First selftrigger results at NP04

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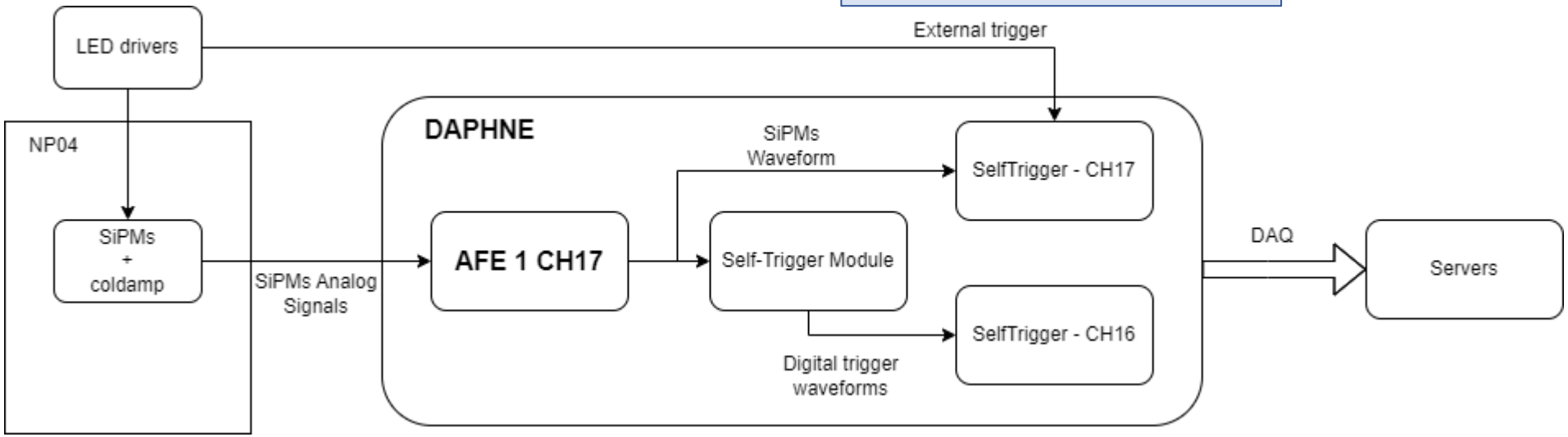
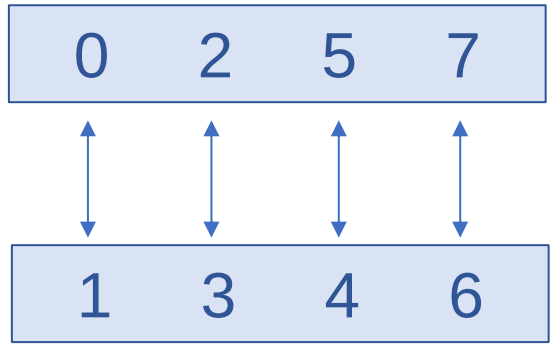
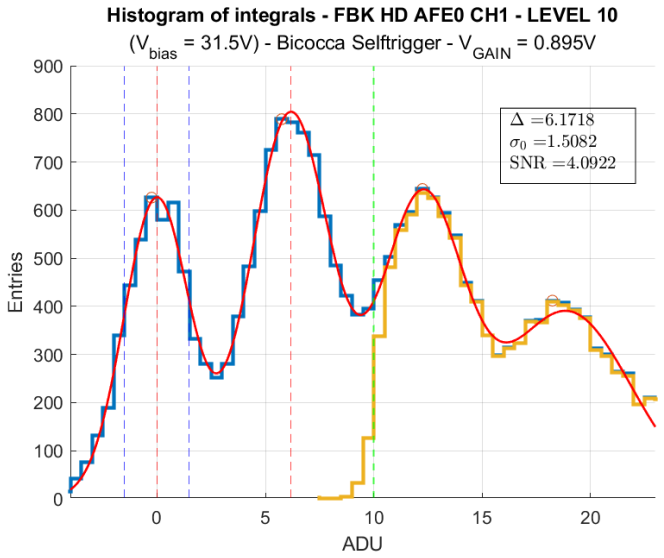
Test setup

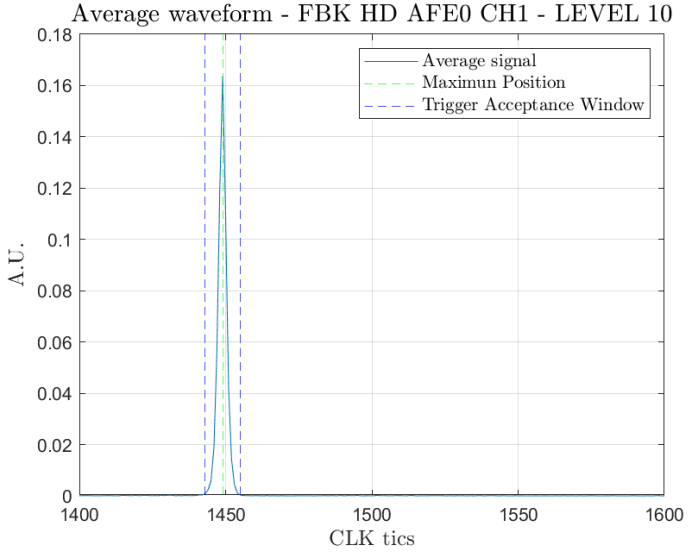


CH Signal-Trigger Map



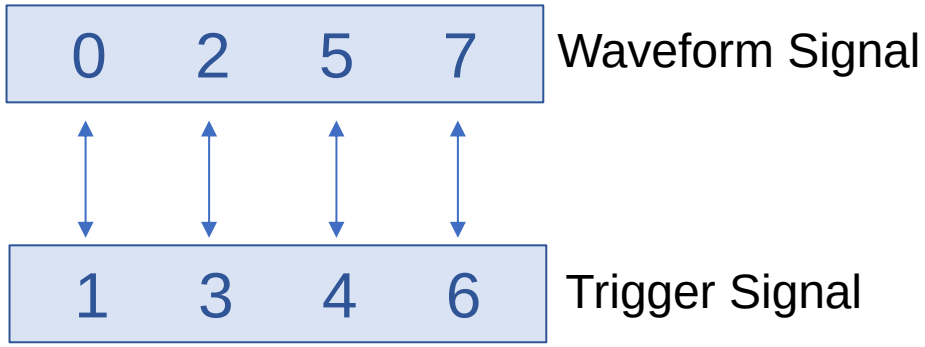
- DAPHNE is configured in such a way to save both the SiPM signals and the internal digital trigger signal, while being triggered externally by a signal that is synchronized with the LED pulser.
- In this way, the reference histogram (blue), and the triggered histogram (yellow) can be built.
- The threshold (green line), separates the populations P and N.
  - TP (true positive): Signals entries that are above the threshold with a trigger signal within the acceptance window.
  - FP (false positive): Signals entries that are below the threshold with a trigger signal within the acceptance window.
  - TN (true negatives): the difference between blue and yellow entries below the threshold.
  - FN (false negatives): the difference between blue and yellow entries above the threshold.



