# MCP-PMT status

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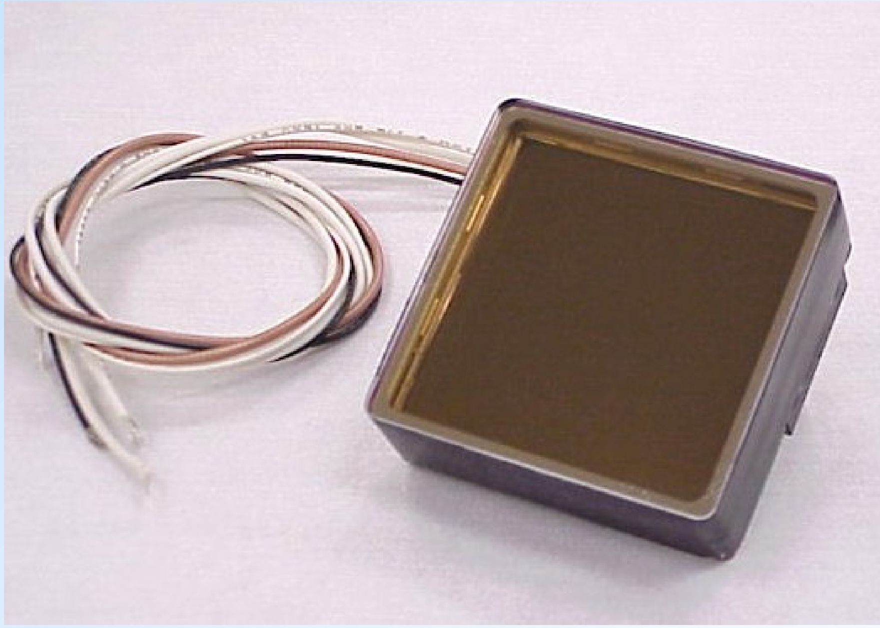
Super KEKB - 2$^{st}$ Open Meeting, 16-19 December 2009

Outline:

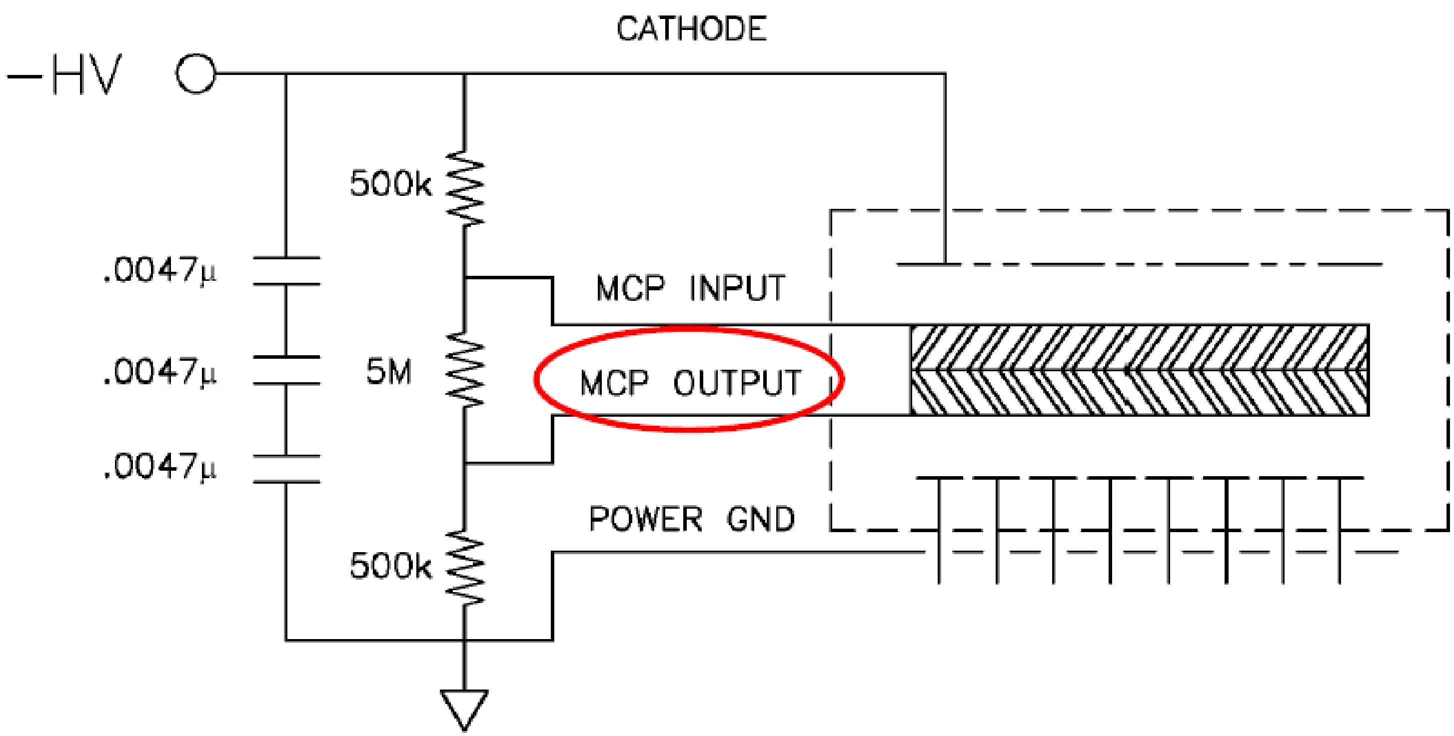
- MCP out timing
- waveform readout
- aging setup
- summary



# MCP out timing 1



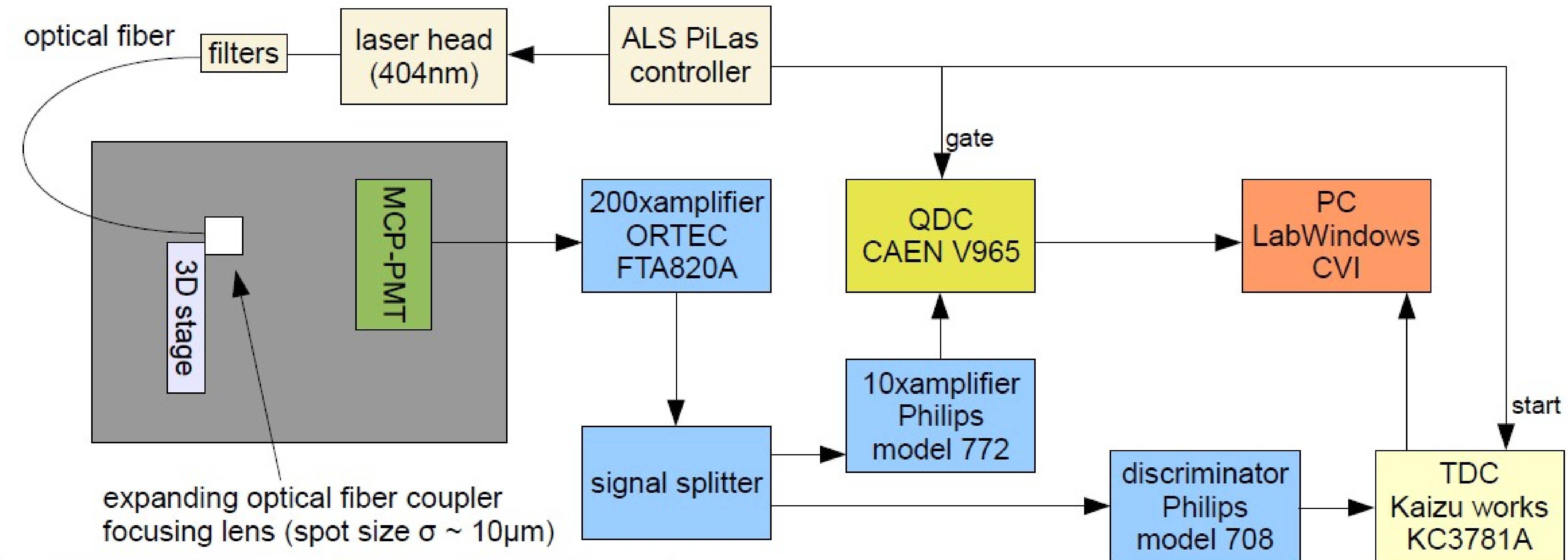
- output from multi channel plates (common for all channels)
- voltage between cathode and MCP set with resistor chain (external)

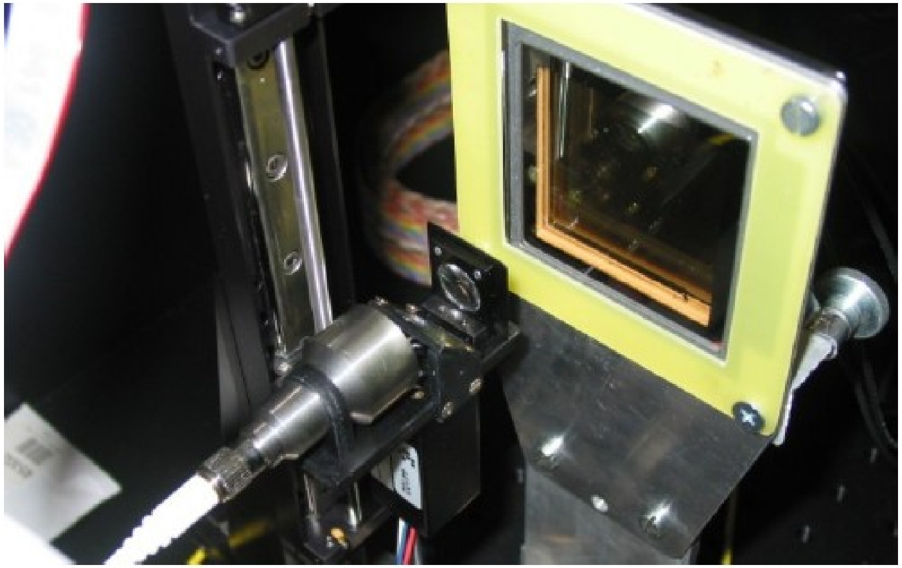



- idea: read timing for whole device from 1 channel
- 64 channels → position
- MCP Out timing?

