WA105 and its related R&D on innovative double phase charge readout system and light readout system at liquid Argon temperature

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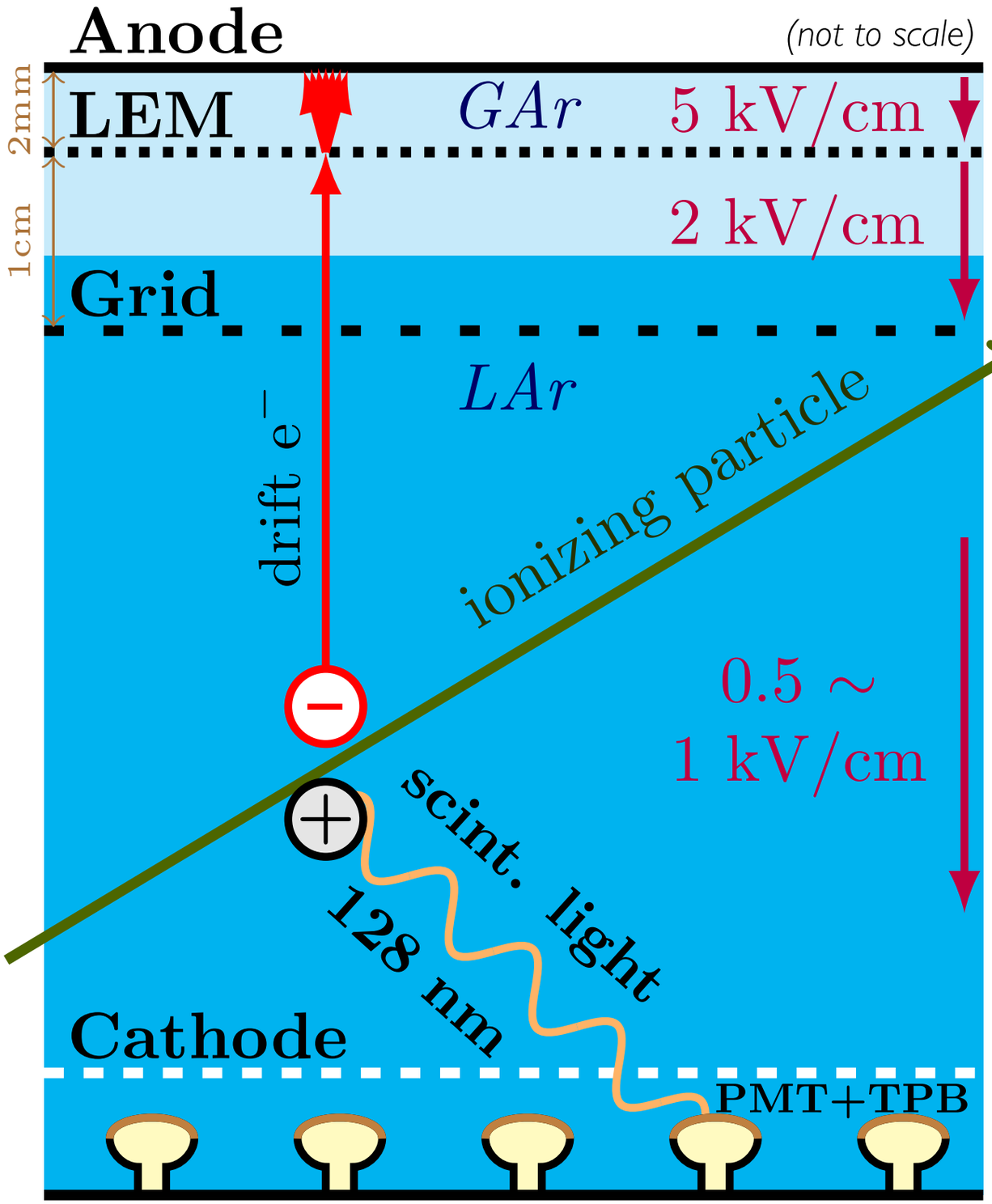
on behalf of the WA105 collaboration

TYL/FJPPL and FKPPL joint workshop

May 10th 2017 — Strasbourg

Dual phase Liquid Argon TPC Concept

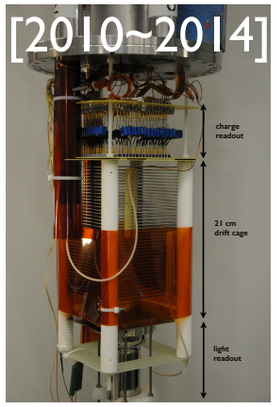


GLACIER concept, A. Rubbia, hep-ph/0402110

- Strong electric field applied across the TPC to collect electrons produced by energy loss. Electron attachment is low, which allow long drifts.
- Scintillation light produced with two well known time constants. Can be used as a event trigger, LAr impurities measurement and as a complementary calorimetry measurement.
- Dual phase technology adds a layer of gaseous argon underneath the readout to amplify the signal by a Large Electron Multiplier
- LArTPCs are considered for the far detector of the future long baseline neutrino experiment (DUNE)

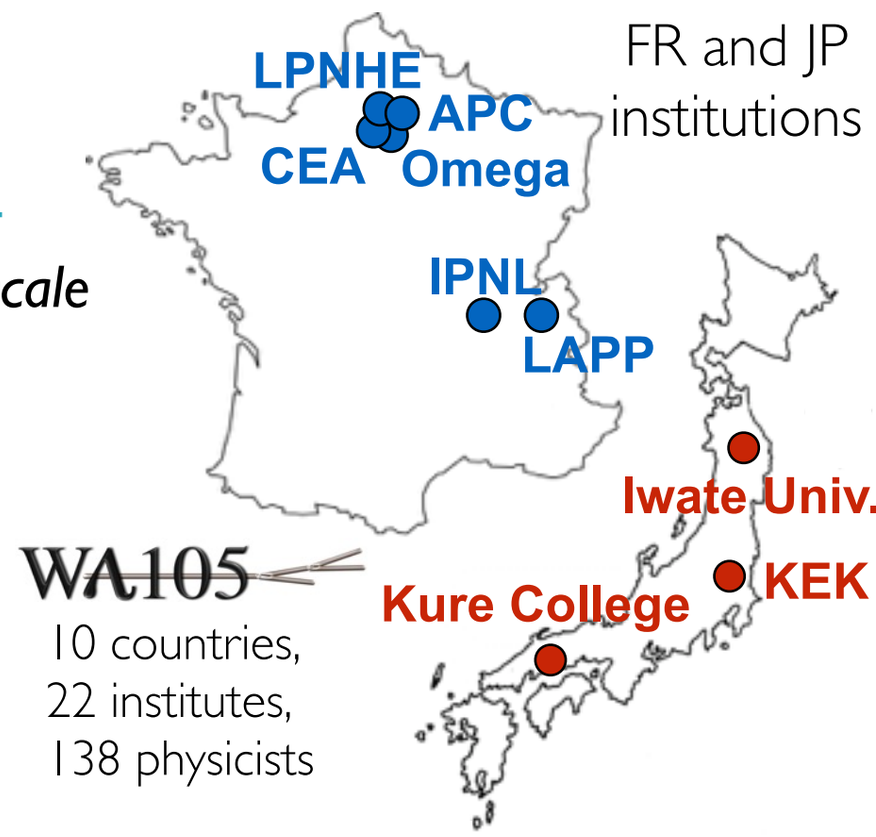
The WA105 Collaboration

Demonstrate the capabilities of the dual phase technology at the kton scale



Years of R&D and prototypes :

Small dual LArTPC of few liters for R&D,
e.g. Anode & LEM designs



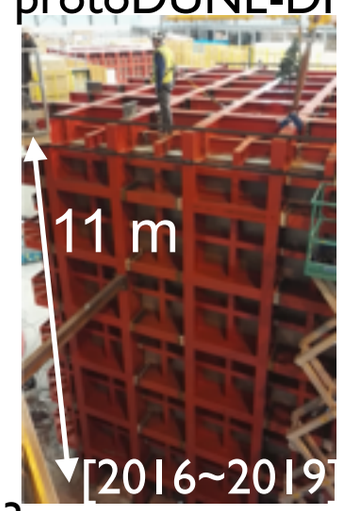
Large dual LArTPC demonstrator of 3x1x1 m^3 fiducial volume, cosmic ray run.

