Latest Erlangen Results

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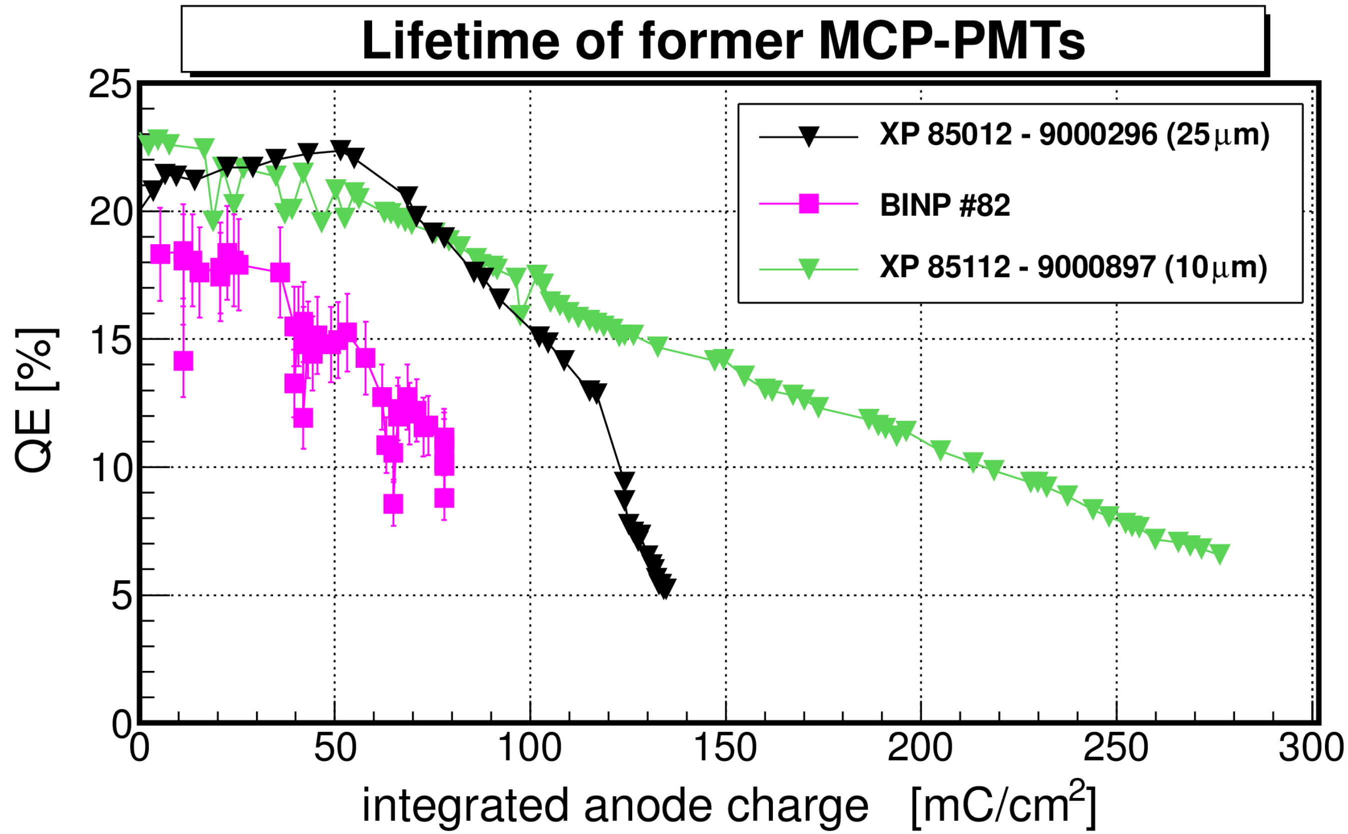
- Status of MCP lifetime measurements
- QE scans of PHOTONIS XP85012/A1
- MCP-TOF as particle ID at test beams

Lifetime of former MCP-PMTs

Status ~1 year ago

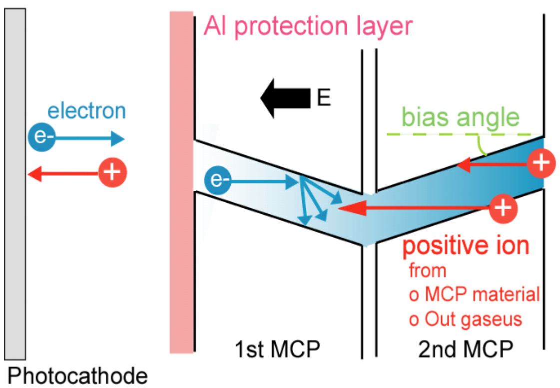
- BINP with Al_2O_3 film at MCP entrance to stop feedback ions
- PHOTONIS with improved vacuum and electron scrubbing of surfaces



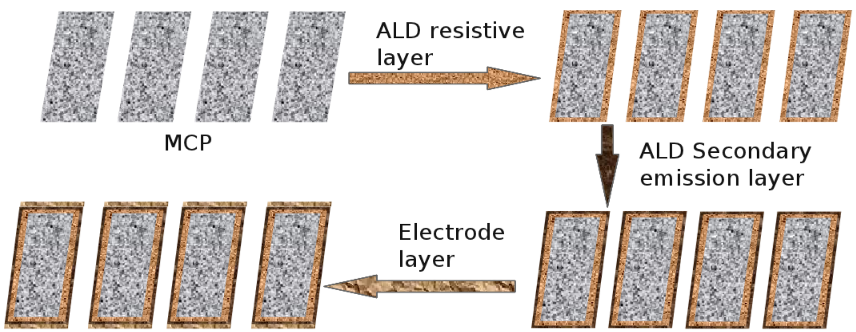
- Quantum efficiency reduced by 50% or more at <200 mC/cm^2
- By far not sufficient for PANDA

Approaches to Increase Lifetime

- Protection layer
  - In front of first MCP layer (older BINP and Hamamatsu)
    - disadvantage: reduction of collection efficiency
  - Between MCP layers (new Hamamatsu)
    - anode region is hermetically sealed from photo cathode region [NIM A629 (2011) 111]



