SVD Hit Time Calibration

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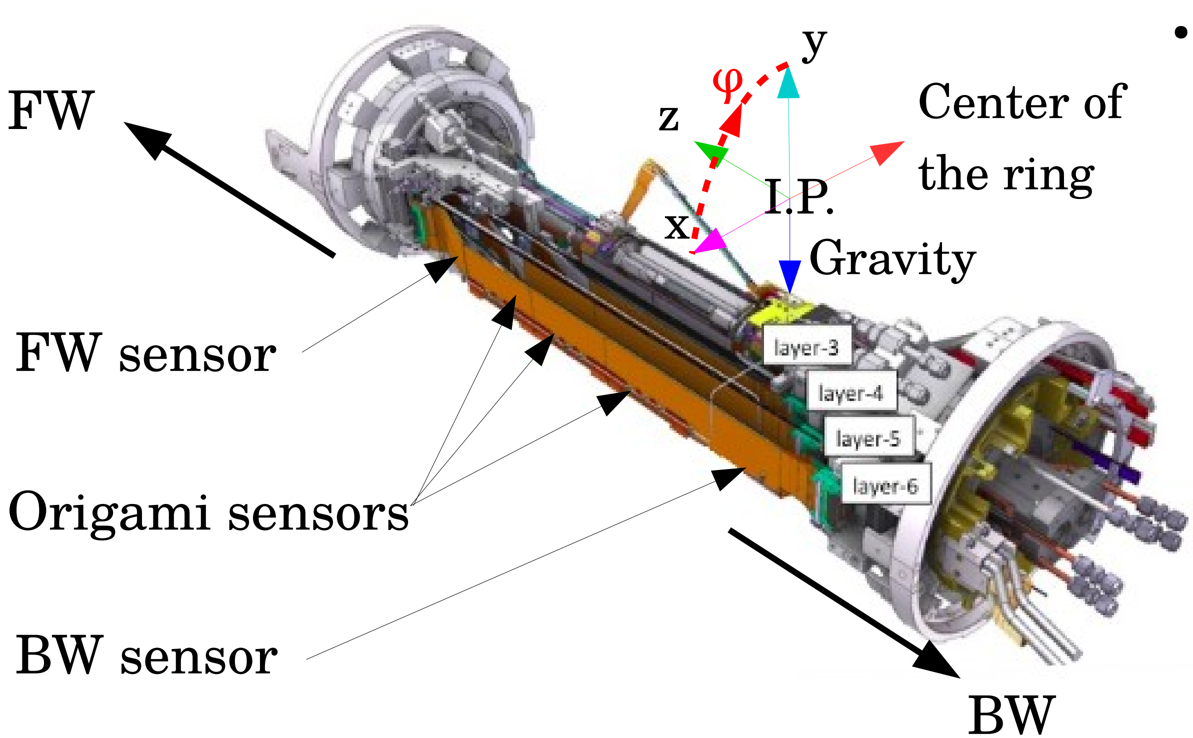
Introduction

- Hints on SVD Phase2 Configuration and signal readout
- Brief introduction on the Center of Gravity (CoG)
- How we did the CoG calibration using the timing informations of the CDC
- Final results on the resolution of the cluster time estimated by CoG
- Conclusions and future plans

Hints on SVD Phase2 Configuration

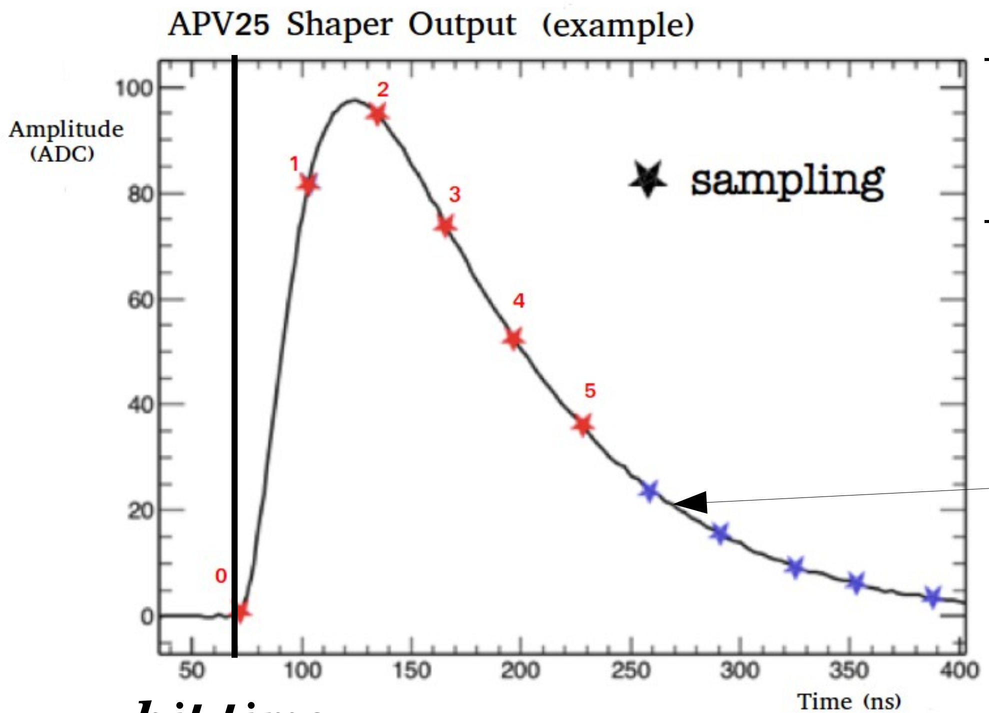
- SVD current configuration:
  - 4 layers: L3, L4, L5, L6 (1 ladder each), positioned at $\varphi = 0$
  - Each layer has a different number of sensors: the L4, L5 and L6 have respectively 3, 4 and 5 sensors of different types: BW + Origami and FW (slanted); the L3 has 2 smaller equal sensors



- Each sensor has 2 sides, U and V, with a different strips configuration:
  - U-side strips are of type *p* and measure the φ direction
  - V-side strips are of type *n* and measure the *z* direction

Hints on signal readout

- The signal of the strips is read by an APV25 chip
- Each APV25 read 128 strips and sample the waveform of each strip with a clock that has a period of 31.45 ns



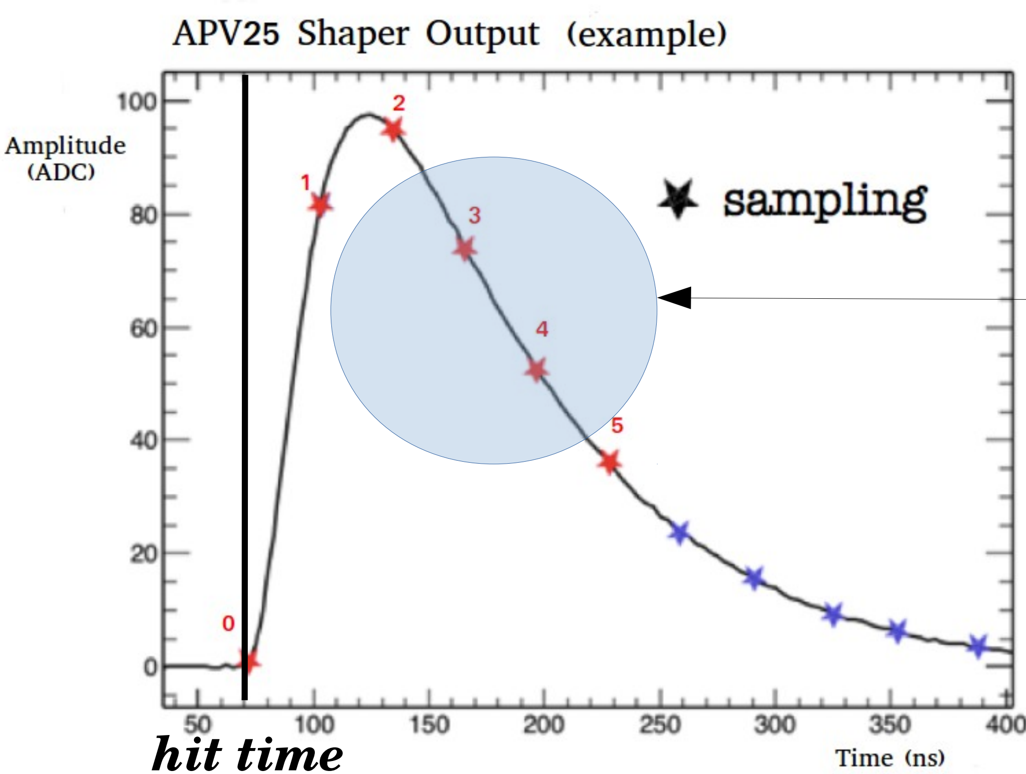
hit time

- APV25 → provides 6 samples of the waveform
- from the 6 samples we reconstruct:
  - the strip charge: the biggest charge of the 6 samples
  - the strip *hit time*: it is the time at which the APV25 signal start rising

Waveform relative to a signal in a strip which is sampled by the APV25

Center of Gravity (CoG)

- How we estimate the *hit time*? Using the **CoG!**
- The CoG is a weighted mean of the time of the 6 samples with the charge



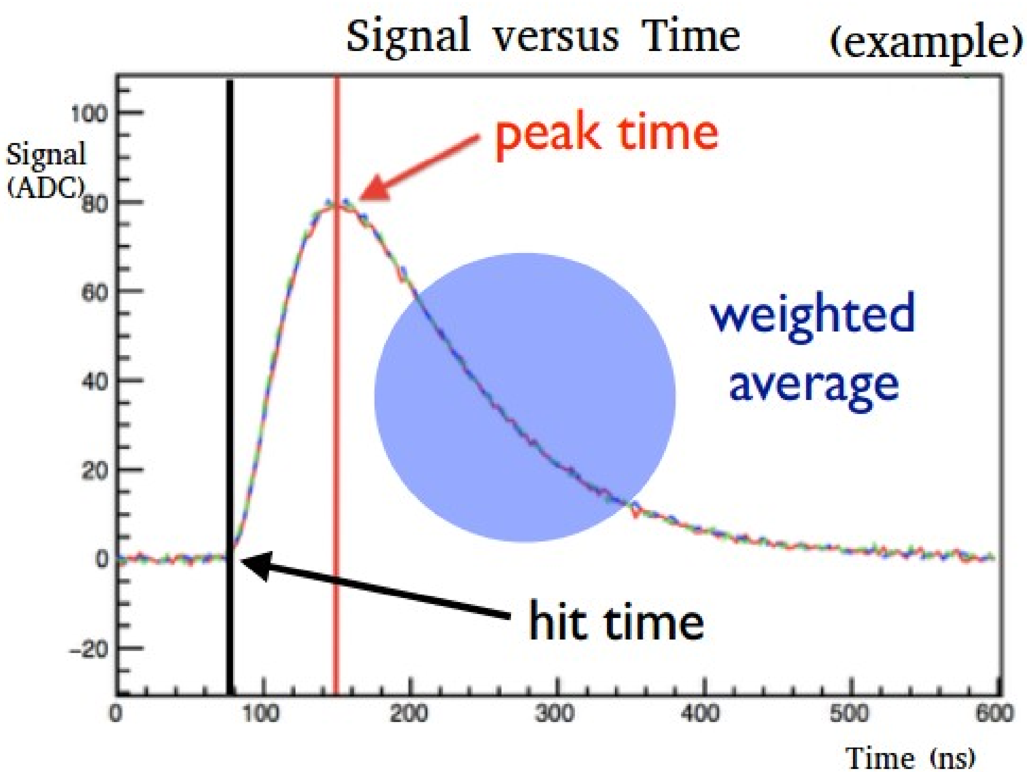
$$t^{raw}_{COG} = \frac{\sum_n A_n \cdot T_n}{\sum_n A_n}$$

- n: 6 samples, n = [0, 1, 2, 3, 4, 5]
- A_n: Charge of each sample
- T_n: Time of each sample

Center of Gravity (CoG)

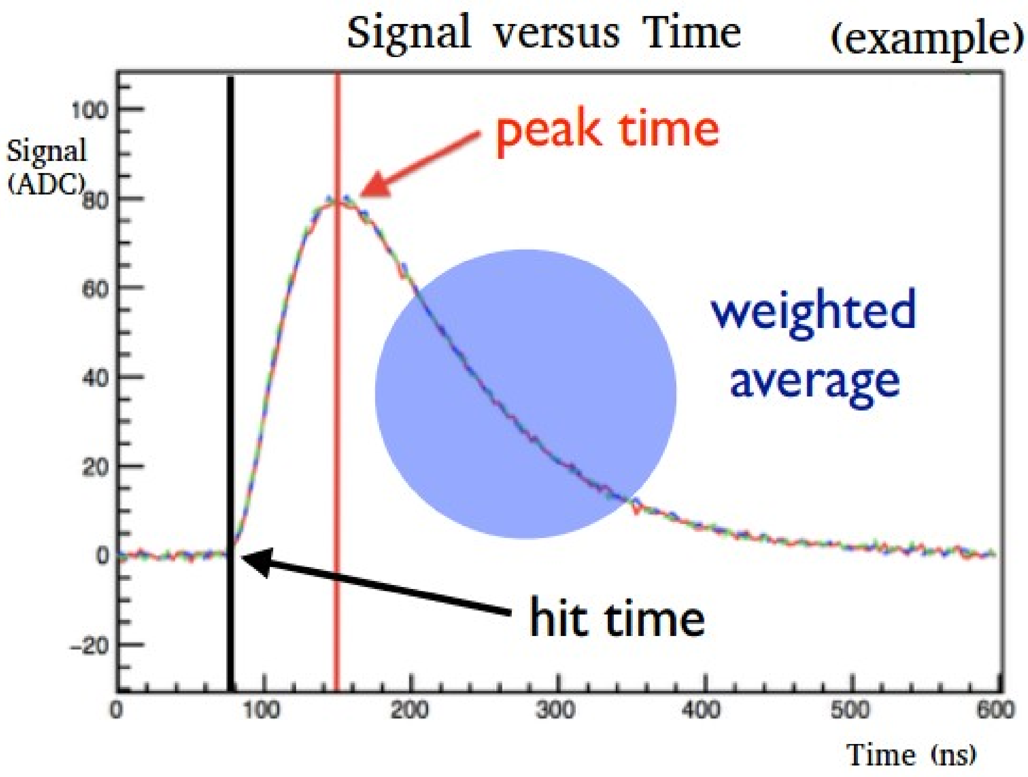
- t^{raw}_{COG} estimates the *peak time*

$$t^{raw}_{COG} = \frac{\sum_n A_n \cdot T_n}{\sum_n A_n}$$



- We want the *hit time*
- t^{raw}_{COG} has to be corrected
- The correction that we applied is the *peaking time* correction (strip-dependent)

Center of Gravity (CoG)



$$t_{COG} = \frac{\sum_n A_n \cdot T_n}{\sum_n A_n} - p.t.$$

t^{raw}_{COG}

- *p.t.*
  → *peaking time* = constants + rising time of the signal (strip-dependent) (written on DB)

- t_{COG} estimates the *hit time*

Clusters time

- SVDShaperDigits

Selection of strips

- SNR threshold > 5: filter for noisy strips
- Strips near the tracks extrapolated on the sensors

CoG

- RecoDigits (*hit time* and amplitude informations...)

SimpleClusterizer

- Clusters (cluster dimension, cluster position, cluster time, ...)
- **Cluster time** = weighted mean of the strip times with charge

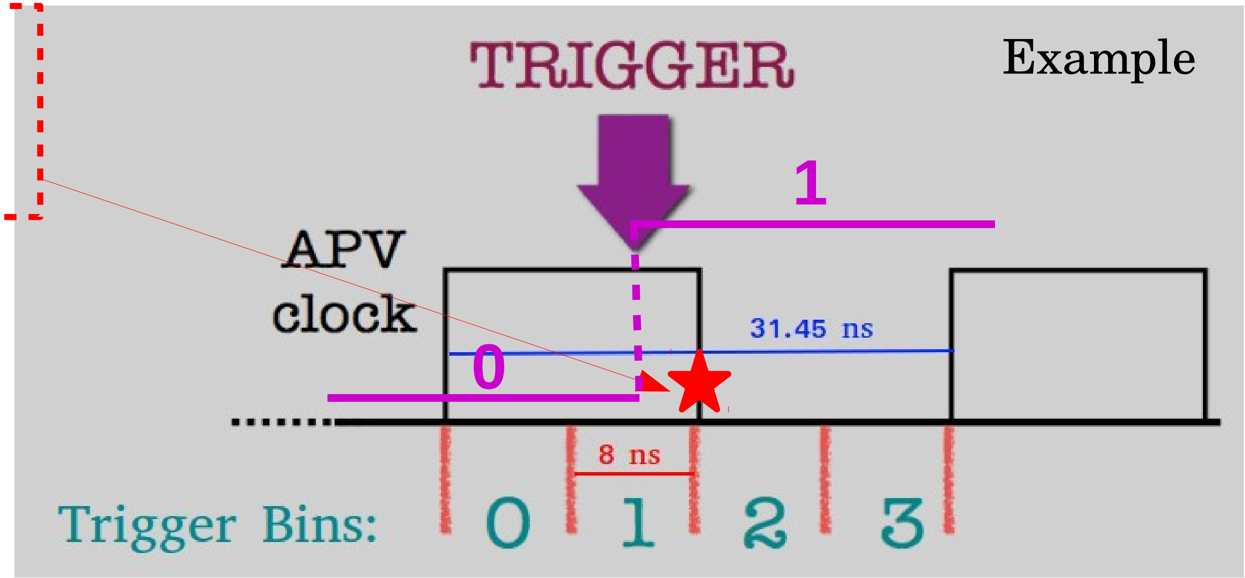
CoG Calibration

- SVD + CDC Cosmics Run 2804 reconstruction
- Cluster time estimated by CoG (applying only the p*eaking time* correction): t_{COG}
- Event time-zero estimated by CDC: t_0
- Scatter plot of t_0 versus t_{COG} distinguishing the different Trigger Bins

Trigger Bins

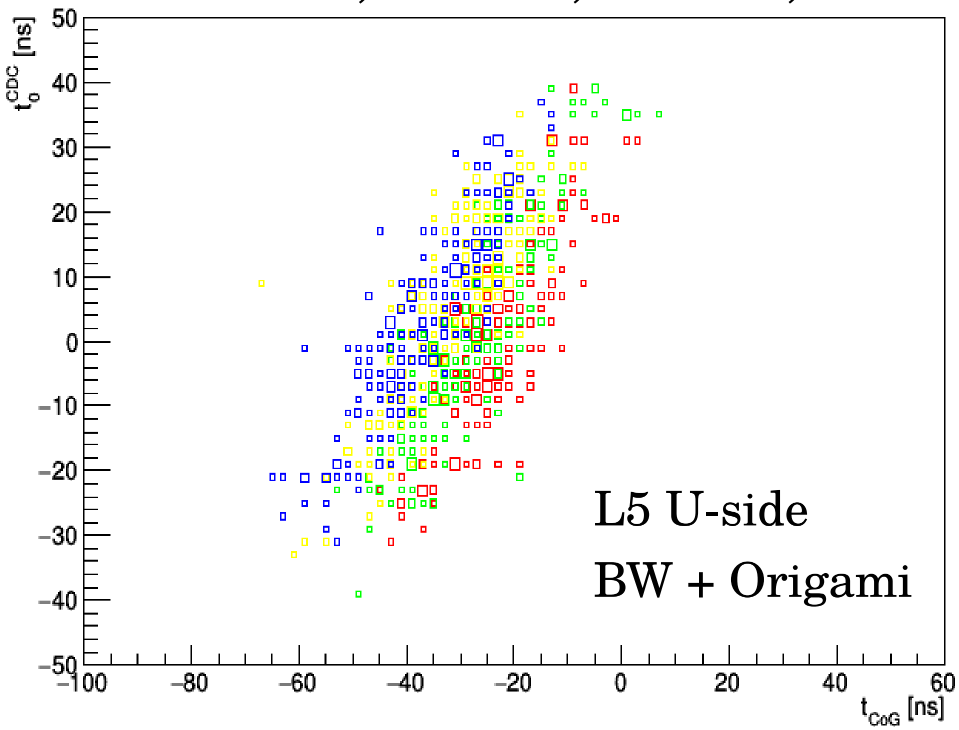
- The APV25 clock has a period of about 31.45 ns. The “check trigger clock” has a period of about 8 ns: it is more precise than APV25 clock.
- Each Trigger Bin (TB) is the 8 ns wide window and it contains the informations about:
  - in which window the signal has arrived
  - the shift in time between the SVD origin of time (first sample) and the CDC origin of time

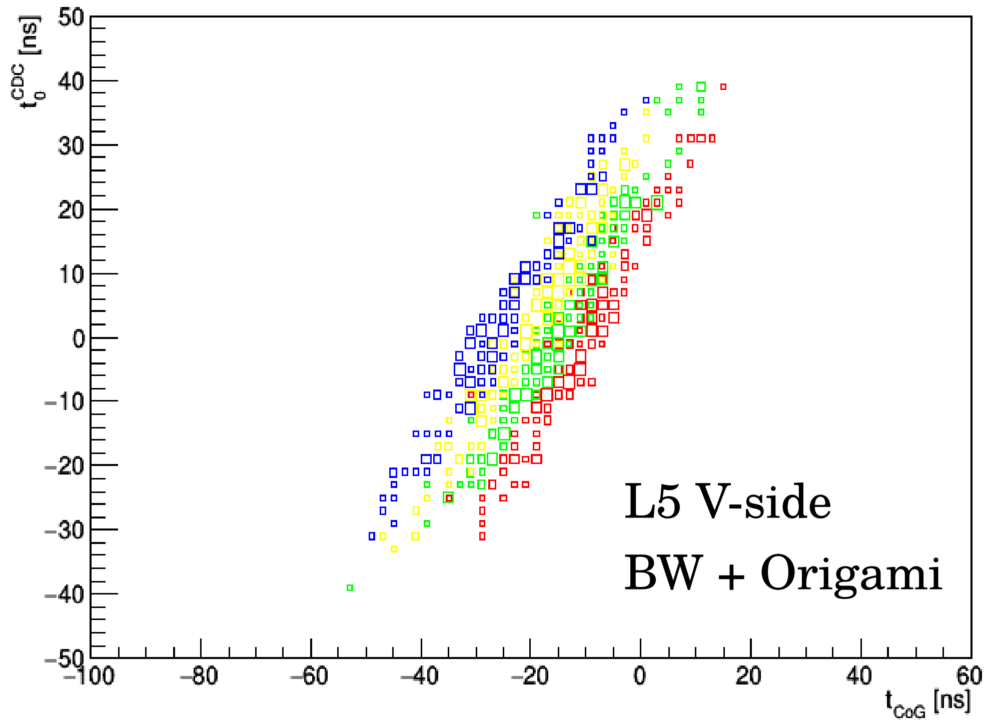
TB in which the signal is arrived



CoG Calibration

- Cosmics run 2804
- t_0 [ns] versus t_{COG} [ns]
- TB = 0, TB = 1, TB = 2, TB = 3

