Update on EICROC0 Testing
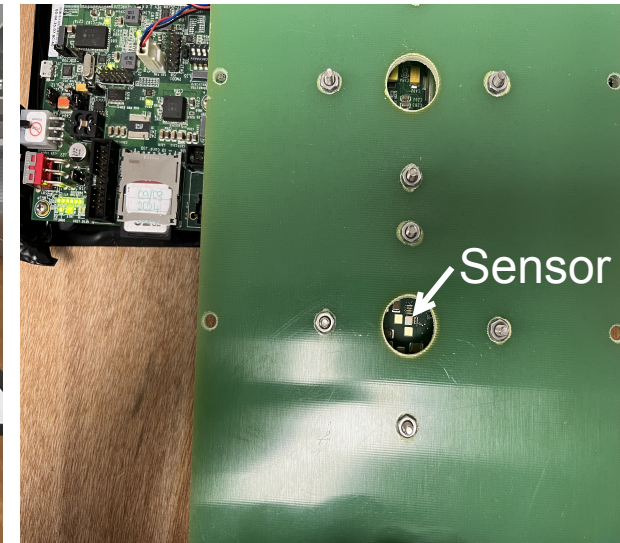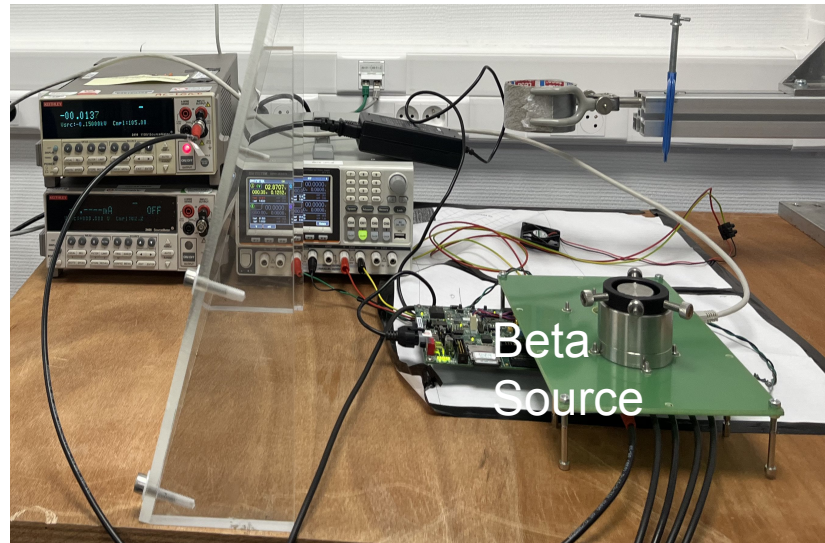# with Beta Source (^{90}Sr)

June 23, 2025

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On behalf of Dominique Marchand, Laurent Serin, and Beng-Yun Ky

Measurements with ⁹⁰Sr β source

❖ **Probe Pre-Amplifier signal on oscilloscope**

Cons:

- 4 channels only at a time
- Only 1 channel per column
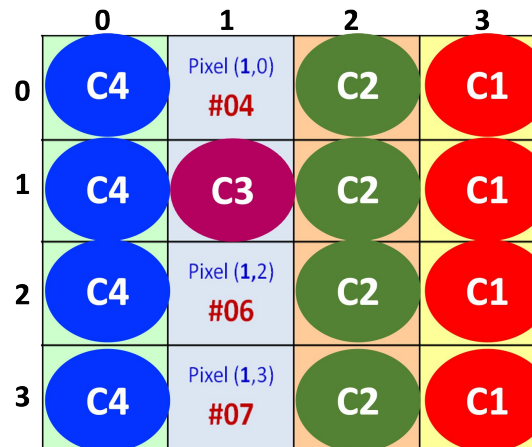- Difficulty as signal maximum can come from other channel.

❖ **ADC + TDC data**

Pros:

- 16 channels at a time
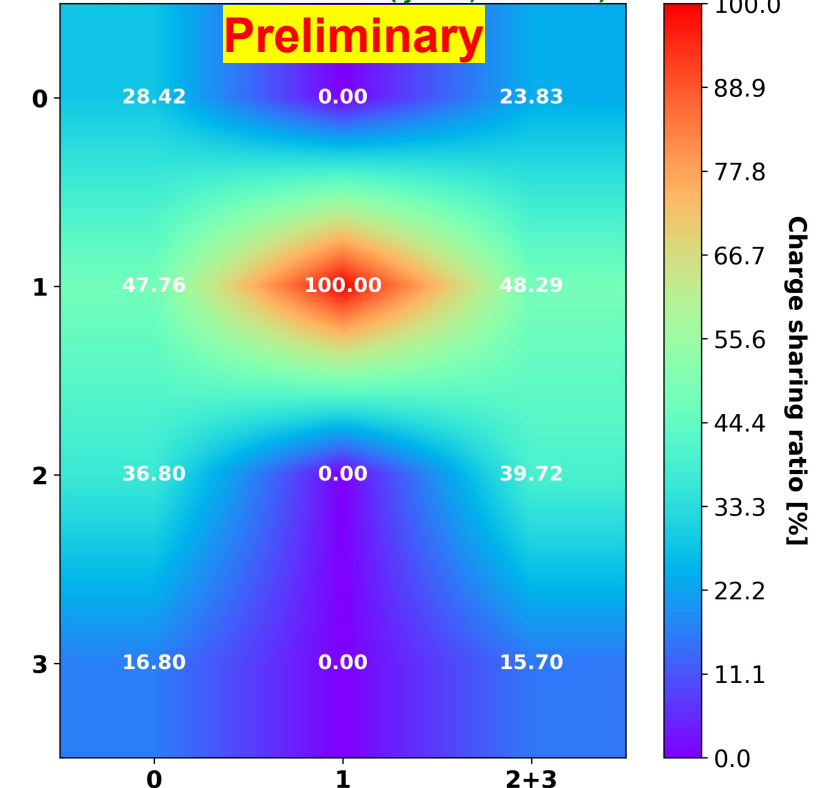- Require a specific firmware

Cons:

- ADC pedestal subtraction

❖ **ADC: Pedestal subtraction**

	0	1	2	3
0	C4	Pixel (1,0) #04	C2	C1
1	C4	C3	C2	C1
2	C4	Pixel (1,2) #06	C2	C1
3	C4	Pixel (1,3) #07	C2	C1