Goals :

- First large cryostat for LAr built by external company (GTT)
- Engineering test of detector components [production, installation, operation]
- Overview of the complete system integration
- Validation of the production & construction schedule for larger LArTPCs

3x1x1 demonstrator

protoDUNE-DP

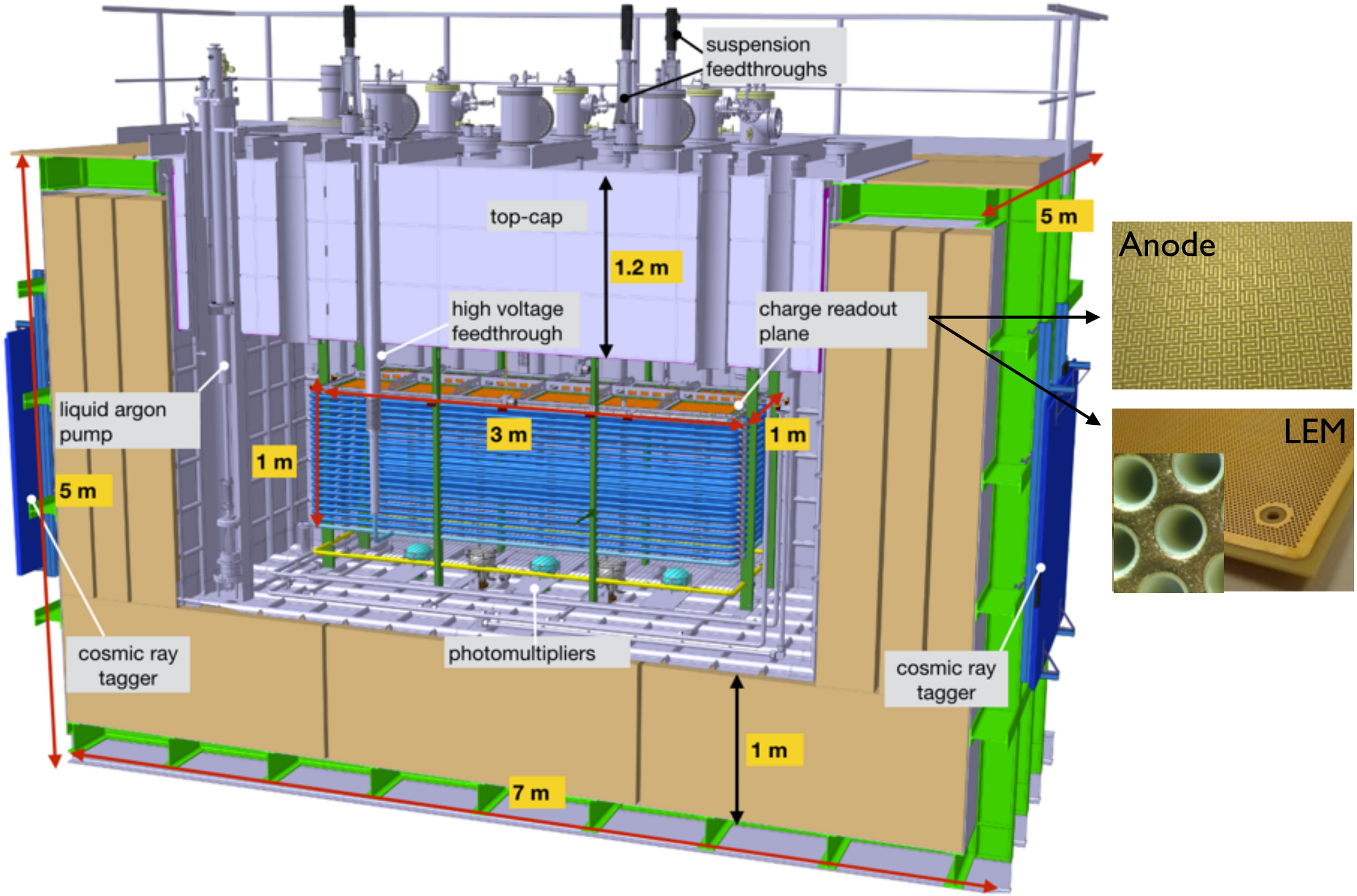


DUNE dual-phase prototype of 6x6x6 m^3 fiducial volume, to be exposed to hadronic beam

Goals :

- Large structure constructed as if underground
- Very high voltage generation and guiding
- Long drift, low purity stability
- Large charge readouts areas
- Calibration, reconstruction and physics analysis of test beam data

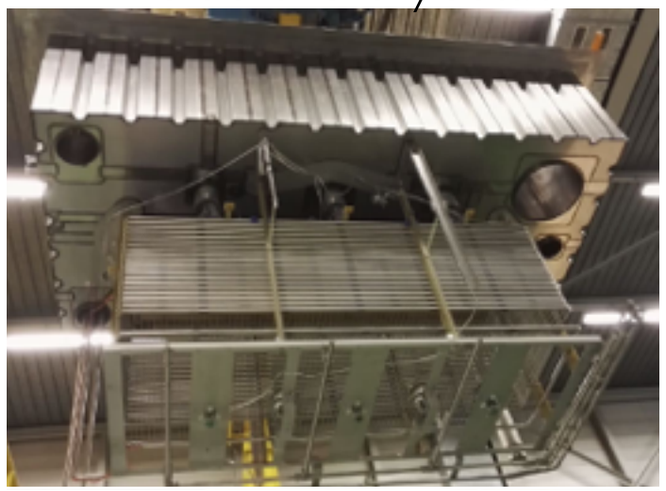
The 3x1x1 m^3 dual phase LArTPC demonstrator

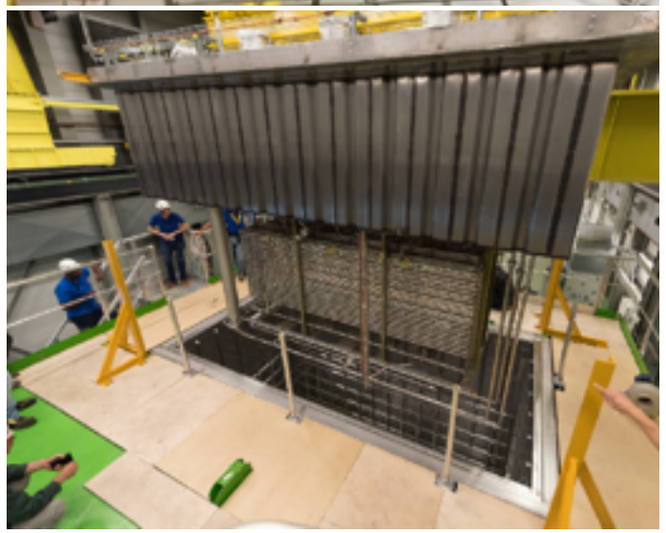


WA105 progress since last year (3x1x1)

