Time calibration

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On behalf of Integration and Software Groups

A big effort from a large community to face off this task

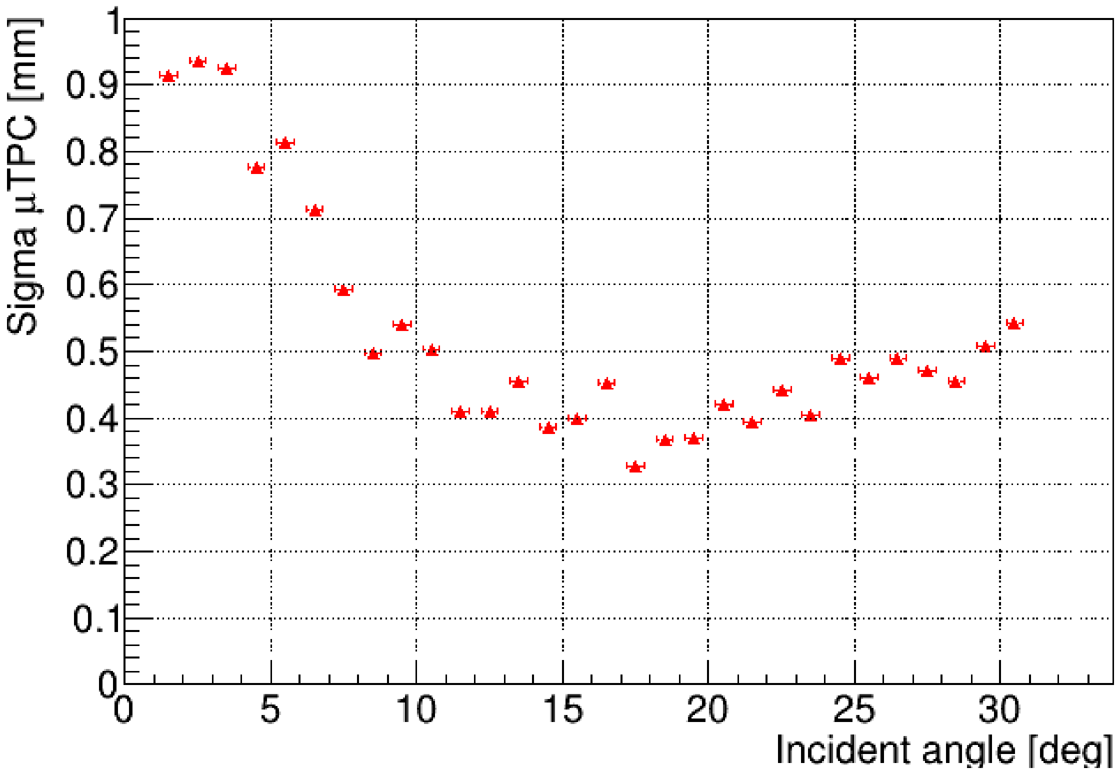
Outlook

1) Summary of the Time Corrections
- introduction
- methods
- results

2)Time-walk discrepancy and signal shape effect
- considerations
- proposal

3)Preliminary studies to understand the problem
- noise reduction with good cluster
- time-walk simulation in CGEMBOSS
- QA procedure and tracking in CGEMBOSS

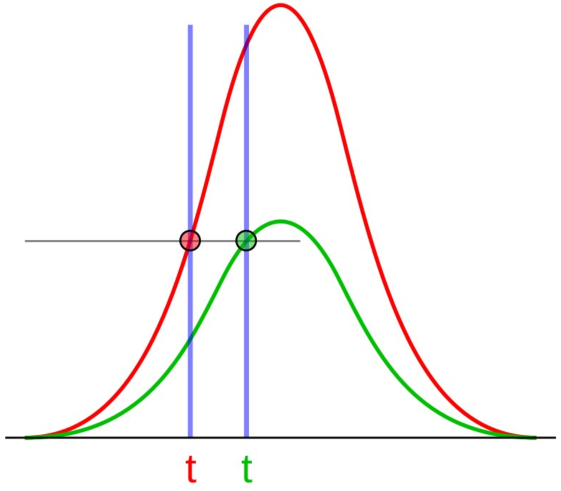
Status of CGEM-IT μTPC resolution



The μTPC is an algorithm to use complementarly at the Charge Centroid for impinging angle larger than 10-15 degrees

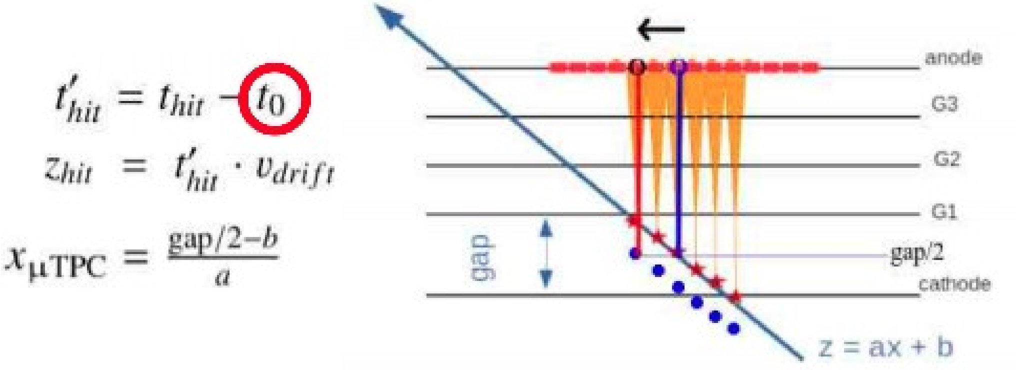
At the moment the sigma of the residual distribution is around 400µm and an improvement is need to match the CGEM-IT performance required

Time calibration summary



Time-walk: the signal amplitude affects the time measurement. The correlation between charge and time is studied as a function of the threshold levels

0-80 ns contributions



Time-reference: Tiger chip are synchronized but the time measurement of the same event can differ due to geometrical differences (i.e. routing, strip length, etc)

0-40 ns contributions

Time-propagation: The signal propagation from the induction point on the strip and the electronic channel affects the time measurements

0-5 ns contributions

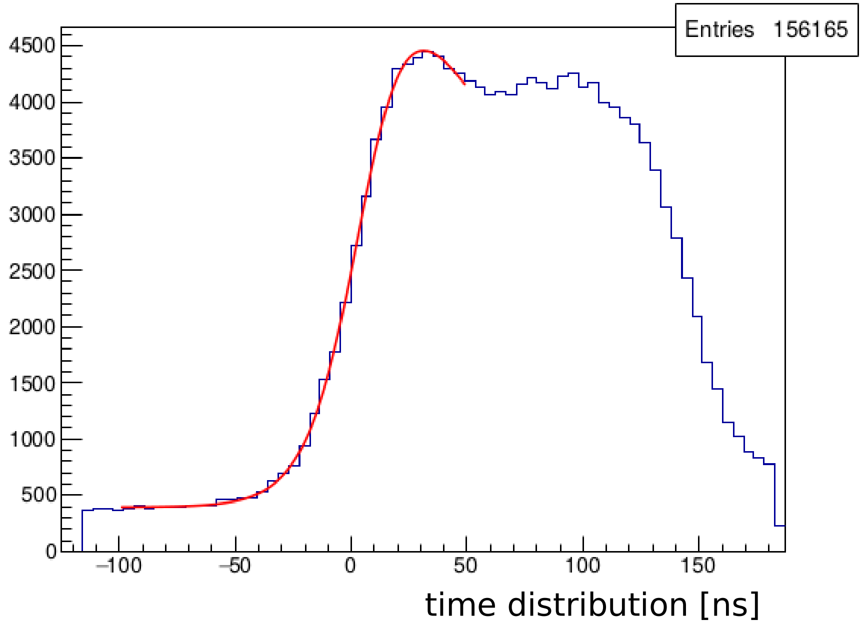
	Strip X	Strip V
Layer 2	0.51c	0.59c
Layer 3	0.35c	0.57c

Time calibration: time measurement

The time corrections have been evaluated from the data acquired in the cosmic data-taking with the CGEM-IT in Beijijng.

A time distribution for different cases (TW or TR) is fitted to extract the time information corresponding to the half maximum.

