Update on lifetime measurements

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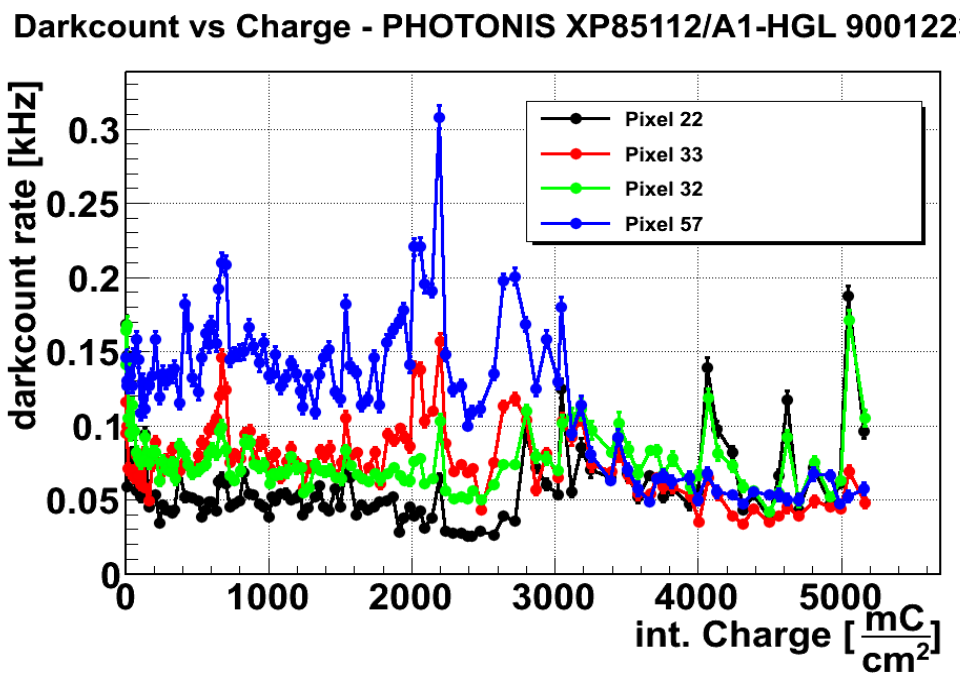
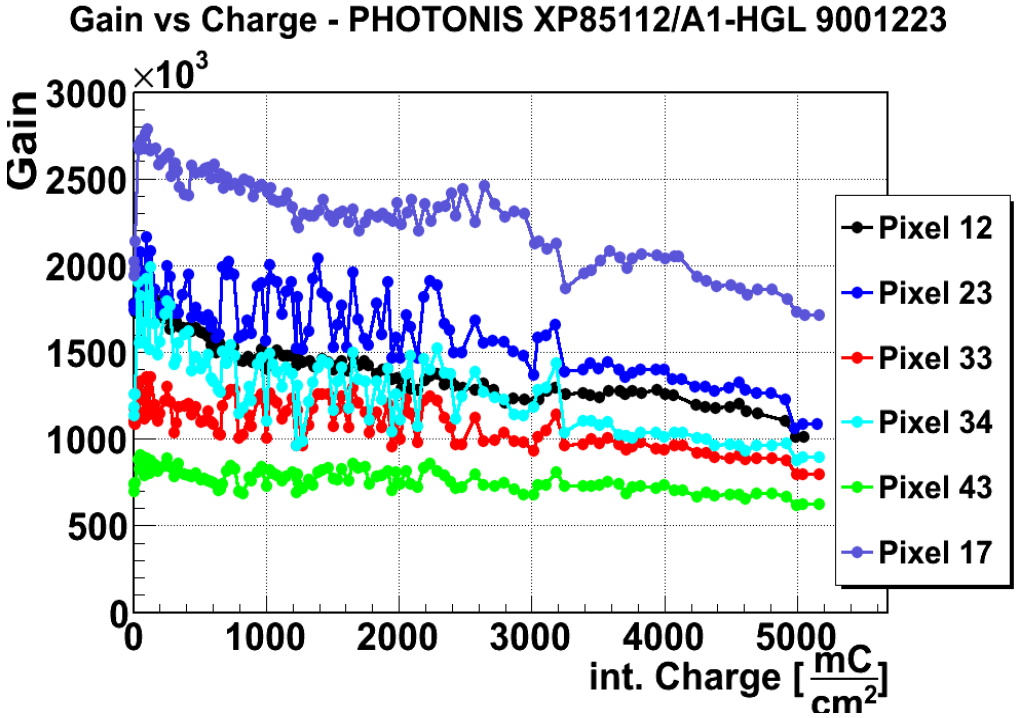
supported by BMBF and GSI

