HRPPD #25 ageing studies
Preliminary analysis - **Ageing campaing II** (Aug.-Sept. 2025)

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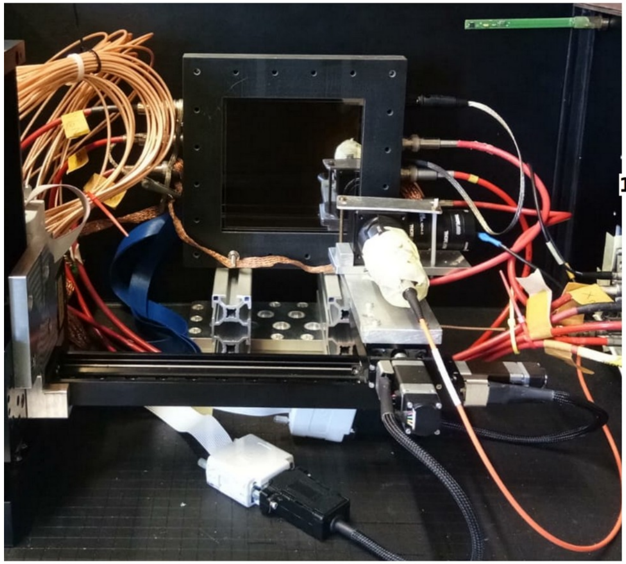
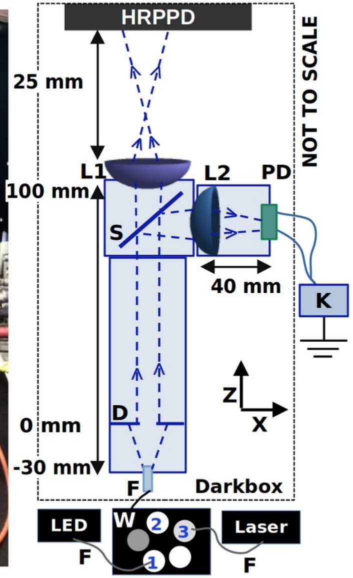
Accelerated ageing campaigns

- Two accelerated ageing with ~**1 cm defocused** spot, continuous **LED**
  - One MCP active,
  - **Both MCPs active (today's discussion)** @ -200_-650_-200_-650_-200V (Gain: 2×10^6)
- Monitoring of input illumination by Photo-Diode (Keithley current)

- Ageing campaign II in **three steps**
- Continuous illumination:
  - Step I – 16 hours (LED current = 85 mA)
  - Step II – 18 hours (LED current = 85 mA/100 mA)
  - Step III – 44 hours (LED current = 300 mA)



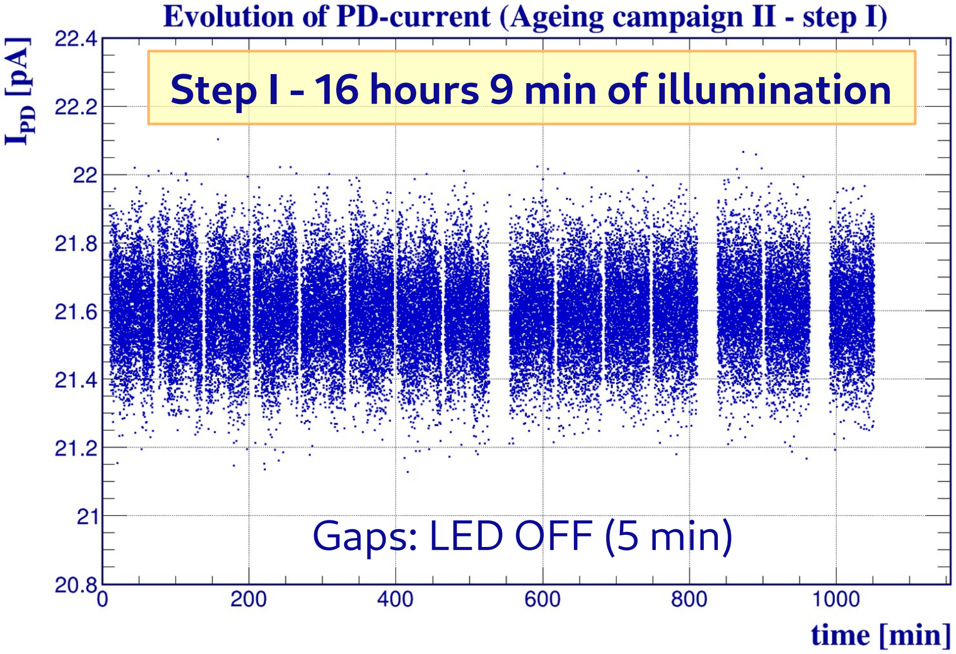


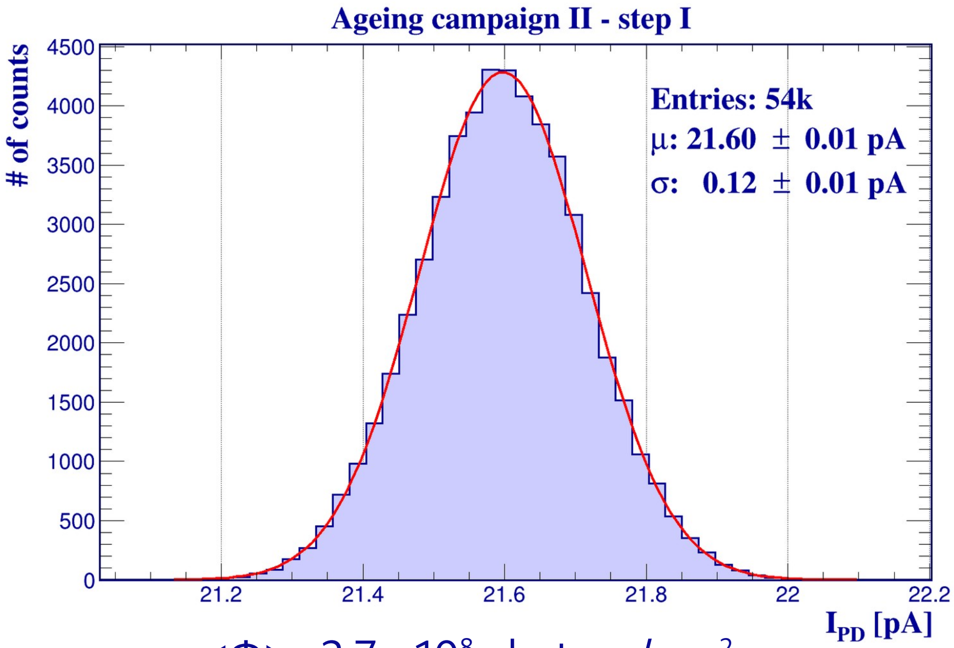
Outline

- Input illumination/ PD current (Keithley)
- Output light-related current at XoX (CAENlog)
- Gain (estimated)
- Output integrated charge
- QE scan, QE degradation

Input illumination/ PD current

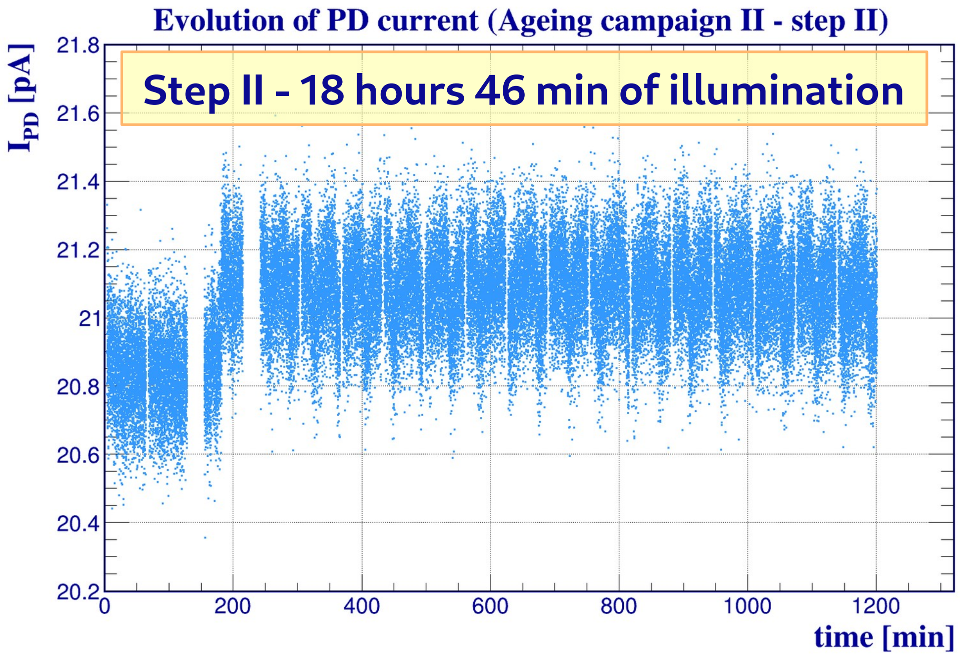
- LED was turned OFF for 5 min after each one hour of illumination.
- This allowed to measure the evolution of leak current at the output (Exit of second MCP).
- Stable illumination during 15 hours: $\langle I_{PD} \rangle = 21.60 \pm 0.01$ pA.

