

WA105 AND ITS RELATED R&D ON INNOVATIVE DOUBLE PHASE CHARGE READOUT SYSTEM AND LIGHT READOUT SYSTEM AT LIQUID ARGON TEMPERATURE

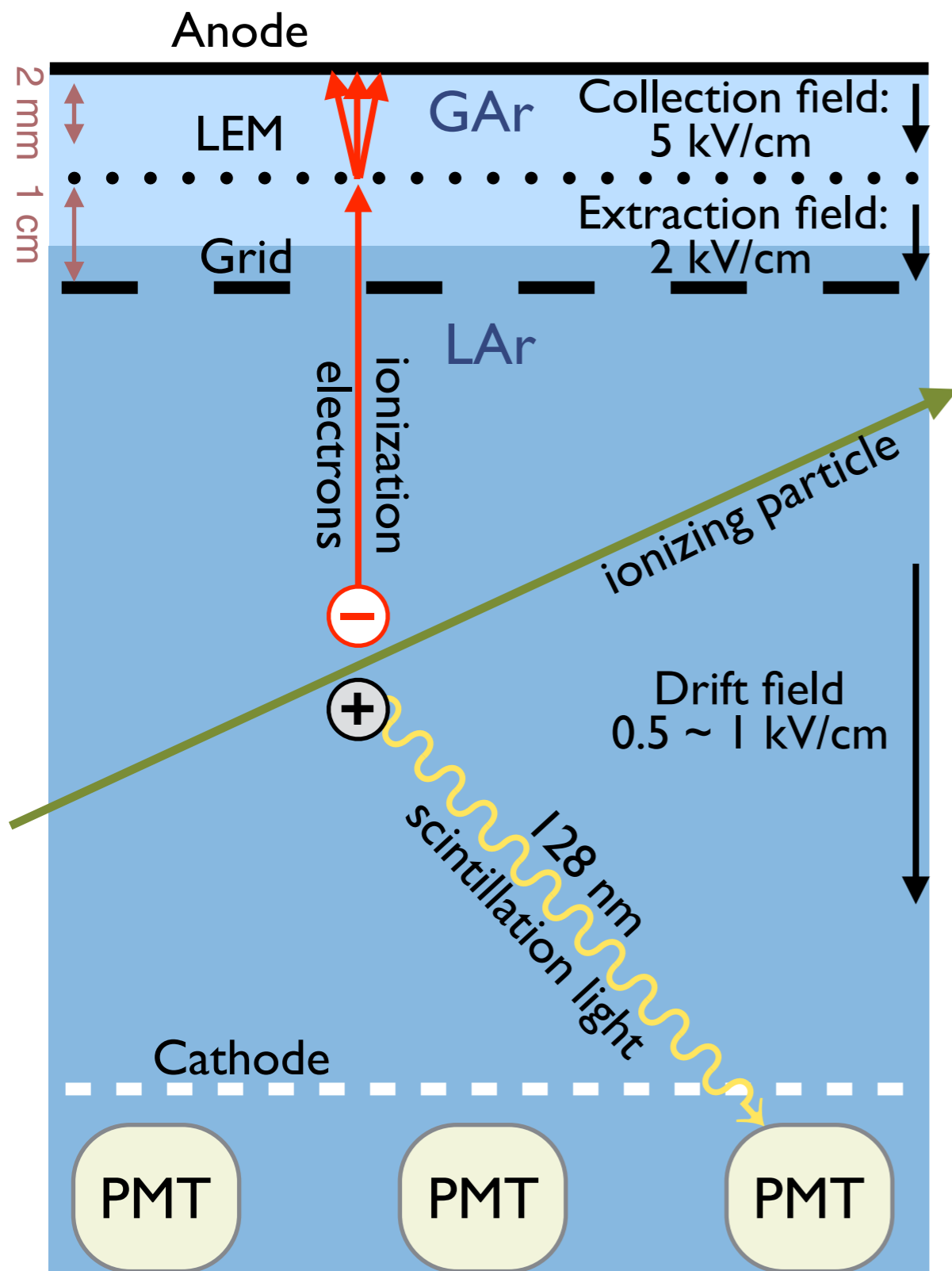
Laura Zambelli (LAPP)
on behalf of the WA105 collaboration

TYL/FJPPL and FKPPPL joint workshop

May 18th 2016 - Seoul

WA105 

Double phase Liquid Argon TPC Concept



GLACIER (Giant Liquid Argon Charge Imaging Experiment) concept, A. Rubbia, hep-ph/0402110

- Fully active volume, no dead material, cheap
- Excellent granularity
- Double phase allows electron amplification and
 - high S/N ratio
 - long drift distance
 - low energy threshold

- charge collection for 3D imaging and calorimetry
- light collection for event timing and to improve the calorimetry measurement

But major R&D efforts needed :

- Excellent Ar purity is required
- HV supply
- ...

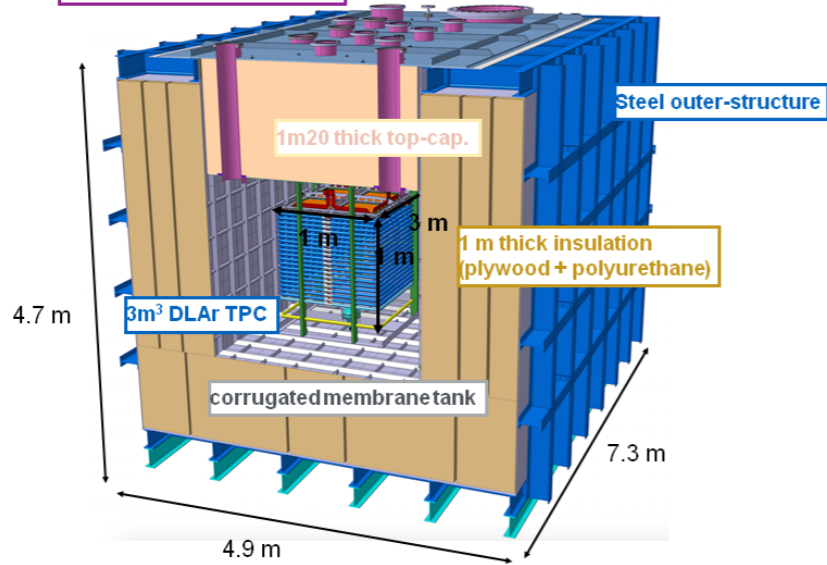
(not to scale)

Prototypes towards the DUNE experiment

2014 ~ 2017

3x1x1 m³
prototype

chimneys and feedthroughs

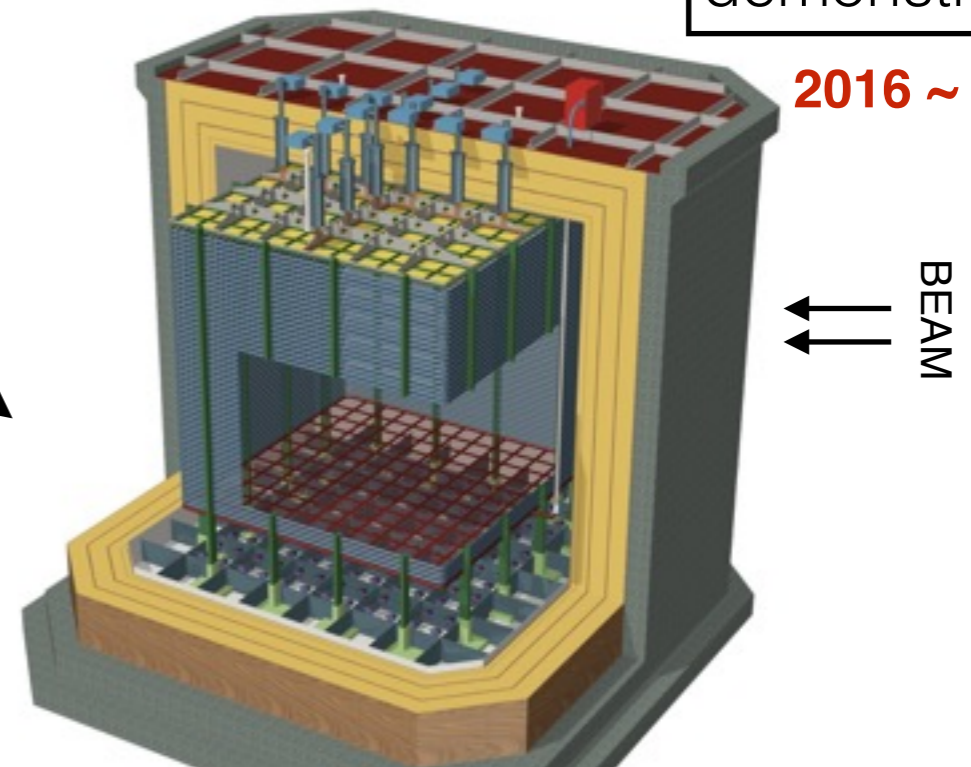


@ CERN BLDG. 182

@ CERN IN NORTH AREA

6x6x6 m³
demonstrator

2016 ~ 2019



BEAM

30 L @ KEK

various small
TPC around the
world



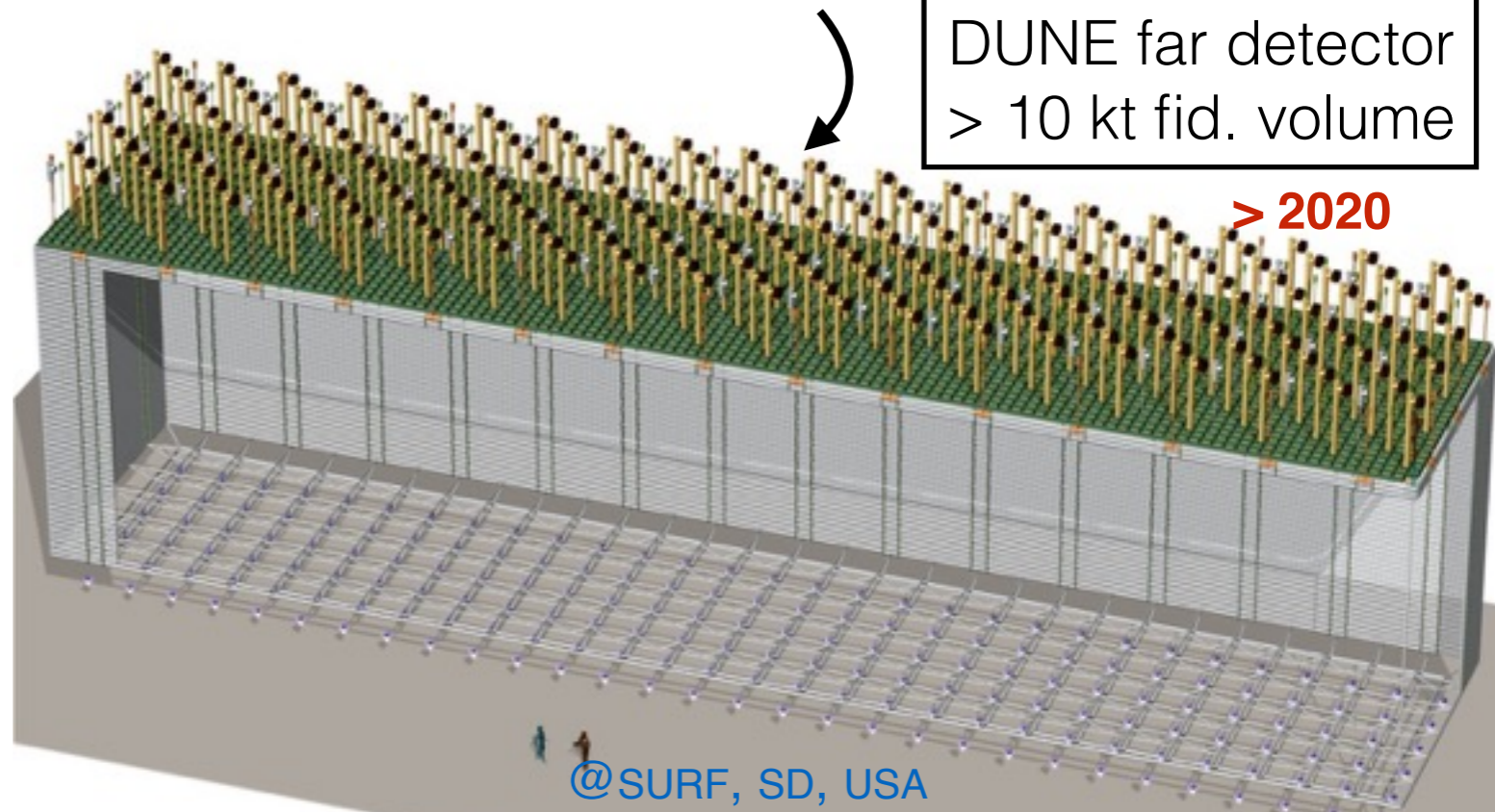
250 L @ CERN



250 L @ KEK

DUNE far detector
> 10 kt fid. volume

> 2020



@SURF, SD, USA

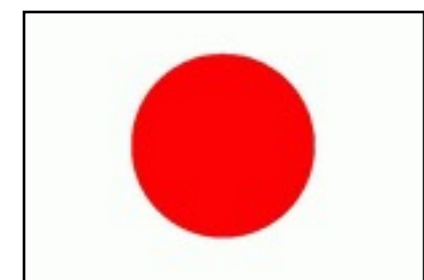
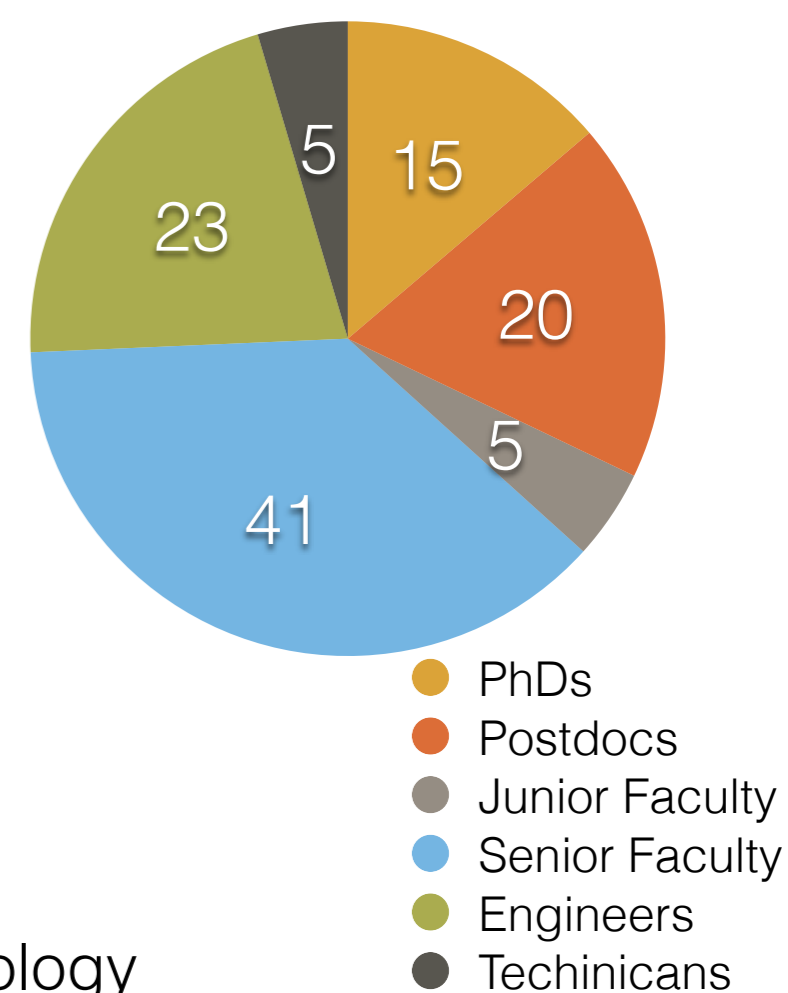
The WAI05 Collaboration

