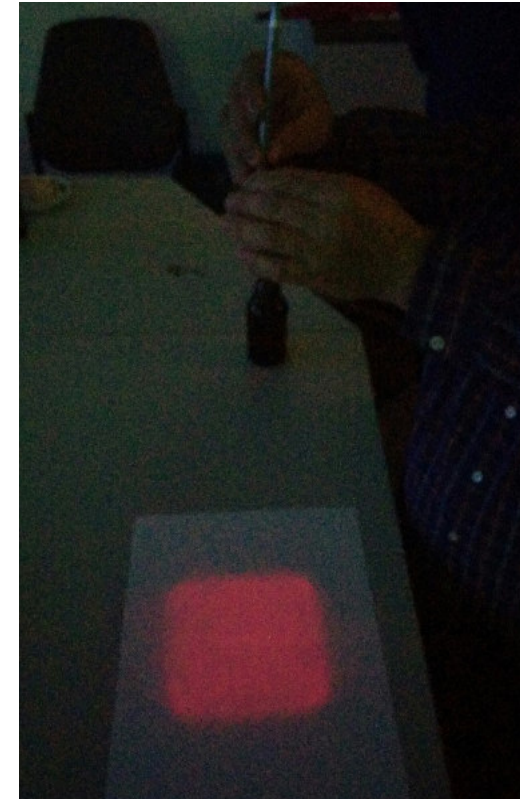


laserpointer...

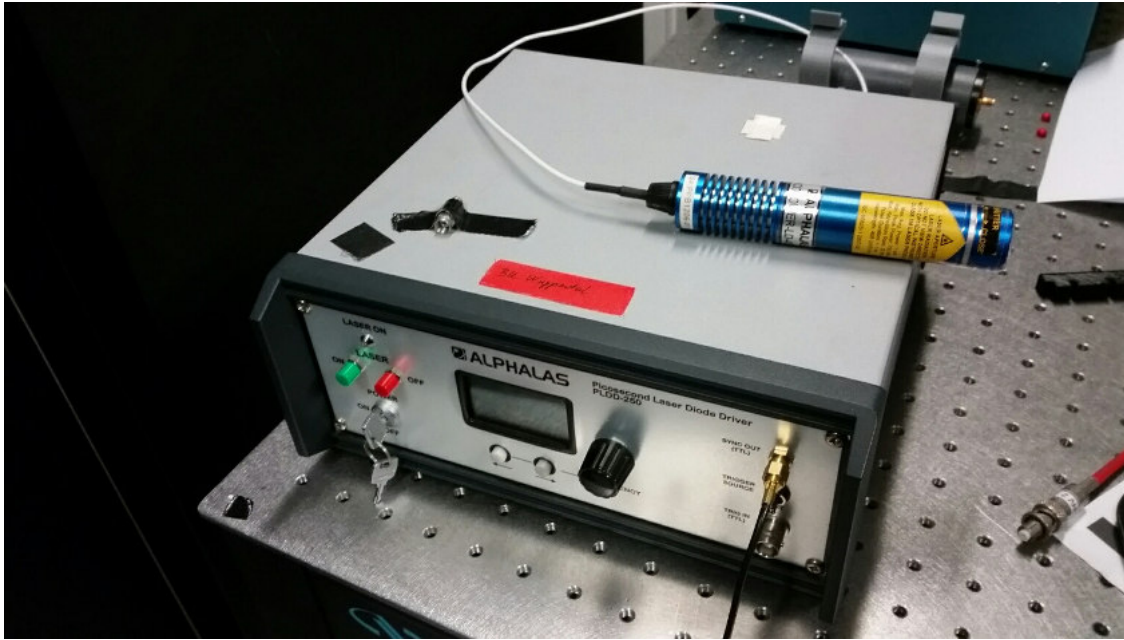


with square diffusor
→ homogenous illumination
→ no $\cos(\alpha)$ dependance !

Square diffusor from Thorlabs, ED1-S20
20deg opening angle
also available as round diffusor, also available with 50deg opening angle
~ 100,- €

illuminated square in 80cm distance: ~30x30cm, ca 5x5 MAPMTs

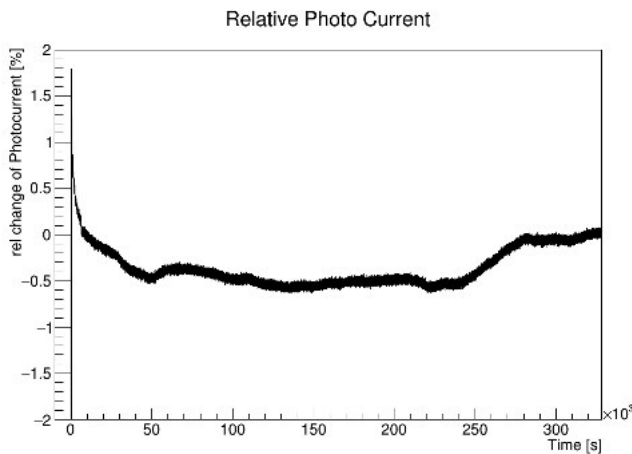
Picosecond Pulse laser



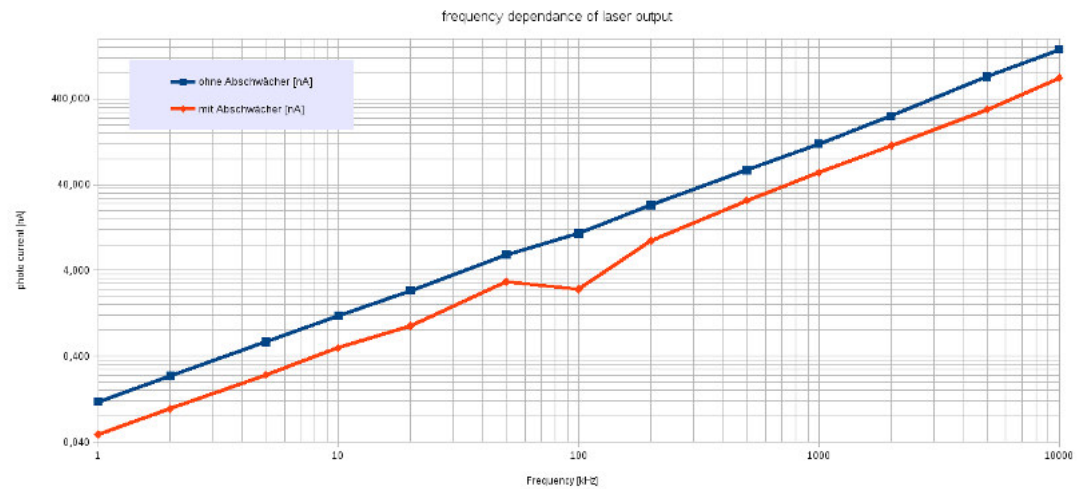
wavelength: 405nm (laser diode)
pulse length: <40 ps

repetition frequency 0 – 20 MHz
amplitude fine regulation: 10% - 100%

self-triggered or external triggered
TTL Trigger SYNC signal



intensity stability over 300k seconds



linearity of pulse intensity with frequency

Constant current source



constant current regulation
<1 μA to 1.5 mA

used to drive LED
(maybe also Laser-LED ???)

