μTPC status

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Outline

- **Time calibration**

  time-walk, time-reference, time-propagation

- **Systematic effects**

  tracking system, environment conditions

- **After calibrations**

  broken cluster, capacitive corrections, tracking improvement

Time calibration

Time calibrations

time-walk

The shape of the signal affets the measured time. The correlation between time and charge is studied.

time-reference

The TIGER chips are syncronized but the time measurement of the same event can differ due to geometrical differences (i.e. routing, strip length, etc).

time-propagation

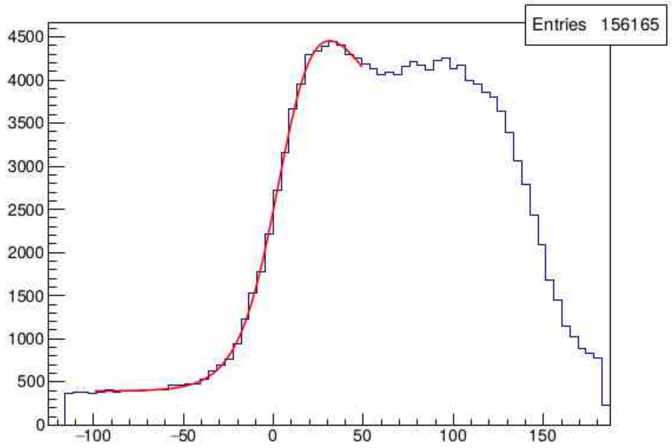
The signal propagation from the induction place on the strip and the chip affects the time measurement.

How to measure the time

The time distribution of the hits can be studied to extact the starting time of a certain group of recorded signal (i.e. all the hits of a TIGER or all the hits measured by a channel with a certain threshold).

The function used to fit the rising edge is:

$$[0] + \frac{[1]\, e^{-[2]\,(x-[3])}}{1 + e^{-\frac{(x-[4])}{[5]}}}$$



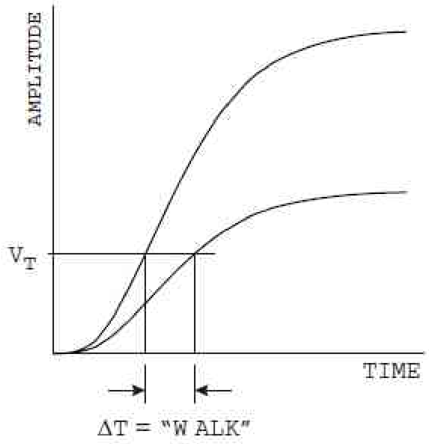
time distribution [ns]

Time calibration -> time-walk

The shape of the signal affets the measured time.

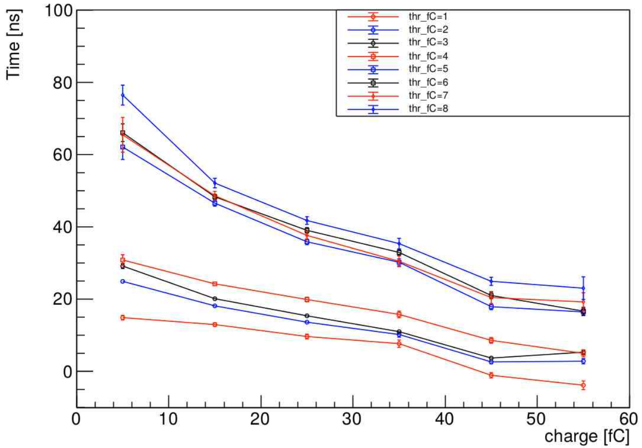
The correlation between time and charge is studied in two different enviroments: experimental and simulation data.

The effect is threshold depends.

