Progress on development of a new TOF concept using MCP-PMT detectors at SLAC

J. Va'vra, SLAC

Light travels 300μm in one ps

People who helped

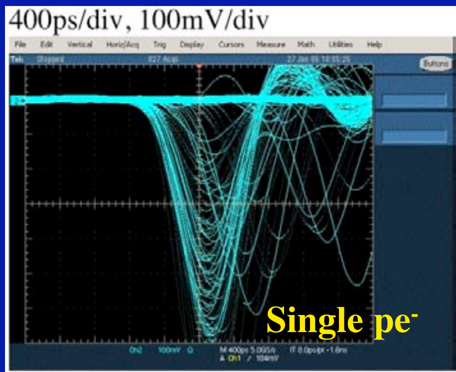
- SLAC test beam:
  J. Schwiening - DAQ system
  B. Ratcliff and D. Leith - discussions

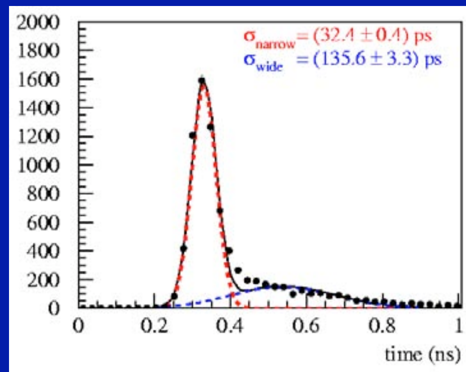
- Fermilab test beam:
  E. May, C. Ertley (ANL),
  E. Ramberg, A. Ronzhin (Fermilab),
  T. Natoli and H. Frisch (U. of Chicago)

σ_{TTS} using a single Burle/Photonis MCP-PMT

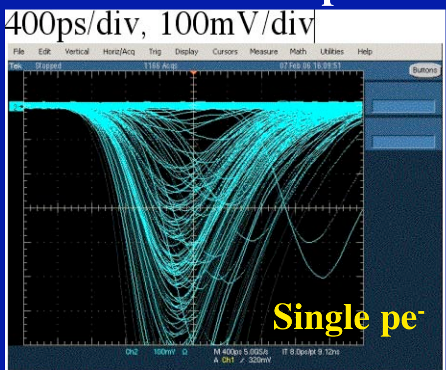
J.Va'vra et al., Nucl.Instr.&Meth. A 572 (2007) 459–462

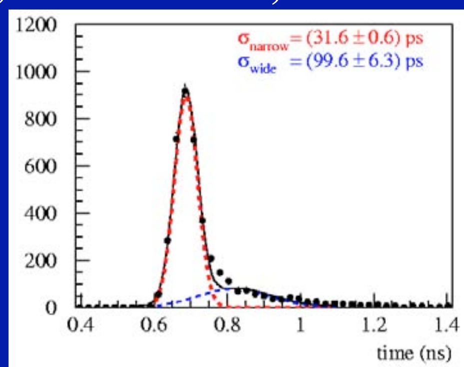
HPK C5594-44 amp., ~1.6 GHz BW, 63x:



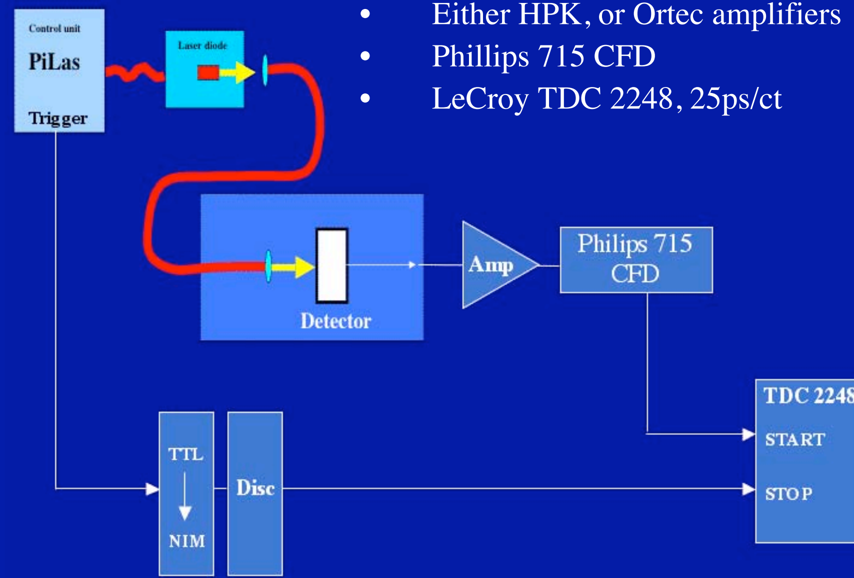


Ortec VT-120 amp.+6dB, ~0.3 GHz BW, 100x:





- 10 μm MCP hole diameter
- 2.8kV on MCP-PMT
- Either HPK, or Ortec amplifiers
- Phillips 715 CFD
- LeCroy TDC 2248, 25ps/ct



Single pe's:

$$\sigma_{TTS} \sim \sqrt{(32^2 - 13^2 - 11^2)} = 27\ \text{ps}$$

PiLas laser diode contribution

Electronics contribution (mostly TDC)

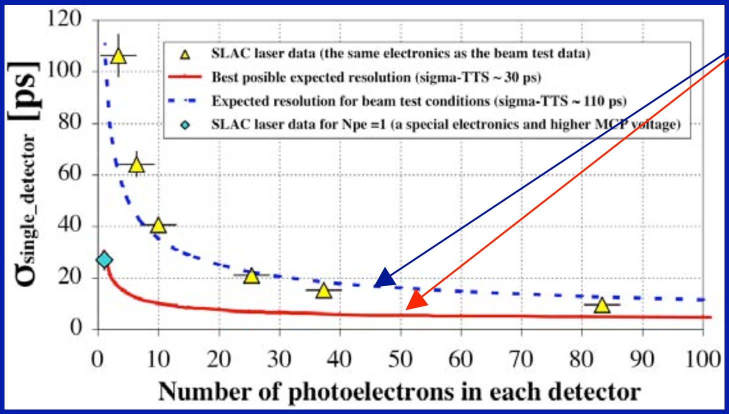
- **My best measurements of σ_{TTS} are obtained with rather slow electronic; to obtain the best result, I "tuned" a cable length between amp. & CFD (find that 20-30ns length yields the best σ_{TTS}).**
- **Point of this slide: one does not have to be fast to get a good σ_{TTS} !**

σ_{TTS} using a pair of Burle/Photonis MCP-PMTs

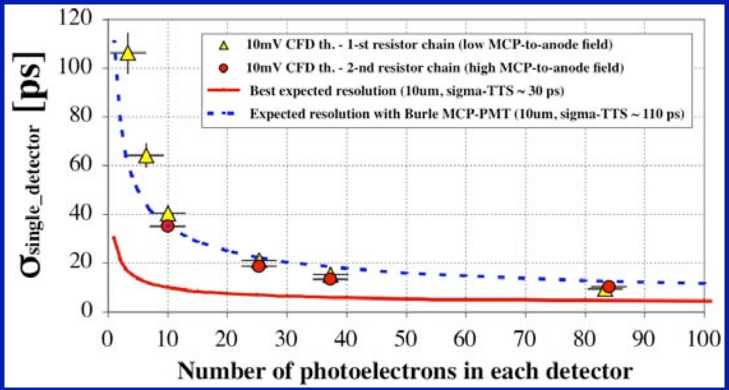
J.Va'vra et al., Nucl.Instr.&Meth., Trieste

$$\sigma \sim \sqrt{[\sigma^2_{MCP\text{-}PMT} + \sigma^2_{Laser} + \sigma^2_{Electronics} + \ldots]} =$$
$$= \sqrt{[\sigma_{TTS}/\sqrt{N_{pe}})^2} + \sqrt{((FWHM/2.35)/\sqrt{N_{pe}})^2 + (4.2\ ps)^2}\ ]$$