June 2016 : Detector assembly finished

July 2016 : Detector lifted inside the cryostat





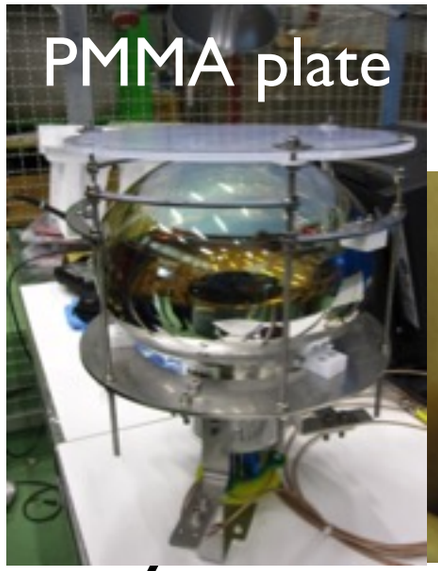
Aug 2016 : Lyon FE electronics + cables installed inside feedthroughs

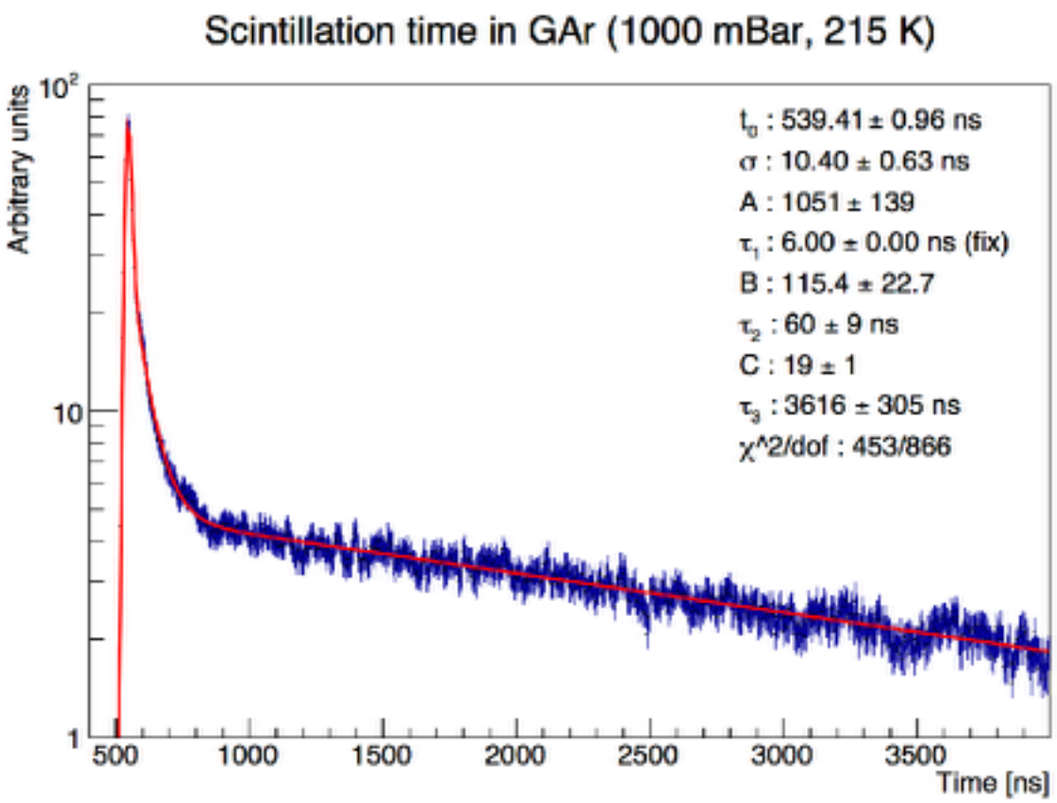
Nov 2016 : control racks, DAQ and cryogenics installed, cabled and tested

Light signal in the 3x1x1 - first measurements

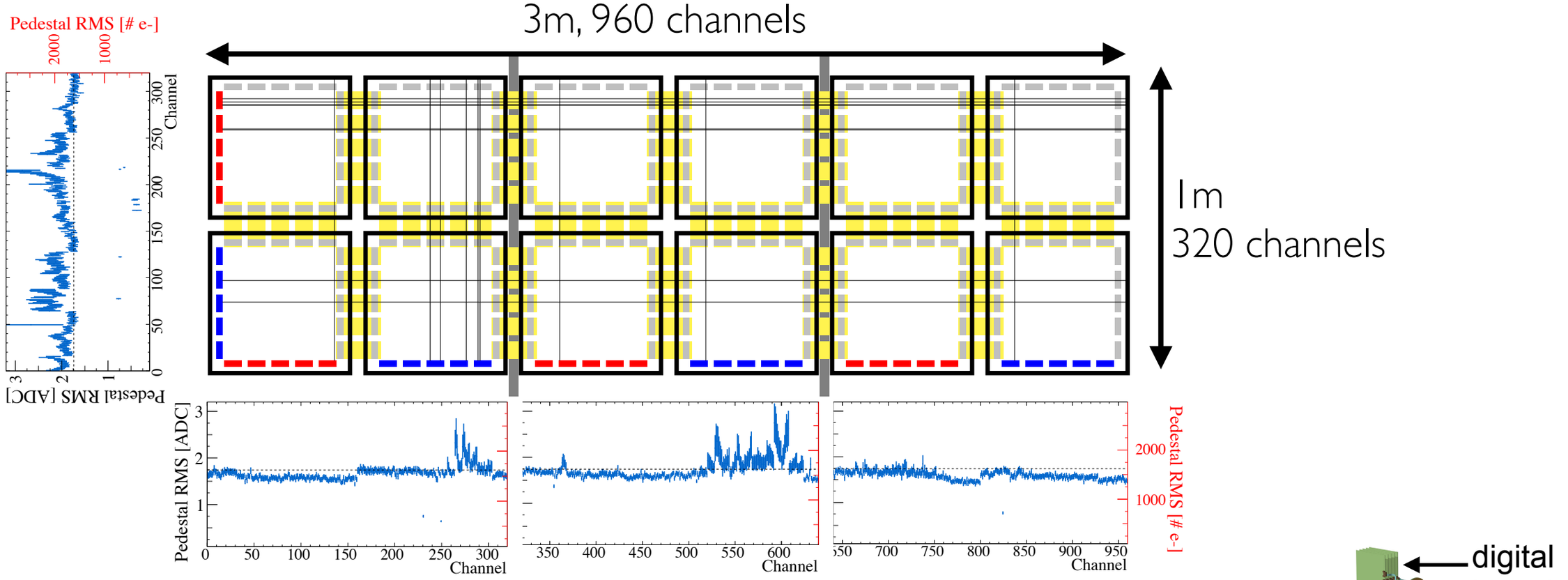
5 PMTs have been installed in the detector with different configurations

- LAr scintillation light is at 128 nm → a TPB layer is needed to convert VUV light to visible wavelength, where PMT operates
- 2 light readouts cards (KEK, CIEMAT) have been developed
  - 3 PMTs with TPB on the PMT photocathode
  - 2 PMTs with TPB on a PMMA plate above the photocathode
  - 3 PMTs with KEK electronics
  - 2 PMTs with CIEMAT electronics



