The photocathode aging in MCP PMT

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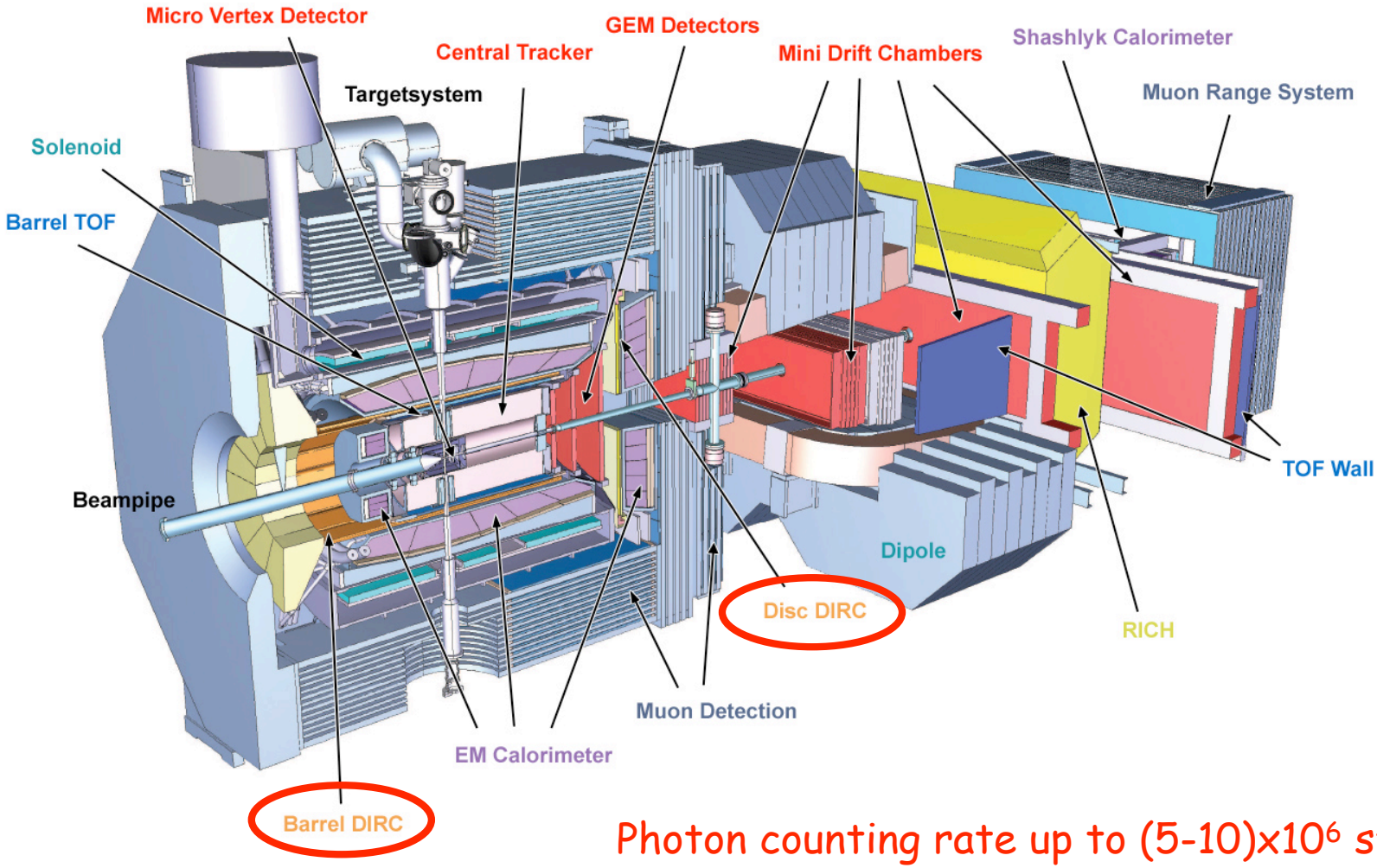
Outline:

- MCP PMT in PANDA
- Photocathode aging
- Lifetime estimation
- Conclusion

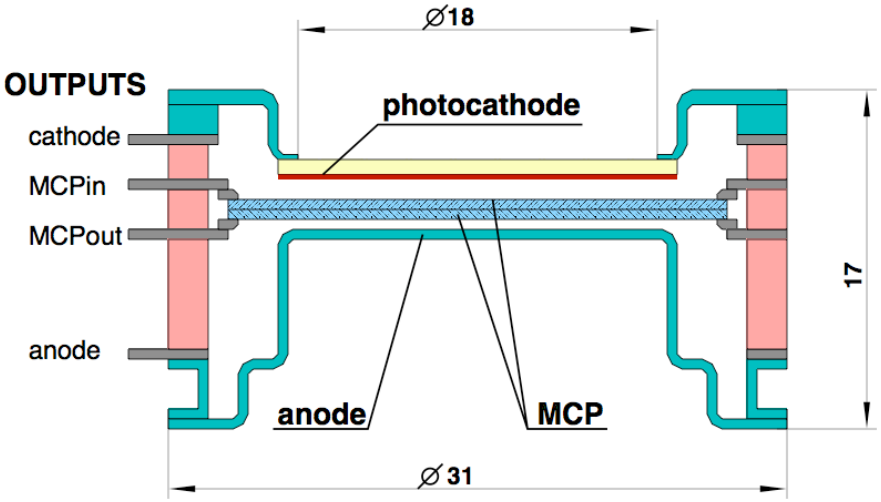
MCP PMT in PANDA

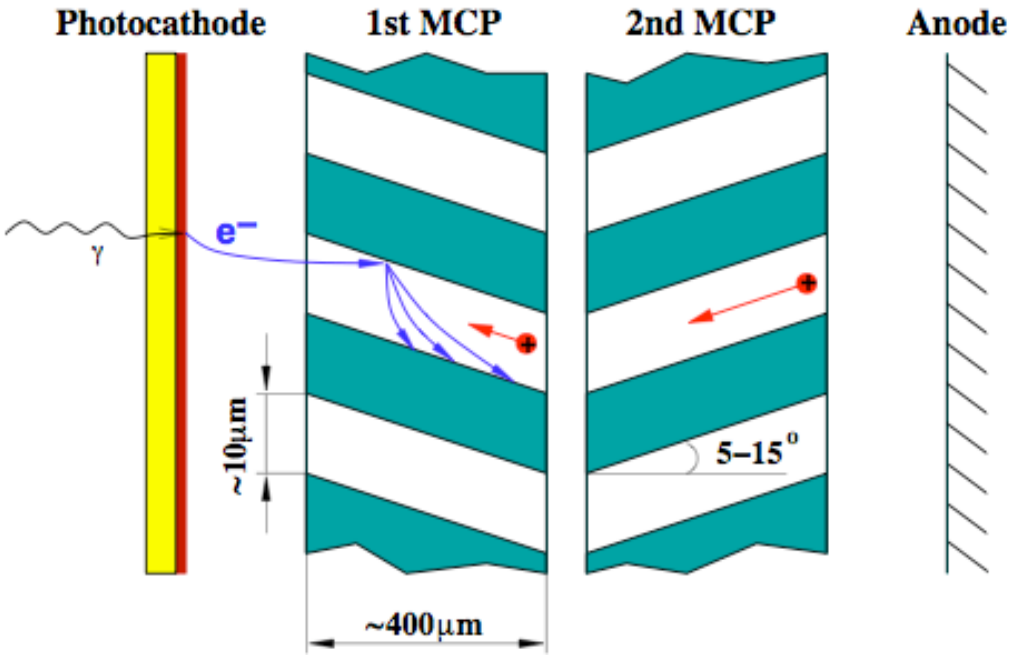


Photon counting rate up to (5-10)x10^6 $s^{-1}cm^{-2}$

Photocathode lifetime > 50-100 C/cm^2

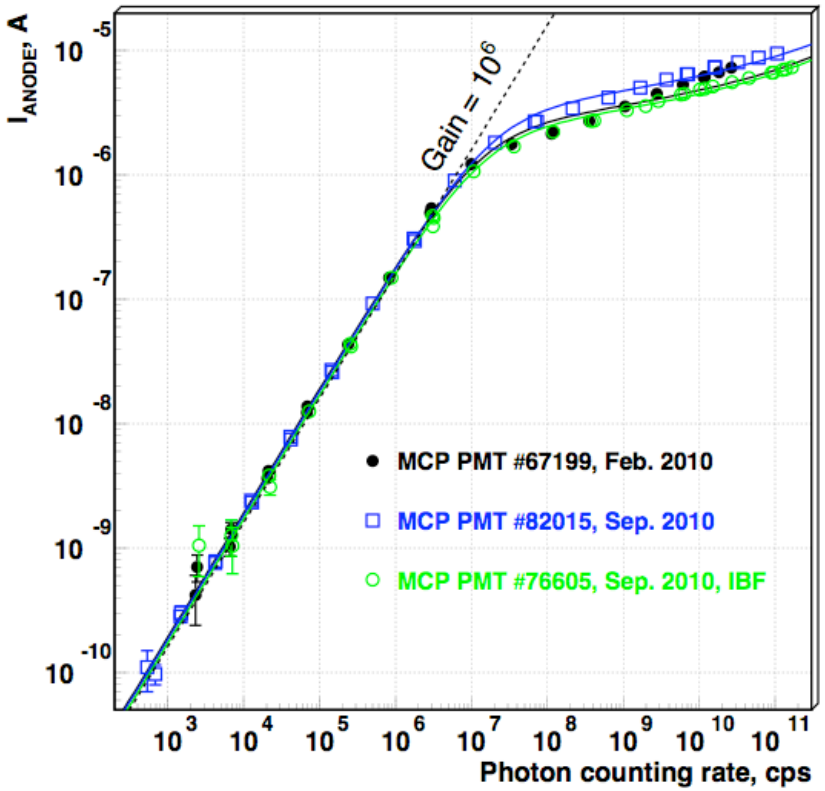
Scheme of MCP PMT

