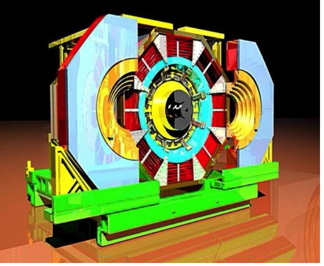
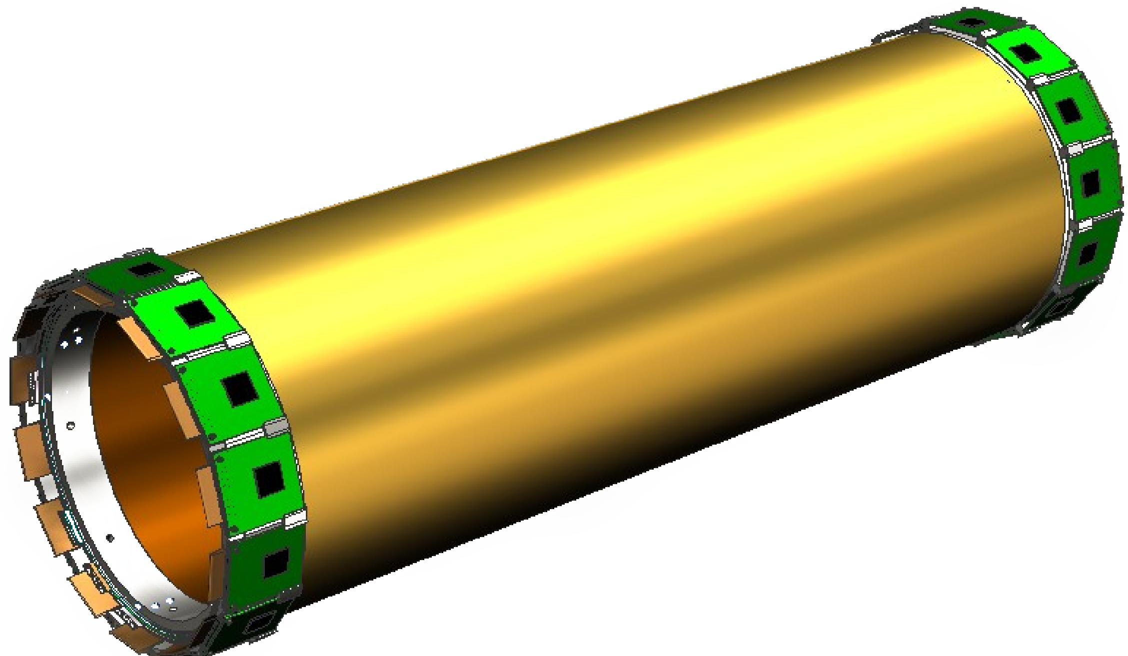




Beam Test preliminary results of the GEM prototypes for the BESIII-IT

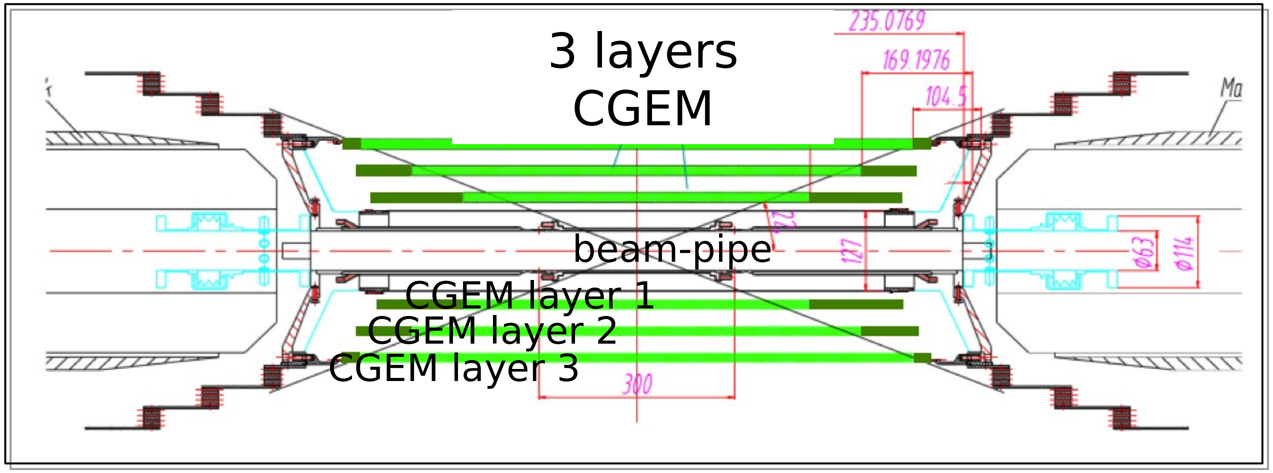
Riccardo Farinelli
on behalf of the
BesIII-CGEM group

Outline

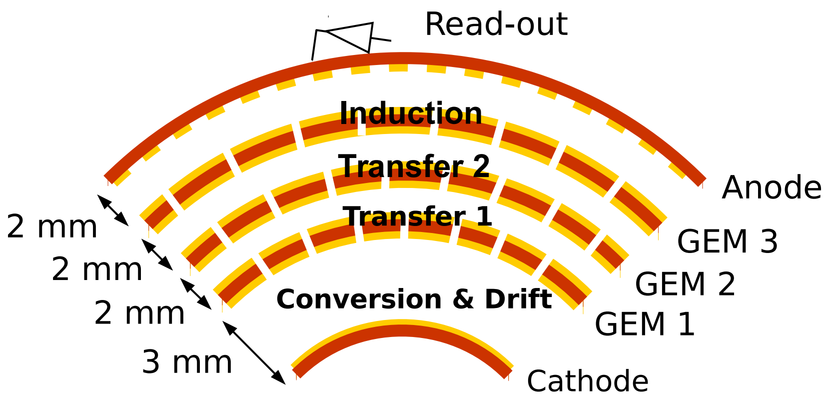
- Prototype and Beam Test (BT) setup
- Analysis approach
- Efficiency and spatial resolution
- Charge Centroid (CC) results and limits
- µTPC method

A CGEM Inner Tracker for BESIII

The Italian group is leading the development of a cylindrical GEM inner tracker for BESIII.



The project has been recently selected as one of the project funded by the European Commission within the call H2020-MSCA-RISE-2014.



