CUORE status

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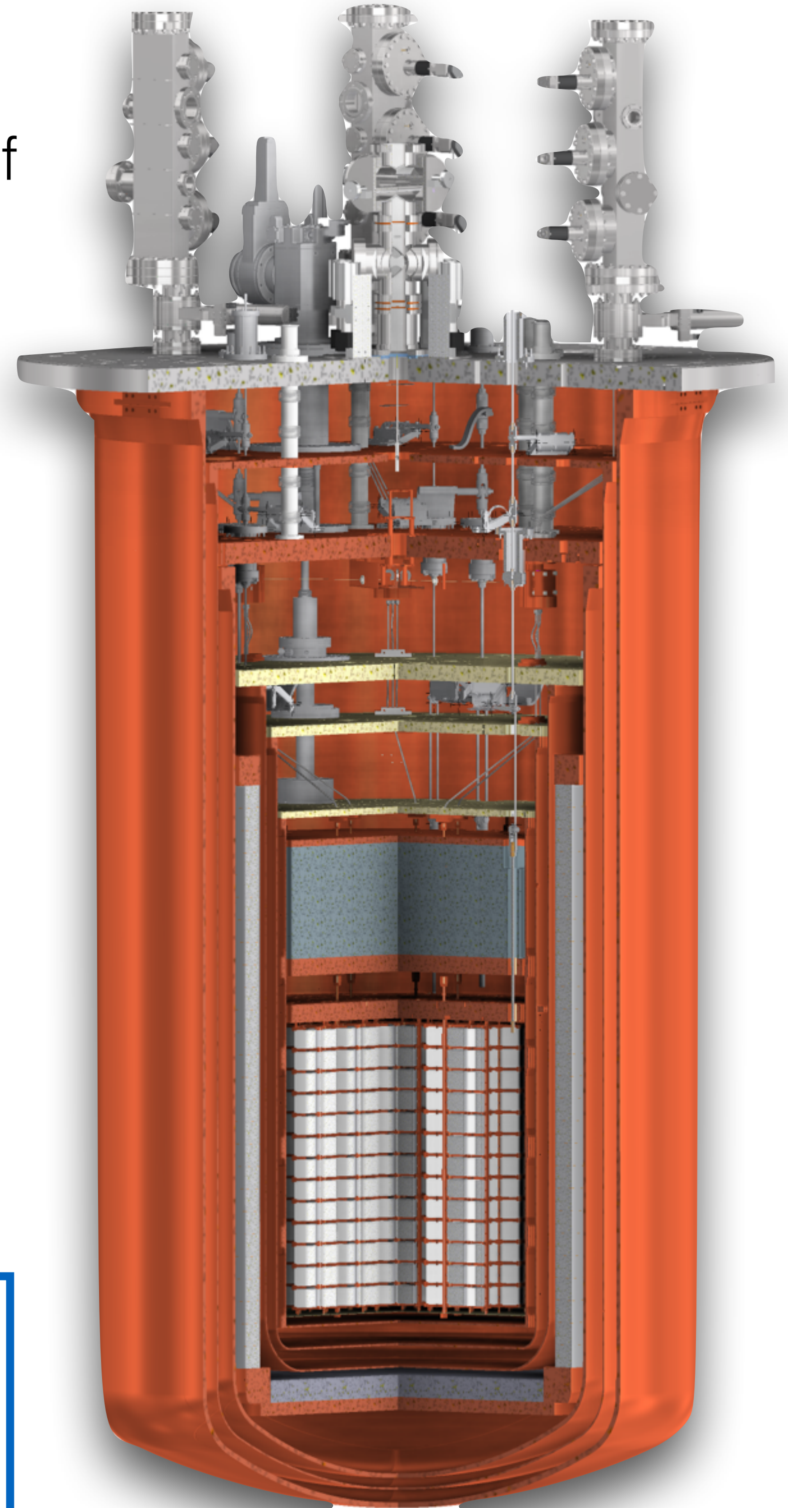
April 3rd, 2017
XLVII LNGS Scientific Committee meeting

The CUORE experiment

- Investigates the decay $^{130}Te \rightarrow {}^{130}Xe + 2e^-$ using an array of 988 $^{nat}TeO_2$ thermal detectors, arranged in **19 towers, 13 floors each**. A total mass of 206 kg of ^{130}Te

Goal parameters:

- Extremely low operating temperature (~10 mK)
- Energy resolution of 5 keV FWHM at $Q_{\beta\beta}$ (2527 keV)
- Background: 10^{-2} c/keV/kg/year in the ROI.
- Sensitivity on $m_{\beta\beta}$ (5y, 90% C.L.): 50 - 130 meV
- Sensitivity on $0\nu\beta\beta$ $T_{1/2}$ (5y, 90% C.L.): 9.5×10^{25} y



Challenge: operate a huge bolometric array, in an extremely low radioactivity and low vibrations environment

Status at the last SC

April 2016

Conclusions

CUORE-0

- Achieved its energy resolution and background level objectives
- Improved 0vDBD limit for ^{130}Te (no 0vDBD evidence)
- Indicated CUORE sensitivity goal is within reach.

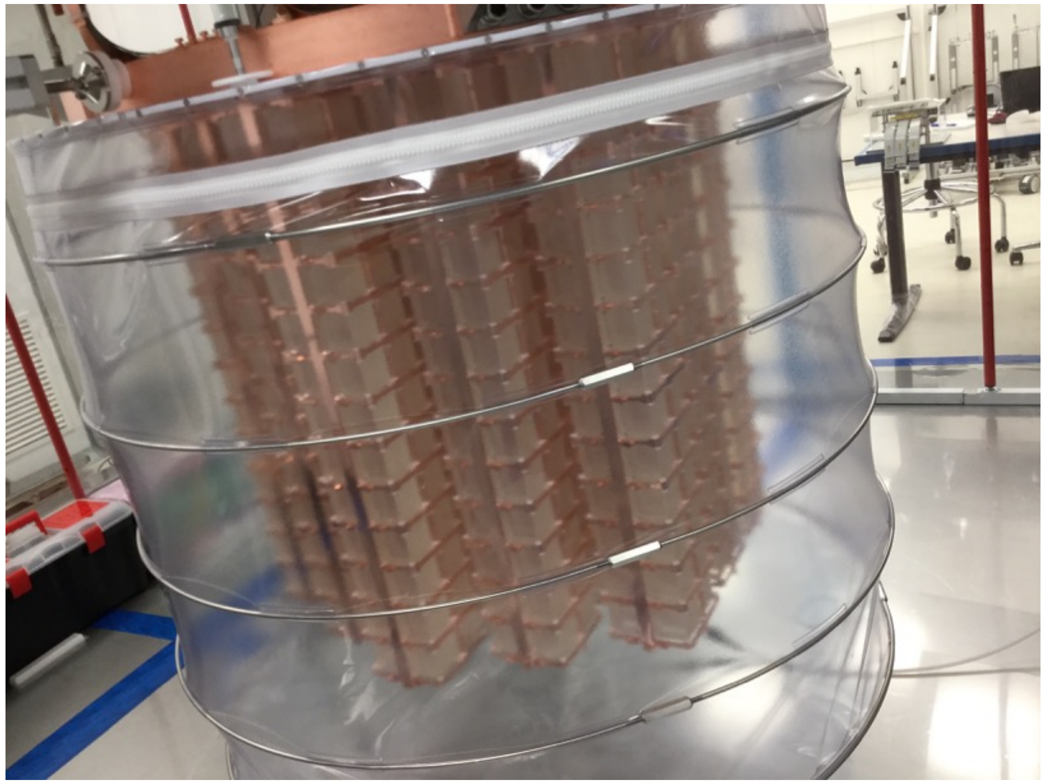
CUORE

- Assembly of the 19 CUORE towers is complete.
- CUORE cryostat assigning is completed
  - stable base temperature of ~ 6 mK
  - positive indications on noise and performances
  - DCS successfully tested
- The cryostat is now ready to host the detector
- Detector installation foreseen in summer 2016
- CUORE cool down expected in late 2016

