

The study of SiW-ECAL with Test Beam

Kyushu University

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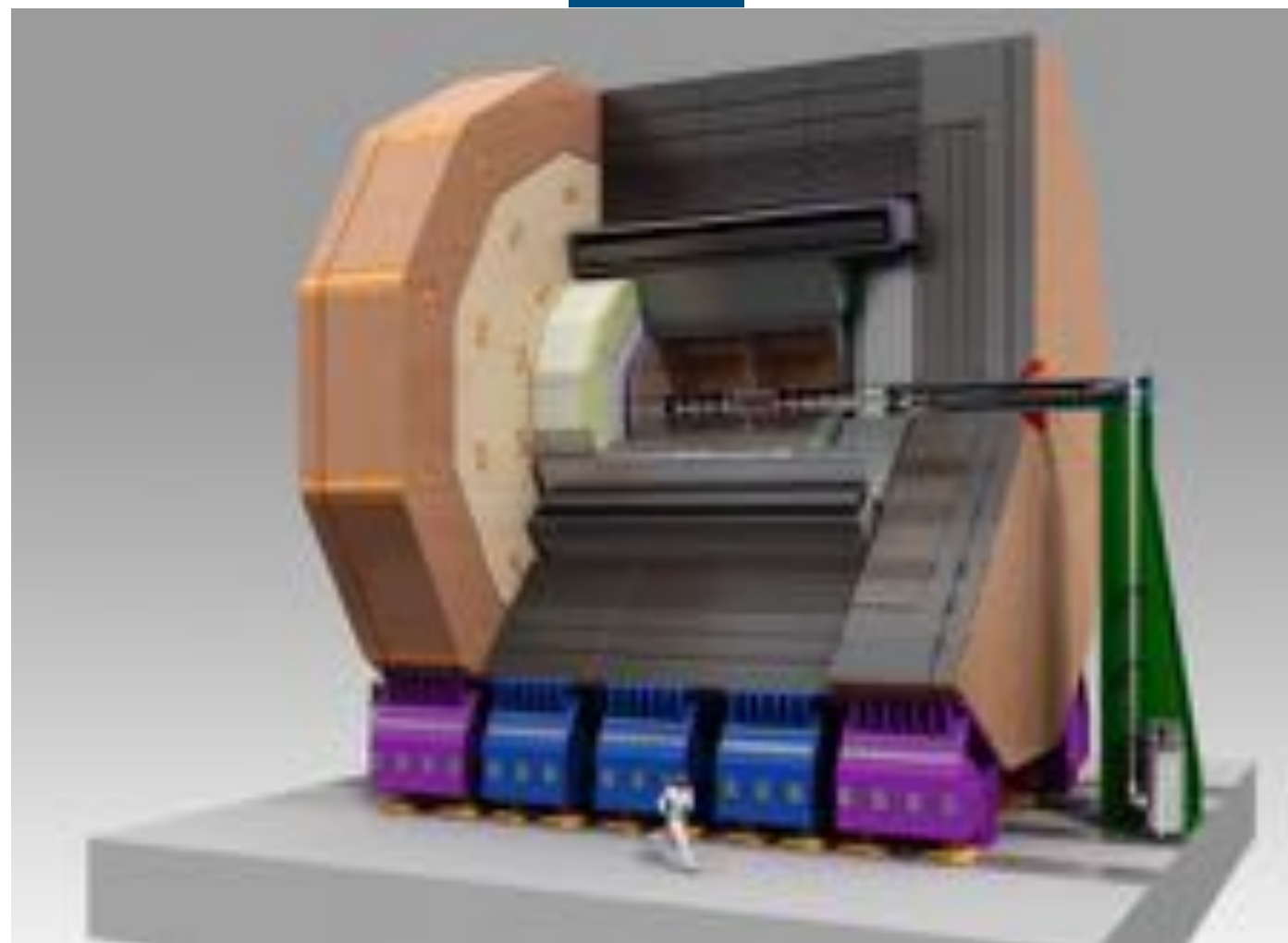
(A: Kyushu University, B: University of Tokyo, C: LLR, D: LAL)

Summer Camp @ Ibaraki 2019/9/6

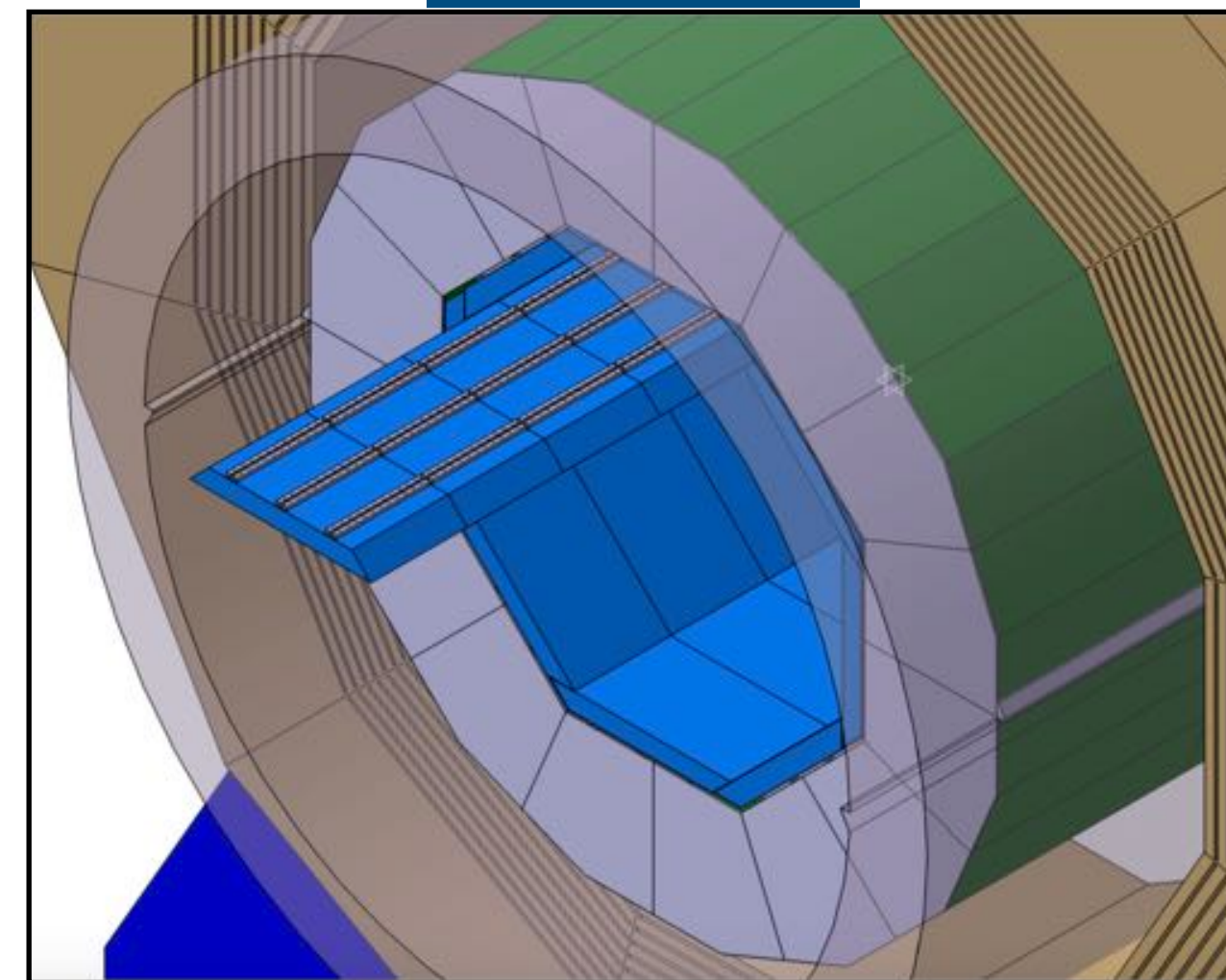
ILD ECAL

- ILD ECAL detector has two candidates, one is the scintillator, the other is the Si semiconductor.
- We study about the technological prototype of the silicon tungsten electromagnetic calorimeter, the SiW-ECAL.

ILD

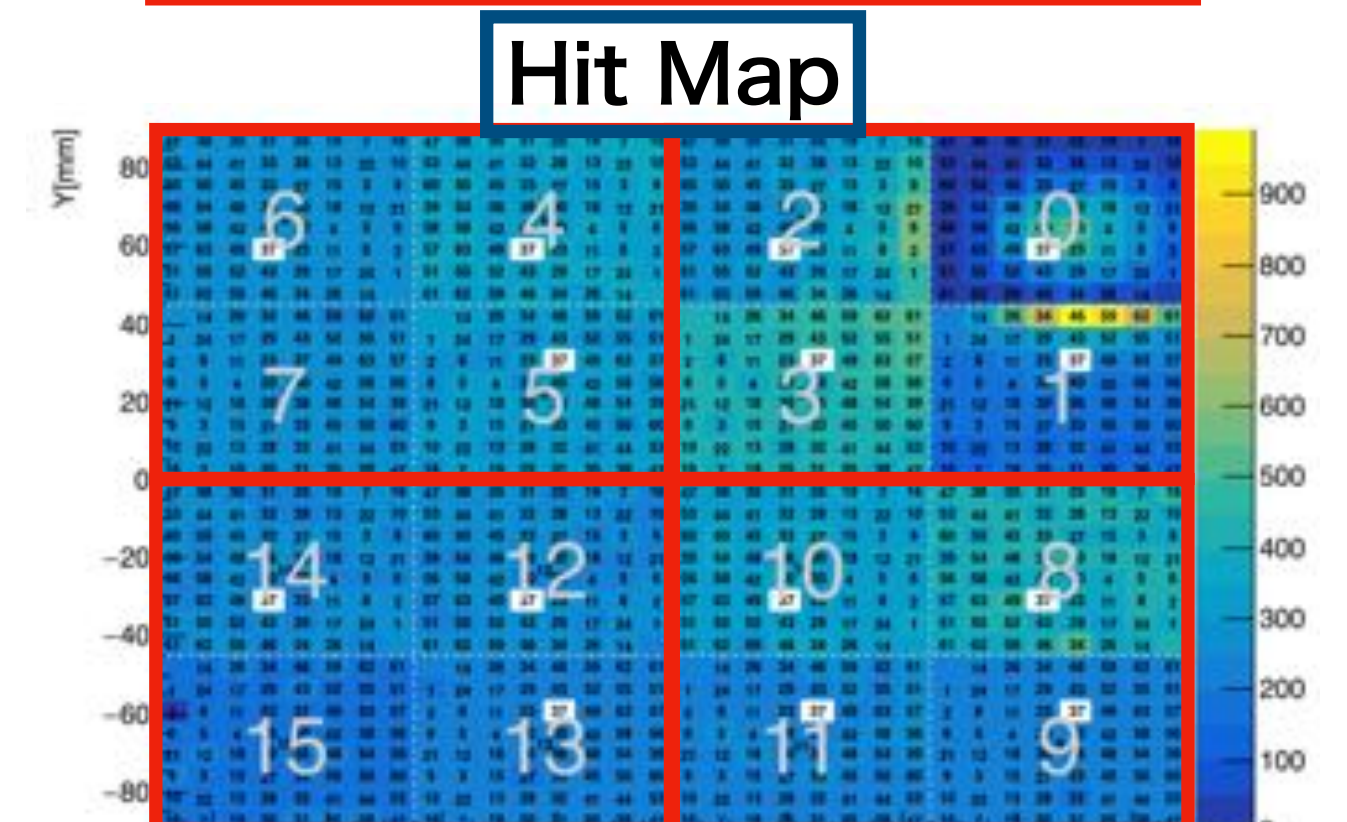
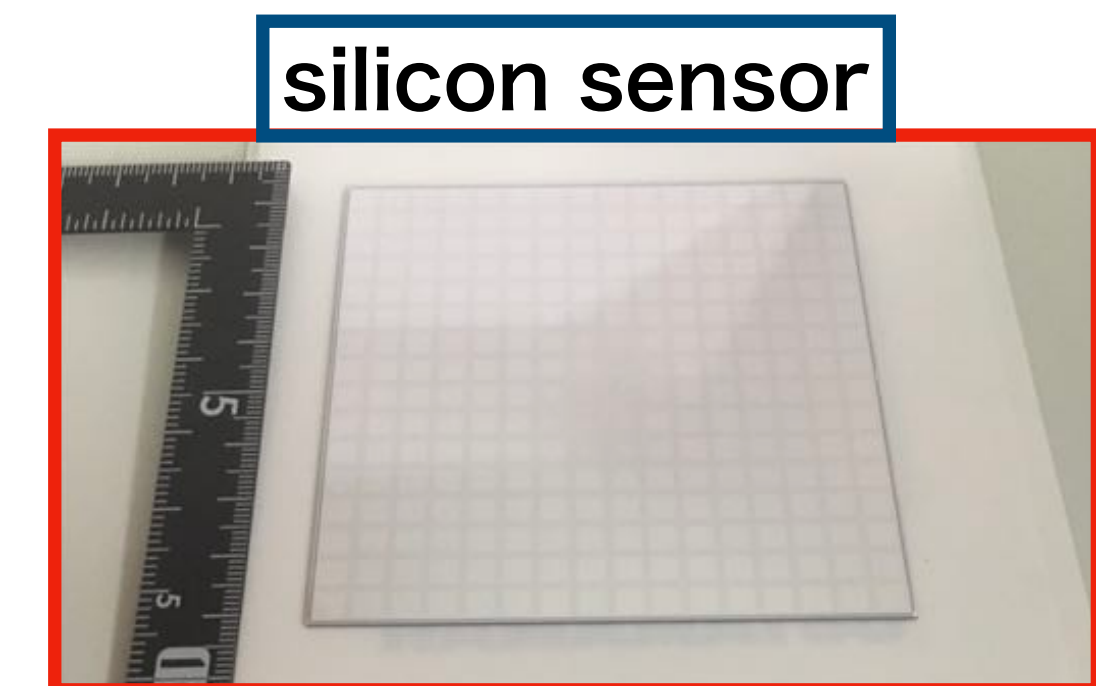
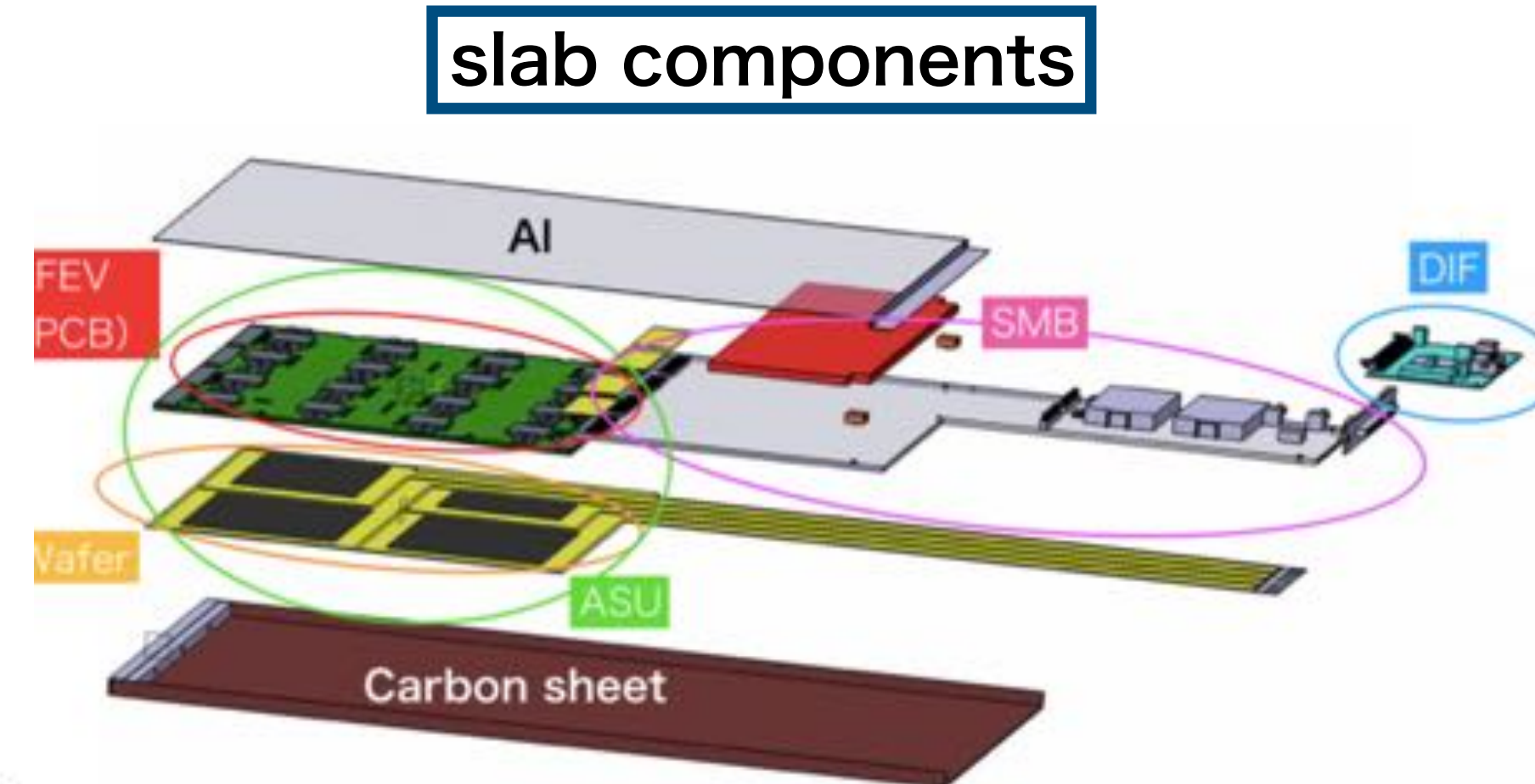
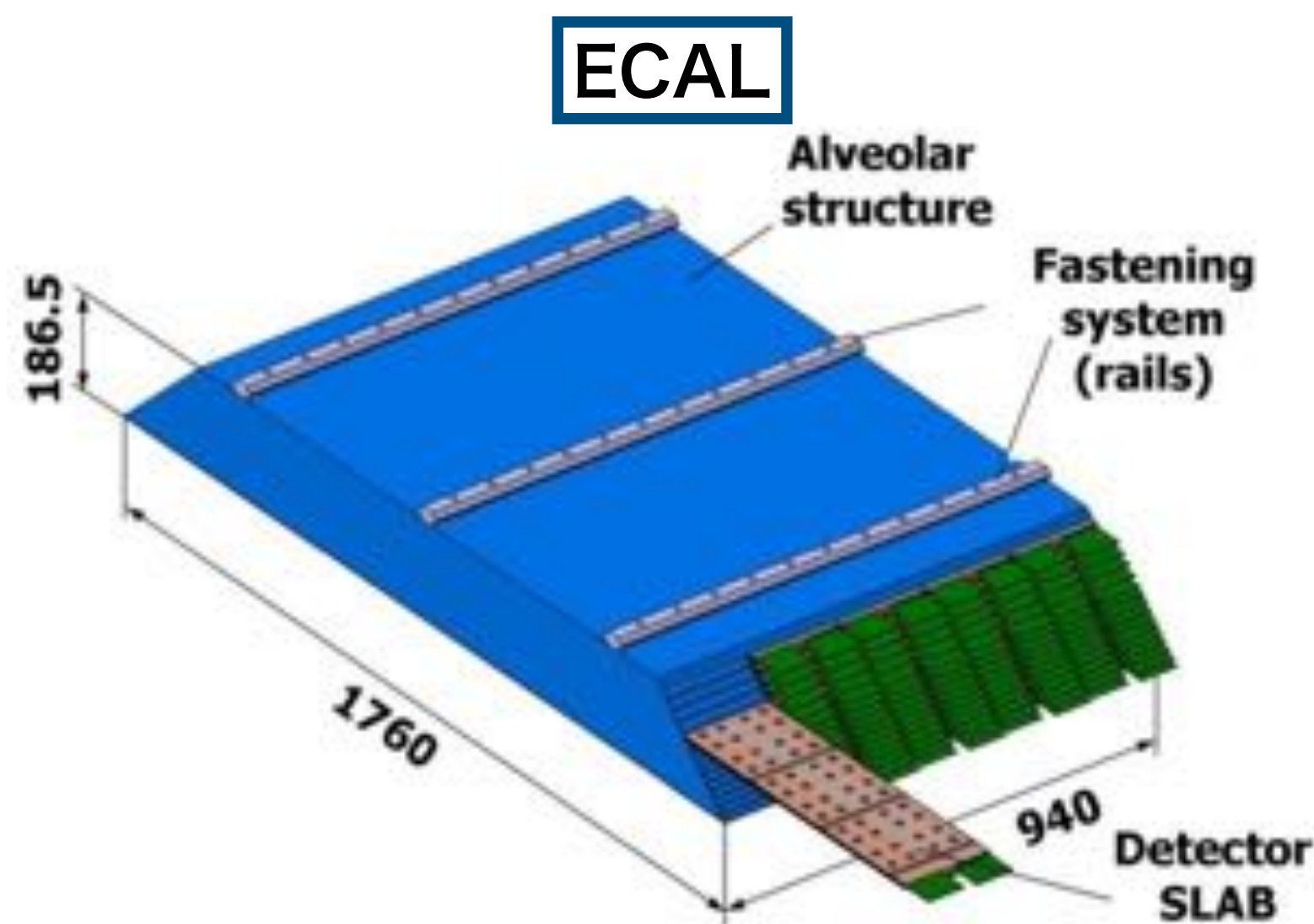