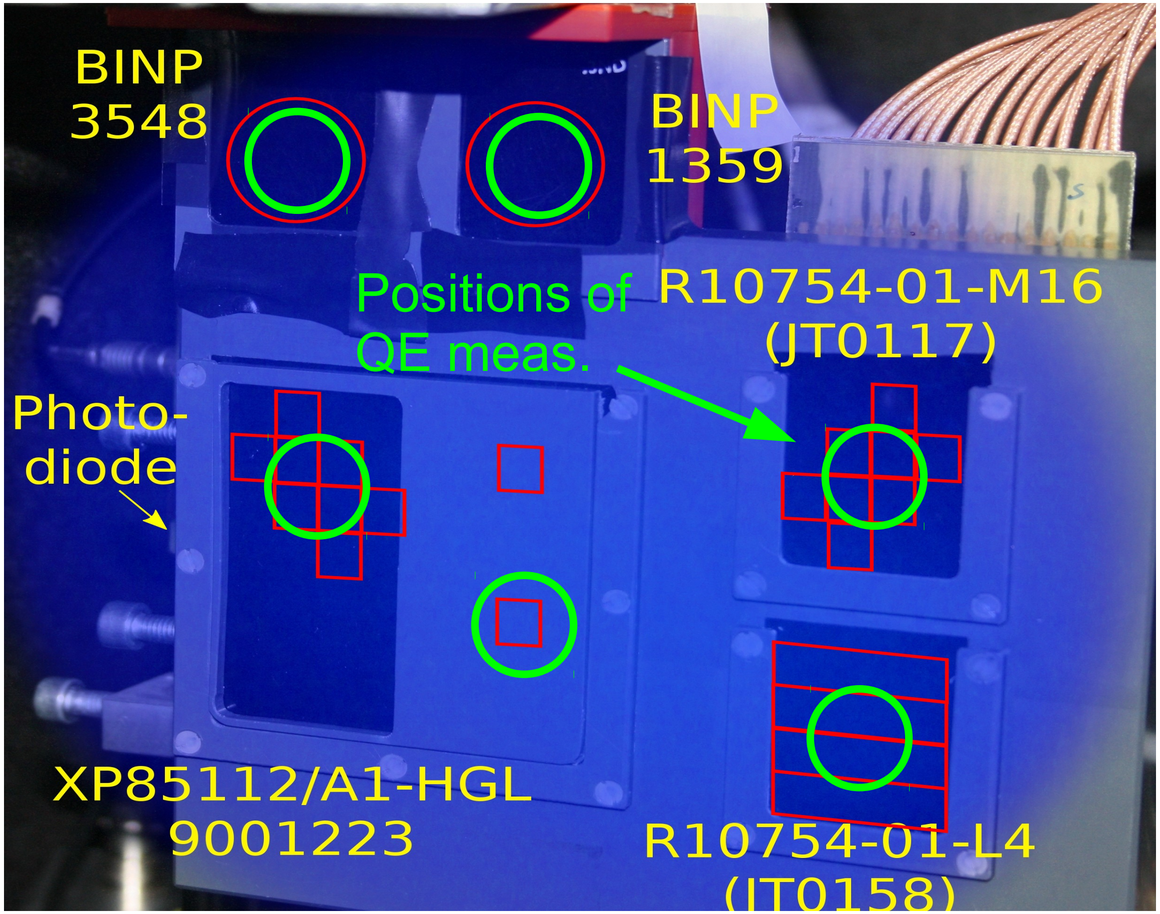
- Improved vacuum + treatment of MCP surfaces [NIM A639 (2011) 148]
  - Electron scrubbing (older PHOTONIS and new BINP)
  - Atomic layer deposition (new PHOTONIS



- New photo cathode [JINST 6 C12026 (2011)]
  - $Na_2KSb(Cs) + Cs_3Sb$ (new BINP)
    - disadvantage: significantly higher dark count rate

Measurement of MCP Lifetime

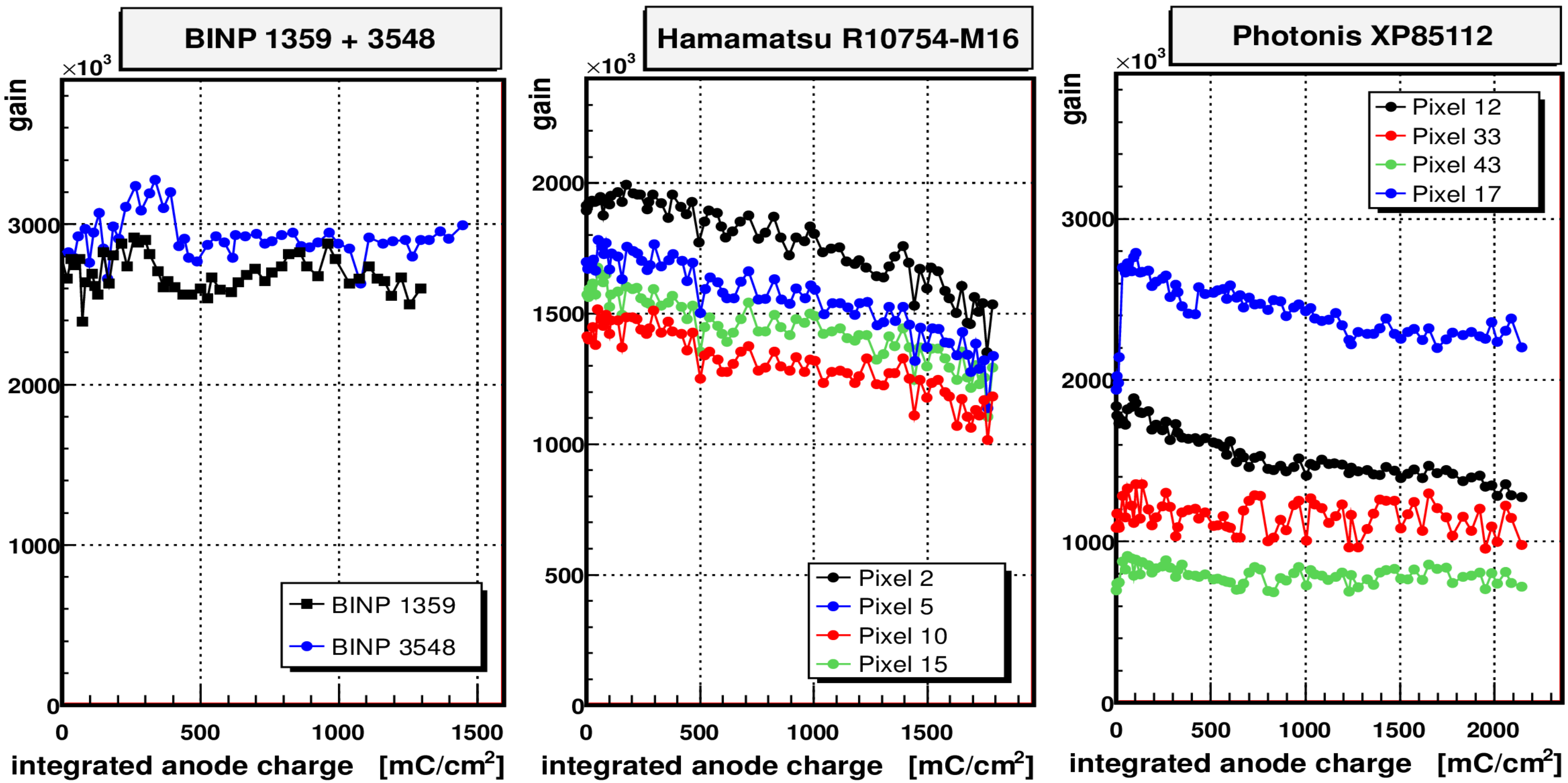
- Continuous illumination
  - 460 nm LED at 0.25 to 1 MHz rate attenuated to single photon level → 3 to 14 $mC/cm^2/day$
- Permanent monitoring
  - MCP pulse heights and LED light intensity
- Q.E. measurements
  - 300–800 nm wavelength band with monochromator $\Delta\lambda$ = 1 nm
  - every few days: wavelength scan
  - every few weeks: complete surface scan



