INTT-SILICON LADDER PERFORMANCE

NARA WOMEN'S UNIVERSITY

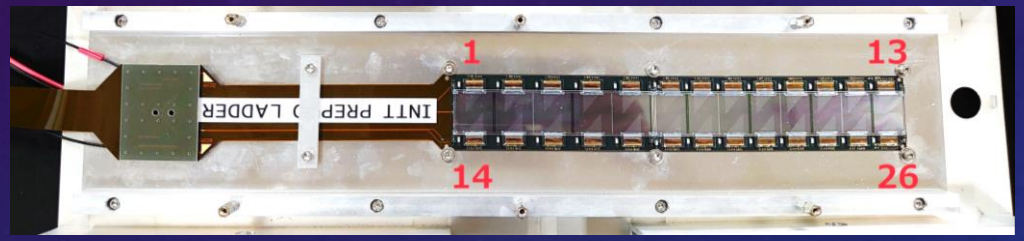
YUMIKA NAMIMOTO

SILICON SENSOR

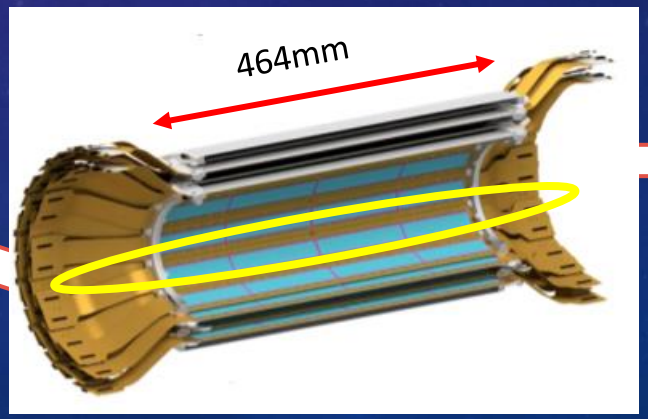
- INTT-silicon ladder is consisted of silicon semiconductor, readout chip (namely FPHX) and HDI. If charged particles pass through, it takes data.

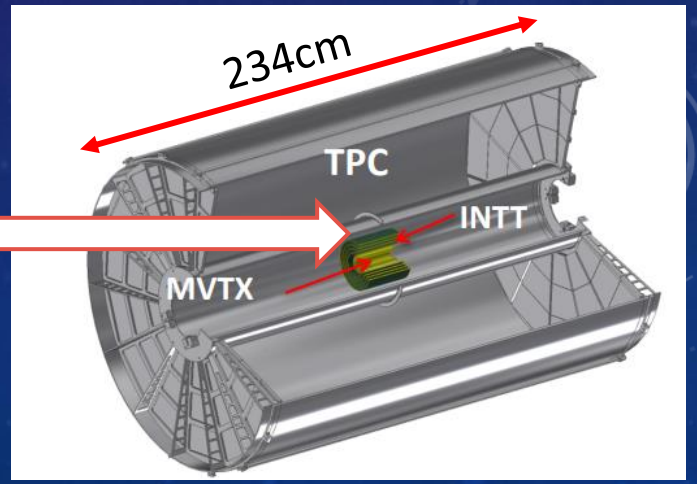
- In half ladder, 26 FPHX chips are exist and it reads signals come from silicon ladder
- Full ladder consisted of 2 half ladder, so it has 52 FPHX chips.

Half ladder



Full ladder

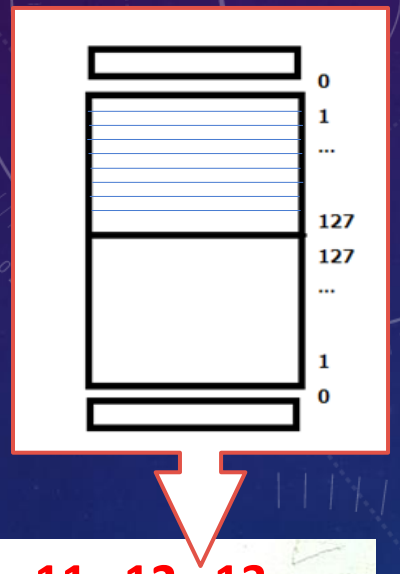


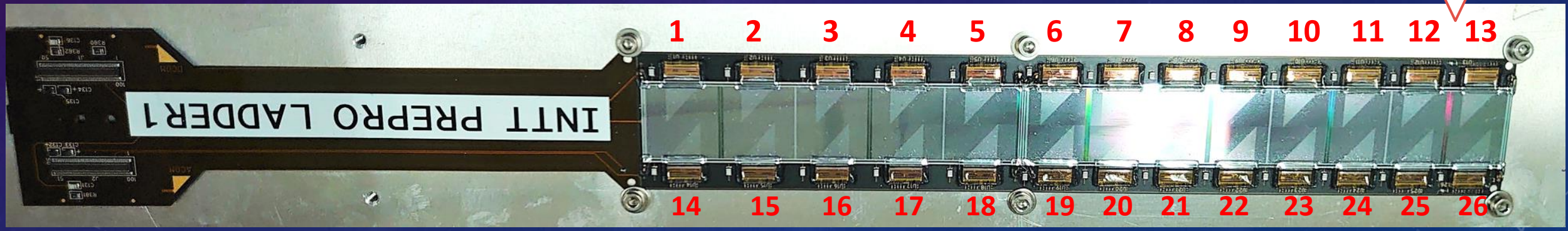


CHIP NUMBER, CHANNEL NOMENCLATURE

- We divide silicon ladder for 26 area.
- 1 area correspond 1 FPHX chip.

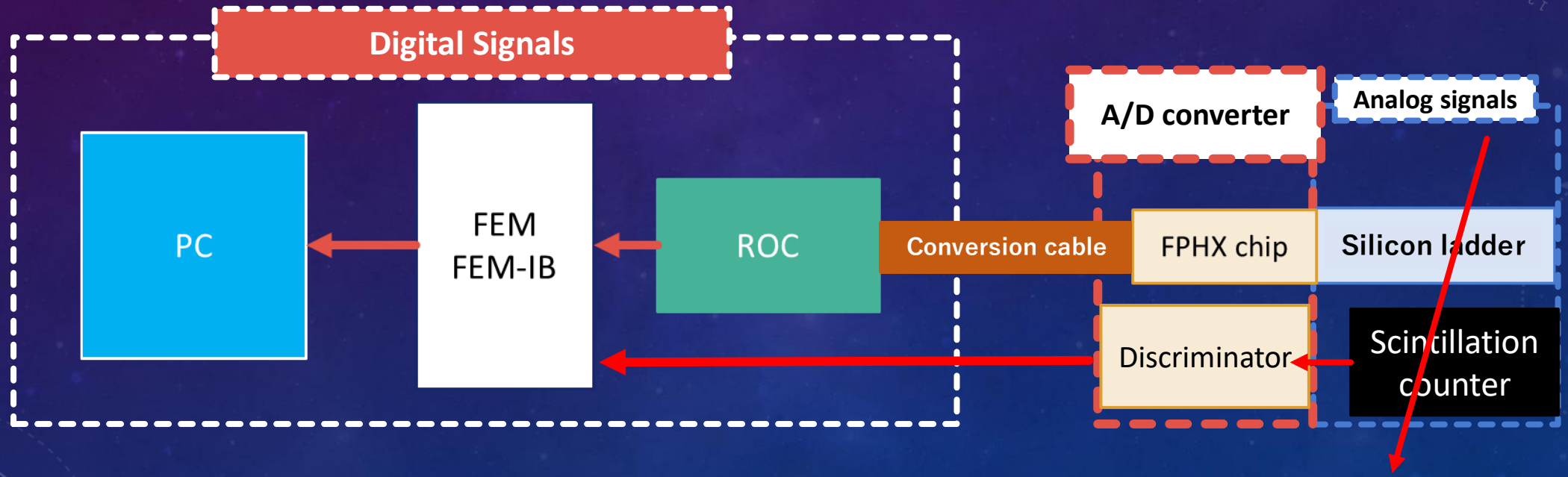
- 1 chip divide 128 channels. Channel size is $78\mu m \times 16(or 20)mm$.
- In silicon sensor, outside is channel 0 and inside is channel127.



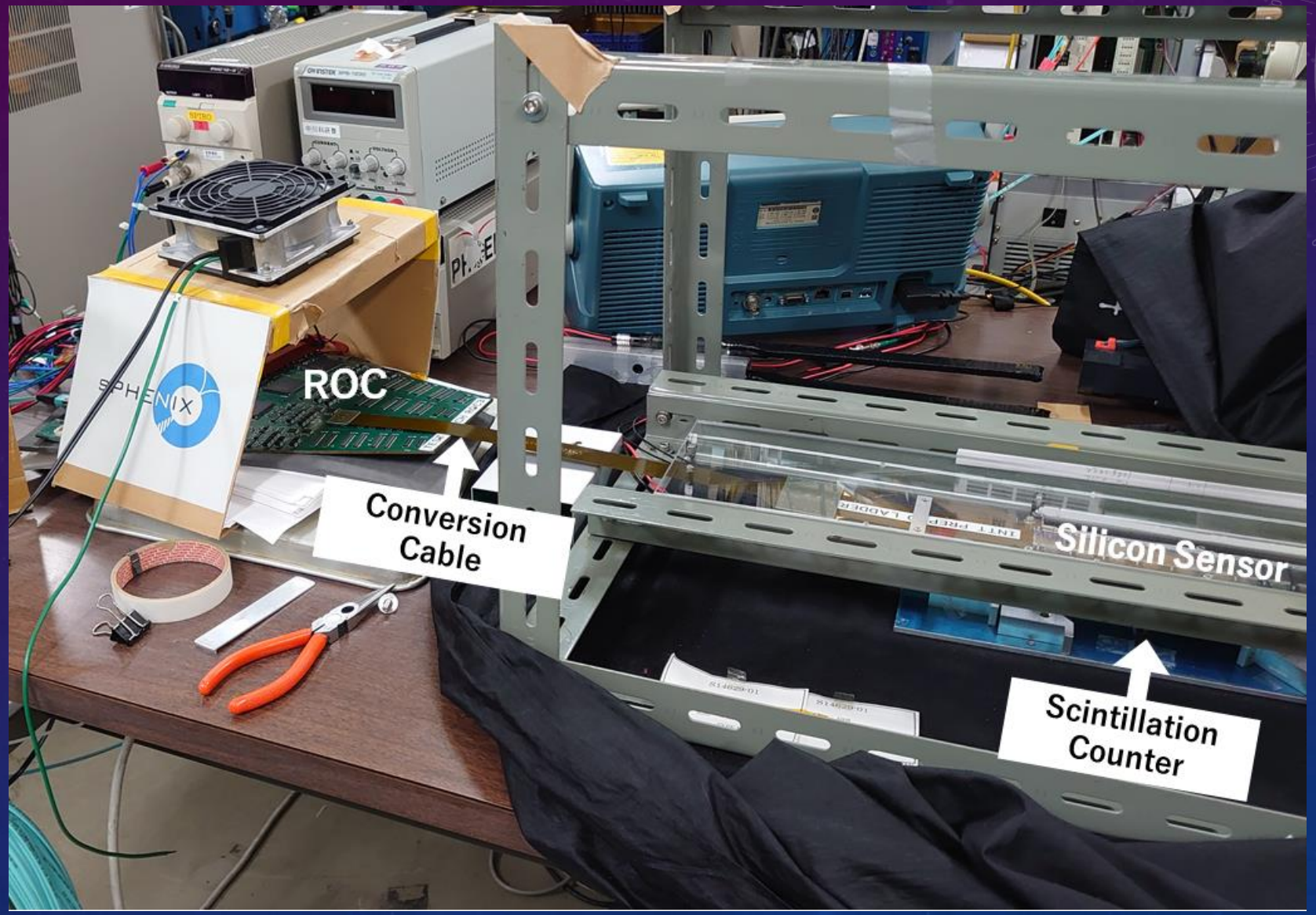


DATA READOUT CIRCUIT

- If silicon ladder detects charged particle, analog signals send to FPHX chips.
- FPHX chips convert analog signals to digitals, and the signals are sent to ROC(Read Out Card) through the conversion cable.
- Digital signals are processed at ROC and later FEM and recorded by PC.

