LABORATORIUM FÜR HOCHENERGIEPHYSIK
LHEP
UNIVERSITÄT BERN

b
UNIVERSITÄT
BERN

Report on the ARGONTUBE project under execution at the University of Bern

Marcello Messina
Albert Einstein Centre for Fundamental Physics
Laboratory for High Energy Physics
University of Bern
on
behalf of
I. Badhrees, A. Ereditato, S. Janos, I. Kreslo, M. M., S. Haug, B. Rossi, C. Rudolf von Rohr, M. Weber, M. Zeller

Outline

- Short introduction to the Liquid Argon Time Projection Chamber concept.
- ARGONTUBE
  - Goals of the ARGONTUBE project
  - Design and Construction
  - Vacuum and cryogenic test
  - Simulation (E-Field)
  - High voltage tests for the drift field
- medium ARGONTUBE as bench-test of ARGONTUBE
  - Purity measurements of LAr with laser tracks
  - DAQ
- Conclusions and outlook

LAr TPC concept

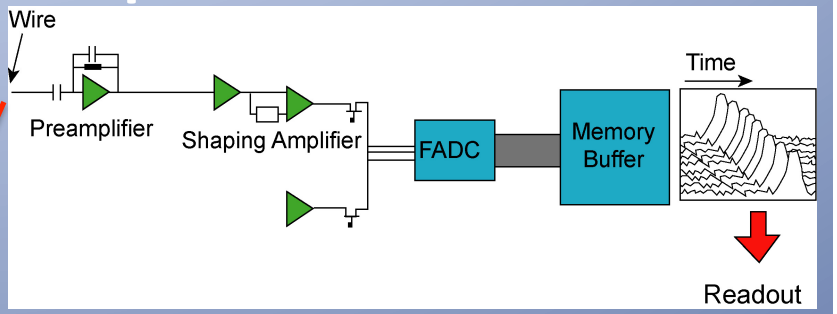
Features:

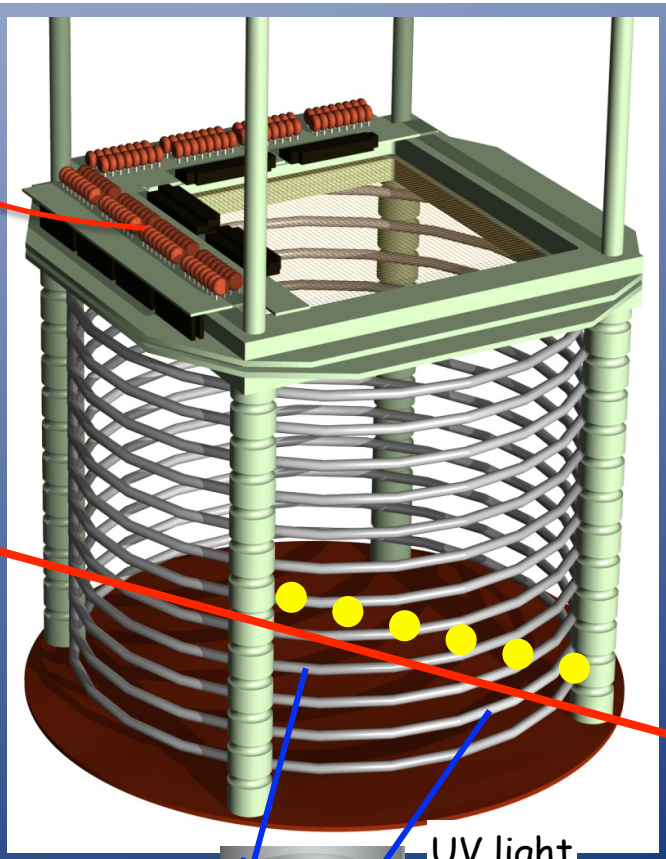
- Homogeneous sensitive volume
- Charge read out
- Collected charge proportional to the deposited energy
- Three dimensional tracker
- Fully homogenous

Charge yield (m.i.p.)	6000 e^-/mm
Photon yield (m.i.p.)	5000 photons/mm (128 nm)
Electron drift velocity	2mm/μs (@ 1kV/cm)

Peculiarities:

- Very good energy resolution for electromagnetic showers
- Good particle identification via the dE/dx measurements
- Good momentum resolution for passing through particles

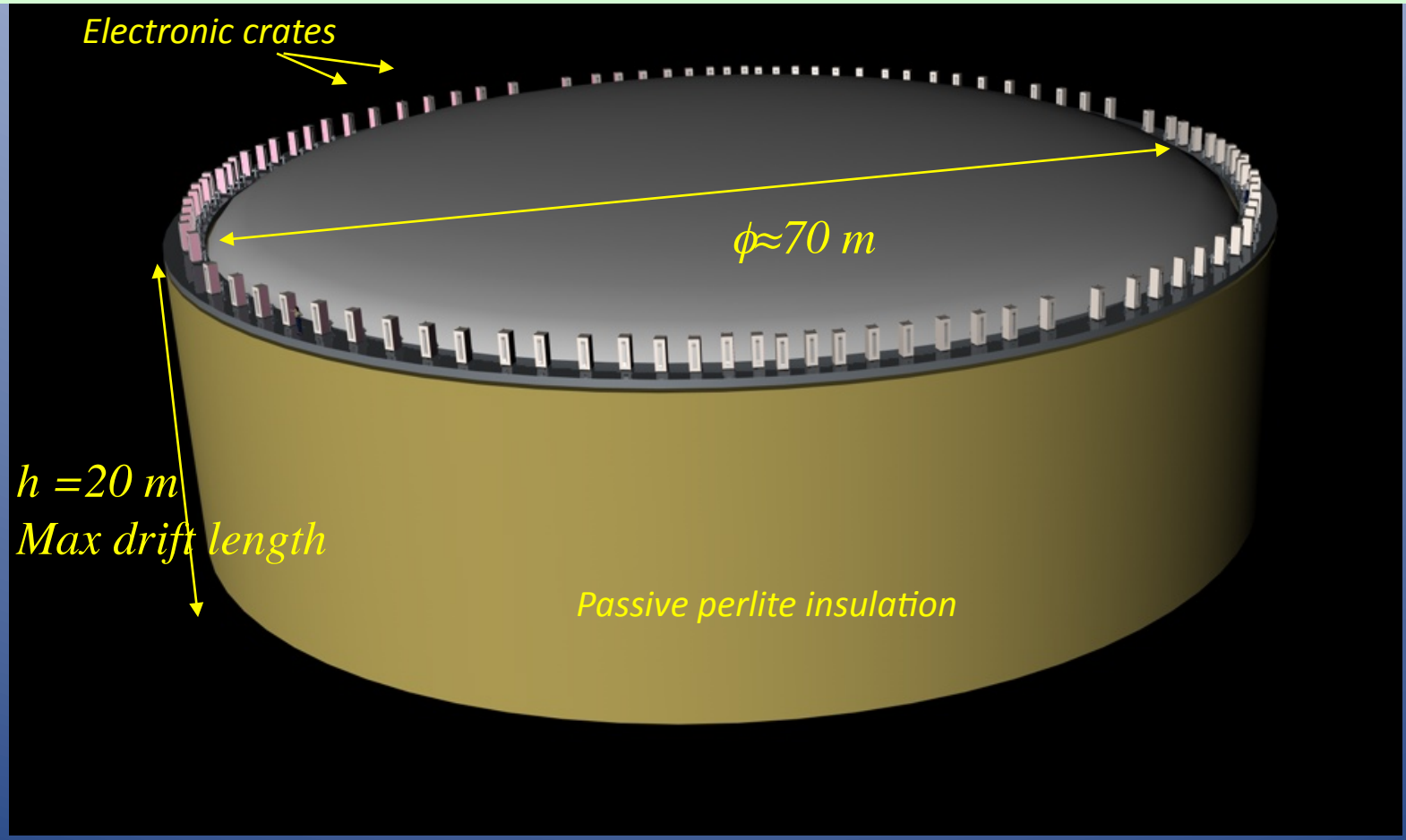




PM providing the trigger and the t_0 for the drift time measurement

GLACIER a 100 kton liquid Argon TPC

A "general-purpose" detector for superbeams, beta-beams and neutrino factories (if B field is applied) with broad non-accelerator physics program (SN ν, p-decay, atm ν, …)

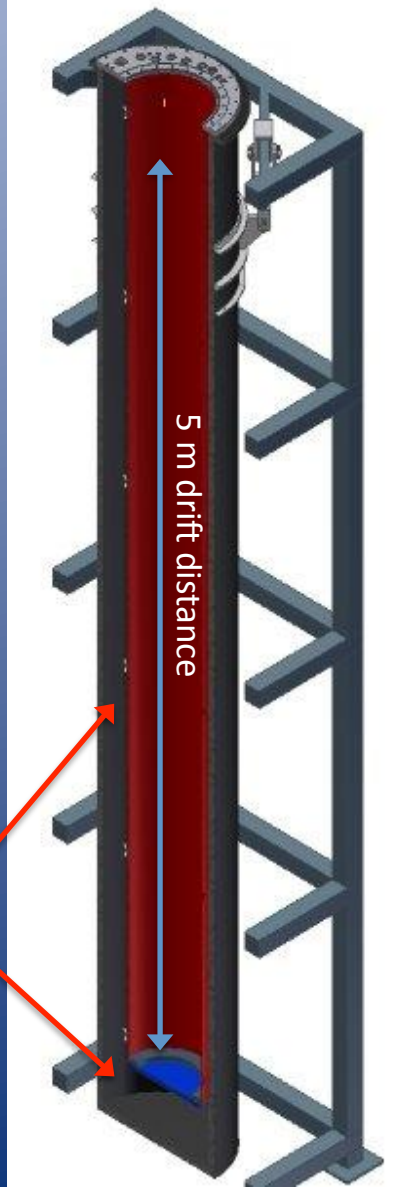


- **Experiments for CP violation: a giant liquid Argon scintillation, Cerenkov and charge imaging experiment,** A.Rubbia, Proc. II Int. Workshop on Neutrinos in Venice, 2003, Italy, hep-ph/0402110
- **Ideas for future liquid Argon detectors,** A. Ereditato and A.Rubbia, Proc. Third International Workshop on Neutrino-Nucleus Interactions in the Few GeV Region, NUINT04, March 2004, Gran Sasso, Italy, **Nucl.Phys.Proc.Suppl.139:301-310,2005,** hep-ex/0409034
- **Ideas for a next generation liquid Argon TPC detector for neutrino physics and nucleon decay searches,** A. Ereditato and A.Rubbia, Proc. Workshop on Physics with a Multi-MW proton source, May 2004, CERN, Switzerland, submitted to SPSC Villars session.