Illumination Overview

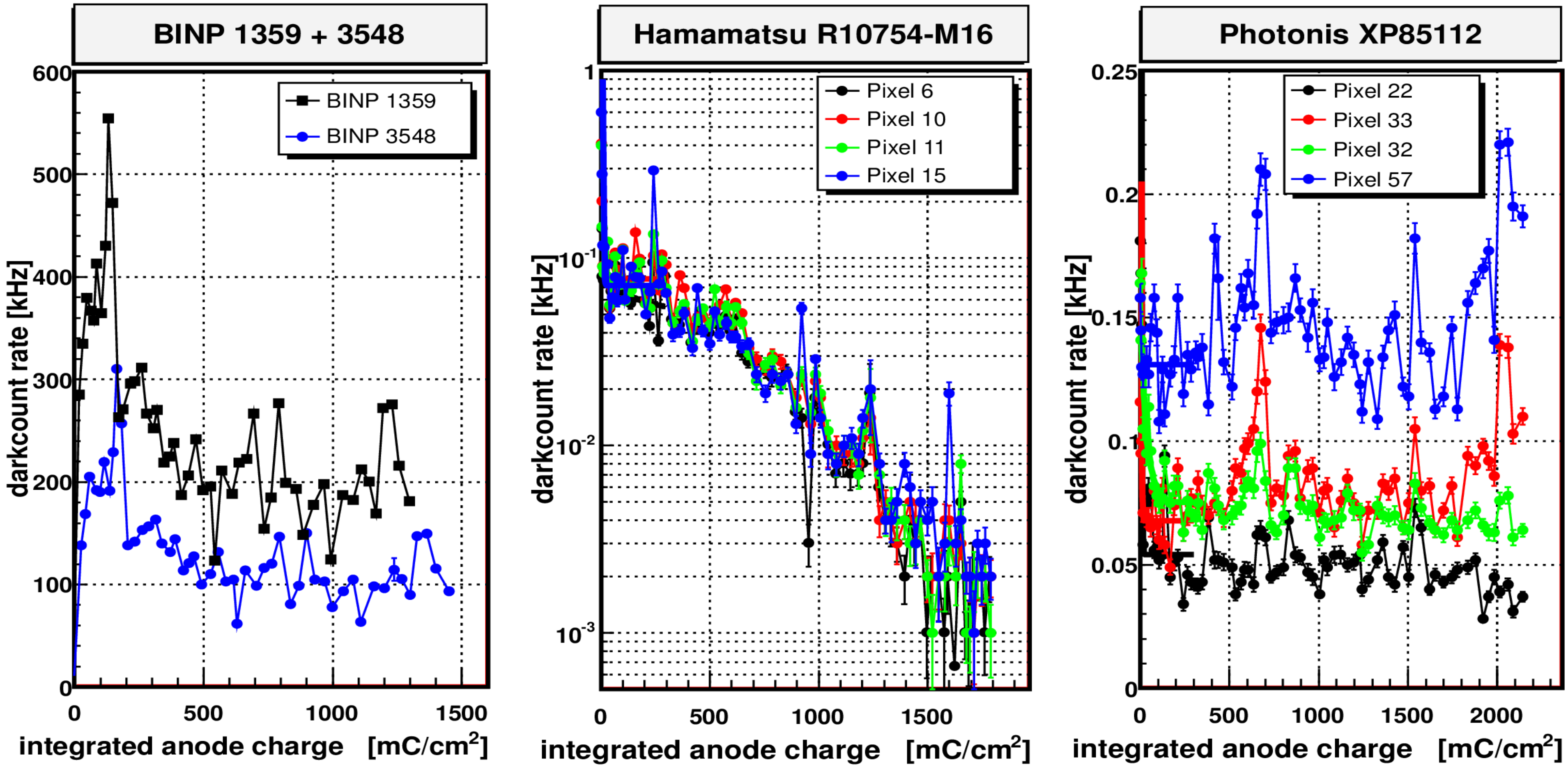
	Hamamatsu R10754X-01-M16	PHOTONIS XP85112/A1-HGL	BINP 1359	BINP 3548
Integrated Anode Charge (August 6th) [mC/cm²]	**2086**	**3021**	**2033**	**2275**
Max applied current per anode [nA]	45.3	56	315	346
Specified max. DC anode current [nA]	100	47 (64 Chans.) 94 (32 Chans.)	1000	1000
Max Differential Charge [mC/cm²/d]	**14.1**	**13.4**	**10.6**	**11.7**
Anode area per pixel (cm²)	0.32	0.36	2.54	2.54
Number of measurements	73	73	50	50
Measured Channels	8	8 + 2 (unexposed) + MCP-Out	1	1
QE-Scans	7	7	6	5
Illuminated area	100%	**50%**	100%	100%
Applied voltage using voltage divider (V)	3300	2050	3100 (+100)	3000 (+100)

Gain vs. Integrated Anode Charge



- Only moderate gain changes
- **This was different in the former MCP-PMTs !**

Darkcount vs. Anode Charge



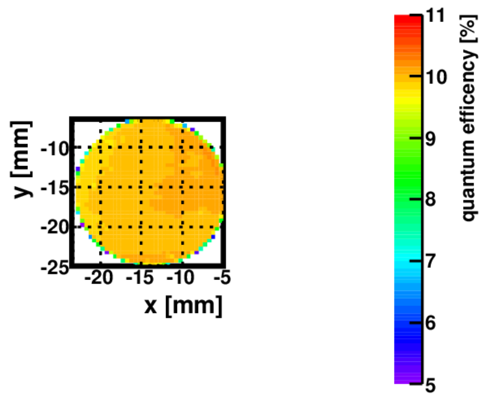
- Only few changes of darkcount rate for BINP and PHOTONIS
- **Big reduction in Hamamatsu R10754X**