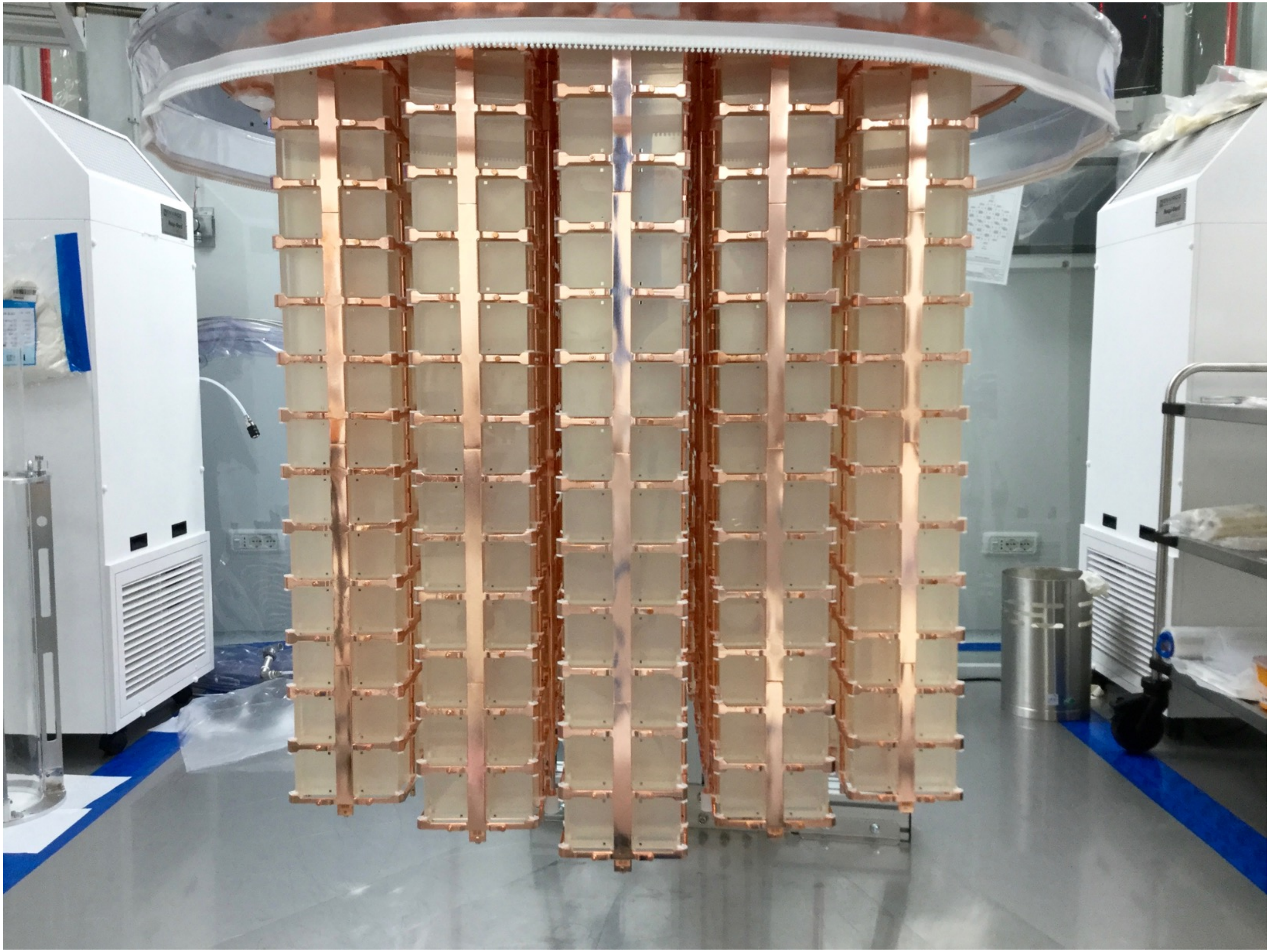
LNGS Scientific Committee, April 11 2016 Paolo Gorla

Detector installation

- The detector installation was the first period in which the detector was exposed to (Rn-free) air
  - Custom-made CR flushed with Rn-free air (Rn concentration <1 Bq/m^3)
  - Radon Abatement System
  - Detector "protective bag" flushed with nitrogen during installation interruptions
  - Strict installation protocol

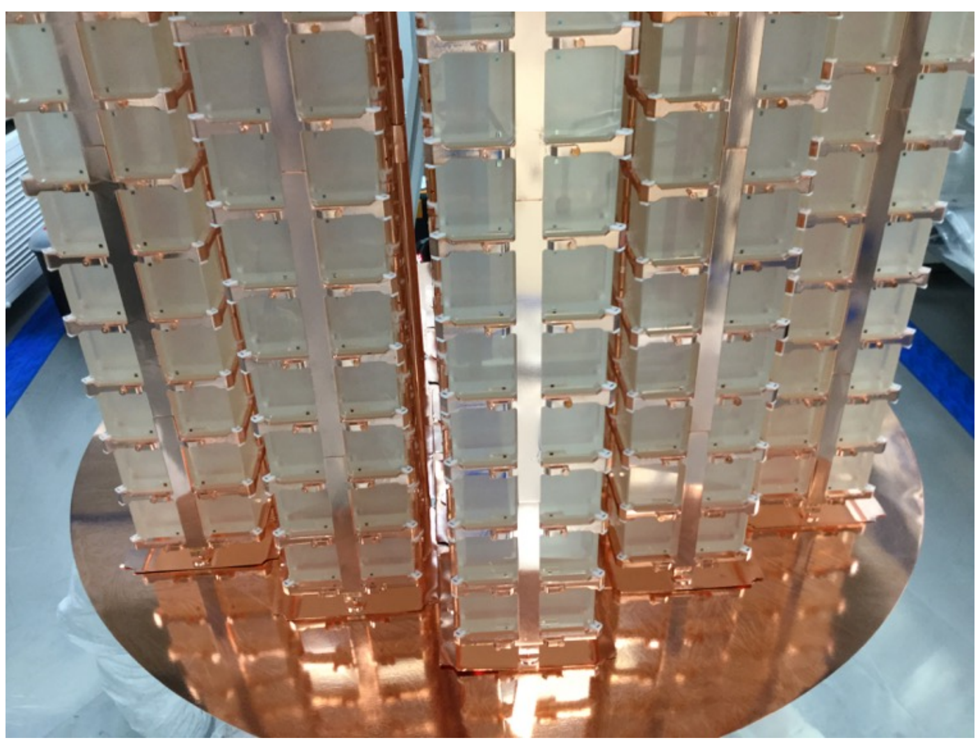


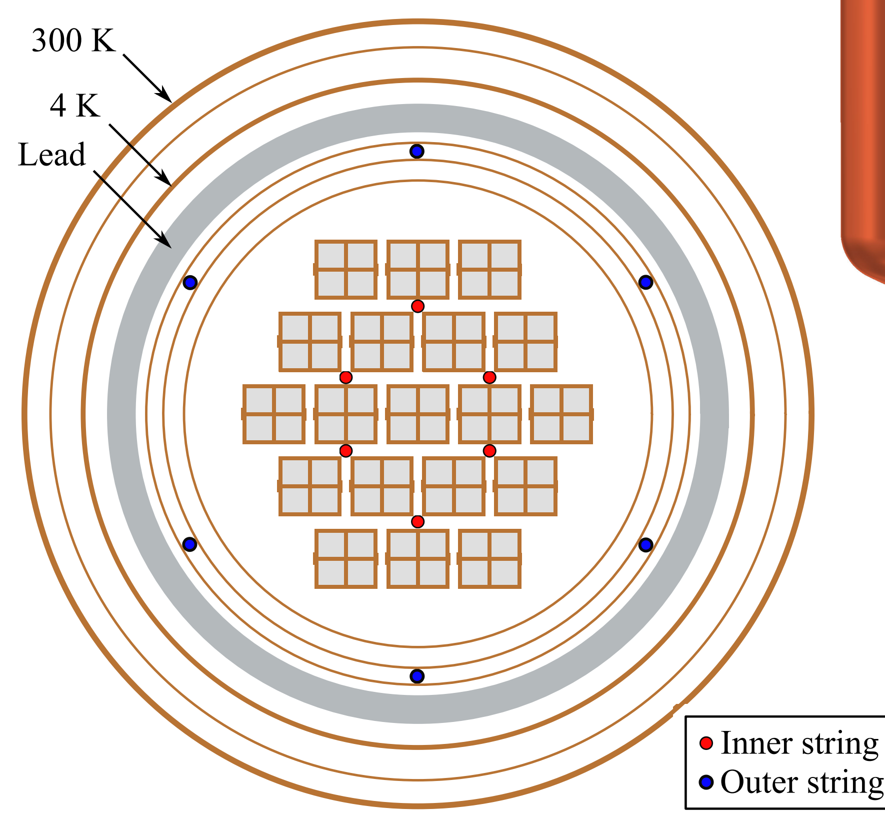
Towers installation concluded on 26/08/2016