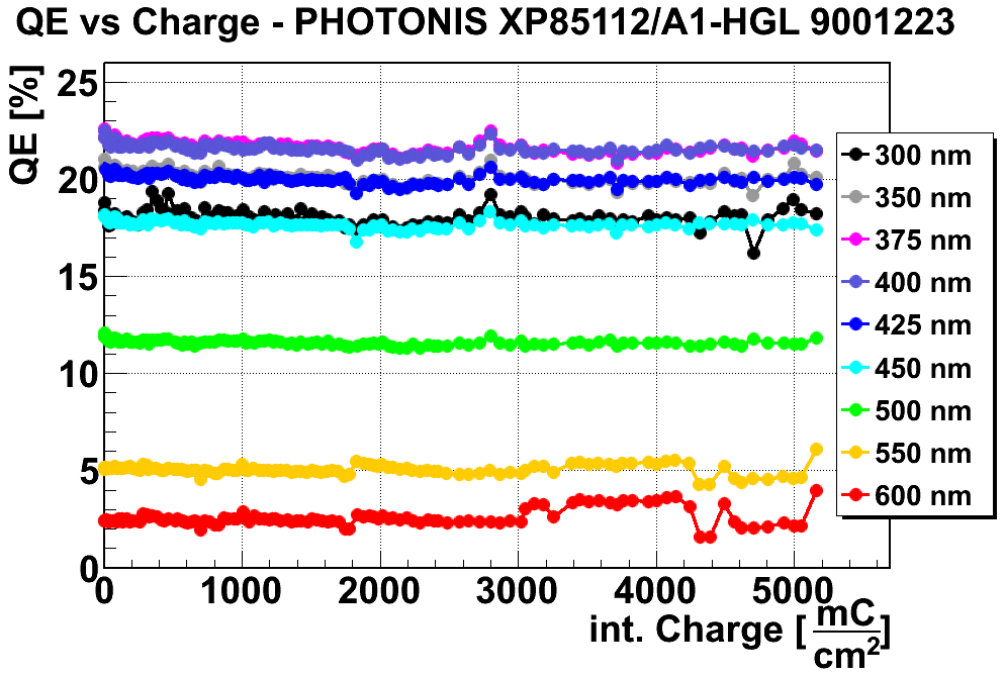
Overview

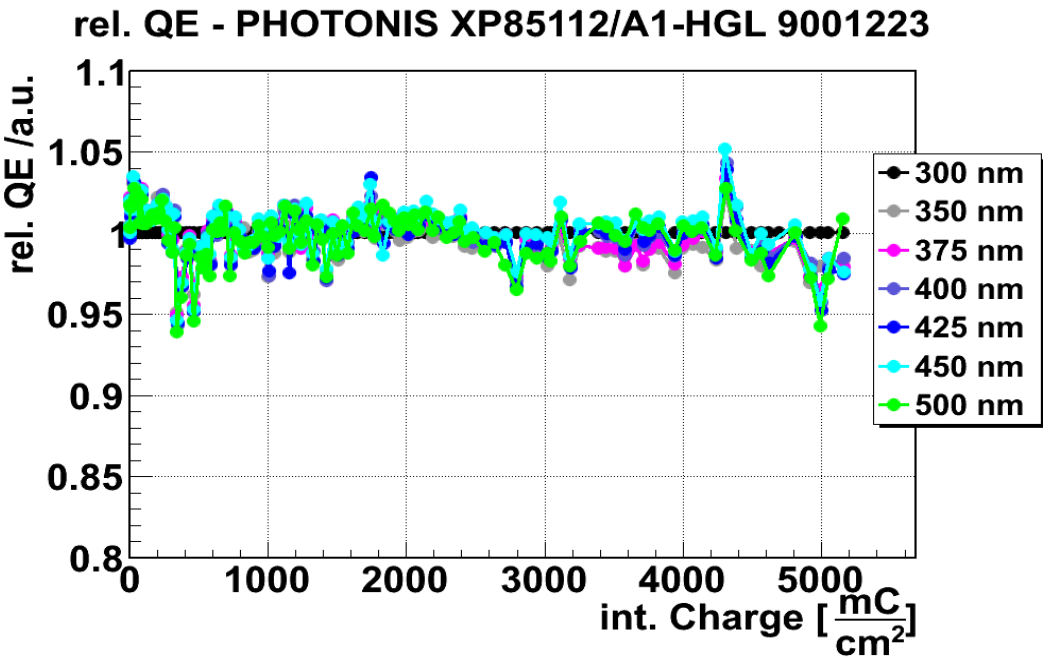
- Recent results of the latest lifetime measurements:
  - XP85112/A1-HGL 9001223 (long illuminated device)
  - XP85112/A1-D 9001332 (illumination started recently)
- Summary and outlook

