Noise Elimination of Cosmic Ray Test for COMET-CDC

2017/12/28 Year-End Workshop
Kuno-laboratory 1st year Master
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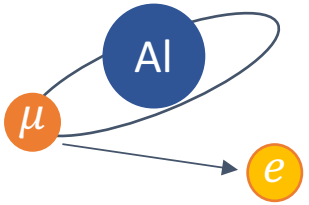
   - Difference of the two types of Power Supplies (LV)
   - Shielding (Covered with alminium foil)
   - Use a fan to remove the noise more.

3. Summary

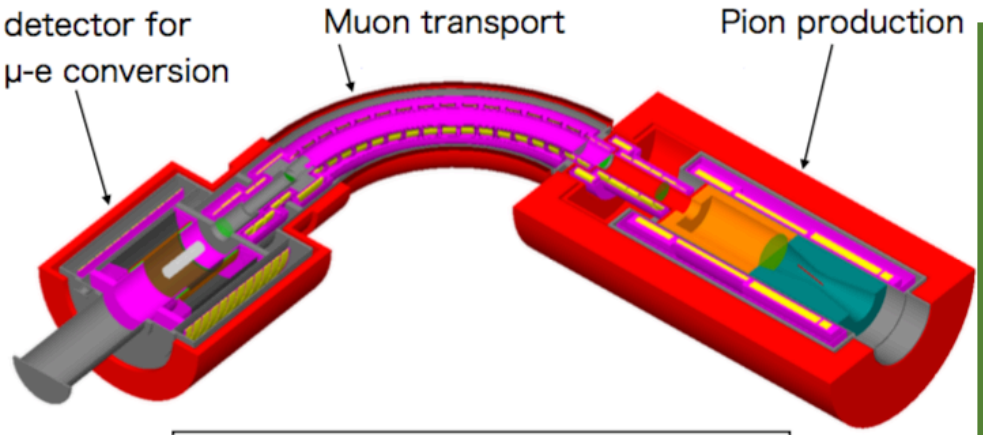
Introduction – COMET Experiment (Phase-1)

- The COMET Phase-I experiment is seeking to measure the neutrinoless, coherent transition of a muon to an electron ($\mu - e$ conversion) in the field of an aluminium nucleus, $\mu^- N \rightarrow e^- N$, with a single event sensitivity of 3×10^{-15}.



- The $\mu - e$ conversion is one of the charged Lepton Flavor Violation (cLFV) processes. The cLFV is mostly prohibited in the Standard Model (BR $(\mu \rightarrow e\gamma) \sim 10^{-54}$).

- The COMET experiment will be built and started in the Hadron Hall at J-PARK in 2019.



COMET Phase-I Layout

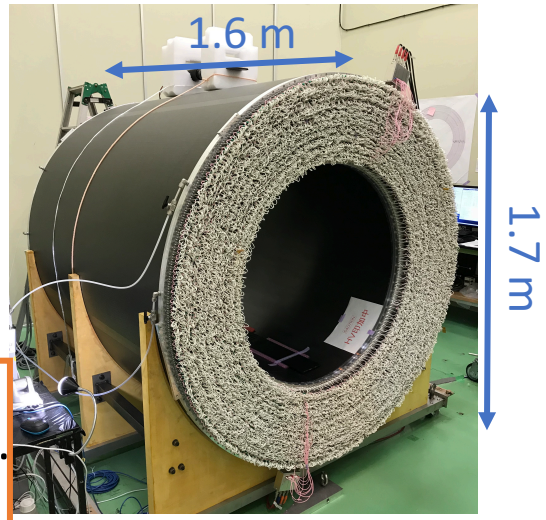
Other Experiments related to cLFV

- MEG Experiment at PSI
  $\mu^+ \rightarrow e^+\gamma$ (BR $< 4.2\times10^{-13}$)
- SINDRUM Ⅱ Experiment at PSI
  $\mu^-\mathrm{Au} \rightarrow e^-\mathrm{Au}$ (BR $< 7\times10^{-13}$)

Introduction – COMET CDC

- The cylindrical detector system (CyDet) is the main detector system for the $\mu - e$ conversion conversion search in COMET Phase-I.

- It consists of a cylindrical drift chamber (CDC) and a cylindrical trigger hodoscope (CTH).



COMET-CDC

Requirements of CDC

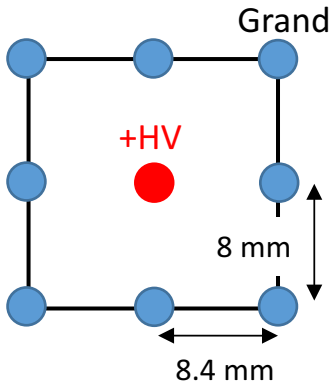
- Momentum resolution of CDC must be less than 200 keV/c. (for the 105 MeV electrons)
- Spatial resolutions should be less than 200 μm. (for the two gas mixtures at 1 T magnetic field)

Status of CDC

- CDC is arranged in 20 sense layers (including 2 guard layers) with alternating positive and negative stereo angles ($64 \sim 75$ mrad).

Wire	material	# of Wires	Diameter
Sense	Au plated W	4986	25 μm
Field	Al	14562	126 μm

Gas	Magnetic Field
He: i-C_4H_{10} = 90: 10	1 T



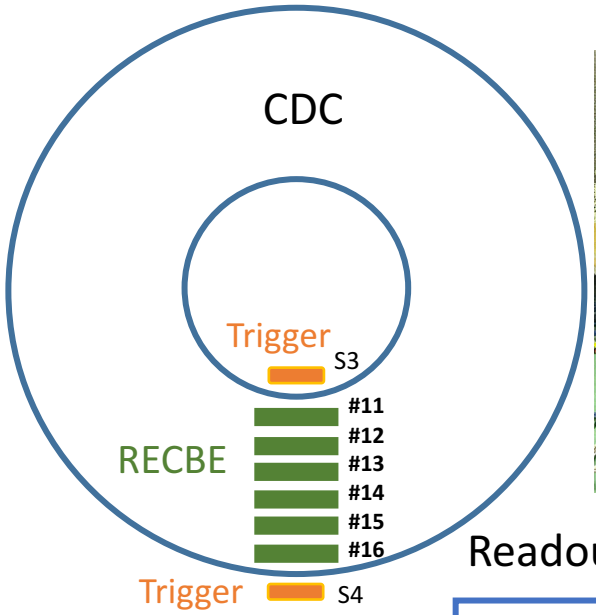
One cell of CDC

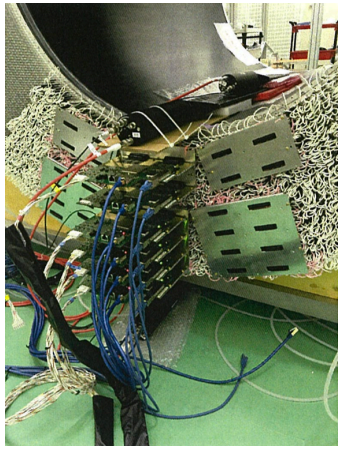
Introduction – Cosmic Ray Test for COMET CDC

- The Cosmic Ray Test for the CDC is now ongoing at Fuji building B4 in KEK.