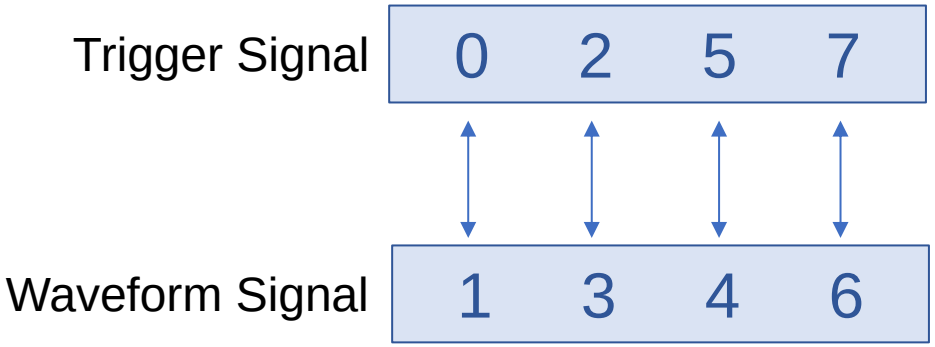


Test setup

CH Signal-Trigger Map – Detector Side 1



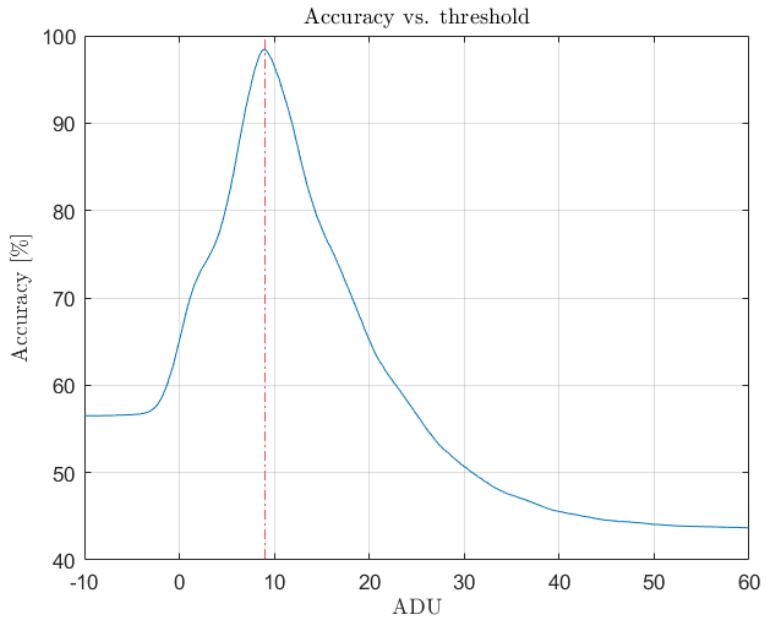
CH Signal-Trigger Map – Detector Side 0



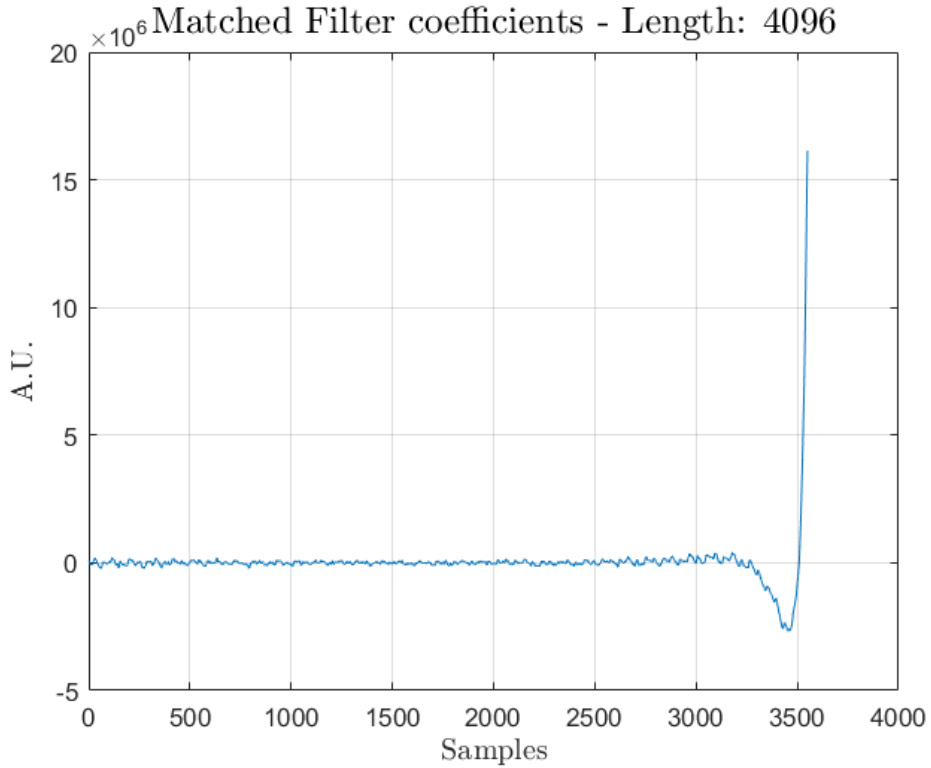
32255	28/10/2024		90	ecristal		104,109		LED	APA:12; channel_mask:50, Pulse_bias_percent_270nm:1400; pulse1_width_ticks: 20; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32256	28/10/2024		90	ecristal		104,109		LED	APA:12; channel_mask:50, Pulse_bias_percent_270nm:1800; pulse1_width_ticks: 20; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32257	28/10/2024		90	ecristal		104,109		LED	APA:12; channel_mask:50, Pulse_bias_percent_270nm:2200; pulse1_width_ticks: 20; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32258	28/10/2024		90	ecristal		104,109		LED	APA:12; channel_mask:50, Pulse_bias_percent_270nm:2800; pulse1_width_ticks: 20; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32259	28/10/2024		90	ecristal		104,109		LED	APA:12; channel_mask:50, Pulse_bias_percent_270nm:3400; pulse1_width_ticks: 20; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32260	28/10/2024		90	ecristal		104,109		LED	APA:12; channel_mask:50, Pulse_bias_percent_270nm:4000; pulse1_width_ticks: 20; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32261	28/10/2024		90	ecristal		111, 112 , 113		LED	APA:34; channel_mask:1, Pulse_bias_percent_270nm:1400; pulse1_width_ticks: 1; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32262	28/10/2024		90	ecristal		111, 112 , 113		LED	APA:34; channel_mask:1, Pulse_bias_percent_270nm:1500; pulse1_width_ticks: 1; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32263	28/10/2024		90	ecristal		111, 112 , 113		LED	APA:34; channel_mask:1, Pulse_bias_percent_270nm:1600; pulse1_width_ticks: 1; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32264	28/10/2024		90	ecristal		111, 112 , 113		LED	APA:34; channel_mask:1, Pulse_bias_percent_270nm:1800; pulse1_width_ticks: 1; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32265	28/10/2024		90	ecristal		111, 112 , 113		LED	APA:34; channel_mask:12, Pulse_bias_percent_270nm:2000; pulse1_width_ticks: 1; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1
32266	28/10/2024		90	ecristal		111, 112 , 113		LED	APA:34; channel_mask:12, Pulse_bias_percent_270nm:2200; pulse1_width_ticks: 1; PDE: 45%	Threshold: 0x2001000012c - Detector Side: 1