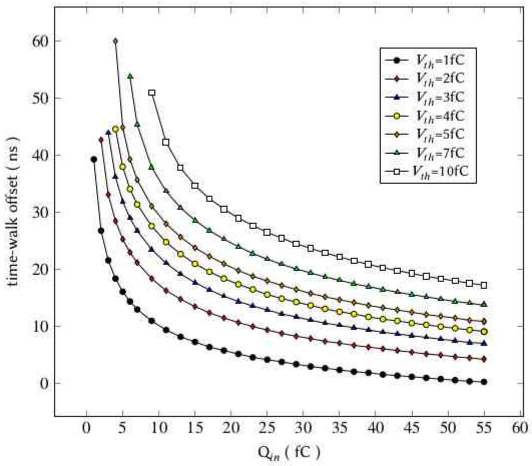


Time calibration -> time-walk

experimental data



simulation data

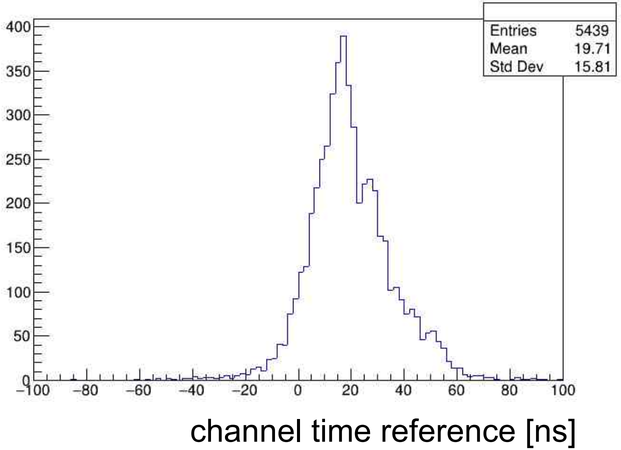


Experimental data are evaluated for different charge intervals and channel thresholds [run 11-16] using the mehod shown in slide 4. Simulation data are evaluated from squared waves injected in the TIGER asic.

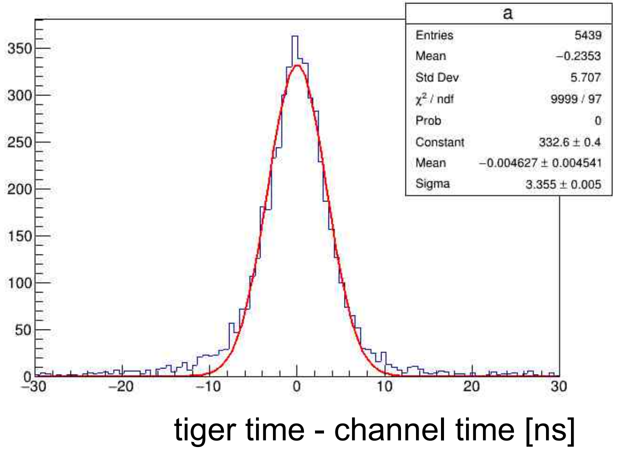
A strong dependency of the time a a function of the charge is evident. The discrepancy between the two methods is gived by the different signal shapes considered. Experimental results will be used.

Time calibration -> time-reference

experimental data



experimental data



Time reference is measured for each channel or for each TIGER chip (~60 channels) using the method of slide 4. A spread from -20 to 80 ns has been observed comparing the different channels, while a difference of about 10-20 ns has been observed between a channels and the others of the same chip.

Time calibration -> time-propagation

direct measurements and simulations

	Strip X	Strip V
Layer 2	0.51 $\pm$ 0.05 c	0.59 $\pm$ 0.05 c
Layer 3	0.35 $\pm$ 0.04 c	0.57 $\pm$ 0.05 c
Simulation	0.36c	0.57c

experimental data

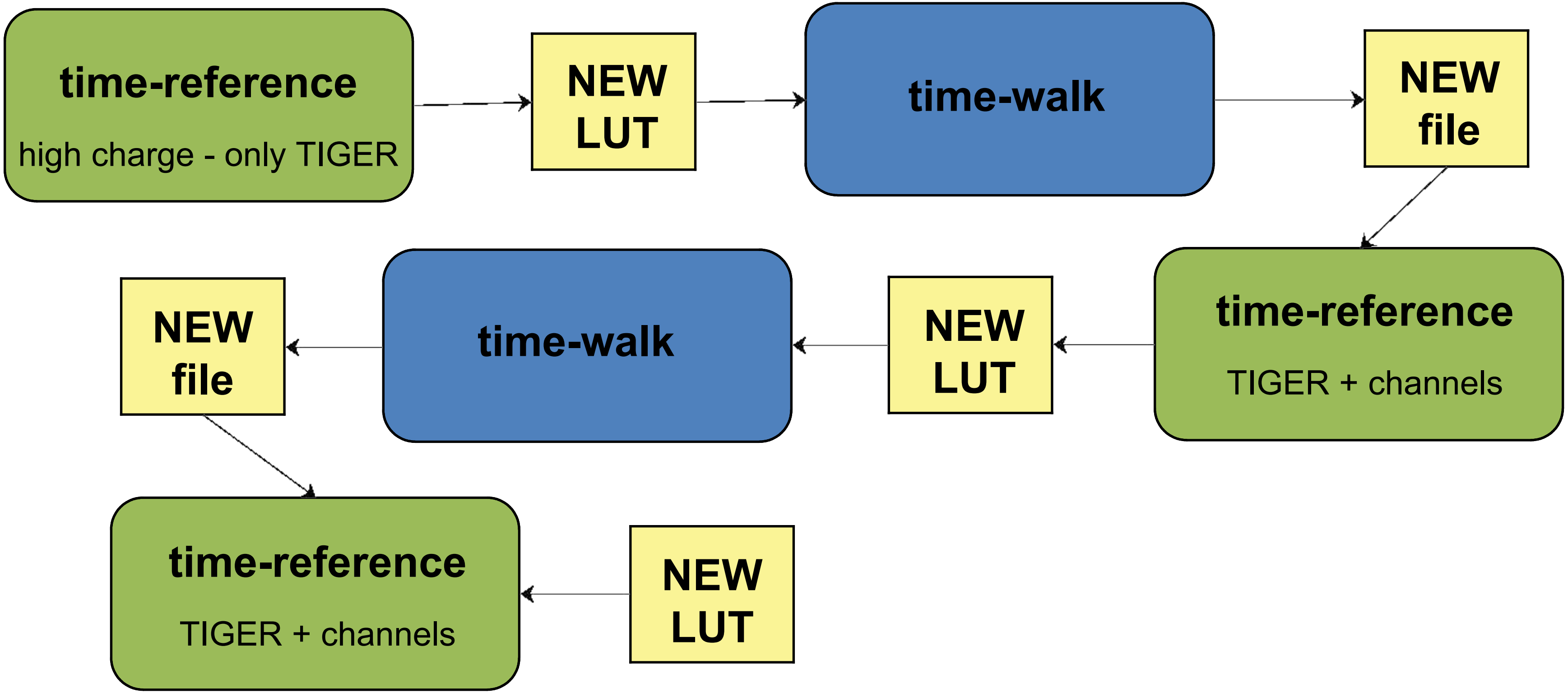
	Strip X
Layer 1	0.83 $\pm$ 0.30 c
Layer 2	0.25 $\pm$ 0.03 c