ILD ECAL



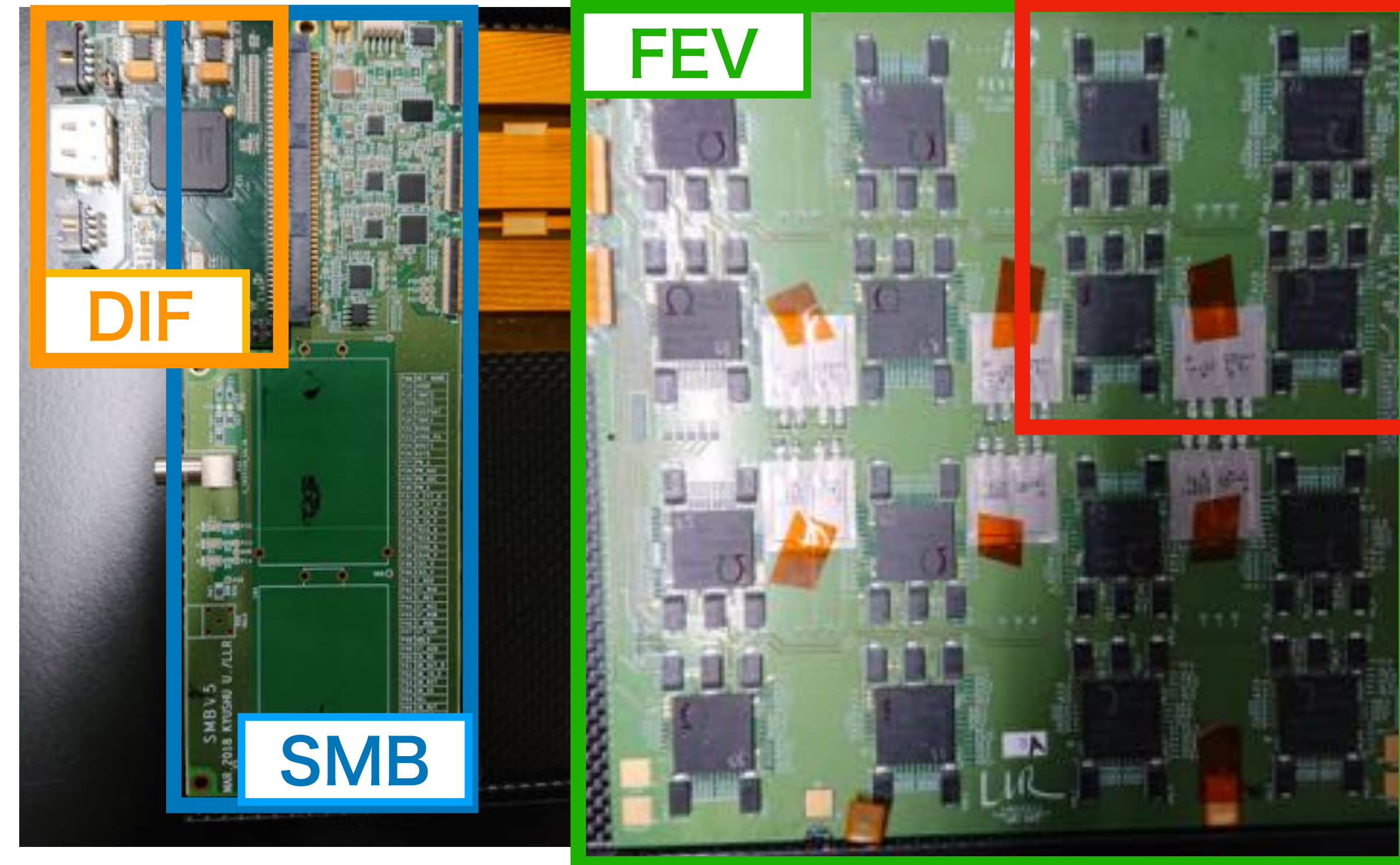
SiW-ECAL

- We call the one detector of the layer in the SiW-ECAL, "slab (short slab)".
- One slab has 4 silicon sensors, and each silicon sensor is connected to 4 ASICs. And one ASIC has 8×8 channels, so total number of channels is 1024 channels.



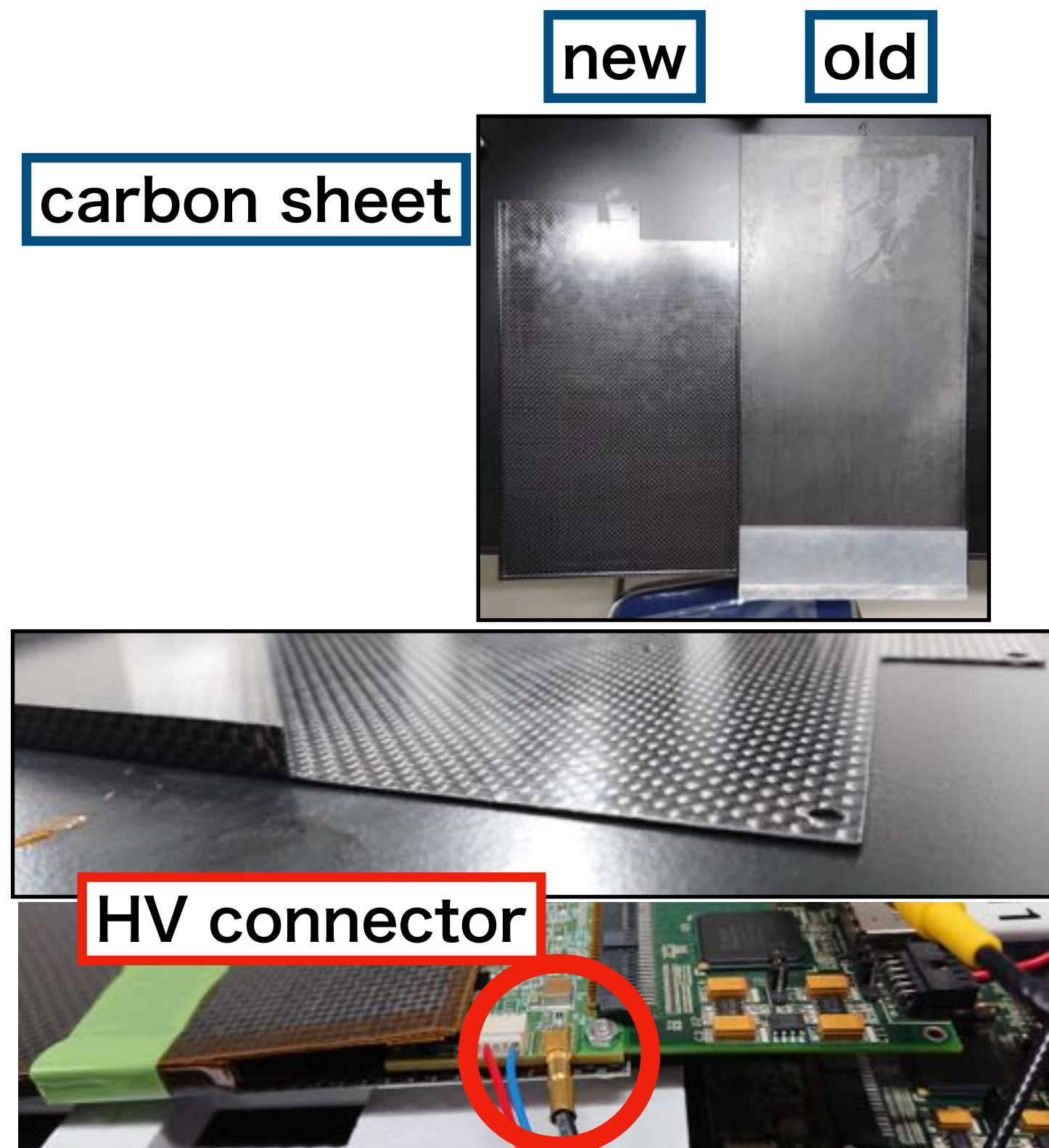
Slab

- DIF : data transmission and reception and clock control
- SMB : data storage and power supply to ASIC
- FEV : converting analog data to digital and transmission



Slab Status

- In the last beam test, we had the problem that the shape of the carbon frame was not appropriate, causing failure in HV connection, so we replaced the carbon sheet to new one.



assembled in Kyushu



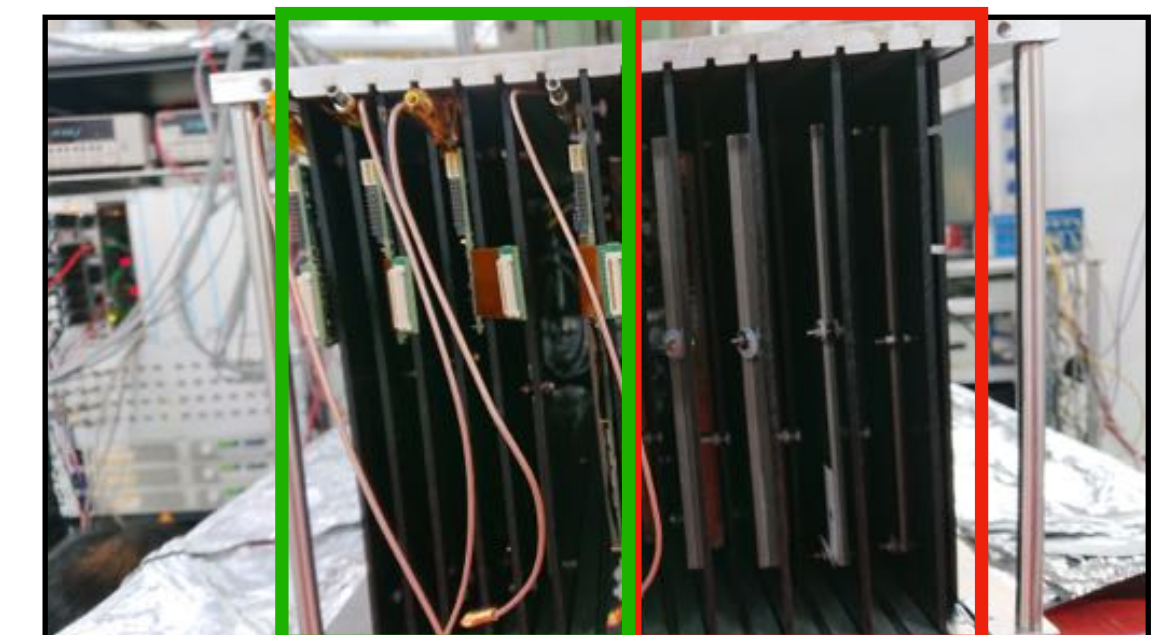
Name	P1	P2	P3	K1	K2
Silicon thickness	650 μm	650 μm	320 μm	650 μm	650 μm

Beam Test

- Purpose :
 - Data acquisition with electron beam (MIP, Shower)
 - Operation test (TDC, Auto Gain, etc.)
- 25th June - 5th July at DESY
- Beam Status : electron, 1 - 5 GeV
- Setup : 5 slabs (Kyushu) and 4 Chip-In-Board slabs (France)
 - MIP (**without tungsten**)
 - Shower (**with tungsten**)



