Status report of MCP-PMTs performance tests

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- Performance tests
  - dark count rate
  - rate stability
  - time resolution
  - surface scans
  - magnetic field behaviour

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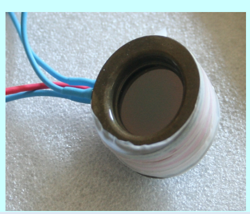
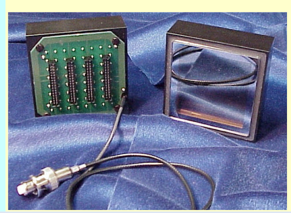
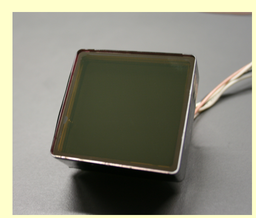
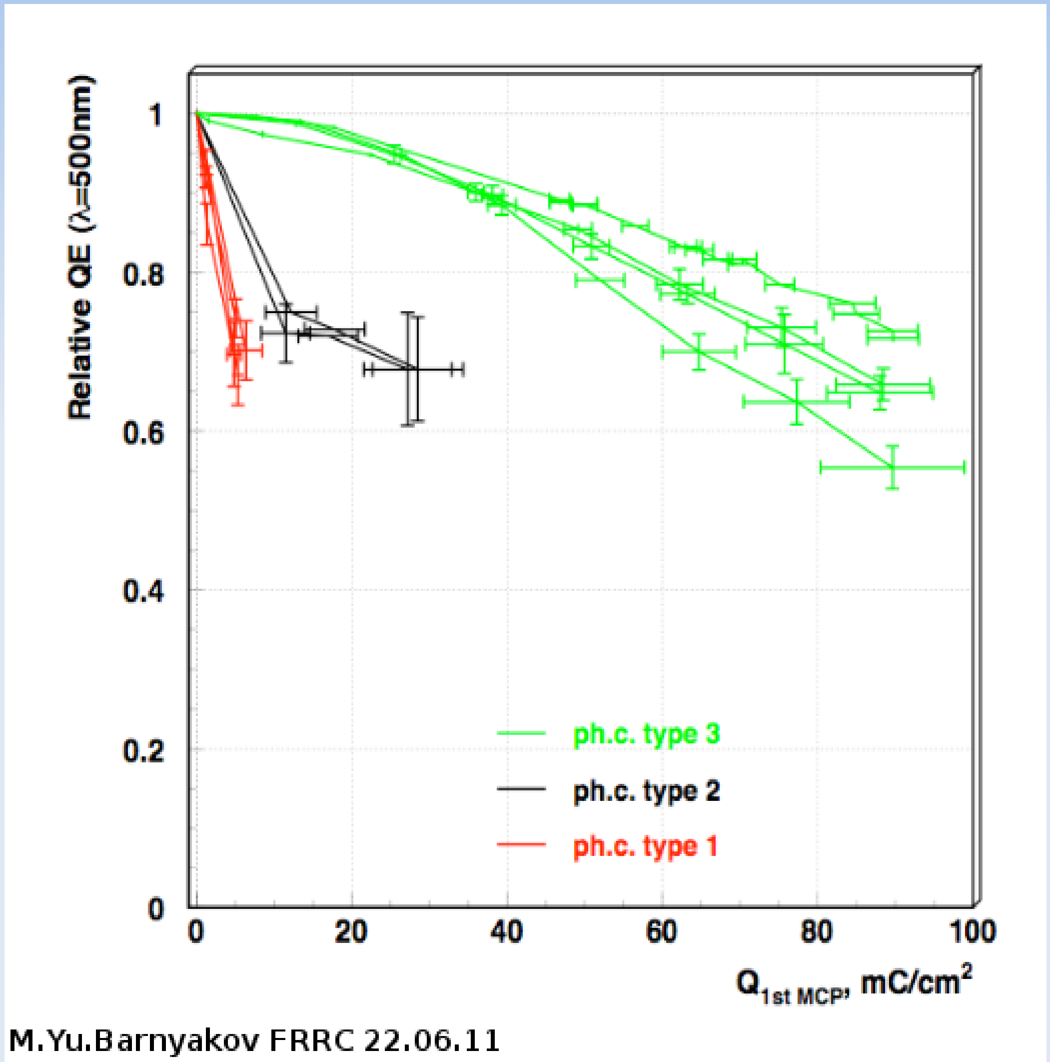
Investigated MCP-PMTs

	BINP	Burle-Photonis			Hamamatsu	
		XP85013	XP85012	XP85112	R10754X-06-L4	R10754X-01-M16
pore size (µm)	7	25	25	10	10	10
number of pixels	1	8x8	8x8	8x8	4x1	4x4
active area (mm²)	$9^2 \pi$	53x53	53x53	53x53	22x22	22x22
total area (mm²)	$15.5^2 \pi$	59x59	59x59	59x59	27.5x27.5	27.5x27.5
geom. efficiency (%)	36	81	**81**	**81**	61	61
peak Q.E. (measured)	21% @ 500 nm	--	22% @ 390 nm	22% @ 390 nm	21% @ 375 nm	21% @ 390 nm
comments	no protection layer different photo cathode		better vacuum polished surfaces		protection layer between MCPs	


- this talk: comparison of several models of MCP-PMTs
  - BINP, Photonis XP85112 and Hamamatsu R10754X