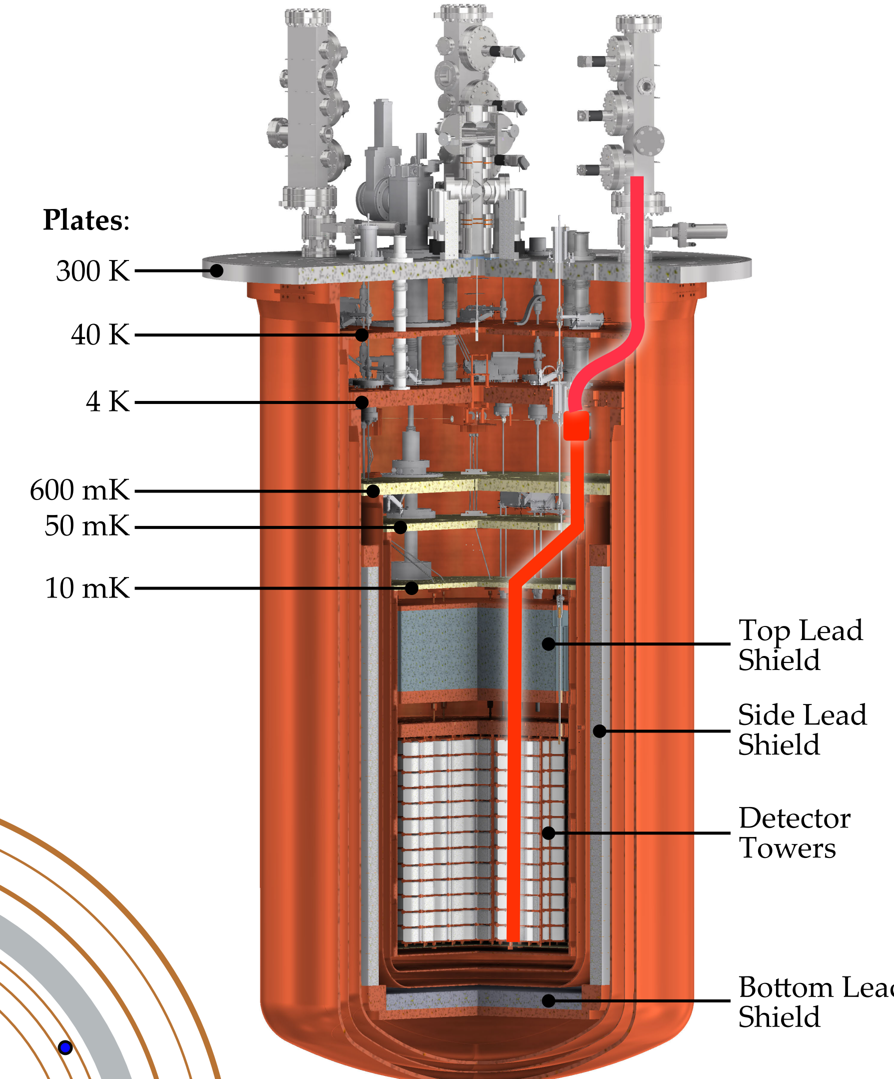


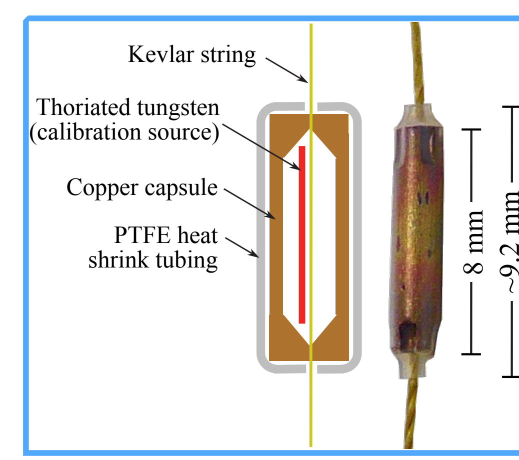
Post installation activities

- Bottom shield copper plate
- Detector plates alignment
- Detector thermalizations
- Test of the Detector Calibration System (DCS)



