

Status and upgrade of the 250L LAr LEM-TPC

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Outline

- Description of the 250L single phase (liquid) argon TPC used on a charged particle beam in J-PARC.
- Review of the 3L double phase argon LEM-TPC developed and tested at CERN.
- Upgrade of the 250L single phase LAr-TPC to double phase argon LEM-TPC.
- Plan to test the upgraded 250L detector in ArDM vessel at CERN.

Liquid Argon

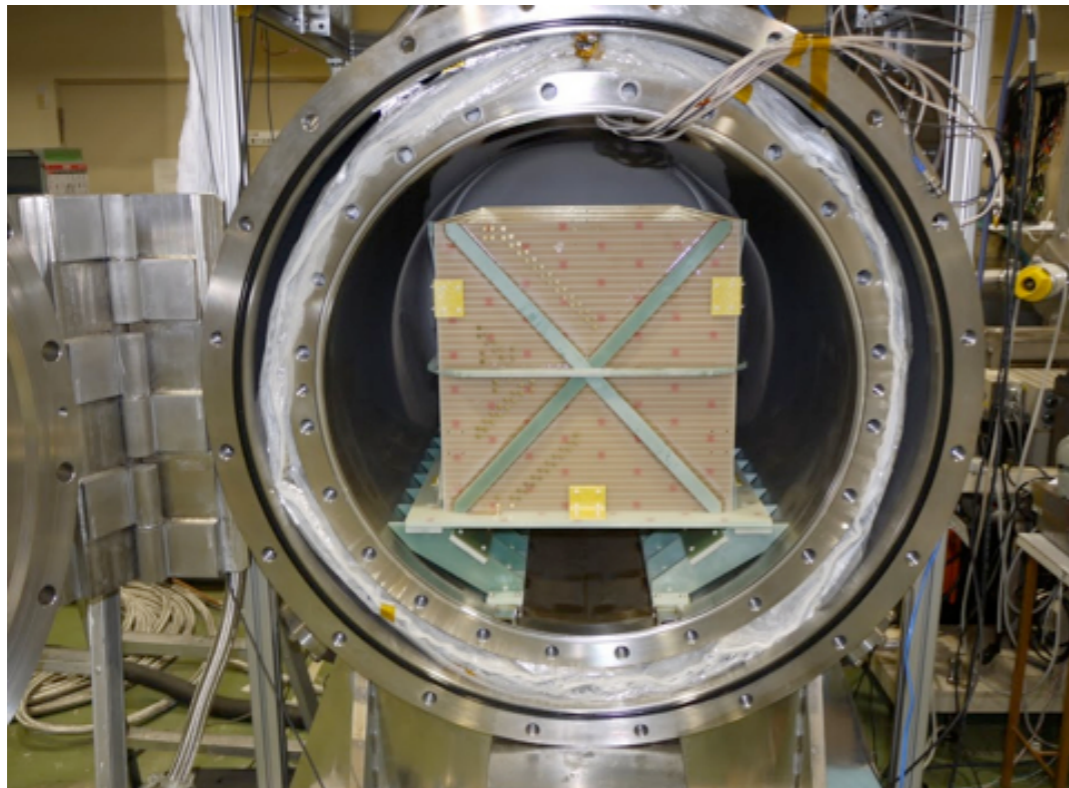
- When a particle releases energy in LAr:
 - Scintillation light at 128 nm is generated (prompt trigger).
 - Ionization electrons are freed. Charge can be transported in LAr by means of an electric field: Time Projection Chamber (three-dimensional image of the ionizing events).
- LAr density : 1.4 g/cm³.
- $\langle dE/dx \rangle_{\text{mip}} : 2.1 \text{ MeV/cm}$.
- Easily available and cheap material.
- Liquid argon is a suitable target for **neutrino detectors, proton decay searches experiments and direct dark matter detectors** as well.

A. Rubbia, arXiv:hep-ph/0402110, 2003.

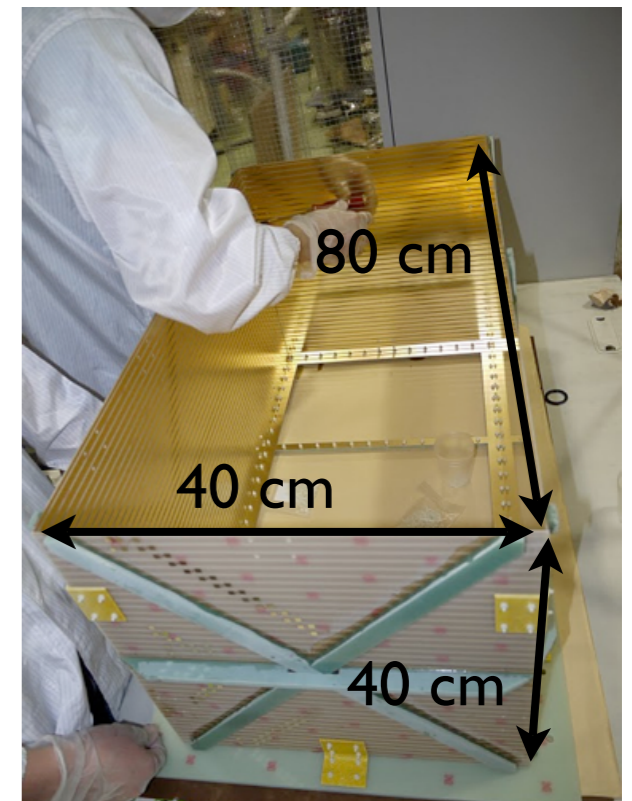
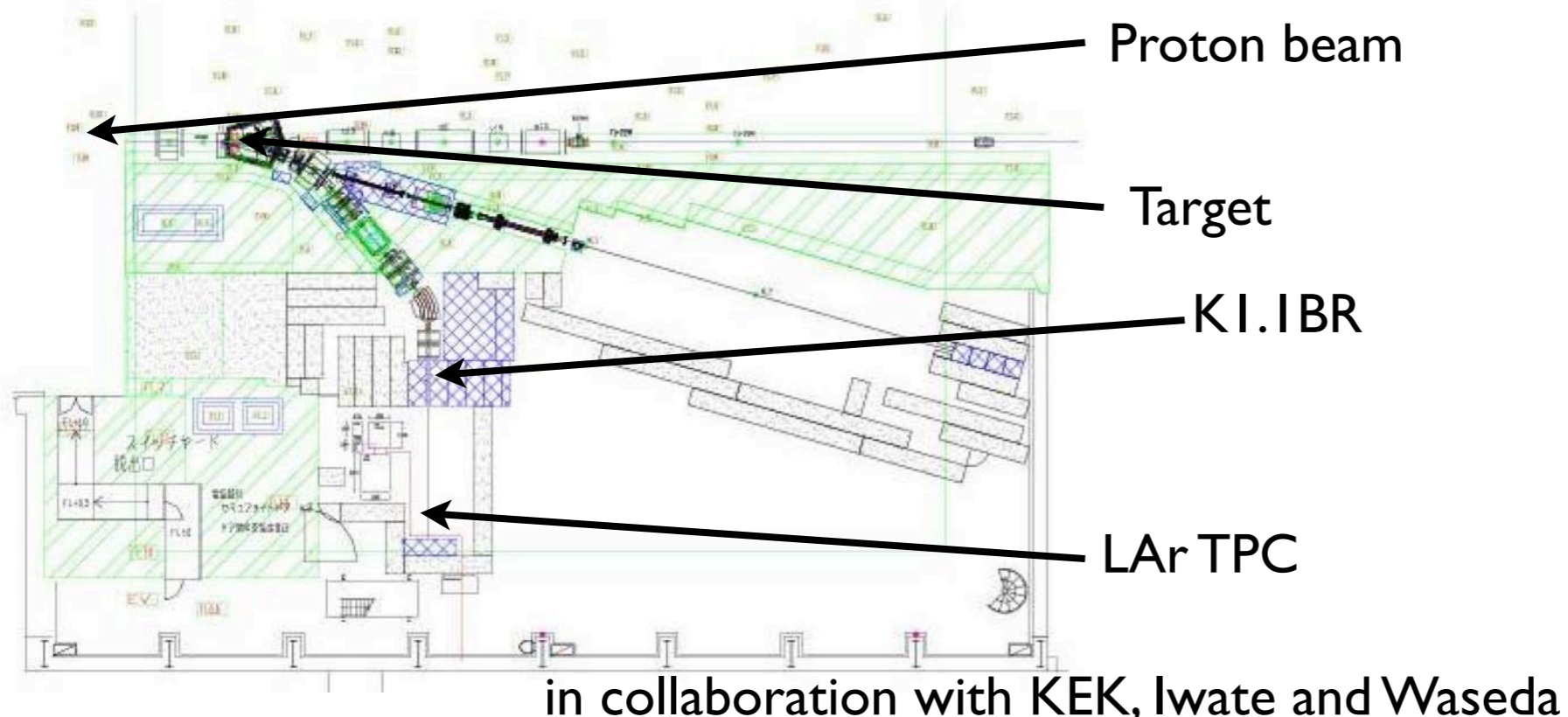
A. Rubbia, J. Phys. Conf. Ser. 39 (2006) 129.

