Full Size Demonstrator

Facility refurbishment at Uni Bern

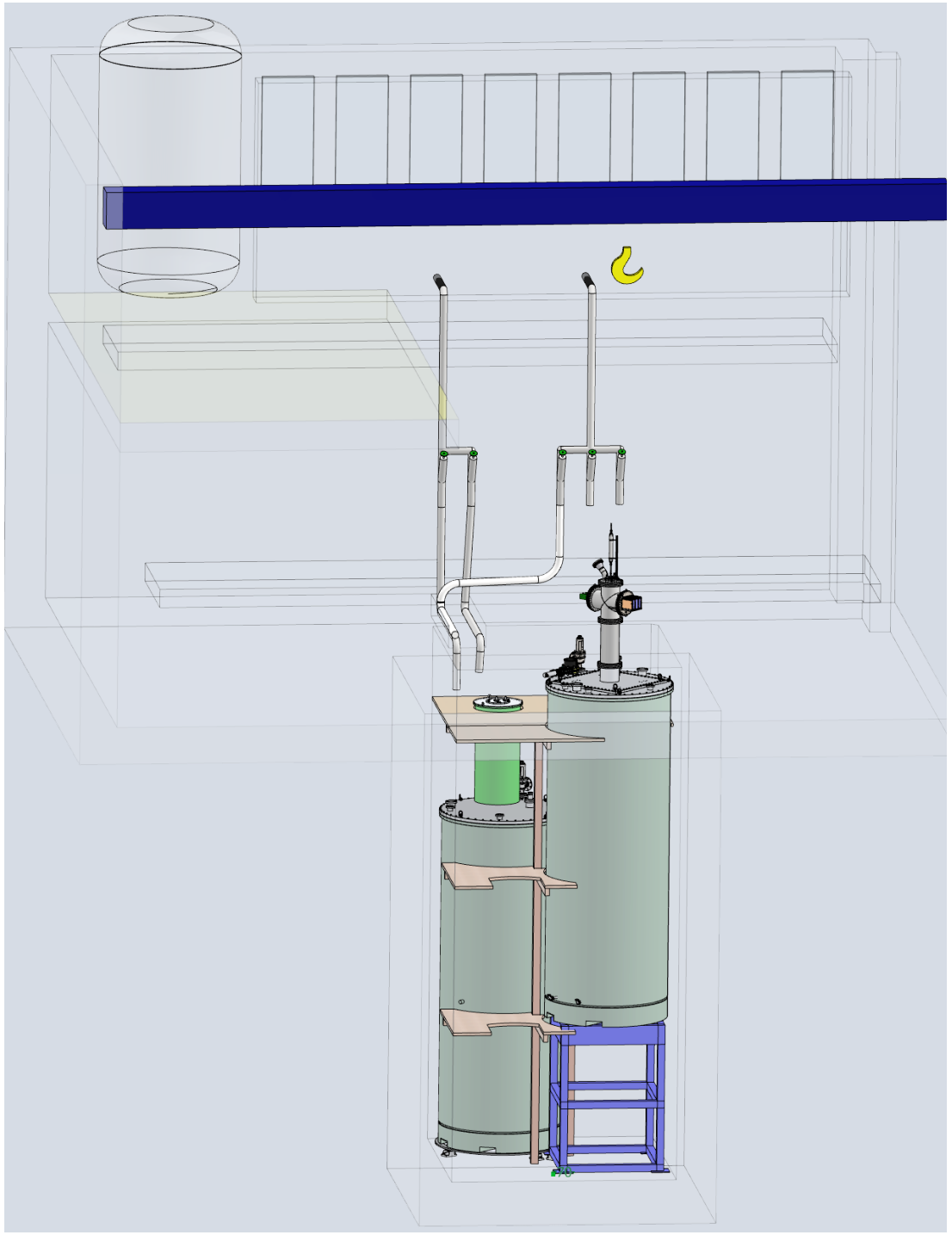
15 August 2024

Saba Parsa, University of Bern

Full Size Demonstrator Facility @ Bern

Layout and overview

- FSD facility consists of two large cryostats for storage and operation
- Supply LAr tank and Cryogenics infrastructure
- Recirculation with cooling and LAr purification system
- Electronics and DAQ infrastructure
- Crane access in the lab
- Mechanical and Electronics workshop
- Assembly area and clean room



Cryogenics scheme

- The cryogenics system requirements were defined, and a first scheme was designed and reviewed during PDR in 2022
- Main parts were purchased end of 2022 and were delivered in 2023
- The cryogenics schemed was refined and completed based on realistic construction possibilities end of 2023

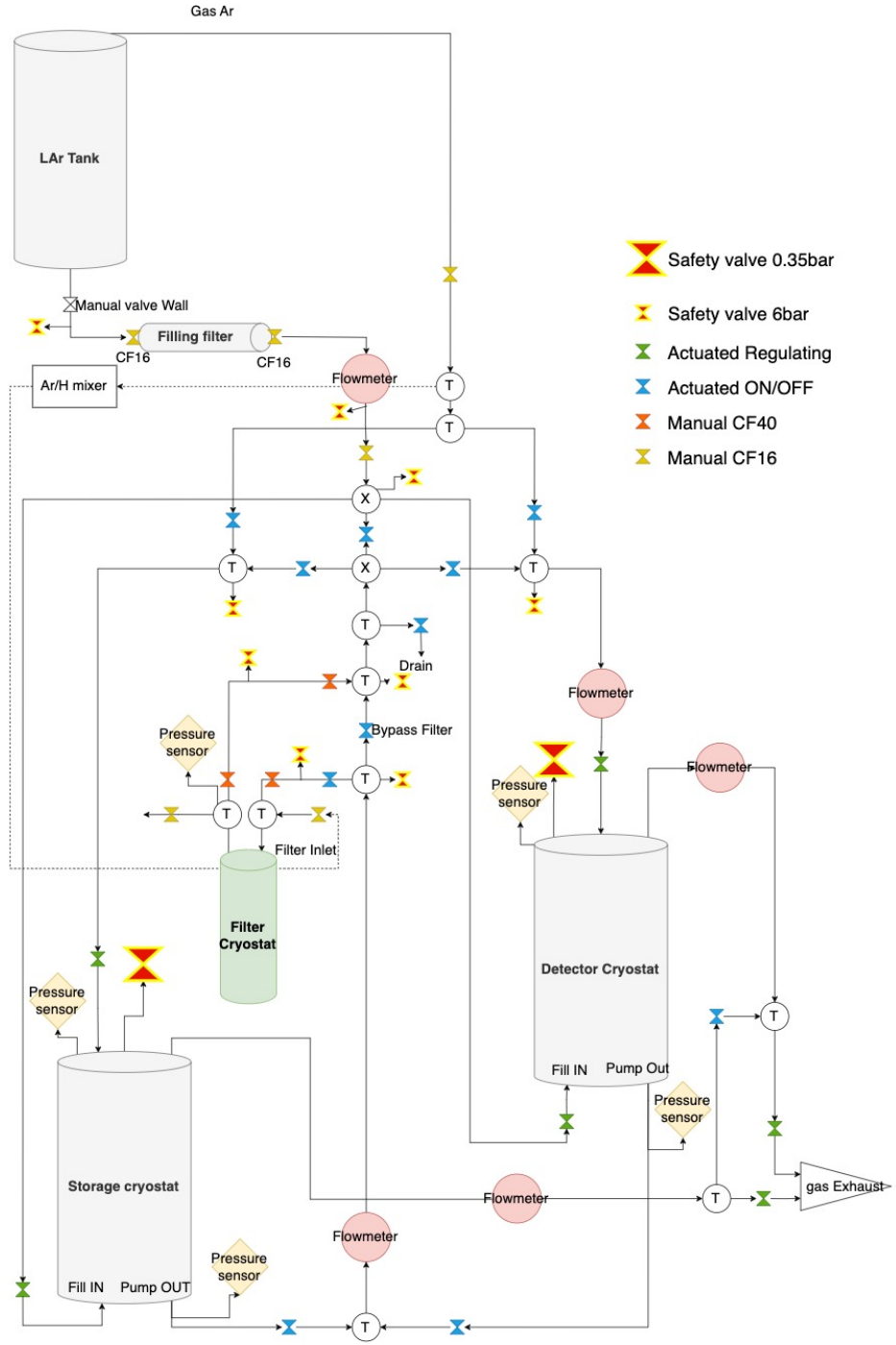
Desired Modes of operation

- Cooldown
- Filling from external/Storage
- Filling + recirculation
- Recirculation w/wout cooling + purification
- Recirculation w/ reduced top flow
- Drain detector to storage
- Warmup with Ar gas
- Storage recirculation
- Drain storage to external

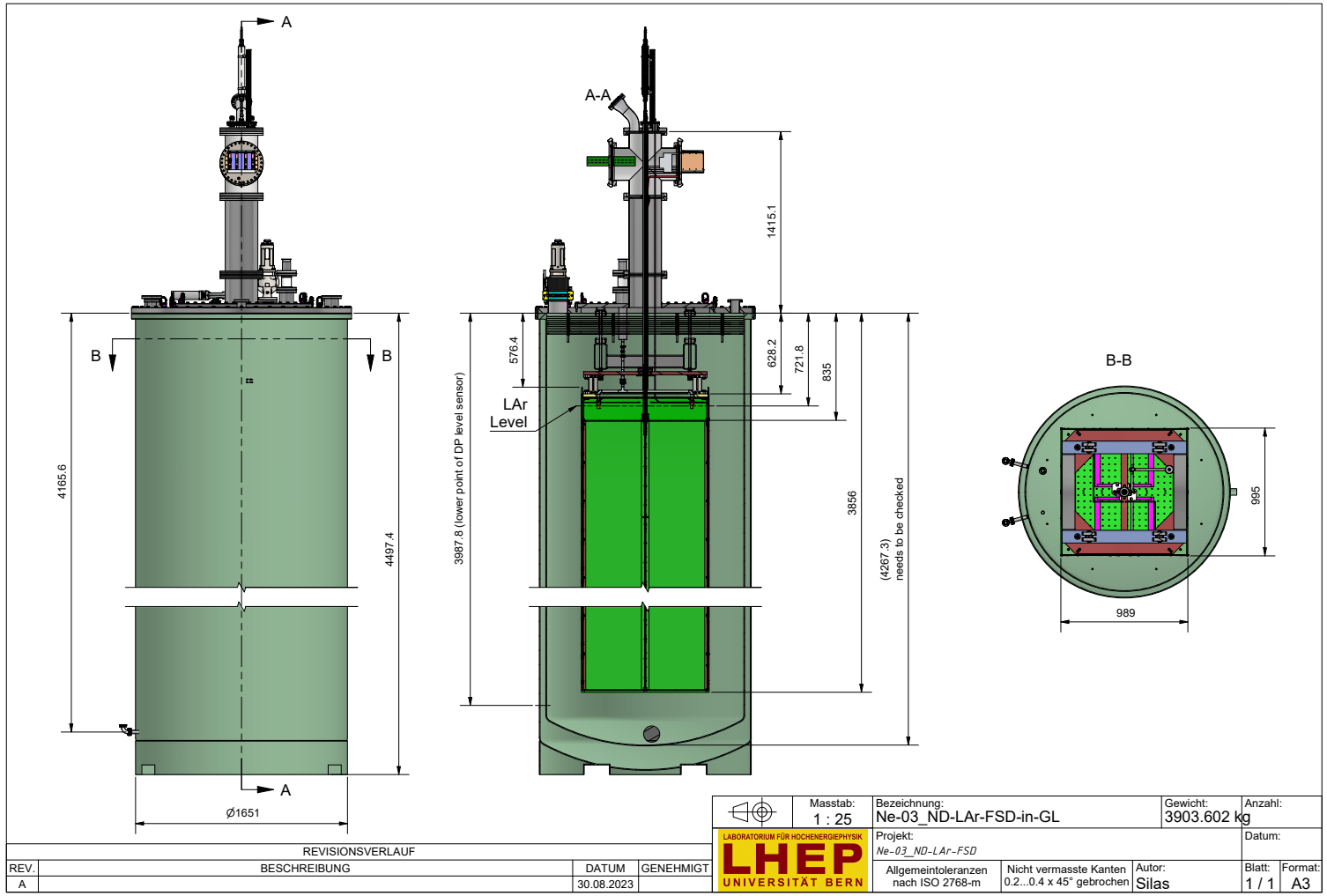
Valves:
- 11 actuated ON/OFF valves
- 6 actuated regulating valves
- 3 manual CF40 valves
- 6 manual CF16 valves

Sensors
- 3 Liquid flow meters
- 2 gas flow meters
- 5 pressure sensors
- 2 safety valves 0.35 bars
- 9 safety valves 6 bars

