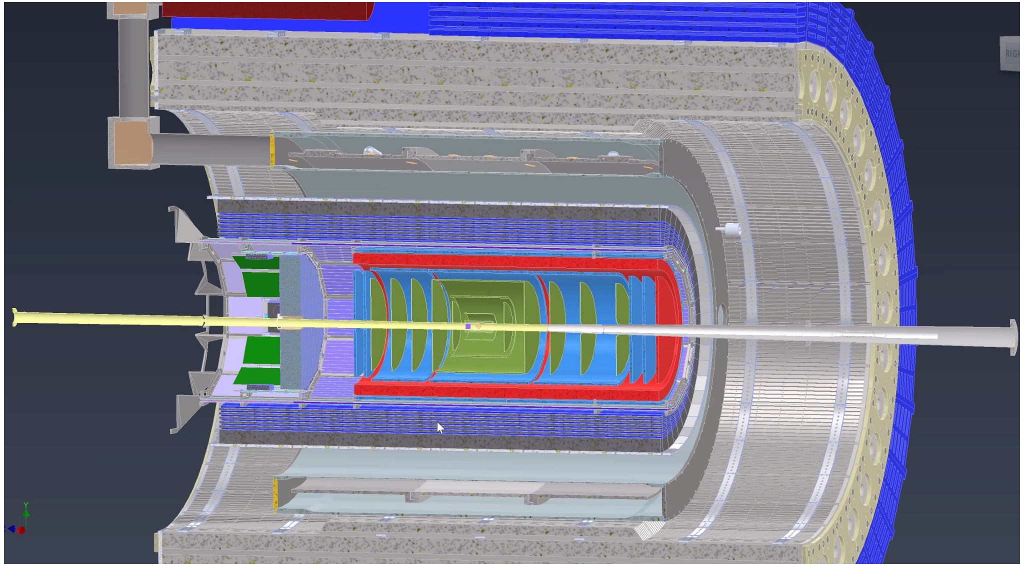


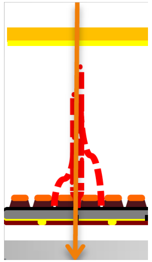
MPGD - ECT

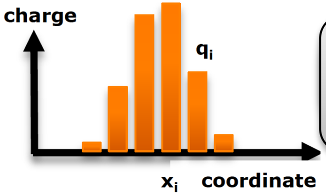
μ – TPC readout and synergies with the ePIC detector

Annalisa D'Angelo

University of Rome Tor Vergata & INFN Rome Tor Vergata Rome – Italy

μ-RWELL Position Resolution





$$x_{hit} = \frac{\sum x_i \cdot q_i}{Q_{tot}}$$

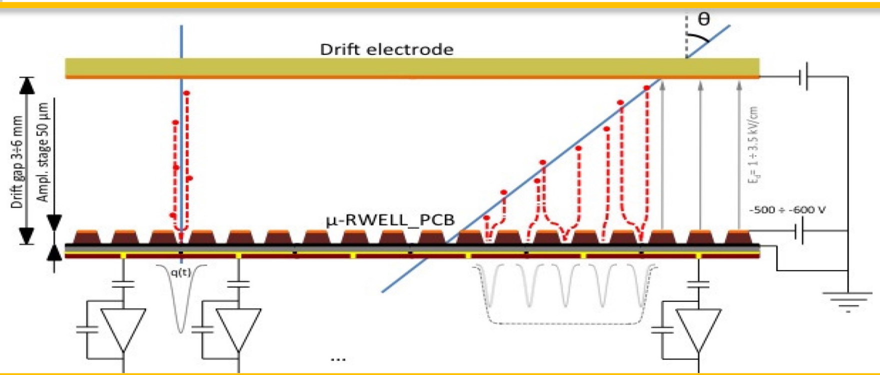
Charge Centroid reconstruction method

↓

The track position is determined as a weighted average of fired strips

↓

GOOD FOR ORTHOGONAL TRACKS



FOR INCLINED TRACKS &/or HIGH B FIELD

the Charge Centroid method gives a very broad spatial distribution on the anode-strip plane.