ARGONTUBE

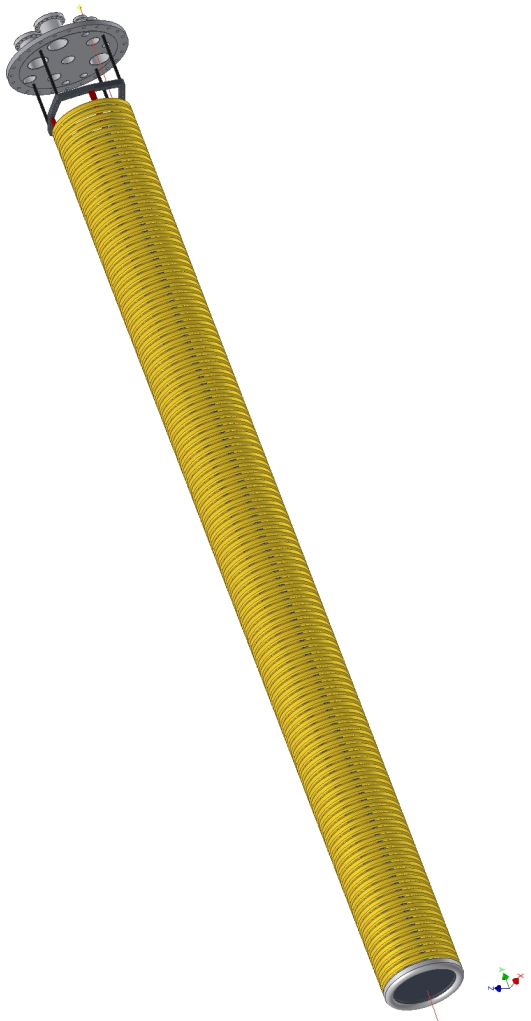
Project aimed at proving the capability of drifting the ionization electrons on long distances in view of the construction of very large mass neutrino detectors

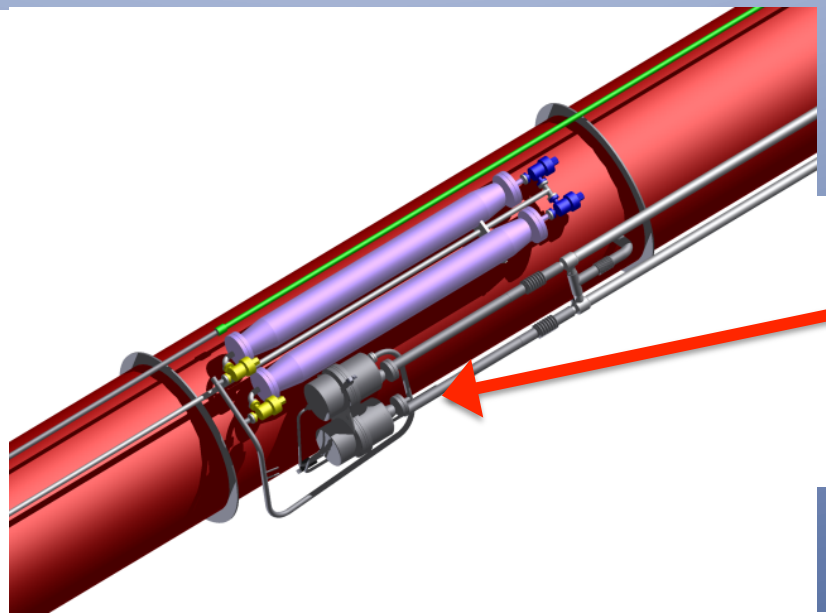
- Main issues
  - 500 kV in liquid Argon
  - Impurities at the level of < 0.1ppb (life time > 3000 ms)
  - Signal over noise ratio of at least factor 10
- Possible studies with ARGONTUBE:
  - Measure the purity limit
  - Study the UV-Laser as purity monitor and calibration method
  - Electron diffusion (parallel and perpendicular to E-field)
  - Test new readout system



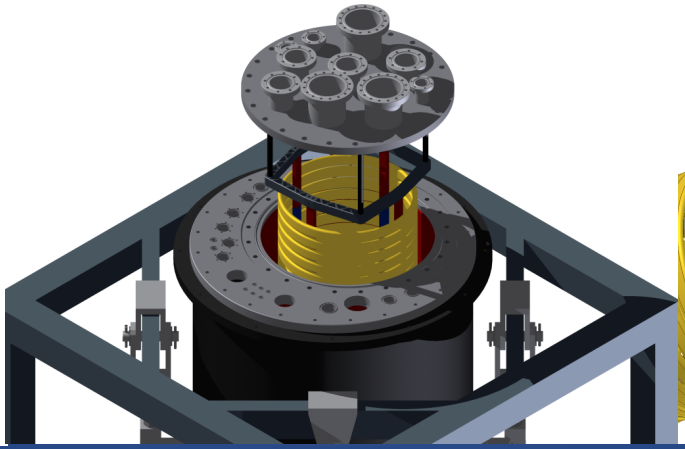
- Outer volume: 1.6 m^3
- Inner volume : 1. m^3
- Active volume: 0.5 m^3
- Active mass: 280 kg

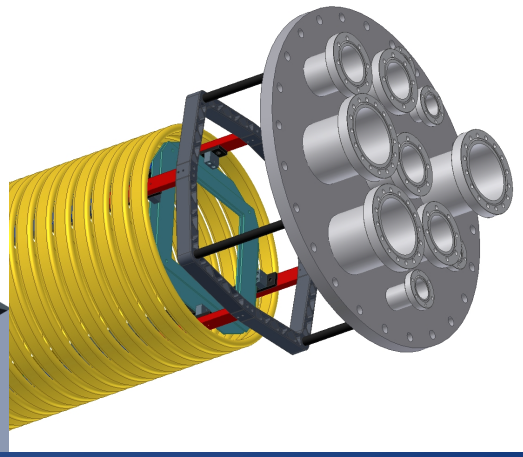
Drawings of the ARGONTUBE



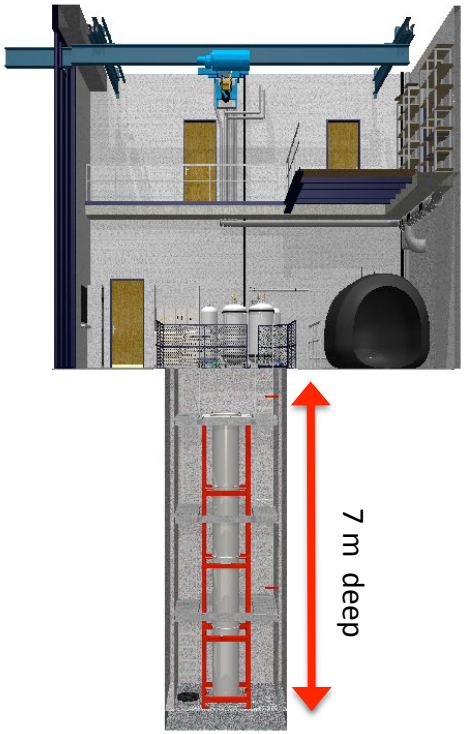


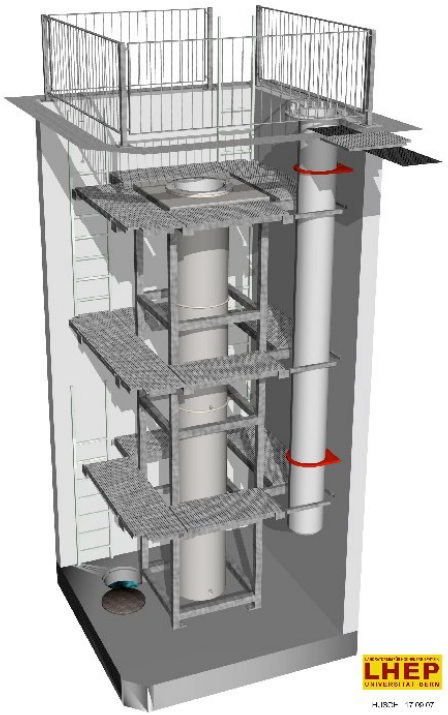
Pneumatic pump for recirculation of the LAr driven with pressurized nitrogen (developed in collaboration with ETHZ and realized by CRIOTEC , ITALY)

