SiW ECAL Beam test

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On behalf of the SiW ECAL group

Out Line

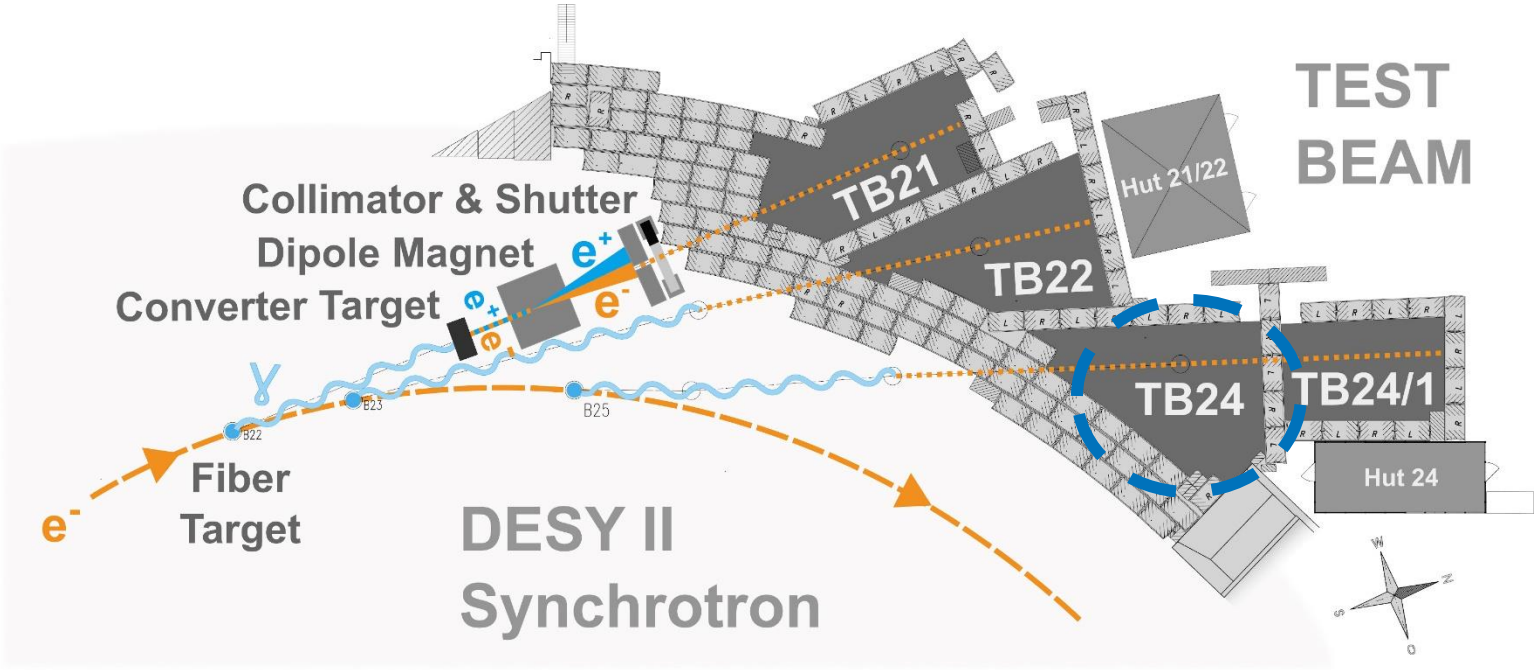
- Background
- Commissioning
- Position Scan
- TDC
- Summary and outlook

Beam test Overview

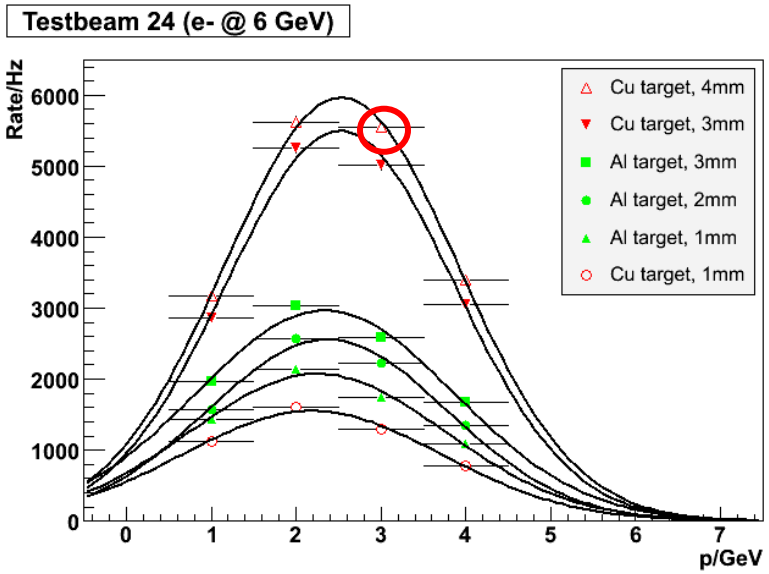
T24

- **Electron beam: MIP level test at 3 GeV**
- **Movable support:~0.1mm precision**

Movable support



Desy Beam hall



Energy vs rate for electron

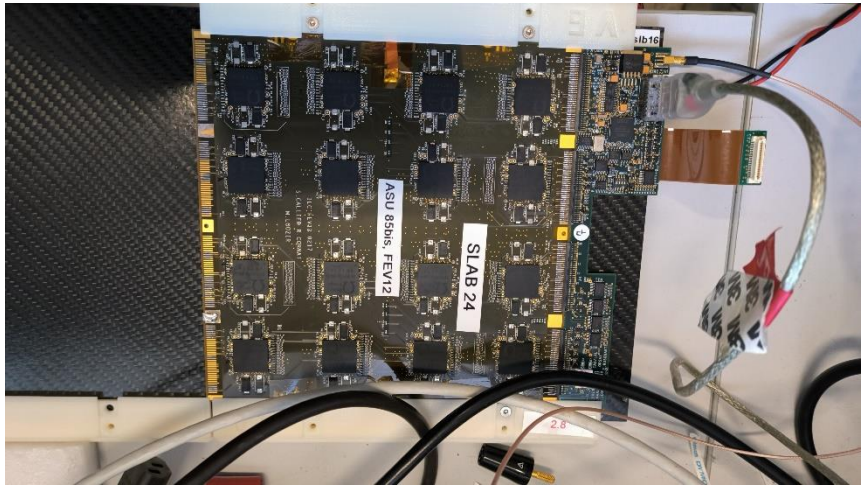
Test setup

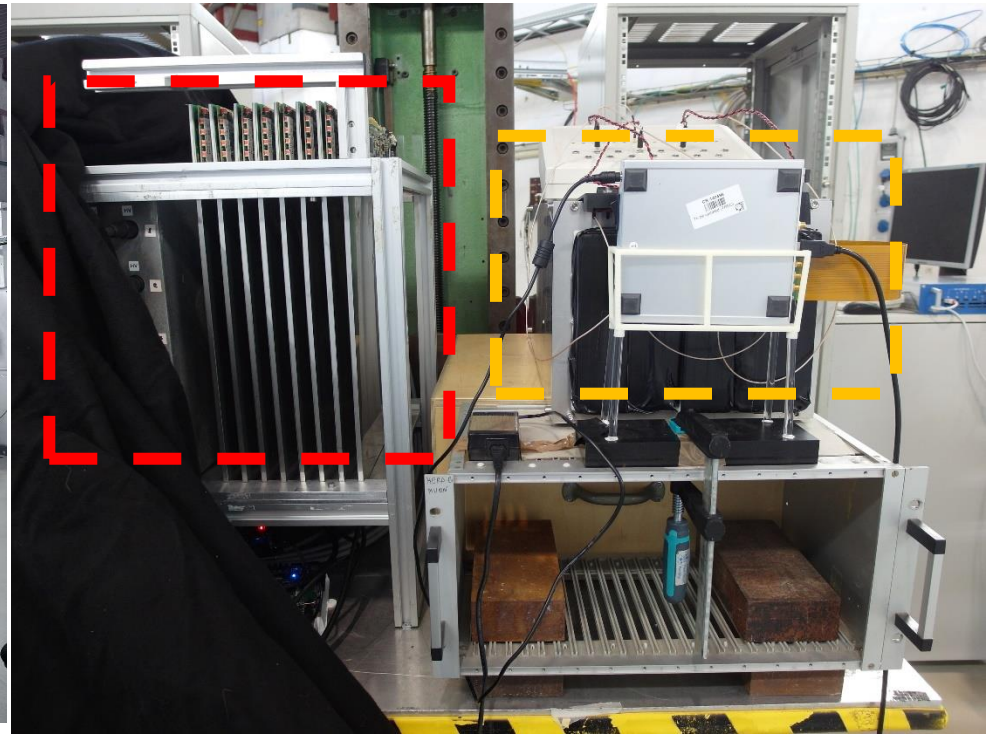
ECAL geometry

- 3 layers
  - 1 chip on board,2 produced recently
  - 16 SKIROC ships
  - 32×32 cells: $5.5 \times 5.5\ mm^2$
  - No absorbers

Data Taking

- ECAL:Mar 4th - Mar 6th
  - Configuration and calibration
  - Position scan
  - a blown fuse identified and replaced
- ECAL+HCAL: Mar 7th – Mar 8th
  - Configuration and calibration
  - Position scan
  - TDC test



