

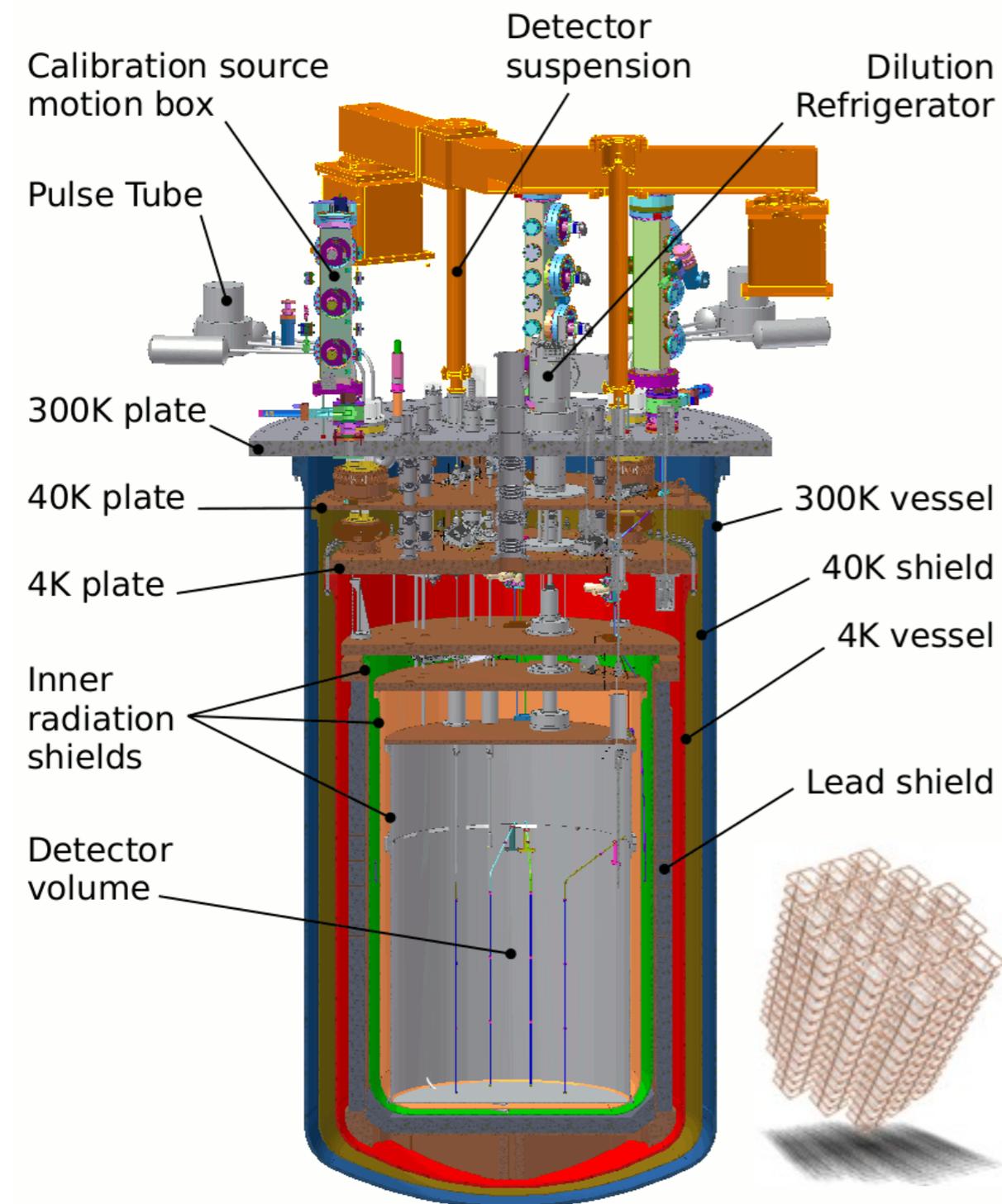
Calibration of the CUORE Detector Array

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(for the CUORE Detector Calibration System Group)

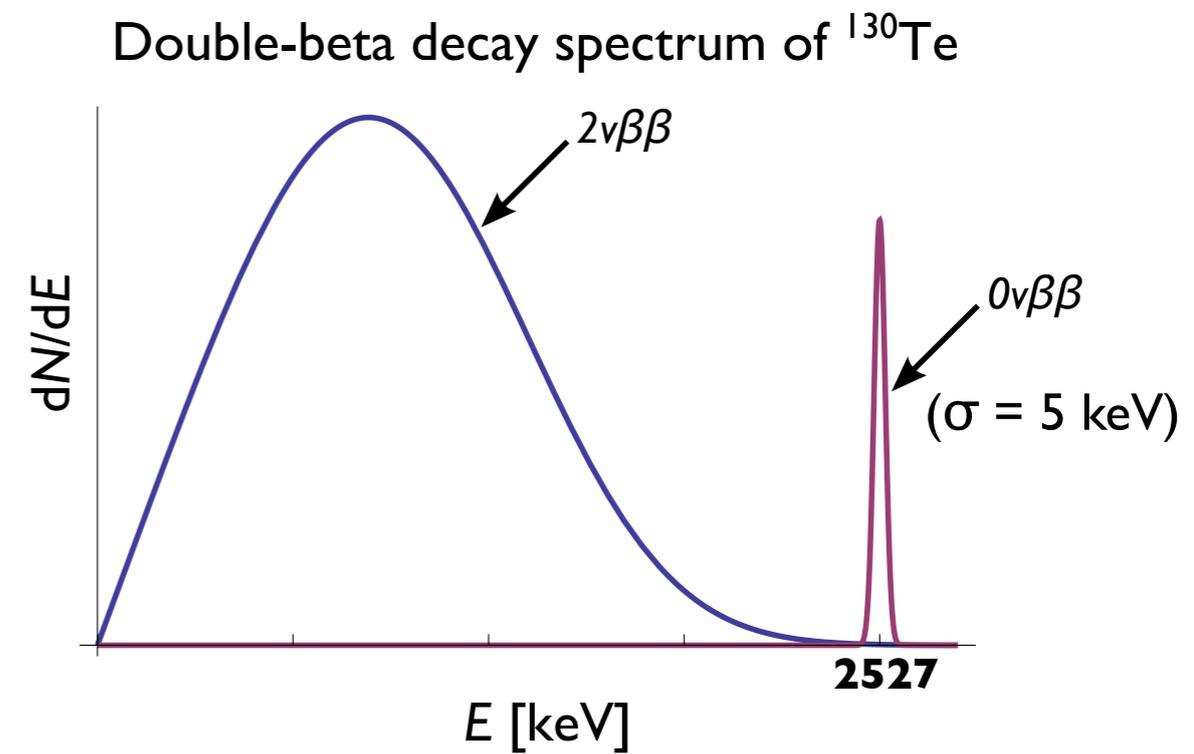
Oct. 24, 2013, APS DNP Meeting, Newport News, VA