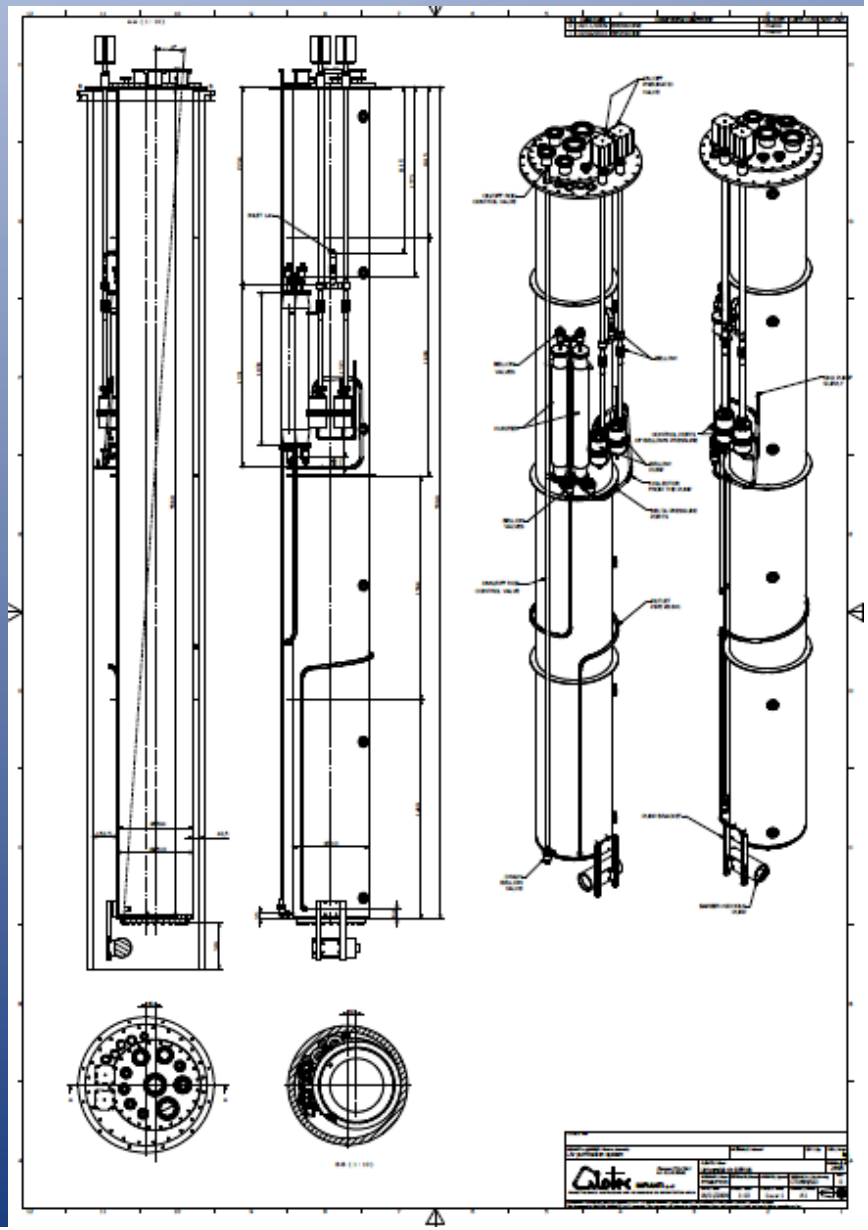




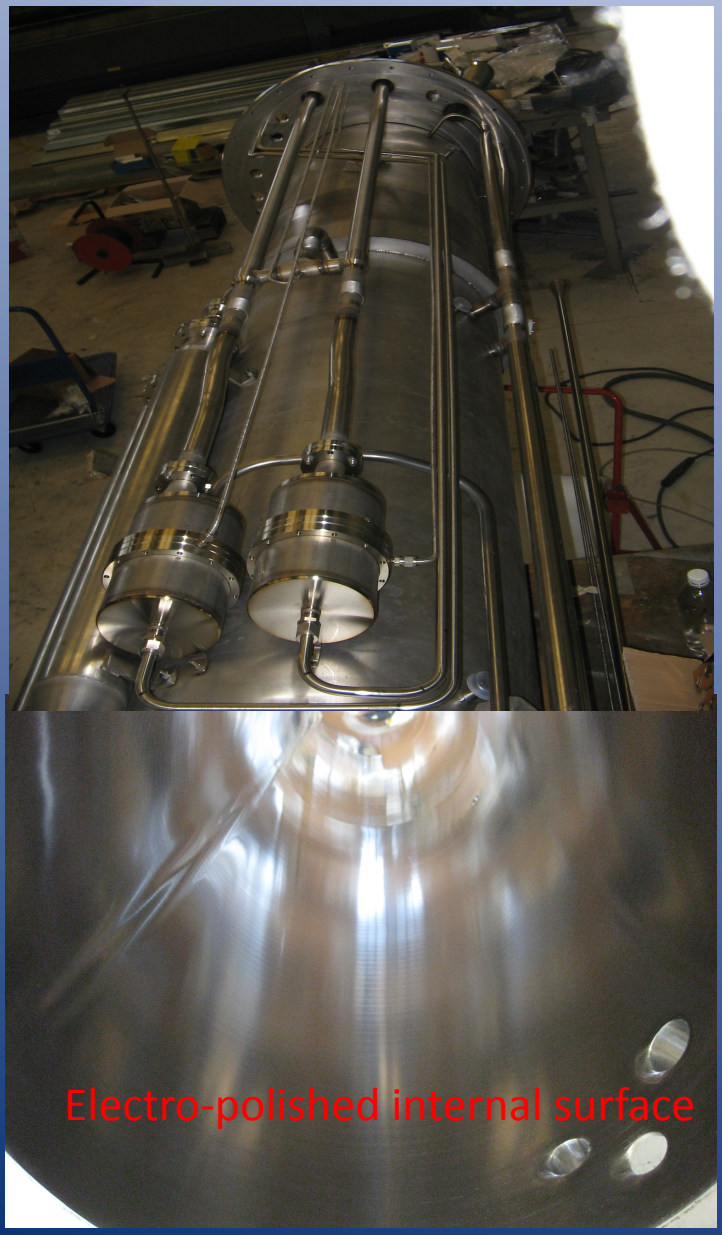
Design and construction







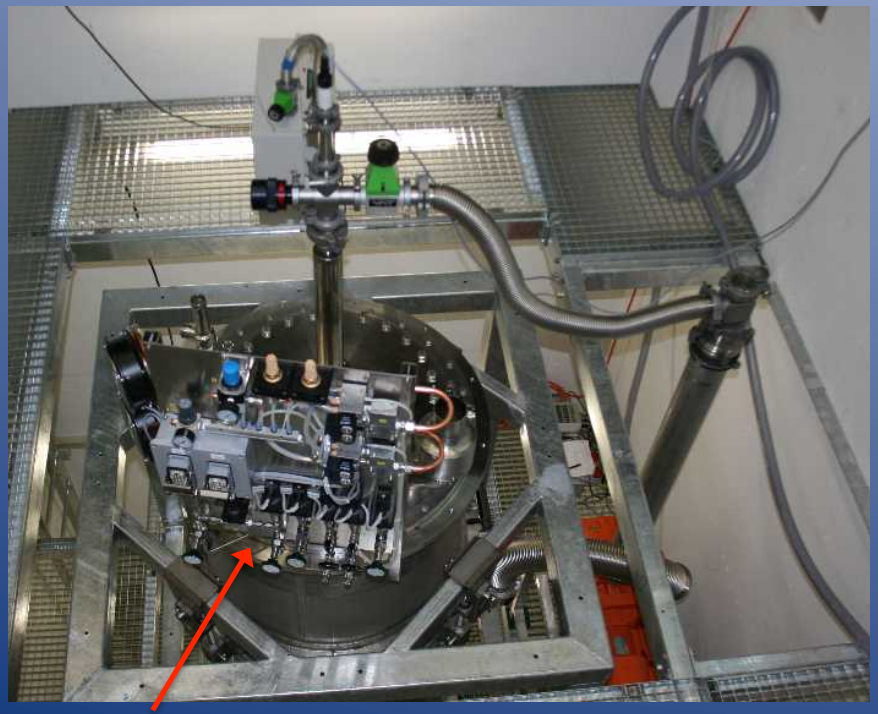
Installation of the inner vessel



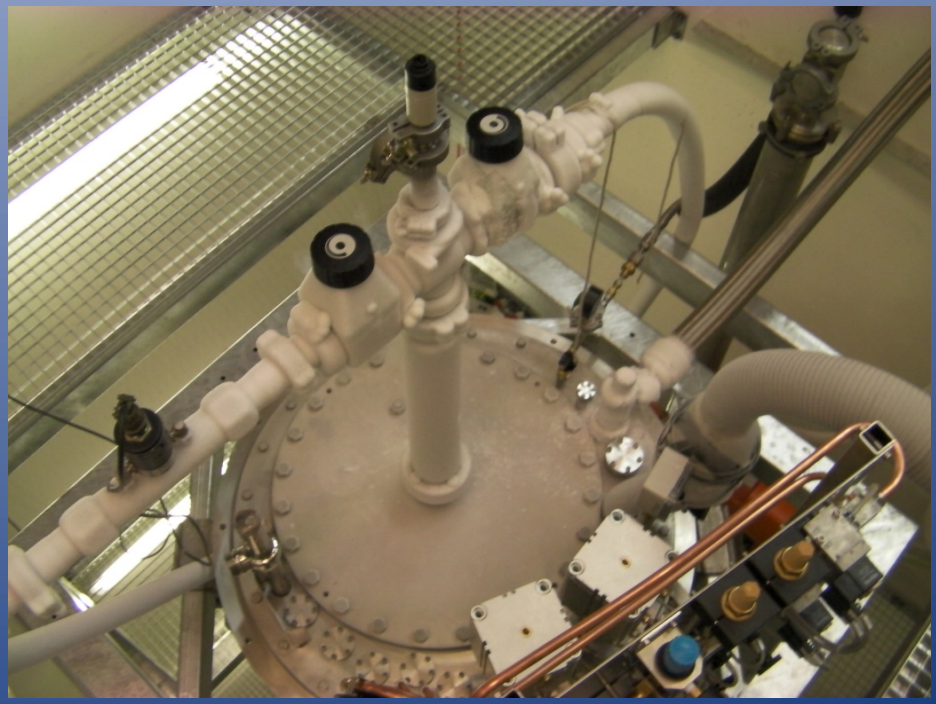
First vacuum and cold test

Vacuum
- rotational pumps
- 12 h of pumping
- vacuum: 7×10^{-5} mbar

Filling
- 6 h
- 2600 litres of Argon
- recirculation system tested at 100 litres/h

