Preparation and operation of SiW-ECAL technological prototype for DESY test beam 2019

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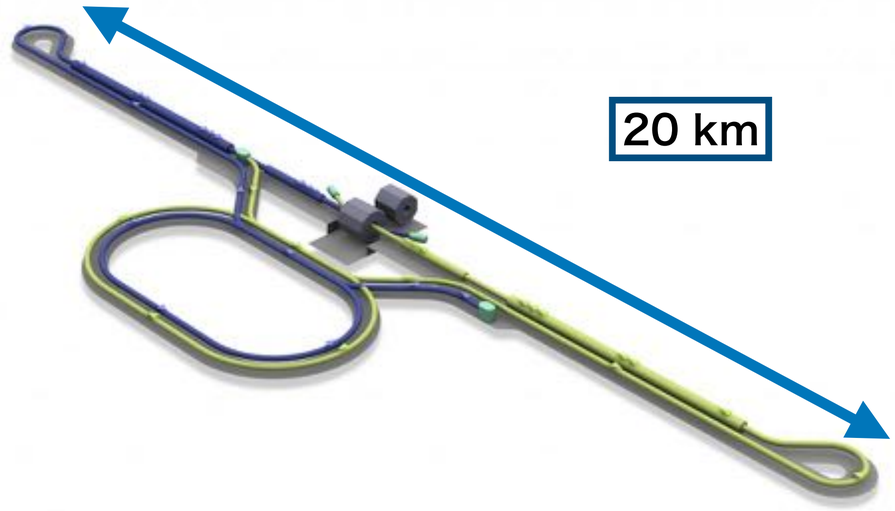
(A: Kyushu University, B: The University of Tokyo, C: LLR, D: LAL)

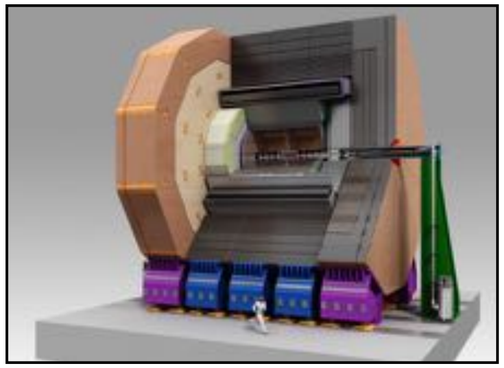
ILC (International Linear Collider)

- Collision of the electron and positron
- Center of mass energy : 250 GeV
- exploring new physics by precise measurement of the SM particle, especially higgs

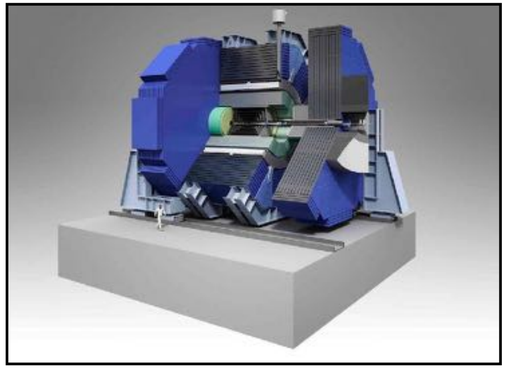


- Two candidates of the detector
  - ILD (International Large Detector)
  - SiD (Silicon Detector)

ILD

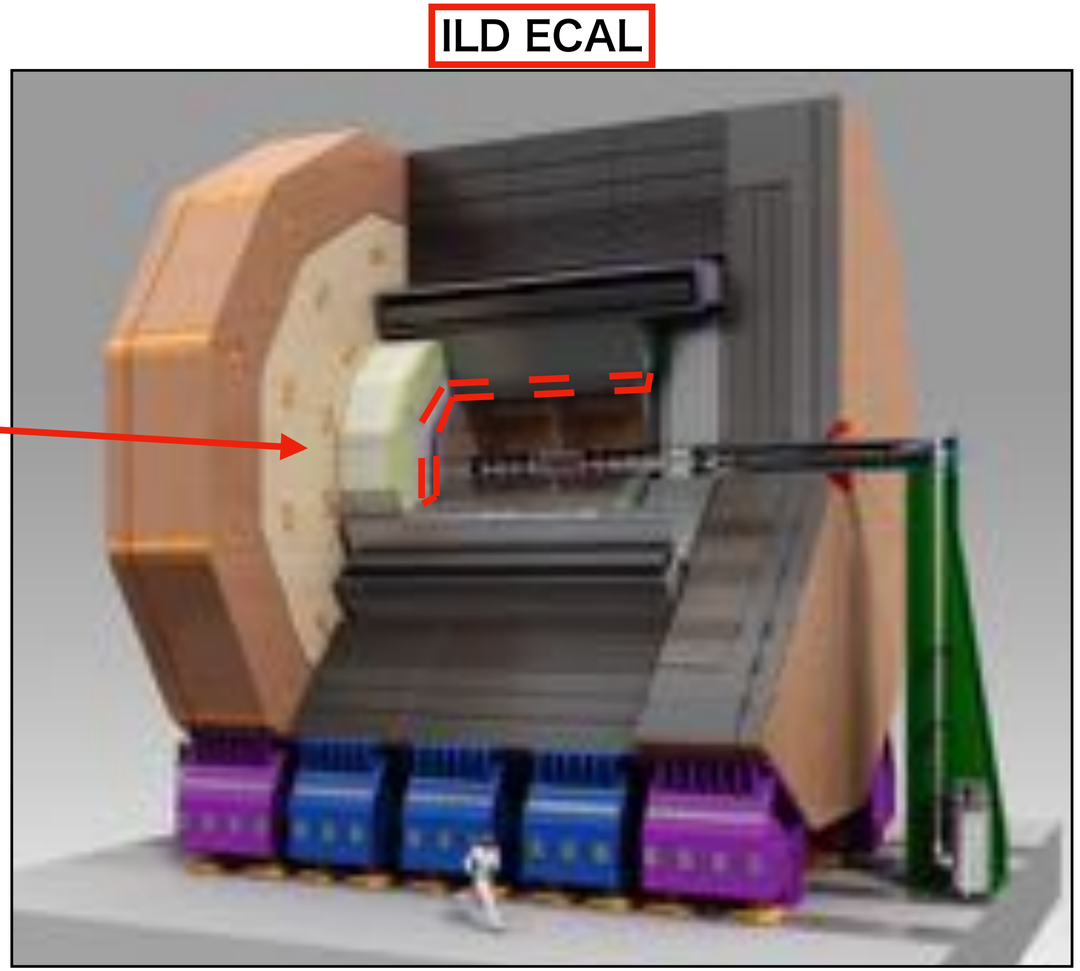


SiD



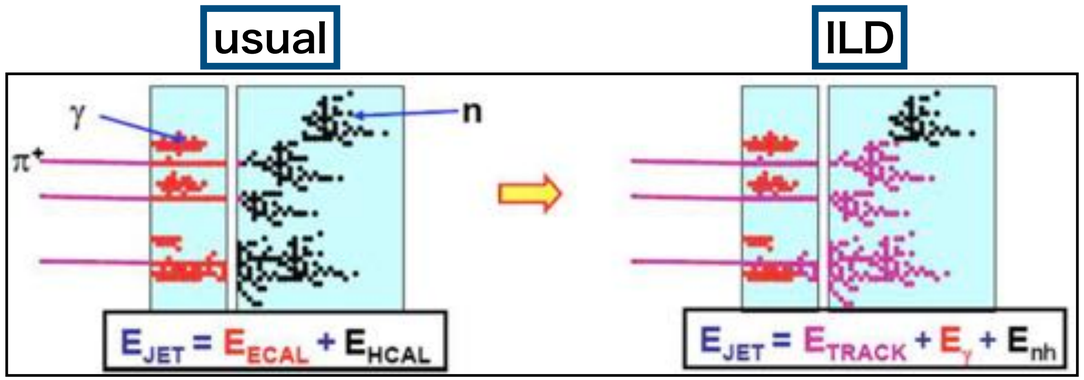
ILD (International Large Detector)

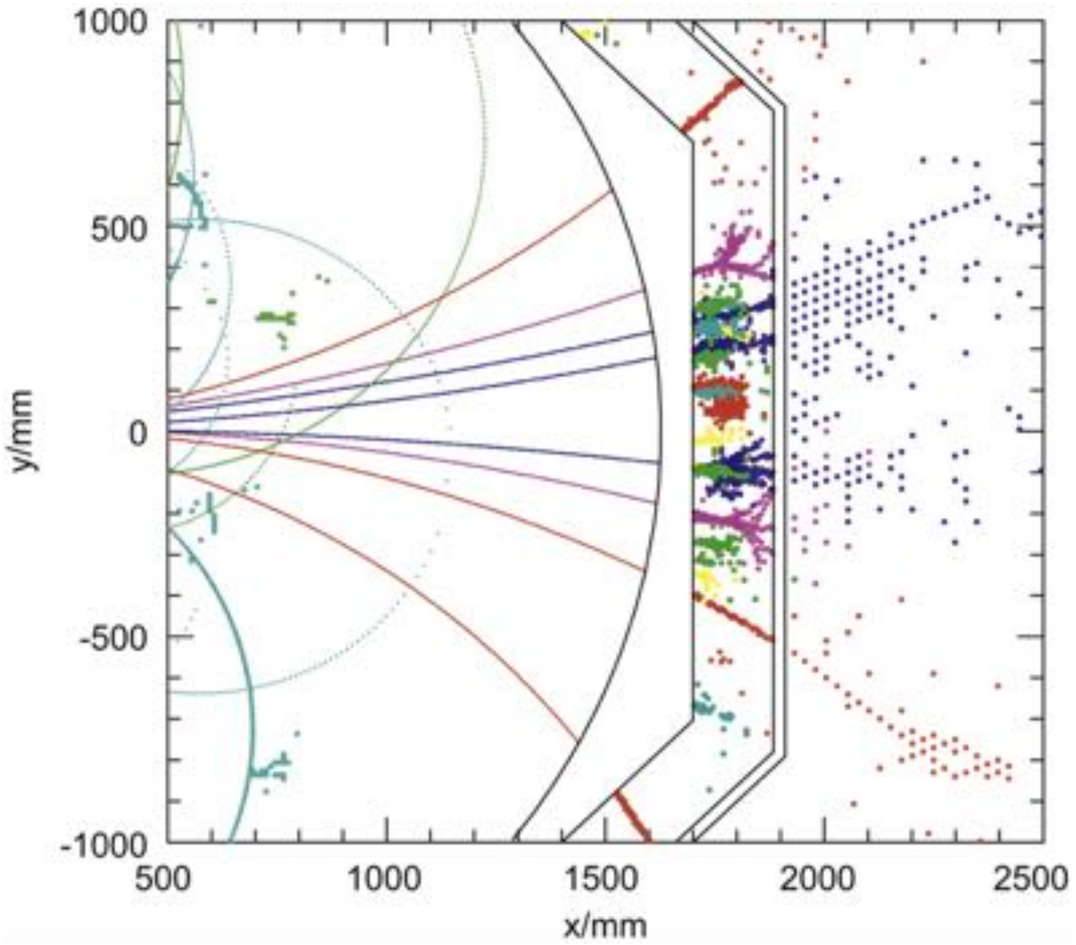
- ILD components
  - Vertex detector
  - Tracking detector
  - Electromagnetic calorimeter
    - ScW-ECAL : using scintillator
    - SiW-ECAL : using Si semiconductor
  - Hadron calorimeter
  - Muon detector