HPK WB Charge Sharing Map

Beta source measurements (IJCLab, Feb. 2024)

Preliminary

	0	1	2+3
0	28.42	0.00	23.83
1	47.76	100.00	48.29
2	36.80	0.00	39.72
3	16.80	0.00	15.70

Charge sharing ratio [%]

100.0 — 88.9 — 77.8 — 66.7 — 55.6 — 44.4 — 33.3 — 22.2 — 11.1 — 0.0

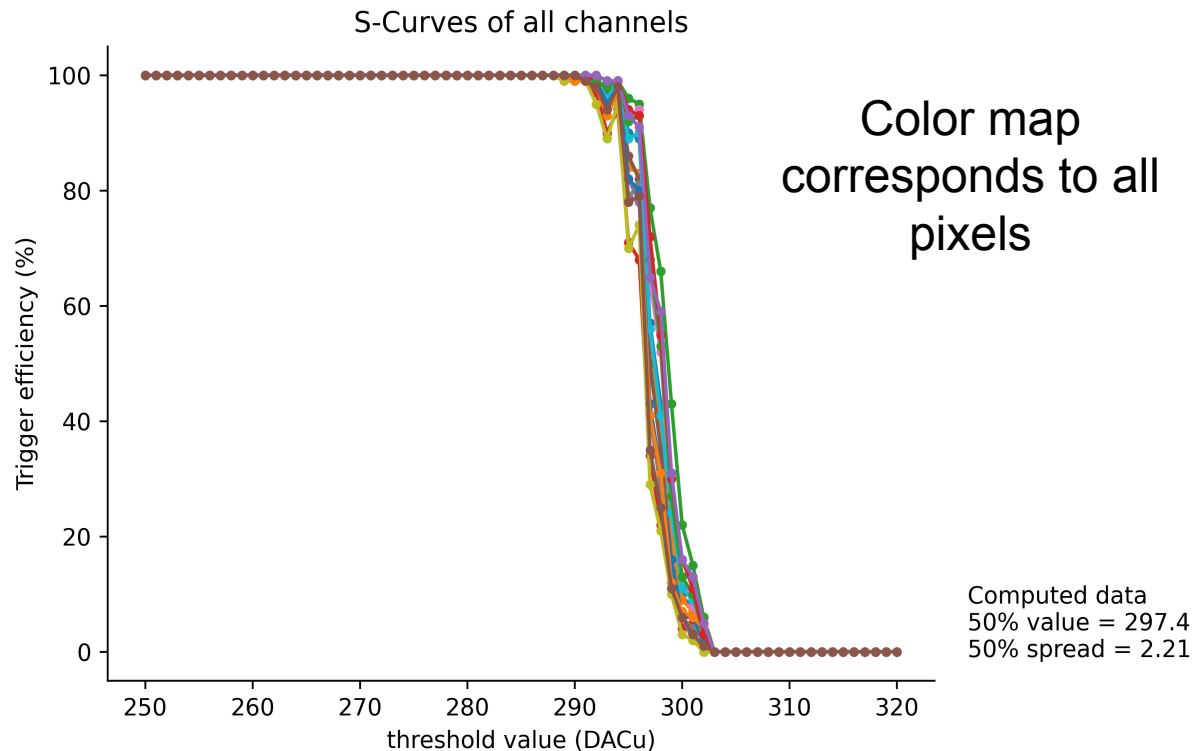Application: **EICROC0 + Wire-bonded BNL AC-LGAD**

Overview

- Beta source measurements using ADC-TDC data with all channels from the ASIC.

- Threshold corrections performed to optimize TDC and ADC using AV code.

- ADC waveform study for Beta source measurements.

- Interesting Results with pedestal subtraction using far pixel.

- Preliminary results for charge sharing.

- Timing resolution study performed between hit and the neighboring pixels.
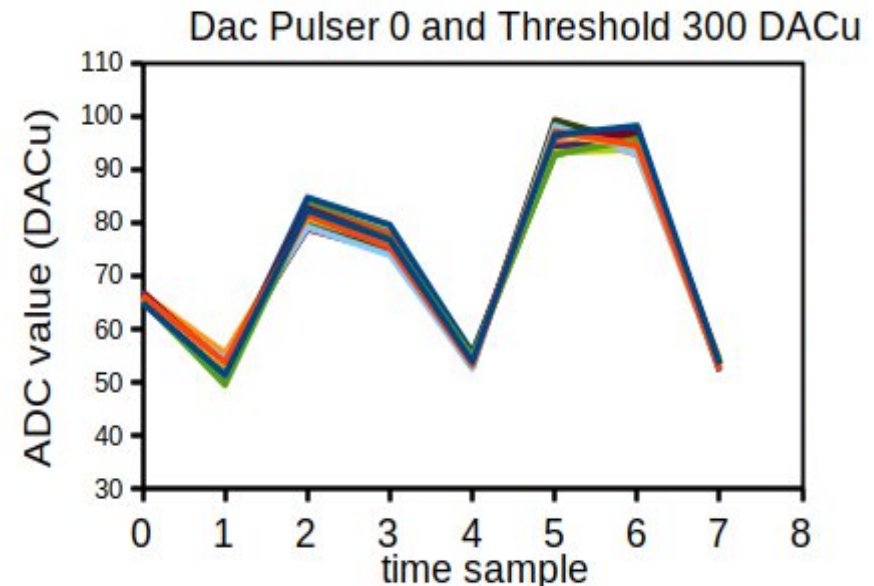
Vref and Vcor Adjustment

- Using Adrien's code:

- **Threshold adjustment** channel-by-channel performed.

- **Baseline adjustment** channel-by-channel done.

Adjustments performed for lower charge DAC Pulser 12 (~5 fC) [CMD pulse] and setting global threshold 300 DACu

S-Curves of all channels

Color map corresponds to all pixels

Computed data
50% value = 297.4
50% spread = 2.21

Raw Average ADC waveform for CMD Delay 0 : all pixels

Dac Pulser 0 and Threshold 300 DACu

Updated BOOT file

- Acquiring TDC and ADC data for all 16 channels when **at least** a hitbit is set to 1 among all 16 channels (meaning that PA signal amplitude passes the discriminator threshold).

