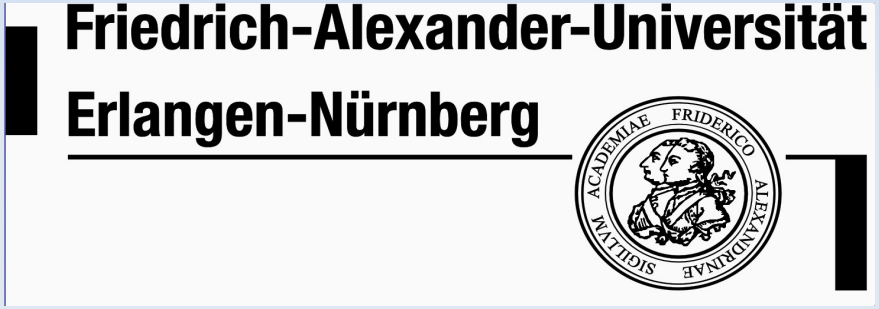
Lifetime and quantum efficiency measurements of Photonis MCP-PMTs and first PANDA-ROOT simulation results



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supported by BMBF and GSI

Overview

- Motivation
- Setup of measurements
- Measurement results for Photonis XP85012 and XP85112
  - Lifetime measurement XP85012
  - XP85112 measurements
    - Crosstalk suppression
    - Quantum efficiency and QE-Scans
    - Lifetime
- Simulation results for the Barrel-DIRC
- conclusion

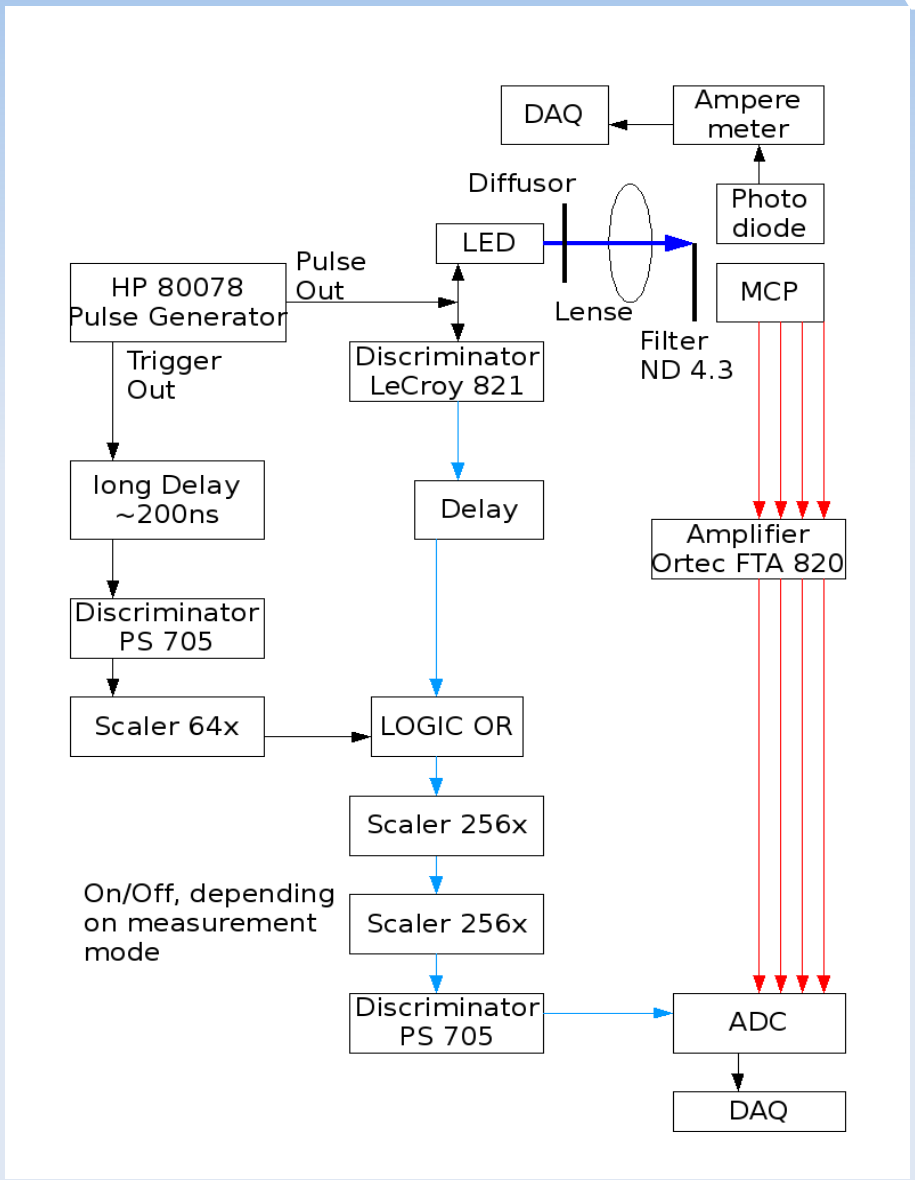
Motivation

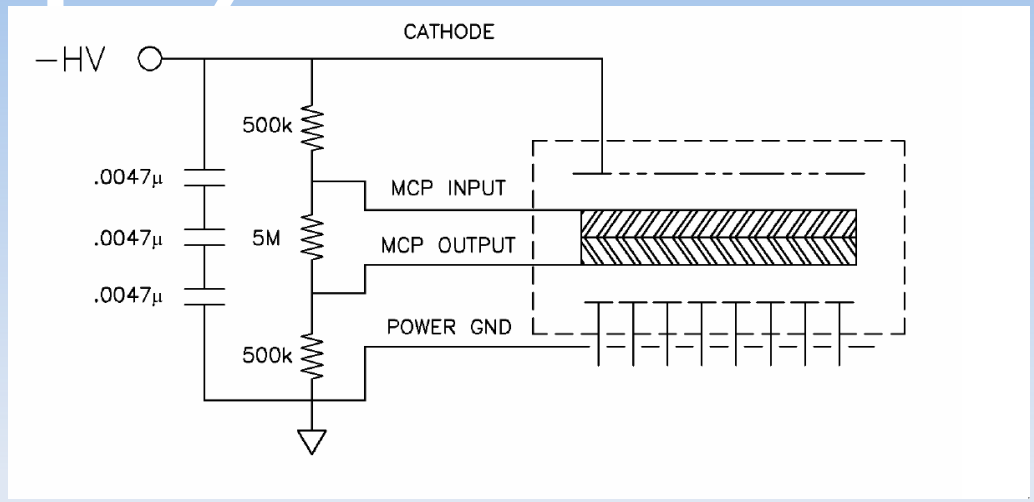
Photo detector requirements for PANDA-DIRCs for the separation of K and π up to several GeV/c:

- B-Field resistance up to 2T
- Gain > $5*10^5$ for single photon detection
- Good time resolution: σ < 100 ps
- Good spatial resolution and geometrical efficiency
- High photon rates (up to several MHz)

→ lifetime?

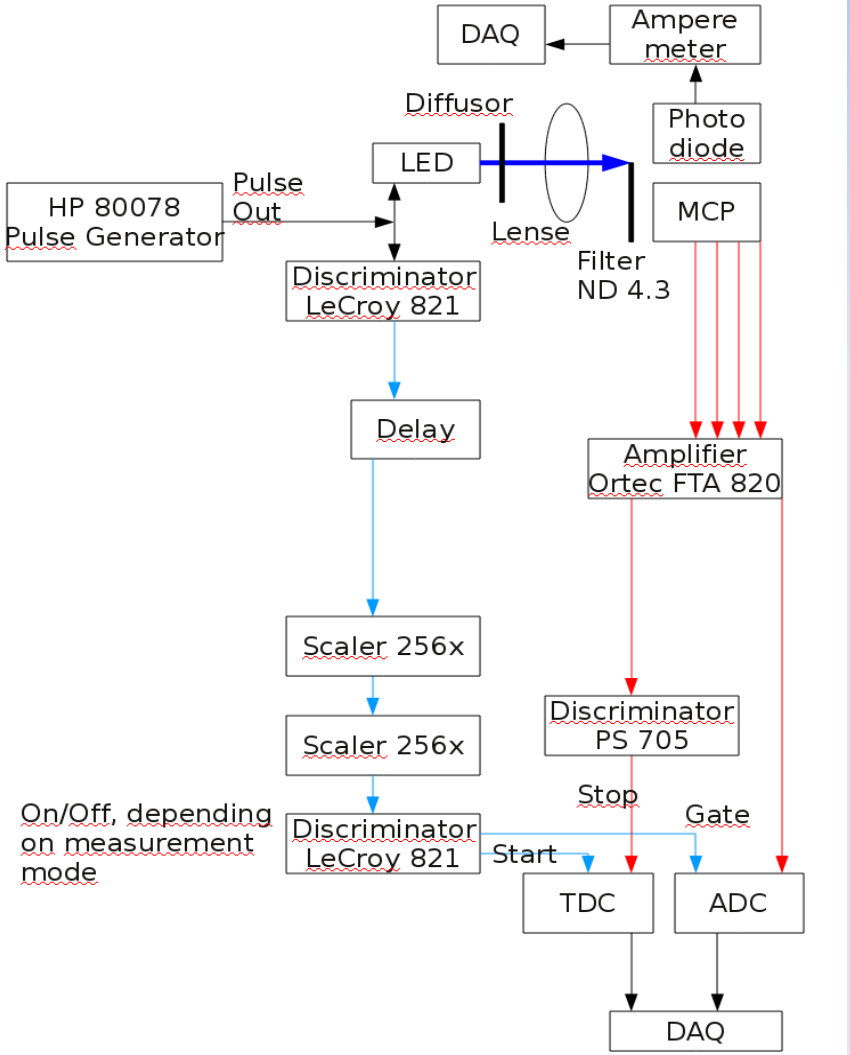
Setup – Photonis XP85012(25µm)

