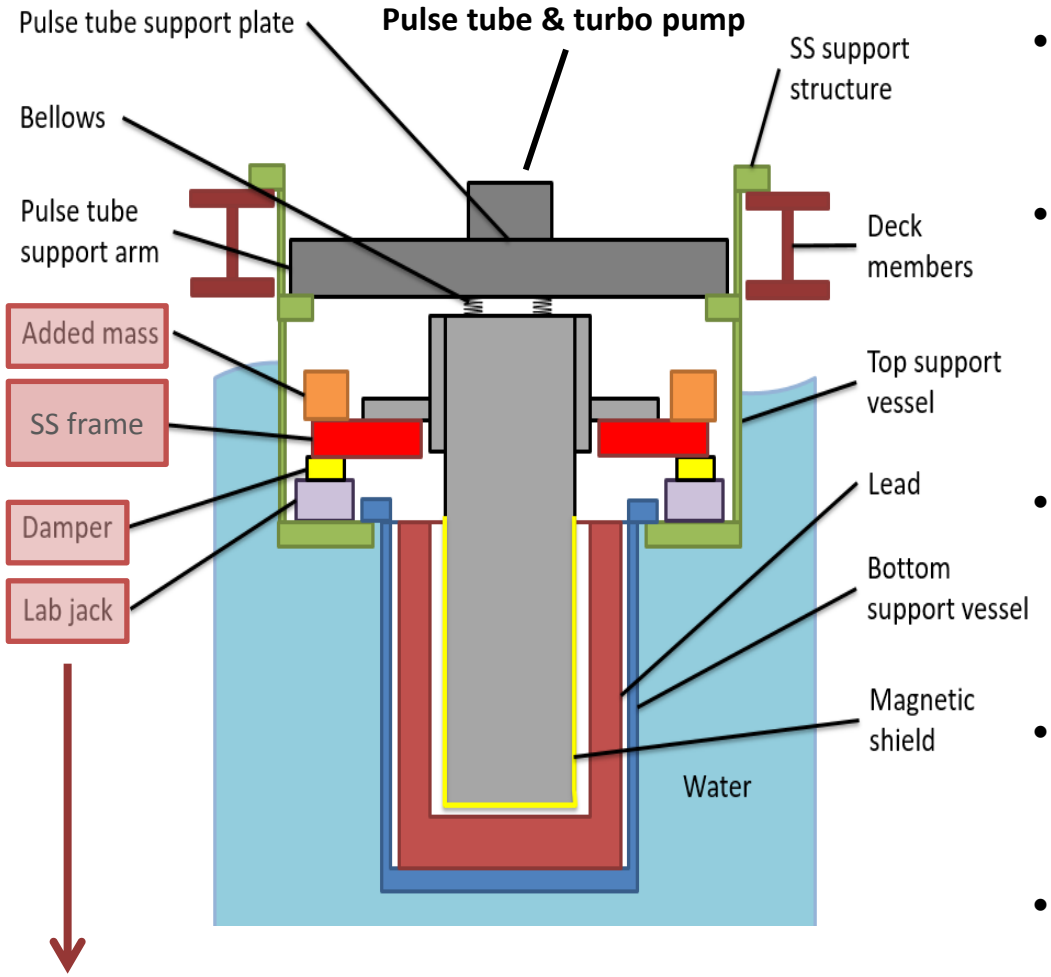


Guiding tube

Plastic chain

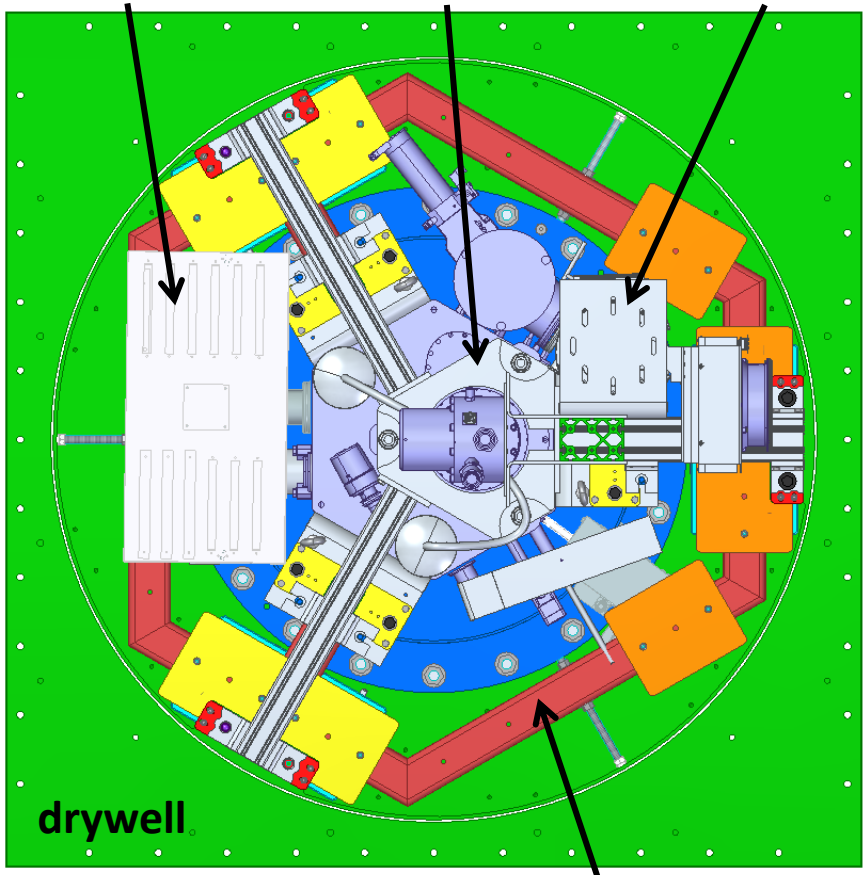
^{133}Ba source

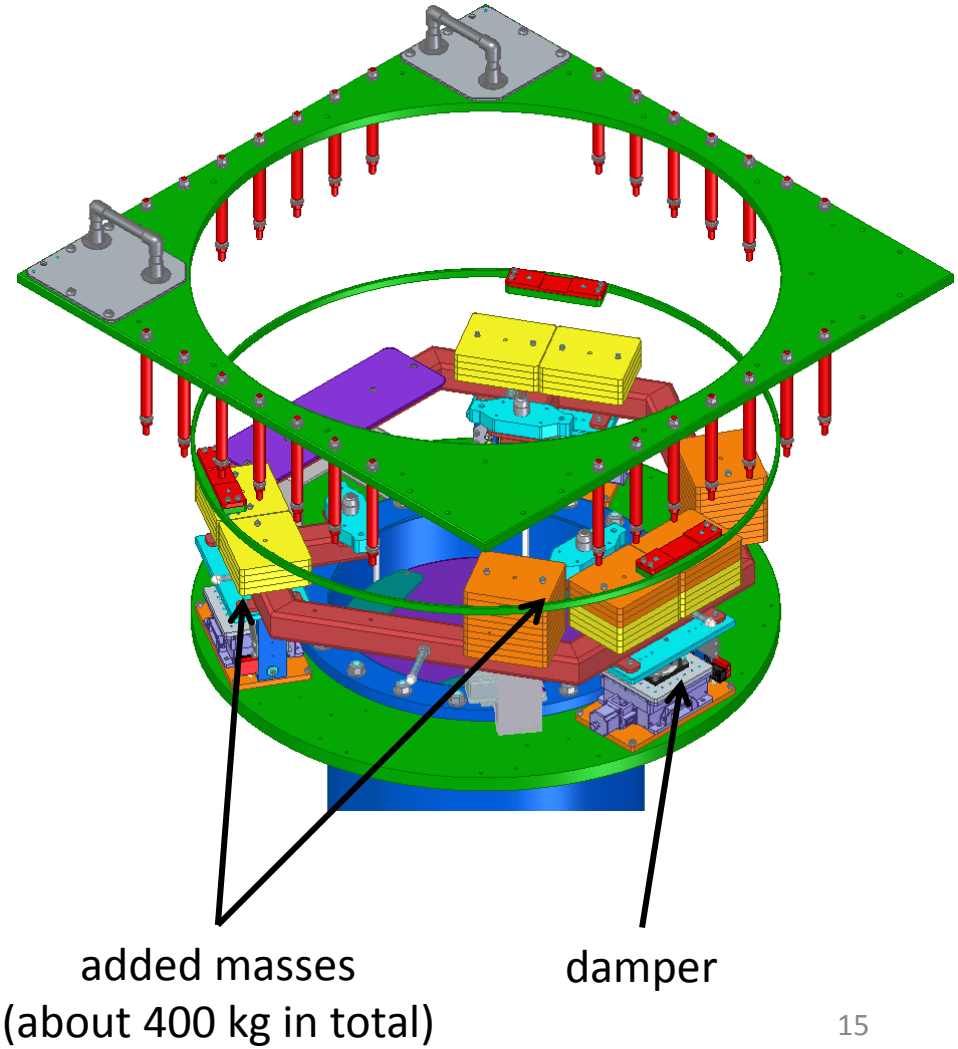
Active two-stages suspension system