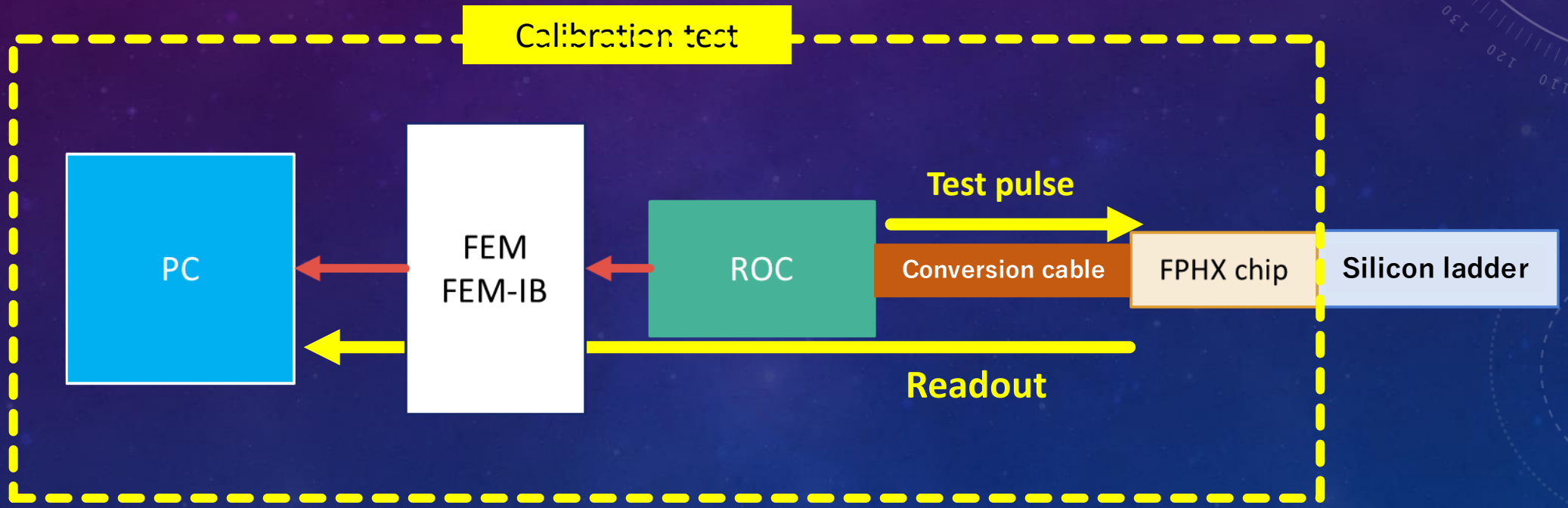


TEST BENCH IN NWU



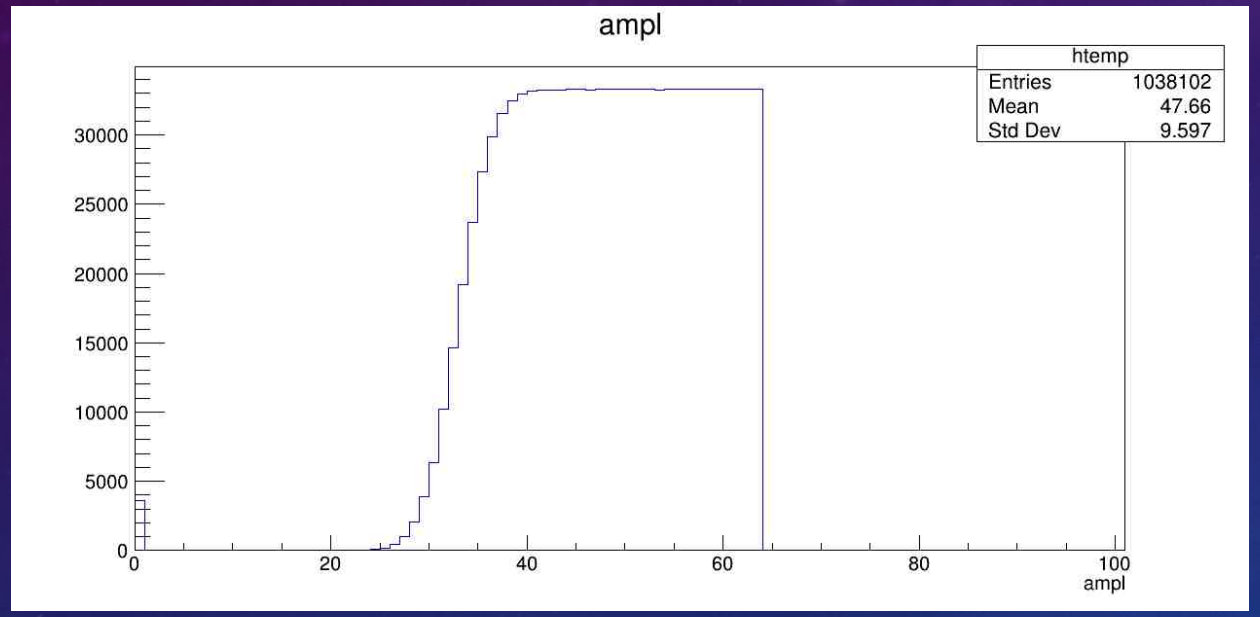
CALIBRATION TEST

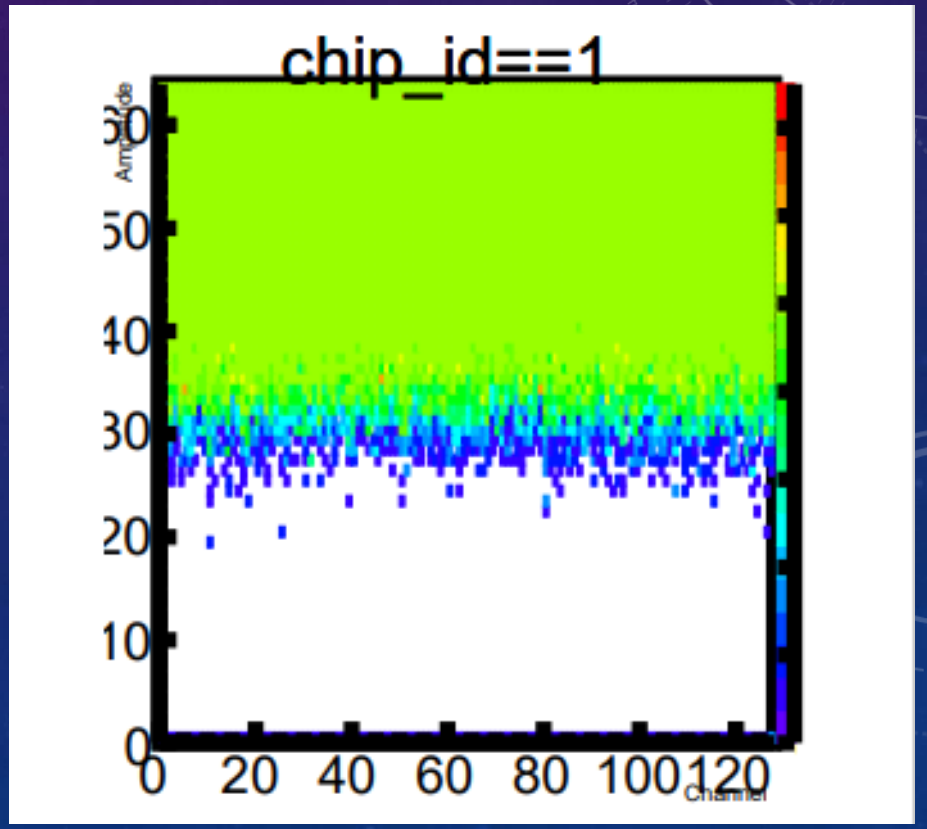
- Calibration test : We send test pulse to FPHX chips from ROC and compare the received data with input pulses.
- 10 test pulses are send to 1 channel.
- We can check the operation about PC, FEM, FEM-IB, ROC and FPHX chips, without silicon ladder.



CALIBRATION TEST: RESULT

- Amplitude vs channel
  - Test pulses are sent to all channels, all chips.
  - We confirm from this plot that each channels received test pluses and how the threshold is scattering.

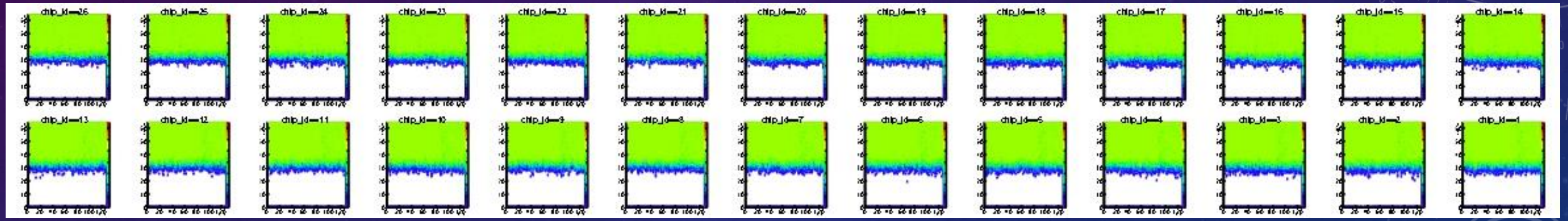


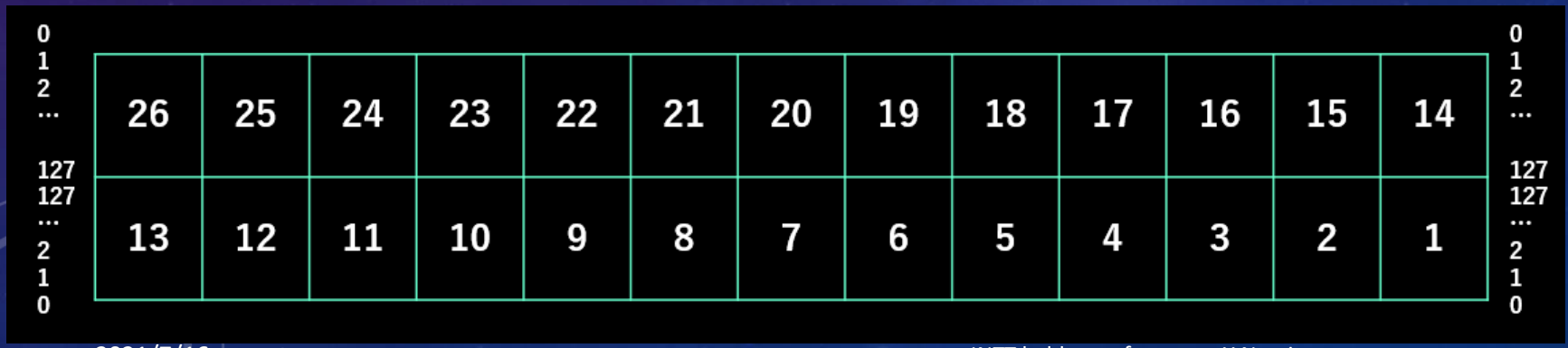


CALIBRATION TEST: RESULT

- This picture shows the result of all chips in half ladder .
- Chips line up like black picture.

