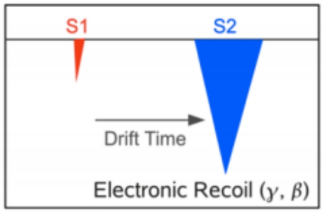
Updates on XeLab project

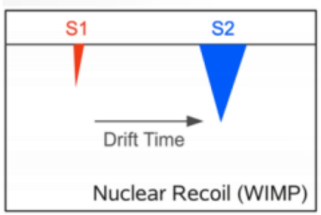
a R&D platform of Xe double phase TPC

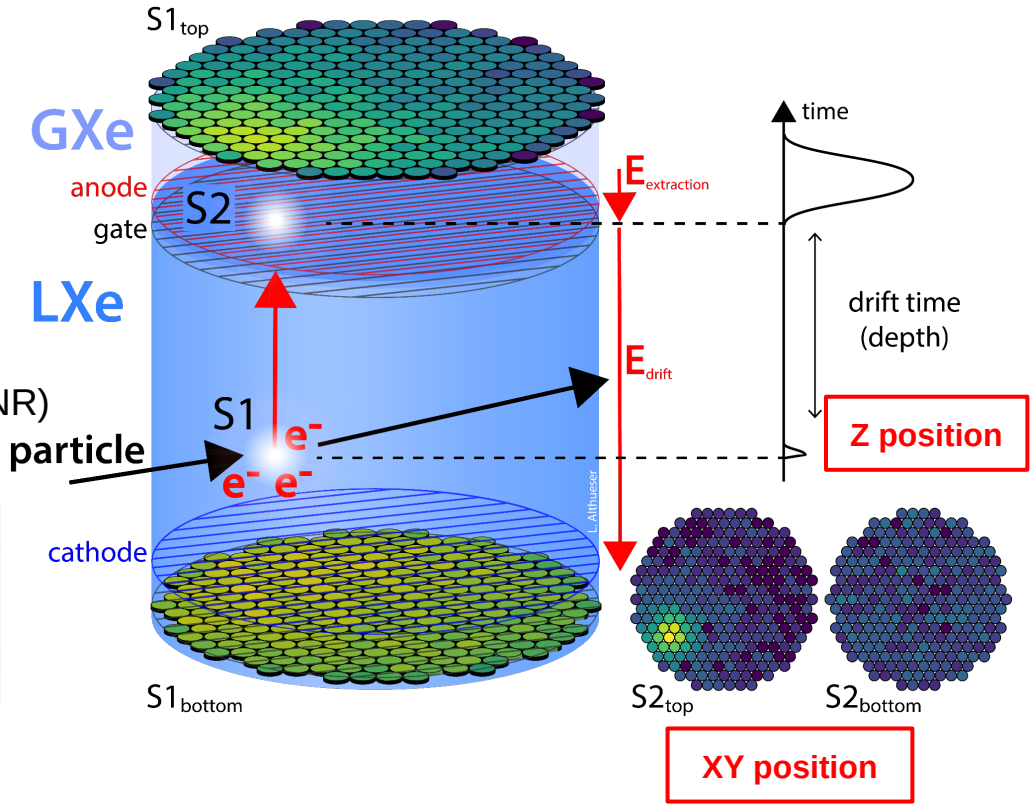
presented by Yongyu Pan – LPNHE
on behalf of the whole XeLab team (LPNHE, Subatech)

Dual phase time projection chamber (TPC)

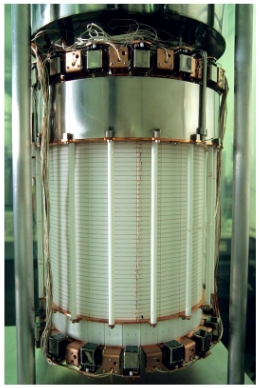
- S1: Prompt scintillation light
- S2: Secondary scintillation light induced by ionized electrons
- Position reconstruction: drift time + PMT pattern
- Using S2/S1 to discriminate electronic recoil (ER) and nuclear recoil (NR)

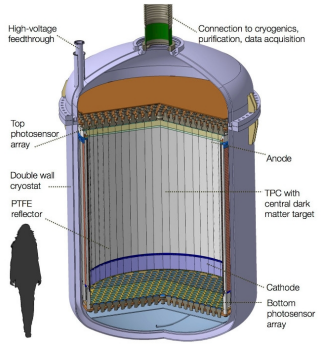






XENON evolution

	XENON10	XENON100	XENON1T	XENONnT	DARWIN
Operation period	2005-2007	2008-2016	2012-2019	2020-2026	2030
Xenon mass	14 kg Xe target	62 kg Xe target	2 t Xe target	5.9 t active Xe 8.5 t total Xe	~40 t active Xe ~50 t total Xe
Height **Diameter**	15 cm 20 cm	30 cm 30 cm	96 cm 97 cm	148 cm 133 cm	~2.6 m ~2.6 m

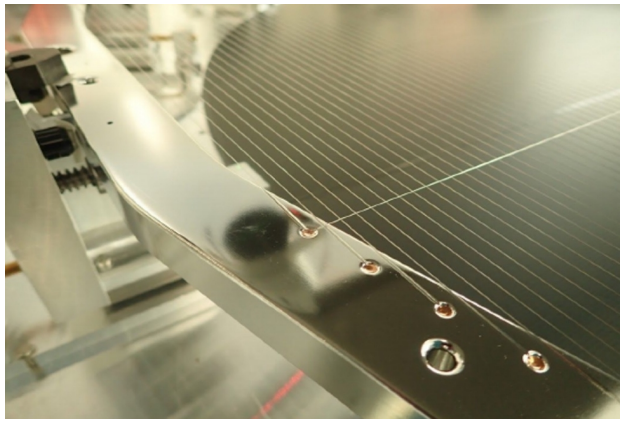
Motivation of XeLab project

Problems in XENONnT:

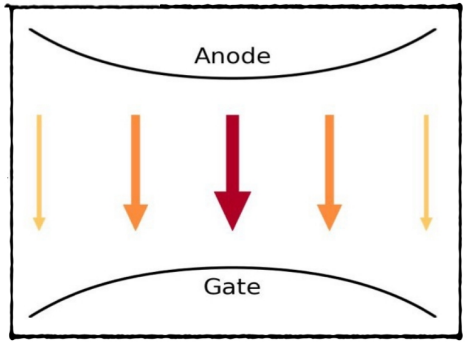
Guarantee the transparency of the electrodes ⇒ parallel wires

⇒ **Sagging (electrostatic force + gravity)** ⇒ perpendicular wires on the electrodes (Anode & gate)

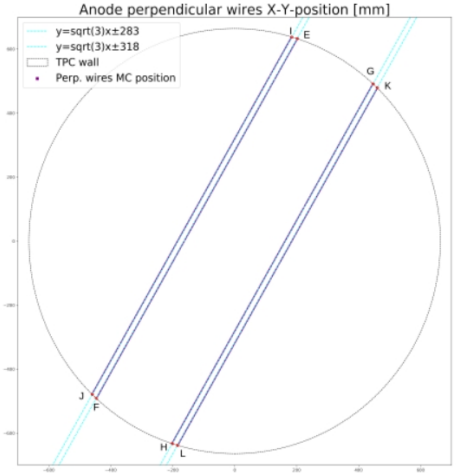
- **non-uniform detector response**
- **micro electric discharges (hot-spots)**



