Status RICH-hardware

MAPMTs and dirich status and measurements

Jörg Förtsch
@HADES-Collaboration Meeting
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BERGISCHE UNIVERSITÄT WUPPERTAL

Overview

- Status MAPMT delivery and measurements
- Dirich measurements

Status MAPMT delivery and measurements

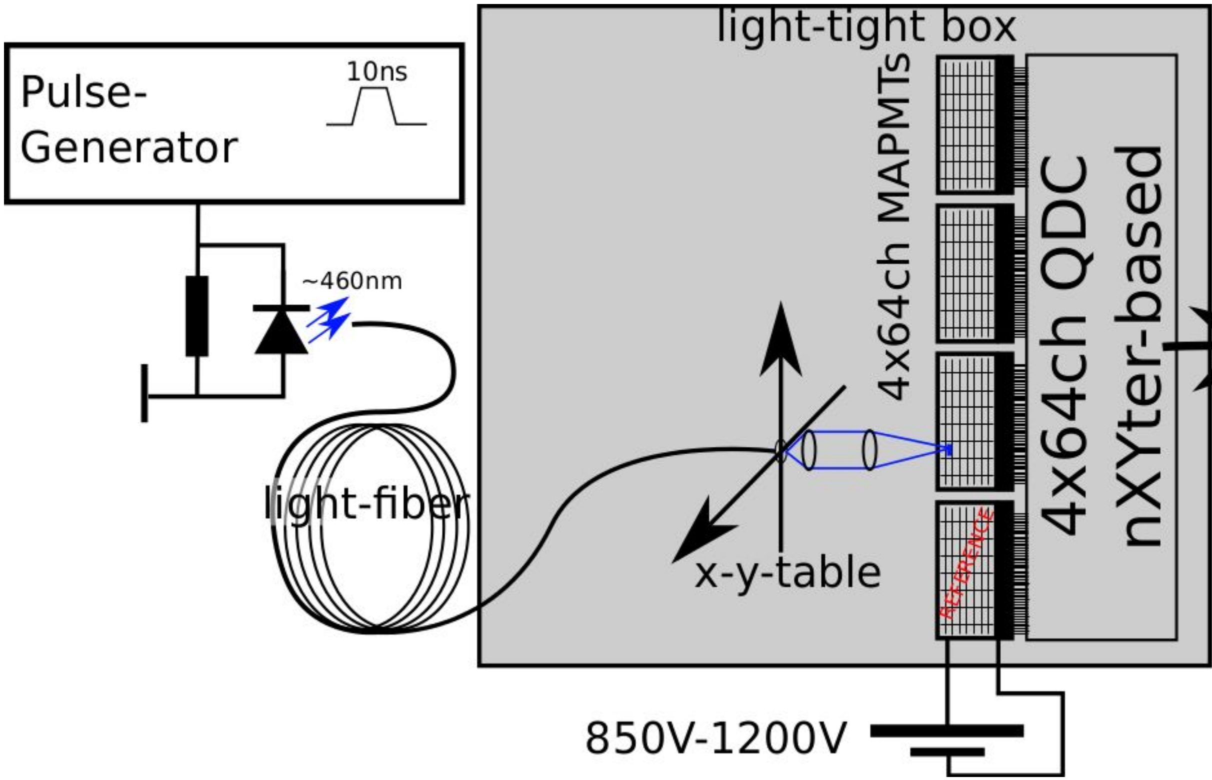
- Current Status
- Test Bench
- Gain measurement
- Efficiency measurement
- Dark Rate measurement

Current status

- Ordered 1100 HAMAMATSU H12700 MAPMTs
  - 50 being delivered each month since October 2015
- Some delay due to problems in production at HAMAMATSU
- The test bench characterizes every single MAPMT soon after delivery to:
  - Sort out PMTs not fulfilling the buying specifications
  - Sort PMTs into different (gain-) categories to group them in the final detector
- Measured 950/1000 MAPMTs - Sufficient to HADES-RICH
  - 141 MAPMTs with new front window ($51.7 \times 51.7\ mm^2$ instead of $52 \times 52\ mm^2$ outer dimensions)
- Properly examined 752/950 MAPMTs
  - Leading to 19 reclaimed and replaced MAPMTs
- “Gain-grouping” will soon be taken care of

The measurement setup

- Triggered light-source emitting “single” photons (∽ 1γ/10 pulses)
- Leading photons to single point on MAPMT
  - Optical fiber + focussing optic (∽0.5 mm)
- Checking for pulses in each MAPMT channel
  - Self-triggered readout-scheme based on n-XYTER-ASIC
- Reference PMT needed



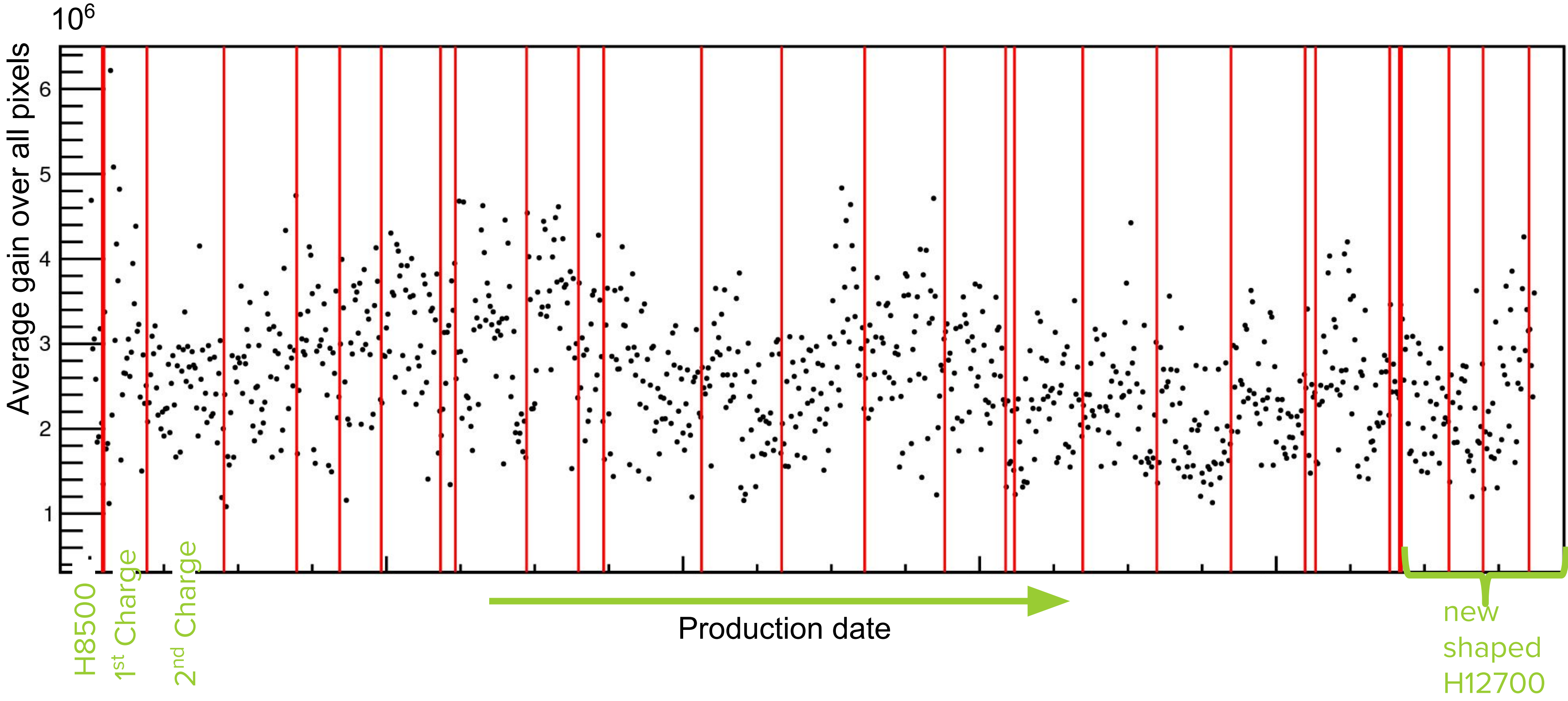
“Reclamation” Status

- Based on a subsample of 752 fully examined MAPMTs

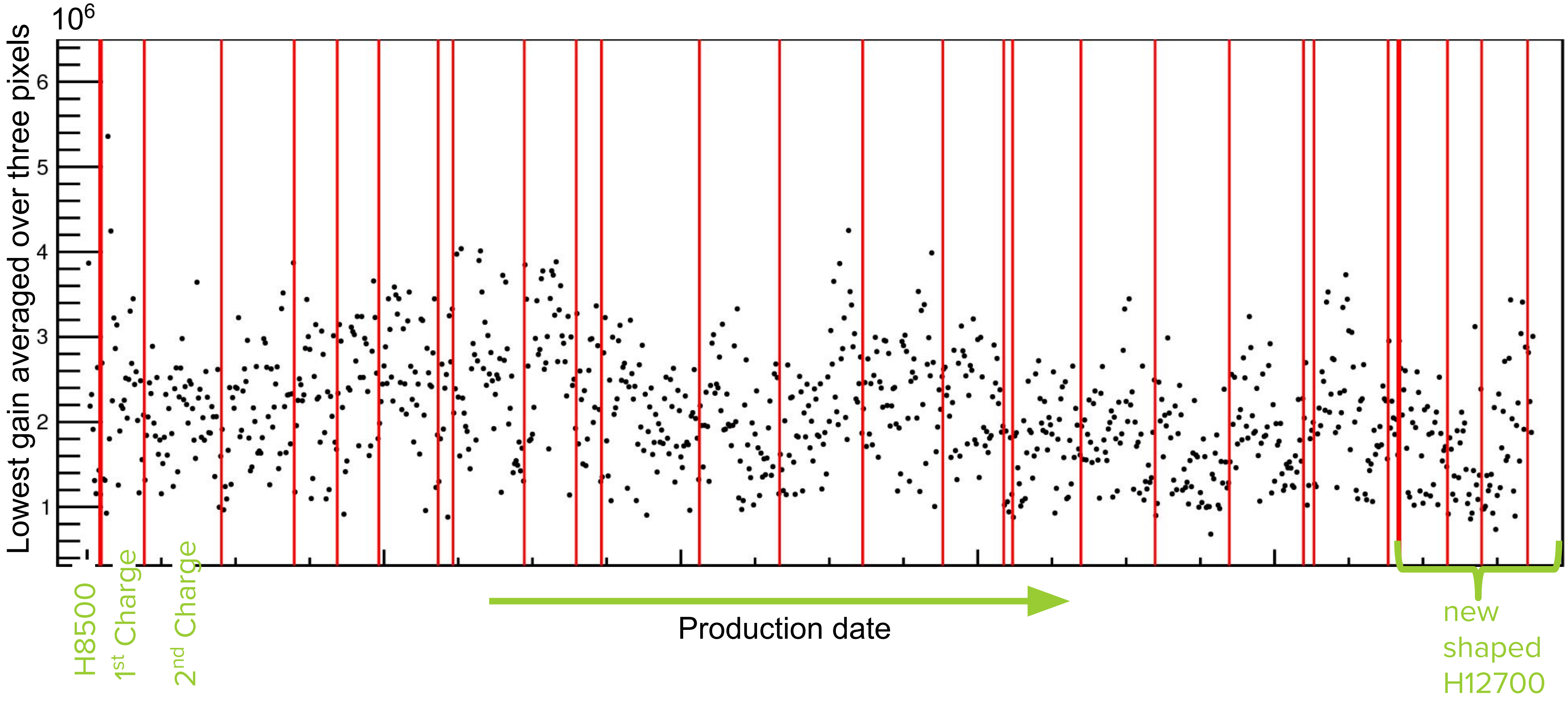
- 26 MAPMTs returned to HAMAMATSU due to non-fulfillment of buying-specs.
  - High noise (one pixel >1 kHz / all pixels >6.4 kHz) : 12-times
  - Efficiency-Artifacts in QE (e.g. inefficient corners, skewed efficiency plane): 9-times
  - Efficiency-Artifacts not visible in QE (e.g. inefficient pixel parts): 7-times
  - High afterpulse rate: 1 PMT (2.7%)
  - Inoperative photocathode due to broken vacuum(?): 1 PMT

- 7 MAPMTs disapproved by HAMAMATSU
  - Mainly those with minor efficiency artefacts (CE-related / Dynode-defect related)
  - Overall low efficient PMTs were also rejected

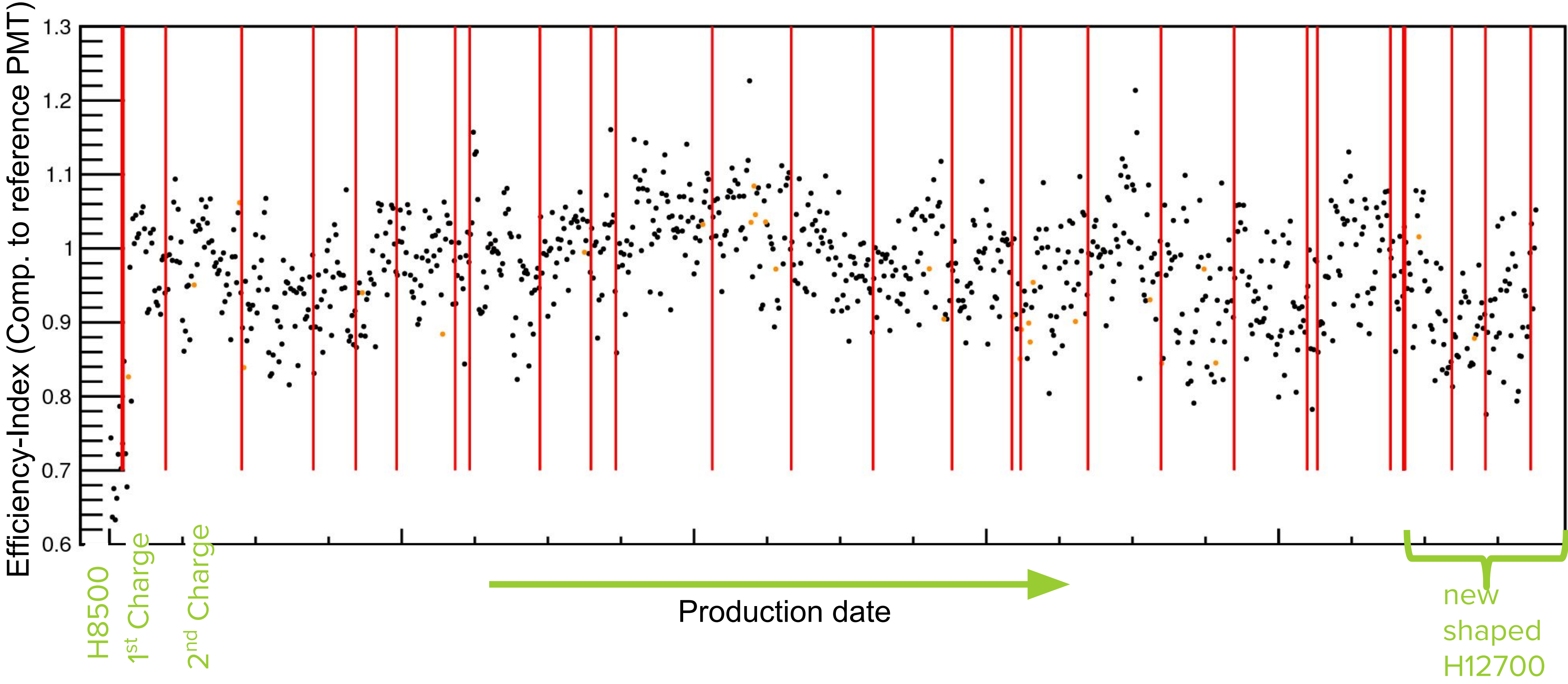
Gain measurement



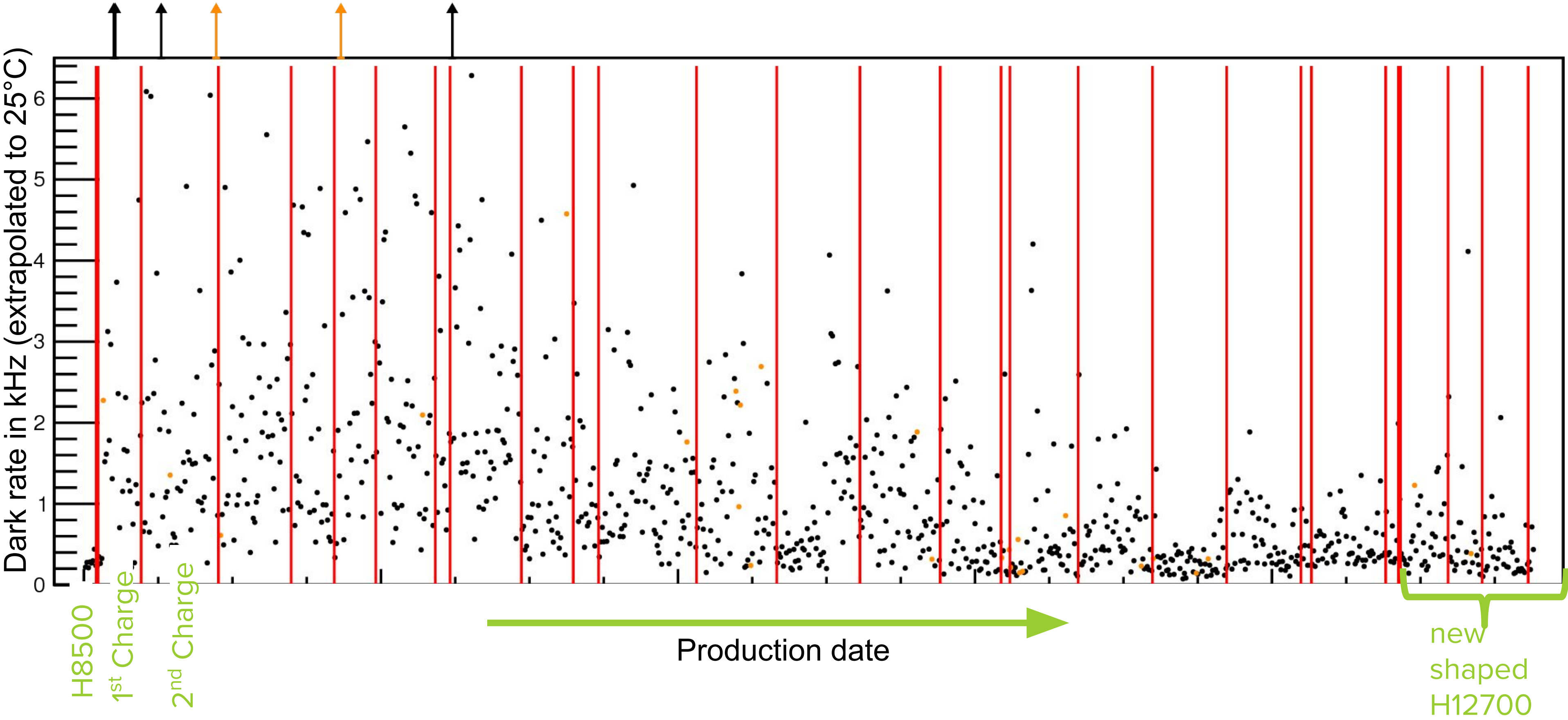
Gain measurement: Lowest gain in three pixels



Efficiency-Index measurement



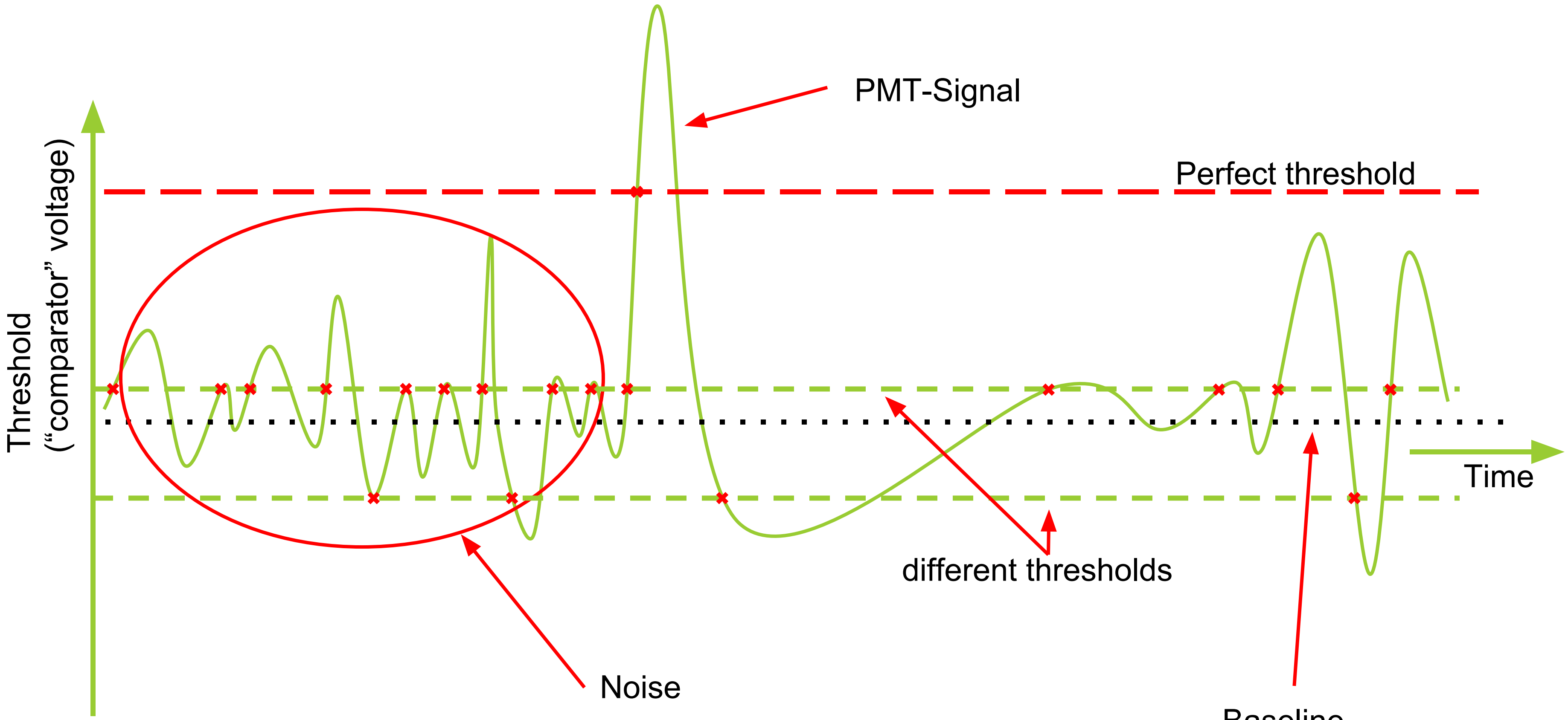
Dark rate (@25°C) measurement



Dirich measurements

- Measurement principle (Threshold scans)
- Impact of the onboard DC/DC Converter
- Single Photon Events
- How to retrieve statistical ADC spectra
  to get the “perfect” threshold-Setting