Condition

- Use bottom side of CDC.
- HV = 1800V, 1825V, 1850V are applied.
- Gas ratio $\mathrm{He}:\mathrm{i}-\mathrm{C}_4\,\mathrm{H}_{10} = 90:10$

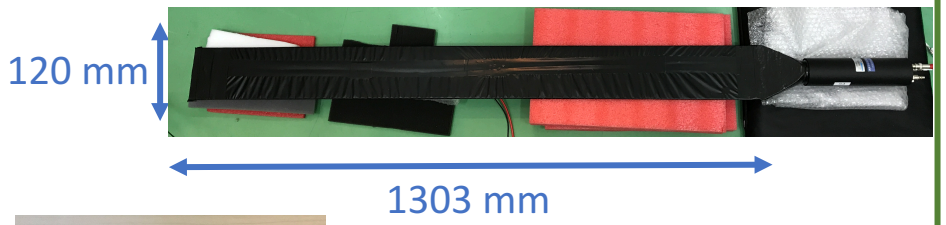


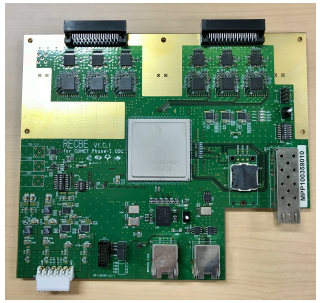


Readout side of CDC

Readout

- 6 Readout boards (RECBE) are connected.
- Use two scintillators for trigger.





Readout Board (RECBE)

Signal used for CRT

ADC : Information of Charge

TDC : Information of Time

Evaluation

- XT relation (relation between drift length and drift time).
- Spatial resolution. -> should be less than 200 μm.
- Hit Efficiency. -> should be enough high.

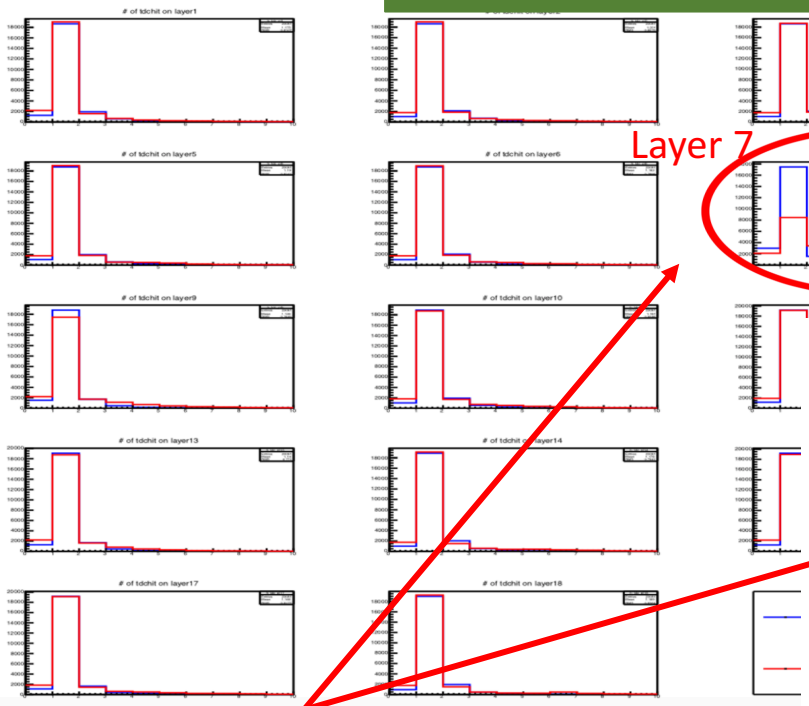
Noise Elimination – Problem in Layer 7

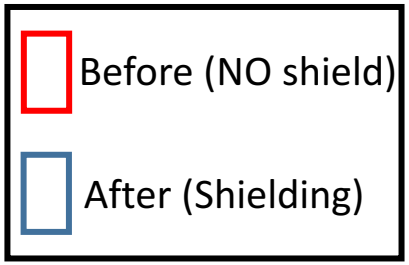
- In the last year's Cosmic Ray Test, We had a problem in Layer 7.

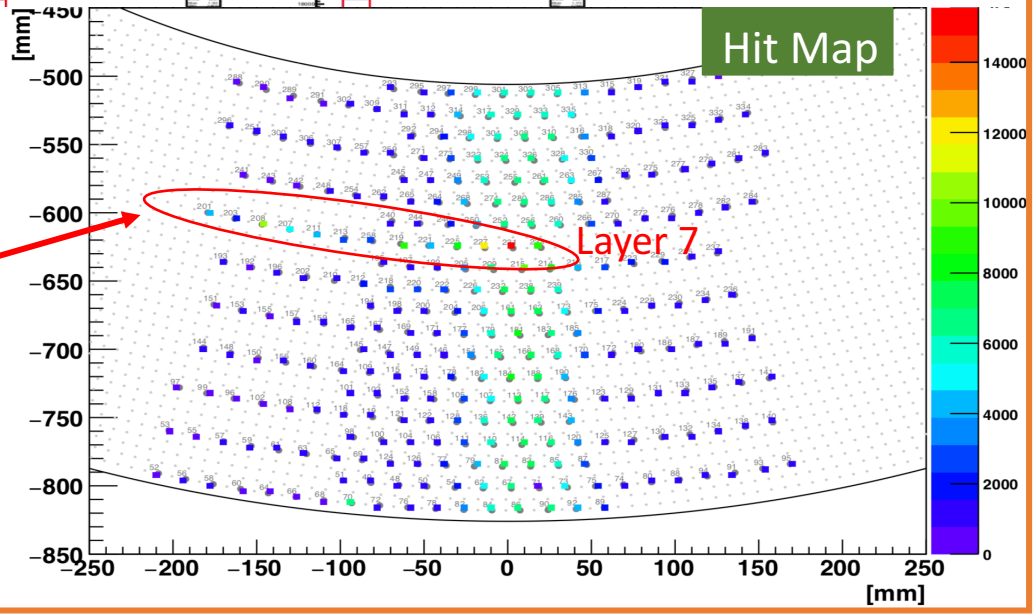
  ➡ Probably because of the noise. So should remove it and improve efficiency!

Last year's result

Number of tdc hit for each Layer HV @1800V From analysis of Okinaka-san





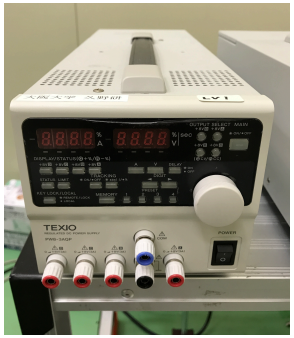


Number of tdc multi hit of Layer 7 is larder than other Layers.
Hit Map is also looks noisy.

