First results of a FINUDA small drift chamber in a cosmic ray test

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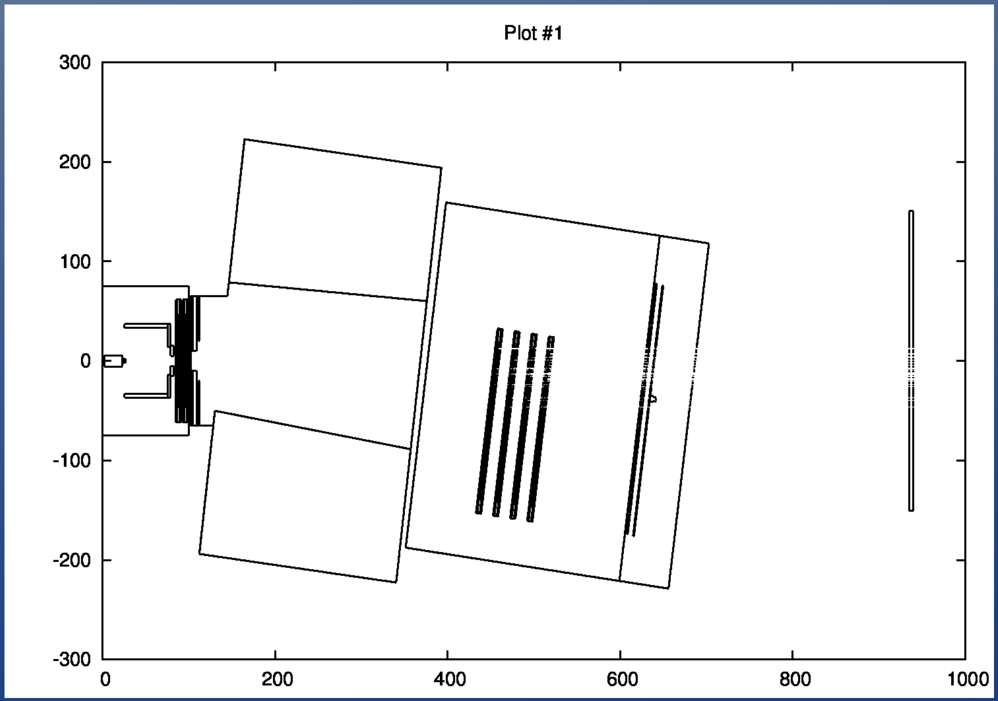
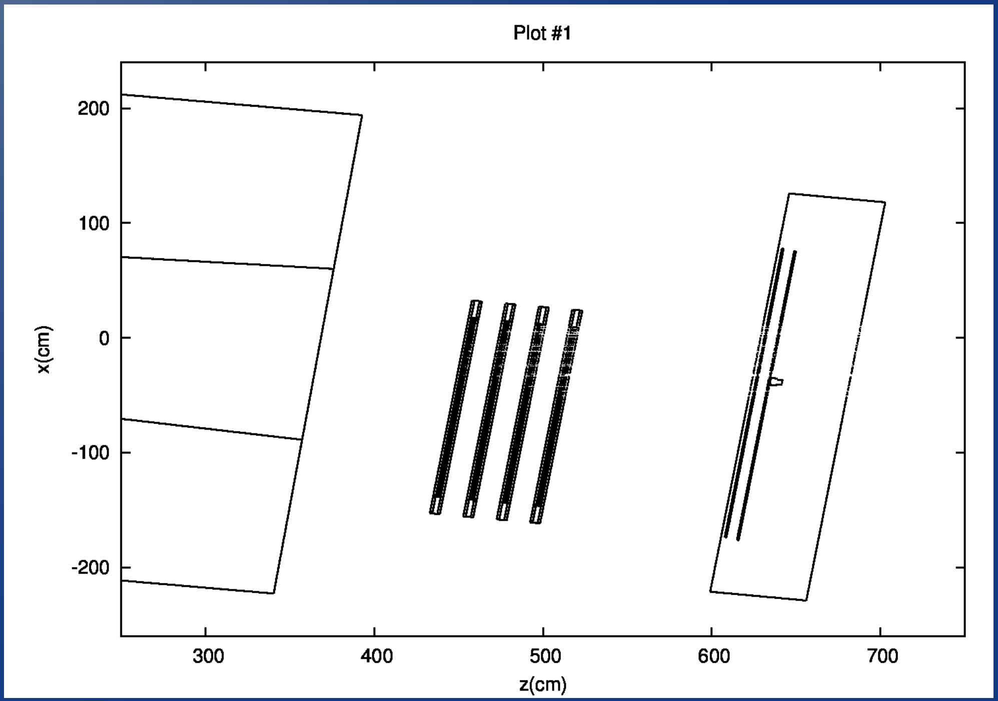
FINUDA drift chambers to improve the track reconstruction of FIRST