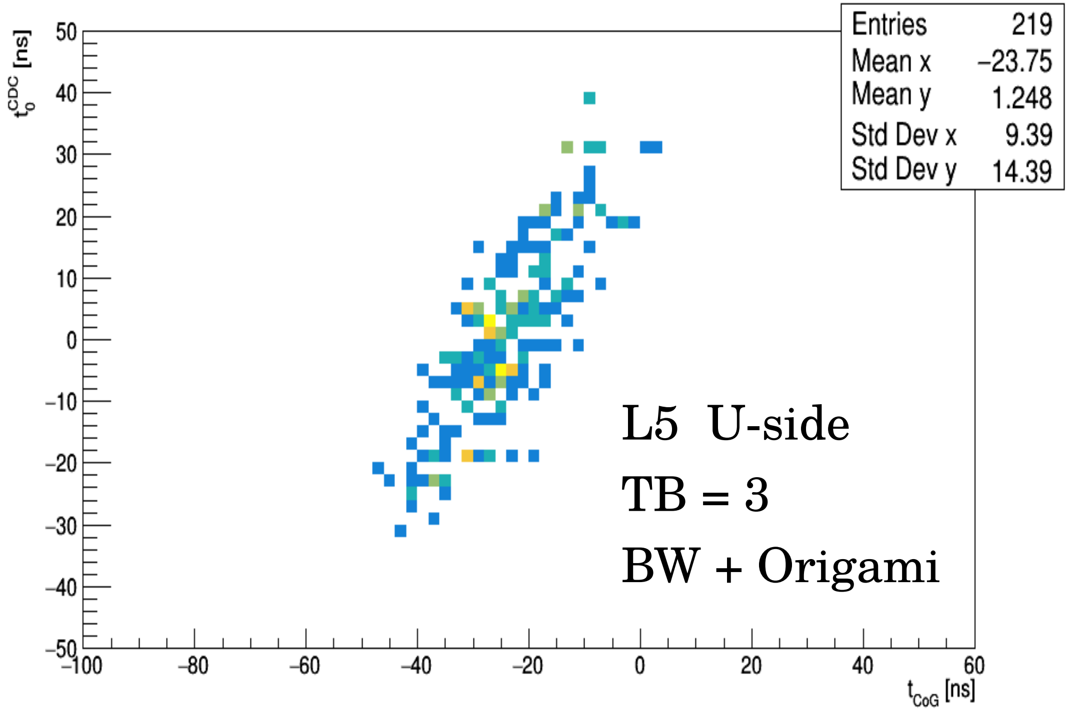


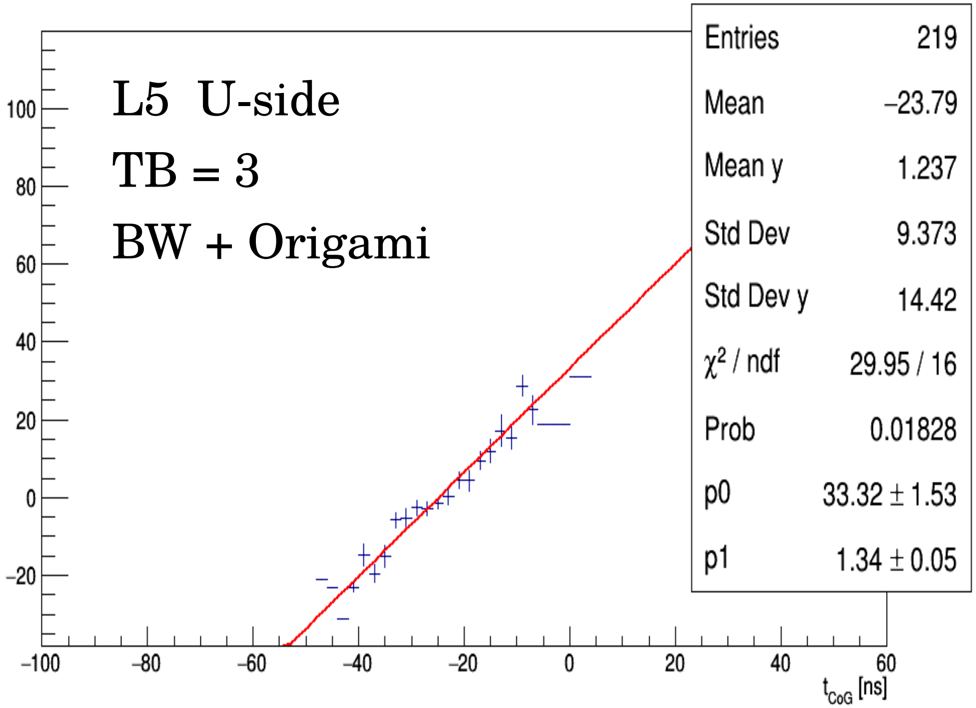


- **Linear correlation between t_0 and t_{COG}!**
- The TB are quite well separated for the V-side

CoG Calibration

- Cosmics run 2804
- t_0 [ns] versus t_{COG} [ns]
- left: Scatter plot, right: linear fit of the ProfileX of the scatter plot
- $f(x) = m \cdot x + q$





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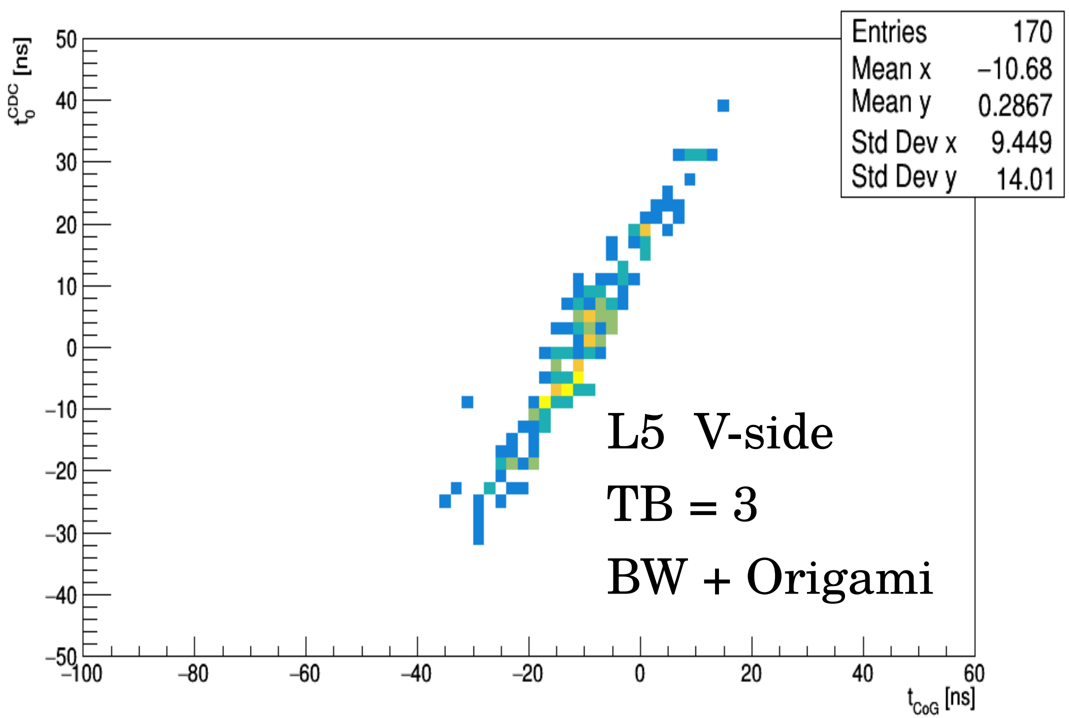
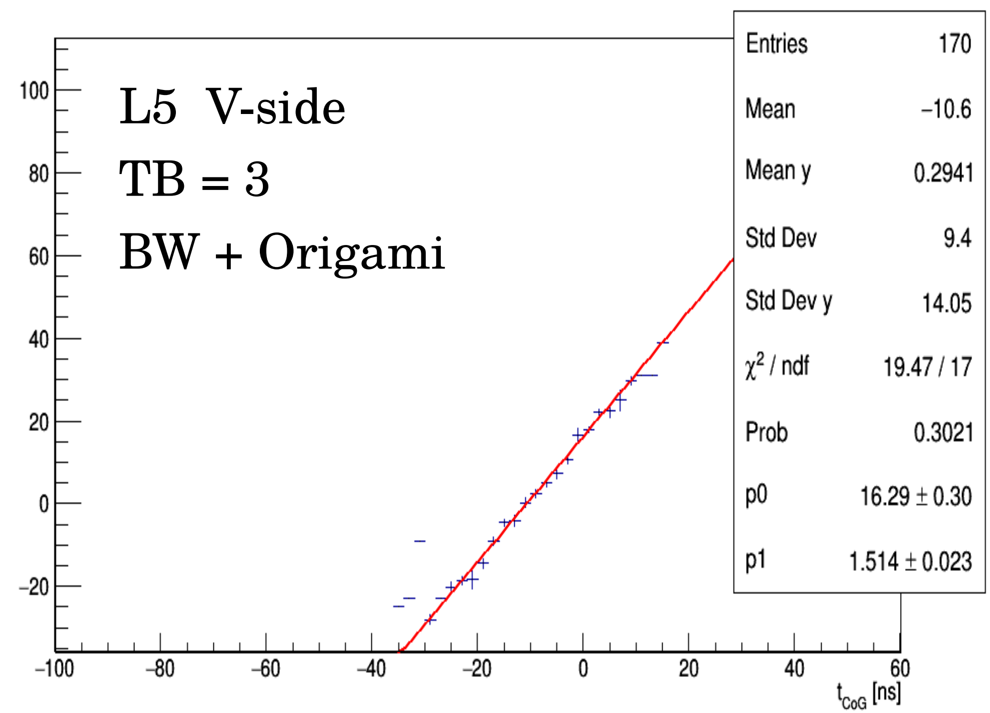
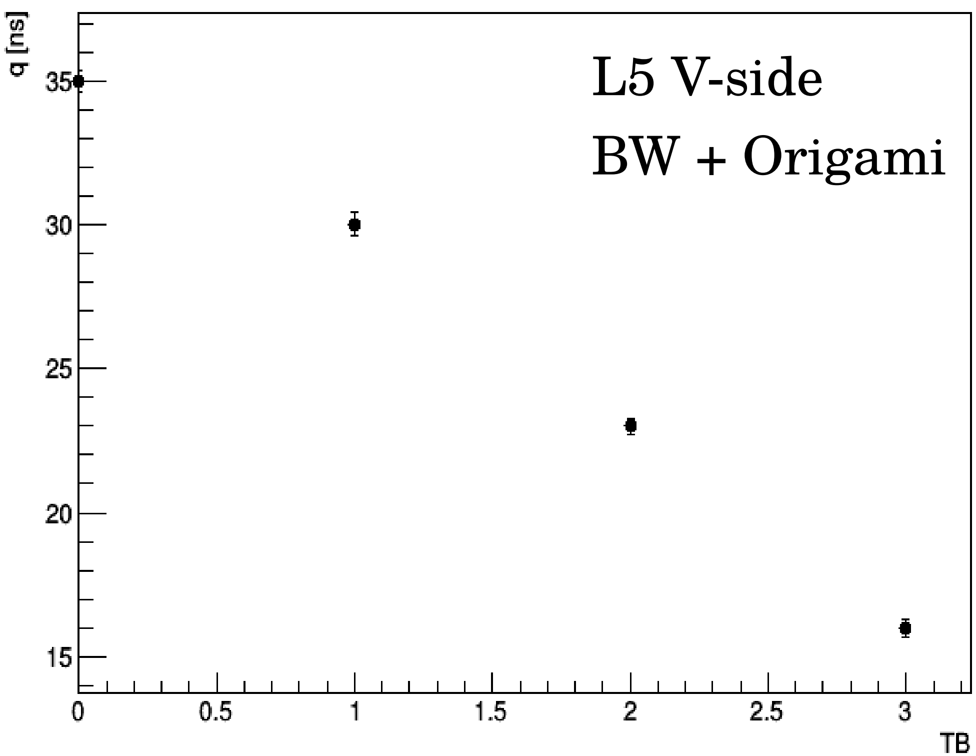


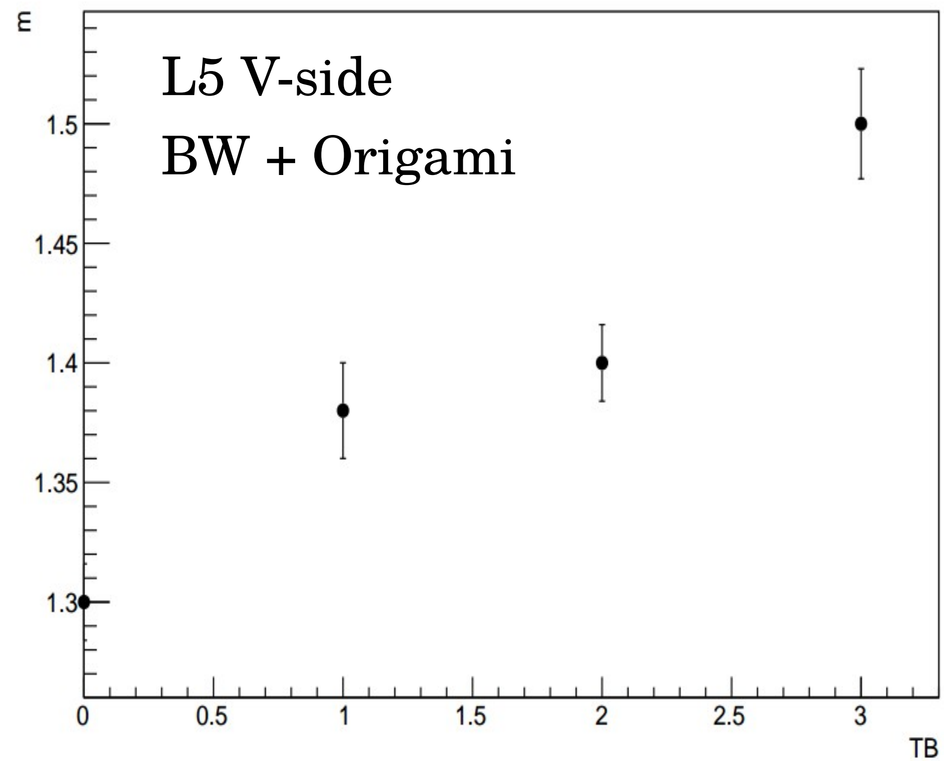


CoG Calibration

Intercept q versus TB



Slope m versus TB

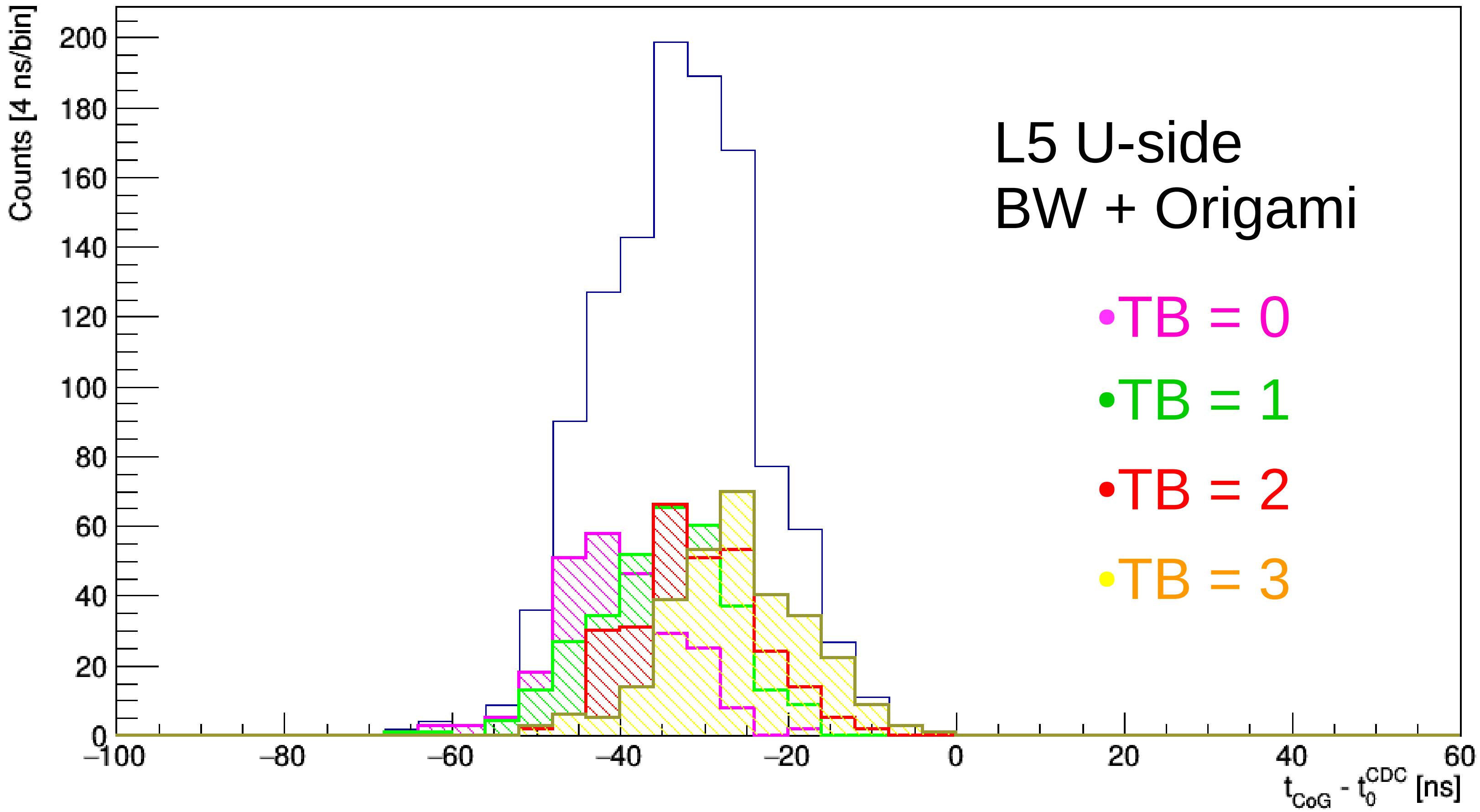


- The slope m and the intercept q are different for each TB
- General trend that we expect if the linear fit is good

CoG Calibration

- Time resolution defined as: $\Delta(T) = t_{COG} - t_0$

Before the correction



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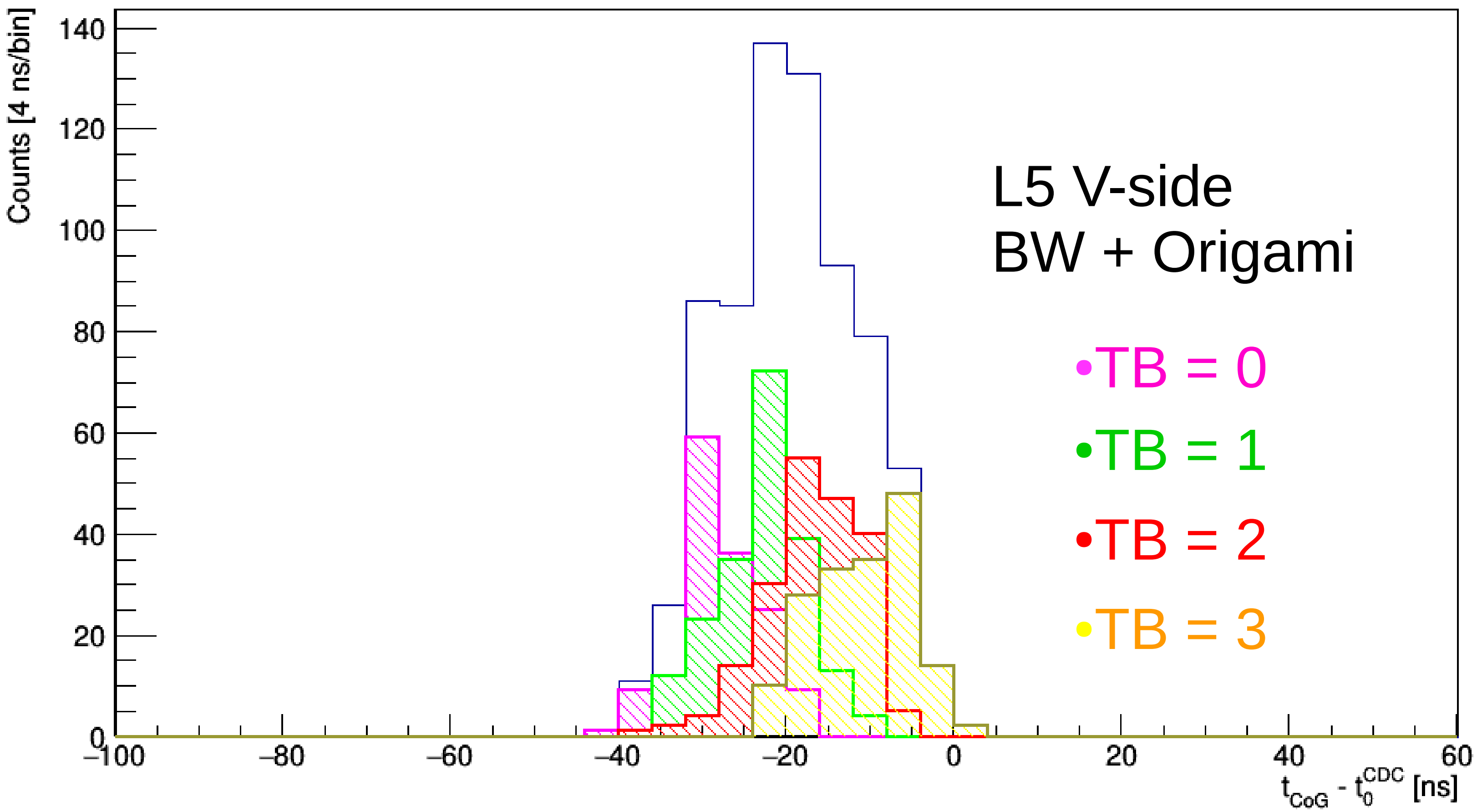


CoG Calibration

- Correction to the CoG obtained by the linear fit of the ProfileX of the scatter plot t_0 versus t_{COG}:

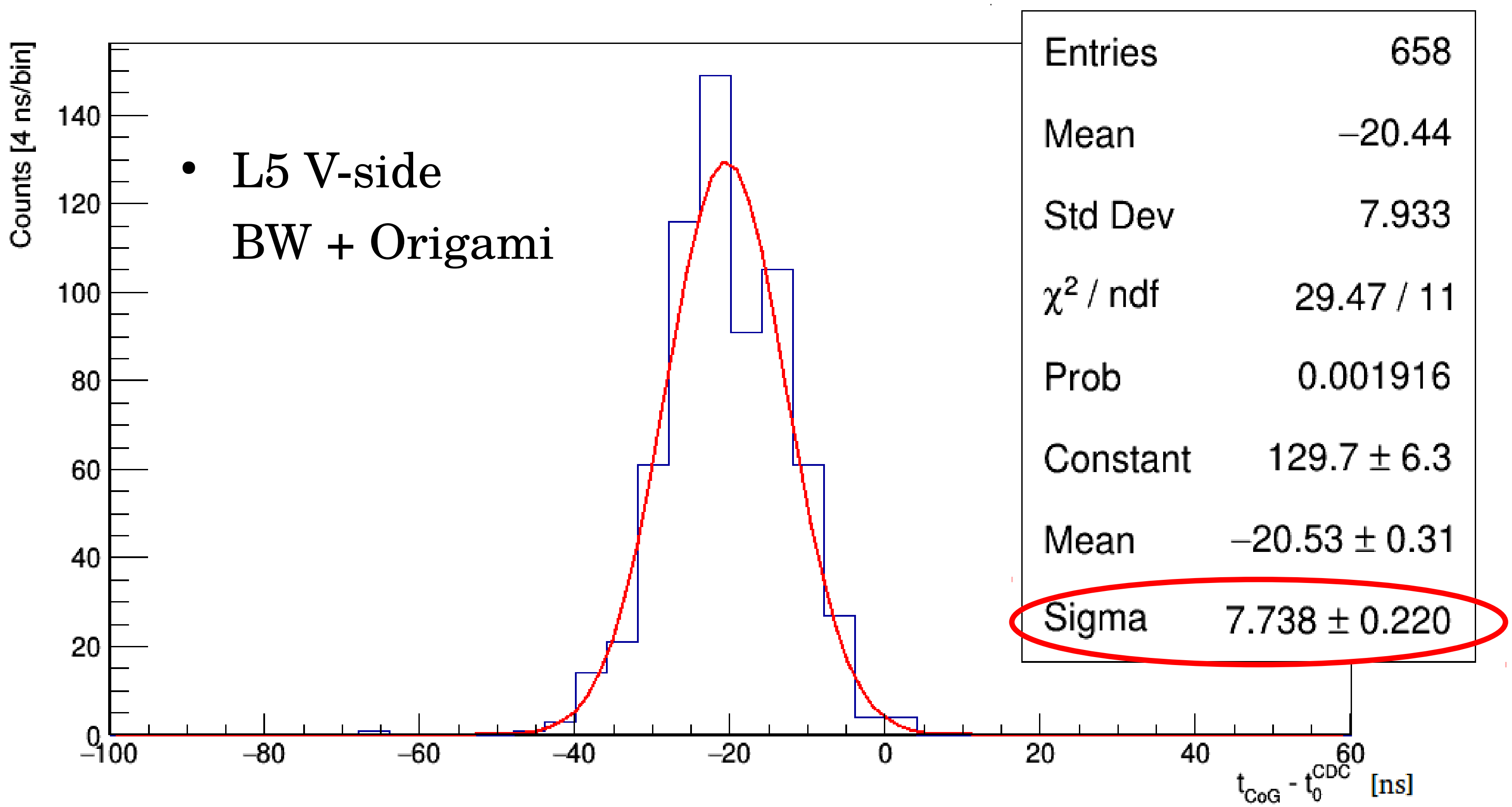
$$t'_{COG} = m \cdot t_{COG} + q$$

- m and q have been obtained from the Cosmics run 2804 (reference run) and they have been used to correct the CoG in the Cosmics run 2712 (a generic run)

- Correction has been applied to all layers and all sensors (except the FW for Layers 4, 5 and 6) and to both sensors of the Layer 3

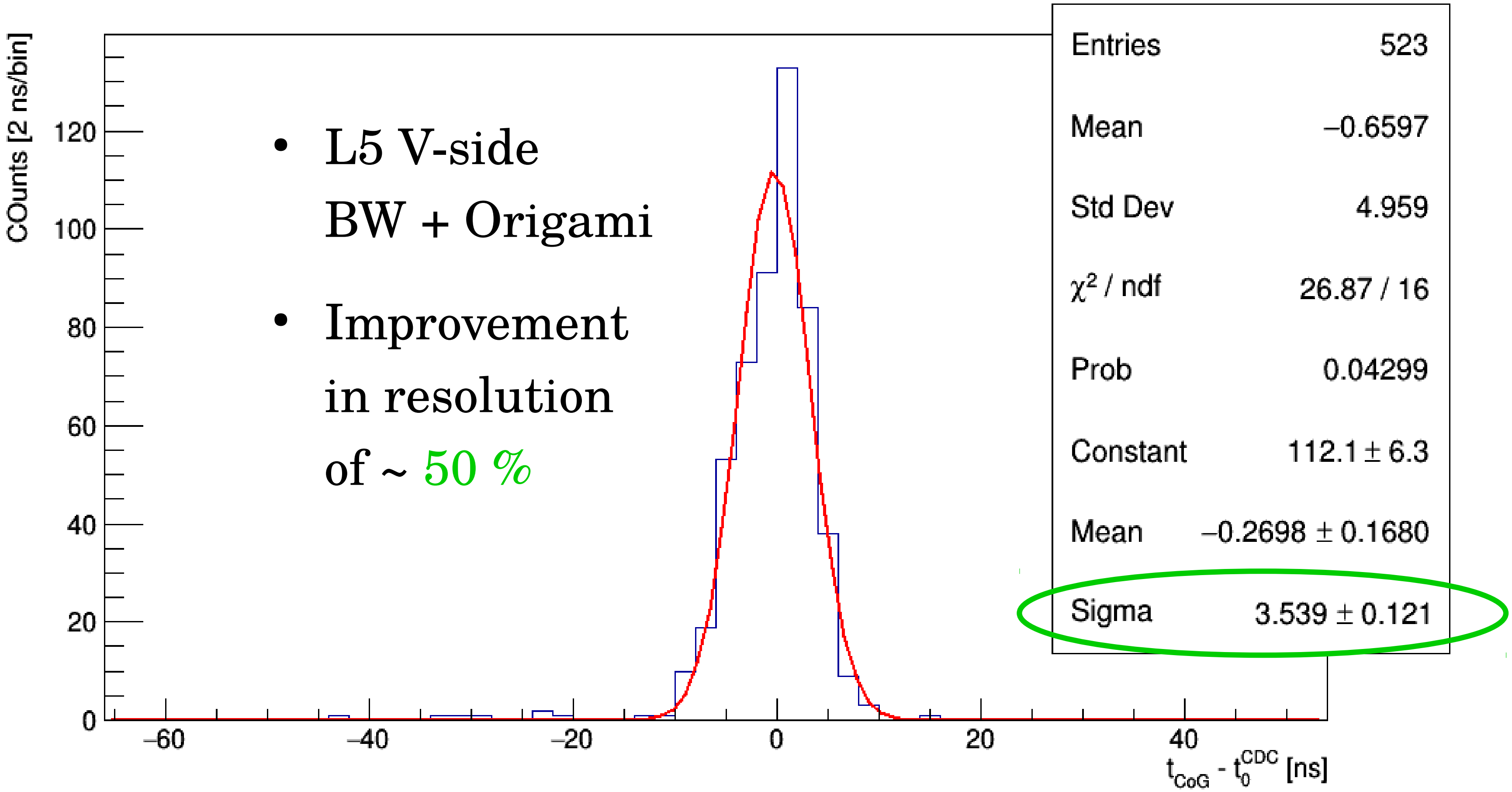
Results

- Run 2712, CoG resolution before correction



Results

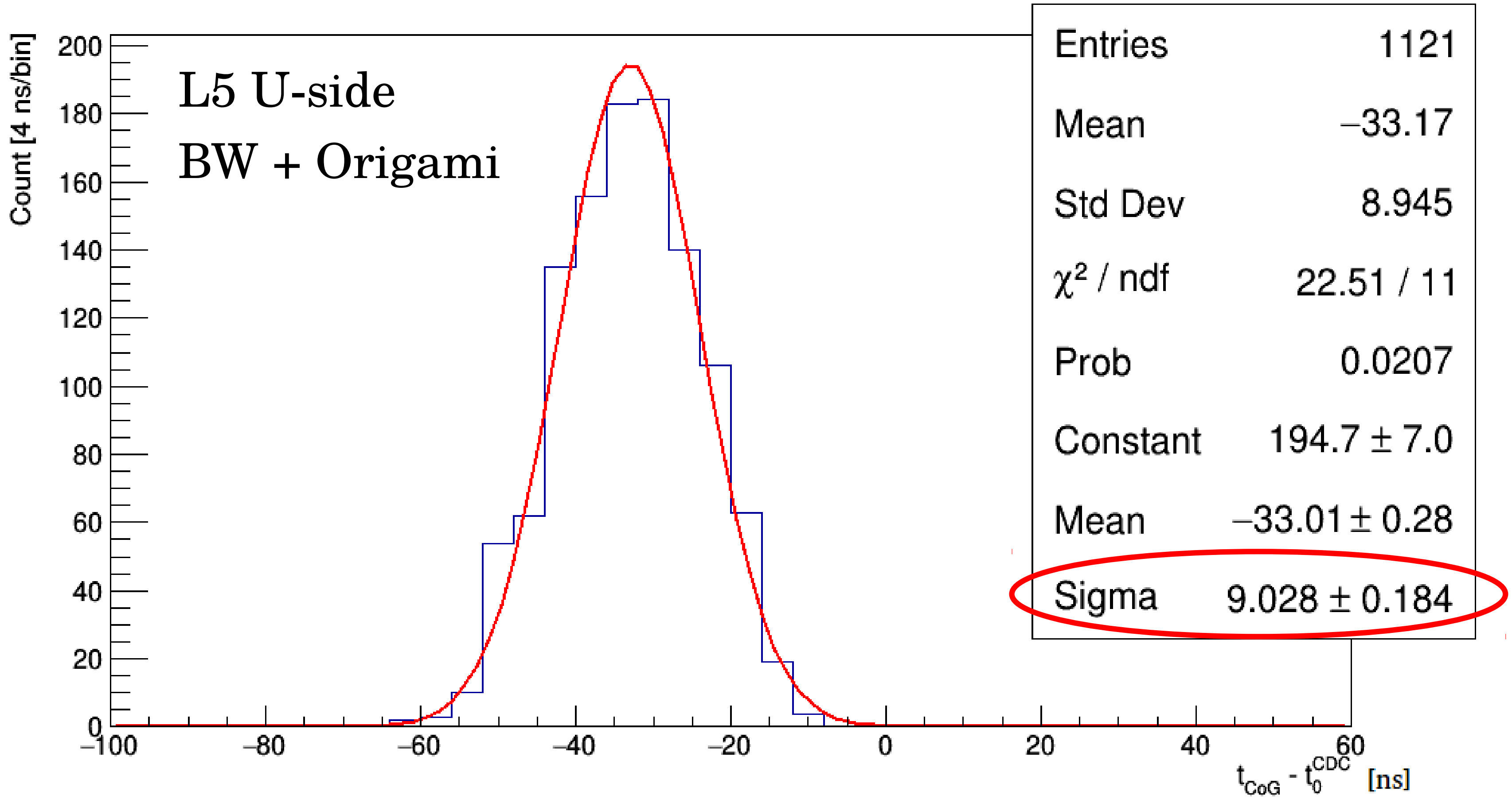
- Run 2712, CoG resolution after correction using the parameters obtained by run 2804



- L5 V-side
  BW + Origami
- Improvement in resolution of ~ 50 %

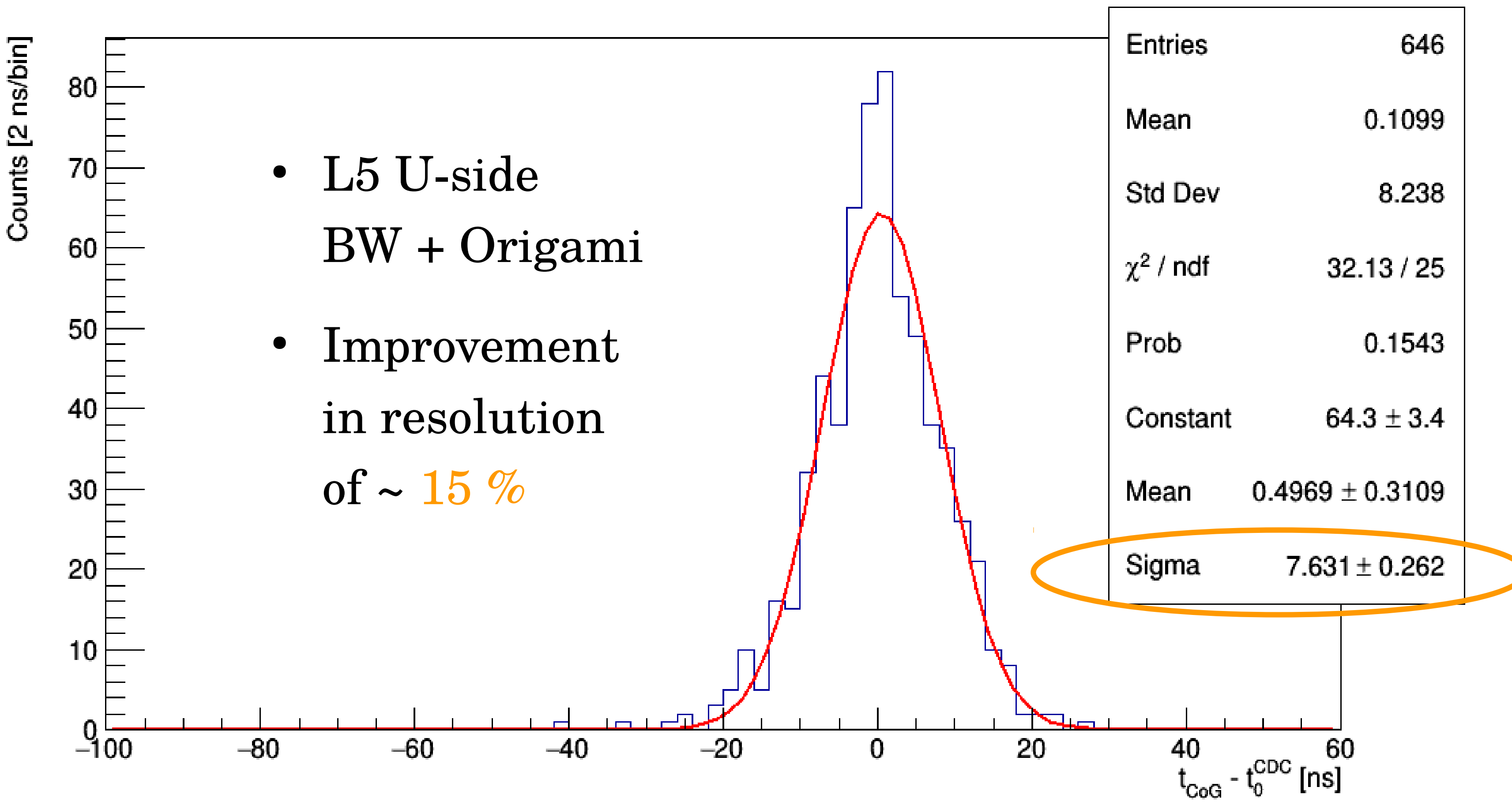
Results

- Run 2712, CoG resolution before correction



Results

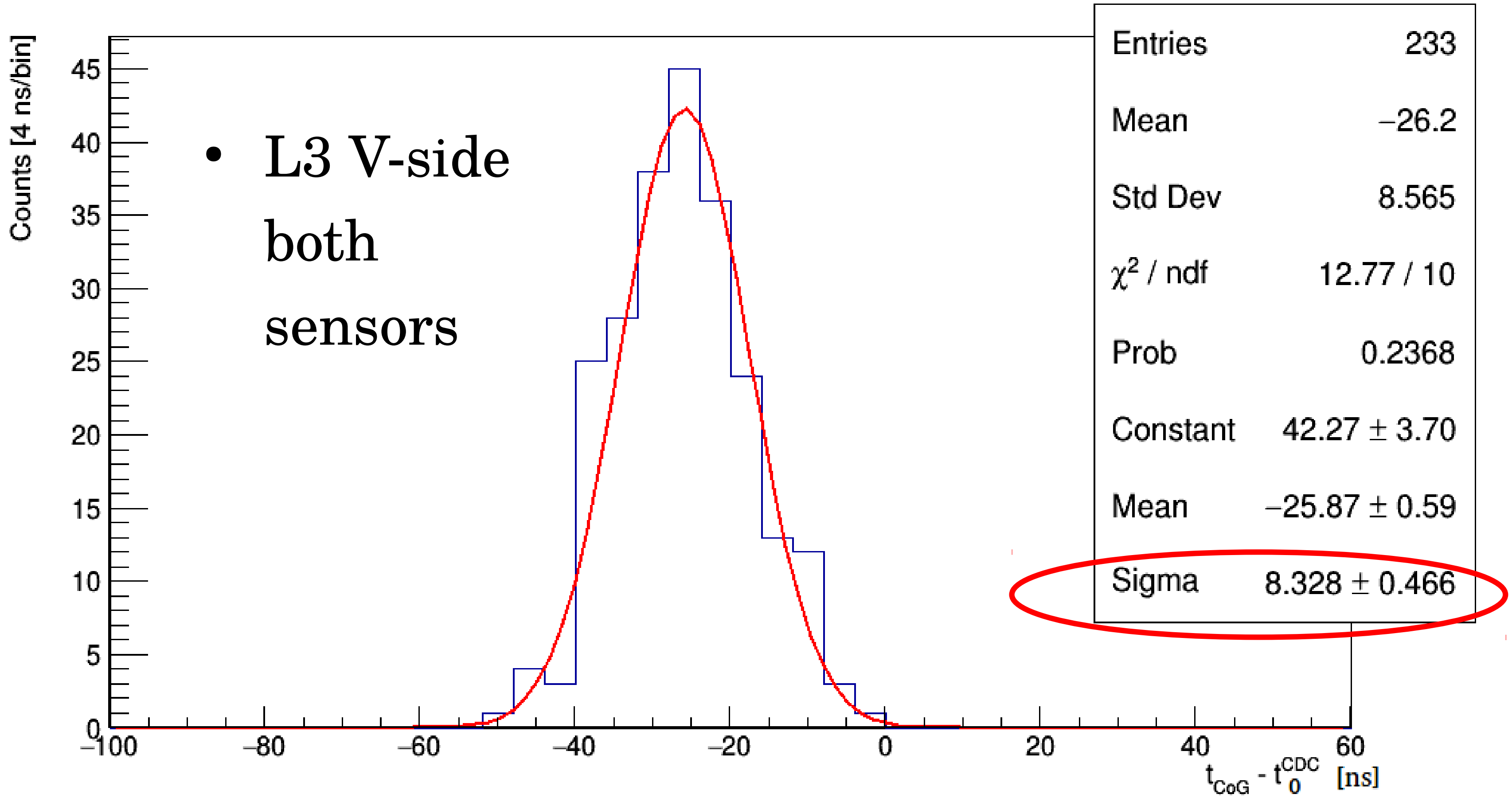
- Run 2712, CoG resolution after correction applied using the parameters obtained by the run 2804



