44th B2GM Trg session 2023.02.08

Status of ECLTRG energy calibration

Eunji Jang

jej6744@gnu.ac.kr

Contents

[Review]

- We found bad channels with gain greater than 1.
- We expected it to be controlled by changing jumper setting.
- Jumper setting change of the 3 sample channels were succeeded.

  (https://indico.belle2.org/event/7727/timetable/#20221130.detailed)

  → **We have to decide consistently which channels to change the jumper setting.**

[Current study]

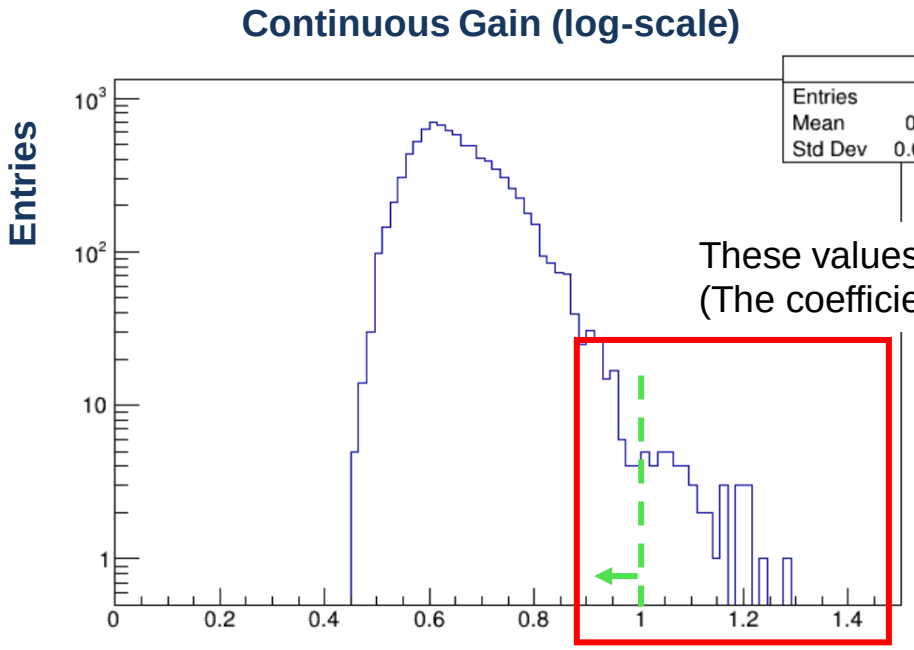
For the consistency check,

1. ECLTRG hit map with chi2 check
2. Cut condition study
3. E(maximum crystal E in a TC) with cell ID

The plot of continuous gain

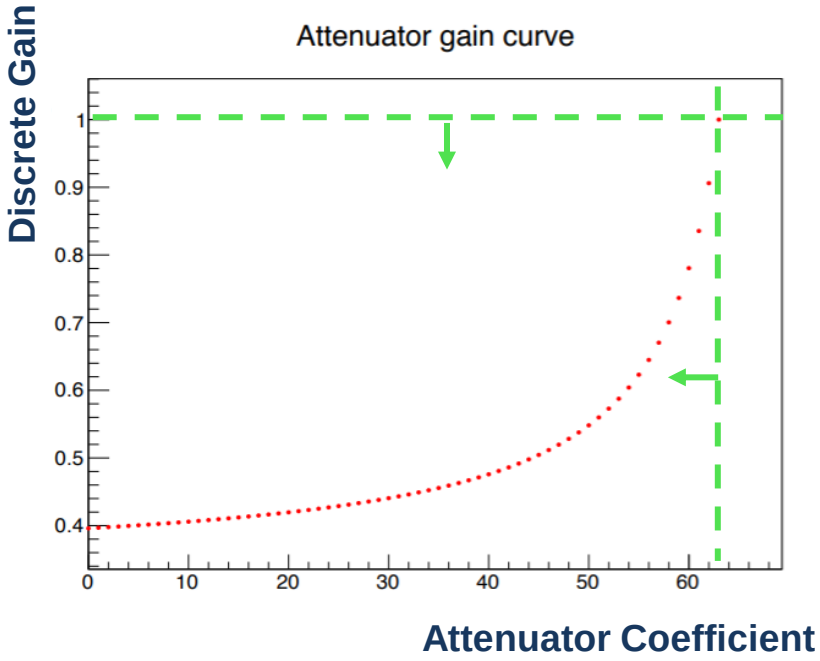
Our purpose for proper calibration :

It is to reduce the high attenuator gain ‘exceeding 1’ by doubling the gain of the jumper.



These values are stored in SDSP as 1.
(The coefficient of 63 has a gain value exceeding 1.)

The gain must be moved to a value less than 1 for correct calibration.



ADC conversion factor (5.25 MeV/ADC)

$$\sum_n \alpha e^n E_i^n = \sum_n \sum_j \beta_j E_j^n E_i^n$$

ECLTRG energy

ECL energy

Gain ratio = New gain / old gain

- Continuous gain by calculating matrix
- Discrete gain by matching attenuator coefficient

$$Gain = \frac{1 + \frac{470}{2500\left(1 - \frac{Att}{63}\right) + 240}}{1 + \frac{470}{240}}$$

ECLTRG hit map with chi2 check

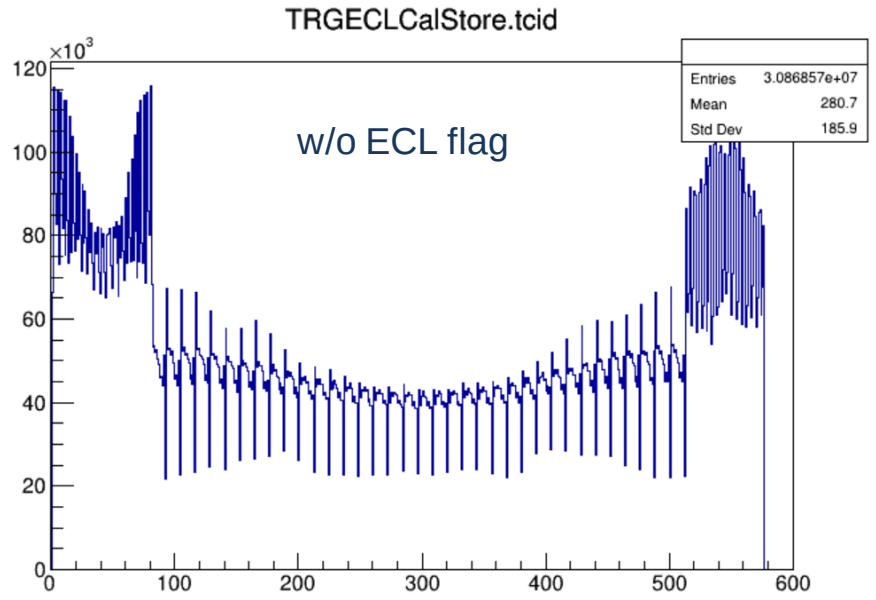
For getting good data, we selected the data with ECL flags.

- ECLQualtiy in ECLDigits : amplitude > low amplitude threshold && **bad χ^2**
- ECLStatus in ECLCalDigits : 7 is 1 + 2 + 4 = 2^0 + 2^1 + 2^2, so bits 0, 1, 2 (energy calibrated, time calibrated, time resolution calibrated).

https://confluence.desy.de/pages/viewpage.action?spaceKey=BI&title=ECL+Quality+flag

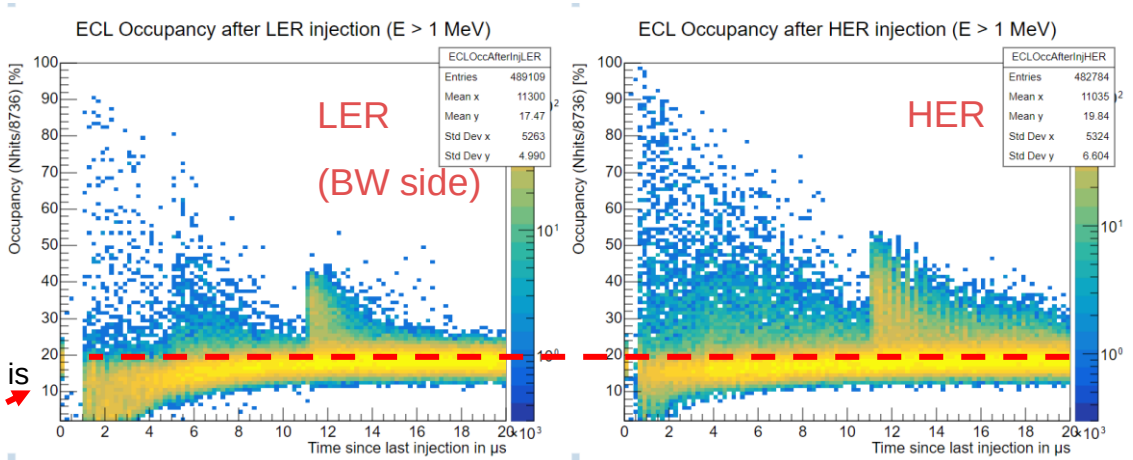
→ The ecl data should be calibrated with energy and timing, and the bad χ^2 data should be removed.