- **Should also work for laser measurements.**

Application:

EICROC0 + wire-bonded BNL AC-LGAD

(courtesy: Beng-Yun Ky)

New BOOT.BIN Implementation

Event 1: Only Pix 15 fires.

|																						
238825963316	0	63	0	0	117	0	0	124	0	0	78	0	0	89	0	0	91	0	0	50	0	0	32	0
238825963316	0	64	0	0	117	0	0	129	0	0	80	0	0	87	0	0	89	0	0	50	0	0	33	0
238825963316	0	65	0	0	116	0	0	125	0	0	78	0	0	88	0	0	90	0	0	51	0	0	35	0
238825963316	0	62	0	0	112	0	0	118	0	0	75	0	0	85	0	0	92	0	0	48	0	0	31	0
238825963316	0	63	0	0	114	0	0	121	0	0	76	0	0	87	0	0	94	0	0	52	0	0	34	0
238825963316	0	62	0	0	111	0	0	127	0	0	78	0	0	85	0	0	87	0	0	51	0	0	33	0
238825963316	0	62	0	0	113	0	0	127	0	0	76	0	0	88	0	0	89	0	0	49	0	0	33	0
238825963316	0	65	0	0	113	0	0	121	0	0	79	0	0	88	0	0	91	0	0	51	0	0	36	0
238825963316	0	64	0	0	112	0	0	120	0	0	77	0	0	87	0	0	92	0	0	53	0	0	35	0
238825963316	0	63	0	0	112	0	0	125	0	0	77	0	0	87	0	0	87	0	0	50	0	0	37	0
238825963316	0	63	0	0	111	0	0	124	0	0	79	0	0	89	0	0	91	0	0	51	0	0	34	0
238825963316	0	64	0	0	112	0	0	121	0	0	78	0	0	87	0	0	93	0	0	50	0	0	32	0
238825963316	0	64	0	0	118	0	0	122	0	0	76	0	0	87	0	0	90	0	0	47	0	0	31	0
238825963316	0	65	0	0	117	0	0	125	0	0	79	0	0	89	0	0	93	0	0	50	0	0	34	0
238825963316	0	63	0	0	114	0	0	121	0	0	76	0	0	87	0	0	91	0	0	49	0	0	33	0
238825963316	0	65	0	929	118	0	0	119	1	0	75	0	0	86	0	0	93	0	0	49	0	0	31	0
238825966595	0	40	0	0	100	0	0	125	0	0	76	0	0	84	0	0	95	0	0	56	0	0	25	0
238825966595	0	41	0	0	98	0	0	129	0	0	83	0	0	87	0	0	94	0	0	57	0	0	26	0
238825966595	0	42	0	0	99	0	0	128	0	0	79	0	0	87	0	0	95	0	0	55	0	0	25	0
238825966595	0	40	0	457	99	0	0	123	1	0	79	0	0	85	0	0	95	0	0	50	0	0	22	0
238825966595	0	44	0	0	103	0	0	129	0	0	80	0	0	84	0	0	95	0	0	55	0	0	24	0
238825966595	0	43	0	0	95	0	0	128	0	0	81	0	0	87	0	0	93	0	0	58	0	0	27	0
238825966595	0	44	0	0	100	0	0	131	0	0	80	0	0	88	0	0	94	0	0	56	0	0	26	0
238825966595	0	45	0	0	101	0	0	127	0	0	82	0	0	85	0	0	93	0	0	55	0	0	26	0
238825966595	0	45	0	0	100	0	0	124	0	0	80	0	0	87	0	0	95	0	0	58	0	0	28	0
238825966595	0	44	0	0	95	0	0	127	0	0	82	0	0	89	0	0	93	0	0	55	0	0	27	0
238825966595	0	45	0	0	98	0	0	128	0	0	80	0	0	87	0	0	93	0	0	57	0	0	27	0
238825966595	0	44	0	0	97	0	0	120	0	0	78	0	0	84	0	0	95	0	0	55	0	0	25	0
238825966595	0	43	0	460	106	0	0	126	1	0	80	0	0	86	0	0	95	0	0	51	0	0	22	0
238825966595	0	42	0	0	102	0	0	130	0	0	84	0	0	87	0	0	93	0	0	50	0	0	21	0
238825966595	0	44	0	0	102	0	0	127	0	0	80	0	0	85	0	0	94	0	0	52	0	0	23	0
238825966595	0	43	0	456	102	0	0	124	1	0	82	0	0	88	0	0	97	0	0	51	0	0	21	0

Event 2: Three Pixels fires.

Difficulty: Pedestal subtraction is difficult as with this firmware no event recorded if no hit bit. Therefore, without source, there is no data.

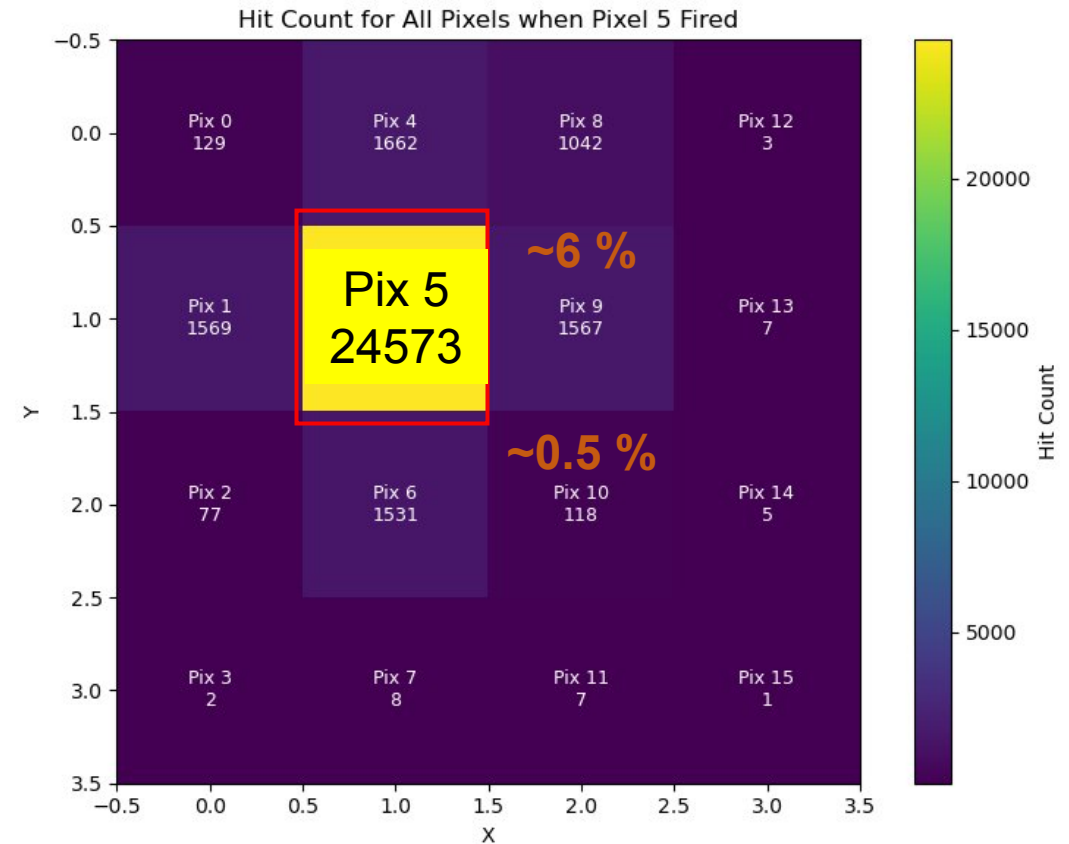Fig.: Screenshot of .csv file from beta source measurement.

