GRAAL: Gem Reconstruction And Analysis Library

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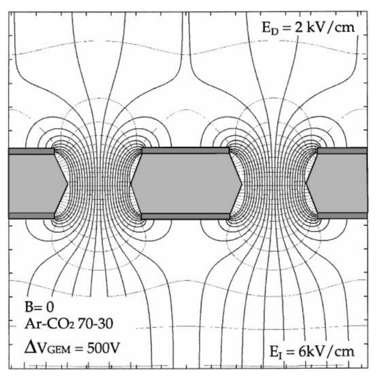
INFN – Section of Ferrara

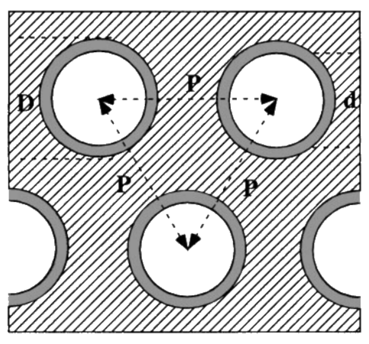
Gas Electron Multiplier



Invented by F. Sauli in 1997

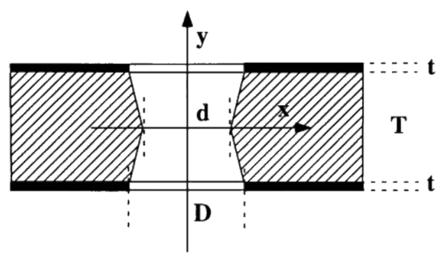
A 50 µm **Kapton** foil with 5 µm copper on the faces

High density holes with 50 (70) µm diameter and 140 µm pitch



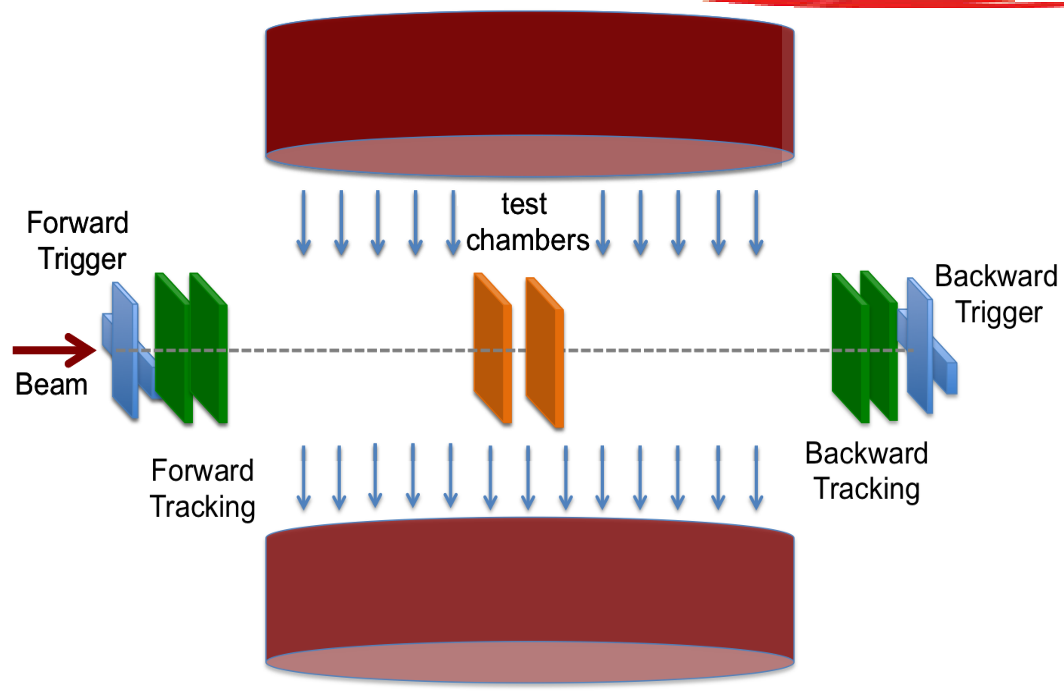
Hundreds of Volt differece between the two faces creates **electric field** of 10^5 kV/cm.

