NP04 Status Update

On behalf of NP04 PDS team

People at CERN this week: Renan, Julio, Anna, Anselmo, Alessandro and Manuel

with help and support from: Laura, Carlos, Michaela Esteban, Federico and Daniel

09/07/2024

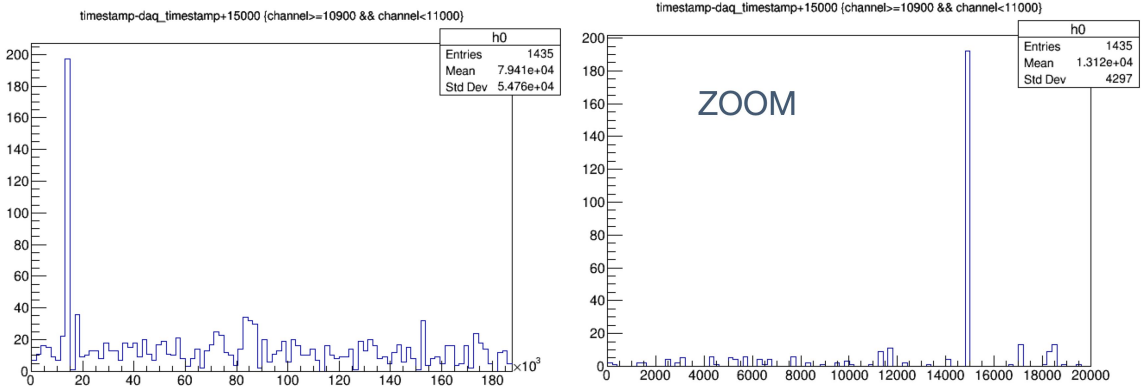
Overview

- Beam is resuming tomorrow at 18:00
- **Threshold**: it has been reduced considerably during the last two weeks, and DAQ errors have been eliminated. The **multilink** for the self trigger is still an option, but less critical than before
- **Calibration**: first full pass has been completed, with proper LED illumination for all 160 modules and scan over OV (slides later)
- **Self trigger**: well advance efficiency analysis (slides later)
- **Waveform Analysis:**
  - Waffles framework getting mature to democratise the analysis
  - First Deconvolution method implemented in waffles (slides later)
  - Ongoing gain analysis (all data available) (slides later)
  - Dynamic range analysis starting tomorrow
  - No time to look at beam data yet (only few plots in next slide)
  - Redo tau slow analysis with newer runs
  - Start with Bi source analysis
- **Higher level analysis**:
  - Definitely need to start transition to offline analysis within LArSoft and better coordinate with PDS DRA group !!!!

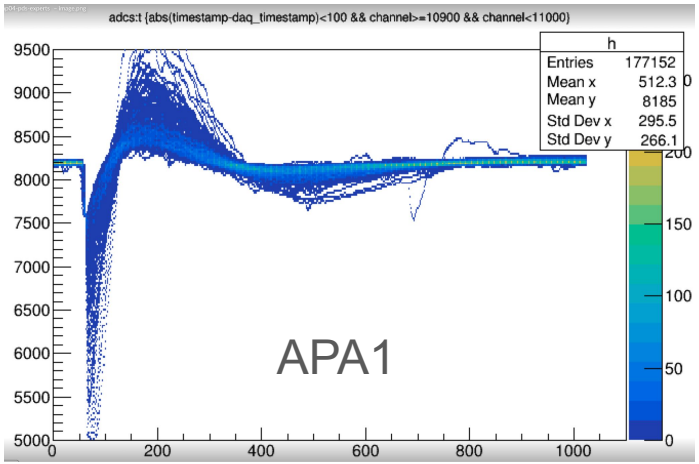
We urgently need more analysers !!!

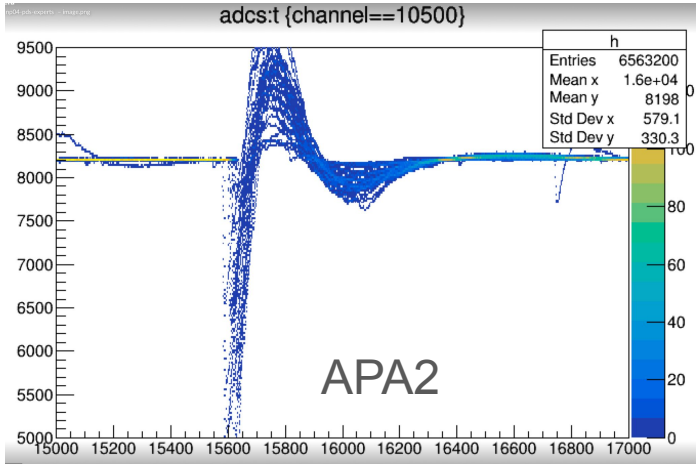
7 GeV Beam data

Time stamp in APA2



Beam waveforms





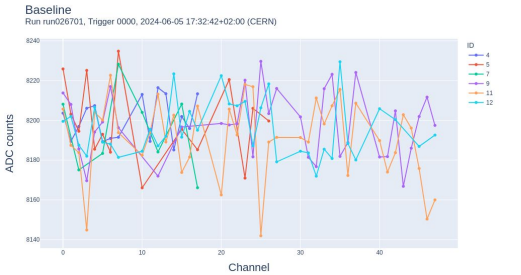
Monitoring of the FELIX senders, FIFOs and trigger rates

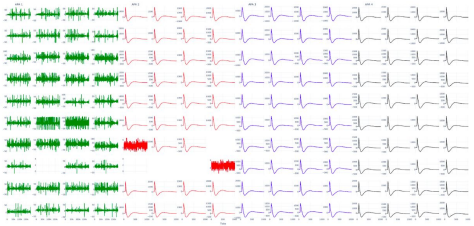
Thanks Carlos, Manuel, Marco !

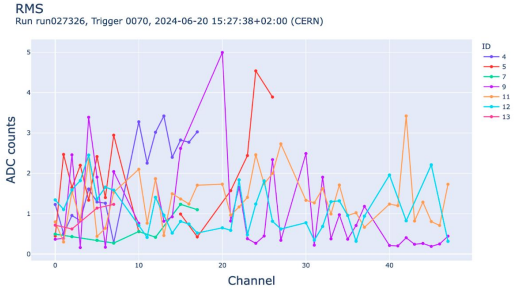
Data Quality Monitoring

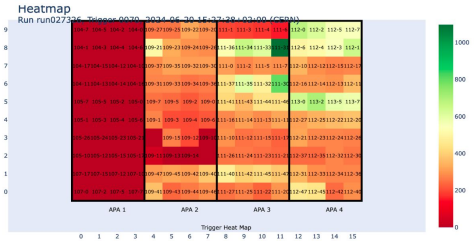
Tool for check that the data we are acquiring is ok → [DQM plots] + [Shifter checking list]

DQM Plots used during the first beam week:



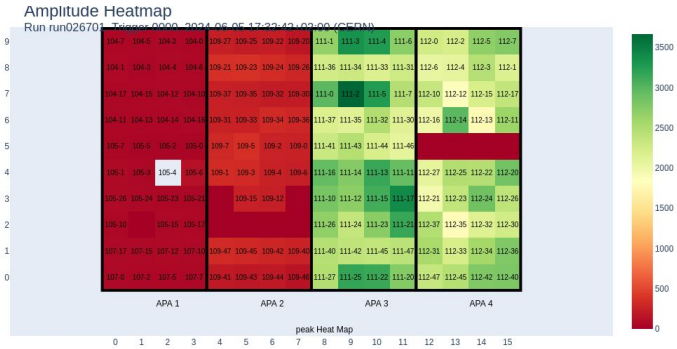






Updates for the next beam:

- Problematic channels were removed;
- Implementation of another heat map, to monitor the maximum amplitude of the mean waveform in each channel:



Thanks Renan!

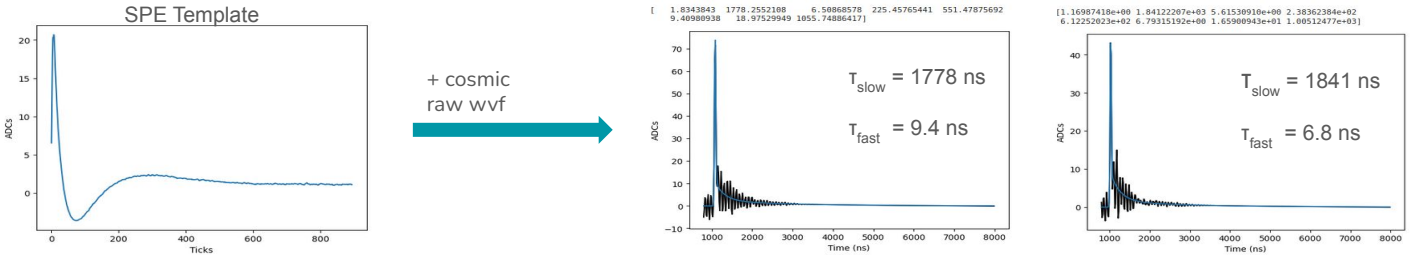
Deconvolution

- **Method:**

1. Compute one template per channel → Average waveform of multiple p.e on the s.p.e scale;
2. Deconvolution: ratio between the ffts of the signal and the template;
3. Application of filters for a better result and computation of the inverse fft;
4. Fit model (under testing):

$$fit = \frac{A_S}{\sqrt{2}} e^{\frac{\sigma^2}{2\tau_S}} \mathrm{Erfc}\left(\frac{t-t_0}{\sigma} + \frac{\sigma}{\tau_S}\right) e^{\frac{t-t_0}{\tau_S}} + \frac{A_I}{\sqrt{2}} e^{\frac{\sigma^2}{2\tau_I}} \mathrm{Erfc}\left(\frac{t-t_0}{\sigma} + \frac{\sigma}{\tau_I}\right) e^{\frac{t-t_0}{\tau_I}} + \frac{A_F}{\sqrt{2}} e^{\frac{\sigma^2}{2\tau_F}} \mathrm{Erfc}\left(\frac{t-t_0}{\sigma} + \frac{\sigma}{\tau_F}\right) e^{\frac{t-t_0}{\tau_F}}$$

