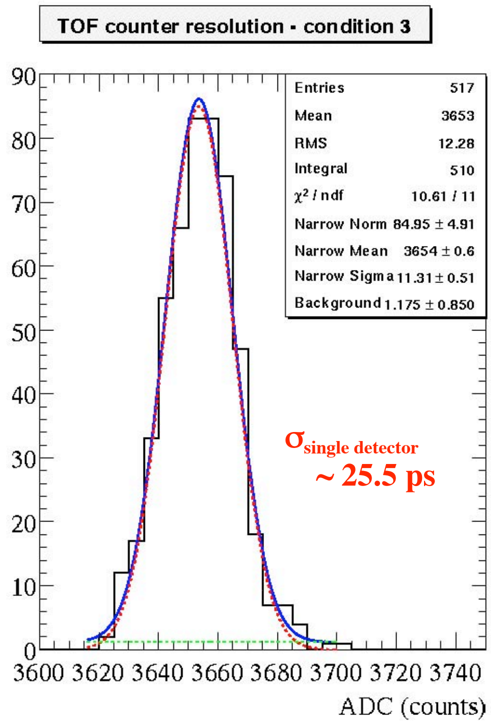
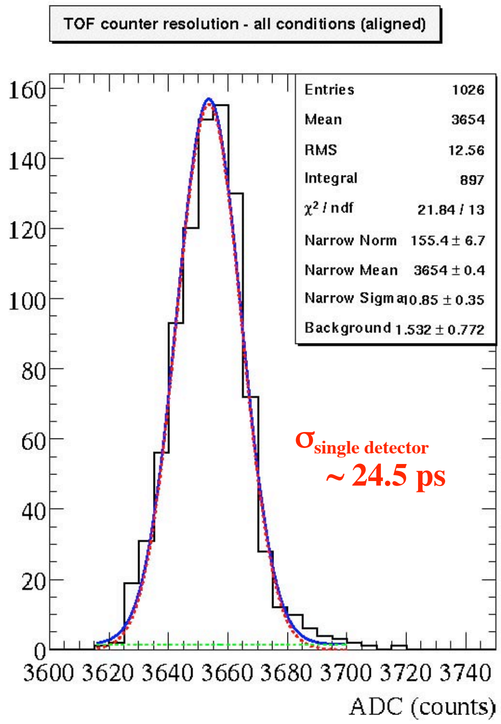
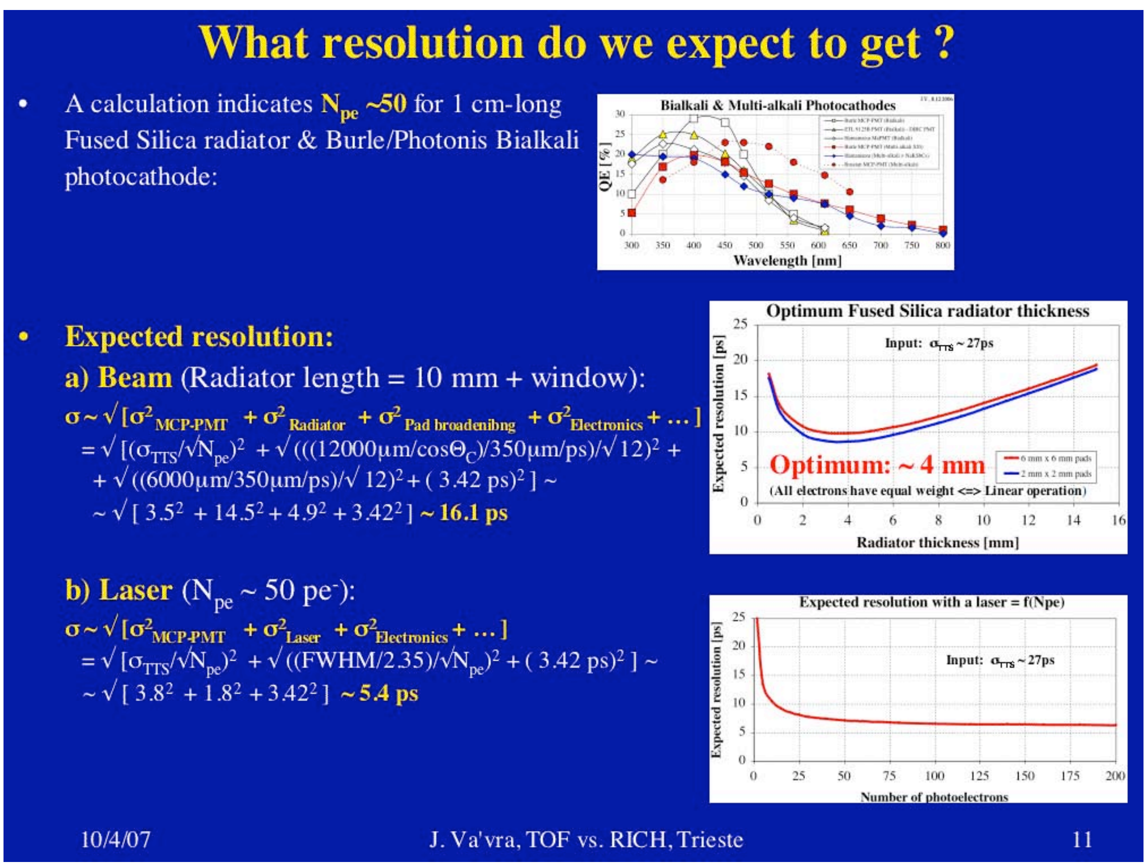