# MCP out timing 2

Rok Dolenec

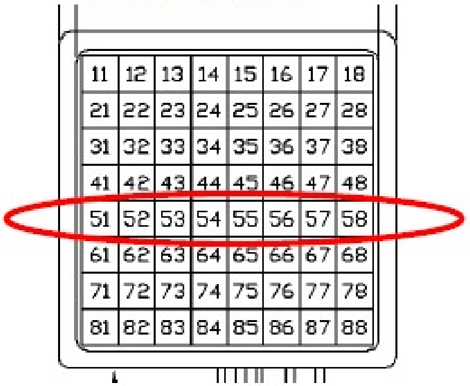


- neutral density filters: illumination ~ 0.1 – 100 photons on average ($N_{ph}$) (amplification modified at higher illuminations/pulse heights)

# MCP out timing 3

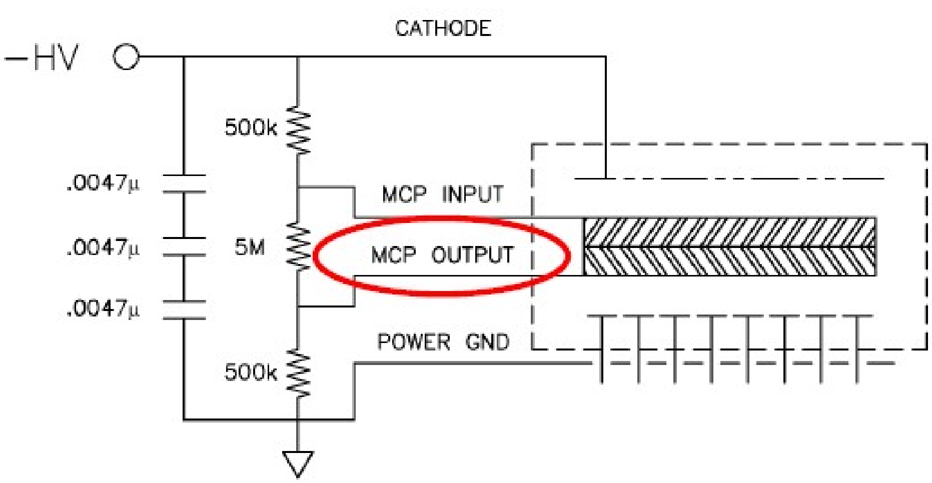
- 8 anodes

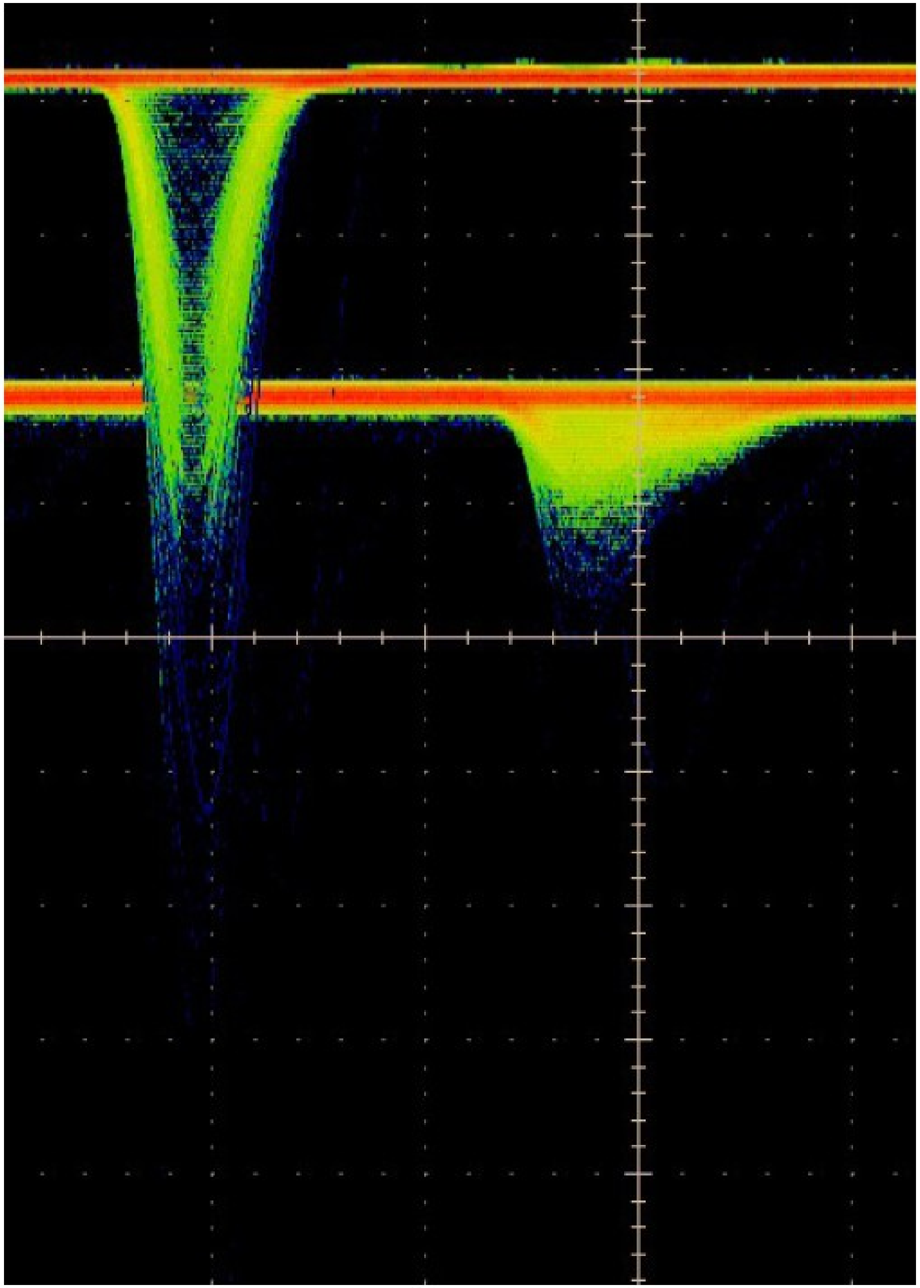



200x

- MCP Output
  - positive polarity
  - signal height ~ ¼ of individual anode

