NP04 PDS LED-calibration

NP04 PDS operation meeting - 07 November 2024

Julio Ureña

Introduction

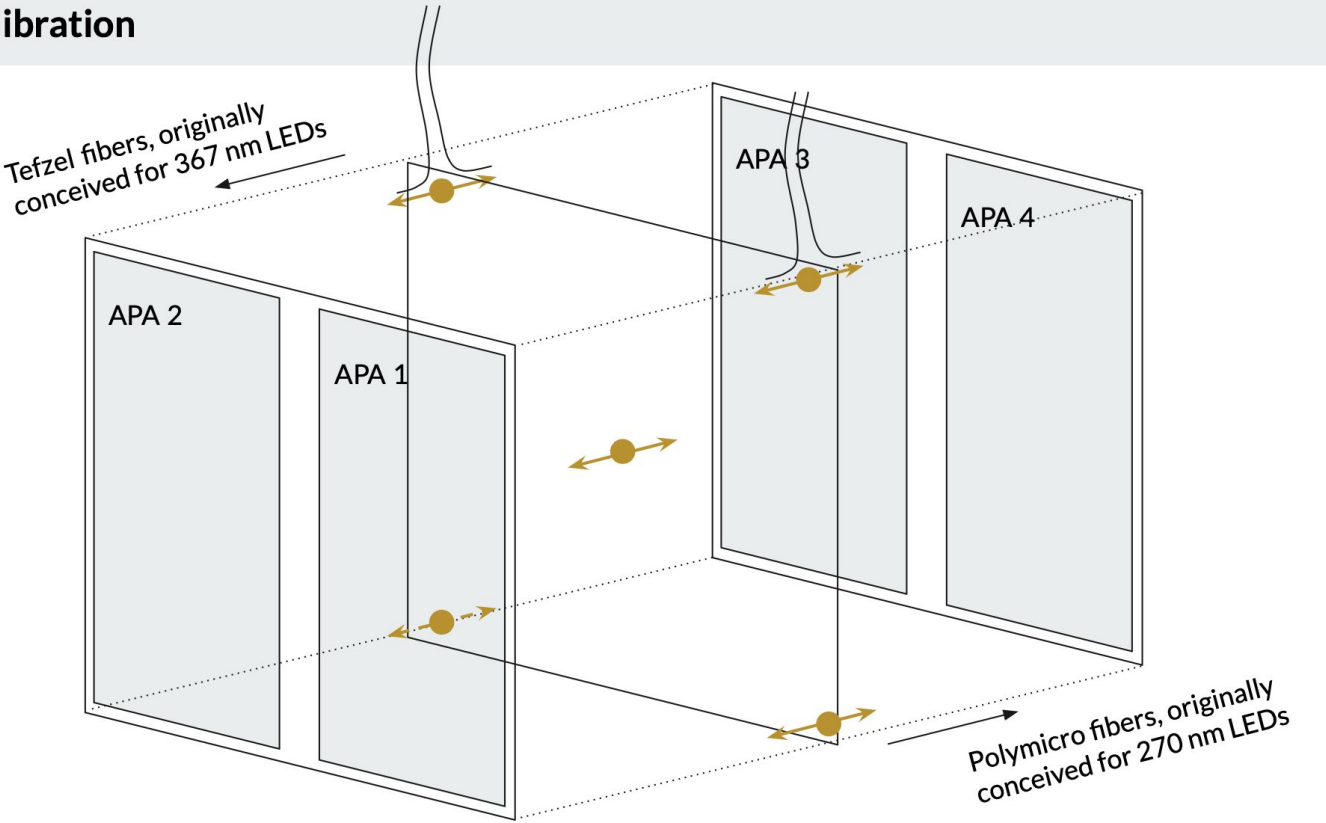
- On July 9, the first *standard* calibration data was taken for all 4 APAs and 3 different overvoltages/PDEs
- The data whose analysis results are presented in this presentation was acquired by Laura Pérez, Manuel Arroyave and Anselmo Cervera
- In total, >7 different calibration batches have been taken *[1]*. Only the first three have been analyzed.

2024/07/09	2024/07/26	2024/07/29-30	2024/08/13	2024/08/28	2024/09/14	2024/09/25
4 APAs, PDE scan: (0.4, 0.45, 0.5)	4 APAs, PDE scan: (0.4, 0.45, 0.5)	APAs 2-4, PDE scan: (0.4, 0.45, 0.5)	4 APAs, nominal PDE, V_gain scan: 0.9, 1.0, 1.1	4 APAs, nominal PDE	APAs 3 & 4, nominal PDE	APAs 2-4, PDE scan: (0.4, 0.45, 0.5)

- As of **2024/10/07** there are lots of LED runs acquired by Esteban C. including PDE- and Vgain-scans
- This analysis has been performed using Waffles *[2, 3]*

From 2024/09/12 talk in Santa Fe CM *See [6]*

LED calibration



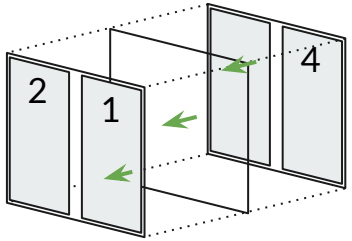
7

LED configurations *See [4]*

- The LED configuration format is
  `(channel_mask, ticks_width,` **`pulse_bias_percent_270nm`**`)`
- The third variable, which tunes the light intensity, is scanned
- As of batch 2, we are taking:
  - **APA 1**: 4 different LED configurations per PDE
  - **APA 2**: 6 " " " " "
  - **APAs 3&4**: 5 " " " " "
- It adds up to (4+6+5)x3 = 45 runs per calibration batch

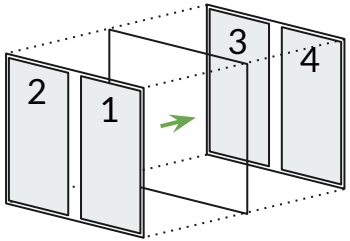
APAs 1 & 2

(4+6) `channel_mask = 50, ticks_width = 20`

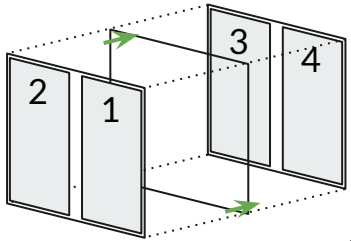


APAs 3 & 4

(3) `channel_mask = 1, ticks_width = 1`



(2) `channel_mask = 12, ticks_width = 1`

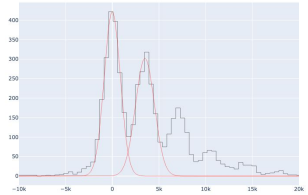


Data processing and analysis

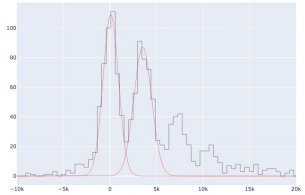
- One `WaveformSet` object per run is generated using `/src/waffles/np04_analysis/LED_calibration/batch_pickle_generator.ipynb`
- Ultimately, this notebook calls the HDF5 reader `/src/waffles/input/raw_hdf5_reader.py> WaveformSet_from_hdf5_file()`
- For each batch,
  - runs are mapped to its LED-configurations via `/src/waffles/np04_analysis/LED_calibration/calibration_batches/run_number_to_LED_configuration.py`
  - LED-configurations are mapped to specific APA-channels via `/src/waffles/np04_analysis/LED_calibration/calibration_batches/LED_configuration_to_channel.py`
  - excluded channels are specified via `/src/waffles/np04_analysis/LED_calibration/calibration_batches/excluded_channels.py`
- For each waveform,
  - Its baseline is computed as the median of the points for time ticks in [0, 100]U[900, 1000]
  - The baseline is subtracted from the waveform prior to integration from time tick 125 to 165
  - The code for these computations can be found in `/waffles/src/waffles/data_classes/BasicWfAna.py> analyse()`
- The set of integrals is histogrammed
- Each one of the first two peaks of the histogram are fit to a gaussian function (one gaussian per peak)
- Automatic identification and fit of the first two peaks is performed by `/src/waffles/utils/fit_peaks/fit_peaks.py> fit_peaks_of_CalibrationHistogram()`

Analysis example - APA 3, Channel 111-13

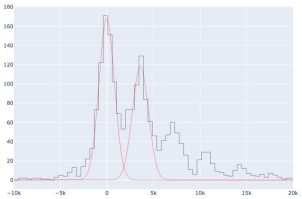
Batch 1, PDE 0.4



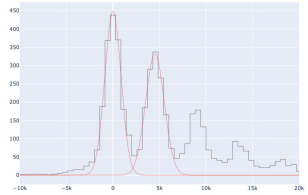
Batch 2, PDE 0.4



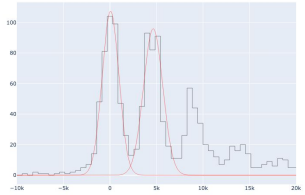
Batch 3, PDE 0.4



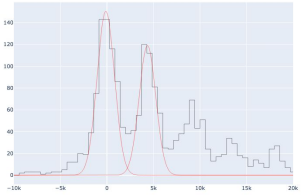
Batch 1, PDE 0.45



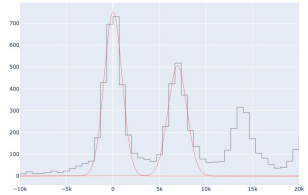
Batch 2, PDE 0.45



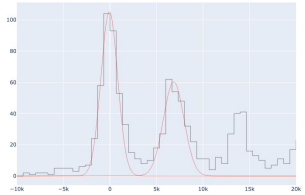
Batch 3, PDE 0.45



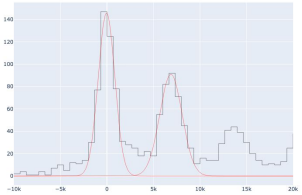
Batch 1, PDE 0.5



Batch 2, PDE 0.5



Batch 3, PDE 0.5

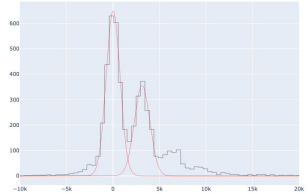


Gain for channel 111-13 in APA 3

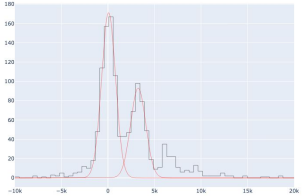
$$E = \sqrt{\sigma_{\mu_0}^2 + \sigma_{\mu_1}^2}$$

Analysis example - APA 4, Channel 112-0

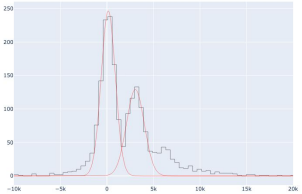
Batch 1, PDE 0.4



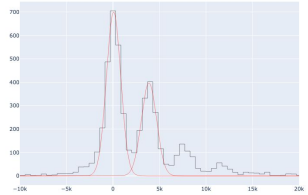
Batch 2, PDE 0.4



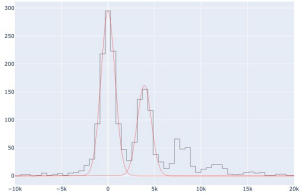
Batch 3, PDE 0.4



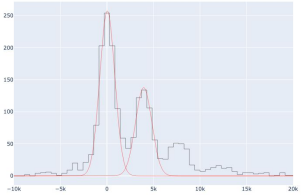
Batch 1, PDE 0.45



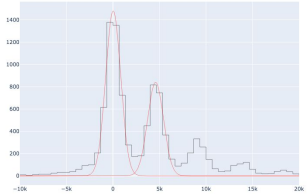
Batch 2, PDE 0.45



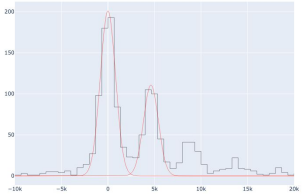
Batch 3, PDE 0.45



Batch 1, PDE 0.5



Batch 2, PDE 0.5



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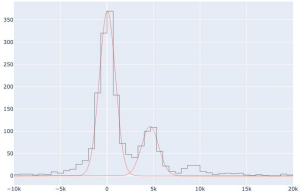
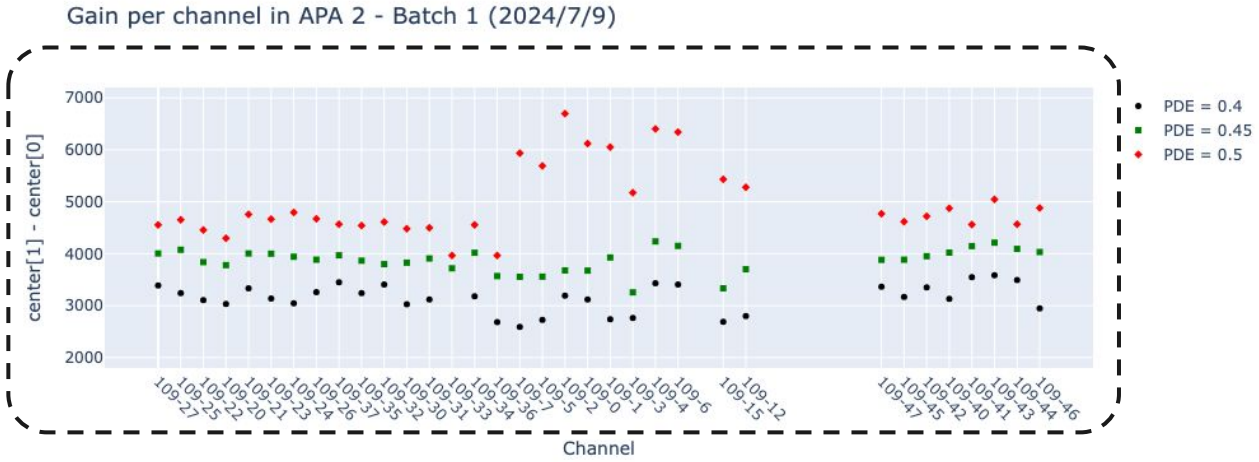


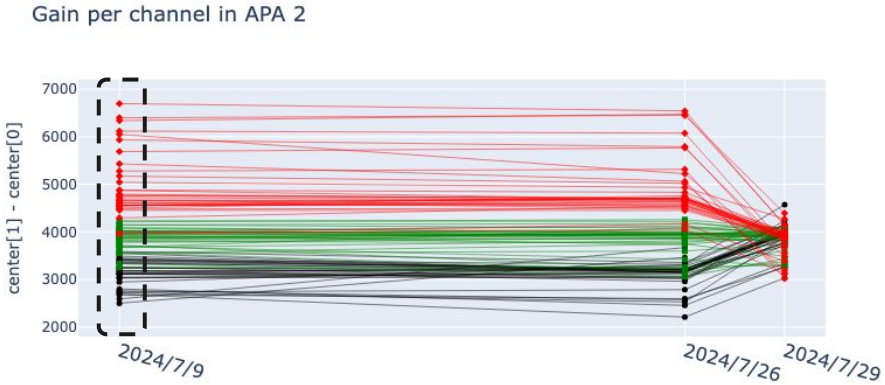
Gain for channel 112-0 in APA 4

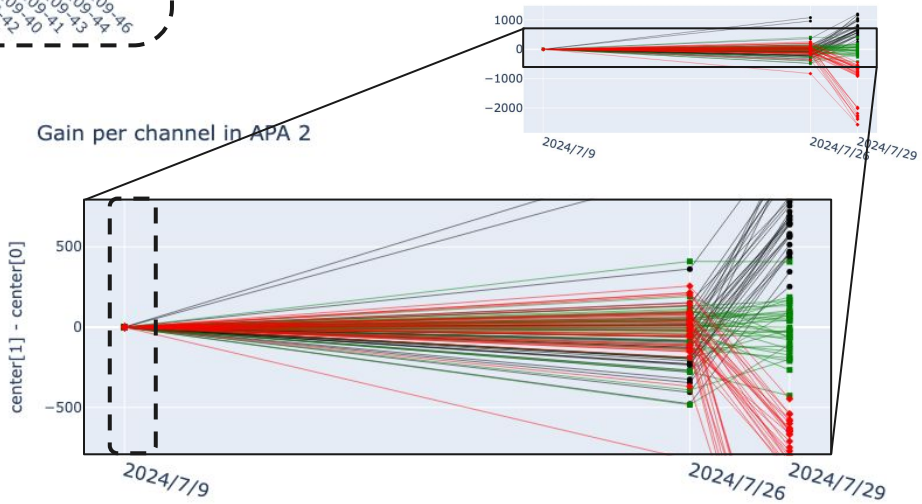
$$E = \sqrt{\sigma_{\mu_0}^2 + \sigma_{\mu_1}^2}$$

Results (APA 2)

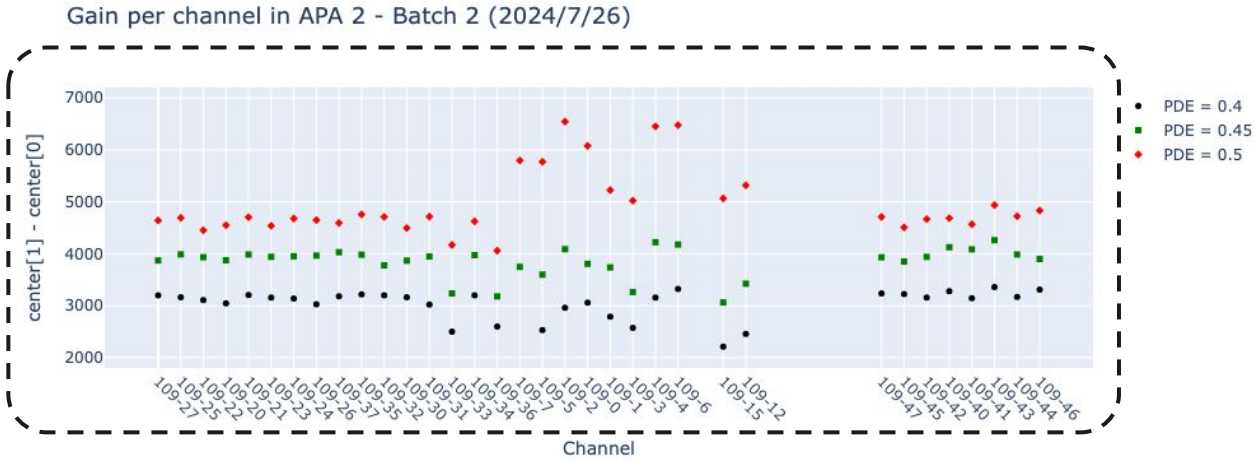


PDE	HPK	FBK
40%	+2 V	+3.5 V
45%	+2.5 V	+4.5 V
50%	+3.0 V	+7.0 V





Results (APA 2)



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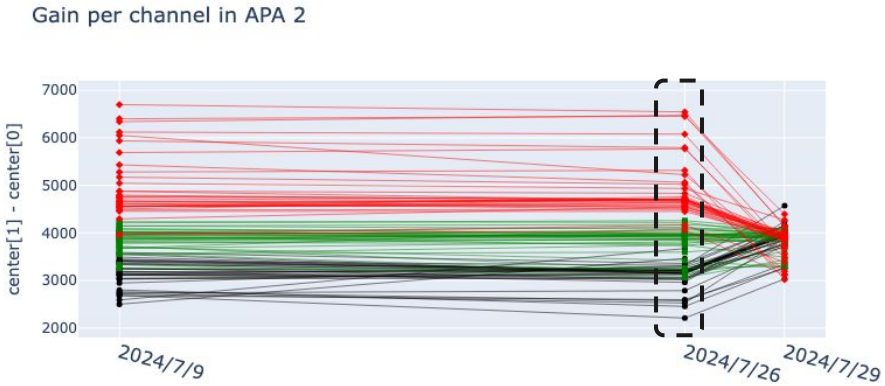
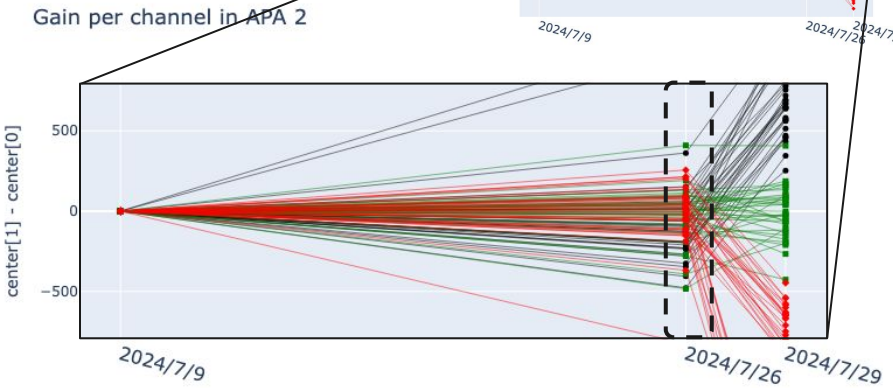
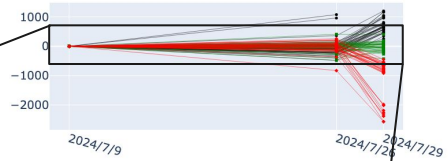
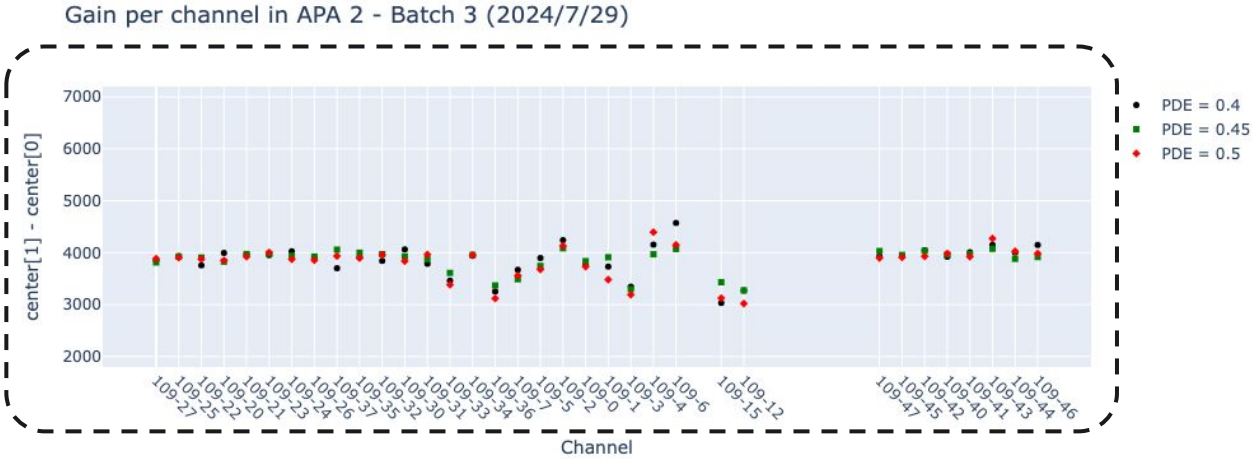






Results (APA 2)



