Update on MCP-PMT lifetime measurements

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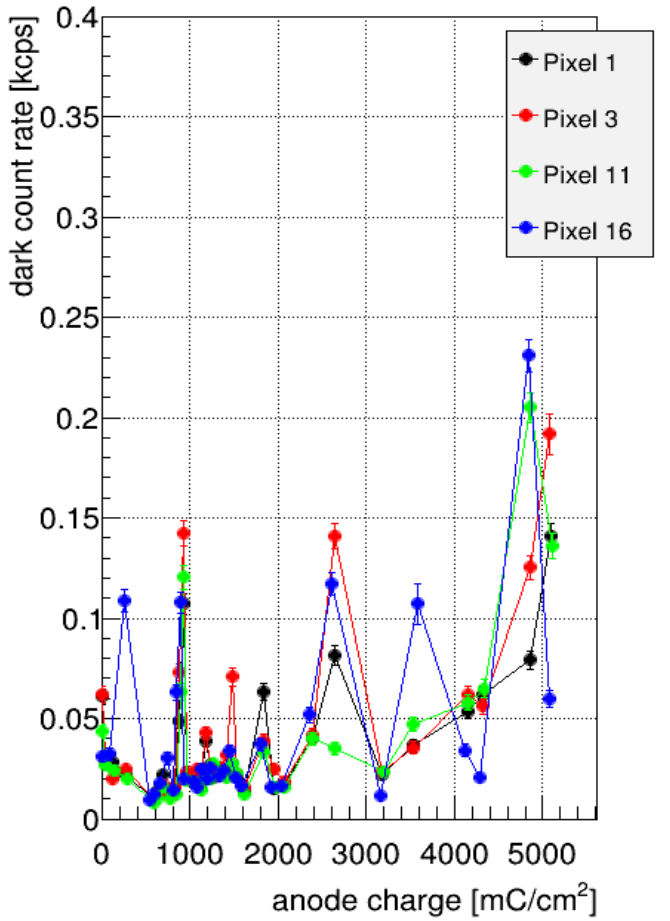
Illumination Overview

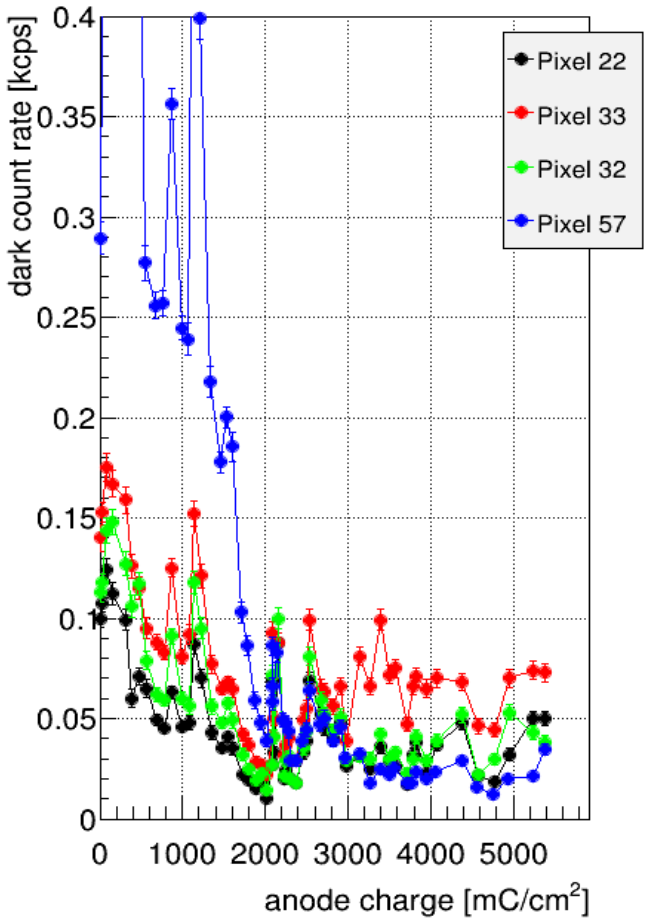
	Sensor ID	Integral charge (Dez. 4, 2014) [mC/cm2]	Diff. charge (maximum) [mC/cm^2/d]	# of measurements	# of QE scans	Comments
Photonis XP85112	9001223	**8205**	13,5	153	14	Start: 23 Aug. 11 ongoing
	9001332	**5390**	21,8	57	7	Start: 12 Dec. 12 ongoing
	9001393	**2476**	11	21	3	Start: 23 Jan. 14 ongoing
Hamamatsu R10754X	JT0117 (M16)	**2086**	14,1	86	7	Start: 23 Aug. 11 Stop: 24 Jul. 12
	KT0001 (M16M)	**5111**	30,1	33	5	Start: 20 Aug. 13 ongoing
	KT0002 (M16M)	**2804**	20,1	28	6	Start: 21 Oct. 13 ongoing
BINP	1359	**3616**	10,6	90	8	Start: 21 Oct. 11 Stop: 06 May 13
	3548	**6160**	11,8	130	11	Start: 21 Oct. 11 ongoing

Dark count rate

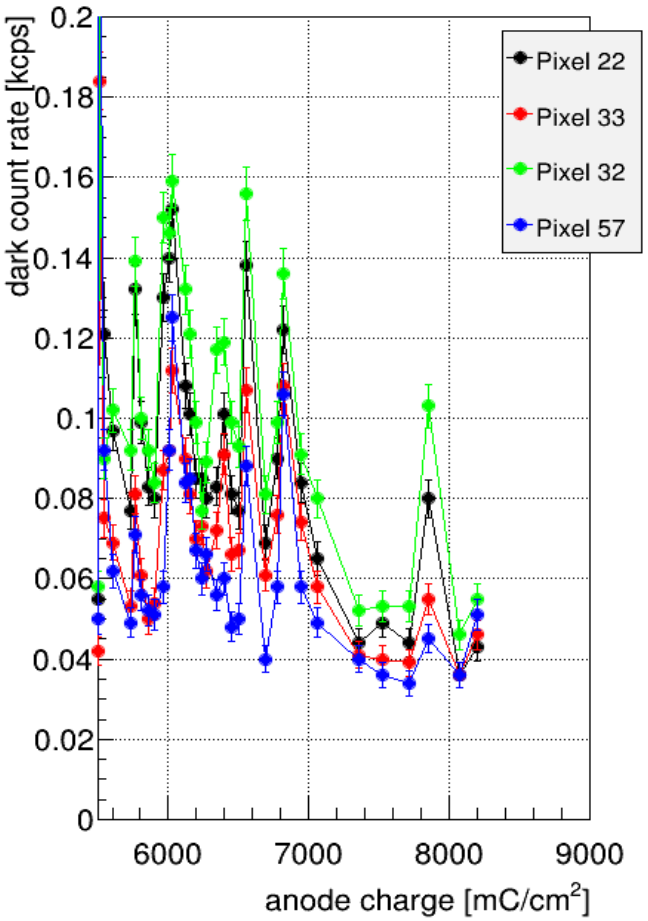
Hamamatsu R10754X (ALD)



