

Update on lifetime measurements of MCP-PMTs

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FOR ASTROPARTICLE
PHYSICS

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PANDA-Meeting 20/3, eZuce not GSI :-/ , Oct 27,
2020



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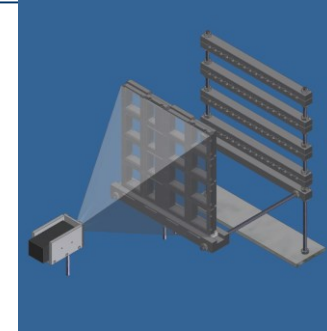
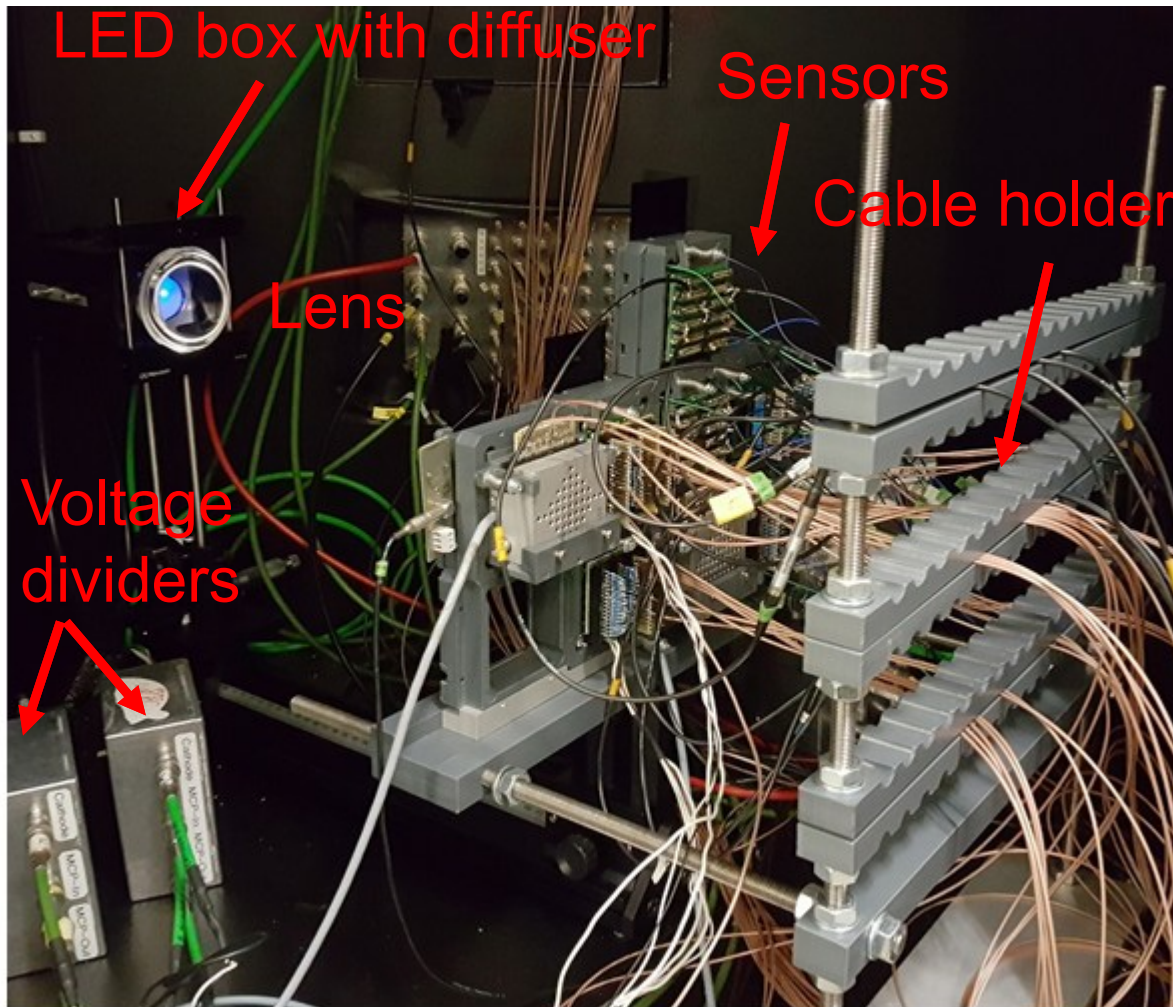
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Parameters of lifetime measurements

