ECLTRG TC timing Calibration and Event Timing Study

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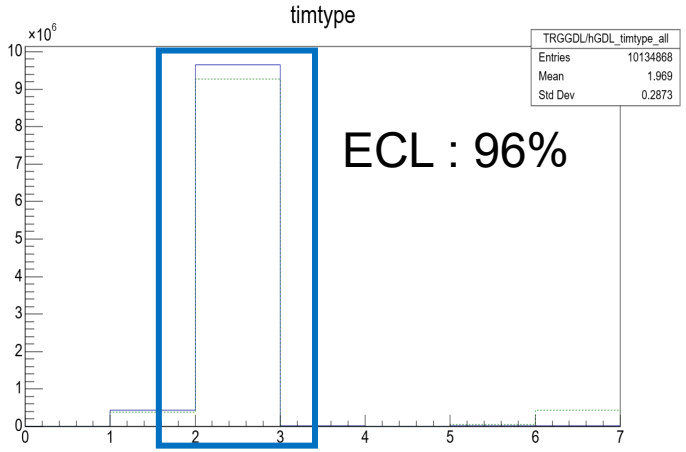
EventT0

- EventT0 is relative time difference between event timing and trigger timing.
  - EventT0 = (event timing) – (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, < 10ns is required but current resolution > 10ns for E < 300MeV.

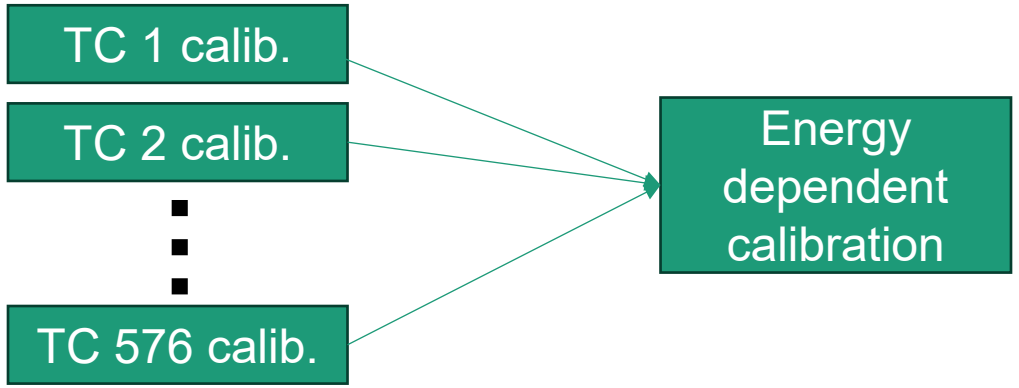
- ECLTRG may improve resolution from trigger side
  - Most of trigger timing(~95%) is determined by ECLTRG in exp33.
  - Trigger timing with consistent quality : TC timing calibration
  - Improve trigger timing itself : ECLTRG timing determination logic



Timetype (exp33 run1193)

TC by TC → Energy dependent calibration

- 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
  - Calibration by odd number runs
    - Test (validation) by even number runs

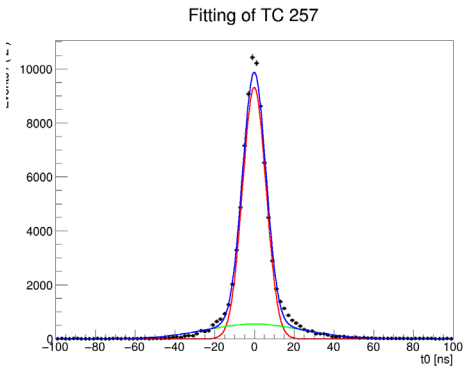


- Method
  - First, extract **integer** CC for each TC and apply for each TC
  - Then, merge all TC and extract global energy dependent CC**(integer)**
  - **CC = int(TC by TC CC) + int(Edep CC)**
    - Denote it as “sequential”
      - Since no enough statistics for individual TC + edep. calibration
  - $\left(\mathrm{t0}_{i,\,\mathrm{cal}} = \mathrm{t0}_i - C_i\right)$ i is TC number or Energy bin.
    - Making $\mathrm{t0}_{i,\,\mathrm{cal}} = 0$ (no bias condition)

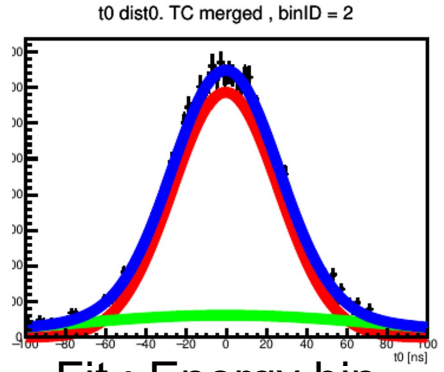
TC by TC → Energy dependent calibration

- **TC by TC calibration**
  - ECL trigger timing is determined by the most energetic TC timing
  - EventT0 = (subdetector timing) - (the most energetic TC timing)

    Event timing trigger timing
  - Fitting to extract CCs from 576 TCs.
  - Fitting with binned likelihood fit
    - 2 Gaussian sharing mean with different sigma

