Updates on the cold box

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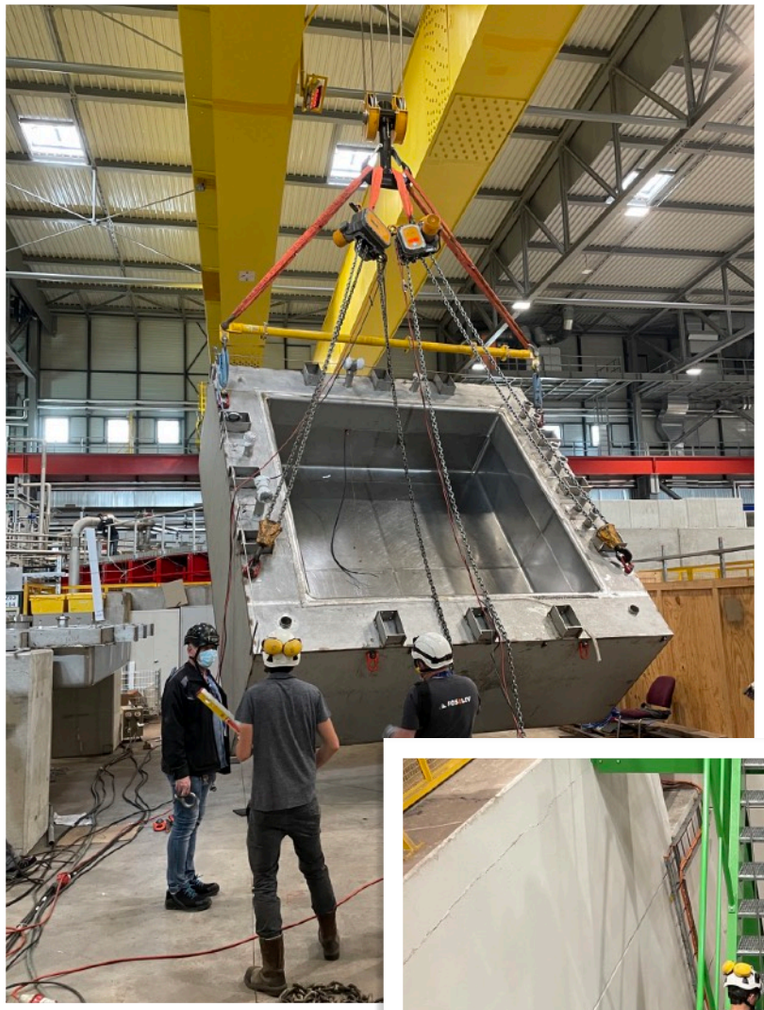
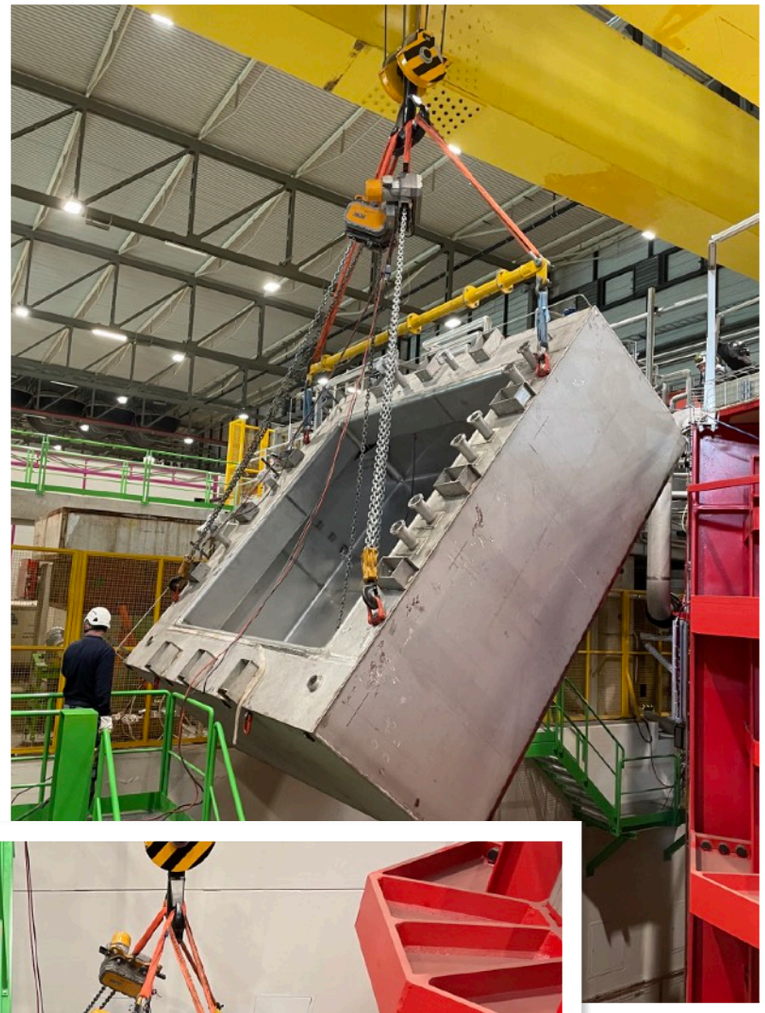
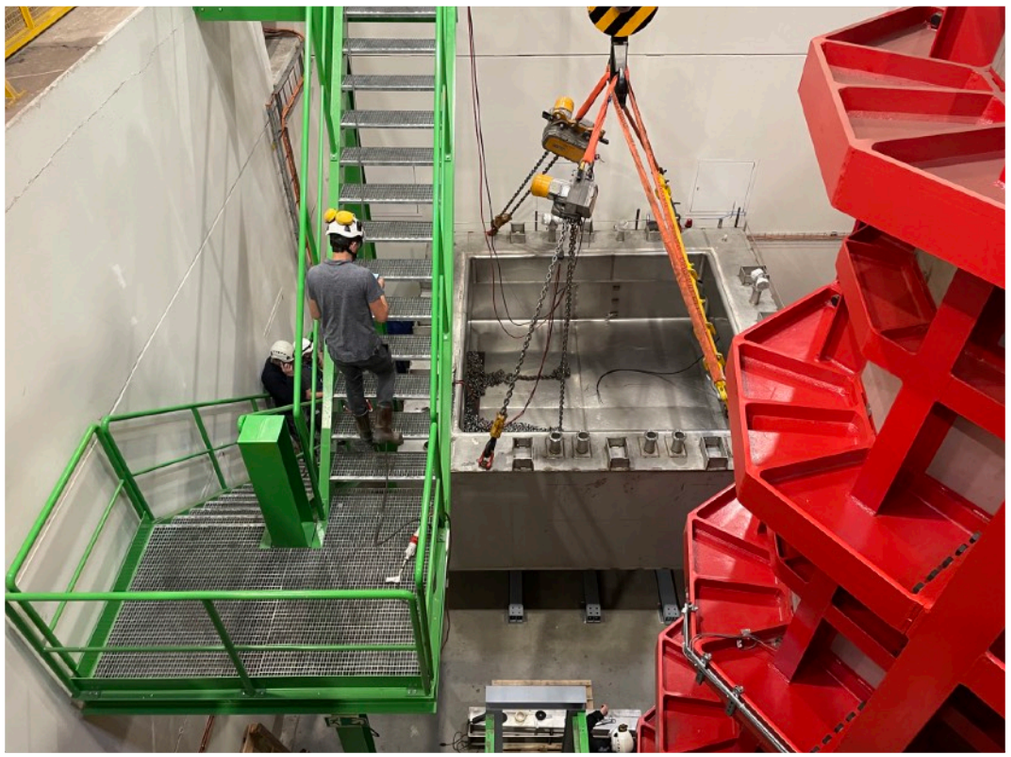
LBNC - Vertical Drift Update - 15th November 2021