Photonis XP85112 (ALD)



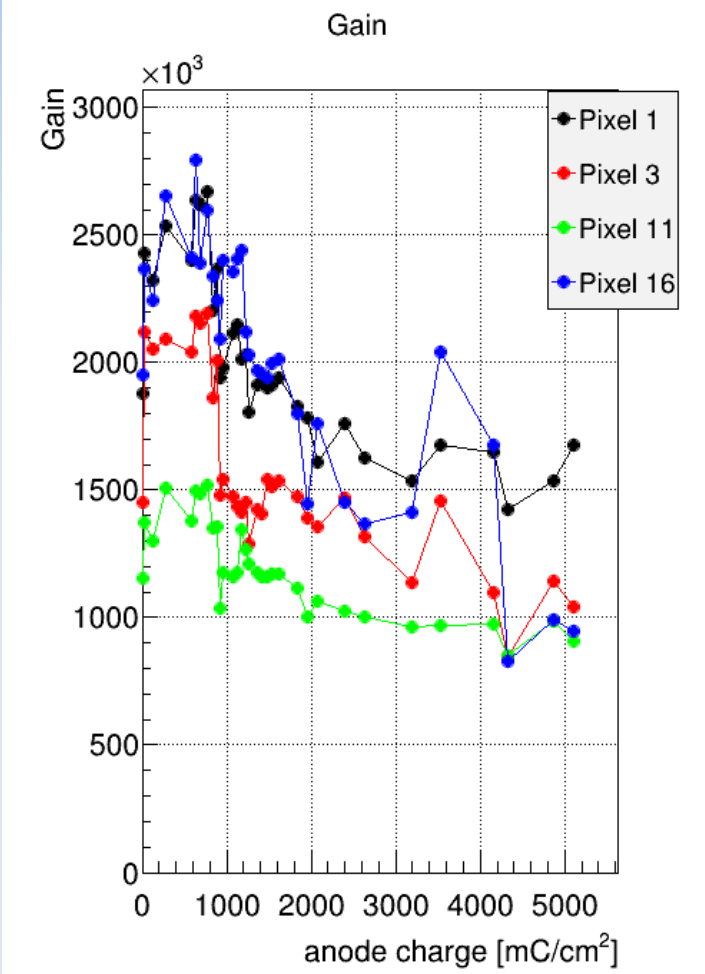
Photonis XP85112 (ALD)



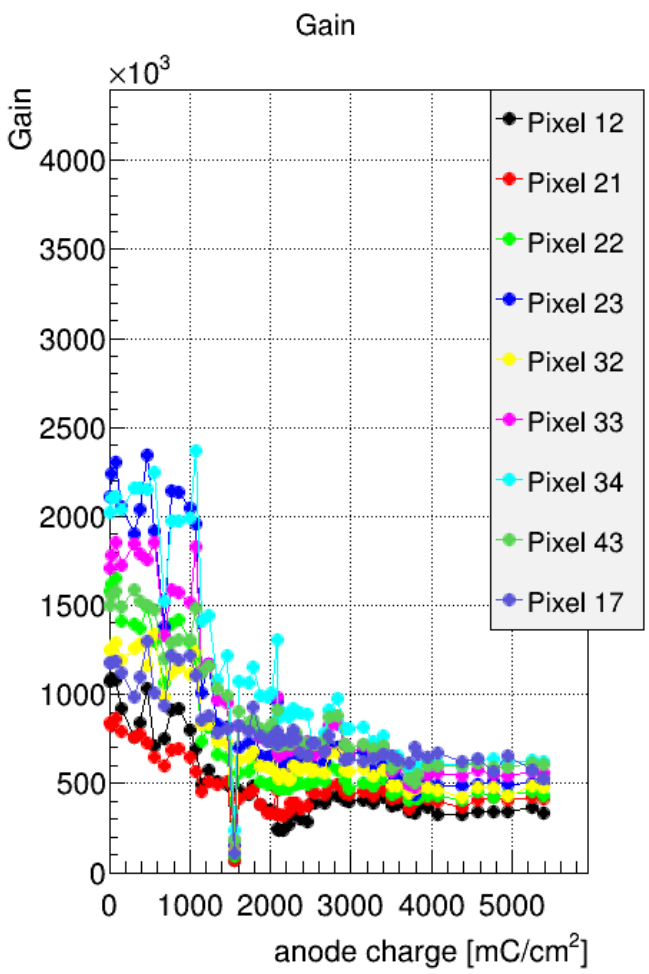
- dark count rate slightly drops at the beginning and stays relativ constant afterwards

