Status on ECL Trigger Calibration
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27, Aug, 2019.

Hadron & Nuclear Physics Lab

Overview

- TC energy calibration
  - Calibration algorithm
  - Performance
    - E_L E_H E_{Lum} working points and resolution
    - Energy sum of two clusters
- TC time offset calibration
  - Calibration algorithm
  - TC timing shift issue - fixed
  - Result
- Summary / Future plans

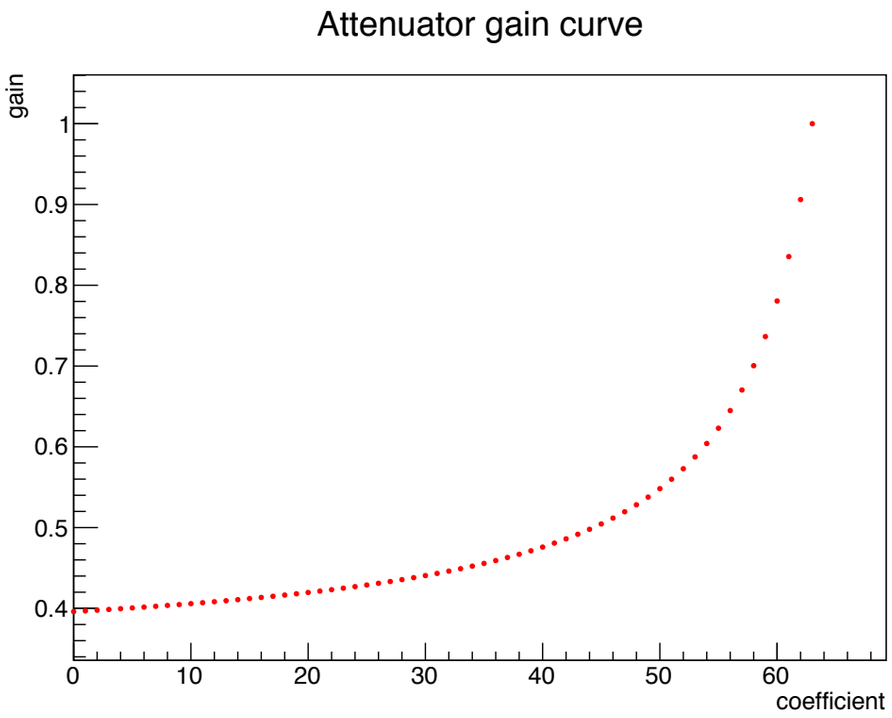
Attenuator Calibration Algorithm

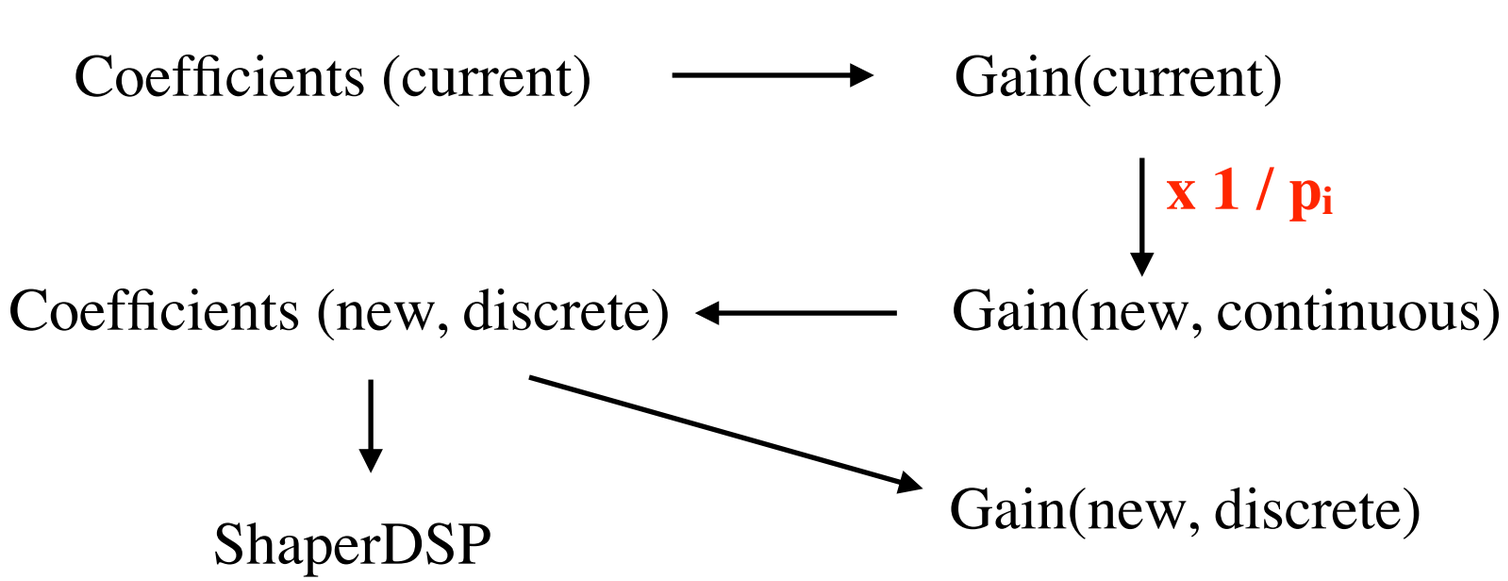
$$f(E^n, E_i^n; p_i) \equiv \sum_n (aE^n - \sum_i p_i E_i^n)^2 \rightarrow min$$

$$\frac{\partial f}{\partial p_i} = \sum_n (-2)(aE^n - \sum_j p_j E_j^n) E_i^n = 0$$

$$\rightarrow \sum_n aE^n E_i^n = \sum_n \sum_j p_j E_j^n E_i^n$$

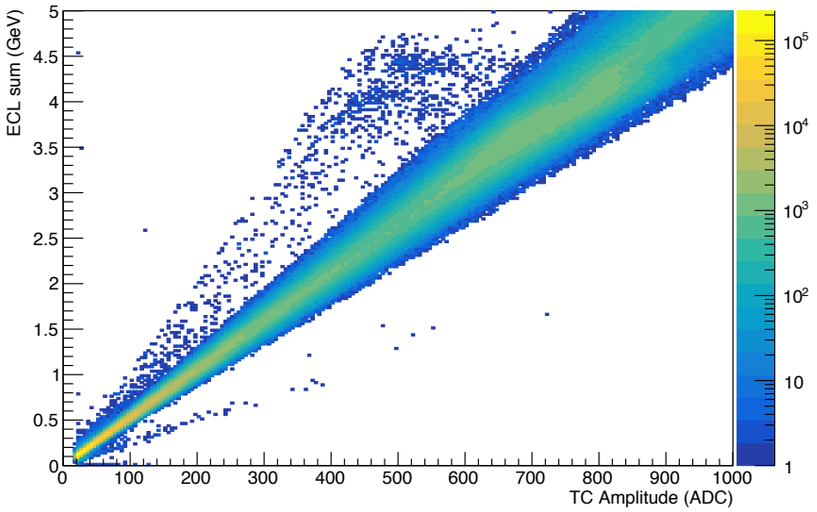
n : event index
i, j : crystal index in TC
E^n : TC energy
E^n_i : crystal energy in TC
p_i : Attenuator gain ratio (current / new)
a : calibration factor (5.25 MeV / ADC)





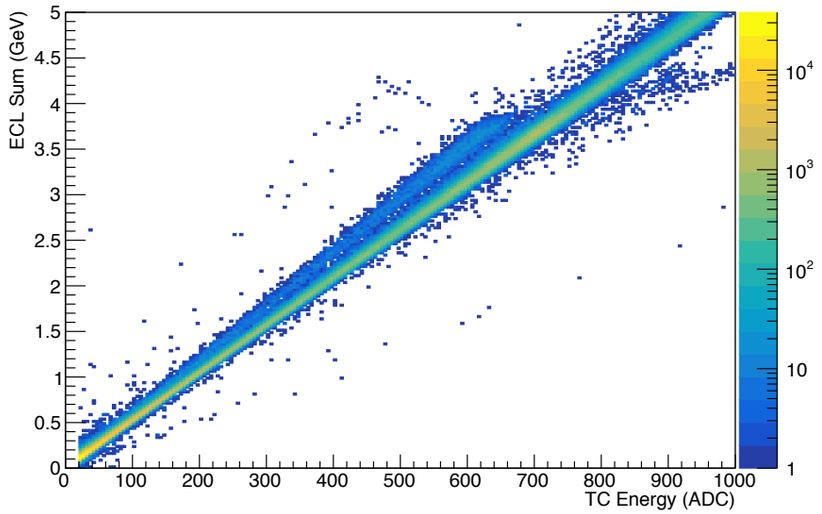
2D ECL vs. TRG scattered plot

Phase2 e0003 r5000~5613

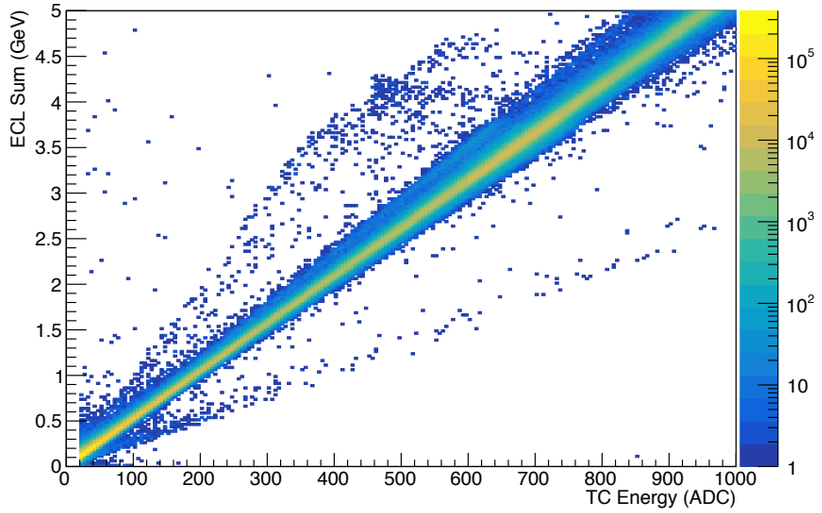


attenuator coefficients update
(first application just before Phase3)