- **Goal:** Simultaneous measurement of different MCP-PMTs under similar conditions as in the PANDA-DIRCs
- Constant illumination with **1 MHz single photons**
 - All MCP-PMTs in **same** light spot
 - Permanent monitoring of integrated anode charge
- QE measurement:
 - Every few weeks:
 - **Wavelength spectrum** with Xenon arc lamp (75 W) and a monochromator ($\Delta\lambda = 2 \text{ nm}$, 250 nm - 800 nm)
 - Also measuring gain and dark counts
 - Every several months:
 - **Surface scans** with picosecond laser (372 nm, spot size: $\varnothing \sim 0.5\text{-}1 \text{ mm}$)

Lifetime setup



- Pulsed LED inside aluminum Box
- Thorlabs engineered diffuser
 - In front of LED to get homogeneous light spot on sensors
- Holding construction for up to 16 sensors all illuminated by same LED
- Cable management behind sensors

Data from Sep/Oct, 2020

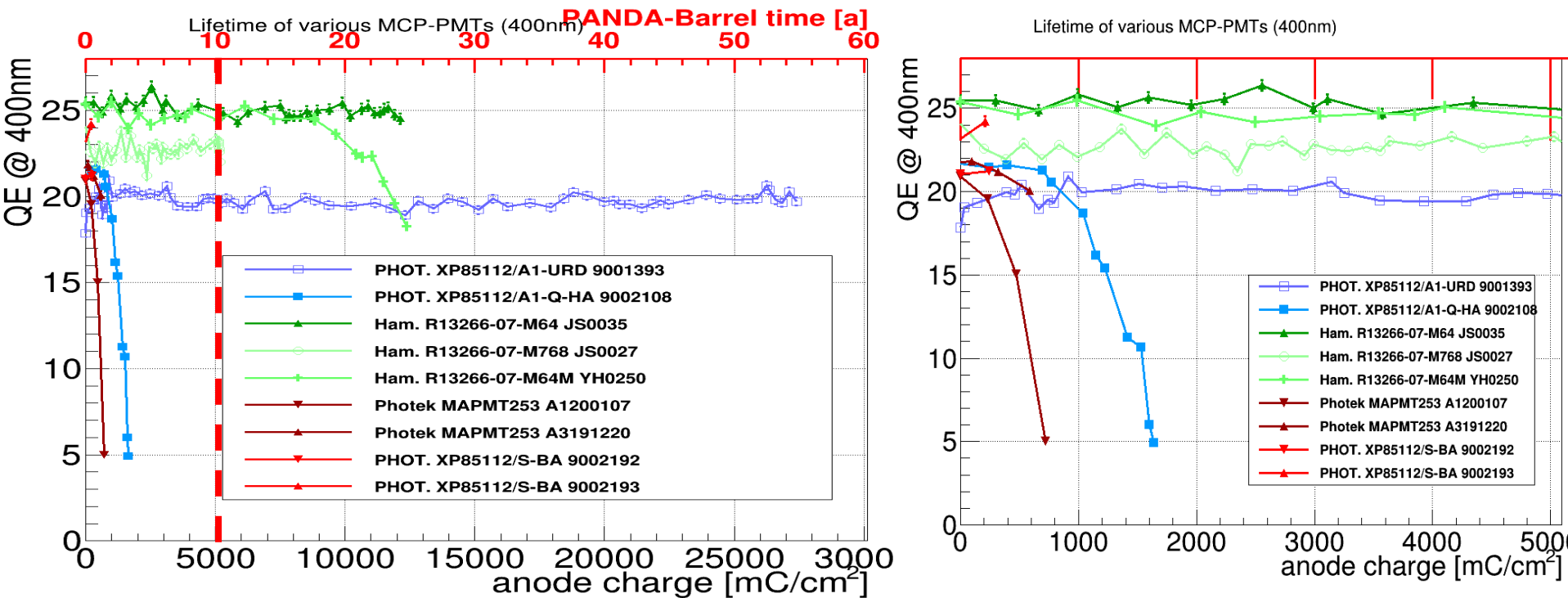
Illumination Overview QE (all sensors with ALD)