Measurement principle (Threshold scans)



How to find the baseline

Find noise:

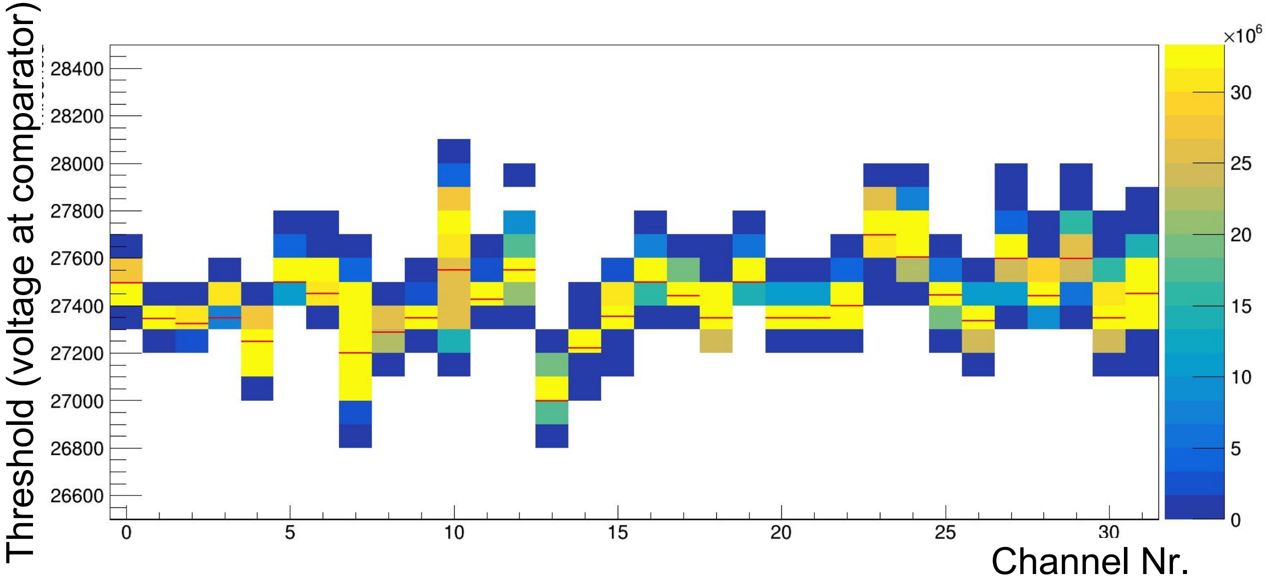
- Iterating through different comparator-voltages
- Measure rate based on scaler readout (no TDC)

Find center of noise:

- Find left and right noise edge (rate > 50 kHz)
- Middle between those two values is baseline (red-line in graphic)

All future thresholds can then be set as:

- baseline + real_threshold

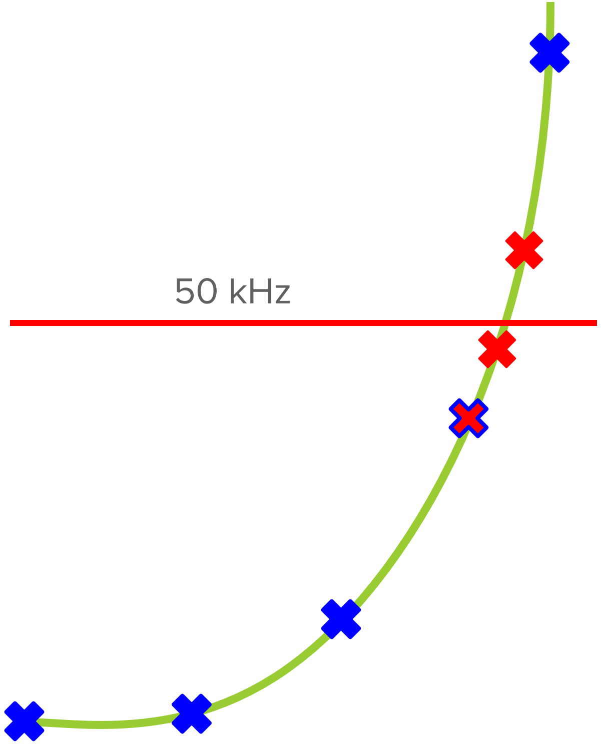


How to find the baseline | New method

- Iterating through different thresholds with large steps
- Measure rate based on scaler readout (no TDC)

- For each cross of 50 kHz reduce step width and continue measuring at last threshold before 50kHz

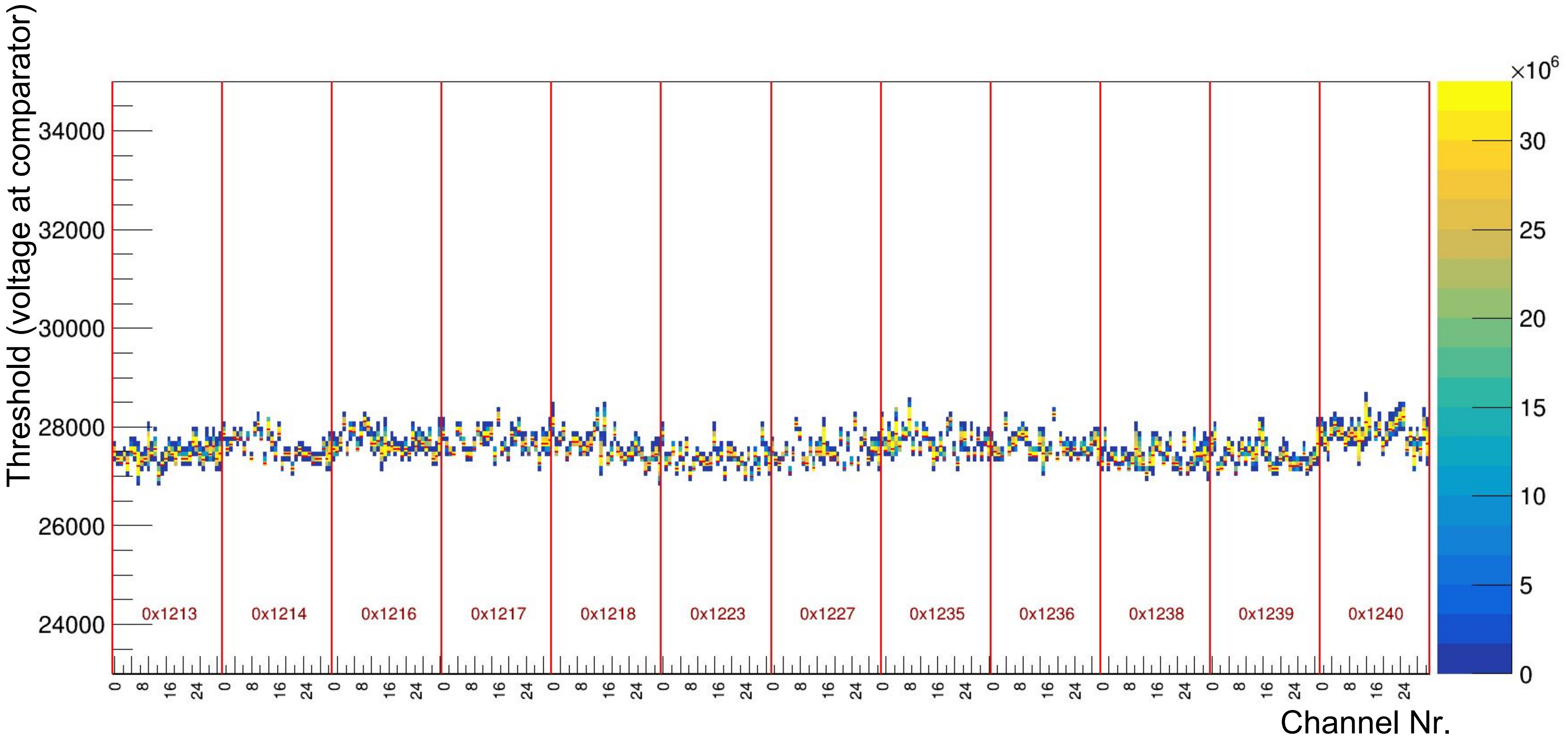
- Continue procedure till the step width is less than “one bit” at the comparator



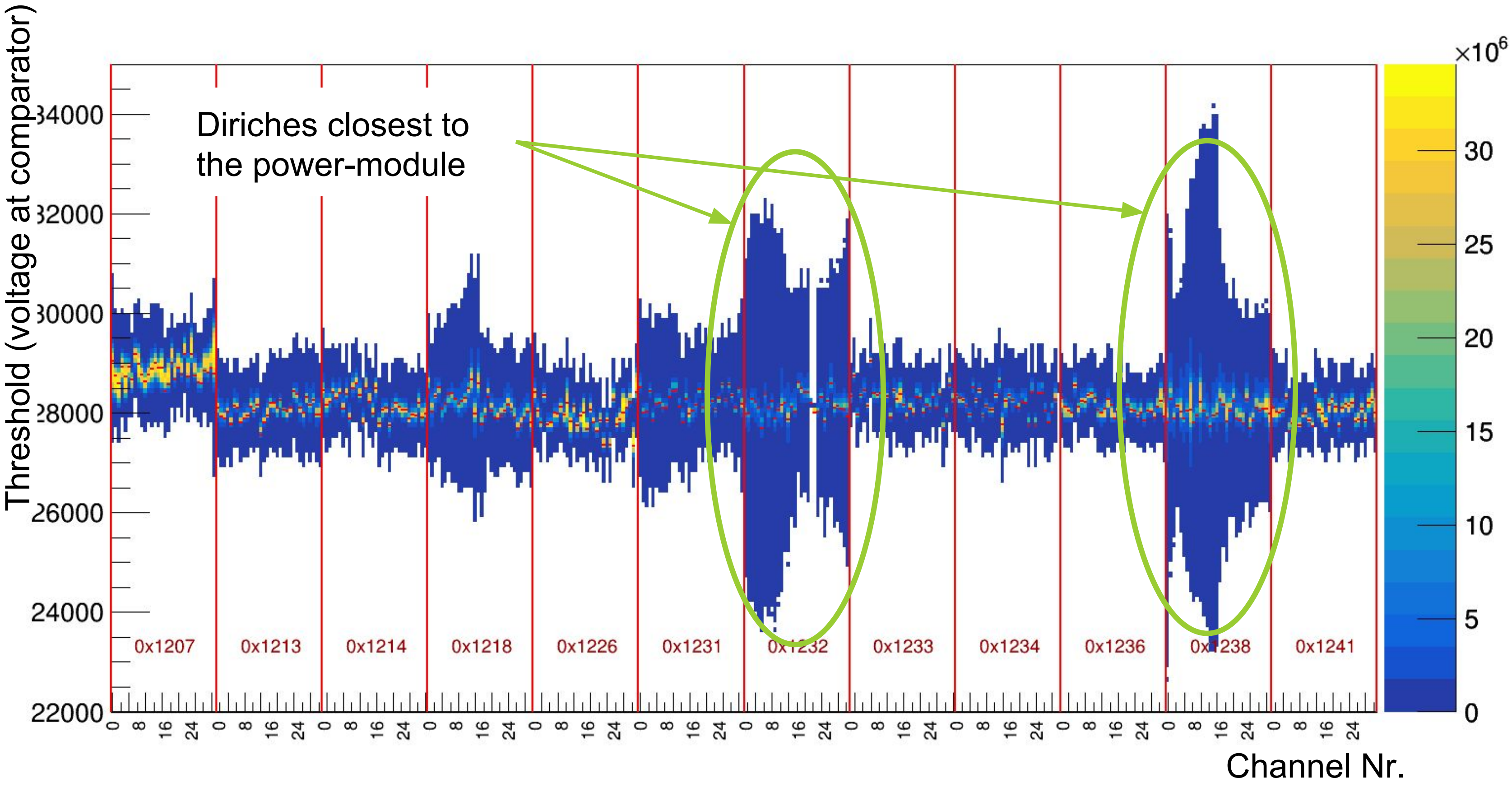
Benefit of this Method:

- Precision not reliant on starting parameter
- Always gives highest precision in an “optimal” time

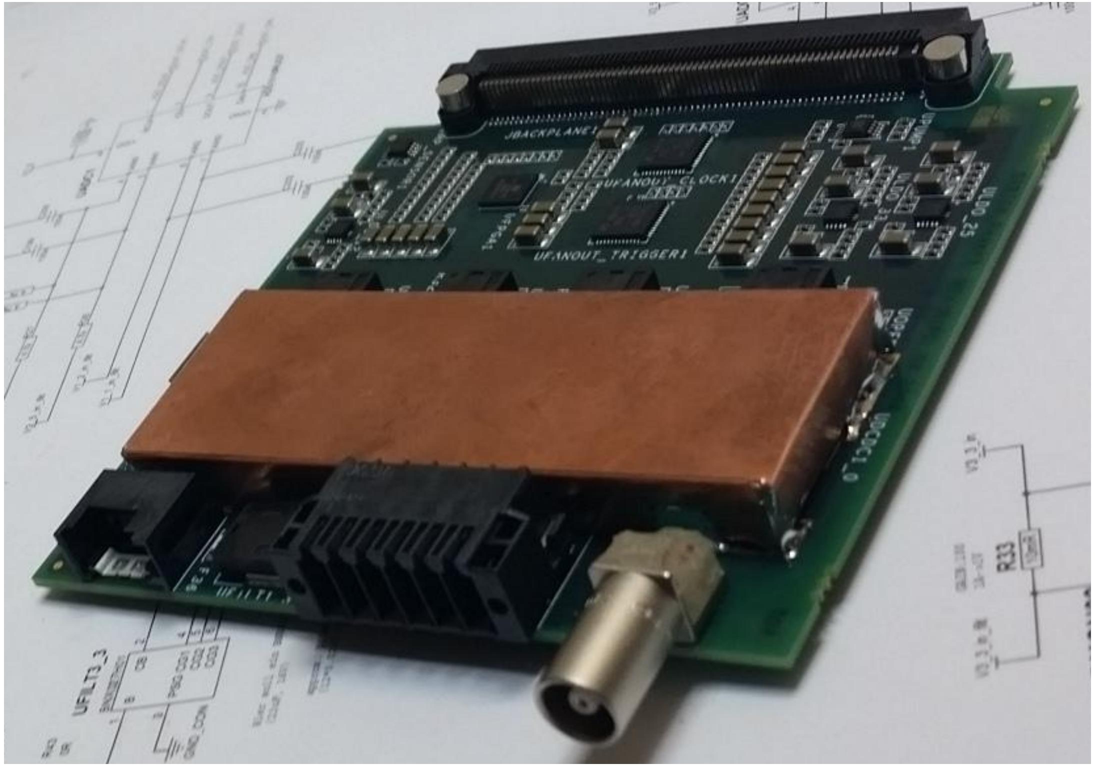
Thresholdscan of diriches using external power supply



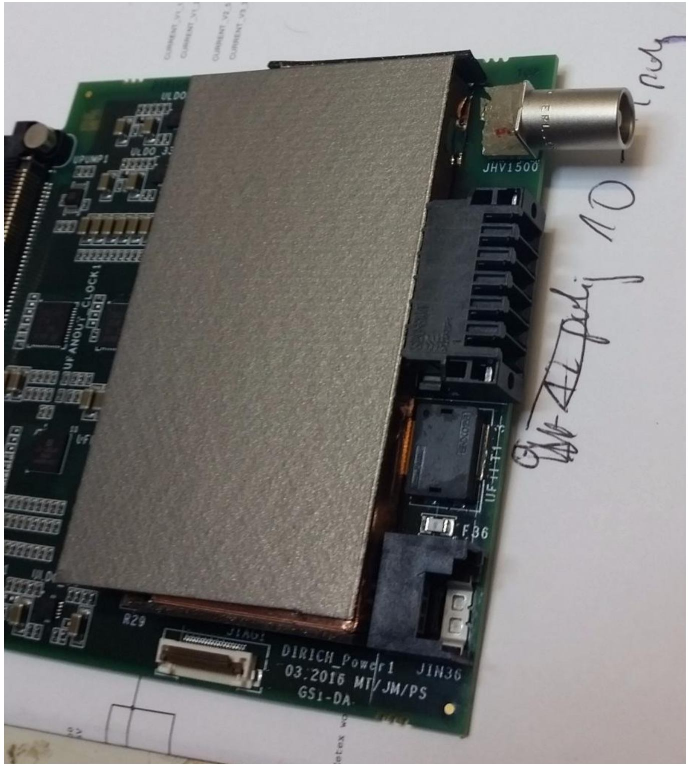
Thresholdscan of diriches using dc/dc power supply



Picture of the shielding

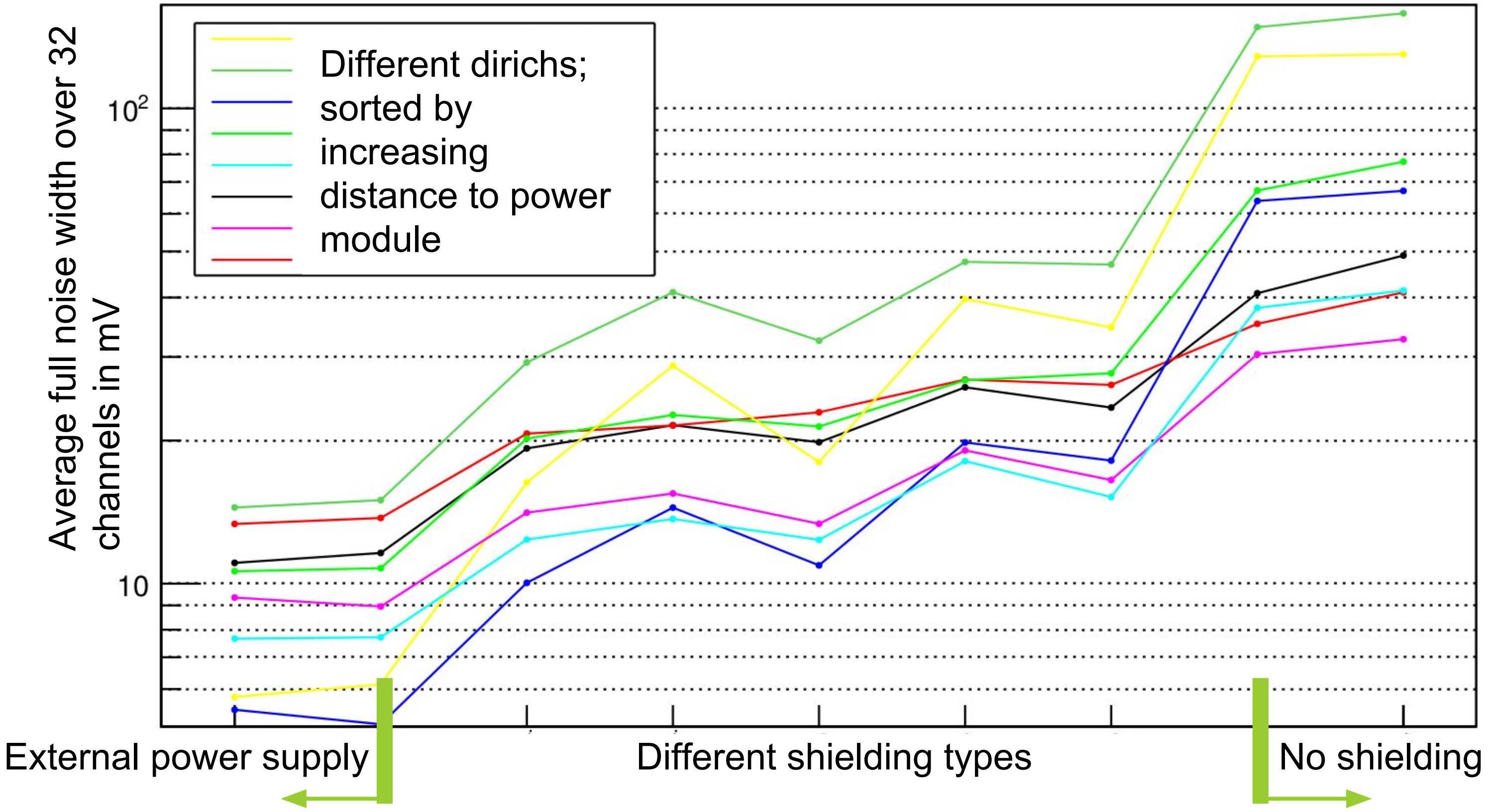


Copper-shielding



EMV-shielding

Impact of different shielding-types on noise induced by DC/DC converter



Further dirich and backplane measurements

- Baseline stability:
  - 80 minutes after startup baseline shift < 5 mV (after pre amplification)
  - Temperatures of less than 20°C
    induce no baseline shift > 5 mV (after pre amplification)