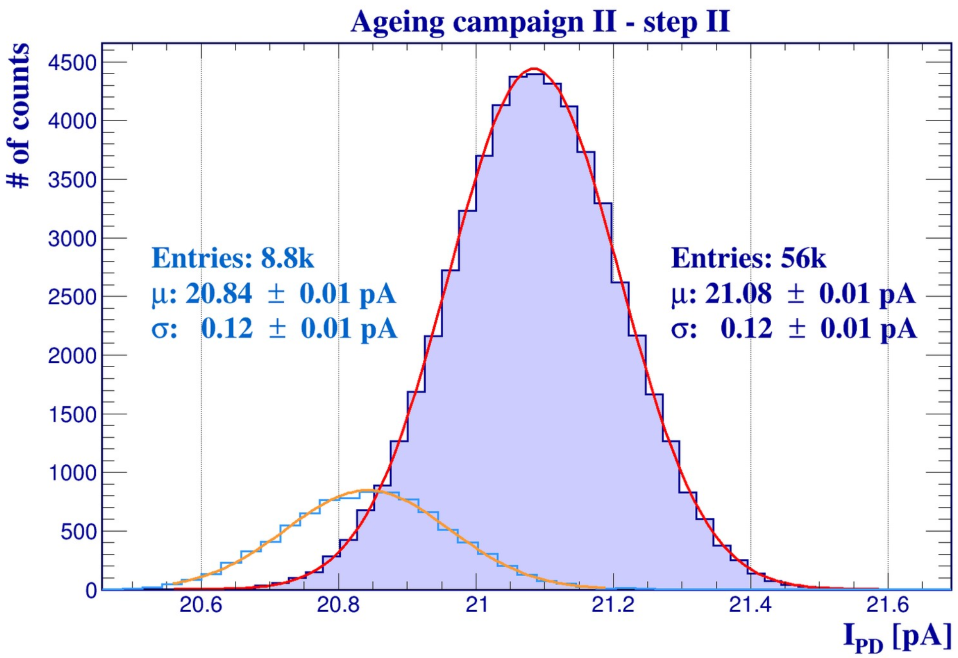




$\langle \Phi \rangle = 2.7 \times 10^8$ photons/ cm^2 - sec

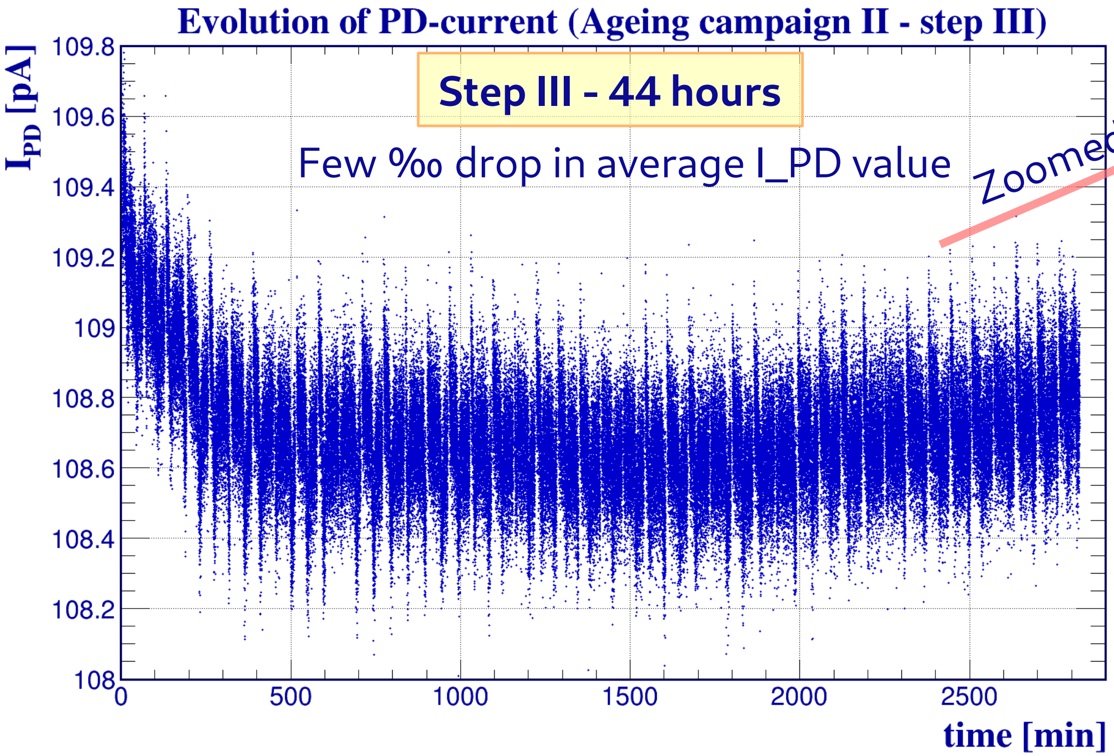
Input illumination/ PD current



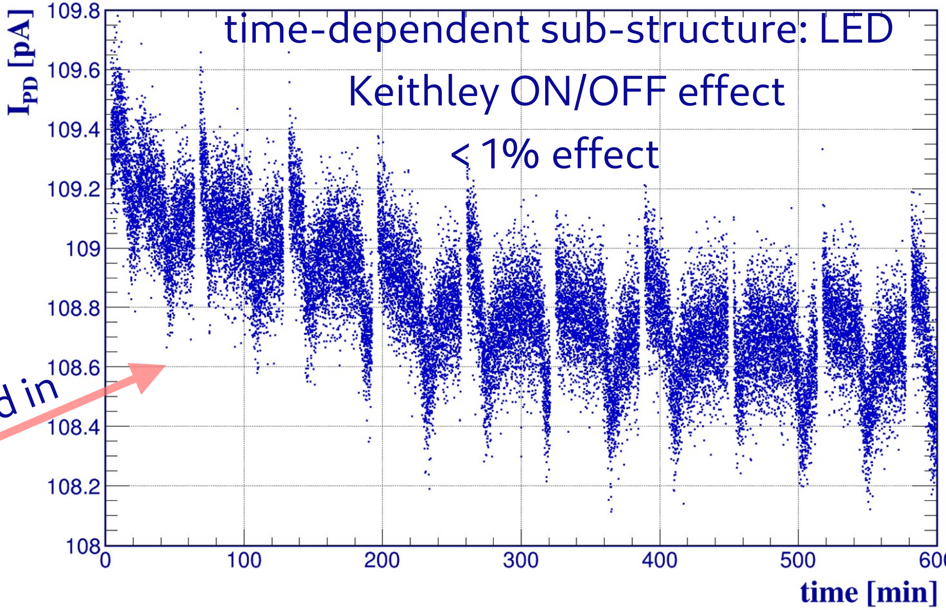


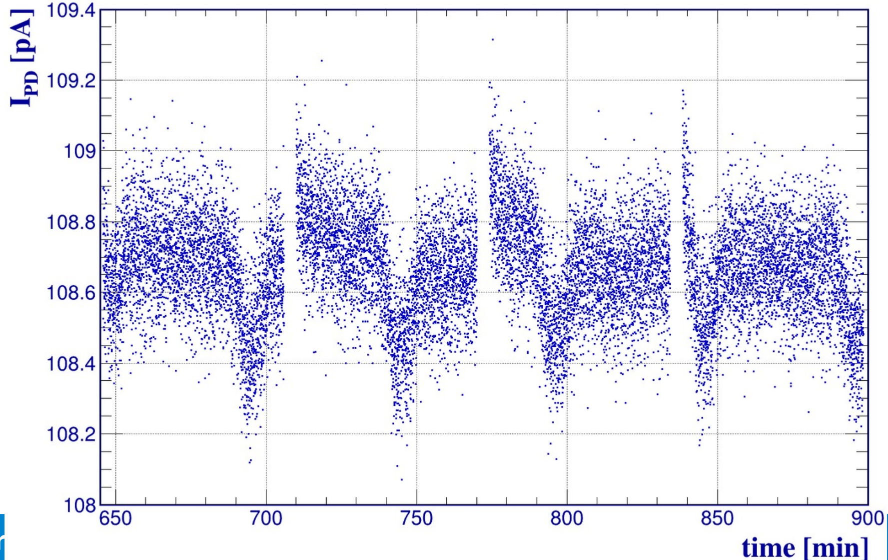
$\langle\Phi\rangle = 2.6 \times 10^8$ photons/ cm^2 - sec

Input illumination/ PD current