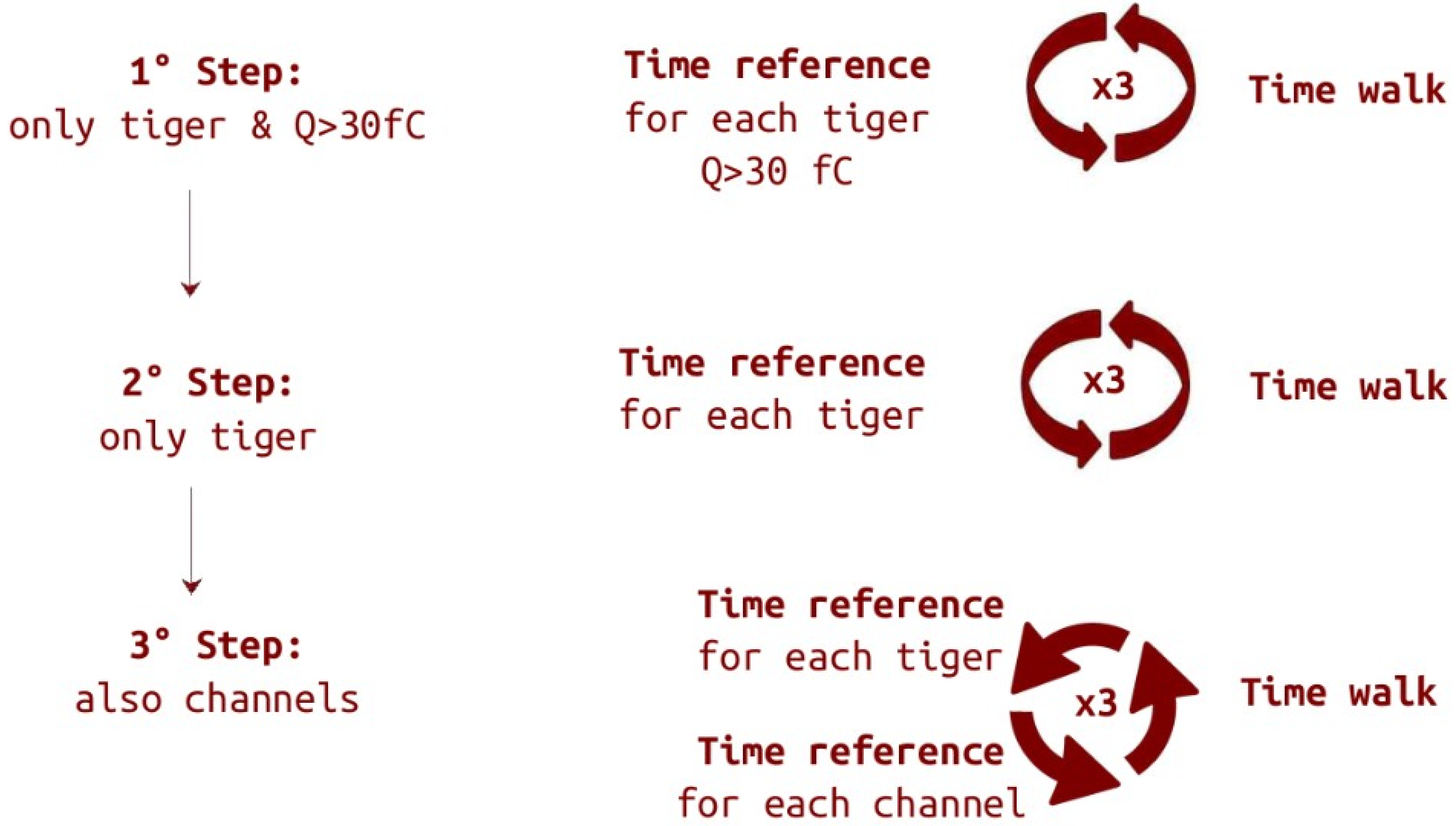
$$[0] + \frac{[1]\, e^{-[2]\,(x-[3])}}{1 + e^{-\frac{(x-[4])}{[5]}}}$$



Time measurement as a function of the TIGER/channels have been performed for the TR; as a function of the threshold and the charge for the TW.

The procedure is performed by the CGEMBOSS package CgemTimeCalibration

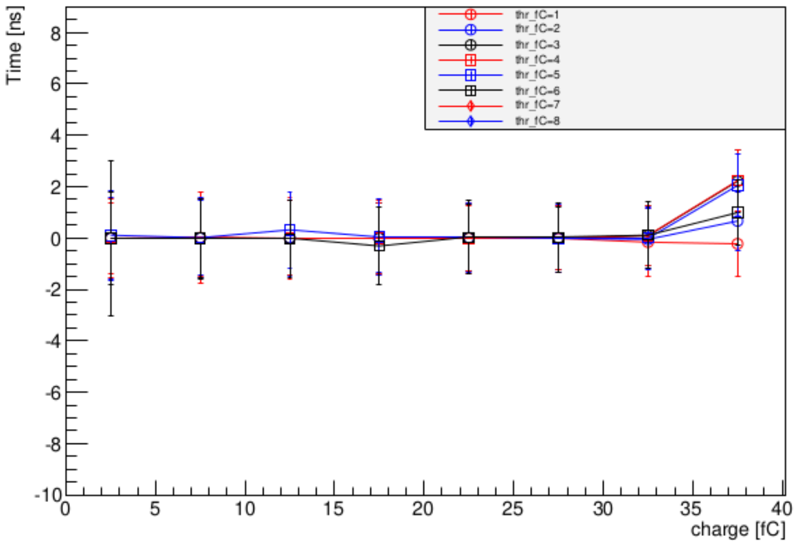
Time calibration: procedure



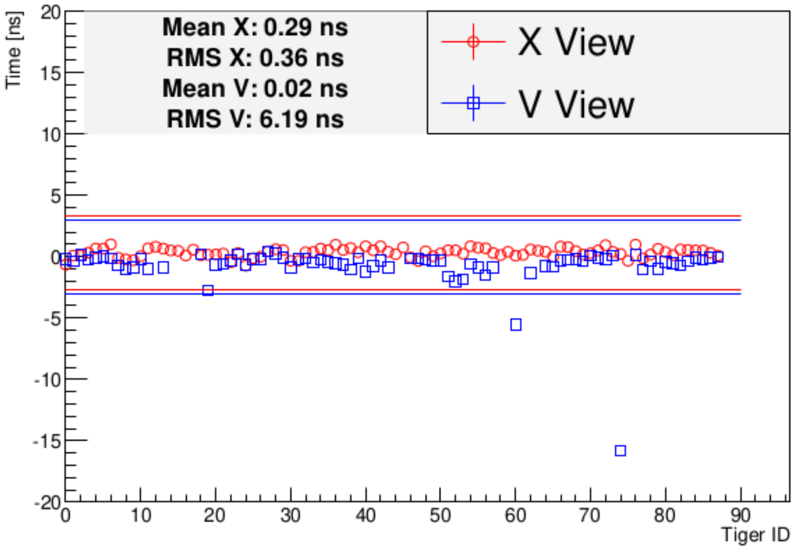
Time calibration: results and quality check

The convergence of the calibration procedure is controlled by several plots included in the CgemTimeCalibration package.

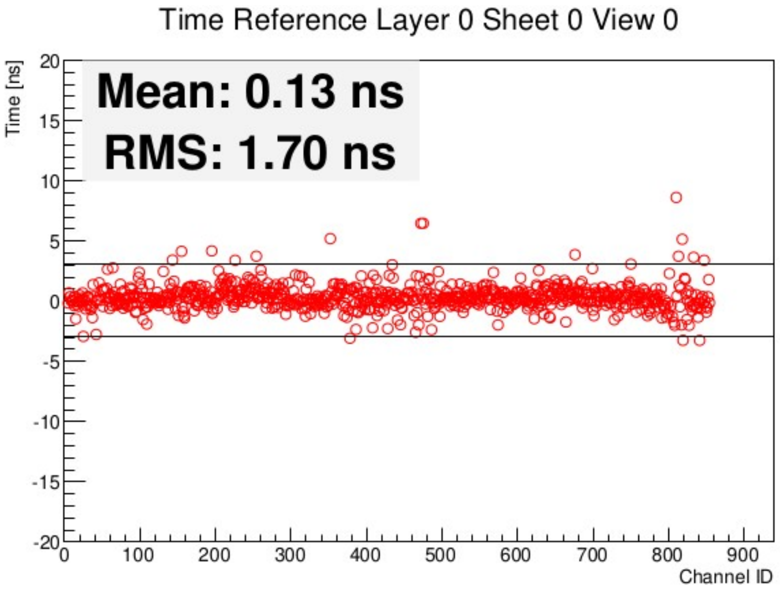
The correction inside each set of the iteration is evaluated. After three cycles, no more corrections are needed.



