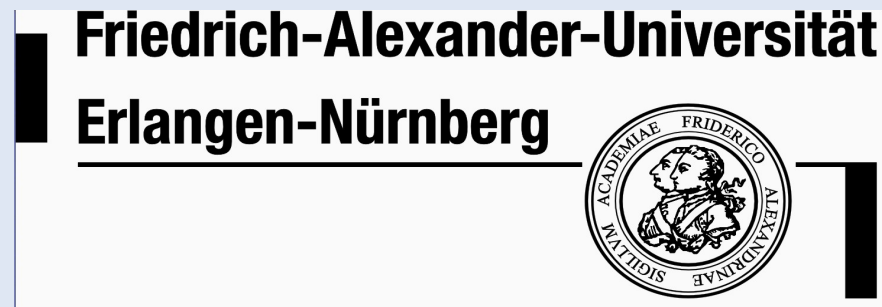


Recent developments in Erlangen



Alexander Britting, Wolfgang Eyrich, Albert Lehmann, Fred Uhlig

supported by BMBF and GSI

Overview

- Measurement of work functions of MCP-PMTs
 - Motivation
 - Setup
 - Results for BINP#73 and #82
- Behaviour of JT0158 (R10754X-06-L4) before and after CERN
- QE and signals of XP85112
- First results of lifetime measurements

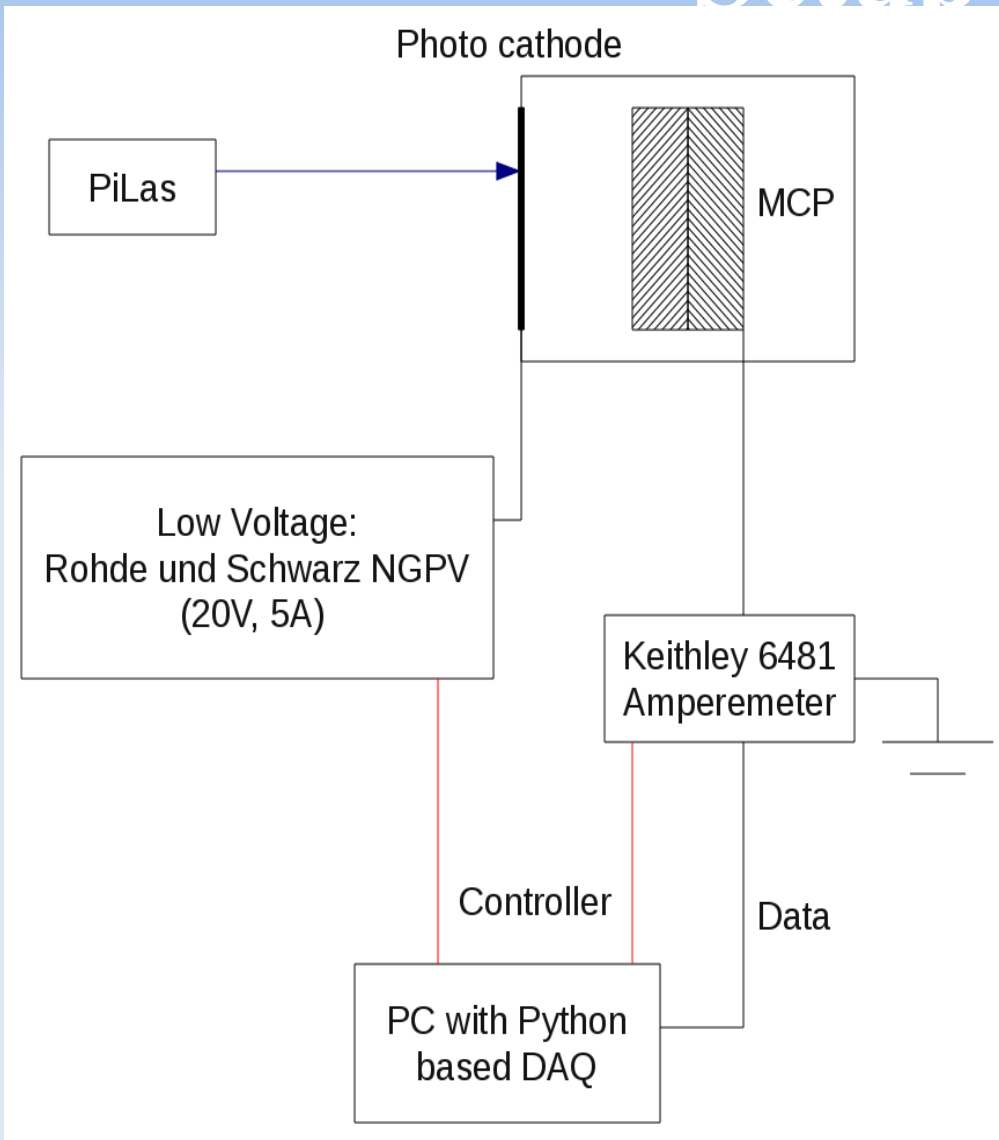
Motivation

Adsorption of neutral gas molecules and **defects** in the photo cathode caused by ion bombardments are limiting the lifetime of the photo cathode.