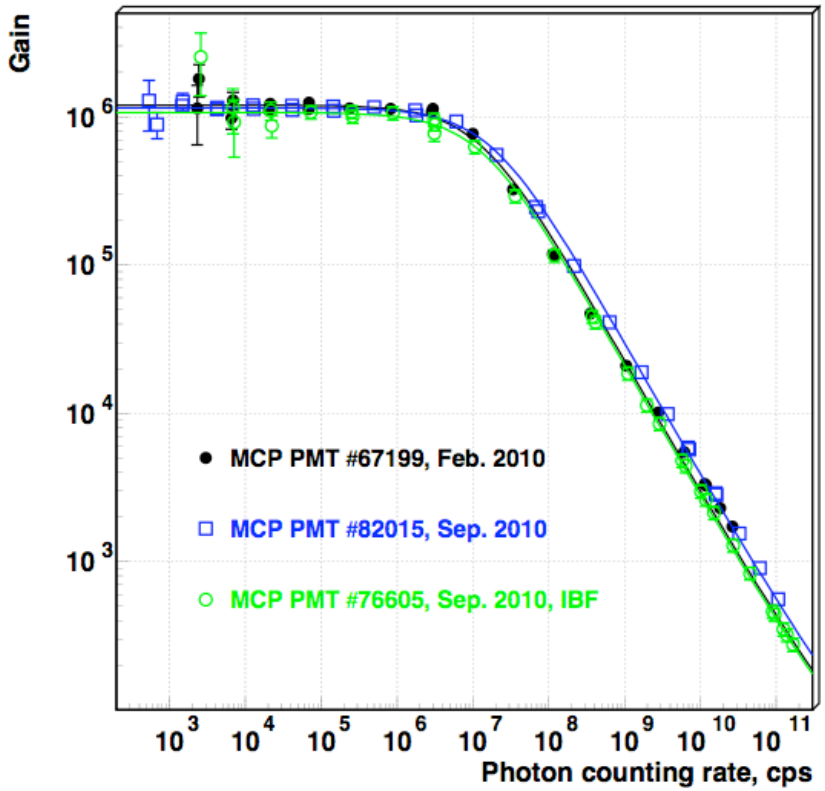




- Gain decrease due to finite MCP conductivity
- Photocathode aging because of positive feedback ions

Gain decrease at high counting rate





$$I(z) = I_{in} e^{\alpha z} \ln(M_0) / F / (1+I_{in}/I_s \cdot e^{\alpha z}) \quad \Rightarrow \quad M = M_0 \cdot \ln(M_0) / F / (1+I_{in}/I_s \cdot e^{\alpha z})$$