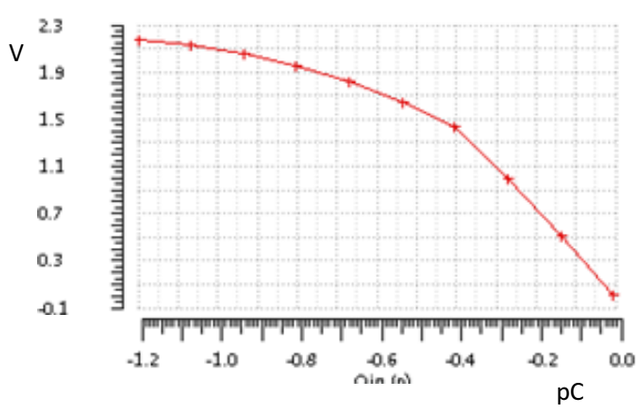


Charge signal in the 3x1x1 during commissioning

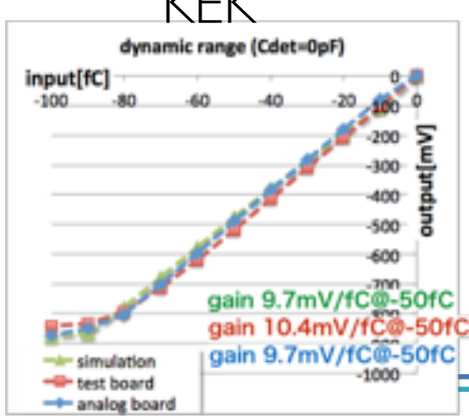


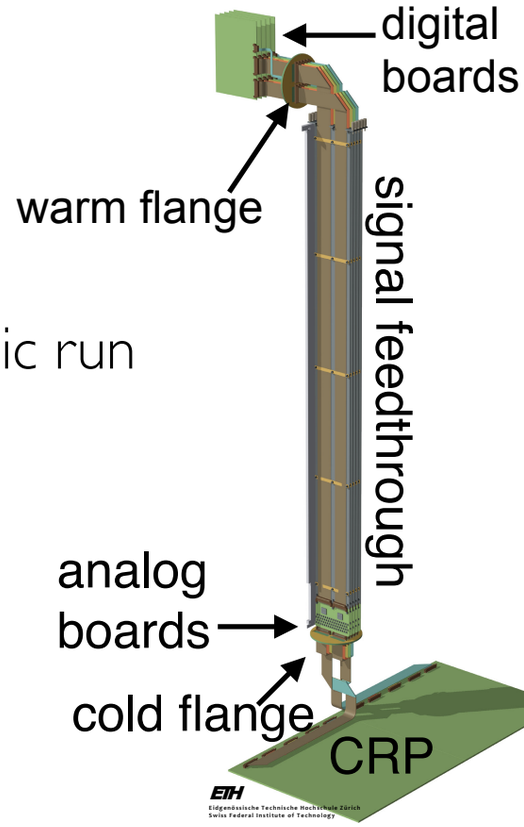
- Out of 1280 channels, 17 found problematic or dead (1.3%)
- Noise at room temperature stable at around 1600 e^-
- Calibration runs have highlighted ~ 4% of crosstalk
- Currently, IPNL FE electronics are installed, switch to KEK boards during the cosmic run

