Multiwire Drift Chamber as SAND Tracker (backup solution)

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SAND Target Tracker (backup solution)

Objective:

To determine if the SAND physics objectives can be achieved with a tracker that has a reduced number of channels, potentially less complexity, and ensuring the detector remains feasible for a single production site.

We keep

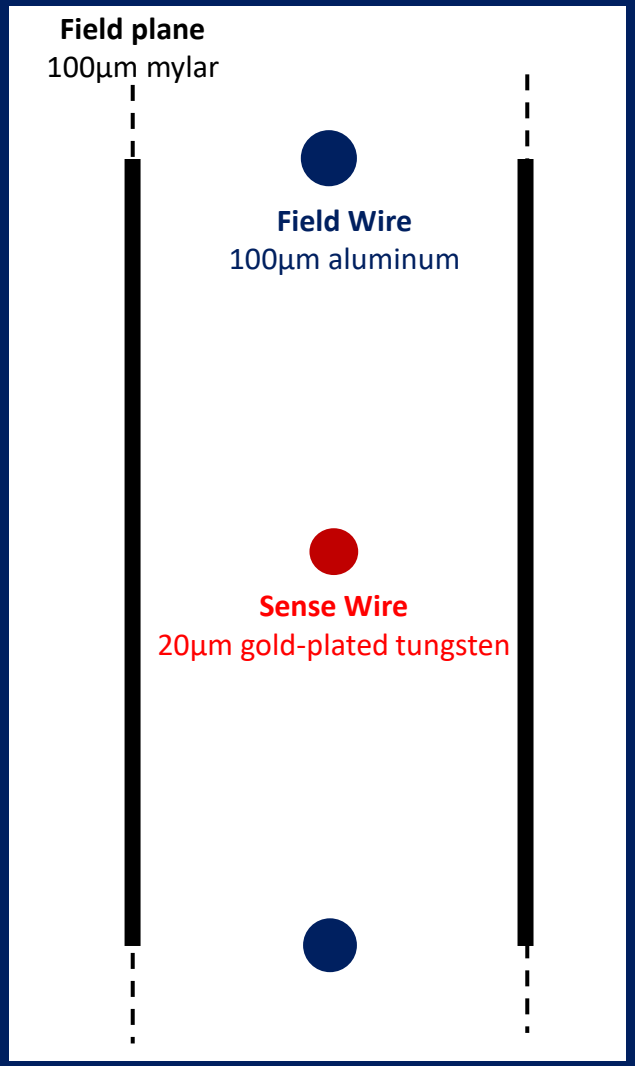
- Gas detector
- Target/Tracker modularity
- Solid Hydrogen concept

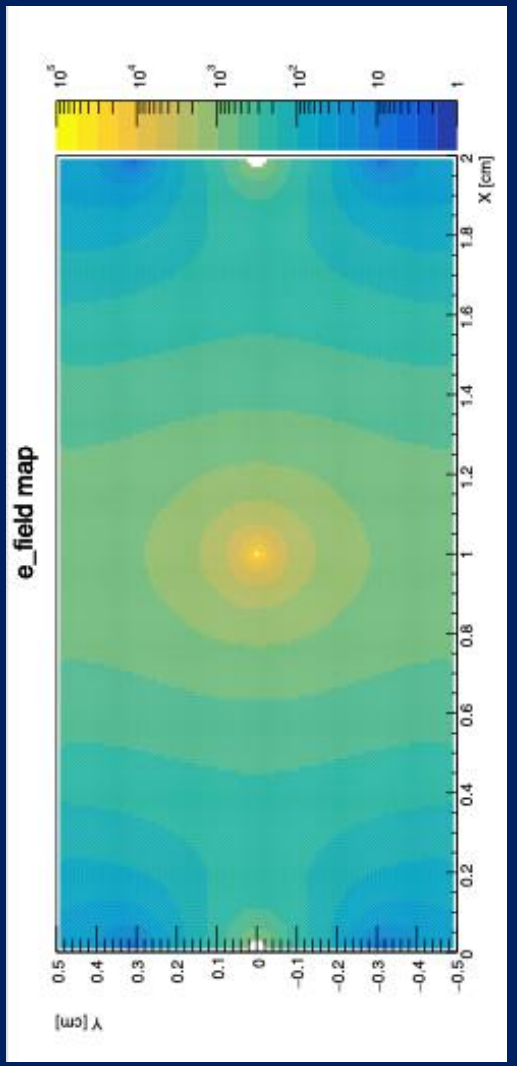
We do without

- Transition Radiation Detector

Drift Chamber Study

- **Simulation of Basic Cell Configuration**
  - Implementation in Garfield++
  - Simulation of Electric Field
  - Optimization for drift properties and signal production

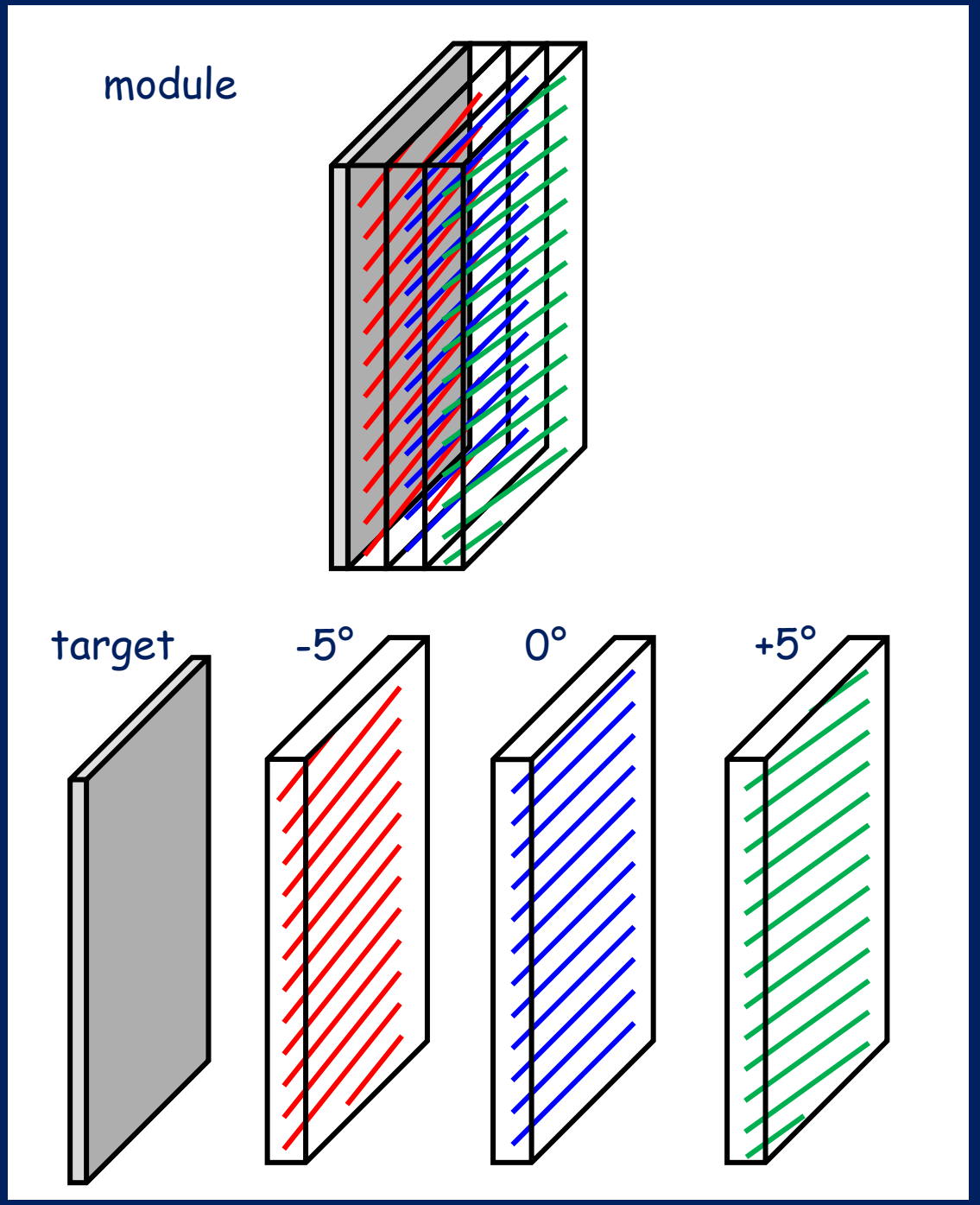




Design and Prototyping

- **Module layout**
  - A target layer of CH_2 or C.
  - 3 multiwire planes
    stereo view: -5°, 0°, +5°
    with respect to the B-field axis.

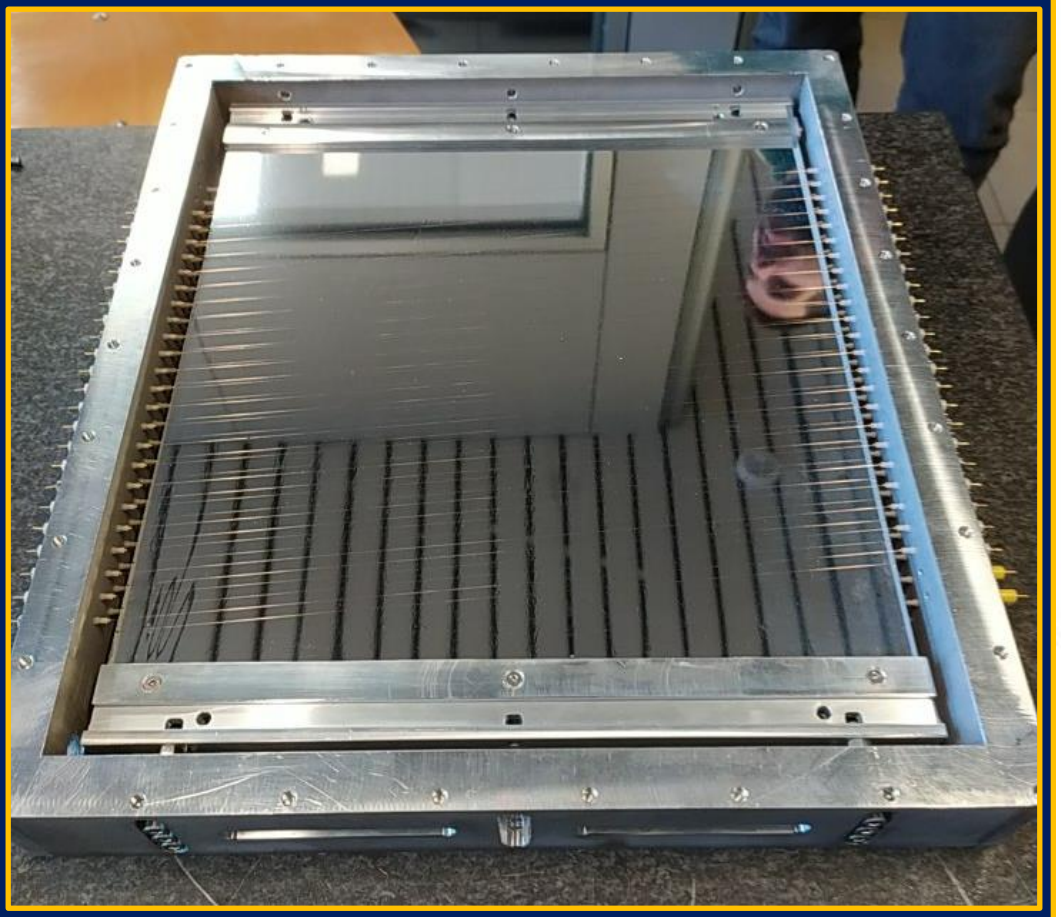
- **Prototypes**
  - Small scale prototype (30x30 cm²)
    test finished
  - Medium scale prototype (120x80 cm²)
    design completed,
    procurement in progress