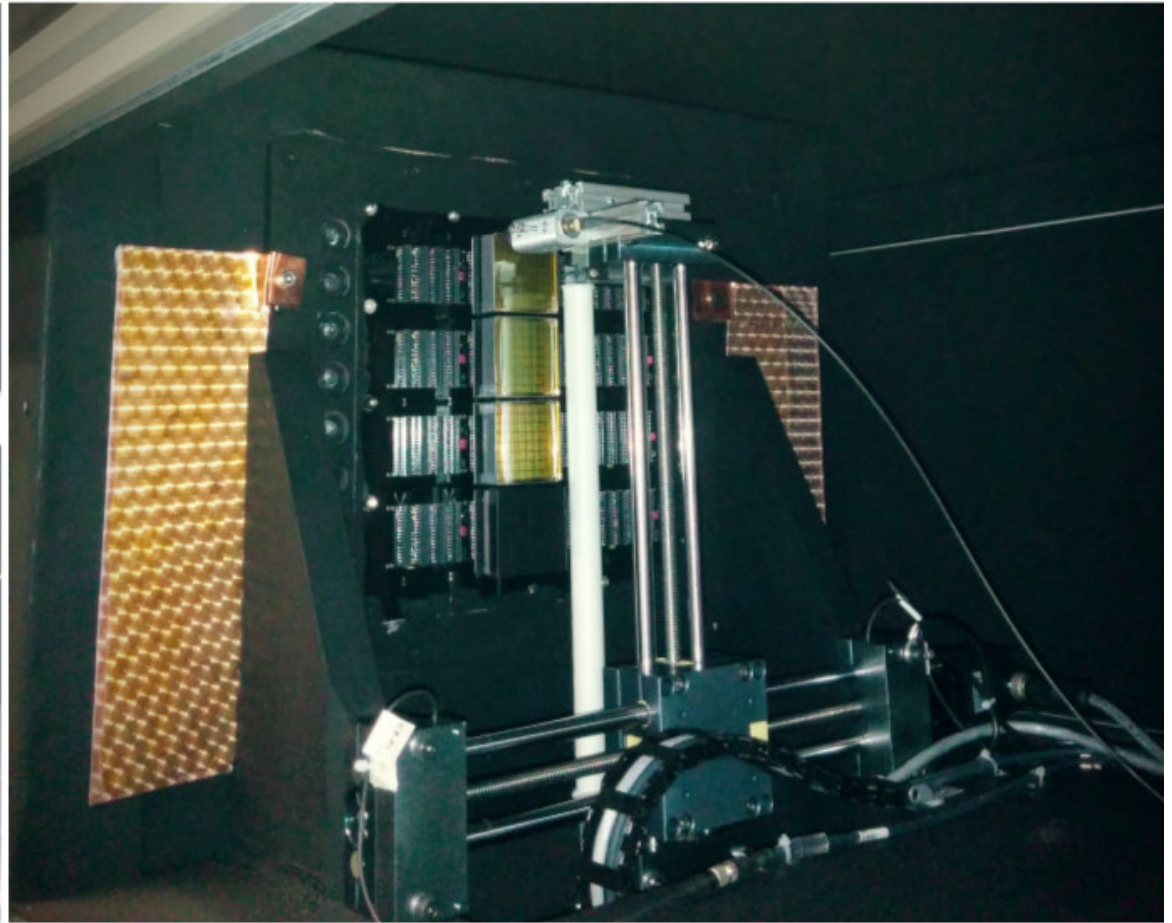


- constant current source in combination with LED / Laser-LED to provide single photon background rate
- good stability and fine regulation
- could be used together with laser pulser to see influence of photon / data rate on reconstruction capabilities
- test high data load

- MAPMT deliver from Hamamatsu running smoothly
- Around 50 MAPMTs per month
- Each PMT is single-photon scanned for testing / classification
- PMT scanning also running smoothly
 - 3 PMTs (+1 reference) per scan
 - single scan ~7h
 - usually 2 scans, 6 PMTs per day
- Status:
 - 400 MAPMTs have been delivered
 - 317 MAPMTs have been tested so far
 - 10 MAPMTs were send back to Hamamatsu (out of specs)
 - another 10-20 will be send back soon