Time walk



Time reference TIGER

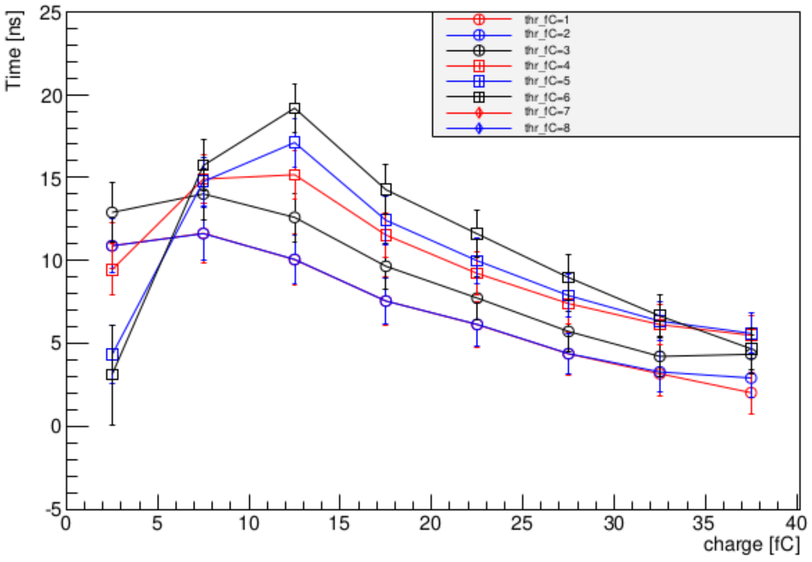


Time reference channels

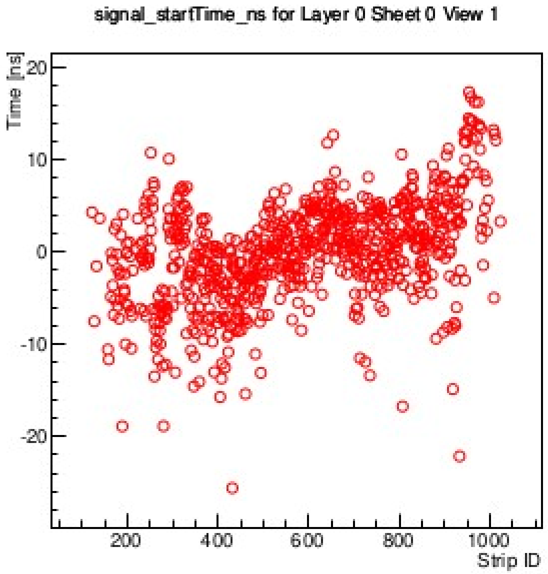
Time calibration: results and quality check

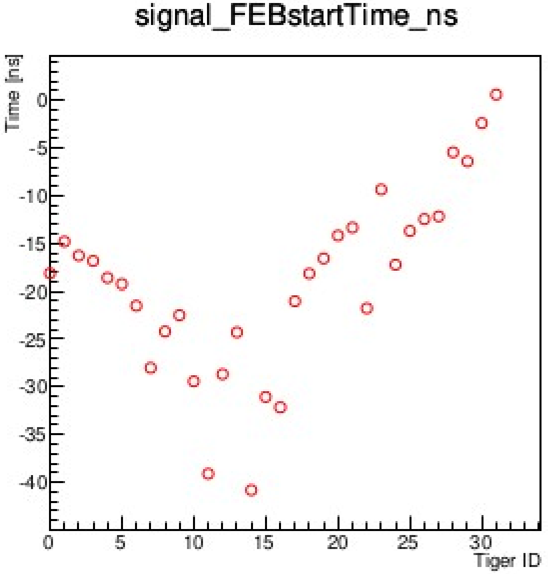
The final results for TW and TR are shown in this slide.

TW ranges from 0 to 20 ns
TR ranges from -40 to 0 ns

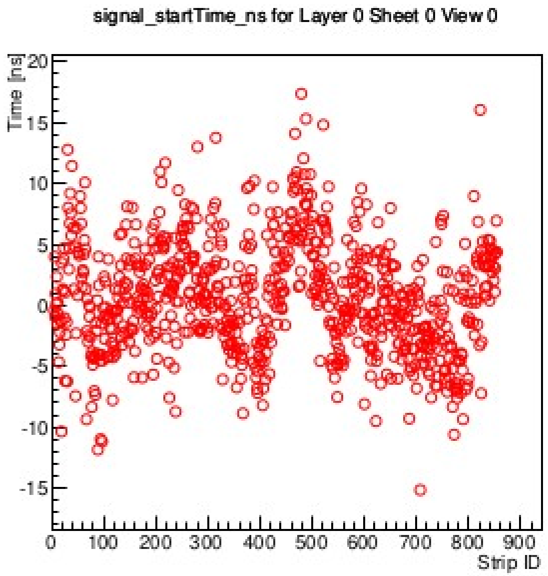


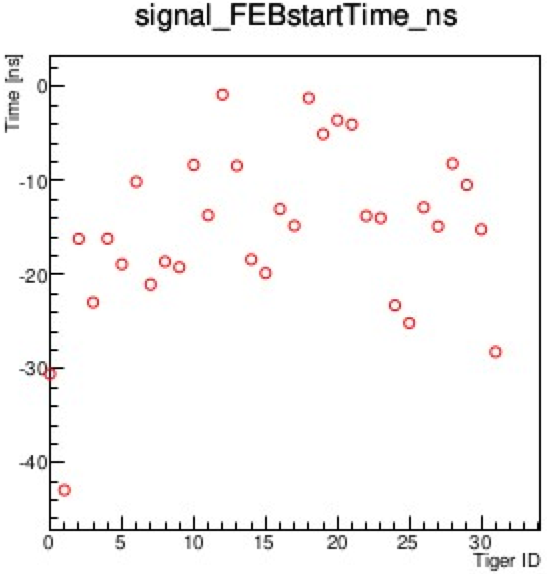
Time walk





L1X





L1V

Time reference TIGER **Time reference channels**

Time calibration: inside CGEMBOSS

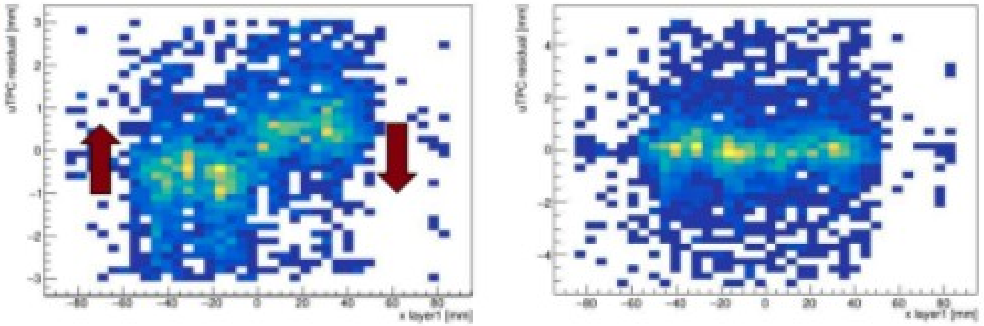
The µTPC algorithm have been modified inside CGEMBOSS in the CgemClusterCreate package in the version 00-00-35. Ready to be tested

```
float CgemClusterCreate::get_Time(CgemDigiCol::iterator iDigiCol){
  //Get digi time
  float time = (*iDigiCol)->getTime_ns();
  //Get rising time from calibration
  float time_rising  = get_TimeRising(iDigiCol);
  //Get time-walk
  float time_walk = get_TimeWalk(iDigiCol);
  //Get time-reference
  float time_reference = get_TimeReference(iDigiCol);
  //
  float time_shift_custom = -35;
  time-=(time_rising+time_walk+time_reference+time_shift_custom);
  return time;
}
```