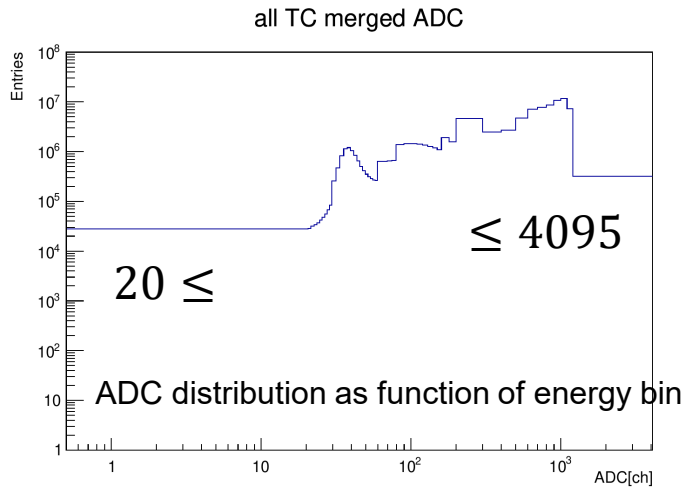


Fit : TC by TC



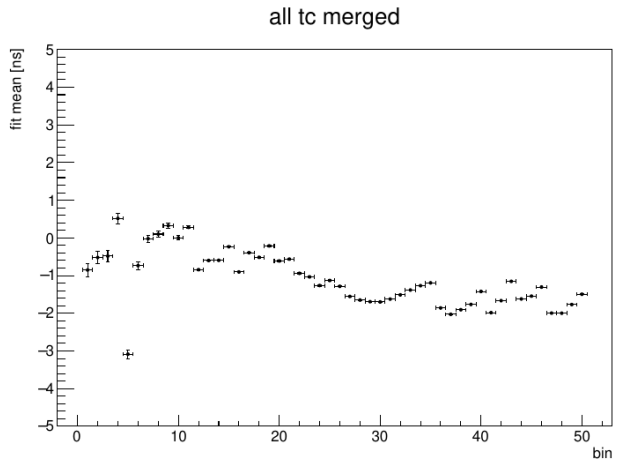
Fit : Energy bin

- **Energy dependent calibration**
  - 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 with binned likelihood fit
    - 2 Gaussian sharing mean with different sigma

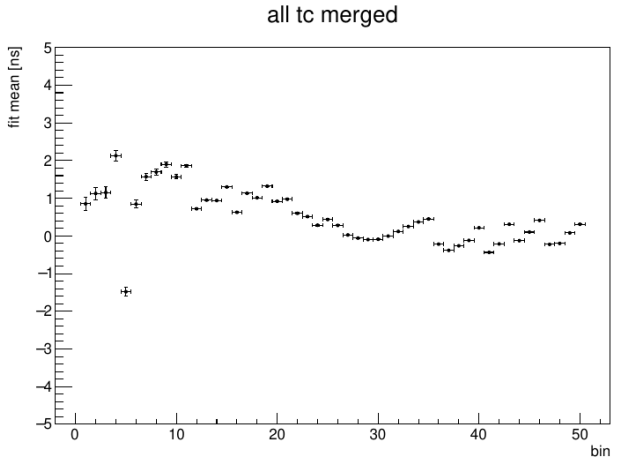


TC by TC → Energy dependent calibration

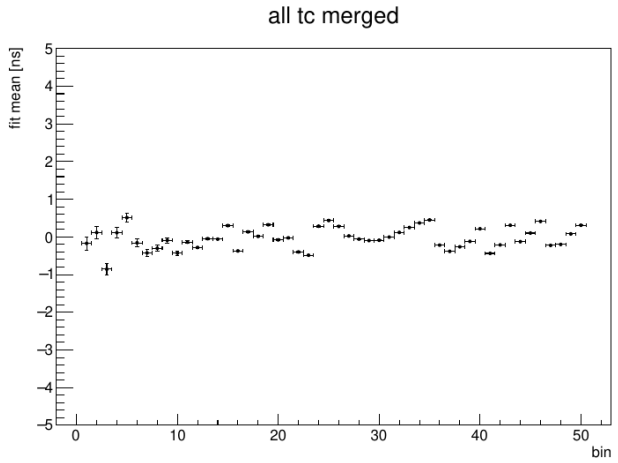
- Flow of Calibration : T0 mean as the function of energy bins