Gain

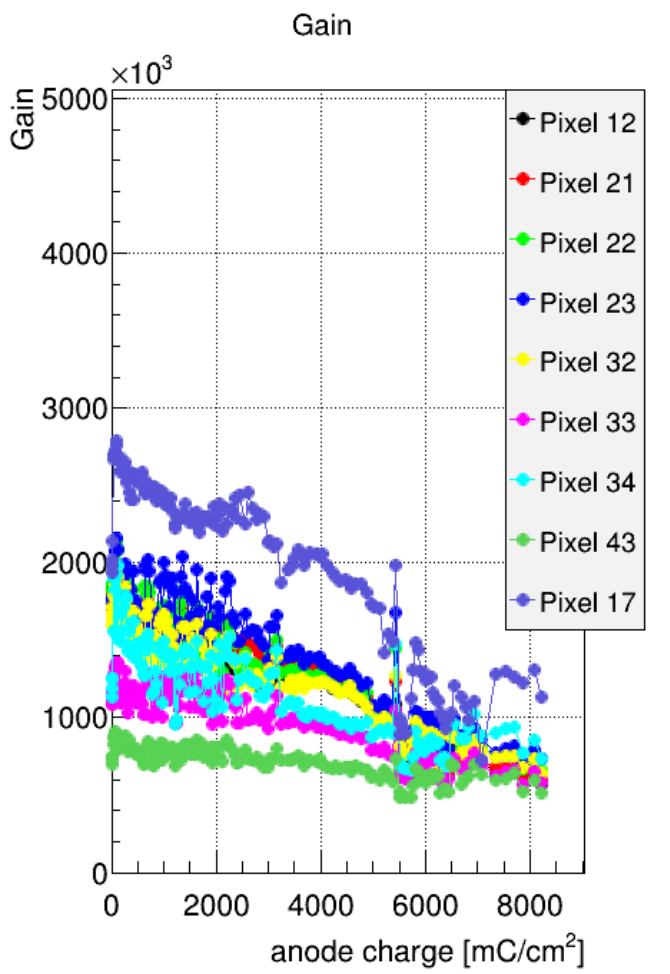
Hamamatsu R10754X (ALD)



Photonis XP85112 (ALD)



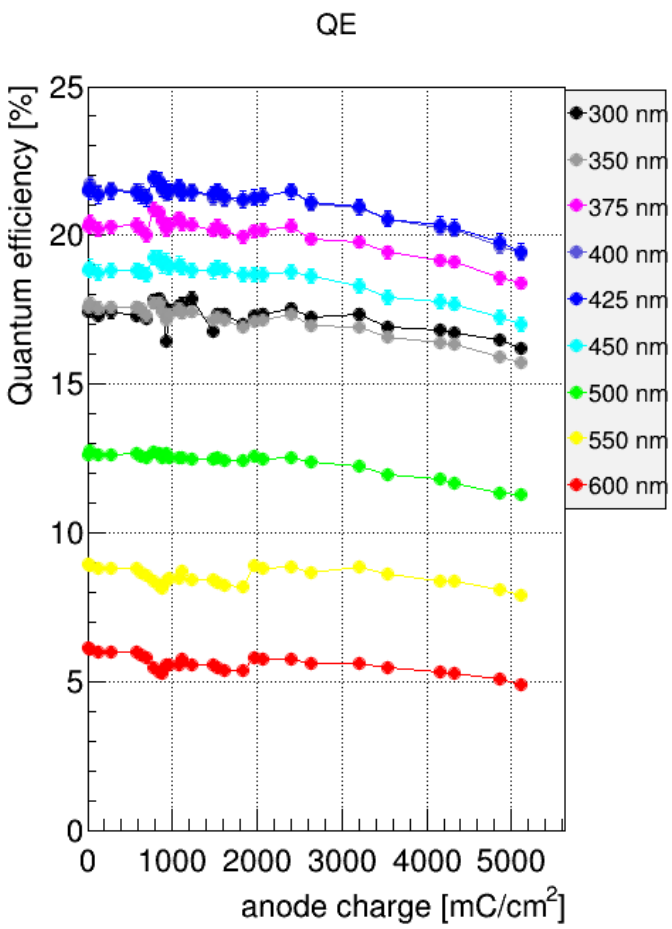
Photonis XP85112 (ALD)



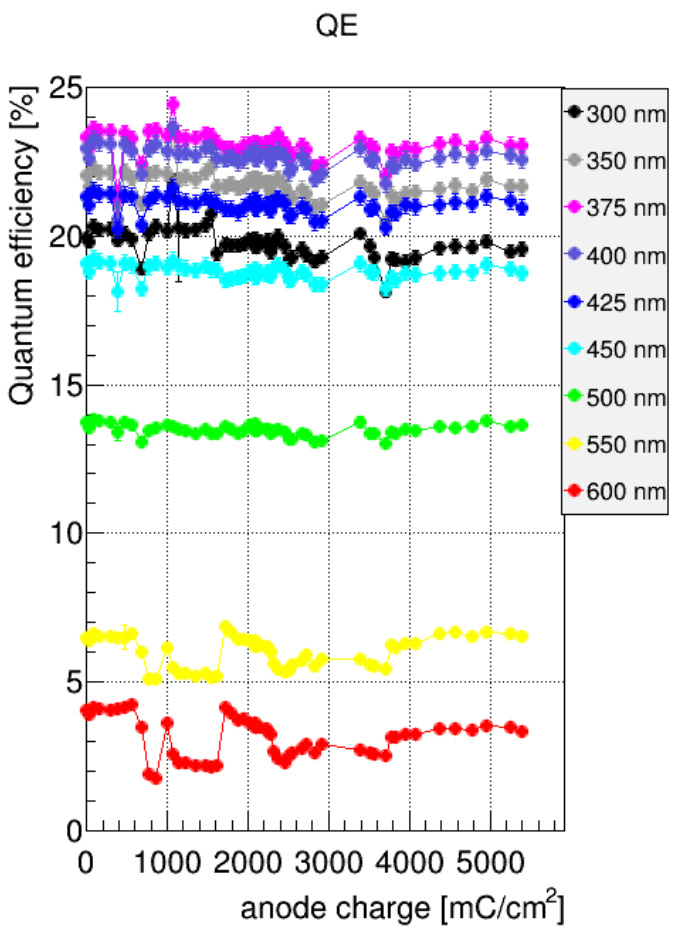
- gain drops by factor 2-3 → can be compensated by increasing the voltage