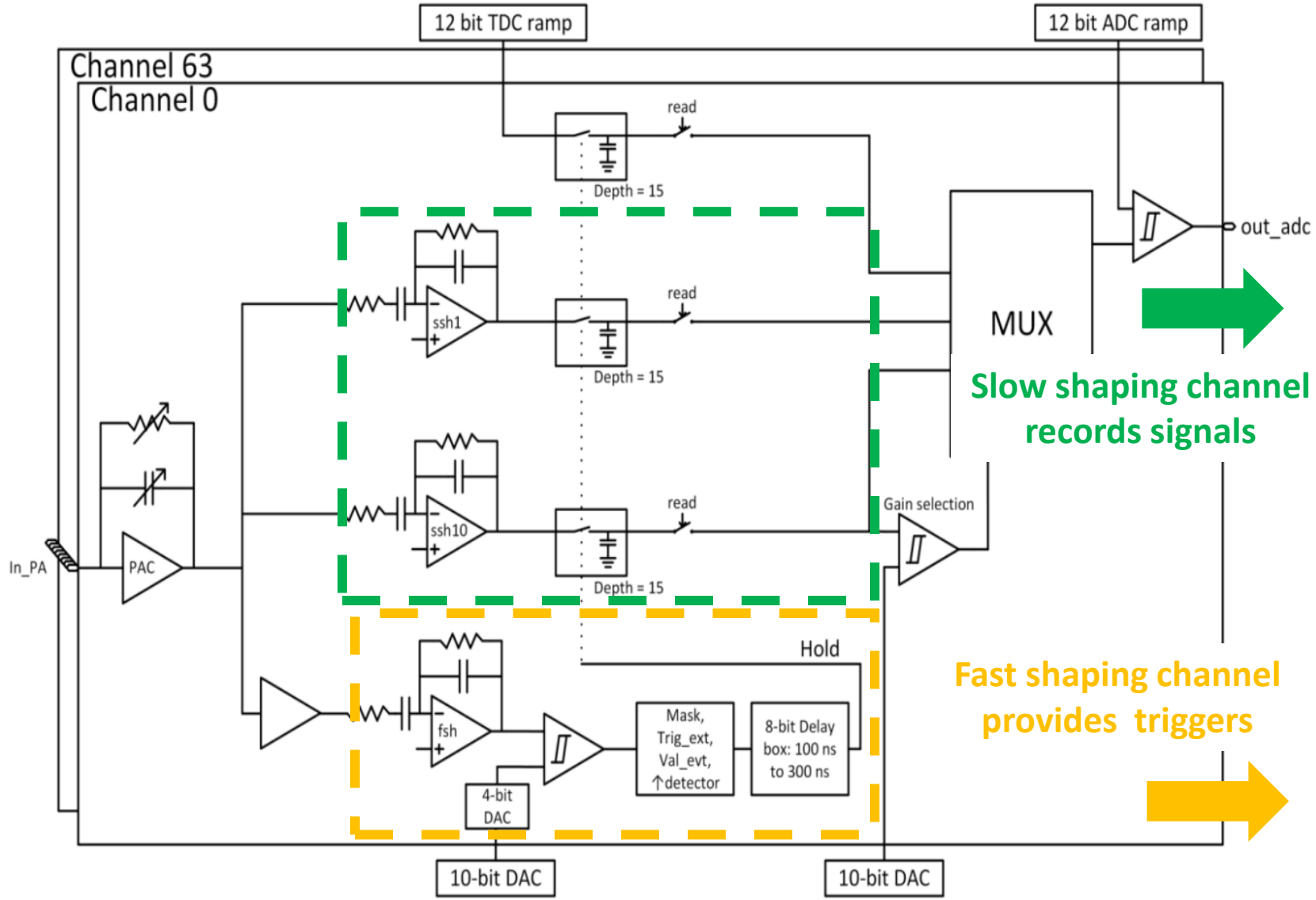


ECAL

ECAL+AHCAL

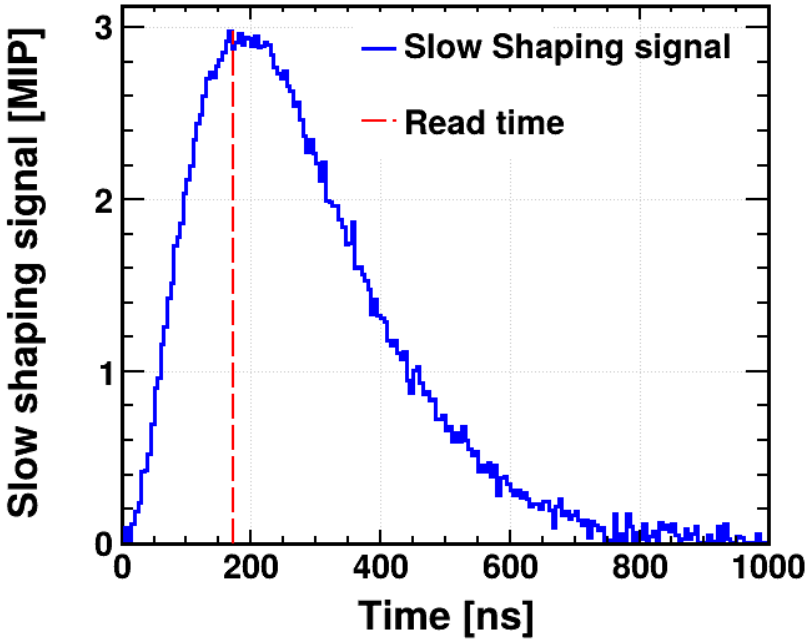
Beam

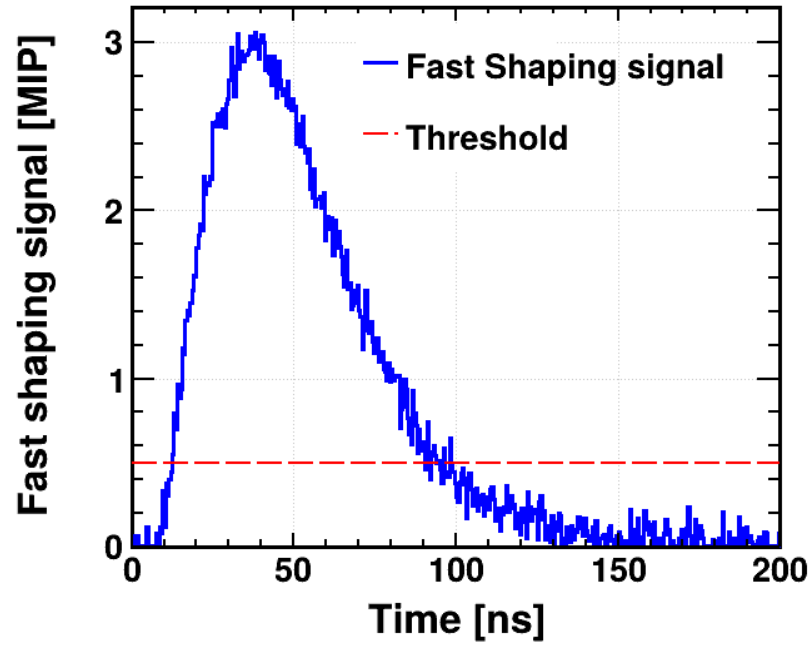
SKIROC chips



Slow shaping channel records signals

Fast shaping channel provides triggers





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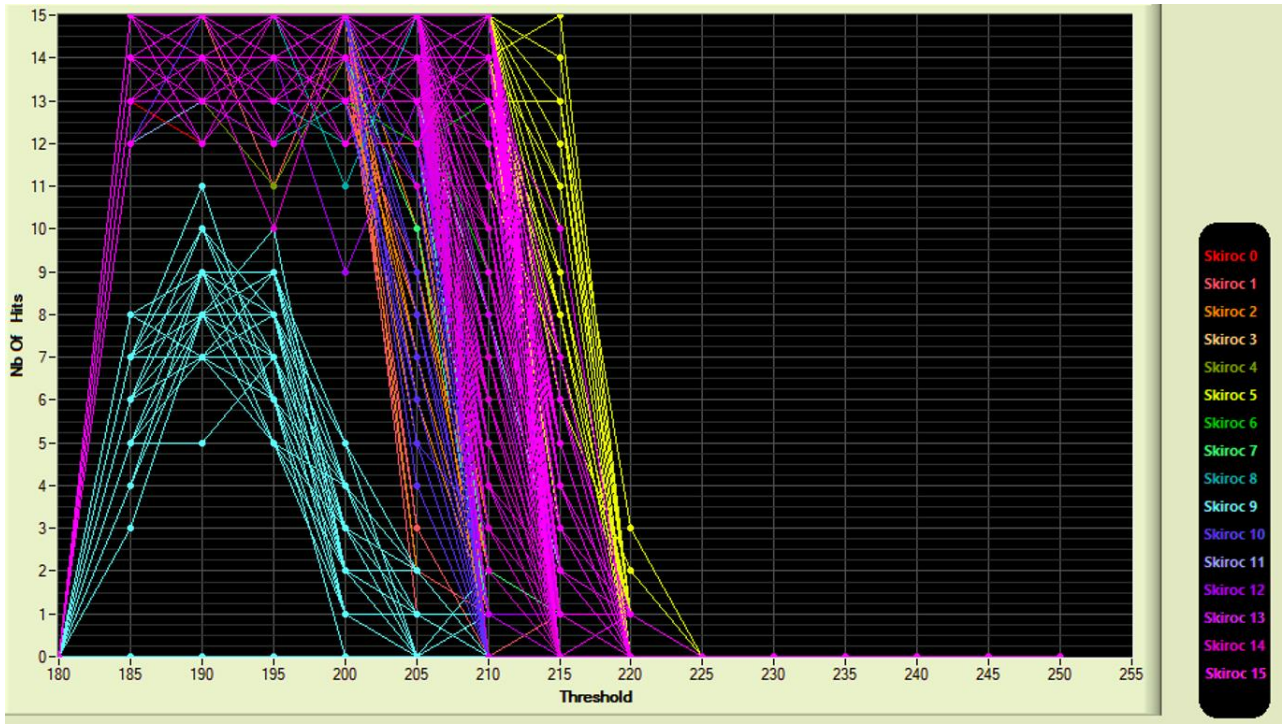
Commissioning

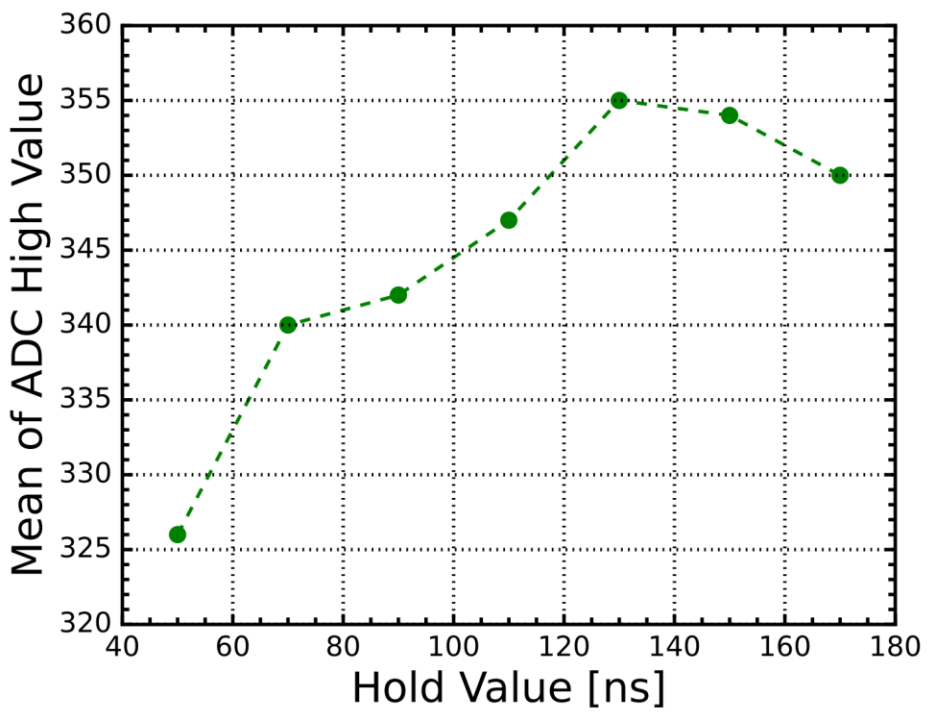
Threshold

- Scanning was processed separately for each channel without signal
- A threshold of **230 ADC** was applied during the beam test, with exceptions for certain chips in specific runs.