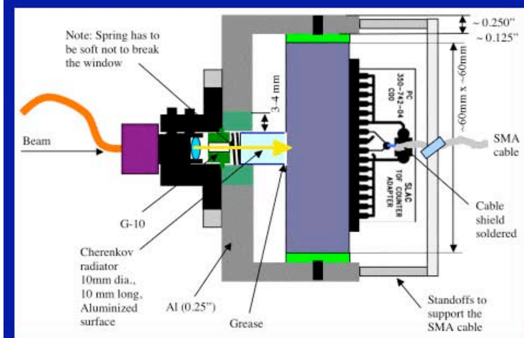


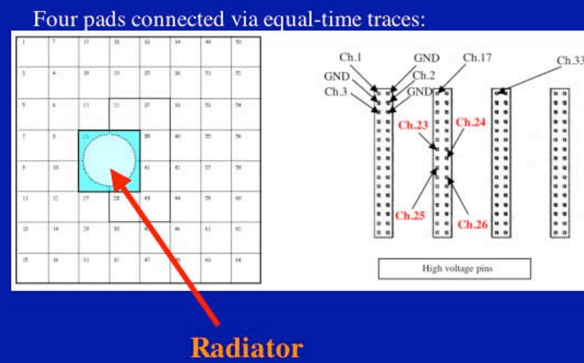
From Trieste RICH 2007 "TOF vs. RICH" talk:

10.4.2007



A TOF counter prototype





- **Burle/Photonis MCP-PMTs with 10 μm MCP holes.**
- **Short together 4 pads to get a signal; all the rest of pads grounded.**
- **A 10mm-long, 10mm dia, quartz radiator, Al-coating on cylinder sides.**
- Ortec 9327Amp/CFD & TAC566 & 14 bit ADC114.
- Calculation: 10mm long quartz radiator & a window should give Npe ~ 50 pe/track.
- Laser diode light adjusted to provide typically Npe ~ 50 pe.
- The laser spot size: ~1mm dia.; beam spot size typically σ ~1-2mm