PFA (Particle Flow Algorithm)

- Separation of the particles in jets
- Reconstruction with appropriate detector
  - charged particle : Tracking detector
  - photon : Electromagnetic calorimeter
  - neutral particle : Hadron calorimeter

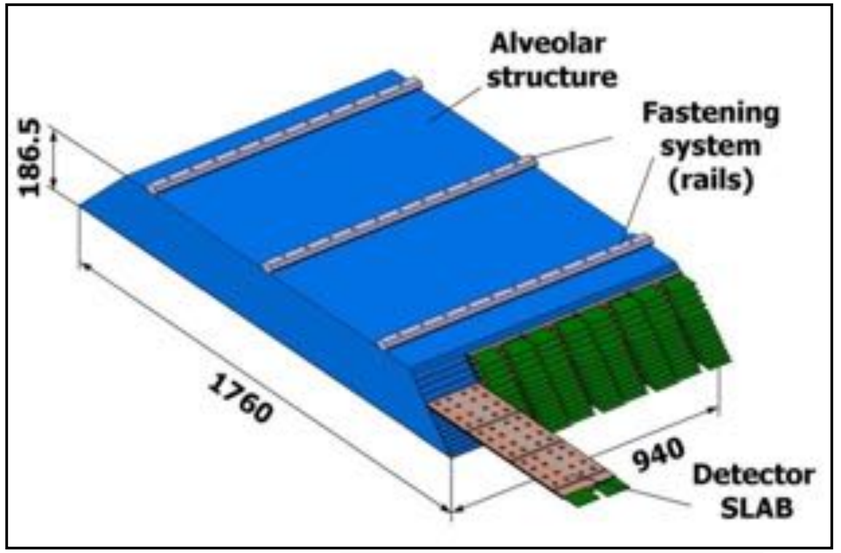


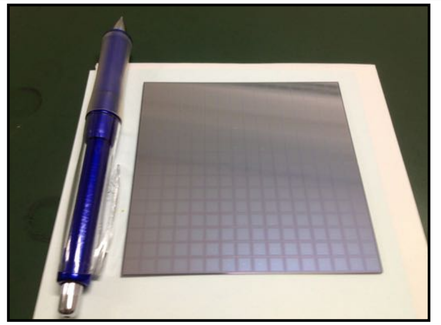


SiW-ECAL

- The electromagnetic calorimeter in ILD is a sampling calorimeter with 20-30 layers
- SiW-ECAL
  - Tungsten (absorber)
  - Silicon (detector)
    - granularity requirement : 5 mm × 5 mm
    - silicon pad : 90 mm × 90 mm (256 pixels)
    - Si thickness : 320 μm, 650 μm

ILD ECAL in Barrel

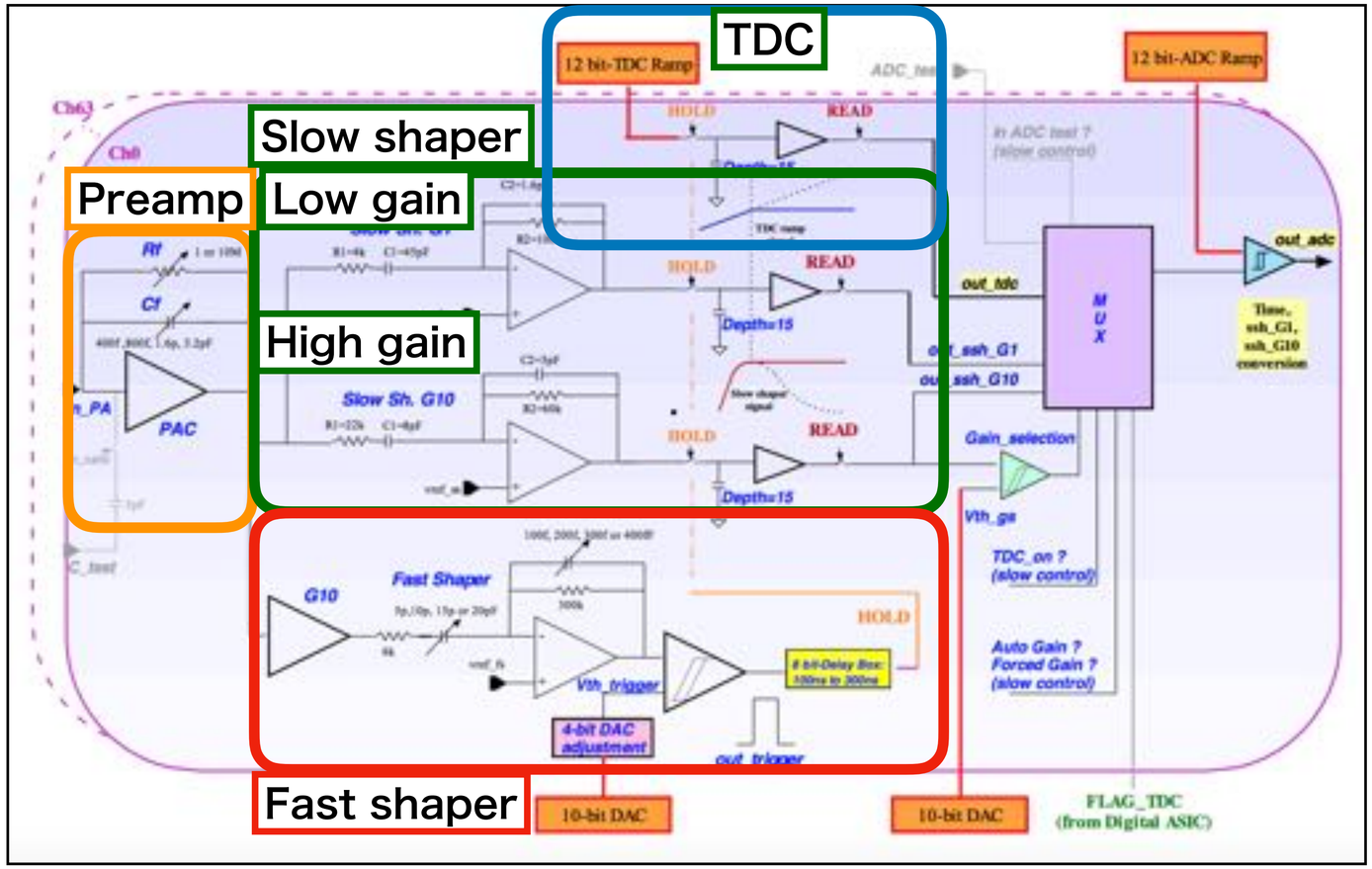




silicon pad

ASIC

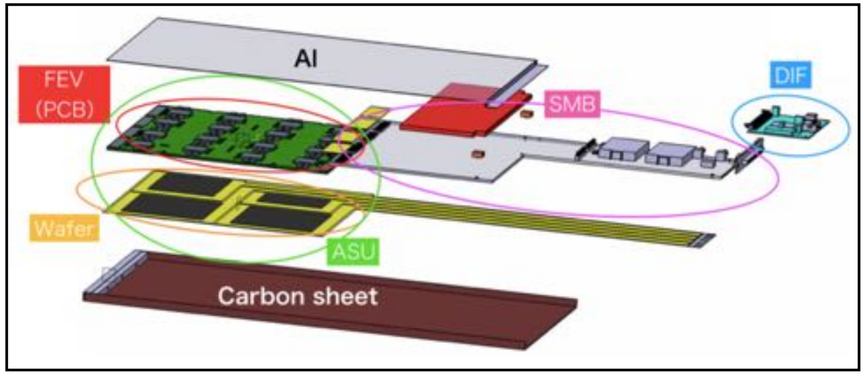
- ASICs (SKIROC2/2A) are used as the integrated circuit for data taking
- SKIROC2A
  - 64 channel
  - 15 memory cells
  - ADC mode
    - ADC high and low gain
  - TDC mode
    - TDC
    - ADC high or low gain



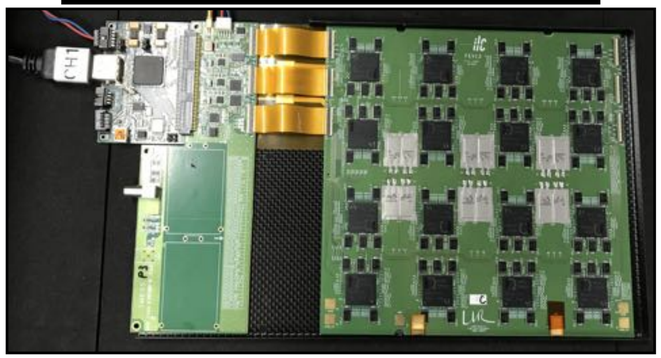
R&D of the SiW-ECAL

- The development phase is proceeding the following changes
- The physics prototype
  - Studying the Si detector satisfying ILD requirement
  - Development of the sensor and reading circuit
- The technological prototype
  - Optimization of the DAQ systems for implementation to ILD
  - slab : just one layer of the SiW-ECAL
  - One slab has 4 silicon pads (1024 pixels)
    - read by 16 ASICs (1 ASIC : 64 ch)