Complete dataset for APAs 1, 2, 3, 4 for a single threshold

Considerations



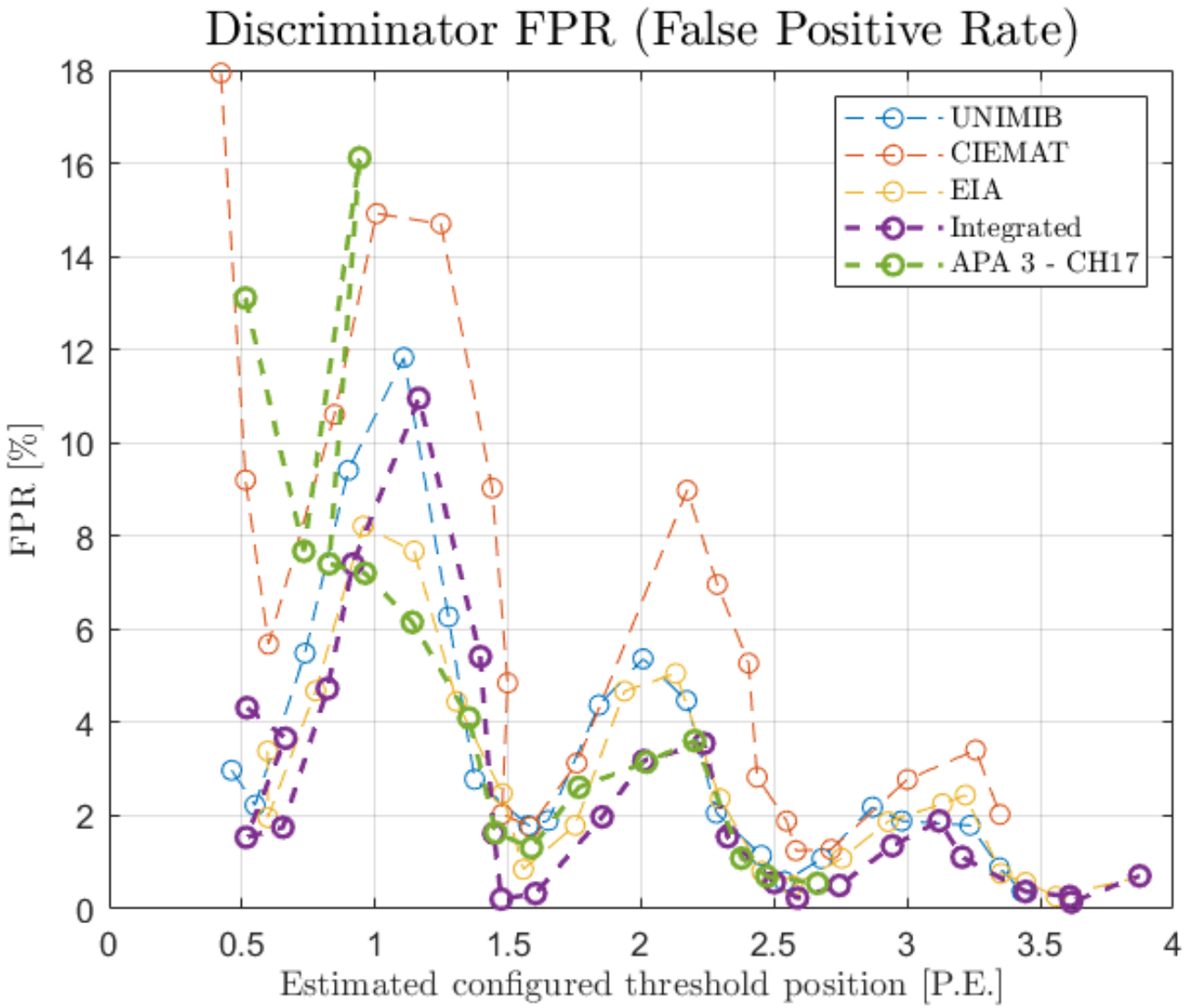
$$Accuracy[\%] = \frac{TP + TN}{TP + TN + FP + FN} \times 100$$



- For each threshold configuration, we sweep the histogram and calculate the FP, TP, TN and FN.
- Given that the threshold position must be calibrated for a given analysis method to generate the histogram, the estimated threshold position is considered the point of maximum accuracy.

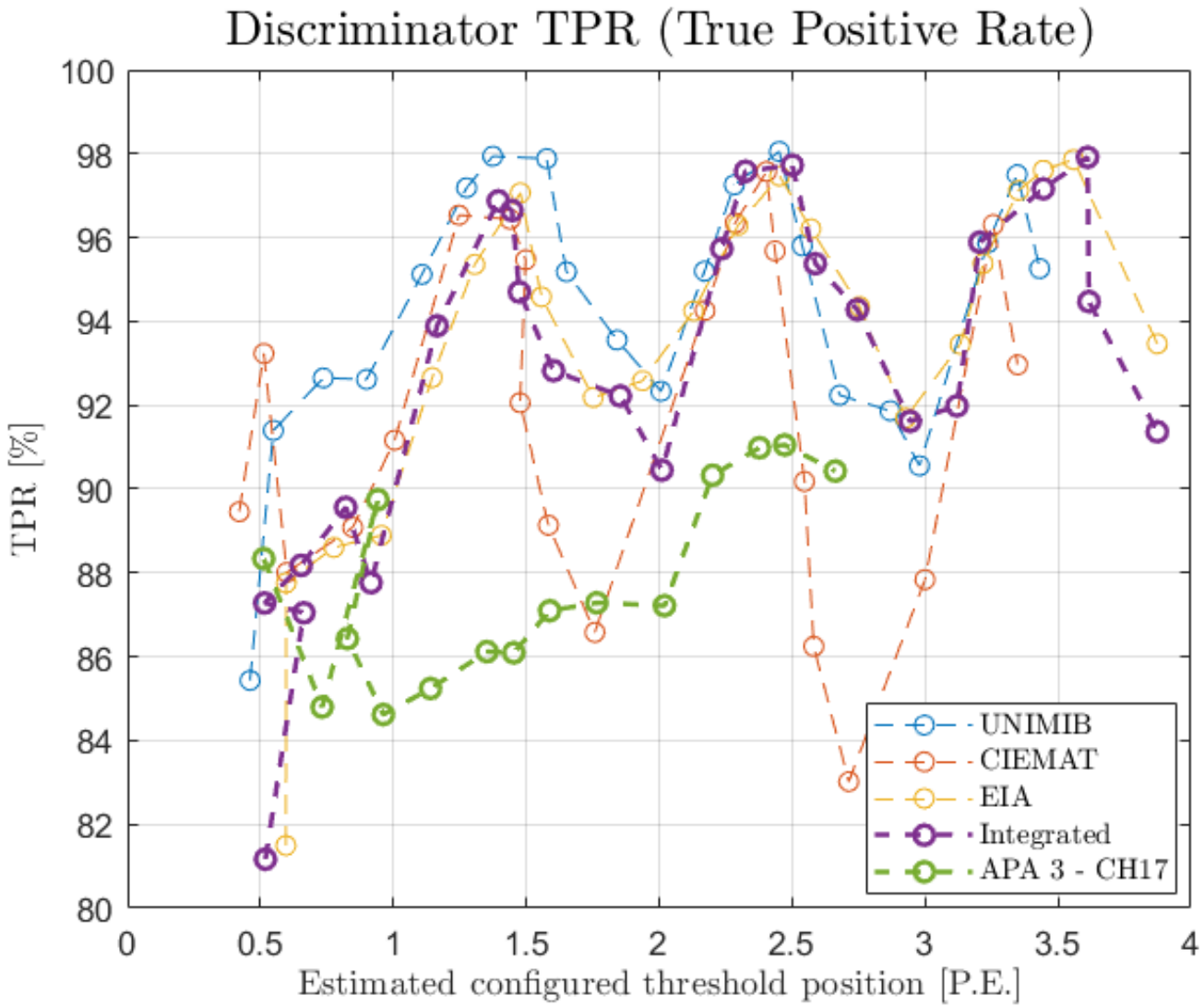
- Note:
  - In laboratory runs, we have used a matched filter to generate histograms and calculate the figure of merits. For this preliminary result, an integrator filter was used which yields a lower SNR than a matched filter.
  - The reason: the matched filter for NP04 does not give satisfactory results and needs to be further investigated.

