TOF counter tests in CRT

J. Va'vra, SLAC

Content

- **Summary of results from runs in CRT with:**
  - LYSO + MCP-PMT
  - Quartz + G-APD (4x4 array)
  - LYSO + G-APD (4x4 array) ✓
  - Scintillator + G-APD (4x4 array) ✓
  - Scintillator + mesh-PMT ✓

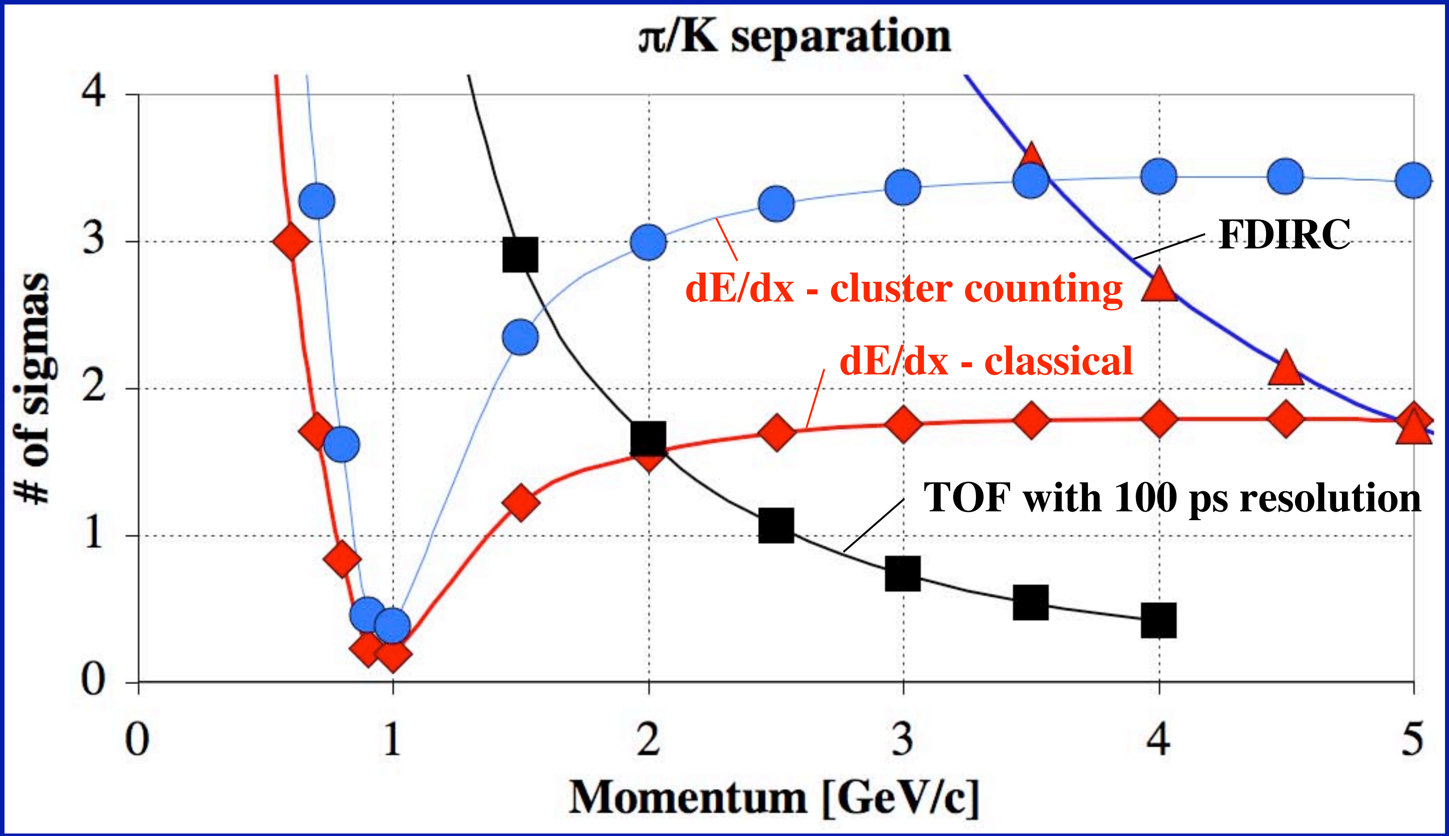
  } Candidates for SuperB ?

- **Mechanical design & initial tests of the DIRC-like TOF counter**

  (Leonid will talk about the initial data analysis, and Dominique & Jihane about the electronics)

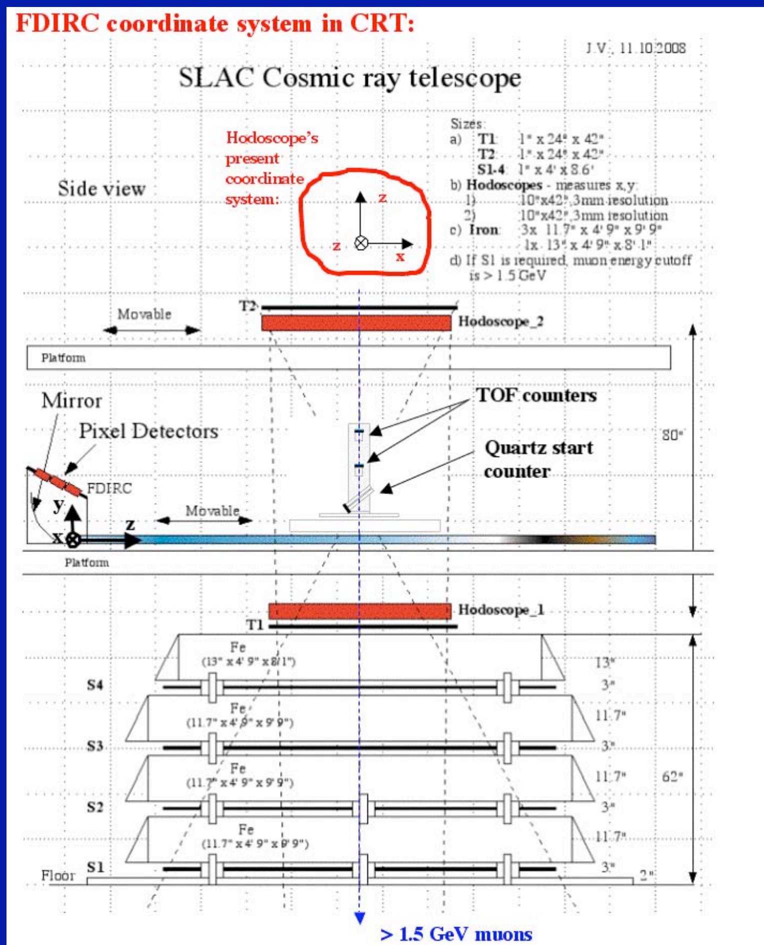
Low cost, pixilated TOF counter with σ ~100 ps