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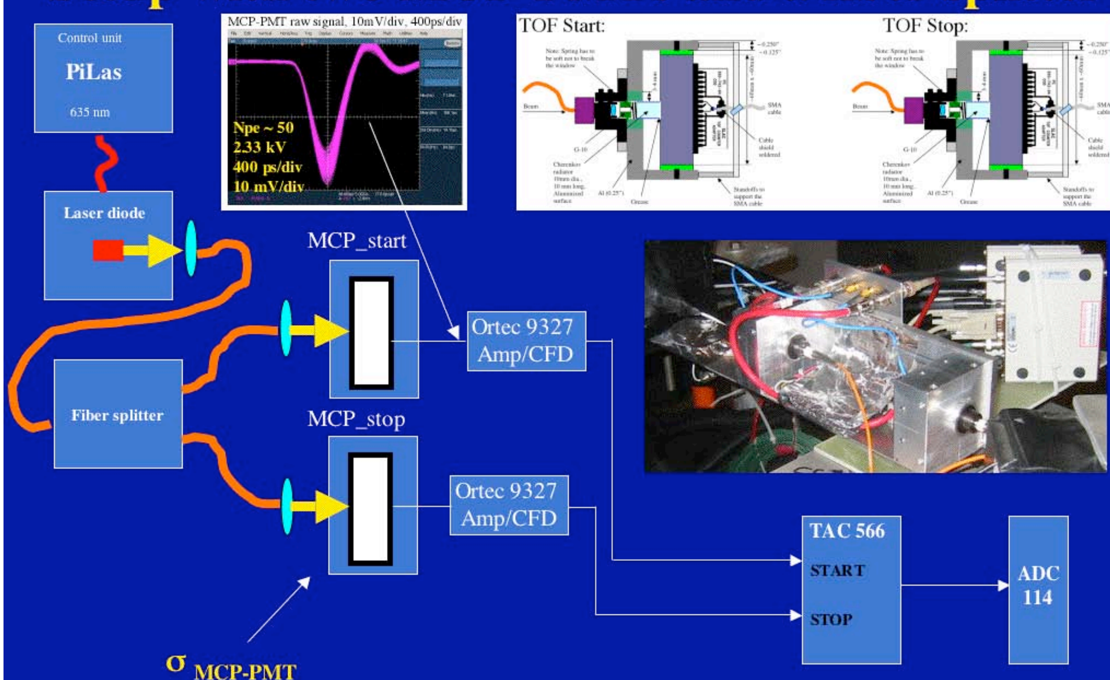
Setup with two MCP-PMTs and a fiber splitter