Hold value

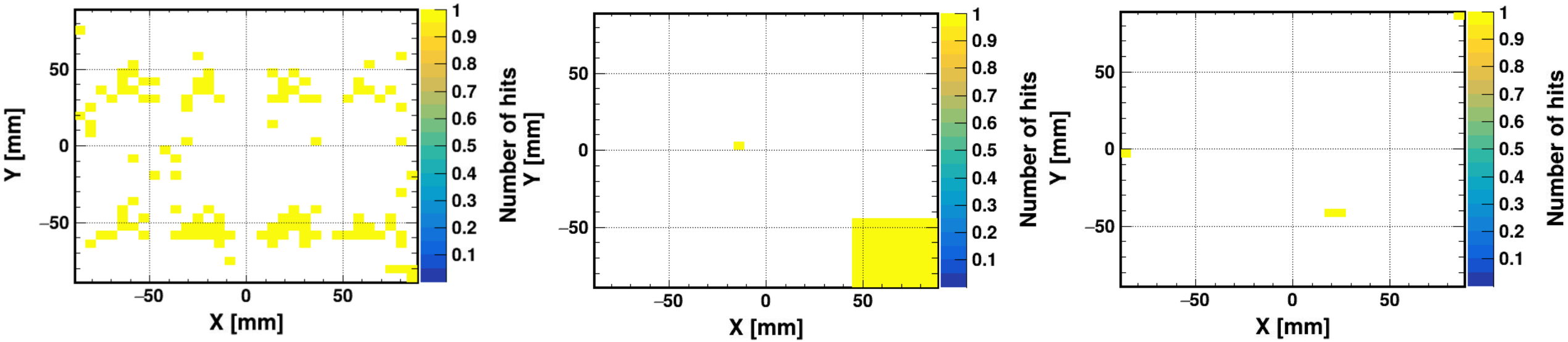
- Hold value was scanned with beam on
- The hold value was set up as **130 DAC**(1 DAC is approximately 1 ns)



Configuration optimization: Threshold(left) and hold value(right)

Masking

- Noisy channels were masked by a scanning program in a short time(5-10min)
- **Layer 8**: **114** channels were masked
- **Layer 11**: **65** channels were masked, including the whole **chip9**
- **Layer12**: **4** channels were masked



Map for masked channels, from left to right: layer 8, layer 11 and layer12

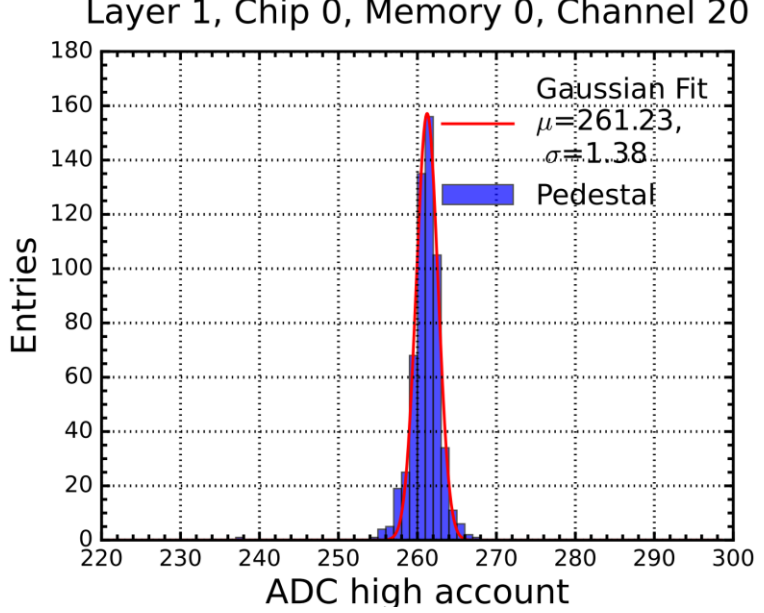
Pedestal

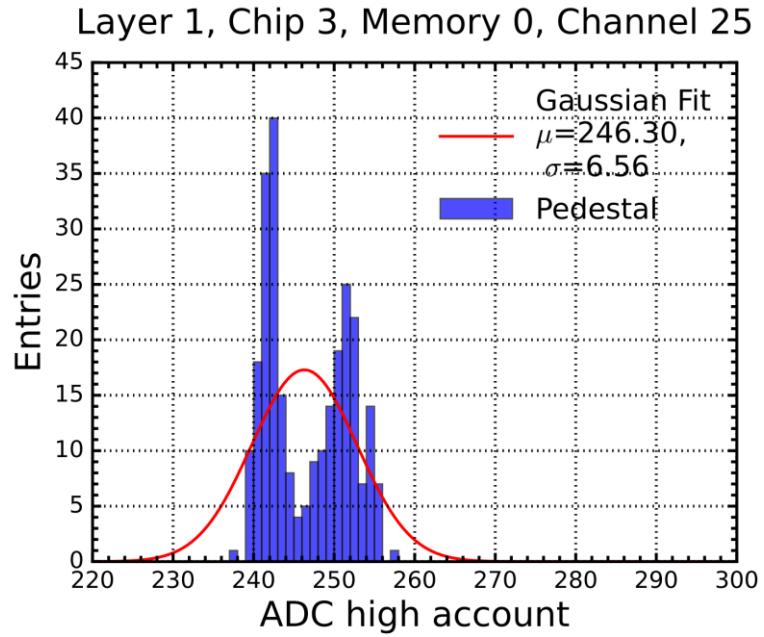
Data acquisition

- Select channels of which the hitbit=0
- Pedestal routine runs: self triggered by charge injection
- Data runs: the unhit channels

Analysis

- Normal channels: use gaussian fit to get the pedestal value and sigma
- Multi-peaks: caused by non-uniformity between different memory depth, crosstalk between channels, retriggering.
- Channels with a sigma > 4 are likely to have multi-peaks





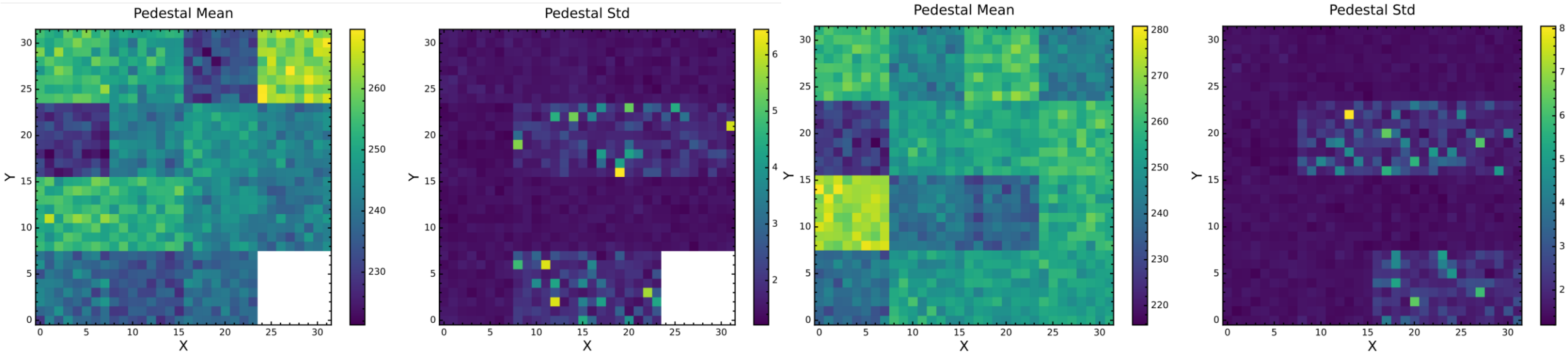
Pedestals from different channels

Pedestal Map

Differences on pedestals were observed among:

- **Chips**
- **Memory cells**
- **Pedestal routine runs and data taking runs**

Further investigation is required



Pedestals from different layers: layer11(left) and layer12(right)

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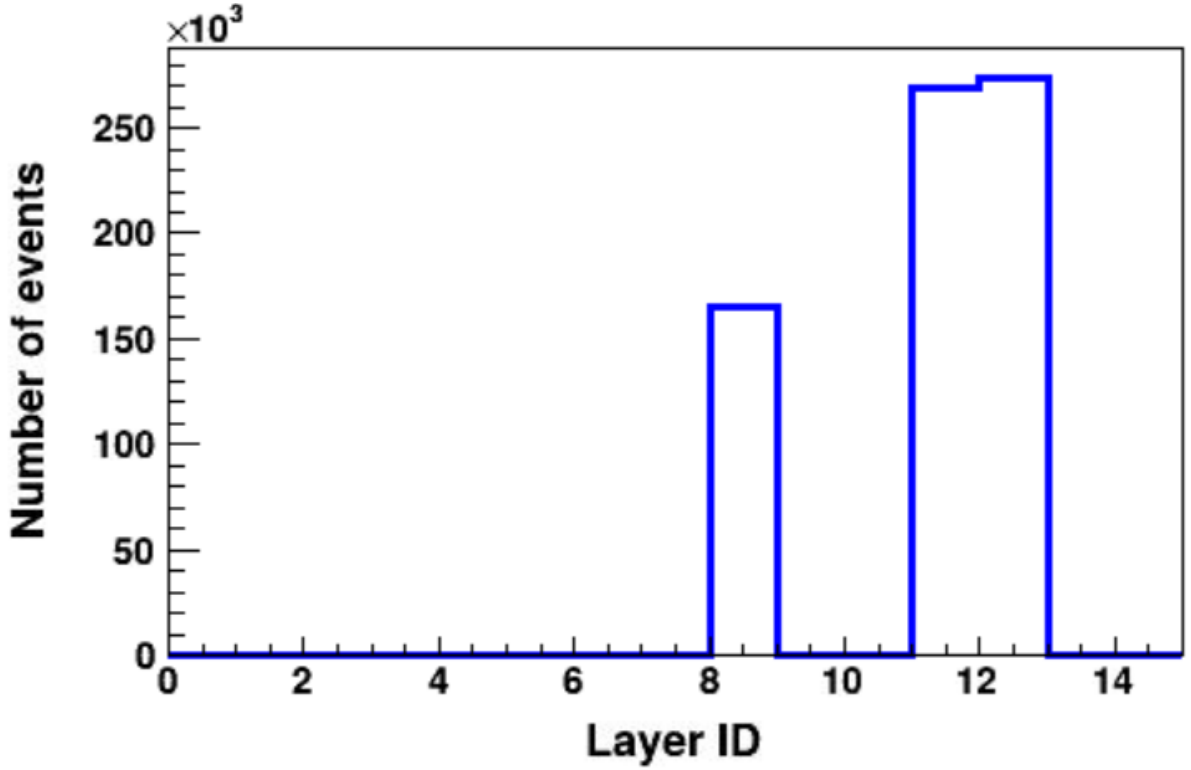
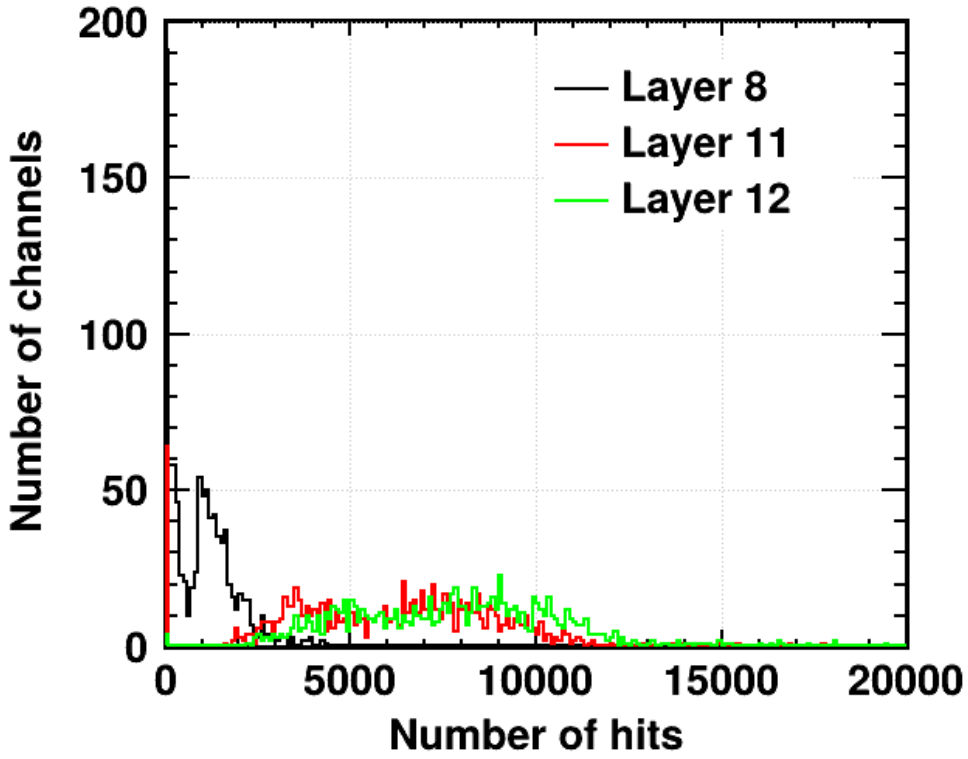
Position Scan

