



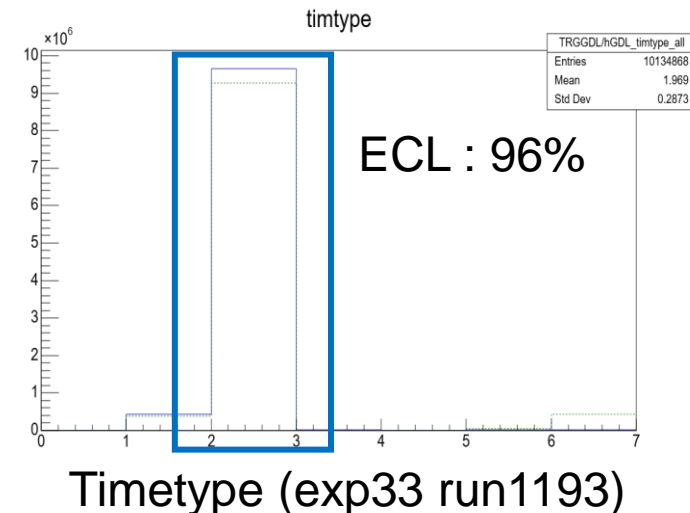
# ECLTRG TC timing Calibration and Event Timing Study

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  - Possible improvement from ECLTRG
- TC Timing Calibration
  - TC by TC
  - Energy dependent calibration(all TC merged)
    - TC by TC energy dependent calibration
- Event Timing
  - Trigger timing determination logic
- Summary & To do

- EventT0 is relative time difference between event timing and trigger timing.
  - $\text{EventT0} = (\text{event timing}) - (\text{trigger timing})$
- SVD sampling is affected by EventT0 resolution
  - In higher luminosity environment, the number of sampling points should be reduced (because of deadtime).
  - For 3points sampling,  $< 10\text{ns}$  is required but current resolution  $> 10\text{ns}$  for  $E < 500\text{MeV}$ .
- ECLTRG may improve resolution from trigger side
  - Most of trigger timing ( $\sim 95\%$ ) is determined by ECLTRG in exp33.
  - Trigger timing with consistent quality : TC timing calibration
  - Improve trigger timing itself : ECLTRG timing determination logic



# TC Timing Calibration : TC by TC

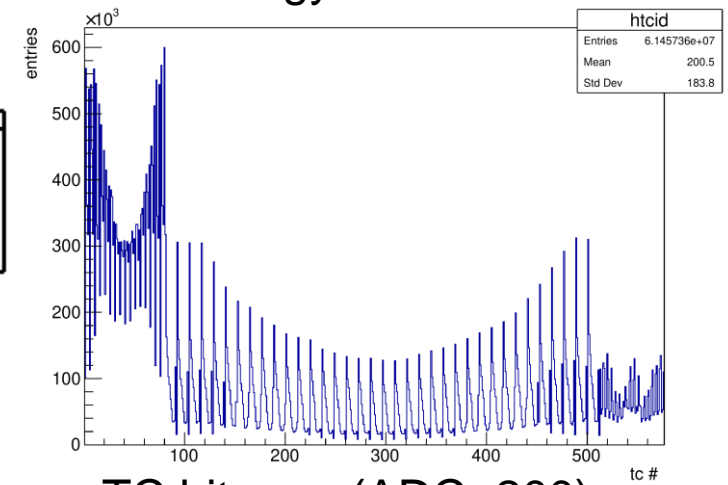
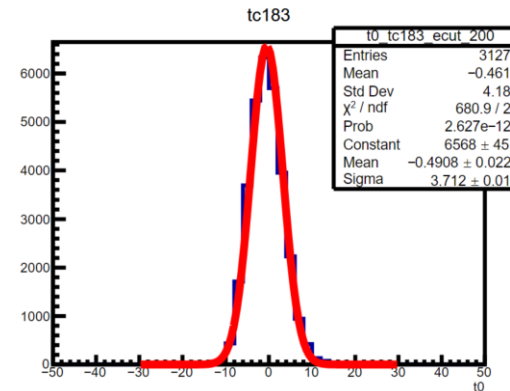
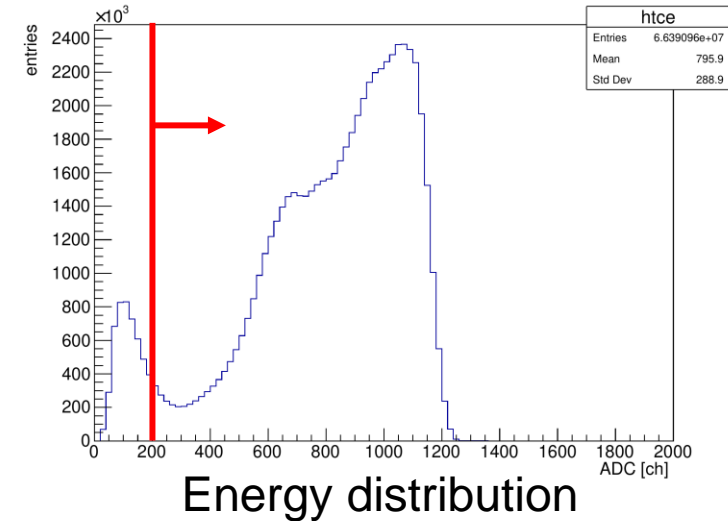
- Method

- ECL trigger timing is determined by the most energetic TC timing
- $\text{EventT0} = (\text{subdetector timing}) - (\text{the most energetic TC timing})$   

Event timing
trigger timing
- EventT0 of each TC ~ timing of the TC
- Fitting to extract calibration constants (chi2 gaussian fit)

- Data

- All runs in prerelease-07-00-00d/s-proc4\_cDST/e0026
- Skimmed by Bhabha\_calib
- TimeType = ECL
- EventT0 per each TC
- TC ID: 1-576
- TC energy > 200 ADC (~1GeV)

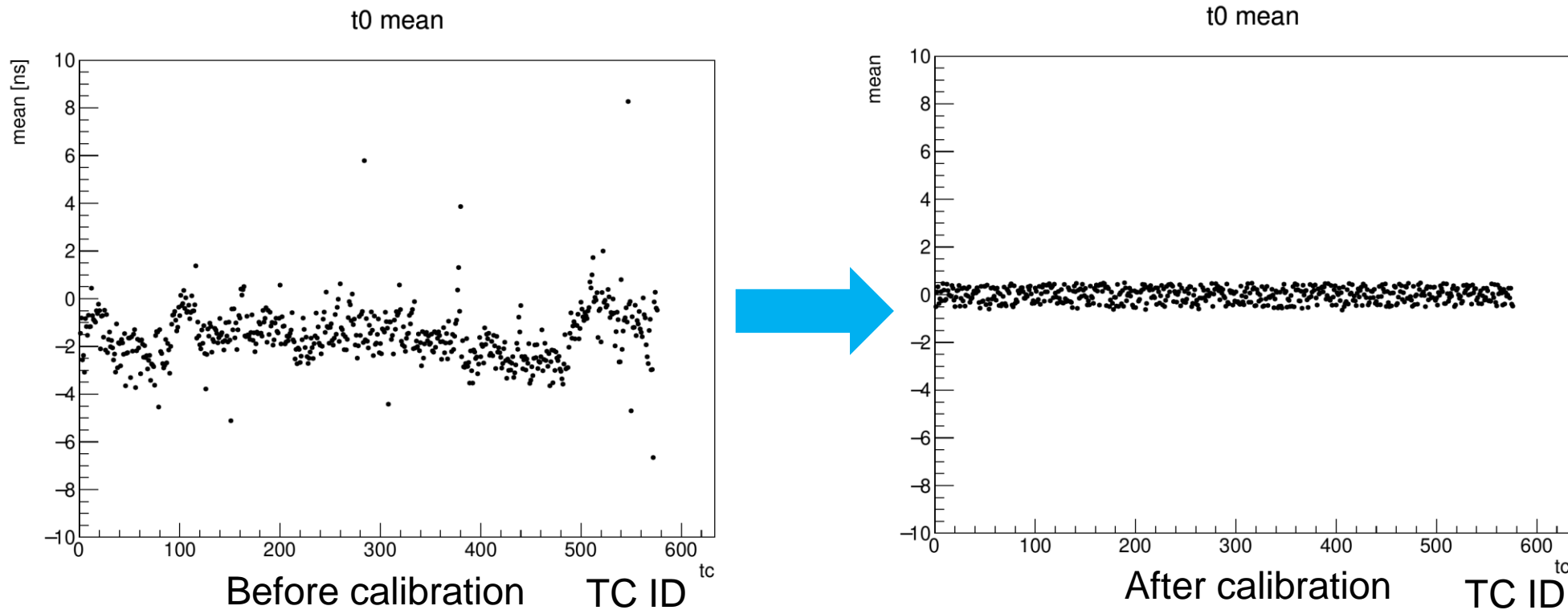


Fit result of TC#183

TC hit map (ADC > 200)