Spectral Quantum Efficiency

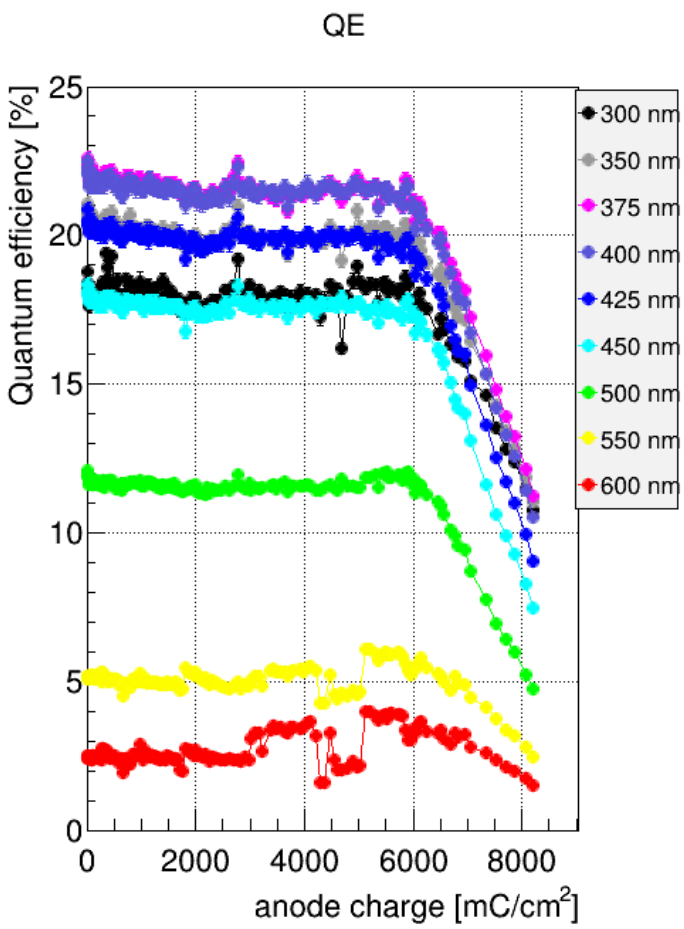
Hamamatsu R10754X (ALD)



Photonis XP85112 (ALD)



Photonis XP85112 (ALD)

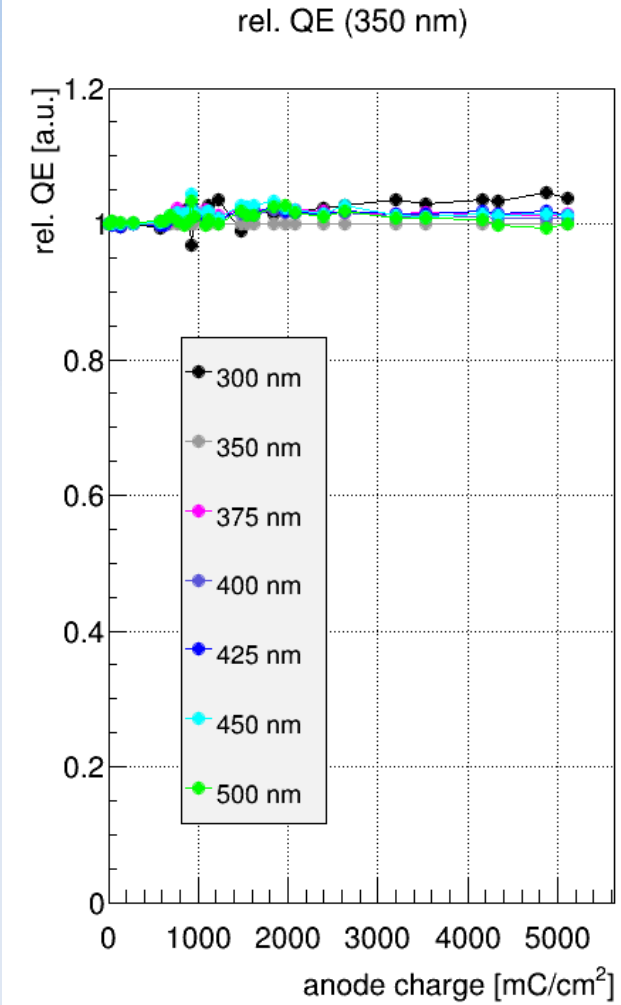


- Hamamatsu R10754X and Photonis XP85112 – 1332 show almost no degradation of QE at ~ 5 C/cm²
- aging of Photonis XP85112 – 1223 started at ~ 6 C/cm²

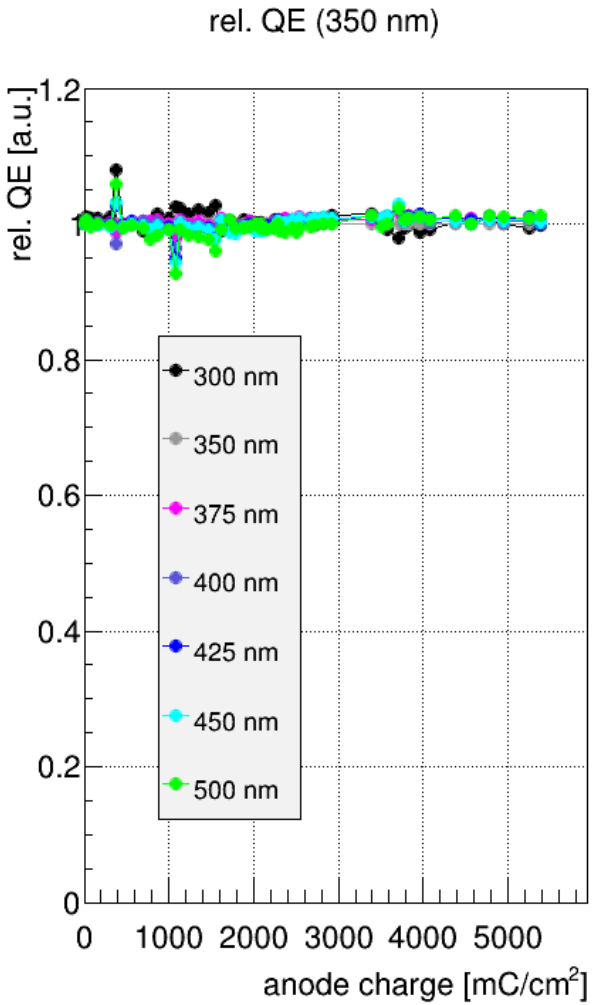
Relative QE

$$rel.QE. := \frac{QE(\lambda)}{QE_{Q=0}(\lambda)} / \frac{QE(\lambda_0)}{QE_{Q=0}(\lambda_0)}; \lambda_0 = 350\text{nm}$$