- L5 U-side
  BW + Origami
- Improvement in resolution of ~ 15 %

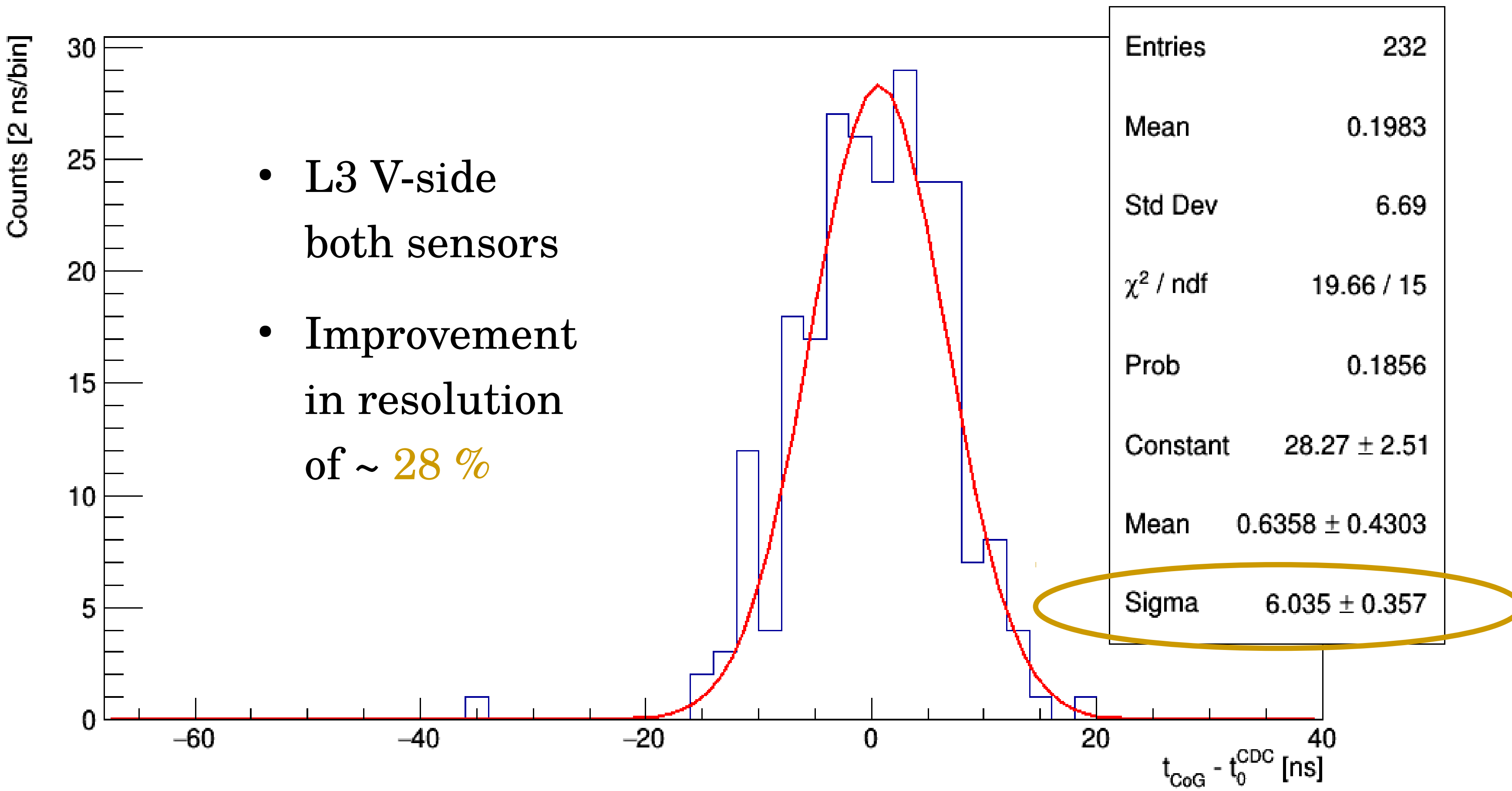
Results

- Run 2712, CoG resolution of L3 V-side (both sensors) before correction



Results

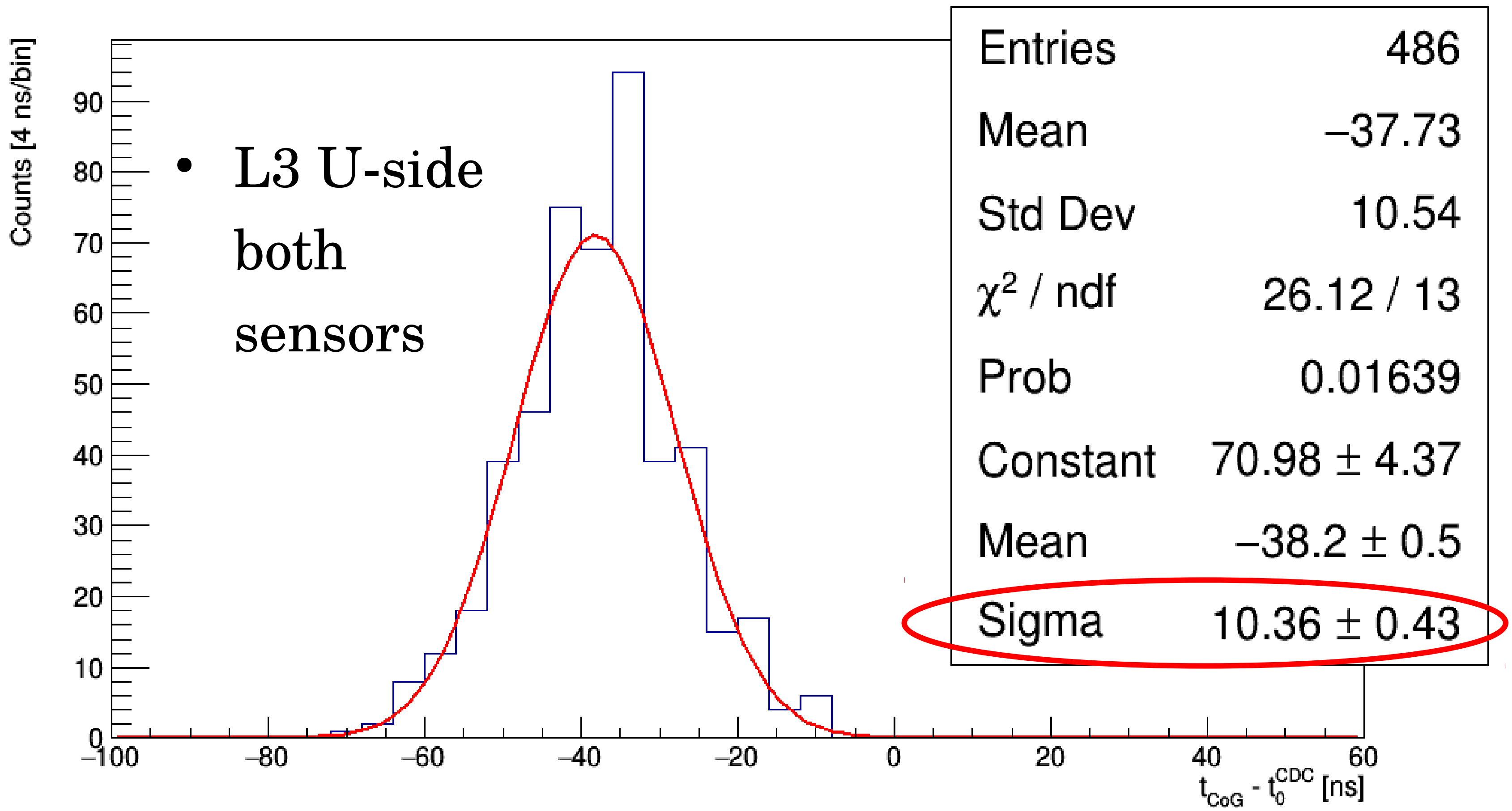
- Run 2712, CoG resolution of L3 V-side (both sensors) after correction using the parameters obtained by run 2804



- L3 V-side both sensors
- Improvement in resolution of ~ 28 %

Results

- Run 2712, CoG resolution of L3 U-side (both sensors) before correction



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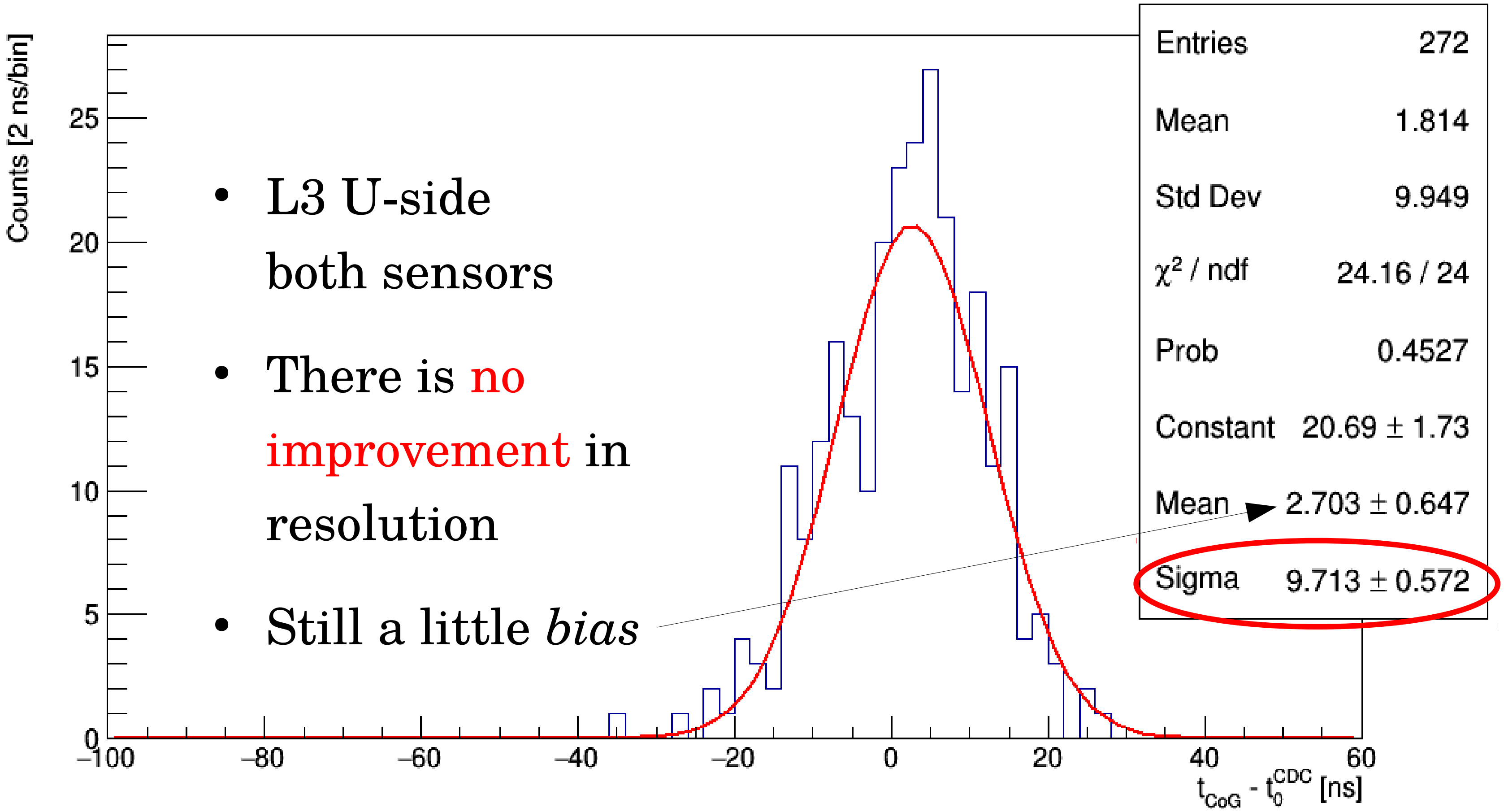


Conclusions

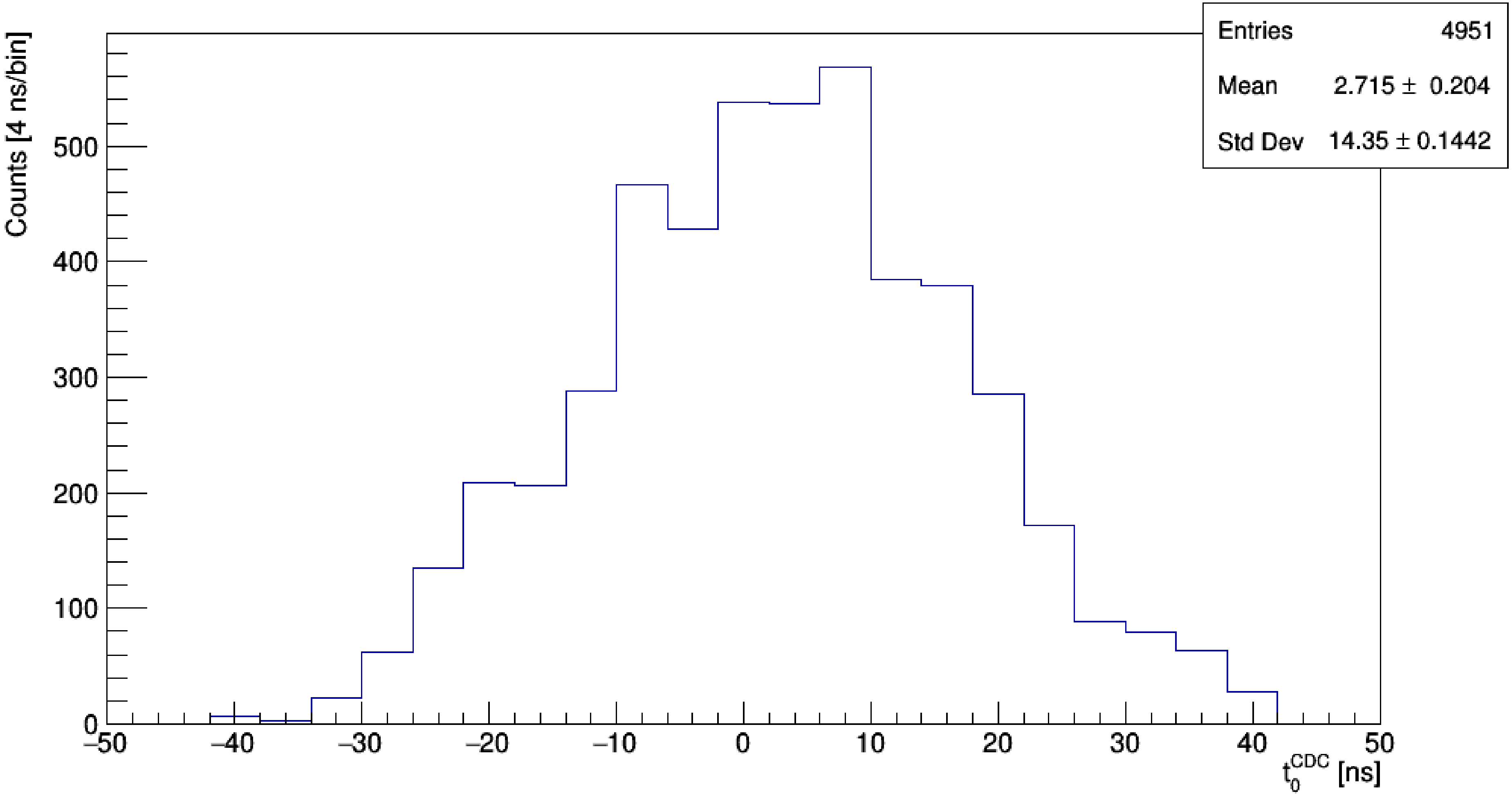
- We observe a bigger improvement of resolution in V-side than in U-side as expected
- The improvement in CoG resolution in the V-side is quite good, ~ 3.5 ns for the L5 V-side and ~ 3.6 ns for the L6 V-side (comparable with what we obtained from the test beam), indeed the resolution is convolved with the CDC resolution (~ 2 ns)

Plan for the future

- Repeat the same studies for the collision runs, considering the clusters associated to the tracks