# TC Timing Calibration : TC by TC

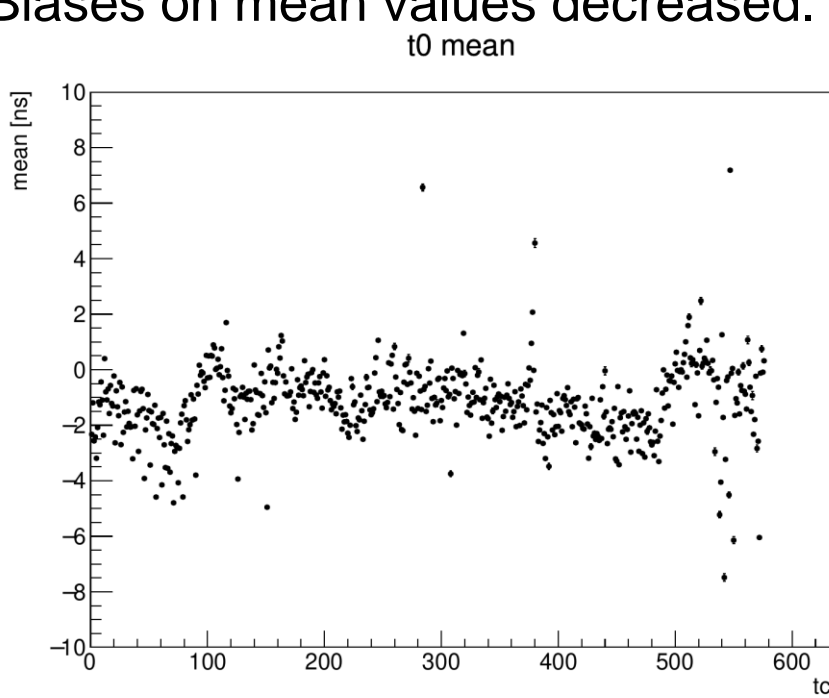
- Calibration :  $(t0_{i, cal} = t0_i - C_i)$  ,  $i = \text{TC ID}$ 
  - $C_i$  is calibration constant calculated by the fitting :  $(t0_{i, cal}) = 0$
  - FAM does not accept floating number so  $C_i$  needs to be integer
  - Checking that calibration constants work well using **bhabha\_calib** skimmed data



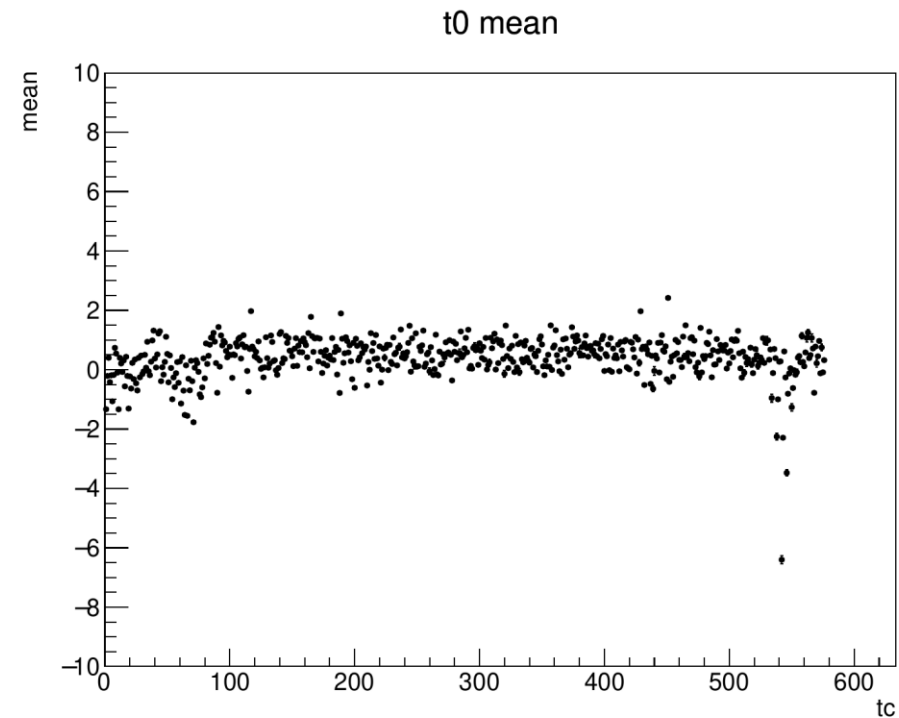
# TC Timing Calibration : TC by TC

- Calibration test

- Using  $C_i$  obtained by Bhabha samples
- Applying to **hadron\_calib** sample (with cut ADC > 200)
- Biases on mean values decreased.