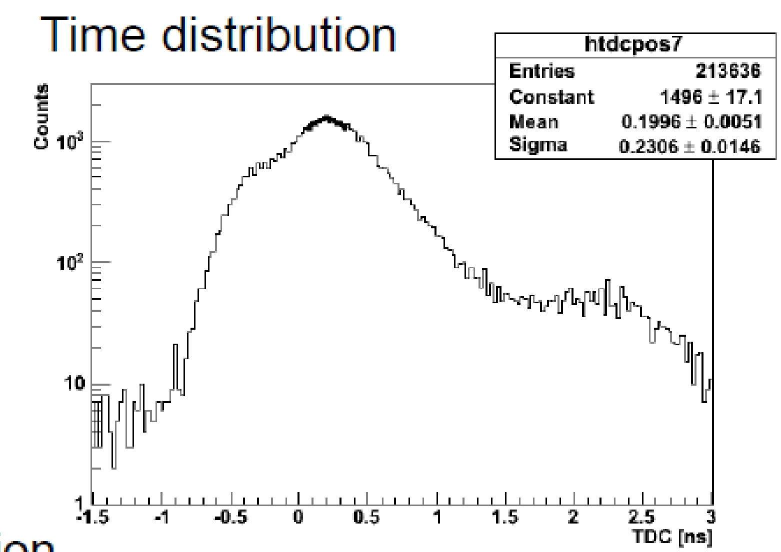
200x, inverted

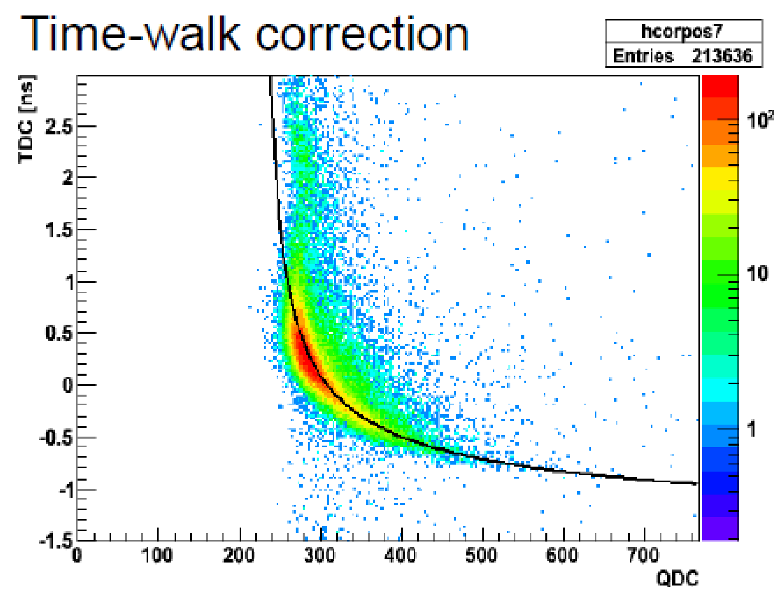


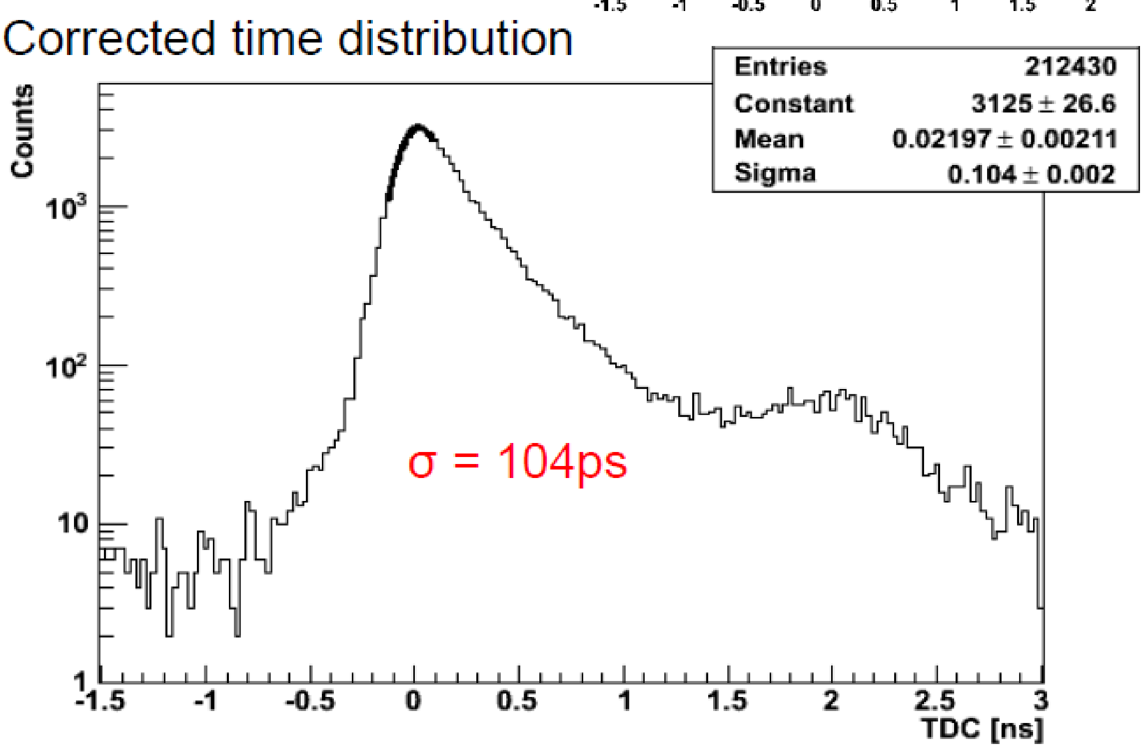



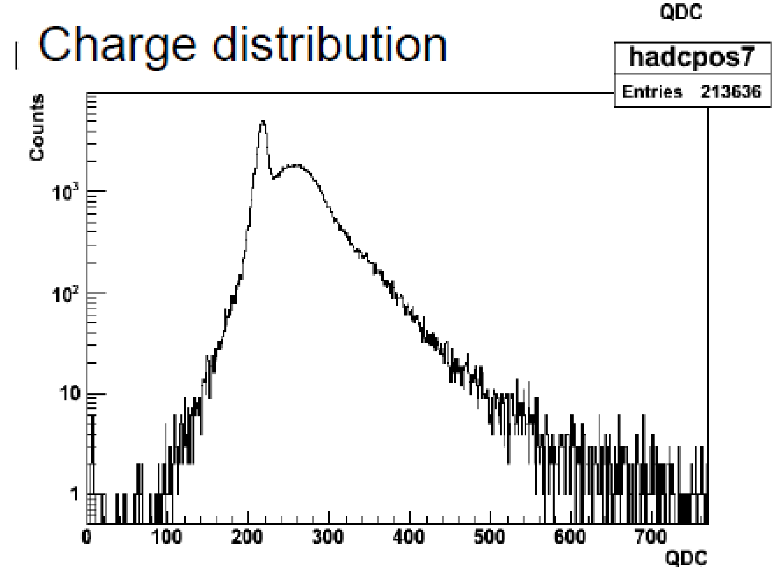
# MCP out timing 4

Rok Dolenec



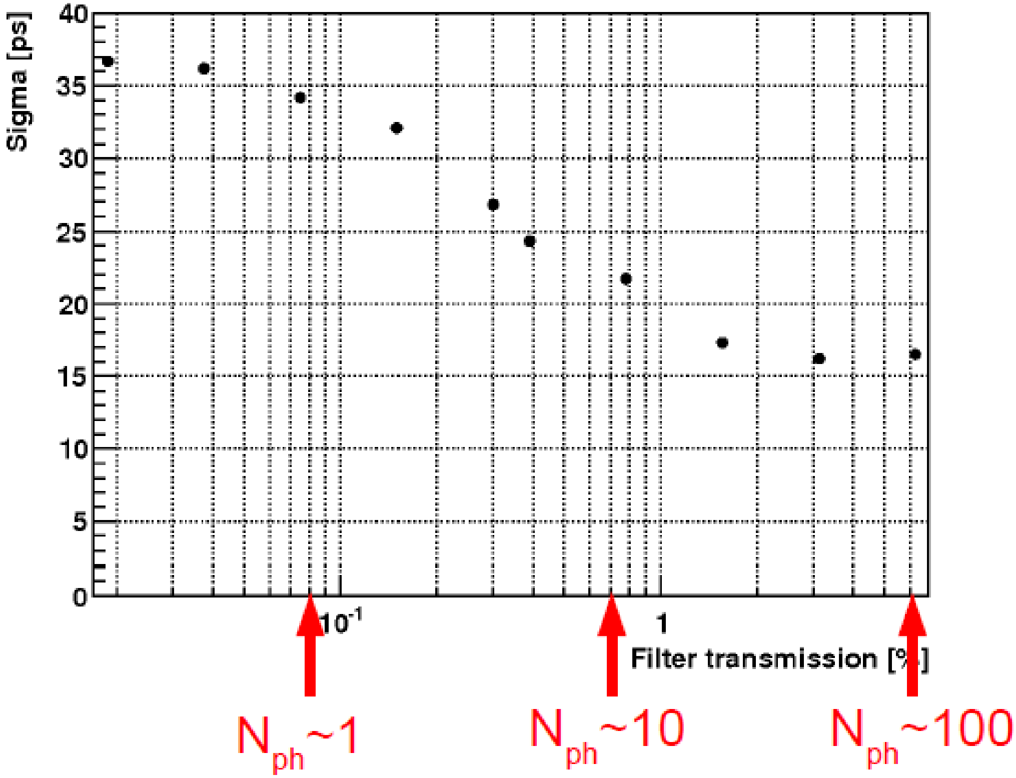



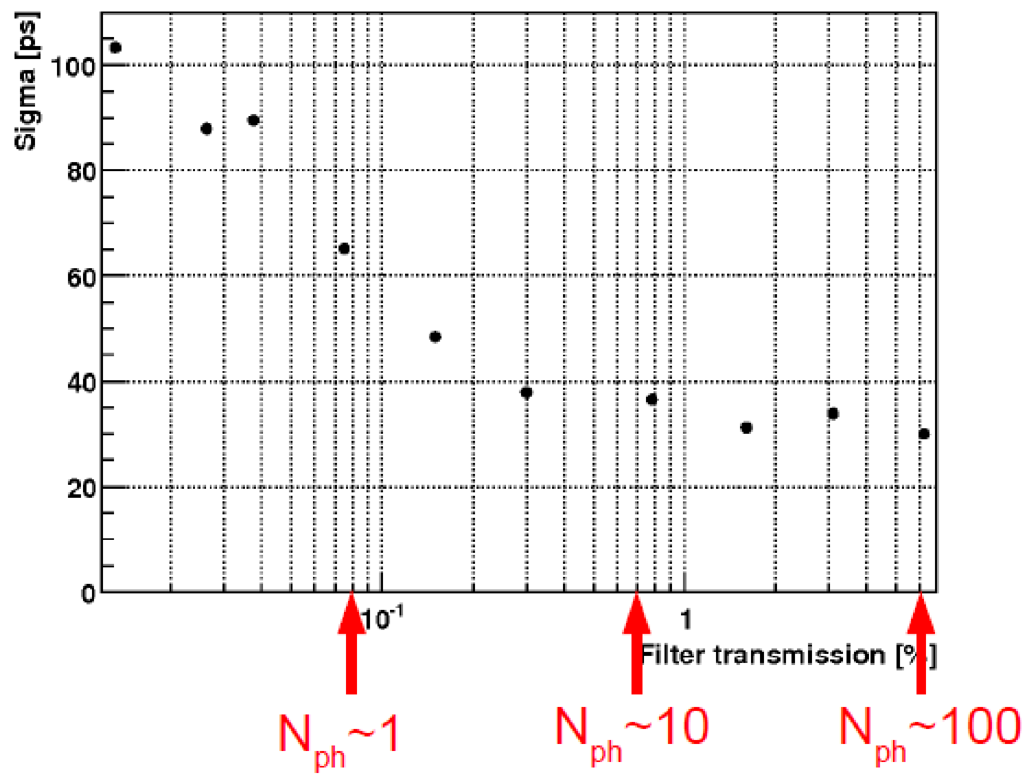
# MCP out timing 5

- filters: illumination ~ 0.1 – 100 photons an average ($N_{ph}$)