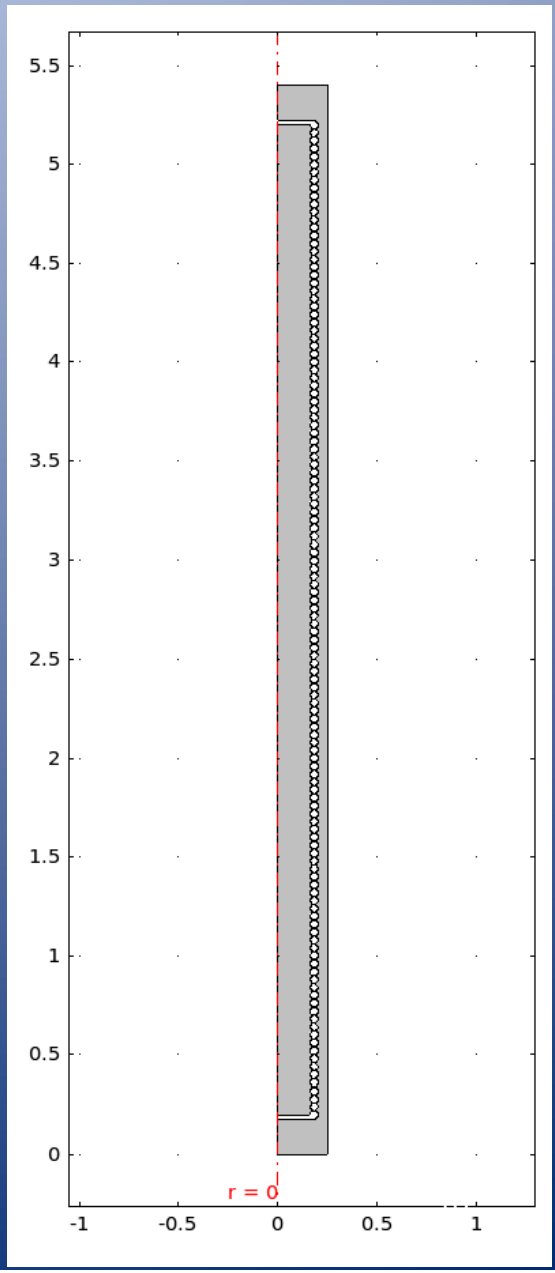


Panel where all the valves to control the recirculation circuit are mounted. Controls with a PLU accessible via Ethernet.



Electric field simulation (2d axis-symmetric)

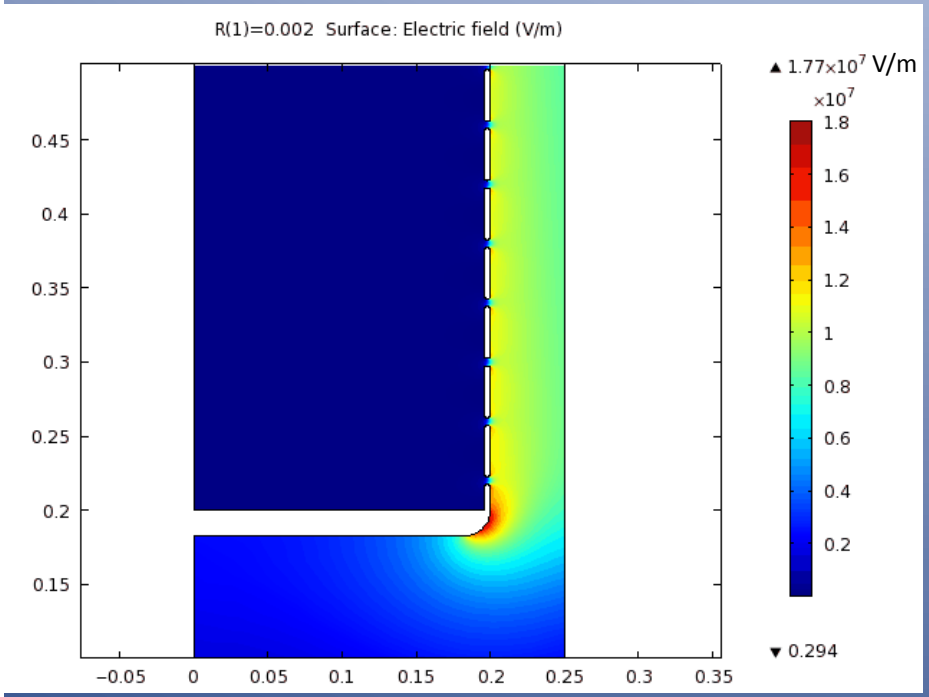
- COMSOL (Finite element analysis software)
- Outer diameter of field shaping rings : 400 mm
- Pitch distance between two rings: 40 mm
- Different thickness and forms of field shaping rings have been considered

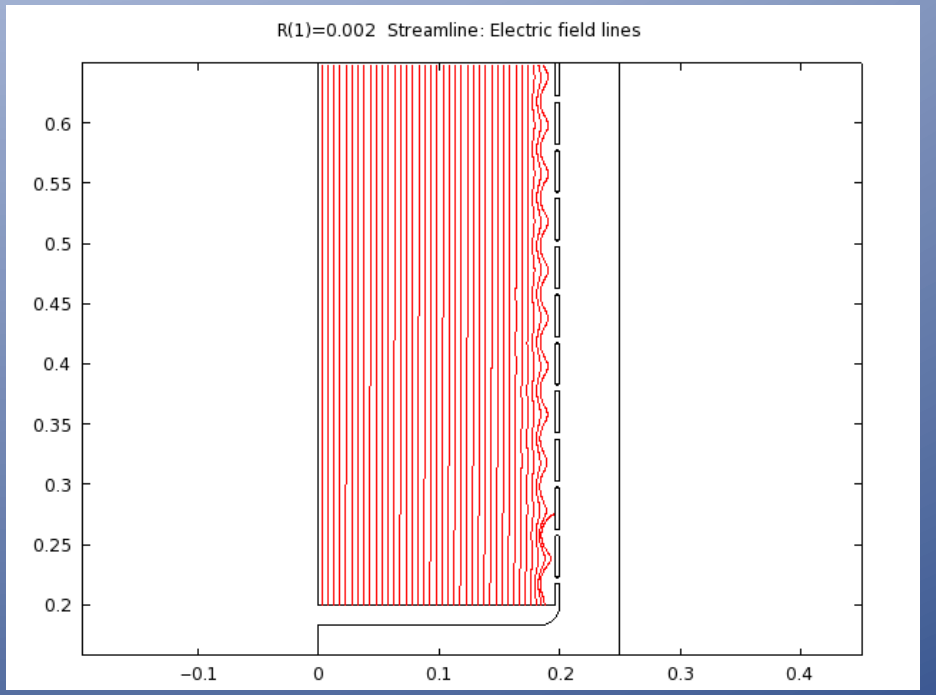


Electric field (V/m)

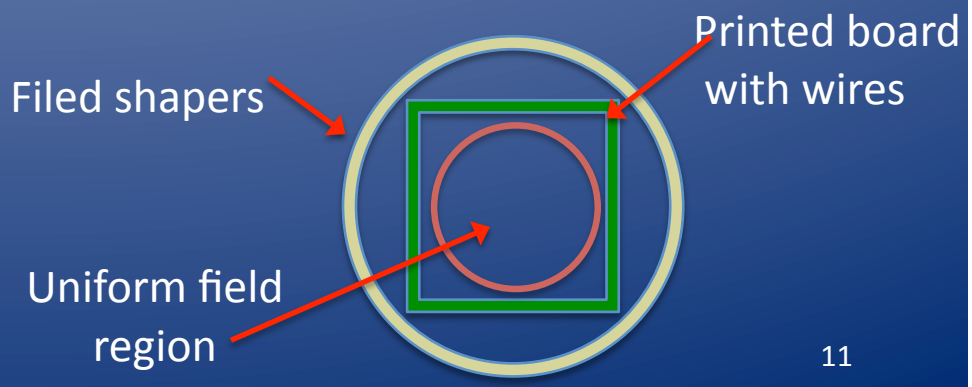
Breakdown voltage in LAr : 1.1-1.4 MV/cm ~10^8 V/m