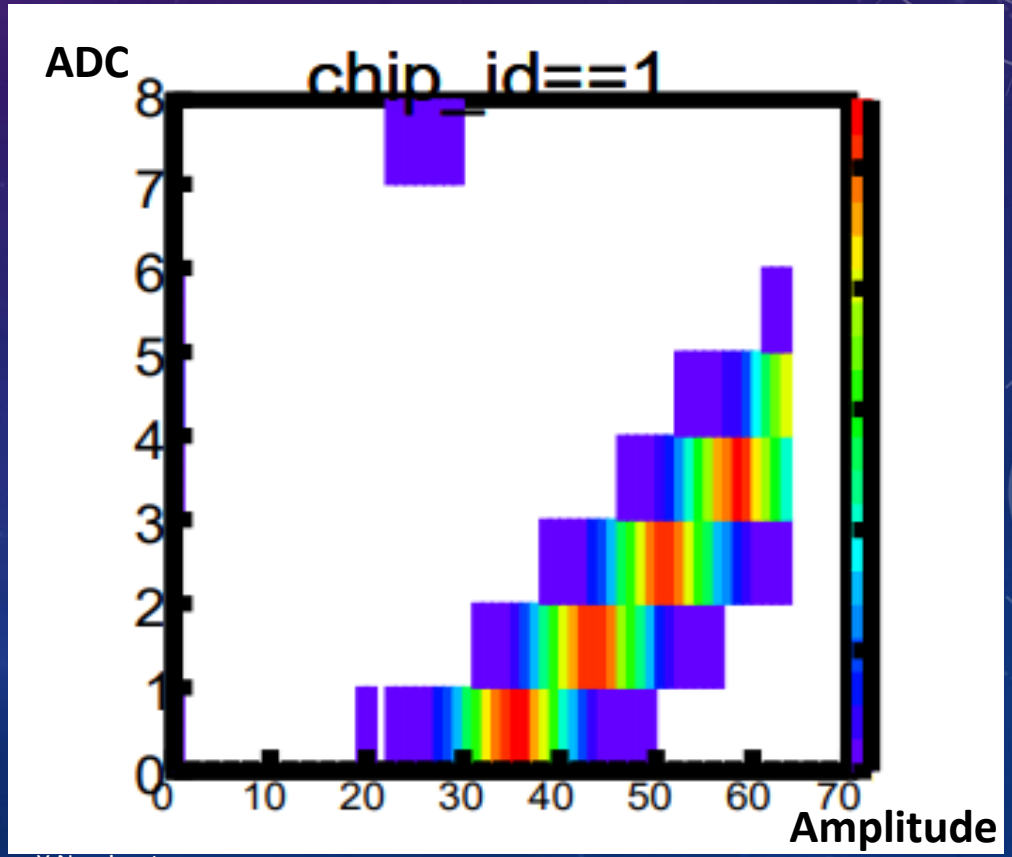
- All channels in 26 chips operate.
- Thresholds are not scattering.





CALIBRATION TEST: RESULT

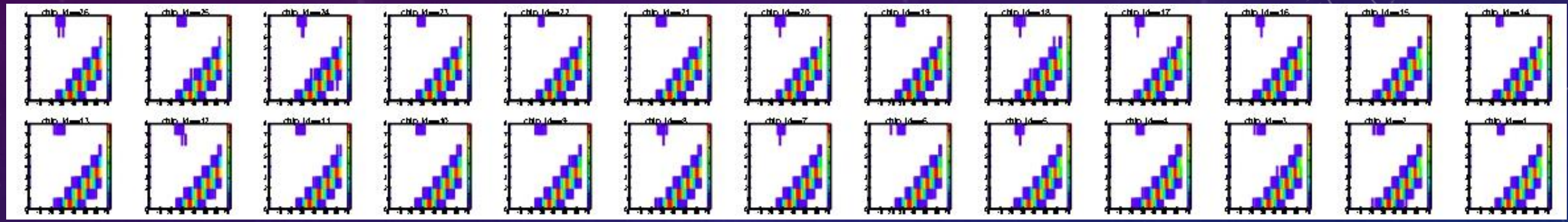
- ADC vs amplitude
  - This plot shows the correlation between the amplitude and output.
  - Amplitude is input pulse height of the test pulse and ADC is output data.
  - In this plot, output ADC is proportional to the input amplitude.



CALIBRATION TEST: RESULT

- This picture shows the plots of all chips in half ladder.

- Linearity of ADC is confirmed in all chips.



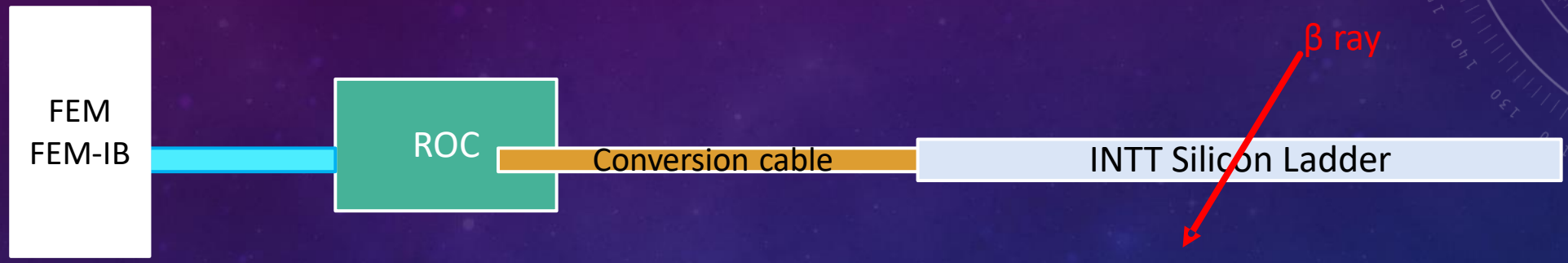
SOURCE TEST

- Source test: Silicon sensor detects β particles, e^- from β source $^{90}\mathrm{Sr}$.
  - e^- from the source: It has many entries and low energies, and we can control hit spot.
  - Cosmic rays: It has less entries and high energies, and we cannot control hit spot.

2 WAYS FOR SOURCE TEST

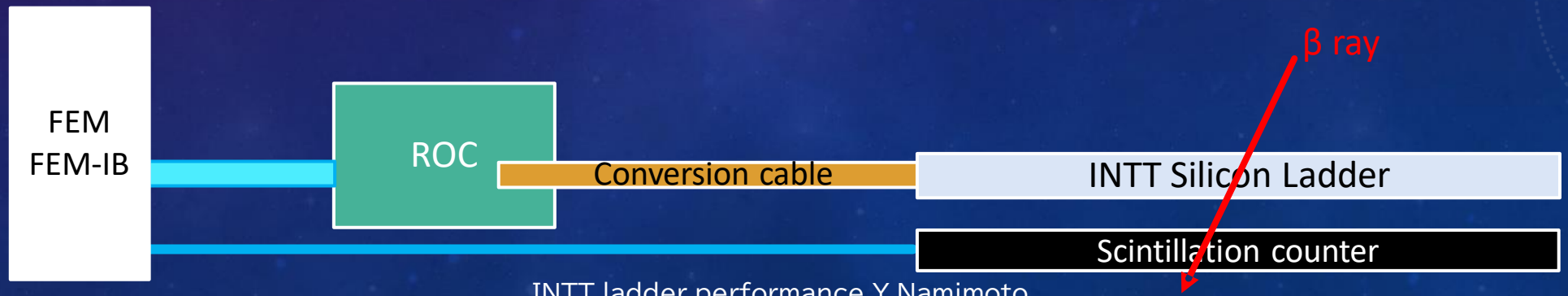
Self trigger test

- We use only silicon ladder.
- If silicon ladder detects charged particle, we get data.



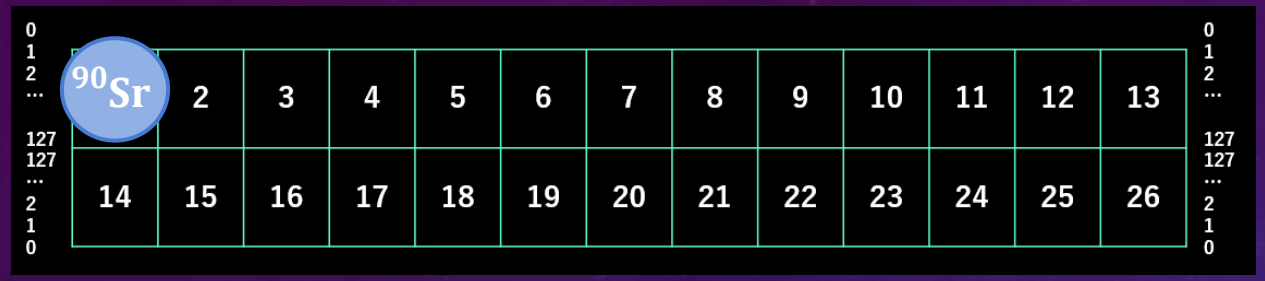
External trigger test

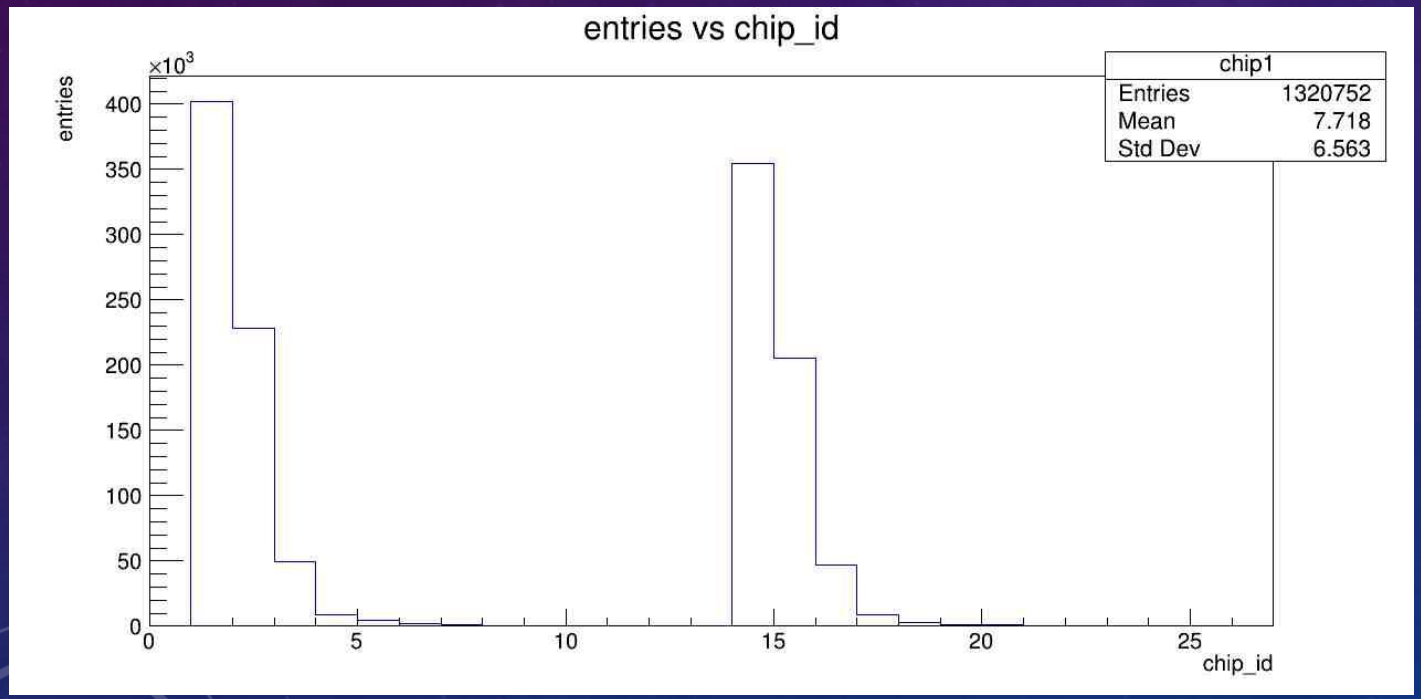
- We use silicon ladder and something for external trigger module, like scintillation counter.
- If both silicon ladder and external trigger module detect charged particle, we get data.