Before calibration TC ID



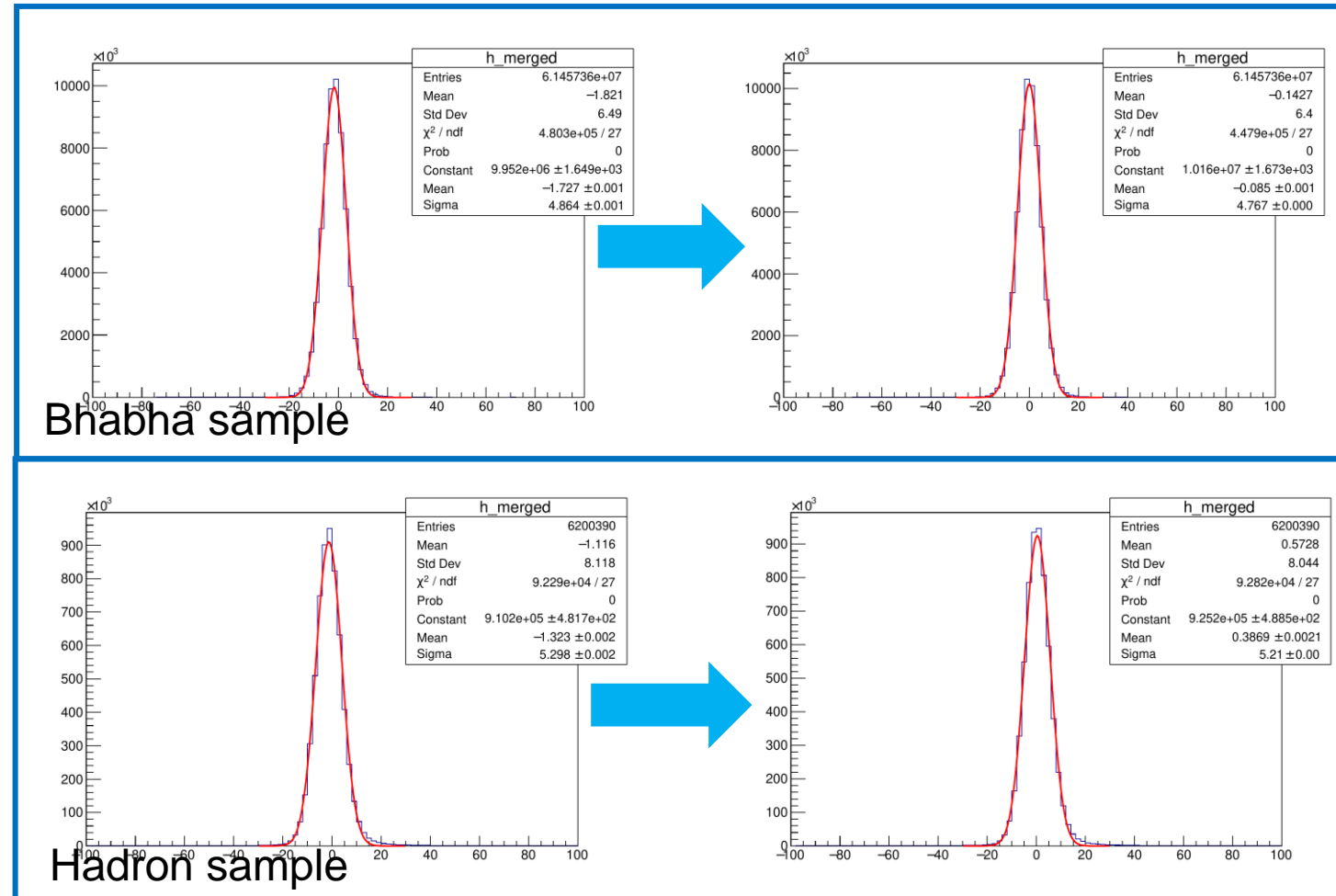
After calibration TC ID

# TC Timing Calibration : TC by TC

- Expected EventT0 variation by the calibration
  - Bare EventT0(all TC merged)
  - Timetype = ECL

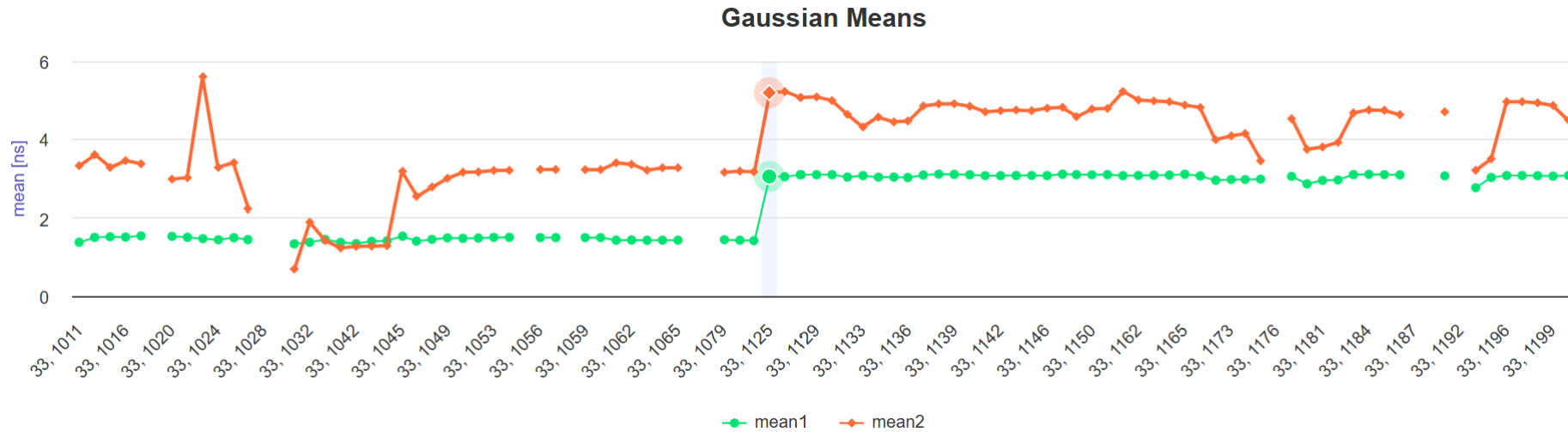
Samples	EventT0	Before	After
Bhabha (Ref.)	Mean	-1.73	-0.09
	Width	4.86	4.77
Hadron (test)	Mean	<b>-1.32</b>	<b>0.39</b>
	Width	5.30	5.21

- For hadron sample
  - Mean bias reduced about 1ns
  - Stddev reduced about 2%.



# TC Timing Calibration : TC by TC

- Calibration constants had been updated to FAM since exp33 run1083

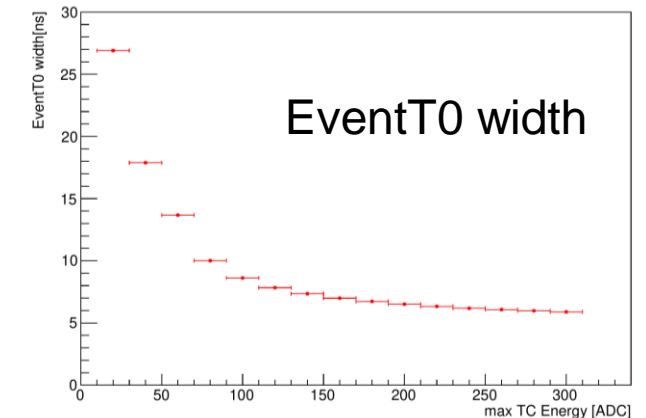
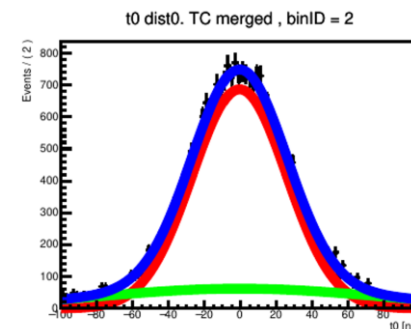
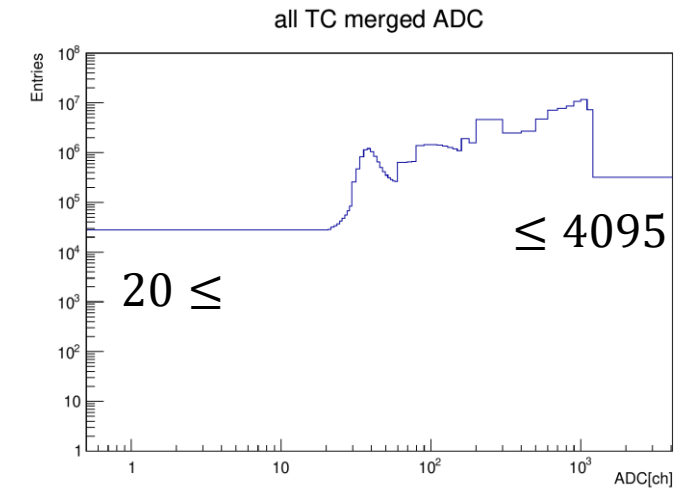