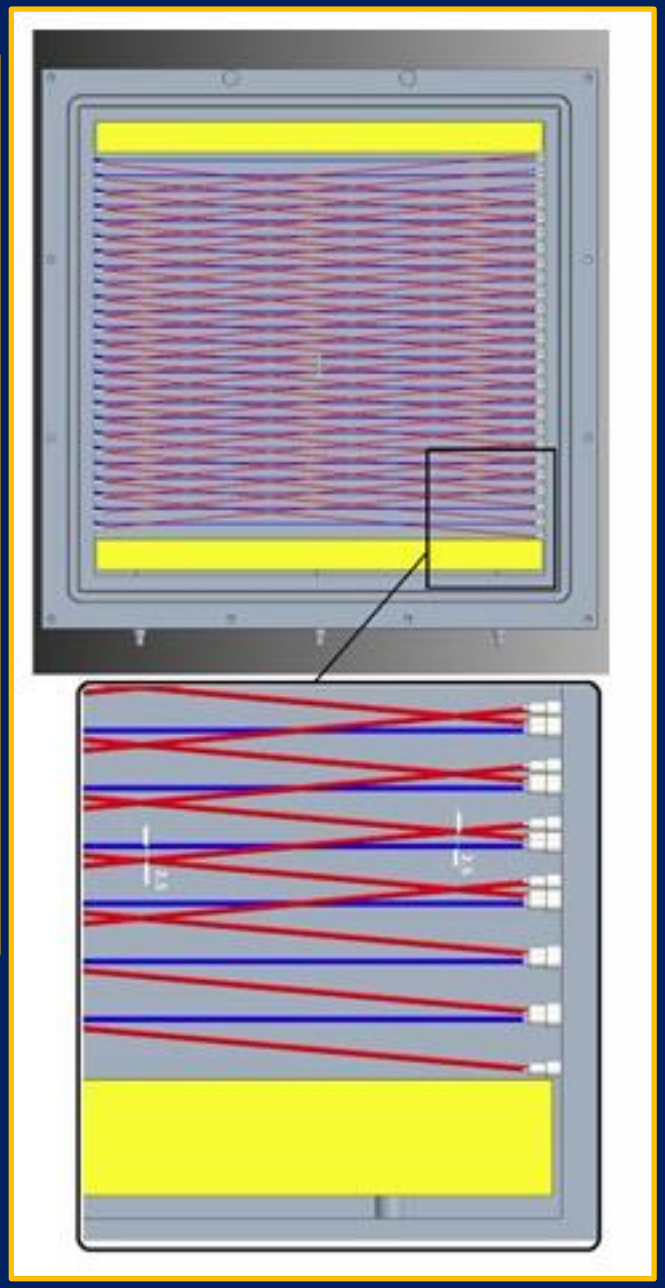


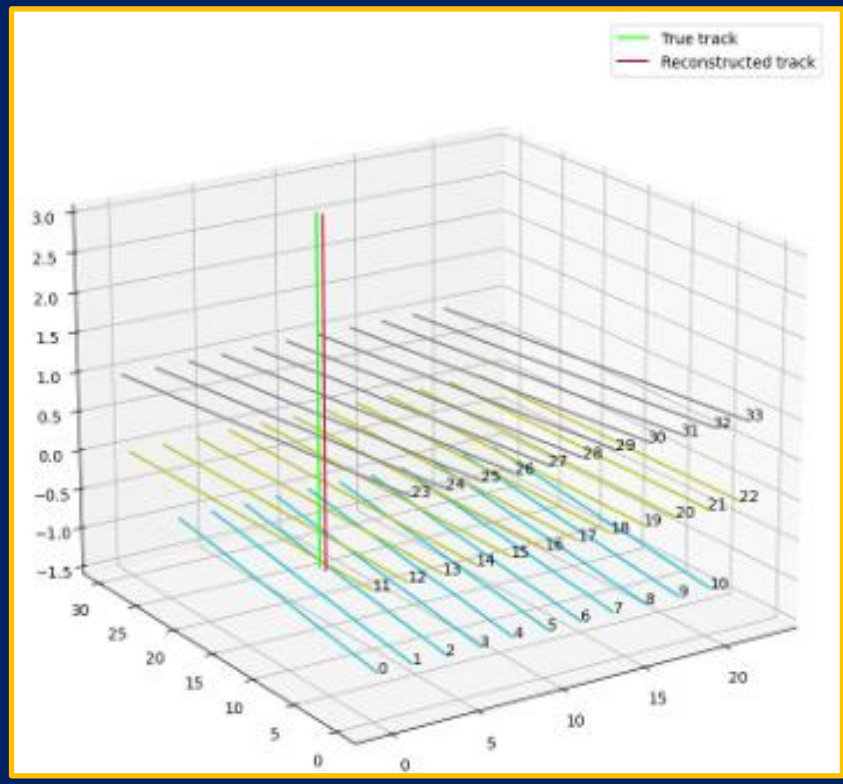
Small Scale Prototype

Aiming at gaining experience in the construction, operation and readout design

- Construction completed:
  - Size: ~30×30 cm^2
  - Without target
  - Leftovers of past experiments
  - Not assembled in a clean room
- Instrumented Channels: 12
  - Readout by 2 KLOE preamplifiers
- DAQ: 3 CAEN digitizer







3 planes / stereo view
→ ghost disentangle

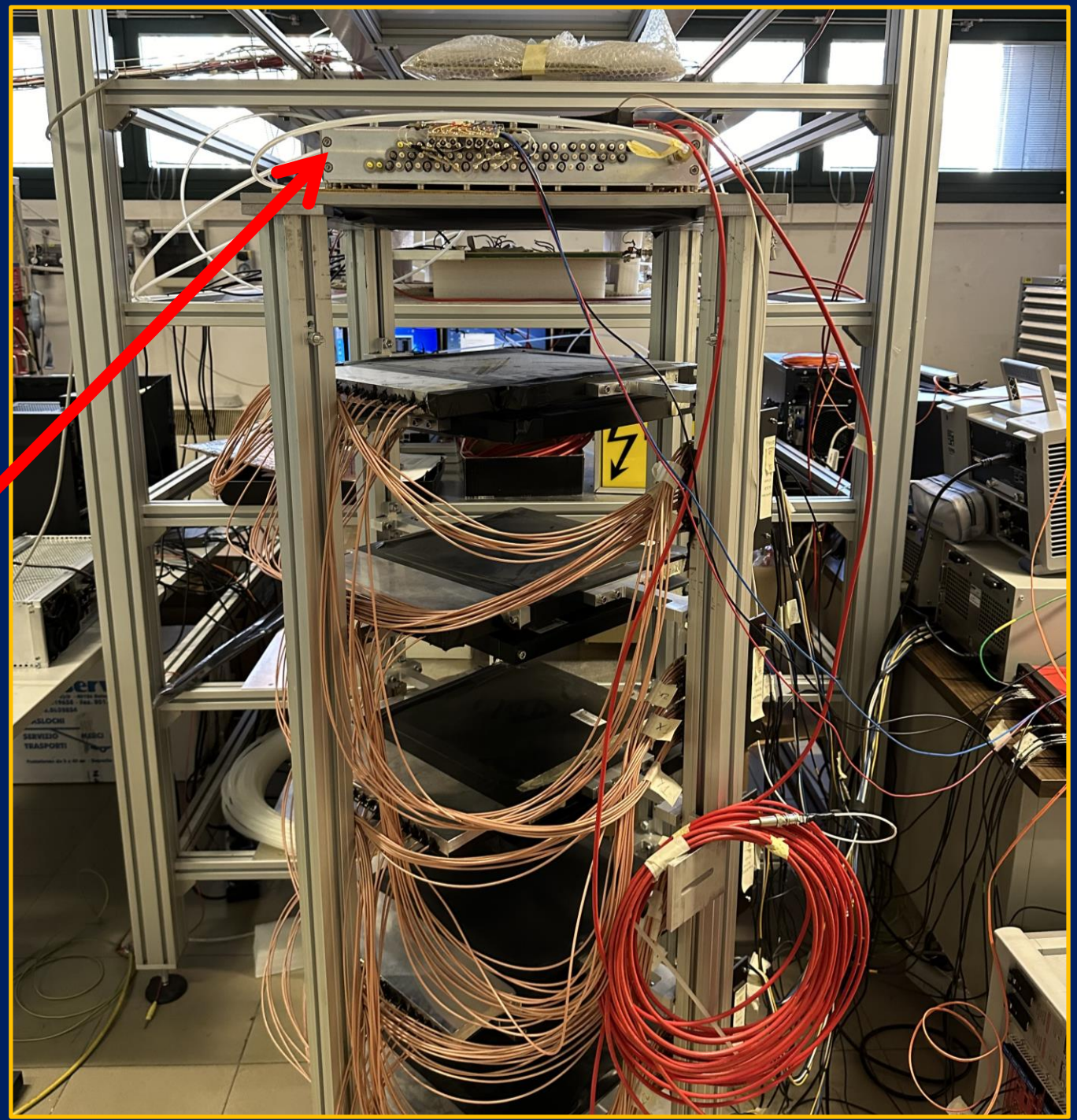
Bending plane: 3 hits (STT is 2)
Transversal plane: lower resolution than bending

Python toy model of the prototype:
- fitting algorithms;
- study detector response;
- evaluate the best geometry