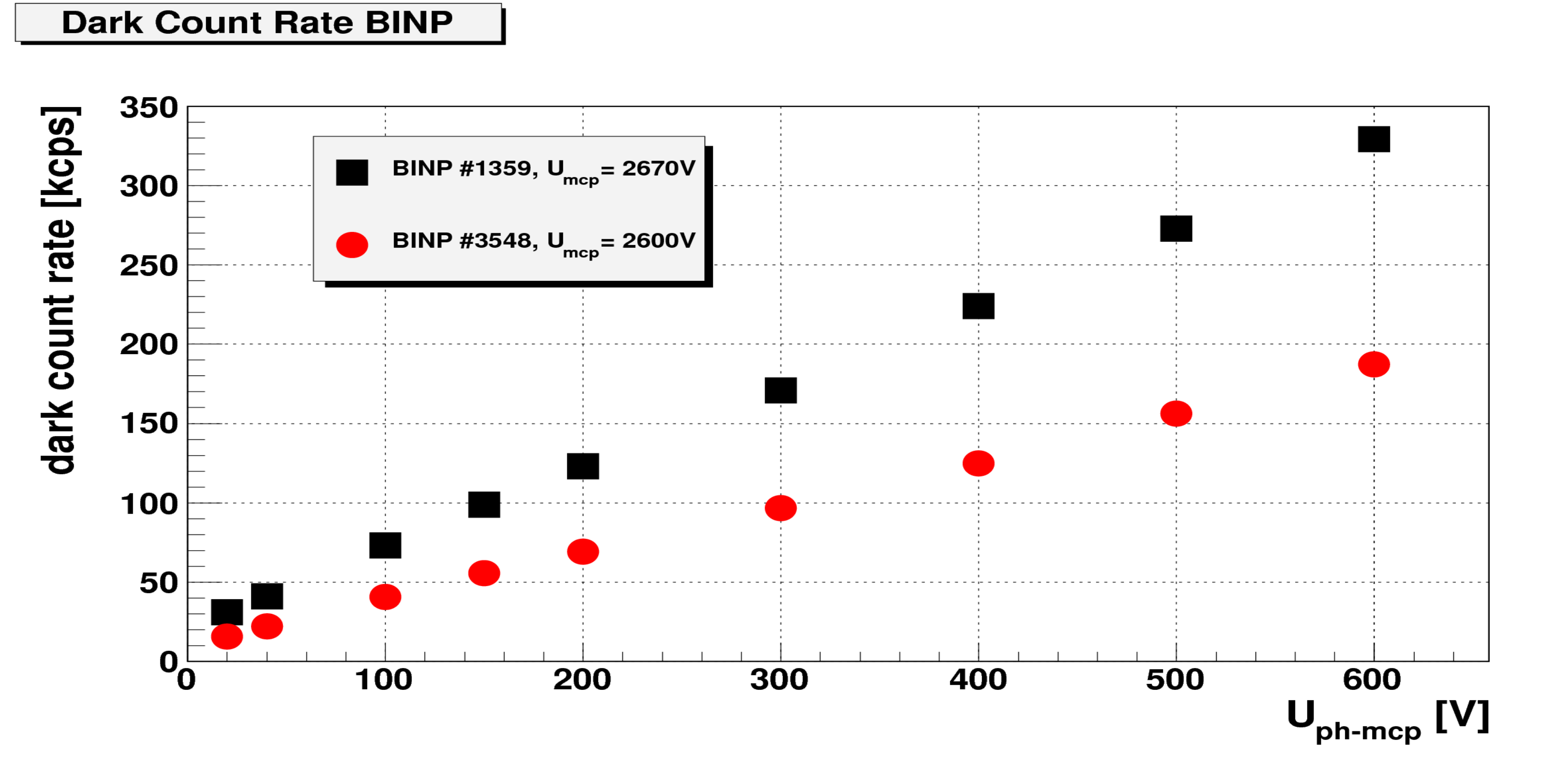
new BINP MCP-PMT



- different photo cathode ($Na_2KSb(Cs)$ + Cs_3Sb) with higher dark count rate (~100 kcps)
- MCP degassing:
  - heating
  - duration of electron scrubbing increased without gain loss