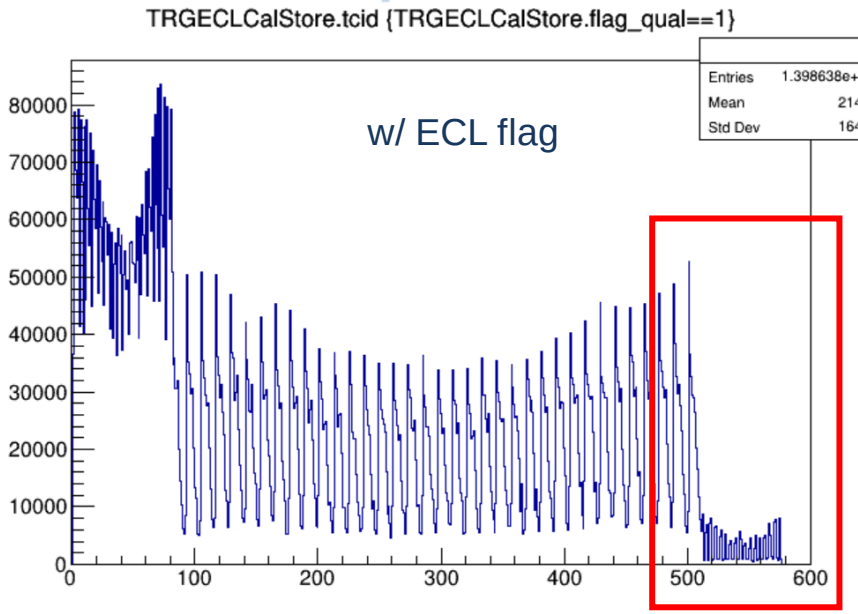
Exp21 (2021/ 11), beam data (bhabha + hadron skim)



Background check

It is an ideal if the line is drawn horizontally.





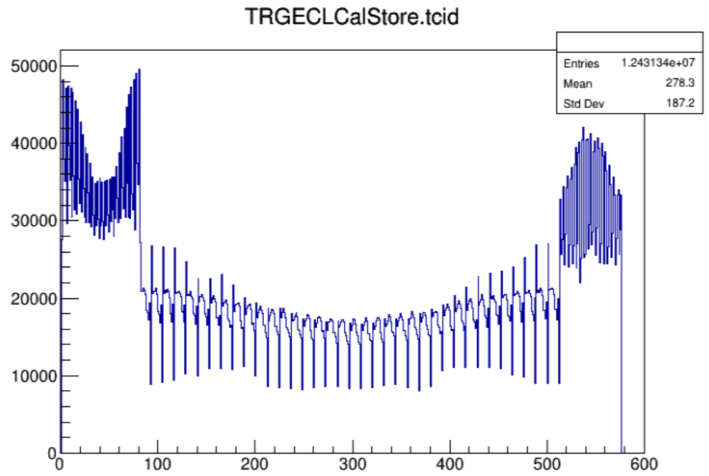
Applying the ecl flag significantly reduced the number of entries in BW.

ECLTRG hit map

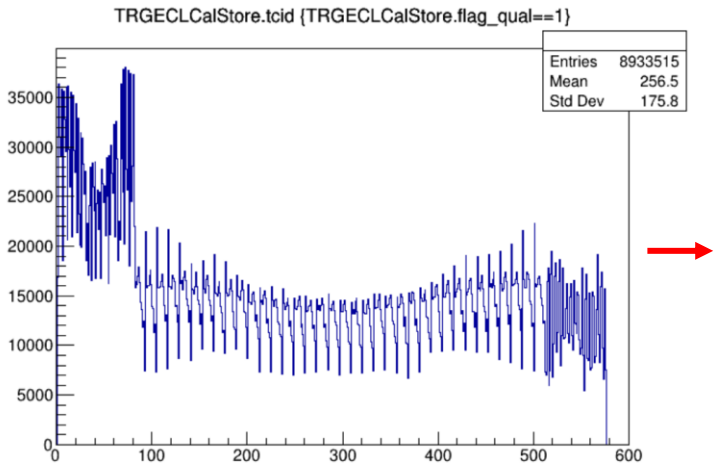
- It was confirmed that the worse the occupancy of LER, the more entries of BW disappeared.

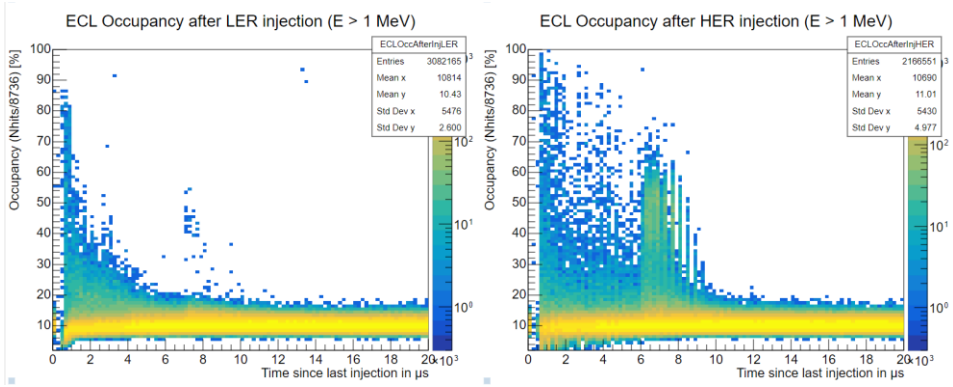
Exp24 (2022/04)

w/o ECL flag



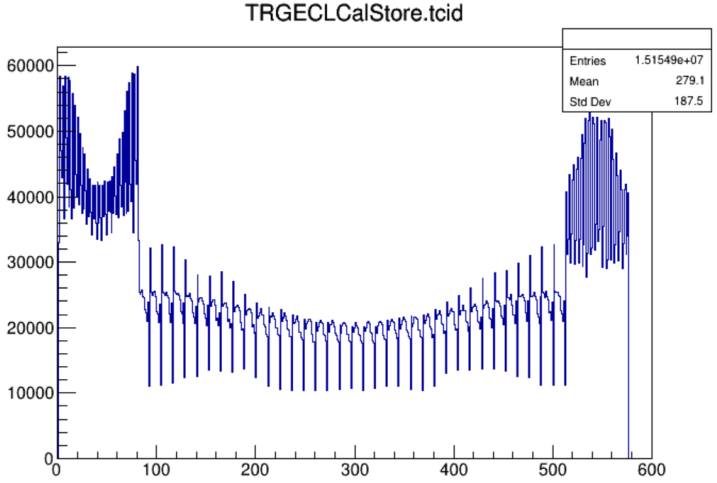
w/ ECL flag



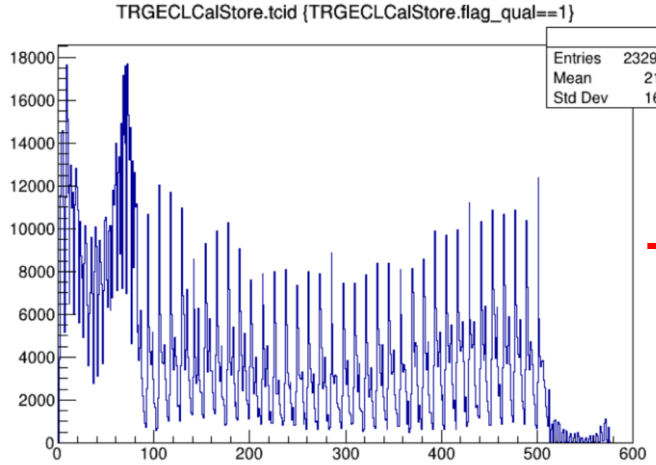


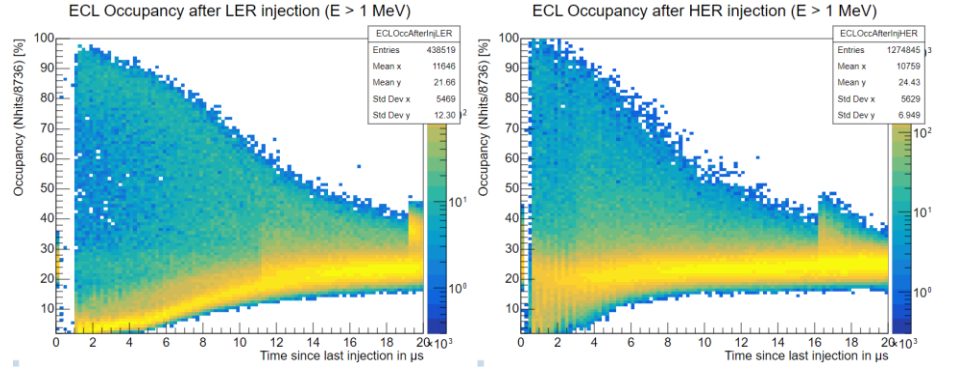
Exp26 (2022/06)