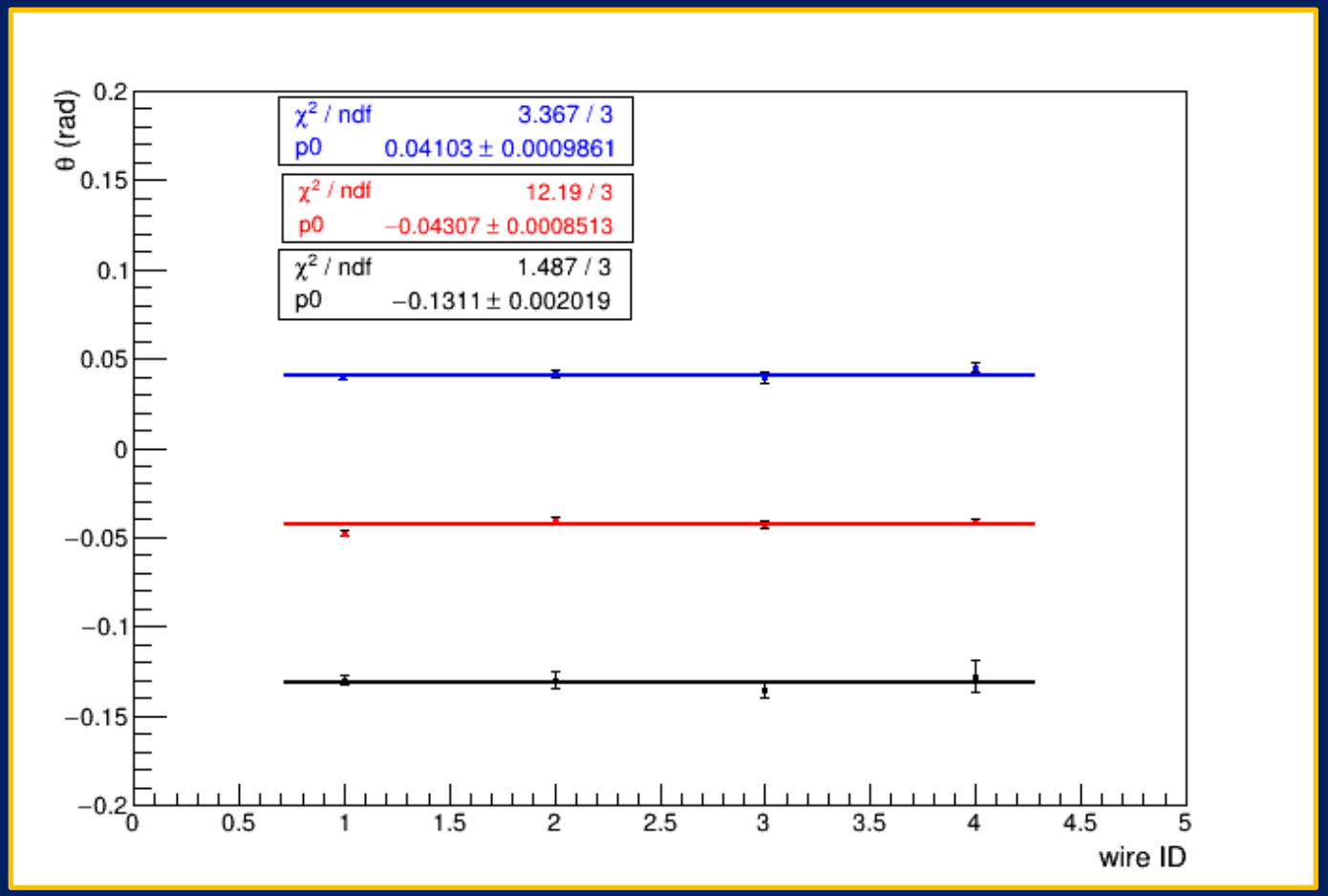
Experimental Setup

From Top to Bottom:

- Plastic Scintillator:
  - size: 15x15 cm2;
  - Thickness 1 cm;
  - readout 1 PMT:
    - Hamamatsu R9880
    - Direct coupling
- Plastic Scintillator:
  - size: ~ 30 x30 cm^2;
  - Thickness ~2 cm;
  - readout 2 PMTs
    - Fiber Coupling
- Drift Chambers (3 Layers):
  - Readout 12 channels (4 per layer)
  - KLOE pre-amplifiers
    - ~1.5 mV / fC
- Tracking system:
  - Position resolution ~2mm



Wire orientation from data



In the tracker reference system:

- θ_3 = - 0,131 ± 0.002 rad
- θ_2 = - 0,043 ± 0.001 rad
- θ_1 = 0,041 ± 0.001 rad

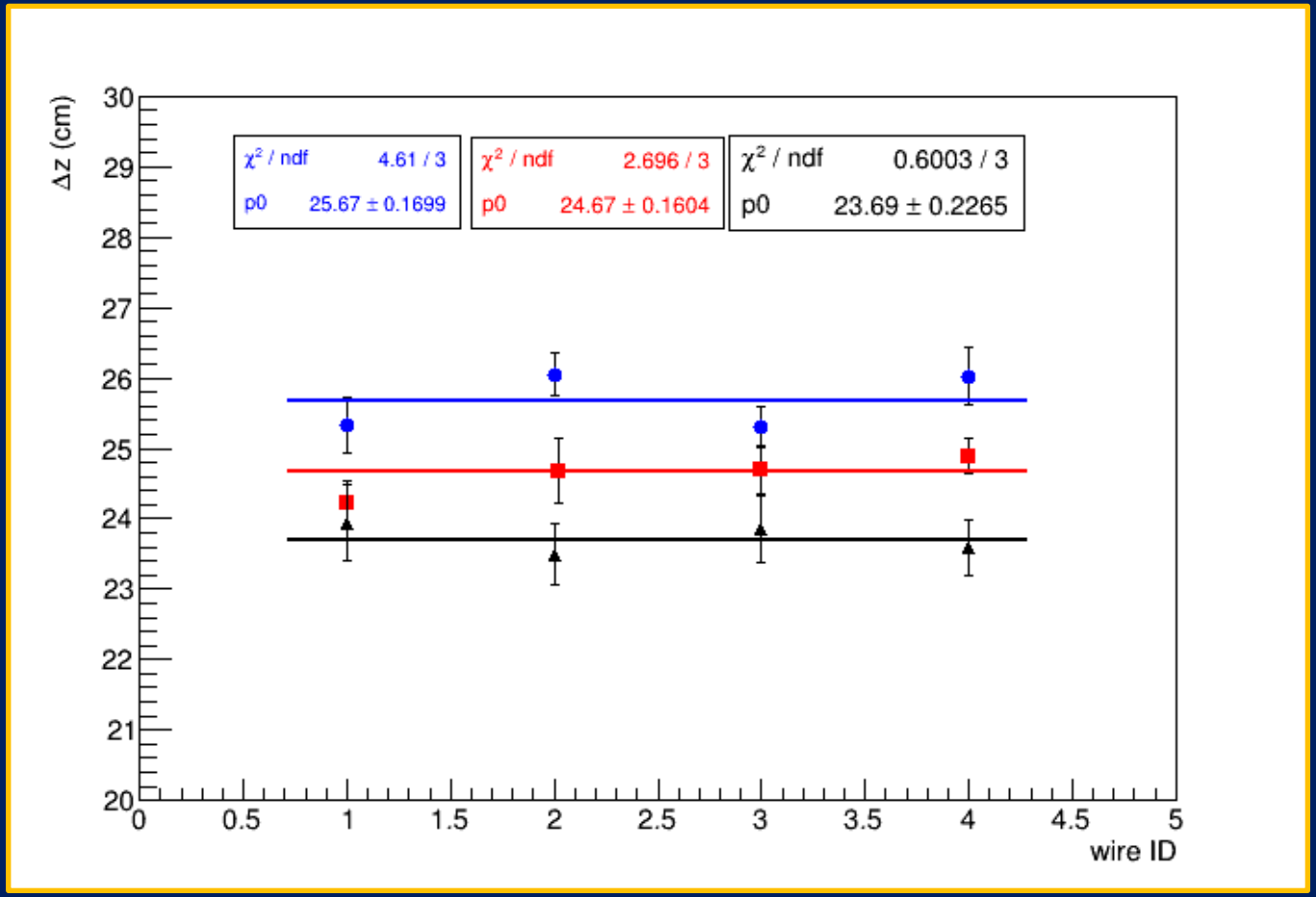
Angles between wires:

$\Delta\theta_{12}$ = 5,0 ± 0.1 °
$\Delta\theta_{23}$ = 4.8 ± 0.2 °

Nominal is 5°

$\Delta\theta_{13}$ = 9.9 ± 0.2 °

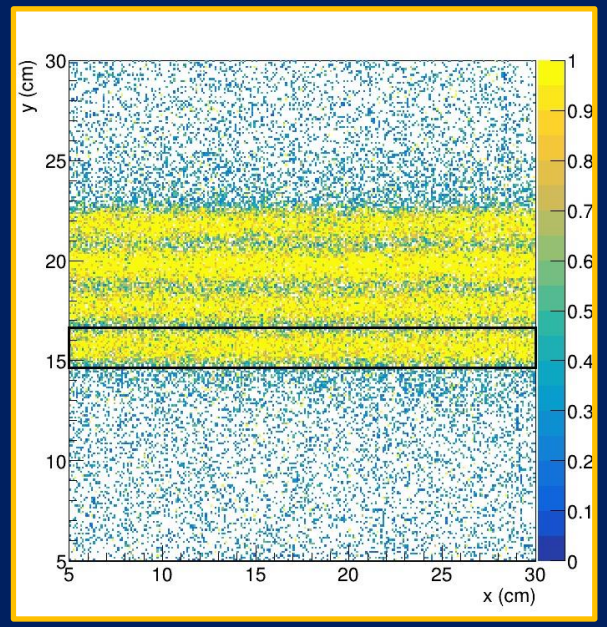
Wire Positions from data

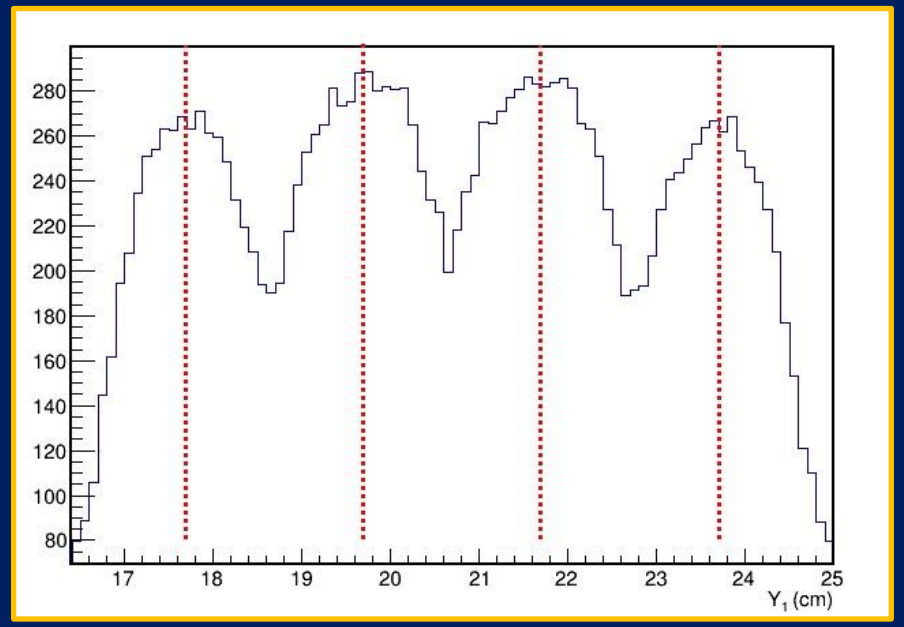


Interdistance:

- Nominal: 1 cm
- Measured 1 cm;
- Error ~ 0.2 cm;

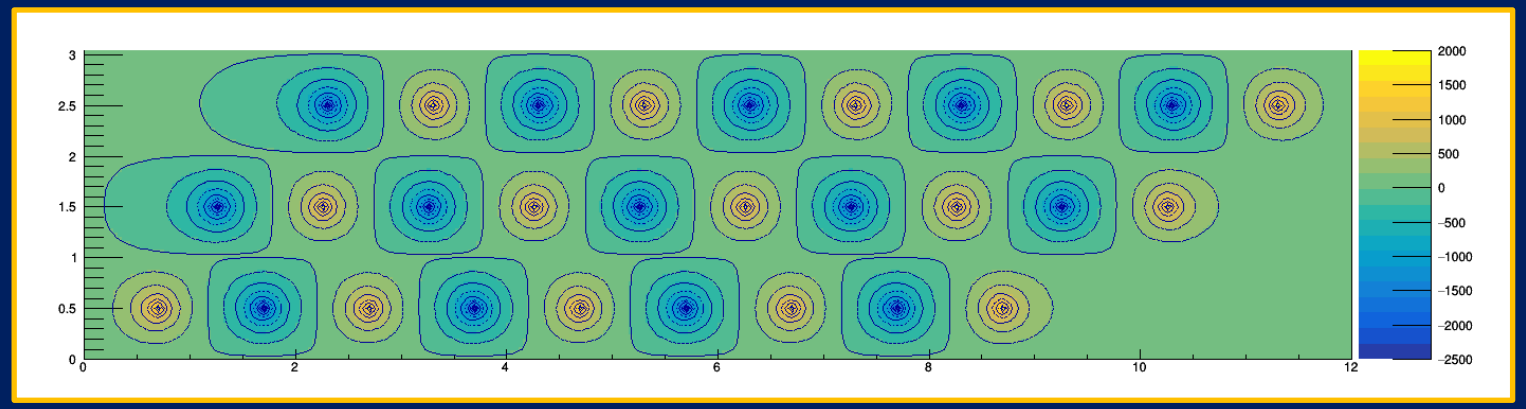
Efficiency – overall «plane»





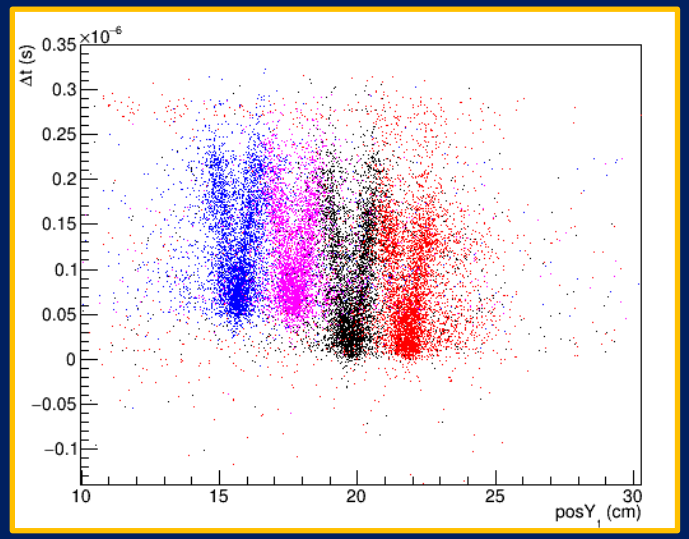
Not uniform across the whole cell size

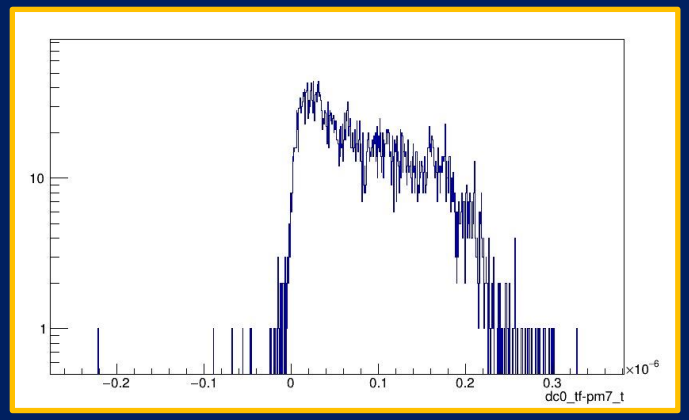
Likely due to electrons drifting towards mylar plane