Shower setup



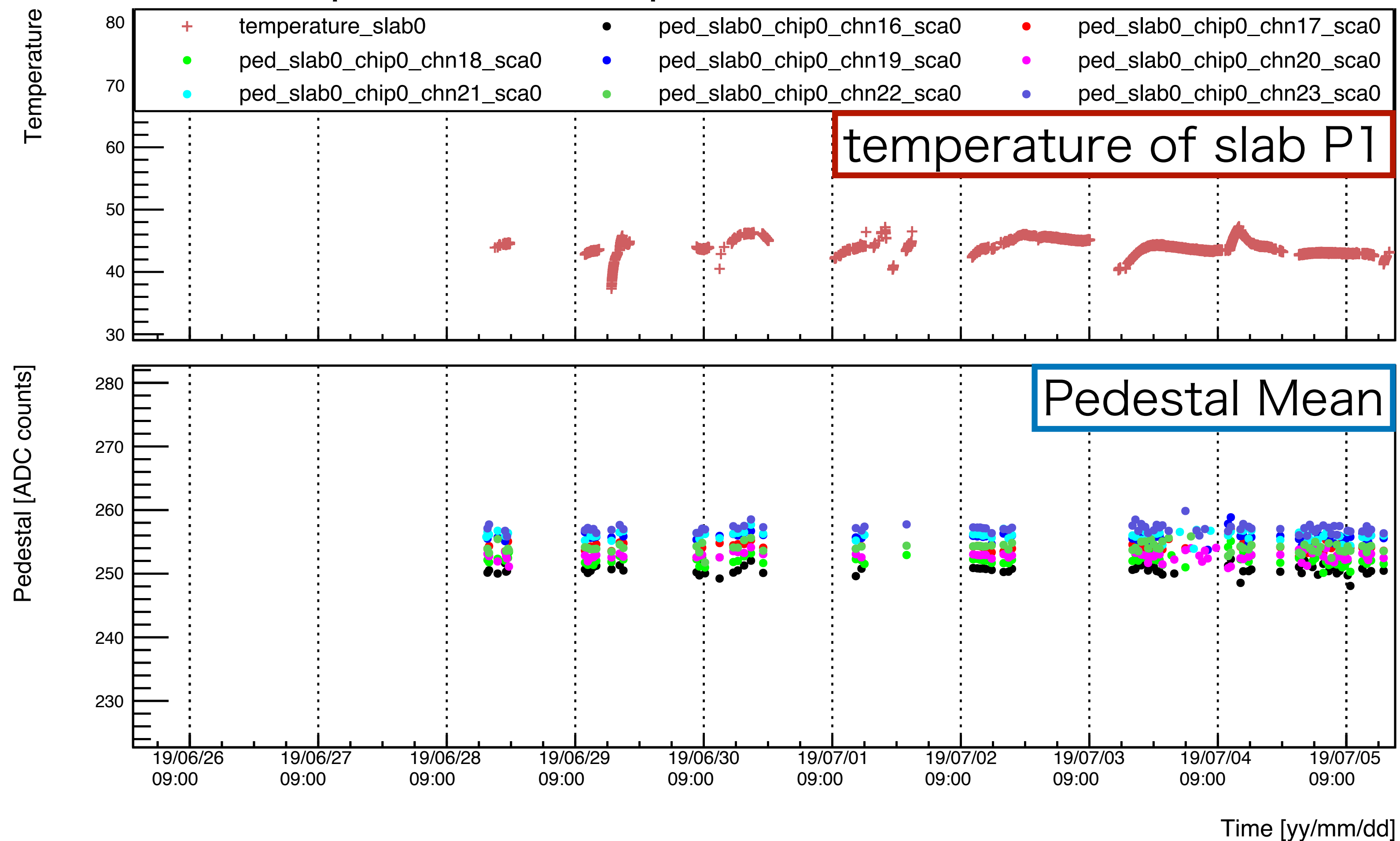
chip on boards slabs

CIB slab



Slab Performance

- Time variation of temperature and pedestal



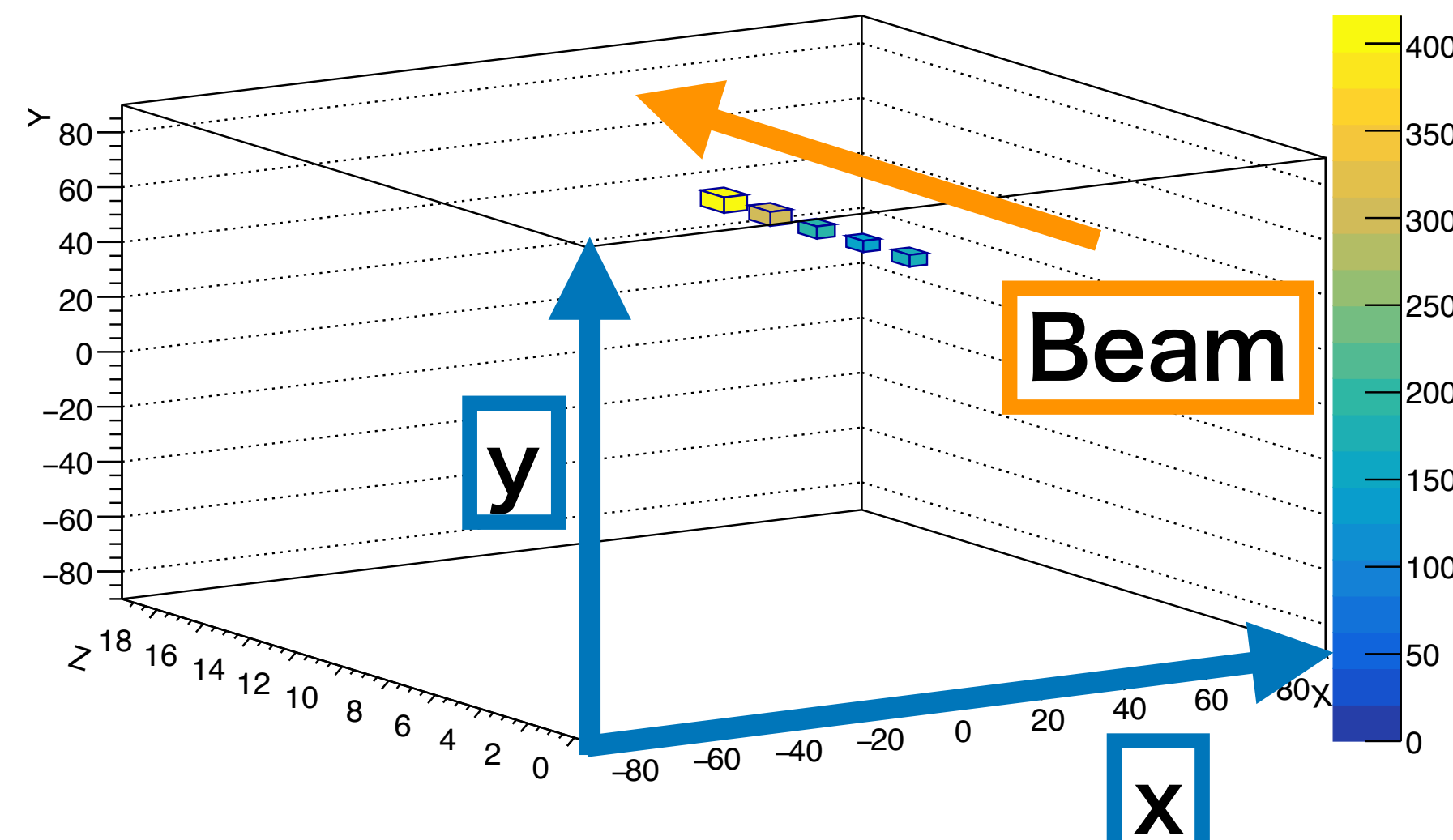
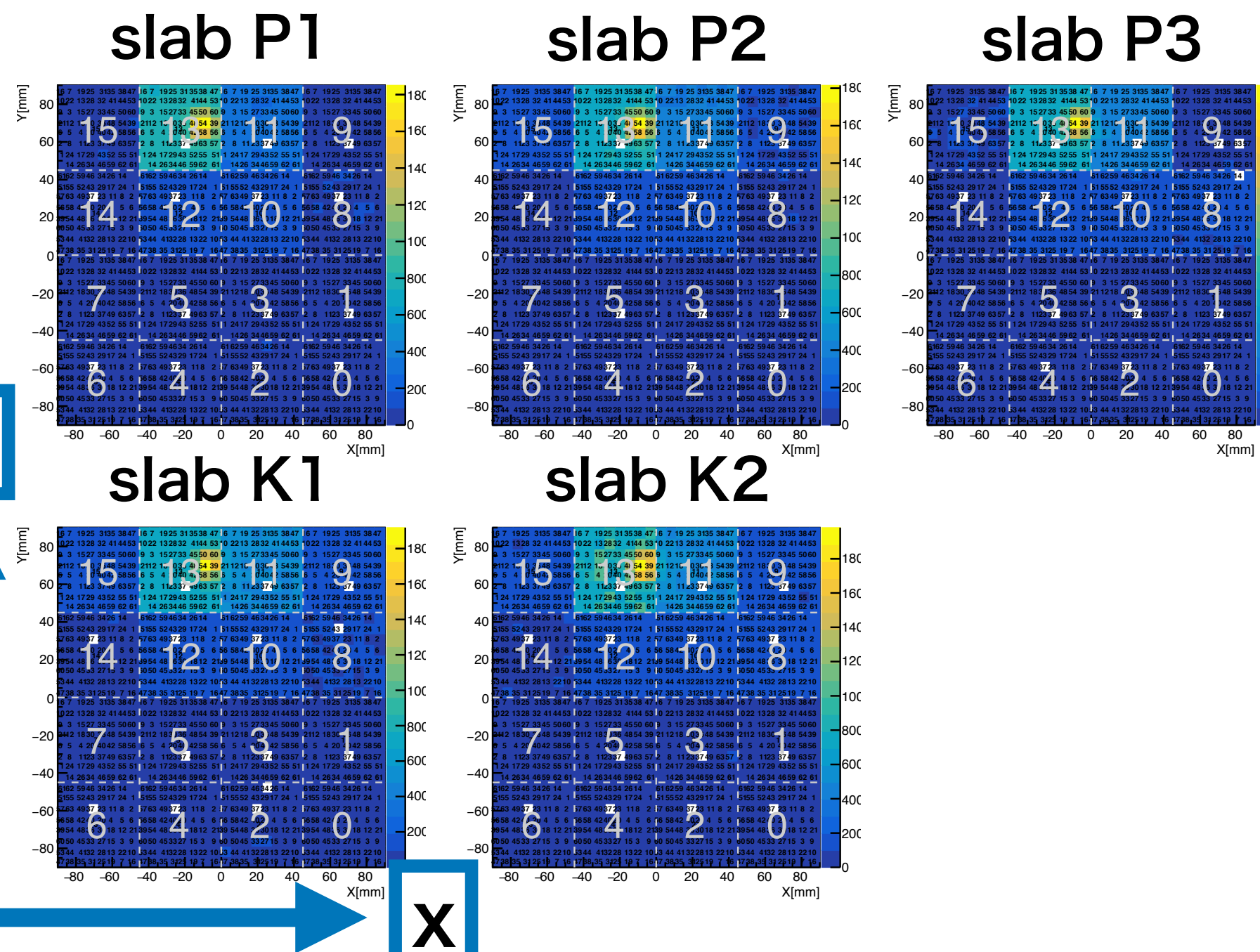
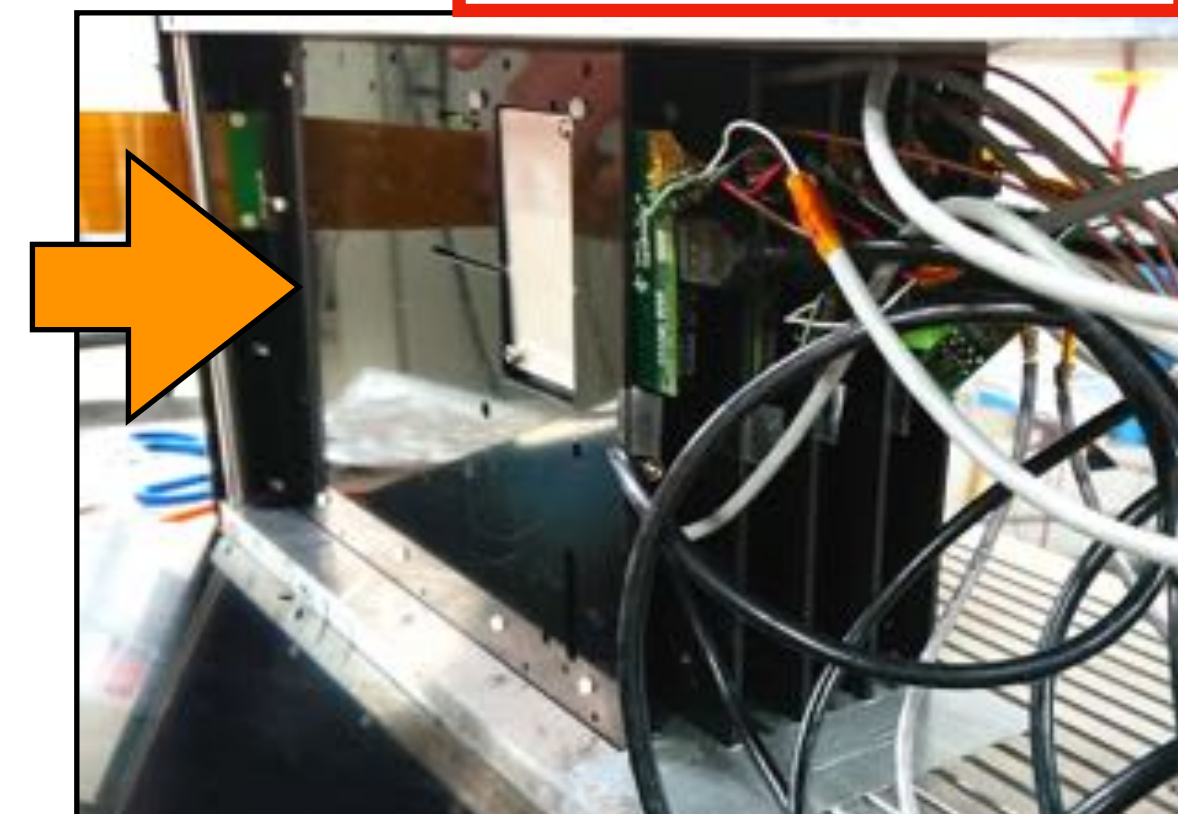
MIP Analysis

- The order of slabs is **P1, P2, P3, K1, K2** from the beam side.

P1 P2 P3 K1 K2

- We can see the events in the hit map and event display.

Beam

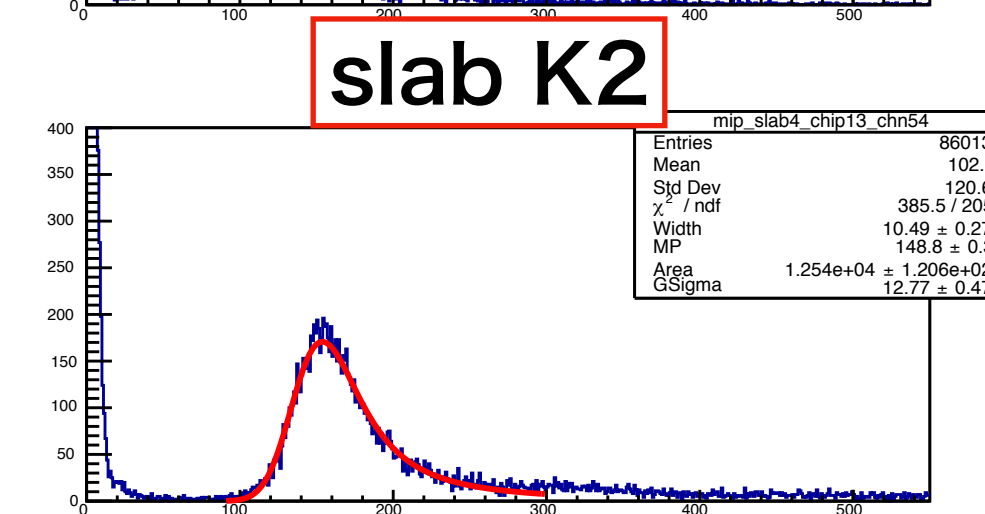
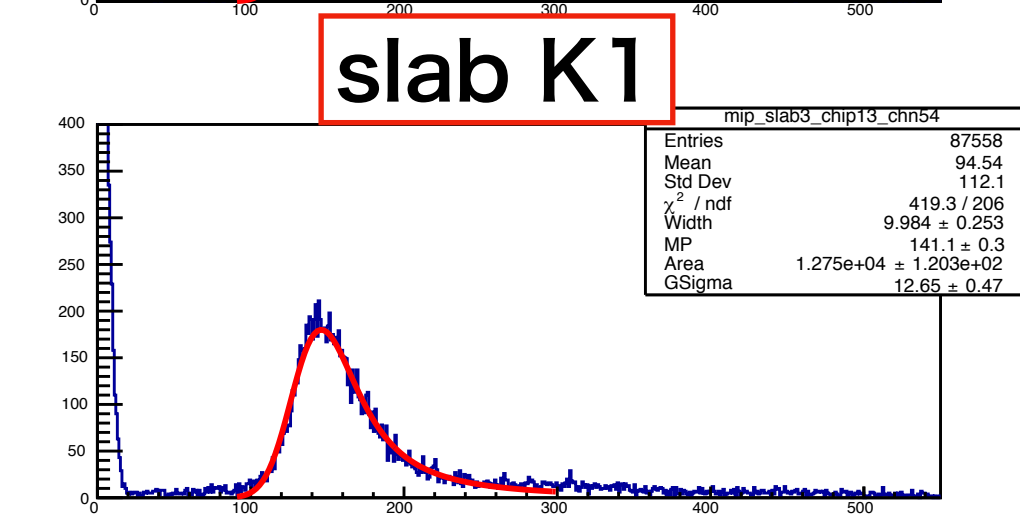
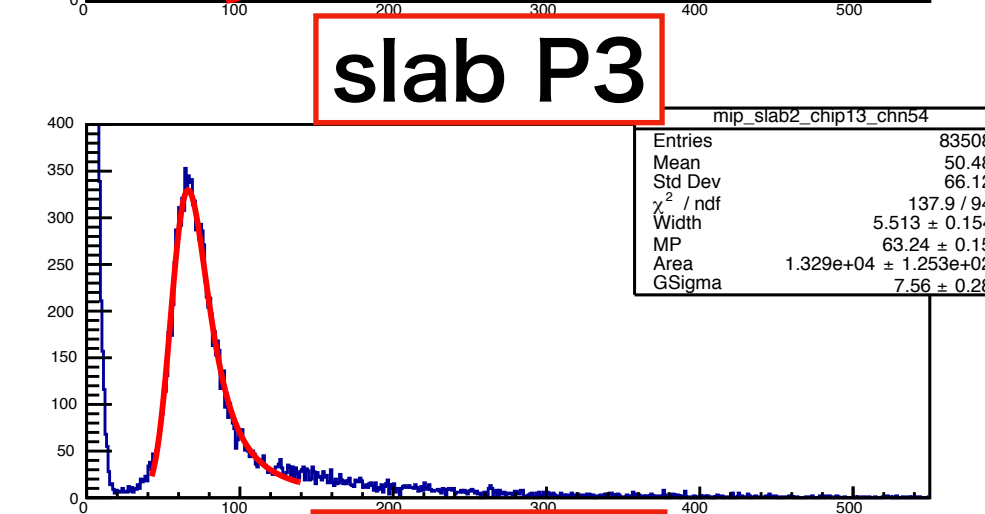
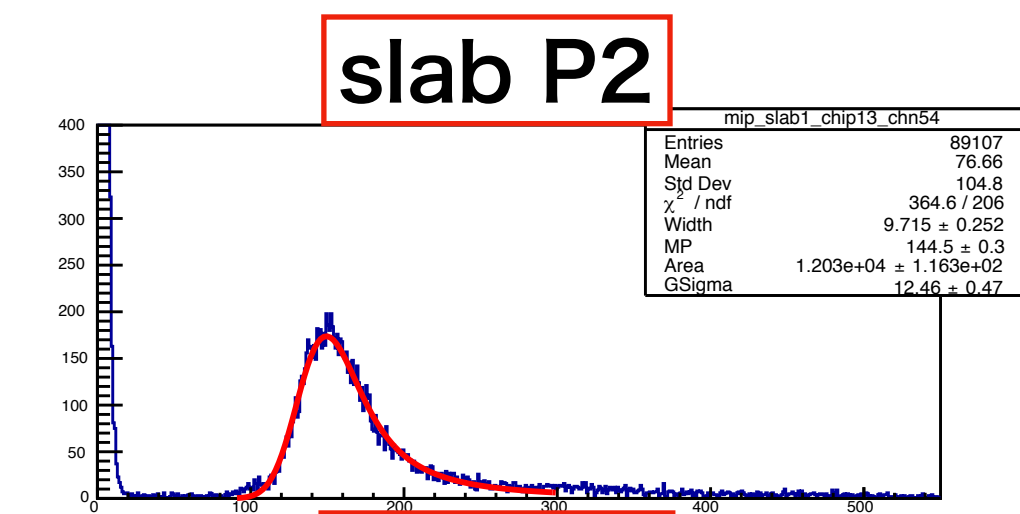
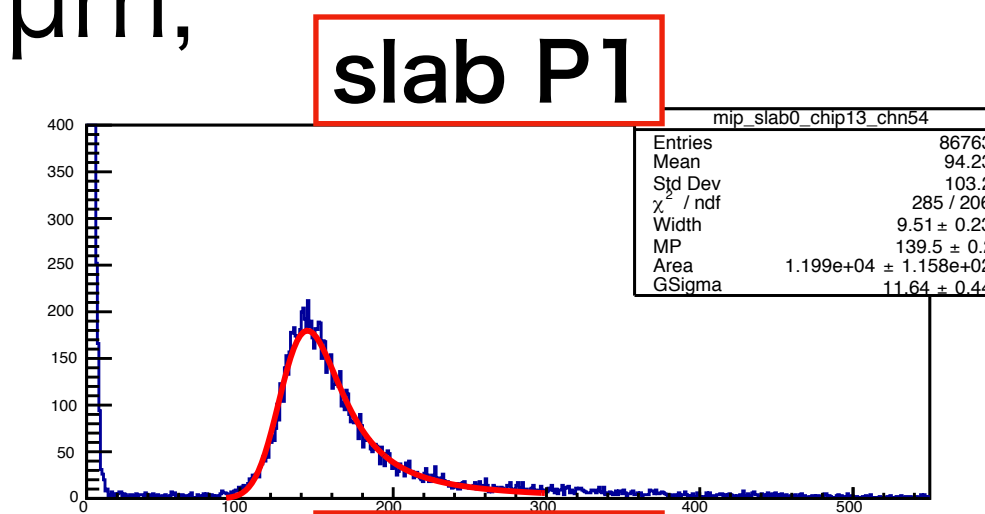