Branching Parts
- 12 Tee pieces
- 2 Cross pieces

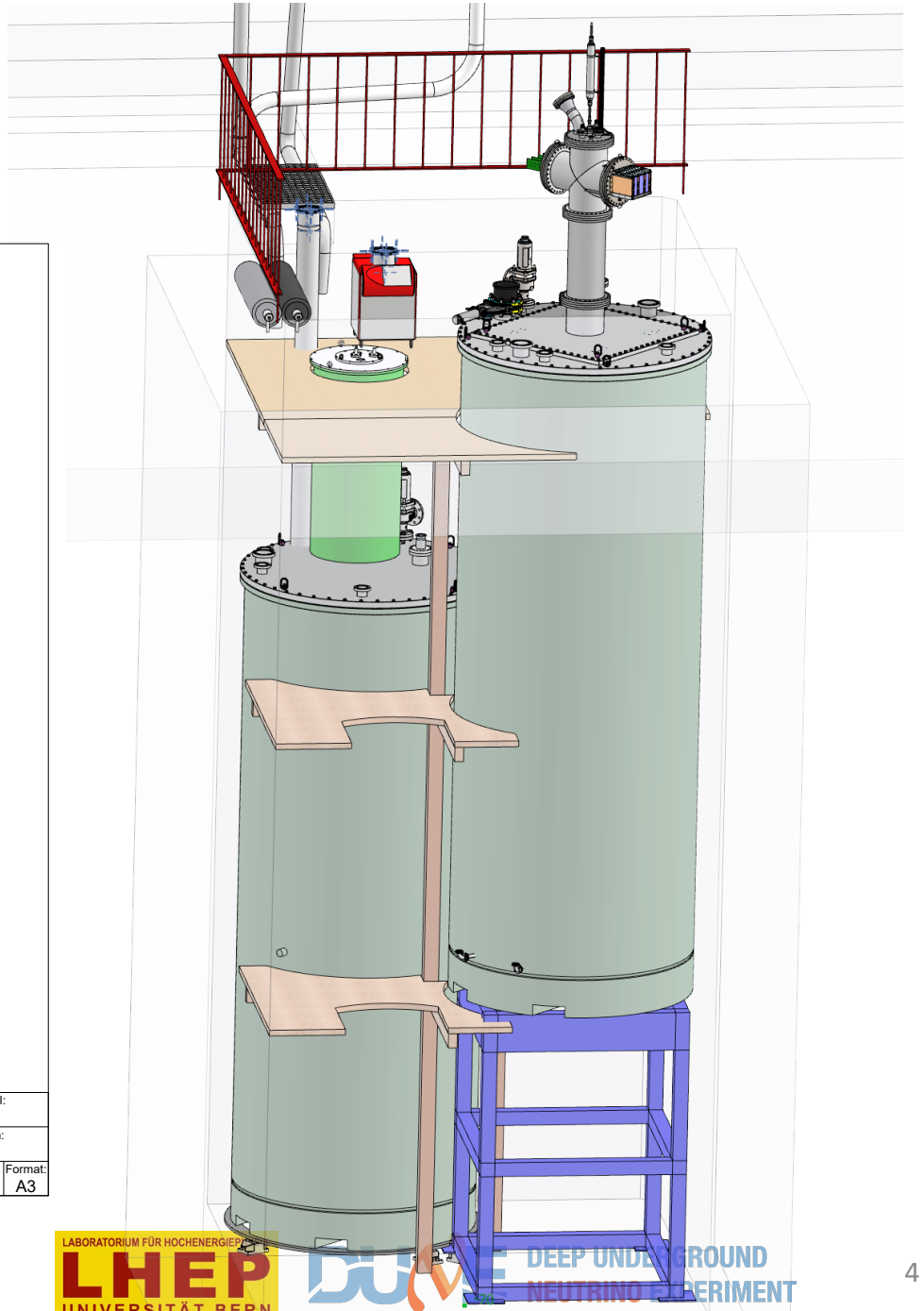


Pit and cryostats positioning

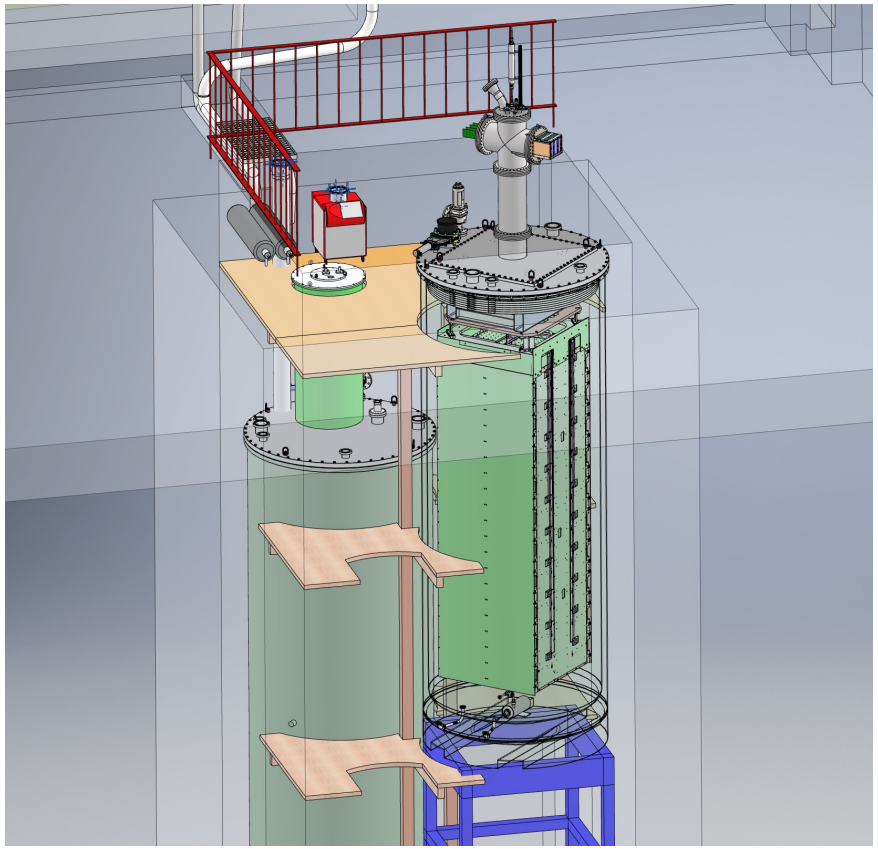


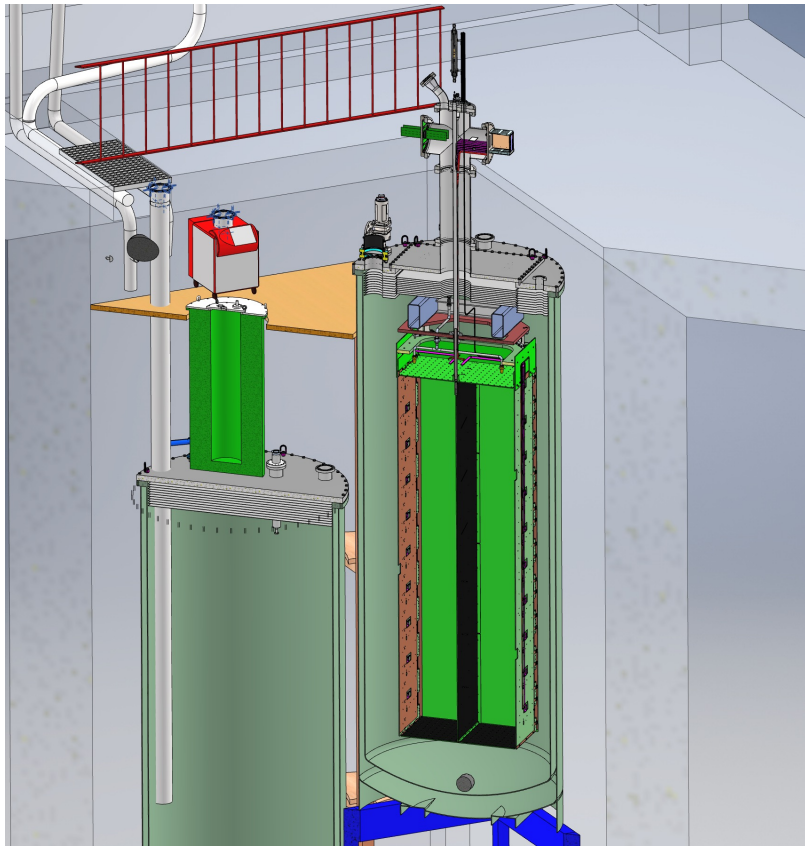
REVISIONSVERLAUF			
REV.	BESCHREIBUNG	DATUM	GENEHMIGT
A		30.08.2023	

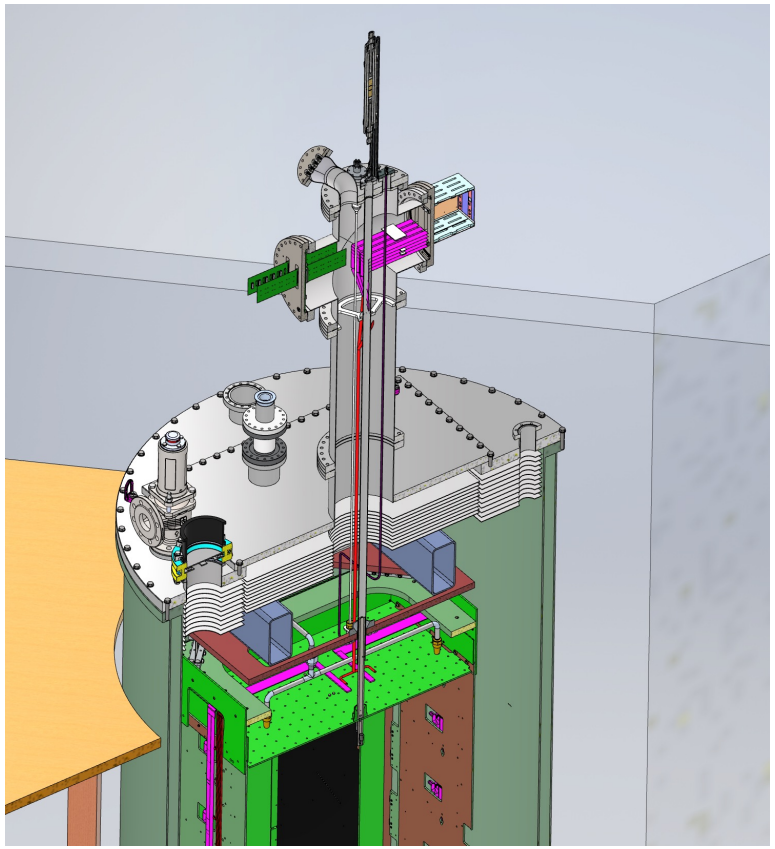
Masstab: 1 : 25	Bezeichnung: Ne-03_ND-LAr-FSD-in-GL		Gewicht: 3903.602 kg	Anzahl:
LABORATORIUM FÜR HOCHENERGIEPHYSIK LHEP UNIVERSITÄT BERN	Projekt: Ne-03_ND-LAr-FSD			Datum:
	Allgemeintoleranzen nach ISO 2768-m	Nicht vermasste Kanten 0.2...0.4 x 45° gebrochen	Autor: Silas	Blatt: 1 / 1 — Format: A3



Details of the Cryostats and Detector design

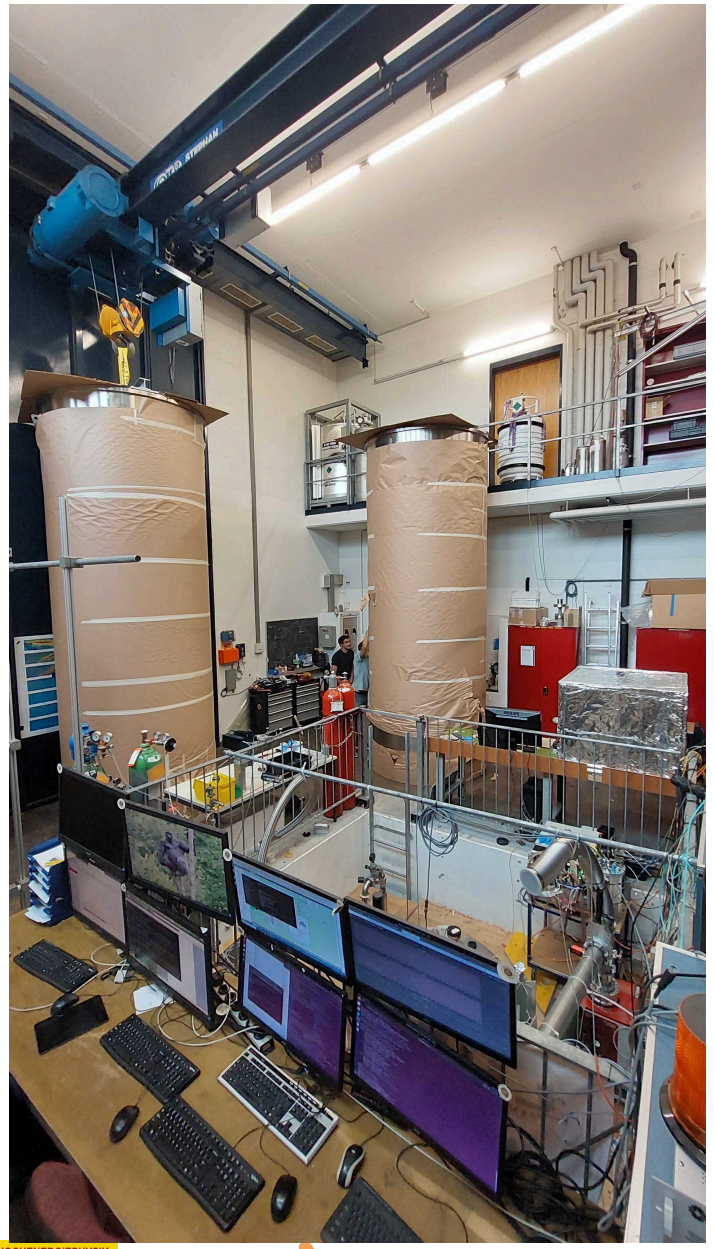






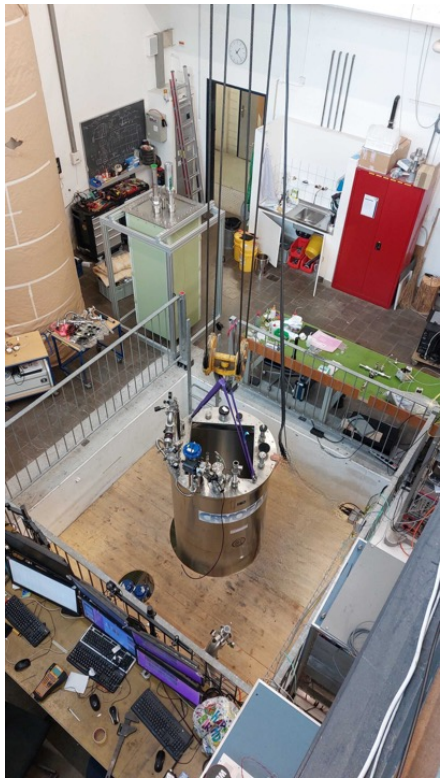
Two new cryostats

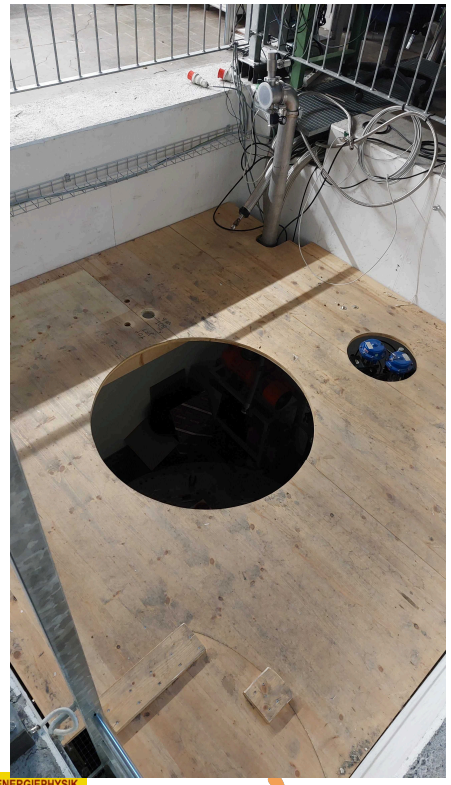
- Delivery of two CryoFab cryostats on August 24th 2023



Clearing the pit

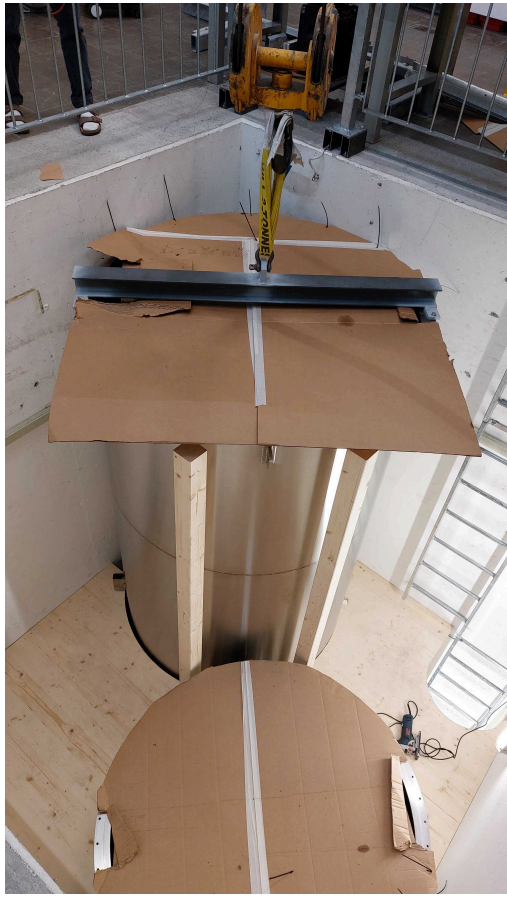
- Clearing the platform, removing electronics after Module-X run and filter regeneration in October 2023
- Removal of cryostat on October 27th 2023



Installation of the two cryostats

- Platforms were removed, 1st week Nov
- Fitting test and planning for platforms were done 2nd week Nov
- Installation of the two lower wooden platforms in Nov-Dec
- Adjustable feet were purchased and fitted to the cryostats in Dec
- Installation of the cryostats in Dec 2023 before the winter break