Parallel wires



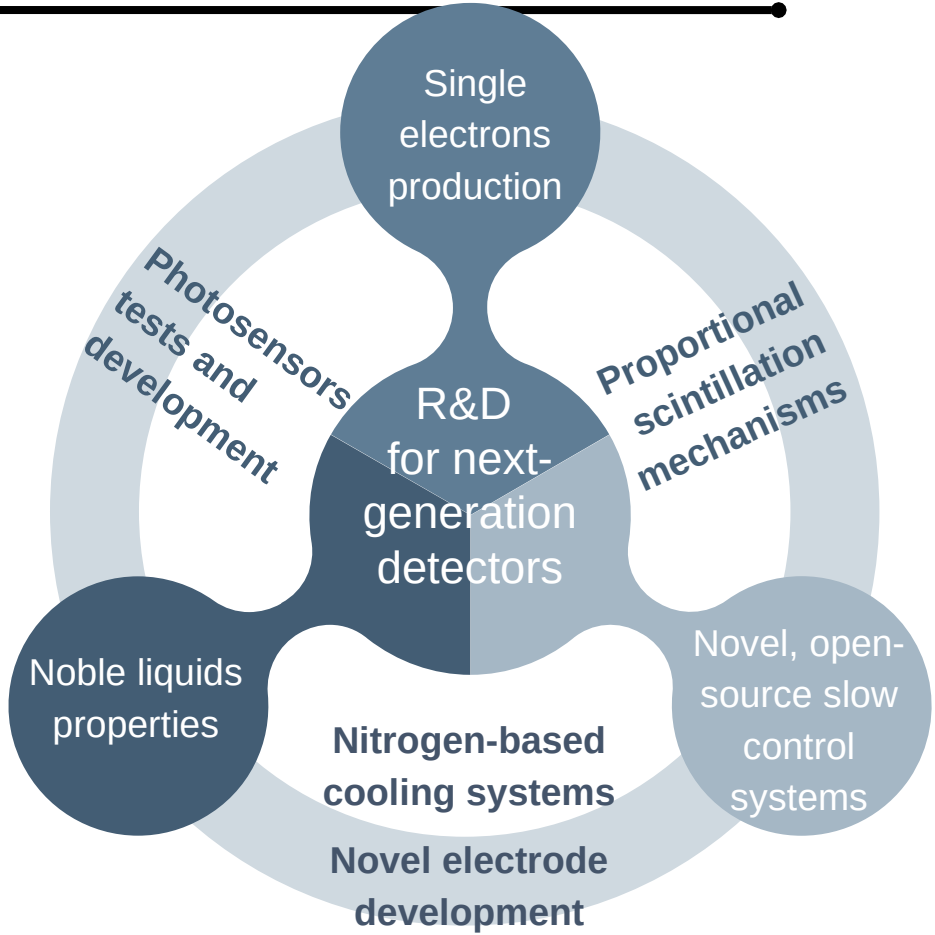
Sagging effect



Perpendicular wires

XeLab, R&D meant for DARWIN

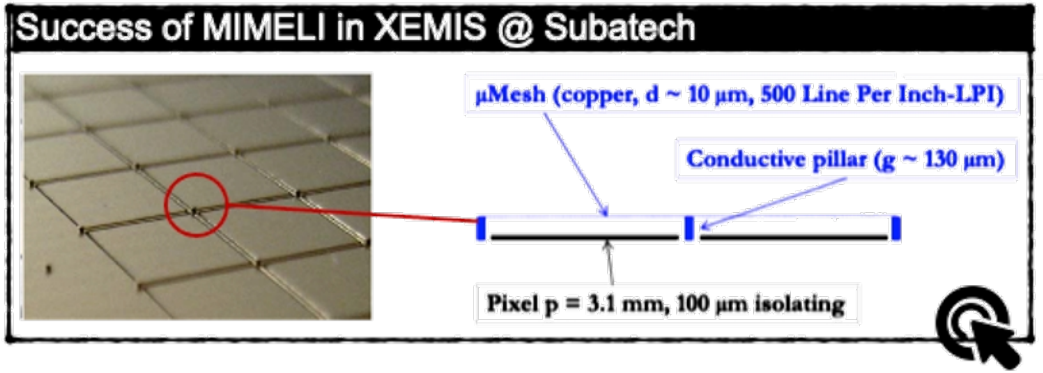
- First site in France working with a Xe dual-phase TPC
- Funded by IN2P3 with local support by LPNHE and Subatech



Novel electrodes

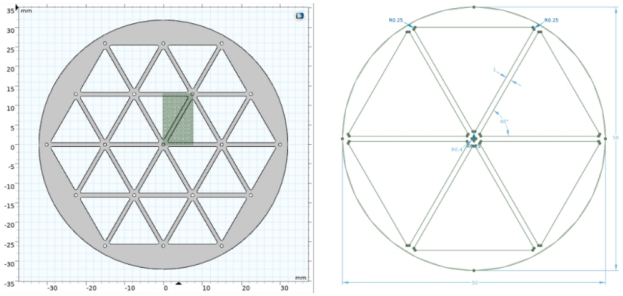
Advantages:

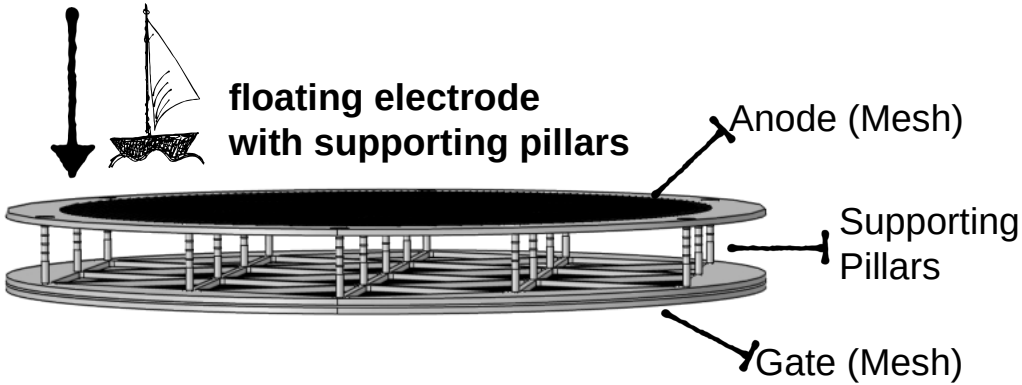
Minimize mechanical distortion
- → possibility of reducing the gate ↔ anode distance (E_{ext} ↑)
- → better S2 resolution
- → More uniform signal response over x, y



Challenges:

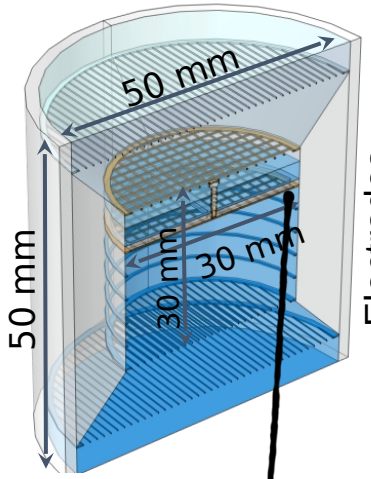
Optical transparency might be reduced (mesh pattern)