- Example: 2 records of run 026071: endpoint 111 and channel 45 → Cosmics

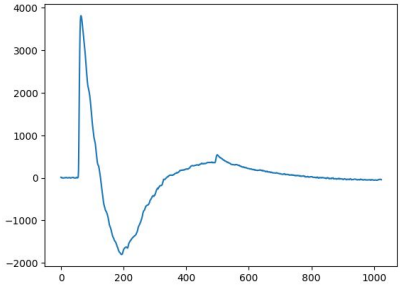


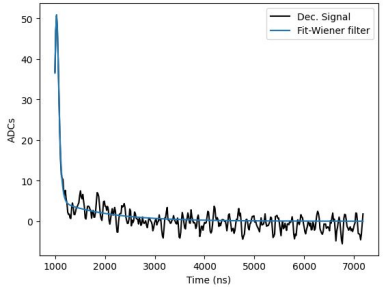
** Black: result from the deconvolution process; blue: fitting

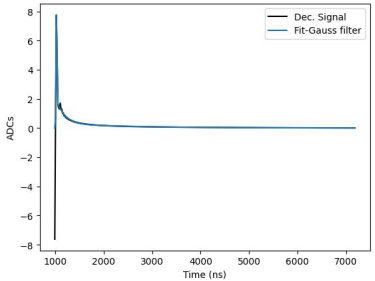
Thanks Renan!

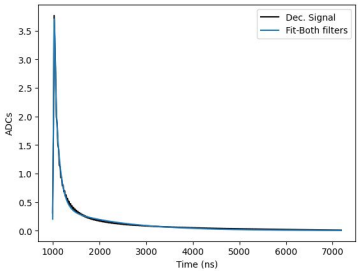
Deconvolution - Methods Comparison

Run 26701: a single waveform on endpoint 111 and channel 20:









Average result for the deconvolution of channel 20:

Method	τs (ns)	error τs (ns)	τf (ns)	error τf (ns)	τi (ns)	error τi (ns)
No Filter	1095	81	7.09	1.18e+05	30.5	5.2e+04
Wiener	1083	24	6.09	1.25e+06	40.3	2.2e+03
Gaussian	1426	293	6.09	1.41e+05	114.5	7.1e+04
Both Filters	1416	11	7.07	1.13	126.9	0.8

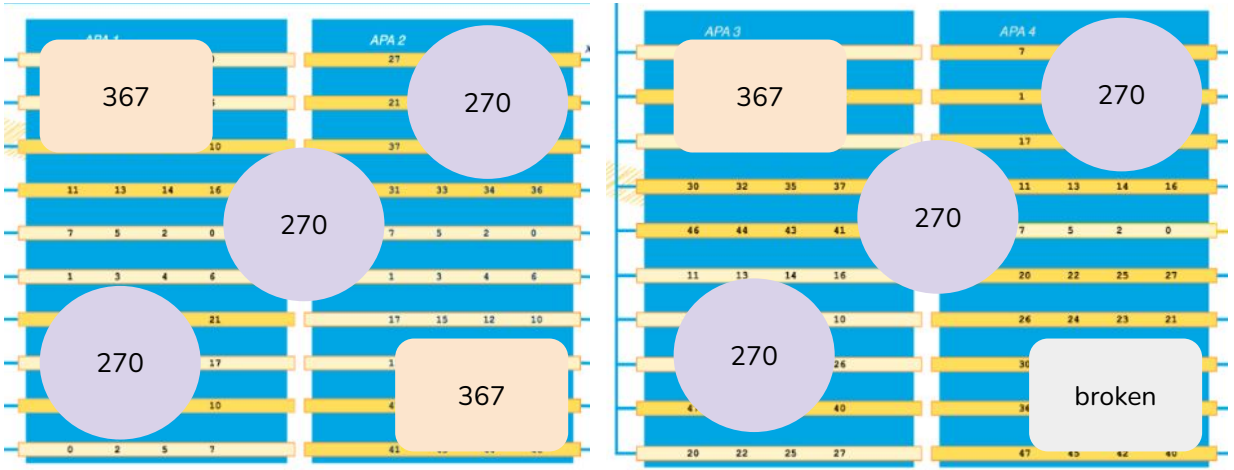
To do list:

- Finish to compute the templates for APAs 2 and 4
- “Improve” the gaussian method filter
- Apply it on WAFFLES

Thanks Renan!

SPE Calibration

Details on how to turn the LEDs for calibrating → here



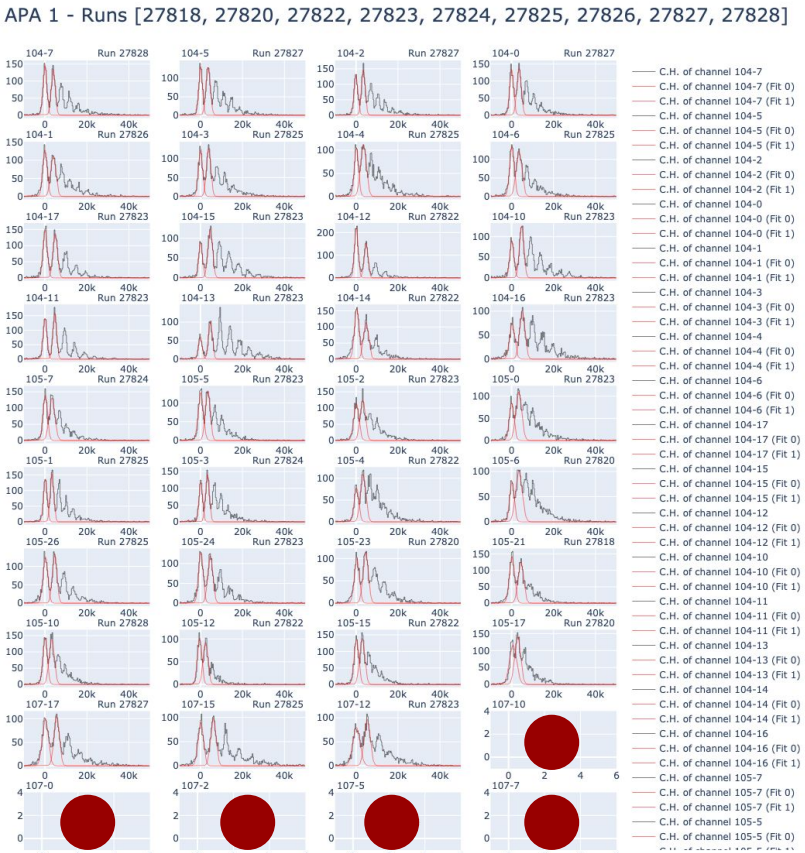
Based on the results which were presented on 20/06 NP04 PDS operation meeting,

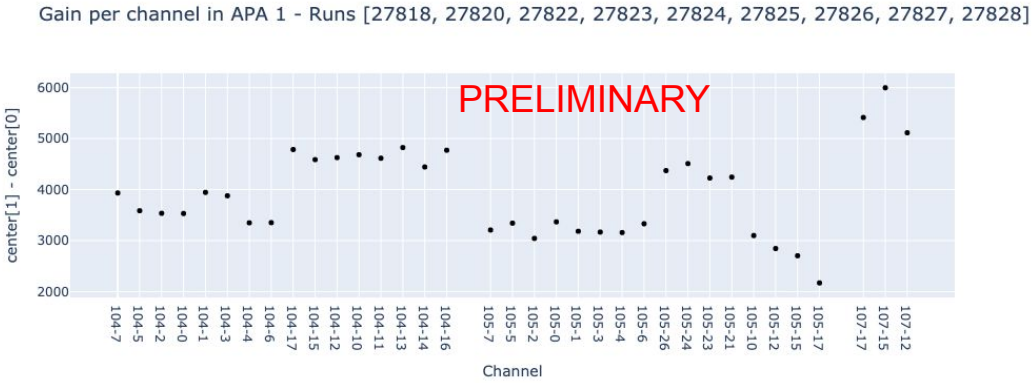
- 8 calibration runs `(27562-27569)` were taken for APAs 3 and 4
  - 4 runs with centered LED (`channel_mask = 1, ticks_width = 1, pulse_bias_percent_270nm = 1400, 1600, …, 2000`)
  - 4 runs with corner LEDs (`channel_mask = 12, ticks_width = 1, pulse_bias_percent_270nm = 1400, 1600, …, 2000`)
- 9 calibration runs `(27818, 27820, 27822-27828)` were taken for APAs 1 and 2
  - All of them with the three LED on the secondary diagonal ON (`channel_mask = 50, ticks_width = 20, pulse_bias_percent_270nm = 1200, 1400, …, 2800`)

