# Update on Picoamp and Lifetime Measurements

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# Picoamp update

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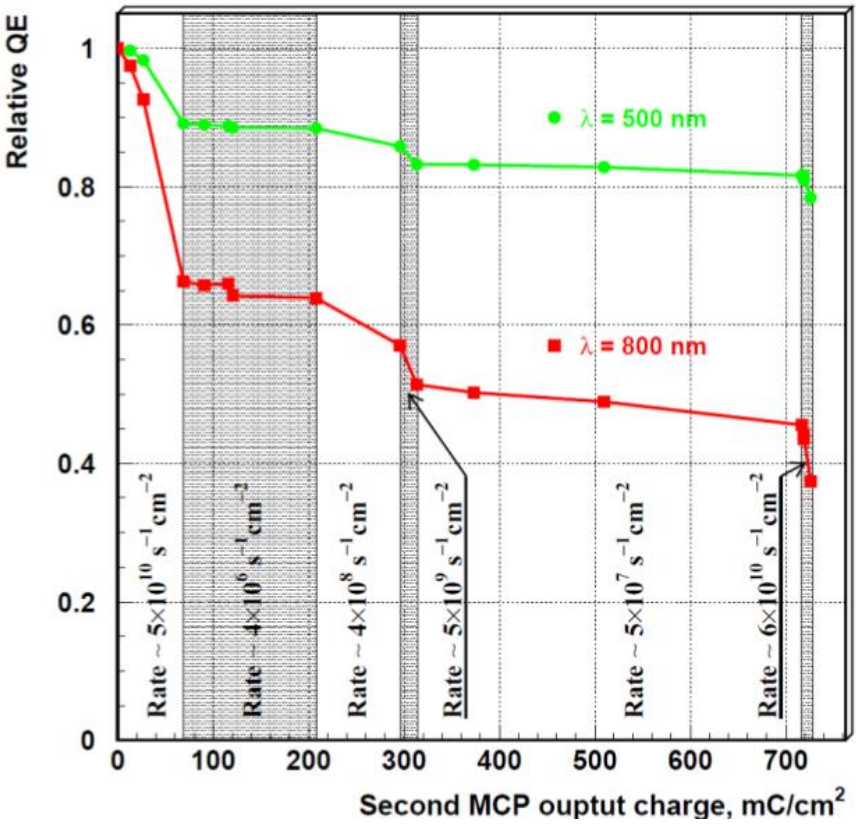
# Motivation

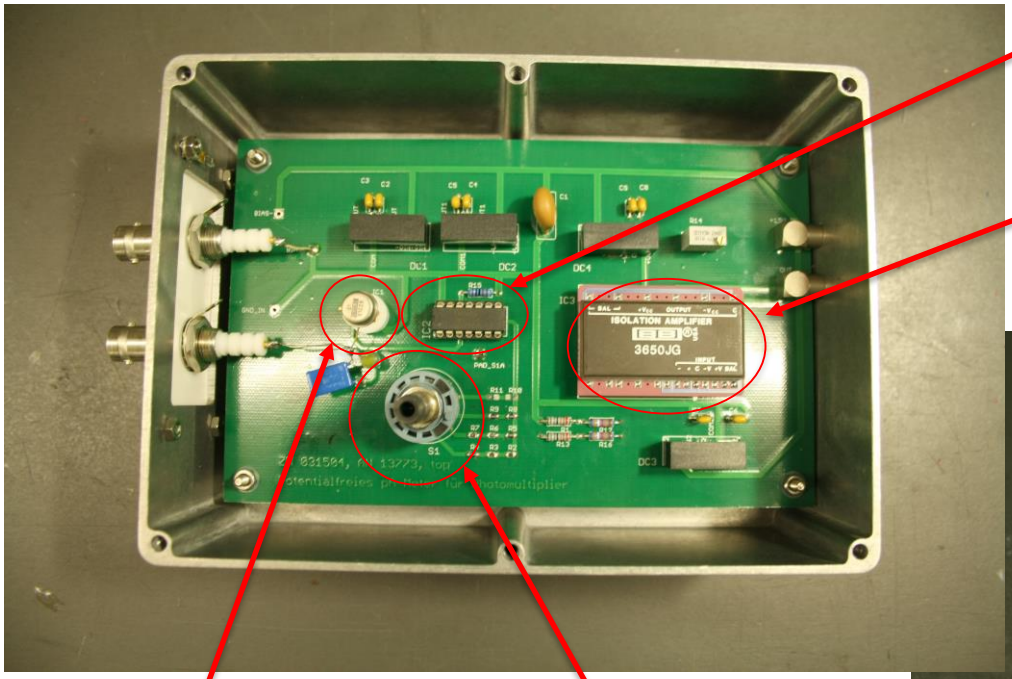
- Lifetime indicator: integrated anode charge (IAC, detected number of photons)
- Huge lifetime increase in the last years (from 200 mC/cm² to >5 C/cm² as PANDA requires)
  - lifetime measurements take up to several years now
- Wish: accelerate the measurement

# Motivation

- MCPs have limited ratestability (IAC not proportional to amount of photons at high photon rates anymore)
- → Illumination with higher intensity alone is problematic (plot by M.Yu. Barnyakov and A.V. Mironov, 2011 JINST 6 C12026)
- Idea: additional current measurement at first MCP or photocathode (PC) to correlate Quantum Efficiency (QE) loss and IAC again
- Problem: very low currents (0.5-5 pA) at high potential (2-3kV)
- → **Potential-free** picoammeter is needed