Now part of the DUNE project, WA105 is now referred to as 'ProtoDUNE dual phase'

7 countries, 15 institutions, ~100 people involved.

Finland, France, Japan, Romania, Spain, Switzerland, UK

New collaborators foreseen



KEK/IPNS, Iwate University, Kure college of technology



CEA/IRFU, and CNRS/IN2P3 institutes: APC, IPNL, LAPP, LPNHE, OMEGA

Milestones achieved :

2013: Project started

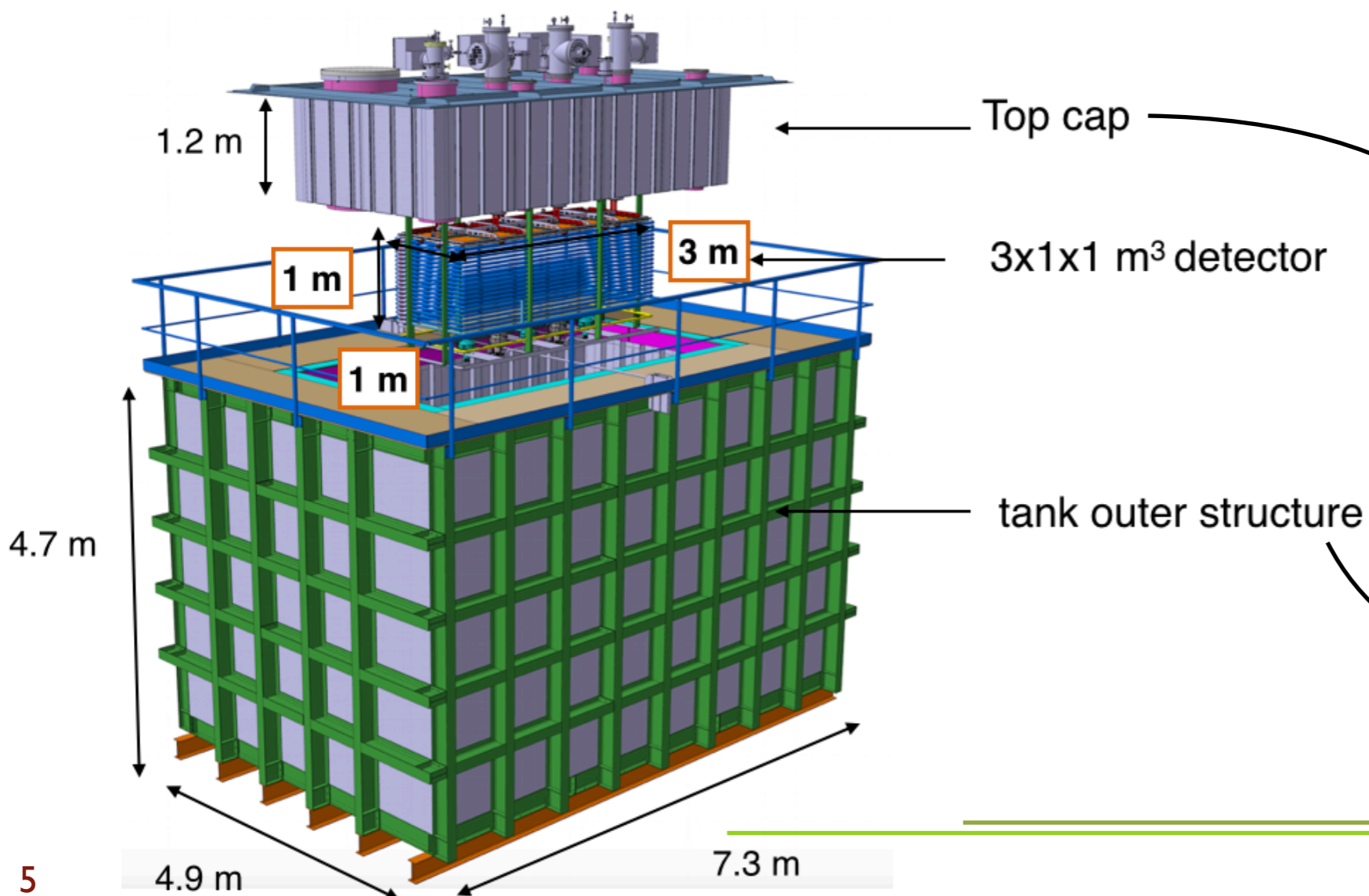
2014: TDR submitted [CERN-SPSC-2014-013 - SPSC-TDR-004(2014)]

2015: SPSC Annual review [SPSC-SR-158], DUNE CDR, WA105 project MOU signed, WA105 integrated into DUNE

2016: SPSC Annual review [CERN-SPSC-2016-017 SPSC-SR-184], EOI call for institutes

Construction of the $3 \times 1 \times 1 \text{ m}^3$ prototype

- 25 ton dual phase argon TPC at CERN
- 3 m^2 of charge readout, 1 m drift
- Construction started in **Dec. 2014**
- Cosmic data taking from **Fall 2016**



3x1x1 prototype

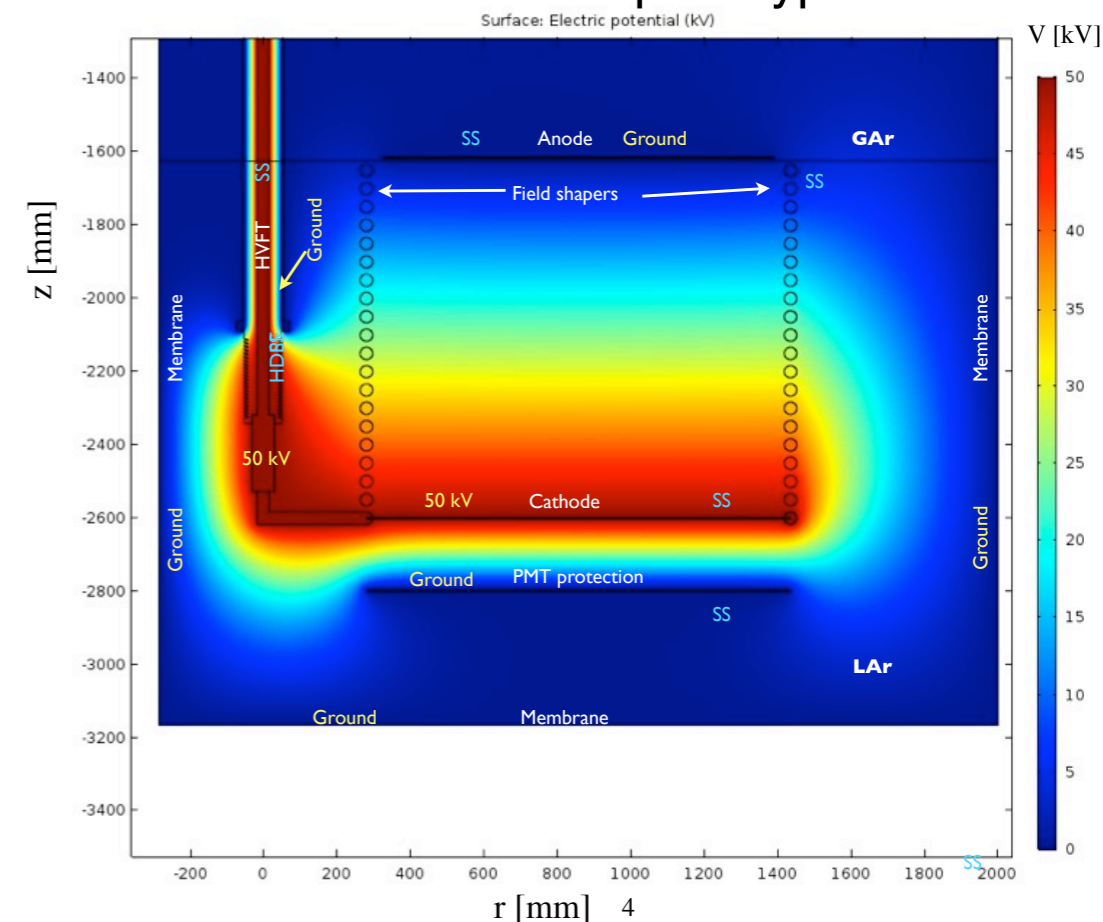
Built for:

- Establishment of routine procedure for mass production
- Quality assurance and control tests
- Calibration of LEMs
- Cryogenic installation, Feedthrough
- Validation of production schedule for the 6x6x6 m³

But, due to the relatively small size of the detector:

- Not a test of large vessel and field cage structure
- Not a large surface of charge readout
- No long drift
- No very high voltage generation
- No exposure to a hadronic beam

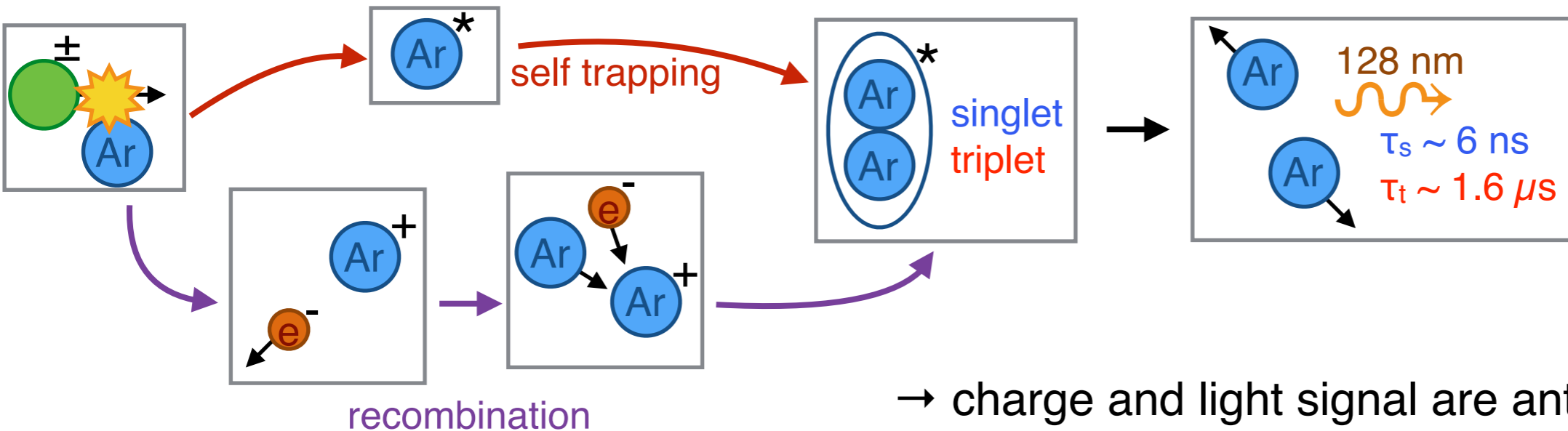
COMSOL simulation of the electric field inside the prototype



The 3x1x1 m³ prototype is not a demonstrator for very large scale detector.
There will be no measurements inputs for the LBL physics program.
However it's an important step towards the 6x6x6 demonstrator.