Statistics

- Layer 8 suffer from the masked channels
- Most channels in layer 11 and 12 have adequate statistics(>1000)



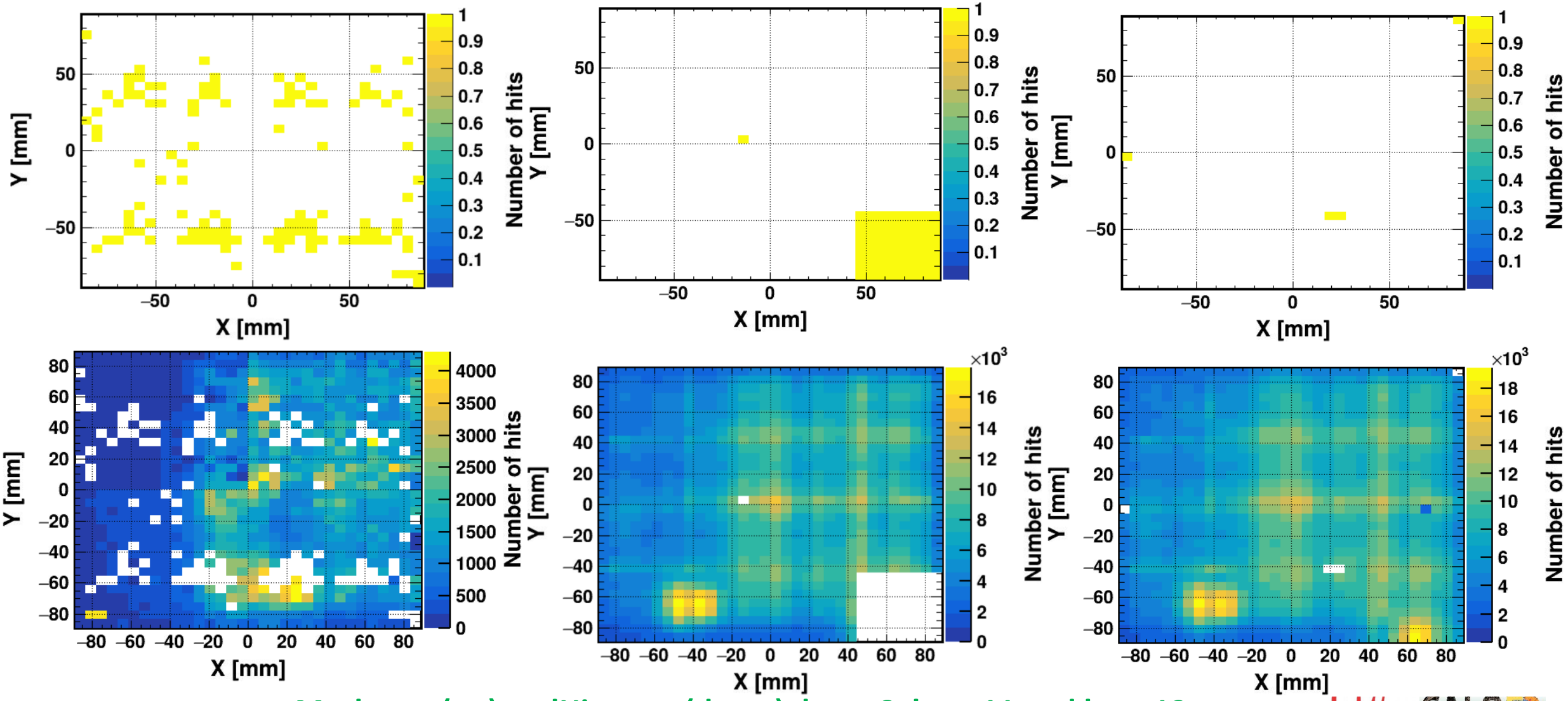
Event Number of layers



Statistics in each channel

Hit Map

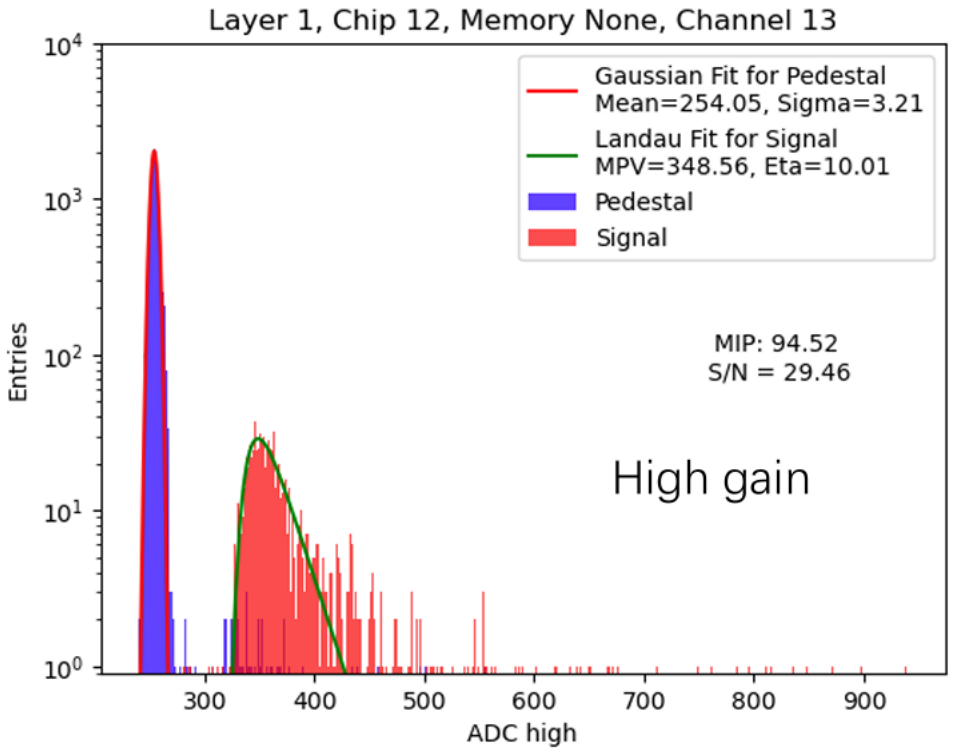
The hit maps are in consistency with the masking channels

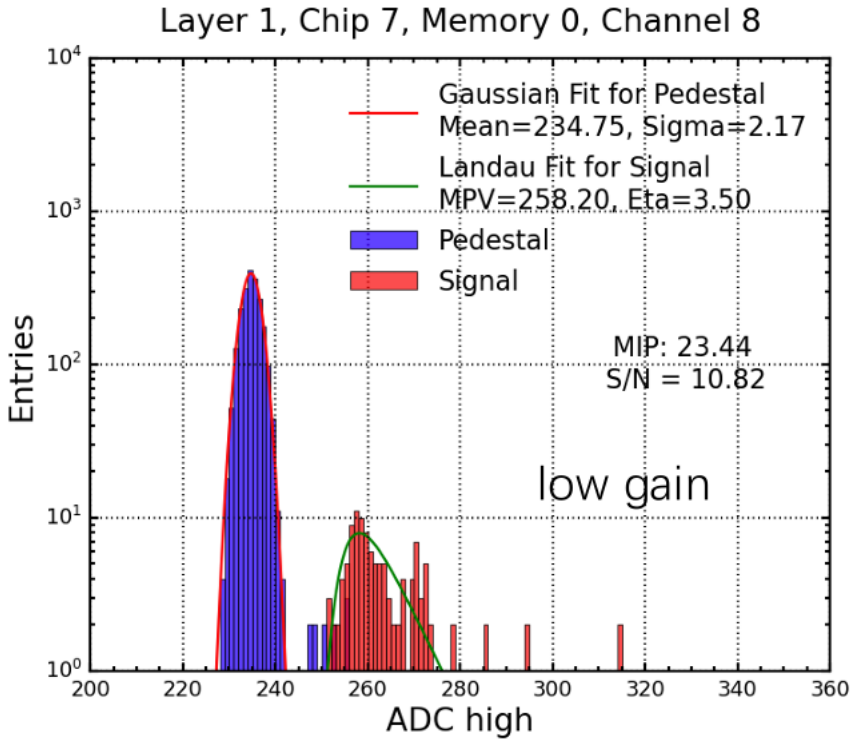


Mask map(up) andHit maps(down): layer 8, layer11 and layer12

Signal Noise Ratio(S/N)

- Pedestal is obtained by the beam data with hitbit=0
- High gain: MPV ~90 ADC(after pedestal extraction), S/N ~ 30
- Low gain: MPV~ 23 ADC, S/N~ 11





