Time Calibration 2.0

Riccardo Farinelli
on behalf of the working team

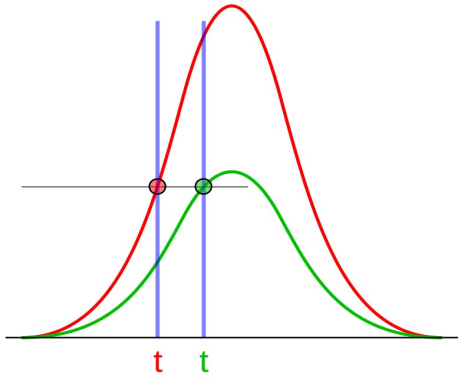
Summary

1. Summary of the Time-Reference studies
2. Time-Reference 2.0 → a new approach
3. Summary of the Time-Walk
4. Time-Walk 2.0 → a new approach
5. µTPC and CGEMBOSS QA
6. Merge algorithms
7. What next?

Time Calibration status

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

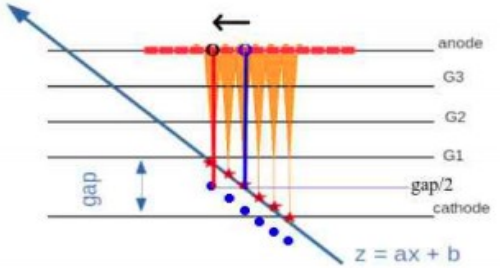
0-80 ns contributions



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

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



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	$0.35c$	$0.57c$

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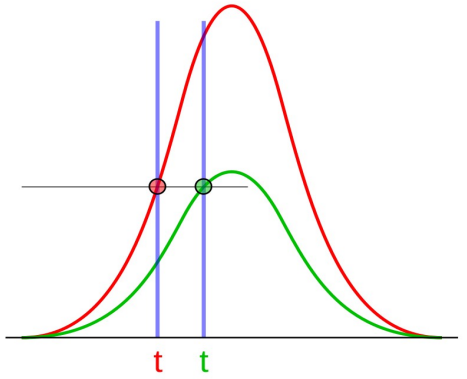

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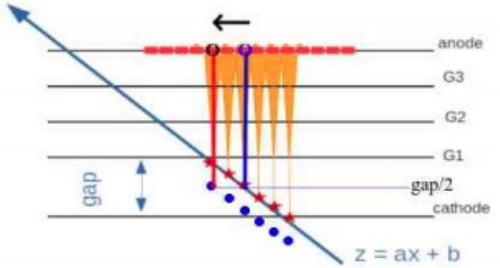

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Time Calibration status

A time calibration code has been implement in CGEMBOSS since late 2020
--> Cgem/CgemTimeCalibration 00-00-03

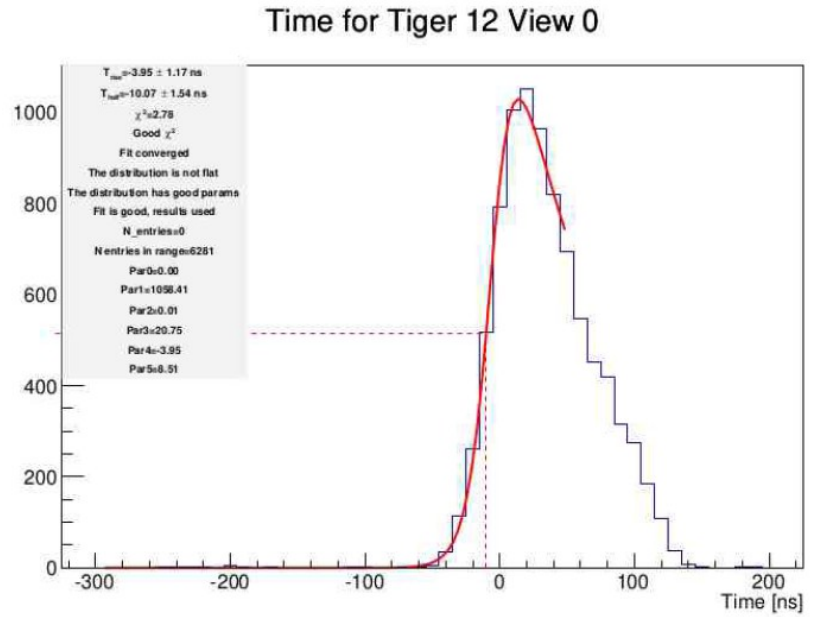
A fitting procedure has been tested to extract the time value for time-walk and time-reference for all the channels/FEB/threshold with a success above 95%

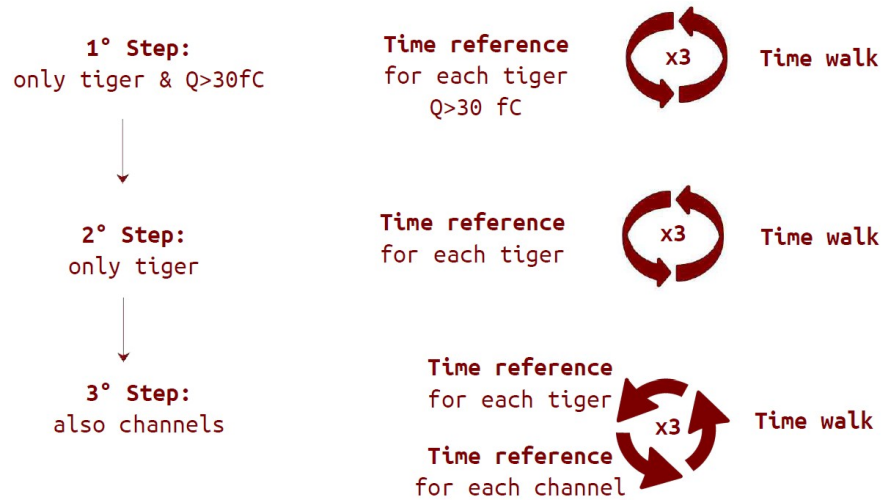
A correction procedure has been developed to apply time-walk and time-reference with a recursive procedure

Small improvements are introduced on the µTPC spatial resolution

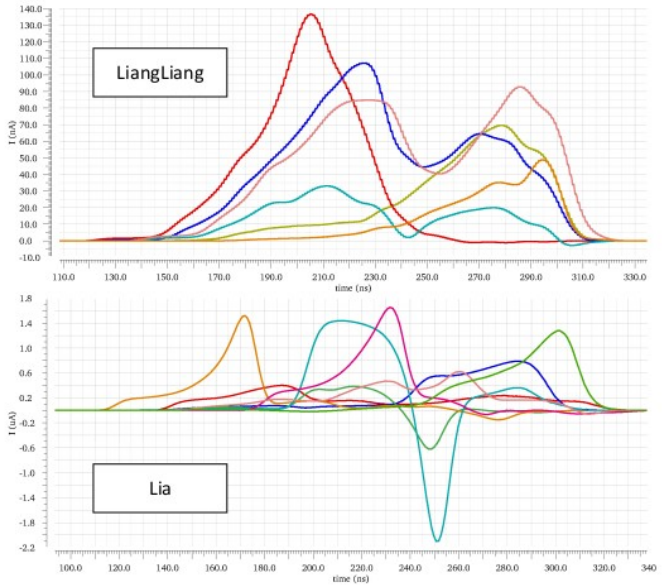
A strange behaviour on the time-walk has been observed in the low charge region

More investigation were needed

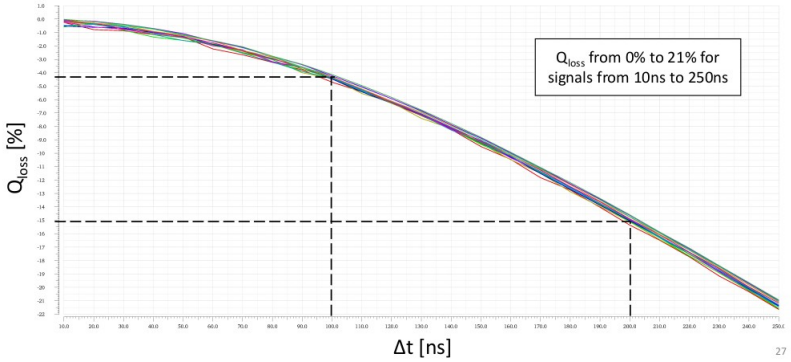


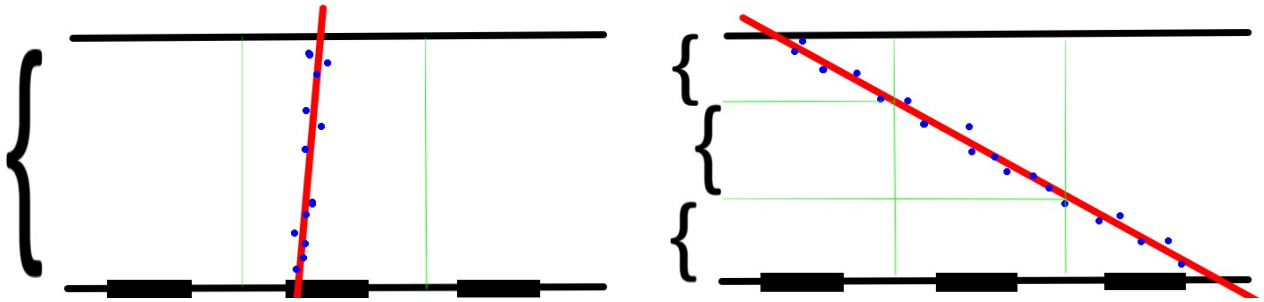


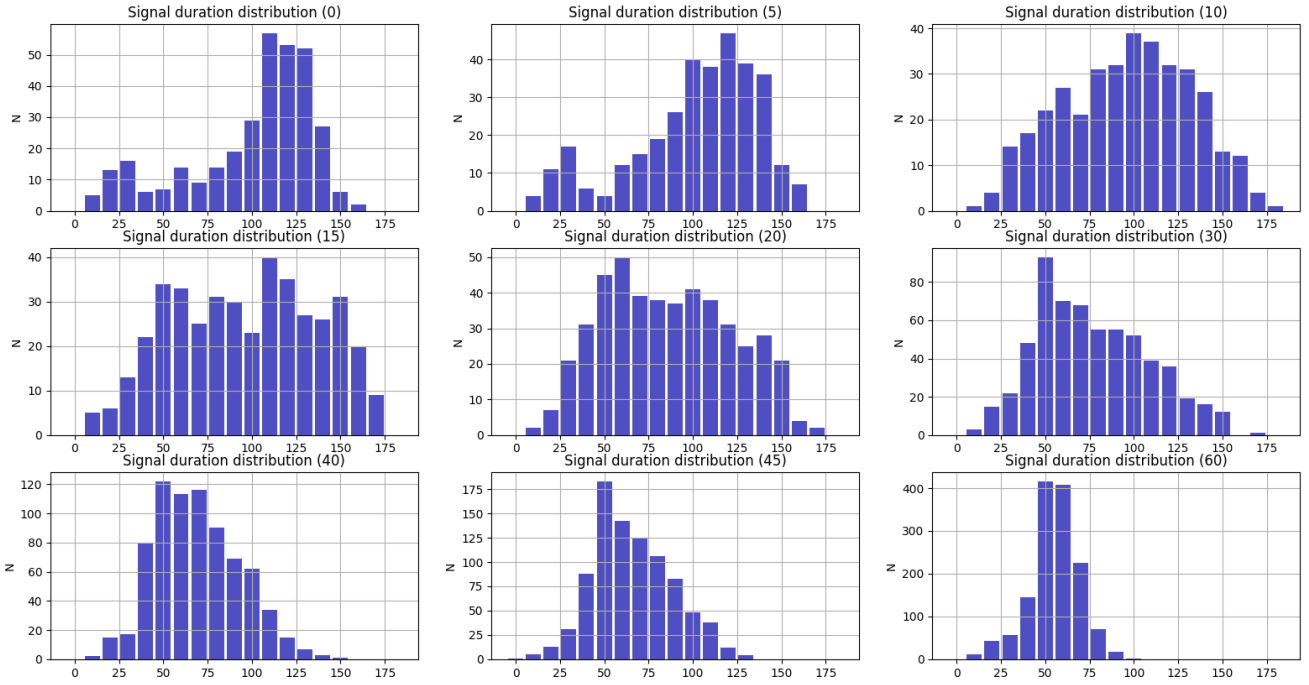
A large discussion on the signal shape



Ballistic deficit vs signal duration (E-branch)







Signal shape effect -> some information have to extracted from experimental data

Stefano suggestions

1. Test the TR of two strips L2X having the same threshold from the same FEB/chip (Q>30fC)

→ we expect the same TR

2. Test the TR of two strips L2X having the same threshold from different FEB (same chip and same GEMROC)

→ evaluation of the relative TR between these two chips from the same GEMROC

3. Same as 2 but we consider two couples, the former a threshold value, the latter with another threshold value

→ the relative TR of the two couples should be the same

→ → → **ok within 5-8 ns (uncertanty on the time evaluation from the fit)**

CgemTimeCalibration: TimeReference

1. Test the TR of two strips L2X having the same threshold from the same FEB/chip (Q>30fC)

→ we expect the same TR

```
*********************************************************************************************
* channel * strip_x_b *  layer *  sheet *  thr_T_fC *  thr_E_fC * timeref_t * par5_chan *
*********************************************************************************************
*     22 *      272 *      1 *      1 * 2.0999999 * 3.3599999 * -14.53077 * 7.4761390 *
*     34 *      299 *      1 *      1 * 2.0999999 * 4.1999998 * -9.066157 * 6.4465322 *
*     36 *      298 *      1 *      1 * 2.0999999 * 3.7799999 * -8.167035 * 6.9532051 *
*     52 *      291 *      1 *      1 * 2.0999999 * 4.1999998 * -17.10828 * 6.7353954 *
*     59 *      288 *      1 *      1 * 2.0999999 * 3.3599999 * -7.611871 * 7.2236995 *
*********************************************************************************************
```

Mean time = -11.28 ns

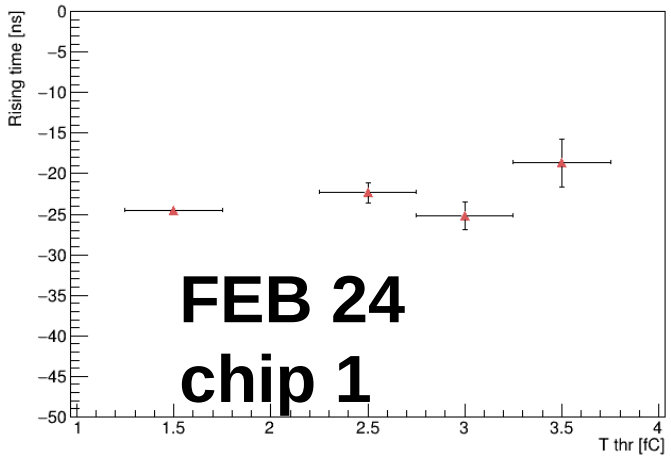
Each time/channel is compatible with the mean value