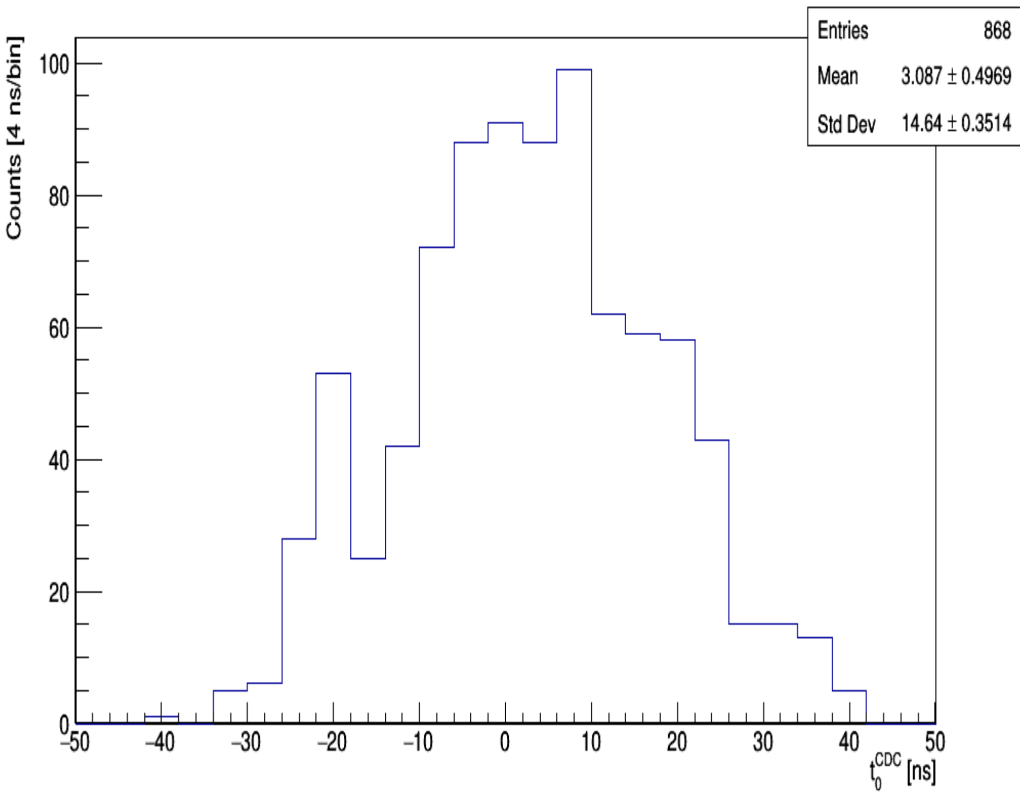
Backup slides

t_0 distribution

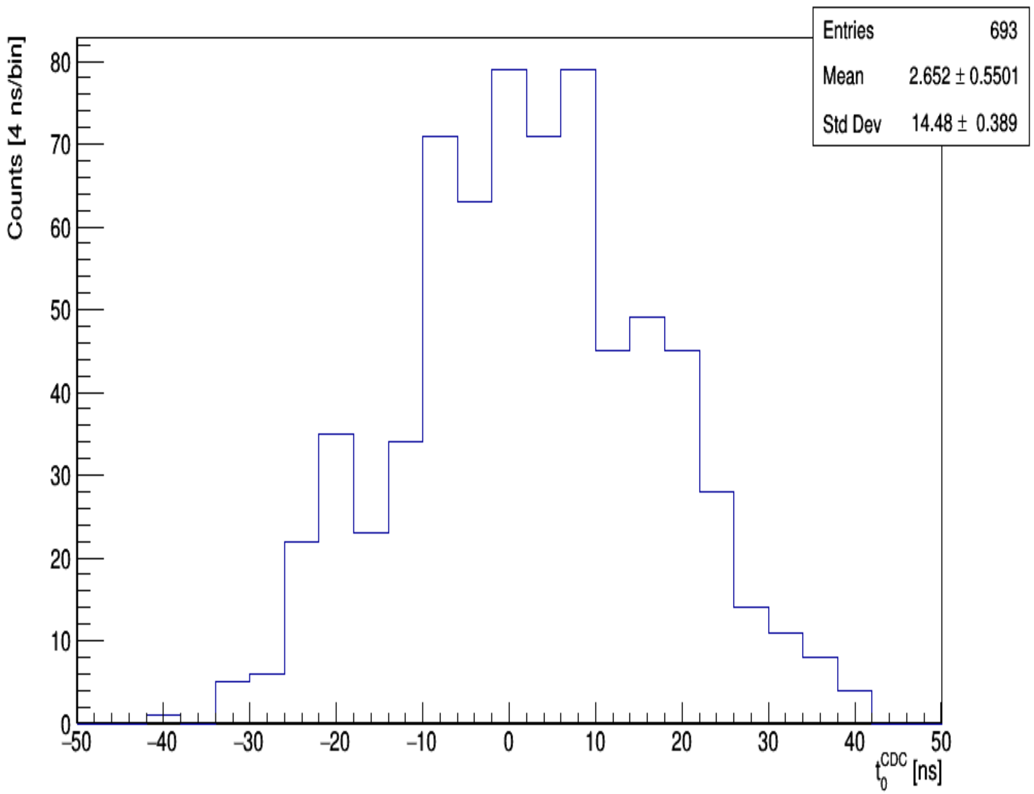


t_0 distribution

L5 U-side, BW+ Origami

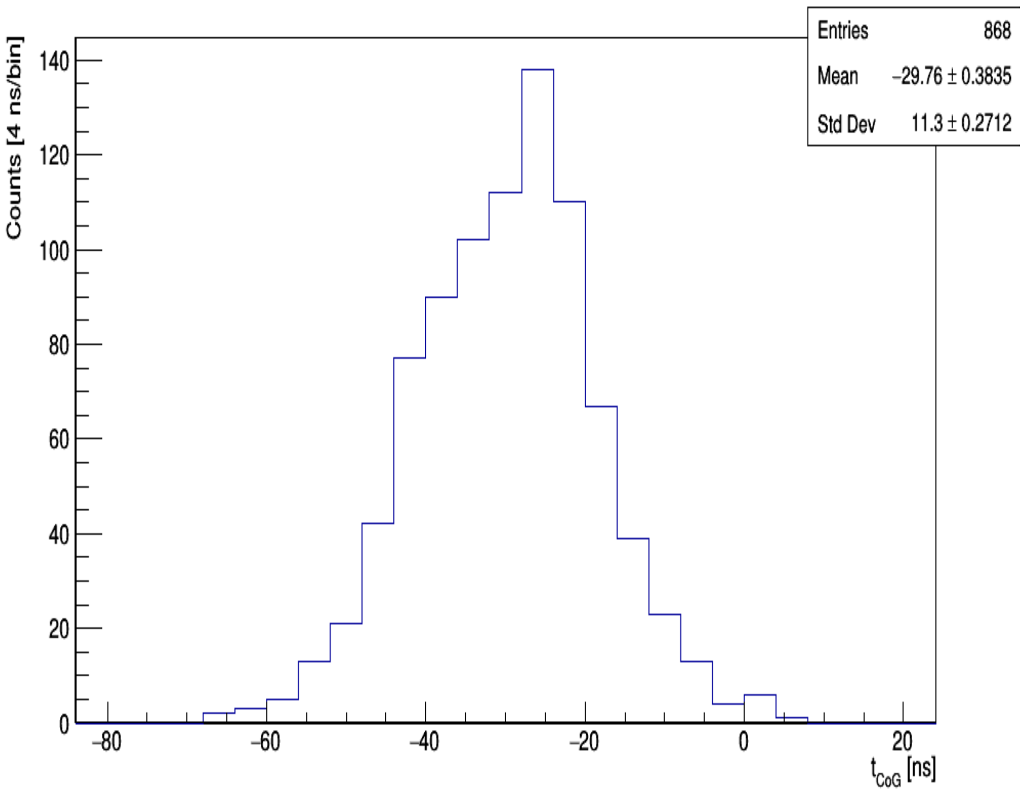


L5 V-side, BW+ Origami

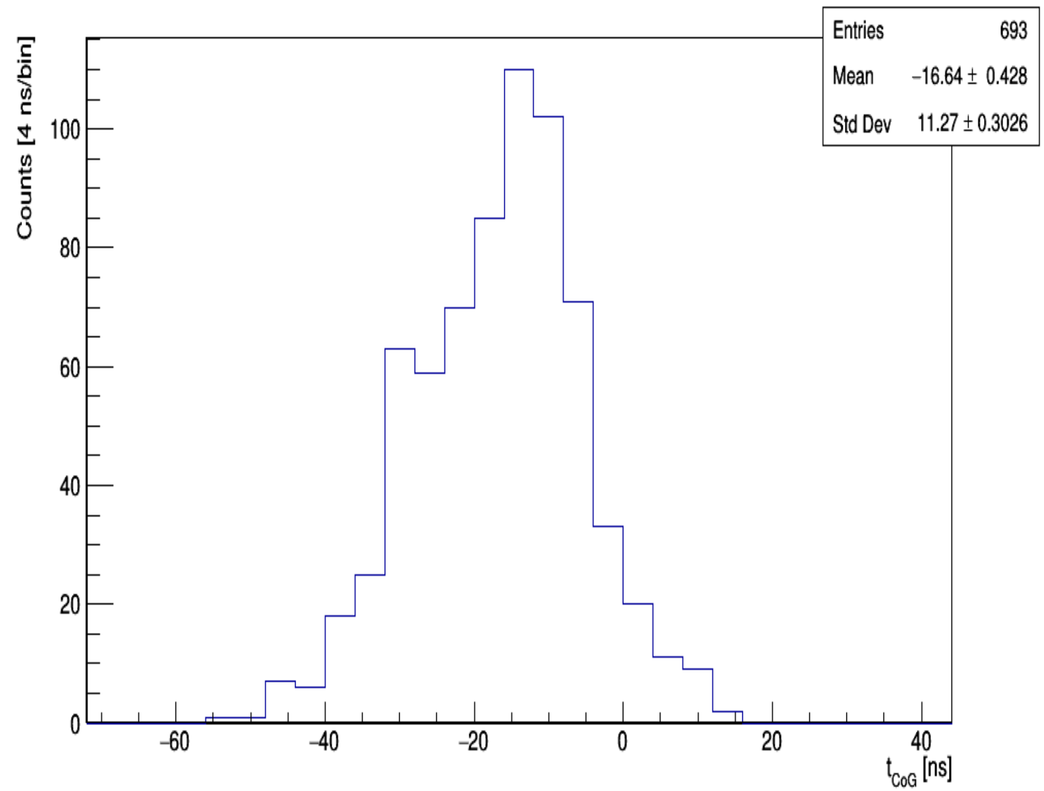


t_{COG} distribution

L5 U-side, BW+ Origami

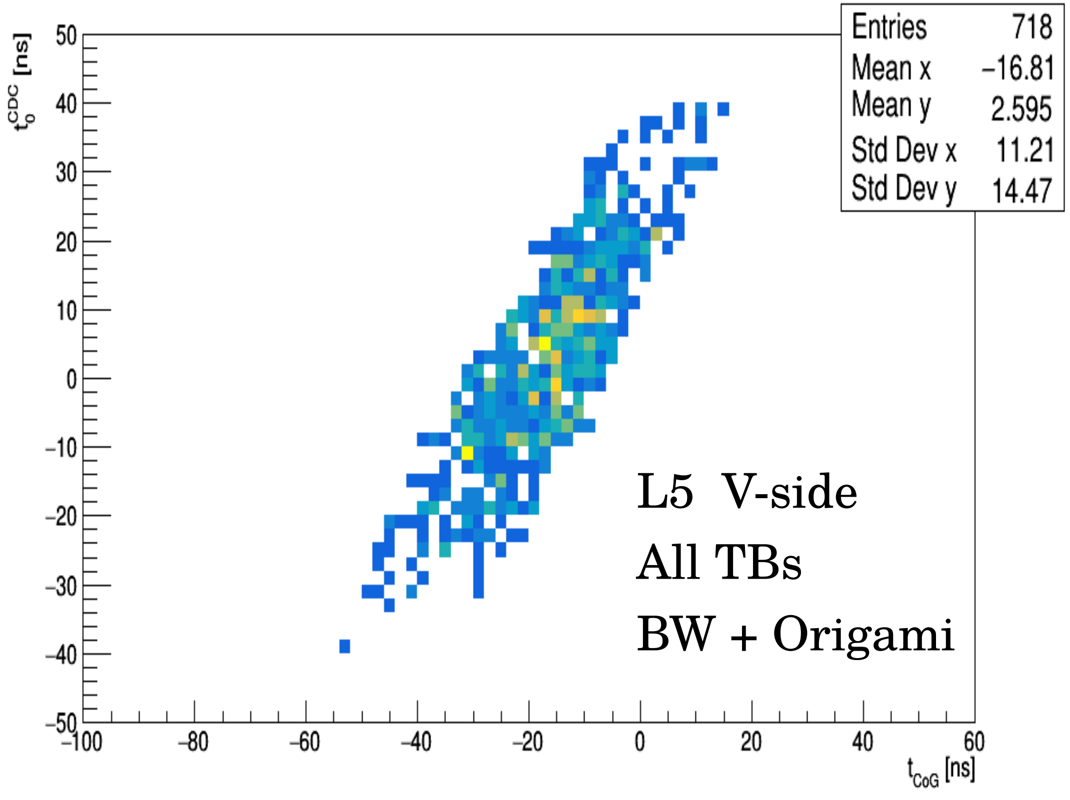


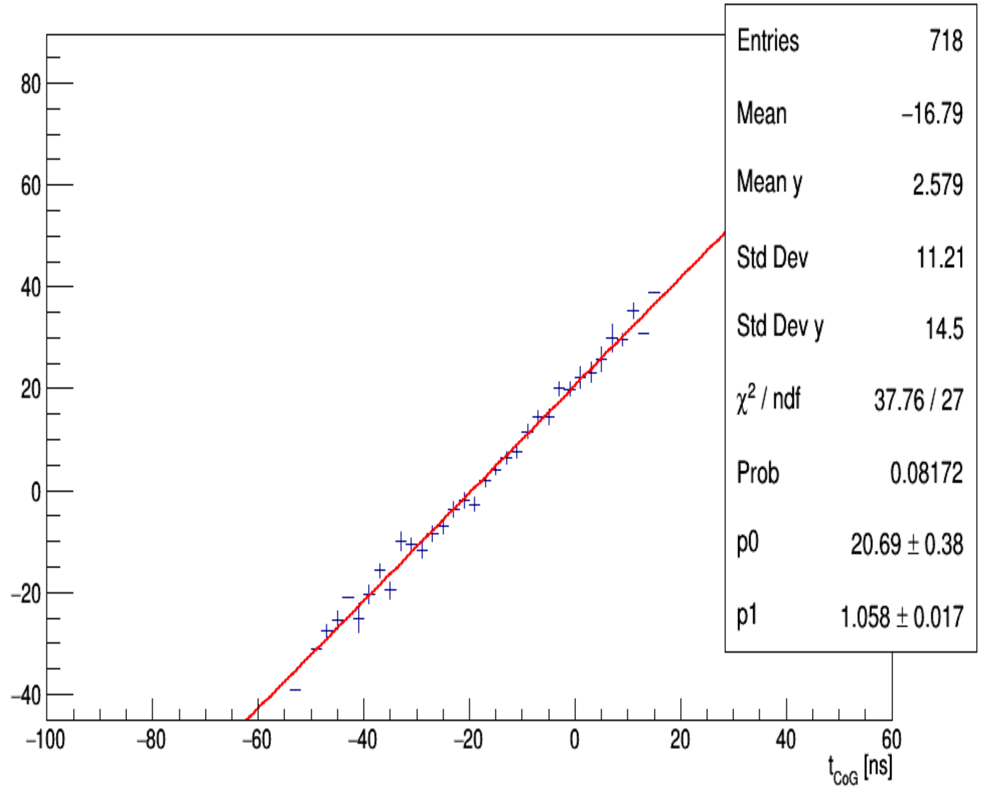
L5 V-side, BW+ Origami



CoG Calibration

- t_0 [ns] versus t_{COG} [ns],
- left: Scatter plot, right: linear fit of the ProfileX of the scatter plot





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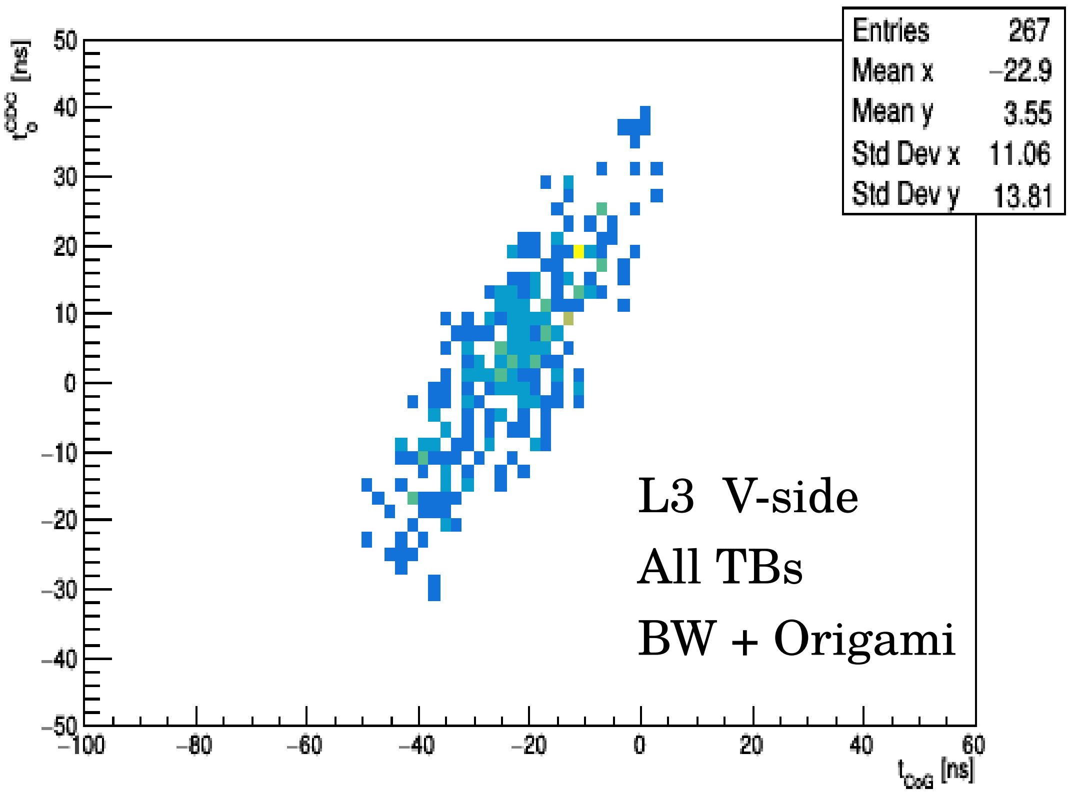

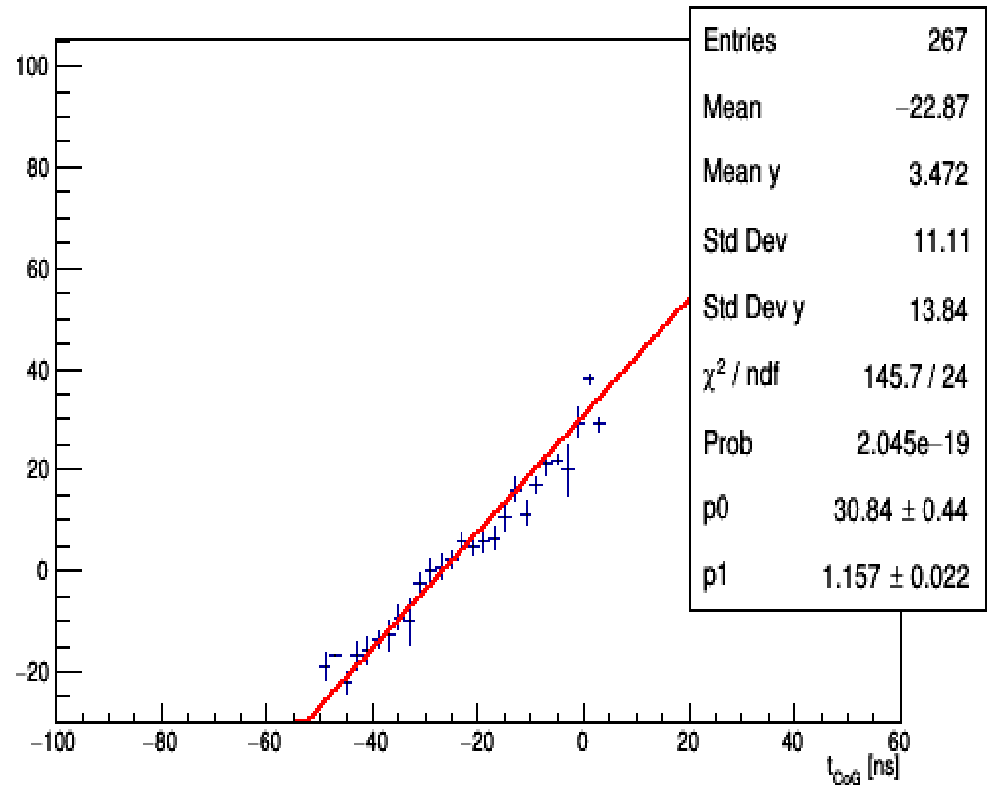

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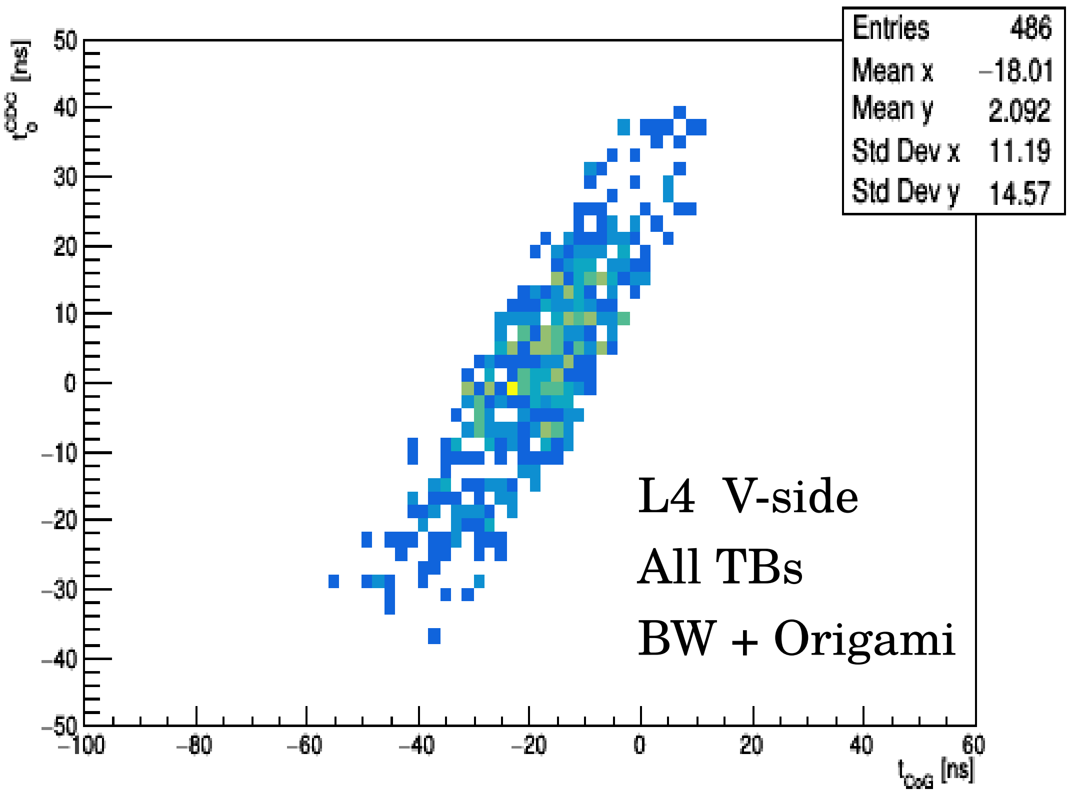

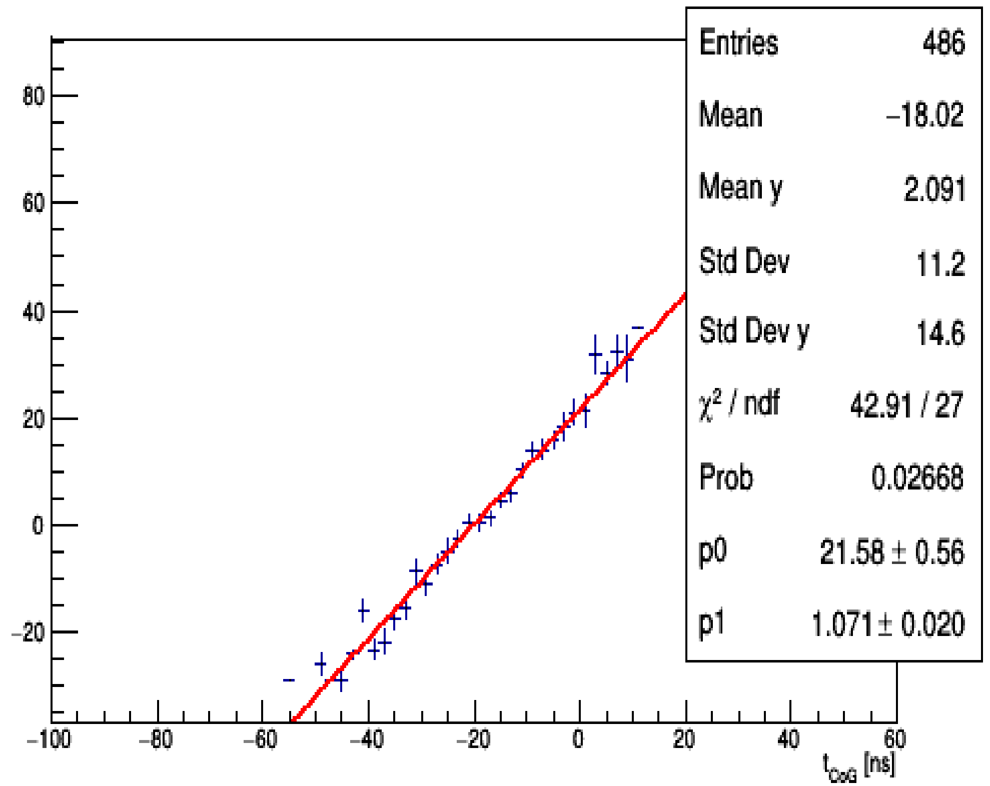

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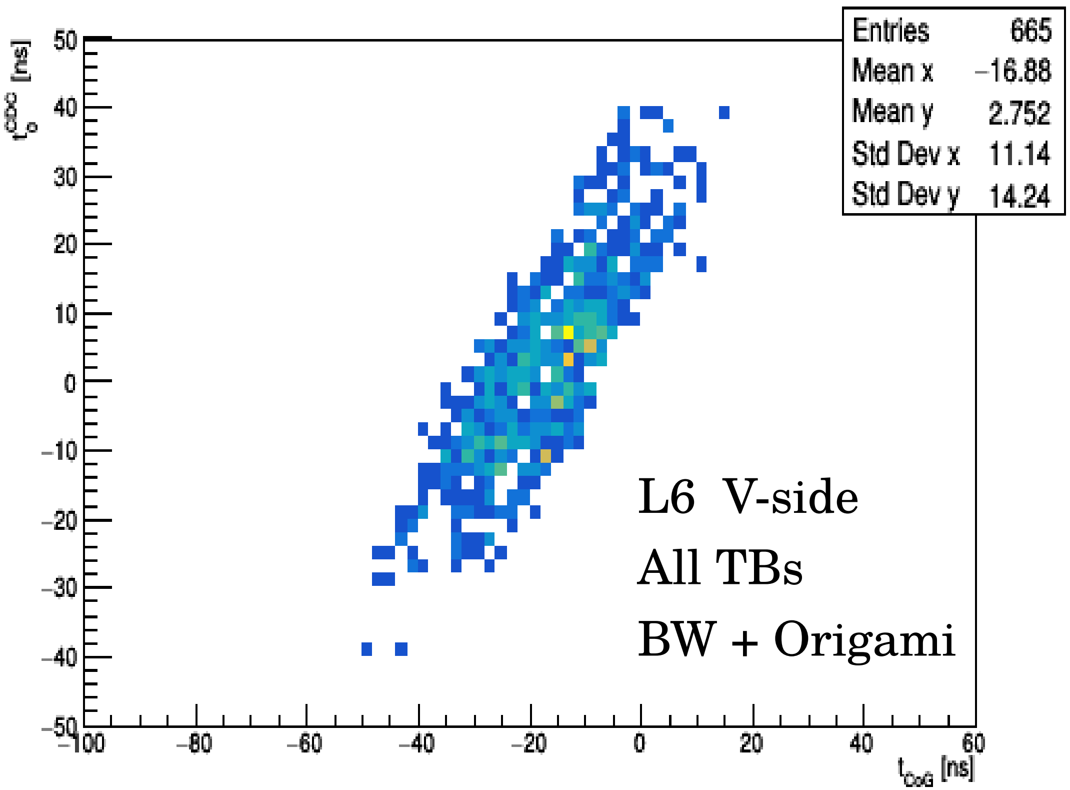

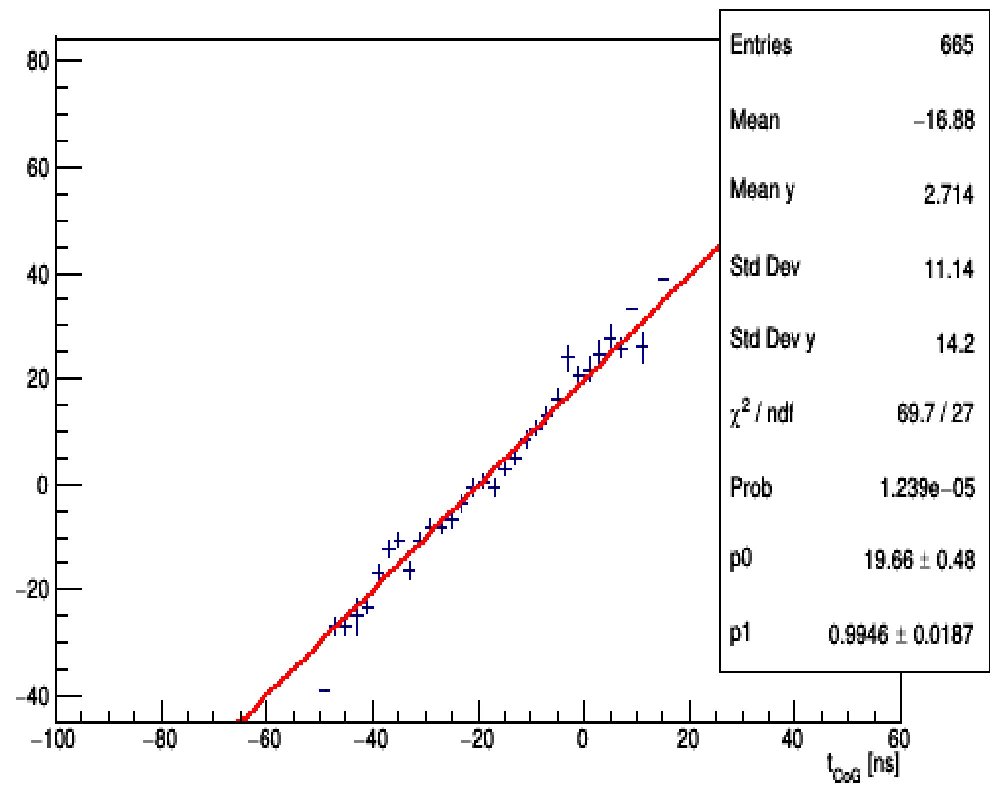

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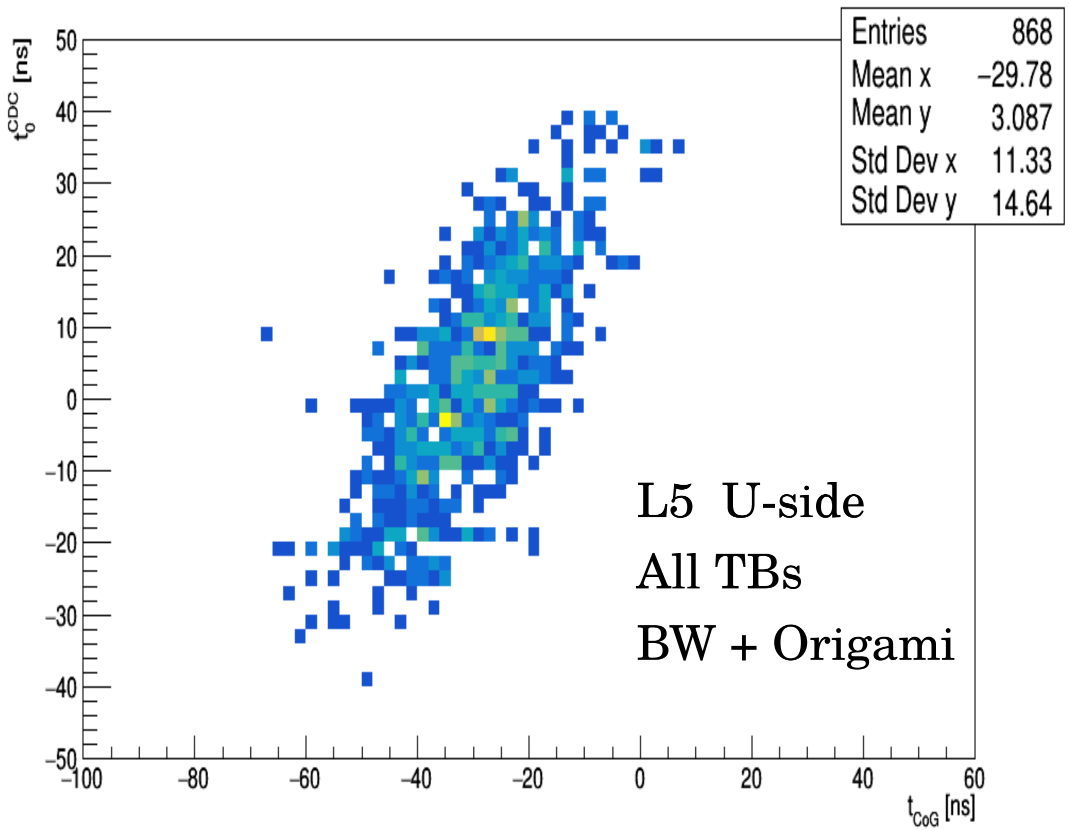