↓

μTPC reconstruction

The spatial resolution is strongly dependent on the impinging angle of the track → A non-uniform resolution in the solid angle covered by the apparatus → Large systematical errors.

A possible solution : ***μTPC reconstruction***

- The electrons created by the ionizing particle drift towards the amplification region
- In the μTPC mode from the **knowledge of the drift time** and the **measurement of the arrival time of electrons**, the **track segment in the gas gap is reconstructed**
- The **fit of the digitized charge signal as a function of the sampling time** gives **the arrival time of drifting electrons**.
- By the knowledge of **the drift velocity,** the 2D trajectory of the ionizing particle in the **drift gap** is reconstructed.

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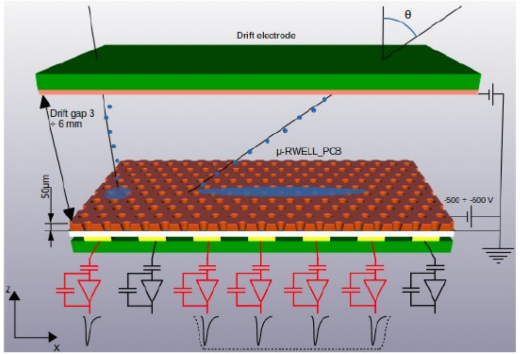


Figure 5. A simplified sketch showing how a non orthogonal track affects the number of fired strips.

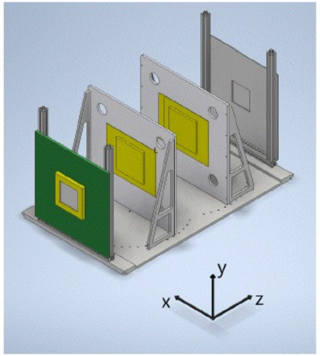


Figure 6. Sketch of the experimental setup with the coordinate system.

The μTPC reconstruction algorithm: $$z_k = v_{drift} \cdot (t_k - t_0)$$

The μTPC algorithm requires knowledge of:

- the reference time t_0
- the strip charge arrival time t_k
- the charge drift velocity v_{drift}

It requires a fit for each hit strip

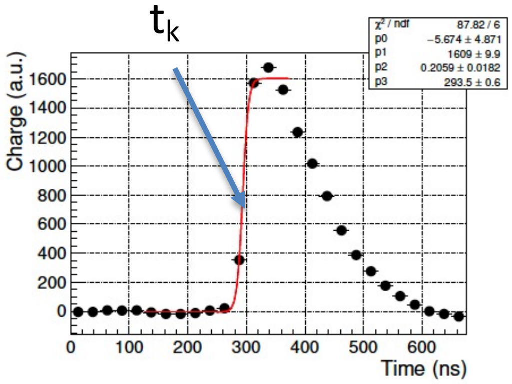
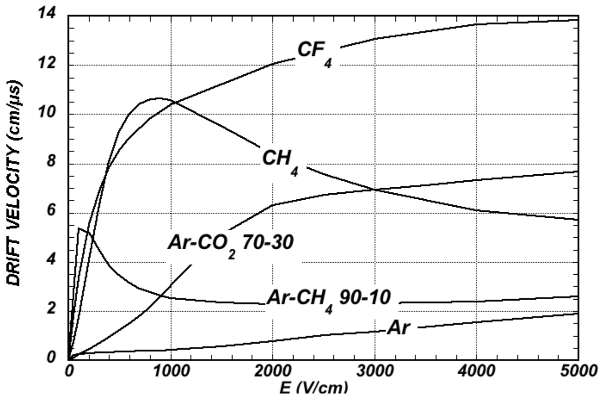