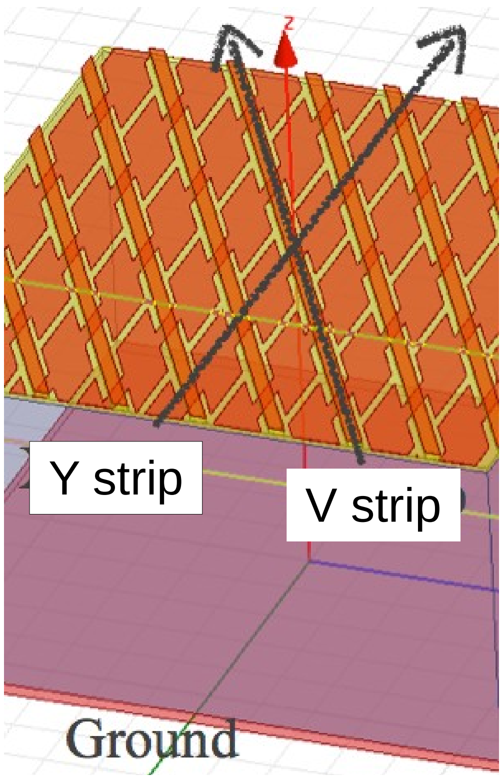
Requirements

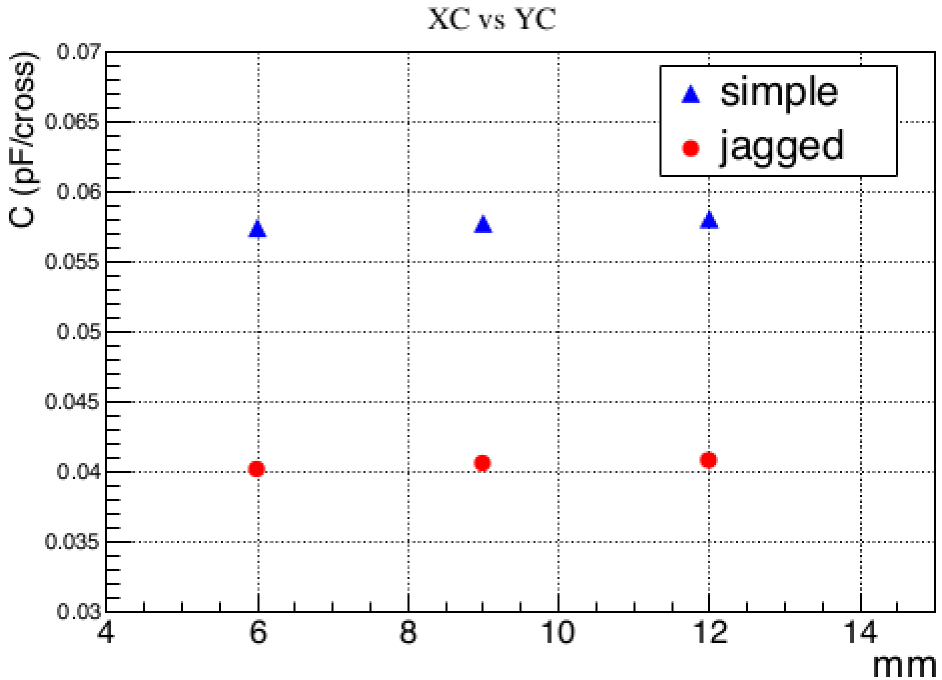
- Rate capability: ~10^4 Hz/cm^2
- Spatial resolution: s_{xy} =~120µm : s_z=~1 mm
- Momentum resolution:: σ_{Pt}/P_t =~0.5% @1GeV
- Efficiency = ~98%
- Material budget ≤ 1.5% of X_0 all layers
- Coverage: 93% 4π
- Operation duration ~ 5 years

Readout plane design and features

BESIII will deploy a readout with two set of strips and a stereo angle produced by TS-DEM department at CERN

- large strip capacitance up to 100-160 pF
- stereo angle depending on the layer geometry: about + 45°, -30°, 30°
  - different stereo angles will help reducing the combinatoric
- strip geometry is 650/570/130 μm
- (pitch, Y wide, V wide)
  - about 10'000 electronics channels
- ground plane at 4 mm from the readout
- jagged strip layout studied to minimize the strip capacitance

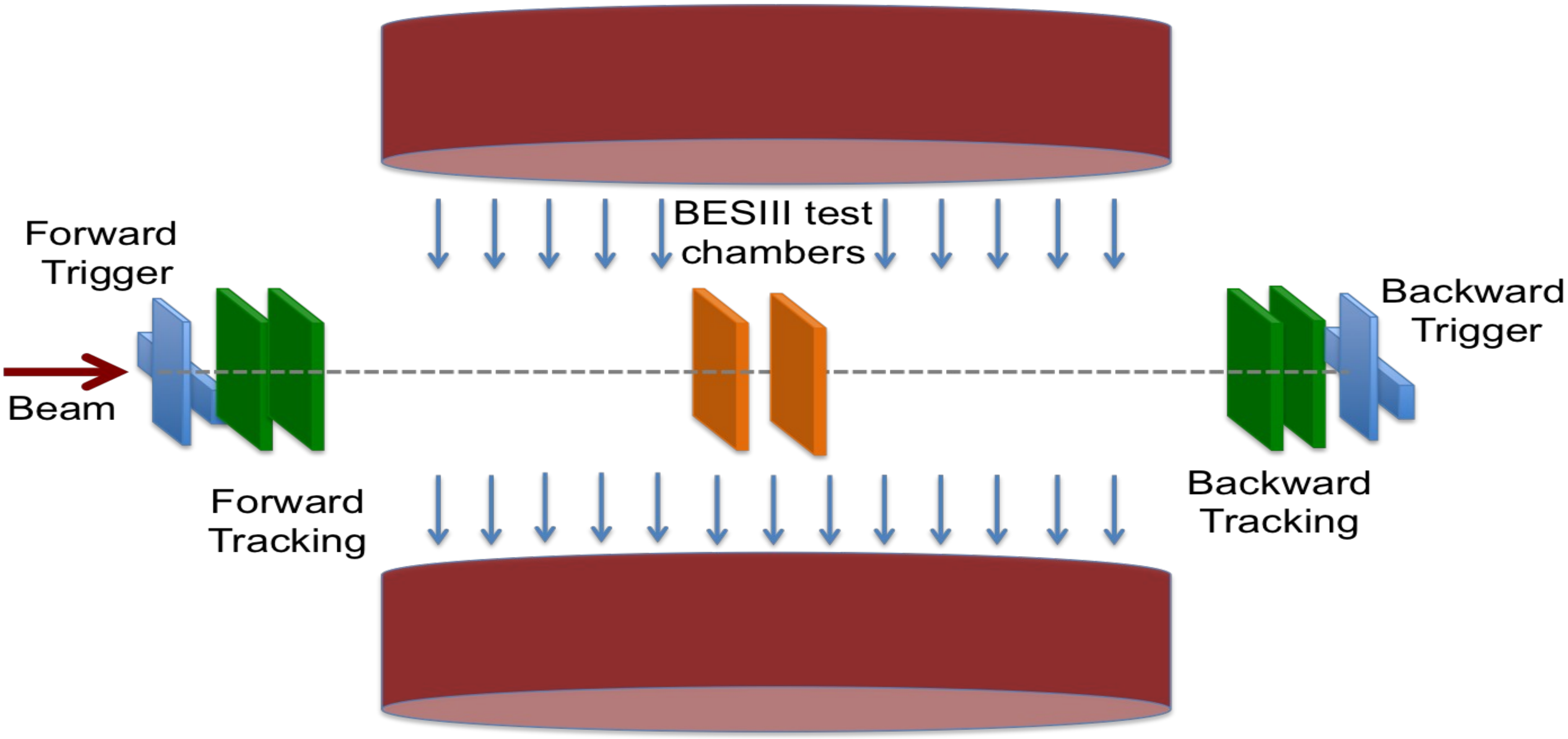




Purpose and measurement of BT

- The purpose of the BT's are:
  - validate the GEM analogue readout in magnetic field;
  - validate Garfield simulation and extract useful for the Hit digitization;
  - find the working point of the triple GEM to reach the requirements.
- Data data plane is focused to perform these measurement with a 5/2/2/2 and 3/2/2/2 mm geometries of the triple GEM:
  - test different gas mixtures as Ar/CO2 (70:30) and Ar/Isobutane (90:10).
  - spatial resolution as function of the magnetic field;
  - cluster size as function of the magnetic field;
  - efficiency measurements at different HV setting;