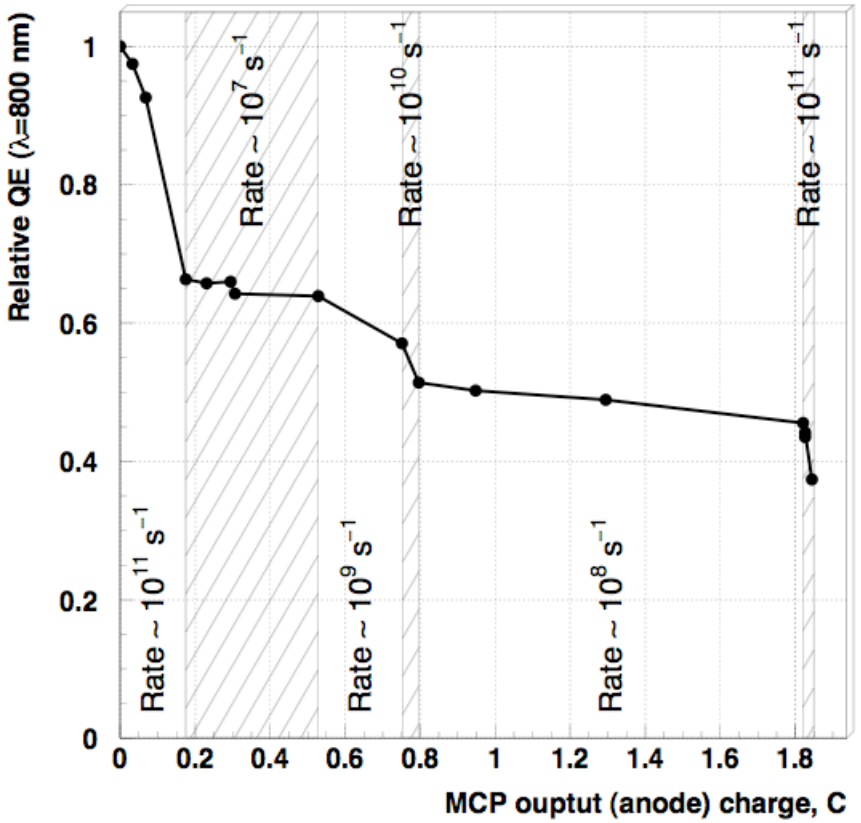
where

$$F = \ln(M_0) + \ln(1+I_{in}/I_s) - \ln(1+I_{in}/I_s \cdot M_0)$$

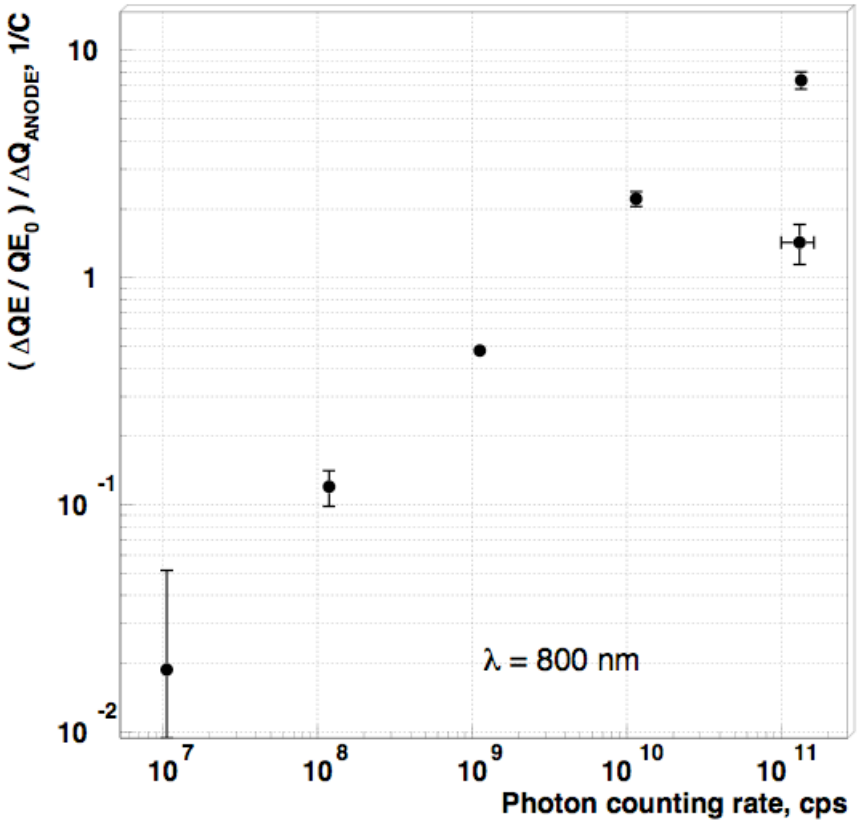
$$\alpha = \ln(M_0)/L$$

A.B.Berkin and V.V.Vasilyev, Proc. of SPIE 5834(2005)218