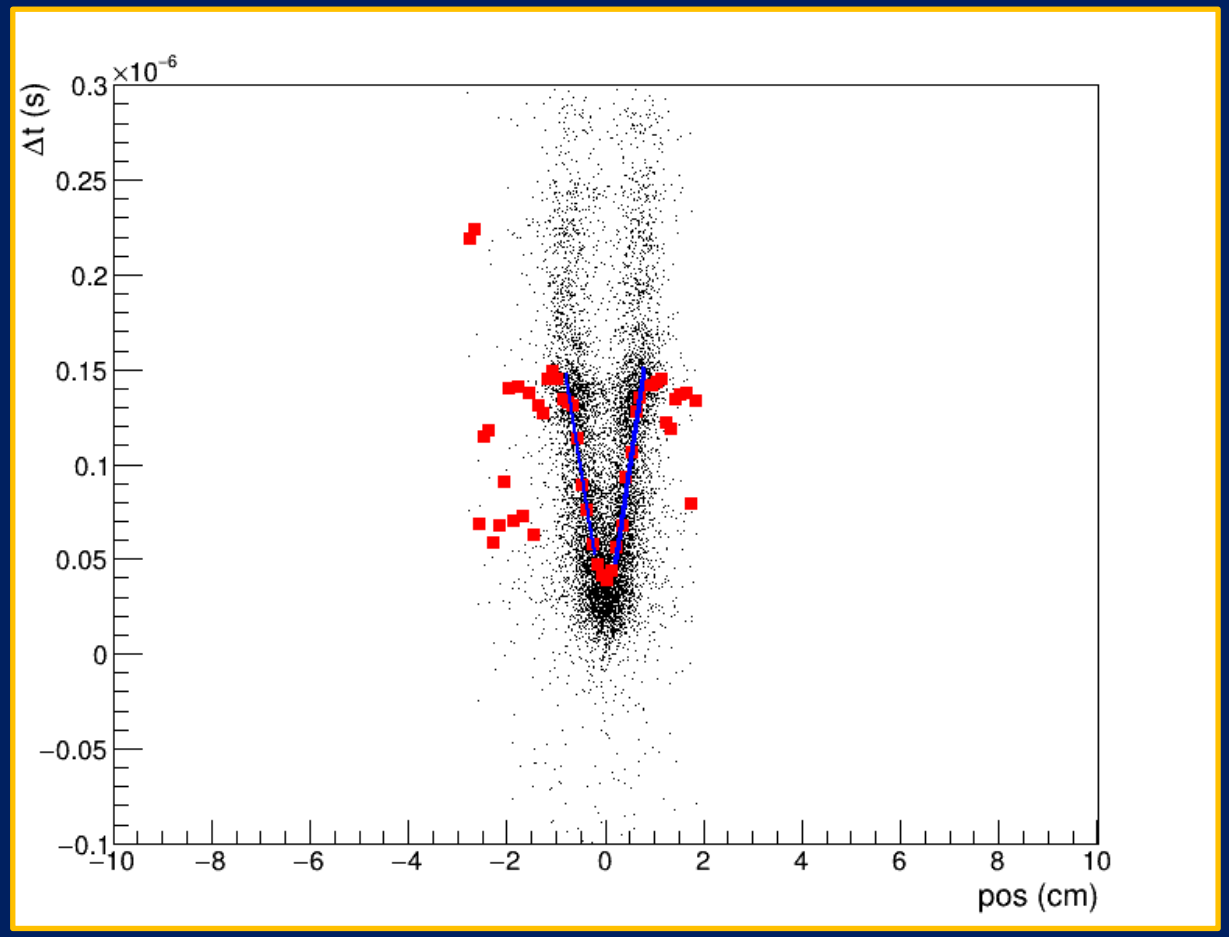


Toy- simulation
Electric Field Potential Map

Drift speed: preliminary estimation

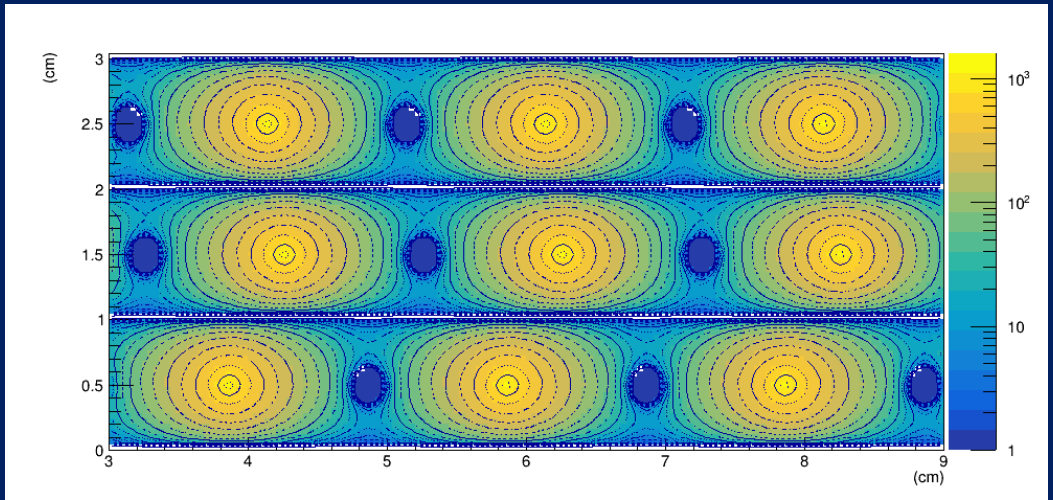






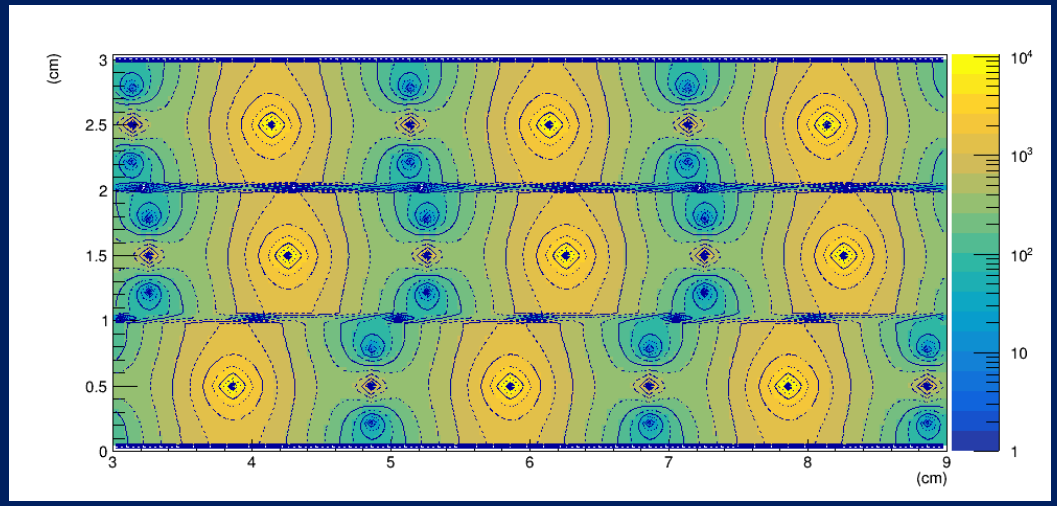
Median values and fit just to have a very rough and preliminary estimation of drift speed: ~60 μm/ns

New Configuration – Run 2 MC toy simulation



Electrostatic Potential Configuration (log scale)

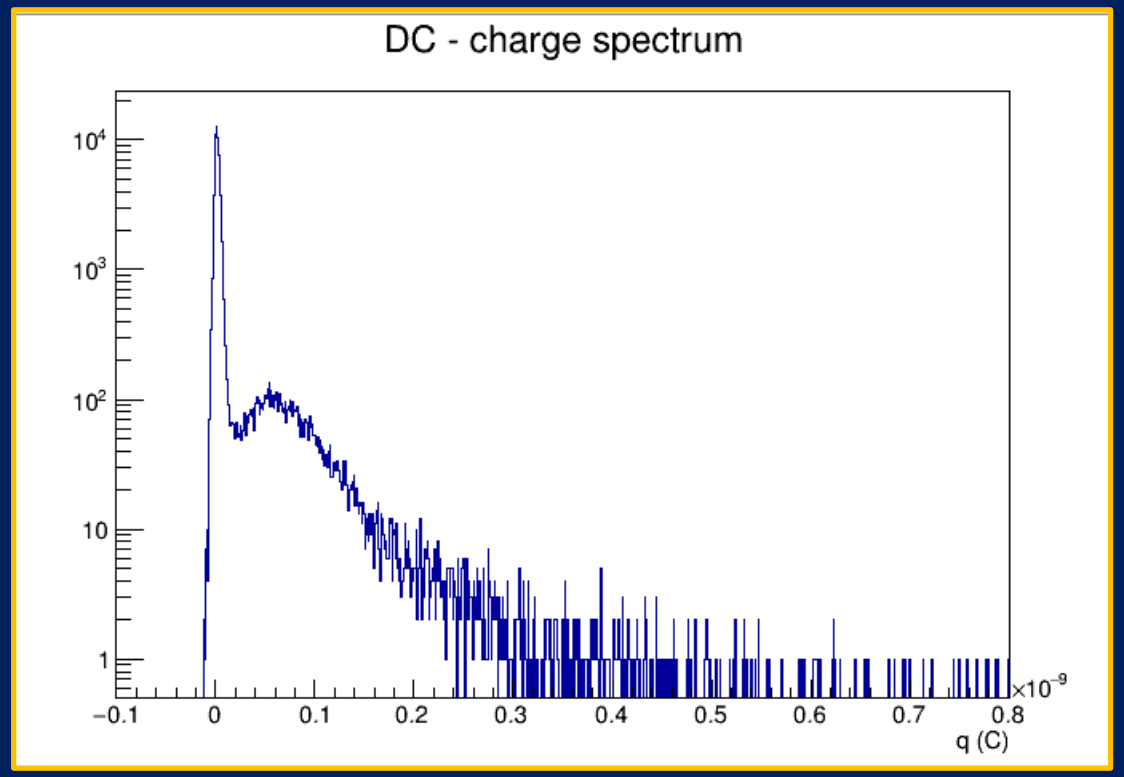
- Sense wire: +1600 V
- Field wire: -100 V
- Mylar planes: grounded

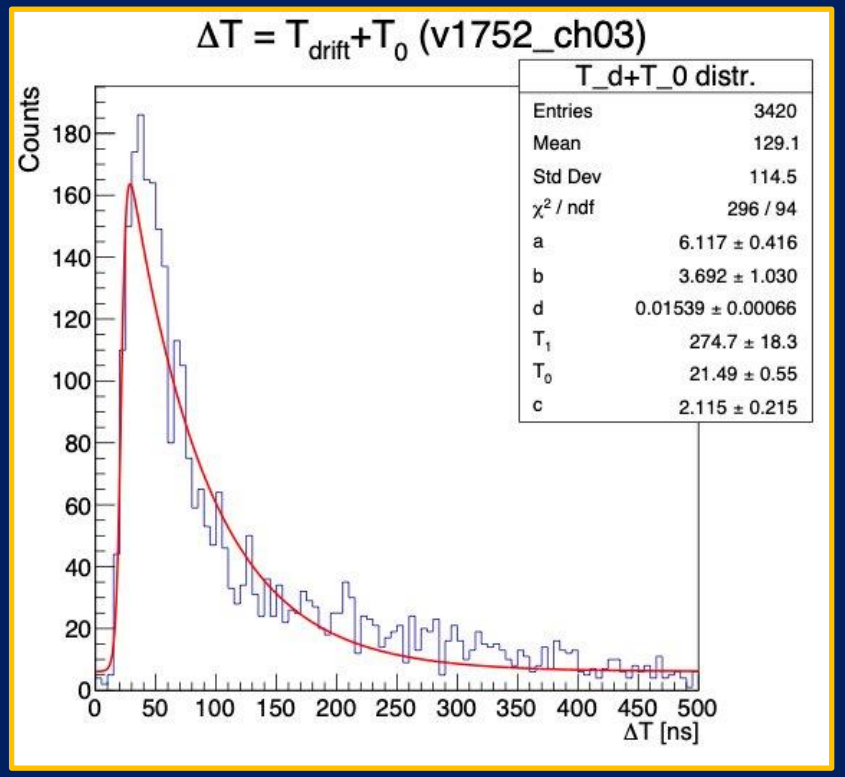


Electric Field Magnitude (log scale)

