Preliminary results of the first medium-scale drift chamber prototype for the SAND inner tracker

Francesco Chiapponi

University of Bologna, INFN Section of Bologna

On behalf of:

Bologna: F. Battisti, V. Cicero, D. Di Ferdinando, R. Farinelli, G. Lupi, M. Guerzoni, A. Margotti, L. Pasqualini, G. Perozzi, F. Poppi, M. Pozzato, A. Ruggeri, G. Santoni, E. Savin, G. Sirri, N. Tosi

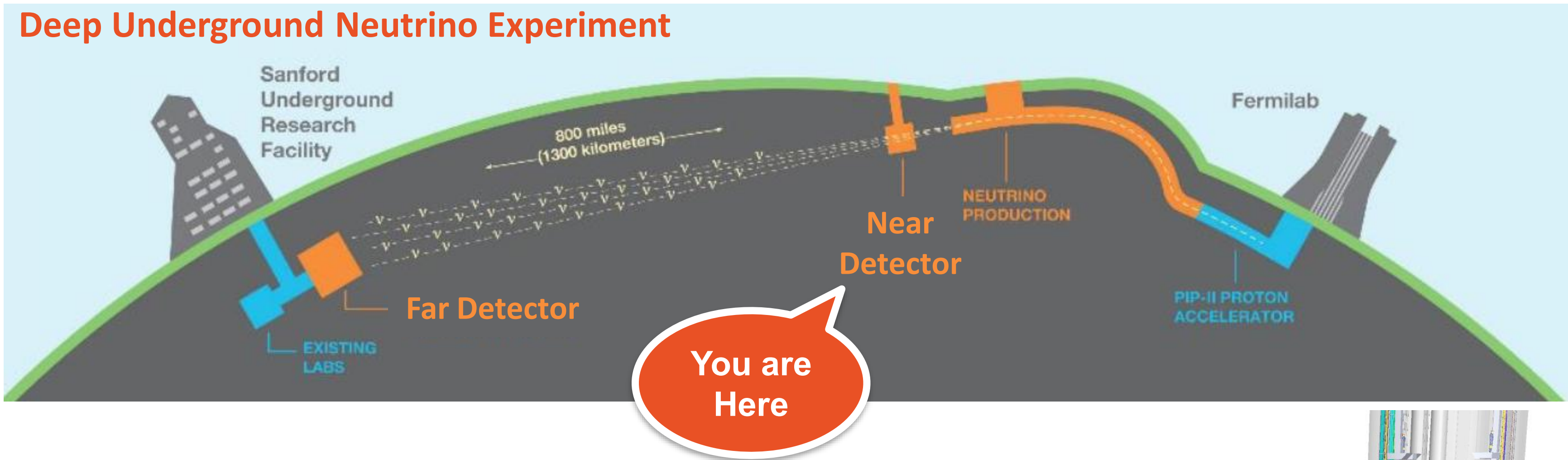
Ferrara: L. Boccia, G. Cibinetto, E. Di Fiore, F.M.Melendi, G. Mezzadri

Pavia: D. Calabro, G.L. Raselli, M. Rossella

6th DRD1 Collaboration Meeting

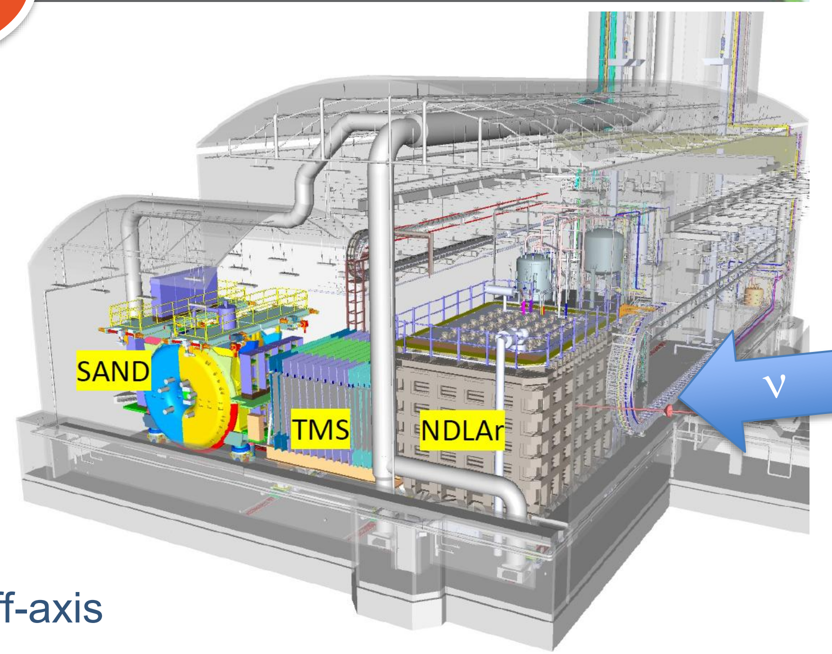
6-10 October - Warsaw

DUNE



The Near Detector

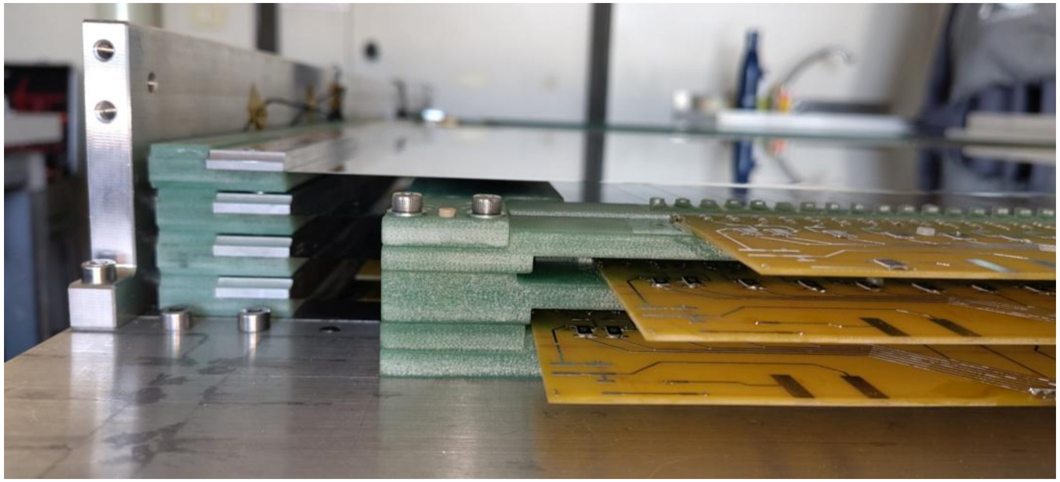
- **ND-LAr**
- **The Muon Spectrometer**
- **SAND**