Q.E. Scans

Q.E. measured at 372 nm

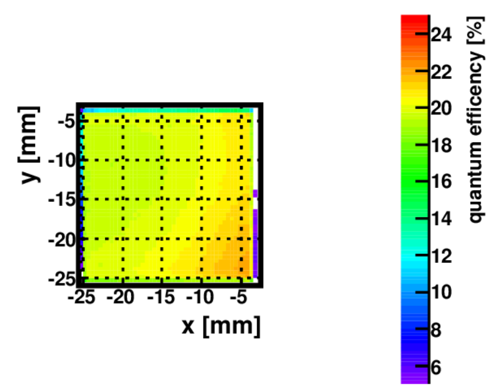
BINP 3548

186 mC/cm^2



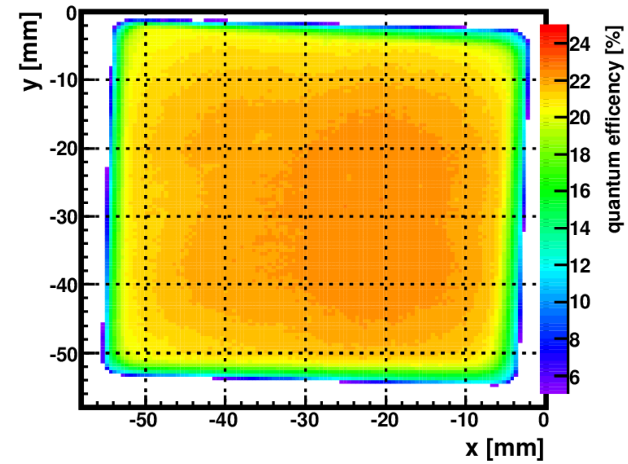
Ham. R10754X-M16

100 mC/cm^2

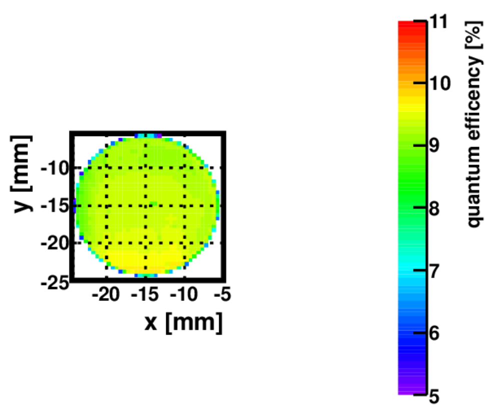


PHOTONIS XP85112

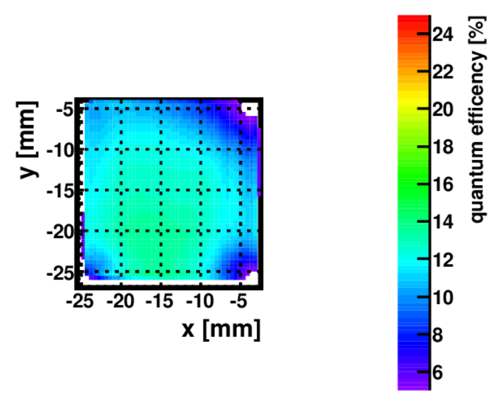
125 mC/cm^2