The field is uniform at level of 10^{-3} in a cylindrical (h= 5m and diameter= 0.2 m) in the middle of the instrumented region





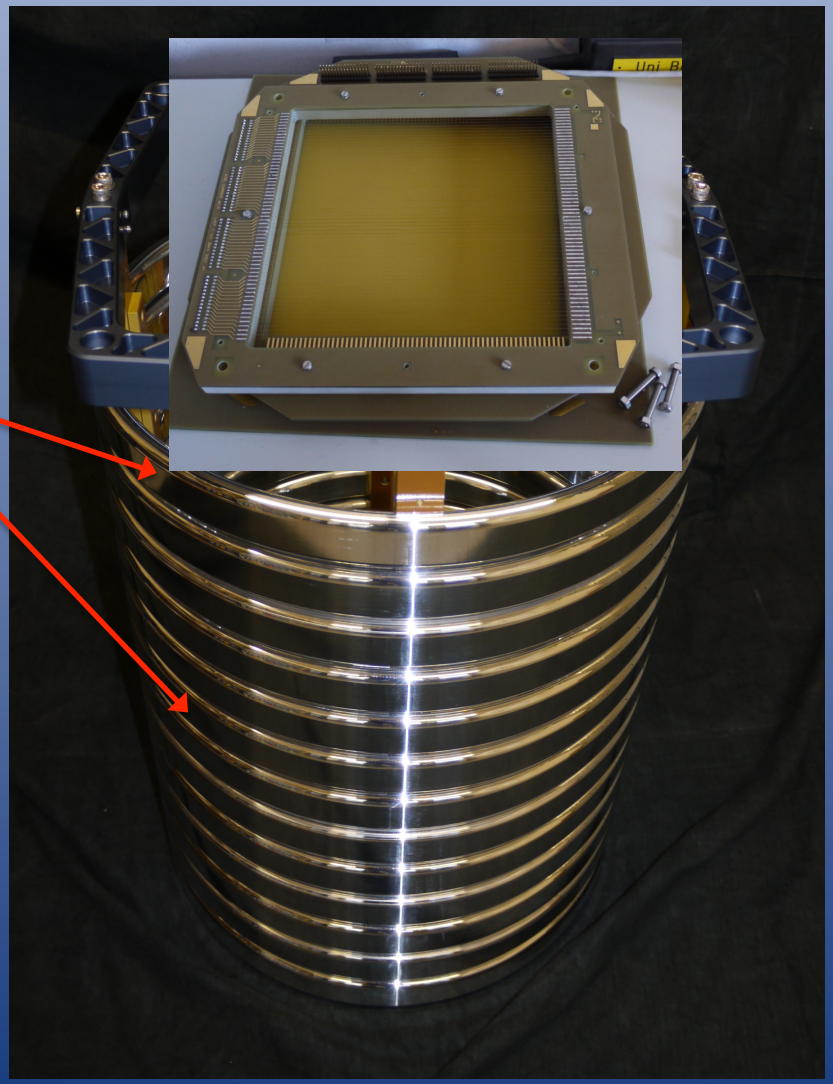
Maximum voltage is largely below the breakdown limit



ARGONTUBE detector

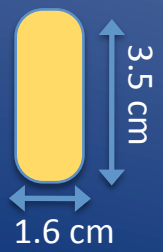
first 4 modules assembled

Gold plated aluminum field shapers.



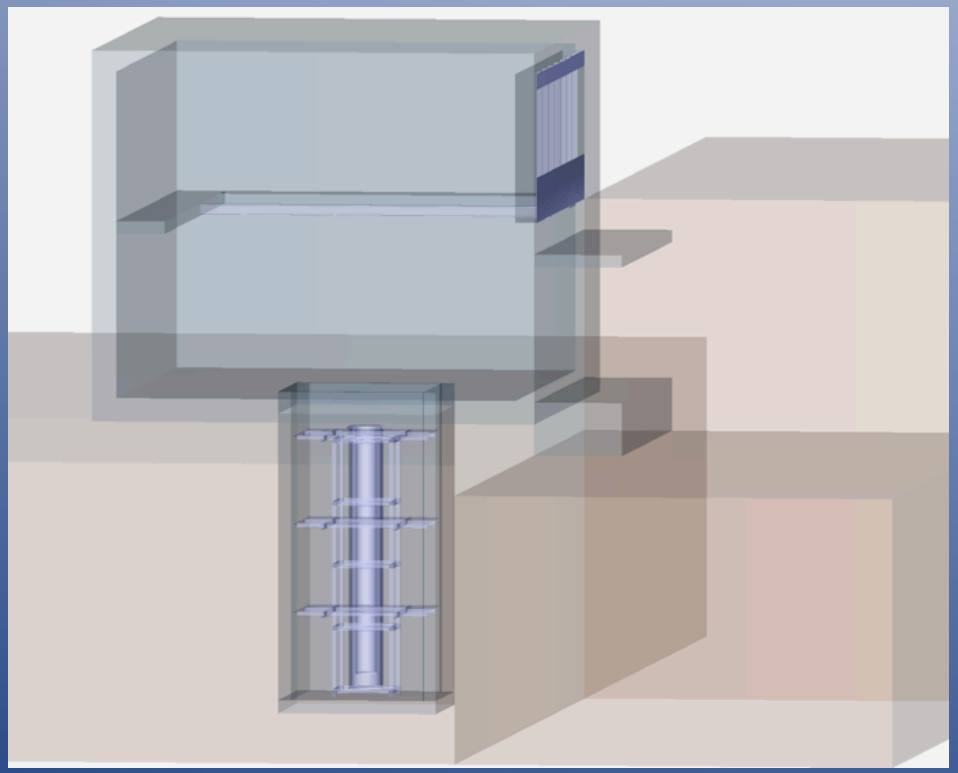
A standard wire chamber will be used as first read out option. New read out device with amplification capability will be tested in a second step.

Rings cross section:



Monte Carlo simulation

So far the geometry of the detector and the walls of the laboratory are described and a cosmic ray generator has been also implemented. Soon we will have also the digitization of the simulated signal.

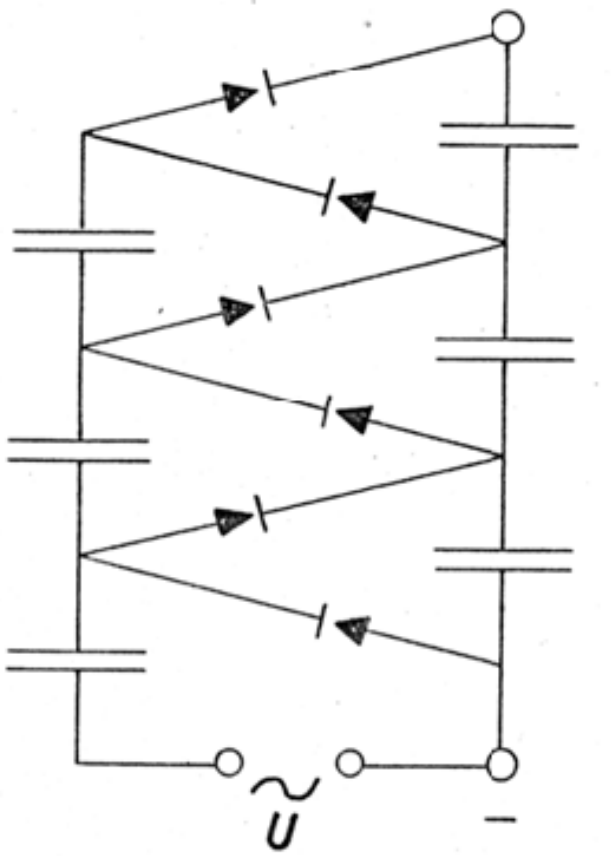


crossing muons in the instrumented volume : 120 events/s
stopping muons in the instrumented volume: 2 events/s

High voltage system

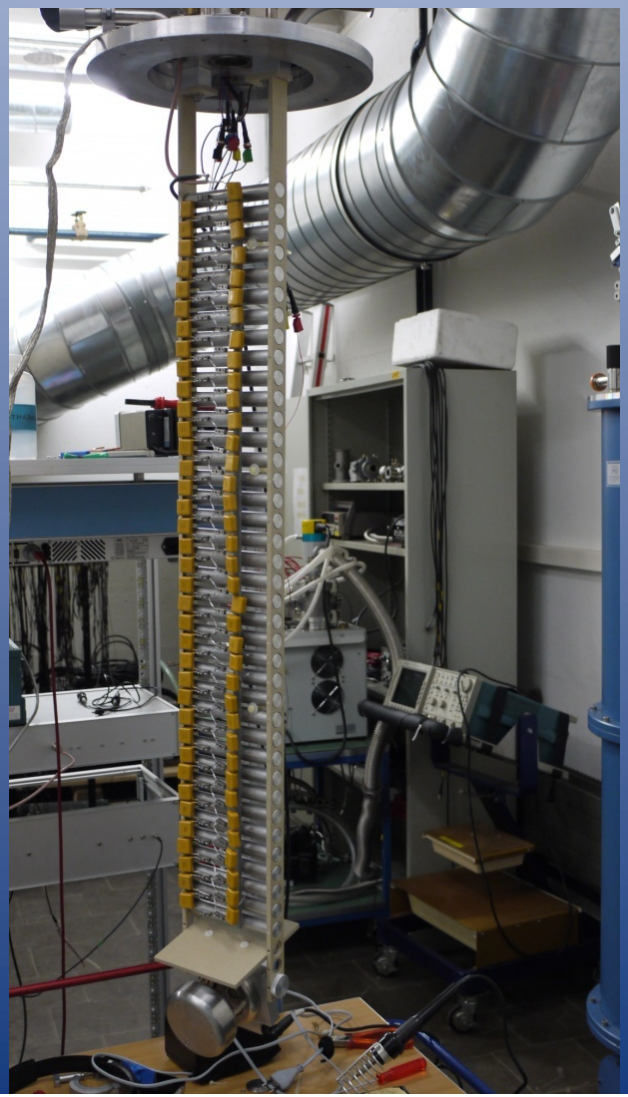
Greinacher/Cockcroft-Walton circuit: chain of rectifying cells installed in liquid