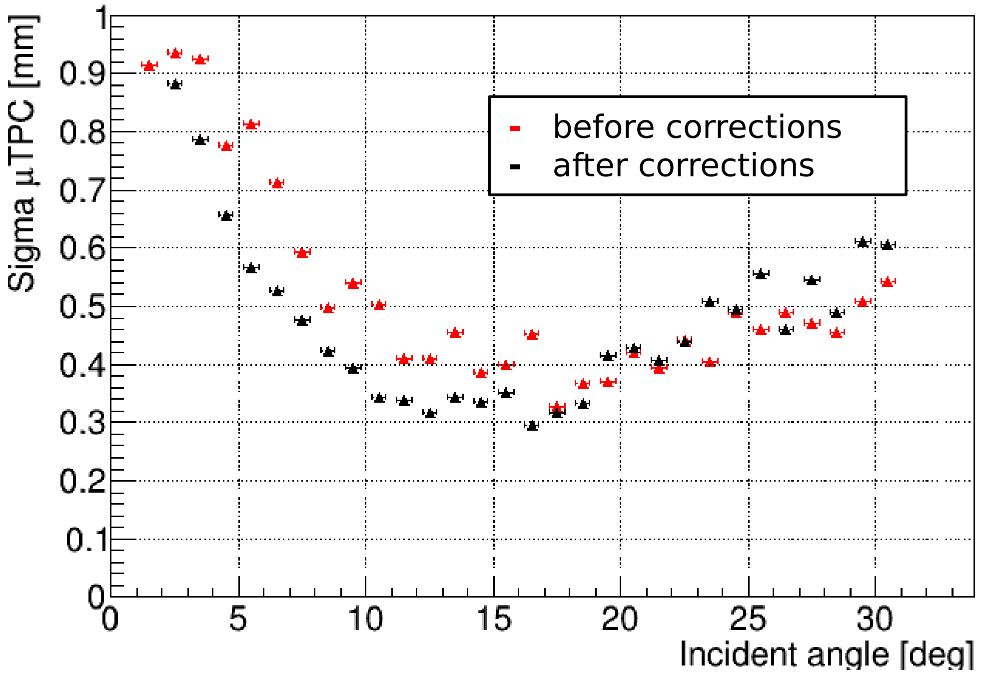
CgemCalibFunSvc.TimeFitFile="/bes3fs/cgemCosmic/data/timeFitCalibConst/timeFit_Run10.txt";

CgemCalibFunSvc.TimeWalkCalibFile = "TimeWalk.root";

CgemCalibFunSvc.LUTfile = "TimeReference.root";
TestHit.LUTfile = "TimeReference.root";
CgemClusterCreate.LUTfile="TimeReference.roo";



Time calibration: correction impact on µTPC



The time calibrations introduce an improvement of the sigma µTPC in the region below 20°.

There the time calibration are successful.

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

The expected improvements should be better than those one. This is related to several points:

- contribution of the tracking system has a large impact (200µm at 15° and 300µm at 25°)
- the alignment and the analysis has been performed with a stand-alone code

Time-walk considerations

There is a large discrepancy in the low charge region between the results from experimental data and the one measured with the injected charge.

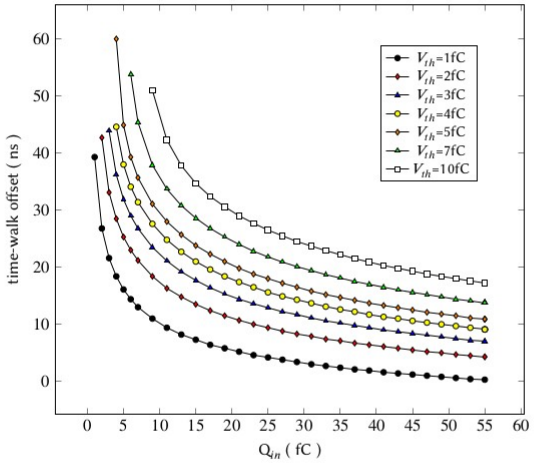
The correlation between the charge and time at different threshold has been measured with different methods.

1. Simulation and on-chip calibration inject a known charge in the electronic channel with a fixed signal shape. This technique allows to measure the time-walk of the electronics

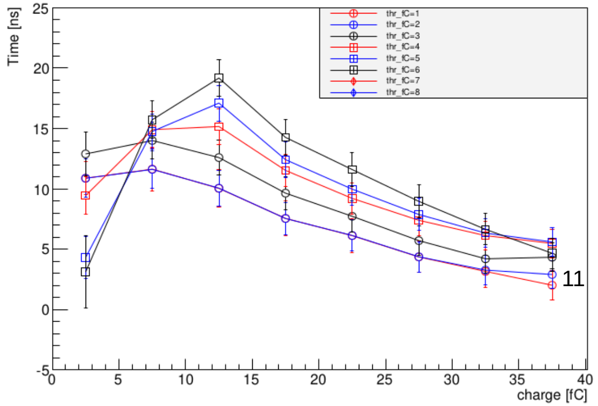
2. Experimental approaches show a similar method but the signal shape used is different. This technique depends on the signal shape: duration, amplitude, multi peaks, etc …

The two methods are differents and they do not measure the same physics quantity.

calibration data



experimental data



Signal shape

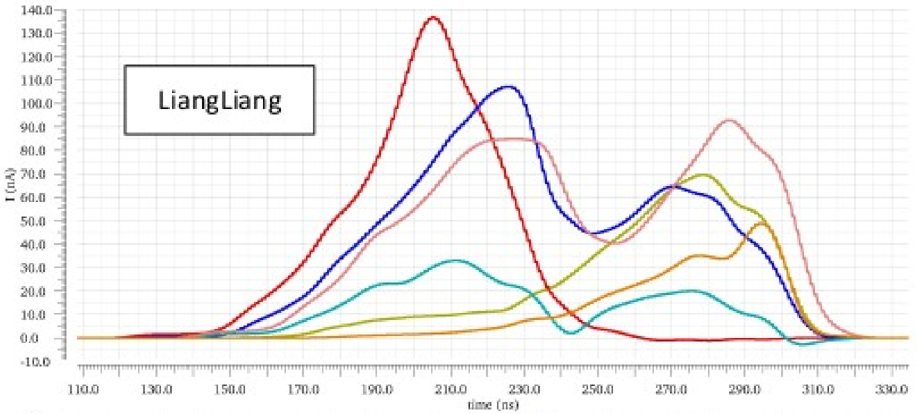
Simulations from the CGEM group show several signal shapes.

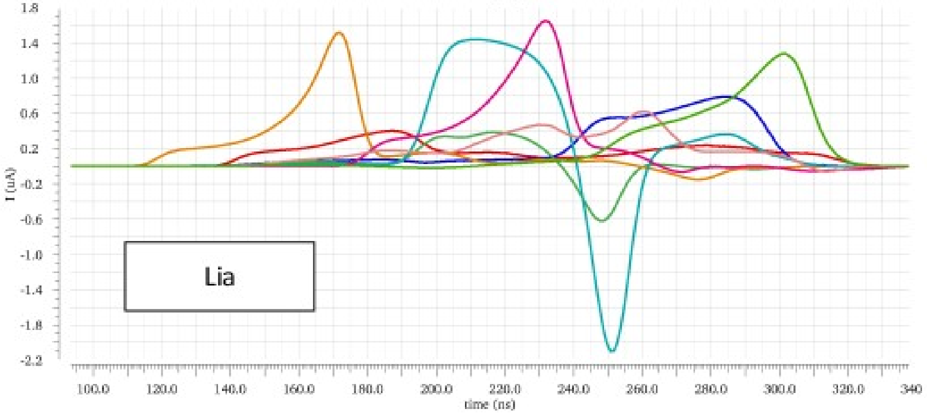
Further studies on these simulations shown that the signal length as an impact on the charge measured due to ballistic effect:

from 0% to 20% charge loss for signal from 10ns to 250ns

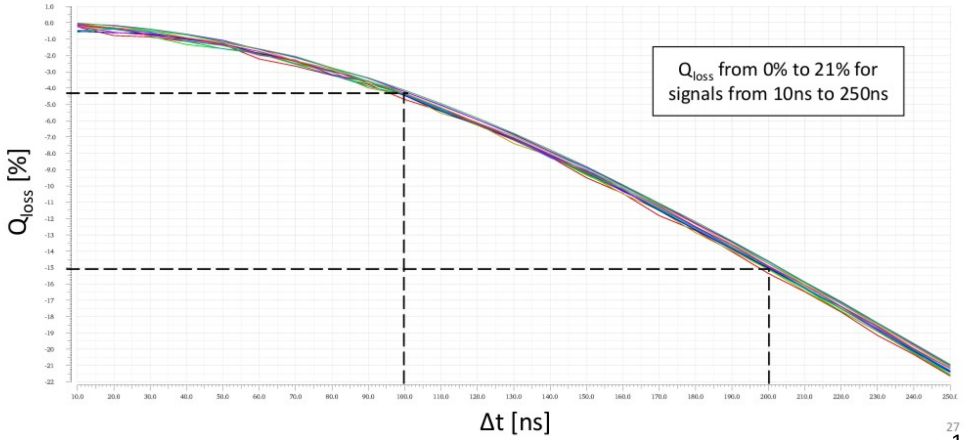
Signal length has an impact on the charge, but what is the impact on the time? What is the proper time to use with the µTPC?