Phase3 e0008 r00303



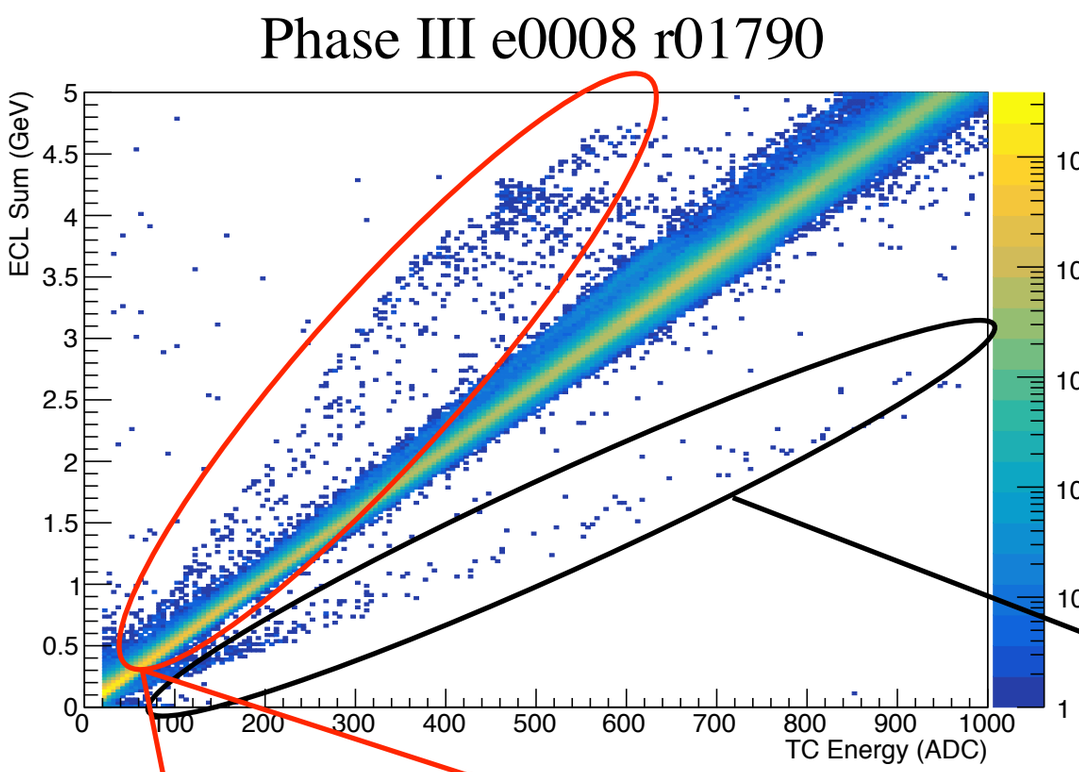
Phase3 e0008 r01790

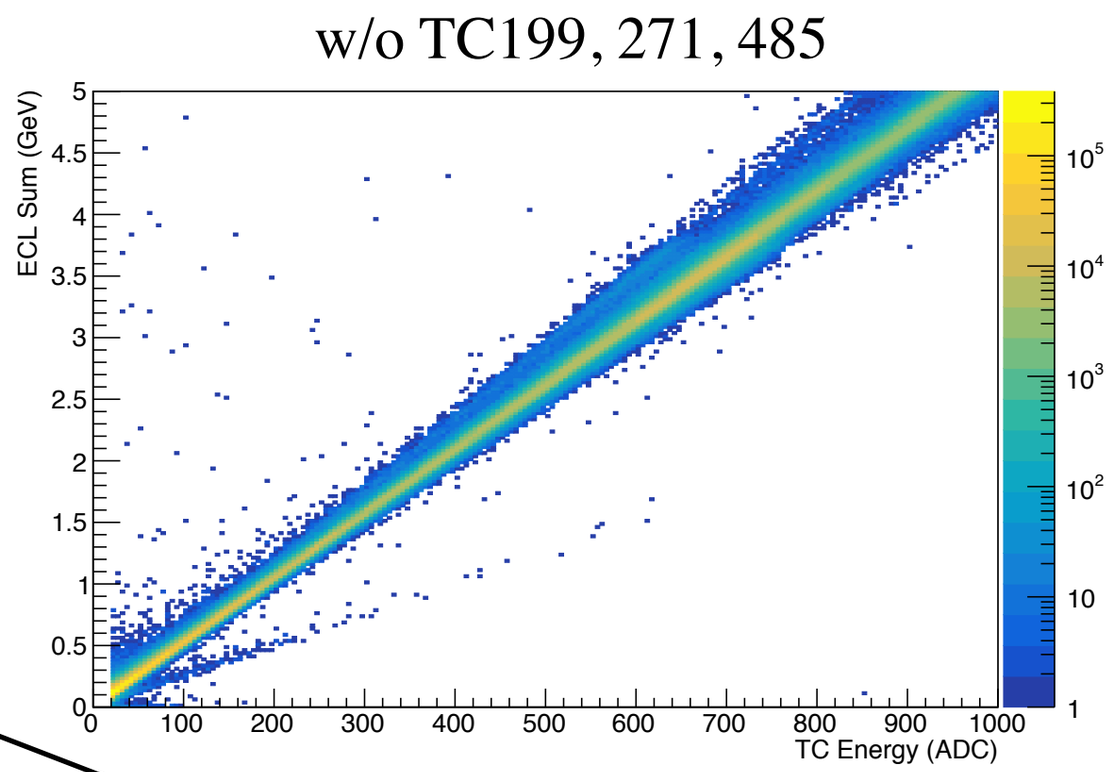


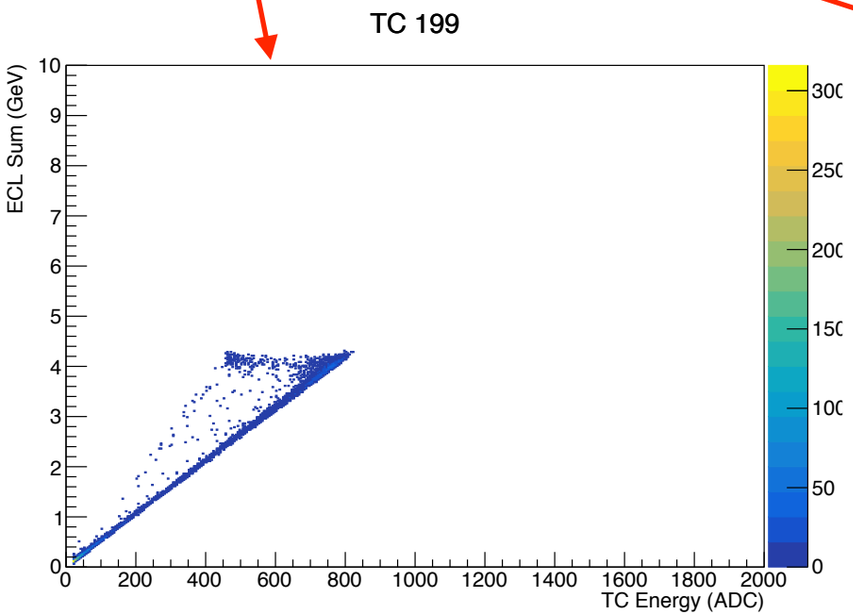
attenuator coefficients update

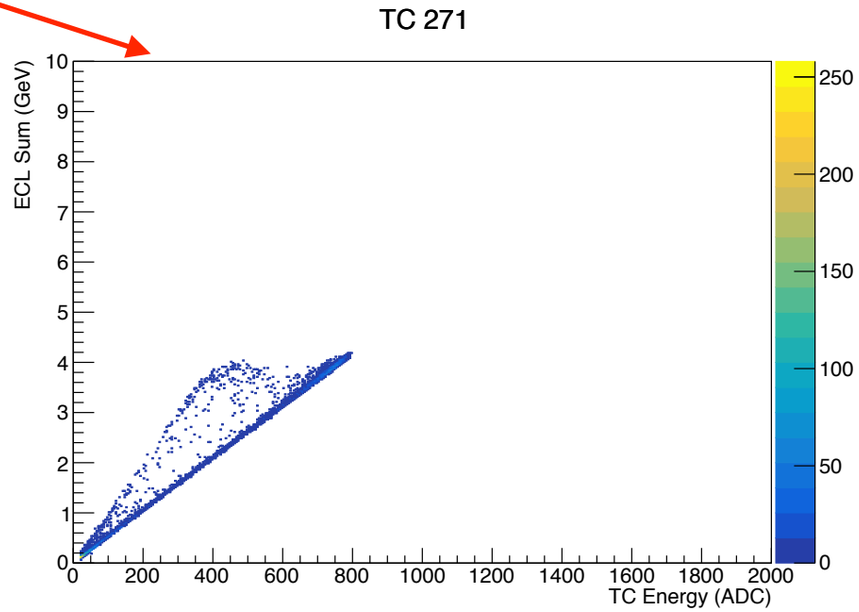
- Energy calibration method had been changed
  - TC by TC calibration(Phase2) → Attenuator calibration (crystal by crystal)
- Resolution seems quite improved. (compared to Phase2)