slab components



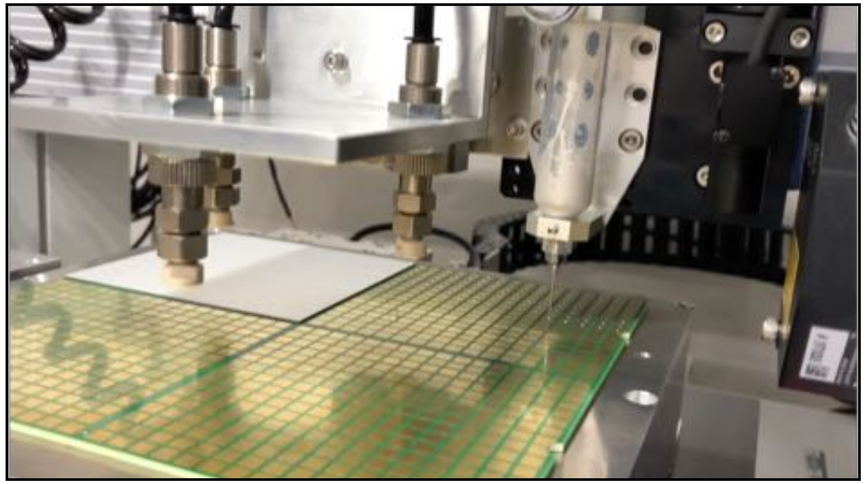
technolosical prototype

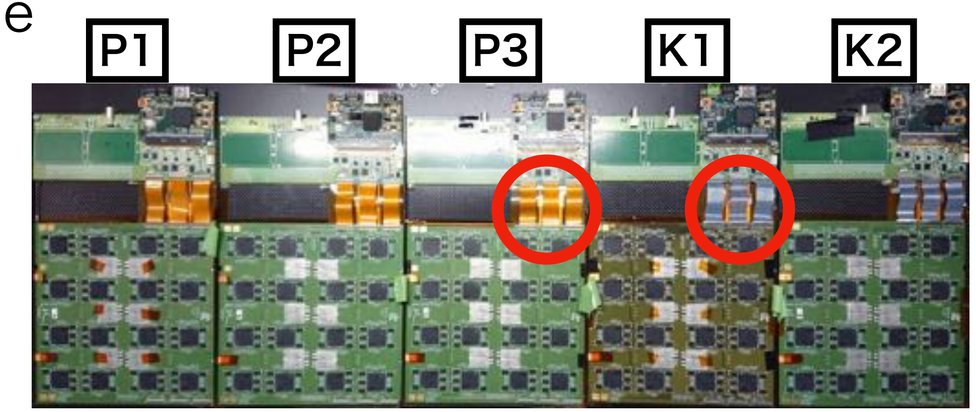


Assembly of the latest model (in Kyushu)

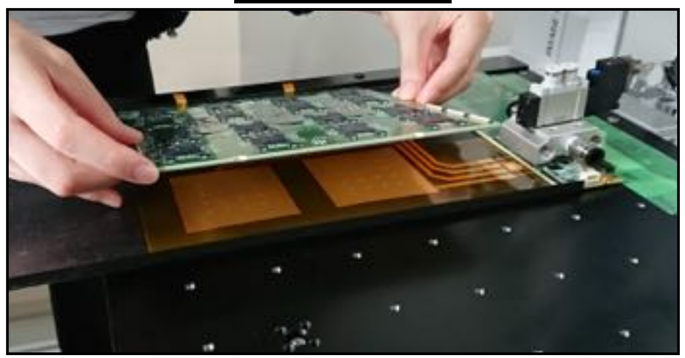
- 5 slabs are assembled in Kyushu University
- Gluing FEV and SMB to FPC
- Si thickness : 320 μm (P3), 650 μm (others)
- The difference between P and K
  - P : Flexible cable
  - K : Micro-coaxial cable

gluing in Kyushu





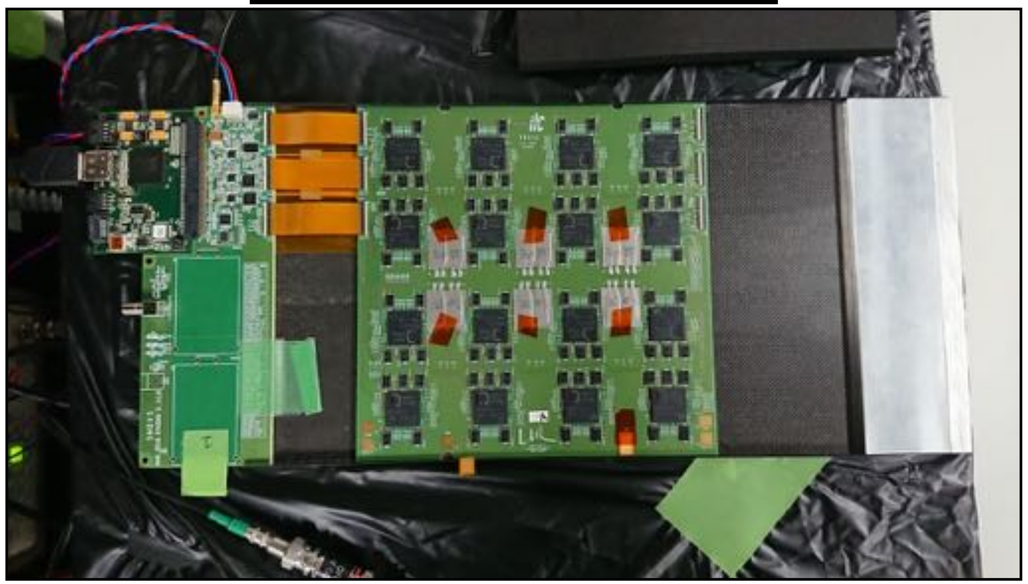
Manually



Previous Test Beam

- 2018 (DESY)
  - evaluation using the just one slab
  - particle : electron

with older carbon plate

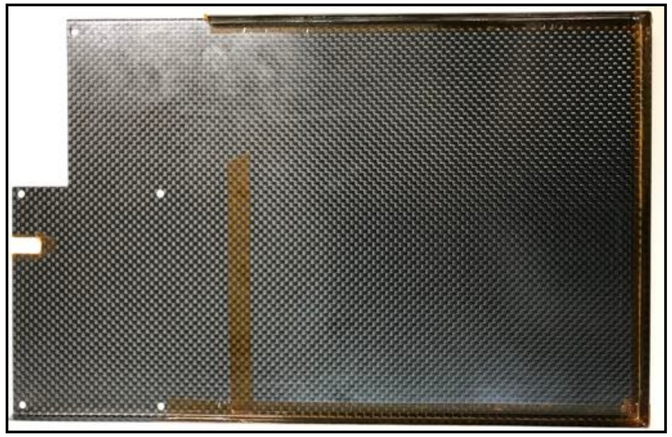


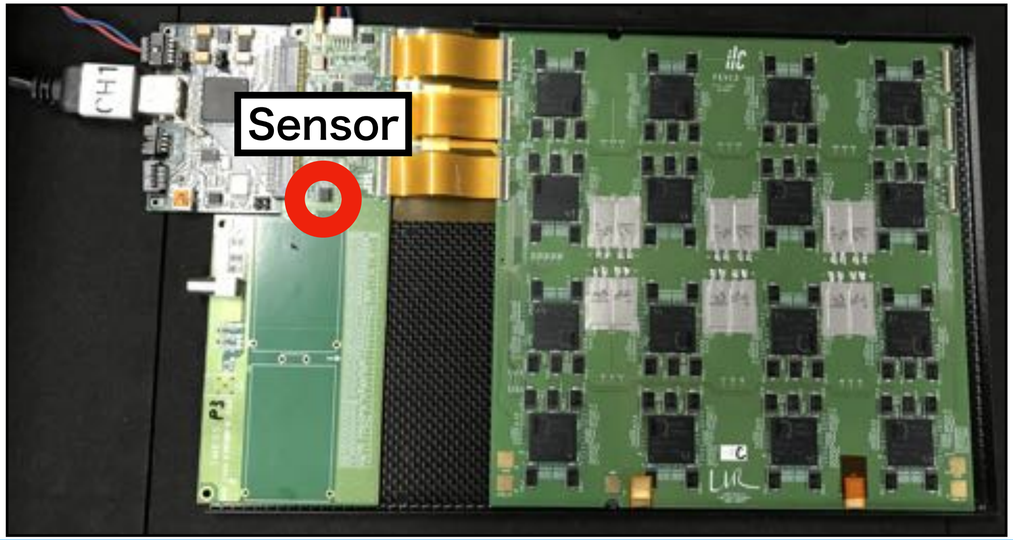
- 2018 (CERN/SPS)
  - evaluation using the 5 slabs
  - particle : muon, electron, pion
  - 4 slabs had the problem in HV → data taking is difficult using the older model's carbon plate

Update from previous TB

- Replace the carbon plate on the backside and cover
  - New carbon plate :
    - cut the edge of the HV connector side
    - pushing with screw
    - leakage current
- Temperature monitoring
  - It is the first time temperature measuring