Charge and time measurement depend on the signal shape. This contribution is not time-walk, it is a separeted contribution to be studied and to be added to the time-walk.





Ballistic deficit vs signal duration (E-branch)

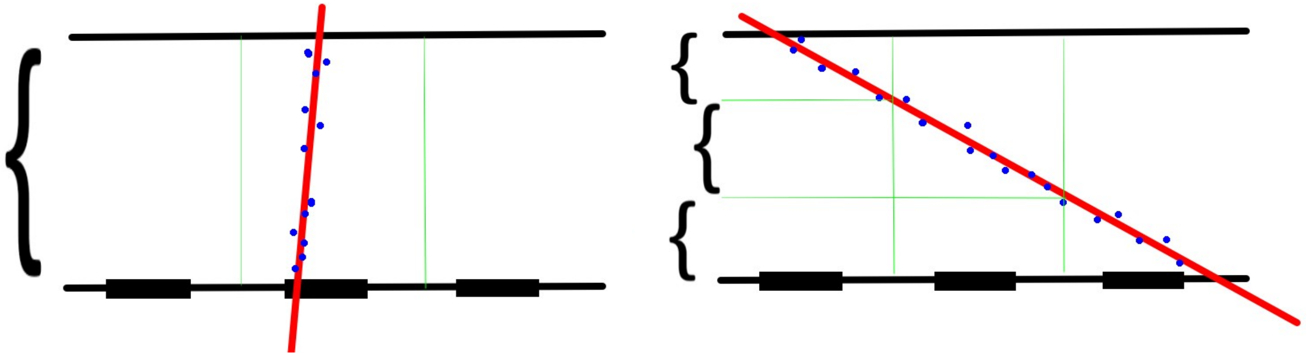


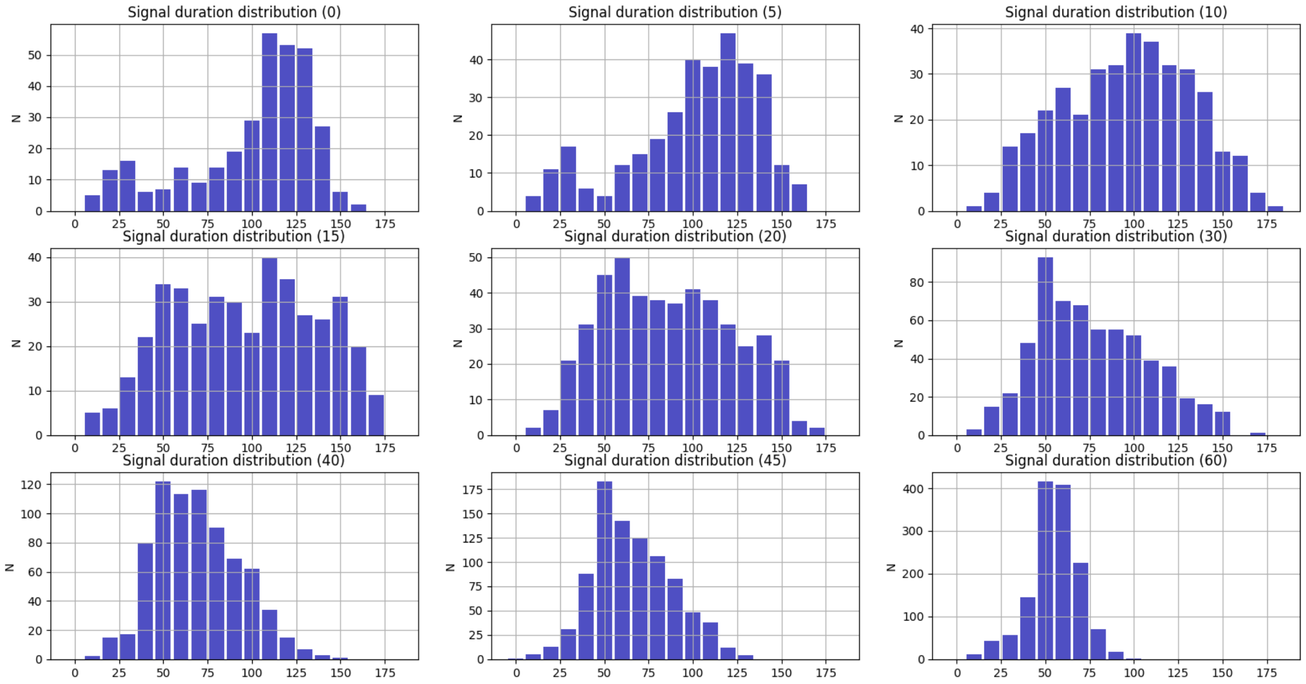
Signal duration

Starting from the simulations as a function of the incident angle we can mesaure the signal duration between 5% and 95% of the charge integration.

The signal duration depends strictly on the incident angle: if the track is orthogonal then the duration length is maximum, then its impact on the charge and the time measurements.

If the track is 60° the signal duration is shorter and there the contribution of the signal shape on the charge and time measurements is smaller.





- HV = 275 / 275 / 275 V
- campi = 1.5 / **2.75** / **2.75** / 5 kV/cm
- gas = Ar-Iso 90-10
- velocità di drift ~ 35 micron/ns

Validation

How can we decide the goodness of our time calibrations?

1. Time-reference -> convergence

2. Time-walk -> it depends on the chip architecture only

3. Signal shape effect -> some information can be extracted from experimental data but this effects needs more comprehension from the integration and the software group

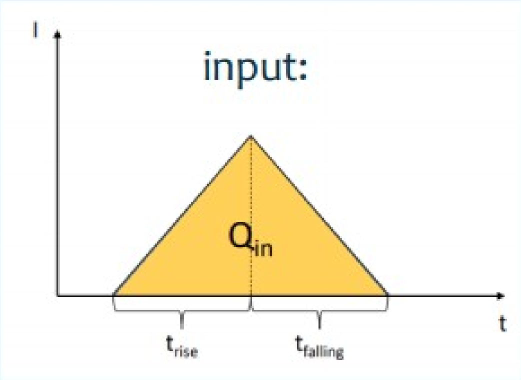
4. uTPC resolution should be the best benchmark for the validation but the contribution of the tracking system is too large

Time-walk simulation in CGEMBOSS

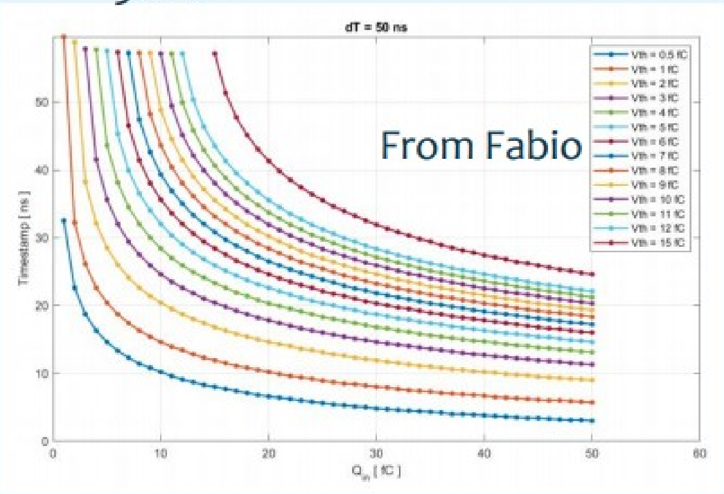
Hang Zhou (USTC)