Two ALD layers Film in front of first MCP **be careful with this numbers (next slide)**

Manufacturer	Sensor ID	IAC [mC/cm ²]	QE start [%]	QE latest [%]	QE latest/QE start [%]
Photonis XP85112	9002192	245	21.0	21.2	101
	9002193	207	23.1	24.2	105
	9001393	27401	19.1	19.7	103
Photek MAPMT253	A1200107	717	20.9	~5	~24
	A3191220	584	21.7	~20	~92
Hamamatsu R13266-07- M768 / M64	YH0250 (64 pix.)	12382	25.4	18.3	72
	JS0035 (64 pix.)	12156	25.5	24.5	96
	JS0027 (768 pix.)	5181	24.3	22.0	91

removed in June 2020

Lifetime data of latest sensors (Sep 14, 2020)

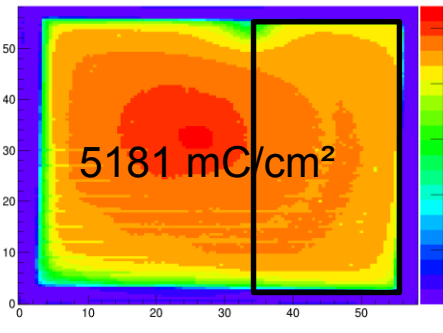
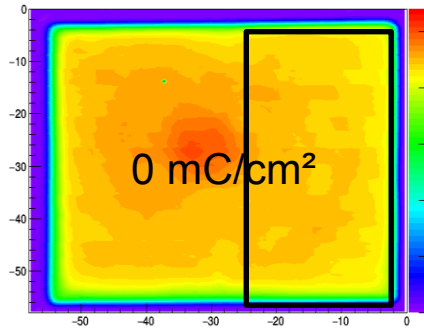
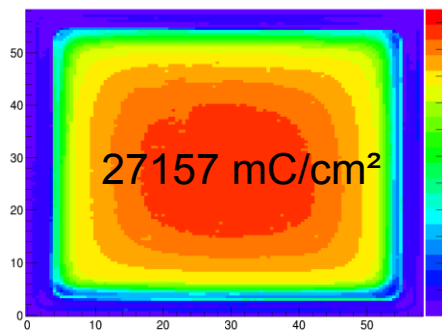
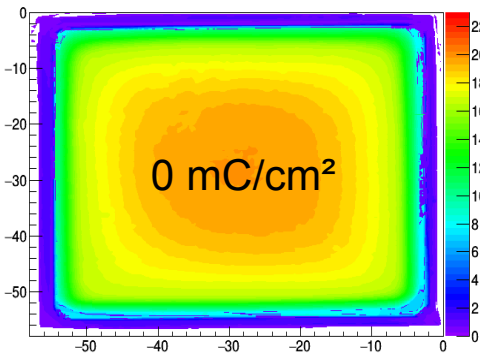


- Most sensors with ALD coated MCPs have lifetime > 5 C/cm²
- Hamamatsu JS0035 removed and shipped back to Japan
- QE(λ) of Photeks can't be measured anymore due to too high darkcurrent (~100nA and more), QE-Scans are (sometimes) possible after waiting for hours-days