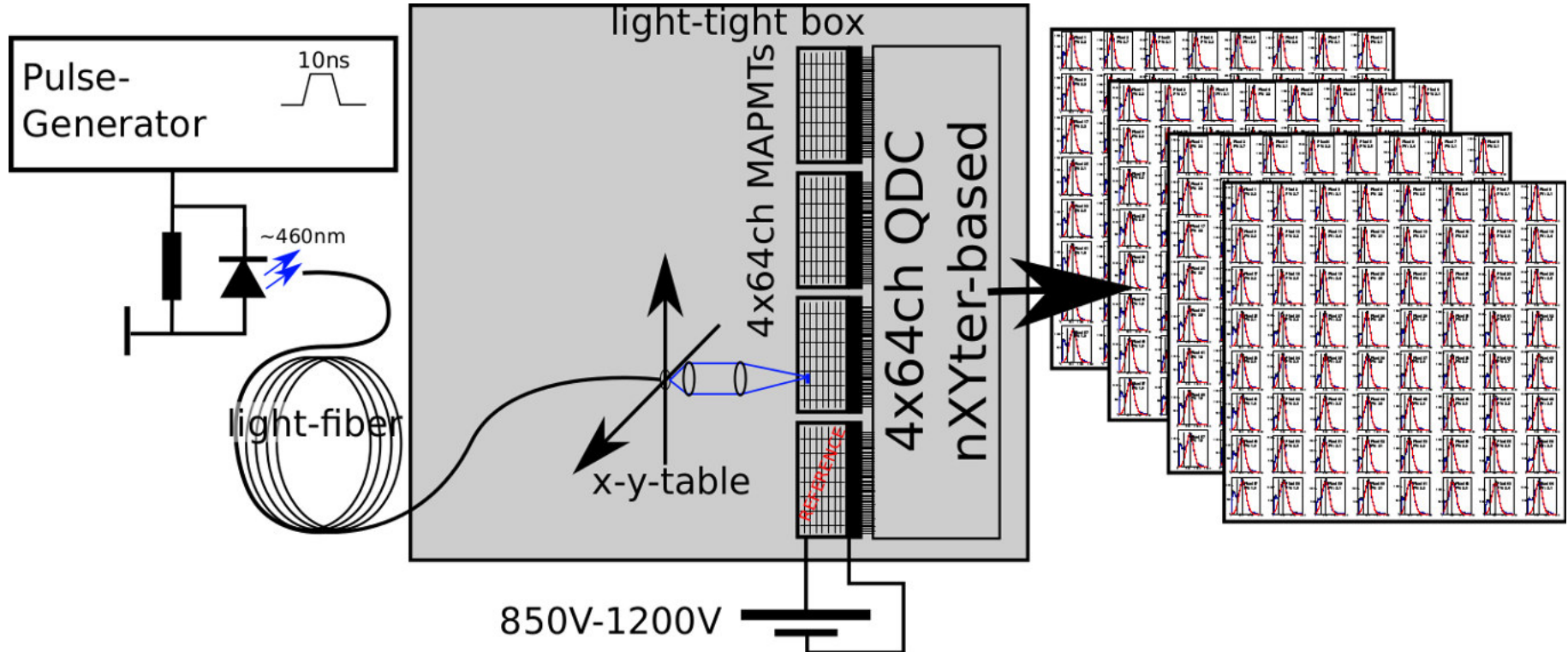


PMT test stand



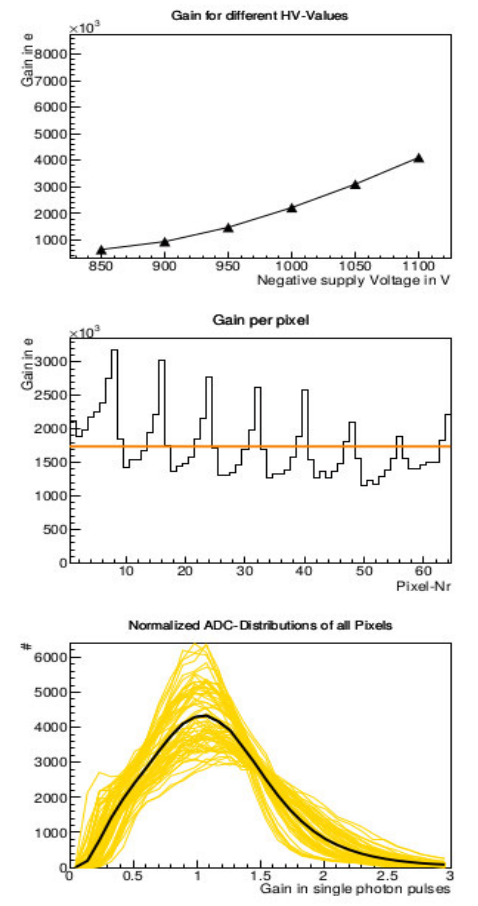
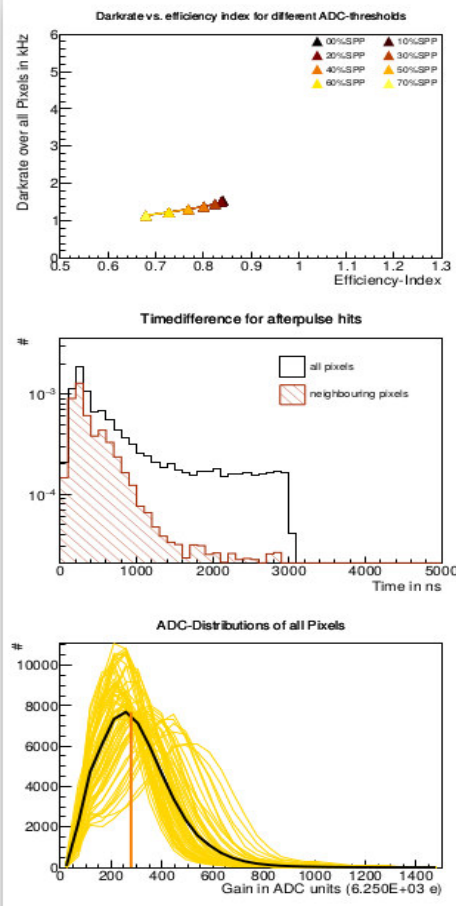
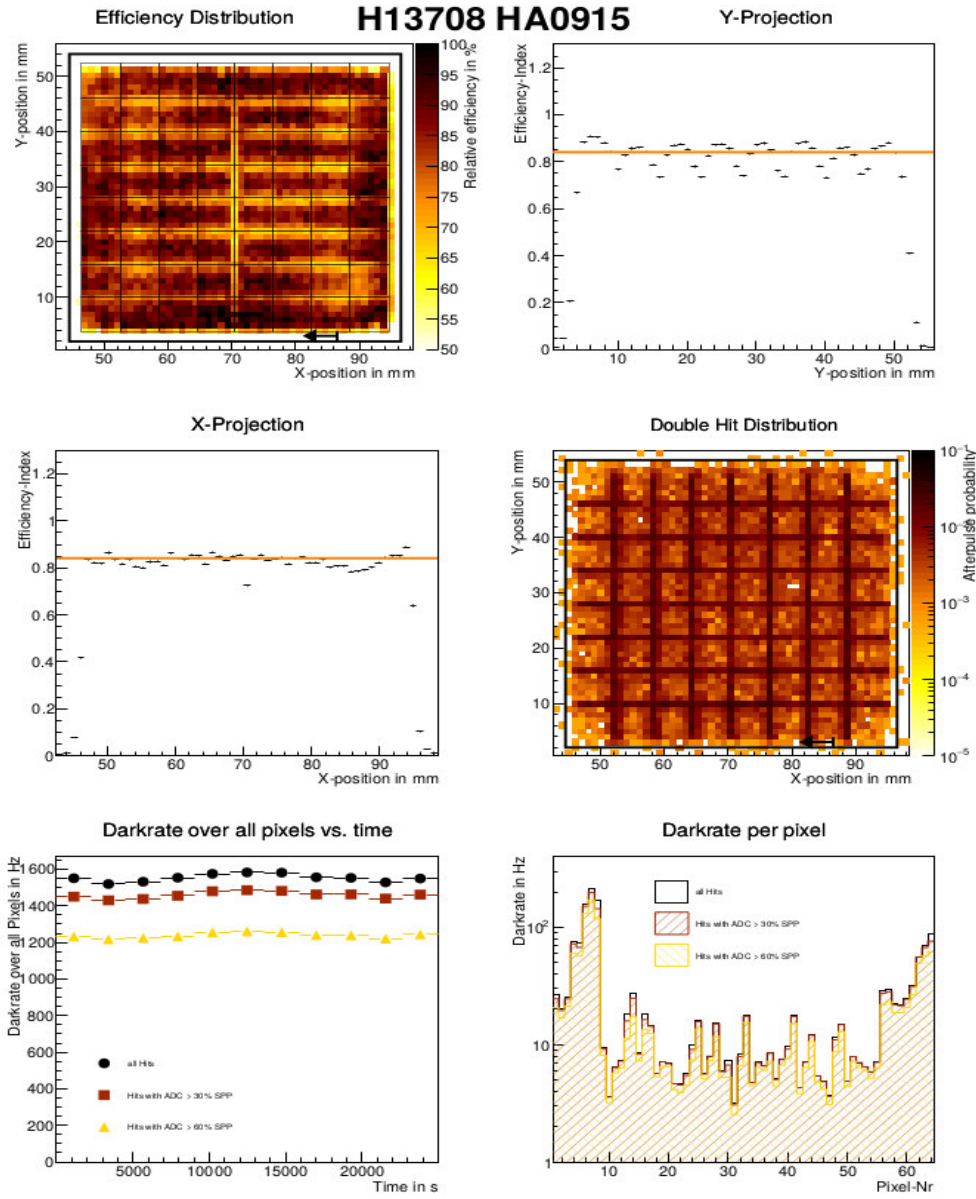
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The PMT teststand



- Triggered LED light source, emitting short pulses (460nm),
• damped to ~ 0.1 photon/pulse
- Light coupled into lightfiber attached to XY-table
- Scan of PMT surface of 3+1 PMTs
- Free-streaming, self-triggered DAQ system (nXYter based)
- Allows to derive all important PMT characteristics (except quantum efficiency)

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H13708 HA0915 / meas.-date: 160520_2015 / meas. -pos: 1 / extrapolated meas.-points: 0

Efficiency Index: 0.841

Effective Area (Area w. rel. Eff.>60%): 86.66%

Efficiency Skewness in X-direction: 1.009

Afterpulse Probability: 0.521%

Average Gain at -1000 V over all Pixels: 1.739E+06 e

Gain reduction for decreasing HV: 1.262E+06 e

Darknoise of all Pixels: 1546.5 Hz

Average Darknoise over the 3 noisiest Pixels: 180.9 Hz

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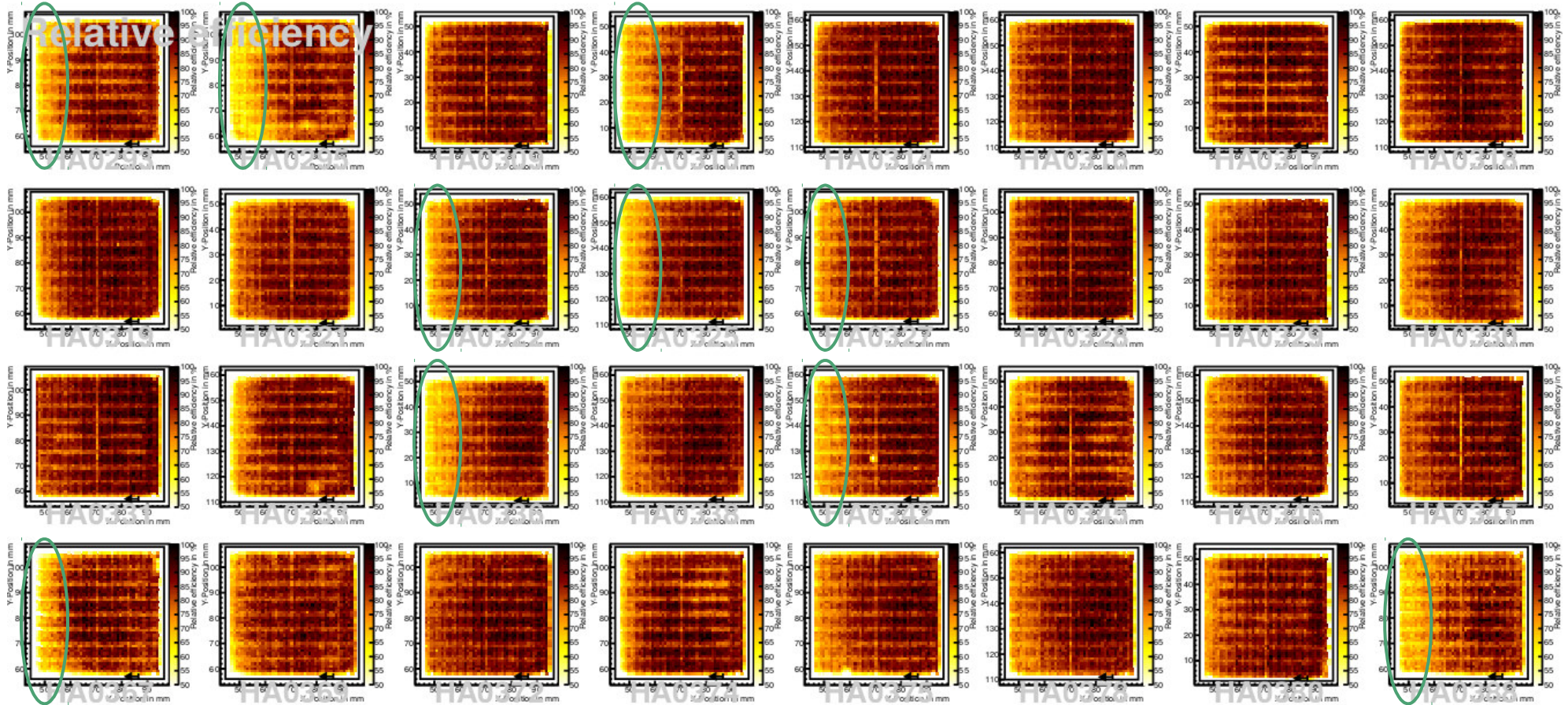
Observed “effects”



- Majority of MAPMTs is perfectly fine, and “ready for use”
- Only general observation: Most PMTs exhibit an efficiency gradient from left to right
- This has been communicated to Hamamatsu, it seems to be connected to the cathode coating process, no simple cure possible.
- This is not “nice”, but will not pose any major problem.
- Overall efficiency of the PMTs is very good !