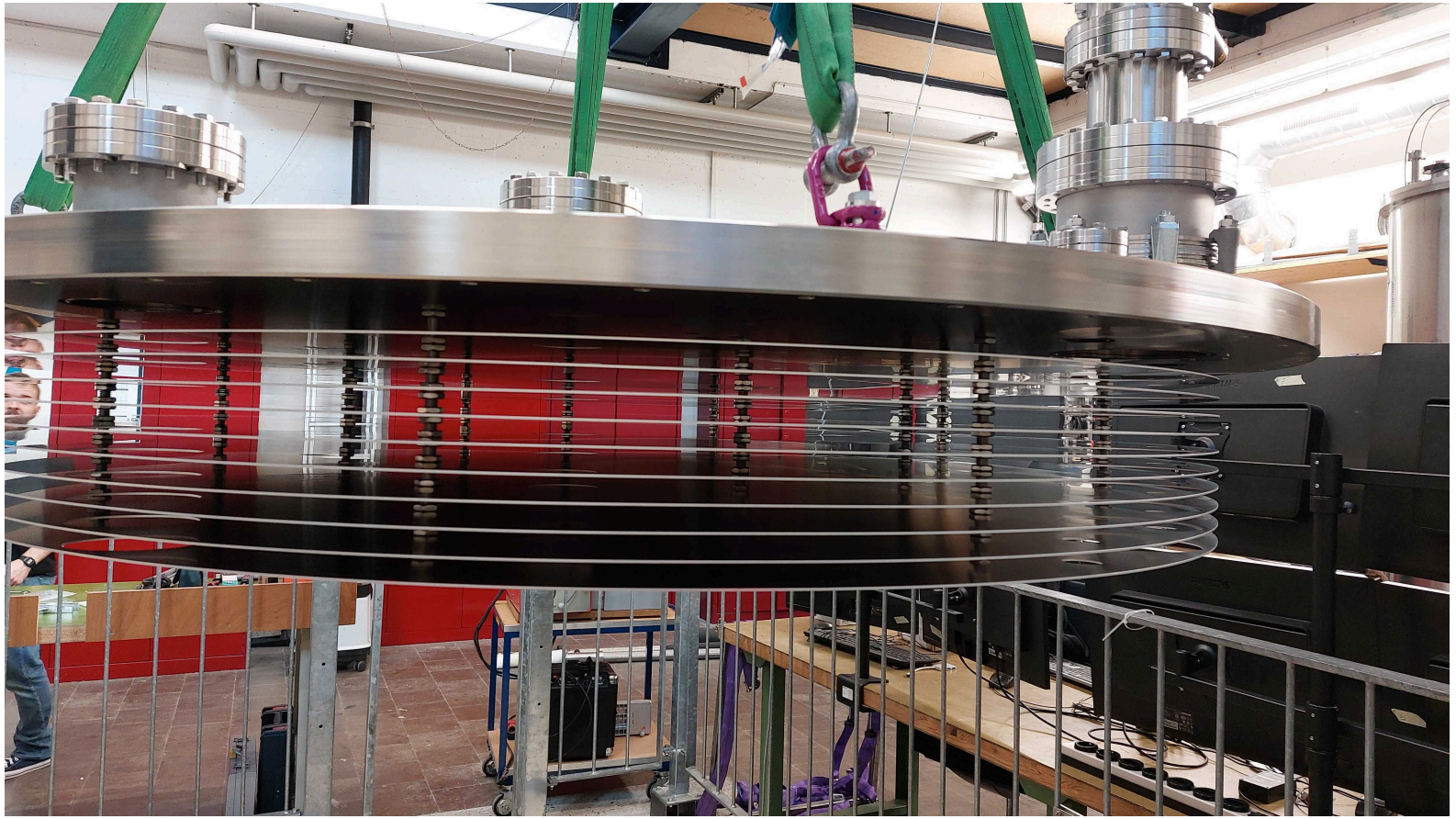


Welding of top flanges

- Both top flanges were welded end of Jan

Installation of Baffles

- Baffles were installed in mid Feb

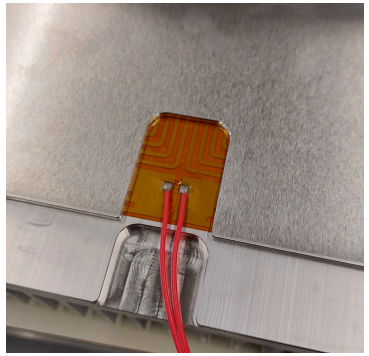
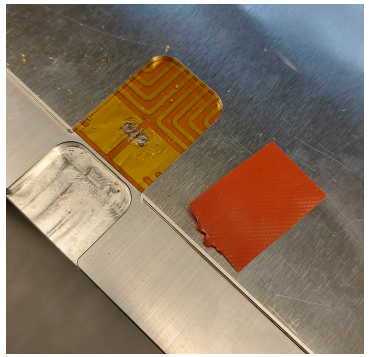
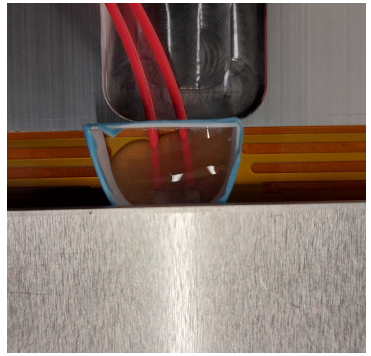


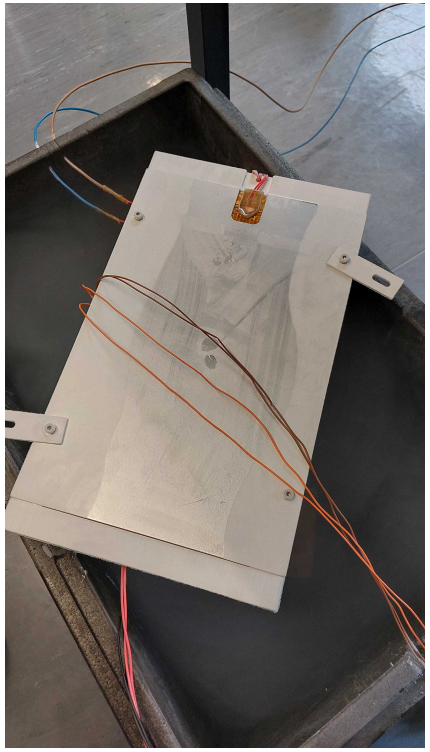
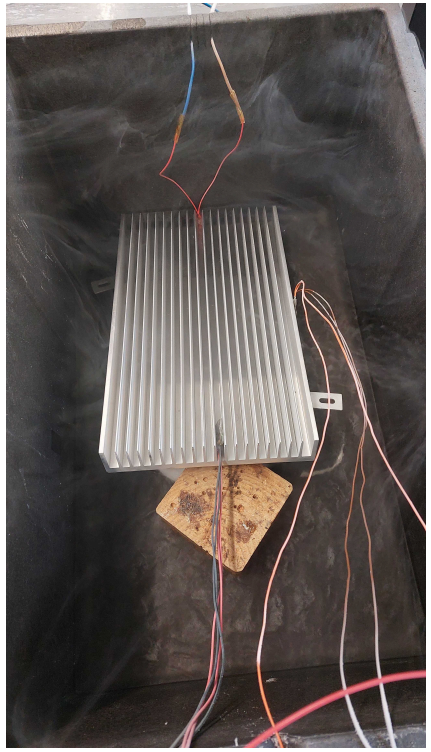
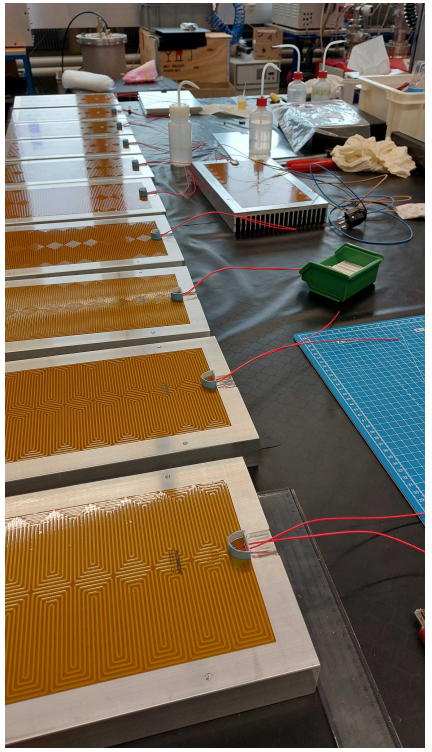
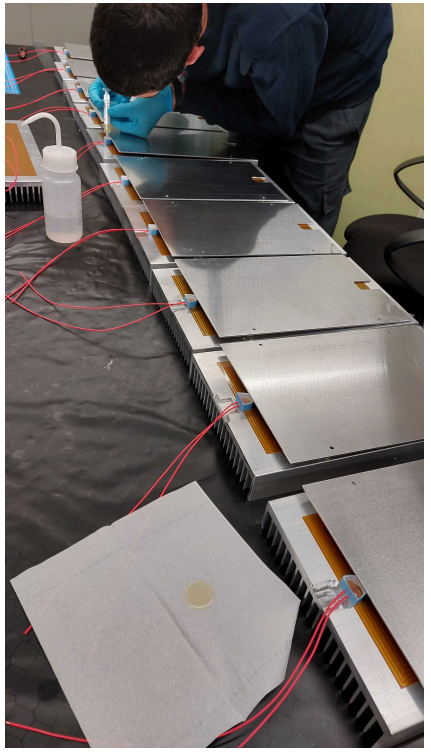
Blind flanges on the storage cryostat

- Getting ready for vacuum test

Heater assembly

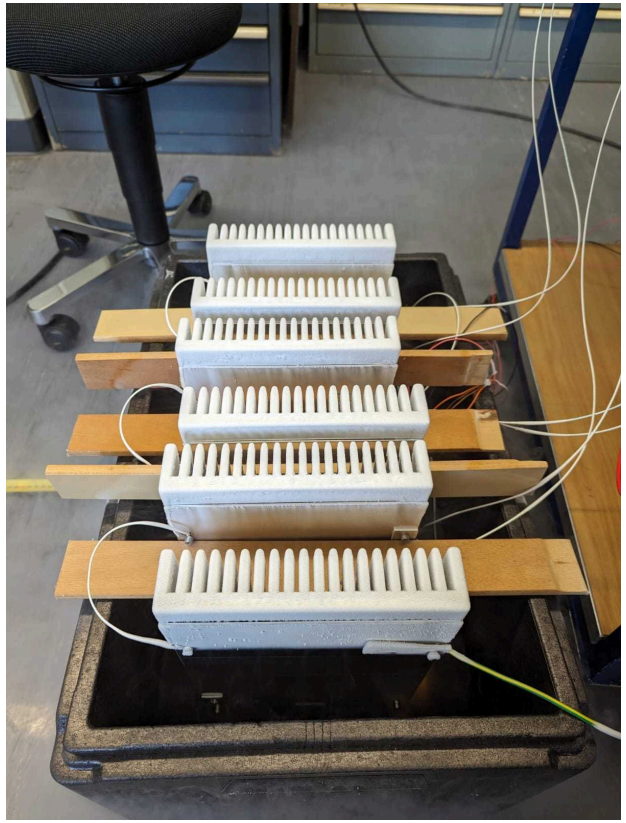
- We reinforced the solder connection on the Polymide heater foils with epoxy