# Pictures of the potential-free picoammeter

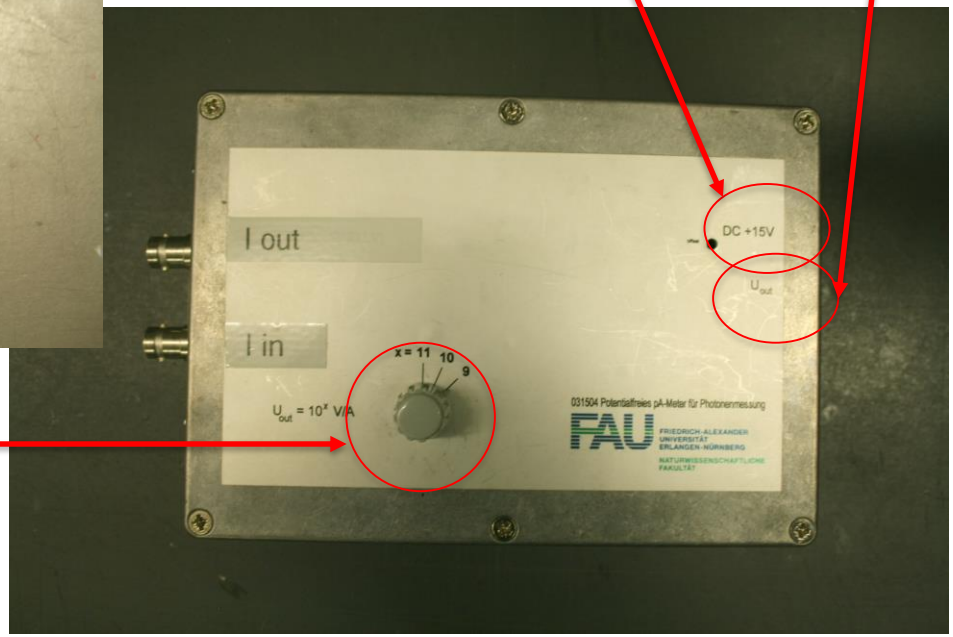



Instrumention amplifier

Isolation amplifier

+15 V operational voltage

Output voltage

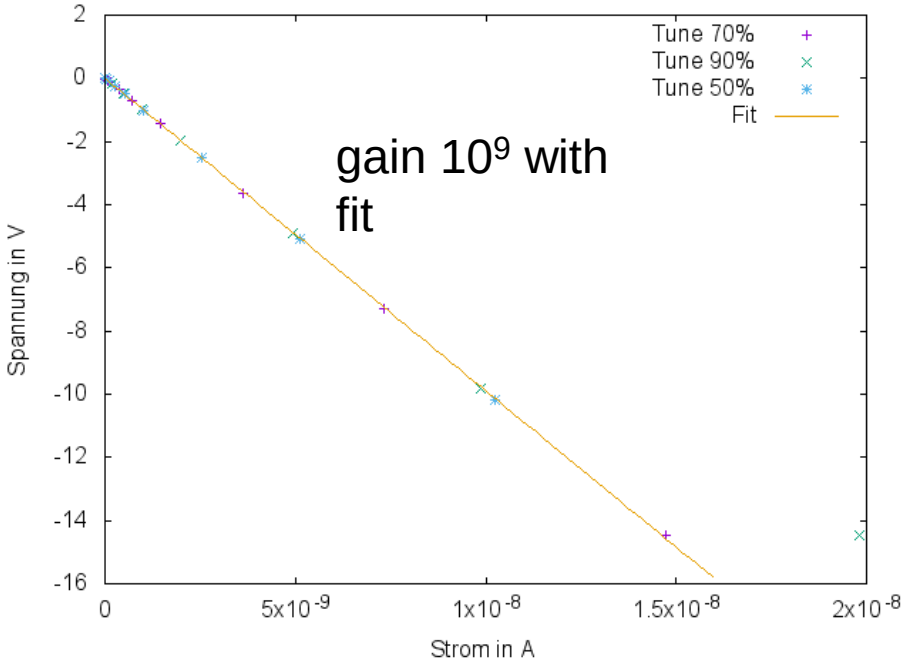


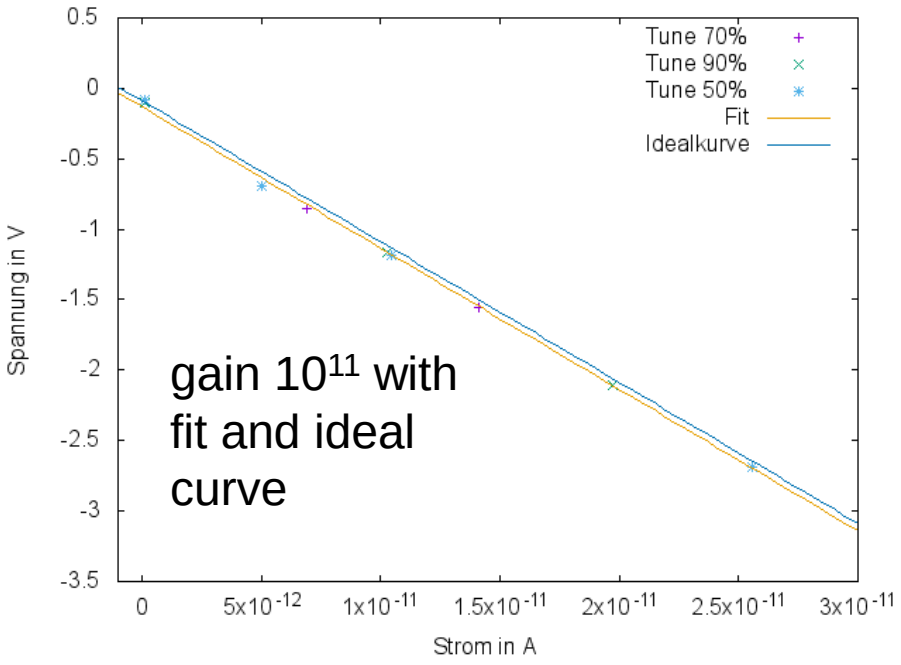

Input amplifier

Potentiometer for variable gain

# Calibration

- First measurements with the picoammeter: calibration
- Generation of small currents with a PiLas Laser and a photodiode
- Calibration with picoammeter 6485 from Keithley

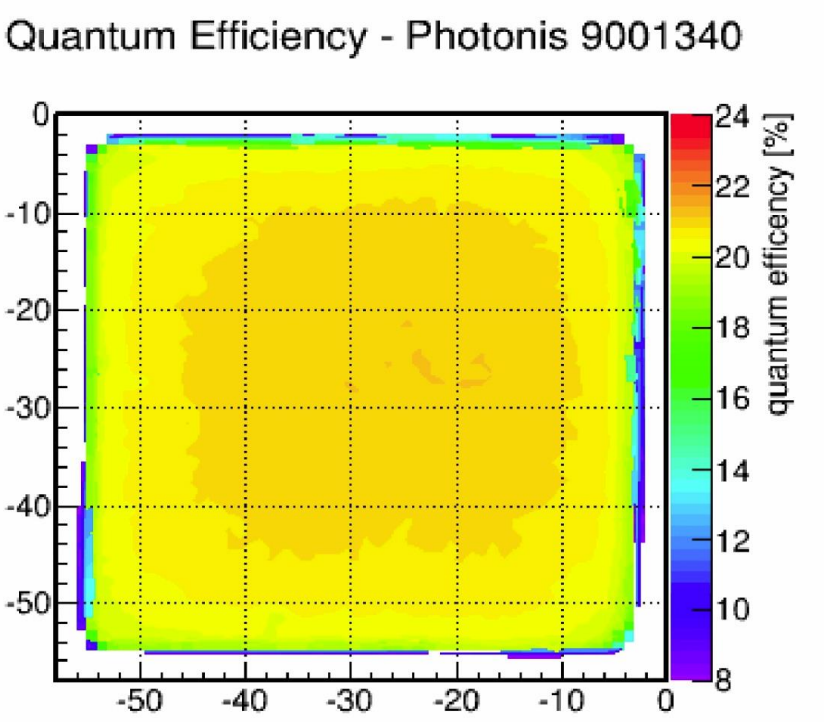


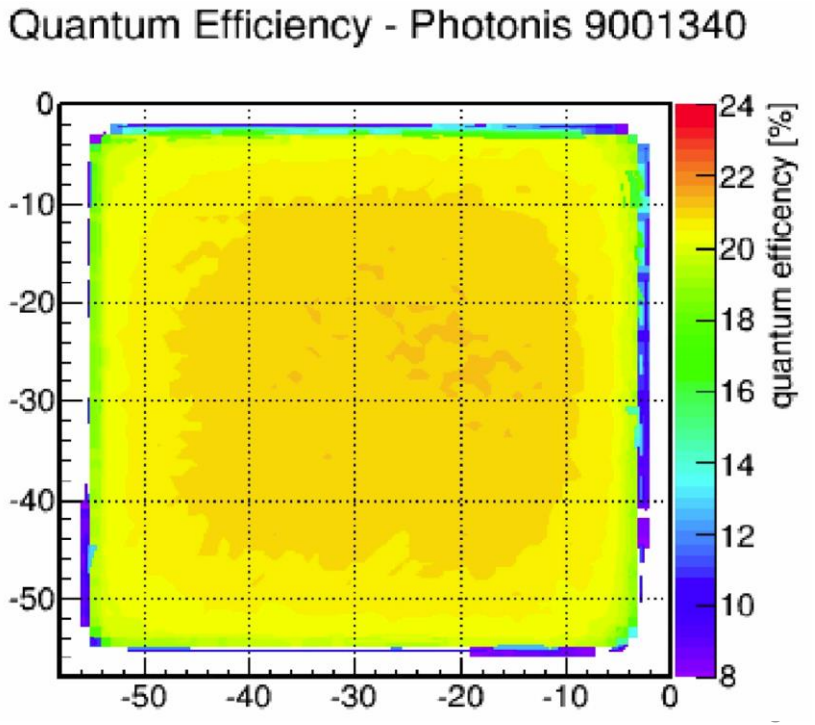




- Very good linearity over 3 orders of magnitude and up to 0.5-1 pA measurable

# QE-Scan

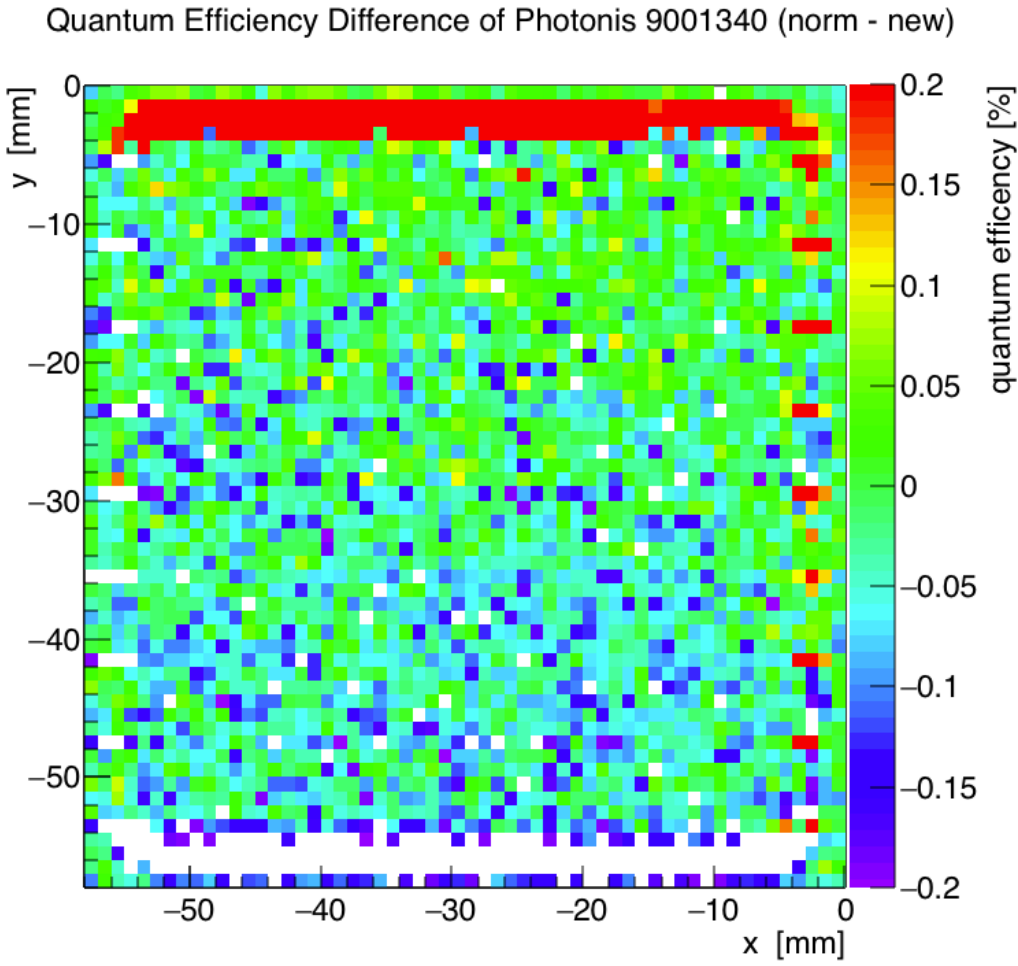
- One of the measurements that can be done with the picoammeter is a Quantum Efficiency (QE) scan
- Left picture: Keithley 6485 ; right picture: new one