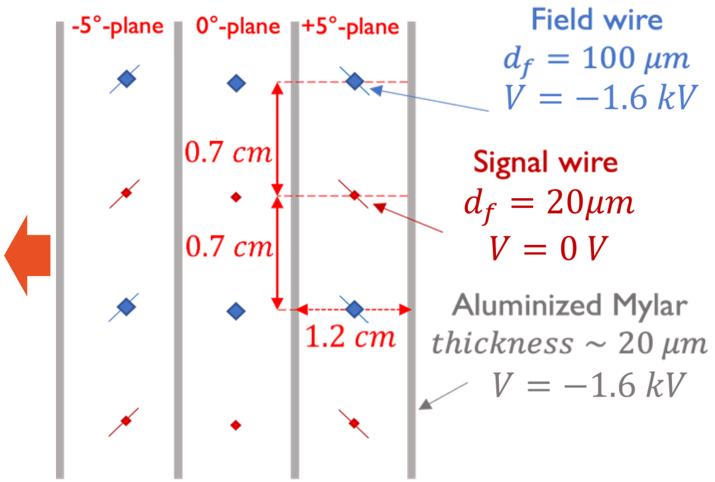


System movable off-axis

The prototype

- **120×80 cm^2** active area
- **wire planes** with stereo angles (-5°, 0°, +5°)
- **4 segmented mylar planes** (20 μm thick)
- **168** readout channels **TIGER + GEMROC**
- Gold-plated tungsten **sense** wire (20 μm)
- Copper-beryllium **field** wire (100 μm)
- Gas mixture **Ar-CO_2 85/15**

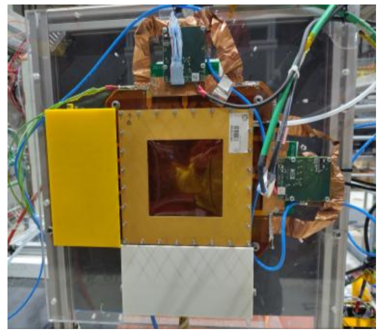




Test-beam setup

CERN-SPS H4 beamline

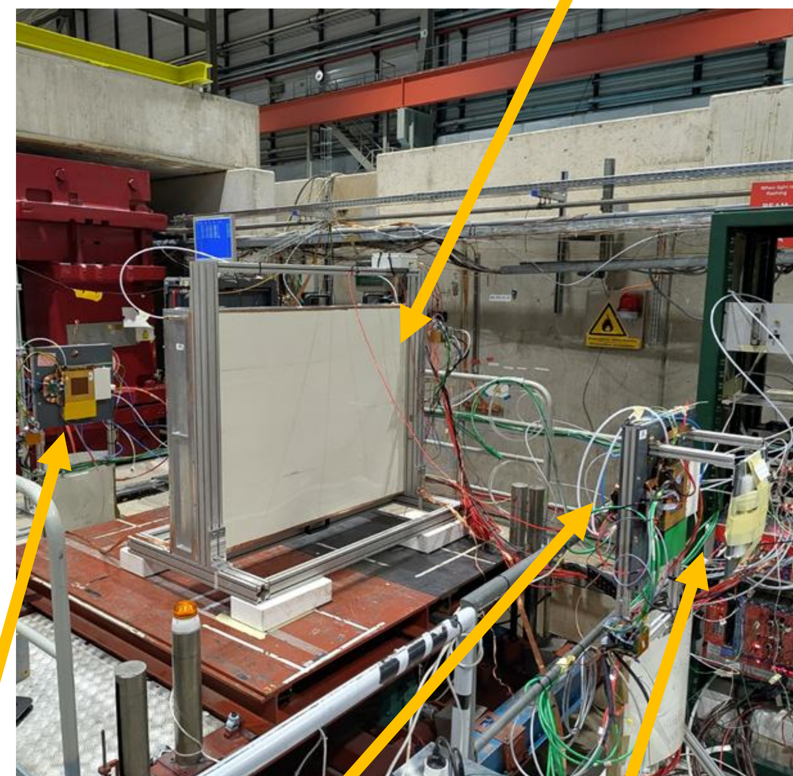
- 4 **GEM** detectors
  - ~10x10 cm^2 active area
  - σ_x=100 µm
  - **Thanks to Ferrara BESIII group!**



- 2 **plastic scintillators**
  - 15x15 cm^2 size
  - 1 cm thick
  - readout: 1 PMT Hamamatsu R9880 directly coupled