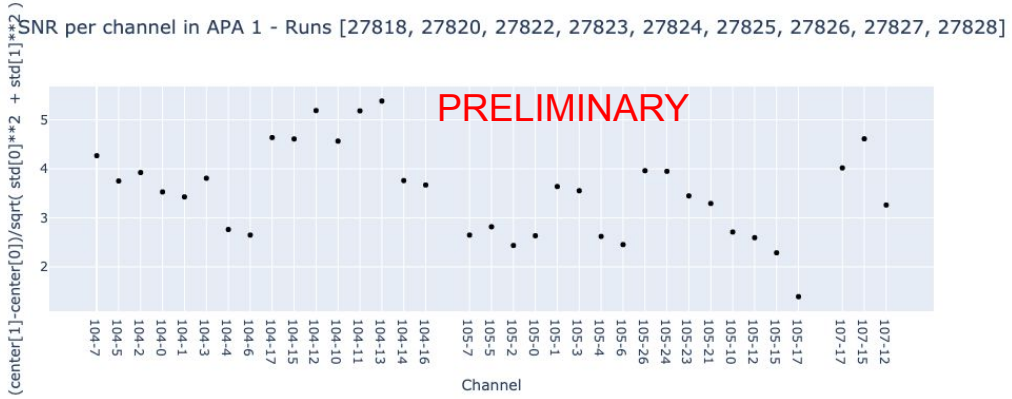
Thanks Laura and Julio!

SPE Calibration: APA 1

In APA1, to overcome full-streaming problem, Use ad-hoc trigger to open 16 ms DAQ window in synchronization with LED





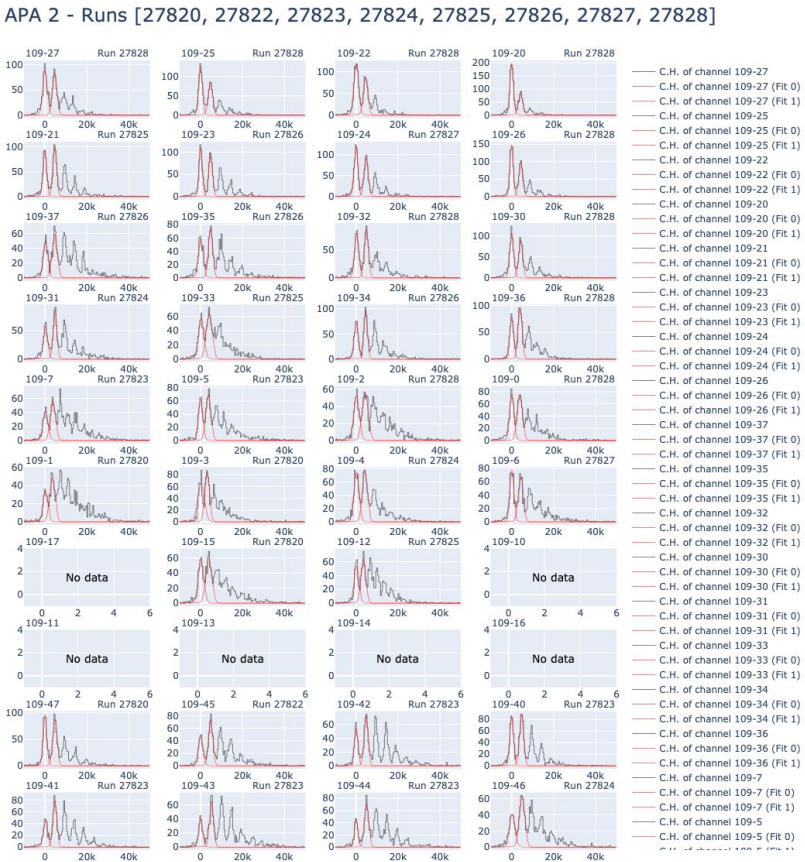


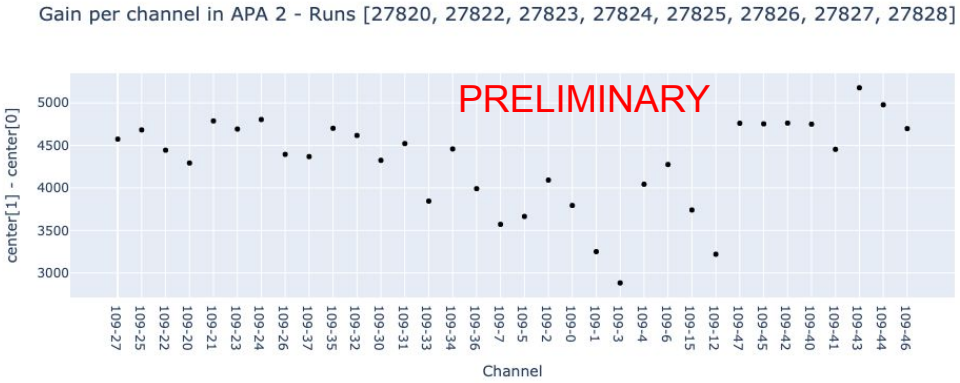
noisy channels

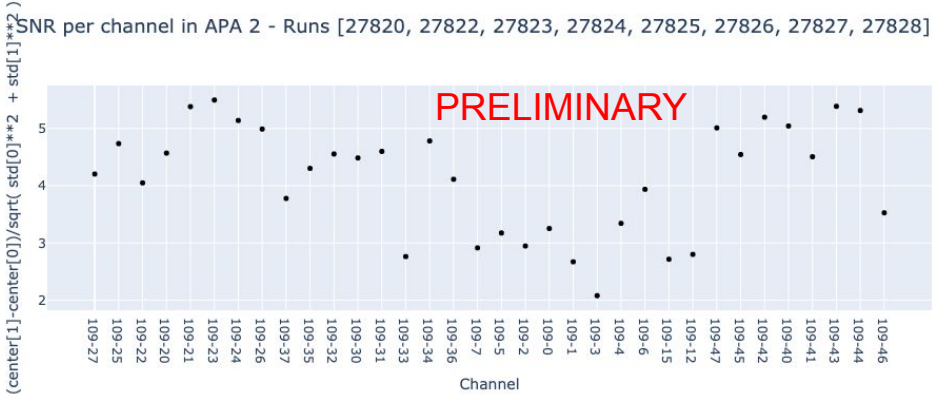
Thanks Julio!

SPE Calibration: APA 2

In all other APAs, use ad-hoc trigger to readout DAPHNE in synchronization with LED, within the 20 Hz DAQ window