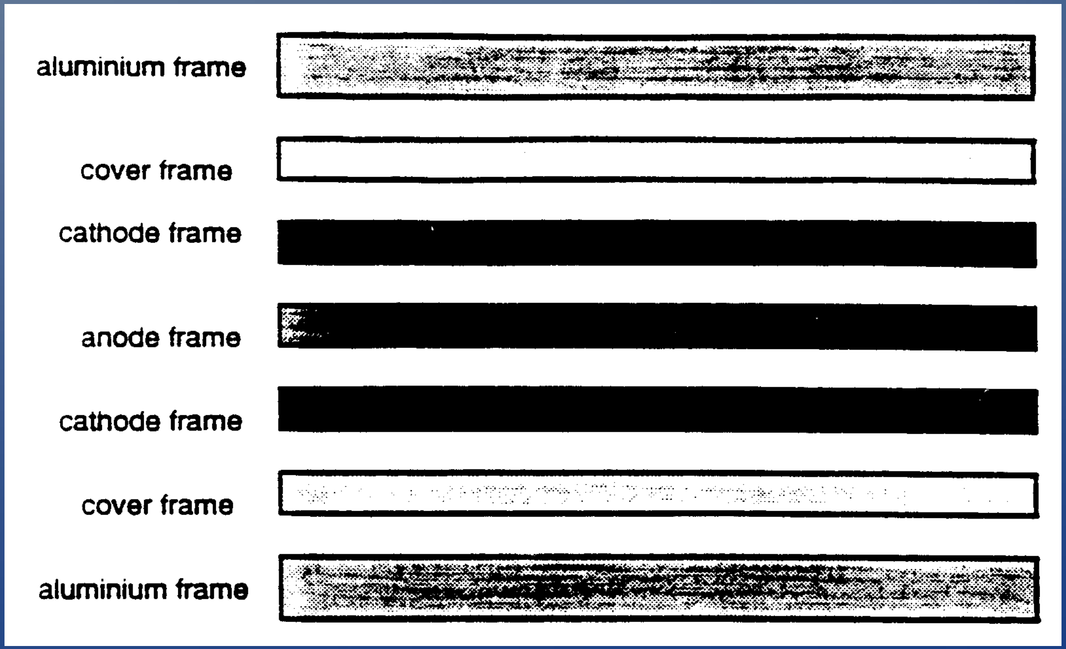
- In the previous FIRST meeting in Catania a configuration of 4 big drift chambers after the magnet was proposed as a possible upgrade of the FIRST detector
- This solution can contribute to the tracking system after the magnet without introducing high fragmantation, thank to the very thin maylar window (36 μm in total for each chamber)
- Their design follows the tracking system requirements of large acceptance, trasparency and high spatial resolution





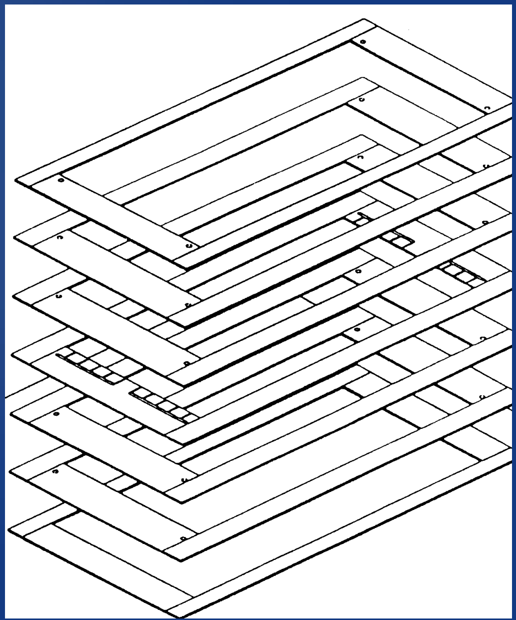
FINUDA drift chambers - 1

- Rectangular wires chambers with resistive anodes to obtaine the coordinate along the sense wire with the charge division method.
- Two different dimensions of drift chambers: $(123\times39\times6)\ cm^3$ the small one and $(187\times68\times6)\ cm^3$ the big one.
- Each drift chamber is built up of five glass fiber frames supporting mylar, cathode and anode wires and two external aluminum frames.



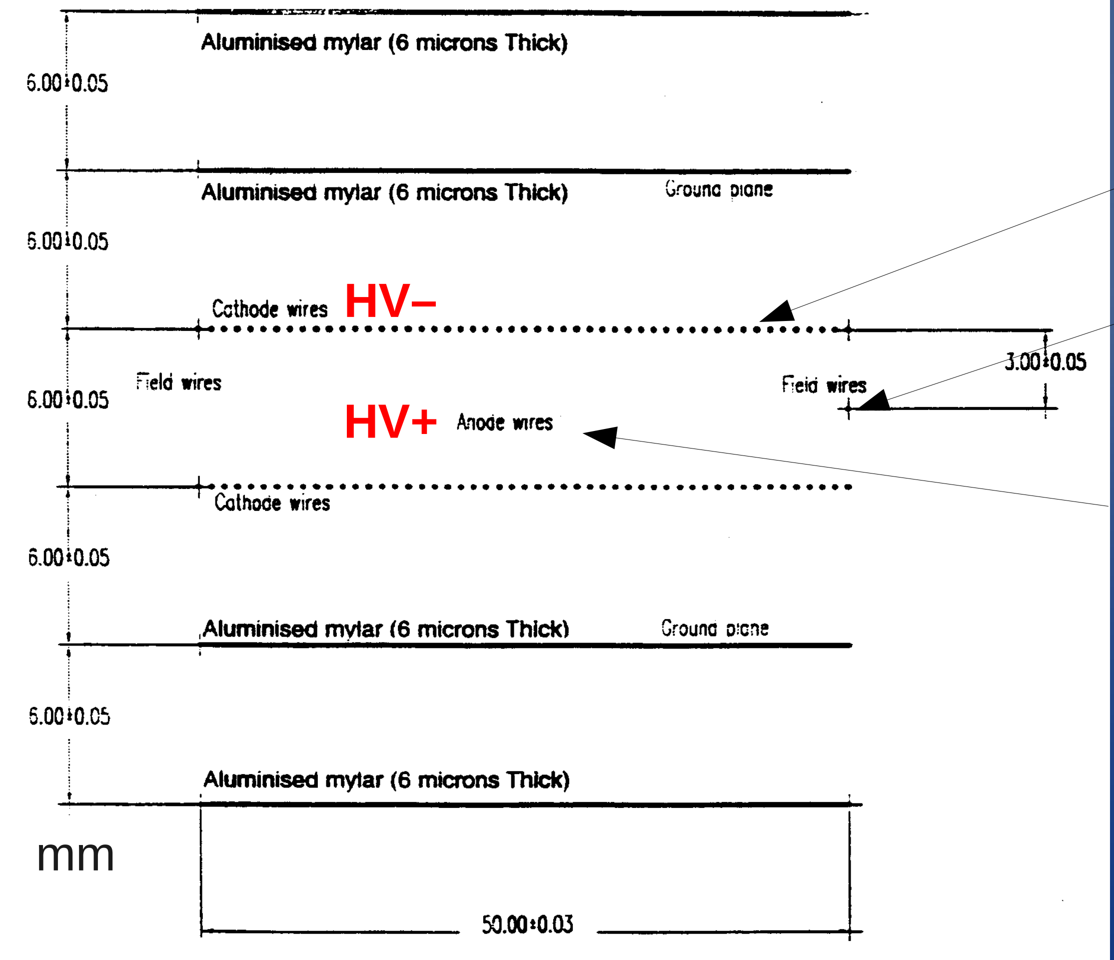
Aluminized mylar sheets glued on both sides of the frame