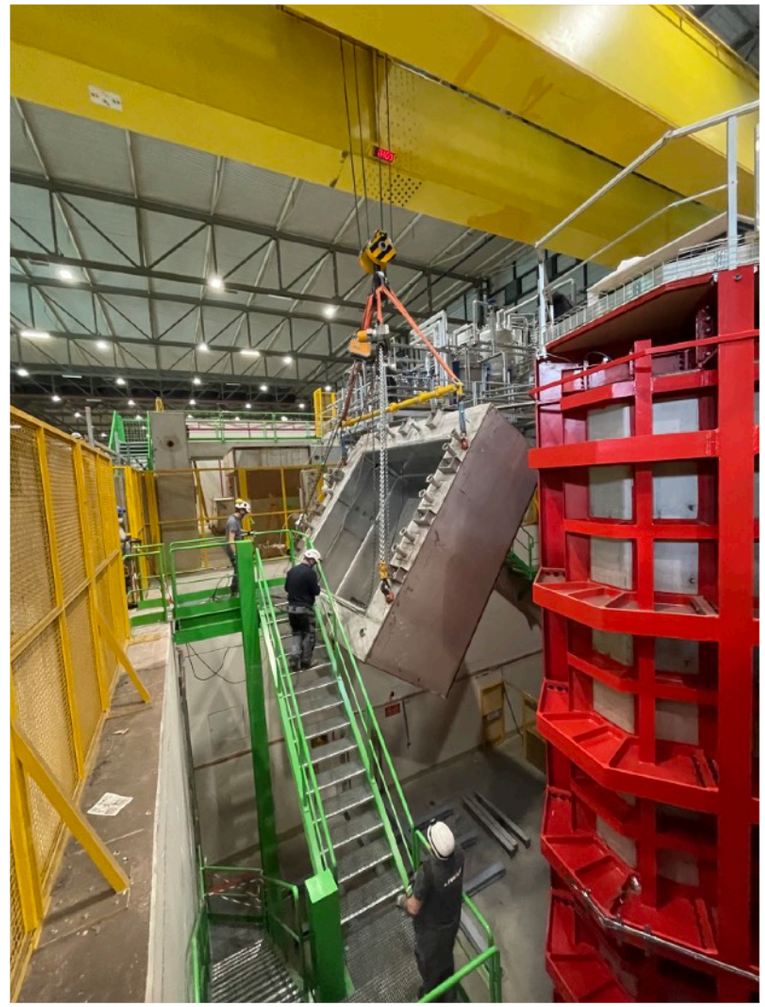
Cold box installation

7th of June





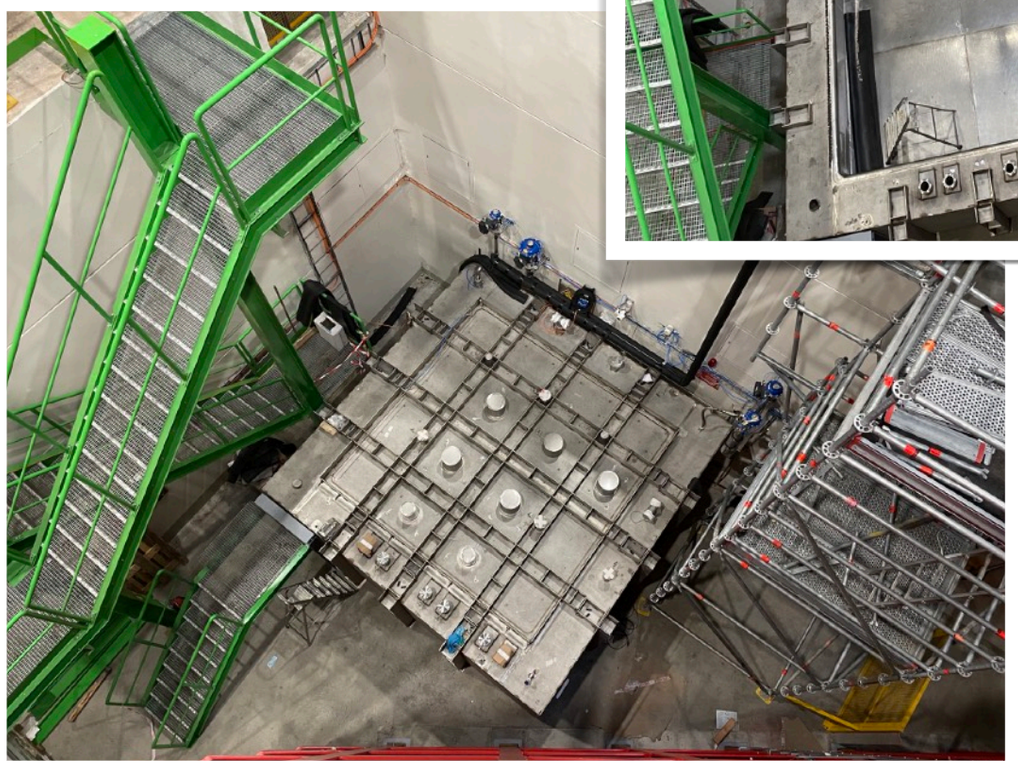




Cold box completed

End of July, mid of August

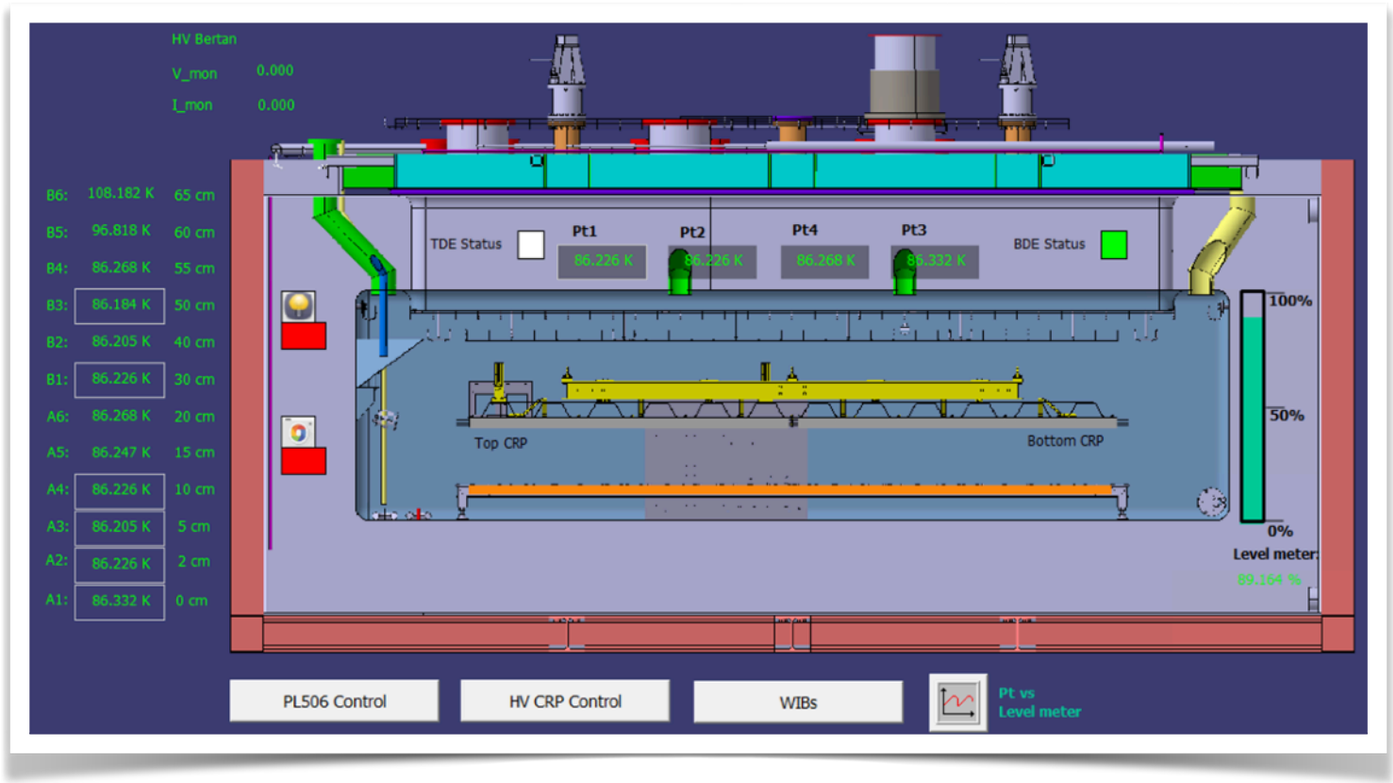
Roof modification complete
Installation of the cryogenic system, cryo valves and pipes
Leak tests:
- Insulation/Ar -> no leaks found (< 5 e-7 mbar.l/s with He sniffing)
- Ar/air -> leaks found with Ar sniffing.
- Improved gasket sealing and repaired the leaks found
- Global residual leak ~0.1 l/min at 30 mbarg