T32 experiment @ J-PARC

Experiment with a LAr TPC on a charged particle beam



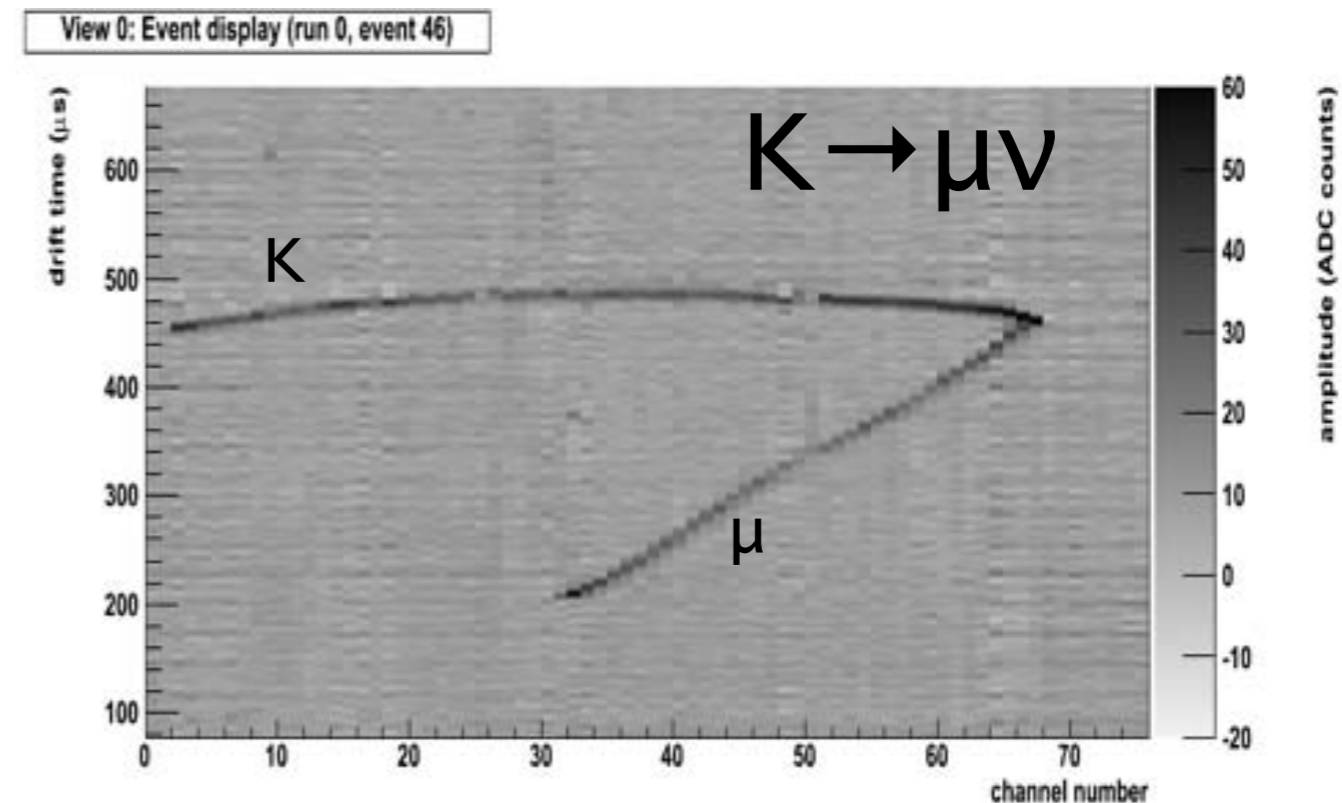
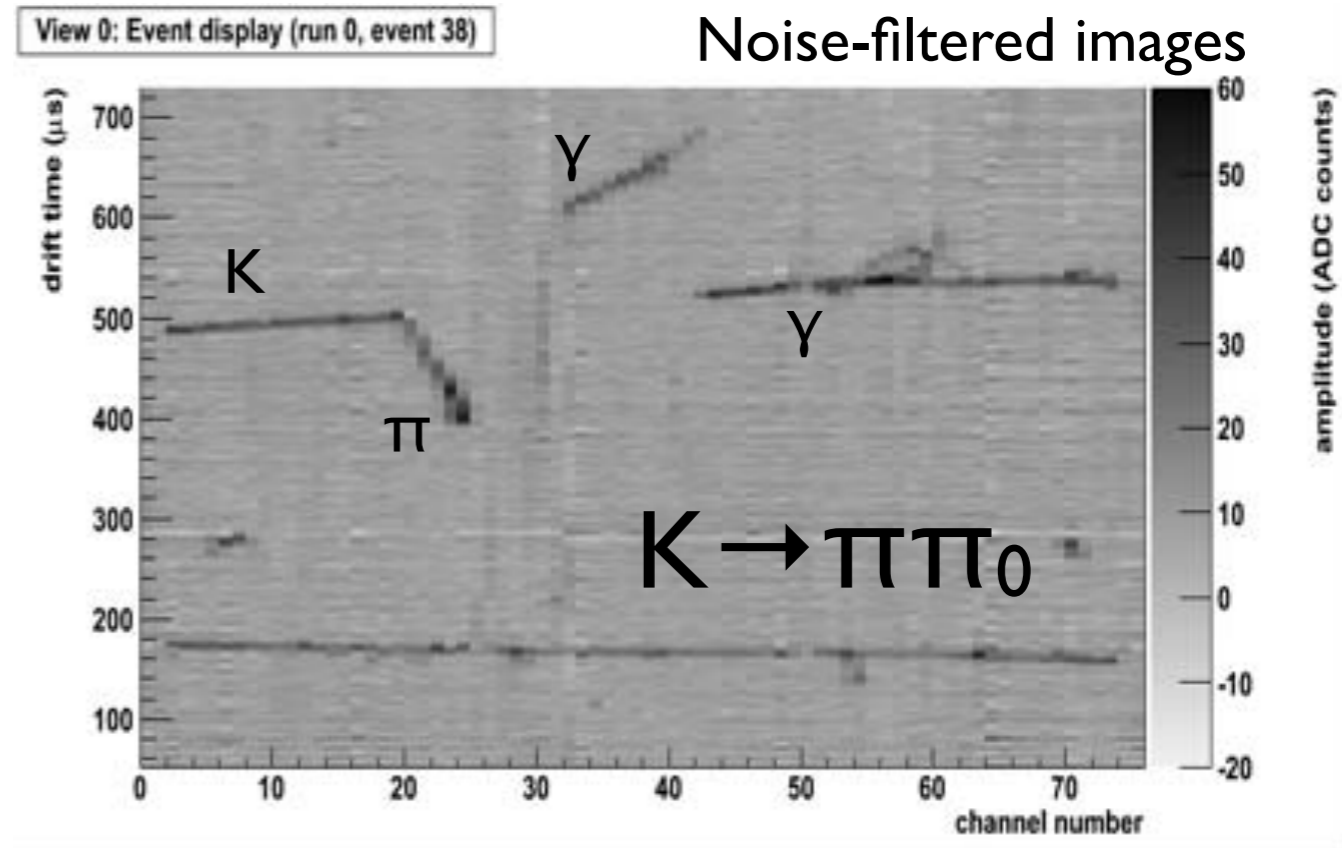
- Measurements with well defined charged particle beam ($e/\pi/K/p$) at J-PARC hadron facility.
- Benchmark the performance of the LAr TPC in particle identification and energy resolution (π/K separation is relevant for proton decay searches).
- Develop simulation software and event reconstruction tools.



in collaboration with KEK, Iwate and Waseda

250L LAr TPC

- Detector operated in single phase mode (no charge amplification is possible).
- ID anode with 1 cm pitch strips (2D reconstruction of the events).
- Cryogenic vessel originally built for MEG liquid xenon calorimeter.
- Established cryogenic infrastructures on the beam line.
- Stable operation for about one week.
- Liquid argon purity (drifting electron lifetime $\sim 650 \mu\text{s}$).
- Exposure to low-momentum K/ π beam:
 - ~ 46000 K, 70000 π , 12000 e, 1500 p.
- TREK instrumentation used for triggering.
- Data analysis is ongoing.
- Upgrade of the charge readout is under construction.