MIP Analysis

- I fitted the MIP peak by using **langaus function**.
- The typical MIP means are 140-150 ch in 650 μm , and 60-70 ch in 320 μm .
- S/N ratio for the charge measurement of all triggered channels

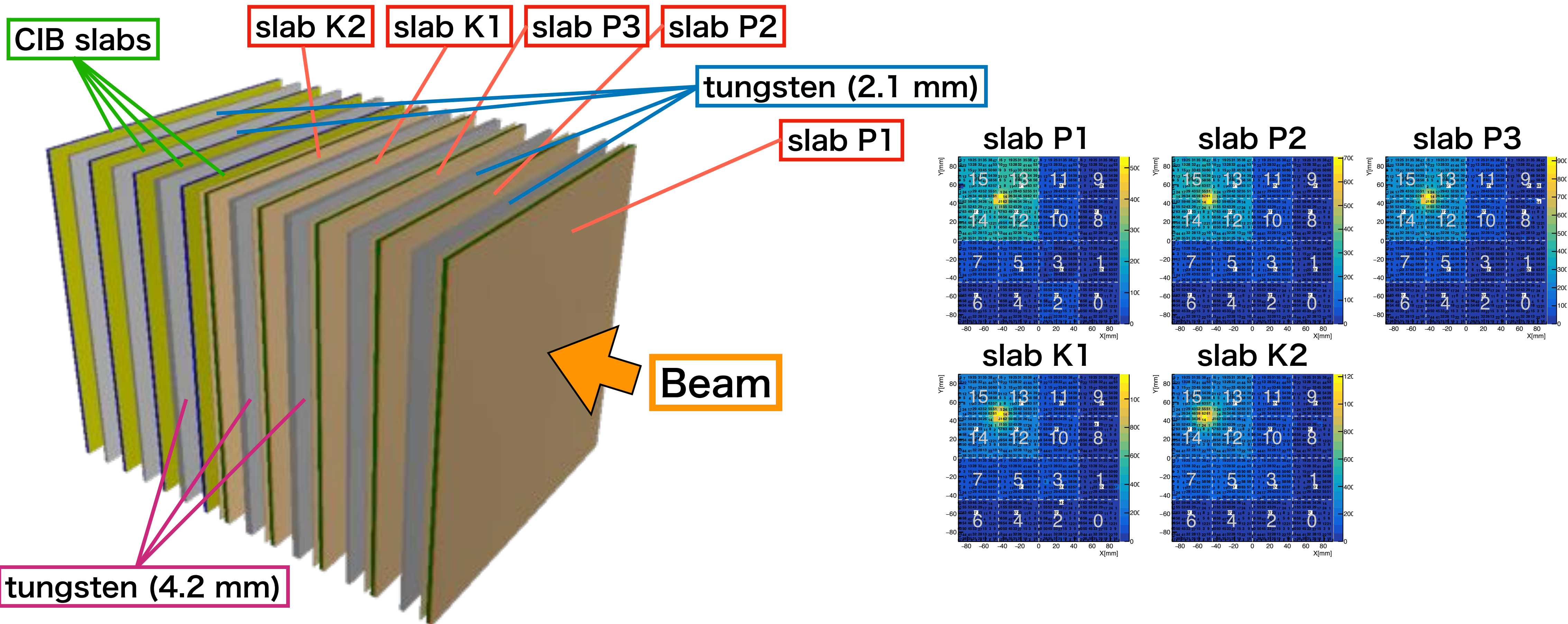
$$\text{S/N ratio} = \text{MIP mean} / \langle \text{pedestal width} \rangle$$

slab	P1	P2	P3 (320 μm)	K1	K2
S/N ratio	49.0	48.9	21.7	50.2	47.5



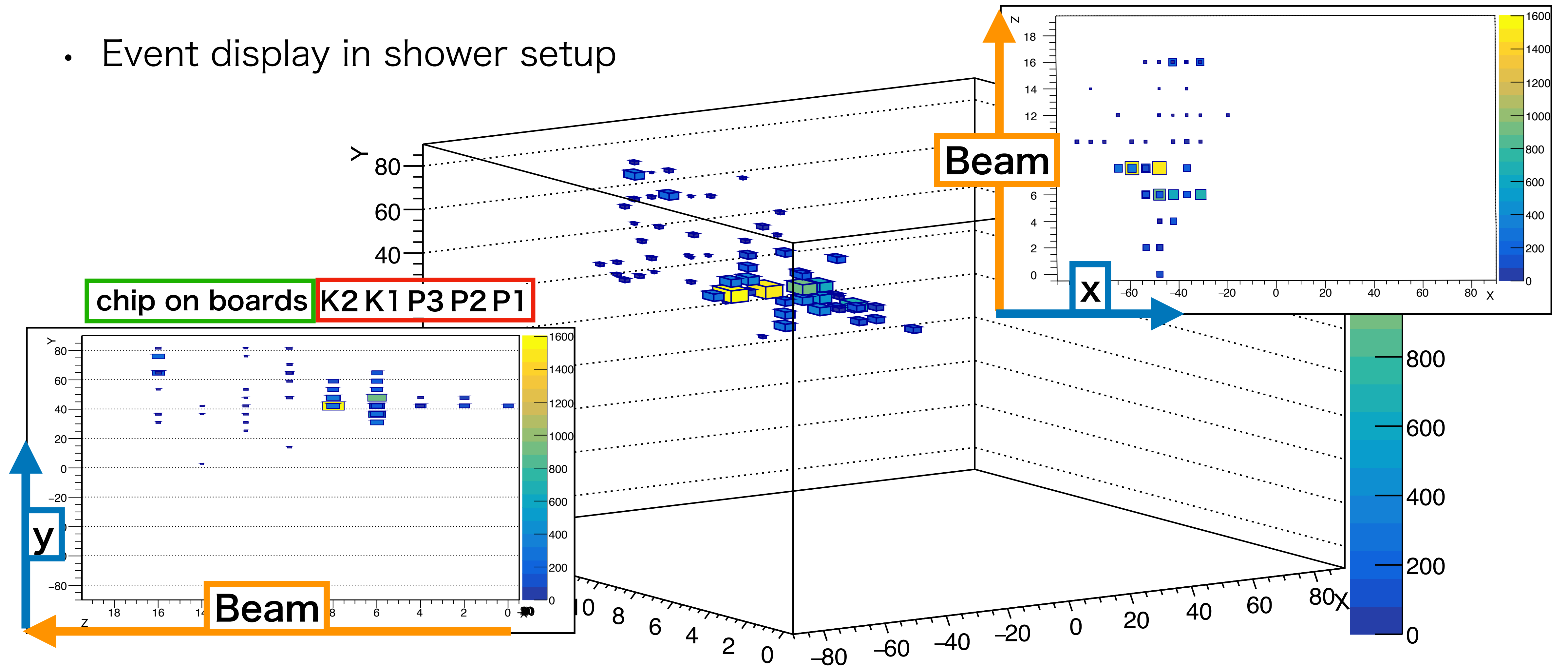
Shower Analysis

- In shower setup, we put the tungsten plates between each slab.



Shower Analysis

- Event display in shower setup



Summary and Plan

- Summary
 - In MIP analysis, we could calculate the S/N ratio for all triggered channels.
 - All analysis are still ongoing, but most of them give good indications.
- Plan
 - analyzing the energy resolution in **shower setup**
 - solving the following problem
 - Re-triggering
 - unstable **HDMI connects**
 - too fragile **HV connectors**

backup

DAQ overview @ lab

- CCC : transmitting start and stop signal to GDCC
- GDCC : transmission and reception to slabs and connecting PC using ethernet

CCC & Generate spill



GDCC



Slab

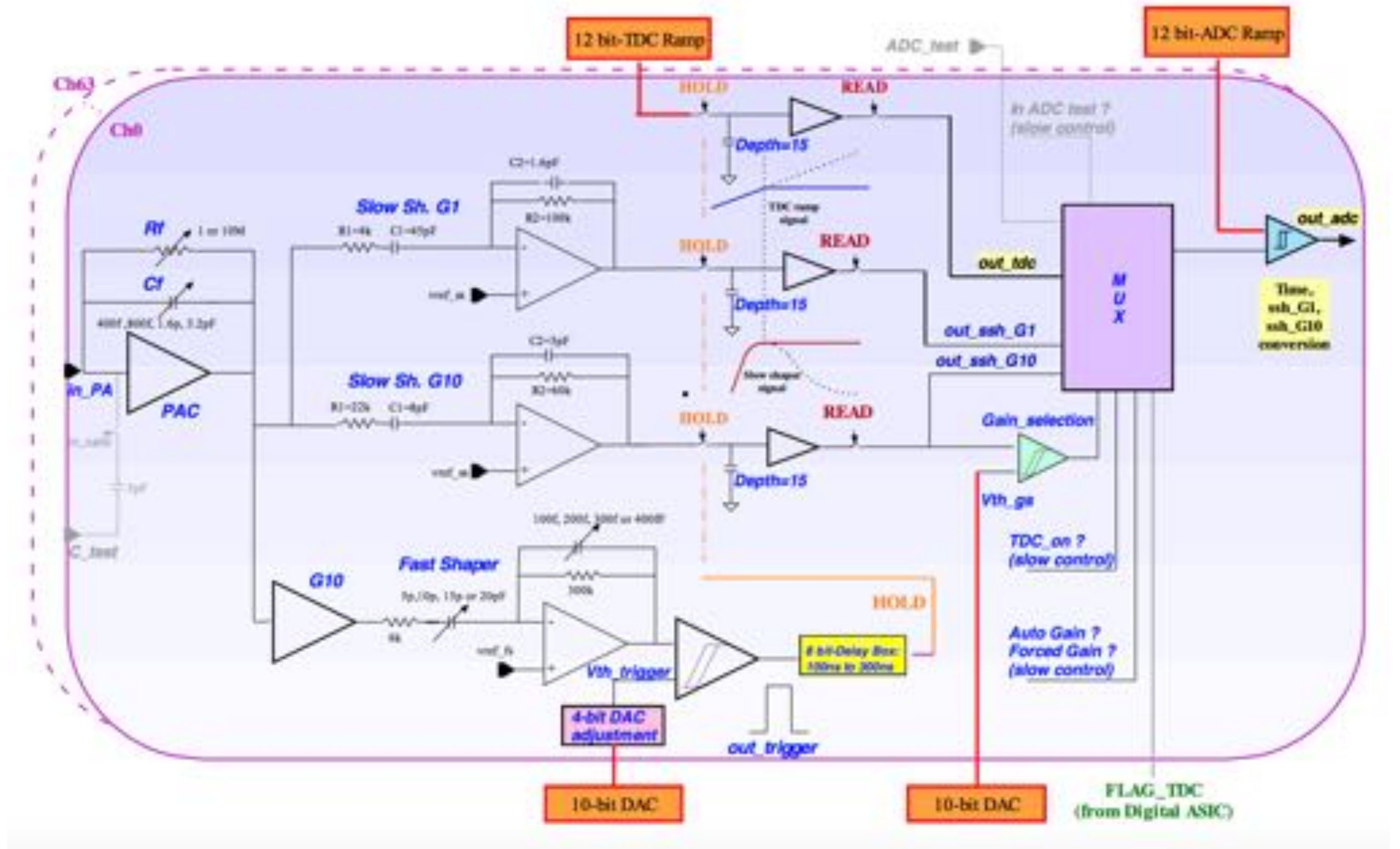


At most 7 slabs

PC

ASIC (SKIROC2/2A)

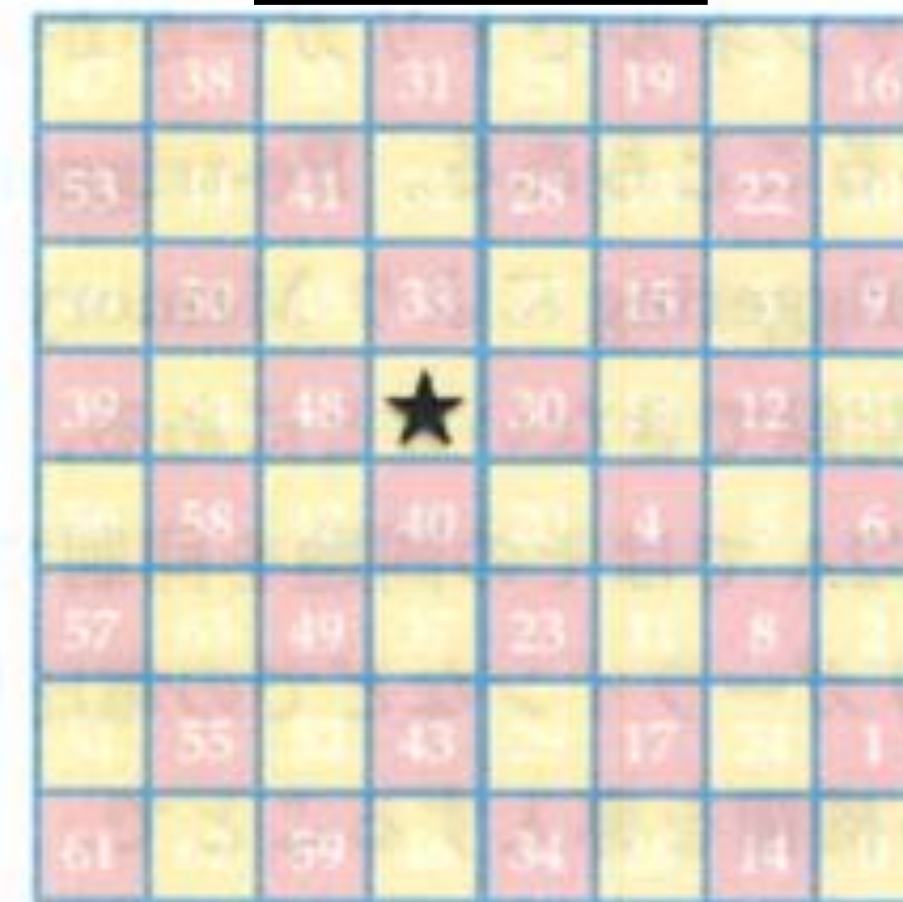
- 15 memory cells
- trigger : 0.5 MIP
- high gain : 0.5 - 150 MIP
- low gain : 150 - 2500 MIP
- to protect Re-trigger



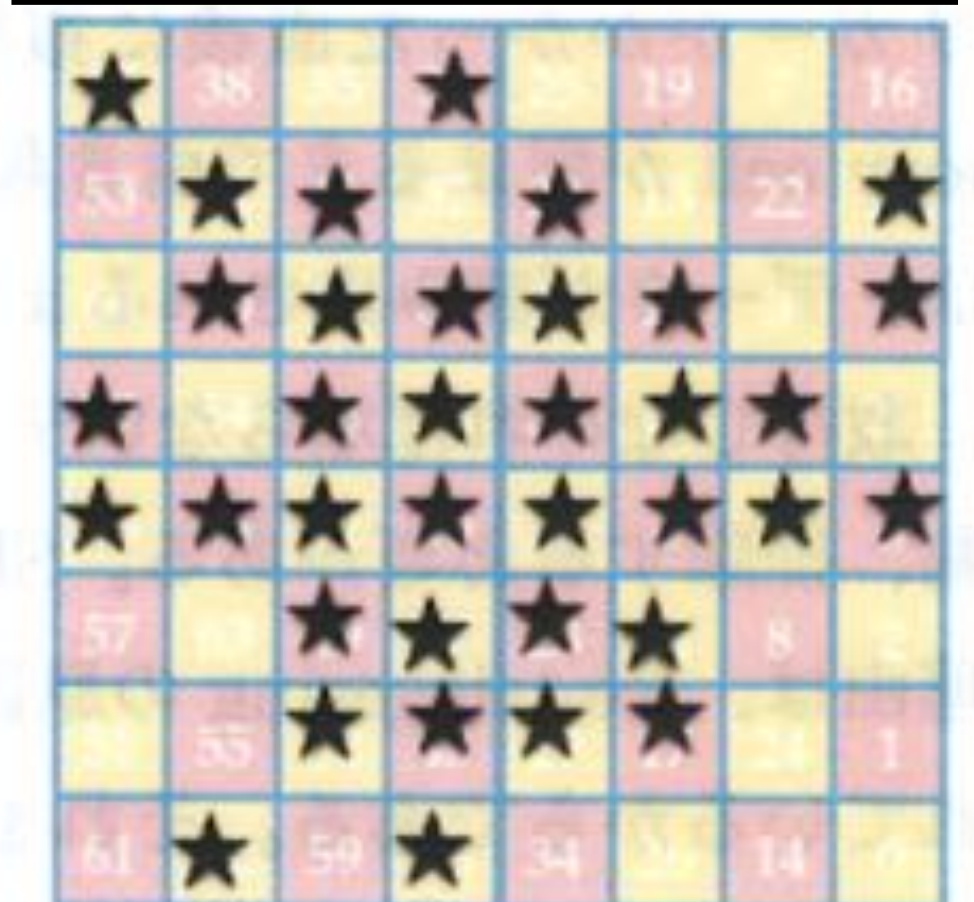
Re-triggering

- the phenomenon filling the memory cells by some triggers after first hit in somewhere
- We don't know the detailing cause.
- Now we are trying to explore this problem.