w/o ECL flag



w/ ECL flag

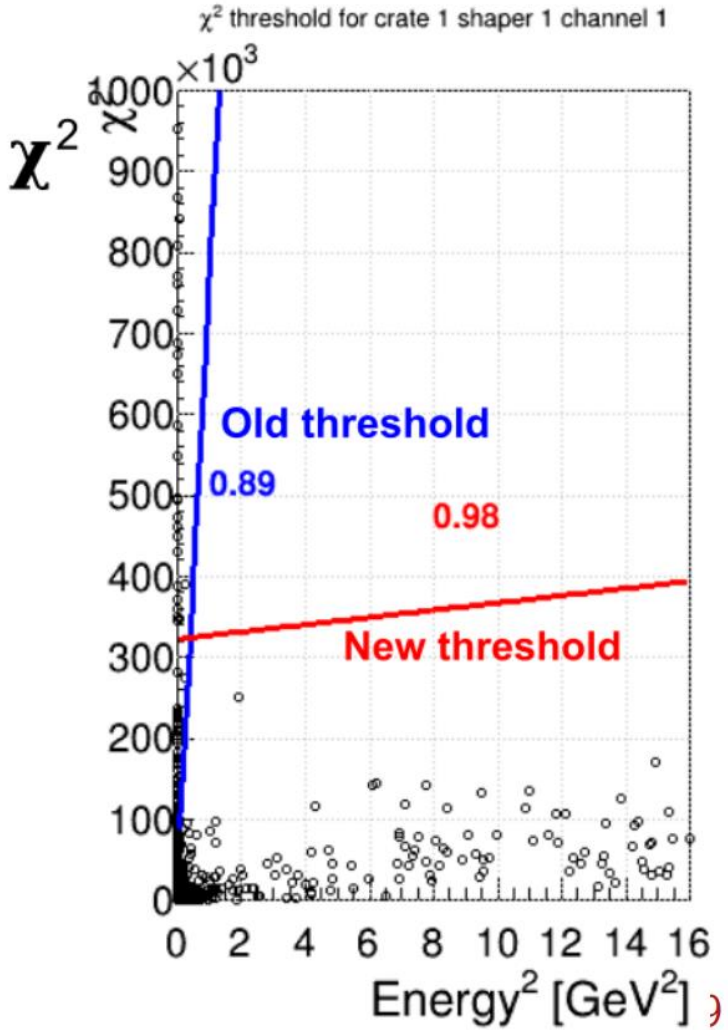




Worst

χ^2 threshold estimation

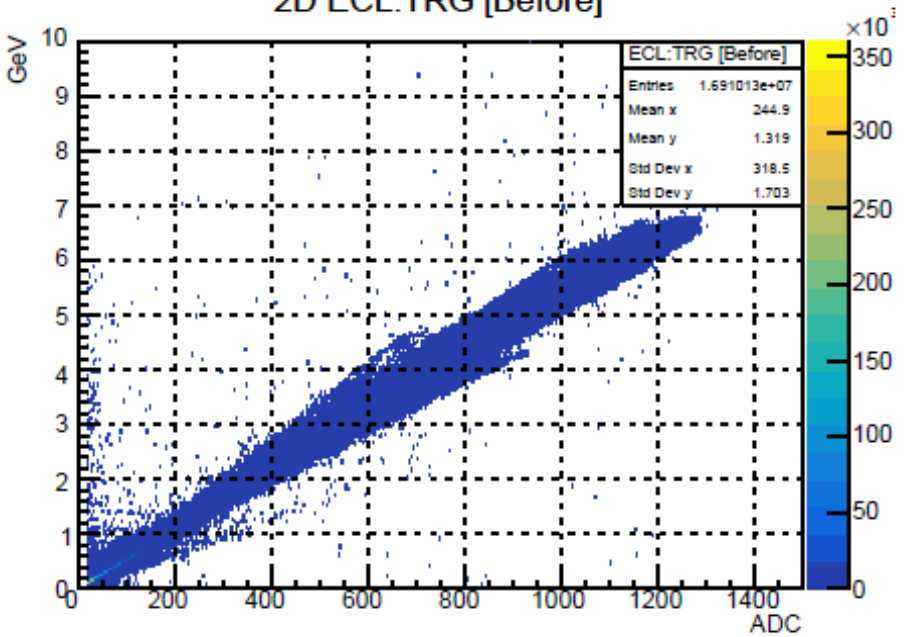
- Currently, all ECL channels use the same χ^2 threshold for setting fit quality flag.
- I have processed several runs from exp 26 (gamma gamma skim) to determine new parameter values for χ^2 threshold (it is determined as $k_0 + k_1 \cdot \text{amp}^2$).
- Overall, new thresholds should be less restrictive for low-energy hits and more restrictive to high-energy hits.
- To fully update *chi*^{2} thresholds in ShaperDSP modules, firmware update is necessary.
  (currently, it is only possible to set same pair of k_0, k_1 for all channels in ShaperDSP)



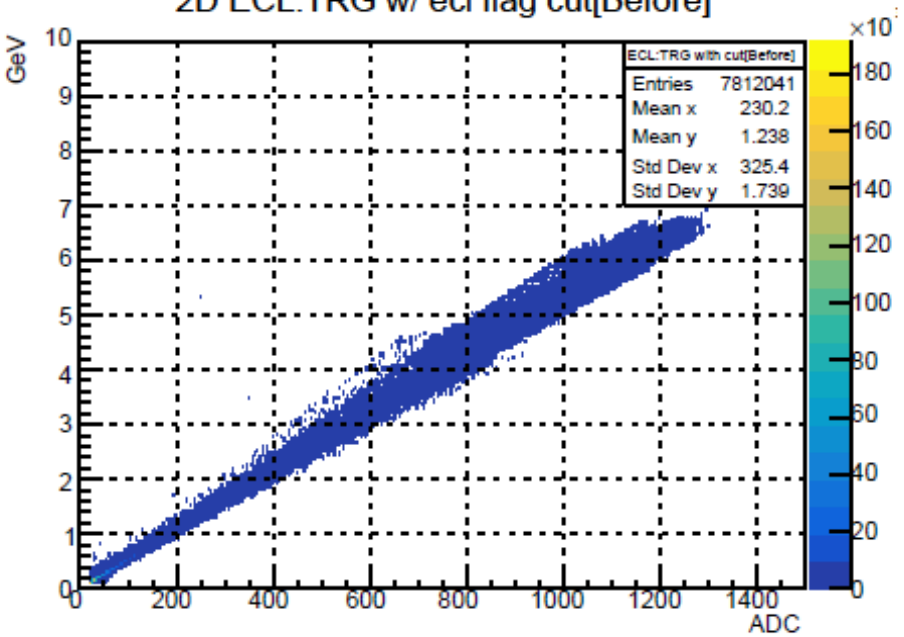
This parameter is related to the beam background.
we were recommended not to use it.

ECLTRG hit map

w/o ECL flag



w/ ECL flag



Used data : exp21

- Many bad distributions can be removed by the ecl flag (χ^2).
- It seems to be more useful to use the ecl flag with other conditions.
- we need additional study and discussion to use the ecl flag well.

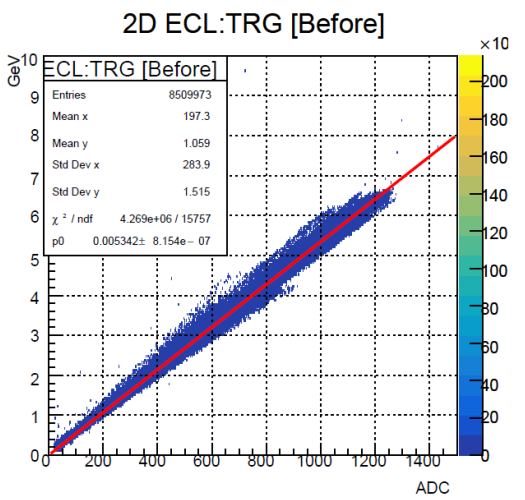
Cut condition study (exp 24/bhabha+hadron skim/0.6 & 1.0/fb)

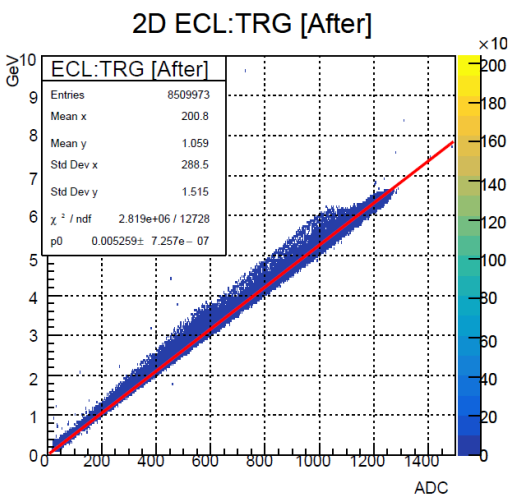
Energy cut used for matrix calculation : ECLTRG E > 30 ADC