False Positive Rate



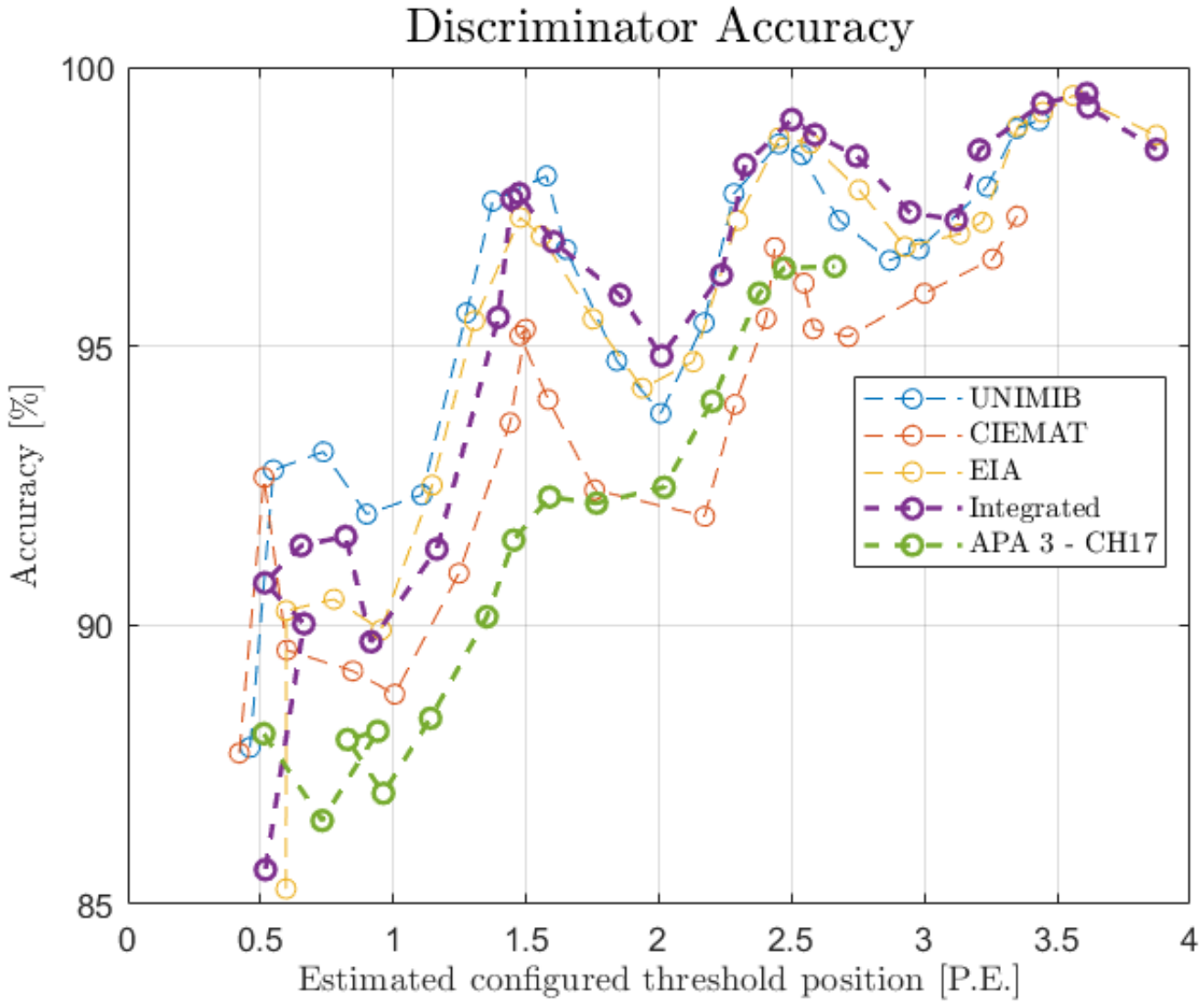
- Here, other measurements different that APA 3 – CH 17, were taken in laboratory conditions.

True Positive Rate



- Here, other measurements different that APA 3 – CH 17, were taken in laboratory conditions.