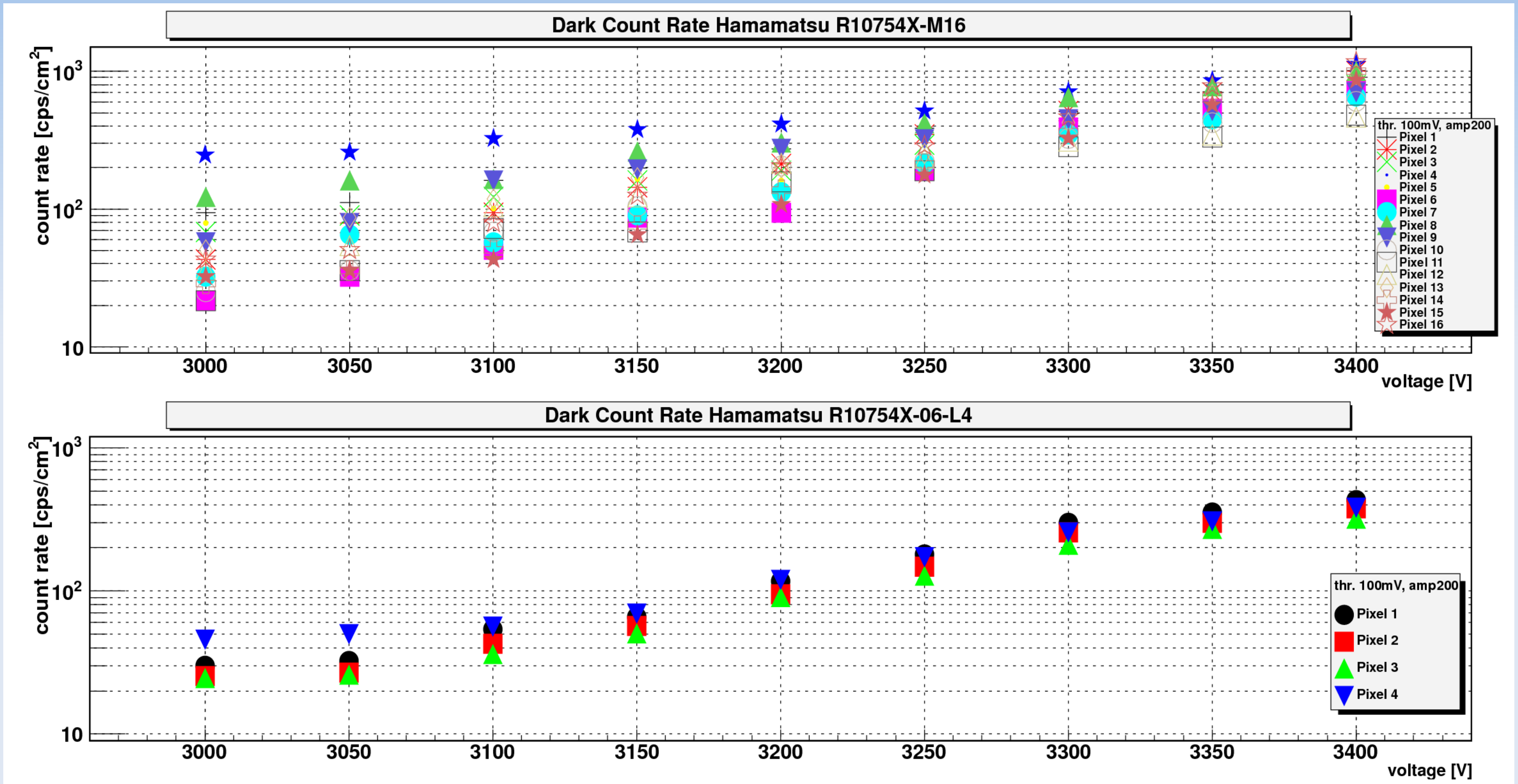
→ longer lifetime

Dark Count Rate of BINP MCP-PMTs



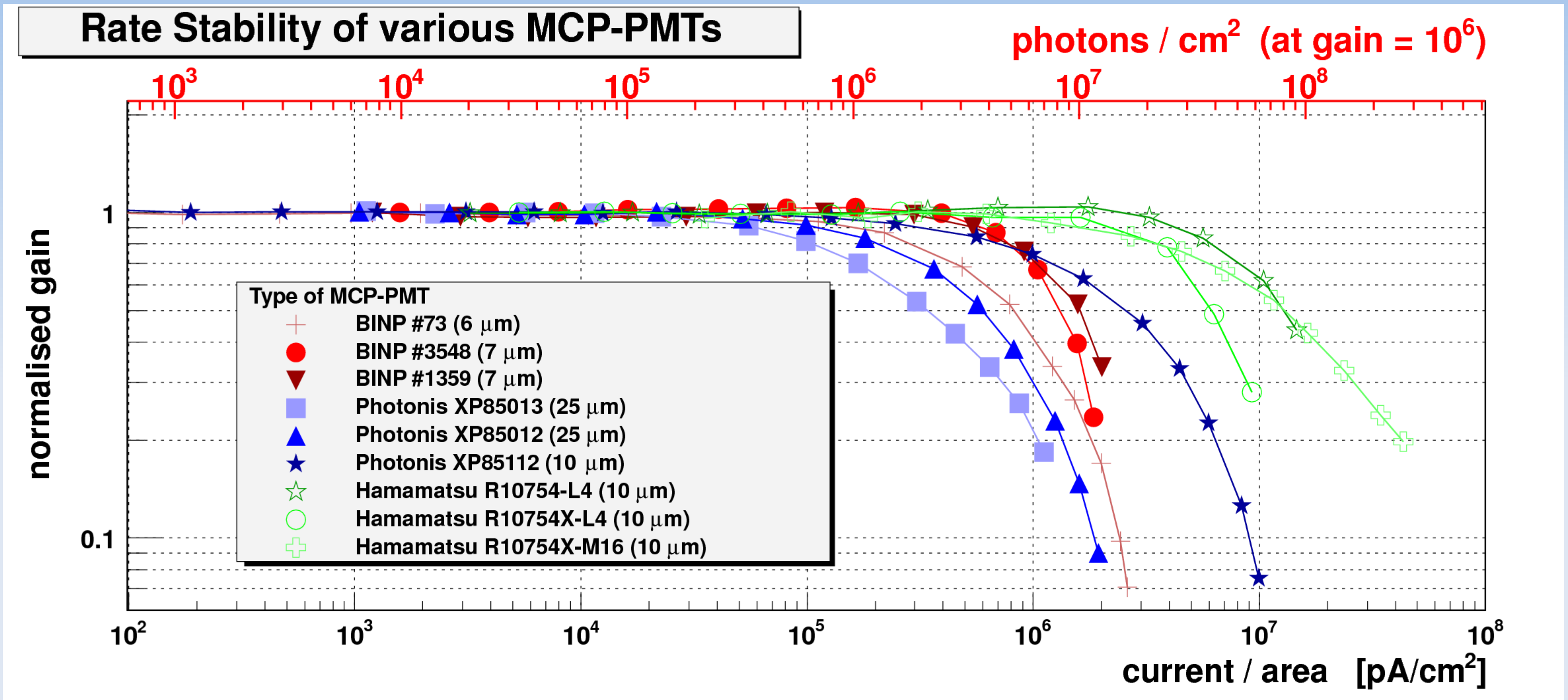
- high dark count rates (100 and 171 kcps at $U_{pc\text{-}mcp}$= 300V, 10^6 gain)
- BINP #3548 has a lower dark count rate because it was longer baked in the production process, but also lower gain

Dark Count Rate of Hamamatsu R10754X MCP-PMTs



- dark count rate of both devices ≤ 1kcps

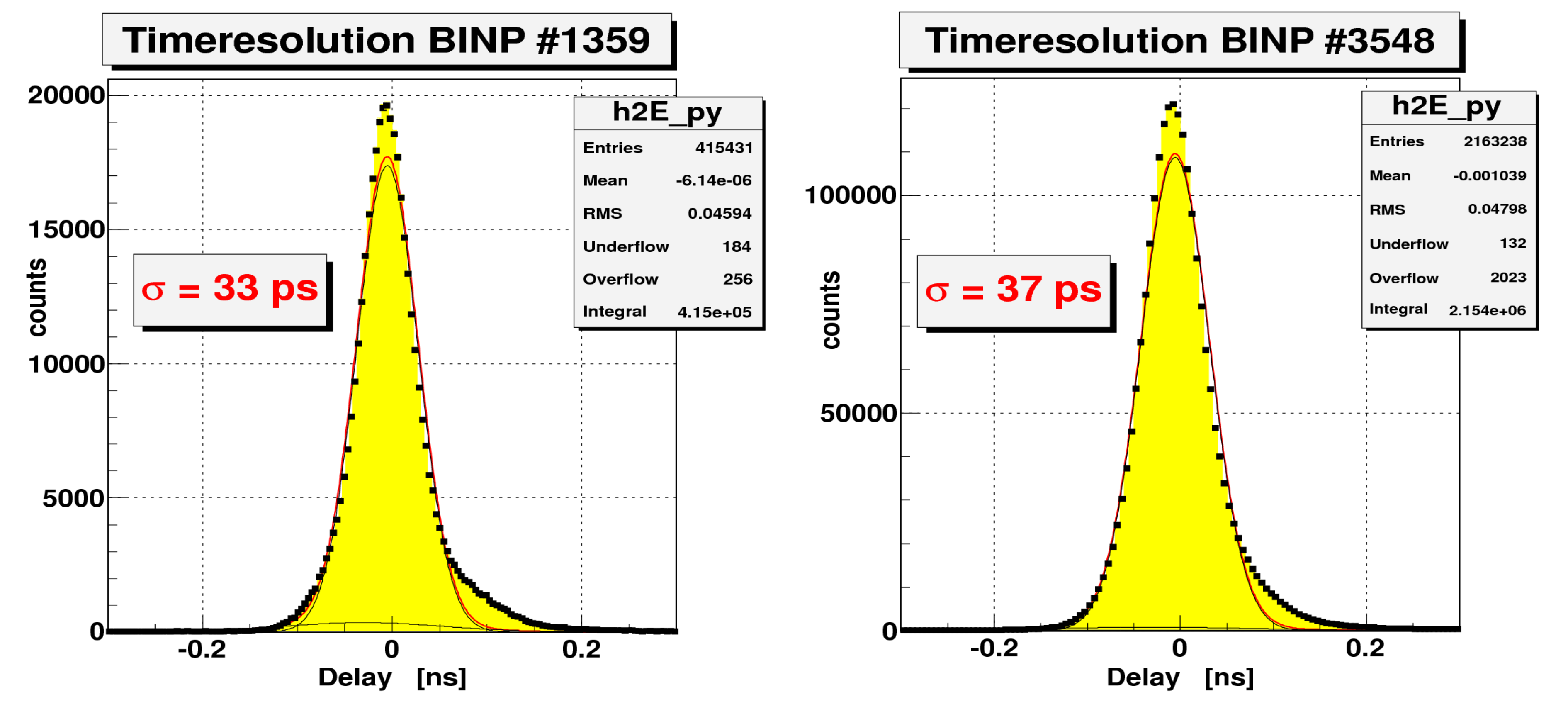
Rate Stability of various MCP-PMTs



- rate capability of new BINP (7µm) improved to ~ 2 Mhz/cm^2 s.ph.
- XP85112 (10µm) and XP85012 (25µm) also stable up to ~ 2 MHz/cm^2 s.ph.
- Hamamatsu SL10 stable up to ~ 7 MHz/cm^2 s.ph.