Figure 7. Charge signal as a function of the sampling time fitted with a Fermi-Dirac function:

$$f(t) = f_0 + \frac{q_k}{1 + e^{-(t-t_k)/\tau}}.$$



Electron drift velocity of different gasses, as a function of the applied electric field

PDG

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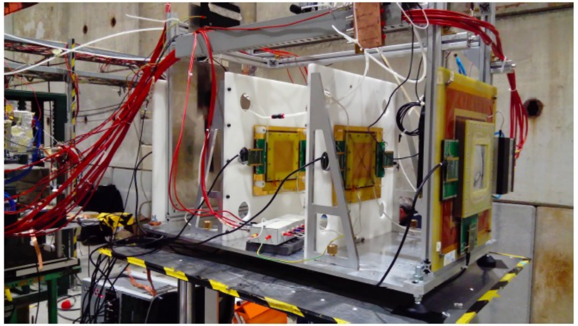
Tests performed on 1D μ −Rwell prototypes



1D 400 μm pitch
Ar:C02:CF4
40:14:45
Gas mixture

Figure 3. Experimental setup: all the detectors have a 10×10 cm^2 active area. The distance between the two μ-RWELL detectors is 30 cm.

- The reference time t_0 is provided by plastic scintillators providing the DAQ trigger

- The reconstructed track: $z = p_0 + p_1 x$ is used to provide the "measured" x at the middle plane of the detector: $x = \frac{z_C - p_0}{p_1}$

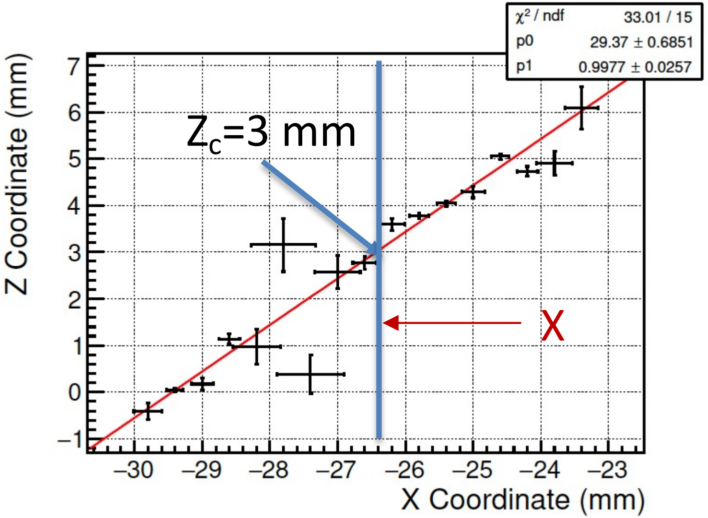


Figure 8. Example of a 45° track segment as reconstructed using the μTPC algorithm with the linear fit: $z = p_0 + p_1 \cdot x$. The smaller the charge collected on a strip, the larger the x coordinate error.