Check of Digitization: time walk

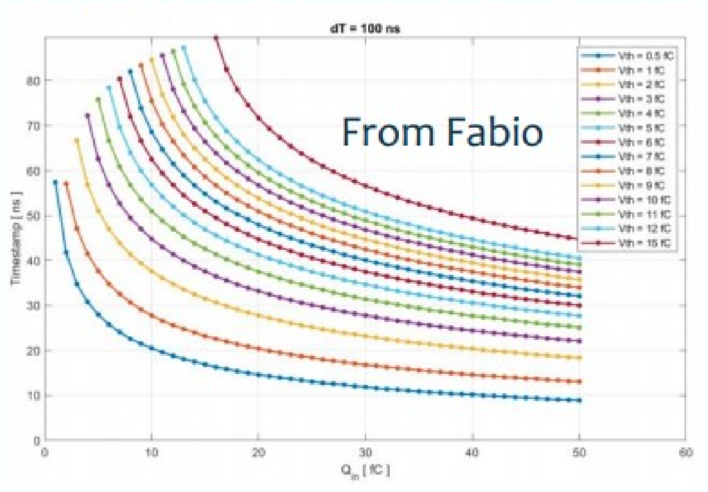
SIGNAL INJECTION



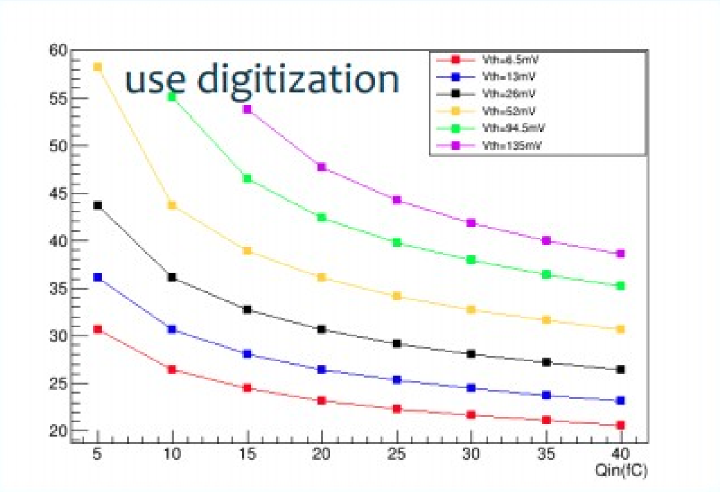
50ns

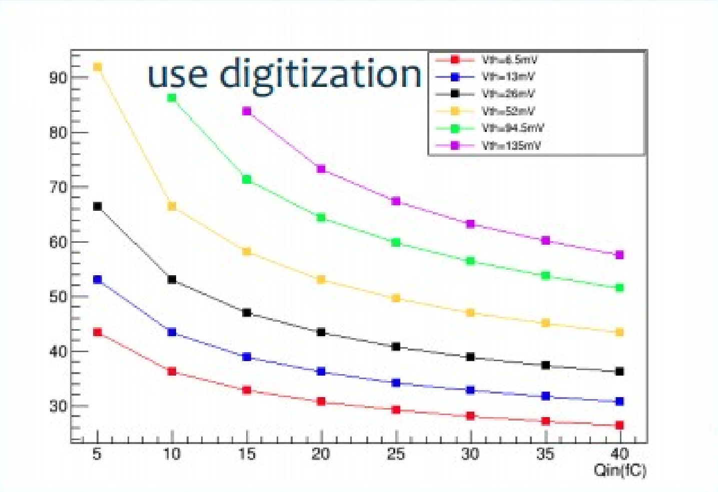


100ns



- Same input to get time walk in digitization
- Time walk behavior is similar
- But it seems there is a time shift between the two sets of results





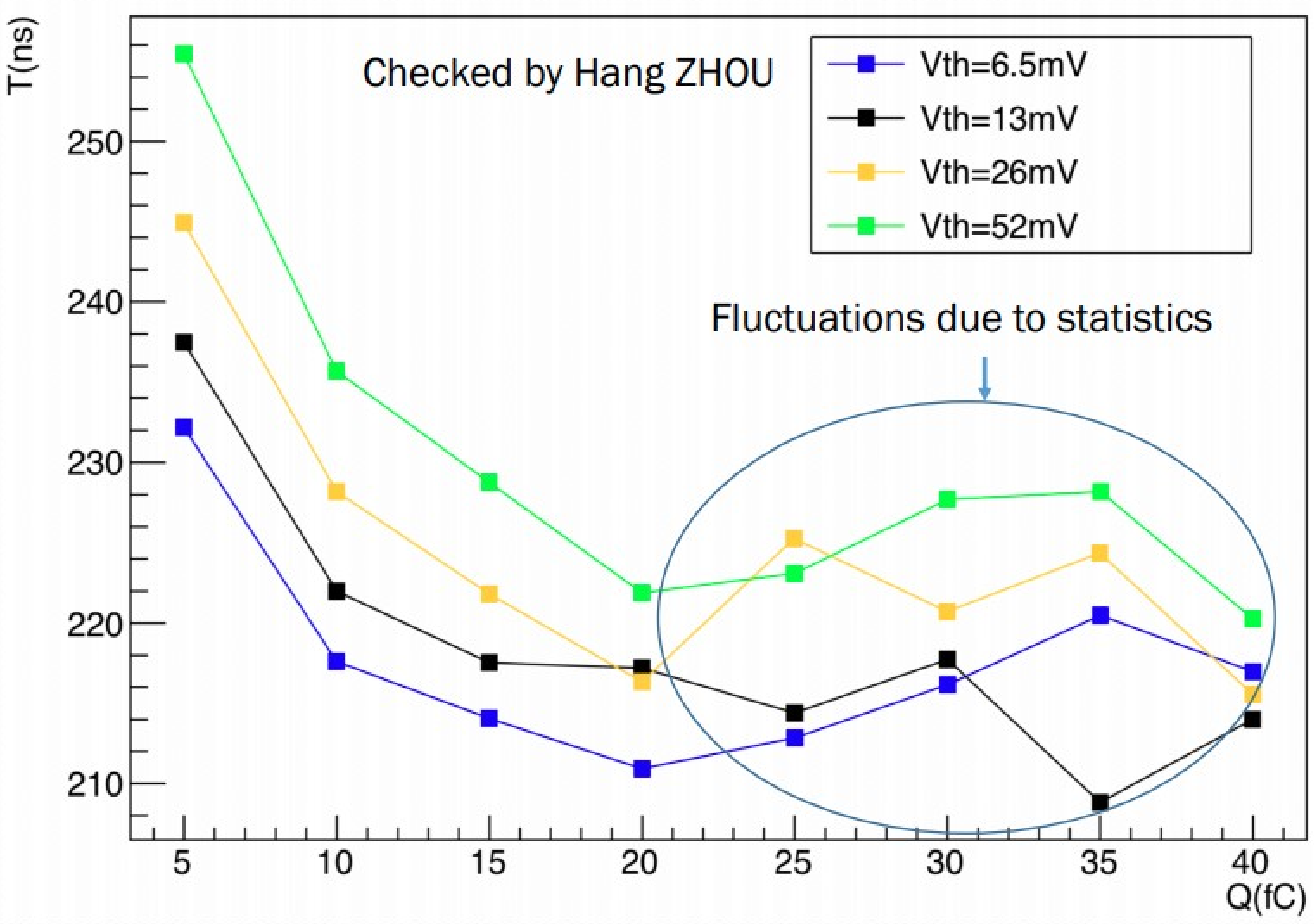
threshold:13 mV ⇔1 fC

8

Time-walk simulation in CGEMBOSS

- Input signal from a simulated sample:
  - 0.1~2 GeV/c e^-
  - incident angle on xy-plane in $(-\pi/2, \pi/2)$
  - $\theta=\pi/2$
- Full digitization without any tuning
- thresholds from LUT
- $T=T_{measured} - T_{event}$