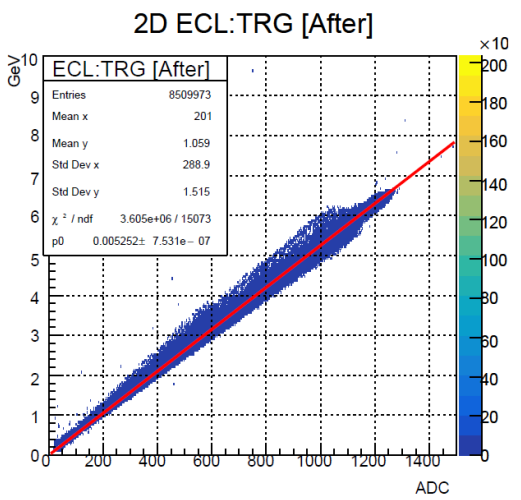
ECLTRG E > 100 ADC

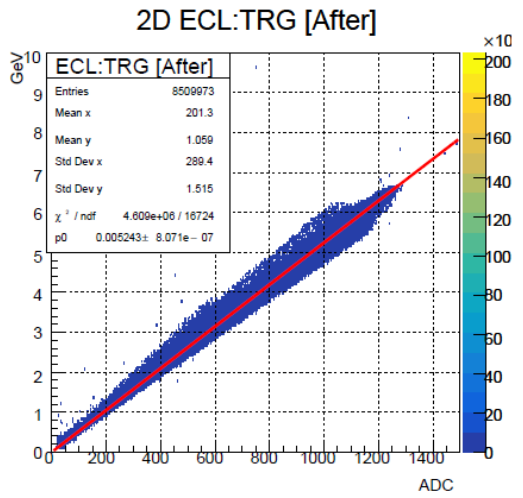
ECLTRG E > 200 ADC

Calculated data size : **0.6/fb**

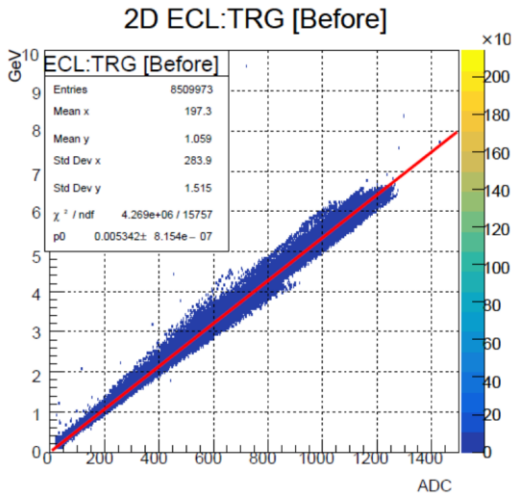


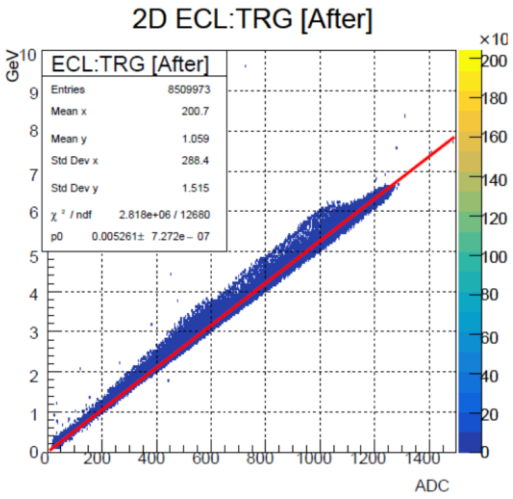


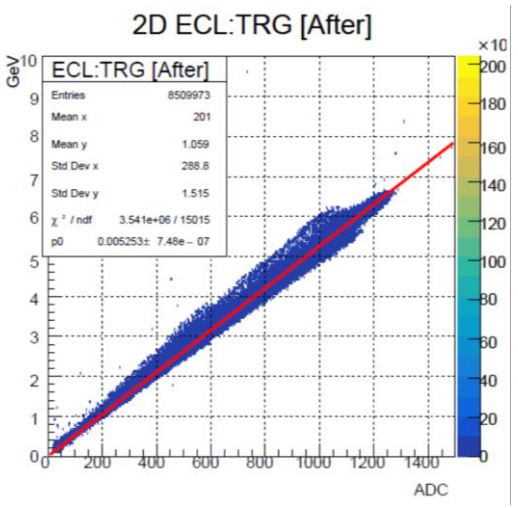


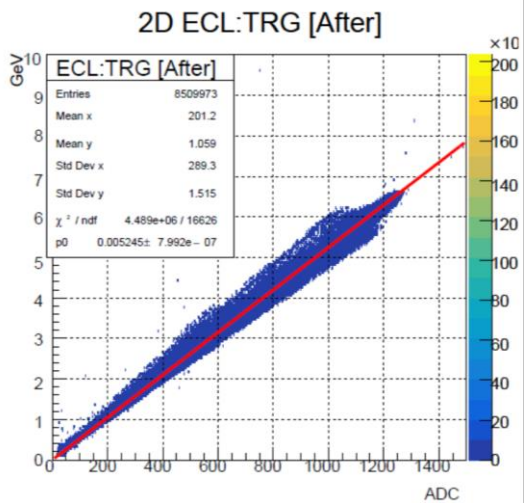


Calculated data size : **1.0/fb**



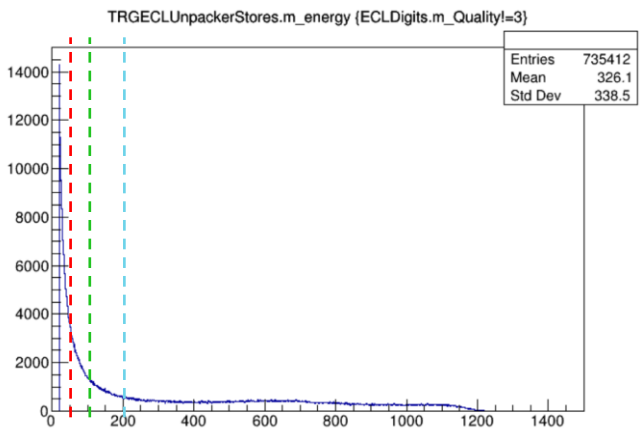






Cut condition study

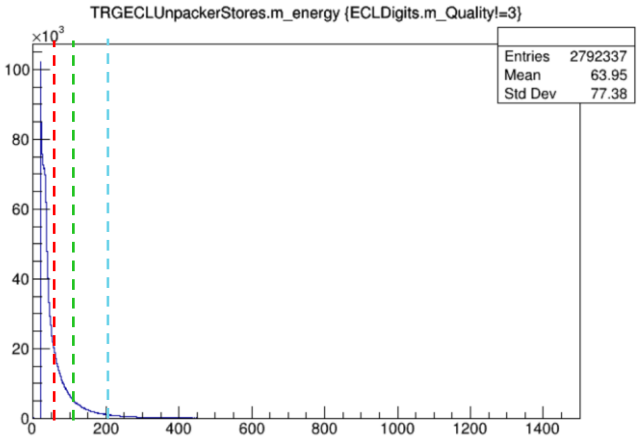
TC E(ADC) in bhabha skim



30 ADC cut

100 ADC cut

TC E(ADC) in hadron skim



30 ADC cut

100 ADC cut

- The resolution is not good at low energy, but
  the calibration result looks better when it is 30 ADC cut than 100 ADC.
- It is expected to be a difference in statistics. so, it is necessary to check with more data.
  (data size : Int L 0.5, 0.6, and **1.0/fb** are not much difference..)

E(maximum cell E in a TC) with cell ID

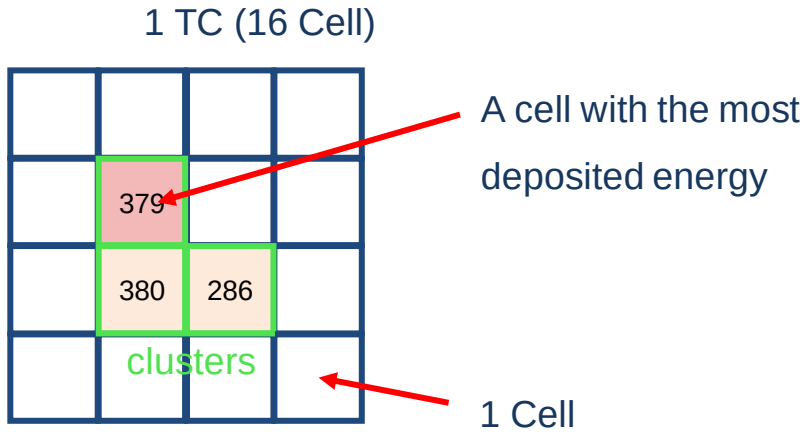
The largest cell energy was confirmed in 2D plot whether the gain was properly applied and what characteristics it had.

→ As a result, the energy is well calibrated according to the gain (or gain ratio).

→ However, two slopes are shown in bad channels.

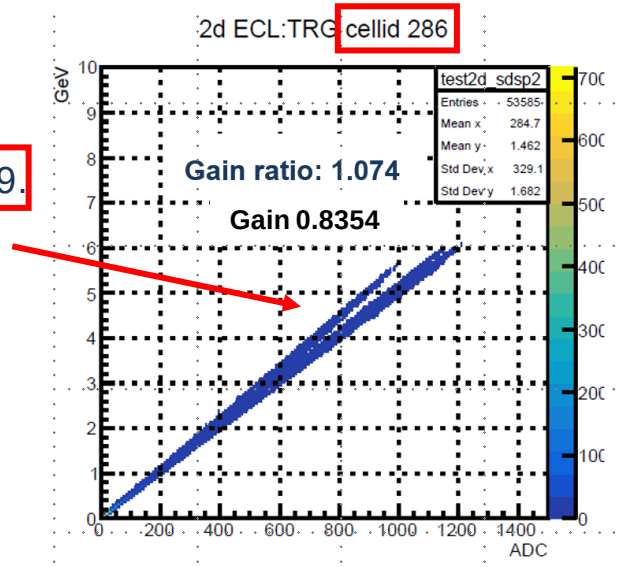
And we expect the energy of the bad chs to be not calibrated.

ex)



Problematic cell ID is 379.