SOURCE TEST: SELF TRIGGER RESULT

- We set ^{90}Sr on chip 1 and did self trigger test.





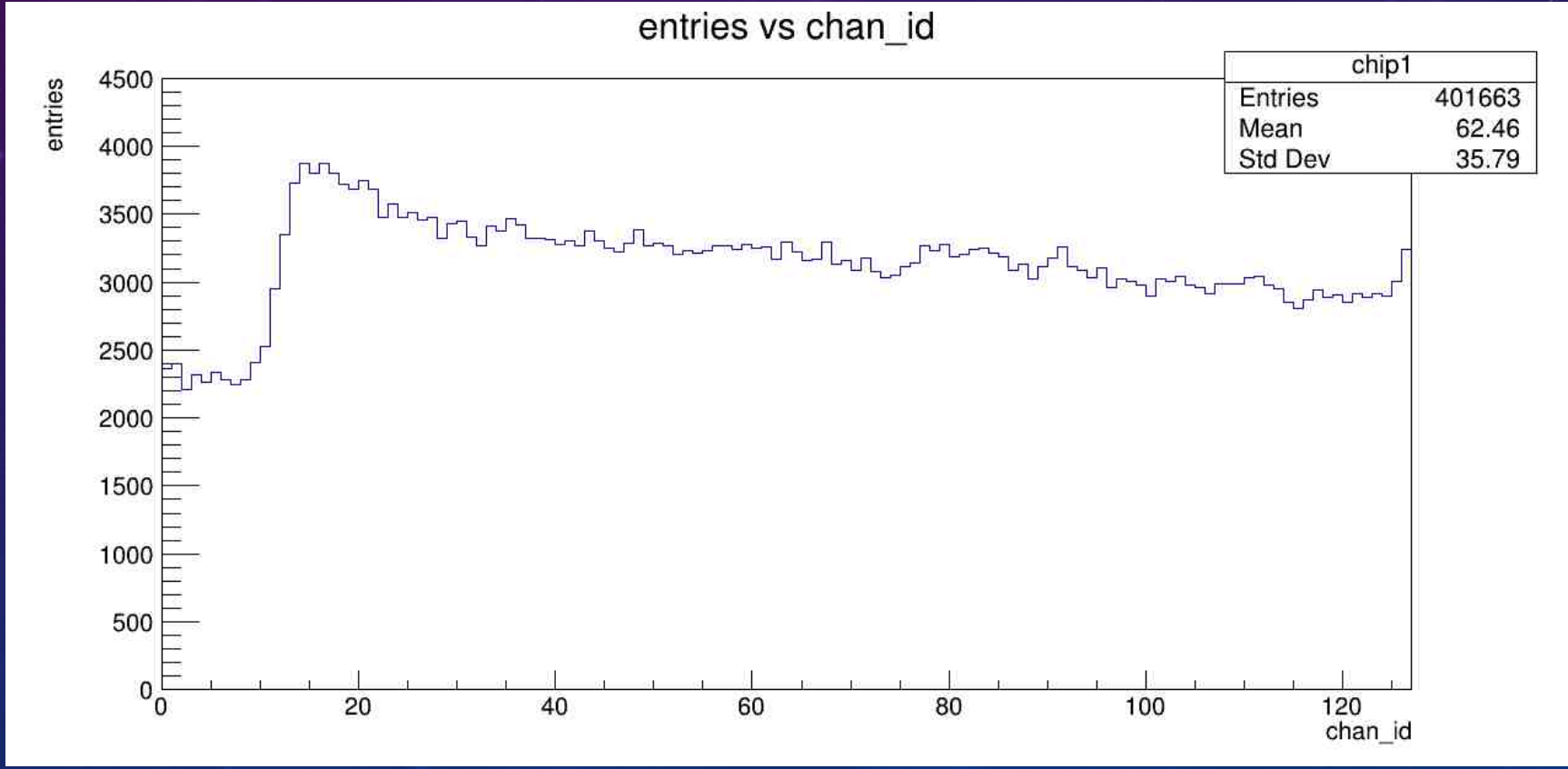
- Chip1, the chip closest to the source has largest entries.
- Around chip1 chips, chip2,3,14,15 has many entries.

SOURCE TEST: SELF TRIGGER RESULT

- This picture shows chip1-channel distribution.
- Channel 0-10 have less entries than it expected. This phenomena occur in all chips.

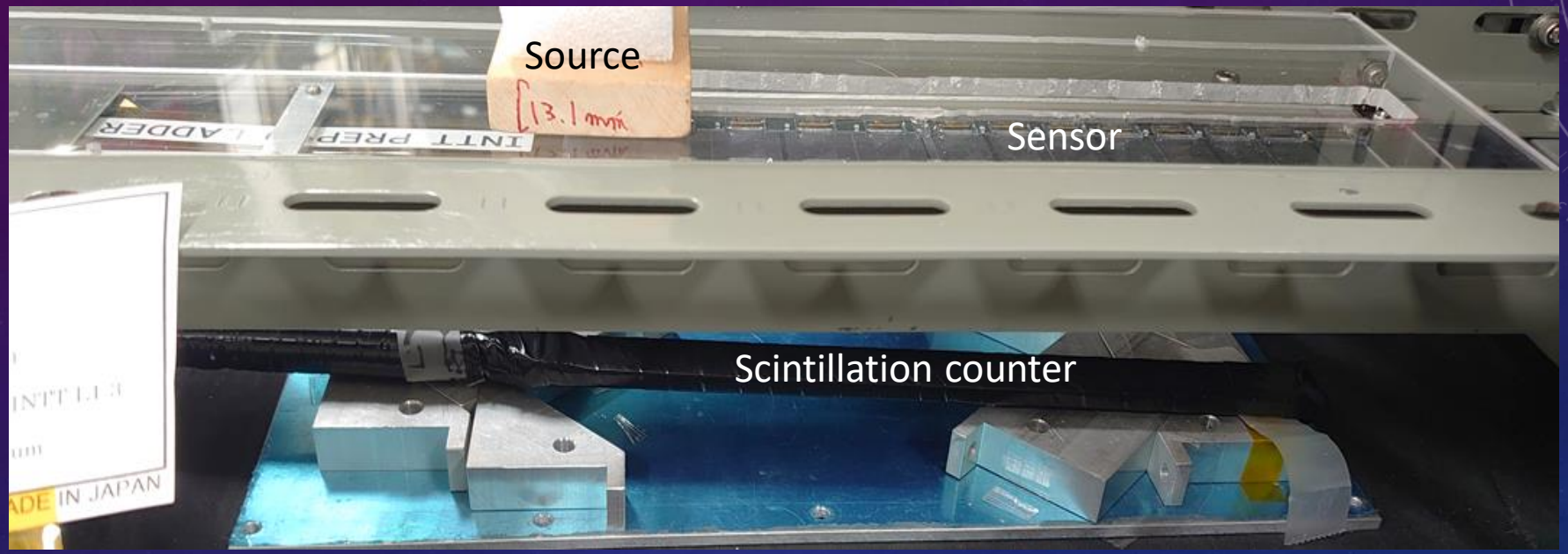
→Is β ray cannot entry to channel 0-10? Or another reasons exists?

→We try to external trigger test.



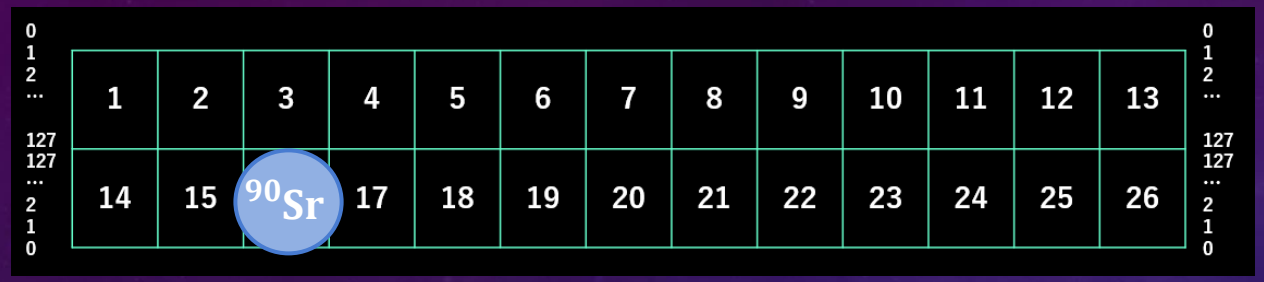
SOURCE TEST: EXTERNAL TRIGGER RESULT

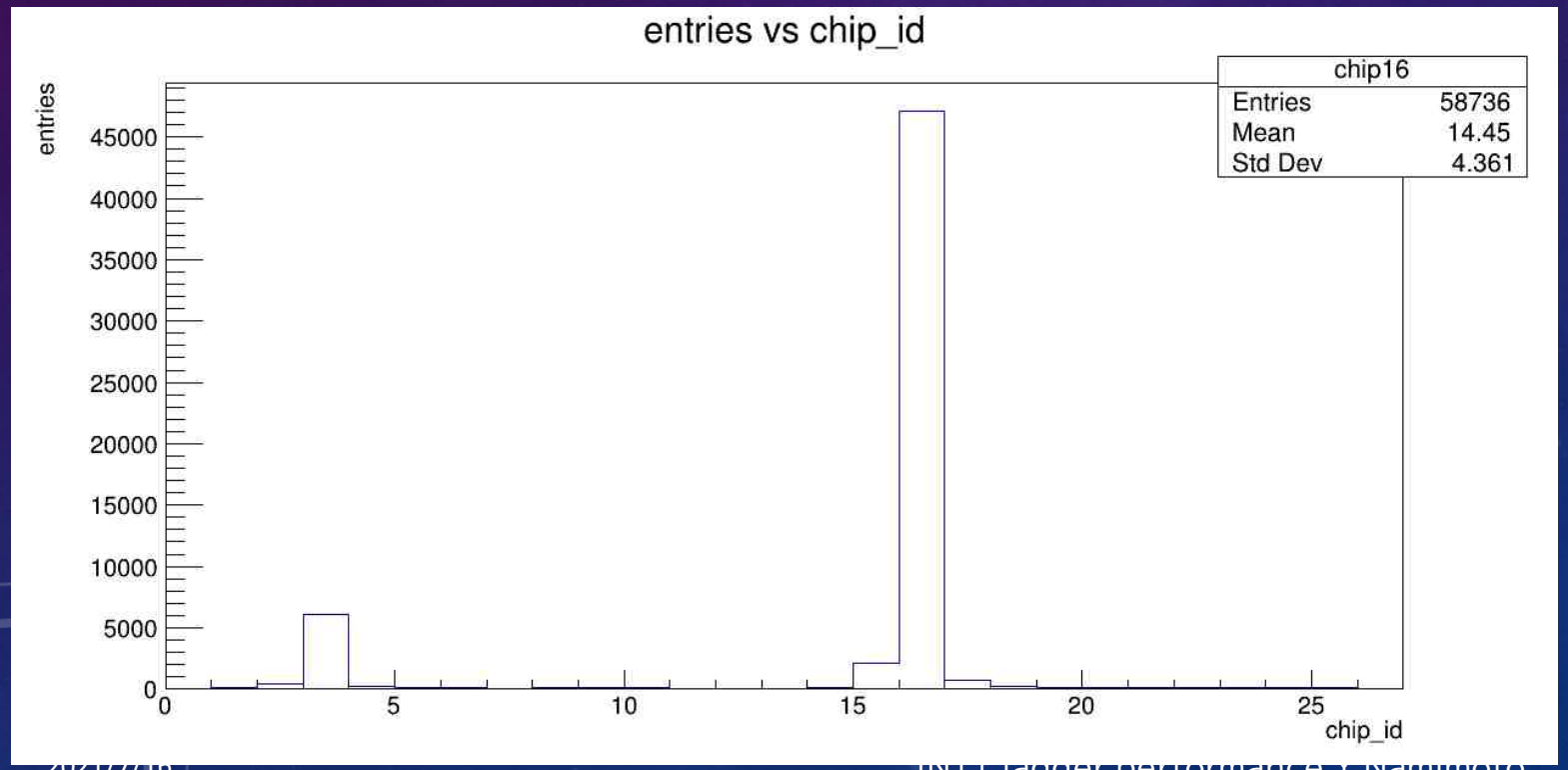
- We use scintillation counter for external trigger.