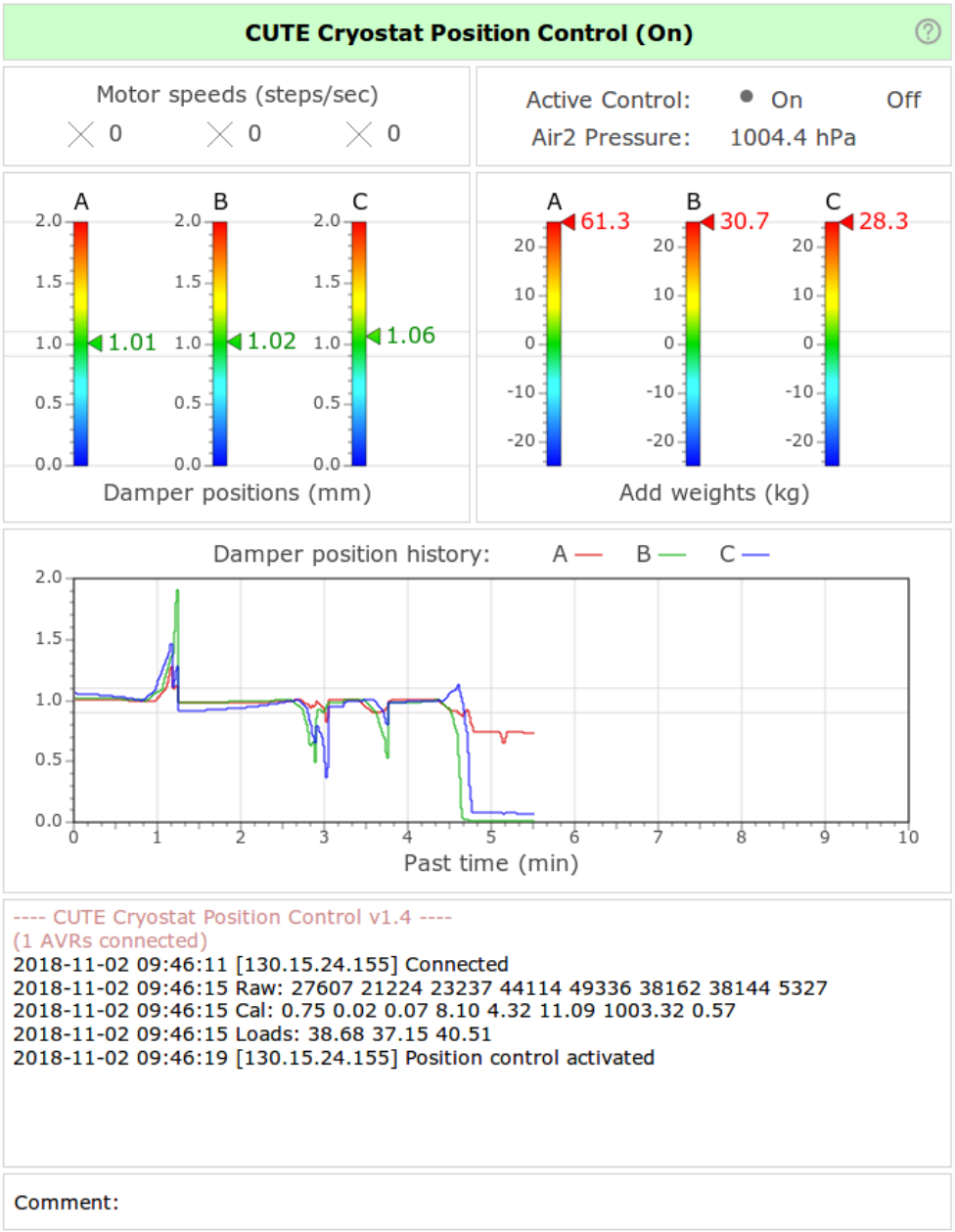


- Our detectors are sensitive to mechanical vibrations
- Pulse tube cooler and turbo pump are strong source of vibrations that may compromize detector performance