- Using a capacitor at the input stage:
  - Noise width marginally reduced
  - Pulse height significantly reduced → Single photon response closer to noise edge
  - → No input capacitor will be used

- Reproducible larger noise widths in certain channels of certain connectors on the backplane could be linked to the routing

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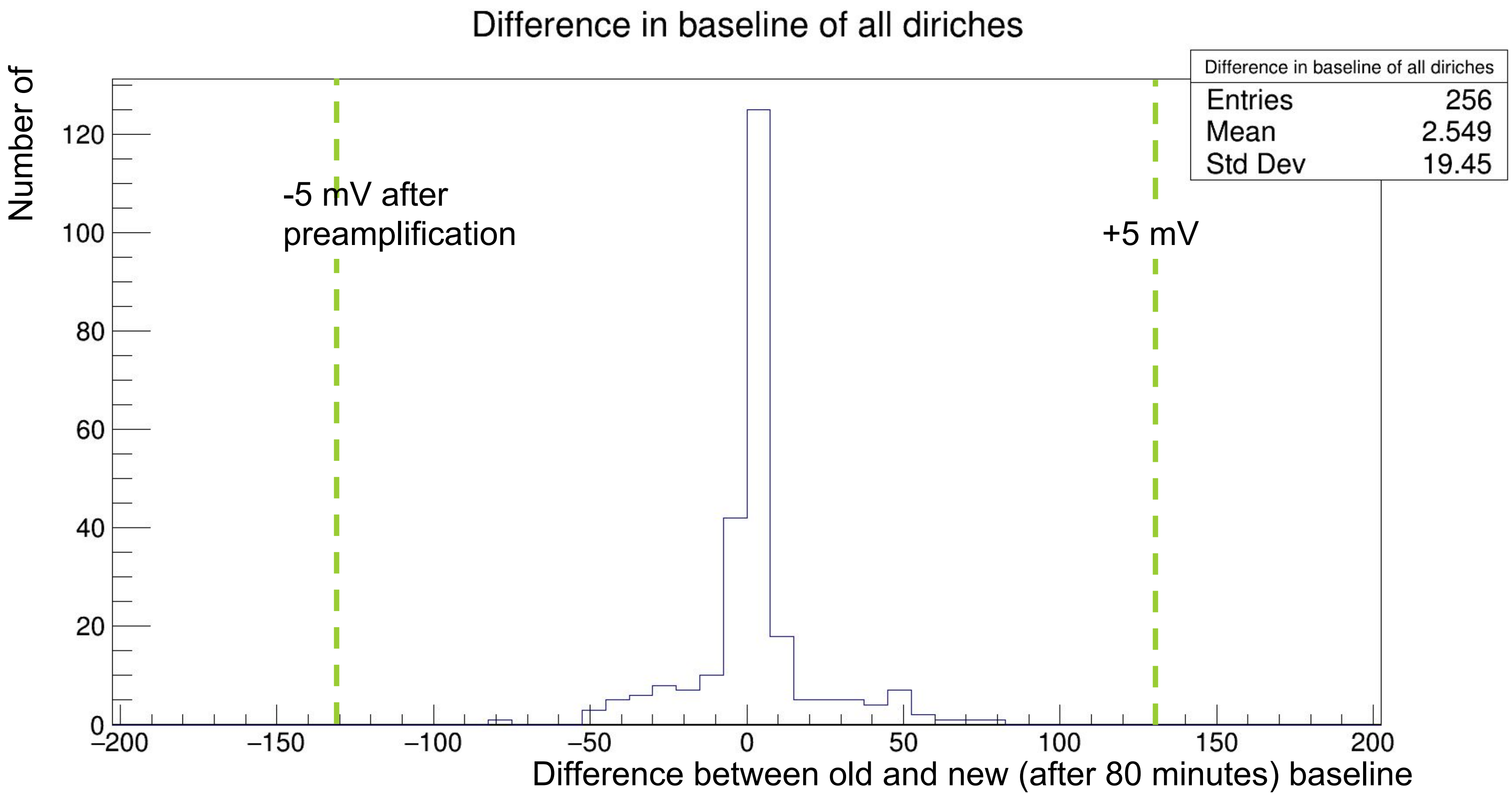
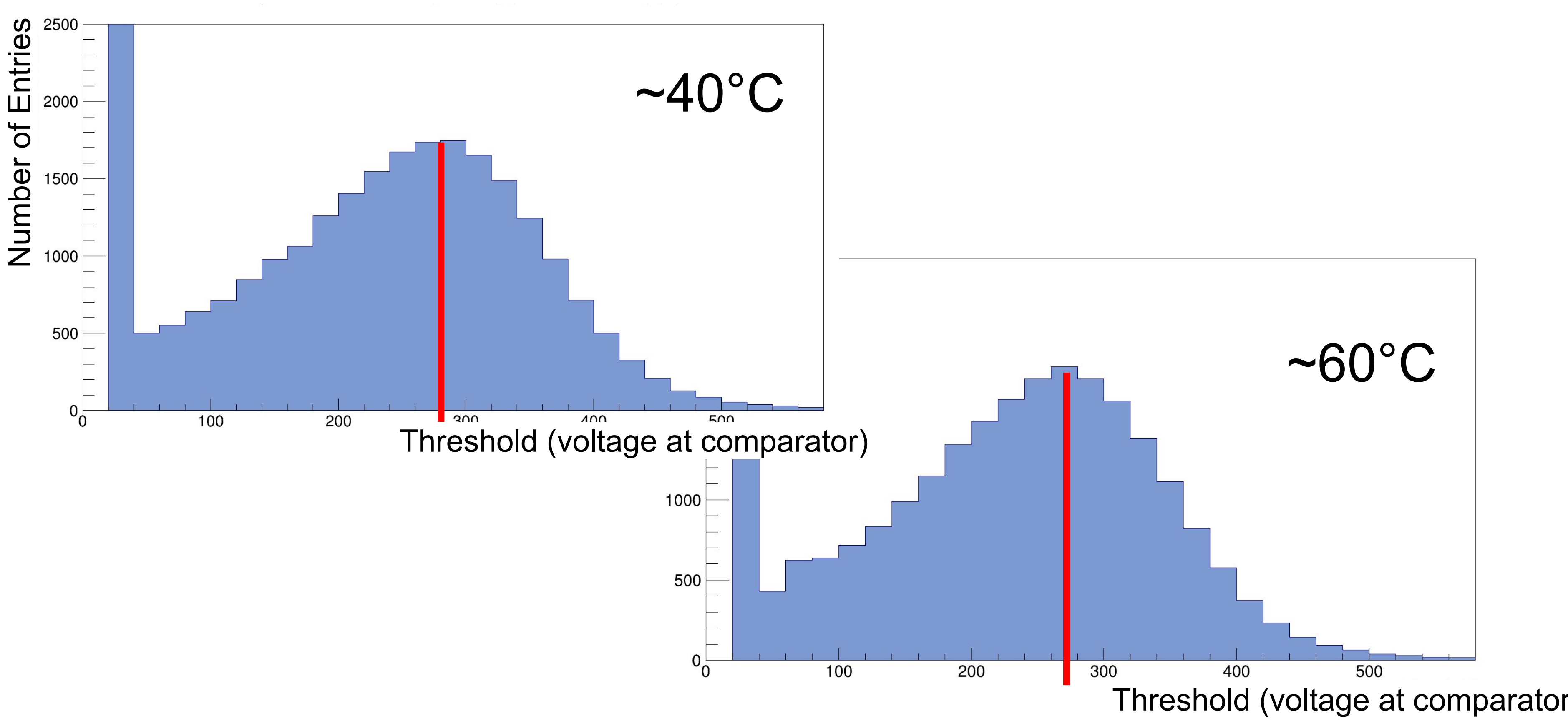
- New dirich and backplane iteration are being produced soon

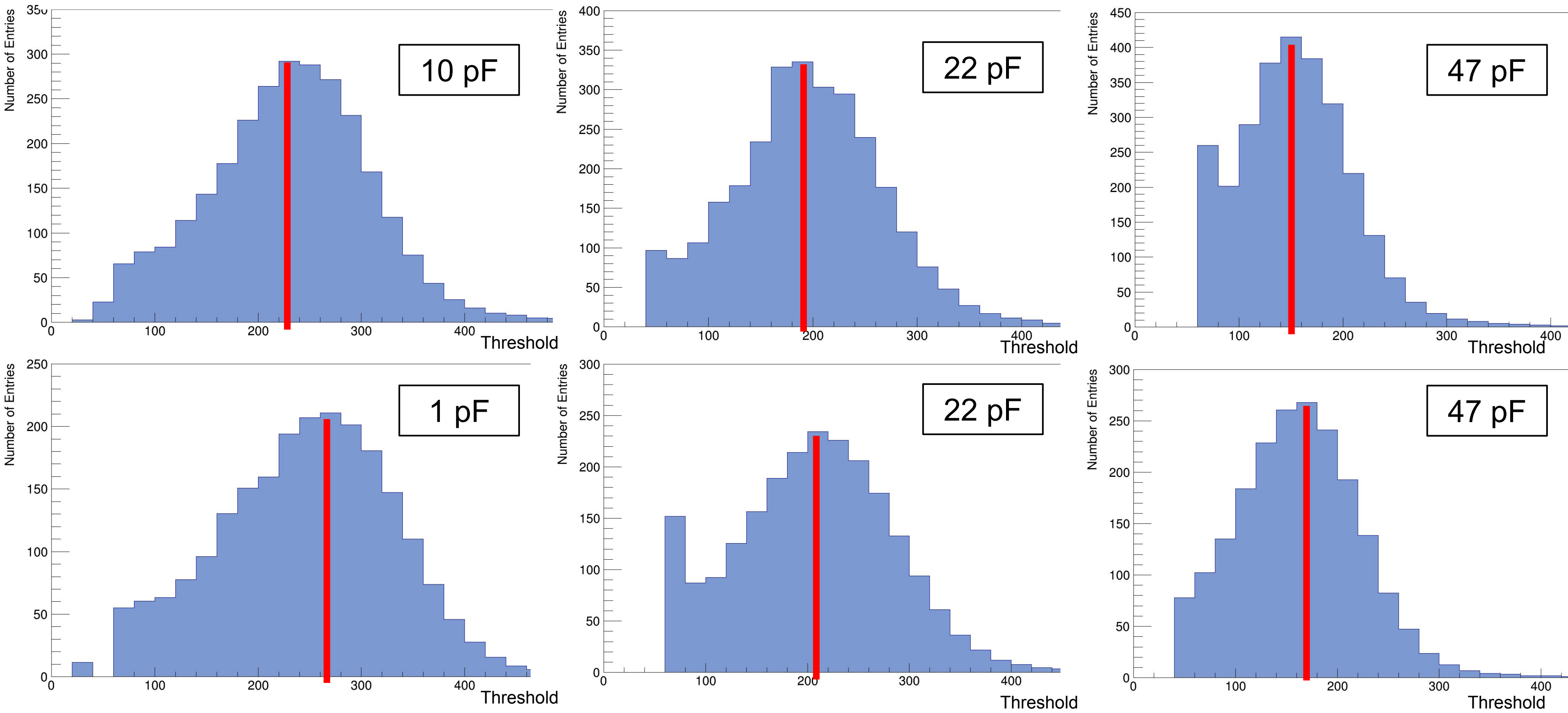
Difference in baseline 80 minutes after startup



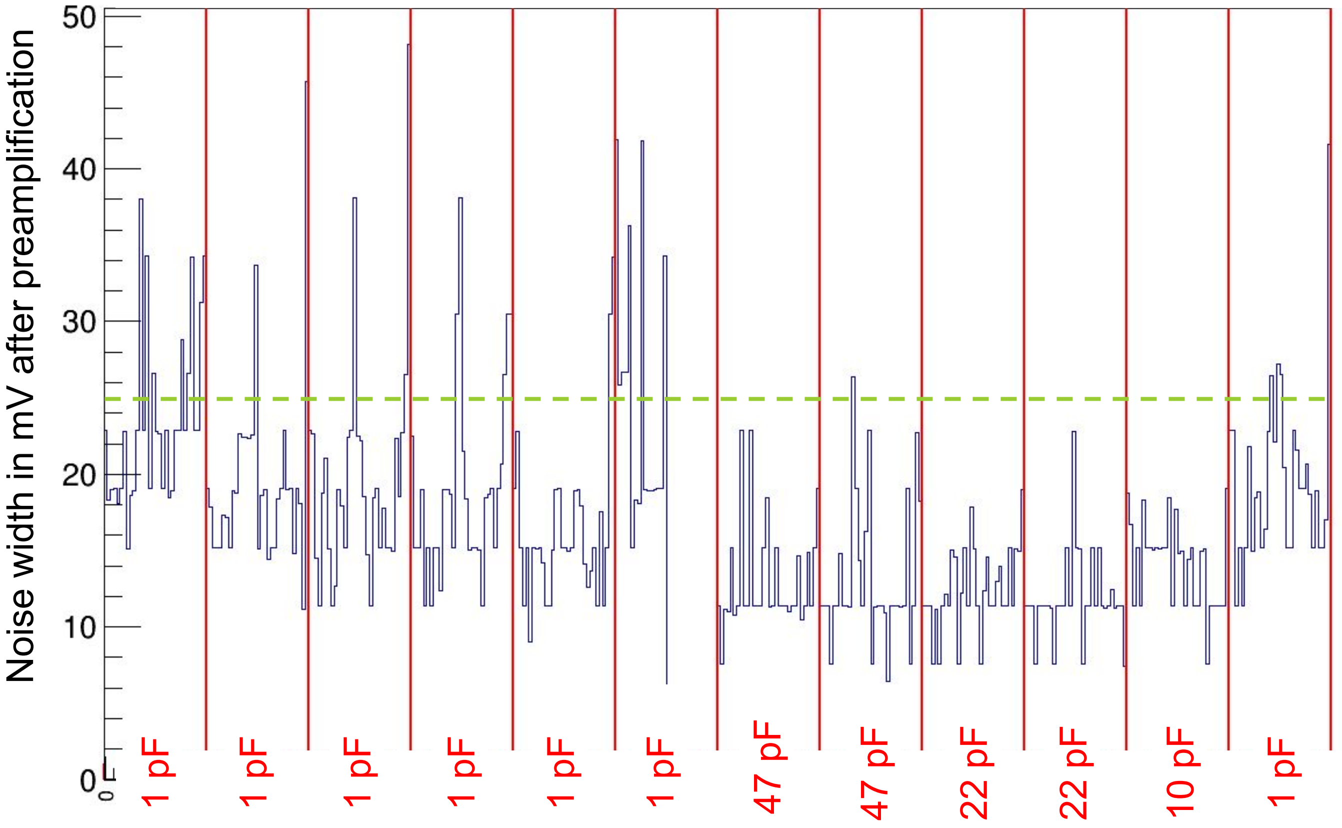
Variation of amplification for different temperatures



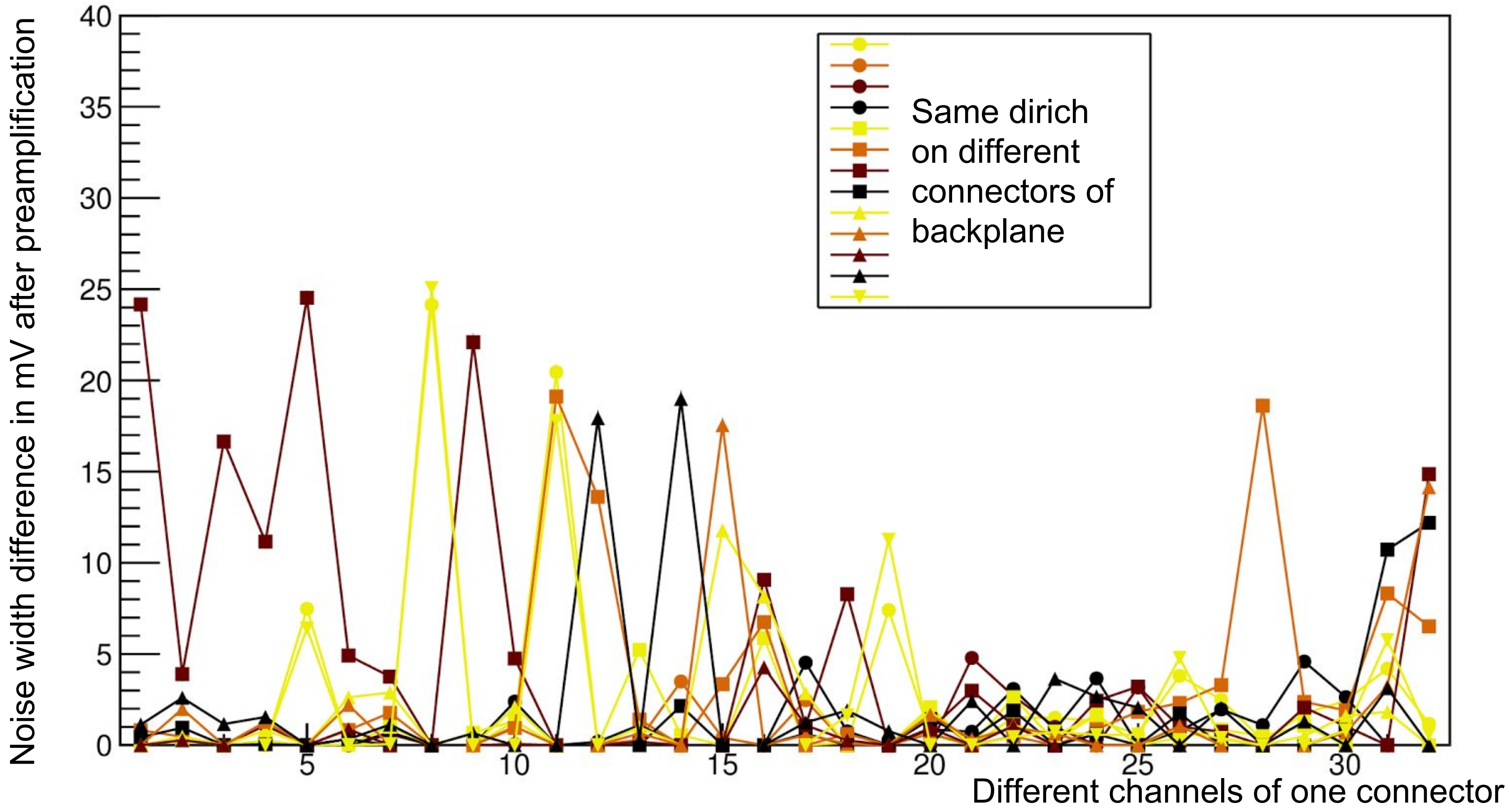
“Pulse height” variation for different input capacities



Noise width for different input capacities



Noise width for different backplane channels



Single photon events

- Full dirich assembly with 3x2 MAPMTs
- MAPMTs covered with ring mask to imitate a Cherenkov ring
- No ToT cuts and “arbitrary” threshold outside of the noise band
- Low intense laser pulsing single photons onto ring-mask covered MAPMTs