J. Va'vra, RICH 2010, Cassis, France:



- Main goal: help PID near 1GeV/c

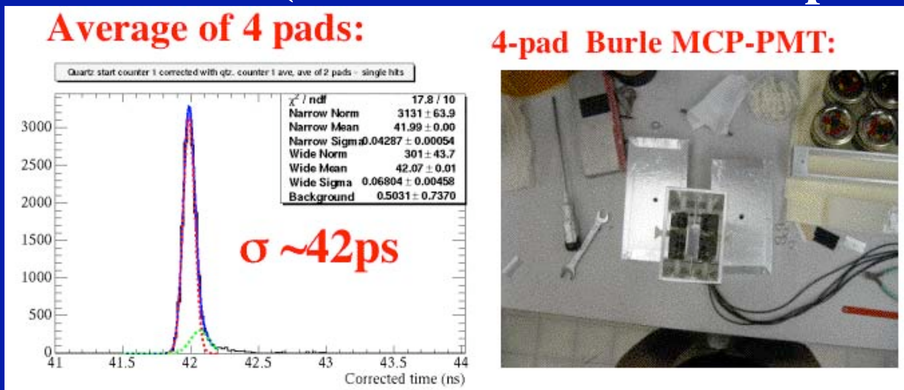
CRT test setup at SLAC



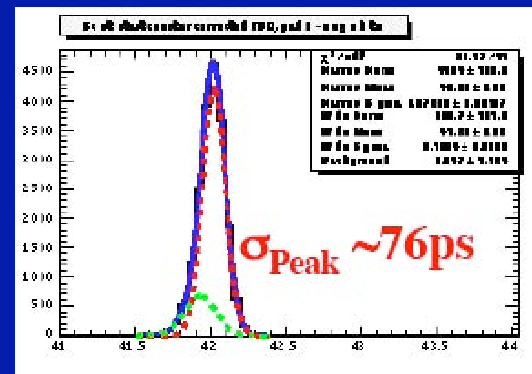
- A muon passing through the entire stack has E >1.5 GeV

Start counter: ESA test beam vs. CRT

Beam test (Start: Accelerator RF pulse):



Pad 3 alone in test beam:



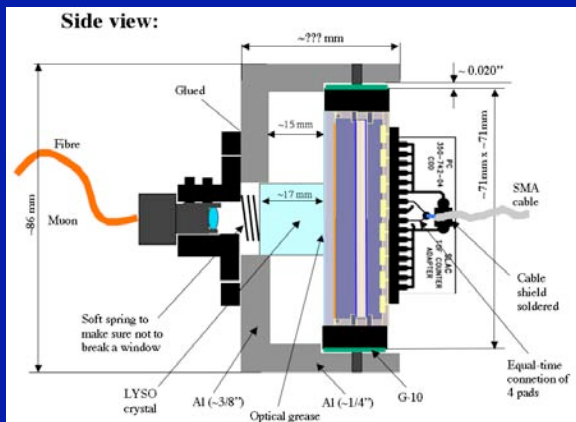
CRT start time:

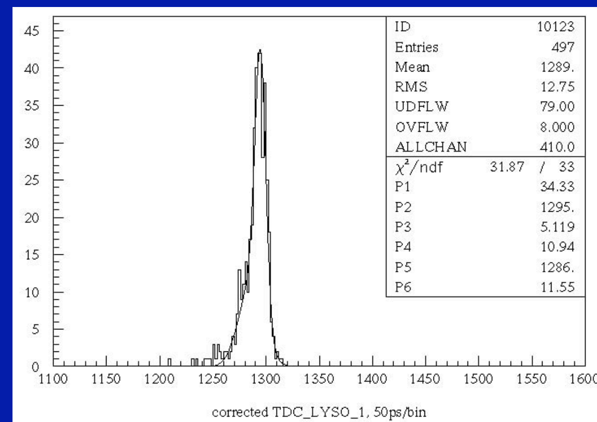
- MCP-PMT has 4 pads
- Pad 3 is used as a start of the entire system. It is processed through a CFD to correct the pulse height in hardware.

- This is de facto a DIRC-like TOF counter (we have routinelly obtained σ ~ 40-45ps in the test beam)

Summary of results

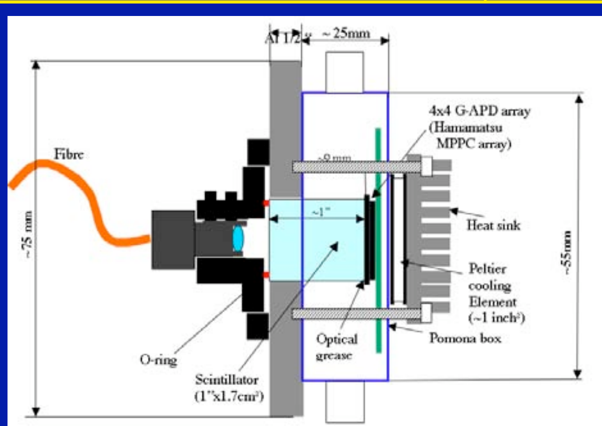
LYSO + MCP-PMT:

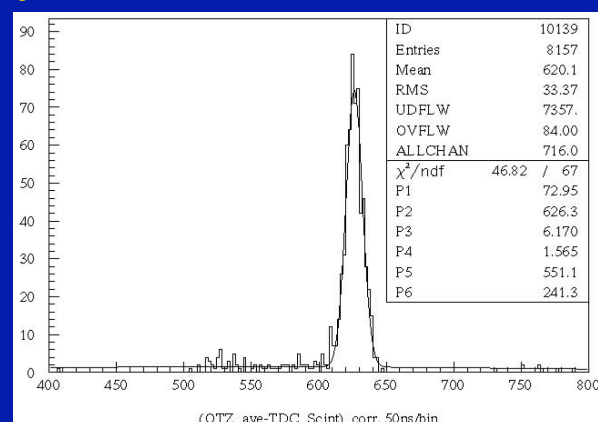




$\sigma \sim \sqrt{\sigma^2_{LYSO} - \sigma^2_{Start}}$
$< \sqrt{(128^2 - 76^2)}$
< 103 ps

Scintillator + G-APD (4x4 array):