**anode** TDC sigma




**MCP Out** TDC sigma



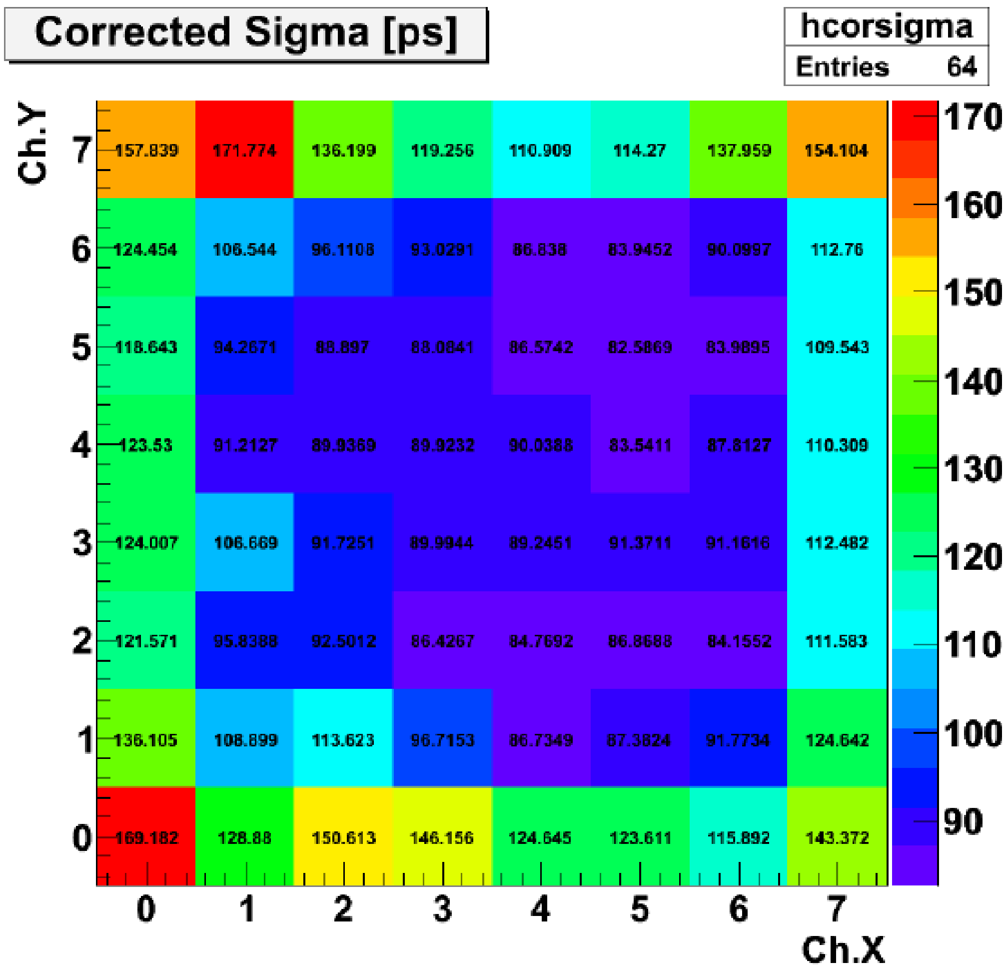

- $N_{ph}$~0.1: σ=37ps
- $N_{ph}$~10: σ=22ps
- $N_{ph}$>10: σ→16ps

- $N_{ph}$~0.1: σ=104ps
- $N_{ph}$~10: σ=37ps
- $N_{ph}$>10: σ→30ps

# MCP out timing 6

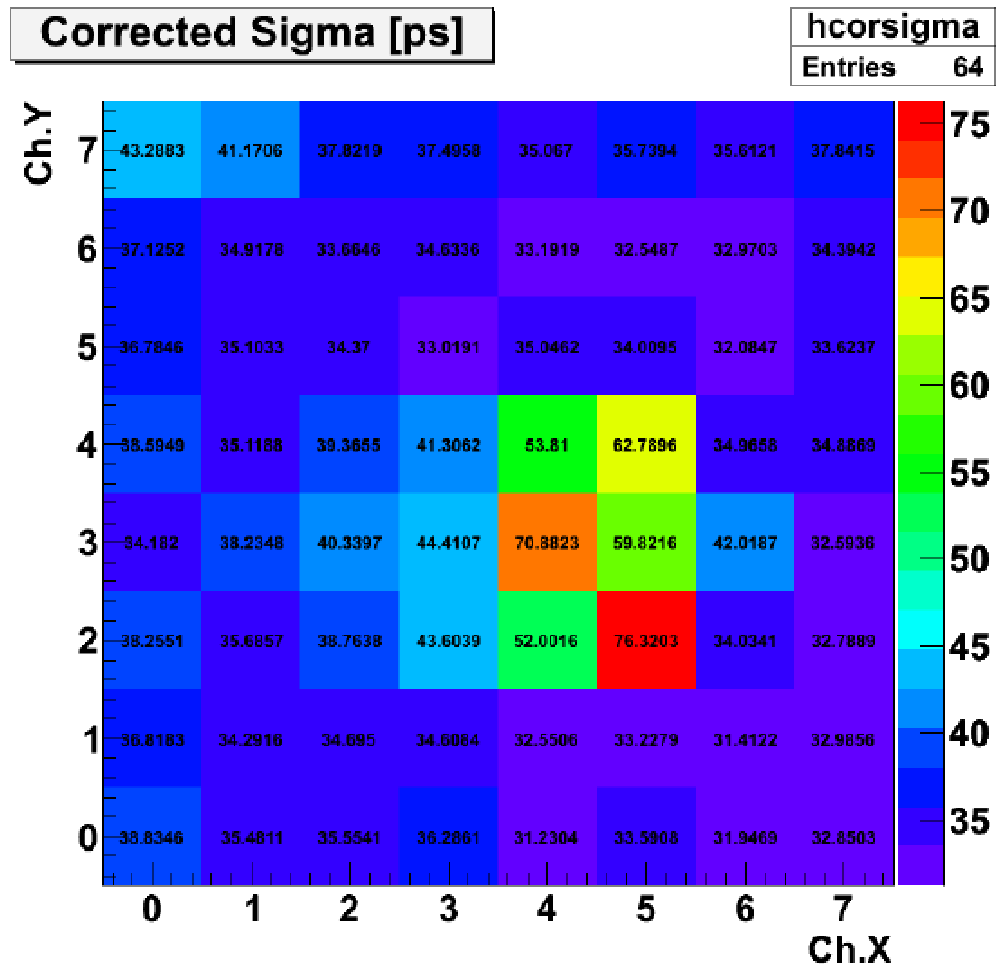
Rok Dolenec

$N_{ph} \sim 0.2$



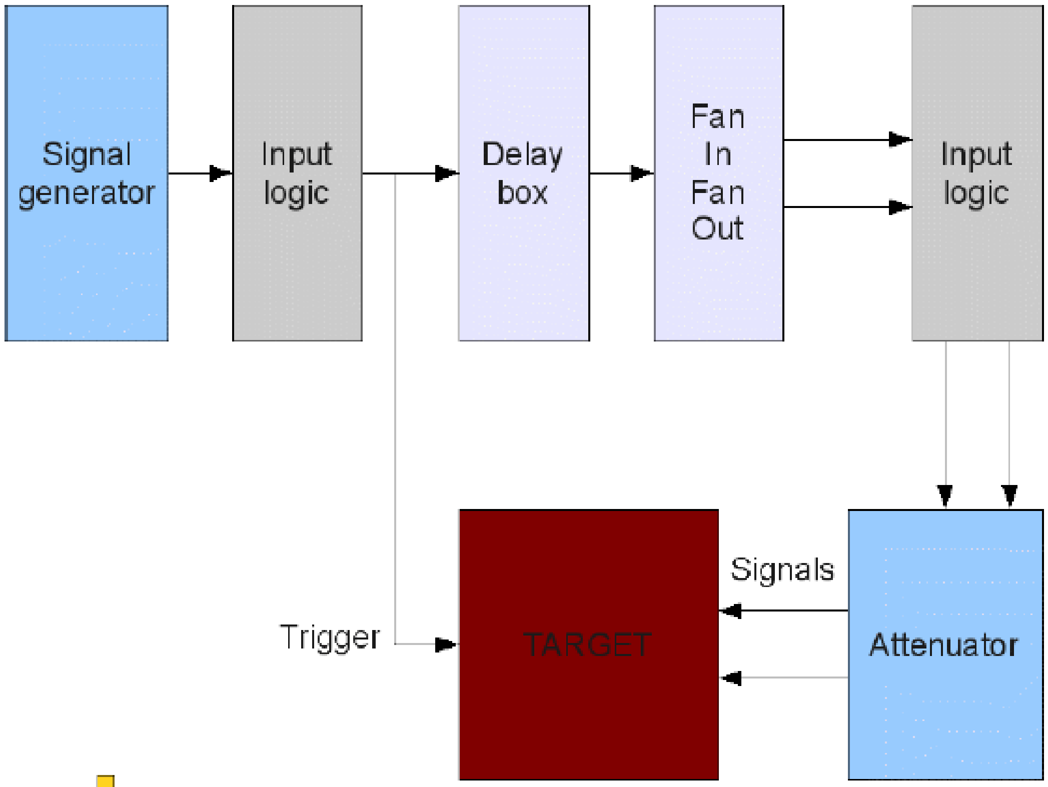

- σ~100ps
- worse at edges of device

$N_{ph} \sim 10$

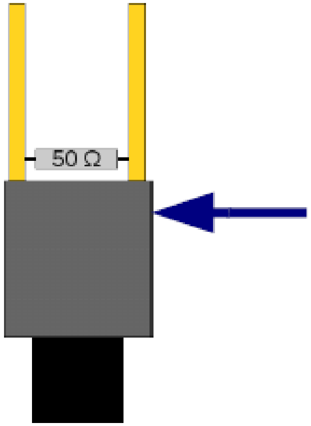



- σ~40ps
- worse for some channels near center

# Waveform readout 1

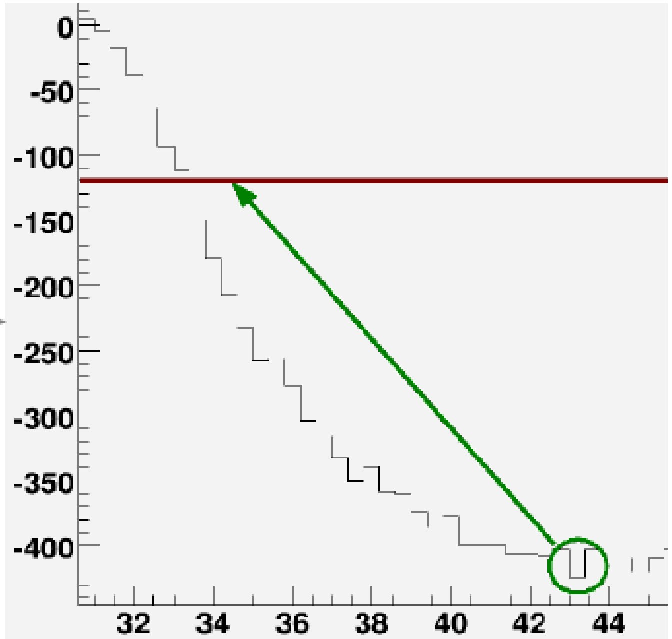


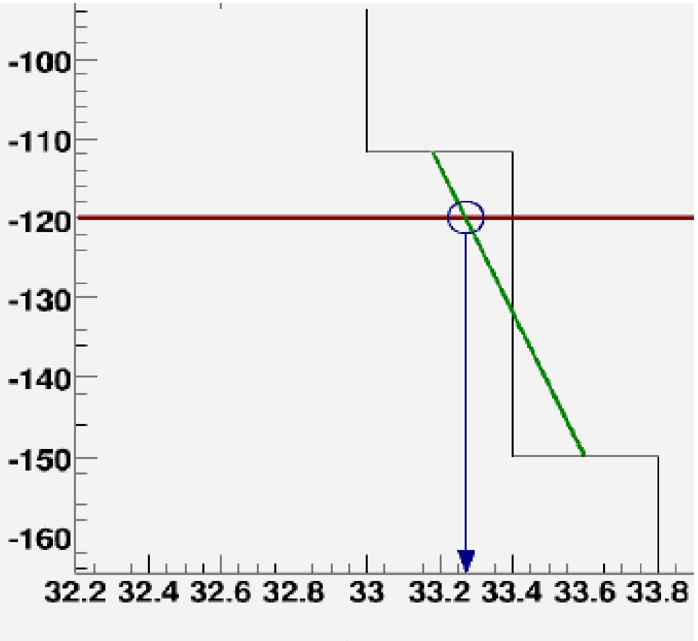

- Dual timer in a 'feedback' loop acts as a signal generator
- Signal transformed into logic pulse
- One logic pulse is send to trigger input of TARGET
- Second logic pulse is send to delay box
- After delay if gets split by a fan in fan out (FIFO)
- FIFO sends 2 copies to input logic
- 2 logic pulses get attenuated
- Attenuated pulses act as input signals