First hit

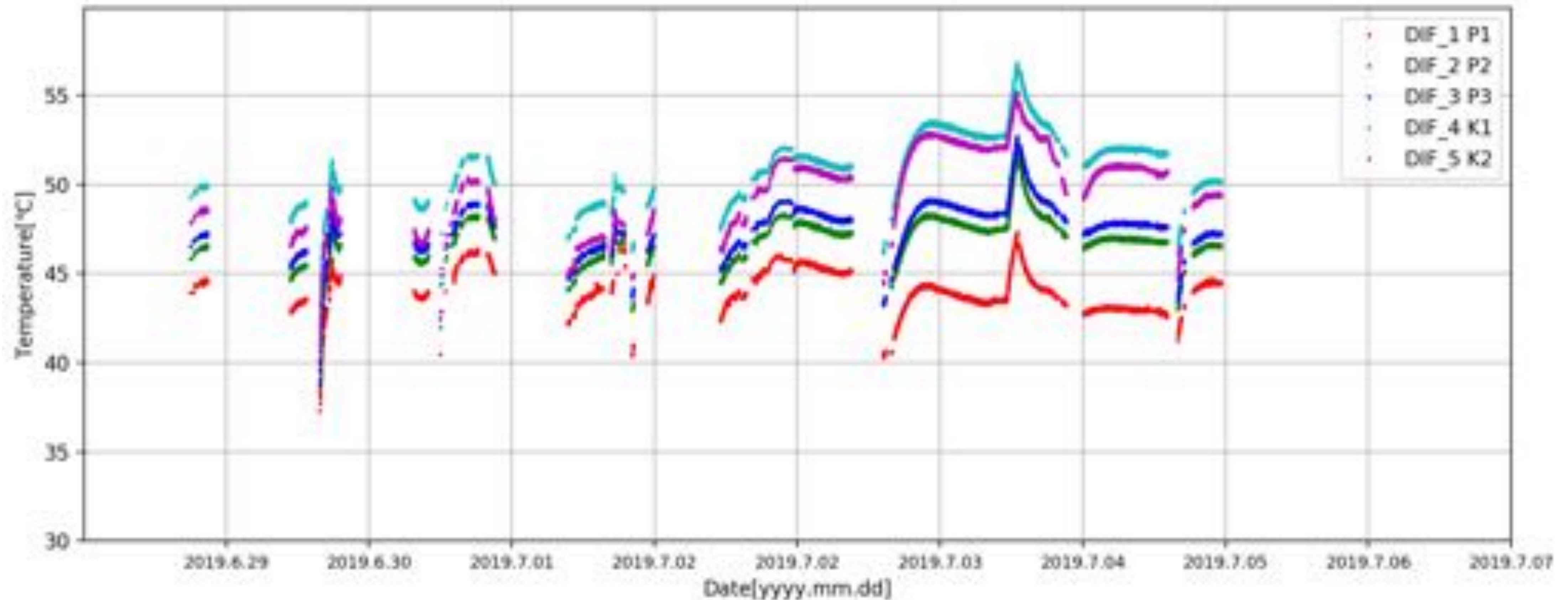


After the first hit

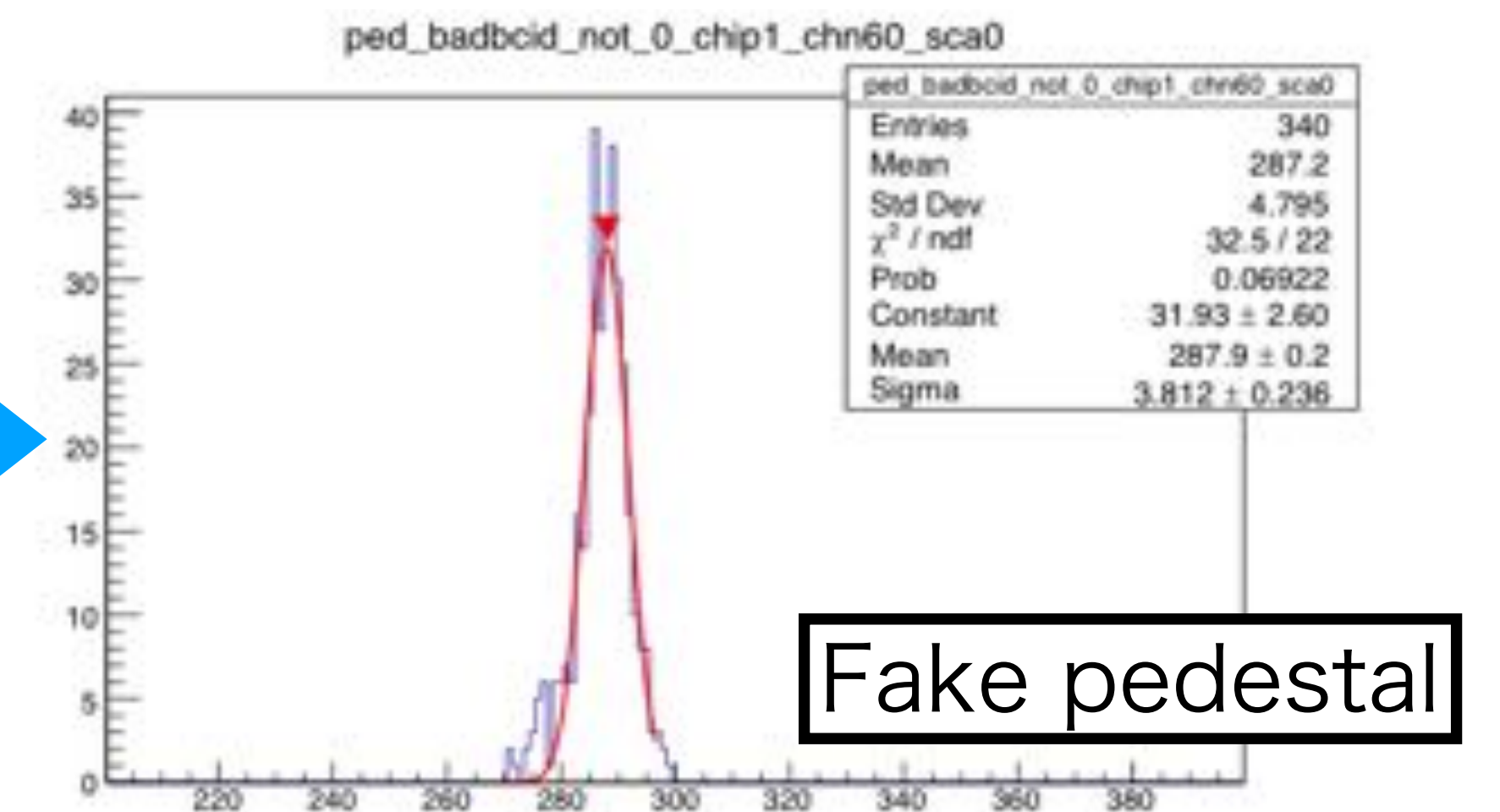
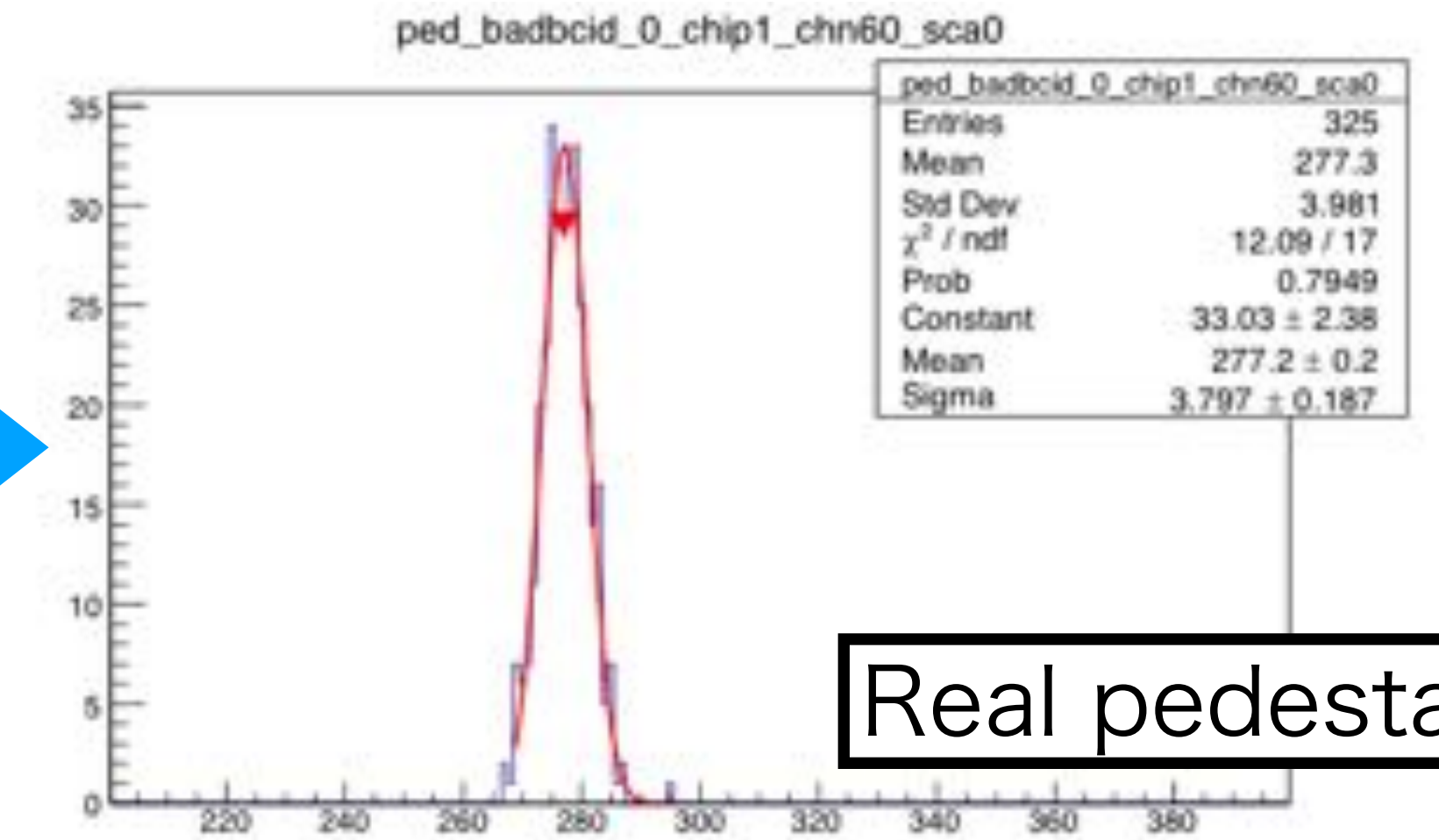
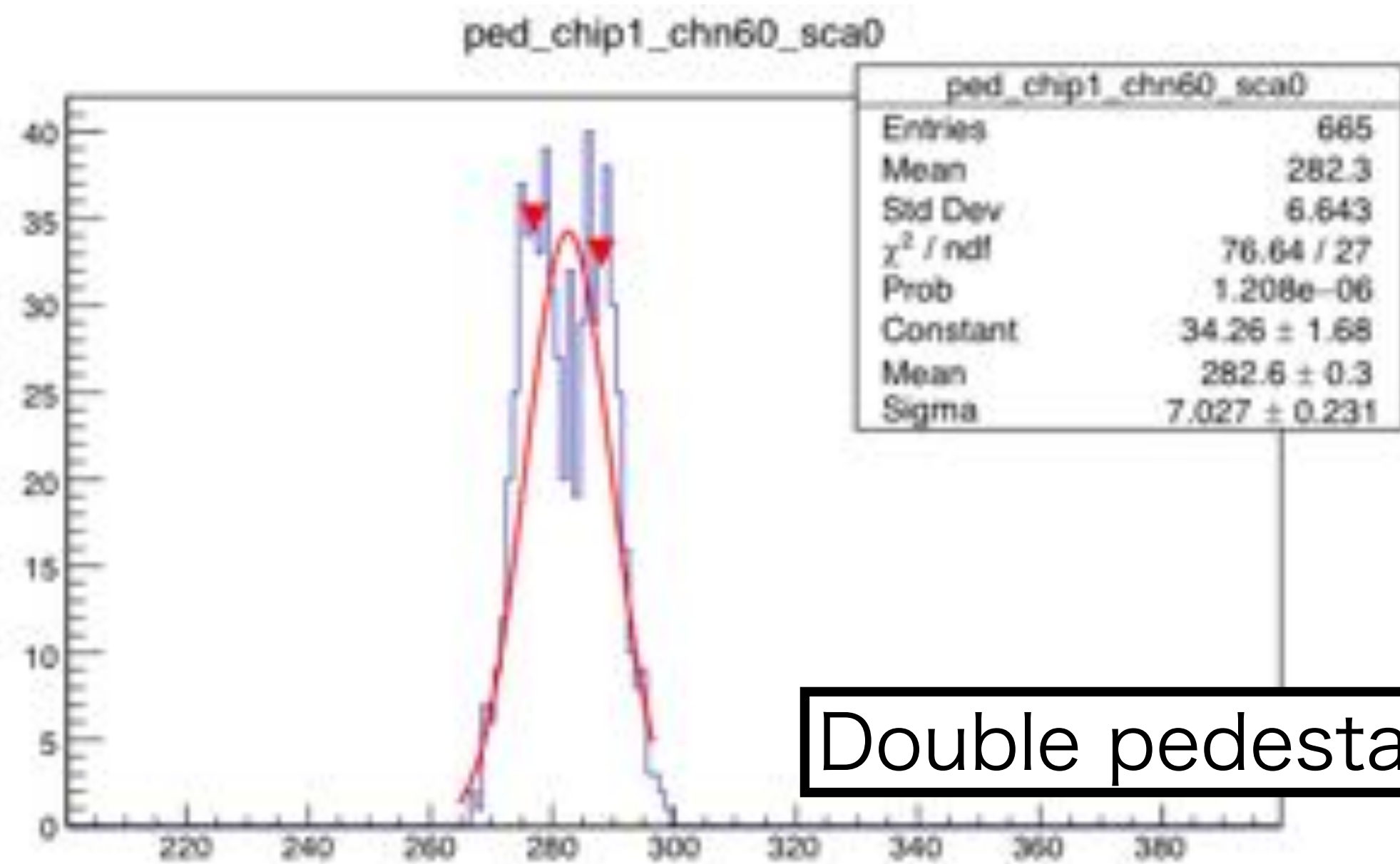