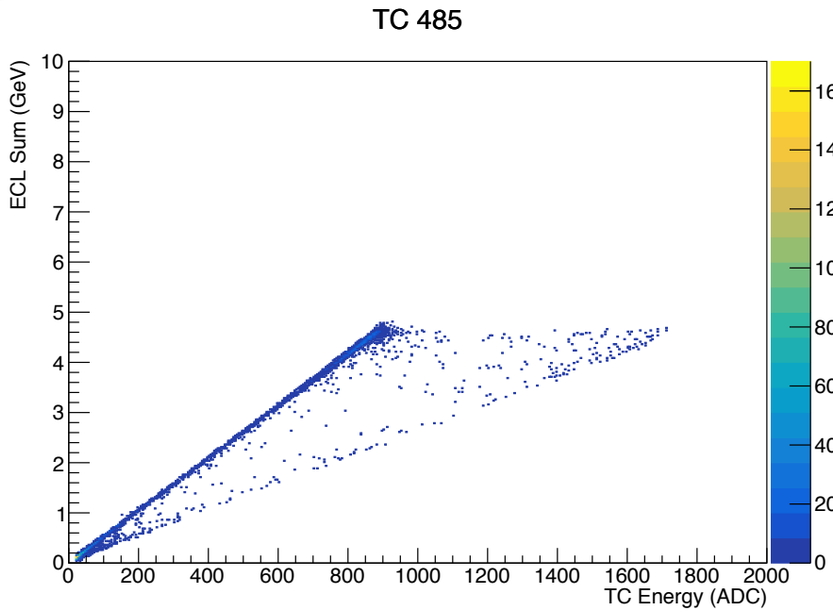
Mis-calibrated TCs









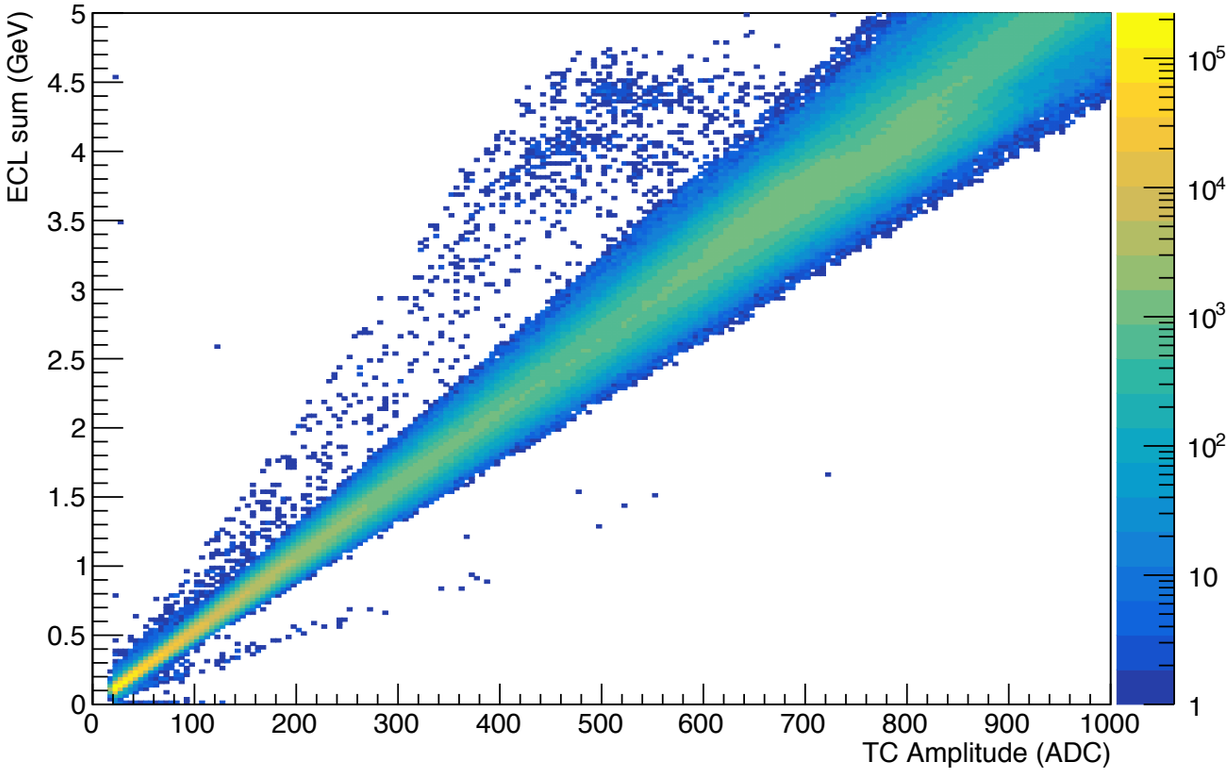


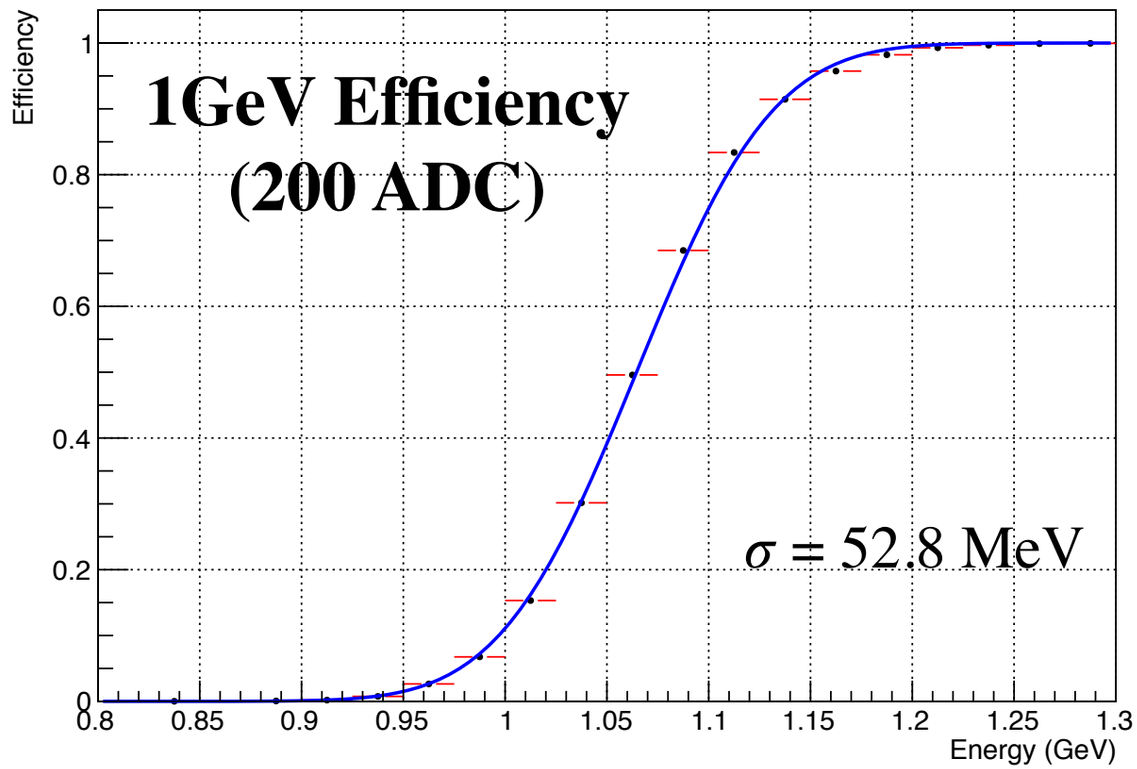
Review Phase II

prod6 Bhabha skim e0003.5000~5613

(During Phase-II ETM used 5 MeV/ADC)