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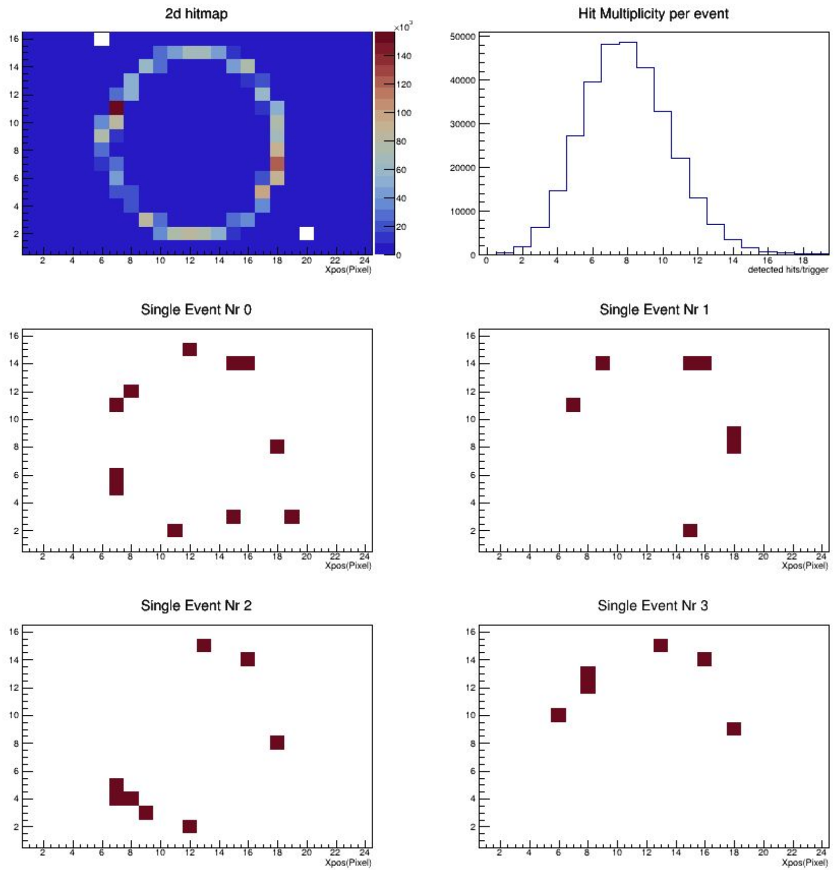
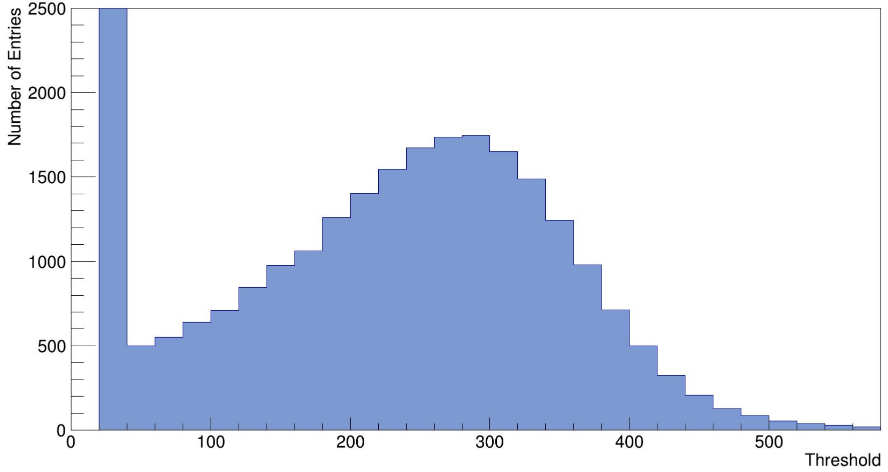
- No crosstalk visible
- Ring image undisturbed and reconstructable



Methods of “perfect”-threshold determination

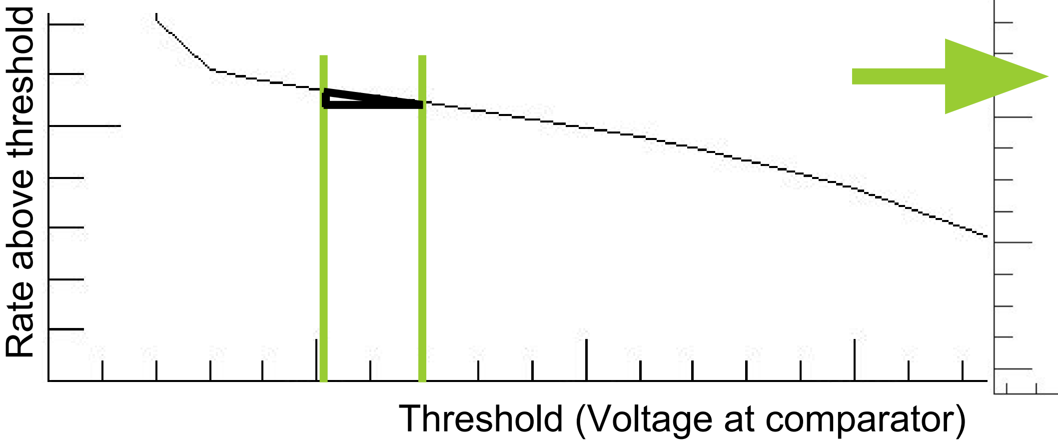
- Set threshold to specific noise value
  - Fastest method (~1min)
  - Ignores any MAPMT-artifacts /-features
- Find valley
  - Fast method (~5 min up to 15 min)
  - Reliable: If no valley is persistent, the minimum gradient is found instead
- Set threshold to certain percentage of the single photon peak
  - Semi-fast method (~15 min)
  - Does not take position of noise-band into account
- Set threshold to certain standard-deviation of the single photon peak (e.g. -3σ)
  - Slowest Method (~30 min)
  - Does not take position of noise-band into account

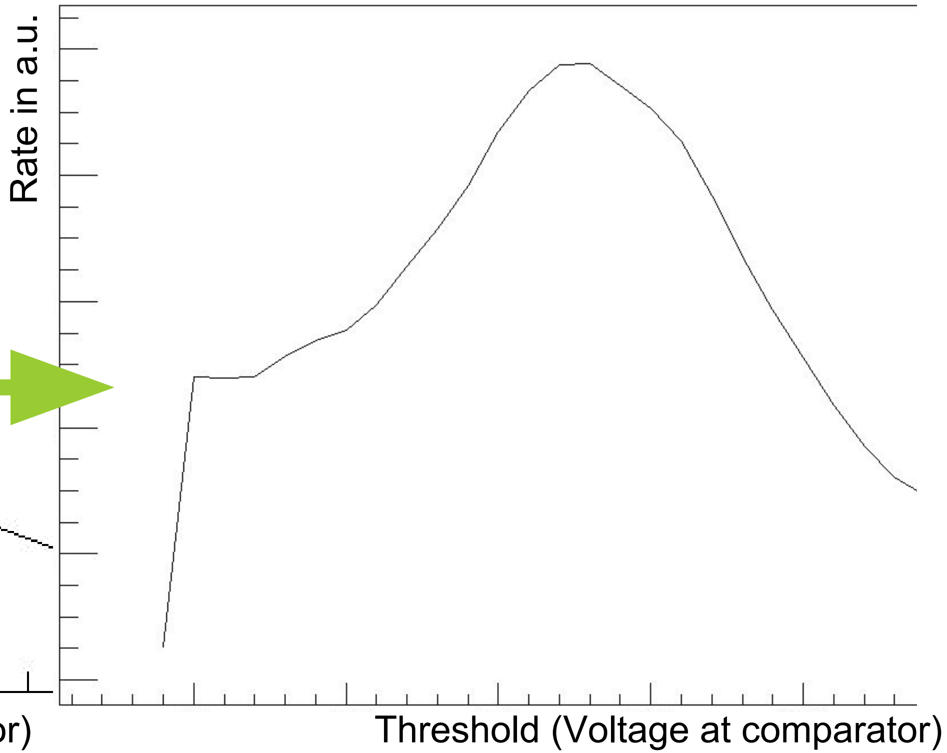


How to retrieve “statistical” ADC spectra

- Measure rate for different thresholds (threshold>baseline+Noise width/2)
- Differentiate rate spectra to get “statistical amplitude spectrum”

- Difference in rate for two different thresholds equals the rate of pulses having a height between those two thresholds

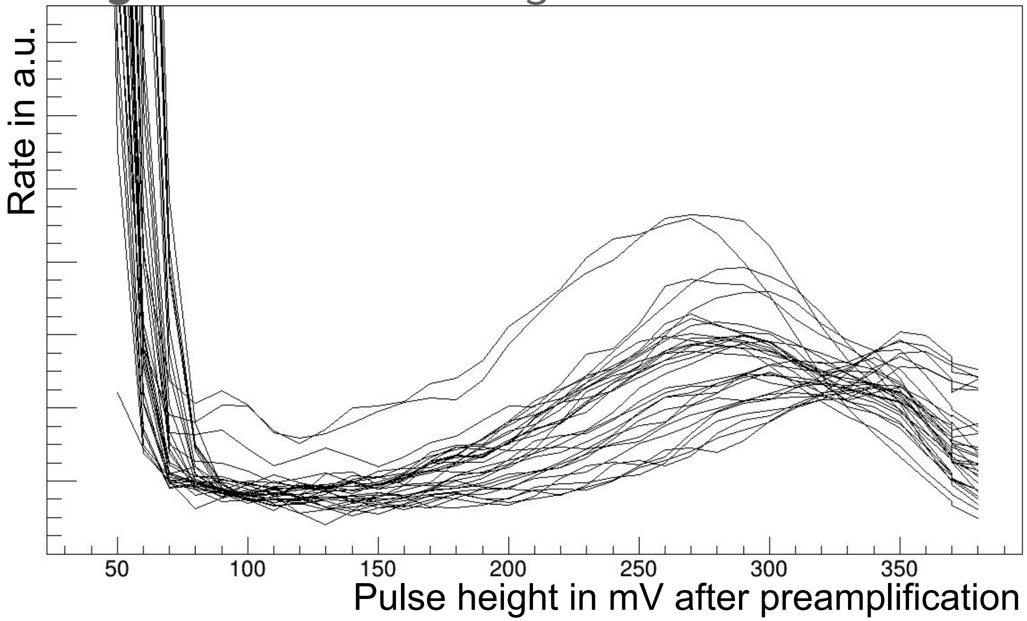


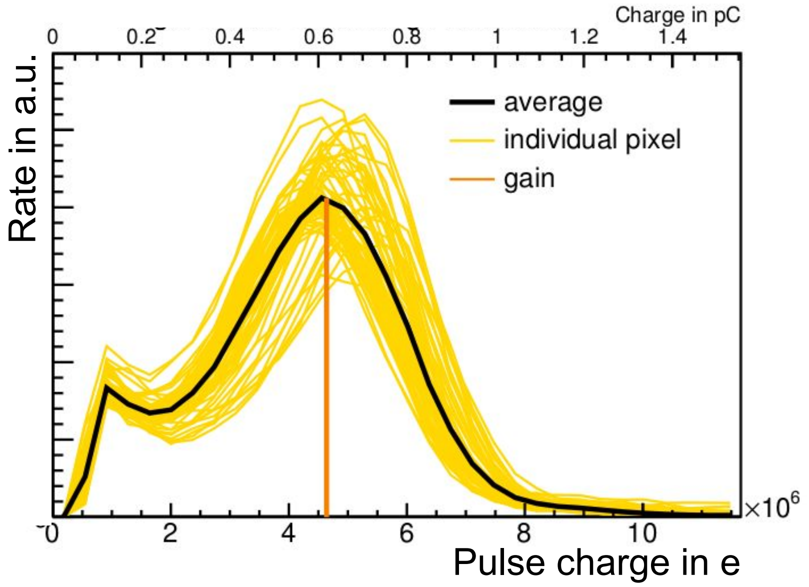


Comparison of ADC-spectra of one MAPMT measured with the dirich and a classical ADC

Left side: Pulse height distributions derived from the rate measurements for different thresholds using one DiRICH (32ch)

Right side: Pulse charge distribution measured with a classical integrating-ADC





Summary

Summary

- All MAPMTs needed for HADES RICH are received and measured
  - Gain grouping for detector soon to be done

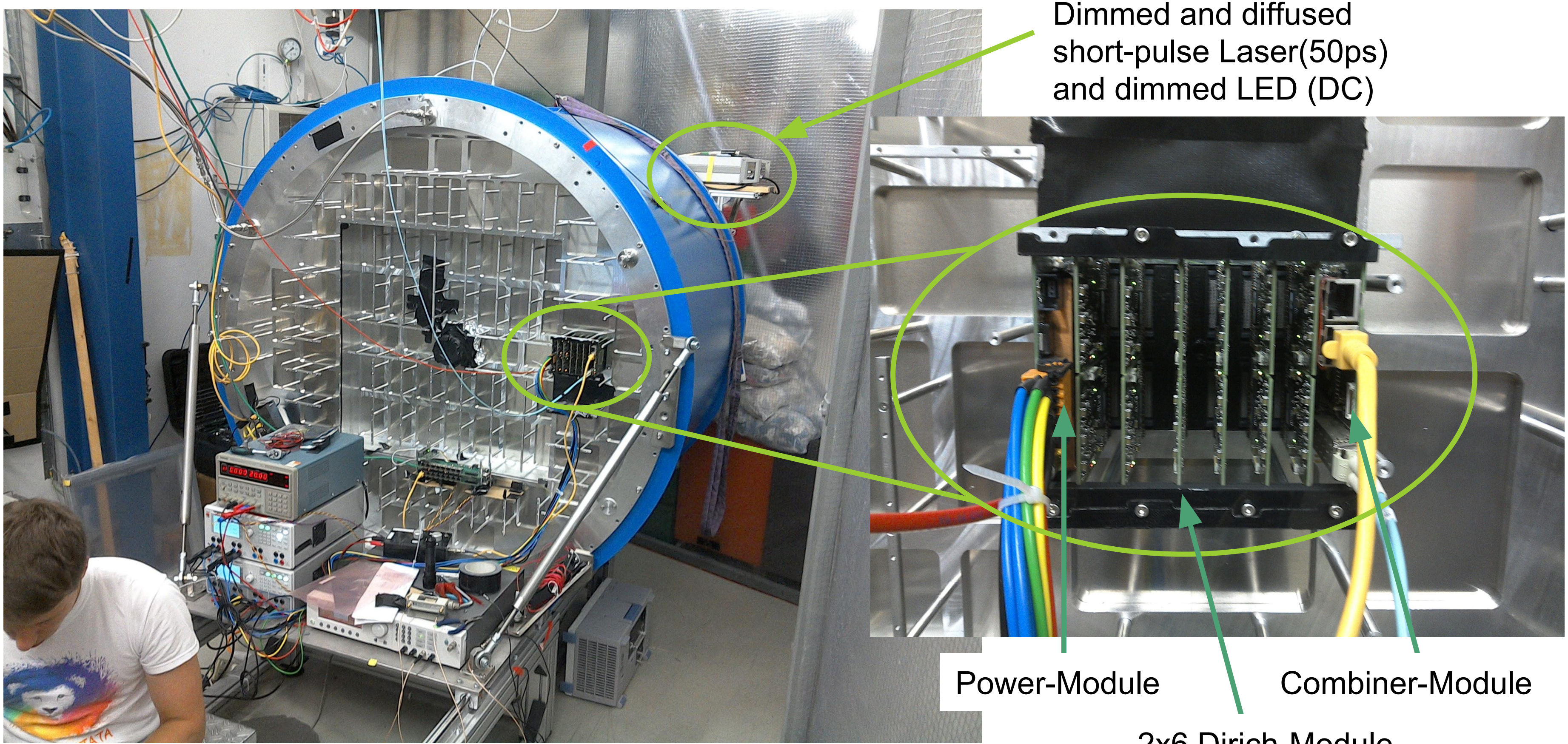
- Measurements of dirich lead to:
  - Modules will be powered by external supply
  - Baseline is stable
  - New Backplane with improved routing will be produced
  - New dirich with minor upgrades and no input capacity will be produced

- Software to ensure a proper placement of the thresholds using differentiated spectra is being worked on