Try to get a more «cylindrical» field configuration

Example – single channel data

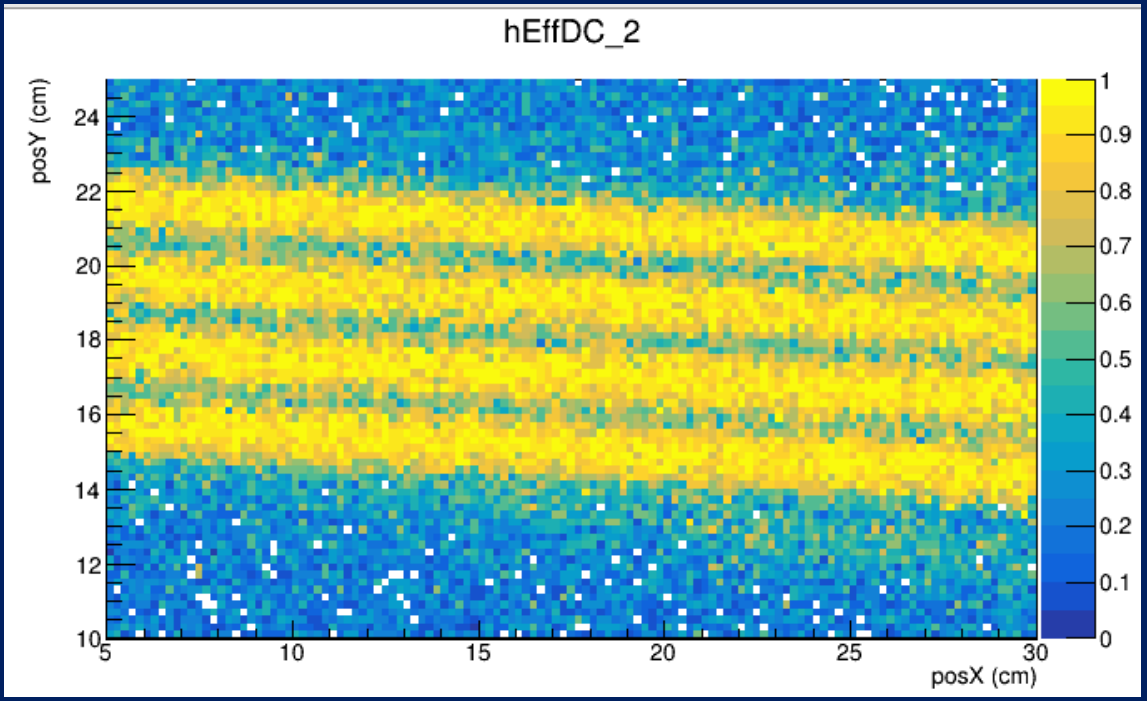


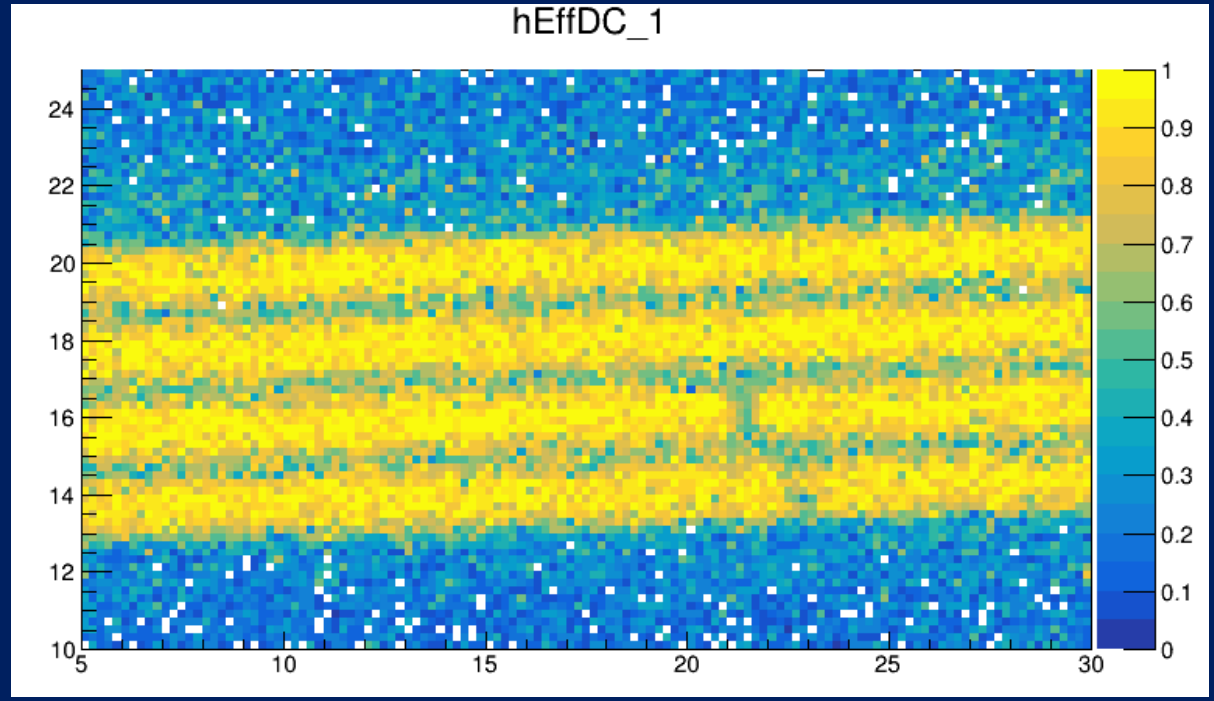


From KLOE, distribution modelled as:

$$T_{drift} + T_0 = a + b\frac{e^{-d(t-T_1)}}{1+e^{-(t-T_0)/c}}$$

Efficiency map - preliminary

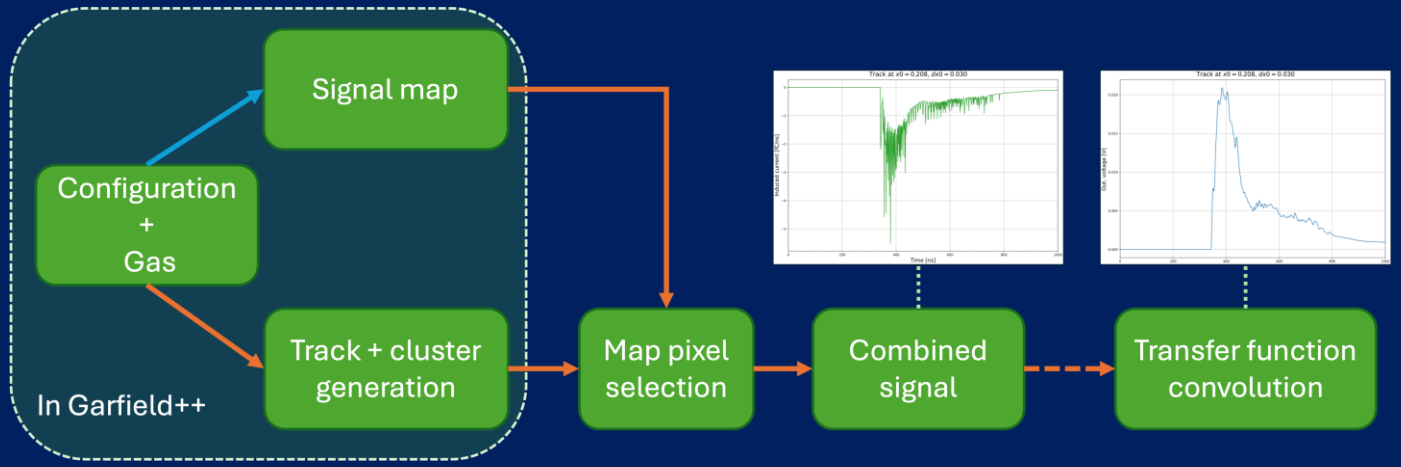


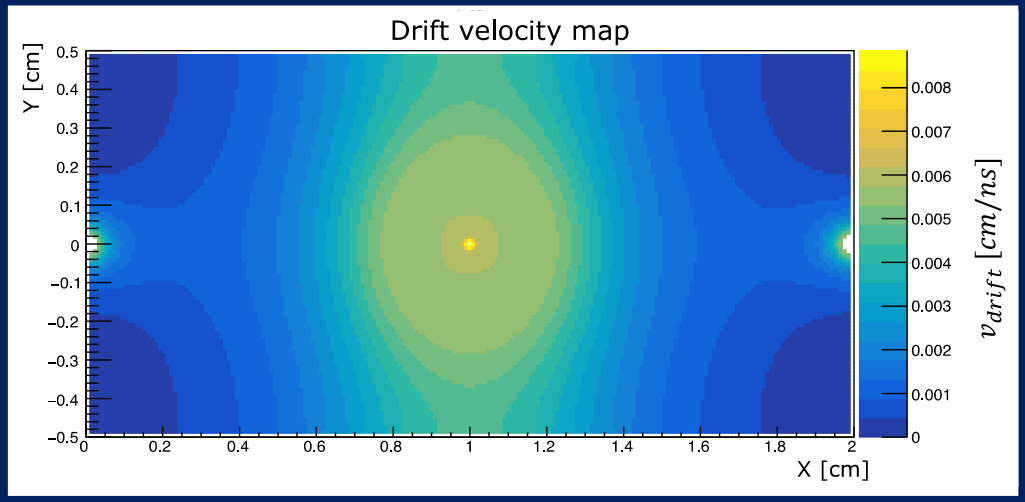


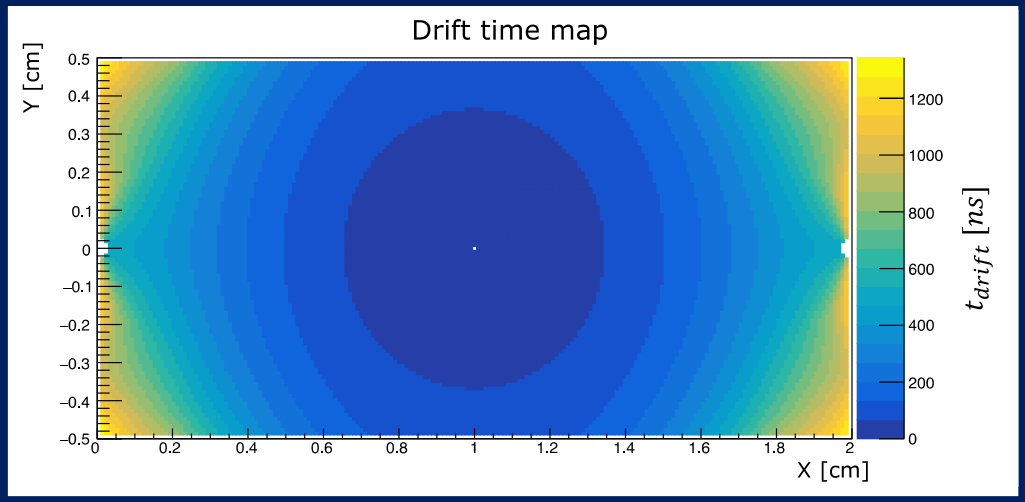
Still visible the region with lower efficiency.

Cell response simulation

- Garfield++ model for studying drift properties and signal production
- Full track simulation in Garfield++ is too slow → Signal maps
- Particle signal by combining mapped electron signals.