QE scans of 2 inch ALD devices, Photonis+Hamamatsu

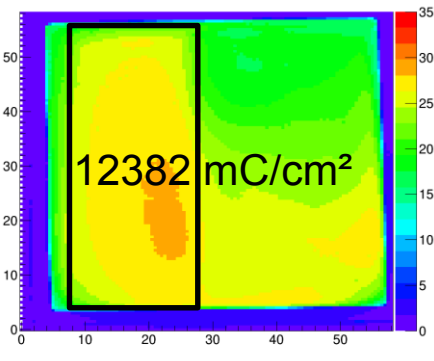
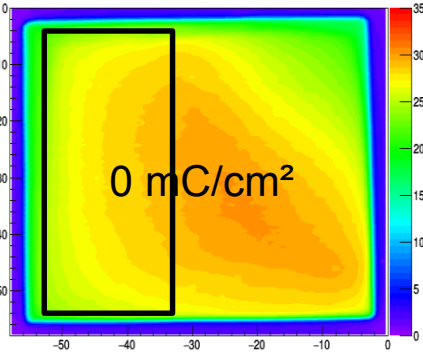
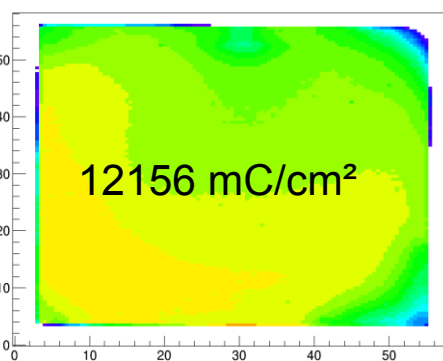
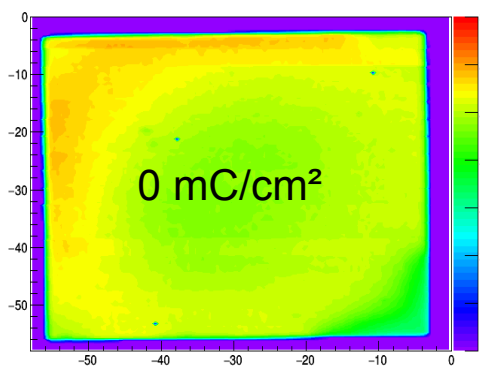
URD (8x8 pix, 2ALD layers)

JS0027 (6x128 pix., film)



JS0035 (8x8 pix., film)

YH0250 (8x8 pix., no film)



Covered

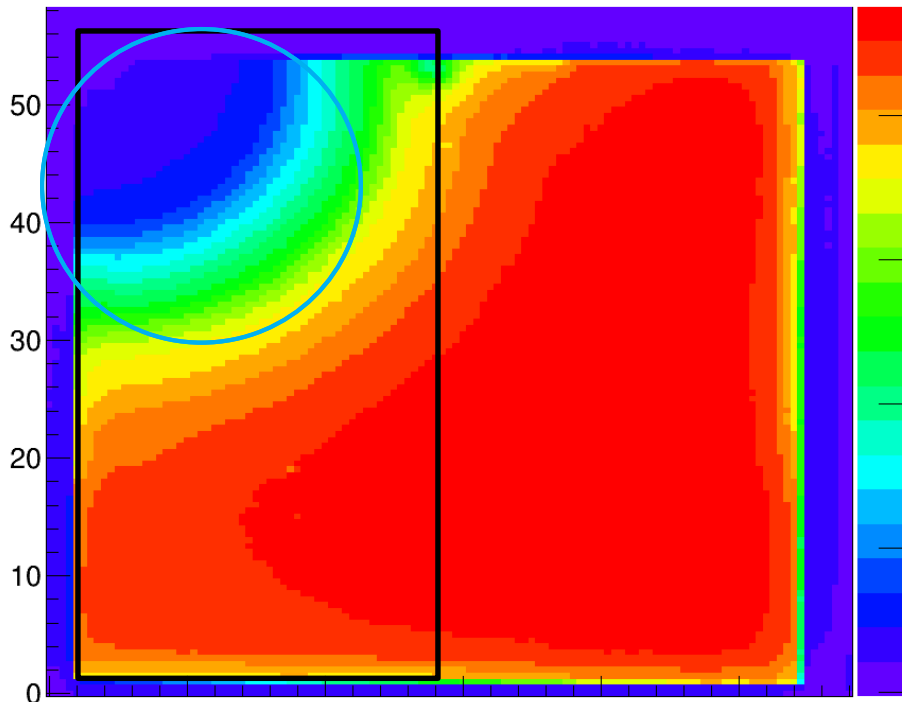
QE scans of Photek A1200107(ALD)