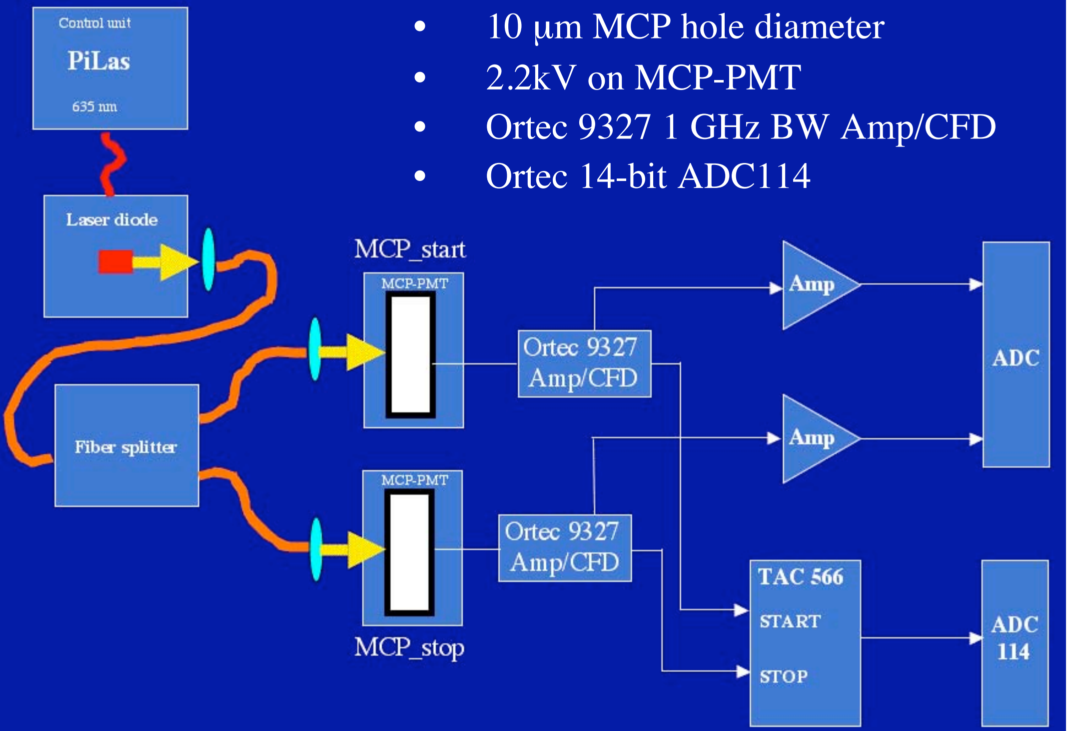
Nominal MCP voltages, low gain:



Increase $E_{cathode\text{-}to\text{-}MCP}$ field:



- 10 µm MCP hole diameter
- 2.2kV on MCP-PMT
- Ortec 9327 1 GHz BW Amp/CFD
- Ortec 14-bit ADC114