Aging of XP85112/A1-HGL 9001223

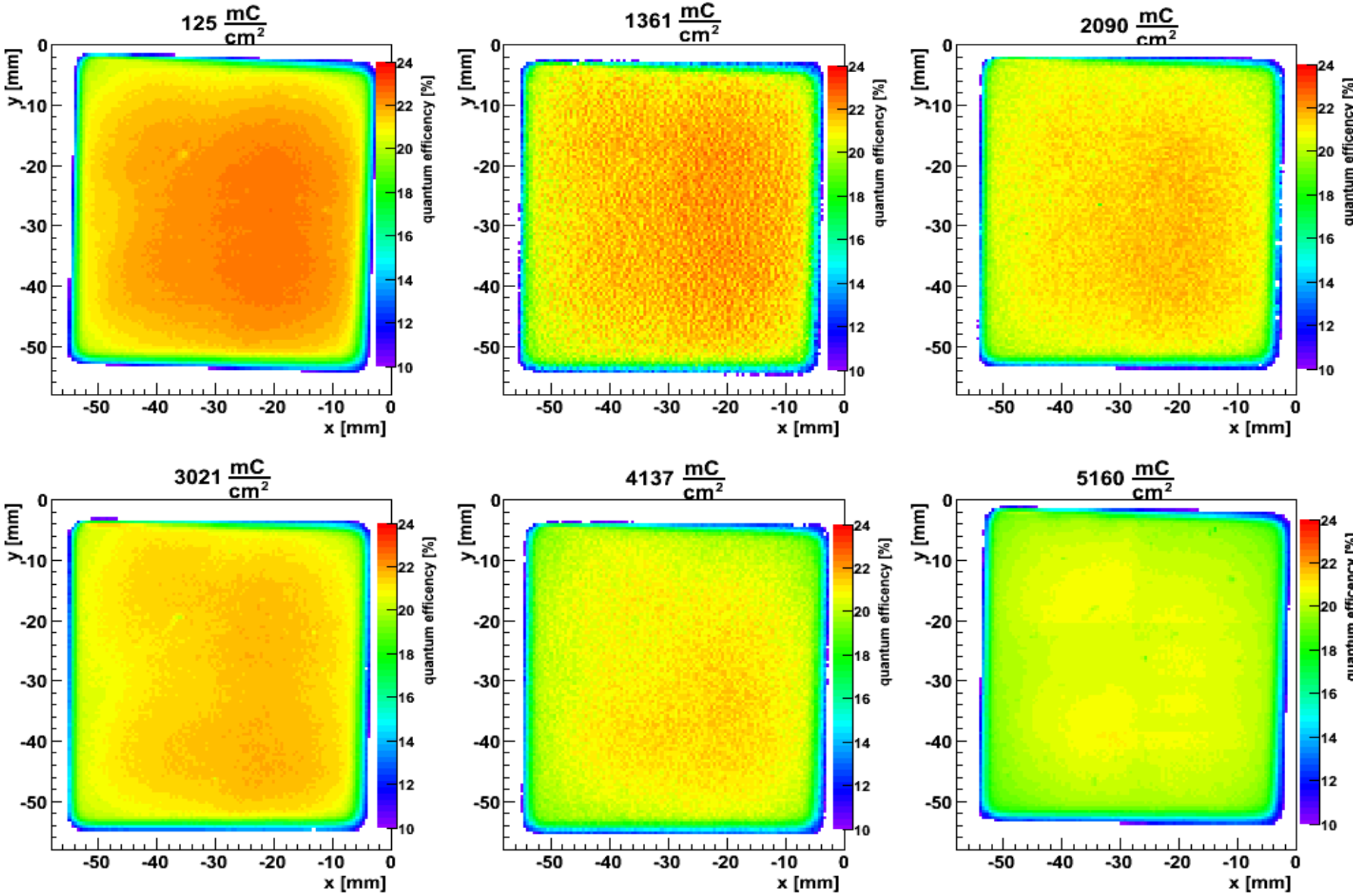






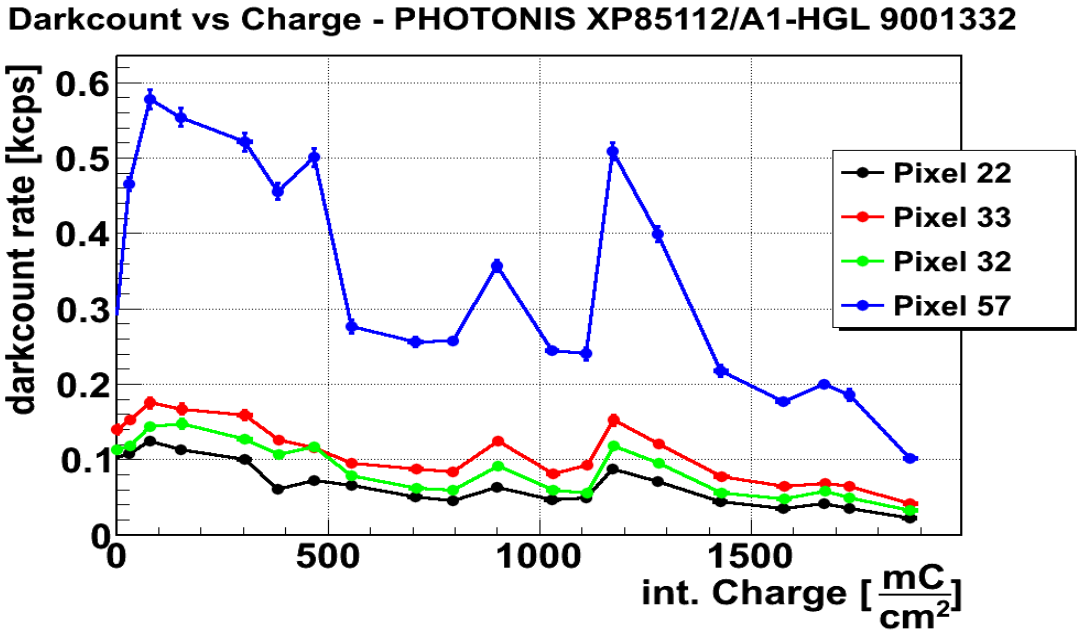


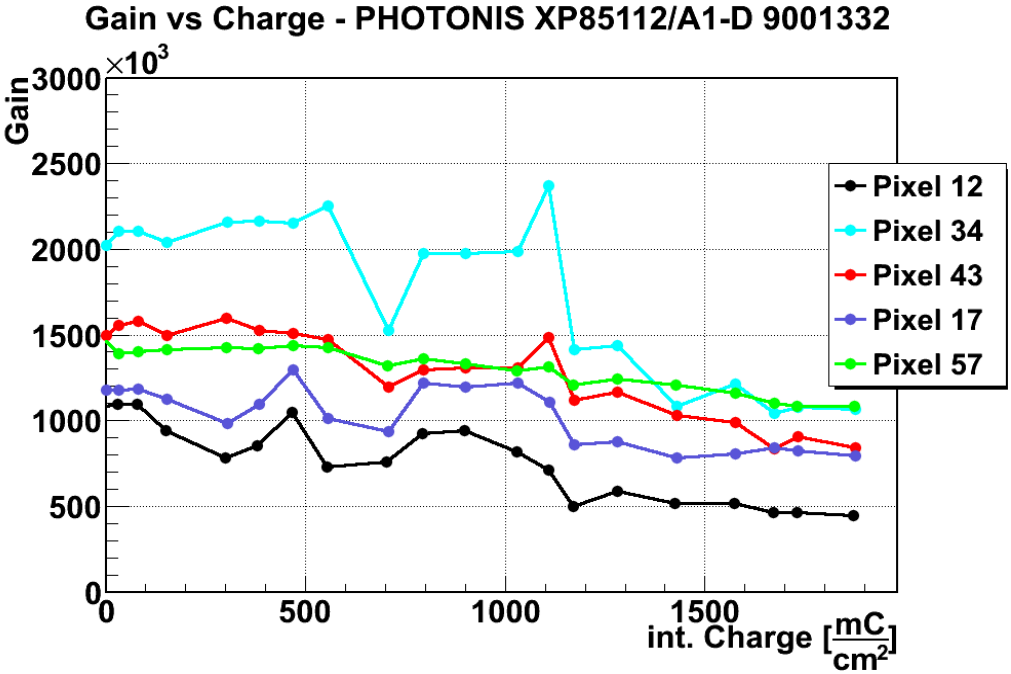