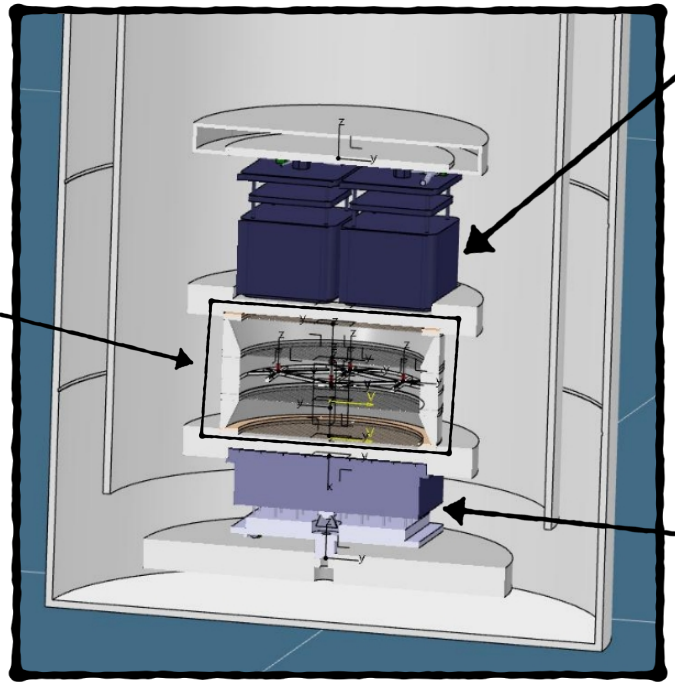


TPC under development

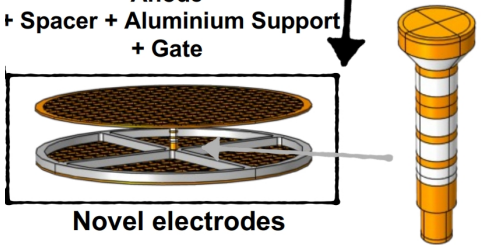
TPC prototype to test the performance of novel electrode with supporting pillar