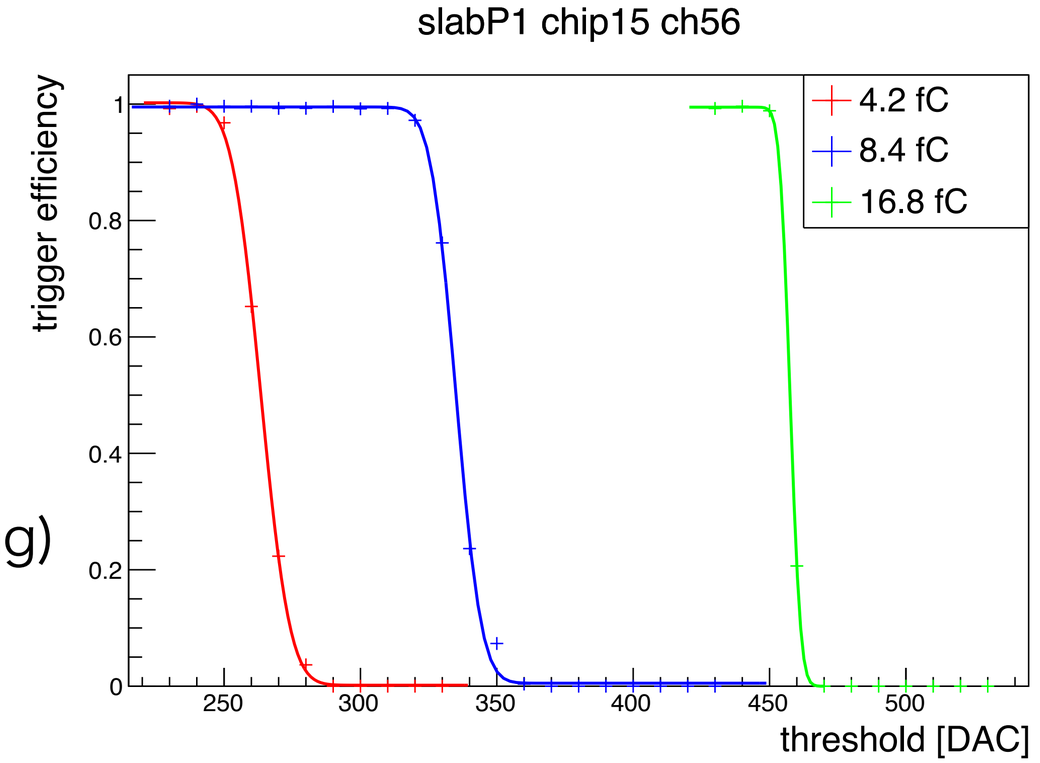
New carbon plate





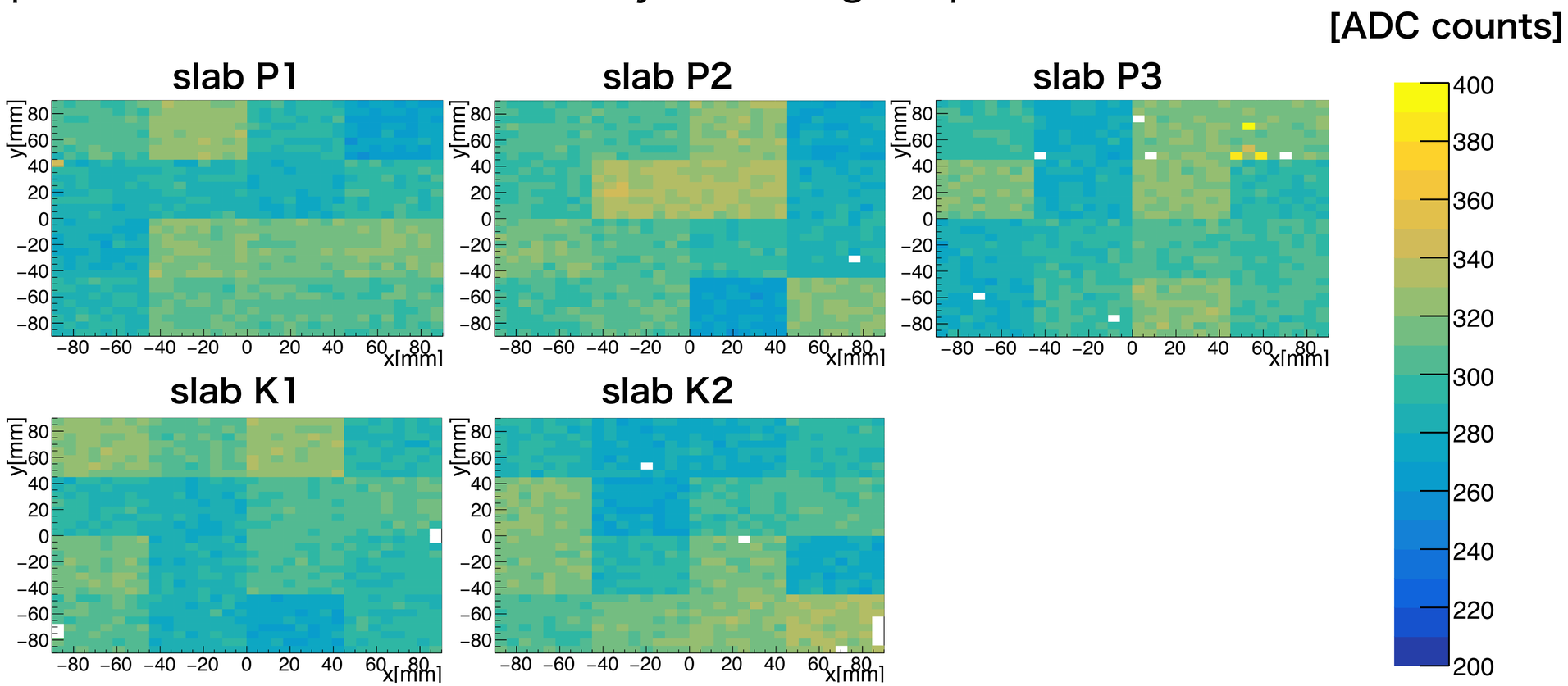
Laboratory Test (1)

- S/N in the trigger line
  - defined by the study of the trigger line (fast shaper in SKIROC)
- threshold scans with charge injections
  - 1.4 mVpp : 1 MIP
  - 2.8 mVpp : 2 MIP
  - 5.6 mVpp : 4 MIP
- We can see the S curve
  (As the trigger line is higher, signal is decreasing)



Laboratory Test (2)

- Pedestal means for all channels are measured with thermal noise
- Each pedestal means are shown by following maps

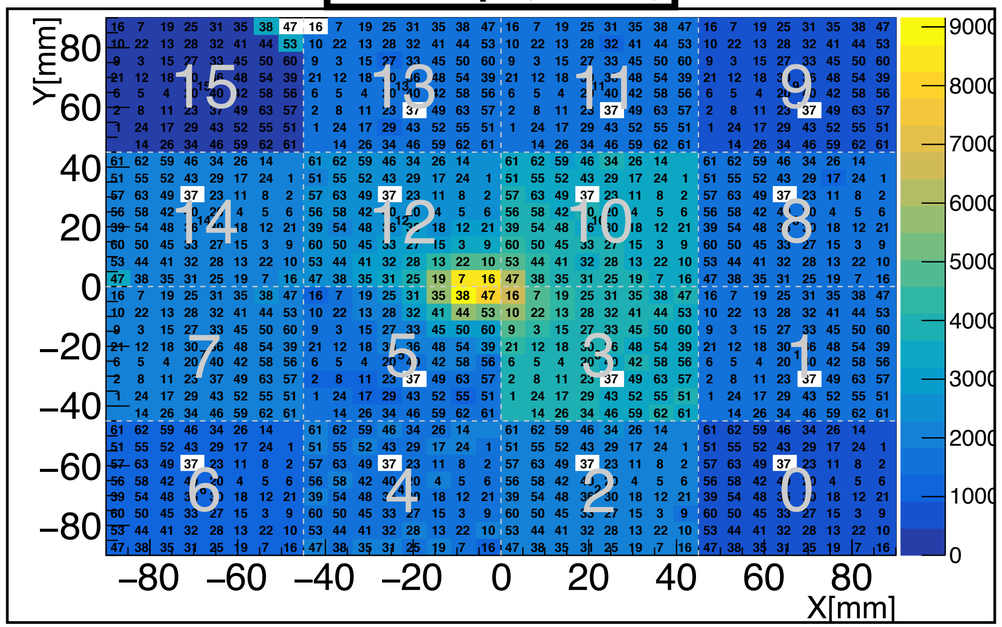


Laboratory Test (3)

- Data acquisition test with radiation sources
- Data were measured using the ^{133}Ba and ^{57}Co as gamma radiation sources
  - ^{133}Ba :
    - 356 keV (62.1%)
      - Ee = 207.25 keV
    - 81.0 keV (34.1%)
  - ^{57}Co :
    - 122 keV (85.6%)
    - 136 keV (10.7%)

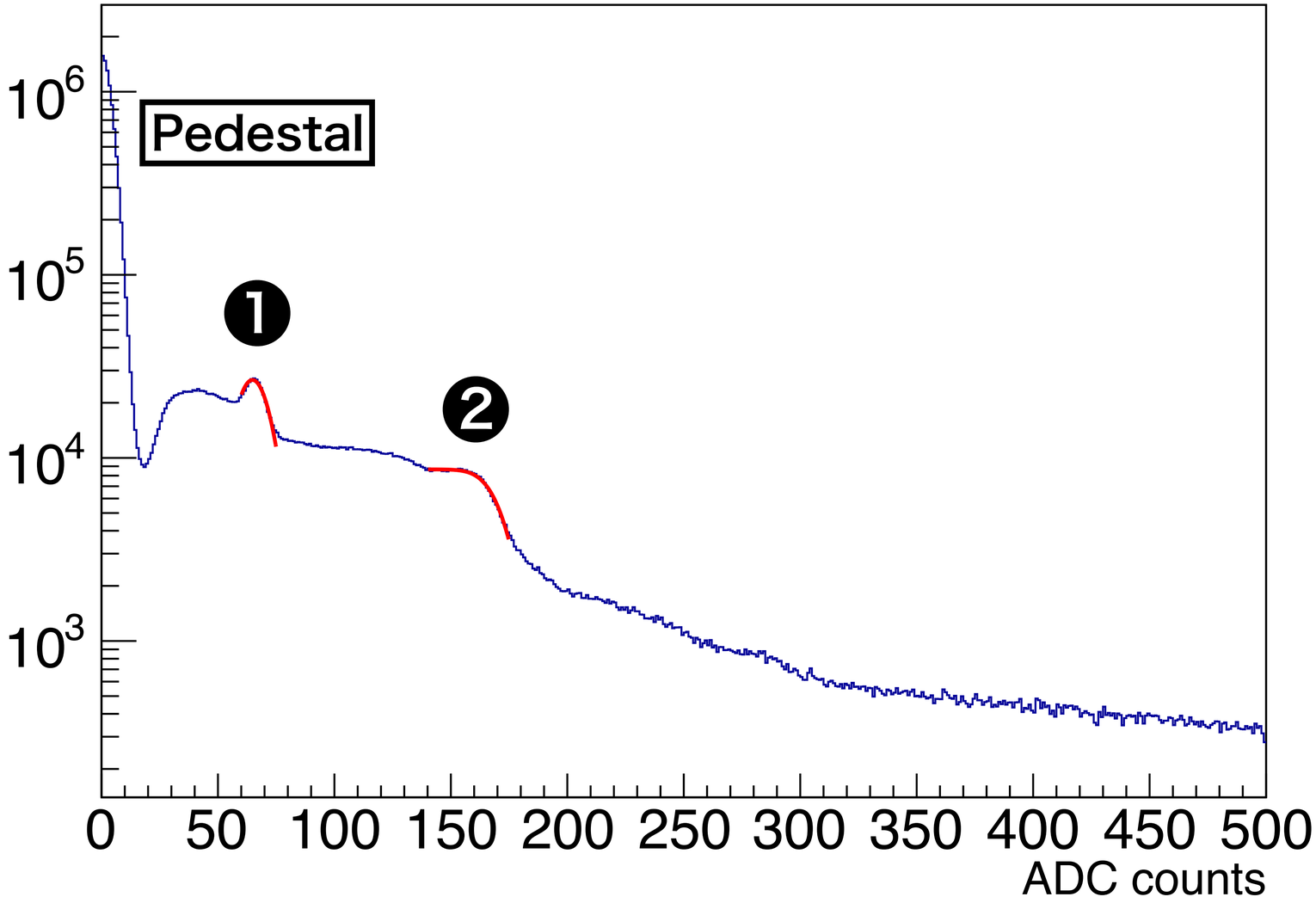
sources

Hit map (^{133}Ba)