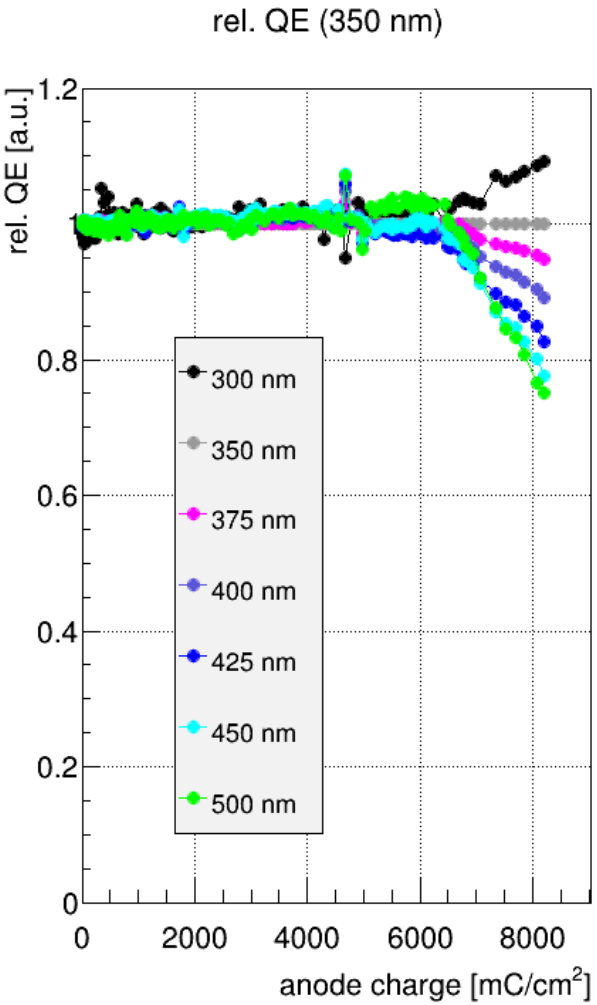
Hamamatsu R10754X (ALD)



Photonis XP85112 (ALD)



Photonis XP85112 (ALD)

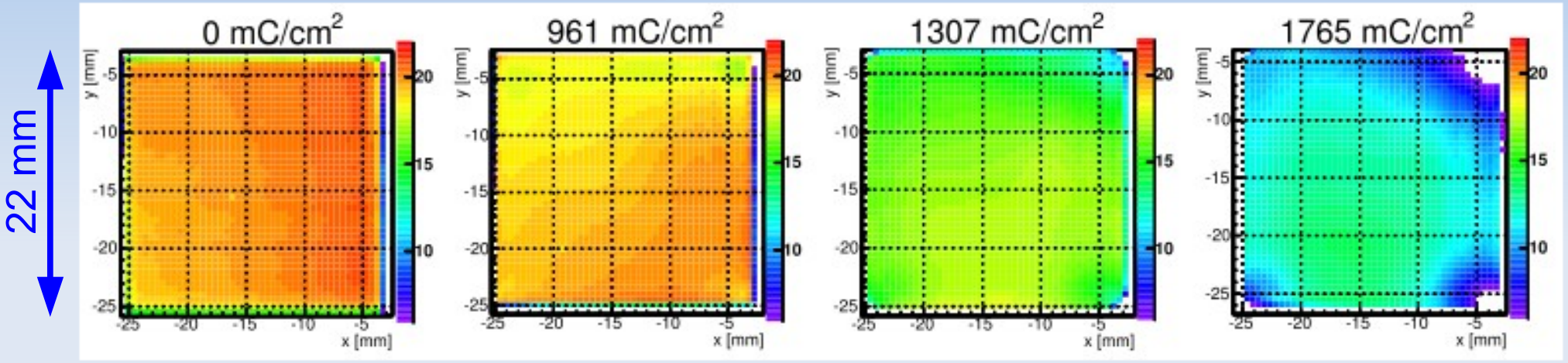


- QE drops faster at higher wavelengths → change of work function

Q.E. Scans (Hamamatsu & BINP)