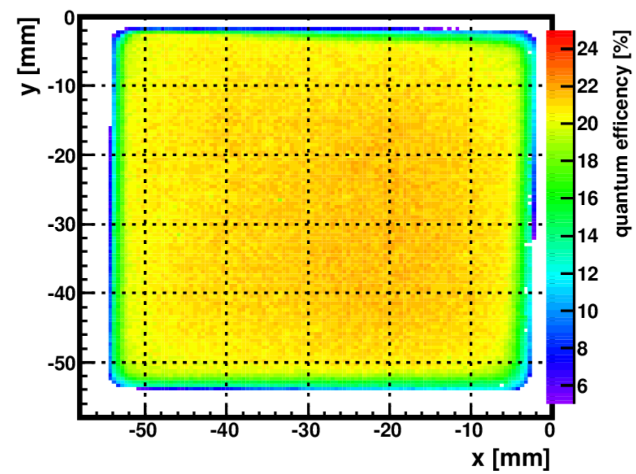
1401 mC/cm^2



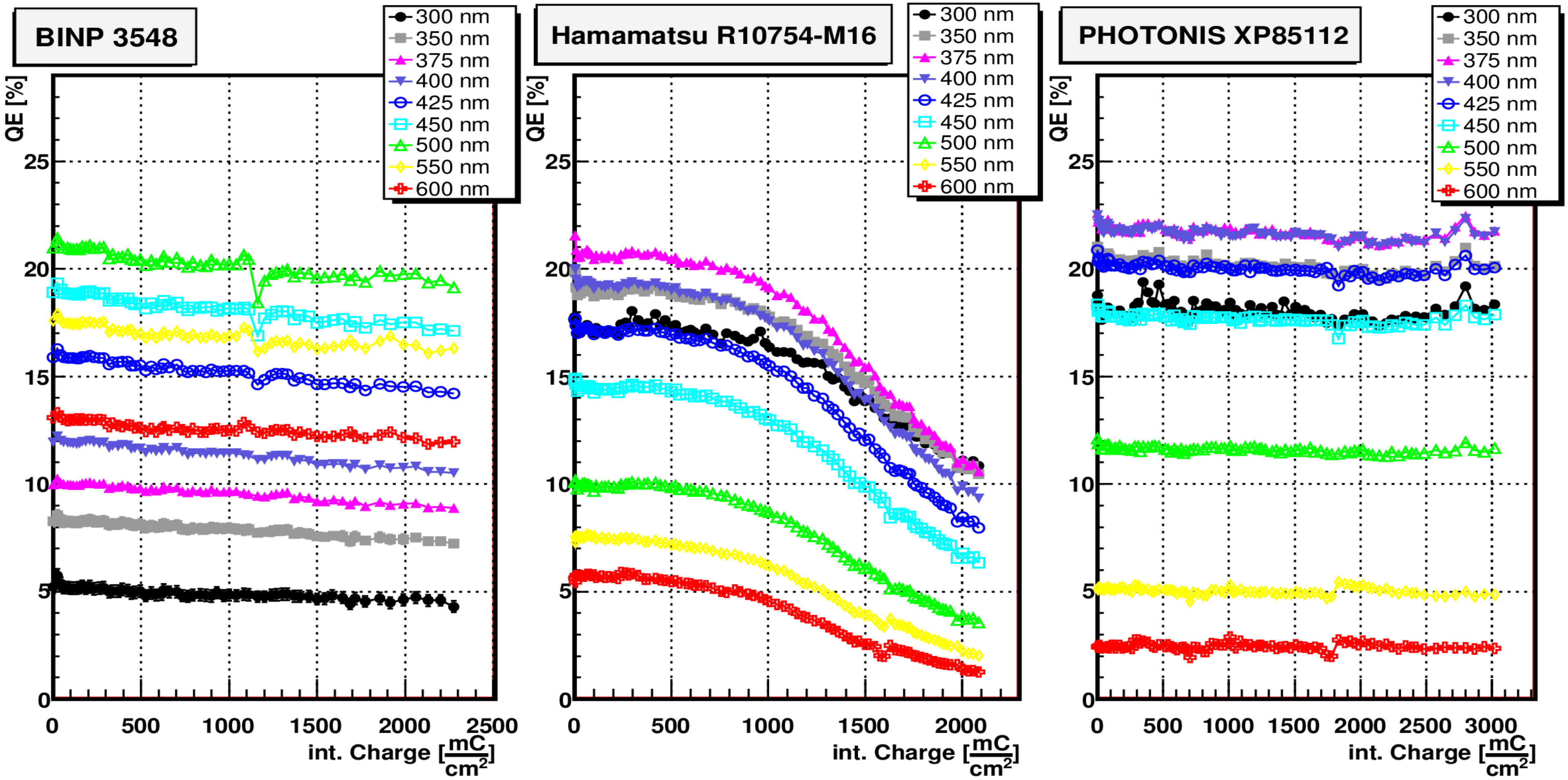
1765 mC/cm^2



2090 mC/cm^2

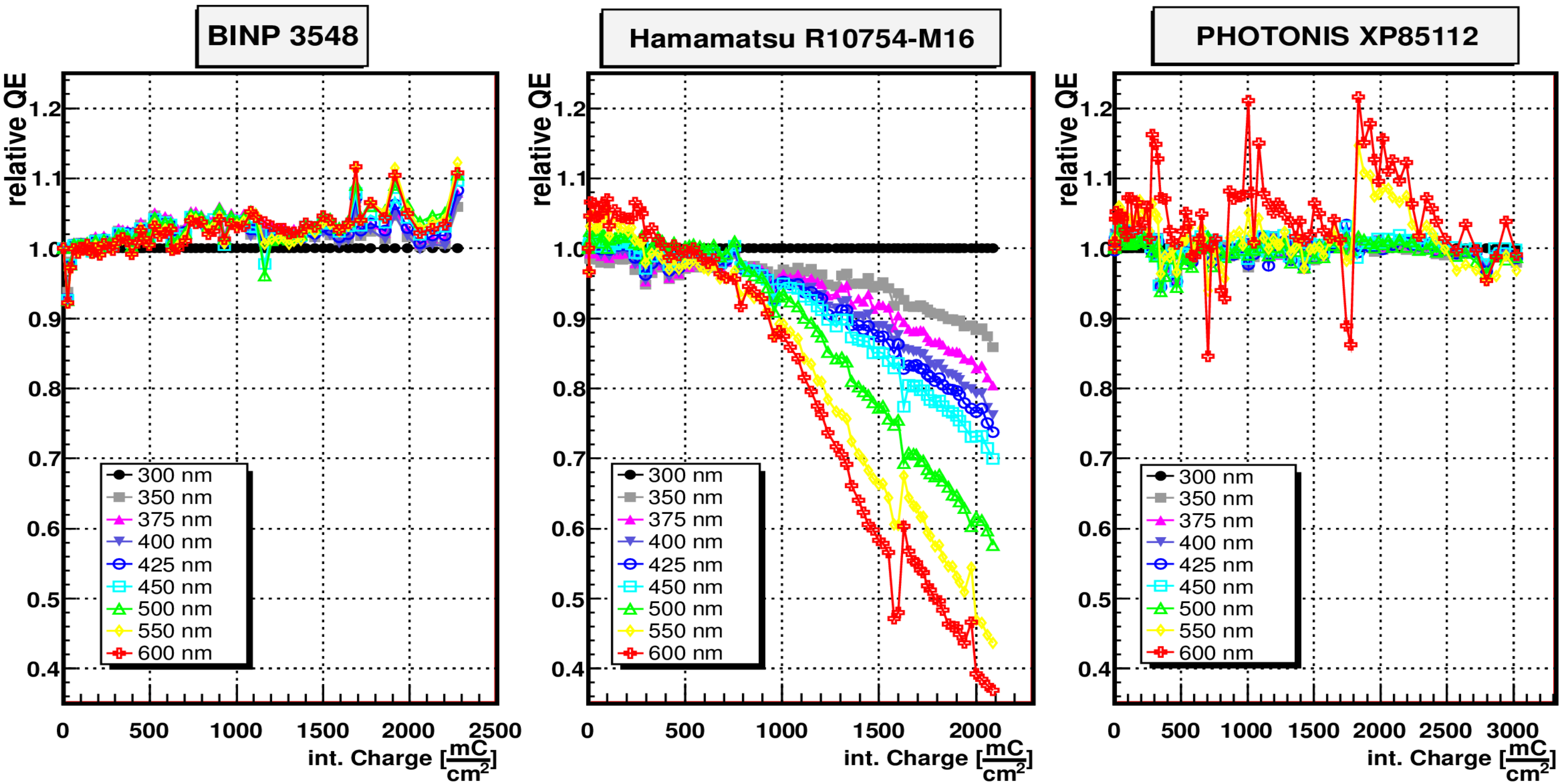


Q.E.(λ) vs. Integral Anode Charge



- Hamamatsu: Q.E. drops significantly above ~1 C/cm2
- **BINP and PHOTONIS: few or no Q.E. drop, resp.**