Schema of the circuit



In the ARGONTUBE project the number of stages will be 125

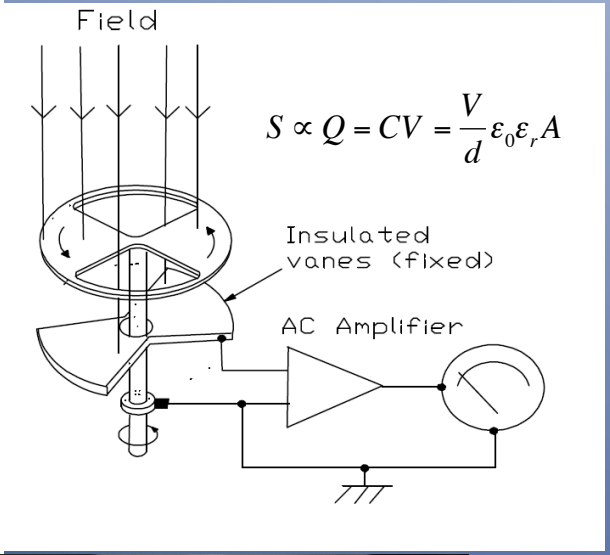
Test setup



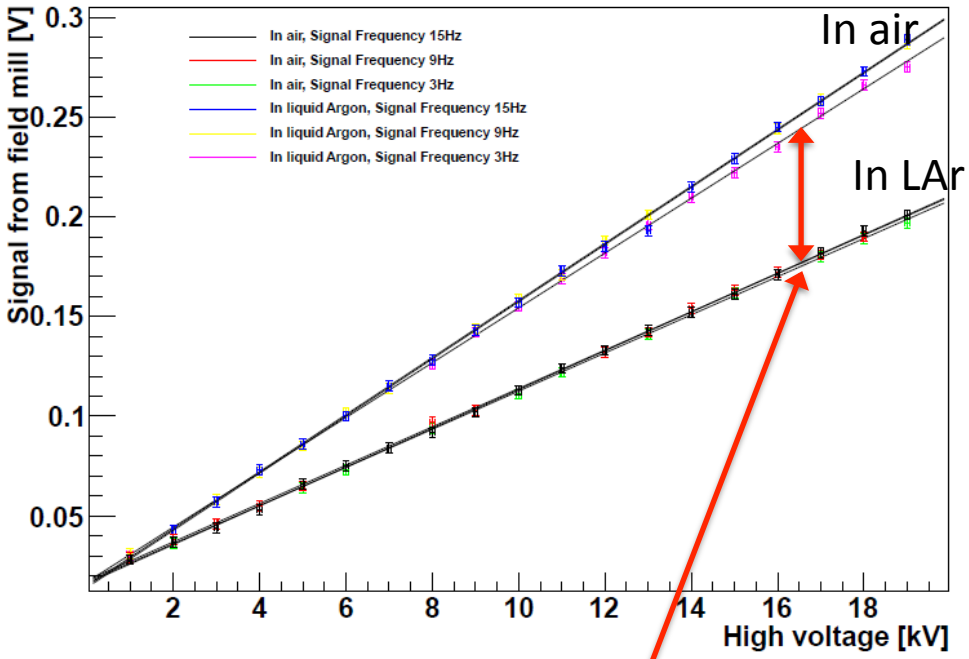
- 37 stages
- AC input voltage 4kV
- Tested in liquid Argon
- Field monitor at the bottom

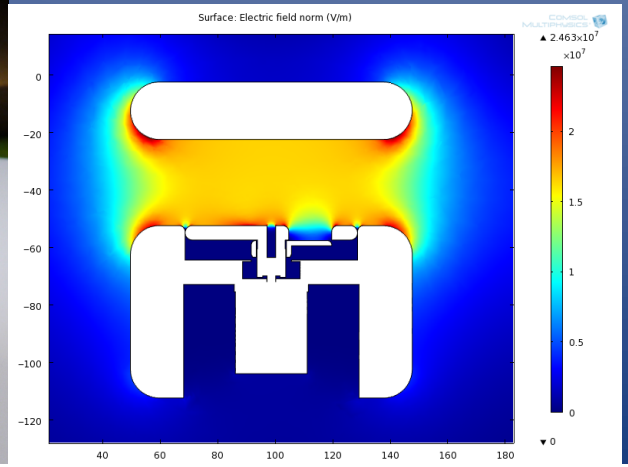
Field mill

Idea developed in collaboration with ETHZ and realized at the LHEP (University of Bern)