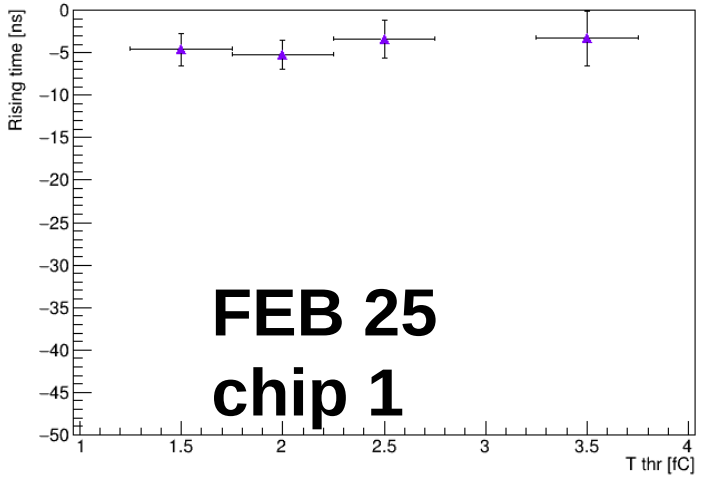
RUN 17

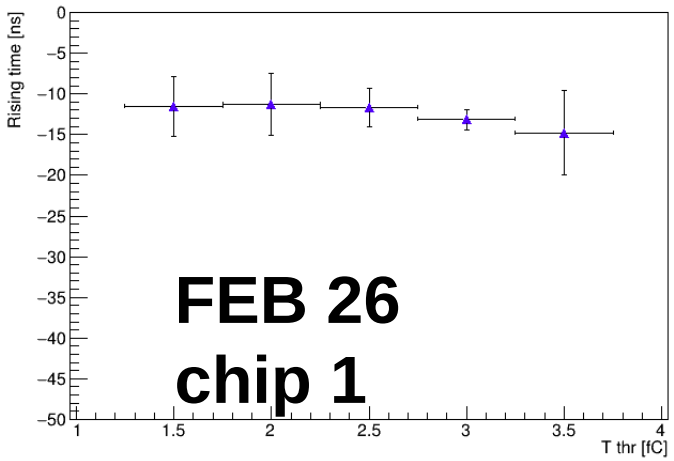
CgemTimeCalibration: TimeReference

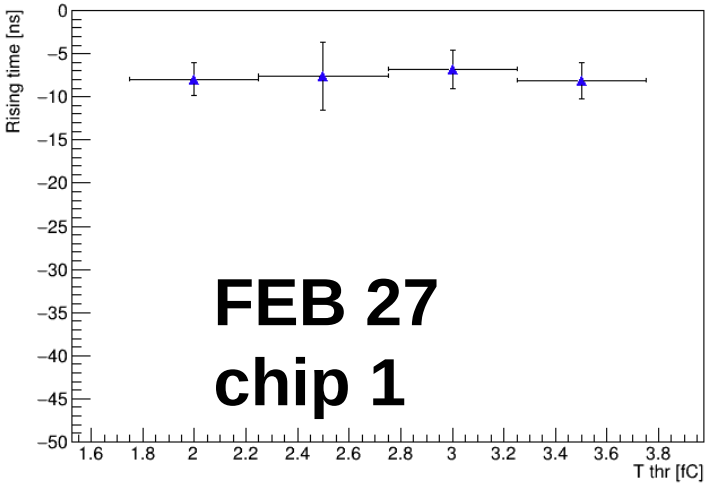
2. Test the TR of two strips L2X having the same threshold from **different FEB** (same chip and same GEMROC)

→ evaluation of the relative TR between these two chips from the same GEMROC



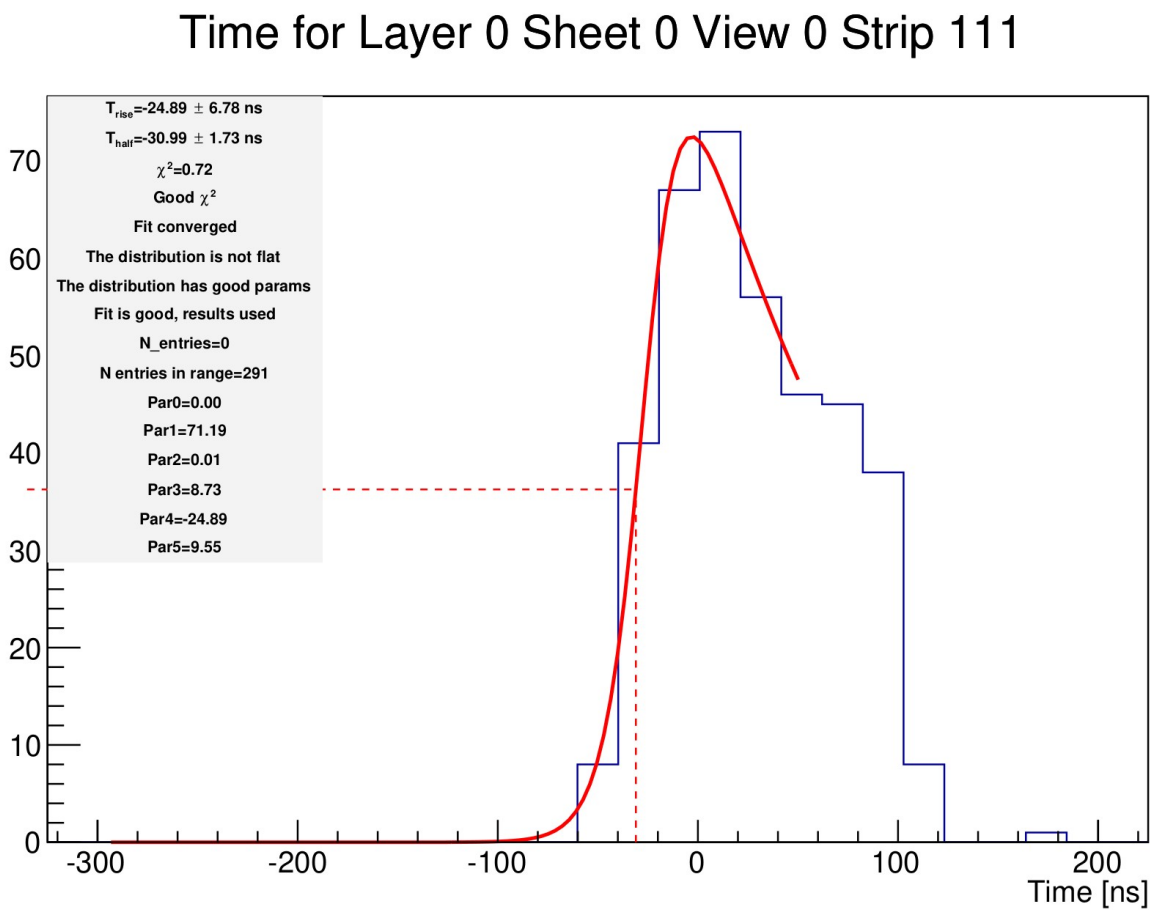






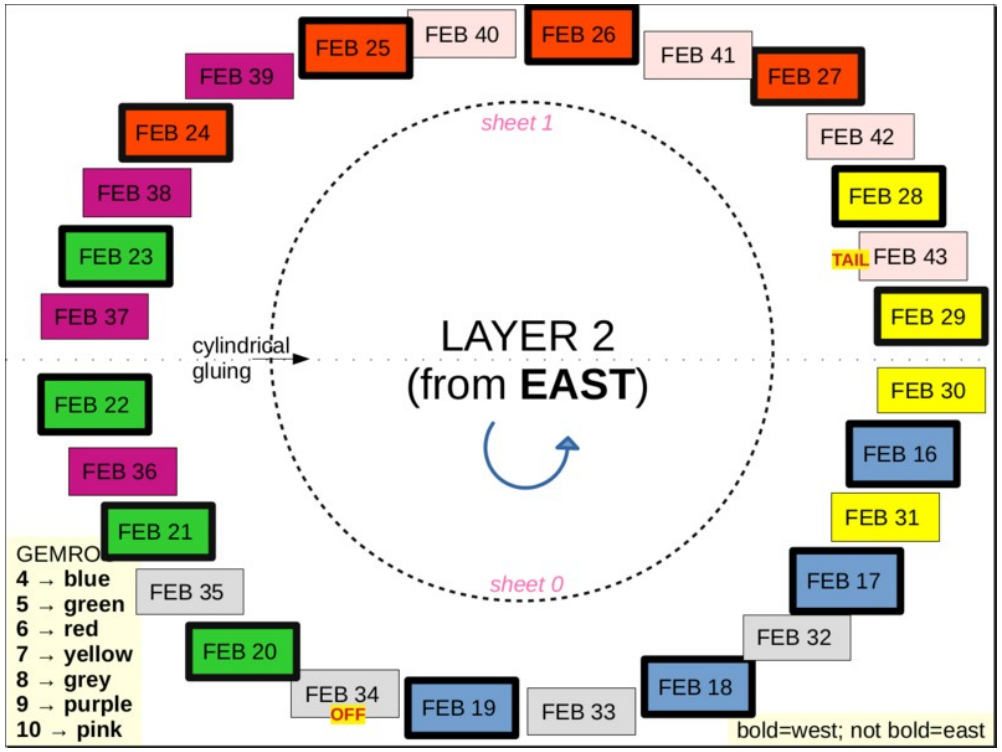
RUN 17

CgemTimeCalibration: TimeReference



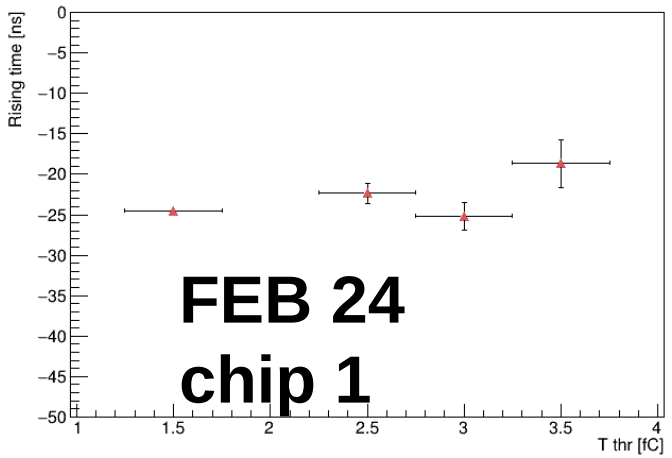
$$[0] + \frac{[1]\, e^{-[2]\,(x-[3])}}{1 + e^{-\frac{(x-[4])}{[5]}}}$$

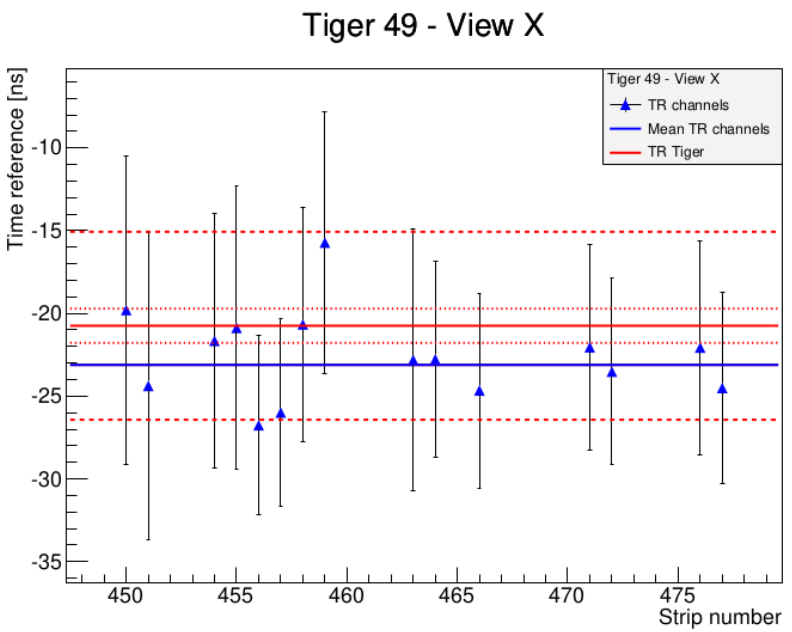
FEB distribution on L2



CgemTimeCalibration: TimeReference 2.0

- Extended the evaluation of the TR on all the channels X with Q>30fC
- Evaluation of the mean TR
- The mean TR differs from the one measured on the TIGER



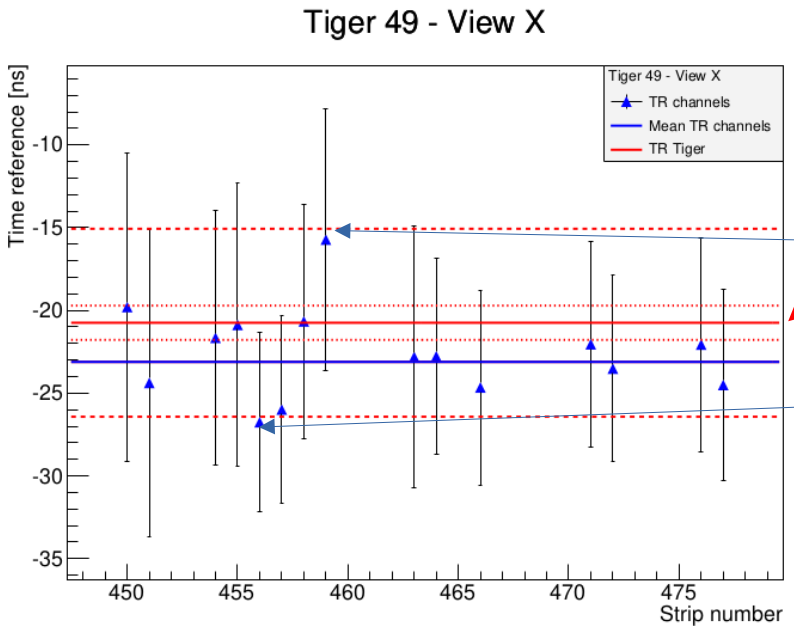


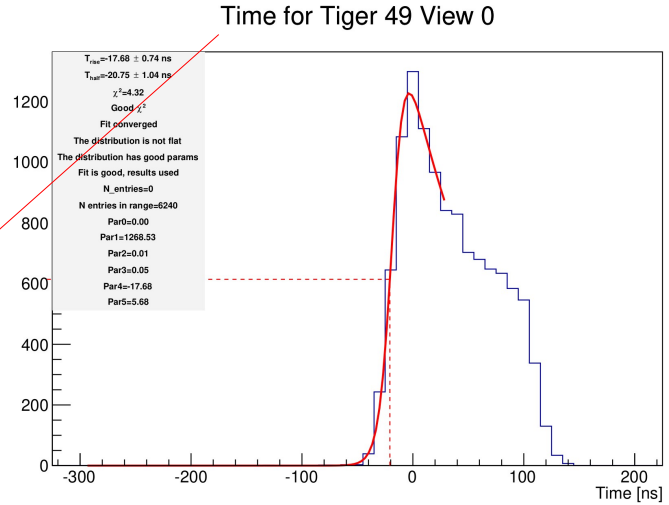
RUN 17

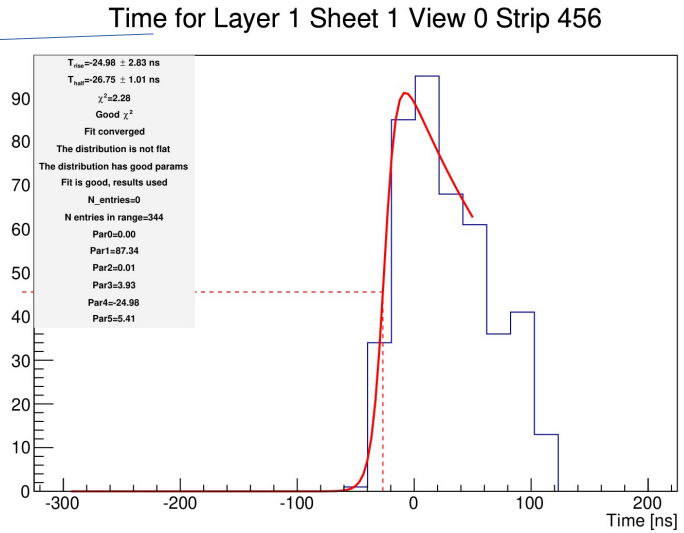
CgemTimeCalibration: TimeReference 2.0

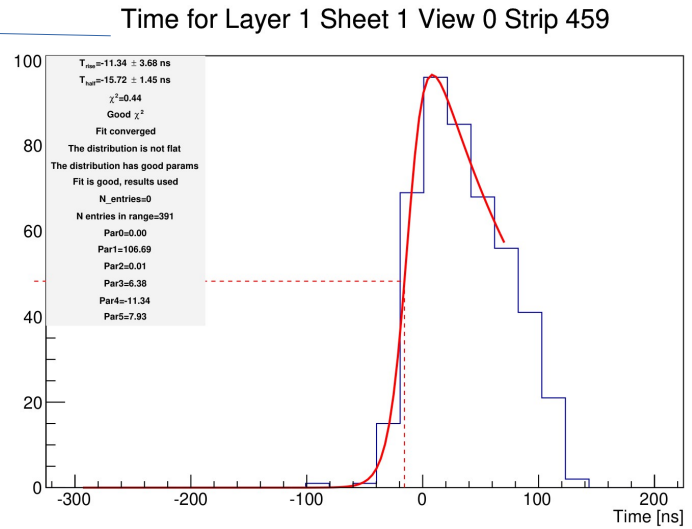
- Extended the evaluation of the TR on all the channels X with Q>30fC
- Evaluation of the mean TR
- The mean TR differs from the one measured on the TIGER