- Might need to update constants with recent experiment number



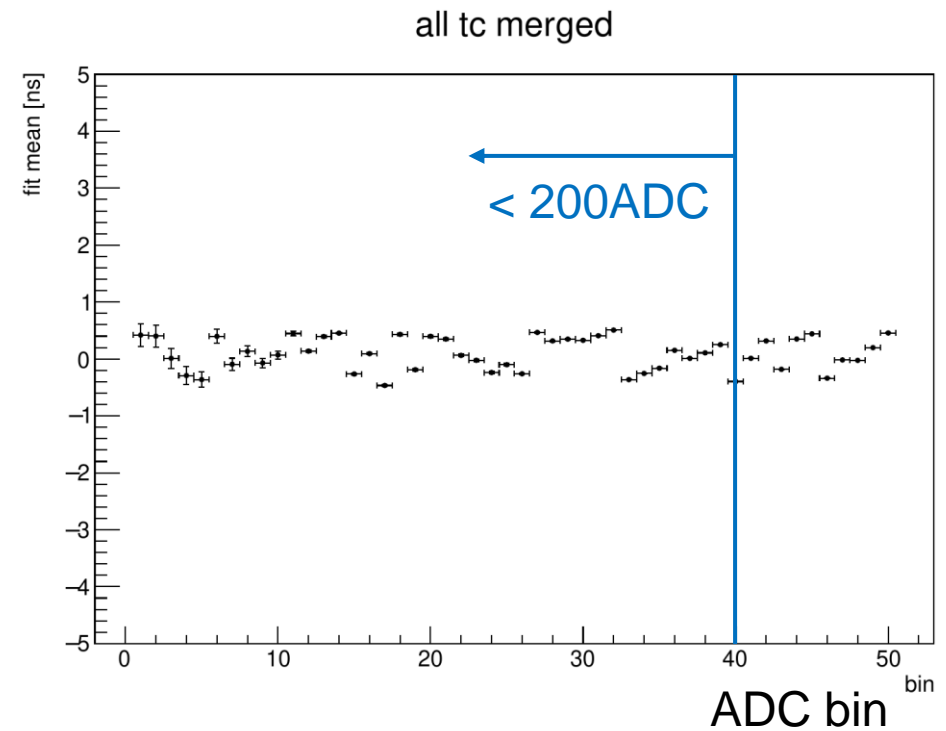
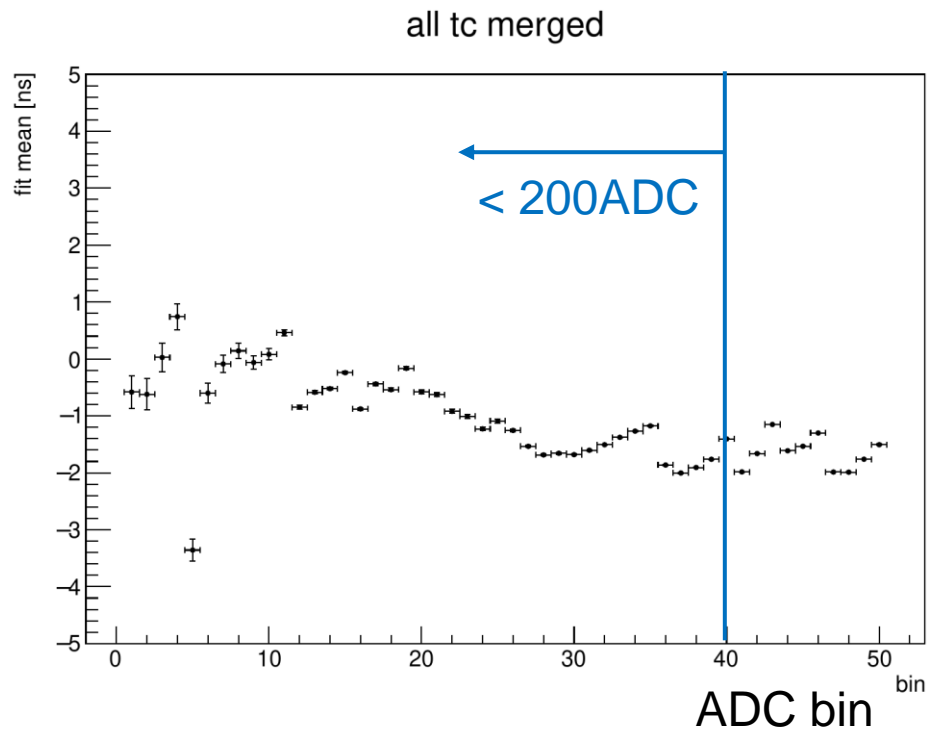
# Energy Dependent TC Timing Calibration

- In low energy region, energy dependent calibration would yield better resolution.
- Data
  - All runs in prerelease-07-00-00d/s-proc4\_cDST/e0026
  - bhabha\_calib, hadron\_calib, radmumu\_calib and tight\_mumu\_or\_highmu\_calib
  - TimeType = ECL
- Method
  - 50 binning for 12bits ADC[0,4095]
    - Dense binning for low energy and coarse binning for high energy
  - EventT0 per each energy bin(50 distributions)
  - Fitting by binned likelihood fit
    - 2 Gaussian sharing mean with different sigma
  - Calibration by odd number runs
    - Test by even number runs



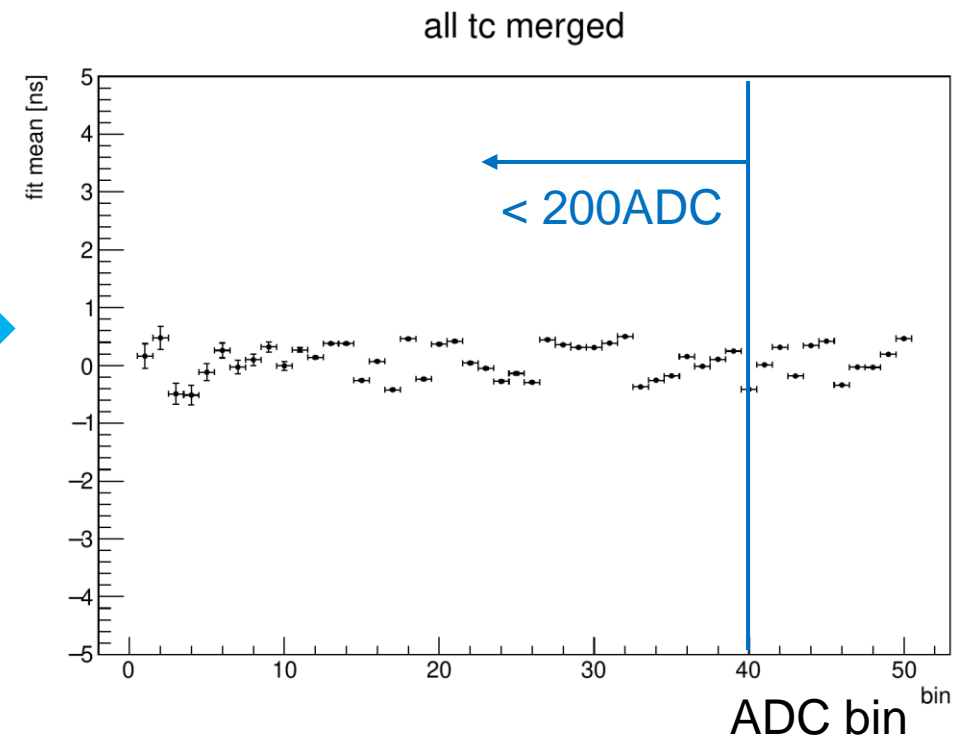
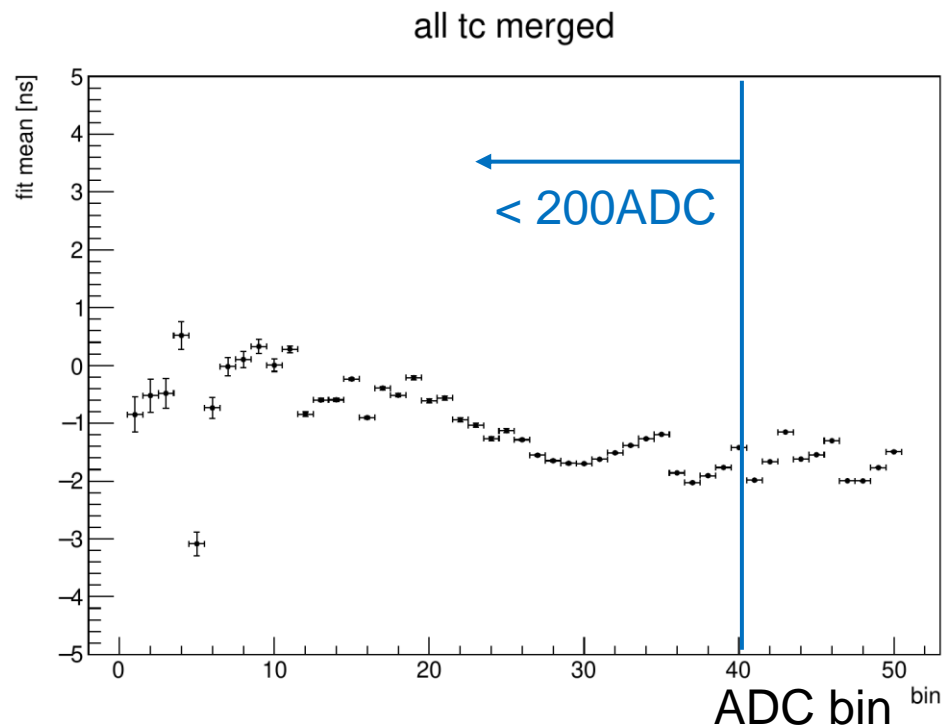
# Energy Dependent TC Timing Calibration