Simulations and direct measurements report a propagation velocity between 0.35-0.6 c.

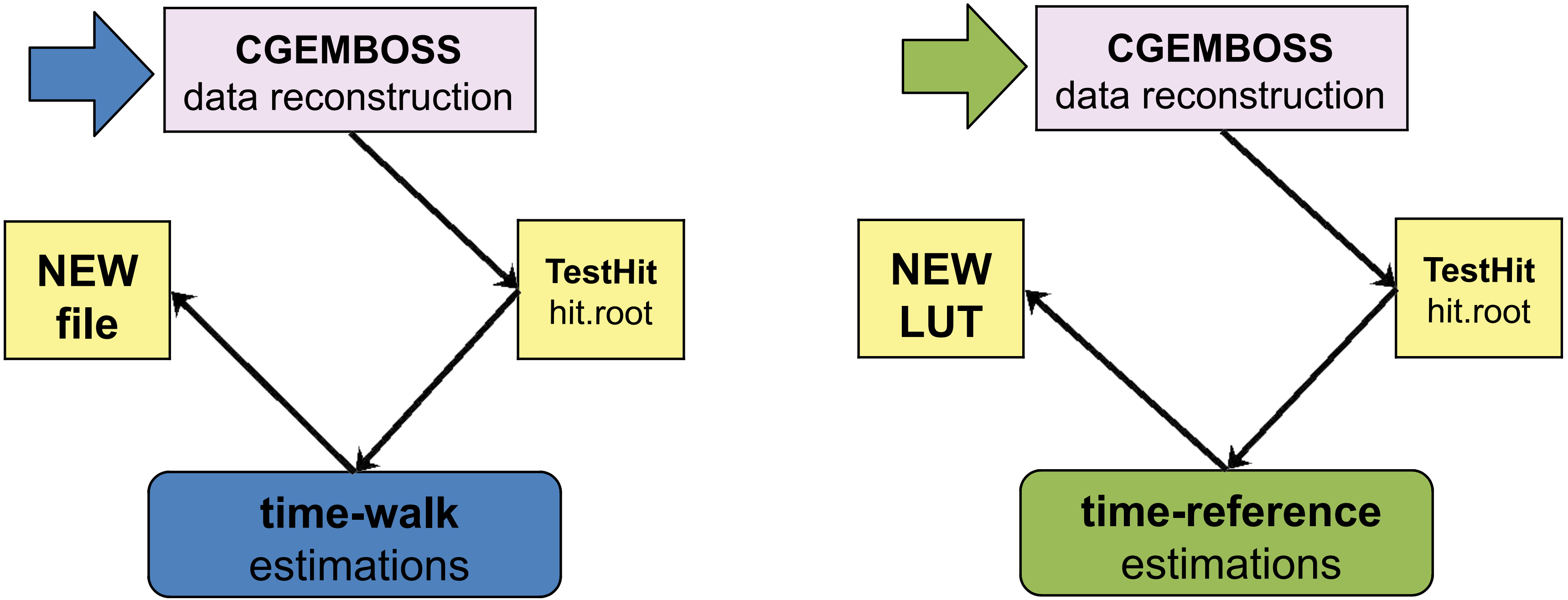
Experimental measurements suffer the low statistic that limits the precision of this evaluation.

The measures are not compatible then up to now this correction is not taken into account.