Single Photon Time Resolution BINP

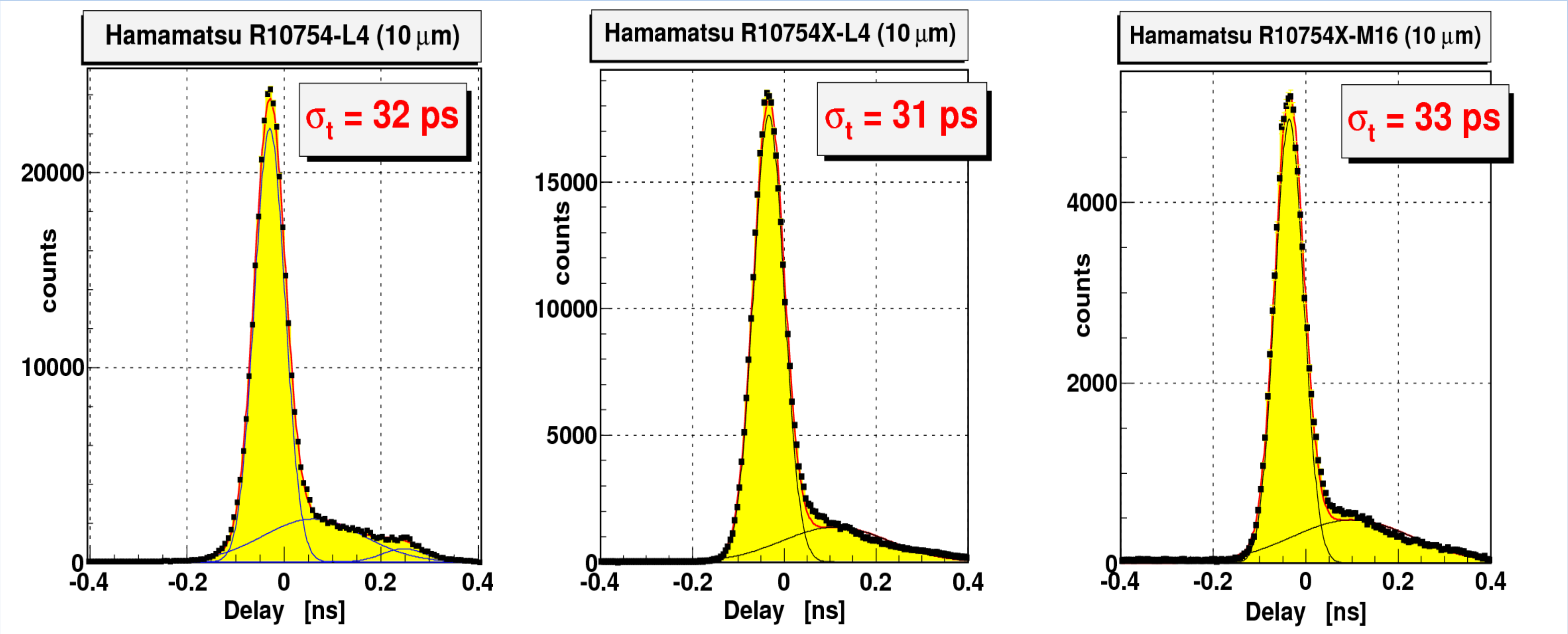
Amplifier Ortec FTA820 (x200; 350 MHz) --- Discriminator Philips Scientific 705



- time resolution σ < 40 ps

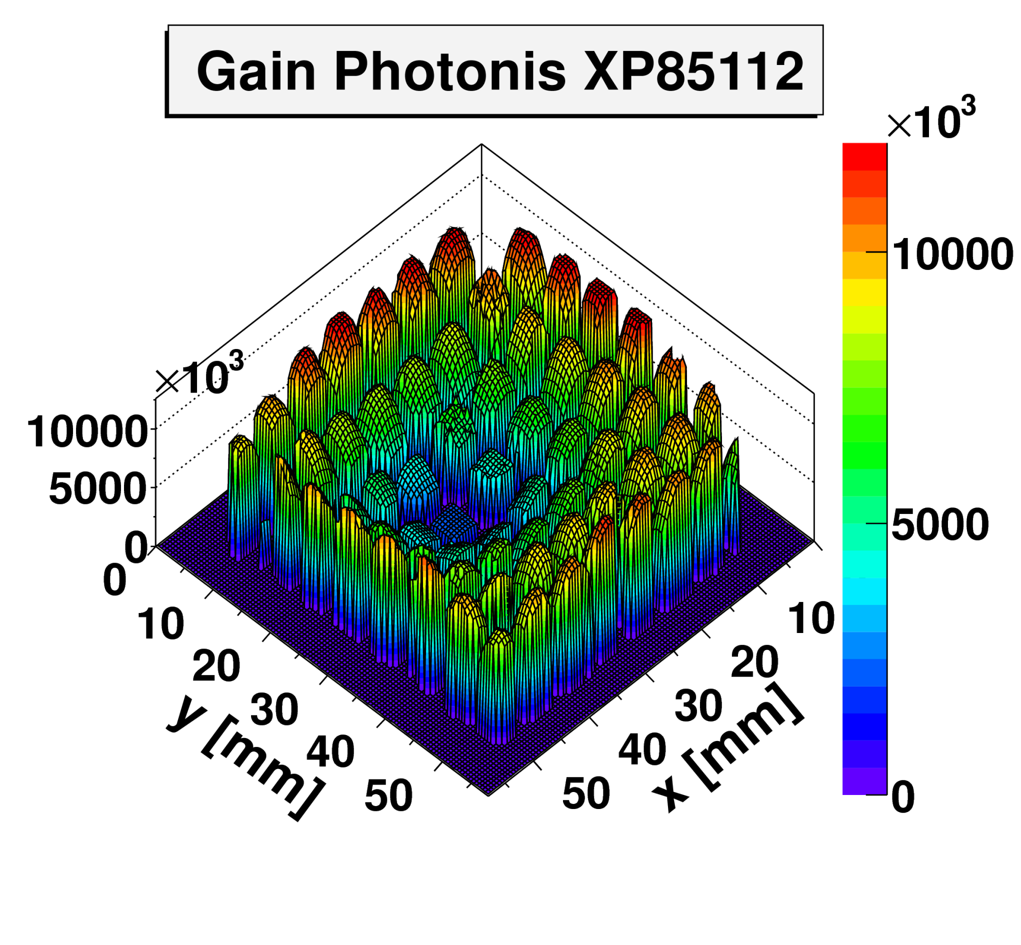
Single Photon Time Resolution Hamamatsu

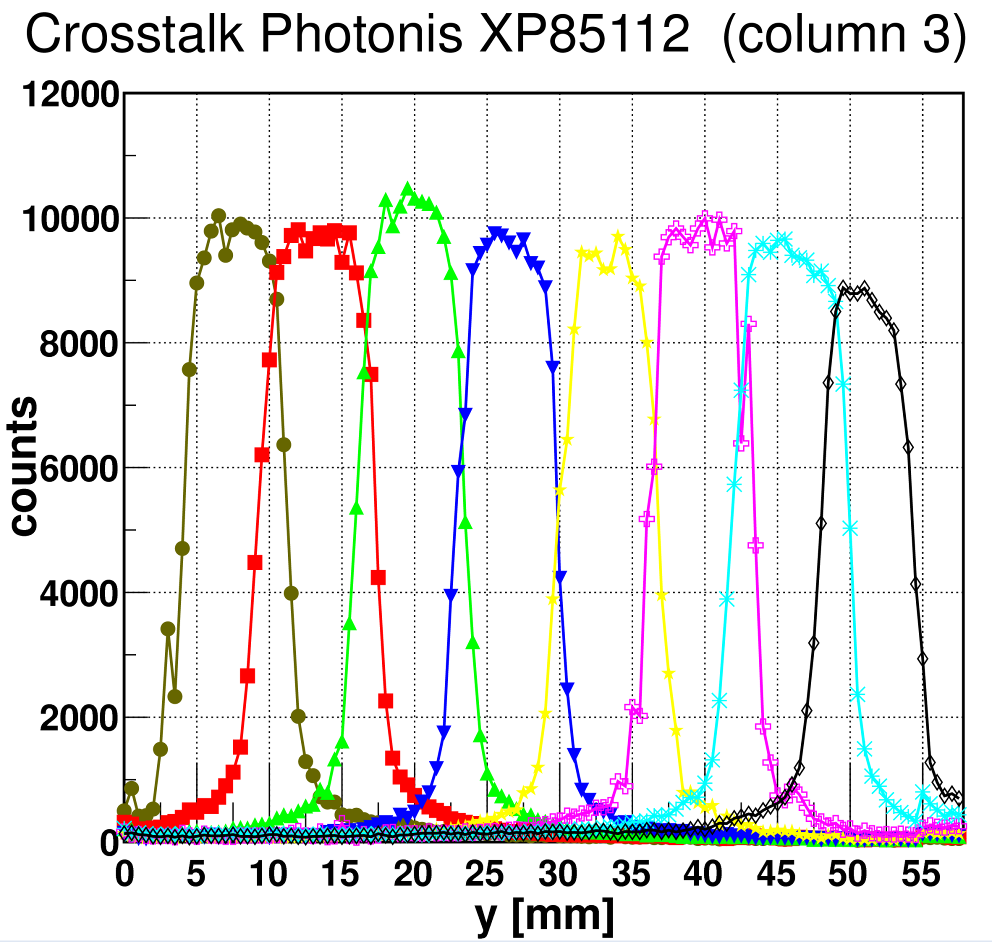
Amplifier Ortec FTA820 (x200; 350 MHz) --- Discriminator Philips Scientific 705



