Status of ProtoDUNE-DP

Filippo Resnati
on behalf of ProtoDUNE-DP Collaboration

LBNC - 19th February 2018

Overview

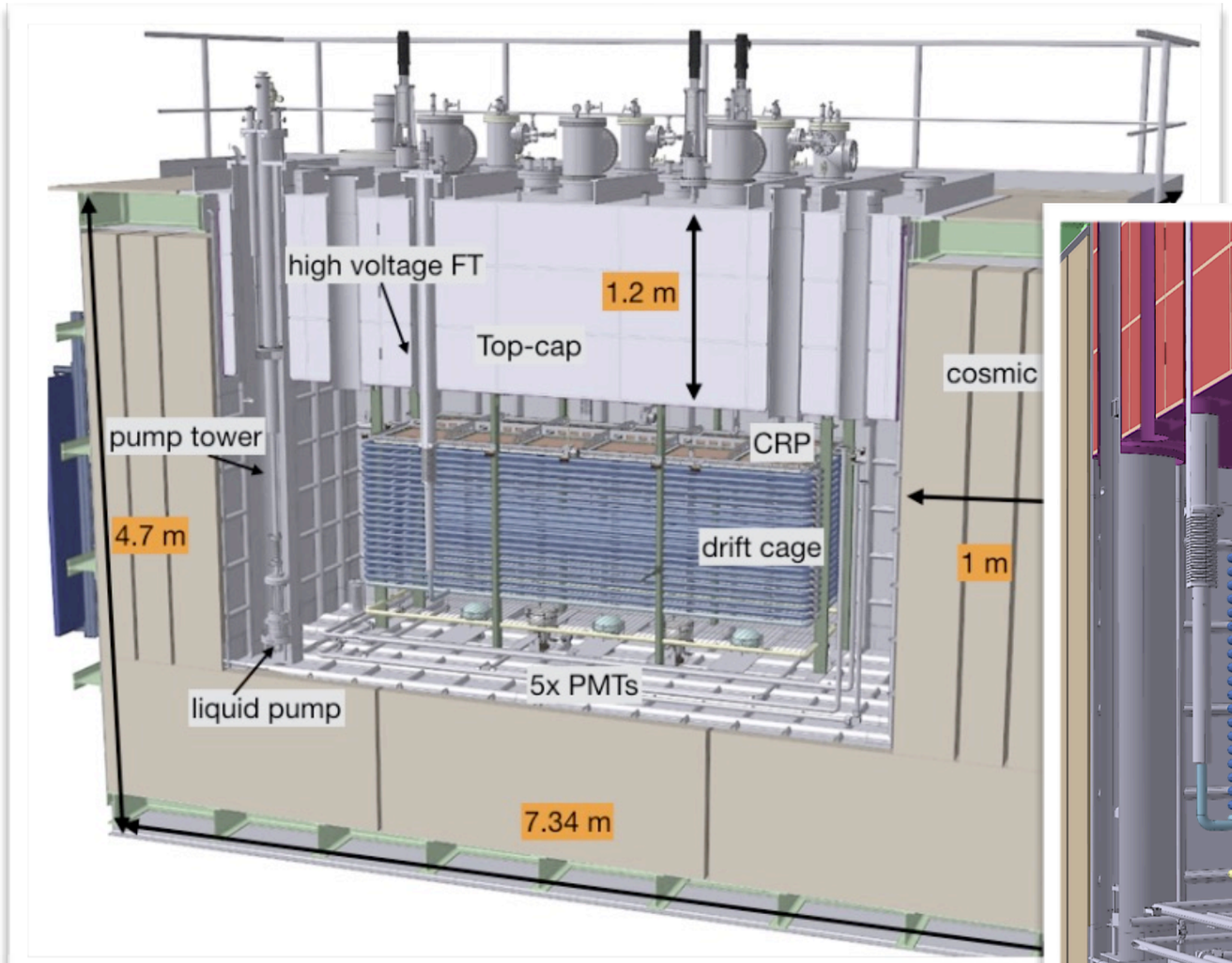
The presentation is divided into two parts:

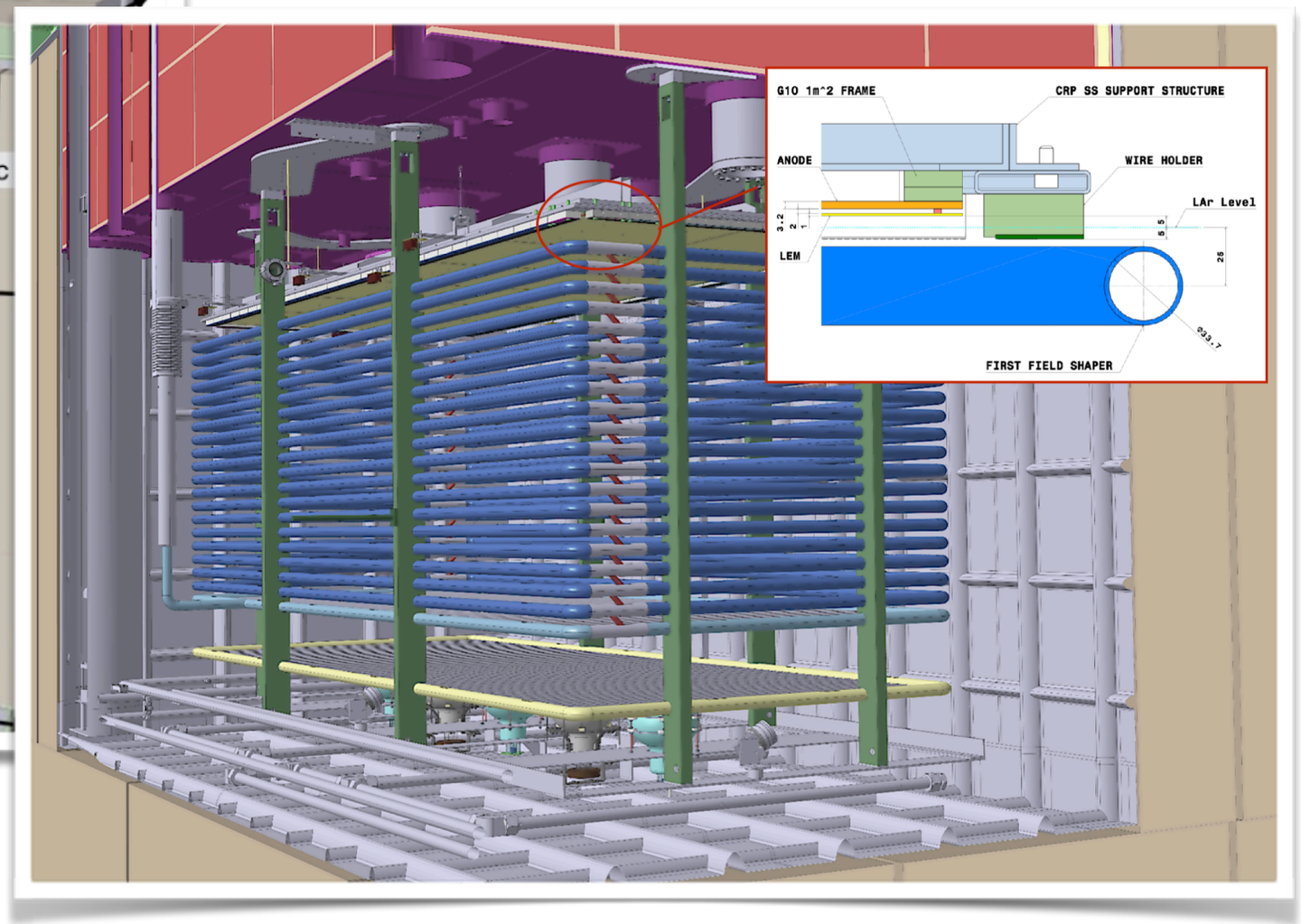
- Overview of the 3x1x1

- Status of the 6x6x6

WA105 3x1x1

3x1x1 m³ active volume LAr TPC operated at CERN in building 182 for > 6 months
Demonstrator of technology at 10-ton scale and proof of the scalability of the solutions
It has allowed to retire many risks of ProtoDUNE-DP 6x6x6





Timeline

July 2016:

- Detector ready and top cap closed

January 2017:

- Start the commissioning of the cryogenics

Beginning June 2017:

- CRP alignment and preliminary HV tests

June 15th-22nd 2017:

- first electroluminescence signal followed by first cosmic muons tracks

July-August 2017:

- data taking at different HV and trigger settings. 350 k events collected

Sept-October 2017:

- dedicated tests on the HV distribution to understand the “multi-LEM operation”. Tests with the LAr level. Tests of LEMs one by one. WA105-3x1x1 review https://indico.cern.ch/event/664977/

November 2017:

- induction, amplification and extraction field scans. Extra 50 k events collected.

December 7th 2017:

- cryostat at atmospheric pressure. Visual inspection with an endoscope

December 8th 2017:

- empty procedure started

February 2018:

- Cryostat and detector warm, entering this week

Cryostat and cryogenics

Stable thermodynamic conditions:
- ~1 kW heat input from the cryostat
- Stable GAr density near 1 bar (+/- 1 mbar) and 87 K (2 K/cm) completely isolated from outside P and T fluctuations
- Front end electronics operating near 110 K

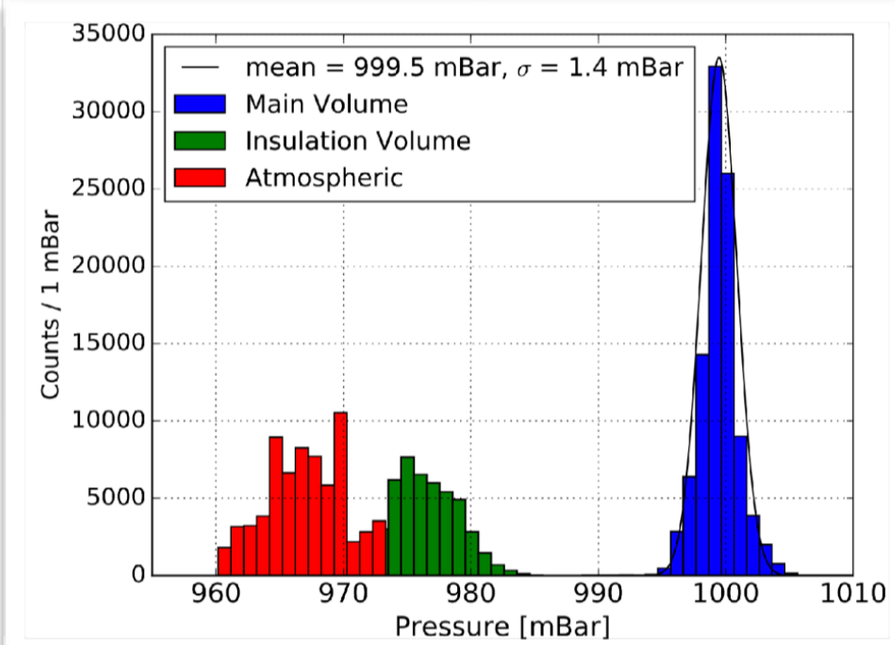
Stable LAr level during LAr purification:
- Avoid slow and fast level changes (waves)
- Avoid bubble formation in critical point (e.g. high field regions)

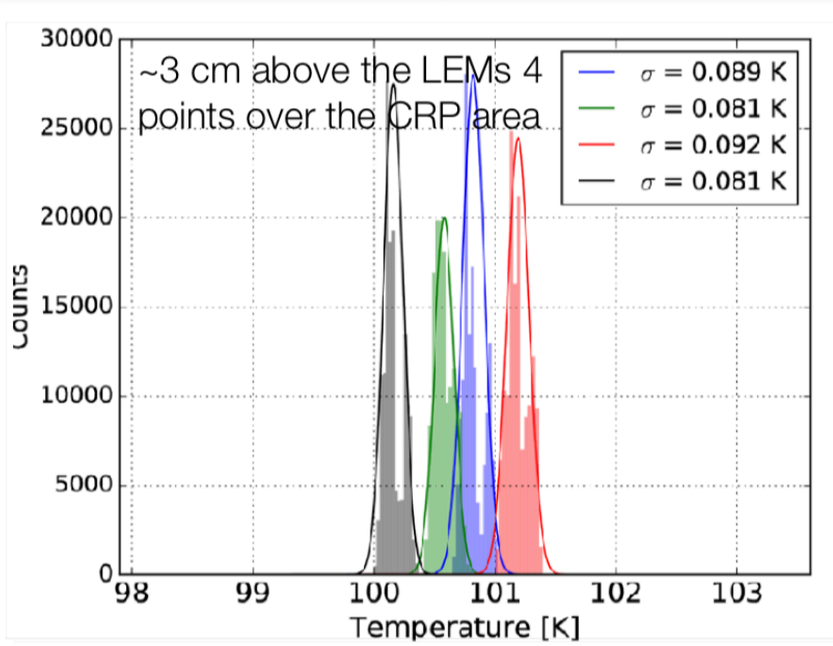
Liquid argon purity:
- Contaminations less than 40 ppt O_2^{eq} (> 7ms)

Cryostat and cryogenics

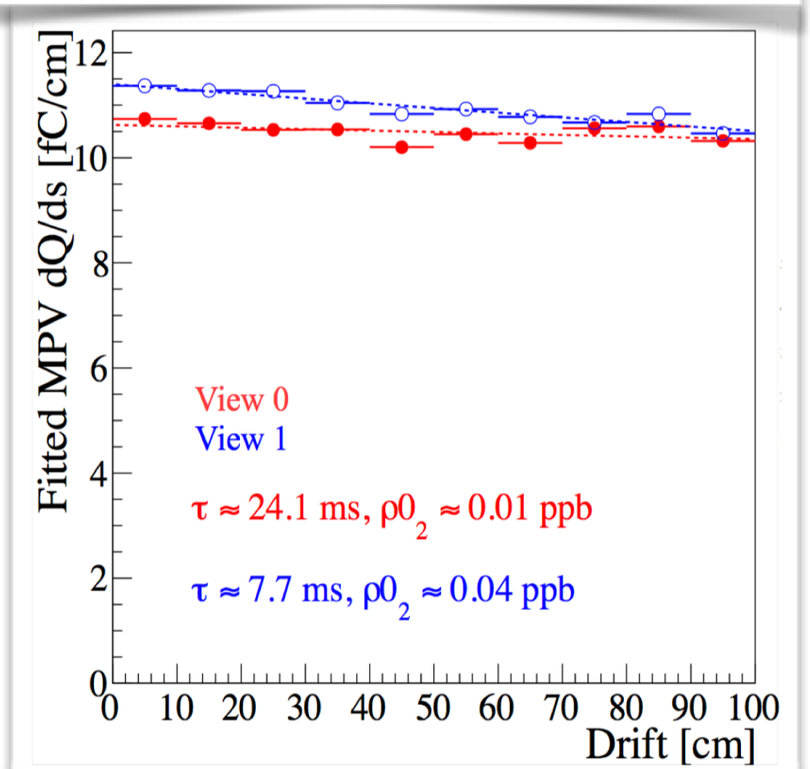
Successfully met the requirements for the dual phase operation

Density of vapour argon
- electron amplification depends on the Gar density
- monitor the density from the pressure and the temperature