Procedure to evaluate the time calibrations



Procedure to evaluate the time calibrations



Why don't we implement the codes to estimate these corrections inside CGEMBOSS?

Limits of this procedure

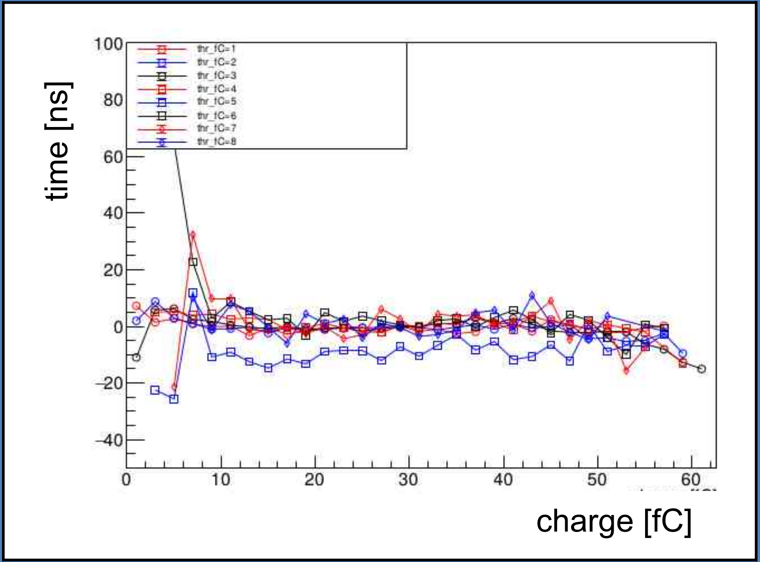
The corrections we want to implement **need time and high statistic**. The procedure is **iterative** and it can reduce the time spread due to the charge and the geometry of the strip or the routing.

The time extraction from the procedure shown in slide 4 requires a high statistic to reduce as much as possible the error. **This is not guaranteed for all the channels** or some charge/threshold configurations.

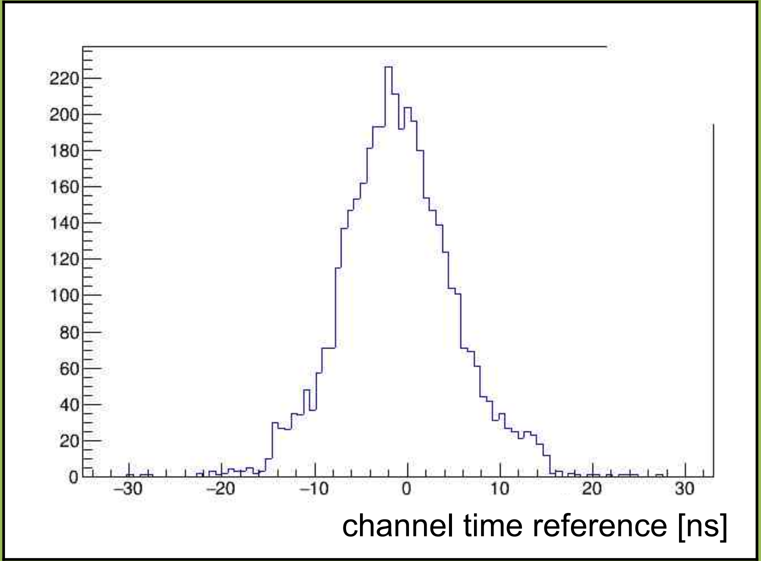
The number of channels is more than 5000 then it is **important** to constrain correctly the **fitting procedure** to automatize it.