- time resolution $\sigma < 35$ ps

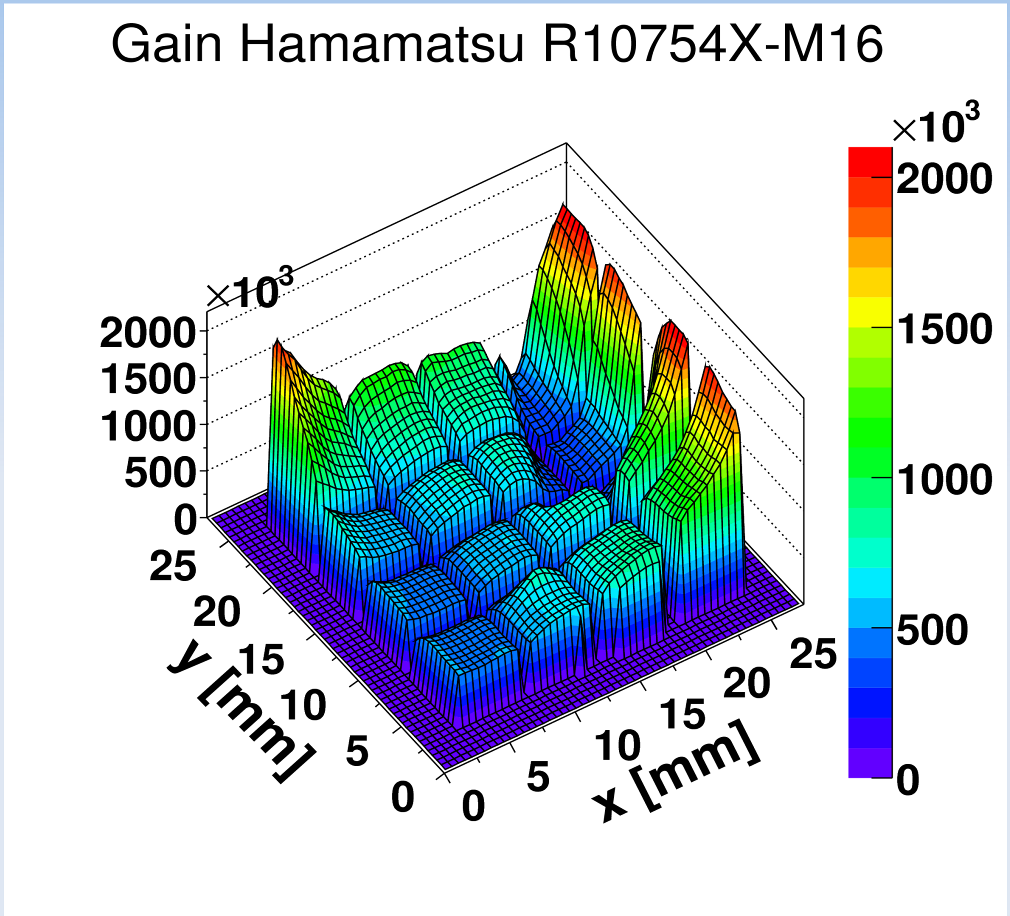
Gain and Crosstalk of XP85112

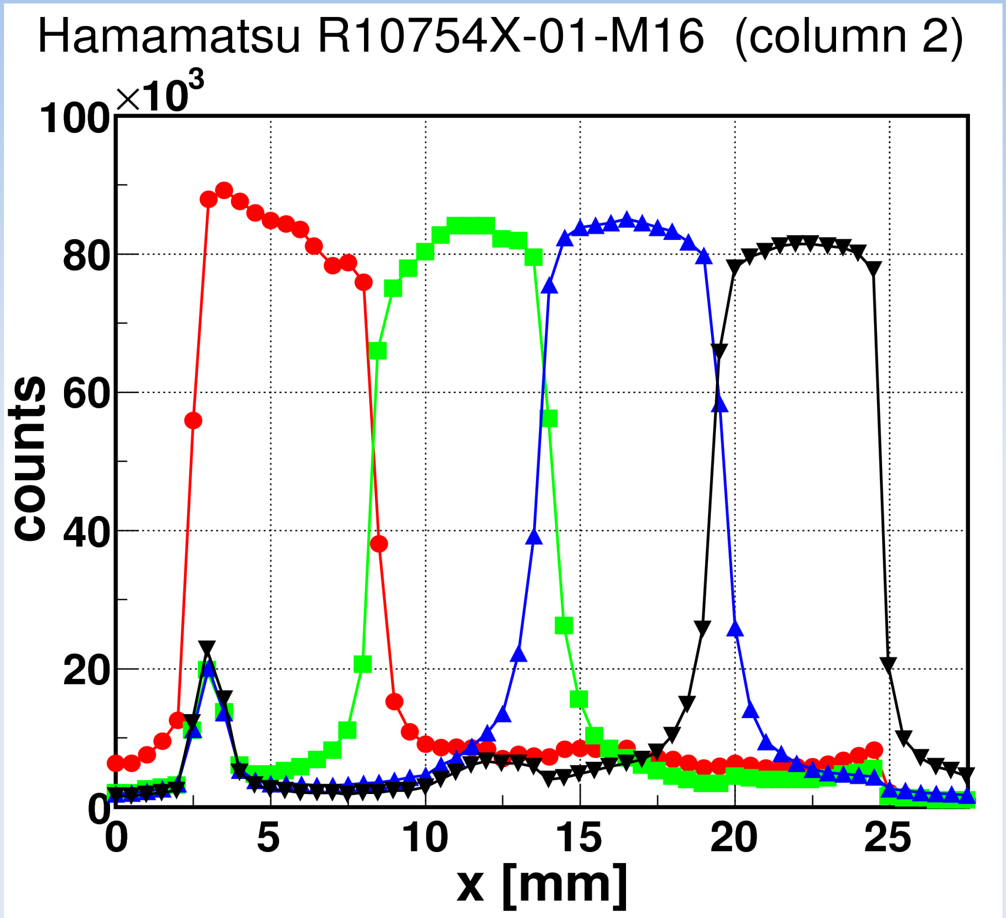




- **up to factor 5 gain variations between pixels** (in center!)
- 50% crosstalk level extends ~1 mm into adjacent pixel
- but no long crosstalk tails