Electrodes



Anode
+ Spacer + Aluminium Support
+ Gate



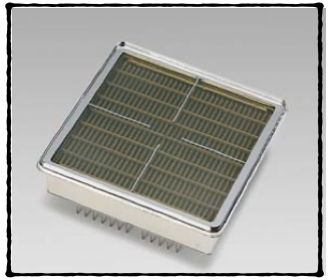
Novel electrodes

Top PMTs array

×4

Hamamatsu R8520-406
Effective area: 20.5 x 20.5 mm

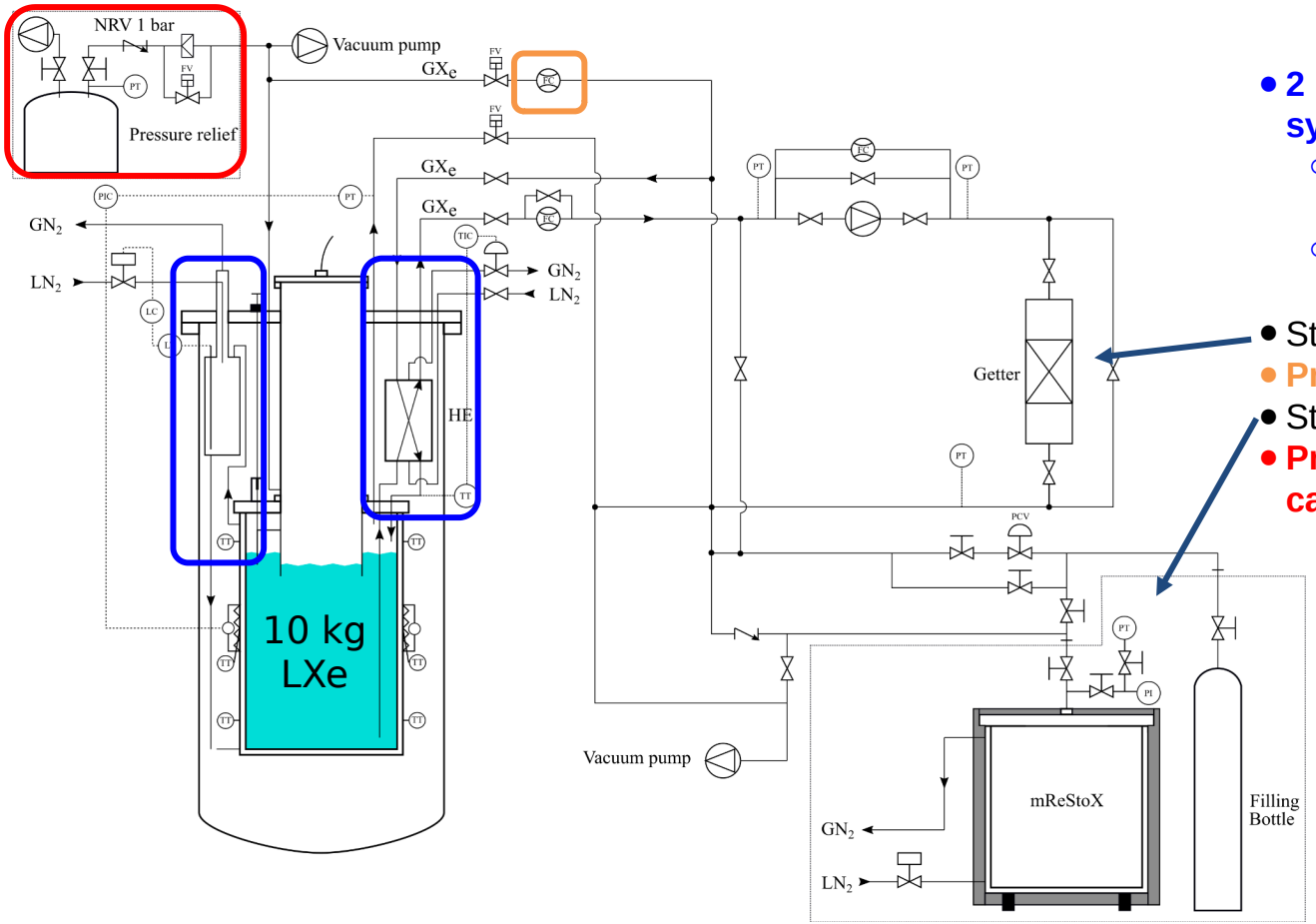
Bottom PMT



×1

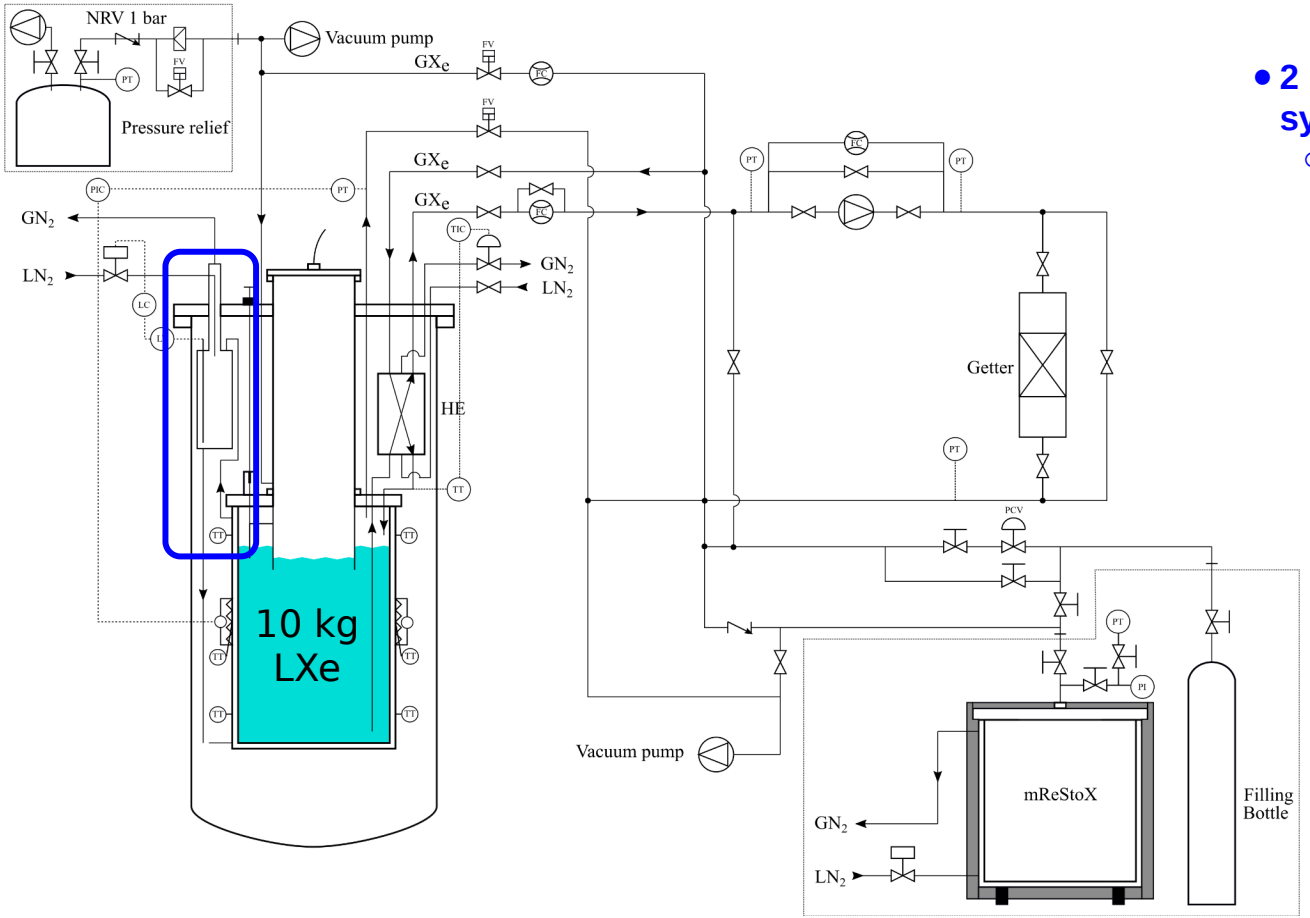
Hamamatsu R12699-406-M4
2 x 2 multianode
Effective area: 48.5 x 48.5 mm

Process & Instrumentation Diagram (P&ID)

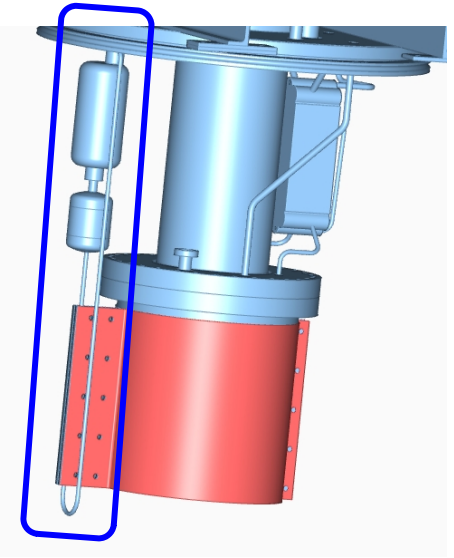


- **2 nitrogen-based cooling systems**
  - **cold copper belt around inner cryostat**
  - **three-phase heat exchanger**
- Standard purification
- **Precise liquid level tuning**
- Storage and recovery system
- **Pressure release system in case of accident**

Process & Instrumentation Diagram (P&ID)



- 2 nitrogen-based cooling systems
  - cold copper belt around inner cryostat



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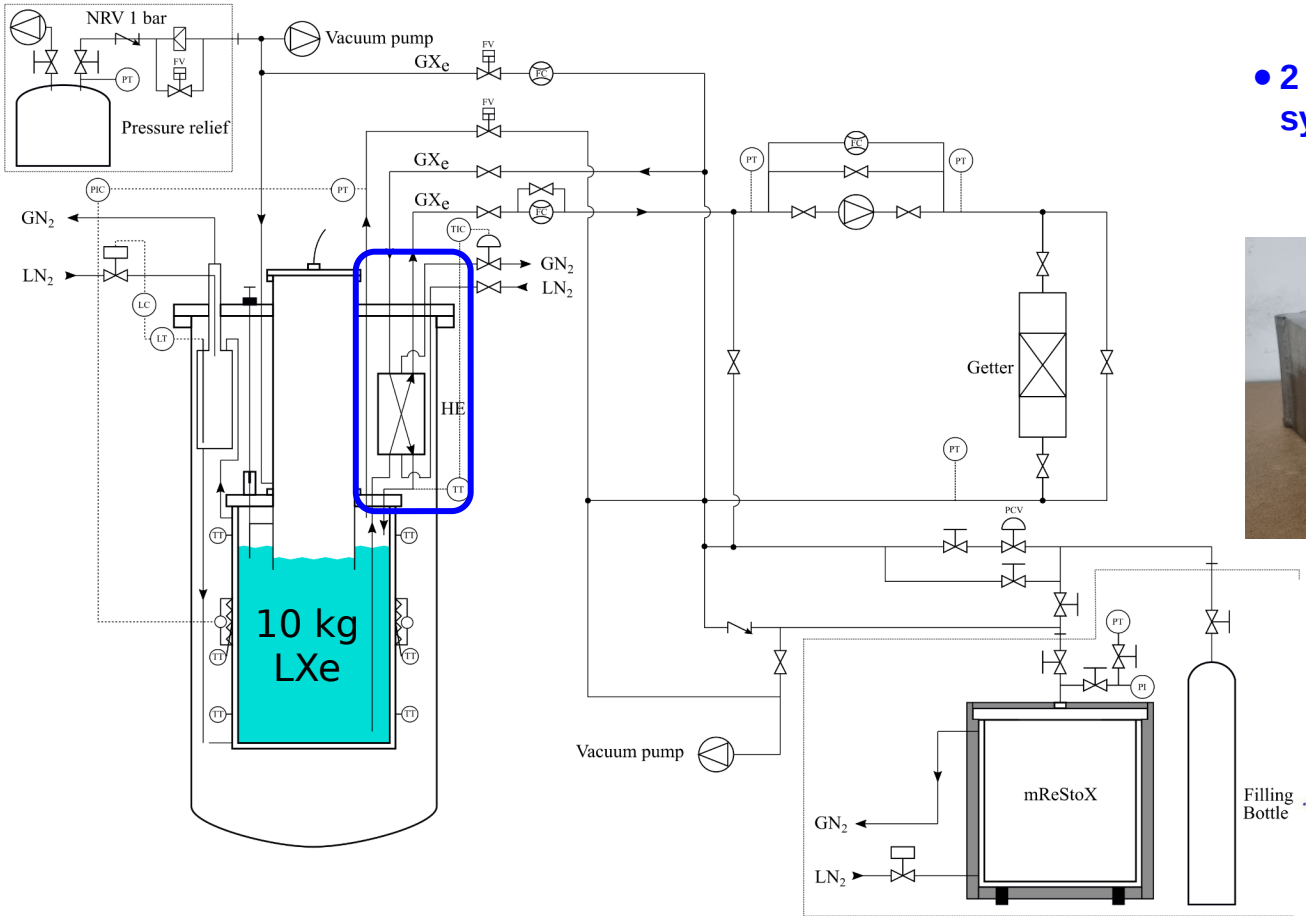
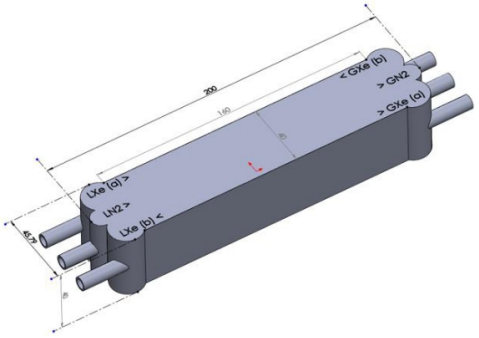