Hit Map (hit bit = 1) with condition on Pix 5 hit=1

Total Events in file ~ 5,500,000

Condition: Hitbit for Pix 5=1
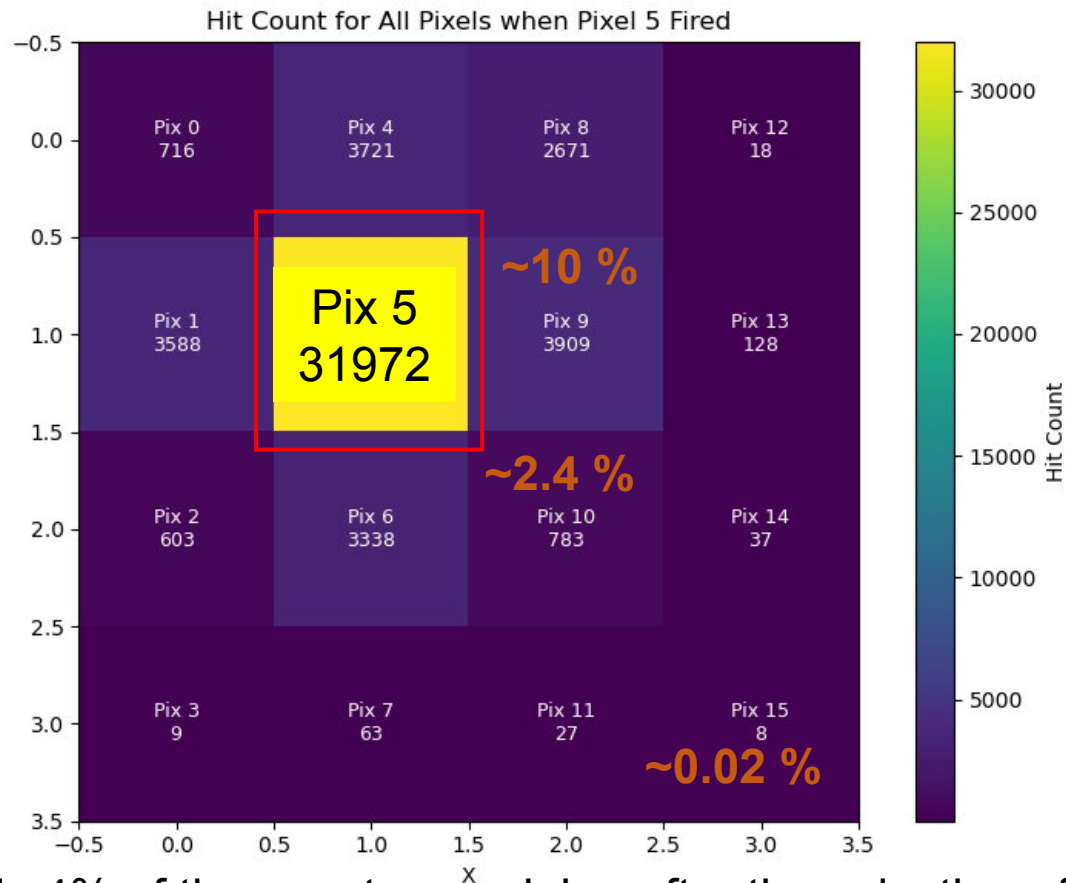
Condition: Hitbit for Pix 5=1 and Pix 5 with Max Amp

- Only 4% of the events remaining after the selection of events with hit bit =1 in pixel 5 and has max amplitude.
- With this condition the first neighbors having hit bit = 1 ~ 6%. (Clearly we need more statistics)
- The far neighbor, almost never crosses the threshold -> The ADC data corresponds to the noise and can be used for pedestal subtraction.

ADC Waveform (Beta Measurements): No Pedestal Subtraction

Loaded Parameters:
N (No. of triggers) = 0
Dac Pulser = 0
Threshold = 350 (To be above noise)

Slow Control Settings:
En_Trigout 1
Choice digprobe 0
Disable Clk gating 0
EN_NOR16 1
On disc 1 (all Pix)
Disable integrator/Mask ADC 0 (all Pix)
Disable PA 0 (all Pix)
EN_TDC 1
On_ctest 0
Cd 00
En_digprobe = 0
Analog probe = 000