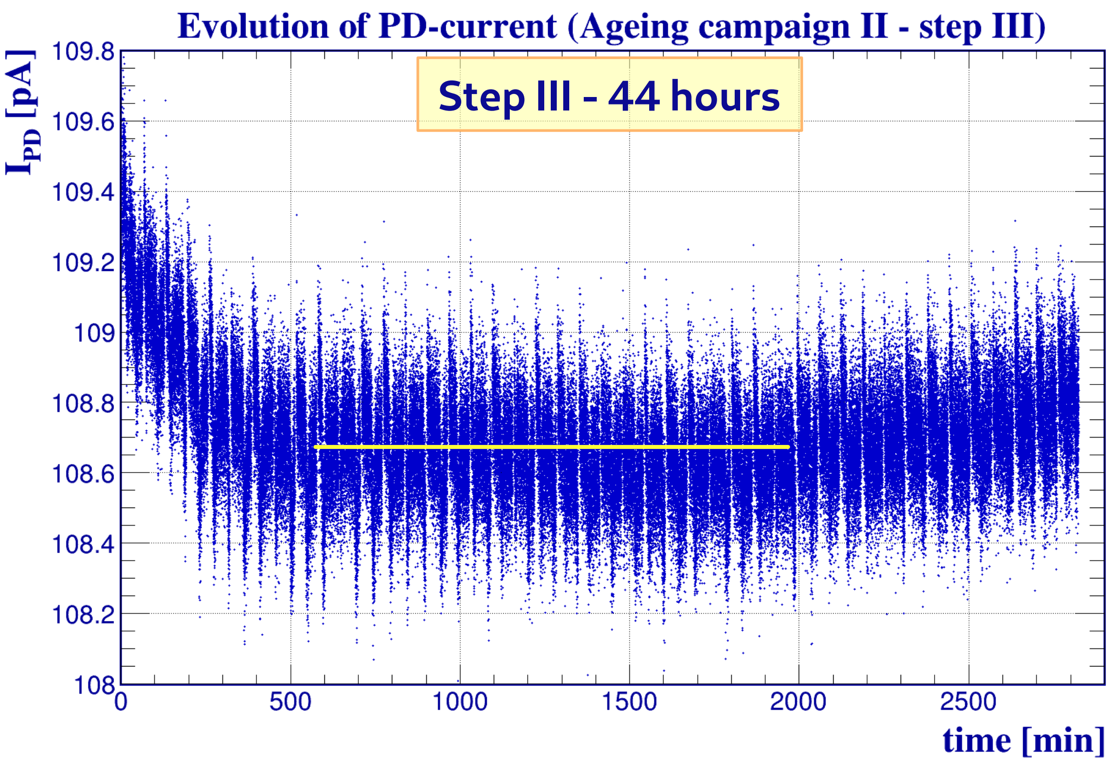


Zoomed in

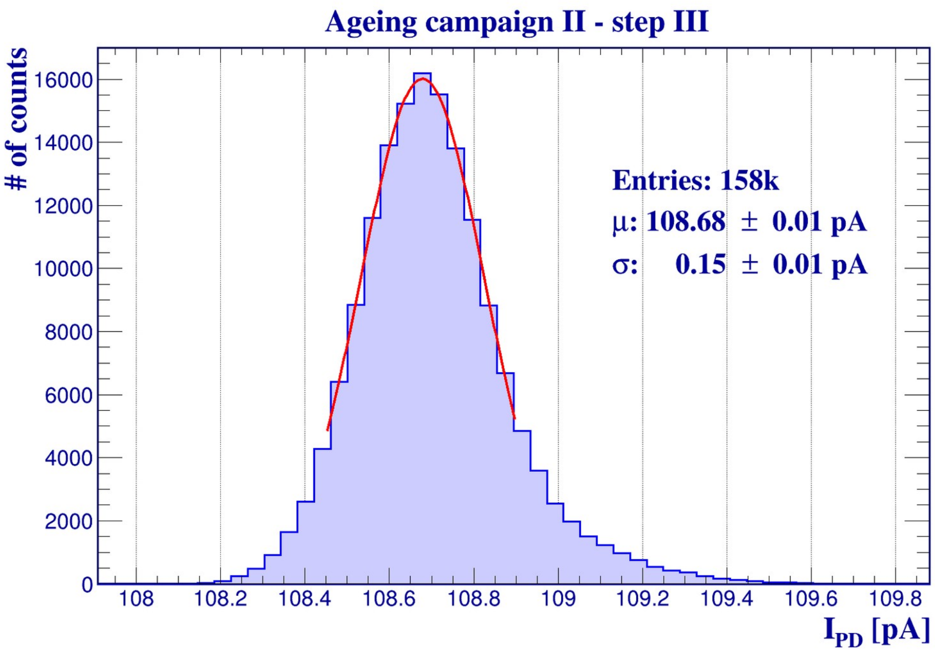




Input illumination/ PD current



Mean I_{PD} extracted from stable part



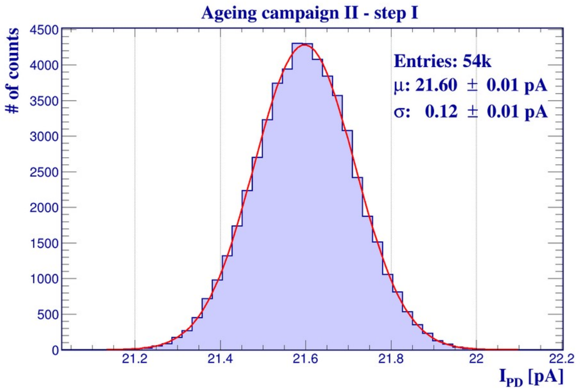
$\langle\Phi\rangle = 1.4 \times 10^9$ photons/ cm^2 - sec

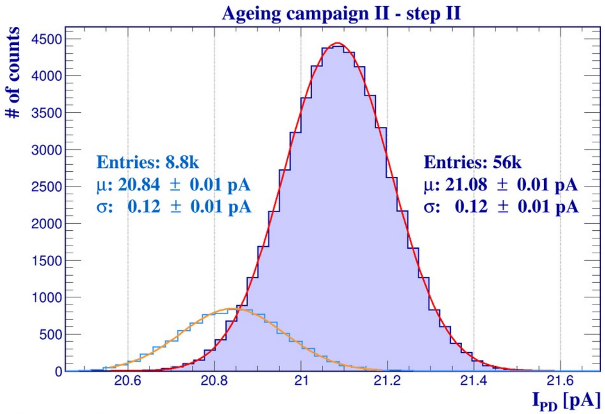
Input photo-current at HRPPD (estimated)