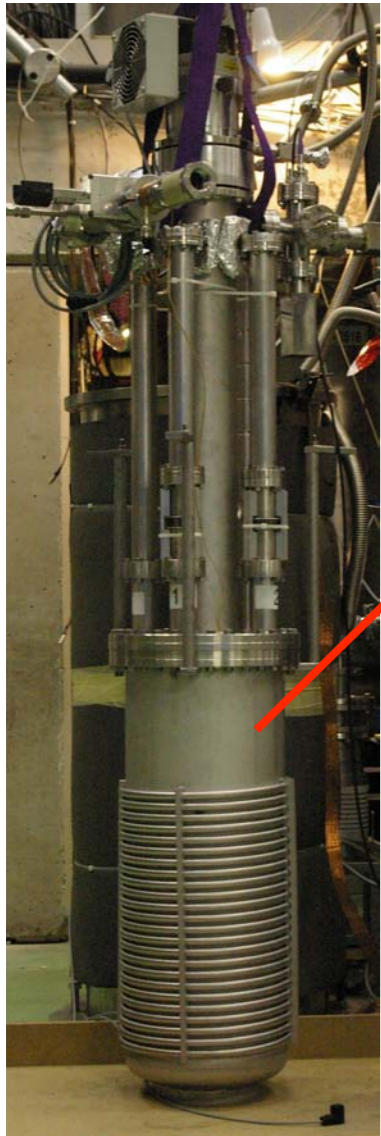


250L upgrade

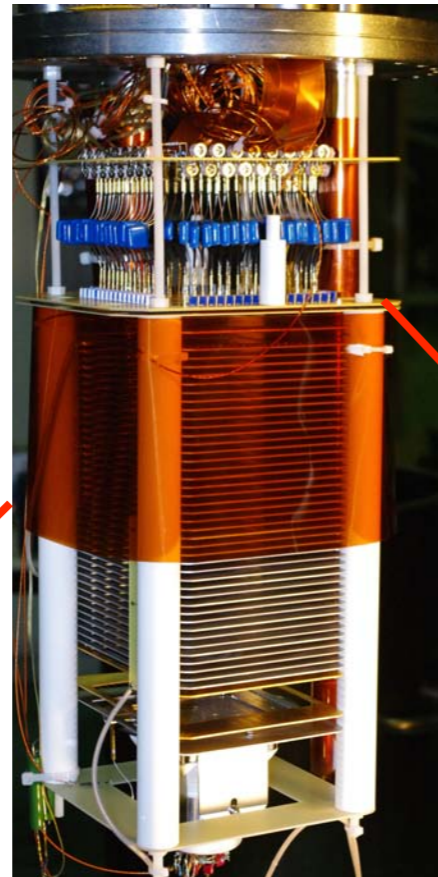
- Triggered by the positive results of the charge readout in the 3L detector (see next slides) and as part of the R&D roadmap towards giant liquid argon detector, the upgrade of the 250L detector is in progress.
- Detector in double phase (liquid vapor) mode with charge amplification to improve the signal to noise ratio. A 80x40 cm² LEM + 2D-projective anode in vapor phase.
- Corollary devices like the extraction grids (to extract the drifting electrons from the liquid to the vapor phase) and the signal planes (to decouple the signals from the high voltage and rout them out of the vessel).
- The whole assembly is the so called readout “sandwich”. It can be thought as a complete charge readout unit.

3L setup

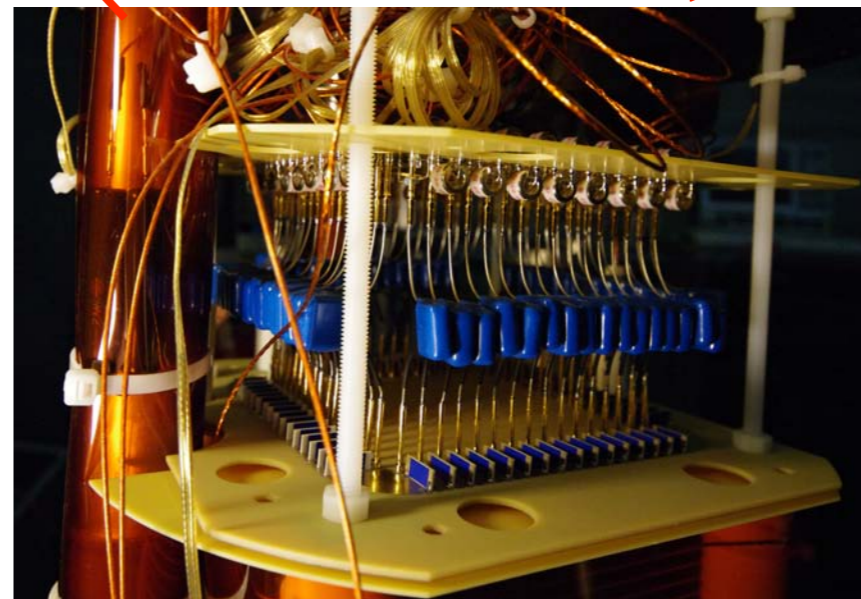
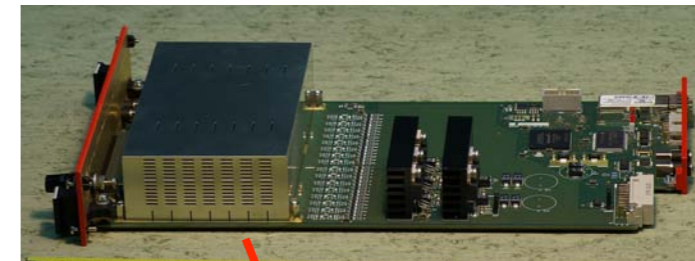
UHV vessel inside
open LAr bath



TPC



CAEN DAQ system



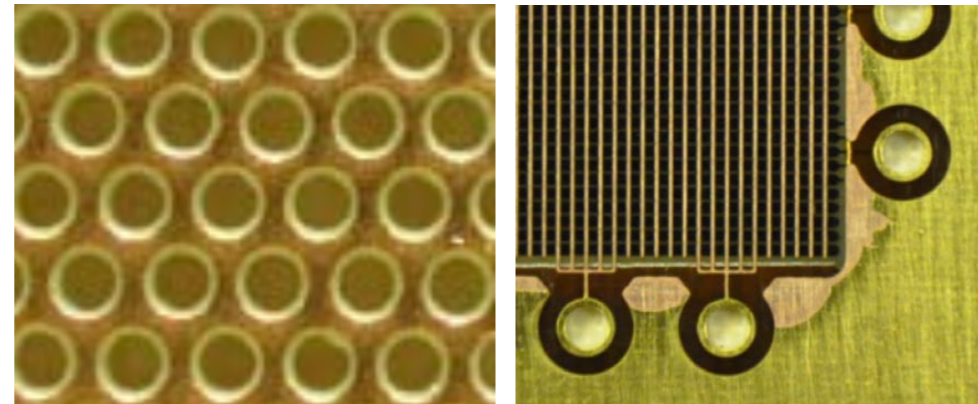
Charge Readout system in
gas phase above pure LAr