SOURCE TEST: EXTERNAL TRIGGER RESULT

- We set β source on chip16 and did external trigger test.
- Channel 0-10 should have hits by β ray.

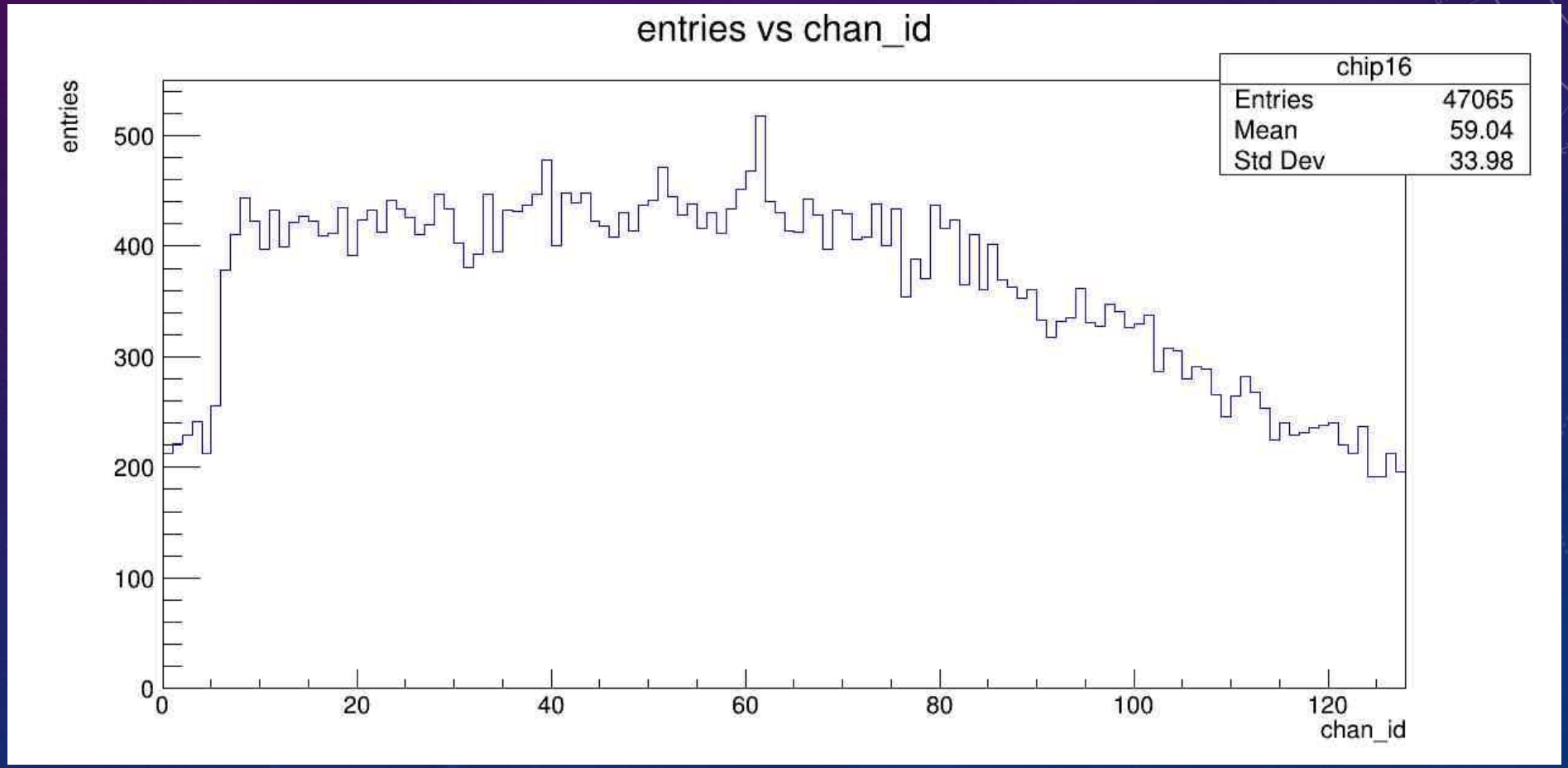




- Chip16 has the largest entries, and chip3, close to source chip has the 2nd largest entries.

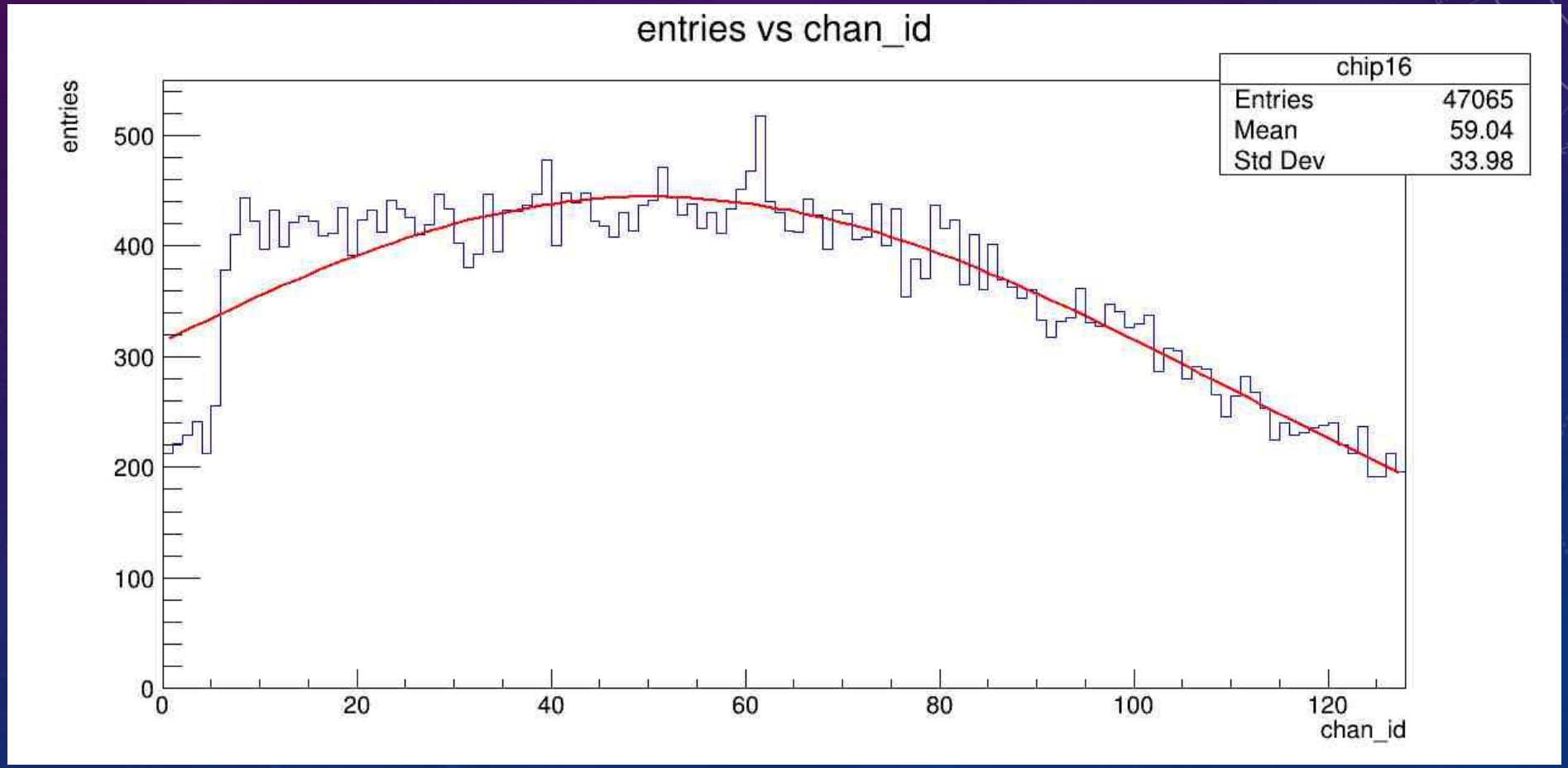
SOURCE TEST: EXTERNAL TRIGGER RESULT

- This picture shows chip16-channel distribution.
- Channel 0-10 have low entries.



SOURCE TEST: EXTERNAL TRIGGER RESULT

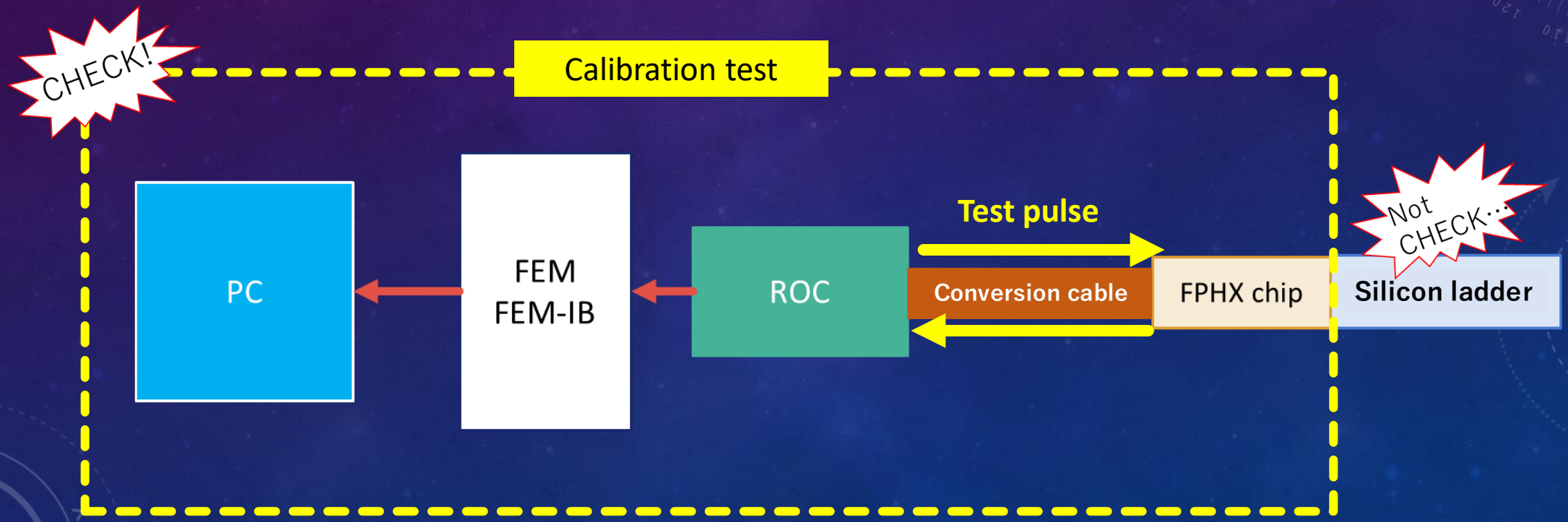
- I try to fit the hit channel distribution with Gaussian.
- Fit range is channel 70-127 to evaluate the hit shape.
- It shows that channel 0 is expected about 320 entries, but it has only 220 entries.