The CUORE Experiment

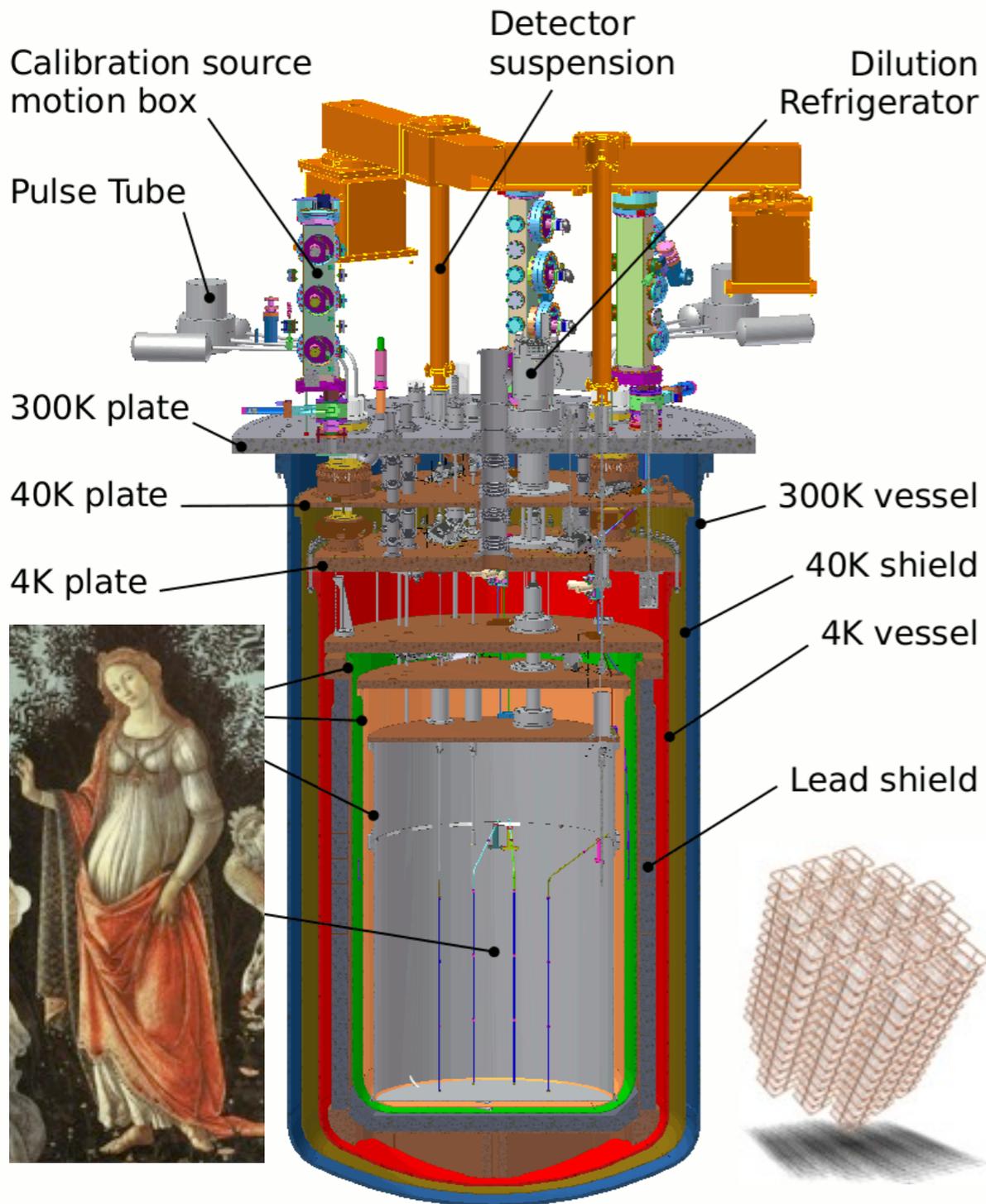


- CUORE is a cryogenic detector to search for $0\nu\beta\beta$ decay located at LNGS in Italy.
- An array of 988 TeO_2 bolometers with 19 towers (^{130}Te mass: 203 kg) is operated at ~ 10 mK.

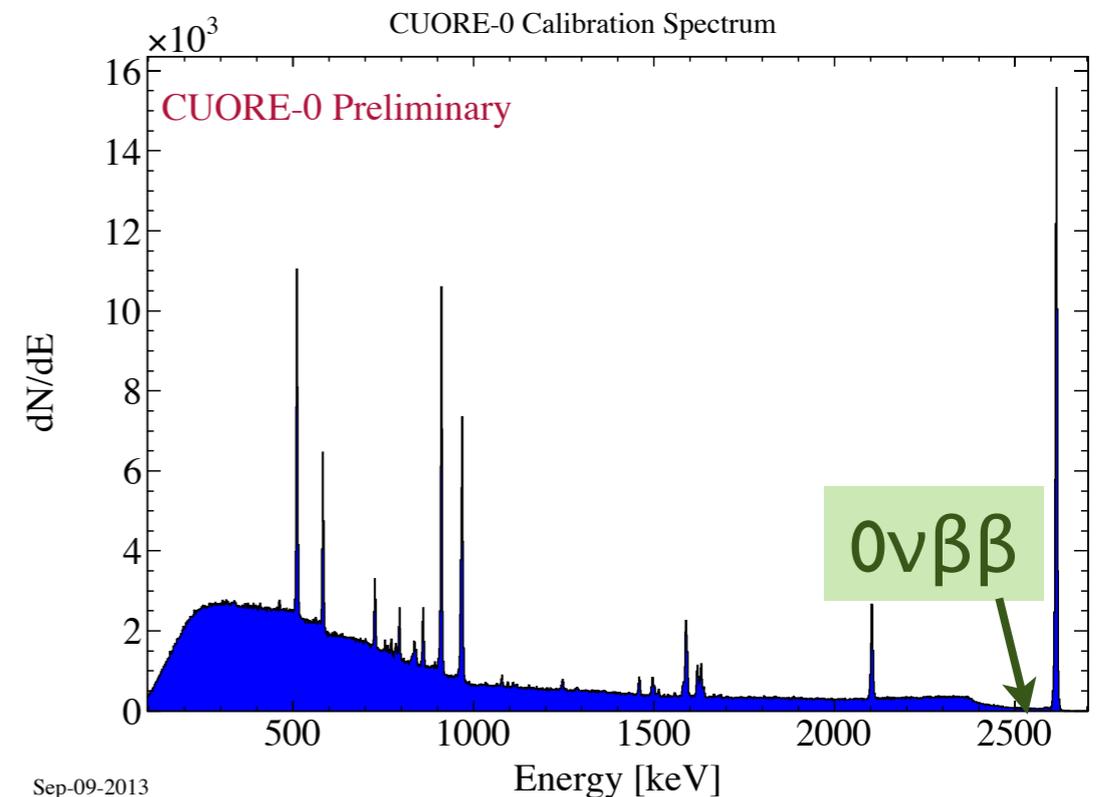


- Energy calibration of bolometers for $0\nu\beta\beta$ decay is critical.

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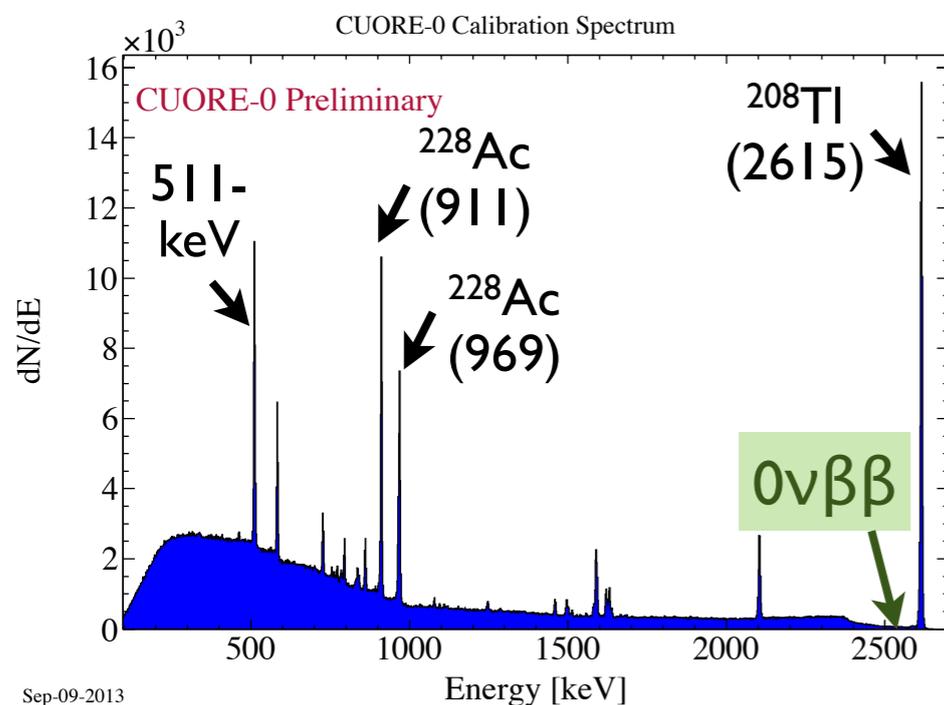


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Calibration Requirements for CUORE



- Independent energy calibration of each bolometer.
- At least 100 events each for the 4 main calibration peaks in 2 days.
- Calibration sources have to travel from the top to the bottom of the cryostat going through various temperature stage.
- Cold calibration source w/ small heat load for the source moving.