ADC waveform for each pixel with a condition Pix 5 has hit bit = 1
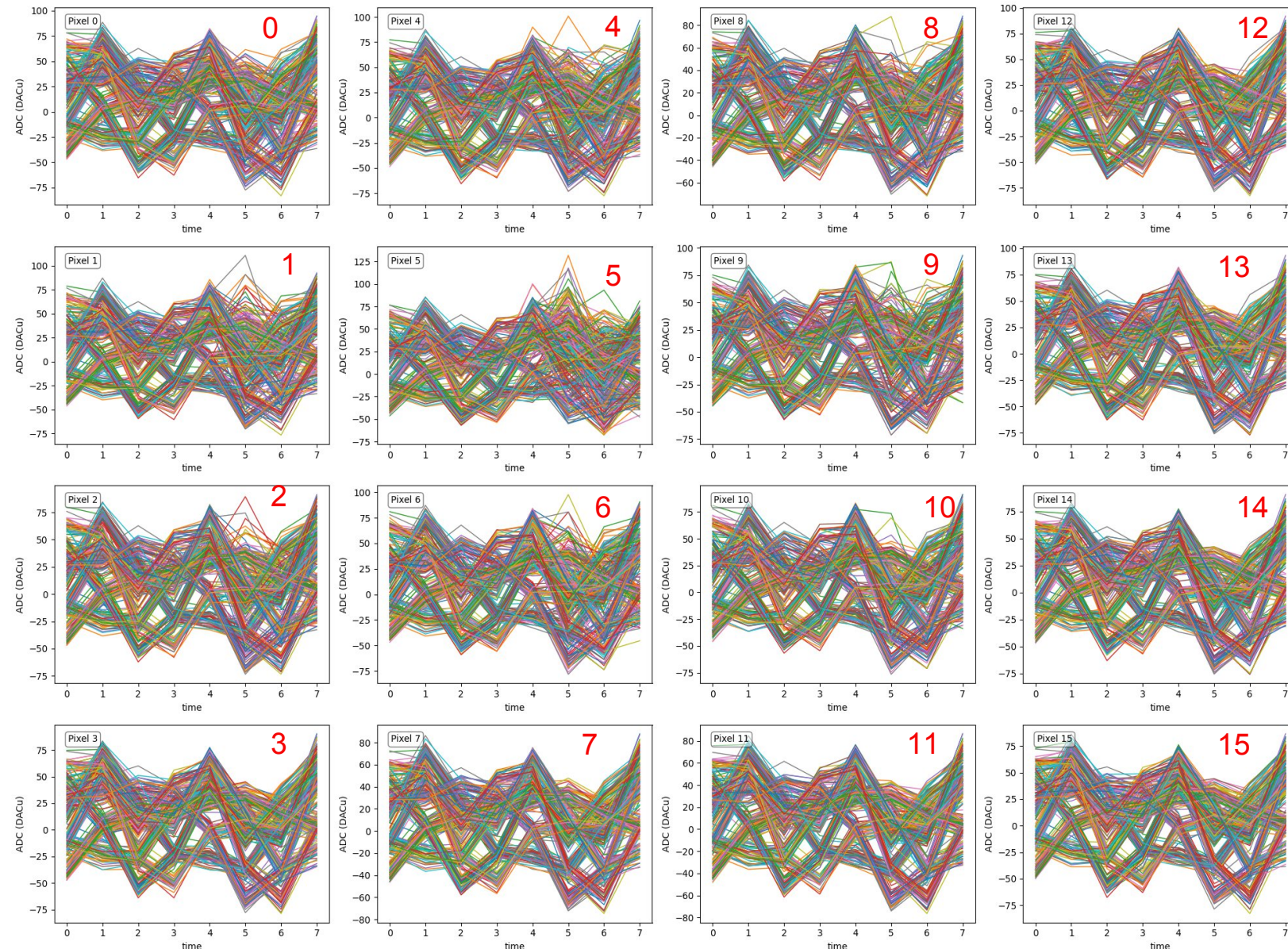
The raw ADC waveform of all channels doesn't show one maxima and is randomly distributed.

ADC Waveform : After Pedestal Subtraction

- Code adapted to select events with specific channel with a hit bit = 1 and same channel has maximum amplitude. No condition on the rest of the channels.

- Pedestal Subtraction for ADC performed using a Pix far from the hit pixel on event-by-event basis.

- Clearly, we start to see maxima in each pixel ->ADC waveform is dominated by the noise that can be subtracted using a far pixel.

ADC waveform for each pixel with a condition Pix 5 has hit bit = 1 and max amplitude

ADC Max Spectrum per Pixel (Pixel 5 with hit bit 1 and Maximum ADC amplitude)

- The Maximum amplitude in the neighboring channels is less as compared to the hit pixel.
- The Width of the spectrum is reduced for pixels away from the hit pixel.

ADC vs ADC (Correlation study between different neighbors)

Pixel / Channel Mapping	Column 0	Column 1	Column 2	Column 3
Line 0	Pixel (0,0) #00	Pixel (1,0) #04	Pixel (2,0) #08	Pixel (3,0) #12
Line 1	Pixel (0,1) #01	Pixel (1,1) #05	Pixel (2,1) #09	Pixel (3,1) #13
Line 2	Pixel (0,2) #02	Pixel (1,2) #06	Pixel (2,2) #10	Pixel (3,2) #14
Line 3	Pixel (0,3) #03	Pixel (1,3) #07	Pixel (2,3) #11	Pixel (3,3) #15