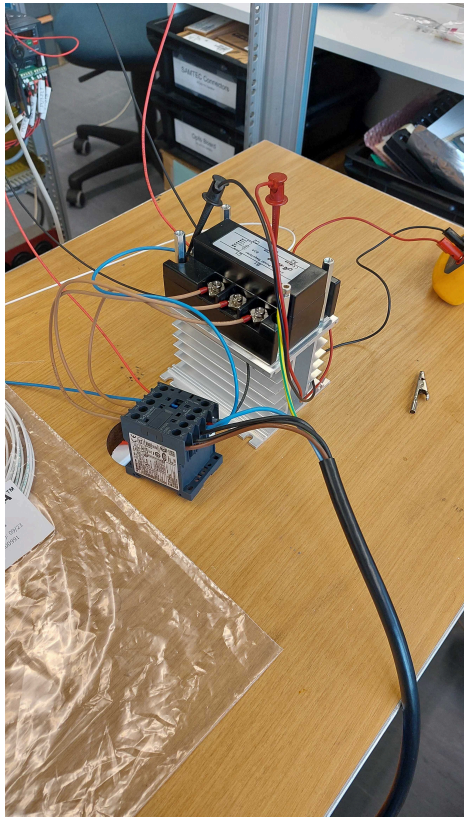




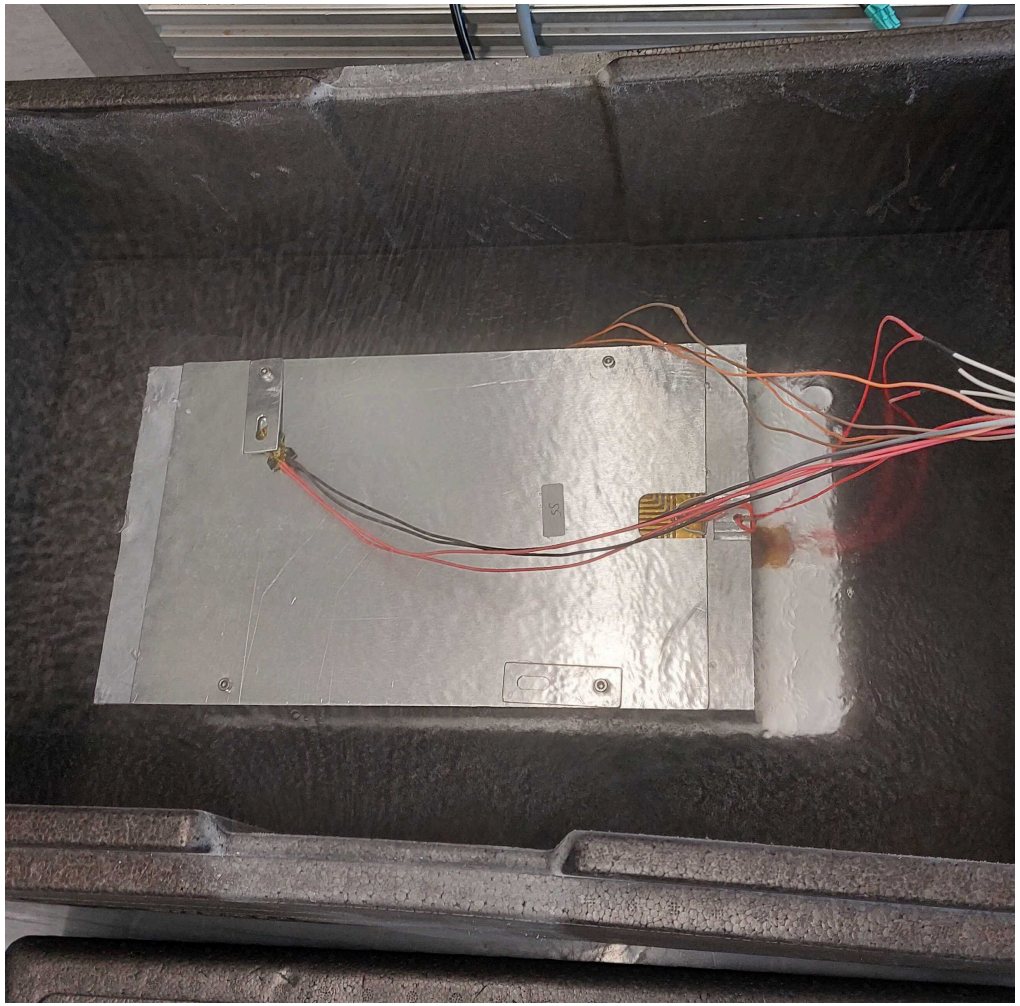





Heater test with PLC control

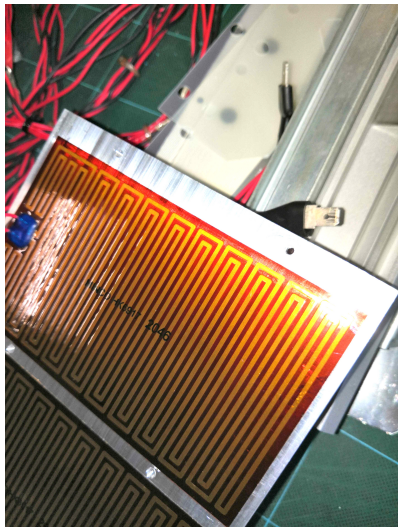
- Heater test with 3000 W in LN

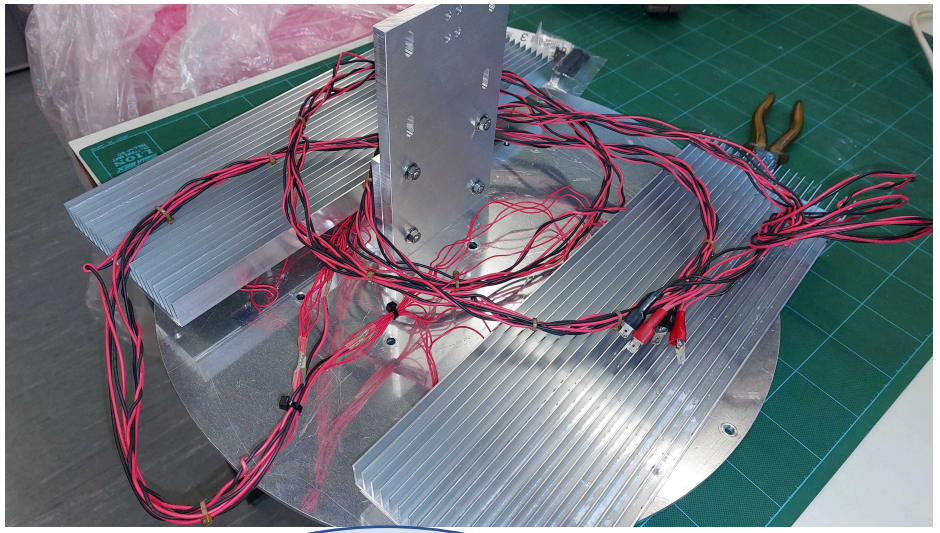






Cryostat LAr heater design



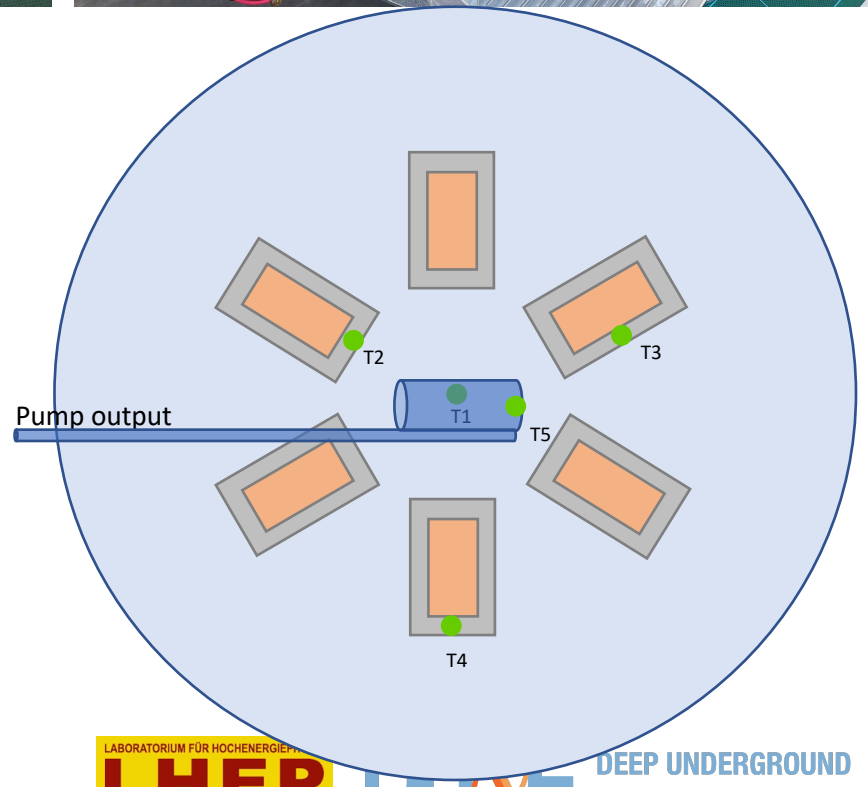


Single Module Cryostat heater

- 2 Aluminum heat exchanger, each with 5 Polyimide heater foil
- Polyimide foil dimensions: 6 x 12.7 cm^2 ~ 110 Ω
- Operated at 70 V, Total power = 490 W
- About 24 h to evaporate the remaining LAr in the cryostat (~30cm)

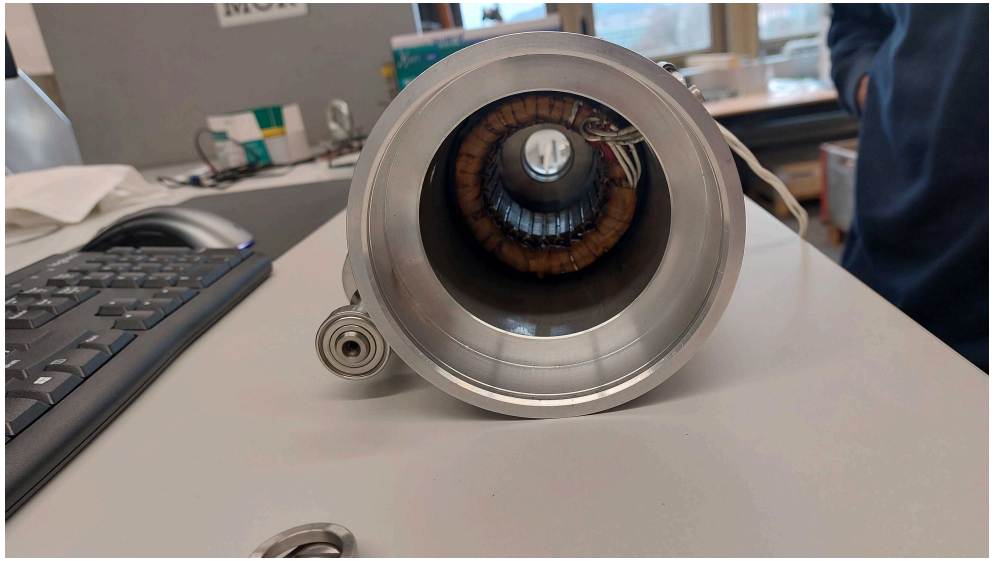
FSD Cryostat heater

- 3 Aluminum heat exchanger, each with 2 Polymide heater foil
- Polyimide heater foil dimensions: 15.2 cm x 30.5 cm^2
- Each pad is rated to 500 W, Total power: 3 kW
- Aluminum profiles dimensions: 20 cm x 35 cm
- 5 Temperature sensors on the heaters and pump



Pump service

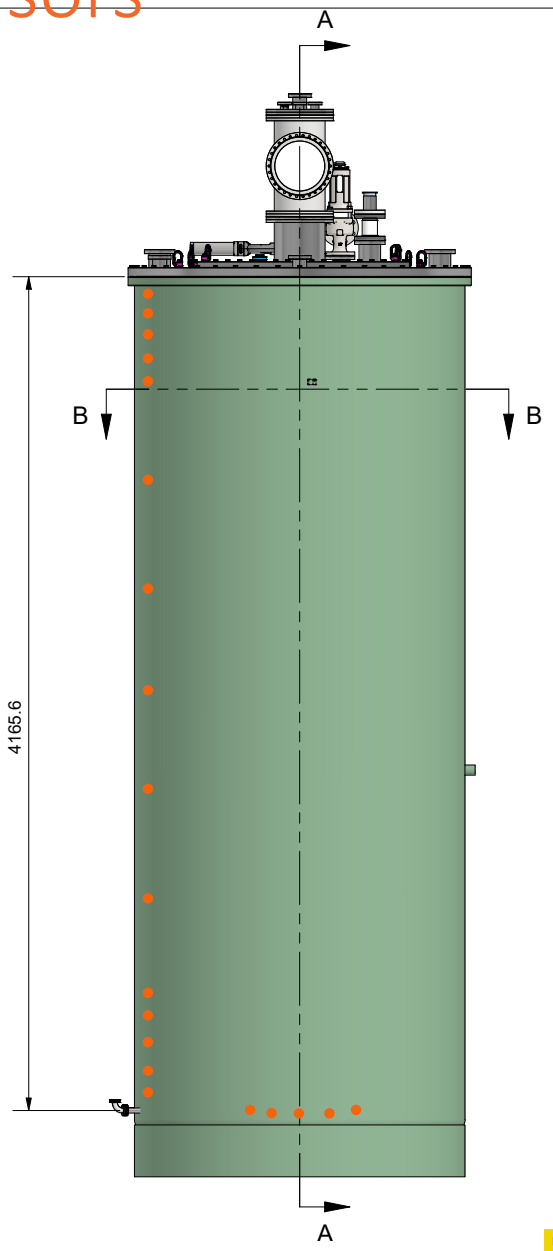
- A service kit was purchased from Barber-Nichols
- Ball bearings are replaced

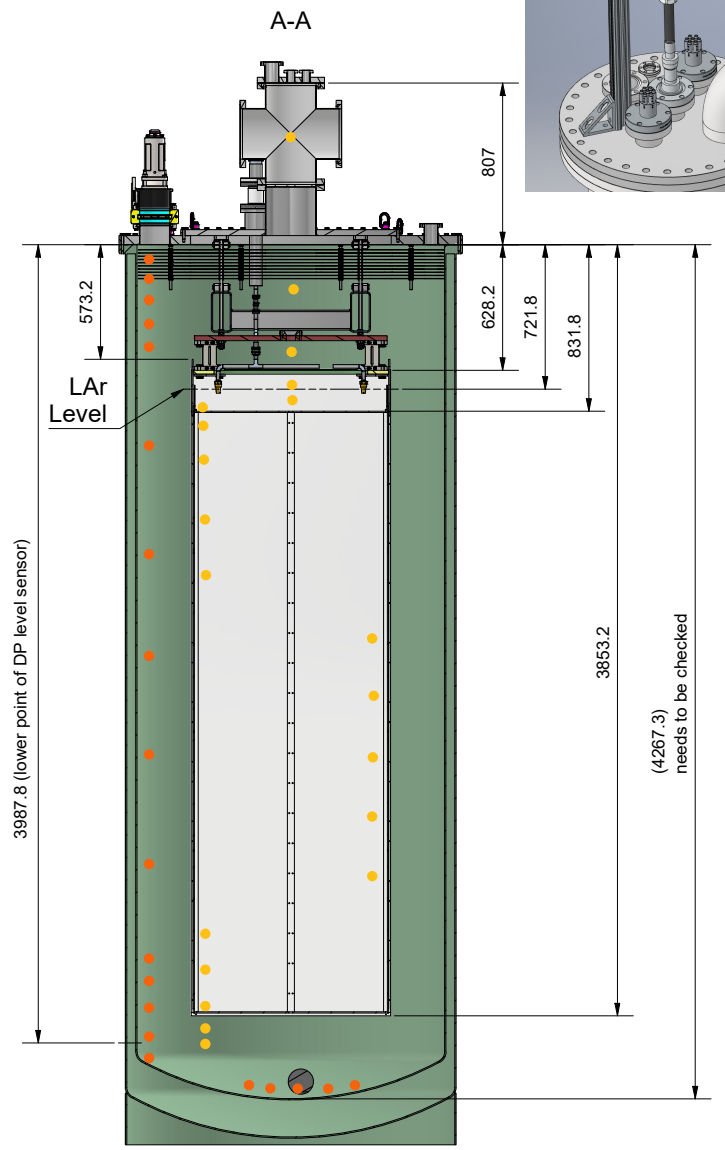


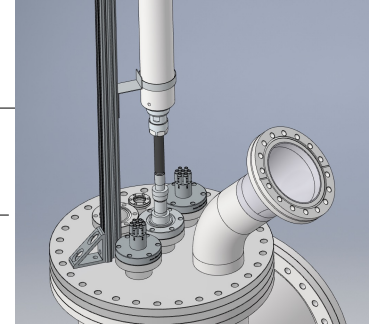
FSD Cryostat Temperature Sensors

- 20 temp sensor for Cryostat Slow control independent of the Module temperature sensors
- Redesign the slow-control PCB and the slowcontorl box
- Feed through CF100 with four DSUB 25 (each connector would have 5 pins free)

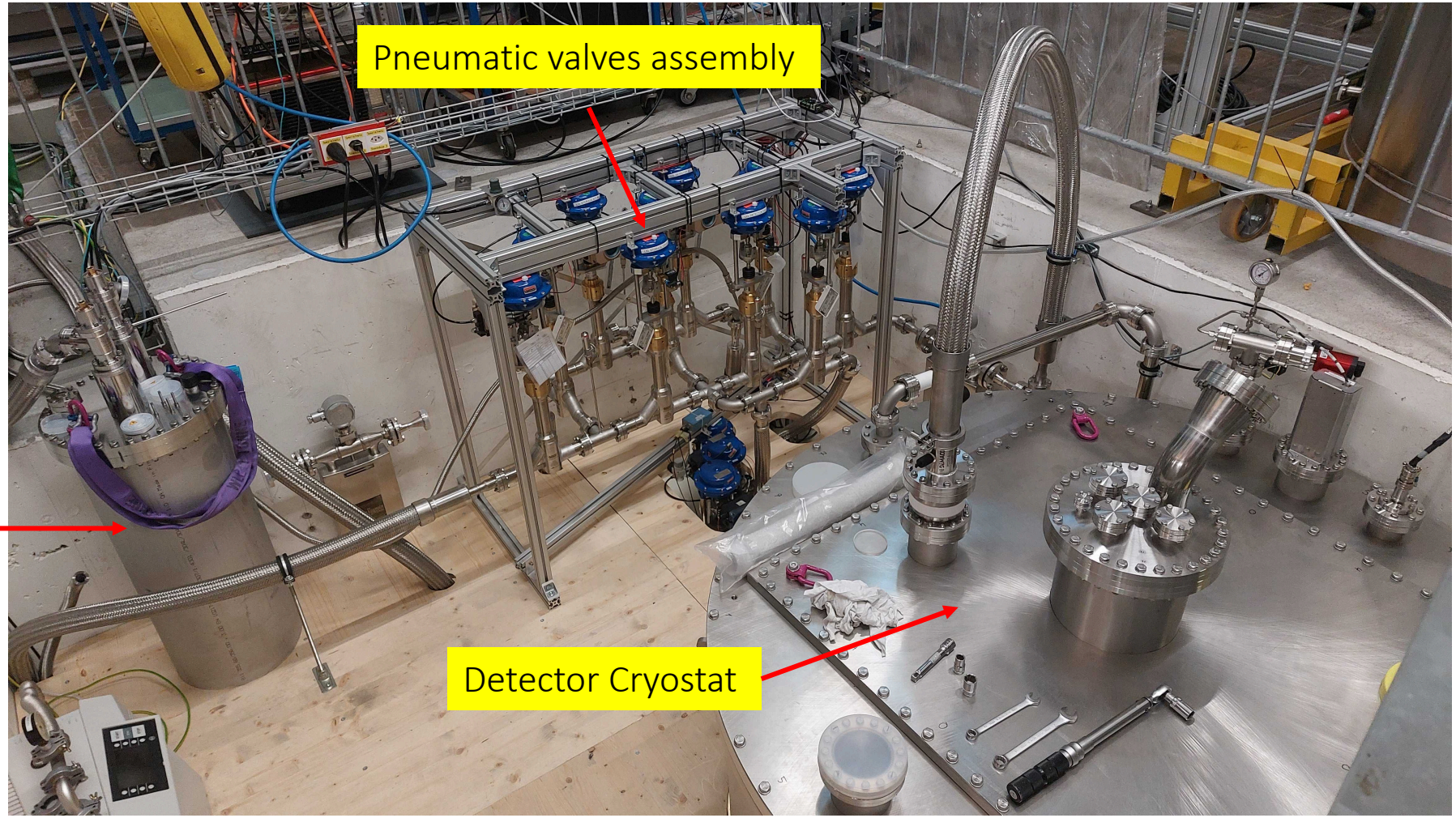
➢ 6 LED connections through the free pins for light calibration. Lemo connectors on the box







Cryo lines installation finished (Top Platform)