ELECTRONS



Noise reduction with CgemLineFit

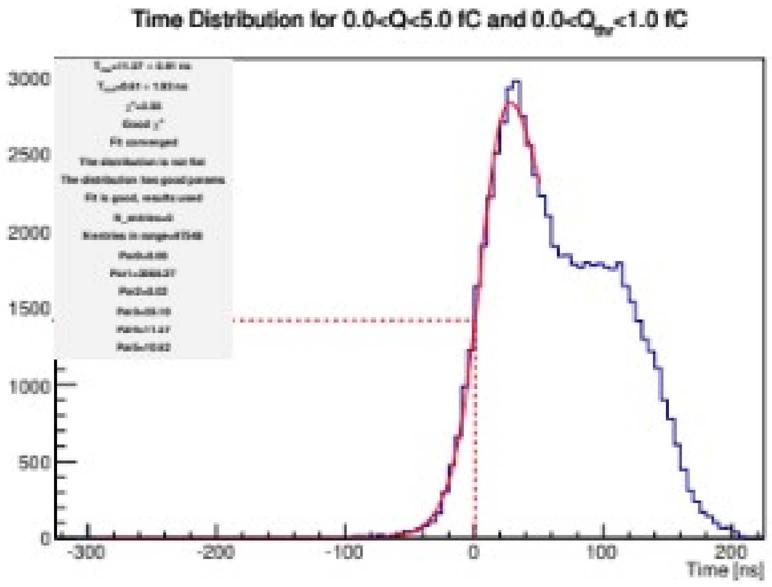
Testing Time Calibrations with CgemLineFit

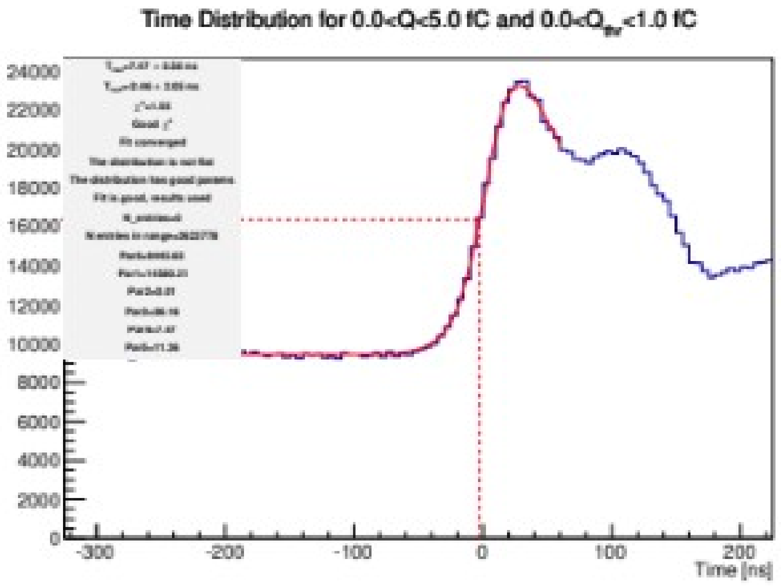
- Only use hits selected by straight line fit
- Main issue: increases memory and run time substantially
- Solution: limiting number of clusters per sheet
- Use 3 as nominal, 1 for debugging
- Only use run 17 data here - highest purity

Cluster/Sheet	% Events	Total Time Needed (minutes)
5	53.31%	90.1
4	51.17%	60.2
3	46.65%	35.2
2	37.96%	17.6
1	15.33%	6.4
No fit	-	3.7

Noise reduction with CgemLineFit

Time Distribution - Time Walk Low Charge

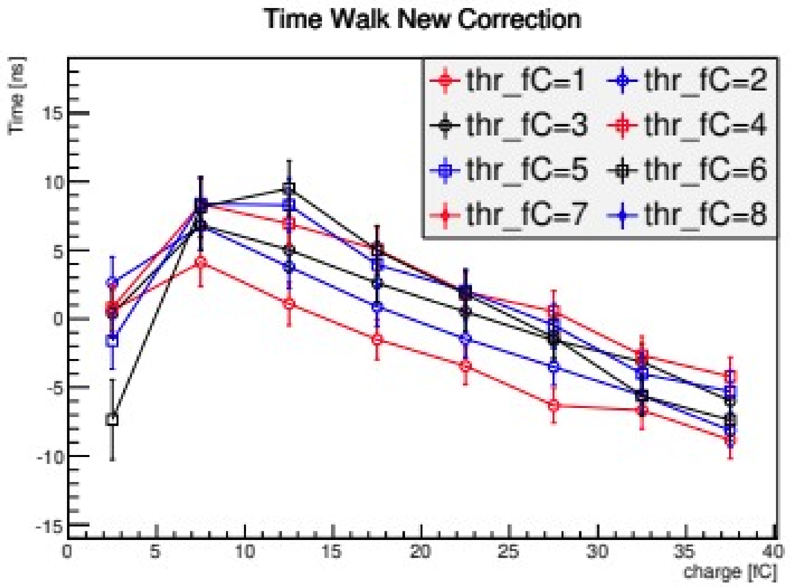


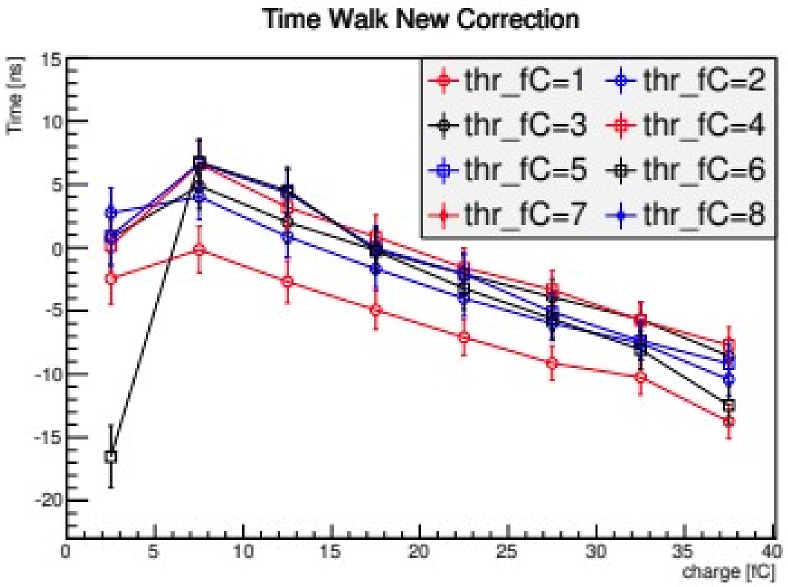


- Fit removes constant background
- Also removes events from the second/third peaks
- Size of the peak is much smaller