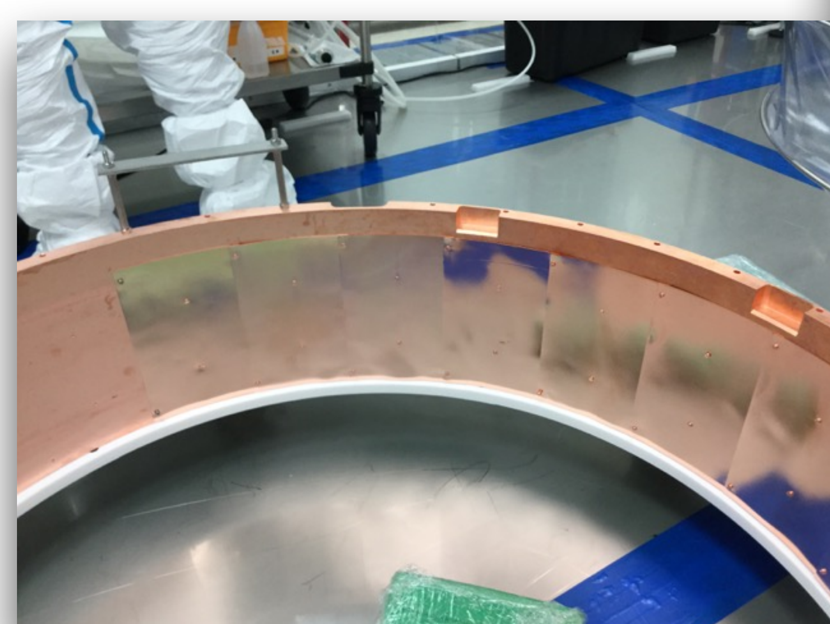


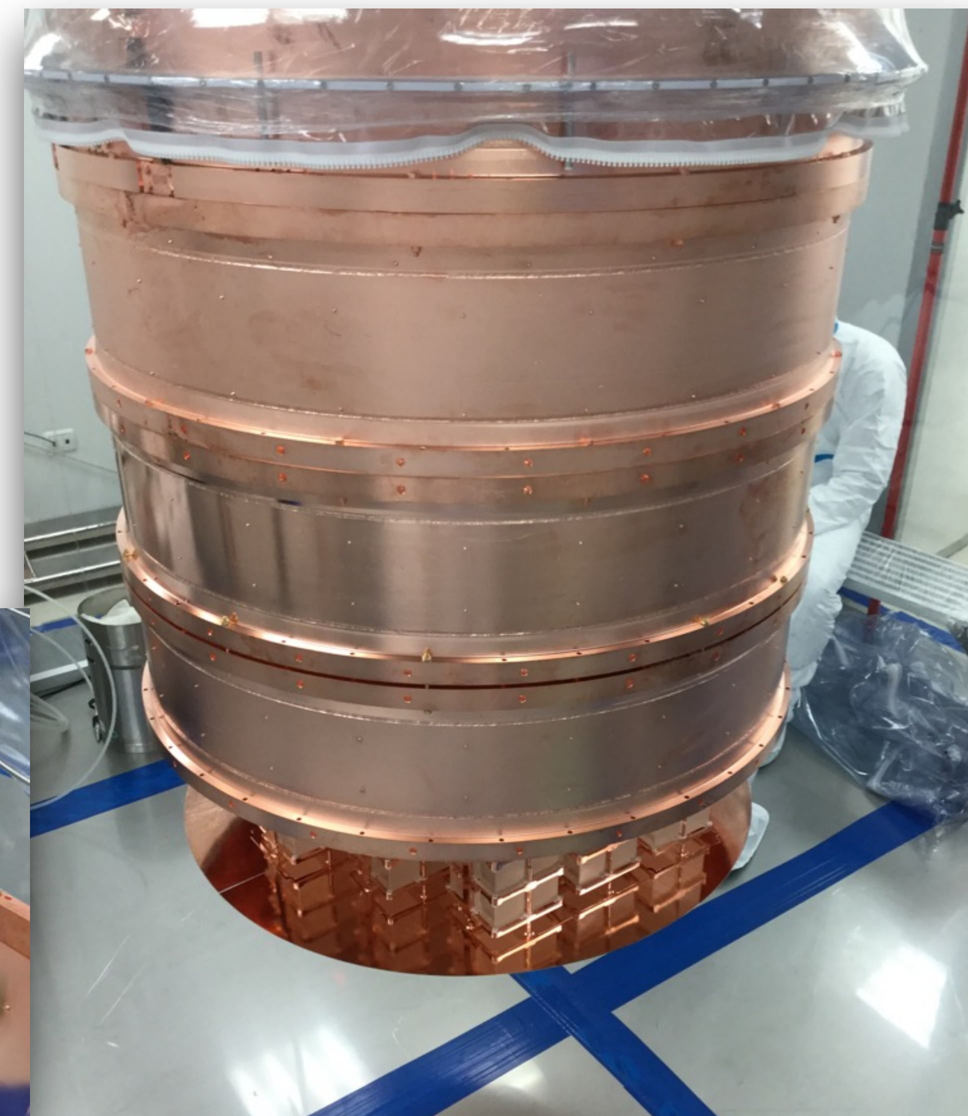




10 mK vessel closure

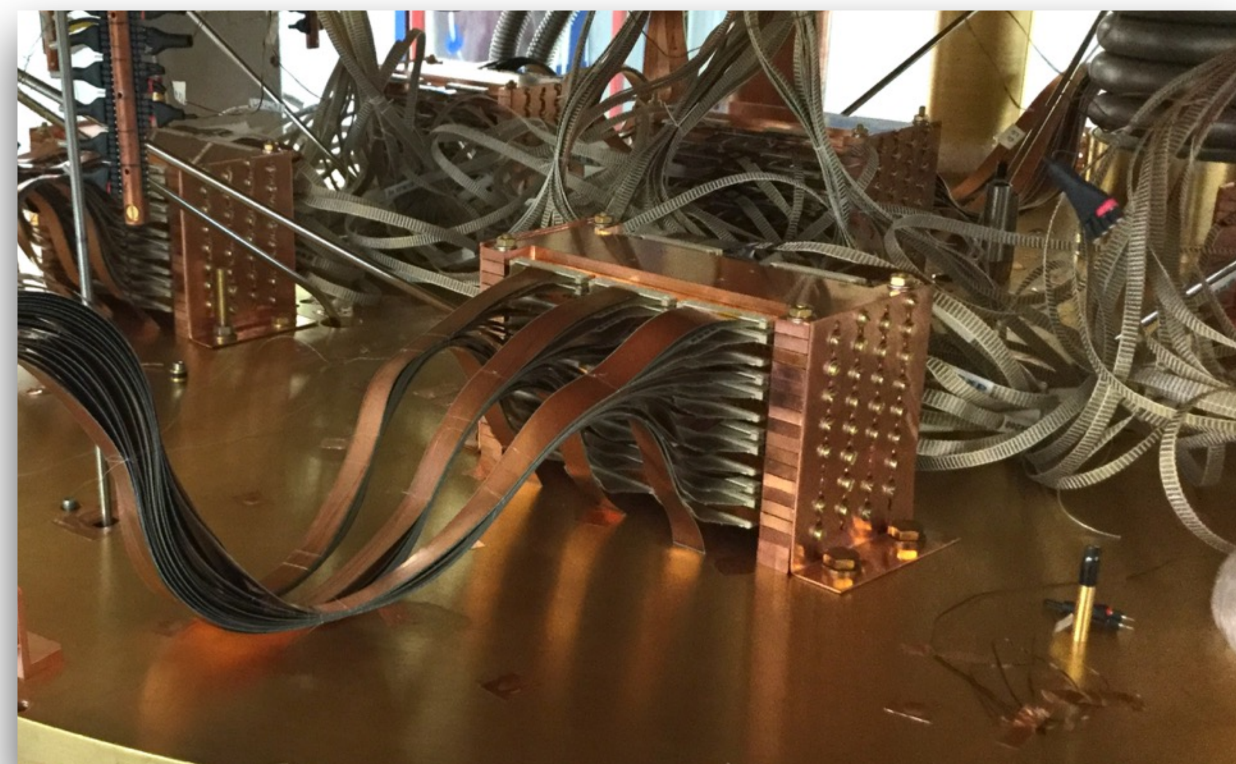
- Innermost vessel, directly facing the bolometers
- Segmented vessel tiled with plasma cleaned (same grade as the detector) copper slabs

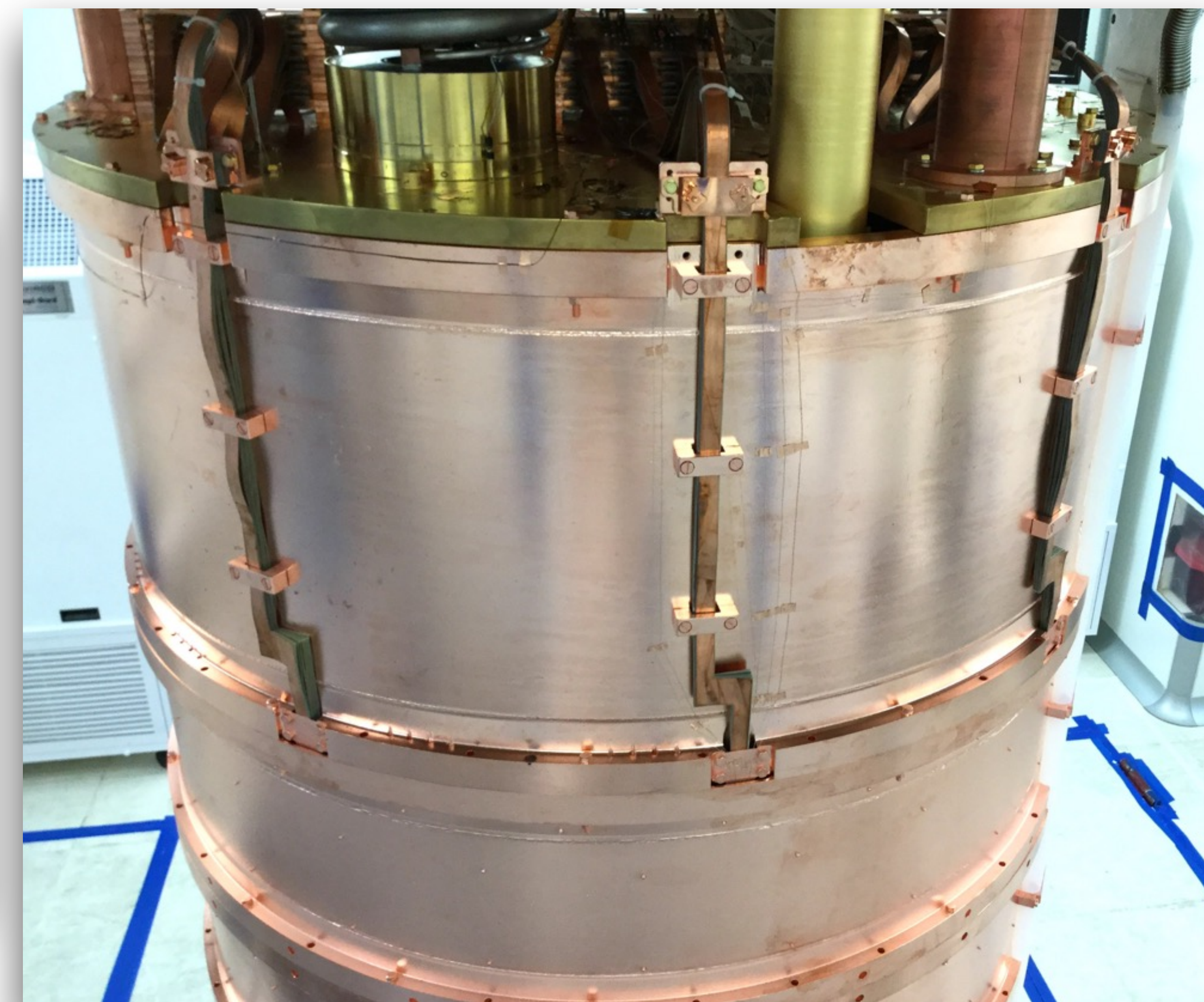




Detector connection

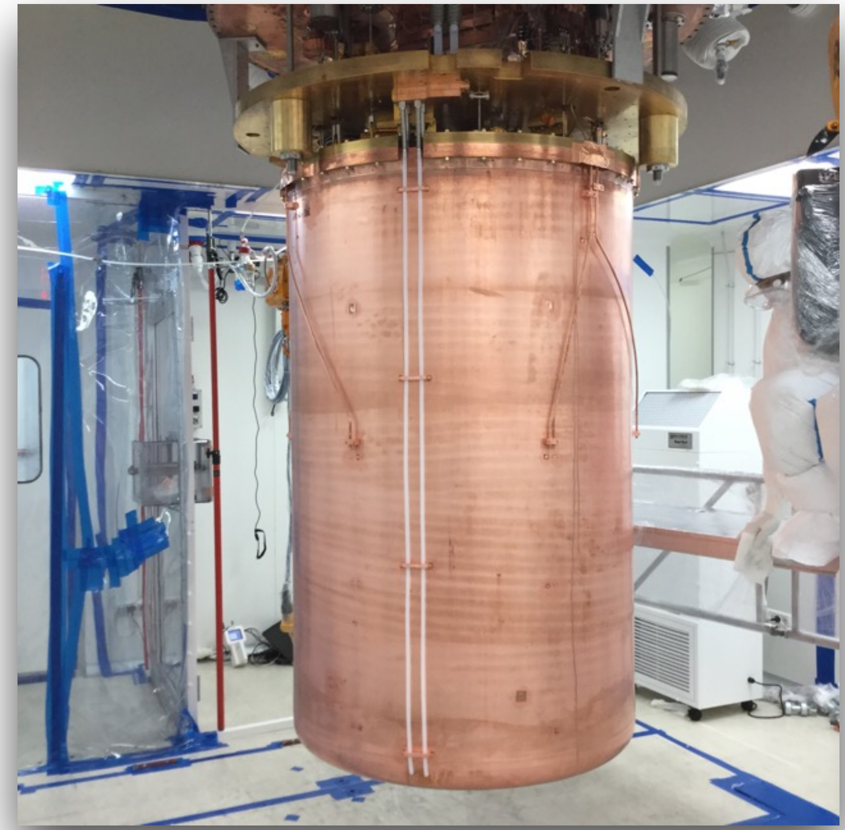
- Towers electrical connection & test
- 983/988 alive detectors confirmed





Cryostat closure (1)