- **Goal:** Measuring amount (and kind) of adsorped gas molecules and defects
- **Problems:**
 - Adsorption can be directly measured by diffraction of low energy electrons (**LEED**), but requires opening of the housing of the PMT
=> destructionless measurement required
 - Work functions are accessible by illuminating with high energy UV light and measuring the photoelectron momenta (e.g. He, ~20eV, UV photoelectron spectroscopy **UPS**). Borosilicate glasses are **intransparent** for such high energy.
- **But:**
 - Changes of the electron affinity affect initial current of diodes
=> shifts in the 1. derivative of the current results from adsorbing gases

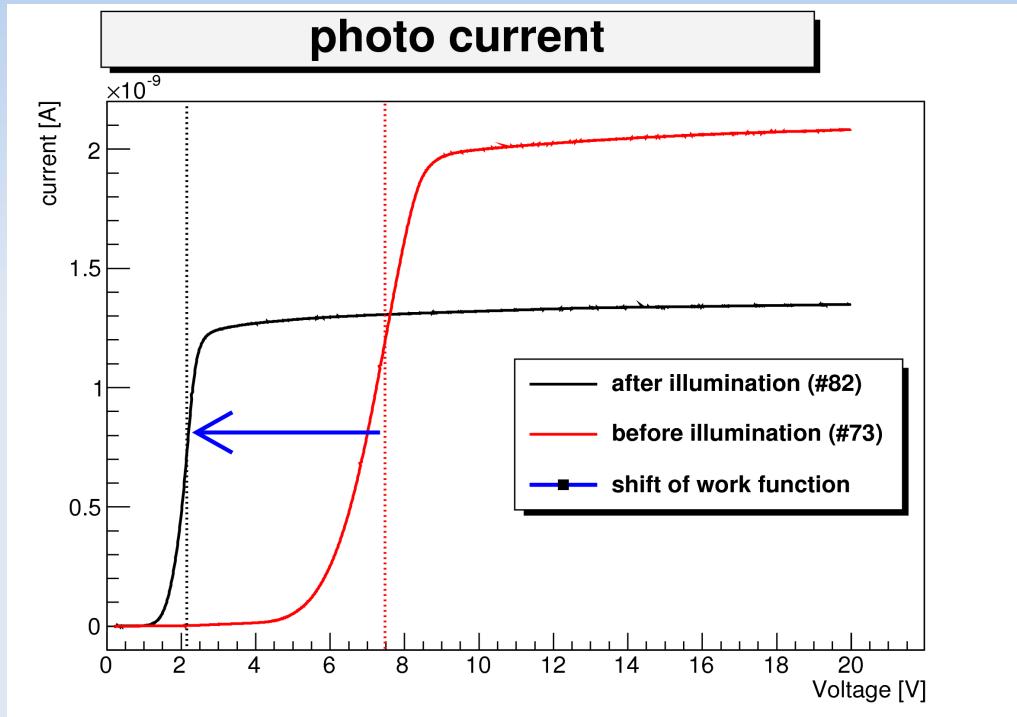
(e.g. Henzler/Göpel - Oberflächenphysik des Festkörpers, Teubner Studienbücher)

Setup



- Photo cathode voltage can be varied in 10mV steps (0 – 20V)
- Low voltage is controlled by IEC-625 (GPIB)
- DAQ is fully automated to control voltage and measuring current

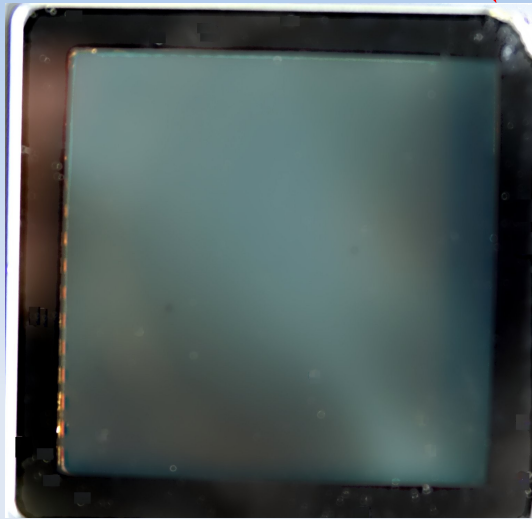
BINP #73 and #82



- Work function differs by 5.4eV, but need not be induced by adsorption since two different devices were investigated
- Decrease of saturation current is generated by decreased quantum efficiency
- Hopefully more information can be gathered with current lifetime measurements