Instrumentation

Final instrumentation available in the cold box:
- Three cryogenic cameras and LEDs
- Vertical array of 12 temperature sensors from 0 to 65 cm
- Heaters (15 kW) and relative temperature sensors
- Capacitve level meter on a wall
- 4x temperature sensors and 6x capacitive level meters on the CRPs
- A purity monitor on the floor
- Relative and absolute pressure sensors for the argon volume, for the GN2-filled insulation space, and for the GN2-filled top electronic signal feedthroughs

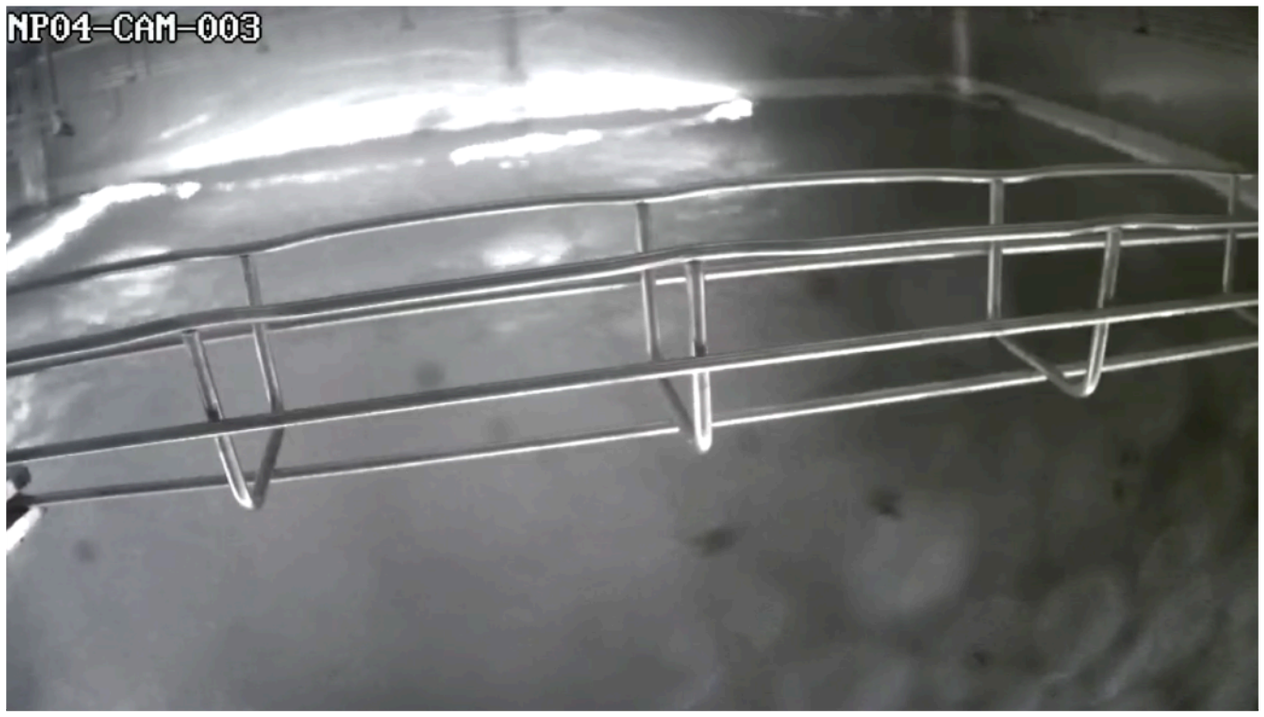
Supervision and control program: levels, temperatures, pressures, LV and HV PS controls, …



First commissioning

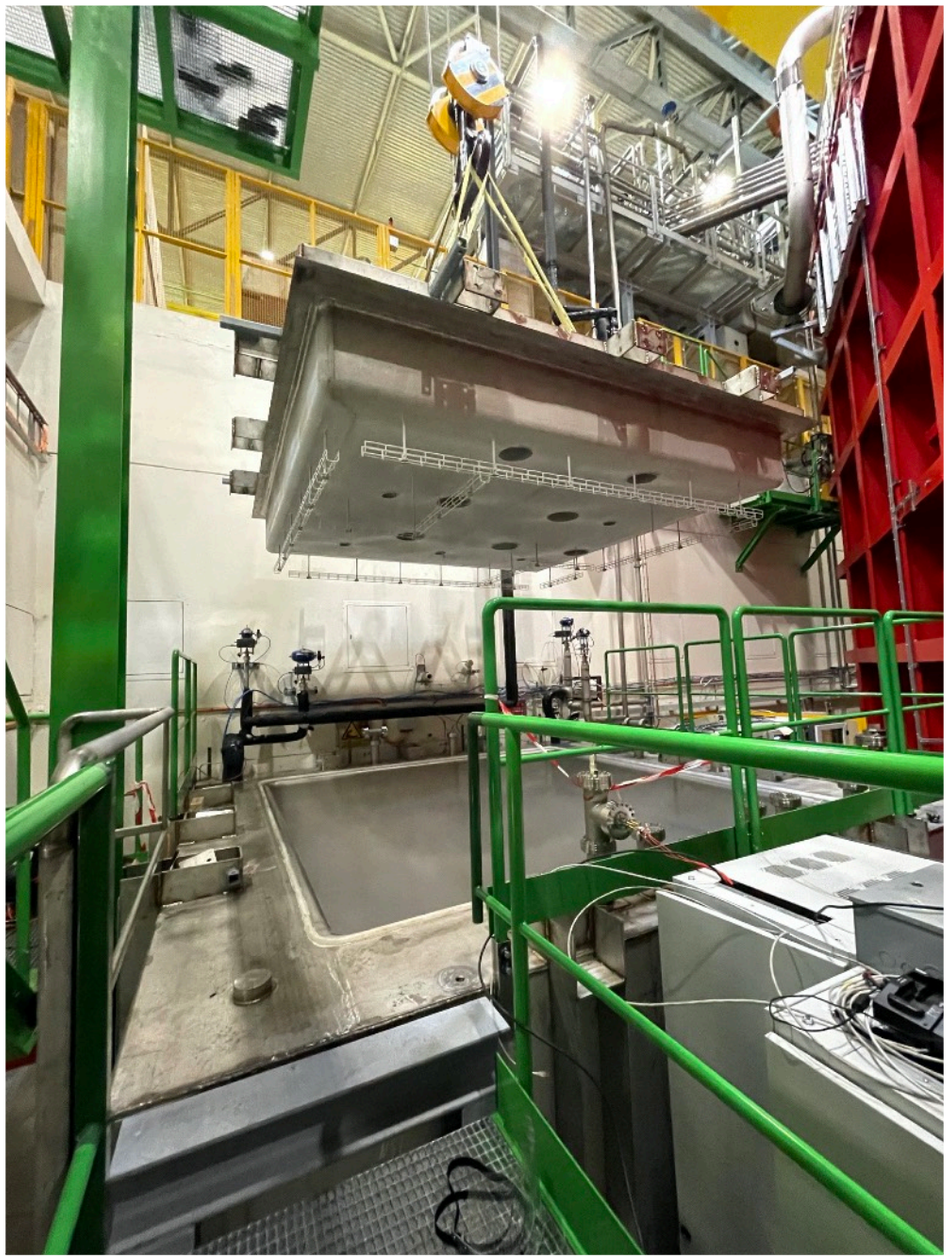
The purpose of the first commissioning
- demonstrate the cold box performance in terms of leak tightness and heat insulation
- validate the capability of the cryogenic system to cope with large heat input from the heaters
- optimise the filling, operation, and emptying processes.

