Progress in Erlangen

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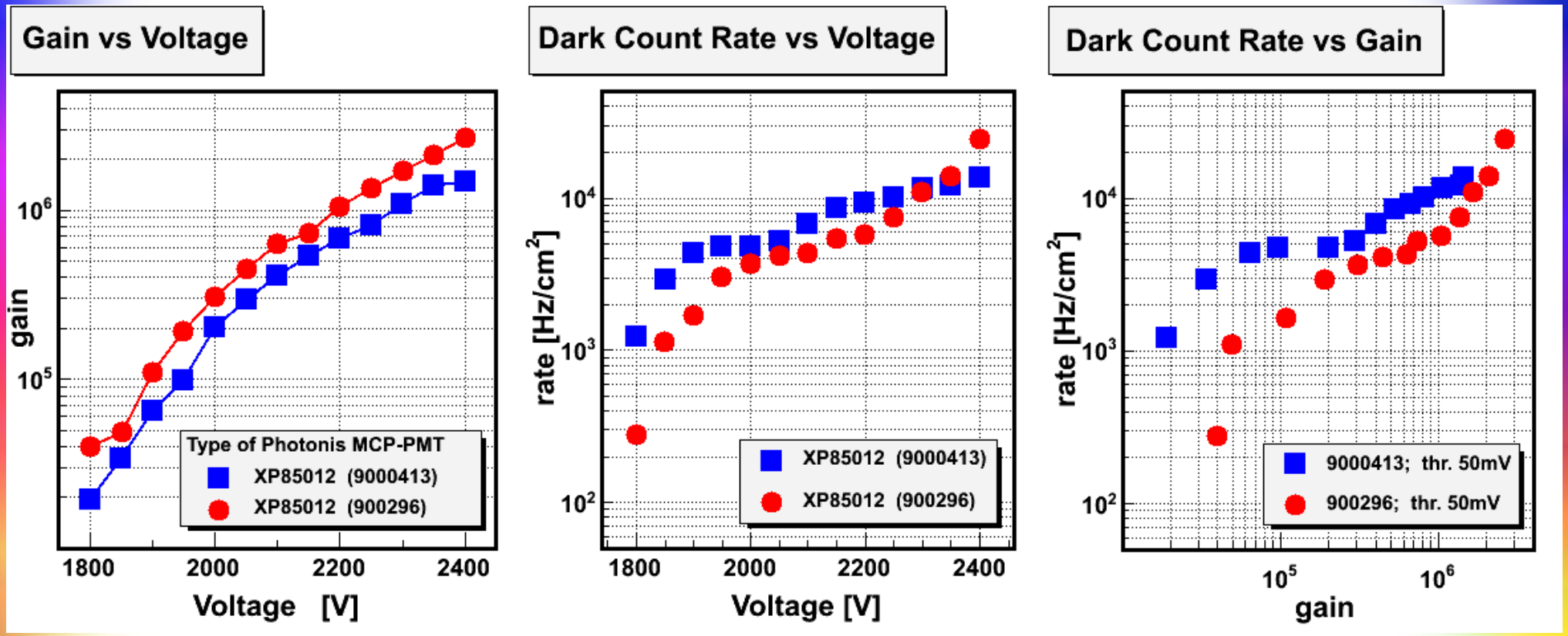
- Burle-Photonis MCP-PMTs
  - Various performance measurements
  - Magnetic field behaviour
- Lifetime measurements
  - Burle-Photonis 85012 and BINP #82
  - Results of other groups

What happened since March Meeting?

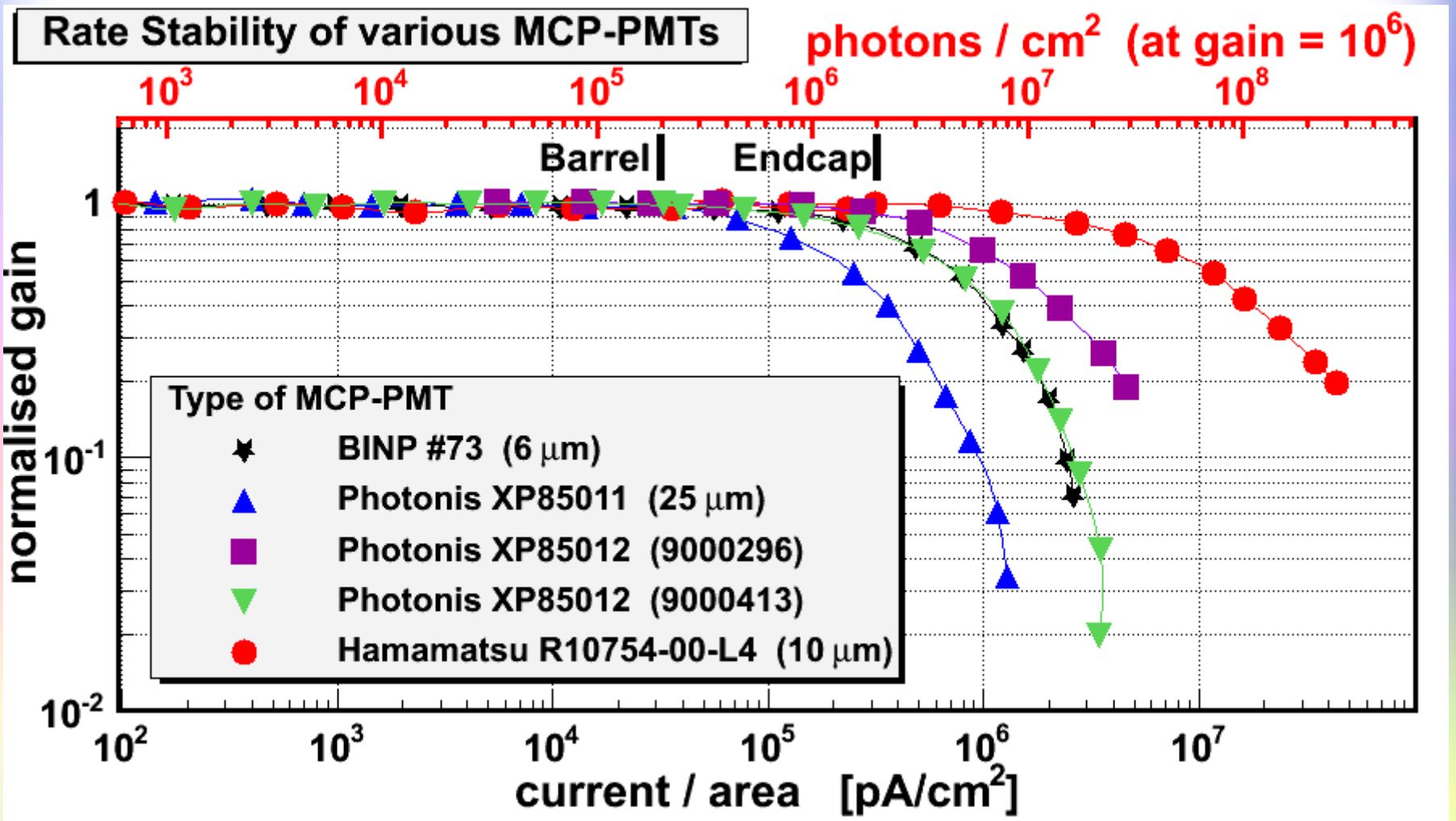
- Lifetime measurements for XP85012 continued (until Apr.16)
- Several other measurements for XP85012 (rate stab., time res.)
- Magnetic field measurements in Juelich (Apr.19-23)
  - 3 models of XP85012 (9000296, 9000413, 9000414)
  - 1 model of Hamamatsu R10754-00-L4 (jt0096)
- Apr. 26/27 botnet attack at physics server
  - demand of reinstallation of all computers in the physics institute
- Mid May: Axle of XY-scanner broke
- June 4: crash of hard drive on our main DAQ computer
  - (almost) no backup existent !!
  - attempt to recover the hard drive in specialized company