Before calibration



TC by TC calibration

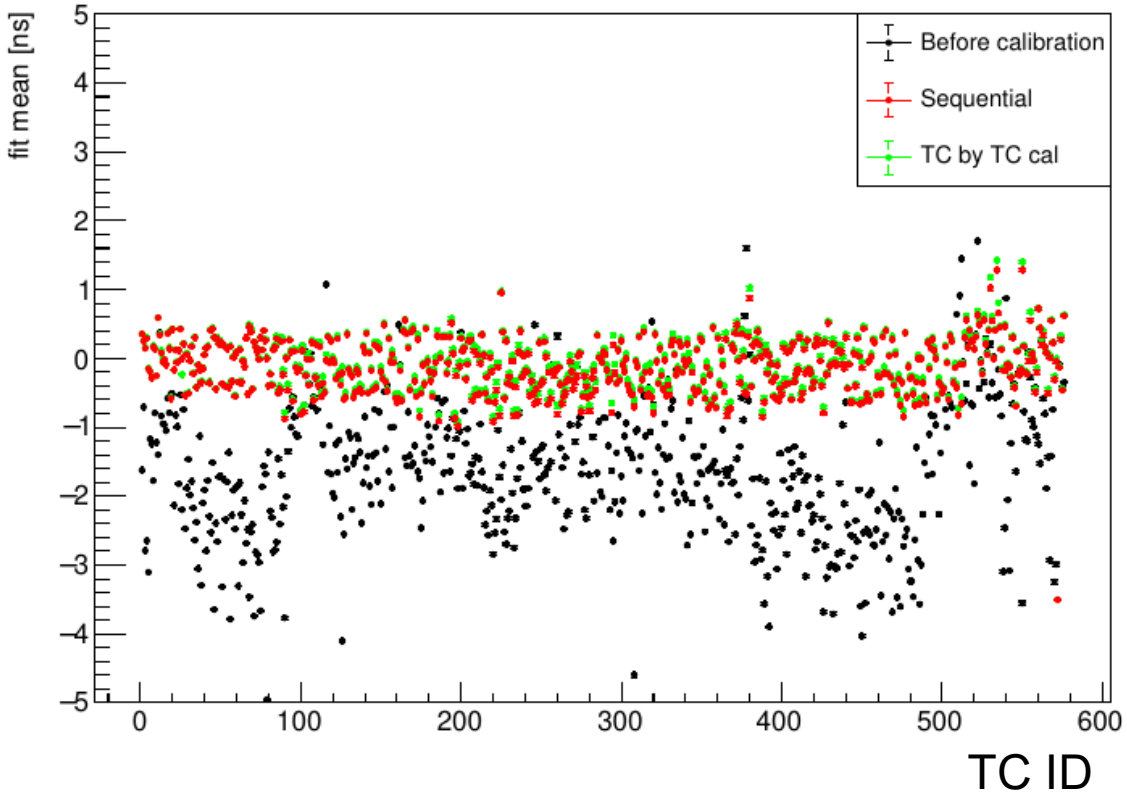


Sequential calibration

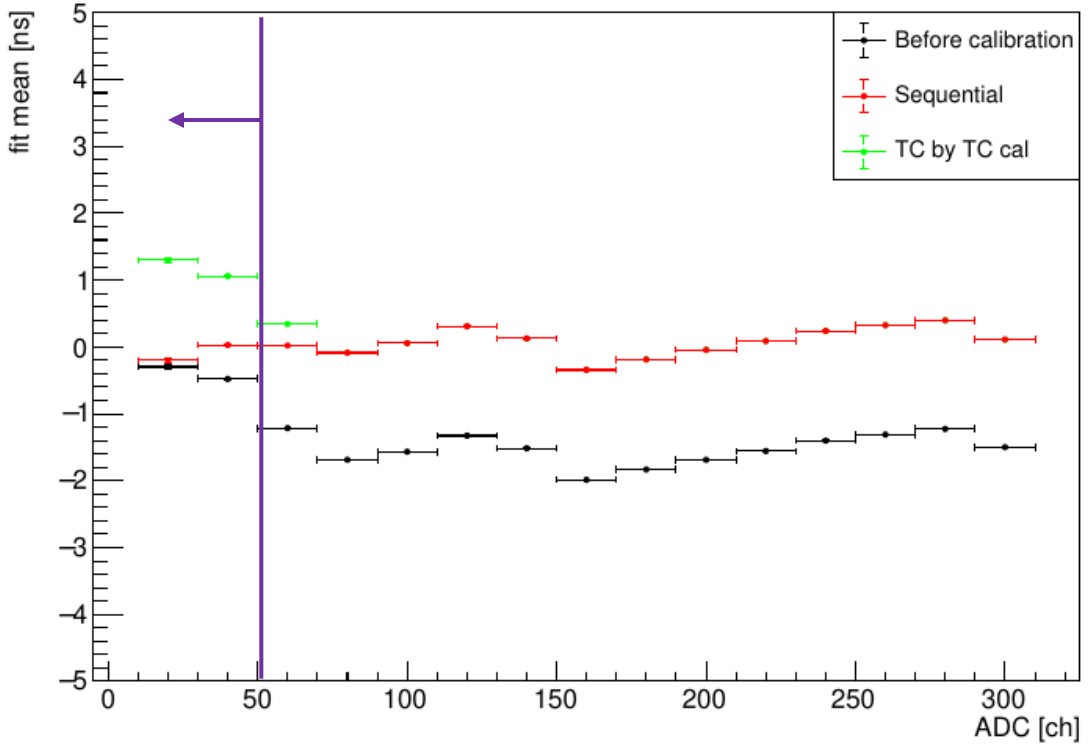
- X axis is Energy bin (defined in backup), Y axis is gaussian mean

TC by TC → Energy dependent calibration

- Result : T0 mean as the function of TCID(left) and TC energy(right)
  - TC by TC and sequential has almost same means after ADC > 70