3x1x1 prototype - Light Signal

Generation of the scintillation light in Argon :

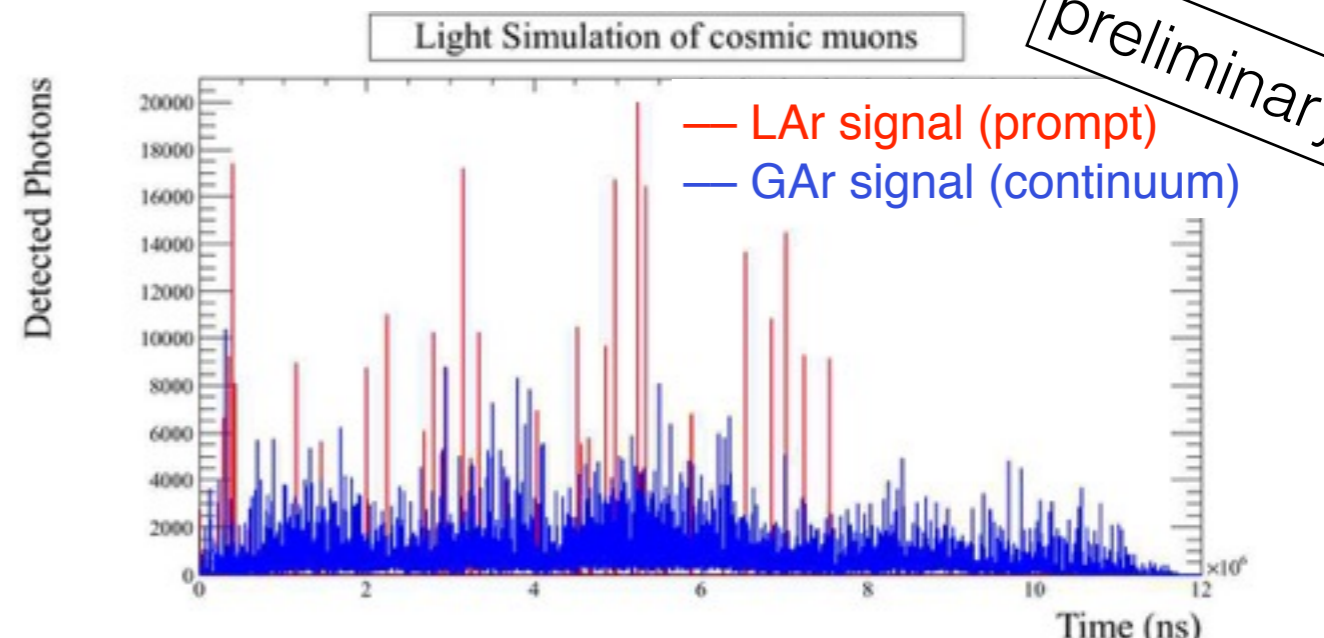
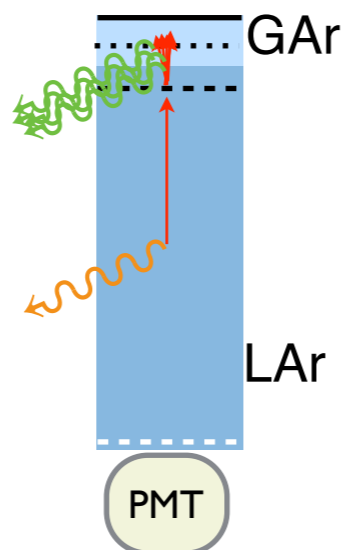
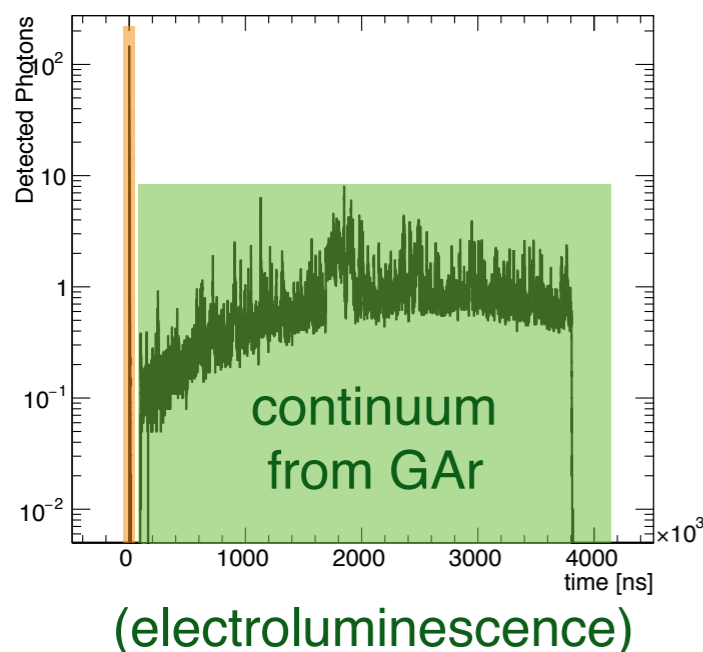


→ charge and light signal are anti-correlated through the recombination process

2 components seen by the PMT:

prompt signal used for - cosmic T_0 (for surface operation)
- SN/p-decay trigger (for underground operation)

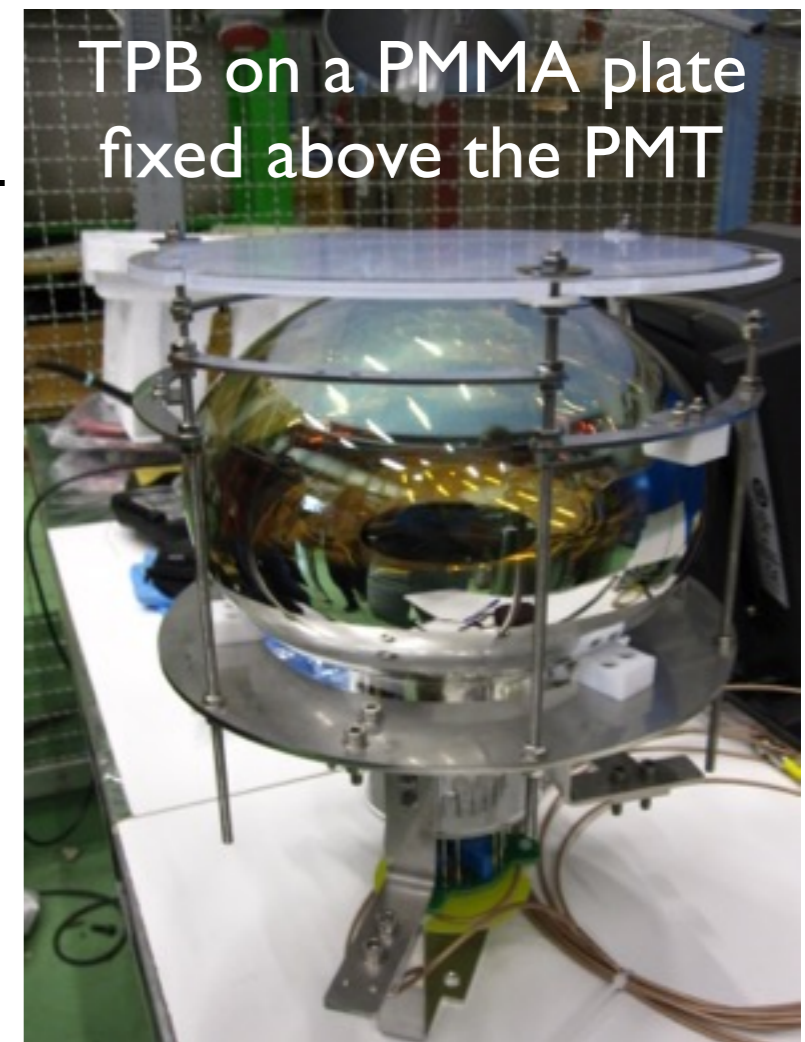
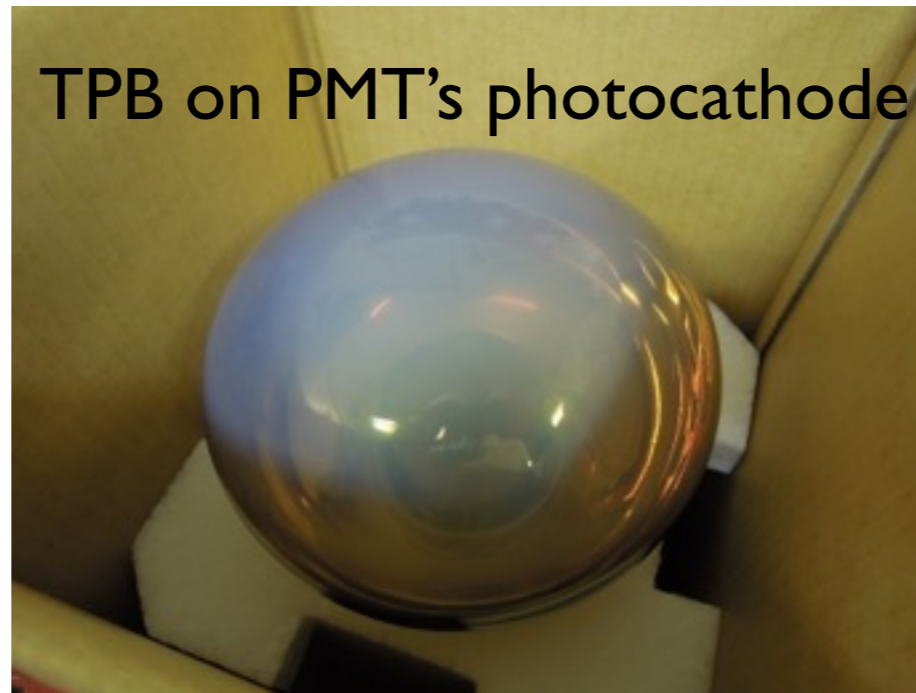
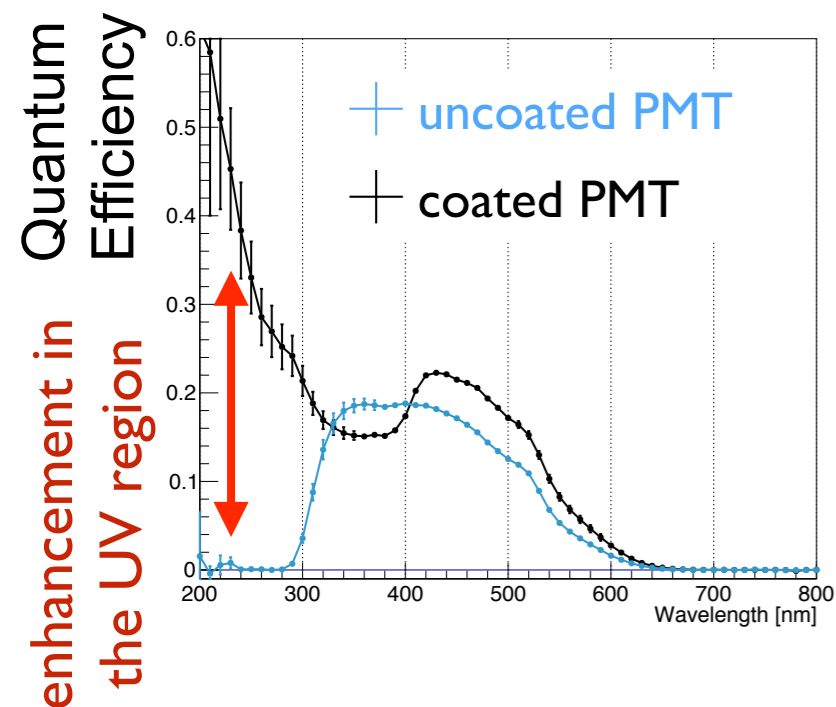
prompt signal
from LAr



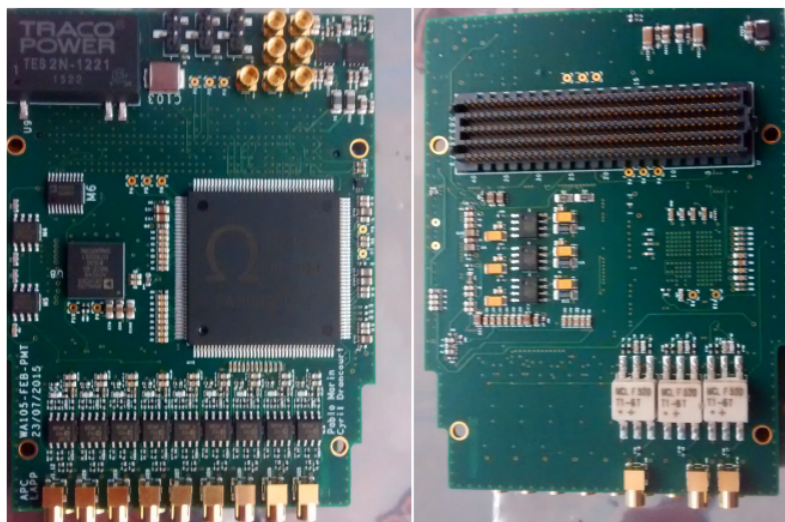
3x1x1 prototype - Light Signal

Argon emits scintillation light at 128 nm
 → outside PMT sensitivity : a wavelength shifter (TPB) is needed.
tetraphenyl-butadiene

2 technologies for the TPB coating procedure:



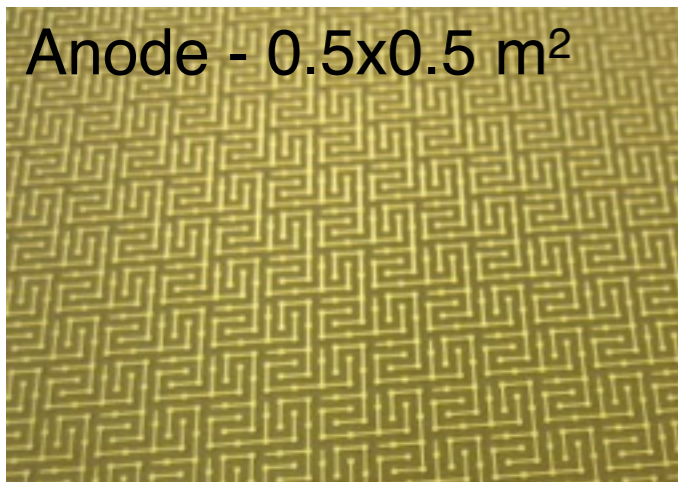
→ 5 PMTs installed in the 3x1x1 prototype



Light readout independent from charge readout.
 Based on FIFO, Discriminator and ADC
 → Event trigger based on sum of PMT signals for light and charge readout.