Is the mean TR better than Tiger TR?
--> Most of the times they are compatible





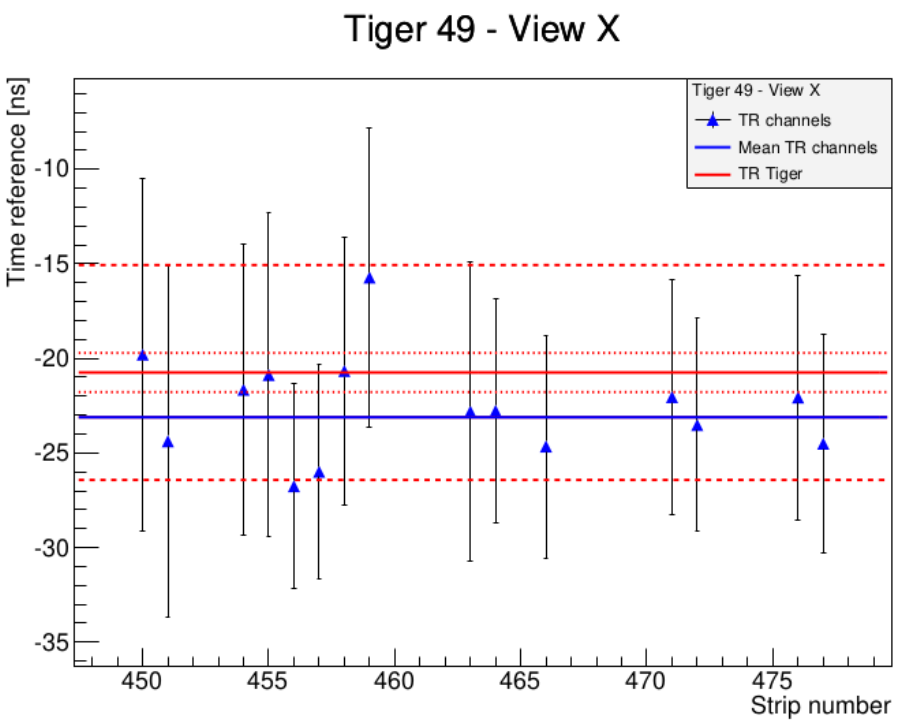


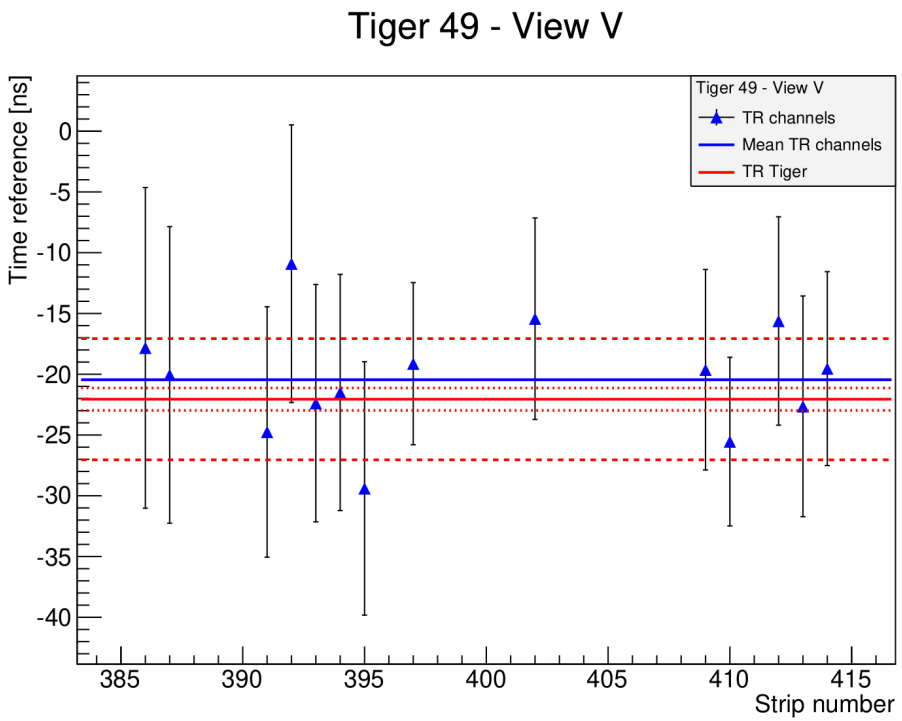


RUN 17

CgemTimeCalibration: TimeReference 2.0

How to threat V strips?
The TR of both views is similar
Can we fit them all togheter?
--> Here it seems yes

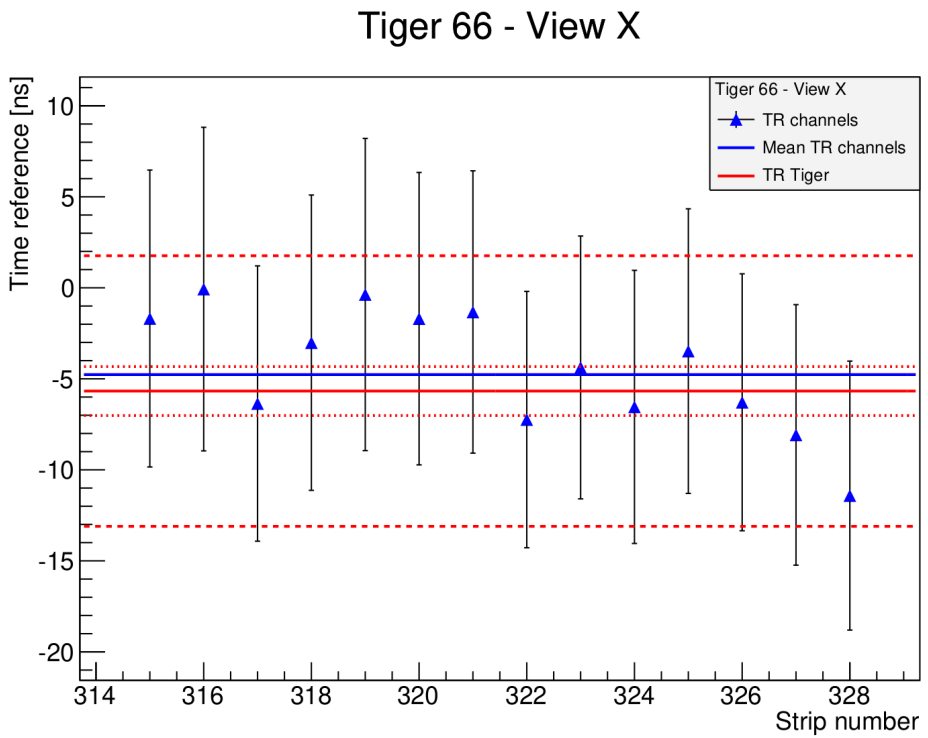


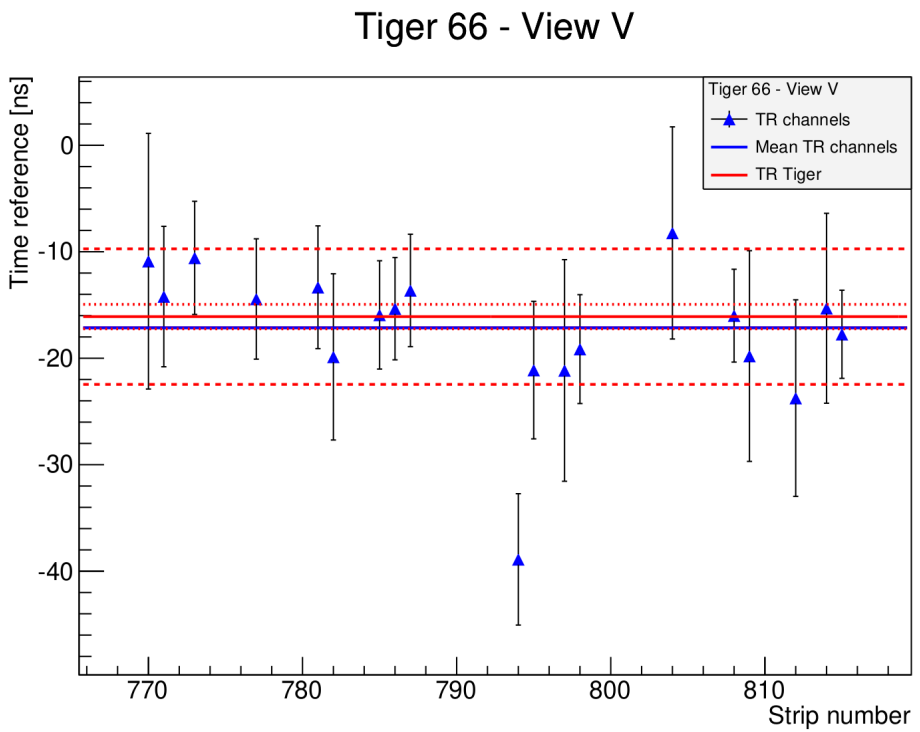


RUN 17

CgemTimeCalibration: TimeReference 2.0

How to threat V strips?
The TR of both views is similar
Can we fit them all togheter?
--> Here it seems **NO**





RUN 17

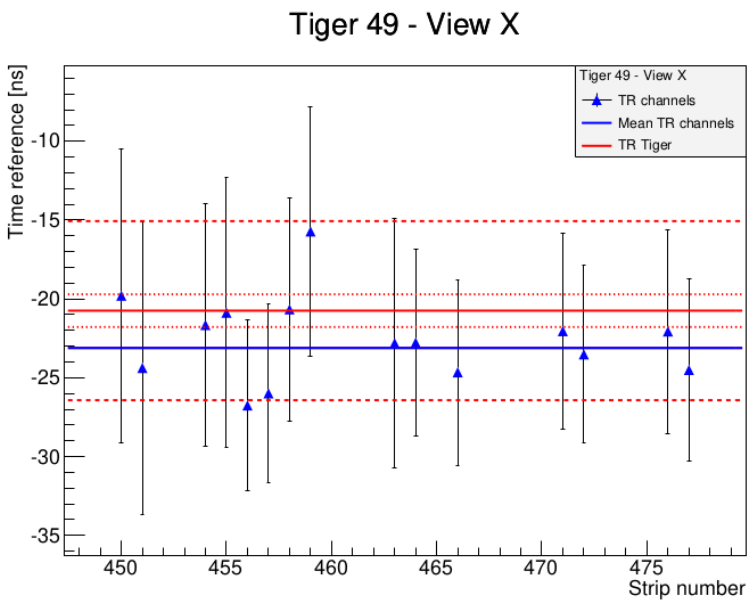
CgemTimeCalibration: Step 2

1. Time-Reference for X and V view is measured separately for each chip by means of the MEAN TR method for Q_hits > 30 fC

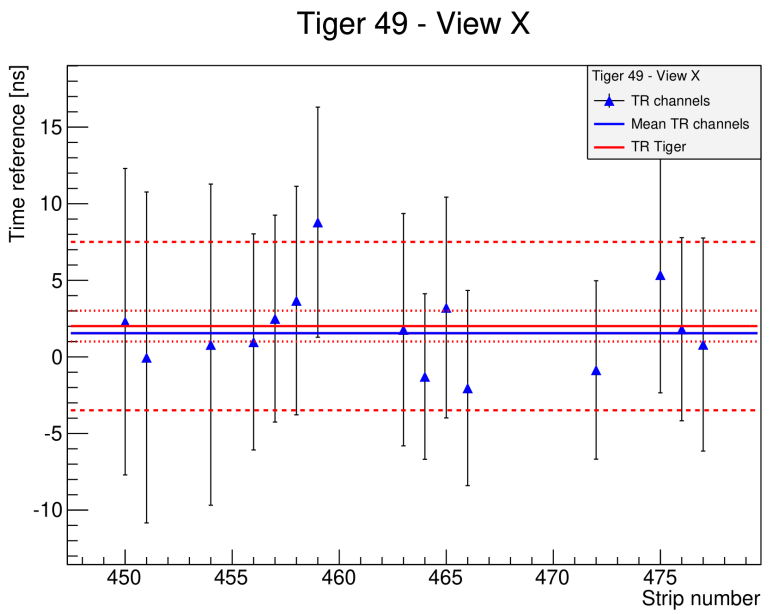
2. We check the TR goodness

CgemTimeCalibration: TR goodness

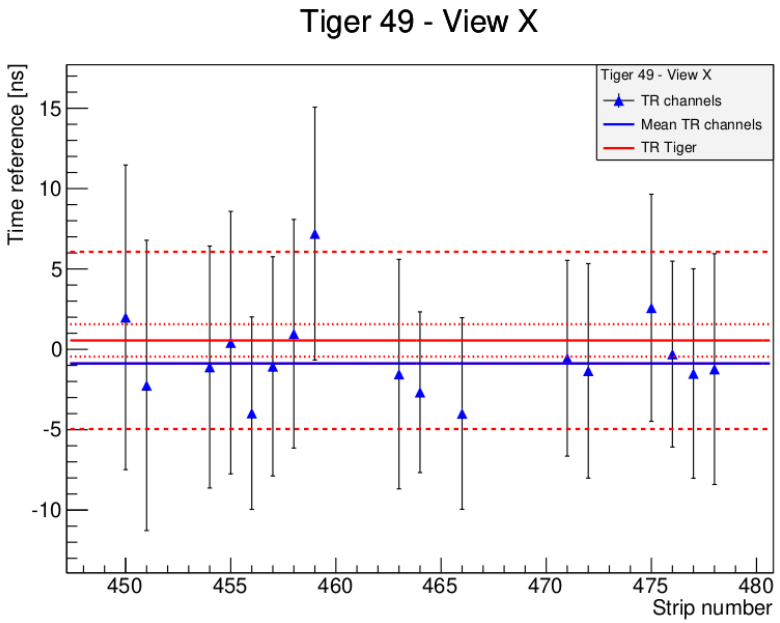
1° round



2° round



3° round



Time alignment is good after the first round within few ns around zero

CgemTimeCalibration: Step 3

1. Time-Reference for X and V view is measured separately for each chip by means of the MEAN TR method for Q_hits > 30 fC