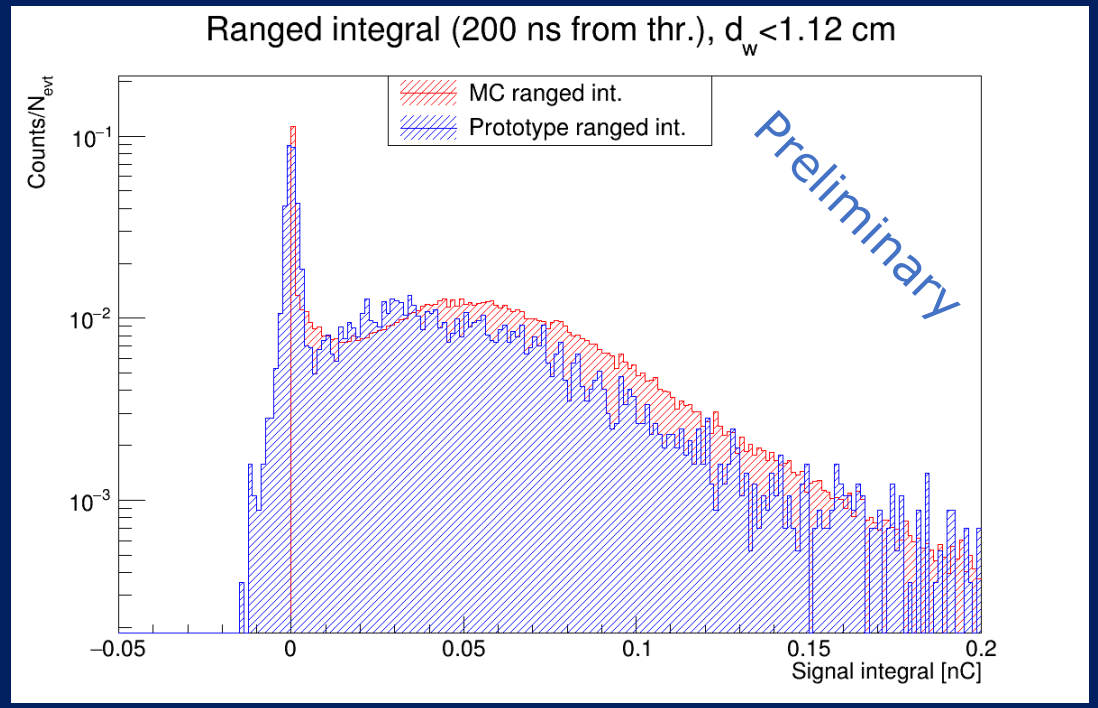




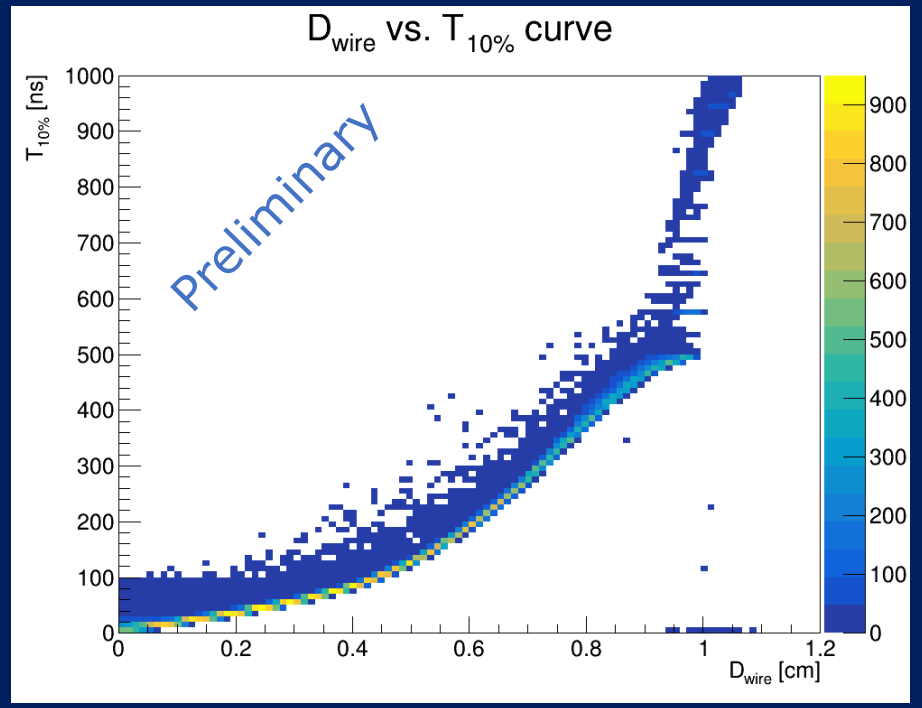


30x30 prototype MC model

- Comparing the prototype data to MC cosmics response simulation

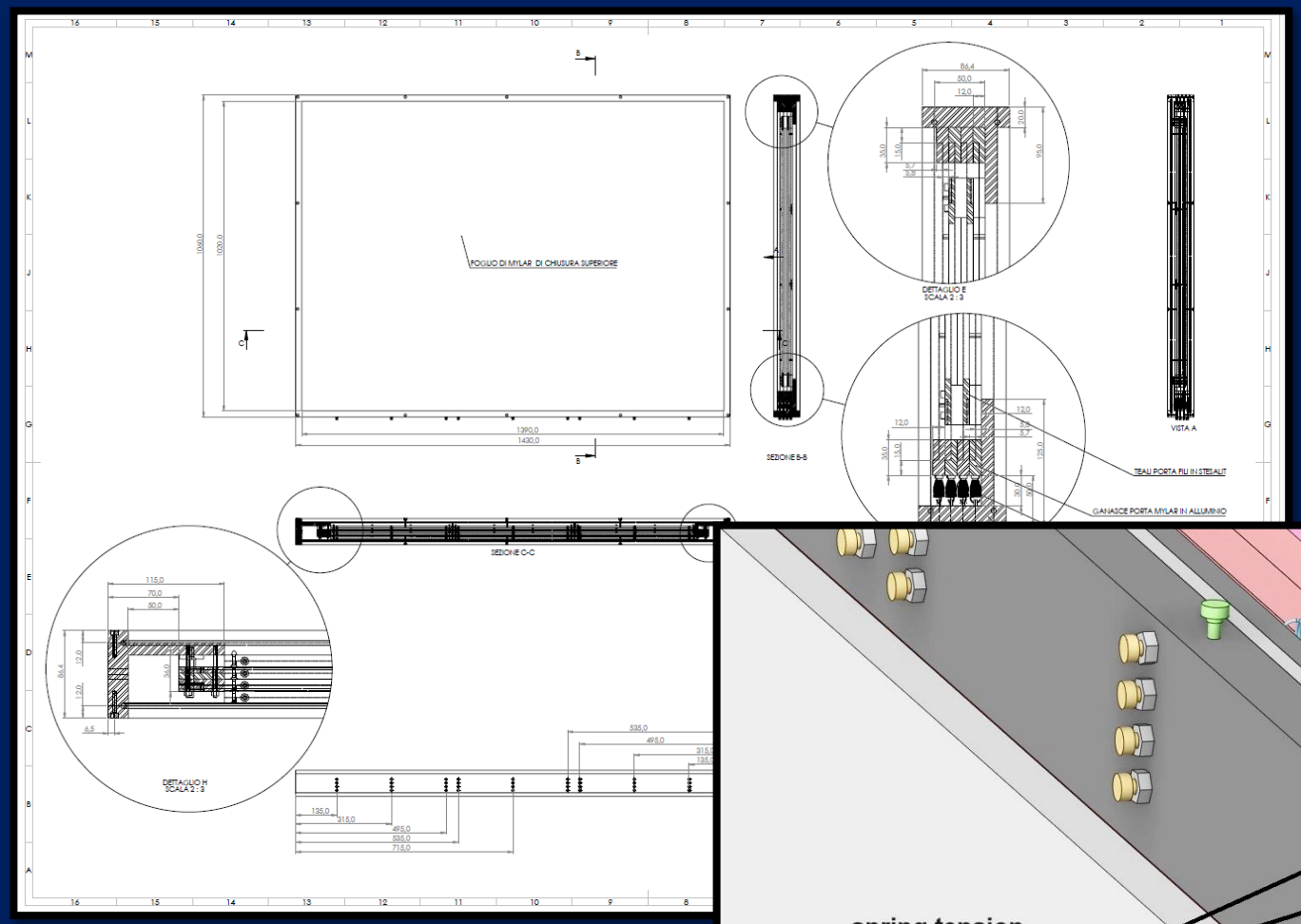


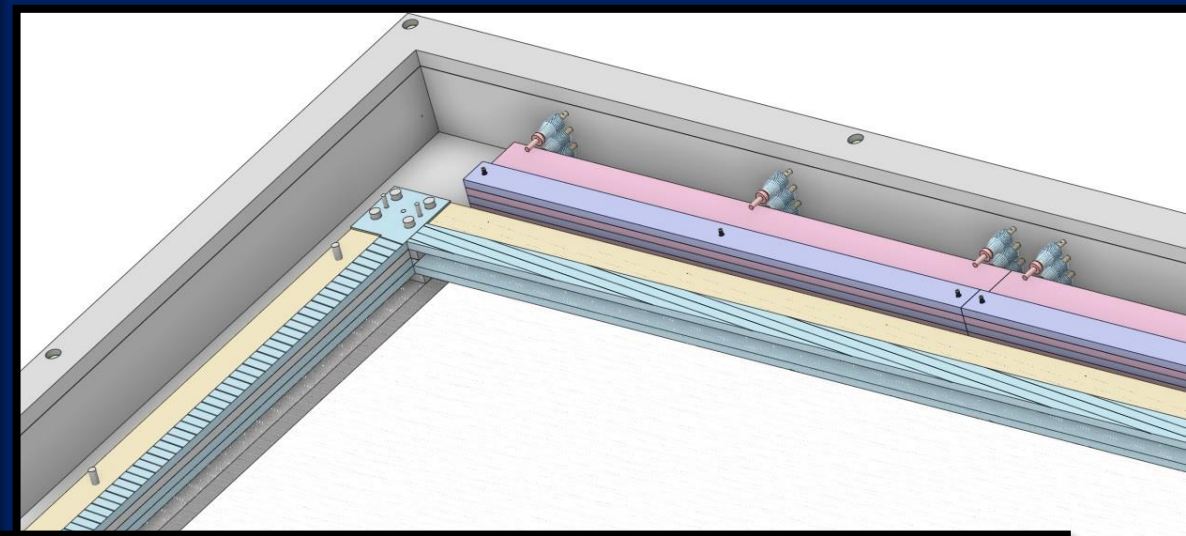
Comparing charge distributions

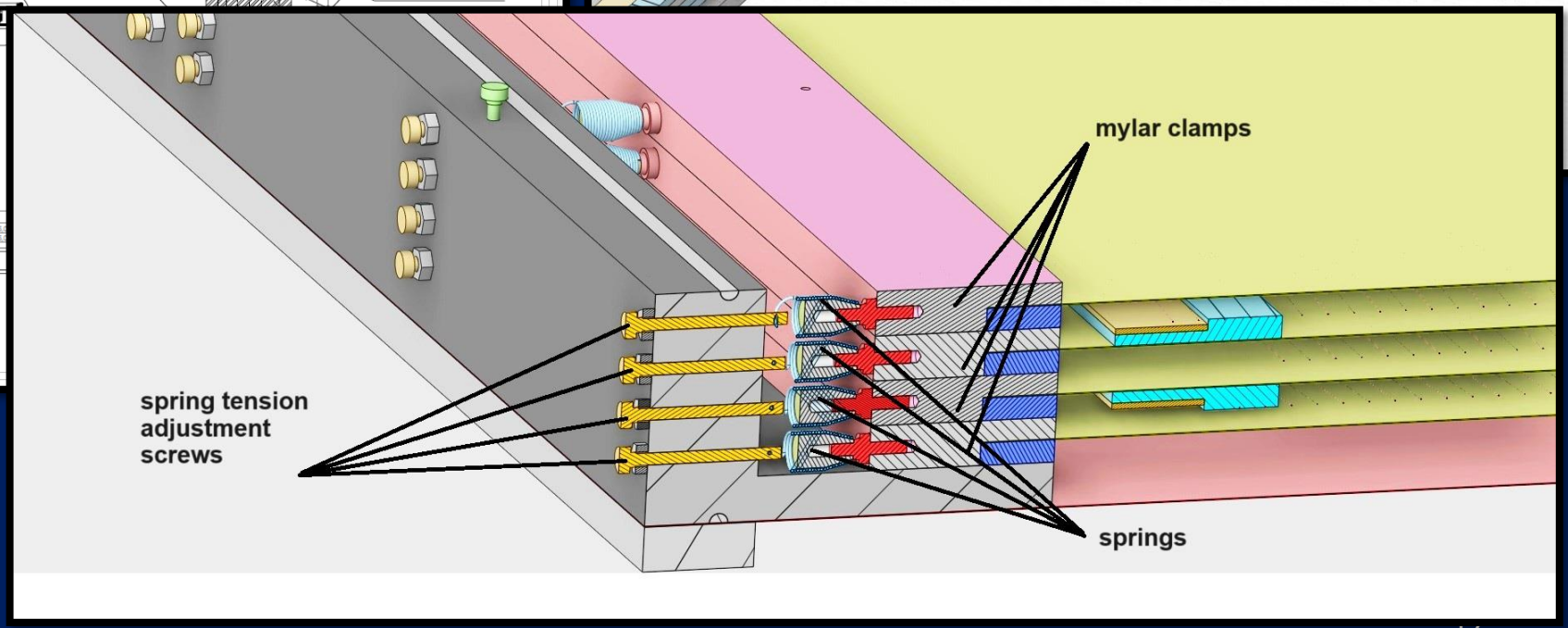


Extracting expected D-T curve

Middle scale prototype – ~80x120 cm^2







Stesalit

Overall geometry

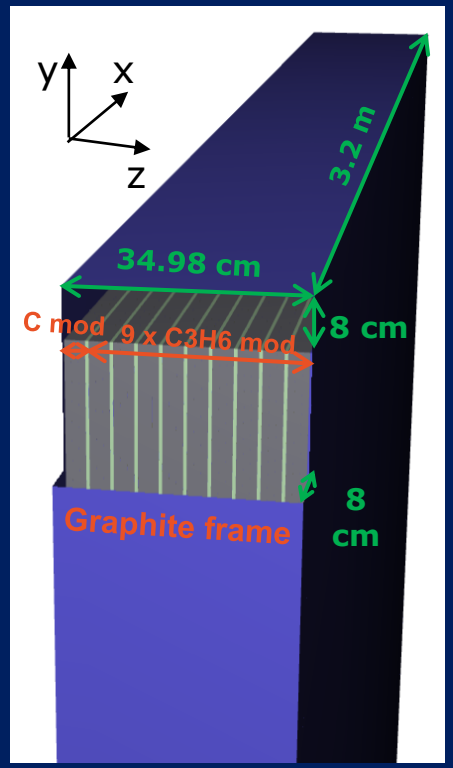
- ~240 drift planes
- Number of channels depends on the cell shape