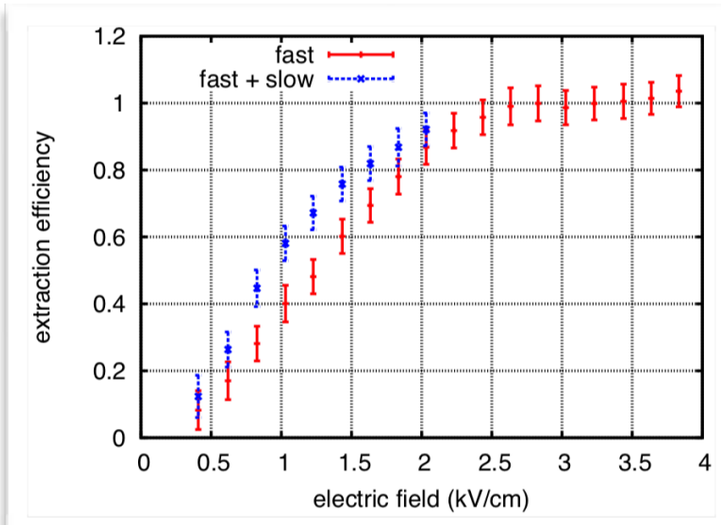


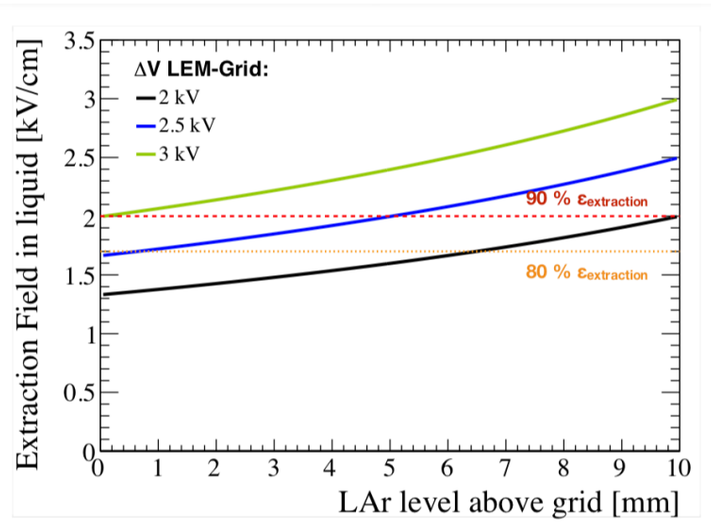
LAr purity
- measured with through going cosmic muons
- drifting electron lifetime estimated to be at least 7.7 ms



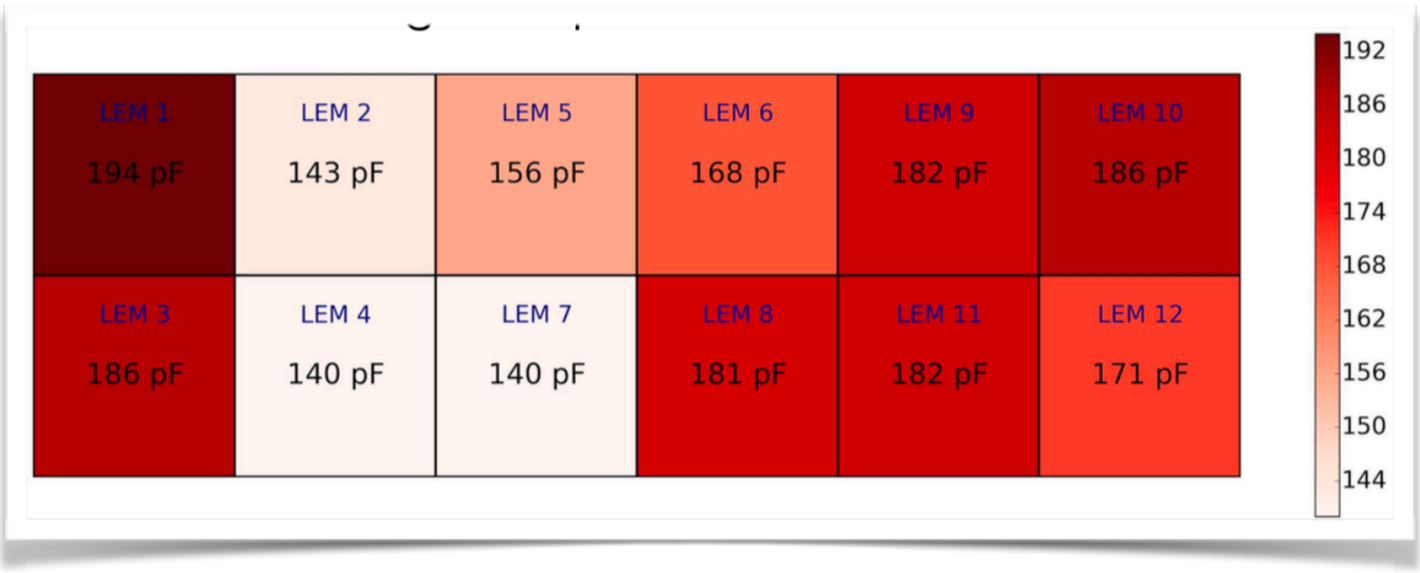
Cryostat and cryogenics

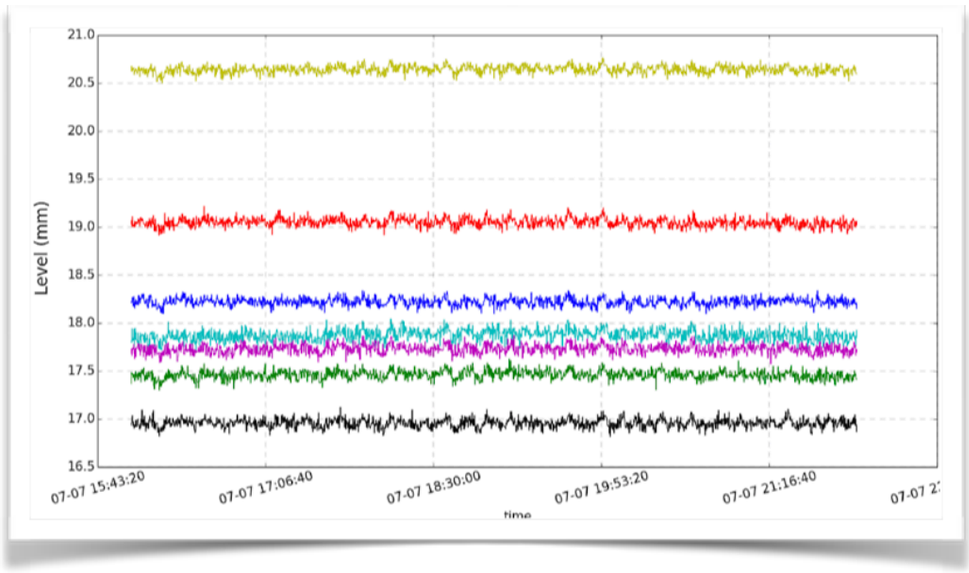
Drifting electron extraction
- for the first time achieved over 3 m²
- sensitive to the extraction field
(grid potential and LAr level)





Monitor the LAr level
- Cryo-cameras for visual checks. Extremely useful also during filling
- 100 um precision capacitive level meters on the sides of the CRP
- LEM-grid capacitive measurements
- CRP position can be adjusted according to the measured LAr level





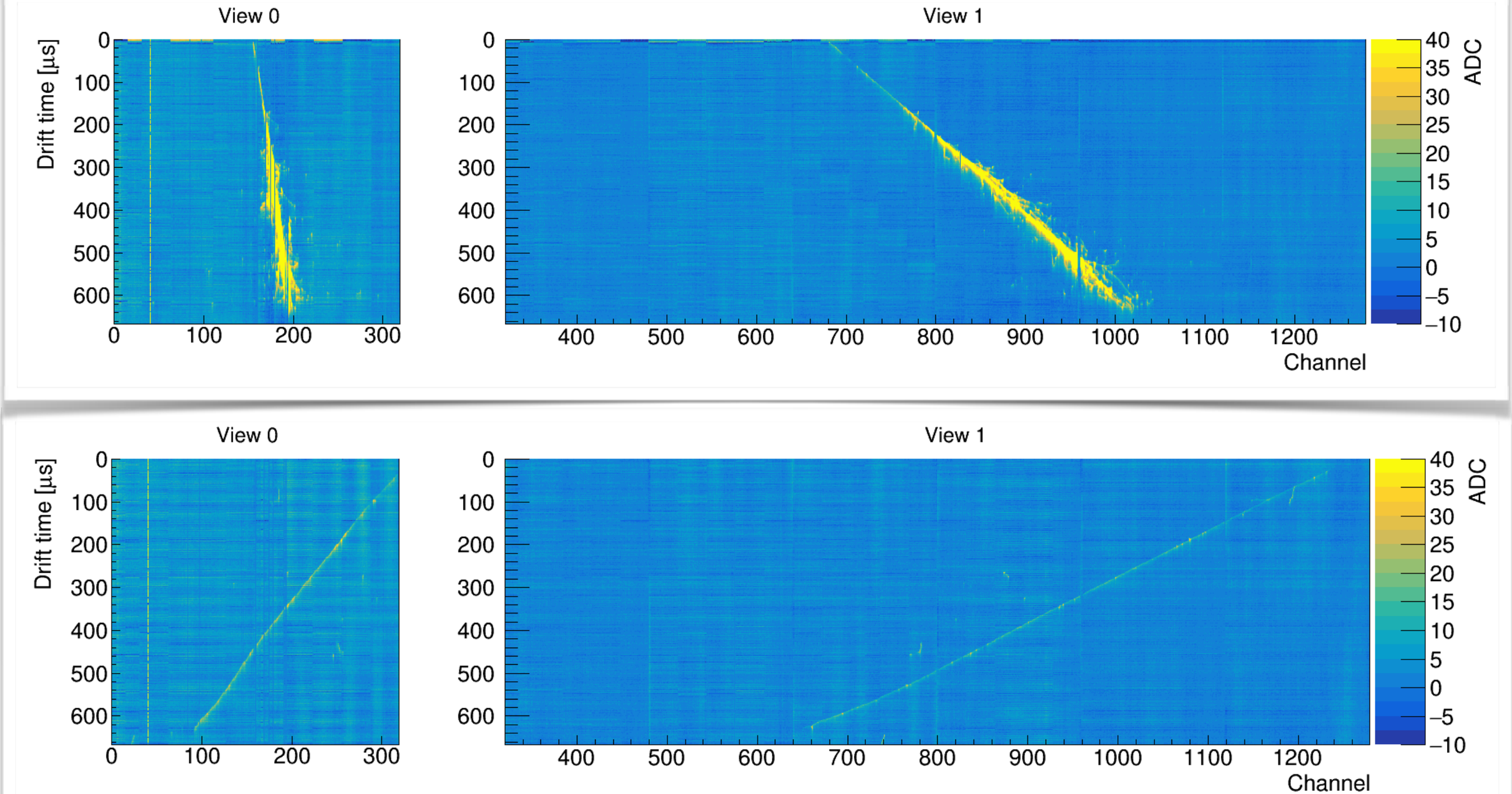
Detector operation

VHV system:
Stably operated for the entire period at nominal voltage (~ -60 kV).
Grid HV:
Limited by discharges at about -5 kV. Evidences of two issues:
- faulty HV-contact
- short between the extraction grid and one LEM

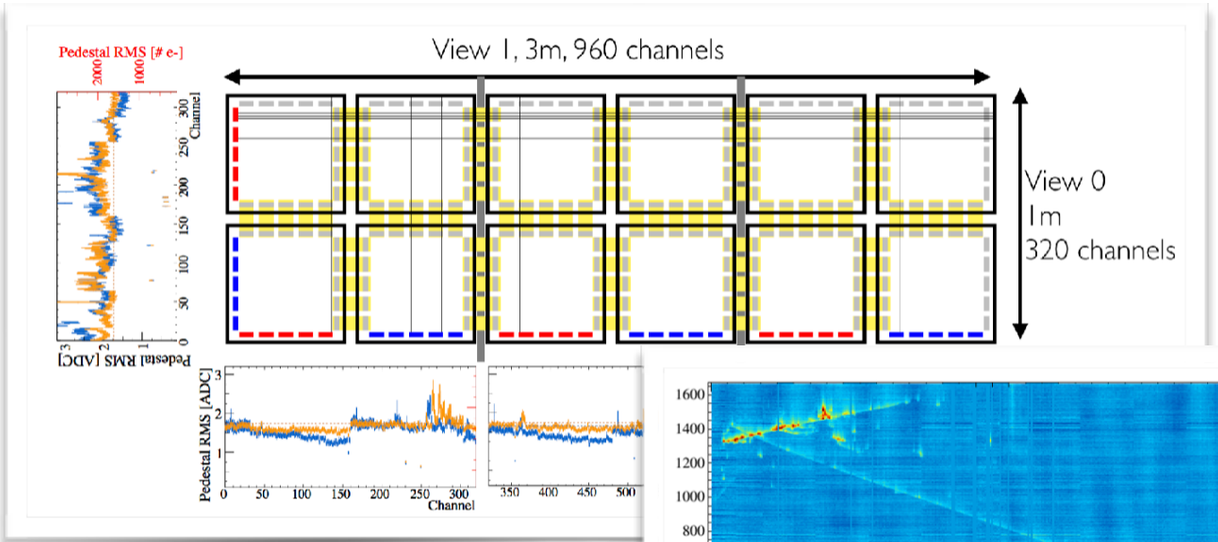
LEM HV (individual):
- Operated 6 LEMs at 32 kV/cm for 1h with no discharges
- Operated 1 LEM at 32 kV/cm for 12 h

CRP operation:
Gained a lot of understanding on the simultaneous operation of 12 LEM
Multiple LEM operation with extraction indicates stability issues beyond 31 kV/cm
Charge readout:
Charge sharing between views, noise at cold and warm, optimisation of S/N
Light readout:
Gained experience with positive and negative bias PMTs, operation and trigger with extraction luminescence, …