Connectors used for 50 Ω termination

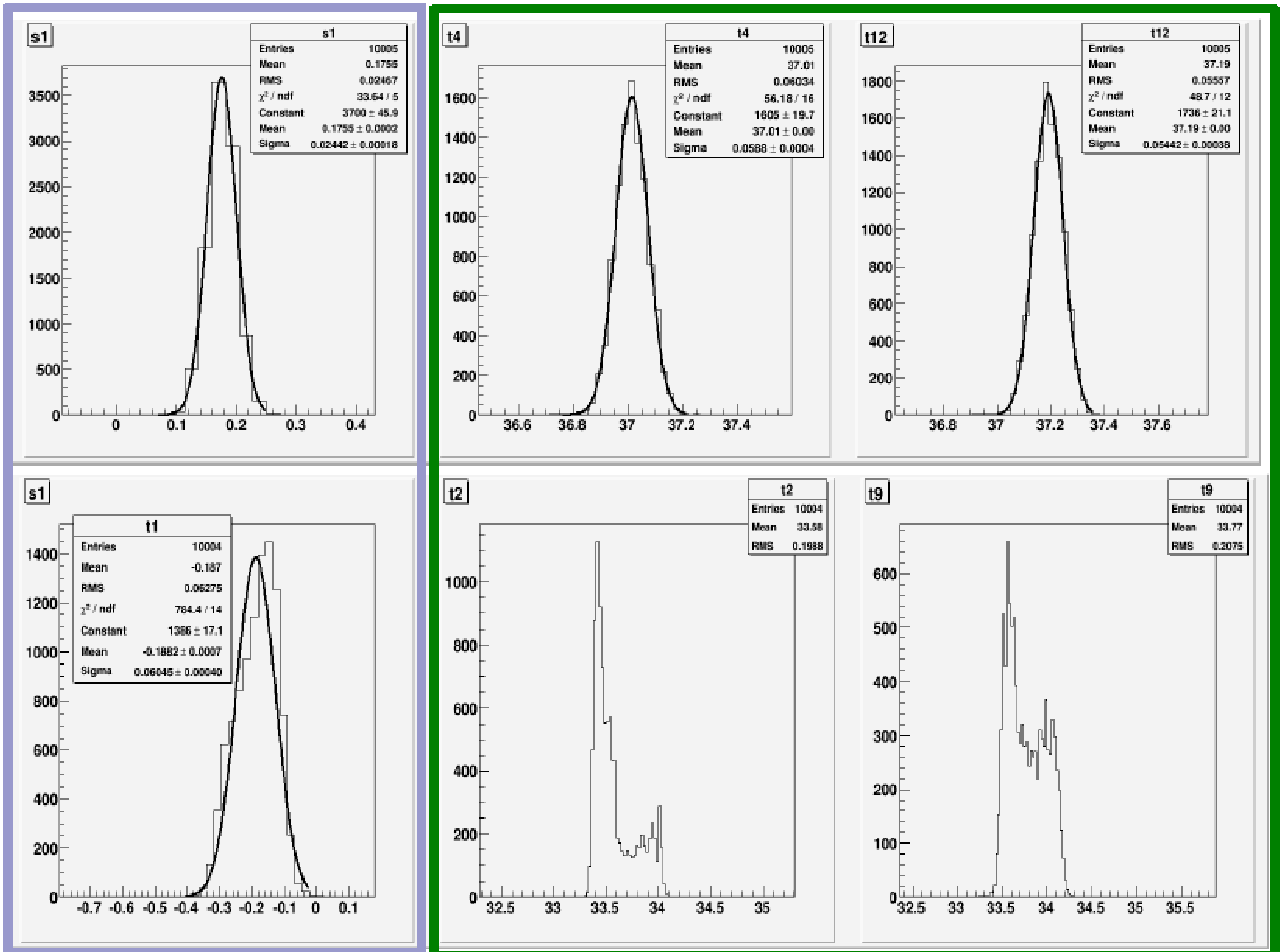
# Waveform readout 2




- Every calculation happens per event
- Get minimum => **y**
- Set threshold => **y** = **t***y (0 < **t** < 1 & change to needs/best result)
- Look for signal < **y** and 'memorize' time bins before and after crossing.
- Linear interpolation to find 'real' time of threshold crossing!

# Waveform readout 3




- Right → single channel timing.
- Left → Time difference between 2 signals on different channels.
- All signals have the same origin and go through same electronics (see setup slide).

Single channel:
top → channel 4-12
bot. → channel 1-9

Double channel: top → channel 4-12
Bottom → channel 1-9

# Long term stability - Aging

Several discussions with Emile Schyns, Group Product, Manager, Micro Channel Plates (final a good lead to the company)

Current performance (no Al protection layer): → 50% drop of efficiency after 10-15C/tube = 350-540mC/cm$^2$

Expect ~ 10 mC/cm$^2$/year on ARICH (scaling the TOP estimate)

Summer 08: move production to Europe, expect to improve the ageing by a factor > 5 (use a different scrubbbing technique, deep UV → electrons)

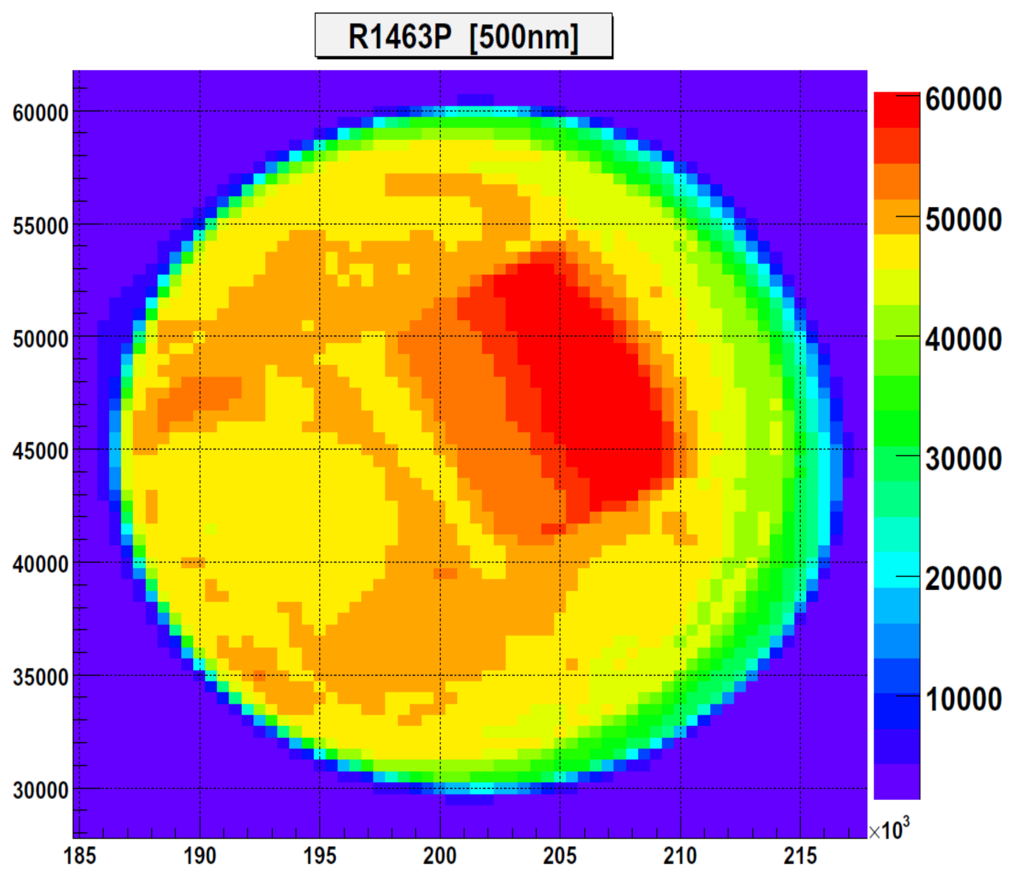
→ Ageing most probably not a problem but need to be tested !

# Aging test

SETUP:

- monochromator 200nm-900nm
- laser source: 400nm,630nm
- LED for aging (blue ~470nm)
- reference PMT for QE
- monitoring PMT
- current monitoring
- DAQ with scalers and ADC

Start aging test end of March



# BACKUP SLIDES

# Photon detector summary

**Many tests have been performed since last meeting:**

- magnetic field test of HAPD, MCP-PMT and MPPC → all perform well - some properties improve
- beam test of MPPC module in 120 GeV muon test beam at CERN
- accelerated aging test of HAPD (@ Hamamatsu)
- measurement of neutron fluencies in Belle
- tests of new ASIC generation

**To do list:**

- aging and long term stability test of HAPD and MCP-PMT
- check possible improvements in photon detection efficiency of HAPD and MCP-PMT
- electronics - test detectors with WFS and new ASIC
- test of MCP-PMT timing properties in magnetic field
- check the timing capabilities of HAPD

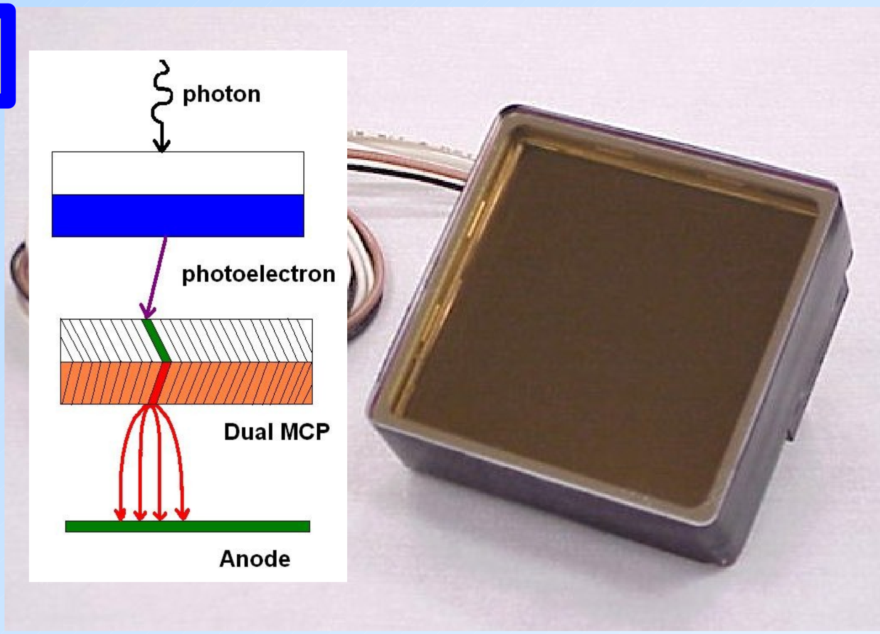
**Decision on photon detector technology → March meeting**