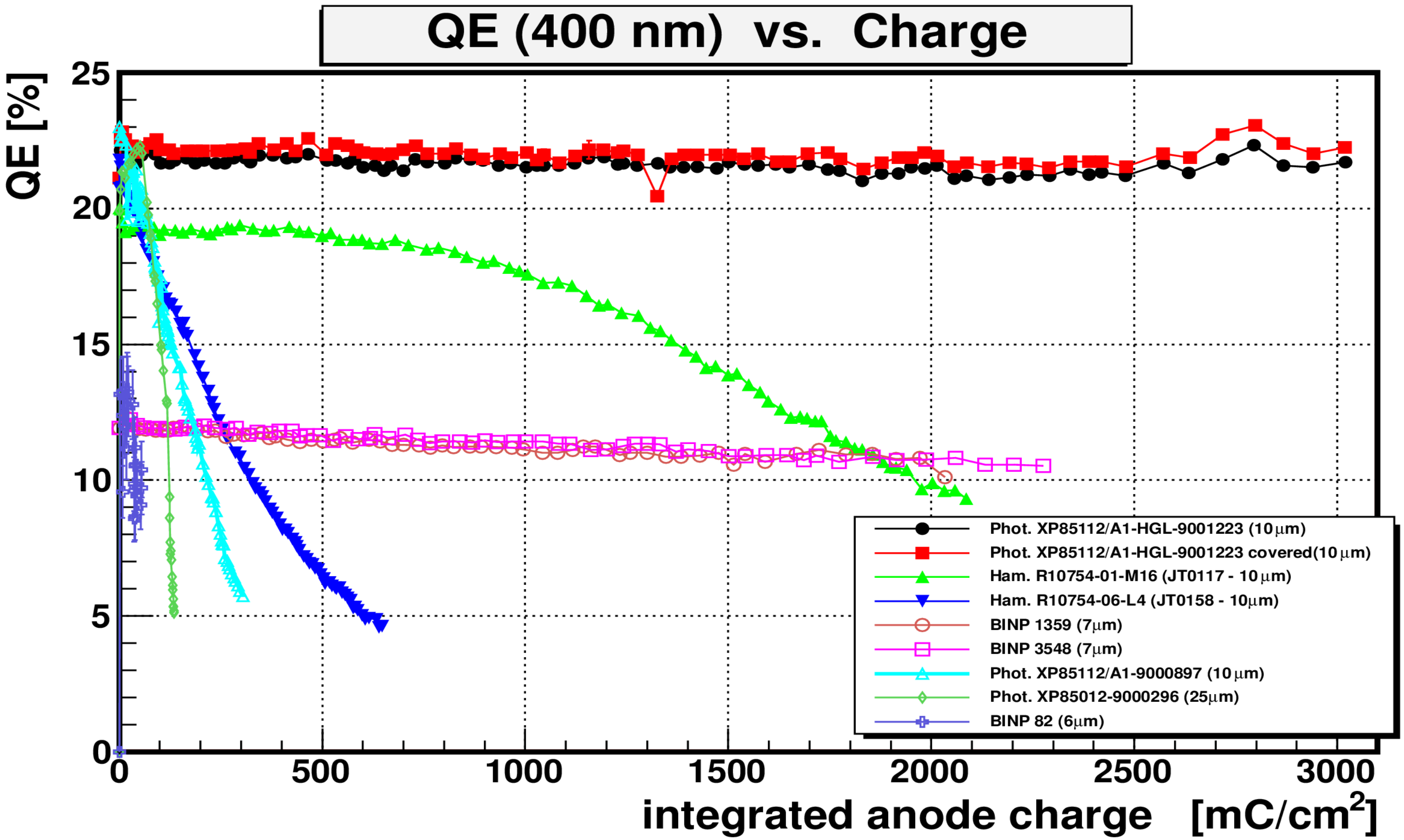
Relative Q.E.(λ) vs. Anode Charge



<u>Ham. R10754X-M16:</u> longer wavelengths drop faster than short ones

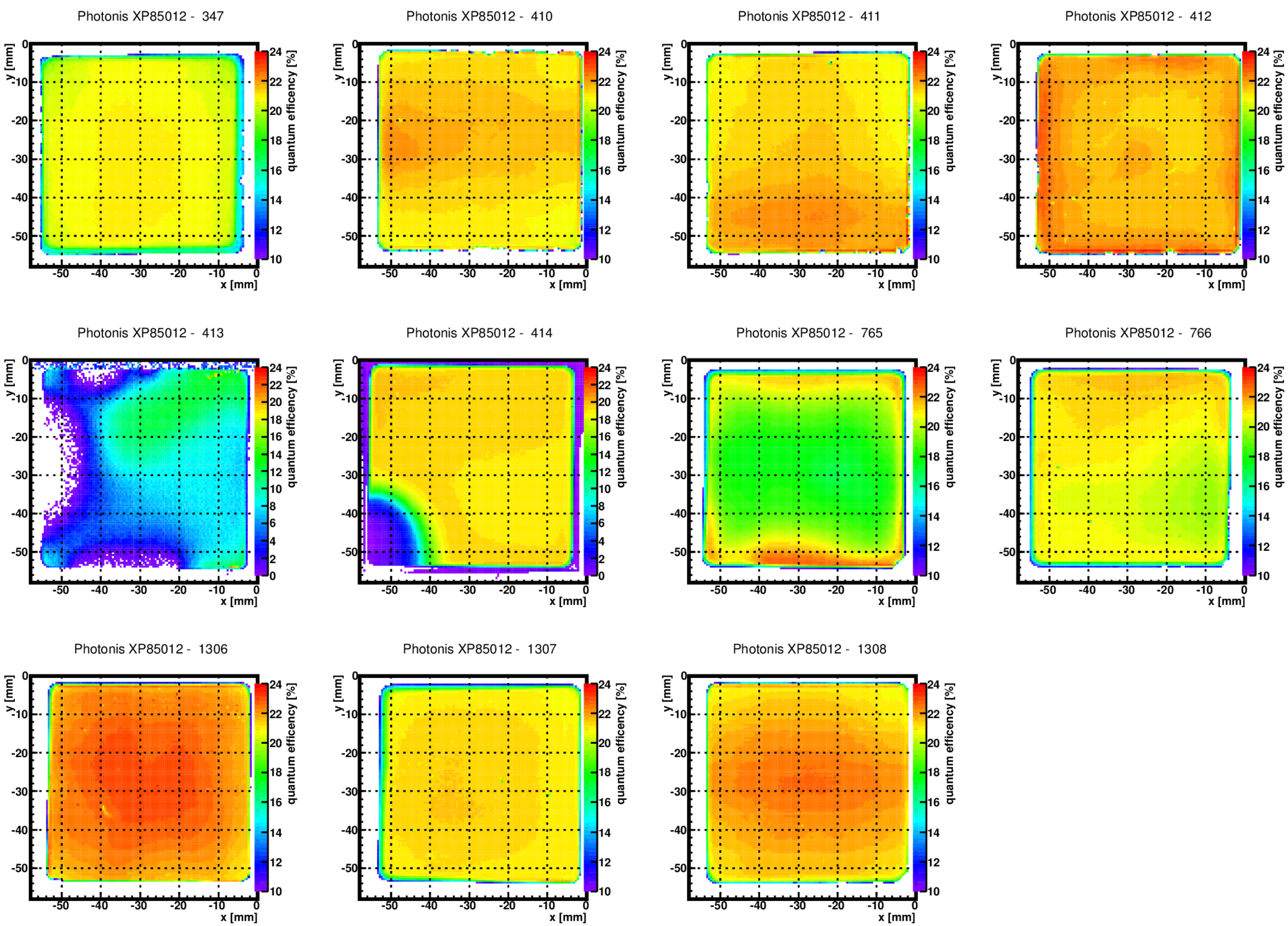
<u>BINP 3548 and PHOTONIS XP85112:</u> **no relative Q.E. degradation**

Lifetime of Different MCP-PMTs



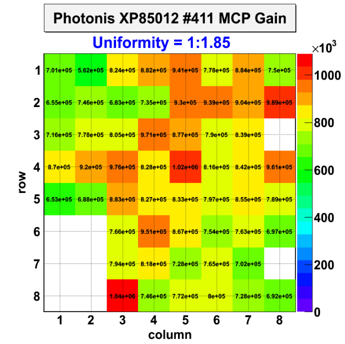
- older BINP and PHOTONIS MCP-PMTs: rapid Q.E. degradation
- new PHOTONIS XP85112: **still no Q.E. drop at >3 C/cm^2**

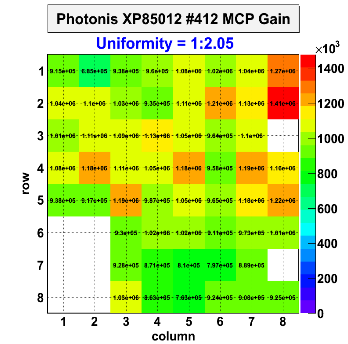
QE Comparison of XP85012

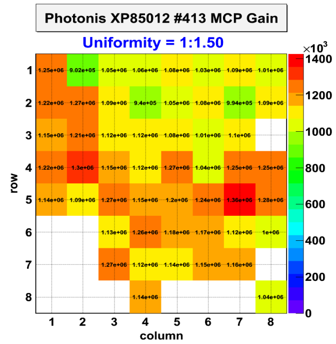


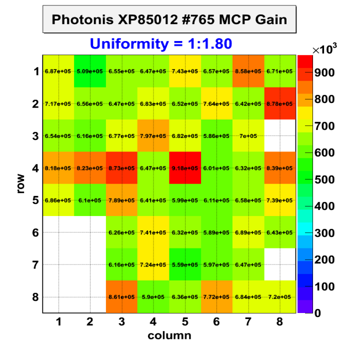
- Tube #413 and #414 with significantly lower QE in certain regions