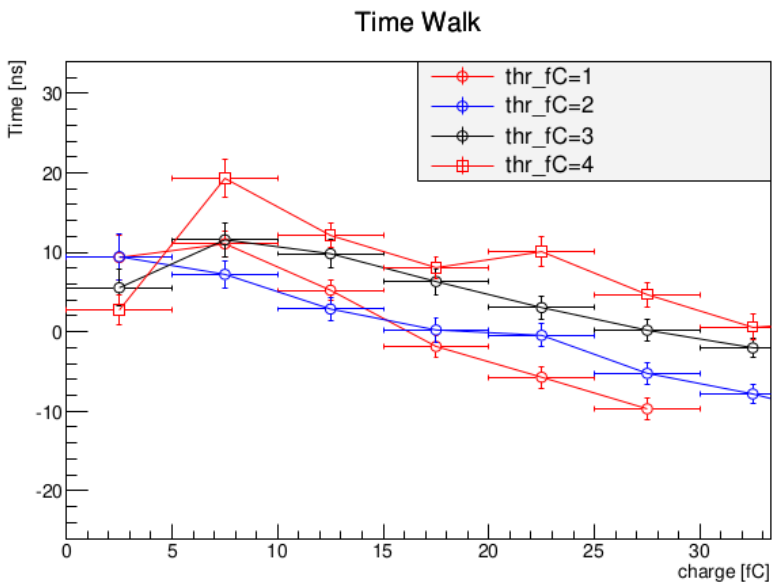
2. We check the TR goodness

3. Now we can evaluate the Time-Walk for each chip

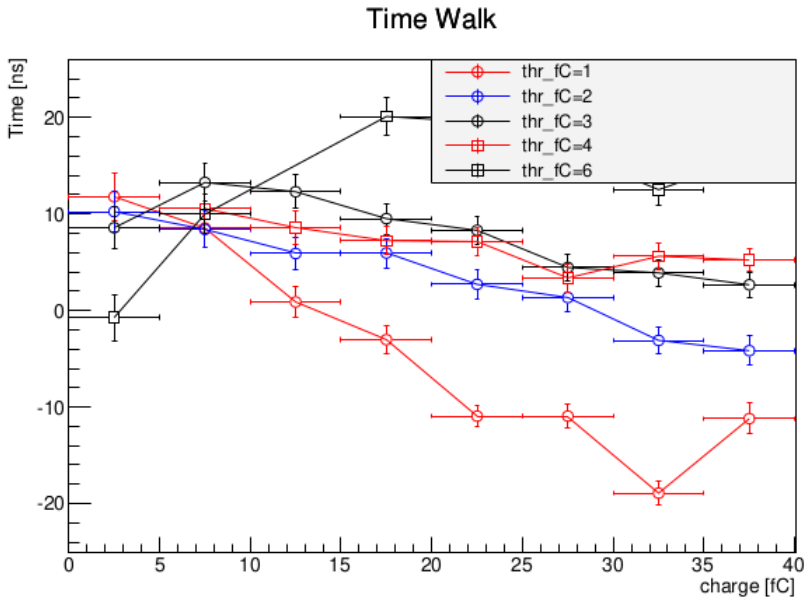
RUN 17

CgemTimeCalibration: TimeWalk

Evaluation of the time-walk on a single chip.
No time correction are applied.
Only X strips are shown



FEB 25
chip 0

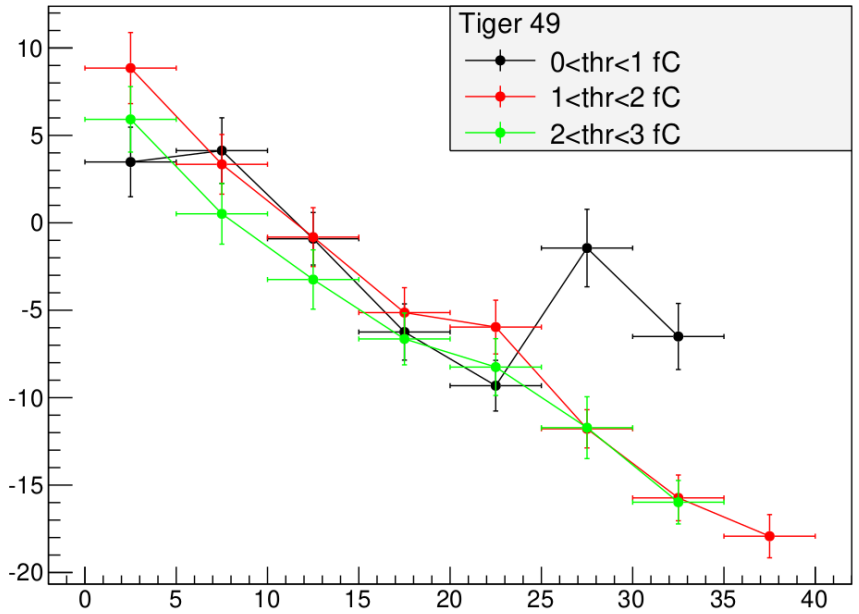


FEB 25
chip 1

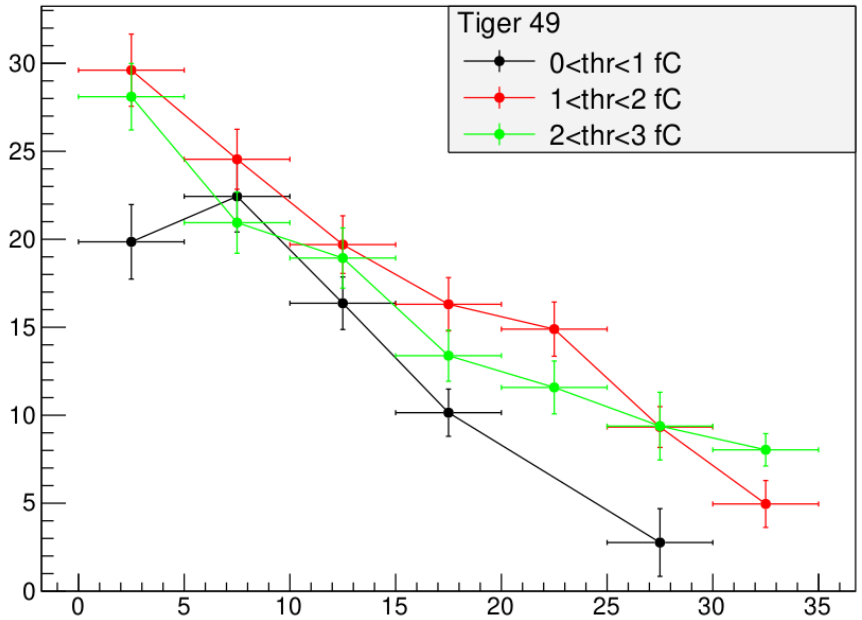
RUN 17

CgemTimeCalibration: TimeWalk 2.0

Evaluation of the time-walk on a single chip.
Only on X strips.
Time evaluated from strips with the same threshold
After the TR the points are shifted of about 20 ns