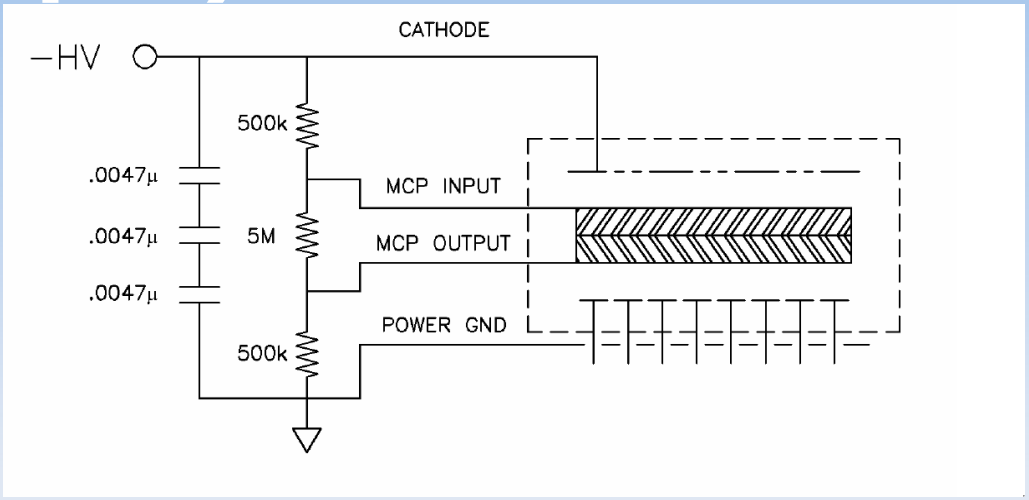




- additional pedestal-events for MCP-Out
- total voltage: 2.3 kV (i.e. ~190/1910/190 V)

Setup – Photonis XP85112(10µm)

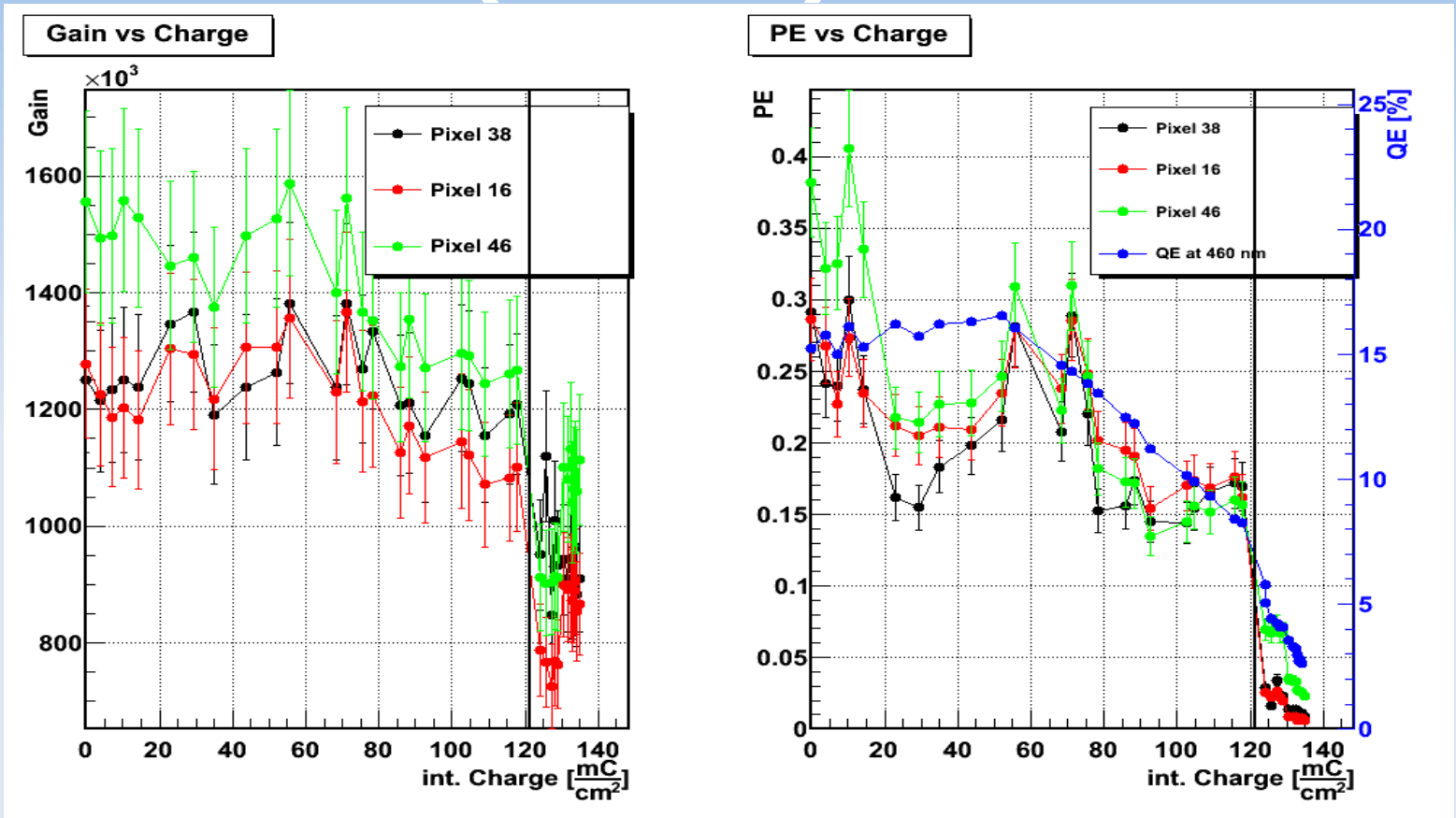




- photo diode and scaler as previous measurement
- total voltage: 2.8 kV (i.e. ~233/2330/233 V)
- TDC used for crosstalk suppression

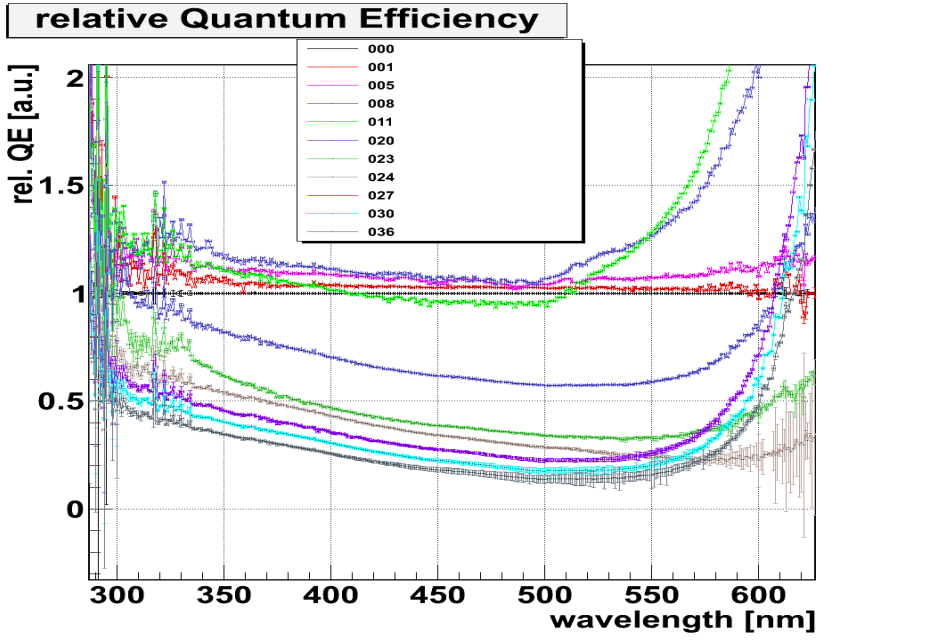
Measurement results for Photonis XP85012 and XP85112

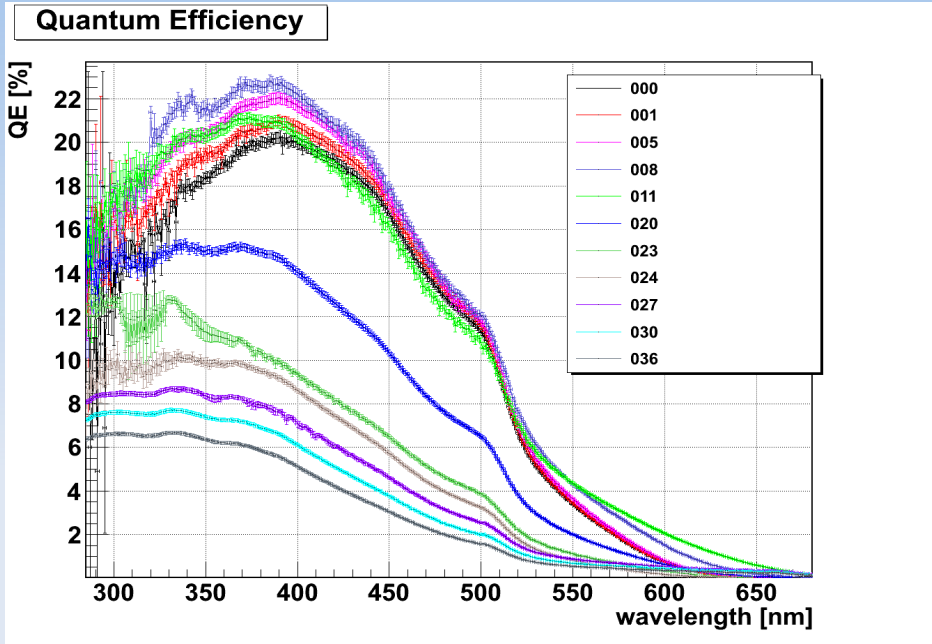
Gain and Number of PE (85012)



- High illumination (~15sec) at ~ 120mC/cm² damaged photocathode
- Gain remained fairly unchanged, PE dropped by ~ 50%