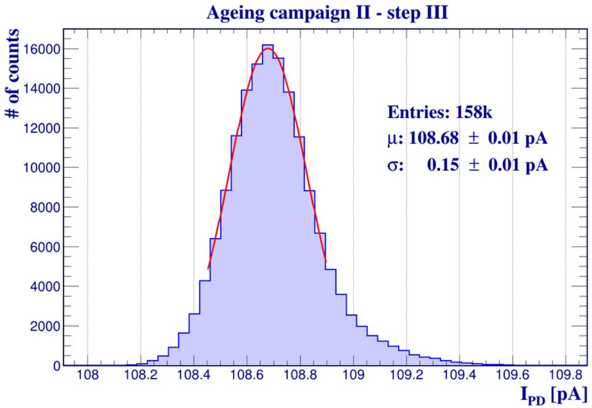
$$\langle I\,(\mathrm{HRPPD})\rangle = \langle I\,(\mathrm{PD})\rangle \times \mathrm{SR} \times \frac{\mathrm{QE\ (HRPPD\#25)}}{\mathrm{QE\ (PD)}}$$

$$\frac{\mathrm{QE\ (HRPPD\#25)}}{\mathrm{QE\ (PD)}} = \frac{0.22}{0.56} = 0.39$$

Splitting Ratio (SR) = 1. 14



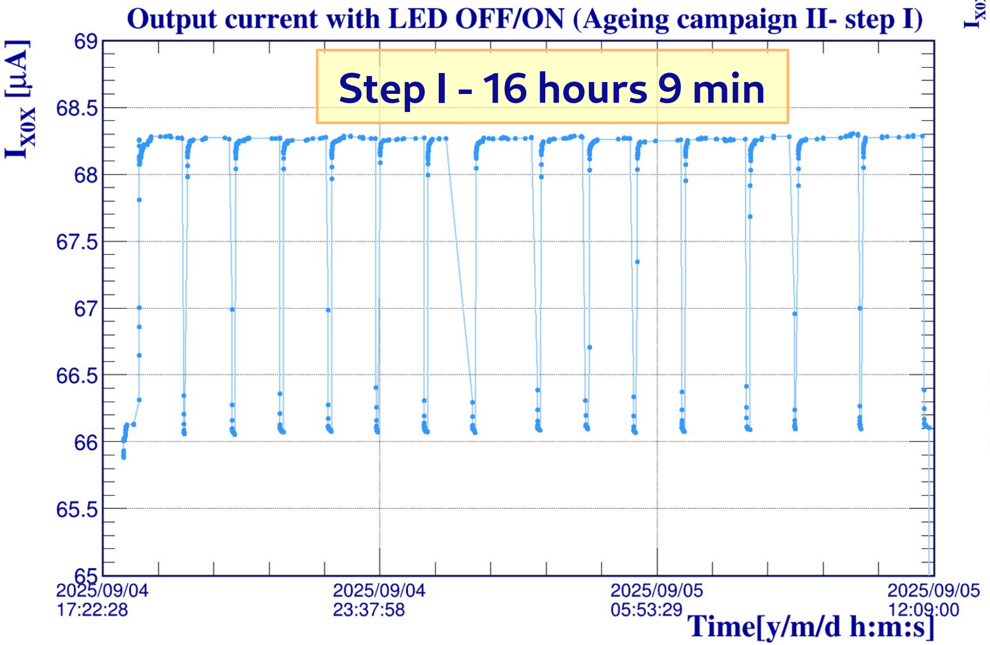


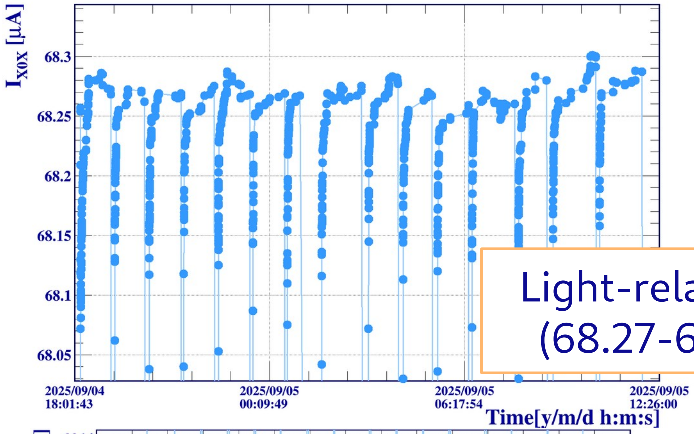


- Step I: $\langle I\,(\mathrm{HRPPD})\rangle$ = 9.60 pA
- Step II-a: $\langle I\,(\mathrm{HRPPD})\rangle$ = 9.27 pA
- Step II-b: $\langle I\,(\mathrm{HRPPD})\rangle$ = 9.37 pA
- Step III: $\langle I\,(\mathrm{HRPPD})\rangle$ = 48.32 pA

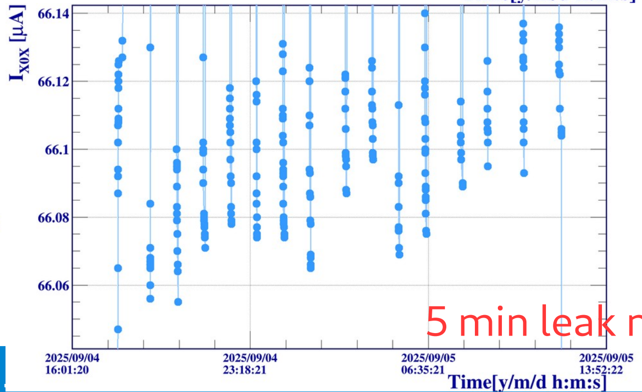
Output current at second MCP exit (XoX)

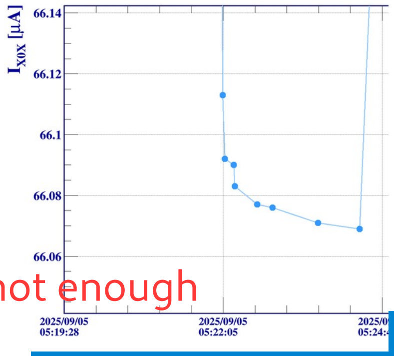
- CAENlog for all electrodes; we looked at XoX current logs.
- LED was OFF for 5 min after each one hour of illumination – provides measure of leak currents.
- Total current (LED ON) is well separable from leak current (LED OFF).





Light-related output current:
(68.27-66.07) μA = 2.20 μA





5 min leak not enough

Output current at second MCP exit (XoX)