Before TR

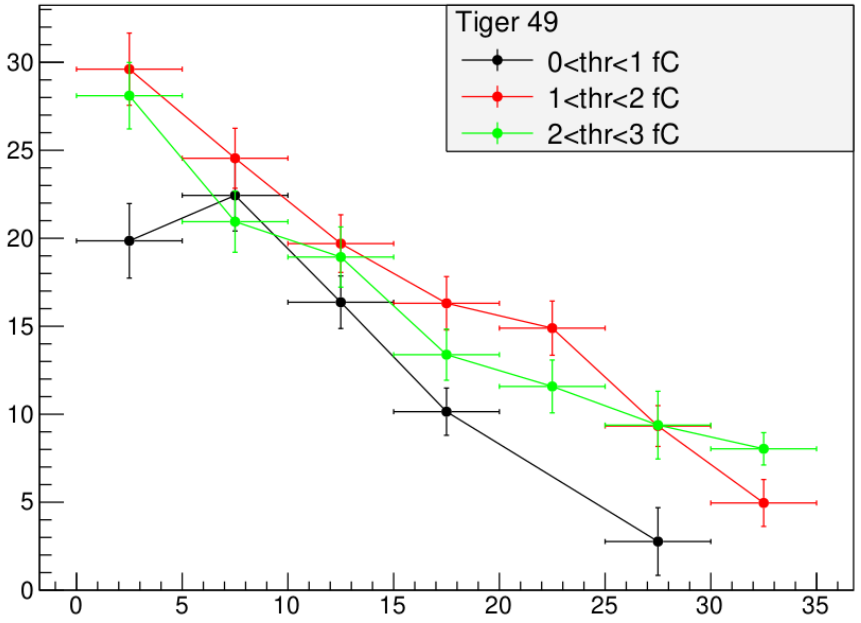


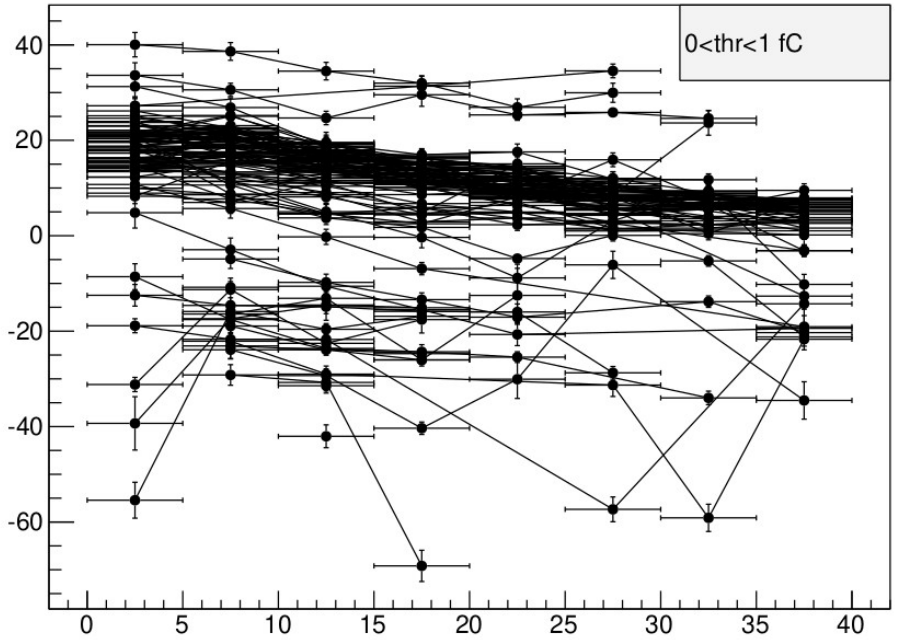
After TR

RUN 17

CgemTimeCalibration: TimeWalk 2.0

We compare the TW from different chips after the TR alignment

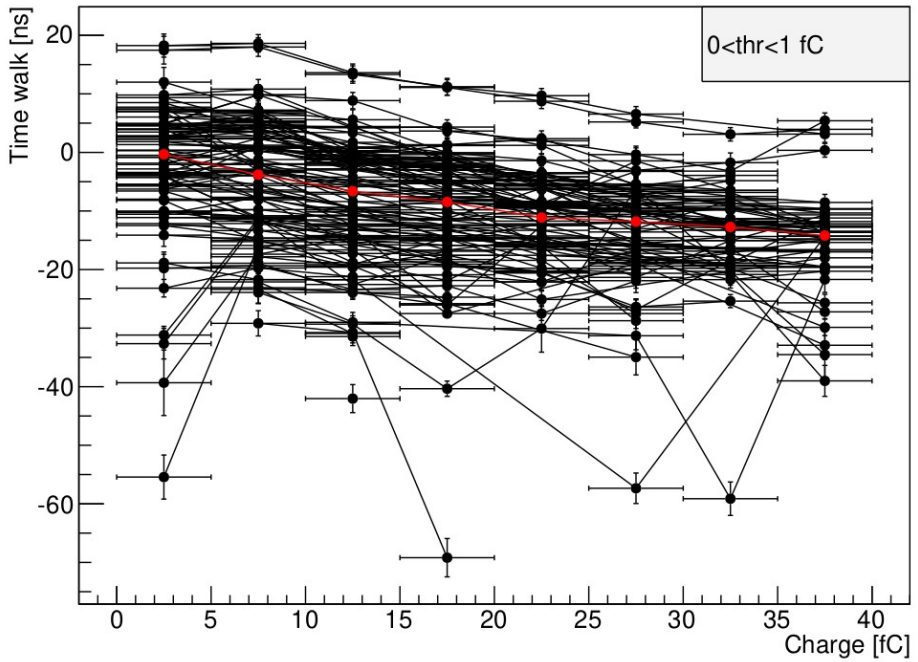




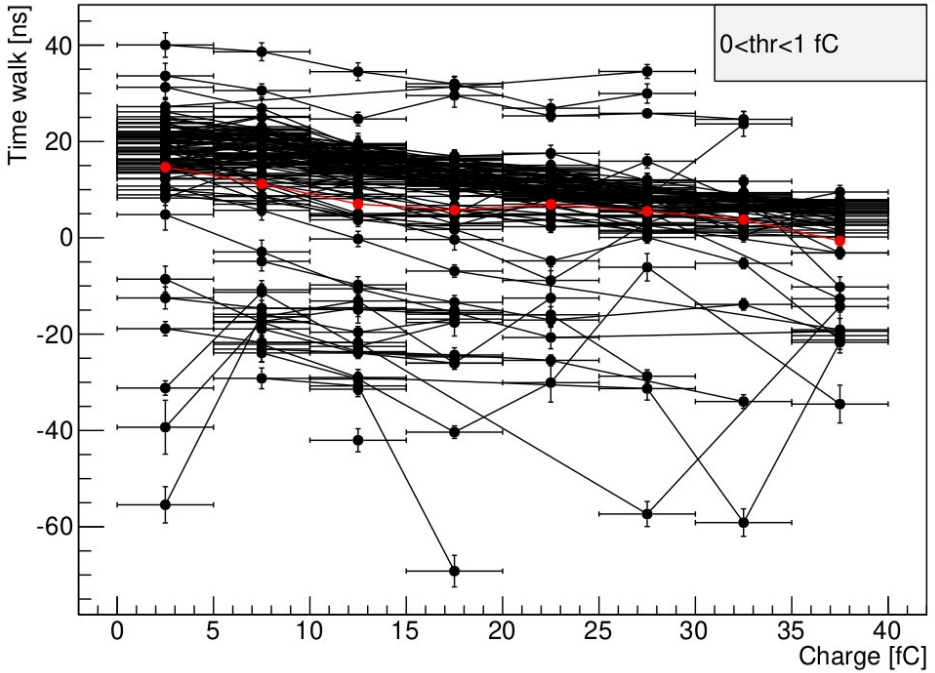
RUN 17

CgemTimeCalibration: TimeWalk 2.0

Thank to the TR the TW spread is reduced



Before TR

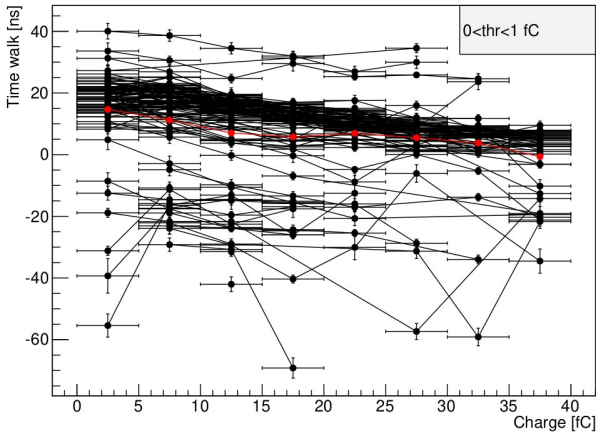


After TR

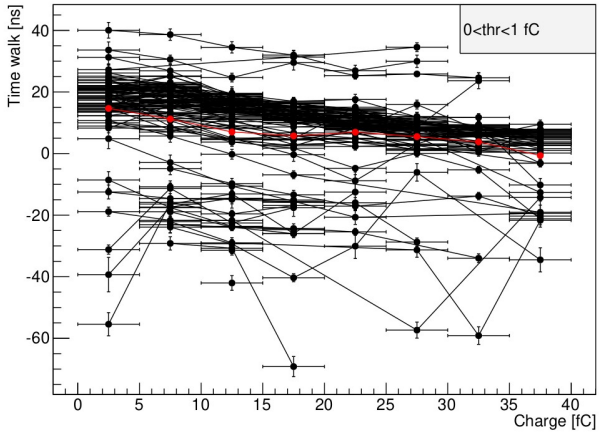
RUN 17

CgemTimeCalibration: TimeWalk 2.0

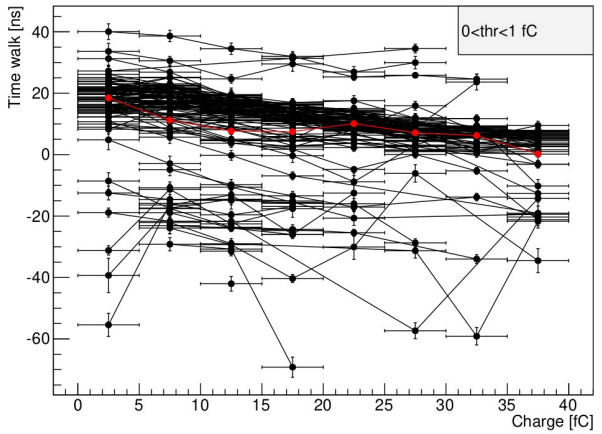
Can we extract an average TW for all the chips?
Lets use some selection to improve it
The mean value is evaluated for each charge.
Points with a large difference from the mean value are rejected



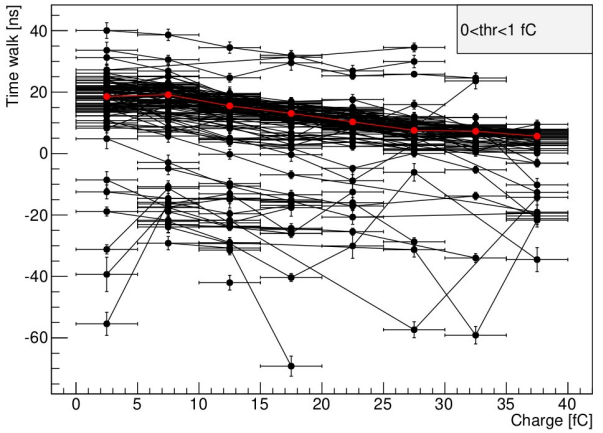
No cuts



5 std cut



3 std cut

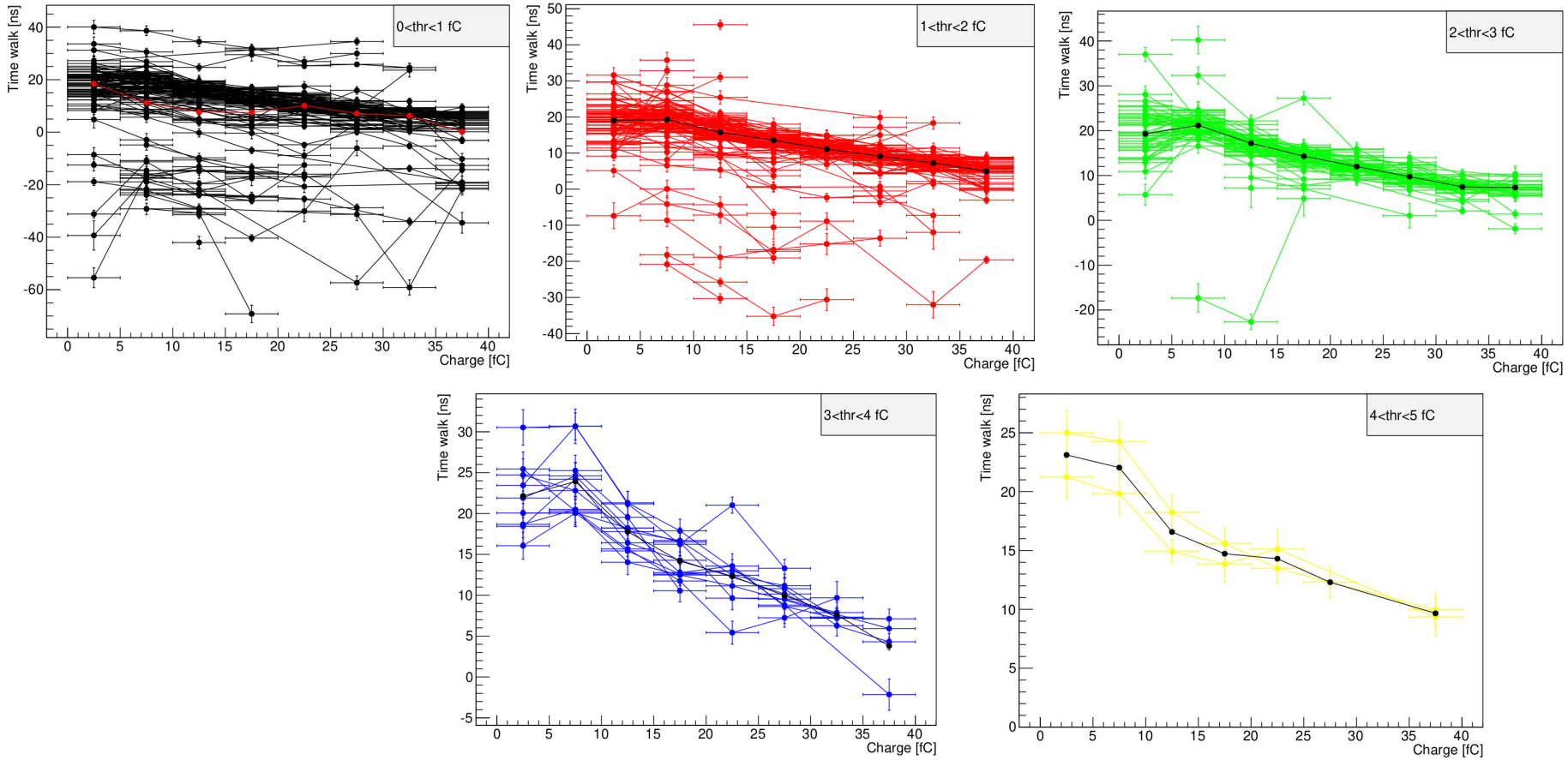


2 std cut

RUN 17

CgemTimeCalibration: TimeWalk 2.0

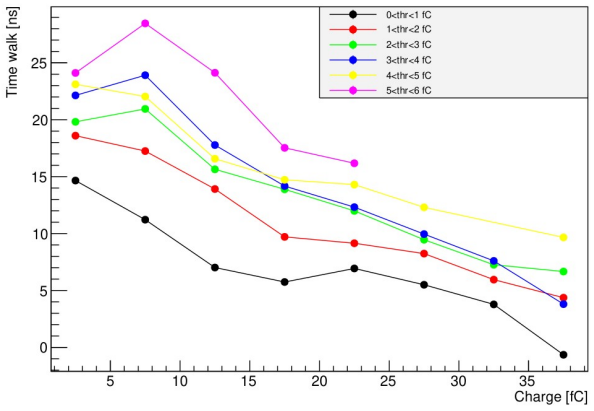
Here below are shown the TW lines for the other threshold with a 2std cut



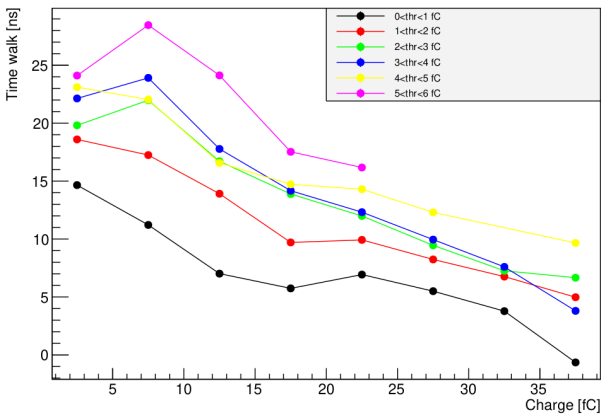
RUN 17

CgemTimeCalibration: TimeWalk 2.0

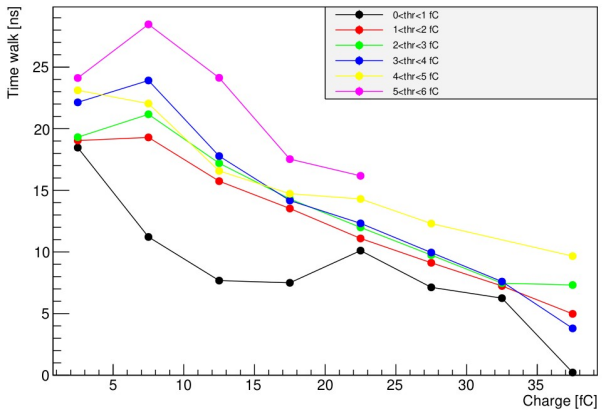
Lets see the results of the TW as a function of the cuts



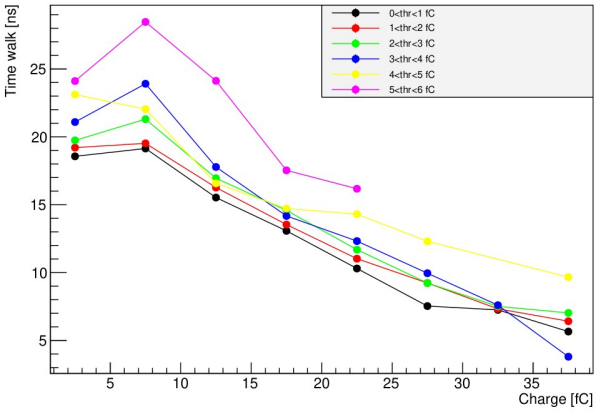
No cuts



5 std cut



3 std cut

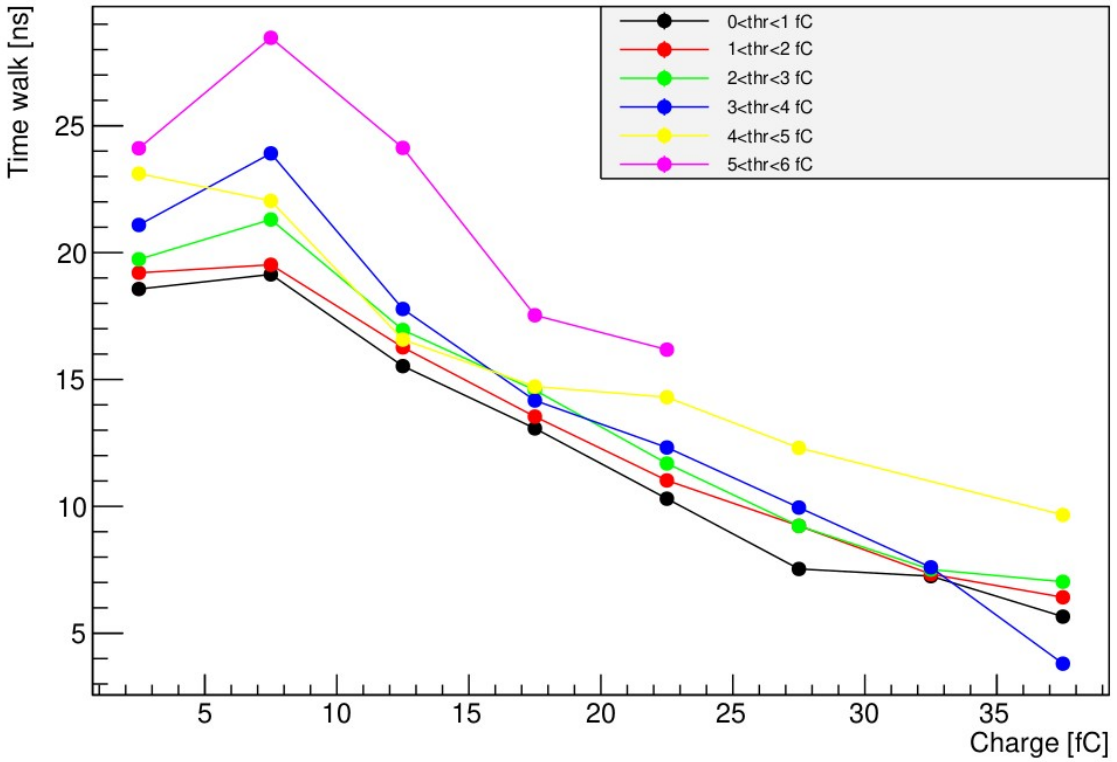


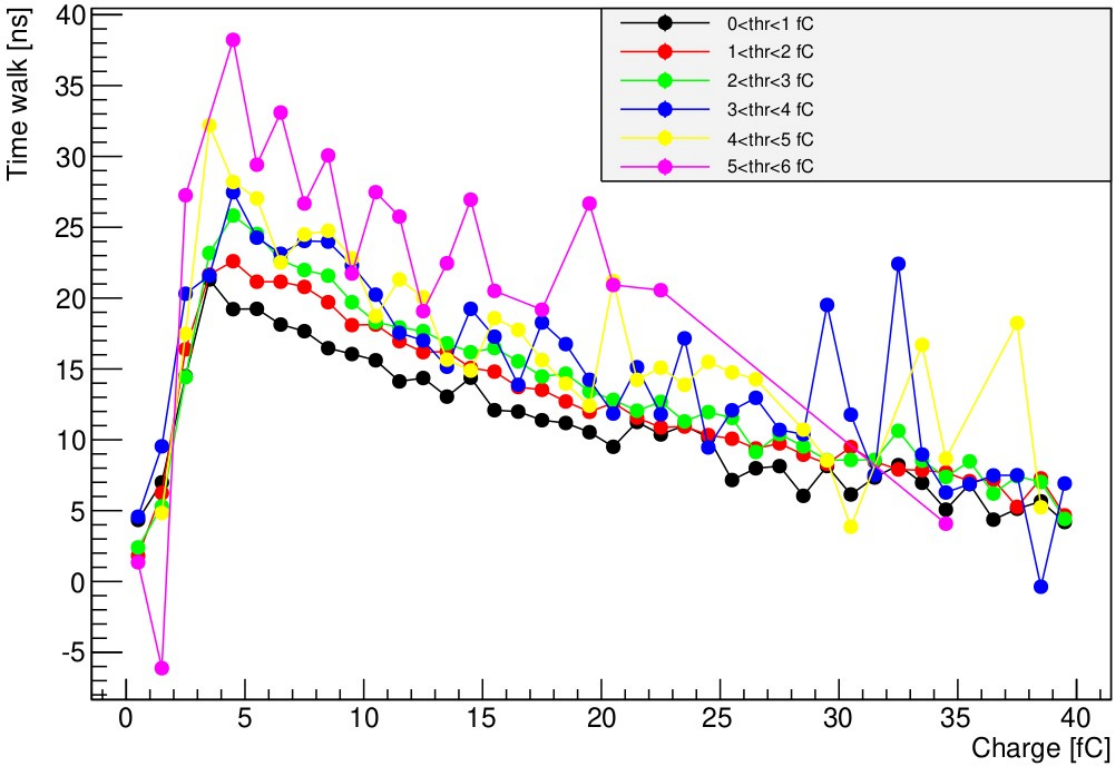
2 std cut

RUN 17

CgemTimeCalibration: TimeWalk 2.0

I tried to increase the number of points and the behavior at low charges is confirmed