3L detector charge readout

Manufacturer: CERN TS/DEM group

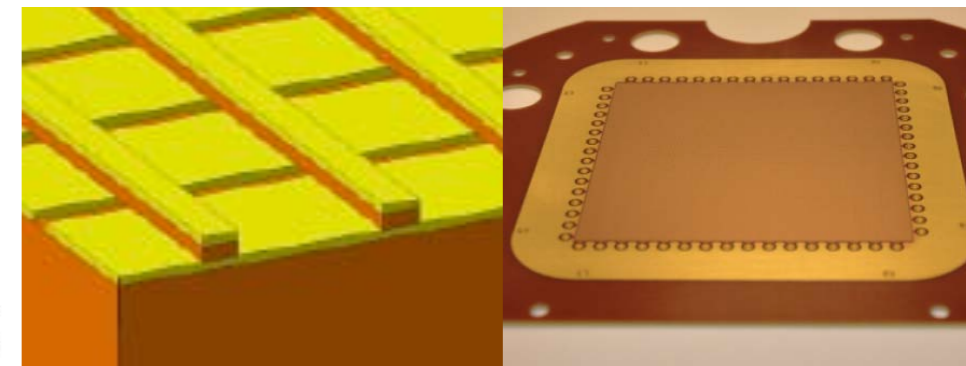
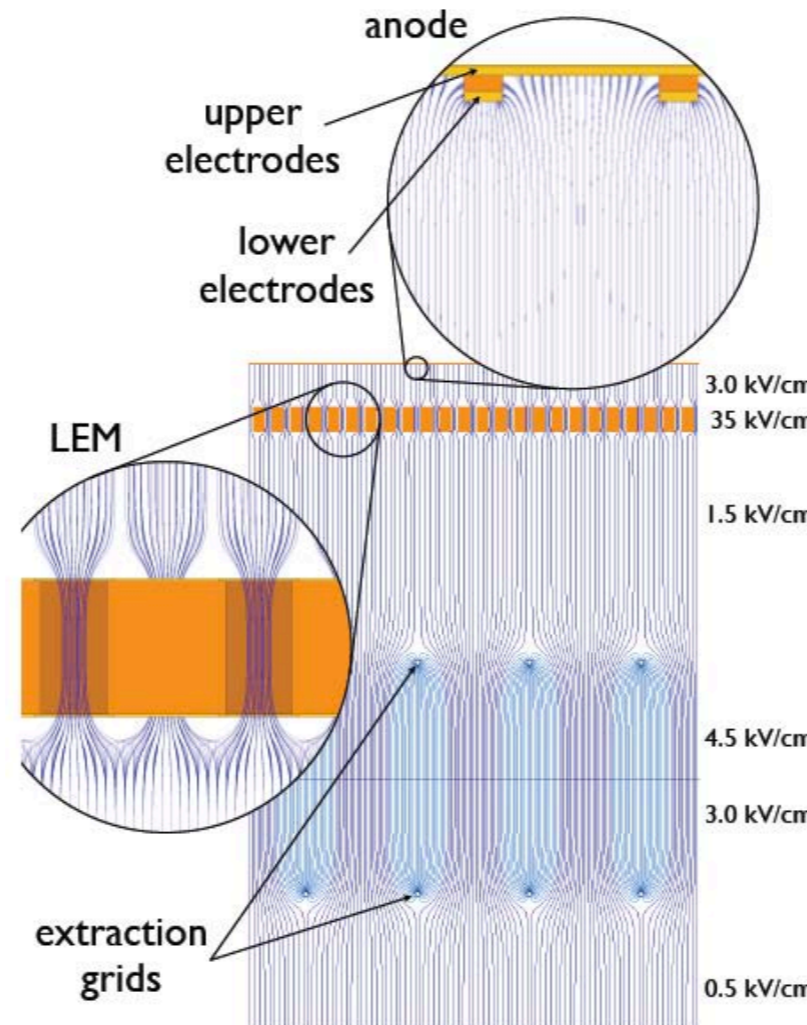
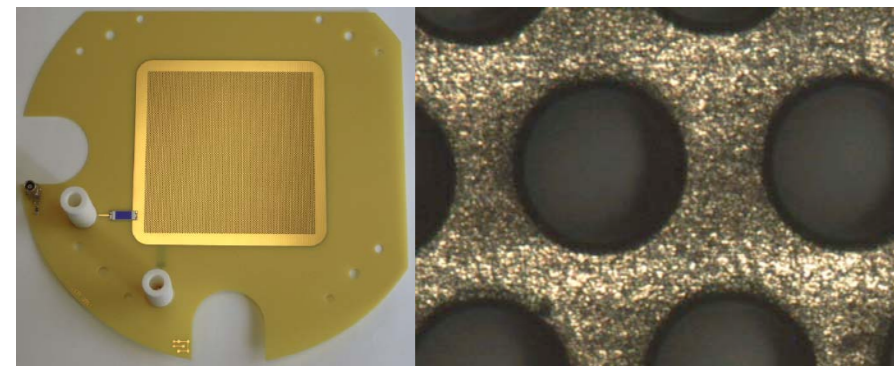
The Large Electron Multiplier

- Macroscopic Gas multiplier extrapolated from the GEMs.
- hardness to cryogenic temperatures and discharges.
- manufactured with standard PCB techniques.
- Large area coverable.



2D projective anode

- Charge is equally collected on two sets of strips (2 views).
- Induced signals have the same shape.
- Readout independent of multiplication stage.

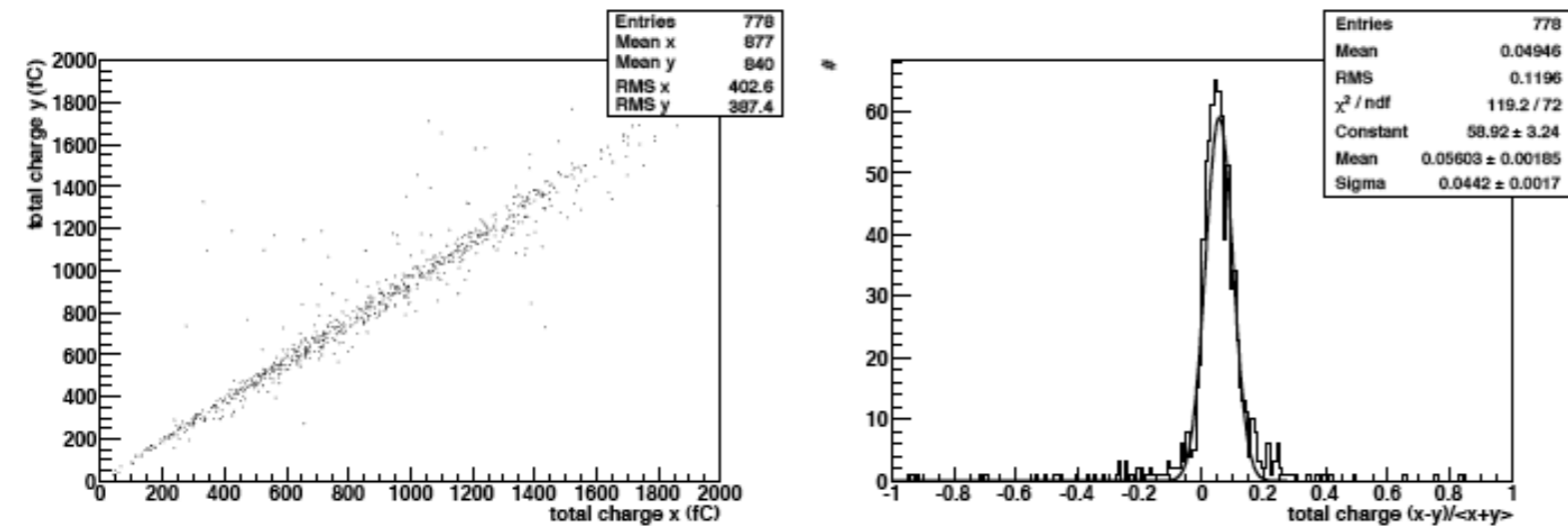


total area	10x10 cm ²
PCB thickness	1.0 mm
hole diameter	500 μm
hole pitch	800 μm
dielectric rim	70-80 μm

Readout pitch	3 mm
Strip pitch	600 μm
Strip width (outer)	120 μm
Strip width (inner)	500 μm
Kapton thickness	50 μm
Number of strips	32x32