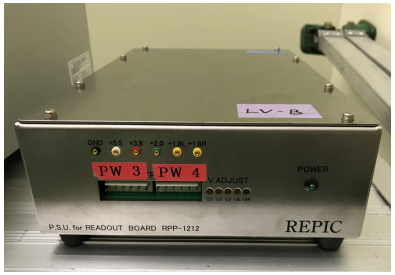
Noise Elimination – two types of Power Supplies

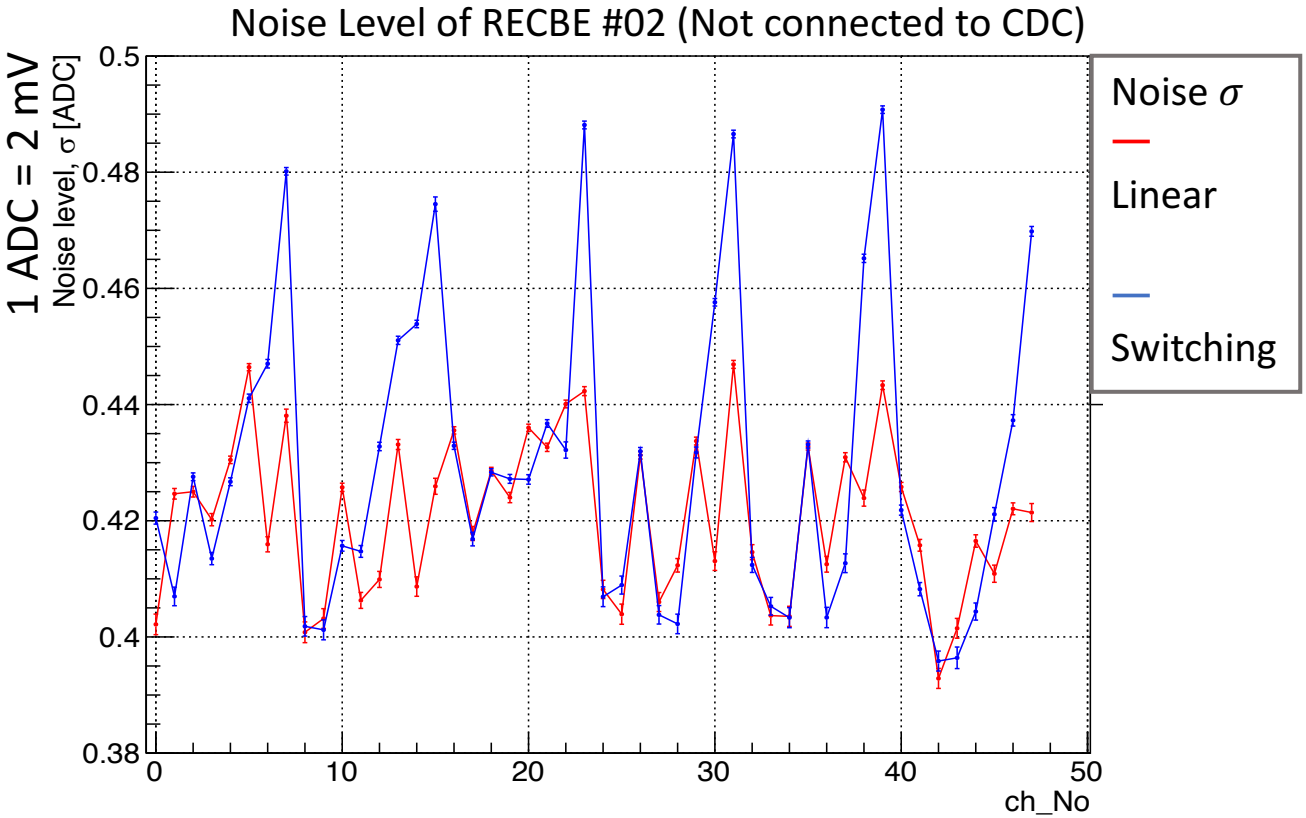
- Use ADC signals for checking the Noise level (Base line of ADC value is about 220 adc)
  ① Check the difference of two types of LV Power Supplies.
- Take the σ which is coming from Gaussian fitting of ADC value.
  ➡ Then define this σ as the noise level.

Linear Power Supply
TEXIO PW8-3AQP



Switching Power Supply
REPIC RPP-1212





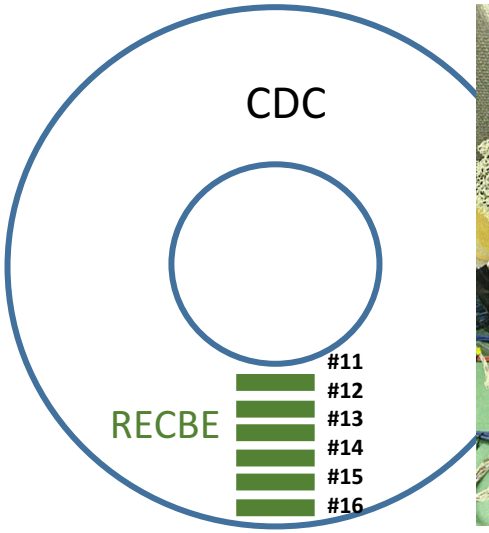
- Noise level of most channels are about 0.40~0.48 (very small).
- We can use Switching Power supply, too. -> save money!

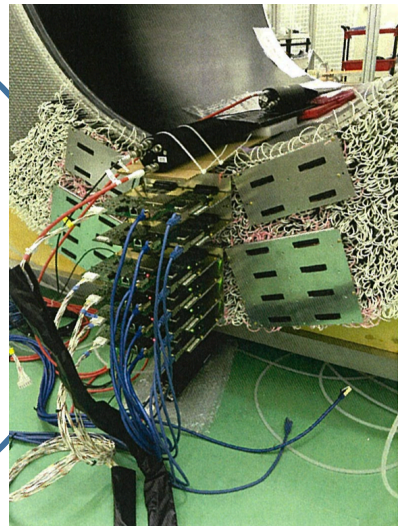
Noise Elimination

- Use ADC signals for checking the Noise level.
  ② Shielding the read out side and check the Noise Level (Use 6 + 1 RECBEs).

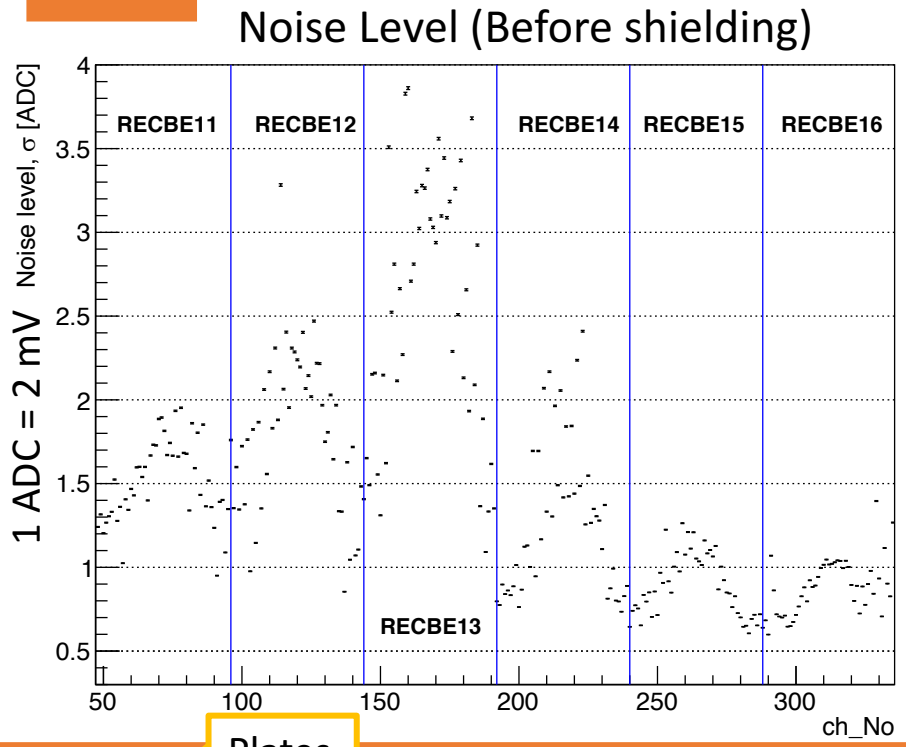
Set Up

- RECBE #11~16 are connected to the CDC.
- RECBE #01 is used for trigger.
- HV is not applied to CDC.