50 mK shield



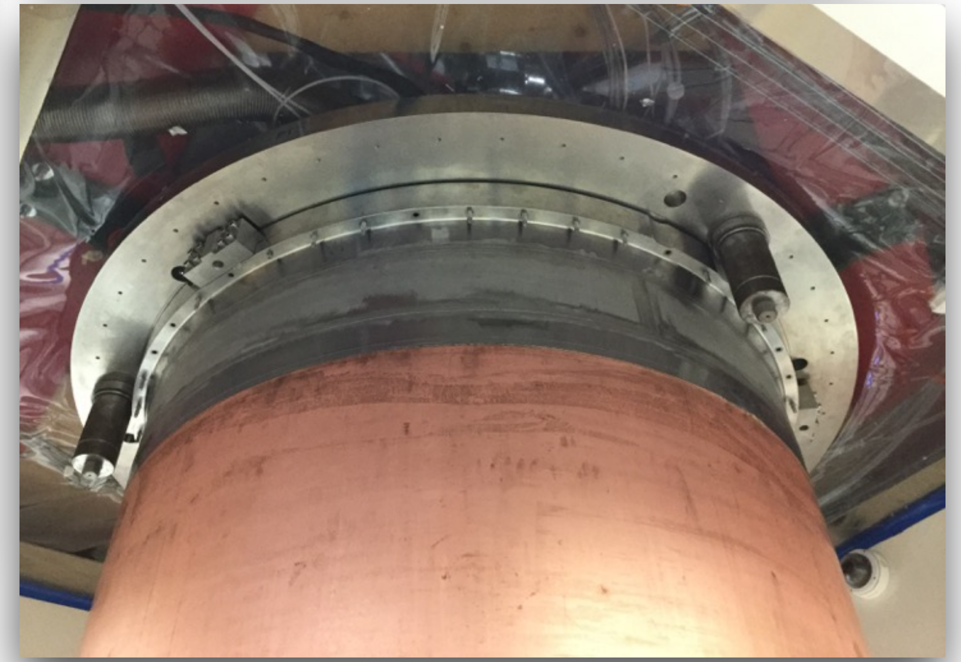
600 mK shield

Roman Lead shield

Cryostat closure (2)

4K vessel (IVC)

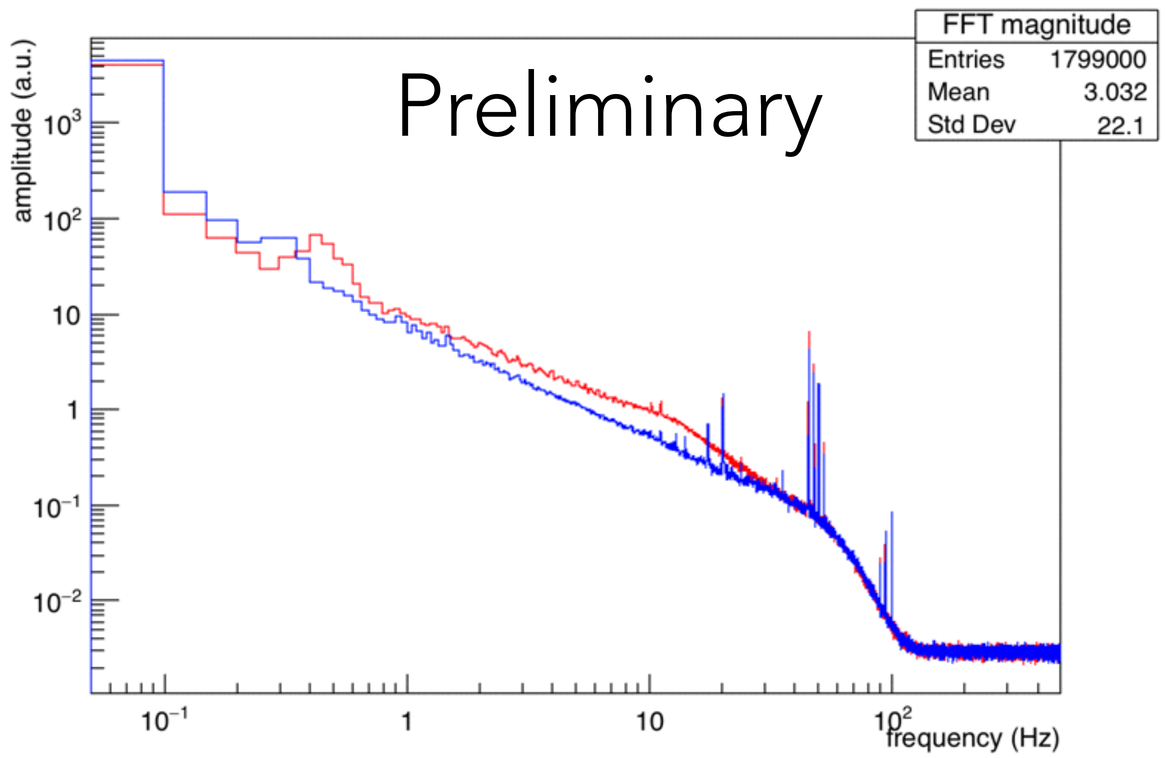
40K vessel
(and the spokesperson)



300K vessel (OVC)

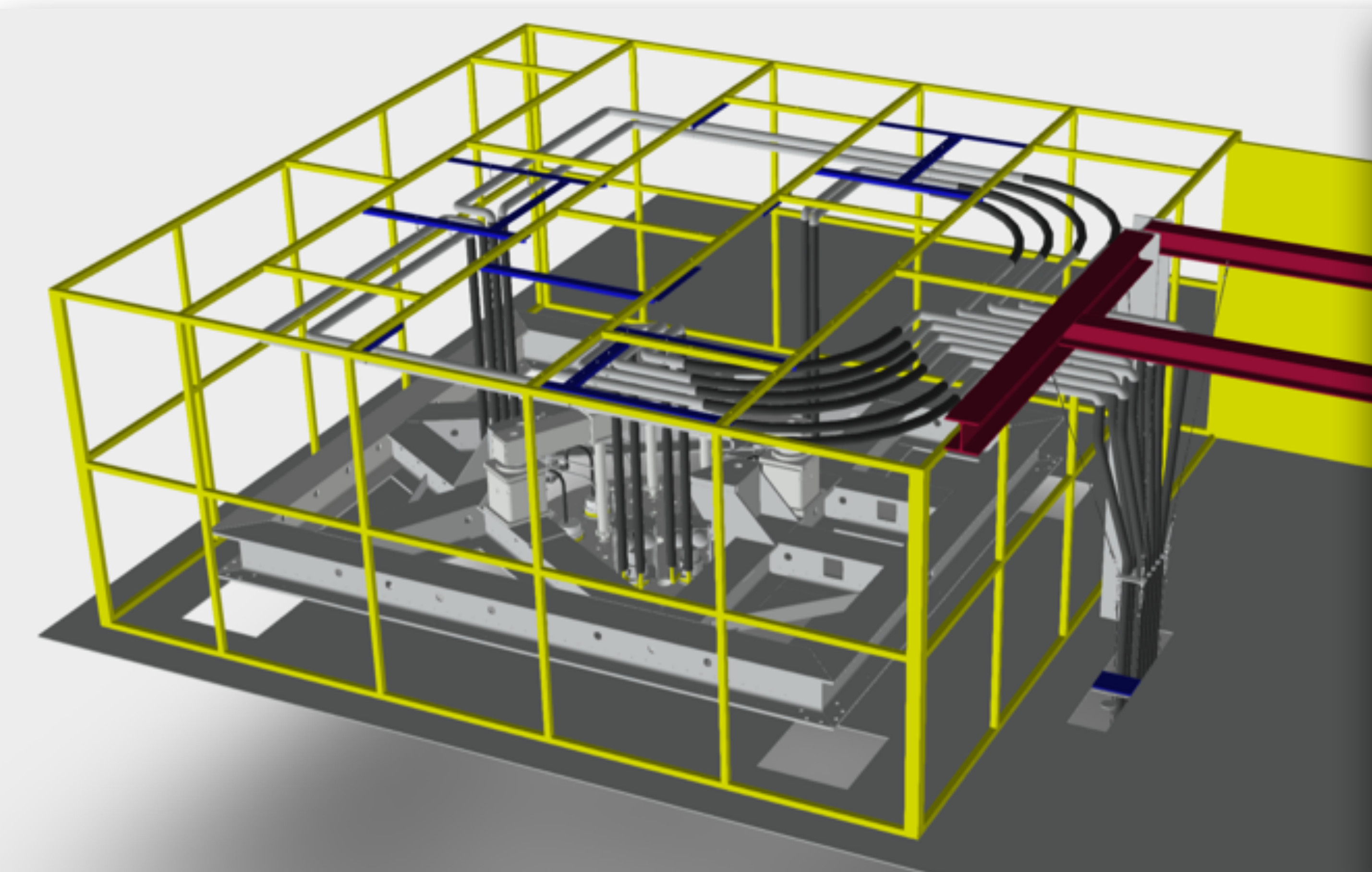
Pulse Tube flexlines

- During the commissioning run, we learned that the main source of noise induced on the detectors was coming from the the vibration of the external cryogenic apparatus (i.e. high pressure ^{4}He Pulse Tubes lines).
- For the the commissioning run, we suspended all the lines with ropes, to avoid vibration on the cryostat structure. This allowed for a reduction of the baseline RMS of 3 orders of magnitude (initial value 50 MeV)