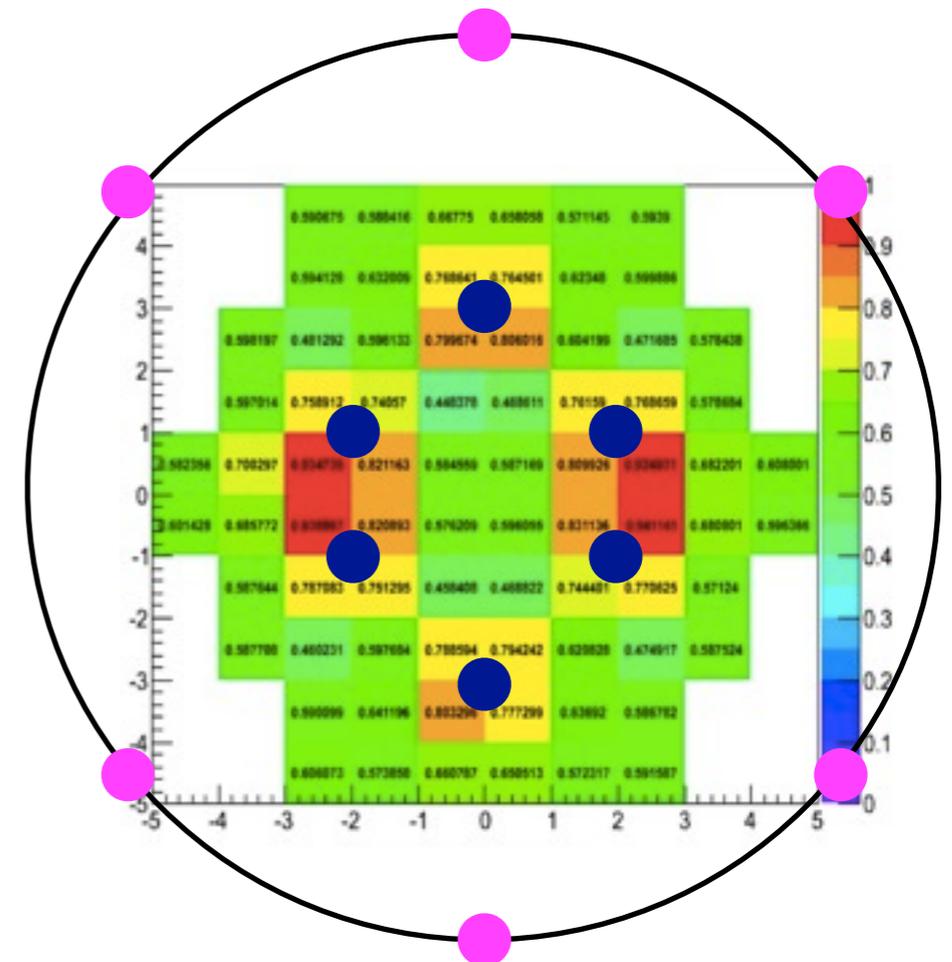
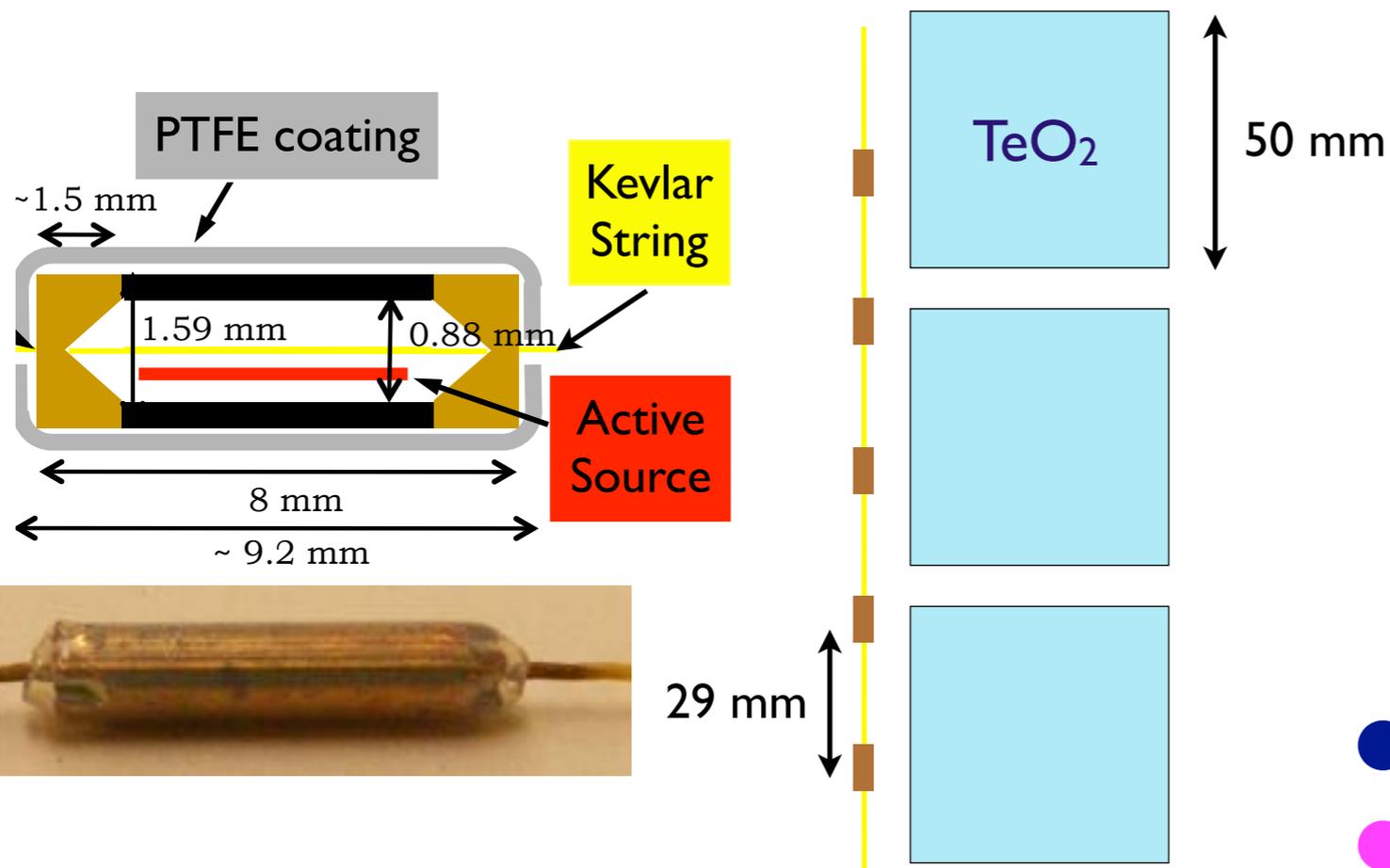
Stage	T [K]	Cooling power available to calibration [W]	Static heat load from guide tubes	Radiation from source string at 4K
40K	40 – 50	~ 1	~1	--
4K	4 – 5	0.3	0.02	--
0.7K	0.6 – 0.9	0.55m	0.13m	0.08 μ
70mK	0.05 – 0.1	1.1μ	negligible	0.3 μ
10mK	0.01	1.2μ	1.07 μ	0.08 μ
detector	0.01	< 1μ	--	0.25 μ