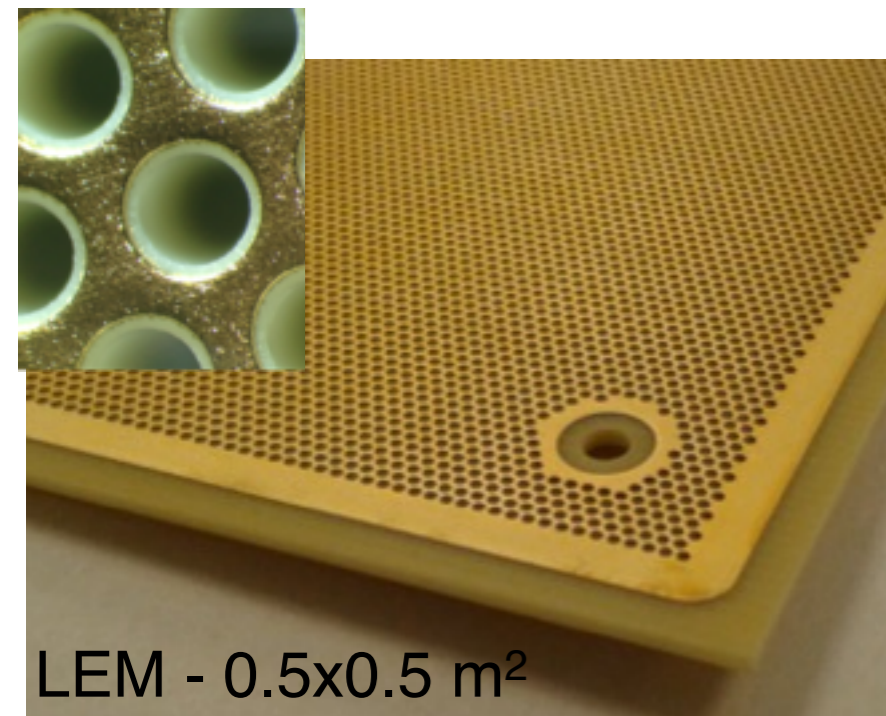
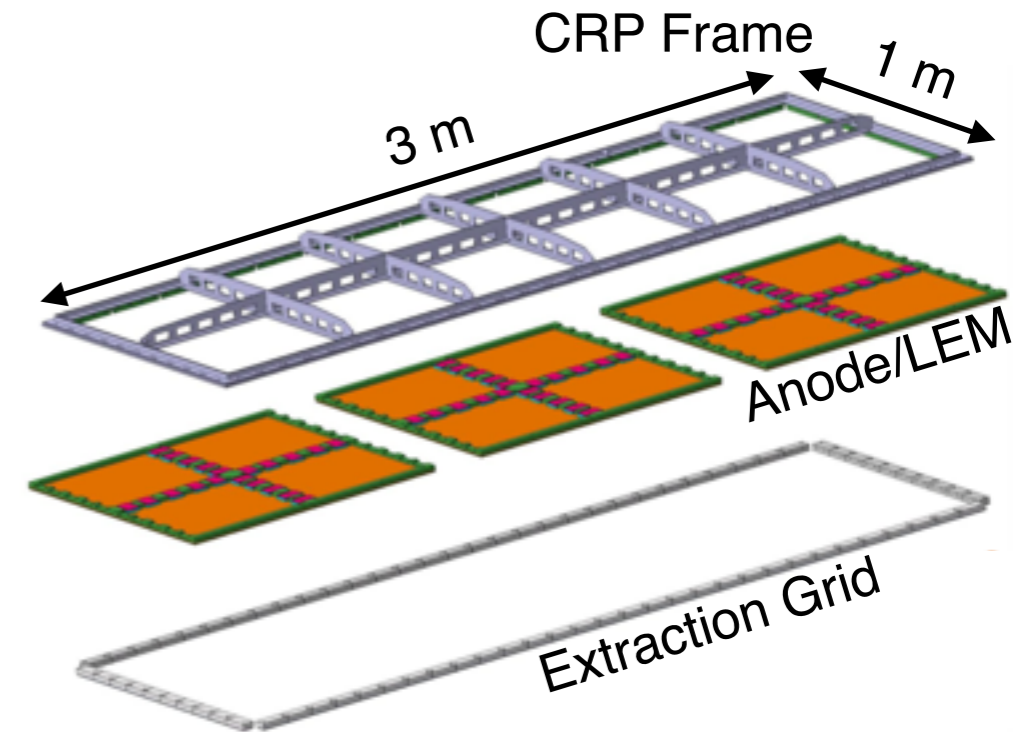
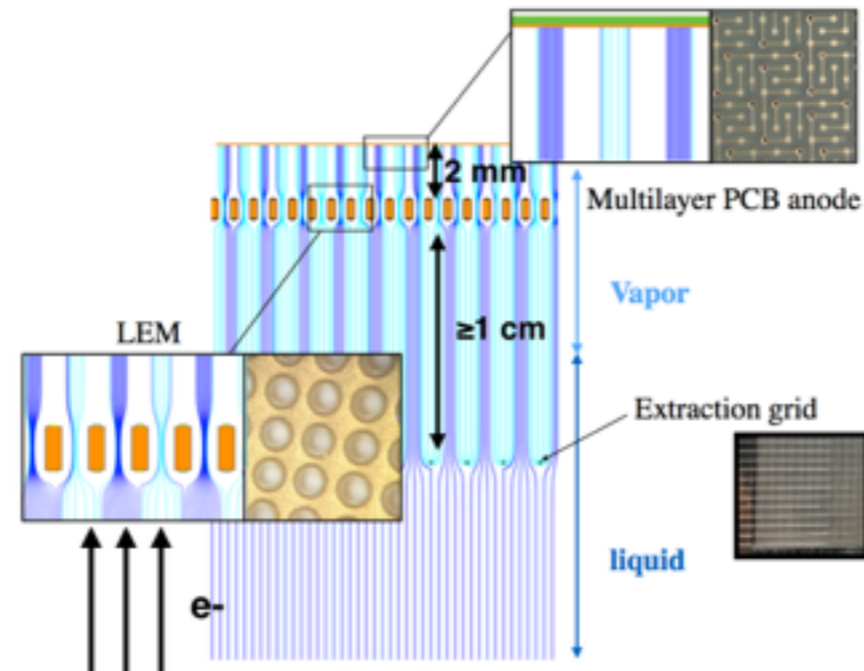
3x1x1 prototype - LEM/Anode

C. Cantini et al, JINST 9 P03017 (2014)



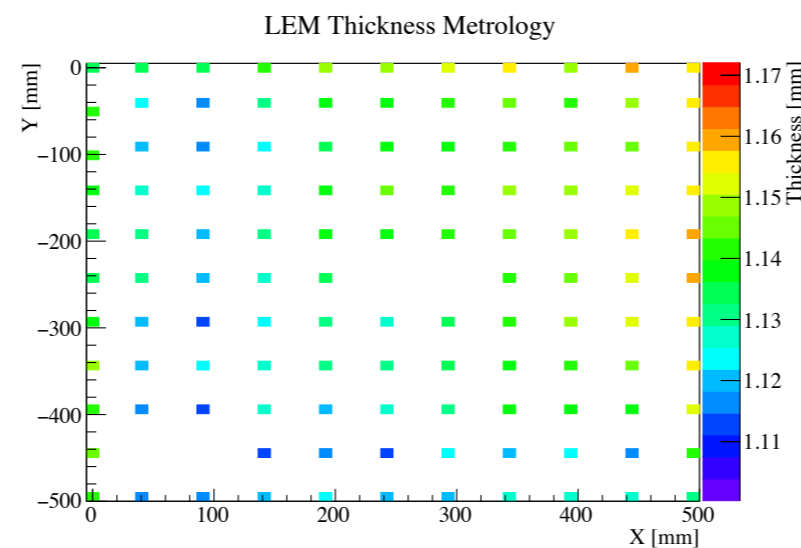
Anode - 0.5x0.5 m²

3.125 mm pitch
5x32 ch in X and Y

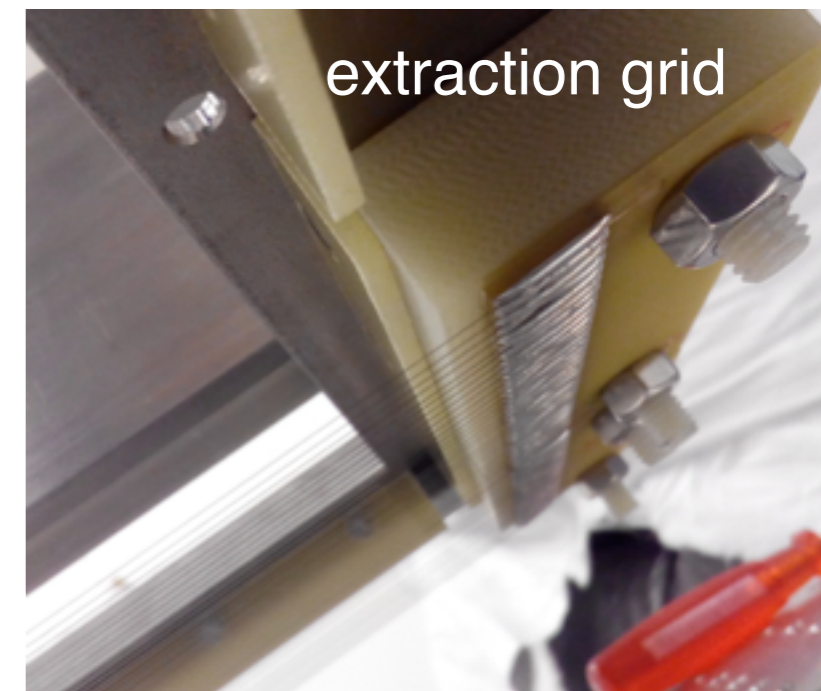


LEM - 0.5x0.5 m²

500 000 holes per LEM



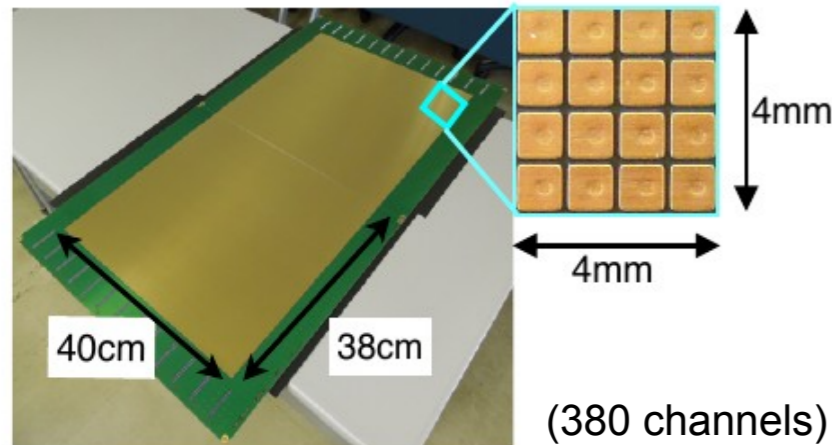
~1 mm thick
RMS ~0.1 mm



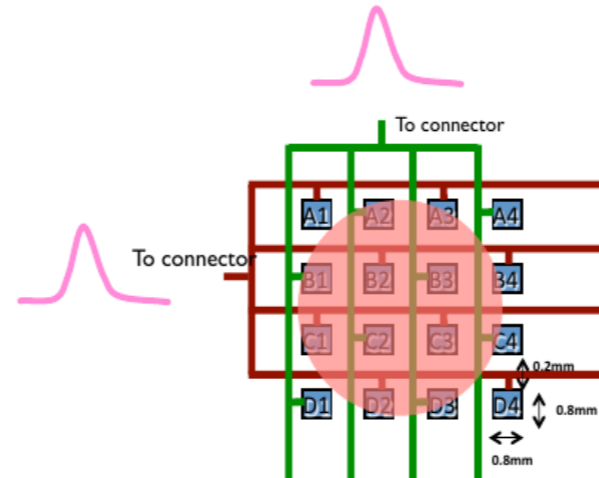
wire: SS 100 μ m diameter.
3.125 mm spacing

3x1x1 prototype - LEM/Anode R&D

Anode R&D at KEK

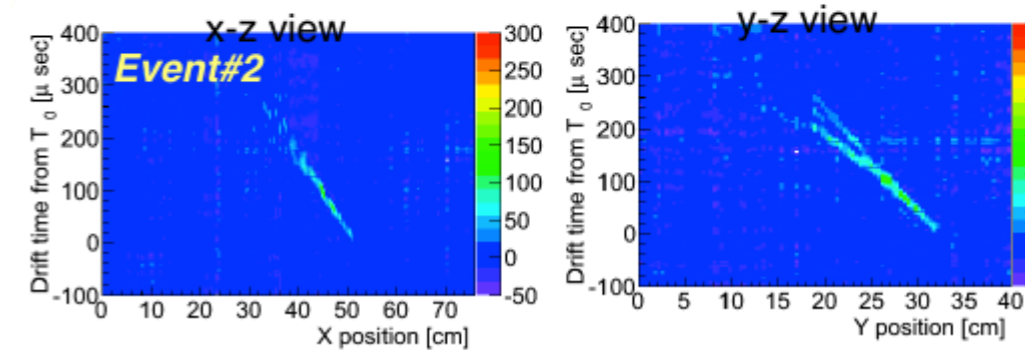


4x4 group of 0.8 mm² 'pixel' electrodes
 → Could be scaled to large area (0.5x0.5 m²)