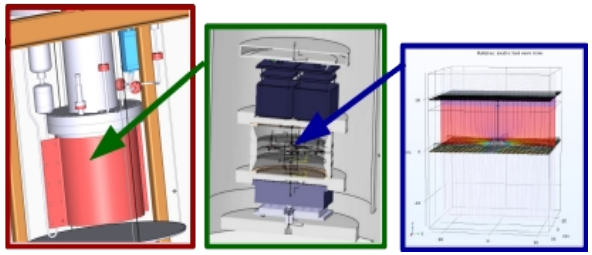
- 2 nitrogen-based cooling systems
  - three-phase heat exchanger



Installation in LPNHE

Dedicated direct line with a 15k liters **nitrogen** reservoir from Sorbonne, Jussieu

Xenon purification circuit and the "manifold" network
(Designed by LPNHE and constructed by DATE company)



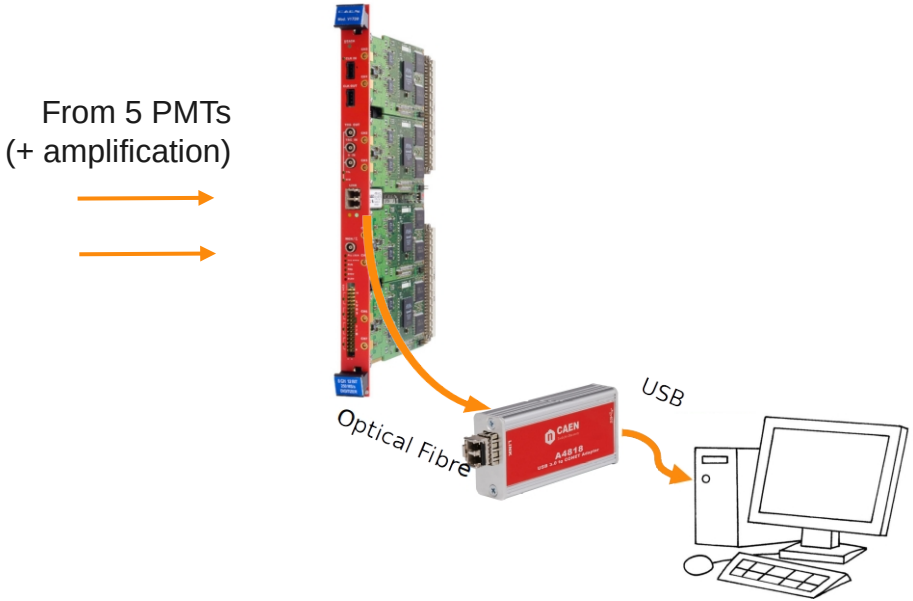
TPC designed by Subatech

@Campus Jussieu, LPNHE,
Salle 12-13-SS03

Data Acquisition System (DAQ)

Hardwares:

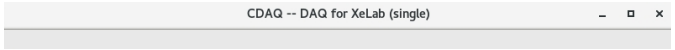
- ADCs: CAEN **v1720**, v1724, v1730 (up to 8 modules per optical link in daisy chain)
  - 8 channels
  - Dynamic range: 2.0 Vpp
  - Resolution: 12-bit
  - Sampling rate: 250 MS/s
- Optical links: CAEN a2818, a3818, **a4818** (CONET-to-USB)

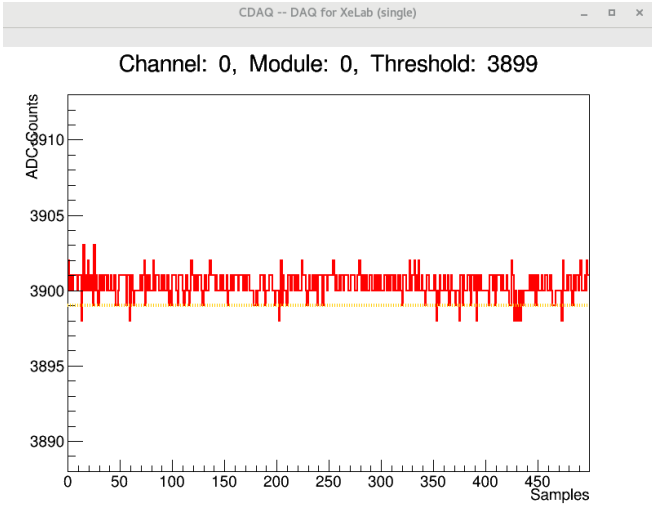


Data Acquisition System (DAQ)

Readout software:

- Based on XenoDAQ (Zurich) https://github.com/Physik-Institut-UZH/XenoDAQ/
- Compatible with CAEN devices
- Graphical interface
- Zero Length Encoding
- Saves data in ROOT, .txt or binary
- Status: Implementation of a4818 communications + bug hunting