QE-Scans XP85112/A1-HGL 9001223

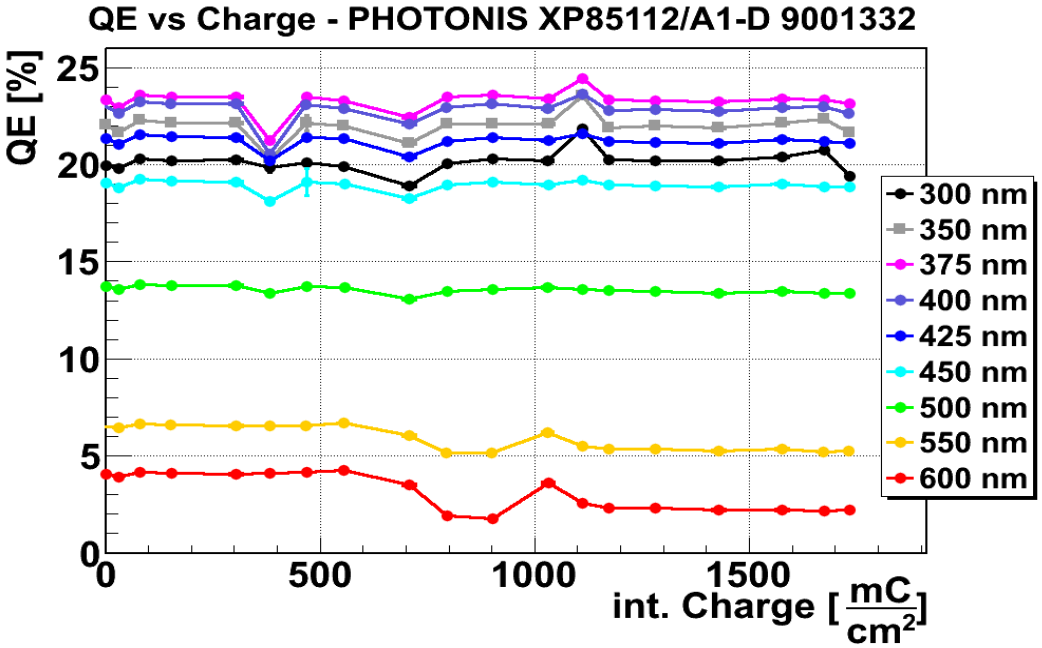


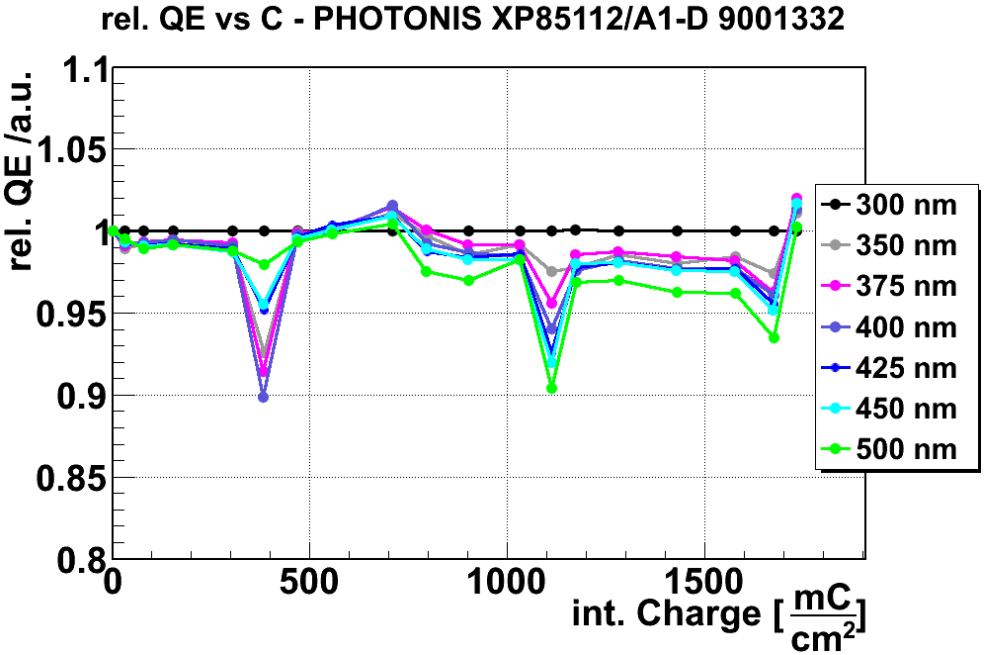
Aging of XP85112/A1-HGL 9001223 is homogenous!