Darkcount of Photonis 25 µm MCP-PMTs



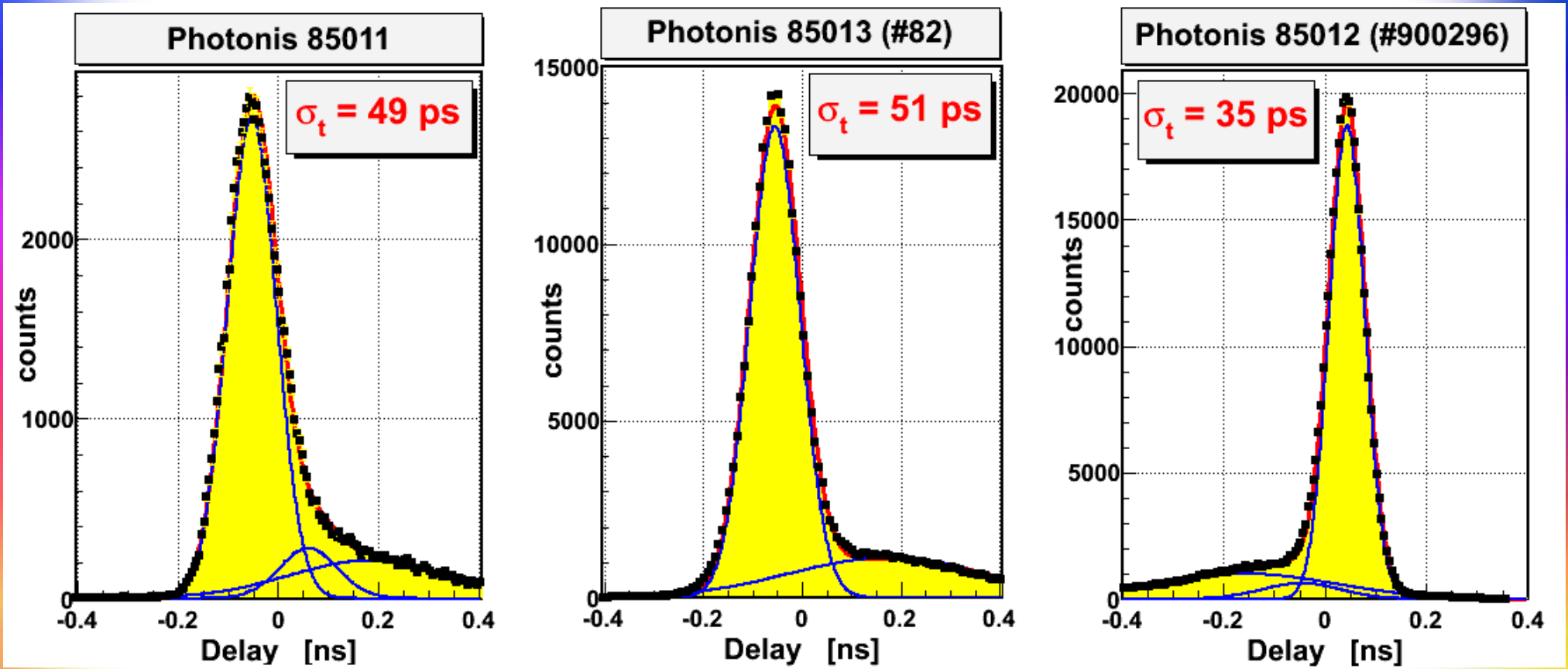
- Darkcount rate (gain 10^6; thresh. 50 mV; ampl. x200): 5-10 kHz/cm^2
- Similar slope for both XP85012 models

Rate Stability of various MCP-PMTs



- Different rate stability for 2 models of Photonis XP85012 (25μm)
- XP85012 stable up to ~1 MHz/cm^2 s.ph. → okay for barrel DIRC

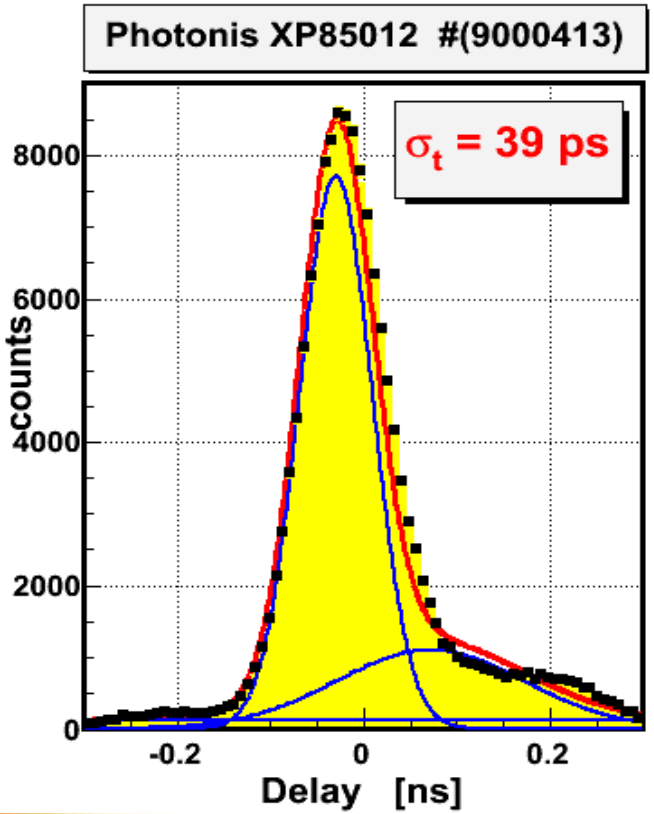
Photonis Single Photon Time Resolution

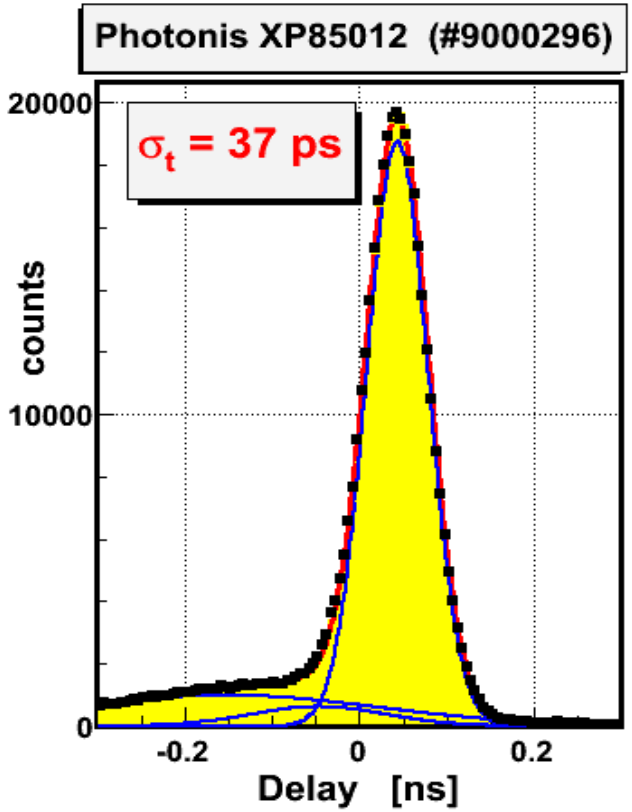


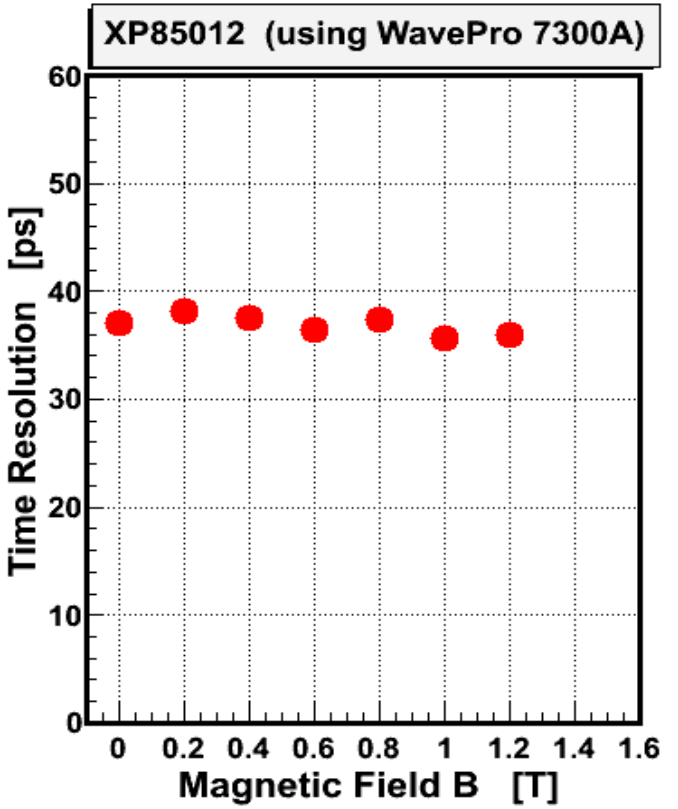
- **single photon time resolution of ~50 ps for 85011 and 85013**
  - Philips Scientific 705 discriminator and Ortec FTA820 amplifier (x200)
- **time resolution of 85012 is significantly better !**

XP85012 Single Photon Time Resolution

Amplifier Ortec FTA820 (x200; 350 MHz) --- Discriminator Philips Scientific 705





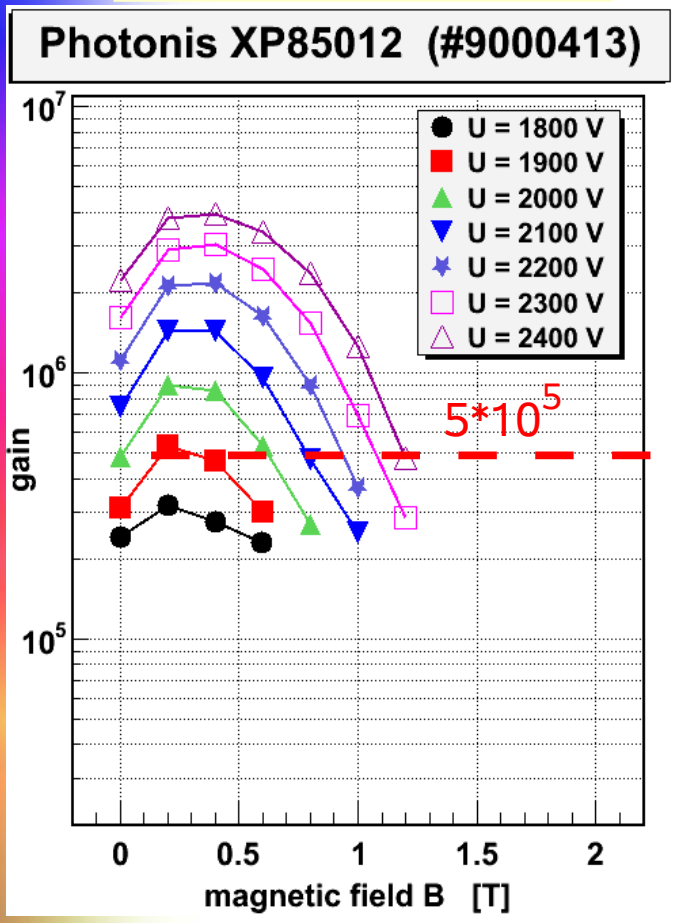


BINP	Photonis				Hamamatsu
#73	XP85011	XP85012	XP85013	Prototype	R10754
6 µm	25 µm	25 µm	25 µm	10 µm	10 µm
27 ps	**49 ps**	**37 ps**	**51 ps**	**41 ps**	**32 ps**