IPNL



KEK

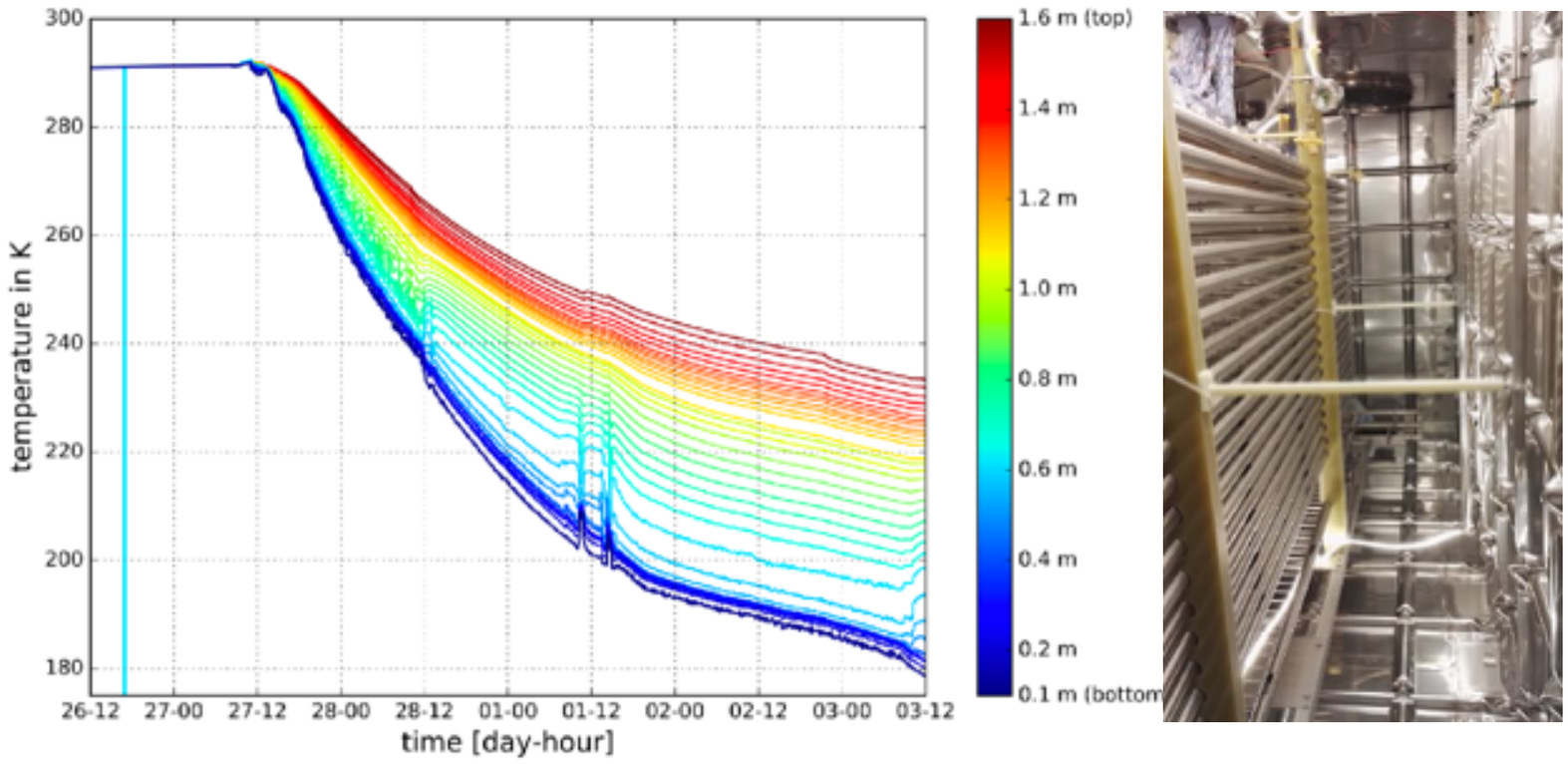


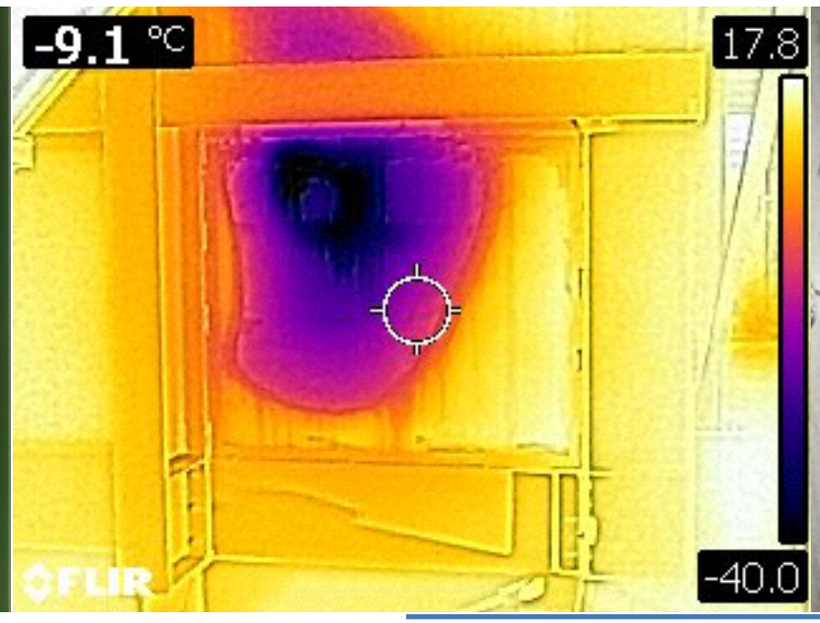


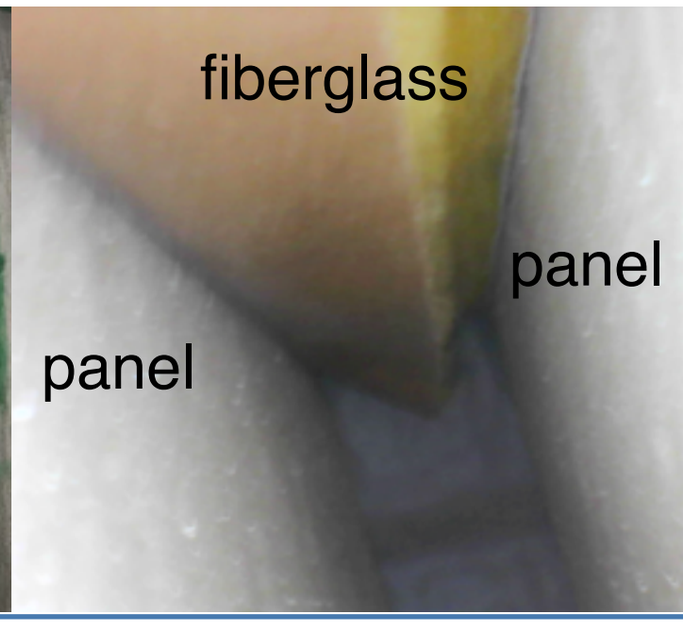
Detector cool down

- Detector cooling started on Feb. 27th 2017
- One week later, an ice formation was observed outside the tank
- Holes were drilled around the cold spots in the membrane, and sheets of fiberglass appeared missing. It was replaced by polyurethane foam

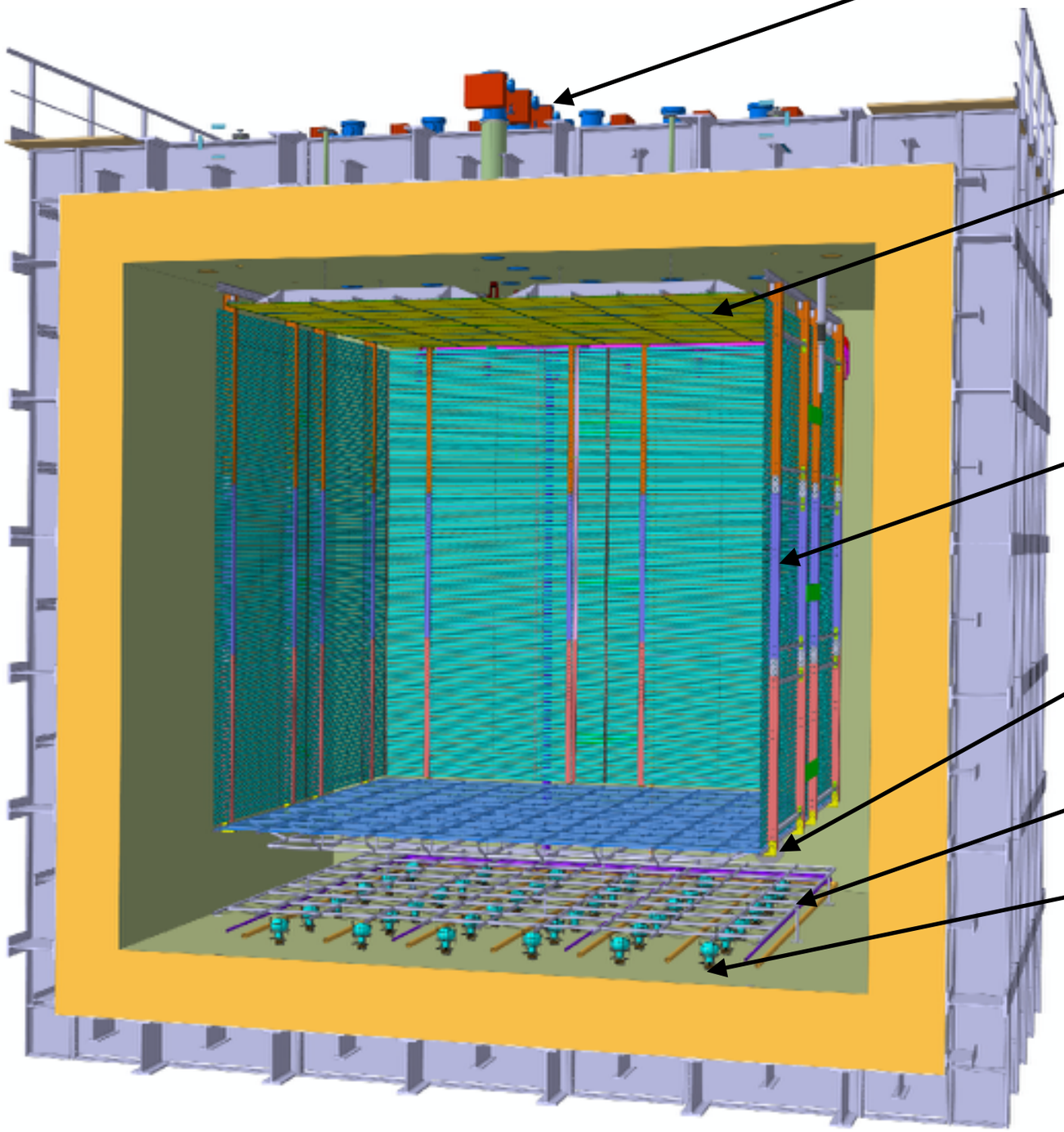
Temperature probes inside the drift cage







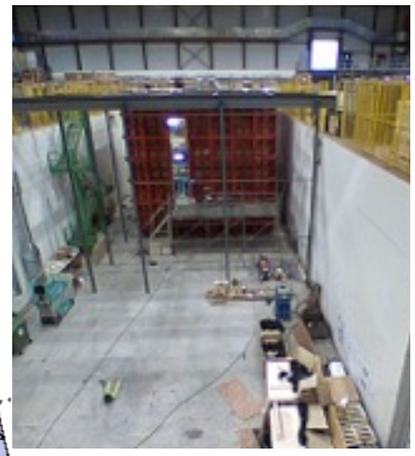
ProtoDune-DP - WA105 6x6x6 m^3 prototype



→Finalisation by the end of November 2016 of executive design of CRPs, field-cage and cathode

DUNE prototypes at CERN - Neutrino Platform

Construction of single and dual phases large demonstrators to be exposed to hadronic beam in 2018
Crucial inputs for the DUNE far detectors technology