Two sample events

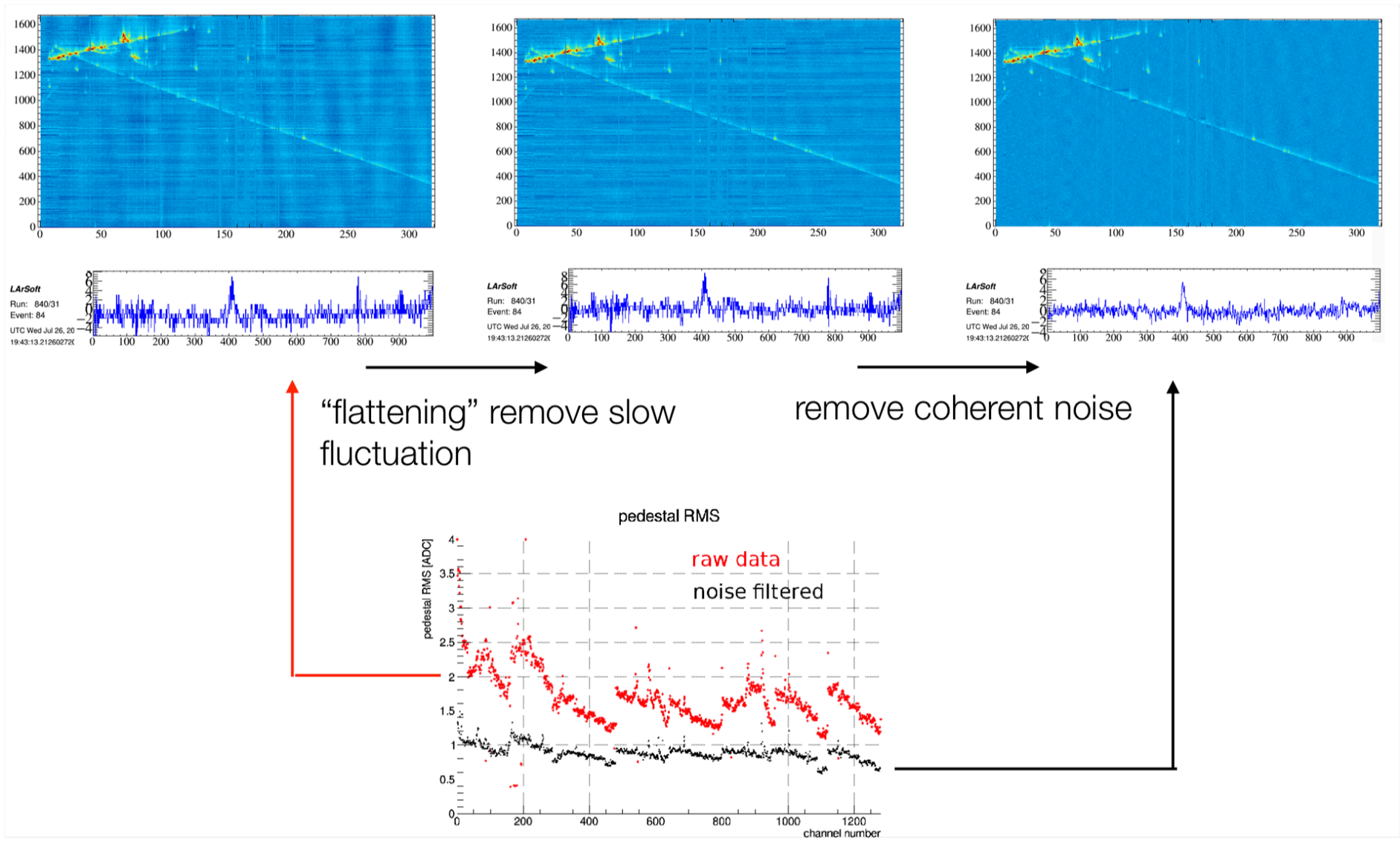


Noise performance

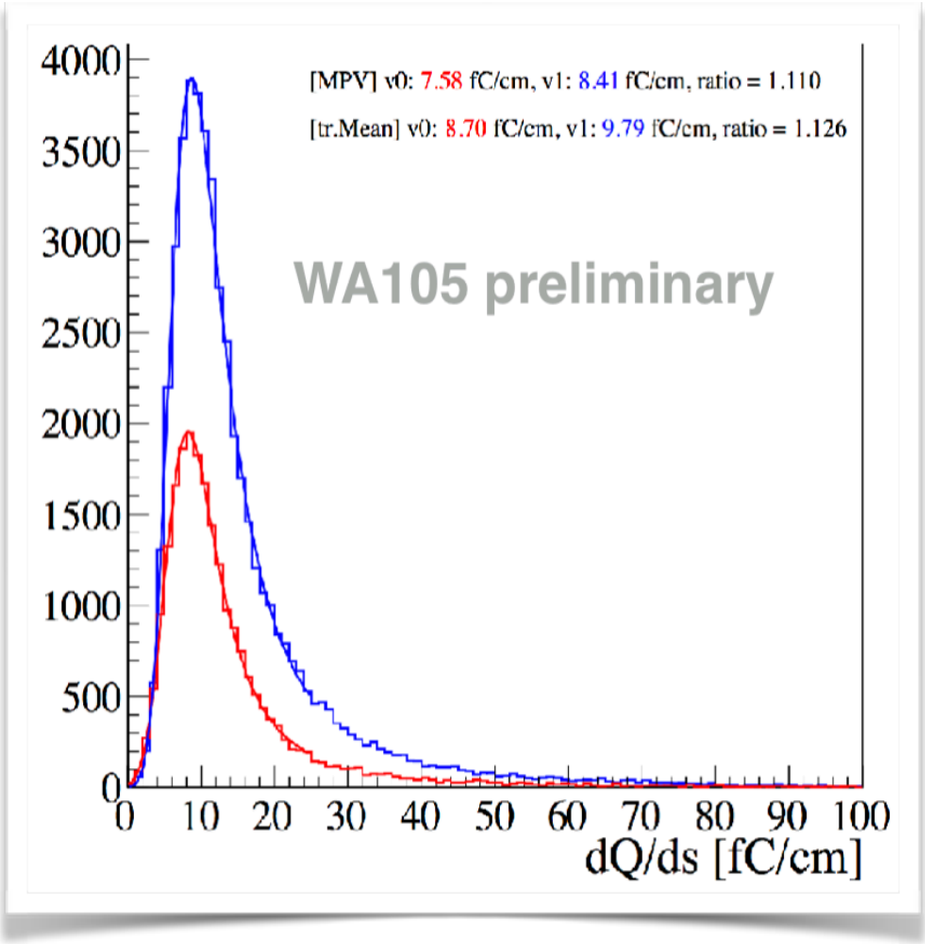


Noise around 1550 e-

From Sebastien Murphy presentations

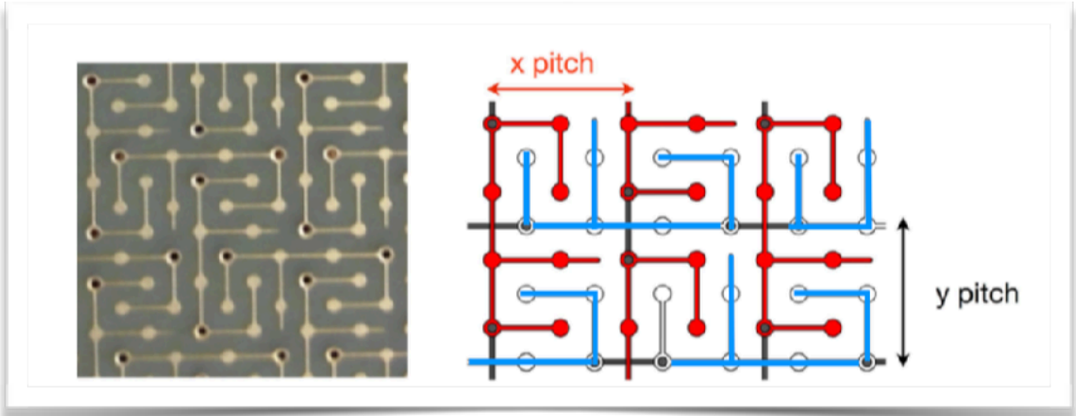


Amplification and readout



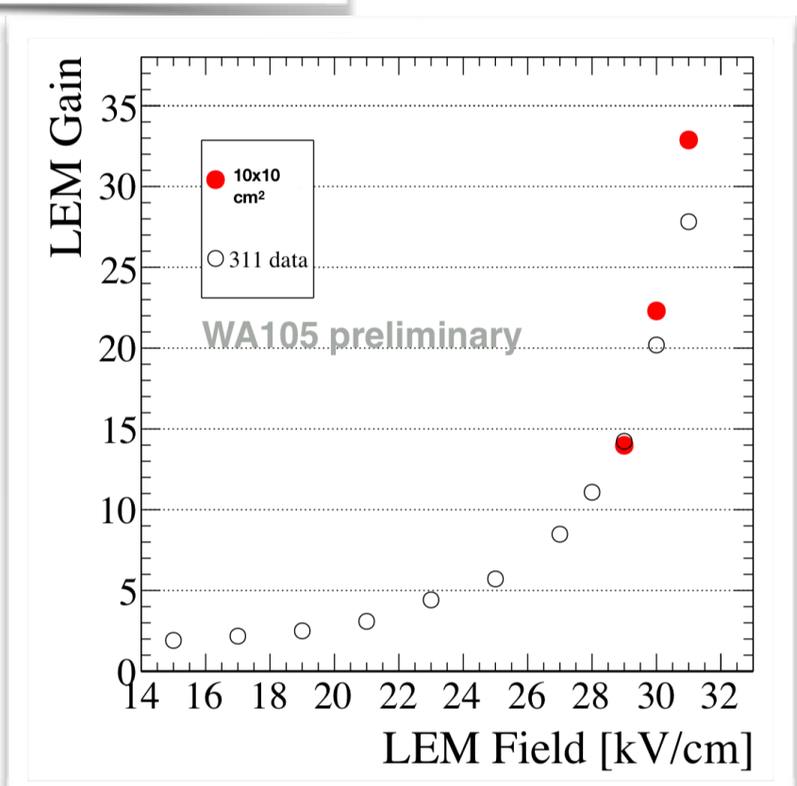
Anode strip design

- minimise the inter-strip capacitance
- ensure equal charge sharing between the views
- measured charge sharing $v_1/v_0 \sim 1.1$



Effective amplification gain

- includes the extraction, collection and induction efficiencies and the actual LEM gain. The goal is 20
- depends on the charging up of the LEM holes
- in the 3x1x1 also limited by the extraction efficiency



Papers in preparation

Editorial board: F. Sanchez, M. Campanelli, V. Galymov, E. Mazzucato, S. Murphy

A 5 ton demonstrator for large-scale dual phase liquid argon time projection chambers

Abstract

Keywords: Neutrino, liquid argon TPC

Contents

3x1x1 summary

Demonstrated:
- cryogenics conditions suitable for the detector operation achievable with the GTT technology
- VHV system performs according to the specifications
- for the first time electron extraction over 3 m^2
- controlled amplification in LEMs of 50 x 50 cm^2
- successful operation of low noise FE electronics in cold
- LEM and electronics robust against discharges
- suitable handling of the data (noise filters, 3D reco, …)

Learned:
- extraction grid limiting the voltage between anode and grid
- pure GAr test at room temperature representative of the behaviour at cryogenic conditions for individual LEM
- Simultaneous LEM operation more difficult than single LEM operation
need to test the entire CRP

Imminent next steps

Visual inspection of the 3x1x1 detector

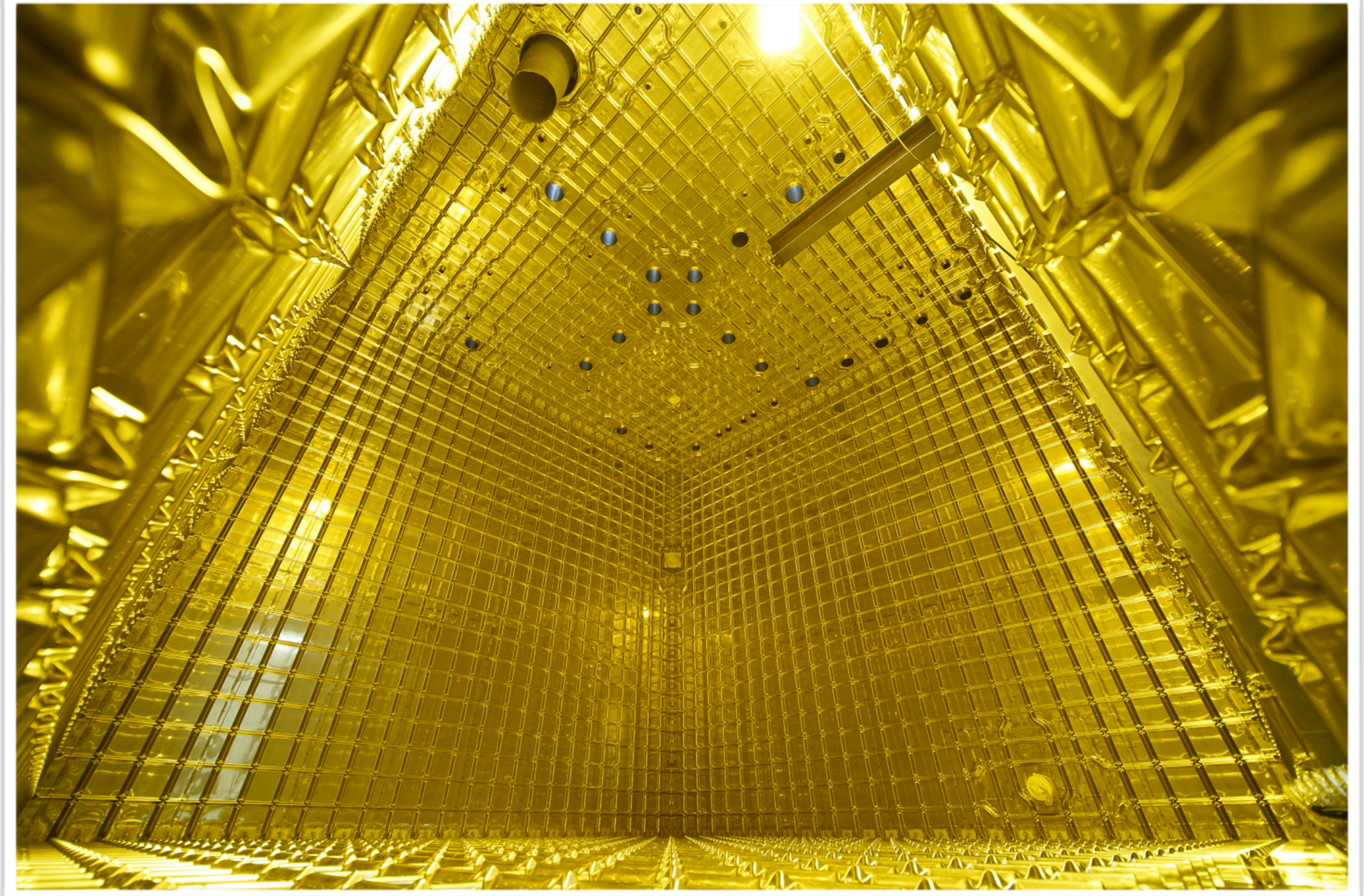
- cryostat is empty and warm, enter on Tuesday 20th.
- find the actual causes of the misbehaving of the grid
- act to minimise the impact on the CRPs of the 6x6x6

Already in progress

- modify the guard rings and clearance of the 50x50 LEMs to allow more HV margin and therefore improve HV stability