Single channel's S/N for high gain and low gain

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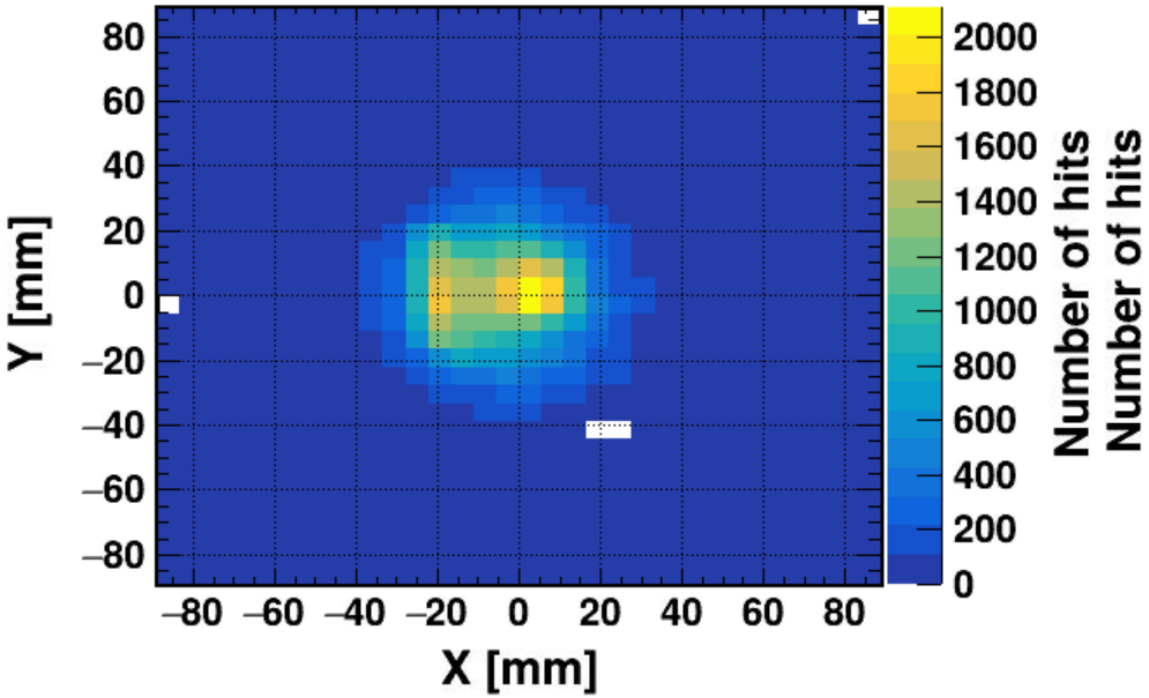
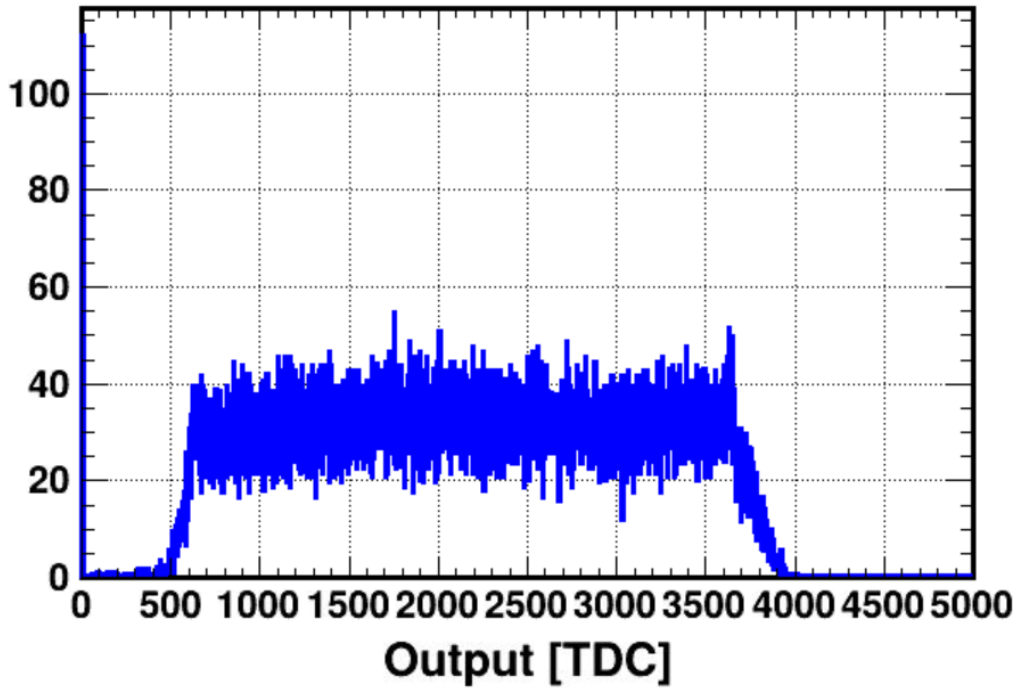
TDC

Configuration

- Autogain mode was activated, Beam aimed at center of the ECAL
- Different fast shaping times were tested across various runs
- 1 TDC is approximately 0.6 ns, needs further calibration



Hit Map of layer 12



TDC mode out put

Out Line

- Background
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Summary and Plan

- **Summary**
  - Two new ECAL layers, along with the COB layer, underwent two weeks of commissioning followed by a one-week beam test at DESY. The fundamental functionalities of these layers were successfully validated.
- **Plan**
  - More details on the pedestal, chip9 in layer11 and TDC should be further investigated
  - The time performance of the ECAL layers will be analyzed, modeled and integrated into ECAL simulation and reconstruction
  - A total of 15 new ECAL layers are planned, with a beam test at CERN scheduled for 2026

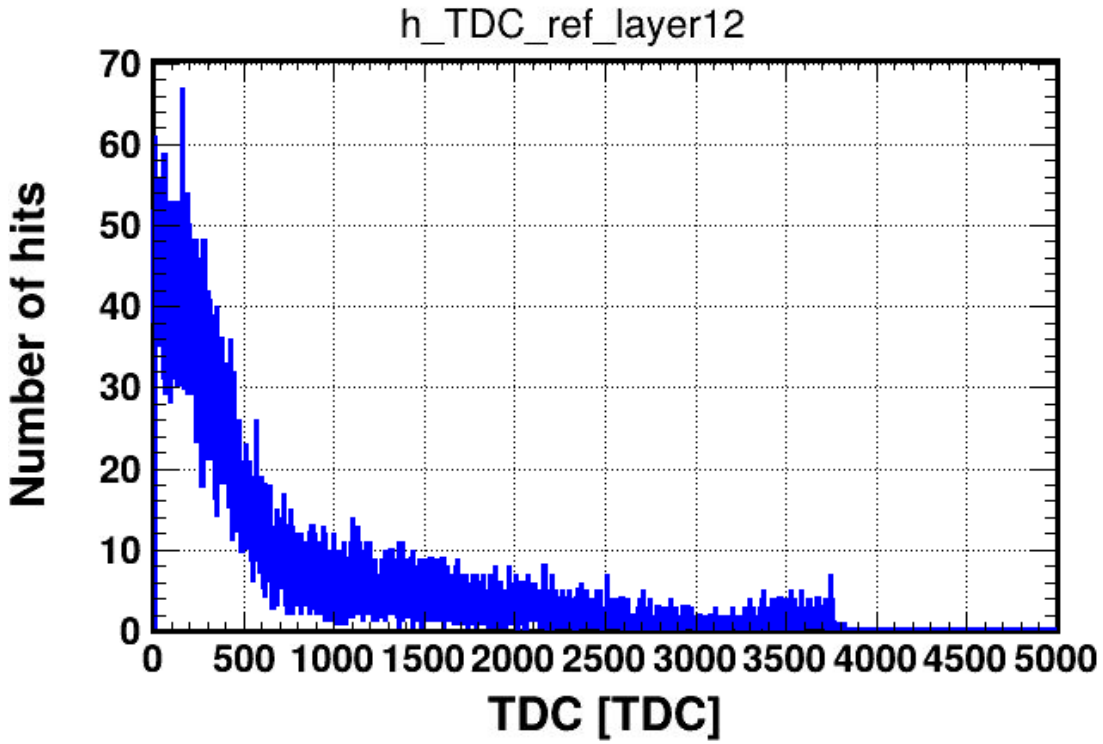
"The research leading to these results has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101057511."

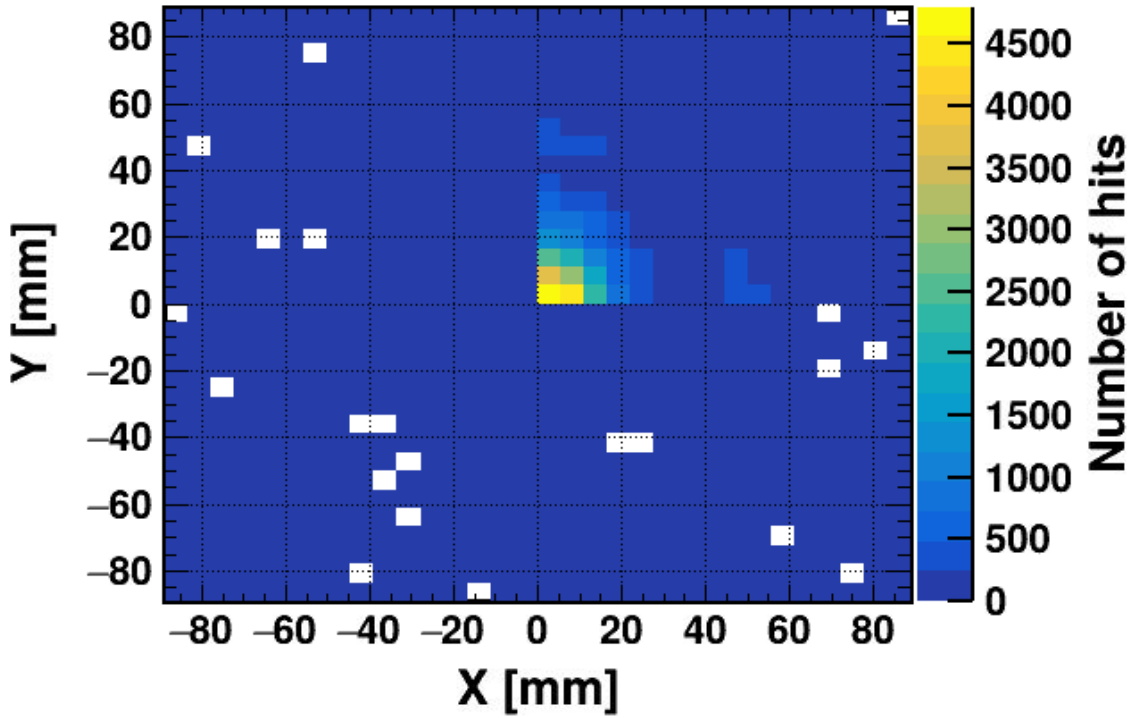
BACK UP

TDC

Event Selection

Hits position coincidence:
difference in X and Y should be less than 2 cell size(11 mm)
Layer 11 used as reference layer
The SNR of the trigger circuit is not obtained in the test beam data, plotted in this slide is the SNR for slow shaping channel





Run 90767

Shaping

Shaping signal function

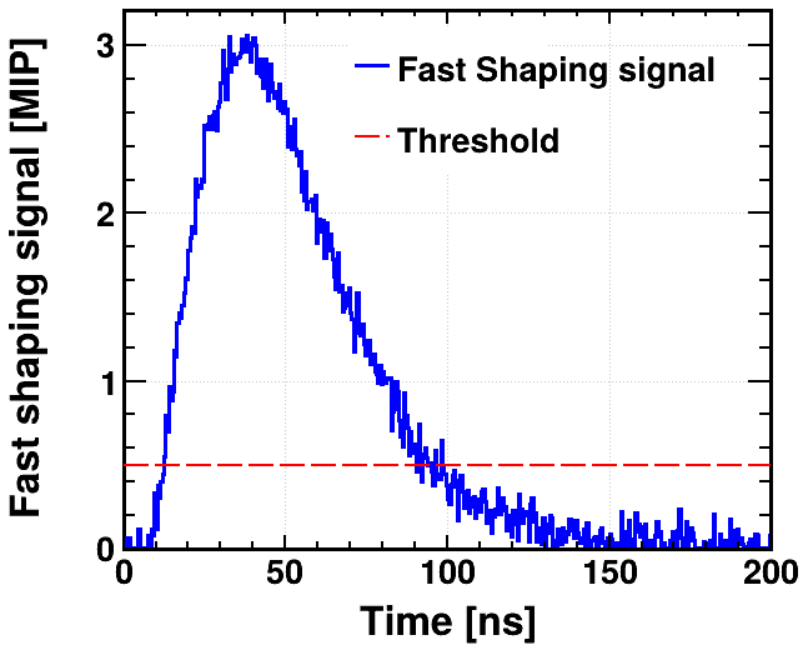
- $S(t) = \sum_i^{subhits} f_{scale} \frac{E_i \cdot T_i^n(t) \cdot e^{-T_i(t)}}{n!} \otimes gauss(0, noise)$
- f_{scale}=4
- $T_i(t) = (t - t_i^{hit})/\tau$
  - fast shaping:$\tau_{\mathrm{fast}} = 30$ ns
  - slow shaping:$\tau_{\mathrm{slow}} = 180$ ns