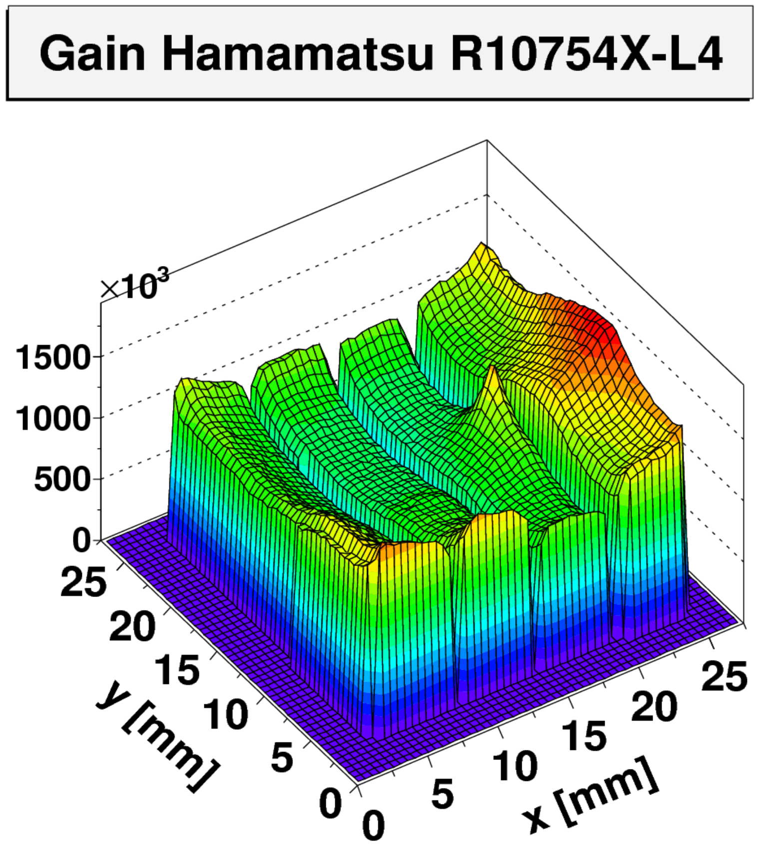
Gain and Crosstalk of R10754X-M16

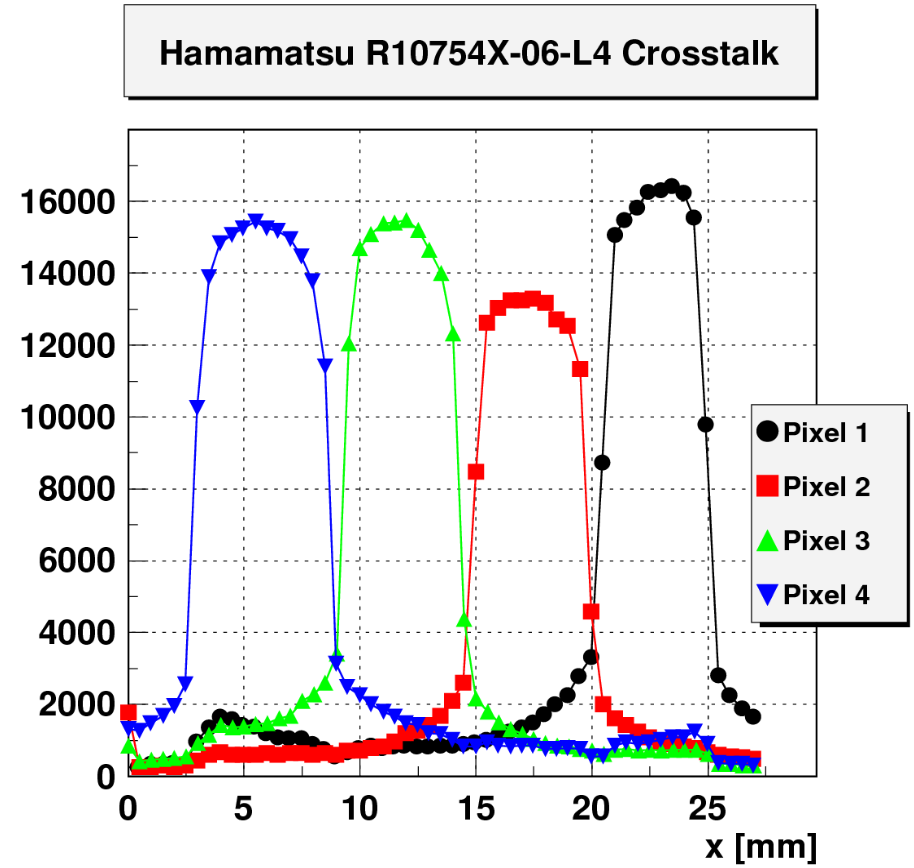




- **gain variations** of factor 3 even within the same pixel
- 50% crosstalk level extends only little into adjacent pixel
- long tails in crosstalk are of electronic nature