SOURCE TEST: LOW EFFICIENCY CHAN 0-10 ISSUE

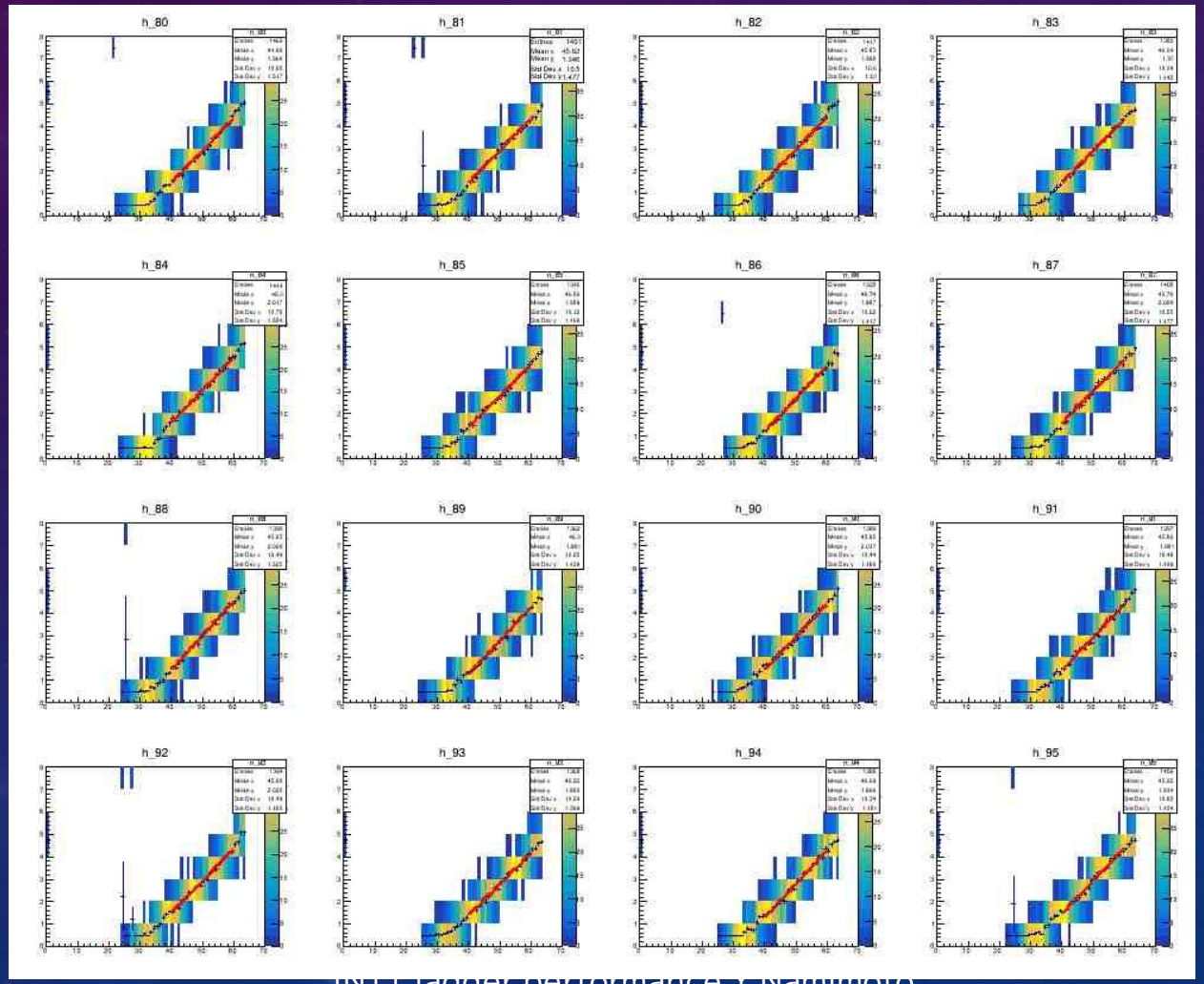
- I try to search which module cause this phenomena.

- Calibration test uses FPHX chips, ROC, FEM, FEM-IB and PC, without silicon ladder. If the result shows something strange, it is expected that these modules cause this phenomena. If it does not, **silicon ladder** causes this phenomena.



SOURCE TEST: LOW EFFICIENCY CHAN 0-10 ISSUE

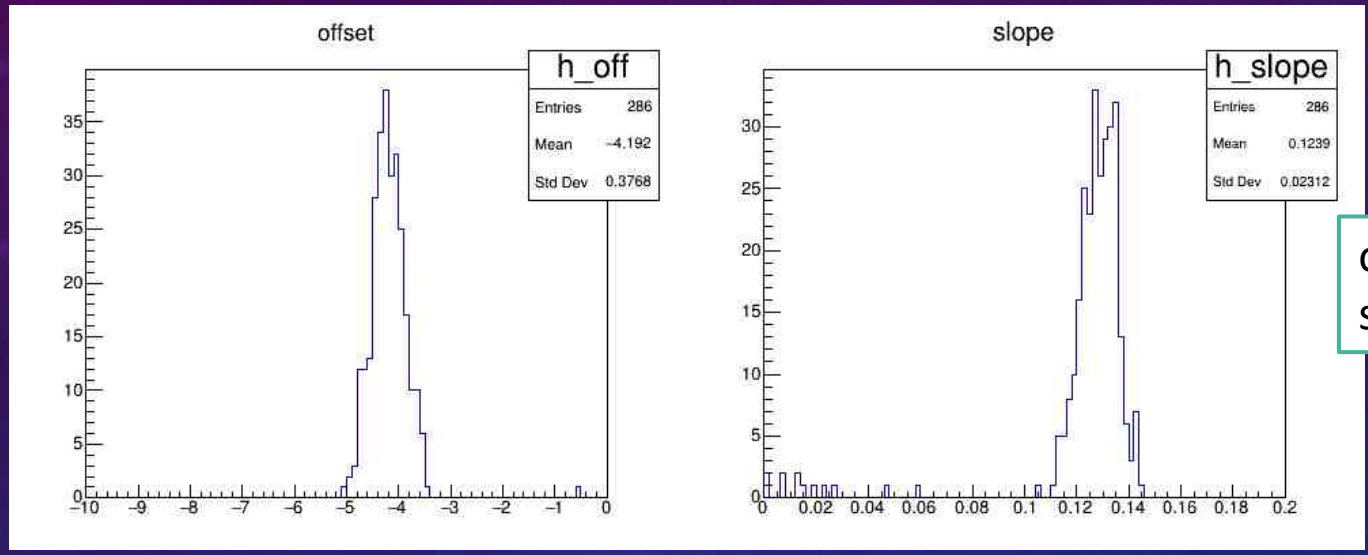
- I compare calibration test result of slope and offset at ADC vs amplitude.
- This program made by Dr. Hachiya.



SOURCE TEST: LOW EFFICIENCY CHAN 0-10 ISSUE

- Left pictures show offset and right pictures show slope of ADC vs amplitude.
- Upper picture is about channel 0-10, and bottom is channel 60-70.

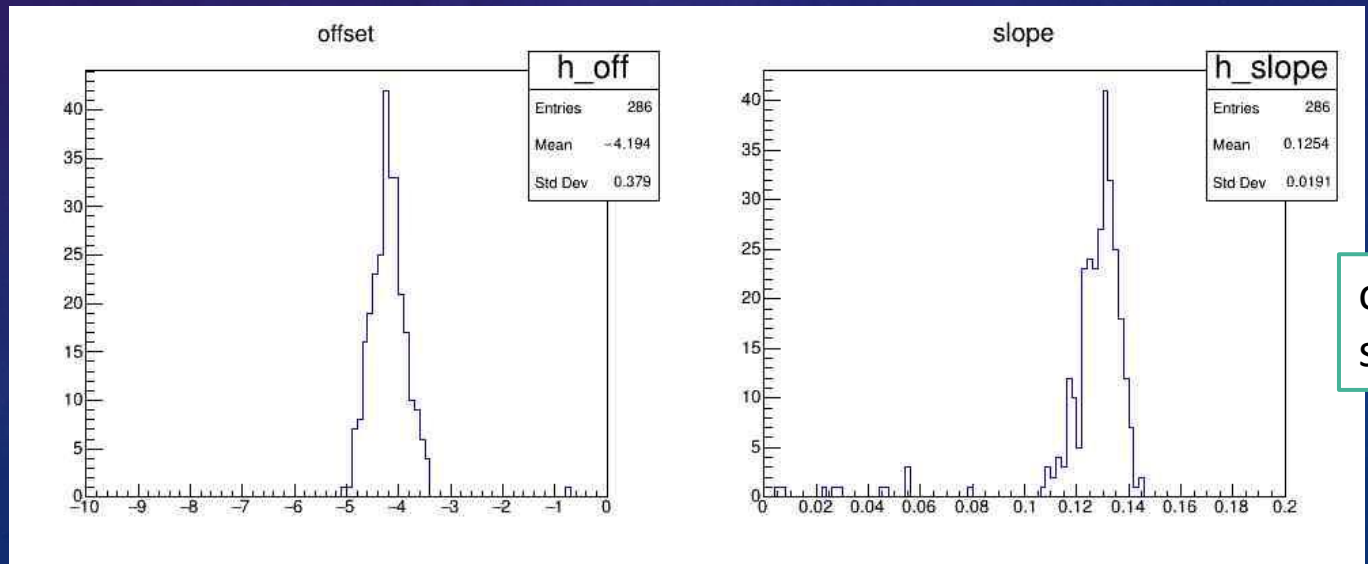
Chan0-10



offset:-4.192
slope:0.1239

There are no difference.