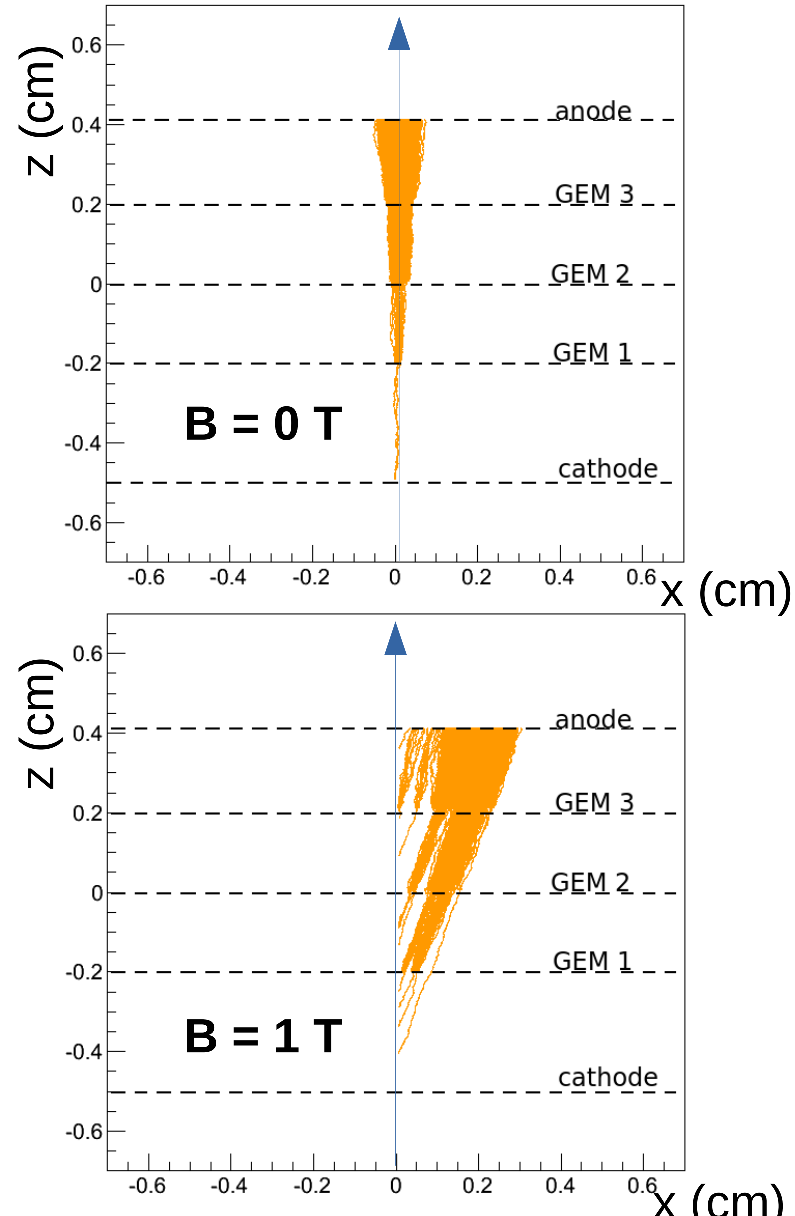
BT setup



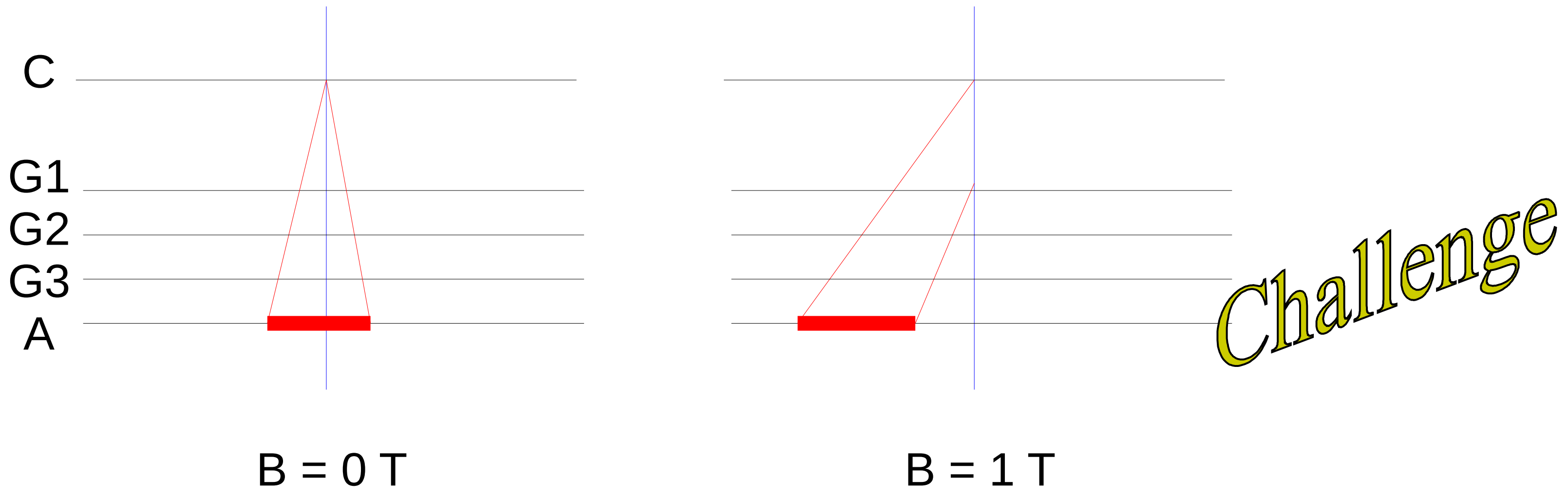
The test chambers are a 10x10 cm^2 planar triple GEM with 3 and 5mm of conversion gap

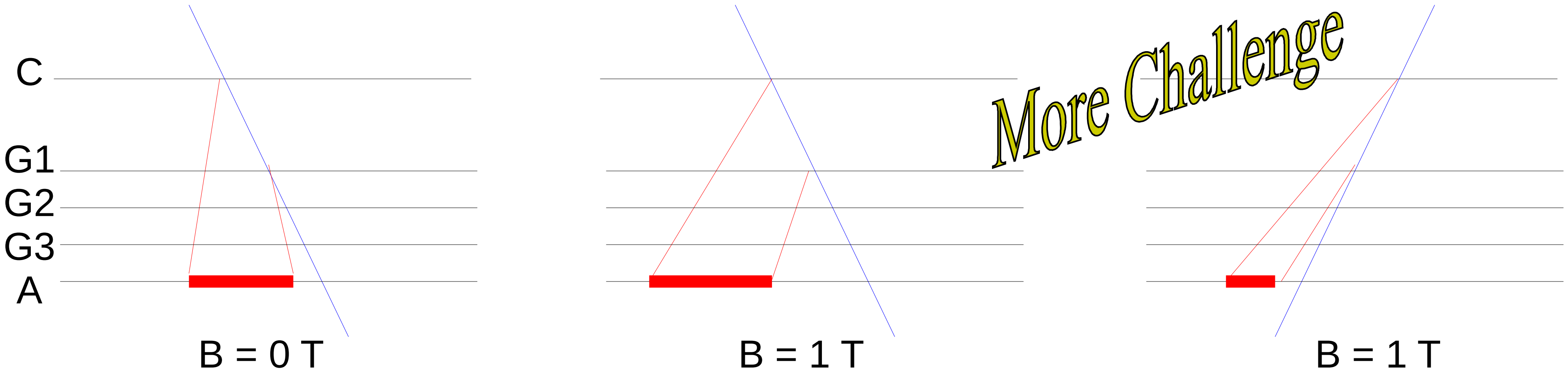
Effect of the magnetic field on the electron avalanche

- The effect of the magnetic field to the electron avalanche has been studied with Garfield simulations:
  - the Lorentz force displaces the electron avalanche,
  - In addition the B field produces a broadening of the charge distribution at the anode;
  - the shape of the charge distribution is no longer gaussian and the charge centroid method reduces its performance.
- The charge centroid distribution and thus the spatial resolution have a strong dependence on the intensitiy of the electric field in the drift gap.