Aging of XP85112/A1-D 9001332

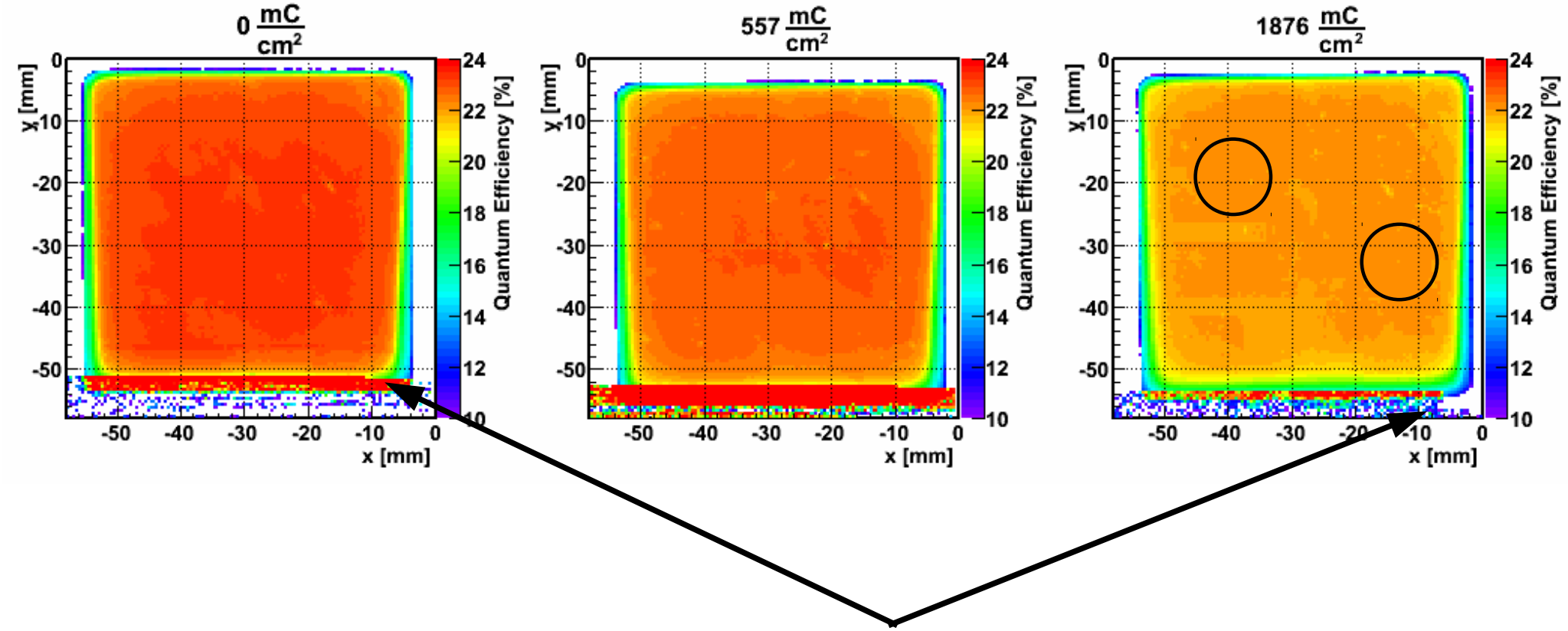






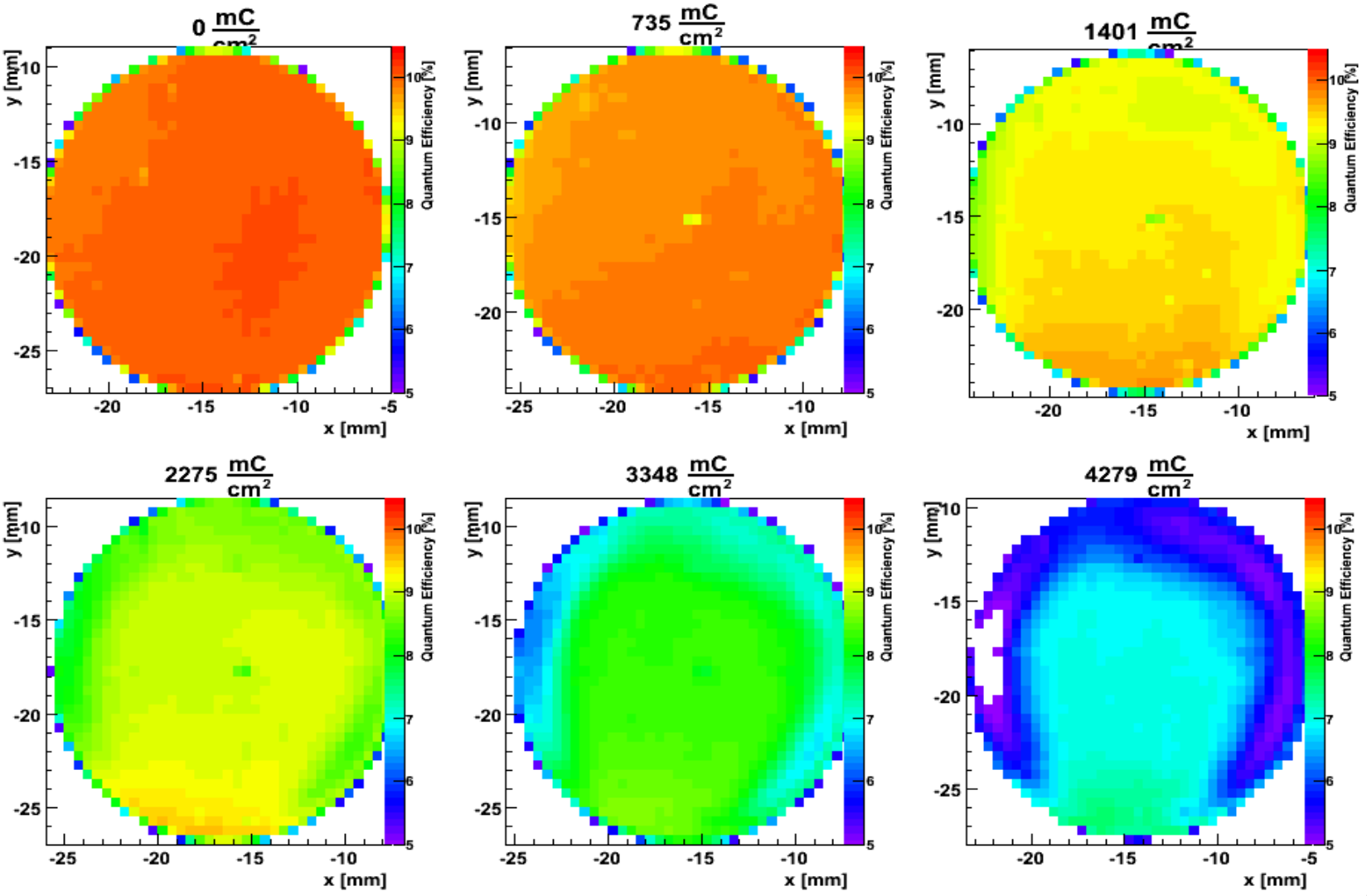


QE-Scans XP85112/A1-D 9001332



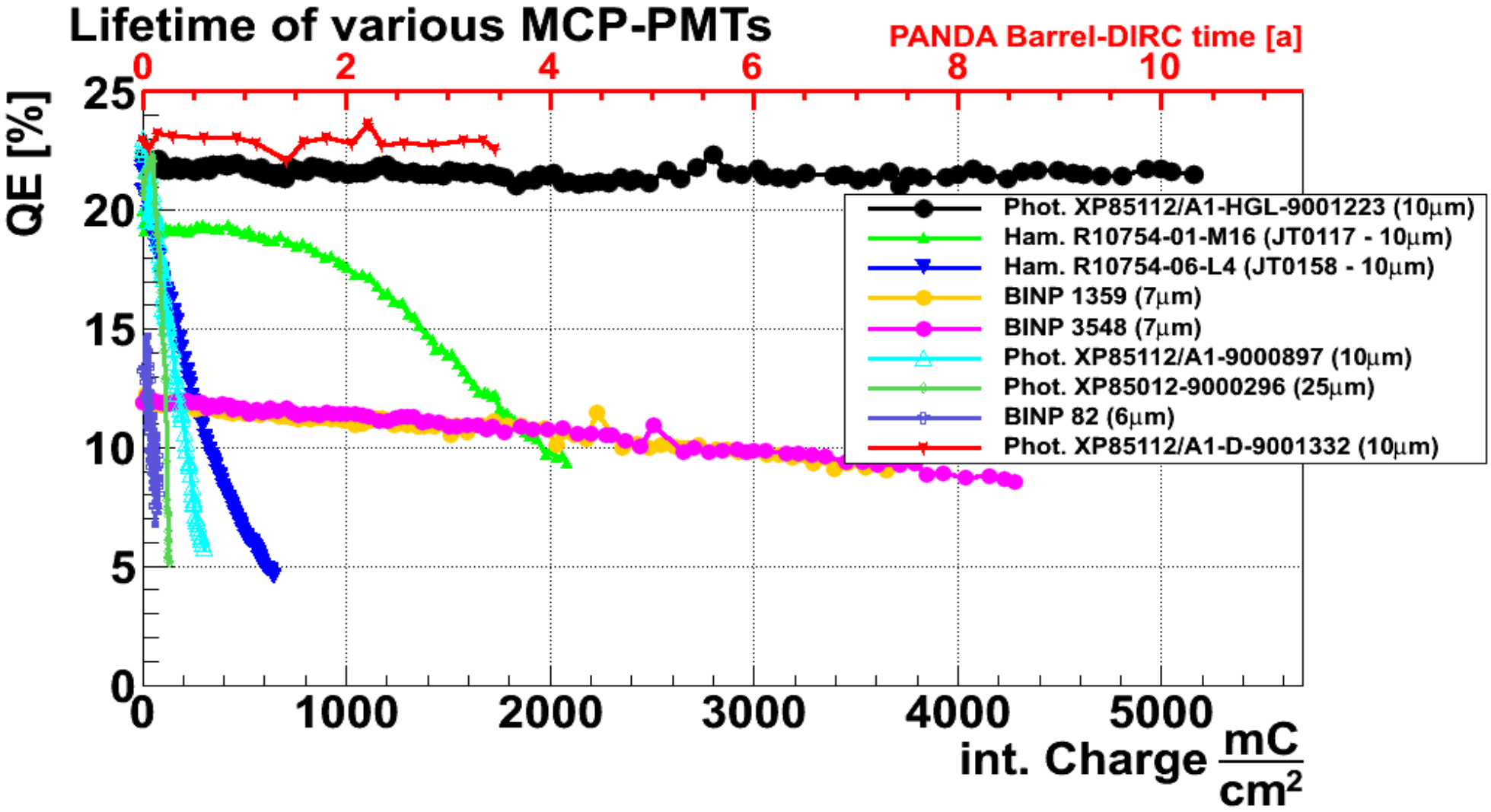
Devices still gets instable after illuminating 'problematic area'

QE-Scan BINP 3548



The aging of the sensor has started at the rim and continues

Comparison with older measurements



- XP85112/A1-HGL – 9001223 has passed PANDA Barrel-DIRC requirements!
- XP85112/A1-D – 9001332 has already passed 2.7 PANDA-Barrel-Years!
- Performance of BINP #3548 is still good

Correlation of darkcount and QE

- Motivation: QE is correlated to work function, but depends on surfaces states and structure

  → angle resolution needed to determine surfaces states, but access is not possible

  → assumption: QE degradation can be described by change of work function

- Idea: Richardson-Dushman equation describes thermal emission of 'hot' surfaces
  → access to work function

$$j = AT^2 e^{\left(\frac{-W_e}{k_B T}\right)} \qquad A \approx \frac{4\pi m_e k_B^2 e}{h^3} = 1.2 * 10^6 \frac{A}{m^2 K^2}$$

Problem: A depends on surface structure → if surface of cathode changes during illumination, A might change