Covered (not illuminated)

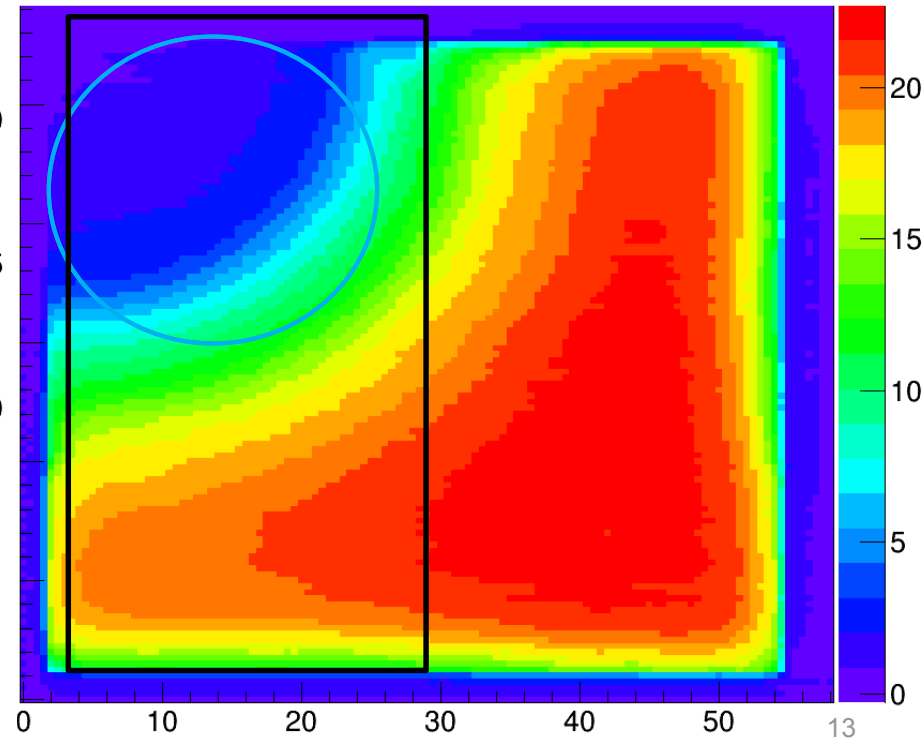
Clear sign of Cathode damage

- Aging starting from the corner

July 28 2020



October 7 2020



QE scans of Photek A3191220 (ALD)