The gain is 1.1691.

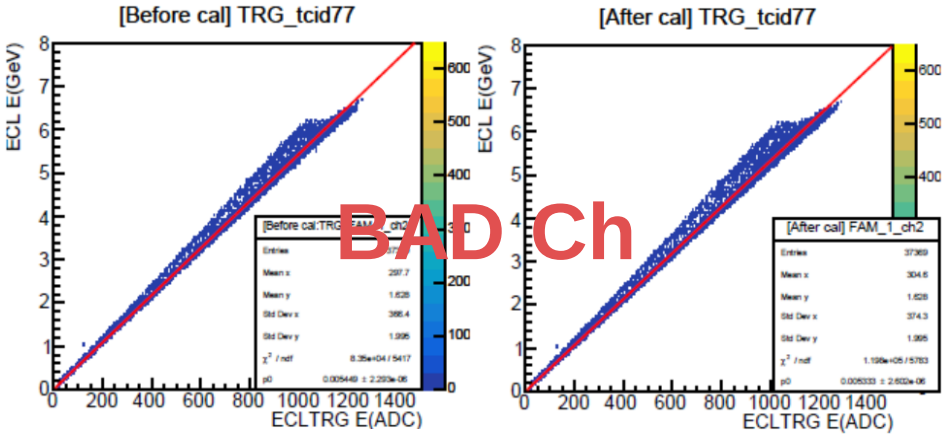


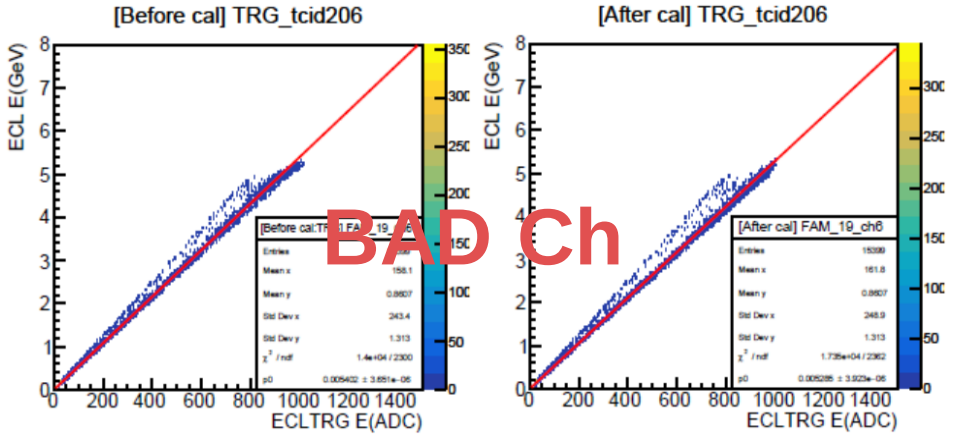
Bad ch TC #77

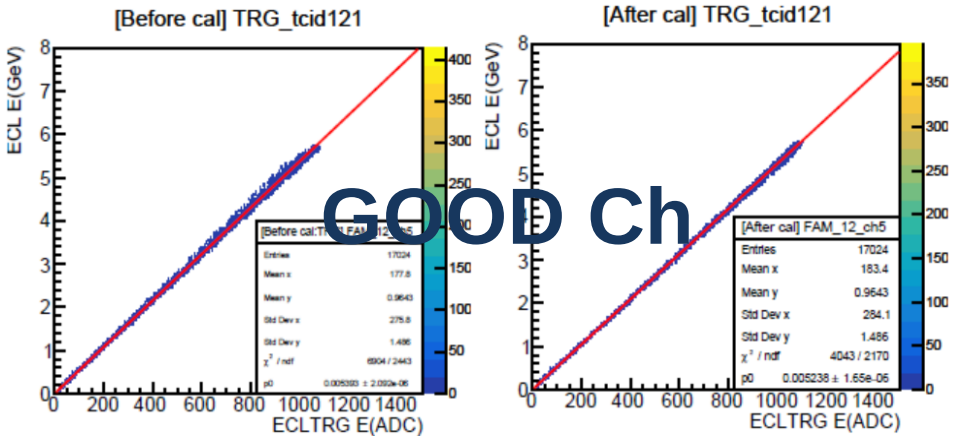
Results of the calibration for each TC ID in 2D plot

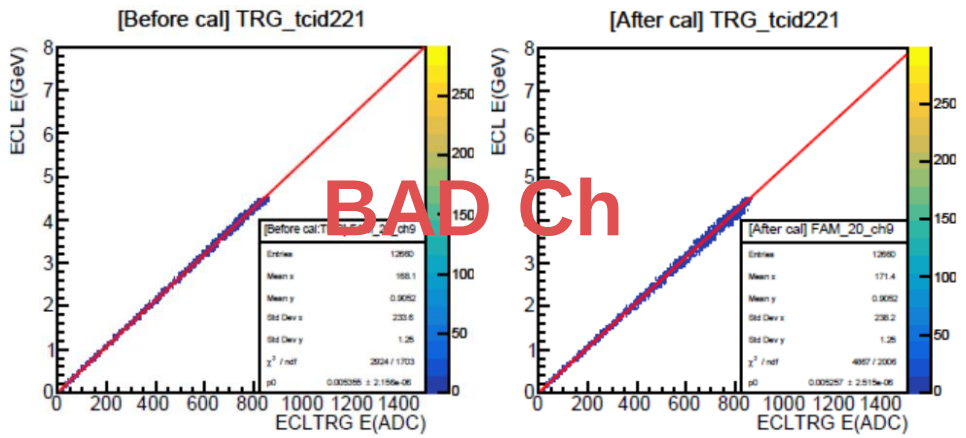
We checked 4 channels to compare good and bad channels.

- Bad channels : TCID 77, 206, 221 (not calibrated with bad ch w/ and w/o gain exceeded 1)
- Good channels : TCID 121 (well calibrated and no gain exceeded 1)









E(maximum cell E in a TC) with cellID

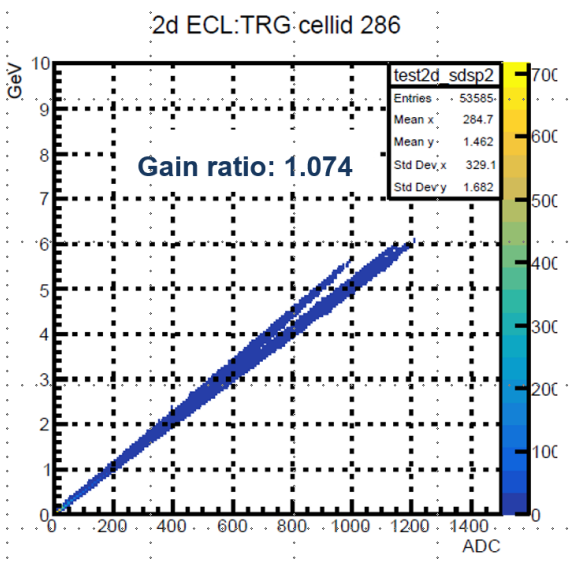
We checked 4 channels to compare good and bad channels.

- Bad channels : TCID 77, 206, 221 (not calibrated with bad ch w/ and w/o gain exceeded 1)
- Good channels : TCID 121 (well calibrated and no gain exceeded 1)

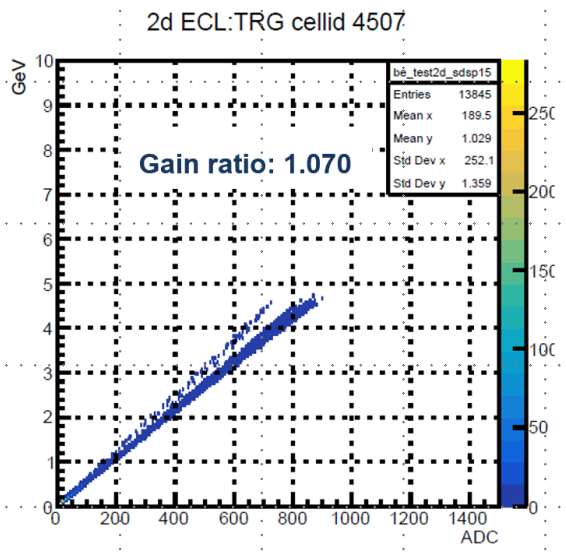
→ This is the results of max cell E in the TC with cell ID:

Only channels with gains exceeded 1 show two slopes in all cell channels.

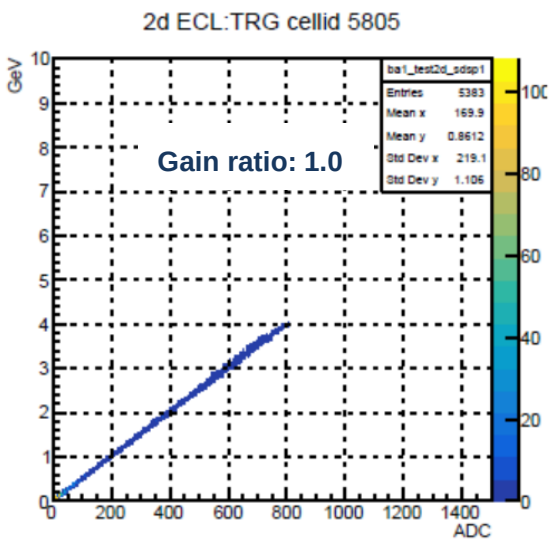
but all the other channels were fine.