QE degradation vs. anode charge

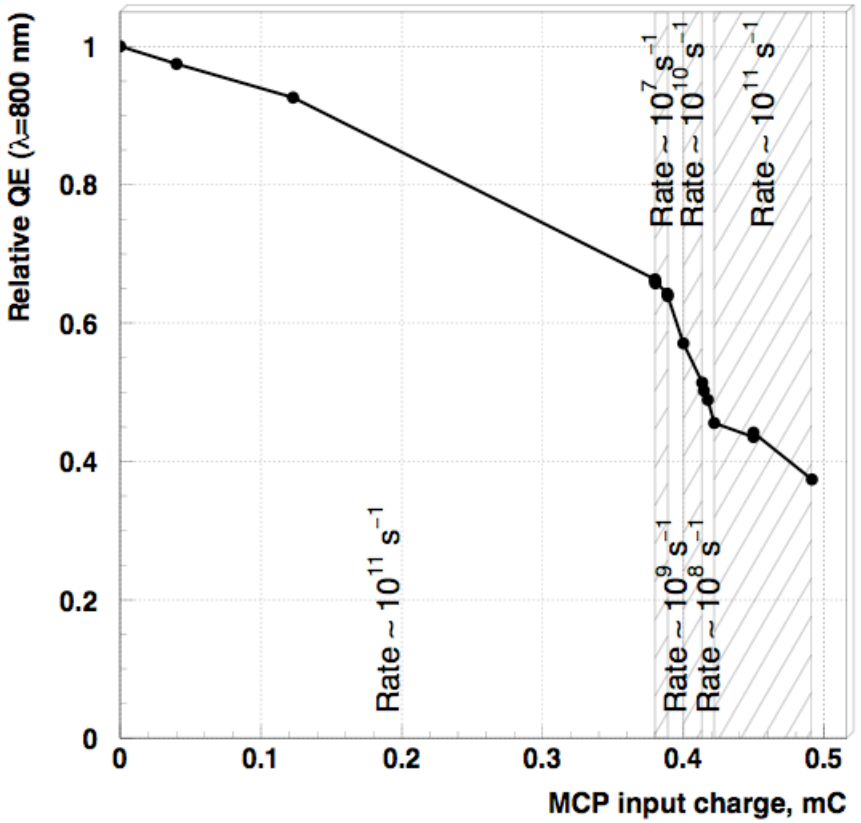


QE (λ=800nm) versus anode charge collected at different photon counting rates

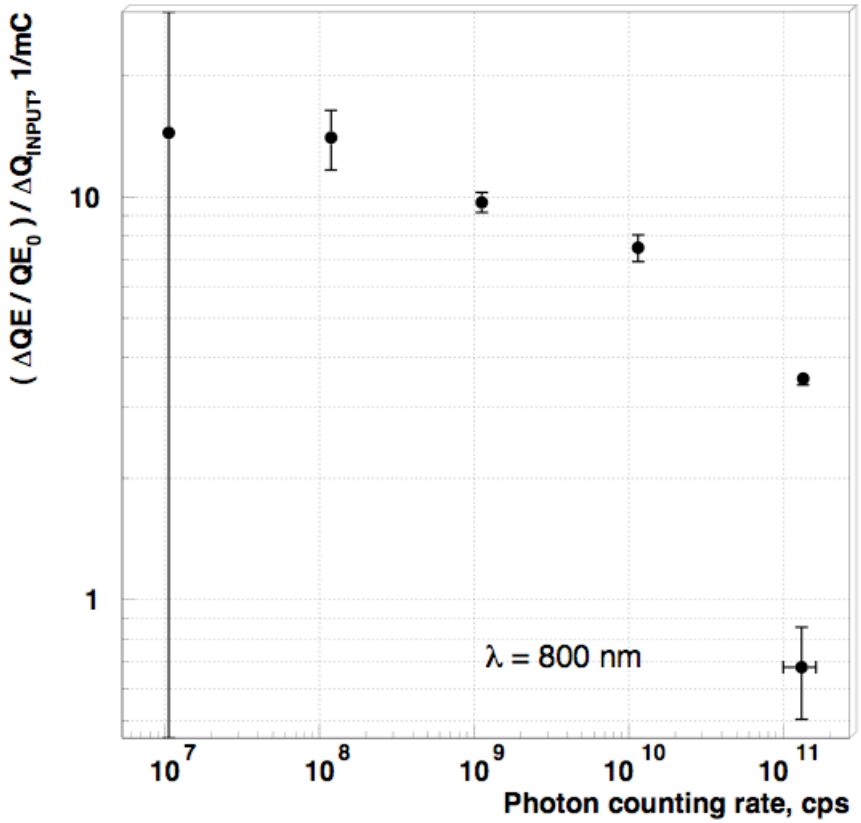