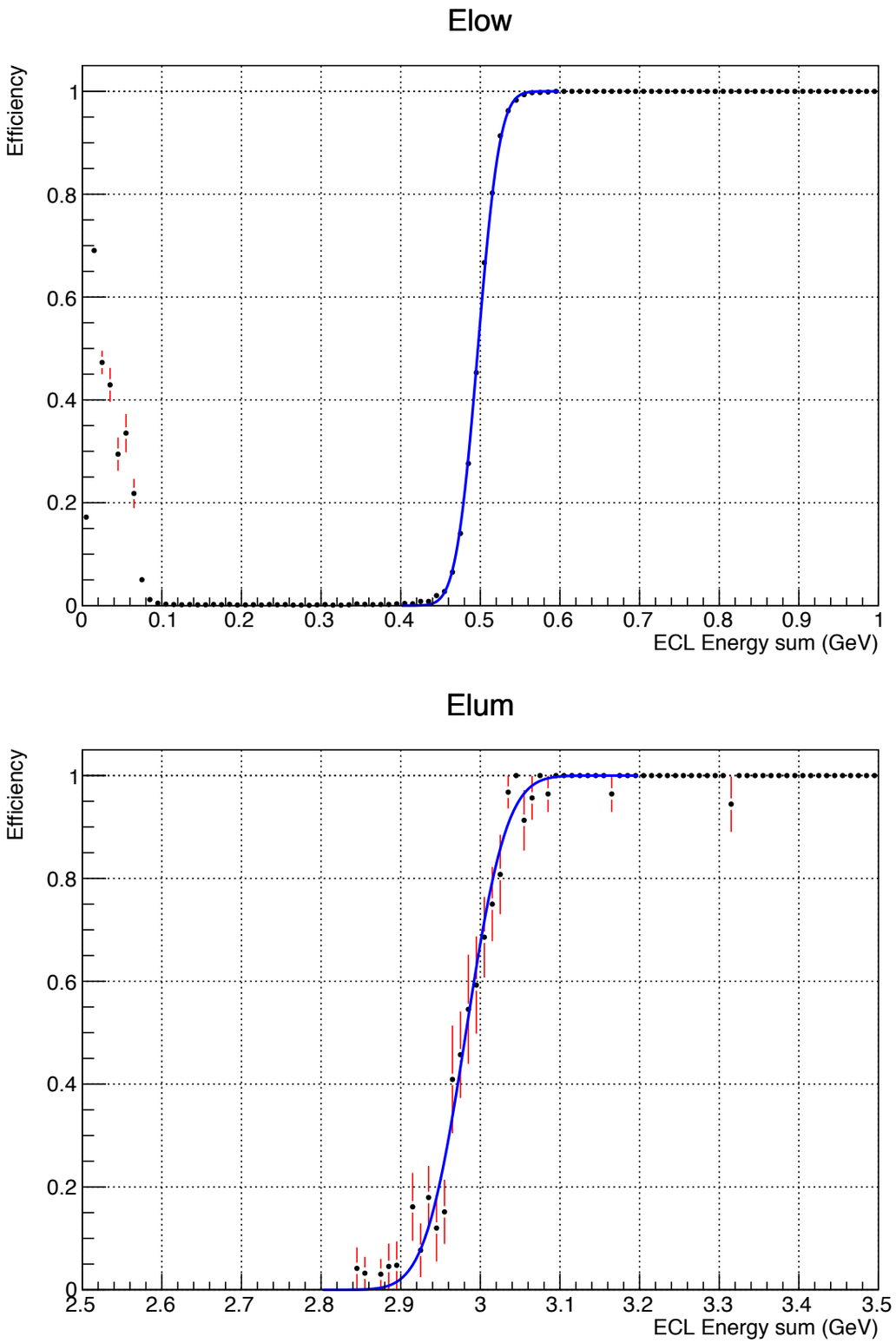
Raw data (5 MeV/ADC)

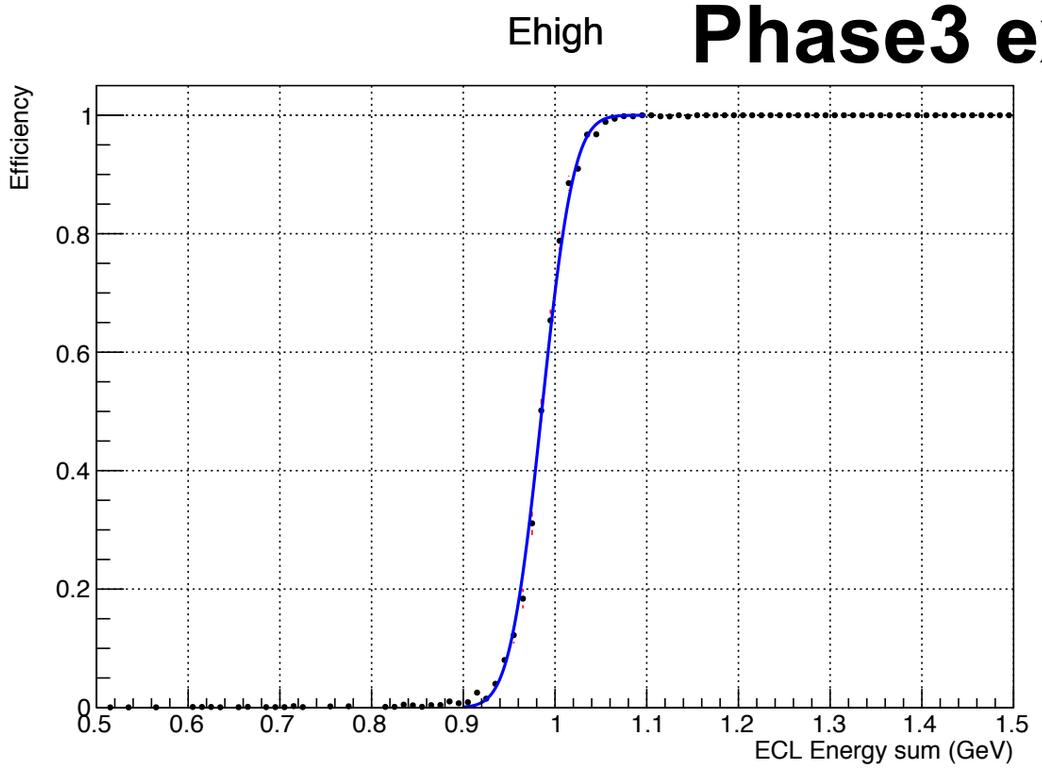




Efficiency Triggered by E_L, E_H, E_{Lum}

Phase3 exp8





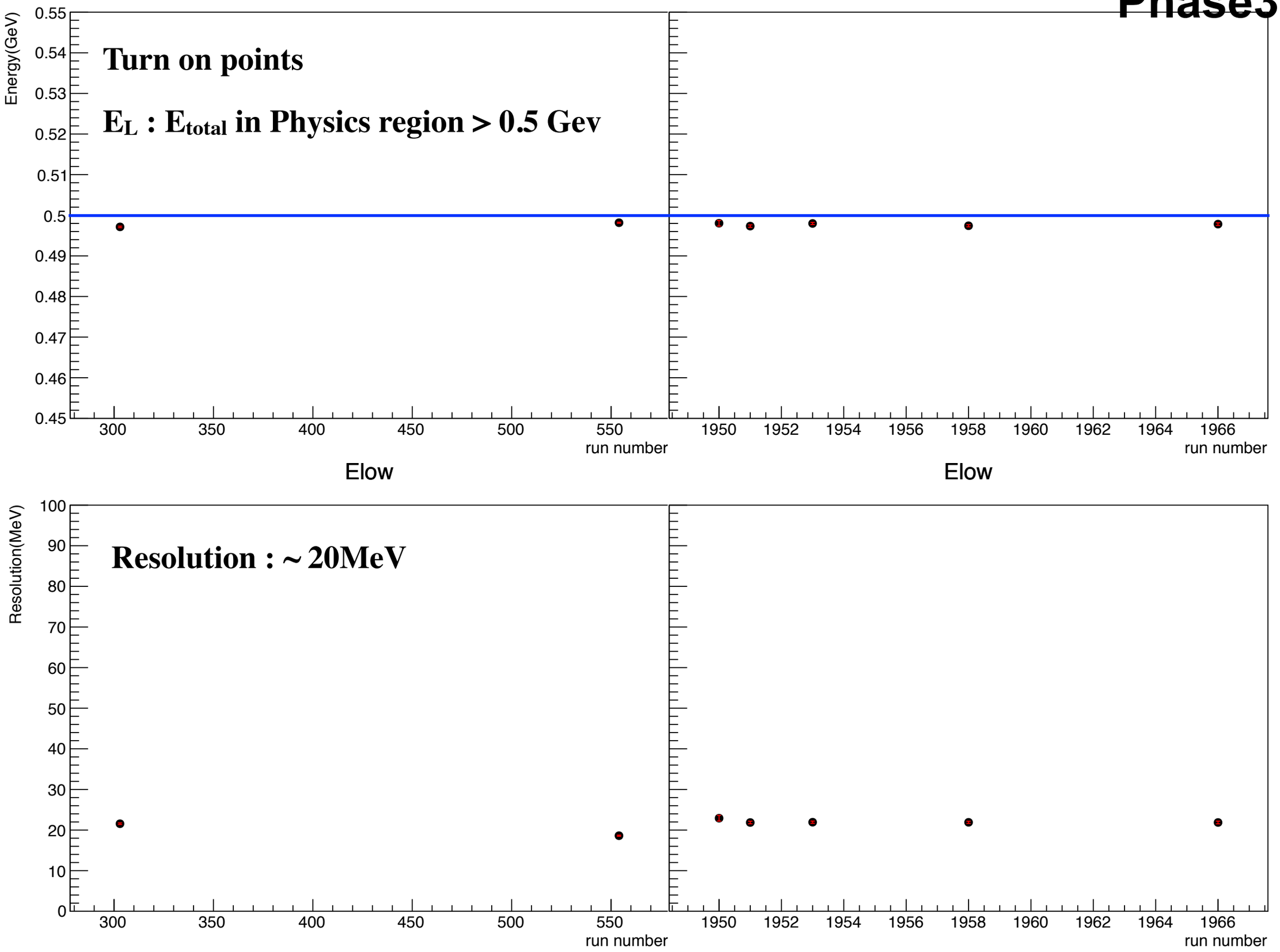
Fit function : $\frac{1}{2}(1 + erf(\frac{x - p_0}{p_1}))$