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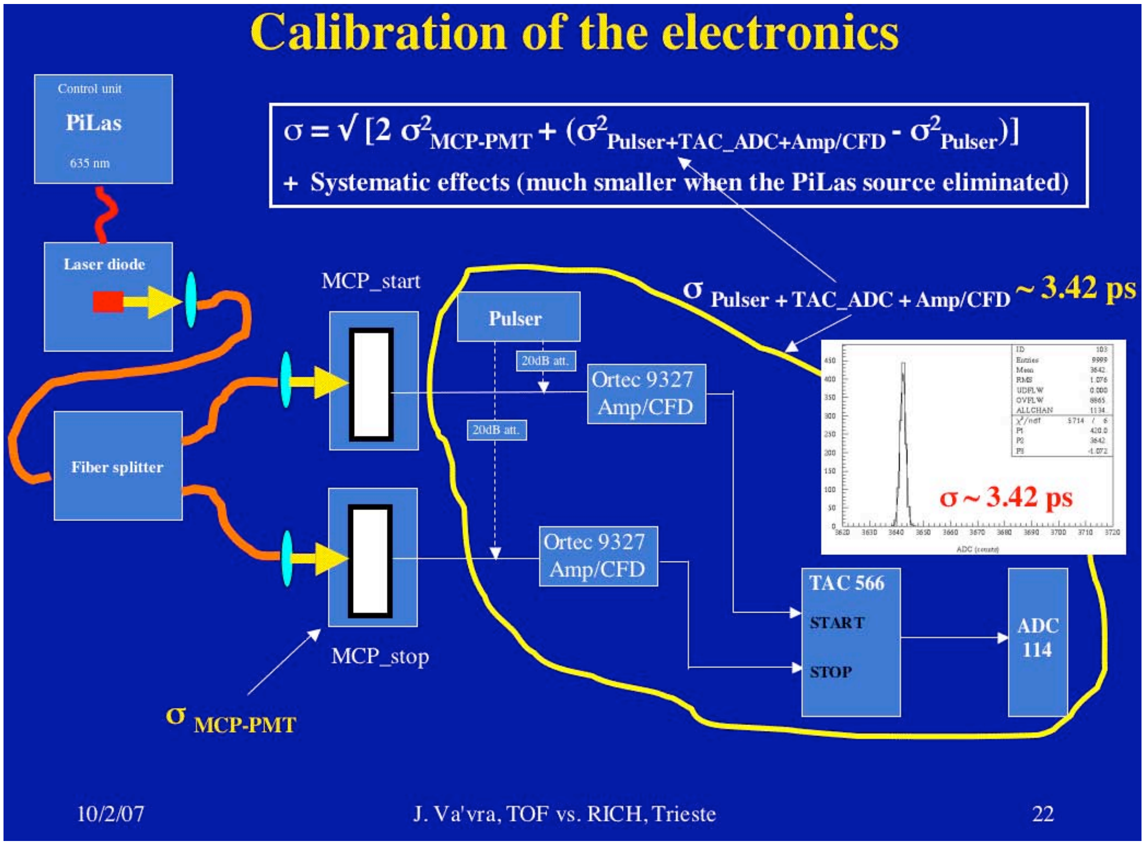
Calibration of the electronics
Control unit
PiLas
635 nm
Laser diode
Fiber splitter
MCP_start
MCP_stop
σ MCP-PMT
σ = √ [2 σ²MCP-PMT + (σ²Pulser+TAC_ADC+Amp/CFD - σ²Pulser)]
+ Systematic effects (much smaller when the PiLas source eliminated)
σ Pulser + TAC_ADC + Amp/CFD ~ 3.42 ps
Pulser
20dB att.
20dB att.
Ortec 9327 Amp/CFD
Ortec 9327 Amp/CFD
σ ~ 3.42 ps
TAC 566
START
STOP
ADC 114
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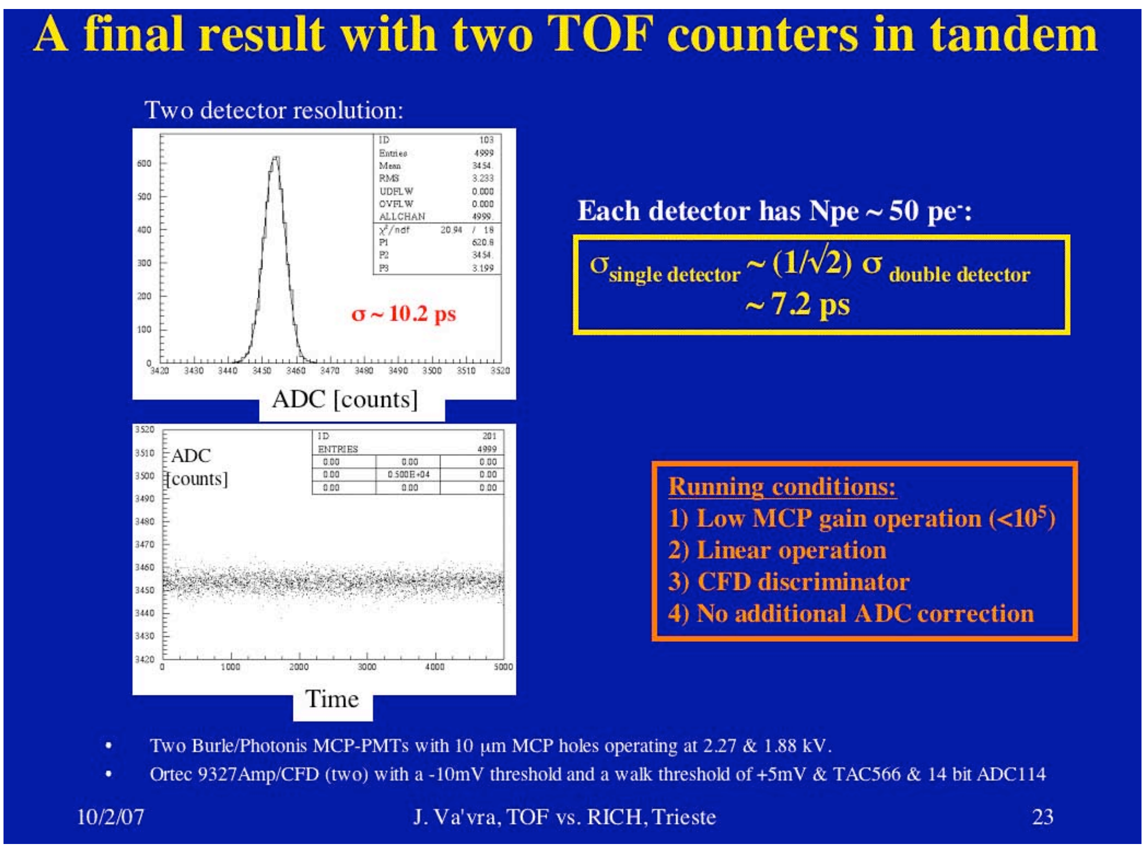
A final result with two TOF counters in tandem