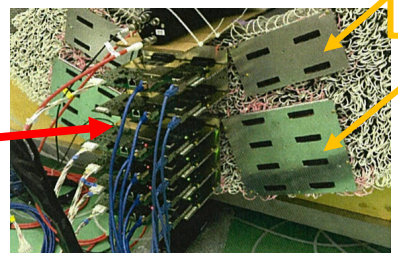




Result



RECBE No.13 has the largest noise.
It is in the middle (Layer 7).
(junction of the two plate)



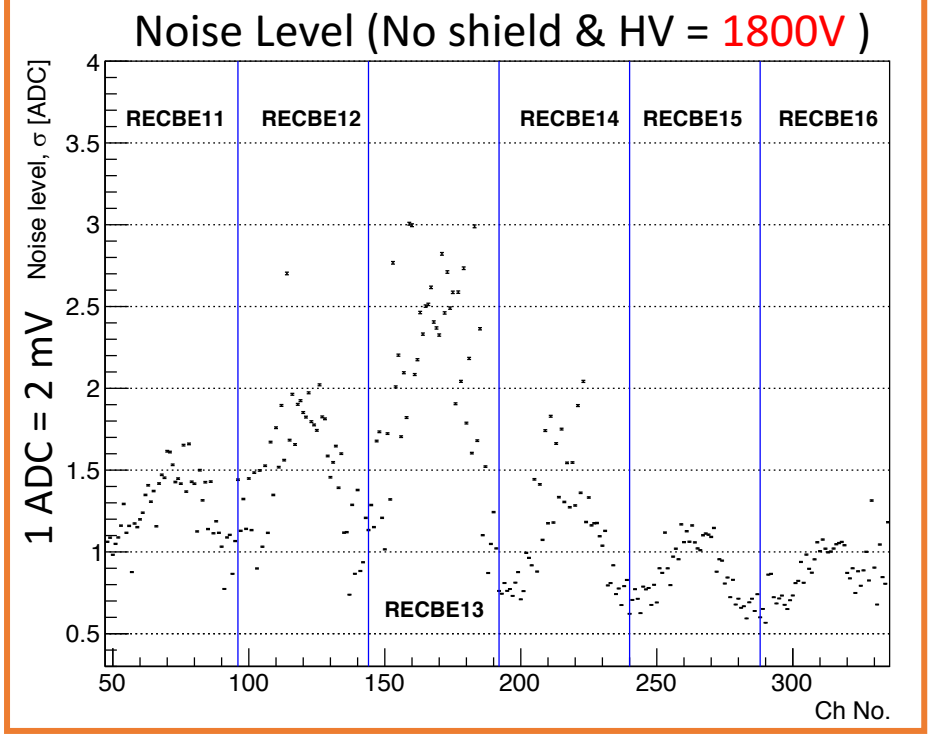
Supposedly most noise comes from around this area.
-> should be shielded.

Noise Elimination – HV dependence

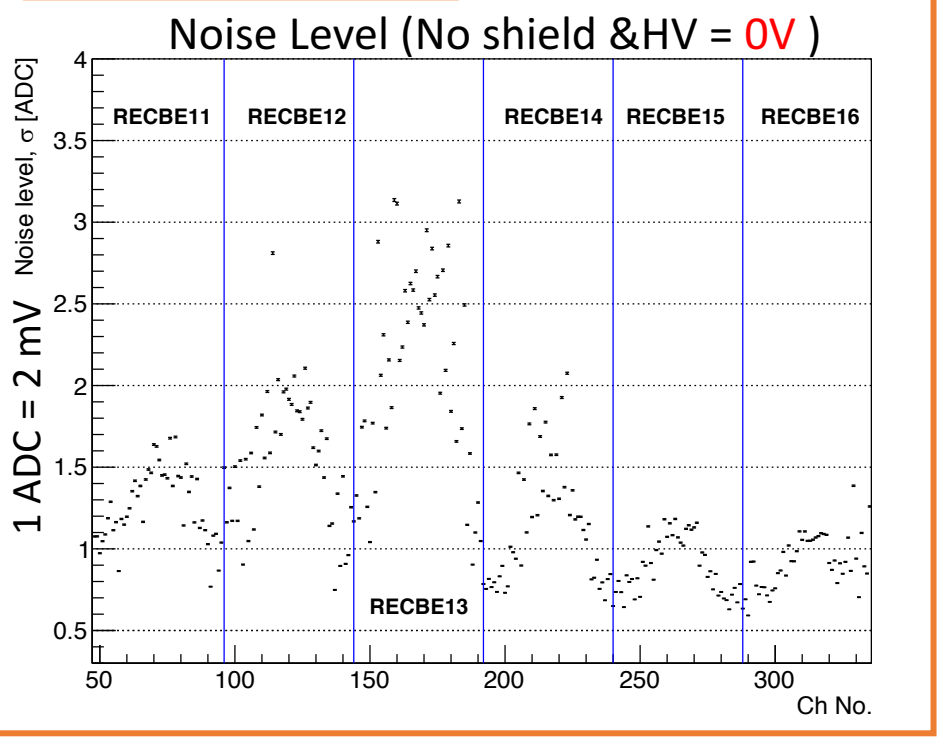
- Before shielding the separated areas,
  there may be noise difference due to the HV dependence which applied to the CDC.

Applied 1800V to the CDC and compared.

HV applied



HV is NOT applied



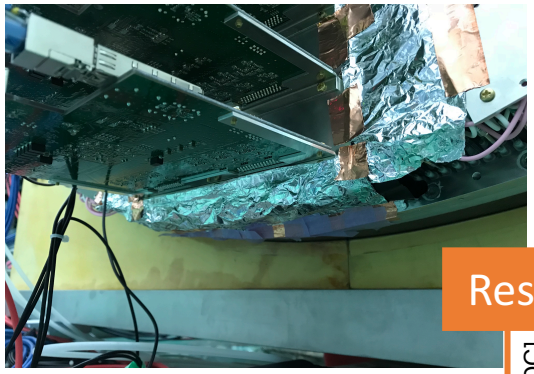
But There was no characteristic difference in the two cases. Turned off the HV.