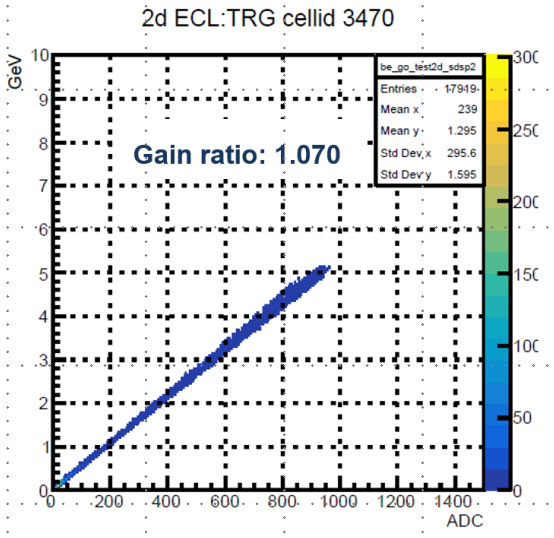
TCID 77



TCID 206



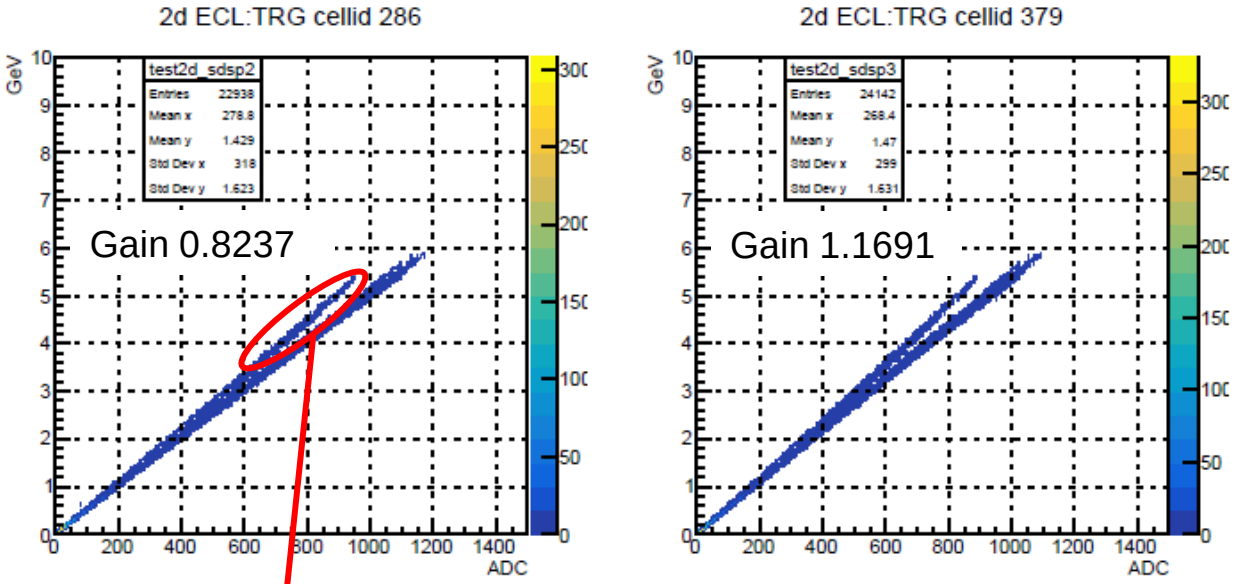
TCID 221



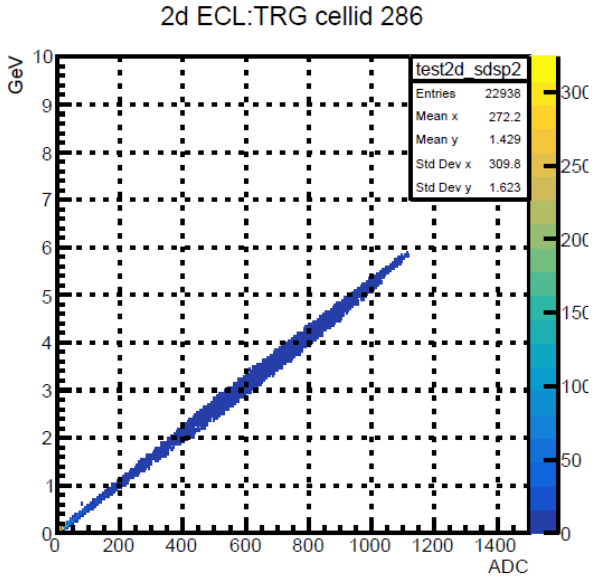
TCID 121

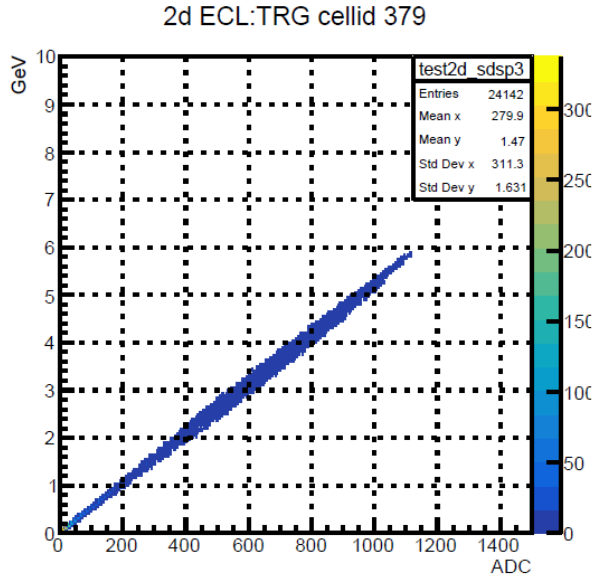
[bad example] TCID 77

Results of discrete gain

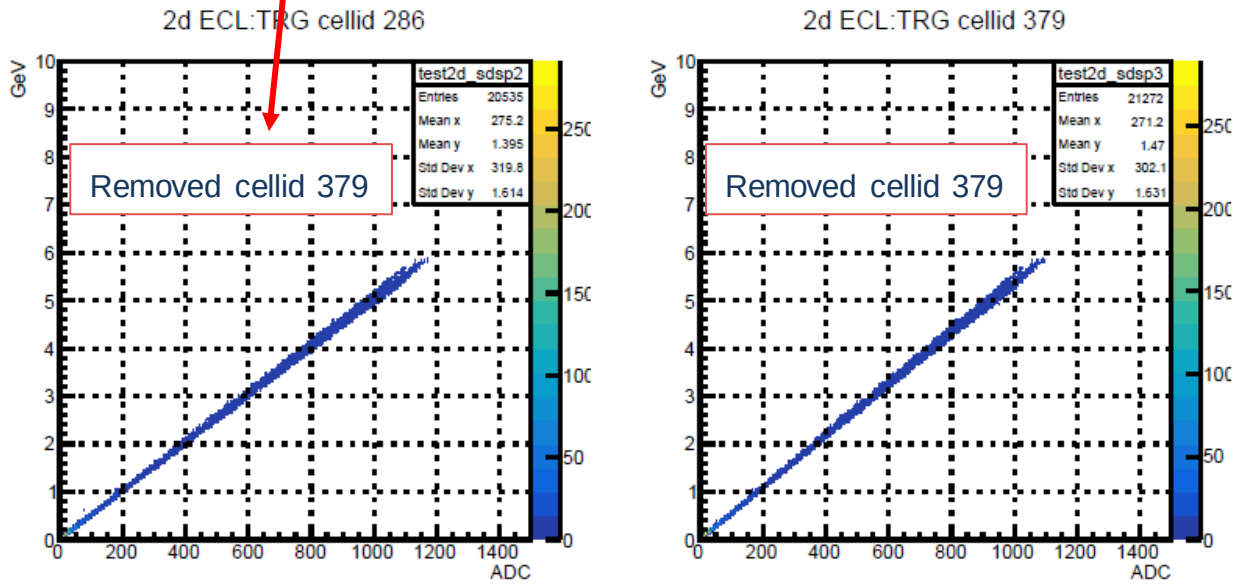


Results of continuous gain





Results of removed problematic gain



- The discrete gain and continuous gain results were compared:
  When changed to continuous gain, the two slopes become one.
- For clarity, we removed the bad channel's energy,
  and as expected, the upper side slope was gone.

Conclusion

- Consistency check is ongoing.
  - We need to discuss how to use the ecl flag.
  - Sufficient statistics are needed to obtain the good cut condition.
  - We reconfirmed that channels exceeding gain 1 were not calibrated.

    This means that we have to adjust channels with a gain greater than 1 by changing jumper-setting.