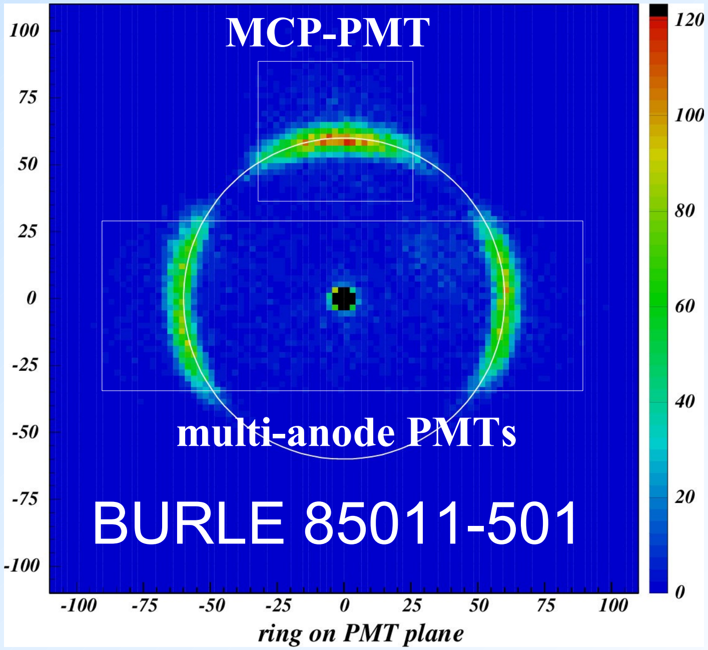
| | HAPD | MCP-PMT | MPPC |
|---|---|---|---|
| $N_{ph}$ | 7 (→14) | 10 (→15) | 30 |
| $\sigma_{\vartheta}$ | 14 | 15 | 14 |
| B = 1.5T | OK (improved perf.) | OK (improved perf.) | OK |
| long term stab. (aging) | OK (HV stability?) | OK? | OK |
| neutron damage | leakage current? → signal / noise | OK(?) | X |
| production | 2.5 y | 2 y | ? |
| pieces | < 600 | < 1000 | < 500000 |
| cost / piece | < 7000 € | < 4000 € | < 20 € |
| electronic s | ASIC | WFS | WFS |
| channels | ~ 75k | ~ 60k | ~ 120k |
| material | ? | ? | ? |

# Photon detector candidate: MCP-PMT

Model 85015/A1 (old sample 85011-501):

- two MCP steps - chevron configuration
- 64 (8x8) anode pads @6.5 mm, gap ~ 0.5mm
- bialkali photocathode
- gain ~ 0.6 x $10^6$ (@2400V)
- 10µm (25µm) pores
- open area ratio ~ 70 % (60 %)
- size ~ □59mm (71mm)
- effective area fraction ~ 80% (52%)
- **excellent timing < 40ps (50ps) - single photon**
- K-MCP 4.4mm (6.1mm), MCP-A 3.7mm (5.2mm)
- window thickness 1.5mm (2mm)



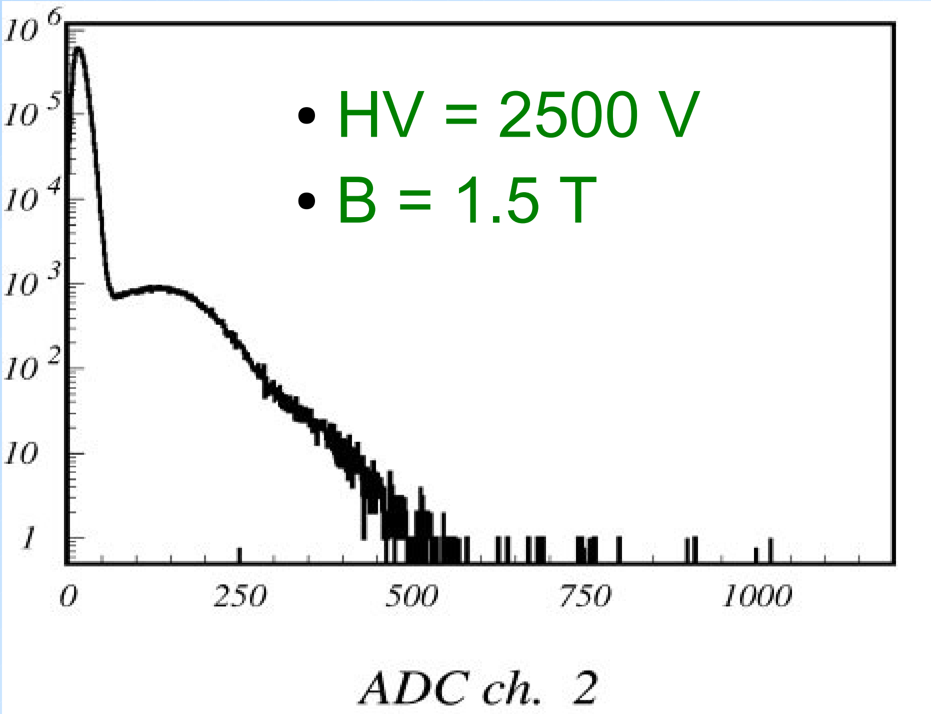




- $\sigma_\vartheta$~15 mrad (single photon)
- number of hits per track N ~ 10
- $\sigma_\vartheta$~ 4.7 mrad (per track)
- → ~ 5 **σ π/K separation at 4 GeV/c**

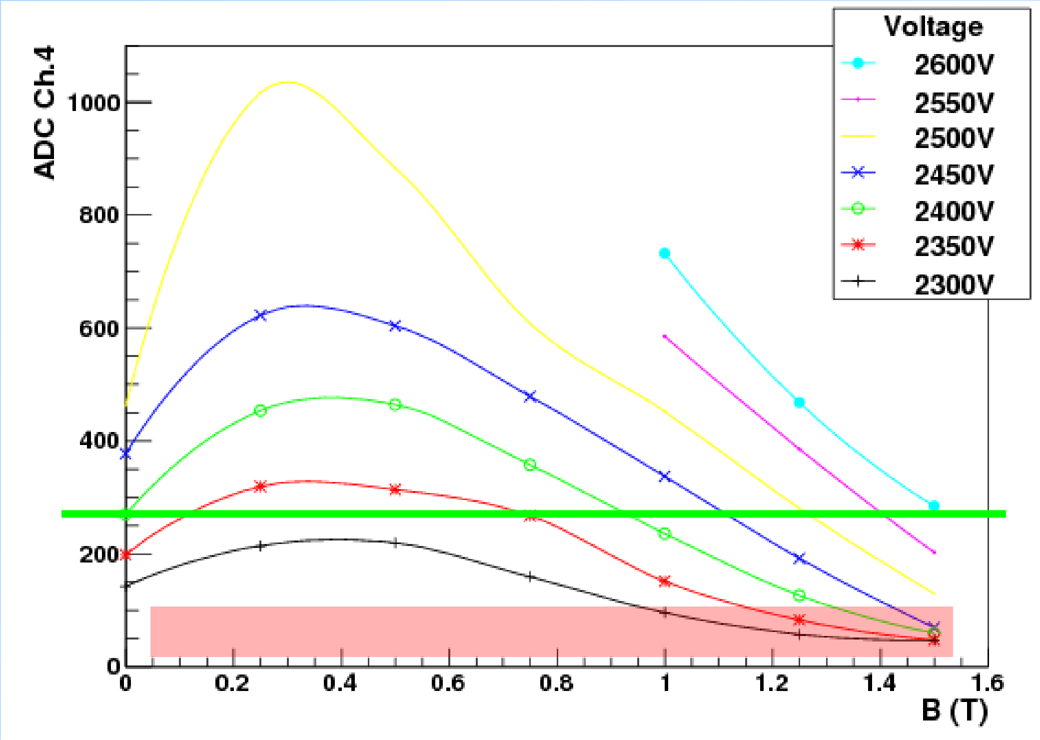
- Tested in combination with multi-anode PMTs

# Tests in magnetic field: ADC vs B

- gain drop observed in magnetic field 1.5T
- increase HV for ~200V to reach the same amplification as in B=0T