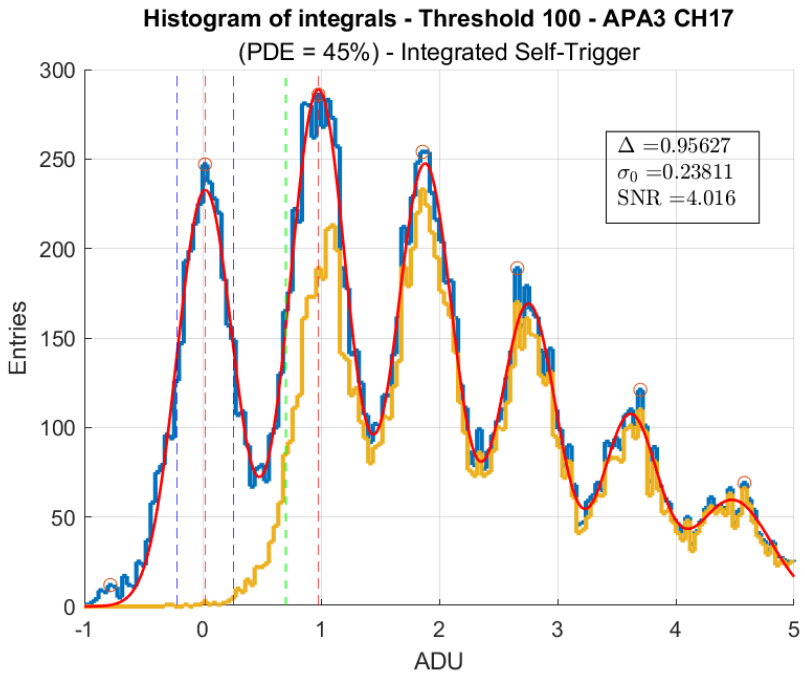
Accuracy

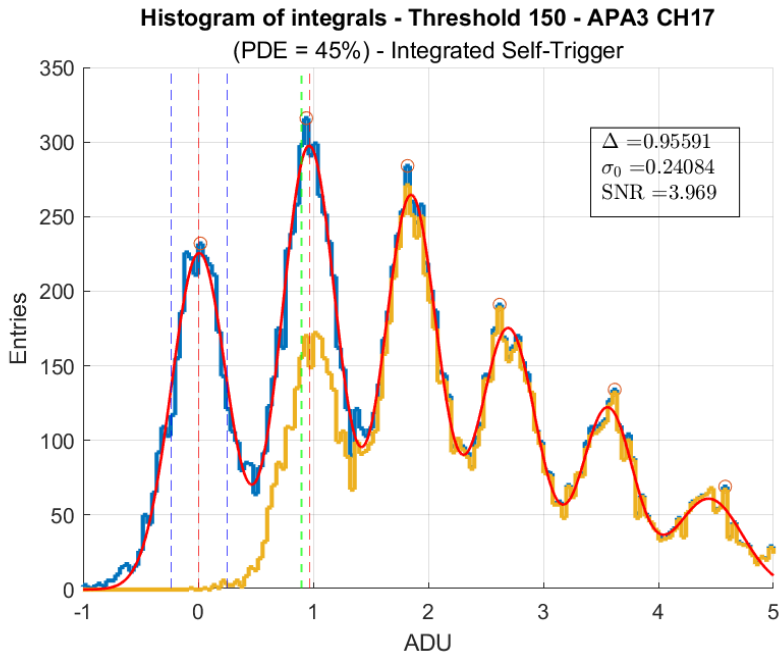


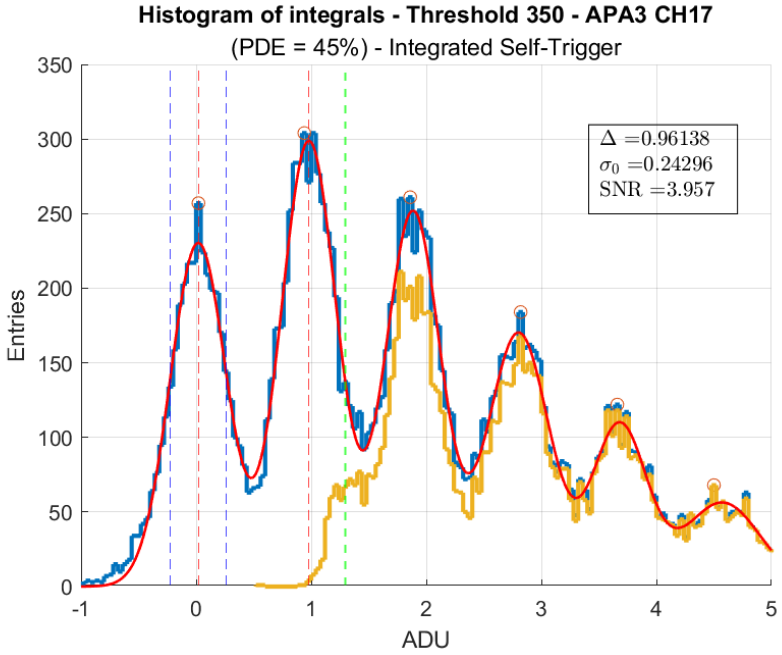
- Here, other measurements different that APA 3 – CH 17, were taken in laboratory conditions.