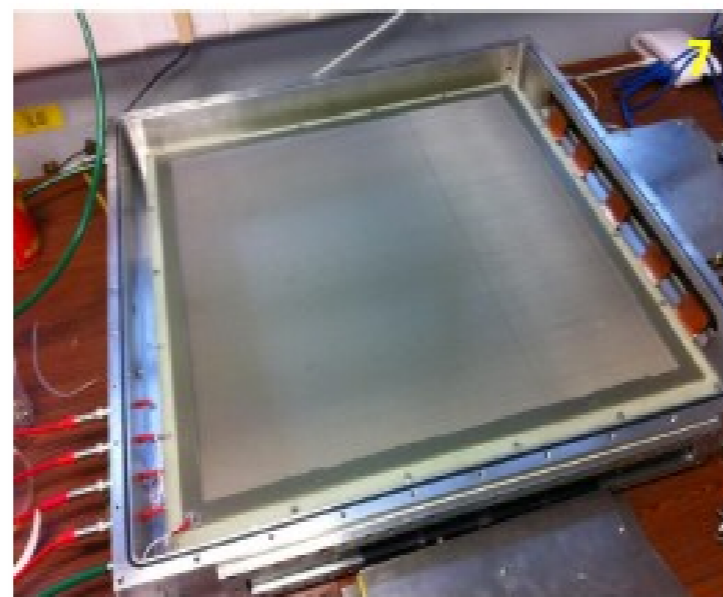
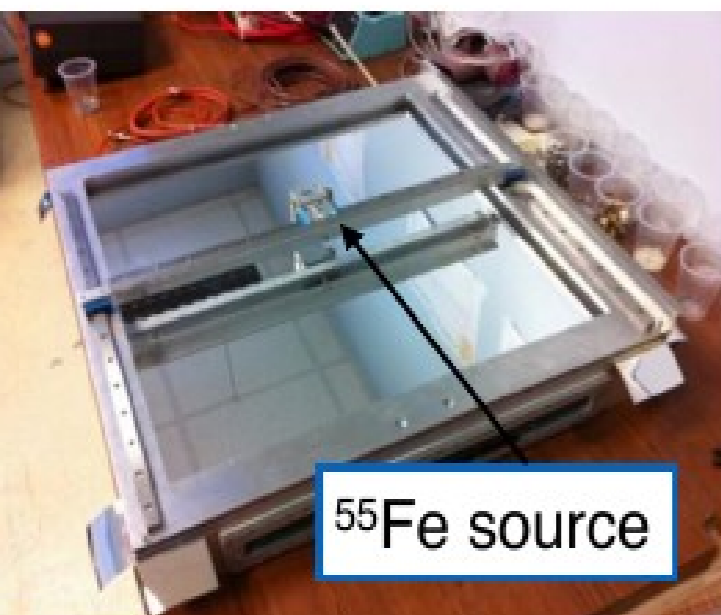


charge equally shared among the 2 views

Tested in real conditions with a 250 L LArTPC

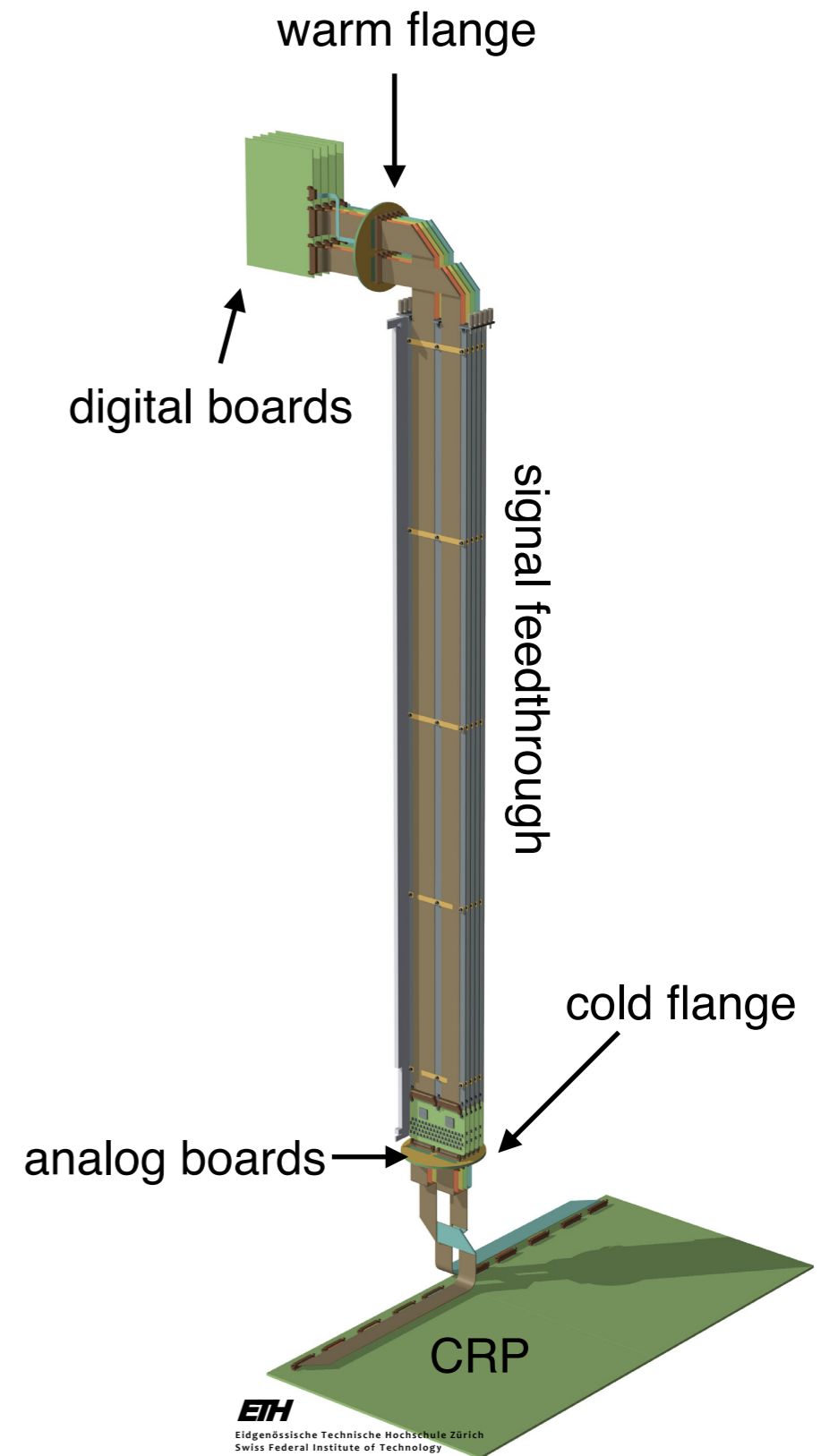
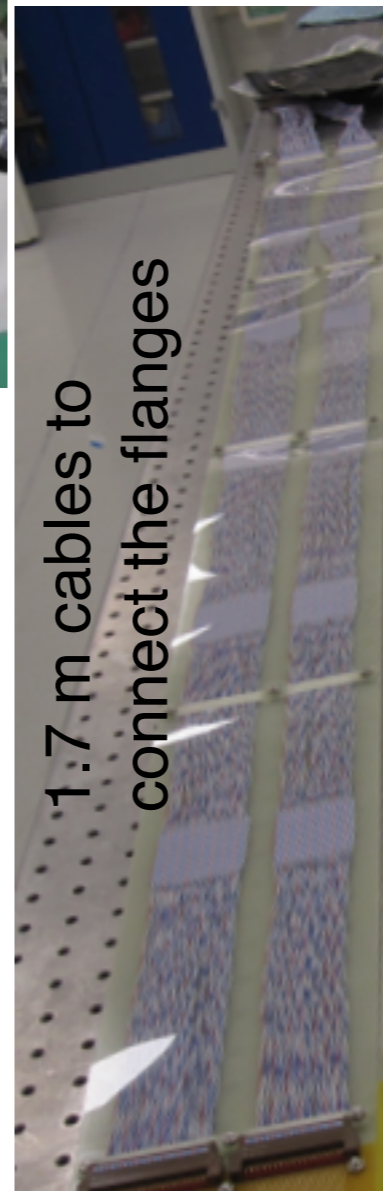
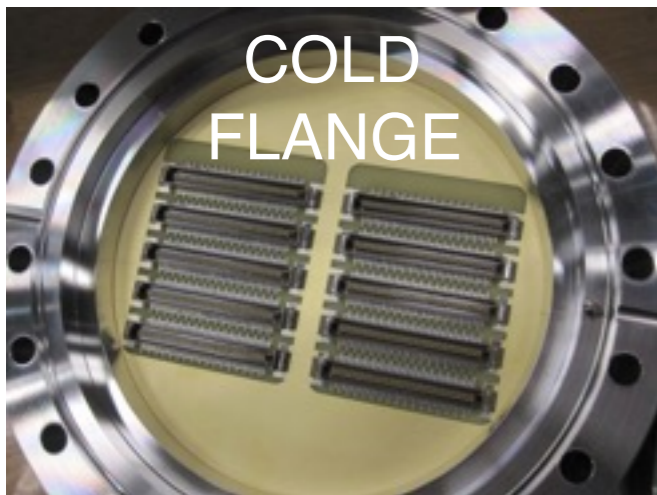
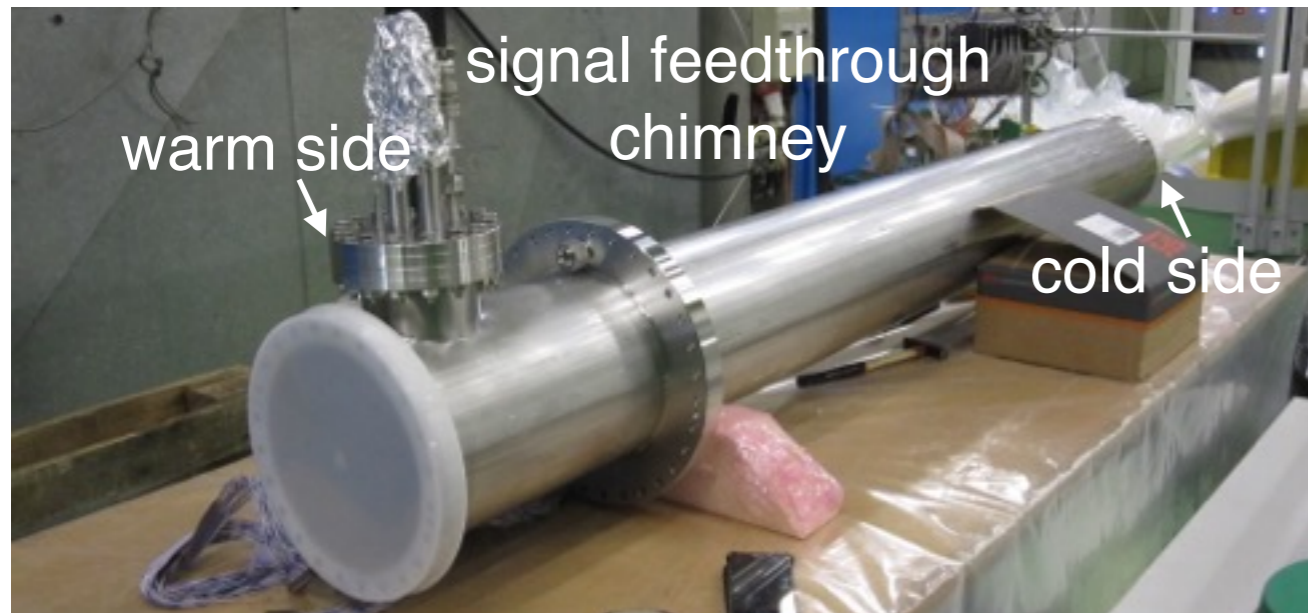