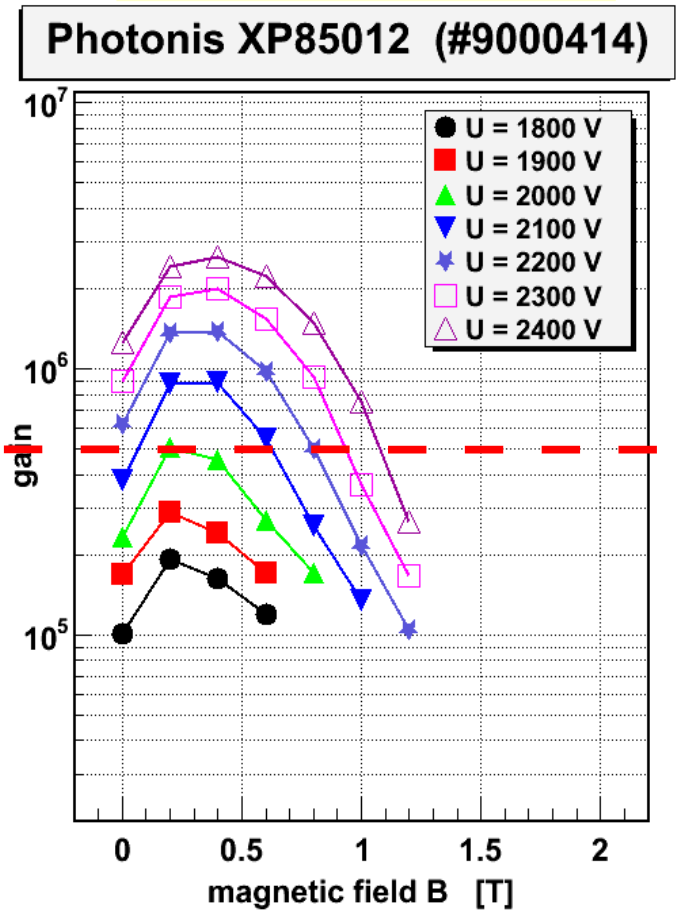
- time resolution of all MCPs 50 ps and better
- **no dependence on the B-field**

Gain in Magnetic Field

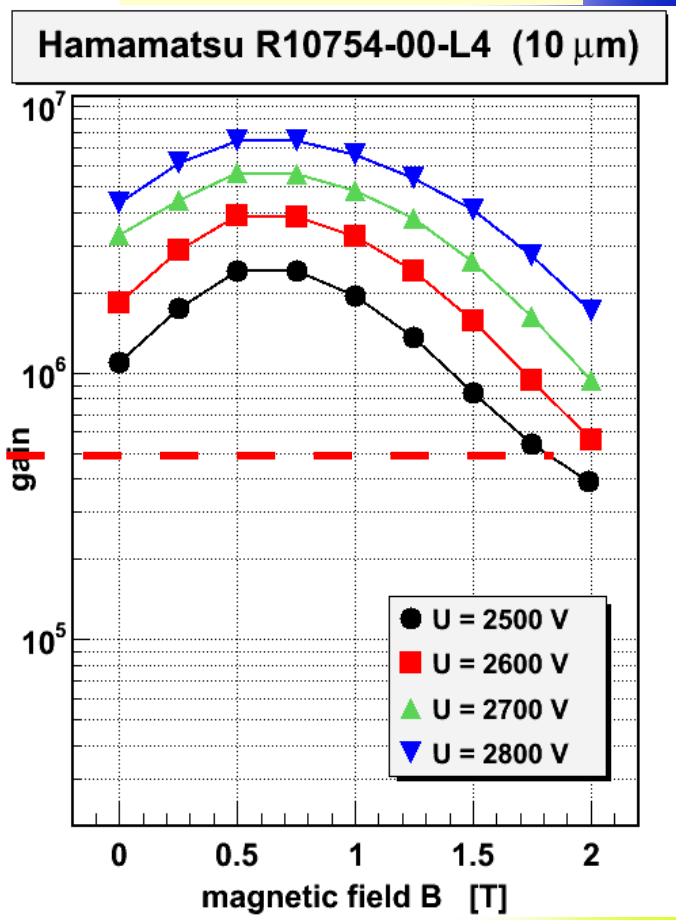
XP85012 (25 μm)



XP85012 (25 μm)



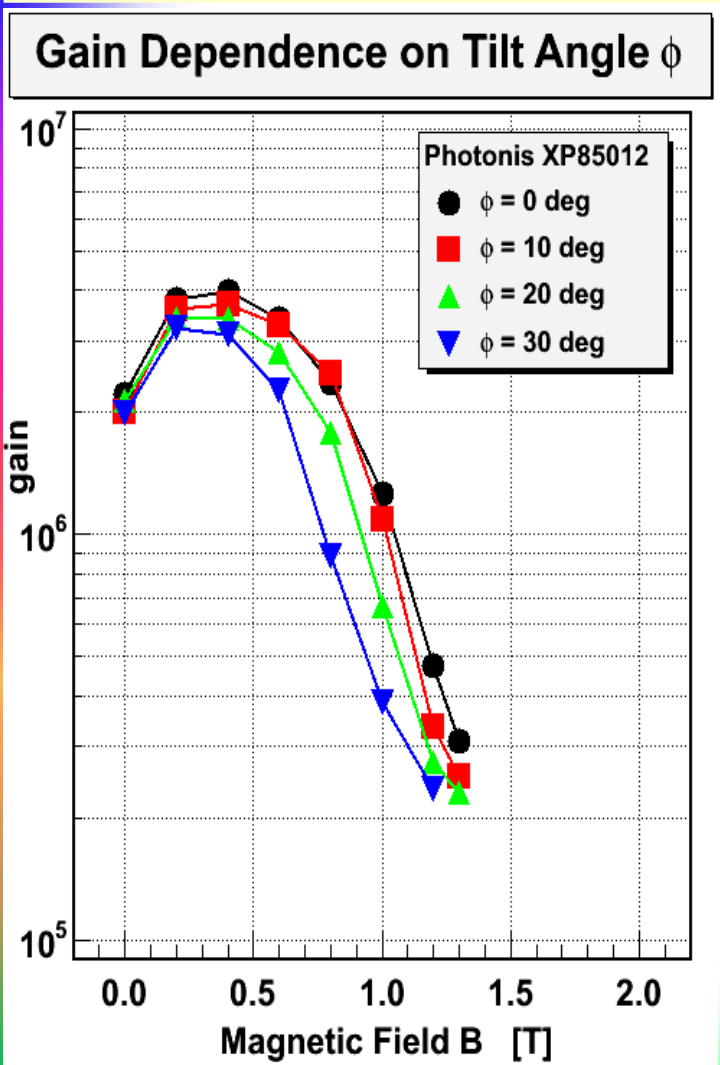
R10754 (10 μm)

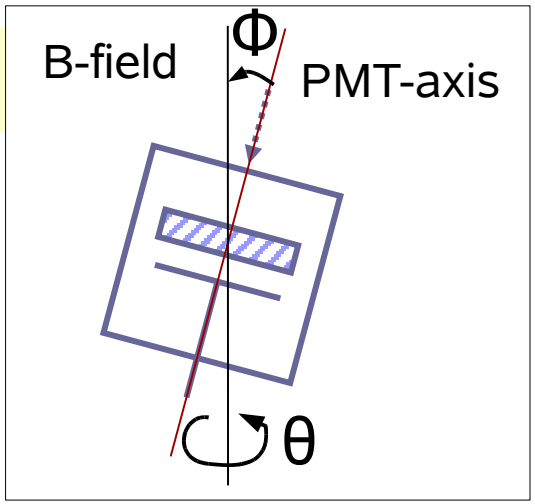


- 25 μm MCP gain breaks down at ~1 T → marginal for Barrel DIRC
- 10 μm MCPs should be suitable for both Endcap and Barrel DIRC

Gain and Direction of B-Field (Φ)

Photonis XP85012 (25 µm)