Electron avalanche behaviours





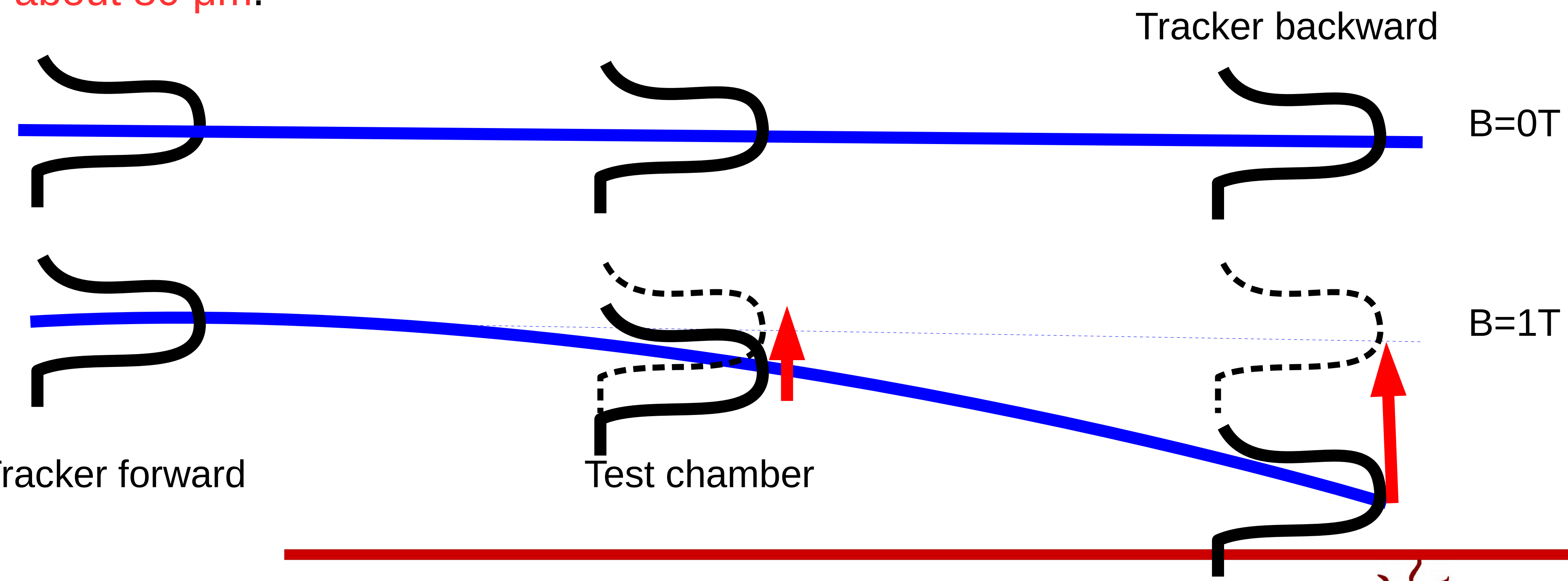
It will be a challenge also for the track reconstruction in a cylindrical detector

Tracking approch

A preliminary alignment of the chambers (tests and trackers) is perform @ B=0T. A straight line is used to fit the particle track.

Meanwhile in magnetic field the tracks are bended and then a second alignment is perform to “adjust” the shift introduced by the magnetic field.

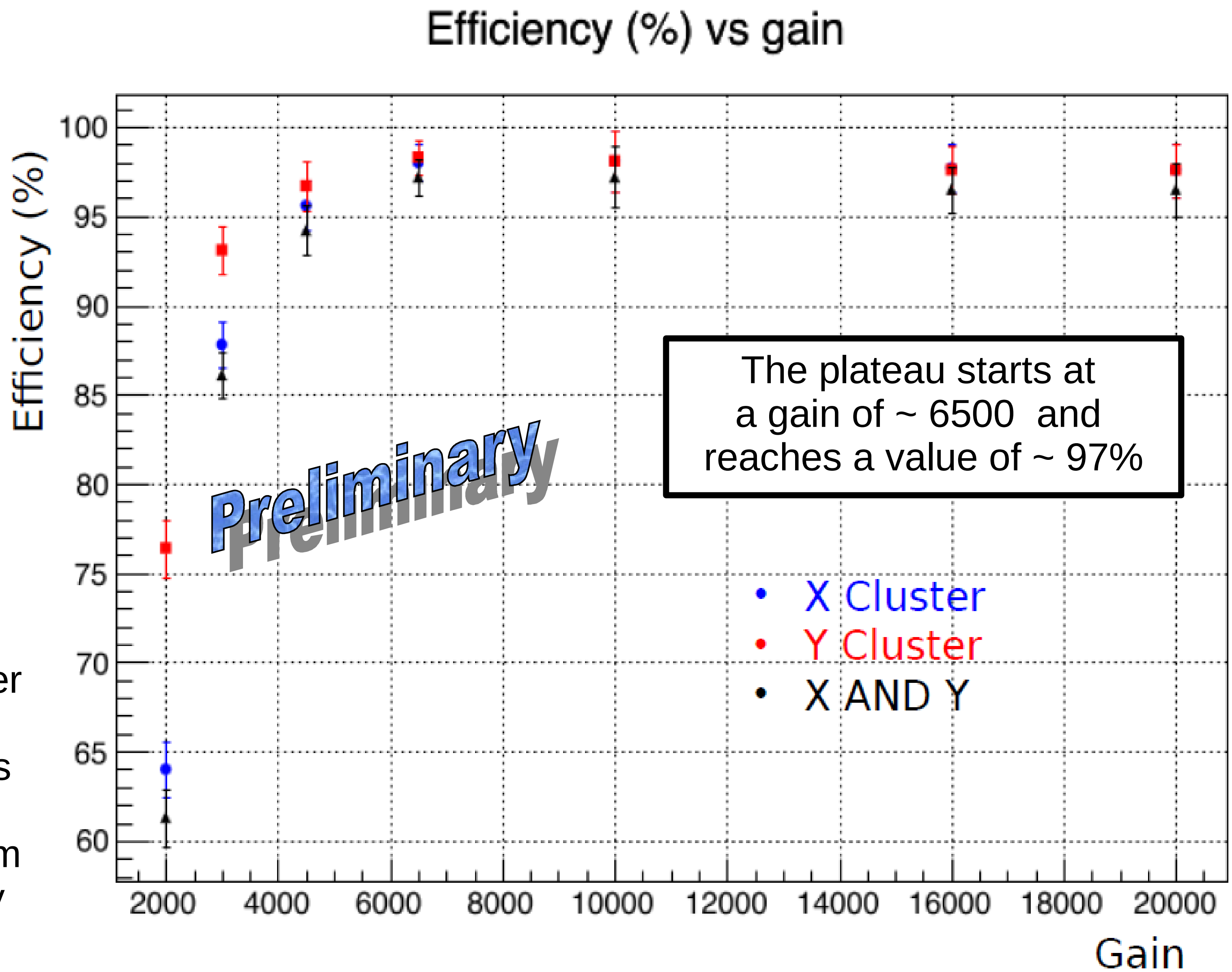
Being the resolution of the trackers about 50 μm, using GEANT4 simulation we extimeted the contribution of the tracking system and the “straight line fit method” of about 80 μm.



Analysis

- After the alignment the tracks are reconstructed by a straight line.
- Only events with 1 cluster per plane are considered.
- The residual, the difference between the position measured by the test chamber and the position extrapolated by the tracking telescope, is calculated for each event.
- The gaussian fitting the residual distribution allows to evaluate the resolution of the chamber.