Histograms

APA 3 – CH 17

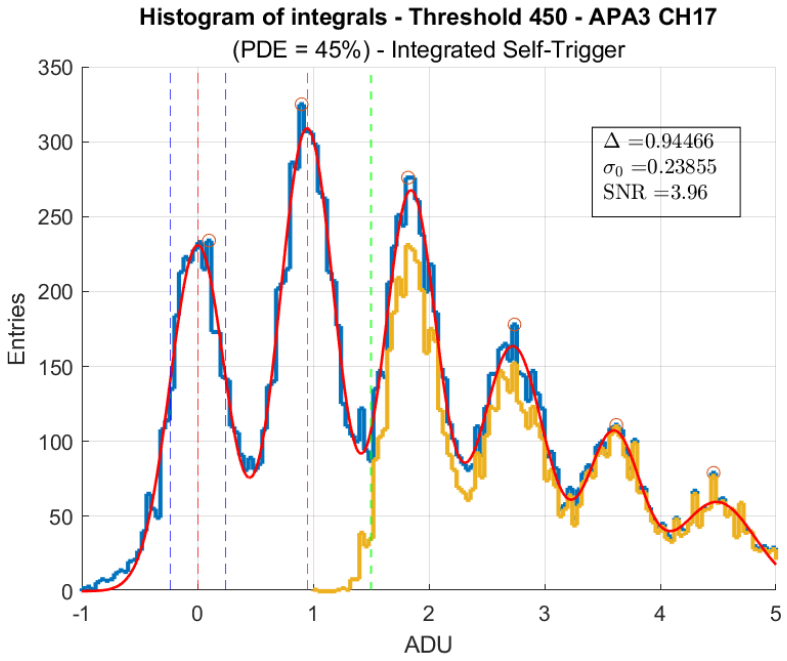


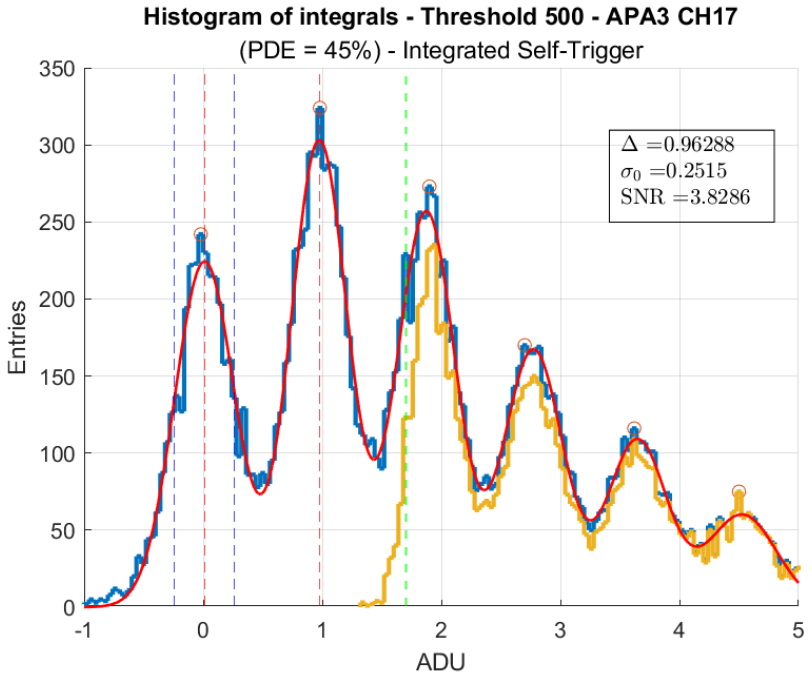




Histograms

APA 3 – CH 17





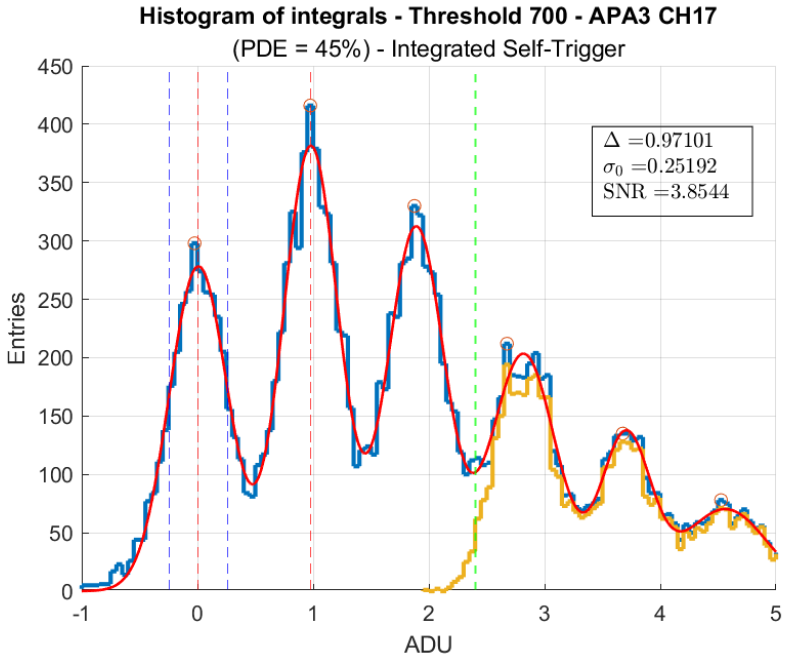
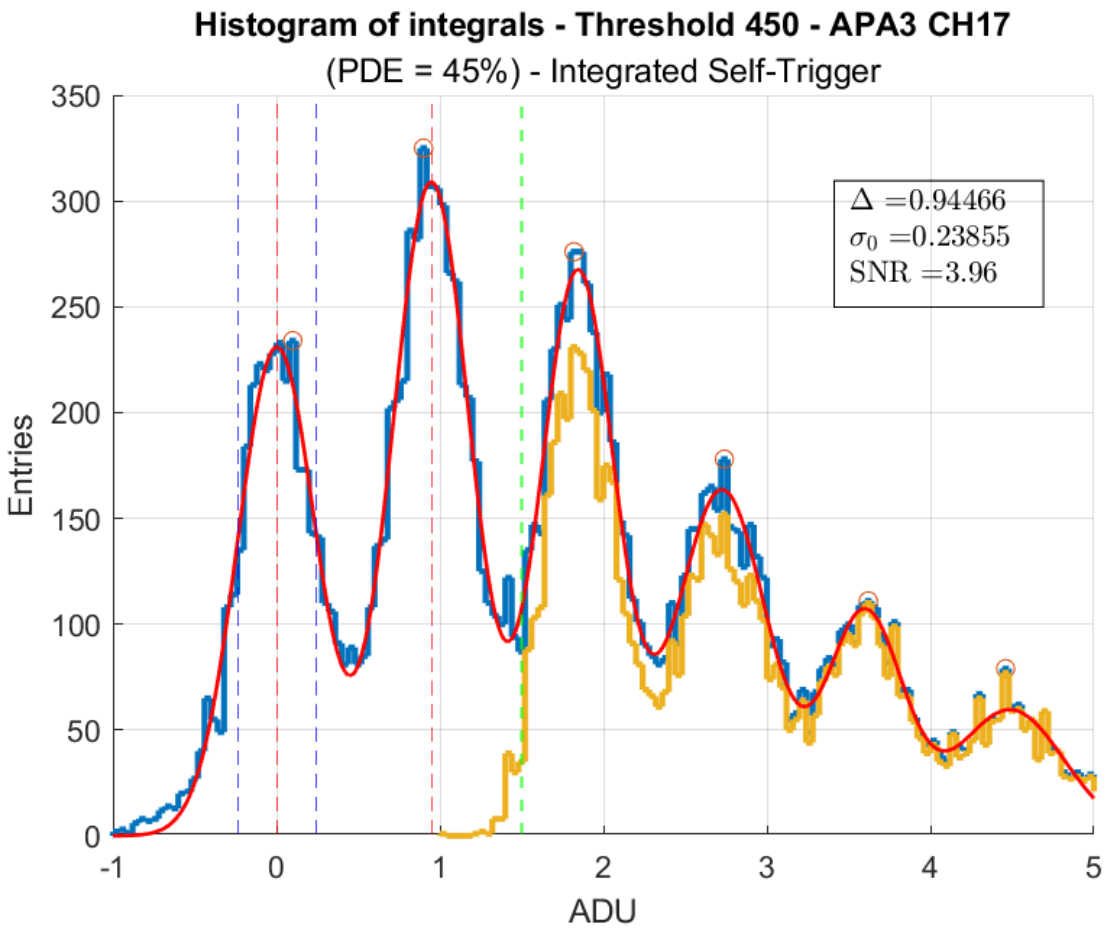


Figure of merits



APA 3 – CH 17

Estimated Threshold Level: 1.58 P.E.

TPR: 87.09% *(96.87%)

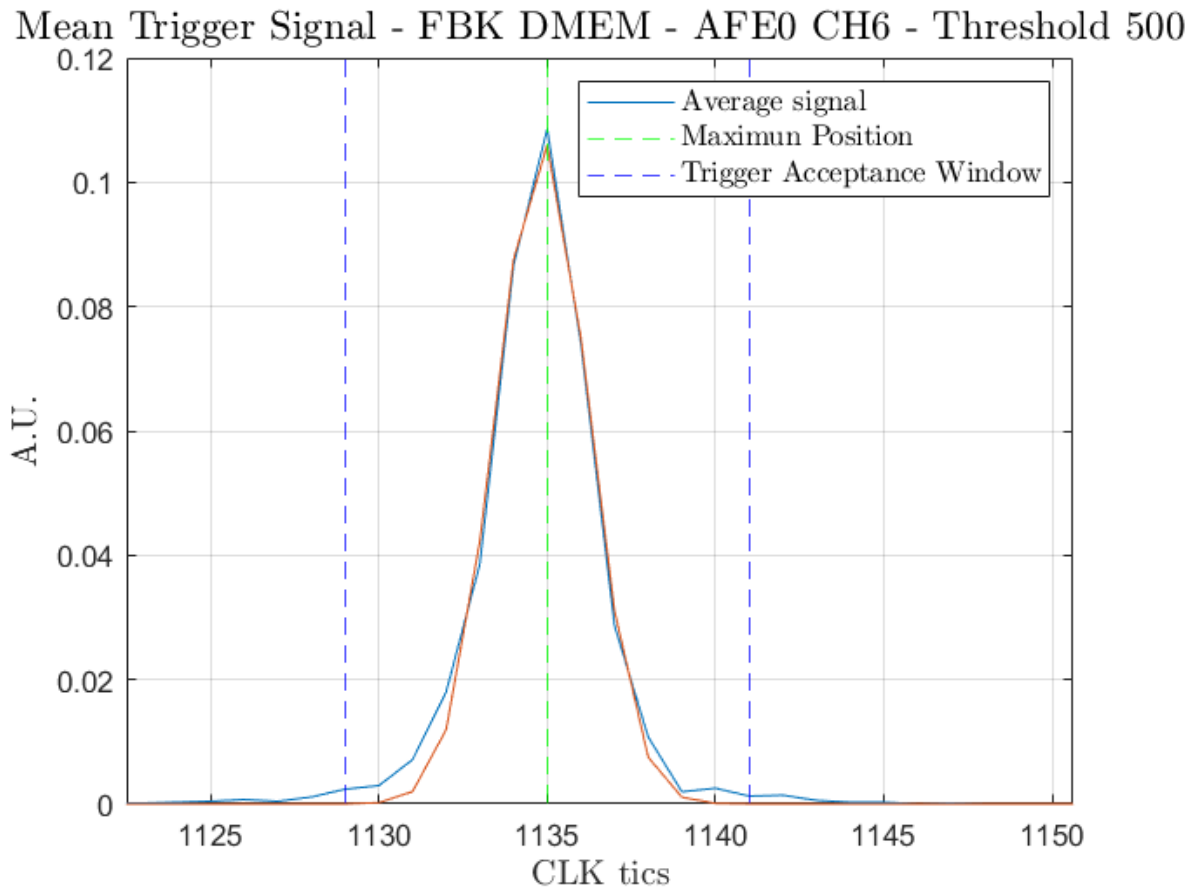
FPR: 1.31% *(0.21%)