Drift region



FINDUDA drift chambers - 2

- Contiguous drift cells 5 cm wide: 6 for the small and 11 for the big chambers
- There are two parallel layers of cathode wires at a relative distance of 6 mm, with two anode wires placed in the center at a relative distance of 200 μm (in order to eliminate the left-right ambiguity)



Copper-Beryllium cathode and field wires of 50 μm of diameter.
Cathode wire pitch is 1 mm.

Field wires in anode plane spaced by 50 mm

Stainless steel anode wires of 25 μm of diameter.
The separation between anode doublets is 50 mm

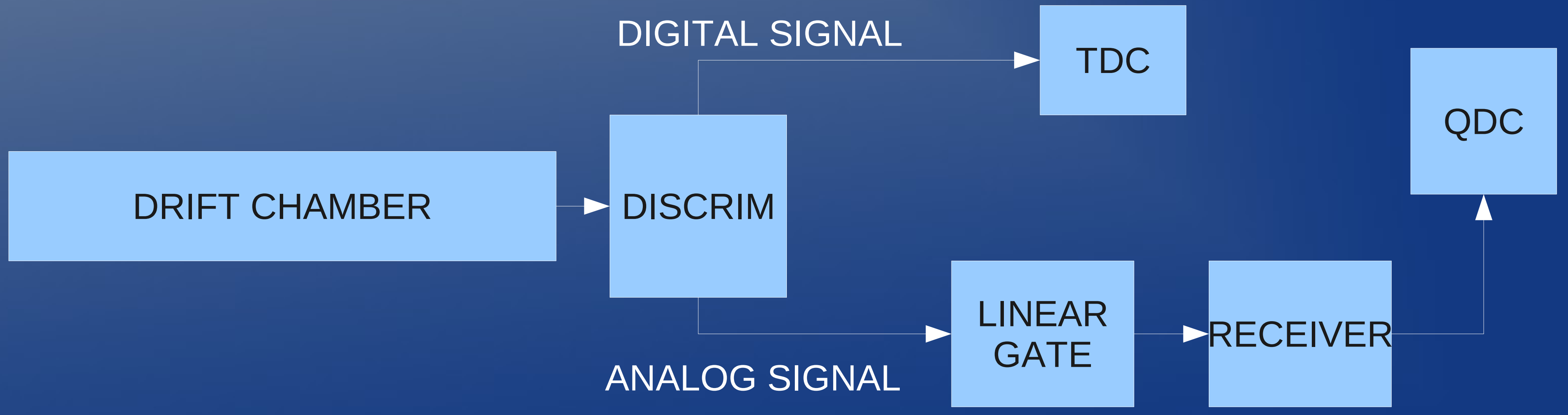
Experimental setup - 1

- The main goal of the cosmic ray test is to study the spatial resolution of the drift chamber that will be used for the fragment tracking after the magnet.
- The experimental setup consists of a trigger system composed of two scintillators of surfaces (20×3.5) cm^2 and (20×9) cm^2, a small FINUDA test chamber and the electronic chain for the DAQ.
- The digital part of the electronic chain consists of a discriminator and a TDC, aimed to provide the spatial resolution on the coordinate along the drift direction.
- The analog part of the electronic chain consists of a QDC and an electronic system which allows to perform a precise charge division measurement of the longitudinal coordinate (less then the 1% of the wire lenght according to FINUDA measurements) composed of a Linear Gate and a Receiver.