p_0 : turn on threshold

$p_1 = \sqrt{2}\sigma$

Efficiency Triggered by E_L, E_H, E_{Lum}

Phase3 exp8



Efficiency Triggered by E_{L}, E_{H}, E_{Lum}

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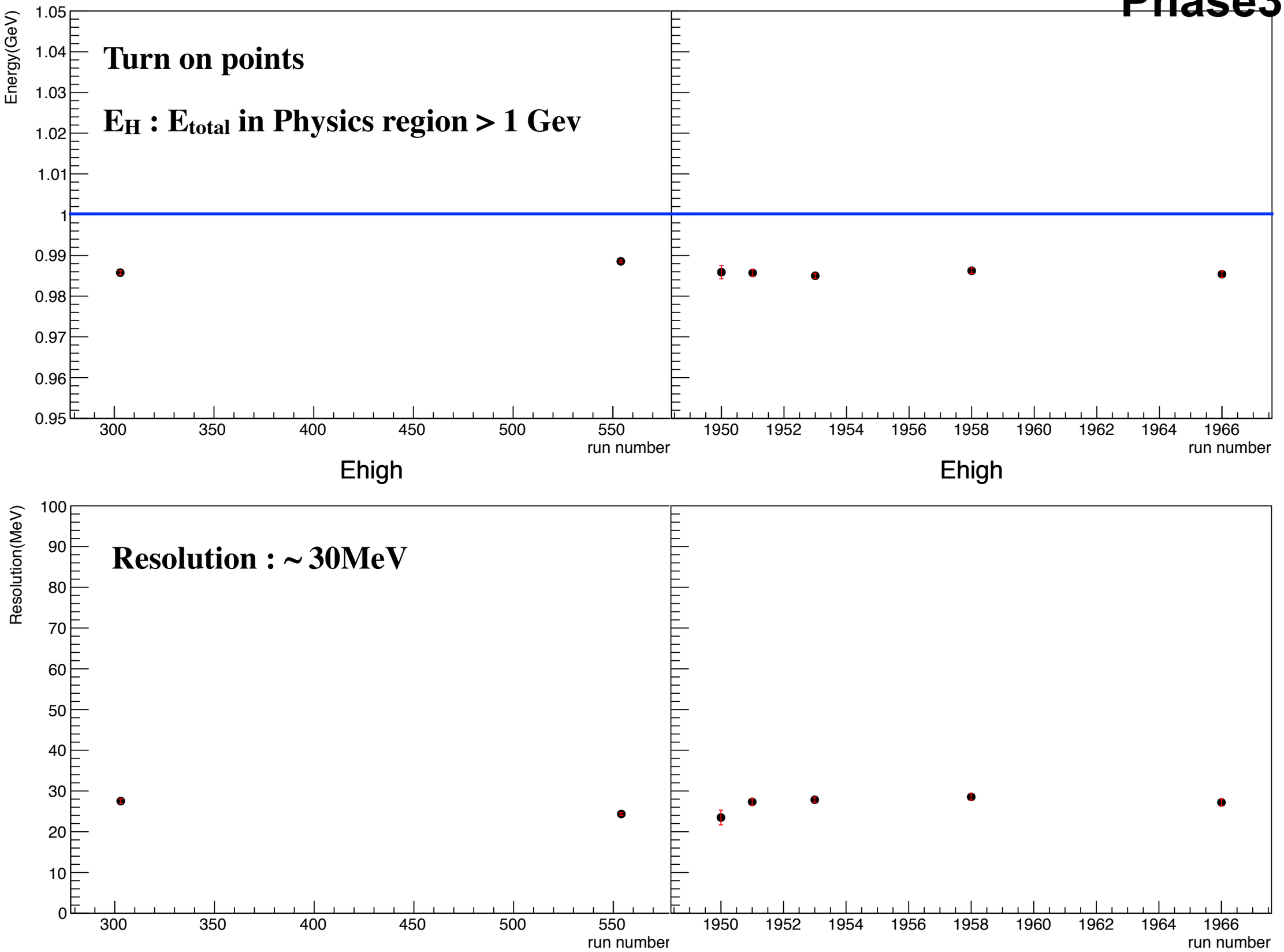
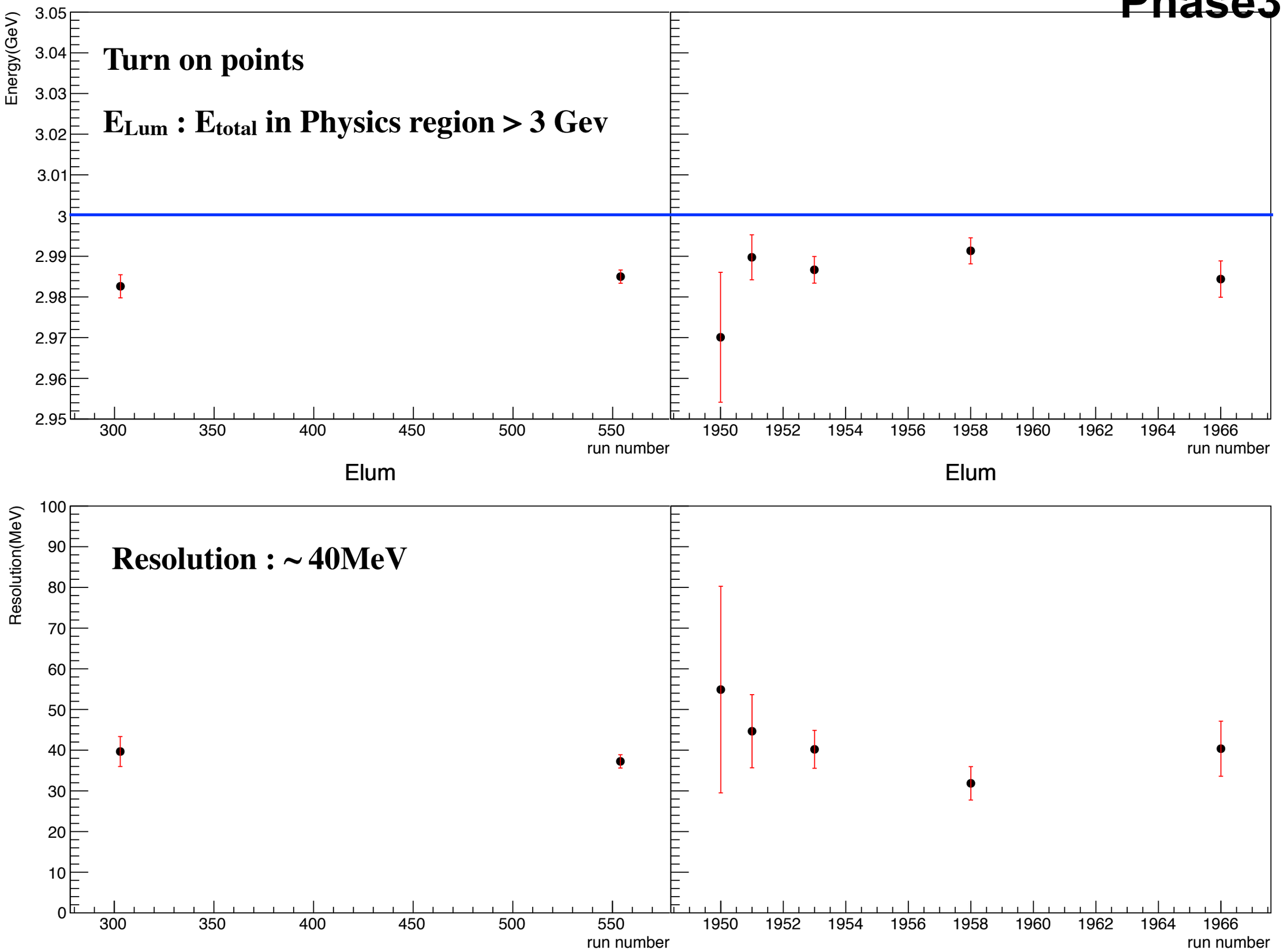


Efficiency Triggered by E_L, E_H, E_{Lum}

Phase3 exp8

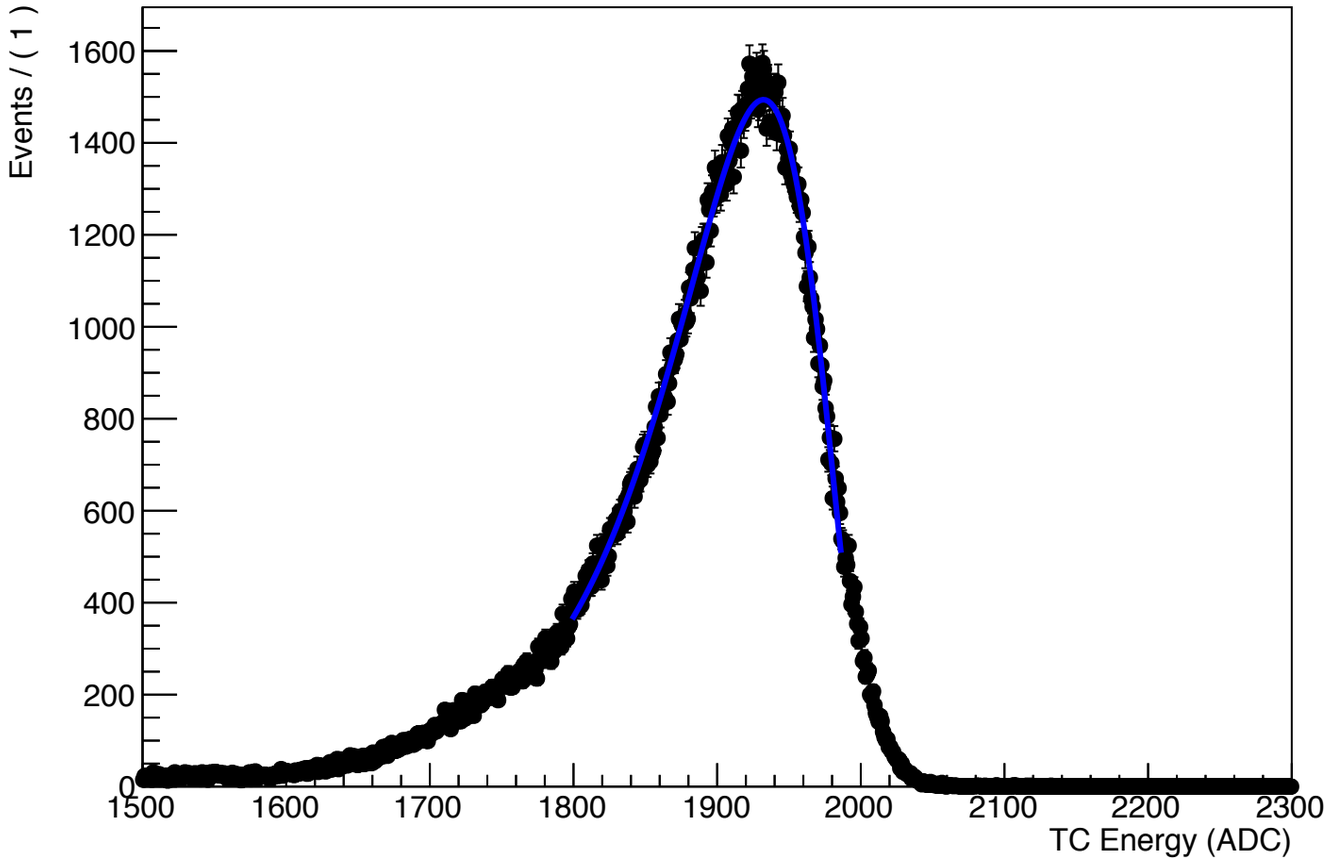


Efficiency Triggered by E_L, E_H, E_{Lum}

	Condition	Resolution	Energy difference
Elow	> 0.5GeV	~20 MeV	~1 MeV
Ehigh	> 1GeV	~25 MeV	~15 MeV
Elum	> 3GeV	~40 MeV	~15 MeV
Phase II 1GeV	> 1GeV	53MeV	~50 MeV