ACC: 92.29% *(97.73%)

* Laboratory results

Trigger Jitter – RUN3

LAB



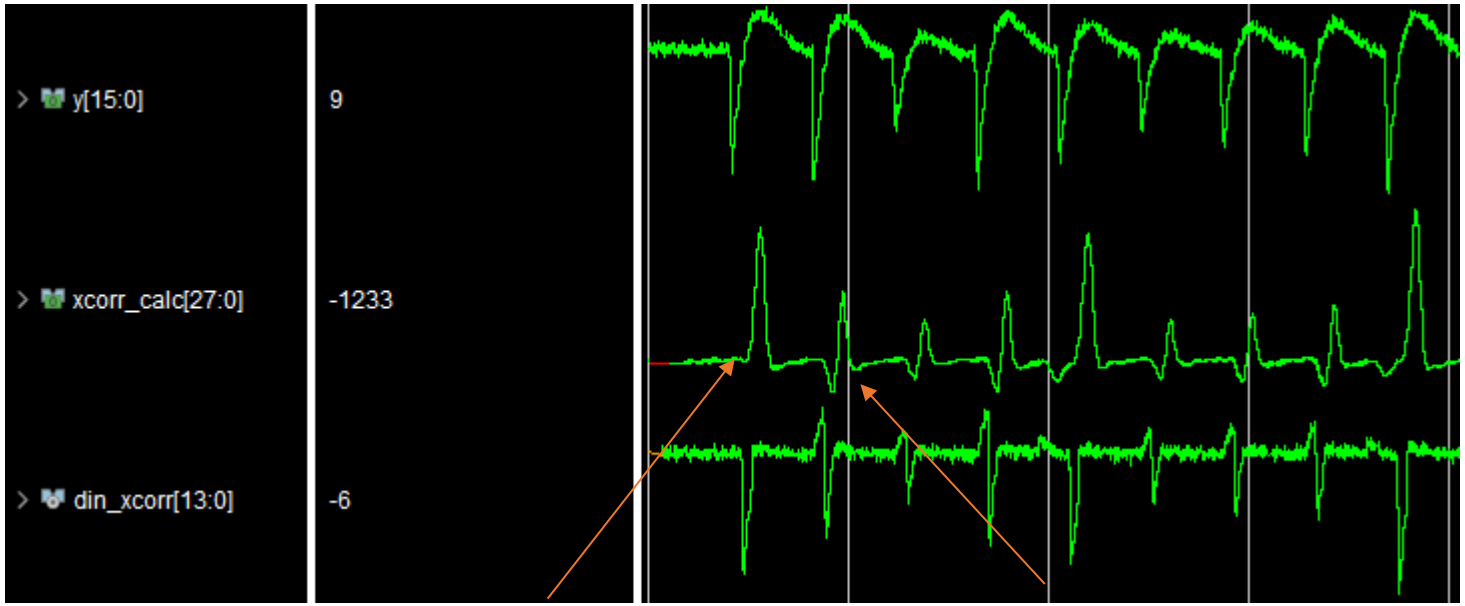
$TAW = 12\ tics$

NP04

$TAW = 14\ tics$

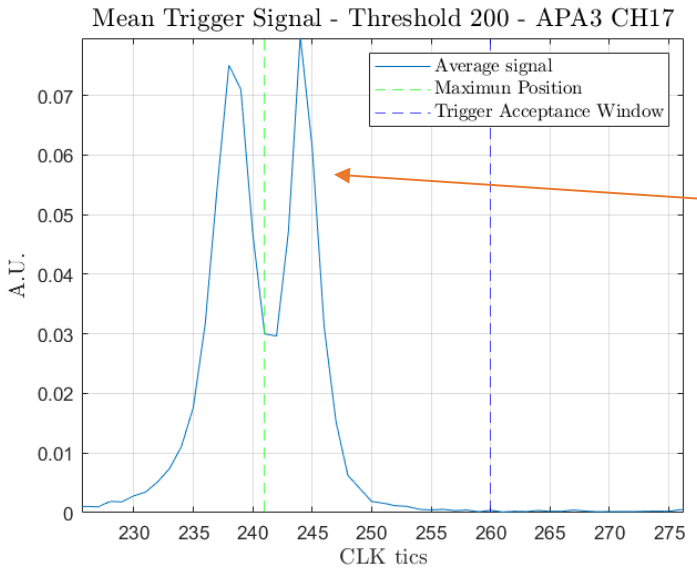
TAW: Trigger Acceptance Window

Module Simulation



Full Height xcorr singal

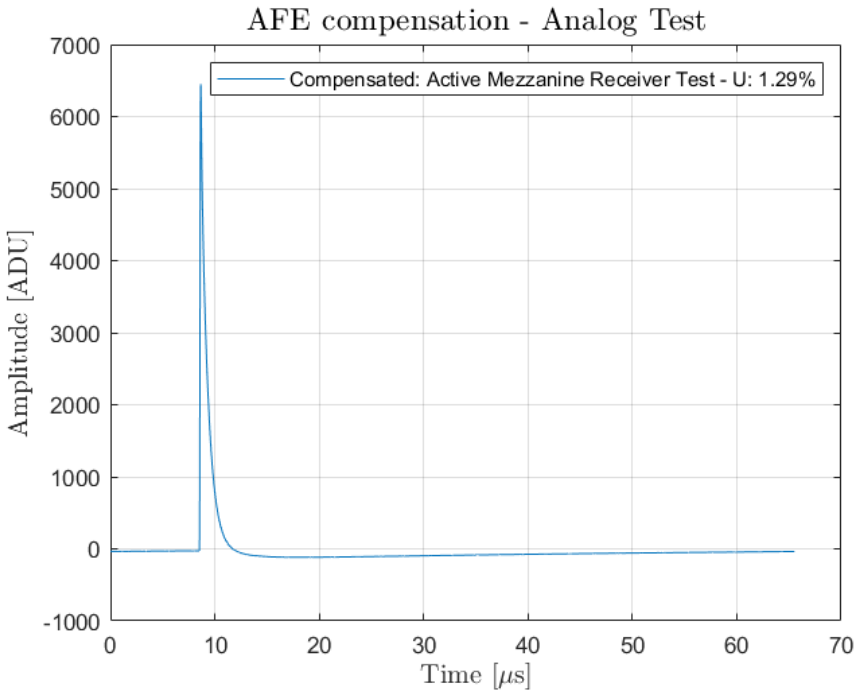
Half Height xcorr singal

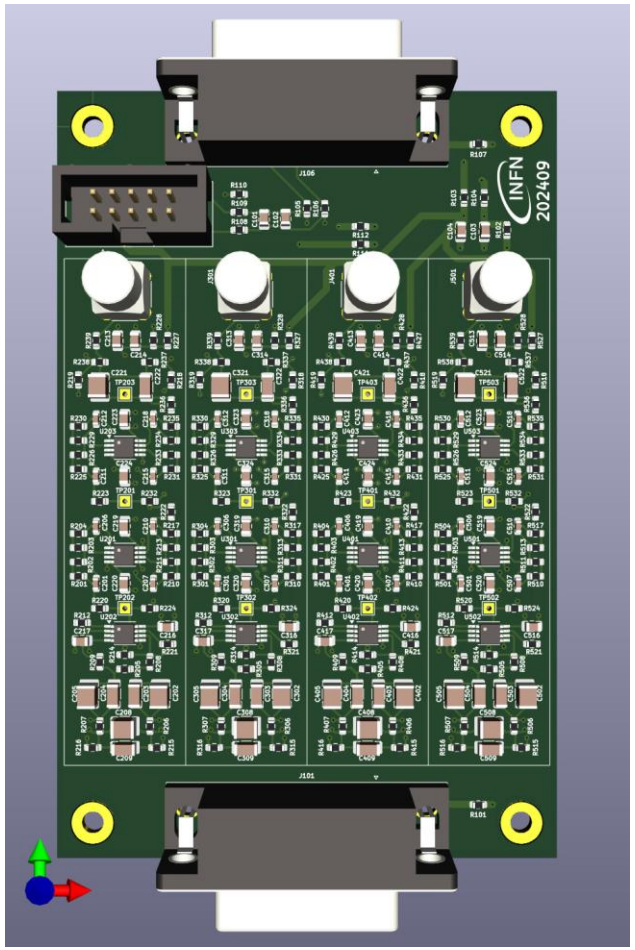


Double peak jitter at ~0.5 P.E. threshold.

- The mayor contributor in accuracy loss is the True Positive Rate. This means that the discriminator is failing to capture events.
- The main cause can be attributed to the high background rate that do not allow the signal undershoot to recover.
- The discriminator height is reduced by approximately half while the undershoot is recovering.
- For low threshold events, any signal event that occurs in this recovery period will be missed with a probability of around 13% because it cannot reach the threshold level.
- This behavior also causes the fixed jitter observed in the jitter measurements.

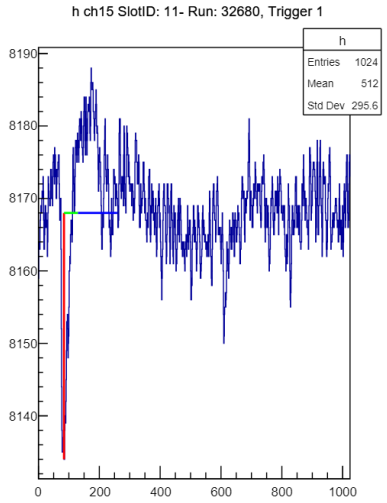
Module Simulation



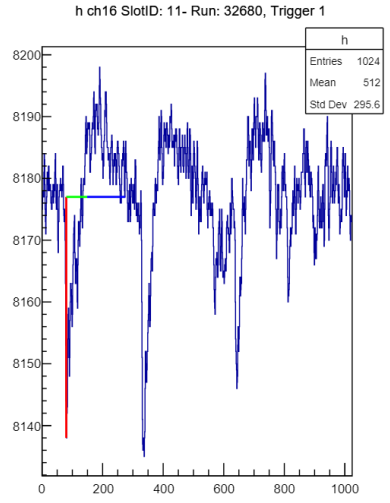


- There is a possibility to almost eliminate the undershoot behavior with recently developed warm receiver for DAPHNE V3 Mezzanine at Milano-Bicocca.
- Laboratory test confirm that we can reduce the undershoot to a 1% level.
- We could swap on DAPHNE V2 with the modified Milano DAPHNE and try to repeat the threshold sweep on one channel.
- We can then measure the performance of the discriminator when signals have almost no undershoot.
- We must evaluate the procedure to connect to a NP04 module and if we have the available time to measure.

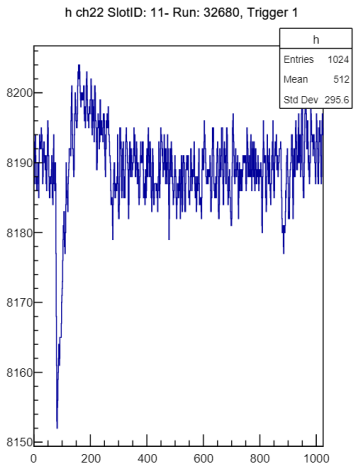
Trigger Primitives



TP	0	1	2	3	4
DA	1	0	0	0	0
charge	697	8388607	8388607	8388607	8388607
max_peak	34	16383	16383	16383	16383
time_peak	20	511	511	511	511
time_pulse	46	511	511	511	511
time_pulse_ob	129	1023	1023	1023	1023
peak_ub	2	15	15	15	15
peak_ob	5	15	15	15	15



TP	0	1	2	3	4
DA	1	0	0	0	0
charge	832	8388607	8388607	8388607	8388607
max_peak	39	16383	16383	16383	16383
time_peak	16	511	511	511	511
time_pulse	69	511	511	511	511
time_pulse_ob	126	1023	1023	1023	1023
peak_ub	3	15	15	15	15
peak_ob	2	15	15	15	15



TP	0	1	2	3	4
DA	0	0	0	0	0
charge	0	0	0	0	0