Specific QE degradation versus photon counting rate

QE degradation vs. MCP input charge

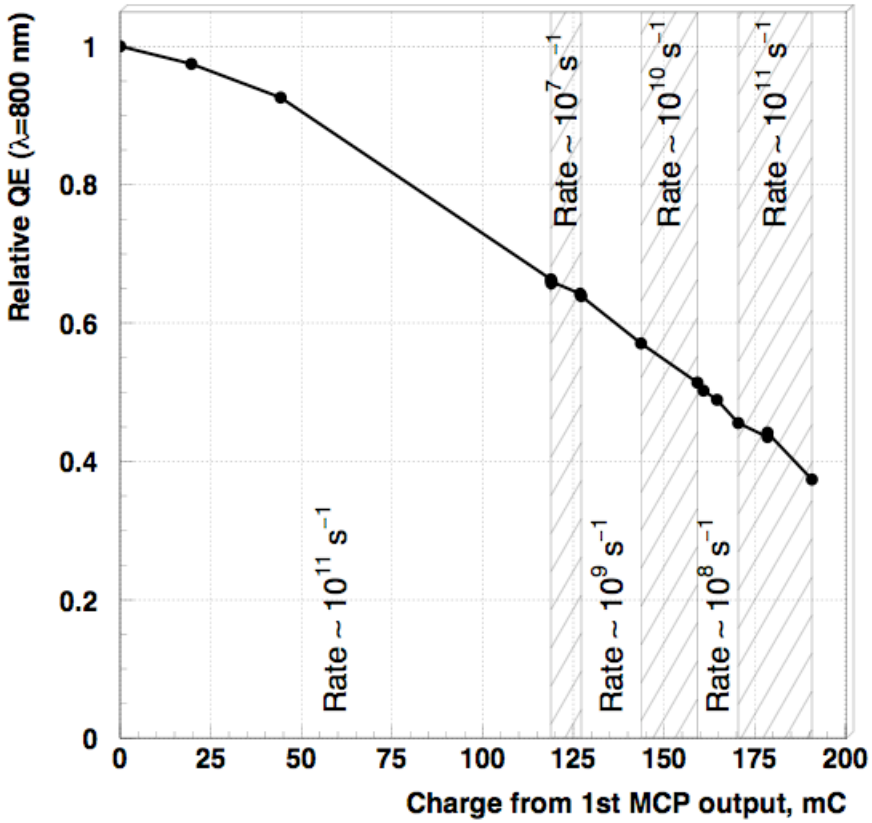


QE (λ=800nm) versus MCP input charge collected at different photon counting rates