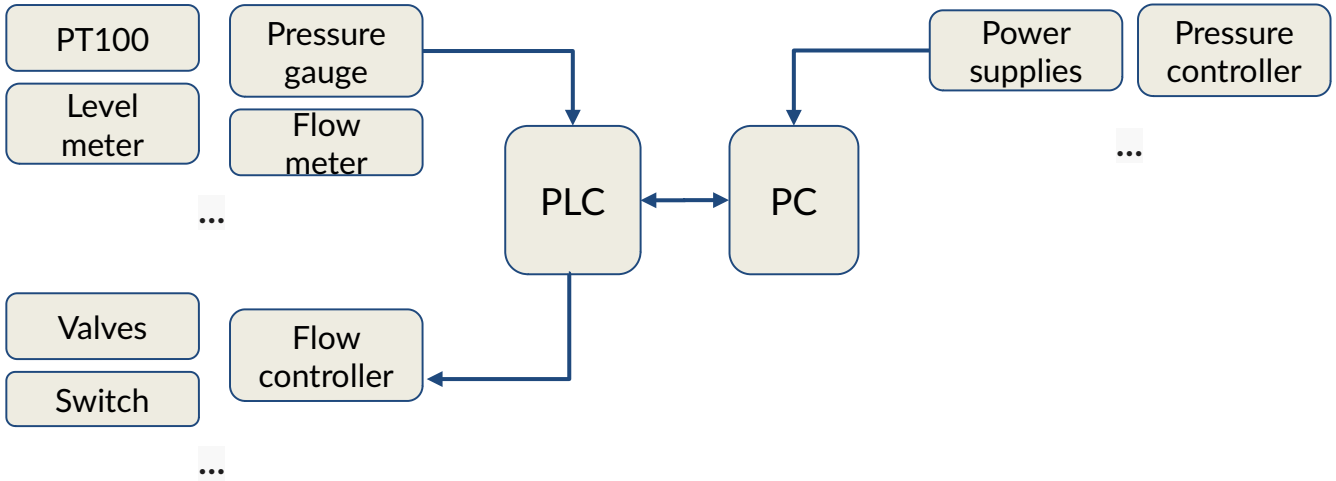
Slow control

Goal 1: **Insure safety of people and Xenon**

--> solution: use hardware solution and a PLC (Programmable logic controller) to check the critical sensors and valves automatically (e.g. input of LN_2)

Goal 2: **Follow and understand the behavior of system**

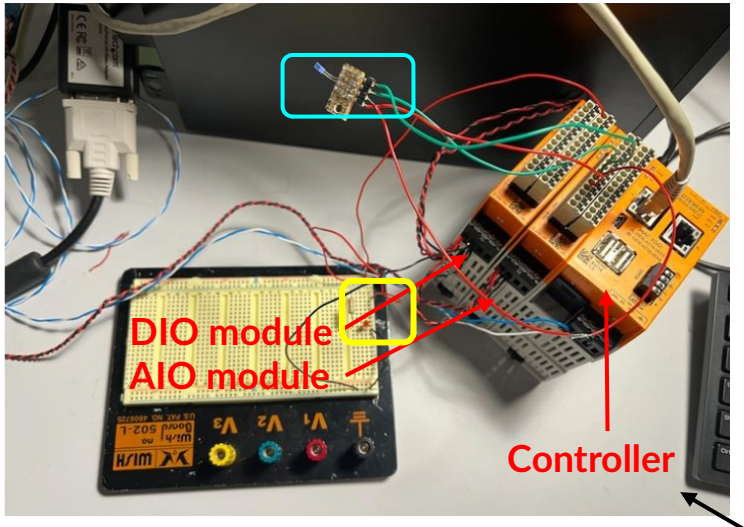
--> solution: monitoring software (database, display, alarms etc) can integrate other instrumentation (temperature sensors, power supplies, pressure monitor, disk space etc)



Slow control

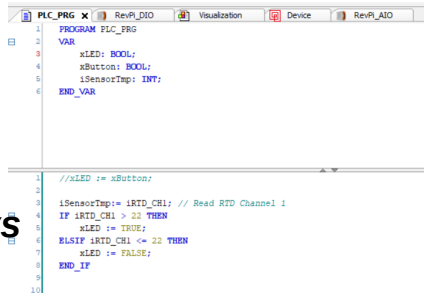
Programmable logic controller (PLC)

— ***Revolution Pi*** (Raspberry Pi based open source tools)



- Access remotely through PC connected to lab
- Test using PT1000 (to RTD of AIO) and LED (to output of DIO) and electric current generator (to mimic the output of pressure gauge)

Control logic programmed by ***Codesys***



Slow control

Monitoring software — ***Astro-slow-control*** https://bitbucket.org/jnikkel/astro-slow-control/src/master/

a sensor ⟷ an exe. file

- Run every few seconds, collect the requested information or sets values
- Examples provided for plenty of hardwares

- Parameter settings

Ch0 On/Off of CAEN HV module
Current value: On

Off On

Ch0 Vset of CAEN HV module
Current value: 5.000 (V)

New Value: 5.000 (V)

- Parameter monitoring

Last db update: May 03, 2023 @ 15:12:00.

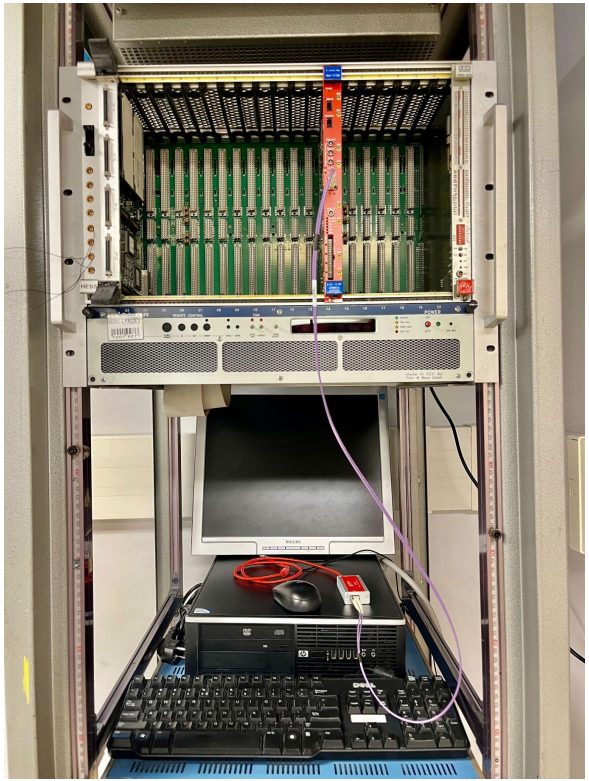
Ch0 Imon of CAEN HV module (HV_elec_CH0_IMon)
0
(A)

Ch0 Vmon of CAEN HV module (HV_elec_CH0_VMon)
4.500
(V)