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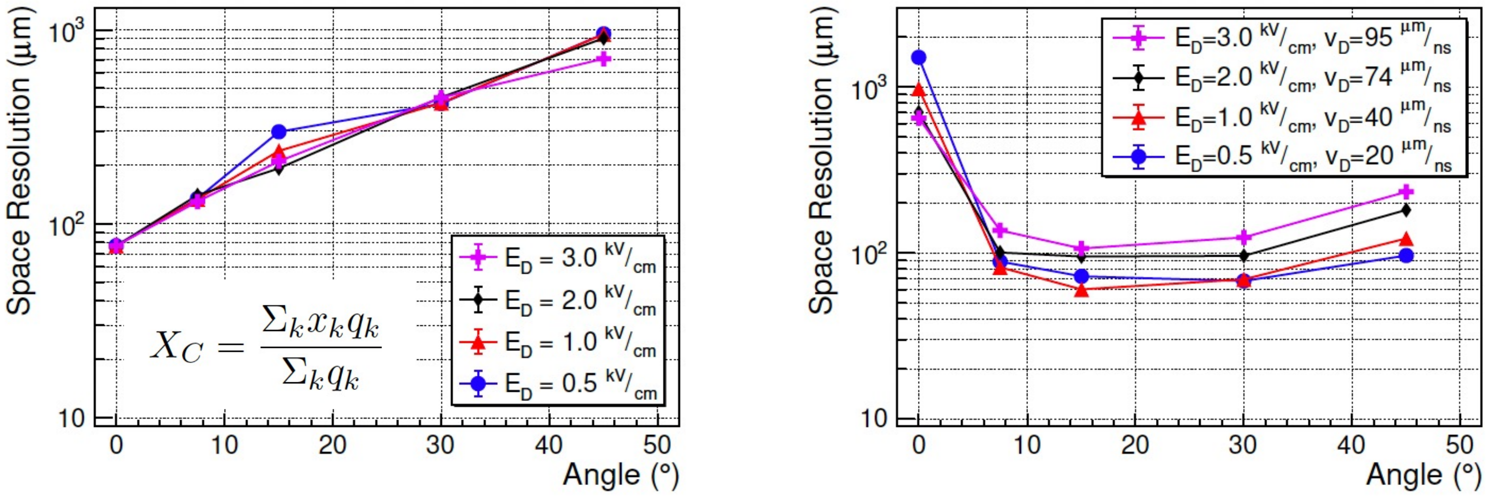
Tests performed on 1D μ −Rwell prototypes



(a) CC space resolution. **(b)** μTPC space resolution.

1D 400 μm pitch
Ar:C02:CF4
40:14:45
Gas mixture

Figure 11. The results of the two reconstruction algorithms, over a large angular range, for various drift field values.

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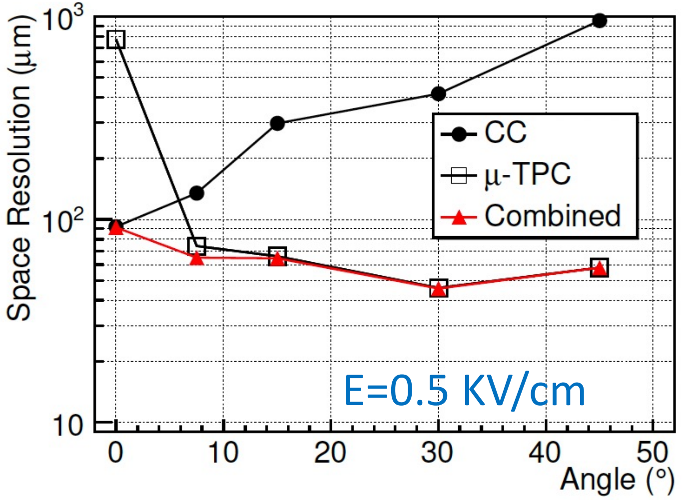
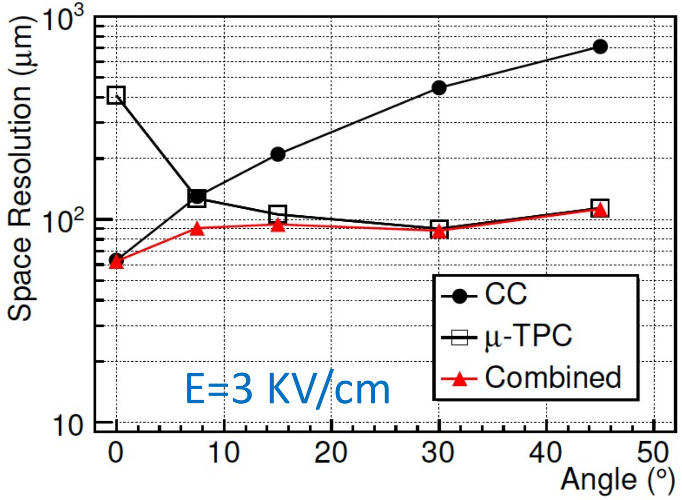
Tests performed on 1D μ −Rwell prototypes