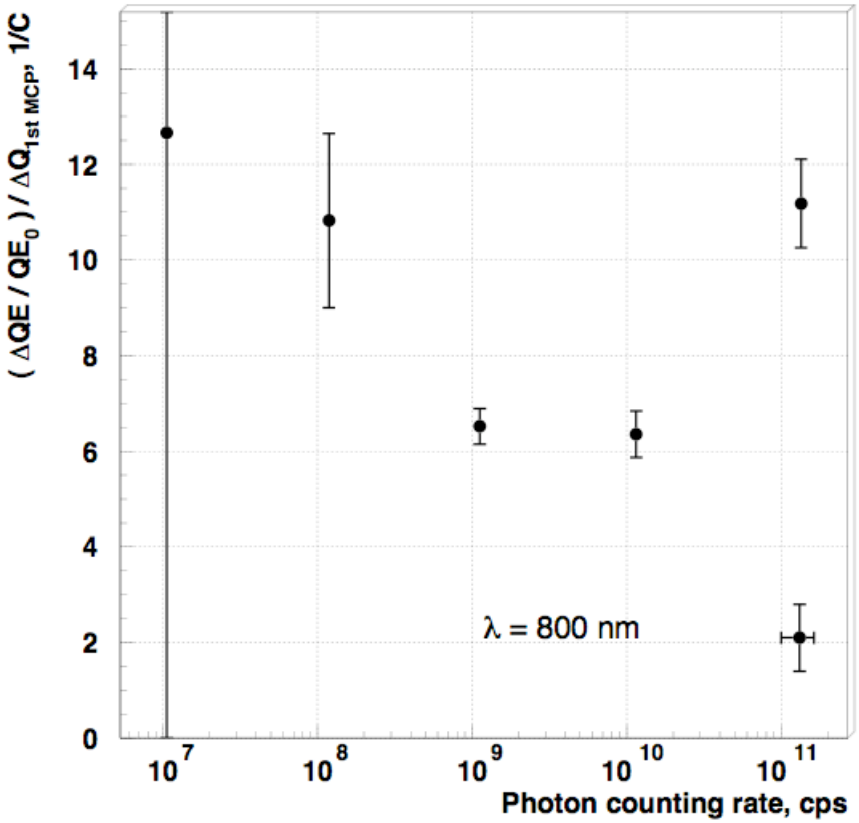


Specific QE degradation versus photon counting rate

QE degradation vs. charge from 1st MCP output

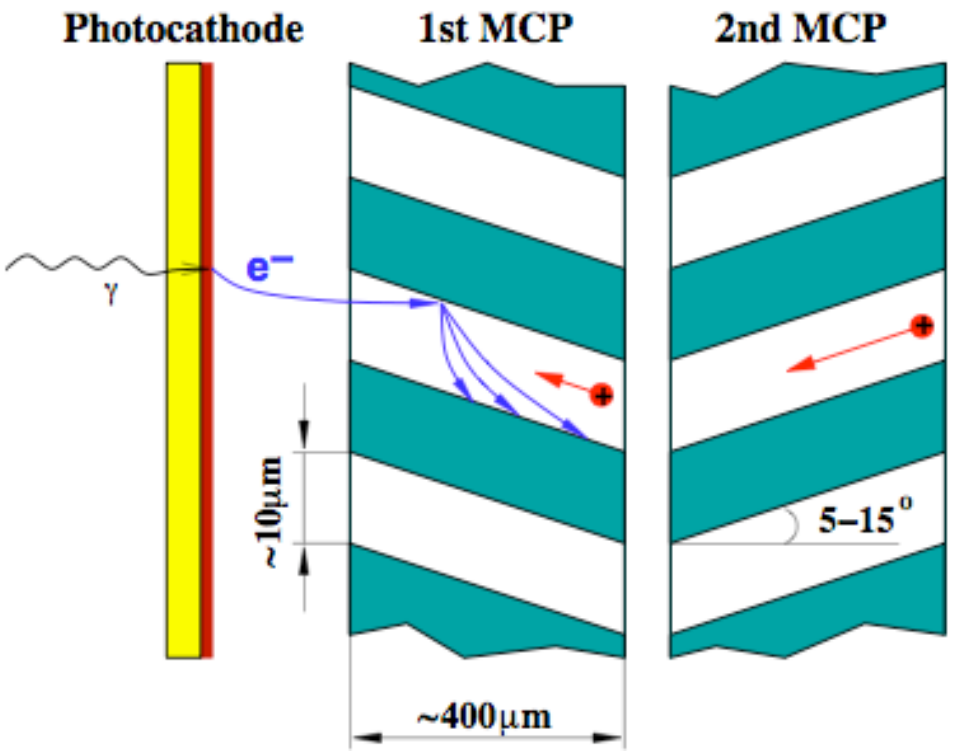


QE (λ=800nm) versus charge from 1st MCP output collected at different photon counting rates



Specific QE degradation versus photon counting rate

Interpretation of results



Hypothesis: only ions produced in the 1st MCP can reach the photocathode.