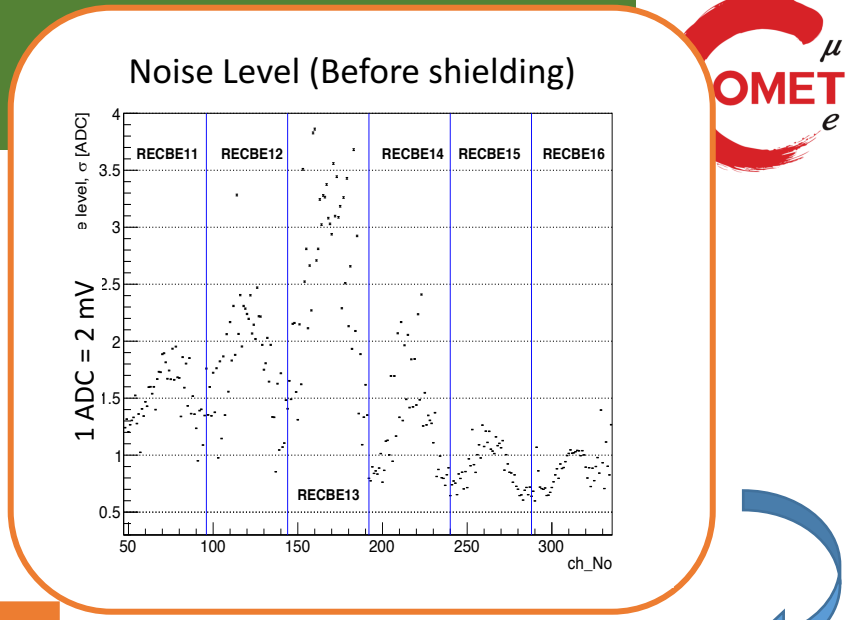
Noise Elimination – Shielding

- Covered all around area with Aluminium foil.

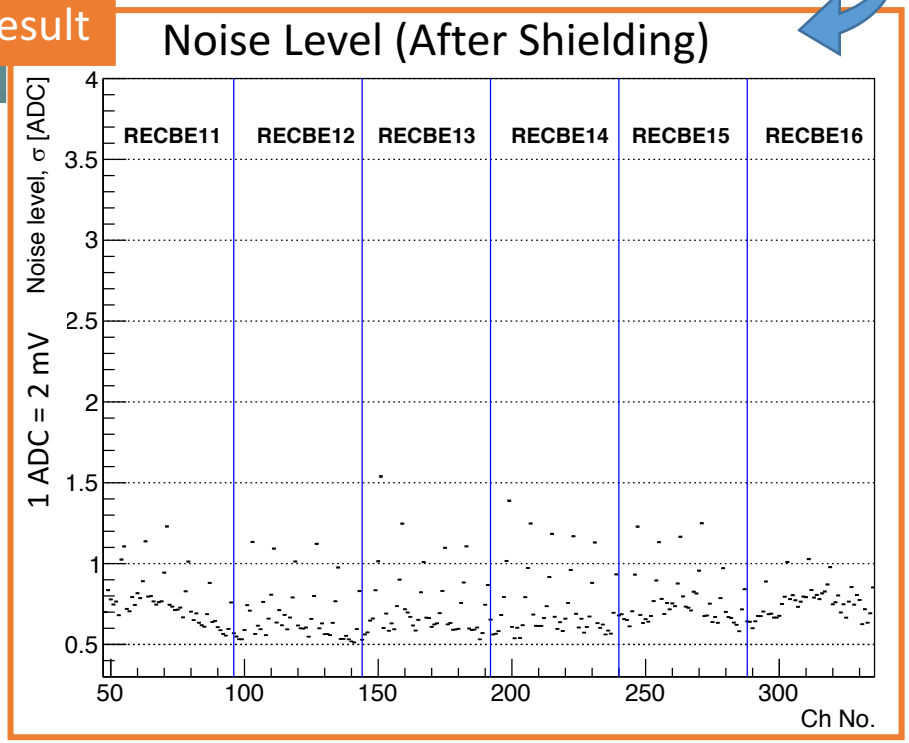
Up, Right and Left side

Down side





Result



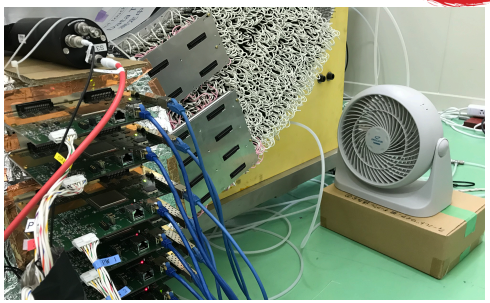
- The noise of all RECBE boards decreased!
  Maximum value is about 1.5 adc.
  (Last Maximum value is about 4 adc)
- Was able to cut 62.5% of the noise!

Use a fan to decrease the noise more.

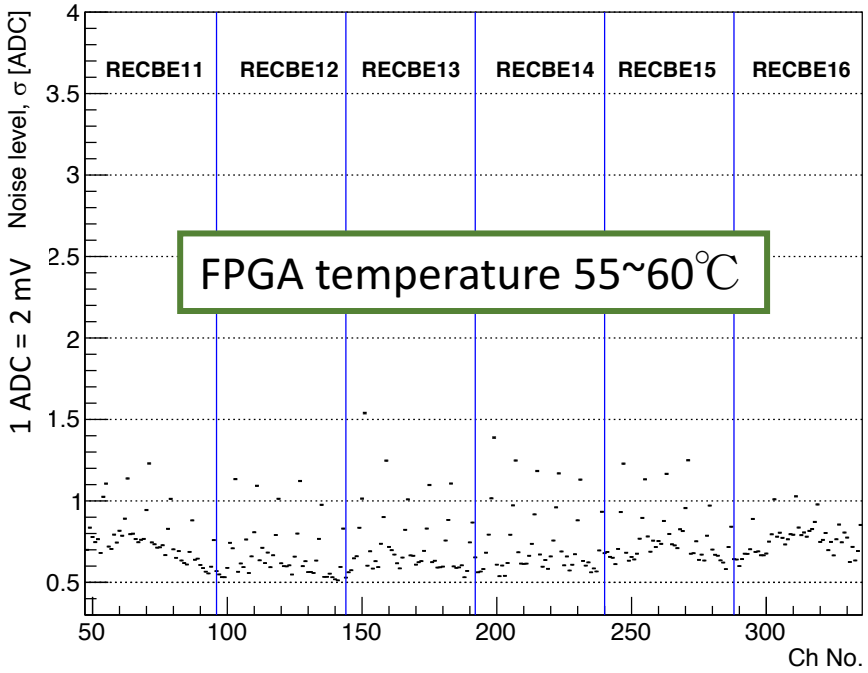
Noise Elimination – Shielding & Fan

Set Up

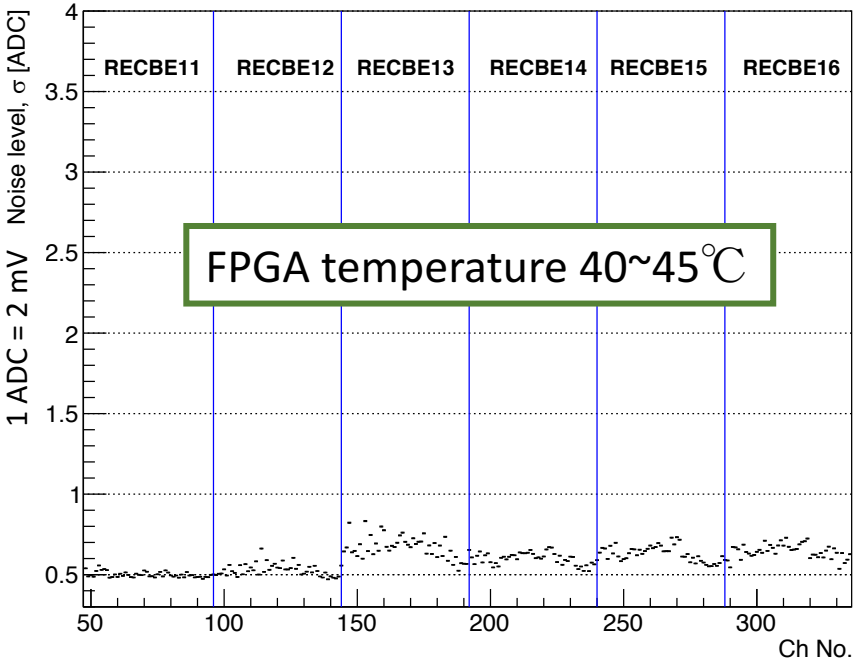
- Covered middle point and both sides with Aluminium foil.
- Put a fan by the RECBE boards and turned it on.