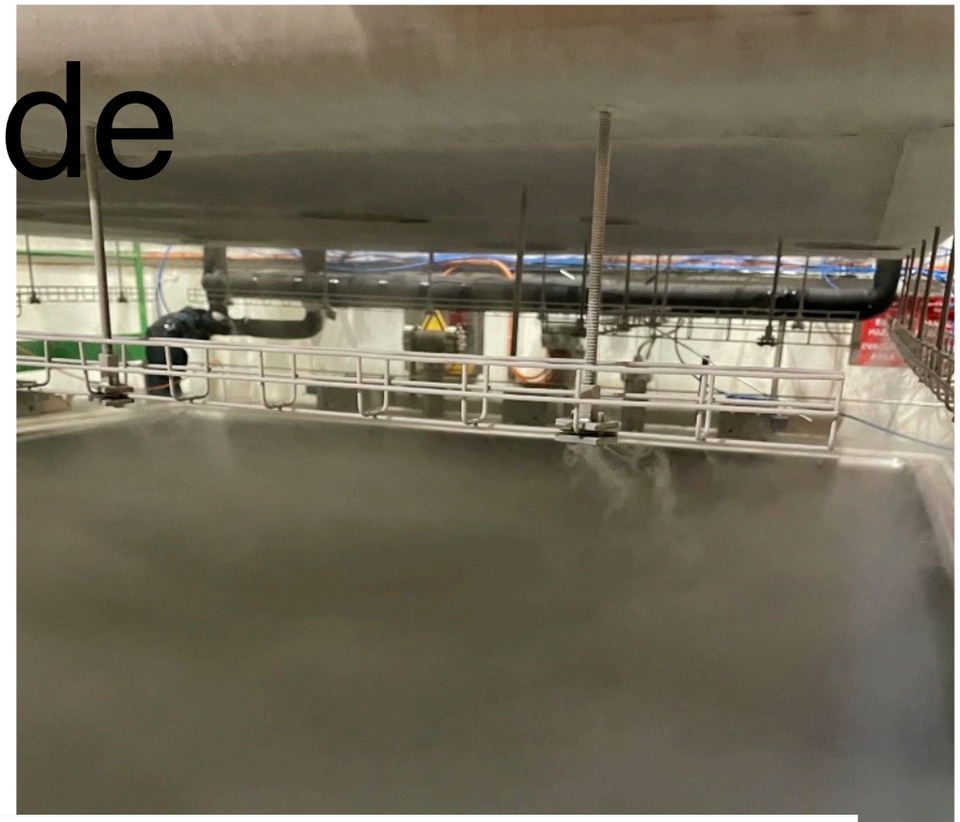
Purged for about a day, filled on the 23rd of September. Test lasted one week.
Liquid argon taken from the output of the purification cartridges of NP02.
The cold box filled at about 70% (40 cm) of its full capacity.
Heat input from the cold box estimated (by evaporation rate) to be 700-800 W.
No cold spots and no leaks detected.
Pressure and the level kept constant re-condensing the boil-off.
Purification bypassed, (cartridge needed to be regenerated).
The cryogenic system able to cope with more than 5 kW additional heat input from the heaters.

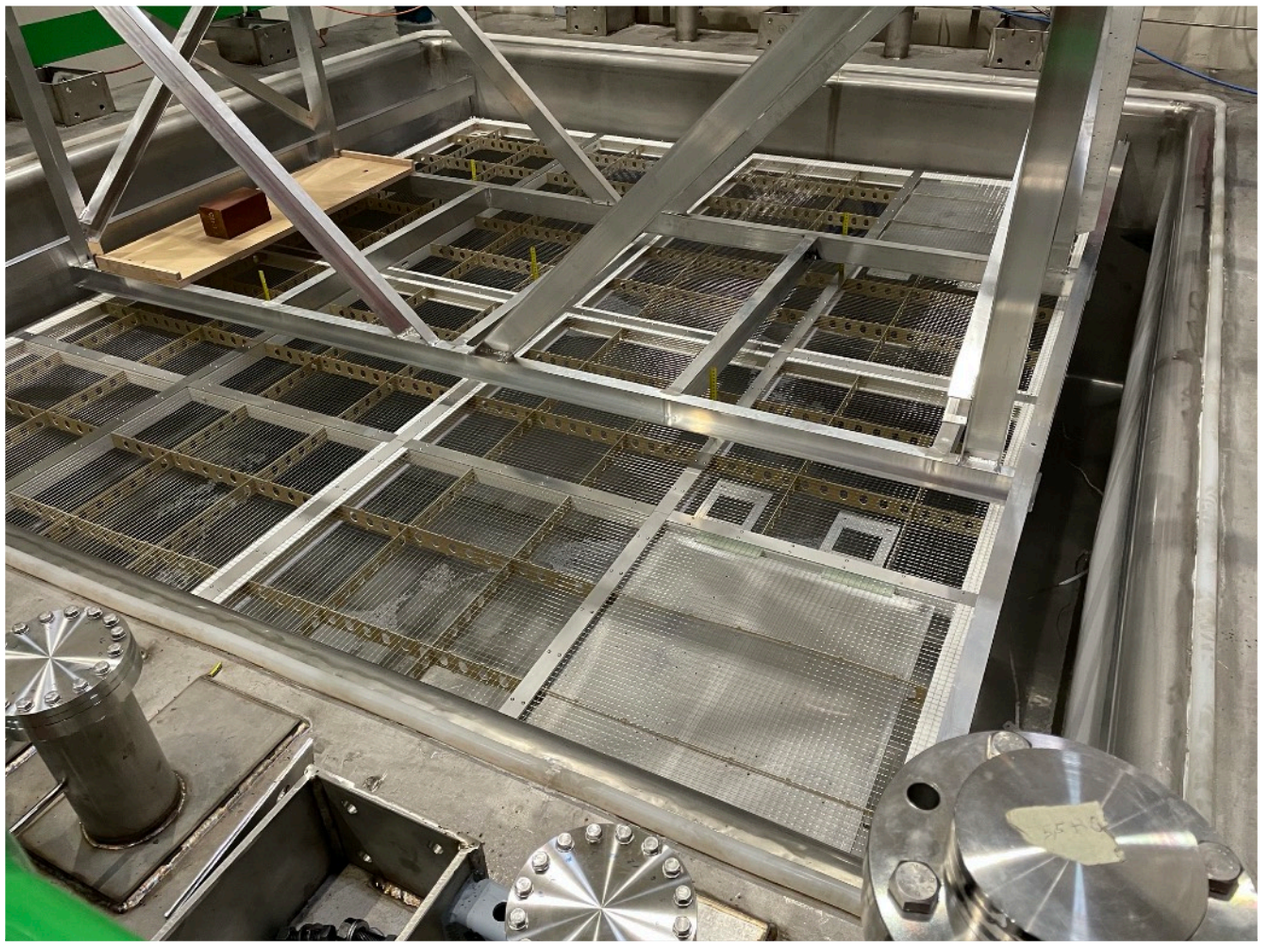


Cryo test of the cathode

Before removing the argon from the cold box, cryo test of the cathode (without PDs) immersing it in LAr bath:
- Deformation only during cool down (caused by temperature gradient)
- No failure observed