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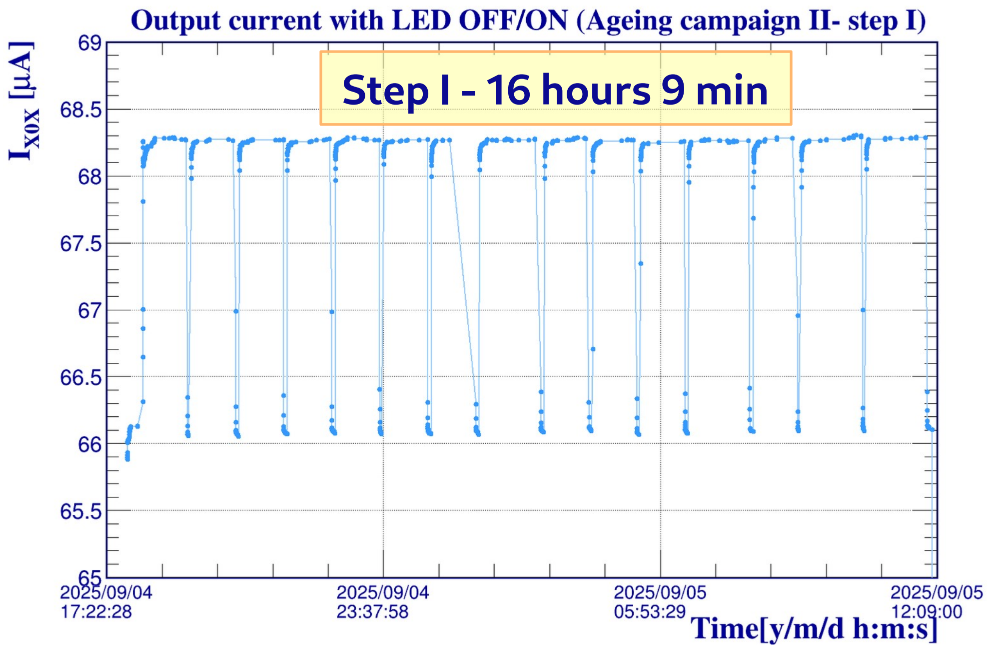
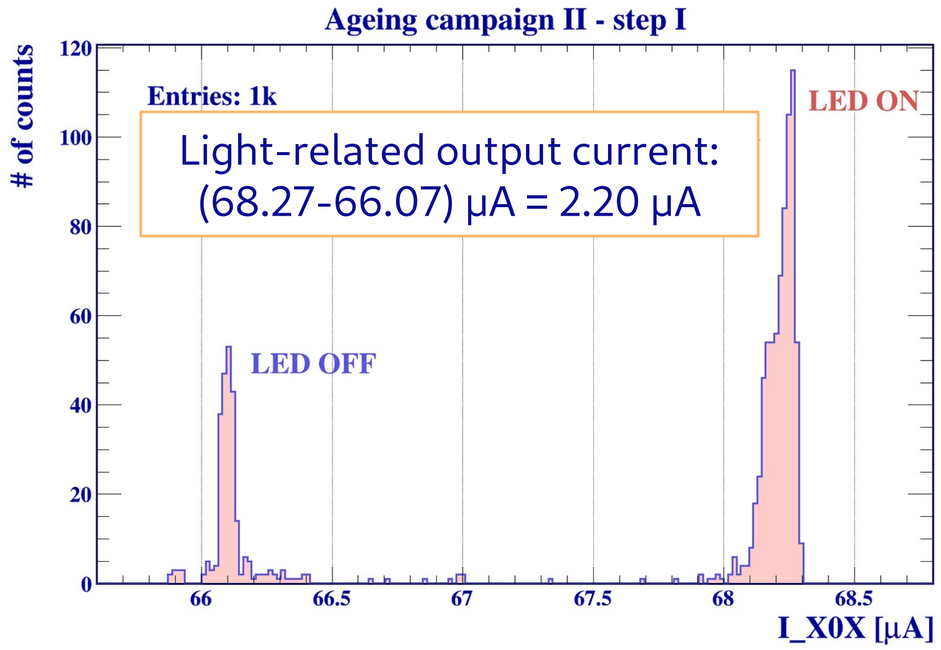
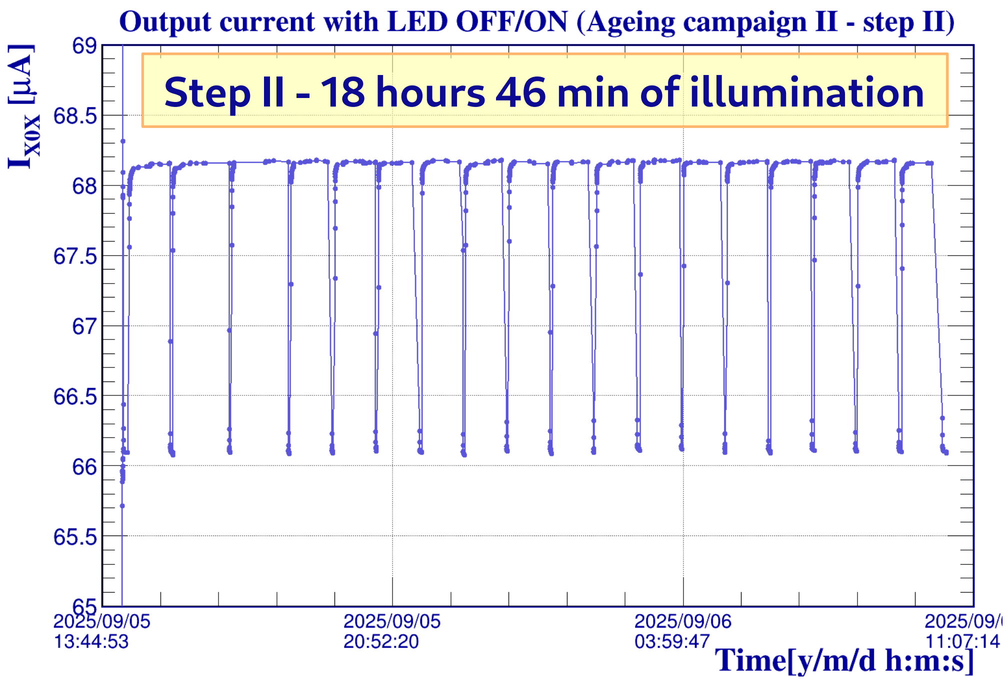
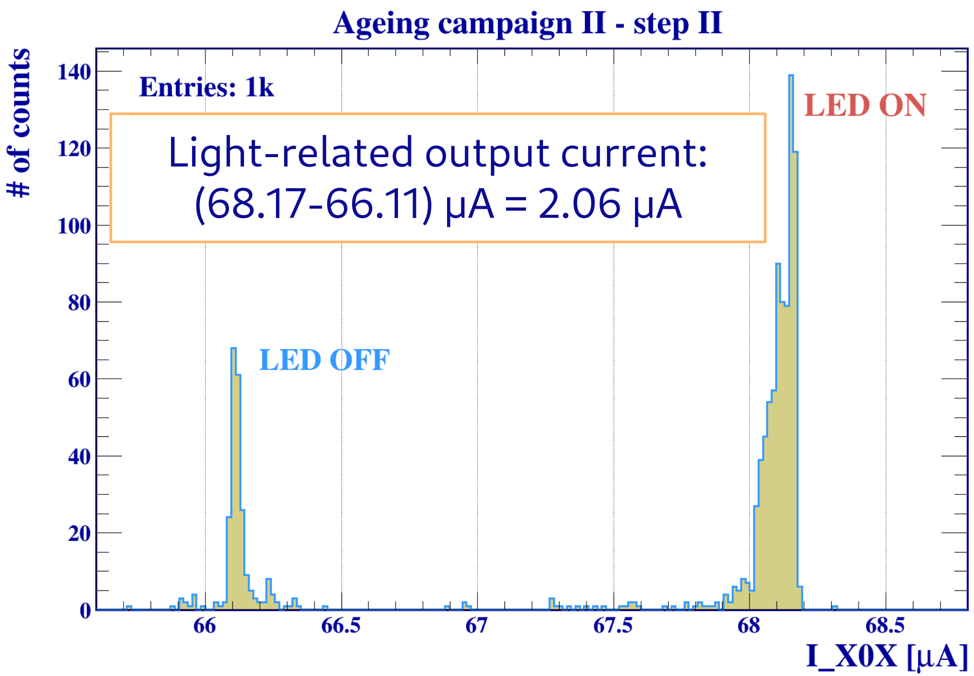