LEM R&D at CEA



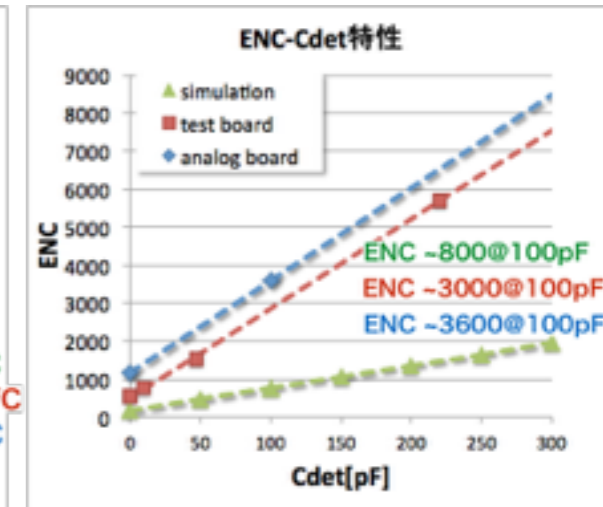
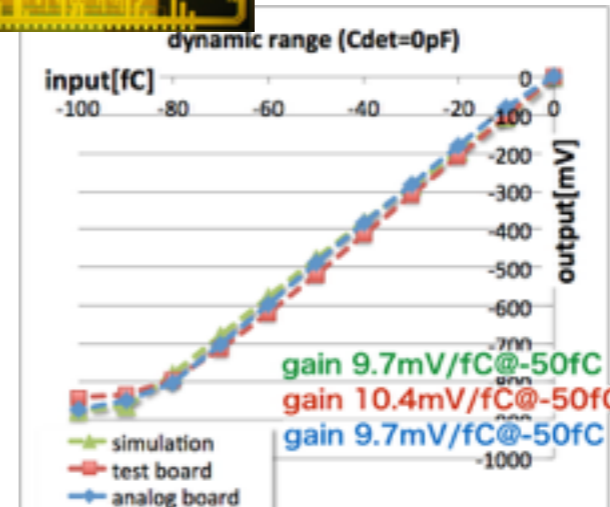
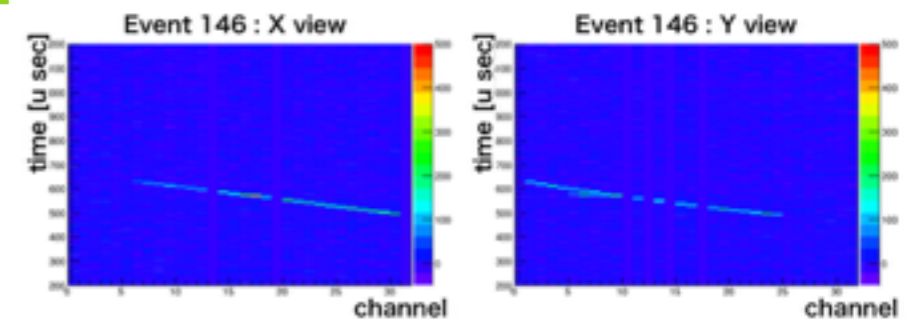
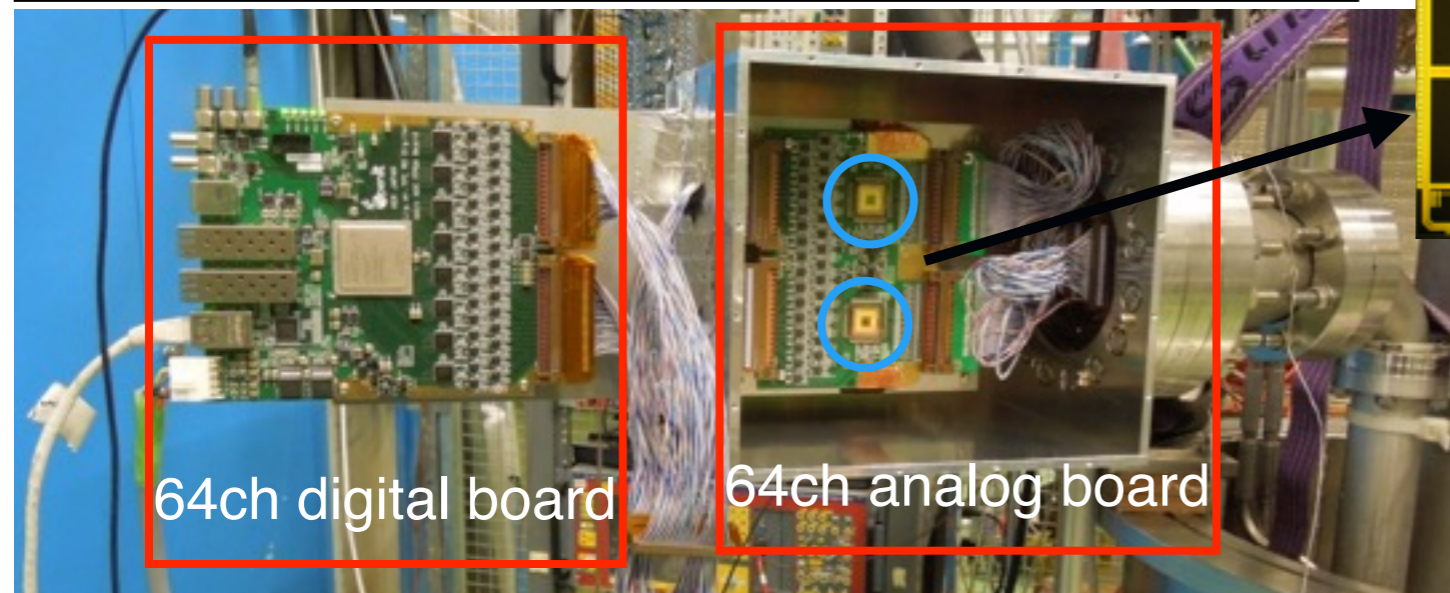
LEM calibration performed by ⁵⁵Fe source scan in a 50x50 cm² box designed at CEA

3x1x1 prototype - front-end electronics



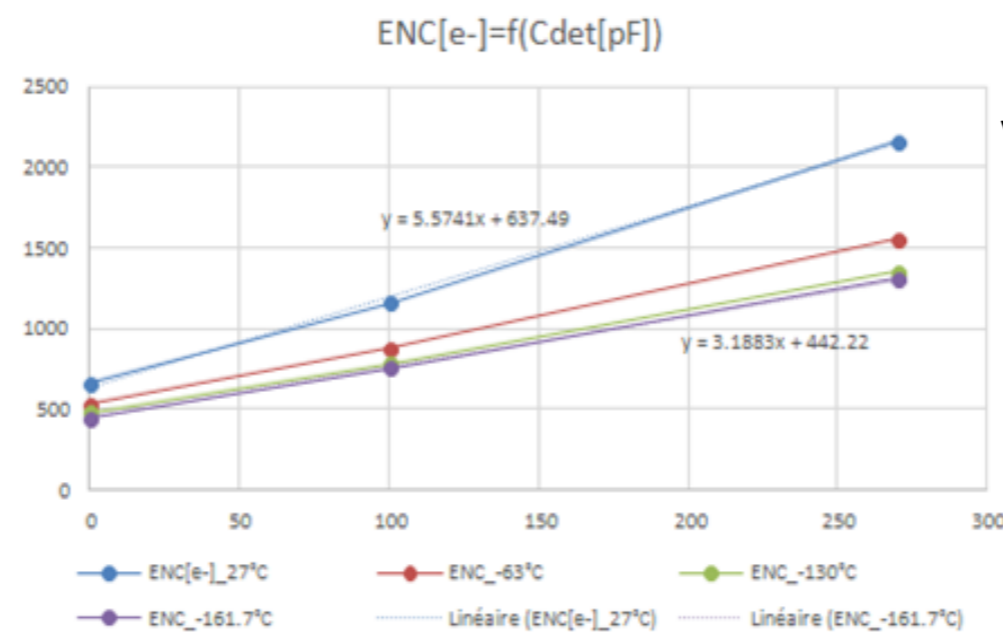
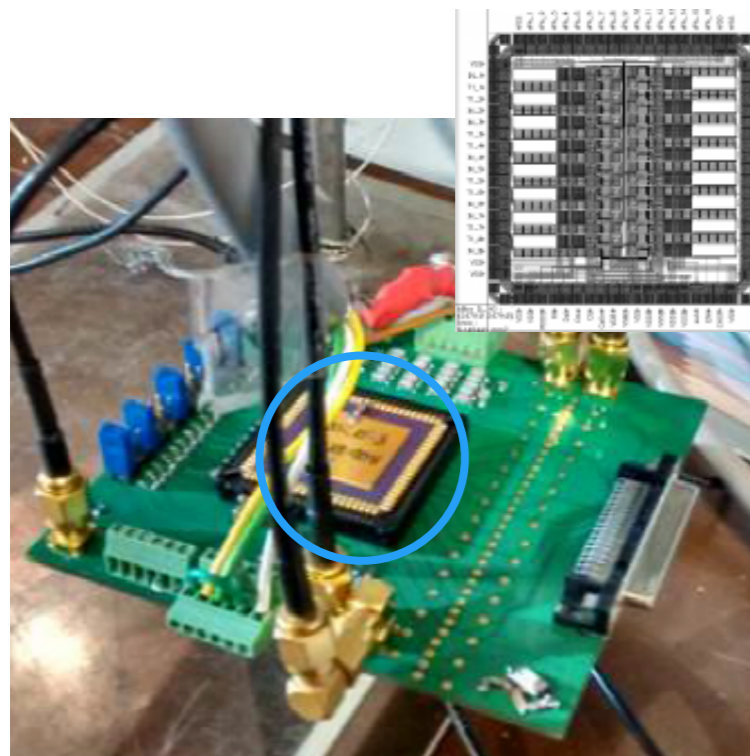
3x1x1 prototype - front-end electronics

KEK Front-End electronics in test (3L LArTPC)

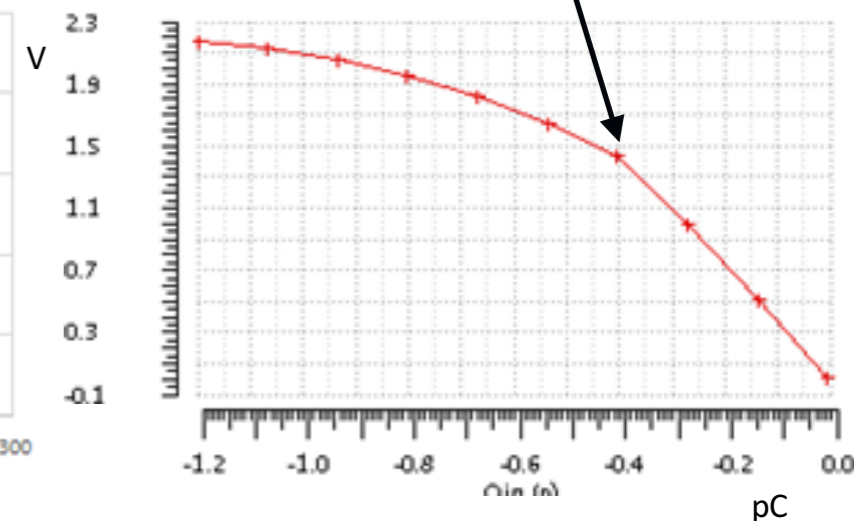


IPNL Front-End electronics testing

→ Both cards will be tested in the 3x1x1



Double slope gain with "kink" at 400 fC



3x1x1 prototype - software

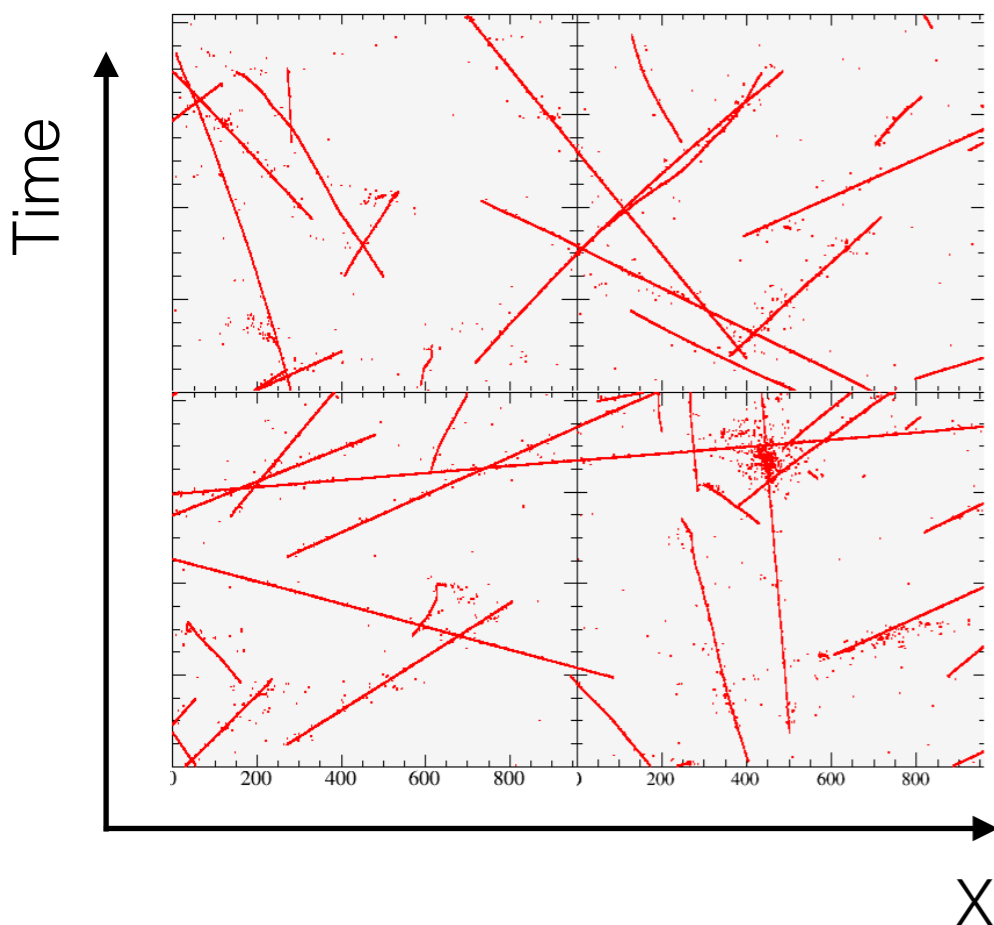
**Responsible
persons from KEK
& IPNL**

Intense development of a multi-purpose software 'QScan' :

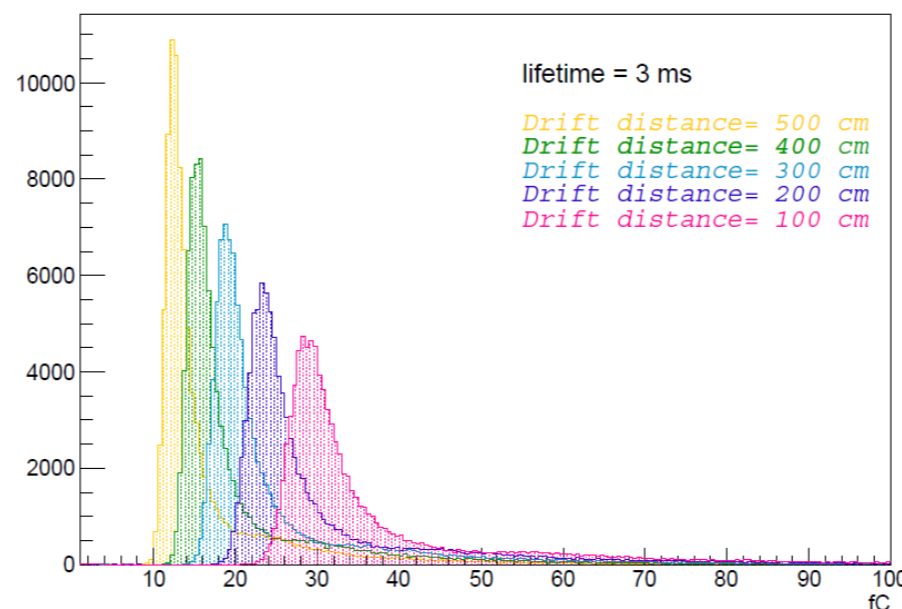
- Simulation (including quenching, diffusion, charge attenuation, electronic response)
- Reconstruction (hit finding, clustering, track finding)