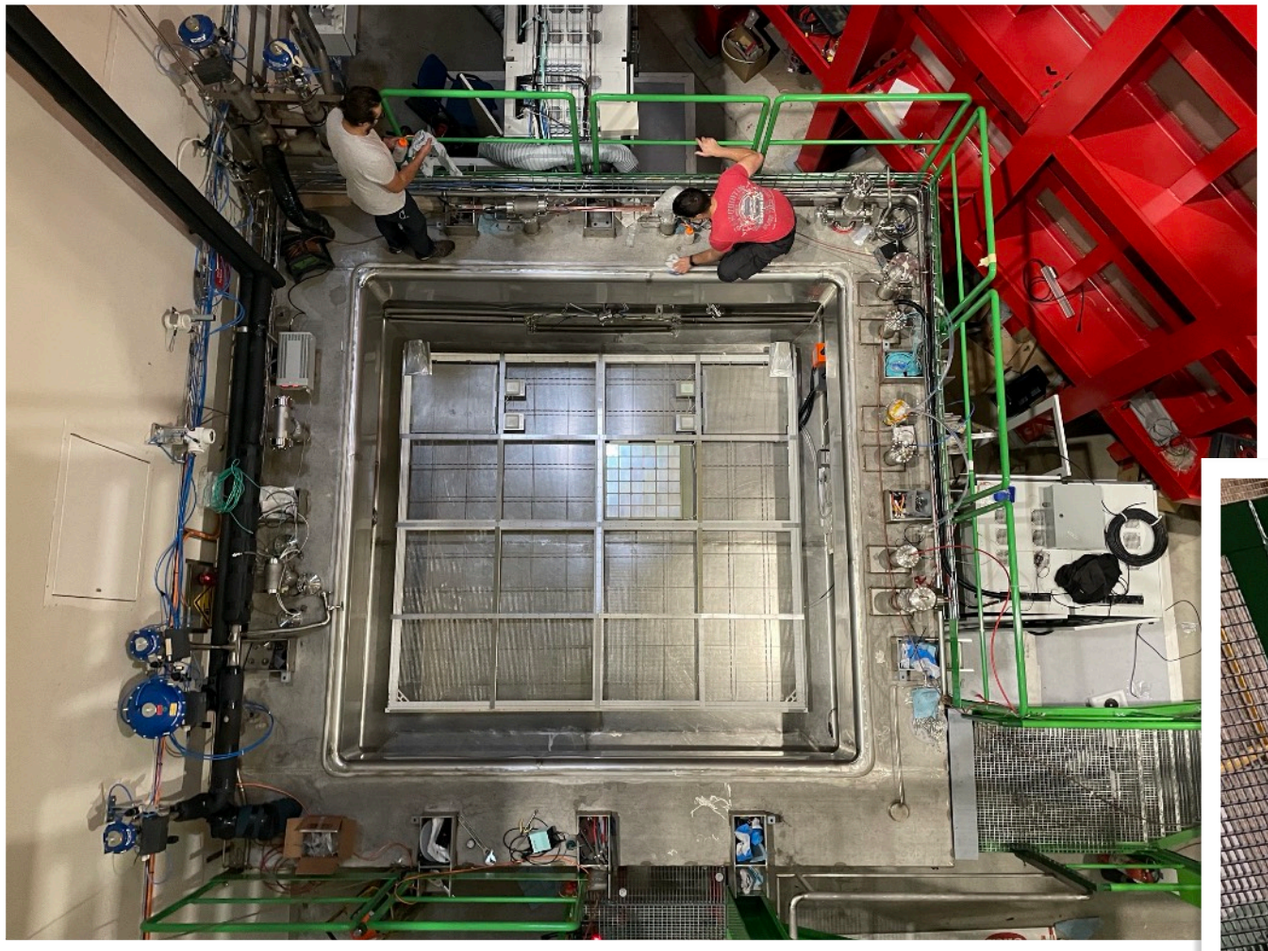
Purity commissioning

The purpose of the second commissioning
- demonstrate the liquid argon purity
- operation of the purification circuit.

Improve the purge -> purge manifold completed and leak tested.
Purged for several days. Cold box was filled on the 13th of October. Test lasted two days.
LAr was taken from the storage tank, purified through the NP02 cartridges (NP02 re-circulation and condensation needed to be stopped).
Right from the filling the drifting electron lifetime larger than 200 us.
Purification and the re-condensation operational (test too short to see purification effects).
Purification cartridge regenerated in anticipation of the first TPC operation.
The achieved purity allows to record right from the filling full drift length tracks.
Cold box emptied and opened. Final flanges welded on the roof to accept feedthroughs.

Installation

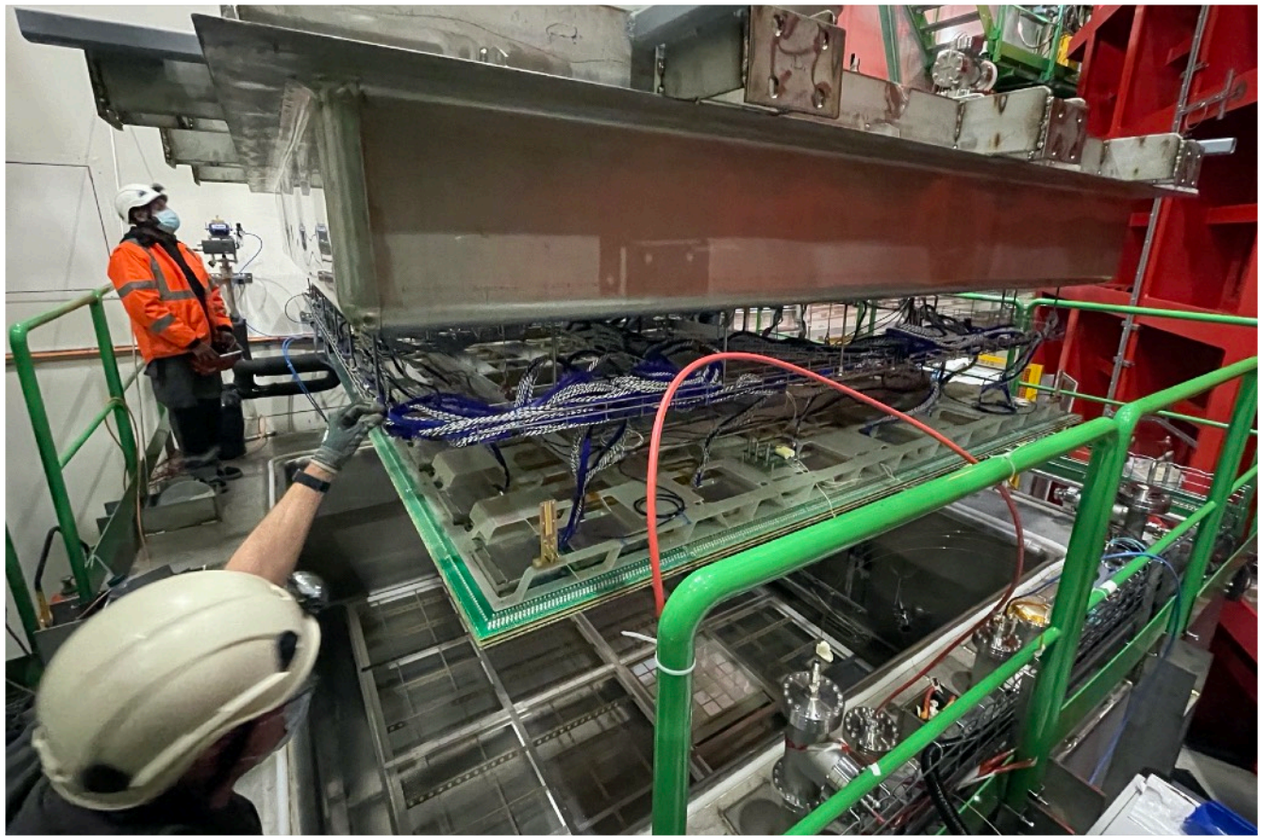
Cathode structure assembled in clean room of building 185.
PD integrated in the cathode in NP04 clean room
CRP constructed in building 185 and transported to EHN1 on 20th of October