1D 400 μm pitch   Ar:C02:CF4 40:14:45   Gas mixture

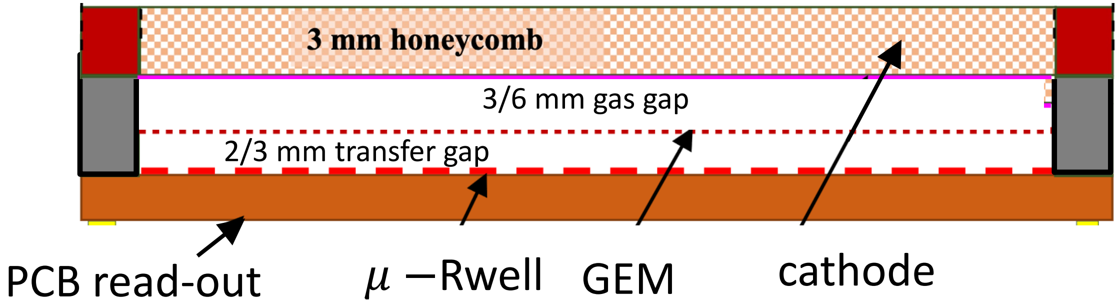


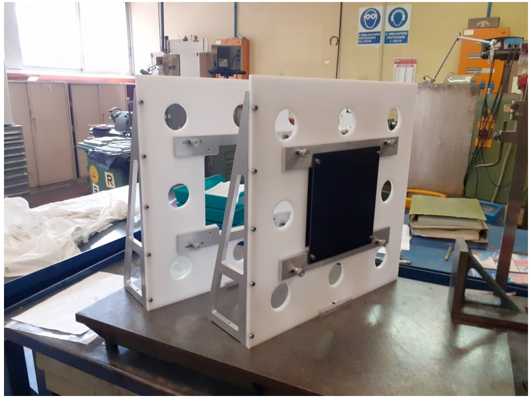


Combined results of 1D space resolution from charge centroid (CC) and μ-TPC algorithms