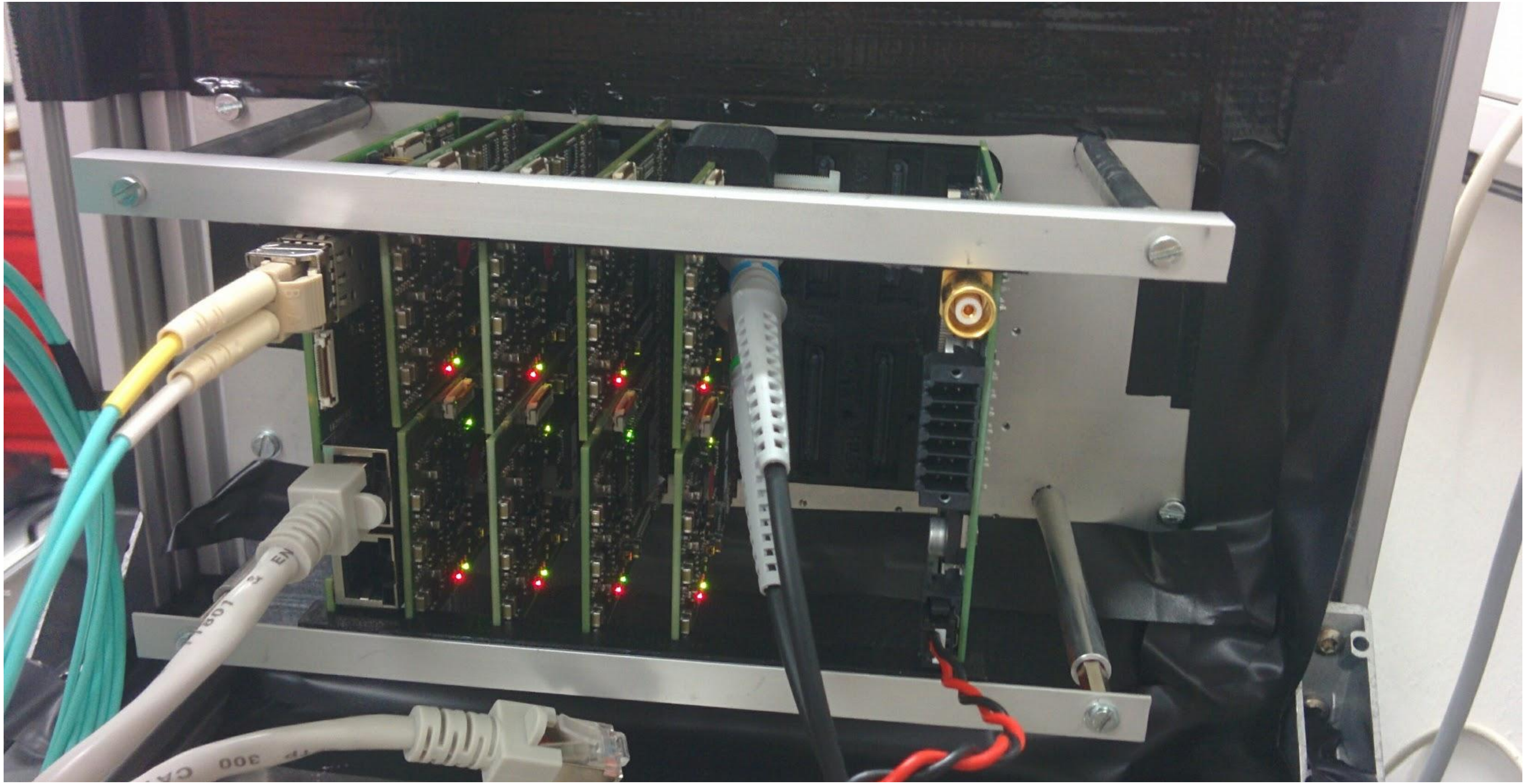
Thank you for your attention

Backup

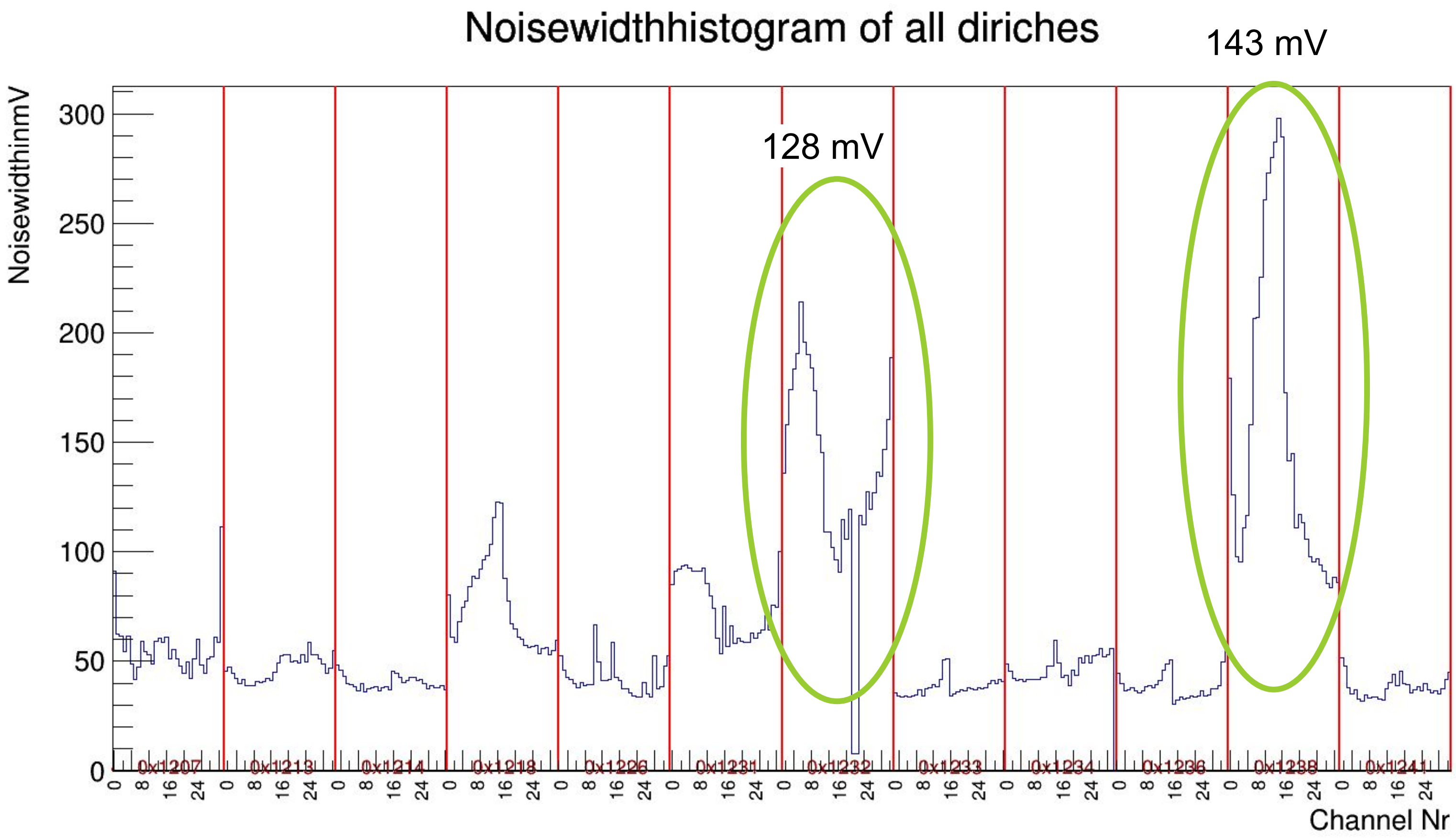
Measurement setup at GSI



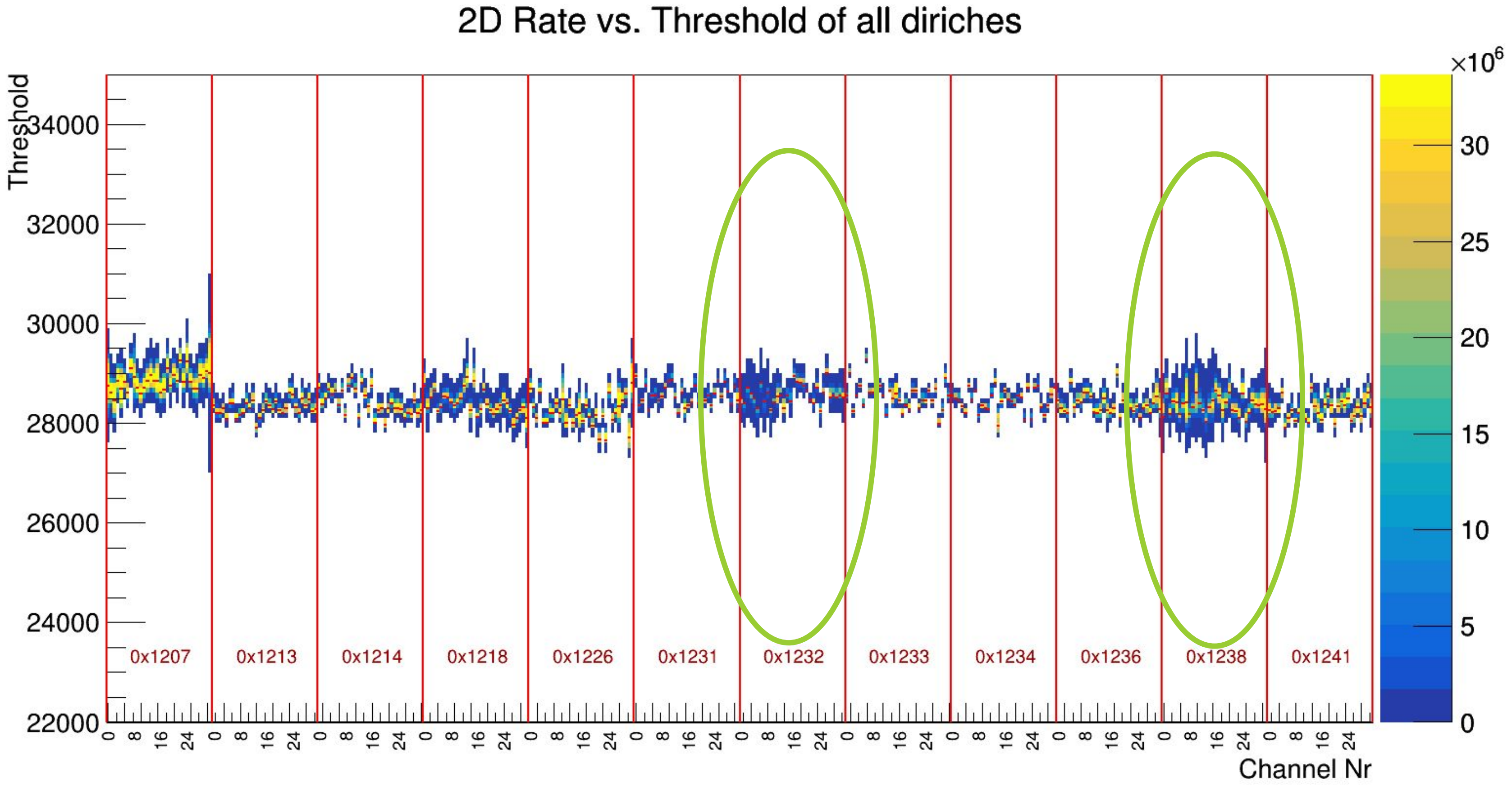
Measurement Setup in Wuppertal



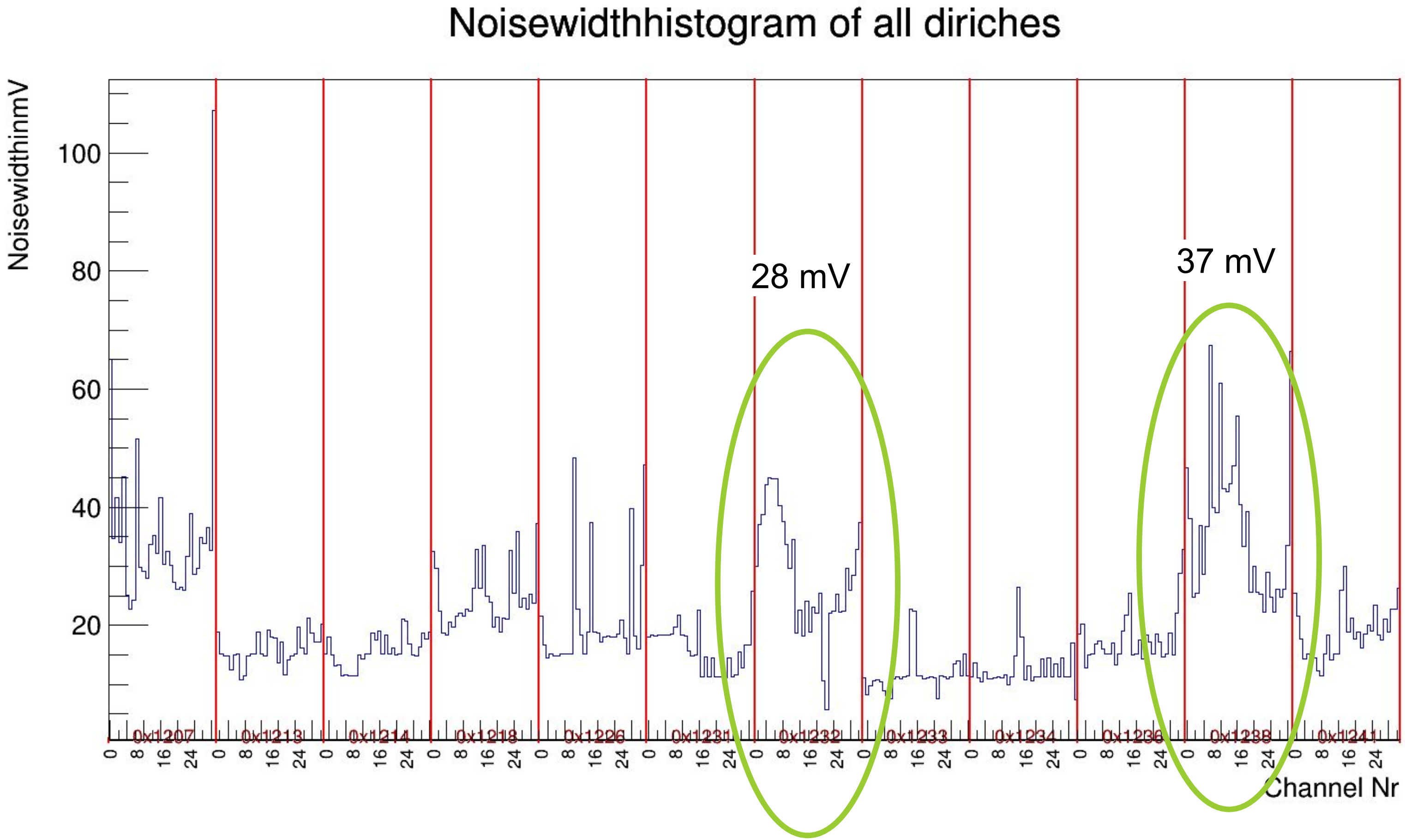
No Shielding - Full Noise width



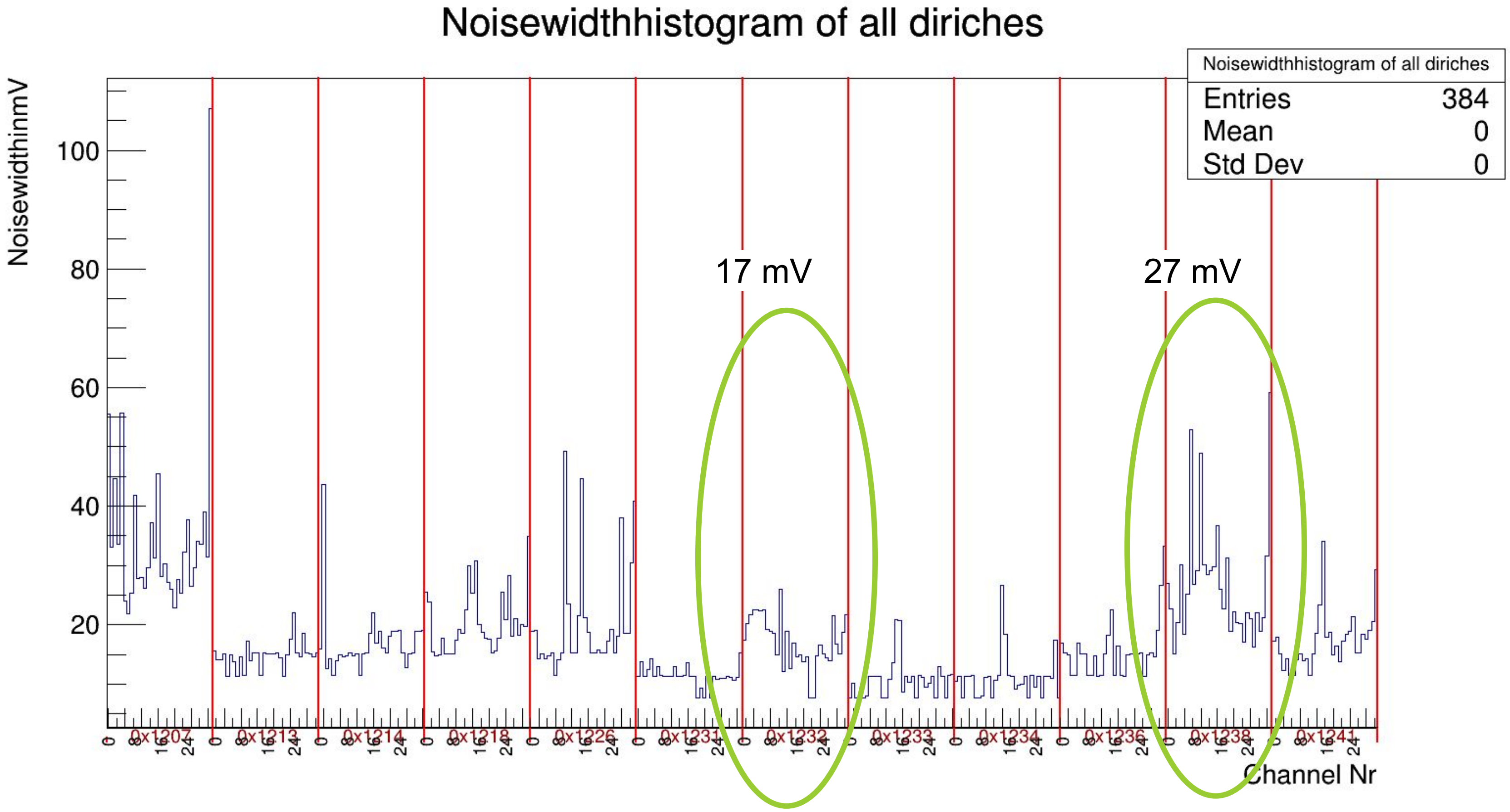
Copper and EMV-Shielding



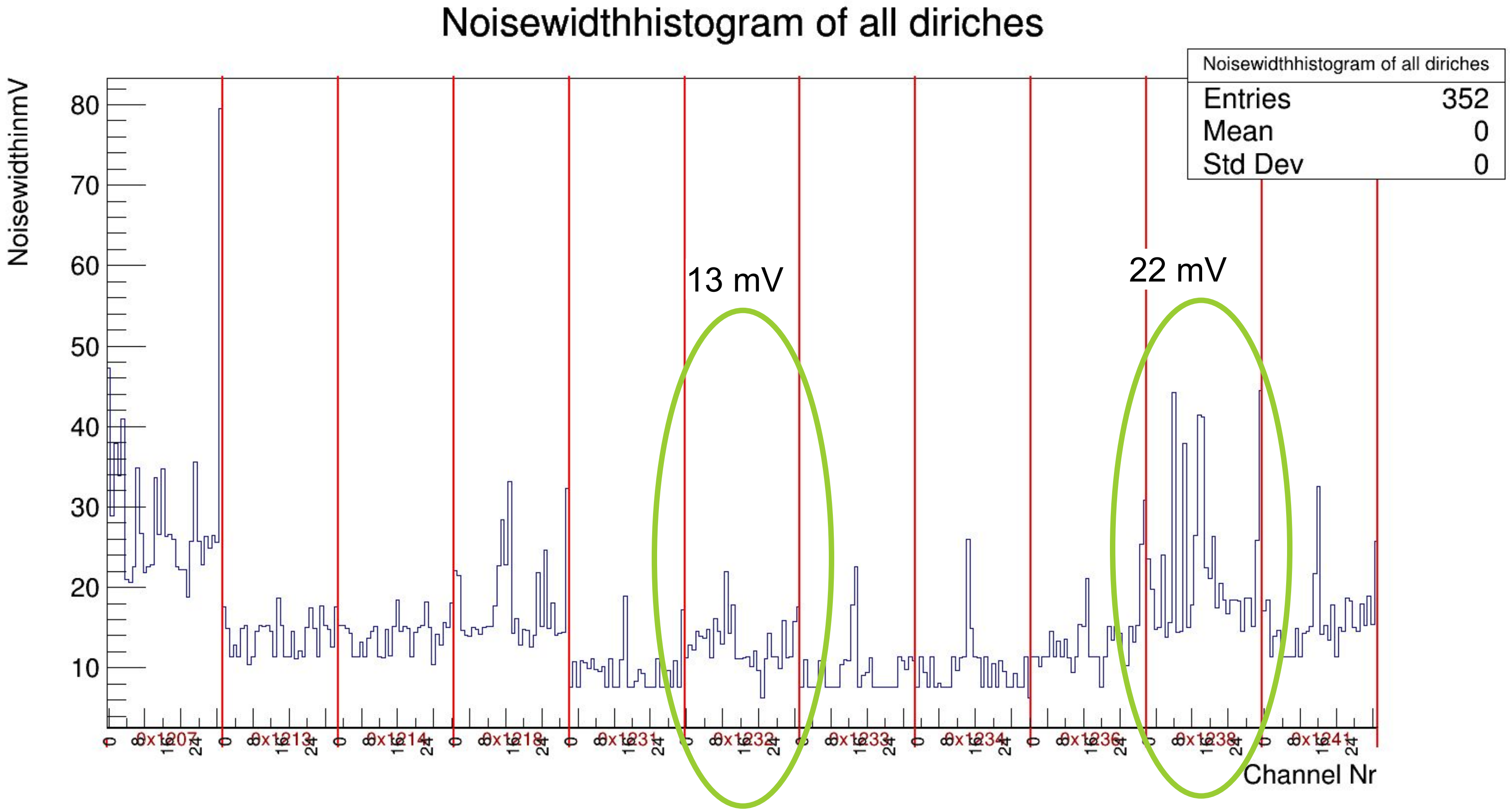
Copper and EMV-Shielding



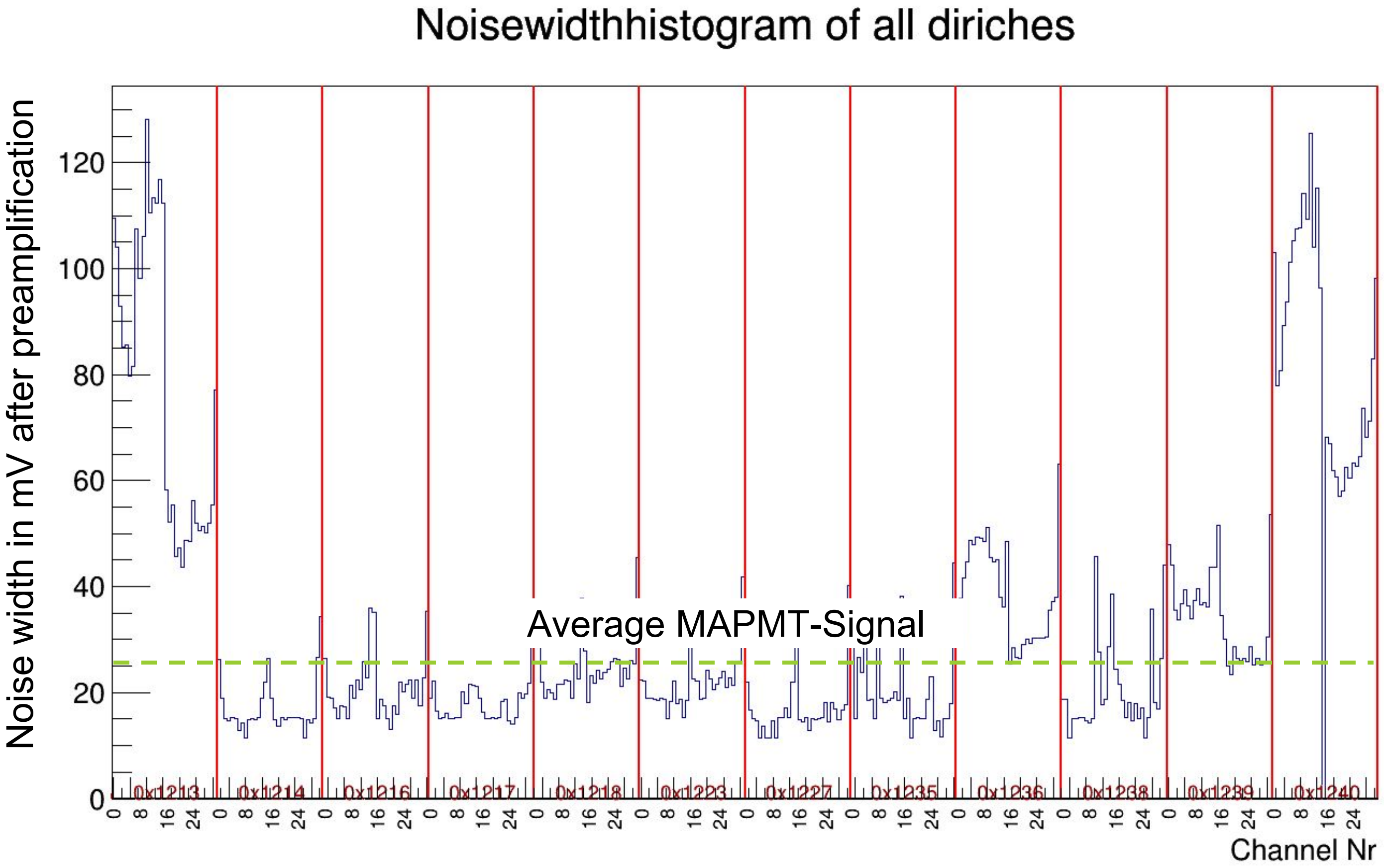
Copper and EMV-Shielding (2 layers)



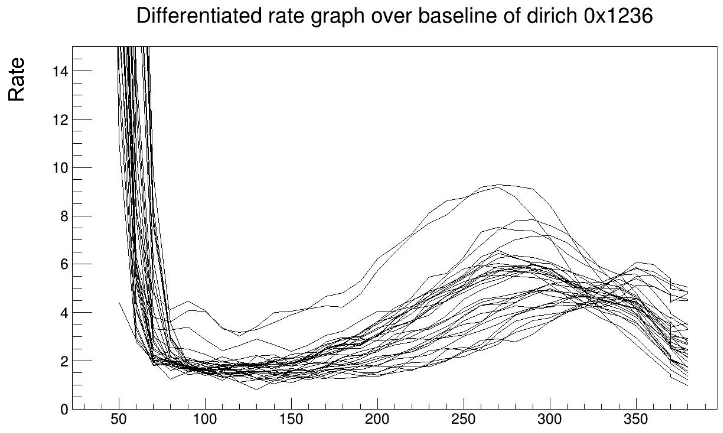
Copper and EMV-Shielding (3 layers)