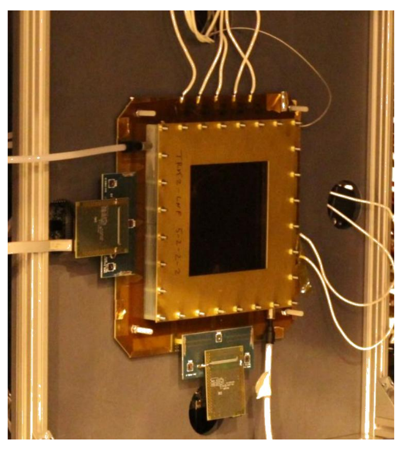
Electron crossing the hole generates an **avalanche**

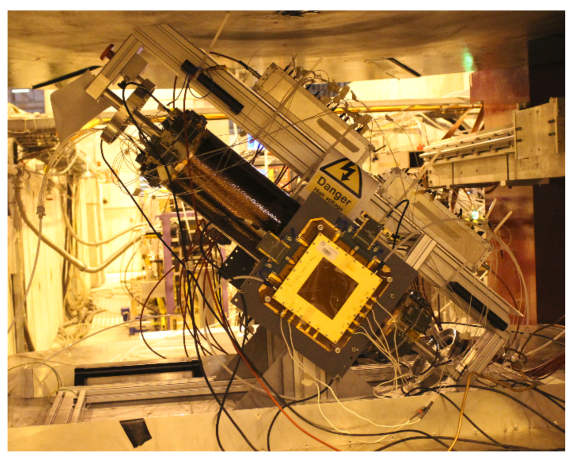


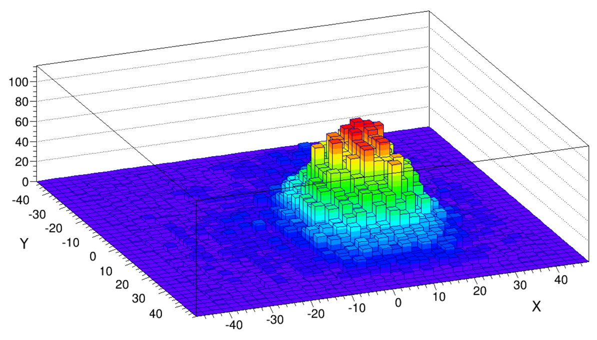
Several stacks of GEM foils can reach a **gain of 10^4**

Test Beam setup









Beam:
I. H4 beam line – NA CERN
II. 150 GeV/c pion/muon
III. 10^3 – 10^5 particles/spill