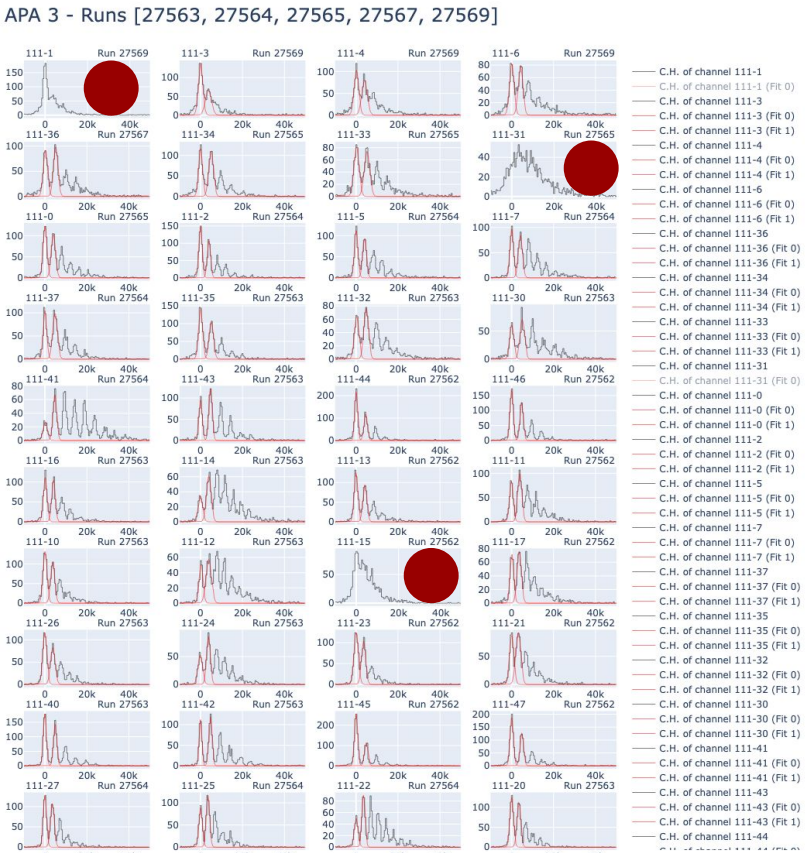


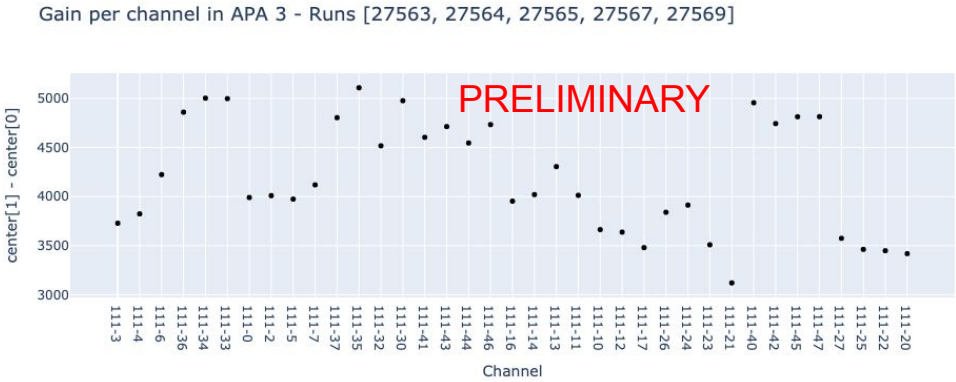


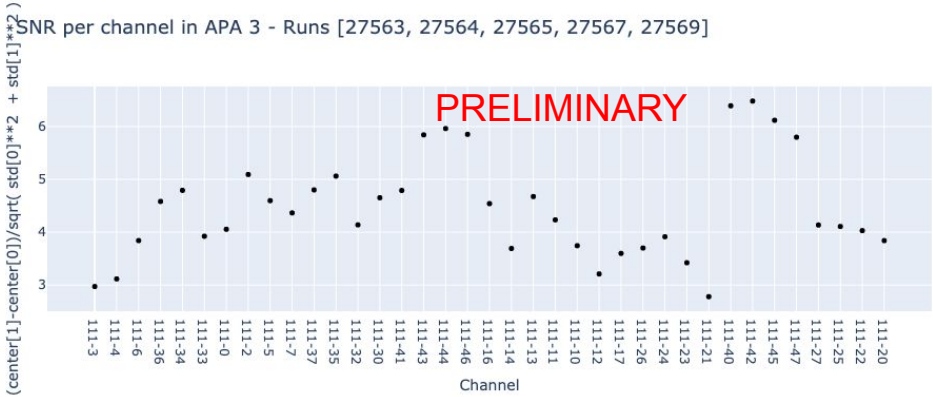
noisy channels

Thanks Julio!

SPE Calibration: APA 3



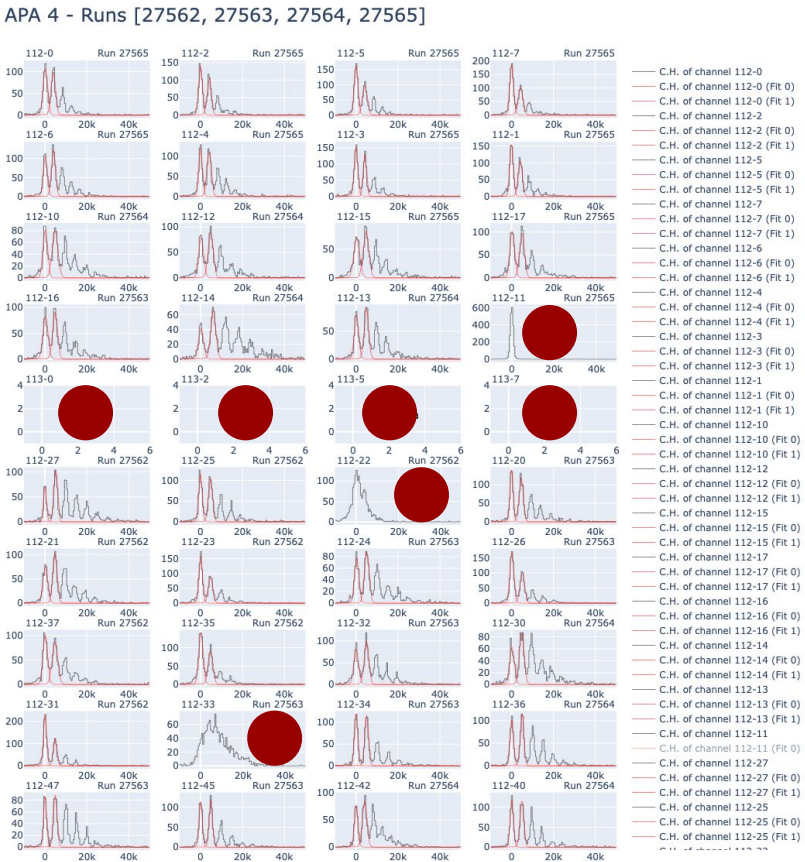


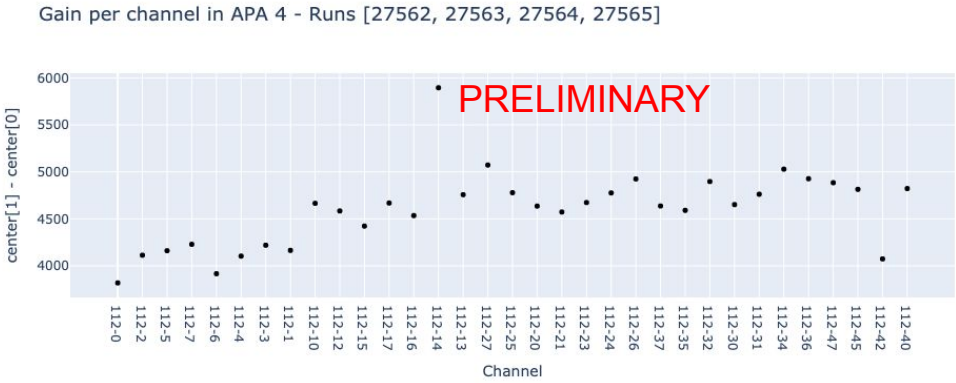


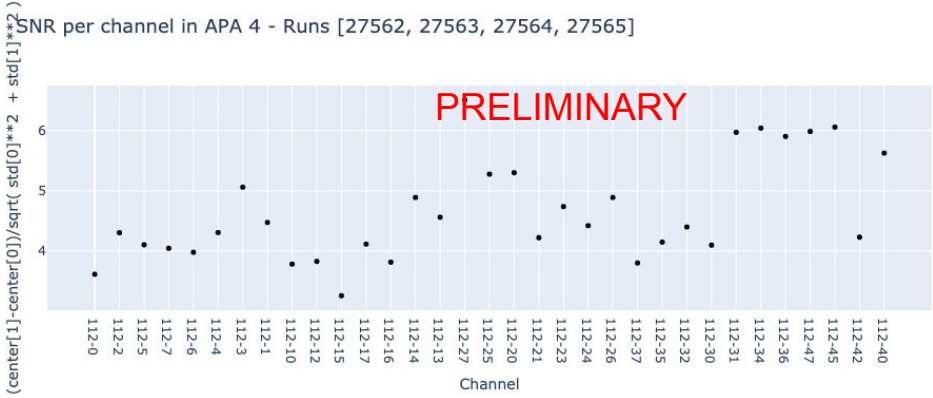
noisy channels

Thanks Julio!

SPE Calibration: APA 4







noisy channels

Thanks Julio!

SPE Calibration

- The format of the entries for these tables is (`channel_mask`, `ticks_width`, `pulse_bias_percent_270nm`).
- Channels which have a '`N-`' are noisy channel (some of them include a guess of what light intensity would allow a calibration in a no-noise case)
- 4 different LED configurations for APAs 1 & 2
- Another 4 different LED configs. for APAs 3 & 4
- There is a finer version here which encompasses 9 (resp. 7) different LED configurations for APAs 1 & 2 (resp. 3 & 4)

APA1 (coarse)			
(50, 20, 2800)	(50, 20, 2800)	(50, 20, 2800)	(50, 20, 2800)
(50, 20, 2800)	(50, 20, 2200)	(50, 20, 2200)	(50, 20, 2200)
(50, 20, 1800)	(50, 20, 1800)	(50, 20, 1800)	(50, 20, 1800)
(50, 20, 1800)	(50, 20, 1800)	(50, 20, 1800)	(50, 20, 1800)
(50, 20, 2200)	(50, 20, 1800)	(50, 20, 1800)	(50, 20, 1800)
(50, 20, 2200)	(50, 20, 1800)	(50, 20, 1400)	(50, 20, 1400)
(50, 20, 2200)	(50, 20, 1800)	(50, 20, 1400)	(50, 20, 1400)
(50, 20, 2800)	(50, 20, 1800)	(50, 20, 1800)	(50, 20, 1400)
(50, 20, 2800)	(50, 20, 2200)	(50, 20, 1800)	N
N	N	N	N