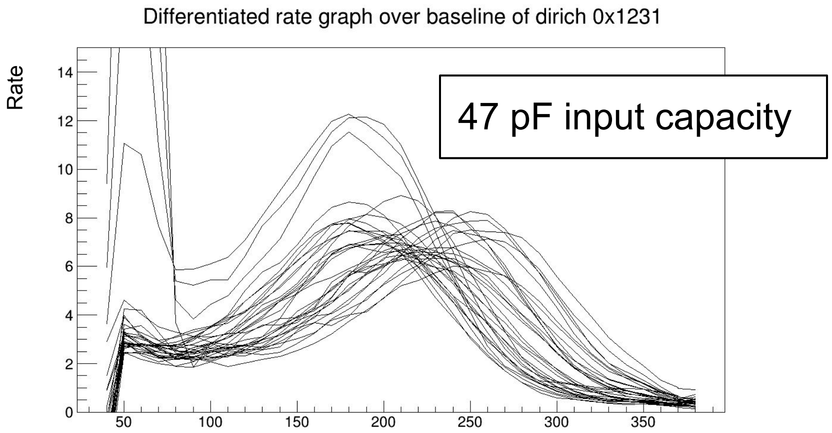


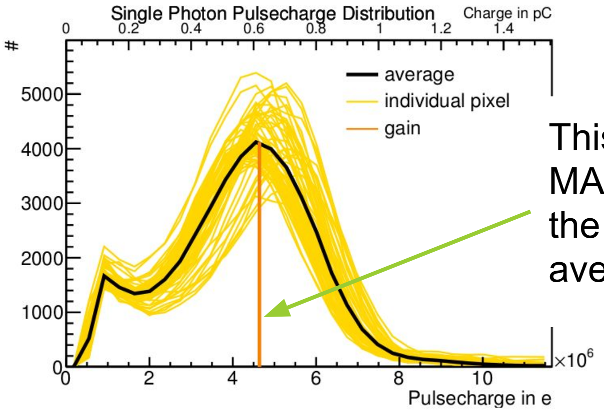
Noise width of dirich using the dc/dc converter



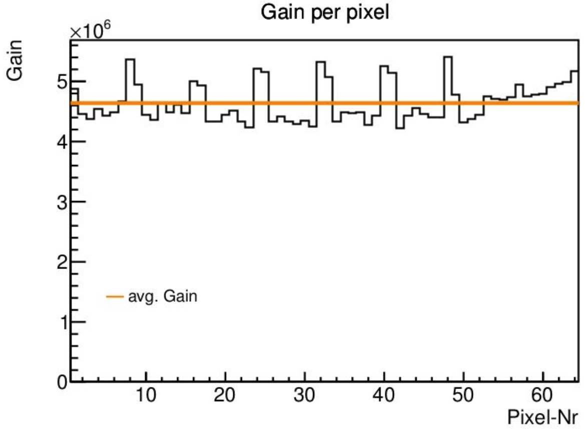
Single Photon Spectra comparison (Gain variation)



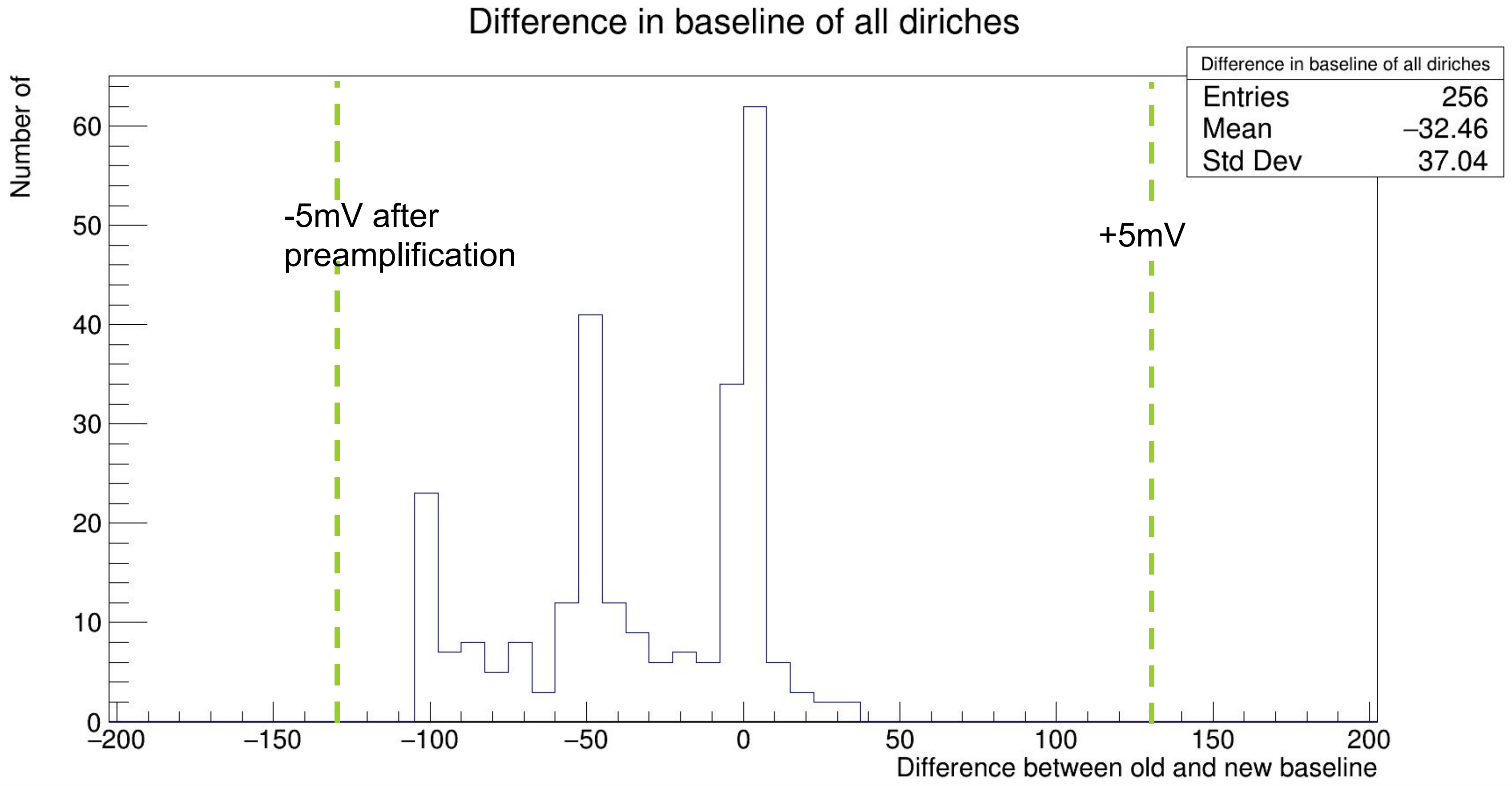




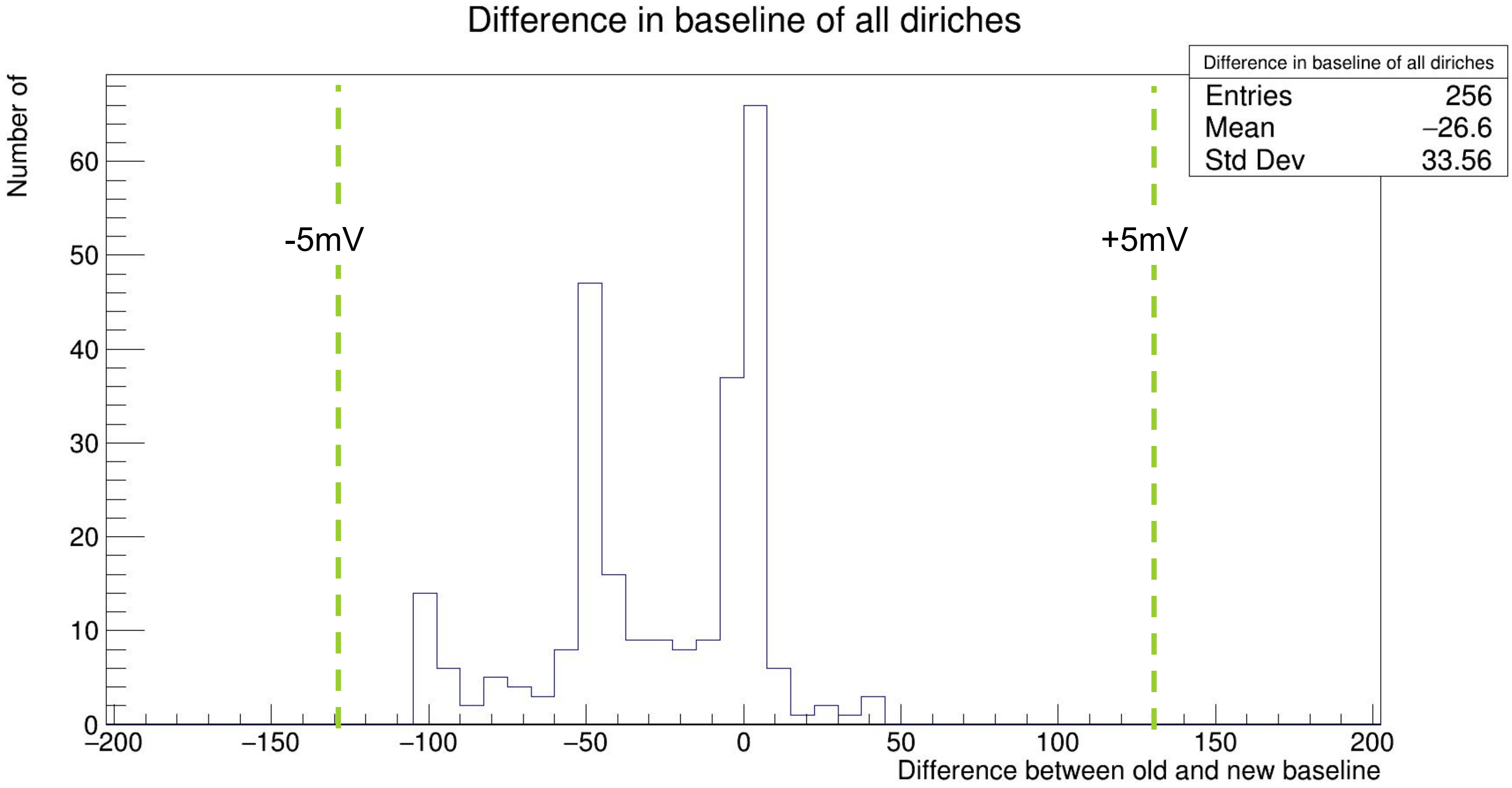
This particular MAPMT has twice the Gain as average