6x6x6

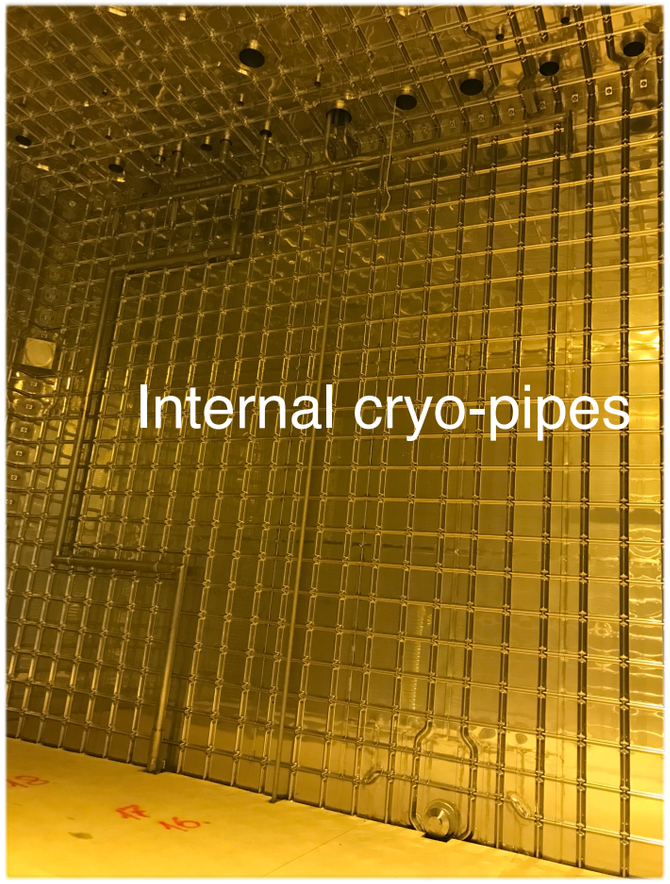
300 ton dual phase argon TPC under construction
on a charge particle beam at the CERN north area

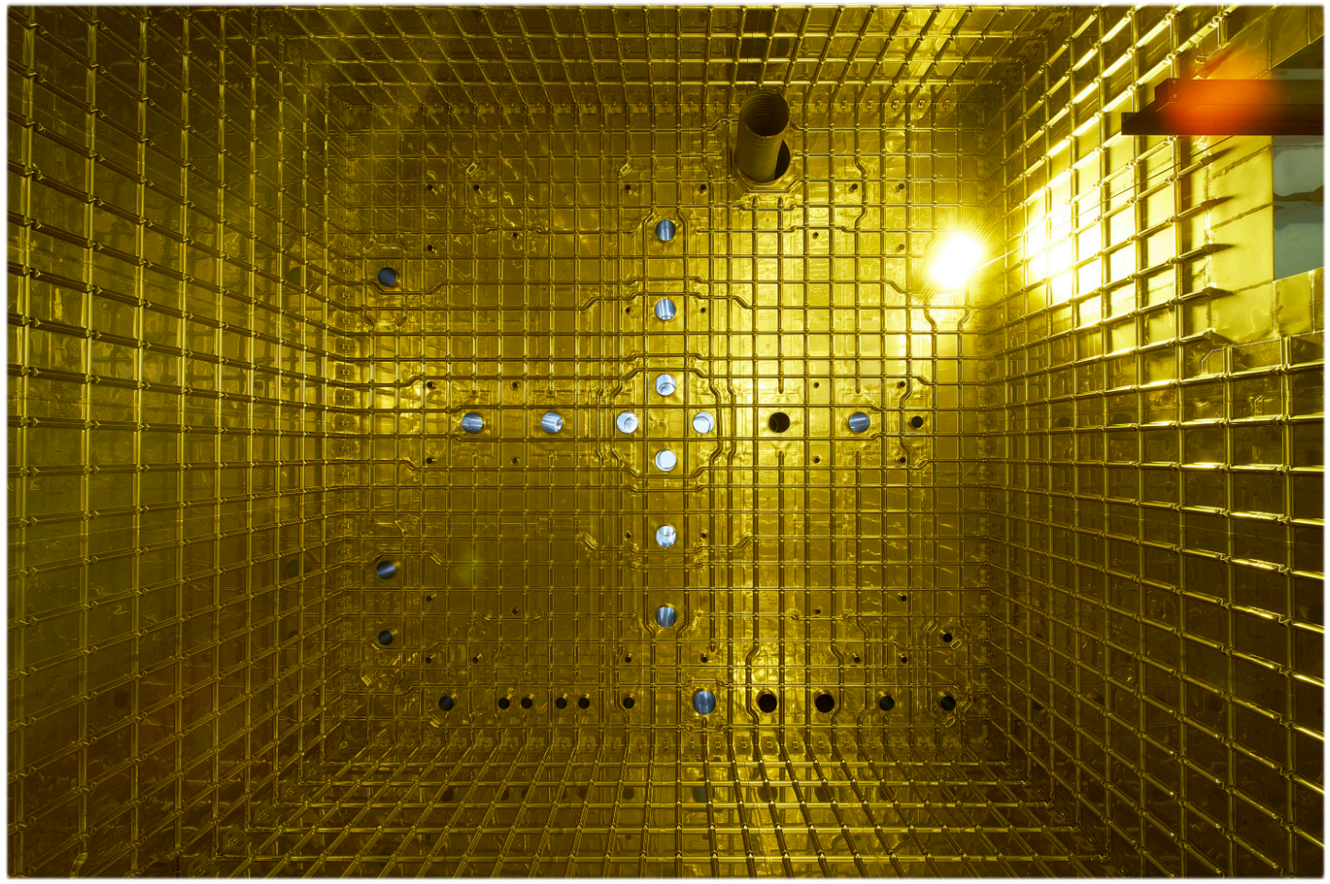


Timeline

7 January 2017: start of the installation of the warm structure
13 March 2017: handover to GTT and Gabadi
22 September: last welding of the corrugated membrane
10 October: finish of the sensitive He-leak check
20 November: cryostat cleaned
November-December 2017
- installation of the internal cryogenic piping
- construction of 8 and installation of 4 field cage sub-modules
- test of the detector ground concept on NP02
- cryogenics racks installation and cabling

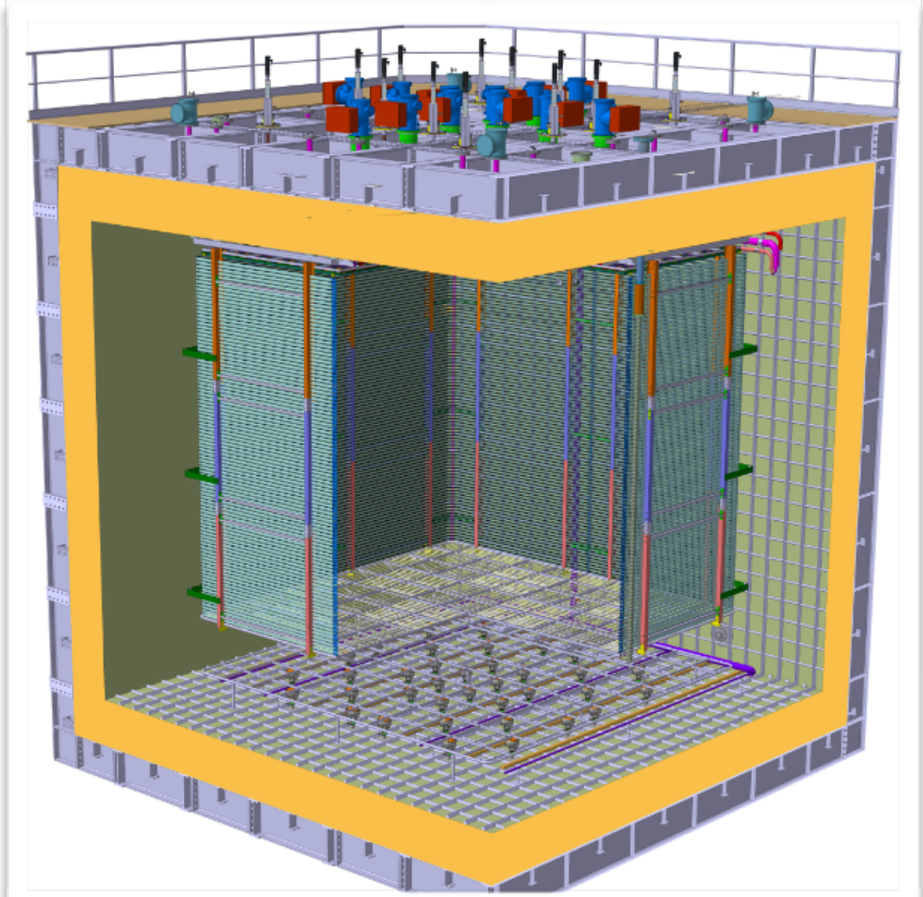
Cryostat

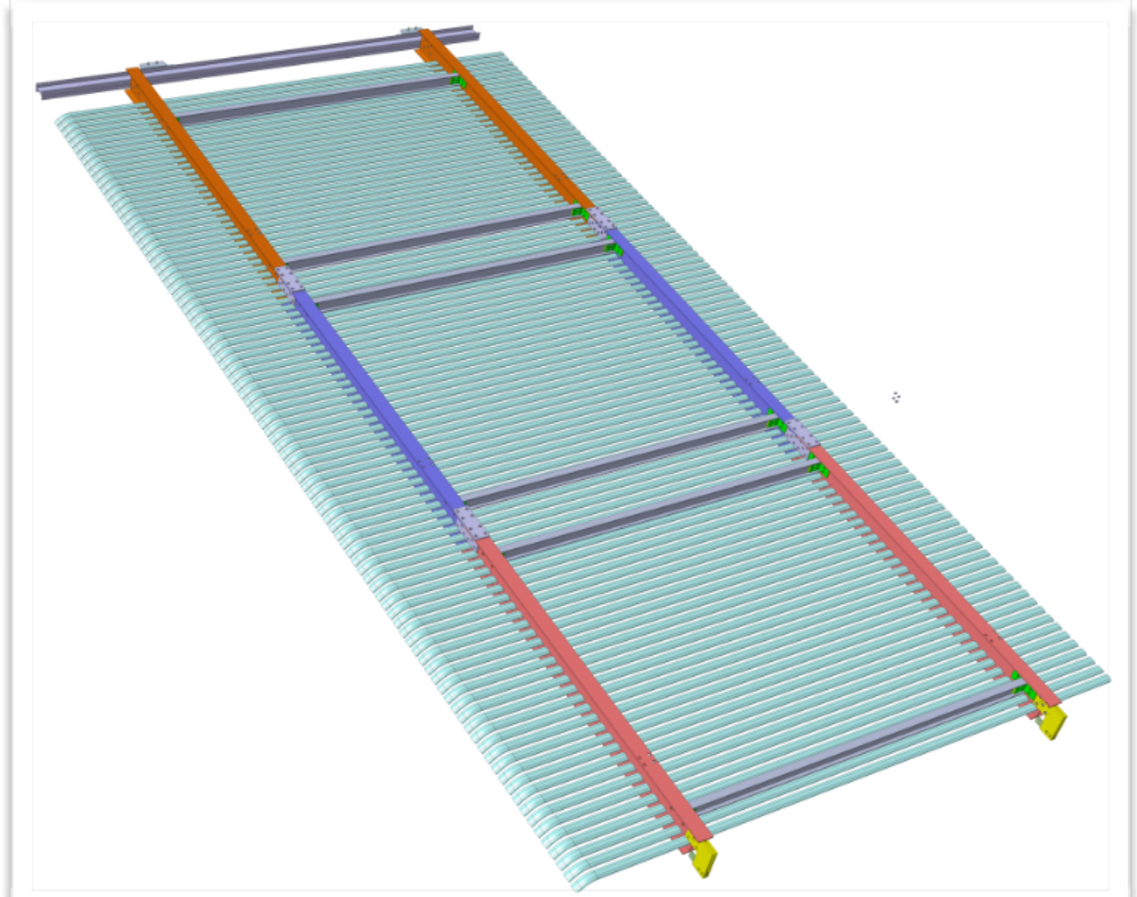




Cryostat fully installed, cleaned and leak tested.
Next step: closing of the TCO once the detector is completed
Internal cryogenics, including all feedthroughs, fully installed and leak tested

Field cage





- 8 vertical modules of 6.3 m x 3 m
- Each module consisting of 3 sub modules
- Aluminium profiles held by horizontal FRP I-beams
- Profiles will be connected mechanically and electrically to form rings
- Two series of resistive divider define the potential on each ring

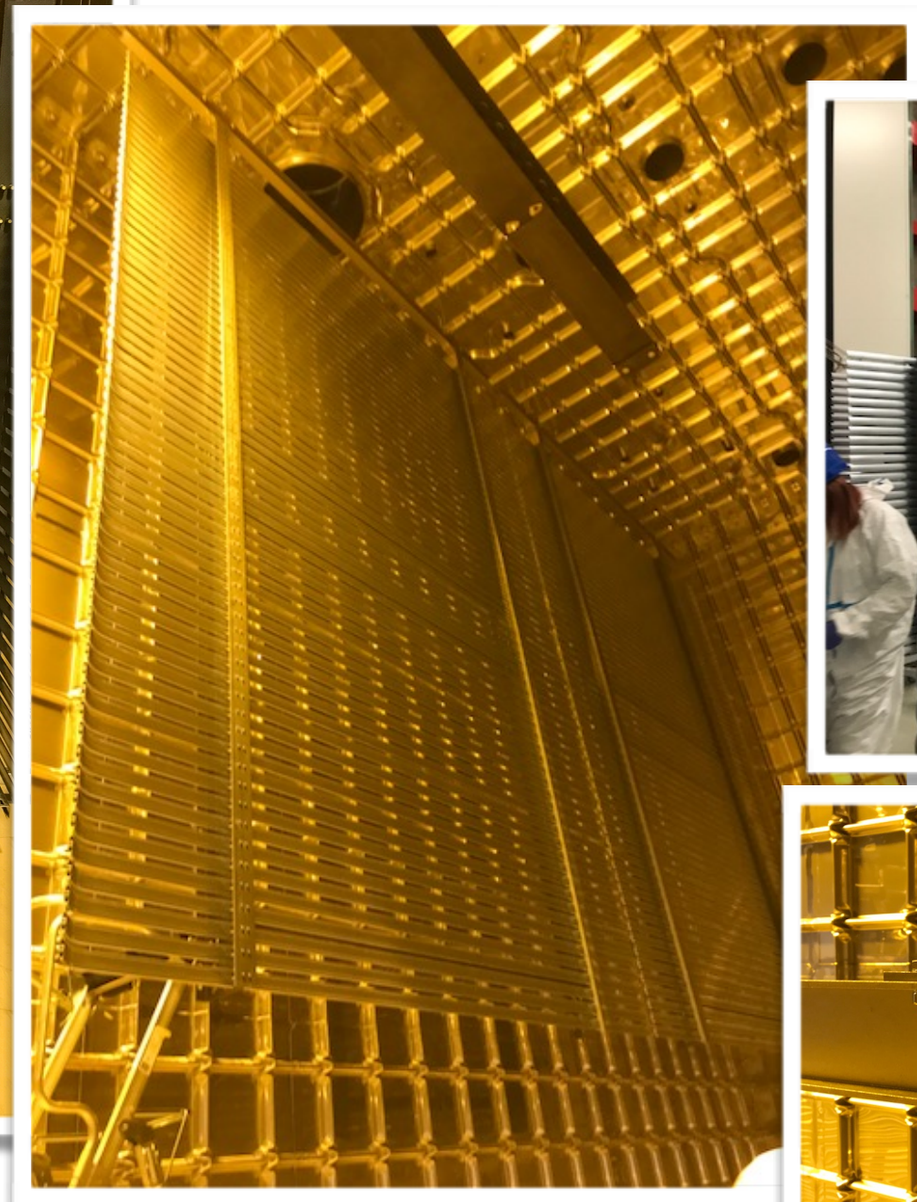
Field cage installation

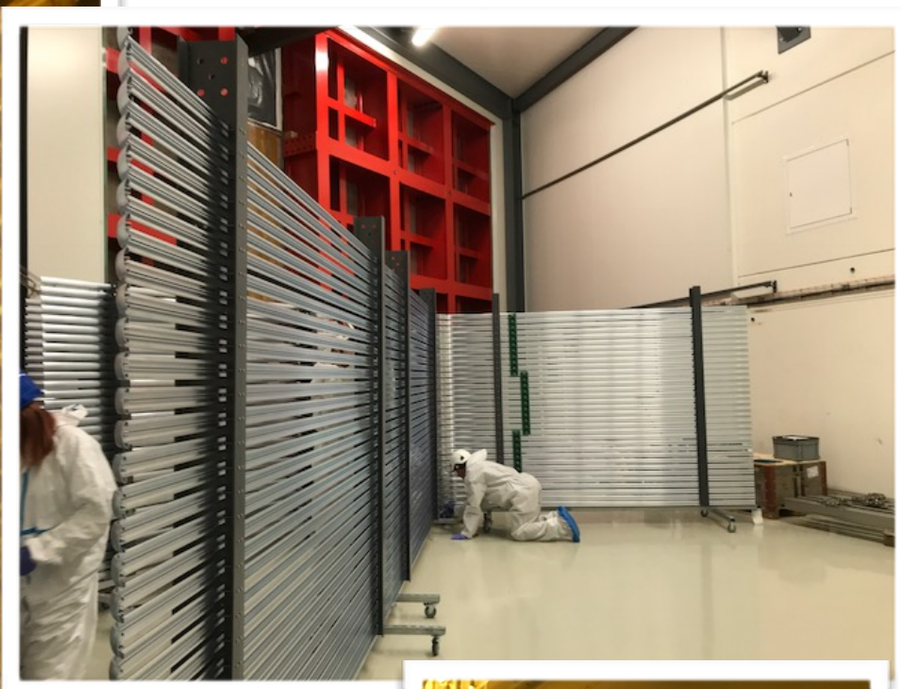
All the material for the entire field cage installation at EHN1