APA2 (coarse)			
(50, 20, 2800)	(50, 20, 2800)	(50, 20, 2800)	(50, 20, 2800)
(50, 20, 2200)	(50, 20, 2200)	(50, 20, 2800)	(50, 20, 2800)
(50, 20, 2200)	(50, 20, 2200)	(50, 20, 2800)	(50, 20, 2800)
(50, 20, 1800)	(50, 20, 2200)	(50, 20, 2200)	(50, 20, 2800)
(50, 20, 1800)	(50, 20, 1800)	(50, 20, 2200)	(50, 20, 2600)
(50, 20, 1400)	(50, 20, 1400)	(50, 20, 2200)	(50, 20, 2800)
dead	(50, 20, 1400)	(50, 20, 2200)	dead
dead	dead	dead	dead
(50, 20, 1400)	(50, 20, 1400)	(50, 20, 1800)	(50, 20, 1800)
(50, 20, 1800)	(50, 20, 1800)	(50, 20, 1800)	(50, 20, 1800)

APA3 (coarse)			
> (12, 1, 2000)	> (12, 1, 2000)	> (12, 1, 2000)	(12, 1, 2000)
(12, 1, 2000)	(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)
(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)
(1, 1, 1800)	(1, 1, 1600)	(1, 1, 1600)	(1, 1, 1600)
(1, 1, 1800)	(1, 1, 1600)	(1, 1, 1400)	(1, 1, 1400)
(1, 1, 1600)	(1, 1, 1600)	(1, 1, 1400)	(1, 1, 1400)
(1, 1, 1600)	(1, 1, 1600)	N - (1, 1, 1400)	(1, 1, 1400)
(1, 1, 1600)	(1, 1, 1600)	(1, 1, 1400)	(1, 1, 1400)
(1, 1, 1600)	(1, 1, 1600)	(1, 1, 1400)	(1, 1, 1400)
(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1600)

APA4 (coarse)			
(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)
(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)
(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)
(1, 1, 1600)	(1, 1, 1800)	(1, 1, 1800)	(1, 1, 1800)
N	N	N	N
(1, 1, 1400)	(1, 1, 1400)	N - (1, 1, 1400)	(1, 1, 1600)
(1, 1, 1400)	(1, 1, 1400)	(1, 1, 1600)	(1, 1, 1800)
(1, 1, 1400)	(1, 1, 1400)	(1, 1, 1600)	(1, 1, 1800)
1, 1, 1400)	N - (1, 1, 1400)	(1, 1, 1600)	(1, 1, 1800)
(1, 1, 1600)	(1, 1, 1600)	(1, 1, 1800)	(1, 1, 1800)

Thanks Julio!

Overvoltage scan

- LED-intensity vs overvoltage scanning done **today** →[RUN LIST]
- (4 led conf) x (3 OV) x (2 APA groups) = 24 runs

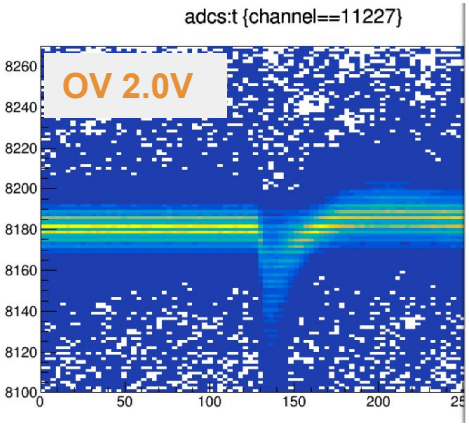
	PDE 40%	PDE 45%	PDE 50%
OV [V] HPK	2.0	2.5	3.0
OV [V] FBK	3.5	4.5	7.0

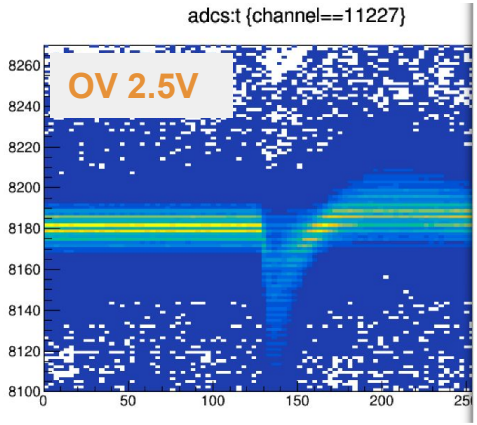
OVERVOLTAGE+INTENSITY Calibration Runs APAs 12.

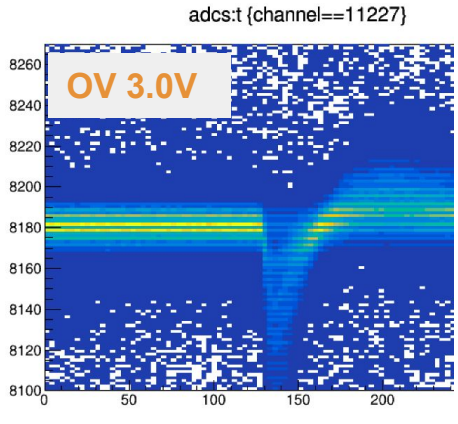
						Calibration Run. Bias DCS:30V. Tests 270nm: SSP_config. pulse_mode:single, mask_channel:50, ticks_width:20, **Pulse_bias_percent_270nm:1400-2800.** Trigger_ad-hoc 0x7:20Hz. 20Hz daq triger_rate.
27898	09/07/2024	10:20	180 s	acervera	104,105,107,109	**OV = HPK_2_FBK_3.5. 1400**
27899	09/07/2024	10:24	180 s	acervera	104,105,107,109	OV = HPK_2_FBK_3.5. **1800**
27900	09/07/2024	10:29	180 s	acervera	104,105,107,109	OV = HPK_2_FBK_3.5. **2200**
27921	09/07/2024	12:03	180 s	acervera	104,105,107,109	OV = HPK_2_FBK_3.5. **2800.** Notice this run was taken after all others in APAs 34
27901	09/07/2024	10:34	180 s	acervera	104,105,107,109	**OV = HPK_2.5_FBK_4.5. 2800.** Run with OV = HPK_2.5_FBK_4.5 by mistake
27902	09/07/2024	10:40	180 s	acervera	104,105,107,109	OV = HPK_2.5_FBK_4.5. **1400**
27903	09/07/2024	10:45	180 s	acervera	104,105,107,109	OV = HPK_2.5_FBK_4.5. **1800**
27904	09/07/2024	10:50	180 s	acervera	104,105,107,109	OV = HPK_2.5_FBK_4.5. **2200**
27905	09/07/2024	10:55	180 s	acervera	104,105,107,109	**OV = HPK_3_FBK_7. 1400**
27906	09/07/2024	11:01	180 s	acervera	104,105,107,109	OV = HPK_3_FBK_7. **1800**
27907	09/07/2024	11:06	180 s	acervera	104,105,107,109	OV = HPK_3_FBK_7. **2200**
27908	09/07/2024	11:11	180 s	acervera	104,105,107,109	OV = HPK_3_FBK_7. **2800**

OVERVOLTAGE+INTENSITY Calibration Runs APAs 34.

						Calibration Run. Bias DCS:30V. Tests 270nm: SSP_config. pulse_mode:single, **mask_channel:1,12,** ticks_width:1, **Pulse_bias_percent_270nm:1400-2000. Trigger_ad-hoc 0x7:6250Hz.** 20Hz daq triger_rate.
27909	09/07/2024	11:18	120 s	acervera	111,112,113	**OV = HPK_3_FBK_7. mask_channel=1. bias_%=1400**
27910	09/07/2024	11:22	120 s	acervera	111,112,113	OV = HPK_3_FBK_7. mask_channel=1. bias_%=**1600**
27911	09/07/2024	11:26	120 s	acervera	111,112,113	OV = HPK_3_FBK_7. mask_channel=1. bias_%=**1800**
27912	09/07/2024	11:32	120 s	acervera	111,112,113	OV = HPK_3_FBK_7. **mask_channel=12**. bias_%=**2000**
27913	09/07/2024	11:39	60 s	acervera	111,112,113	**OV = HPK_2.5_FBK_4.5. mask_channel=1. bias_%=1400**
27914	09/07/2024	11:41	60 s	acervera	111,112,113	OV = HPK_2.5_FBK_4.5. mask_channel=1. bias_%=**1600**
27915	09/07/2024	11:44	60 s	acervera	111,112,113	OV = HPK_2.5_FBK_4.5. mask_channel=1. bias_%=**1800**
27916	09/07/2024	11:47	60 s	acervera	111,112,113	OV = HPK_2.5_FBK_4.5. **mask_channel=12**. bias_%=**2000**
27917	09/07/2024	11:50	60 s	acervera	111,112,113	**OV = HPK_2_FBK_3.5. mask_channel=1. bias_%=1400**
27918	09/07/2024	11:53	60 s	acervera	111,112,113	OV = HPK_2_FBK_3.5. mask_channel=1. bias_%=**1600**
27919	09/07/2024	11:56	60 s	acervera	111,112,113	OV = HPK_2_FBK_3.5. mask_channel=1. bias_%=**1800**
27920	09/07/2024	11:59	60 s	acervera	111,112,113	OV = HPK_2_FBK_3.5. **mask_channel=12**. bias_%=**2000**