Calibration curves





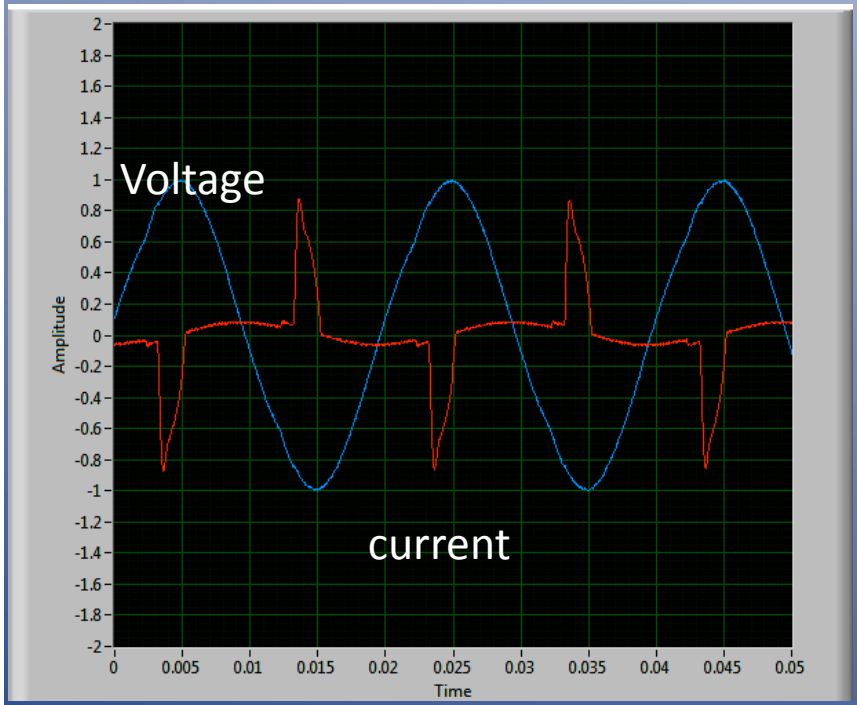
Dielectric constant of liquid argon

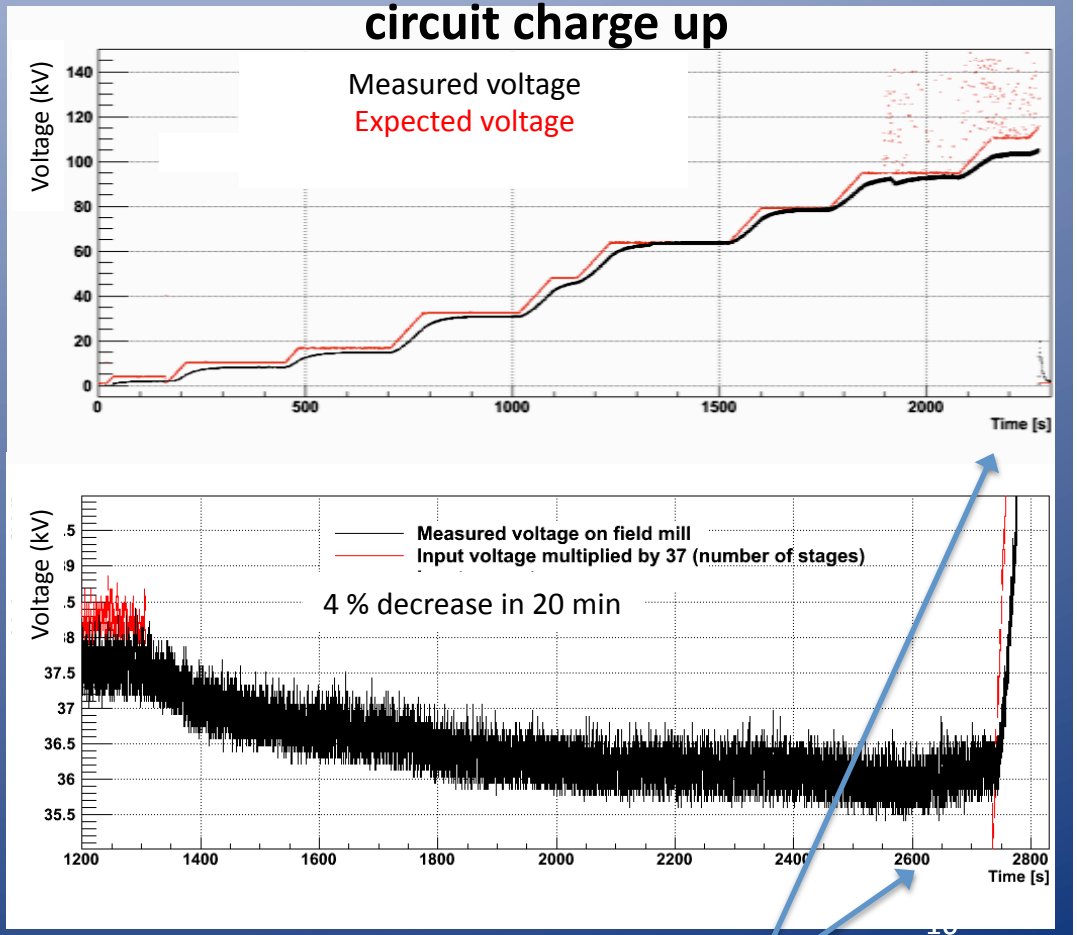
Literature :1.52

Measured :1.48±0.03

CHARGE up test

Monitoring of the injected signal



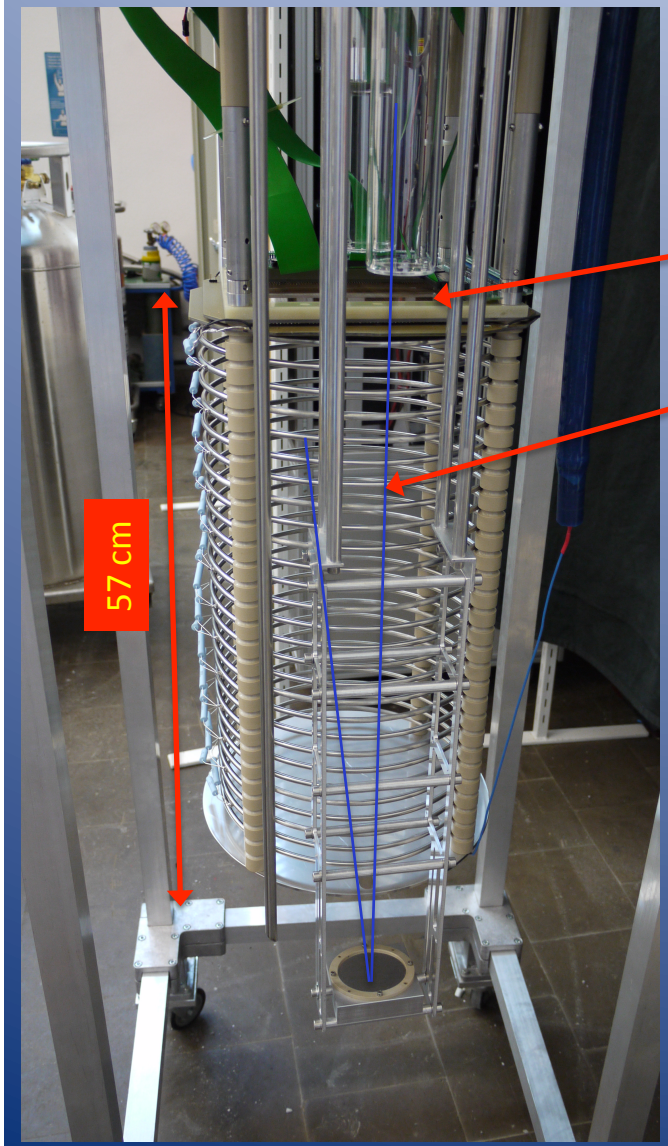


- Max Output : 4 kV peak to peak
- Frequency: 50 Hz
- Measuring system of output voltage and current

Charge up time scale

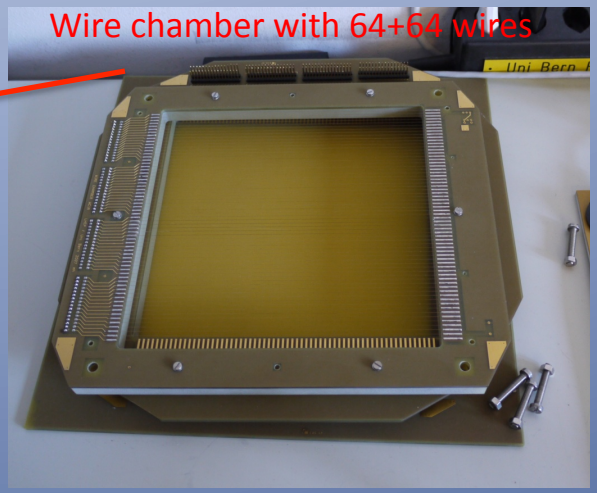
medium ARGONTUBE

a bench-test for the ARGONTUBE and even more[1,2]



Laser beam

Wire chamber with 64+64 wires



Then main issues studied with medium ARGONTUBE

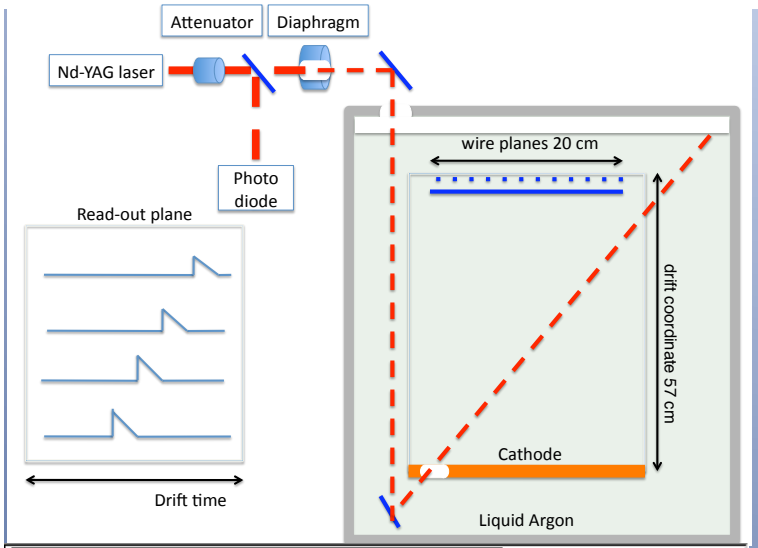
1. Purity monitor using a laser beam.
2. Recirculation system based on bellow pumps and TRIGON filters (twin system as the one for ARGONTUBE)
3. DAQ based on VME standard, fully developed at LHEP. Front-end pre-amplifiers, custom made in collaboration with CNRS (Lyon) and ETH (Zurich).

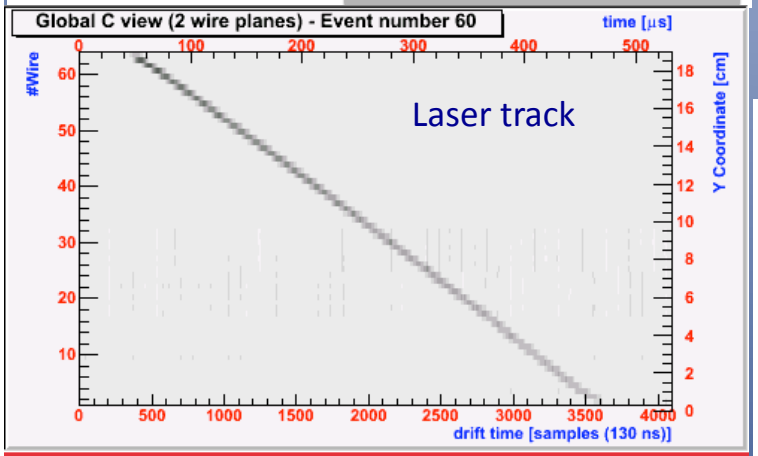
1. Measurement of the two-photon absorption cross-section of liquid argon with a time projection chamber. New J.Phys.12:113024,2010
2. A prototype of liquid Argon Time Projection Chamber for the study of UV laser multi-photonic ionization. JINST 4:P07011,2009.