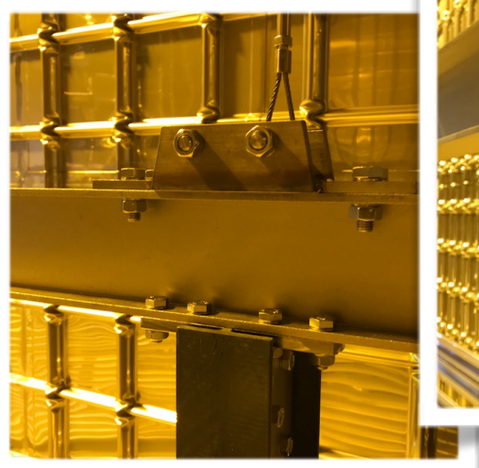
From mid November 2017 to mid December 2017:
- assembly of 8 sub modules + 1 left for training
- floor trial assembly of the 3 top sub-modules with 3 HVDB with clips. Impedance test performed.
- installation sequence for full panel successfully tested.
- installation of 2x 2/3 modules in the cryostat (1 day, 4 people)

Field cage installation

CERN - ETHZ - UTA

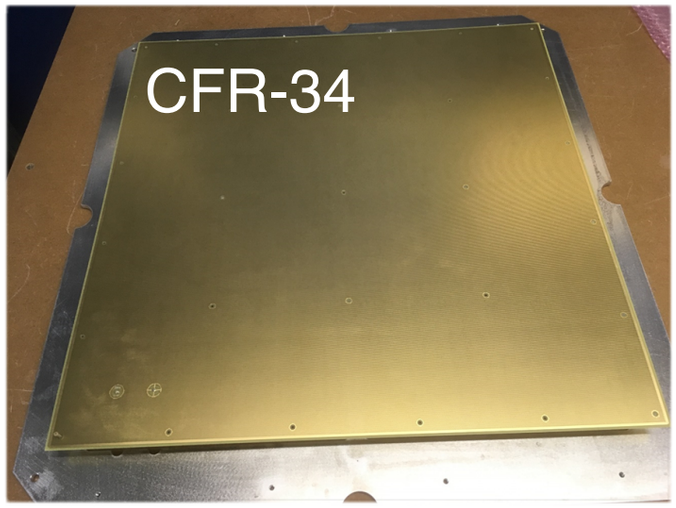


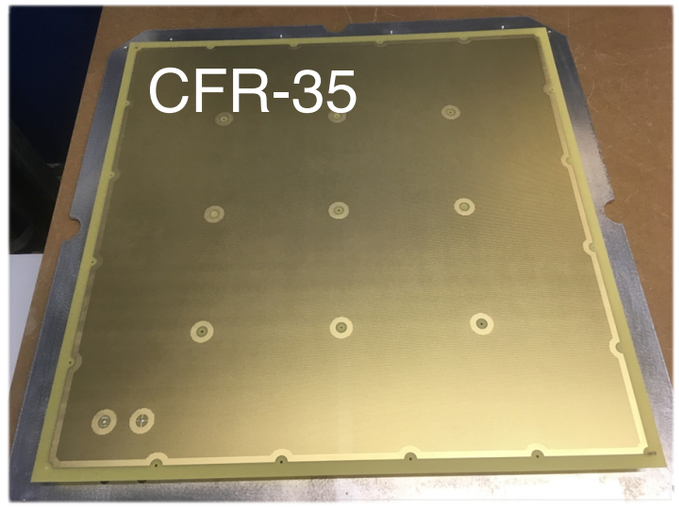


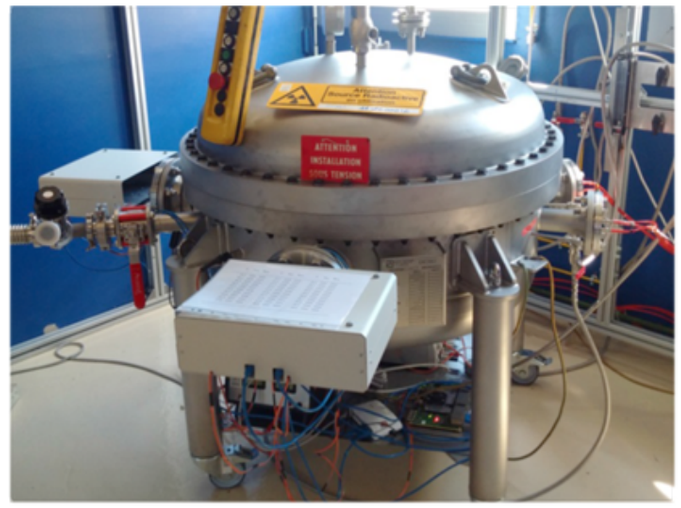


LEM optimisation (1)

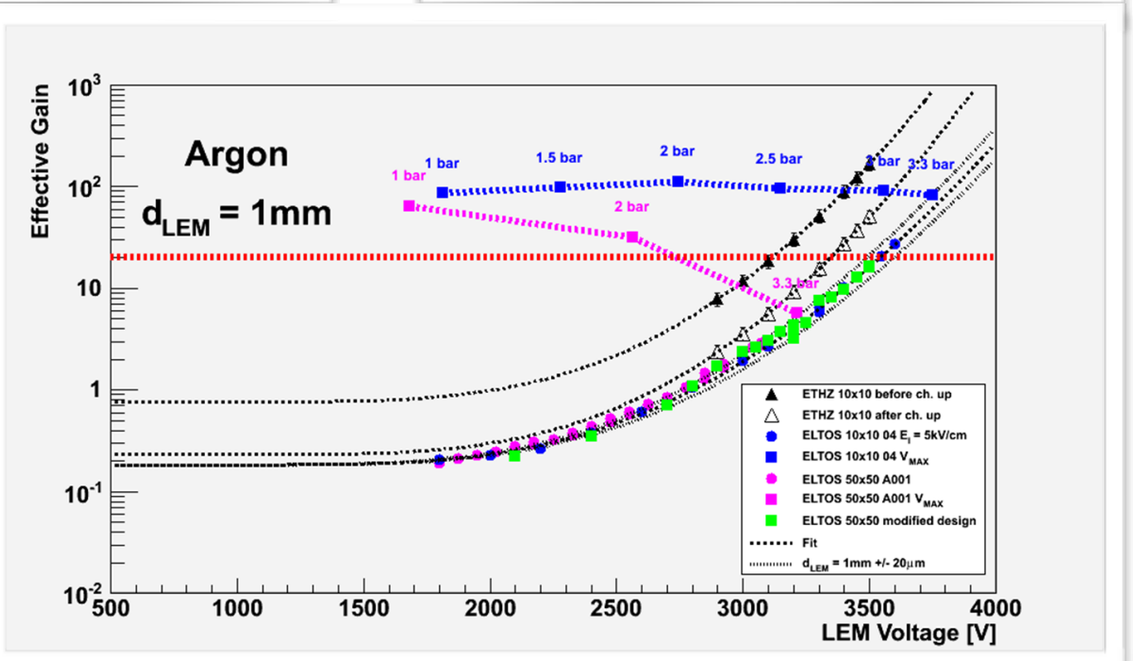
Hole, pitch, rim, and electrode thickness already optimised for the 3x1x1
Investigate if sparking due to edge (guard ring/clearance) effects
CEA/Irfu working on a new design (CFR-35) to improve the HV performance
Studies performed in pure GAr at room temperature and 3.3 bar
In CFR-34, discharge occurrence more probable along the borders





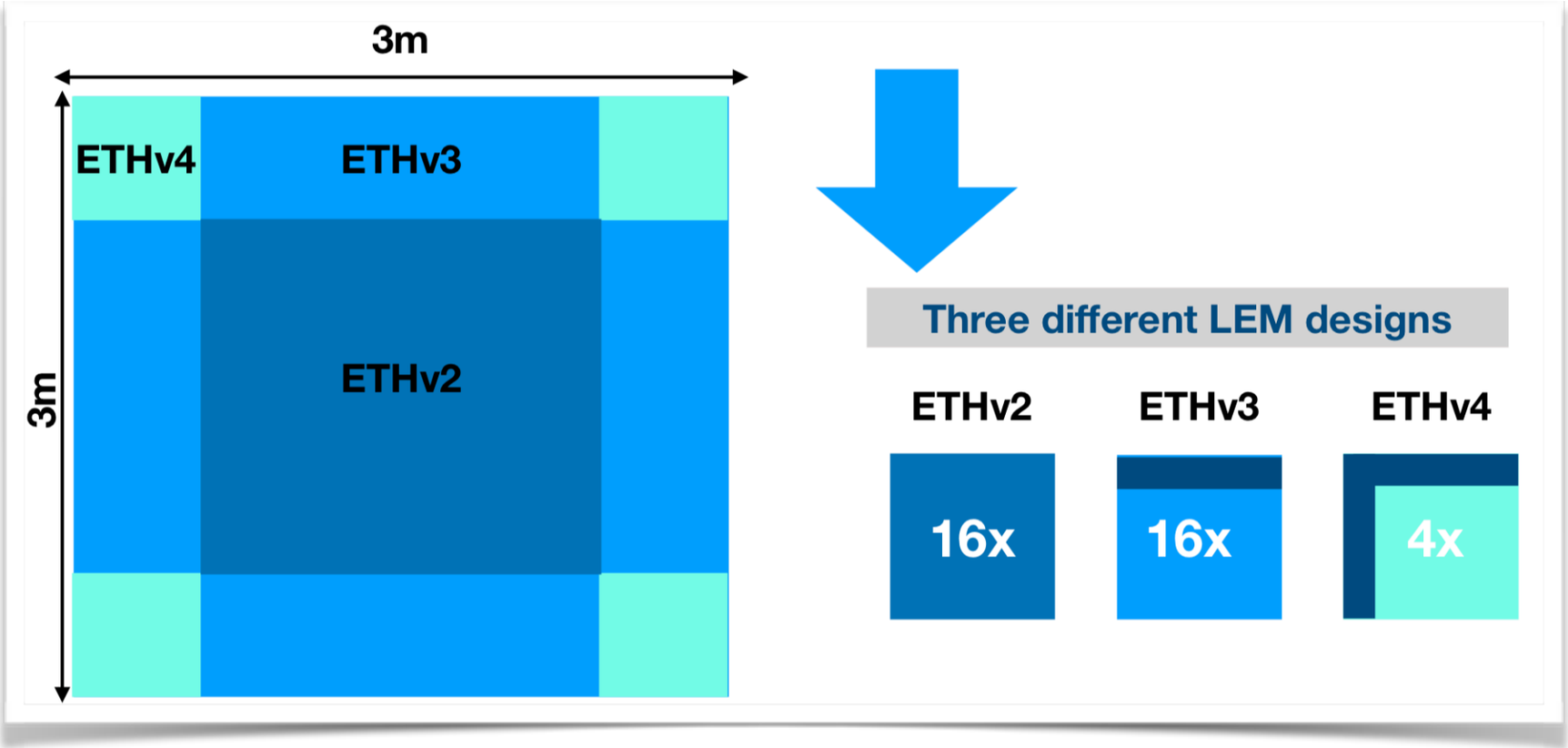


In CFR-35, discharge onset increase (from 3.2 kV to 3.5 kV) at a cost of reduction of the active area (from 97% to 85%)
Optimisation of the active surface ongoing:
- maintain the HV characteristics and increase the active surface to 92%
- CFR-36 being tested in Saclay



LEM optimisation (2)

The 3x1x1 operation showed that the LEMs in a CRP cannot be considered independent
At ETH, working on the simulation of the LEM boundaries to identify the most potentially sensitive areas and understand the effect of the different boundary parameters



In order to maximise the active area (up to 96%) in the CRP, three different LEM design depending on the position of the LEM in the CRP are proposed.
Tests setup in preparation and first cold tests foreseen in March

LEM procurement

- 36 LEMs (1 CRP) of CFR-34 already available and fully characterised at Saclay (performance comparable to 3x1x1)

- 36 LEMs (CFR-35) in production at ELTOS available at CERN in March (expected higher gain and less active area)

- 36 LEMS (CFR-35/36) ordered from ELTOS, ready in April procurement ongoing (CFR-35/36 decision end of February)

- Anodes for 2 (3) CRPs ready in April (June)

- Questions still open for the next CRP

Latest SPSC recommendation

Dear colleagues,
thank you for the documents you sent us and the useful meeting we had on Monday. During the closed session we discussed the status of the experiment and the perspectives for 2018. In particular, we appreciate and strongly support your efforts to gain a full understanding of the problems encountered with the 3x1x1 m3 prototype. In the current SPS schedule, we maintained a 4-week beam slot for ProtoDUNE-DP in H2 (week 42-45, i.e. at the end of the proton run) but we plan to revise it as soon as the Collaboration takes decisions on the CRP's and the strategy to validate the new design. Recording data with the beam is surely valuable but, if this is not possible or introduces additional risks, we believe it is even more important to demonstrate the Dual Phase concept at the kton scale with cosmics at the beginning of LS2, namely in a time-scale useful for the DUNE Technical Design Report. We would like to be informed on the next critical decisions and your updated plan as soon as new information are available and we look forward to meeting you in April.

Collaboration reaction

The Proto DUNE-DP collaboration is committed to demonstrate the Dual Phase concept at the kton scale in a time-scale useful for the DUNE Technical Design Report, as recommended by SPSC.