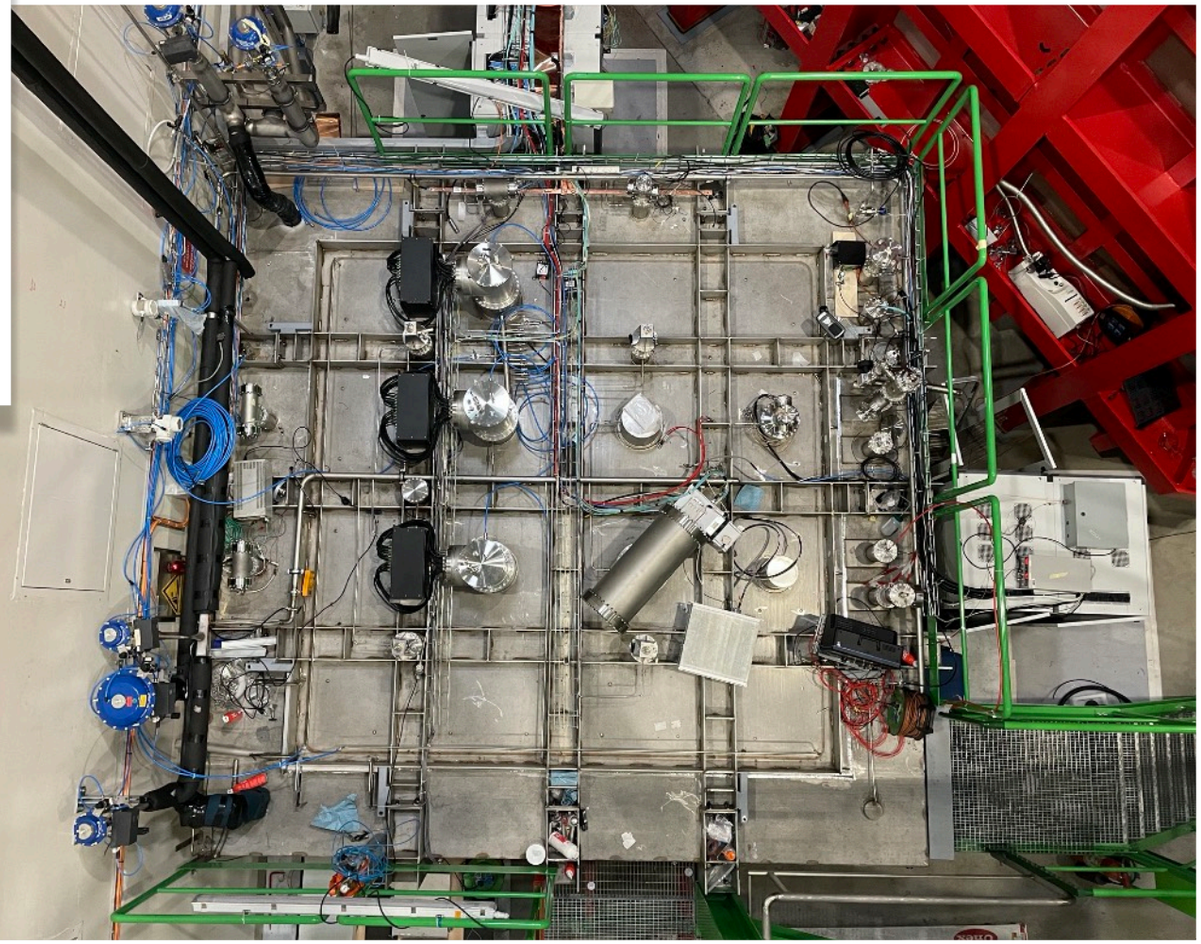
Installation from 21st - 25th of October

Installation

Cold box closed on 25th of October

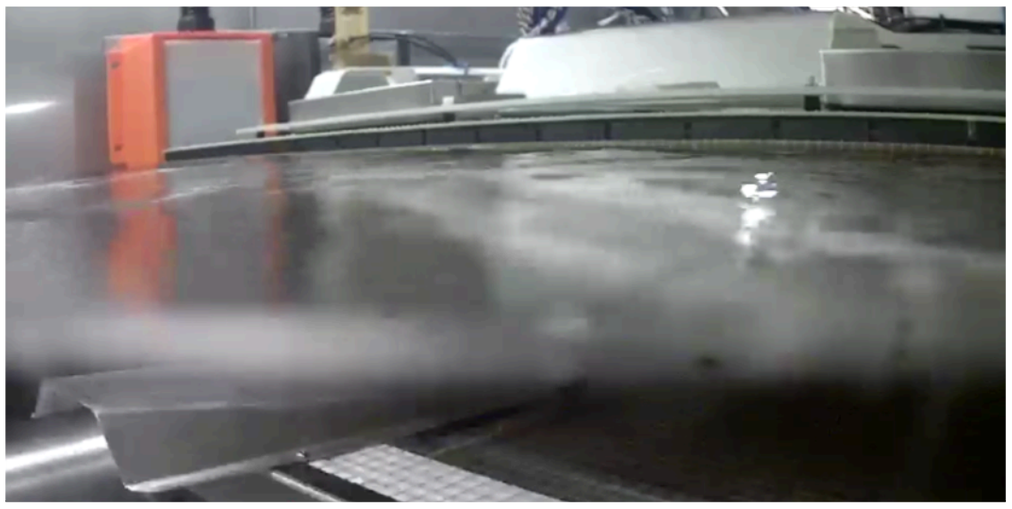


Roof fully instrumented by the 29th



First run with TPC

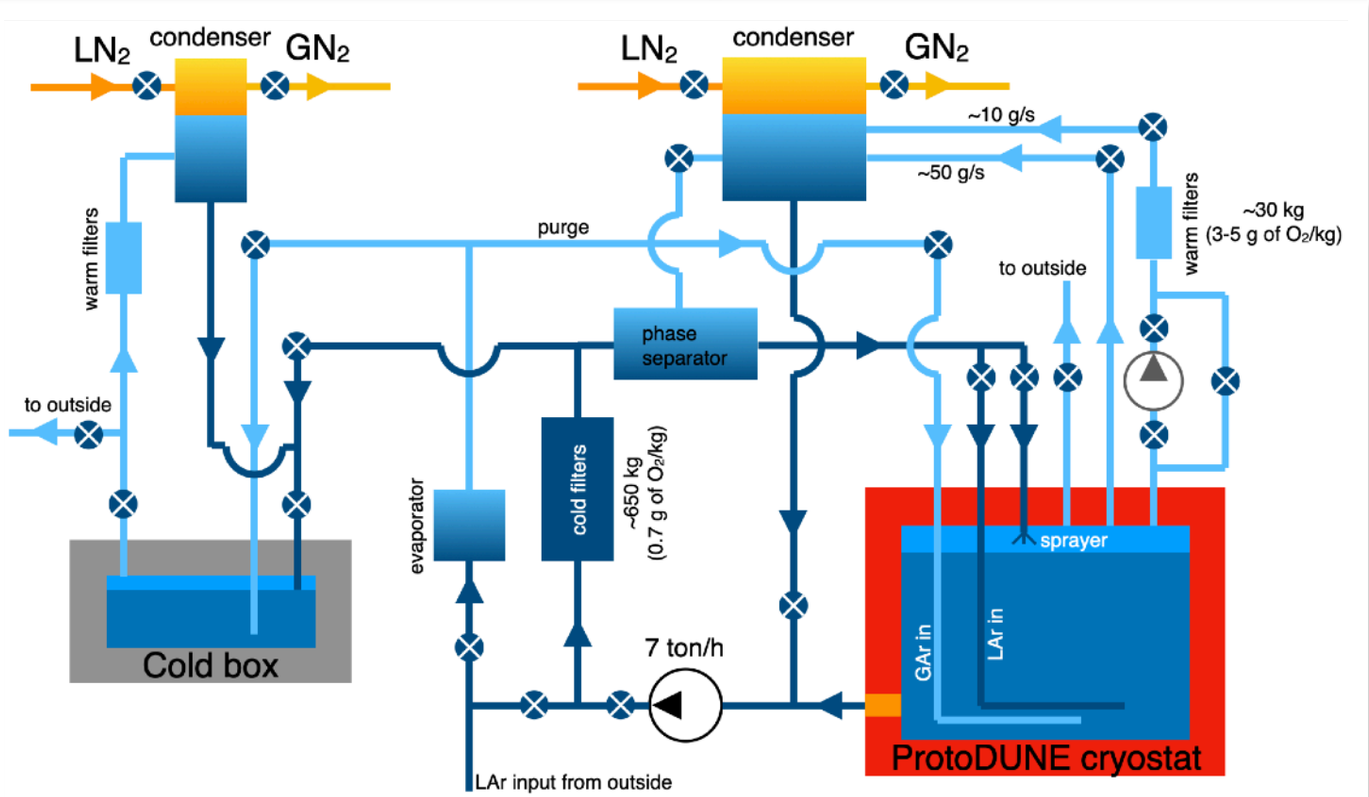
Purged for one week. Filled on the 4th of November (60 cm). LAr from the outside tank.
Filling start ~10:30 completed at ~21:00. LAr purity regularly controlled during filling.
LAr purity increased as the filling progresses:
Drift electron lifetime from 100 us at the beginning reached > 500 us when the box was full.
Effect of the dilution of the initial impurities in more and more pure liquid argon, without input of additional impurities.
Re-condensation (and purification) activated when reached nominal level.