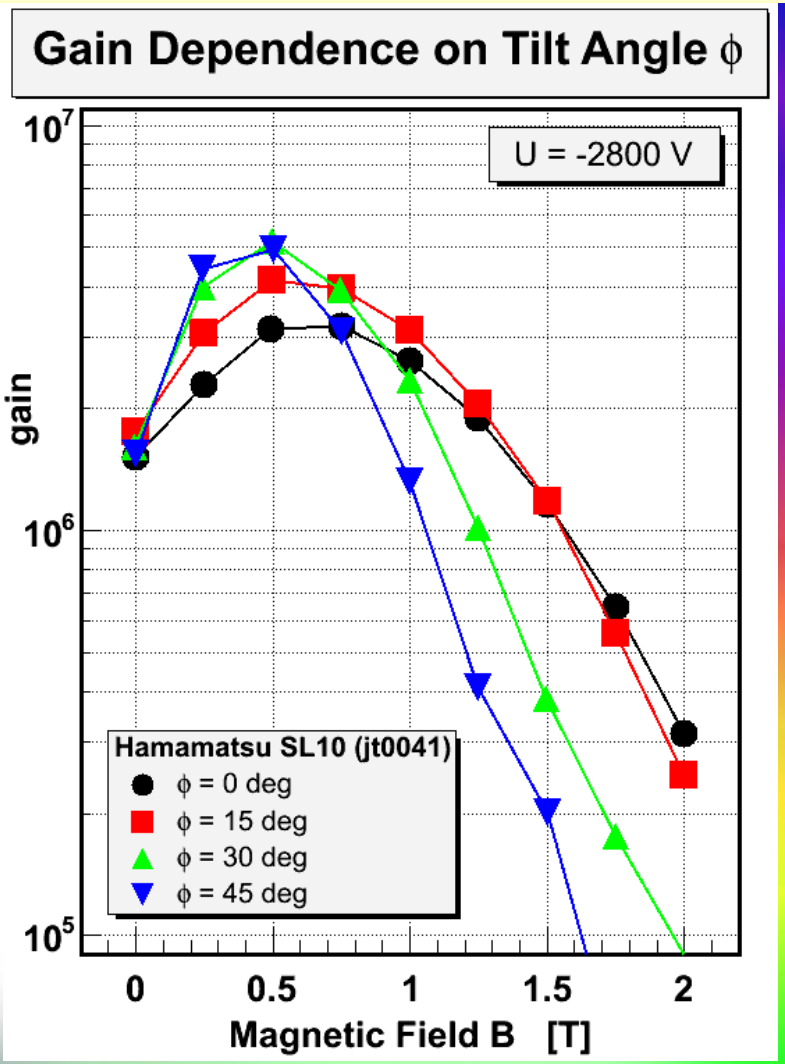


ϕ = tilt angle between B-field direction and PMT-axis

θ = rotation angle of PMT around B-field direction

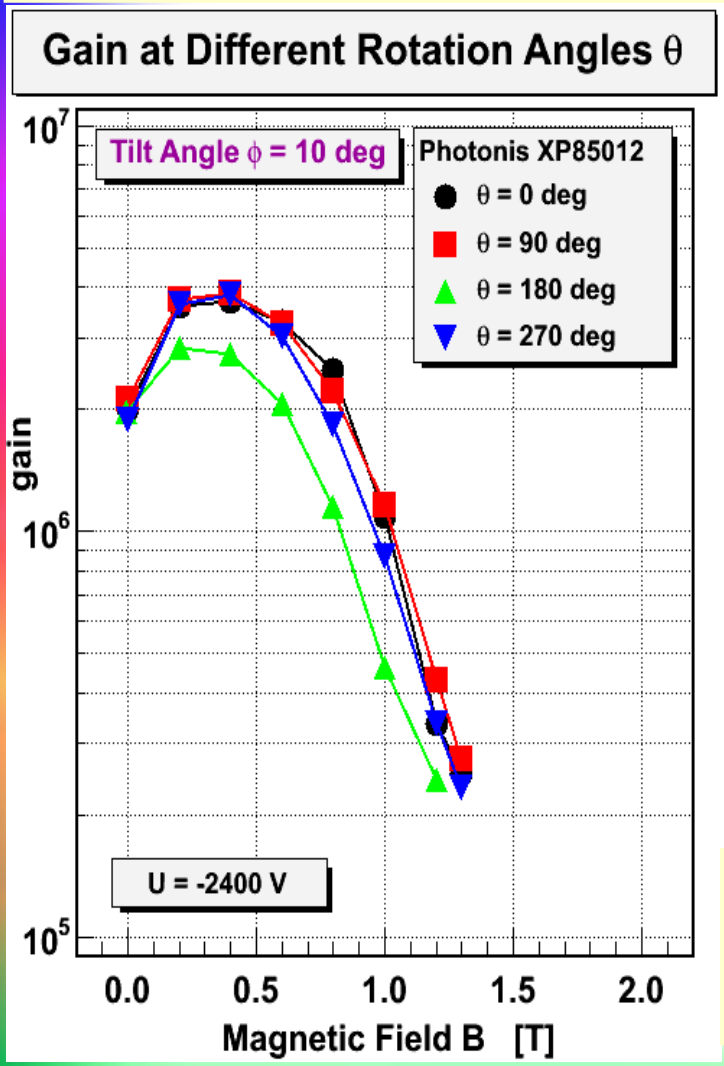
Significant gain loss at high B-field and large ϕ-angles

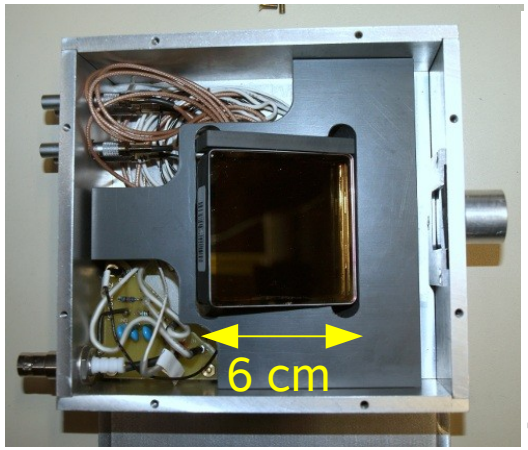
Hamamatsu R10754 (10 µm)



Gain and Direction of B-Field (θ)

Photonis XP85012 (25 µm)