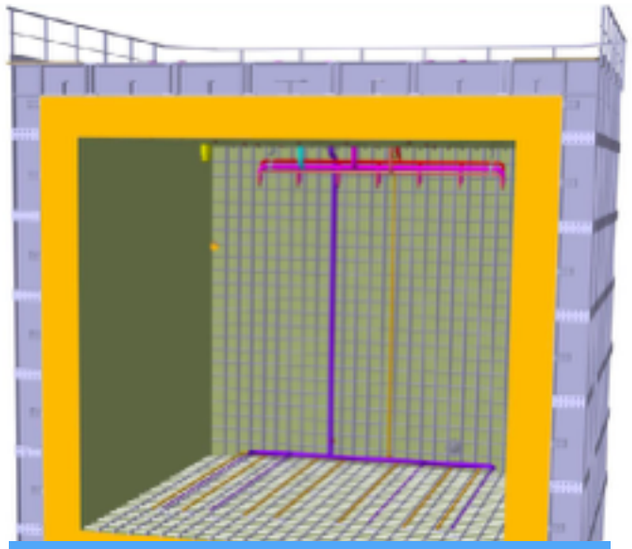
EHN1 hall extended

Dual phase LArTPC
[WA105 - NP02]

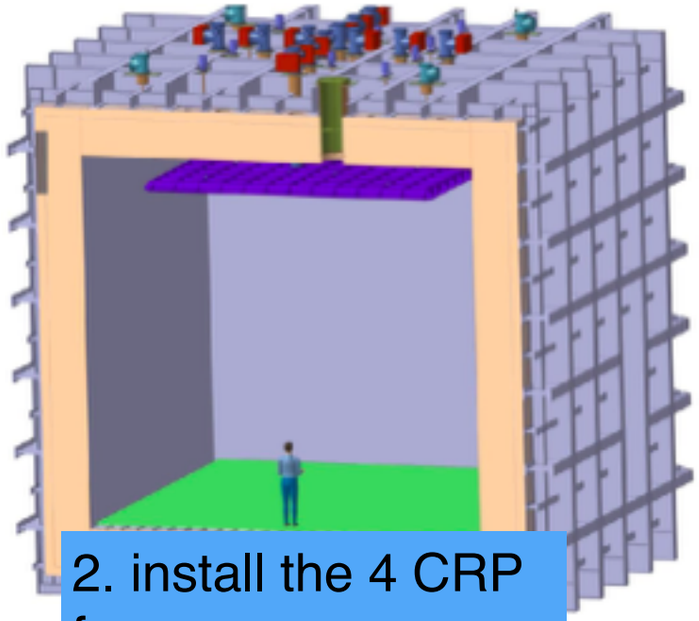
Single phase LArTPC
[WA104 - NP04]

protoDUNE construction & integration (2017~2018)

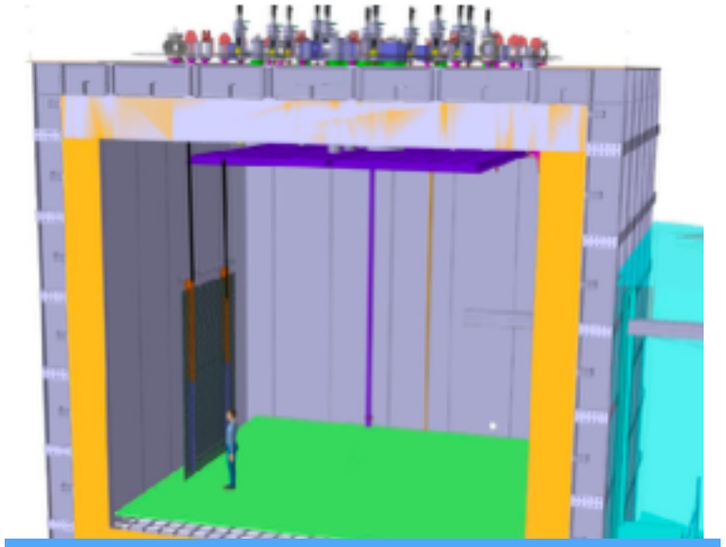
Technical coordinator at IPNL, Integration co-coordinator at LAPP



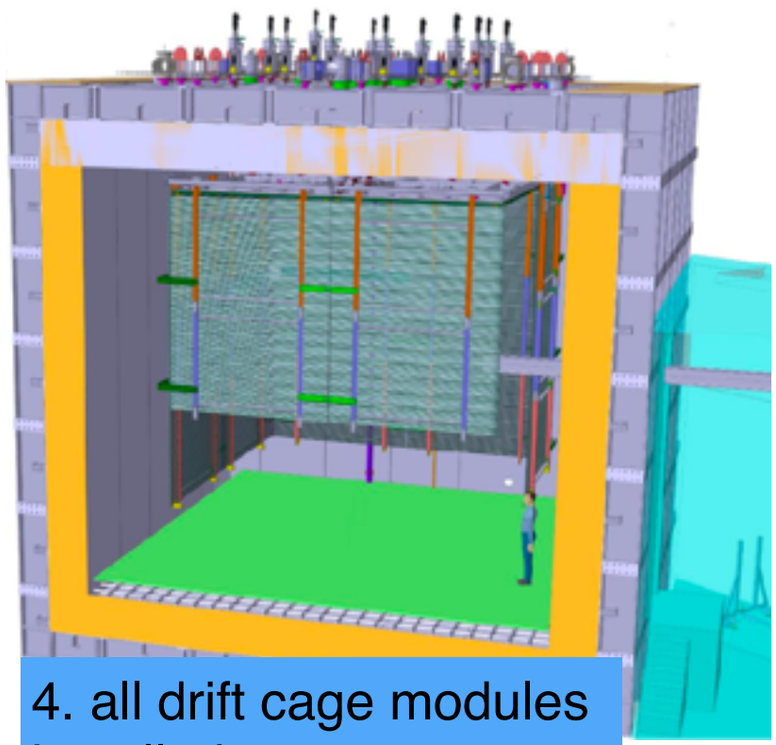
1. install internal piping & temporary floor