3L detector performance

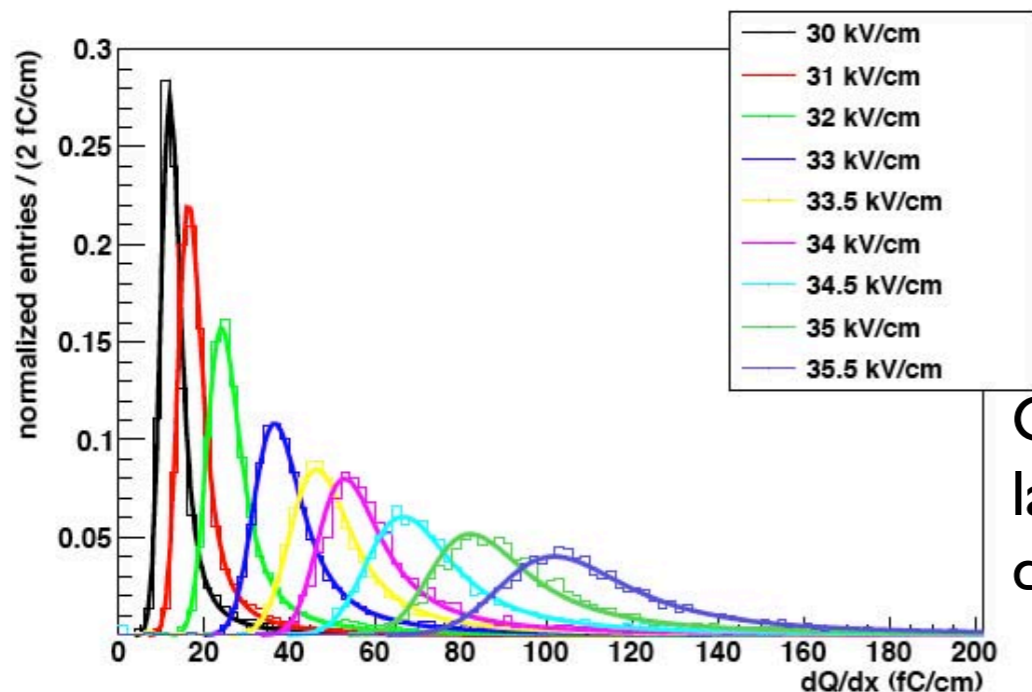
Cosmic muons have been used to characterize the detector



- Signal shape of x and y views: identical.
- Charge sharing better than 5% correct anode design parameters.

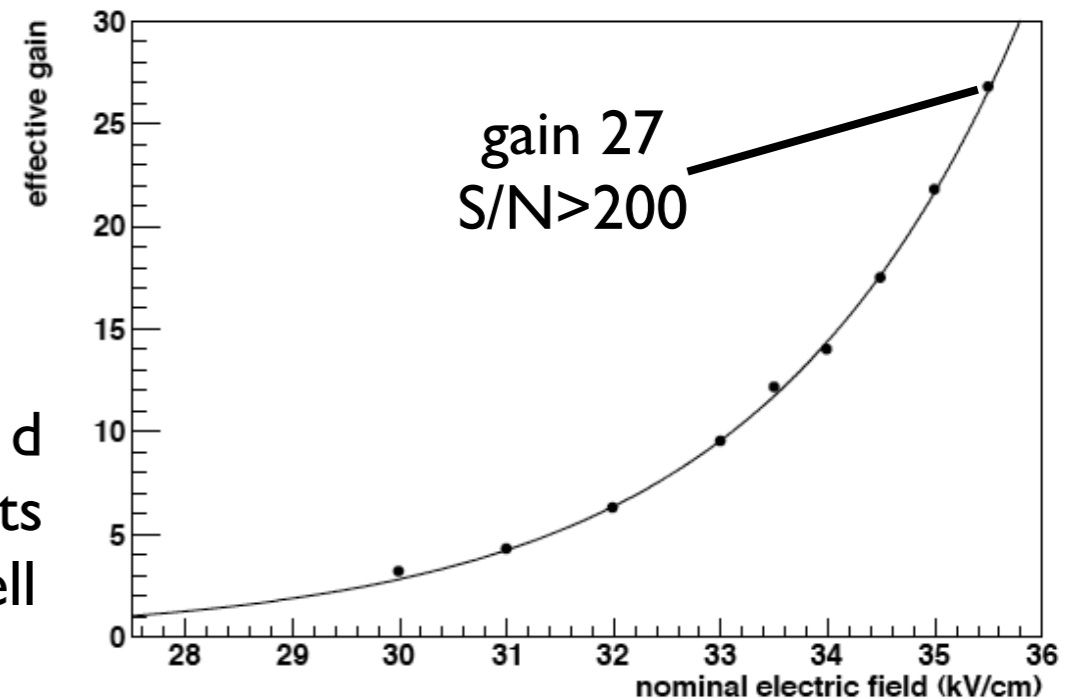
$$(x-y)/\langle x+y \rangle \sim 5\%$$

dQ/dx distribution



Gauss-convoluted landau distribution fits dQ/dx histograms well

Gain curve



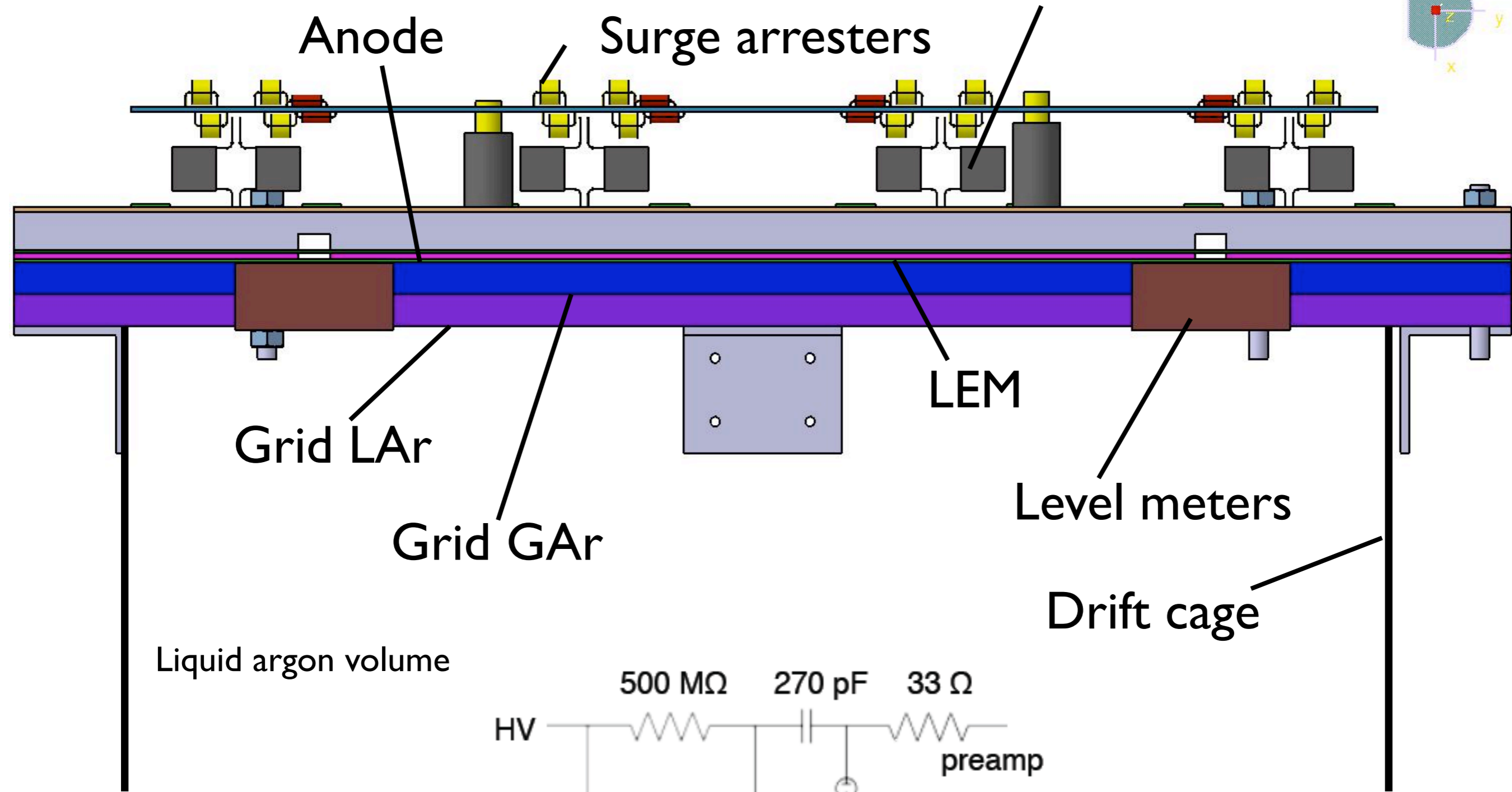
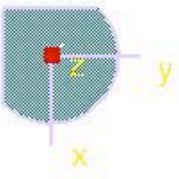
Readout “sandwich” for 250L