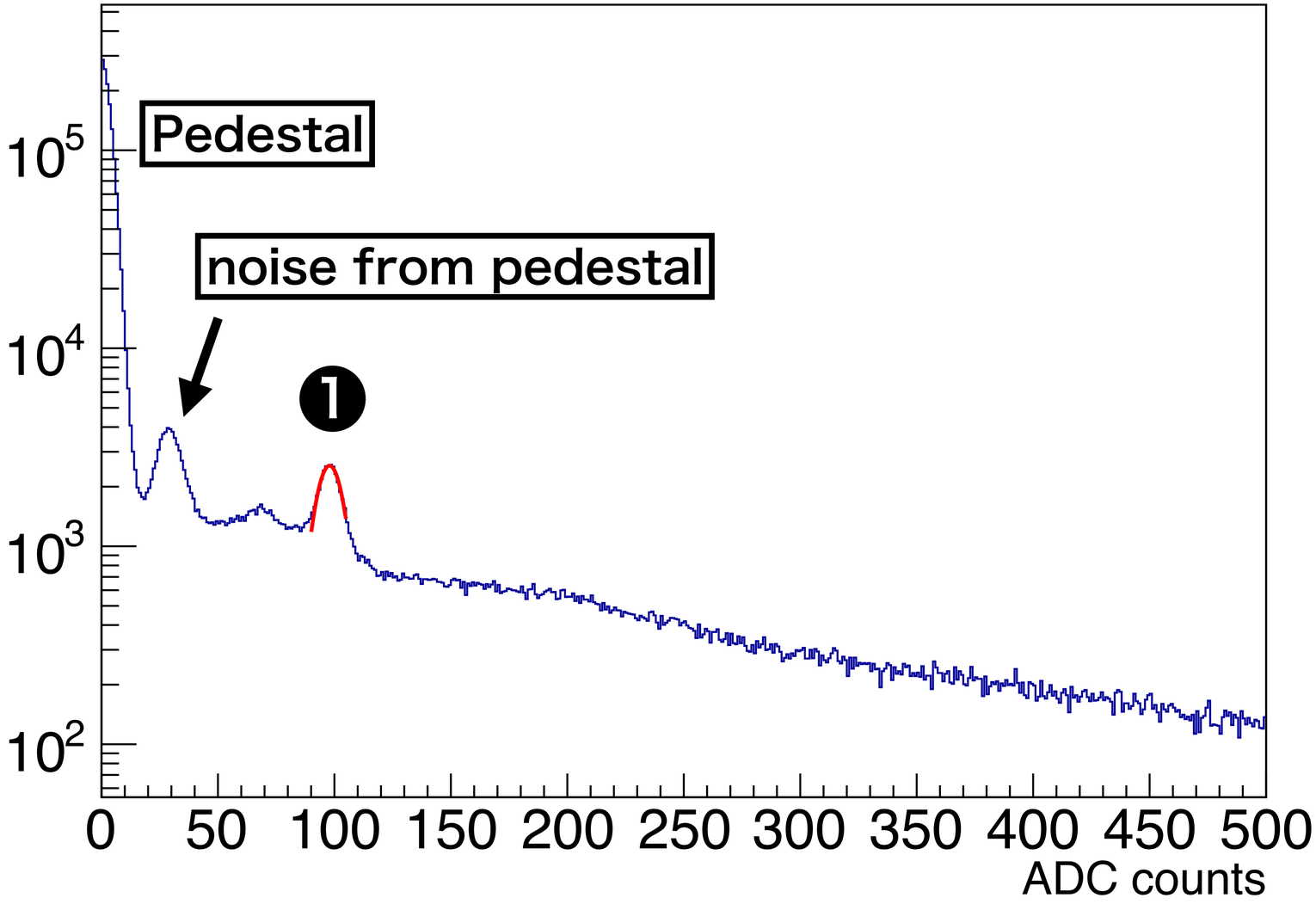
Laboratory Test (3)

- ^{133}Ba ADC Histogram
- ❶
  - Photoelectric peak
  - 81.0 keV
  - 64.8 ch
- ❷
  - Compton edge
  - 207.25 keV
  - 173.0 ch



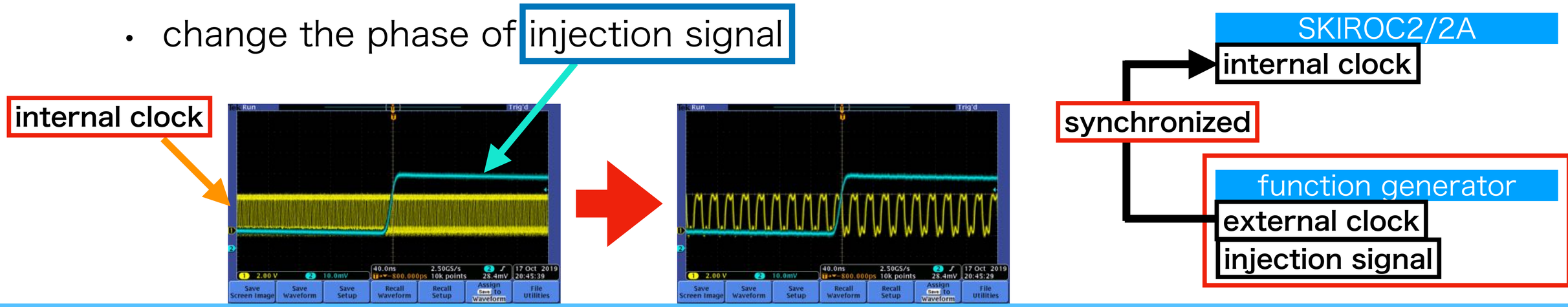
Laboratory Test (3)

- ^{57}Co ADC Histogram
- ❶
  - Photoelectric peak
  - 122 keV
  - 97.9 ch



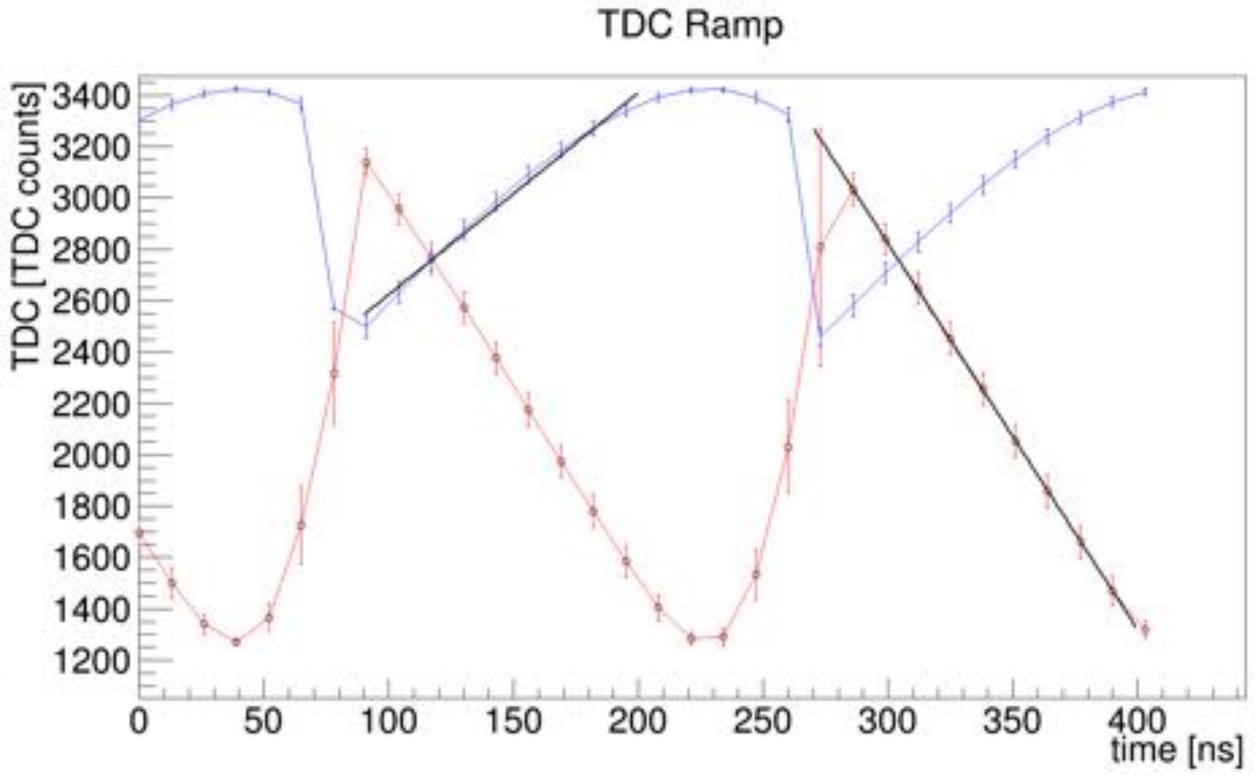
Laboratory Test (4)

- TDC mode operation test
- SKIROC2/2A has the ramp wave as one of the internal clocks
  - frequency : 2.5 MHz or 5 MHz (we can choose with rewriting firmware)
- The ramp wave can be measured with
  - synchronization of internal and external clock (injection signal)
  - change the phase of injection signal



Laboratory Test (4)

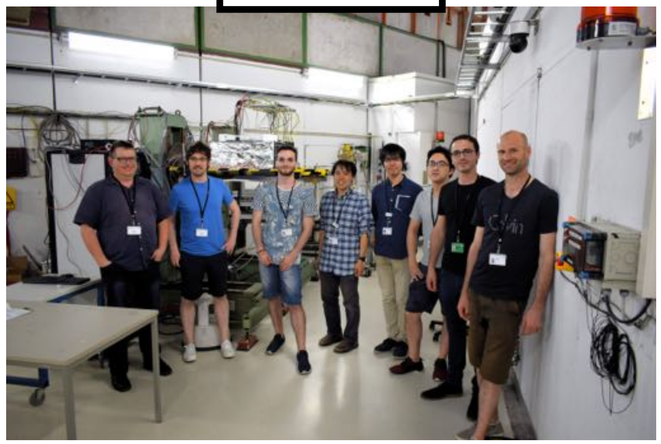
- using the following parameters
  - injection frequency : 200 kHz
  - injection voltage : 2.8 mVpp (2 MIP)
  - trigger : 230
  - ASIC channel : 13 channel
- TDC to real time conversion parameter
  - 0.127 ns / TDC count (up)
  - 0.066 ns / TDC count (down)



Test Beam 2019 (1)

- Purpose :
  - Data acquisition with electron beam (MIP, Shower)
  - Operation test (TDC, Auto Gain, etc.)
- 25th June 2019 - 5th July 2019 (DESY)
- Beam Status : electron, 1 - 5 GeV
- Setup : 5 slabs (Kyushu) and 4 Chip-In-Board slabs (France)
  - MIP (without tungsten)
  - Shower (with tungsten)