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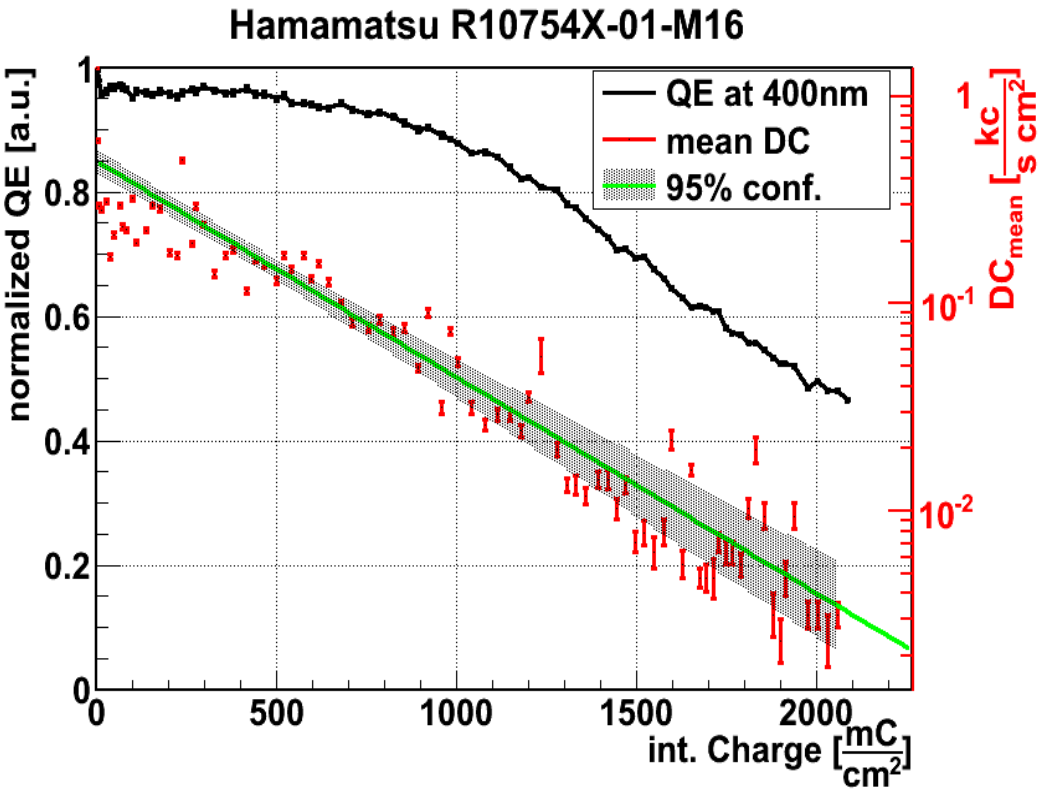
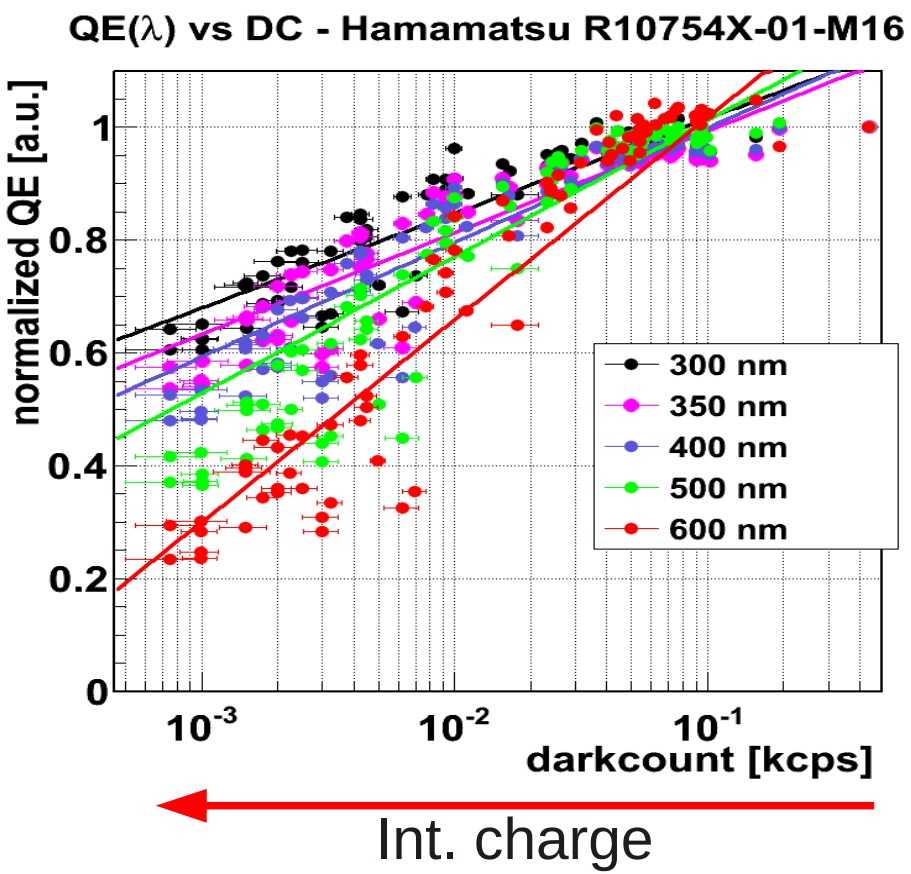
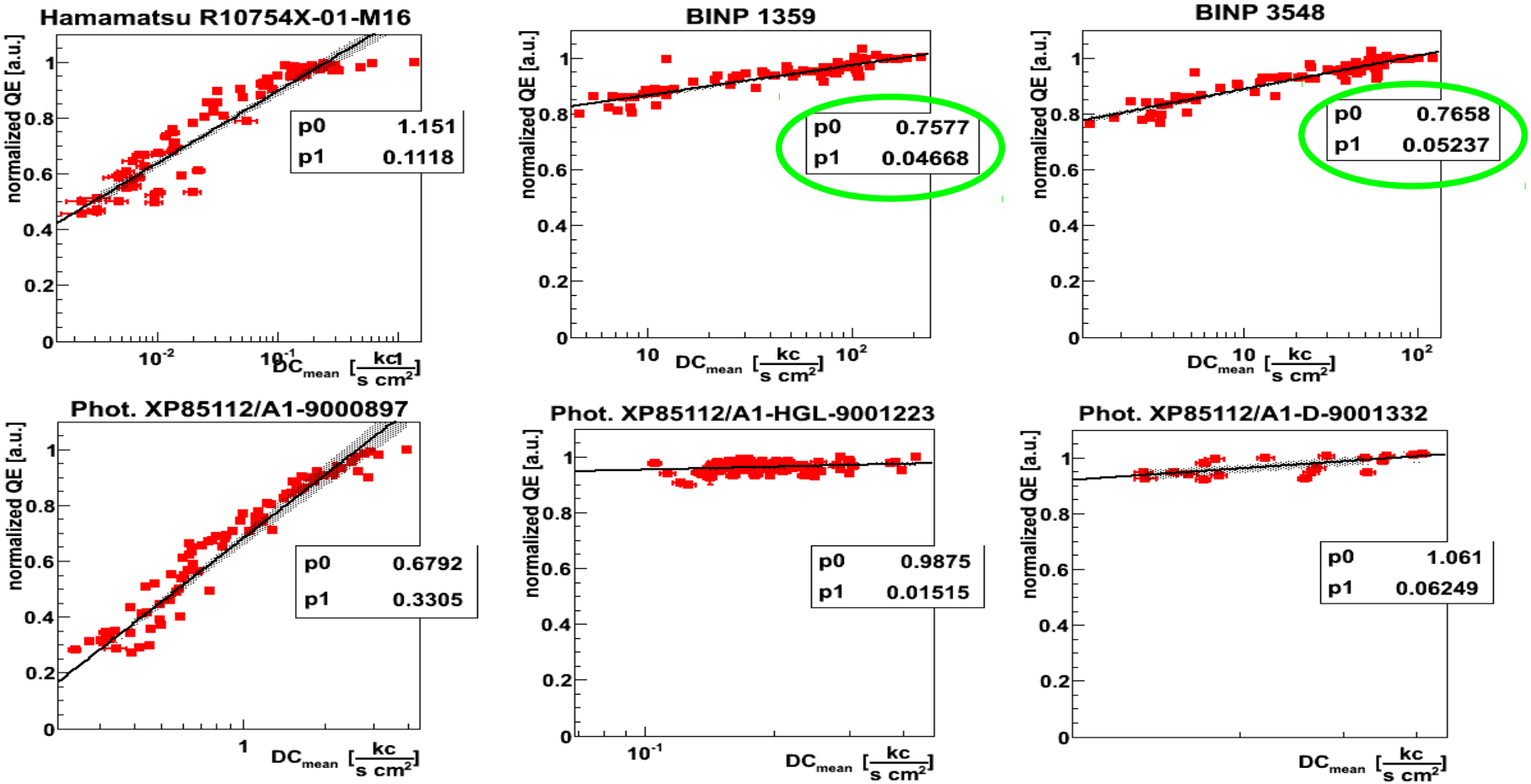
DC vs QE





- Slope increases for higher wavelengths, since QE drops faster for higher wavelengths (except BINPs)
- Darkcount is averaged for multipixel sensors
- All aging devices behave similar

DC vs QE (2)