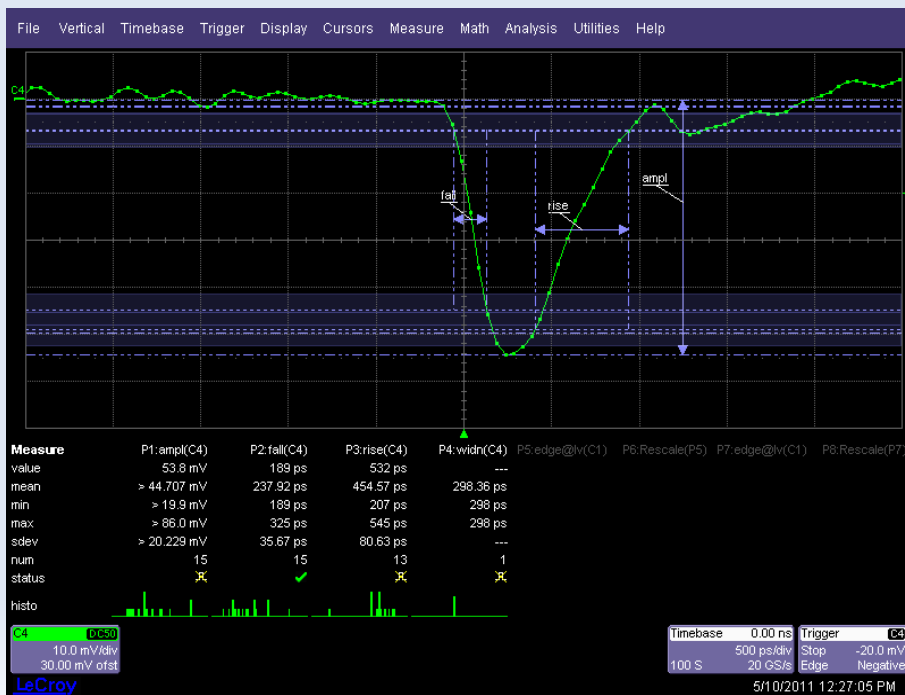
What happend to the L4?

cracked corner

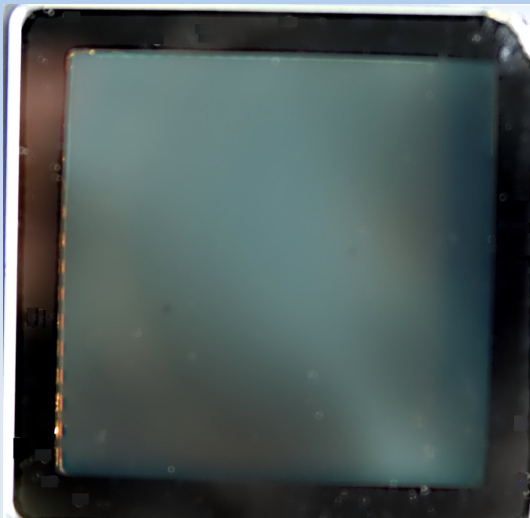


L4 and M16 were cracked at a corner during installation at CERN

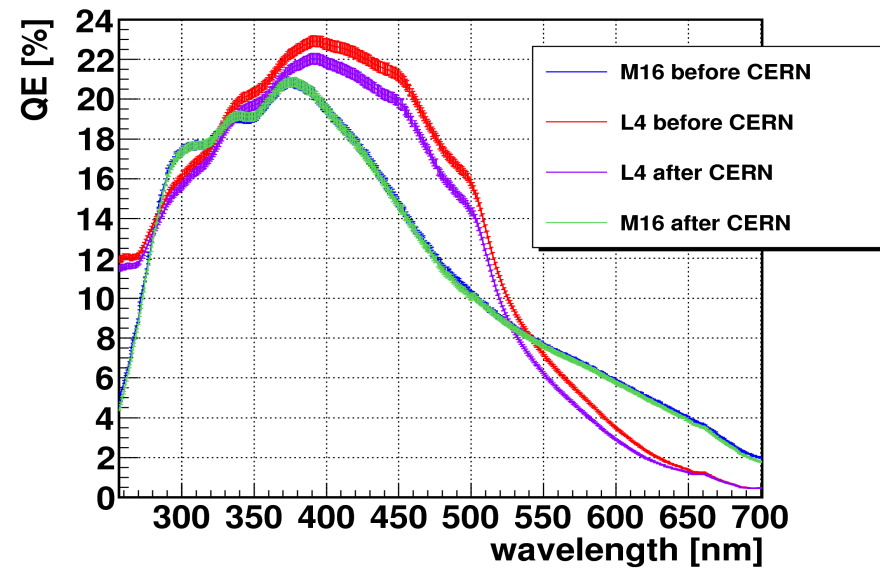
| L4 | before | after CERN |
|------------|--------|------------|
| width (ps) | 298 | 859 |
| fall (ps) | 238 | 329 |
| rise (ps) | 454 | 869 |