Pix 4 vs Pix 5 (I neighbor)
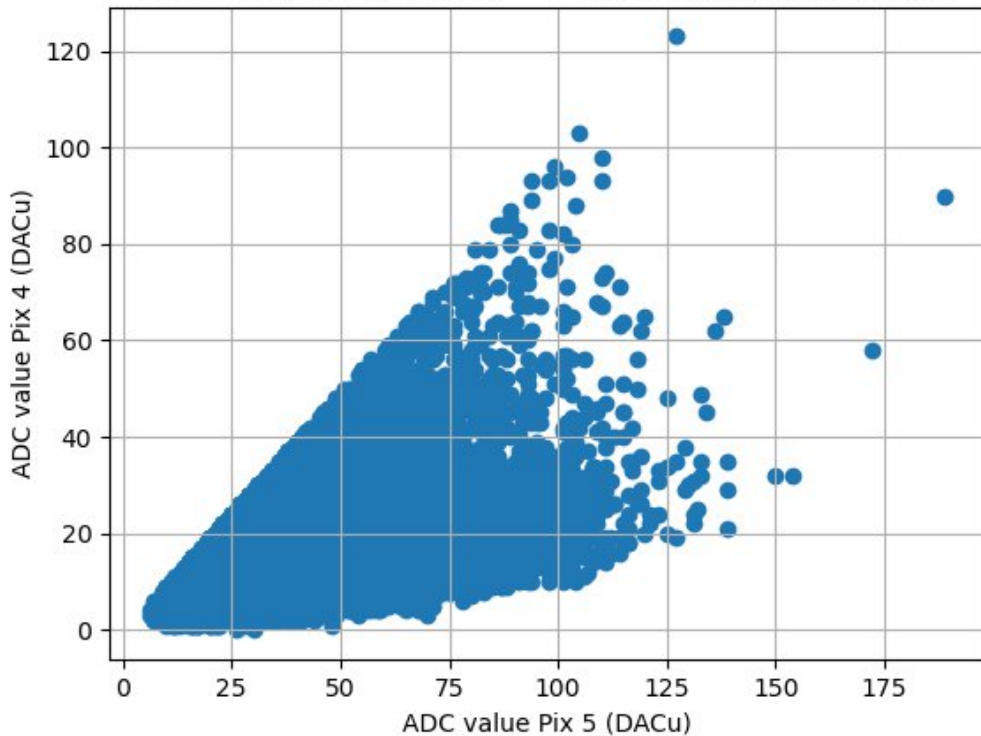
Pix 3 vs Pix 5 (II neighbor)
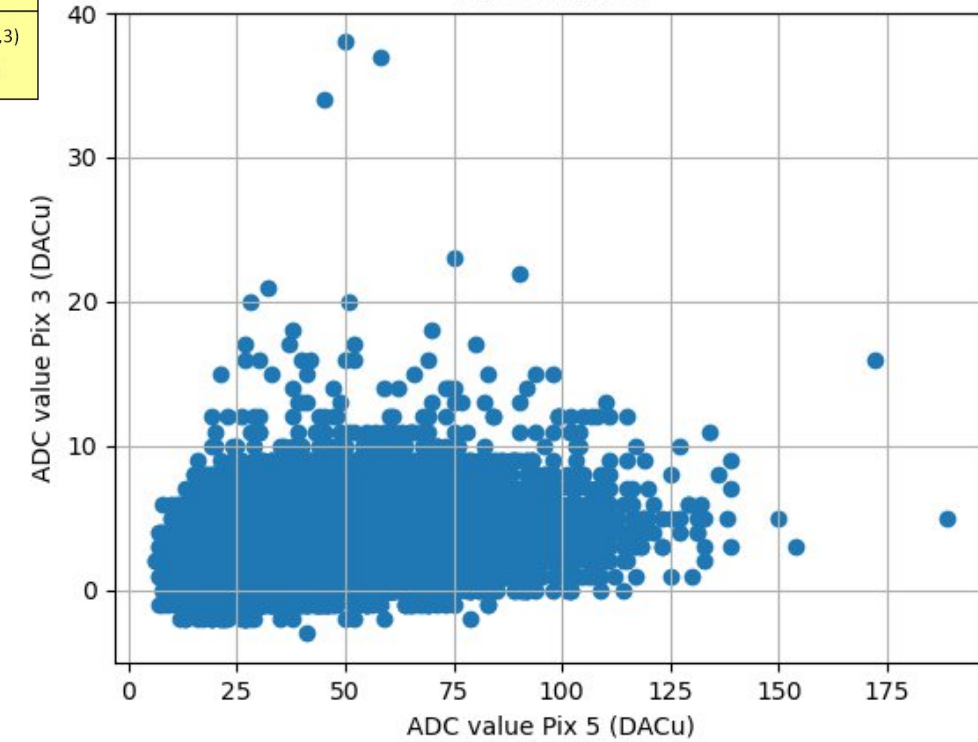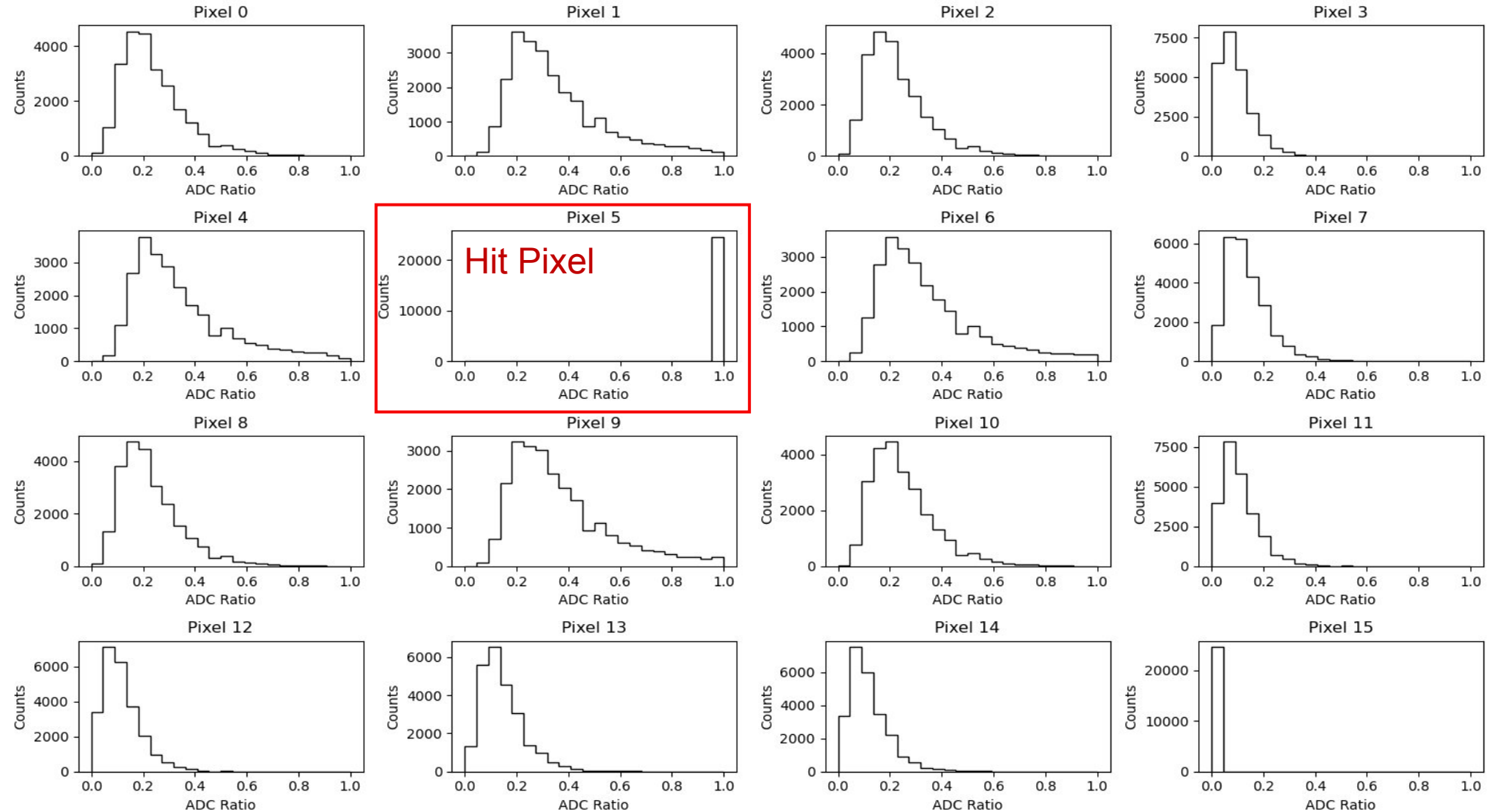

- The results appear consistent with the scope data.
- The correlations are neighbor order dependent, i.e., first neighbor shows clear correlations with hit pixel.