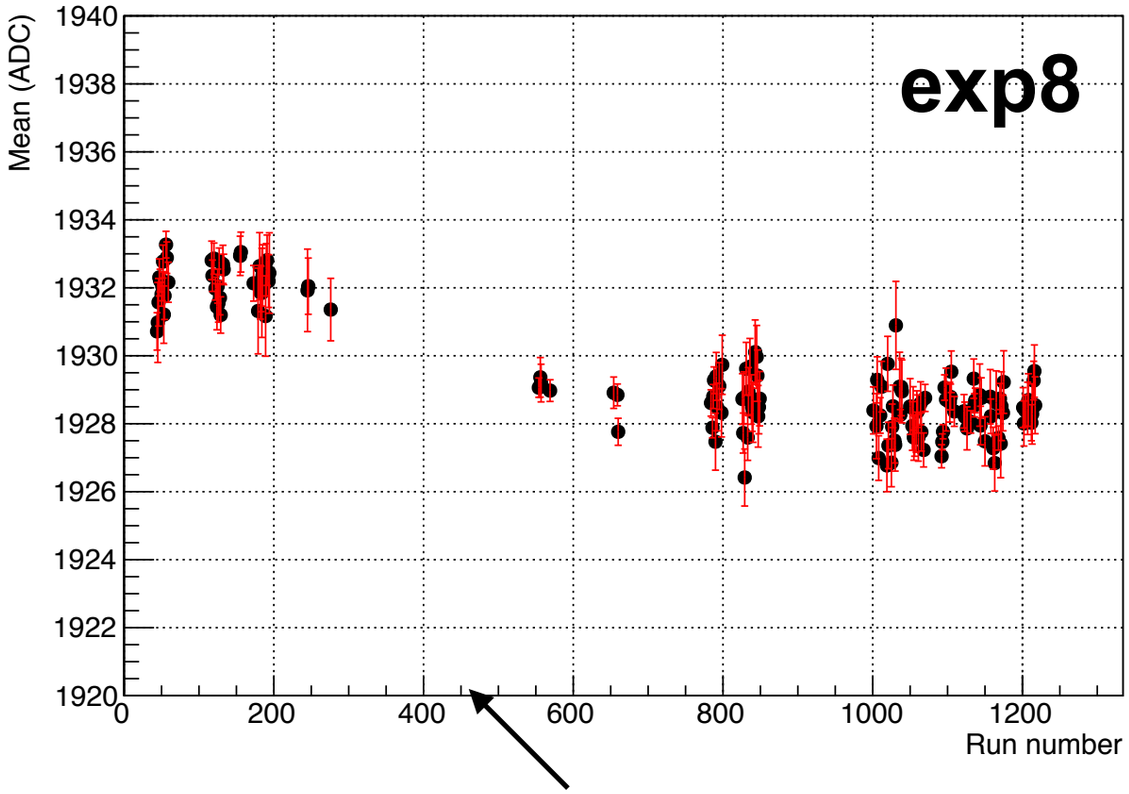
- When we look at the efficiency plots triggered by Elow, Ehigh and Elum, Turn on point seems stable
- Turn on points are slightly lower than given condition (~1 MeV, ~15MeV, ~15MeV for Elow, Ehigh, Elum respectively)
- Of course, resolution is improved (52.8MeV -> 25MeV at 1GeV)

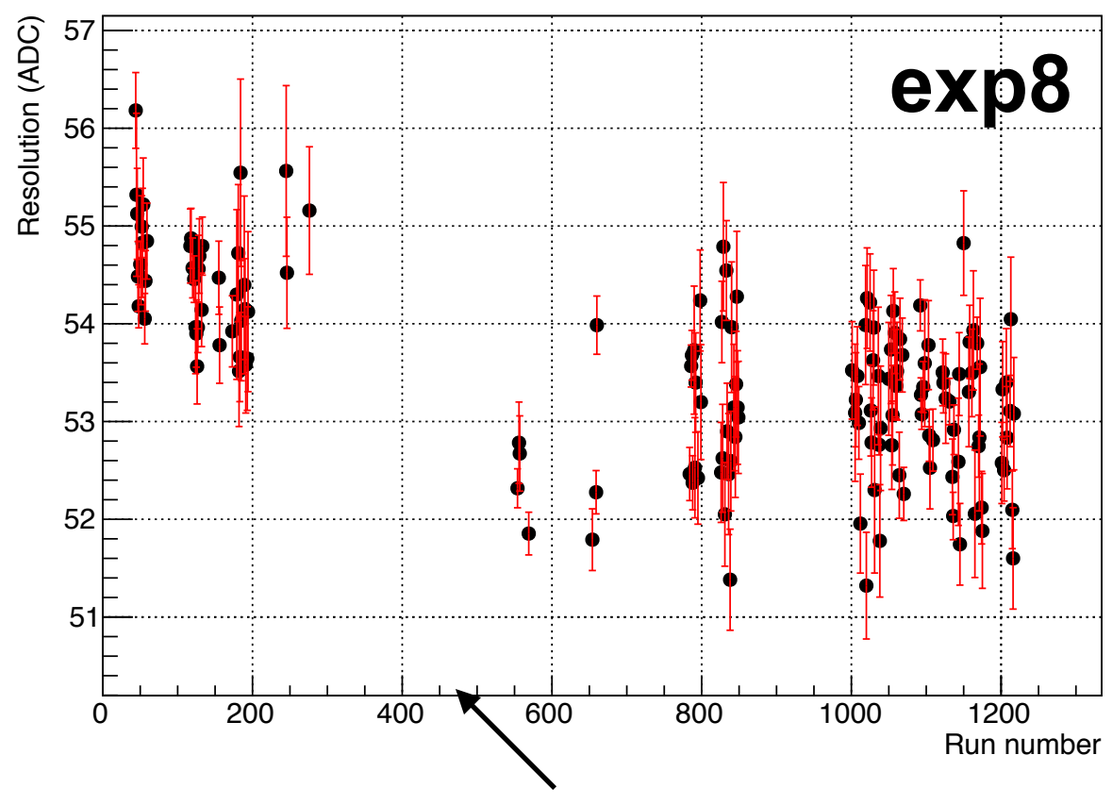
Energy sum of two clusters



- Selection criteria
  - Entries > 1M for each run
  - Bhabha_veto == 1
  - Number of Clusters == 2
- Fit to Novosibirisk function

Energy sum of two clusters





- TC cluster energy sum looks quite stable (mean values are in 2~3 ADC)
- Attenuator update slightly affects on energy mean and resolution

T0 calibration algorithm

- Same as ECL time offset calibration algorithm

$$f(t'_1, \ldots, t'_{576}) = \sum_{n,i,j} \frac{(t_i^n - t_j^n - t'_i + t'_j)^2}{(\sigma_{i,j}^n)^2} \rightarrow minimize$$

Inserting a reference TC time offset $t'_{184} = 0$,

$$\frac{\partial f}{\partial t'_i} = 0 \rightarrow \sum_{j \neq 184} \frac{t'_i - t'_j}{(\sigma_{i,j}^n)^2} + \frac{t'_i}{(\sigma_{i,184}^n)^2} = \sum_{j \neq 184} \frac{t_i^n - t_j^n}{(\sigma_{i,j}^n)^2} + \frac{t_i^n - t_{184}^n}{(\sigma_{i,j}^n)^2}$$