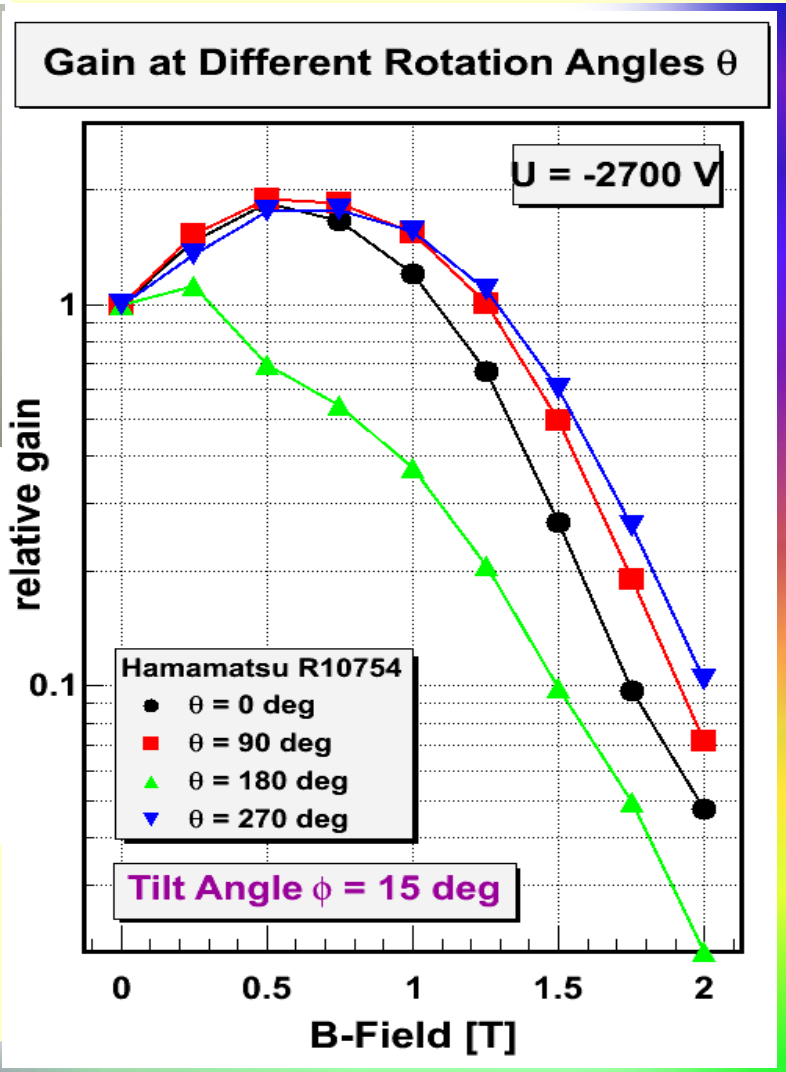




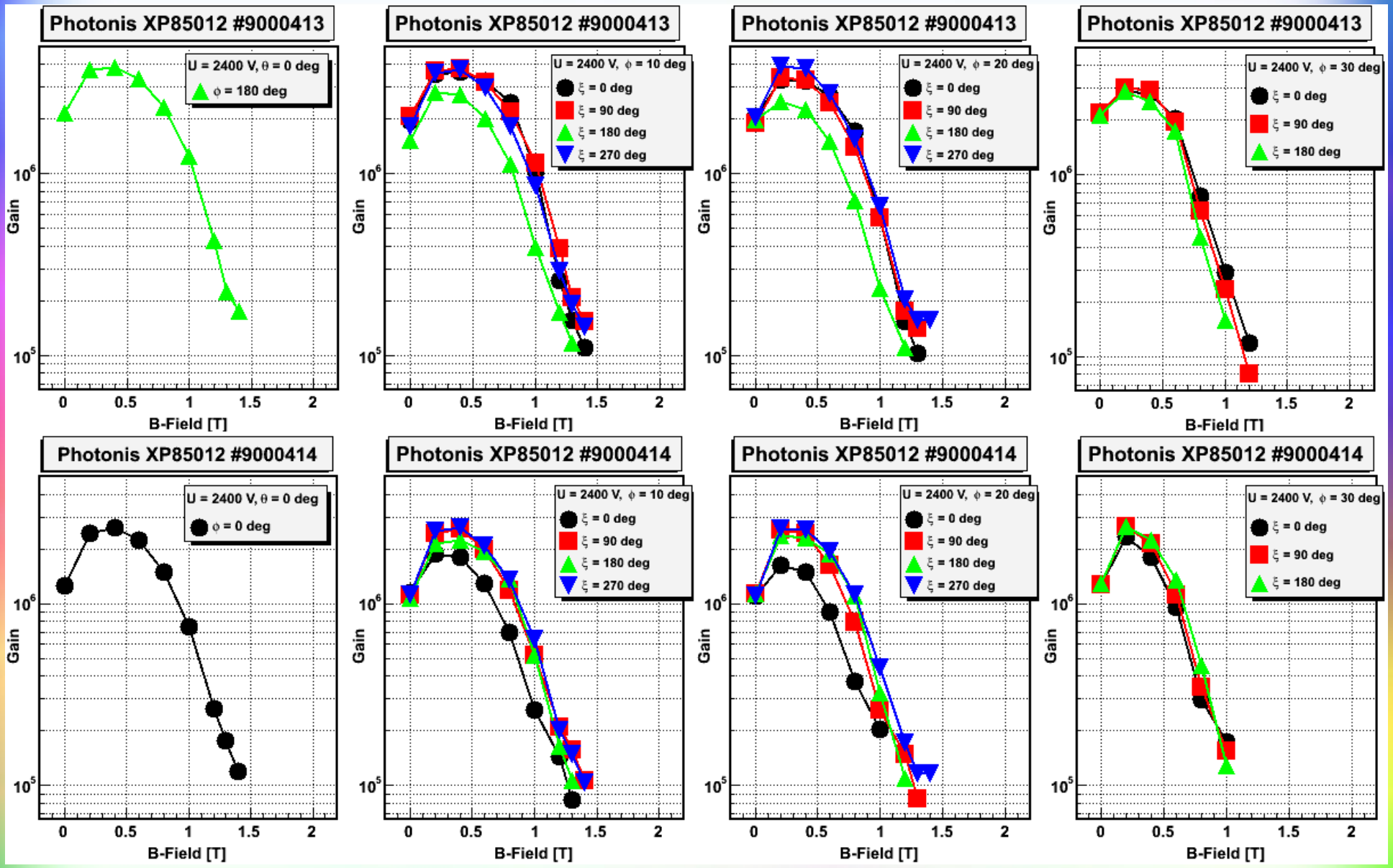
PMTs built with some ferromagnetic material → rotation and tilting of PMT inside B-field with special inserts in alubox

gain slope changes rapidly when pores point along B-field

Hamamatsu R10754 (10 µm)



Comparison of θ and ϕ Behaviour

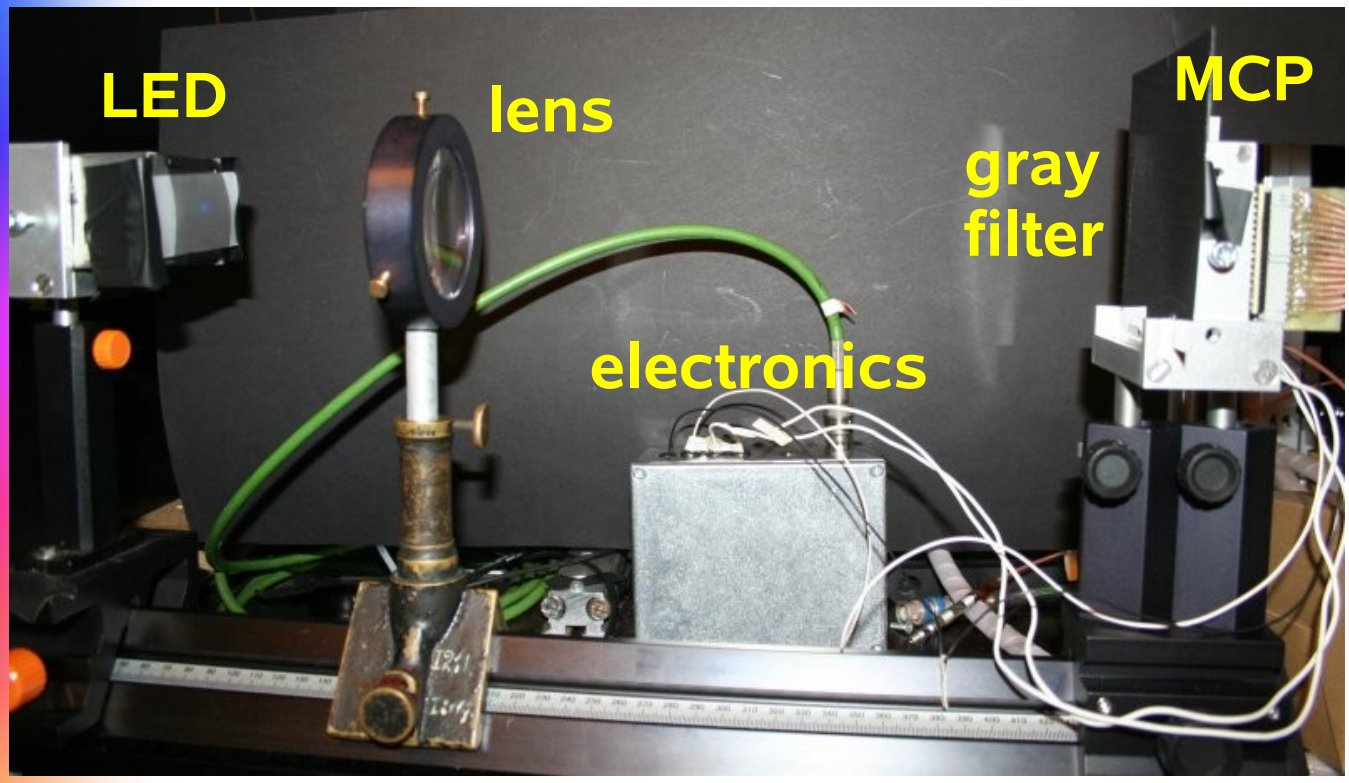


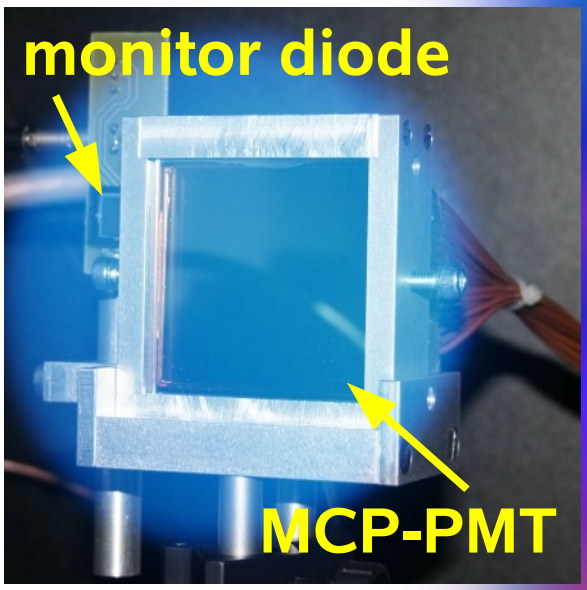
- Chevron angle = 16^{o} ; orientation in θ (= ξ) PMT dependent

How to Measure MCP Lifetime

- Continuous illumination
  - 460 nm LED at 272 kHz rate attenuated to single photon level
  - ~0.4 photo electrons (ph.e.) per pixel → ~3.5 mC/cm^2/day
- Permanent monitoring
  - record MCP pulse heights at highly prescaled rate using CAMAC DAQ
  - measure LED light intensity using the current of a photo diode
- [Ir]regular quantum efficiency (Q.E.) measurements
  - 300–800 nm wavelength band with 1 nm monochromator resolution
  - measure current of calibrated reference diode [Hamamatsu]
  - measure current of shorted (2 MCPs and anode) MCP-PMT
- Analysis
  - calculate Q.E. from current ratio of MCP-PMT and reference diode
  - extract gain and number of ph.e. from pulse height spectra