# QE-Scan

- The figure shows the difference of the two measurements
- Very good agreement between them
- The red and white stripe come from the different positions of the two scans



## Concerns

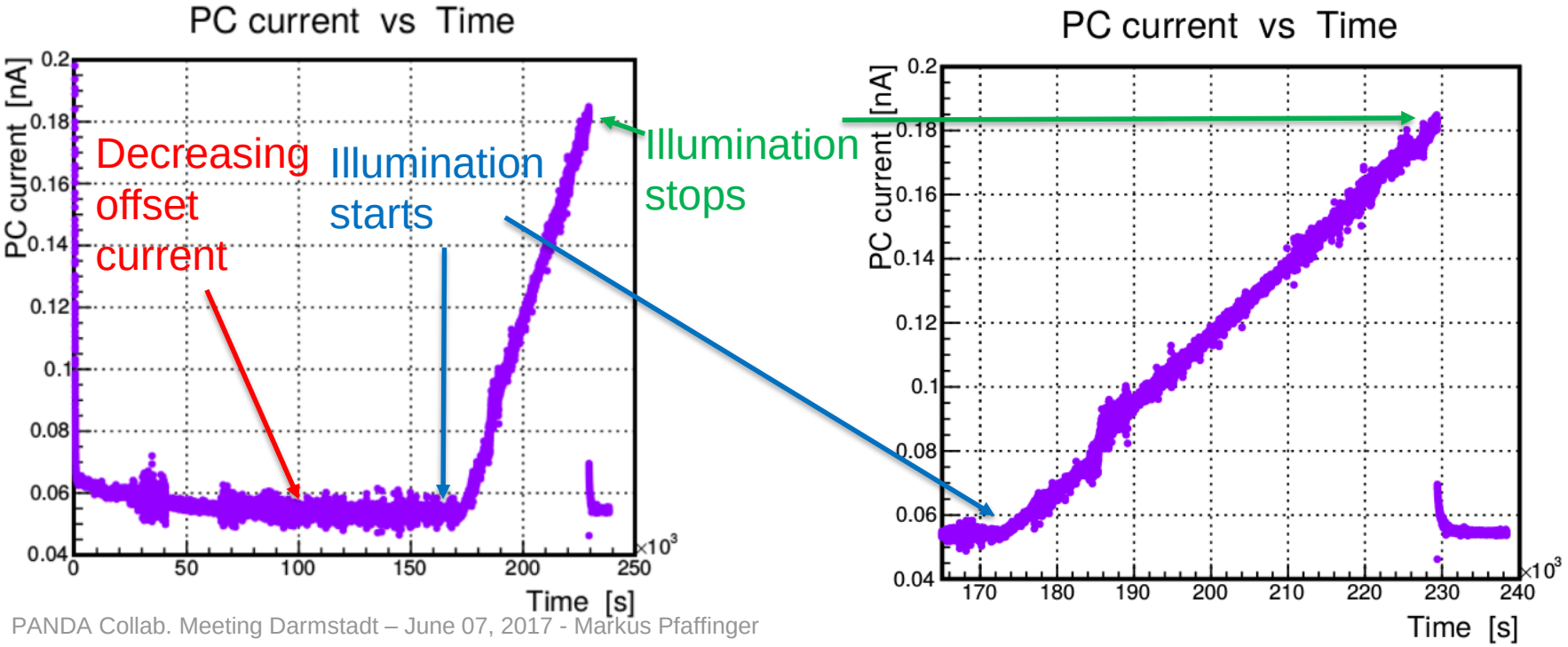
- Measurements with MCP-PMTs are only possible at the photocathode (PC) due to finite resistance of the microchannel-plates (unlike standard-dynode PMTs)
- The input operation amplifier is very sensitive and breaks quite easily (at the moment the third one is built in)

## Measurements

- But it works: some measurements with a MCP-PMT and a standard-dynode PMT on the next slides
- Setup: laser with square diffuser illuminates sensor and a photodiode, a neutral density filter is in front of the sensor
- Measured currents: at the photocathode (with new picoammeter+ multimeter 199 from Keithley), the anode (Keithley 6485) and a reference photodiode (Keithley 6487)

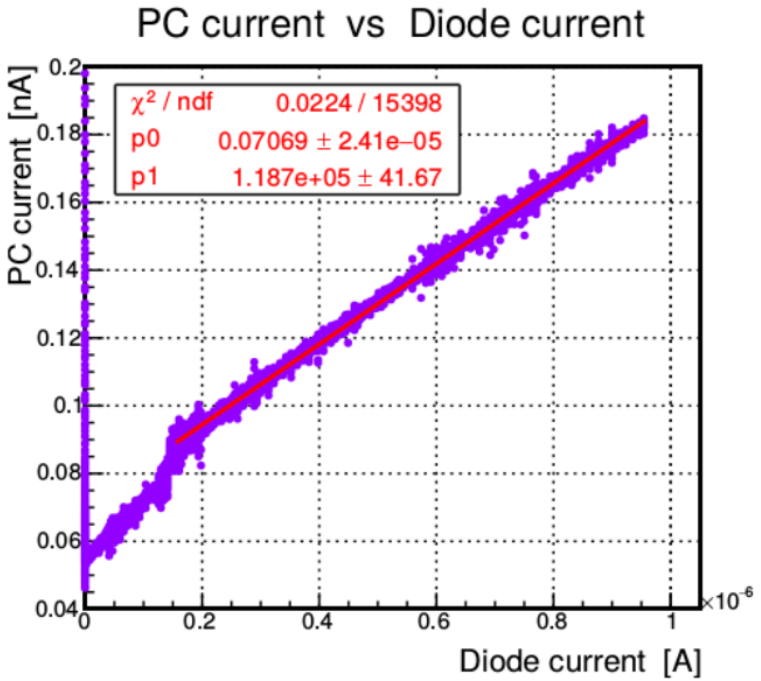
# Test measurement with standard-dynode PMT

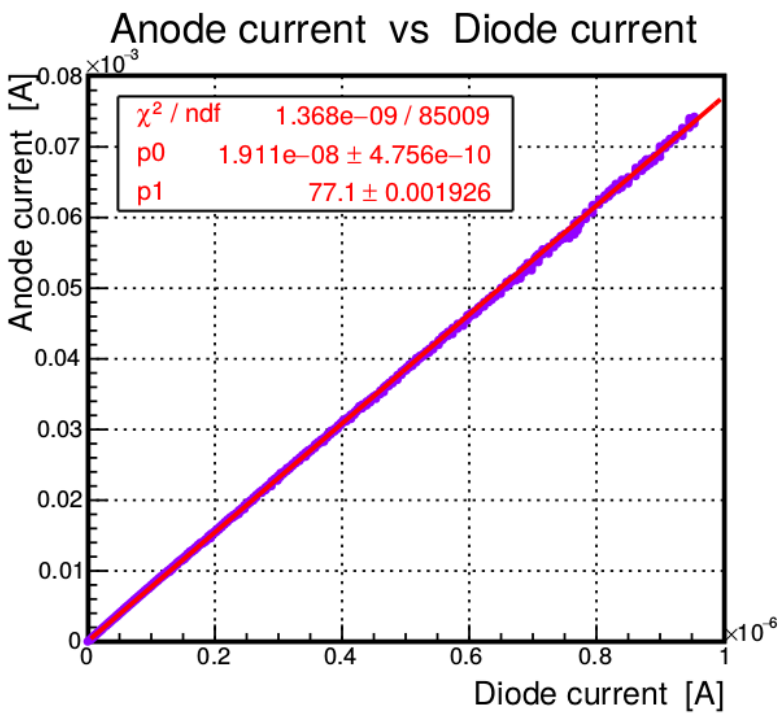
- Hamamatsu R1450 photomultiplier tube at 1350V (gain of about 650000 )
- 48 hours darkness, then illumination with increasing light intensity, then switching laser off