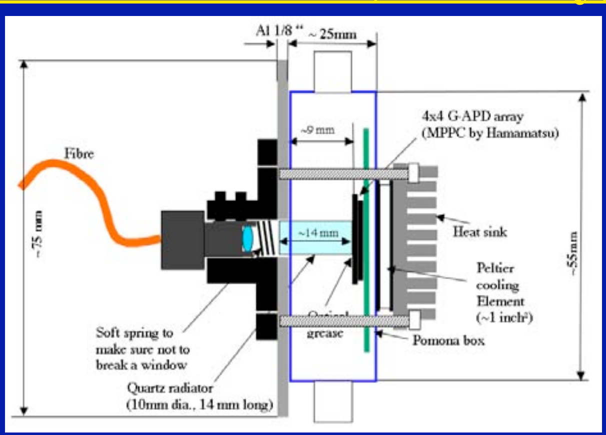


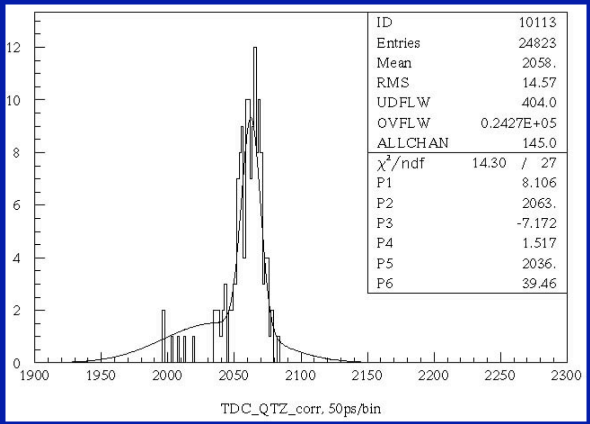
$\sigma \sim \sqrt{\sigma^2_{LYSO} - \sigma^2_{Start}}$
$< \sqrt{(154^2 - 76^2)}$
< 134 ps

Corrections & cuts: k_z & ADC corrections, Size & ADC & E > 1.5GeV cuts

Summary of results

Quartz + G-APD (4x4 array):



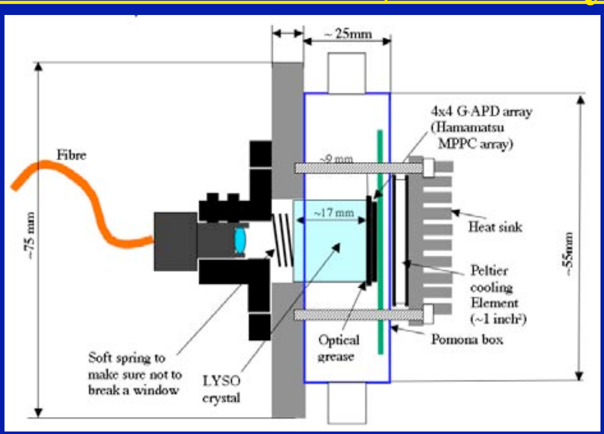


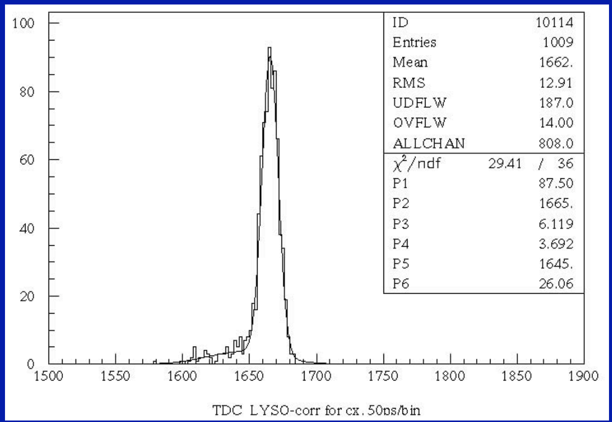
$\sigma \sim \sqrt{\sigma^2_{LYSO} - \sigma^2_{Start}}$

$< \sqrt{(179^2 - 76^2)}$

< 162 ps

LYSO + G-APD (4x4 array):





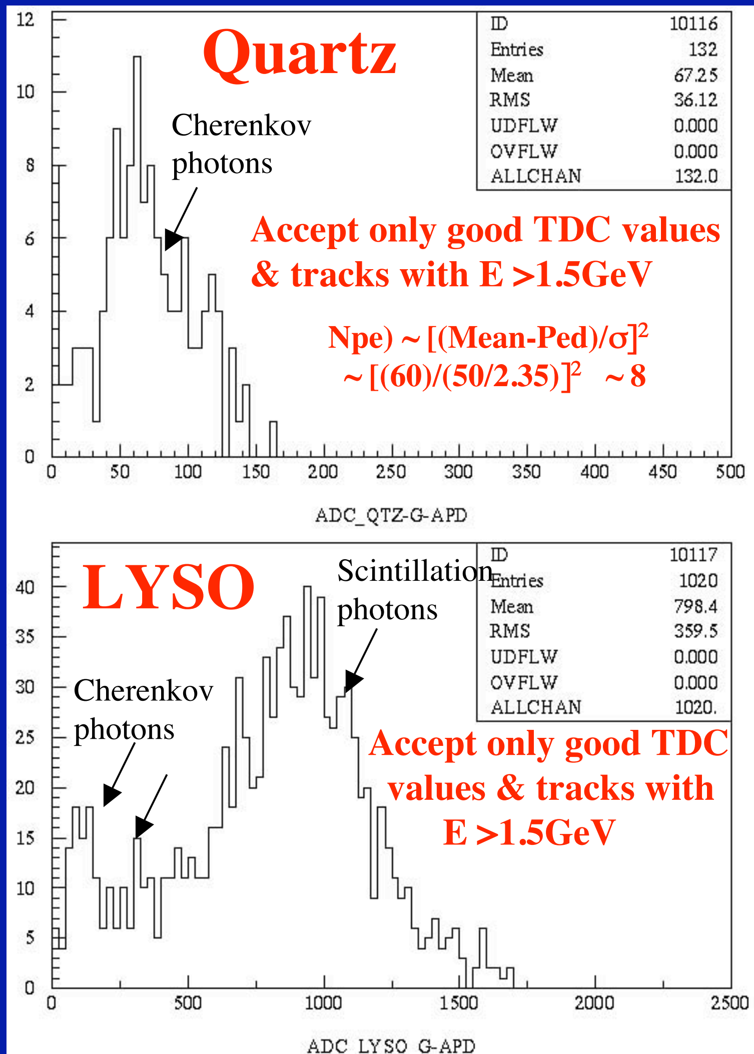
$\sigma \sim \sqrt{\sigma^2_{LYSO} - \sigma^2_{Start}}$