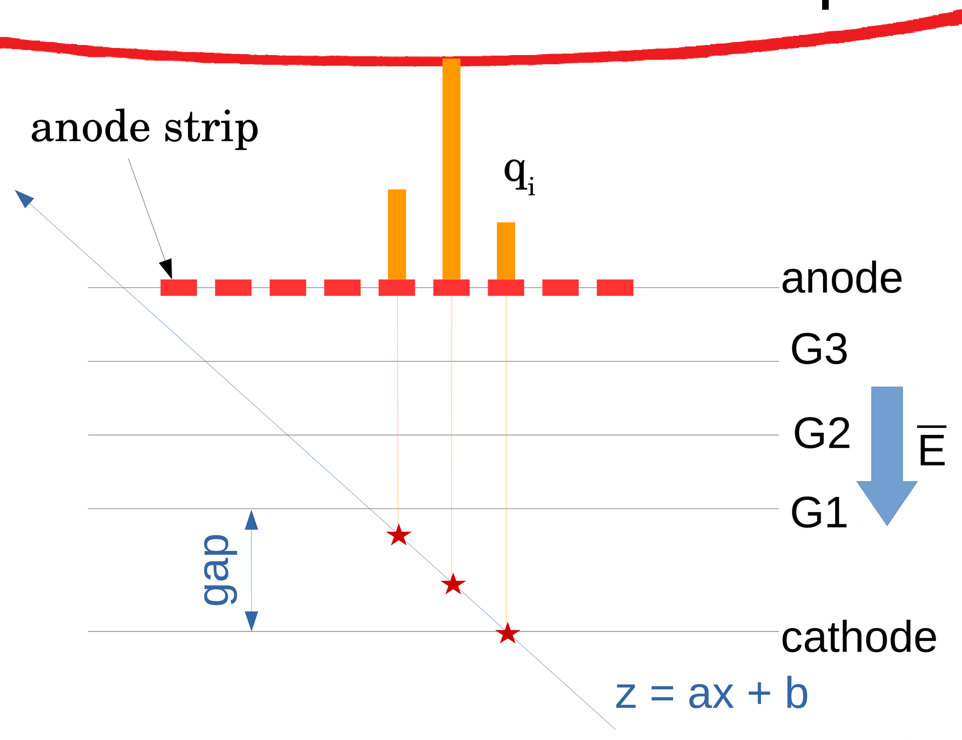
Magnet:
IV. Dipole magnet: 0 to $\pm$1.5 T

Tracking system:
V. Four triple-GEM with 2D readout

Test detectors:
VI. Two triple-GEM with variable setting
VII. A cylindrical triple-GEM

Electronics:
VIII. APV25 electronics with mmDAQ software

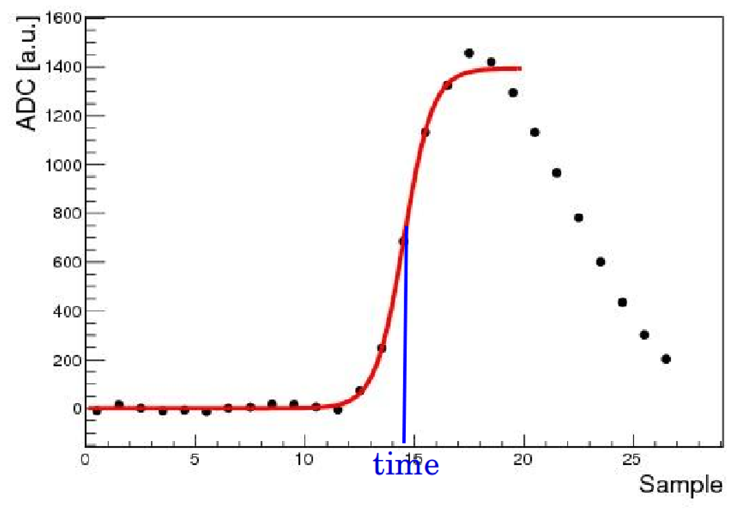
Reconstruction technique



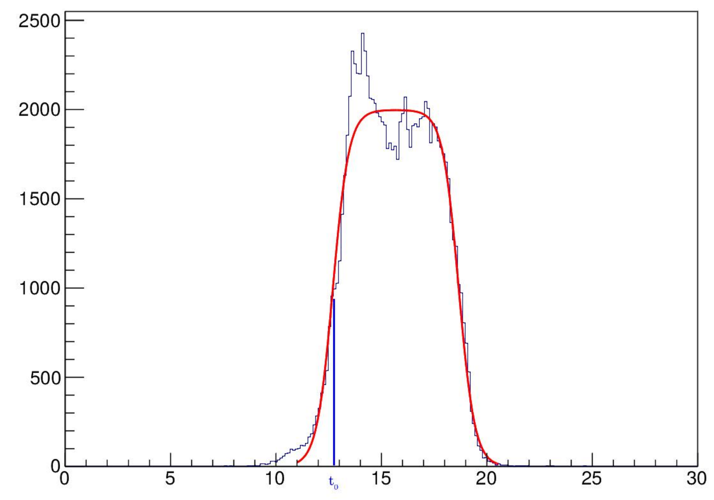
Digitization

1. **Strips** signal above threshold generate a "hit".
2. **Charge** and **time** are extracted with a FD fit
3. Hits are **sorted** to ease the clusterization
4. Hit **time distribution** is studied to measure the time reference needed by µTPC