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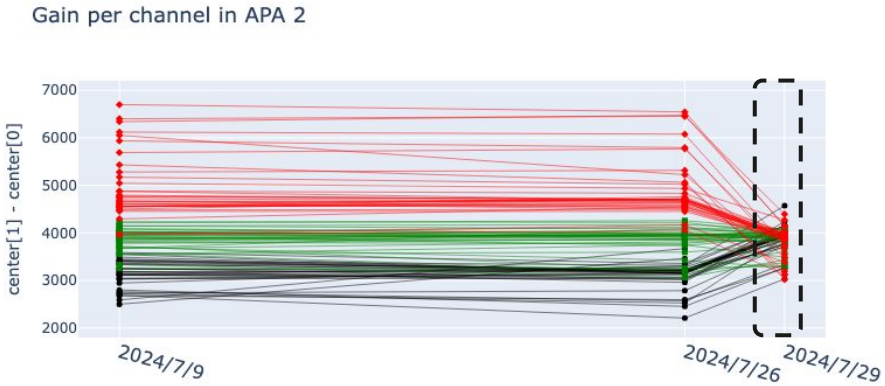
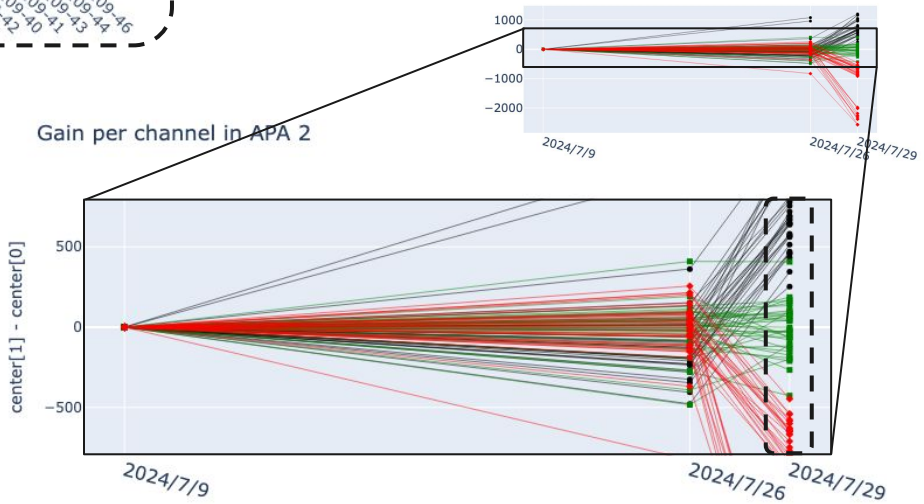
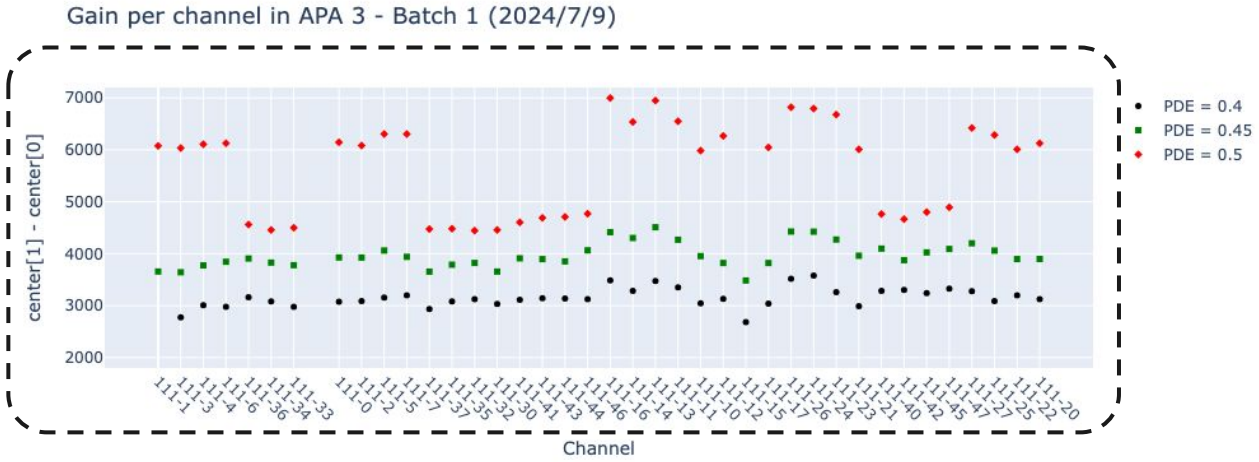




Results (APA 3)



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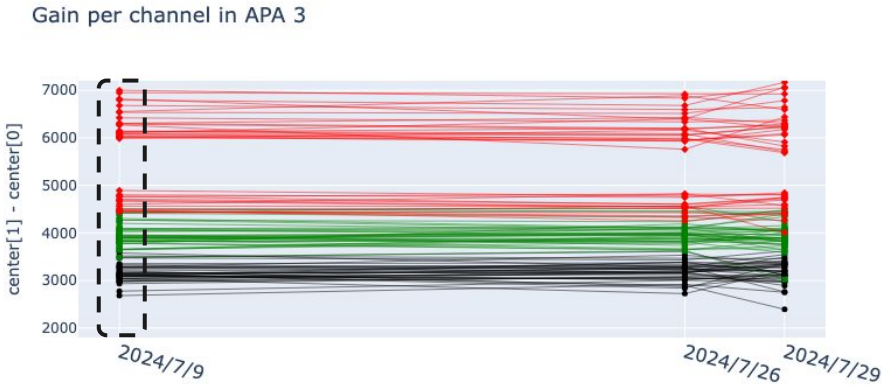
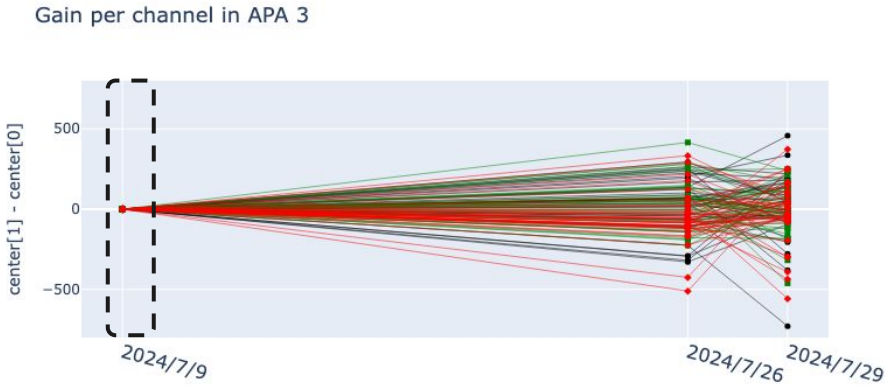
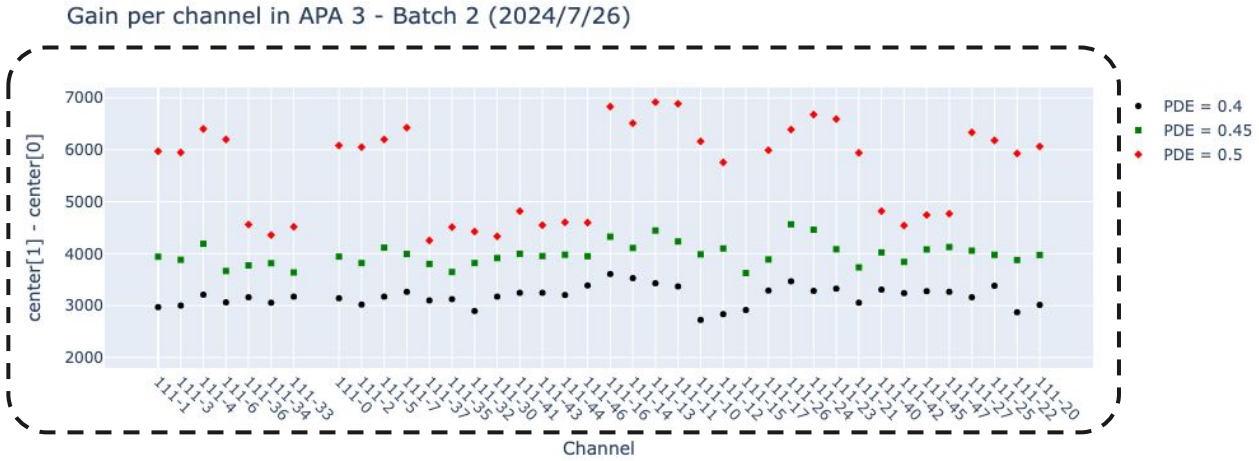




Results (APA 3)



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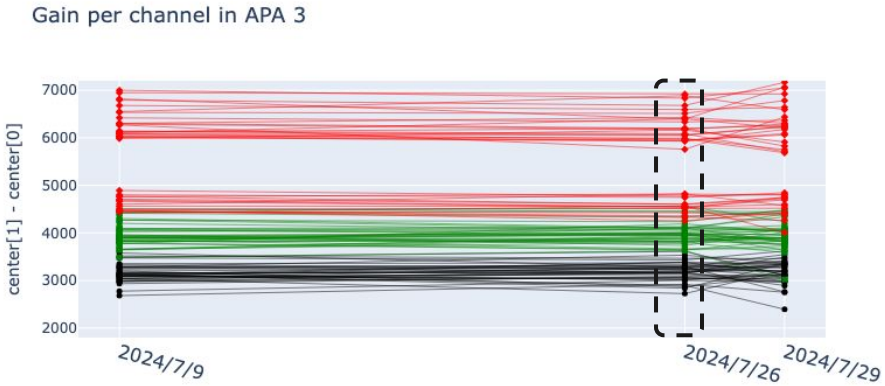
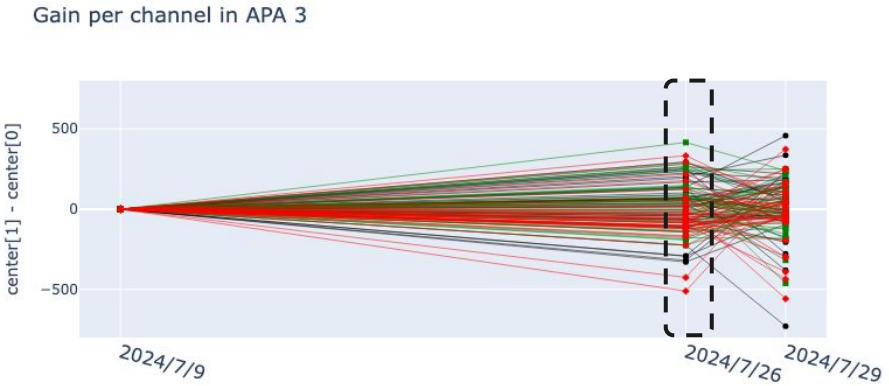
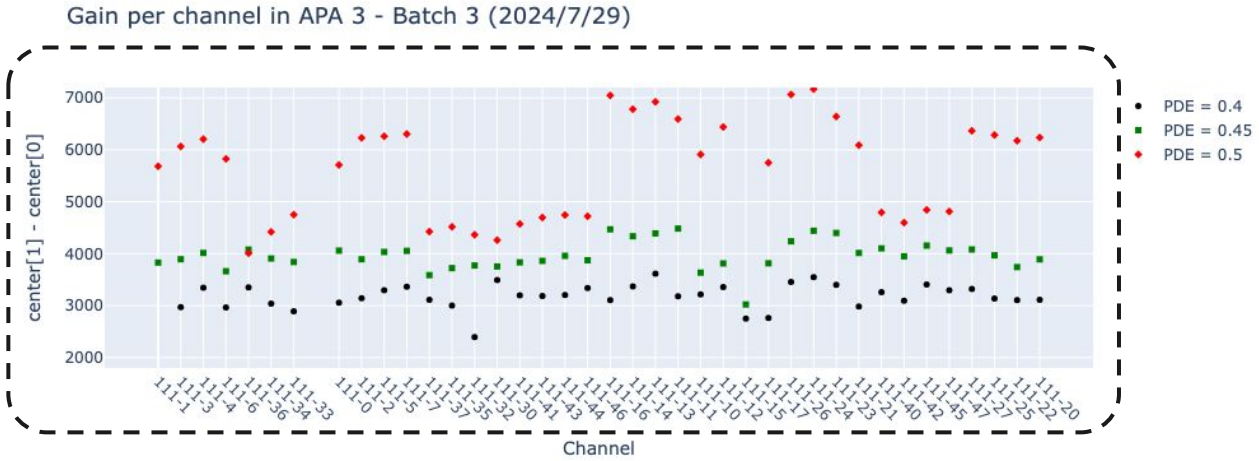




Results (APA 3)



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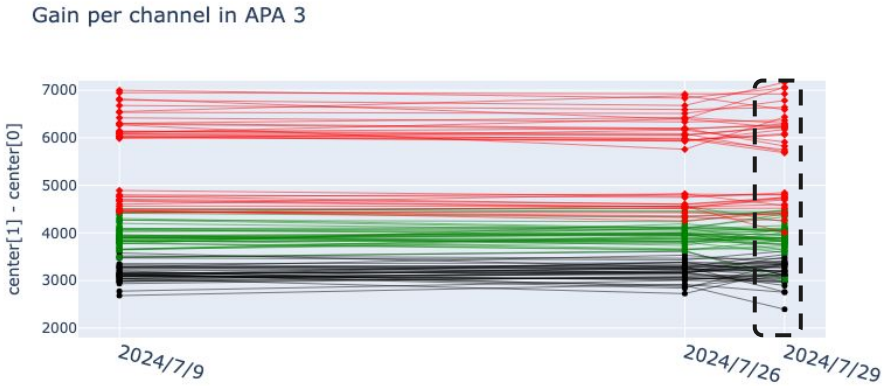
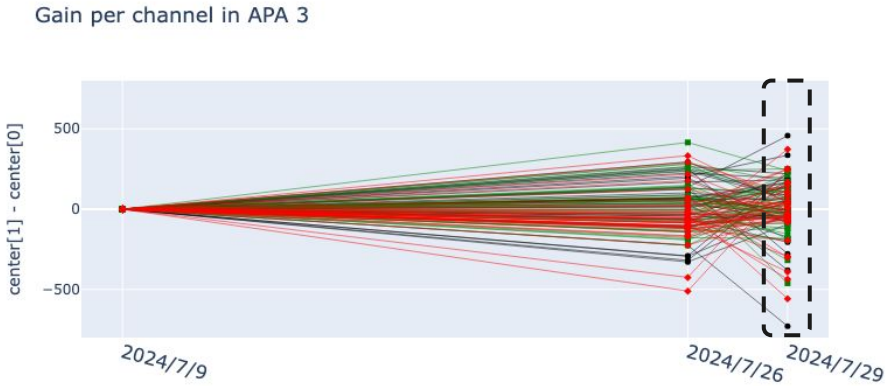
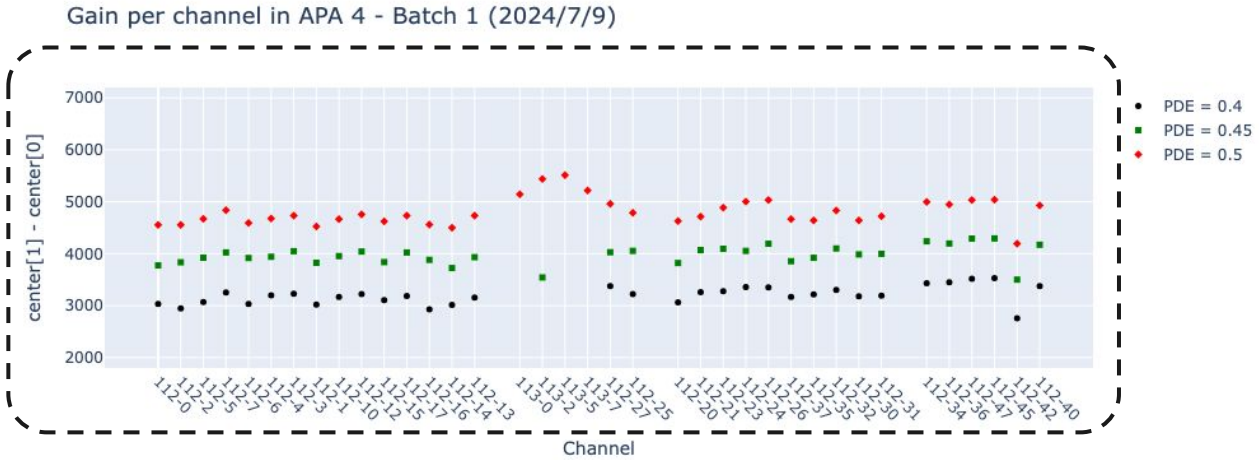




Results (APA 4)



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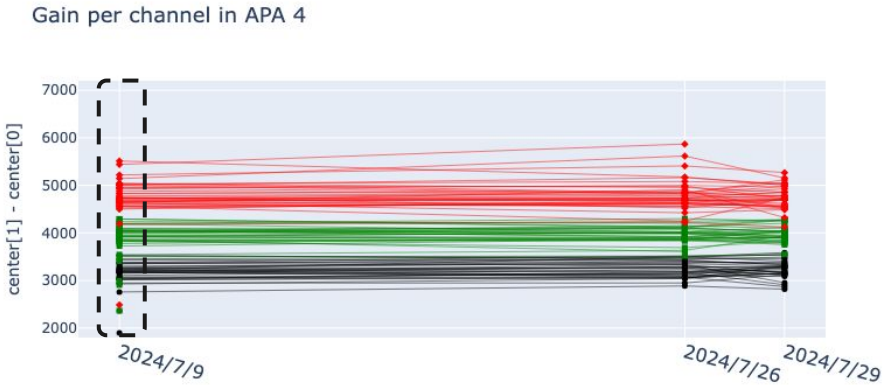
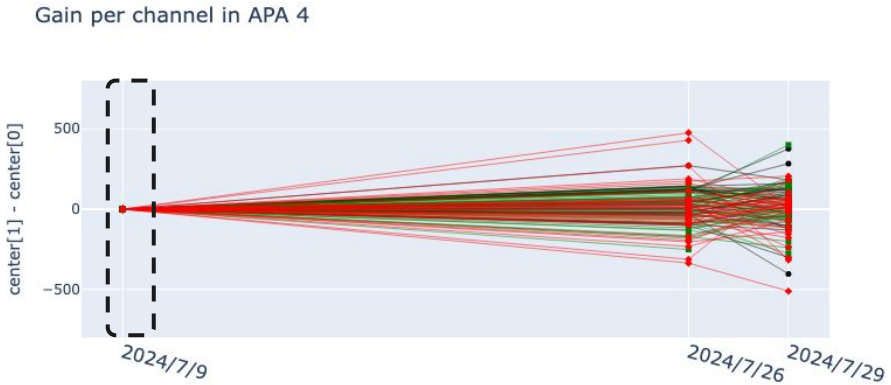
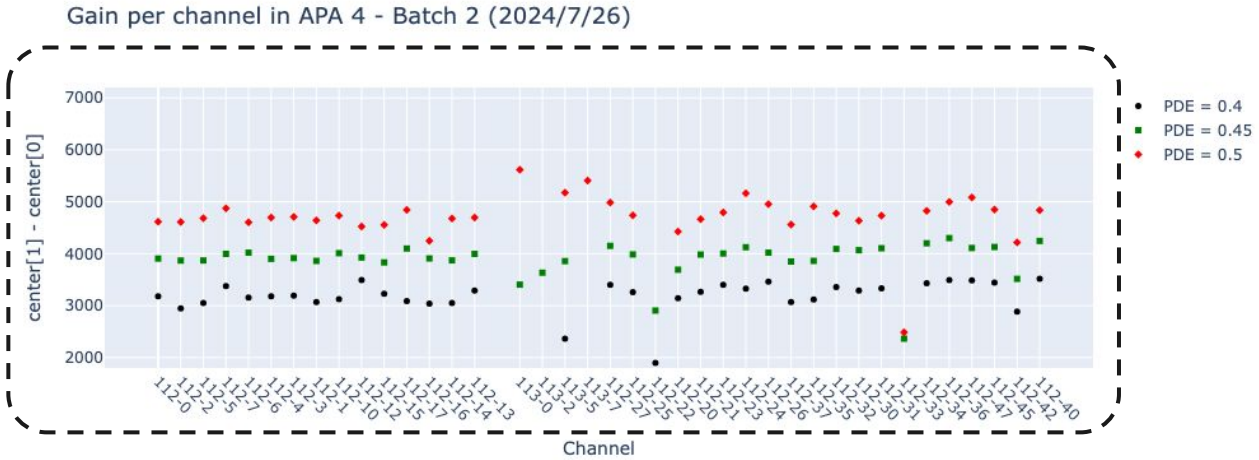




Results (APA 4)



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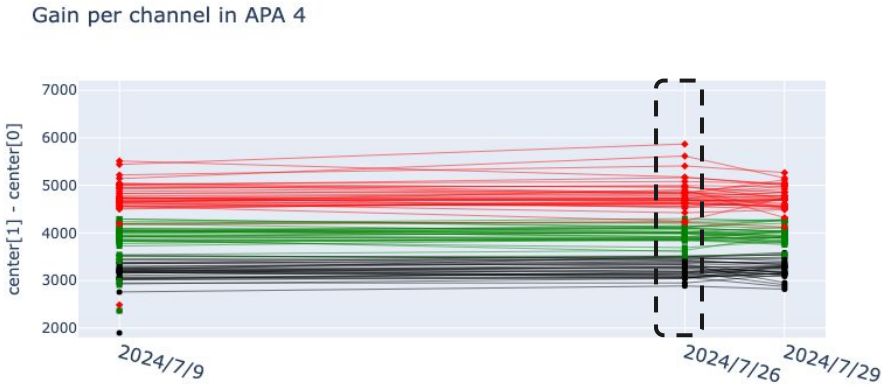
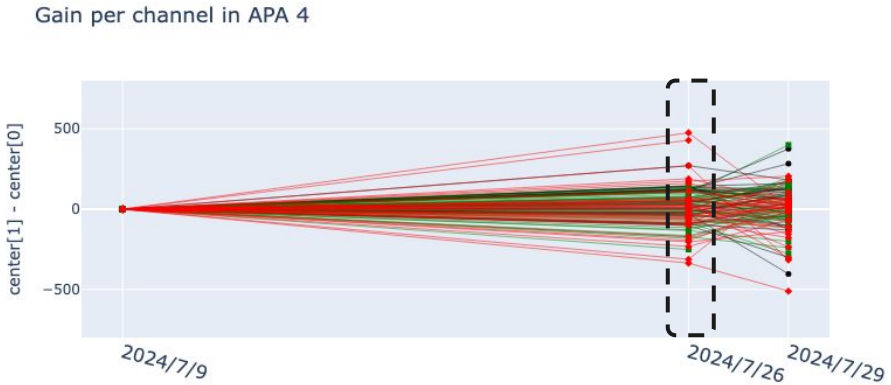
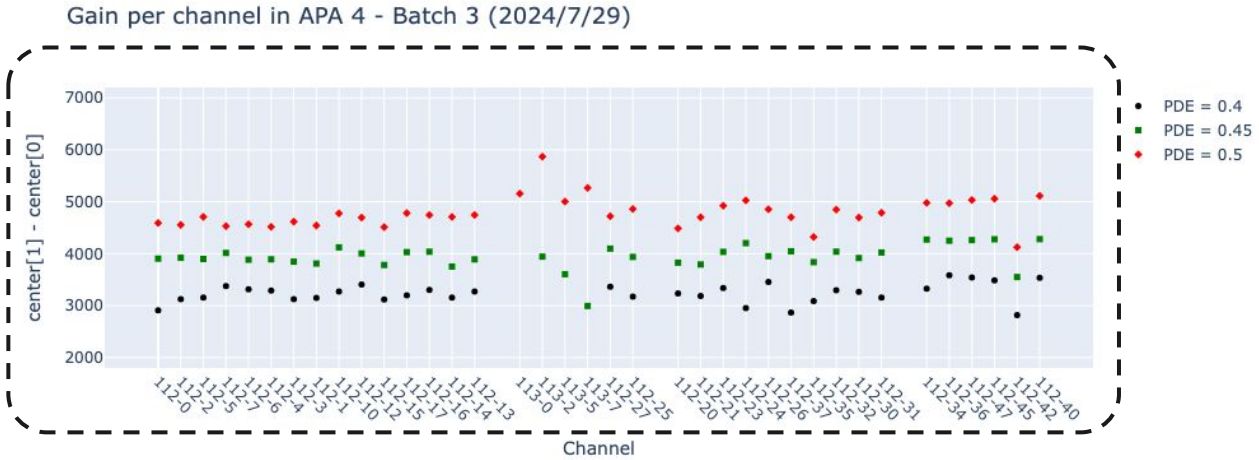