Noise Level (Al foil & No fan)



Noise Level (Al foil & fan)



- The noise of all RECBE boards decreased!
  Maximum value is less than 1 adc.

Finally cut 75% of the noise!

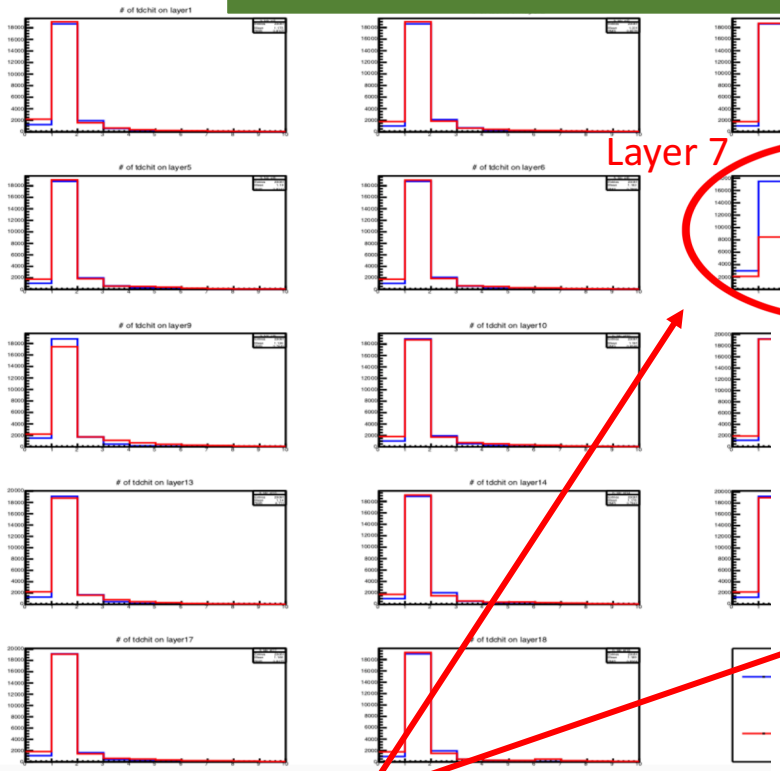
Noise Elimination – Hit efficiency & Hit Map

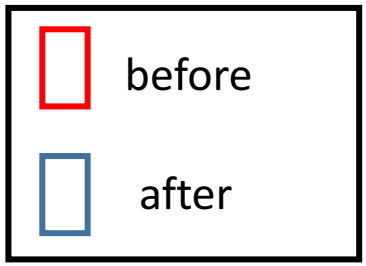
- After shielding and using a fan, hit efficiency and Hit Map of Layer 7 got better!

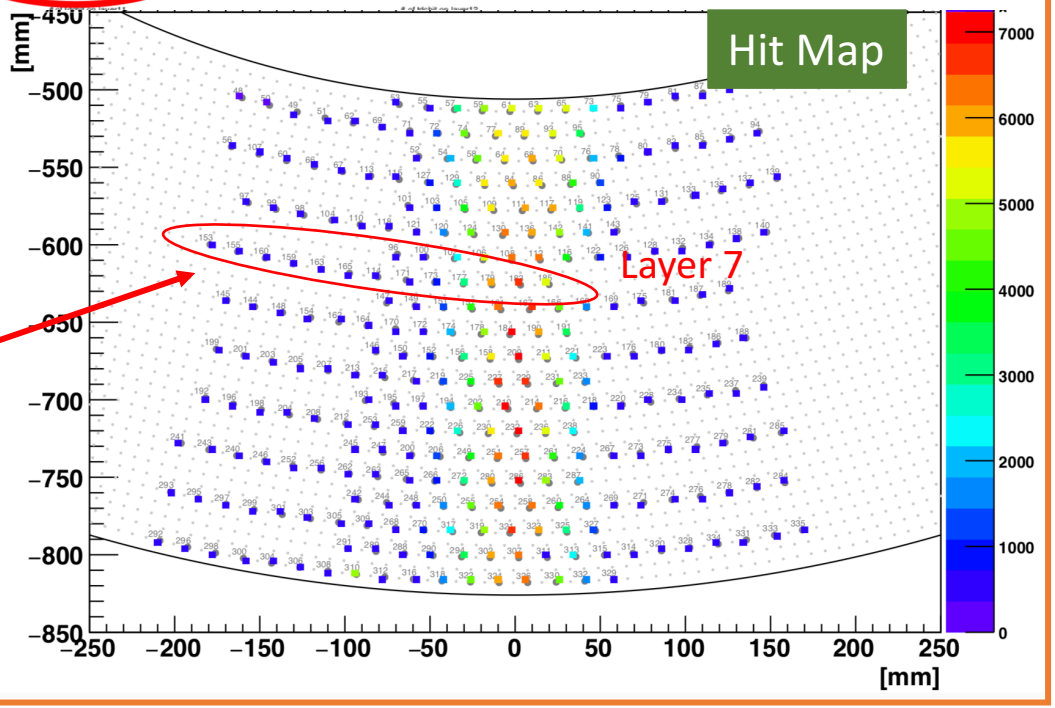
Result

Number of tdc hits for each Layer

HV @1800V From analysis of Okinaka-san







tdc multi hits of layer 7 decreased.
Nunber of tdc single hit increased.
Also Hit Map became so clear.

Summary

1. Introduction
   - Cosmic Ray Test for COMET-CDC is in progress in KEK.
   - This test is mainly evaluating the
     XT relation, Spatial resolution and Hit Efficiency of CDC.

2. Noise Elimination
   - Noise problem of Layer 7.
   - Difference of the two types of LV Power Supplies is so small.
     -> We can use both Power Supplies.
   - Covering with Al foil makes the noise very small.
   - Also by using a fan, the noise will be able to cut more.
   - Single hit of tdc increased and Hit Map improved.

Back Up

Noise Elimination – two types of Power Supplies

- There may be the structure of switching frequency (Noise) for Switching Power Supply.

  ➡ Search the Noise Level of each LV Power Supplies with **probe** (analog).