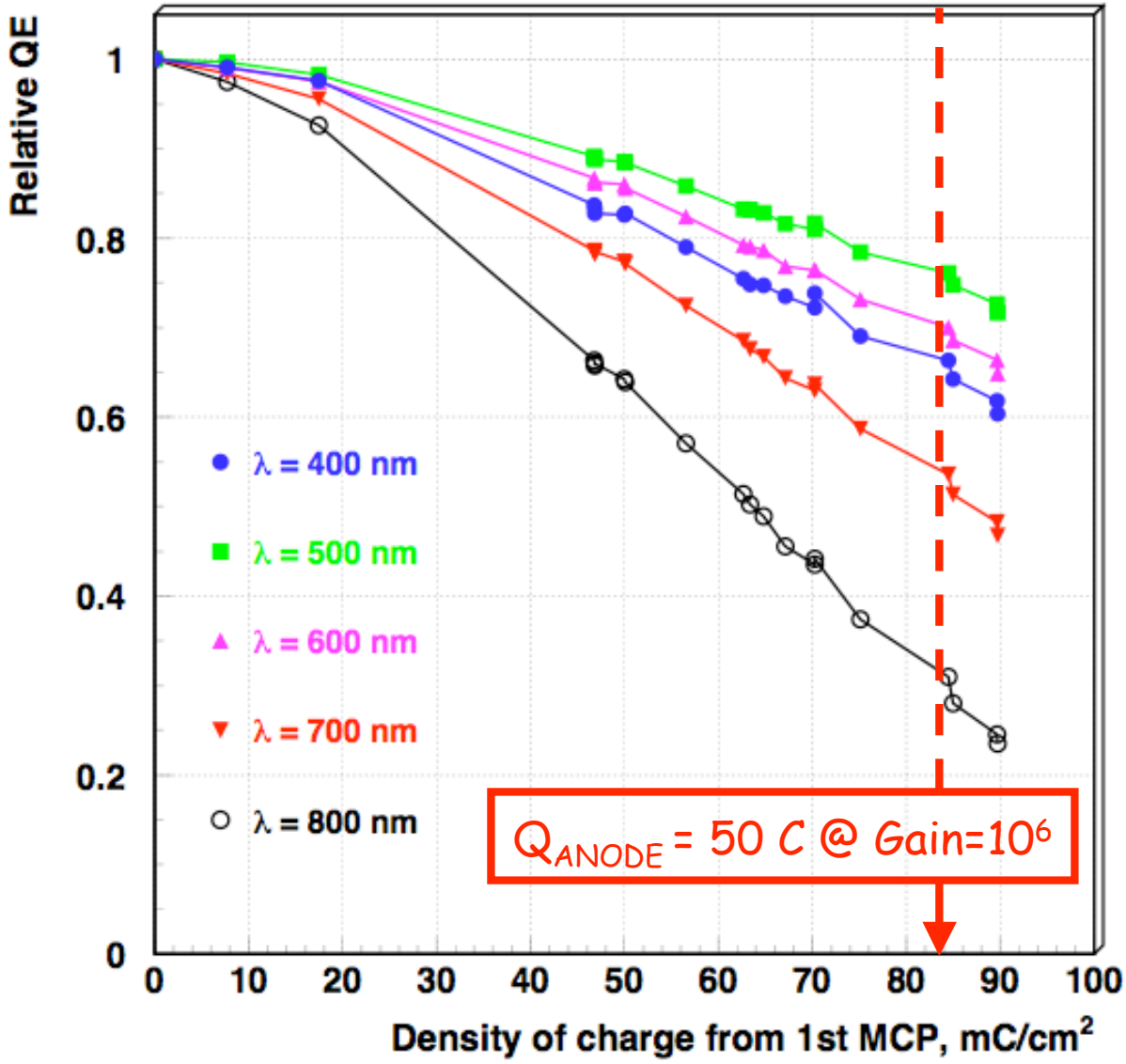
Then at low counting rate (in linear region) the QE degradation should be:

1. proportional to collected output (and input) charge;
2. proportional to square (for 2 MCPs) or cube (for 3 MCPs) root of the overall PMT gain.

Usefulness:

1. Fast measurement of the potocathode lifetime.
2. Proper PMT design for the lifetime improvement.

Lifetime estimation



Summary

- The dependence of specific QE degradation on the photon counting rate has been measured.
- It seems that the photocathode aging is determined by ions produced in the first MCP.
- Estimated lifetime of the tested MCP PMT is ~50 C of anode charge.