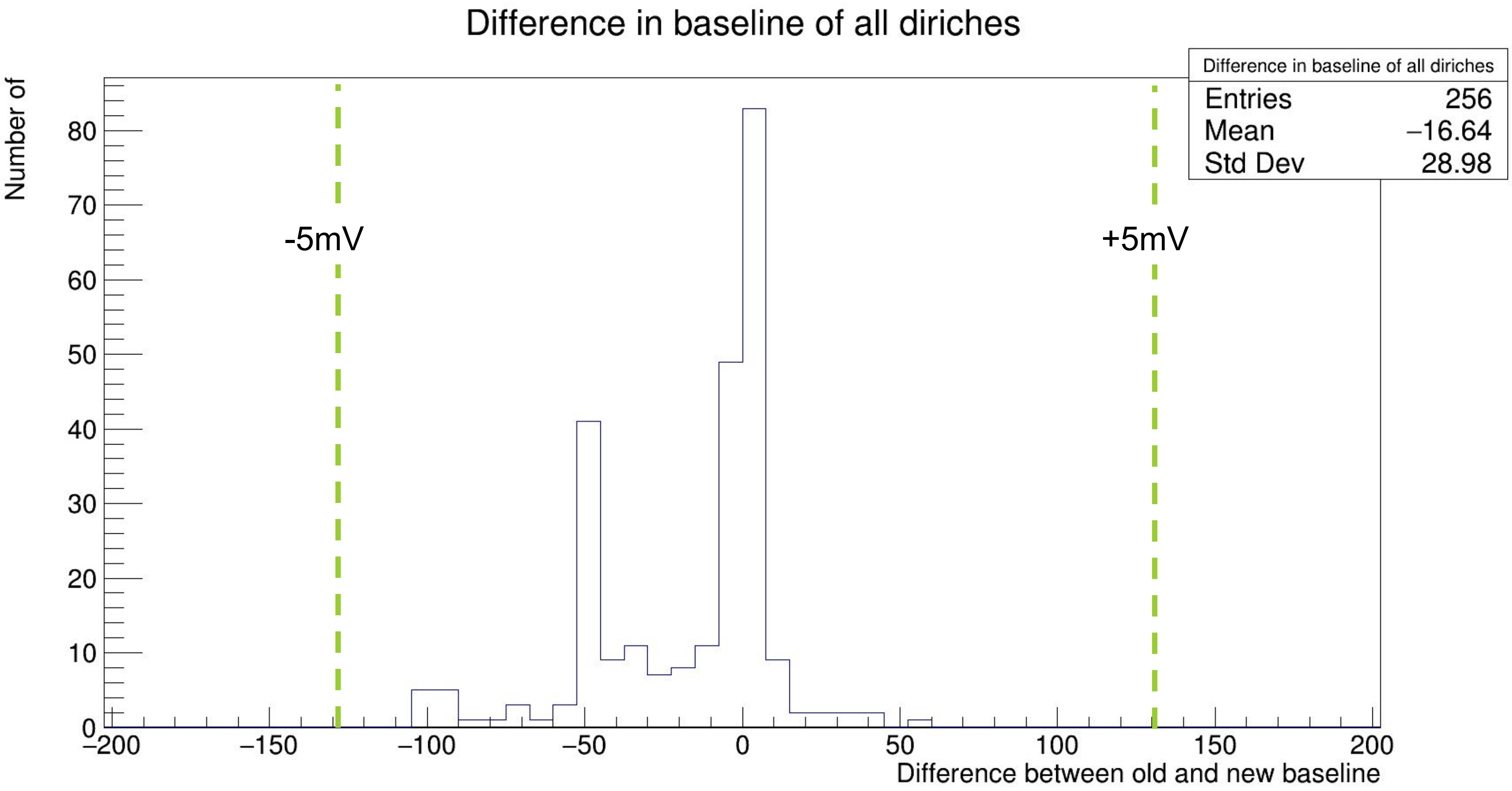
Difference in Baseline after 10 minutes



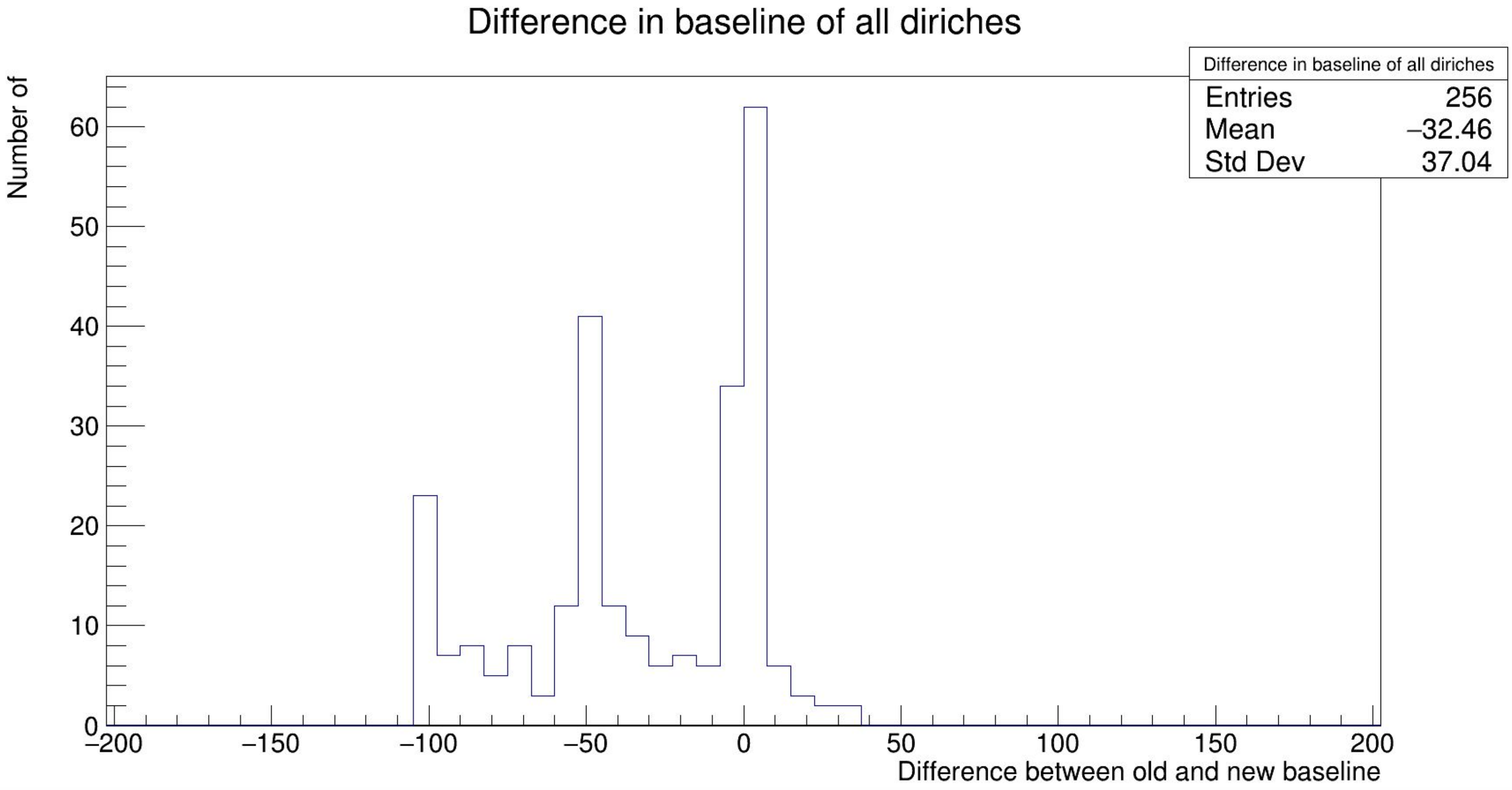
Difference in Baseline after 30 minutes



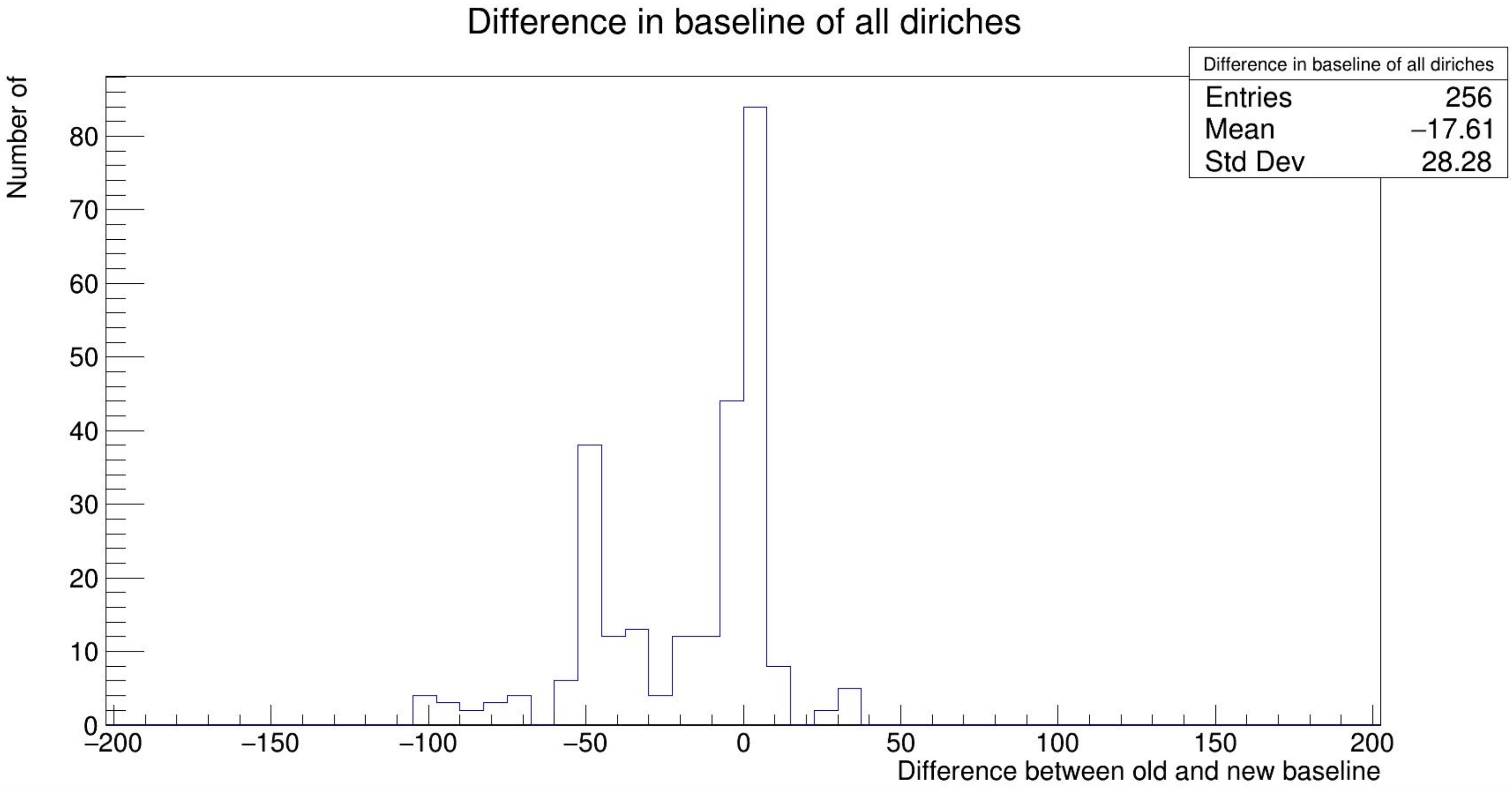
Difference in Baseline after 60 minutes



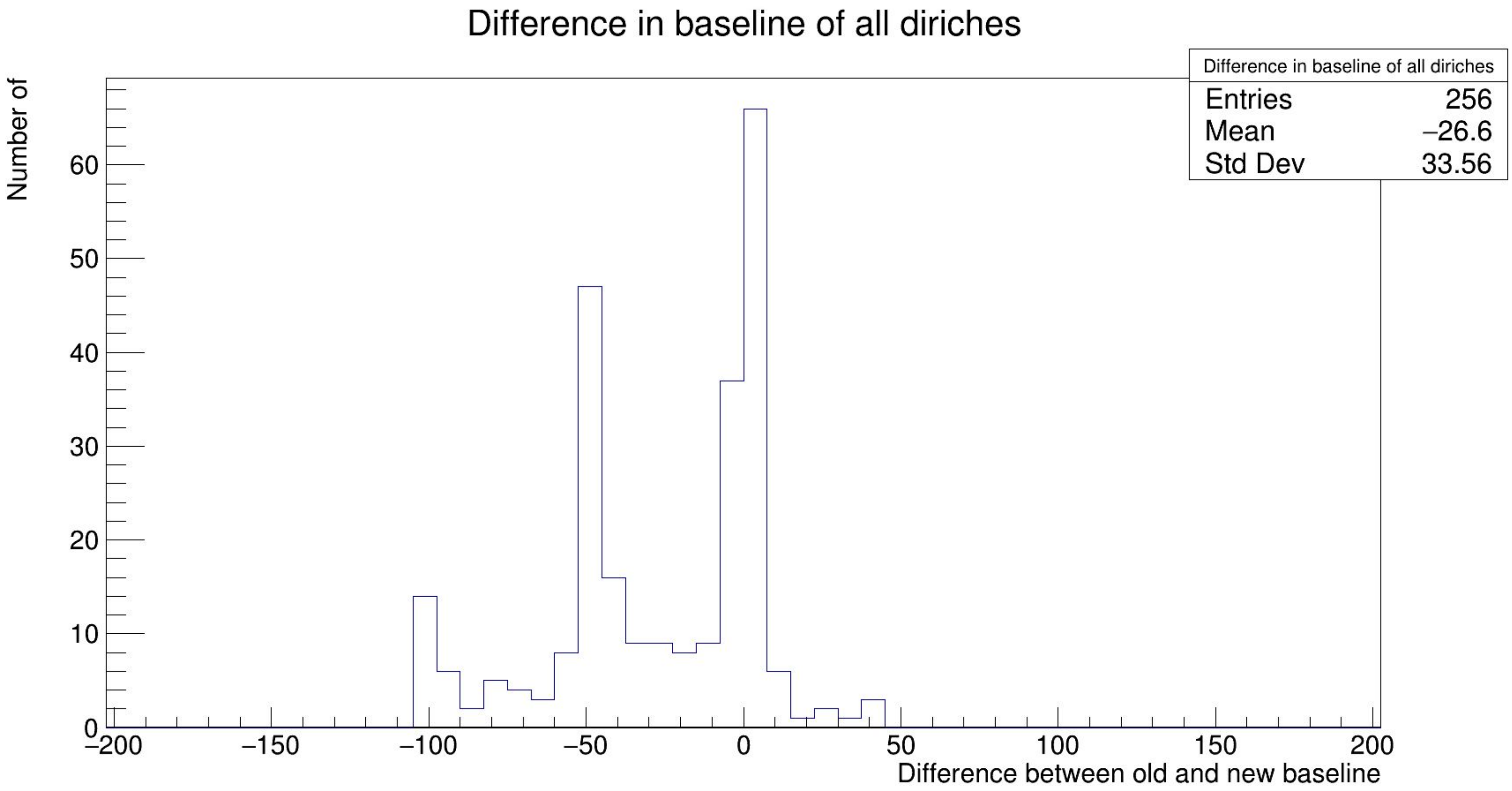
Difference in Baseline after 10 minutes



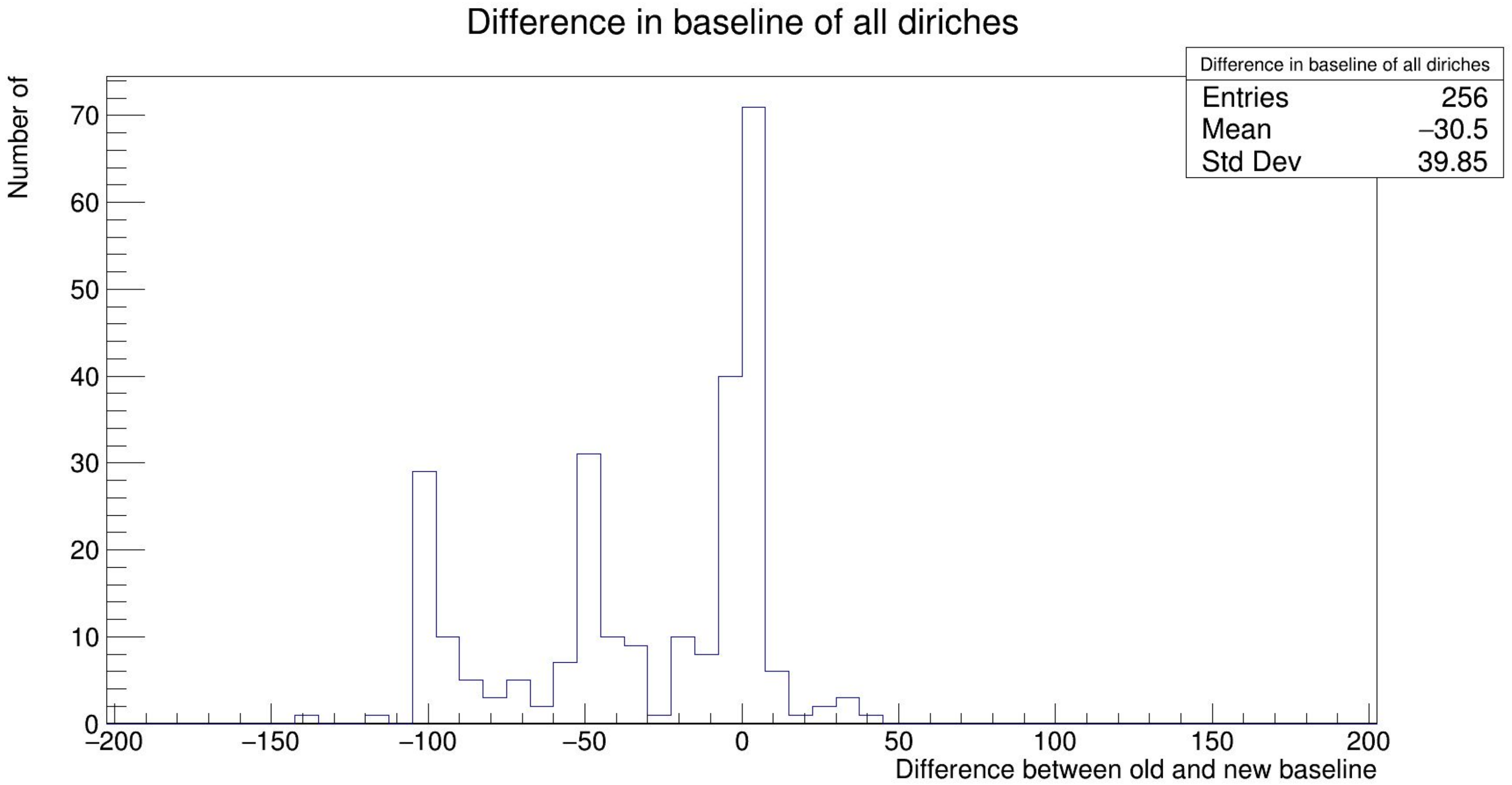
Difference in Baseline after 20 minutes



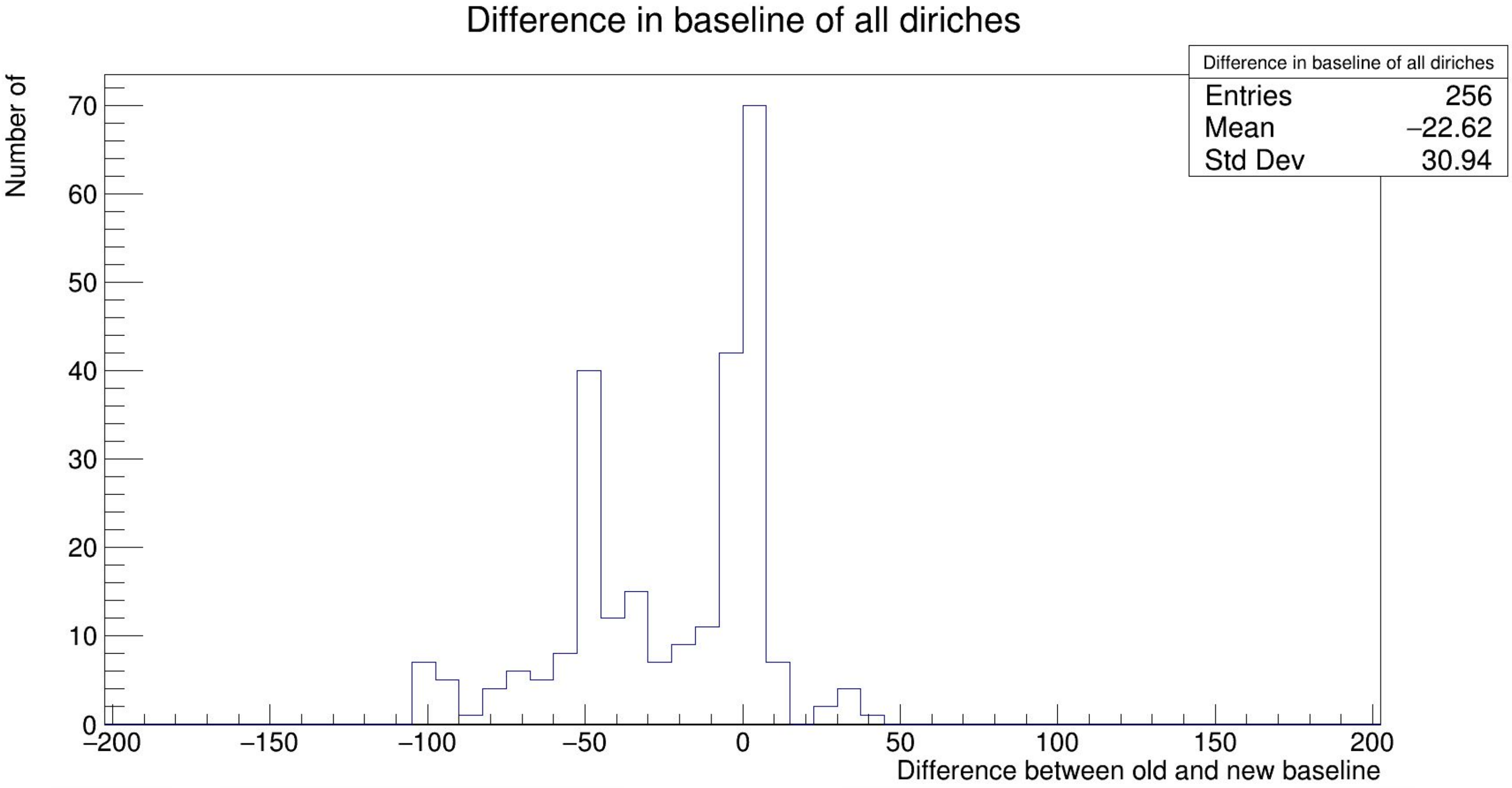
Difference in Baseline after 30 minutes



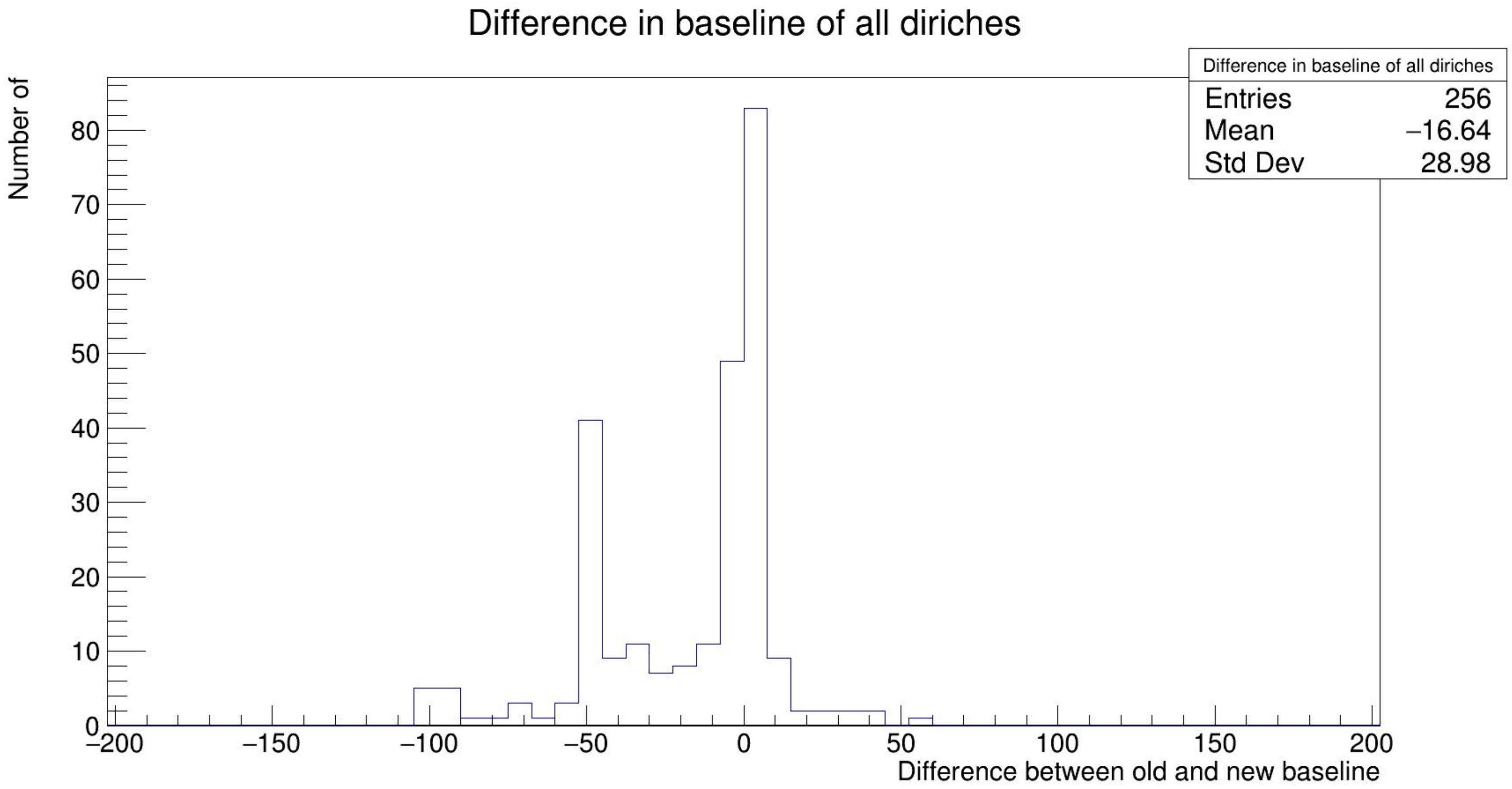
Difference in Baseline after 40 minutes



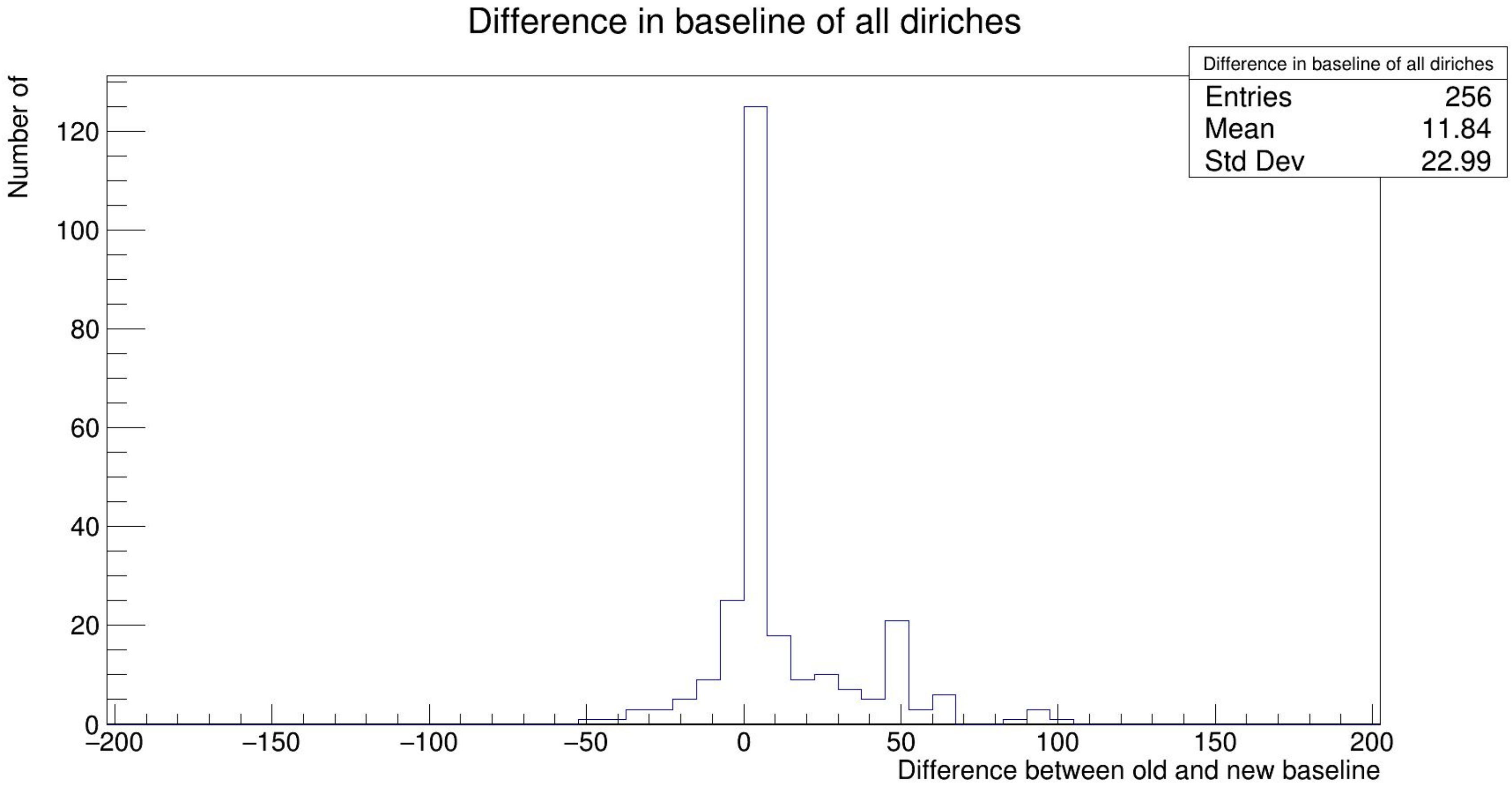
Difference in Baseline after 50 minutes



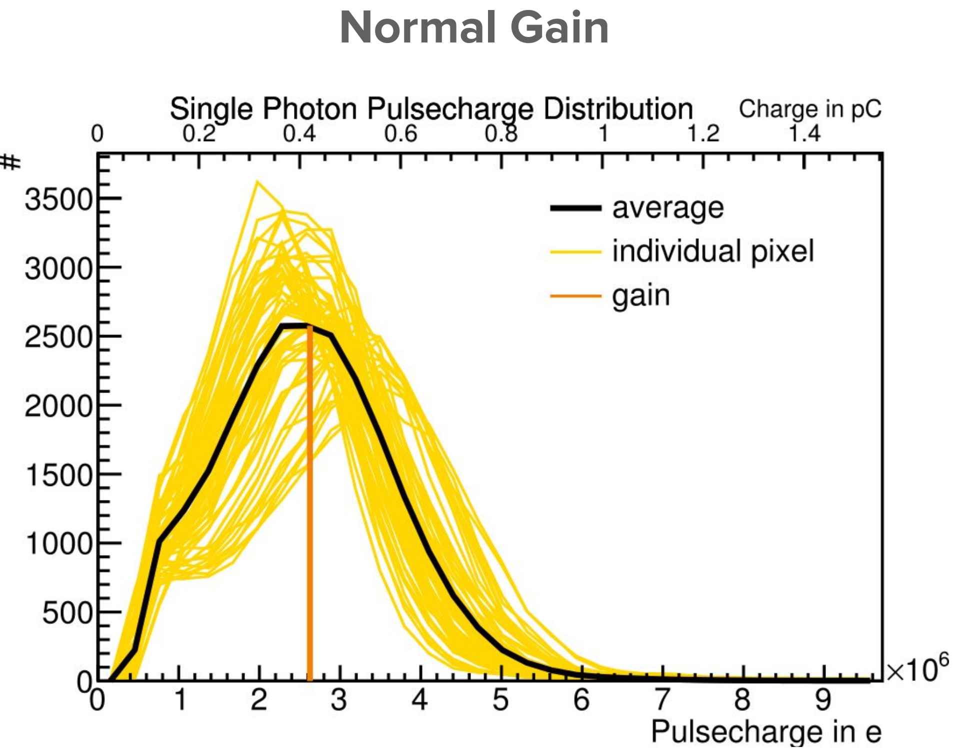