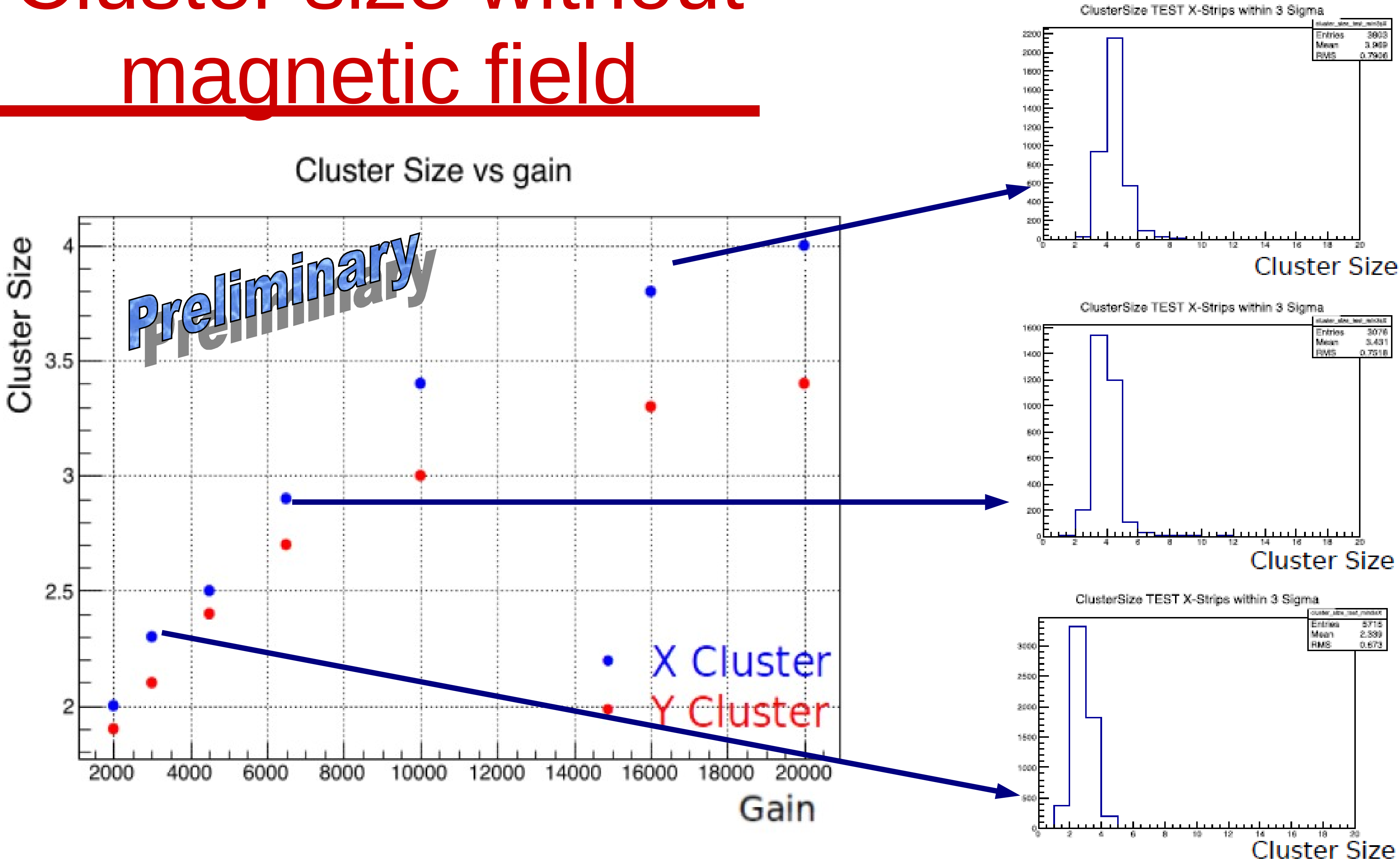
Efficiency without magnetic field



Test chamber properties:

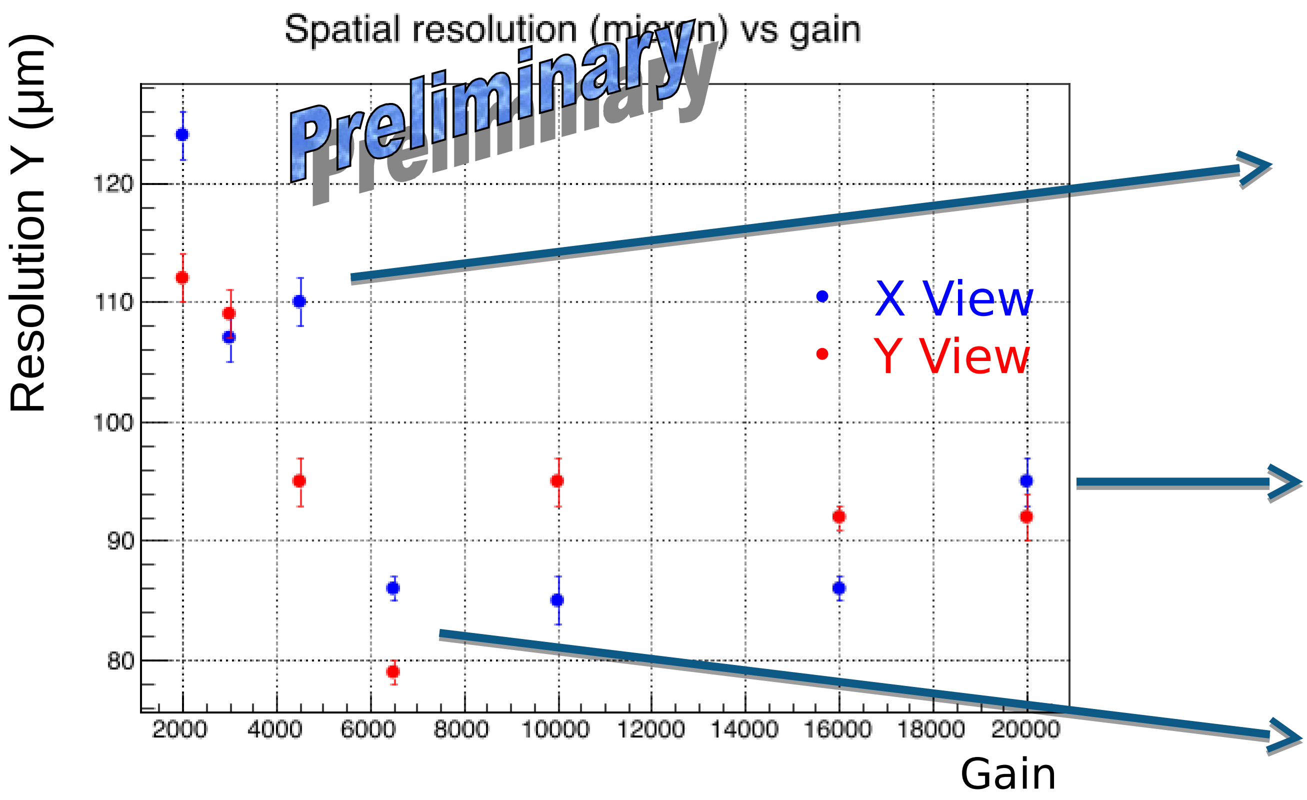
- Ar/Iso gas mixture
- 5/2/2/2 mm geometry

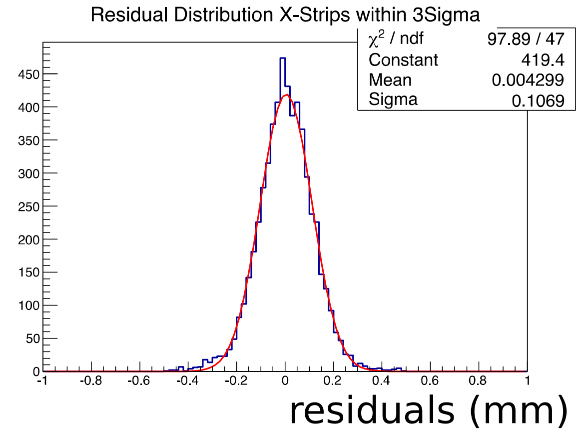
Cluster size without magnetic field

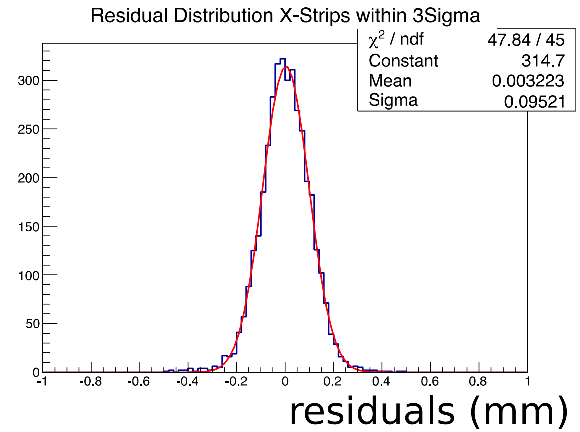


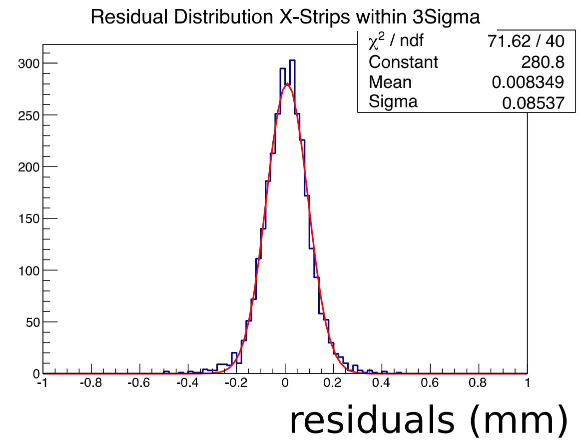
- The cluster size is the number of contiguous strips fired.
- Test chamber properties: Ar/Iso gas mixture and 5/2/2/2 mm geometry.