- Both are mounted on separate plate with soft coupling (bellows) to cryostat to minimize vibrations
- The bellows makes system sensitive to pressure fluctuations in SNOLAB
- Active suspension system tracks/controls cryostat position better than 1 mm

Suspension system assembly







Remote control of suspension system

Tracks environmental condition (pressure, water level, noise level)

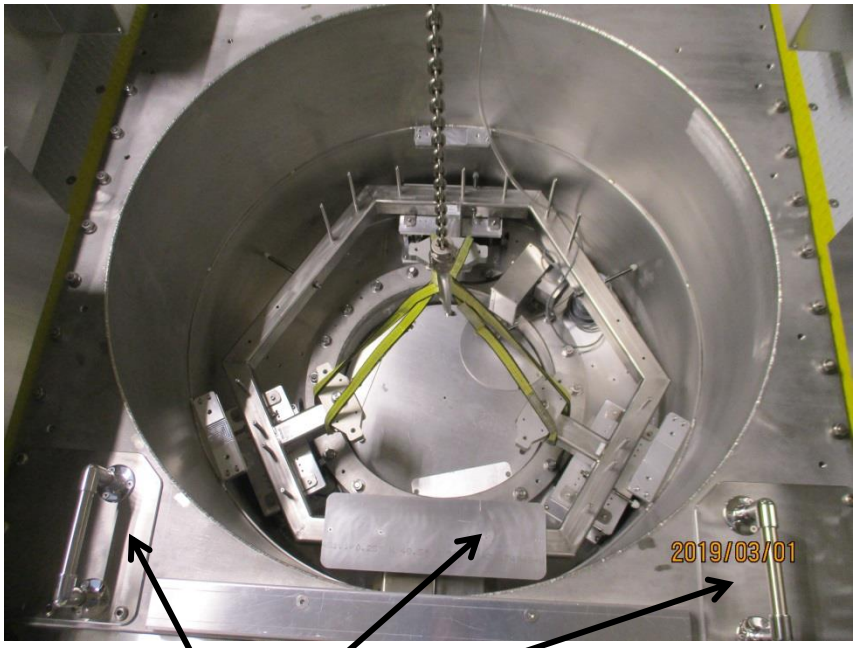
Records of all system parameters into database