- **Drift chamber**

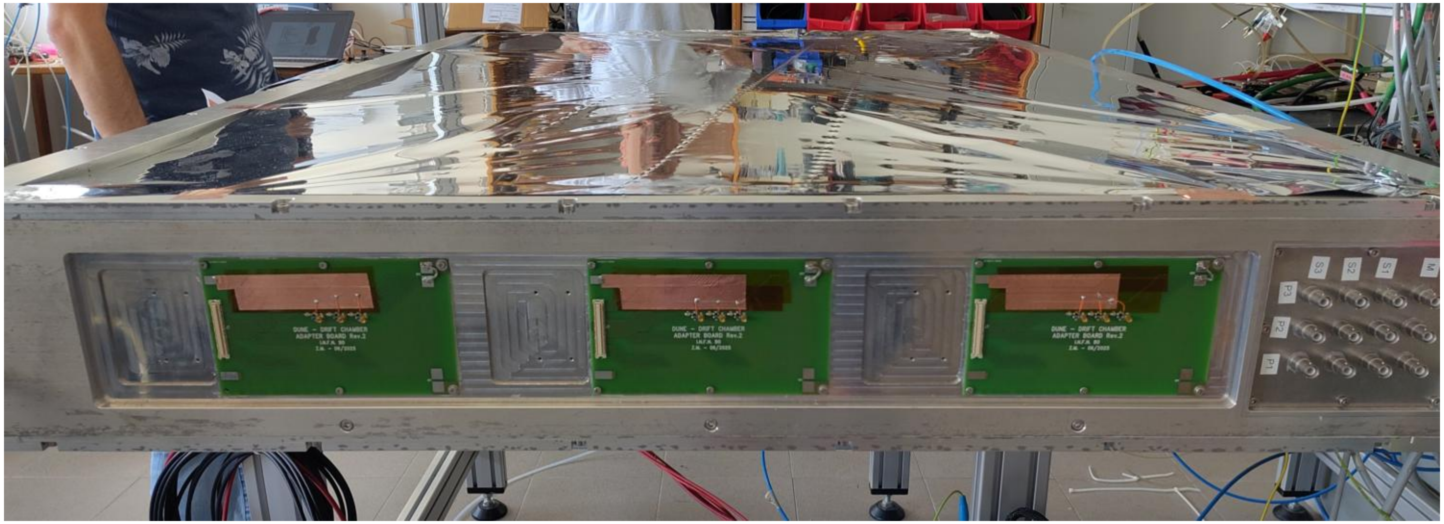
DUT : **drift chamber**



2 **GEM** (front) 2 **GEM** (back) 2 **scintillators**

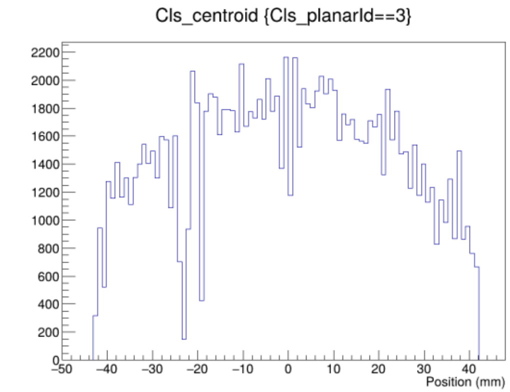
Readout scheme

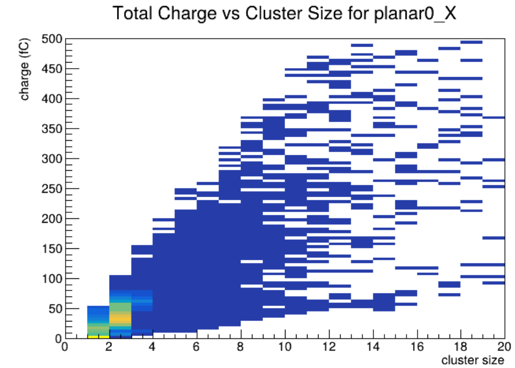
- GEMs and DCH signals read out with the **TIGER ASIC**
- For the DCH, a **transition board** routes 64 channels to a Front-End Board mounting TIGER
- **3** transition boards are necessary to read all DCH channels

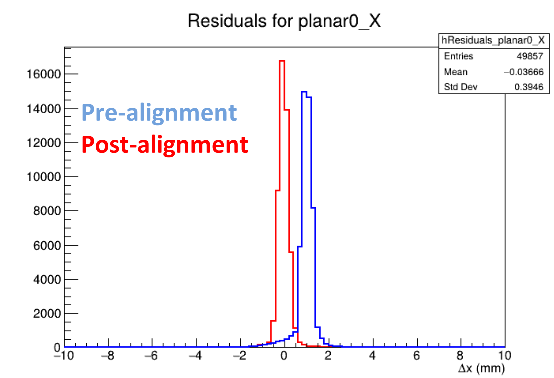


After the test-beam…

- New **analysis framework** is being developed
- **Alignment** and **tracking** implemented
- Quick-look plots available for:
  - Clusters
  - Tracks
  - Drift Chamber layers
- The goal is to reconstruct a sample of good tracks to **study drift chamber performance** *e.g.* **efficiency**, **drift velocity, spatial resolution**

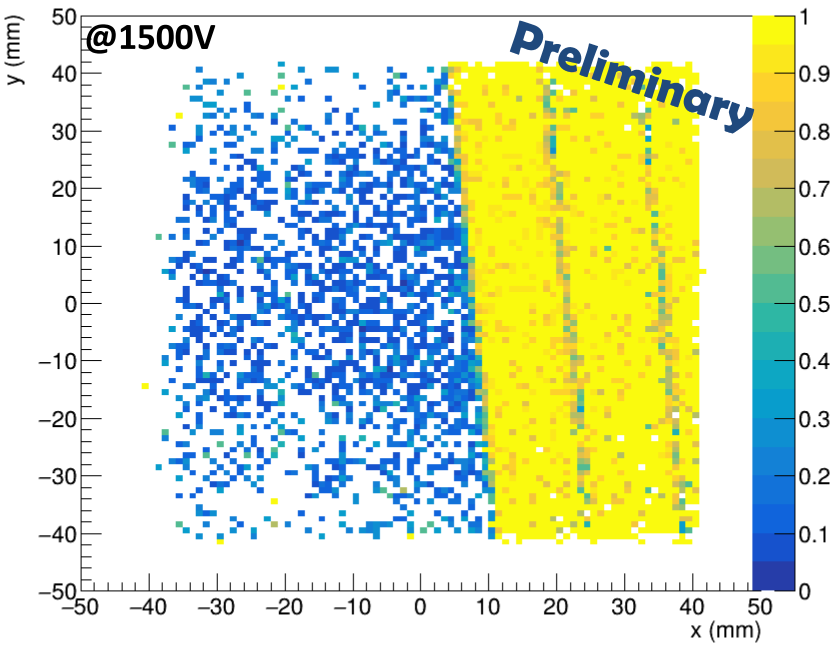


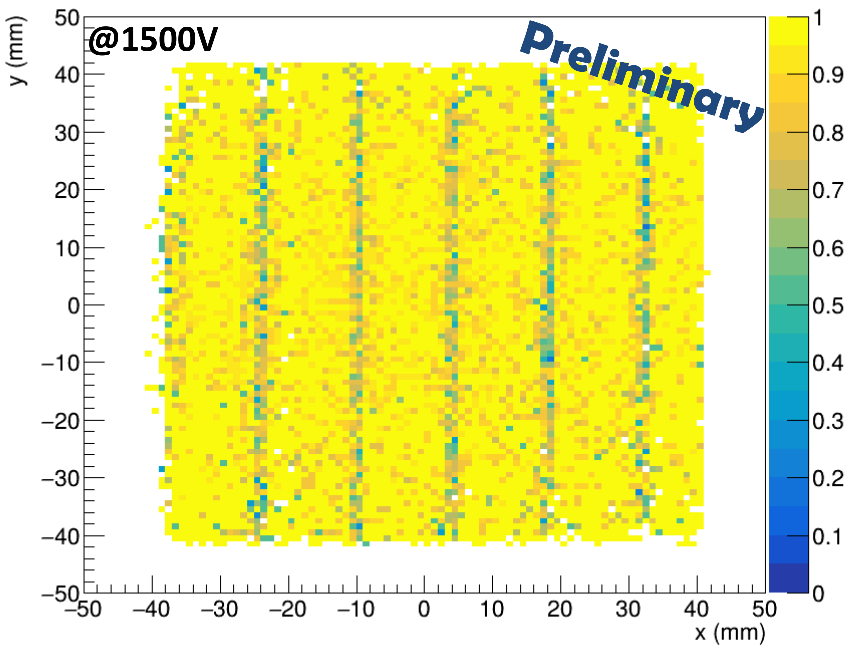




Channel Efficiency

- One cluster in each tracker + DCH signal above threshold
- Efficiency **exceeds 95%** across most of the area, with **lower values** observed **near the cell edges** possibly due to reduced charge collection near the boundaries.