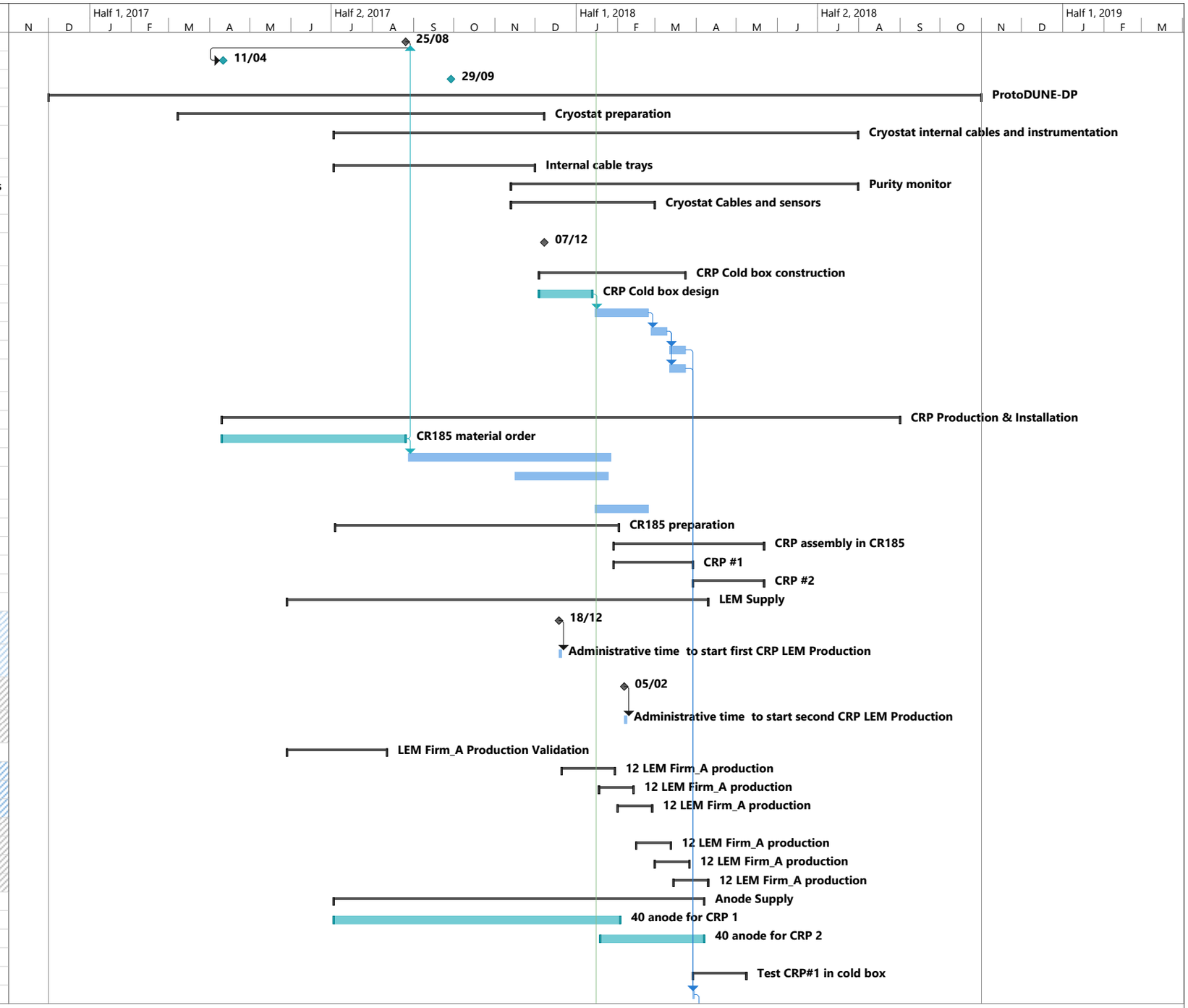
Independently of the availability of the particle beam, investigate the possibility of instrumenting the 6x6x6 with two CRPs only. This enables to learn a lot on the testing and installation procedure and leave the space for the parallel procurement of additional two CRPs

Setup a plan for testing the final CRPs in realistic thermodynamic conditions prior to the installation in the cryostat

Review the schedule to make it compatible with LAr filling in November 2018

Schedule for 2 CRP scenario

ID	Task name	Start date (dd//mm/yy)	Finish date (dd//mm/yy)	Duration
1	Procurement started	25/08/2017	25/08/2017	0 days
2	Clean room in Blg 185 available	11/04/2017	11/04/2017	0 days
3	Started assembly in Blg 185	29/09/2017	29/09/2017	0 days
4	**ProtoDUNE-DP**	**01/12/2016**	**31/10/2018**	**490 days?**
5	**Cryostat preparation**	**08/03/2017**	**07/12/2017**	**197 days**
14	**Cryostat internal cables and instrumentation**	**03/07/2017**	**31/07/2018**	**271,57 days?**
15	**Internal cable trays**	**03/07/2017**	**30/11/2017**	**109 days**
19	**Purity monitor**	**13/11/2017**	**31/07/2018**	**176,57 days**
27	**Cryostat Cables and sensors**	**13/11/2017**	**28/02/2018**	**68 days?**
30				
31	Cryostat is ready for detector installation	07/12/2017	07/12/2017	0 days
32	**CRP Cold box construction**	**04/12/2017**	**23/03/2018**	**70 days**
33	CRP Cold box design	04/12/2017	12/01/2018	20 days
34	CRP Cold box parts procurement	15/01/2018	23/02/2018	30 days
35	CRP Cold box assembly	26/02/2018	09/03/2018	10 days
36	CRP Cold box cryogenic installation	12/03/2018	23/03/2018	10 days
37	CRP Cold box instrumention and control	12/03/2018	23/03/2018	10 days
38				
39	**CRP Production & Installation**	**10/04/2017**	**31/08/2018**	**355 days?**
40	CR185 material order	10/04/2017	25/08/2017	100 days
41	Clean Room Material reception	28/08/2017	26/01/2018	100 days
42	Signal Patch panel design and production	16/11/2017	24/01/2018	40 days
43	HV Patch panel design and product	15/01/2018	23/02/2018	30 days
44	**CR185 preparation**	**04/07/2017**	**01/02/2018**	**143 days**
51	**CRP assembly in CR185**	**29/01/2018**	**21/05/2018**	**81 days**
52	**CRP #1**	**29/01/2018**	**29/03/2018**	**43,57 days**
67	**CRP #2**	**29/03/2018**	**21/05/2018**	**37,43 days**
82	**LEM Supply**	**29/05/2017**	**09/04/2018**	**216 days?**
83	**Green Light LEM CFR-35 production for first CRP**	**18/12/2017**	**18/12/2017**	**1 day?**
84	Administrative time to start first CRP LEM Production	19/12/2017	20/12/2017	2 days
85	**Green Light LEM CFR-35 or 36 production for second CRP**	**05/02/2018**	**05/02/2018**	**1 day?**
86	Administrative time to start second CRP LEM Production	06/02/2018	07/02/2018	2 days
87	**LEM Firm_A Production Validati**	**29/05/2017**	**11/08/2017**	**55 days**
91	**12 LEM Firm_A production**	**21/12/2017**	**29/01/2018**	**18 days**
96	**12 LEM Firm_A production**	**18/01/2018**	**12/02/2018**	**18 days**
101	**12 LEM Firm_A production**	**01/02/2018**	**26/02/2018**	**18 days**
106	second CRP at Firm_A	14/02/2018	14/02/2018	0 days
107	**12 LEM Firm_A production**	**15/02/2018**	**12/03/2018**	**18 days**
112	**12 LEM Firm_A production**	**01/03/2018**	**26/03/2018**	**18 days**
117	**12 LEM Firm_A production**	**15/03/2018**	**09/04/2018**	**18 days**
122	**Anode Supply**	**03/07/2017**	**06/04/2018**	**190 days**
123	40 anode for CRP 1	03/07/2017	02/02/2018	145 days
124	40 anode for CRP 2	19/01/2018	06/04/2018	56 days
125				
126	**Test CRP#1 in cold box**	**29/03/2018**	**08/05/2018**	**28 days?**
127	Transport to cold box area	29/03/2018	30/03/2018	1 day

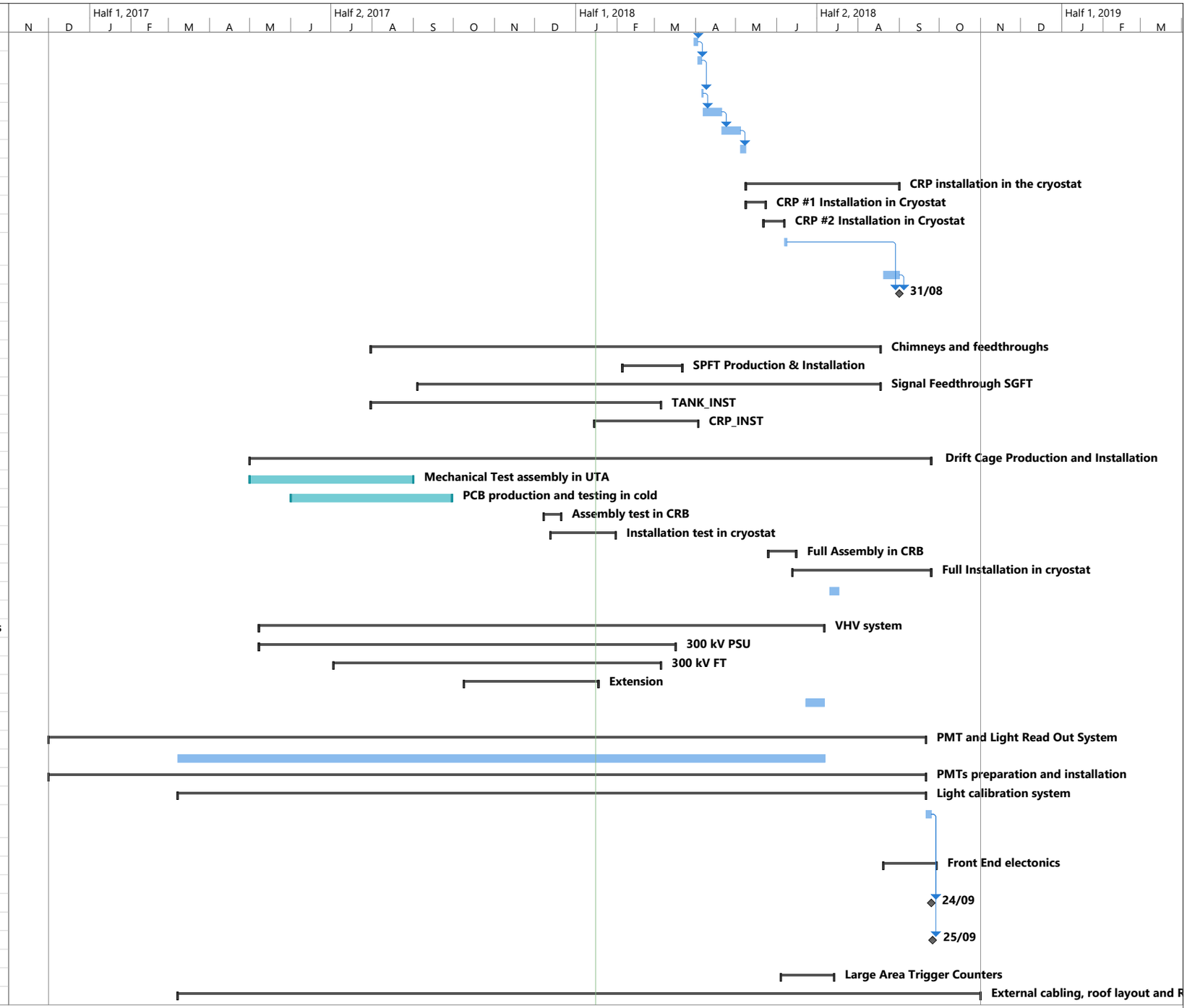


Projet : ProtoDUNE-DP-150118
Date : 16/01/2018

Tâche	Récapitulatif du projet	Tâche manuelle	Début uniquement	Échéance
Fractionnement	Tâche inactive	Durée uniquement	Fin uniquement	Avancement
Jalon	Jalon inactif	Report récapitulatif manuel	Tâches externes	Progression manuelle
Récapitulative	Récapitulatif inactif	Récapitulatif manuel	Jalons externes	

Schedule for 2 CRP scenario

ID	Task name	Start date (dd//mm/yy)	Finish date (dd//mm/yy)	Duration
128	Unpack the CRP	30/03/2018	02/04/2018	1 day?
129	Cable the CRP to the cold box Feedthroughs	02/04/2018	05/04/2018	3 days
130	Insert into the cold box	05/04/2018	06/04/2018	1 day?
131	Perfom cooling and test	06/04/2018	20/04/2018	10 days
132	Open and heat the box	20/04/2018	04/05/2018	10 days
133	Packing in transport box	04/05/2018	08/05/2018	2 days
134				
135	**CRP installation in the cryostat**	**08/05/2018**	**31/08/2018**	**83,43 days**
136	**CRP #1 Installation in Cryostat**	**08/05/2018**	**23/05/2018**	**11 days**
143	**CRP #2 Installation in Cryostat**	**22/05/2018**	**06/06/2018**	**11,57 days**
150	CRP lateral position adjustment (warm conditions)	06/06/2018	08/06/2018	2 days
151	CRP cabling to SGFT	20/08/2018	31/08/2018	10 days
152	All CRPs installed and cabled	31/08/2018	31/08/2018	0 days
153				
154				
155	**Chimneys and feedthroughs**	**31/07/2017**	**17/08/2018**	**265 days**
156	**SPFT Production & Installation**	**05/02/2018**	**21/03/2018**	**33 days**
160	**Signal Feedthrough SGFT**	**04/09/2017**	**17/08/2018**	**240 days**
172	**TANK_INST**	**31/07/2017**	**05/03/2018**	**146 days**
178	**CRP_INST**	**15/01/2018**	**02/04/2018**	**56 days**
182				
183	**Drift Cage Production and Installatio**	**01/05/2017**	**24/09/2018**	**356 days**
184	Mechanical Test assembly in UTA	01/05/2017	31/08/2017	89 days
185	PCB production and testing in cold	01/06/2017	29/09/2017	87 days
186	**Assembly test in CRB**	**08/12/2017**	**20/12/2017**	**9 days**
190	**Installation test in cryostat**	**13/12/2017**	**30/01/2018**	**25 days**
194	**Full Assembly in CRB**	**25/05/2018**	**15/06/2018**	**15 days**
199	**Full Installation in cryostat**	**12/06/2018**	**24/09/2018**	**74,43 days**
215	Beam plug installation	10/07/2018	17/07/2018	5 days
216				
217	**VHV system**	**08/05/2017**	**06/07/2018**	**294,57 days**
218	**300 kV PSU**	**08/05/2017**	**16/03/2018**	**215 days**
222	**300 kV FT**	**03/07/2017**	**05/03/2018**	**166 days**
226	**Extension**	**09/10/2017**	**17/01/2018**	**63 days**
230	Insertion and assembly in cryostat	22/06/2018	06/07/2018	10 days
231				
232	**PMT and Light Read Out System**	**01/12/2016**	**20/09/2018**	**461 days?**
233	LRO electronics	08/03/2017	06/07/2018	338 days
234	**PMTs preparation and installation**	**01/12/2016**	**20/09/2018**	**461 days?**
245	**Light calibration system**	**08/03/2017**	**20/09/2018**	**392 days**
249	Lower the Ground grid to its fnal position	21/09/2018	24/09/2018	2 days
250				
251	**Front End electonics**	**20/08/2018**	**28/09/2018**	**30 days**
256				
257	End of installation inside the cryostat	24/09/2018	24/09/2018	0 days
258				
259	**Ready to seal TCO & cryostat**	**25/09/2018**	**25/09/2018**	**1 day**
260				
261	**Large Area Trigger Counters**	**04/06/2018**	**13/07/2018**	**30 days**
265	**External cabling, roof layout and Rac**	**08/03/2017**	**31/10/2018**	**421 days**