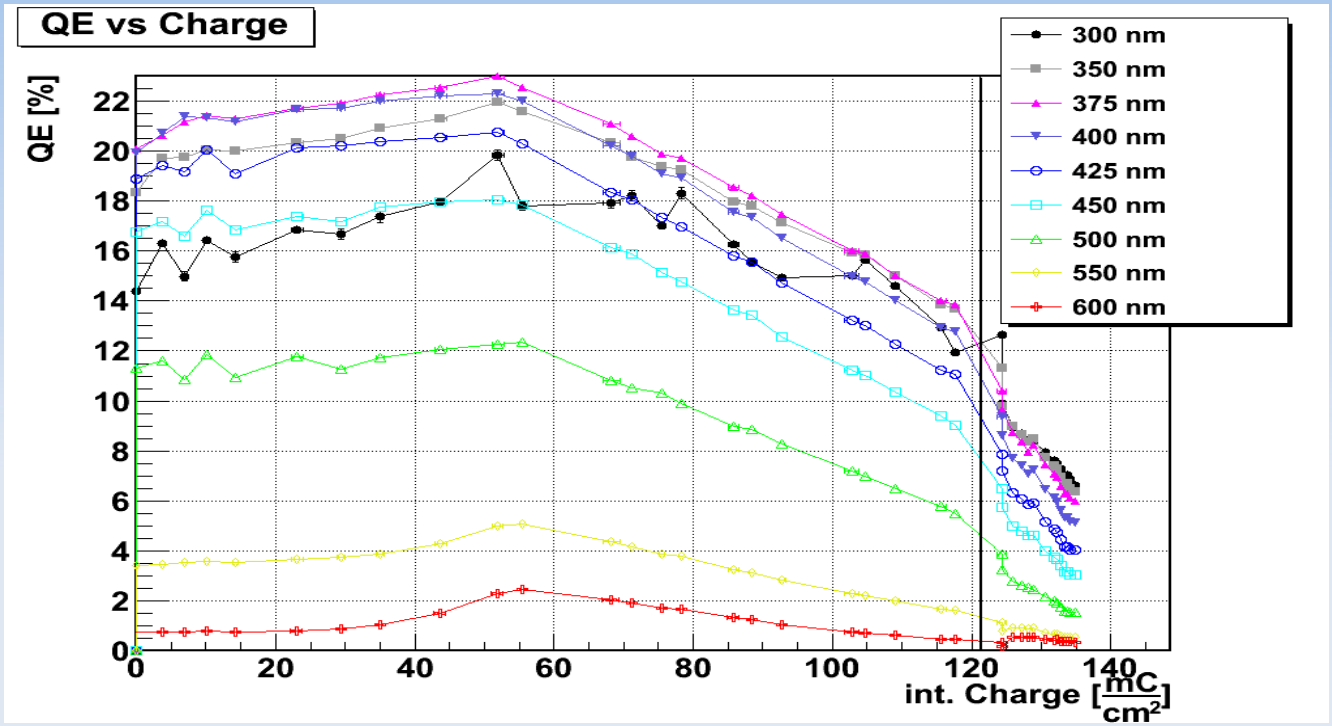
spectral and relative QE (85012)





- QE increased at the beginning
- Rel. QE: lower wavelengths behave more stable than higher ones
- Halogene lamp was substituted by a Xenon-lamp at the end of the illumination (after ~125mC/cm²) for better measurements at 280nm< λ <350nm

Lifetime: QE (85012)

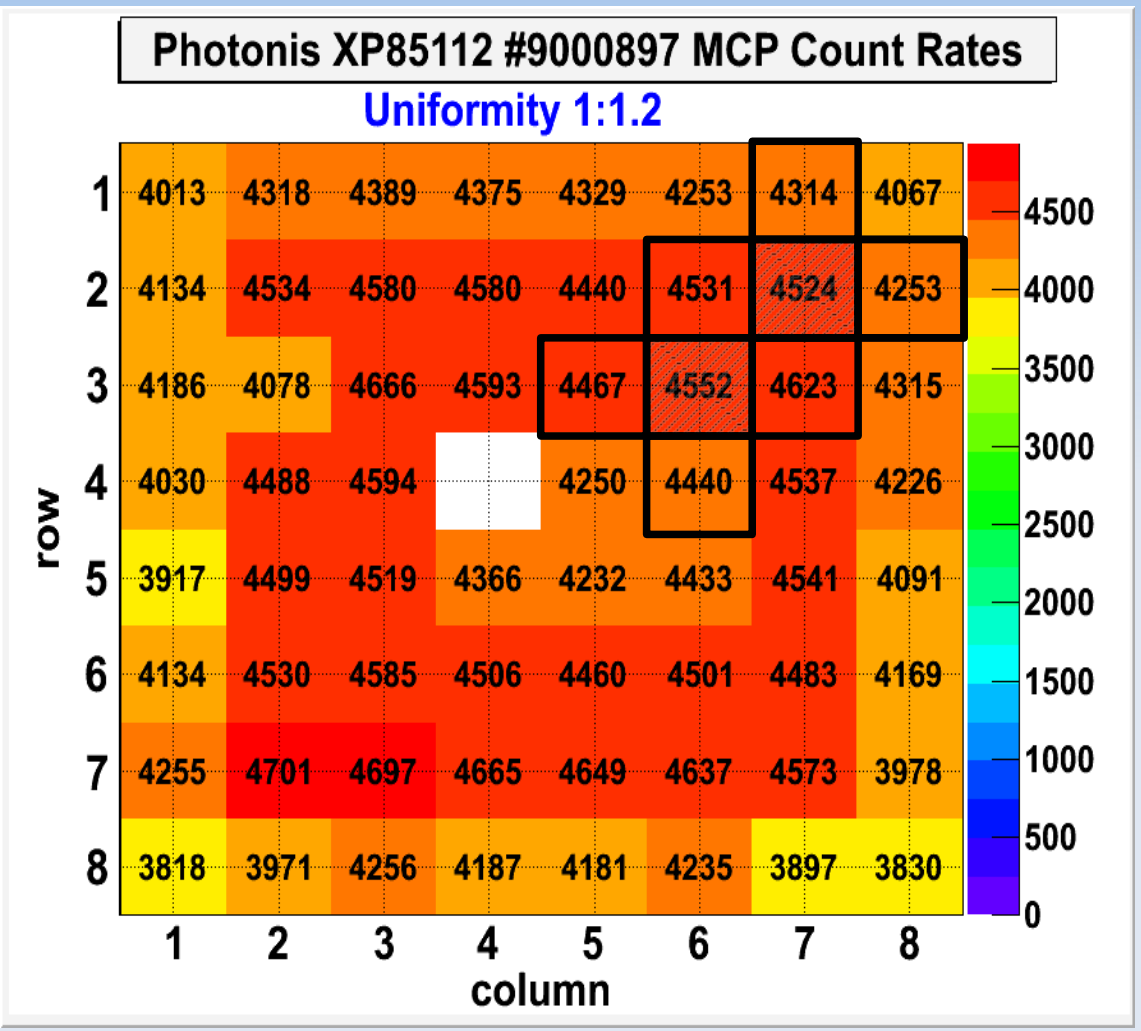


- QE increased up to 50mC/cm²
- High illumination damaged cathode, perhaps outgasing of MCP because of high MCP temperature (Banykav et al. NIM 567, page 17-20)

Improvements for XP85112

- Better resolution of QE for short wavelengths by Xenon-lamp
- Measurement of dark count rate
- QE-Scans for monitoring all pixels
- Measuring Gain with fit and center of charge, problem XP85012 crosstalk and charge charing
- Idea: For Crosstalk suppression read-out of 8 ADC and TDC channels cut-off coincident signals

Crosstalk suppression for Gain measurement



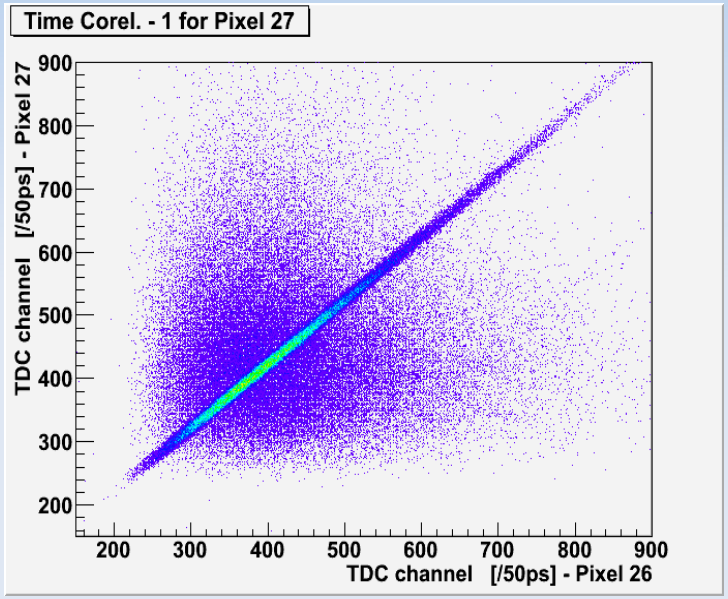
Read-out of 8 Channels => 4 Pixels (1-4) can be used to suppress crosstalk of the surrounded channel (0)

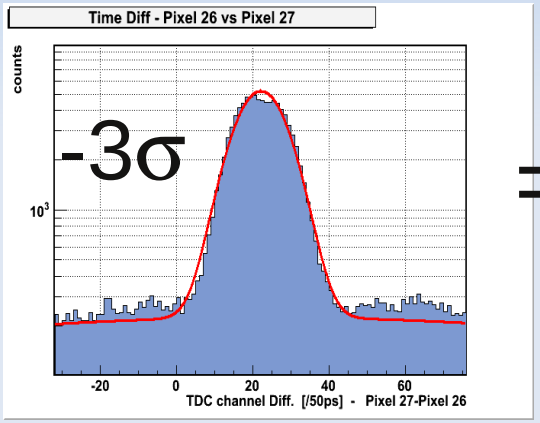
2 Possibilities:

1. ”Total-Cut”: Events with signals in pixel 1-4 are neglected
2. ”Direct-Cut”: Coincident signals induced by charge sharing are neglected

Crosstalk suppression: Direct-Cut

Charge sharing results in coincident TDC signals:





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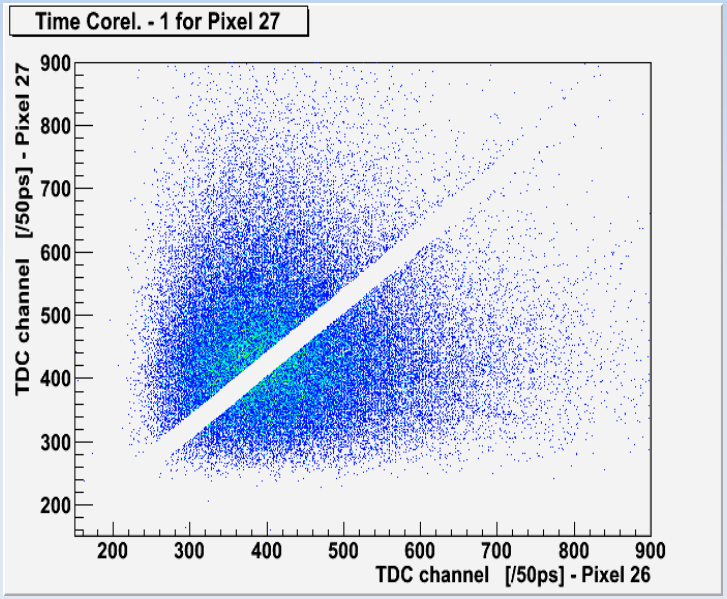
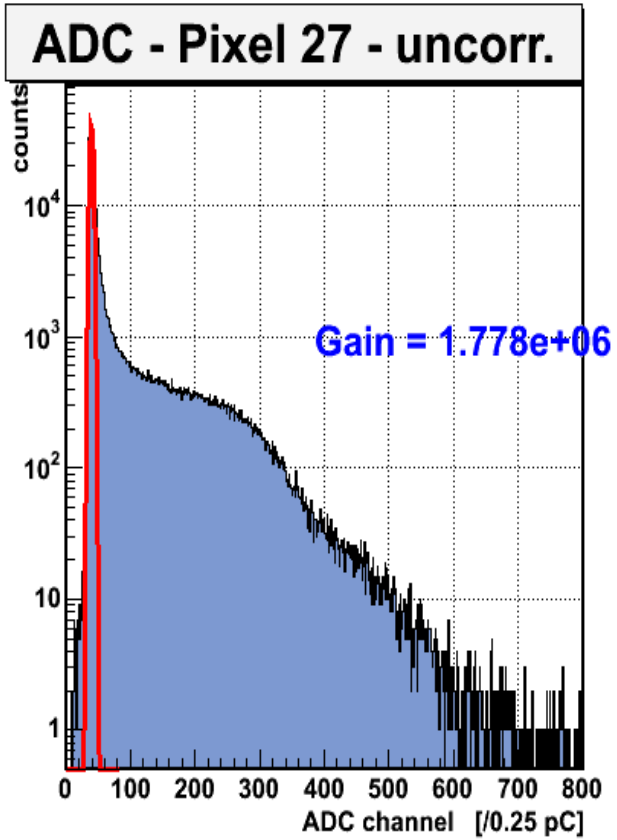
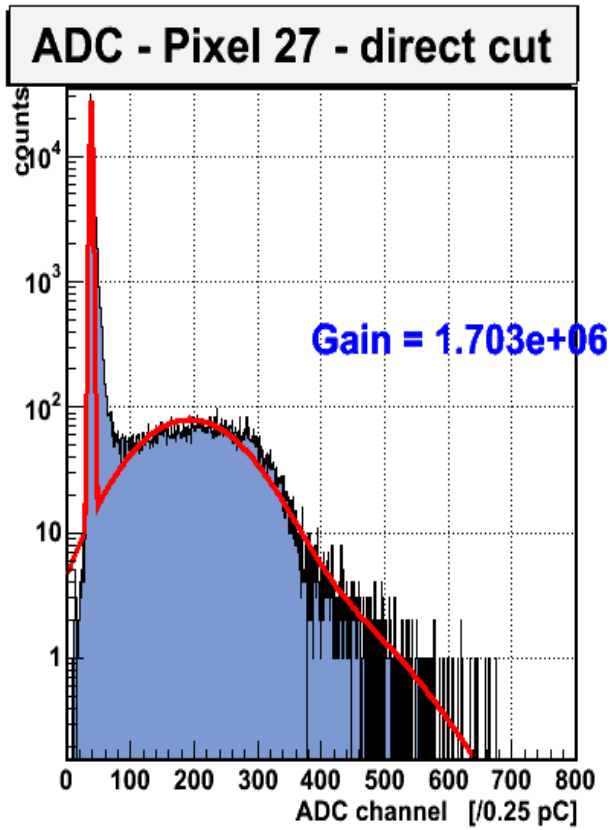
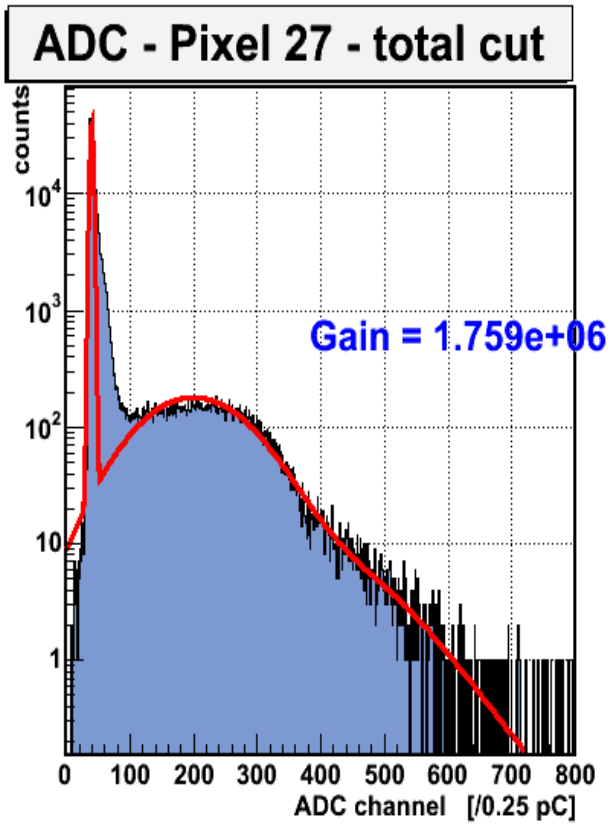