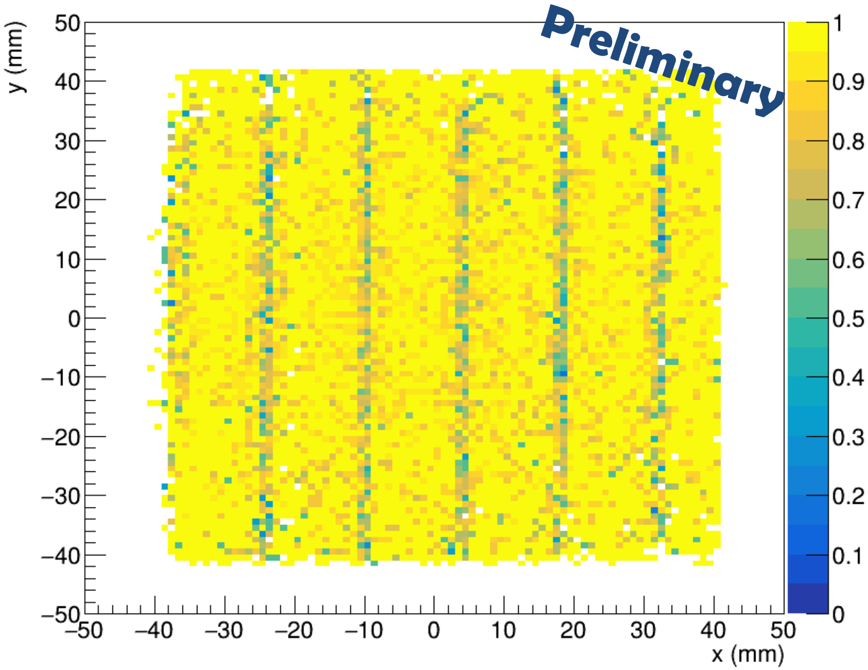




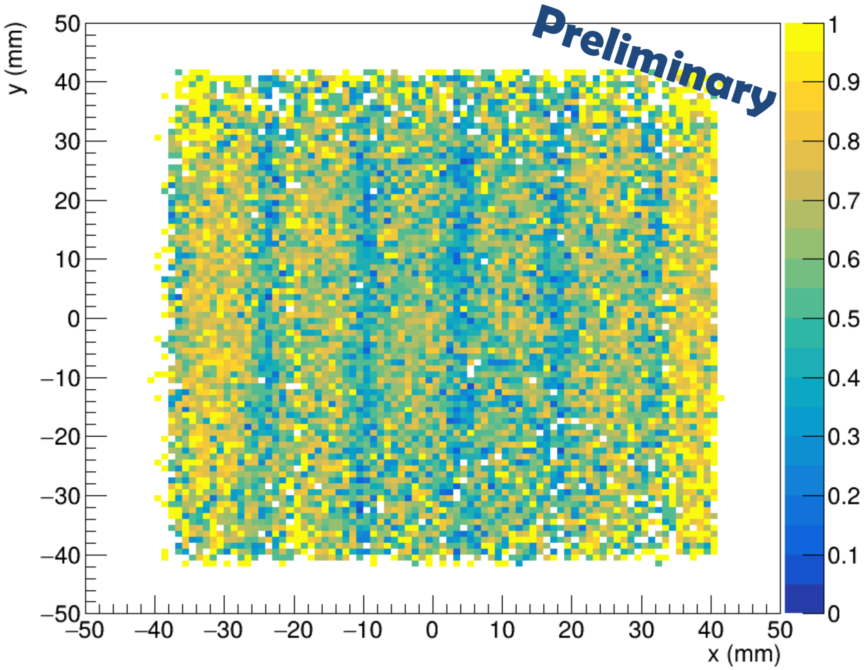
Channel Efficiency

- **Loss off efficiency** above 1600 V due to a combination of high charge and high rate

HV 1500 V



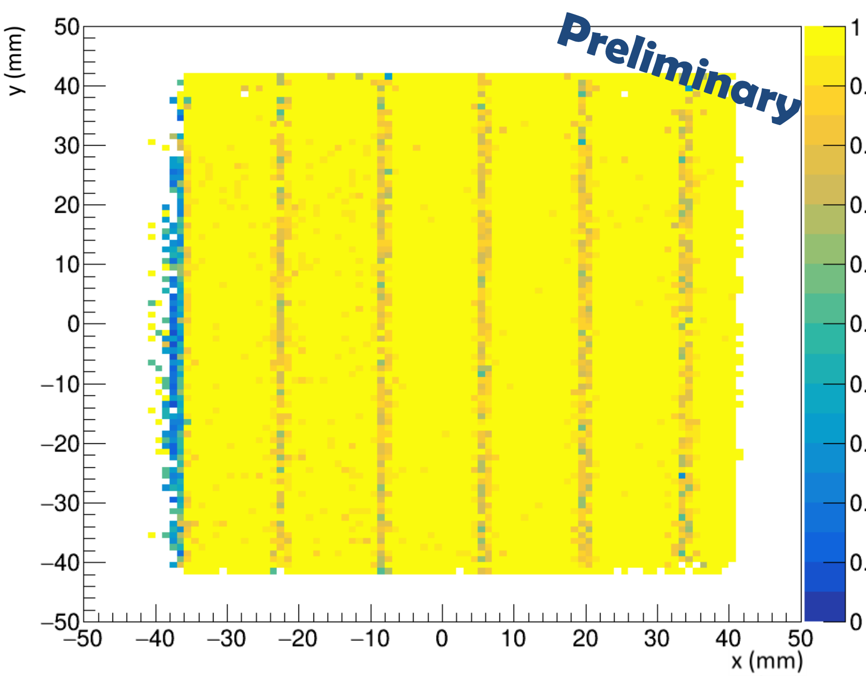
HV 1700 V



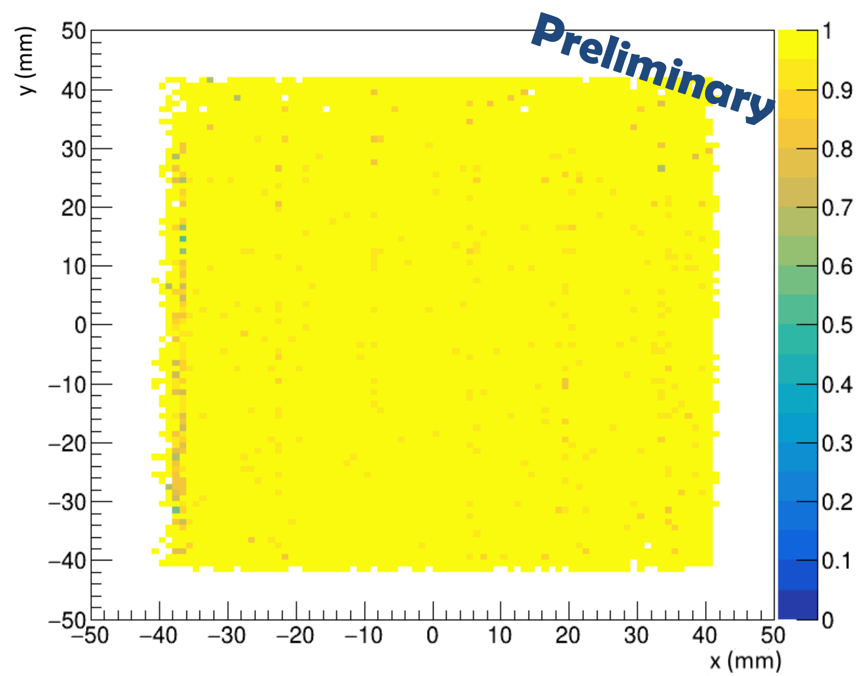
Channel Efficiency

- **Full recovery** lowering the muon rate (<1 kHz/cm^2)