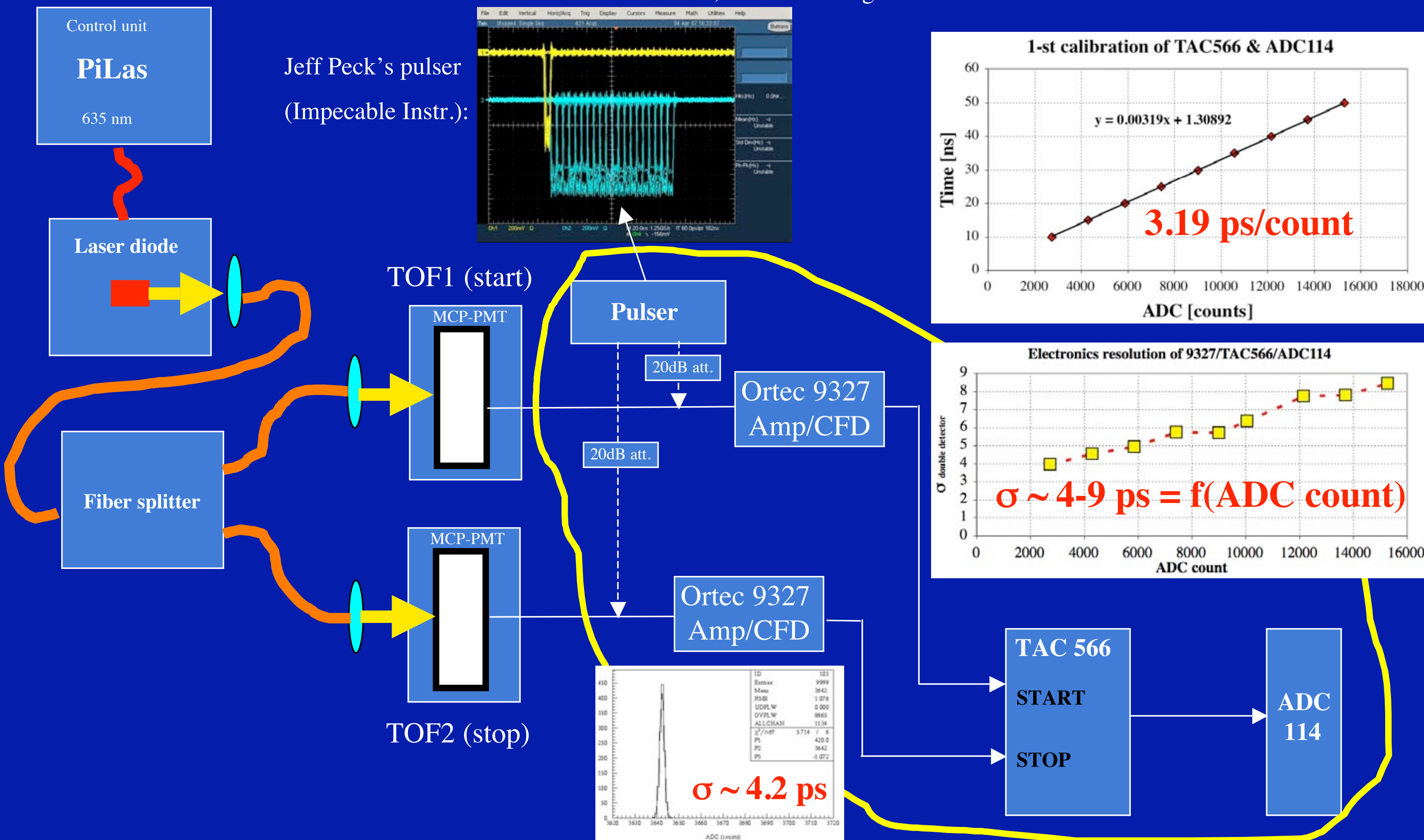
- <u>Point of this slide</u>: If one extrapolates resolution to Npe = 1, one obtains much worse σ_{TTS} with this type of electronics !!
- Increasing $E_{cathode\text{-}to\text{-}MCP}$ field does not help much.

Single pe's:

σ_{TTS} (extrapolate to Npe=1) ~ 110 ps

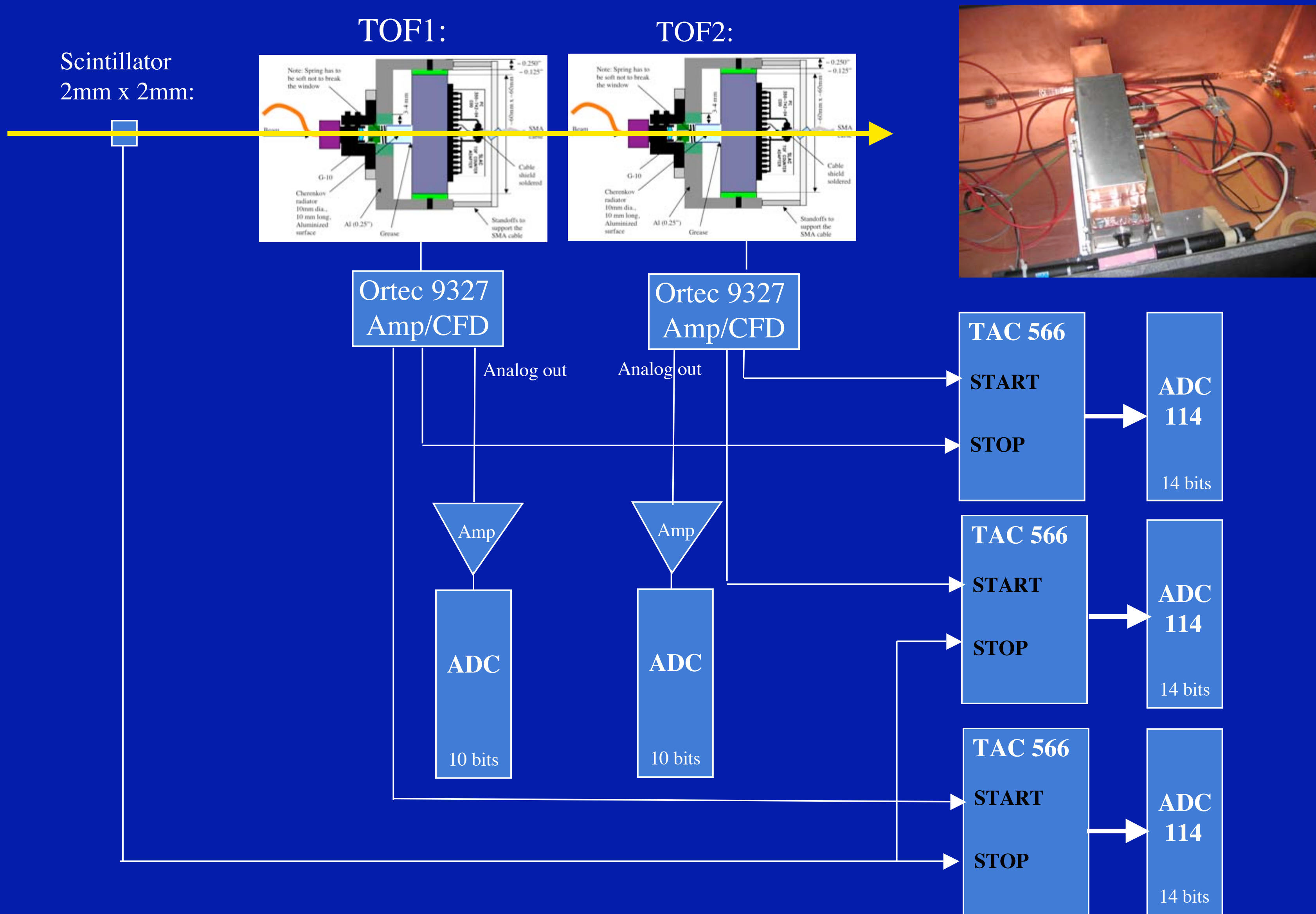
Time calibration of the electronics

J.Va'vra, MCP-PMT log book 4



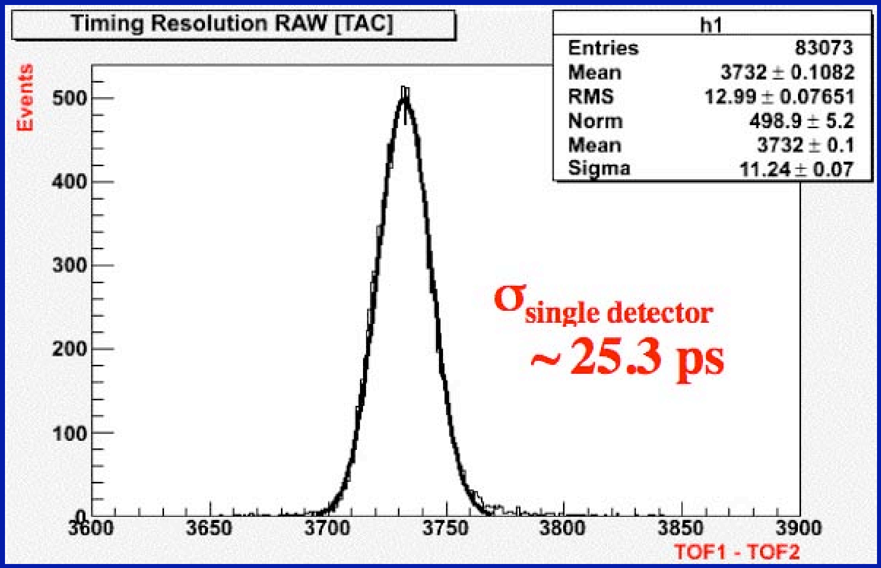
- The best electronics performance, to my knowledge, but for small ADC values only.