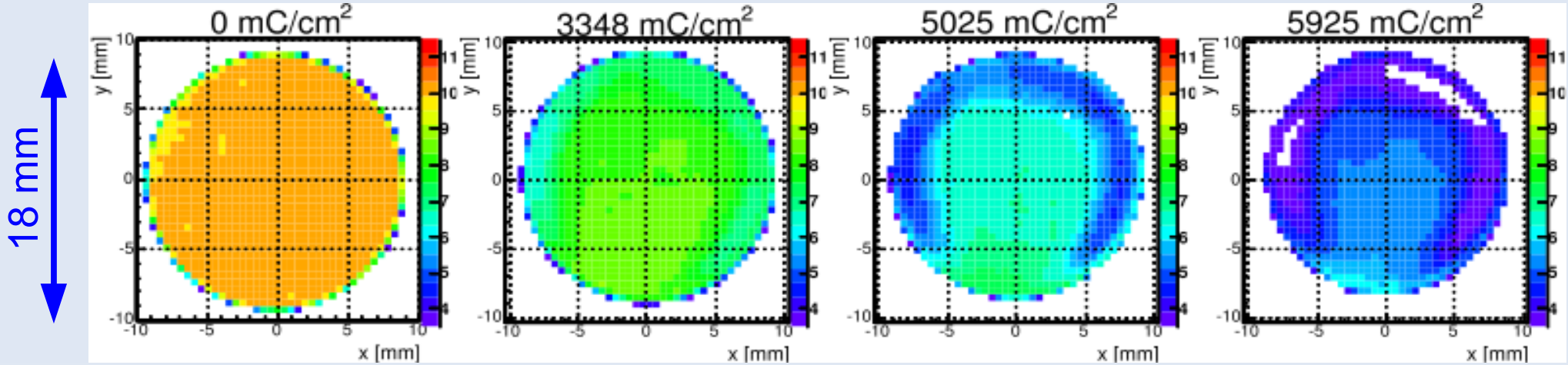
Q.E. measured at 372 nm

film **Hamamatsu R10754X-M16**



new PC **BINP 3548**

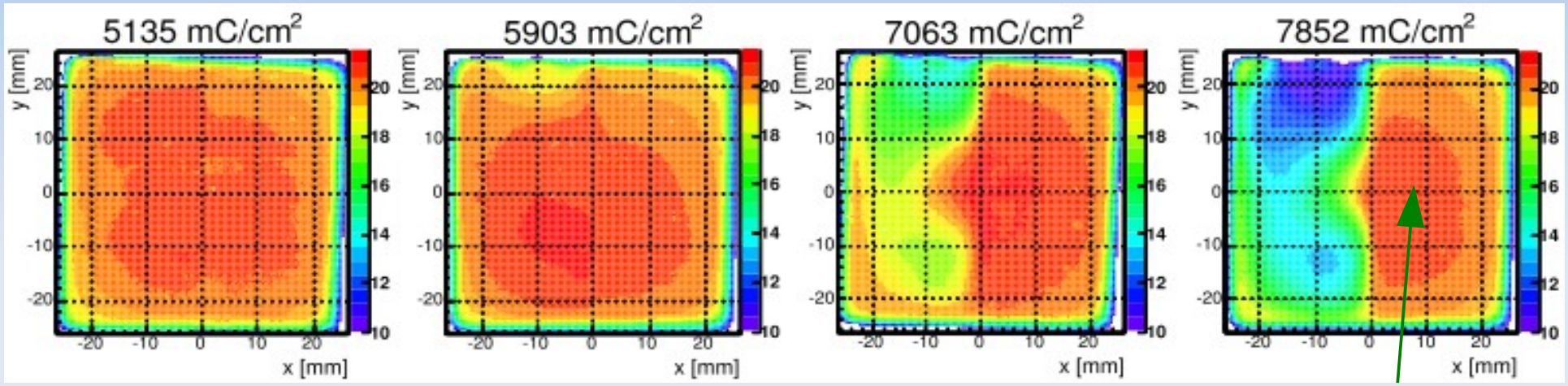
QE degradation evolves from rims and corners



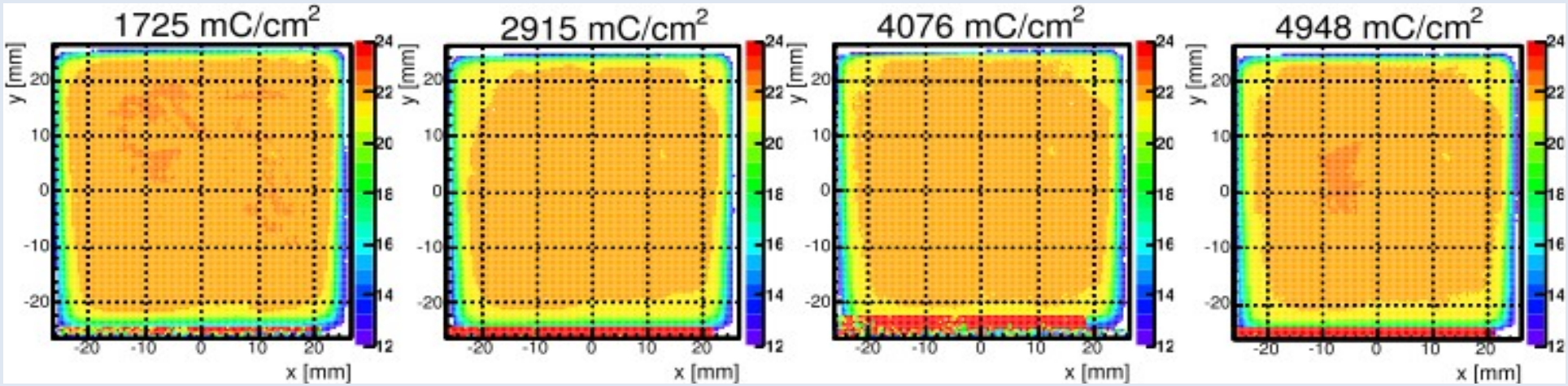
Q.E. Scans (PHOTONIS ALD)