HV 1500 V



HV 1700 V

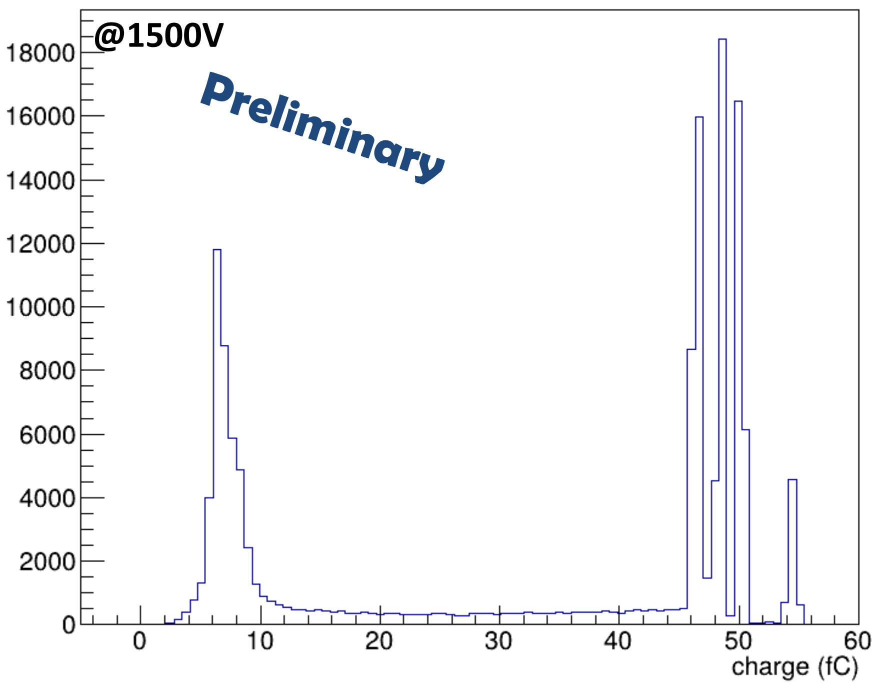


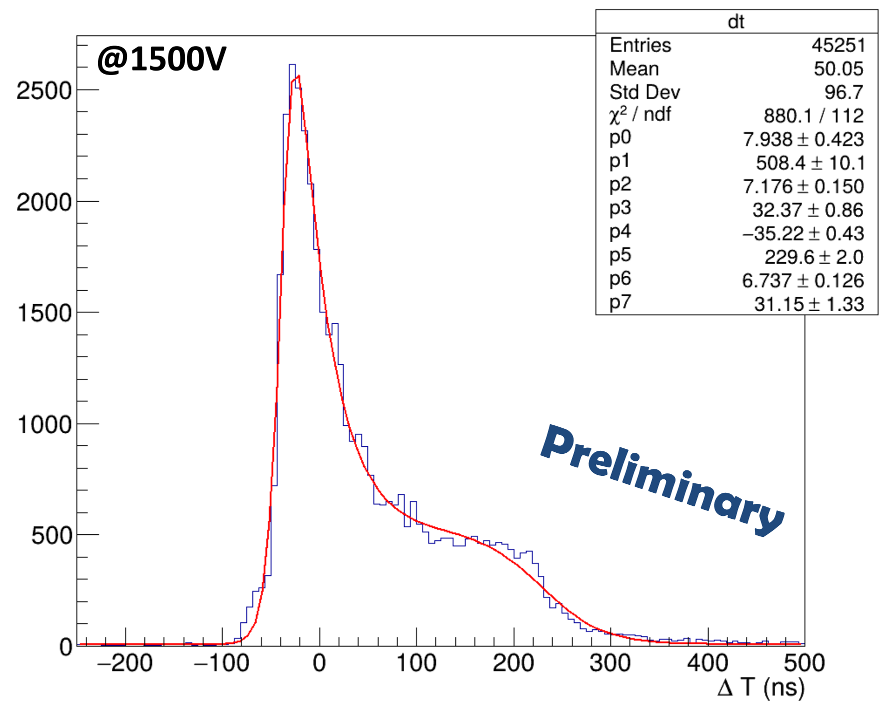
Time and charge distributions

- TIGER channels **saturate** at **~50 fC**
- At 1500V most of the signals are saturated

- **ΔT** = Time(PMT) – Time(Drift)
- Fitted with two Fermi-Dirac

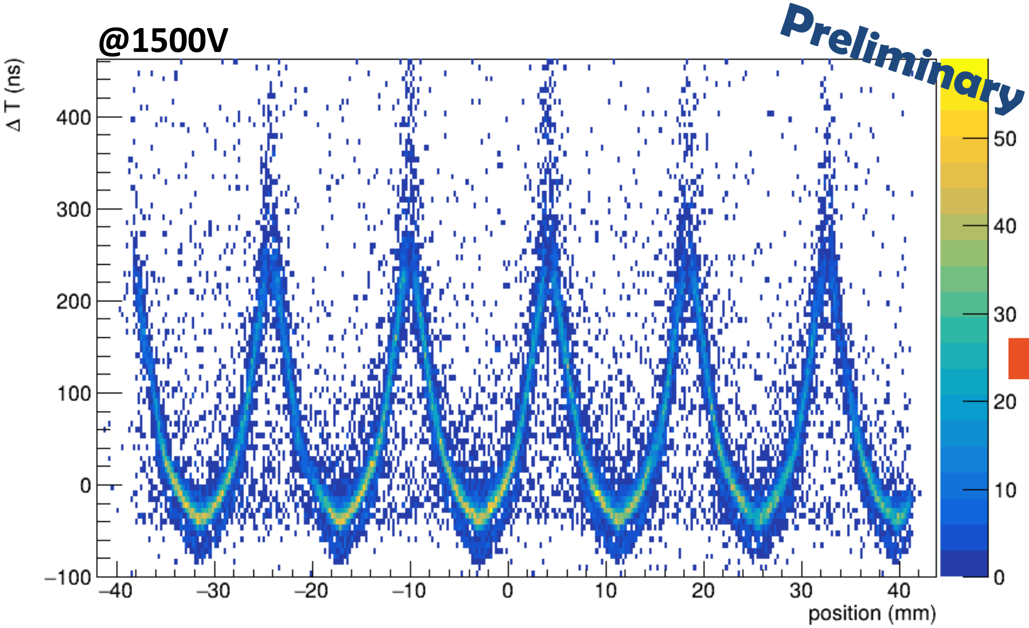
$$f(t) = p_1 + \frac{p_2\left(1 + p_3 e^{-\frac{t-p_5}{p_4}}\right)}{\left(1+e^{\frac{-t+p_5}{p_7}}\right)\left(1+e^{\frac{t-p_6}{p_8}}\right)}$$