Experimental setup - 2

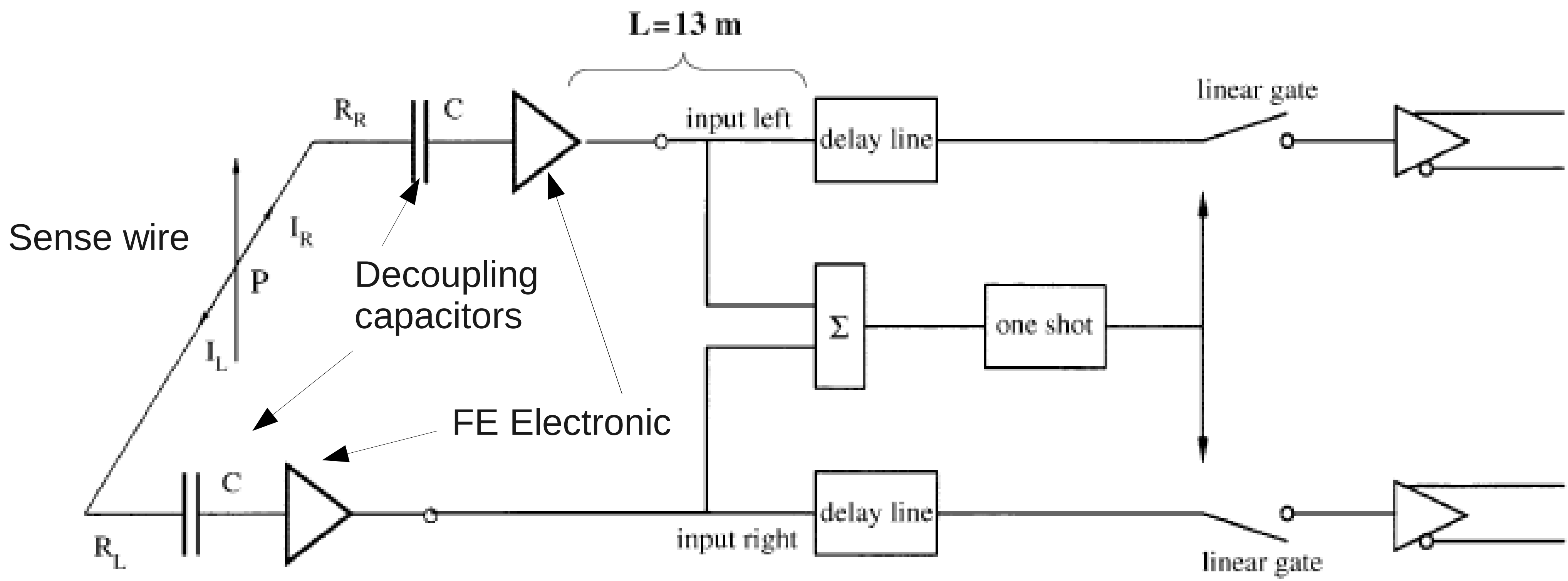
A small chamber is composed of 6 cells and 12 sense wires, therefore Its readout needs 24 analog and 24 digital electronic channels

- Double Threshold Discriminator: 32 digital and 32 analog channels
- TDC: 64 channels, resolution ≈ 1 ns
- Linear Gate and Receiver: 32 channels. Between them a delay line of twisted cables of 600 ns
- QDC: 64 channels, resolution ≈ 400 fC/counts



The Linear Gate

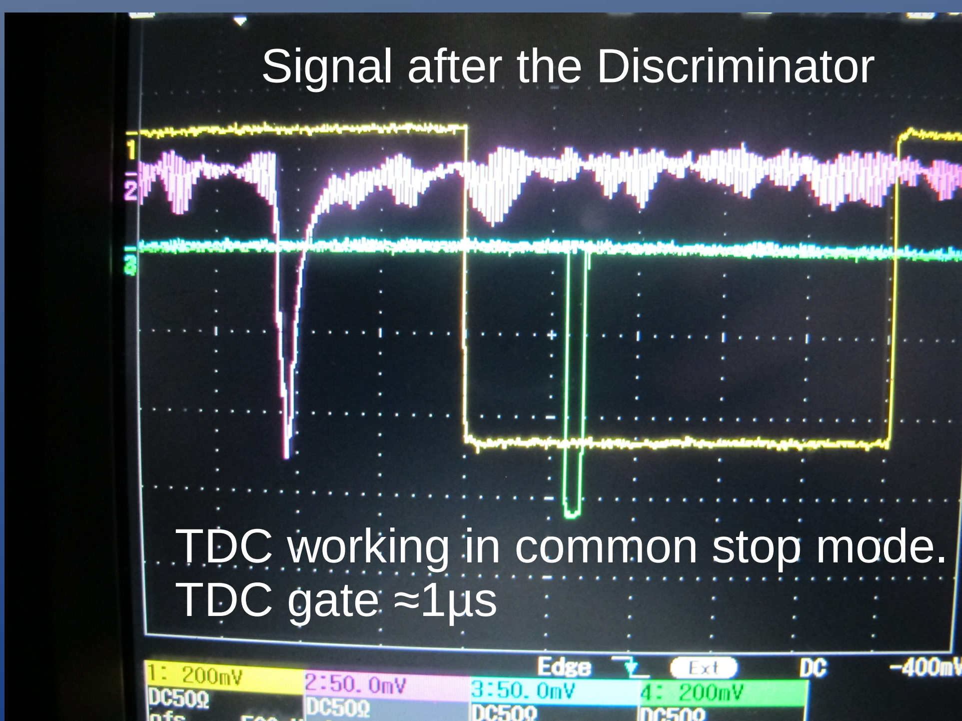
- The Linear Gate sums the front and the rear of each wire, and if the sum is greater than the threshold of 30 mV it opens, and allows the two signals to pass through and to be trasmitted to the QDC.
- The gate opens only for the duration of the anode pulse (120 ns): only this part of the signal is trasmitted to the QDC