Q.E. measured at 372 nm

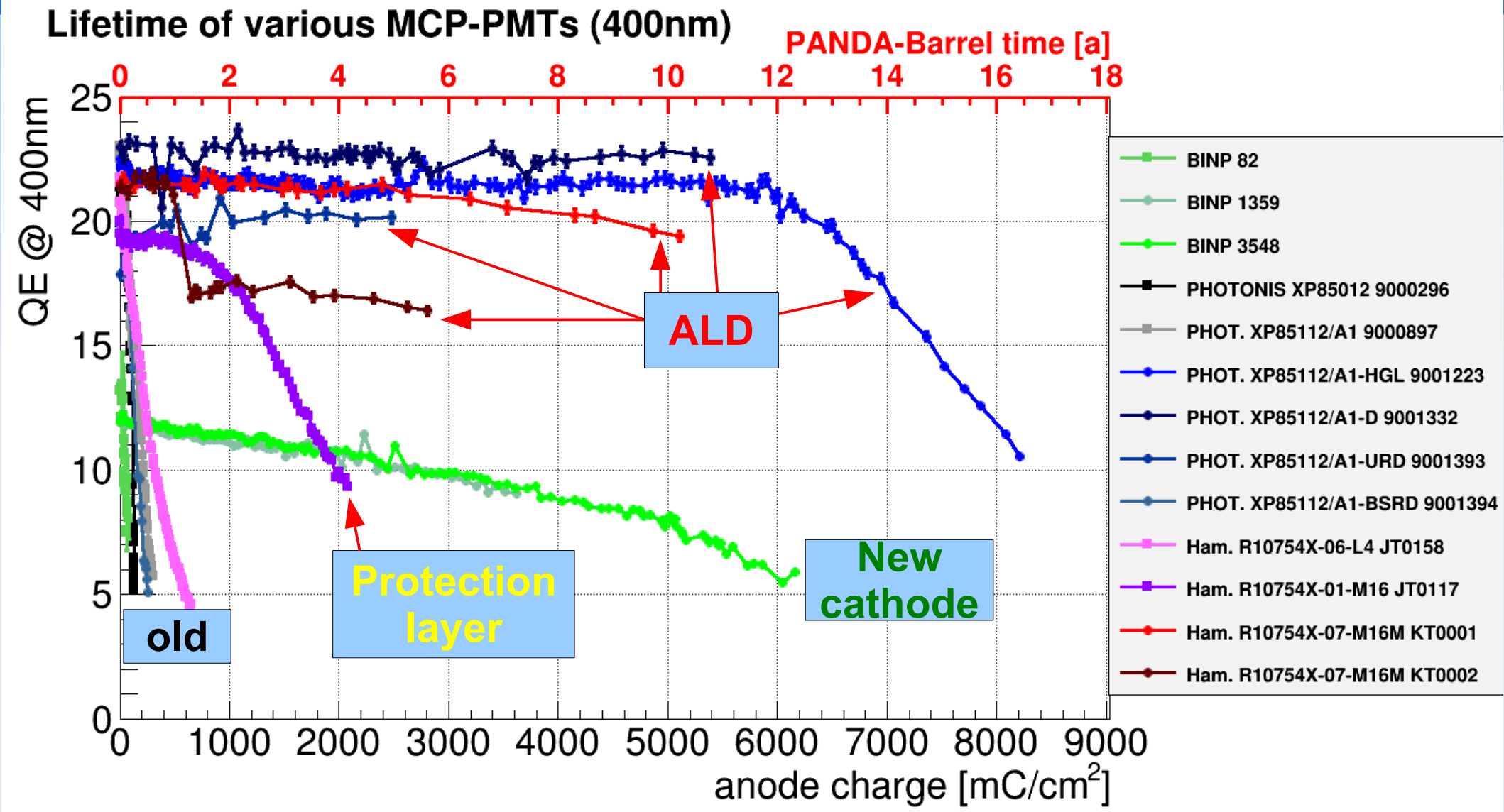
ALD **PHOTONIS XP85112 (9001223)**



ALD **PHOTONIS XP85112 (9001332)**



Comparison of MCP-PMTs



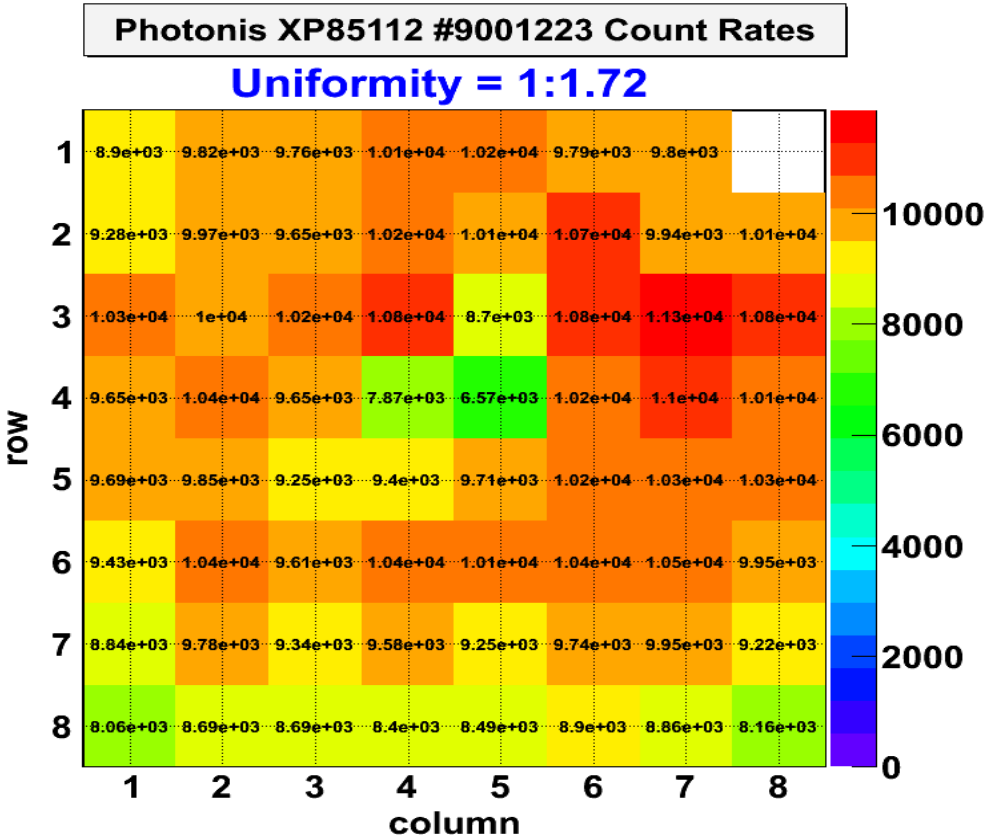
Summary and Outlook

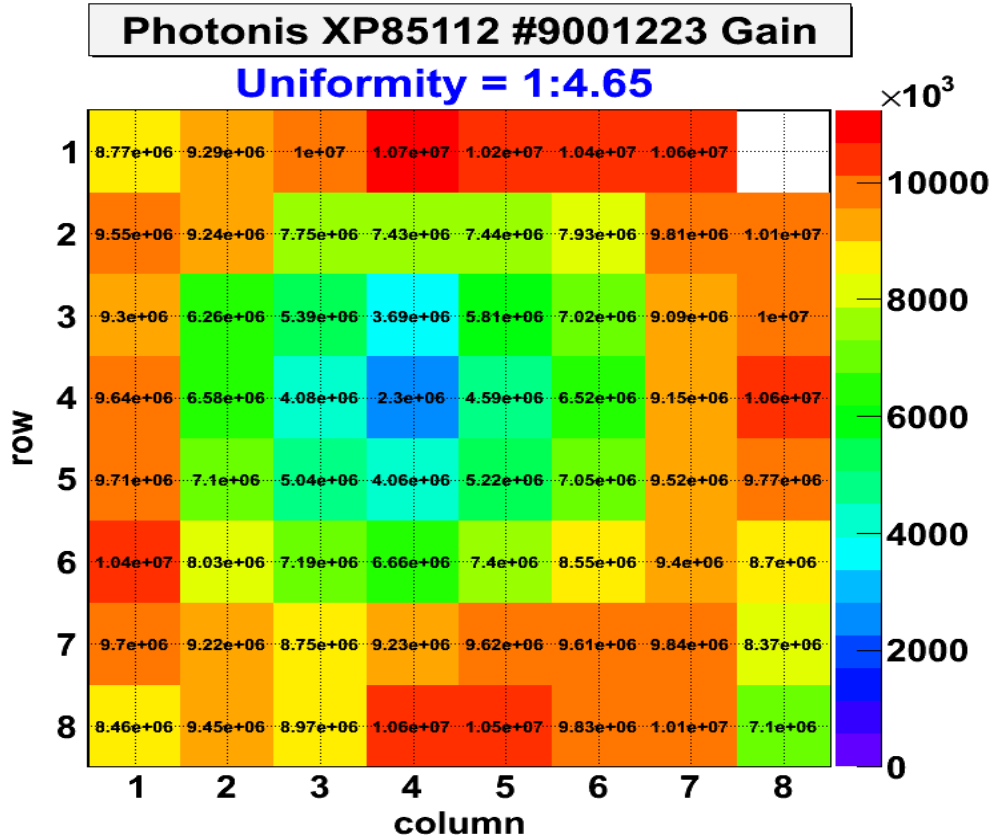
- Requirements: ~ **5 C/cm²** (50% duty cycle, 10 years)

- Lifetime of MCP-PMTs has substantially increased:
  - ALD coated devices show best performance
  - Surface scans show that aging starts at the corners/edges
  - 3 MCP-PMTs have reached/passed 5 C/cm²:
    - Photonis XP85112/A1-HGL - 1223 has passed ~ 8 C/cm² → first aging effects visible at ~ 6 C/cm²
    - Photonis XP85112/A1-HGL – 1332 and Hamamatsu R10754X have passed ~ 5 C/cm² → not aging effects visible

- Future improvements/plans:
  - Change MCP material (leadglas → borosilicateglas)
  - Integrate additional MCP-PMTs in setup

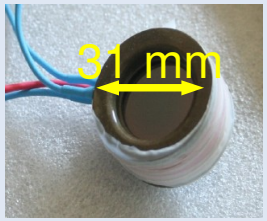
PHOTONIS 1223



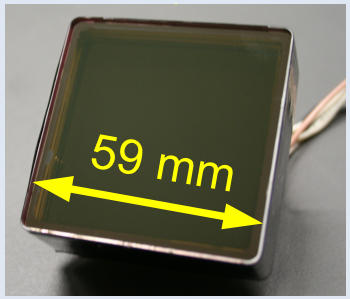


Overview of latest MCP-PMTs

	BINP	PHOTONIS	Hamamatsu	Hamamatsu