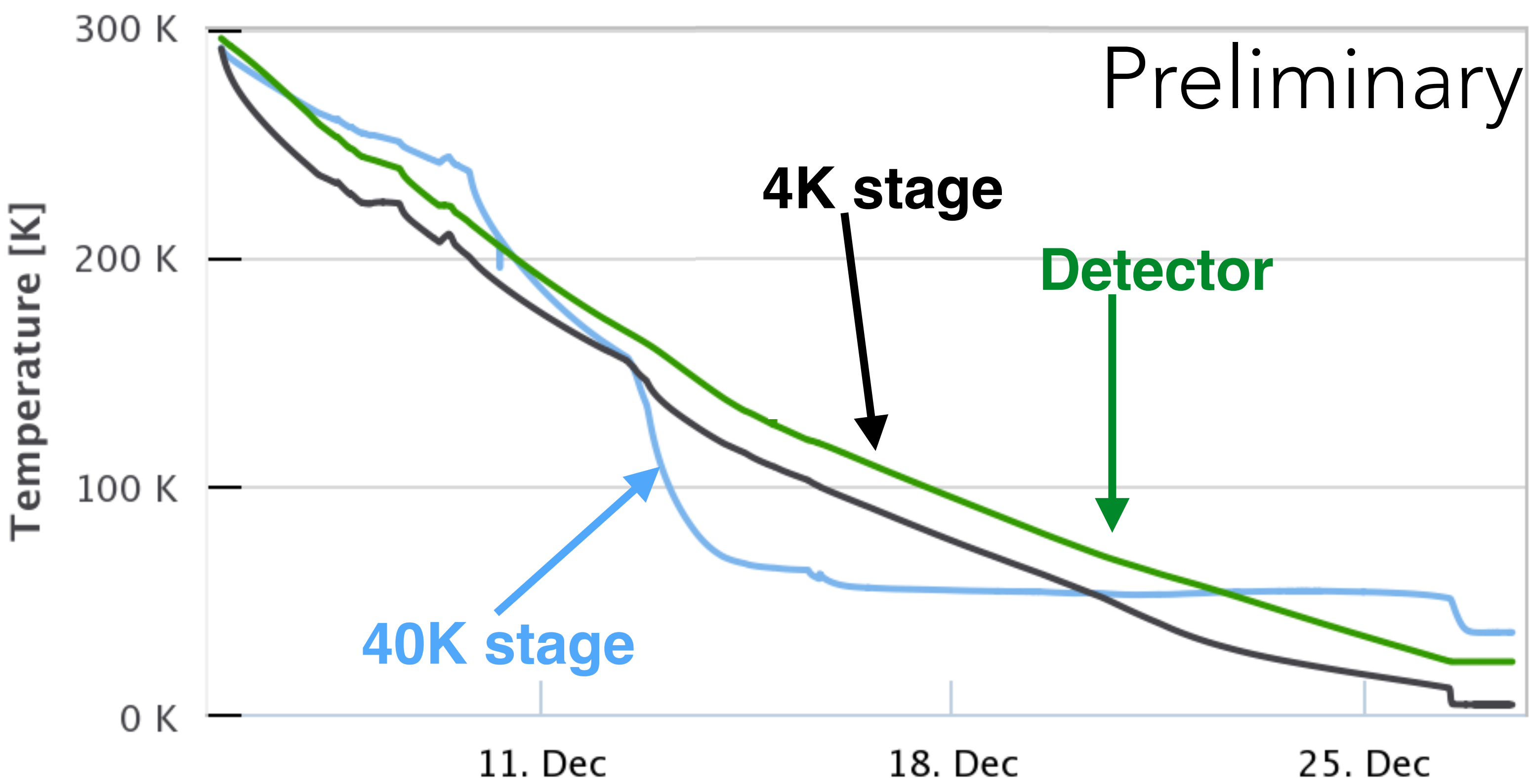


Pulse Tube flexlines

- We decoupled all the devices connected with PT from the cryostat
- We designed a new routing for the high pressure ^{4}He PT lines



Cooldown to 4K

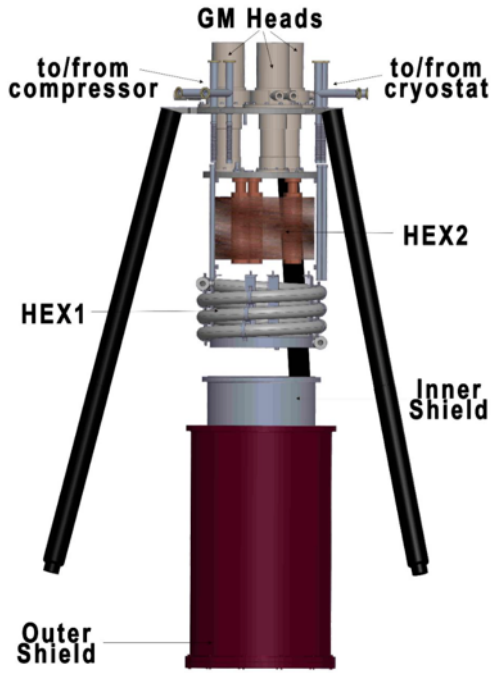


Total mass:

- 40K : ~0.98 Ton
- 4K:~7.4 Ton
- 600 mK: ~0.83 Ton
- 50 mK: ~3.8 Ton
- 10 mK: ~1.5 Ton

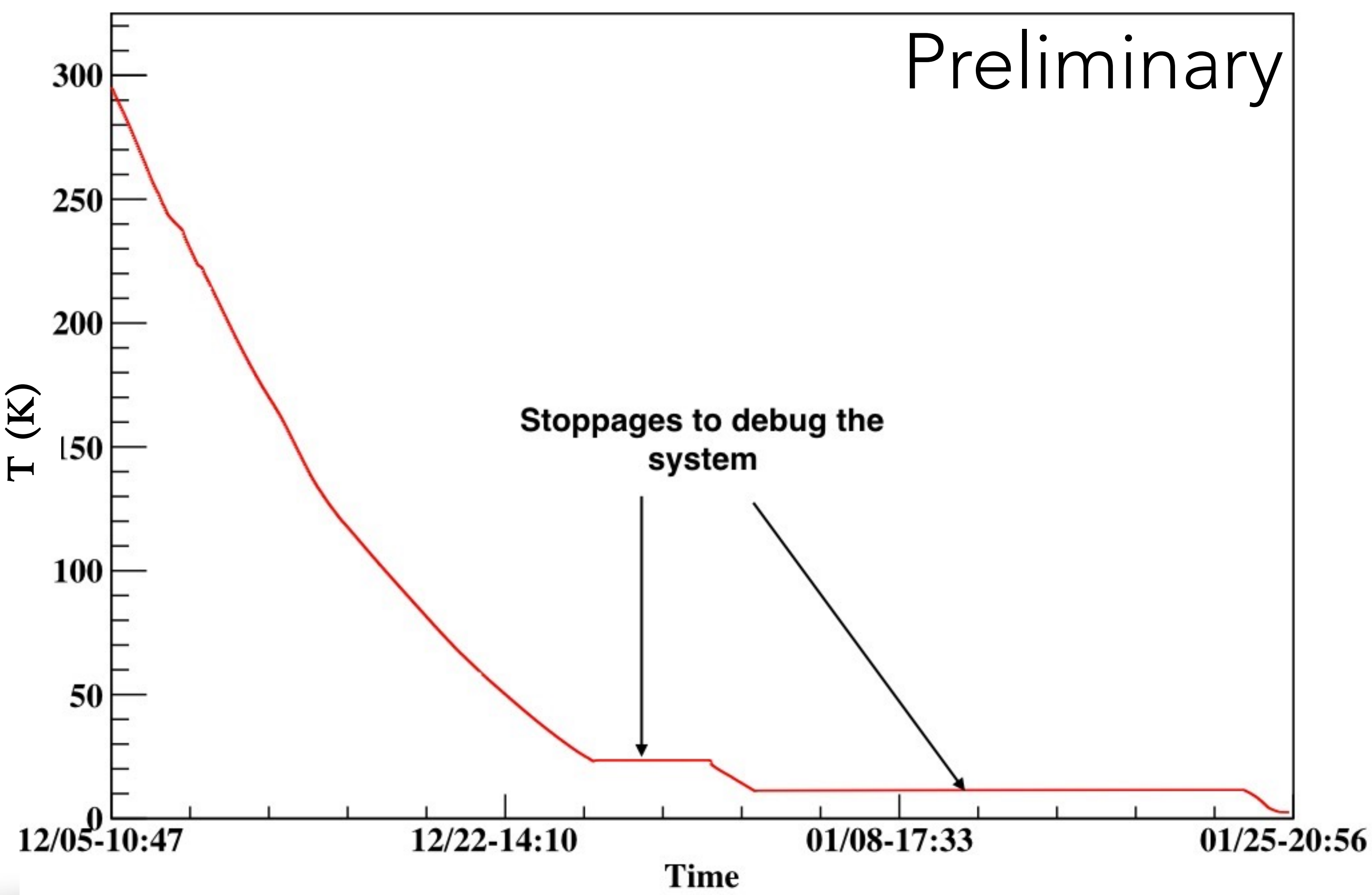
Cooldown time: ~ 22 days
1st stage T: ~ 35 K
2nd stage T: ~ 3.4 K