Future test on 2D GEM+μRwell+ μ TPC

2D GEM - μRwell Technology



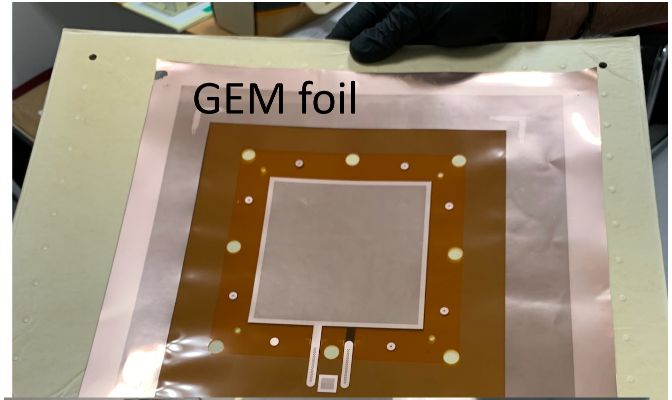


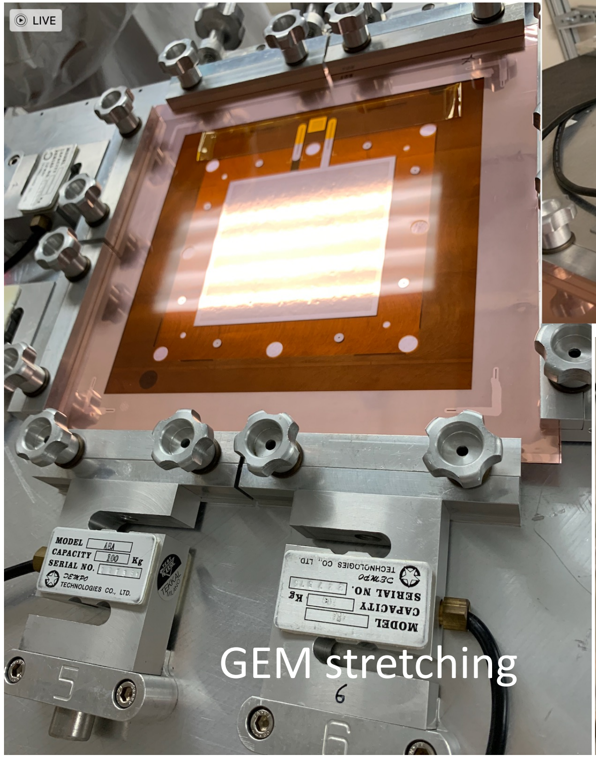
New detector holders

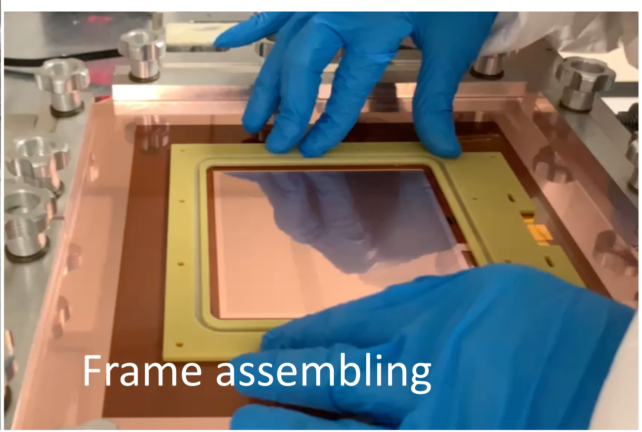
- Two 2D 10cm x10 cm GEM- prototype with 400 μm pitch *à la Compass* are being produced
- A Test beam will take place at CERN on 13-27 November 2024.
- The detector response will be tested as a function of the tracks angle in 2D

2D 10x10 cm^2 GEM-μRwell prototype assembly

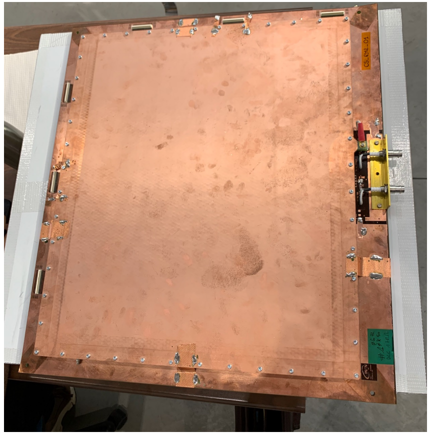
GEM-μRwell 10x10 cm^2 prototypes assembly