PLC

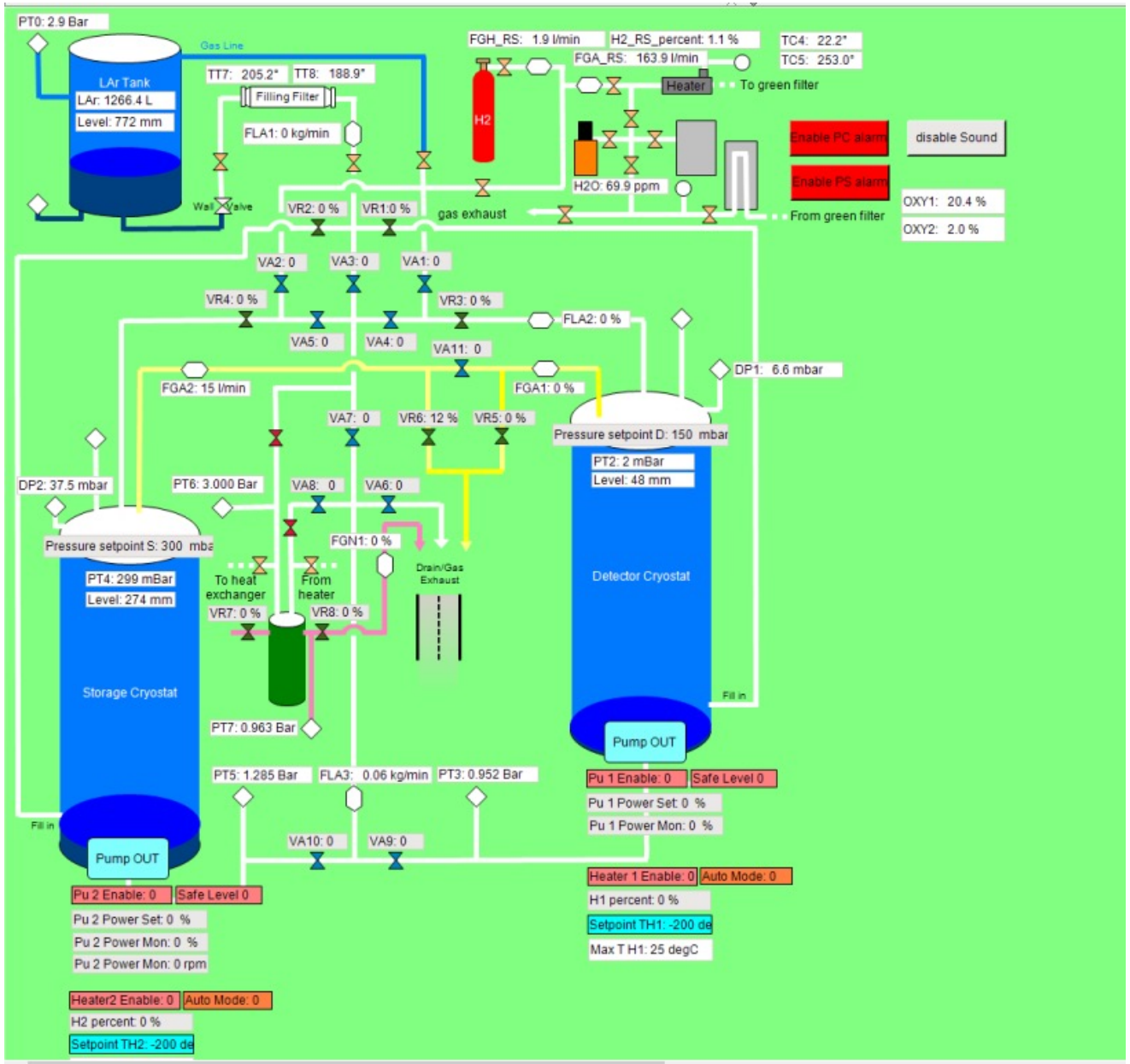
Valves control and sensors readback

PID control:

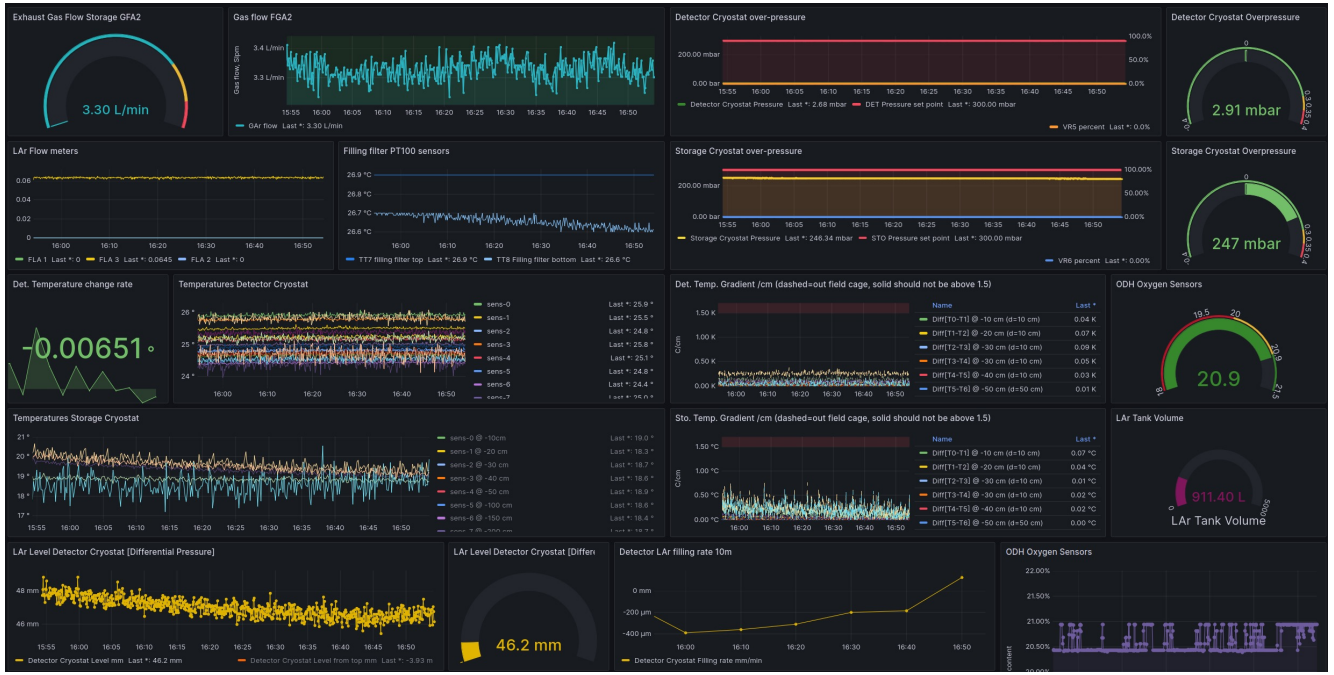
- Cryostat overpressure regulation
- Temperature gradient regulation
- Heater Temperature regulation

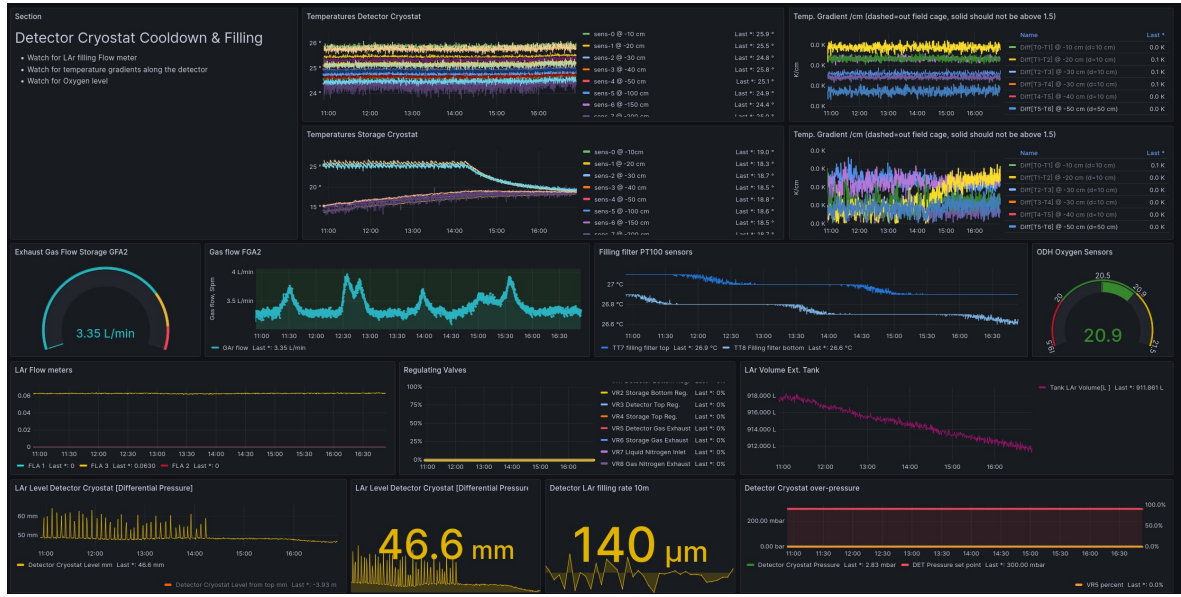
Alarms and interlocks

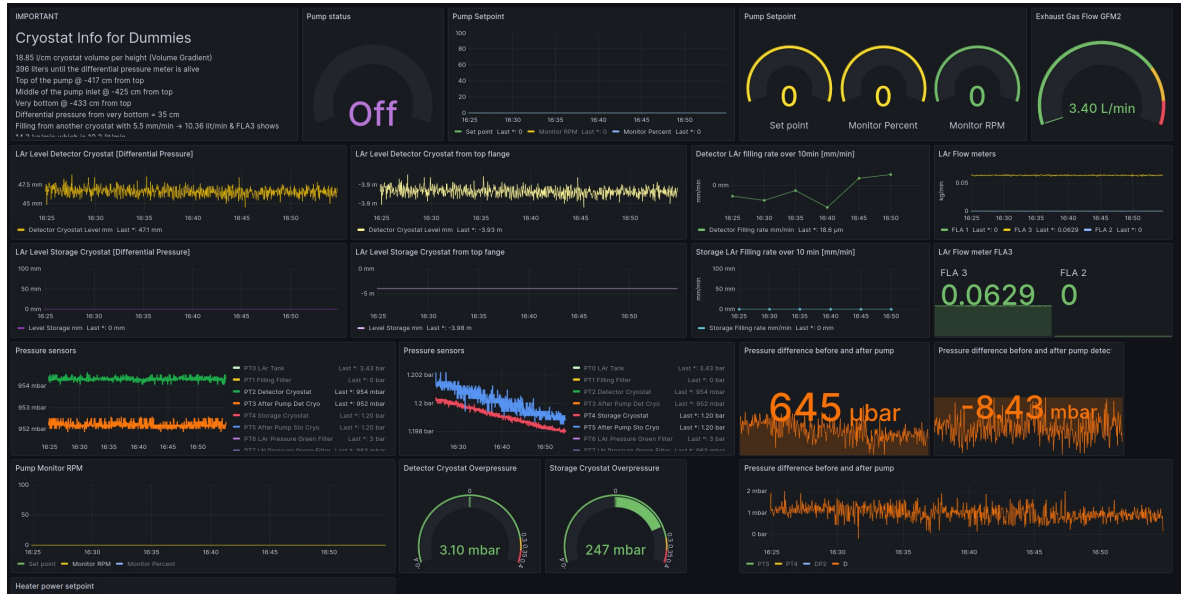
- Oxygen sensors
- Cryostat overpressure



Grafana monitoring is ready







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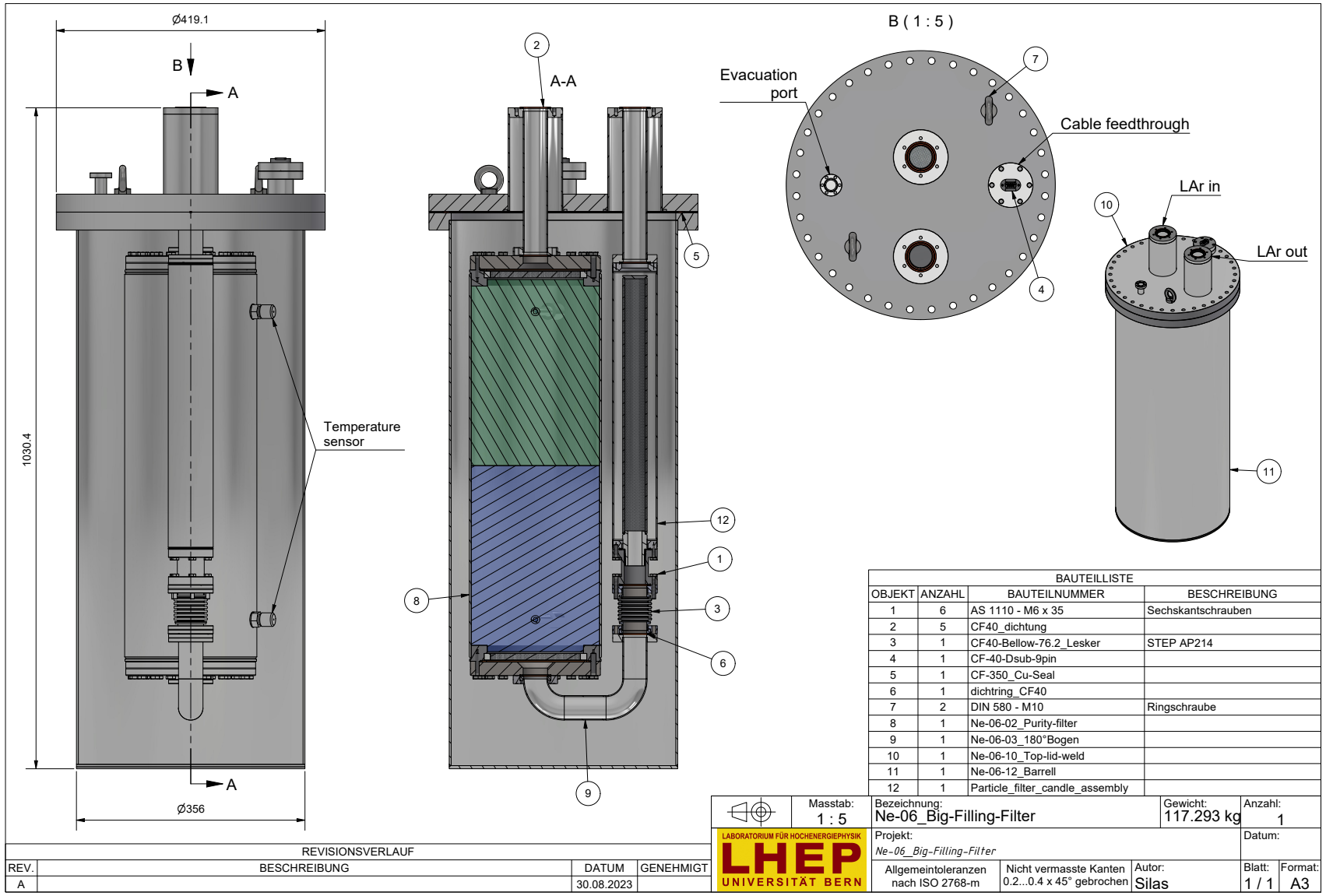
DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT

Filling filter

- The new filling filter is assembled, and leak tested
- The inner structure of the filling filter is the same as the recirculation filter: 10 liters of Copper Getter and 10 liters of Mol. Sieve



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DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT

Cryogenics Readiness tests

Cryogenics controls tested with LAr -> In a good shape

GAr Tests	
Gas Argon test Pressurize cryostats, PID Pressure Control	done
Gas Nitrogen test Pressurize Nitrogen jacket green filter, PID pressure control	done
LAr test with > 40 cm LAr in Storage Cryostat	done
LAr test cool down test,	done
Heater test	done
Pump test	done
LAr test with > 40 cm LAr in Detector Cryostat	
Heater test	done
Pump test	done
Recirculation storage bypass filter	done
Recirculation Detector bypass filter	done
Drain from storage to detector	done
Drain from Detector to Storage	done