Results (APA 4)



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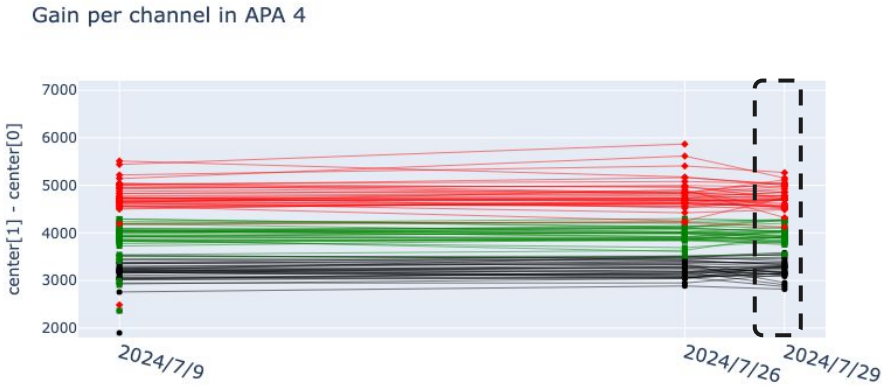
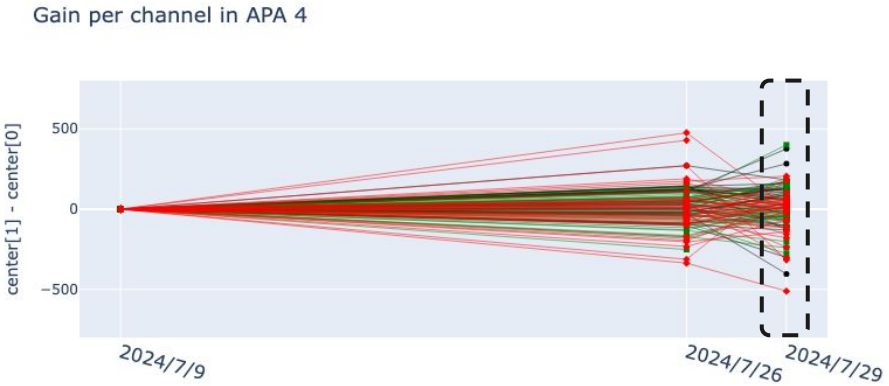
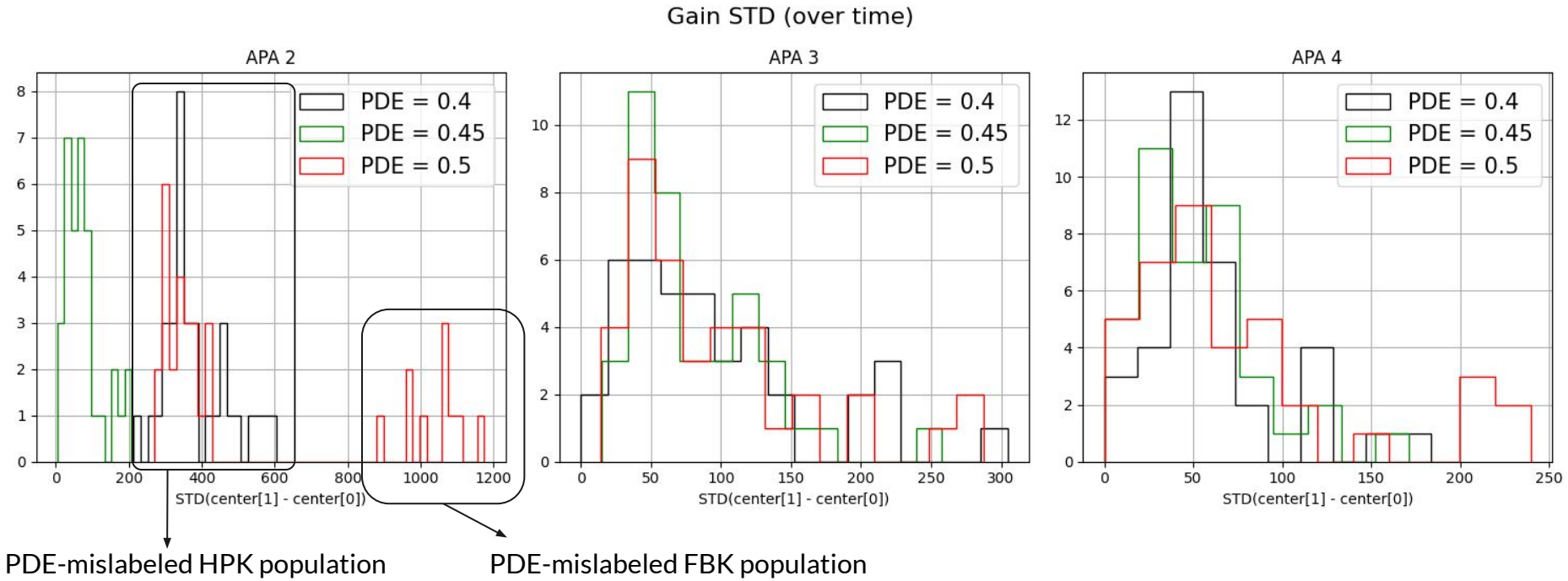
50%	+3.0 V	+7.0 V





Results

- For each APA,
  - For each PDE,
    - For each channel,
      - compute the STD of the three gains (one per batch)
      - that's one sample within the given (APA, PDE)-histogram



Inaccessible data

- All of the data for calibration batch 1 is accessible
- In batch 2, excluding runs for APA 1, there are 2 unavailable runs:

run	batch number	date	pde	'affected' APAs	cause
28149	2	2024/07/26	0.4	(2,)	Rucio is not able to find data for this run
28177	2	2024/07/26	0.5	(3,4)	Rucio is not able to find data for this run

- In batch 3, there are 4 unavailable runs:

28485	3	2024/07/29-30	0.4	(2,)	Unable to open file [...] File has been truncated
28487	3	2024/07/29-30	0.4	(2,)	Apparently the first datafile contains no waveform. Further inspection is needed.
28362	3	2024/07/29-30	0.4	(3,4)	Rucio is not able to find data for this run
28375	3	2024/07/29-30	0.5	(3,4)	Unable to open file [...] File has been truncated

Summary

- Conclusions:
  - Results for APA 2 in batch 3 suggest that the PDE may have not been effectively changed among runs
  - Otherwise, gain over time seems to distribute with an STD which is smaller than 300 (integral a.u.)

- Question:
  - There is a number of Vgains (in [931, 3192]) for which there are (LED) PDE scans (40, 45 and 50%).
  - This data was acquired by Esteban C. from 2024/10/10 to 2024/10/18.
  - Among these, do we have a preference on which batches to analyse first for gain calibration?

- Next steps:
  - Analyse batches >3 for APAs 2, 3 and 4
  - Analyse batches >=3 for APA 1
    - Analysing APA 1 data requires some more development in the HDF5 reader

Reference list

[1] PDS Run list spread sheet
https://docs.google.com/spreadsheets/d/14fpCjNZFnyq72wugfSGXdAcTrgFroA1AI2In7VeyZIY/edit?gid=1435679499#gid=1435679499

[2] Waffles github
https://github.com/DUNE/waffles

[3] Waffles documentation webpage
Laura P. Molina
https://waffles.readthedocs.io/en/latest/index.html

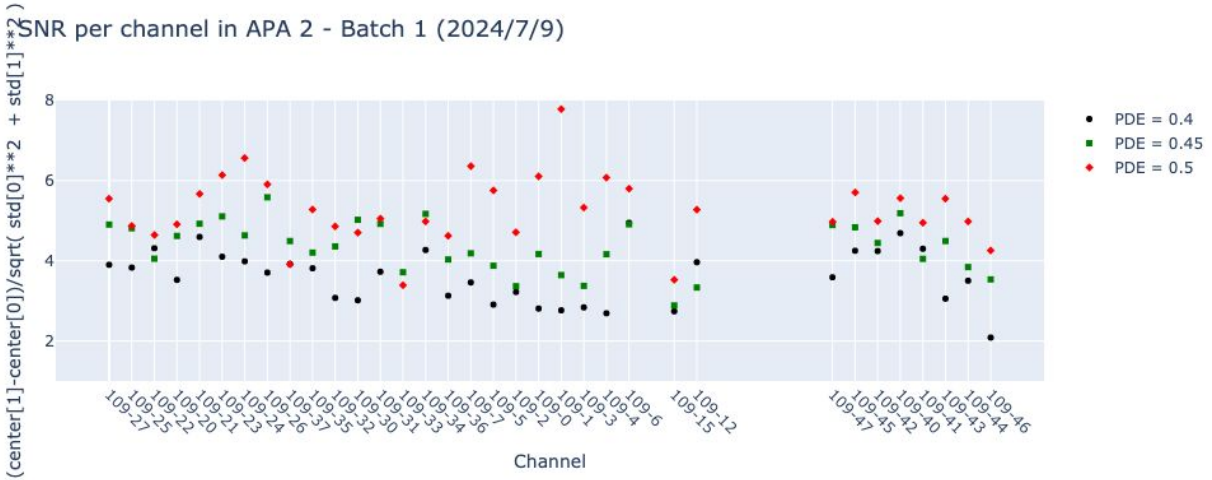
[4] LED channel mask generator
Jairo Rodríguez
https://docs.google.com/spreadsheets/d/19meioB5ZXi4BVxlhS04Yg-nJeYS8p_bSmS_pvpNNEsU/edit?gid=0#gid=0

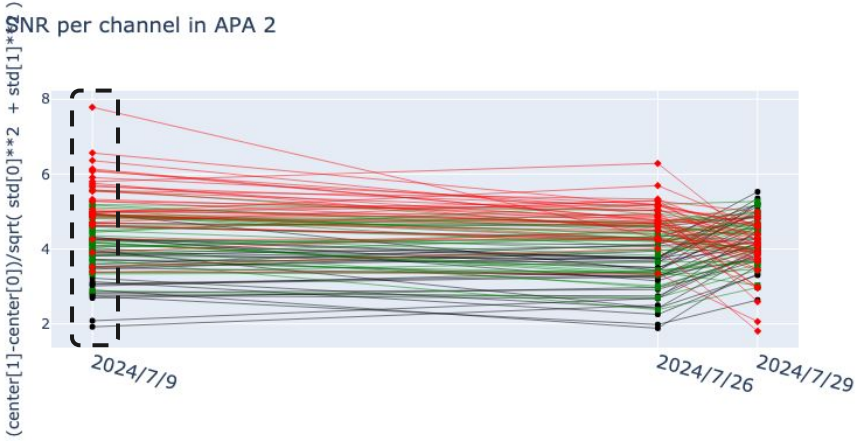
[5] Federico Galizzi's talk (29/08/2024)
Single Photo- Electron characterization and noisy channels
https://indico.fnal.gov/event/66006/contributions/298862/attachments/181088/248257/20240839_PDHD_spe_noise.pdf

[6] Julio Ureña's talk (12/09/2024)
LED calibration and Waffles
https://indico.fnal.gov/event/62283/contributions/299537/attachments/181479/248907/LED_calibration_and_Waffles.pdf

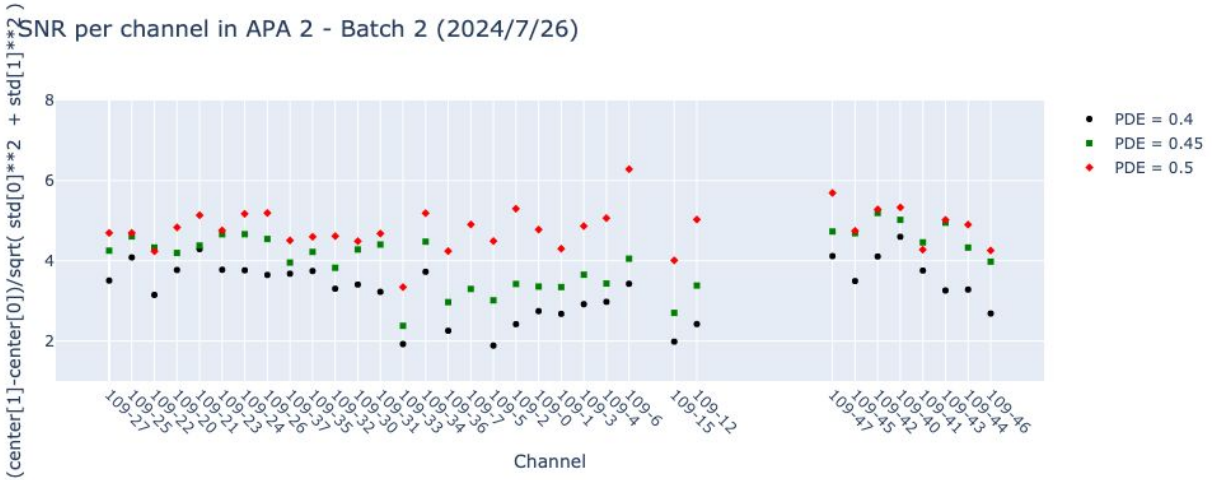
Backup

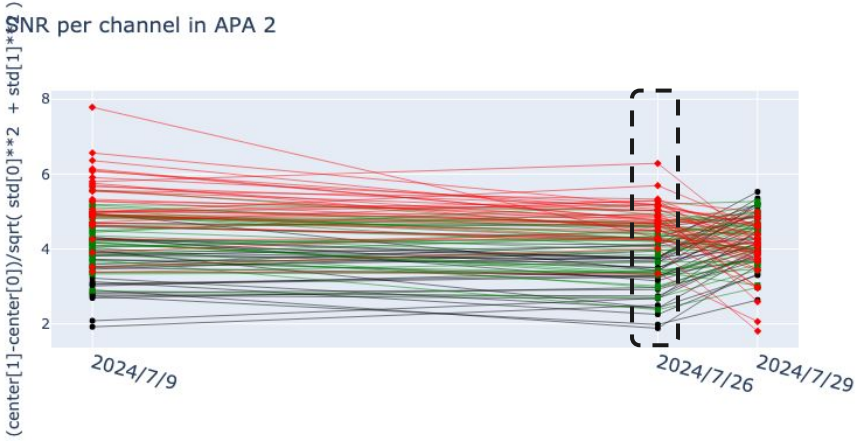
Results (APA 2, SNRs)



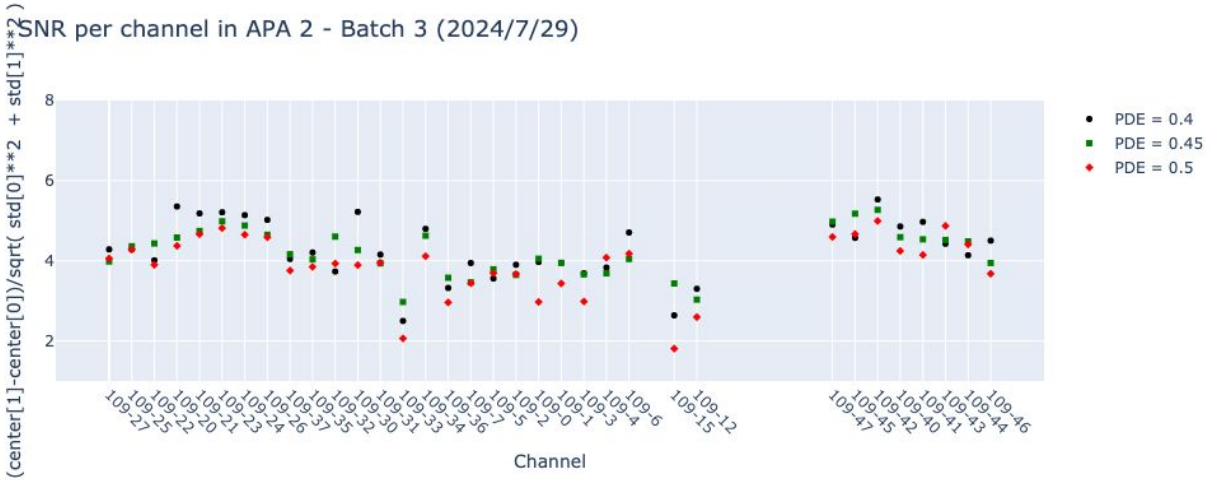


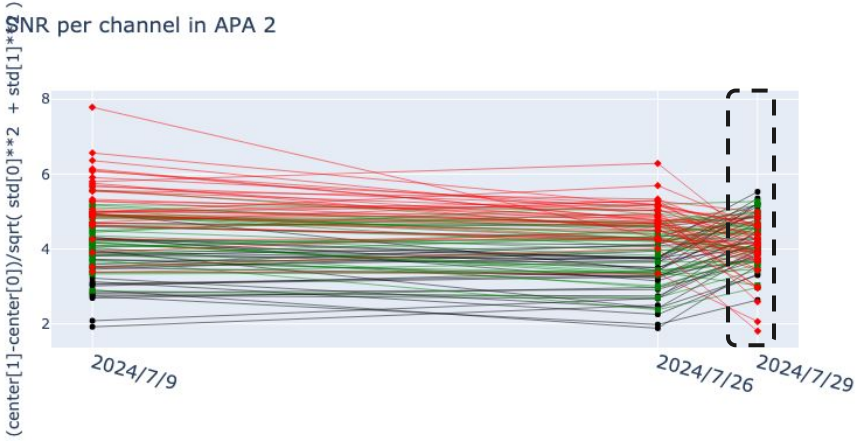
Results (APA 2, SNRs)



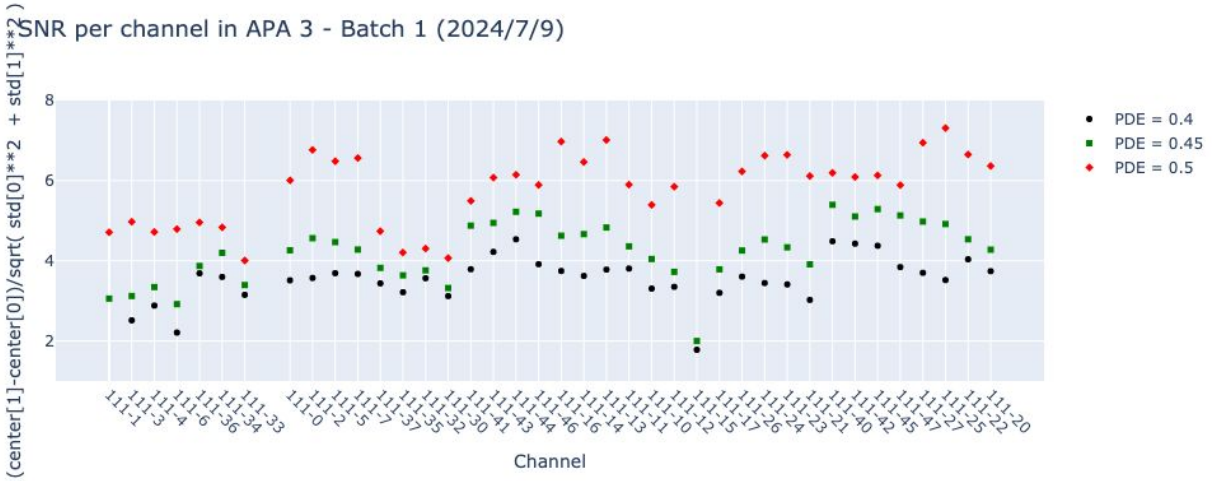


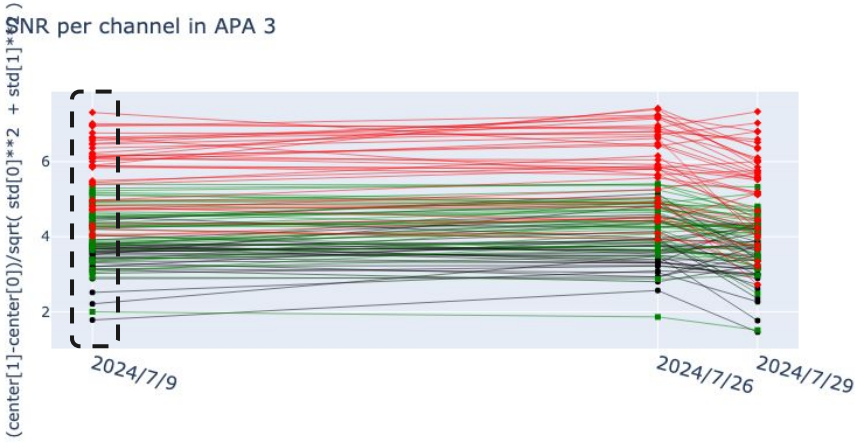
Results (APA 2, SNRs)



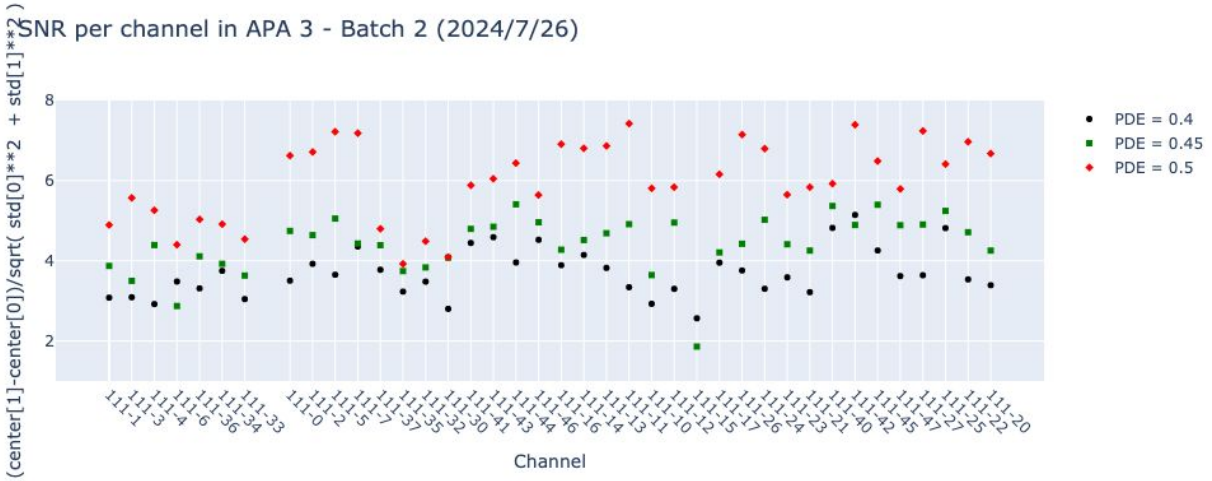


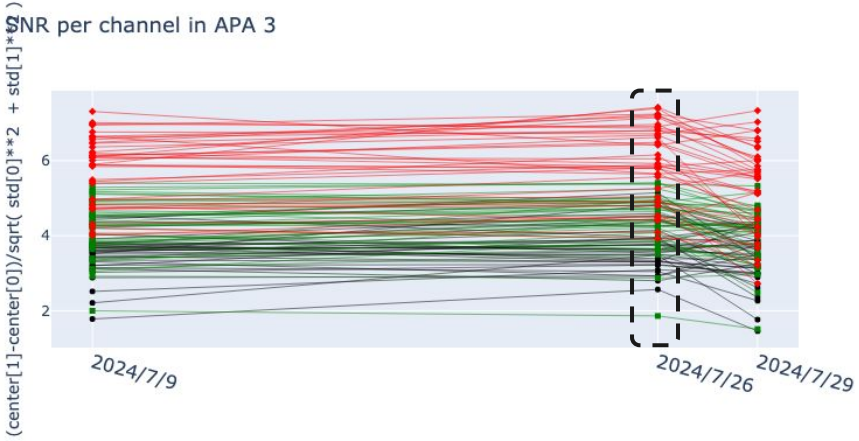
Results (APA 3, SNRs)