First run with TPC

~20 min after activation of the re-condensation it was realised that the purity was completely lost: No PrM signals and several tens of ppm O_2 in argon vapour.
The condenser, while being activated, went under pressure, presumably sucking air from a not perfectly sealed overpressure valve.
The day after profited to exercise the activation of the condenser.
Voluntarily replicate the under-pressure in the condenser:
- no information from PrM (LAr too dirty already)
- no variation in the O_2 content in the vapour, and PrM

Mitigations:
- establish a more robust procedure to avoid the risk of under-pressure
- improve the control program in this respect
- next time wait to activate the condenser



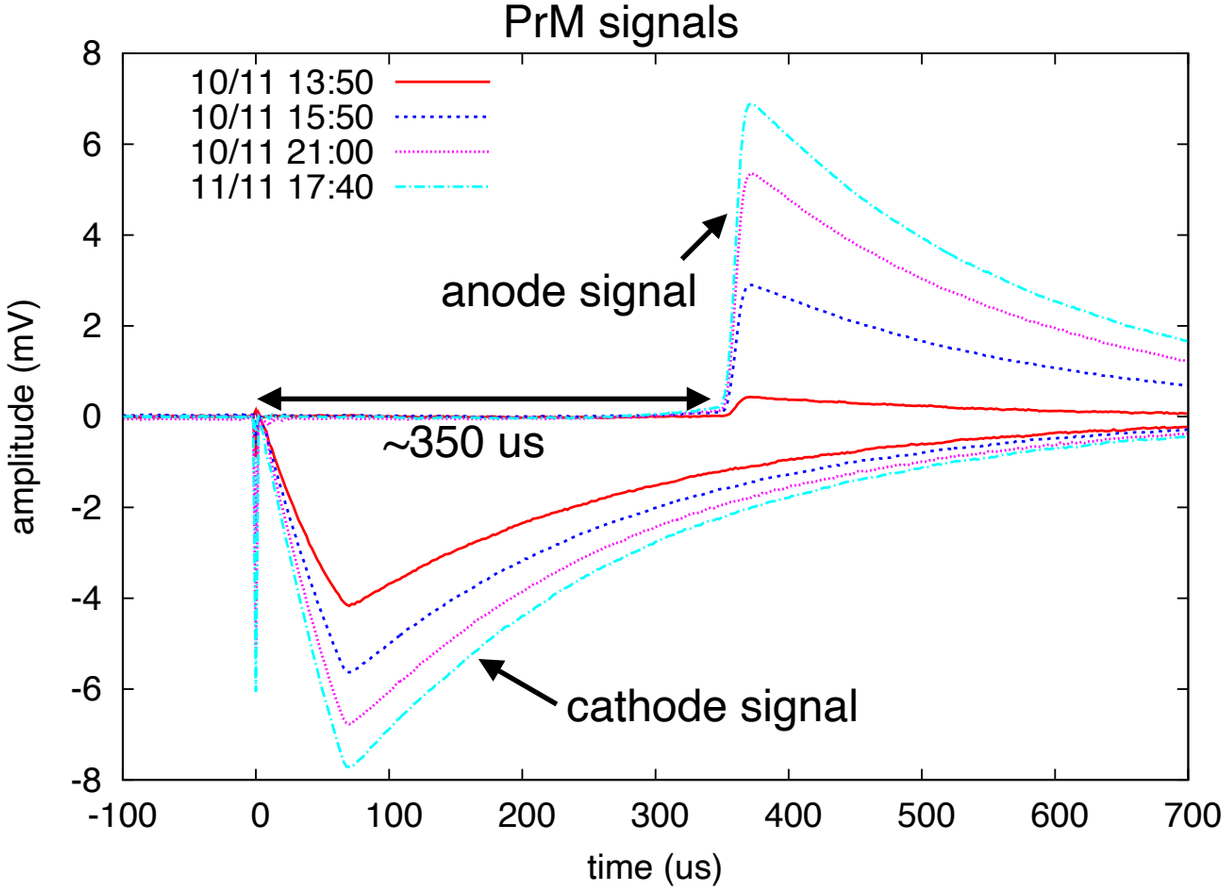
Actual run

Empty process started on the 6th of November.
Cold box lid stayed in place. When empty took the occasion to work on three penetrations:
- spare -> improve grounding on the CRP metal frame
- BDE -> improve the noise
- CRP level meters -> change broken connectors

Purged for one day. Filling done on the 10th of November.
Filling started ~11:00 and completed ~16:30. LAr taken from NP02 (much faster).

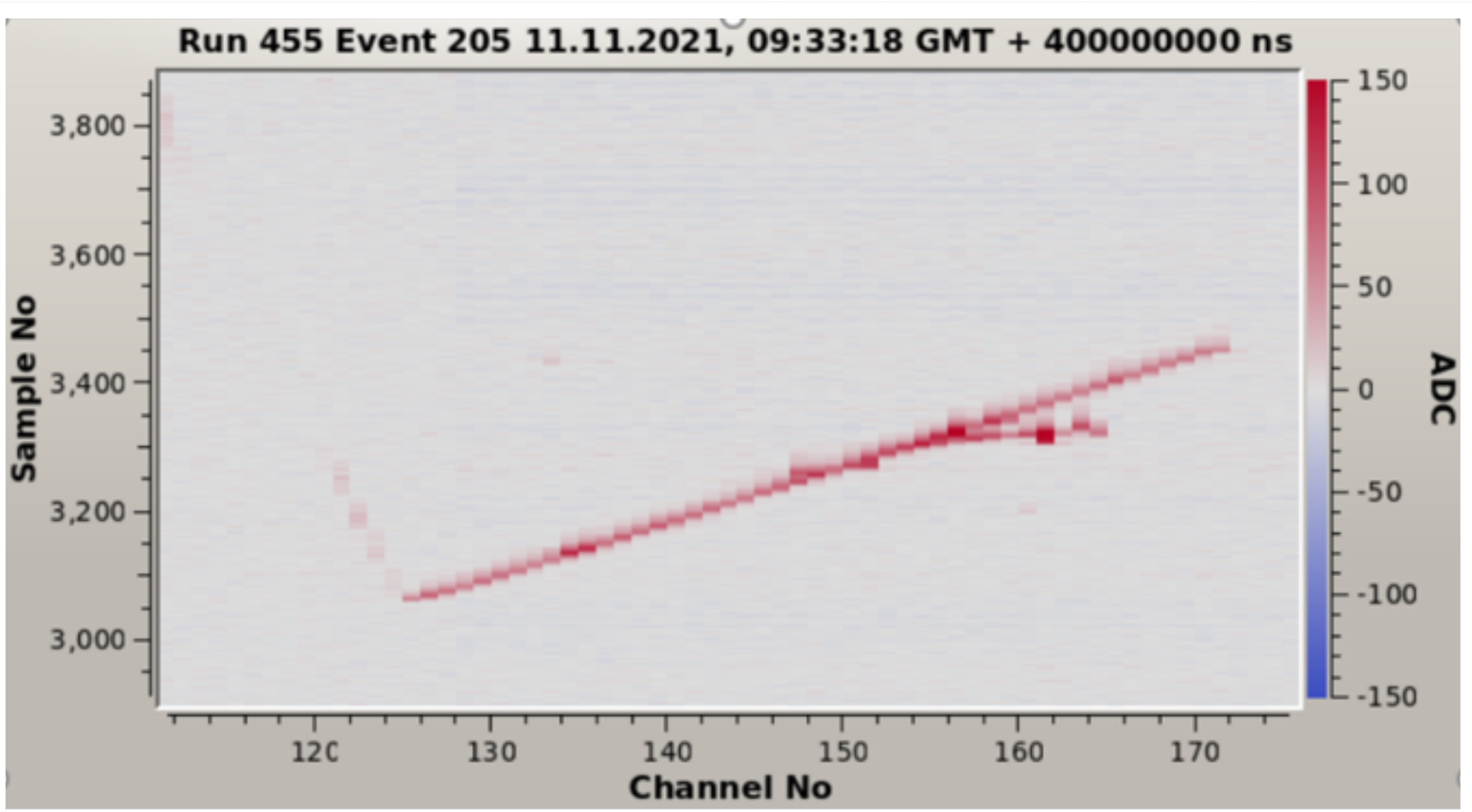
Confirmed that LAr purity increases while filling. Purity after filling > 1 ms
Expected negligible loss of signal from the TPC cathode *O*(150 us)

Re-condensation not activated (boil-off exhausted to the atmosphere)
LAr level decrease 2 cm/day (filled 5 cm above the nominal)
Minor loss of purity from the filling to today.