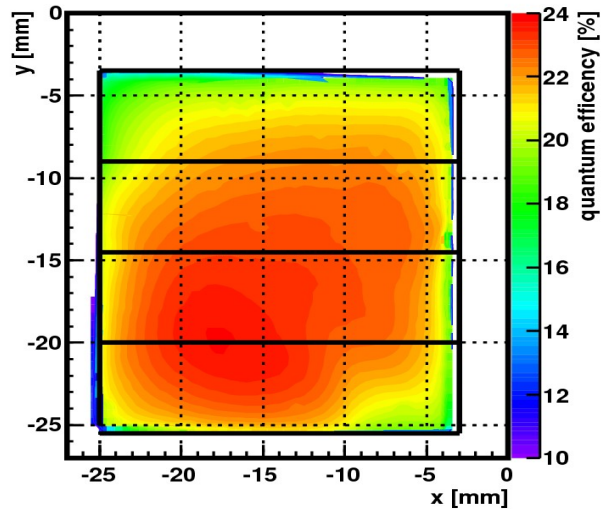
L4 – Quantum Efficiency



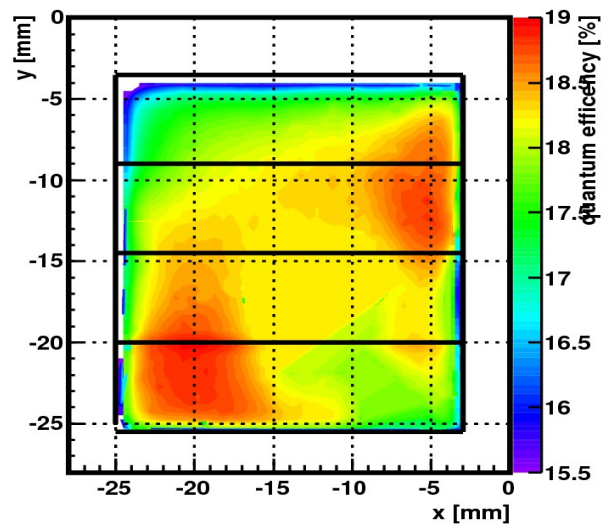
Quantum Efficiency of various MCP-PMTs



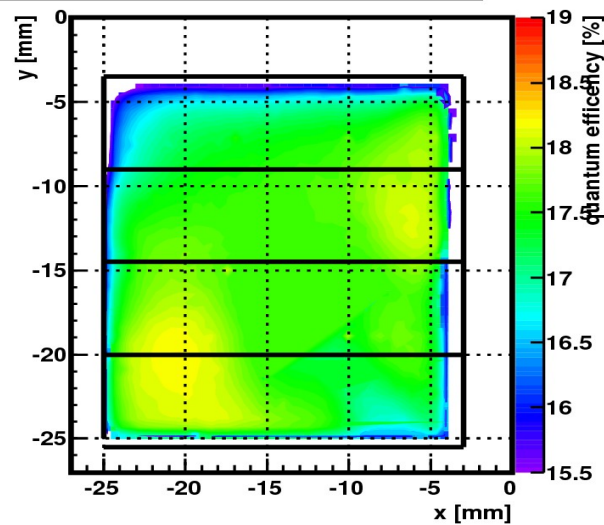
Juli 9th (before CERN)



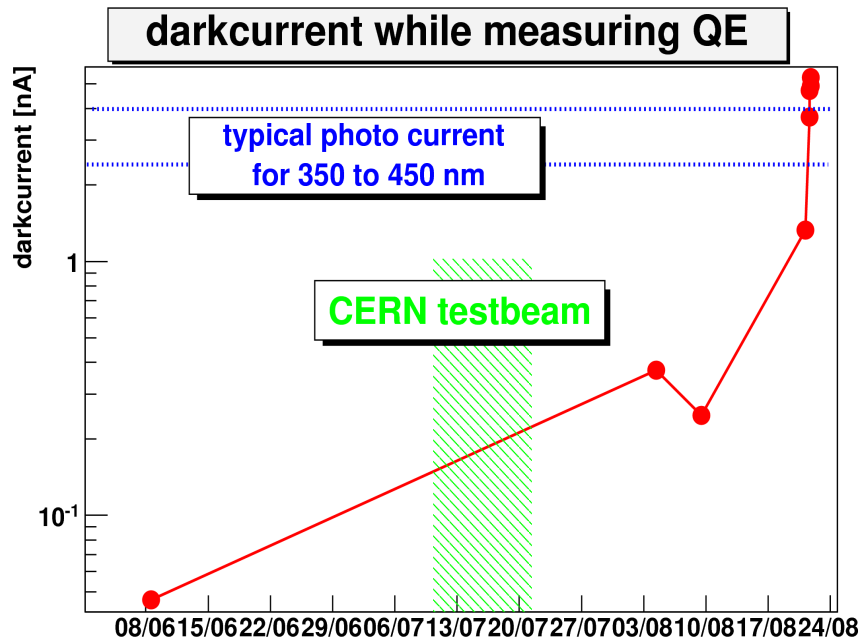
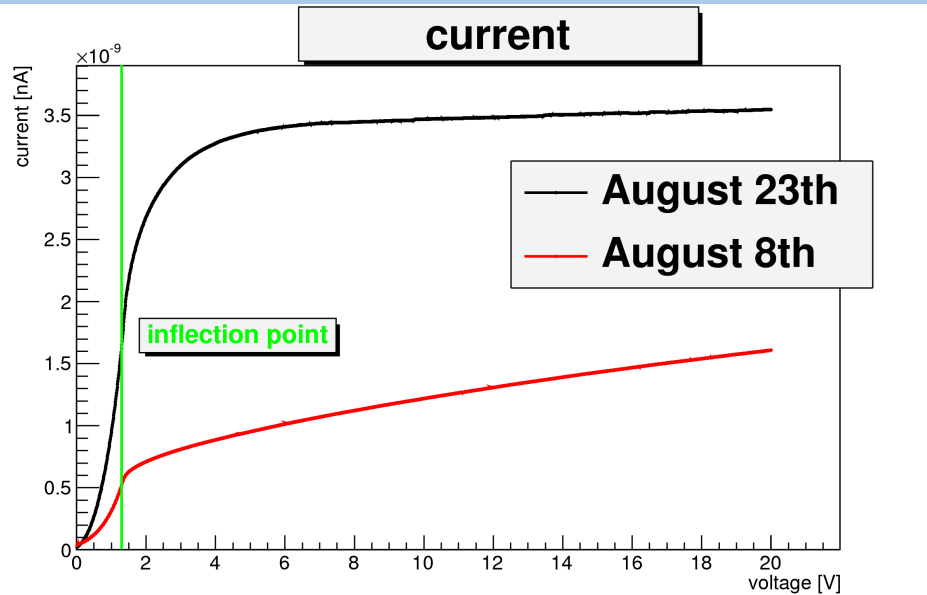
August 5th (after CERN)