Gas argon volume

HV decoupling capacitors

Anode

Surge arresters



Grid LAr

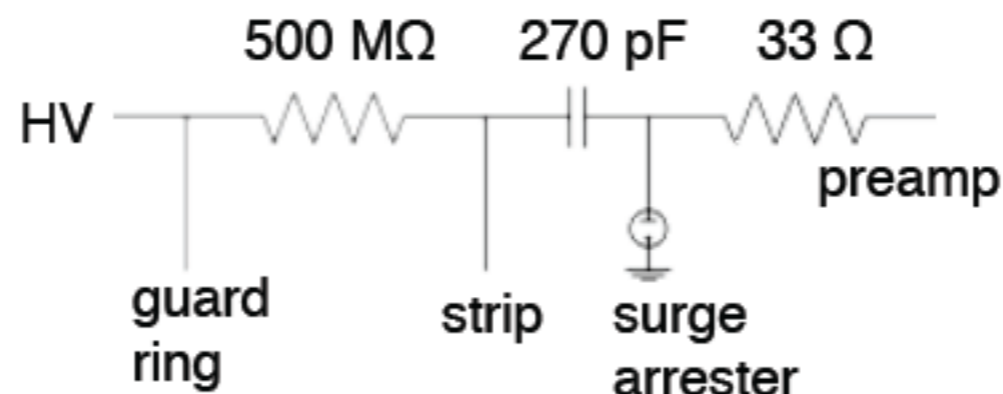
Grid GAr

LEM

Level meters

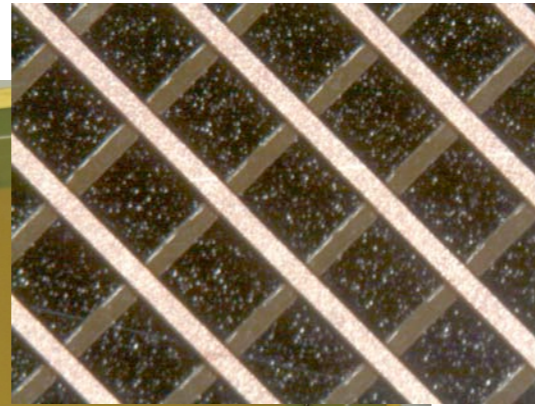
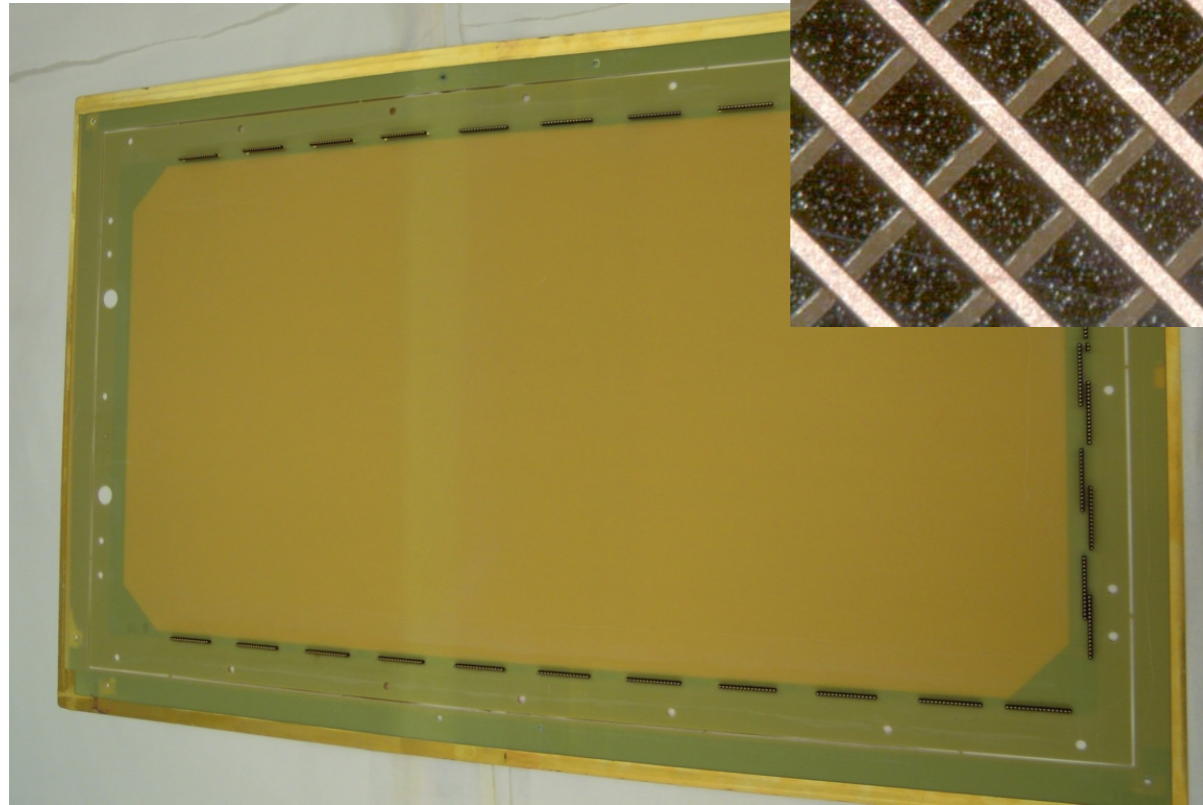
Drift cage