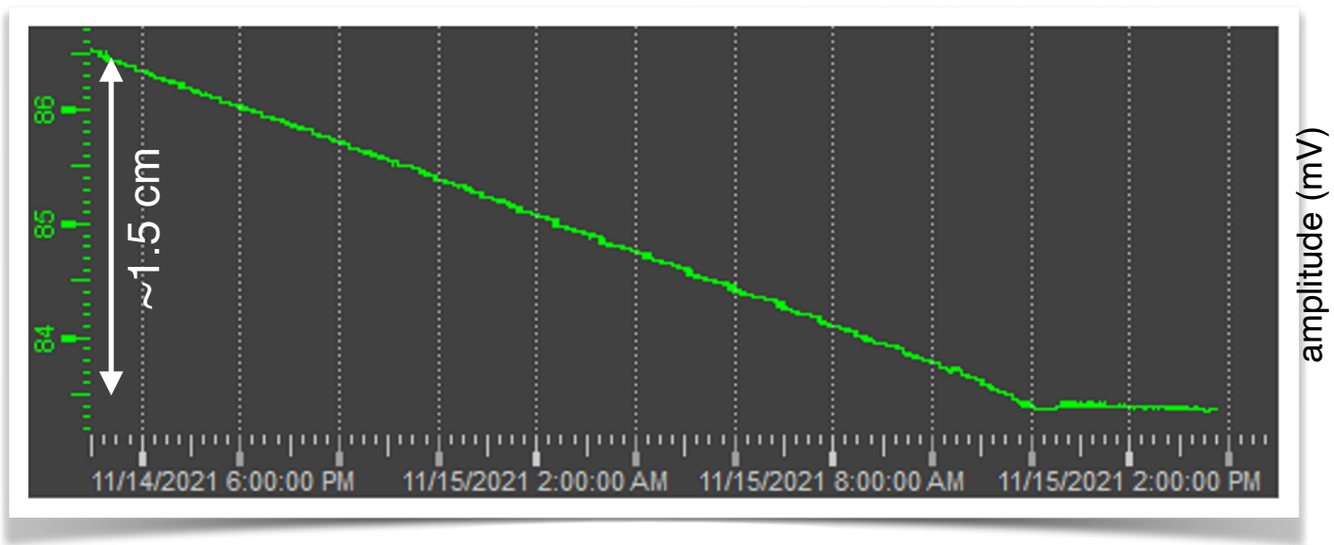
First events

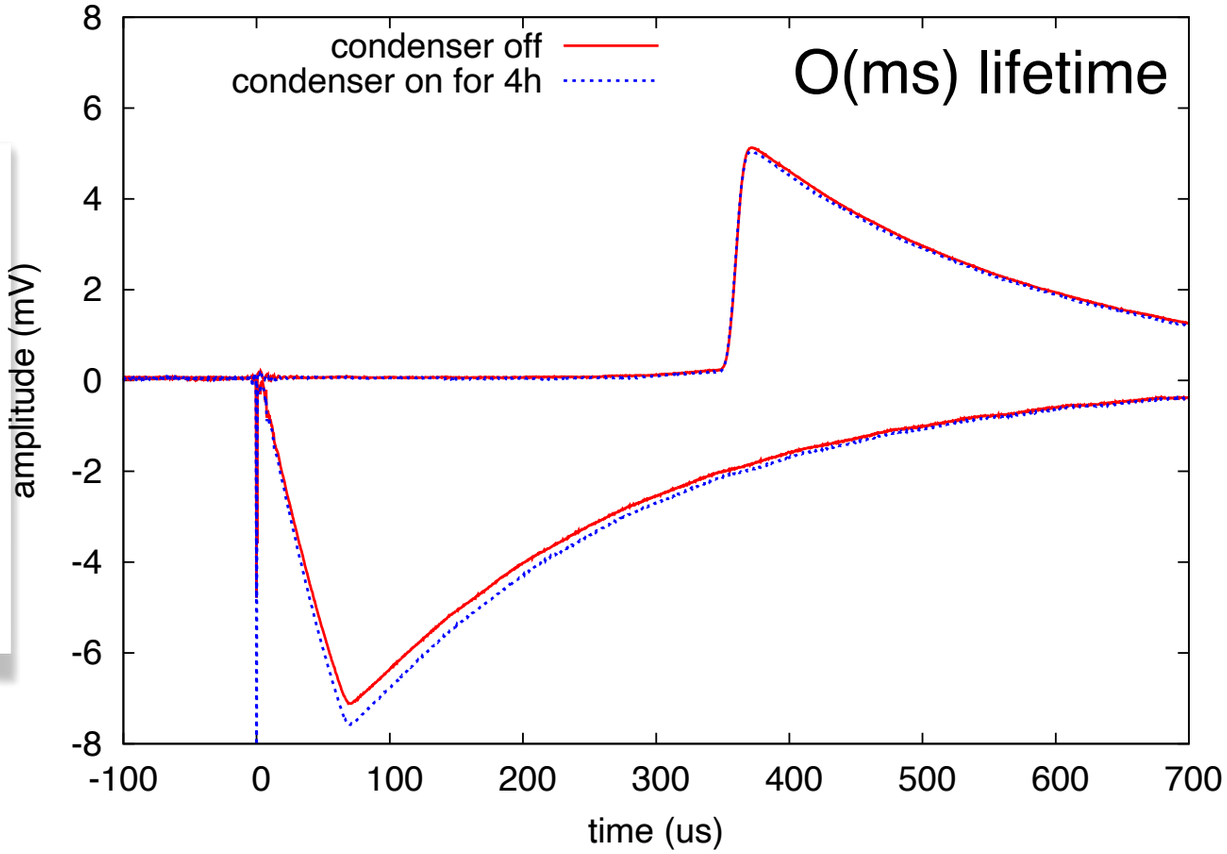
Immediately after the smooth of HV ramp up of the cathode and the CRP bias the first tracks from cosmic muons were observed with both the top and bottom electronics.
Search of noise sources (remove not strictly needed equipment for the operation and improving some grounding) resulted in a significant improvement of the noise on the top electronics.



Condensation on

Re-condensation and purification was turned on this morning.
Purity slightly decreased (expected) while not purifying from Thursday.
The activation of the condenser did not introduce impurities.
LAr level is stable and it’s sufficiently high to allow data-taking.
Data being recorded as we speak.
Understand the effect of purification will require several days.





Conclusions

Cold box is the adequate setup to characterise the large CRPs in a full TPC.
All requirements for cryogenics and cold box are met and exceeded.

Established all the operational procedures:
from the installation of the equipment to the filling, operation and decommissioning.

Clear picture of what will imply testing the four CRPs for the Module-0.

The loss of purity during the first run is a concern. Need to demonstrate long term stability.

Cosmic muon event is being recorded with both top and bottom electronics.

Next steps:
- Concentrate on the optimisation of the electronic noise.
- Record of enough data to characterise the CRP and TPC response.