Results (APA 3, SNRs)





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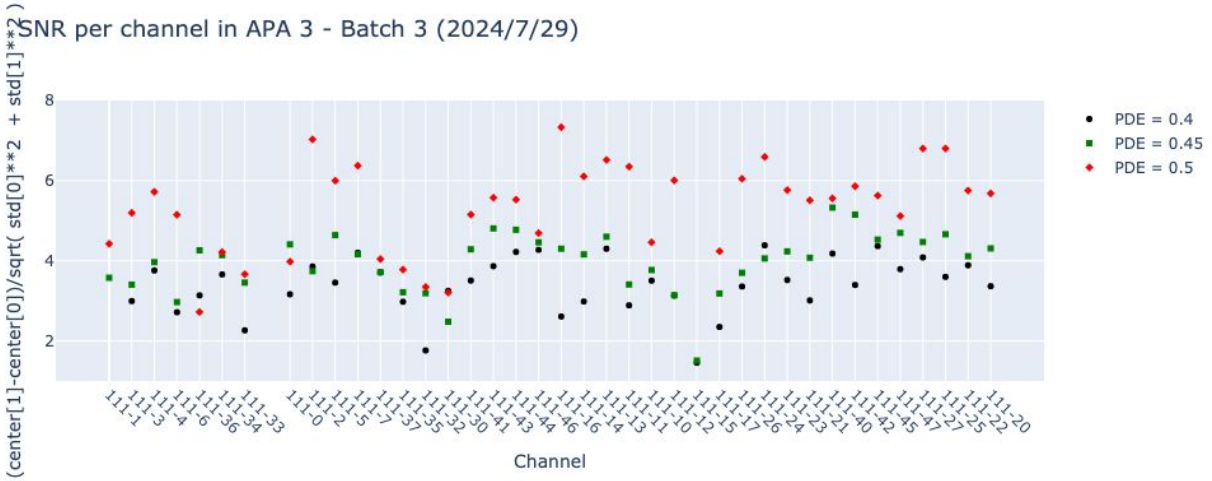
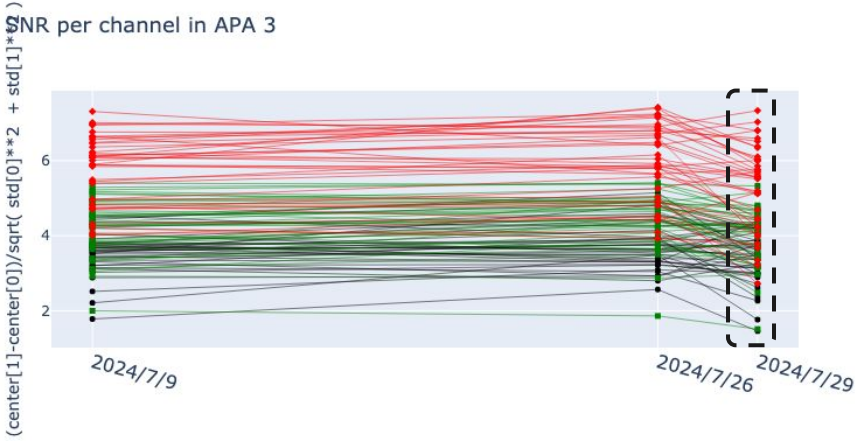
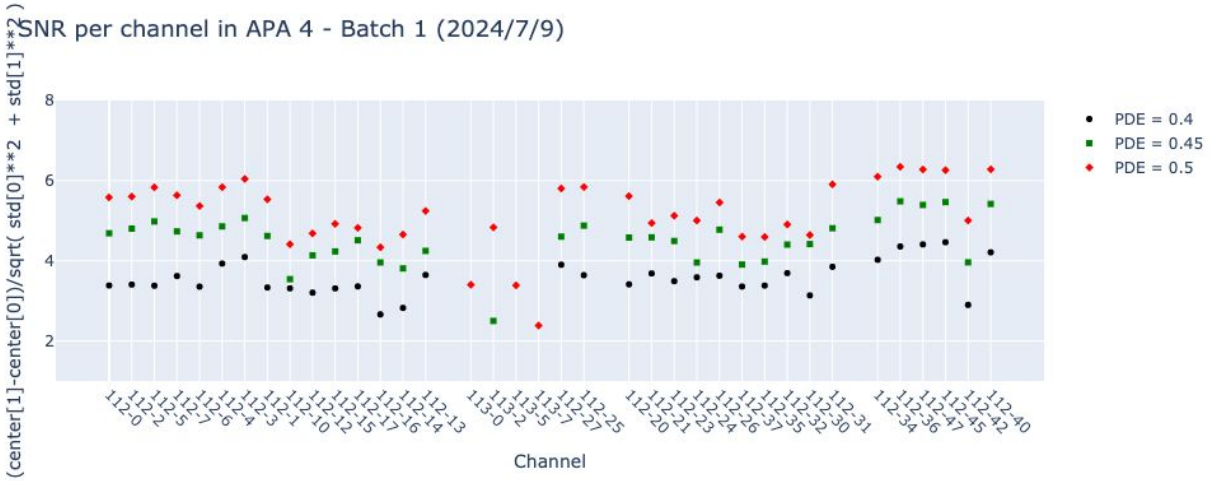
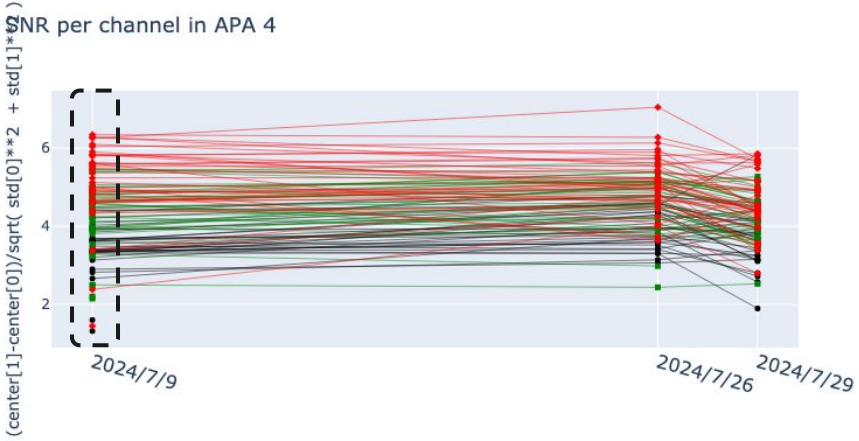


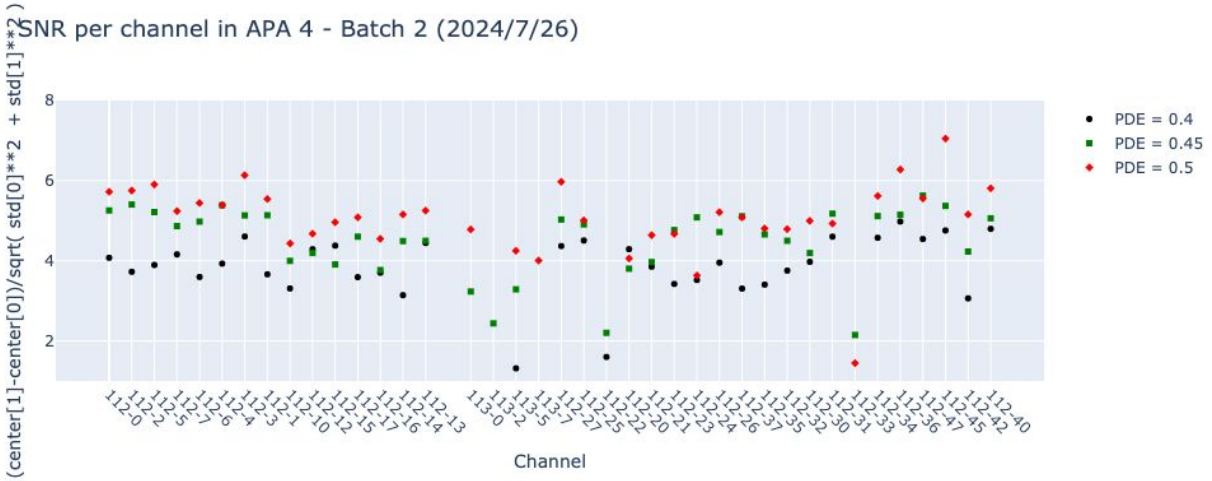


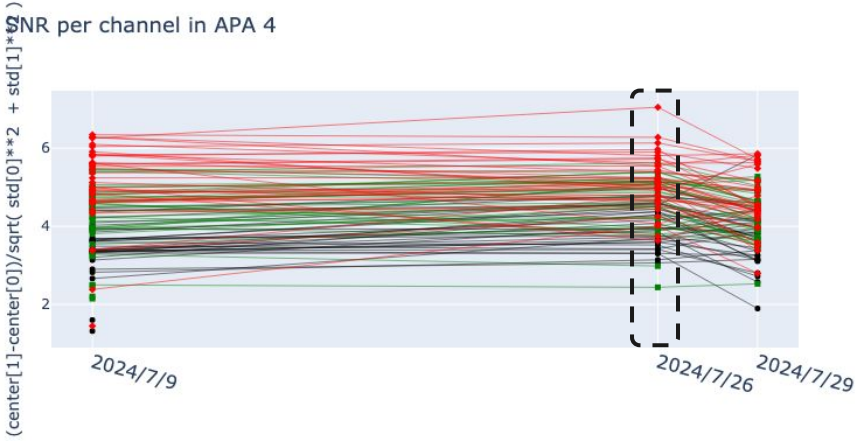
Results (APA 4, SNRs)



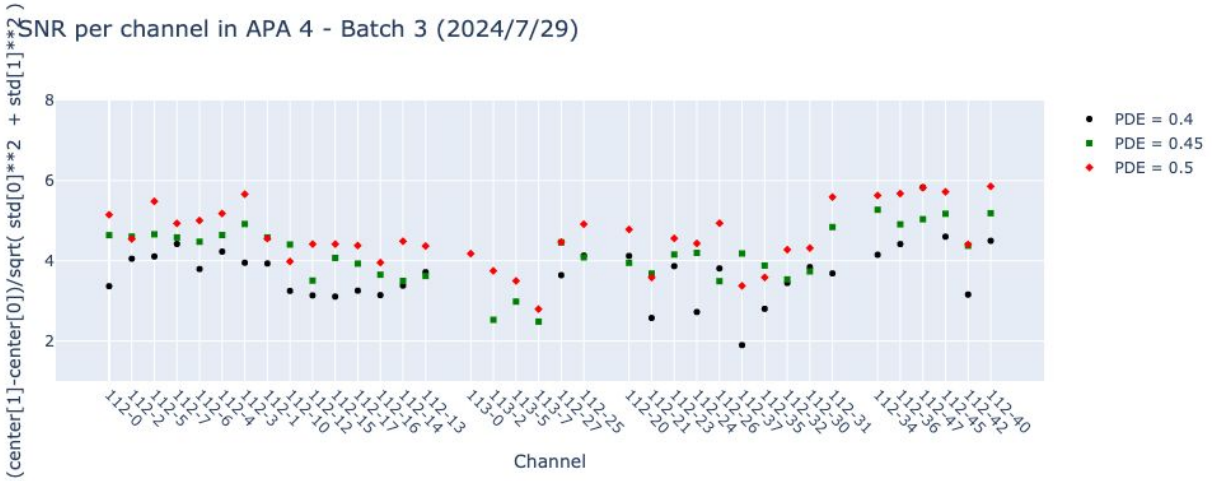


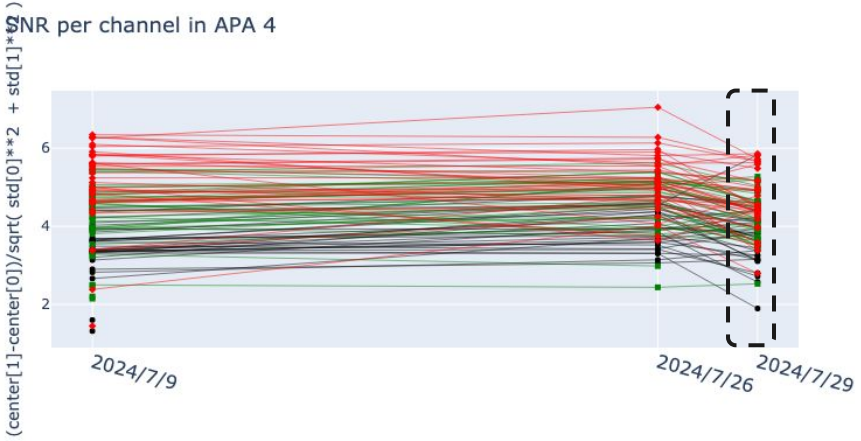
Results (APA 4, SNRs)





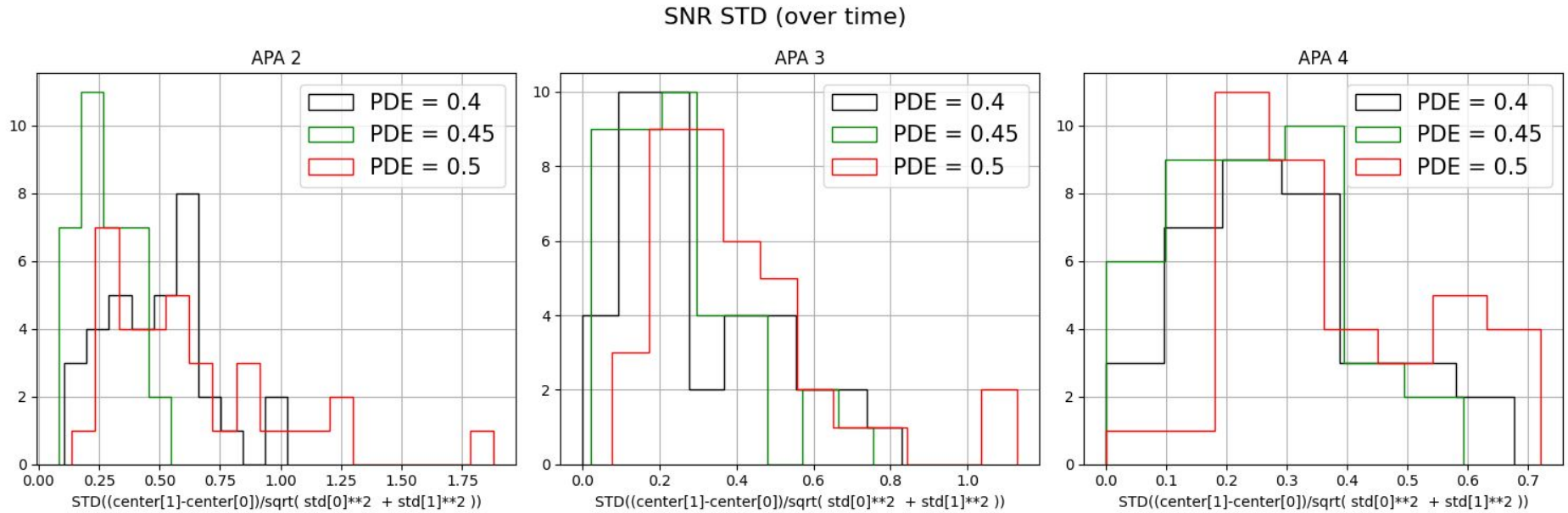
Results (APA 4, SNRs)



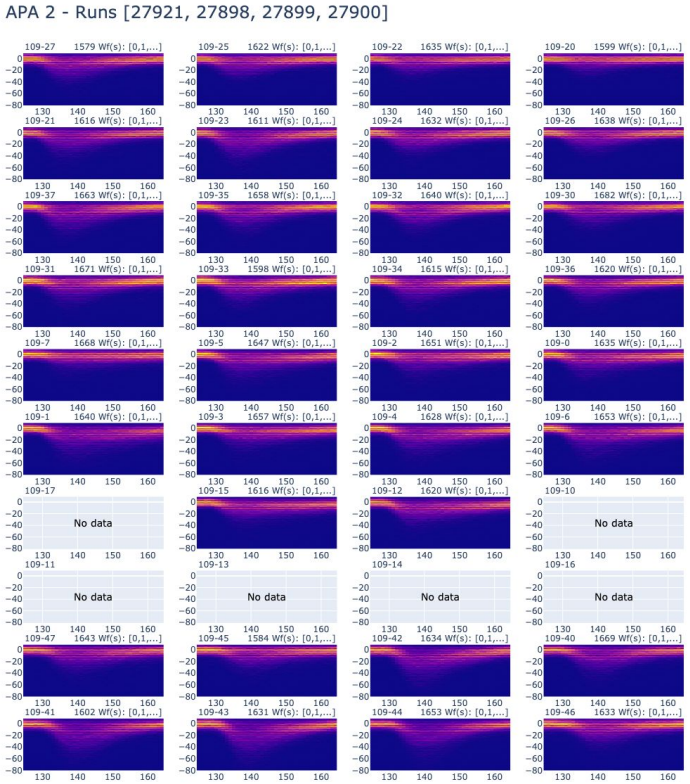


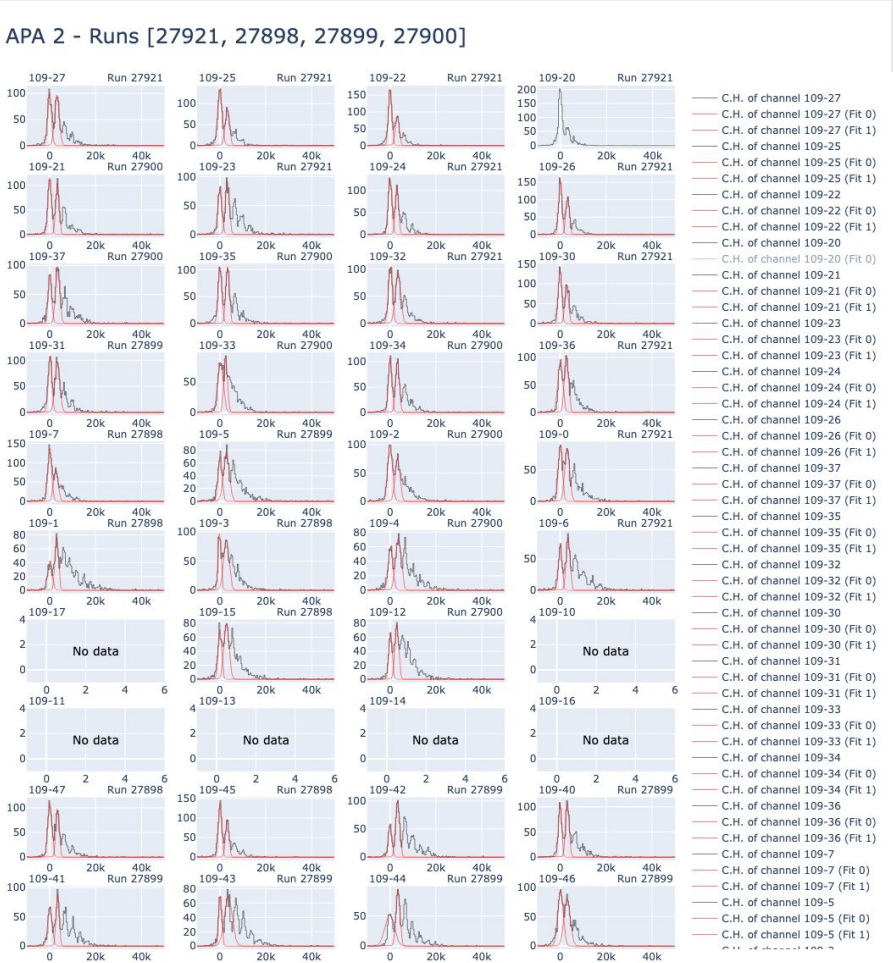
Results

- For each APA,
  - For each PDE,
    - For each channel,
      - compute the STD of the three SNRs (one per batch)
      - that's one sample within the given (APA, PDE)-histogram

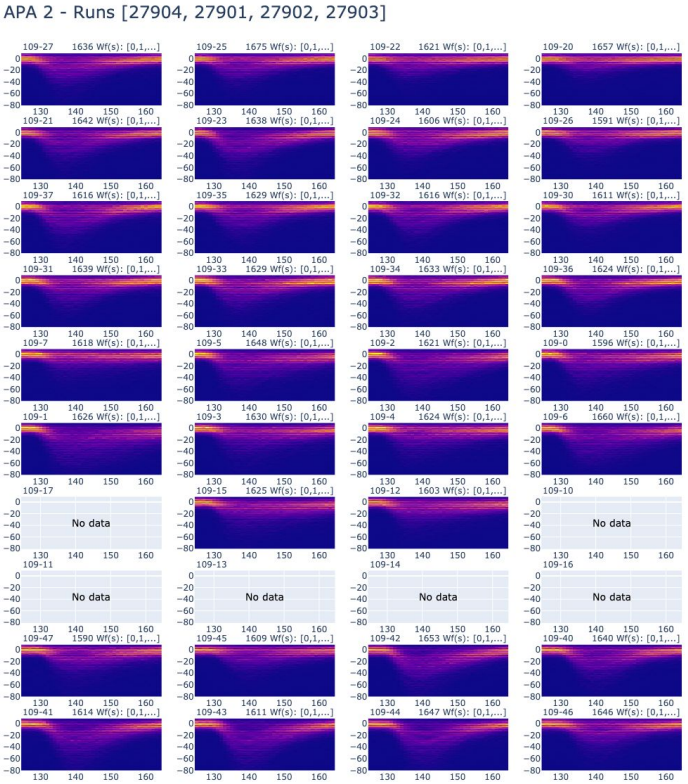


Results (APA 2, batch 1, PDE 40%)