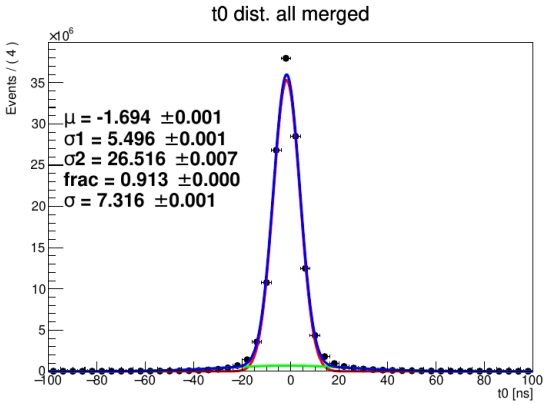
Low Energy region



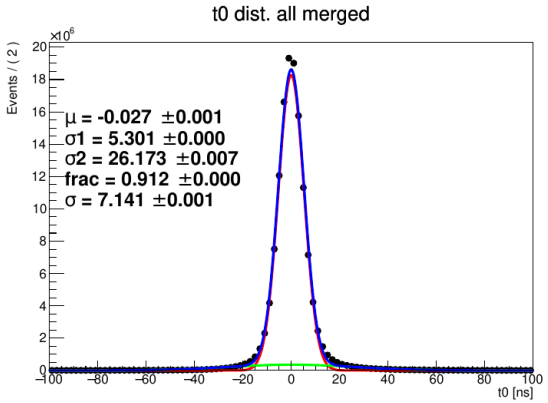
TC by TC → Energy dependent calibration

- Fit result for all energy
  - There is almost no difference between TC by TC and sequential calibration.
    - The reason is in the front page : Almost same means after ADC > 70

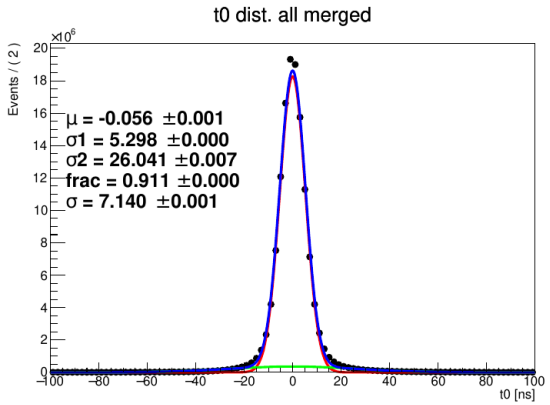
	Before calibration	TC by TC	Sequential
Mean	-1.694	-0.027	-0.056
Width	7.316	7.141	7.140



Before calibration



TC by TC calibration

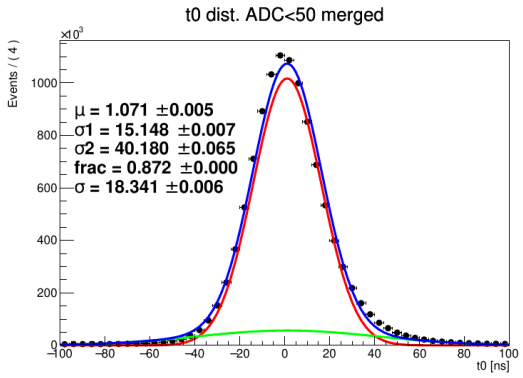


Sequential calibration

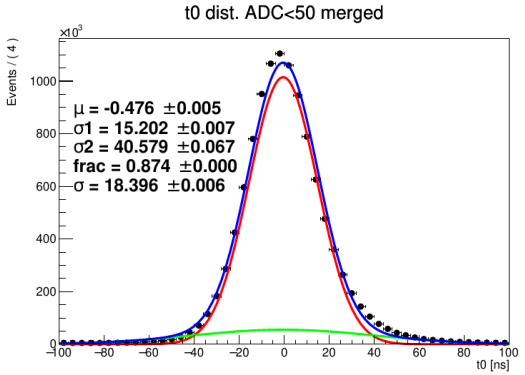
TC by TC → Energy dependent calibration

- Fit result in the region where TC E < 50 ADC
  - Sequential method significantly reduces bias on mean.

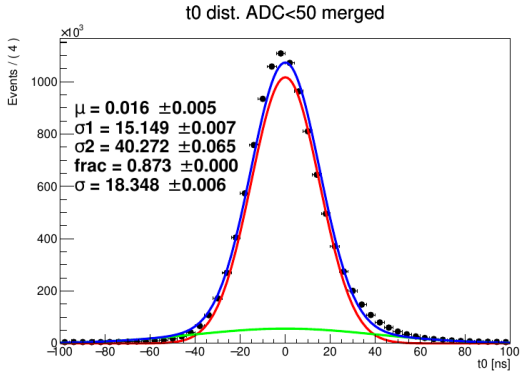
	Before calibration	TC by TC	Sequential
Mean	1.071	-0.476	0.016
Width	18.34	18.40	18.35