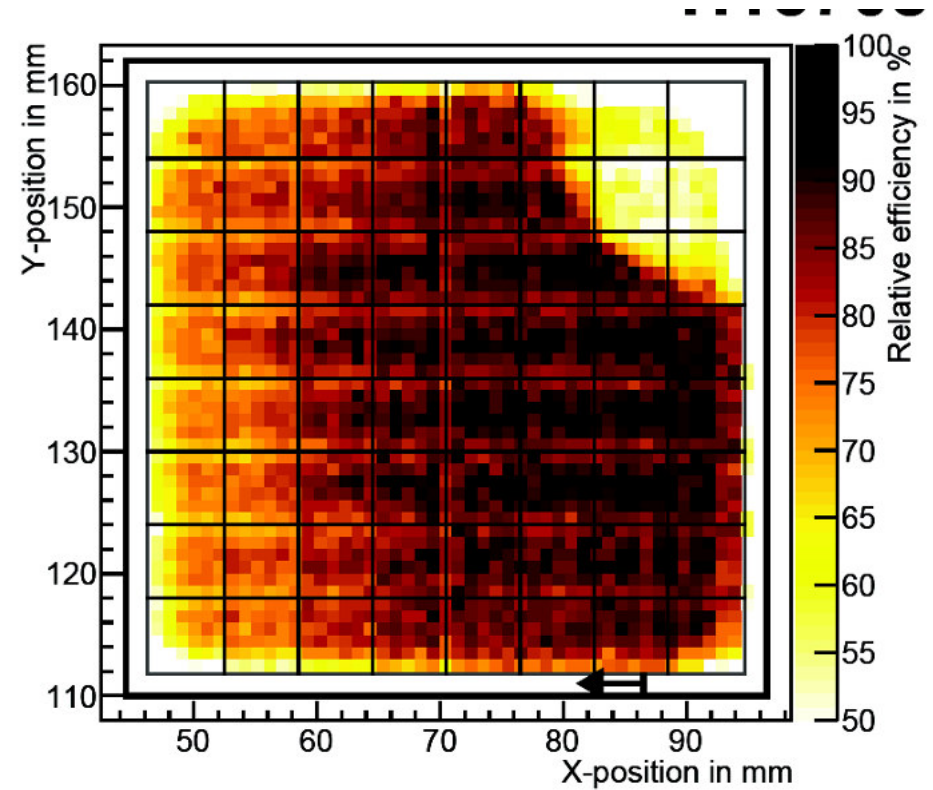
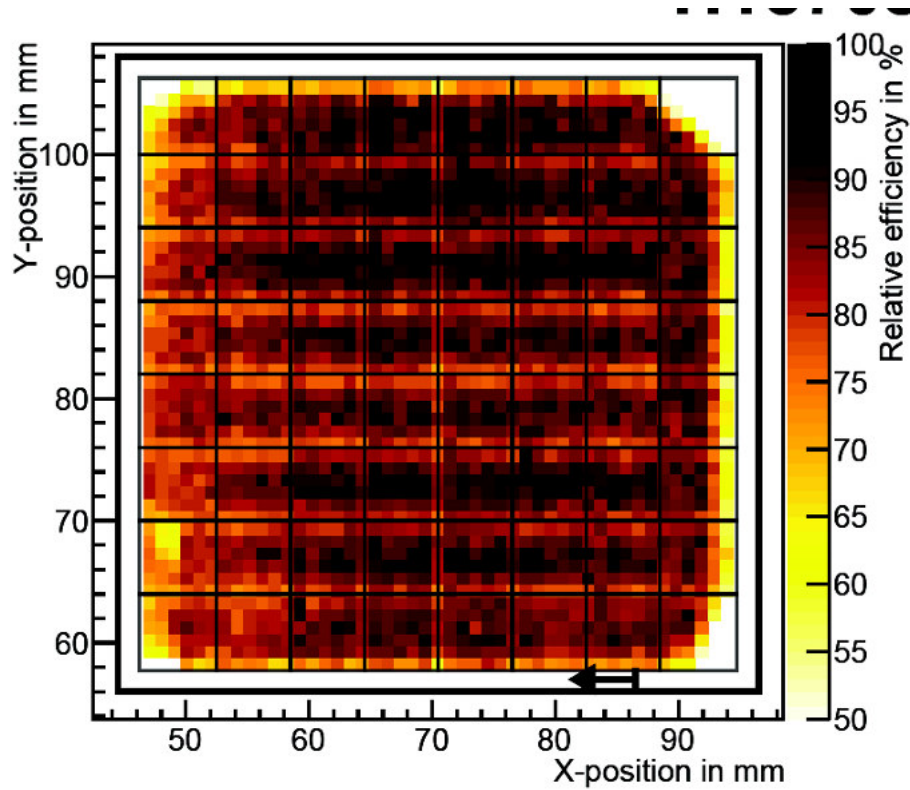
- The following slides show examples of typical “defects” which have been observed on some of the PMTs. Most of these have been send back to Hamamatsu.

non-uniform efficiency, "tilted efficiency"



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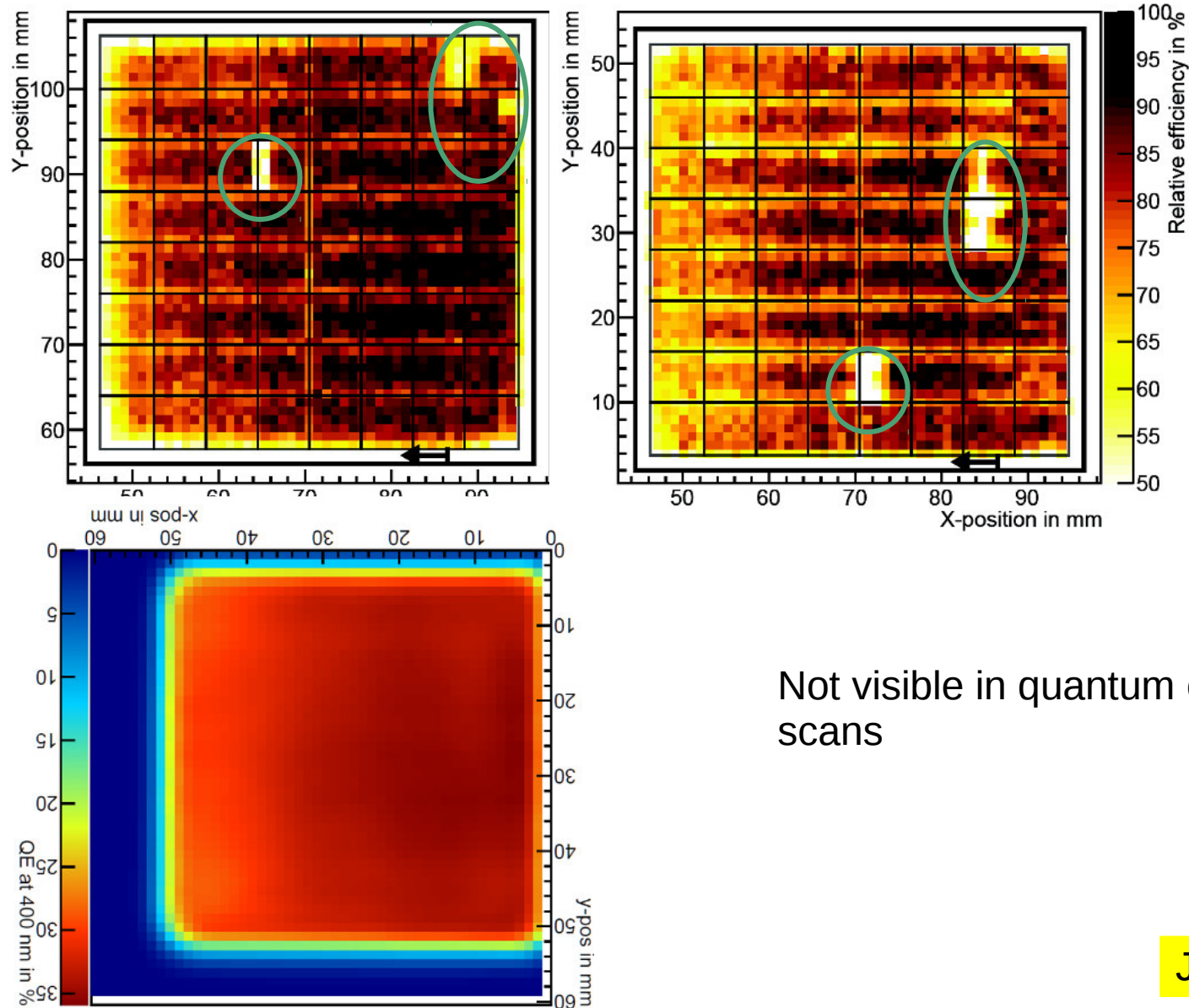
Deficits in quantum efficiency