- 5 Pulse Tubes + Fast Cooling system

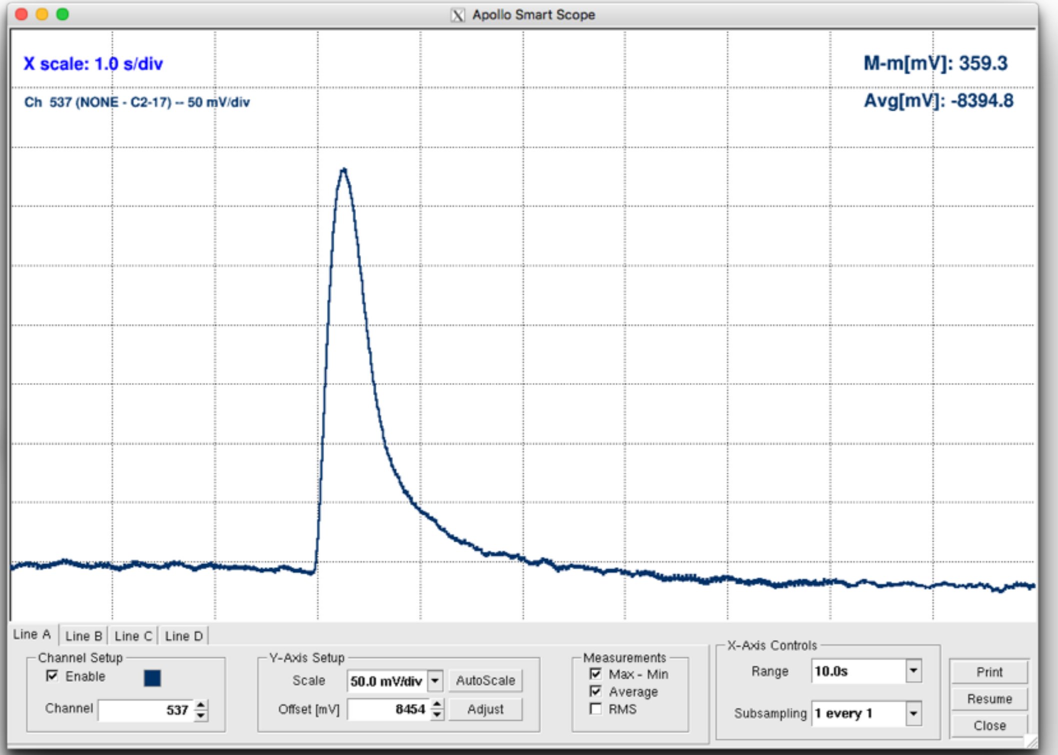


Cooldown to base T

Diode thermometer at 10mK plate



- We reached a stable base temperature of 8 mK on Jan 27th
- We observed the pulses just after the cool down without any optimization



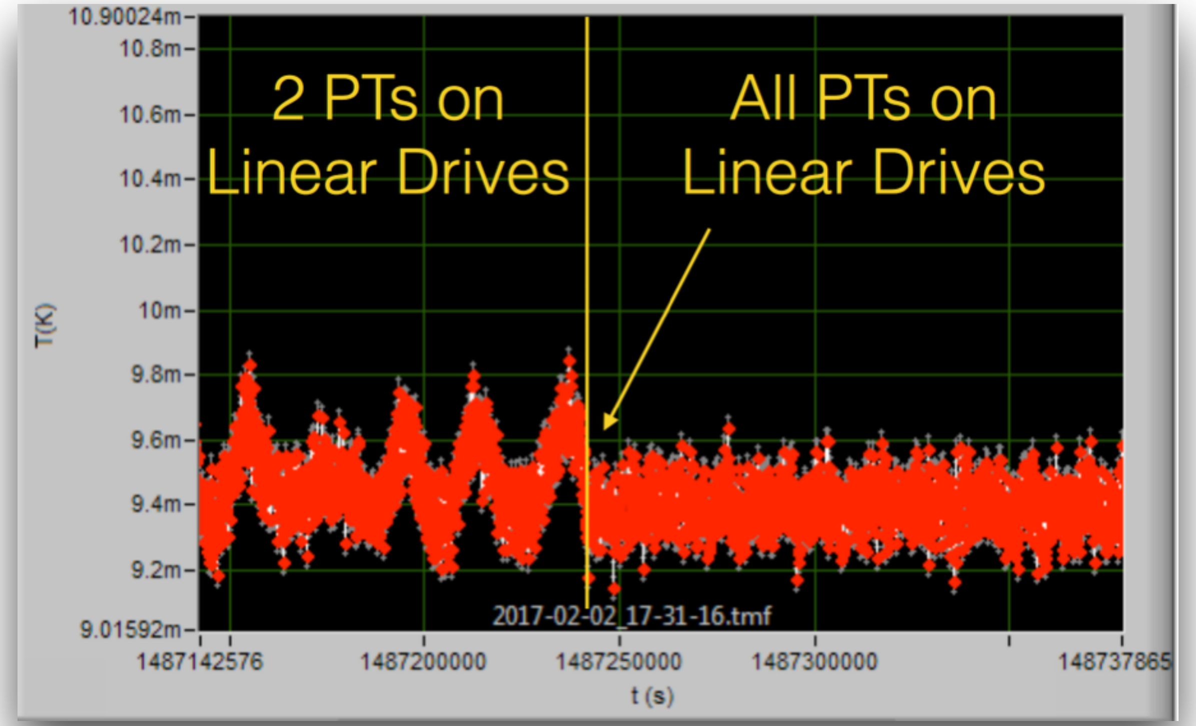
Noise optimisation

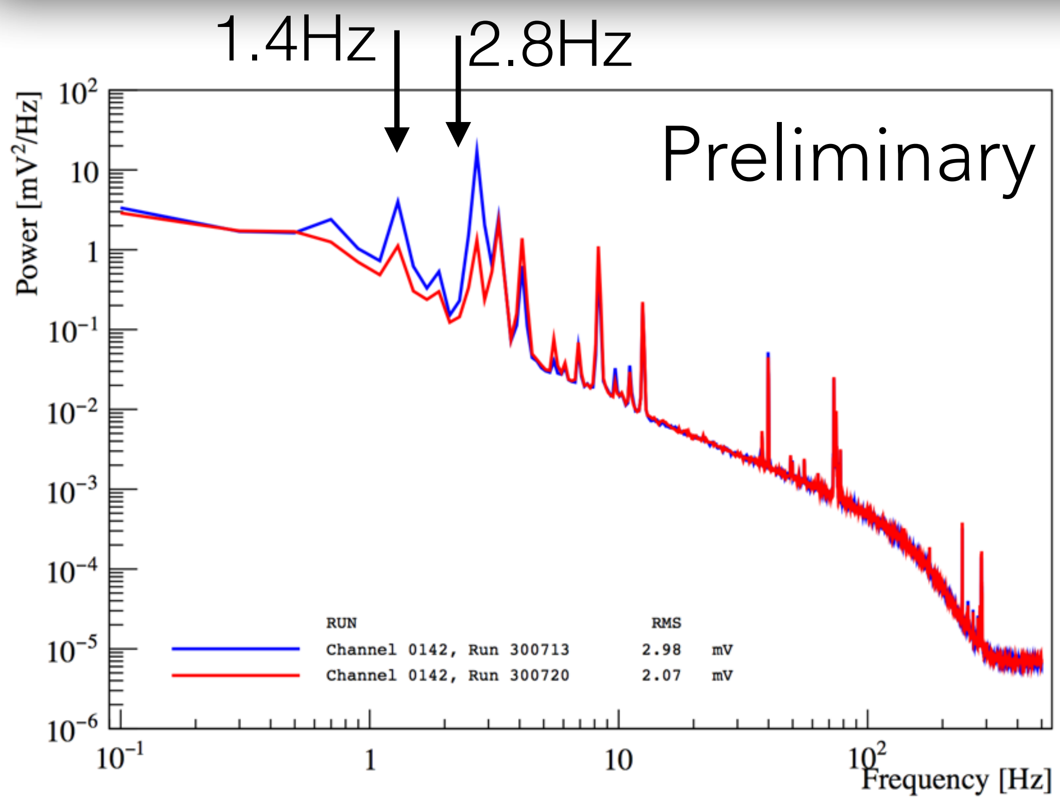
- Effectiveness of lessons and solutions adopted after commissioning runs
- S/N ratio good but not yet optimal (but roughly 3 orders of magnitude better respect to the beginning of the commissioning run)

- We chose a subset of ~30 channels to study the noise sources
- Plan: progressive study of the different sources:
  - Vibration dampers in operations
  - Readout Cable routing and blocking
  - Pulse Tubes phases control