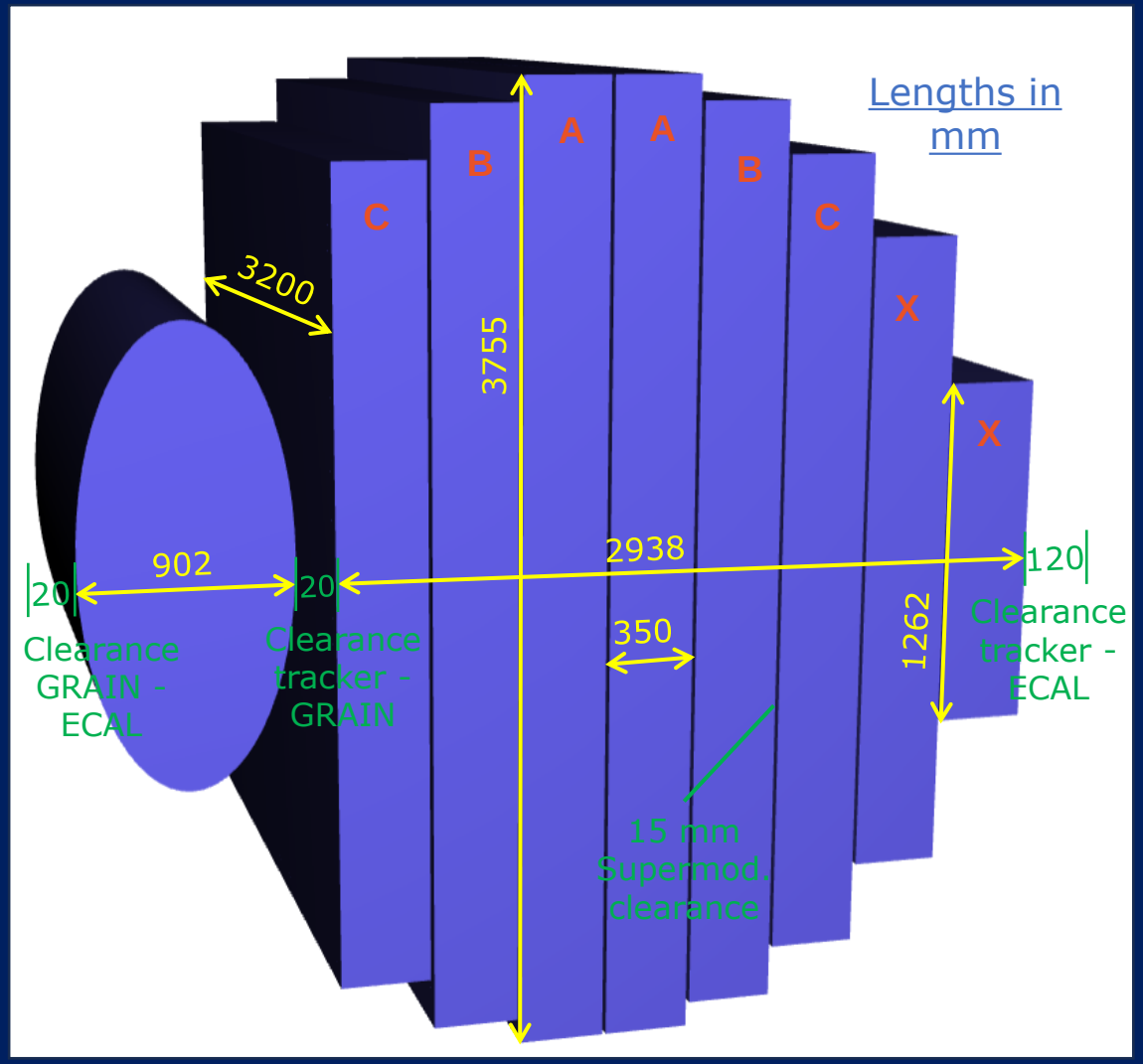
2 x 1 cm² cells

- ~3.6x10⁴ channels
- ~ 7.2x10⁴ wires

1.4 x 1.2 cm² cells

- ~5.2x10⁴ channels
- ~10.4x10⁴ wires

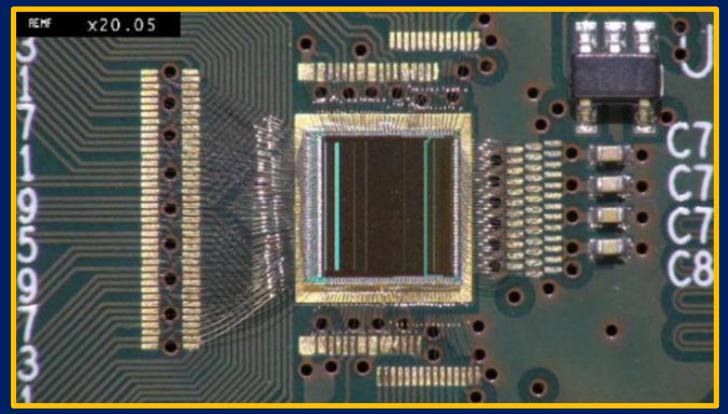


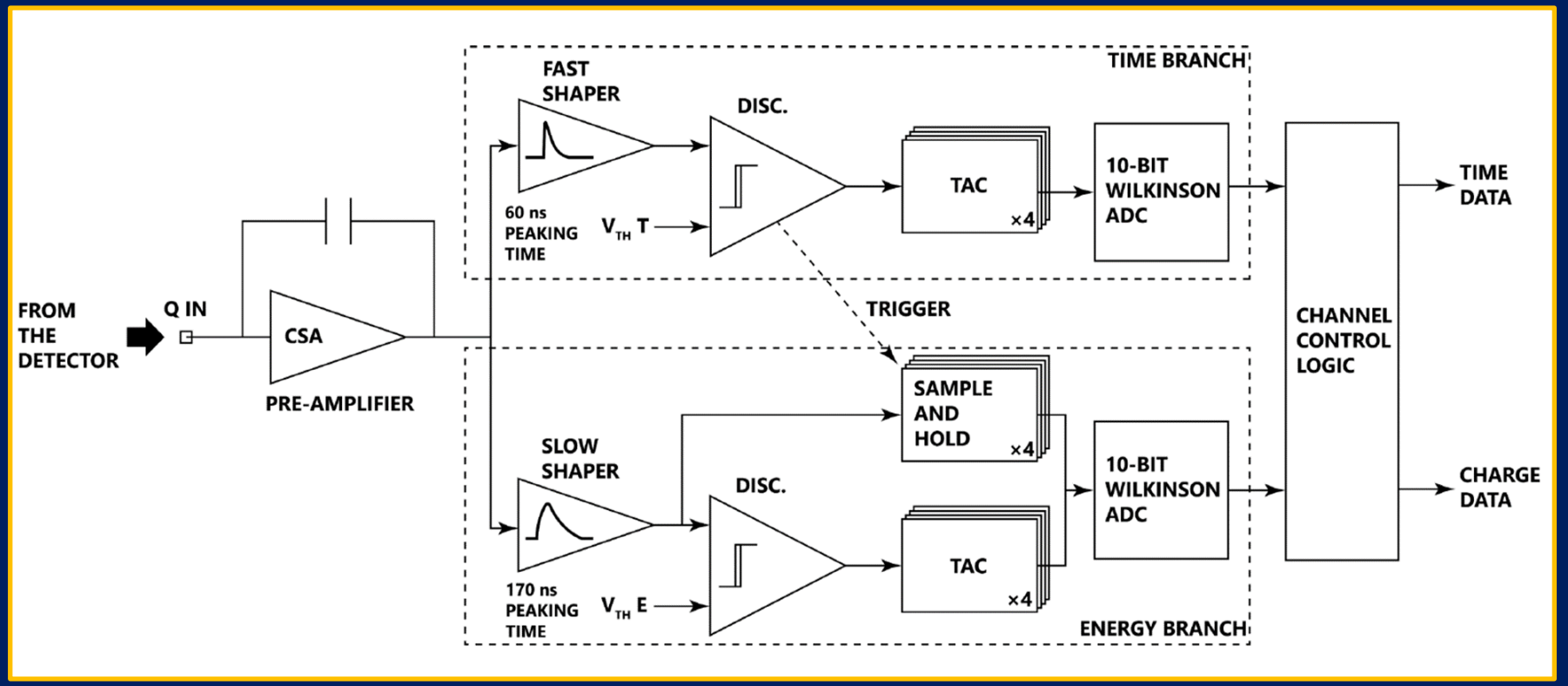


Prototype Drift-Ch 1200x800

Readout – TIGER ASIC

- UMC 110nm technology
- 64 channels per ASIC (2 ASIC per FEB)
- Time and charge measurement
- One demo board is now in Bologna





Conclusions

- Drift Chamber small scale prototype:
  - Working and taking data with different field configurations;
  - Good reconstruction of :
    - Wire orientations;
    - Wire Z positions;
  - Efficiency not uniform on the whole cell:
    - Probably due to electrons drifting to the mylar plane.
    - Trying to investigate more «central» field configuration

- Middle scale prototype:
  - Mechanical design should be finalized;
  - Garfield Simulation done, optimization in progress;
  - Front-end: TIGER ASIC under investigation (one demo board is under test in Bologna).