CUORE Calibration Source



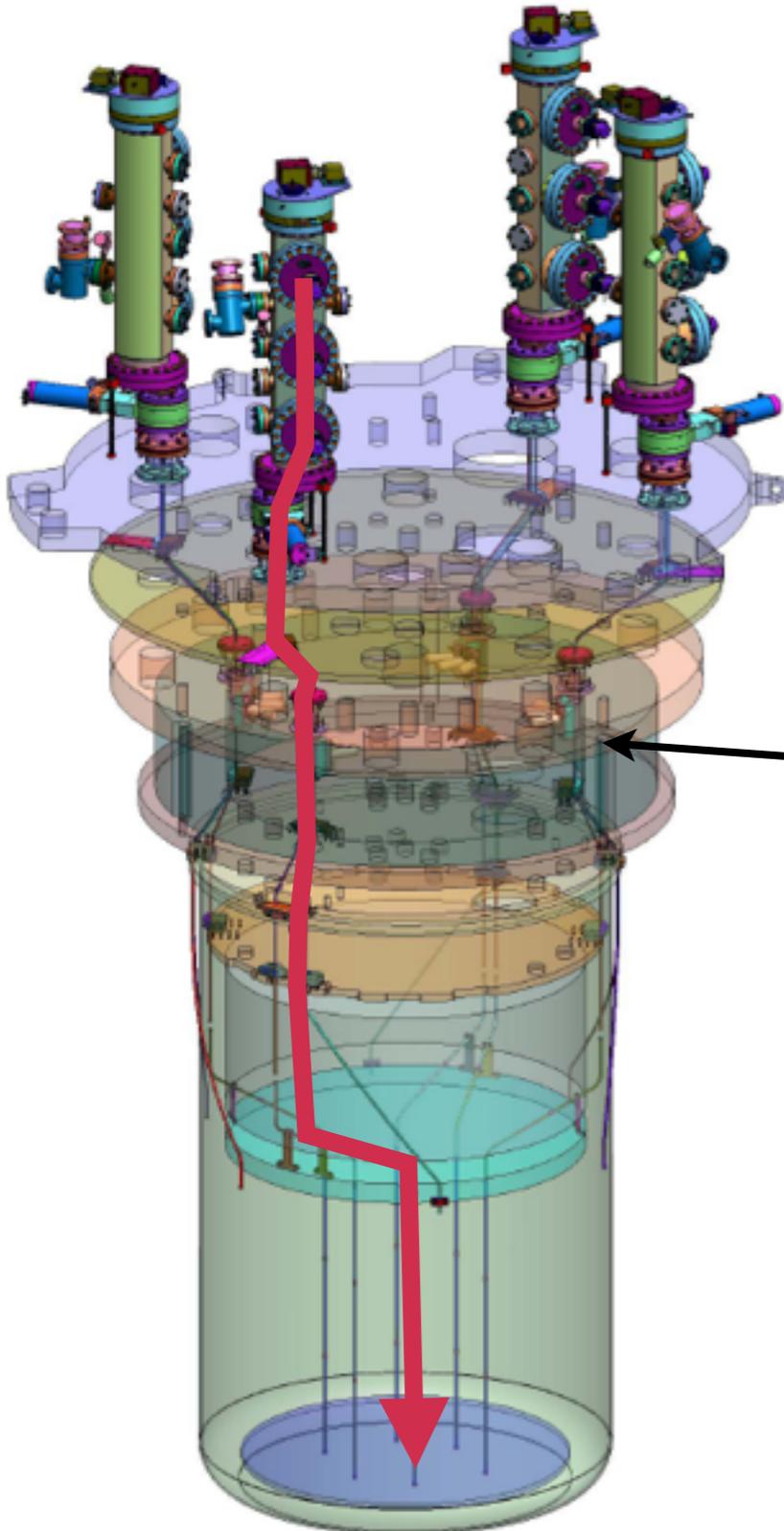
- Calibration source is capsules of thoriated tungsten wire crimped on continuous Kevlar string.
- One string consists of 1 PTFE guide ball, 8 weight capsules, and 25 source capsules.

Expected normalized hit on the 7th floor crystals

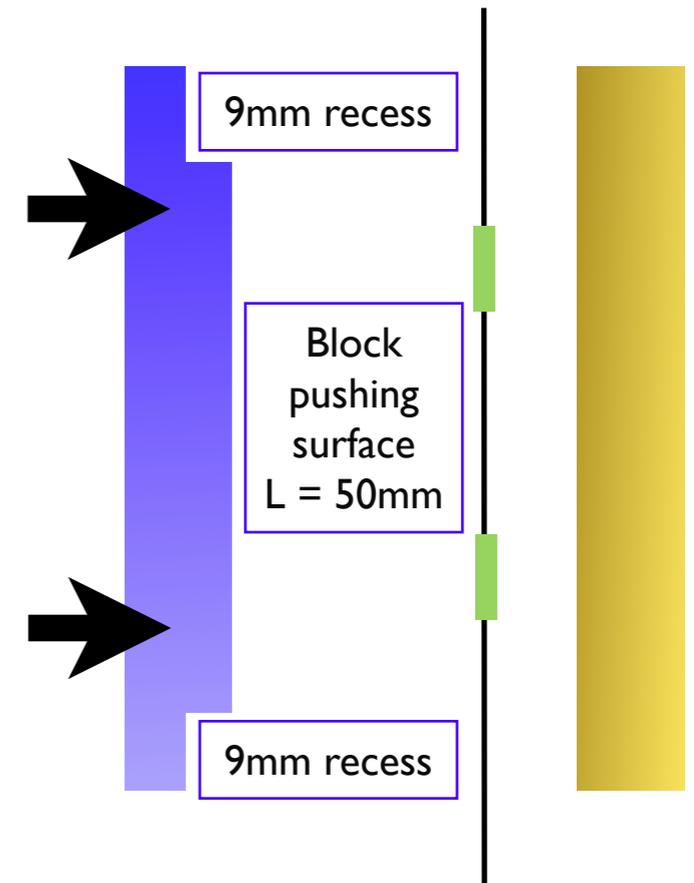
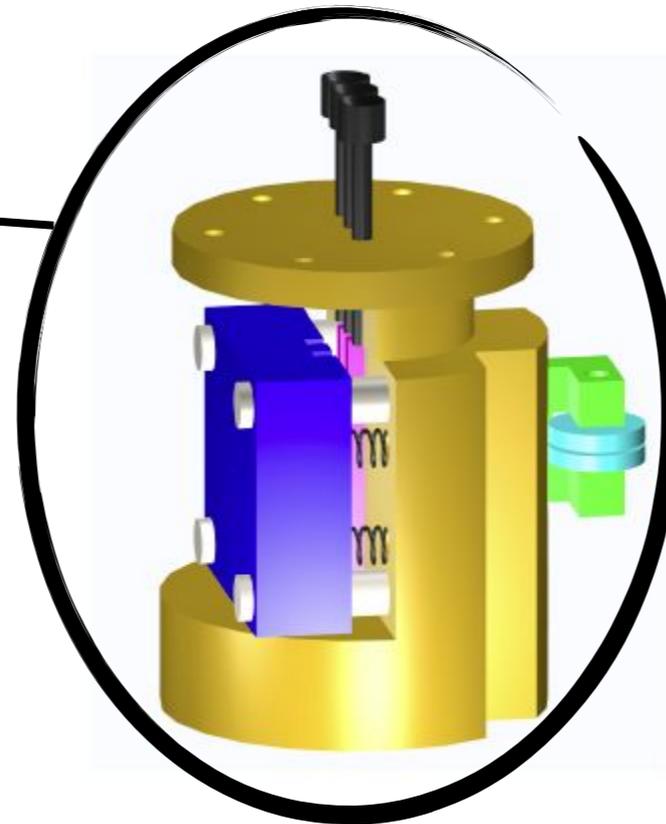