Two detector resolution:
σ ~ 10.2 ps
ADC [counts]
ADC [counts]
Time
Each detector has Npe ~ 50 pe-:
σsingle detector ~ (1/√2) σ double detector
~ 7.2 ps
Running conditions:
1) Low MCP gain operation (<10⁵)
2) Linear operation
3) CFD discriminator
4) No additional ADC correction
• Two Burle/Photonis MCP-PMTs with 10 µm MCP holes operating at 2.27 & 1.88 kV.
• Ortec 9327Amp/CFD (two) with a -10mV threshold and a walk threshold of +5mV & TAC566 & 14 bit ADC114
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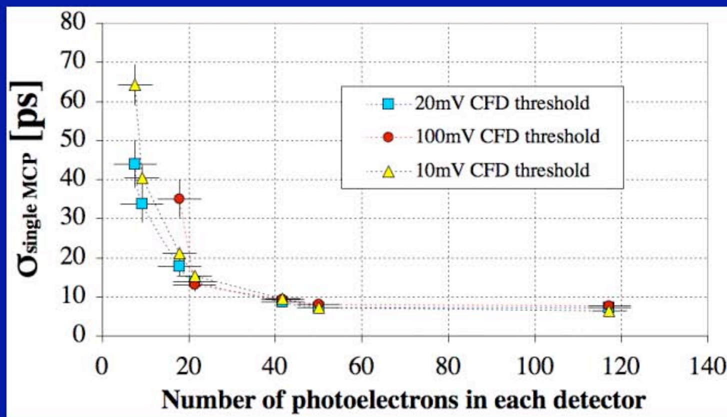
A single MCP resolution = f(Npe)$_{threshold}$