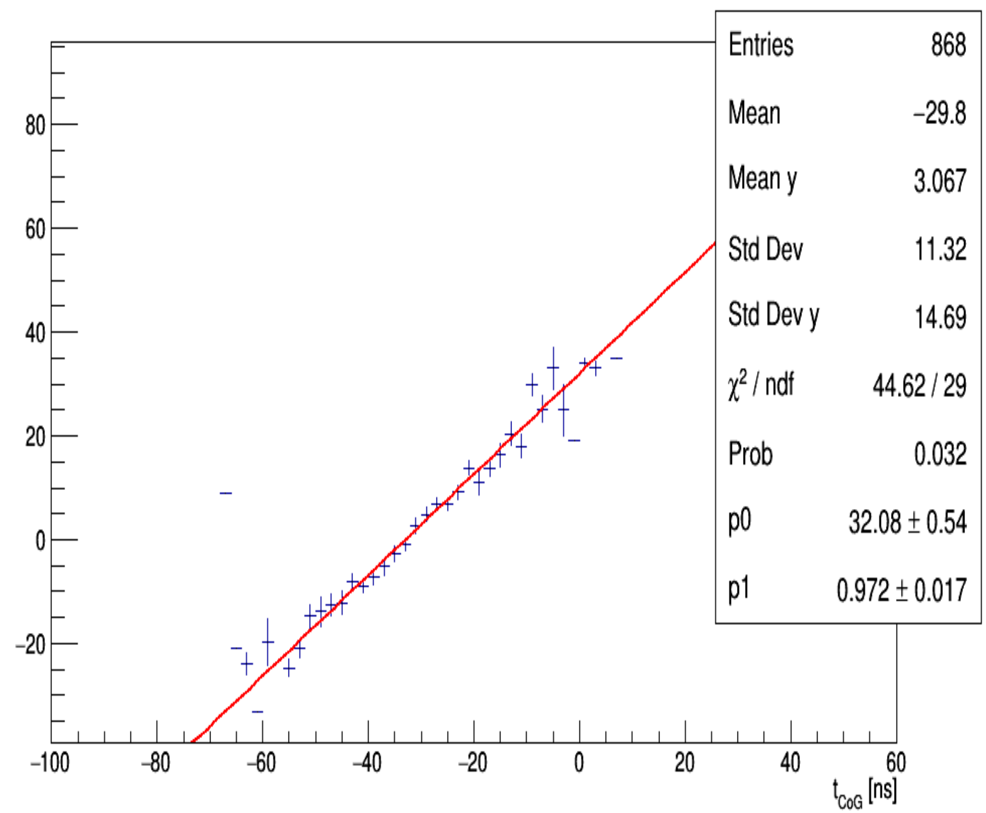

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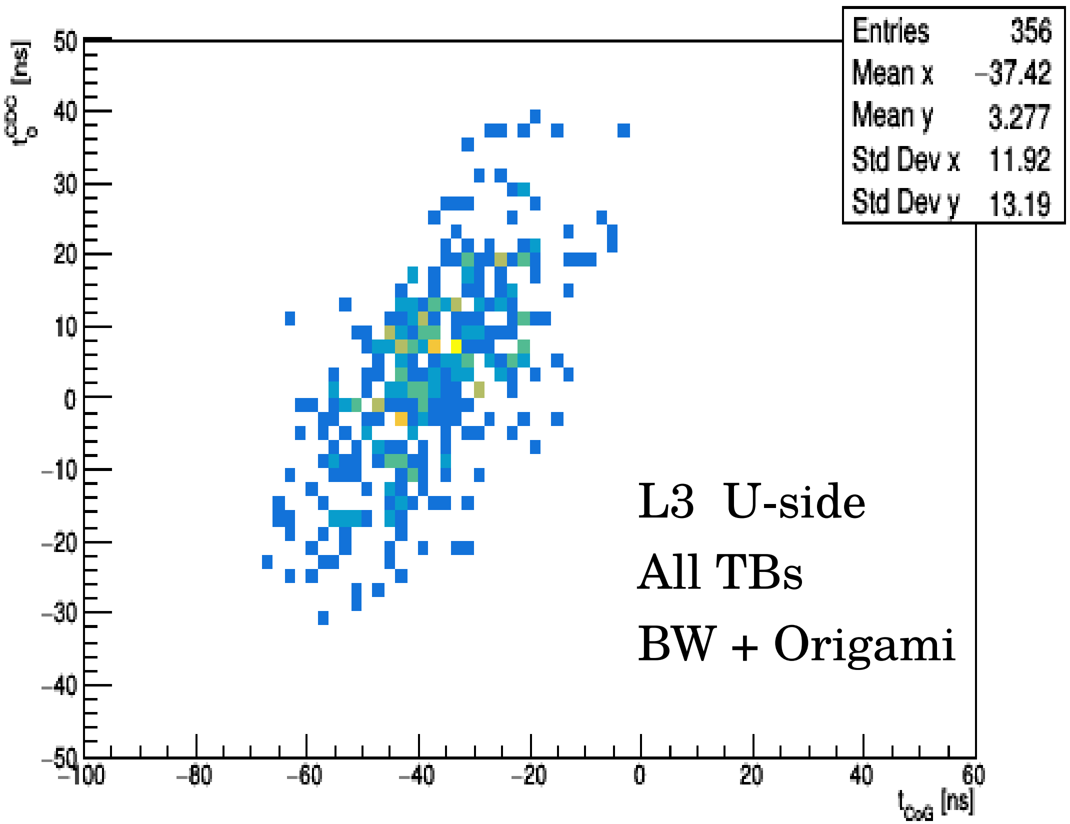

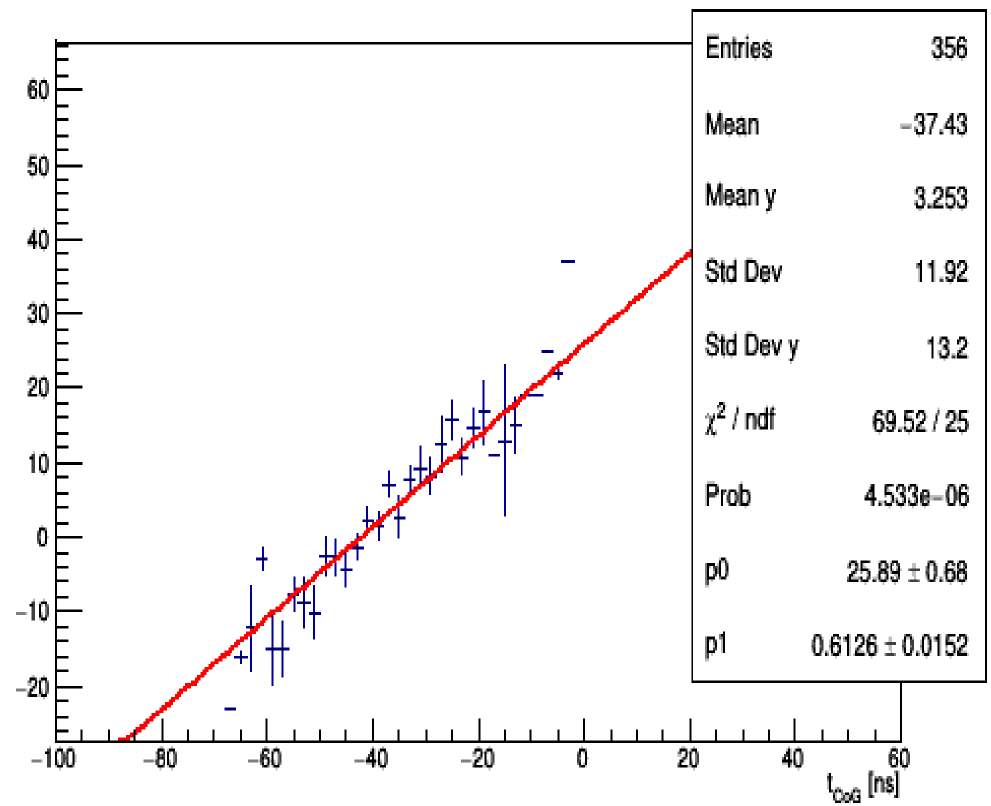

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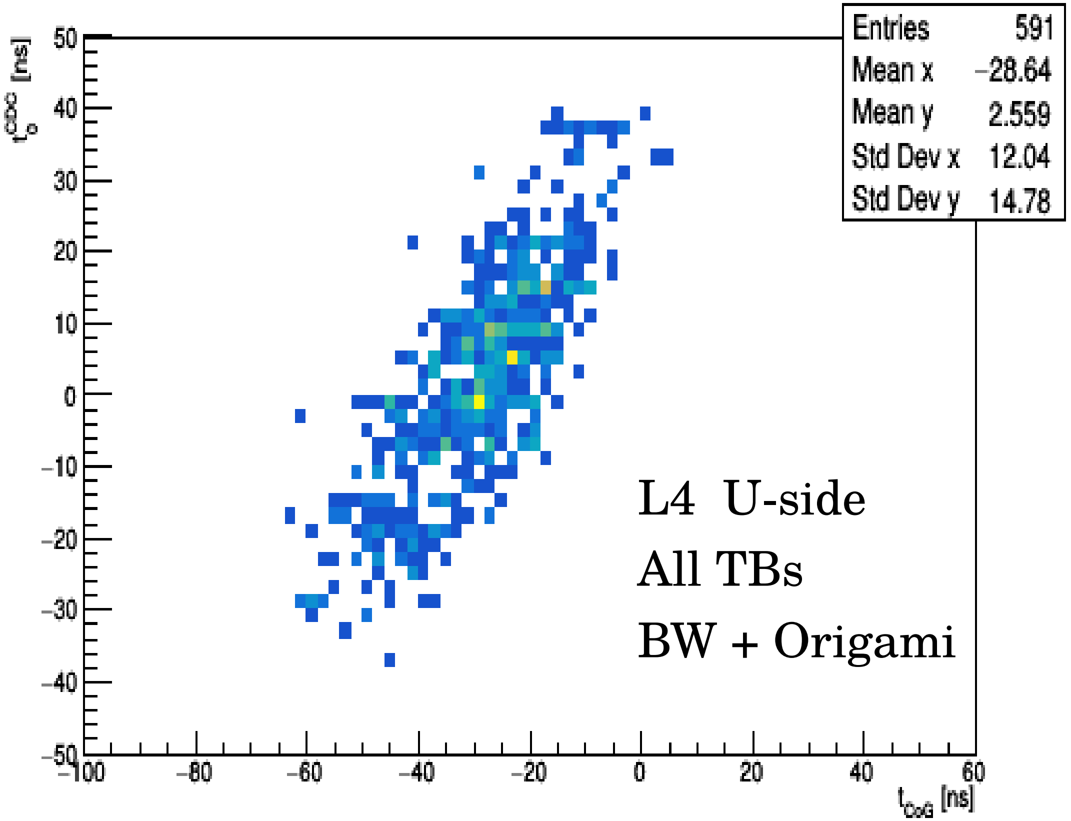

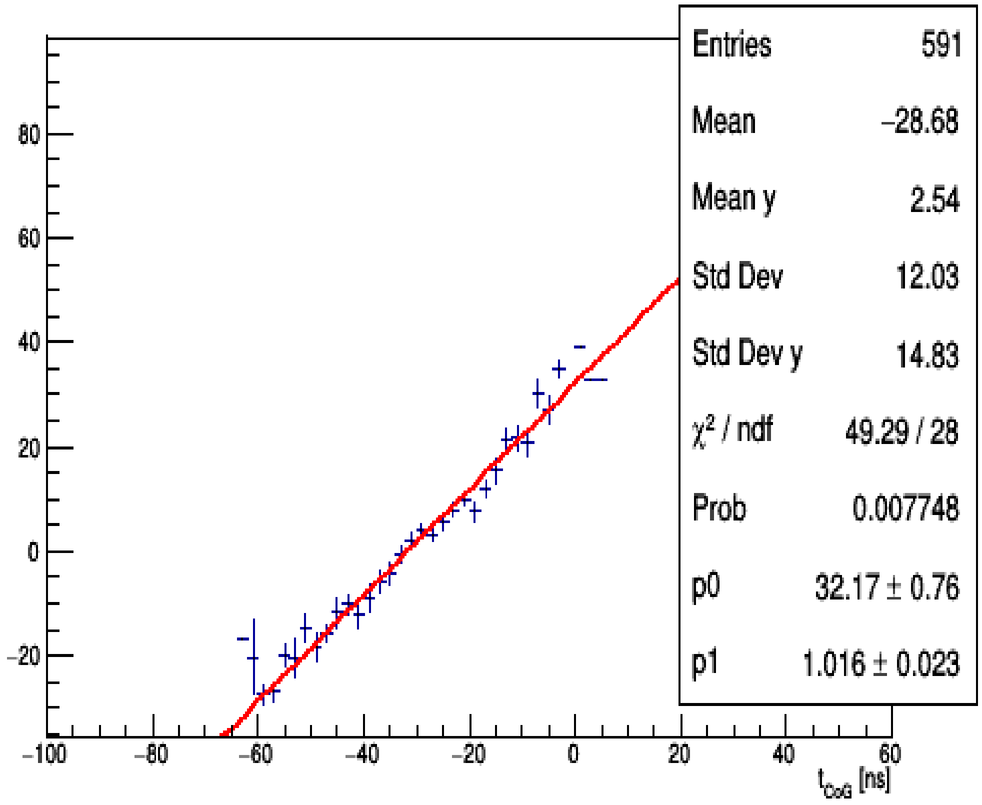

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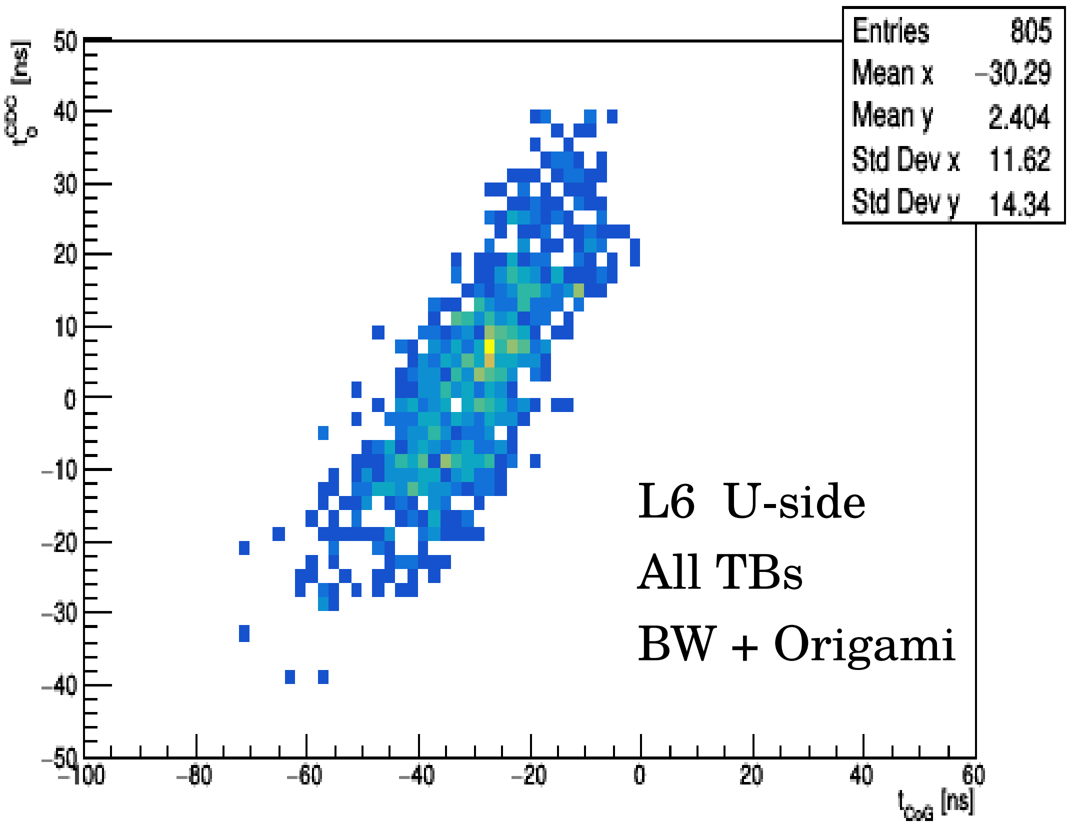
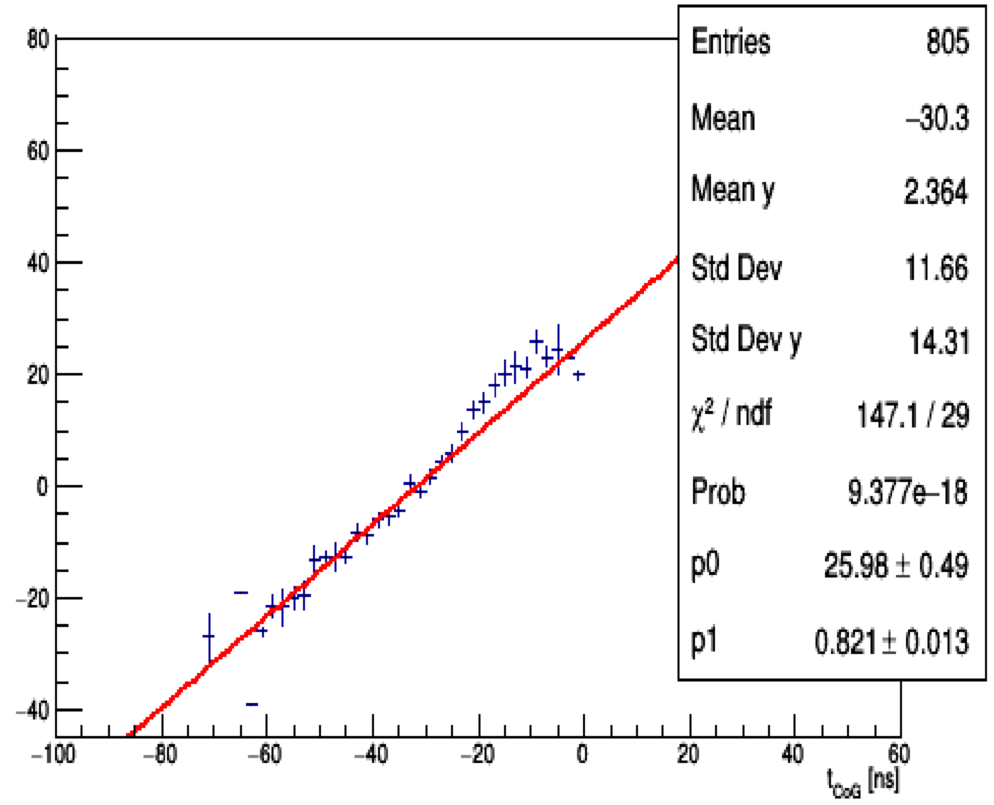
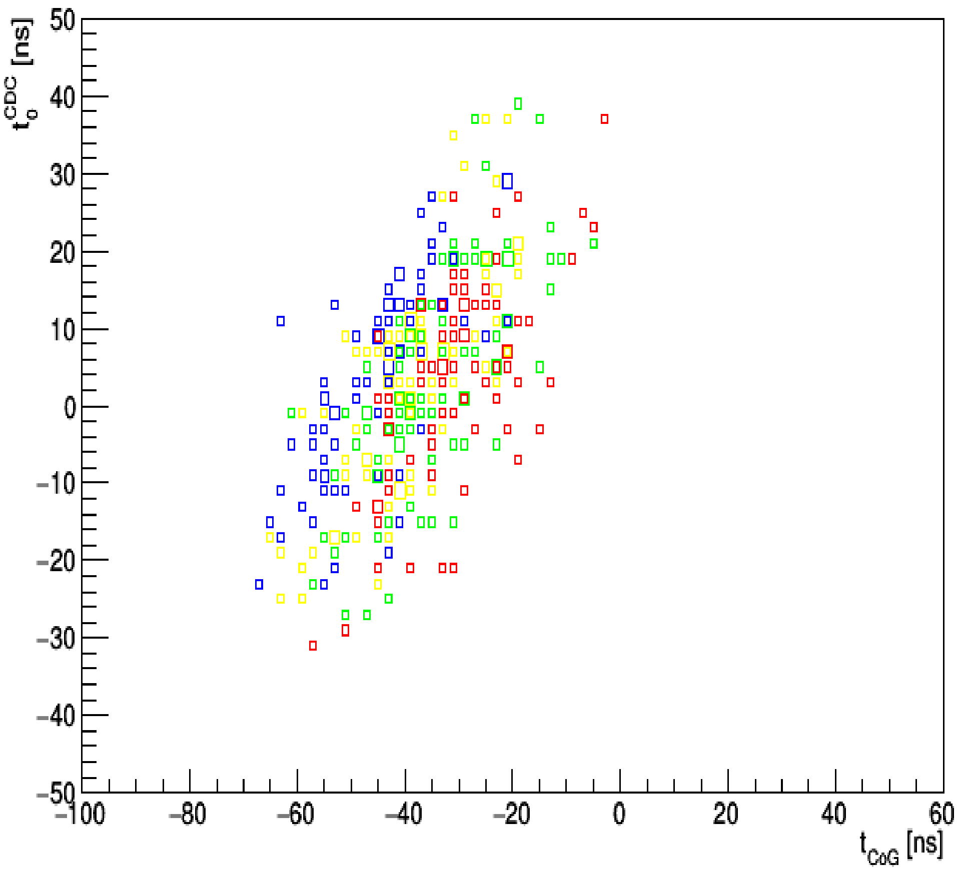