Clearly visible also in quantum efficiency scans

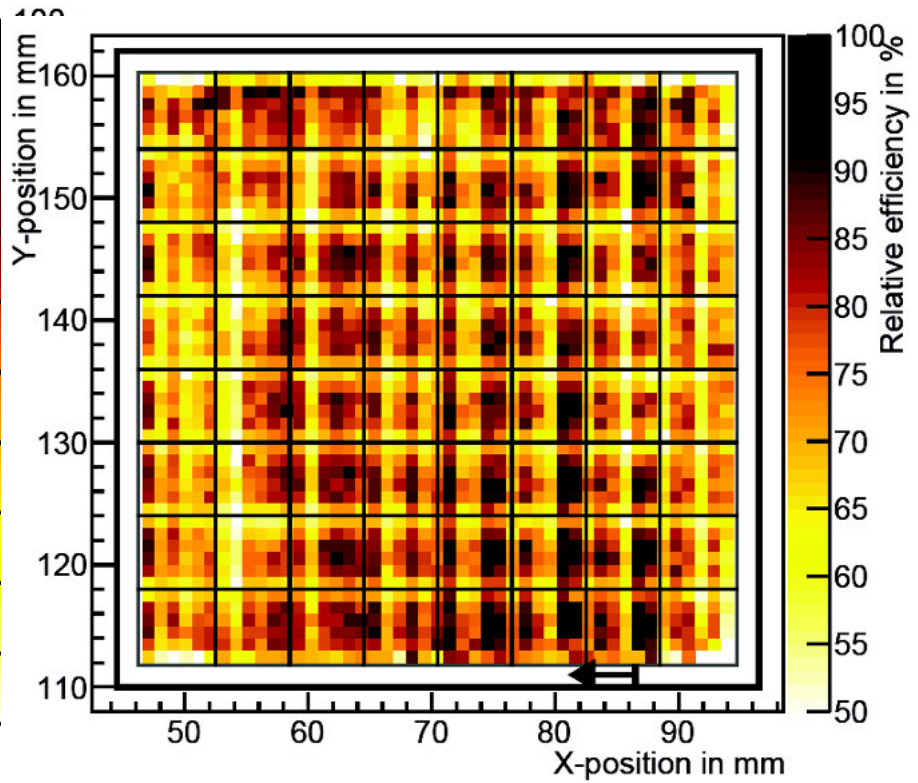
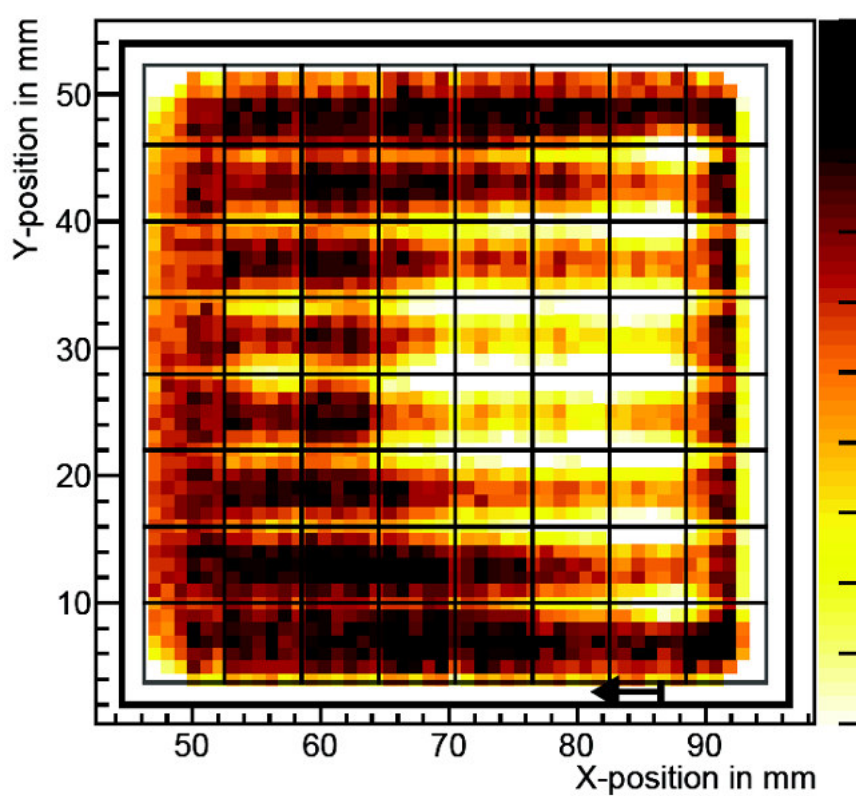
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Efficiency defects in dyndode system

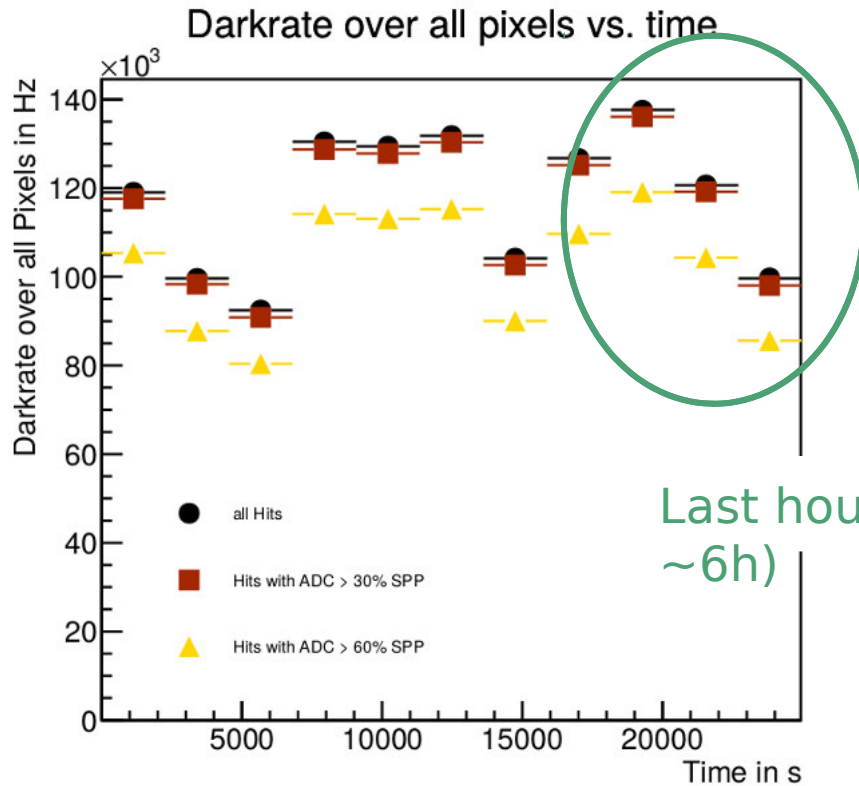


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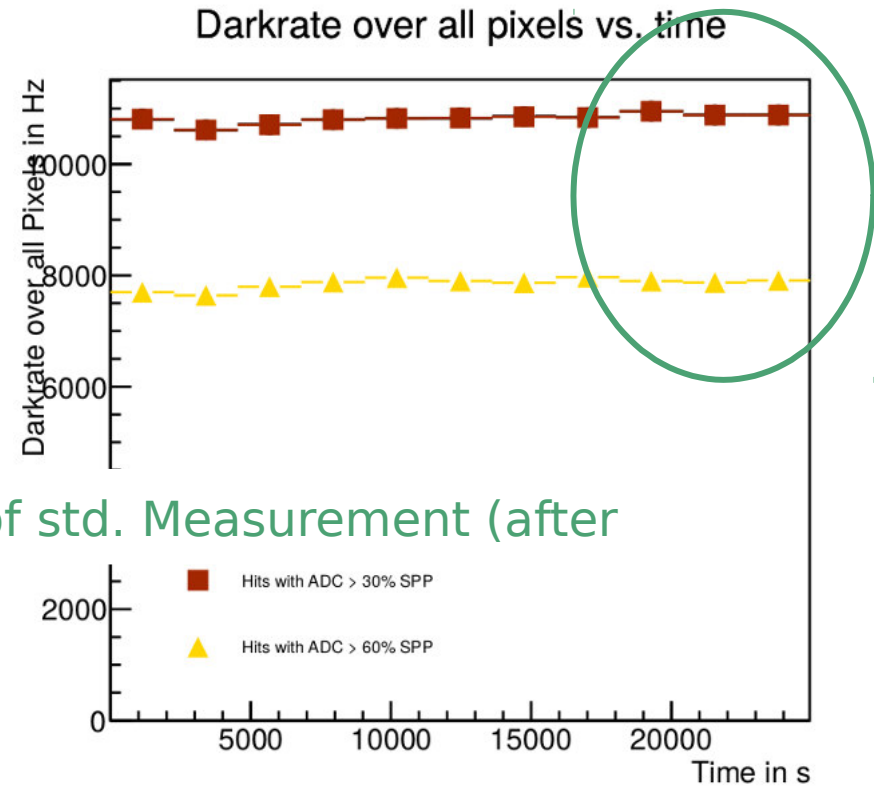
Unhomogeneous / bad efficiency