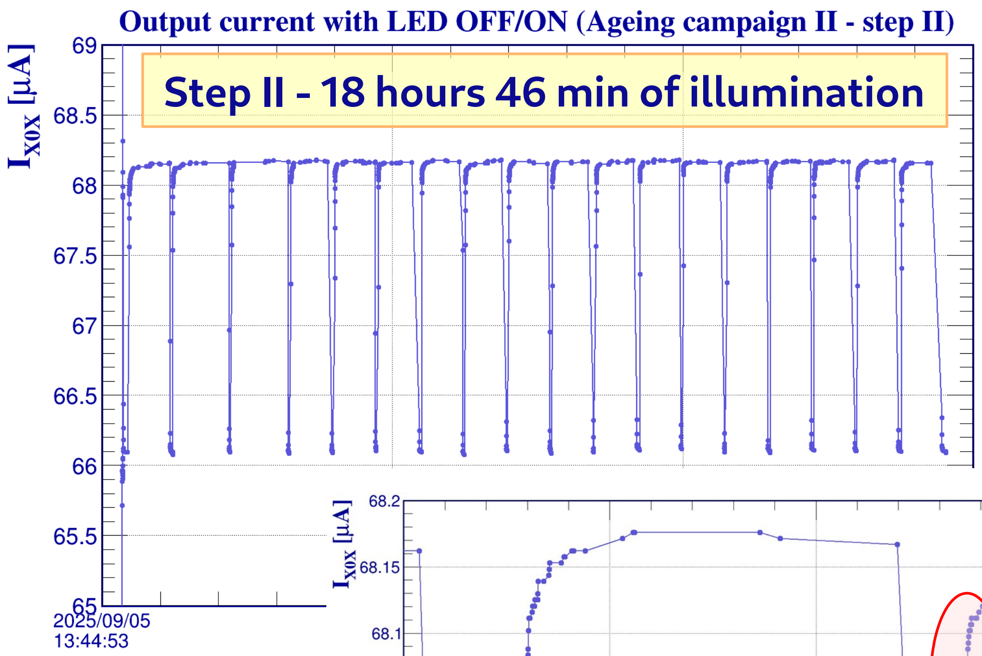


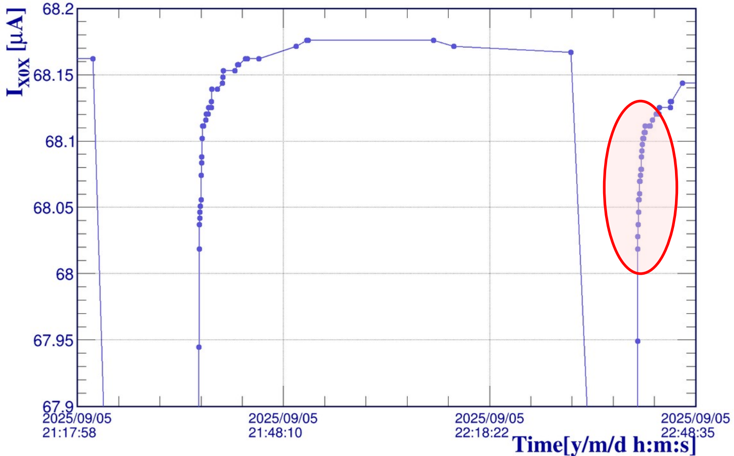
Output current at second MCP exit (XoX)

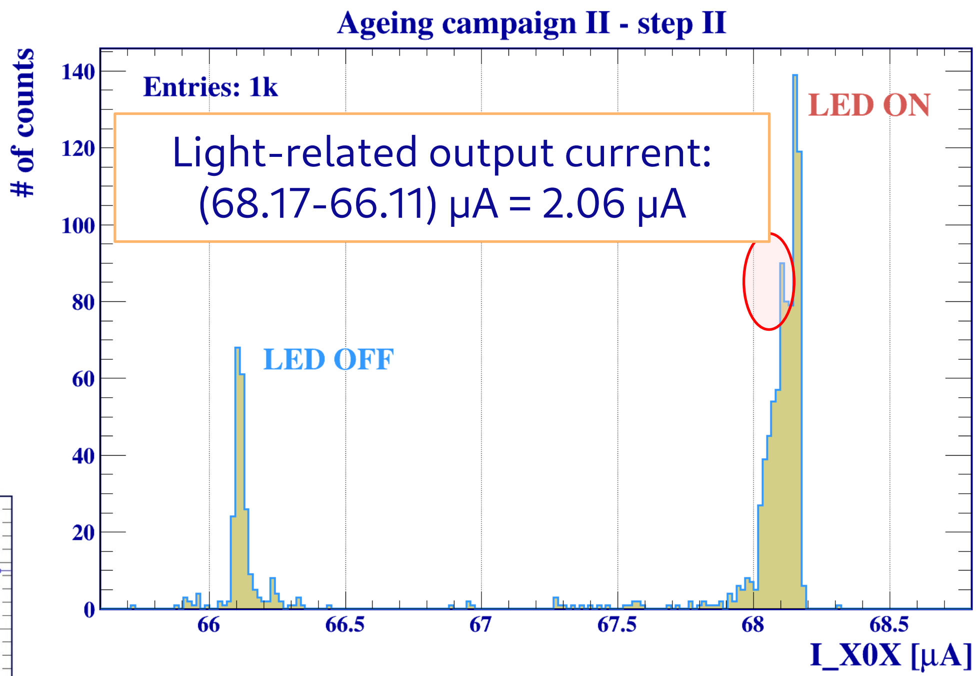




Output current at second MCP exit (XoX)

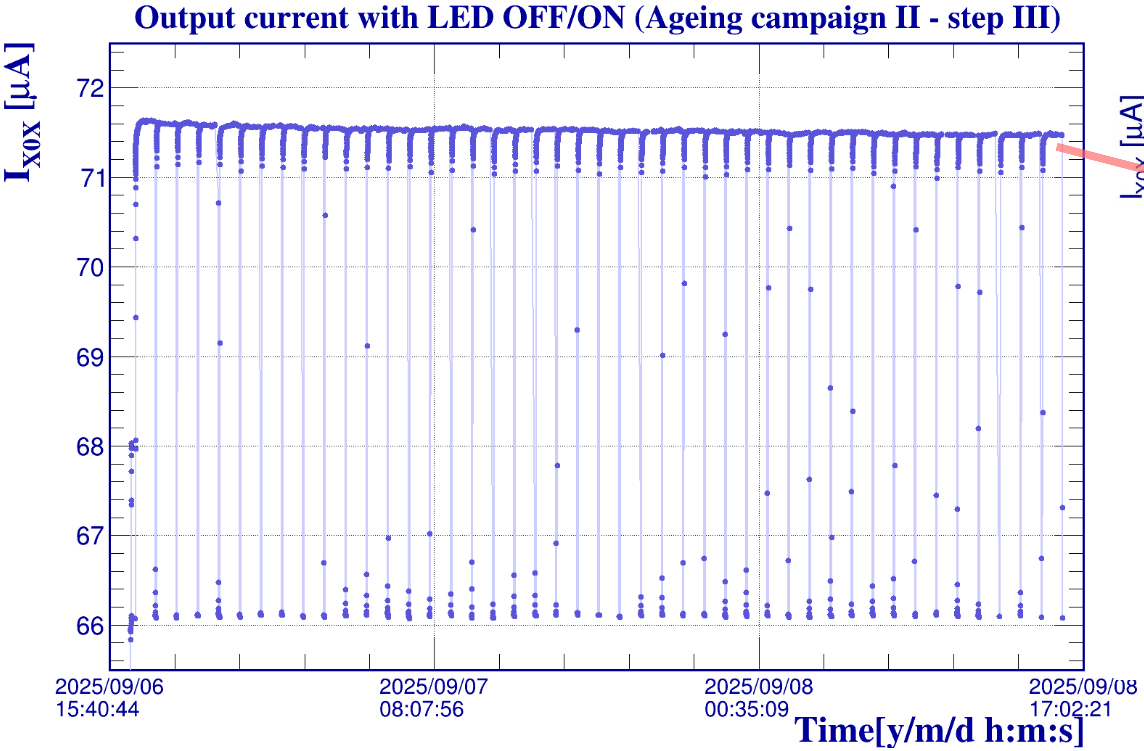


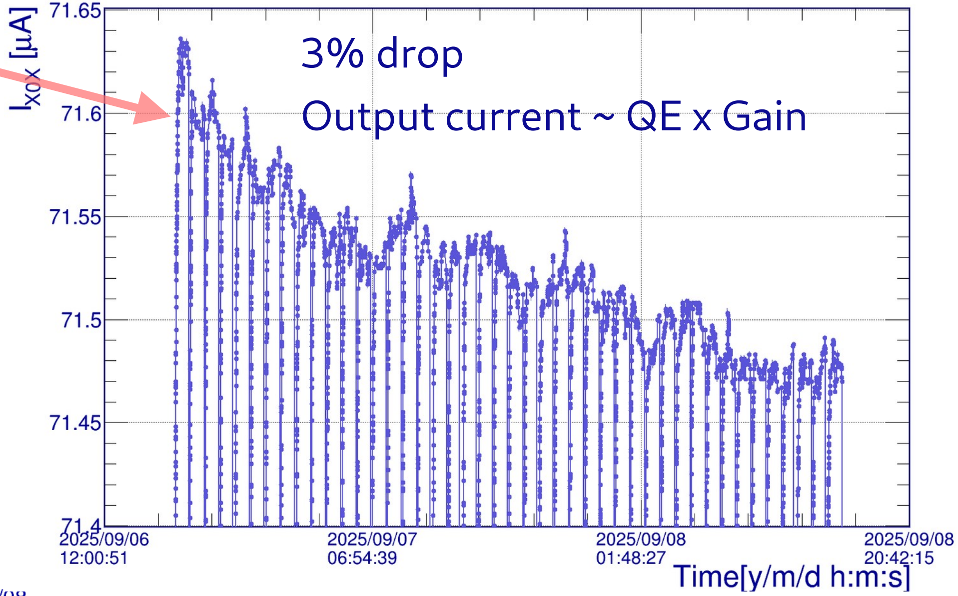




Output current at second MCP exit (XoX)