Members



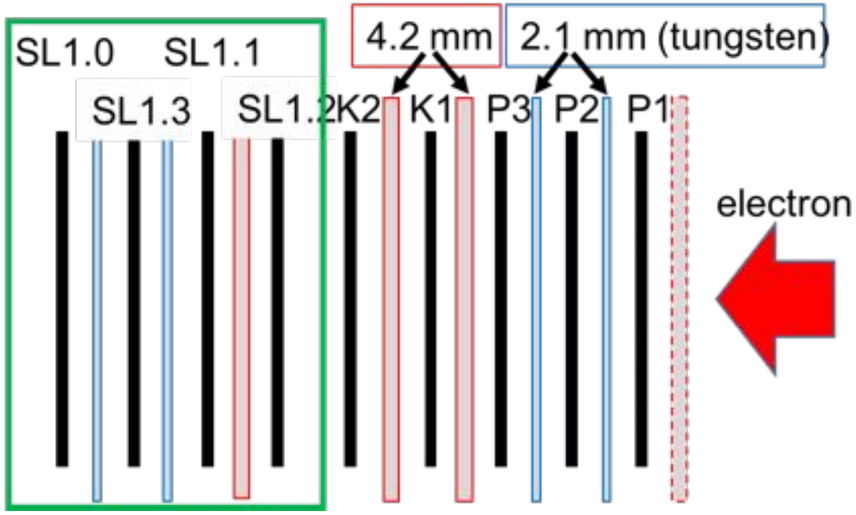
Chip In Board

Test Beam 2019 (2)

- The following box was used in TB2019
  - 5 slabs (Kyushu) were installed to this box
  - 4 CIB slabs (France group) were also installed
- The order of slabs is shown by the picture
- In shower setup,
  We use two pattern thickness for tungsten
  4.2 mm and 2.1 mm
- In detail explanation will be talked in analysis session

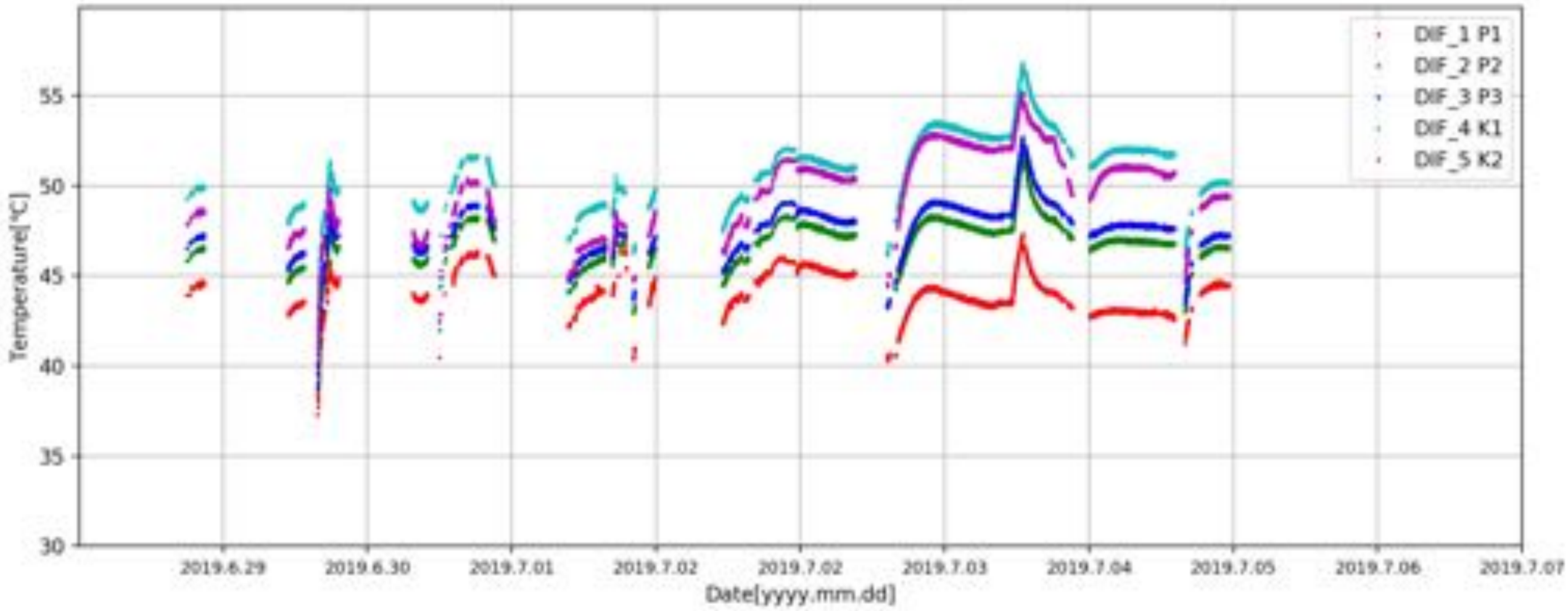
box used in TB2019

Shower setup



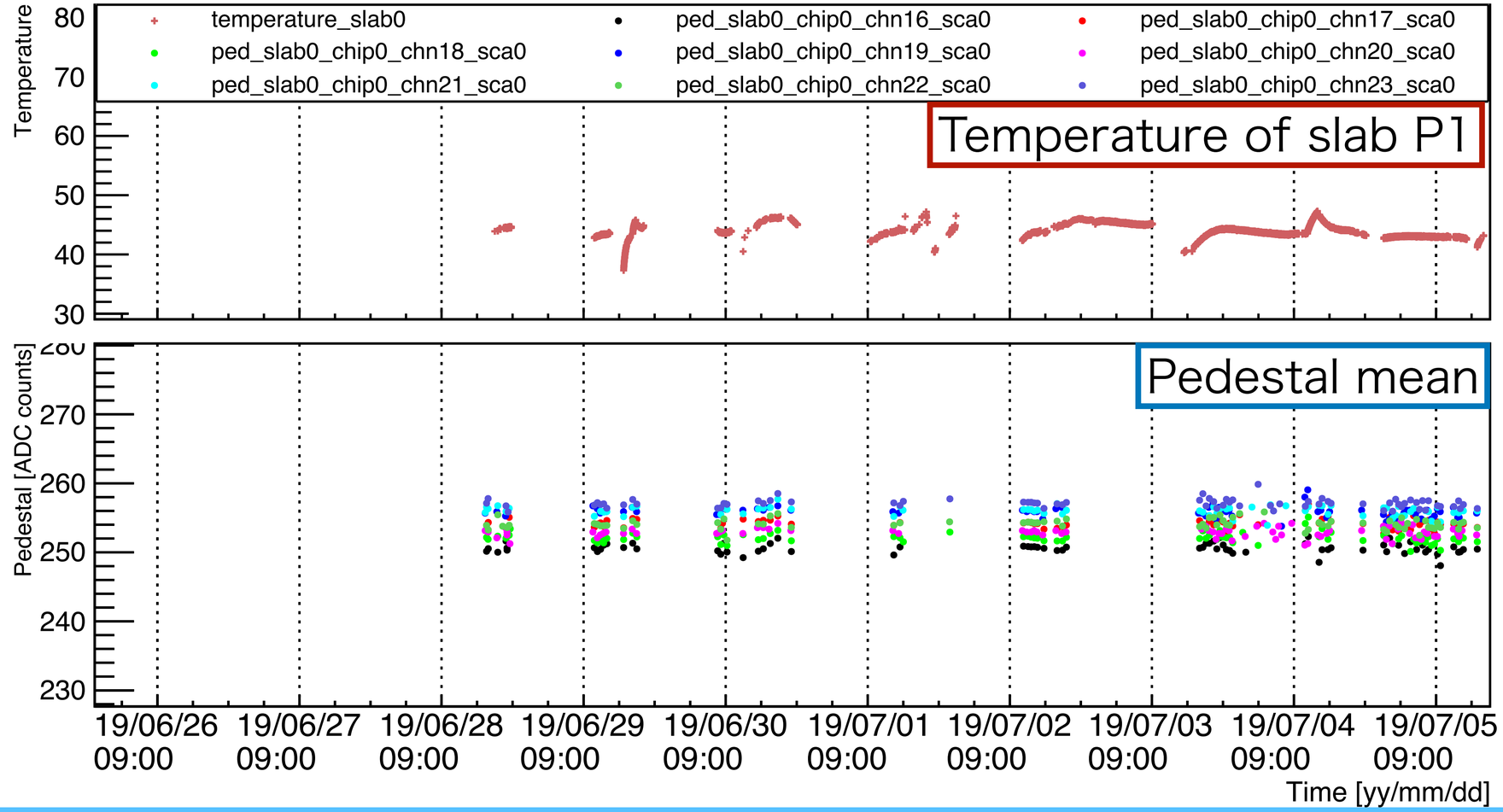
Temperature for all slabs

- Time variation of temperatures for all slabs



Temperature and Pedestal mean variation

- Time dependance of the temperature and pedestal mean



Some issues (1)

- Some issues were happened for connections
- HDMI connection
  - HDMI connections are unstable and loose
- HV connector
  - HV connectors are too fragile
- Complicated cable connection
  - Three cables per a slab must be connected to outside of the box