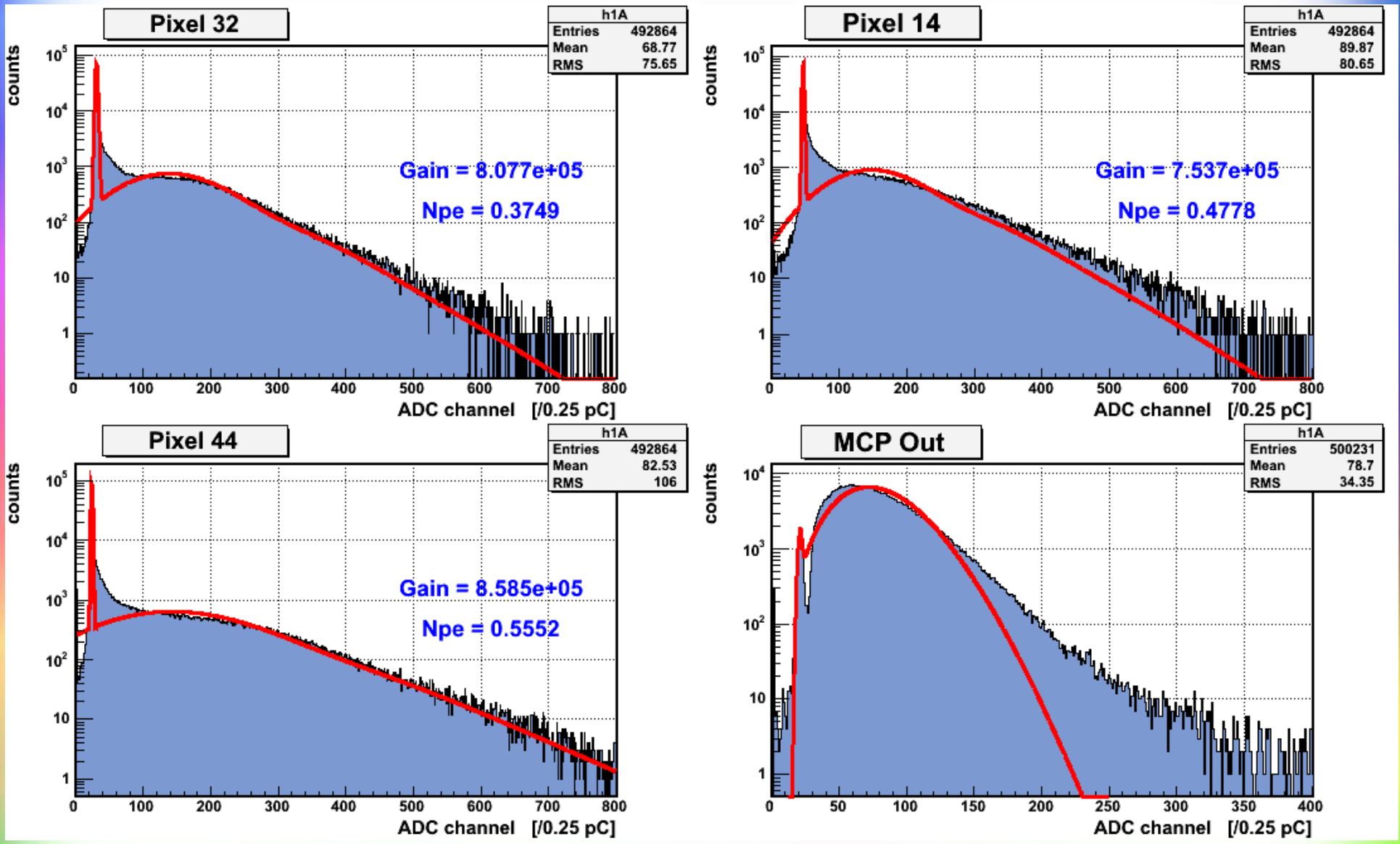
Setup for Illumination





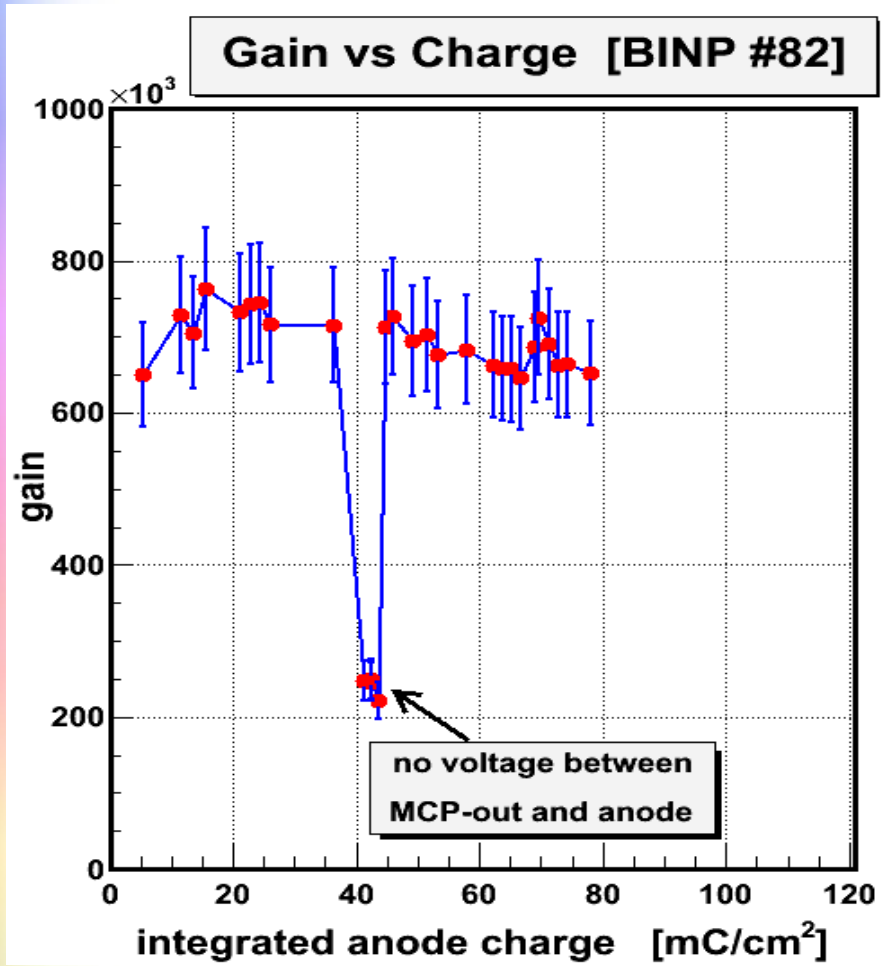
- importance of solid and repeatable setup (often taken apart)
- lens creates roughly parallel light of the LED spot
- homogeneous illumination of whole MCP (blue area of light) and monitor diode

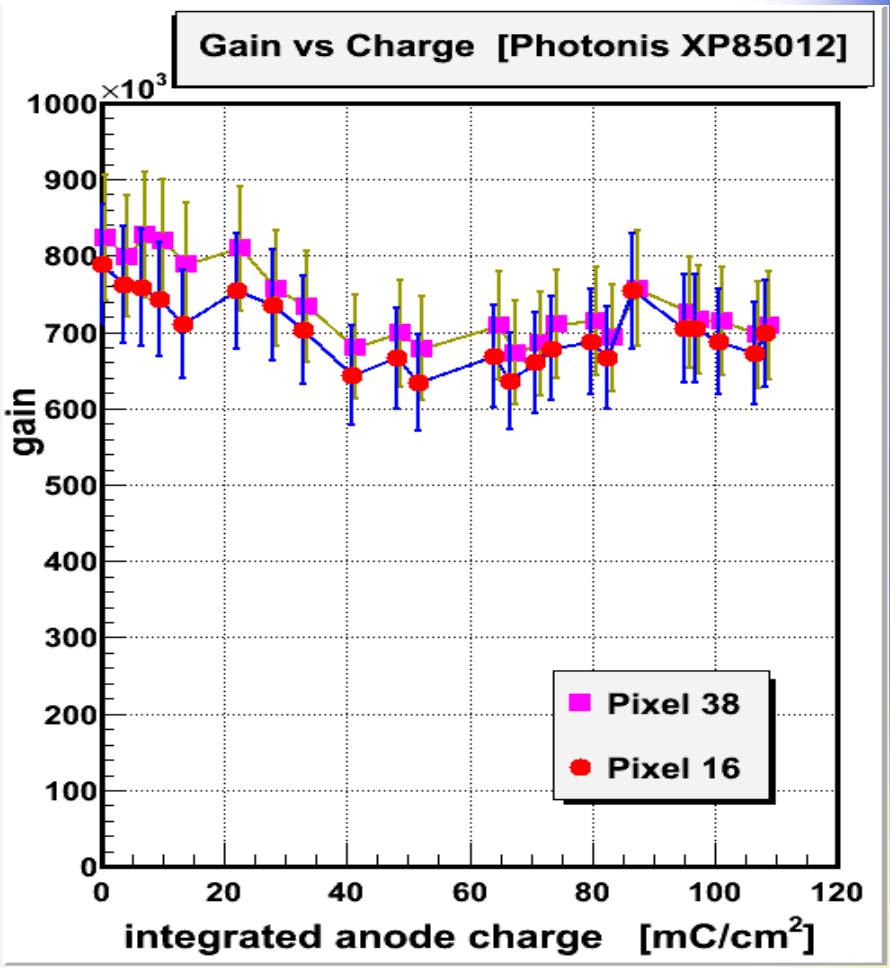
Pulse Heights of Photonis XP85012



- Gain: ~$8 \cdot 10^5$ per pixel; Npe: ~0.4 per pixel [~4 at MCP-out ??]