Normalized ADC spectrum w.r.t. hit pixel 5

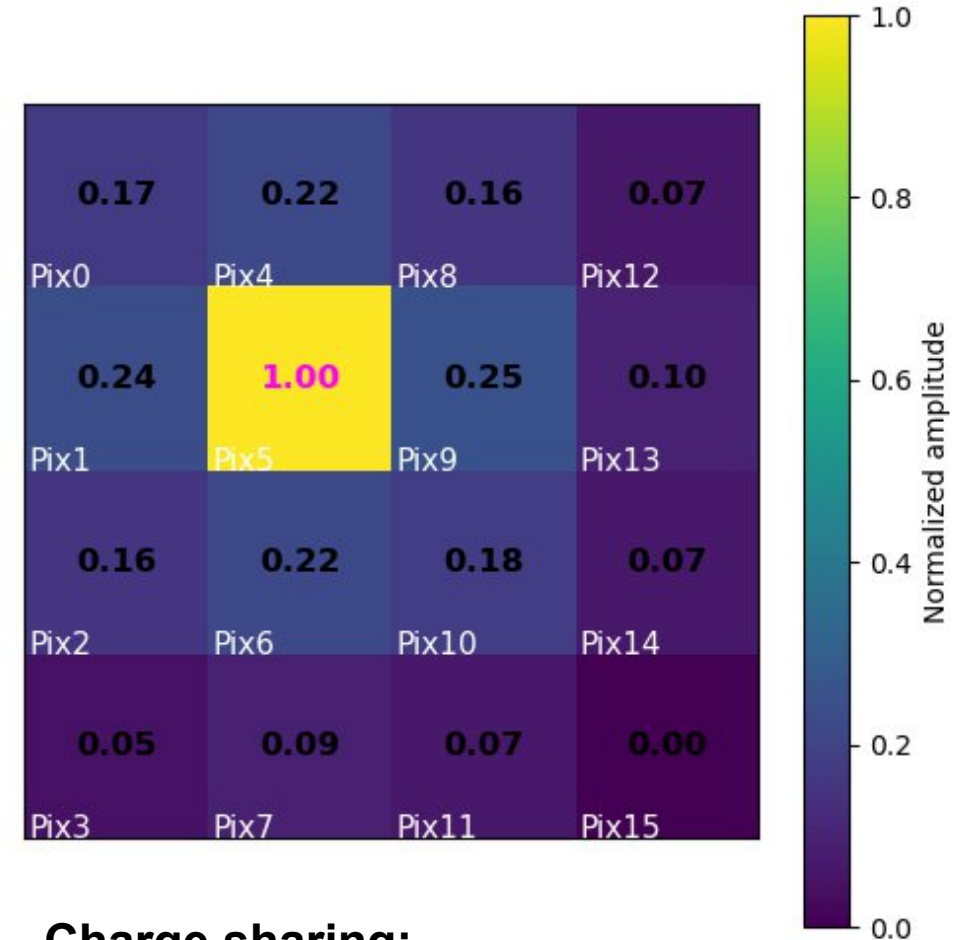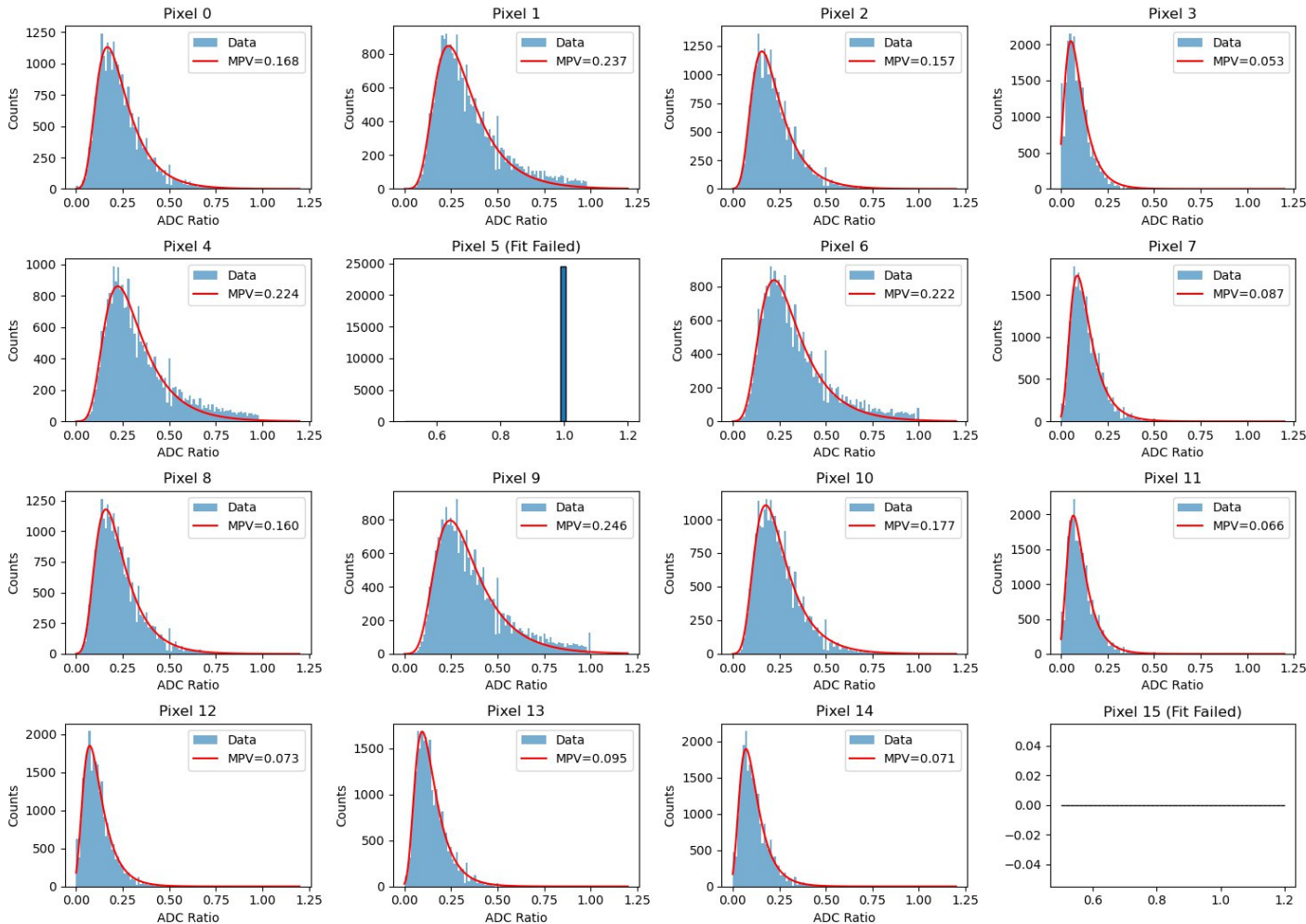Normalized ADC Spectrum per Pixel (Pixel 5 with hit bit 1 and Maximum ADC amplitude))