Before calibration



TC by TC calibration



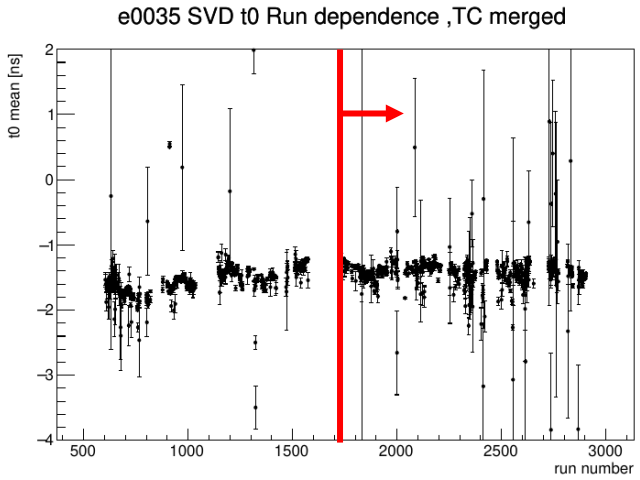
Sequential calibration

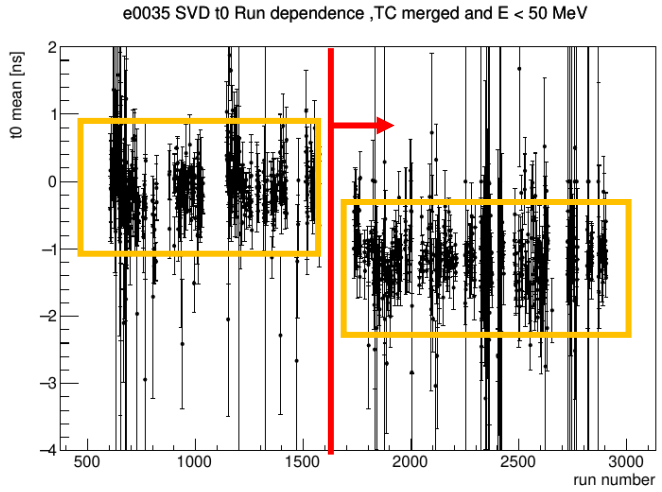
TC by TC → Energy dependent calibration

- Calibration constants are uploaded to FAM since 24.11.27

1035	2024/11/27 18:23 JST	yuuji unno	Parameter	TRGECL	Update of energy dependent TC timing correction				no change	Updated energy dependent TC timing bias correction on FAM. The bias correction parameters were obtained

- Check with e0035 SVD's OnlineEventT0 mean:
  - No major change in t0 mean in **all energy regions**, but change can be seen in **low energy region (E <50ADC)**

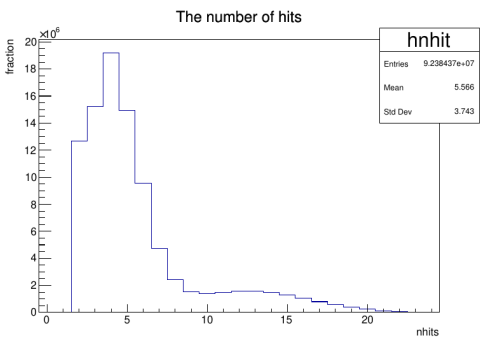


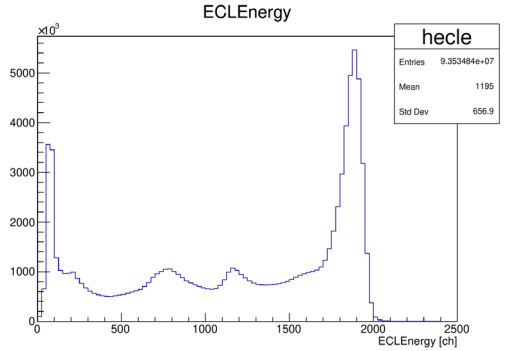


- Updating CC obtained from recent experiment number will be done.
  - Current CC is too old.
  - It seems that update will be needed when subdetector's configuration is changed.

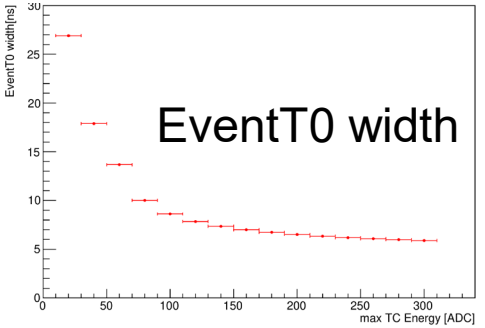
Trigger Timing Determination Logic

- 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
  - nTC > 1





- Energy weighted trigger timing from ECL
  - (trigger timing) = $\frac{\Sigma_i^N E_i t_i}{\Sigma_i^N E_i}$
    - Subscript i means TC number, E_i is TC energy and t_i is TC timing
    - summing up to $N'\mathrm{th}$ energetic TC