Results of the time calibrations

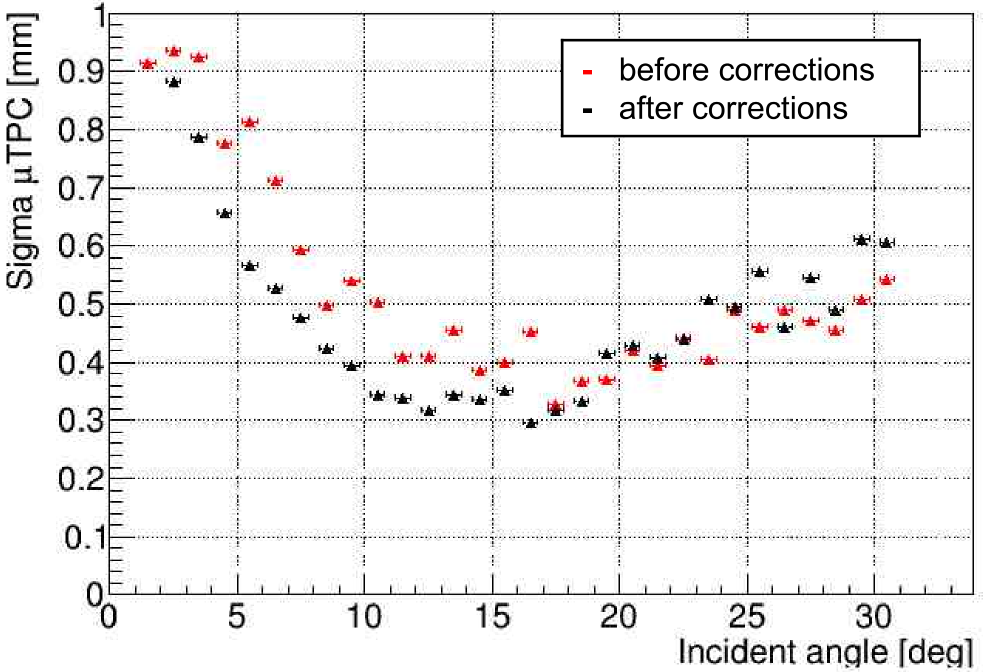
time-walk



time-reference



Results of the time calibrations → Layer1



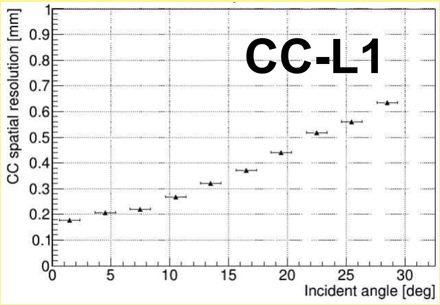
The time calibrations introduce an improvement of the **sigma µTPC** in the region below 20° incident angle. The time calibrations are successful.

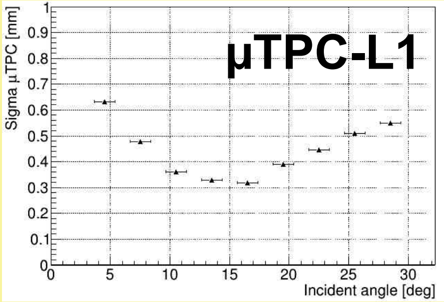
The fluctuations above 20° are due to low statistic in the sigma evaluation. In this range the µTPC should be flat.

Systematic effects

Systematic effects

Tracking system





Enviroment

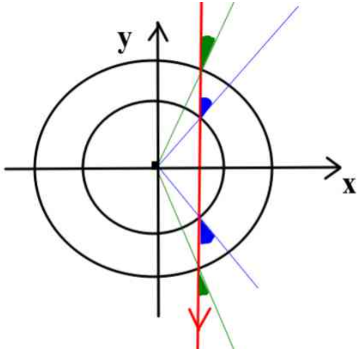
$$t'_{hit} = t_{hit} - t_0$$

$$z_{hit} = t'_{hit} \cdot v_{drift}$$

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

Time and drift velocity can be affected by temperature, pression and humidity of the gas mixture

Tracking system → toy MC

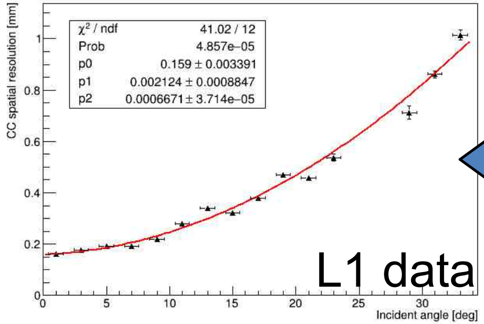


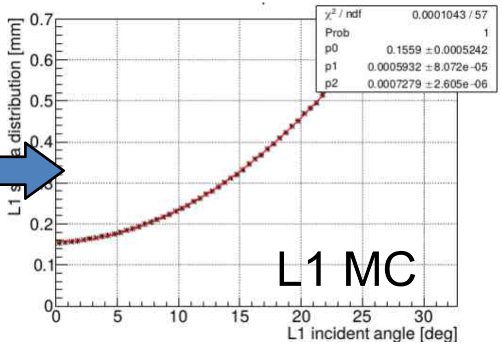
1. Randomize the position of the cosmic ray [0, R_L1]

2. Smear the track incident angle of 0.36 deg (from Marco’s calculation) for L1down and L2down

3. Evaluate the **expected CC resolution** at the impact point using the function

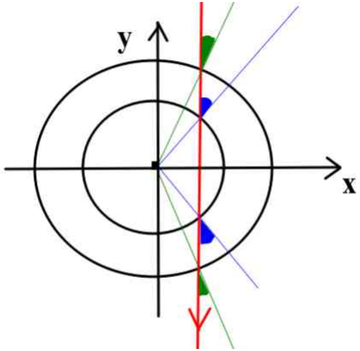
CC_res = 80 µm + 3.0 µm/deg * angle + 0.65 µm/deg^2 * angle^2