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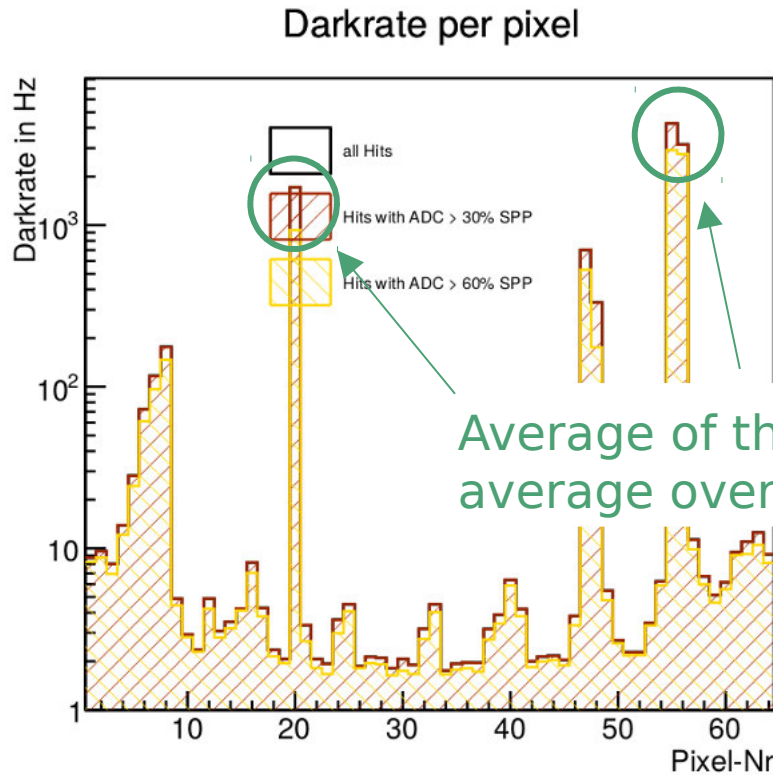
Last hour of std. Measurement (after
~6h)



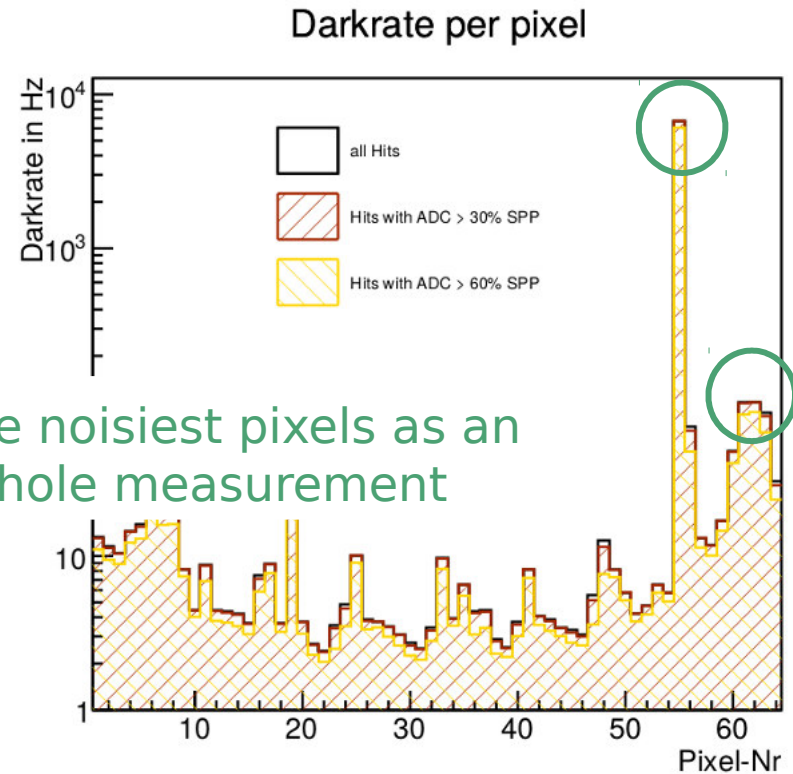
Dark-noise specification:

- Average dark noise (over all pixels): < 100 Hz/pixel, < 6.4 kHz/PMT
- Not a single pixel above 1 kHz

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Average of the three noisiest pixels as an average over the whole measurement

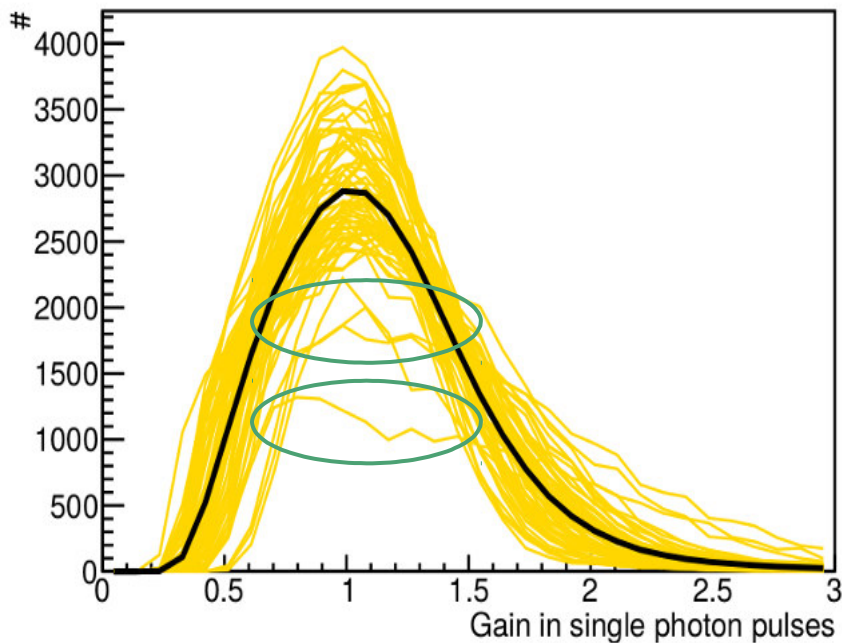


Dark-noise specification:

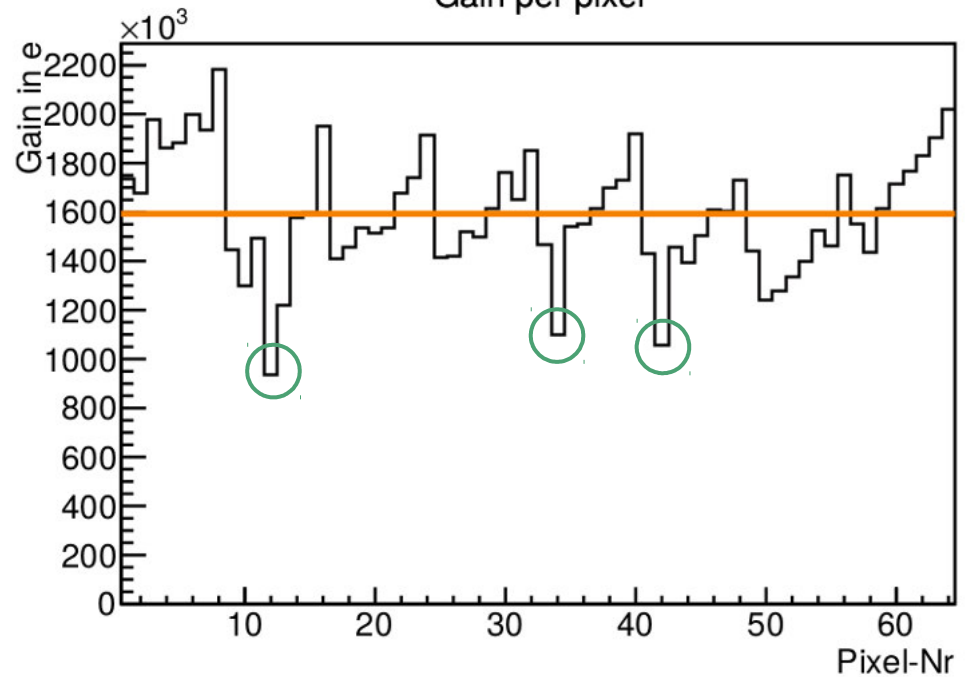
- Average dark noise (over all pixels): < 100 Hz/pixel, < 6.4 kHz/PMT
- Not a single pixel above 1 kHz

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Normalized ADC-Distributions of all Pixels