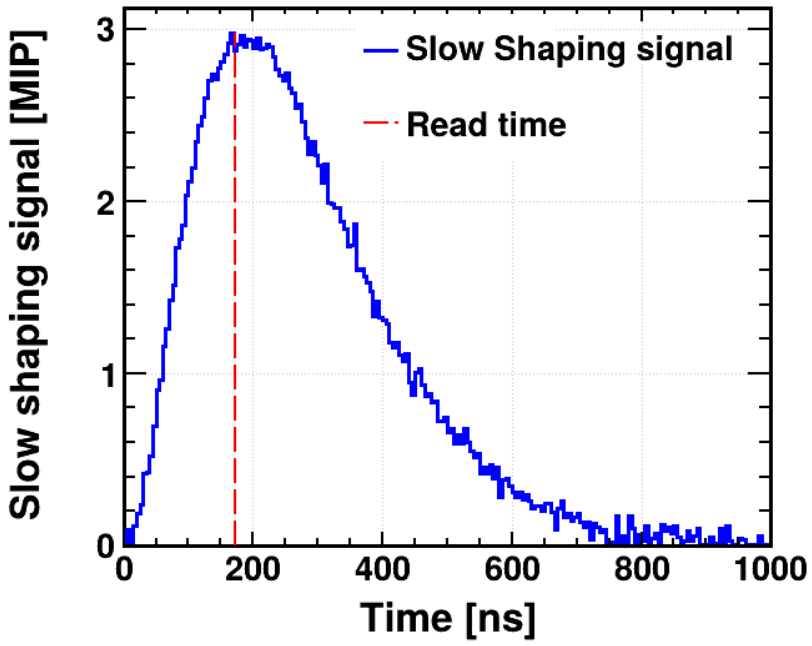
- Order of CR_RC filter
  - $\mathrm{n_{fast}} = 2$
  - $\mathrm{n_{slow}} = 2$
- Noise
  - Fast: 1/12 MIP
  - Slow: 0.05 MIP

Digi Hit

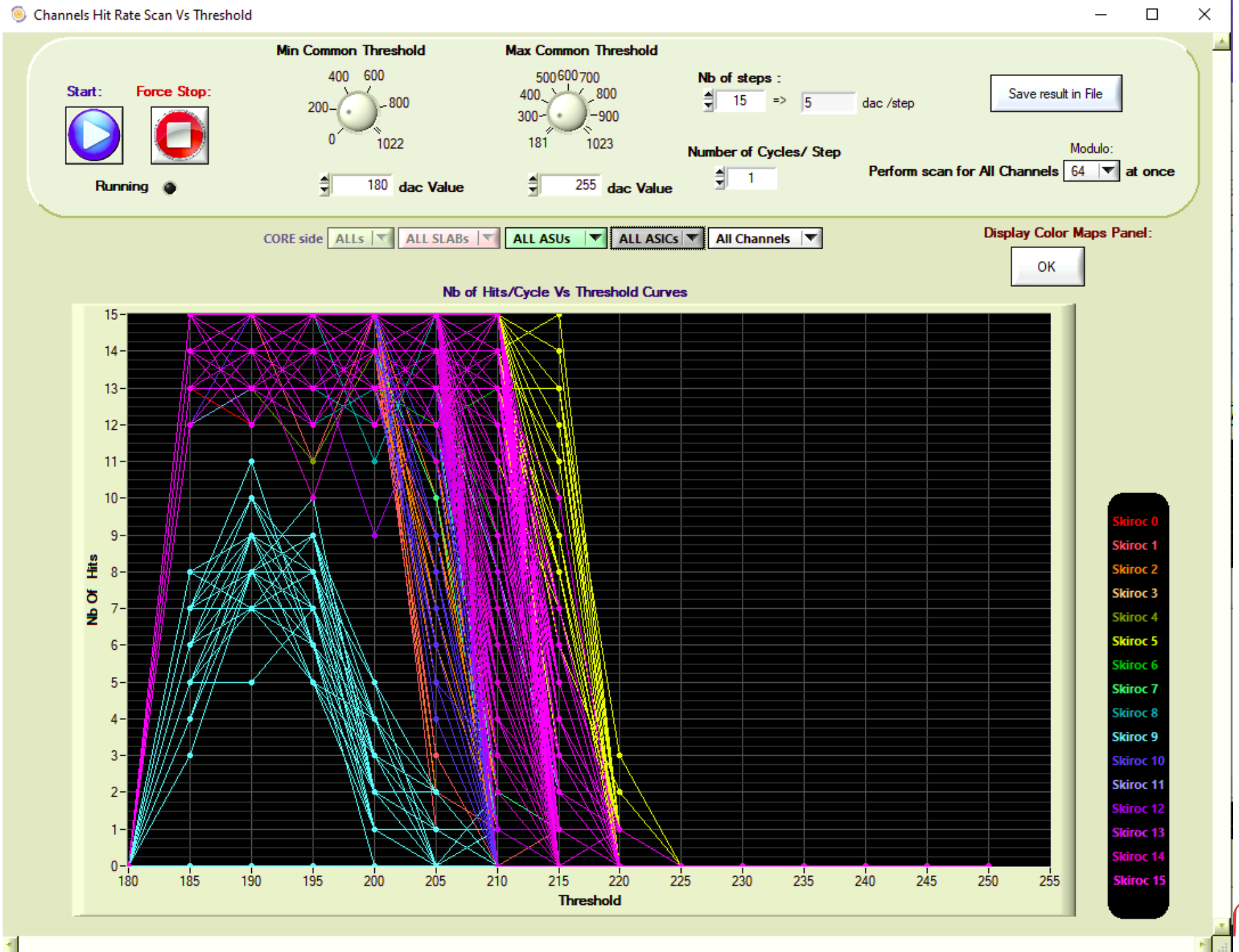
- t_{Digi}: the time when $S_{fast}(t_{Digi}) > 0.5\mathrm{MIP}$
- Energy: Slow shaping signal after delay $S_{slow}(t_{Digi} + t_{delay})$
- delay time: 160ns

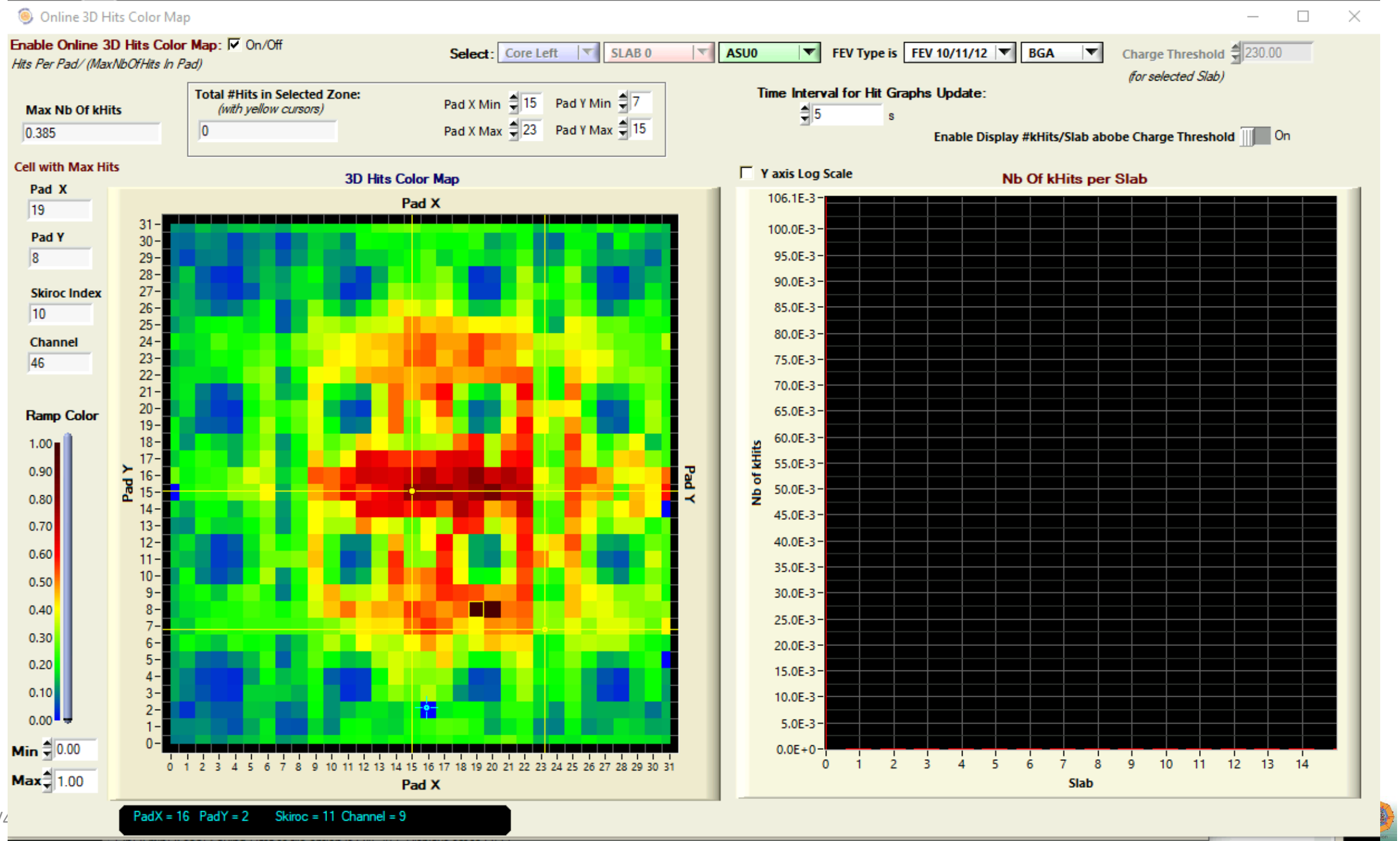
Validation of this model? Beam test at DESY in March this year





Digitization for Fast shaping(left) and slow shaping(right)


Channels Hit Rate Scan Vs Threshold
Min Common Threshold
Max Common Threshold
Start:
Force Stop:
Running
180 dac Value
255 dac Value
Nb of steps :
15 => 5 dac /step
Save result in File
Number of Cycles/ Step
1
Modulo:
Perform scan for All Channels 64 at once
CORE side
ALLs
ALL SLABs
ALL ASUs
ALL ASICs
All Channels
Display Color Maps Panel:
OK
Nb of Hits/Cycle Vs Threshold Curves
Nb Of Hits
Threshold
Skiroc 0
Skiroc 1
Skiroc 2
Skiroc 3
Skiroc 4
Skiroc 5
Skiroc 6
Skiroc 7
Skiroc 8
Skiroc 9
Skiroc 10
Skiroc 11
Skiroc 12
Skiroc 13
Skiroc 14
Skiroc 15


Online 3D Hits Color Map
Enable Online 3D Hits Color Map: On/Off
Hits Per Pad/ (MaxNbOfHits In Pad)
Select: Core Left SLAB 0 ASU0
FEV Type is FEV 10/11/12 BGA
Charge Threshold 230.00
(for selected Slab)
Max Nb Of kHits
0.385
Total #Hits in Selected Zone:
(with yellow cursors)
0
Pad X Min 15
Pad X Max 23
Pad Y Min 7
Pad Y Max 15
Time Interval for Hit Graphs Update:
5 s
Enable Display #kHits/Slab abobe Charge Threshold On
Cell with Max Hits
Pad X 19
Pad Y 8
Skiroc Index 10
Channel 46
Ramp Color
1.00 0.90 0.80 0.70 0.60 0.50 0.40 0.30 0.20 0.10 0.00
Min 0.00
Max 1.00
3D Hits Color Map
Pad X
Pad Y
Y axis Log Scale
Nb Of kHits per Slab
Nb of kHits
Slab
PadX = 16 PadY = 2 Skiroc = 11 Channel = 9