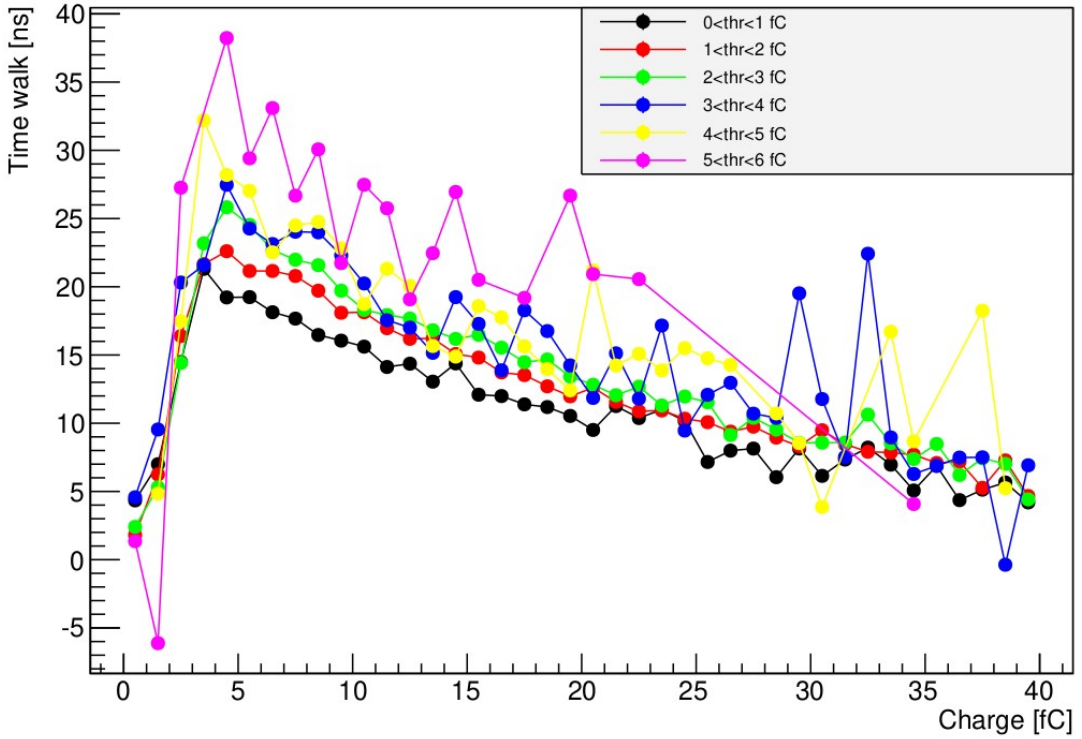


RUN 17

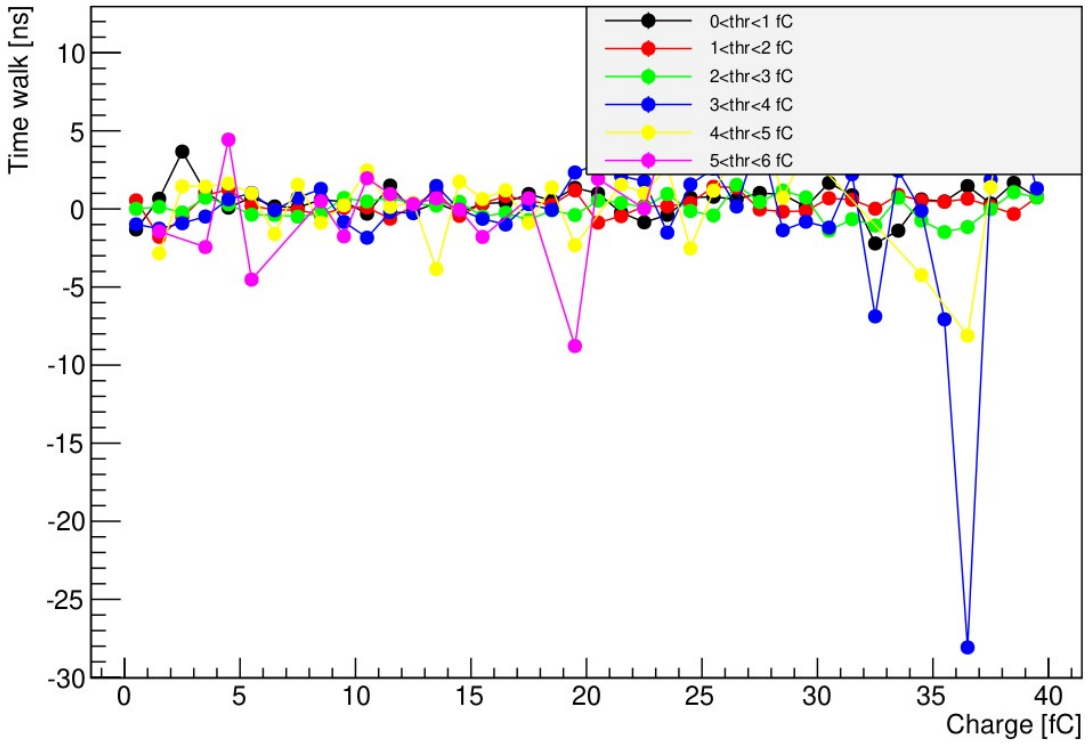
CgemTimeCalibration: TimeWalk 2.0

Check the convergence of the TimeWalk corrections after one round

1° round



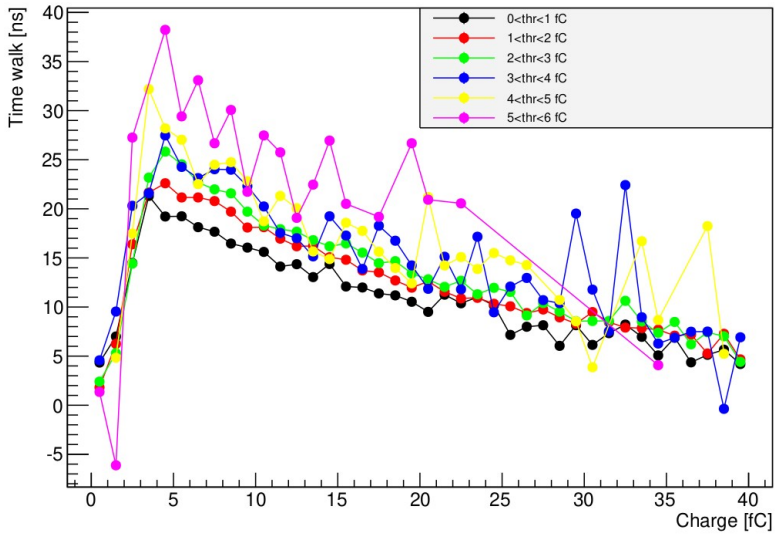
2° round



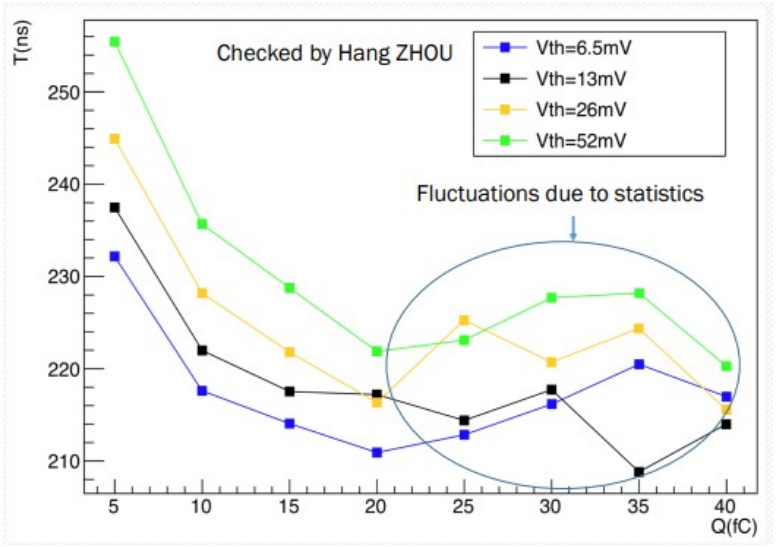
RUN 17

CgemTimeCalibration: TimeWalk comparison

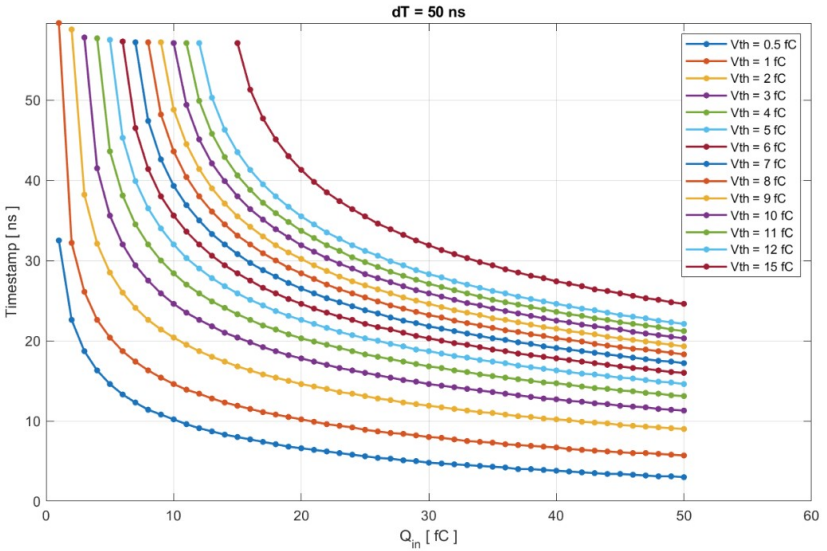
Go to the main page



Data calibration RUN 17



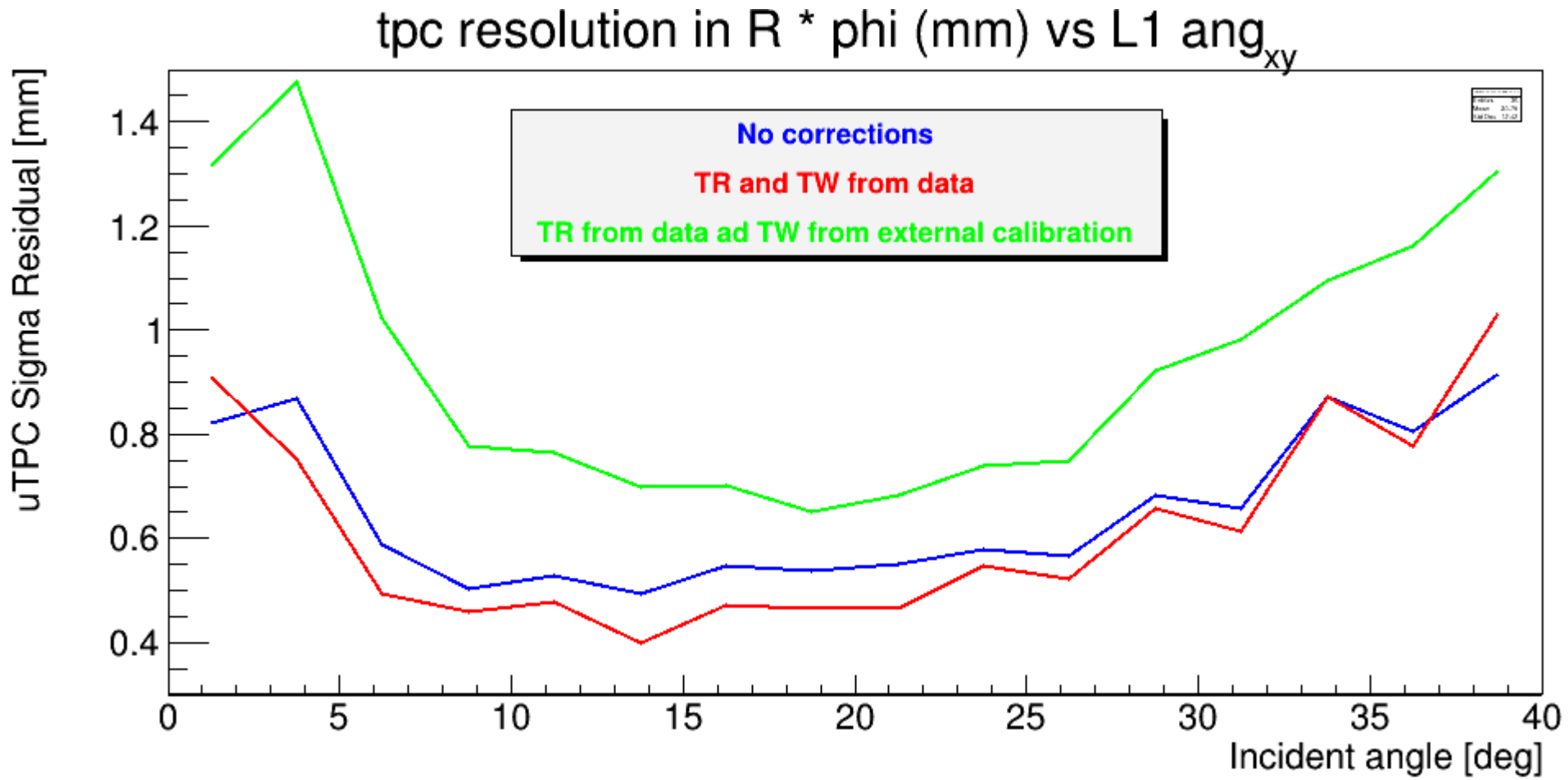
CGEMBOSS simulation



Silicon calibration

Data calibration shows a lower TW in the low charge region.
Data calibration and CGMEBOSS simulation “share” the same signal shape