Difference in Baseline after 60 minutes

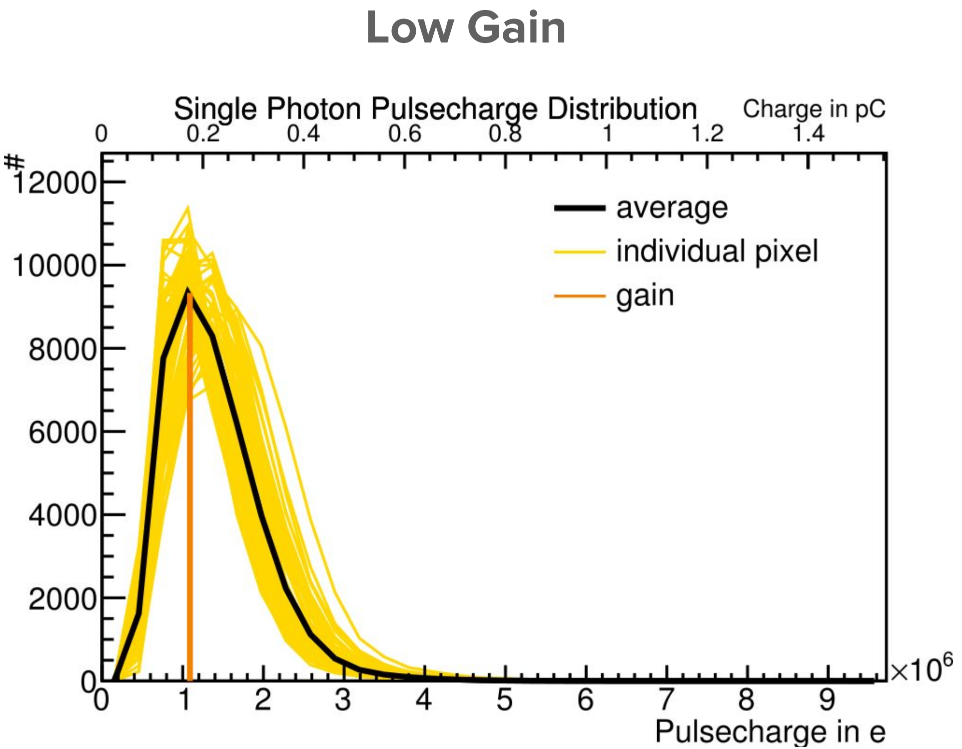


Difference in Baseline after 70 minutes



Problem before last collaboration meeting

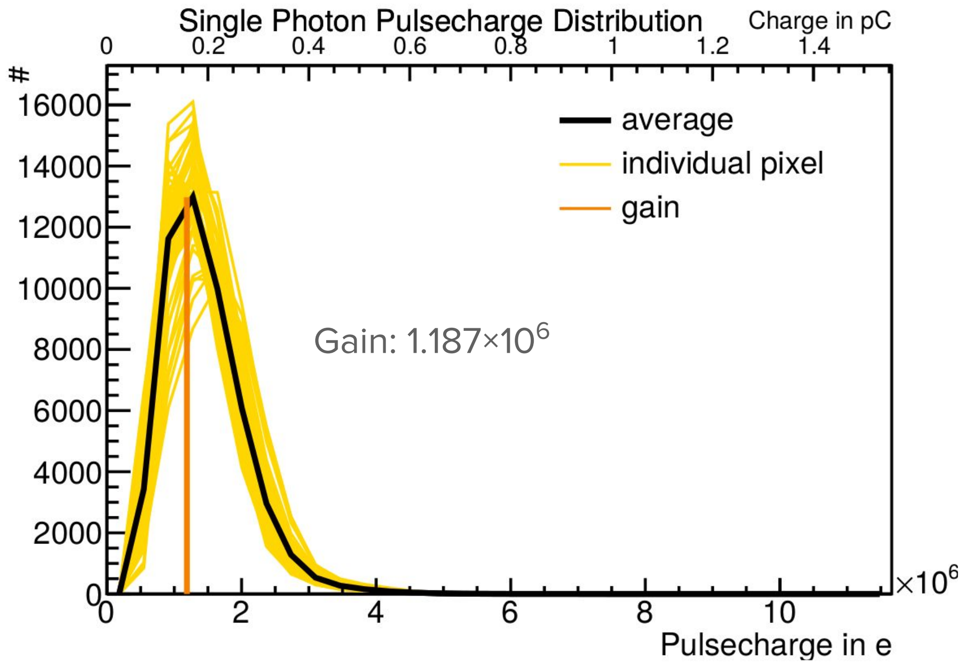




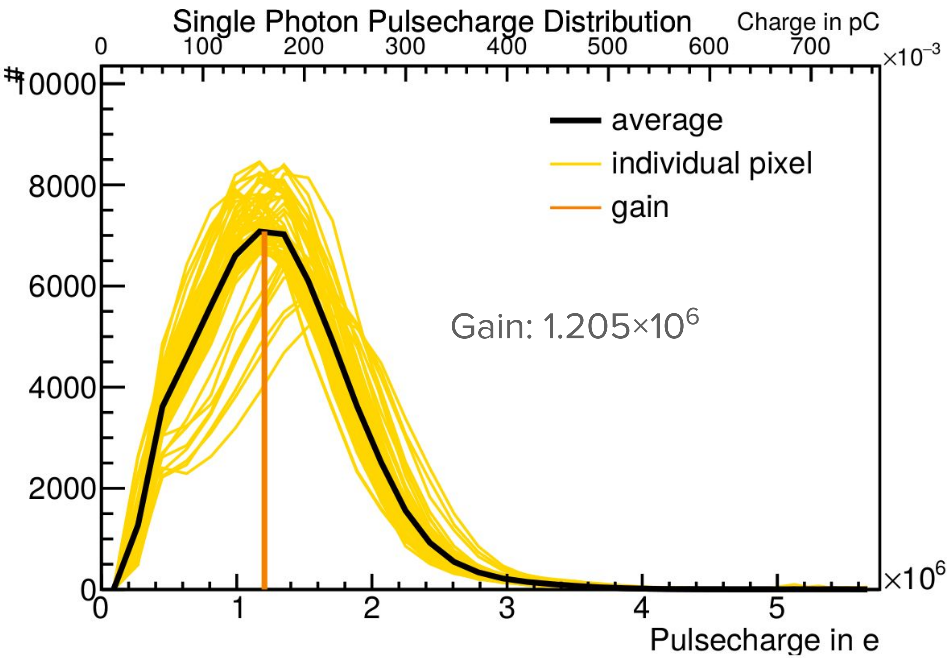
- Buying specifications: Gain > 0.8×10^6

Measurement with altered setup (I)

High Attenuation

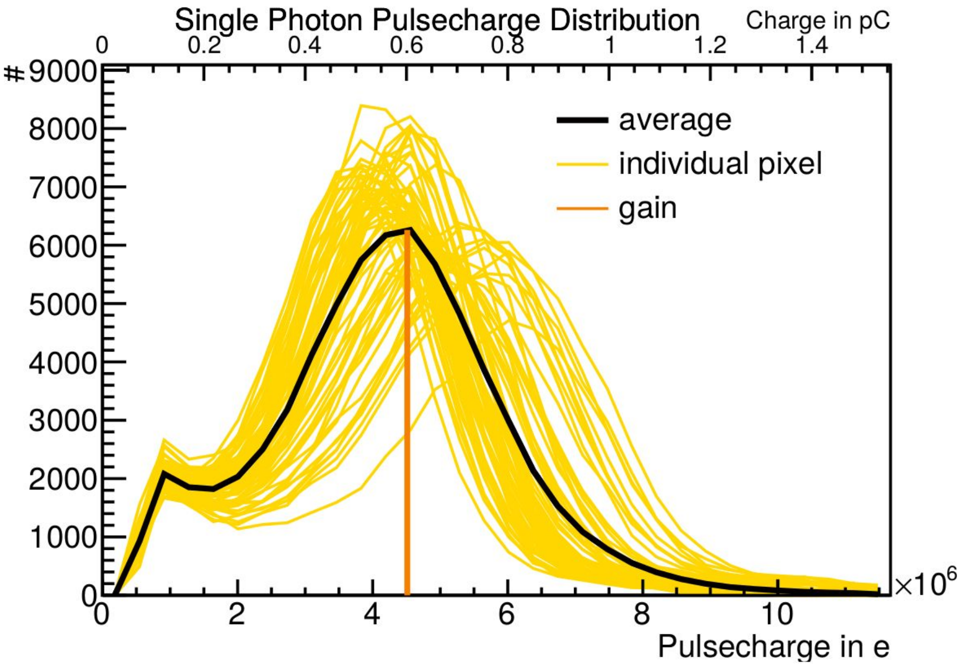


Low Attenuation



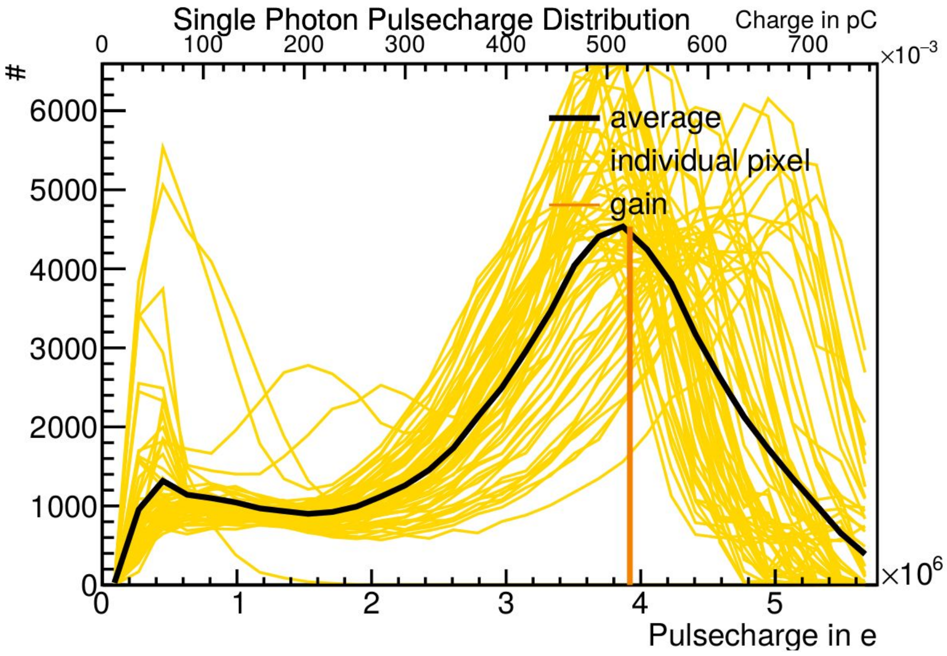
Measurement with altered setup (II)

High Attenuation



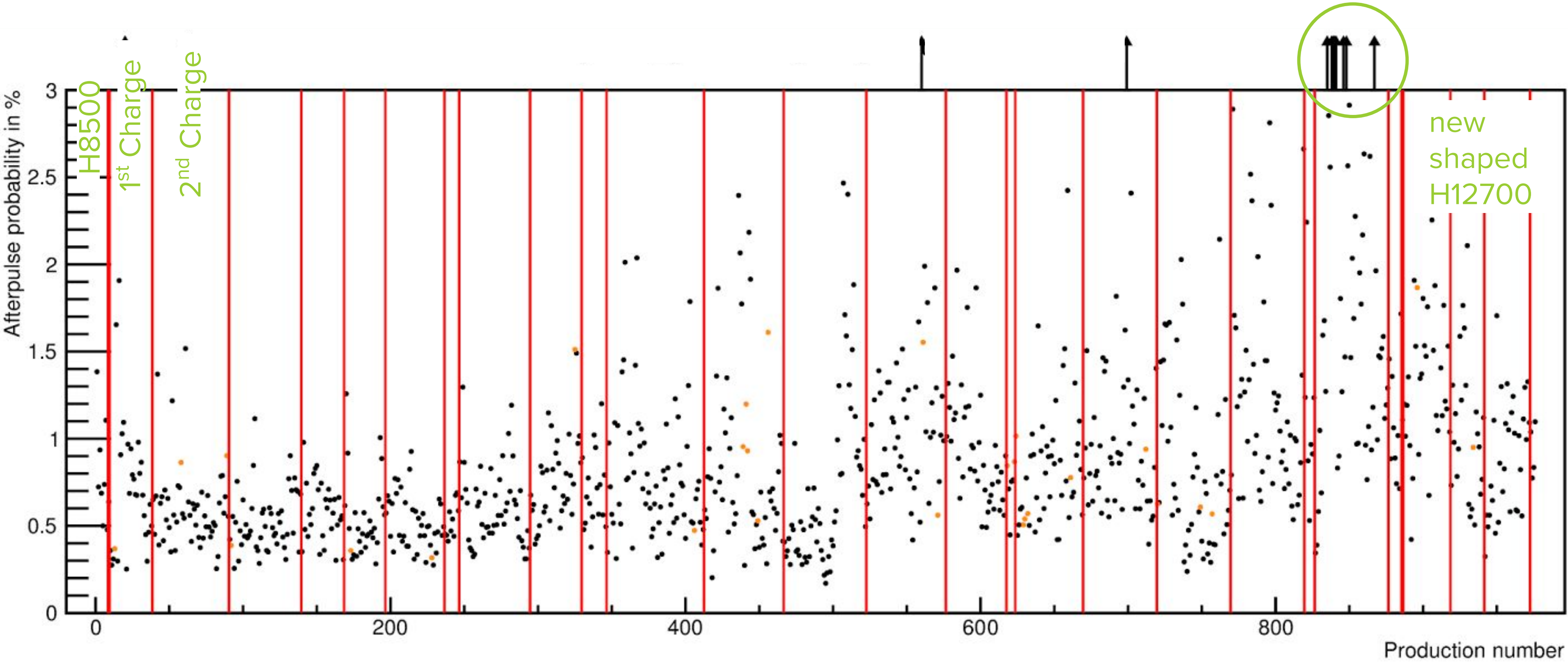
Gain: 4.512×10^6

Low Attenuation

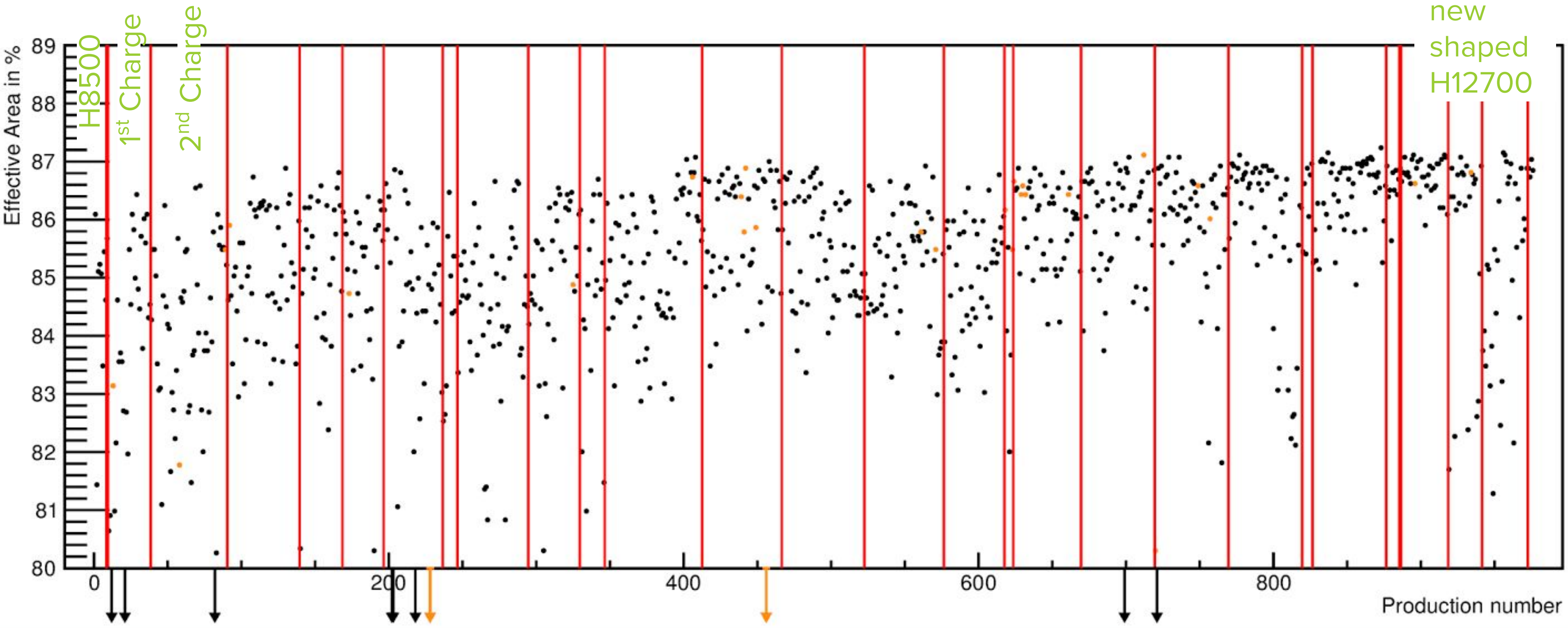


Gain: 3.919×10^6

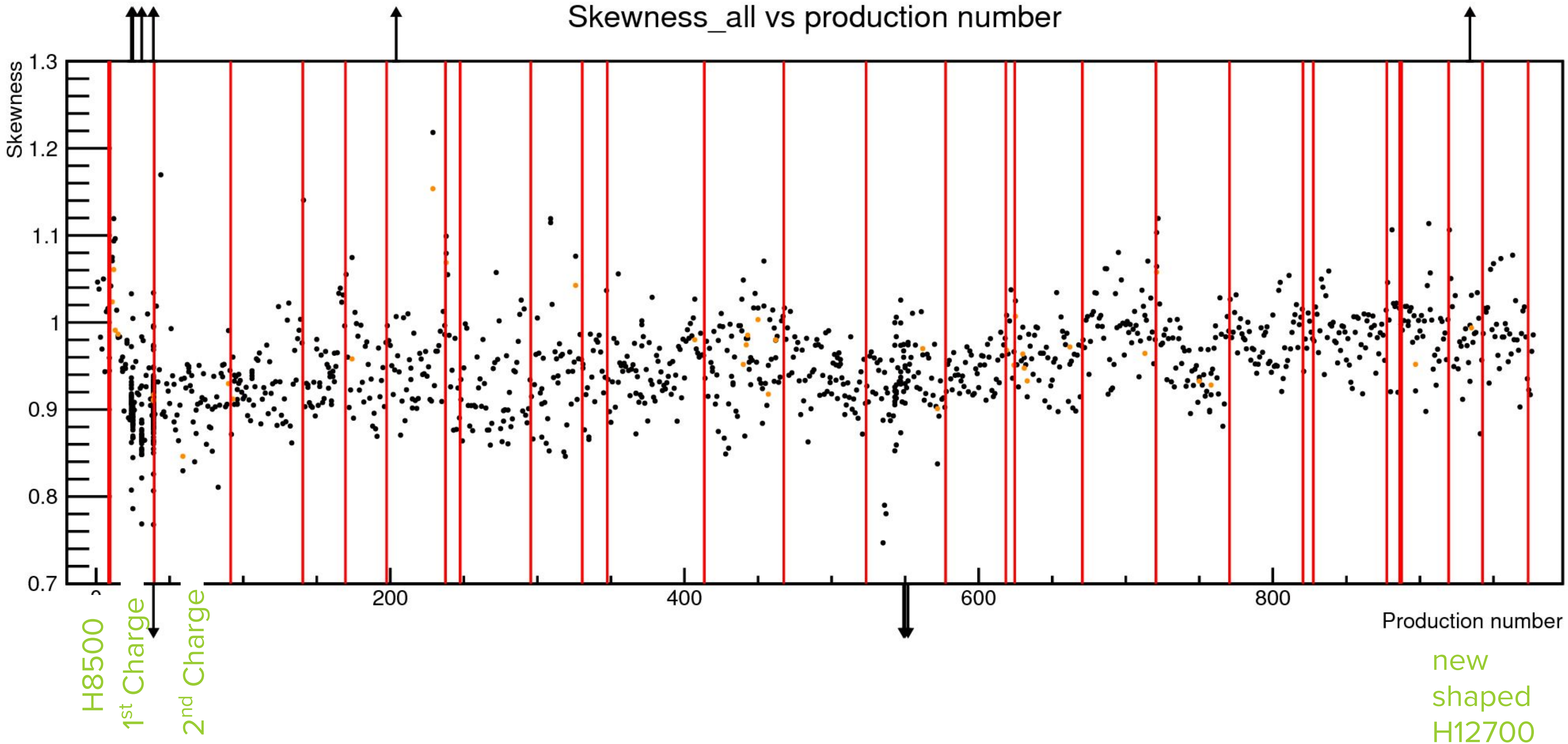
Afterpulsing



Effective Area



Skewness



new
shaped
H12700