REPIC RPP-1212 (Switching PS)
DC-DC converter

型名	回路方式	発振周波数 (kHz)	入力電流 (A)
BRNS6	降圧チョッパ	600	※1
BRNS12	降圧チョッパ	600	※1
BRNS20	降圧チョッパ	600	※1

※1 仕様を参照下さい。

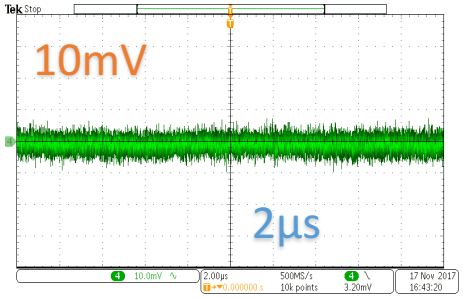
AC-DC unit

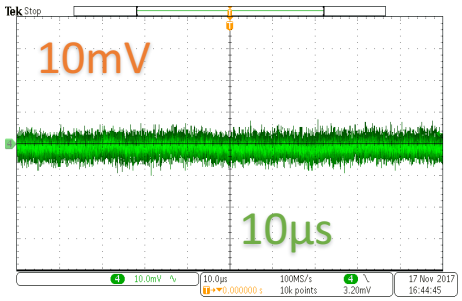
型名	回路方式	発振周波数 (kHz)	入力電流 (A)
PBA10F	他励フライバック	100	0.3
PBA15F	他励フライバック	100	0.4
PBA30F	他励フライバック	100	0.7
PBA50F	アクティブフィルタ	60~550	0.7
	シングルフォワード	130	
	アクティブフィルタ	60~550	

➡ 60~550kHz
130kHz, 600kHz

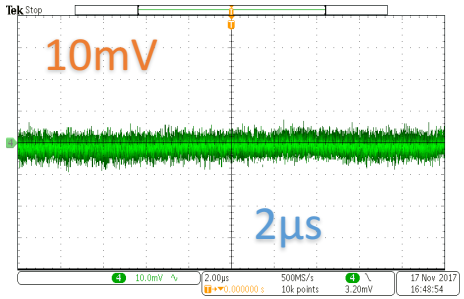
Search these frequency

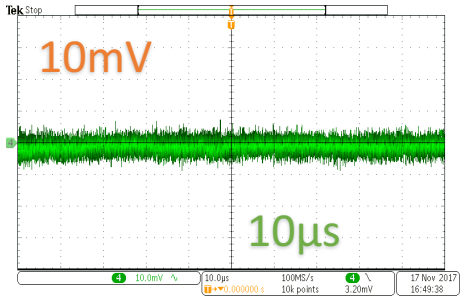
Switching PS　RPP-1212



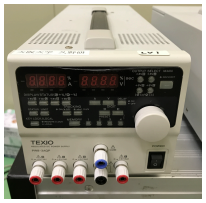


Linear PS　TEXIO PW8-3AP





- Could not see the difference and specific frequency of these value.

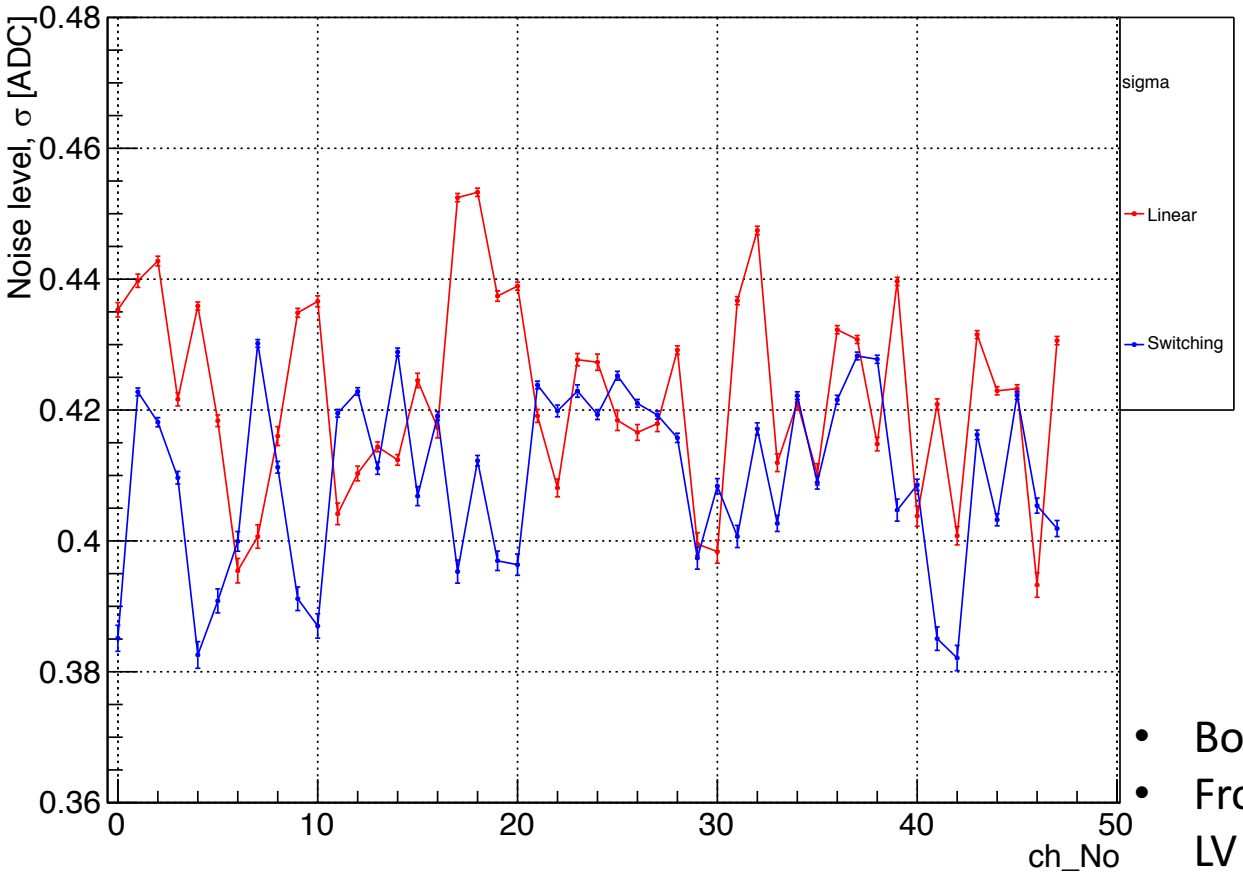


Noise Elimination – LV dependence with a fan

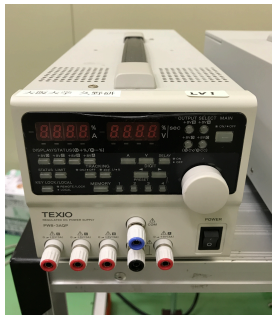
- Compare the lowest Noise Run.

Result

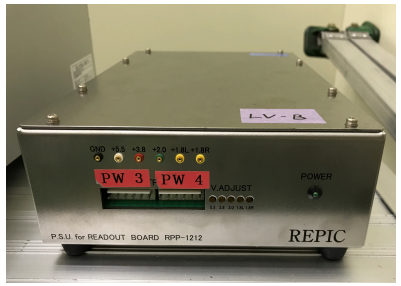
Linear with fan Switching with fan



Linear Power Supply
TEXIO PW8-3AQP



Switching Power Supply
REPIC RPP-1212



- Both results show small Noise Level.
- From this result, we can ignore the LV dependence again.