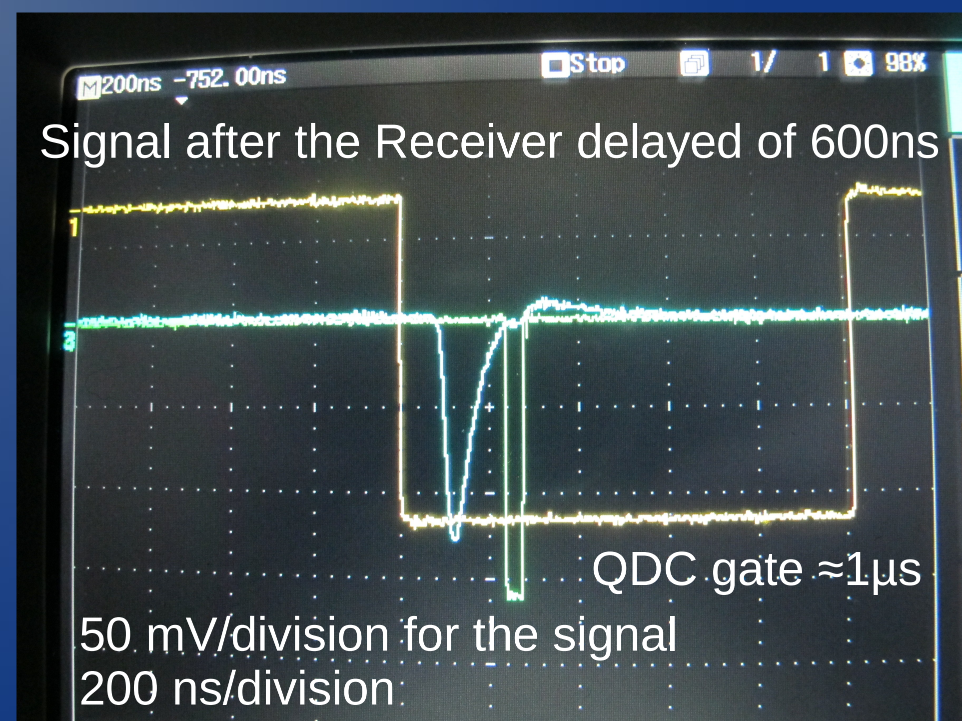


Experimental setup - 3

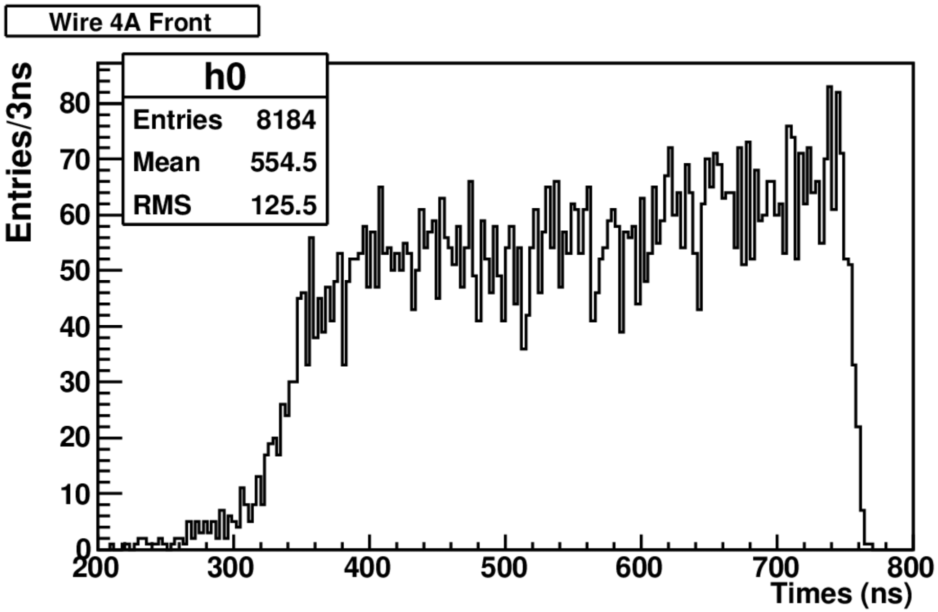
The chamber signal, TDC and QDC gate

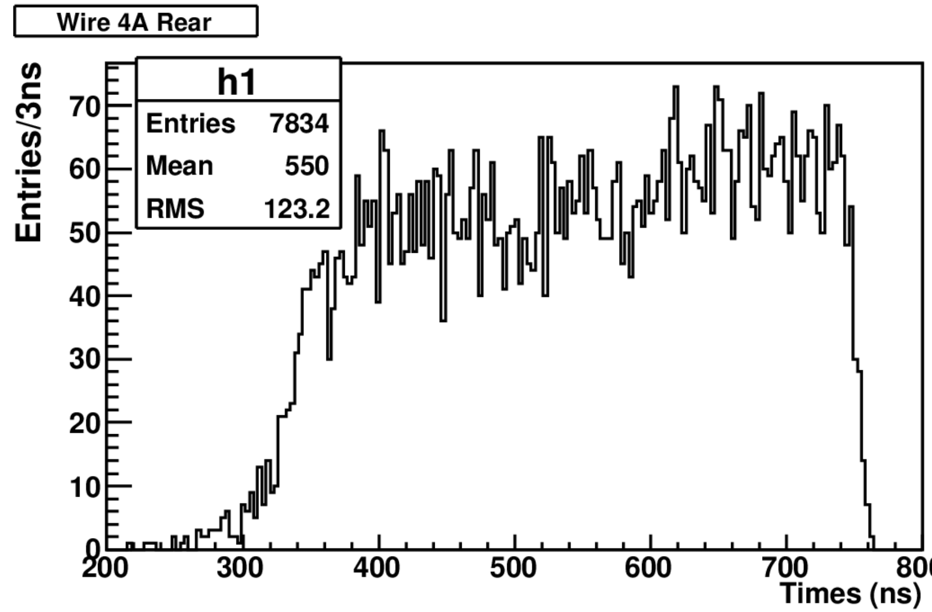
- A small drift chamber is working filled with a Ar-CO2 (80-20) gas mixture at the operating voltage of +1670 V, -3340 V
- At the threshold of 40 mV, the efficency is ≈90% and the single rate is ≈20 Hz
- At this working voltage the signal rise time is less than 40 ns and its amplitude is in the range 50-350 mV