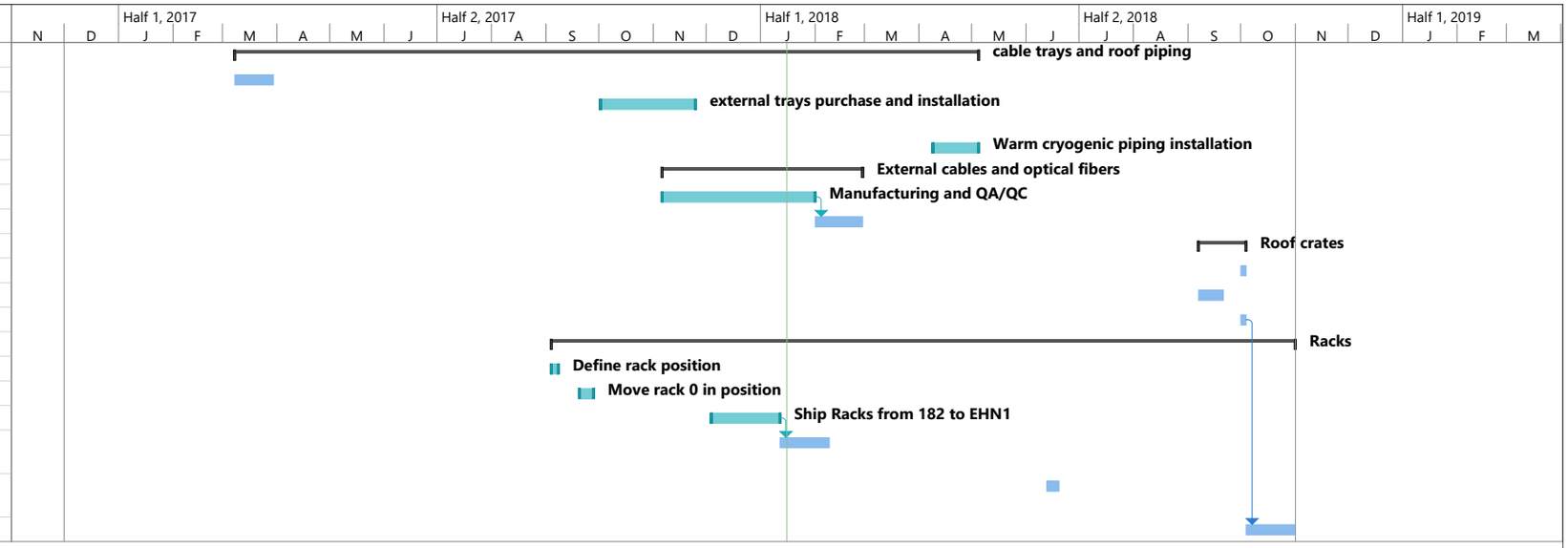


Projet : ProtoDUNE-DP-150118
Date : 16/01/2018

Tâche	Récapitulatif du projet	Tâche manuelle	Début uniquement	Échéance			
Fractionnement	Tâche inactive	Durée uniquement	Fin uniquement	Avancement			
Jalon	Jalon inactif	Report récapitulatif manuel	Tâches externes	Progression manuelle			
Récapitulative	Récapitulatif inactif	Récapitulatif manuel	Jalons externes				

Schedule for 2 CRP scenario

ID	Task name	Start date (dd//mm/yy)	Finish date (dd//mm/yy)	Duration
266	**cable trays and roof piping**	**08/03/2017**	**04/05/2018**	**293 days**
267	design and 3D layout	08/03/2017	29/03/2017	16 days
268	external trays purchase and installation	02/10/2017	24/11/2017	40 days
269	Warm cryogenic piping installatio	09/04/2018	04/05/2018	20 days
270	**External cables and optical fibers**	**06/11/2017**	**27/02/2018**	**72 days**
271	Manufacturing and QA/QC	06/11/2017	31/01/2018	53 days
272	Installation	01/02/2018	27/02/2018	19 days
273	**Roof crates**	**07/09/2018**	**03/10/2018**	**19 days**
274	Low voltage	01/10/2018	03/10/2018	3 days
275	PMT calibration	07/09/2018	20/09/2018	10 days
276	Cameras	01/10/2018	03/10/2018	3 days
277	**Racks**	**04/09/2017**	**31/10/2018**	**293 days**
278	Define rack position	04/09/2017	07/09/2017	4 days
279	Move rack 0 in position	20/09/2017	27/09/2017	6 days
280	Ship Racks from 182 to EHN1	04/12/2017	11/01/2018	19 days
281	Rack cabling and connection to external cabling	12/01/2018	08/02/2018	20 days
282	Install light system HV modules in rack	12/06/2018	19/06/2018	5 days
283	General slow control testing	04/10/2018	31/10/2018	20 days



First CRP test in the cold box foreseen in April
All the components at CERN by the middle of August

Projet : ProtoDUNE-DP-150118
Date : 16/01/2018

Tâche	Récapitulatif du projet	Tâche manuelle	Début uniquement	Échéance
Fractionnement	Tâche inactive	Durée uniquement	Fin uniquement	Avancement
Jalon	Jalon inactif	Report récapitulatif manuel	Tâches externes	Progression manuelle
Récapitulative	Récapitulatif inactif	Récapitulatif manuel	Jalons externes	

Page 3

Critical items

LEM HV, grid HV, first field shaper and signal feedthroughs, some of which need some development

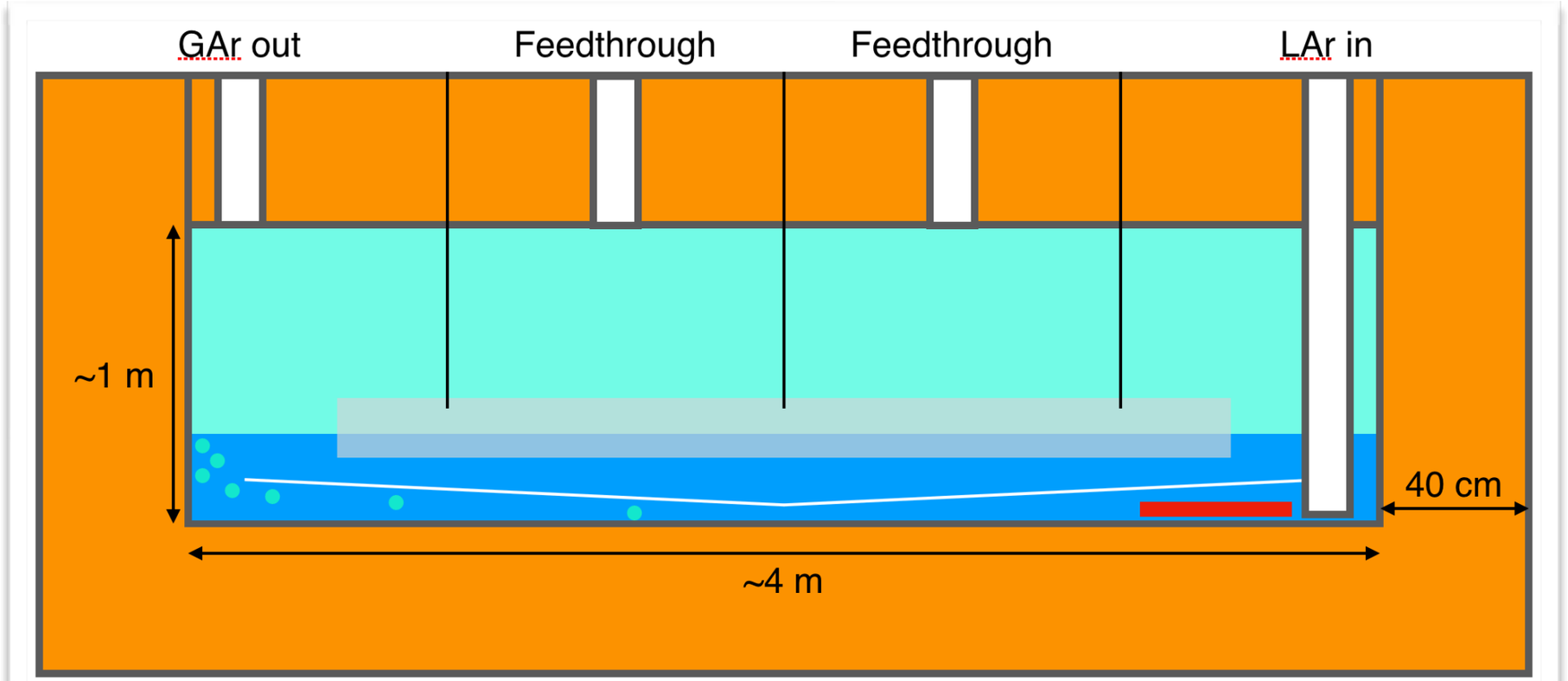
HV distribution box on the CRPs

Cathode and cathode connection to the feedthrough

PMT protection grid

Beam plug

NP02 cold box test



Goals

Electrical and mechanical tests of each final CRP in nominal thermodynamic conditions:

- Characterisation of the operation voltage of each LEM
- Test the planarity of the CRP itself
- Test the tensioning of the extraction grid wires
- Test the HV contacts and connections (LEM & grid)

NP02 cold box test

Characteristics

Mechanics:

- Self sustained SS structure
- Internal dimensions of ~4x4 m^2 x 1 m
- SS non-corrugated primary membrane
- CRP hanging from the top (3x1x1 solution)

Cryogenics:

- Passive insulation (polyurethane foam)
- Initial purging of GAr to remove air
- LAr boil-off released into the atmosphere
- Controlled LAr refilling to maintain the level

Status

Engineering:

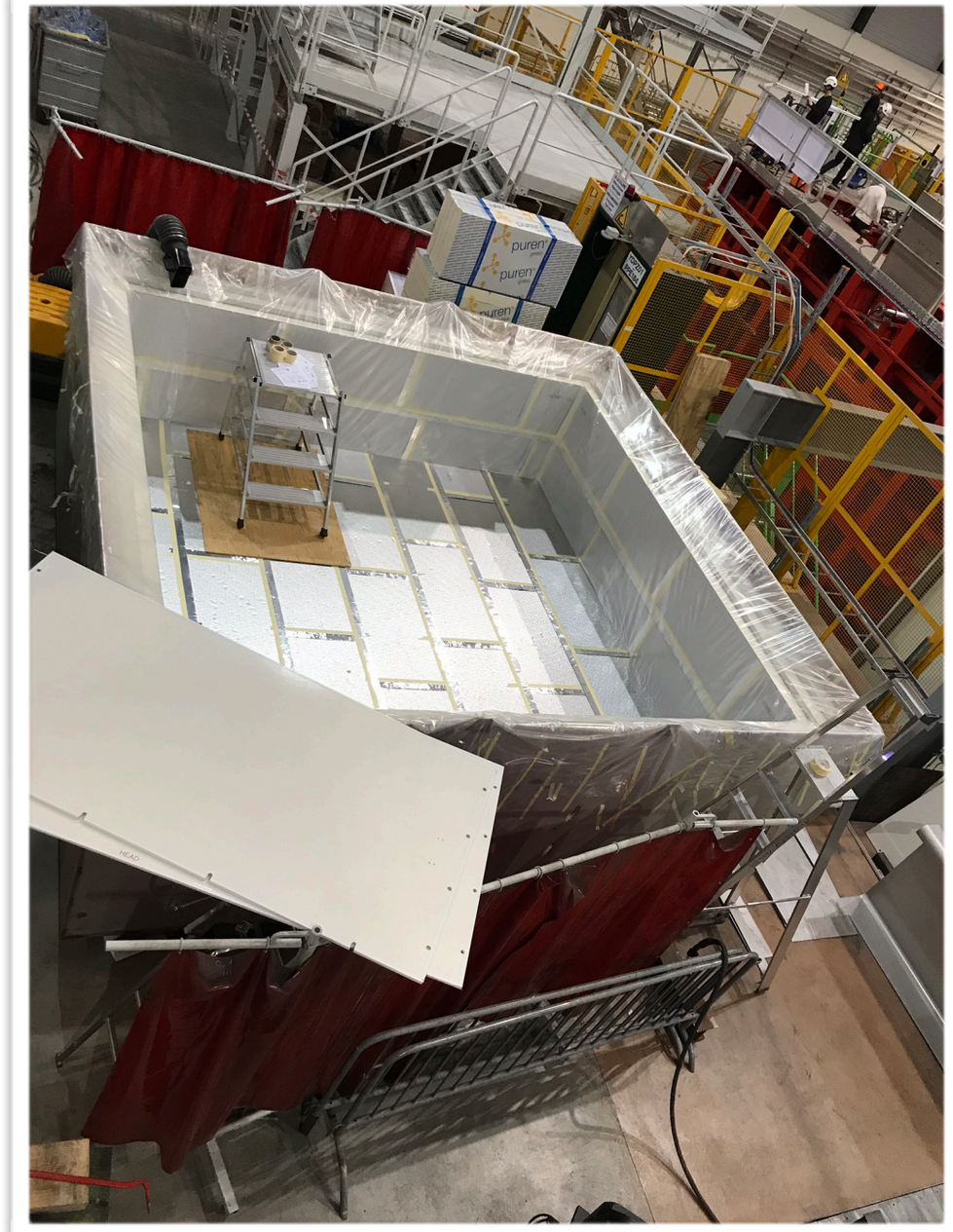
- Finalisation of the last production drawings

Material procurement:

- Most of the material in hand

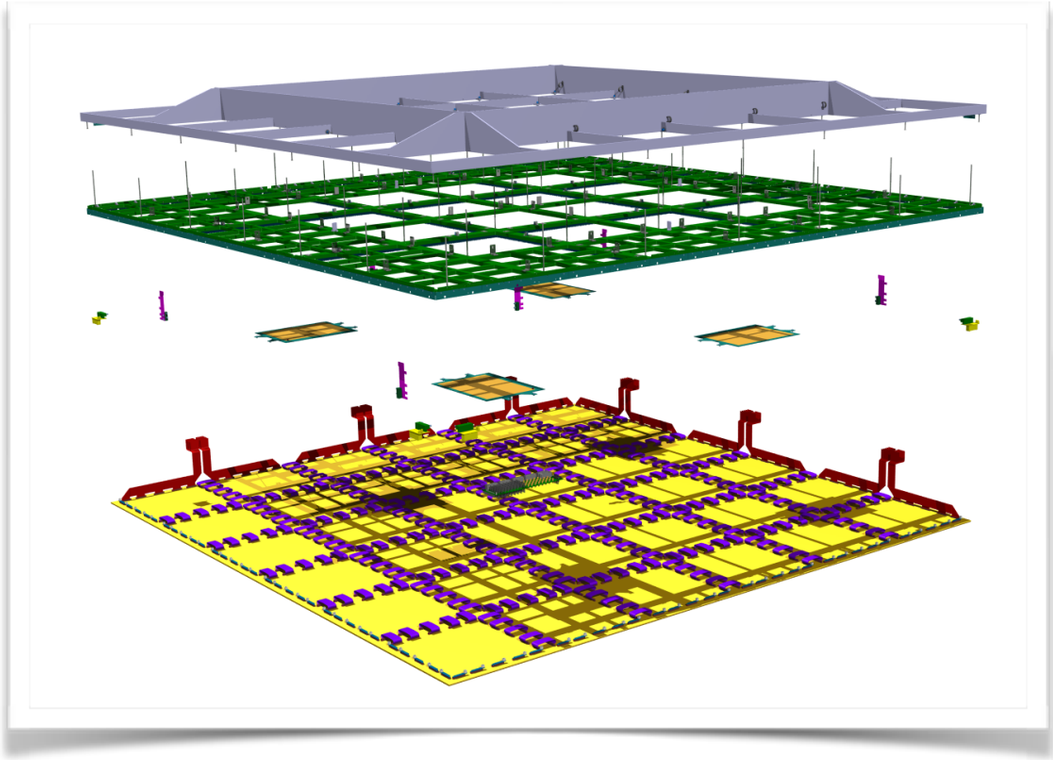
Construction:

- begin at the end of January at CERN by a team of CERN technicians and welders
- Installation in building 182 (safety and cryogenic equipment already available)
- Cryogenic system presently under design



CRP preparation

All mechanical parts have been ordered including all construction structure, screws, bolts, decoupling systems, etc…
Final Invar frames production started in priority at the firm, beginning of November 2017.
First Invar frame delivery is expected end of February 2018.