August 22th (after CERN)

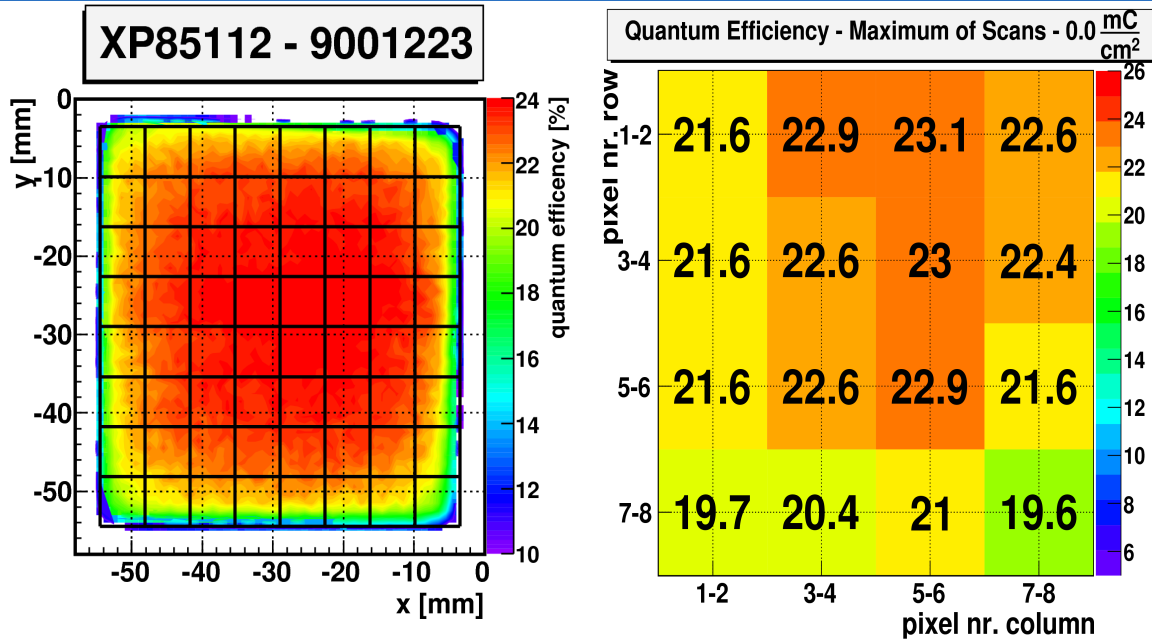


L4 – work function and dark current

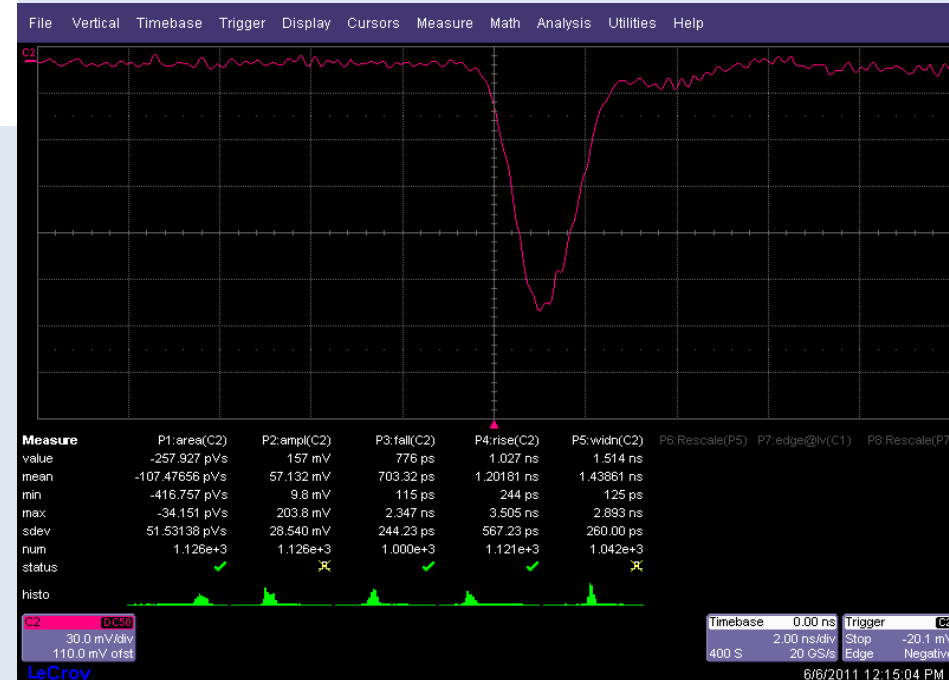
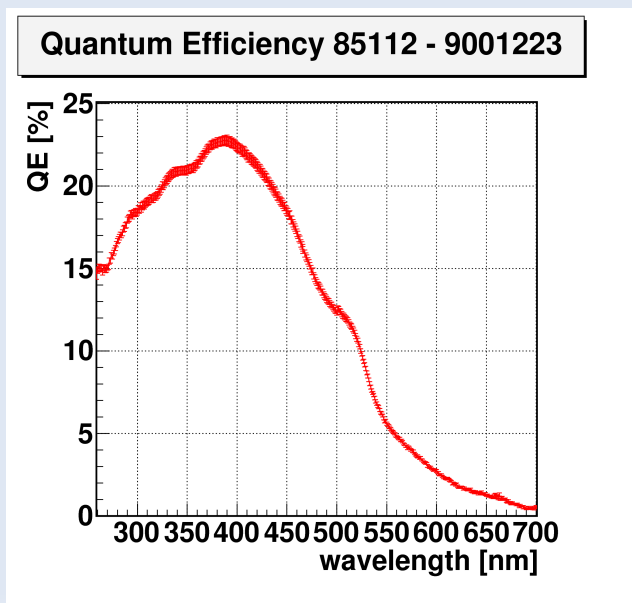


- Saturation current has tremendously increased, despite same light flux (PiLas 20kHz, unattenuated)
- This can be explained by ionization of gas molecules
- Inflection point almost unchanged ($\Delta U = 50\text{mV}$)
- Dark current increased dramatically ($\sim 50\text{pA}$ to 5.3nA) and exceeded the typical photo current

85112



| 85112 | before | after CERN |
|------------|--------|------------|