Time variation of temperature

- Time variation of temperature for all slabs

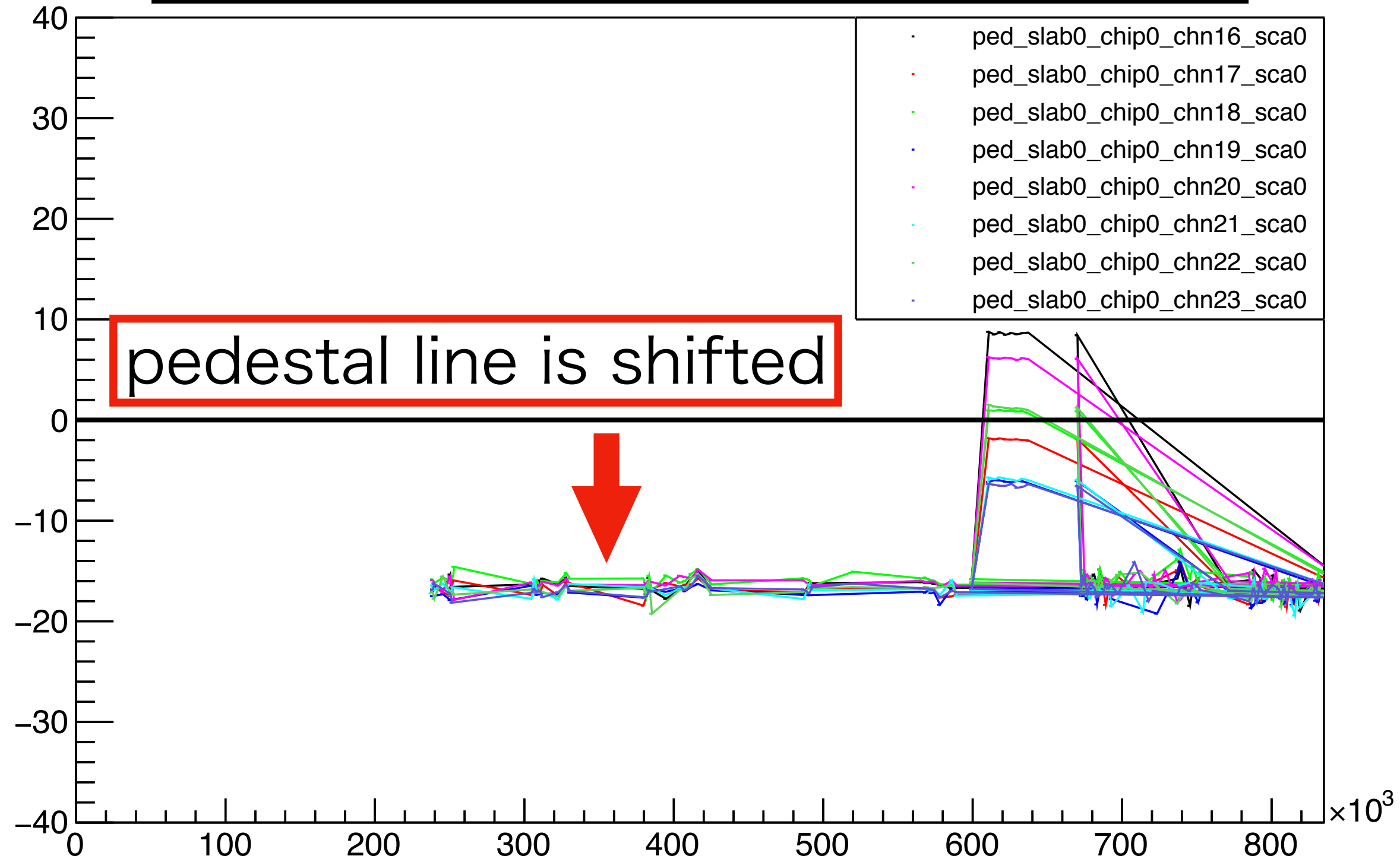


Double pedestal

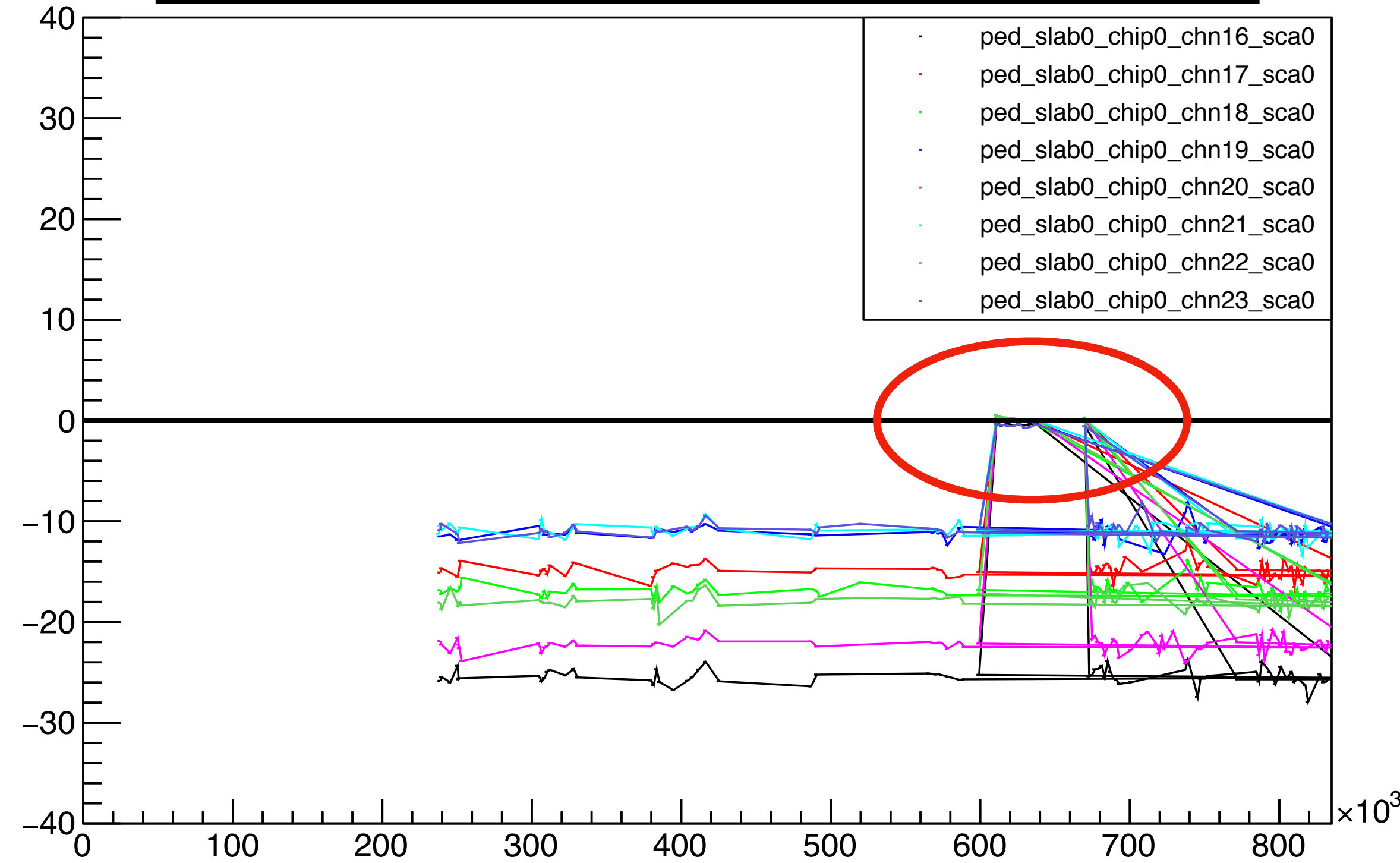


Pedestal shift in TDC mode

Pedestal calibration in TDC mode by charge high gain in ADC mode

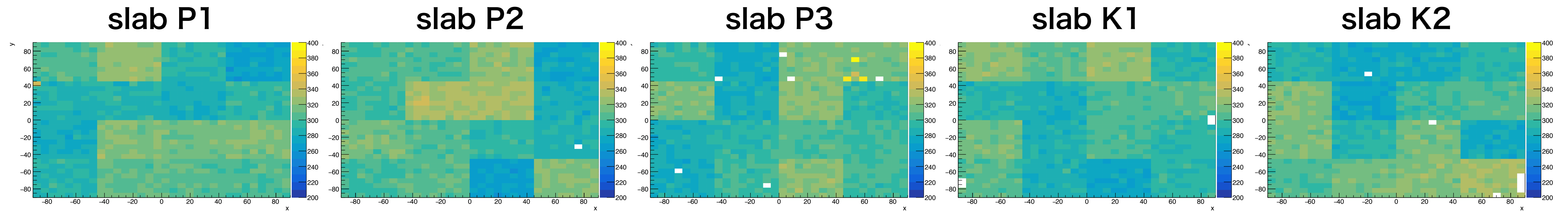


Pedestal calibration in ADC mode by charge low gain in ADC mode

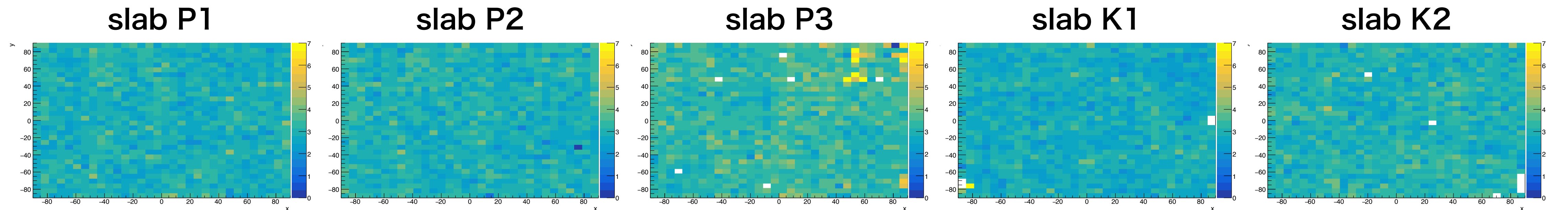


Pedestal Map

- Pedestal mean Map

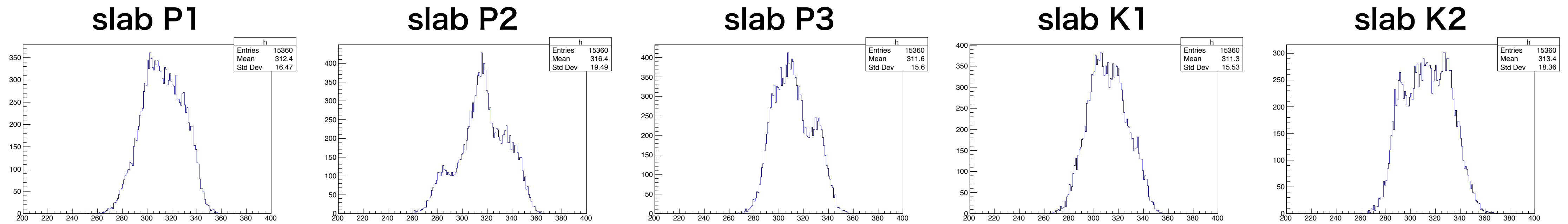


- Pedestal width Map

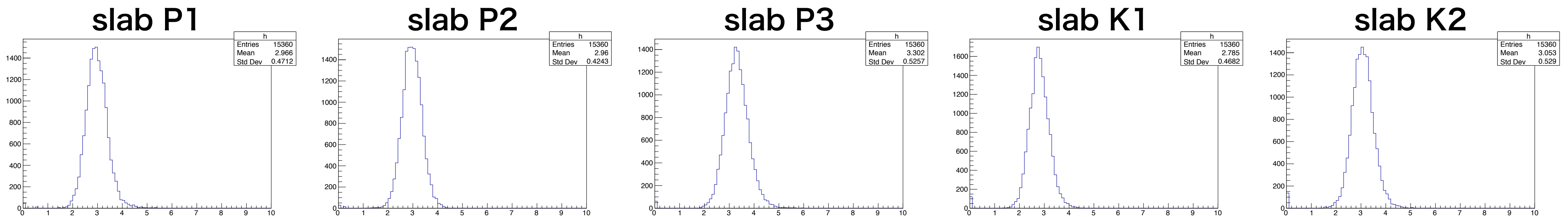


Pedestal distribution

- Pedestal mean distribution



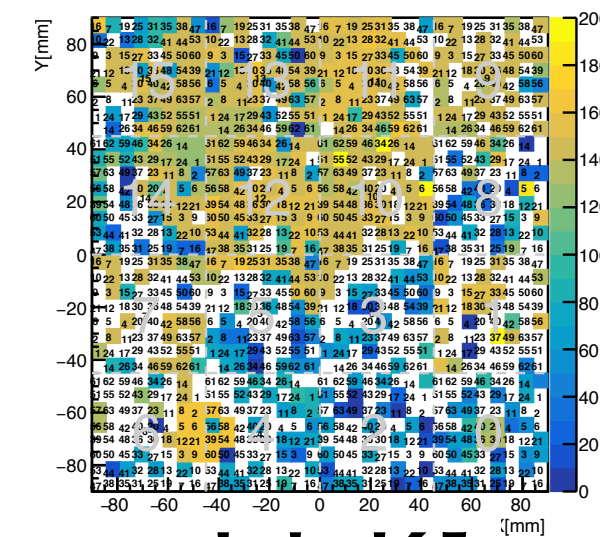
- Pedestal width distribution



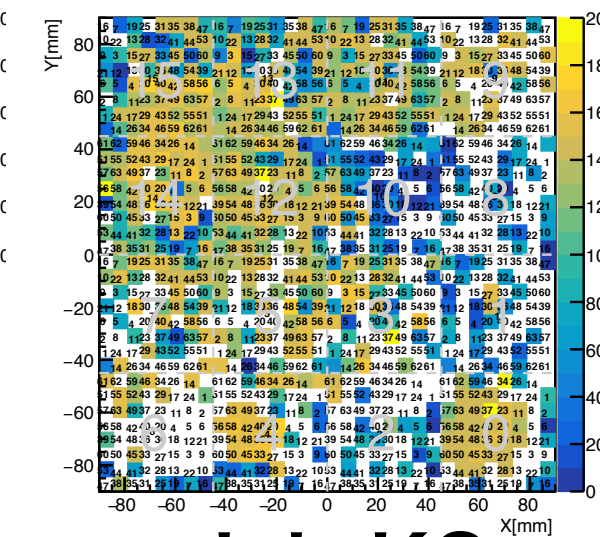
MIP Map

- slab P1
nothing : 21/1024 channels, $\chi^2/\text{ndf} < 3$: 674/1024
- slab P2
nothing : 9/1024 channels, $\chi^2/\text{ndf} < 3$: 695/1024
- slab P3
nothing : 14/1024 channels, $\chi^2/\text{ndf} < 3$: 819/1024
- slab K1
nothing : 10/1024 channels, $\chi^2/\text{ndf} < 3$: 833/1024
- slab K2
nothing : 8/1024 channels, $\chi^2/\text{ndf} < 3$: 798/1024

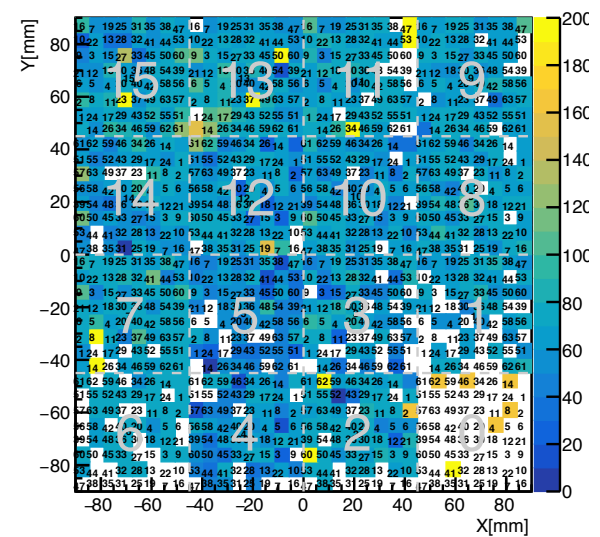
slab P1



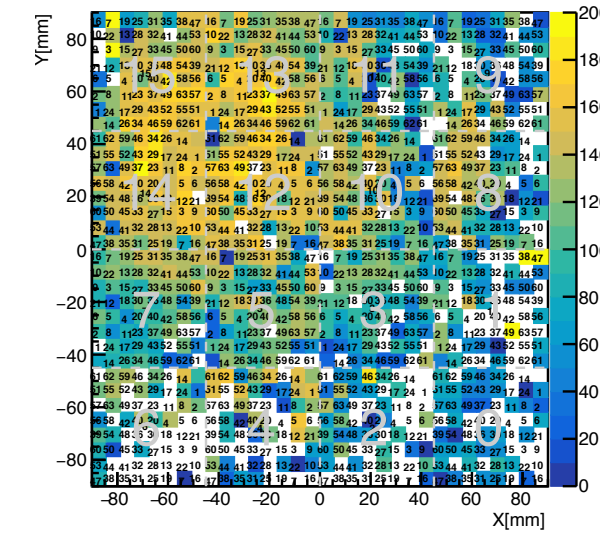
slab P2



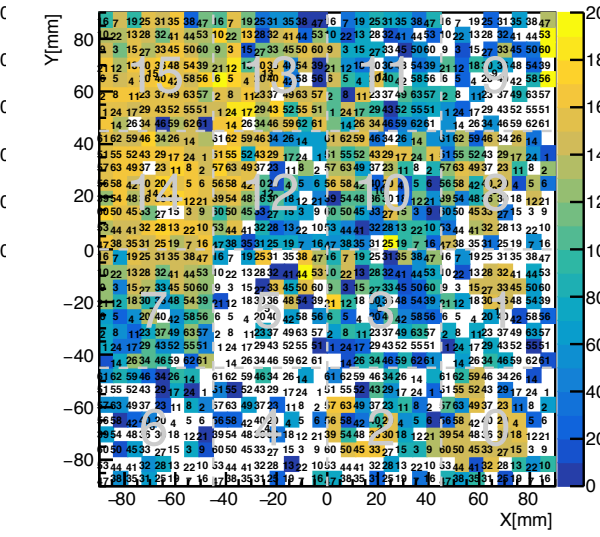
slab P3



slab K1



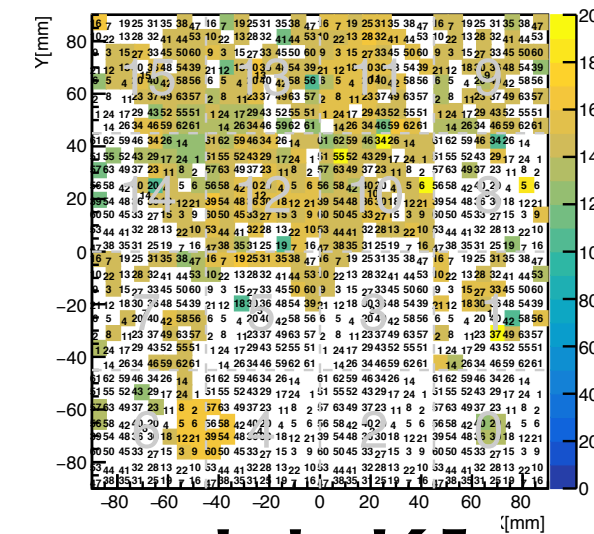
slab K2



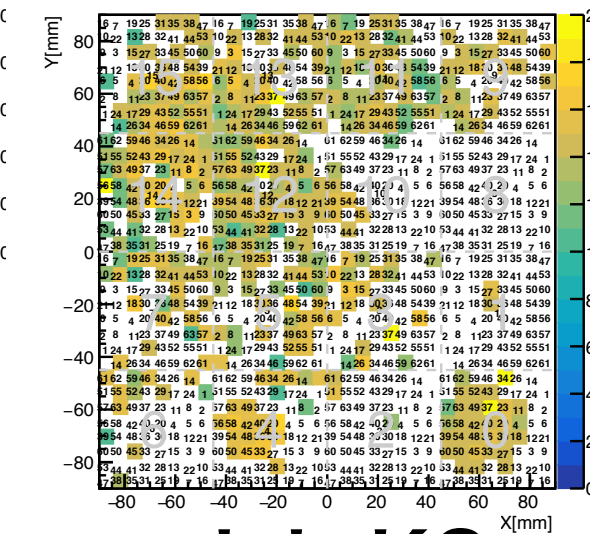
MIP Map used to S/N ratio analysis

- slab P1
chi2/ndf<3 & mean>100 : 384/1024 channels
- slab P2
chi2/ndf<3 & mean>100 : 396/1024 channels
- slab P3
chi2/ndf<3 & mean>50 : 709/1024 channels
- slab K1
chi2/ndf<3 & mean>100 : 477/1024 channels
- slab K2
chi2/ndf<3 & mean>100 : 357/1024 channels