- Calibration :  $(t0_{i, cal} = t0_i - C_i)$  ,  $i = \text{ADCbin}$ 
  - $C_i$ (integer) is calibration constant calculated by the fitting :  $(t0_{i, cal}) = 0$
  - Checking that calibration constants work well using odd number runs



# Energy Dependent TC Timing Calibration

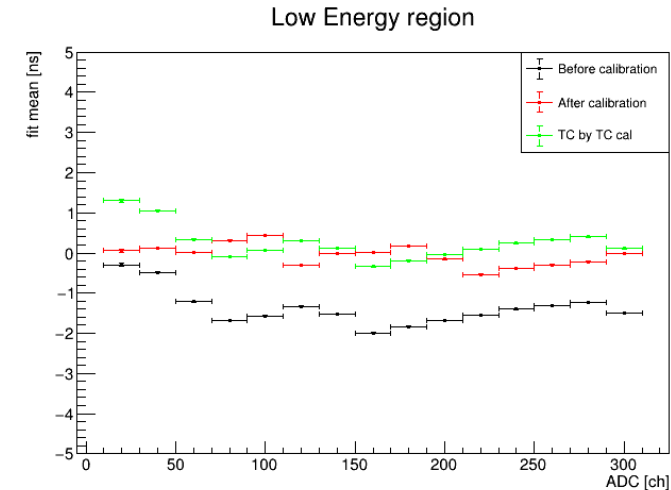
- Calibration test
  - Using  $C_i$  obtained by odd number runs
  - Applying to even number runs
  - Biases on mean values decreased.



# Energy Dependent TC Timing Calibration



- Effectivity in low energy regions
  - Before calibration
  - After energy dependent calibration
  - TC by TC calibration(obtained with ADC > 200)
- For ADC < 300
  - Width of energy dependent calibration is worse than TC by TC calibration



ADC < 300 Calibration result				
Samples	EventT0	Before	E dep.	TC by TC
Odd (Ref.)	Mean	-1.69	0.01	-0.02
	Width	7.31	7.30	<b>7.22</b>
<b>Even (test)</b>	<b>Mean</b>	-1.69	0.01	-0.02
	<b>Width</b>	7.32	7.31	<b>7.23</b>

# Energy Dependent TC Timing Calibration



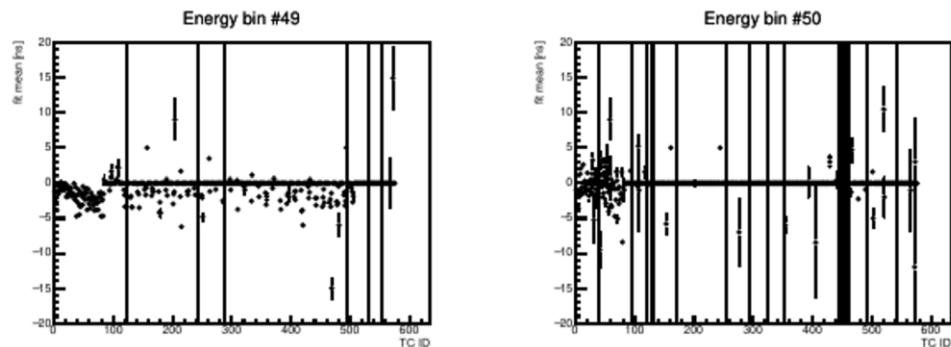
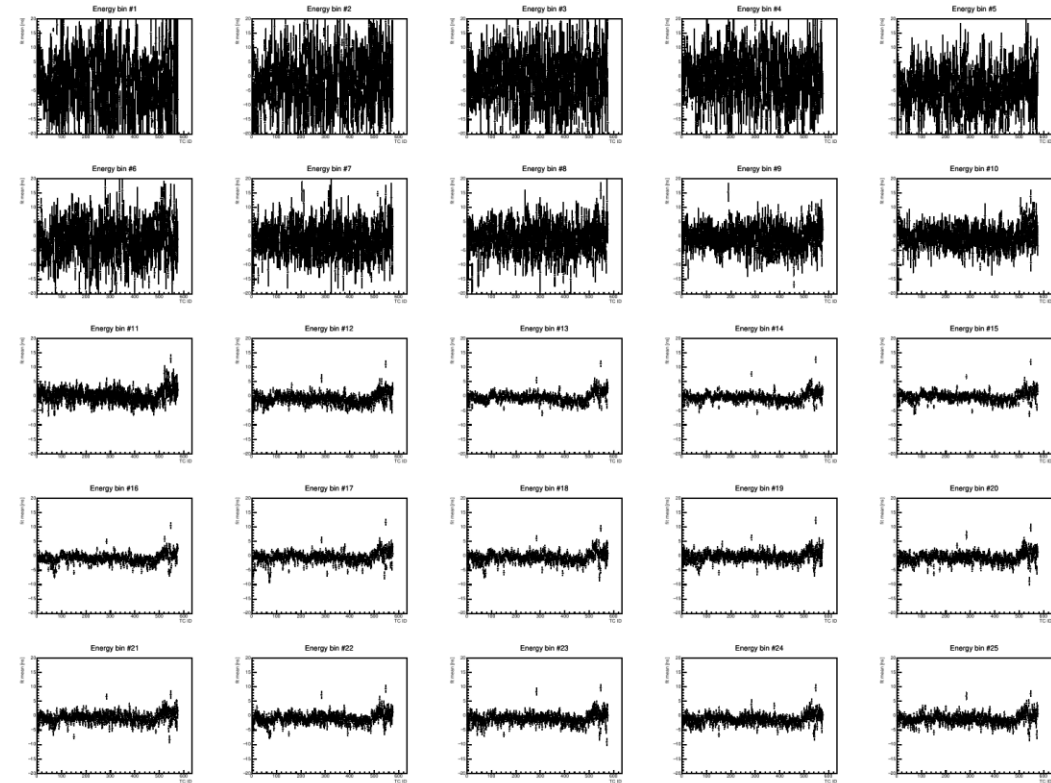
- For all energy regions
  - The same behavior in low energy region can be seen.
  - TC by TC calibration seems to be better for now.