Step III - 44 hours



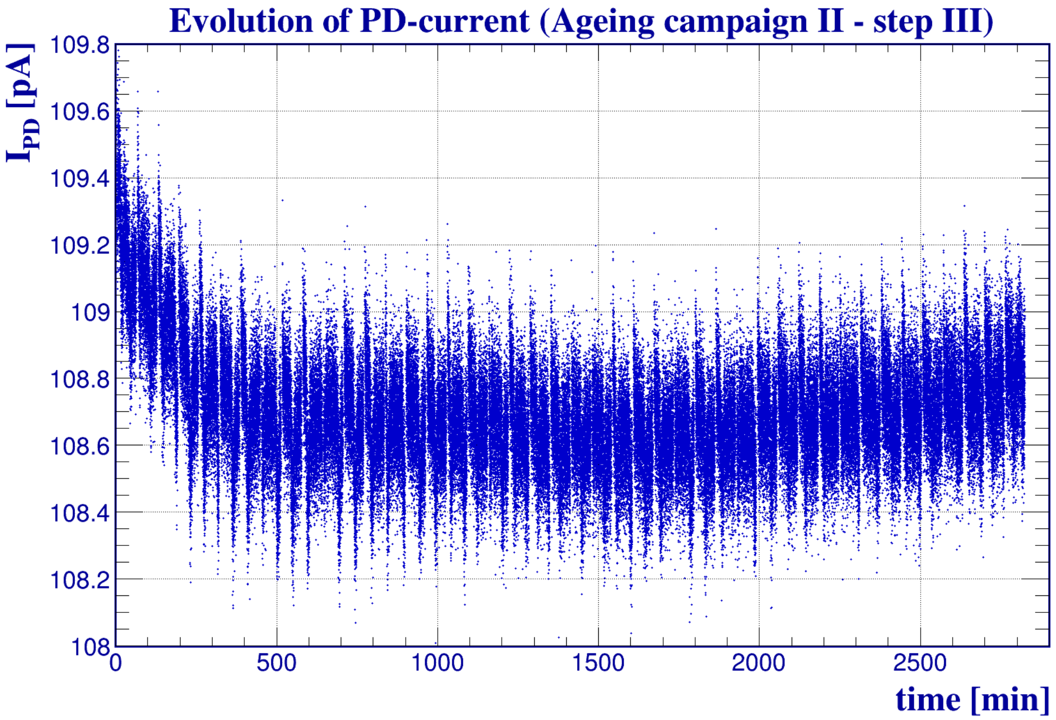


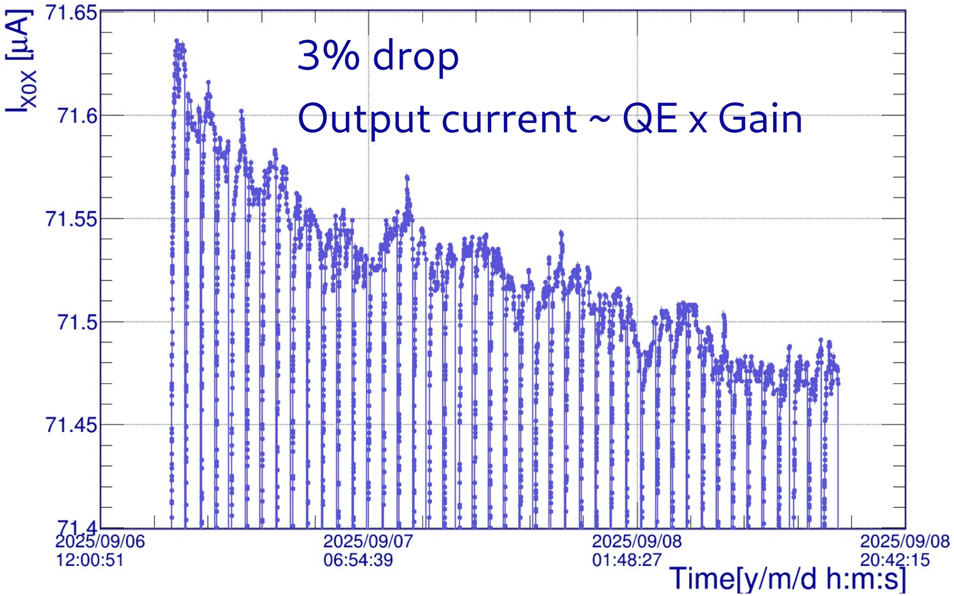
3% drop

Output current ~ QE x Gain

Output current at second MCP exit (XoX)