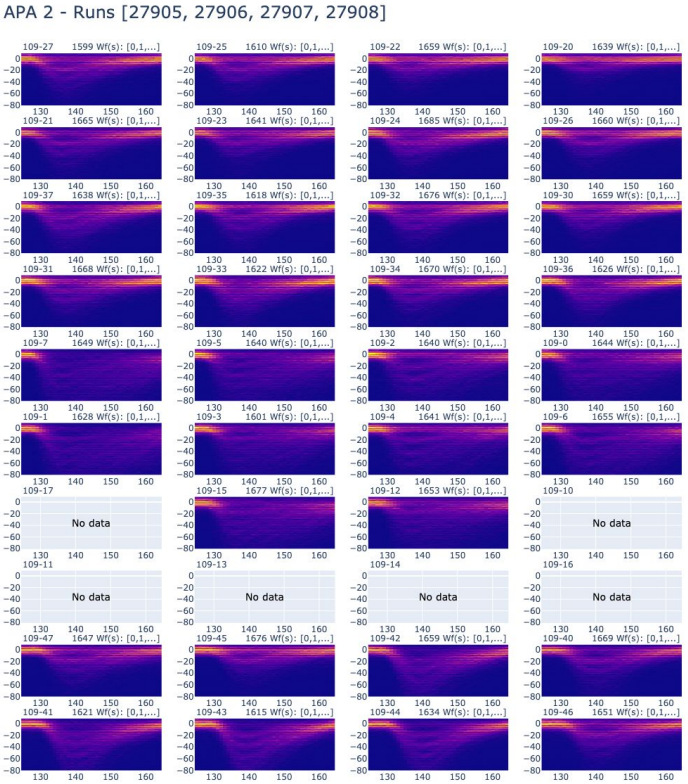


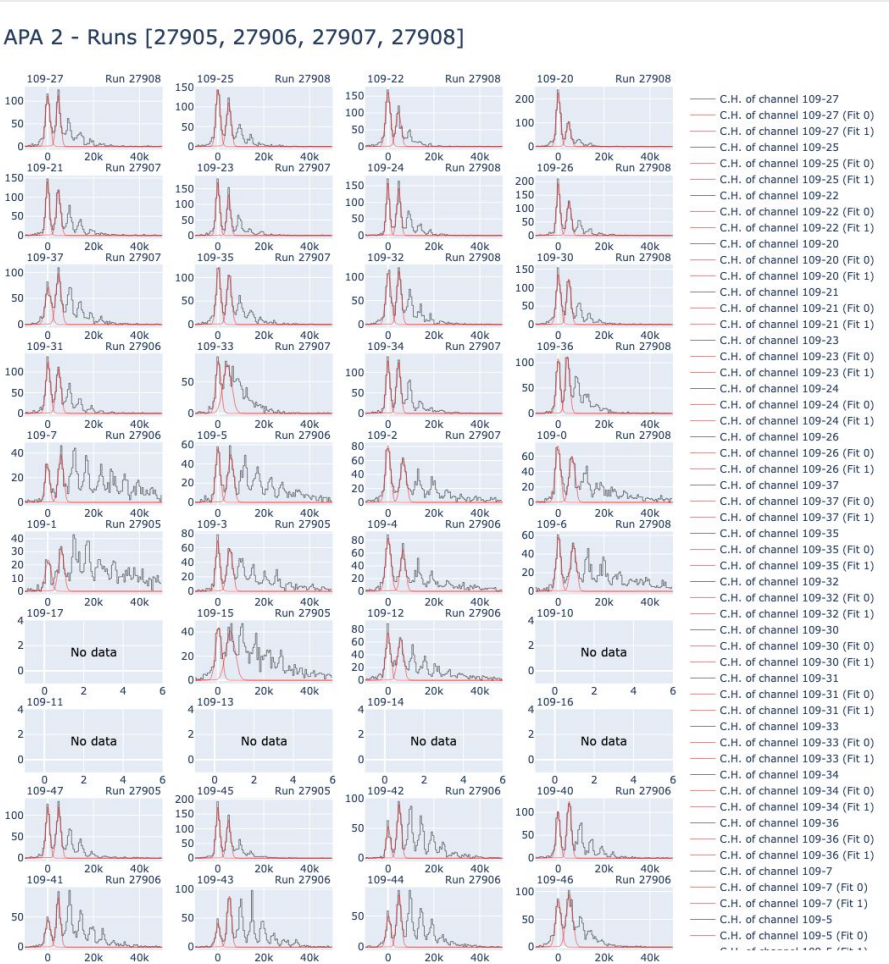


Results (APA 2, batch 1, PDE 45%)

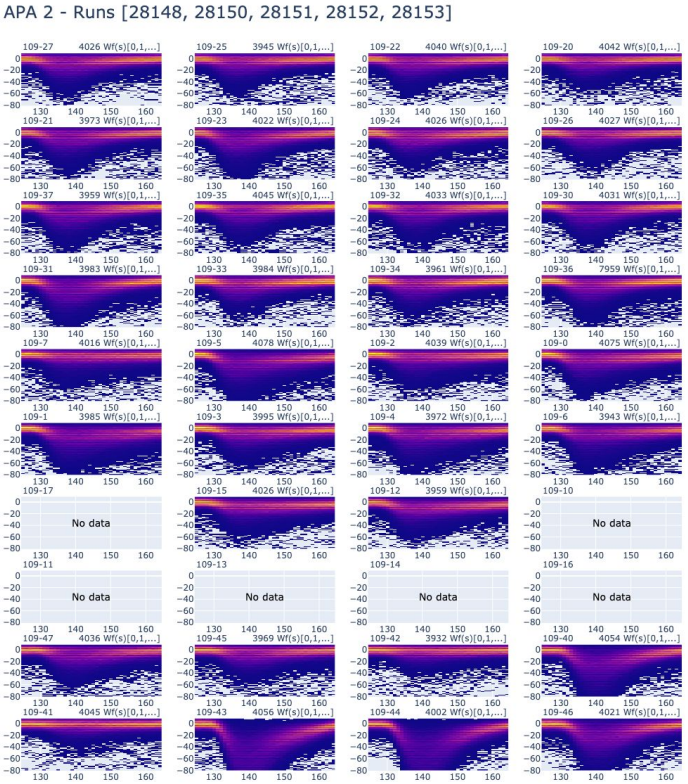


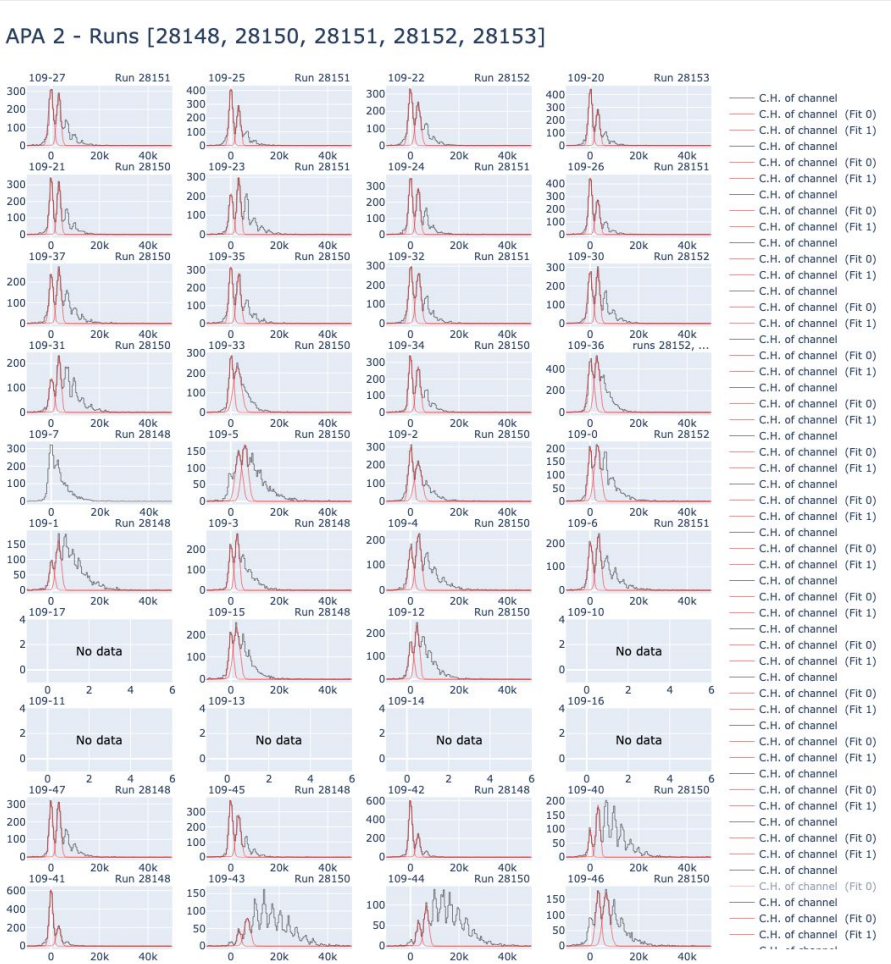
Results (APA 2, batch 1, PDE 50%)



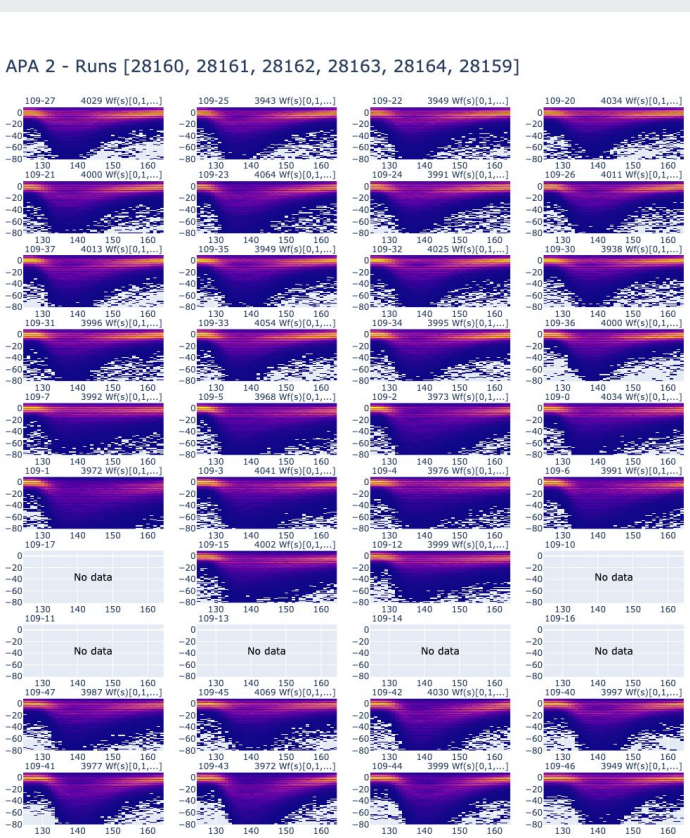


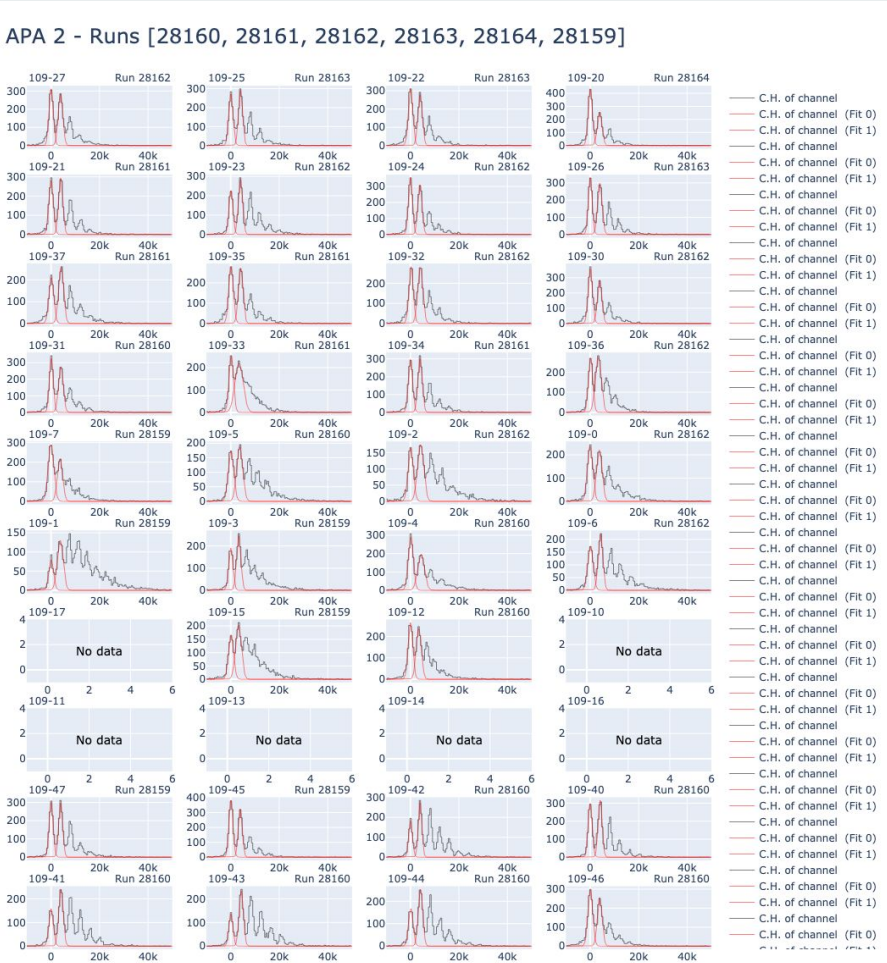
Results (APA 2, batch 2, PDE 40%)



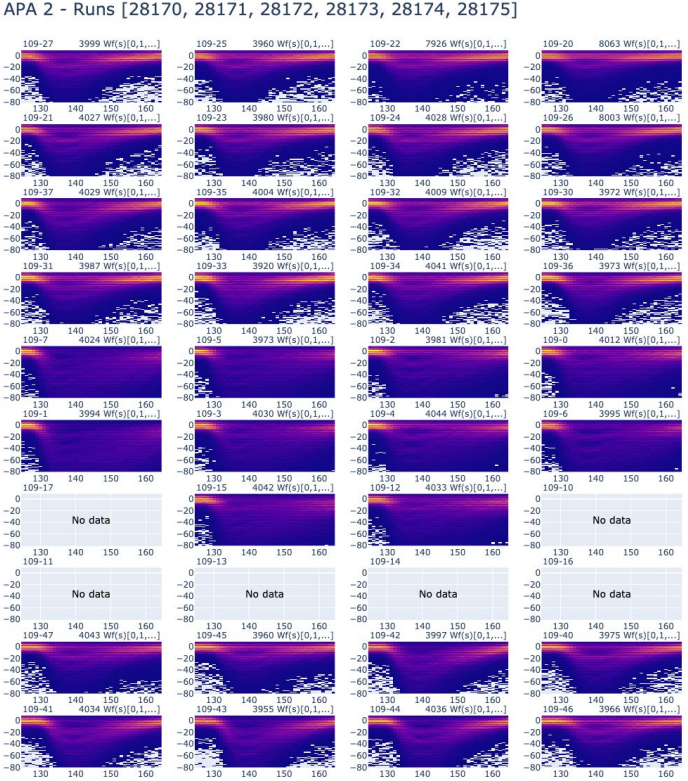


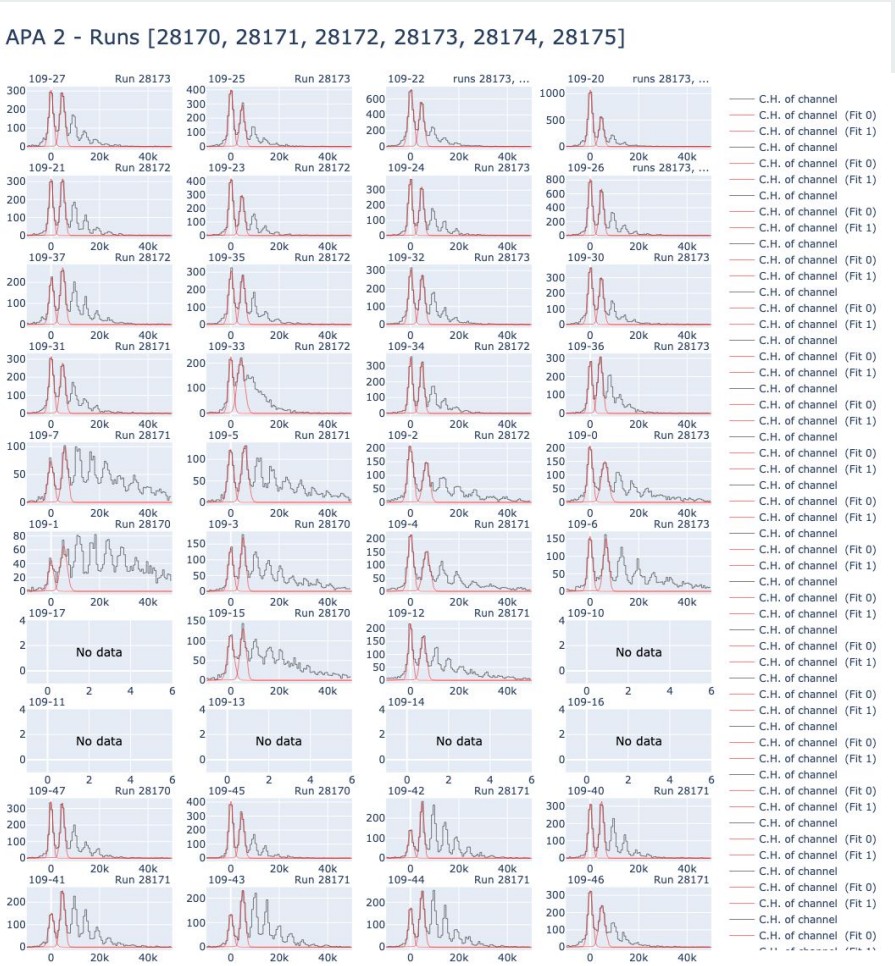
Results (APA 2, batch 2, PDE 45%)



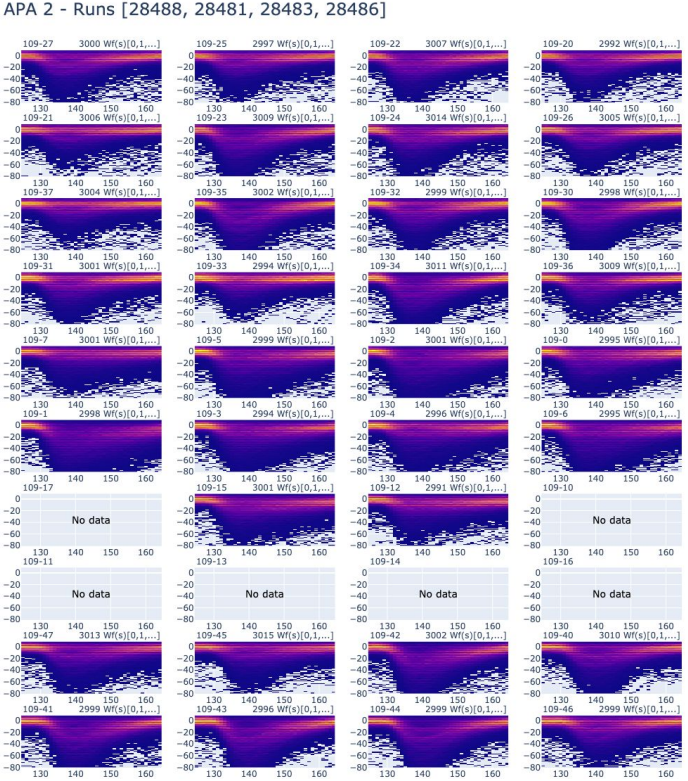


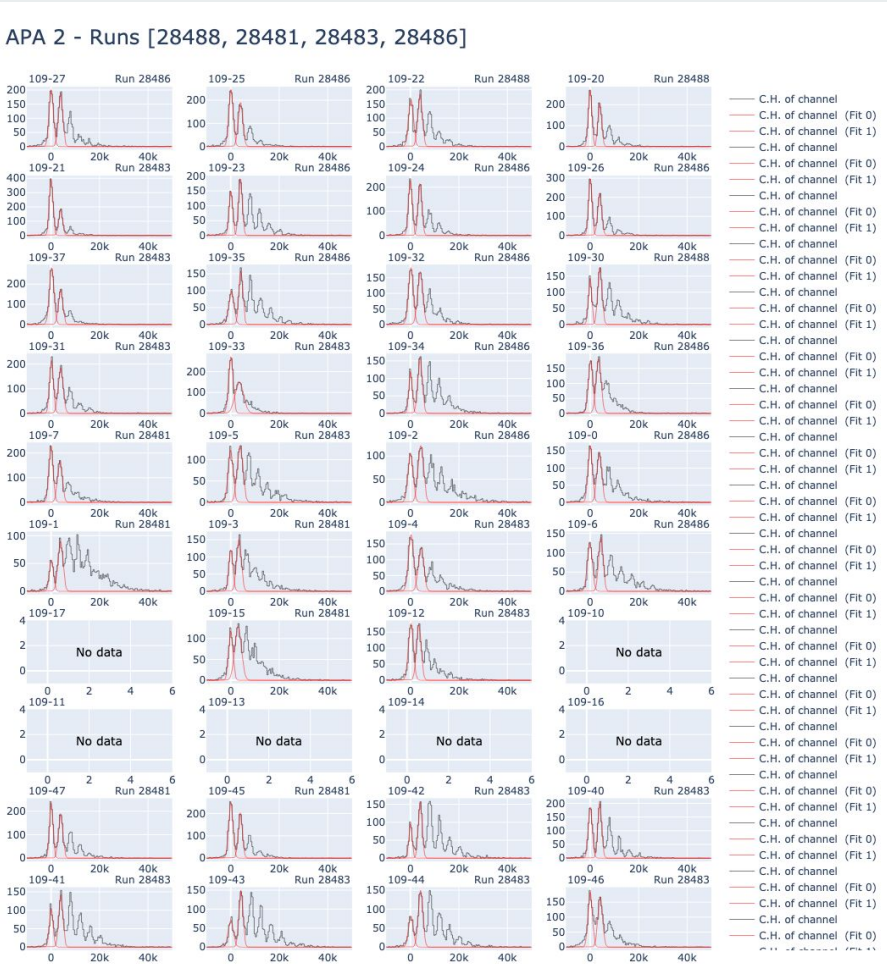
Results (APA 2, batch 2, PDE 50%)



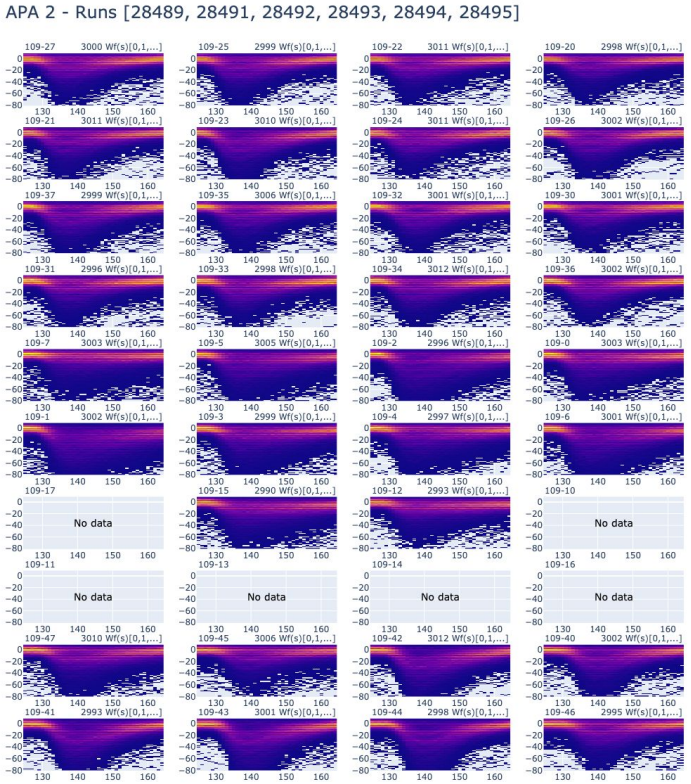


Results (APA 2, batch 3, PDE 40%)