# Measurement with standard-dynode PMT

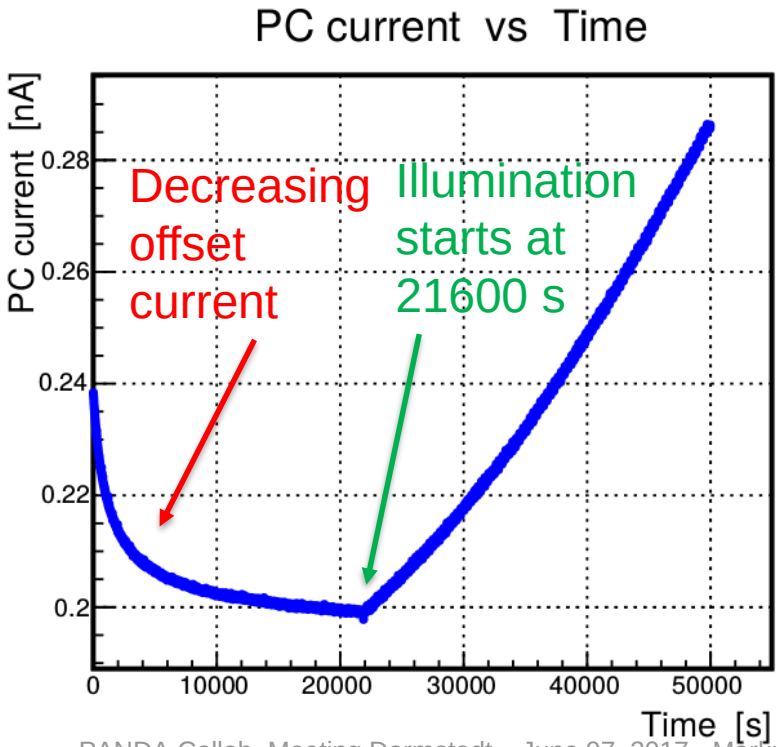
- Hamamatsu R1450 photomultiplier tube at 1350V
- (Almost) linearity in PC vs diode current
- Very good linearity in anode vs diode current
- No gain loss at higher light intensities

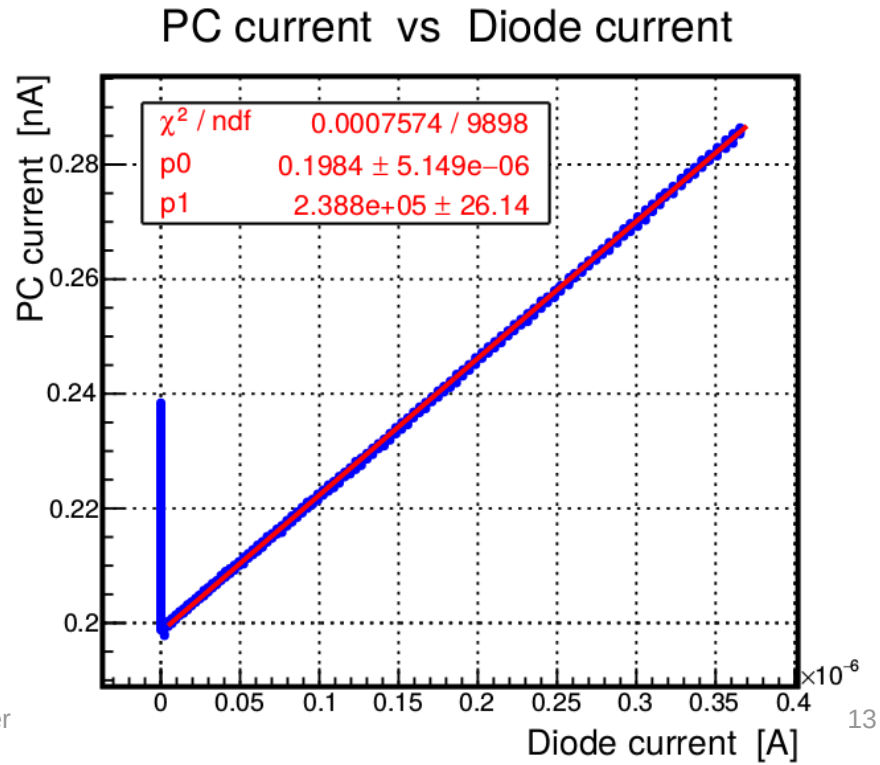


# Measurement with MCP-PMT

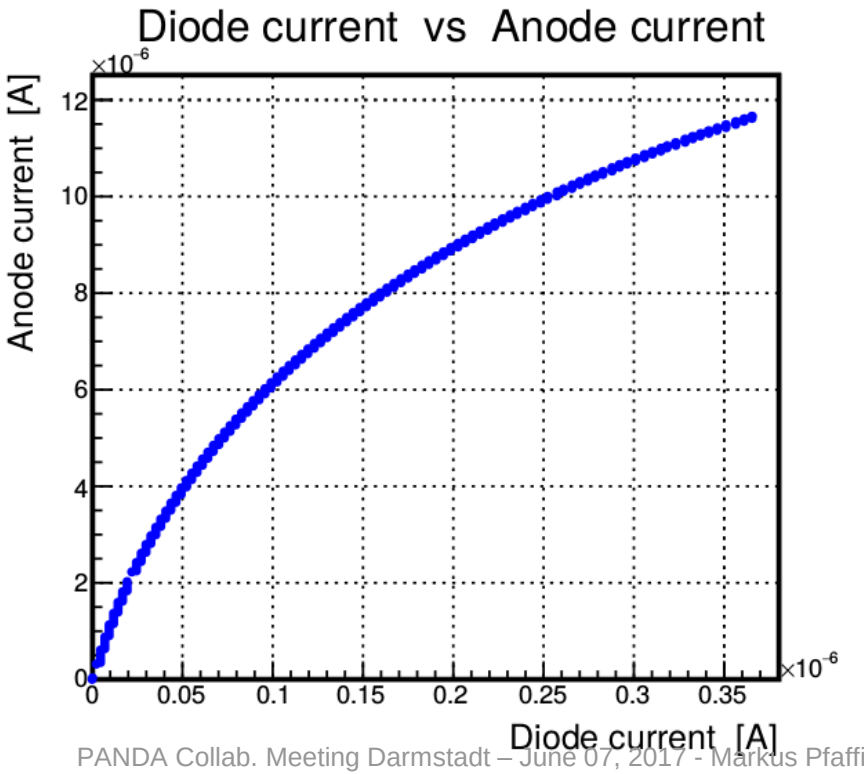
- Photonis XP85012 9002085 at 1600V (gain of about 600000)
- 6 hours darkness, then increasing light intensity
- Very good linearity between PC current and diode current