CC L1 + tracking system

Tracking system → toy MC



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3. Evaluate the **expected CC resolution** at the impact point using the function

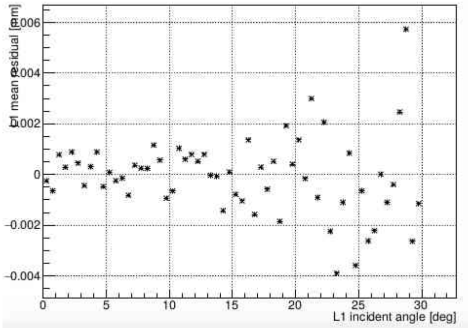
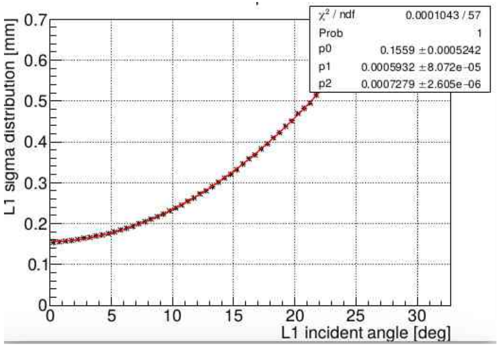
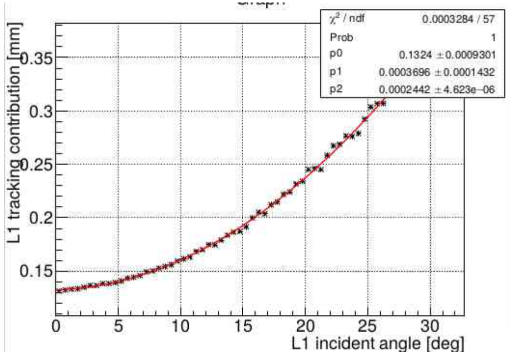
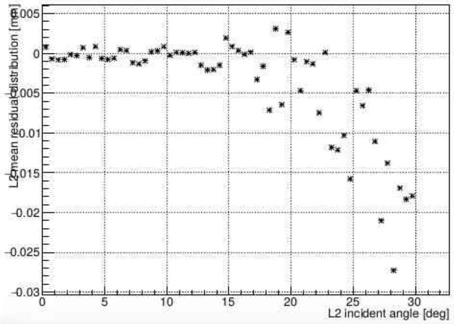
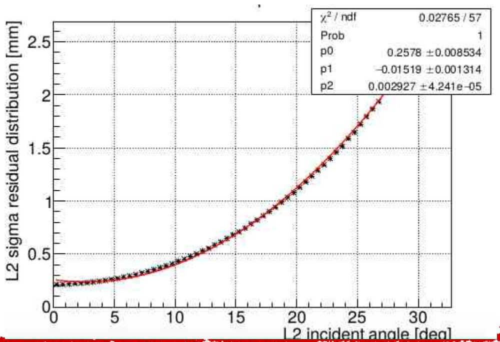
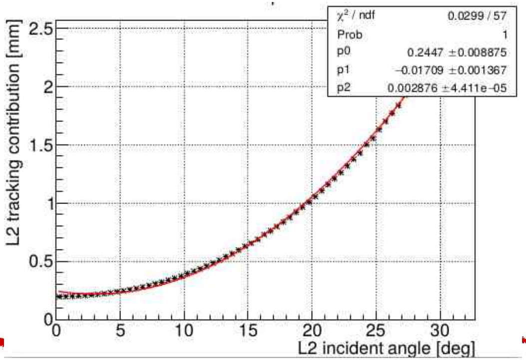
   CC_res = 80 μm + 3.0 μm/deg * angle + 0.65 μm/deg^2 * angle^2

4. Smear the four point on the X direction and extract the corresponding Y

5. Use three point to reconstruct the track and measure the residual distribution and the constribution of the tracking system = sqrt(sigma_recon^2 - sigma_true^2)

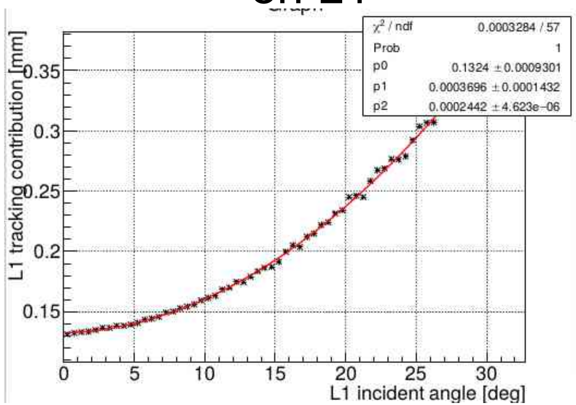
The function used to evaluate the CC_res has been calculated in order to match the reconstructed CC_res in the MC data with the experimental data below 20μm