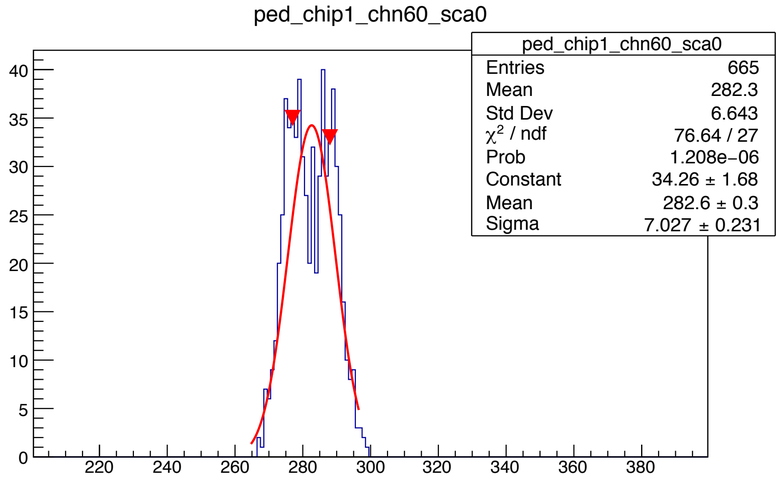
Complicated cable connection

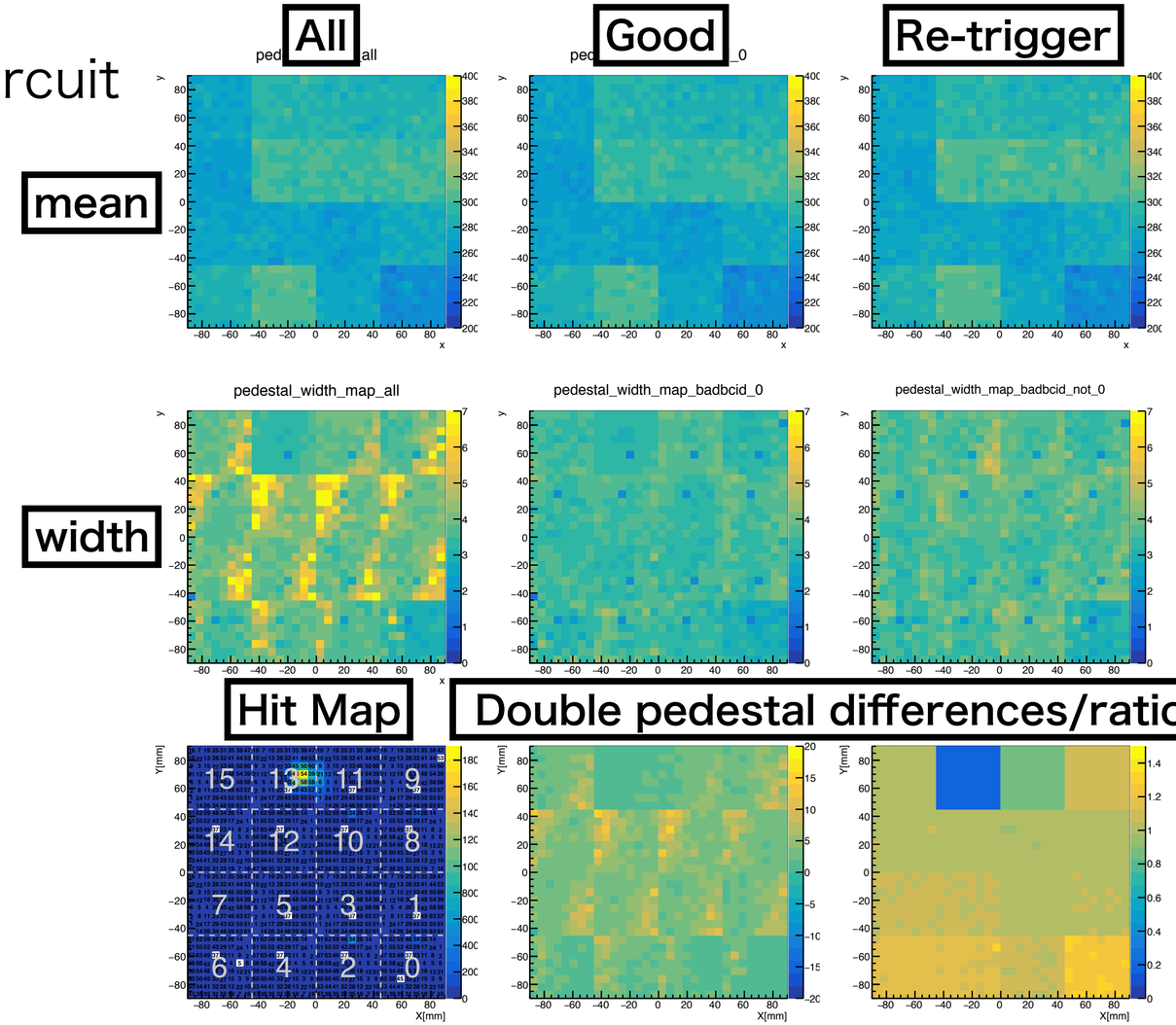
outer

inner

Some issues (2)

- Some issues were found for reading circuit
- Re-triggering :
  - dummy hits after the hit
- Double pedestal
  - now studying





Summary and next plan

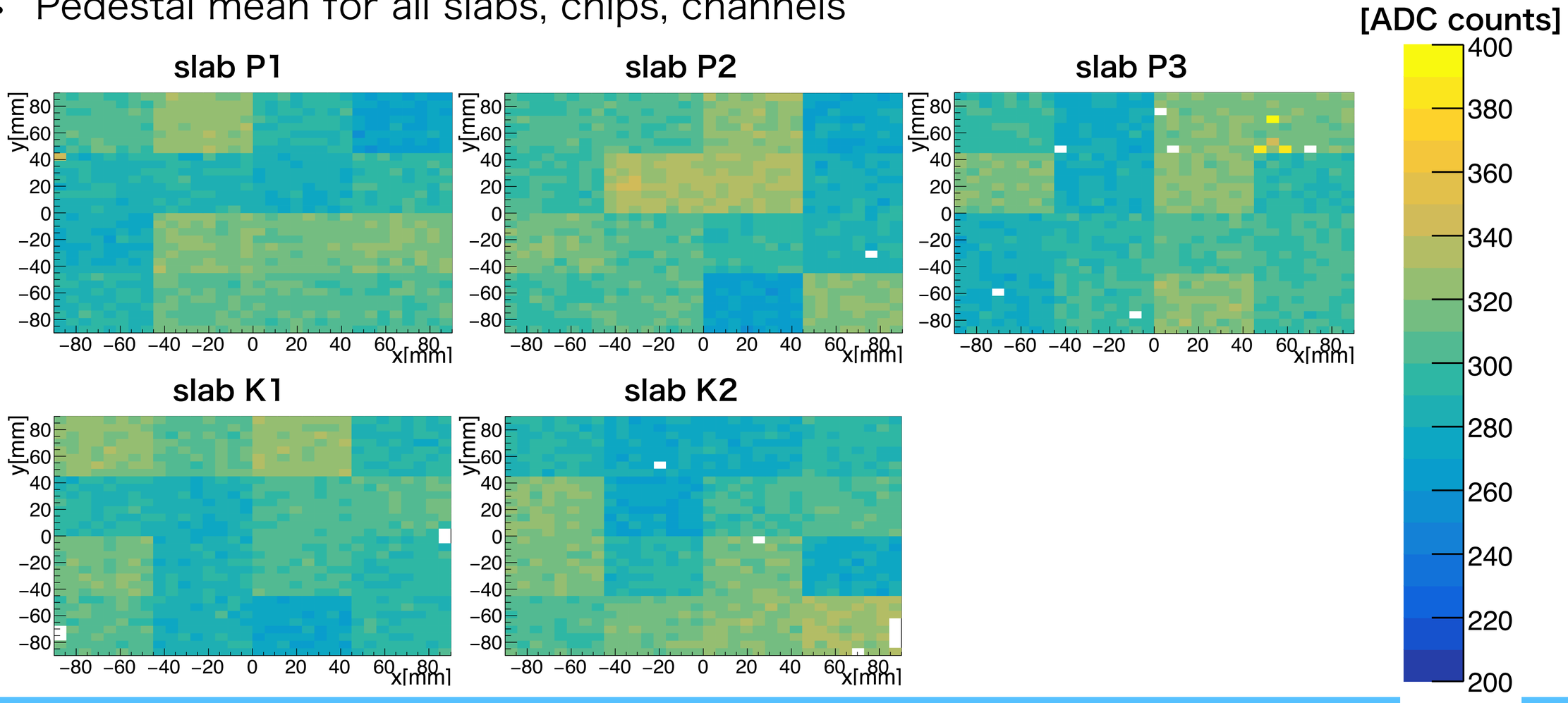
- Summary
  - Now, reading circuit for SiW-ECAL is optimized
  - We improved the slabs from the last Test Beam
  - We measured ADC data using gamma radiation sources
  - We calculated TDC convert parameter with charge injections
  - In detail analysis results are talked in the after talk

- Next plan
  - measurement of TDC for all channels

backup

Pedestal mean

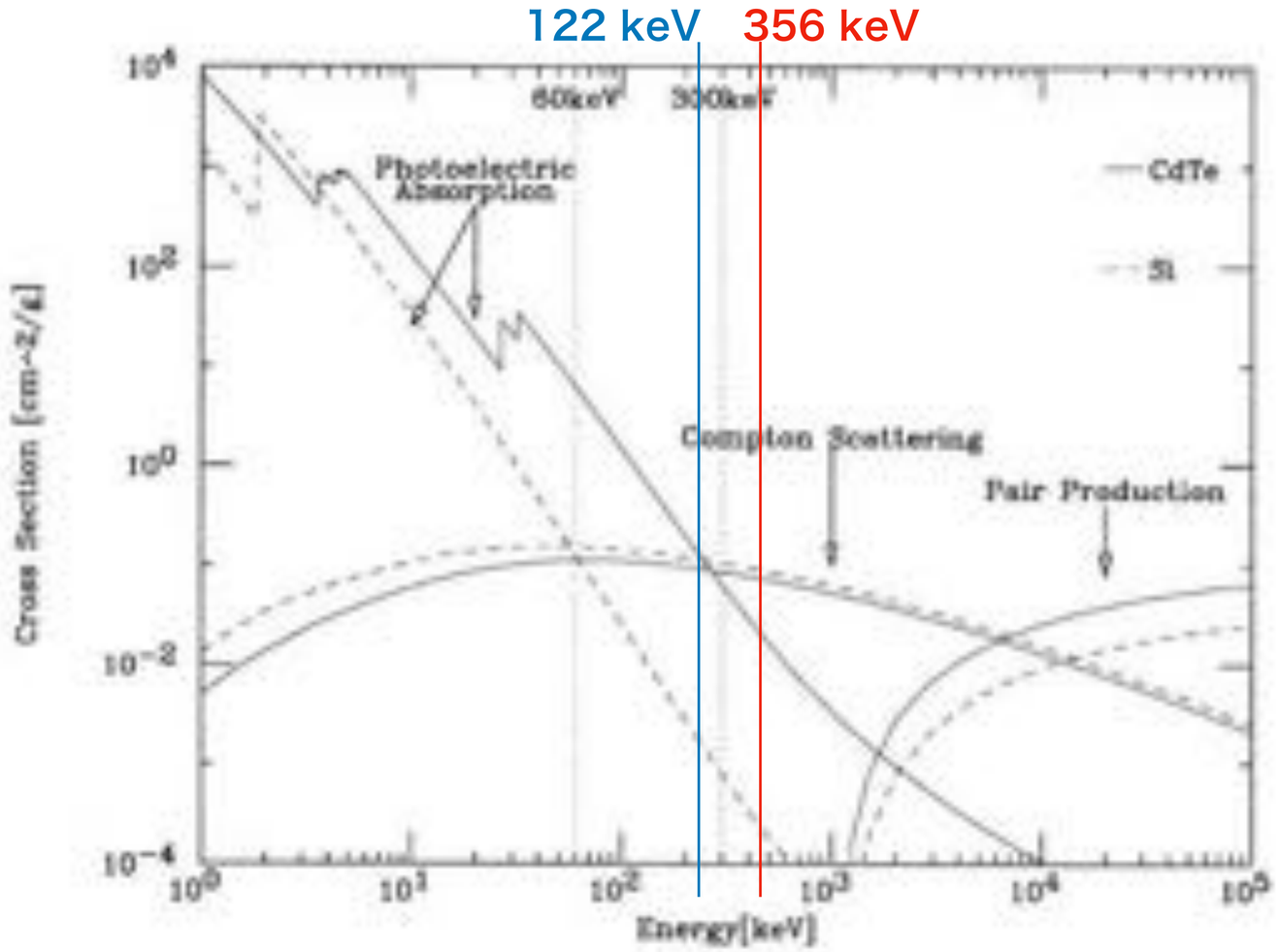
- Pedestal mean for all slabs, chips, channels