Strip signal



Hit time distribution



Clusterization

Charge centroid:

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

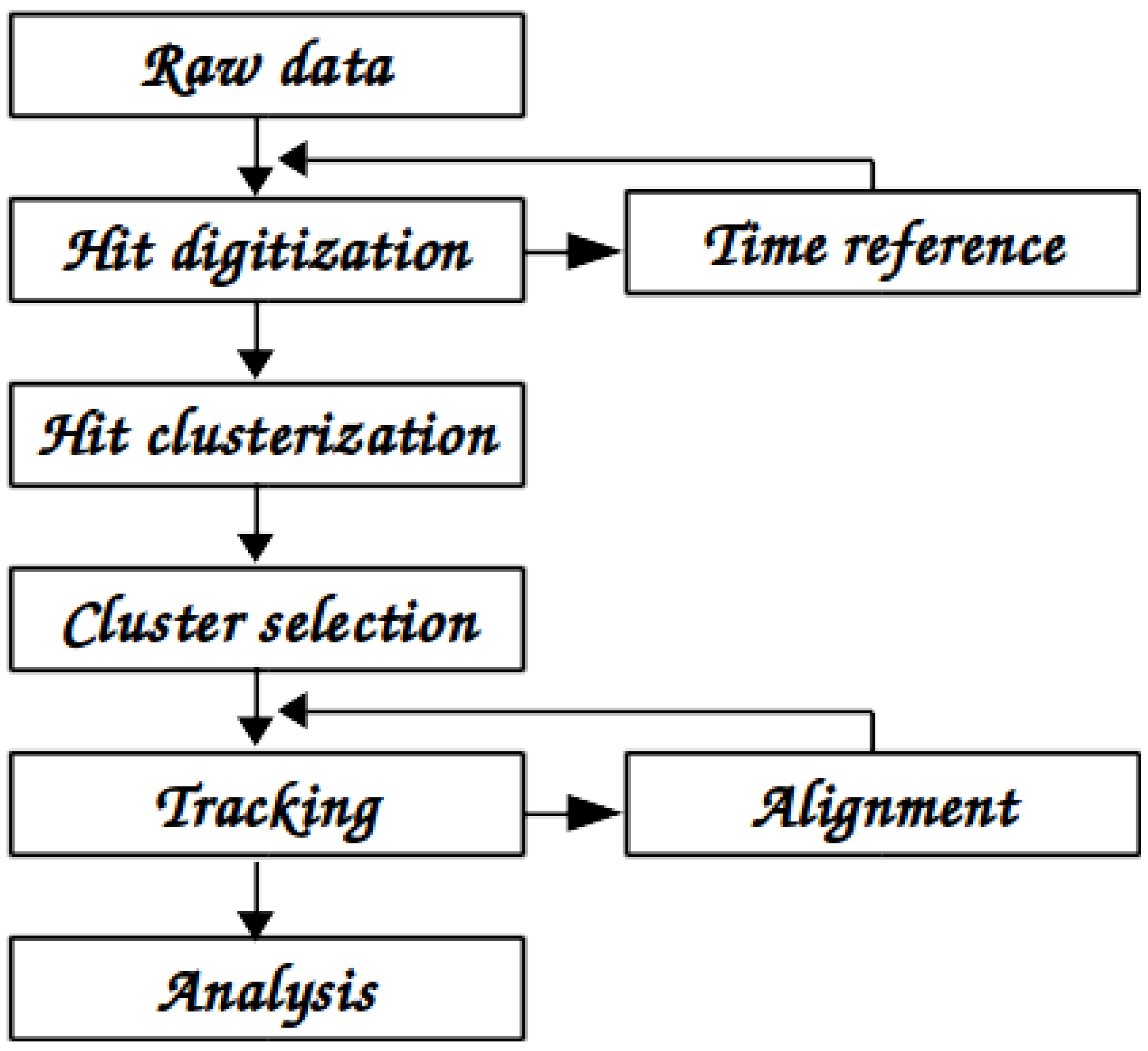
µTPC:

$$x_{\mu TPC} = \frac{gap/2 - b}{a}$$

Merge

$$x_{merge} = w_{cc} x_{cc} + (1 - w_{cc}) x_{\mu TPC}$$

1. **Contiguous** strips are clusterized to measure the incident particle position
2. Charge information is used in **Charge Centroid**
3. **µTPC** associates a bidimensional point to each fired strips and reconstructs the particle path in the drift gap
4. **Merge** the two algorithms with optimized weight function of cluster size and track incident angle



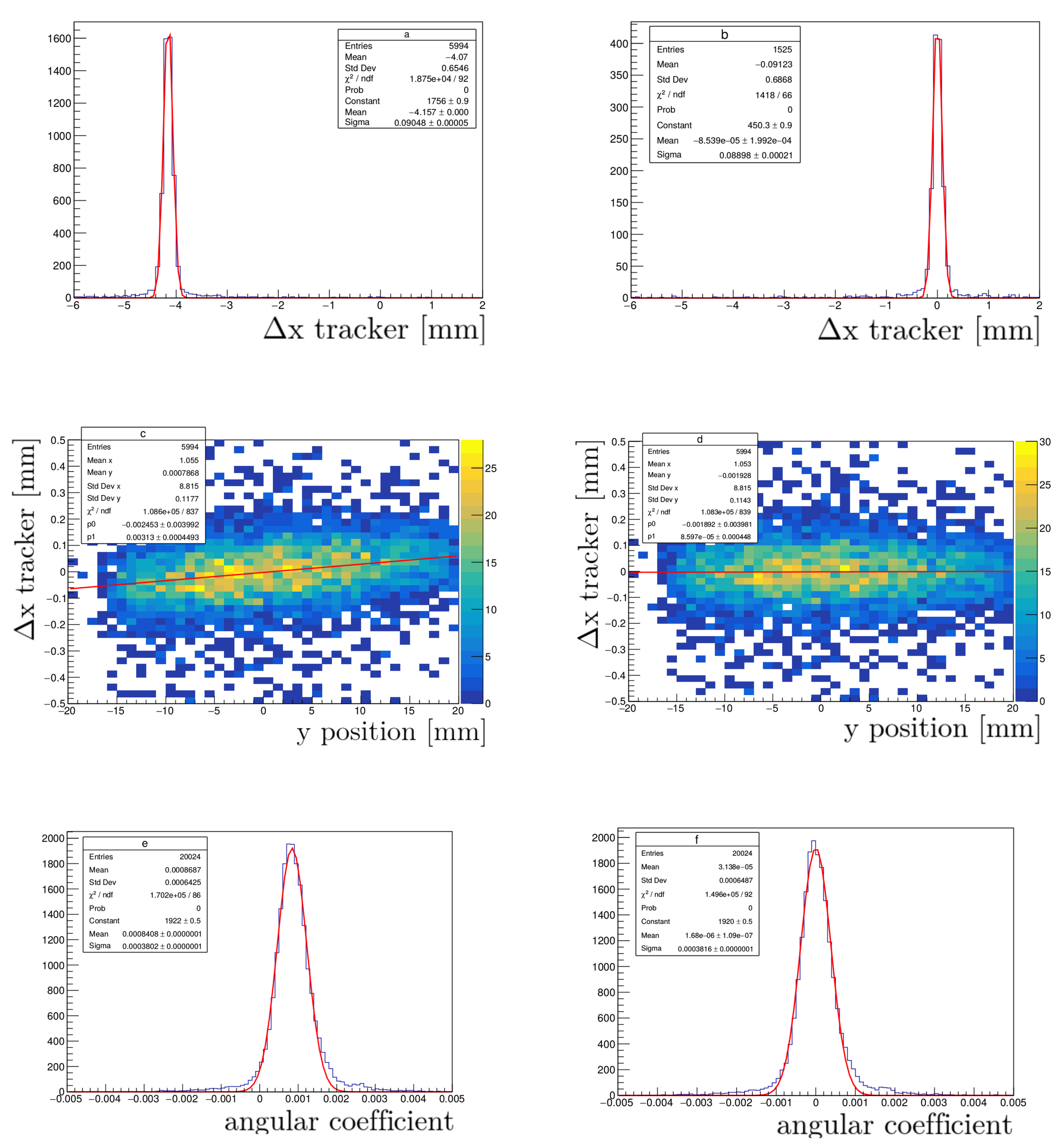
Alignment

Tracking system:
1. Select the good events: all the trackers must be fired
2. Use a straight line to fit the particle track