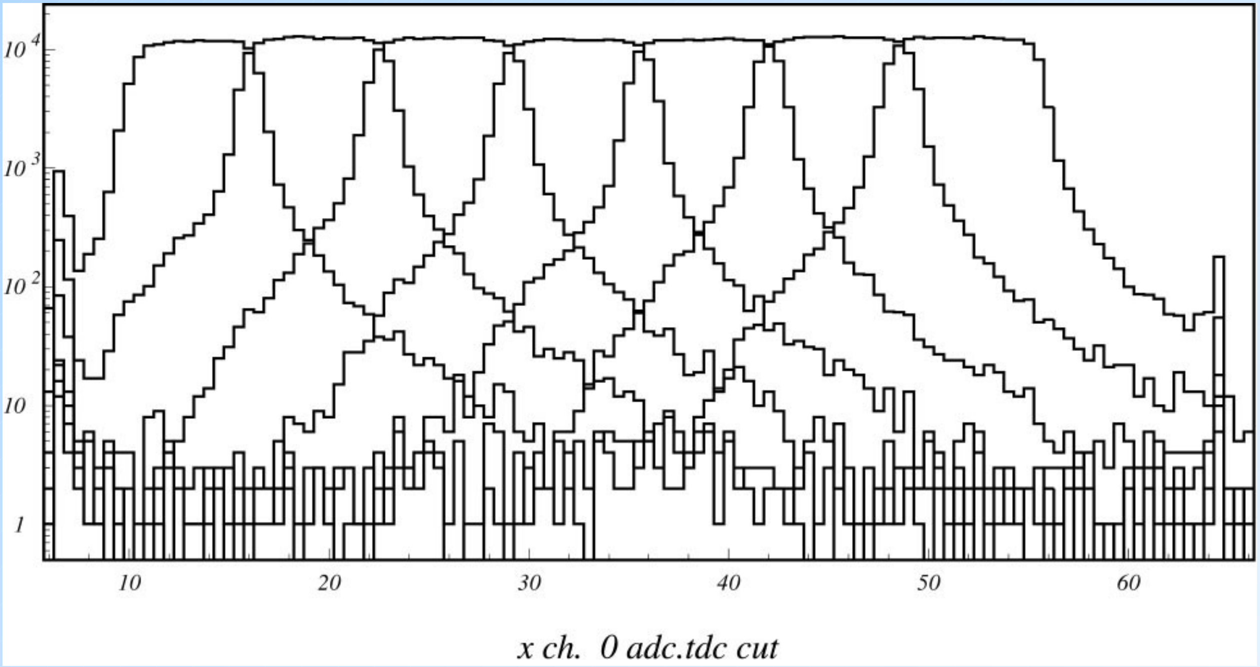

- single photon ADC distribution measured in magnetic field



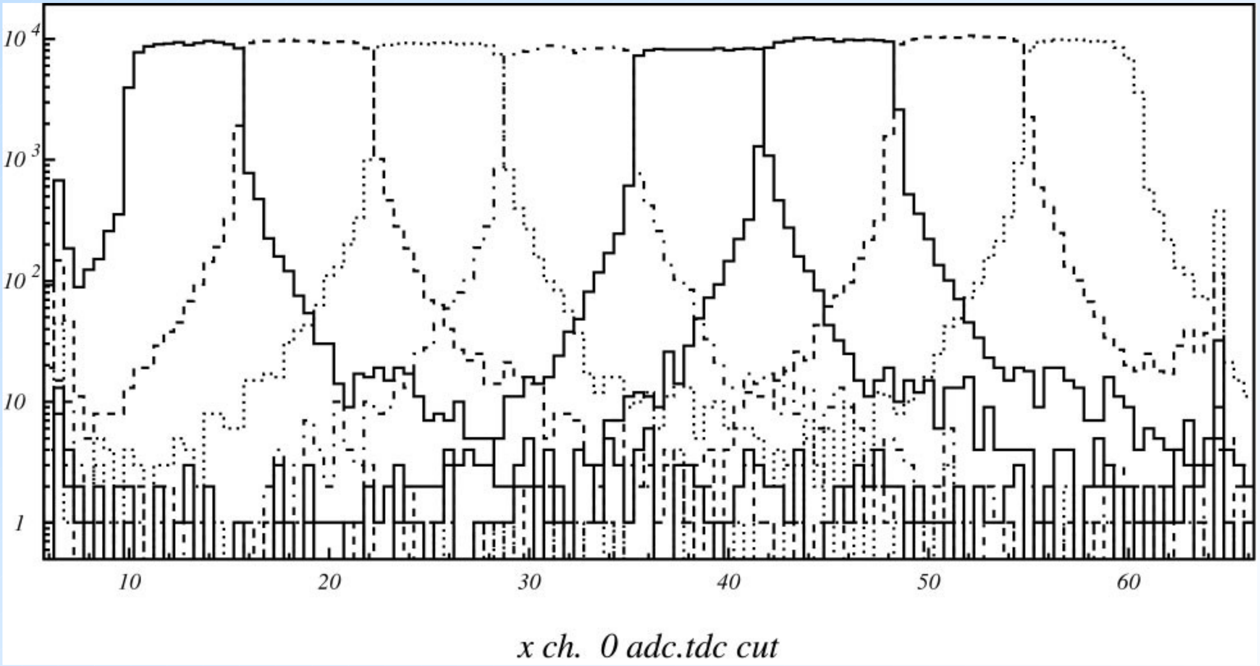

- gain as a function of magnetic field for different operation voltages.

# Tests in magnetic field: charge sharing

Number of detected hits on individual channels as a function of light spot position.




- HV = 2400 V
- B = 0 T



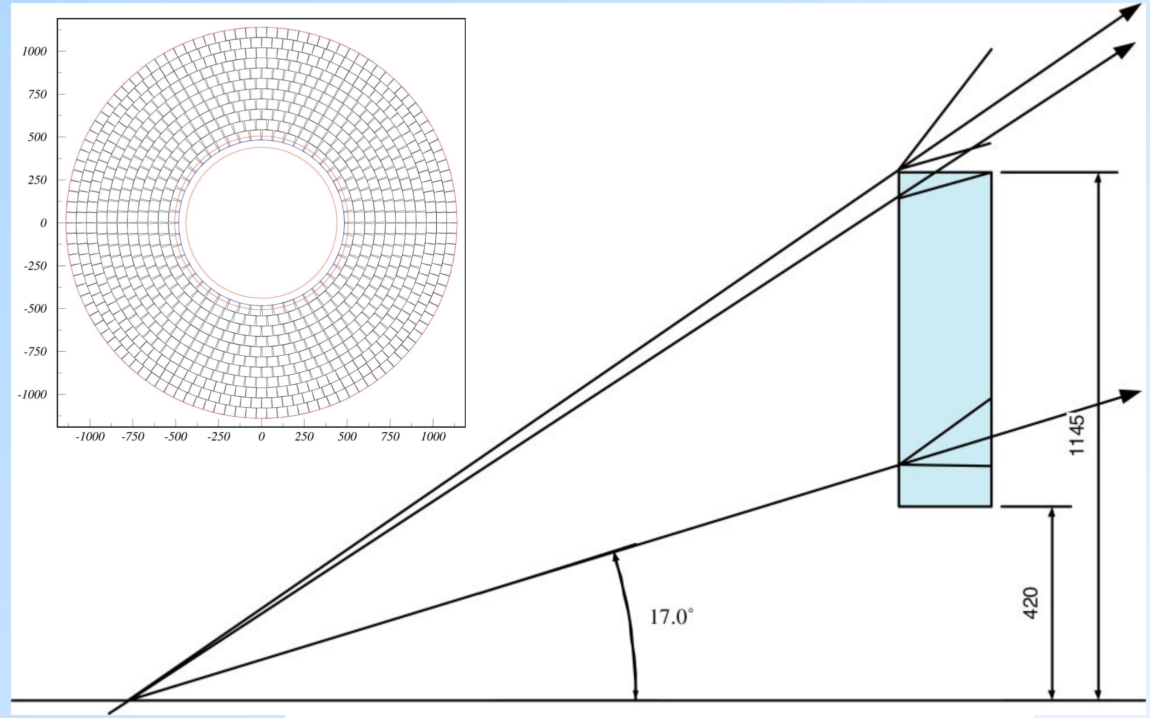

- HV = 2500 V
- B = 1.5 T

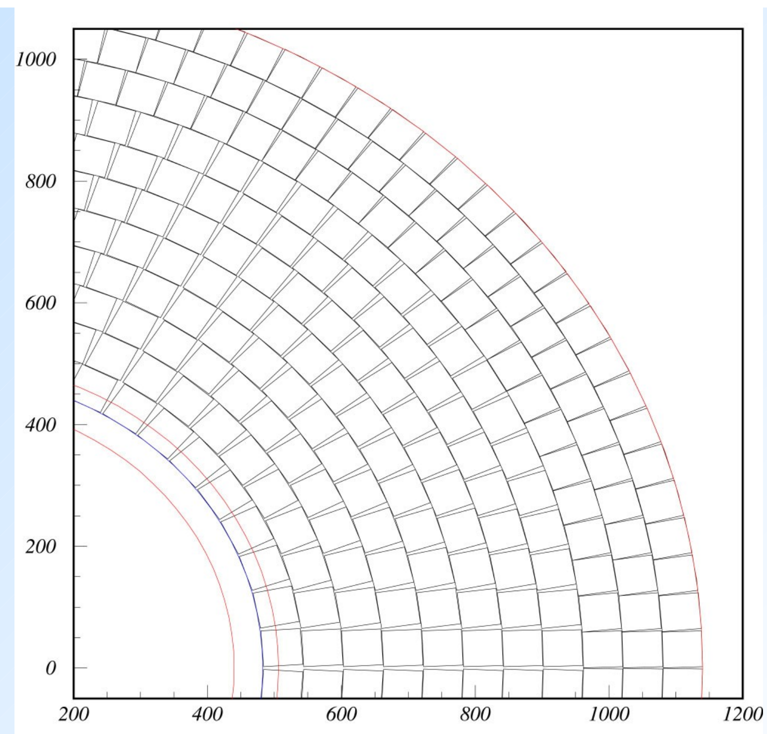
Reduced effects of charge sharing and photo-electron backscattering are

# Tiling scheme

- Number of MCP-PMTs and covered area fraction

| ring | # PMTs | fraction |
|---|---|---|
| 1 | 48 | 86% |
| 2 | 54 | 87% |
| 3 | 60 | 88% |
| 4 | 66 | 88% |
| 5 | 72 | 89% |
| 6 | 78 | 89% |
| 7 | 84 | 89% |
| 8 | 90 | 90% |
| 9 | 102 | 96% |
| 10 | 108 | 96% |
| 11 | 114 | 95% |
| **all** | **876** | **91%** |