$\left(\sum A^n\right)\overrightarrow{t'} = \sum \overrightarrow{t^n}$ 575×575 Matrix equation

where, t_i^n : time for TC i in n-th event

t'_i : time offset for TC i

$(\sigma_{i,j}^n)^2 = 1/(E_i^n)^2 + 1/(E_j^n)^2$: time resolution

E_i^n : Energy deposit for TC i in n-th event

Currently,

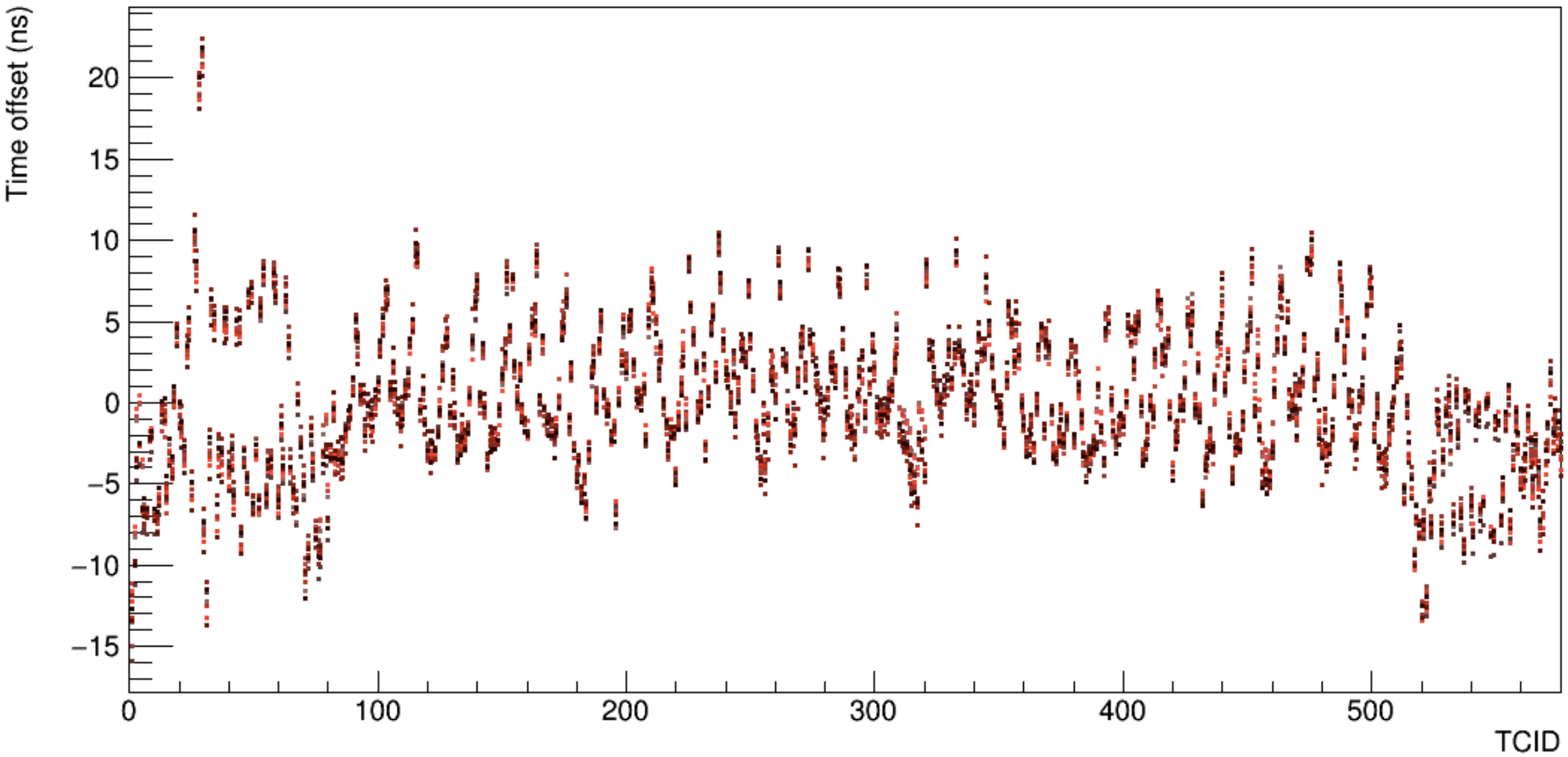
1ns at 1GeV

5.25 MeV / ADC

Timing shift issue

- Unno san found FAM firmware problem and fixed it during phase3 run
- Time offset calibration was resumed (last B2GM).
- TC timing became stable.
- New time offset was updated on FAM and it is applied from exp8 run02974.

Time offset

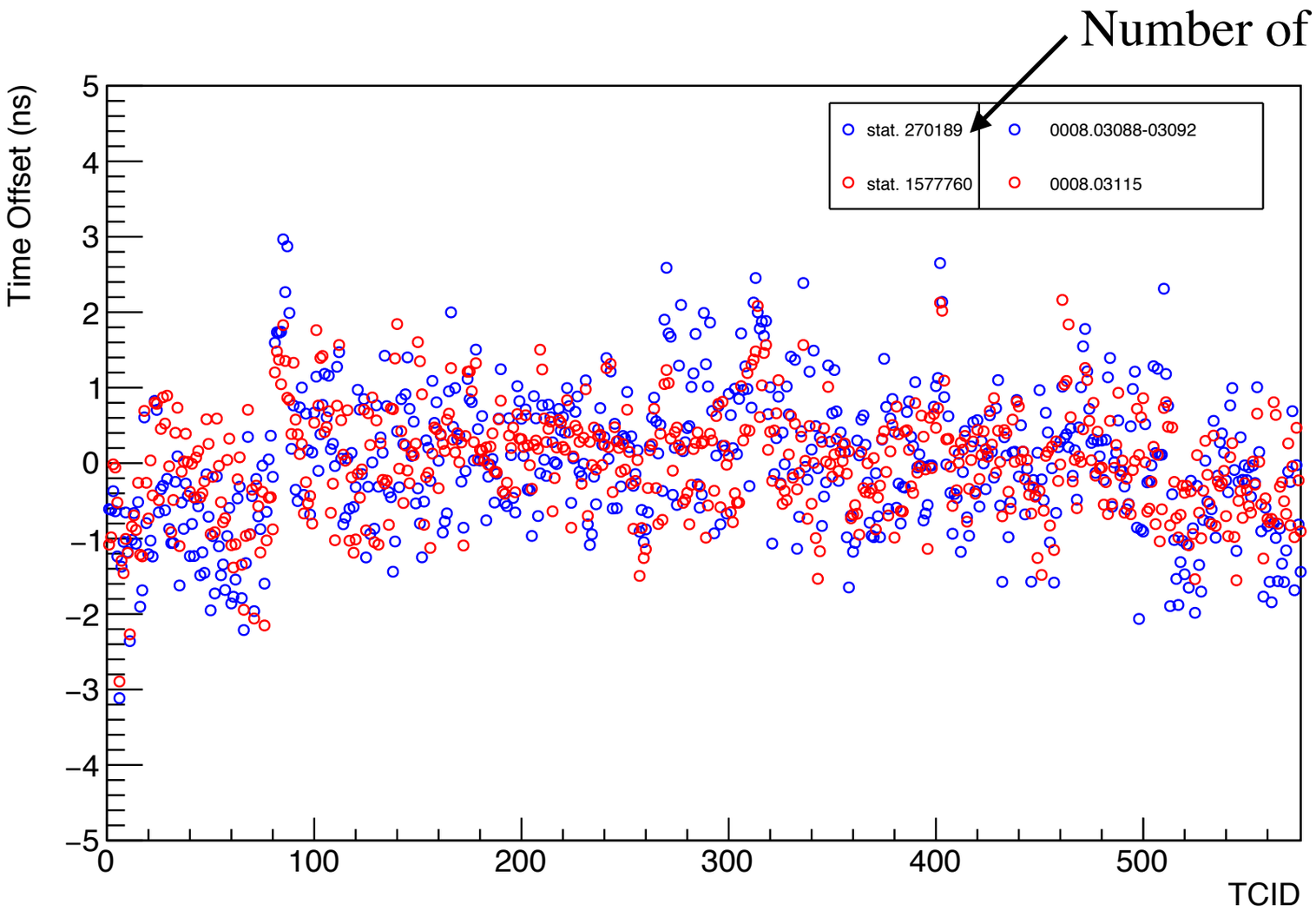


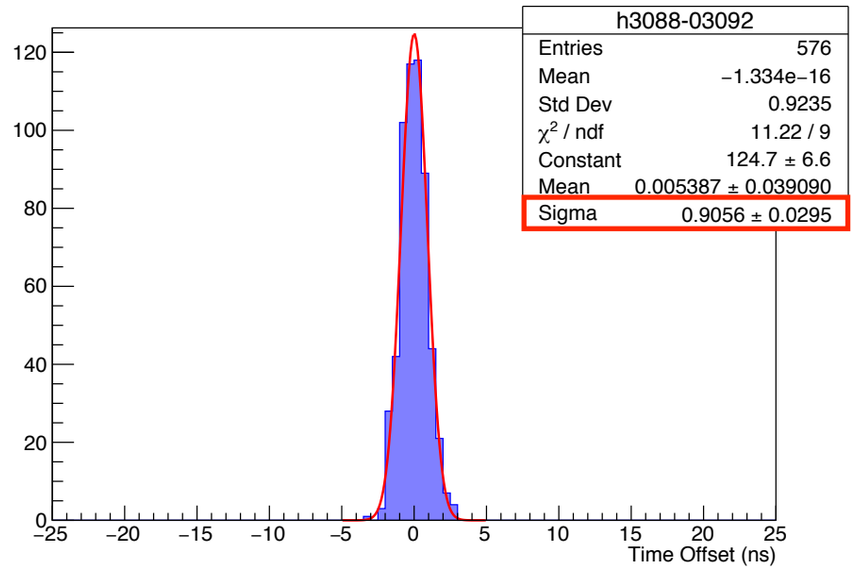
0008.01539
0008.01544
0008.01553
0008.01715
0008.01737
0008.01738
0008.01790
0008.01791
0008.01792
0008.01801