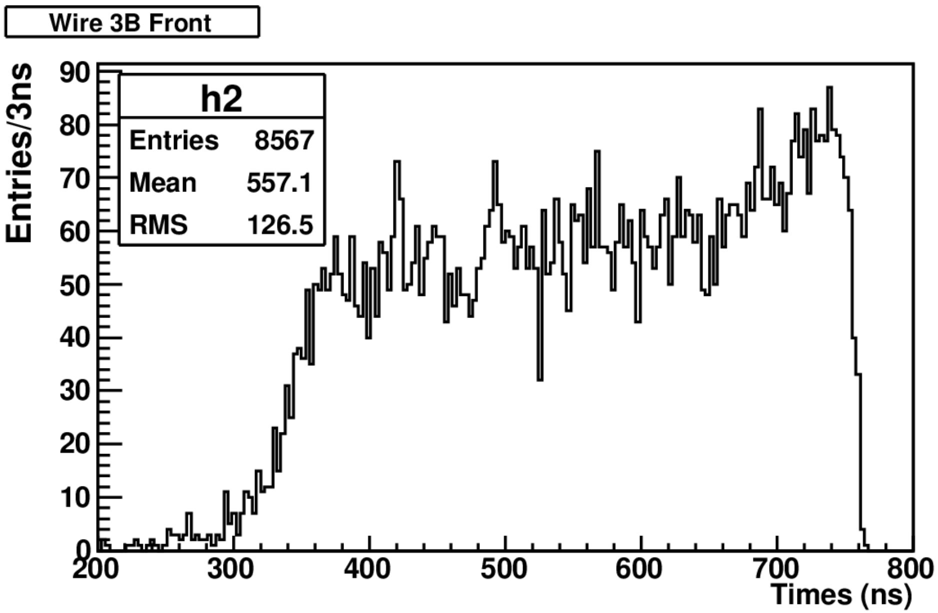


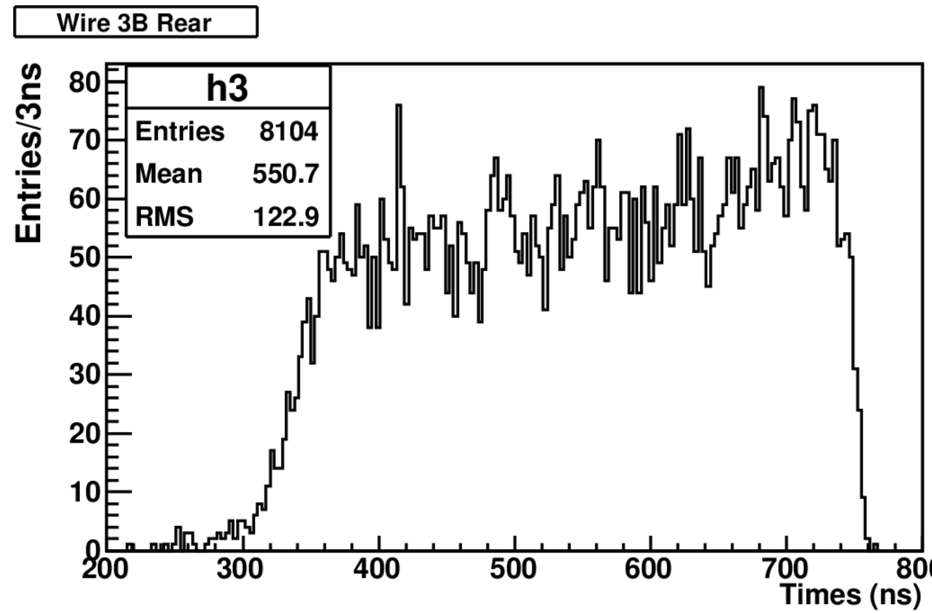


Times Distributions







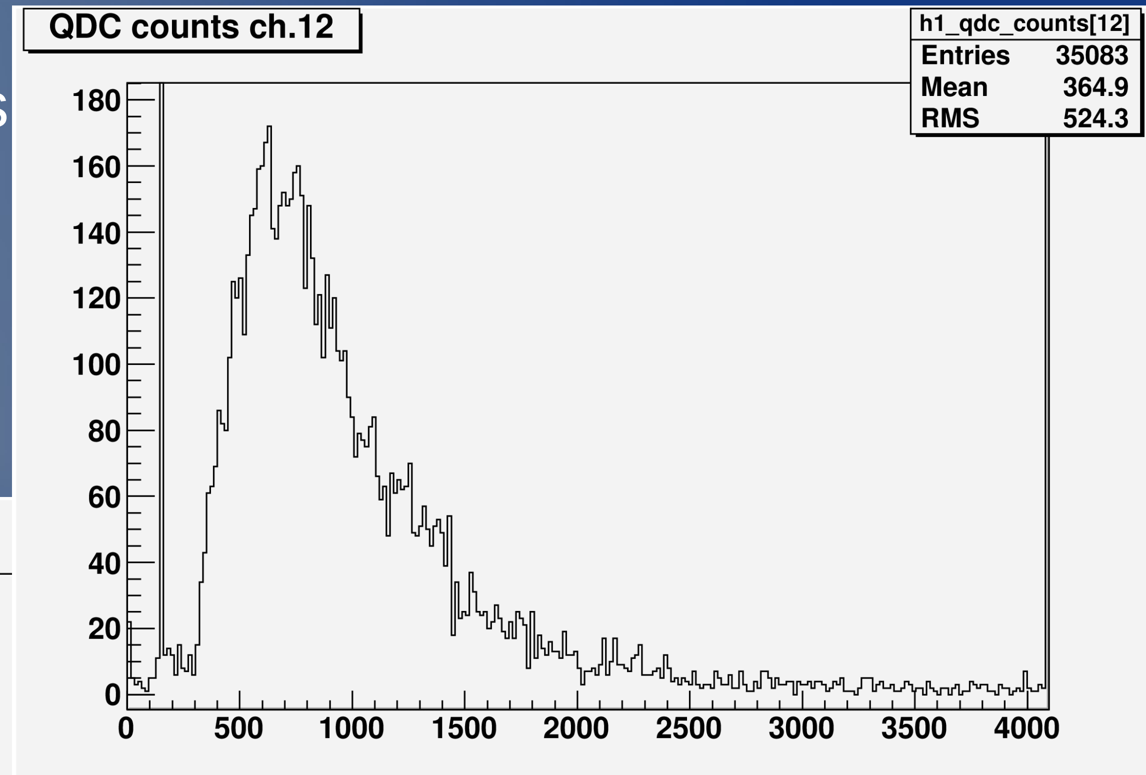


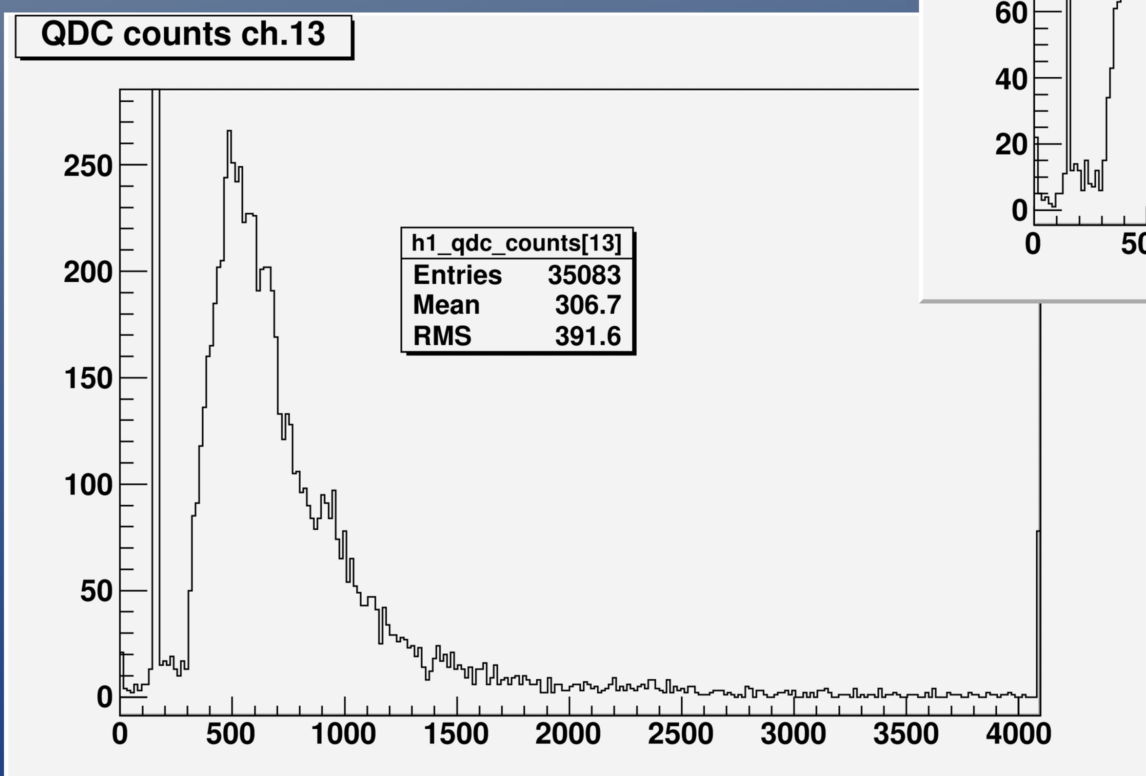
Some considerations about the time distributions

- TDC works in COMMON STOP so the events at 760 ns are the ones near the anode
- The time jitter of the signal is ≈ 500 ns
- In a naive costant velocity model the drift velocity can be estimated from the maximum drift time and the cell dimension read from one wire of the doublet (2.5 cm): $\mathbf{v_{drift} \approx 50\ \mu m/ns}$
- The distributions are “almost” flats as expected with cosmic rays (randomly distributed), so we can expect that the drift velocity is almost saturated
- The excess of counts near the anode can be due to the other half cell too and not only to a major electric field
- We can roughtly extimate the spatial resolution along the dritf direction from the rise of the time distribution near the anode (≈ 20 ns) —> **1 mm** !!
- However an accurate model of the drift cell is essential for high precision track reconstruction