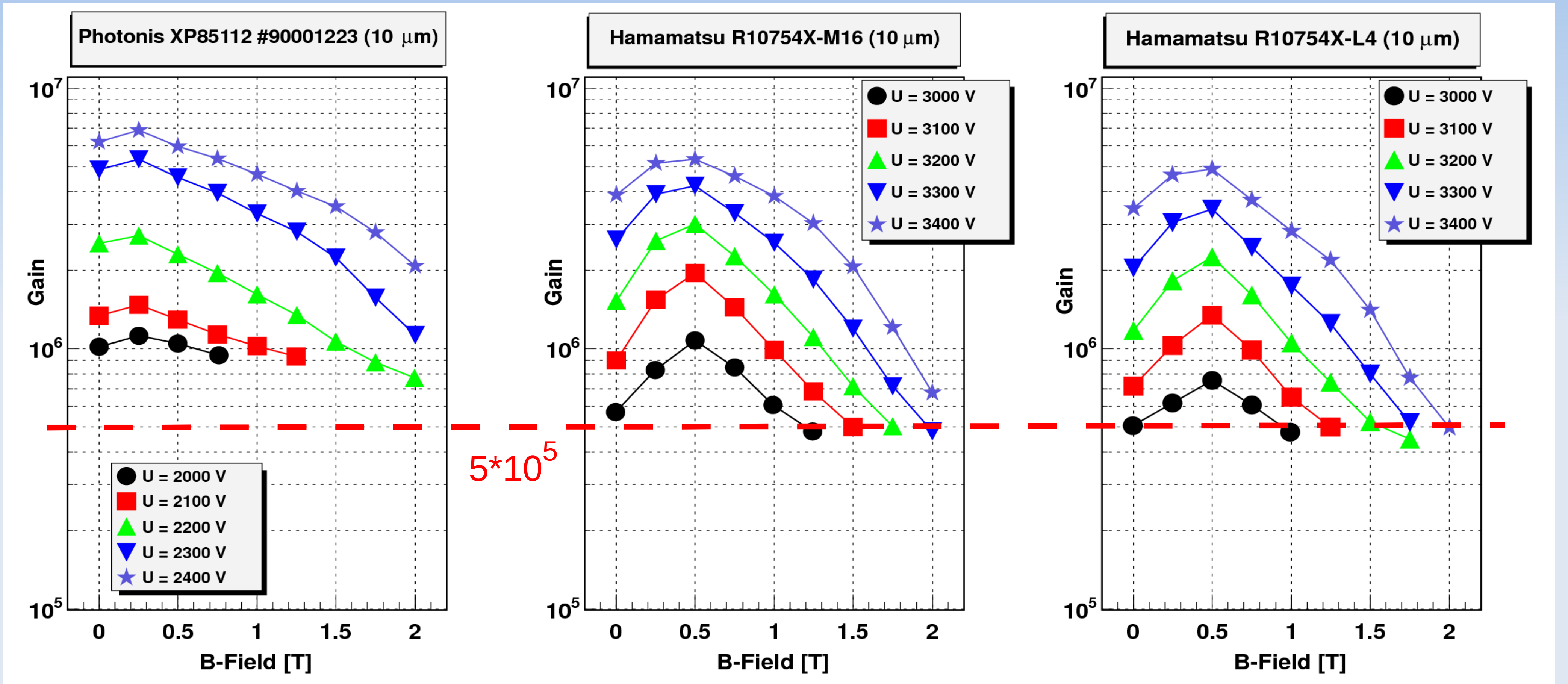
Gain and Crosstalk of R10754X-L4





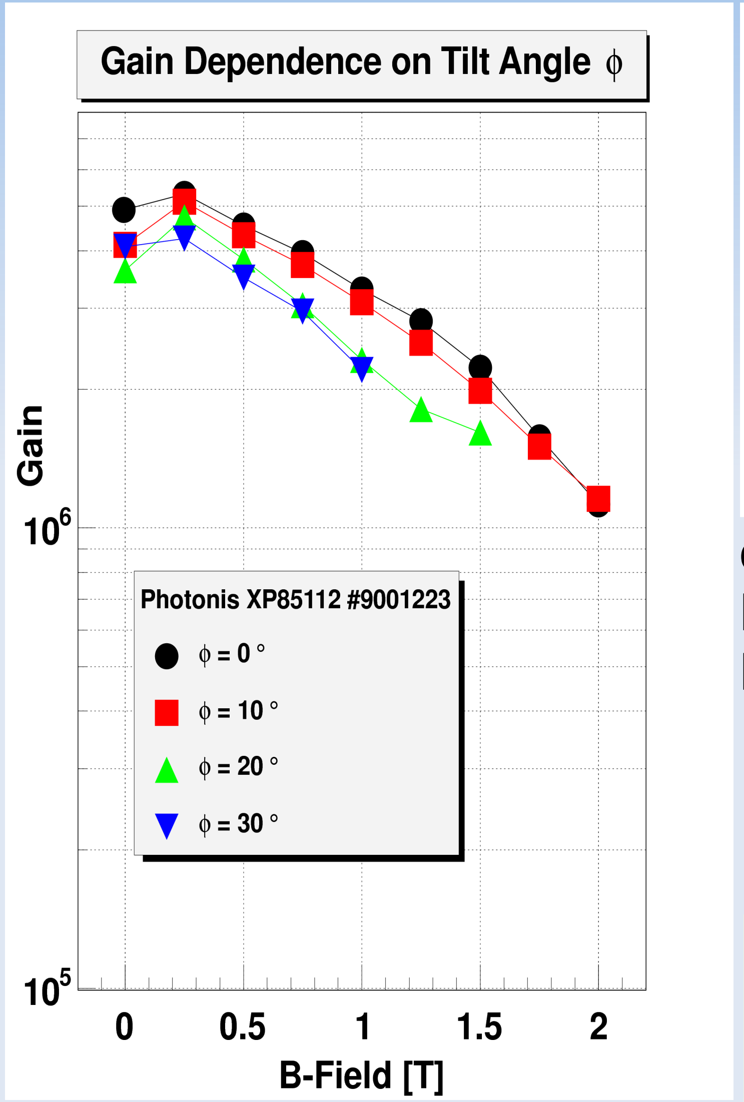
- **gain variations** of factor ~2
- better crosstalk behaviour than the R10754X-M16 (4x4 pixels)
- long tails in crosstalk are of electronic nature

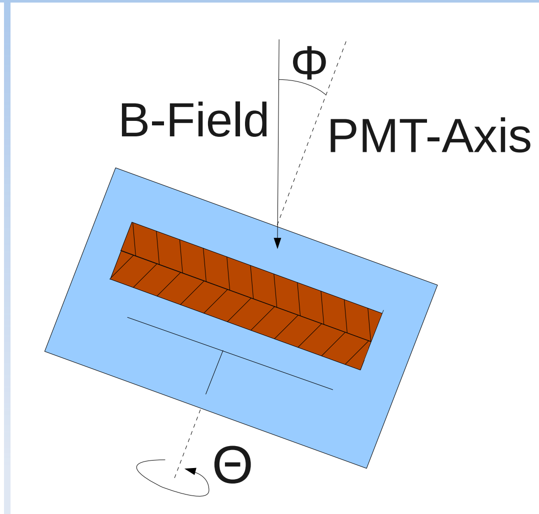
Gain in Magnetic Field



- 10 µm MCP usable up to 2 Tesla

Gain and Direction of B-Field (Φ)