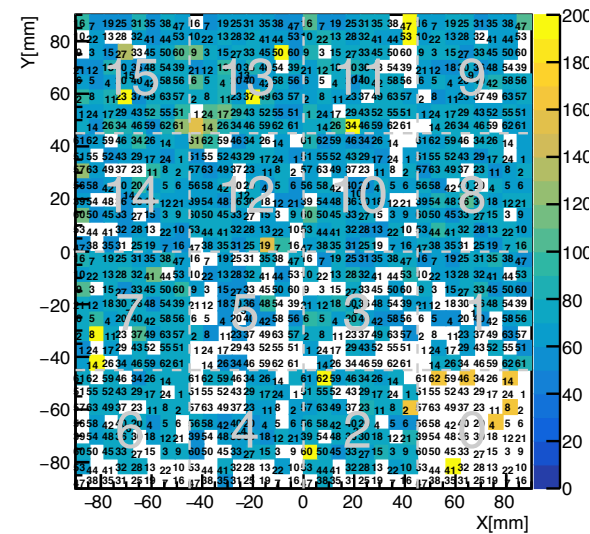
slab P1



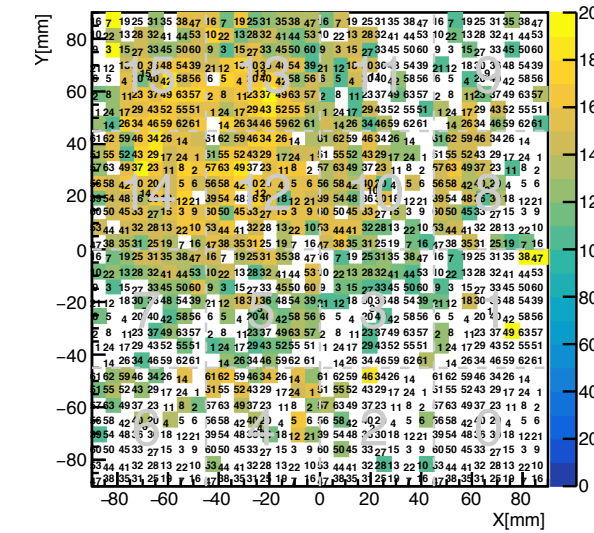
slab P2



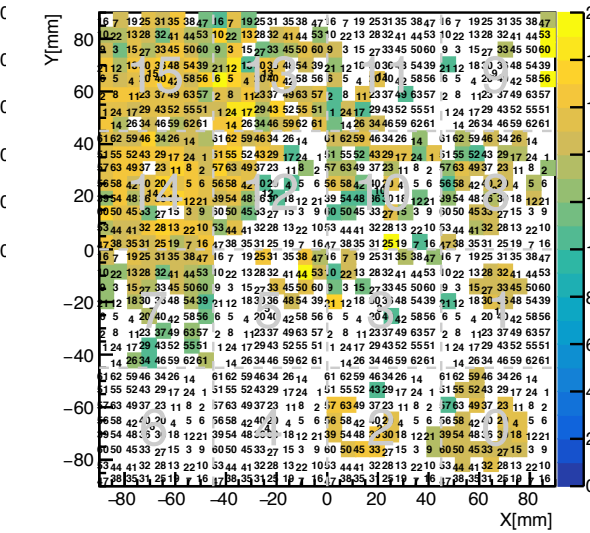
slab P3



slab K1

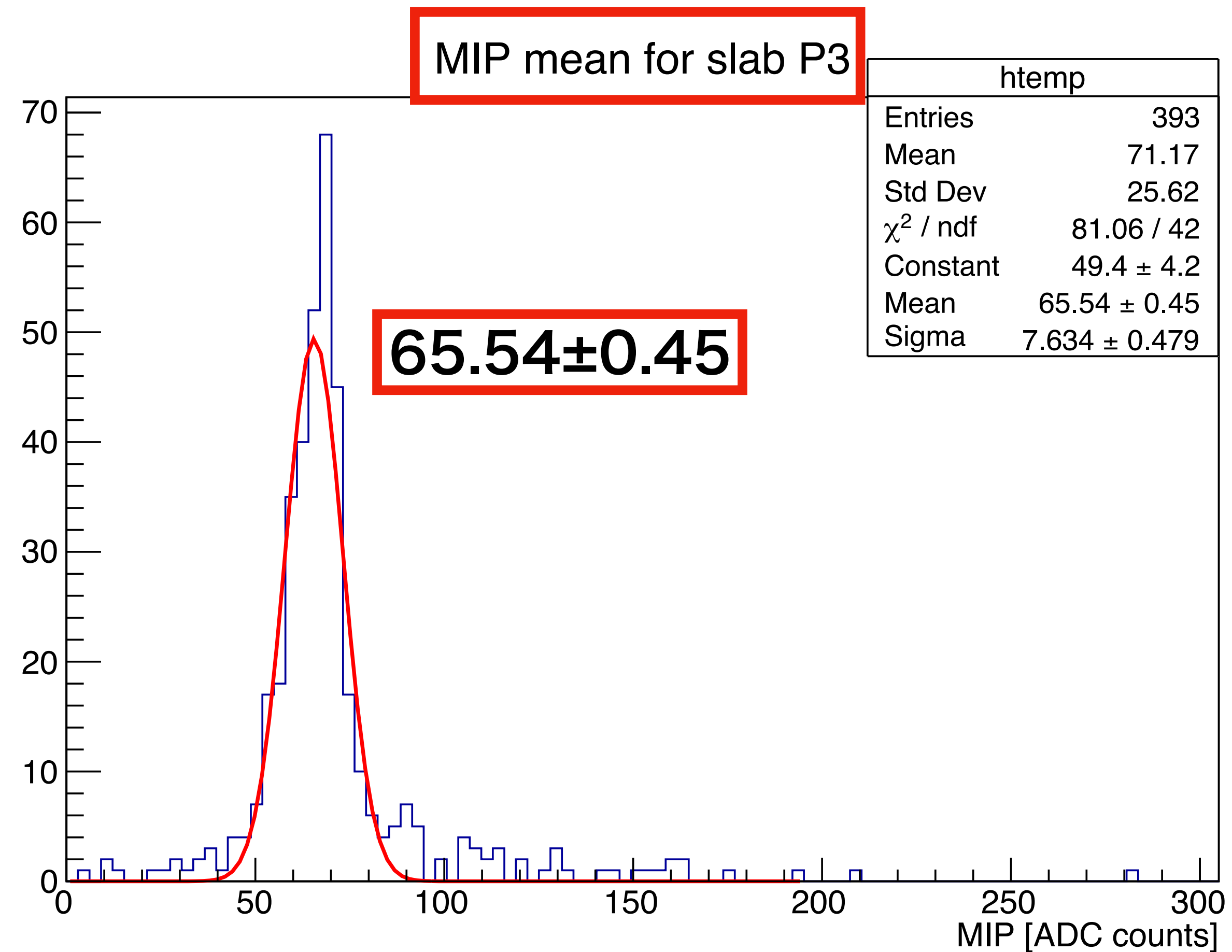
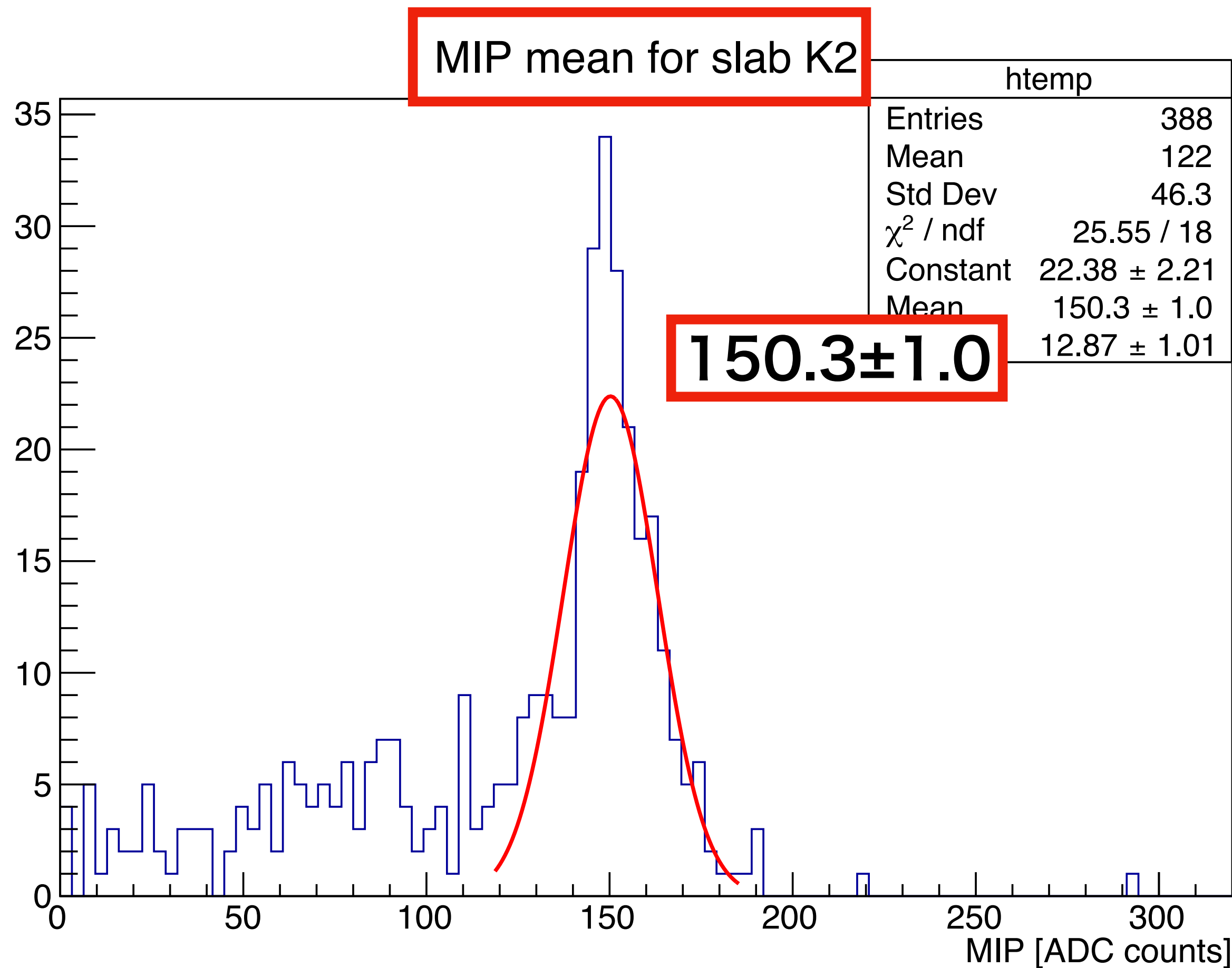