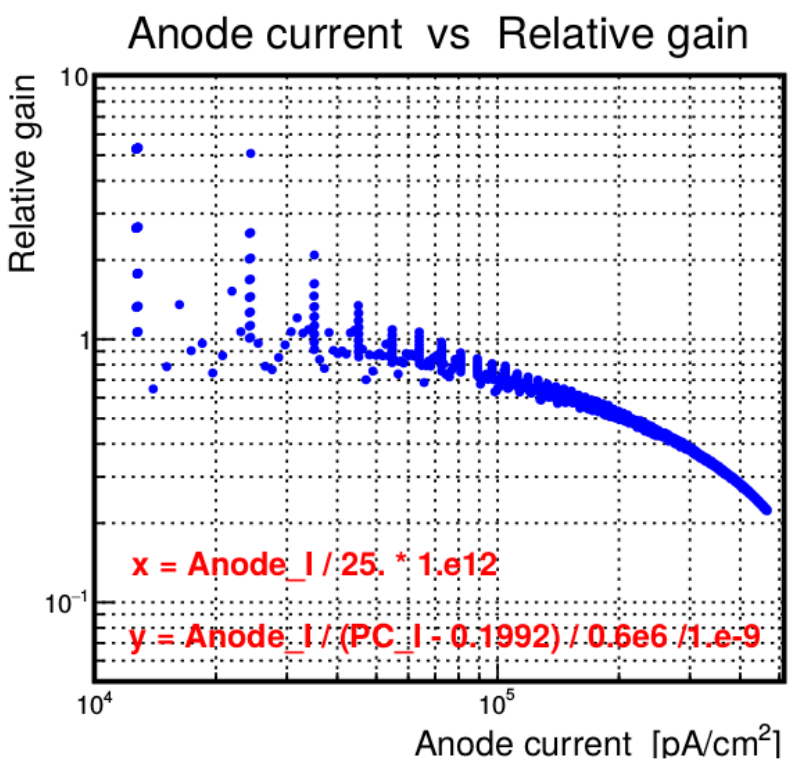


# Measurement with MCP-PMT

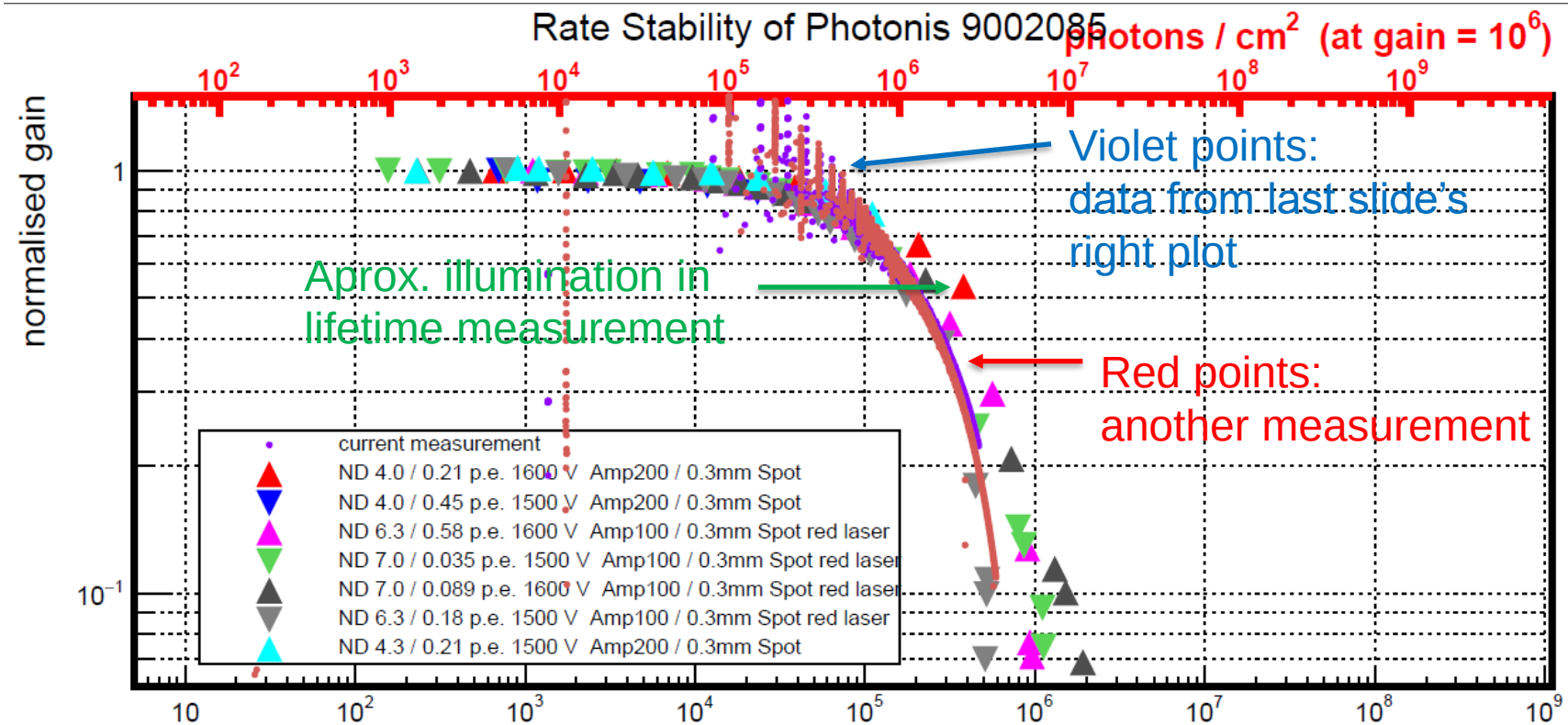
- with increasing light the anode current is not increasing linearly anymore
- one can plot this as relative gain vs anode current



# Measurement with MCP-PMT

- If the data from the current measurement is plotted with the data of the single photon pulse rate stability measurement one can see very good agreement



# Picoamp summary

- Possible to measure:
  - QE
  - Rate stability

- Problem:
  - Potential free only up to 2 kV
  - ➢ 2 inch Hamamatsu not measurable (3kV operation voltage)

- New picoamp with up to 4kV isolation in production

# Results of latest measurements

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# Data from may 15, 2017

## Illumination Overview QE (all sensors with ALD)

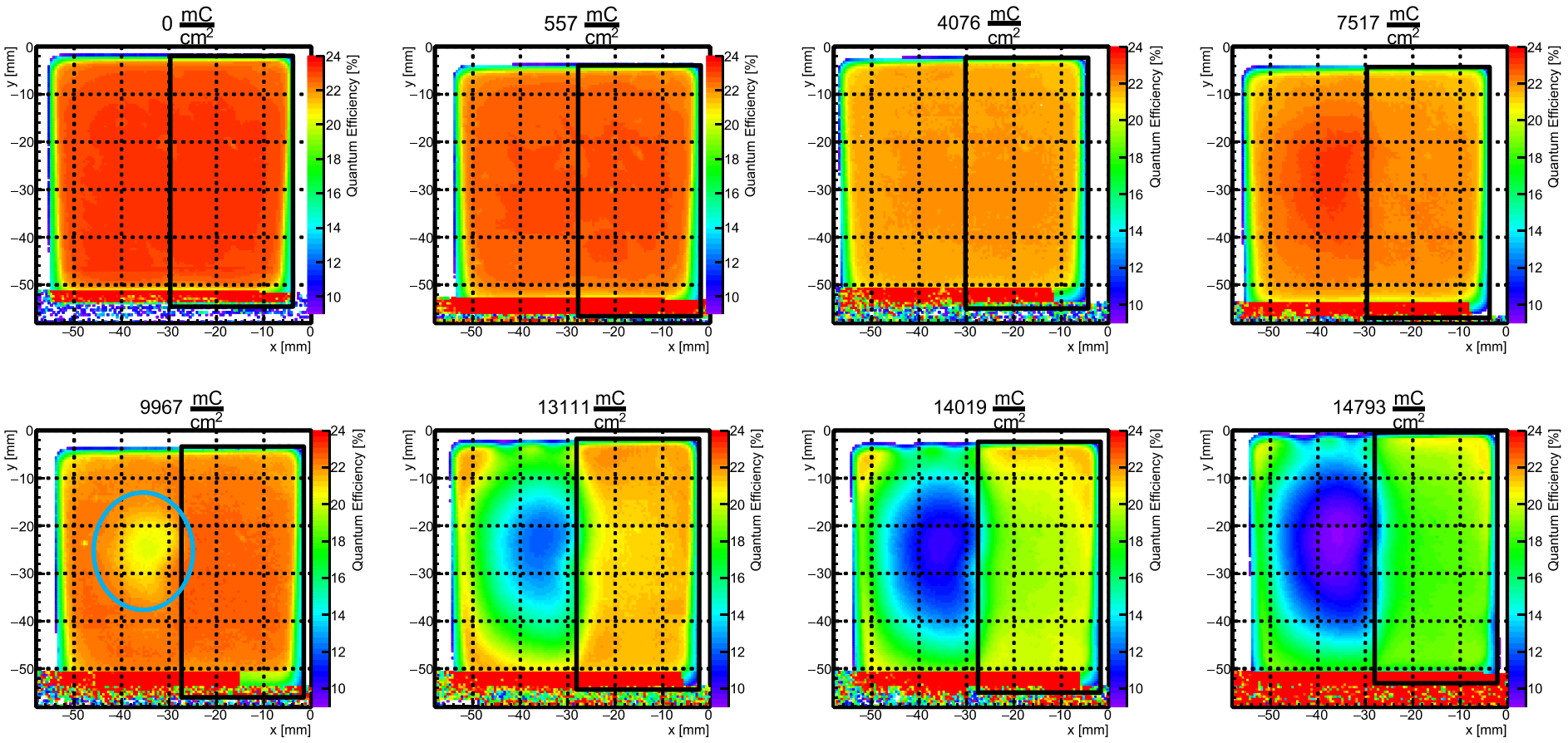
Film between MCP  Two ALD layers  Film in front of first MCP

| | Manufacturer | Senor ID | Integral Charge [mC/cm2] | QE start [%] | QE latest [%] | QE latest/QE start [%] |
|---|---|---|---|---|---|---|
| 2 Inch | Photonis XP85112 | 9001223 | 9234 | 22.1 | 5.3 | 24 |
| | | 9001332 | 15008 | 23.0 | 10.6 | 46 |
| | | 9001393 | 13413 | 19.1 | 19.3 | 101 |
| 1 Inch | Hamamatsu R10754X | KT0001 (M16M) | 17211 | 21.7 | 7.7 | 35 |
| | | KT0002 (M16M) | 14601 | 21.1 | 8.4 | 40 |
| 2 Inch | Hamamatsu R13266-07-M768 / M64 | JS0022 (64 pix.) | 2814 | 17.4 | 8.6 | 49 |
| | | JS0035 (64 pix.) | 1956 | 25.5 | 25.2 | 99 |
| | | JS0018 (768 pix.) | 707 | 18.0 | 8.6 | 48 |
| | | JS0027 (768 pix.) | 1009 | 24.3 | 22.0 | 91 |