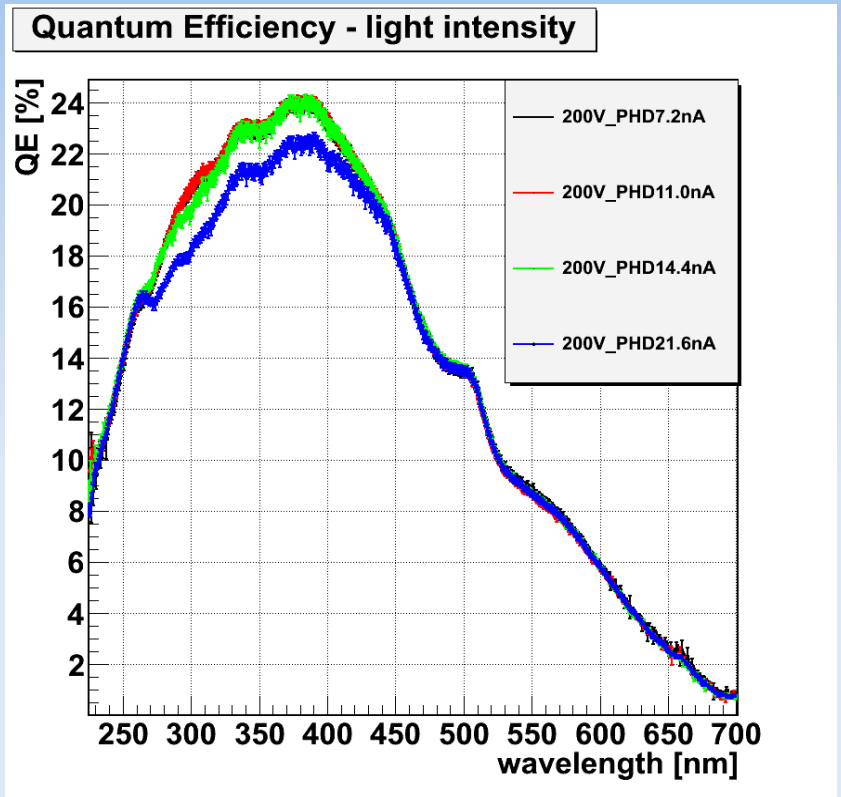
Result of crosstalk suppression

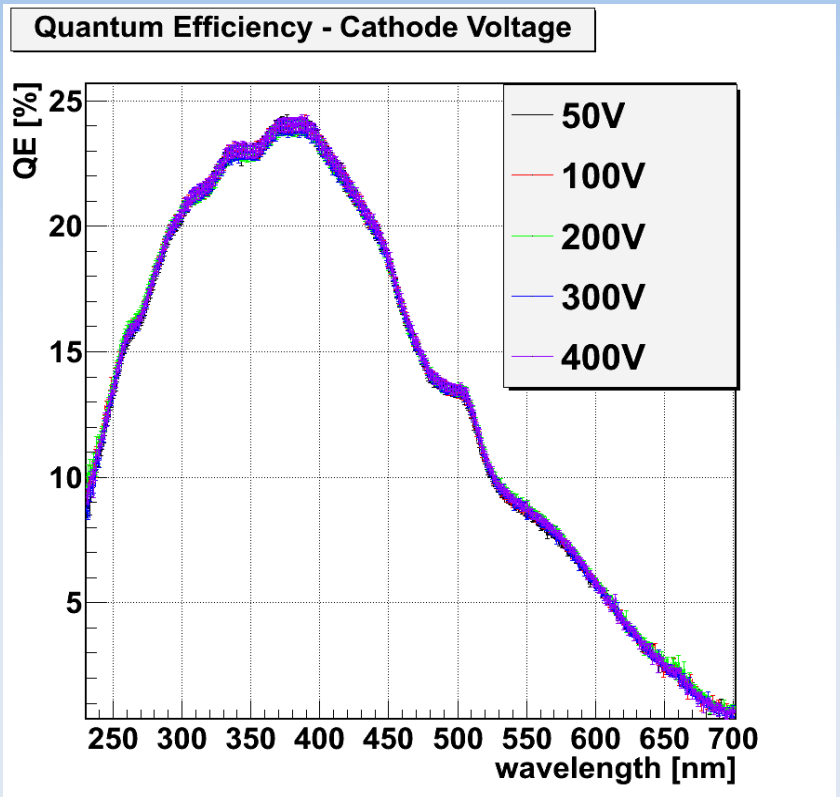






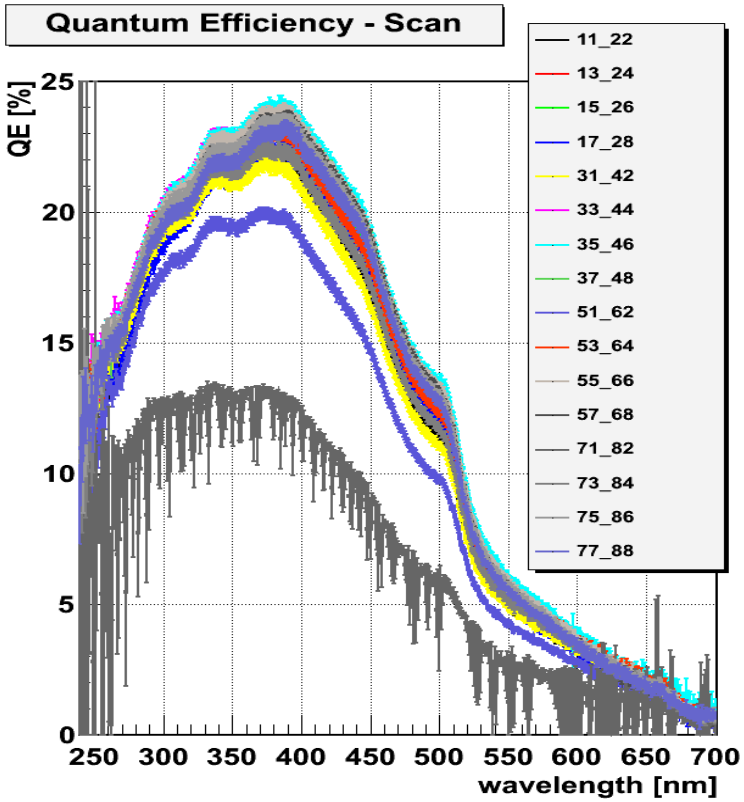
QE measurement

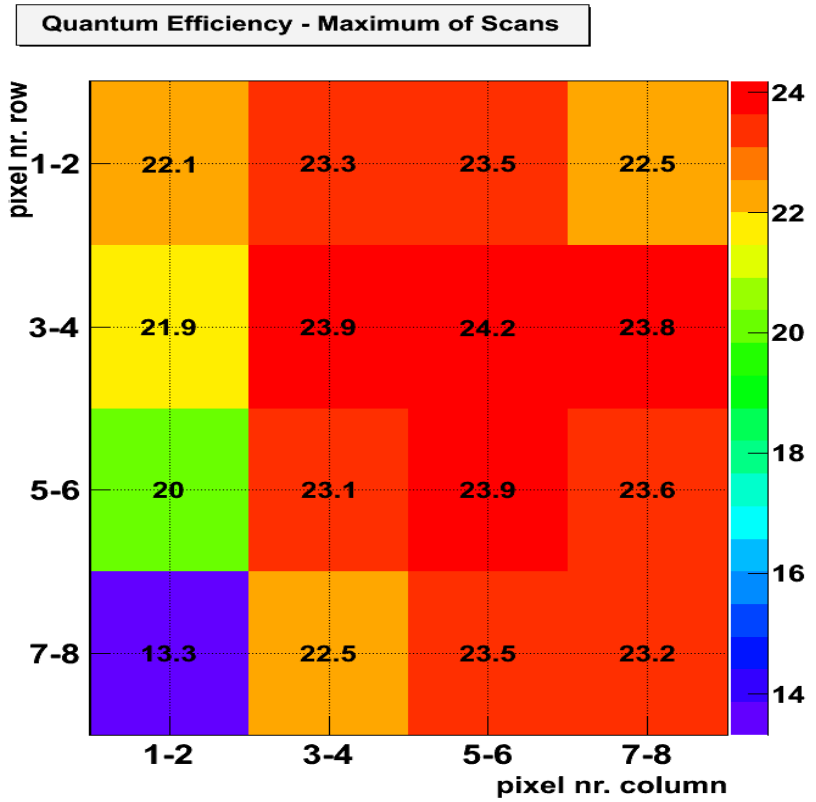




- QE stays constant for voltages above 50V
- Higher light intensities result in higher currents of the MCP. => Current is limitied by resistance of MCP material

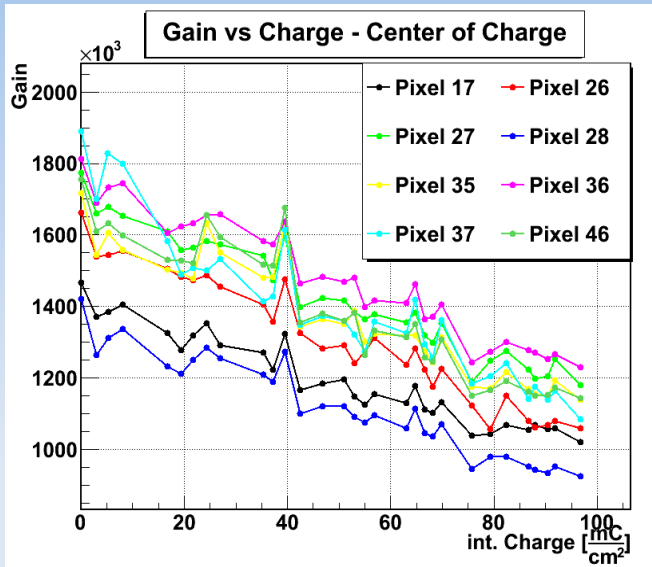
QE Scans

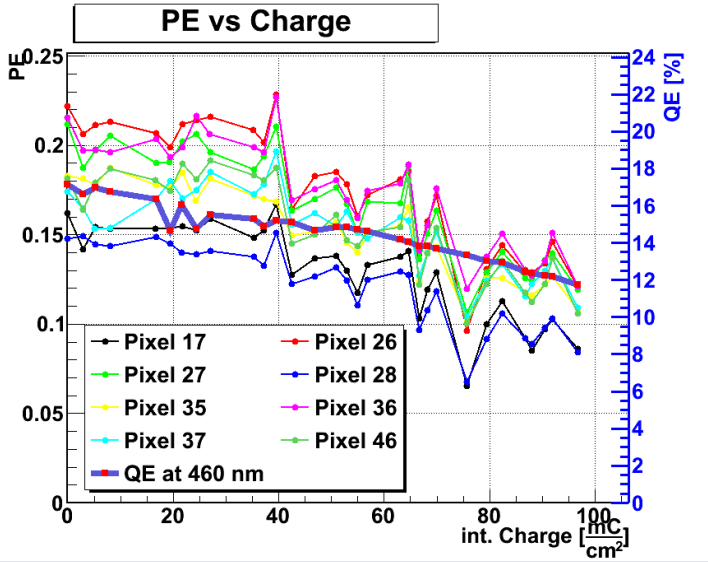


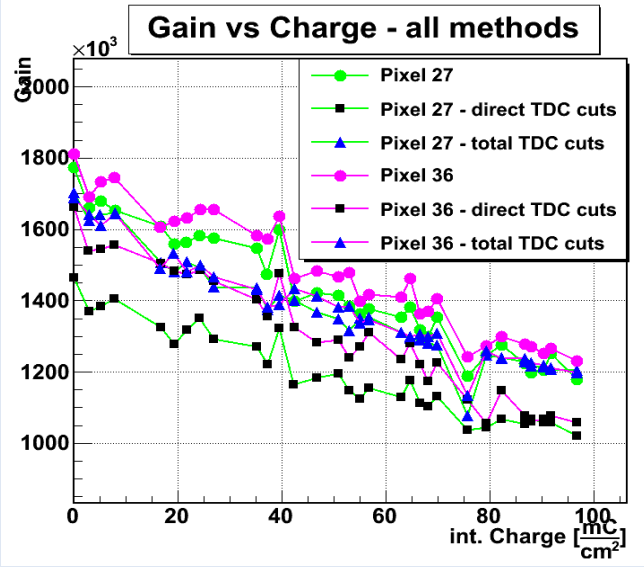


- Lightspot size: ø ~1cm
- QE is extremly reduced on the lower left side, MCP seems to be damaged in this region (high dark count rate etc.) from the beginning