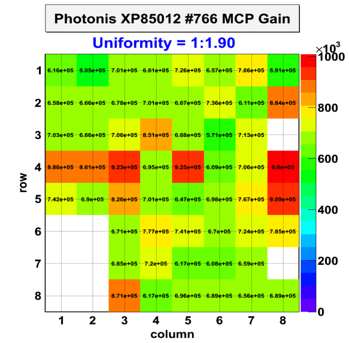
Gain Comparison of XP85012

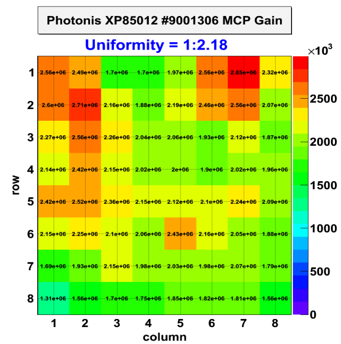


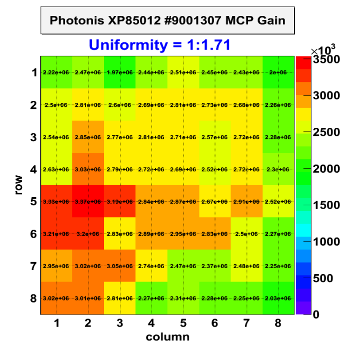


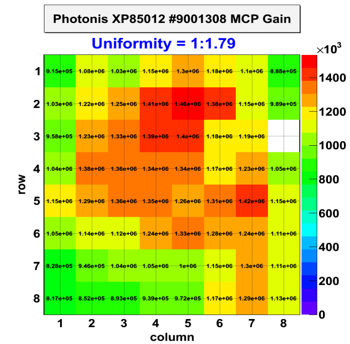












- Tube #347, #410 and #414 with lower gain --> ask Fred

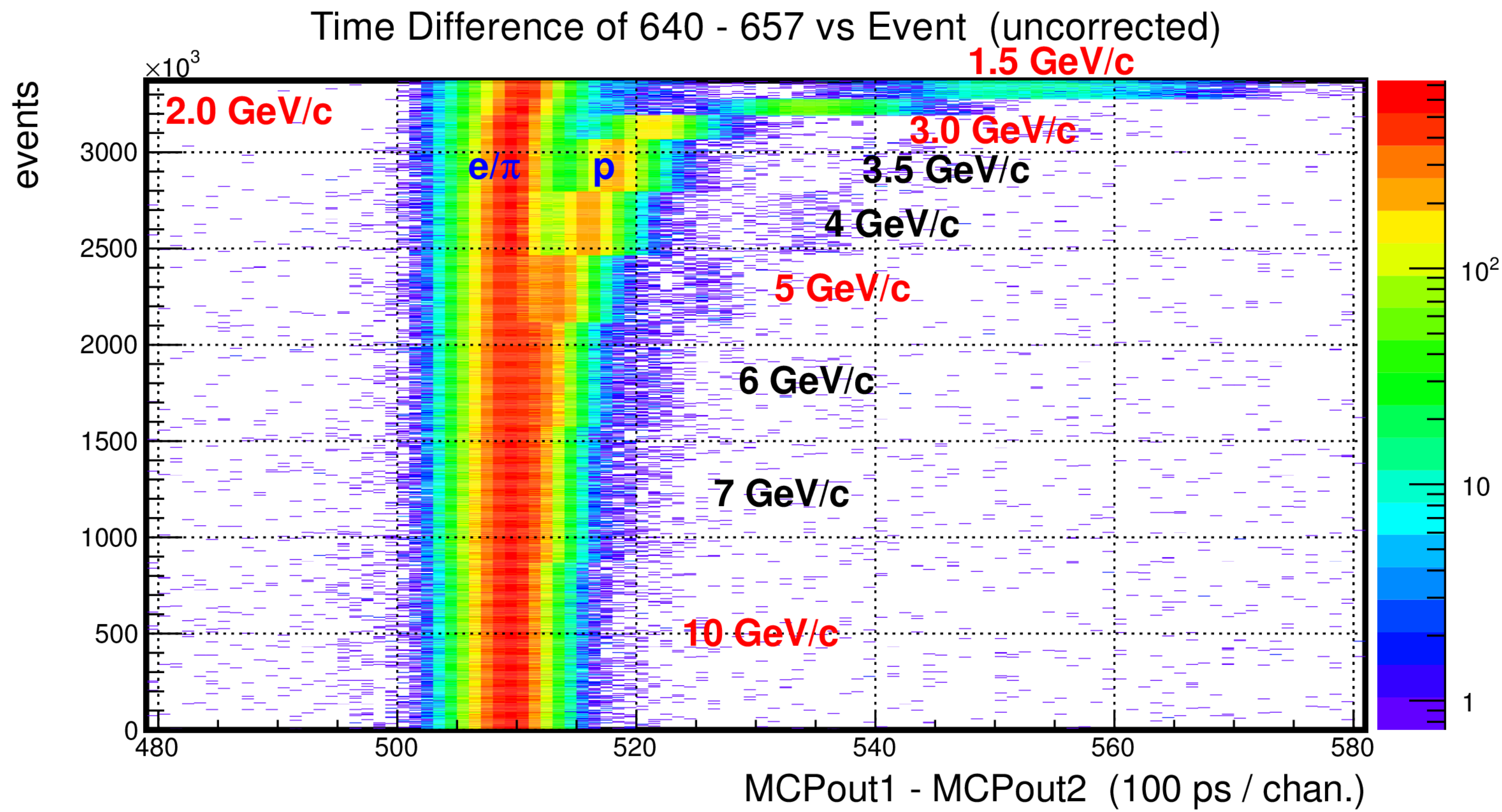
MCP-TOF

- **Goal:** particle identification using time-of-flight (TOF) with picosecond resolution