Liquid argon volume



2D projective anode and LEM

Manufacturer: CERN TS/DEM group



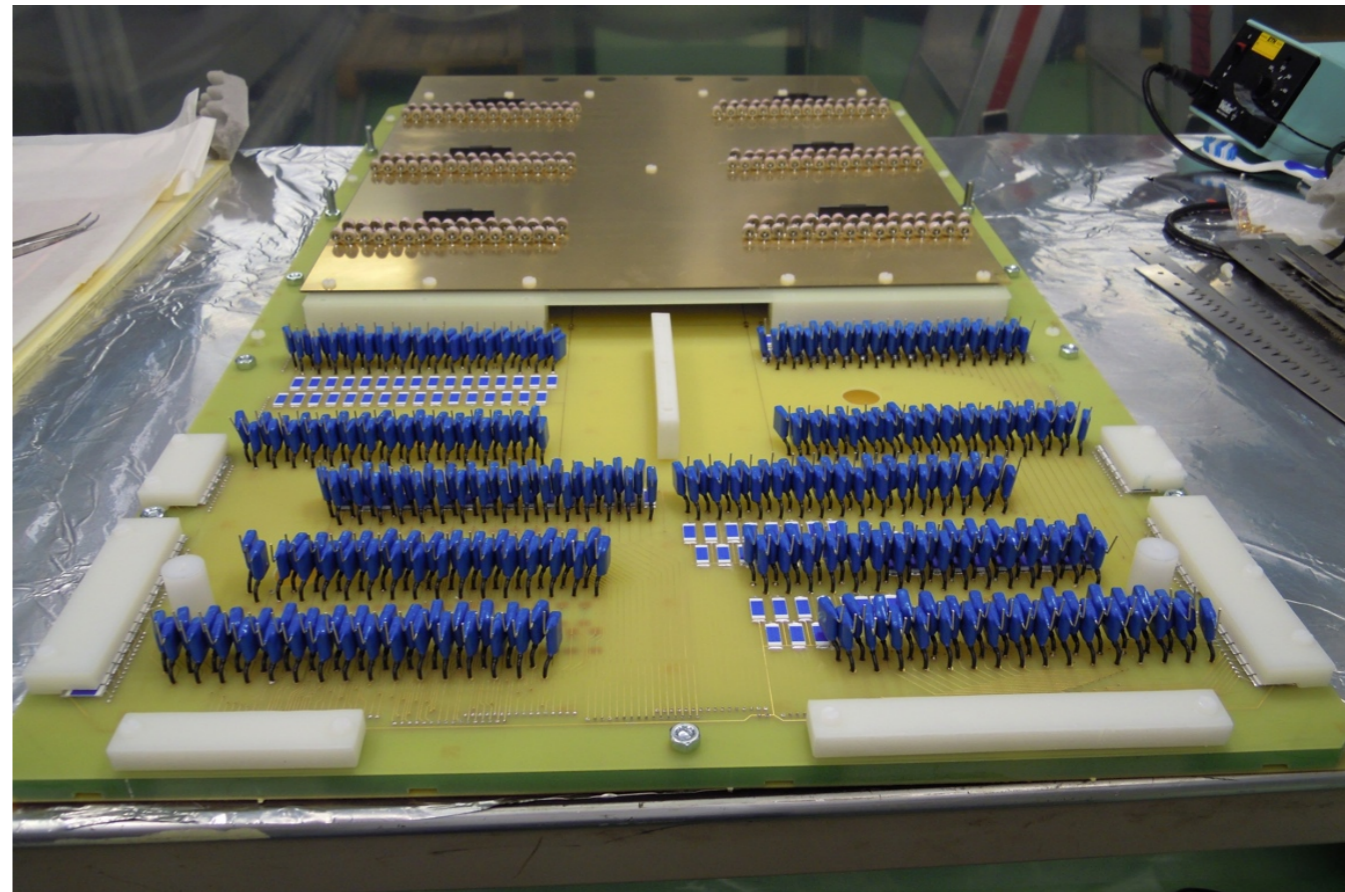
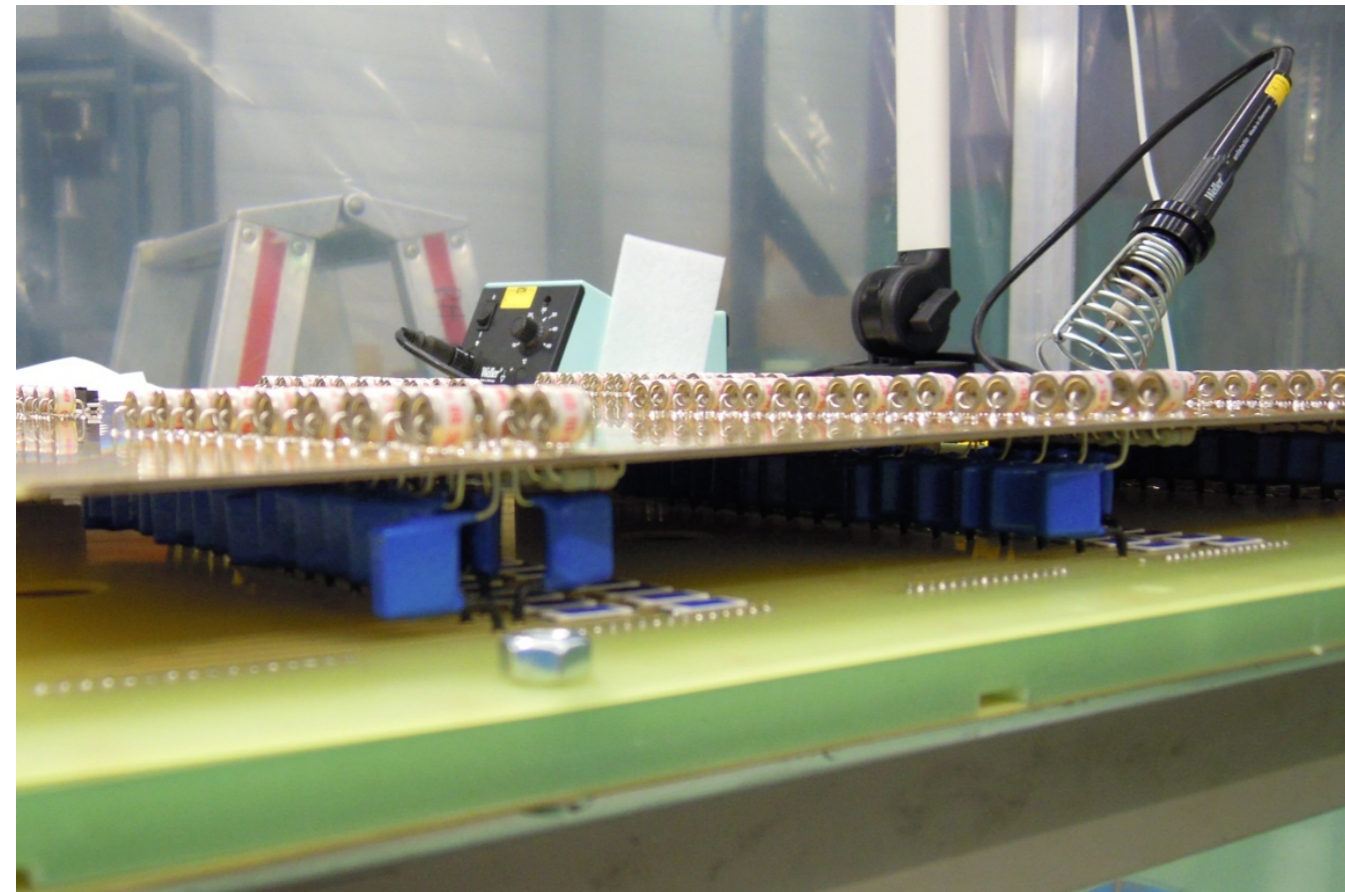
- 40 x 76 cm² active area (biggest ever constructed).
- 256 + 256 channels.
- 45° between the 3 mm wide strips and the beam axis.
- 55 cm long strips (longest).

- 40 x 76 cm² (~0.5x10⁶ holes)
- 8 segments to decrease the LEM capacitance.
- PCB: 1 mm thick
- hole: \varnothing 0.5 mm, 0.8 mm pitch

Manufacturer: ELTOS



Complete readout sandwich



Before sending the readout to Japan, a test run is planned in the ArDM vessel at CERN (cosmic muons).

Preliminary tests (pulse test of the anode, HV test in air of the LEM and the anode) are ongoing.

The run in ArDM vessel is foreseen before the Summer.

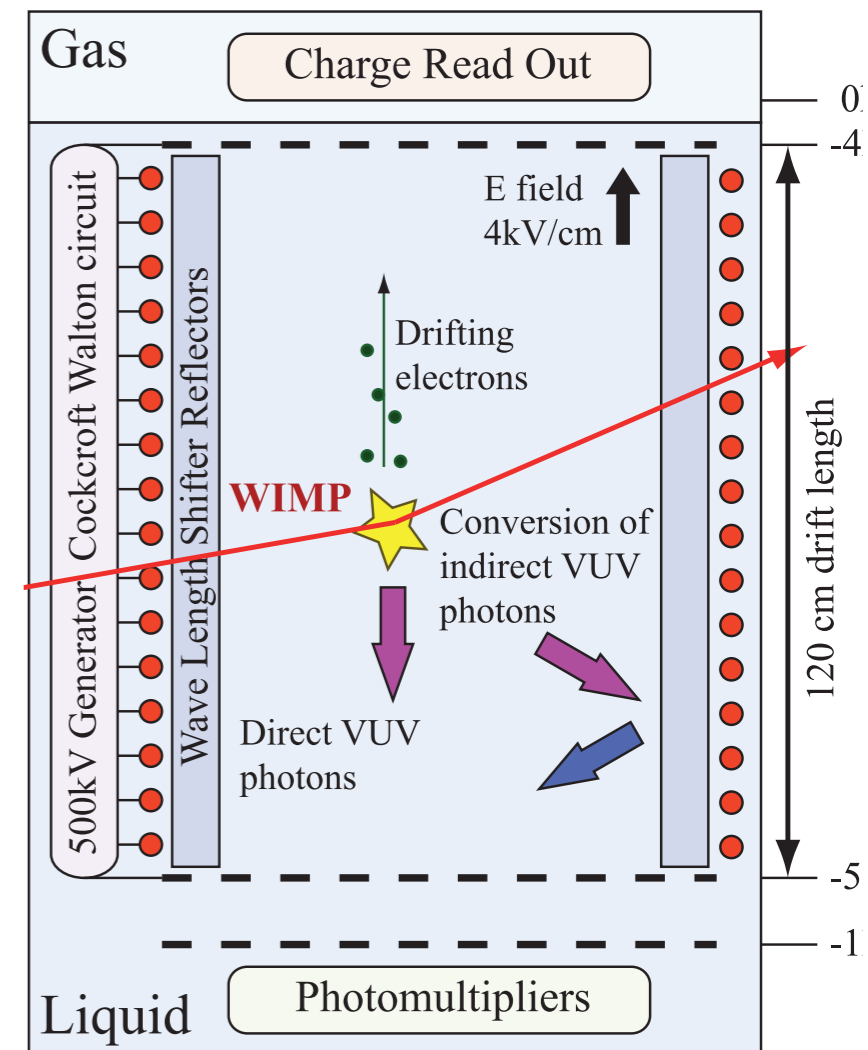
ArDM

Reference: A. Rubbia, J. Phys. Conf. Ser. 39 (2006) 129

A 1 ton LAr detector for the detection of nuclear recoils induced by WIMPs. To be moved to the Canfranc Underground Lab (starting in the Summer).