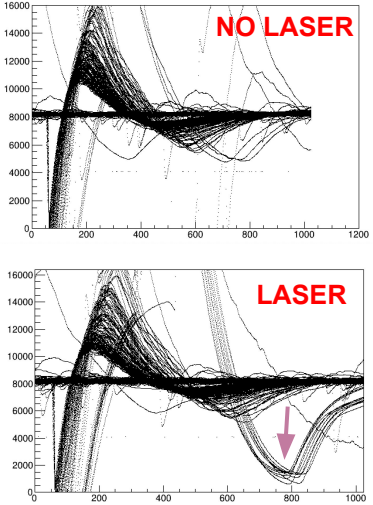
Laser tests

- There is a plan to use Ionization laser for PDS calibration purposes: i.e. light yield map
  - 1064 nm class-4 laser with main harmonics at 532 and 266 nm.
    - 266 nm light is the one used to create an artificial ionization track
    - 1064 nm light is minimized with proper band pass filters.
    - 532 nm is kept with a dual band pass filter since a class three green laser is used for alignment purposes
- Last week the first tests were done (many thanks to David, Jose and Wallison)
  - Class 4 laser at minimum intensity pulsed at 10 Hz
  - Class 3 green laser to understand effect of 532 harmonic

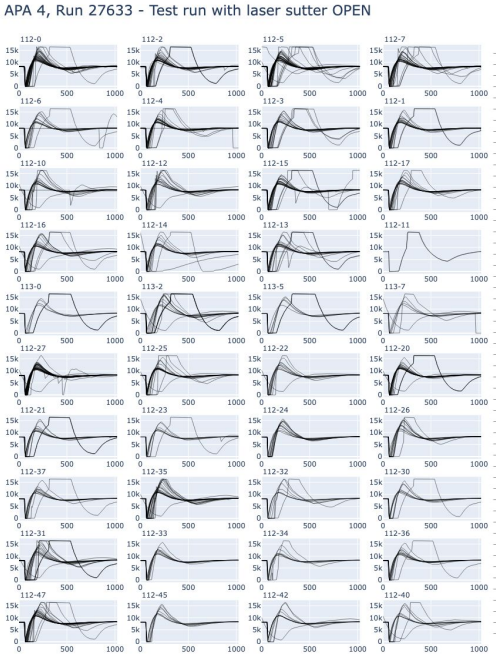
Thanks David!

Class 4 laser waveforms

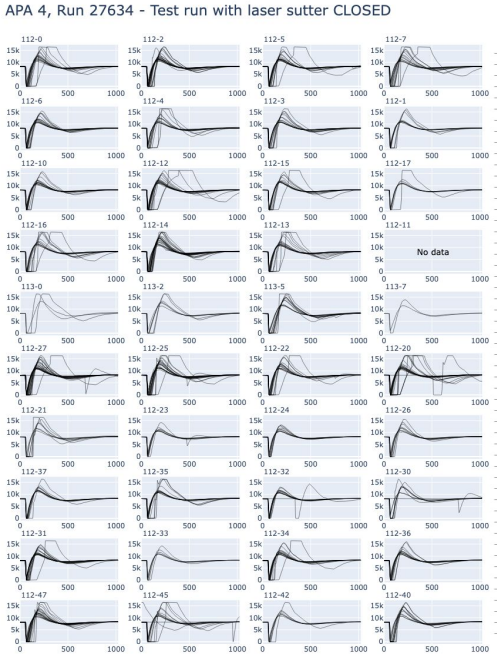
all channels



individual channels in APA4



LASER

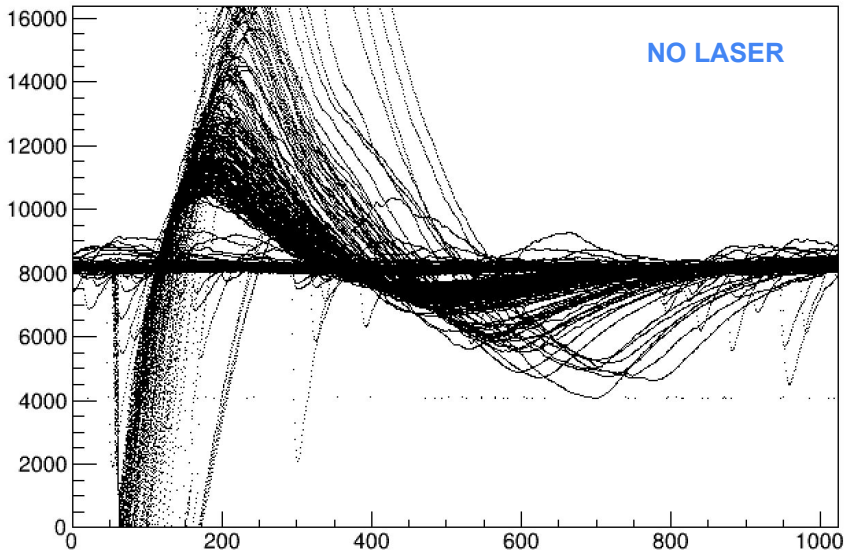


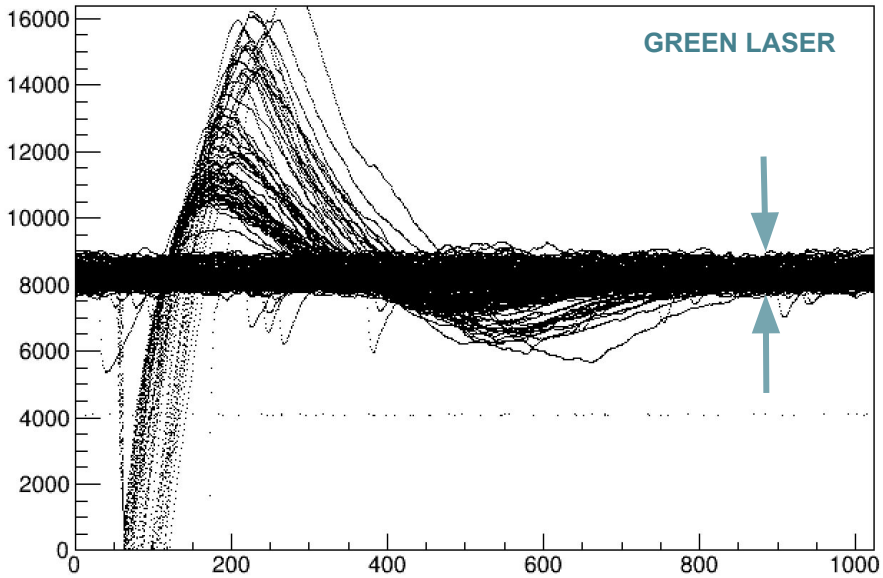
NO LASER

- Too much light even at minimum intensity
- This is expected to be due to scattering of the initial laser light, NOT scintillation light
  - Which harmonic is producing that PDS signal: 266 or 532 ? → Are we sensitive to 532 light → Test it with green laser

Thanks Julio!

Class 3 laser waveforms





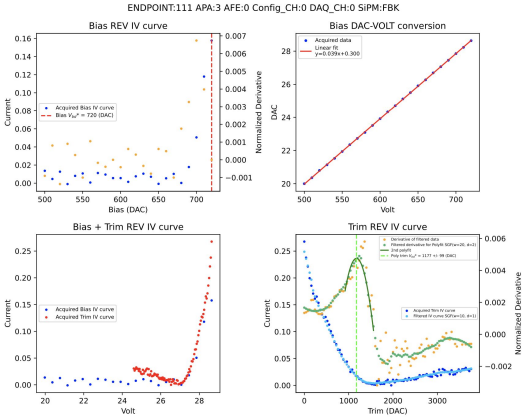
- Continues (no pulsed) light with much lower intensity
- PDS sees that light
- Next step will be to filter out the green light with the proper band pass filter
- Not obvious we can use IoL for the PDS but will keep trying !!!!!

Thanks David!

IV Status

We acquire IV curves weekly (last data from Jul-02-2024)

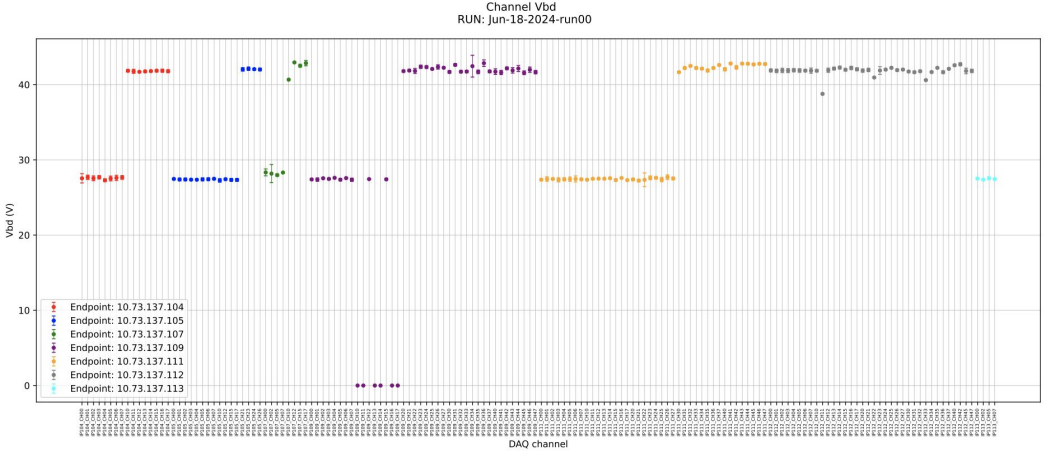
All tools for the IV analysis are ready (see PDS repository):