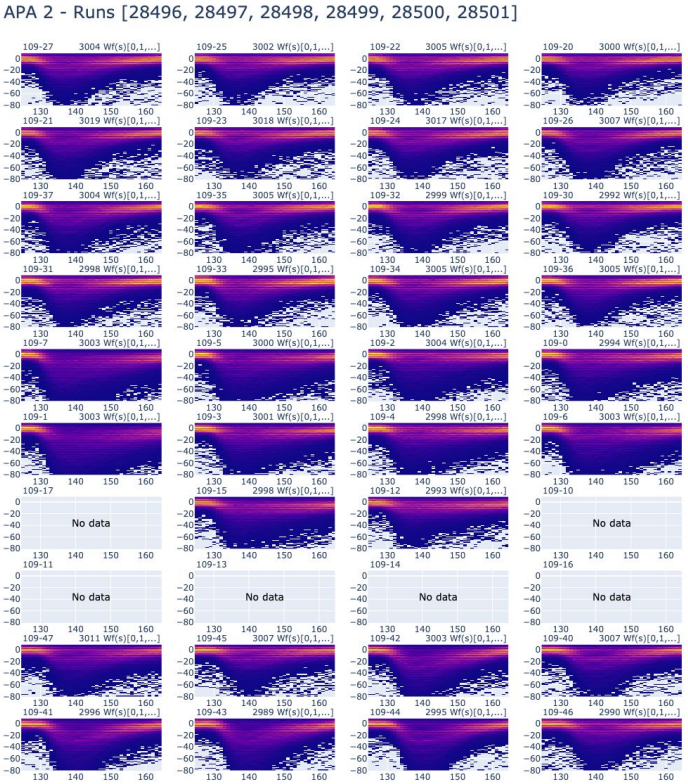


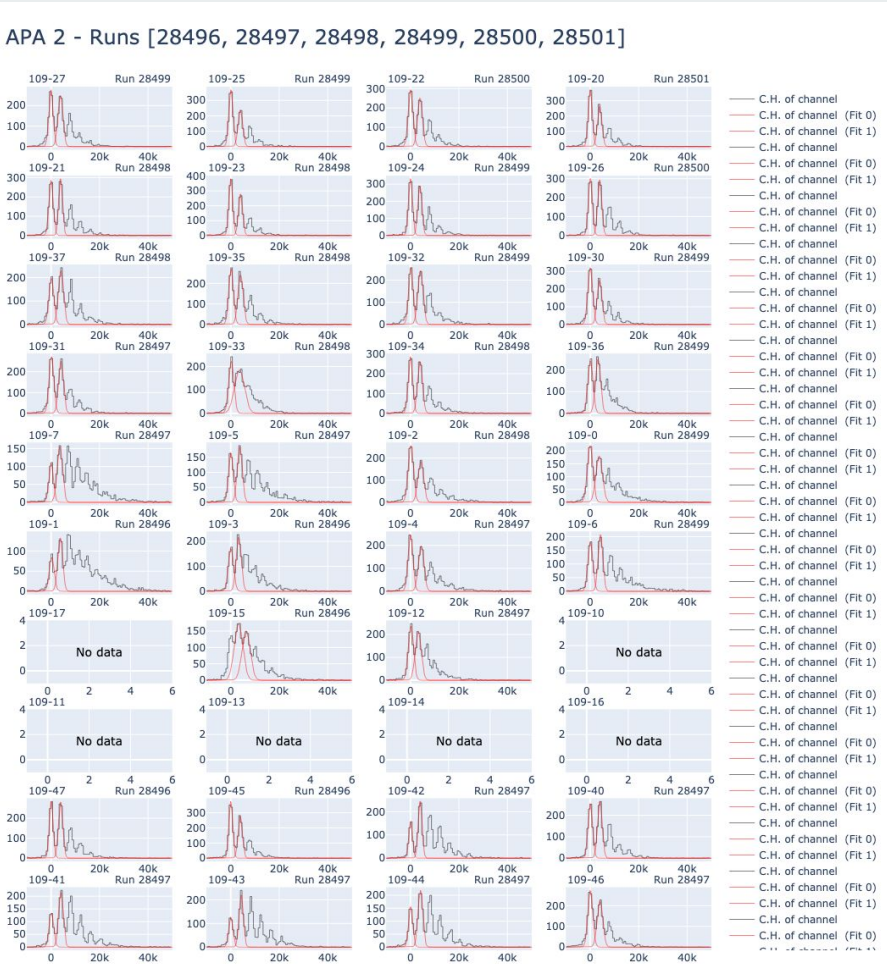


Results (APA 2, batch 3, PDE 45%)

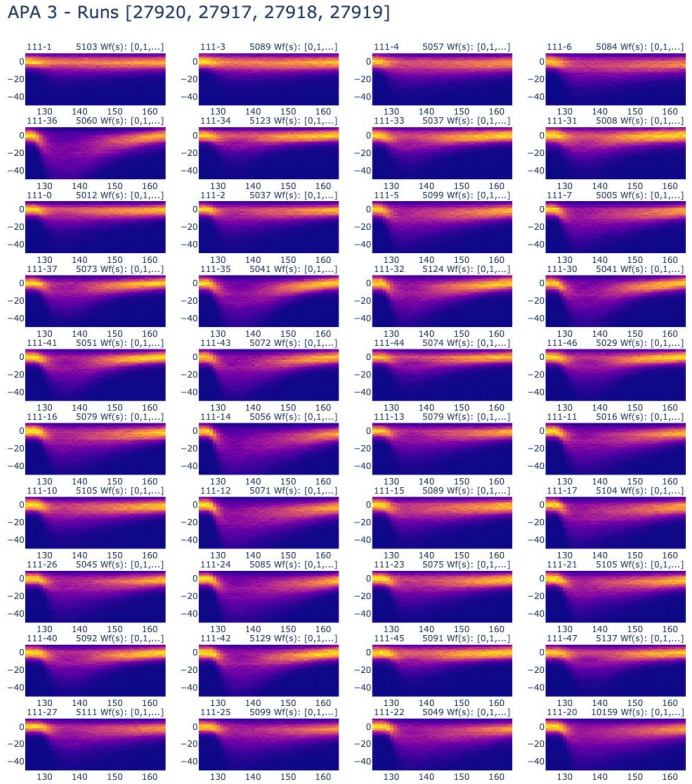


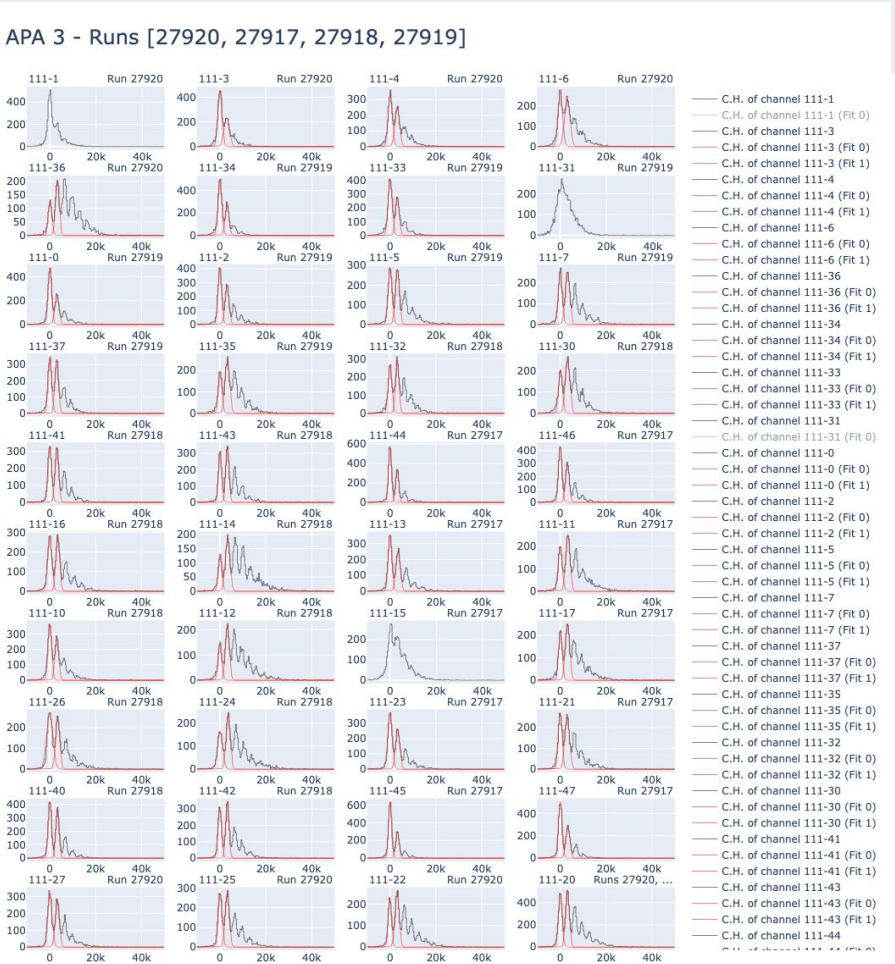
Results (APA 2, batch 3, PDE 50%)



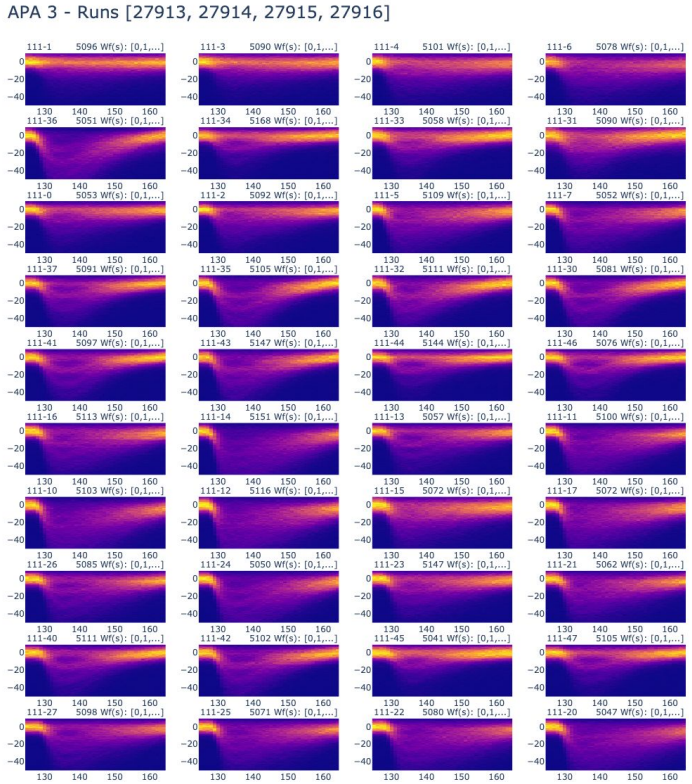


Results (APA 3, batch 1, PDE 40%)

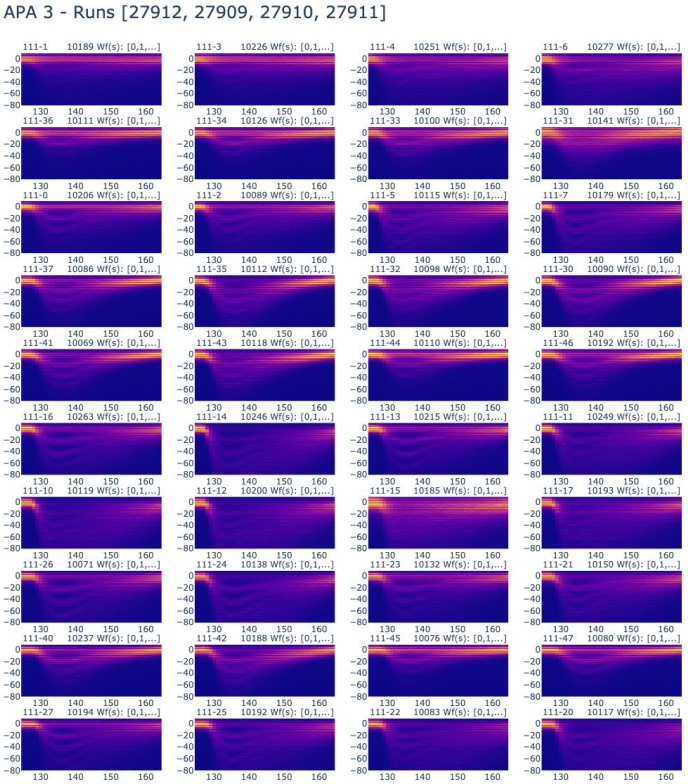


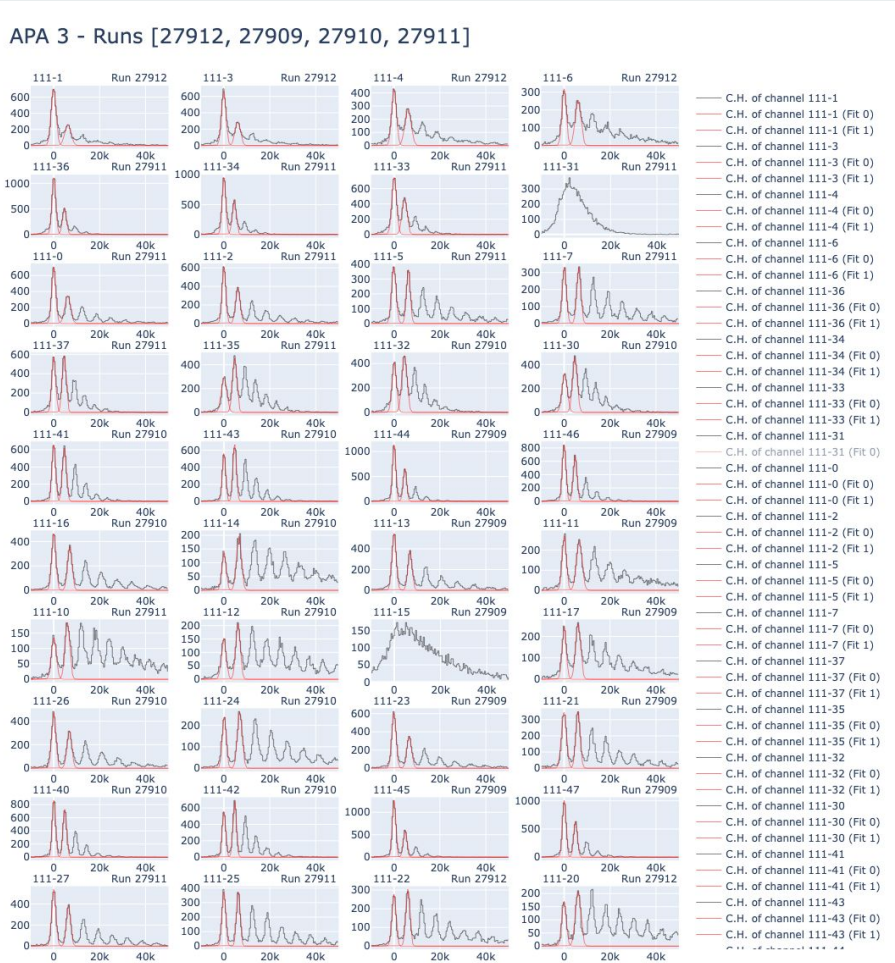


Results (APA 3, batch 1, PDE 45%)



Results (APA 3, batch 1, PDE 50%)





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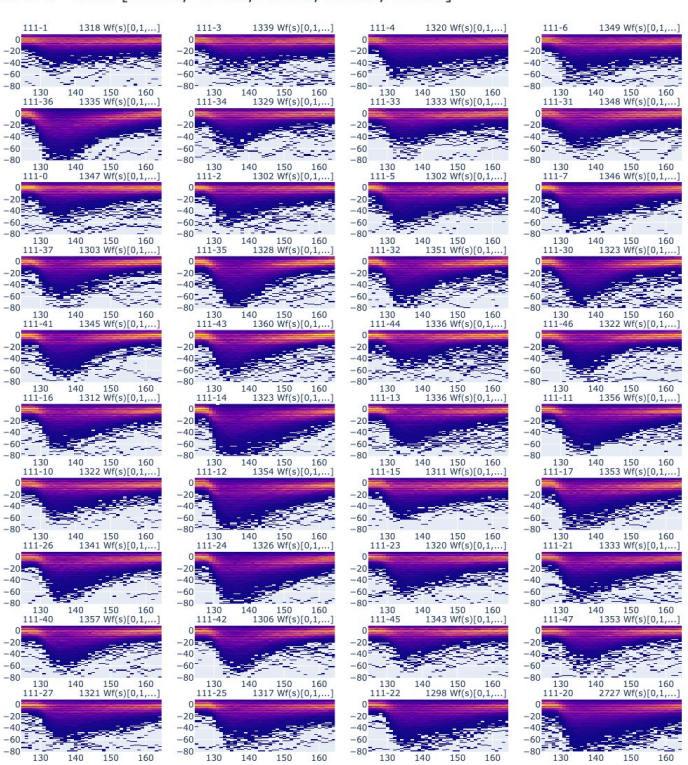
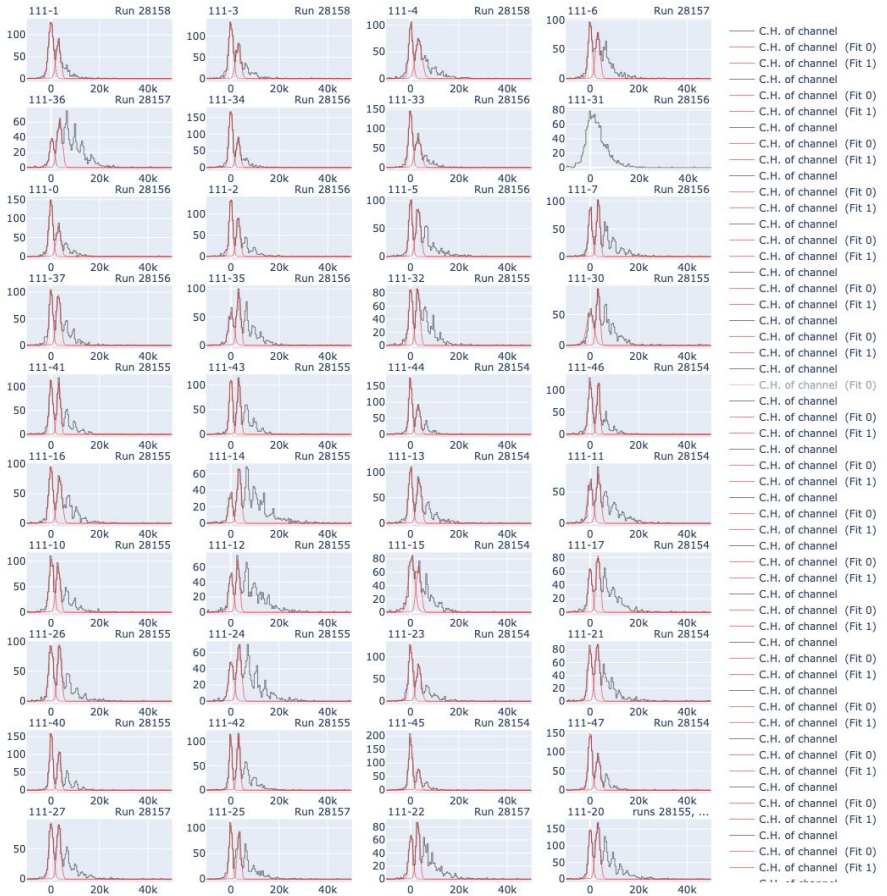
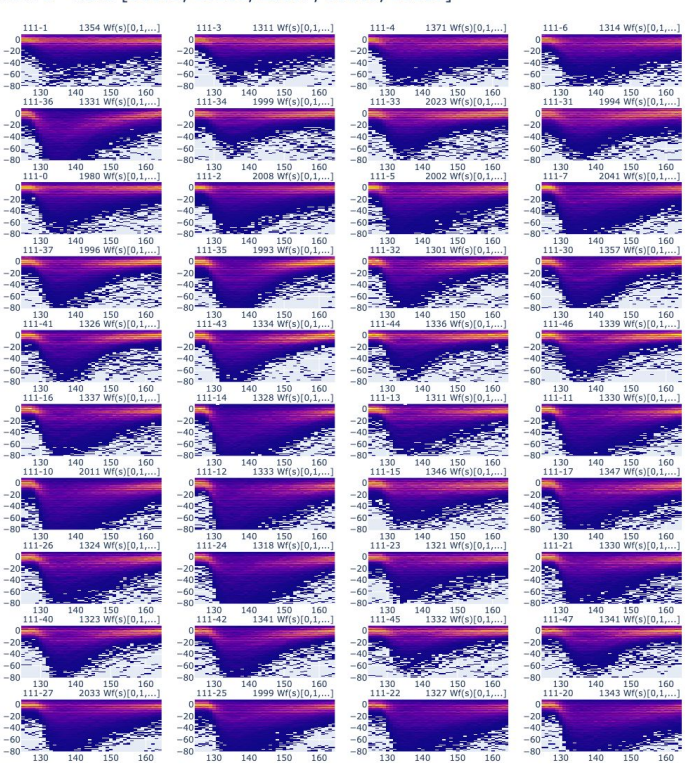
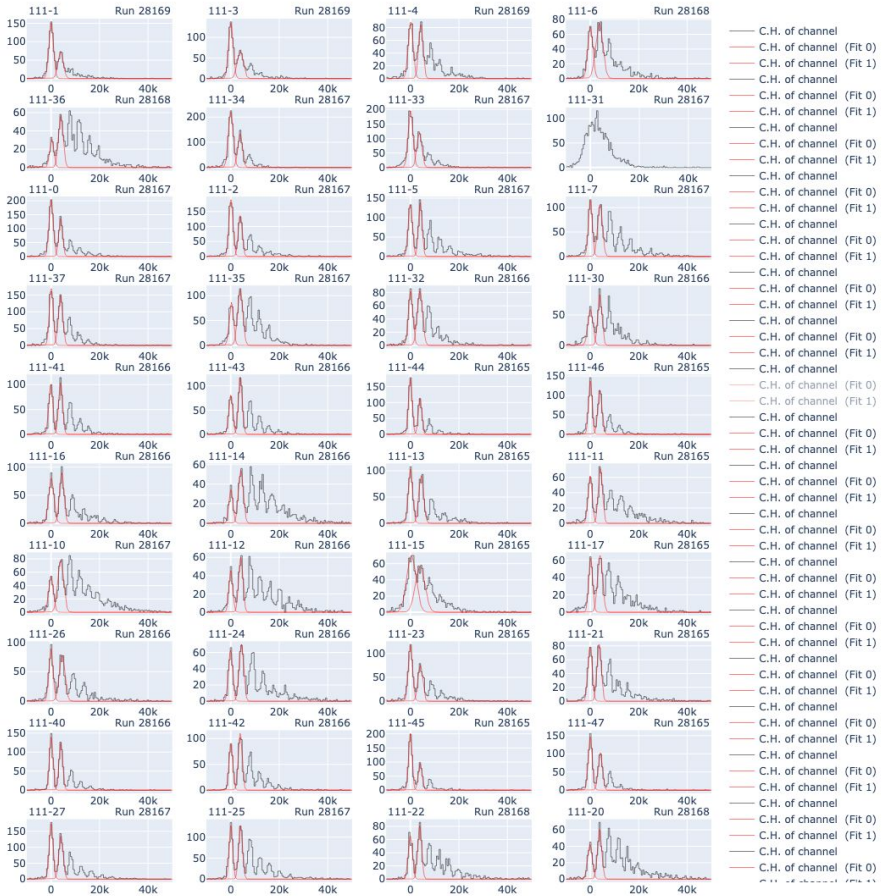