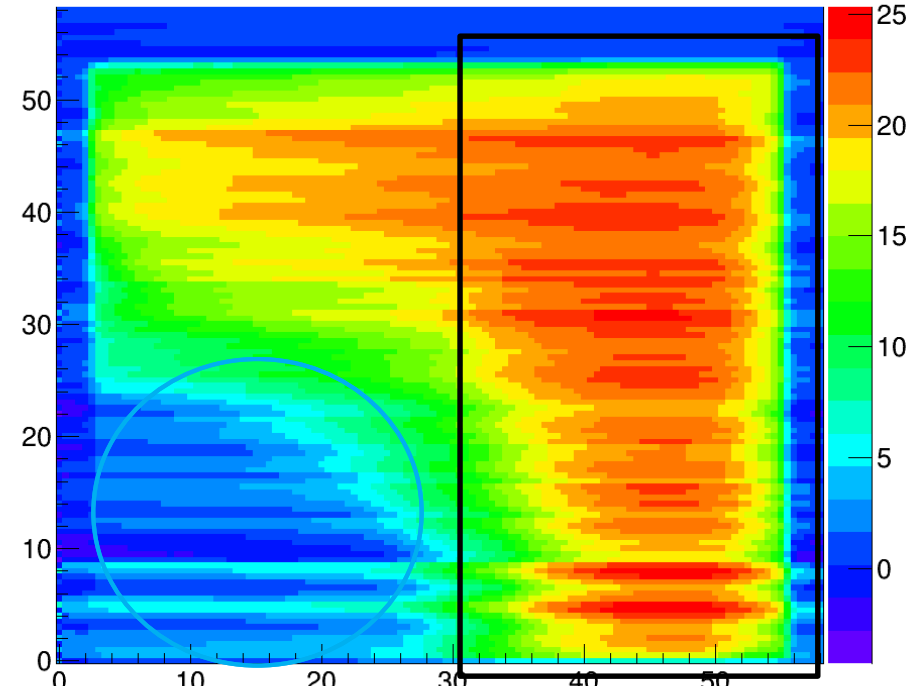
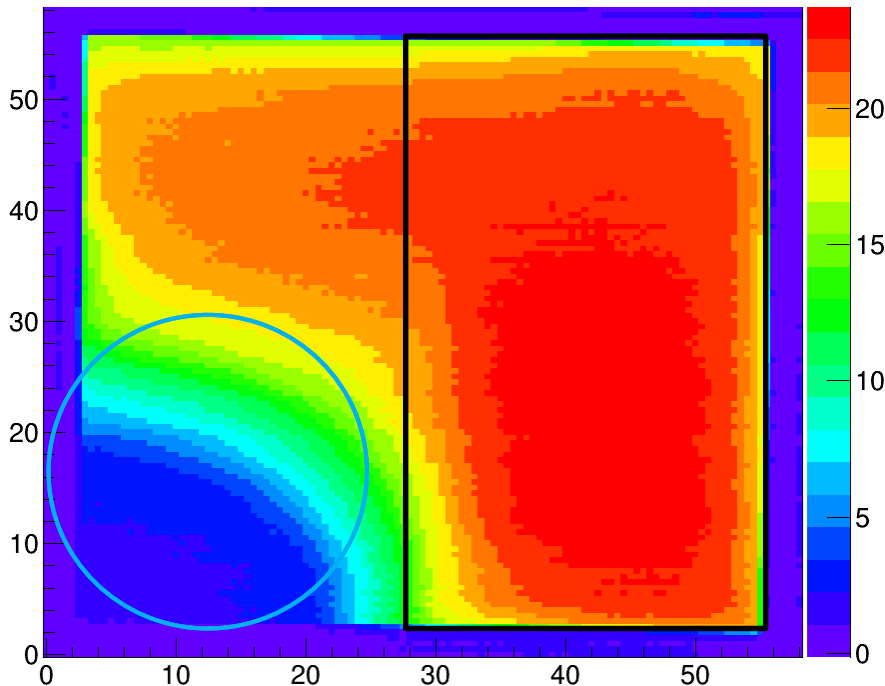
Covered (not illuminated)

July 28 2020

Clear sign of Cathode damage

- Aging starting from the corner
- noisy scan due to high darkcurrent

October 5 2020



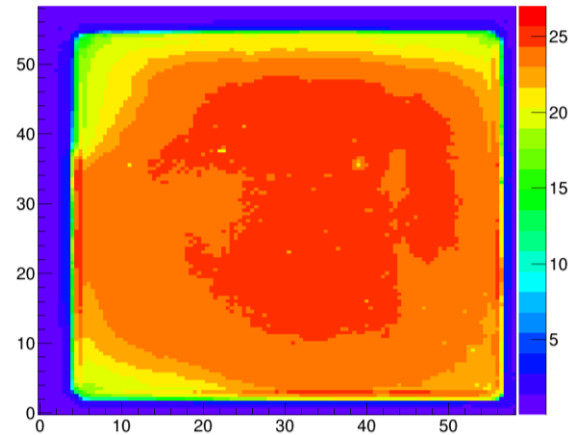
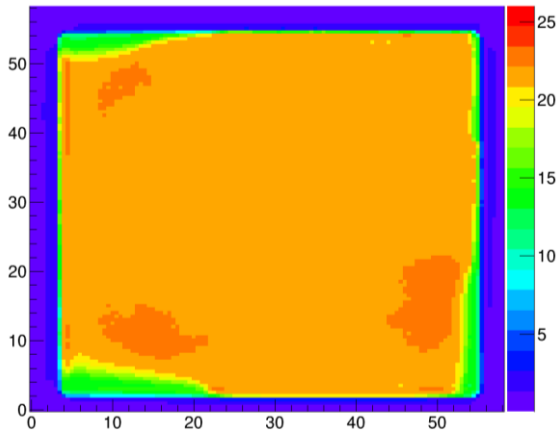
QE scans of new Photonis 9002192&9002193