$< \sqrt{(152^2 - 76^2)}$

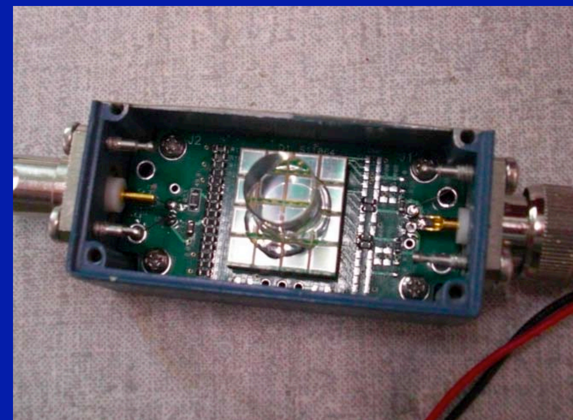
< 132 ps

Corrections & cuts: k_z & ADC corrections, Size & ADC & E > 1.5GeV cuts

Pulse height: LYSO vs. Quartz + G-APD



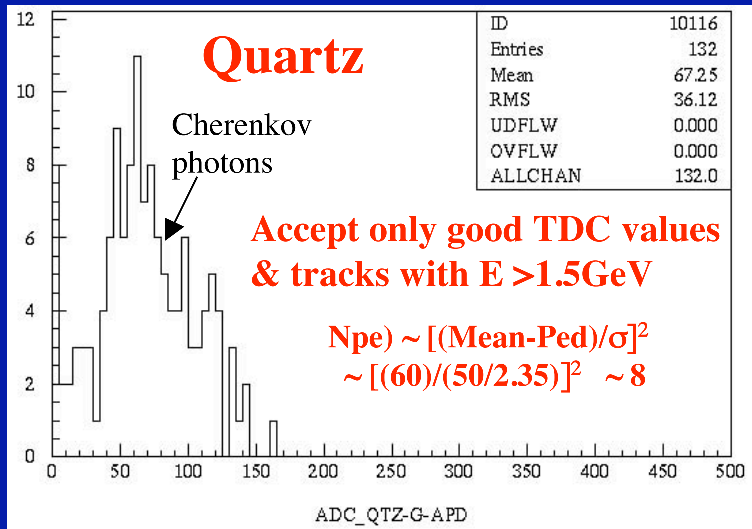
10mm-long quartz radiator:



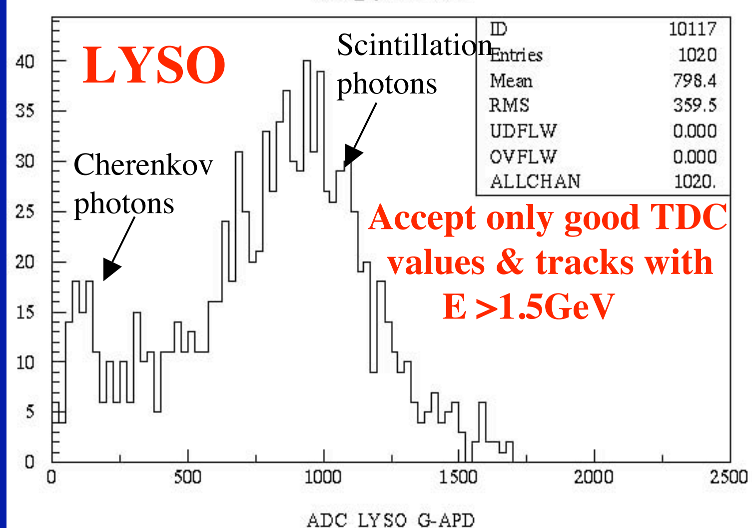
17mm^3 LYSO crystal:

ADC: LYSO vs. Quartz vs. Scintillator + G-APD

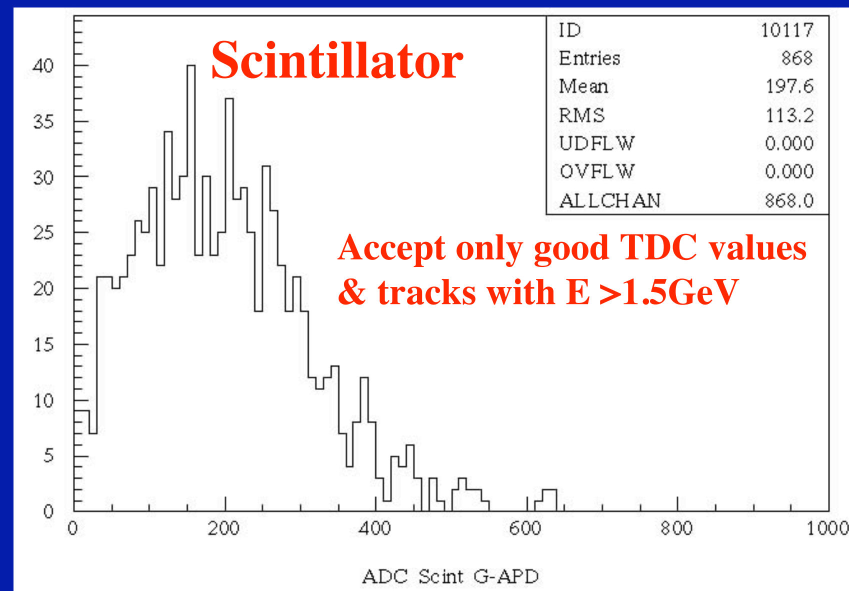
10mm thick quartz crystal



17mm thick LYSO crystal



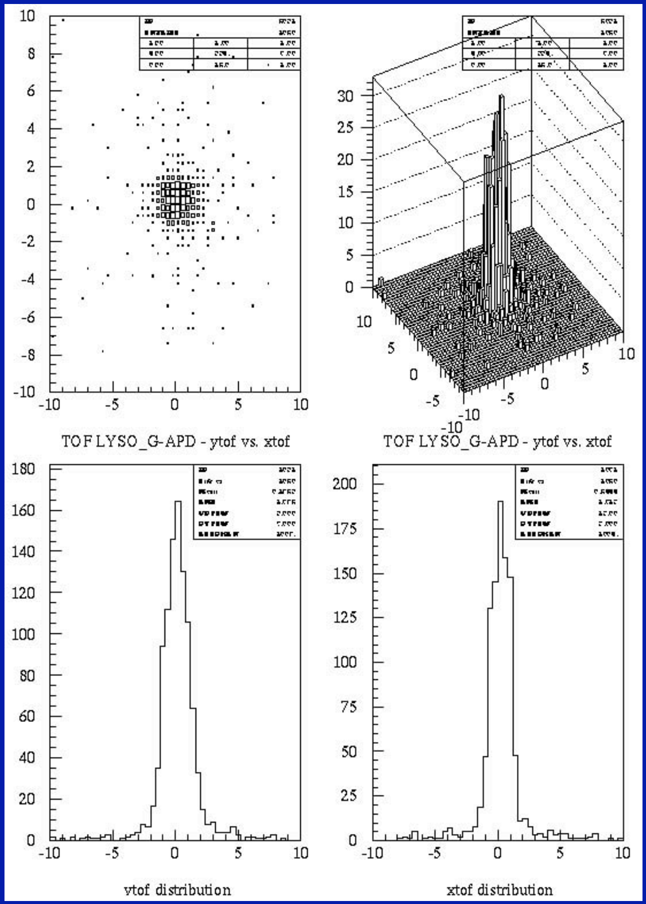
25mm-long scintillator:



Clearly, this scintillator is producing less light than the LYSO crystal.