- *Vbd_determination.py* to determine Vbd of each channel
- *Vbd_quality.py* to verify if results of a given run are coherent with previous ones
- *Vbd_plot_single_run.py* to study the Vbd distribution in a given run

  - Only 6 disconnected channels
  - Channels of AFE0 E107 and AFE1 END109 are noisy and it's hard to determine Vbd
  - 4 channels have a low Vbd (we're investigating them, we noticed that they are characterized by a steep IV curve)

We're comparing these with CACTUS results

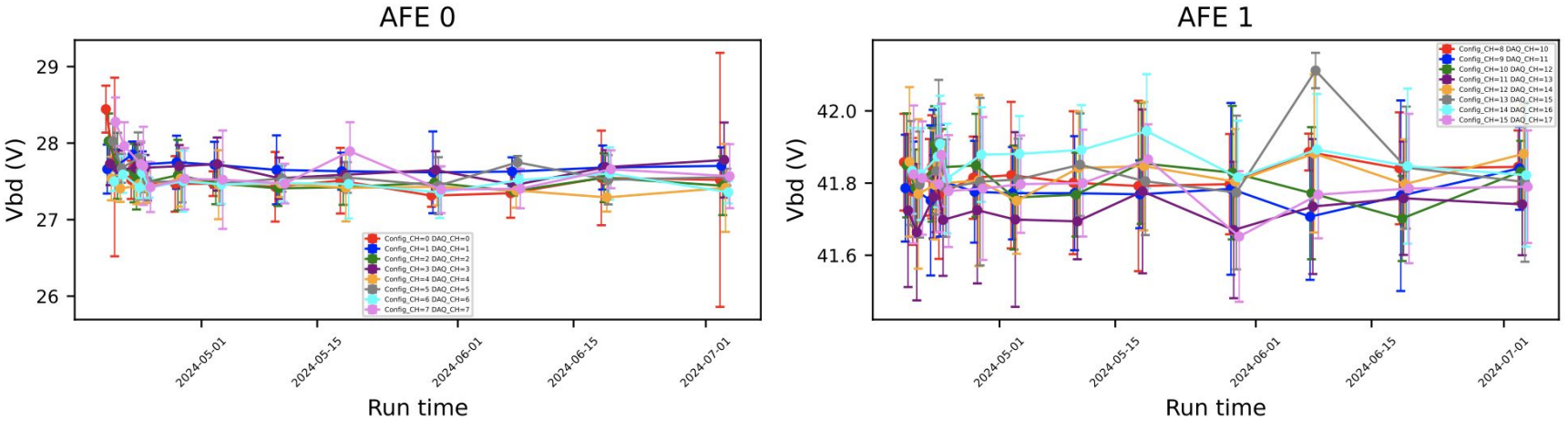


Thanks Anna!

- *Vbd_plot_all_run.py* to check the Vbd evolution in time

Constant behavior for all channels, do not consider Jul-02-2024-run00 and Jun-07-2024-run00 (noisy runs)

ENDPOINT:104



- *Vbd_best.py* to compute the mean value of Vbd by using good runs, for each channel.

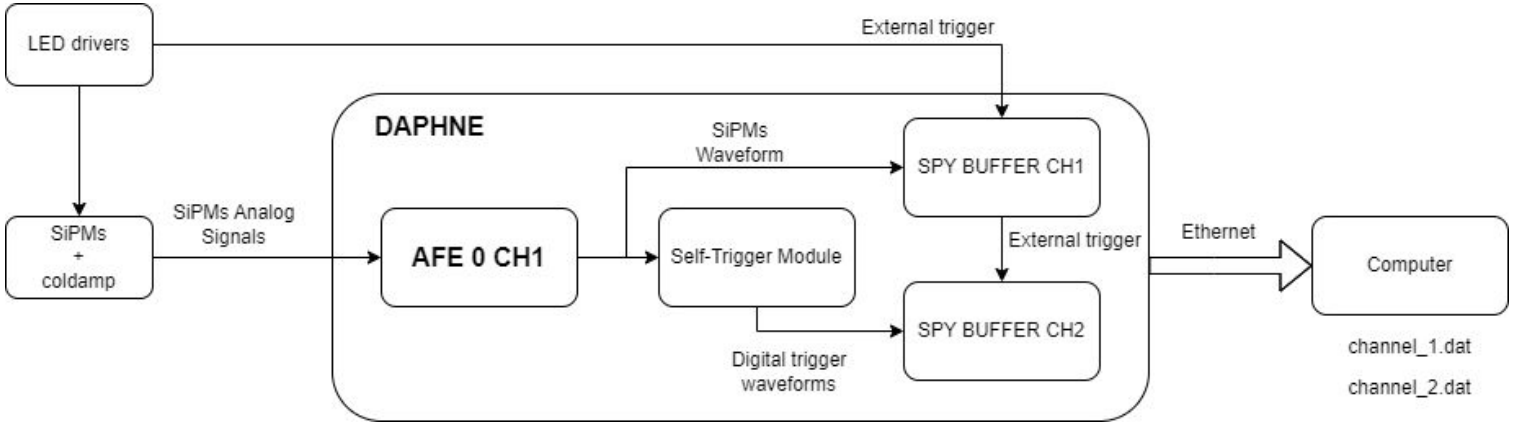
This is the best estimation we have for the breakdown voltage, and it will be used to compute Vop.

- *Vop_map.py* to create json maps with operation voltage, for Daphne configuration.

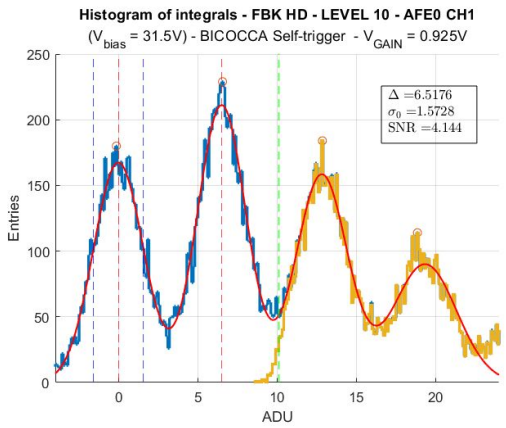
The operation voltage is given in terms of Bias and Trim DAC counts, where the bias is fixed for all channels of the same AFE.

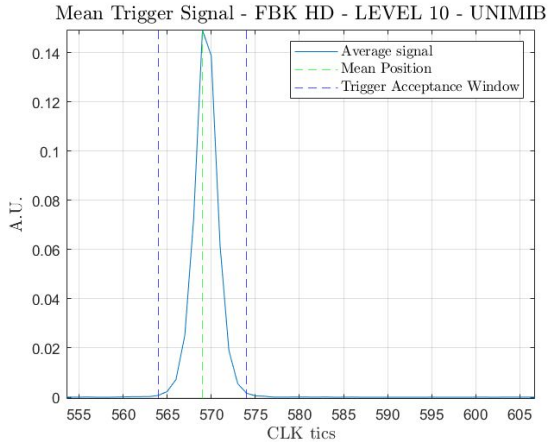
Thanks Anna!

Self-trigger tests at Milano-Bicocca



- Three algorithms are being tested: EIA, CIEMAT and UNIMIB.
- 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.

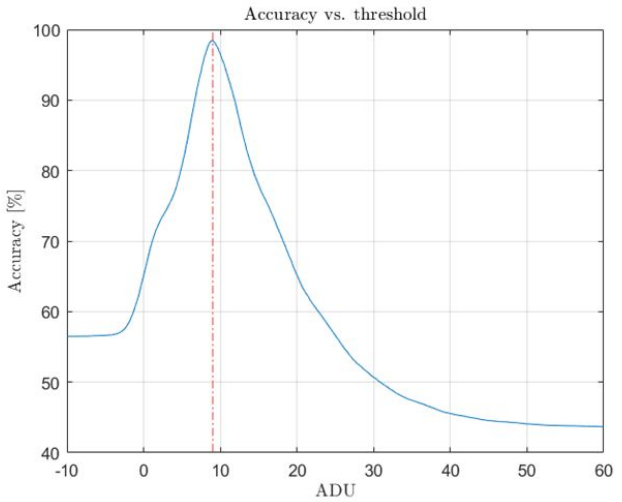




Thanks Esteban/Federico!

Self-trigger tests at Milano-Bicocca

- Main performance figure of merits are:
  - Accuracy
  - Trigger Jitter
  - False Positive Rate
  - True Positive Rate
- Each figure of merit is evaluated for different sets of the configurable sets of thresholds.
- We completed two runs:
  - For the first run the algorithms were not optimal and updated, serving as a test to develop the analysis tools..
  - The second run of the most updated versions finished last friday and we are in the process of analysis of the results.
- The nest steps are:
  - Test at NP04 to have a full comparison in real conditions.
  - Converge into a solution.



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

Thanks Esteban/Federico!