Plan

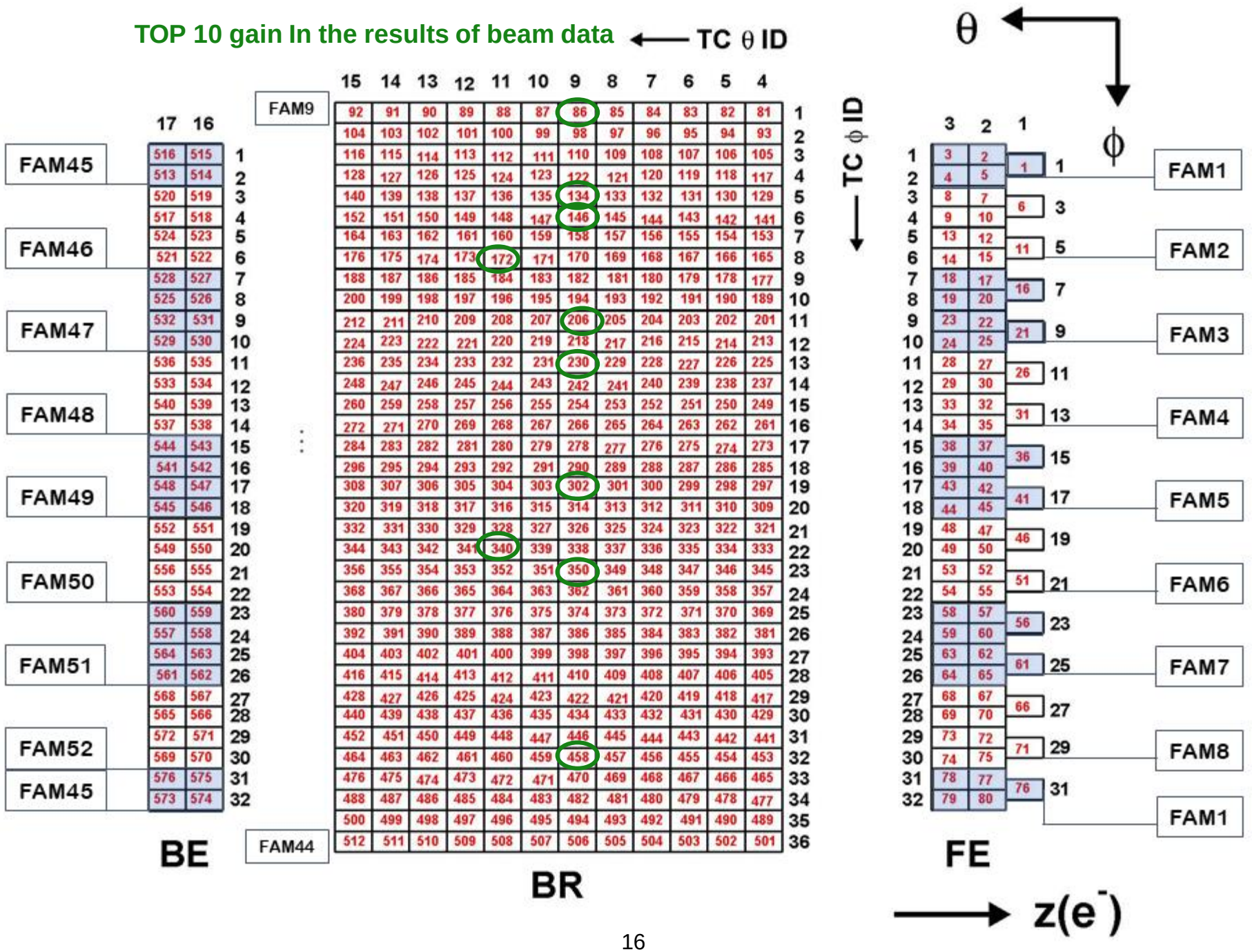
- We will get optimal calibration conditions by studying background, statistics, and cut conditions,

  after that, we will complete the consistency checks and will change the jumper setting after discussing with the ECL group.

Backup

TC map

TOP 10 gain In the results of beam data



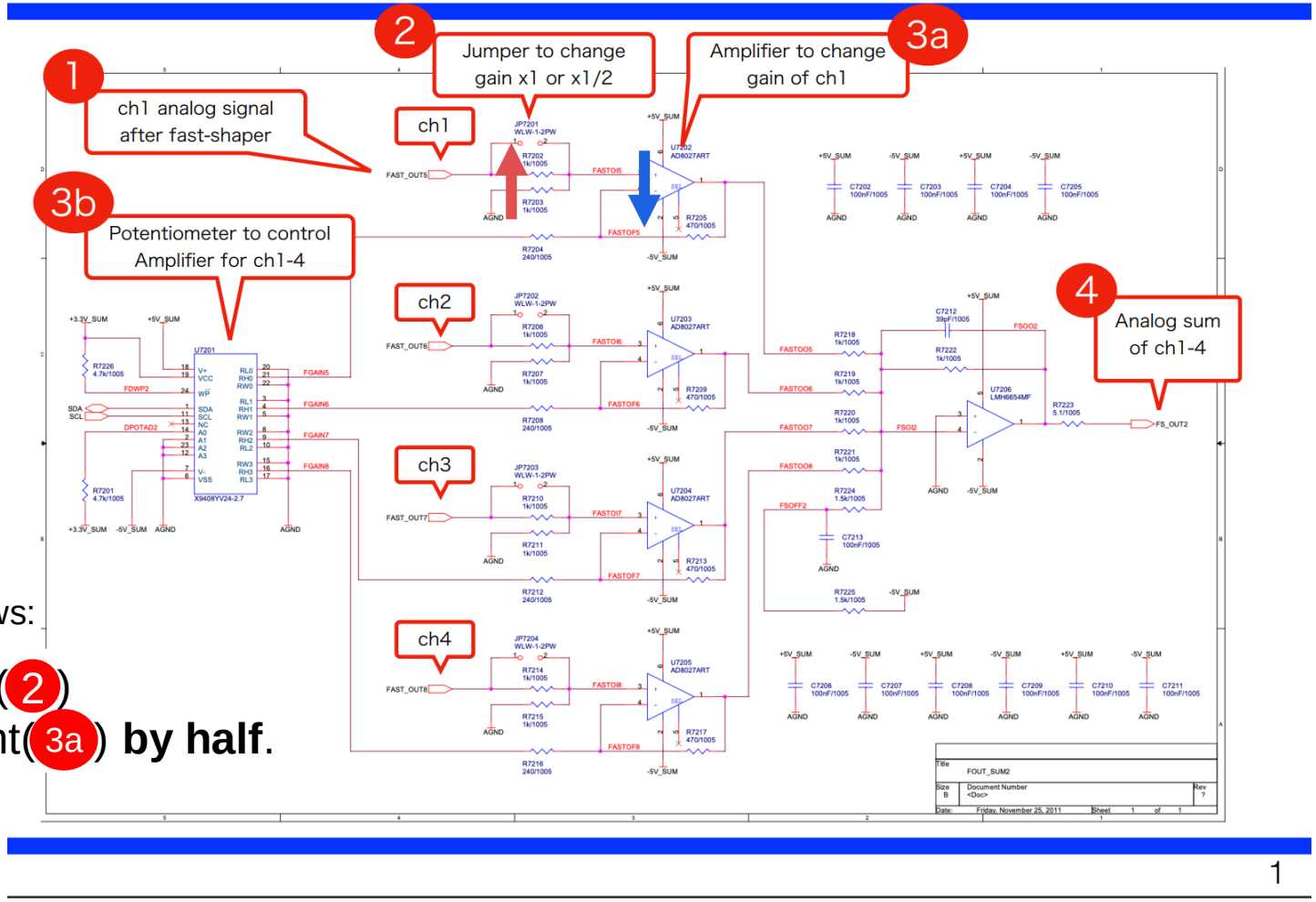
How to calibrate ECLTRG energy

- **Attenuator coefficient (6 bit)** is downloaded by ECL server to (3b) the “potentiometer”
- Based on the coefficient, the potentiometer changes voltage value in (3a) “**amplifier**” and then the gain of (1) is changed.
- At (4), analog sum for ch1-4 is done.
- Note that gain is changed by factor 2 with jumper ON and OFF at (2).

※ The relationship btw the jumper and the coefficient is as follows:

- **Doubling** the gain by using the jumper-change(2) reduces the corresponding attenuator coefficient(3a) **by half**.