3. Extrapolate the particle position to the test detector

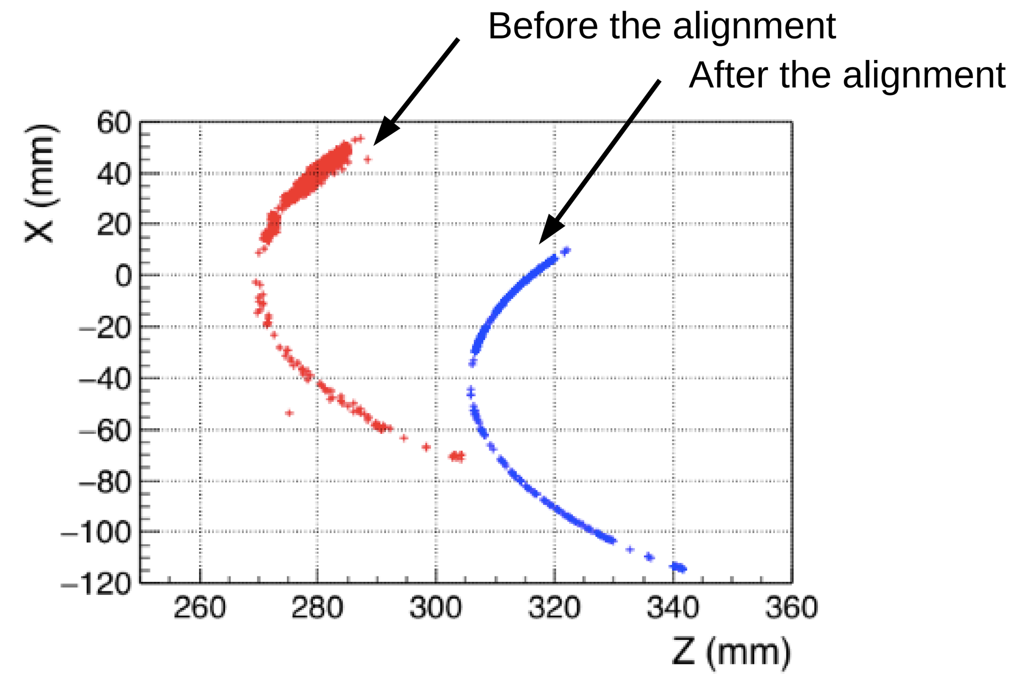
Test detector:
4. Measure the expected position on the detector combining the track line with a plane for planar GEM or a cylinder for the CGEM
5. Calculate the residual distribution and fit it with a Gaussian

Alignment with an iterative procedure:
6. Use the mean value of the residual (X,Y,Z or Φ) to 1D-alignment
7. Use bidimensional plot (residual vs position) to remove tilt in the detector recostruction
8. In case of cylinder, align the center

Before After



Planar GEM



Cylindrical GEM