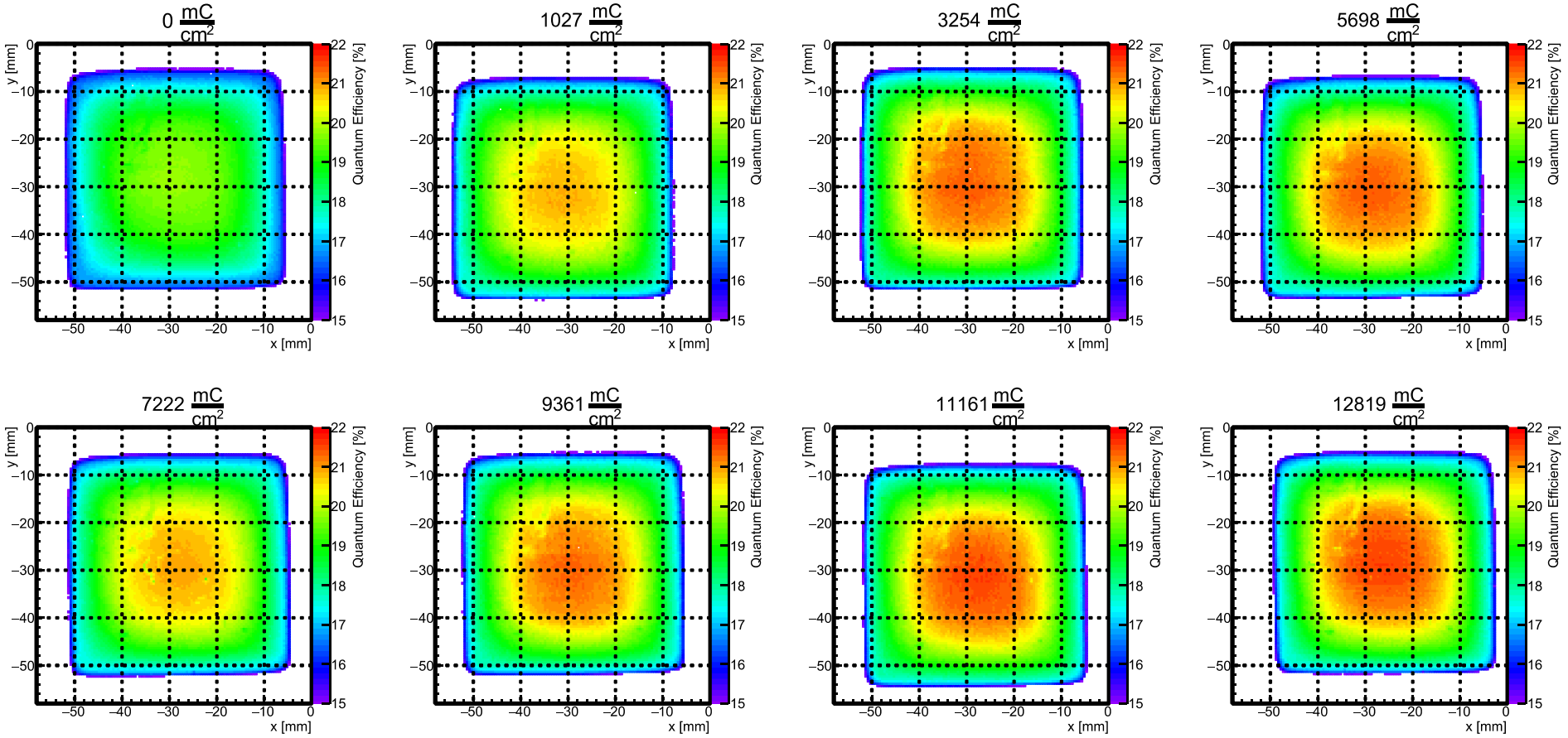
# QE scan of Photonis 9001332 (ALD)

Covered (not illuminated)

Clear sign of Cathode damage

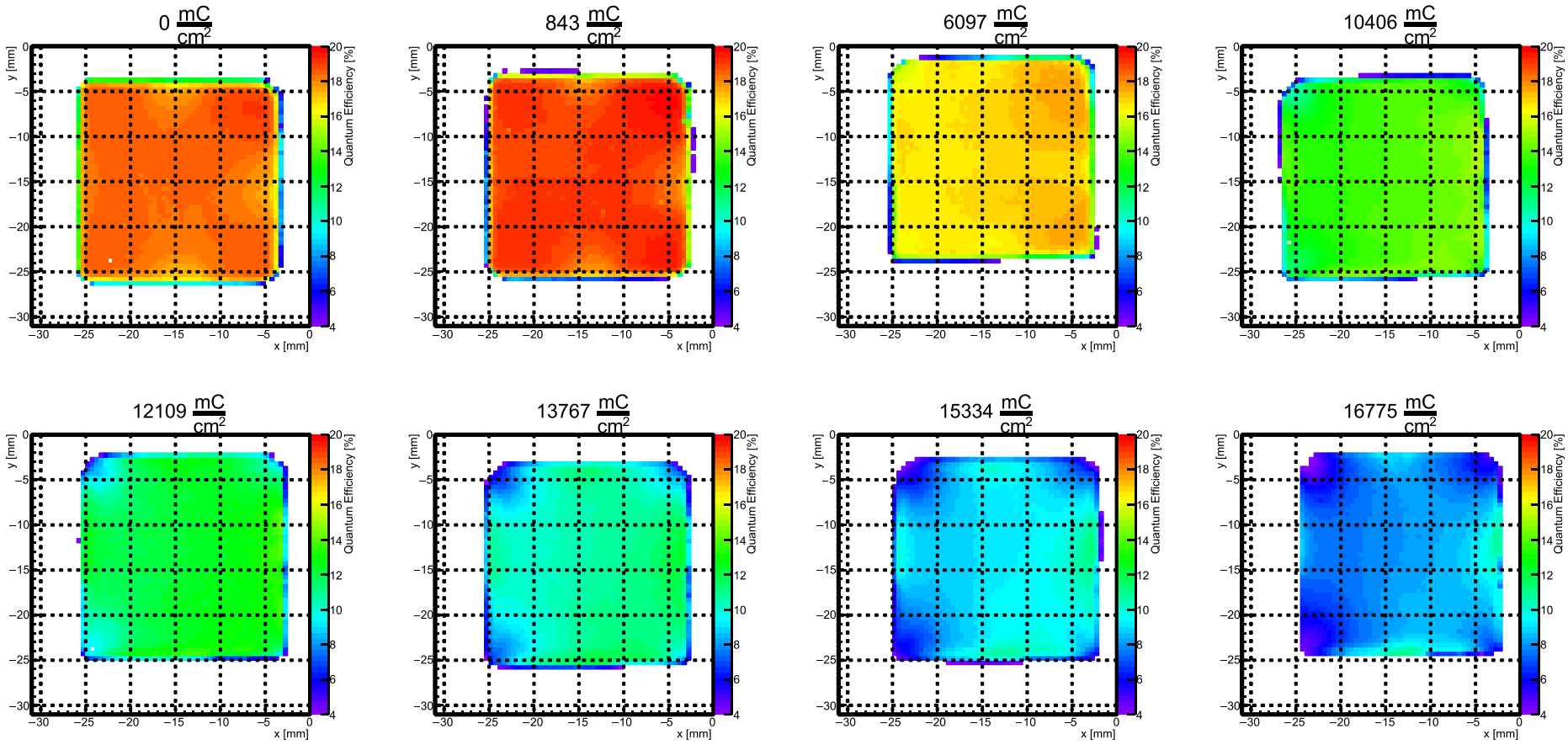


# QE scan of Photonis 9001393-URD (double ALD)



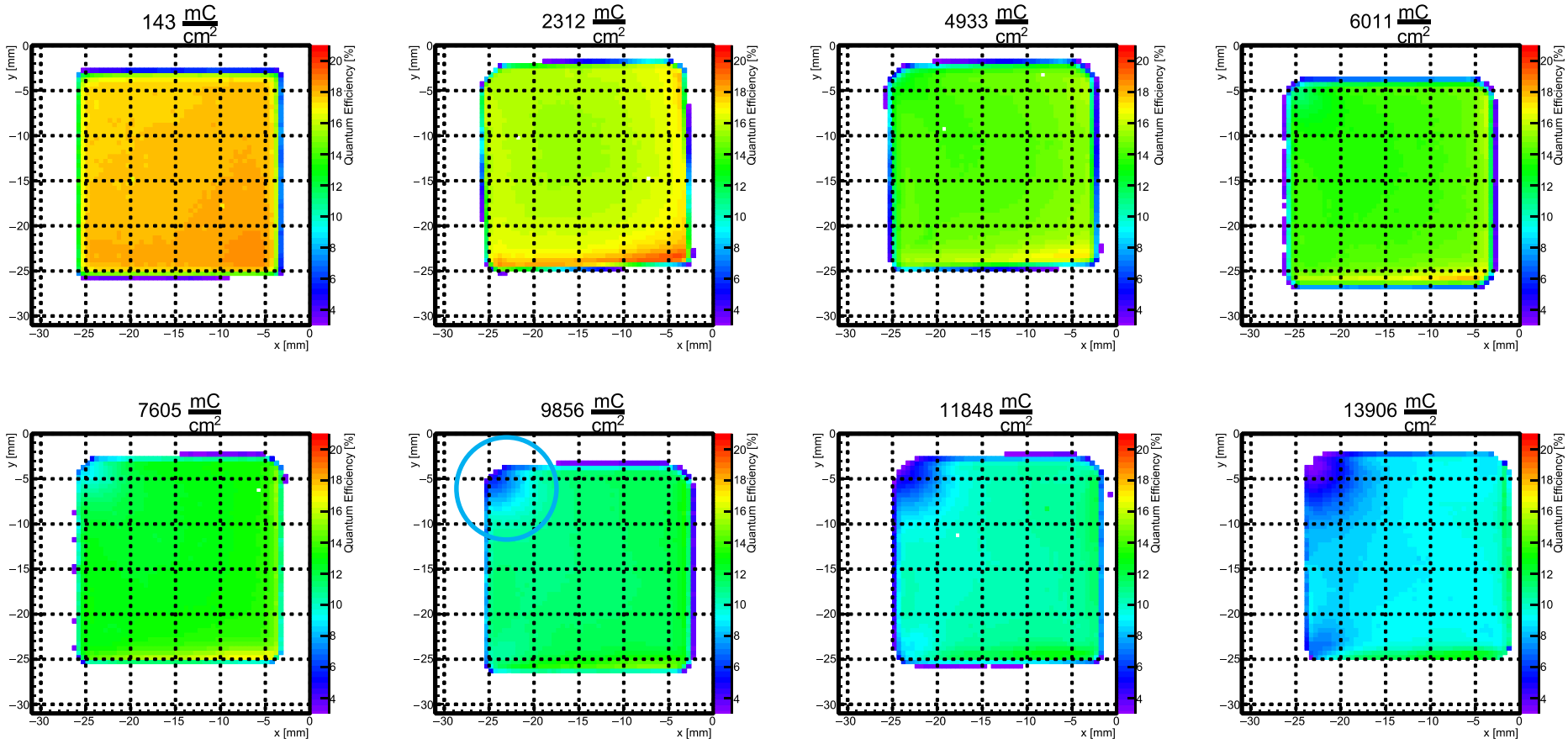
# QE scan of Hamamatsu KT0001 (ALD)