Spatial resolution









- The spatial resolution without magnetic field reaches a value of about 90 μm at a gain of 6500.
- Test chamber properties: Ar/Iso gas mixture and 5/2/2/2 mm geometry.

Comments of the showed results

- The previous results are measured with a 5/2/2/2 mm geometry of the triple GEM and Ar/Isobutane gas mixture.

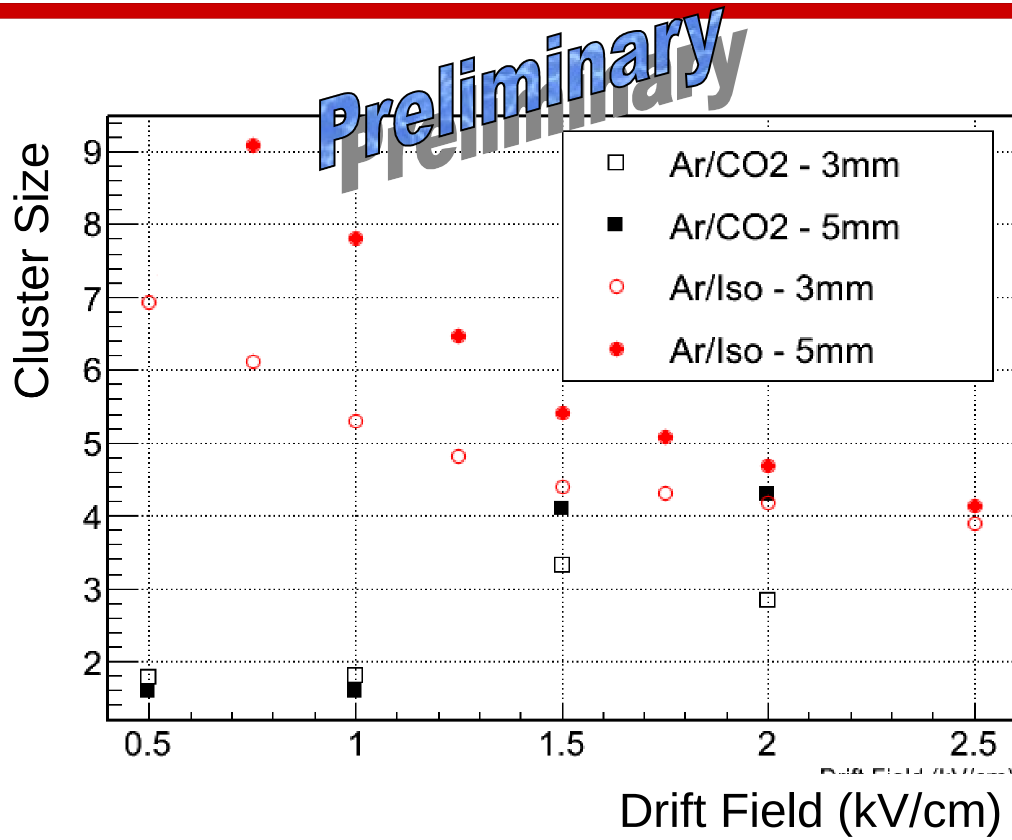
- The results with Ar/CO_2 gas mixture and 3/2/2/2 geometry show the same efficiency behavior: a working point is reasonable from a gain of about 6500.

Results in magnetic field

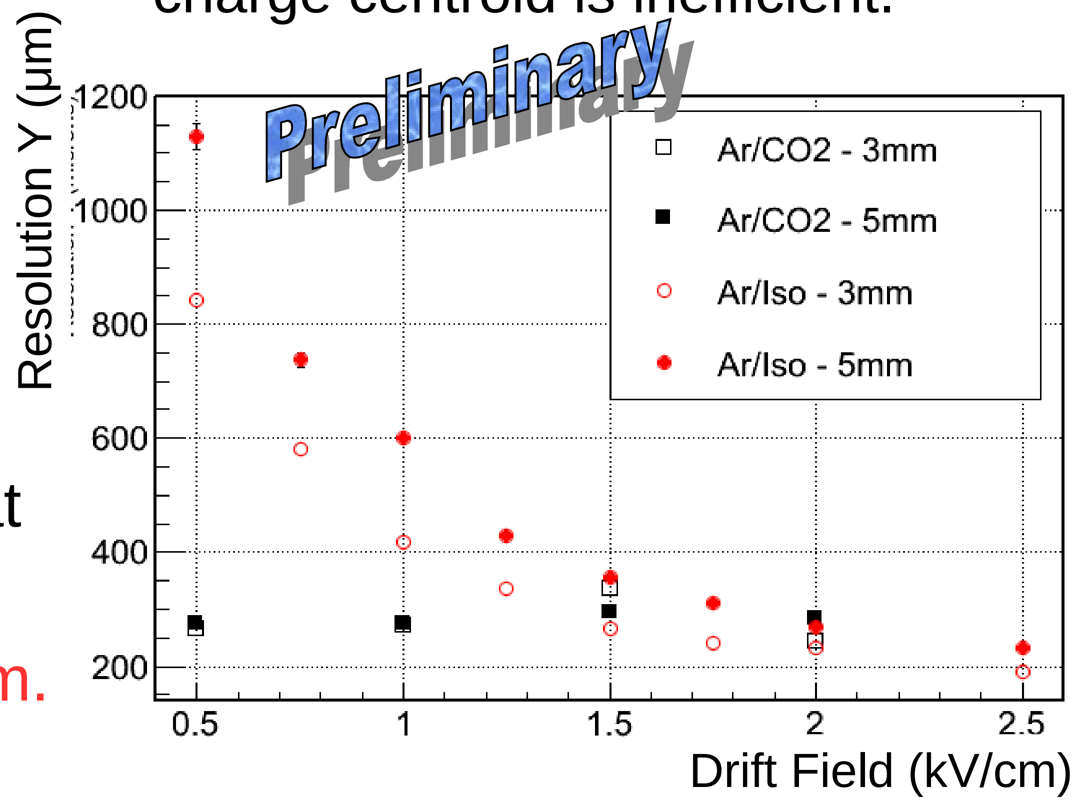
- Using the results of the previous slide we started to look at the performance in magnetic field

- Instead to study the behavior of the prototype as function of the gain, we fixed gain of ~ 8000 and we performed a scan in drift field

Drift field scan – B = 1 T

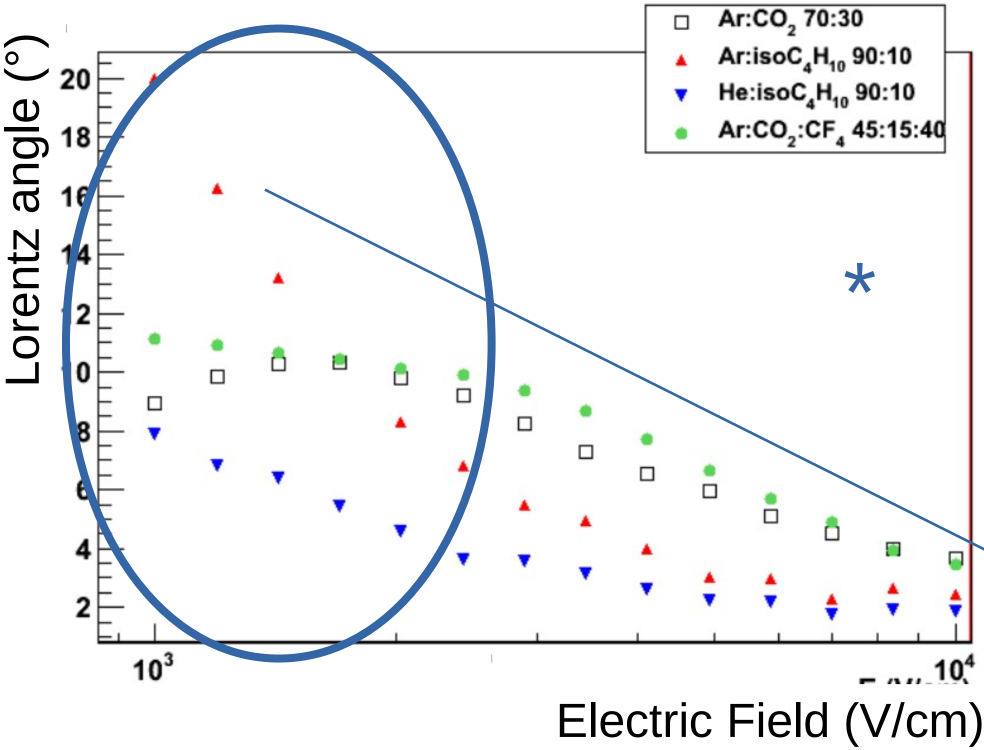


- The cluster size with Ar/CO_2 does not depend by the drift field but Ar/Iso does.
- For high values of cluster size the charge centroid is inefficient.