slab K2

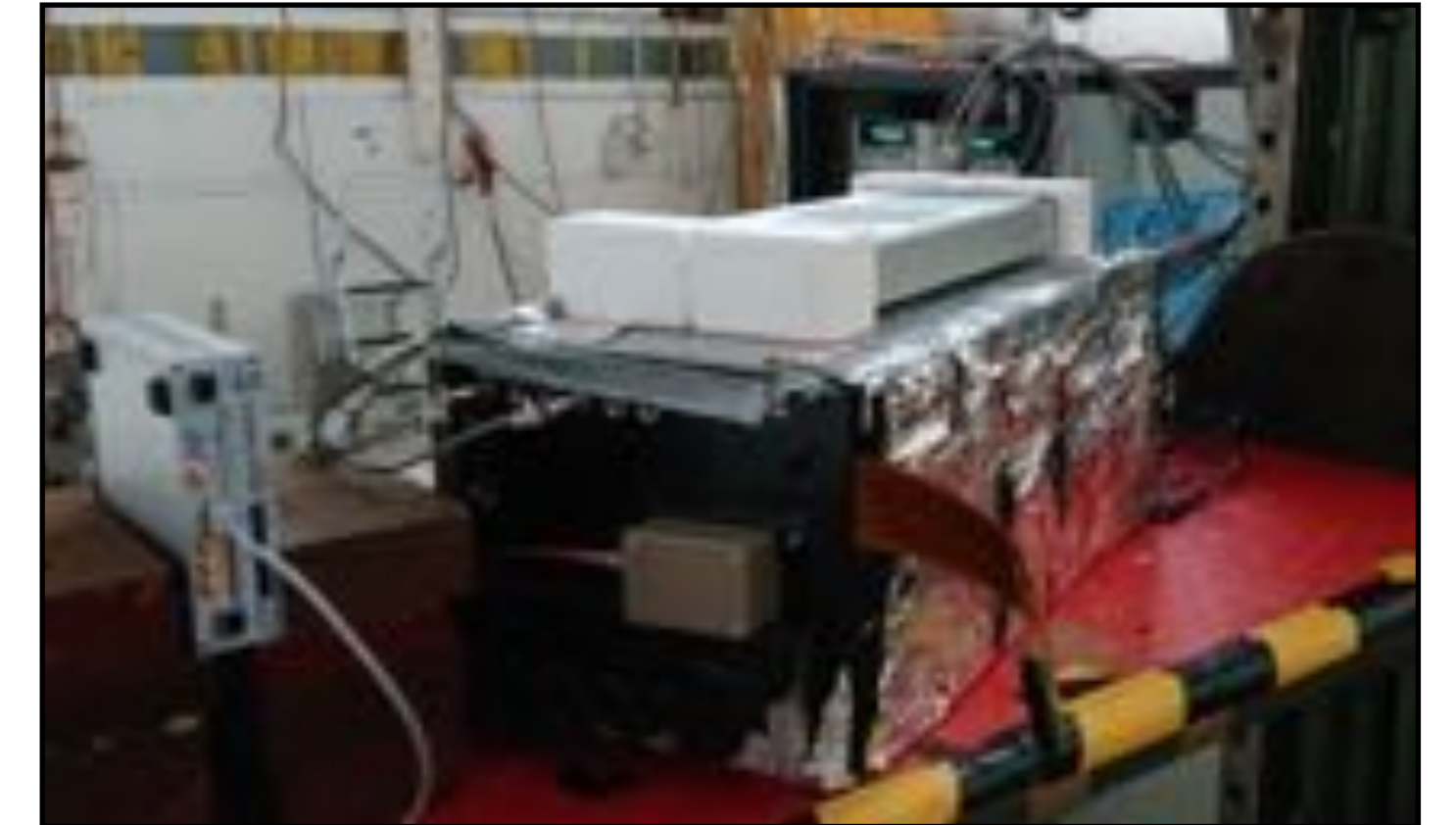


MIP mean distribution

- MIP mean distribution of triggered channels

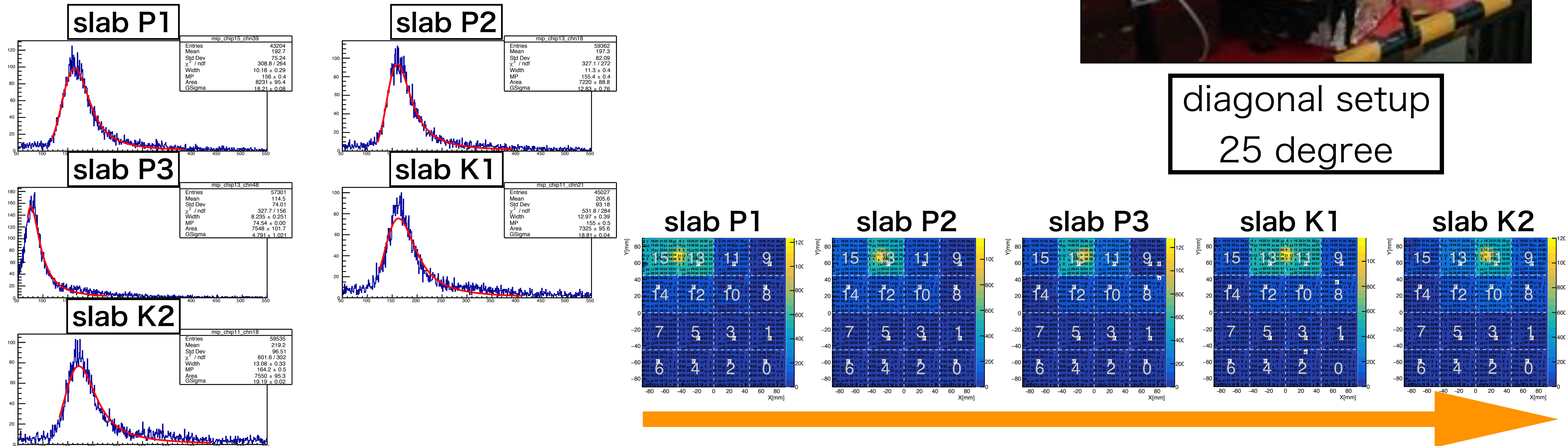


Diagonal Analysis

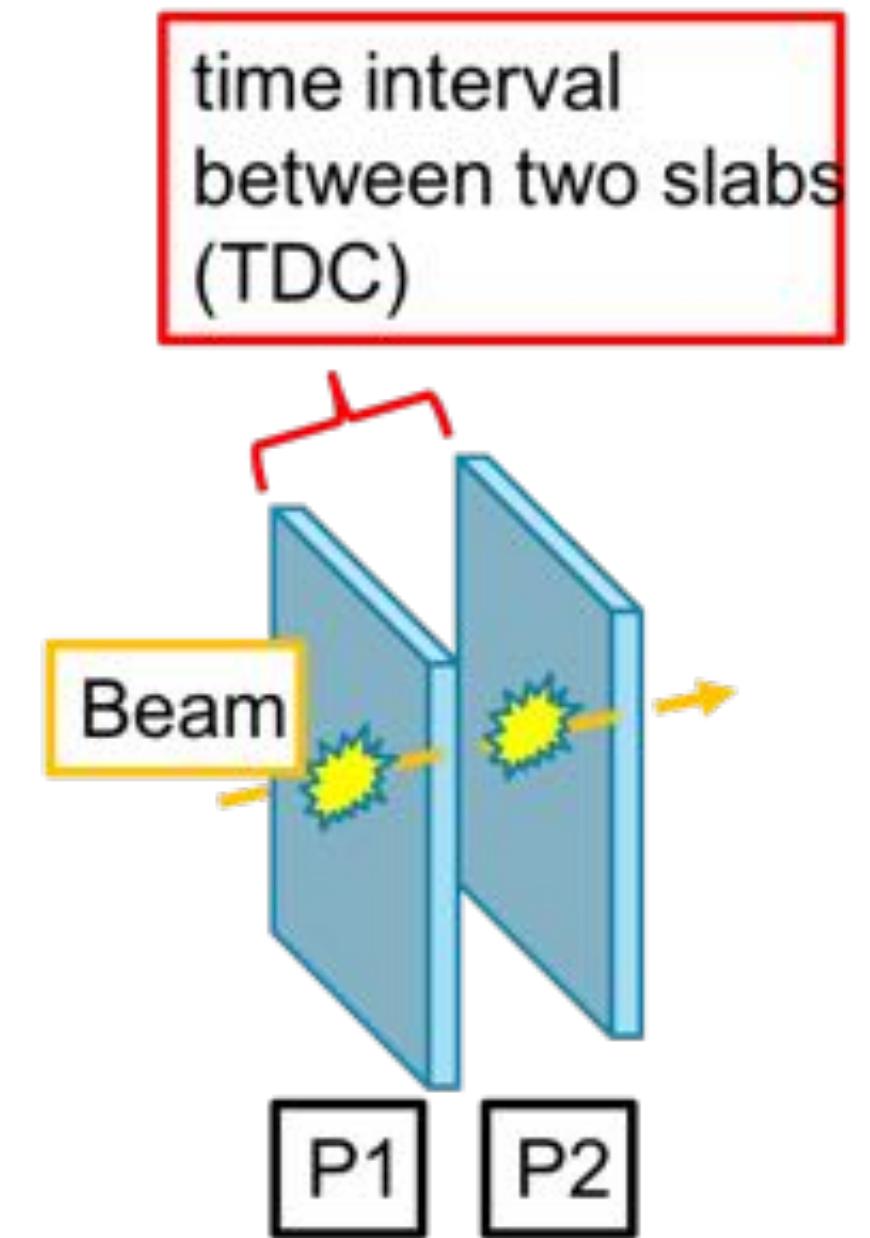
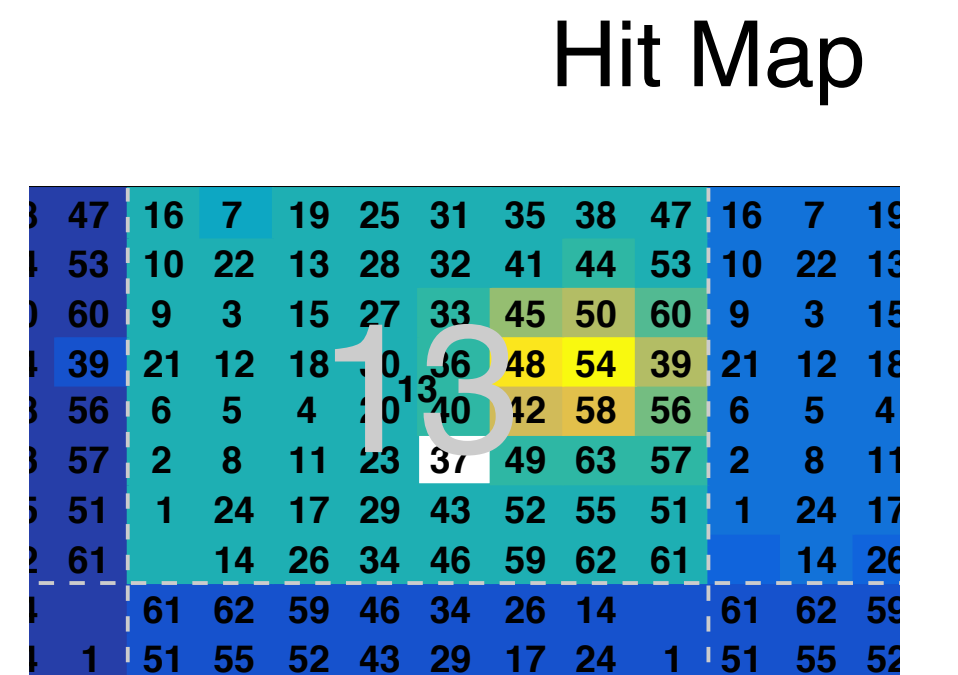
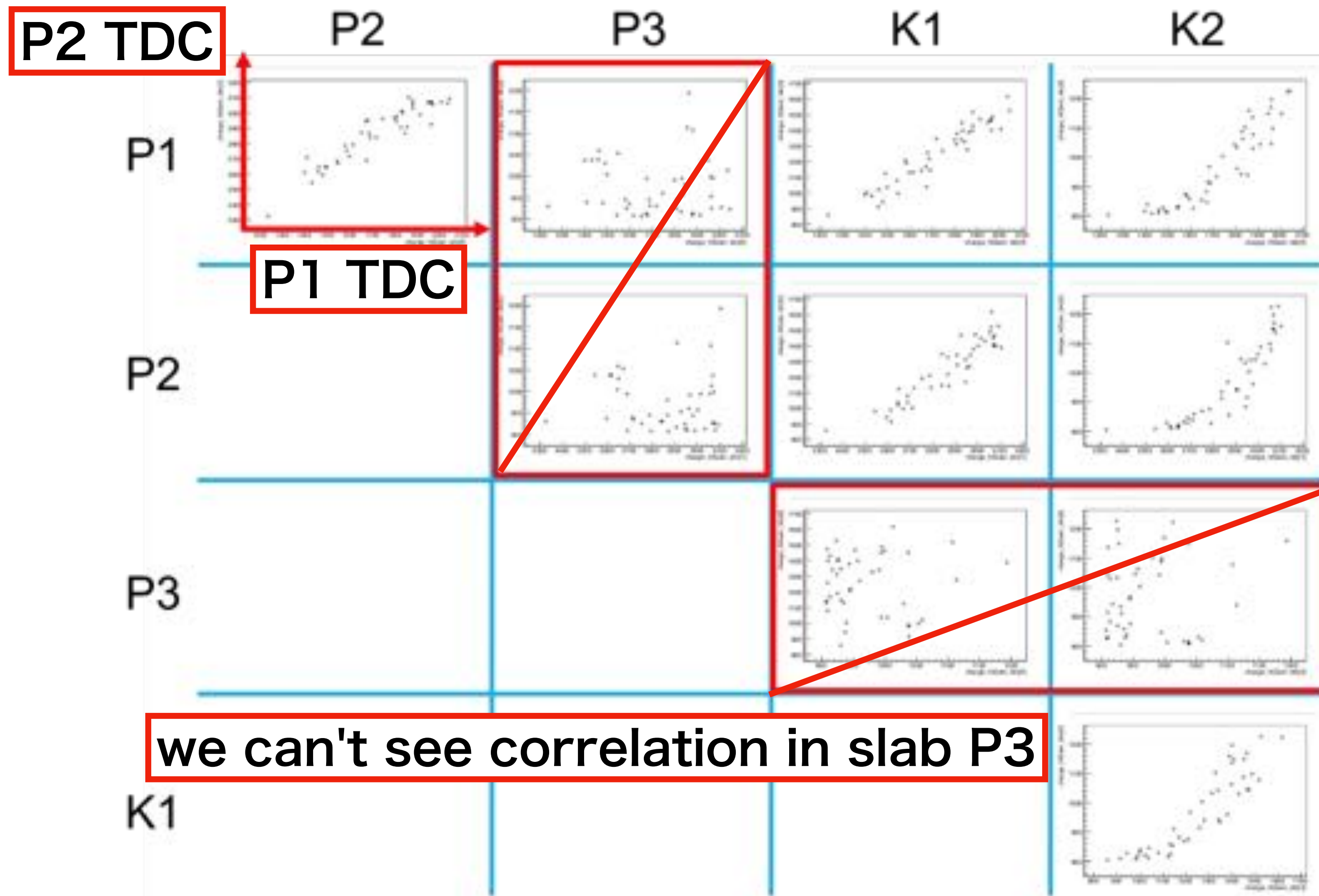


diagonal setup
25 degree

- We can see that hit point is moving in the each Map.
- In the slab K1, MIP means are 145.33 and 155.05 ch at 0 and 25 degree, respectively.



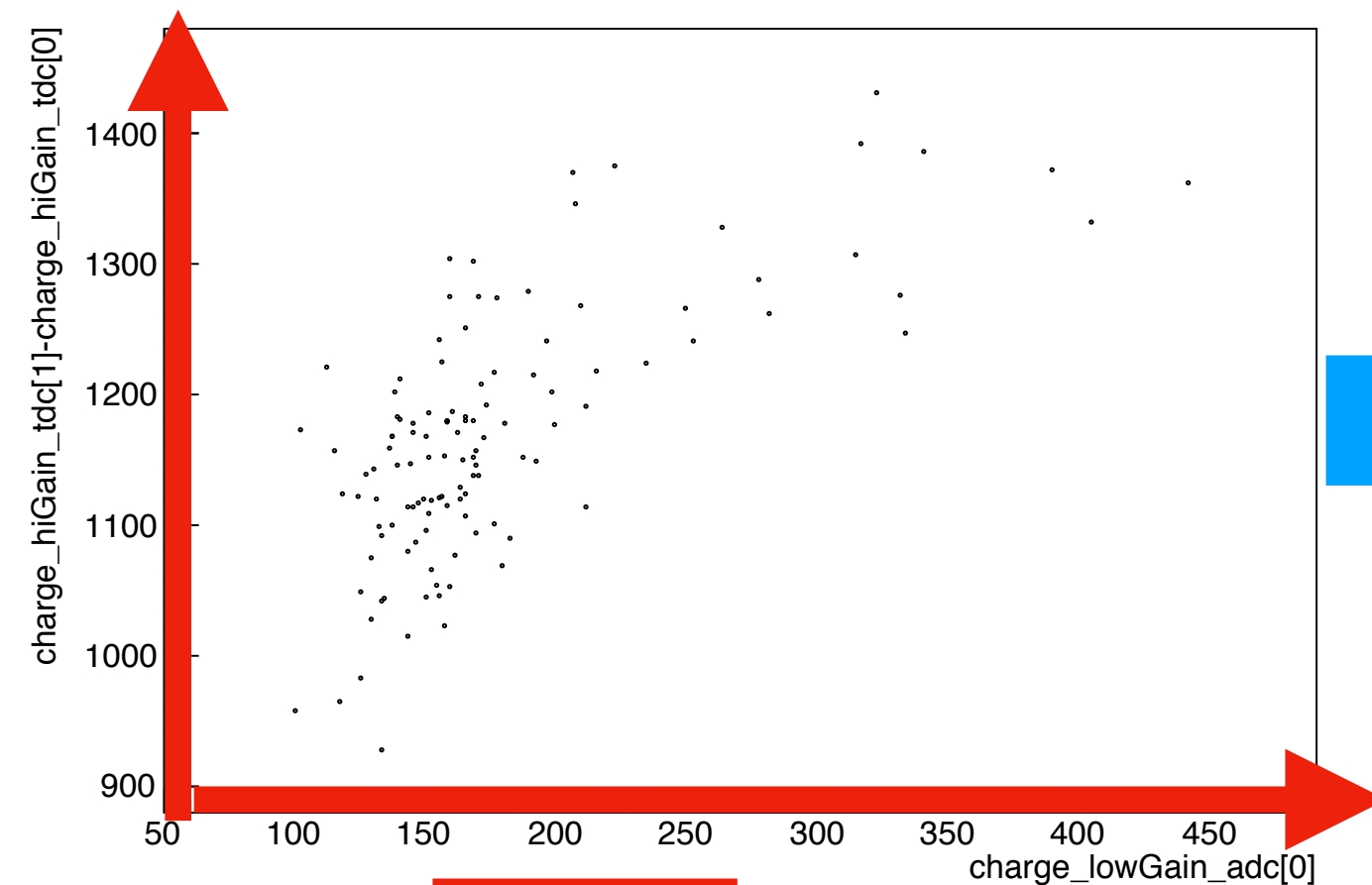
Correlation of TDC



Time Walk

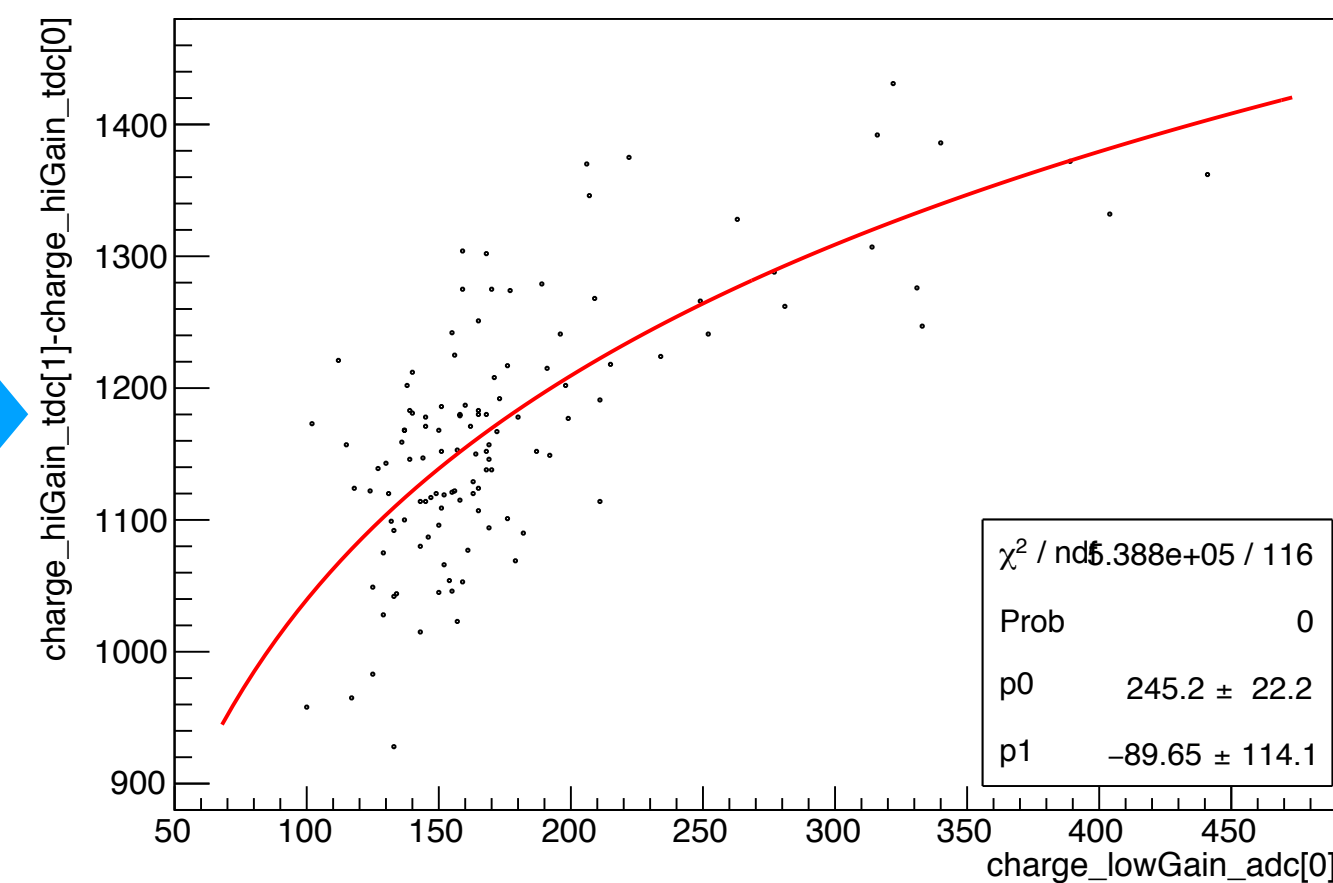
- The energy dependence of TDC difference
- fitting function : log function

TDC difference

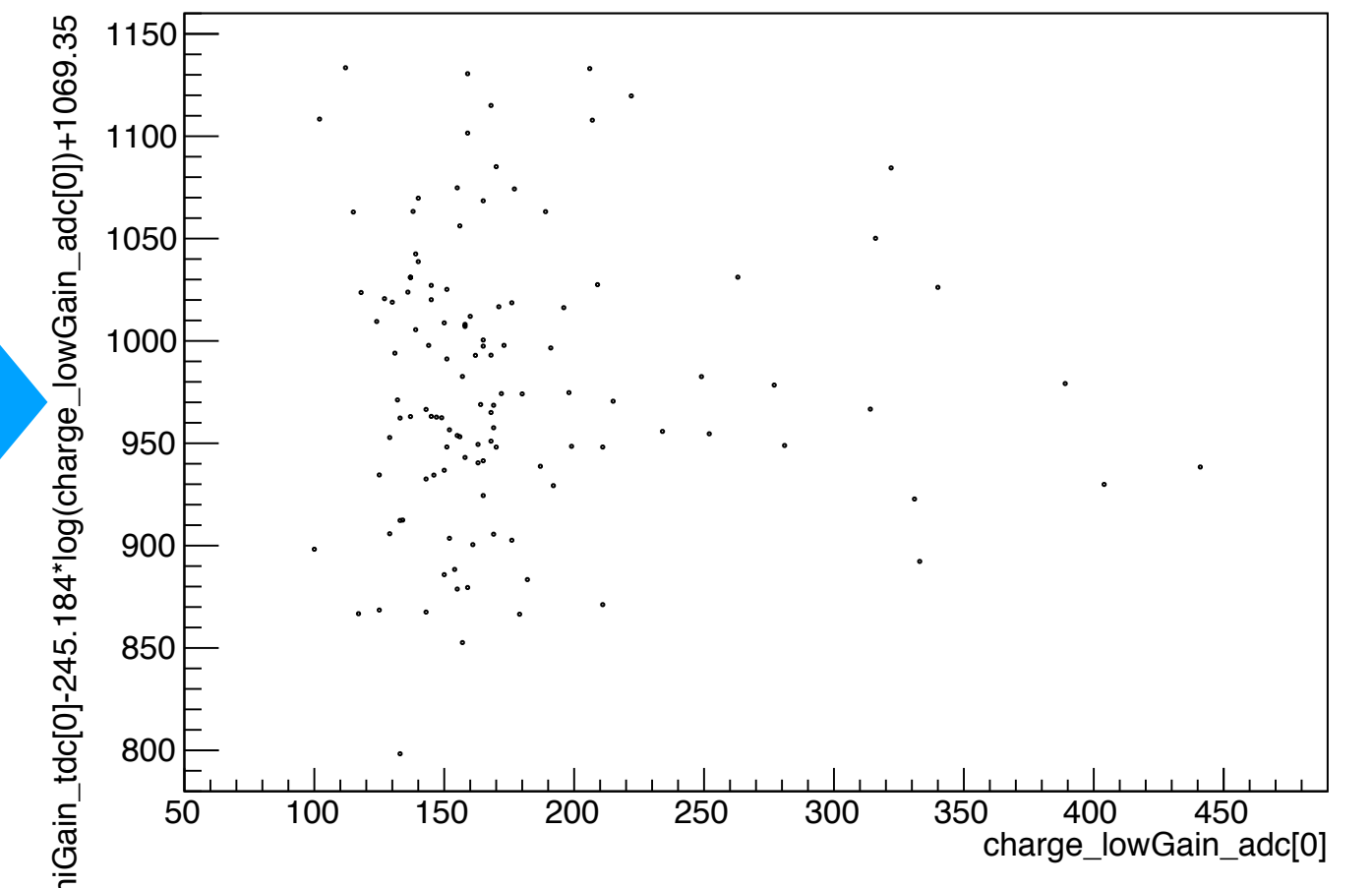


ADC

Fit



Correction



TDC Analysis

- Timing resolution before and after the time walk correction