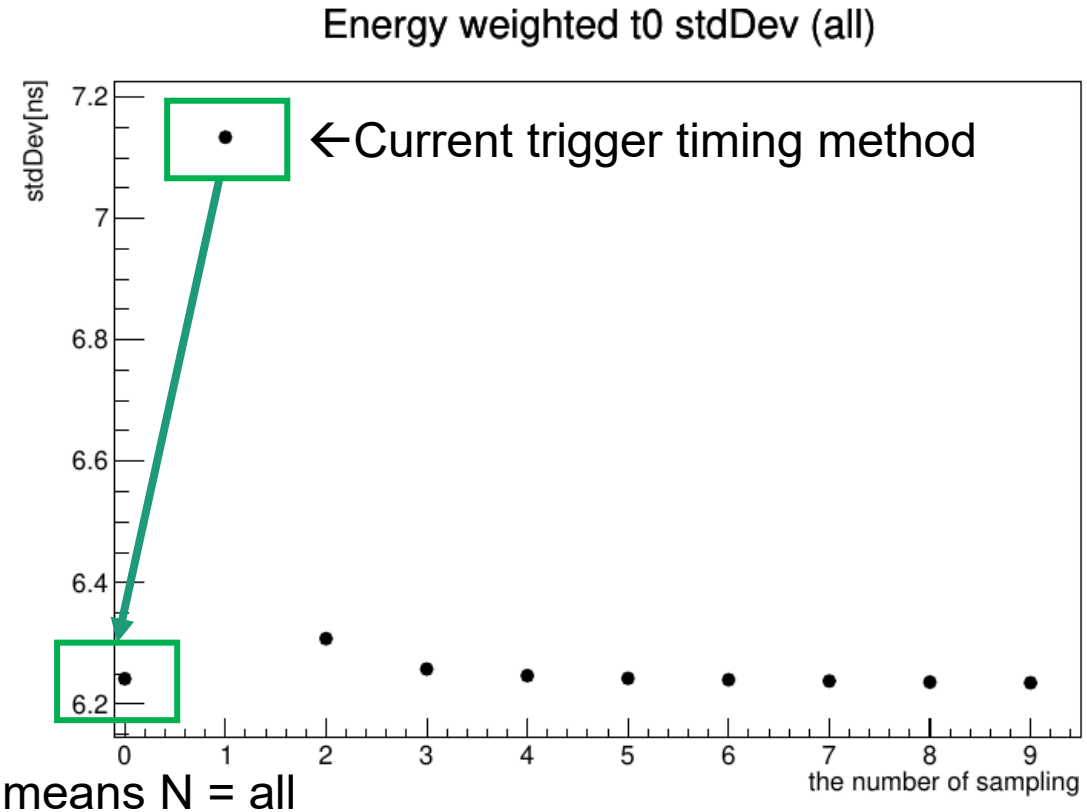


  - **Find optimized N** that minimizes **widths** of EventT0 distribution.
  - EventT0 = CurrentEventT0 + (most energetic TC timing) – (energy weighted trigger timing)

Current trigger timing method

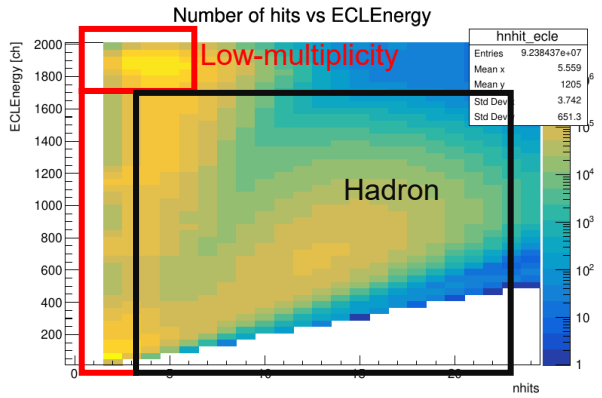
Trigger Timing Determination Logic

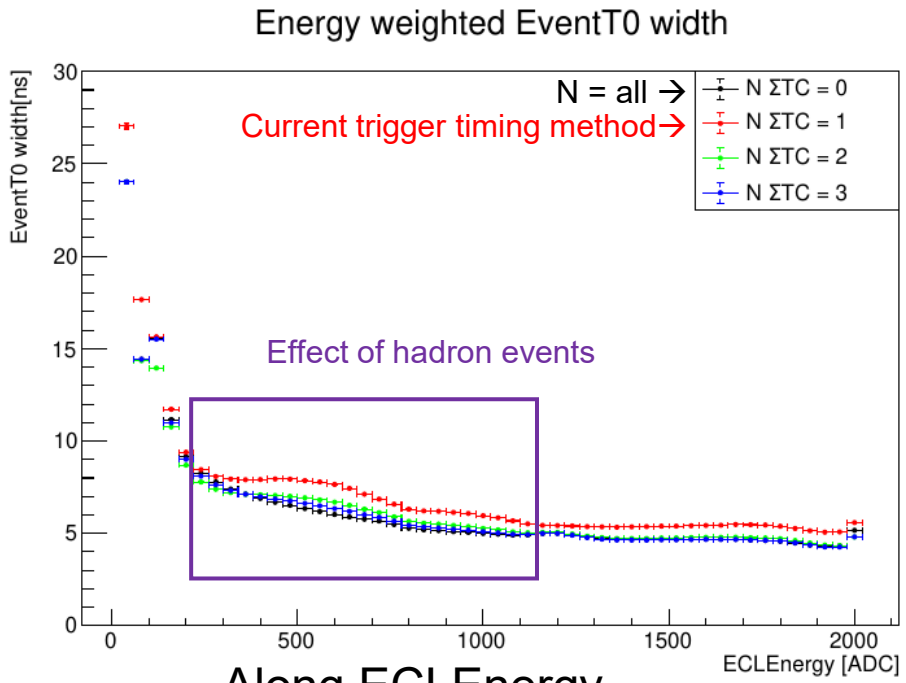
- N = all shows good result.
  - We can expect about 12% of decrease of EventT0 width
    - Especially good for hadron events (10 – 20%)



0 means N = all = N

All energy region





Along ECLEnergy

Summary

- TC Timing Calibration
  - TC by TC - energy dependent calibration : Reducing bias in low energy region
  - But consistent update of CC will be needed.