The detector is presently assembled on surface at CERN to fully test all functionalities:

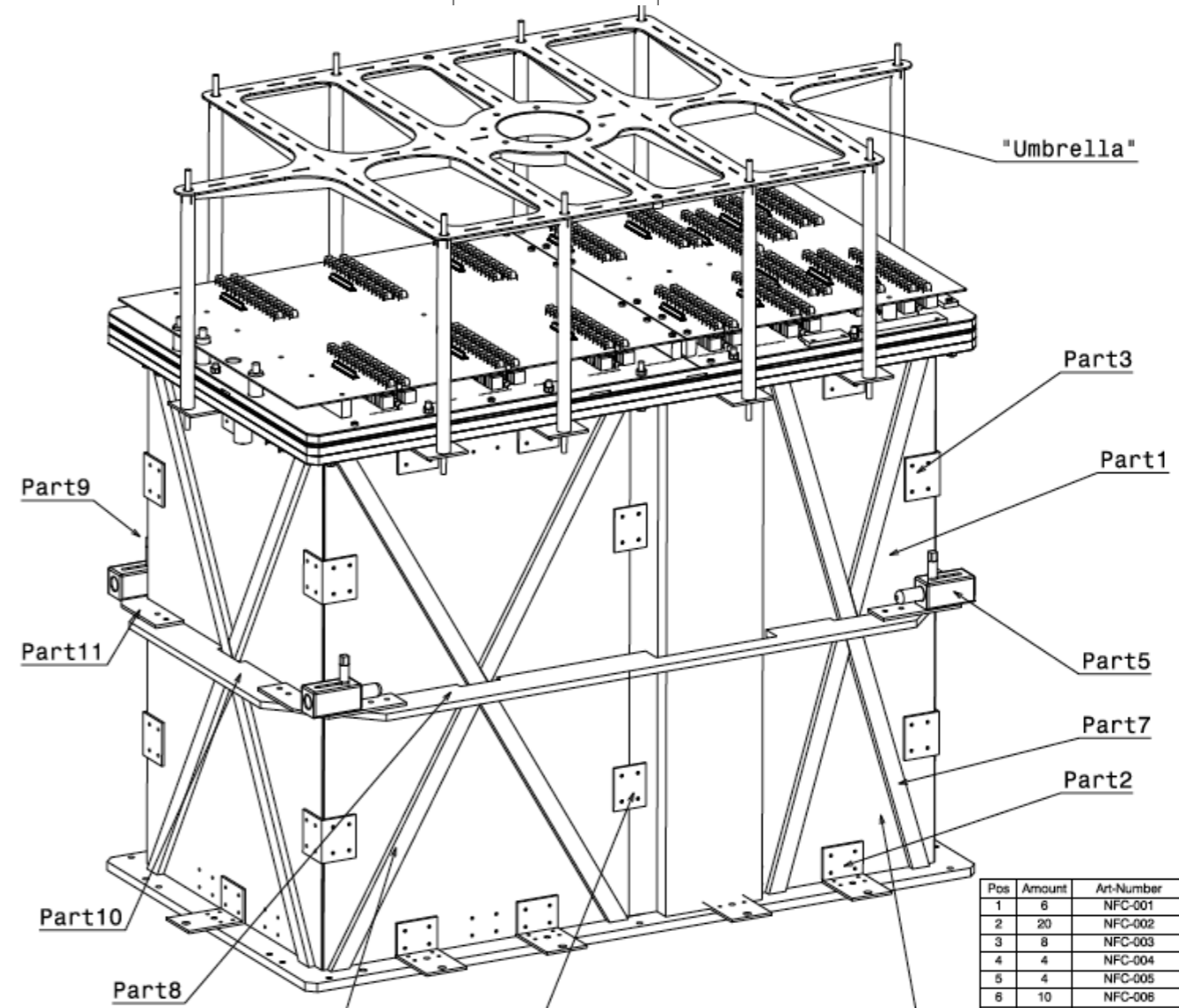
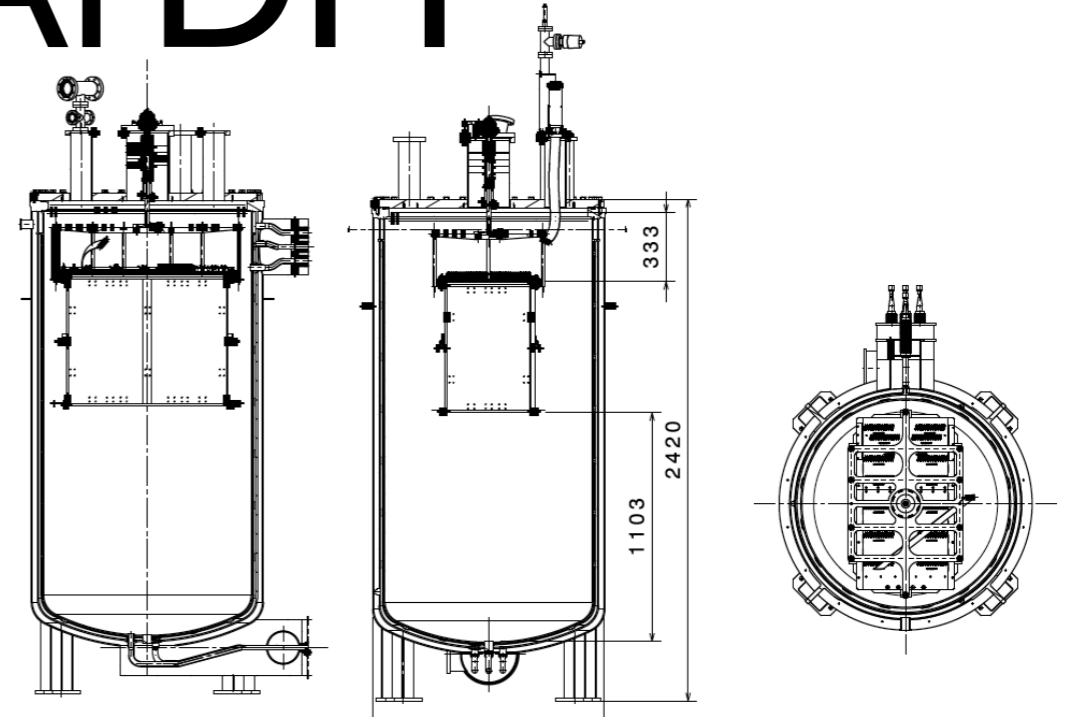
- Light readout (PMTs, WLS reflectors).
- HV system (Greinacher circuit).
- Slow control and safety (PLC).
- Cryogenics system with cryo-cooler (presently under testing).
- LAr purification (liquid and gas recirculation systems).



14 cryogenic PMTs

250L in ArDM

- The aims of the test are:
 - Benchmark the charge readout sandwich (gain, stability, uniformity).
 - Measure the argon purity (\sim ppb level) in ArDM vessel and the effectiveness of the argon purification system.
- The installation in ArDM:
 - New 60 cm drift cage compatible with the readout sandwich (in construction).
 - New mechanics support for hanging the detector to the ArDM top flange.
- Features of the detector:
 - Greinacher as HV system in order to avoid a very HV feedthrough (\sim 60 kV).
 - 4 cryogenic PMTs below the cathode to trigger the acquisition.



Conclusions

- **T32 experiment:**
 - Single phase (liquid) argon TPC on e/ π /K/p beam in J-PARC (Japan).
 - Data taking during Fall 2010. Analysis of $\sim 1.3 \times 10^5$ beam events is ongoing.
- **To improve the image capabilities (S/N, 3D reconstruction) an upgrade of the LAr-TPC is foreseen:**
 - Double phase argon TPC with a LEM amplification stage in argon vapor and two dimensional projective anode (readout sandwich).
 - The production of the readout sandwich is completed. Preliminary tests of functioning are ongoing.
- **The readout sandwich will be tested before the Summer at CERN in ArDM vessel:**
 - Mechanical parts and new drift cage are in production.
 - Soon ready to test the biggest double phase argon TPC.