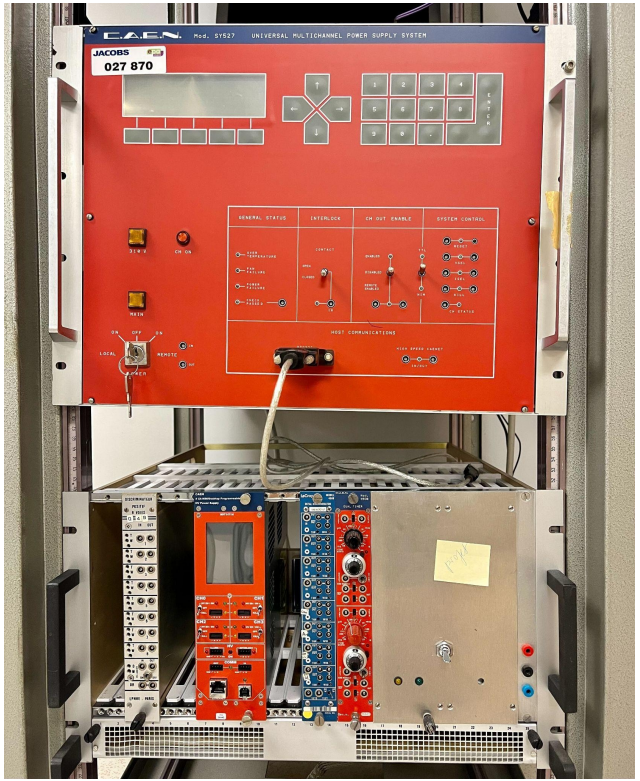
- Other functions

Plots MPlot Scatter Sys Log Runs Users Alarms Config Control LogBook Cams

Current hardware setups



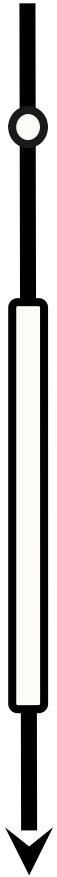
DAQ system



High voltage supply for PMTs

High voltage supply for electrodes

Next steps



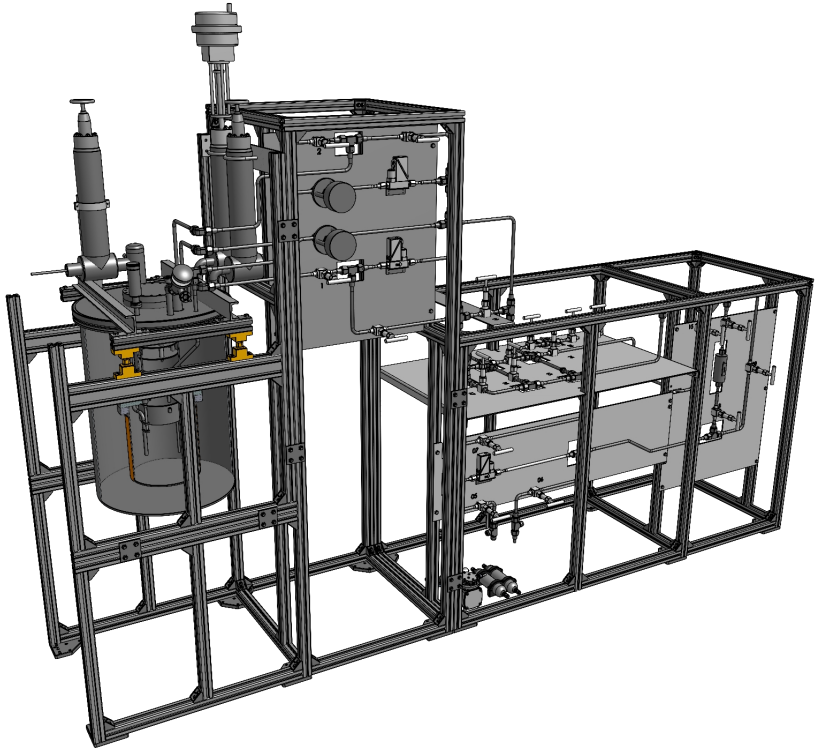
July 2023

- Installation of the entire cryogenic system
- Installation of mReStoX

September 2023

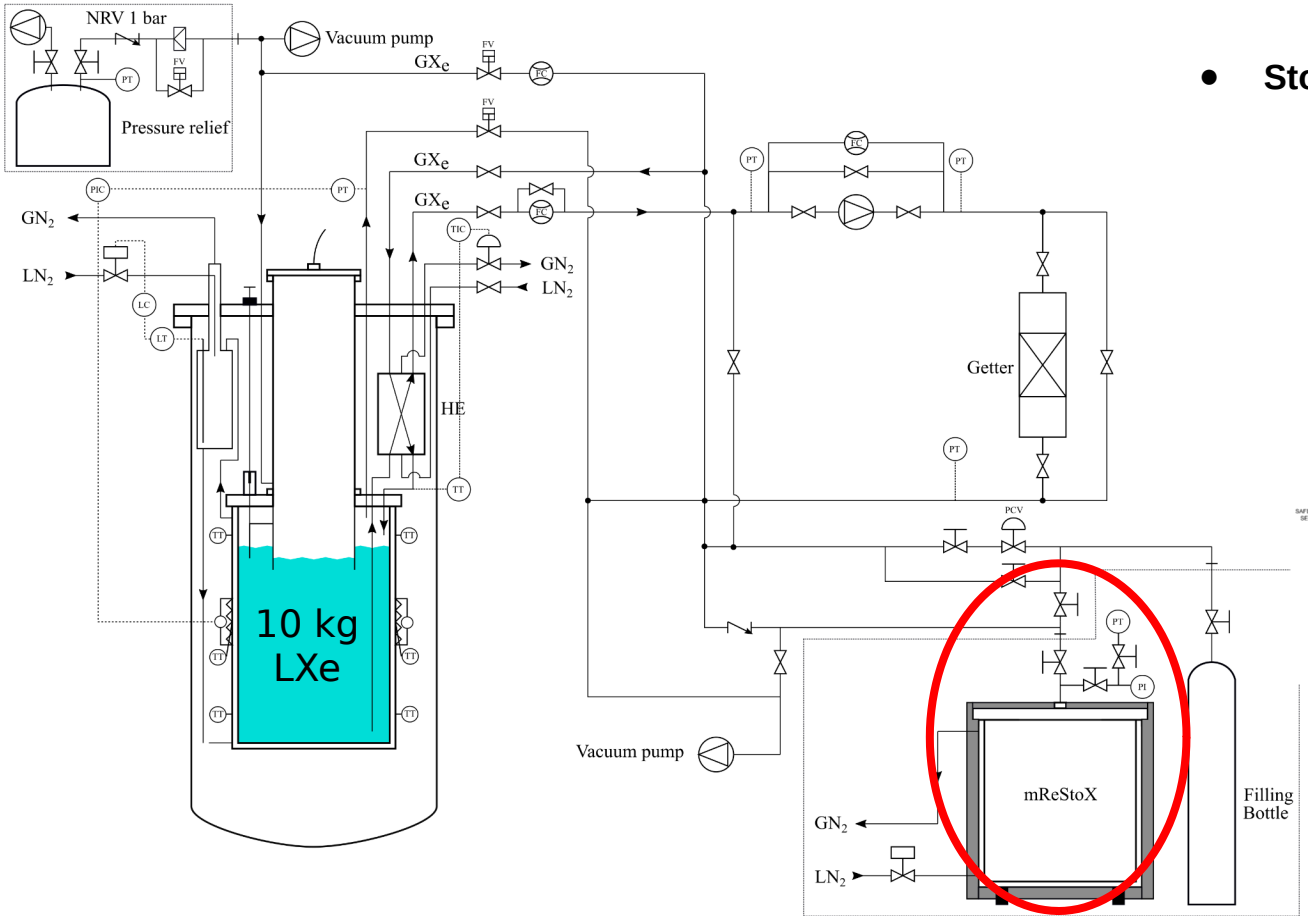
- 3 month of commissioning (leaks, cooling, filling and recovery)
- Freezing the material choice for the electrodes (pillars)
- TPC design almost completed then its construction will start

Thank you for your attention!