CRT tracking resolution: do we see a size of the LYSO crystal ?

x-y distributions:

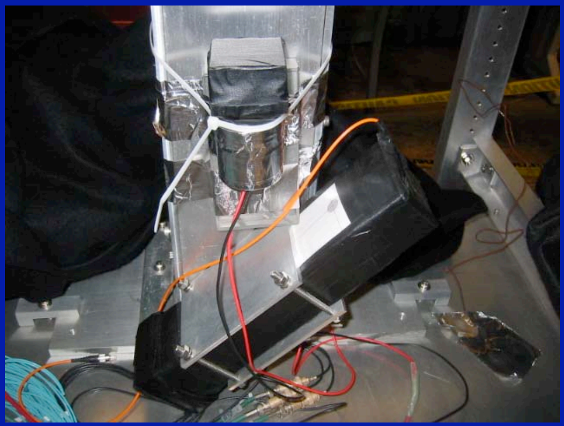


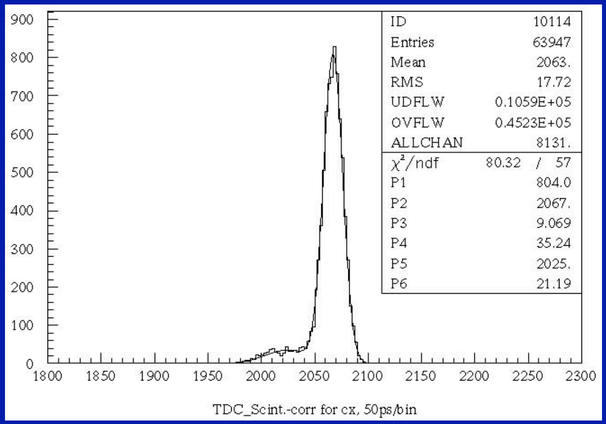
- Crystal size: 17 mm^3
- Plot x-y distribution of tracks at a height of the LYSO crystal for good TDC hits

- Measure: size in x-direction ~2 ± 0.4 cm; Size in y-direction ~2.4 ± 0.8 cm
- y-direction has a slightly worse resolution

Summary of results

1”-thick scintillator + mesh-PMT:





$\sigma \sim \sqrt{\sigma^2_{LYSO} - \sigma^2_{Start}}$
$< \sqrt{(227^2 - 76^2)}$
< 214 ps

- The same “bad” scintillator.
- There is another run to analyze with slightly different condition

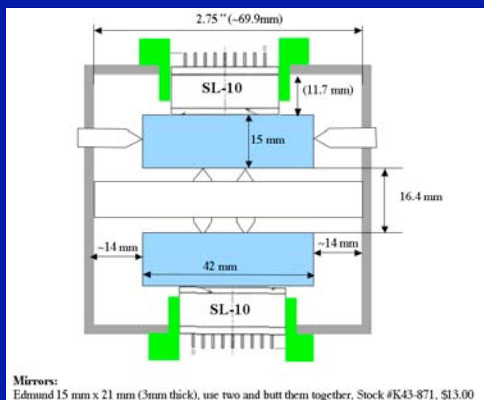
Conclusion up to this point:

If a G-APD array cost would come down in 2-3 years, the solution of "Good scintillator + G-APD" may not be that bad, but right now it would be too expensive

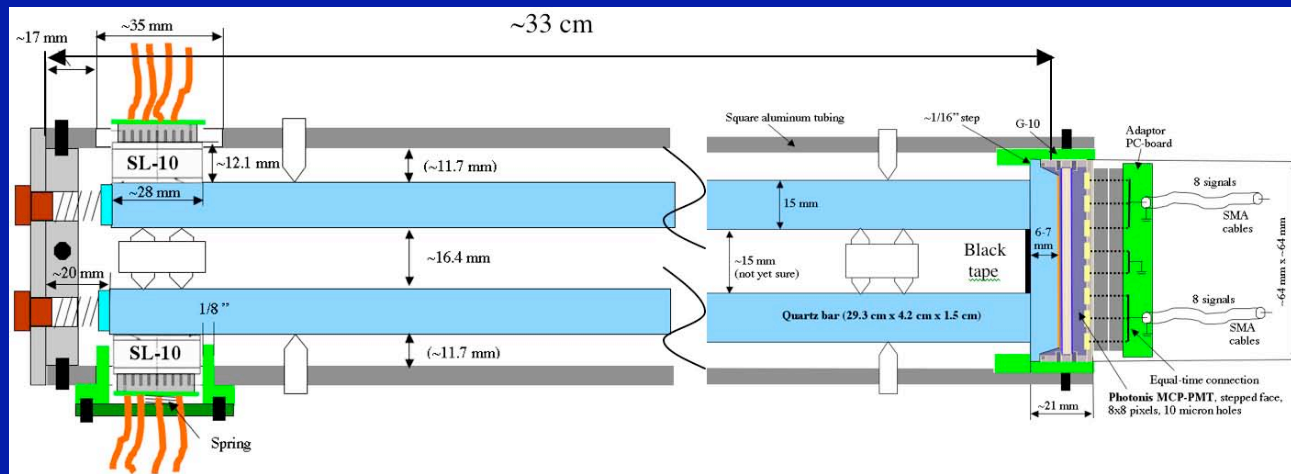
DIRC-like TOF counter design

J. Va'vra: detector design, Matt MCulloch: making parts

Front view:



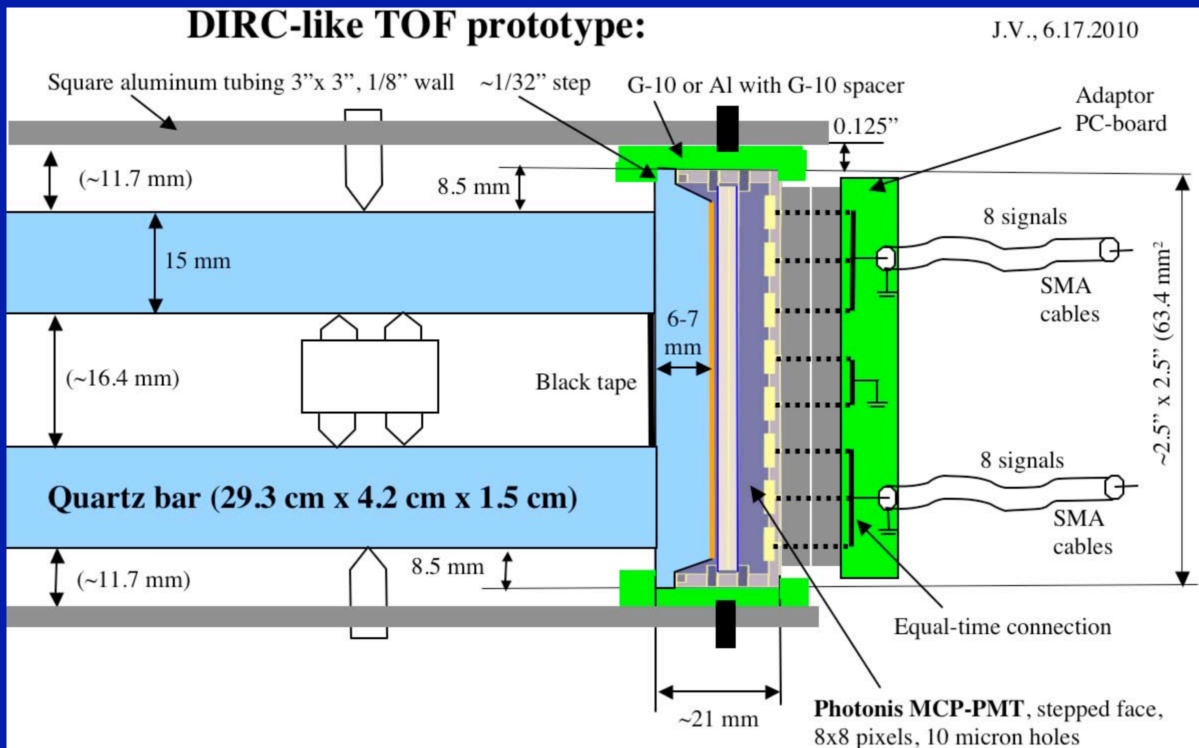
Side wiew:



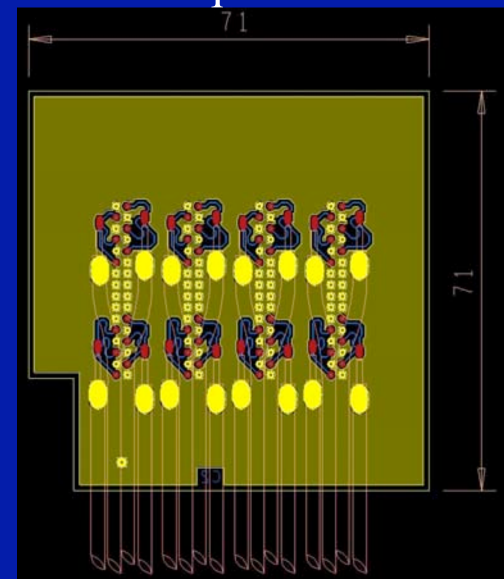
- **Only one end with the Photonis stepped-face MCP-PMT is instrumented at the moment. The end with HPK SL-10 would come later.**
- **This tube has the cathode-to-MCP distance of only 0.85mm, which means that the TTS distribution does not have a long tail.**
- **Mirrors are held by small dots of epoxy, and greased to the quartz surface. Can be removed, if desired.**

Pad connections relative to bar coupling

J. Va'vra: design & testing, Matt McCulloch: making parts, D. Breton: provided the PC board



Dominique's board:

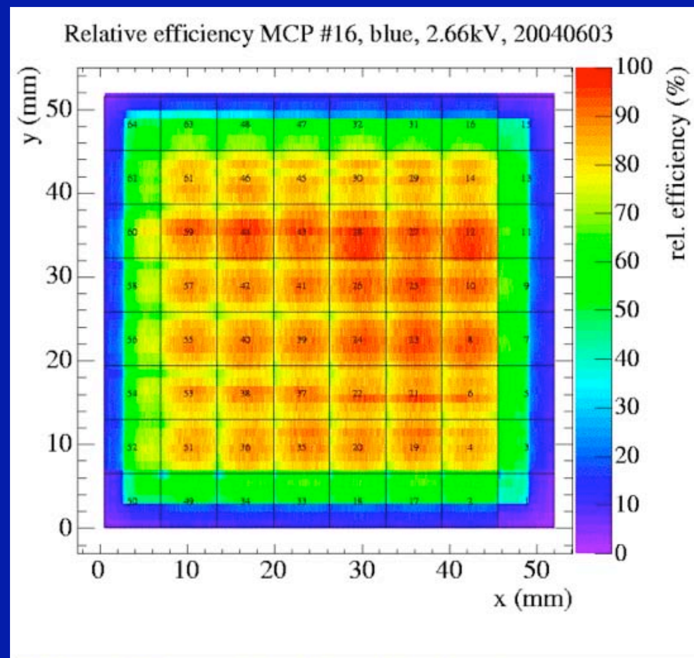


- **3 vertical pads shorted together.**
- **Therefore there are 8 pads coupled to the top bar and 8 to the bottom bar.**
- **There is an attempt to block the light leakage from one bar to another by adding a black tape on the MCP window.**

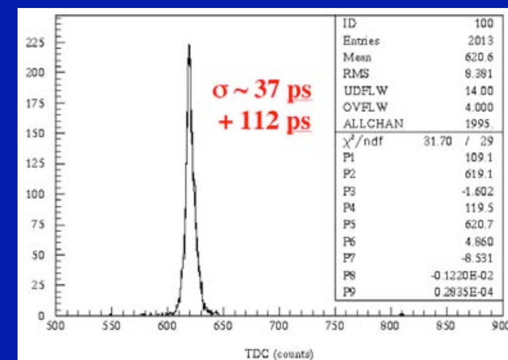
Details of MCP-PMT

Information from Photonis/Burle

Scan of a similar stepped face tube:

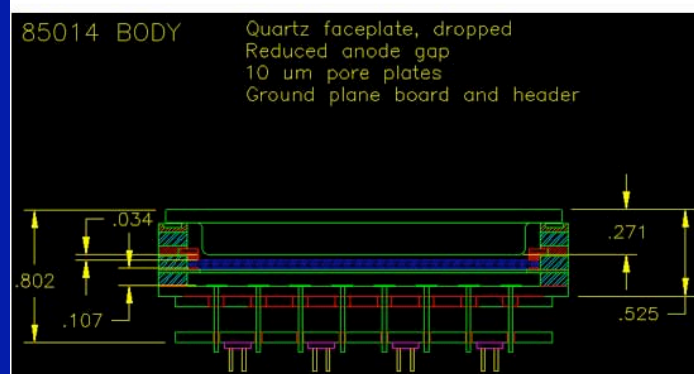


No tail in the TTS distribution:



(Measurement by J.V. on a similar stepped face tube)

MCP-PMT's geometry:

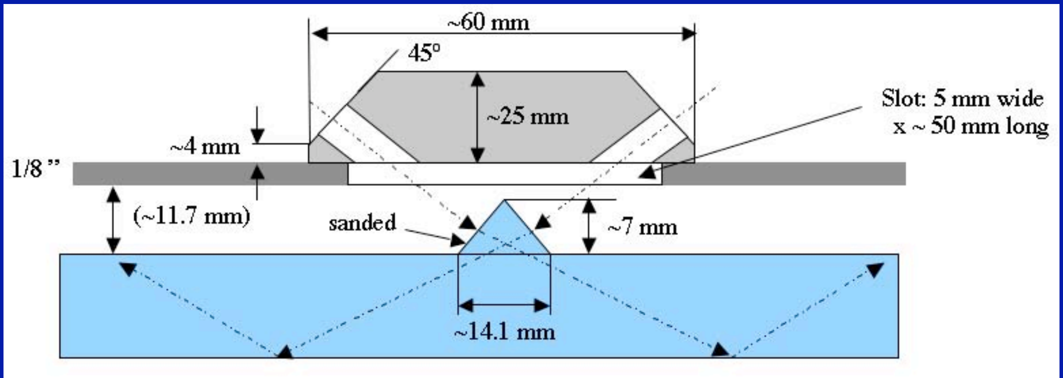


- **A portion of outer pads is lost due to the window's stepped face design.**

DIRC-like TOF laser calibration & Faraday cage

J. Va'vra: design & testing, Matt McCulloch: making parts, D. Breton: provided the PC board

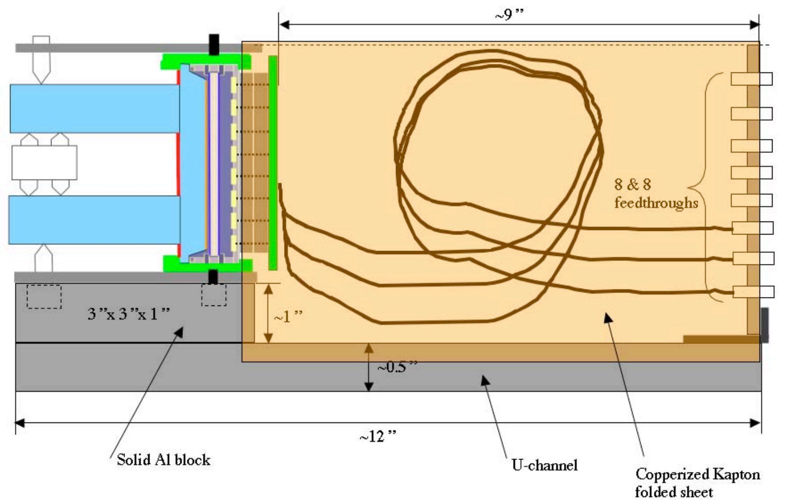
Laser entry:



Prism (both short sides sanded, bottom side is left polished and glued to the bar, center of the bar):
Edmund 45°, 10 mm x 10 mm, Stock #K32-330, BK7 glass, $30.

Fiber ends with a lens, which produces a parallel laser (?) beam, which hits sanded surface of the prism. This is supposed to scatter the light into more pads.

To reduce the noise, I had to create a Faraday cage to enclose the PC board:

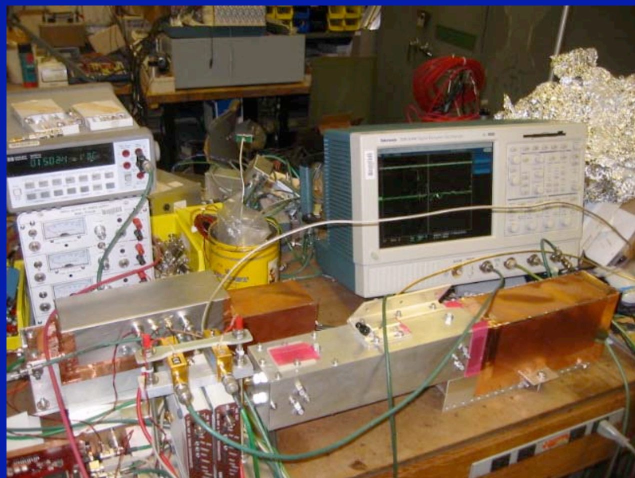


PC boards sums up three pads

- **Laser arrangement was intended to setup the single photoelectron operation.**
- **It was NOT intended to align the individual pads !**

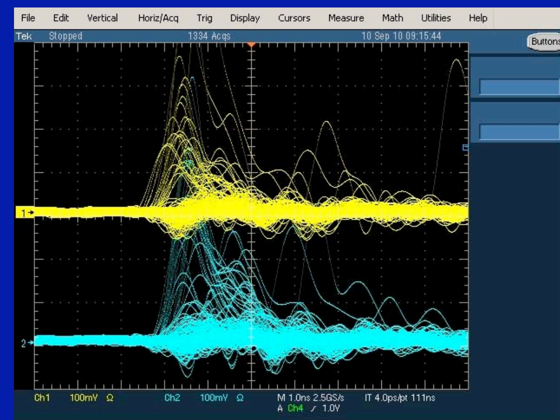
Lab tests prior mounting the counter in CRT

J. Va'vra, initial measurements to determine the operating point



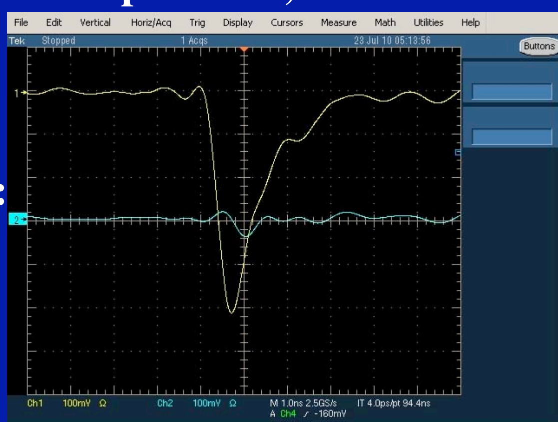
Single pe$^-$ pulses:
MITEG amp., 1GHz BW

1)



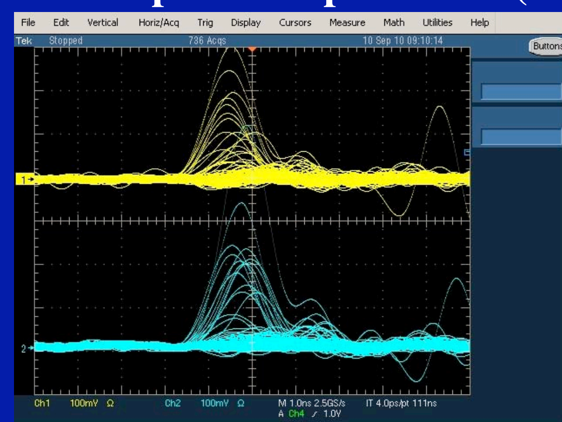
Single pe$^-$ pulses:
HPK amp. C5594, 1.5GHz BW:

Cross-talk:
5-8%



Single pe$^-$ pulses:
MITEG amp. + Low pass filter (530MHz BW)

2)