Chan60-70

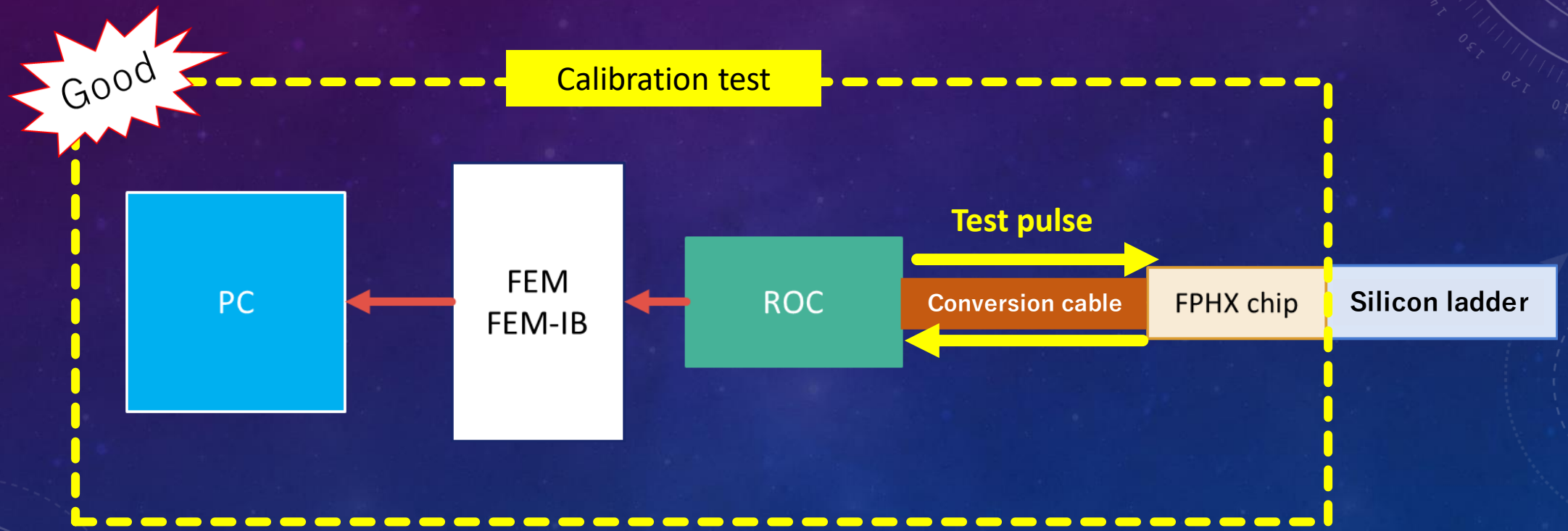


offset:-4.194
slope:0.1254

SOURCE TEST: LOW EFFICIENCY CHAN 0-10 ISSUE

- Calibration test does not show strange result.

→The phenomena are caused by between FPHX chip and silicon ladder, or only silicon ladder.

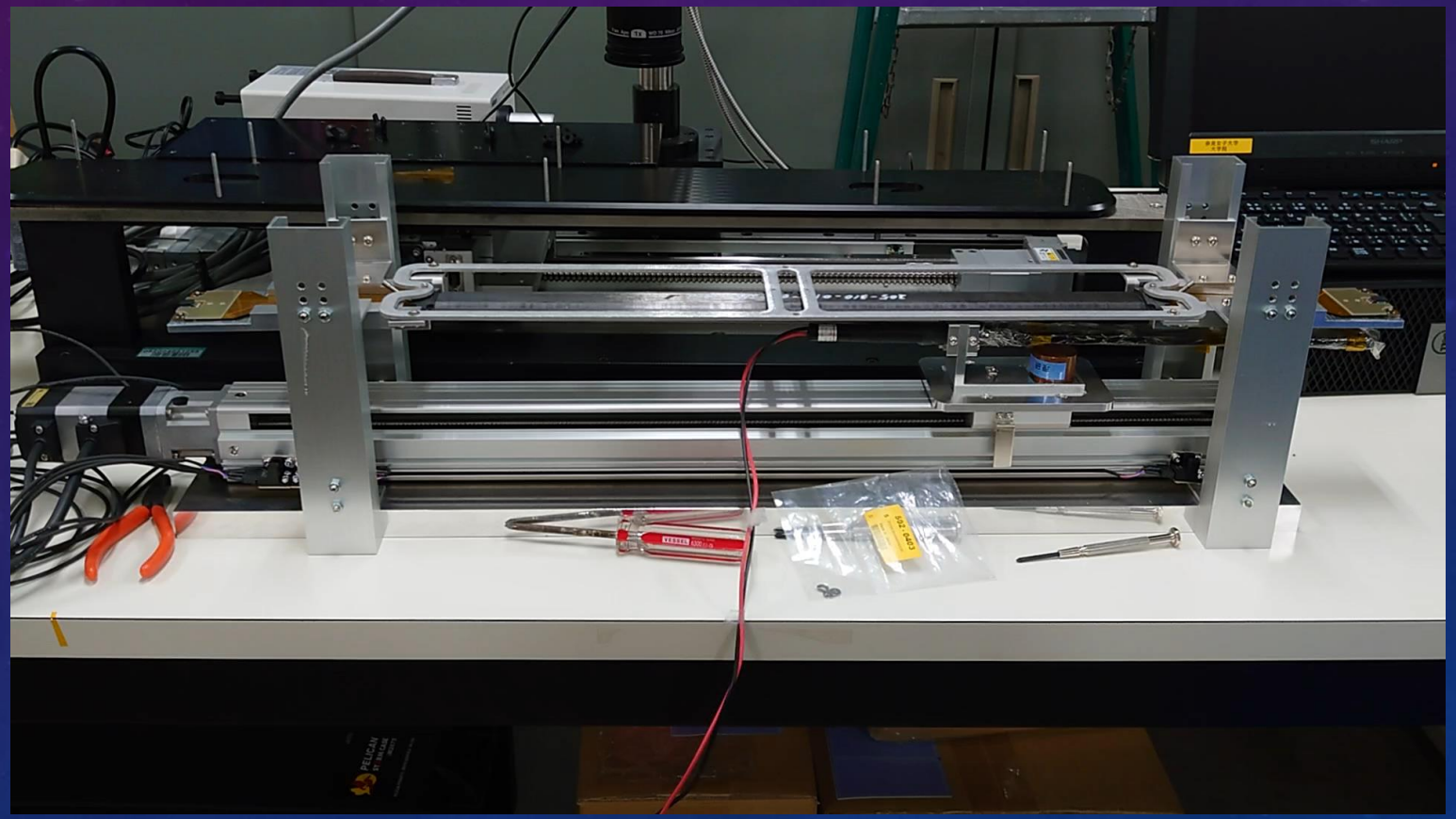


SOURCE TEST SUMMARY

- We find low efficiency issue at channel 0-10.
- No suspicious behavior was observed in the calibration results for the ladder. So the issue can be caused by between FPHX chips and silicon ladder, or only silicon ladder.
- We can check silicon ladder’s operation easily and rapidly by using radiation source.
- The next step is to investigate silicon ladders response using a radiation source test fixture.

SOURCE TEST FIXTURE

- Now, we get source test fixture. Toward sPHENIX experiment start in 2023, now we mass product silicon ladders, so we should check all ladders rapidly.
- Using this fixture, Radiation source move automatically. We can expose all 26 chips to β ray in one time, automatically. It is useful to many sensors checking automatically.