max_peak	0	0	0	0	0
time_peak	0	0	0	0	0
time_pulse	0	0	0	0	0
time_pulse_ob	0	0	0	0	0
peak_ub	0	0	0	0	0
peak_ob	0	0	0	0	0

- The trigger primitive's generator module is still under test using cosmic runs.
- The first test yielded results where the module was not synchronous with the main self-trigger, randomly assigning primitives values to waveforms.
- This issues were addressed and currently the module is synchronous, and primitives are being correctly calculated for the first peak.
- The latest test results showed that the module has problems calculating subsequent peaks due to the undershoot behavior and on occasions returns no primitives for a clear triggered signal.
- We addressed these issues by modifying the state machine and we will continue to evaluate the performance of the module.

Conclusions

- The selftrigger runs comprises of over 600 runs.
- This preliminary analysis has been done in MATLAB by importing the data in a pickle format. To analyze over 600, we will port our analysis code to Waffles to have a more native environment ready to go for NP02, where we intend to repeat these tests.
- The process of migrating could take at least 2 weeks.
- Channel 17 of APA 3 was analyzed, confirming that the datataking was successful in terms of producing relevant data. (A lot of effort was poured into stabilizing the system for long duration runs where the system was booting and doing shutdowns every 3 minutes).
- We obtained lower figures of merit compared to laboratory test. This is attributed to the presence of high background rate affecting the recovery time of the internal filters issuing the trigger signals.
- The trigger primitives is still under test, latest cosmic runs (yesterday) confirmed that primitives are correctly calculated for the first peak, while failing to calculate subsequent ones due to undershoot behavior of the signals. Moreover, in certain occasions, the generator fails for clear signals. This issues where addressed and we schedule to make another run today or tomorrow.
- A possibility to test the system compensating the undershoot could confirm that indeed this is the issue (signal undershoot) at hand, while also having a confirmation of the methodology to eliminate the undershoot (undershoot compensation).