Tracking system → toy MC

	Residual Mean value	Residual sigma	Contribution of the tracking system
L1			
L2			

Tracking system → toy MC

Contribution of the tracking system on L1

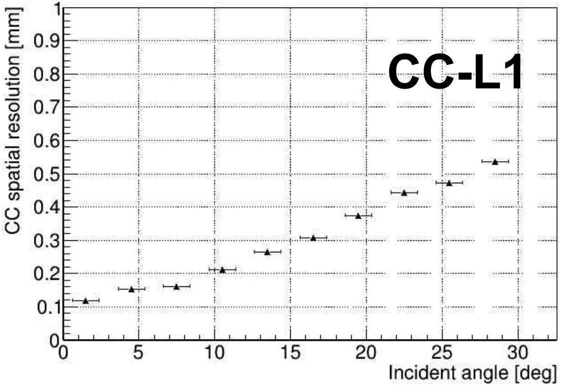


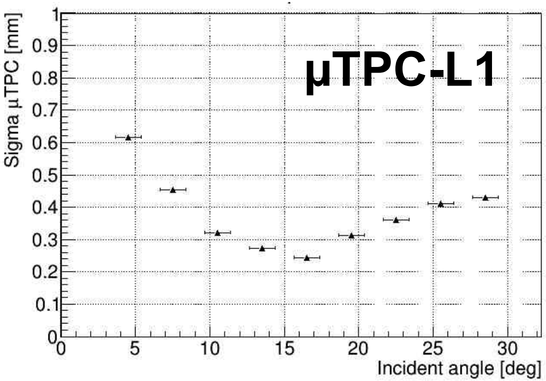
1. The thrend of the constribution of the tracking system now is reasonable with respect to the one shown on April

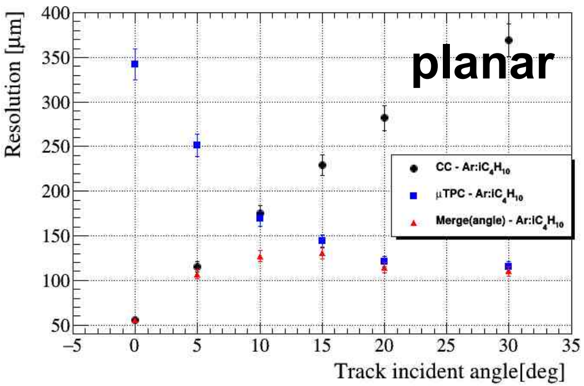
2. This results is important to understand the behavior of the μTPC once the incident angle is larger than 15° but it does not explain the difference between μTPC resolution of the CGEM and the planar GEM.

3. The MC resolution for L1 matchs the experimental data but the MC resolution of L2 does not. L2 seems to be different from L1 or the systematic are not measured properly. A different function could be used to estimate the CC resolution as a function of the angle for L2.

Tracking system → toy MC







Even if we substract the contribution of the tracking system from the CC and μTPC sigma measurements, the performance measured in the CGEM is different from the one measured on the planar.

This means that there are other systematics that we have to take into account.

Enviroments systematics → Magboltz simulations

Temperature, pressure, gas mixture contaminations can affect the drift properties of the electrons, such as longidudinal diffusion (time resolution) and drift velocity.

Some Magboltz simulations have been performed to evaluate if the variations of these enviroment variables can affects the μTPC parameters then its resolution.

We consider a gas mixture Argon:isobutane (90:10) + $15*10^{-3}$ O2 and $15*10^{-3}$ H20 in agreement with the article linked there (these values are an overestimation)
https://www.sciencedirect.com/science/article/pii/S016890021931544X

Enviroments systematics → Magboltz simulations

Drift velocity [µm/ns]	P = 1003 mbar	P = 1013 mbar	P = 1023 mbar
T = 10 °C	37.12	37.20	37.27
T = 20 °C	36.89	36.97	37.02
T = 30 °C	36.70	36.77	36.80

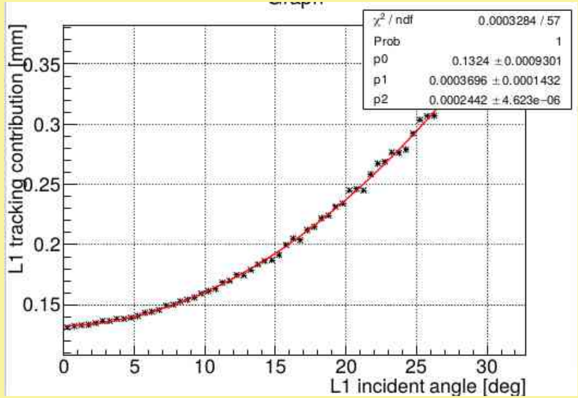
Longitudnal diffusion [cm^2/s]	P = 1003 mbar	P = 1013 mbar	P = 1023 mbar
T = 10 °C	5398	5375	4920
T = 20 °C	5234	5800	5351
T = 30 °C	5755	5649	5502