- Trigger Timing
  - Energy weighted trigger timing : N = all, hadron event's EventT0 widths are reduced by ~20%.
  - Advantage of N = all
    - Sorting energy is not needed. (whose time complexity is O(NlogN) ~ O(N^2))
    - Same time complexity with finding maximum TC energy : O(N)
  - More discussion will be done.

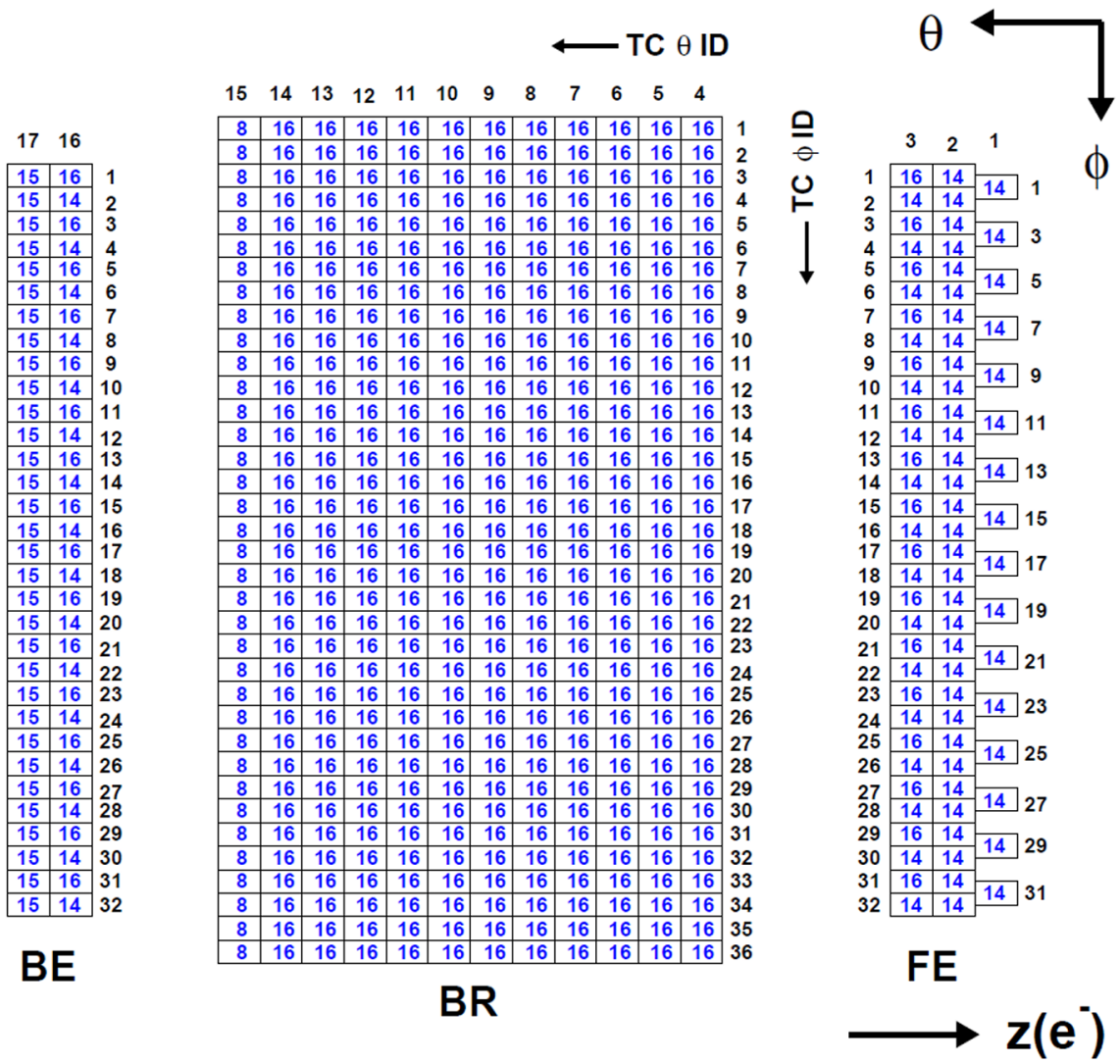
backup

ECL trigger

- ~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 ~ 5 MeV / ADC

TC map



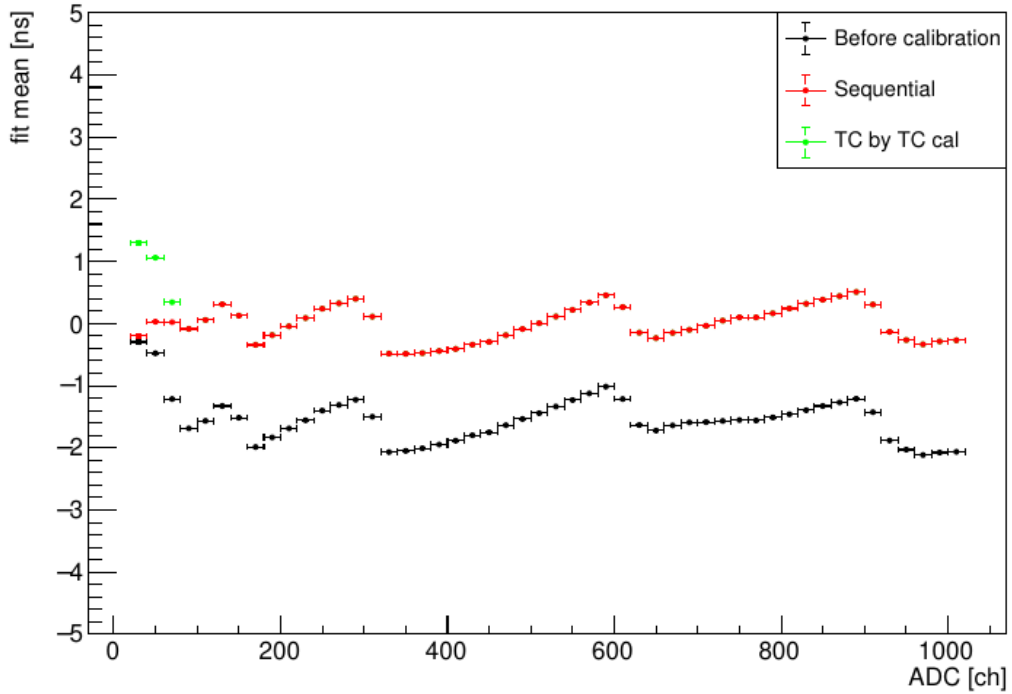