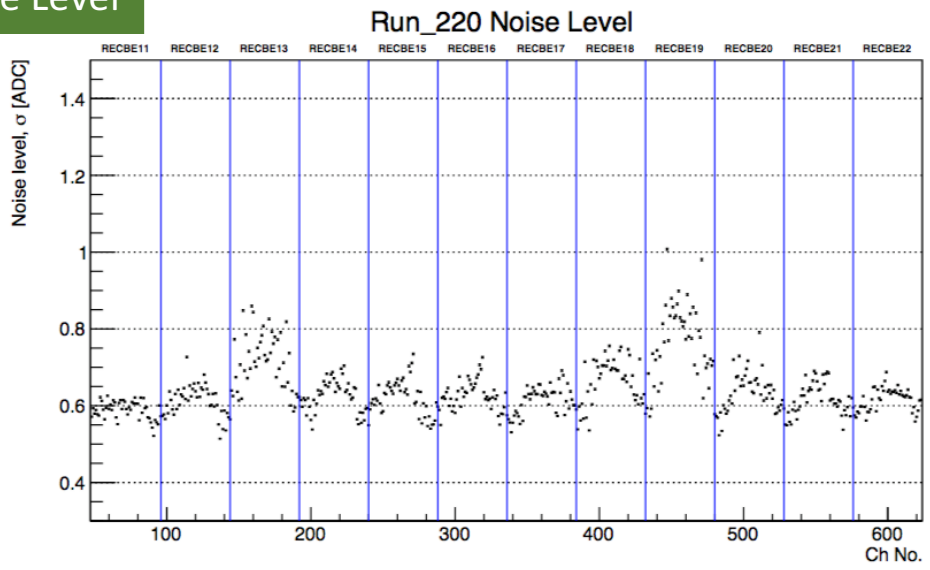
Ongoing Work – Validation Program

- I made a Validation Program of New SETUP for Cosmic Ray Test (Use 12+1 RECBEs) which can distinguish the Run has some problems or not.

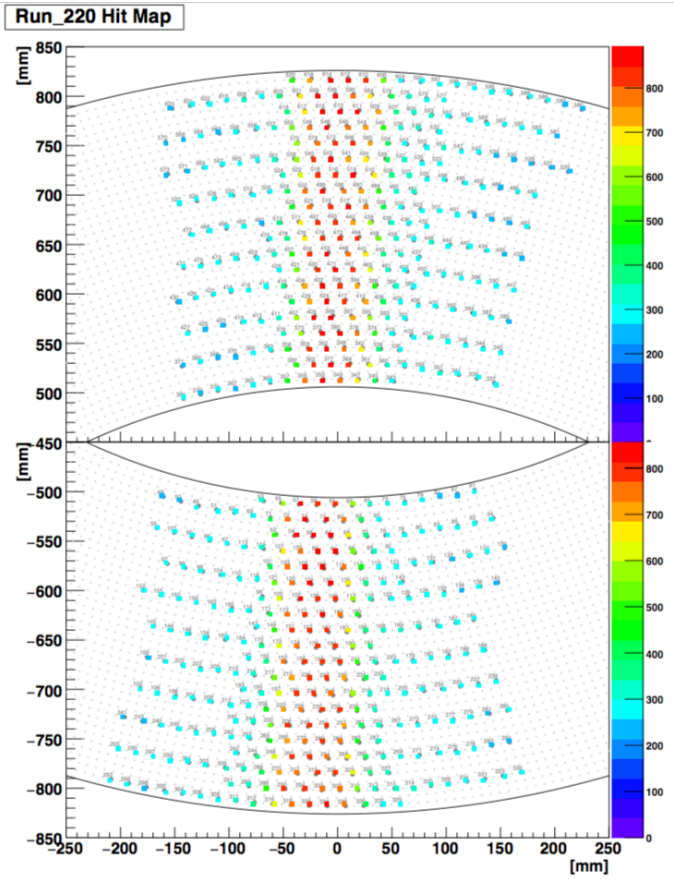
- This program shows histograms and graphs of
  ① ADC
  ② TDC (driftTime)
  ③ ADC sum (charge Q)
  ④ tdcNhit (# of tdc hits)
  ⑤ Noise Level
  ⑥ Hit Map

→ for all channels (48ch) of all RECBE boards used in Cosmic Ray Test. (now 622ch total)

Noise Level



Hit Map

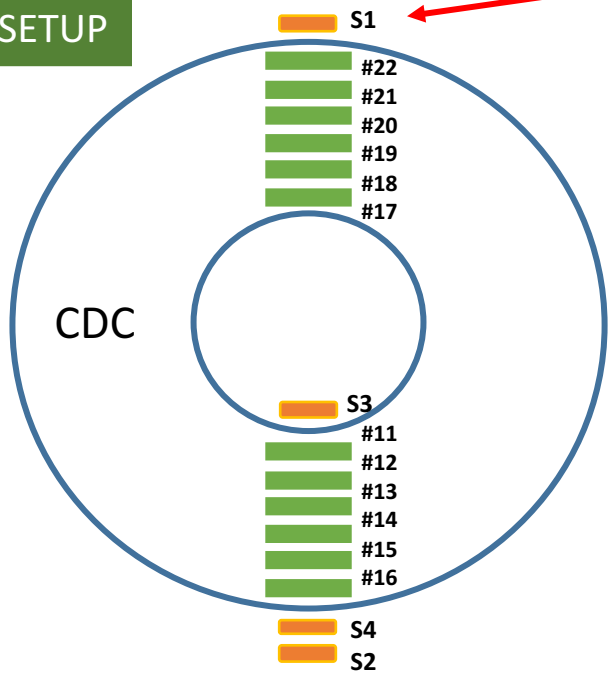


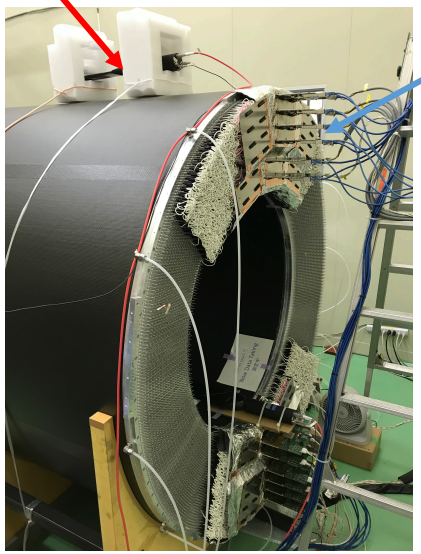
Ongoing Work – Alignment Analysis

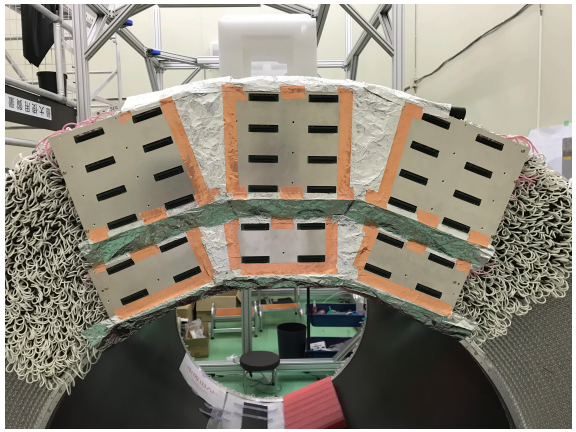
- We finished taking data of New SETUP. (11/23 ~ 12/11)
- Totally use 12+1 RECBE boards.

  6 RECBEs -> Upper side 6 RECBEs -> lower side 1 is used for trigger
- One of the small scintillator S1 is located on the top of CDC.

SETUP







Also covered with Al foil to shield.

Trigger rate	Condition
S1&S2 -> 0.03 Hz	Trigger = S1&S2
S3&S4 -> 3.74 Hz	HV = 1825V

Now I'm trying to analyze
and compare the top and bottom area of

- XT relation (drift length and drift time).
- Spatial resolution. -> Less than 200 μm.
- Hit Efficiency. -> Enough high.