| Width (ns) | 1.44 | 1.42 |
| fall (ps) | 703 | 684 |
| rise (ns) | 1.20 | 1.34 |



Lifetime measurements

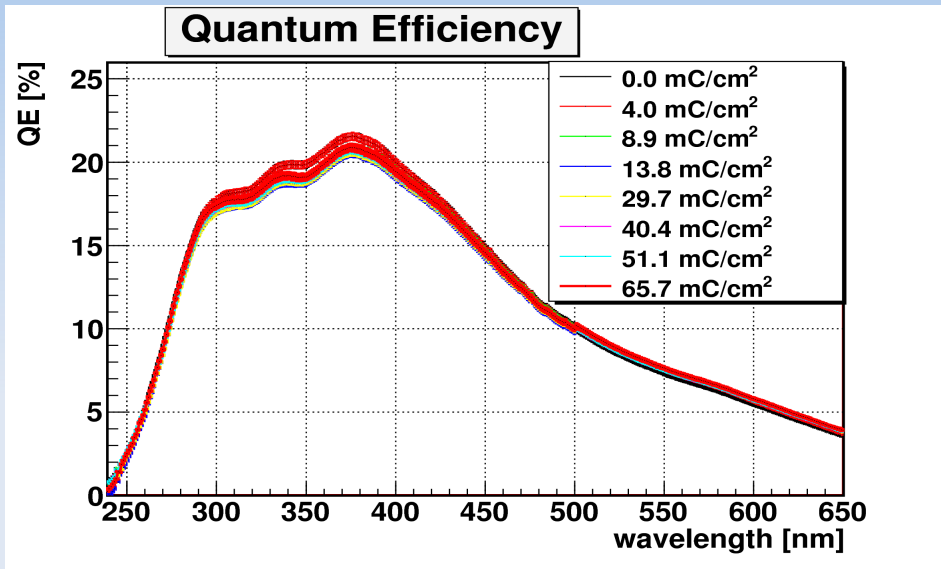
- Lifetime measurements of Hamamatsu JT0117 (R10754X-01-M16), JT0158 (R10754X-06-L4) and Photonis XP85112/A1-HGL – 9001223 have started at August 23th.
- Light flux for L4 attenuated by additionally ND 0.3, to achieve single photon level => about 50% of integrated charge than M16 and 85112, but can be changed later on
- Frequency: 275 kHz
- Collected charge per day:
 - ~5.0-5.5 mC/cm² (M16, 85112)
 - 2.8 – 3mC/cm² (L4)