The first neighbors show more tailing, and it reduces for pixels away from the hit pixel..

charge sharing using MPV from Landau Fit

Hitbit for Pix 5=1 and Pix 5 with Max Amp
Ped subtraction using Pix=15
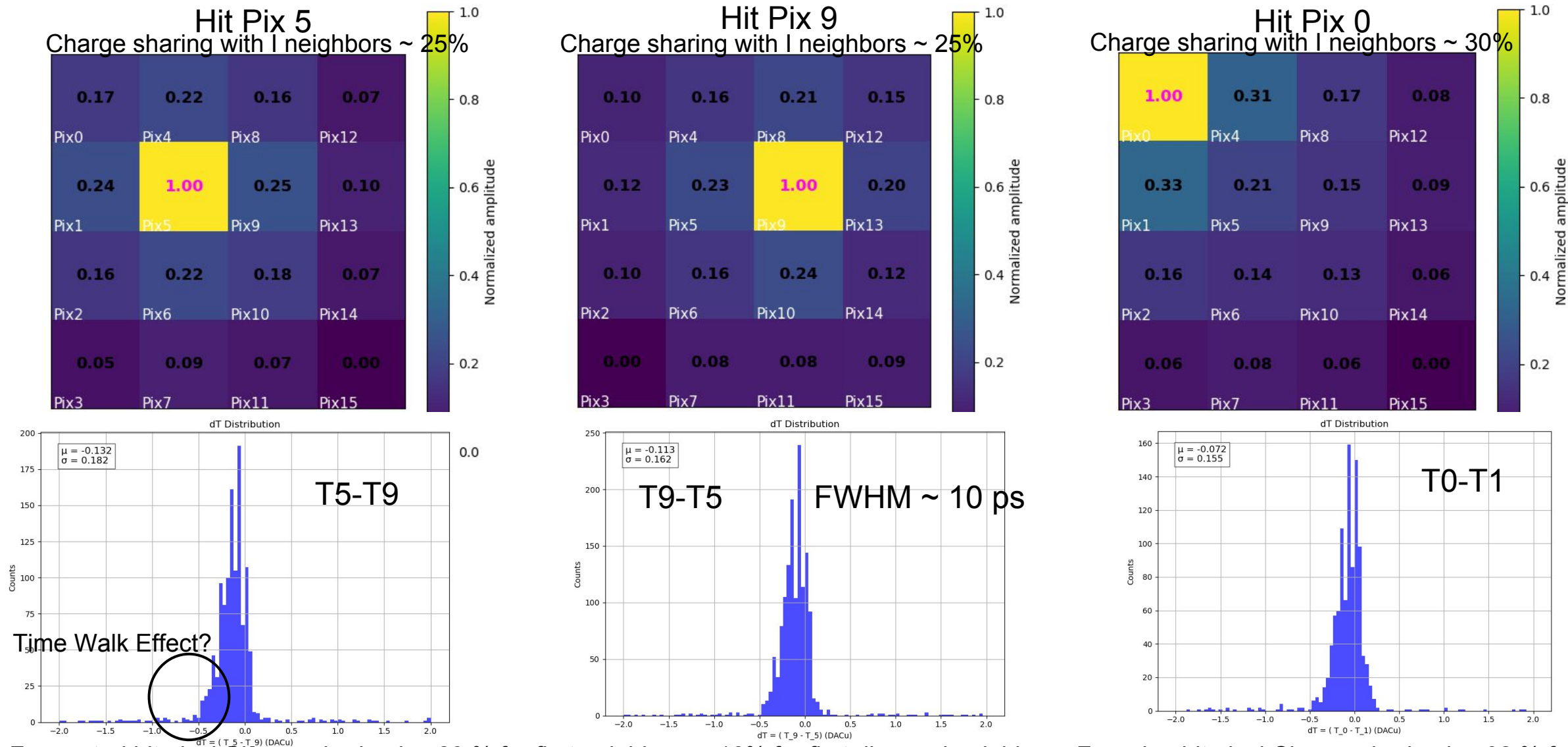

Landau Fit of ADC Ratios Per Pixel

Charge sharing:
~23 % for first neighbors
~ 16% for first diagonal neighbors.

Comparison between Pix0, Pix5 and Pix9 as hit pixels

- For central hit pixel Charge sharing is ~23 % for first neighbors ~ 16% for first diagonal neighbors. For edge hit pixel Charge sharing is ~32 % for first neighbors ~ 20 % for first diagonal neighbors. (Edge effects?)
- For all cases, diagonals have approximately 60 % of the charge sharing as compared it direct neighbor.
- The time resolution ~ 10 ps between the central pixels.

Conclusions

- 95 % of the events are cut with event selection cut (hit bit =1 in pixel of interest and has max amplitude).

- For pedestal subtraction, the far pixel chosen, which almost never crosses the threshold (implying corresponds to the noise).

- The analysis shows consistency with the scope data.

- Charge sharing studied using Landau fitting.

- For central hit pixel Charge sharing is ~23 % for first neighbors ~ 16% for first diagonal neighbors. For edge hit pixel Charge sharing is ~32 % for first neighbors ~ 20 % for first diagonal neighbors. (Edge effects?)

- For all cases, diagonals have approximately 60 % of the charge sharing as compared it direct neighbor.

- The time resolution ~ 10 ps between the central pixels.

Future perspectives

- Acquire more data to get more statistics.

- Exhaustive study of all the sensor boards (FC + HPK + WB).

- EUNPC 22-26 Sep, 2025: Abstract selected for the oral talk. Thanks for all the suggestions.