Lifetime XP85112: Gain/PE

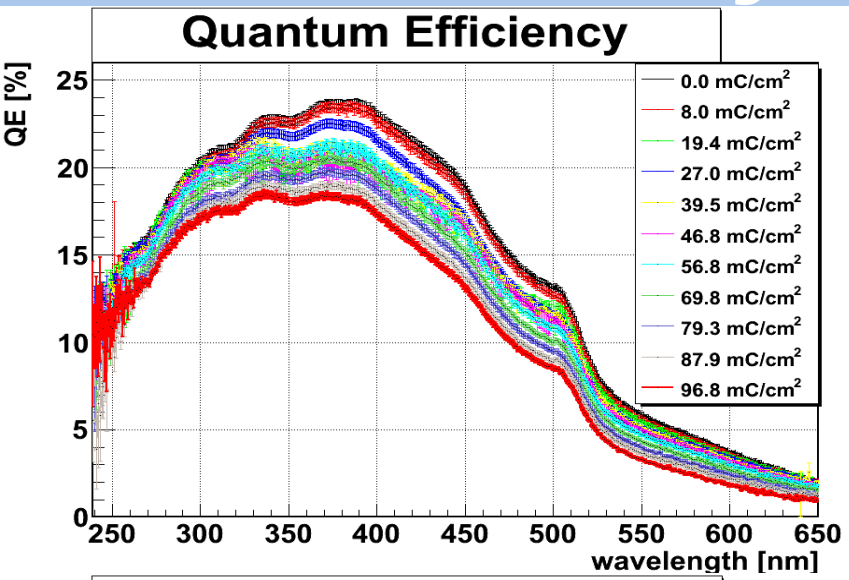


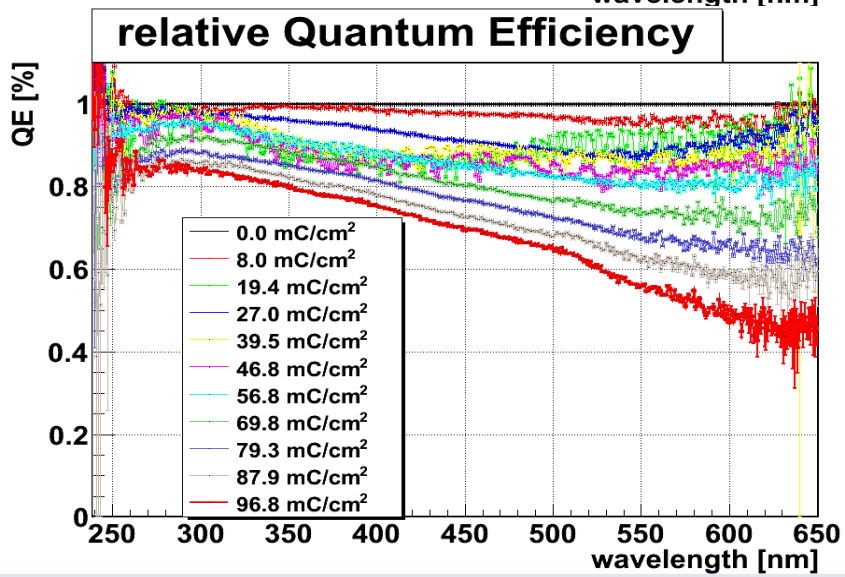


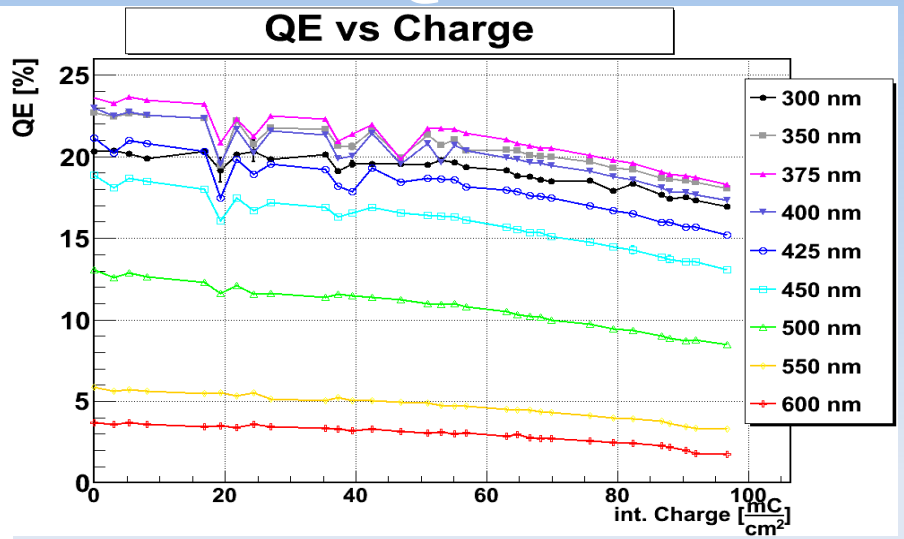


- Gain drops by ~25-40%
- ”total-cut” and center of charge result in same Gain, ”direct-cut” is a bit lower

Lifetime XP85112: Quantum efficiency and rel. QE

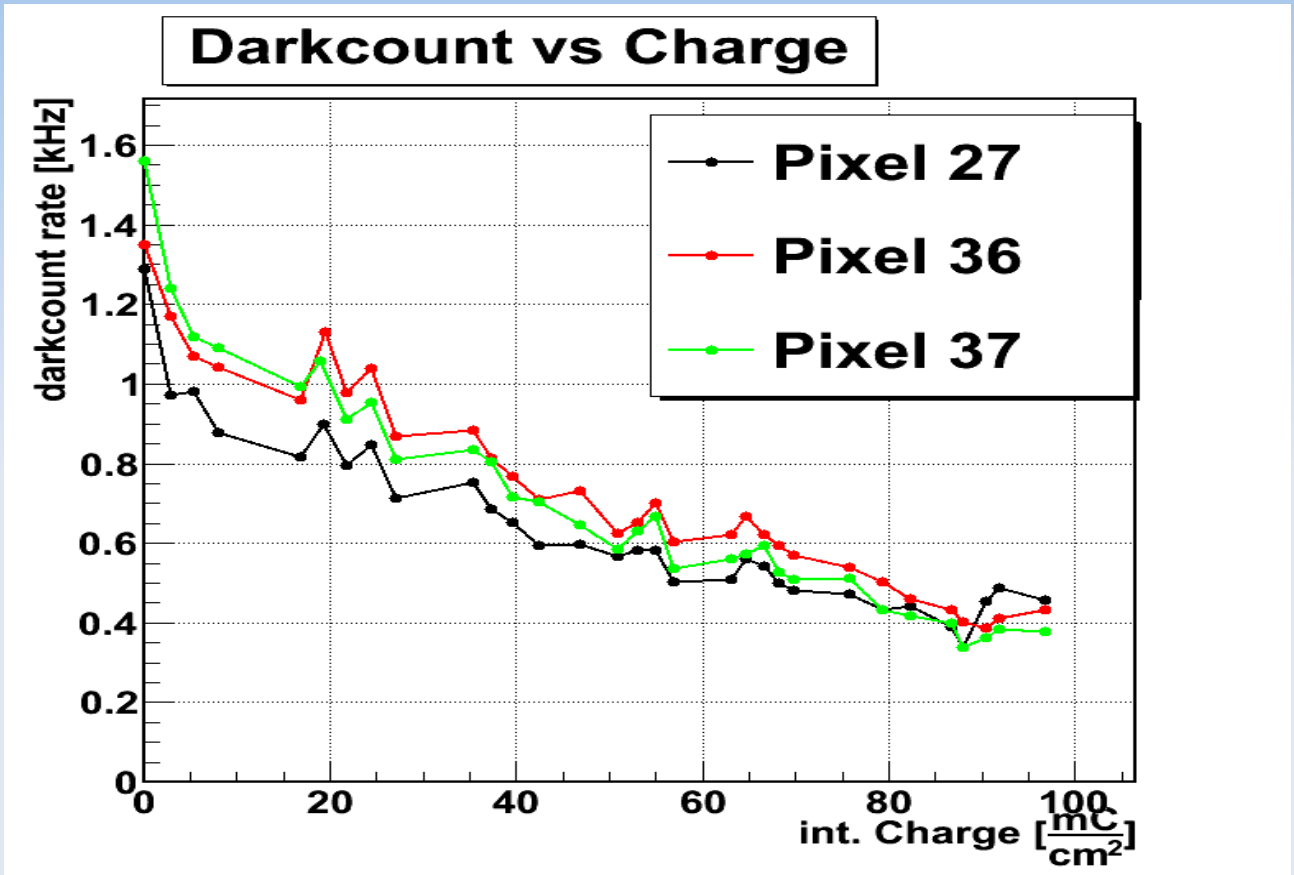






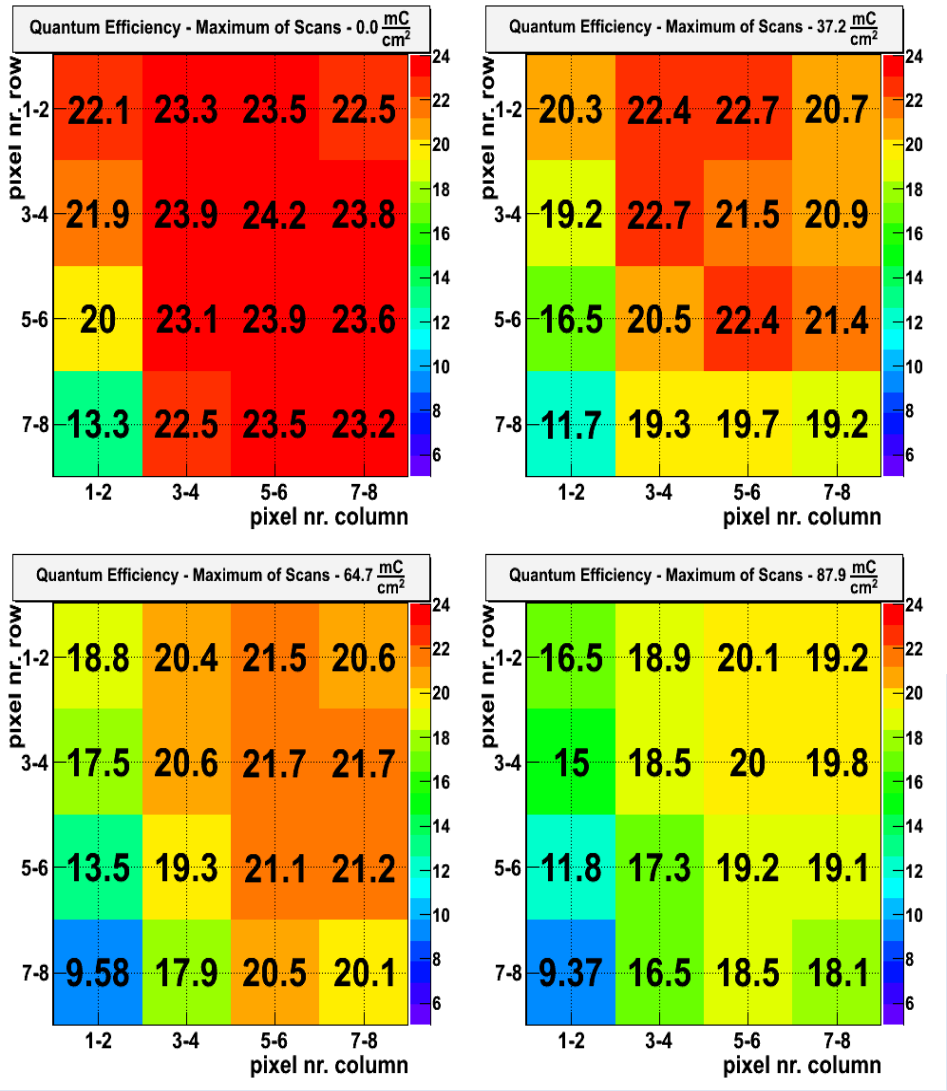
- QE drops significantly lower than for XP85012
- No increase at the beginning
- Rel. QE drops faster for higher wavelengths (same as XP85012)
- Expected: ~ 250mC/cm² for 50% loss, linear extrapolation (380nm)