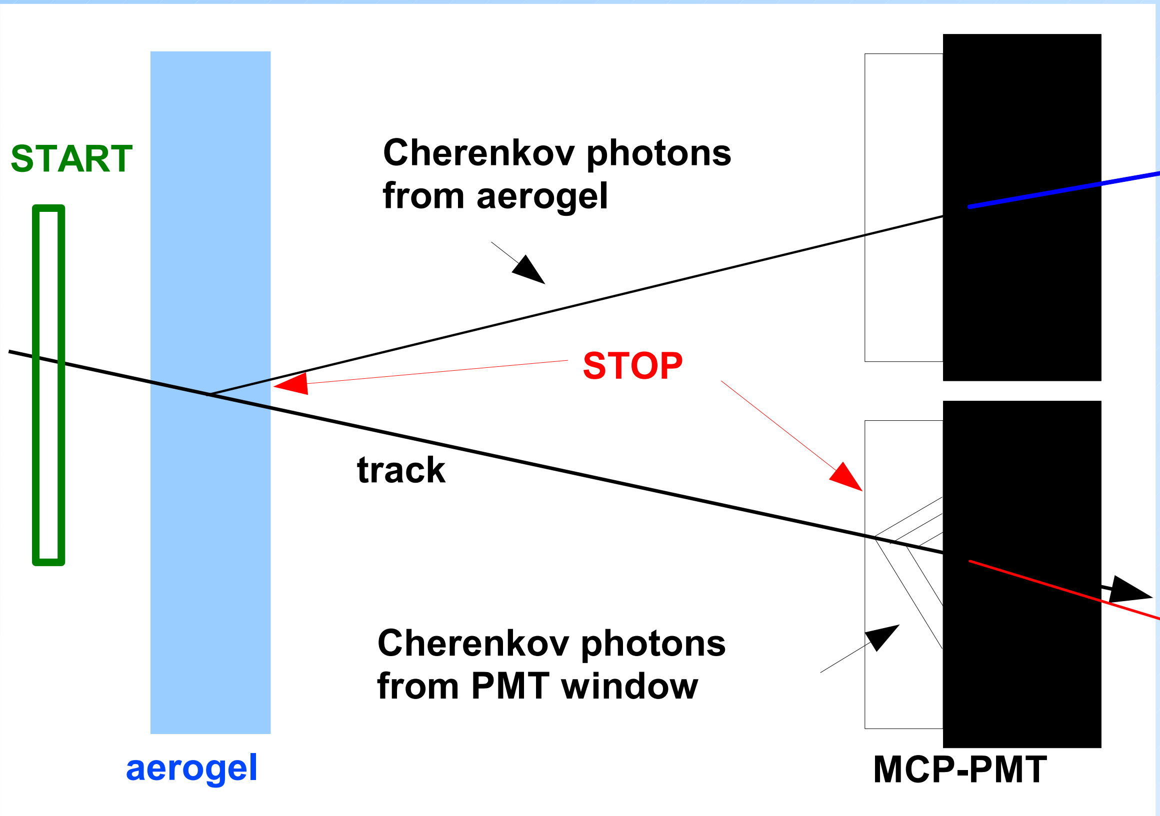


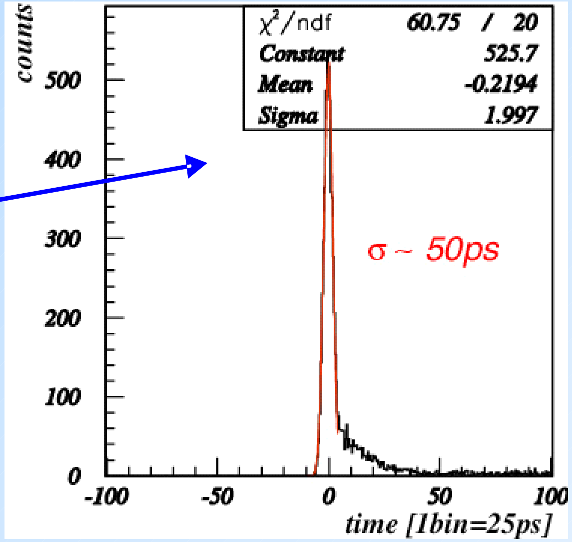




Total number <1000 and rough estimate for price < 4M€ (uper limit)

# Additional feature: RICH+TOF

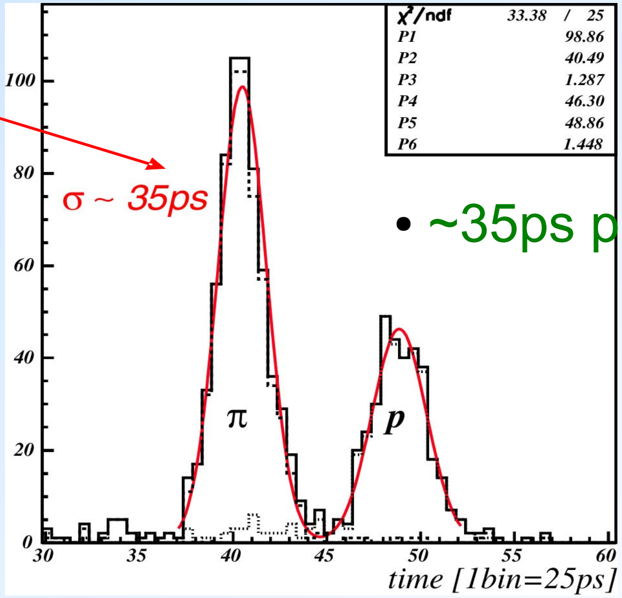
Make use of fast photon detectors: measure time-of-flight with Cherenkov photons from PMT window and aerogel




Beam test:

- 50ps per single photon (~20ps per track)

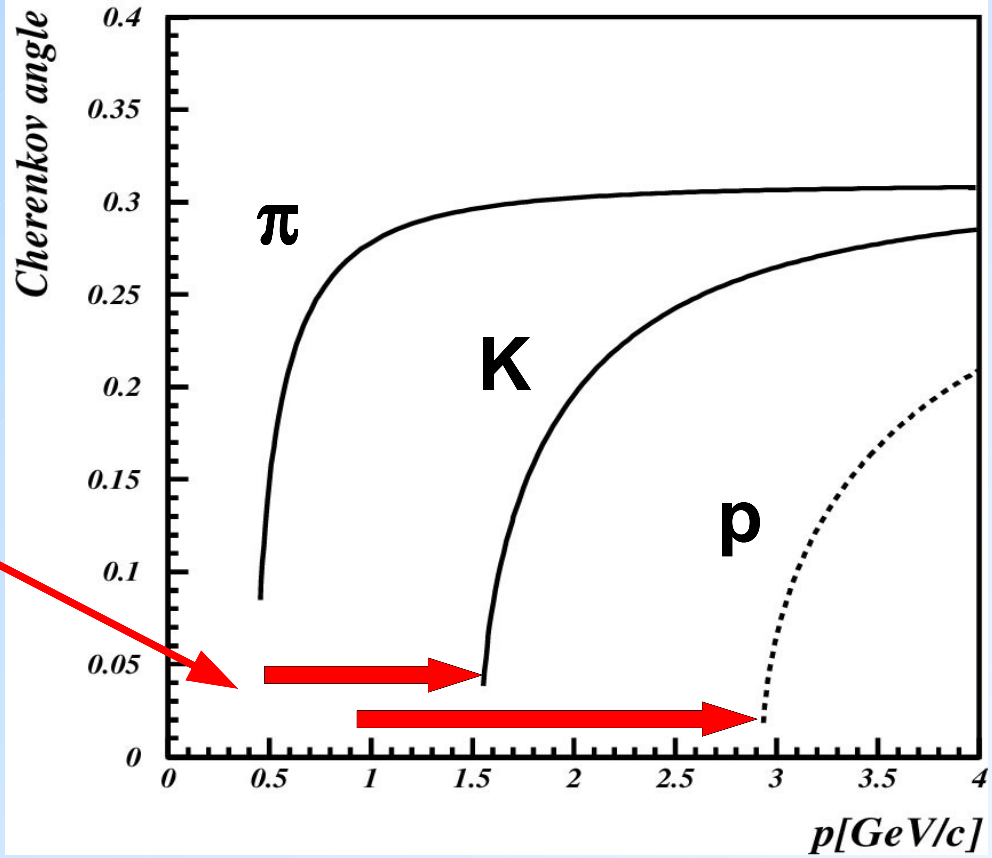



- ~35ps per track

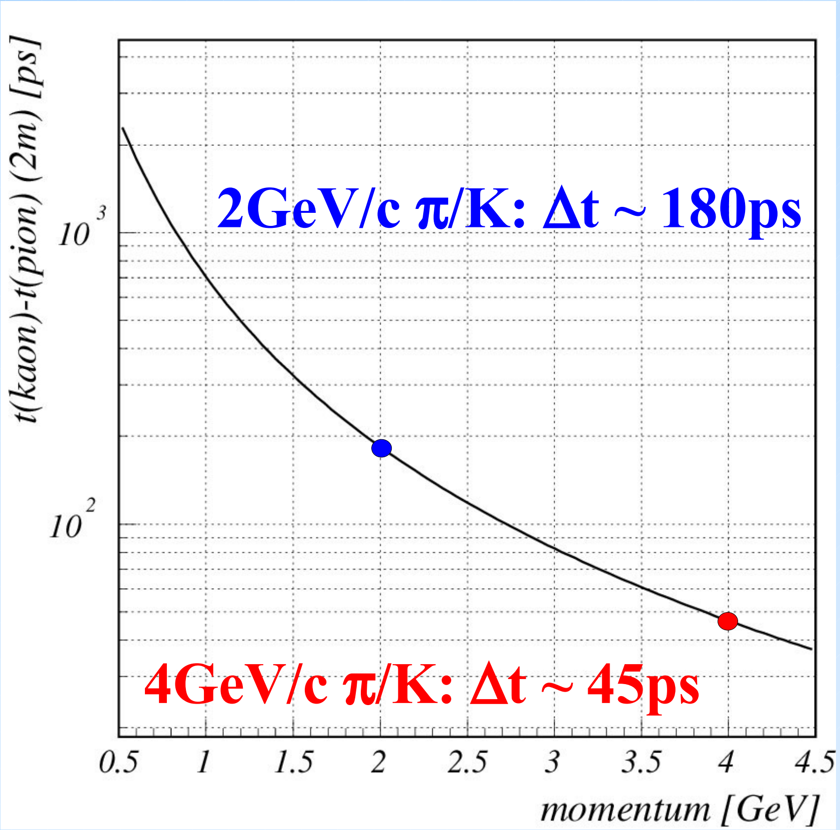
- Cherenkov photons from the window can be used to positively identifiy particles below the threshold in aerogel

# TOF capability

Using Cherenkov photons emitted in the PMT window (n~1.46) PID can be extended into the lower momentum region:
Kaons and protons can be positively identified below the Cherenkov threshold in aerogel (n~1.05).




Cherenkov angle in aerogel (n=1.05) for pion, kaon and proton.




Time-of-flight difference for pions and kaons from IP to forward PID (2m).

# Summary and plan

- xxx

Plan:

- xxx