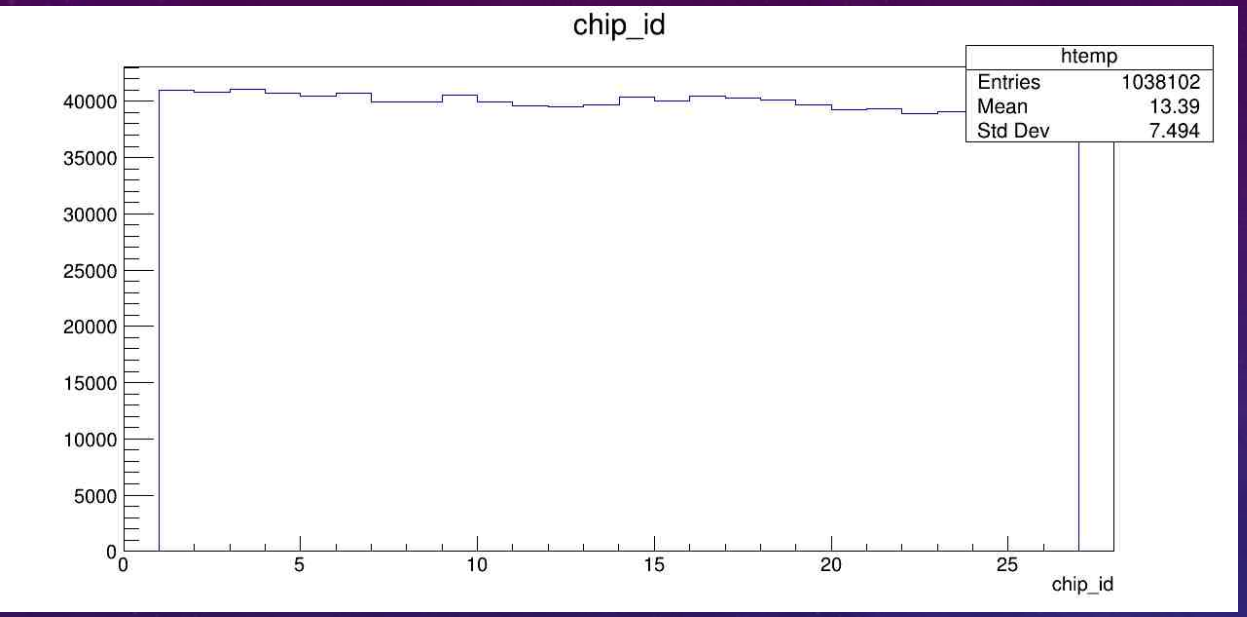


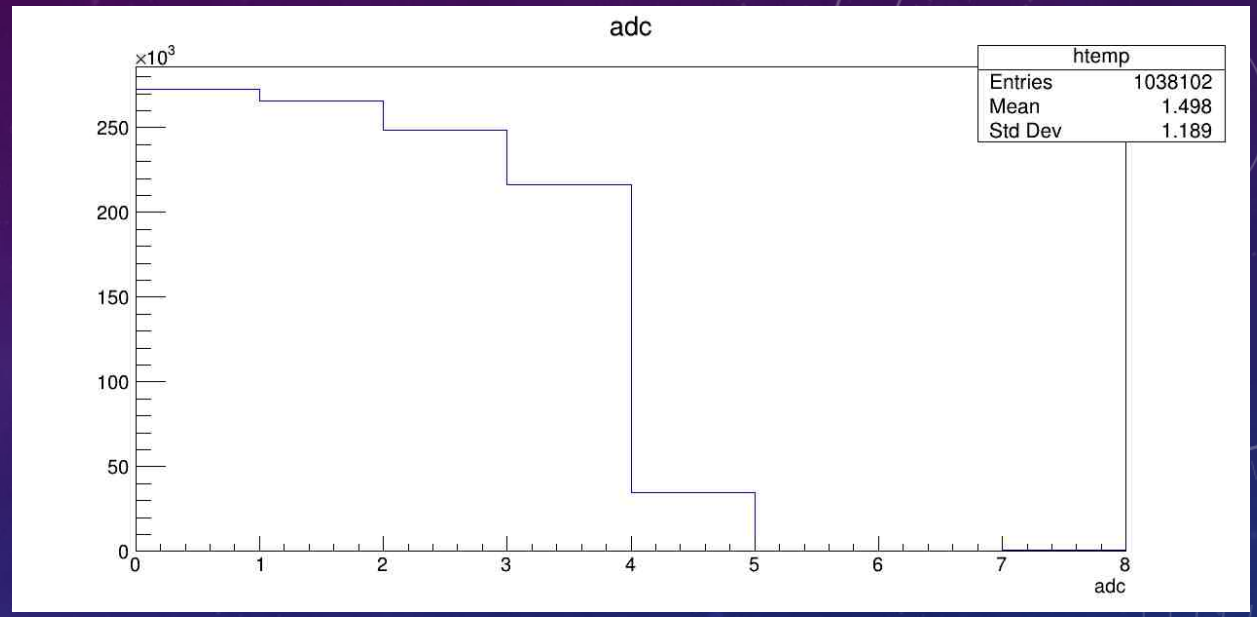
SUMMARY

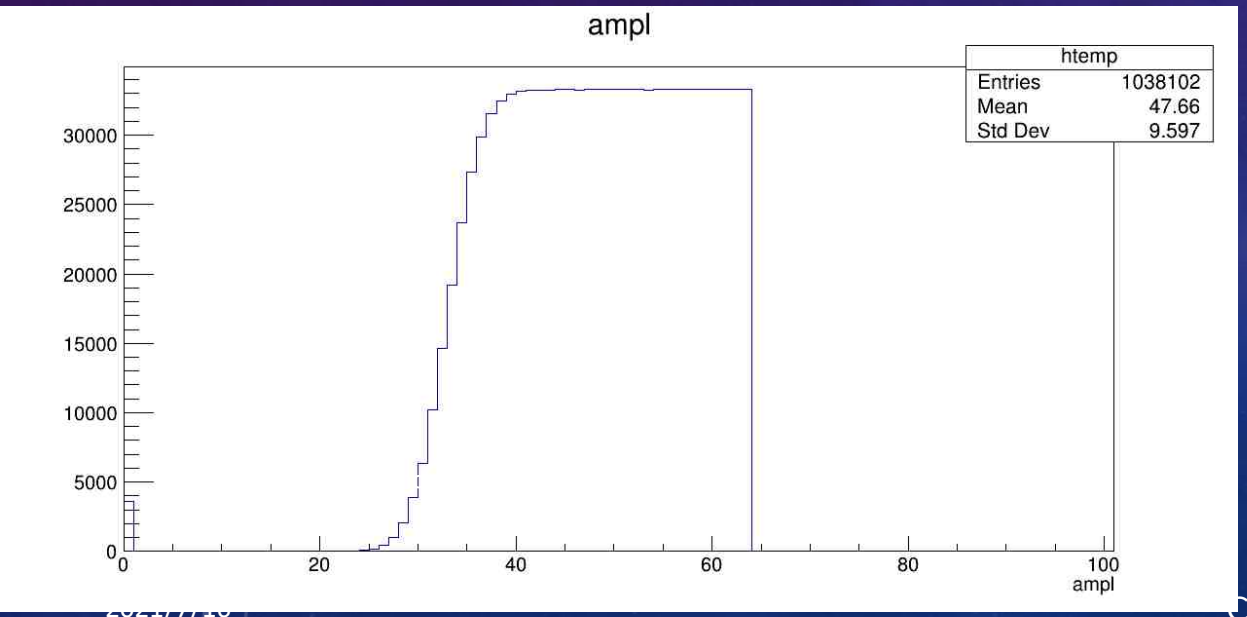
- We can see the signals from β source by using silicon ladder.
- We developed 2 methods to test the INTT ladder.
  - Calibration test is useful to check if the readout system including channel-by-channel response works or not.
  - Source test is useful to see the response of the radiation.
- Now we check source test fixture operation. Sometimes it takes noises, so we try to search noise source and remove the signals.
- After we understand the fixture operation, we will be able to check many ladders easily and rapidly.

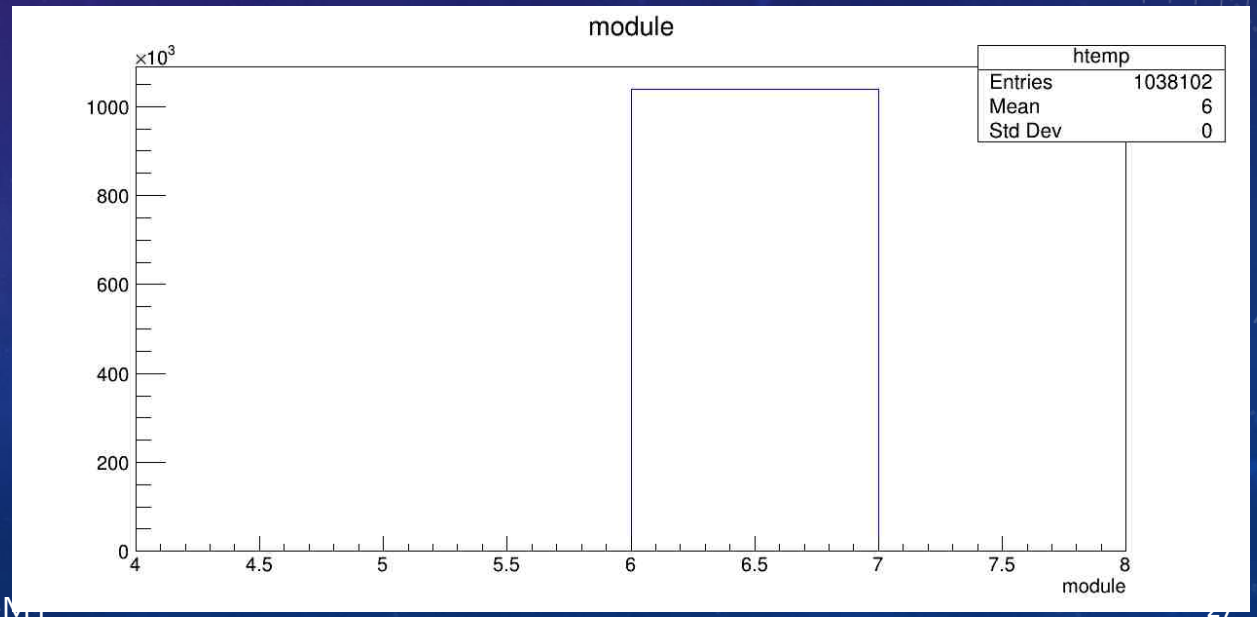
BACK UP

CALIBRATION TEST





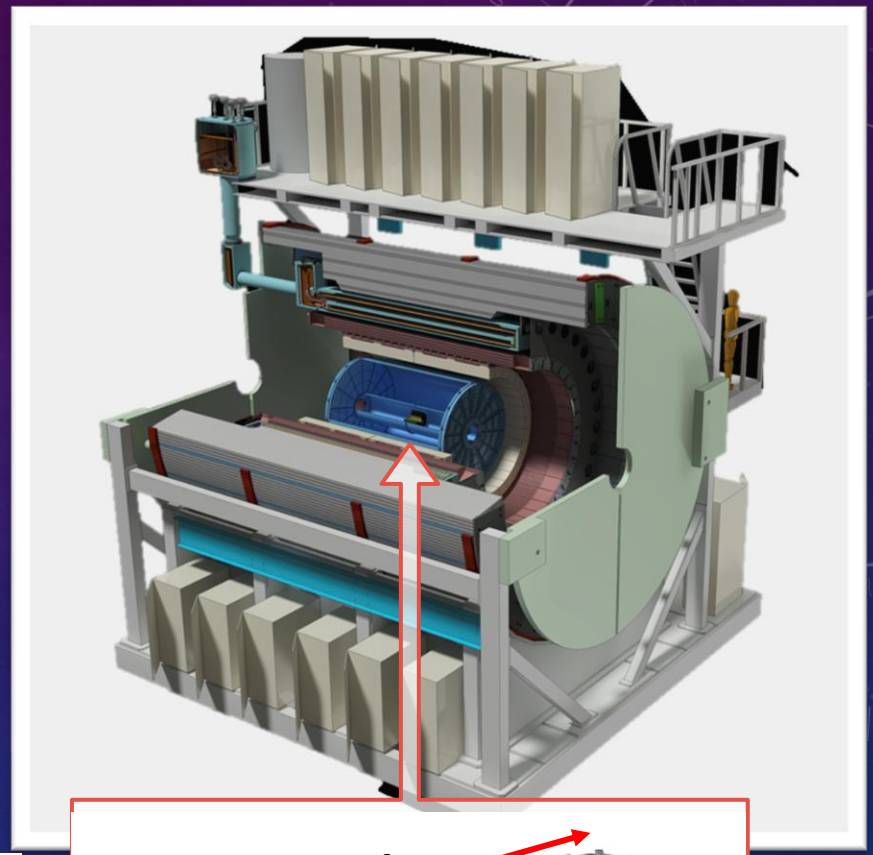




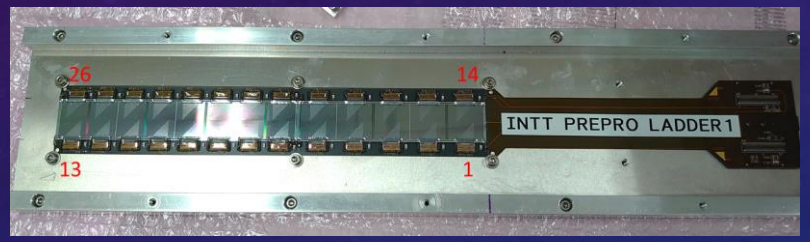
ABOUT INTT

- INTT(INTermadiate Tracker) is a detector of SPHENIX experiment.
- One of three track detectors where is close to collision point.

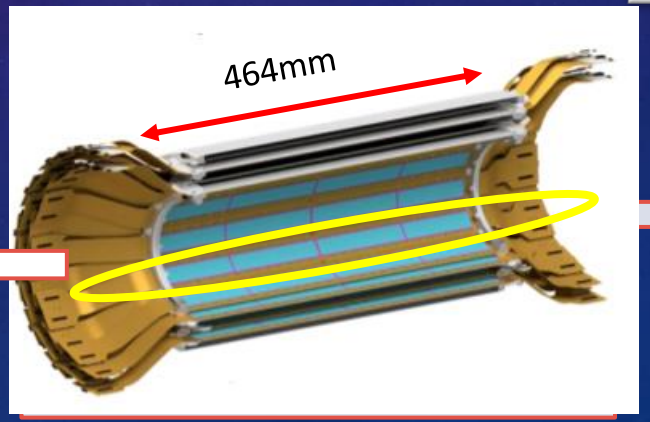
- It is consisted by silicon semiconductor, if charged particle comes through, it takes data.

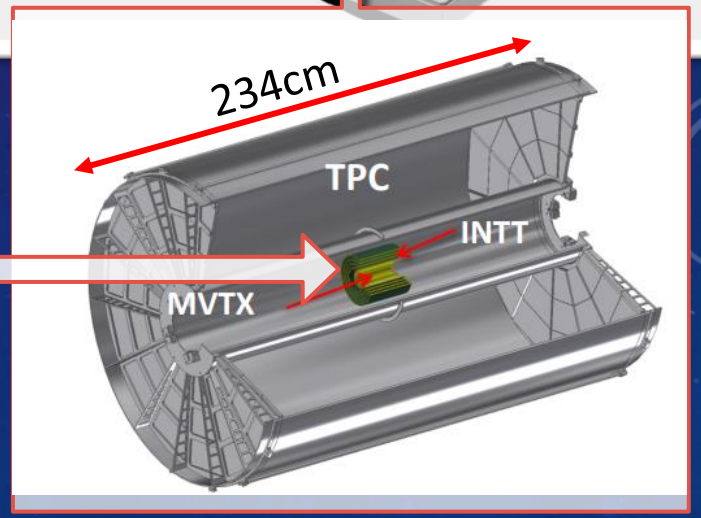


Half ladder



Full ladder





ABOUT ADC

- We can set thresholds of silicon sensor from PC.
- ADC value can change to mV value by bottom equation.

Default

	ADC	mV
DAC0	10	250
DAC1	23	302
DAC2	48	402
DAC3	98	602
DAC4	148	802
DAC5	172	898
DAC6	223	1102
DAC7	248	1202

$$\text{Threshold(mV)} = \text{ADC} \times 4 + 210\text{(mV)}$$