All E Calibration result				
Samples	EventT0	Before	E dep.	TC by TC
Odd (Ref.)	Mean	-1.69	0.01	-0.02
	Width	7.31	7.22	<b>7.13</b>
Even (test)	Mean	-1.69	0.00	-0.03
	Width	7.32	7.22	<b>7.14</b>

- Fittings for the table are in backup

# TC by TC - Energy Dependent Calibration

- Calibration :  $(t_{0_{ij, cal}} = t_{0_{ij}} - C_{ij})$  ,  $i = \text{TCID} , j = \text{ADCbin}$
- Fitting result of first 25 energy bins
  - One figure representing one Energy bin
  - X axis = TCID, Y axis = common mean of gaussians
- Too low statistics for low energy TC
  - Yielding too big calibration constants
- Fitting failure in high energy bins



- Need more study to use this calibration method

# Trigger Timing Determination Logic

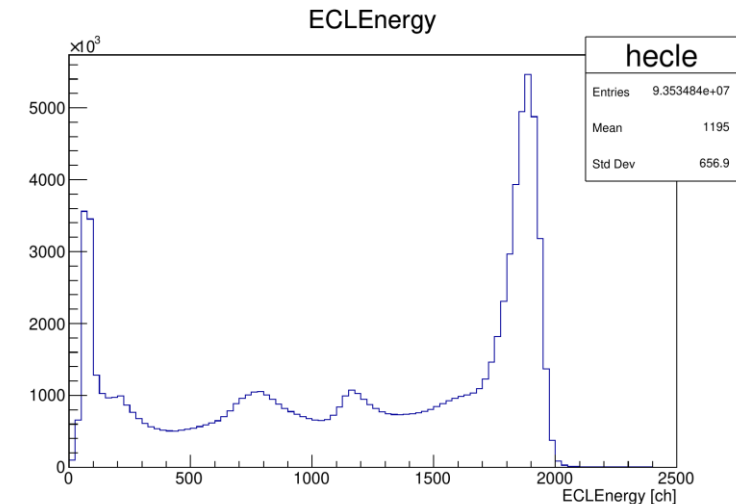
- Data

- All runs in prerelease-07-00-00d/s-proc4\_cDST/e0026
- bhahba\_all\_calib, hadron\_calib, radmumu\_calib and tight\_mumu\_or\_highmu\_calib
- TimeType = ECL

- Energy weighted trigger timing from ECL

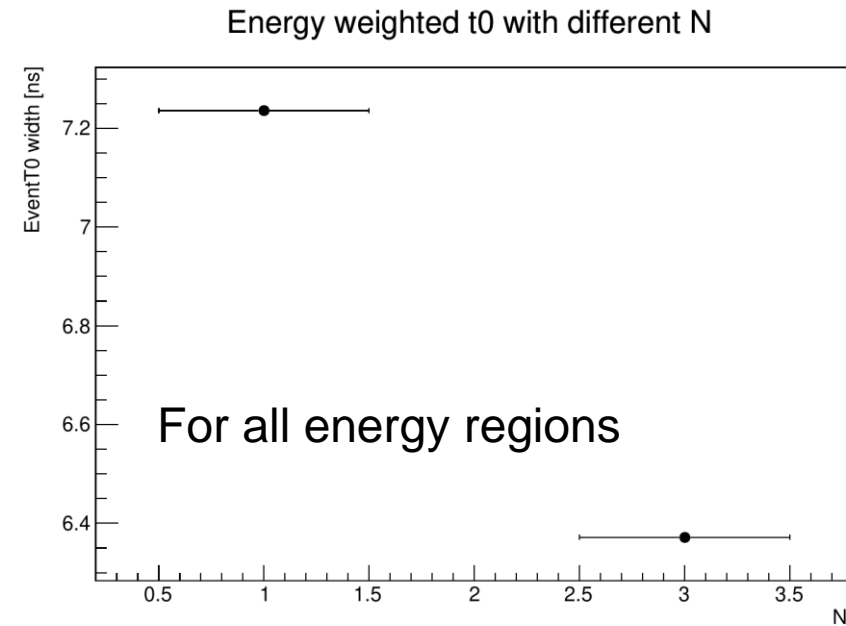
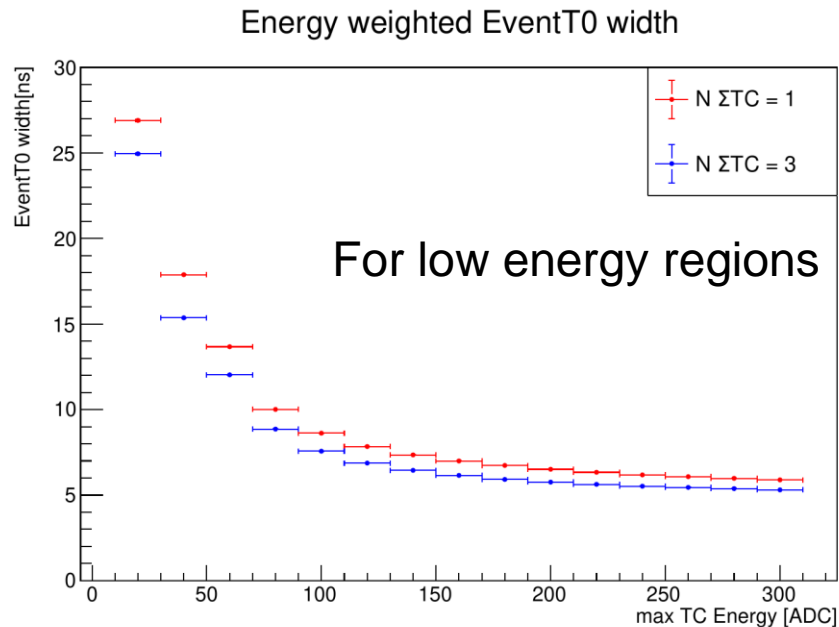
- $(\text{trigger timing}) = \frac{\sum_i^N E_i t_i}{\sum_i^N E_i}$ 
  - Subscript  $i$  means TC number,  $E_i$  is TC energy and  $t_i$  is TC timing
  - summing up to  $N'$ th energetic TC

- $\text{EventT0} = \text{CurrentEventT0} + (\text{most energetic TC timing}) - (\text{energy weighted trigger timing})$   
 Current trigger timing method



# Energy Weighted Trigger Timing

- $N=3$  : If  $n\text{TCs} < 3$ ,  $N = n\text{TCs}$  and if  $n\text{TCs} \Rightarrow 3$ ,  $N=3$
- In low energy regions, 8-15% of improvement on resolution
- In all energy regions,  $\sim 12\%$  of improvement



- Further study is ongoing.