	1359 / 3548	XP85112/A1-HGL 1223 / 1332 / 1393	R10754X-01-M16 JT0117	R10754X-01-M16M KT0001 / KT0002
Pore size (µm)	7	10	10	10
Number of pixels	1	8x8	4x4	4x4
Active area (mm²)	$9^2\pi$	53x53	22x22	22x22
Geom. Efficiency (%)	36	81	61	61
Photo cathode	Bi-alkali	Bi-alkali	Multi-alkali	Multi-alkali
Peak Q.E.	495	390	375	375
comments	$Na_2KSb(Cs)+Cs_3Sb$ cathode	**ALD**	Prot. layer between 1. and 2. MCP	**ALD**

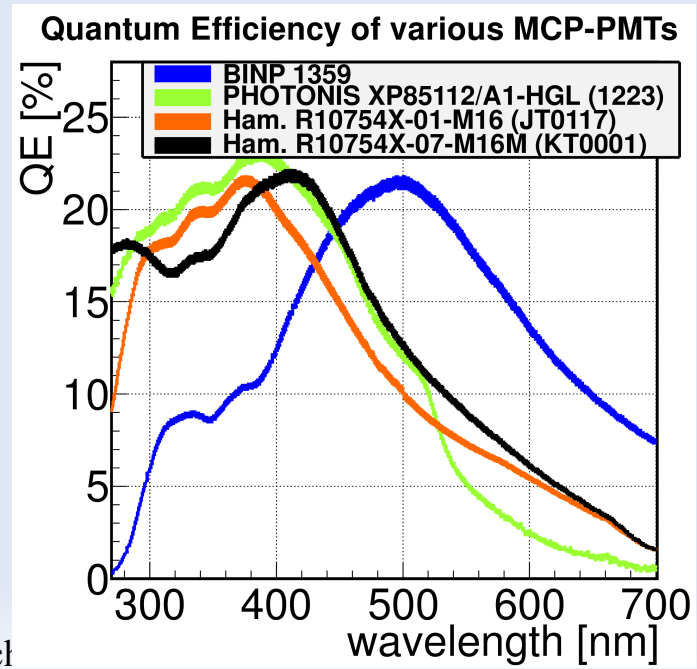


BINP
1359/3548



PHOTONIS
XP85112/A1-HGL

Hamamatsu
R10754X-01-M16



Lifetime measurement procedure

- Simultanous measurements of several different MCP-PMTs under similar conditions as at the PANDA-DIRCs
- Constant illumination (1 MHz single photons) of all MCPs within same lightspot→ **permanent monitoring** to calculate collected anode charge
- Every ~ 3 weeks: Measurement of **Gain**, **darkcount** and **QE**
- QE is measured seperatly using a Xenon arc lamp with monochromator ($\Delta\lambda$ = 1nm, 250-700nm)
- QE surface scans are done every 2-4 months with PiLas (372nm, Ø ~1mm)