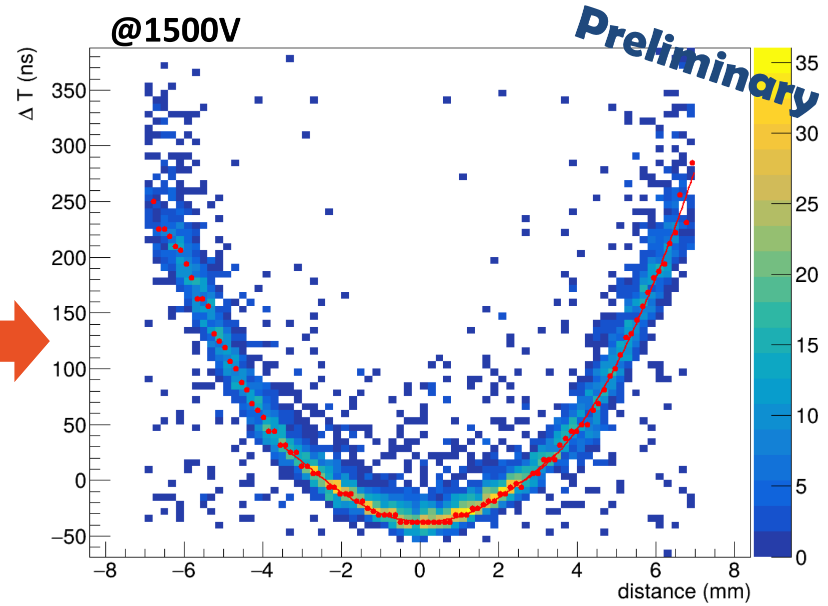




Distance-time relation

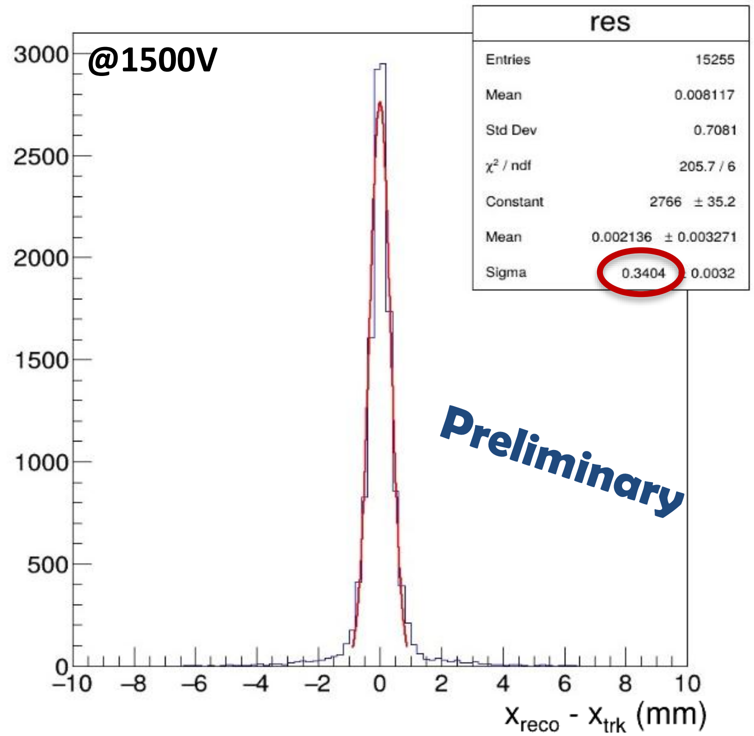
- Preliminary plot of ΔT vs. Track Position
- **ΔT** = Time(PMT) – Time(Drift)
- **Position** = x coordinate provided by the GEM tracker
- Drift velocity **not saturated** at 1500 V.





Residuals

- **Residuals distribution** for the second wire plane (0° wires)
- Selected only orthogonal tracks
- σ_x ~350 µm



Conclusions and outlooks

- All plots are **preliminary** and need further refinement
- **Analysis are ongoing**
- Operations **limited** by TIGER **saturation** and **loss of efficiency** above 1600V
- Results are promising till now

Next steps:

- **Study full signal shape** with VTX preamplifiers (1.5mV/fC) and VME digitizer
- **Beam test** @ BTF (Frascati)
- R&D on a full-scale prototype