Cryogenics Readiness tests

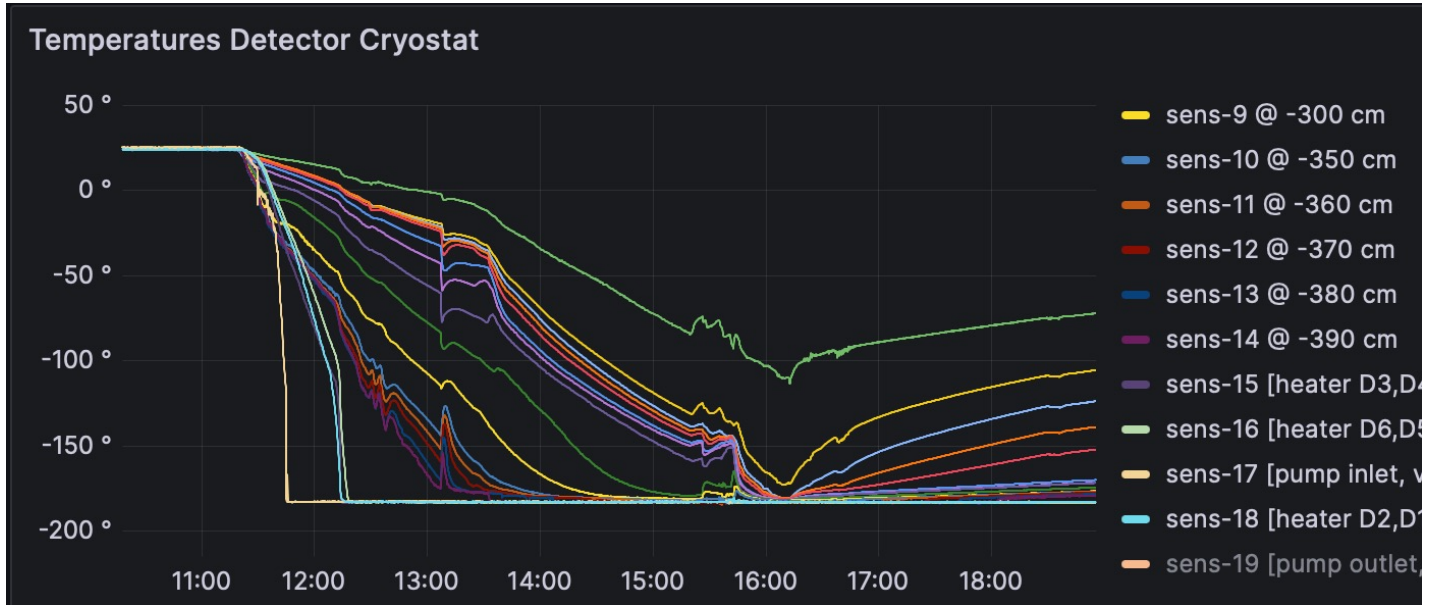
Cooldown Summary:

Filling rate: 9 lit/min (from the external tank)

8.3 lit/min (from level rise)

4 hours to fill 50 cm DP

Cryostat Volume gradient: 18.85 lit/cm

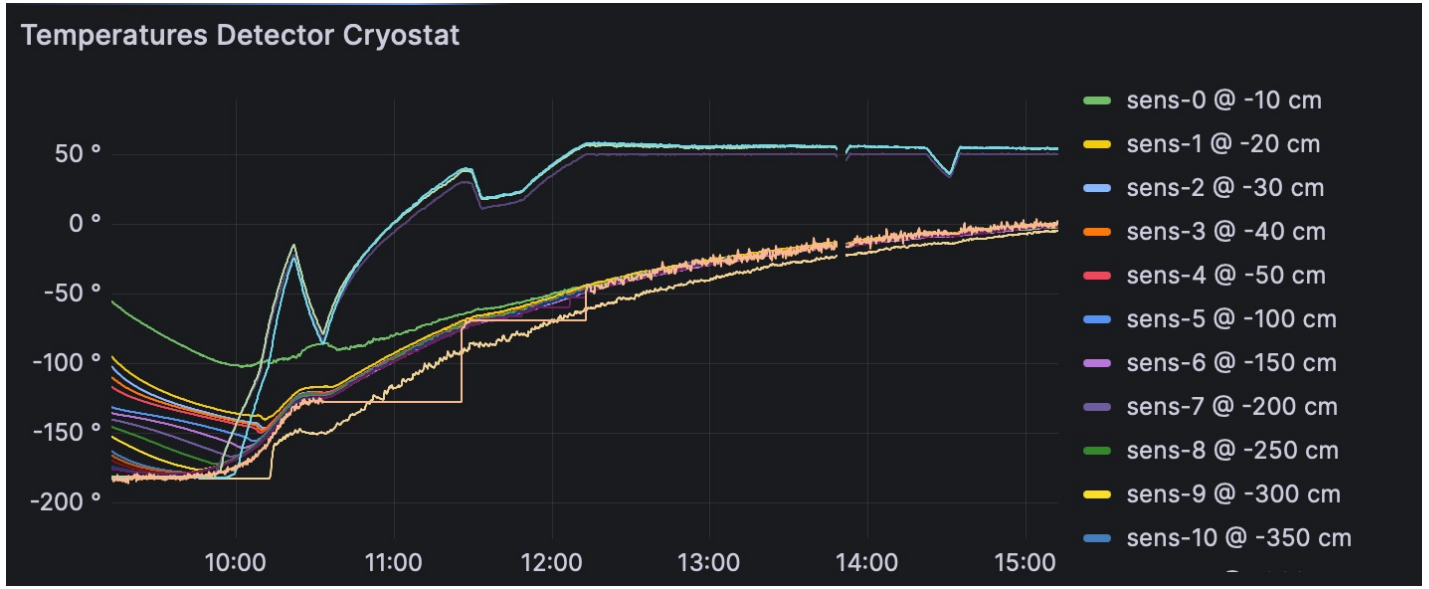


Warmup Summary:

Heater max power 3 kW -> regulating heaters temp at 50˚C max

Evaporation time: ~ 1 hour 15 min ->(85 liters)

Warmup Total time: 8 hours from LAr temp to ~ room temp



Cryogenics Readiness tests

Cooldown & Fill from external (2431 liters used form tank)

Storage level DP: 738 mm (Started transfer)

Cooldown and Fill Detector Cryostat

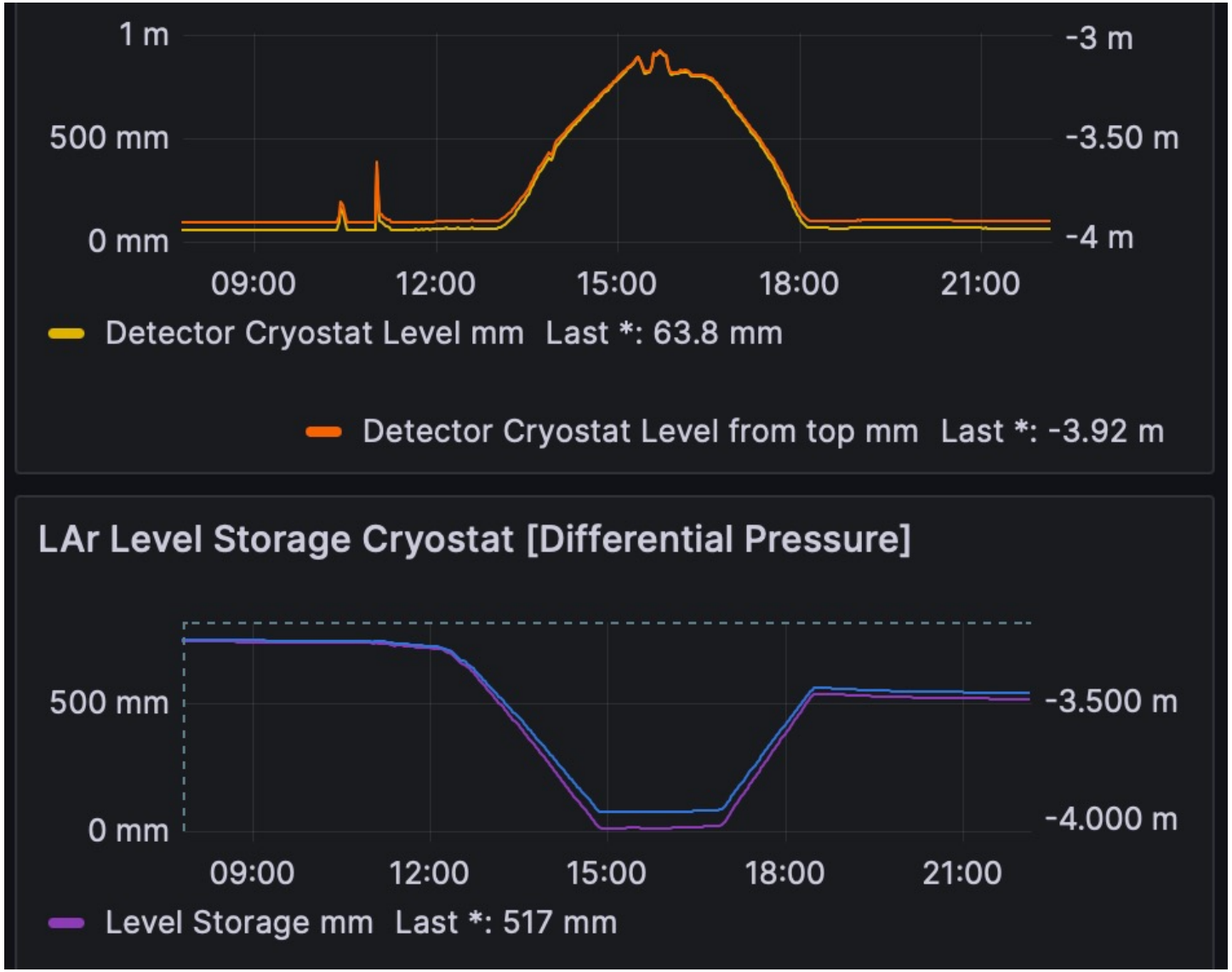
Detector Level DP: (calibration issue!, reads 840 mm, should be ~ 530 mm)

Transfer back to Storage

Storage level DP: 530 mm (End of transfer)

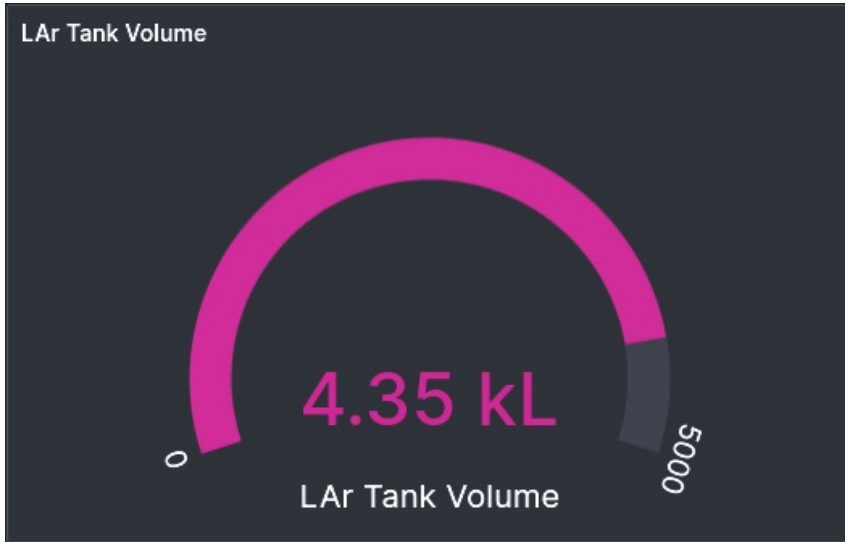
396 liters until differential pressure sensor is alive

Estimate about 100 liters stays in the cryostat



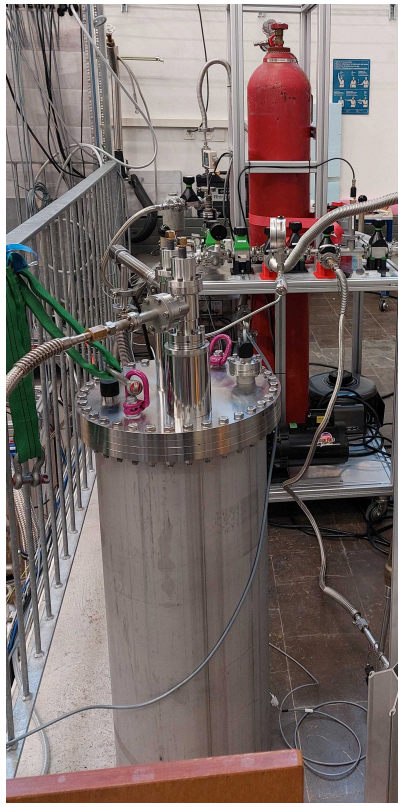
Filter Regeneration Stand

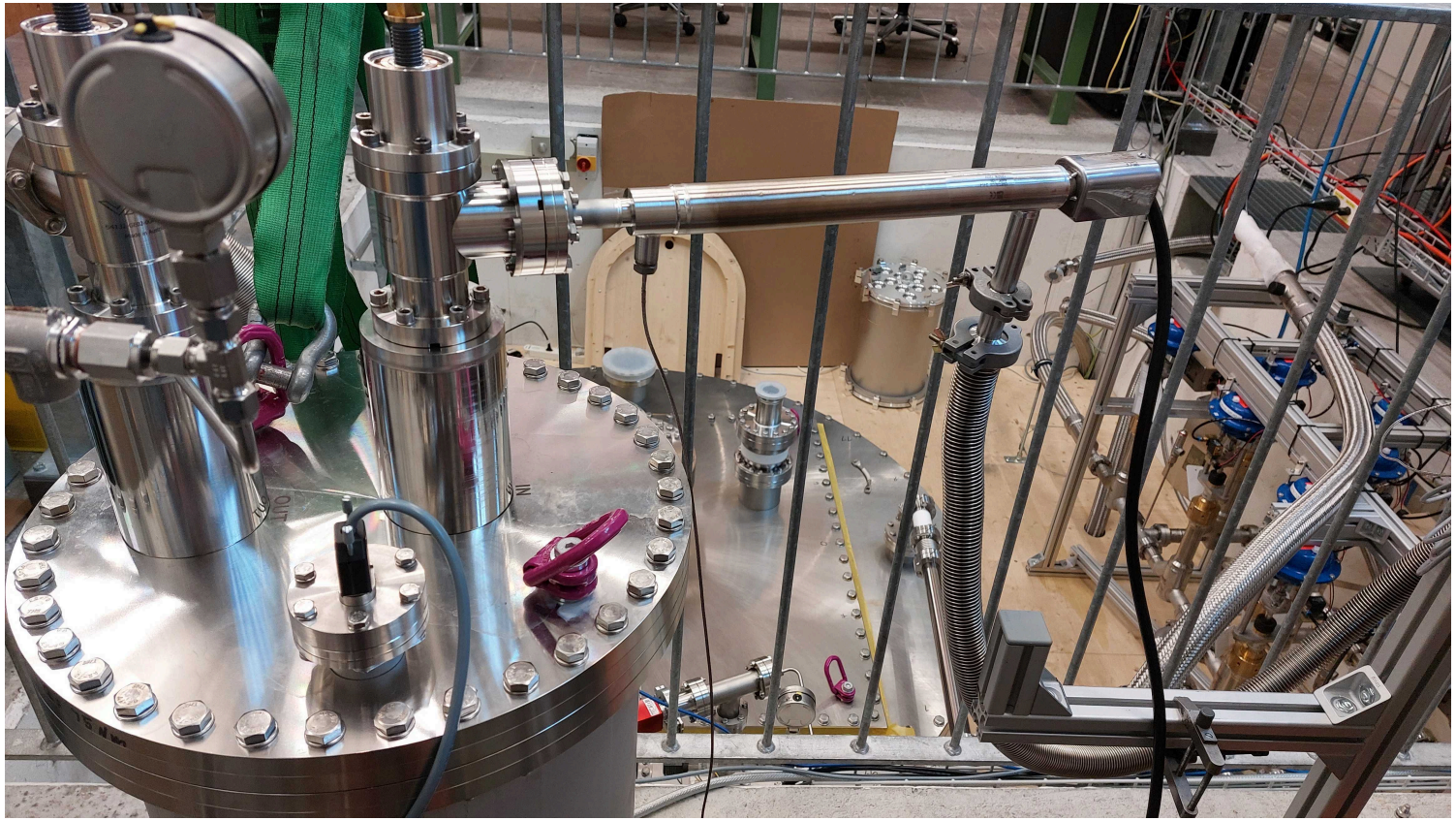
- Filter Regeneration Satand is ready
- Leak test was done
- Sensors are cabled to the PLC
- LAr delivery on 10 July -> Tank is full
- Regeneration stand was tested on 17 July