CFD threshold:

10 mV <=> 2-3 pe

20 mV <=> 3-6 pe

100 mV <=> 15-20 pe

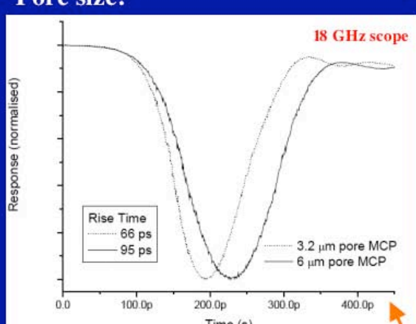
- Two Burle/Photonis MCP-PMTs with 10 μm MCP holes operating at 2.27 & 1.88 kV.
- Ortec 9327Amp/CFD (two) with a walk threshold of +5mV & TAC566 & 14 bit ADC114

- **Can we aim for a 5mm thick radiator (Npe ~25 pe$^-$) ?**

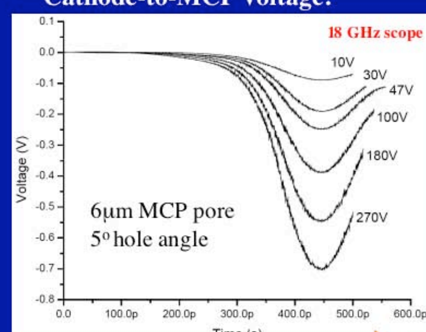
Rise time = f(pore size, E$_{MCP-to-anode}$, E$_{Cathode-to-MCP}$)

(Photek Ltd. information)

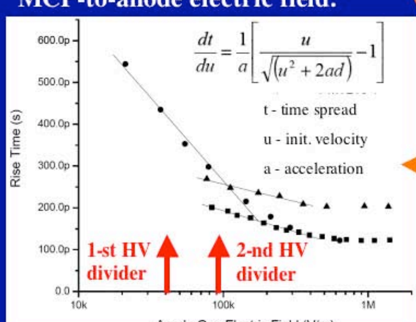
Pore size:



Cathode-to-MCP voltage:



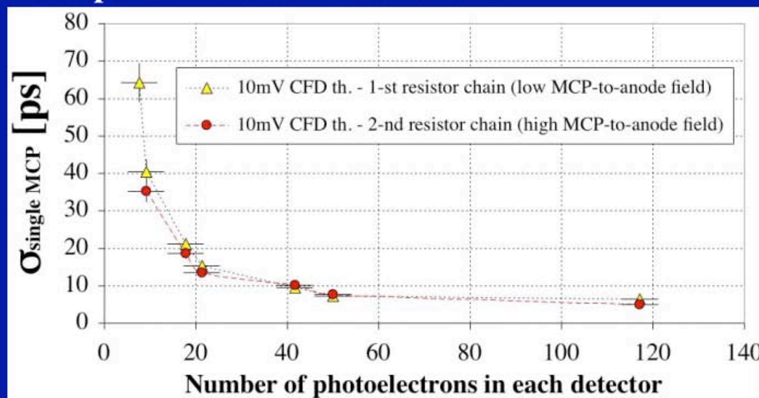
MCP-to-anode electric field:



- **Rise time is determined by:**
  - **- Transit time variation in MCP pores**
    Smaller MCP pore size, faster rise time
  - **- Exit velocity variation from MCP towards anode**
    Larger MCP-to-Anode electric field, faster rise time
  - **- Exit velocity variation from cathode towards MCP**
    Small effect for red wavelengths & Bialkali
    [635 nm <=> ~2 eV => dt/du|$_{max}$ ~ ((2-ϕ)/200)*1000ps],
    ϕ ~1.5-2 eV. Could be a problem for λ < 300 nm !!

A single MCP resolution = f(Npe)$_{\text{MCP-to-anode field}}$

Comparison of two resistor chains:



- Two Burle/Photonis MCP-PMTs with 10 μm MCP holes operating at 2.27 & 1.88 kV.
- Ortec 9327Amp/CFD (two) with a -10mV threshold and a walk threshold of +5mV & TAC566 & 14 bit ADC114

- **Some improvement when running a high MCP-to-anode field.**
- **Not worth the risks of a possible damage and reduction of the operating range for the magnetic field application.**