## Clear sign of Cathode damage



# QE scan of Hamamatsu KT0002 (ALD)

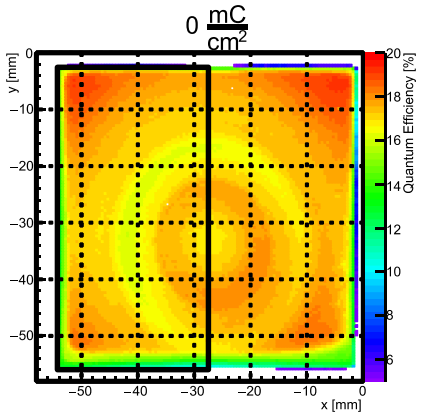
## Clear sign of Cathode damage

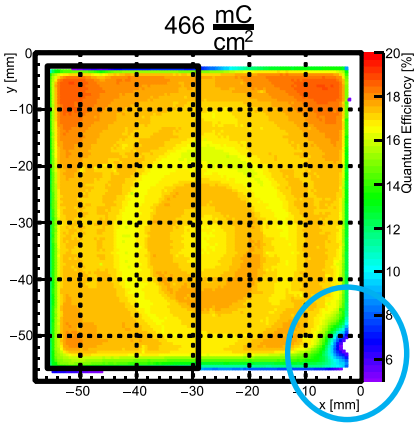


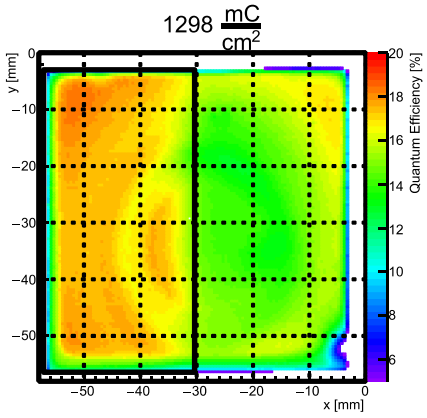
# QE scan of Hamamatsu JS0022 (8x8, ALD)

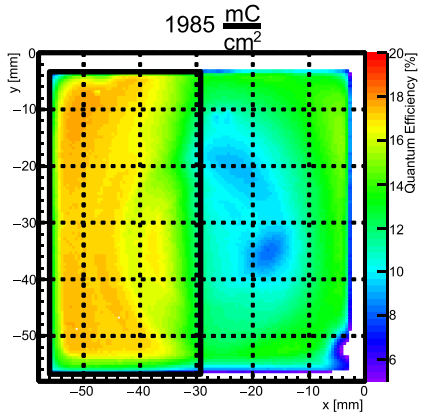
Covered (not illuminated)