- Internal - 4.4 Bq of ²³²Th each
- External - 27 Bq of ²³²Th each

Calibration Procedure

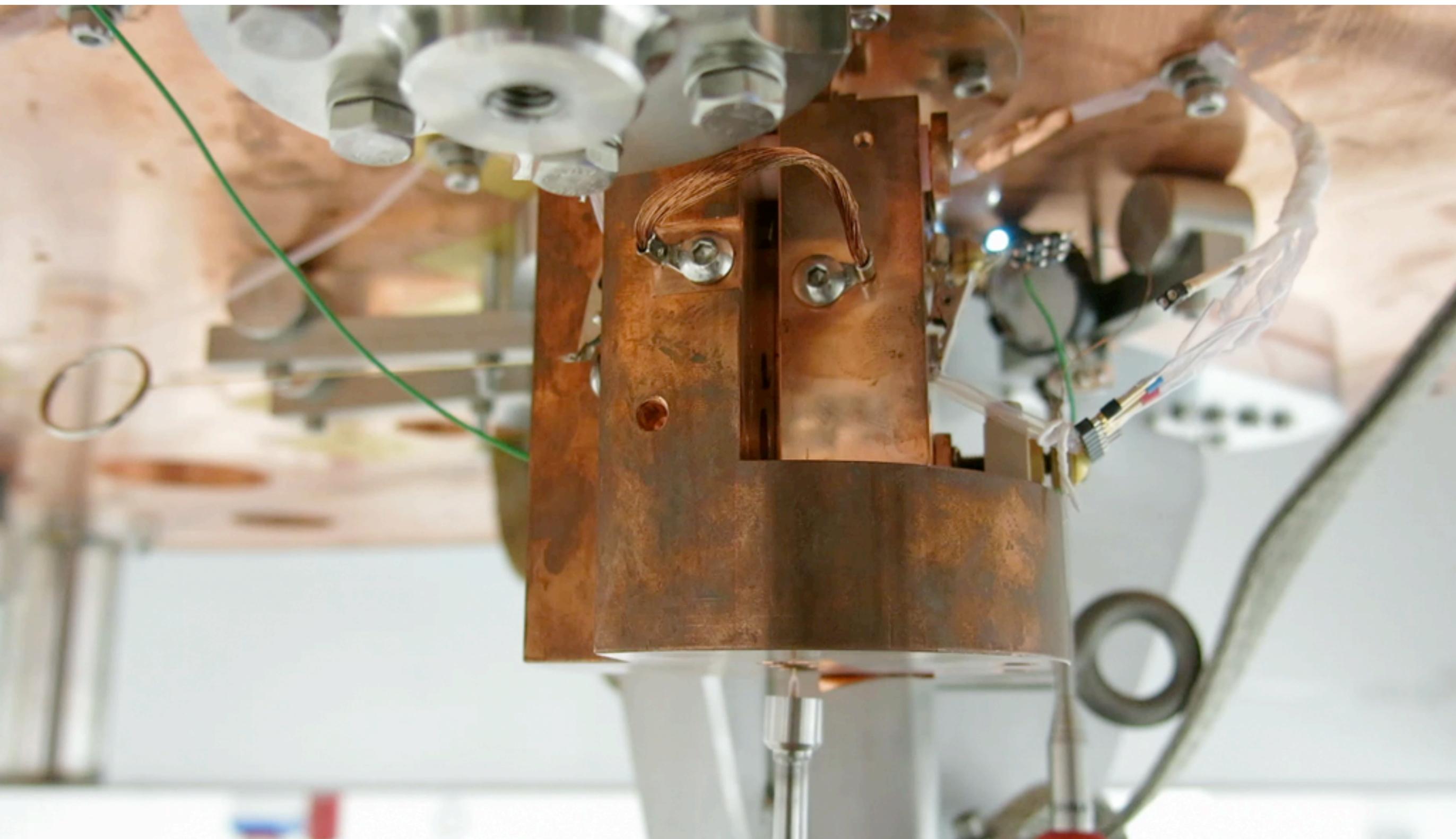


- A source string starts to move from the top of the cryostat at 300K to the bolometers.
- The source capsules are mechanically squeezed by a thermalizer attached to 4K plate and cooled down.



- Cooled down source capsules arrive near the bolometers.

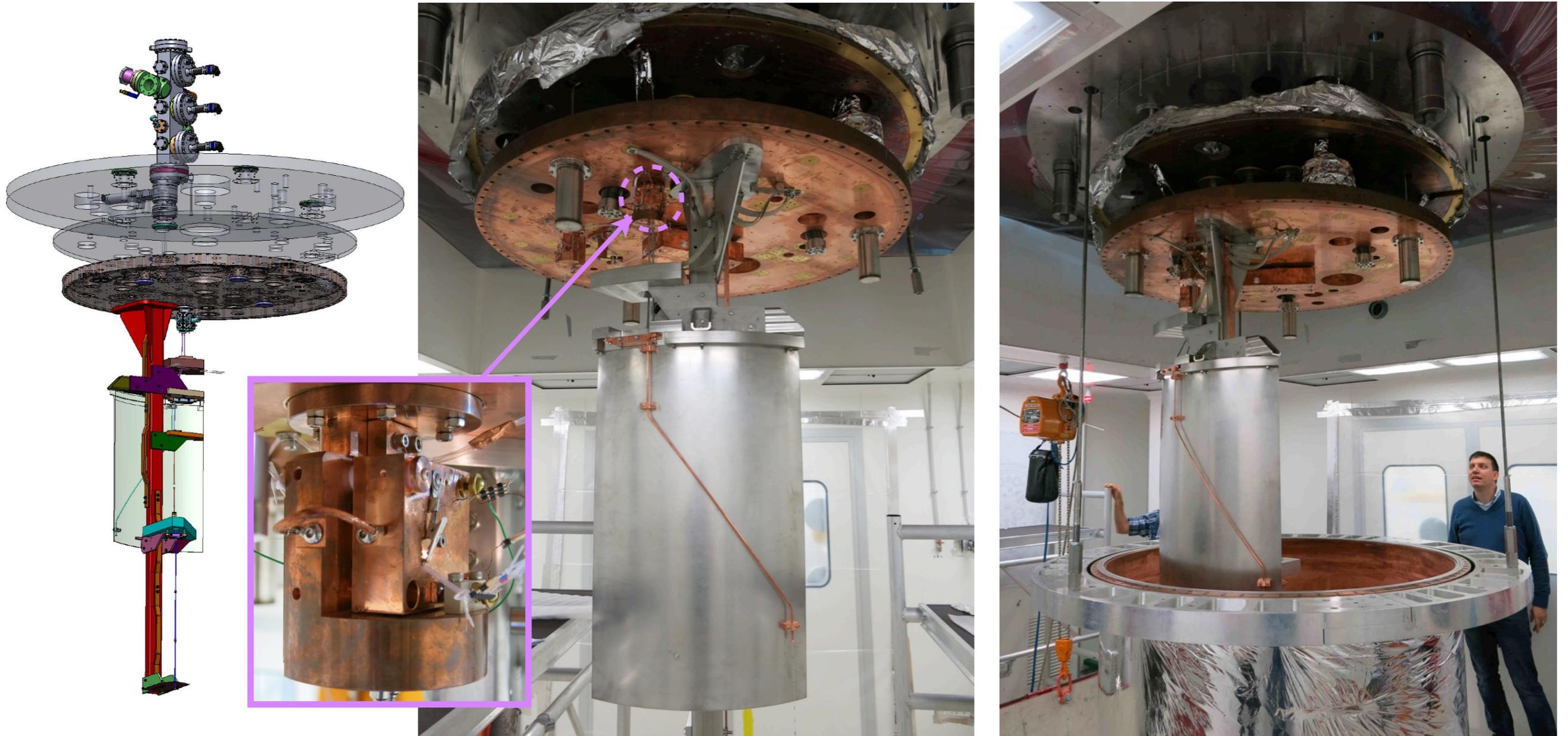
Calibration Procedure



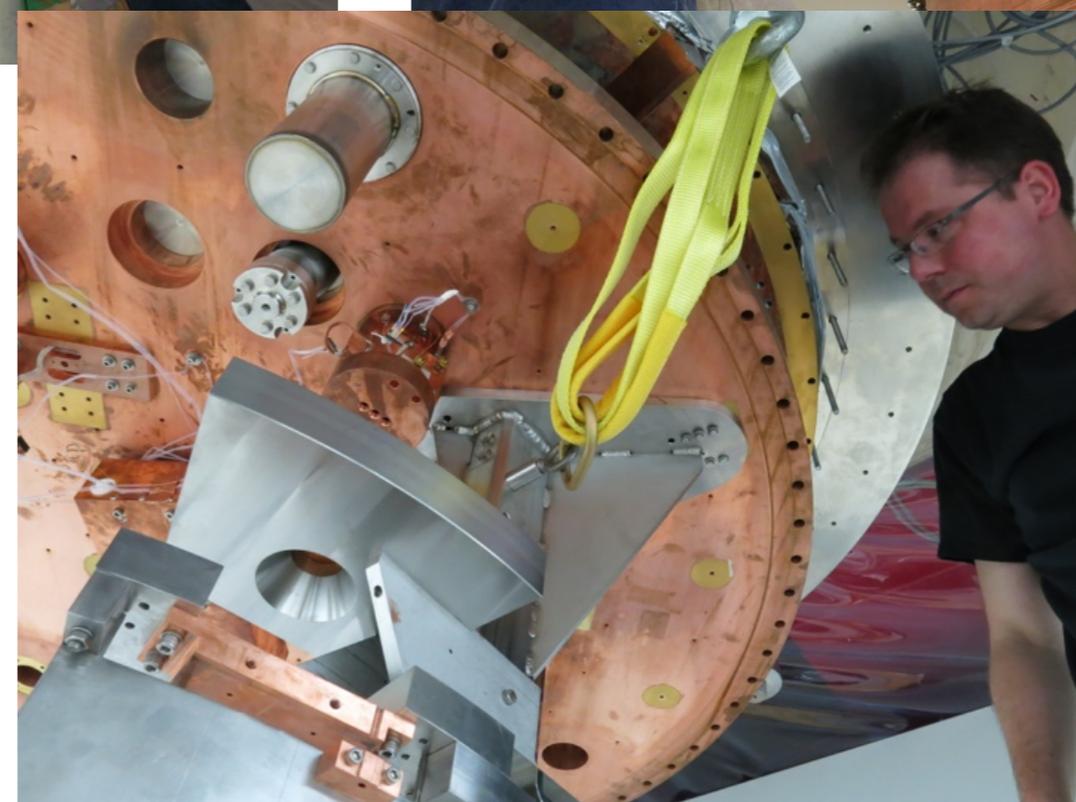
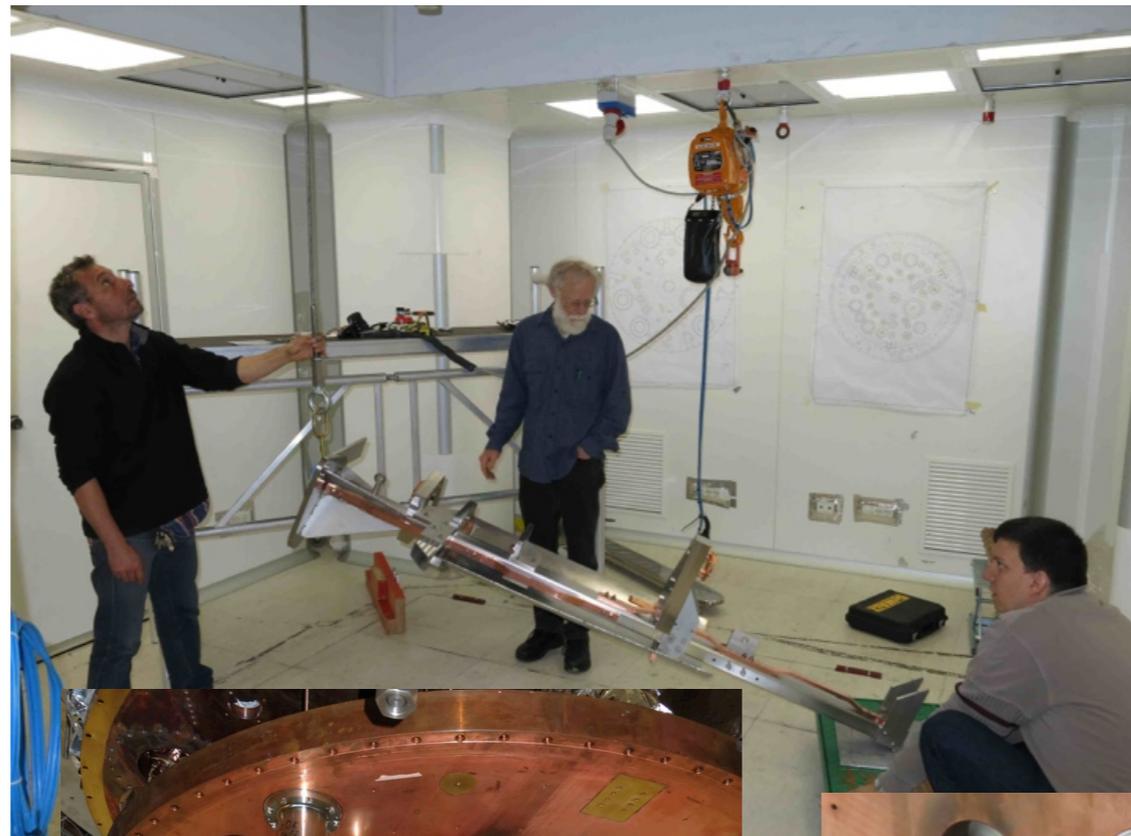
Calibration System Cool Down