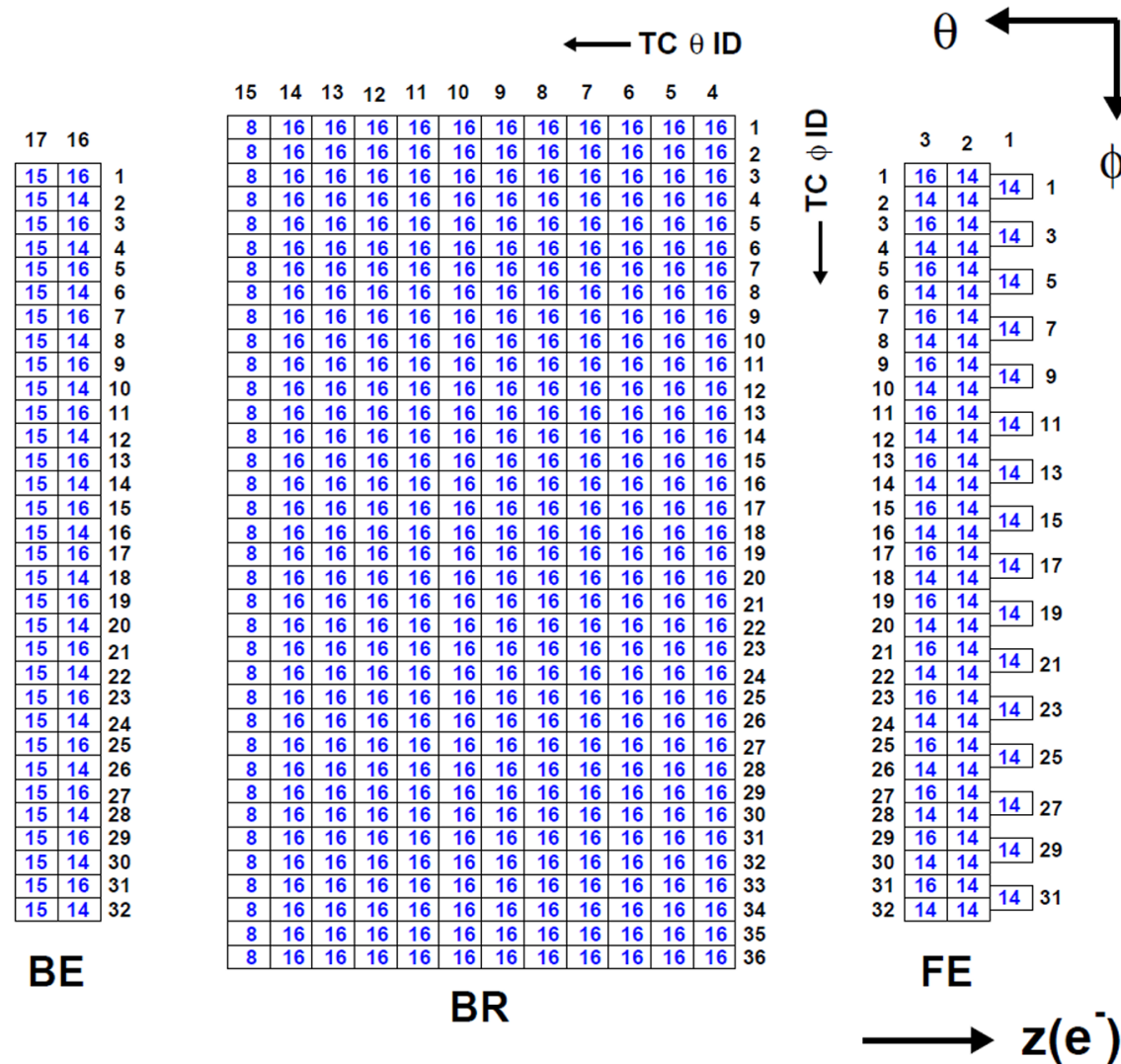
# Summary & To Do

- TC Timing Calibration
  - TC by TC : Bias on EventT0 ↓, 2% of improvement on EventT0 resolution
  - Energy dependent : Bias on EventT0 ↓
  - TC by TC – Energy dependent
    - Applying sequentially
- Event Timing
  - Energy weighted trigger timing : for  $N = 3$ , about 10% of improvement on resolution
    - Change of  $N$
  - Other methods that can be applied on FPGA

# backup

- ~9000 CsI(Tl) crystal
- 576 Trigger Cells (TCs)
- DSPshaper -> FAM -> TMM -> ETM -> GRL/GDL
  - FAM : FADC Analysis Module
  - TMM : Trigger Merger Module
  - ETM : ECL Trigger Master
- FAM determine timing and energy of TC
  - Timing of TC : mainly FADC waveform fitting
  - $E \sim 5 \text{ MeV} / \text{ADC}$

# TC map



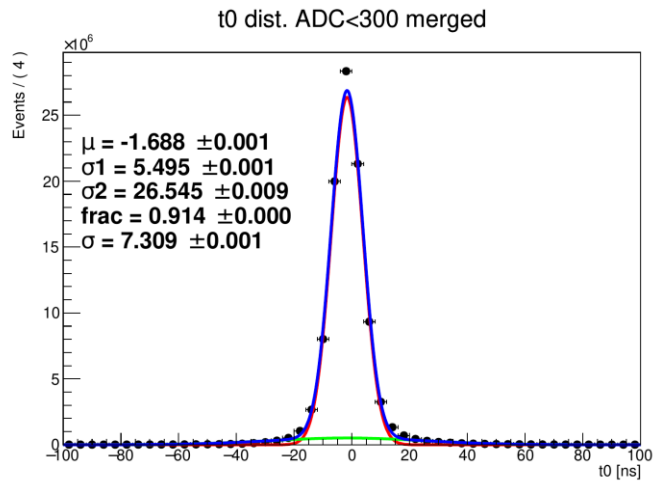
# Binning definition



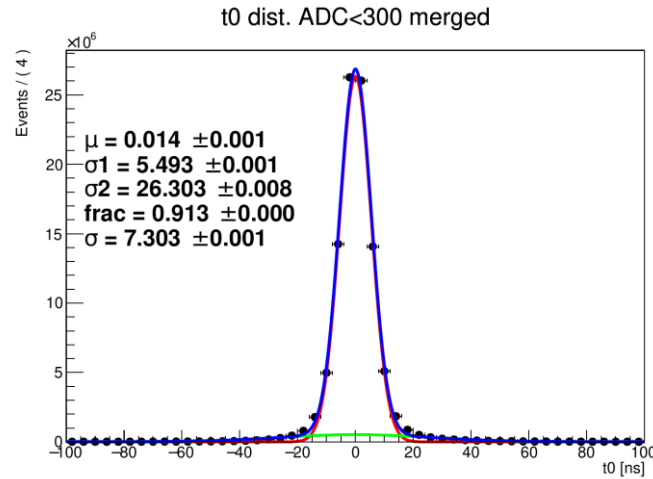
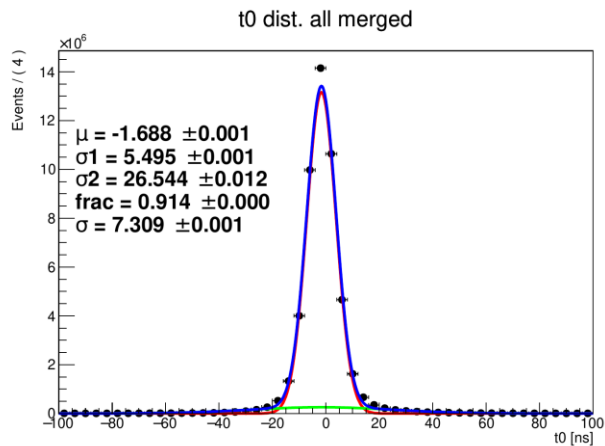
- 50 bins
- [0,20], [21], [22], [23], [24], [25], [26], [27], [28], [29],  
[30,31], [32,33], [34,35], [36,37], [38,39], [40,41], [42,43], [44,45], [46,47], [48,49],  
[50,51], [52,53], [54,55], [56,57], [58,59], [60,64], [65,69], [70,74], [75,79], [80,89],  
[90,99], [100,109], [110,119], [120,129], [130,139], [140,149], [150,159], [160,179],  
[180,199], [200,299], [300,399], [400,499], [500,599], [600,699], [700,799],  
[800,899], [900,999], [100,1099], [1100,1199],[1200,4095]

# E dep. Calibration fitting

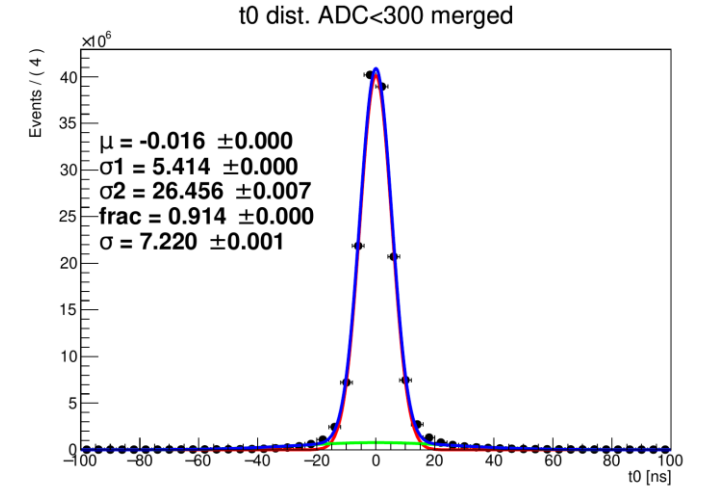
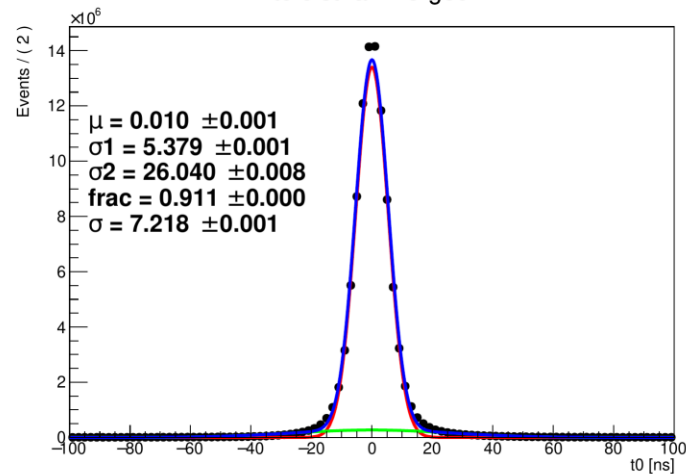
- Odd number runs