Gain per pixel

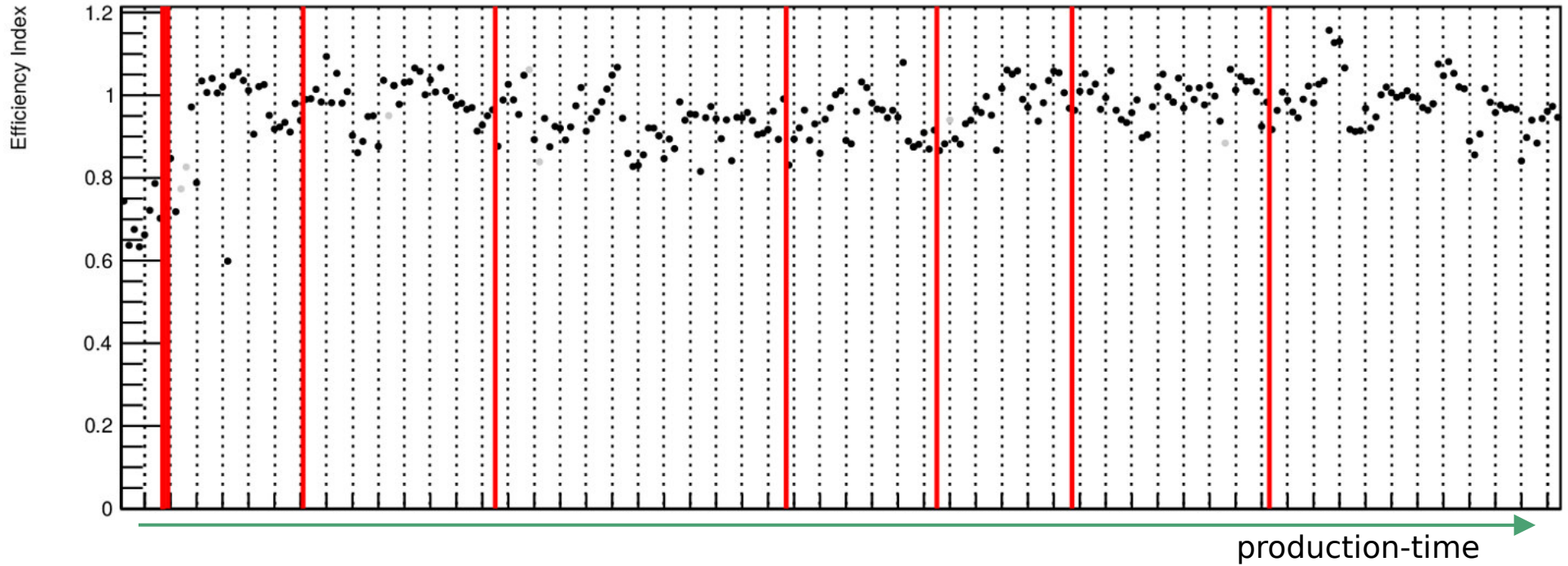


SEP spectrum specification:

- Clear pronounced single photon peak in at least 61 out of 64 pixels per PMT
- Average PMT gain $> 0.9 \times 10^6$

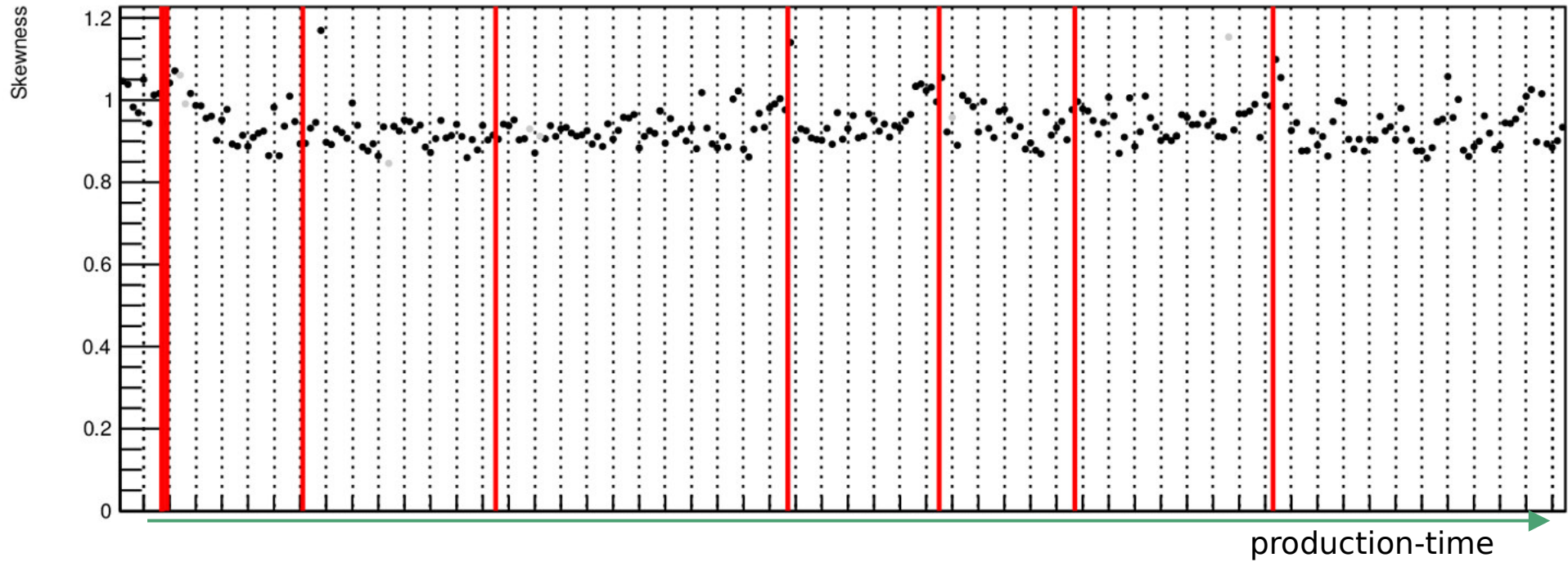
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Trend analysis: Efficiency index



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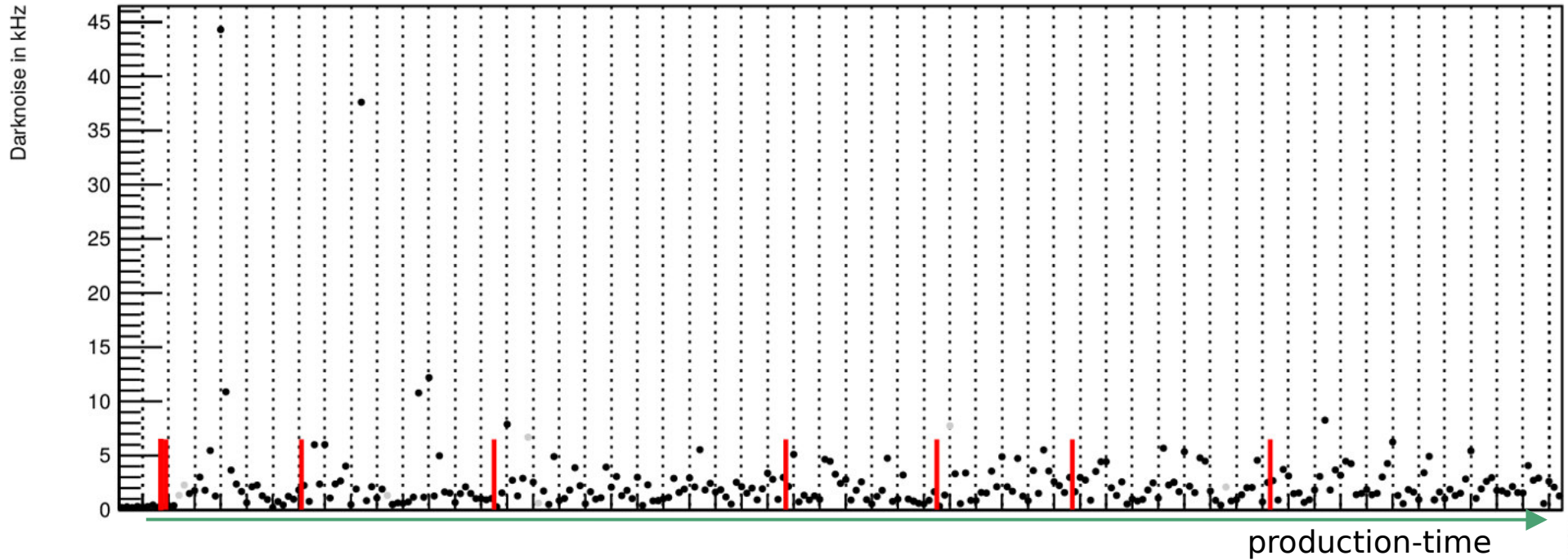
Trend analysis: "Skewness" factor