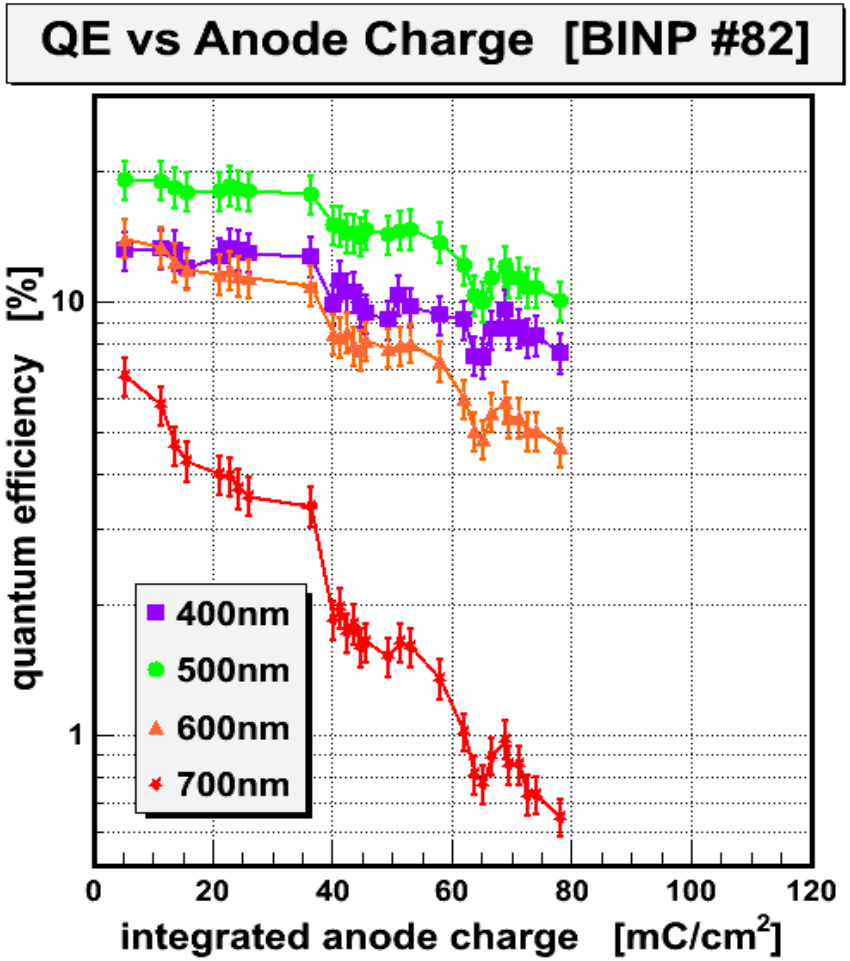
Gain after Illumination

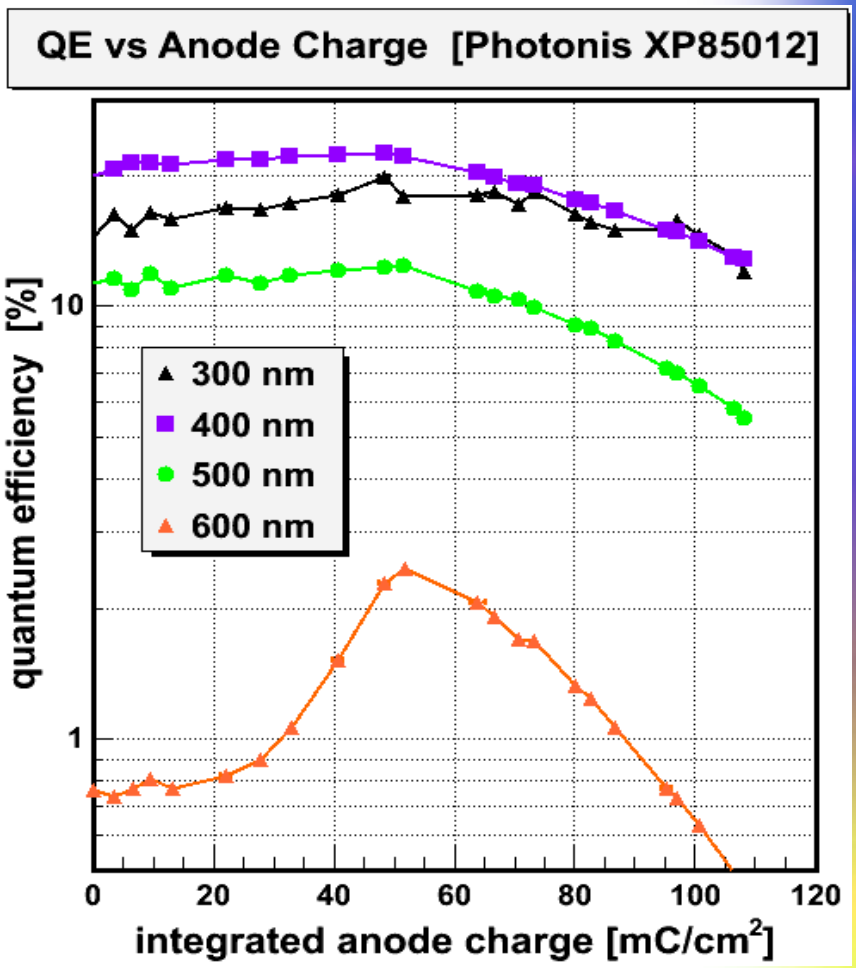




- **Moderate gain variations** for BINP #82 and Photonis XP85012

QE after Illumination



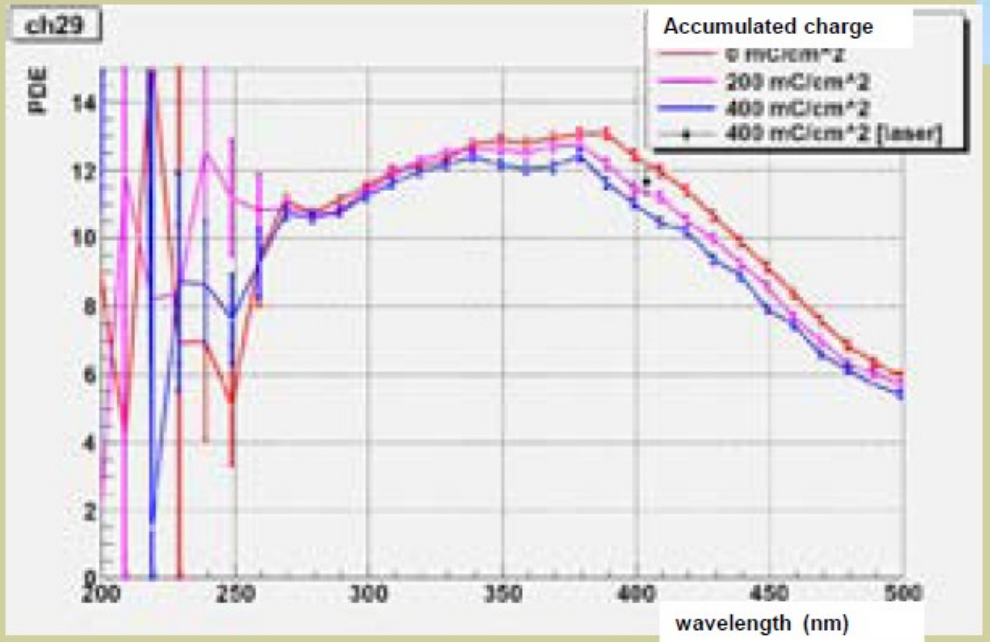


- BINP #82: decrease of QE depends upon wavelength
- XP85012: first slight increase of Q.E. then it starts dropping

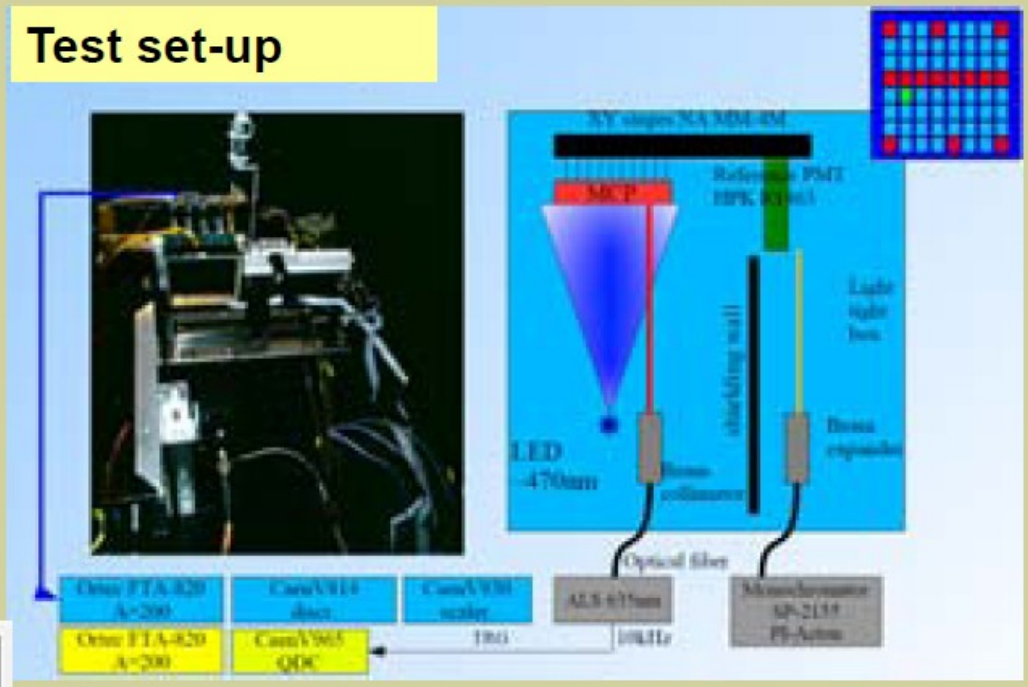
Lifetime Measurements in Ljubljana

Ageing studies

Test set-up: high rate illumination of the whole photosensitive surface by LED, pulsed laser monitoring of the amplification. Reference PMT is used for periodic QE measuemnets with a monochromator in the same set-up.