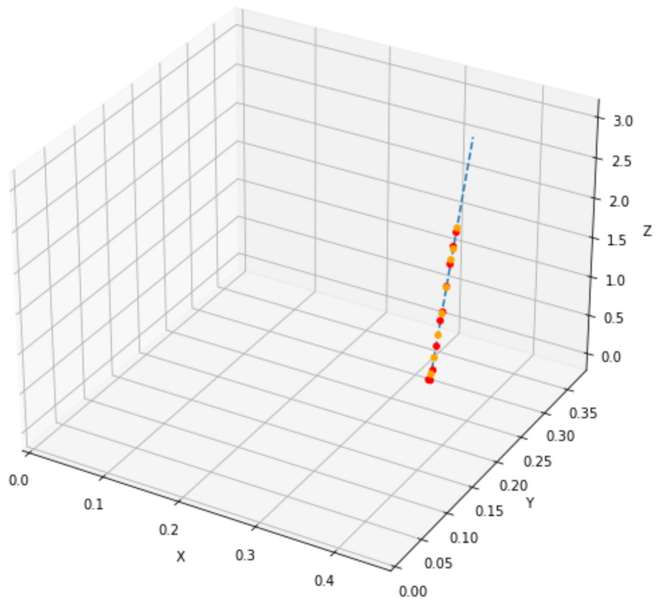
By Carlo Gustavino

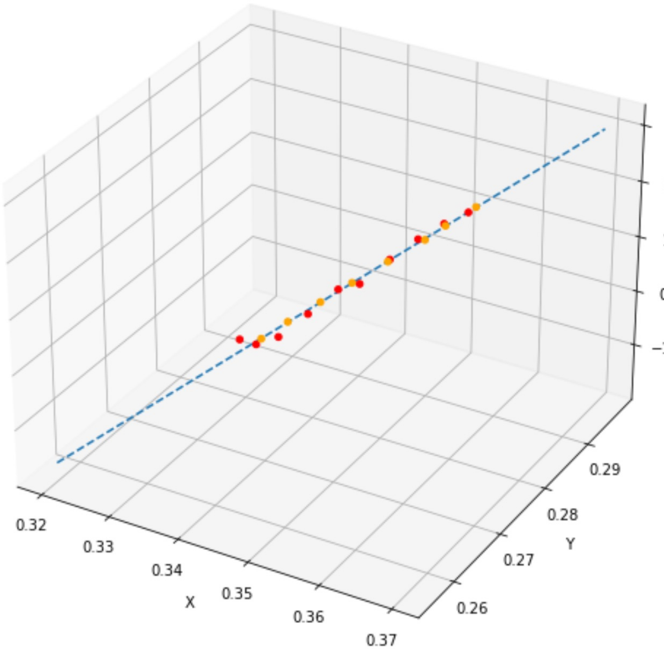


30 mm drift gas gap

Ar:CO_2 70:30

590 V



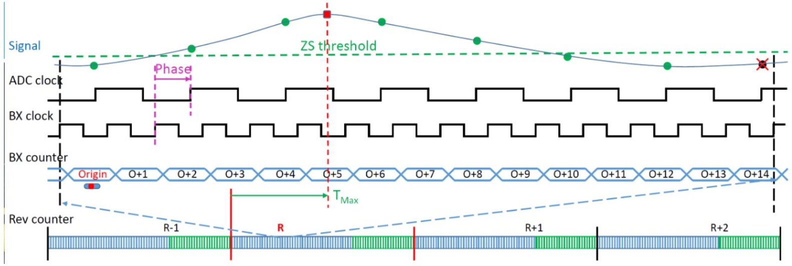


First tests on large gas gap
With capacitive sharing show good 3D track reconstruction

Requirements to the DAQ electronics

- Start time t_0
- Charge sampling at 50 MHz
- Number of sampling larger than the maximum drift time
- Precise t_k determination in the data stream: rise-time fit not the time of the maximum collected charge

Readout Strategies



- Signal is continuously sampled with an ADC
- Signal samples above threshold are retained
- Nominal (physics data) readout: signal amplitude and timing is derived → Time of max (as on example) or time of arrival (fitting samples on rising edge)
- On demand readout: signal shapes or raw non ZS data are provided → Calibration, detector studies
- Guarantees best noise immunity and thus best S/N ratio → Allows on line common mode noise (CMN) subtraction before ZS

μ-TPC PROs and Cons

PROs

The $\boldsymbol{\mu}$-TPC algorithm provides:

- Improved position resolution for Inclined/bent tracks
- The timing information is embedded in the detector response

CONs

The $\boldsymbol{\mu}$-TPC algorithm requires:

- Precise charge timing information
- A start timing information
- A fit for each strip signal
- A fit for each track
- Never systematically applied on 2D μ-Rwell detectors
- Never applied to 2D GEM- μ-Rwell detectors
- Very complicated for multiple tracks
- Is it compatible with charge sharing?