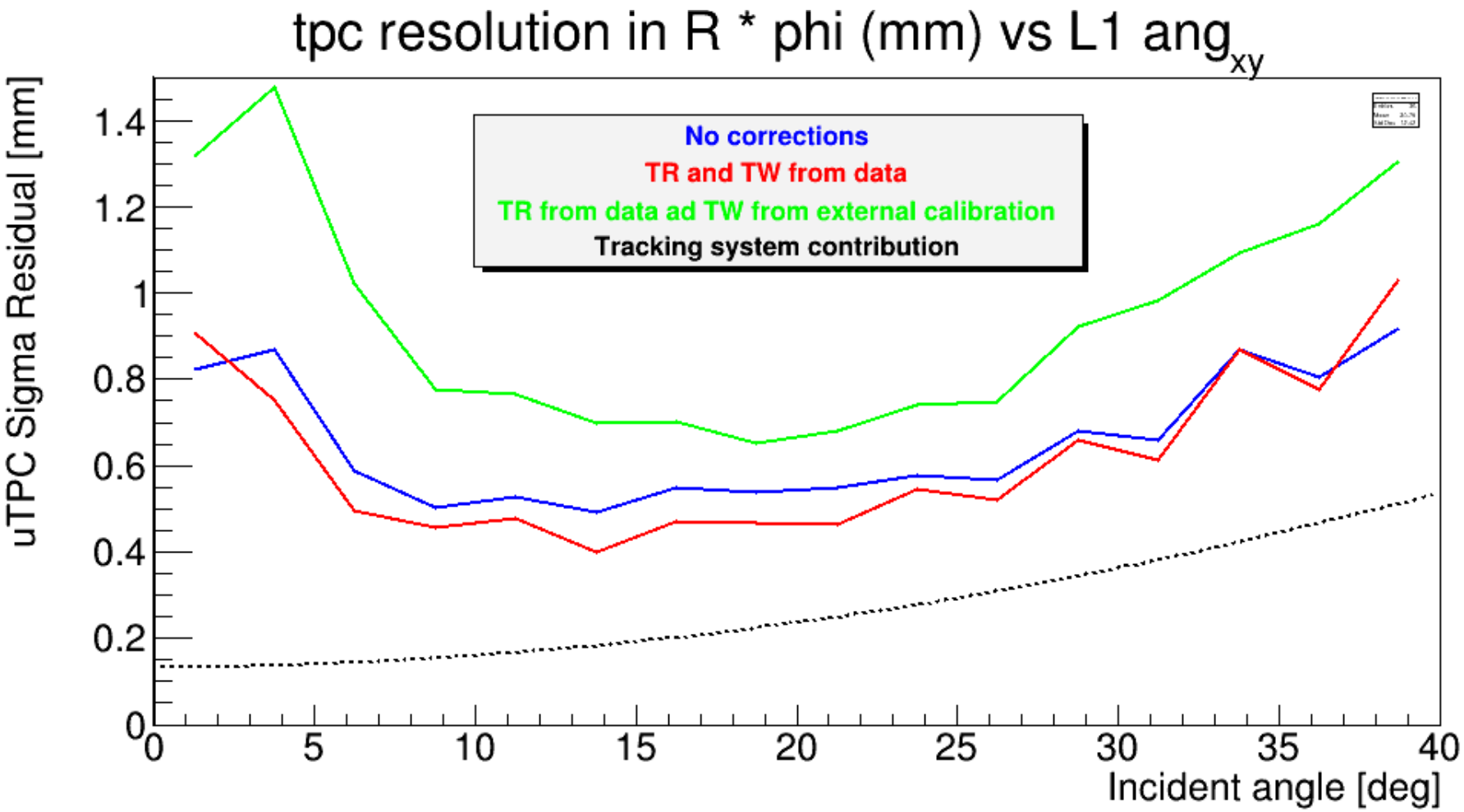
CgemTimeCalibration: QA results



The µTPC is affected by the time correction used.
An improvement is shown for the red line and a worsening for the green line.

--> we need to repeat the green study with a large signal length (100ns instead of 50ns)

CgemTimeCalibration: QA results

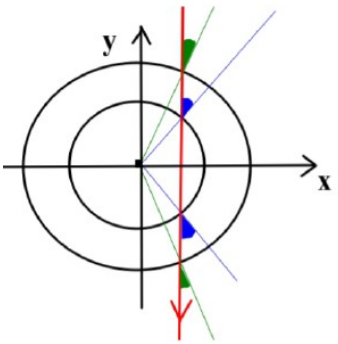


The µTPC seems “flat” between 10° and 25° (and this should be **enough** for the BESIII requirements -> do not spent time above 25°?)
The contribution of the tracking system impact this measurements and its evaluation in underestimated (my personal option)

--> It is possible to evaluate the tracking system contribution with a technique similar to the TOY-MC within CGEMBOSS and the real
--> geometry?

TOY-MC: tracking contribution

Toy simulation



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

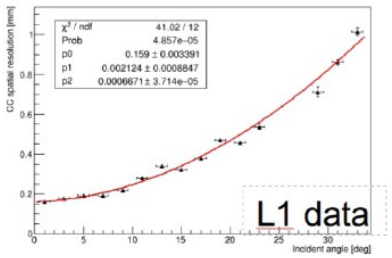
2. Smear the track incident angle of 0.36 deg (from Marco's calculation) for L1down and L2down

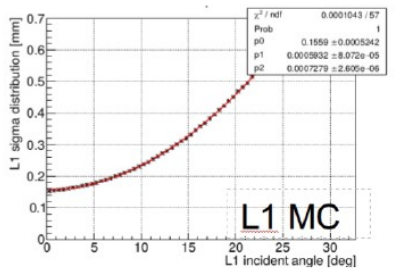
3. Evaluate the expected CC resolution at the impact point using the function
CC_res = 80 μm + 3.0 μm/deg * angle + 0.65 μm/deg^2 * angle^2

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

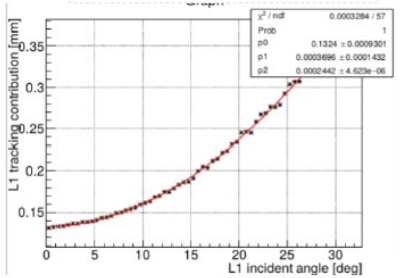
5. Use three point to reconstruct the track and measure the residual distribution and the constribution of the tracking system = sqrt(sigma_recon^2 - sigma_true^2)

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





Contribution of the tracking system on L1



Toy results

1. The threnḍ of the constribution 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.

Merge: intro

Let’s test the merge algorithm within CGEMBOSS

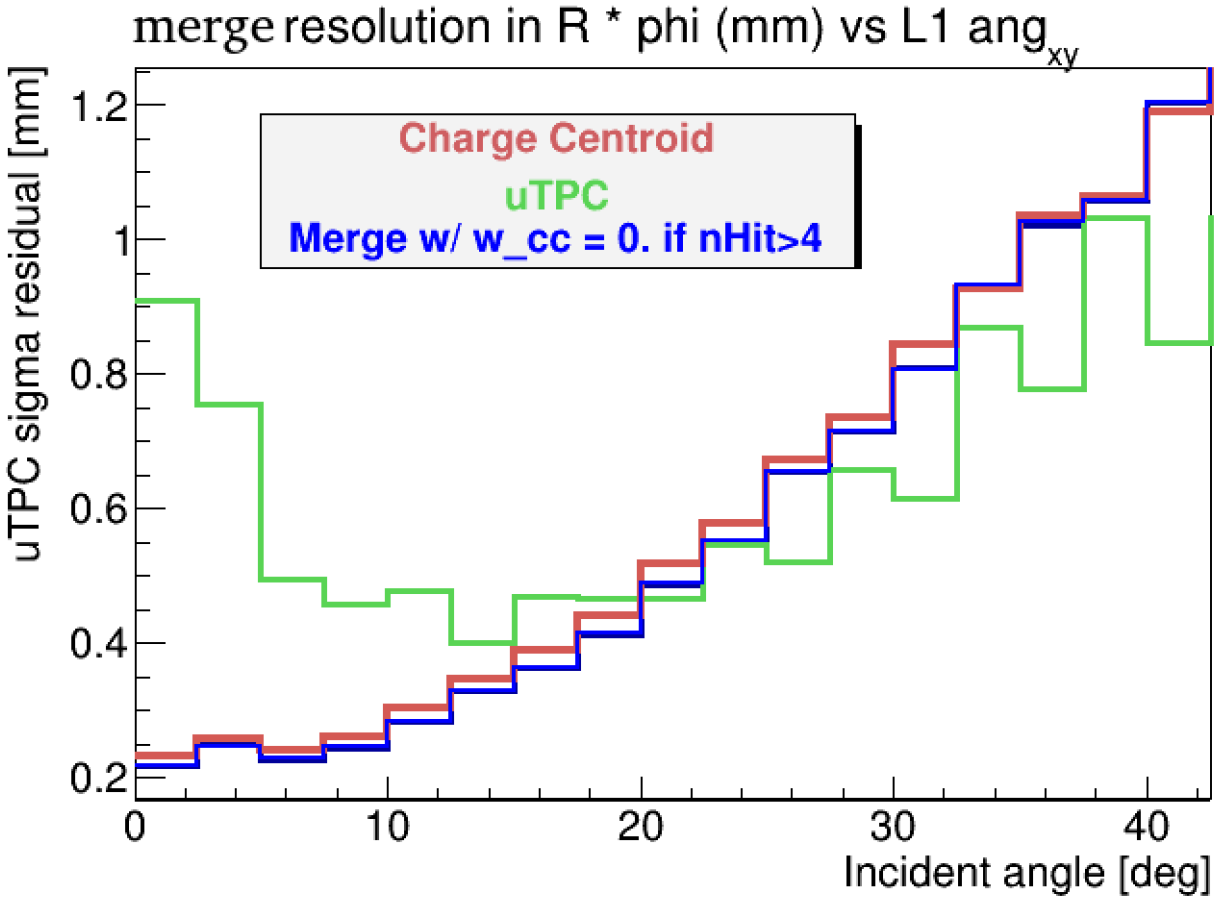
Reminder: studies from planar GEM used two method:

- based on the cluster size
- based on the incident angle

Inside CGEMBOSS we will test the first one

$$x_{\mathrm{merge}} = w_{\mathrm{cc}} \left(x_{\mathrm{cc}} - \Delta_{\mathrm{cc}} \right) + \left(1 - w_{\mathrm{cc}} \right) x_{\mathrm{tpc}}$$

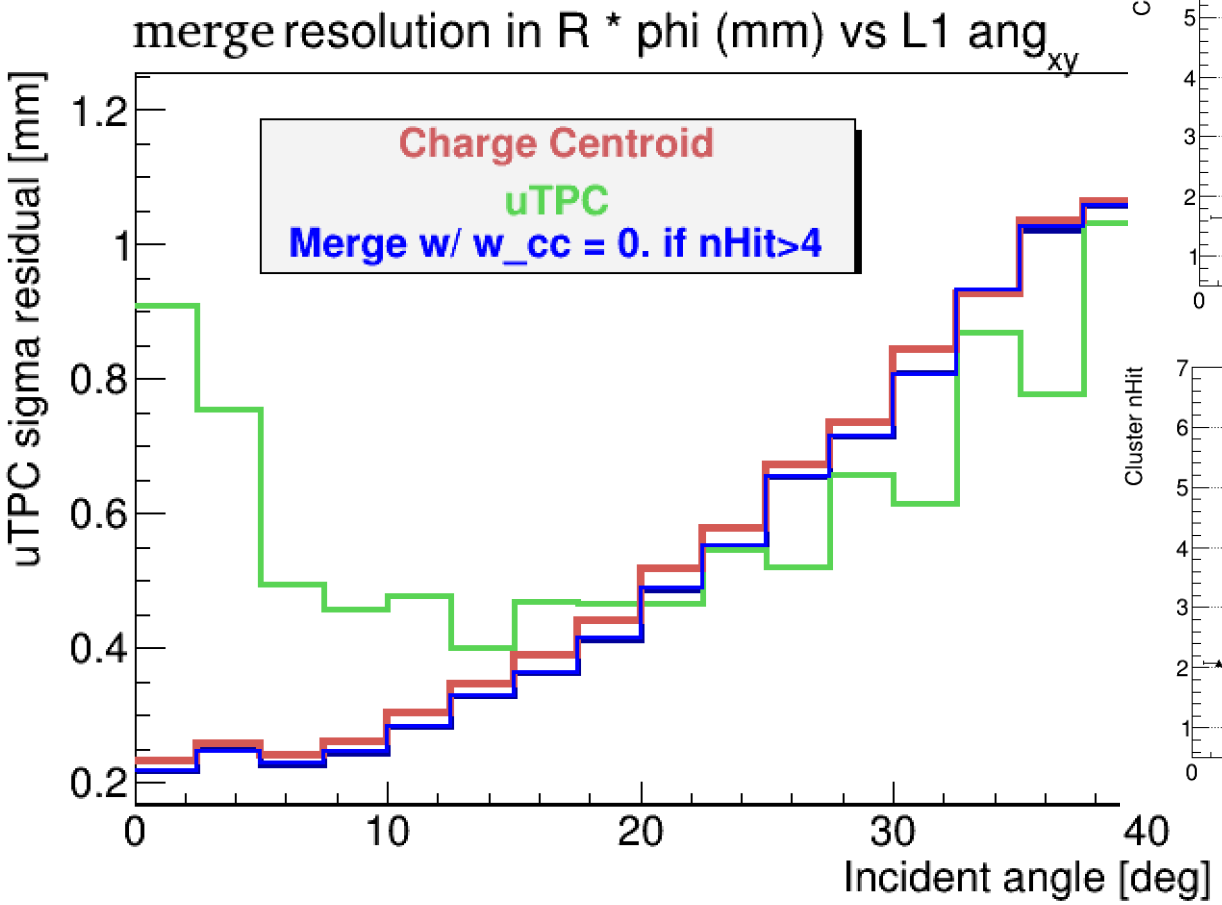
Merge: QA results

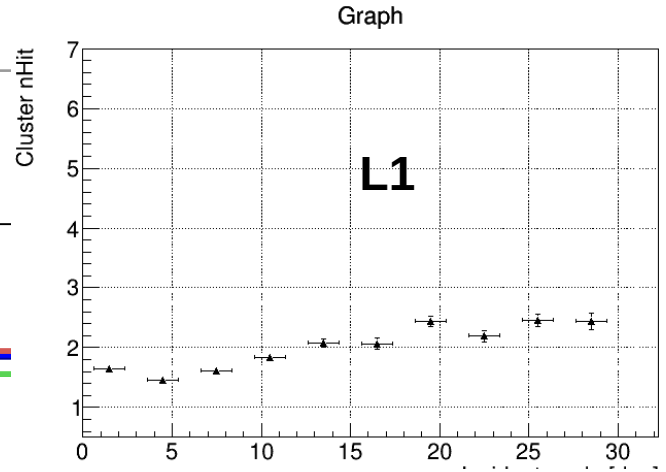


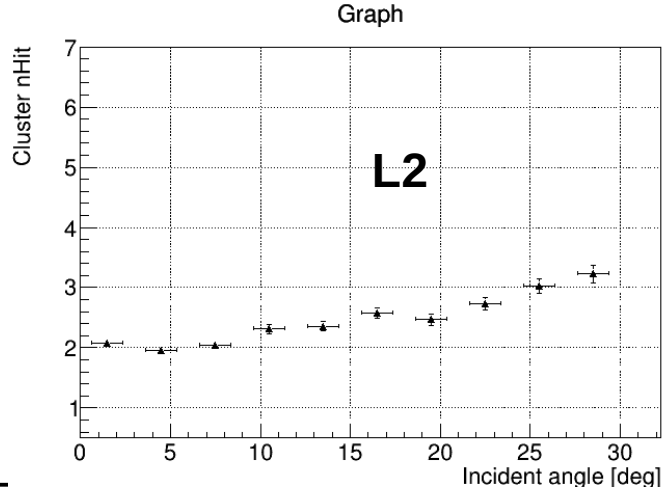
The same algorithm used with planar GEM is not effective for large angles