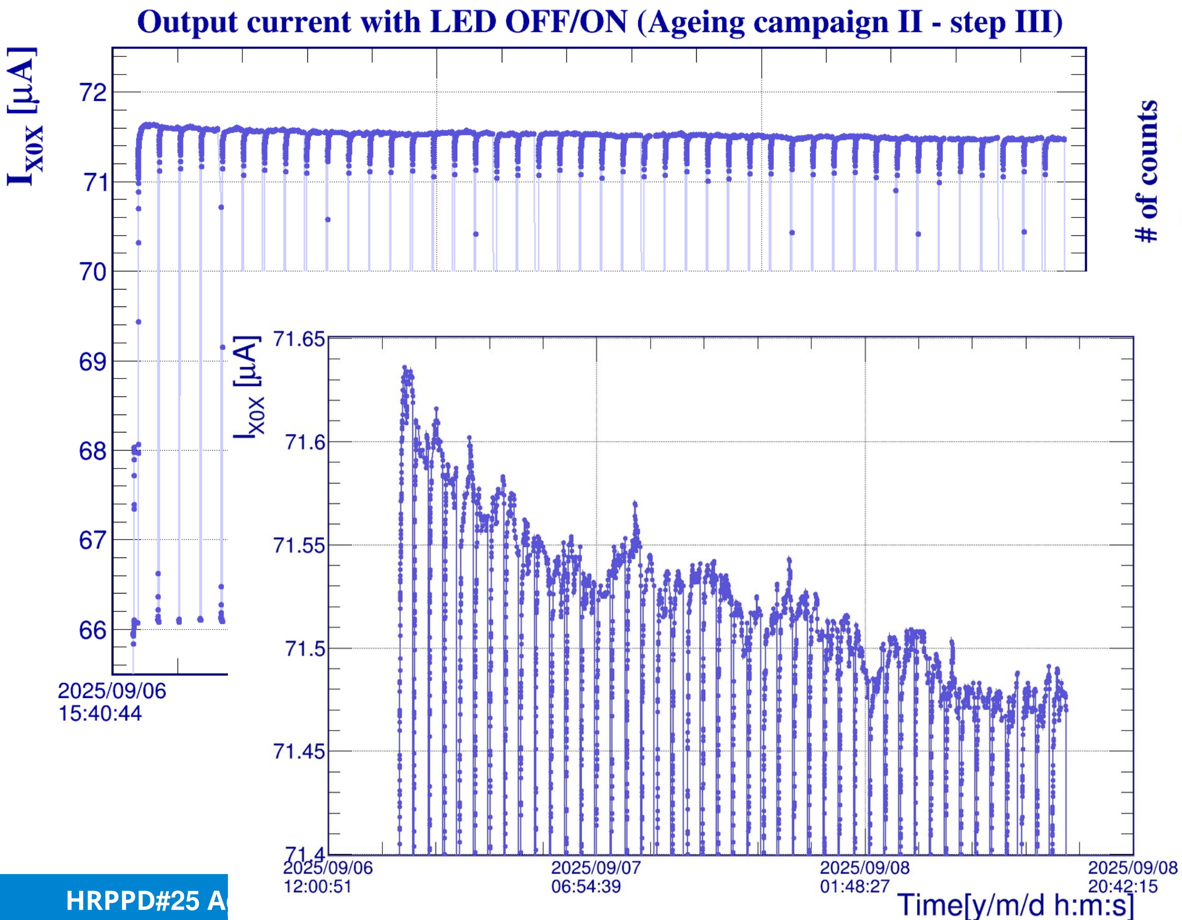
Step III - 44 hours

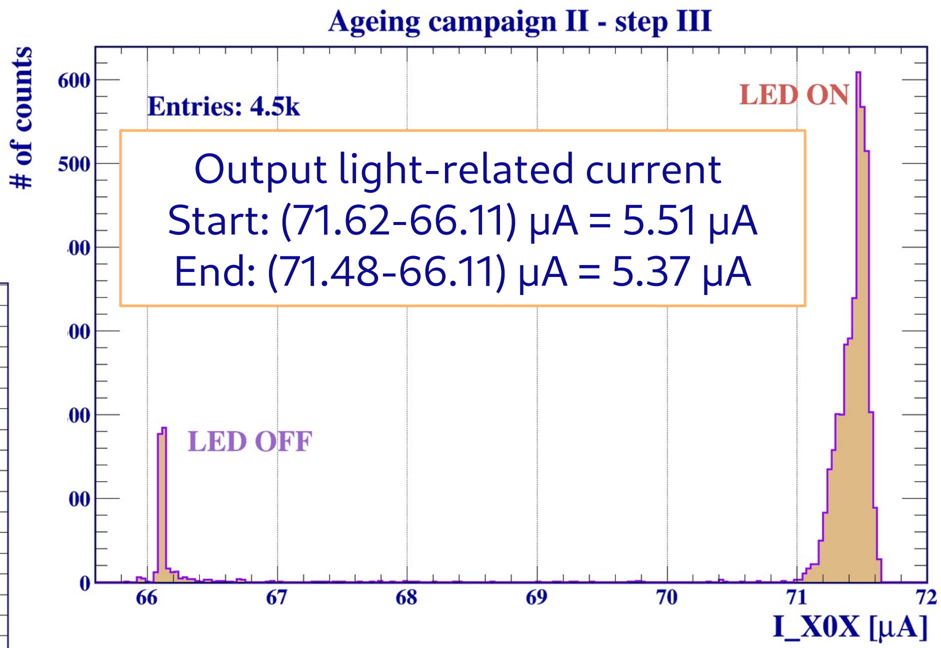




Output current at second MCP exit (XoX)

Step III - 44 hours





Output light-related current
Start: (71.62-66.11) μA = 5.51 μA
End: (71.48-66.11) μA = 5.37 μA

Gain

Average input photo-current (estimated)

- Step I: <I (HRPPD)> = 9.60 pA
- Step II-b: <I (HRPPD)> = 9.37 pA
- Step III-start: <I (HRPPD)> = 48.55 pA
- Step III-end: <I (HRPPD)> = 48.37 pA

Average light-related output (at XoX) current

- Step I: <I (Xox)> = 2.20 μA
- Step II: <I (XoX)> = 2.06 μA
- Step III-start: <I (XoX)> = 5.51 μA
- Step III-end: <I (XoX)> = 5.37 μA

Gain from Incom datasheet: ~ 2 M

Average Gain (estimated)

- Step I: <I (Xox)>/ <I (HRPPD)> ~ 0.230 M **(saturation factor ~8.7)**
- Step II: <I (XoX)>/ <I (HRPPD)> ~ 0.220 M **(saturation factor ~9.1)**

  → larger saturation with lesser input illumination (Hint of Gain deterioration)
- Step III-start: <I (XoX)>/ <I (HRPPD)> ~ 0.113 M **(saturation factor ~17.7)**
- Step III-end: <I (XoX)>/ <I (HRPPD)> ~ 0.111 M **(saturation factor ~18.2)**

Integrated charge

- illumination spot ~ 1 cm^2

Output integrated charge

- Step I: 2.20 μC/s x 16h 9min / cm^2 ~ 0.13 C/cm^2
- Step II-b: 2.06 μC/s x 18h 46min / cm^2 ~ 0.14 C/cm^2
- Step III: 5.37 μC/s x 44h / cm^2 ~ 0.85 C/cm^2

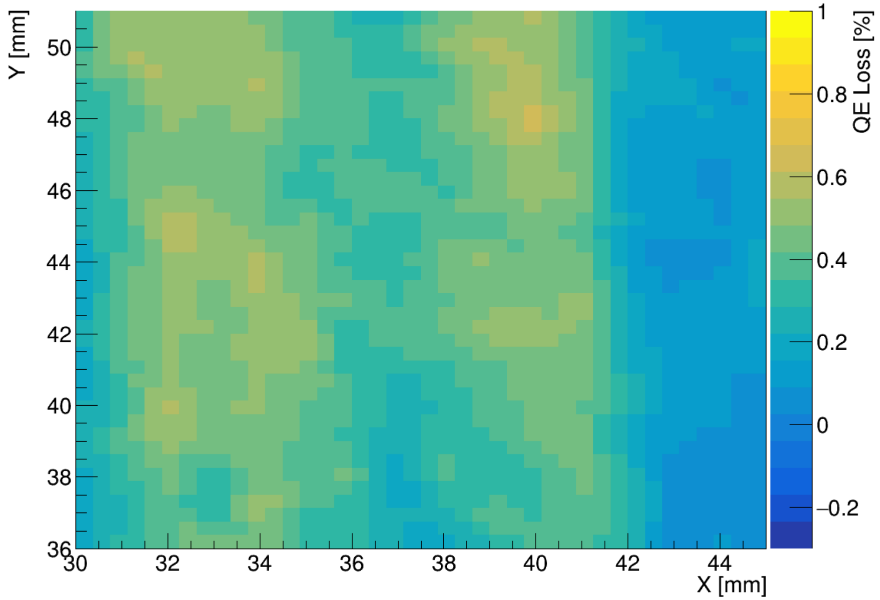
Total output integrated charge (ageing campaign II) ~ 1.12 C/cm^2

QE degradation

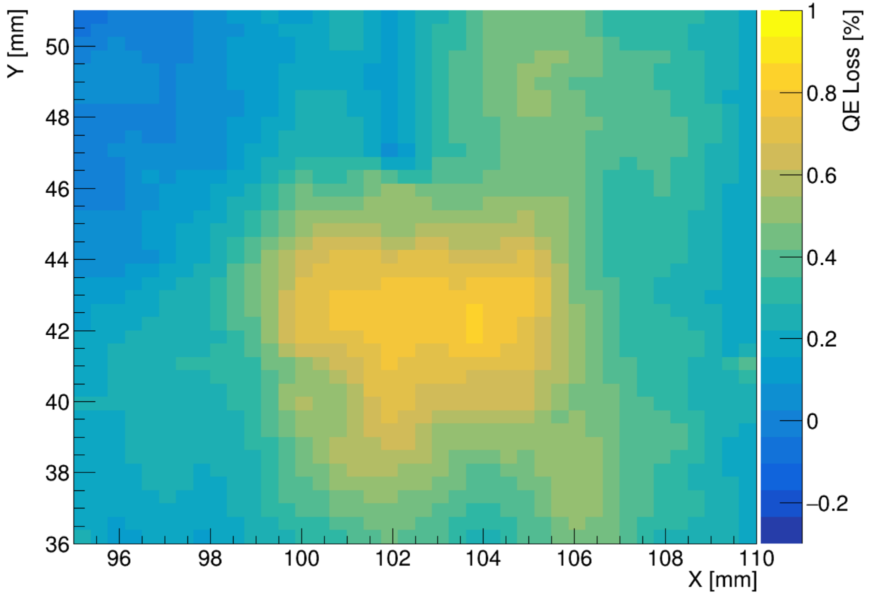
- QE degradation at the end of Ageing Camp.II
- **Relative QE degradation** on the aged-spot **< 1%**

$$\frac{\text{QE before} - \text{QE after}}{\text{QE before}}$$

Reference Region



Ageing Region



Ageing campaign III (April-May 2026)

- Both MCPs active
- Consideration for 625 V instead of 650 V
- Same optics set-up
- Same strategy
    - Two well-separated regions
    - Measurements before, on both regions
        - QE, relative PDE, gain, DCR, after pulse rates
    - Illumination (~ 10^8 photons/cm^2-sec) followed by measurements

Preparation studies:

- Detail characterisation of light sources
    - Time evolution (sub-structure) – I_{PD} Vs. $I_{LED, SET}$
    - Sub-structure dependence on light Intensity
    - Position-dependence (Movements of the fibre)
- Effects of Keithley ON/OFF on current values

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