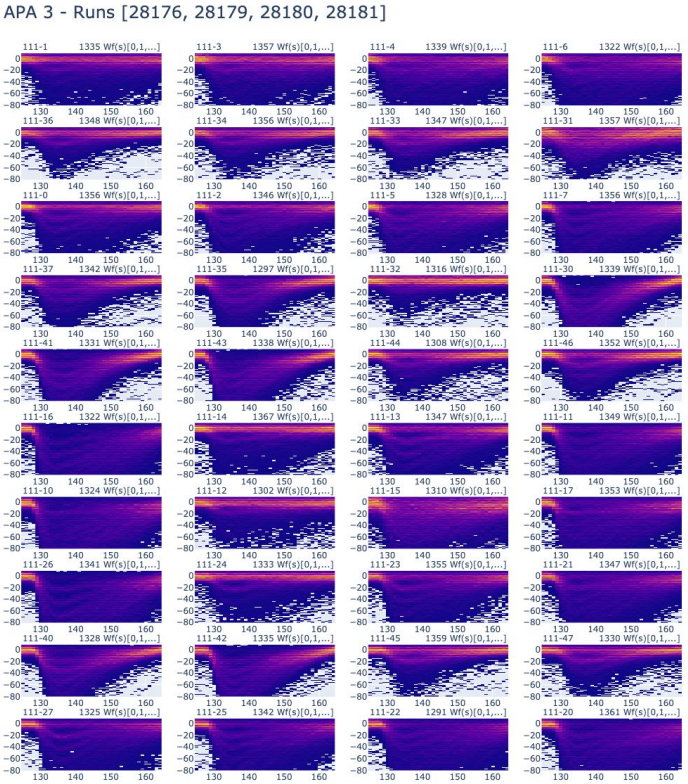


Results (APA 3, batch 2, PDE 45%)

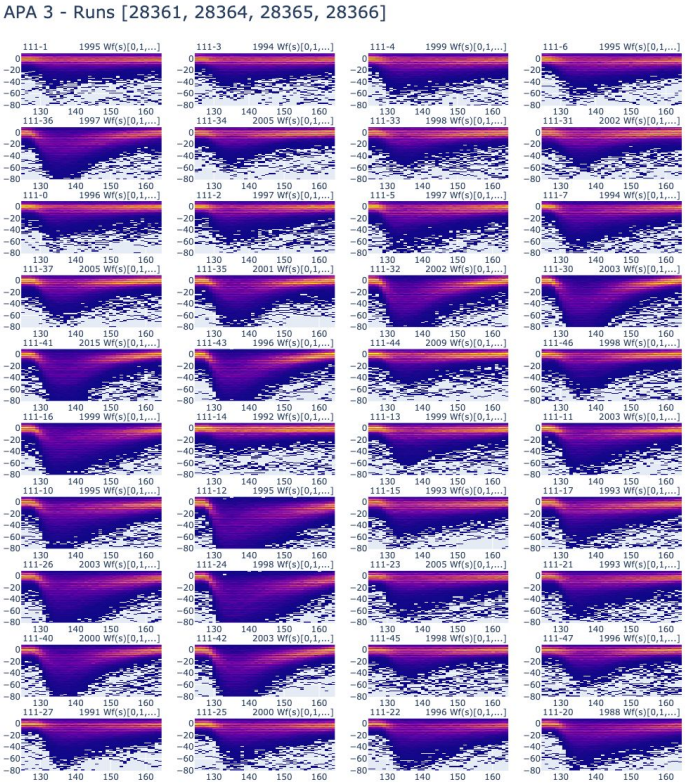


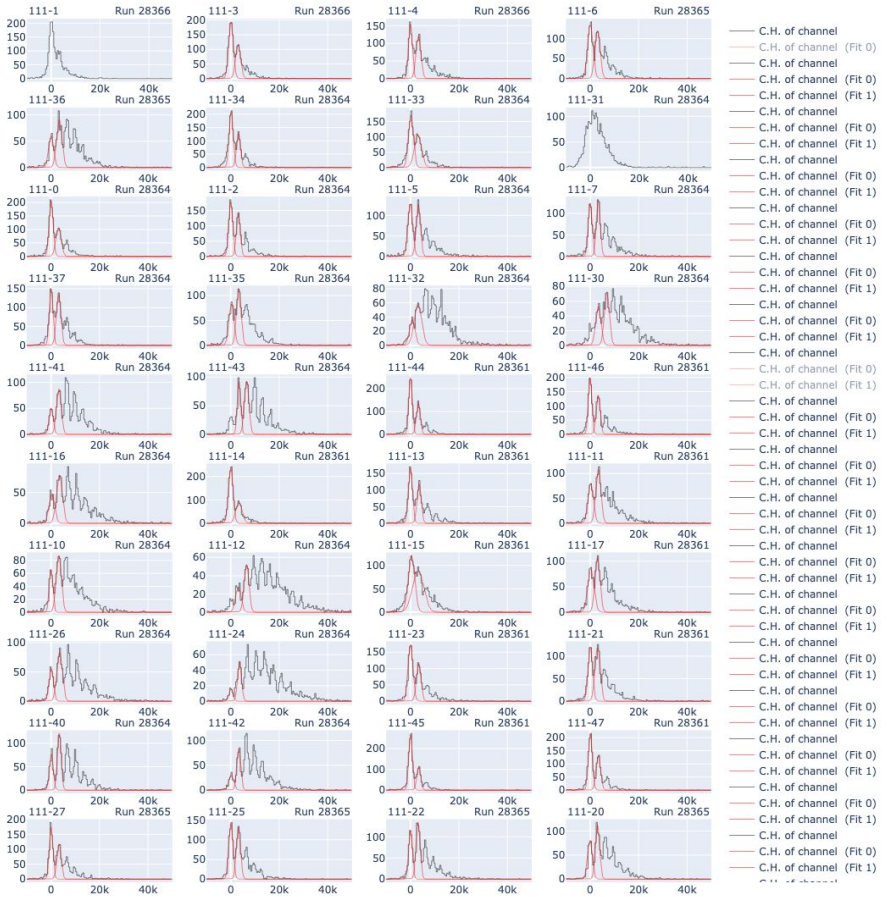


Results (APA 3, batch 2, PDE 50%)

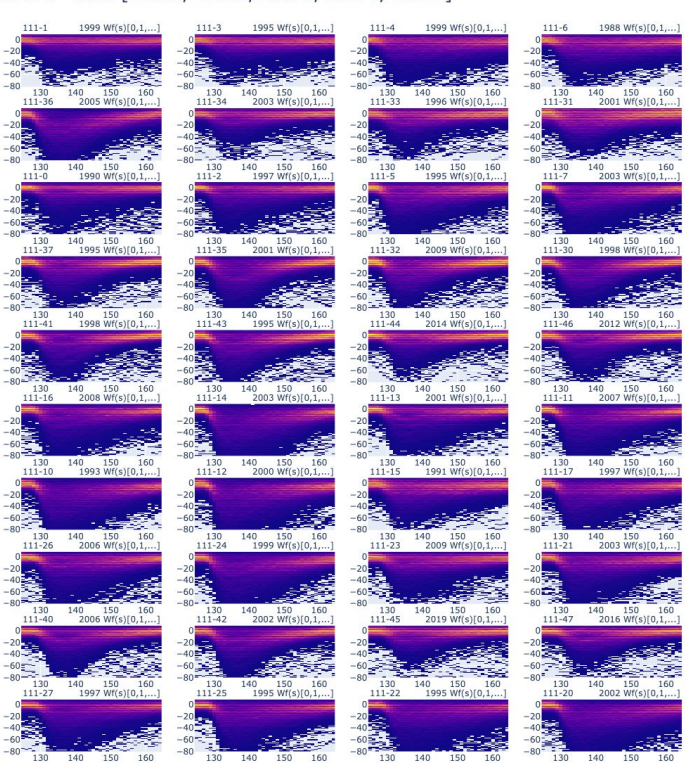


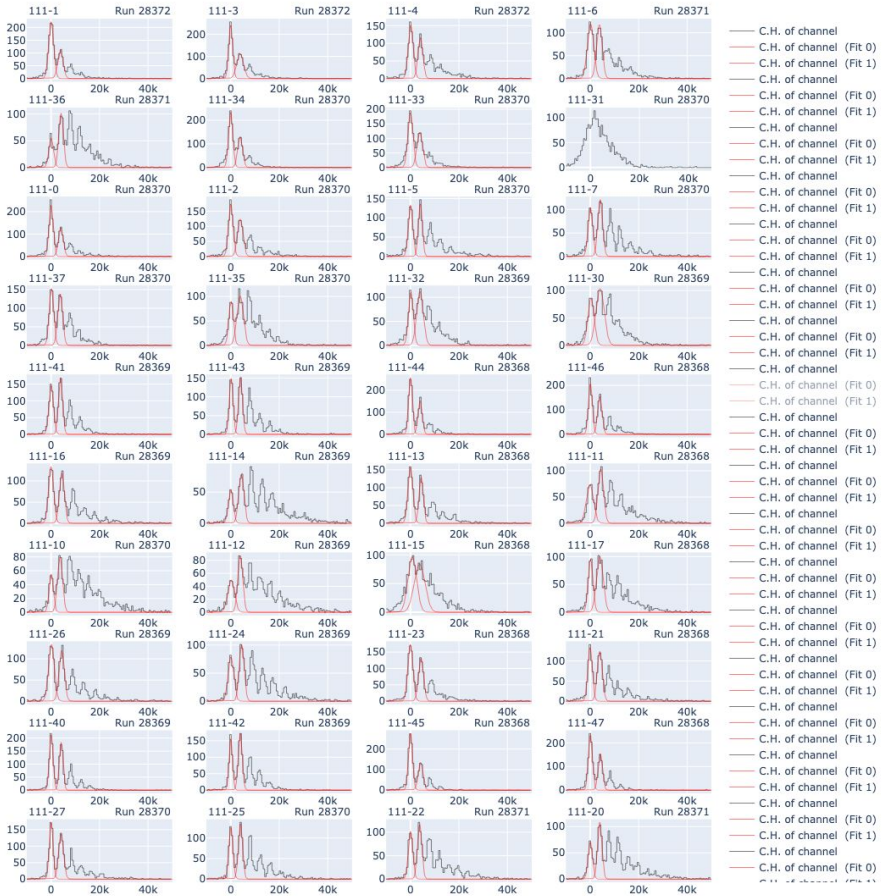
Results (APA 3, batch 3, PDE 40%)



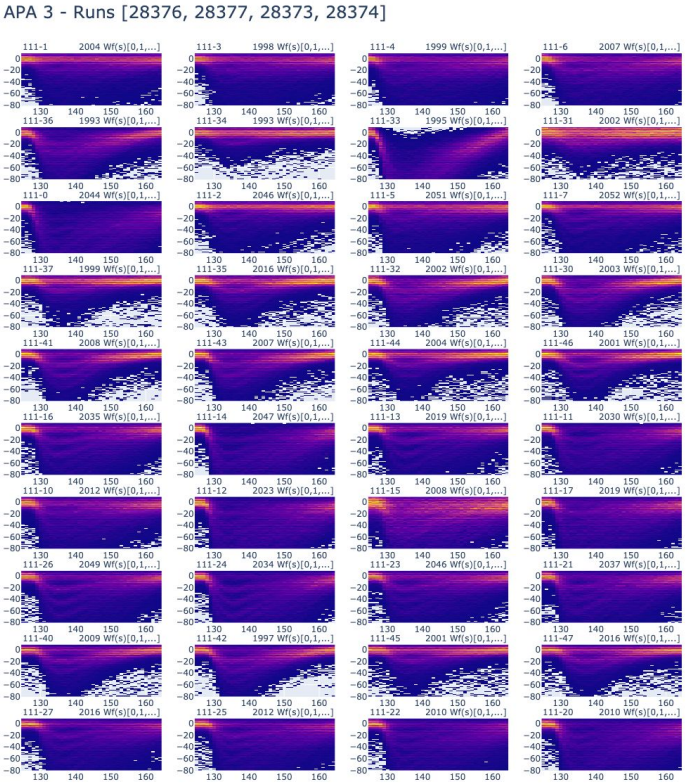


Results (APA 3, batch 3, PDE 45%)

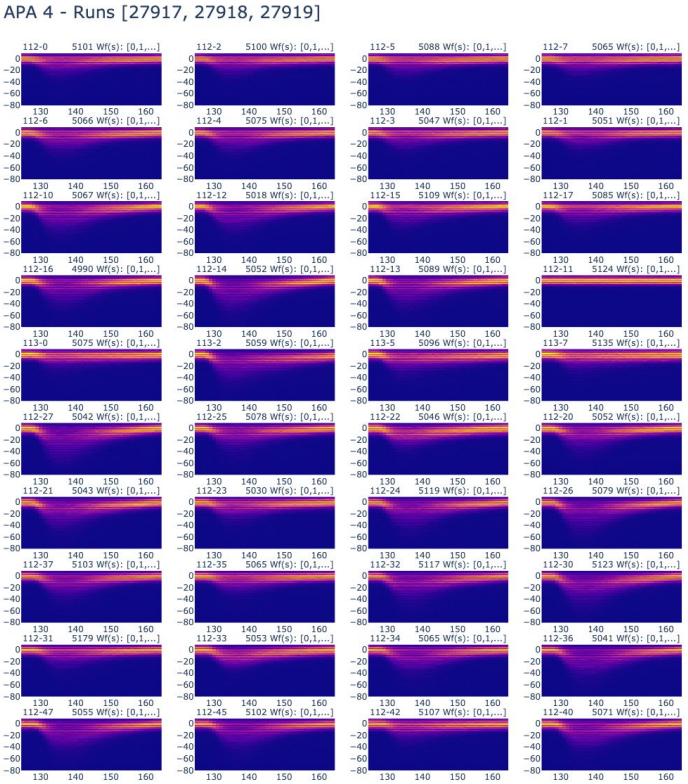


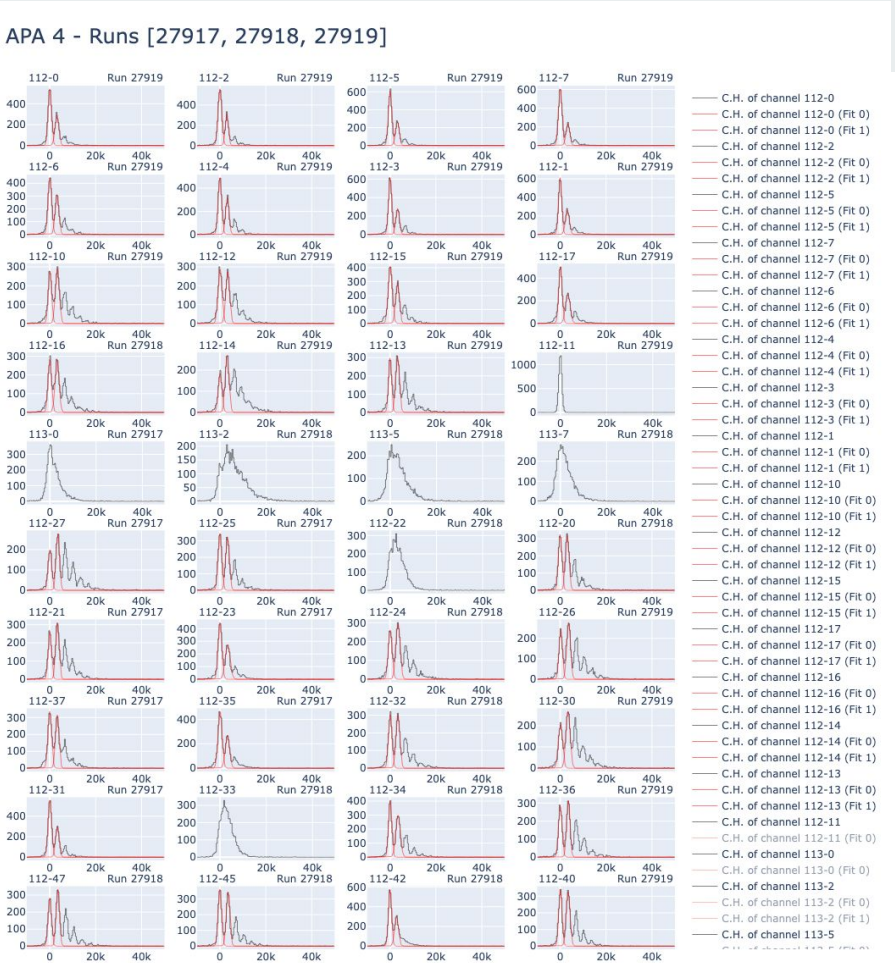


Results (APA 3, batch 3, PDE 50%)

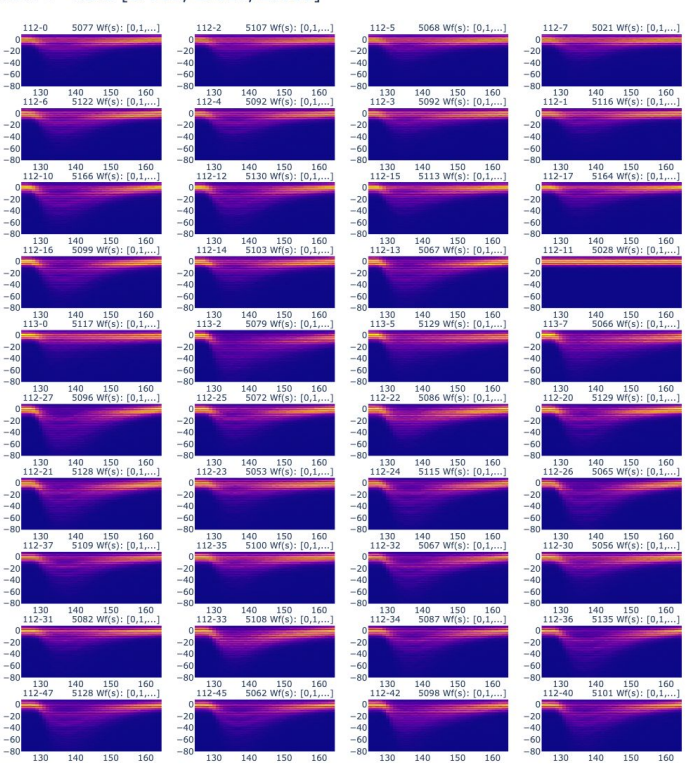


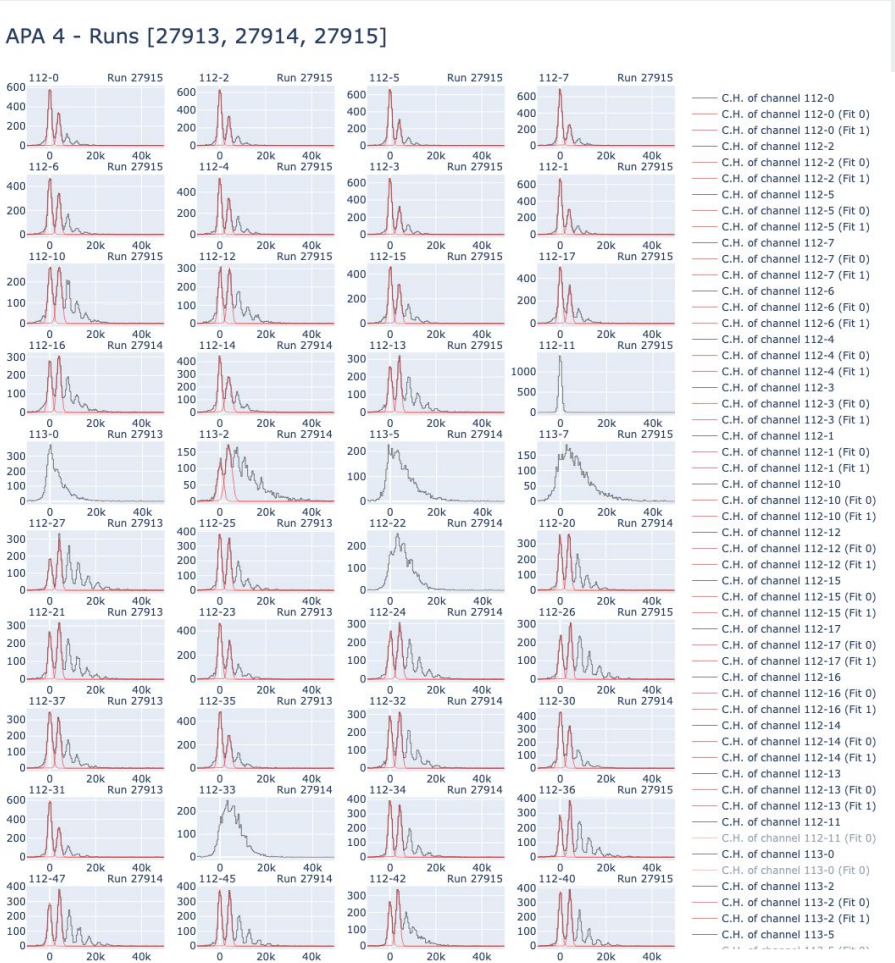
Results (APA 4, batch 1, PDE 40%)