Binning definition

- 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]

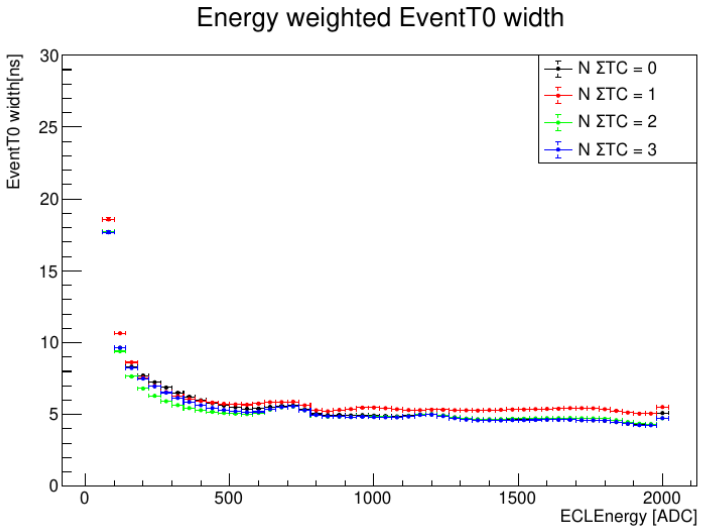
TC by TC → Energy dependent calibration

- T0 mean as the function of TC energy (not TC energy bin)
  - Wider ADC region

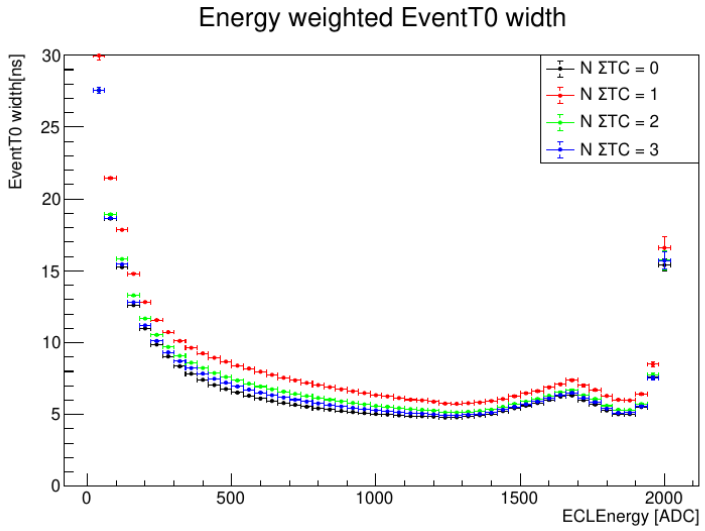


EventT0 widths for different samples

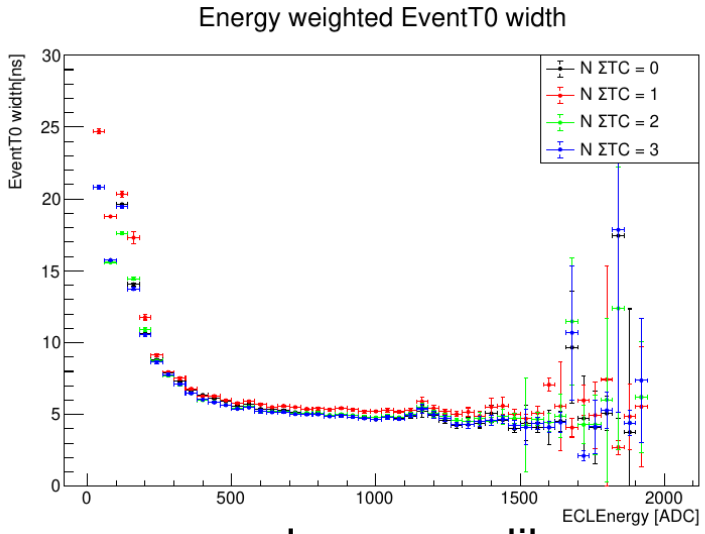
- X axis : ECLEnergy
- Why is good for hadron : N is large, and energy of each hit is small.



Bhabha_all_calib



hadron_calib



radmumu_calib