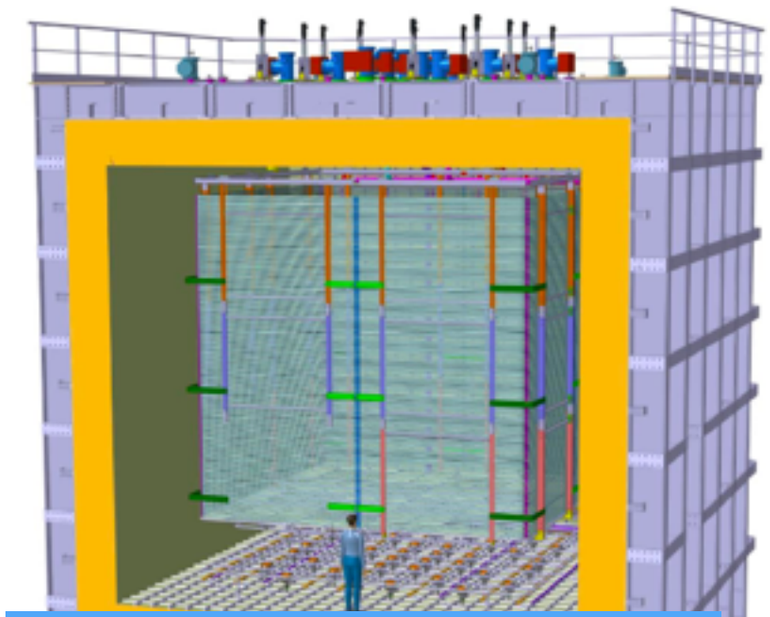
2. install the 4 CRP frames



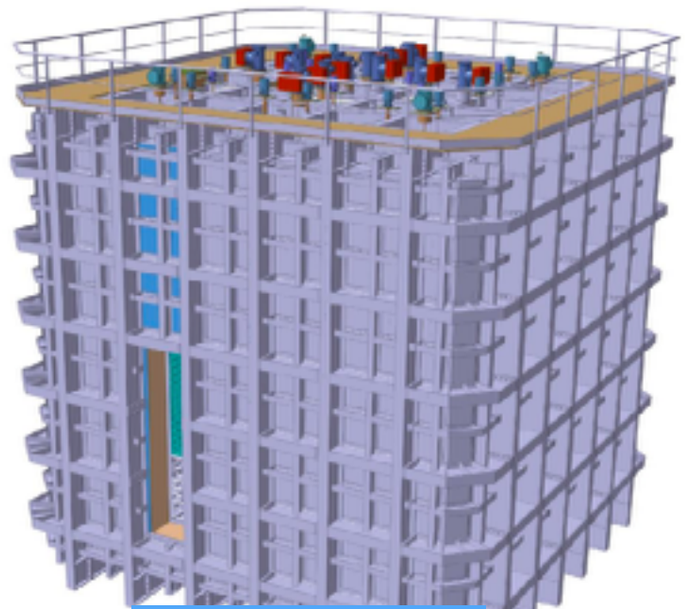
3. install the first drift cage modules



4. all drift cage modules installed



5. remove temporary floor and install photomultipliers

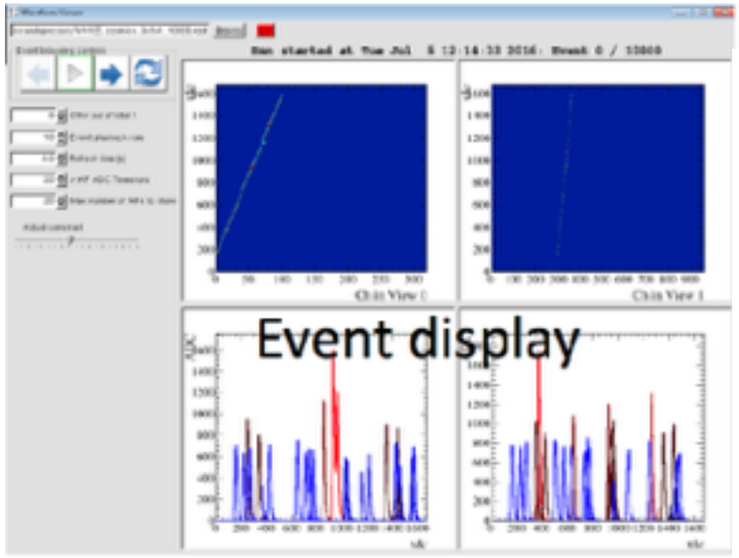


6. seal TCO

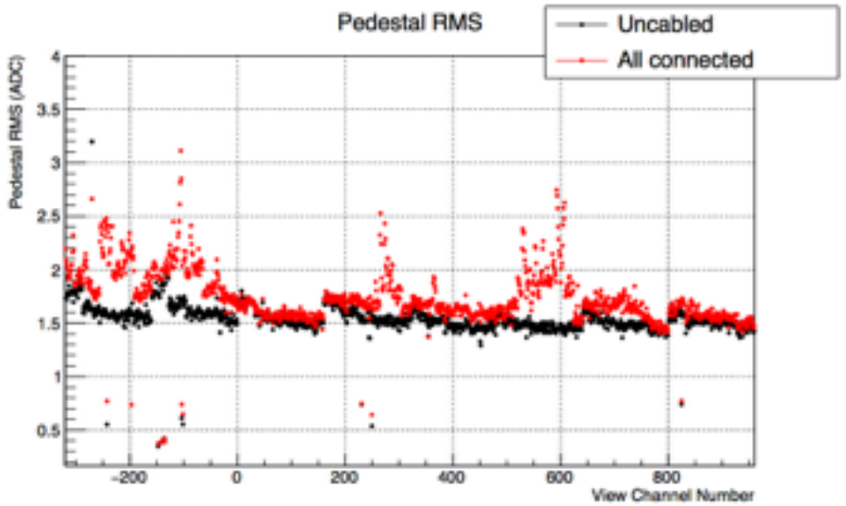
Software developments

Software coordinator at KEK

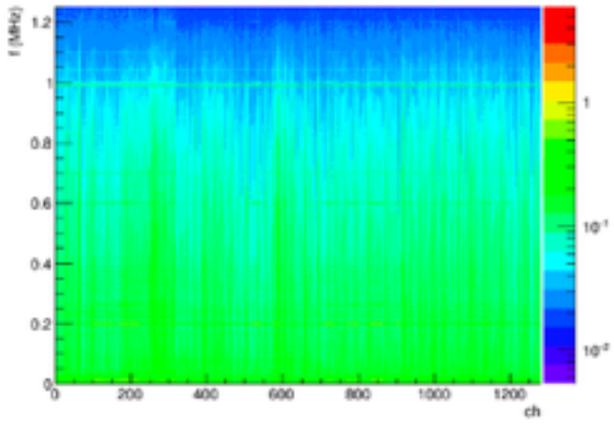
Online tools



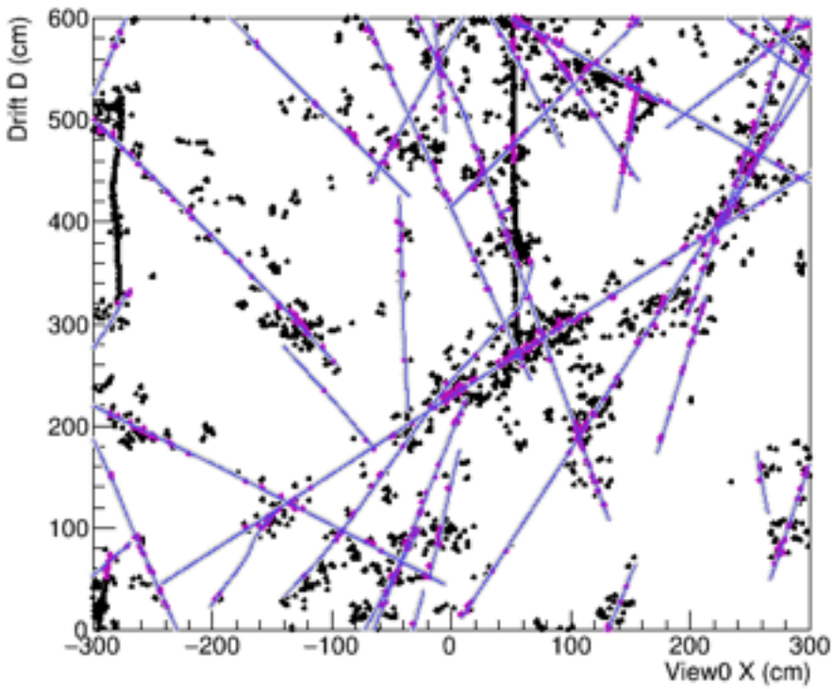
Systematic check of the noise



Perform FFT on raw data



Offline tools



Reconstruction of a simulated 8ms cosmic ray events through the protoDUNE-DP

Hits attached to a track

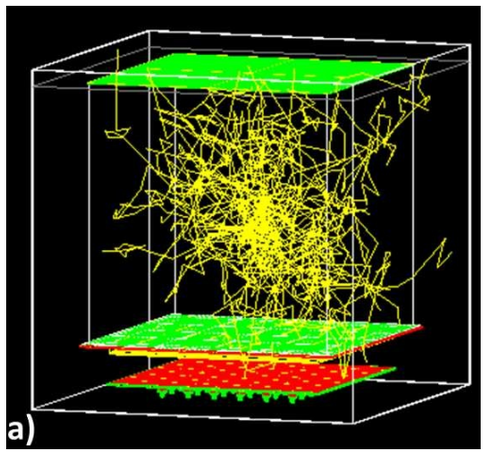
Track Path

Delta Rays

Unmatched hits

Software developments

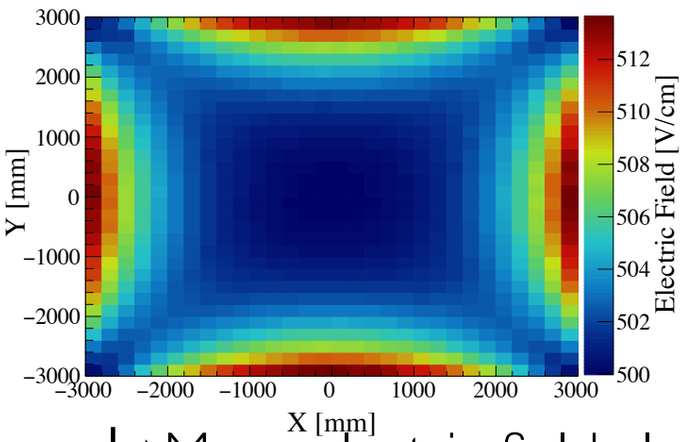
Light maps



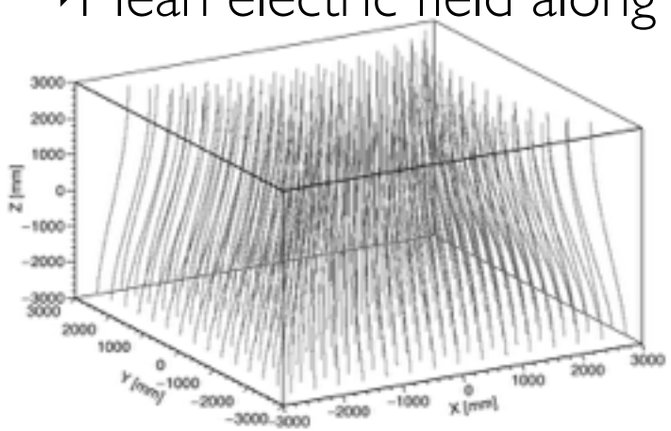
- Map photons propagation time and survival probability from creation point to the PMT array
- Detector is divided in 3D voxels, 10^7 photons generated per voxels
- Photon absorption on detector components , tracking parameters (absorption length, rayleigh scattering) are careful studied
- Allow studies on the electroluminescence gain, cosmic tagger/rejection using light, calorimetry

↳Path of photons in the protoDUNE

Electric field maps



↳Mean electric field along z-axis