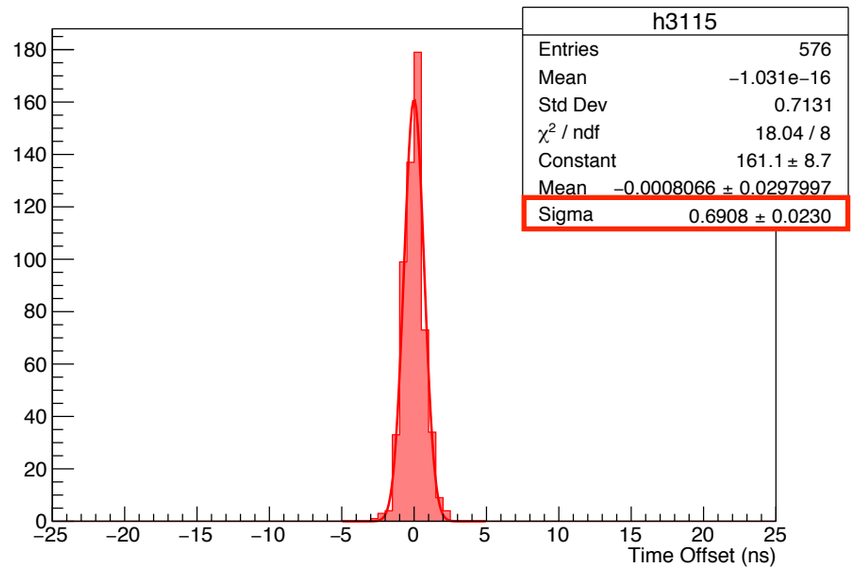
- We resumed time offset calibration
- Few ns deviation
- Time offset was updated during Phase3
  (this update is reflected from e8 run2974)

- Prompt Bhabha skim && 3D Bhabha veto == 1
- 1GeV < TC energy < 10 GeV
- # of entries > 10M for each run

After time offset download







- After time offset parameter was downloaded on FAM, Time offset estimation was performed.
- Deviation less than 1ns

Status / Plan

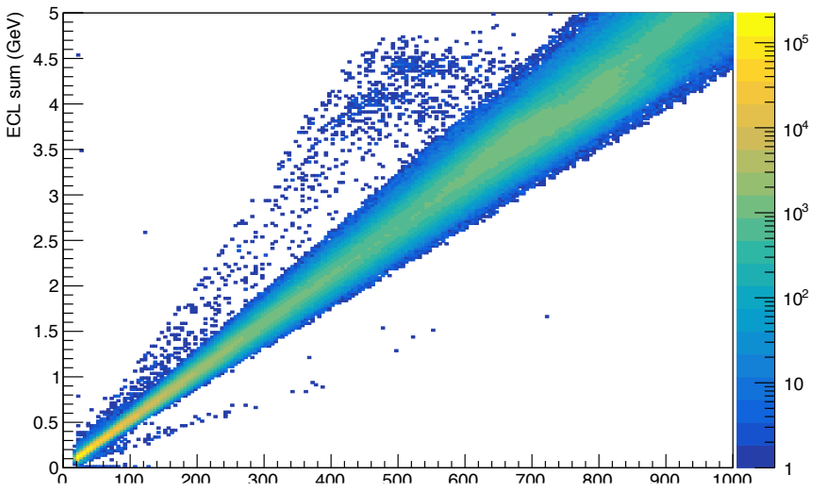
- Attenuator calibration shows improvement of accuracy and resolution
- TC timing/energy looks quite stable during Phase III
- Large time resolution from Xtal by Xtal timing discrepancy
- Time offset calibration module is released (from release 04)

- **New attenuator coefficient preparation by using cosmic before next physics run**
- **Preparation of attenuator calibration module**
- **Test pulse utilization**
  - **Automatization of energy and timing calibration**

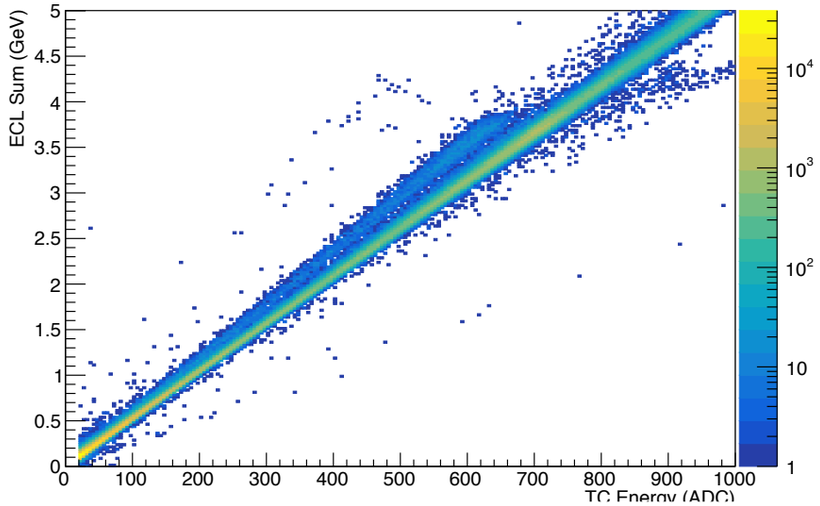
back up

2D ECL vs. TRG scattered plot

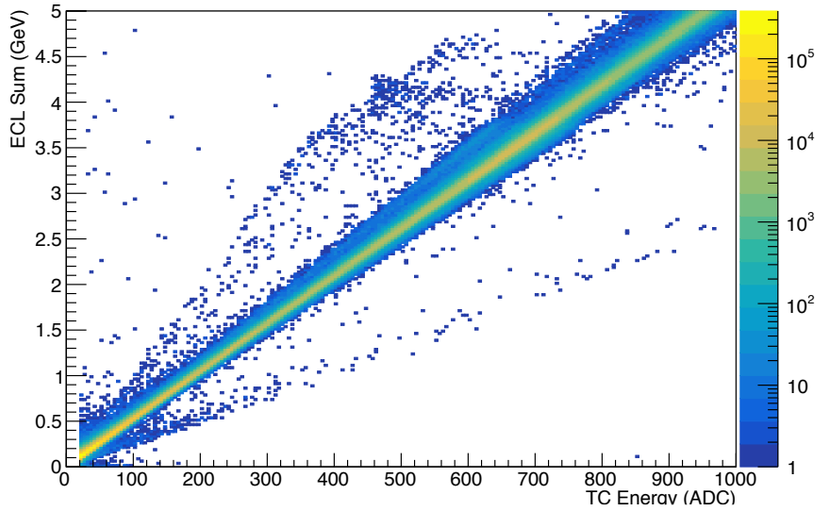
Phase2 e0003 r5000~5613

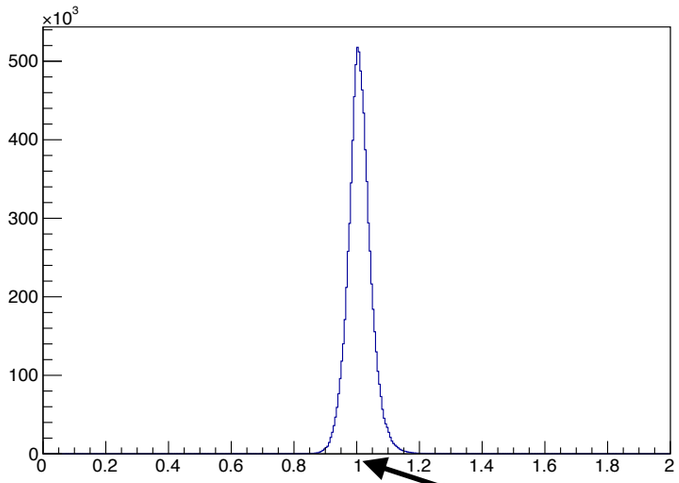


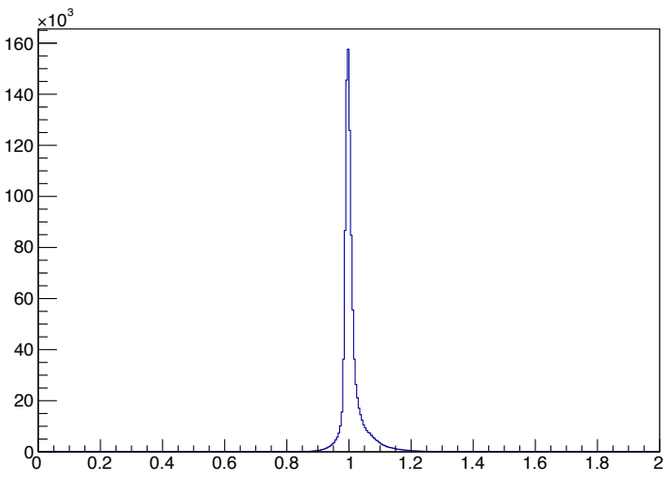
Phase3 e0008 r00303

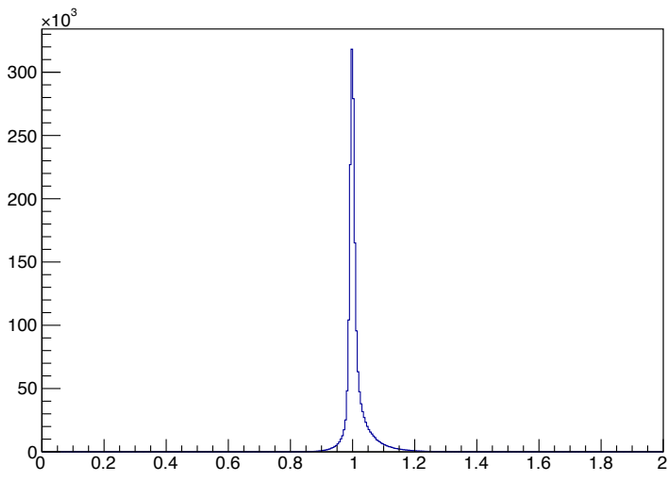


Phase3 e0008 r01790









tan^{-1}(slope) distribution : “1” correspond to 5.25MeV/ADC