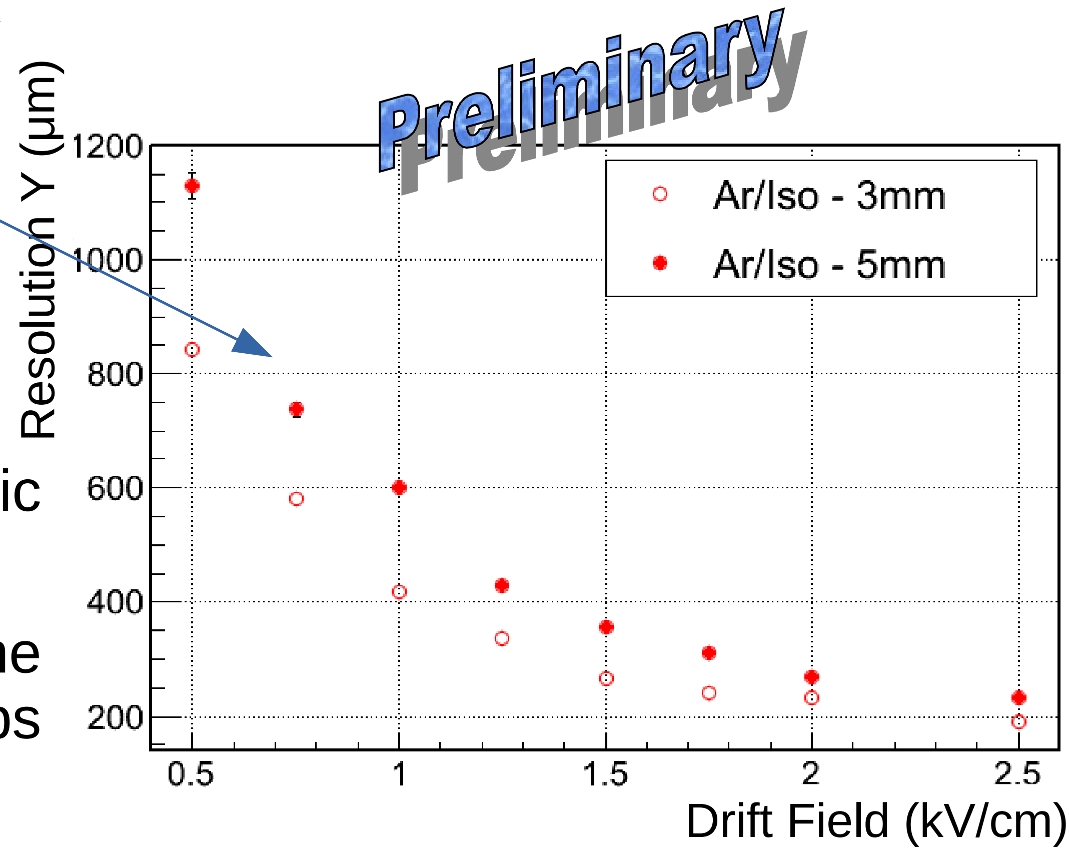


- Ar/Iso seems to work better at B = 1 T and high drift field values
- it reaches a resolution of ~190 µm.

Drift field scan – B = 1 T



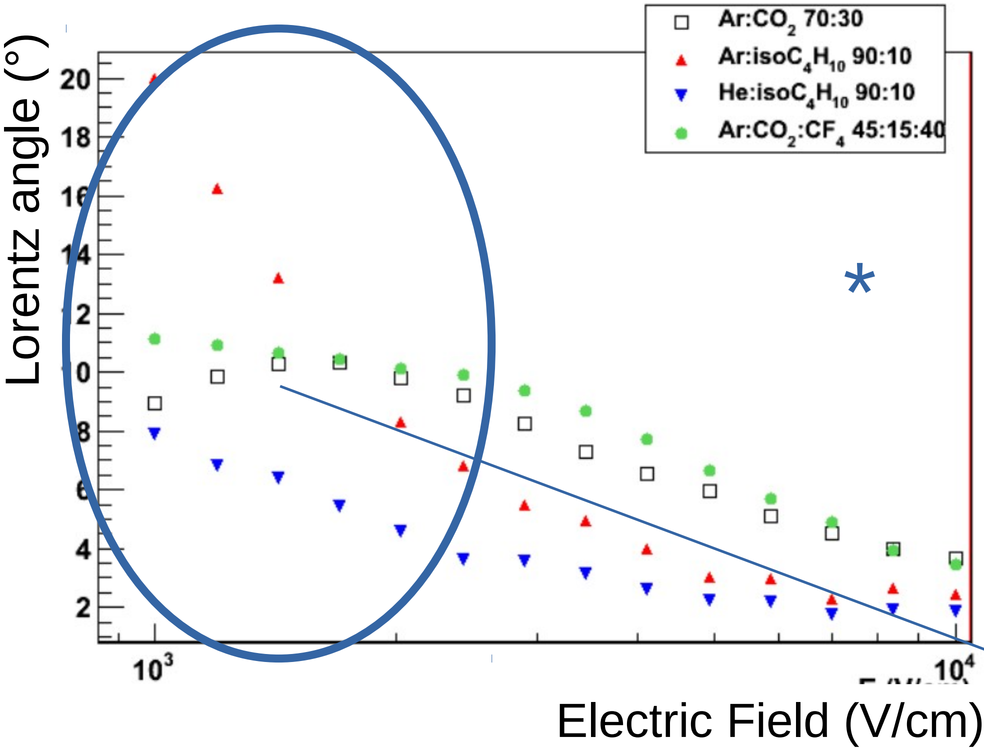
- The behaviors of the spatial resolution and the Lorentz angle are the same.
  - The main reason of the worsening of the CC is the increasing of the Lorentz angle.



- Y coordinate suffer of the magnetic field effect.
- X coordinate is reconstructed from the longitudinal (Y) and stereo (V) strips then it suffers for the B field too.