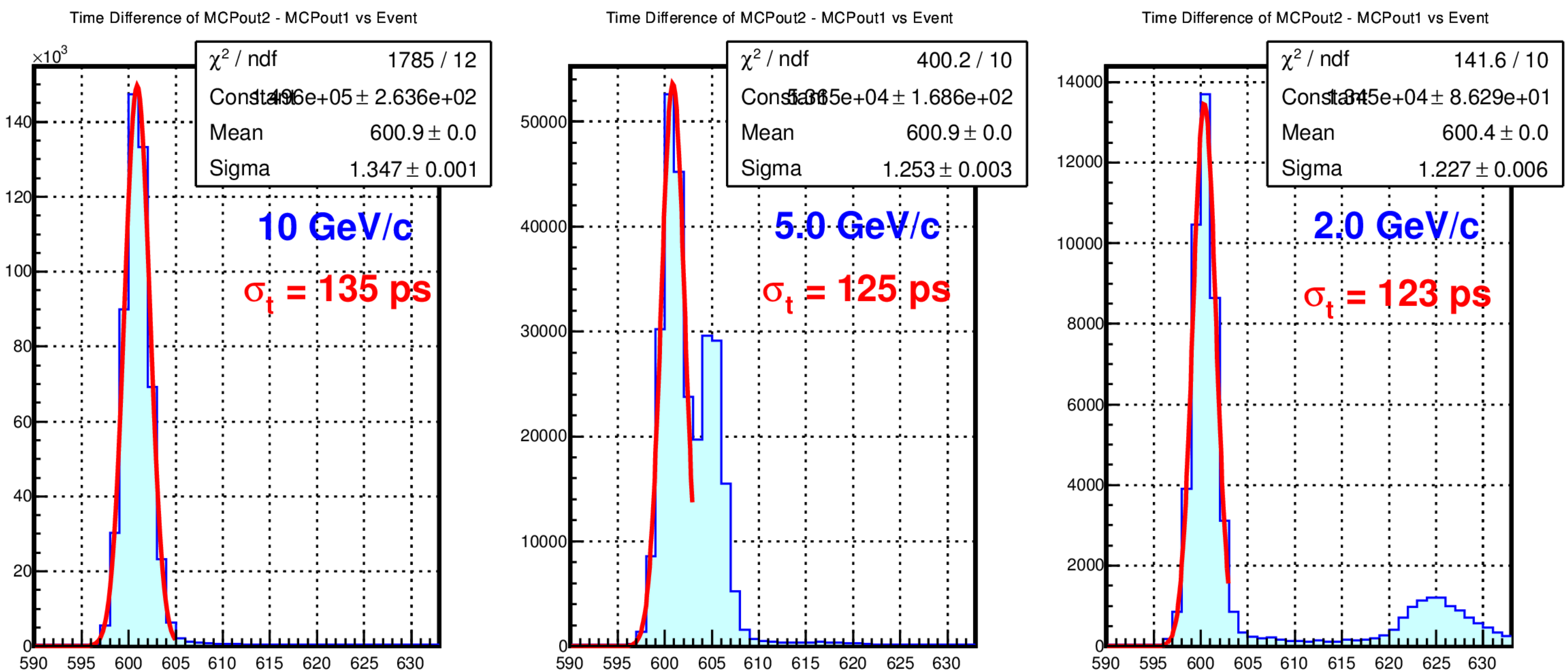
- Equipment:
  - Two XP85012 MCP-PMTs with plexi-glass radiator (10 and 20 mm)
  - Always 4 pixels shorted --> ~ 13x13 mm2 spacial resolution
  - **MCPout + 16 pixels --> TOF + tracking**

- Setup at CERN (T9):
  - 2 MCP stations ~7.5 m apart
  - position adjustable in x and y
  - reached π/p separation up to ~5 GeV/c

TOF Separation for e/π and p

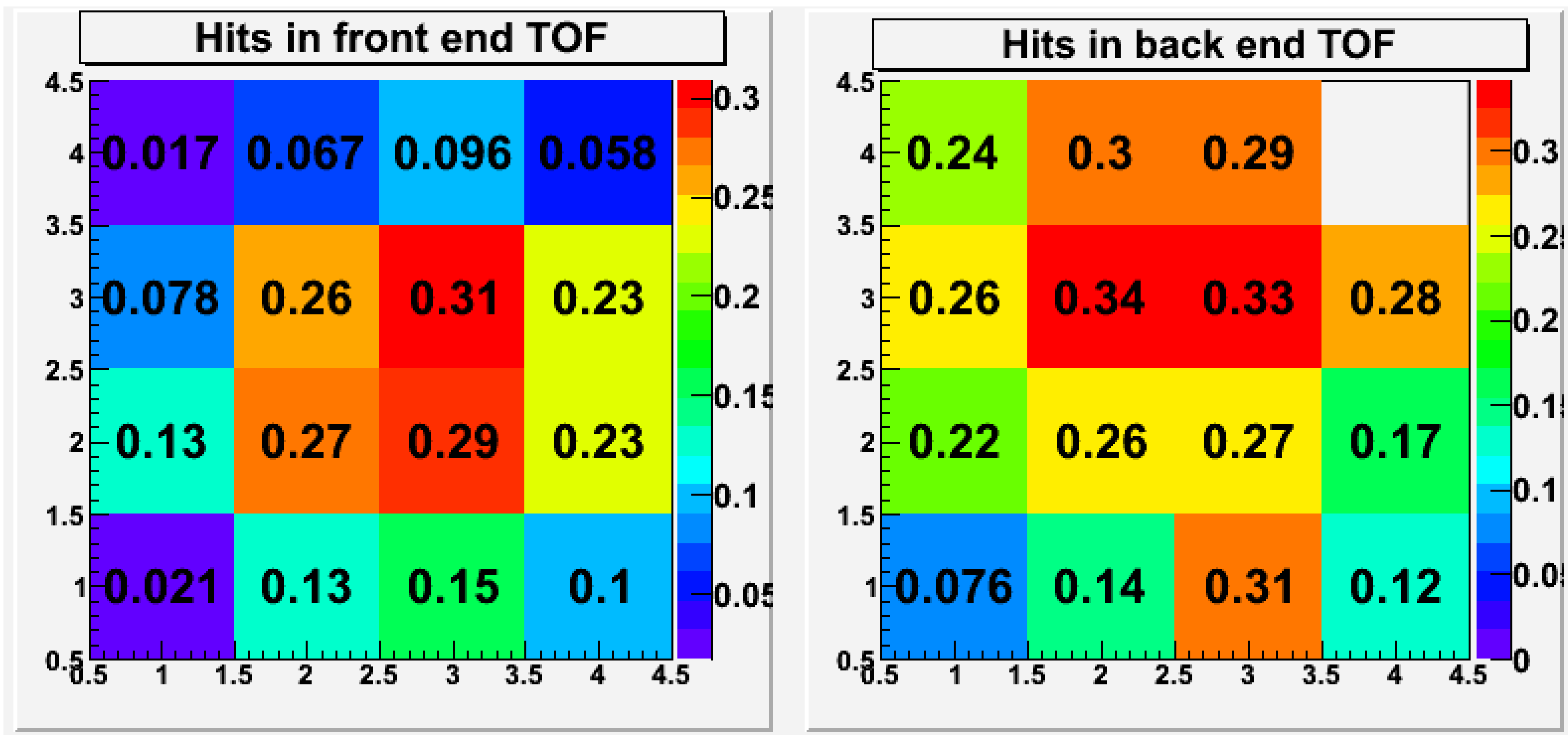


TOF Separation for e/π and p



- Pions and protons well separated at 5 GeV/c
- **Time resolution per MCP better than 100 ps**

Beam profile with MCP-TOF



- Beam position centered at front MCP-PMT (3.5 GeV/c)
- Beam center slightly shifted and wider at rear MCP-PMT

Summary

- **Significant increase of lifetime of MCP-PMTs** due to the recent improvements in design
  - **huge step forward !**
  - equipping the PANDA barrel DIRC with MCP-PMTs is in reach
  - **ALD technique appears very promising**

- MCP-TOF seems to work well
  - Pion/proton separation up to 5 GeV/c at 7.5 m flight path
  - Much better time resolution should be possible with time walk correction (not possible with current setup)
  - For pion/kaon separation at >2 GeV/c better time resolution needed