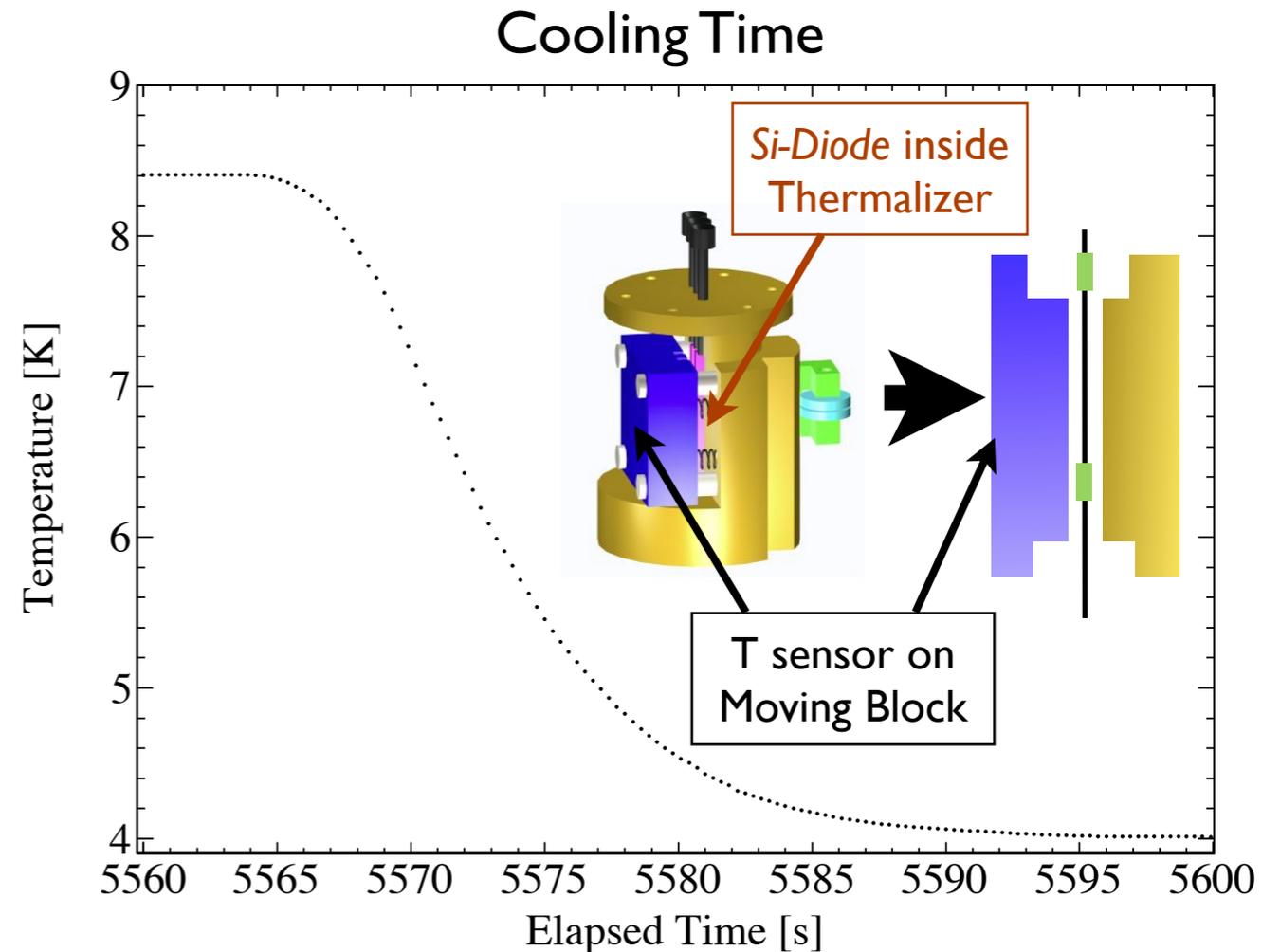
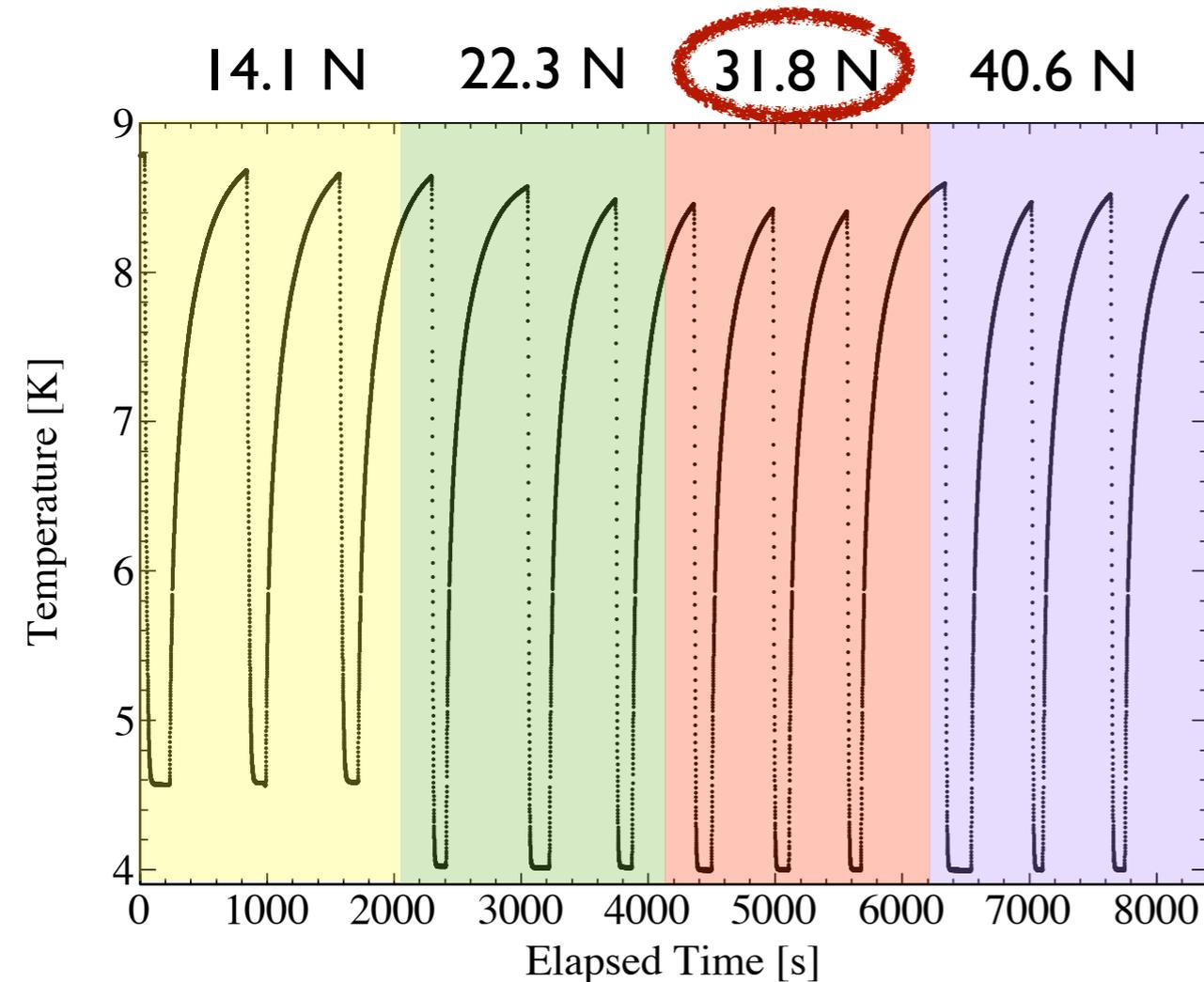
- First of 4 modules was integrated in the cryostat.
- In-situ cooling test of calibration system (at 4K) was performed in July 2013.