Noise reduction with CgemLineFit

Time Walk Summary



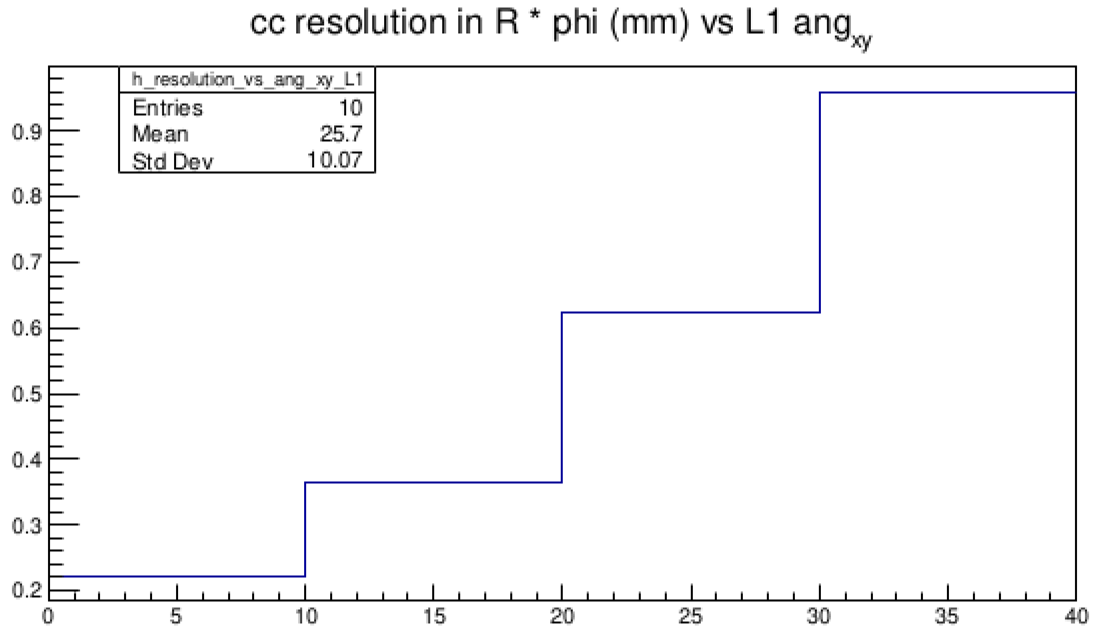


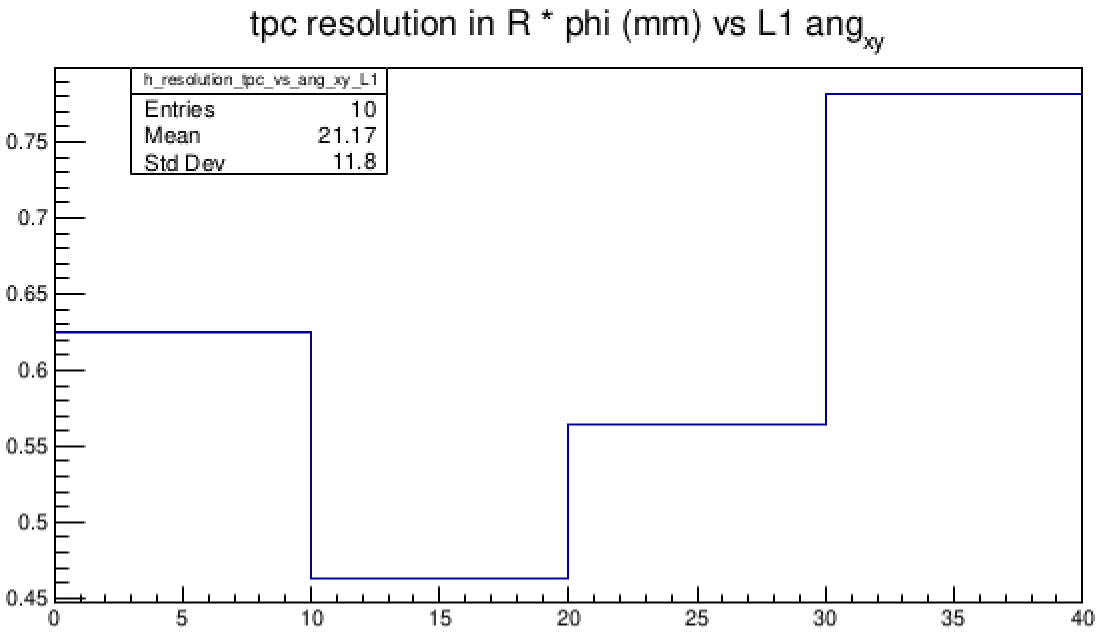
- Left for fit, right no fit
- Corrections at low Q are actually lower with the fit

QA with the alignment in CGEMBOSS

The latest alignment procedure have been implement in CGEMBOSS and now the QA procedure is under test to define the improvement of the results.

The work is ongoing and it will be used to validate the Time Corrections.





Incident angle [deg] **Incident angle [deg]**

Next steps

1 . The Time-Walk discrepancy between experimental data, simulation and calibrations has to be understood.

The proposal is to use the final QA with the alignment from CGEMBOSS to valuate the goodness and the impact of the Time Calibration using the TW from both methods.

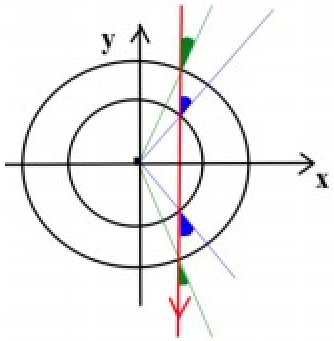
2. Mass production of the time-calibration for each data set acquired up to now and their validation with the existing tools

3. Development of the merging algorithm to improve the spatial resolution and to reduce the tracking system contribution

Thanks

Backup: TOY-MC

Toy simulation



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

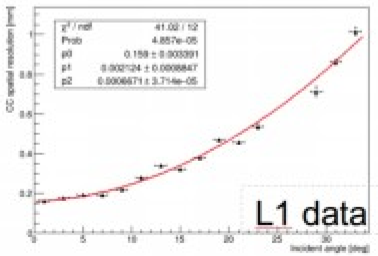
2. Smear the track incident angle of 0.36 deg (from Marco's calculation) for L1down and L2down

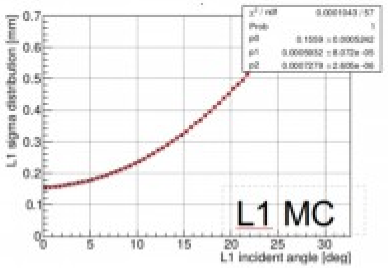
3. Evaluate the expected CC resolution at the impact point using the function
   CC_res = 80 µm + 3.0 µm/deg * angle + 0.65 µm/deg^2 * angle^2

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 contribution 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

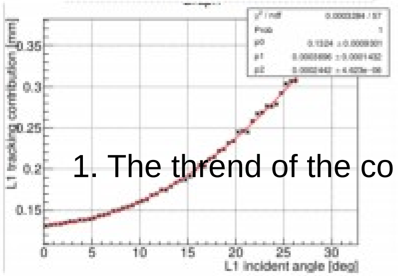




Contribution of the tracking system on L1

Toy results

Contribution of the tracking system on L1



1. The thrend of the co

1. The thrend of the contribution of the tracking system now is reasonable with respect to the one shown on April 8

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.
(See next slide.)

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.
(Compare the plot of the previous slide with the one in the next.)

4. The CGEM CC resolution has a parabolic behavior as a function of the angle while in the planar GEM it has a linear behavior. This is not understood.

Mass production: the capacitive corrections

Do we need to fix the time calibration to start this study?

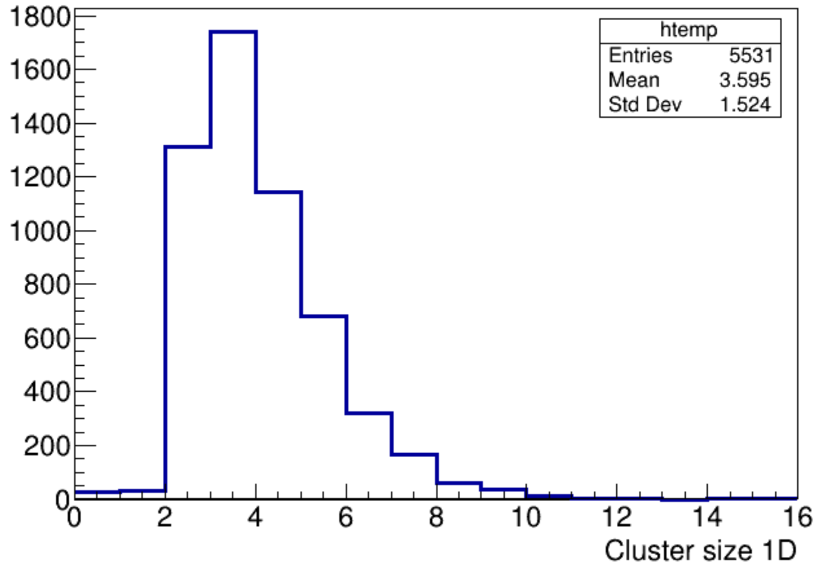
Do we need to update my code in CgemClusterCreate?

To start these studies we need to implement some variables in the CgemDigi Collection or something similar.

Is it possible to perform those studies in a data-driven way?

> The statistic and the cluster size range is small

> we need to define the calibration to merge different runs



Mass production: the capacitive corrections

Time calibrations depends on:

1. cluster size
2. position inside the cluster
3. charge

The impact on the µTPC resolution is significant but it needs a large training of the algorithm from the CGEM-IT data.

A first test using the capacitive and diffusion correction from the planar GEM did not shown improvements.