- Electric inside the fiducial volume is distorted at the border
- Effect can be stronger if space-charge effect is considered (field screening due to clouds of Ar^+ drifting towards the cathode)
- COMSOL simulation provides the expected field component in a 3D grid
- For each of these voxels, drifting electron path to the anode is computed

→Drifting electrons path from the cathode to the charge readout plane

Conclusions and Prospects

Important milestones achieved in the past year !

- 3x1x1 prototype assembled, cabled and tested in 6 months
- Apart from cryogenics problems, the tight schedule has been respected
- The detector is now in commissioning process
- First light and charge signal measured
- Large experience already gained for protoDUNE-DP

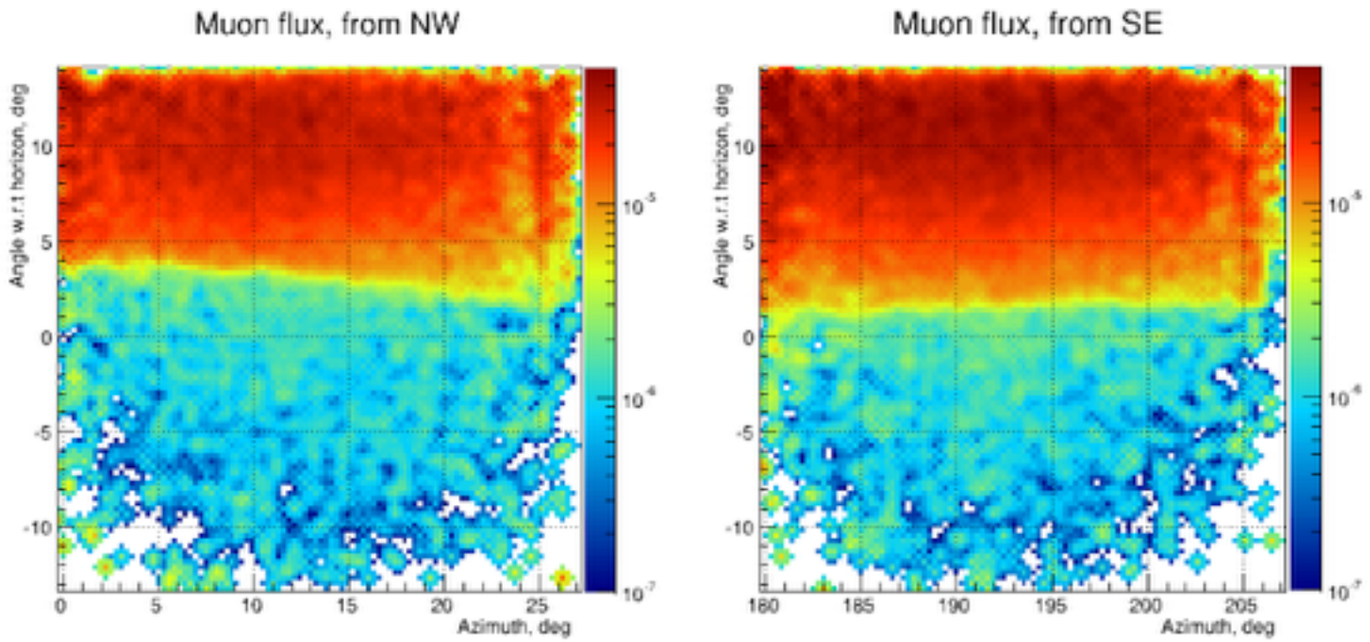
- The protoDUNE design has been finalized in November
- Cryostat construction started
- Purchase of material for assembly started

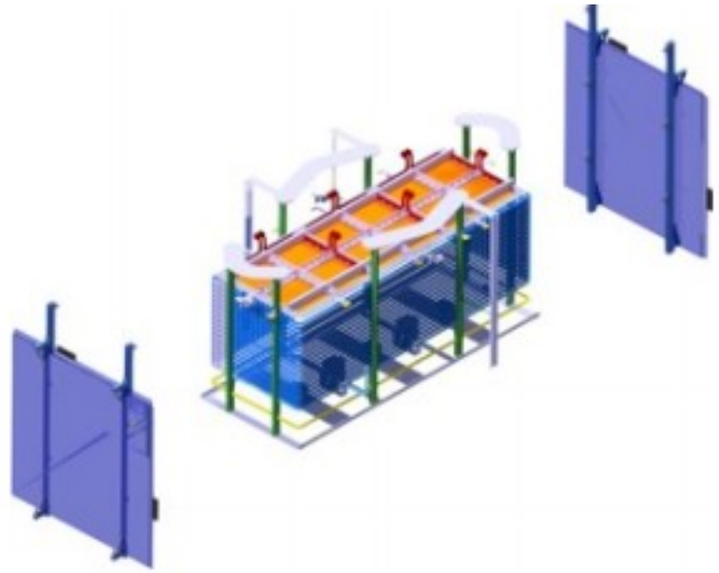
See our 2017 SPSC report for many more details :

Yearly progress report on WA105/ProtoDUNE dual phase - CERN-SPSC-2017-011, SPSC-SR-206

Trigger signal in the 3x1x1 - first measurements

Cosmic Ray taggers have been installed on each side of the cryostat
The idea is to trigger horizontal cosmics to mimic as much as possible the protoDUNE and DUNE signals





Impurities evolution in the 3x1x1