Thank you

INFN BOLOGNA
Istituto Nazionale di Fisica Nucleare
Sezione di Bologna

DRD1
Gaseous Detector Technologies

Backup

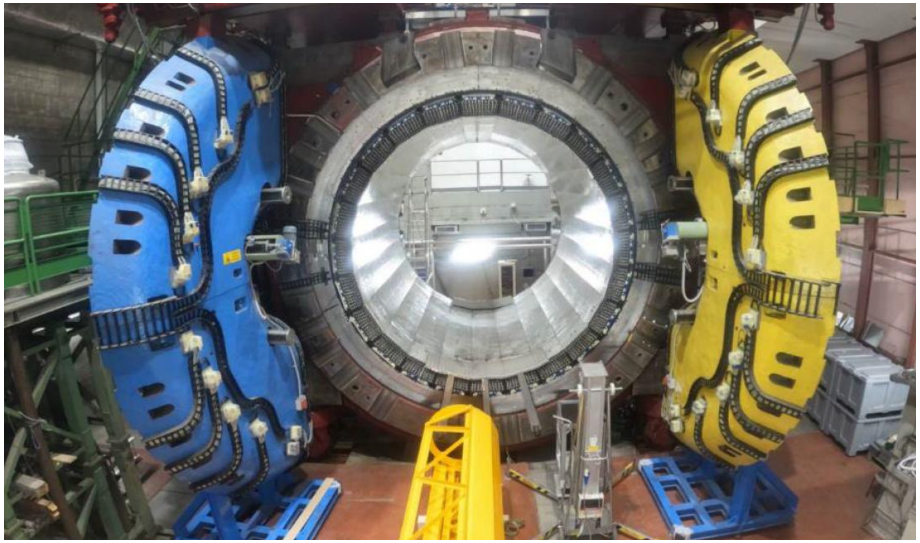
SAND

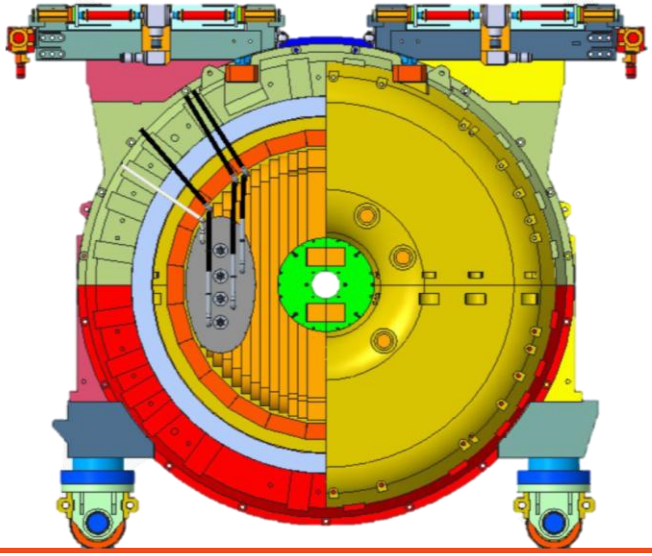
System for on-Axis Neutrino Detection

- Permanently on-axis
- **ECAL**: Pb + scintillating fibers

$$\sigma_E/E \cong 5\%/\sqrt{E(GeV)}$$
$$\sigma_t \cong 40ps/\sqrt{E(GeV)}$$

- **GRAIN** : 1t LAr active target
- **Inner Tracker**

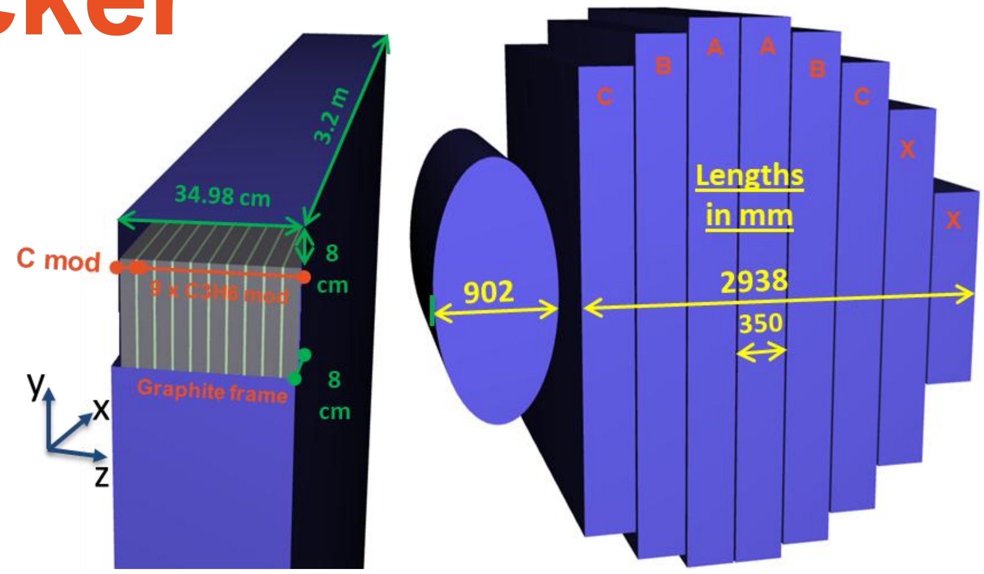




Objectives:

- Measurement of $\boldsymbol{\nu/\bar{\nu}}$ **flux** (absolute and relative)
- Measurement of ν **cross sections on Ar, CH_2, C (→ H)**
- **Calorimetry**
- **High precision tracking**

The inner tracker



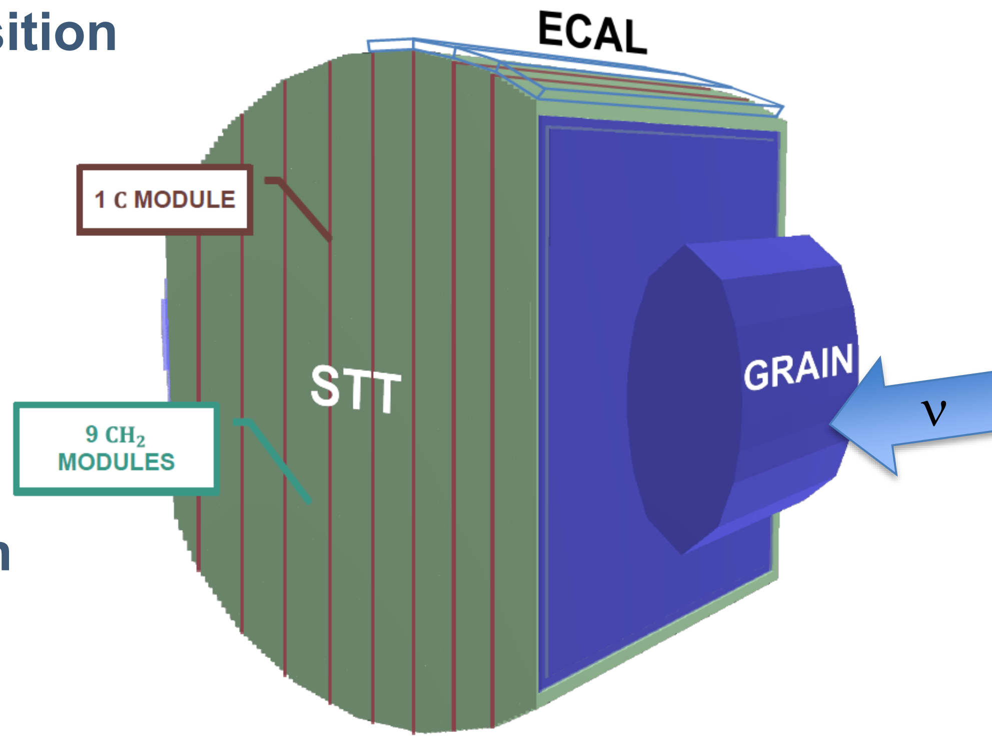
- 4.7 t tracker composed of **8 super-modules**
- Each super-module contains 10 modules
  - 9 with **polypropylene** (C_3H_6) targets, used as C-H target
  - 1 with **graphite** target
- A single module is composed by
  - a drift chamber with **3 wire planes**
  - the **target** material

- Modules height varies **from 1.2 to 3.8 m**, for a fixed width of **3.2 m**
- **~220 drift planes**
- From $\mathbf{3.6 \cdot 10^4}$ to $\mathbf{5.2 \cdot 10^4}$ **readout channels,** depending on the cell geometry

The inner tracker

Objectives:

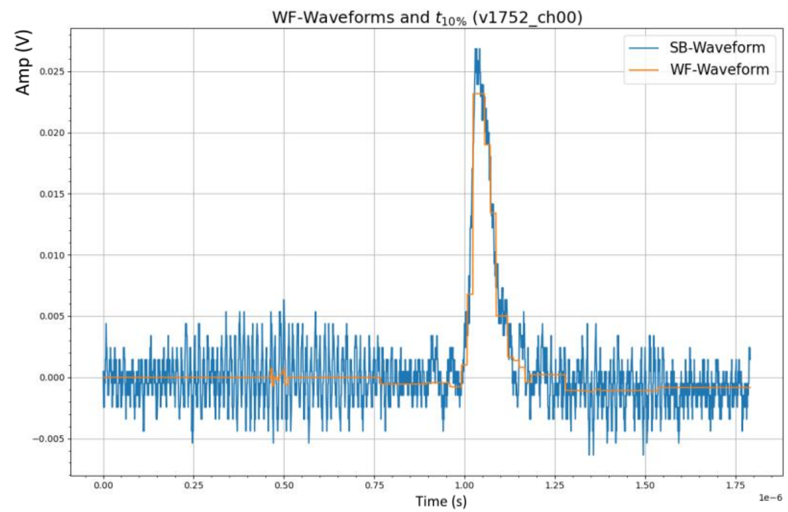
- Separate **neutrino and antineutrino events** (charge ID)
- Identify **beam flavor composition**
- Measure the **energy** of **charged** and **neutral particles*** (π_0, n)
- **Correct systematic errors** combining H and Ar cross sections
- Localize **neutrino interaction vertices** in the target material (precision < 5 cm)
- Timing resolution **< 10 ns**