→ Software ready for 3x1x1 data analysis

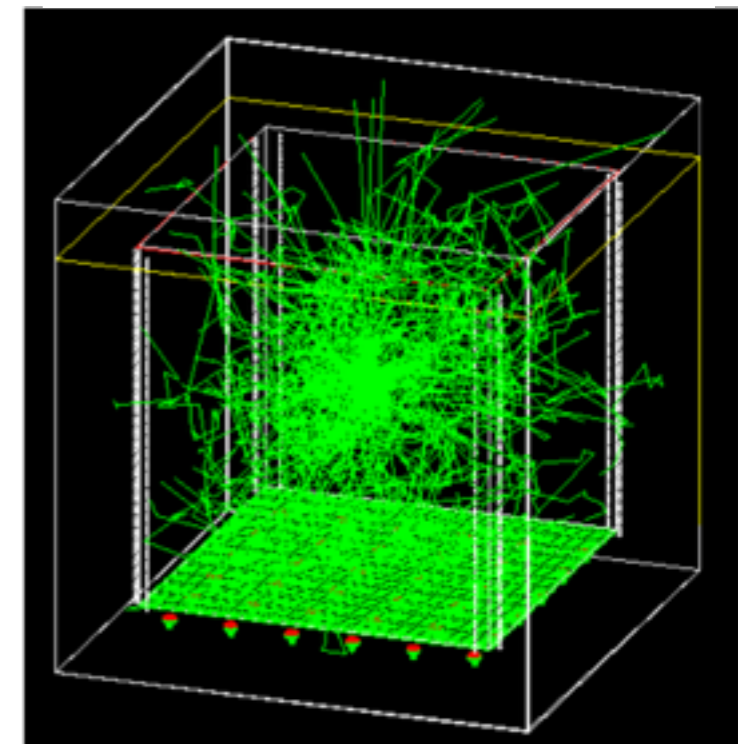
simulation of a beam event
overlaid with comics in the
6x6x6 prototype



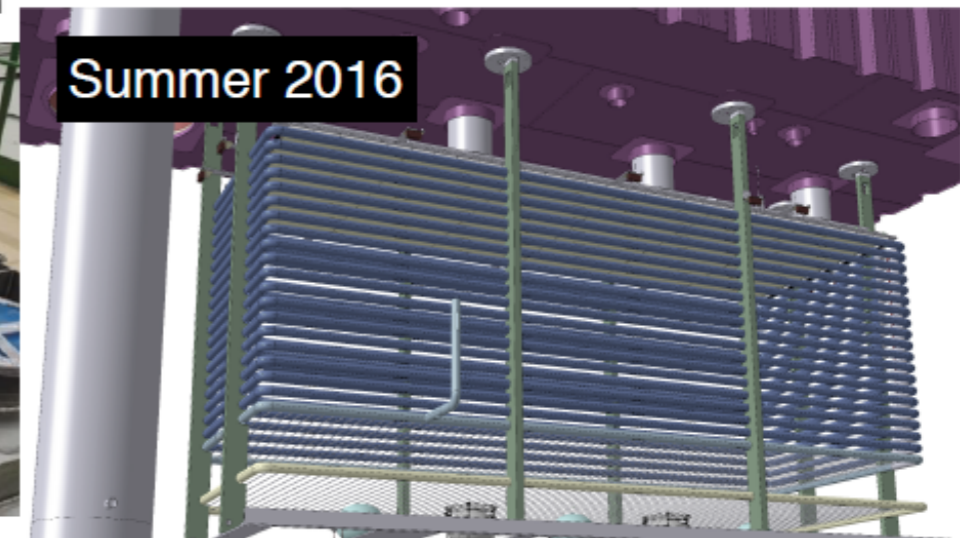
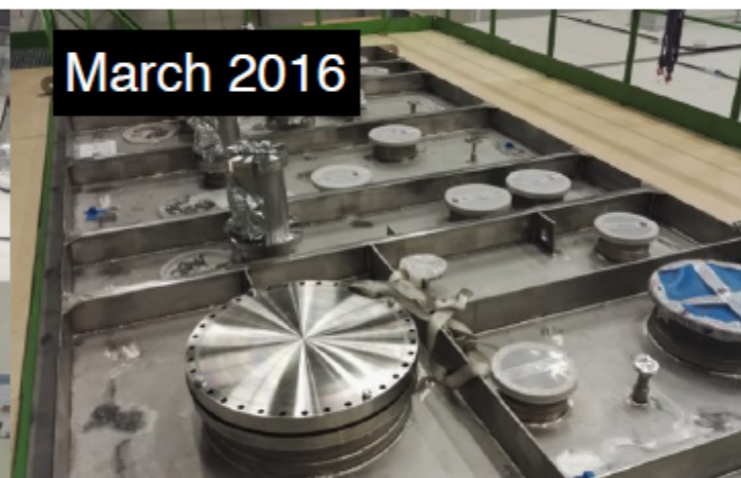
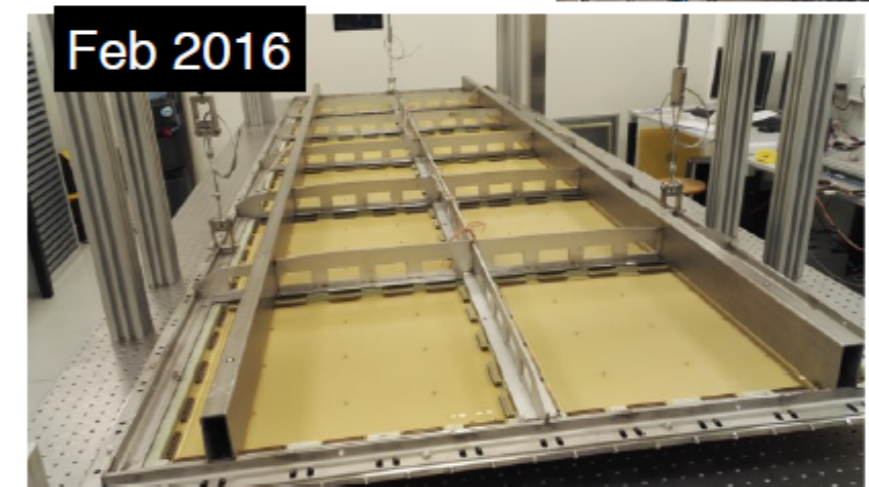
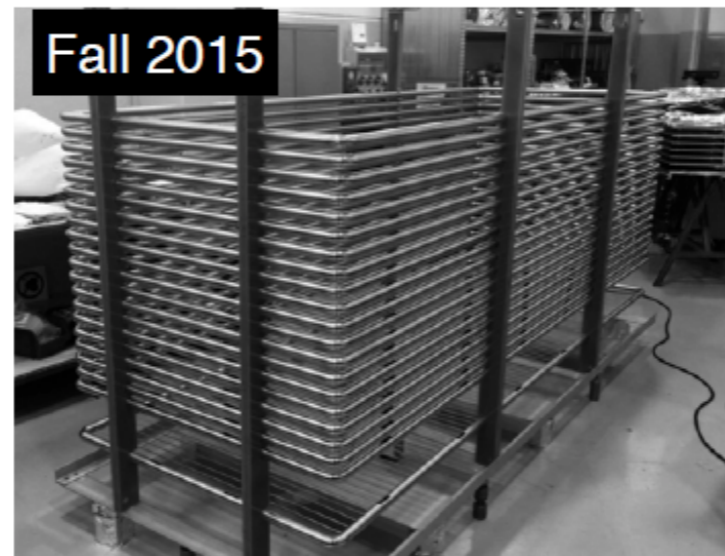
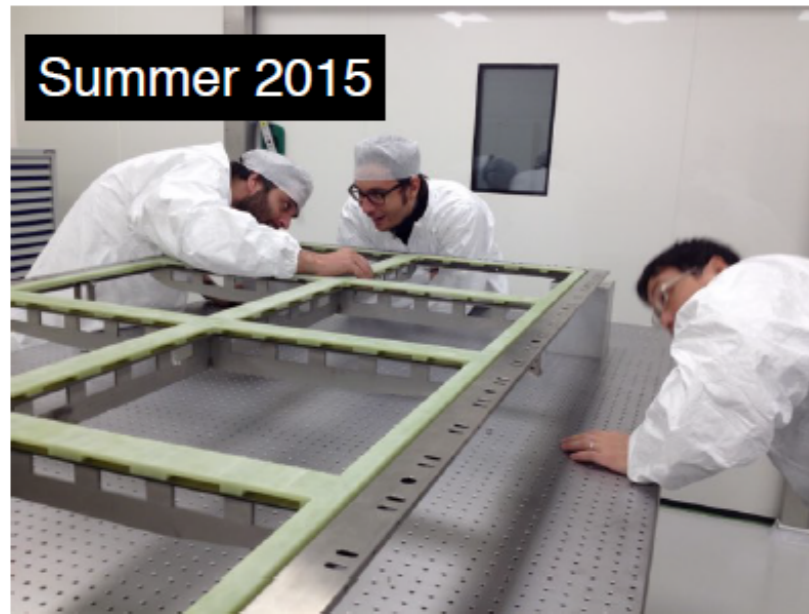
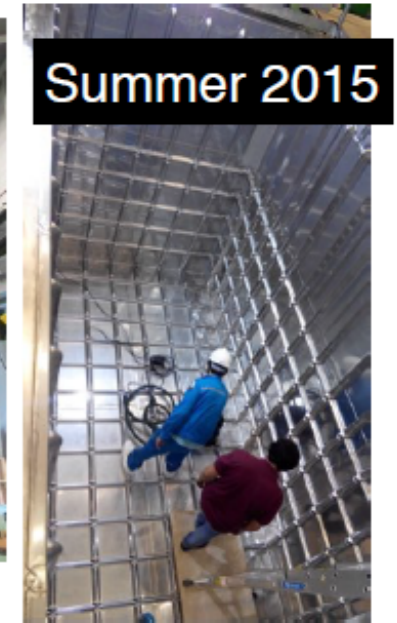
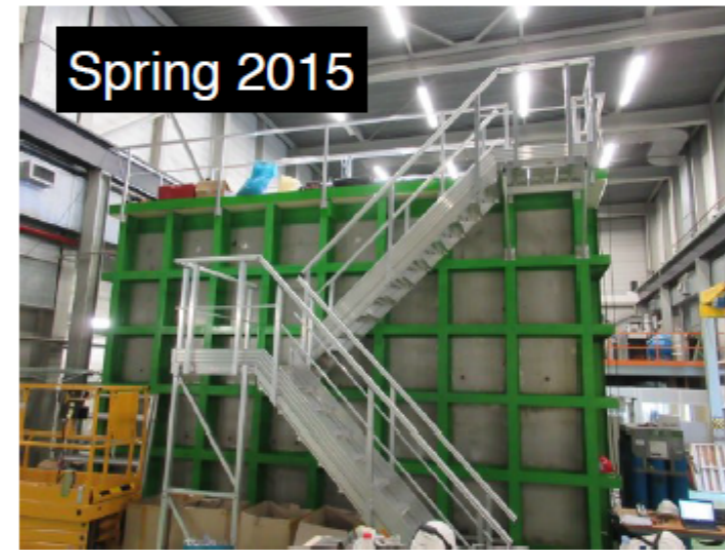
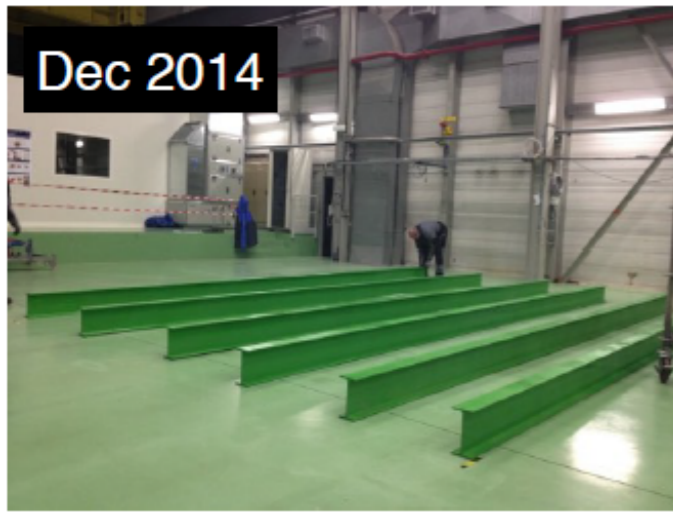
effect of the attenuation on
the amount of charge
collected for different drift
distance