Variations below 1% in drift velocity and about 7% (max) in the longitudinal diffusion are found for large variations of T and P

Systematic effects results

Tracking system

L1 tracking contribution has been evaluated but it doesn't explain the planar difference



Enviroment

Variations of temperature, pression and humidity have a small contribution

$$t'_{hit} = t_{hit} - t_0$$
$$z_{hit} = t'_{hit} \cdot v_{drift}$$
$$x_{\mu TPC} = \frac{gap/2-b}{a}$$

After calibrations

After calibrations

Broken clusters

Microsectors introduce some broke-cluster on the readout. Larger cluster may improve the µTPC reconstruction

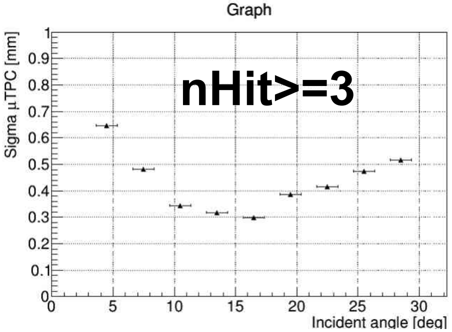
Capacitive effects

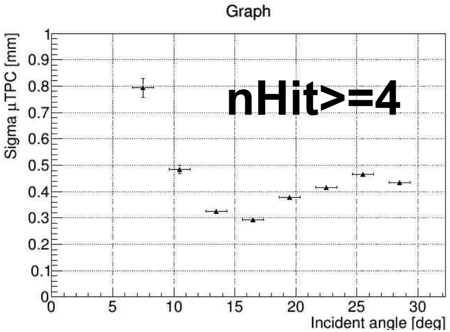
From studies on the planar GEM, some algorithms can improve the µTPC using the charge information

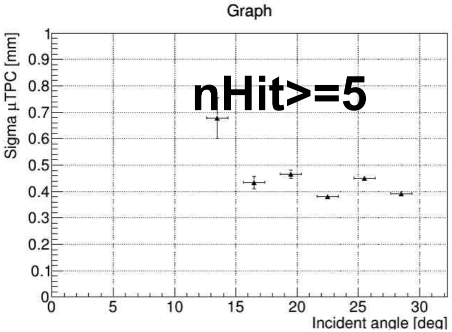
Tracking improvements

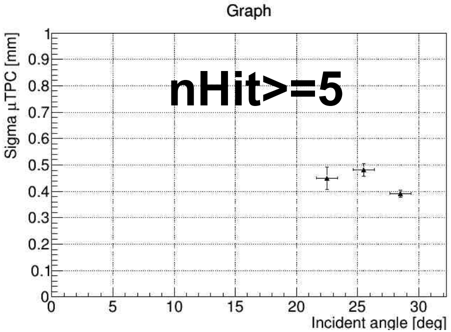
The code for the 2D tracking in CGEMBOSS can improve the results and increase the statistic

Broken clusters → µTPC vs cluster size





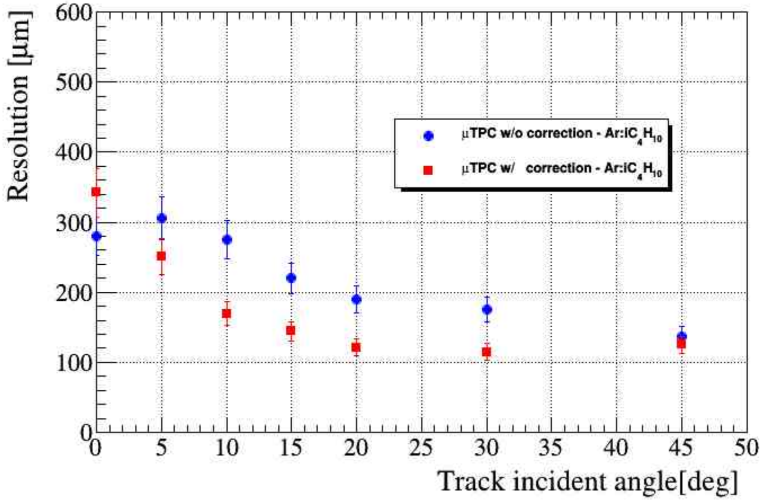




µTPC sigma is shown for some contrains on the number of hit in the cluster.

No significan improvement are observed if only large cluster size is considered

Capacitive effects



The charge information can be used to improve the μTPC resolution.

After calibrations → To Do

Broken clusters

Not needed

Capacitive effects

To be implemented once all the other contributions are understood

Tracking improvements

To be tested with the new code in CGEMBOSS