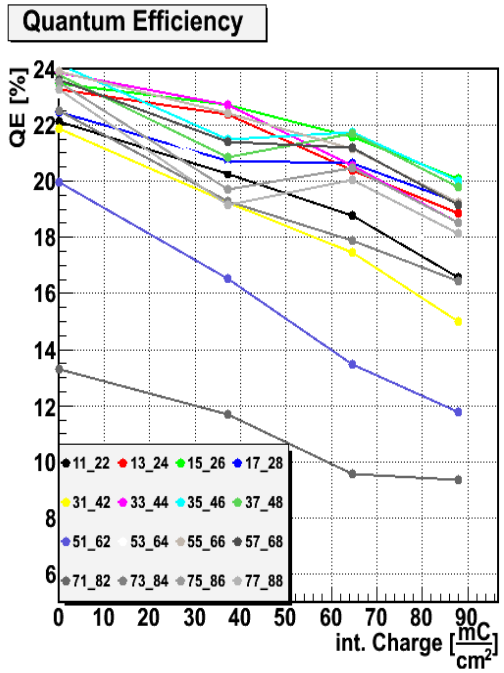
Lifetime XP85112: Dark count rate

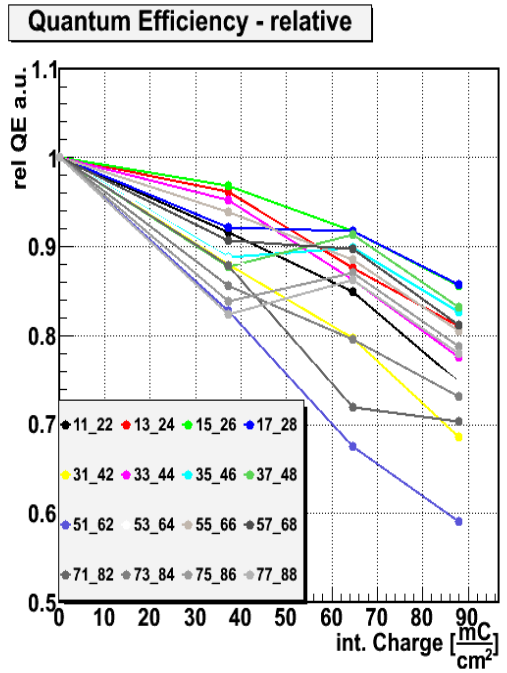


Dark count rate decreases with higher int. Charge for all pixels

Lifetime XP85112: QE Scans



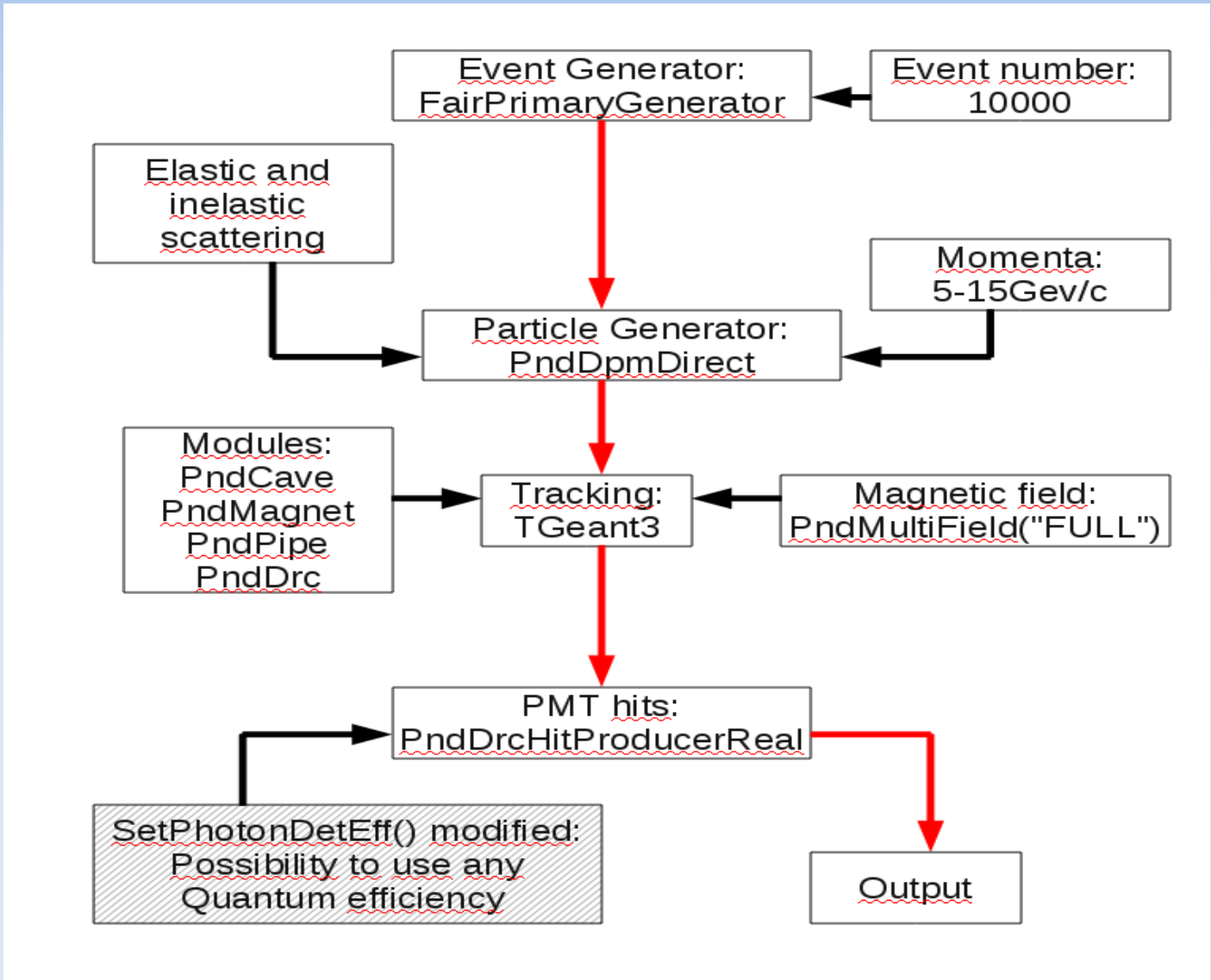




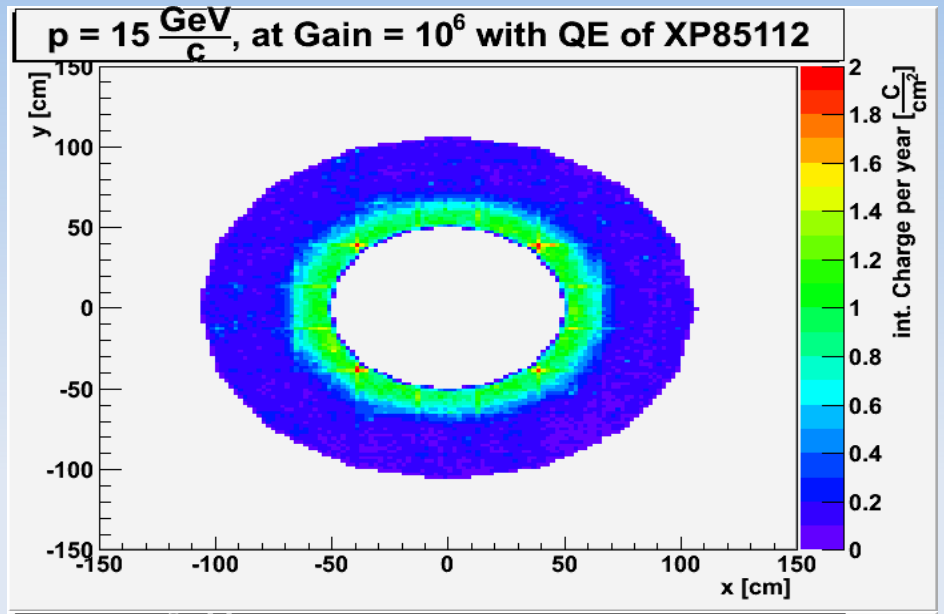
Lower left decreases faster than the other areas of the MCP

Simulation results for the Barrel-DIRC

Setup


Event Generator:
FairPrimaryGenerator
Event number:
10000
Elastic and
inelastic
scattering
Momenta:
5-15Gev/c
Particle Generator:
PndDpmDirect
Modules:
PndCave
PndMagnet
PndPipe
PndDrc
Tracking:
TGeant3
Magnetic field:
PndMultiField("FULL")
PMT hits:
PndDrcHitProducerReal
SetPhotonDetEff() modified:
Possibility to use any
Quantum efficiency
Output