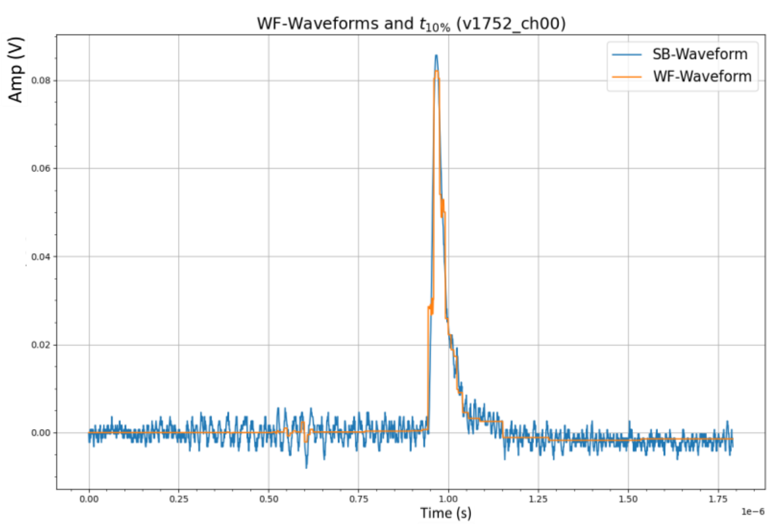


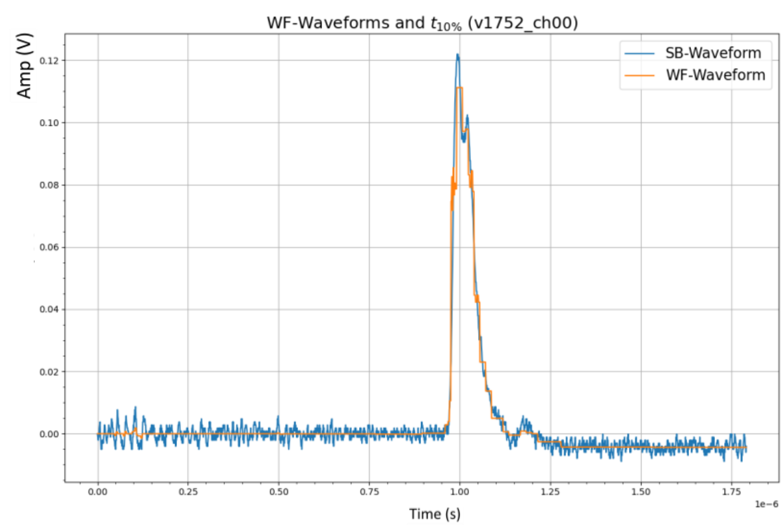
* with the help of the calorimeter

Drift chamber signals

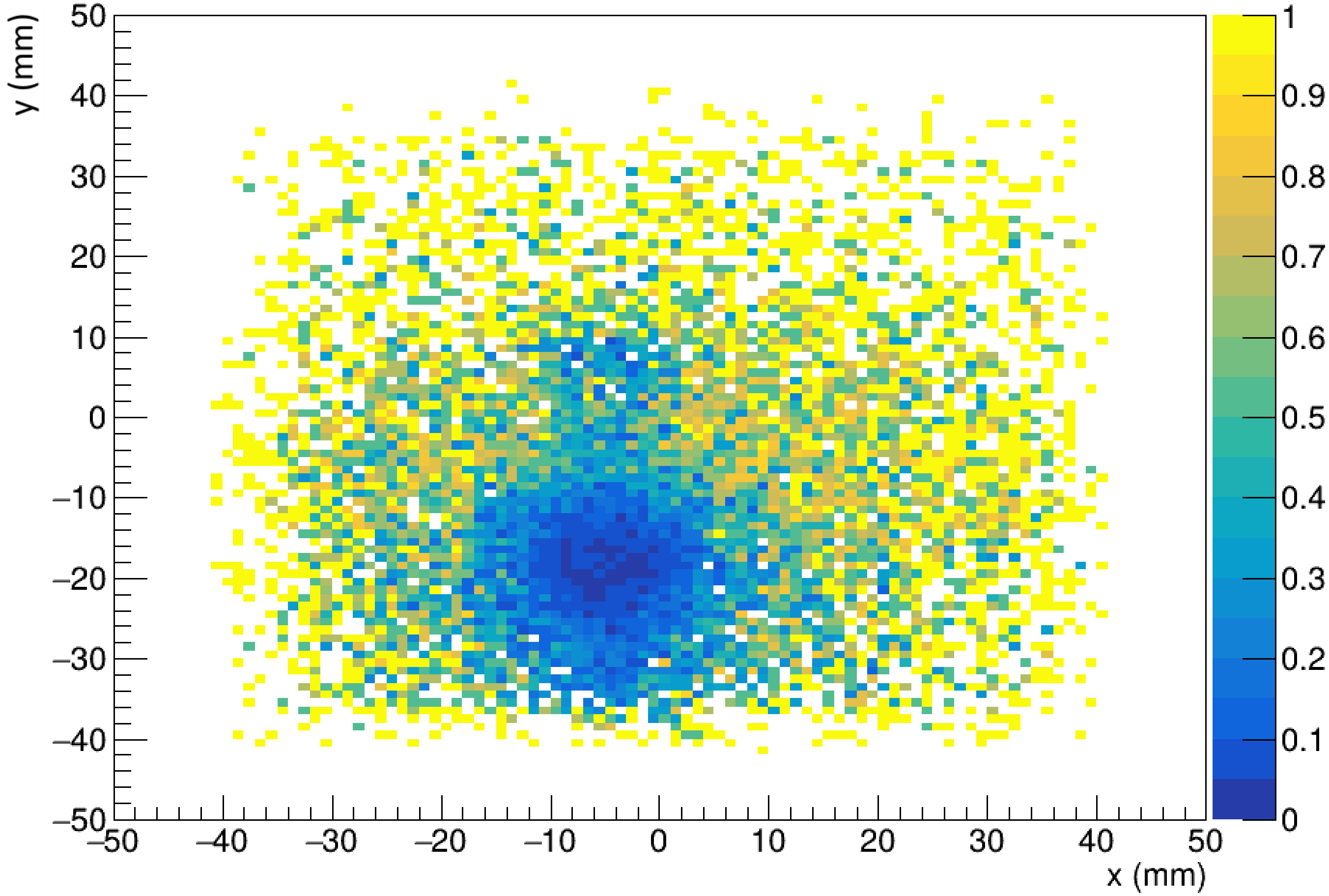
- From Garfield++ a 3×10^4gain is expected at 1600V
- Signals taken with VTX amplifier + VME digitizer
- Gain: 1.5 mV/fC







Pion run



y (mm)
50
40
30
20
10
0
−10
−20
−30
−40
−50
−40
−30
−20
−10
0
10
20
30
40
50
x (mm)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0