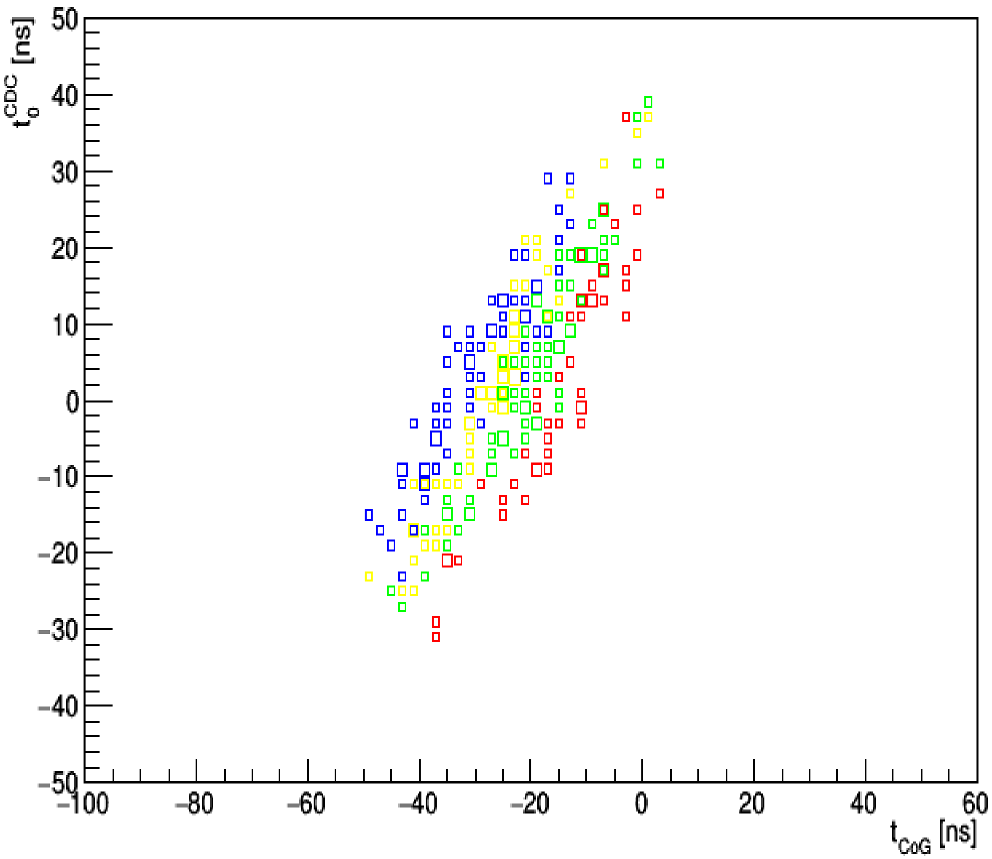


CoG Calibration

L3 U-side, both sensors, run 2804

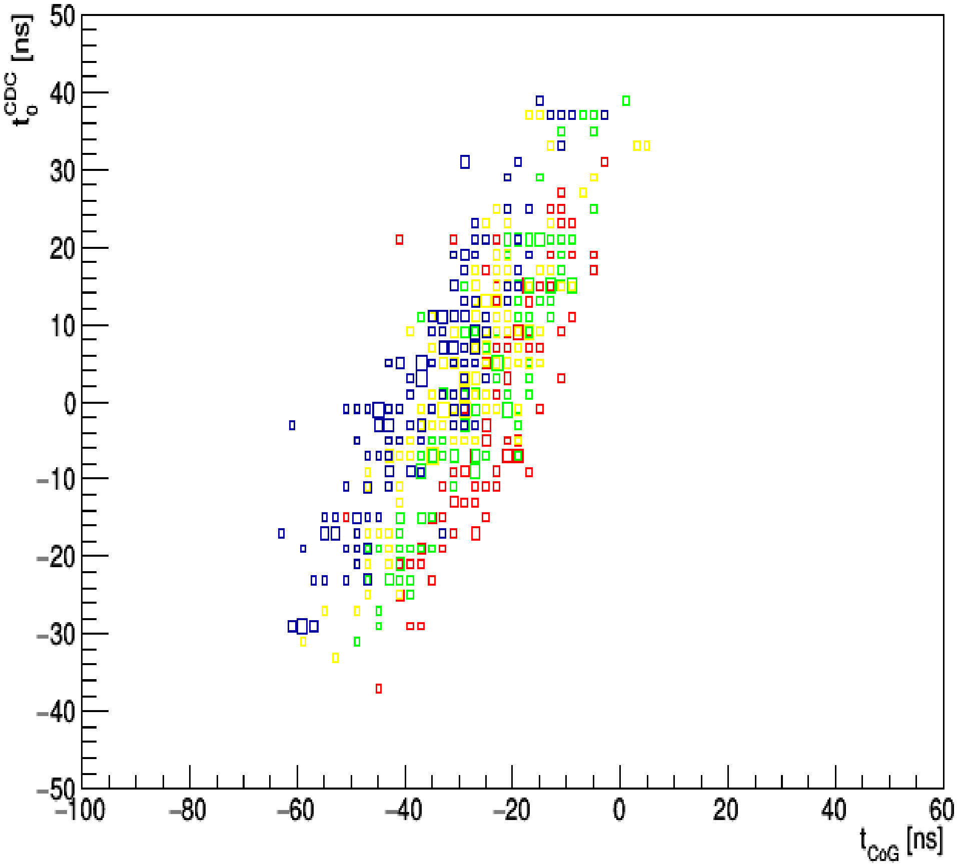


L3 V-side, both sensors, run 2804

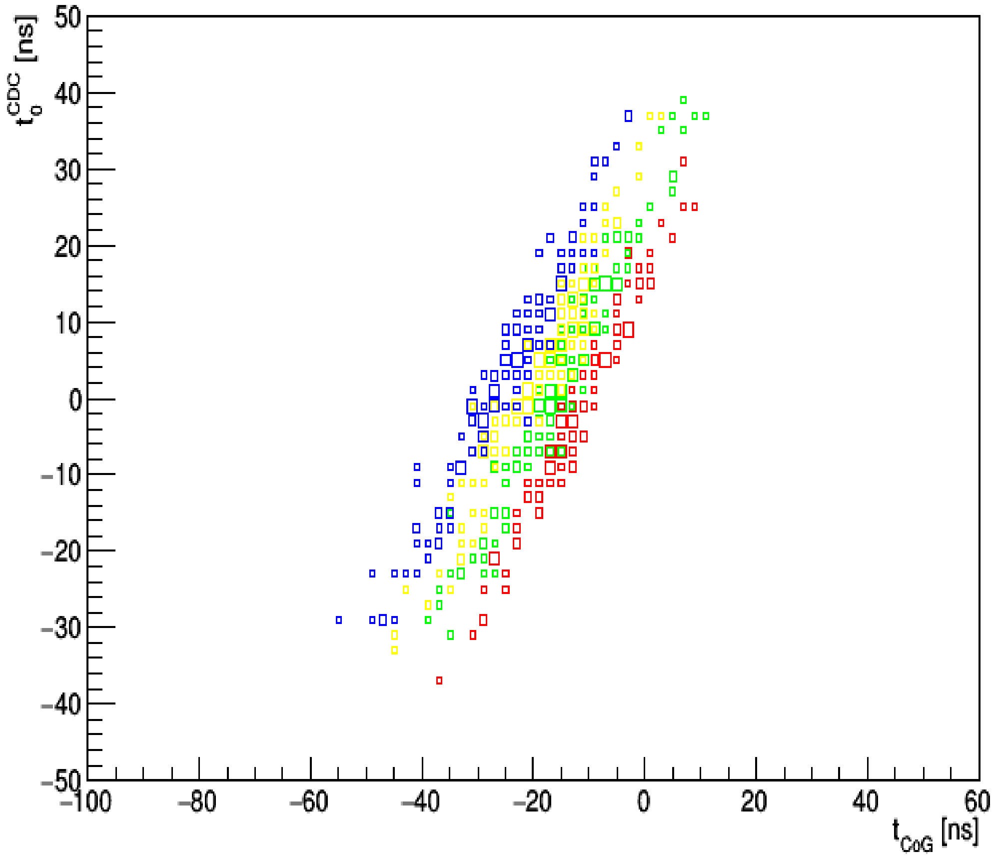


CoG Calibration

L4 U-side, BW+ Origami, run 2804

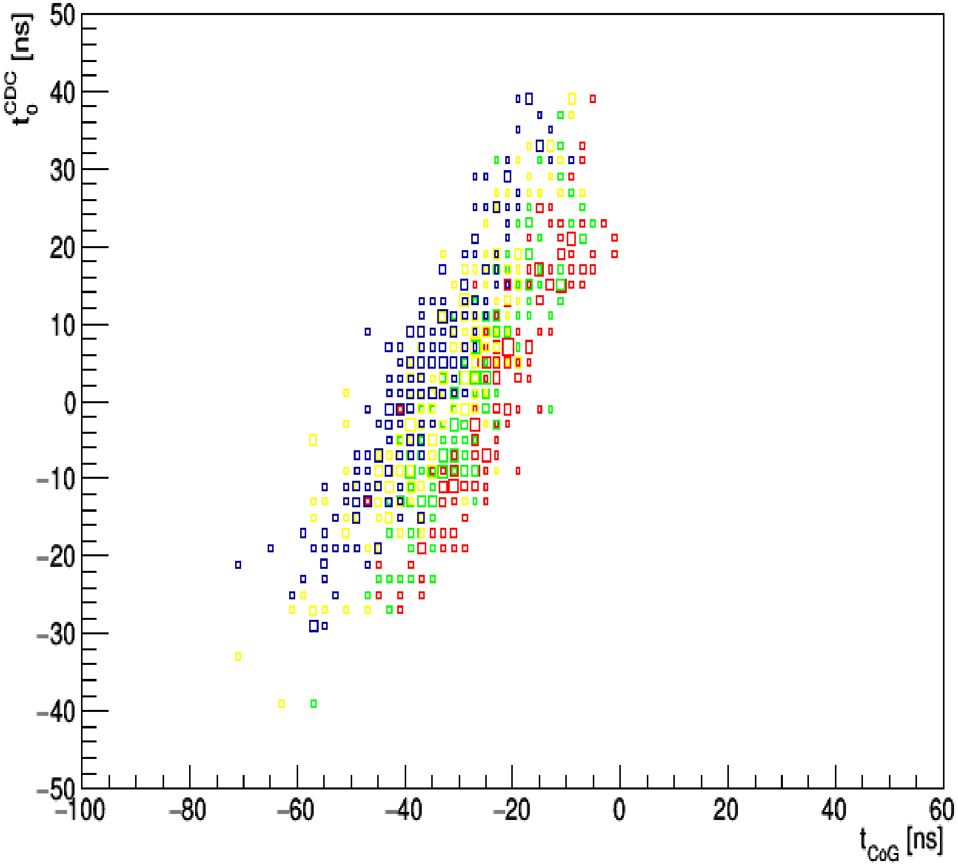


L4 V-side, BW+Origami, run 2804

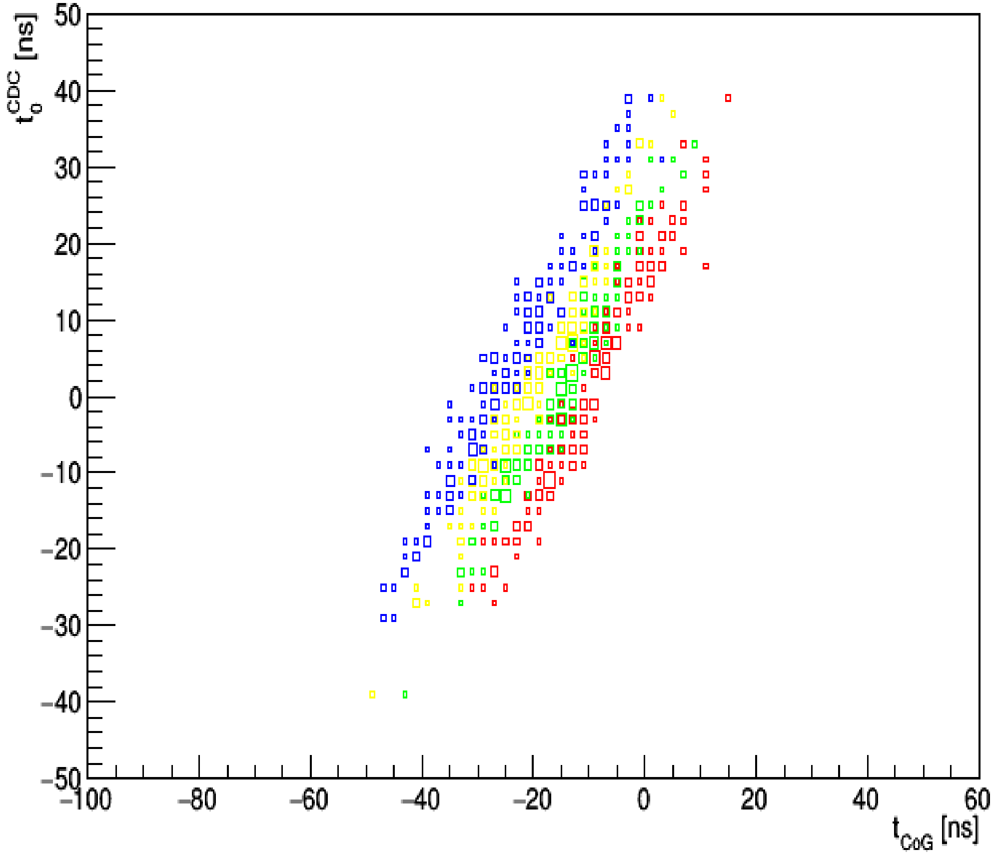


CoG Calibration

L6 U-side, BW+ Origami, run 2804



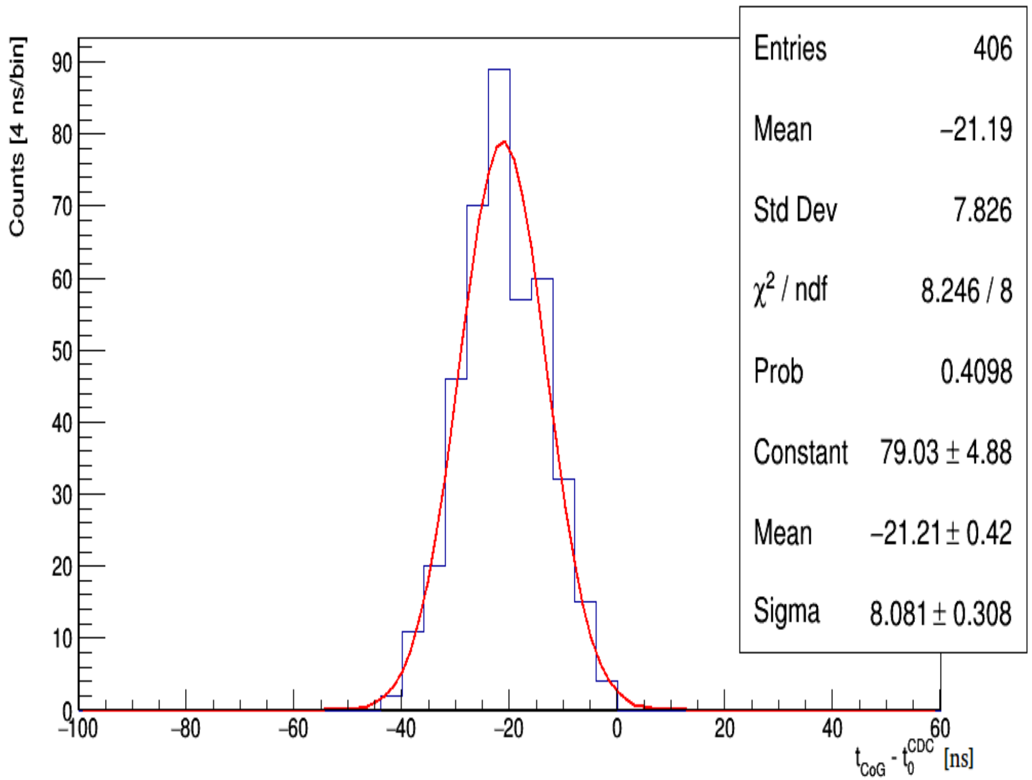
L6 V-side, BW+Origami, run 2804



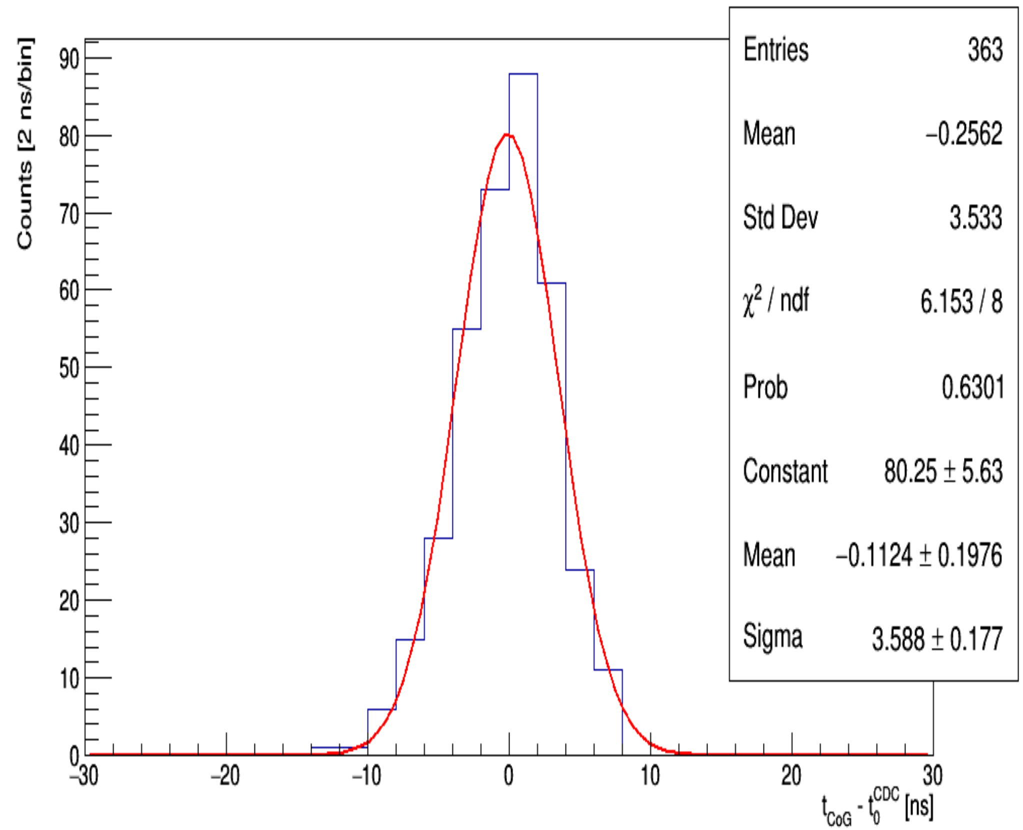
CoG Calibration

- L4 V-side BW + Origami

before correction



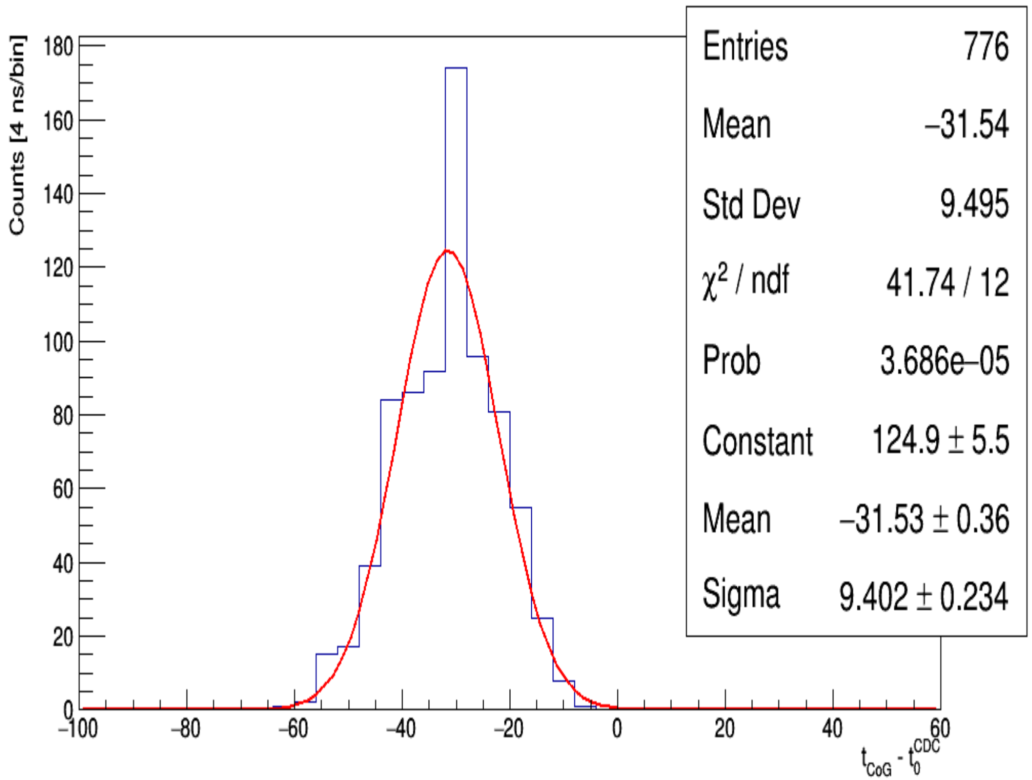
after correction



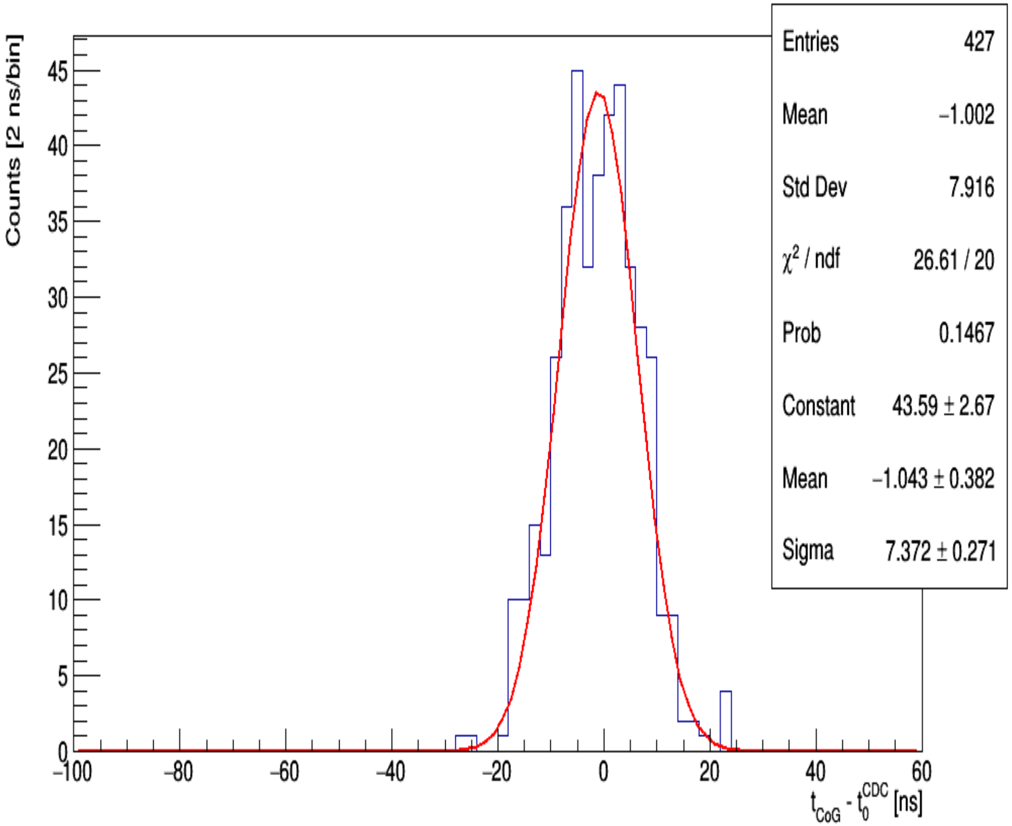
CoG Calibration

- L4 U-side BW + Origami

before correction



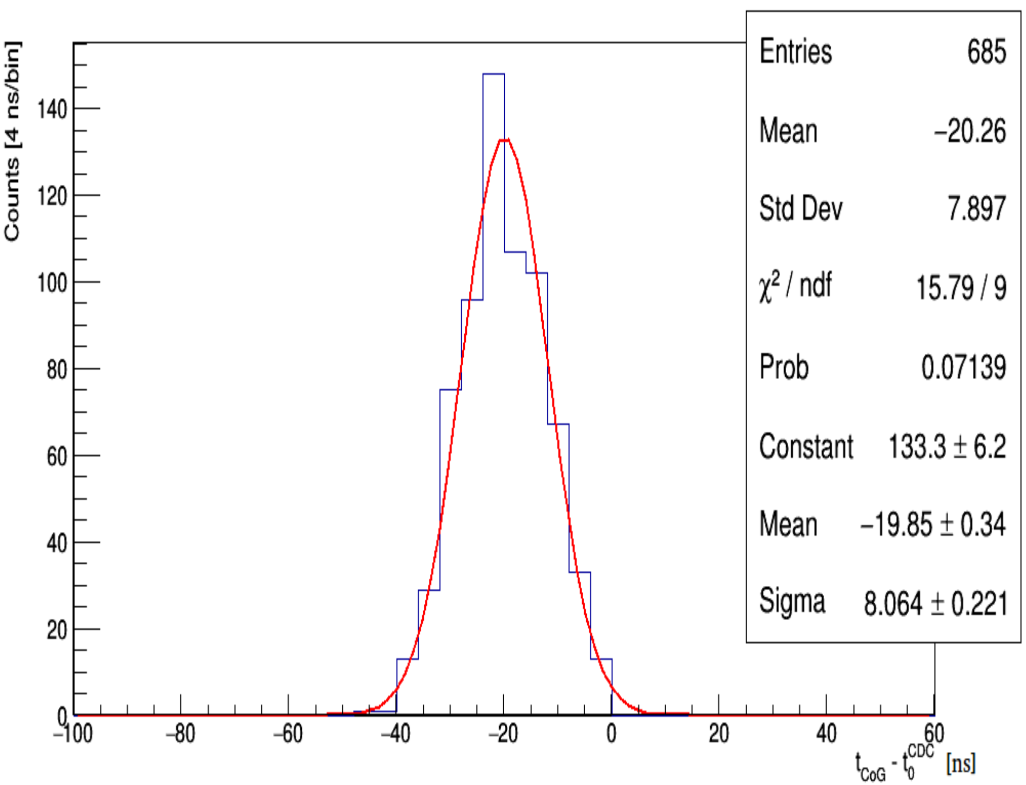
after correction



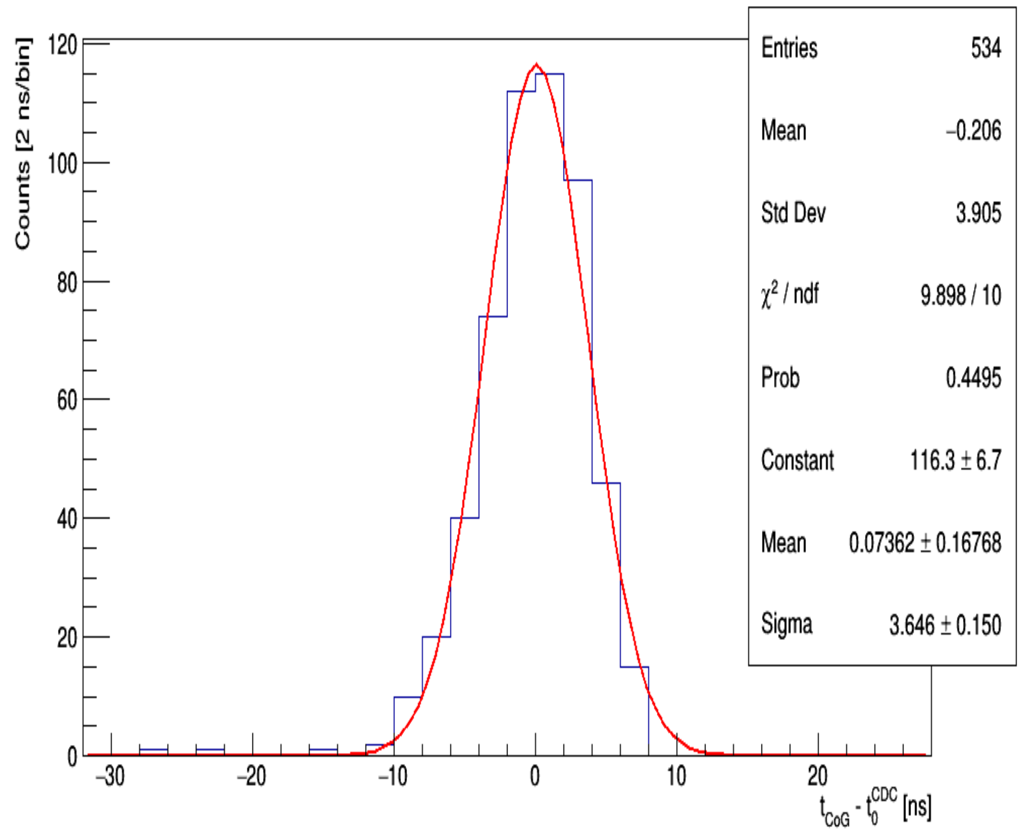
CoG Calibration

- L6 V-side BW + Origami

before correction



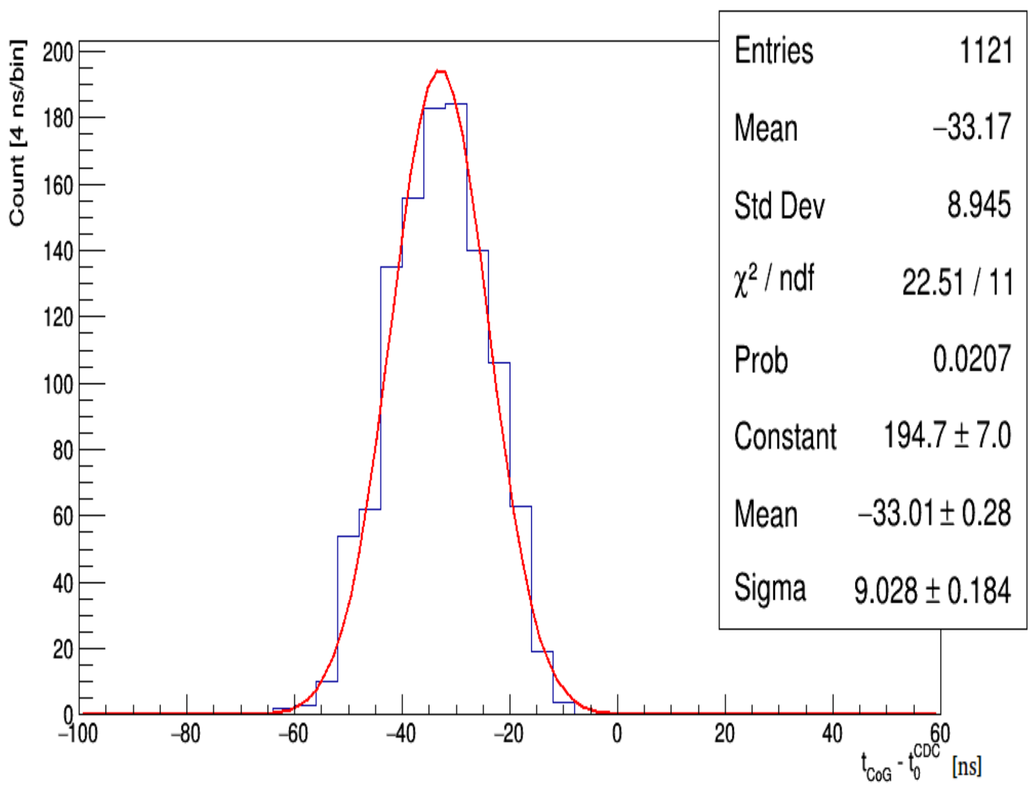
after correction



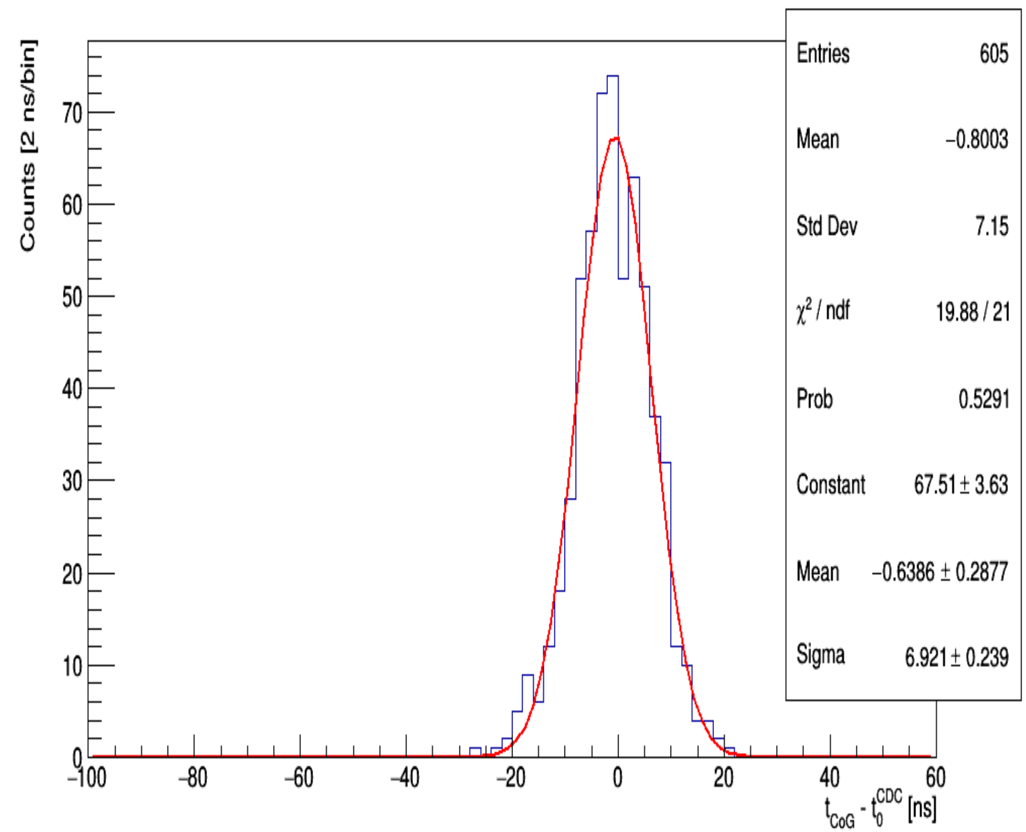
CoG Calibration

- L6 U-side BW + Origami

before correction

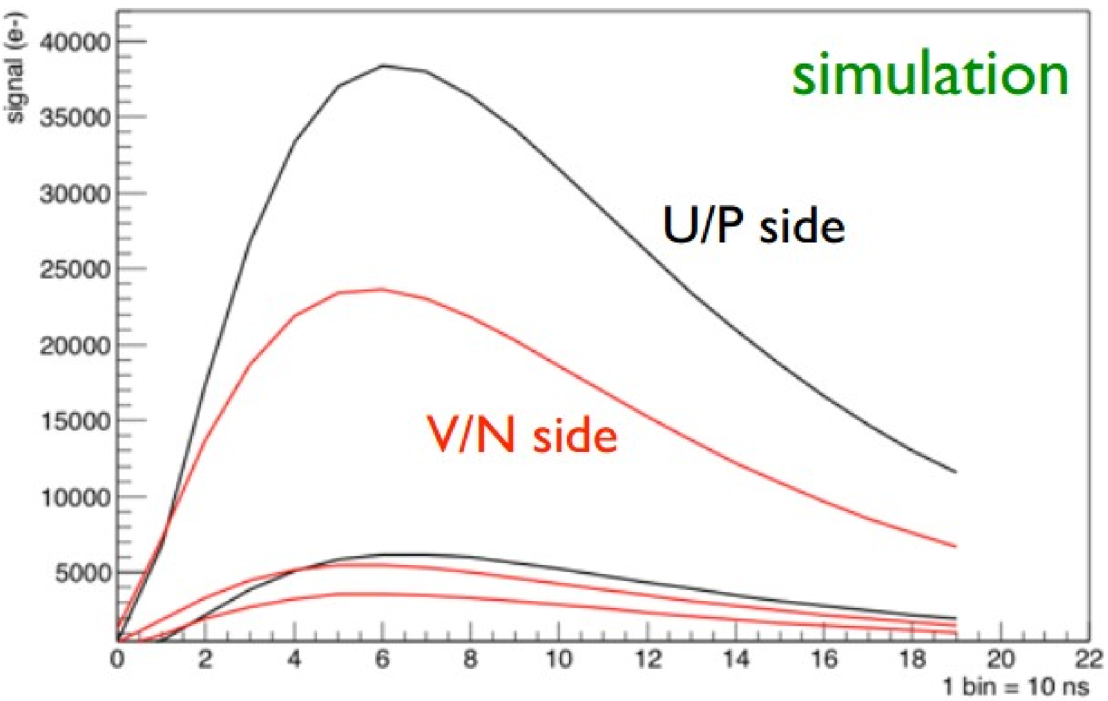