Event Selection

- Bcid=0 to exclude empty events and retriggering events

Decoding

Data profile

- Binary√
  - Run:090560-090650
  - DecodedVictor code:eudaq = false
    - package ends with 0xEEEEEEEE
- ASCII(.dat)
  - Run:090651-090704
  - No decoding algorithm
- **Raw√**
  - Run:090560-090768
  - All Test Beam runs
  - DecodedVictor code:eudaq = true
    - package starts with 0xABCD
- Slcio
  - Run:090557-090768
  - Some cosmic runs are included
  - No decoding algorithm

Difference between Data profiles

- Binary vs Raw
  - They were exactly the same except the layer ID
  - Binary:0,1,2
  - Raw:8,11,12

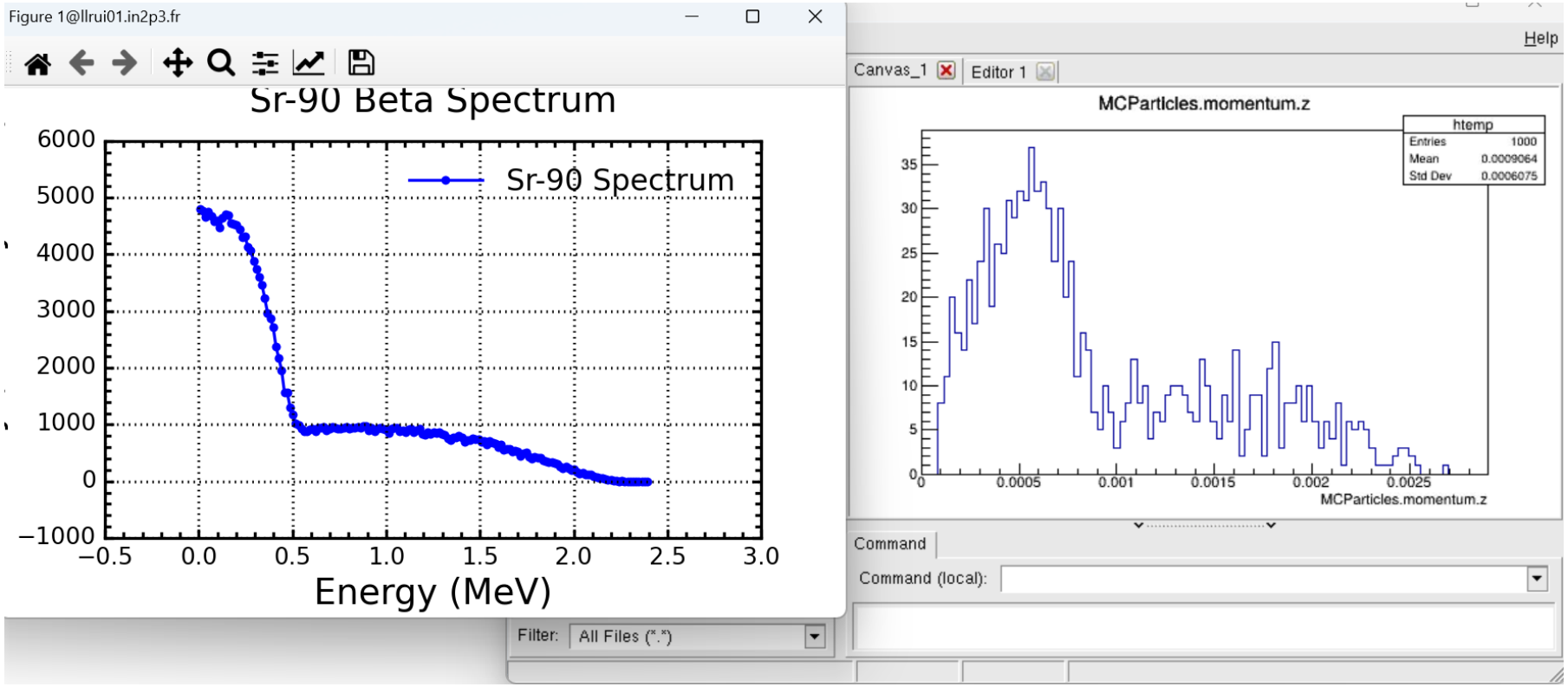
2 Proposals

- Use the rootfiles converted from raw files for future analysis
- Make a datalist for all beam data with description for runs, like pedestal, position scan, etc.

Sr90 Setup

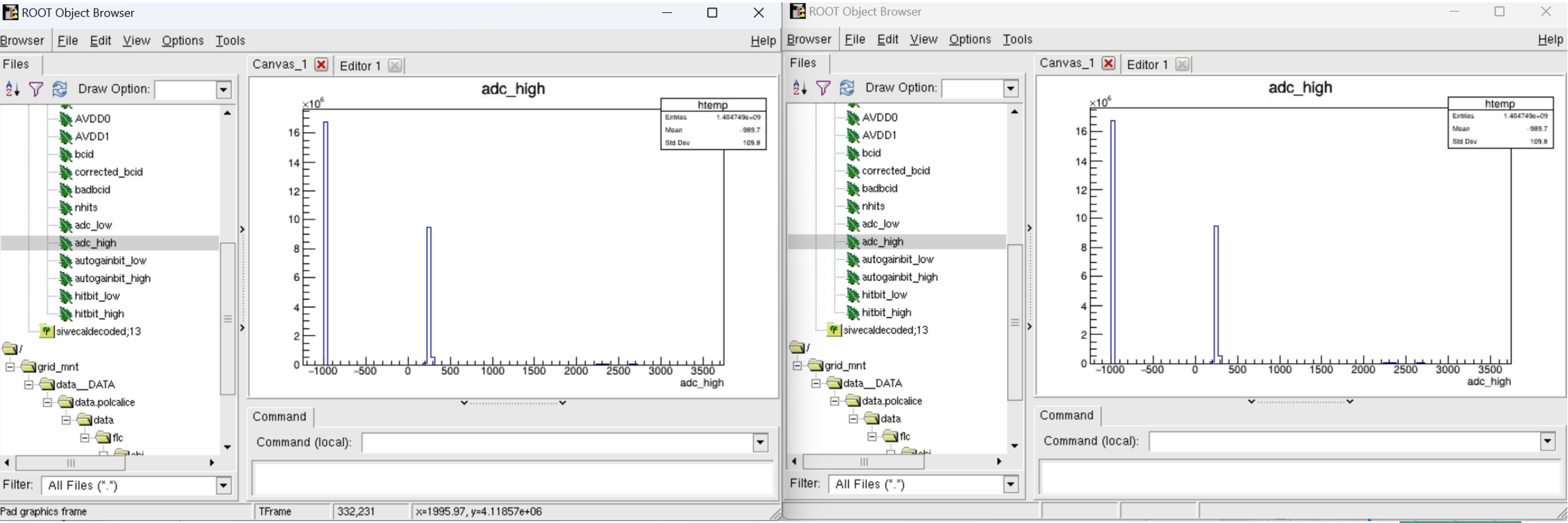
Left: draw from the Sr90 input file

Right: MC Pz, /gps/direction 0 0 1



Different ways to convert root files

- .bin-> root
- .raw->root



- They are exactly the same
  - using run90623
  - Layer id is different for .bin & .raw

```
0 1 9 0 0 different adc_high -999 247
0 1 9 0 1 different adc_high -999 235
0 1 9 0 2 different adc_high -999 232
0 1 9 0 3 different adc_high -999 263
0 1 9 0 4 different adc_high -999 240
0 1 9 0 5 different adc_high -999 246
0 1 9 0 6 different adc_high -999 250
0 1 9 0 7 different adc_high -999 236
0 1 9 0 8 different adc_high -999 254
0 1 9 0 9 different adc_high -999 249
0 1 9 0 10 different adc_high -999 245
0 1 9 0 11 different adc_high -999 237
0 1 9 0 12 different adc_high -999 228
0 1 9 0 13 different adc_high -999 255
0 1 9 0 14 different adc_high -999 256
0 1 9 0 15 different adc_high -999 250
0 1 9 0 16 different adc_high -999 253
0 1 9 0 17 different adc_high -999 2351
0 1 9 0 18 different adc_high -999 217
0 1 9 0 19 different adc_high -999 249
0 1 9 0 20 different adc_high -999 248
0 1 9 0 21 different adc_high -999 257
0 1 9 0 22 different adc_high -999 237
0 1 9 0 23 different adc_high -999 244
0 1 9 0 24 different adc_high -999 238
0 1 9 0 25 different adc_high -999 254
```

```
0 11 9 0 0 different adc_high 247 -999
0 11 9 0 1 different adc_high 235 -999
0 11 9 0 2 different adc_high 232 -999
0 11 9 0 3 different adc_high 263 -999
0 11 9 0 4 different adc_high 240 -999
0 11 9 0 5 different adc_high 246 -999
0 11 9 0 6 different adc_high 250 -999
0 11 9 0 7 different adc_high 236 -999
0 11 9 0 8 different adc_high 254 -999
0 11 9 0 9 different adc_high 249 -999
0 11 9 0 10 different adc_high 245 -999
0 11 9 0 11 different adc_high 237 -999
0 11 9 0 12 different adc_high 228 -999
0 11 9 0 13 different adc_high 255 -999
0 11 9 0 14 different adc_high 256 -999
0 11 9 0 15 different adc_high 250 -999
0 11 9 0 16 different adc_high 253 -999
0 11 9 0 17 different adc_high 2351 -99
0 11 9 0 18 different adc_high 217 -999
0 11 9 0 19 different adc_high 249 -999
0 11 9 0 20 different adc_high 248 -999
0 11 9 0 21 different adc_high 257 -999
0 11 9 0 22 different adc_high 237 -999
0 11 9 0 23 different adc_high 244 -999
0 11 9 0 24 different adc_high 238 -999
0 11 9 0 25 different adc_high 254 -999
0 11 9 0 26 different adc_high 227 -999
0 11 9 0 27 different adc_high 248 -999
0 11 9 0 28 different adc_high 236 -999
```