Fermilab electronics setup with two MCP-PMTs

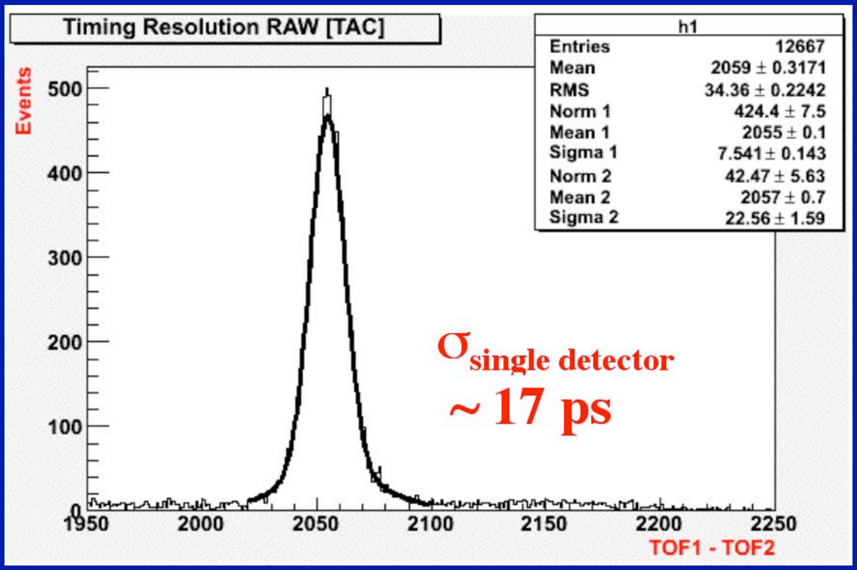


Beam tests at SLAC and Fermilab

SLAC beam test, 10 GeV e^+:



Fermilab beam test, 120 GeV p:

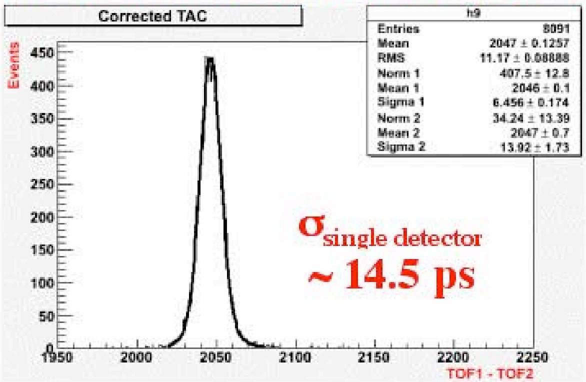


- **No ADC cut or correction to CFD timing at this point**
- **Fermilab test: replace quartz radiator (a new aluminum coating on cylinder sides made by Photonis).**