after correction



U-side and V-side different waveform

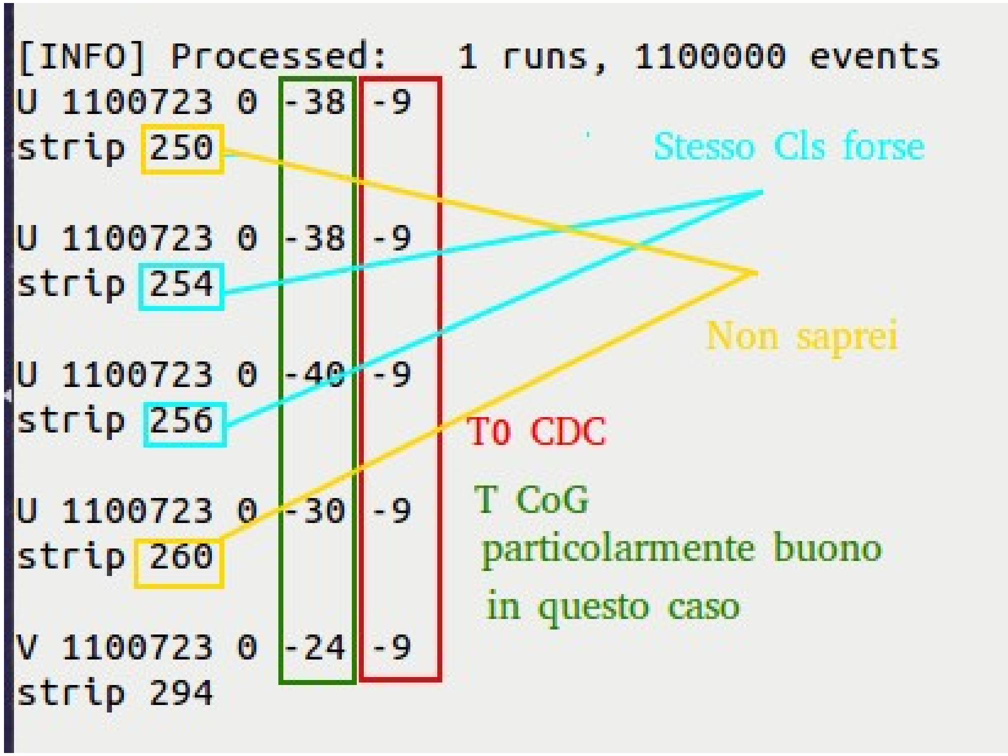
- The V-side and U-side have different waveform, due to the fact that electron are faster than holes: this could contributes to the different estimation of CoG



- The U-side resolution for the L3 U-side is influenced by the fact that we are joining both sensors but we realized that they are different

Splitting of the Clusters

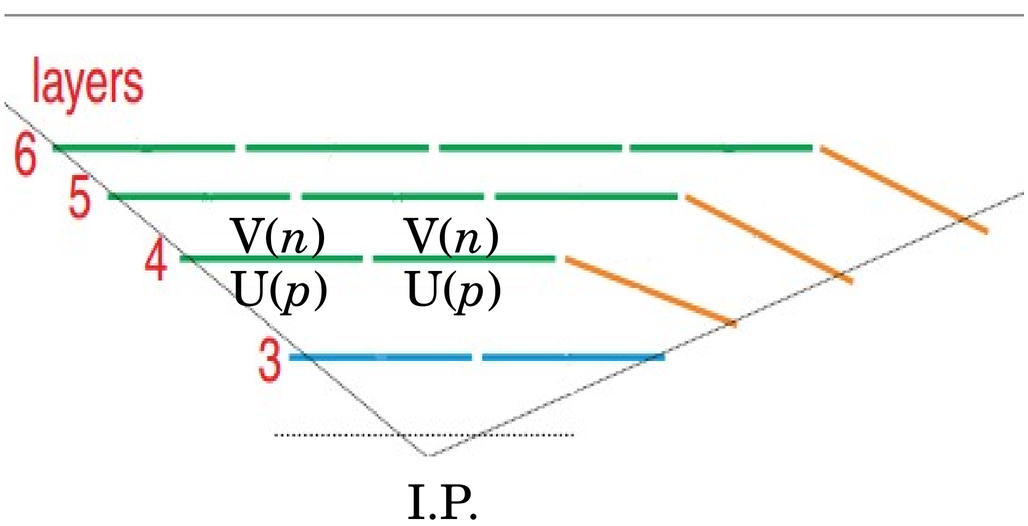
- Different entries between U and V due probably to not physics events or to signals which start in event and propagates in the following event or to splitting of clusters

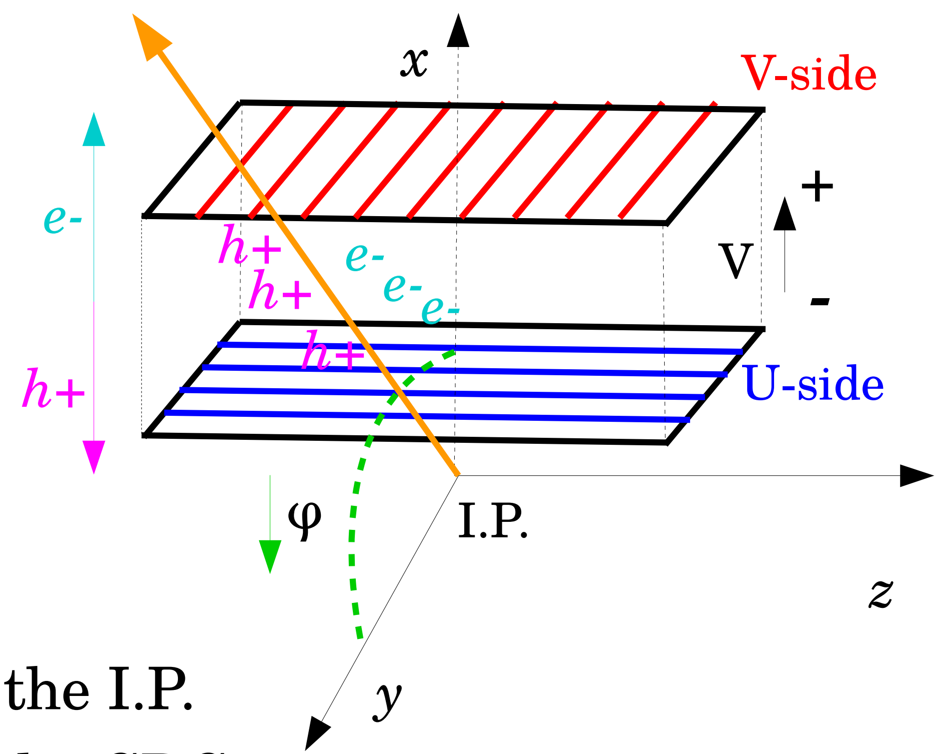


- This problem maybe will be not a problem with collision tracks because the clusters are smaller

Hints on SVD configuration

- Each sensor has 2 sides, U and V, with a different strips configuration: the strips of the U-side are of type *p* and measure the φ direction while the strips of V-side are of type *n* and measure the *z* direction





- U-sides are those that watch through the I.P.
- V-sides are those that watch through the CDC