The schematic of ShaperDSP



The result of gain after jumper change

1

Cell ID 4073 (TCID 206)	Gain (float)	Coefficient
Before	1.2050	63
After	0.6495	56

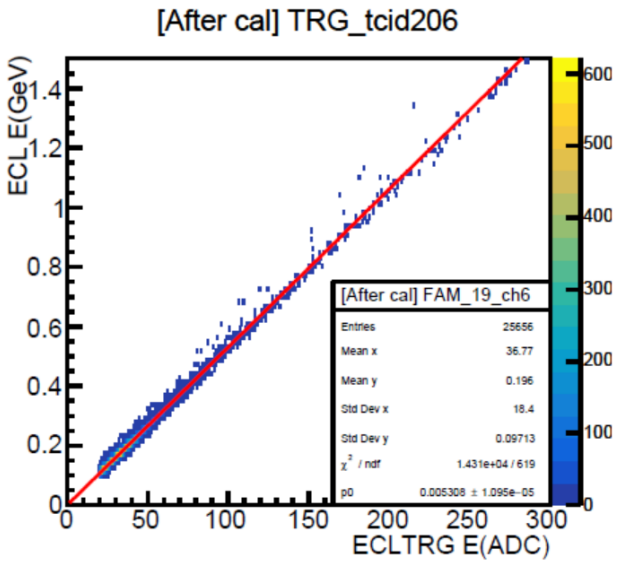
2

Cell ID 4468 (TCID 86)	Gain (float)	Coefficient
Before	1.1641	63
After	0.6376	56

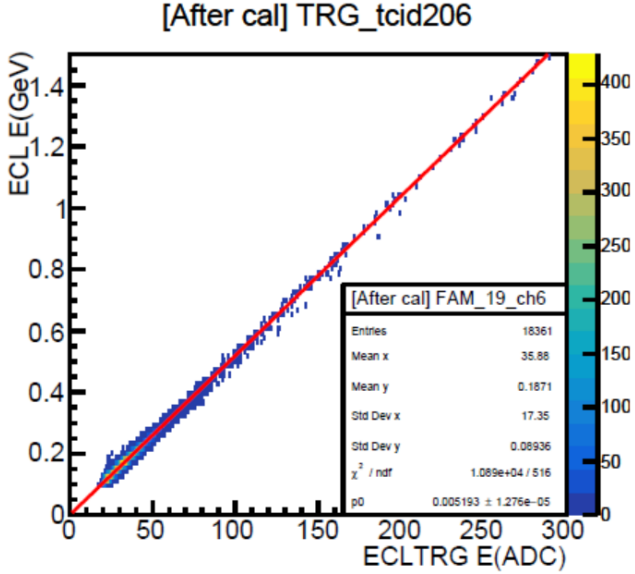
3

Cell ID 4514 (TCID 230)	Gain (float)	Coefficient
Before	1.0877	63
After	0.6045	54

(a) Before jumper change (exp18)



(b) After jumper change (exp27)



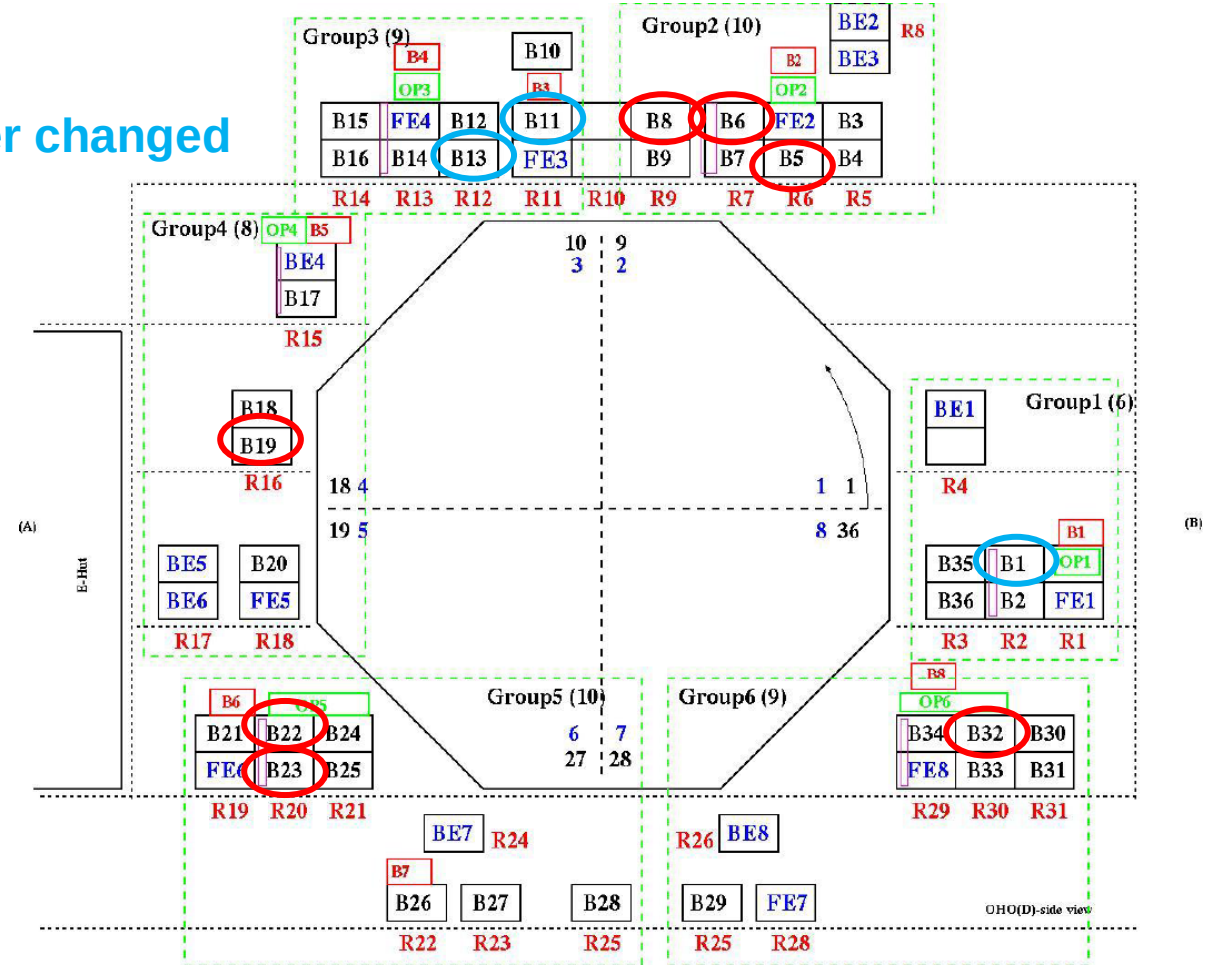
Top 10 gain (continuous) in barrel

We set the Top 10 according to the value of the gain.

Top 10 gain (continuous) out of 28 channels in barrel

	Coefficient	Gain(cont.)	CollectorID	ShaperID	Channel	CellID	TCID
1	63	1.2050	11 (B11)	6	1	4073	206
2	63	1.1641	1 (B1)	6	16	4468	86
3	63	1.1533	19 (B19)	6	12	4539	302
4	63	1.1167	6	6	5	4054	146
5	63	1.0919	23	6	9	4123	350
6	63	1.0877	13	6	8	4514	230
7	63	1.0548	5	6	12	4483	134
8	63	1.0509	8	8	15	5504	172
9	63	1.0498	22	8	15	5560	340
10	63	1.0485	32	6	13	4160	458

Jumper changed



Used data : exp 26 (2022a)

- Bhabha + hadron skim (0.6 /fb)
- 5.25 ADC conversion factor

4. List of ‘Attenuator coefficient 63’ in barrel for consistency check

[exp27 local **cosmic** vs exp21 **beam**]

	CellID	TCID	Gain_float (cosmic)	Coefficient	Coefficient old (before cal.)	Gain_float (beam)	**gain ratio (cosmic/beam)**
1	4073	206	1.1906	63	63	1.2054	**0.9878**
2	4539	302	1.1696	63	63	1.1698	**0.9998**
3	4862	411	1.1481	63	61	0.8589	**1.3367**
4	4054	146	1.1352	63	63	1.1225	**1.0112**
5	4468	86	1.1328	63	63	1.1781	**0.9616**
6	4034	86	1.1230	63	62	0.9564	**1.1741**
7	5560	340	1.1099	63	63	1.0642	**1.0430**
8	4514	230	1.1060	63	63	0.9395	**1.1773**
9	4123	350	1.1023	63	63	1.1005	**1.0016**
10	4483	134	1.0797	63	63	1.0638	**1.0150**
11	5504	172	1.0786	63	63	1.0656	**1.0122**
12	3973	337	1.0600	63	58	0.7235	**1.4649**
13	1775	214	1.0585	63	60	0.7706	**1.3736**
14	6878	414	1.0517	63	63	1.0420	**1.0093**
15	4160	458	1.0482	63	63	1.0531	**0.9954**

[exp24 **beam** vs exp21 **beam**]

	CellID	TCID	Gain float (cosmic)	Coefficient	Coefficient old (before cal.)	Gain_float (beam)	**gain ratio (beam/beam)**
1	4073	206	1.2025	63	63	1.2053	**0.9976**
2	4468	86	1.1683	63	63	1.1780	**0.9917**
3	4539	302	1.1615	63	63	1.1697	**0.9929**
4	4054	146	1.1206	63	63	1.1225	**0.9983**
5	4123	350	1.091	63	63	1.1005	**0.9920**
6	4514	230	1.0901	63	63	1.0880	**1.0019**
7	5504	172	1.0629	63	63	1.0655	**0.9975**
8	5560	340	1.0611	63	63	1.0641	**0.9972**
9	4483	134	1.0575	63	63	1.0637	**0.9941**
10	4160	458	1.0481	63	63	1.0531	**0.9952**
11	6852	330	1.0402	63	63	1.0415	**0.9987**
12	6878	414	1.0385	63	63	1.0419	**0.9966**
13	4015	457	1.0324	63	63	1.0238	**1.0084**
14	4197	146	1.0248	63	63	1.0271	**0.9978**
15	4039	98	0.9996	63	63	0.9982	**1.0013**

“We have to decide **consistently** which channels to change the jumper setting.”

- It was confirmed that the difference in gain between local/global cosmic and beam run was up to 1.46.
- However, the results of the gain shift compared between beams were almost identical to 1.
- A coefficient consistency study is required to know the exact reason.