Measurement program

- MIP programs :
  - Position scan
  - Angle beam
  - TDC mode
  - Re-triggering / Double pedestal
- Shower programs :
  - TDC mode
  - Auto gain
  - Edge effect

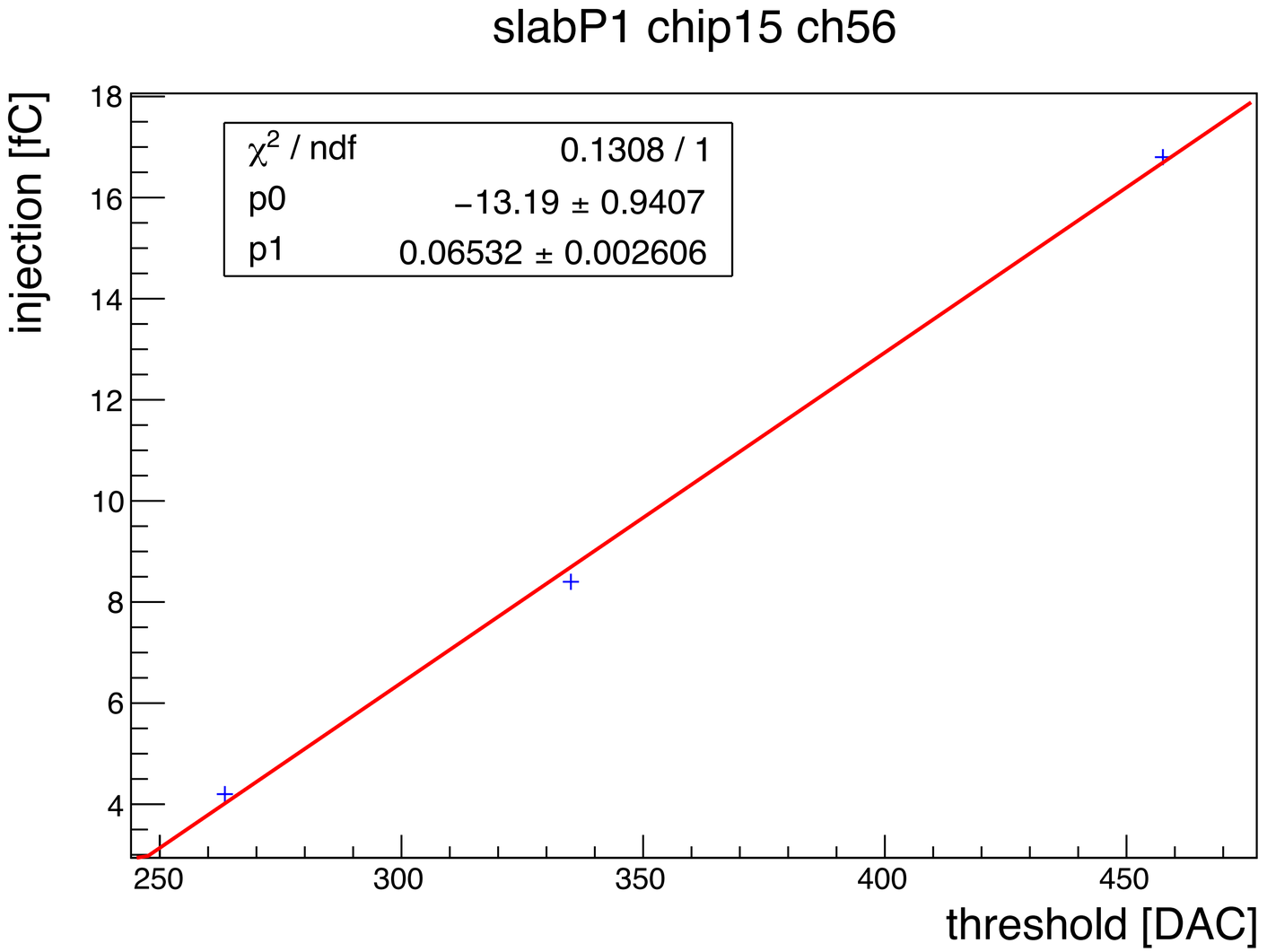
Laboratory Test (2)



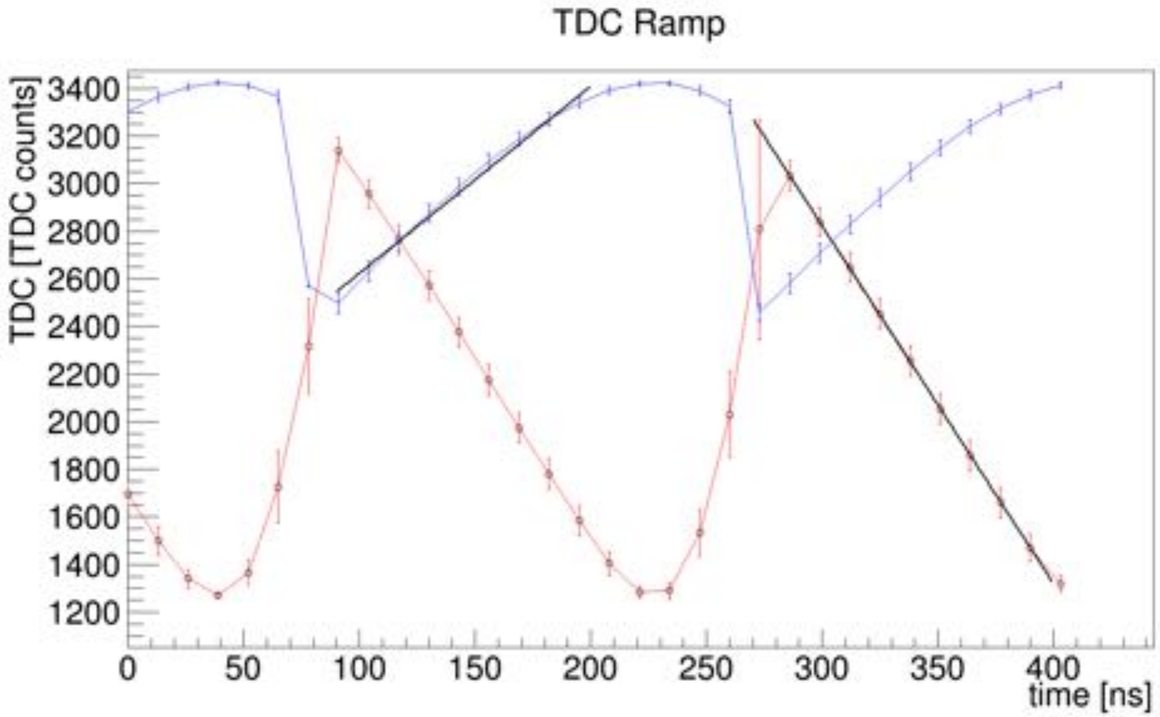
<引用>
修士論文「テルル化カドミウム（CdTe）半導体を用いた硬X線・ガンマ線撮像用ピクセル検出器の開発」
東京大学大学院理学系研究科物理学専攻
宇宙科学研究所高橋研究室
渡辺伸
2000 年1 月

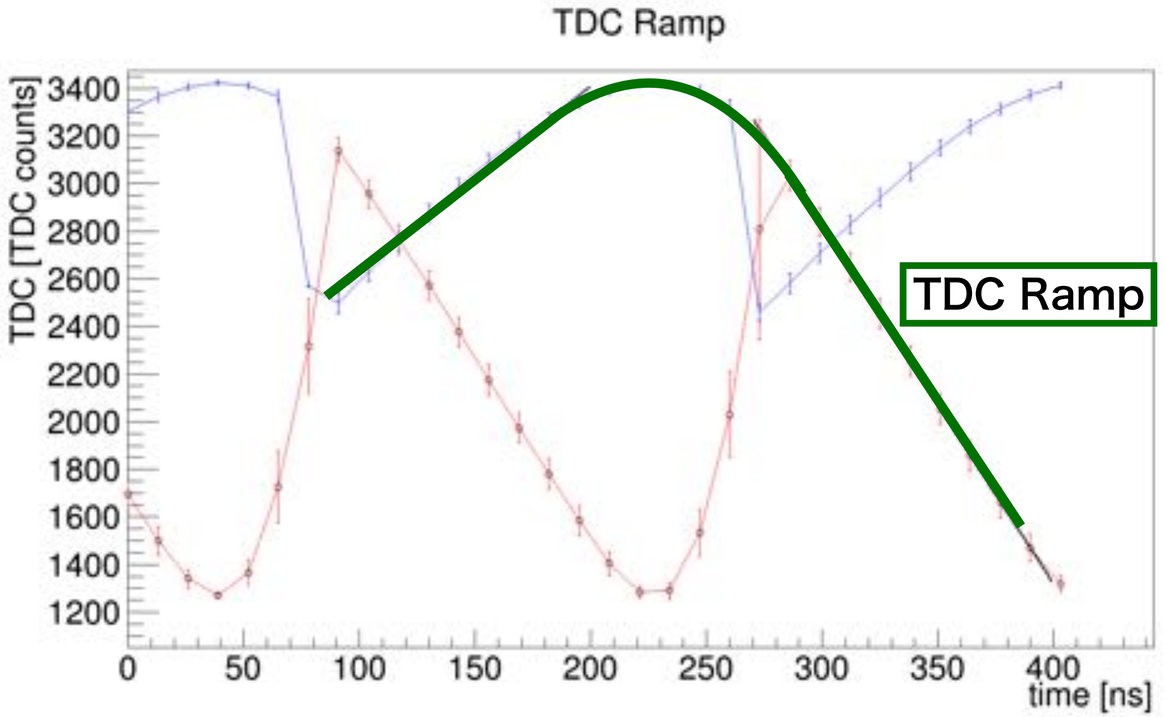
Laboratory Test (3)

- Linearity of threshold



Laboratory Test (4)





Update in this TB (1)

- Replace the carbon plate on the backside and cover
- New carbon plate :
  - cutting the edge of the HV connector side
  - pushing with screw
  - leakage current (imperfect insulation found)