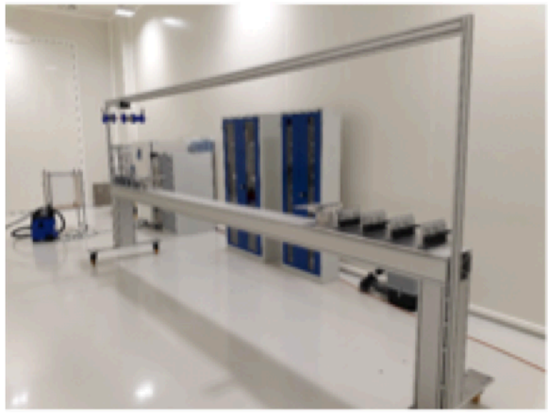


Full G10 frames batch delivery at CERN:
- side bars for extraction grid support
- extraction grid supporting combs
- supports for level-meters and thermometers

CRP preparation

Building 185 Clean Room organisation

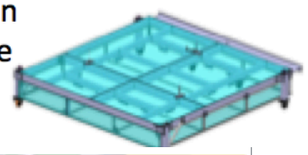
- the grid wire assembly tool has been received on Jan 19th

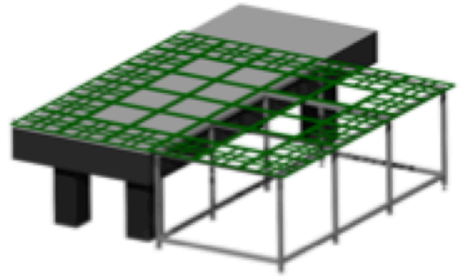


Before end of January:

- Complete the Installation of the grid wire assembly tool
- Perform assembly tests and apply all quality controls to grid elements

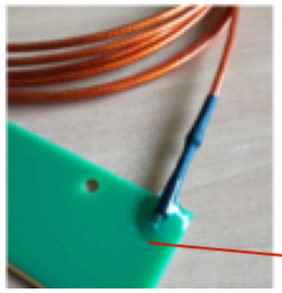
- assembly tooling recently ordered:
  - Optical table extension
  - Extraction grid storage
  - CRP Transport box
  - 2 x mobile cranes

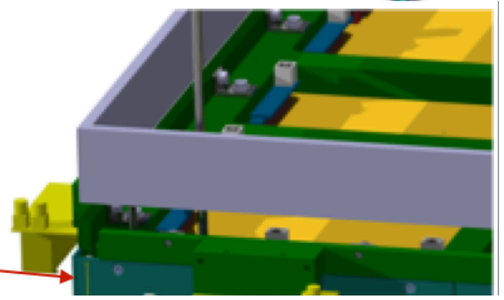




Extraction grid HV connectors

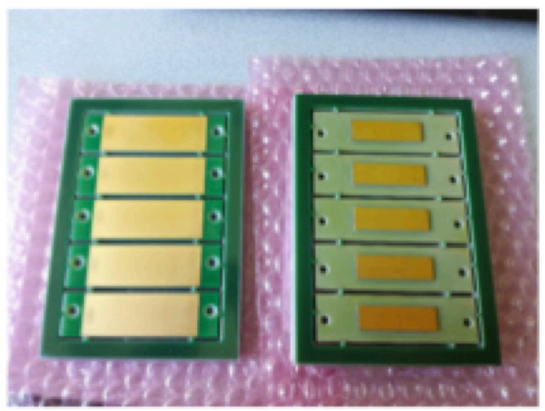
- A connection to avoid sparking has been developed and optimised
- Test in cold GAr will be performed at high voltage in different configurations

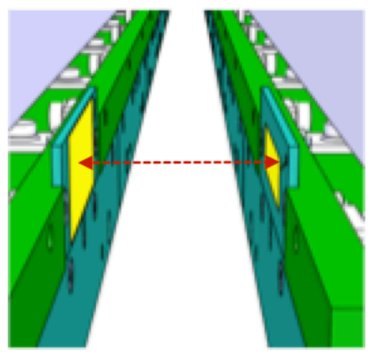


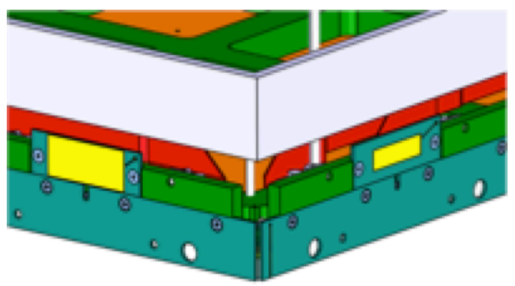


Distance meters

- All the parts are available.
- Electronic system is being assembled and tested.
- Final cabling on cryostat roof, feedthrough and patch-panel is in discussion.







VHV system summary

Feedthrough:
Order to CINEL: 3 HVFTs with 5 male connectors (2 for 38.2 mm cables, 2 for 22 mm cables, 1 for cable 14 mm cables)
- 1st HVFT with one connector received at the beginning of February
- To be HV tested before starting the production of the others

Power supply:
- One Heinzinger PNChp 300000-05 neg High Precision High Voltage Power Supply, with negative output polarity with 10 m HV-cable presently at EHN1
- Upgrade of the Control Unit for the previous Heinzinger PNChp 300000-05 (at CERN since December 2014 and used for WA105 detector) has been ordered on 13.11.2017 and recently shipped to CERN

Cathode:
- being engineered

Field cages: partially installed in the cryostat

Status of the electronics

Main components ASIC amplifiers, ADCs, FPGAs, IDT memories already procured in 2015-2016. 3x1x1 pre-production batch in 2016.

→ Fall 2017 submitted orders for the completion of production of cryogenic FE cards and digitization cards on 2017 budget

Analog cryogenic FE:

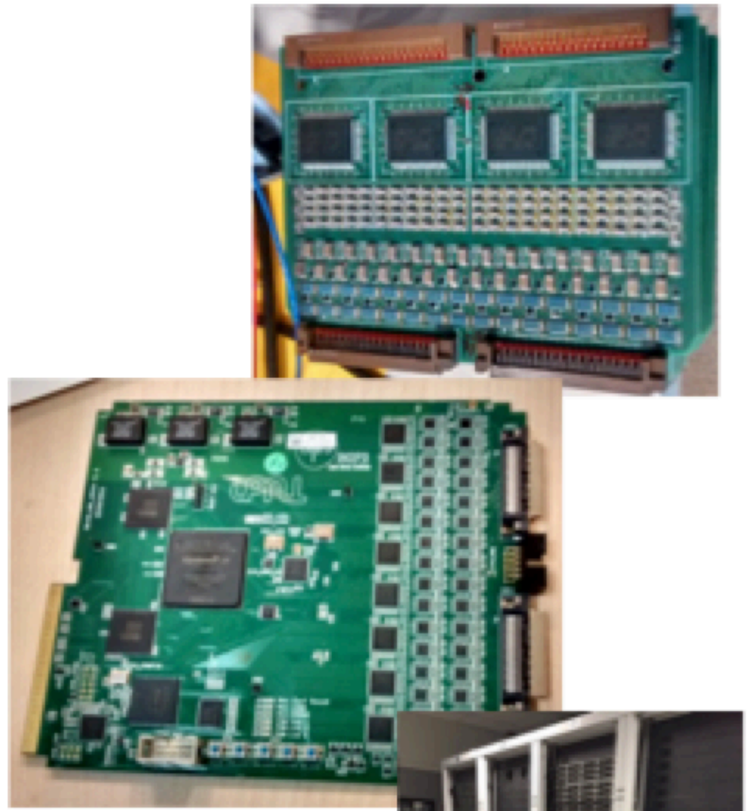
- Production being completed of remaining 100 FE cards for 6x6x6

Digitization cards:

uTCA 64 channels AMC digitization cards (2.5 MHz, 12 bits output, 10 GbE connectivity)

- Production completed of remaining 100 AMC cards for the 6x6x6

→ Delivery of both FE and AMC Digitization cards expected by end of February.



White Rabbit timing/trigger distribution system:

- Components already produced in 2016 for the entire 6x6x6

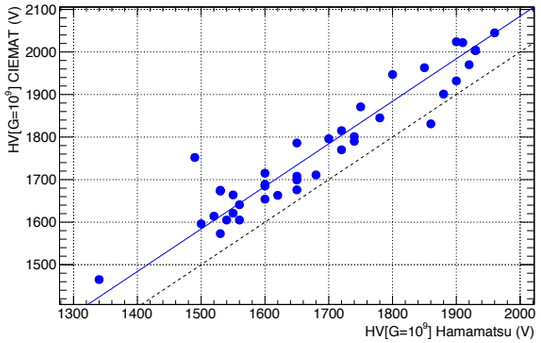
DAQ infrastructure

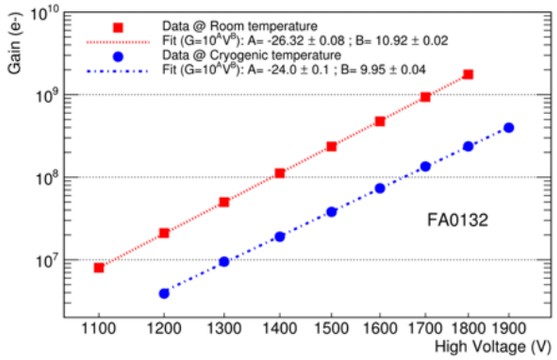
- Storage servers installed in the fall 2017.
- Network infrastructure (switches/routers) installation being completed by CERN by end of January

Preparation of the light system

Full characterization of 36 (+4 spares) 8” Hamamatsu PMTs completed at room and cryogenic temperature

- **Dedicated cryogenic test facility** used for testing 10 PMTs at once
- **Final system** (HV divider, mechanical support and 23 m cables) **assembled and validated in LN_2**
- **Database ready** including: **dark current and gain vs HV** curves + **SPE waveforms** for each PMT
- **Extra tests**: PMT light linearity, PMT response vs light frequency, tests at different T regimes
- All PMTs are **ready for installation** and are being prepared to be **shipped to CERN**
- **TPB coating** will be done at CERN (same facility as ICARUS) in April-May

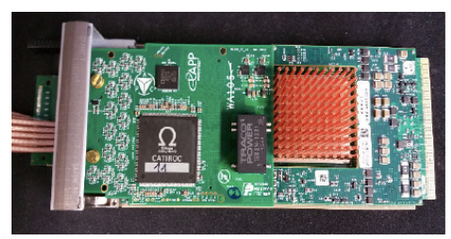


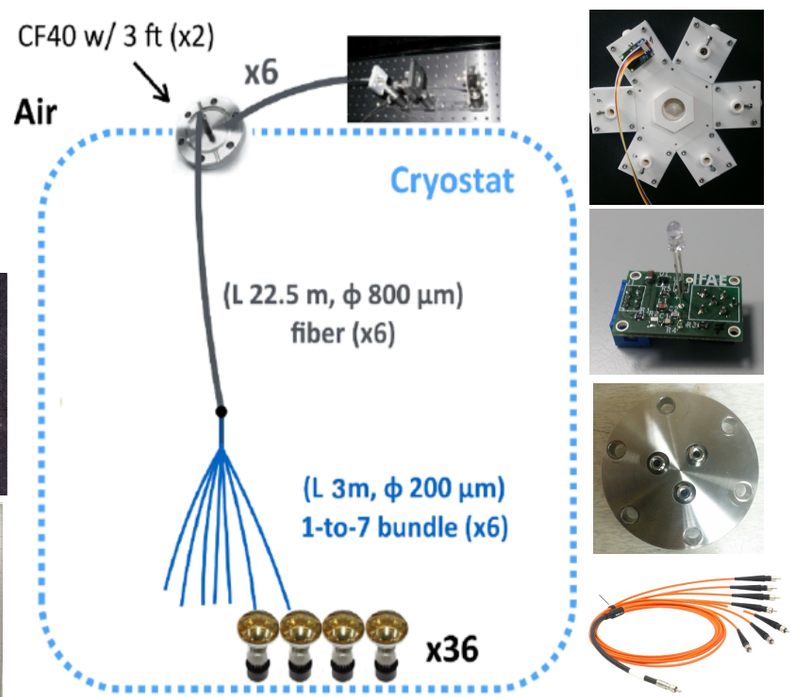


TPB coated PMT

PMT calibration system

- **Design validated** (black box with 6 LEDs (+1 SiPM) outside the cryostat + 6 fibers into the cryostat divided at the end in 7 fibers arriving to each PMT)
- All final fibers, bundles and optical feedthroughs **procured and tested in LN_2**
- **Light source components** being **assembled**
- **Full** light calibration system **test in March**





Front End Electronics

- **Preparing** firmware / software
- **Tests** with pulse generator and one PMT **in March**
- **Integration** with micro-TCA **in April-May**
- Ready for **installation in June**

Summary

- Activities at EHN1 on cryostat and cryonics ongoing
- Installation of the first 4 modules of the field cage accomplished
- Learned a lot from the 3x1x1 operation
- Visual inspection of the detector will soon happen
- Acting on the LEM design to increase the HV margin
- Production of several detector components ongoing
- Critical items - like the LEMs - are being optimised
- A lot of effort to finalise and procure the critical items (feedthroughs, …)
- Cold box tests are a key element in the strategy

The Proto DUNE-DP collaboration is committed to demonstrate the Dual Phase concept at the kton scale in a time-scale useful for the DUNE Technical Design Report