PT motor control

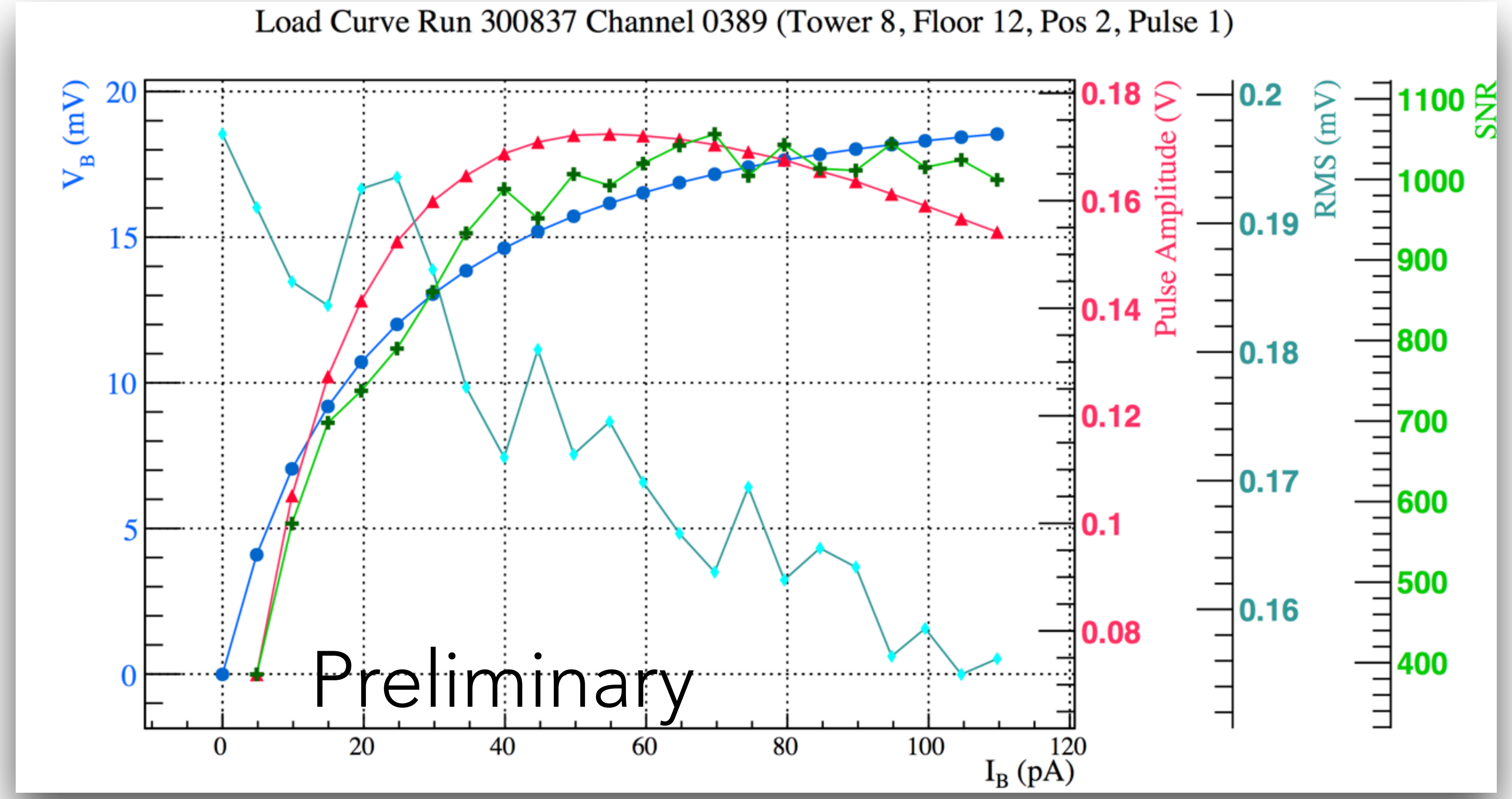
- The main improvement in the noise on the detector was observed when moving the control of the PT motor-head from Cryomech compressor motor to the linear drive control devices.
- This induced a stabilisation of the MC base temperature.
- We can also monitor and control the relative phase shifts between different PTs using the pressure sensors installed on the PTs lines.
- Further improvement expected by the optimisation of the phase shifts.





Temperature scan

- Once we reached a reasonable noise configuration, we started the temperature scan to study the detector performance at different temperatures
- We chose 3 towers as representative for the 988 channels
- For a given temperature, we measured the load curve (scan of the voltage across the NTD varying the biasing current) and we measured the performance in terms of Signal to Noise Ratio and Energy resolution

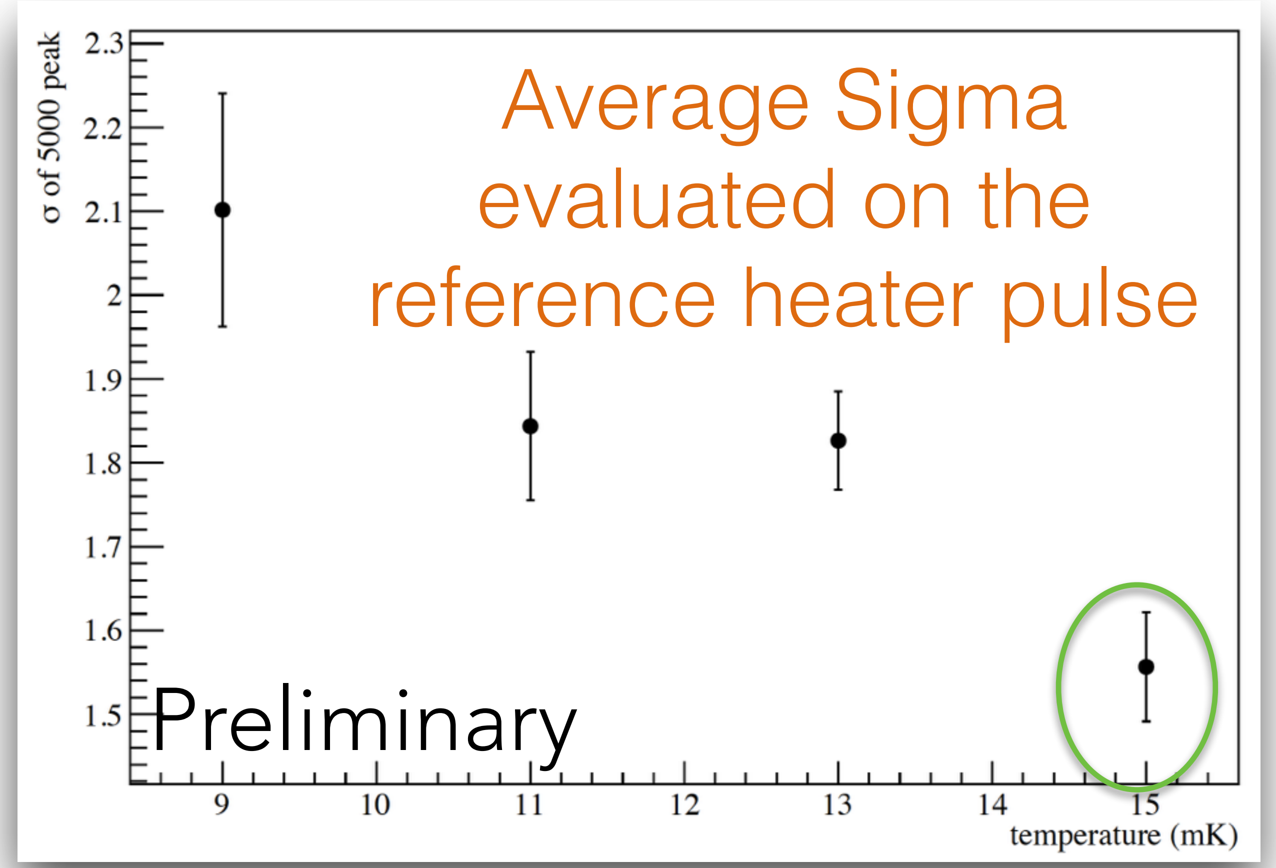


LC at 15 mK

WP at different temperatures

- We focused on 4 temperature configurations: 9mK, 11mK, 13mK and 15mK.

	Average NTD resistance @ WP [MOhm]
9mK	1551.8
11 mK	764.0
13 mK	354.1
15 mK	180.7



The full interpretation of these results is still ongoing but: among these temperatures, the best performing one is 15mK.

Short term activities

CUORE

We are ready to start a first calibration and background data collection campaign to understand the background and performance of the full detector.

- We have chosen the operating temperature of the detectors.
- We are setting the optimal operating conditions of the bolometers for the chosen temperature.
- We are testing the deployment of the calibration source in the cryostat.
- We will optimise thresholds and gains for all the channels.
- We will lift the external shield (Lead + PE + H_3BO_3)
- We will calibrate the detectors and will start the background data taking within 2 weeks.

Conclusions

- The CUORE Pre-Operations phase is almost over.
- We are ready to acquire the first run of $0\nu\beta\beta$ data. We'll present within few months the first physics results.
- This unprecedented challenge required an incredible effort in different physics fields in order to match the stringent experiment requirements
- The success of the CUORE is fundamental also for the future of all the other bolometric experiments in the world which will operate a thousand of detectors at cryogenic temperature.

The CUORE Collaboration