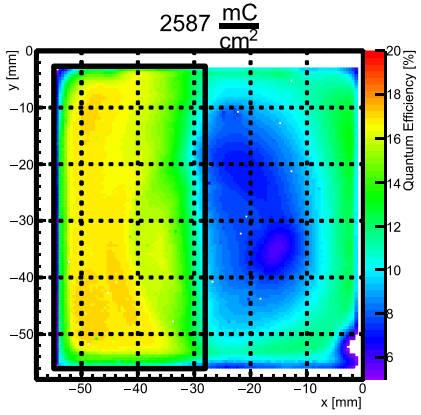
Clear sign of Cathode damage



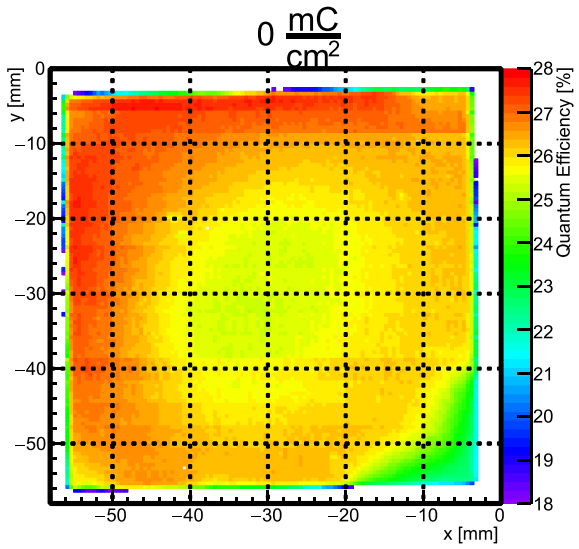



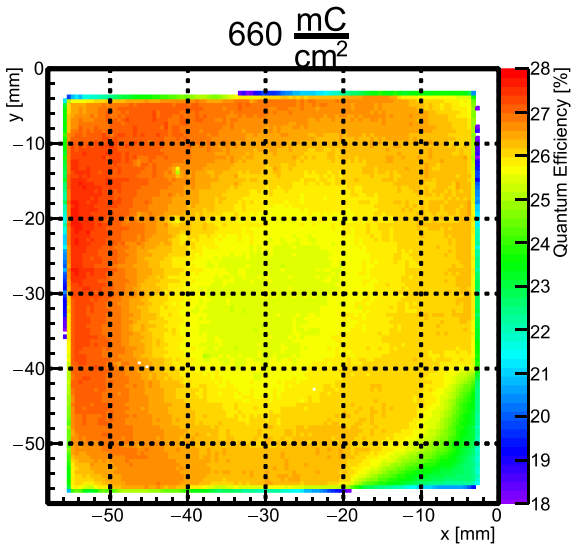



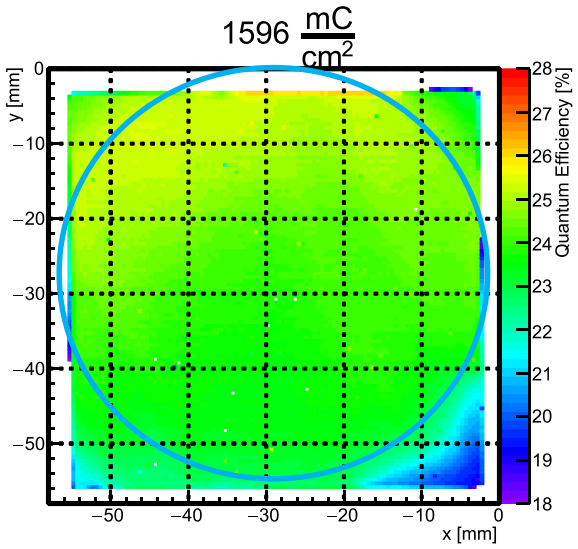



# QE scan of Hamamatsu JS0035 (8x8, ALD)

## Clear sign of Cathode damage

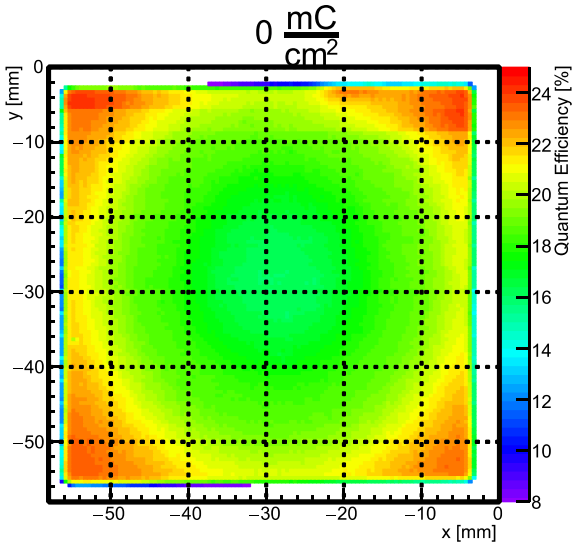


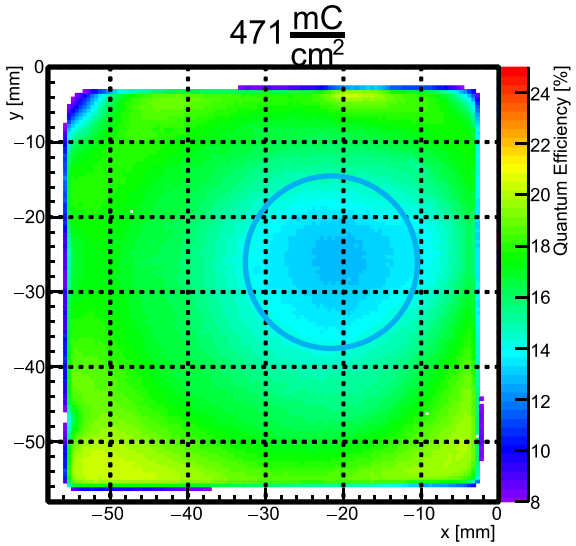



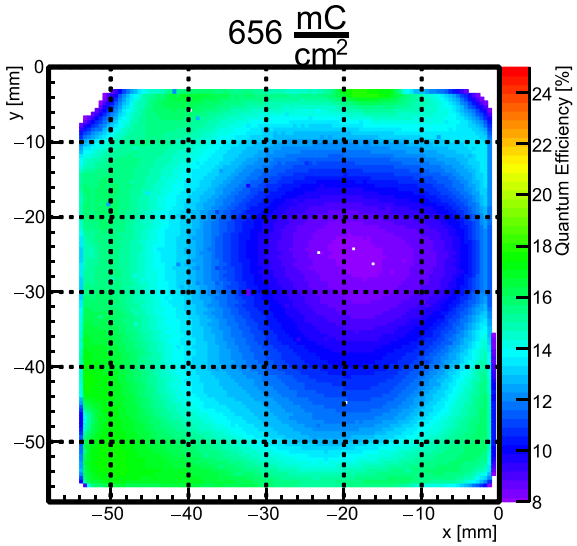



# QE scan of Hamamatsu JS0018 (6x128, ALD)

## Clear sign of Cathode damage



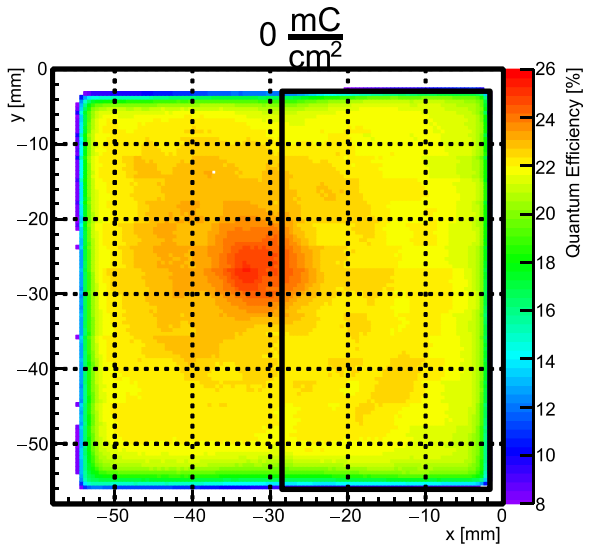



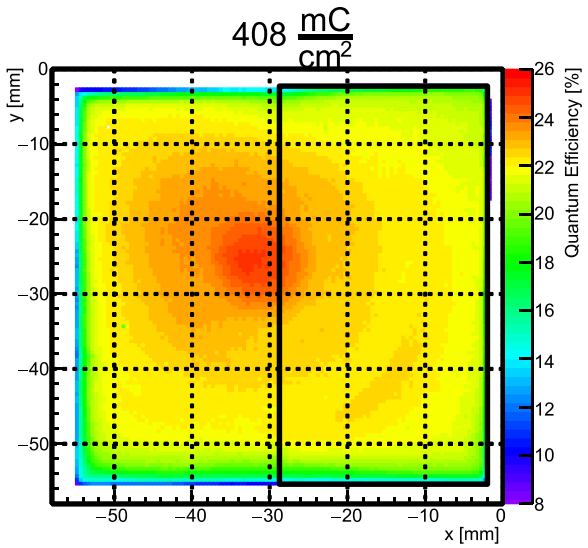



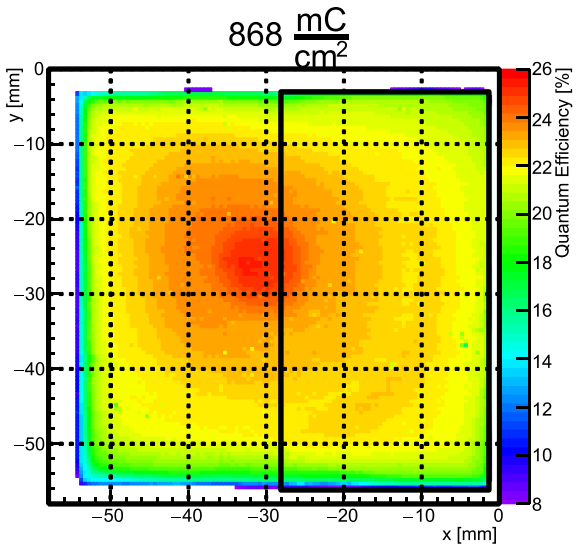
# QE scan of Hamamatsu JS0027 (6x128, ALD)

Covered (not illuminated)

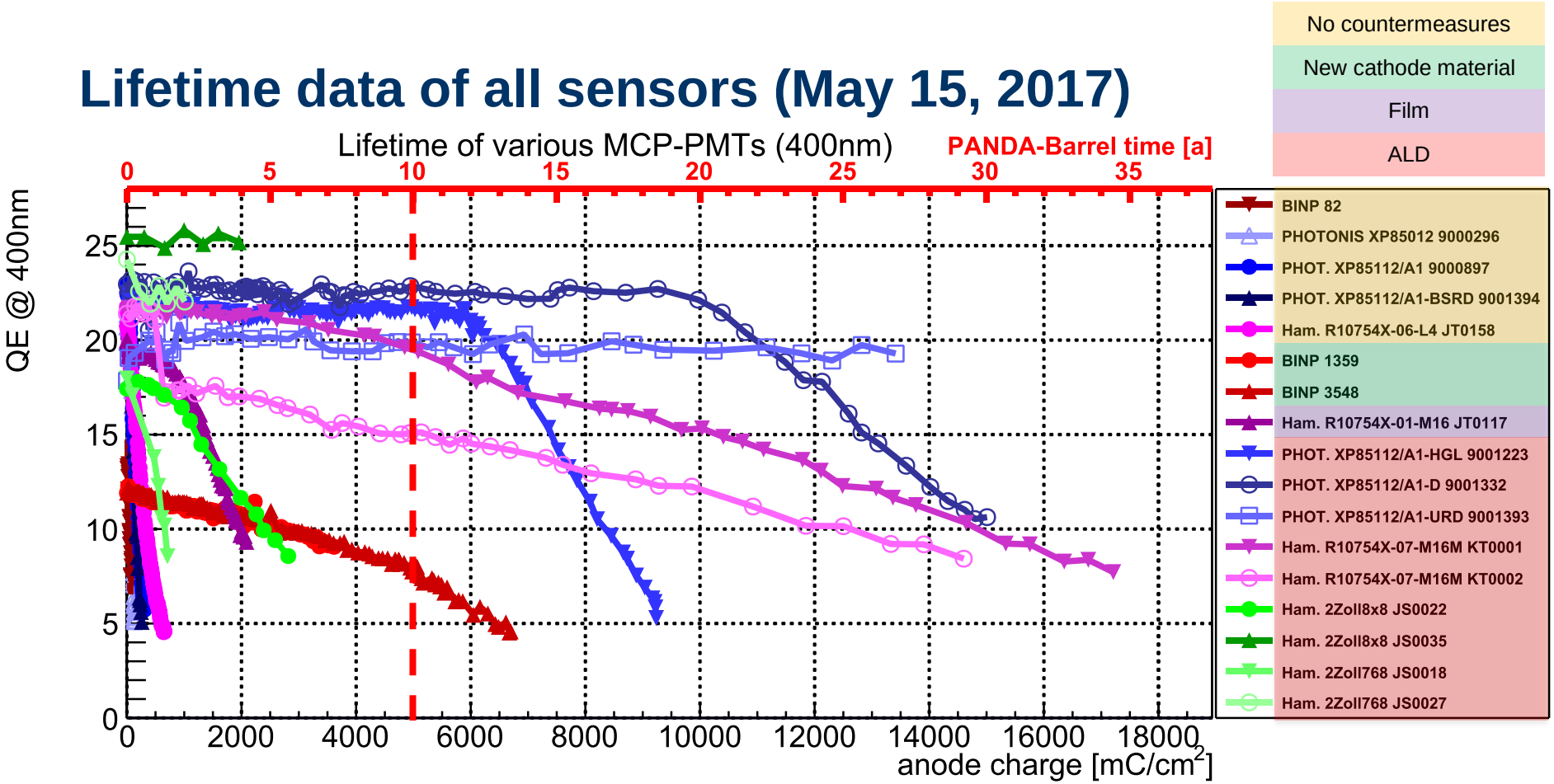
Clear sign of Cathode damage



# Lifetime data of all sensors (May 15, 2017)



# Summary and outlook

- New high QE tube sent back to Photonis
- Double ALD Photonis tube (1393) at 13.6C/cm² without damage

- New Picoamp in production (up to 4kV potential free)
  - Possible to measure Hamamatsu sensors
  - Compare results of both picoamps

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# Thank you for your attention!

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