Test set-up

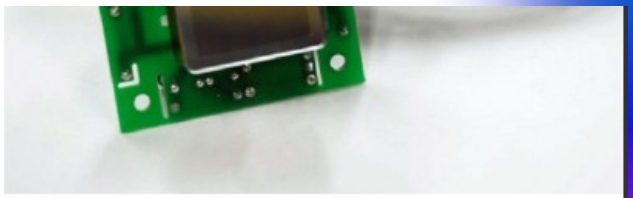


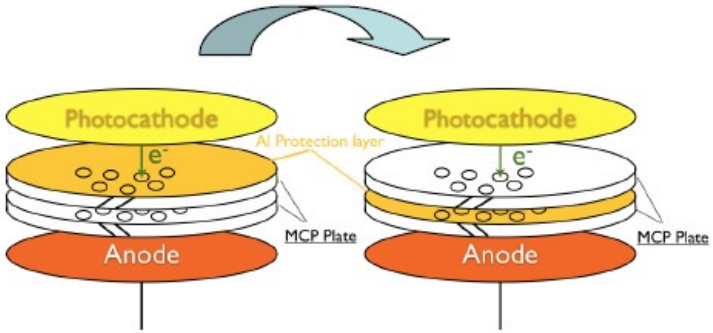
Results: after 400 mC/cm^2 (= Belle II lifetime) the efficiency drops by about 10% → no problem for operation.

According to P. Krizan this was an old 2x2 Planacon tube with 10 µm pores and NO protection layer, NO surface treatment and NO improved vacuum → **STRANGE ?!**

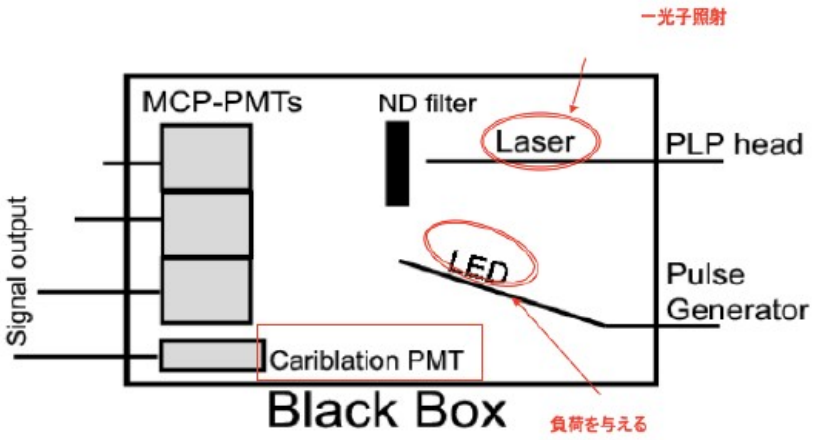
Lifetime Measurements in Nagoya (I)

- Square-shape MCP-PMT
  - Develop new version with Hamamatsu
    - Change of internal structure and cleaning method
  - Change to put Al protection layer on 2nd MCP
    - Recover correction efficiency (35%→60%)
    - Expect less effect of 1st MCP to lifetime
      - Because of $1/10^3$ smaller number of electrons



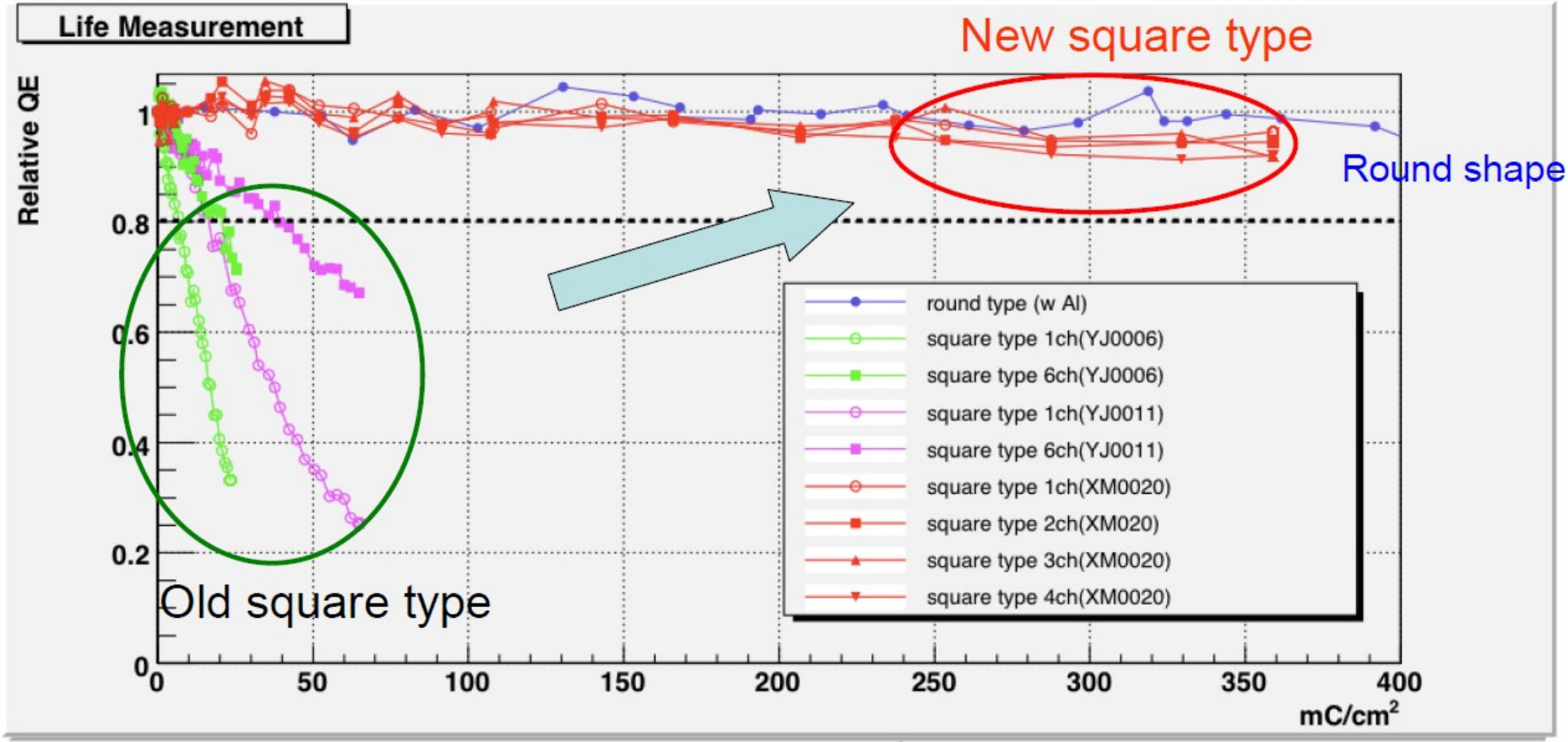


- Lifetime measurement
  - Light load by LED pulse (1~20kHz)
    - 20~50 p.e. /pulse
  - Relative efficiency, gain and TTS
    - By pulse laser at single photon level
    - Monitored by standard PMT



Lifetime Measurements in Nagoya (II)

- QE variation
  - <10% drop at 350mC/cm^2 ; sufficient lifetime

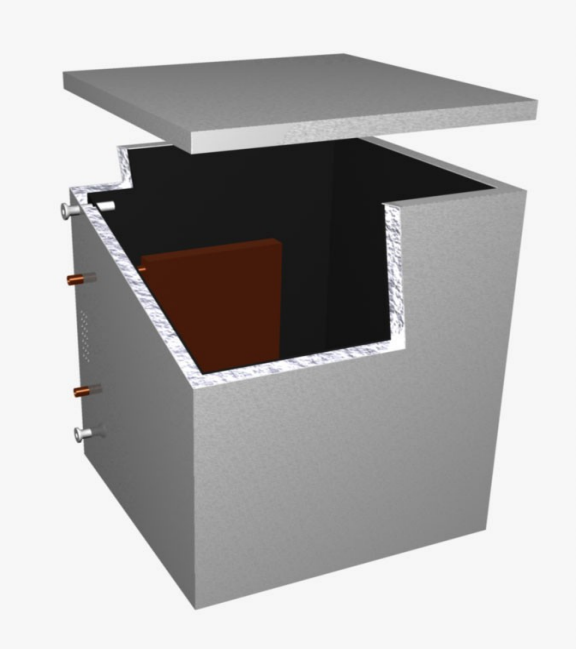


0.5 year 1year 1.5year 2year 2.5year 3year

@Belle-II

Construction of a Cooling Box

- Size: ~60x60x60 cm^3
  - large enough for XY-scans of multi-pixel SiPMs
  - vacuum insulated panels
  - cooling medium: dry gas



- Thermostat ministat 230-cc
  - temperature: **-40 ... 200 °C**
  - temp. constancy: 0.02 K
  - external temperature control

- Box construction finished
  - Minor adjustments still needed
  - **First tests very soon**

Summary and Outlook

- New Photonis XP85012 (with better vacuum) shows very good performance in rate stability and time resolution, but magnetic field immunity only up to about 1 Tesla
- Lifetime result for new XP85012 is somewhat disappointing
- Ordered new Photonis XP85112 (with 10 μm pores) with same form factor as XP85012 (delivery end of June)
- Trying to get SL10 with protection layer through Nagoya
- Diamond dynode PMTs not yet delivered
- Preparations for performance measurements of SiPMs
  - new cooling box exists and will be ready for tests very soon
  - several SiPM candidates available