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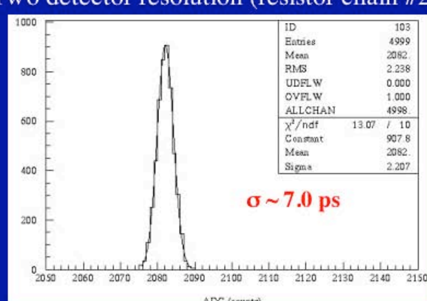
The best result with two TOF counters in tandem

Two detector resolution (resistor chain #2):



Each detector has Npe ~ 115-120 pe⁻:

$\sigma_{\text{single detector}} \sim (1/\sqrt{2})\ \sigma_{\text{double detector}} \sim 5.0$ ps

Running conditions:
1) Low MCP gain operation ($<10^5$)
2) Linear operation
3) CFD discriminator
4) No additional ADC correction

- Two Burle/Photonis MCP-PMTs with 10 μm MCP holes operating at 2.85 & 2.43 kV.
- Ortec 9327Amp/CFD (two) with a walk th. of +5mV & TAC566 & 14 bit ADC11

Contribution of the MCP-PMT itself to the above single detector resolution:

$$\sigma_{\text{MCP-PMT}} < \sqrt{1/2}\ \{ \sigma^2 - [\sigma^2_{\text{Pulser+TAC\_ADC+Amp/CFD}} - \sigma^2_{\text{Pulser}}]\} < 4.5 \text{ ps}$$

7.0 ps 3.42 ps < 2 ps (manufacturer)

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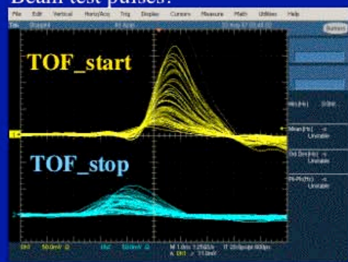
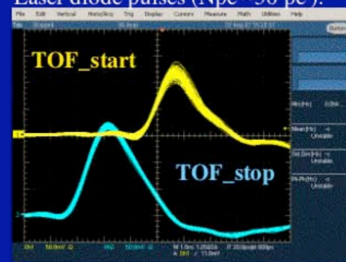
Beam test - problem with the radiators

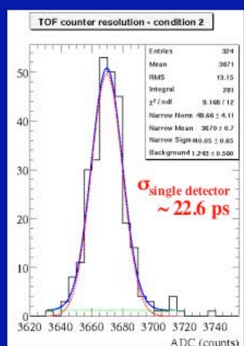
To make these pictures possible, send monitor signals over a long delay cable => rise time is degraded:

Beam test pulses:



Laser diode pulses (Npe ~50 pe⁻):





- **A poor reflectivity of radiator's Al coating created a non-uniform number of photoelectrons. The 2-nd radiator's yield is worse than the 1-st one.**
- **One could still correct it if we would have a fast ADC !!**

  (Ortec 9327 Amp/CFD provides a fast bipolar monitor of the amplifier. However, an ordinary ADC, such as LeCroy, would integrate it to a fixed constant. We did not have a better ADC available, which could be used to correct for the pulse height variation. If we would have it, we would get a better result.)

- $\sigma_{single\ detector} \sim (1/\sqrt{2})\ \sigma_{double\ detector} \sim 22.6$ ps

Conclusions

- **<u>Our present best laser diode results:</u>**
  - $\sigma_{single\ MCP} \sim 7.2$ ps for Npe ~ 50, expected from a 1cm thick radiator.
  - $\sigma_{single\ MCP} \sim 5.0$ ps for Npe ~ 120.
  - $\sigma_{TTS} \sim 27$ ps for Npe ~ 1.
  - Electronics contribution (Amp, CFD, TAC, ADC): $\sigma_{Total\_electronics} \sim 3.4$ ps.
  - Upper limit on the MCP-PMT resolution: $\sigma_{MCP\text{-}PMT} \sim 4.5$ ps (Npe ~120).
- **<u>Our present best test beam results:</u>**
  - $\sigma_{single\ MCP} \sim 22.5$ ps (believed to be due to a poor radiator Al-coating).