| | 85112 | M16 | L4 |
|--------------------------------------|----------------------|------|------|
| Active Channels | 11 (10 + MCP-Out) | 8 | 4 |
| Illuminated channels | 8 | 8 | 4 |
| Unexposed channels | 2 | 0 | 0 |
| Illuminated area | 50% | 100% | 100% |
| Nr. of QE measurements | 2 | 1 | 1 |
| Nr. of crosstalk suppressed channels | 2 | 2 | 4 |
| Voltage (V) | 2050 | 3300 | 3300 |

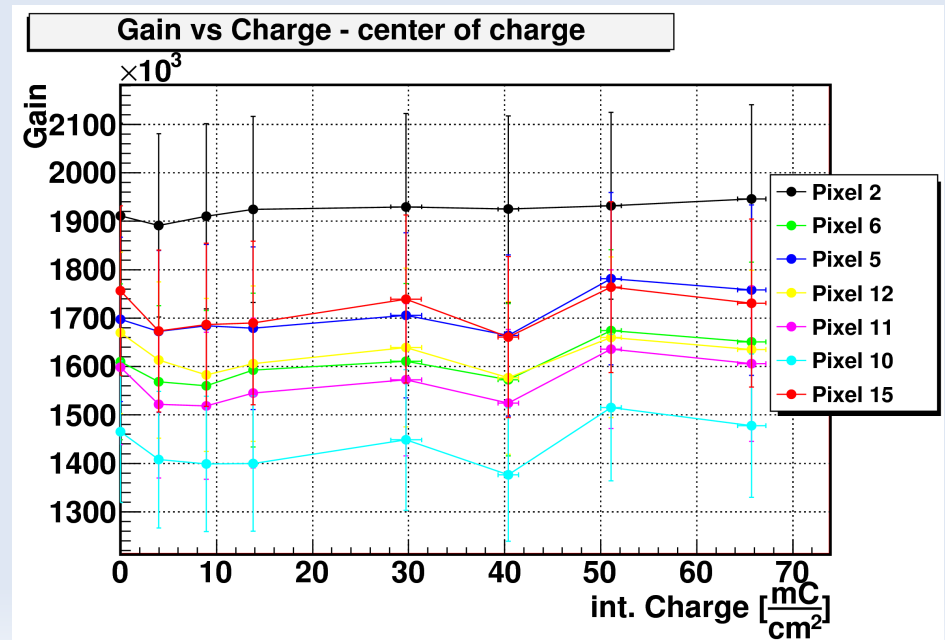
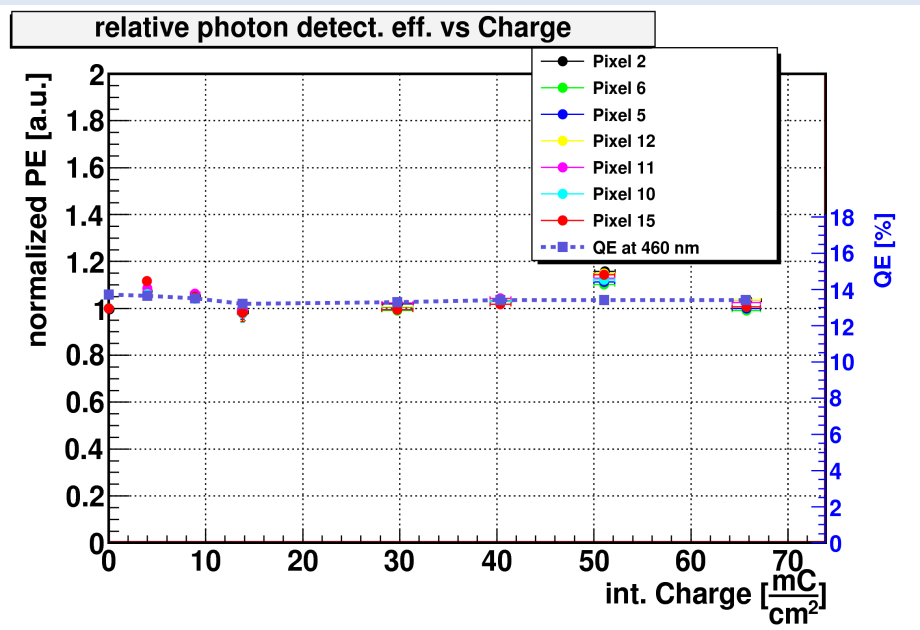
Sept. 6, 2011