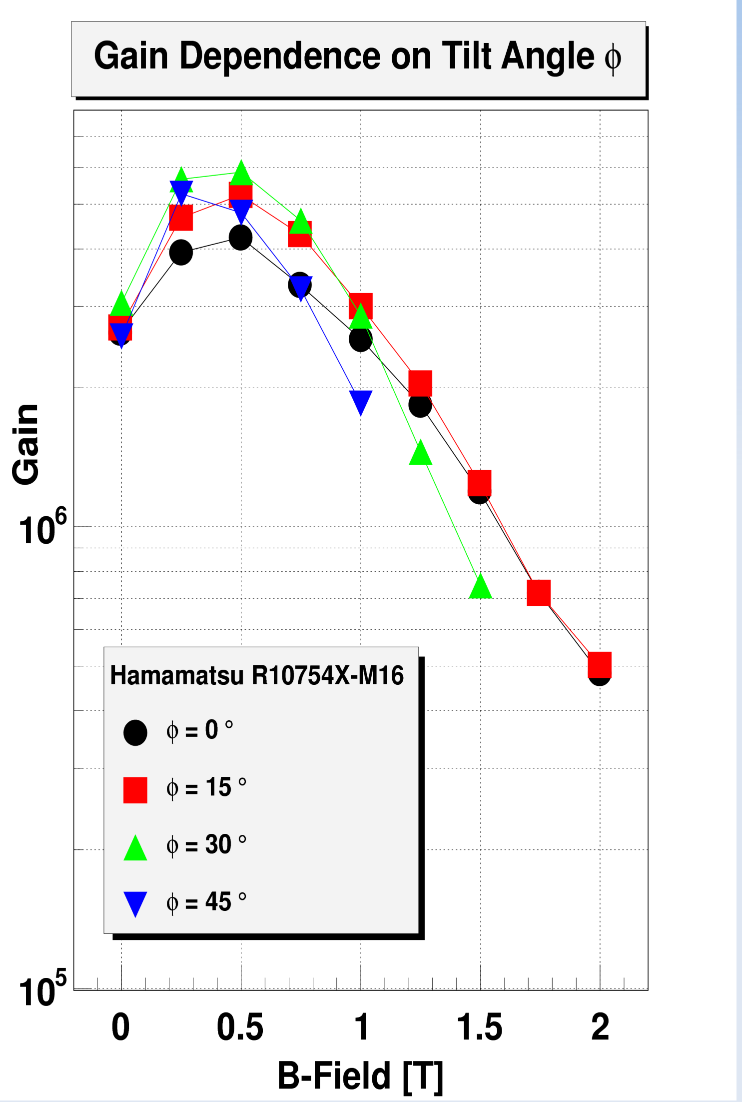




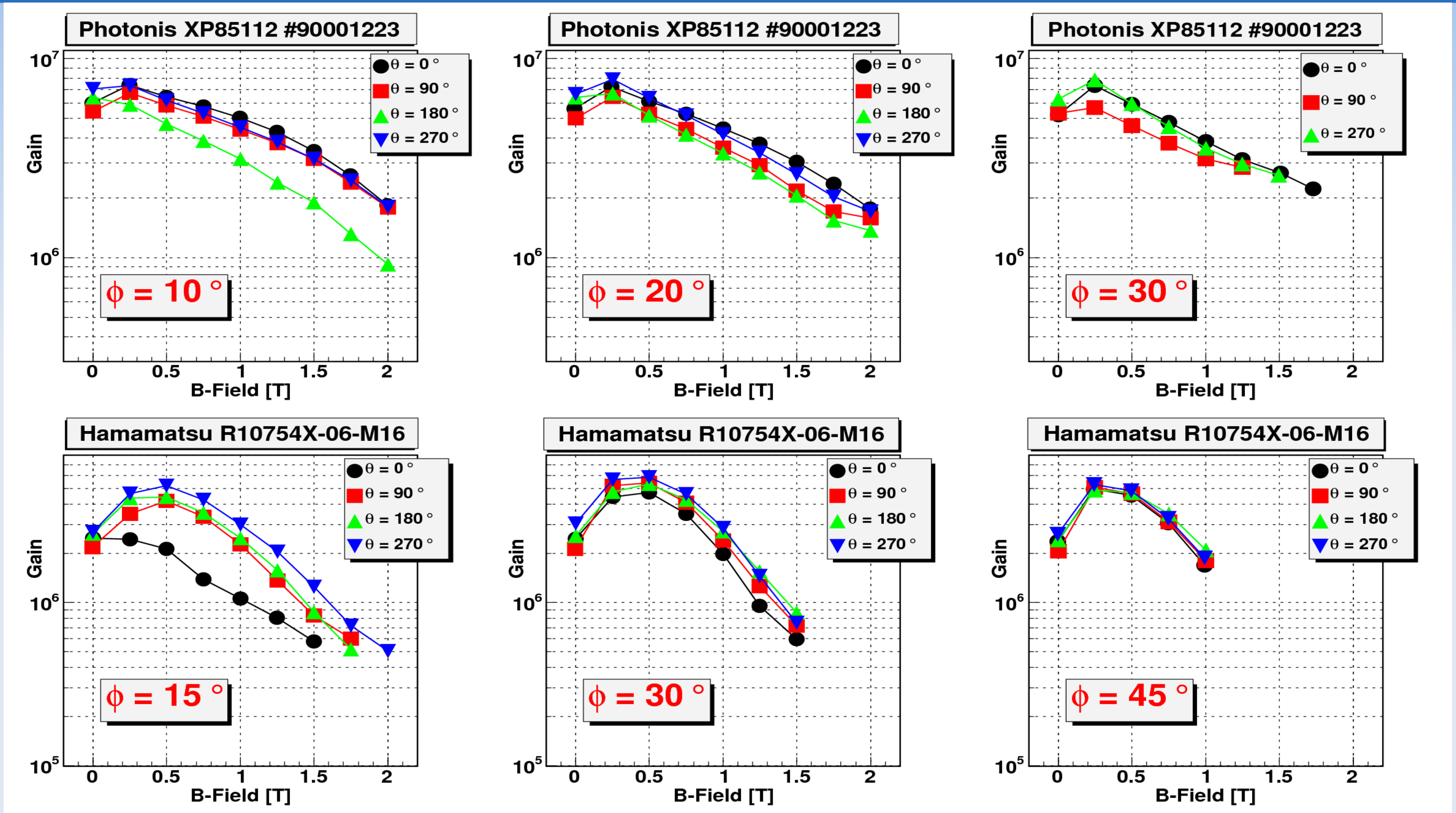
φ = tilt angle between B-field direction and PMT-axis

θ = rotation angle of PMT around B-field direction

Gain breaks down at high B-field and large φ-angles



Gain and Direction of B-Field (θ)

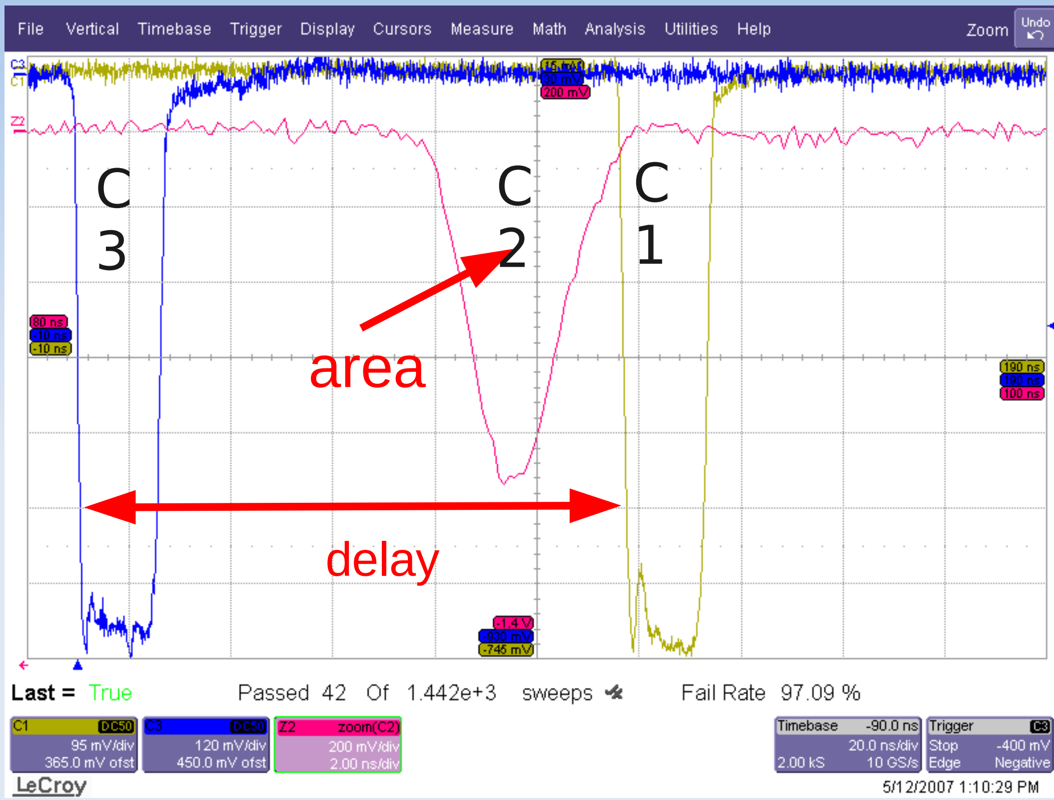


- Dependence only at specific rotation angles θ, and at tilt angles, which are similar to the chevron angle of the MCP

Summary and Outlook

- Performance of newer Photonis XP85112 #9001223 (10 μm) also shows good performance in rate stability, time resolution and magnetic field immunity
- Hamamatsu R10754X-M16/L4 models suitable for both PANDA DIRCs in terms of rate stability, timeresolution and B-Field immunity
- SensL SiPM array and Hamamatsu SiPMs performance tests (dark count, timing) in cooling box

Time Resolution Measurements



- 3 GHz / 20 Gs oscilloscope
- measure area (C2)
- measure delay of PiLas reference pulse C3 to MCP pulse C1 ⇒ jitter ≡ time resolution

- timewalk to be corrected for
  - sampling noise of oszilloscope
  - longterm drifts in delay