Filter Regeneration

- The Filling filter is regenerated
- The Inline gas heater is controlled with a Variac, 120V, 10 A
- Regeneration took about 3 days





Filter Regeneration

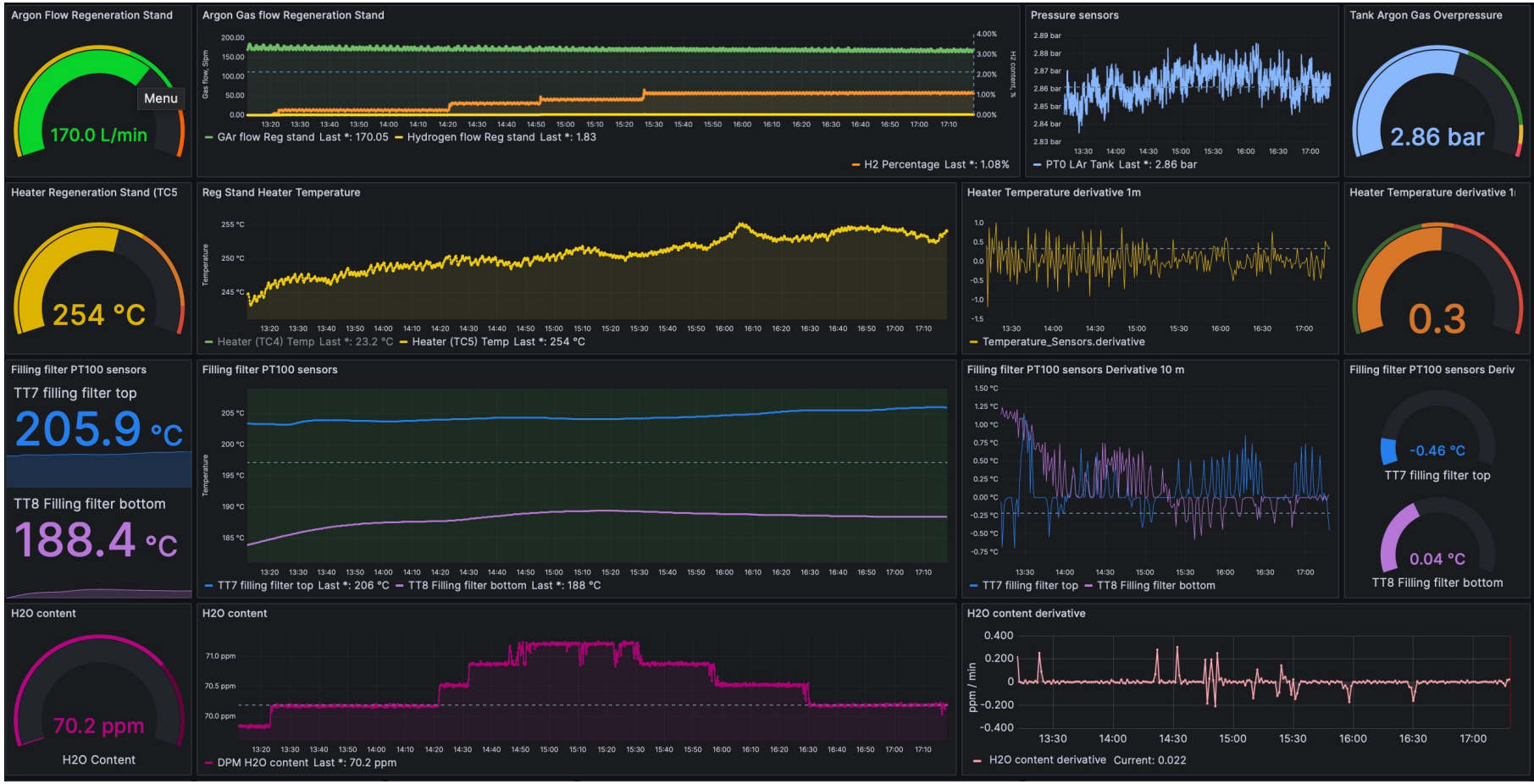
Day 1

- Started with very small amount of H2 concentration 0.2 %
- Went up to 0.5%, 1%, 1.5%
- Filter temp sensors showed some bumps for reduction process
- H2O sensor showed between 80 to 100 ppm water concentration
- Late in the evening Filter temp had a bump to max 229 C.
- We stopped H2 flow over night,

Filter Regeneration

Day 2

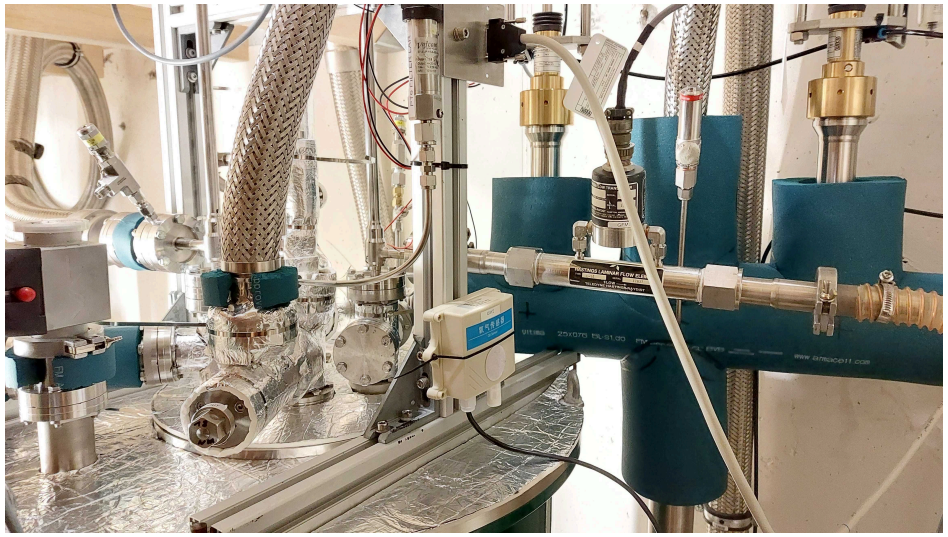
- Started again with 0.2 % H2
- Went up to 0.5%, 0.75%, 1%
- Temperatures stayed stable
- We had a bump in H2O, and then started dropping
- At 3pm H2 bottle was empty, we stopped the regeneration



Installation of Insolation material

- Armaflex Ultima tubes of different diameters for cryo lines (Blue)
- Special insolation material for filter parts exposed to hot temperatures (White with Alu foil)

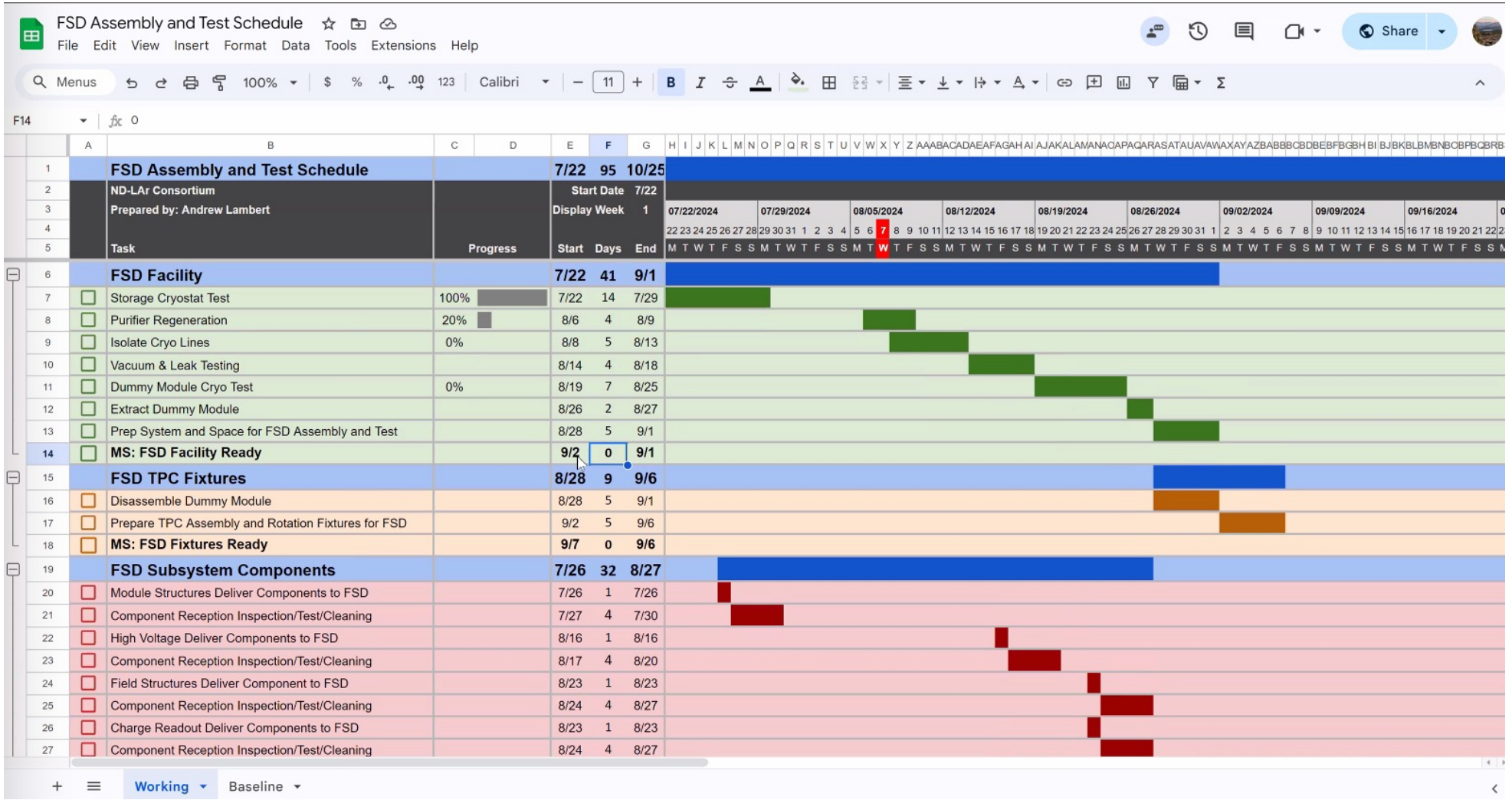
Top platform 0



Platform -1

Platform -2

FSD Test Schedule



Highlights of the FSD facility schedule

- Installation of the Cryogenics finished end of May
- Dummy module assembled and inserted into the detector cryostat end of July
- End of August 2024: Cryo run + Mechanical test
- Reception and Assembly of the FSD Module end of August?
- End of September 2024 ? : FSD run

• Assembly jig	✅
• Module structure (mechanical test)	✅
• HV filter	✅
• ArcLight/LCM	August
• Charge readout	August
• Light readout	August
• Field shell	August
• Calibration system	August?

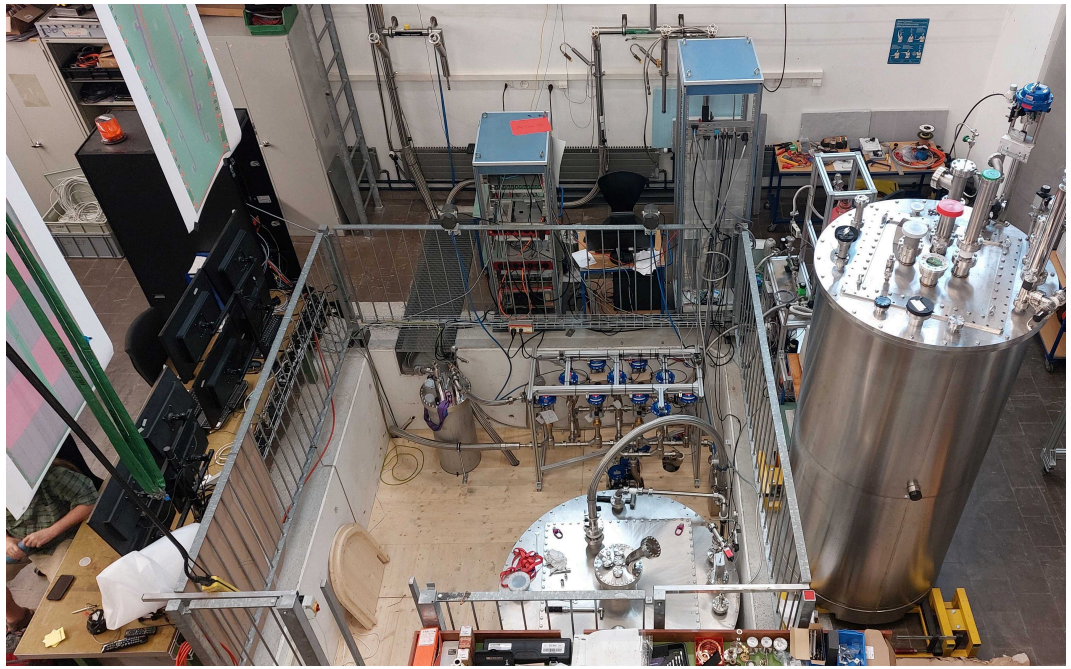
- DAQ? What are we going to use?
  2x2 run control software? Need support!

Thanks to everyone for supporting this effort!

Next steps

- Isolation material on the cryo lines On going
- Seal the top, Evacuate and leak test

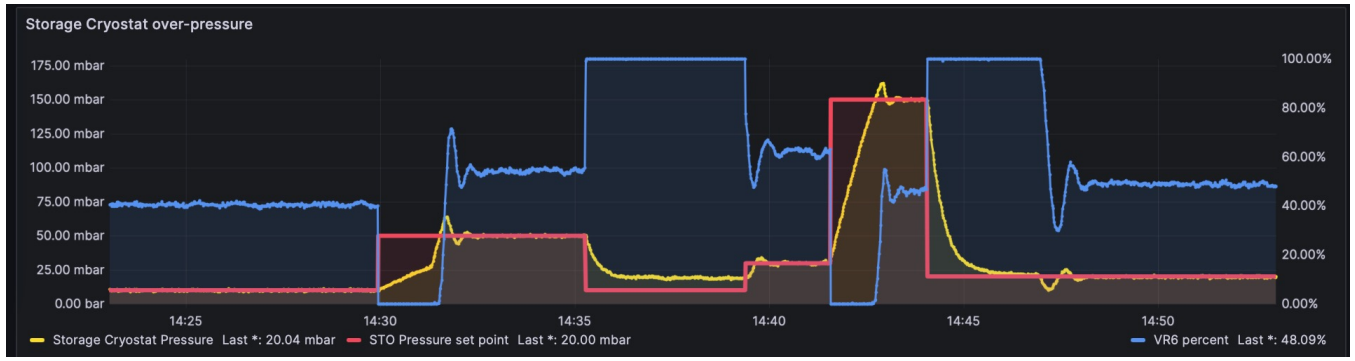
PLC work & Grounding work continues in parallel