--> Let's try something else

Merge: QA results



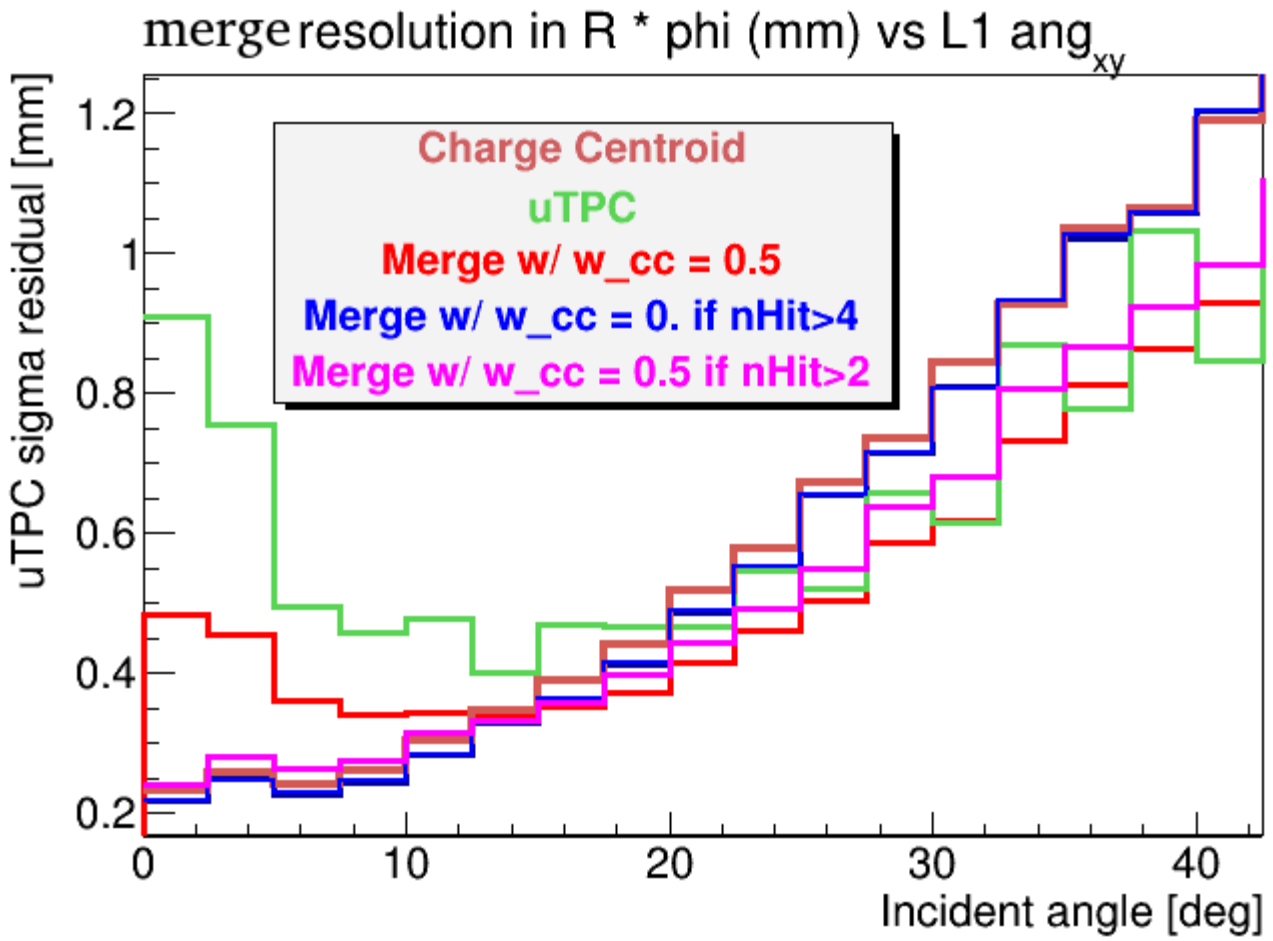




The same algorithm used with planar GEM is not effective for large angles

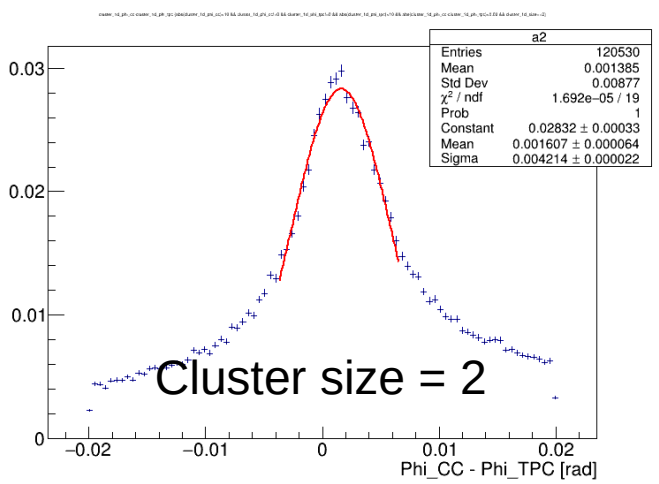
--> Let's try something else

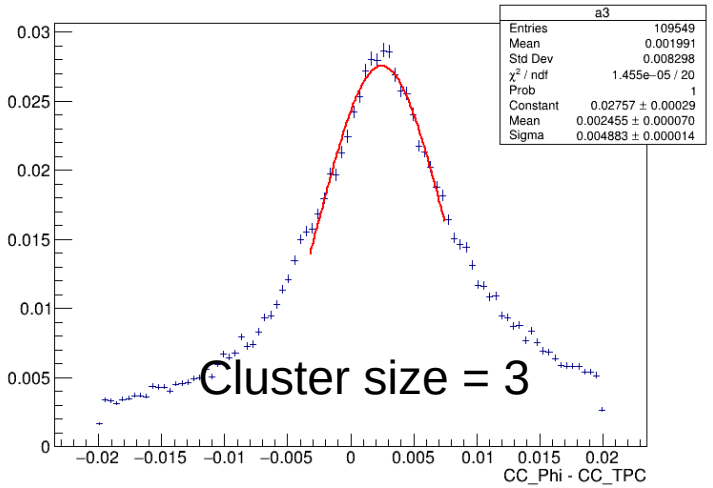
Merge: QA results

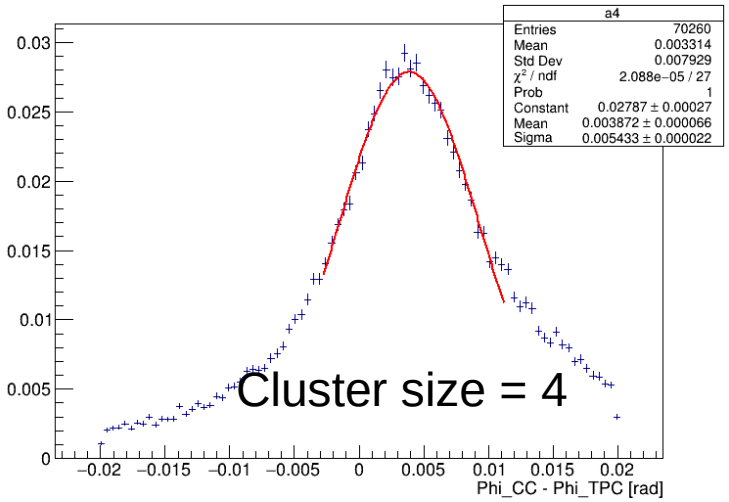


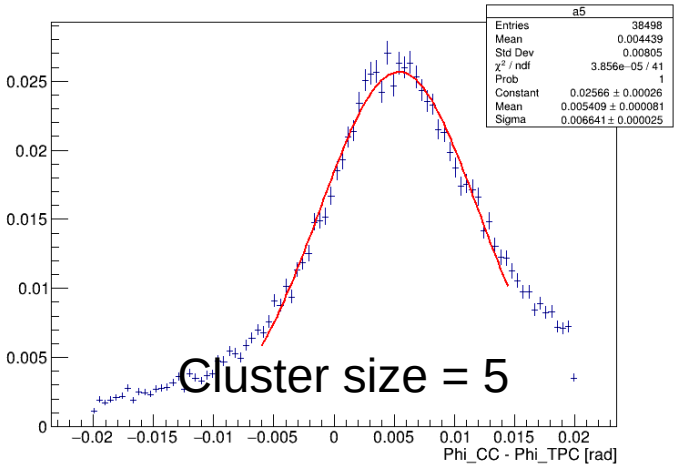
The pink lines seems to be the best solution. It copies the CC below 15° and it follows the µTPC above 25°

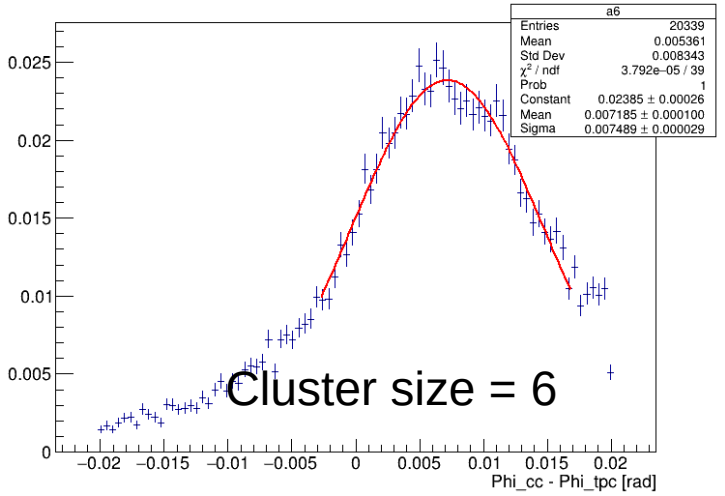
Merge: Phi_CC - Phi_TPC

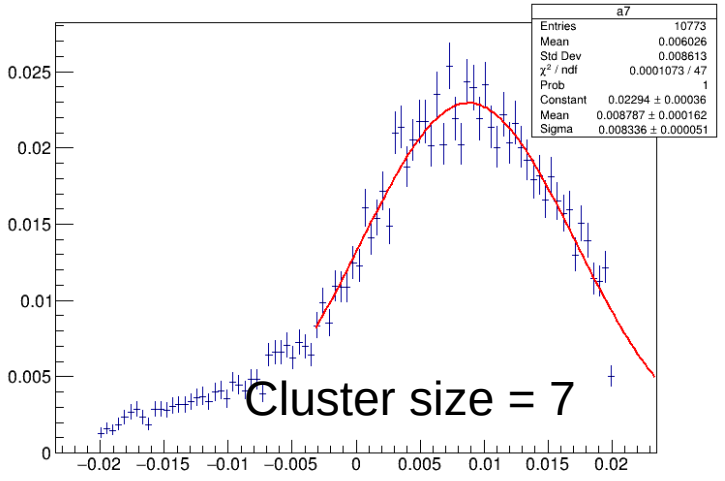




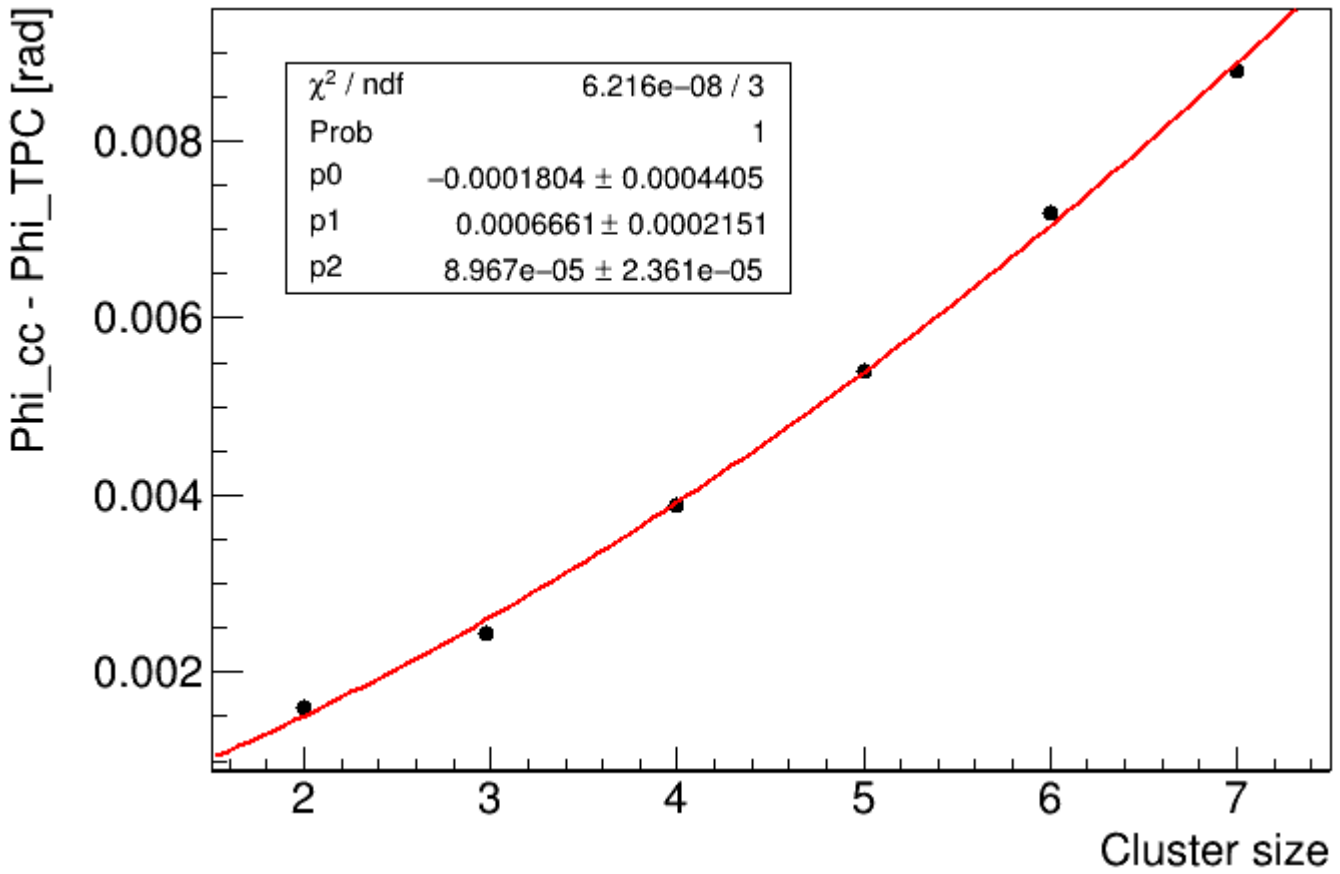








Merge: Phi_CC - Phi_TPC



This studies has to be performed for L1/L2 and Phi/V separated.

--> Preliminary studies do not impact significantly on the “best” merge

Old Conclusion

The behavior of the time-walk is different from chip to chip.

--> There was a time shift but the trends are similar

These differences have to be investigated: Statistic? Impinging angle? Noise?

--> Fluctuation I guess

Some trend looks similar. We need to apply the time-reference to test if the behavior is the same

--> Done

We need a separate approach to the low charge region: increase the charge bin from 5 to 1 fC?

--> A different bin size does not solve the problem

What is the impact of the saturation in the high charge region? Do we have to remove the saturated hits?

--> Still to be investigated

Do we have to use the “cleaned” sample from the CgemLineFit algorithm?

--> Still to be implemented, this is the latest study to understand the TW from data

New Conclusion

The TW evaluated on the data is a good starting point for our studies. An impact on the µTPC resolution is provided by the TW (no significant impact are shown by the TR alone and no TW)

The merging algorithm evaluated with planar GEM (and APV) is not effective. More news might come from the latest TB with TIGER and triple-Gem but my opinion is to focus our studies on the CGEM (because the CGEM+TIGER still differs from the GEM+TIGER)

A merging solution has been found to have the best from CC and µTPC **but**

--> the evaluation of the tracking system contribution is need within CGEMBOSS. This is very important for the fine µTPC calibration (i.e. more TW and TR loops, TR for the channels, diffusion and capacitive corrections …)

--> As soon as the merging function will be implemented in RecCgemCluster we need to use the merge in the QA and CgemLineFit