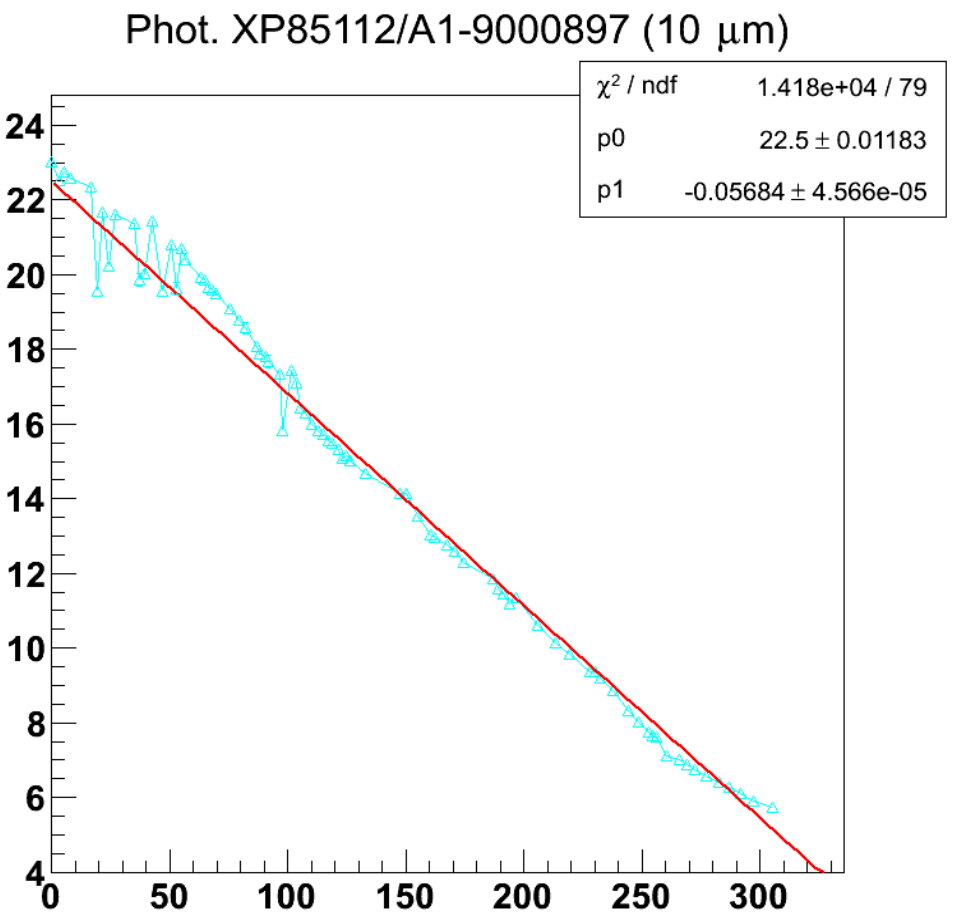


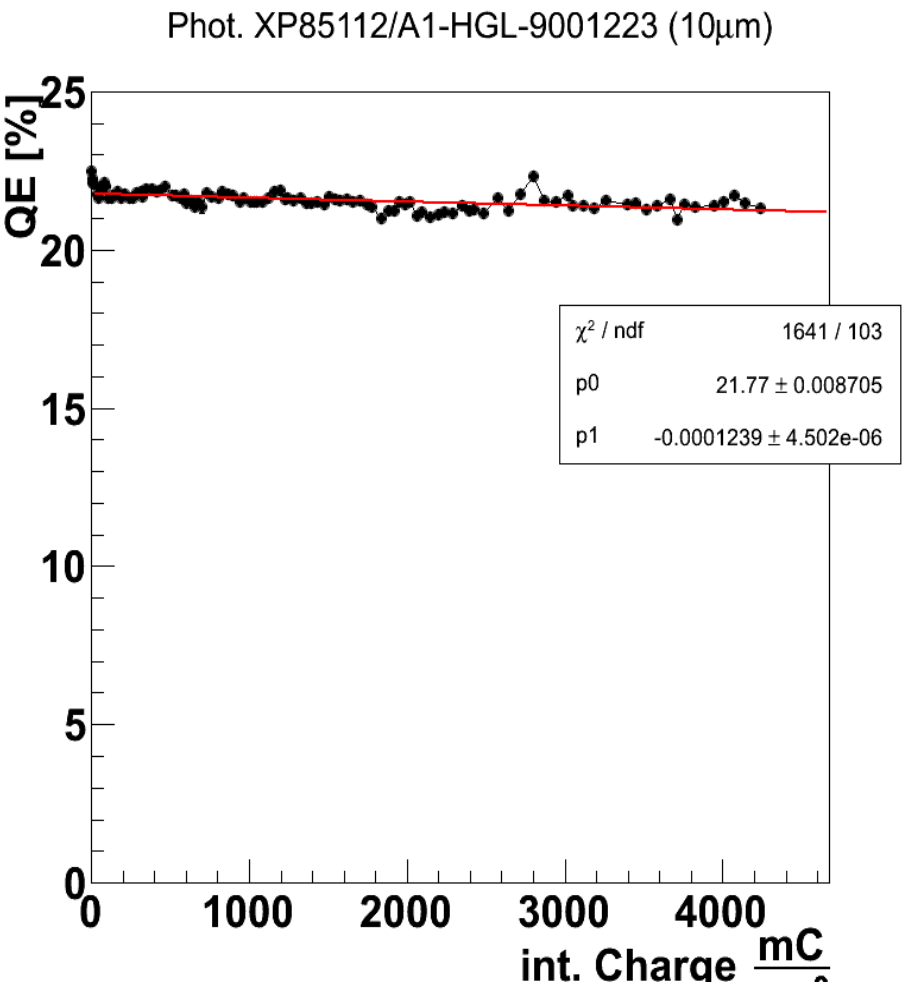
- Fitted function: $a + b * \log(DC)$
- Fitted values of BINP 1359 and 3548 are comparable → expected for similar devices
- Degradation of Phot. 9001223 and 9001332 not yet sufficient → more data/time needed

Summary and Outlook

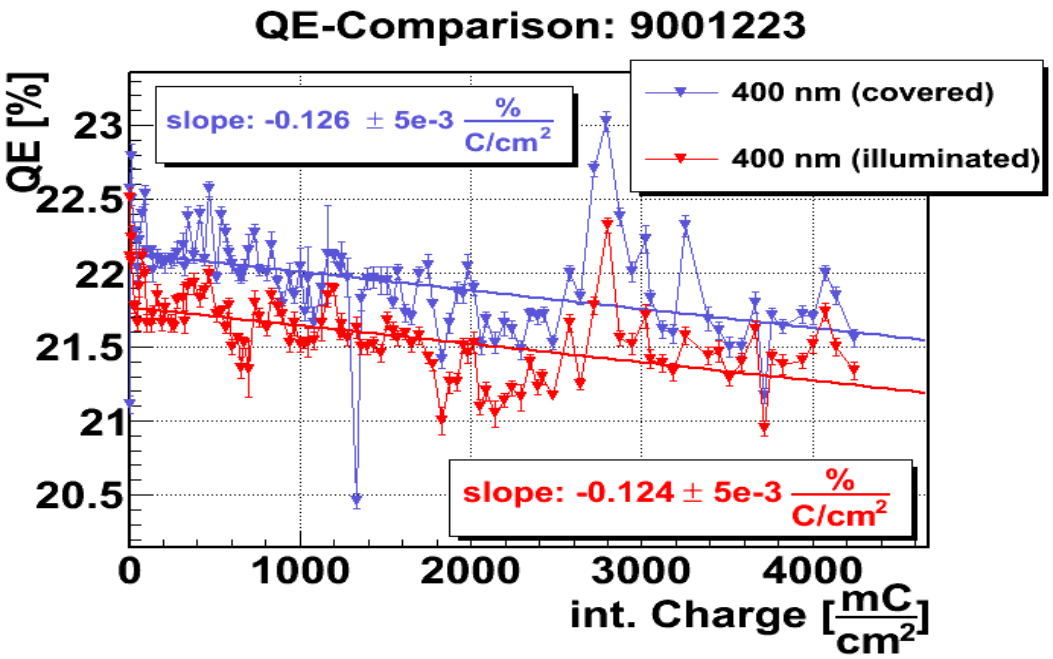
- Lifetime measurements ongoing:
  - PHOTONIS XP85112/A1-HGL - 9001223 has passed ~5.2C/cm² (~ 10.4 PANDA-Barrel-years!)
    → **First sensor fulfilling Barrel-DIRC requirements!**
  - XP85112/A1-D - 9001332 has passed ~1.9 C/cm² unharmed (~ 3.8 PANDA-Barrel-years):
    - **lifetime expected to be similar to 9001223**
    - 5 C/cm² should be reachable within the next 12 months
  - Surface-Scans do not reveal any faster aging areas for both PHOTONIS sensors
  - QE of BINP 3548 decreases faster at the rim
- Darkcount and QE is strongly correlated, but more data needed to check whether lifetime can be monitored 'online'

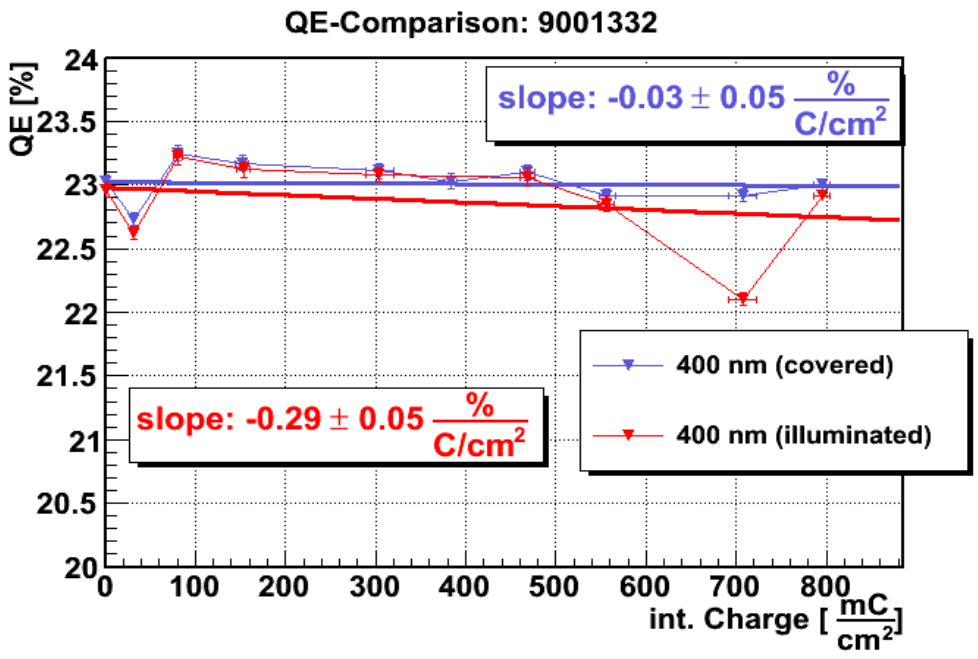
Backup


Phot. XP85112/A1-9000897 (10 µm)
χ² / ndf 1.418e+04 / 79
p0 22.5 ± 0.01183
p1 -0.05684 ± 4.566e-05
24
22
20
18
16
14
12
10
8
6
4
0
50
100
150
200
250
300