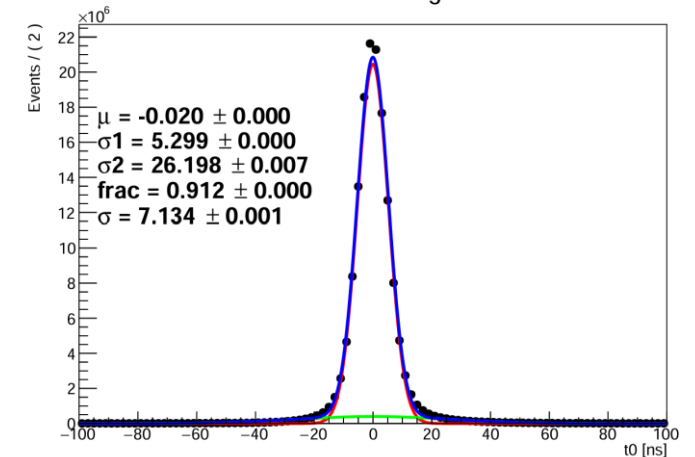
before



E dep.  
t0 dist. all merged

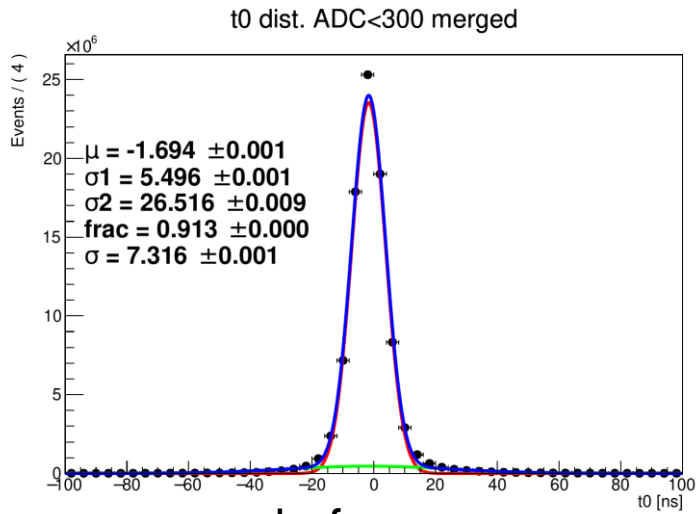


TC by TC  
t0 dist. all merged

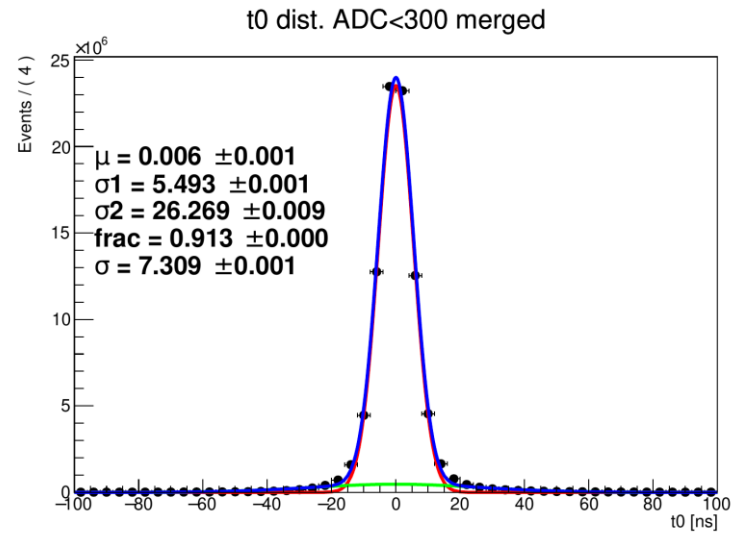
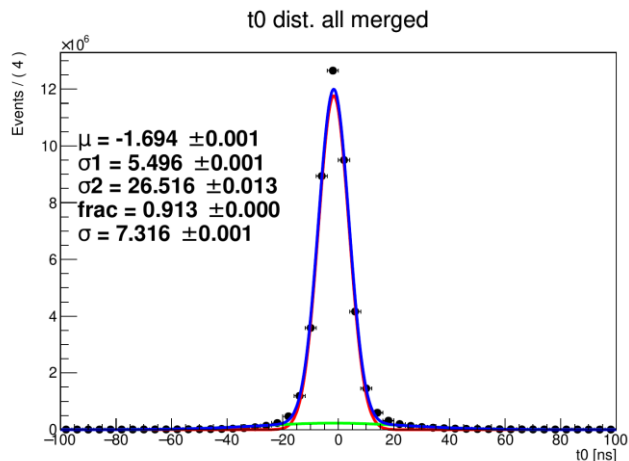


# E dep. Calibration fitting

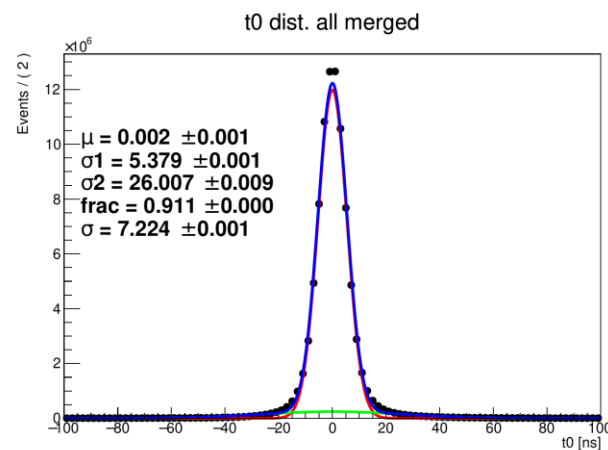
- Even number runs



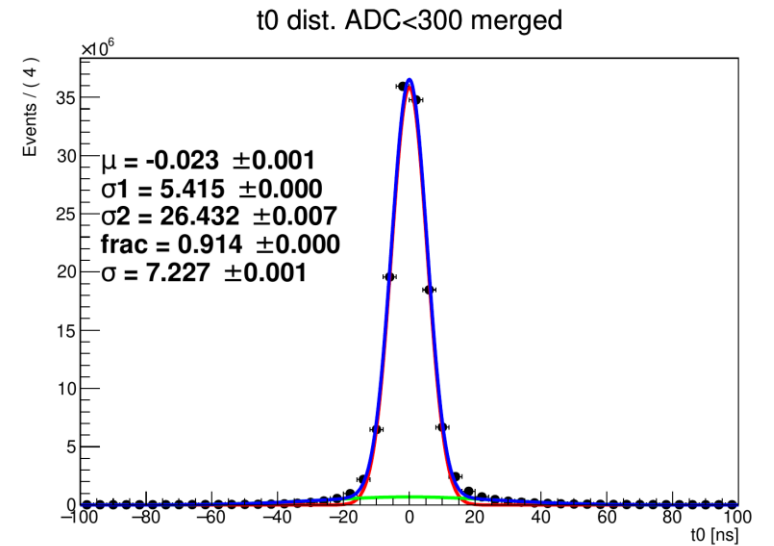
before



E dep.



ECLTRG



TC by TC