* Data from Garfield simulations

Drift field scan – B = 1 T



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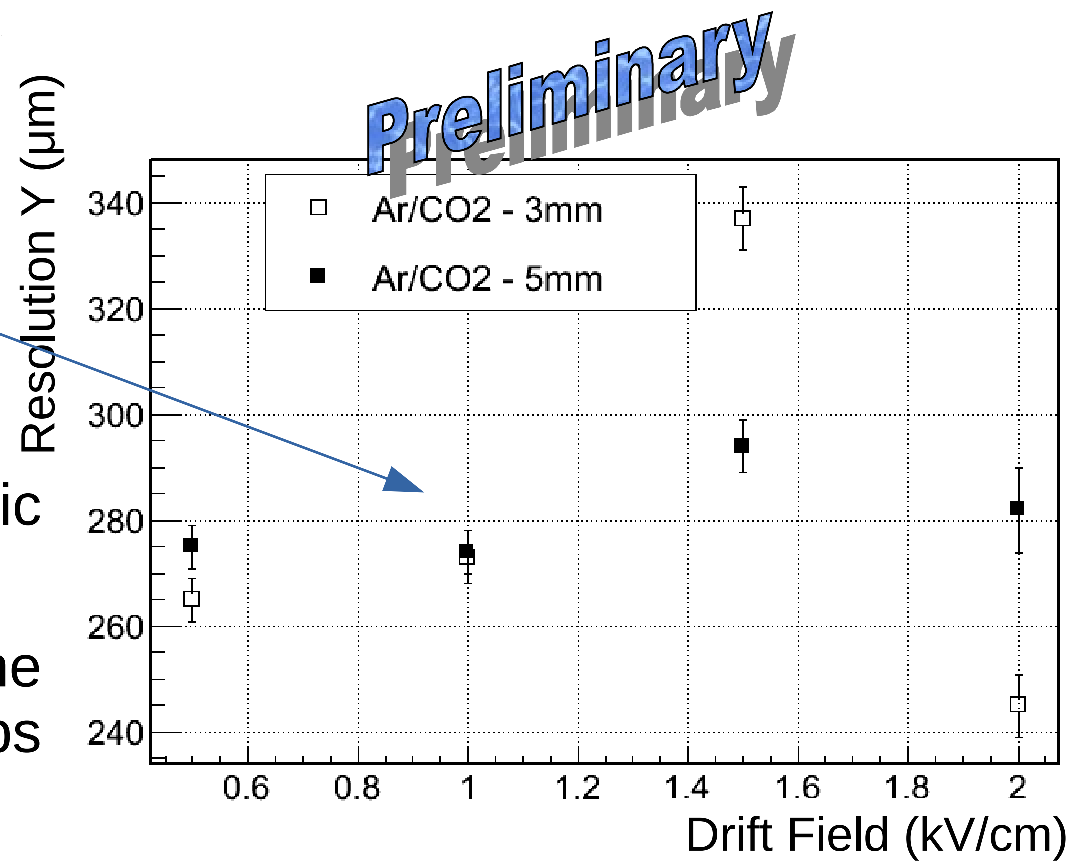
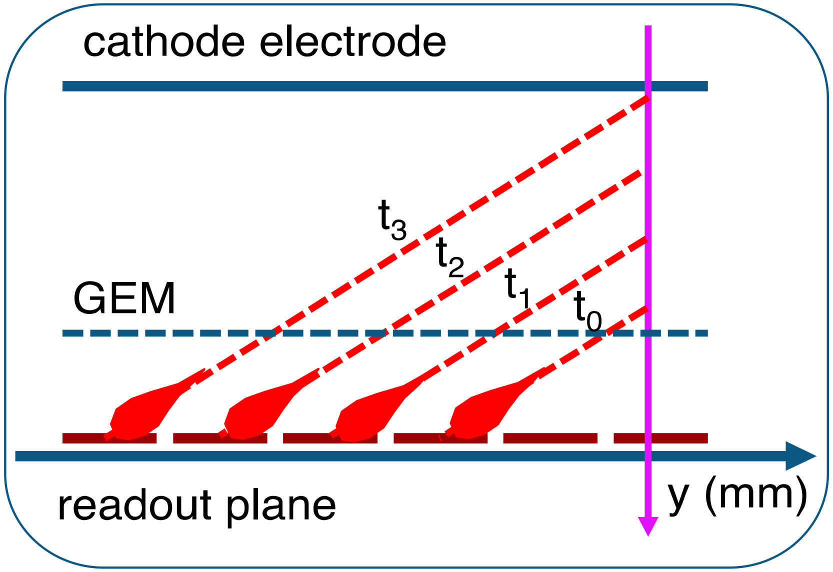


- Y coordinate suffer of the magnetic field effect.
- X coordinate is reconstructed from the longitudinal (Y) and stereo (V) strips then it suffers too.

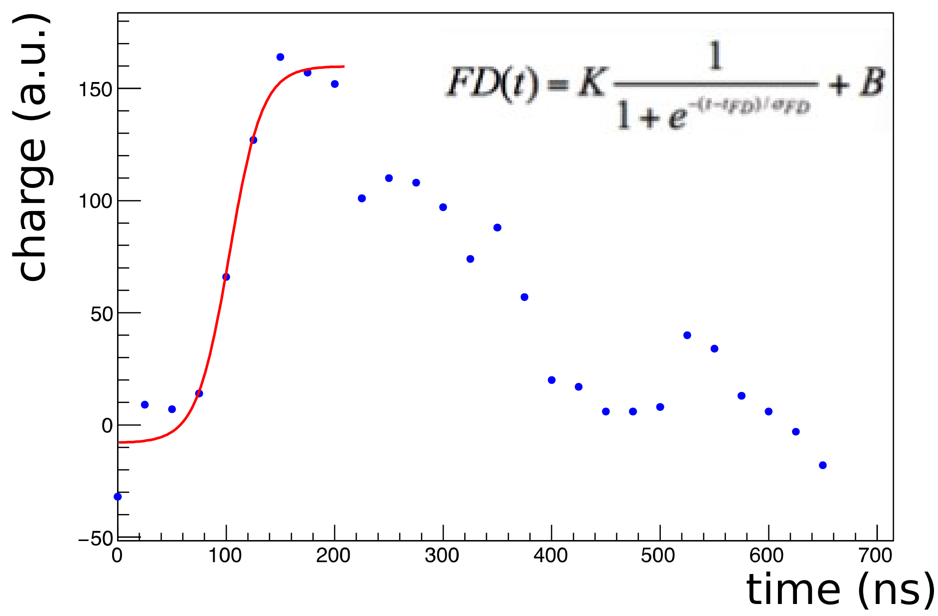
* Data from Garfield simulations

µTPC readout method

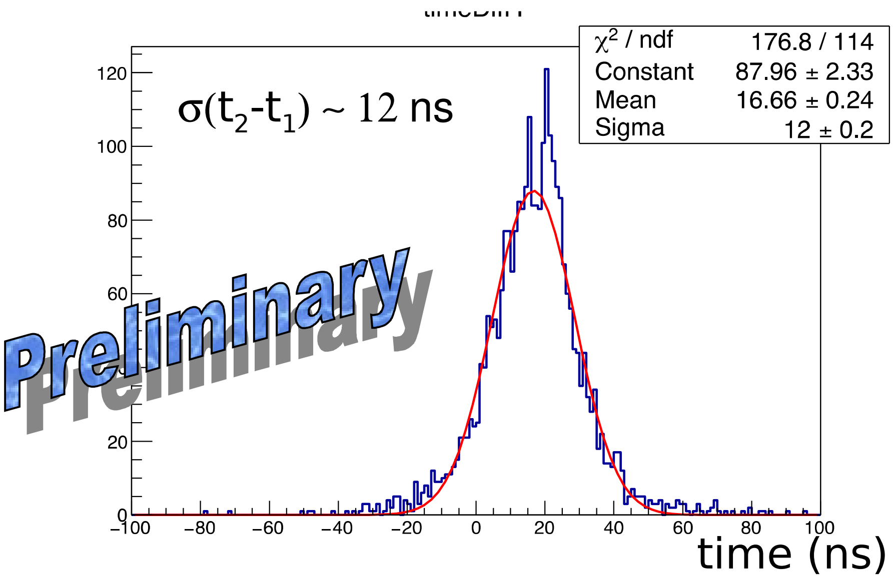
- The time information can be used to improve the spatial resolution with B field and not perpendicular tracks.
- Time information can be extracted from the sampling of the APV signal.
- A time resolution of 12ns allows this approach.



Fit to the charge samples to extract the drift time



difference from t_2 and t_1



Summary and Conclusion

- About the gas mixtures:
  - Ar/CO_2 in magnetic field doesn't show big differences between low and high drift field. The spatial resolution is about ~300 µm.
  - Ar/Iso in magnetic field shows a huge dependence by the drift field due the increasing of cluster size.
    The spatial resolution changes from ~1mm to ~190 µm.
- About the geometry, the results with the 3/2/2/2 and 5/2/2/2 mm configurations have similar behavior. A 3mm conversion gap performs better with the CC reconstruction method.
- µTPC readout is feasible and it gives a better resolution as the cluster size increases then it can be used as alternative method when CC becomes ineffective

Thanks