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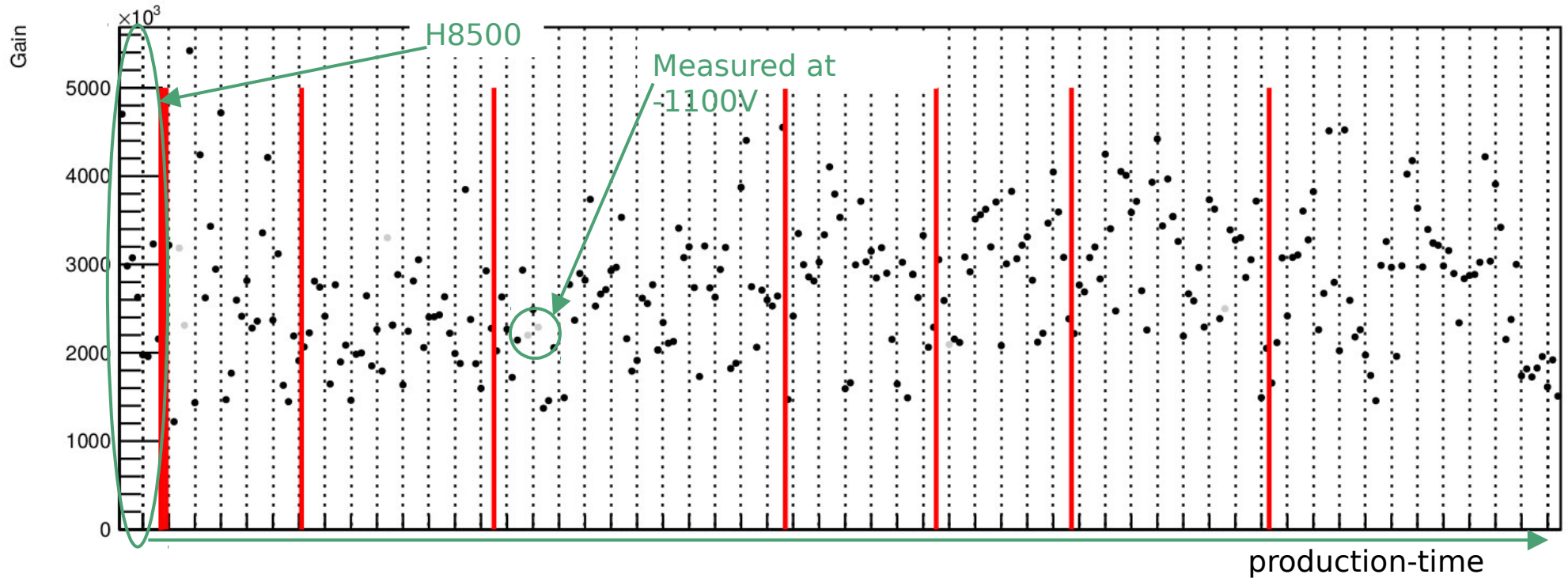


Trend analysis: Total dark rate



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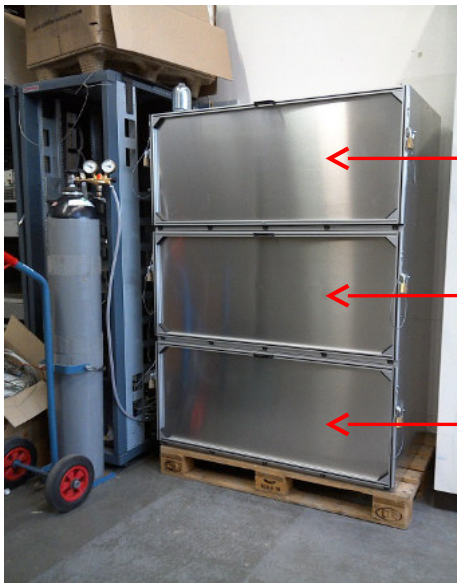
Trend analysis: Average PMT gain



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PMT storage box



← Drawer 1,2,3

← Drawer 4,5,6

← Drawer 7,8,9



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A reliable storage for the PMTs

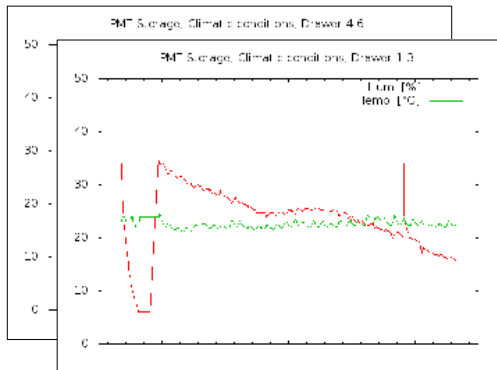
Datalogger



Sensor data



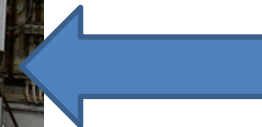
20160609	16:31:01	23.5	33.6
20160609	16:32:01	23.5	29.3
20160609	16:33:01	23.5	28.3
20160609	16:34:01	23.5	28.2
20160609	16:35:01	23.5	27.4
20160609	16:36:01	23.5	26.8
20160609	16:37:01	23.5	26.3
20160609	16:38:01	23.5	27.0
20160609	16:39:02	23.5	31.0



Data output



PMT Storage Box



N₂ flow



Nitrogen supply

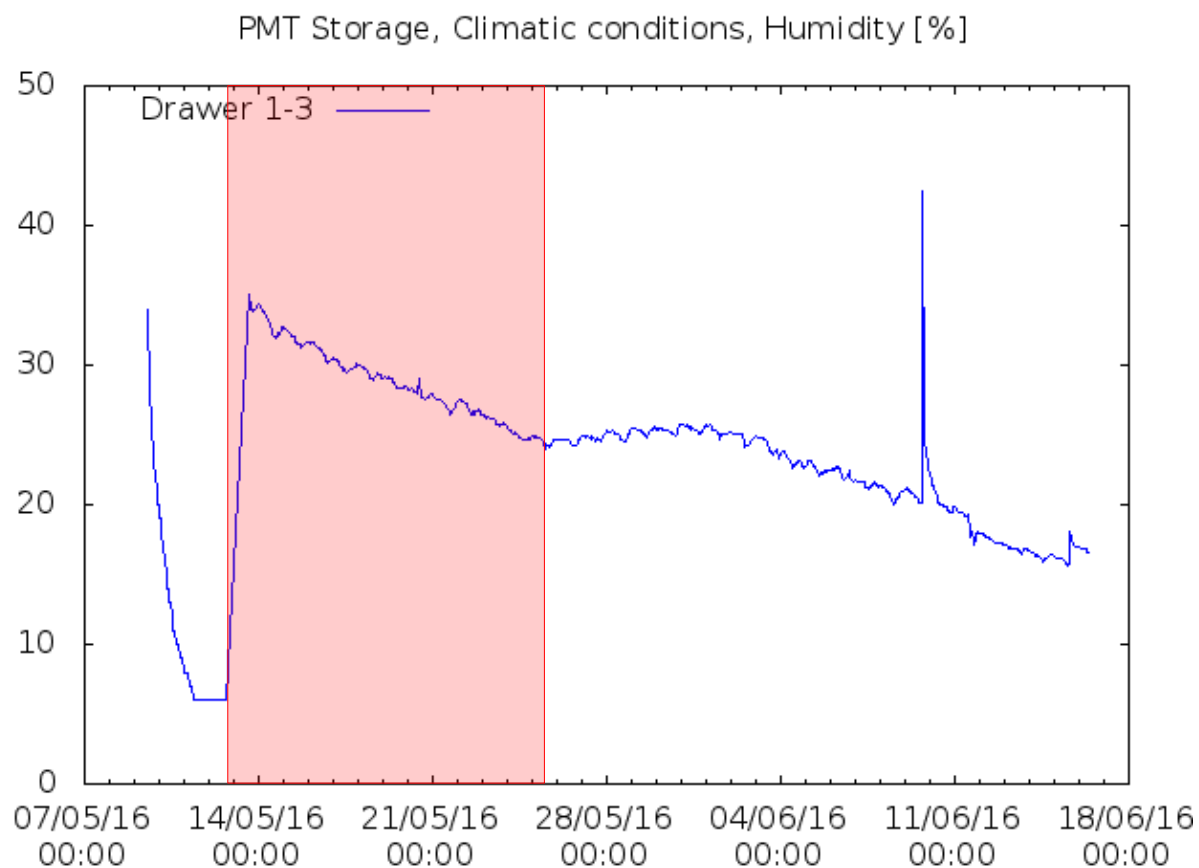
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PMT Storage

Humidity conditions of the top compartment



13/05/2016
 Storing of 160 PMTs in
 the top compartment
 N_2 flow : 15 l/h



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