Plans for next two weeks

- Tomorrow at 18:00 beam is resumed, and we will have beam for two weeks
- There are plans to run mainly at +-1 GeV, and also some data at 5 GeV to explore kaon production. We can request a beam scan if needed.
- Few details in the firmware to be debugged:
    - Counters for daq statistics and bandwidth debugging were added (Carlos) and there are problems in some of them. New version being tested by Marco Roda
- Merge the MiB selftrigger into the main branch of the firmware. This will be used at some point during the next two weeks
- Apart of this, focus on the waveform analysis and in the connection with PDS DRA analysis

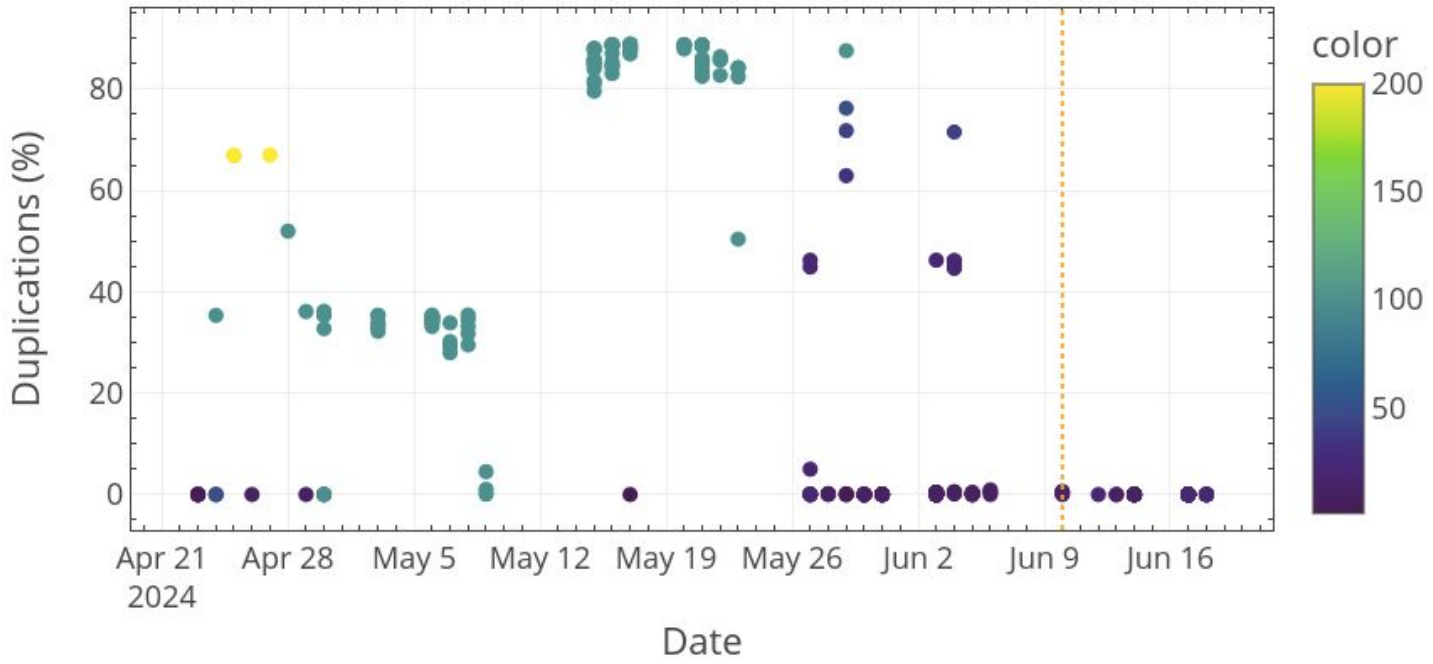
We urgently need more analysers !!!

A waffles tutorial could be organised for next week

BACKUP

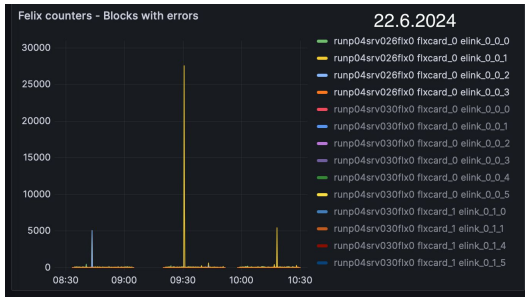
Duplications

Duplication problem solved by DAQ team in the new environment release (we do not see more repeated waveforms from ~10 June)

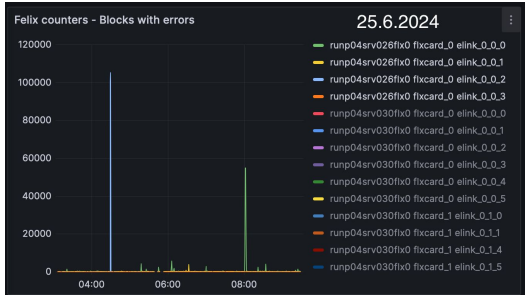


Trigger rate

- Beam run 27373 (22. 06. 2024) :
  - APA1 - 3.69 Gbps
  - APA2 - 0.43 Gbps
  - APA3 - 0.80 Gbps
  - APA4 - 0.75 Gbps
- Beam run 27412 (25.06. 2024):
  - APA1 - 3.69 Gbps
  - APA2 - 0.44 Gbps (↑ 0.01 Gbps)
  - APA3 - 0.82 Gbps (↑ 0.02 Gbps)
  - APA4 - 0.77 Gbps (↑ 0.02 Gbps)
- NON-beam run 27568 (30.06. 2024):
  - APA2 - 1.69 Gbps (↑ 1.25 Gbps)
  - APA3 - 1.69 Gbps (↑ 0.87 Gbps)
  - APA4 - 1.69 Gbps (↑ 0.92 Gbps)



max #errors ~ 27 000

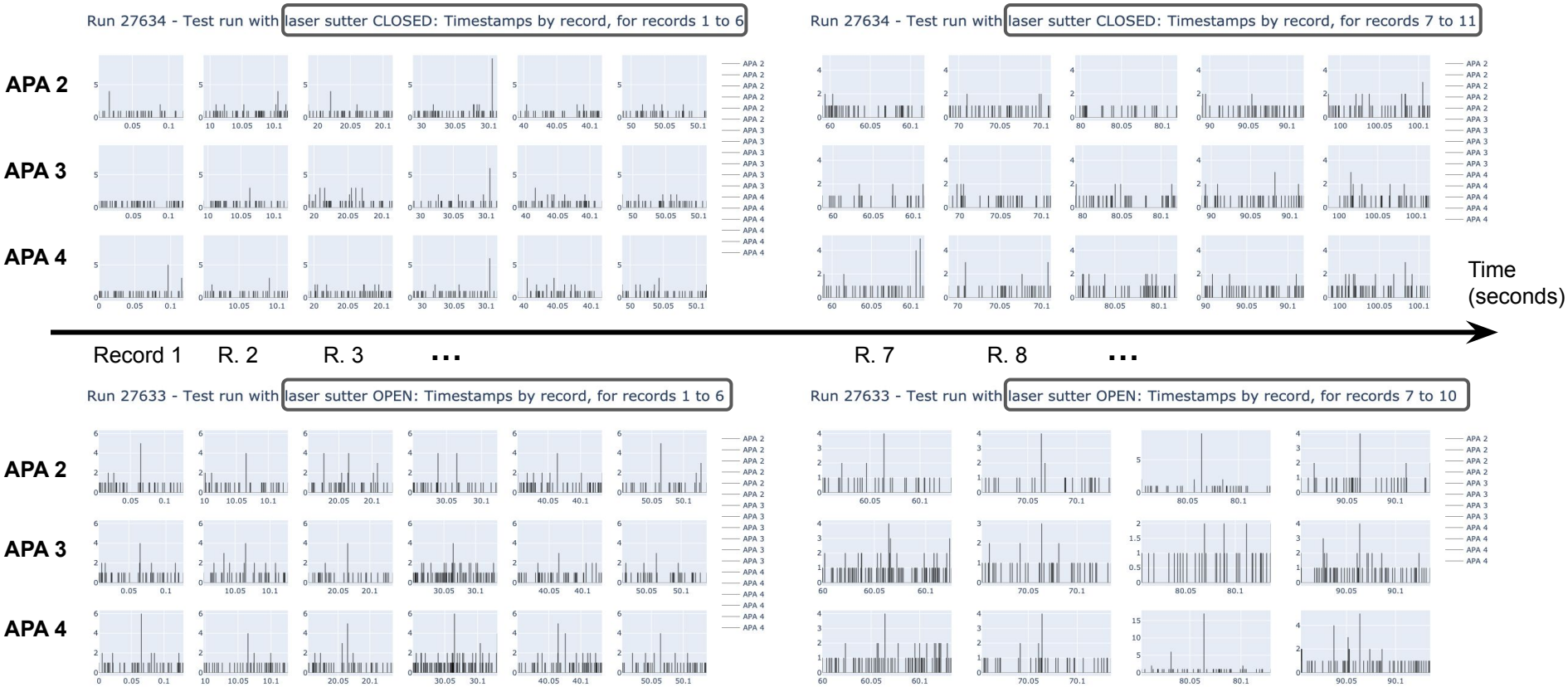


max #errors ~ 100 000

max #errors ~ 2

Thanks Michaela!

Class 4 laser coincidences



Thanks Julio!