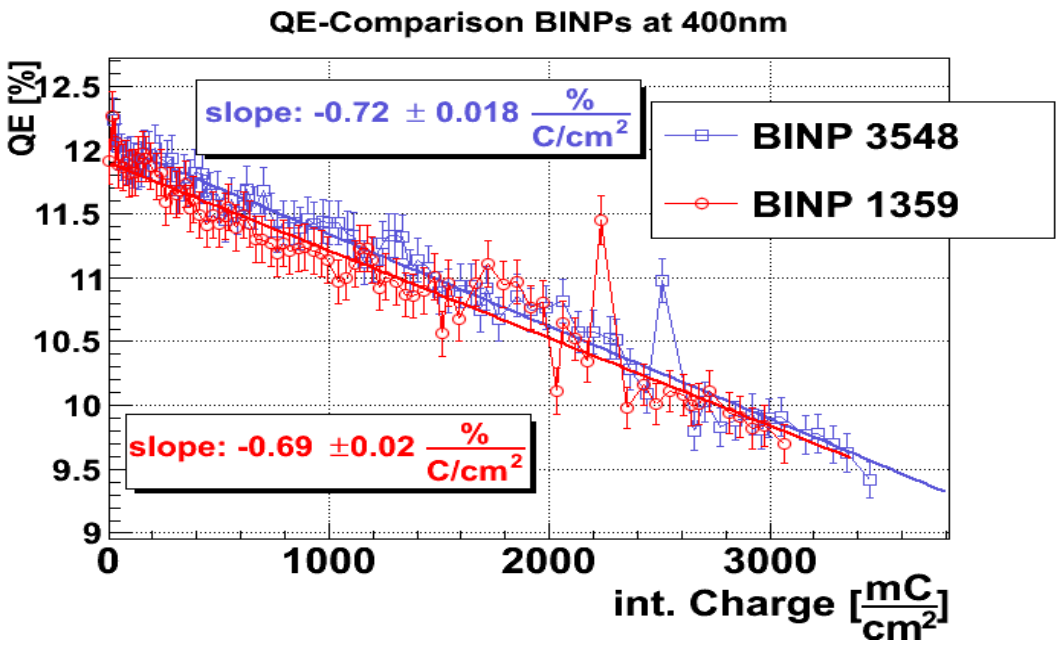

Phot. XP85112/A1-HGL-9001223 (10µm)
QE [%]
25
20
15
10
5
0
χ² / ndf 1641 / 103
p0 21.77 ± 0.008705
p1 -0.0001239 ± 4.502e-06
0
1000
2000
3000
4000
int. Charge mC

Comparison of QE (400nm)

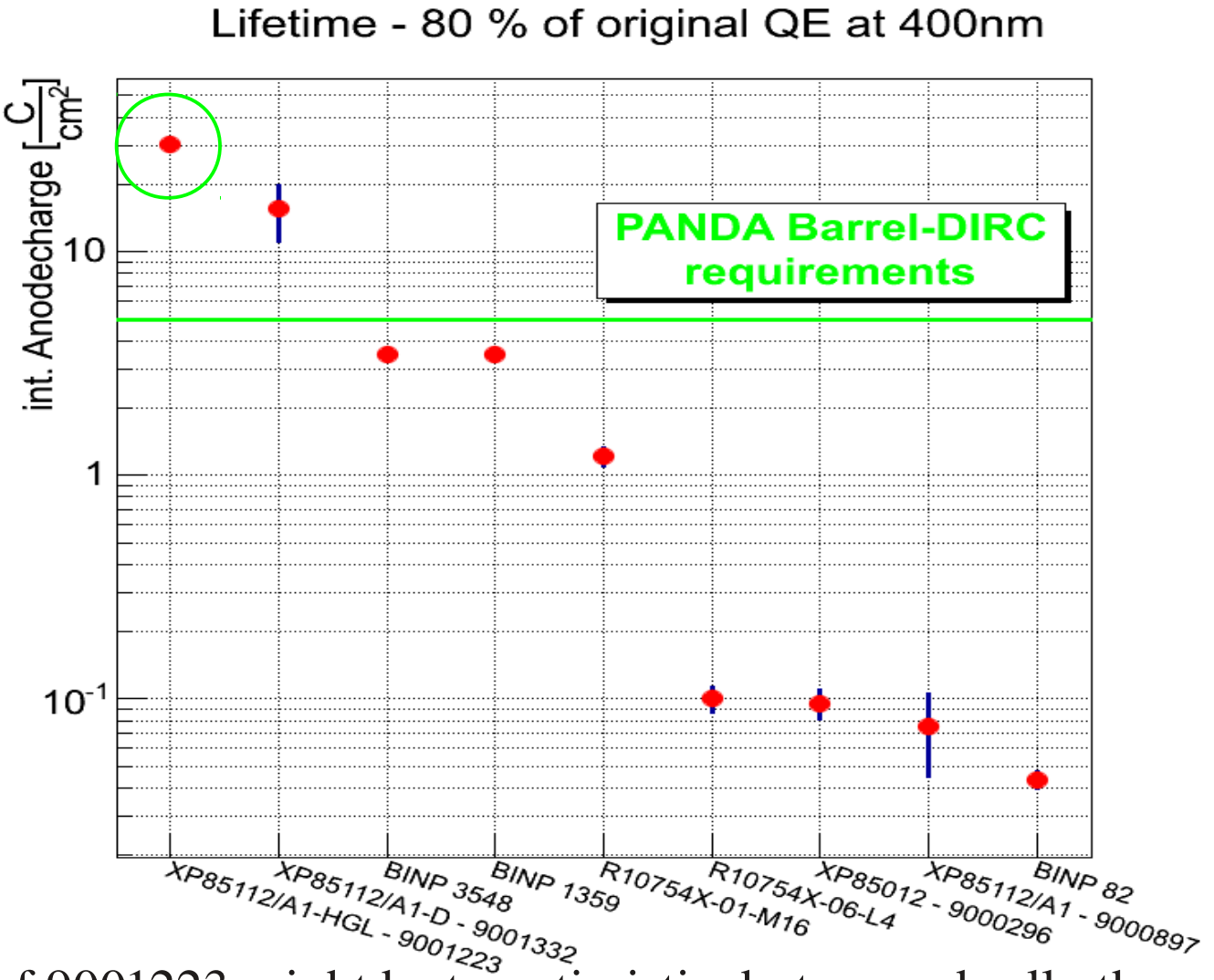




- Equal slopes for 9001223: Maybe hint for aging dominated by ionized neutral gas
- More data needed for 9001332
- Aging of BINPs about 10 times faster!



Lifetime



- Lifetime of 9001223 might be to optimistic, but exceeds all others → sufficient for PANDA Barrel-DIRC
- M16 and 9000296 are fitted with polynom of 2. order