Position Scan

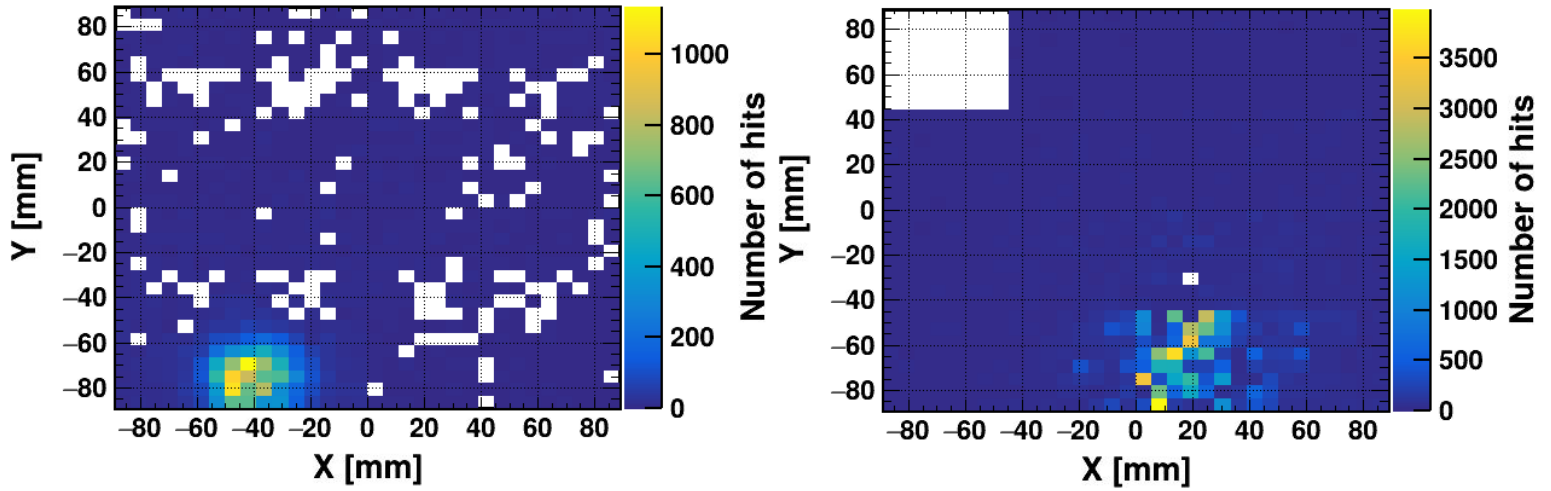
Data profile

- ECAL alone
  - 90623 – 90646
  - 90651- 90704
- ECAL+AHCAL
  - 90722-90725

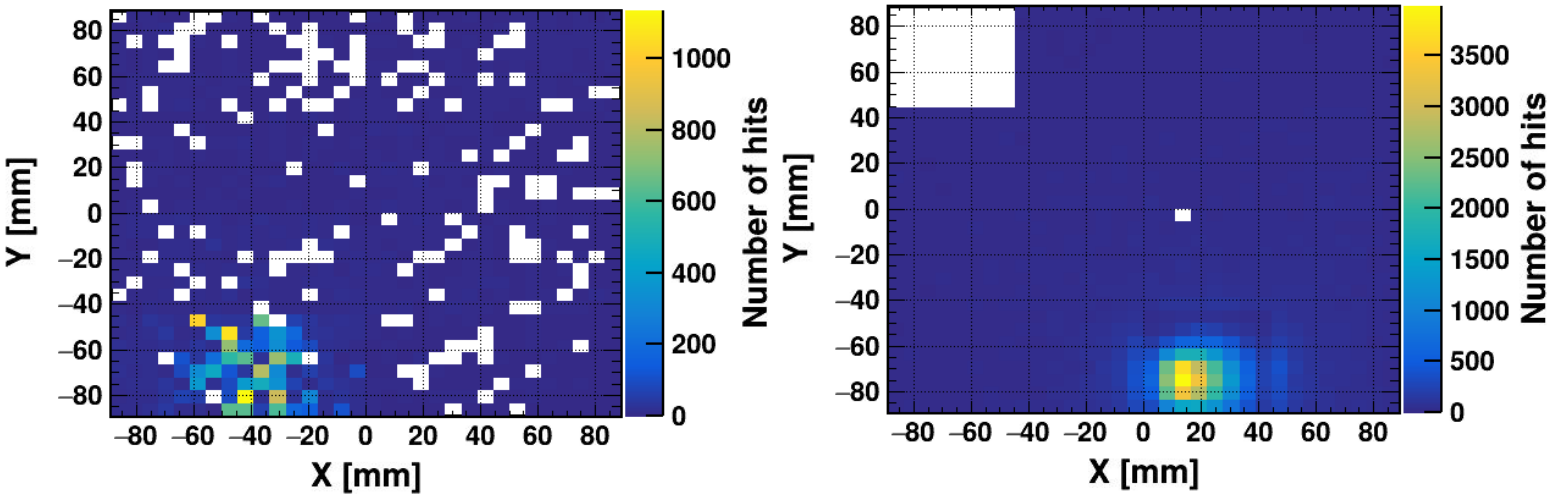
Mapping

- `fev11_cob_rotate_chip_channel_x_y_mapping.txt` matches layer 8
- `fev10_chip_channel_x_y_mapping.txt` matches layer 11 & 12
- The hit map is consistent with the one on Elog with proper mapping file

Hit Map of run 090660



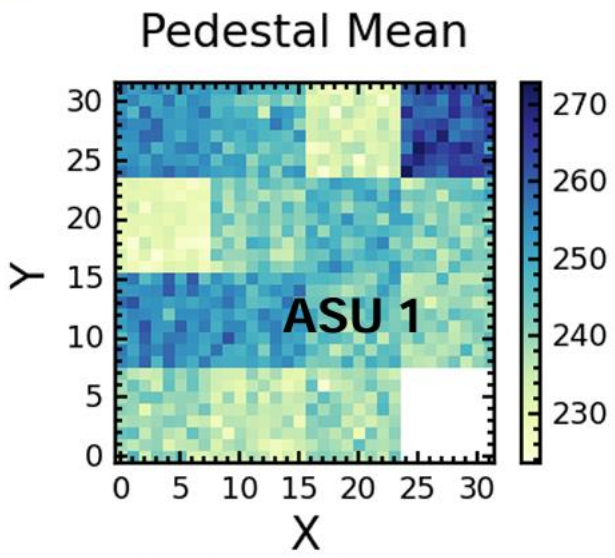
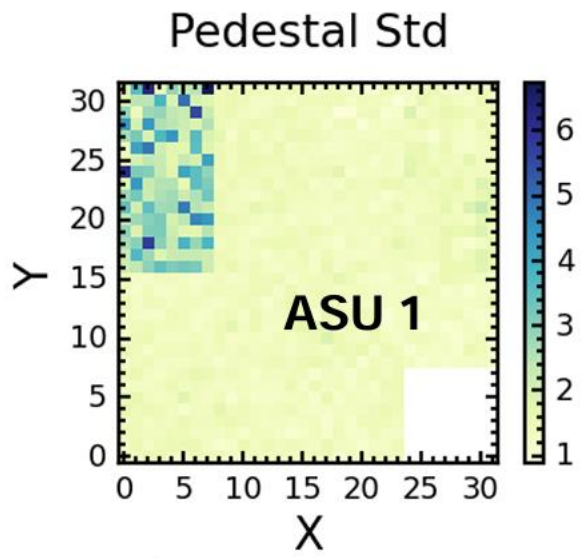
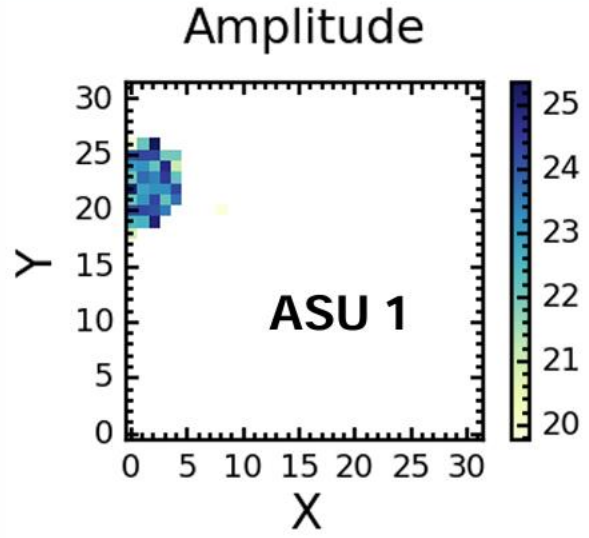
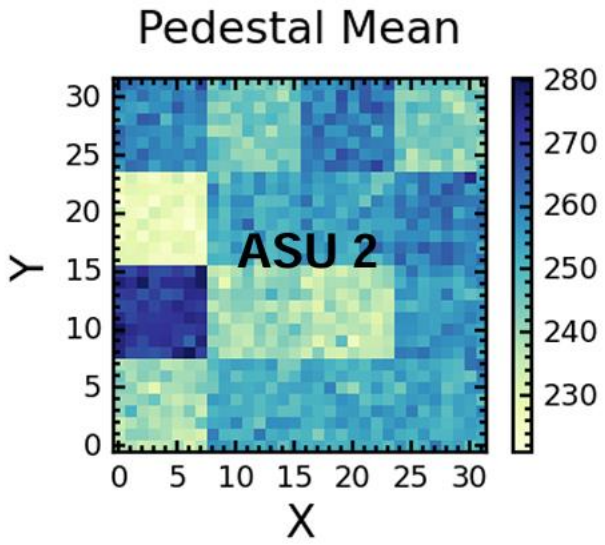
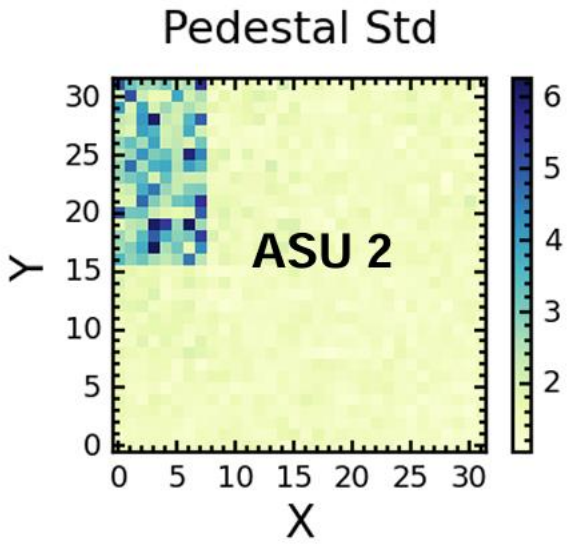
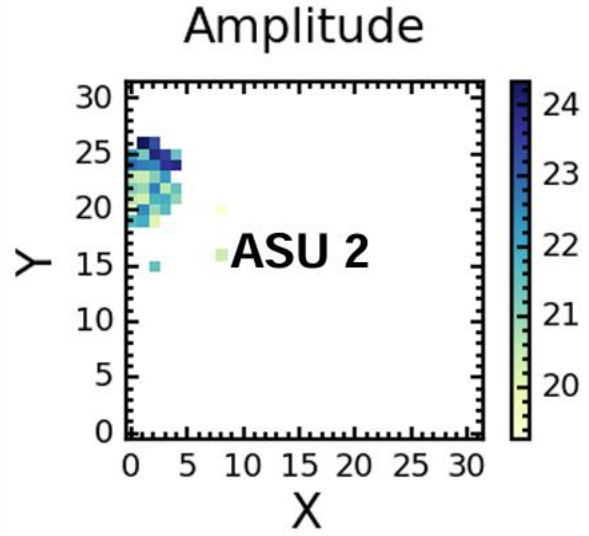
Fev11_cob_rotate: layer8(left) and layer11(right)



Fev10: layer8(left) and layer11(right)

Datalist TDC

Run Number	Hits	Fast Shaper	Delay	Comments
90748	~1M	90 ns	150 ns	AutoGain- Force Low Gain; shooting in ASIC 0 Seemingly flat TDC dsitribution in ASIC 0~1M
90749	~1M	30 ns	90 ns	Much narrower distribution from 1200--2000 in ASIC 0 "High Gain" see attachement 6; **NO TDC**
90750	50000	60 ns	90 ns	**no TDC.**
90751		90 ns	150 ns	idem 90748. Configuarion is back to non-TDC ?
90760		90 ns	130 ns	
90761	1142189	90 ns	150 ns	
90762	Failed			
90763	small test	90 ns	150 ns	ALL ASICs
90764, 90765	Large !			At center of the the ECAL; All TDC, 90 ns, 130 ns
90766, 90767	2 x 1.15M	30 ns	150 ns	Distributions seems OK (beam spot, TDC).
90768, 90769				Final Pedestal runs

MIP map and pedestal map of position scan run

- Data: Run_number = "090623 which is position scan run.
- Different pedestal map with pedestal run. First study, Need further study.
- MIP ≈ 24