Lifetime measurements

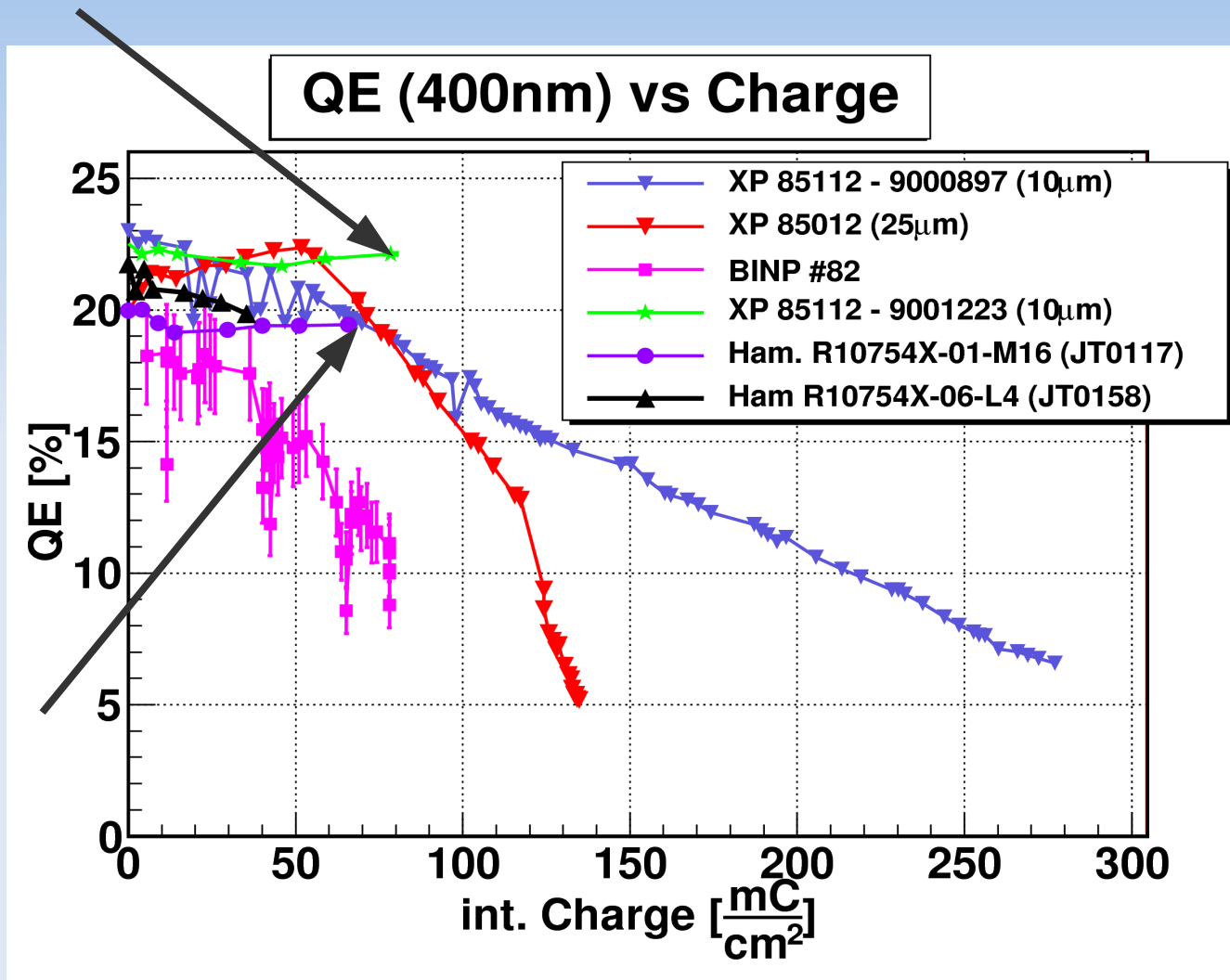
M16



Quantum Efficiency, Gain and relative photon detection efficiency unchanged for all MCP-PMTs



Lifetime measurements (2)



- Although just 65 mC/cm² (M16) (78 mC/cm² (85112) and 35.5 mC/cm² (L4)) lifetime already exceeds all previous models
- Int. charge of L4 is half of M16/85112, since the illumination is attenuated by an additional ND 0.3

Summary

- Difference in work function can be measured in 'diode mode'.
Goal: Measuring correlations between work function and QE
- L4 is damaged by cracked corner, M16 seems unharmed. Impact on lifetime measurements unpredictable at the moment
- No degradation obvious at the moment after 65 mC/cm² (M16) (78 mC/cm² (85112) and 35.5 mC/cm² (L4)) after 13 days of illumination
- More details next time:
 - Magnetic field measurements of XP85112 – 9001223
 - Ongoing lifetime measurements