Calibration System Installation Activities

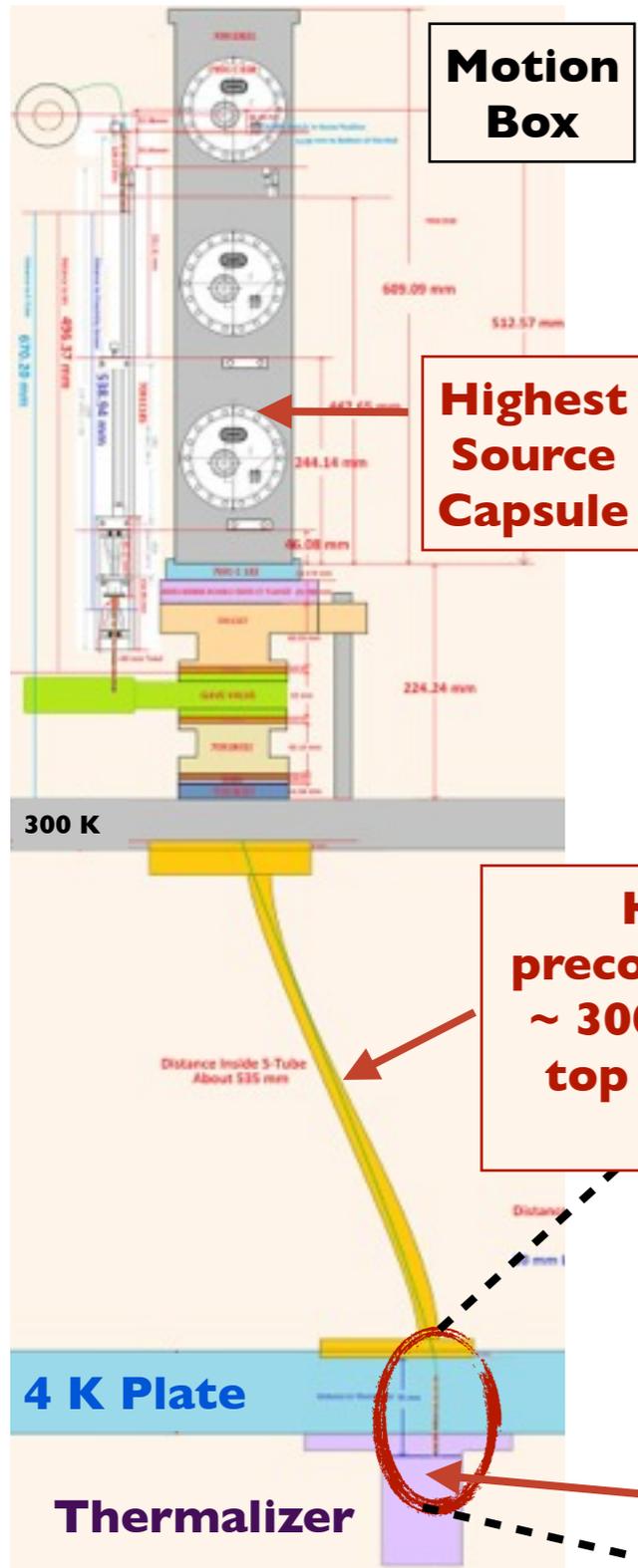


Results : Source Squeezing Force

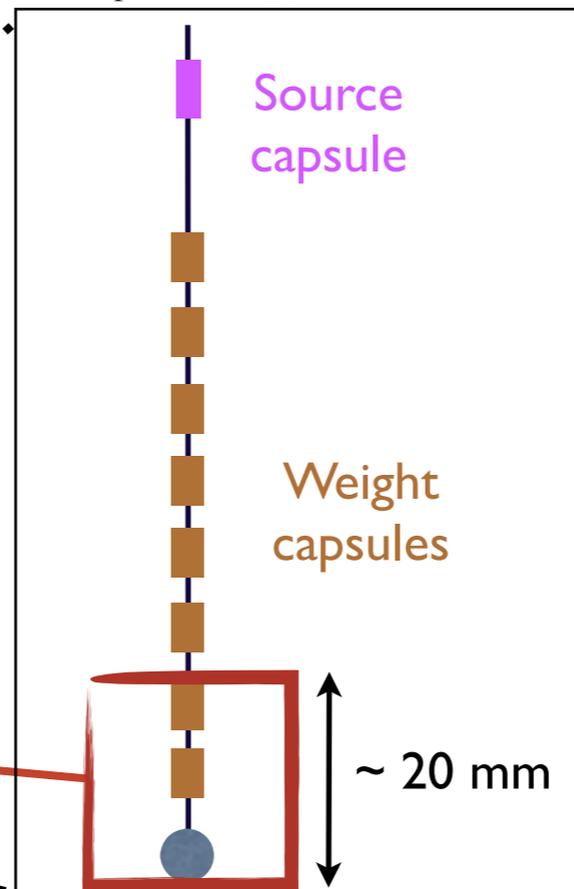
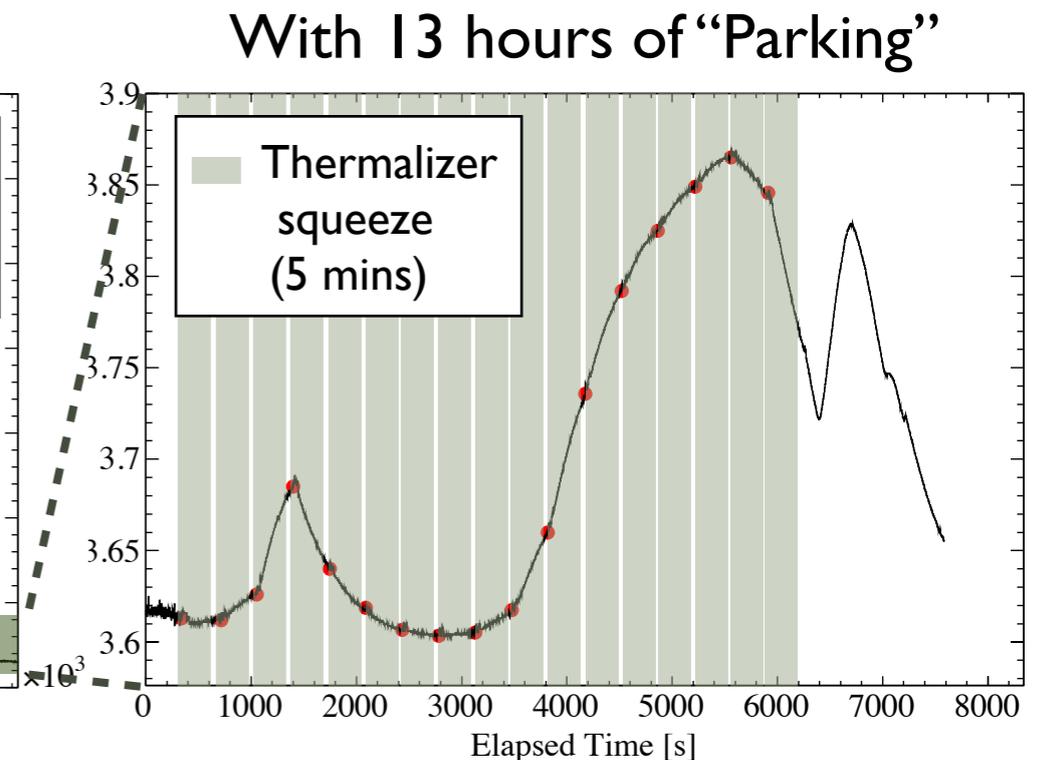
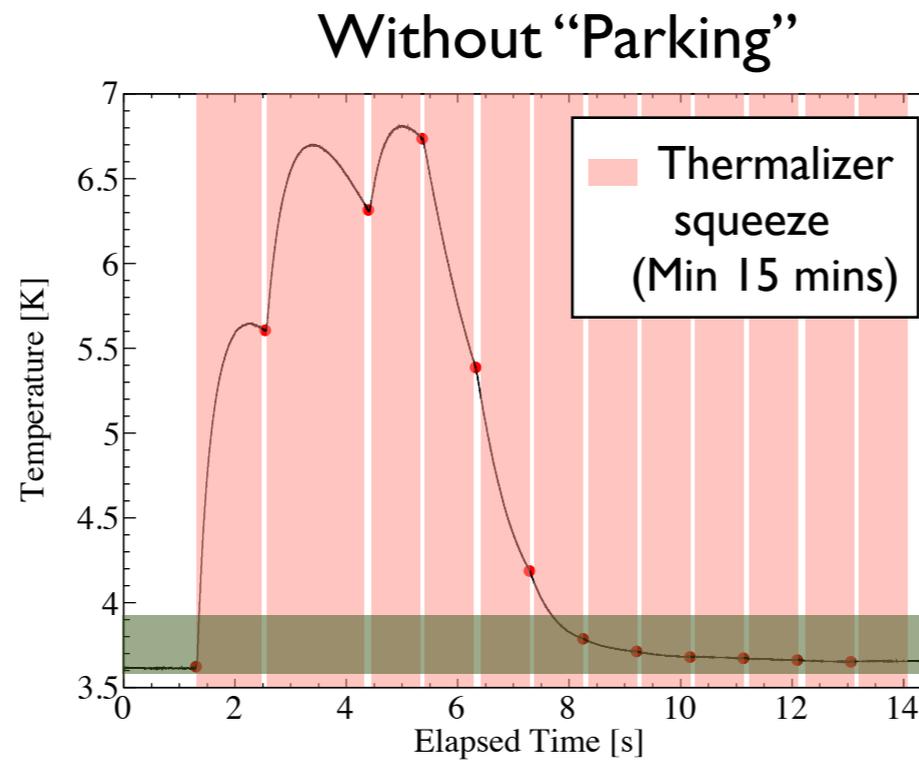


- Measured temperature variation of Si-diode (which simulates a warm source capsule) w/ 4 different configuration to determine the squeezing force of thermalizer.
- Exerting 31.8 N of squeeze force has been decided for the thermalizer operation.
- ~ 30 s of squeezing is enough to cool down Si-diode to the base temperature.

Precooling of the Source

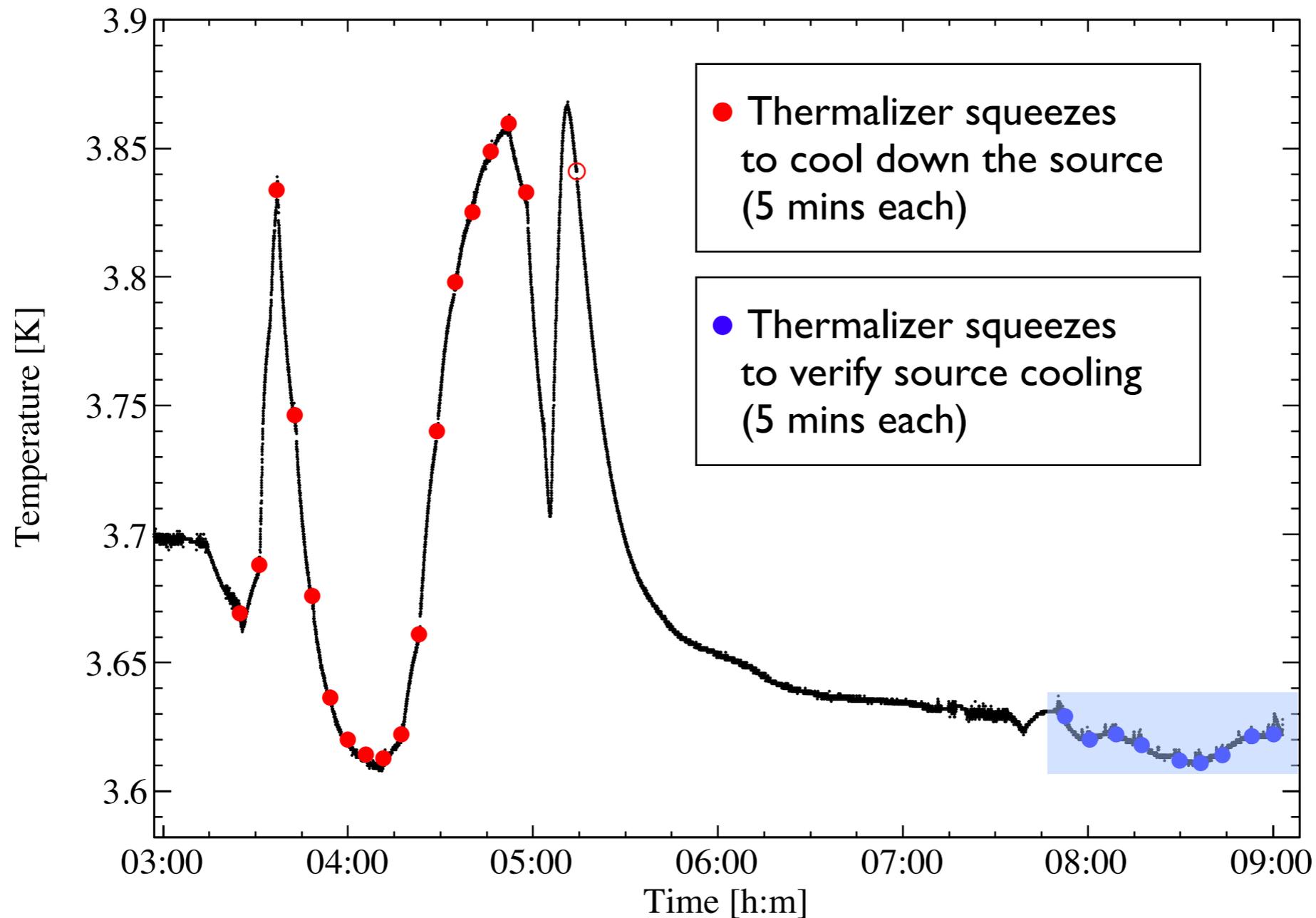


Highest precooled region ~ 300 mm from top of moving block



■ Precooling of the bottom capsules for hours ("parking") reduces the cooling time and heat load.

Verification of Source Capsule Cooling



- No significant temperature increase was observed from the verification squeezes.

Summary



- First of 4 DCS modules was integrated in the cryostat and 4 K test was performed in July 2013.
- We have successfully demonstrated software controlled operation of the calibration system and measured its intrinsic properties.
- The squeezing force and source cooling time of the thermalizer have been determined.
- Precooling of the source capsules dramatically reduces the time required for the source deployment and heat load on the thermalizer.
- We also verified that the thermalizer is indeed cooling the source capsules by measuring the temperature of the capsules after squeezing.
- Construction of 3 remaining modules is underway.

CUORE Collaboration