Provides possibility to off-line analysis of behavior

Suspension system assembly

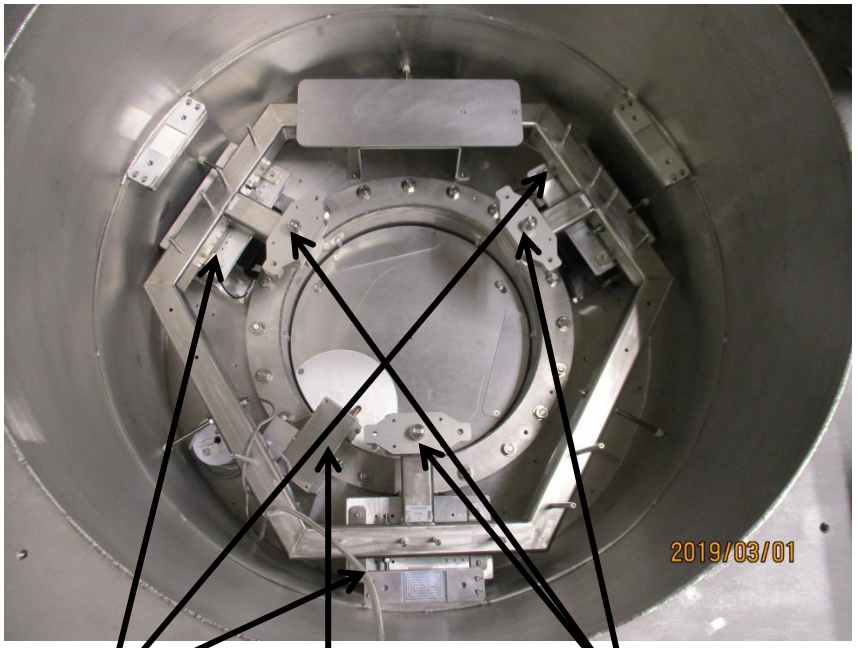
installed at March 1st, 2019

Lowering suspension frame into drywell



Service handles & step

Suspension frame is installed



Lab jacks

Cryostat alignment pins

Calibration system

Cryostat delivery to SNOLAB underground site

Time-schedule

Date (week)	Task
Feb 4, 2019	• Prepare suspension frame for shipping
Feb 5th, 2019	• Installation Review Phase 2B
Feb 11, 2019	• Assemble, clean, and package of calibration system • Ship suspension and calibration to SNOLAB • Fix last cryostat deficiencies
Feb 18, 2019	• Clean and package cryostat • Ship suspension system underground
Feb 25, 2019	• Install calibration and suspension systems
Mar 25, 2019	• Ship cryostat to SNOLAB and ship underground with CUTE staff presence
Apr 1, 2019	• Cryostat installation • Preparation for Operational Readiness Review
May 2019	• Operational Readiness Review

CUTE tasks before Early Operation

Date	Step
May, 2019	• DAQ mounting, and implement DAQ architecture for underground/surface CUTE lab
May, 2019	• Preparation for Operational Readiness Review
June, 2019	• Cleanroom operation test *- air quality test* *- operational test* *- working procedure improvement*
July, 2019	• Test all procedures , its correction based on the results of first run without/with detectors
July, 2019	• Evaluation of required manpower for run preparation&running
end of 2019	• Radio-assay of materials used for CUTE facility production
end of 2019	• Completion of CUTE background model

Payload for CUTE

Commissioning

Task	Time Period
Testing of CUTE facility at SNOLAB • *Without detectors* • *With detectors (G115/TES chip)* • *Revision/fixing problems/commissioning*	*May 2019 – June 2019*
Testing SuperCDMS detectors • Si HV Pathfinder • HVeV detector • First tower (6 iZIP Ge Detector)	*July 2019 – May 2020*
Own R&D activity • HVeV detector from enriched ^{28}Si • Scintillating bolometers based on YVO_4, ZnSe, $^{arch}PbMoO_4$ crystals • Advanced light detectors	*from Sept 2019*

Early operation