Results of simulation

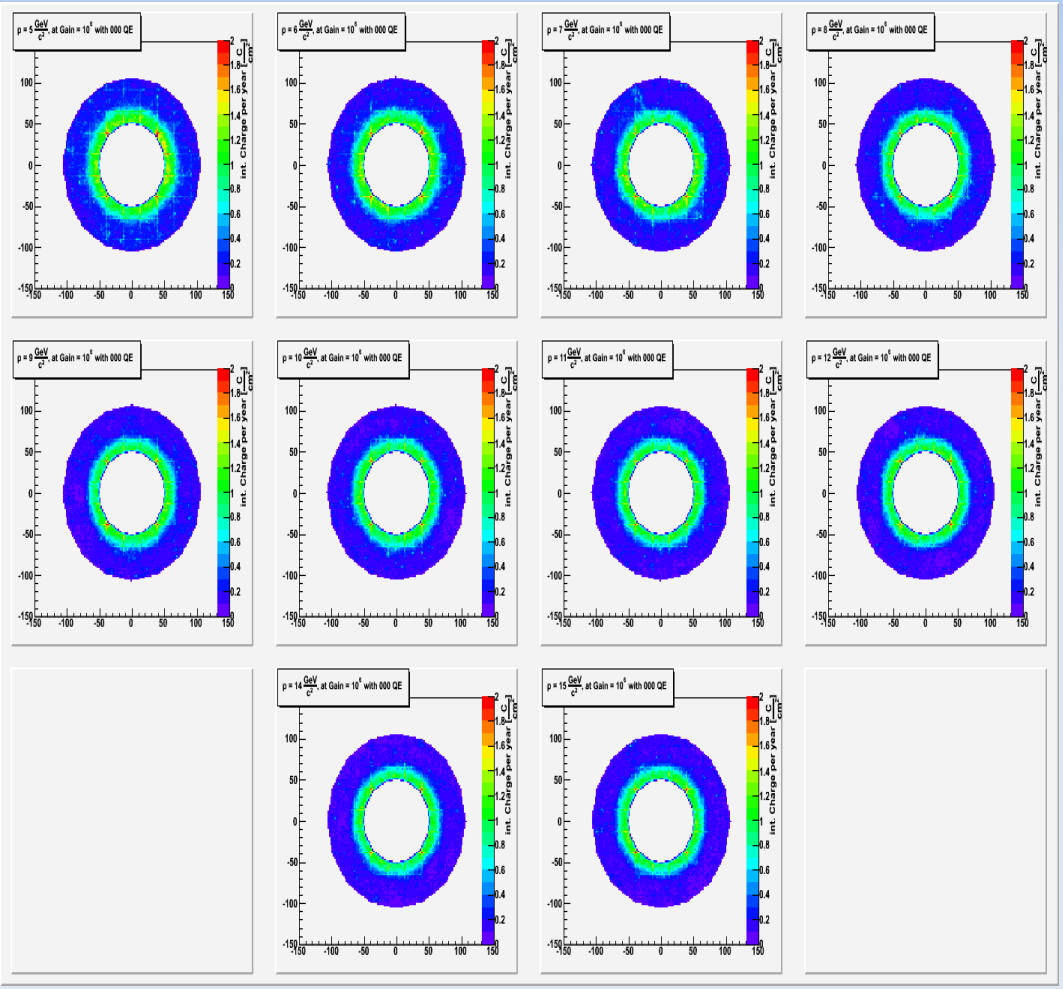


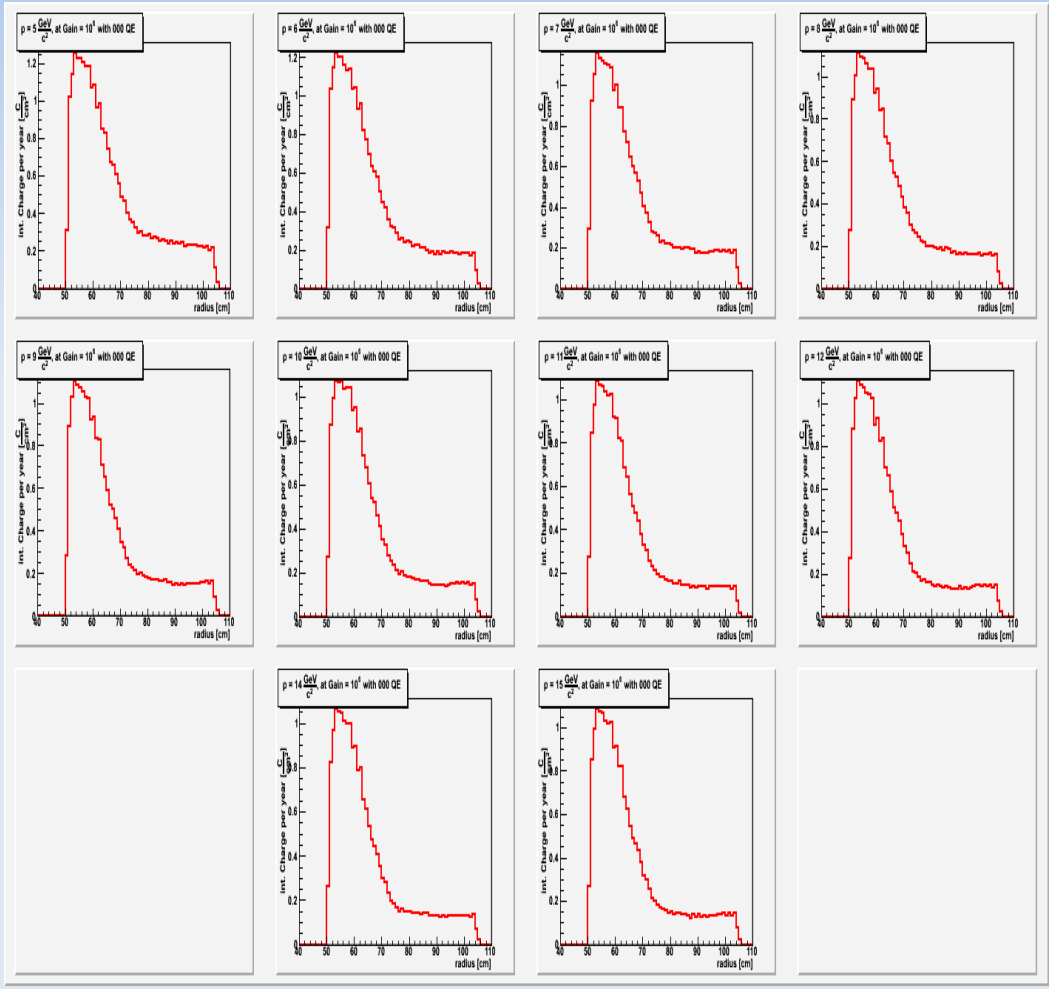
- Int. Charge is radial dependent
- For lower momenta: int. Charge increases by ~10%
- Maximum: 1.1C/(cm²*a) (1.2C/(cm²*a) for 5Gev/c)

Conclusion

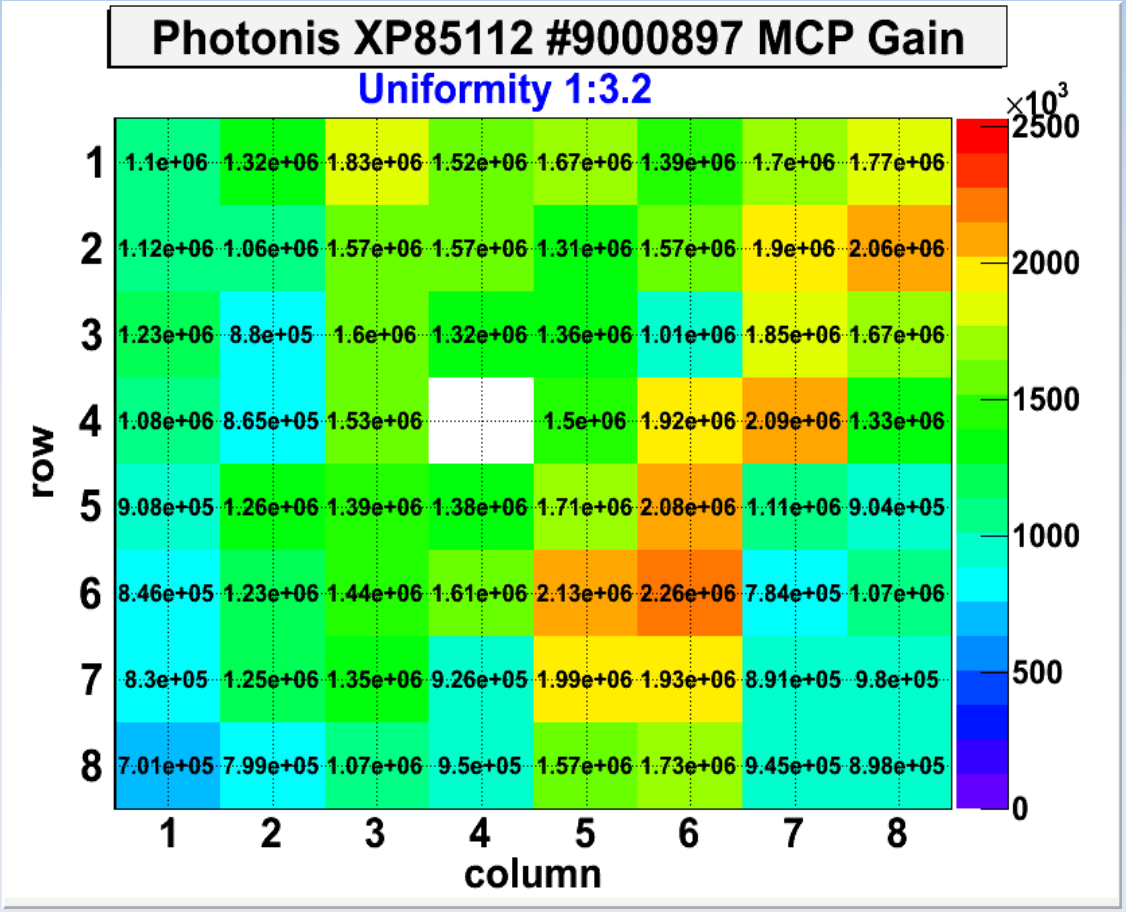
- QE lifetime of XP85112 seems to be increased to XP85012, but Gain drops. More int. Charge is needed and lifetime measurement is ongoing
- Expected charge of ~1C/cm² in PANDA still exceeds MCP lifetime
- Simulation of the expected lifetime for the Disc-Dirc is in progress

Results of simulation





QDC-Gain


Photonis XP85112 #9000897 MCP Gain
Uniformity 1:3.2
row
column
×10^3
2500
2000
1500
1000
500
0
1 1.1e+06 1.32e+06 1.83e+06 1.52e+06 1.67e+06 1.39e+06 1.7e+06 1.77e+06
2 1.12e+06 1.06e+06 1.57e+06 1.57e+06 1.31e+06 1.57e+06 1.9e+06 2.06e+06
3 1.23e+06 8.8e+05 1.6e+06 1.32e+06 1.36e+06 1.01e+06 1.85e+06 1.67e+06
4 1.08e+06 8.65e+05 1.53e+06 1.5e+06 1.92e+06 2.09e+06 1.33e+06
5 9.08e+05 1.26e+06 1.39e+06 1.38e+06 1.71e+06 2.08e+06 1.11e+06 9.04e+05
6 8.46e+05 1.23e+06 1.44e+06 1.61e+06 2.13e+06 2.26e+06 7.84e+05 1.07e+06
7 8.3e+05 1.25e+06 1.35e+06 9.26e+05 1.99e+06 1.93e+06 8.91e+05 9.8e+05
8 7.01e+05 7.99e+05 1.07e+06 9.5e+05 1.57e+06 1.73e+06 9.45e+05 8.98e+05
1 2 3 4 5 6 7 8