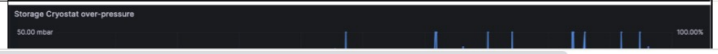


Backup

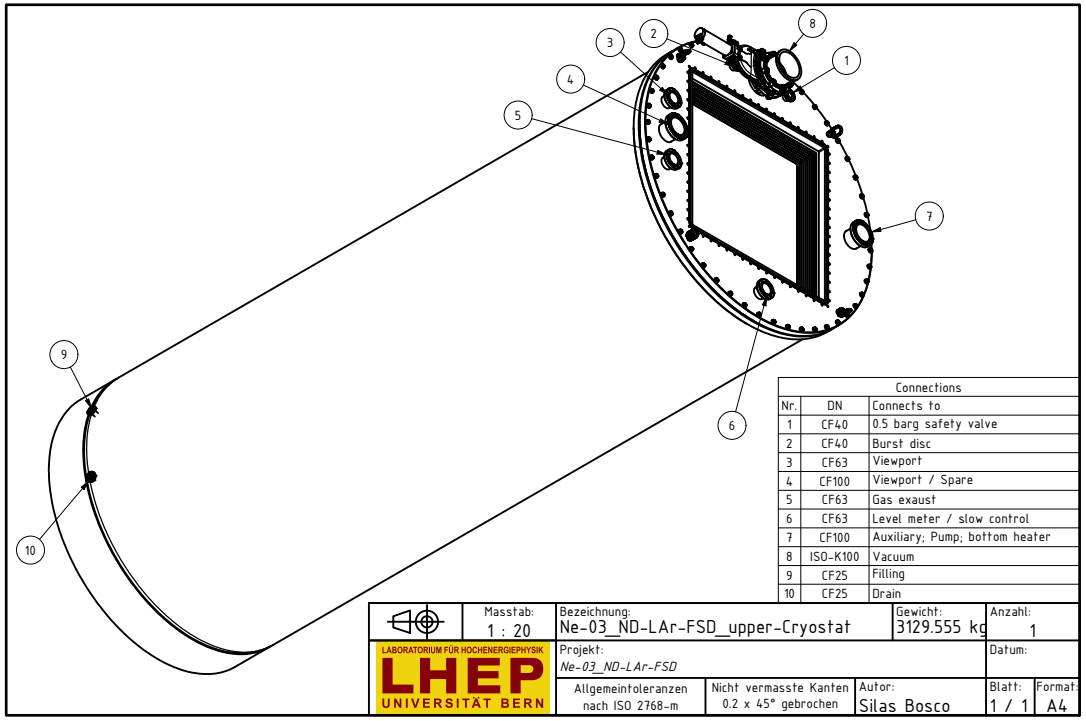
PLC Programing

- Cryostat Pressure Control PID is working
- Tuned PID parameters for overpressure

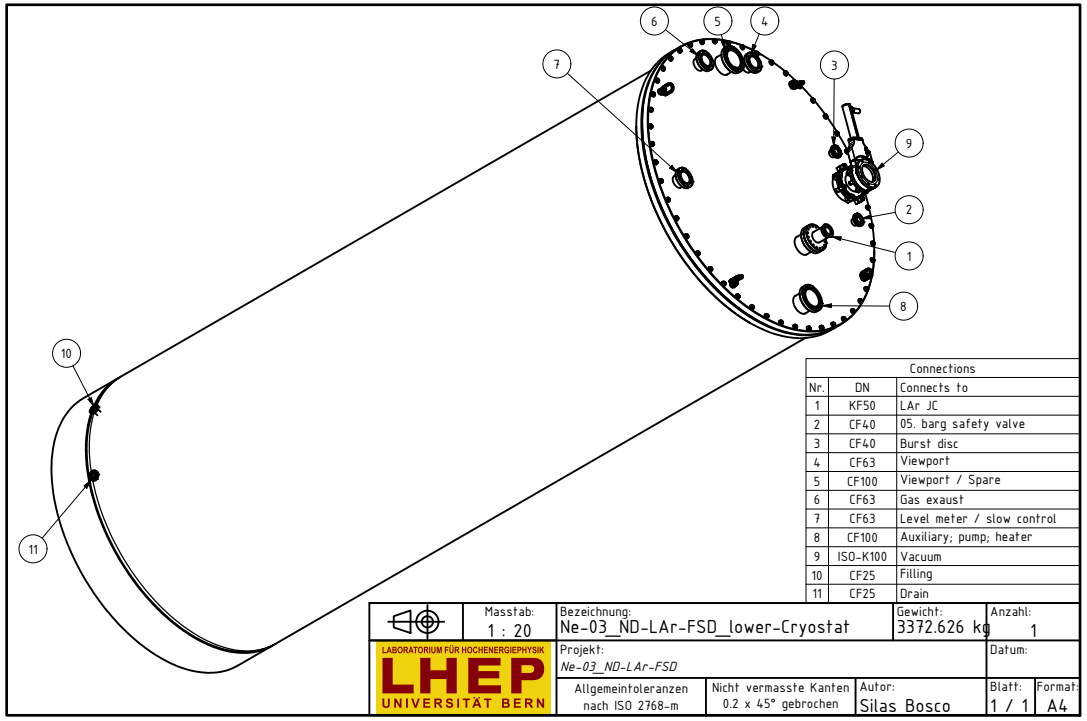


Test	KP	Tn	Tv	Td	Plot
1	1	200000	0	0	
2	1	200000	100	0	
3	1	200000	1000	0	
4	1	200000	10000	0	
5	1	200000	100000	0	
					

Cryostats for Detector and Storage



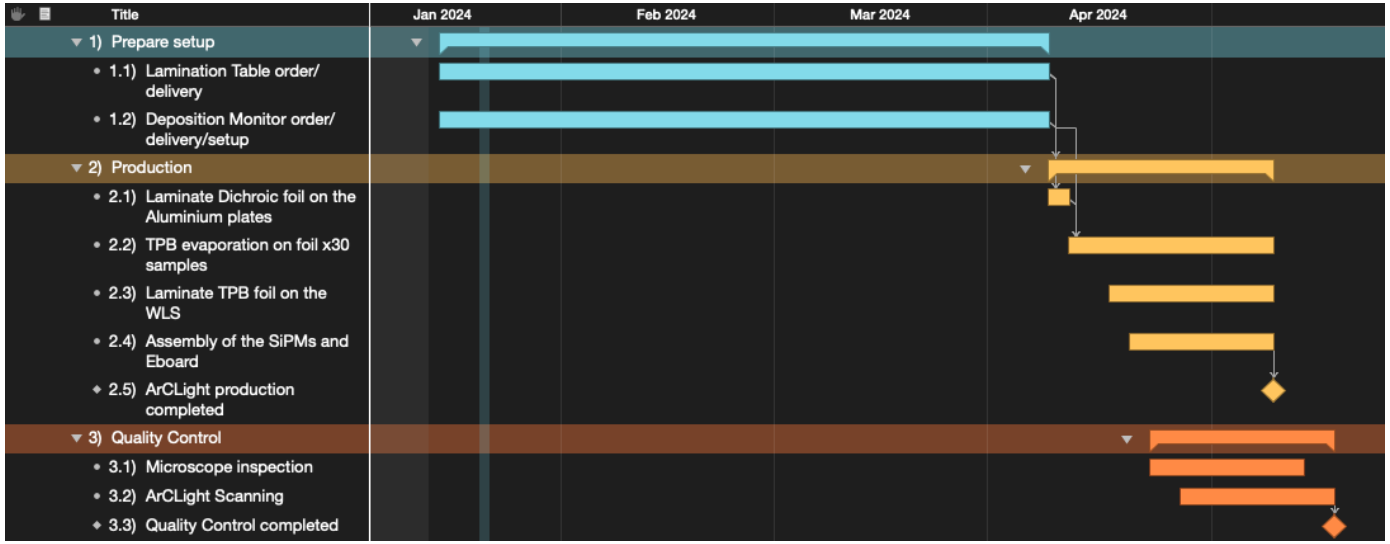
Detector cryostat

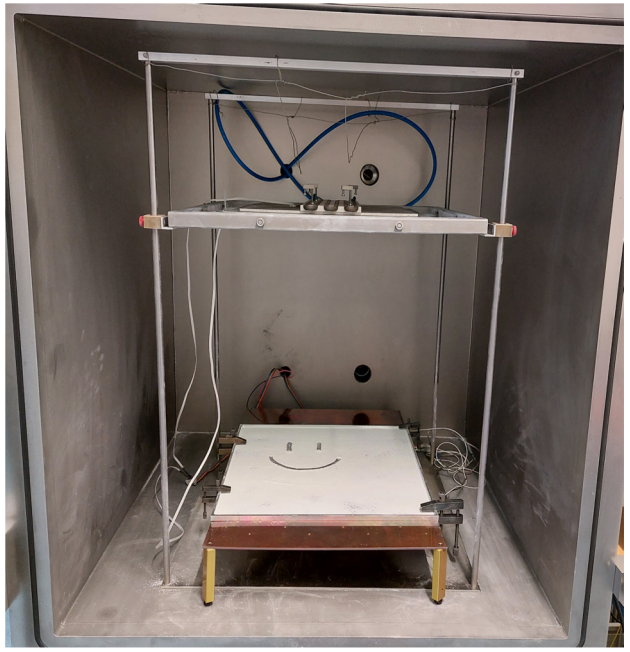


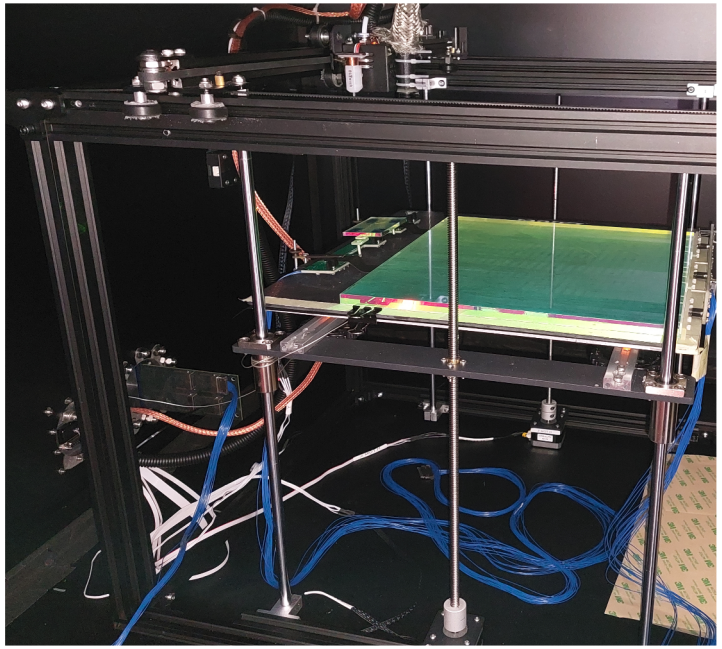
LAr storage cryostat

ArCLight production

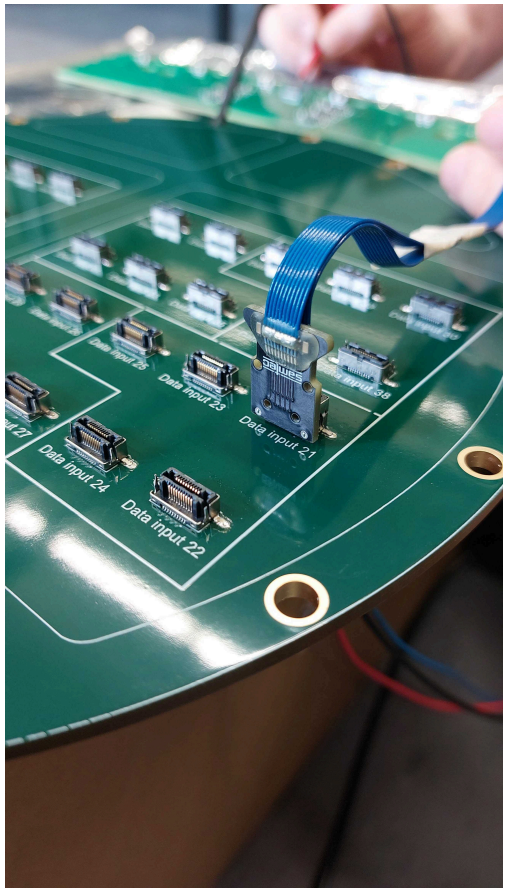
- Preparation for large scale production
  - Automated Lamination table
  - Revival of the clean room (controlled environment -> Humidity, dust)
  - Deposition sensors
  - Anti-static gun for surface treatment
- Production in April (after 2x2 commissioning)
- Quality control tests
  - Optical inspection w/ Microscope
  - LY scanning of the surface w/ LED

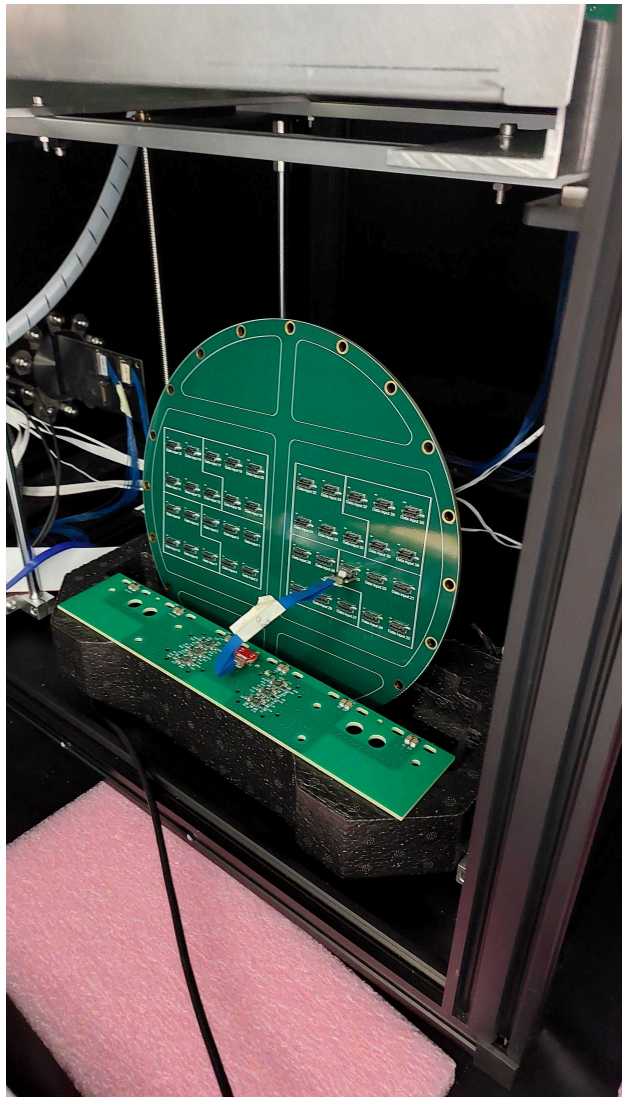


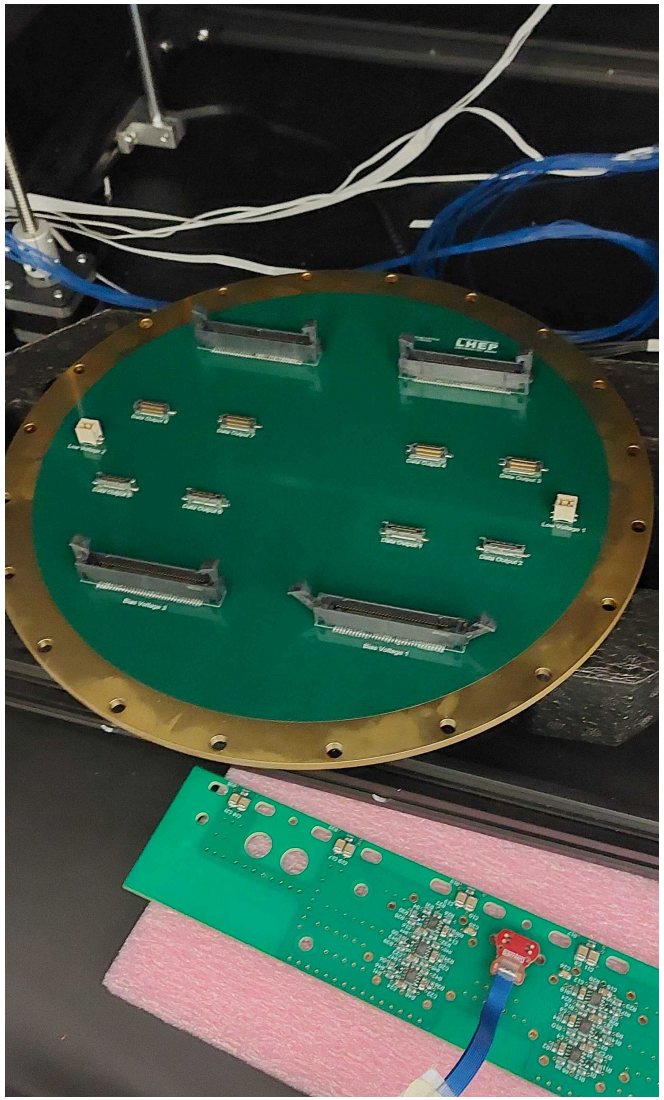




Light readout feedthrough testing







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DEEP UNDERGROUND NEUTRINO EXPERIMENT