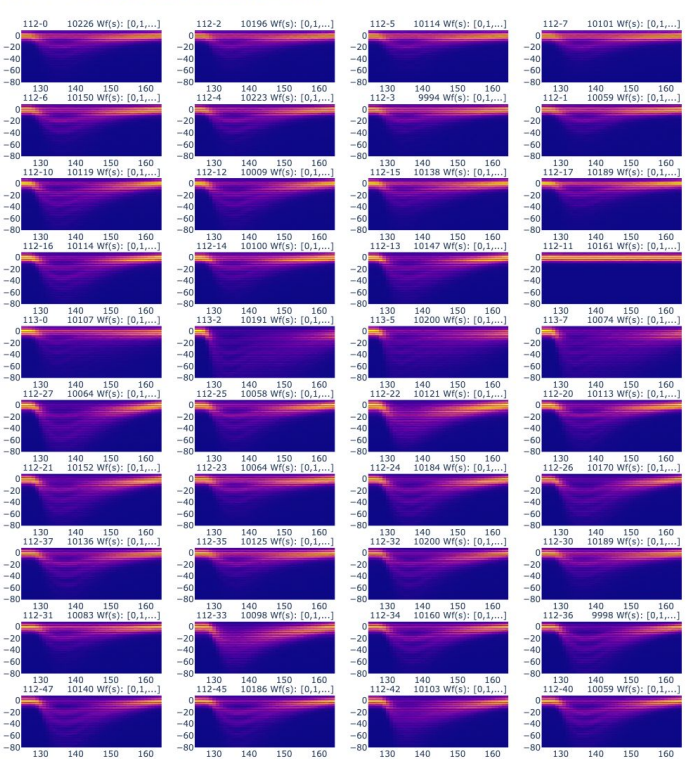


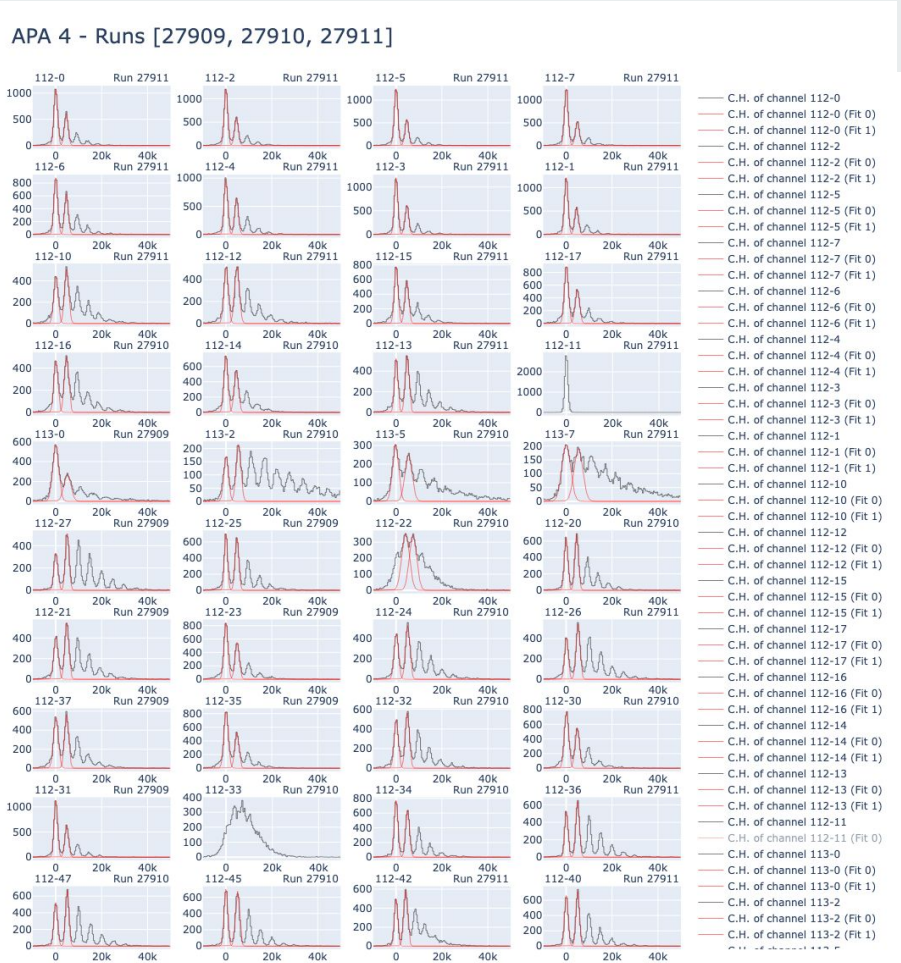
Results (APA 4, batch 1, PDE 45%)



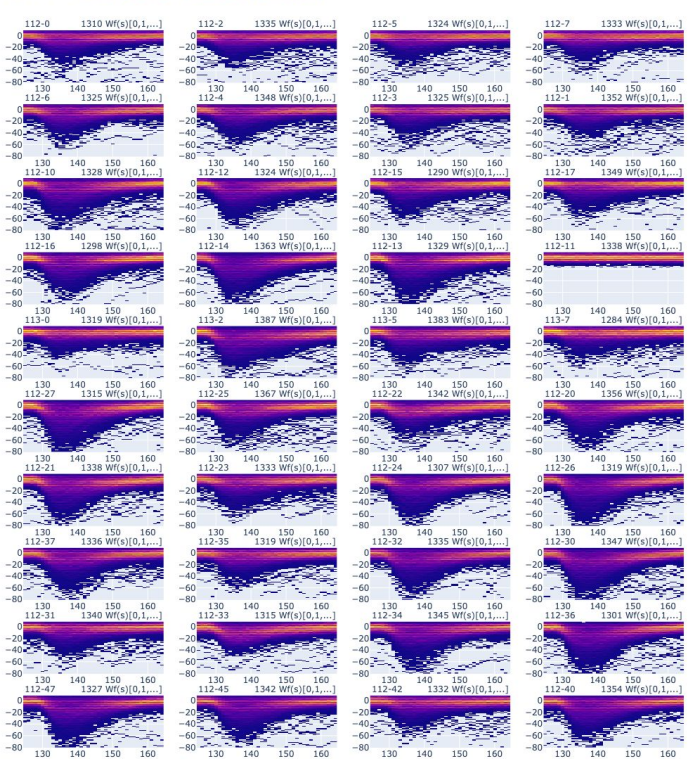


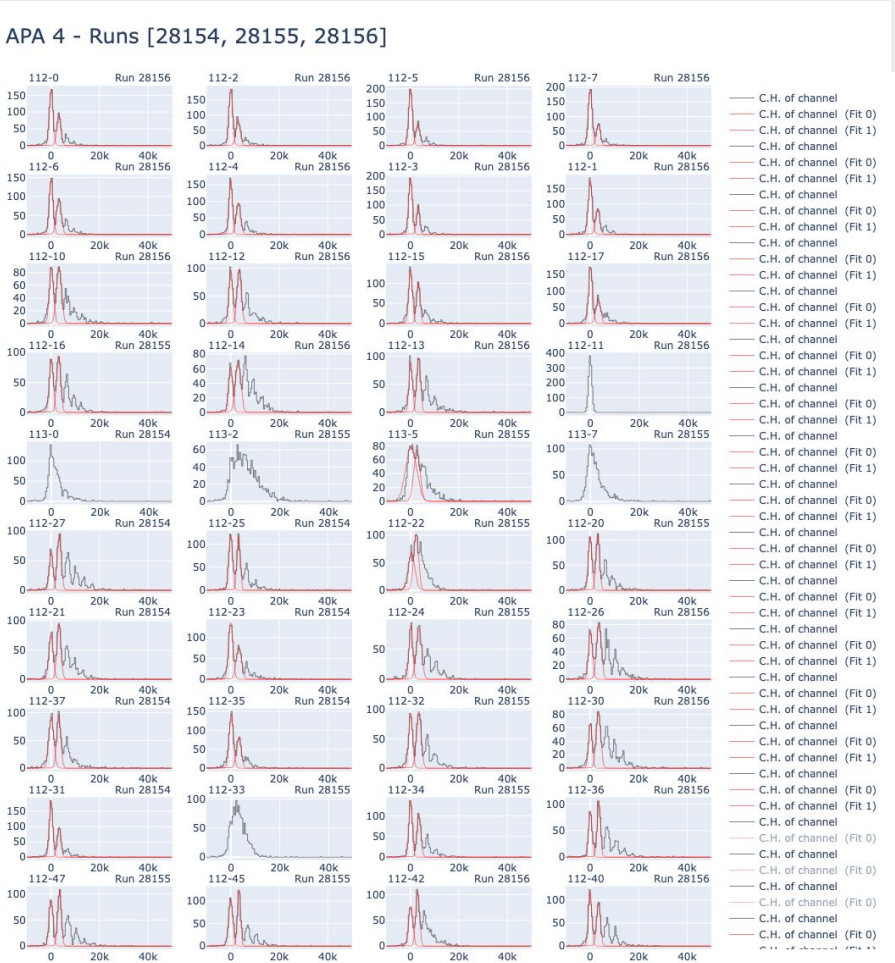
Results (APA 4, batch 1, PDE 50%)



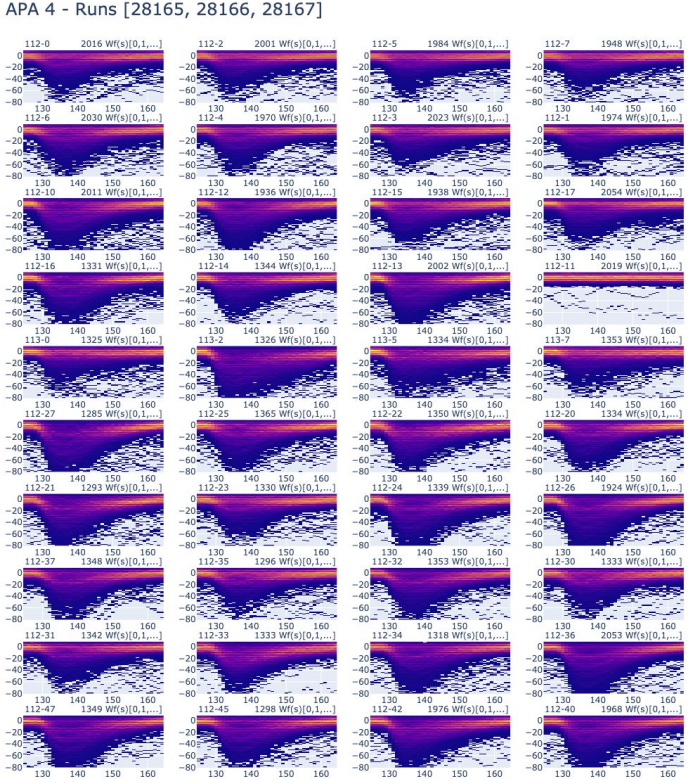


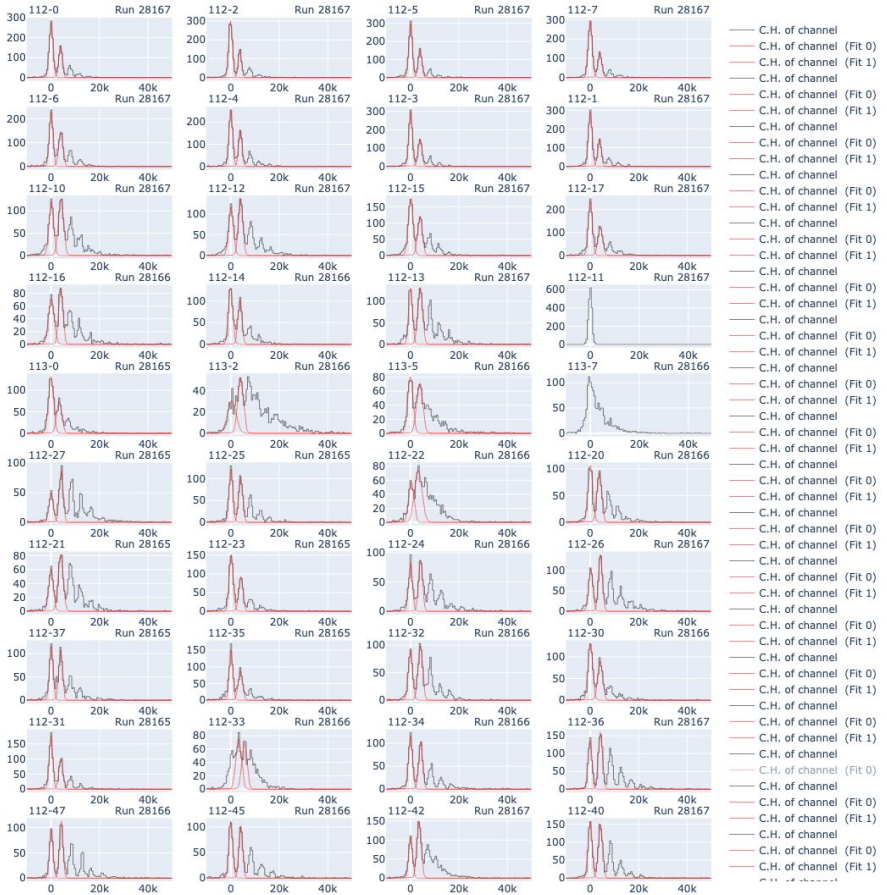
Results (APA 4, batch 2, PDE 40%)



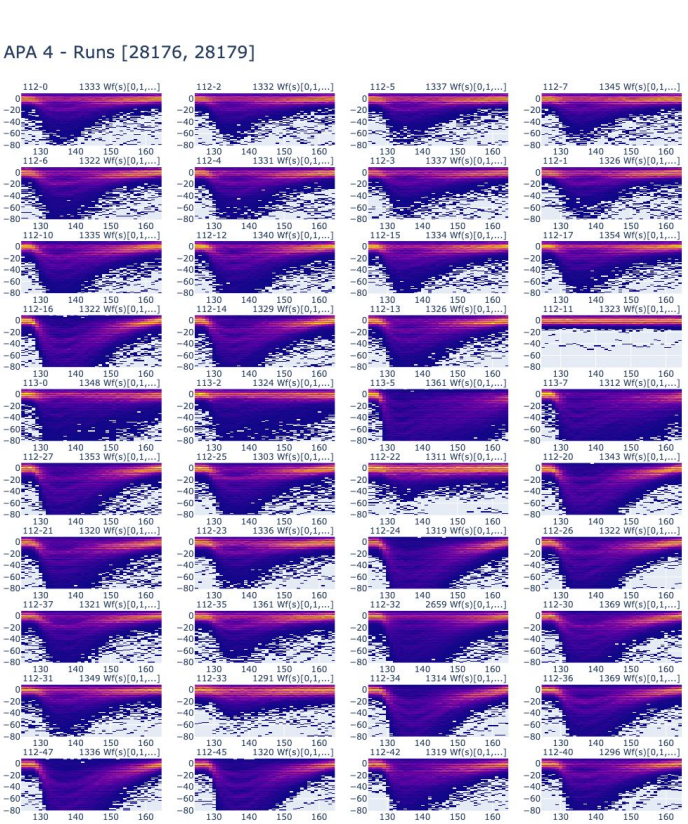


Results (APA 4, batch 2, PDE 45%)

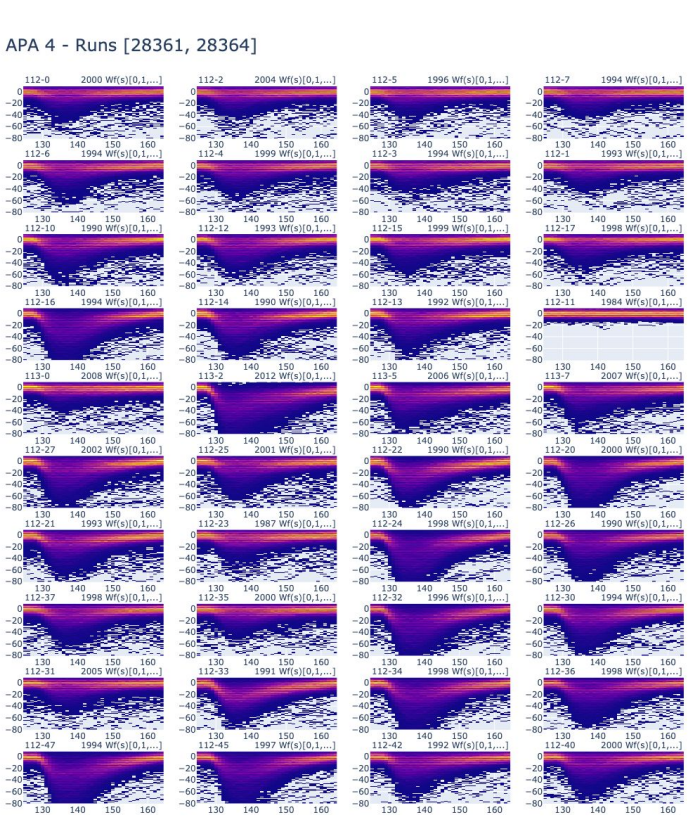


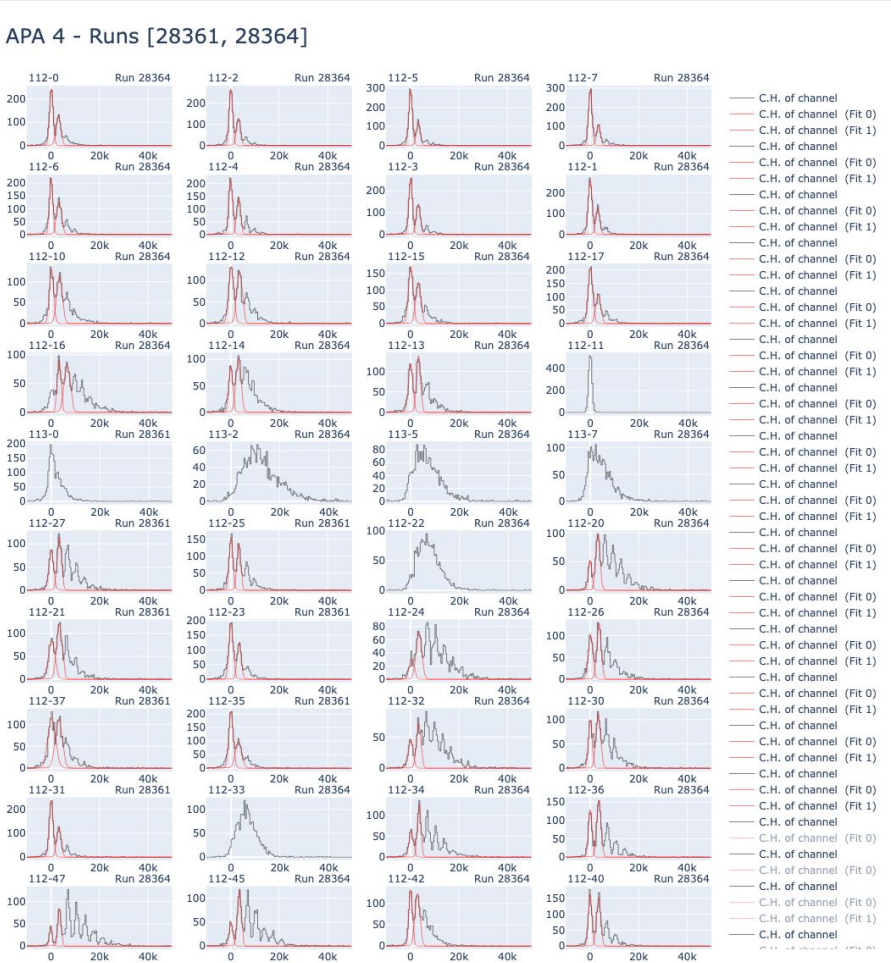


Results (APA 4, batch 2, PDE 50%)

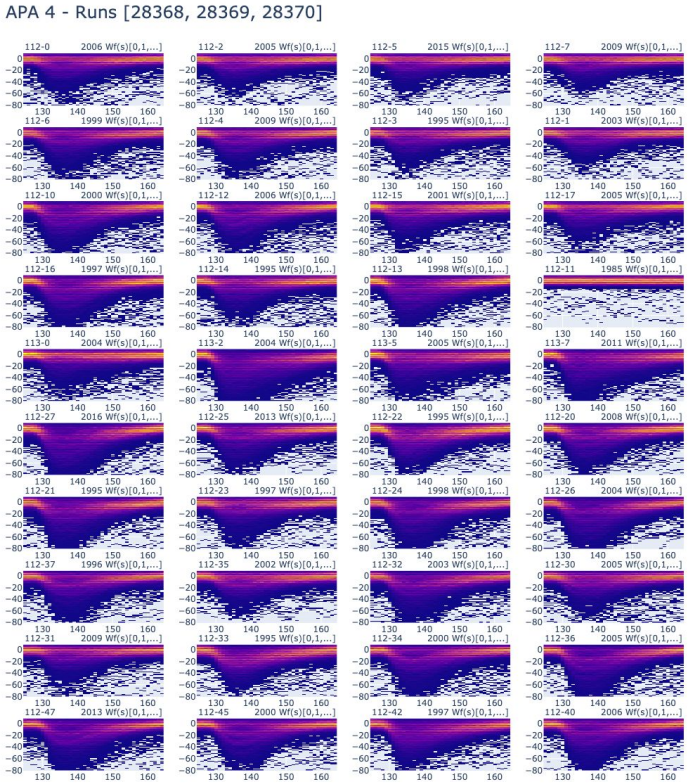


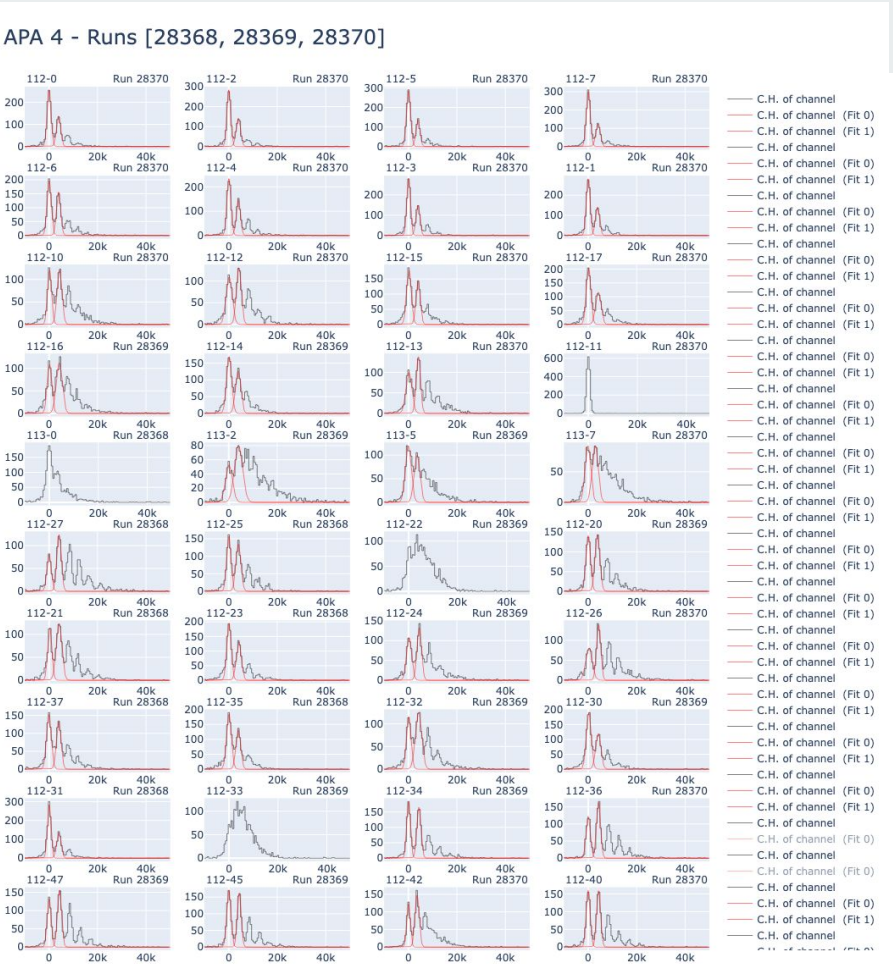
Results (APA 4, batch 3, PDE 40%)





Results (APA 4, batch 3, PDE 45%)





Results (APA 4, batch 3, PDE 50%)