Charge Distribution

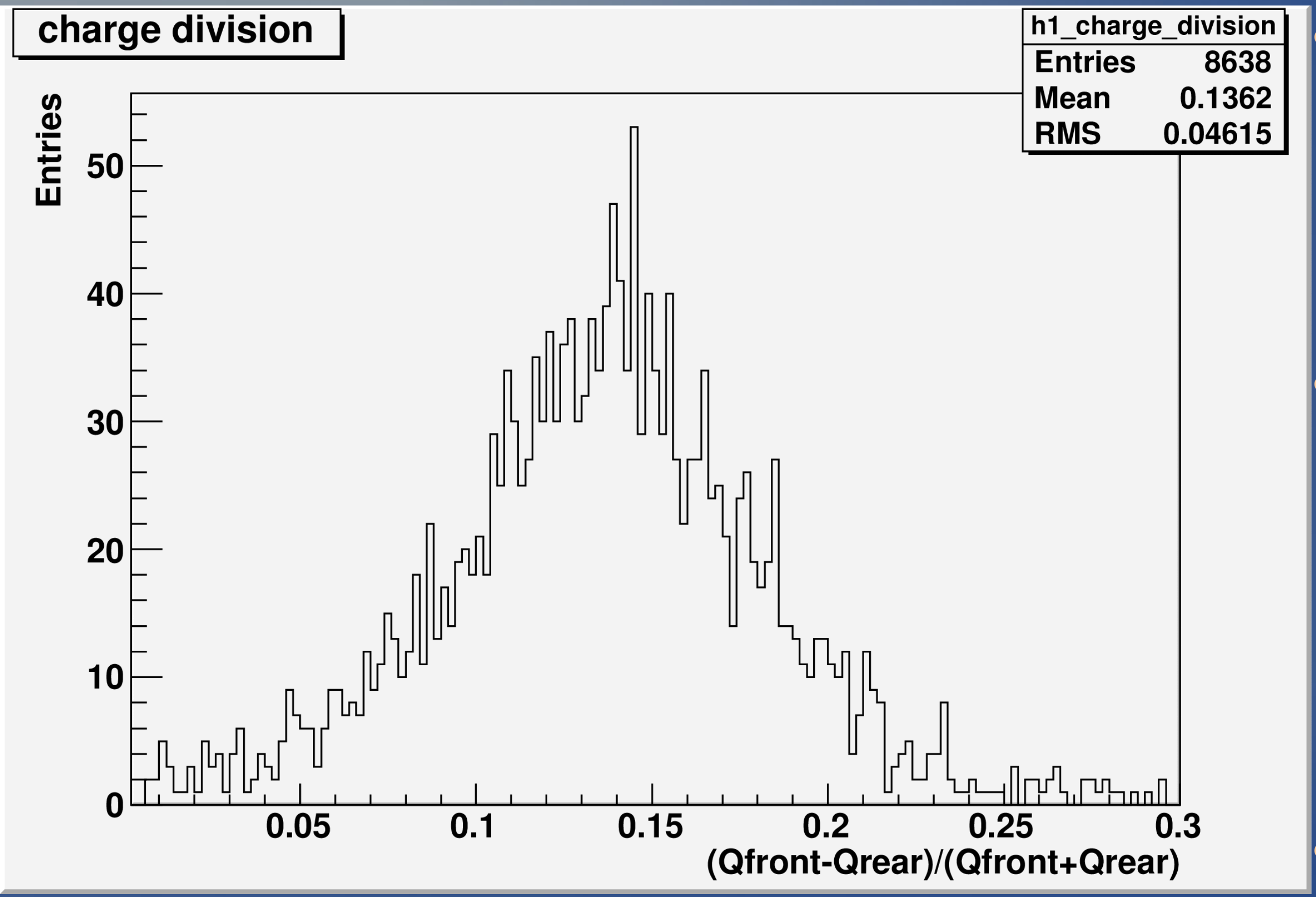
- These are the charge distributions in QDC channels for the wire 3B front and rear
- The signal is well separeted from the noise for this HV run





- The acquisition of pedestals is possible sending a NIM signal to a special input of the Linear Gate that so opens the gates for signals of each amplitude!

Charge Division Distribution



- The coordinate along the wire is: X = k × (Qf-Qr)/(Qf+Qr) where k is a proportionality factor depending on the wire resistivity and length.
- Taking the mean and the rms of the distribution and knowing the position of the trigger and the length of the anode wire (93 cm) we can roughtly extimate the spatial resolution along the wire: —> **3.4 cm** !!
- This is not so bad considering:
  - the roughtly calculation
  - expecially that the scintillators are 9 cm and 3.5 cm wide!

Conclusions

What has been done

- A cosmic rays test for a small drift chamber is working at LNF
- The DAQ seems to work correctly
- The first time and charge distributions seems reasonable
- It is been possible to give a first extimation of the spatial resolution of the chamber: 1mm along the drift direction and 3.4 cm along the sense wire!

Next steps

- Improvement the acquisition code and the analysis algorithms
- Simulate the electric field in the cell with GARFIELD to obtain a precise knowledge of the drift space-time relations
- Test the big drift chambers
- ...and finally study the performances of the chamber in a test beam, first with elecrons at the BTF (LNF) and then with ions at LNS