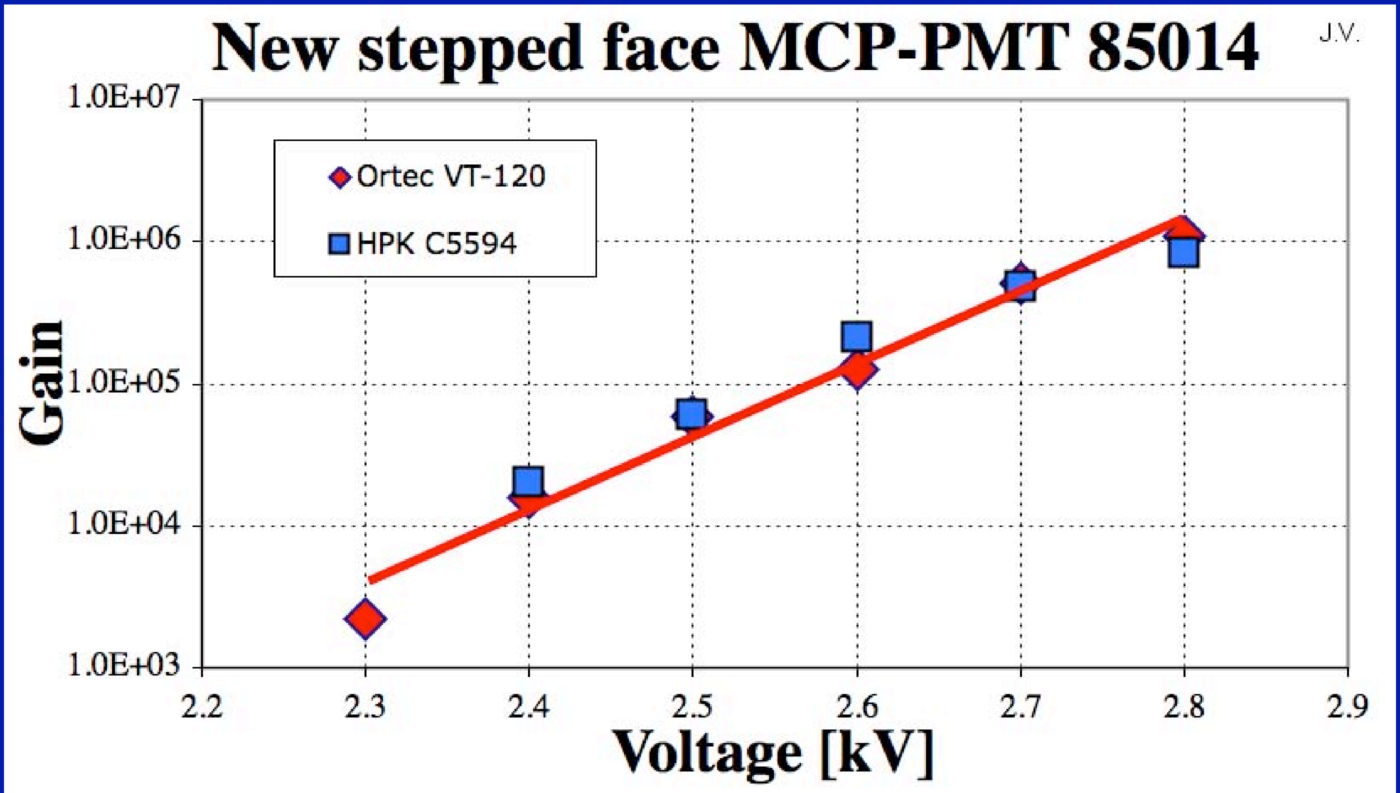


Cross-talk has improved with adding a low-pass filter

- **Reduce the cross-talk using low pass filters.**

Gain calibration

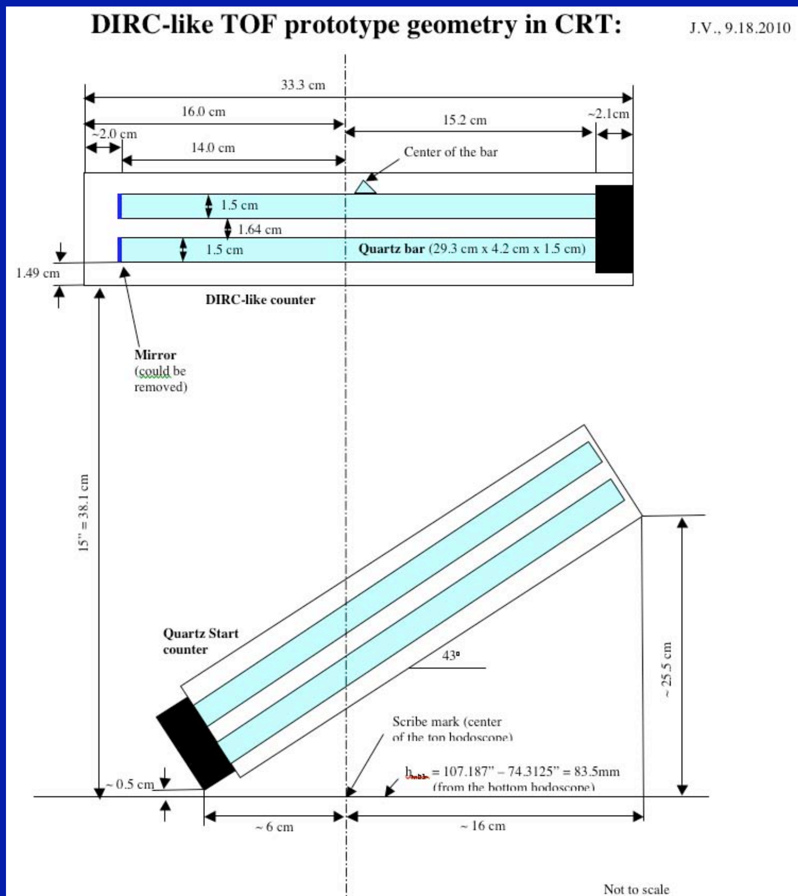
J. Va'vra



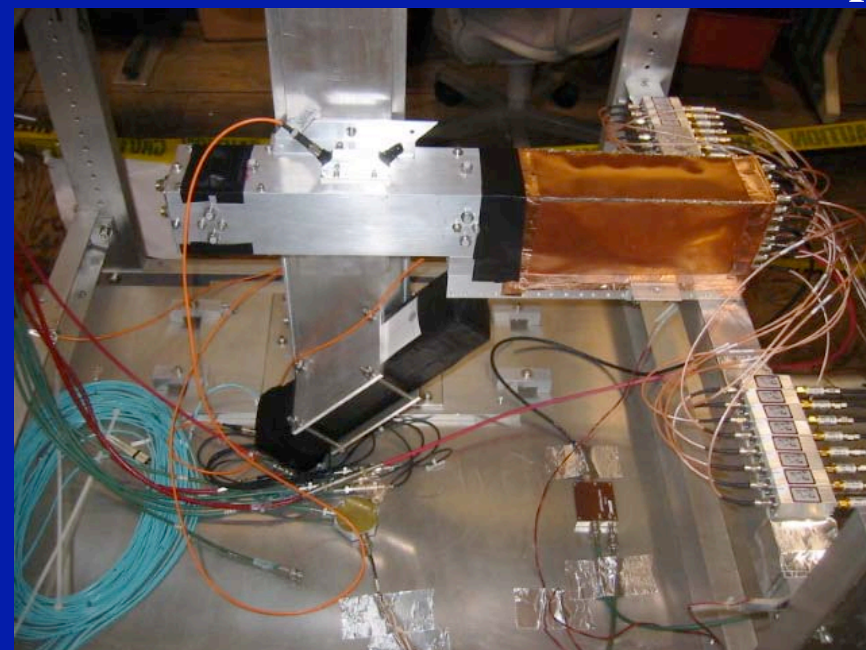
- **Run the tube at -2.7kV @ a gain of ~7x10^5**

Geometry of the mechanical support in CRT

J. Va'vra, Matt McCulloch



DIRC-like TOF counter in CRT setup:



- **A muon track sees 5 bars => large multiple scattering ! Therefore we need to work with >1.5 GeV muons.**