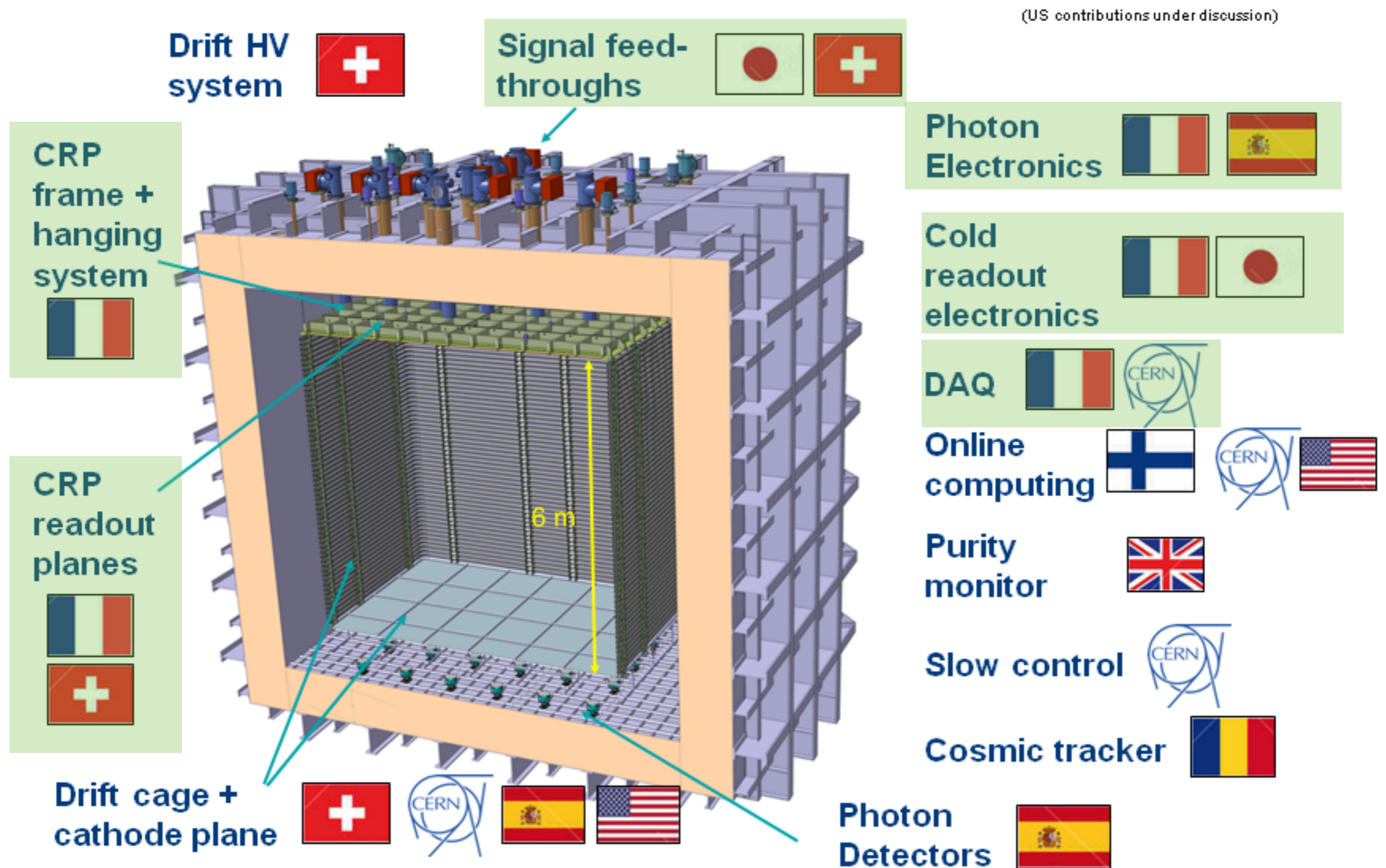
tracking of photons to the
PMT



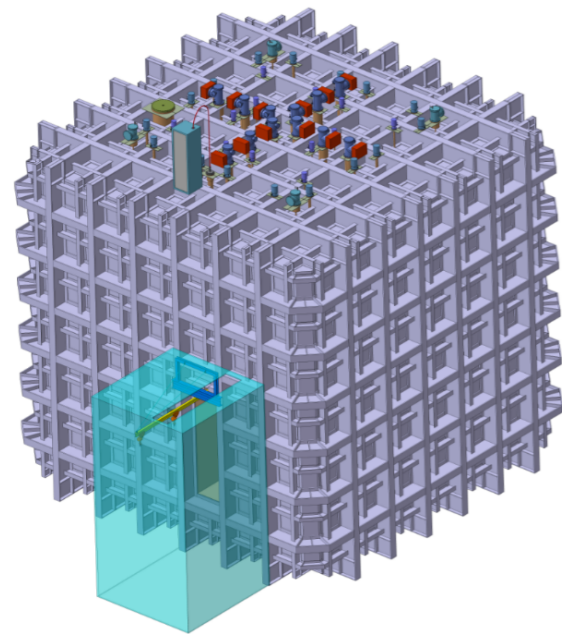
Construction of the 3x1x1m³ prototype



France and Japan involvements for the 6x6x6 prototype

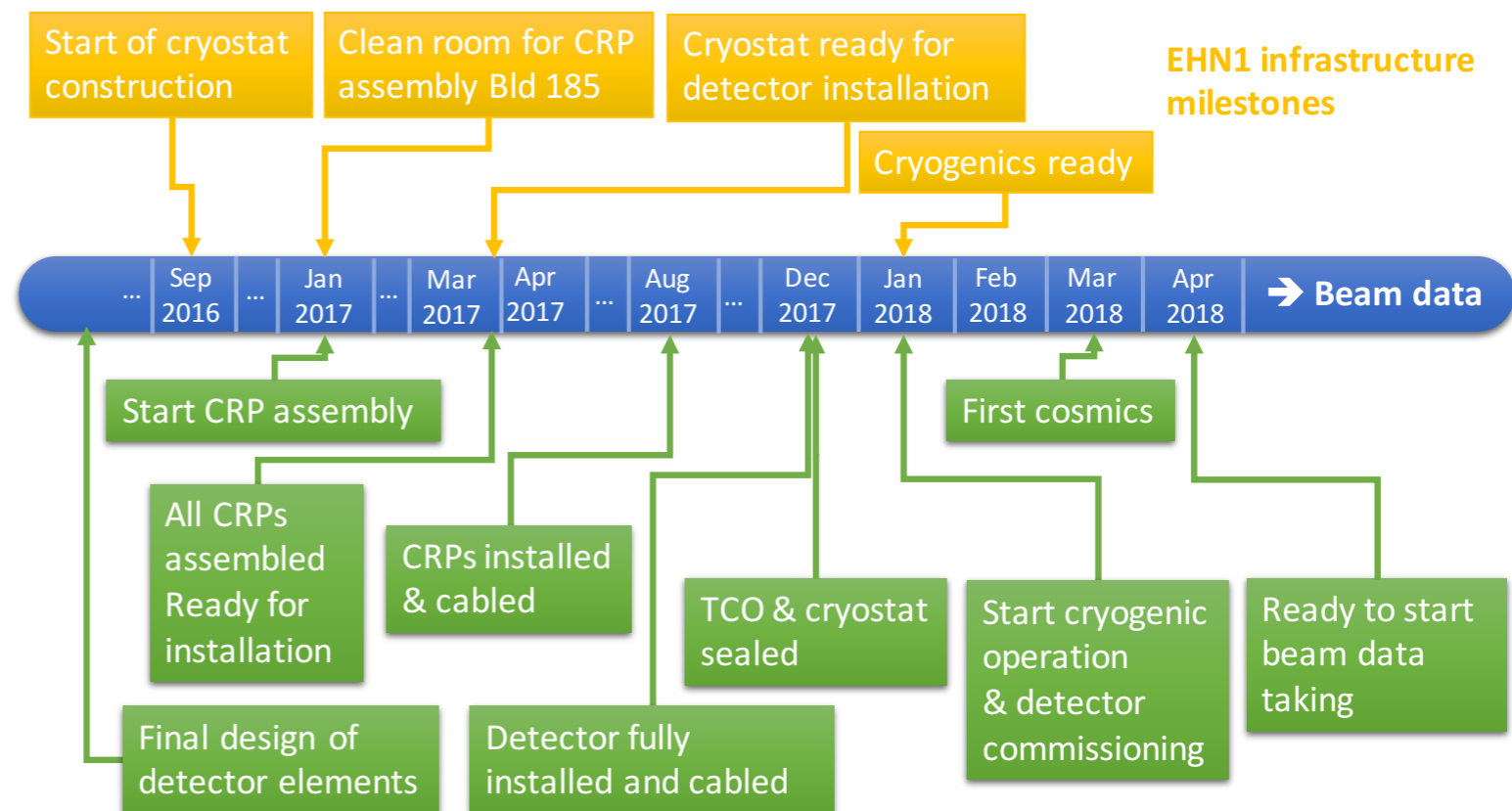


Towards the 6x6x6 protoDUNE construction



clean room buffer attached to the structure

Detector construction timeline :



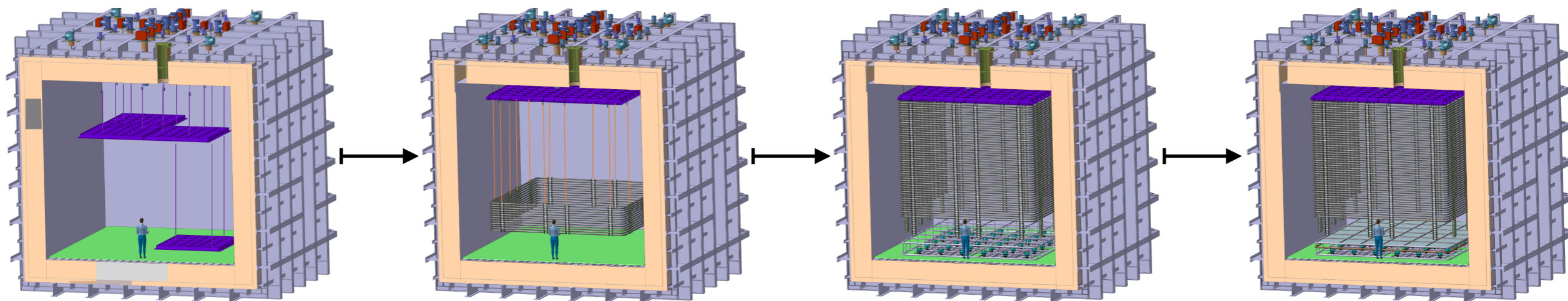
Detector installation procedure :

CRP lifting

field shaper installation

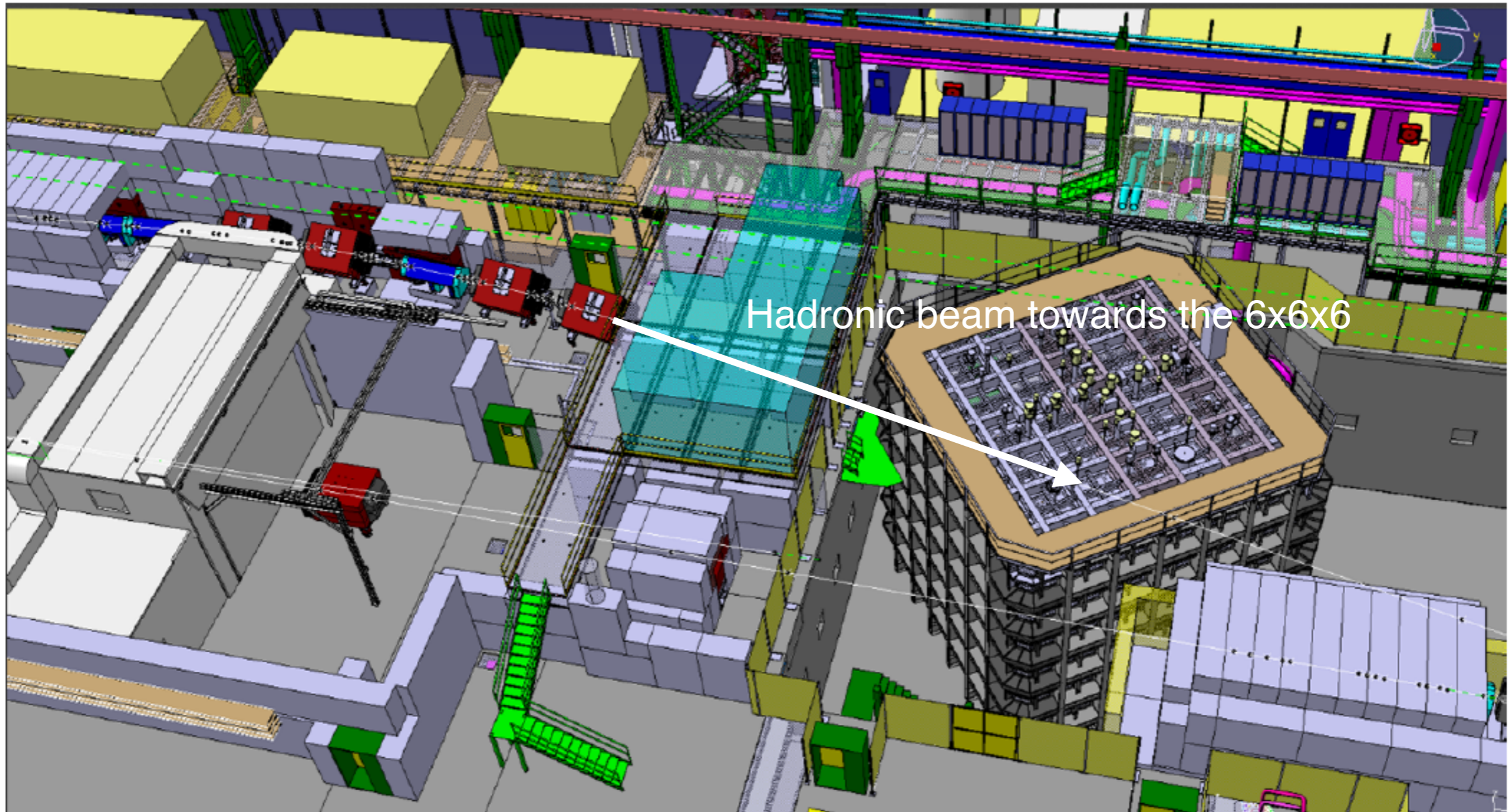
PMT installation

cathode installation



Installation of the 6x6x6 protoDUNE in the North Area

Pion from 0.4 GeV/c to 12 GeV/c beam requested to CERN (H2 beamline)



En route for the 6x6x6 !

Progress of the extension of the North Area (picture taken 27th of April)



Conclusions & Prospects

WA105 is a small collaboration with important goals !

France and Japan are collaborating together within WA105 on several items :

- Front-End electronics for the charge readout
- Light detector and readout
- Anode and LEM
- Software
- Analysis

It's essential to maintain these efforts during this important preparation and construction phase and to prepare the analysis. **The funding of FJPPL is a great opportunity to reinforce the existing collaboration.**

In Dec. 2015, a master student from Iwate Univ. (Y. Kuromori) benefitted from such support for the successful development and testing of the Japanese FE electronics at CERN.