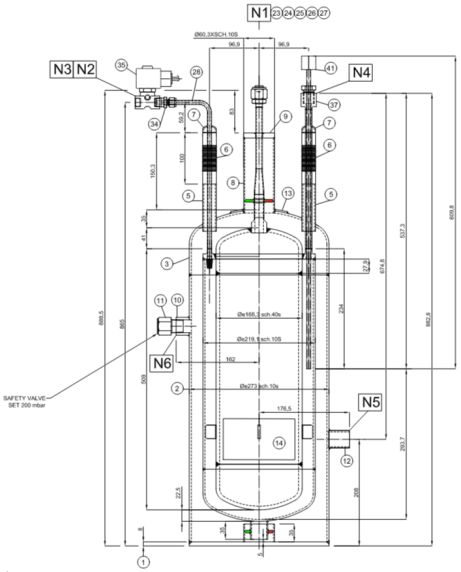


Back up slides

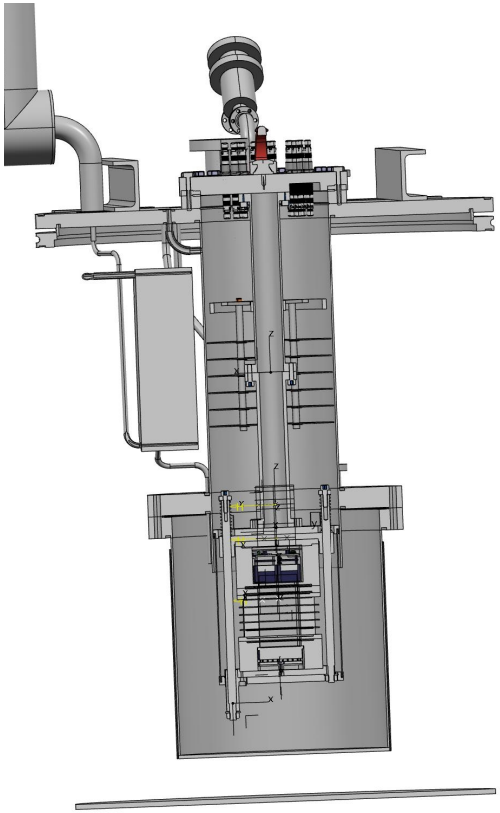
Process & Instrumentation Diagram (P&ID)

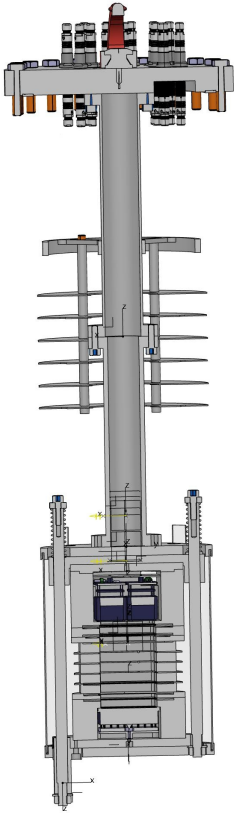


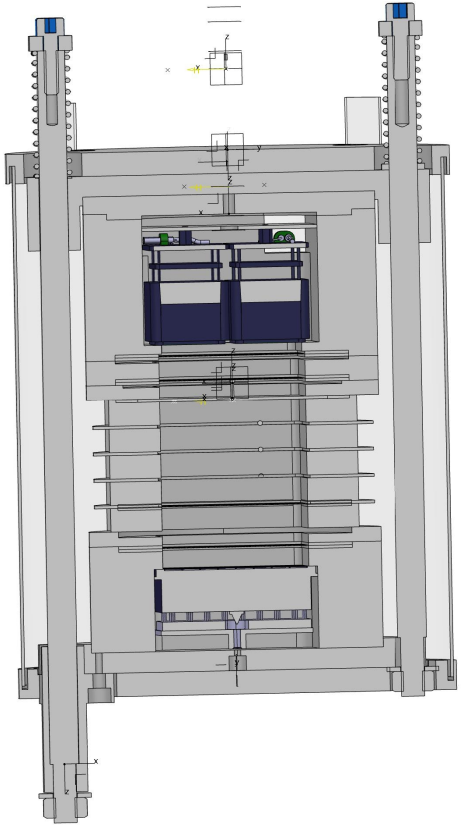
- **Storage and recovery system**



Integration TPC / cryostat

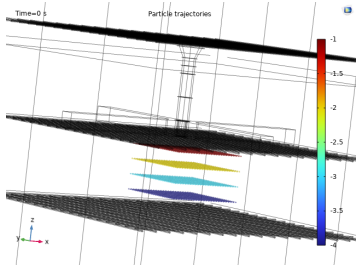




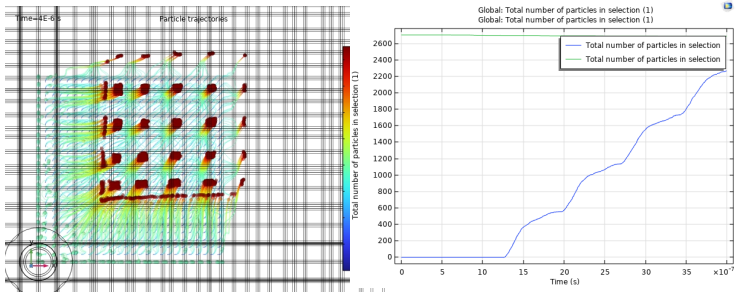


Xelab: Electrons / TPC model

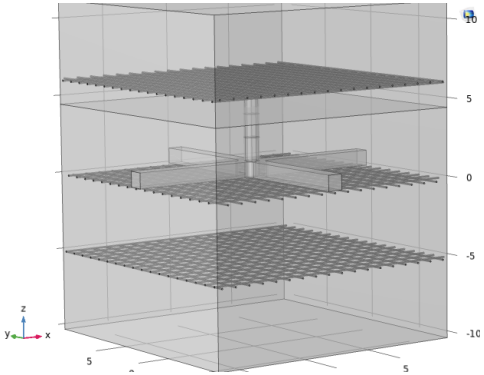
Integration of the electron drift model in the 3D electrostatic model.
Response Function of the TPC , to use with Garfield for photon emission : possible interpolation of the electron exit position at interface.



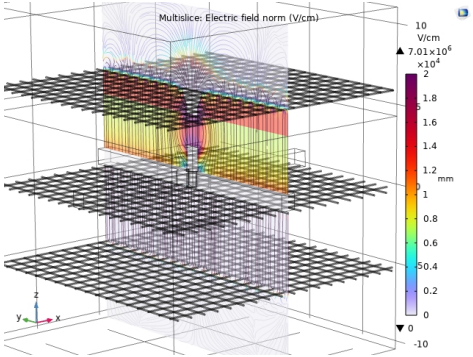
Electrons Release grid in LXe



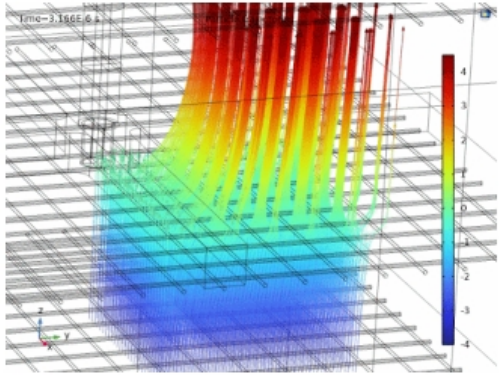
Top View : Electrons Release grid in LXe



Geometry of the TPC electrodes.



E-field with wire electrodes (1mm pitch , 0.1mm wire)



Full Electron Drift path in LXe