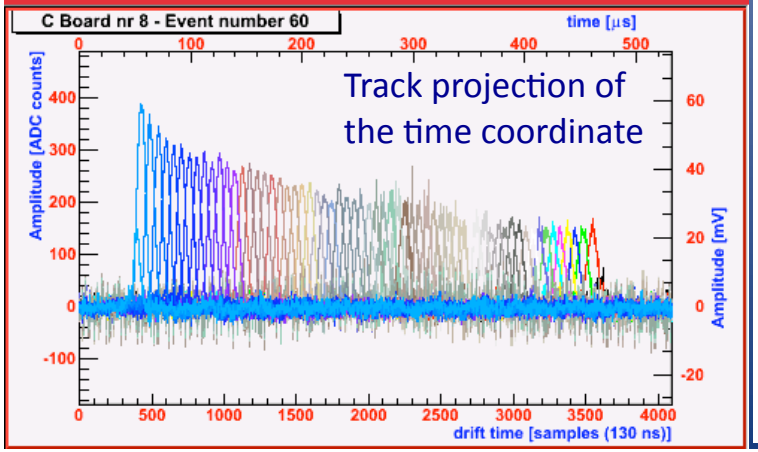
Laser beam

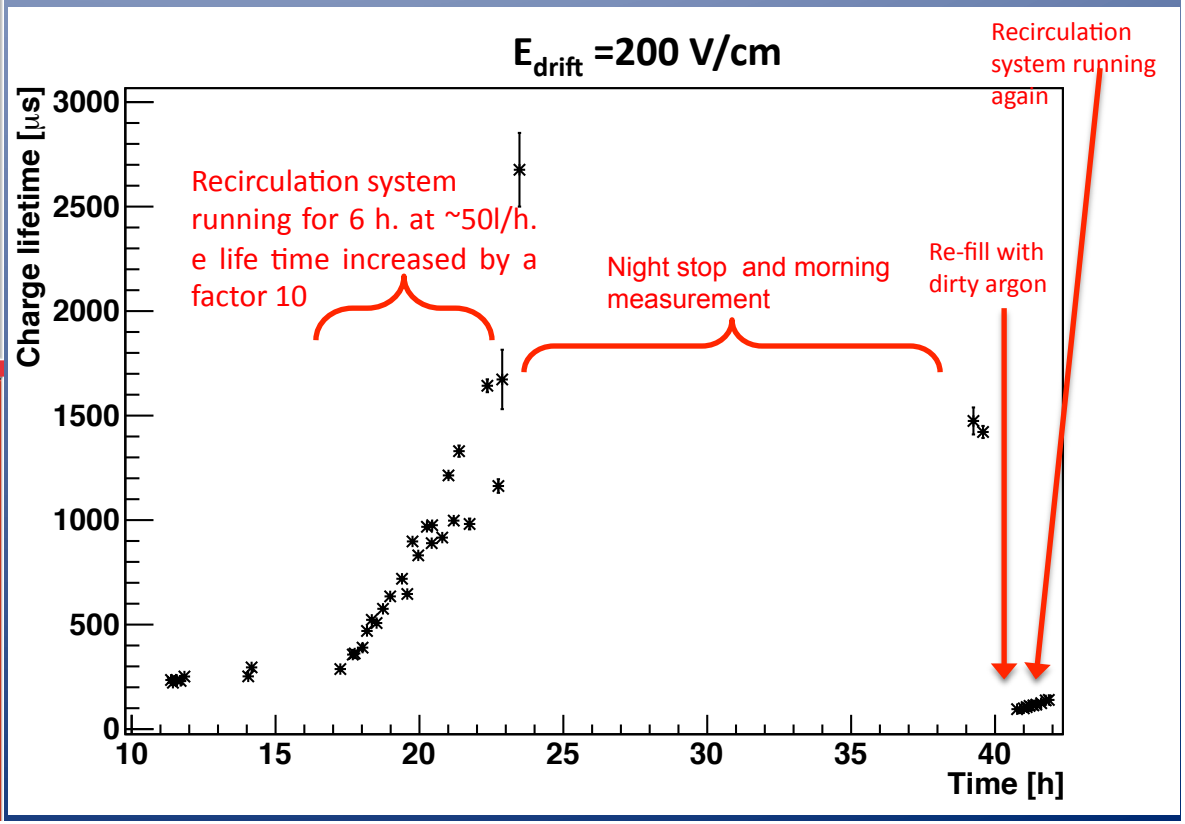
to monitor the purity of the LAr

Longest life time 2500 μs (~ 0.1 ppb) hitting the sensitivity limit of the detector. Longer life time can only be measured with the ARGONTUBE



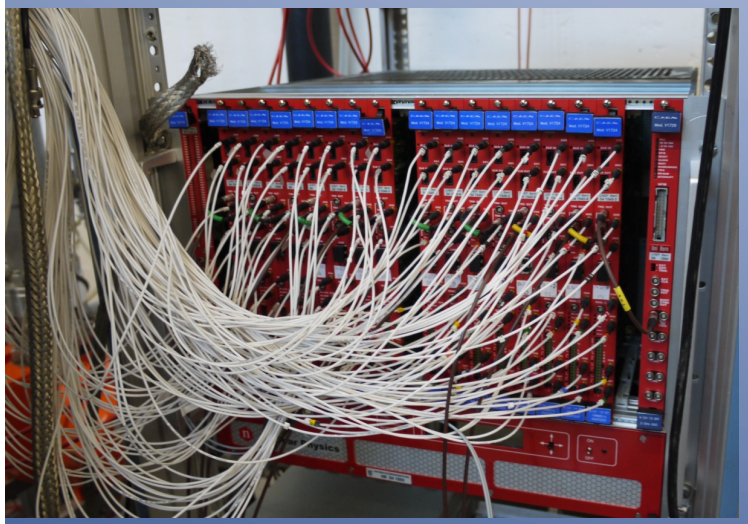






DAQ

Already tested on medium ARGONTUBE and ready to work for ARGONTUBE

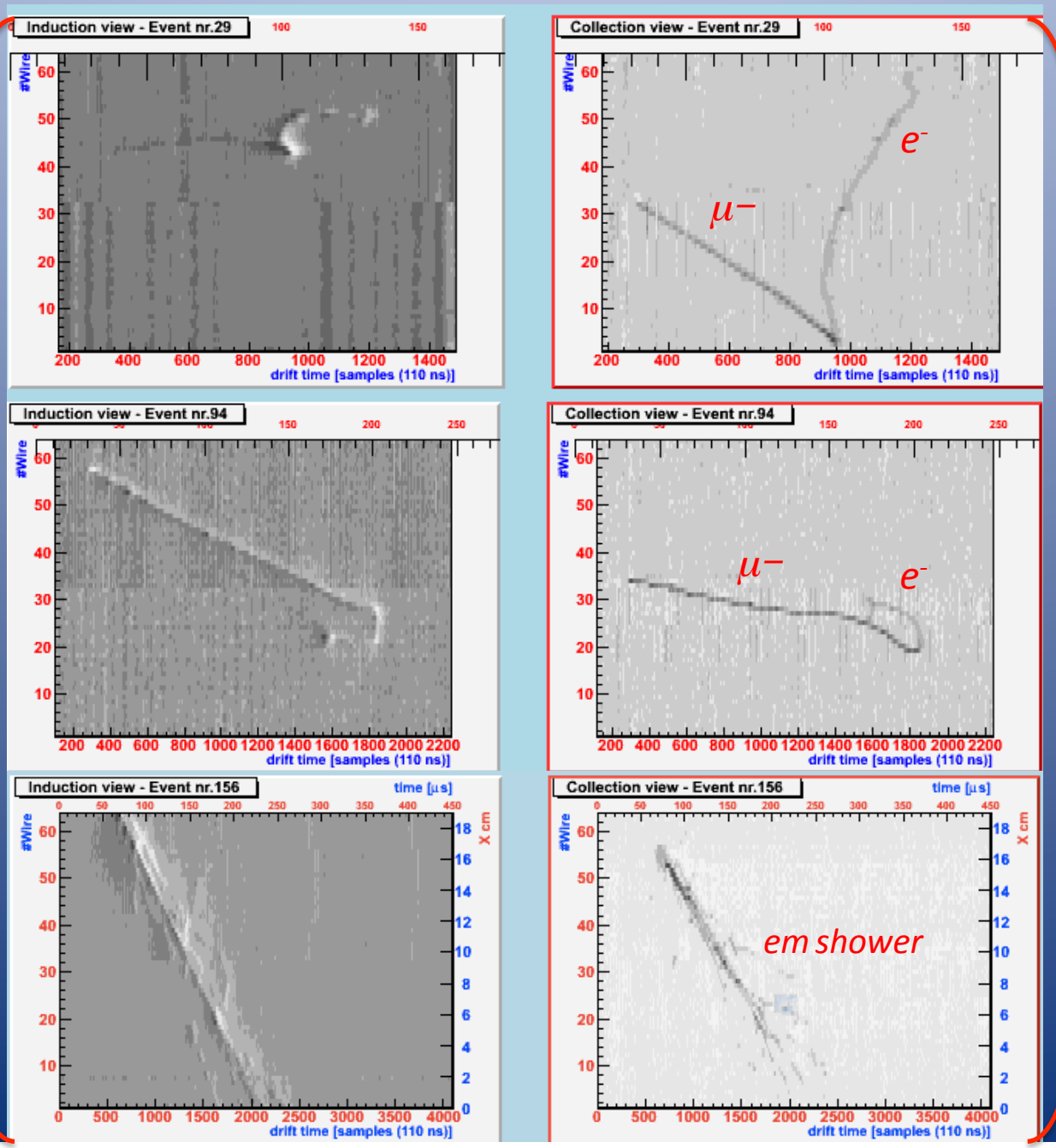


Sampling: 10 ns
DAQ window: 256kSamples/ch = 512kb/ch
Event Size = 512kb/ch * 128ch = 65MB/e

Sampling: 100 ns
DAQ window: 32kSamples/ch = 64kb/ch
Event Size = 64kb/ch * 128ch = 8MB/ev

- 1 Crate
- 16 ADC boards V1724 (CAEN) with 8 channel each and 128 channels overall
- 4MB memory per board
- VME controller V2718 (CAEN) with a max data flow 70MB/s (optical link)

Events gallery



Conclusions and outlook

- Dewar and inner vessel of the ARGONTUBE have been installed and tested.
- Vacuum and filling test was successful.
- Recirculation system for Argon purification is working,
  and electron life time on the scale of ms has been measured with the medium ARGONTUBE.
- The maximum voltage reached so far is 110 kV.
- DAQ and event display is working stably.
- TPC with 5 m drift distance is under construction and 4 modules have already been assembled

Next steps:

- Complete the construction of the TPC
- High voltage test in ARGONTUBE (200-500 kV) in the most favourable conditions.
- Detect a muon track as long as 5m