both not covered (not illuminated)

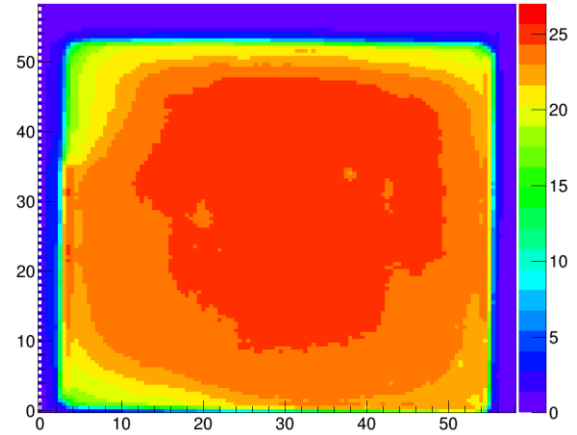
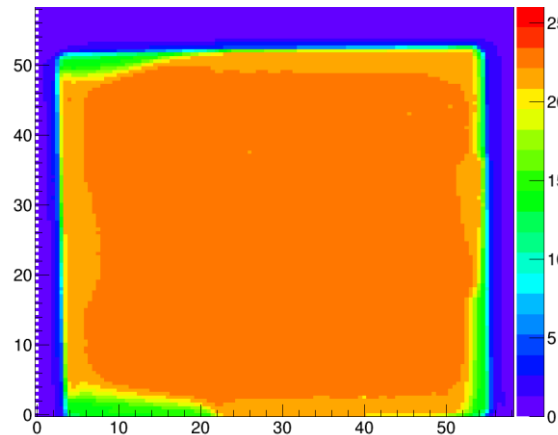
9002192 (1:10:1 divider)

9002193 (4:10:1 divider)

June 04 2020



October 7 2020



CE measurement issues of Photonis 9002192 and 9002193

- first CE measurement in July: both sensors: $\sim 75\%$, seem a bit low
- second CE measurement in September (directly before Juelich):
 - 9002192: $\sim 95\%$ CE
 - 9002193: $\sim 85\%$ CE
- third CE measurement in October (directly after Juelich):
 - 9002192: $\sim 17\%$ CE
 - 9002193: $\sim 20\%$ CE
- no setup changes between second and third measurement, even almost the same illumination levels, but the number of photoelectrons in the charge spectrum is a factor of 4-5 lower, which has direct impact on the CE
- need to investigate whether this is a real effect of the magnetic field

Summary

- Requirements: $> 5 \text{ C/cm}^2$ at 10^6 gain (50% duty cycle, 10 years)
- Photonis
 - Best sensor at 28 C/cm^2 without any sign of cathode damage
 - 9002192&9002193 integrated now
- Hamamatsu:
 - Later produced (higher serial number) 2 inch tubes tend to have better performance
 - JS0035 now at 12 C/cm^2 back to Japan
 - YH0250's QE started dropping at $\sim 9 \text{ C/cm}^2$
- Photek:
 - both (all three) sensors already show aging effects, no matter if the side was illuminated or covered or the sensor even was off
 - our assumption: „microleaks“ as called by Hamamatsu, as both Hamamatsu and Photonis experienced these when starting with 2 inch tubes

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Thank you for your attention!

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