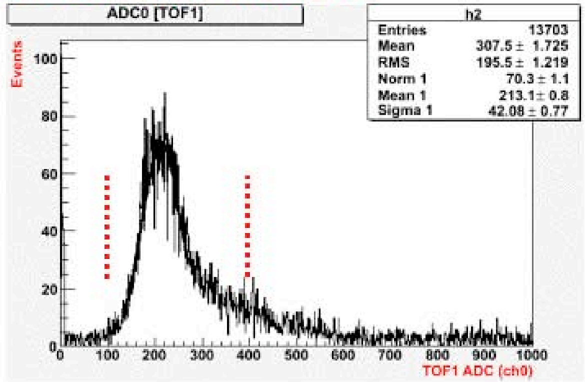
Beam test at Fermilab

120 GeV p:

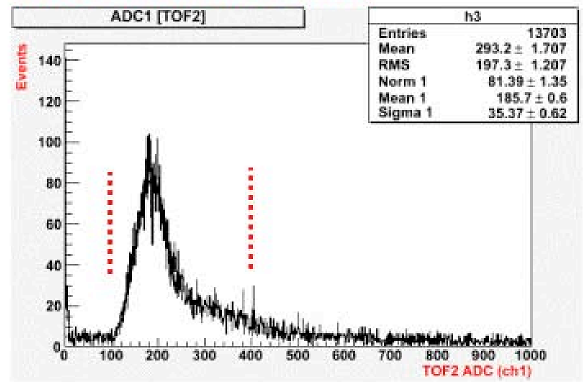
Loose ADC cuts and PH correction:



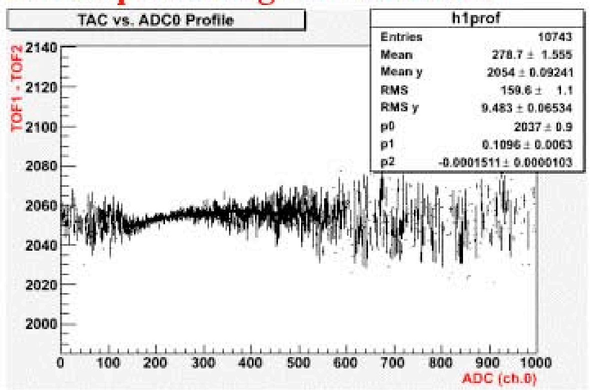
ADC0 with loose cuts:



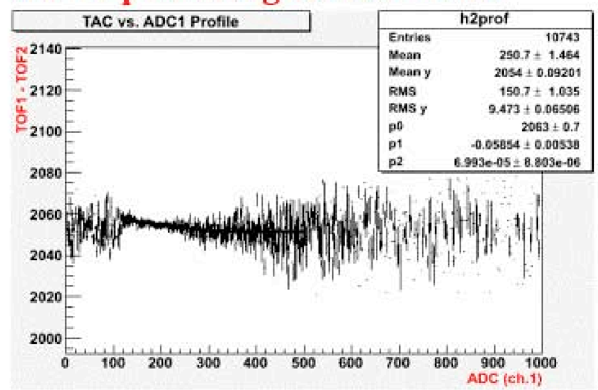
ADC1 with loose cuts:



ADC0 pulse height correction:



ADC1 pulse height correction:

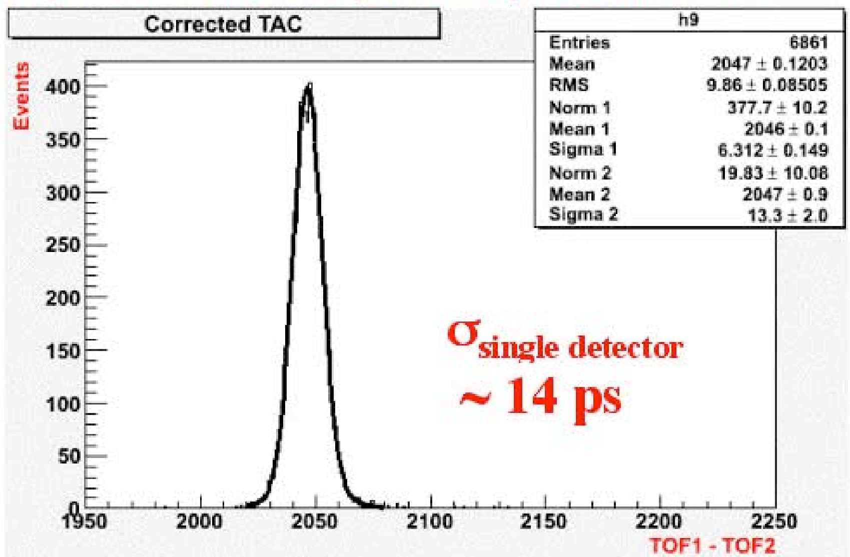


- **ADC correcion to CFD timing & <u>loose</u> ADC cuts**

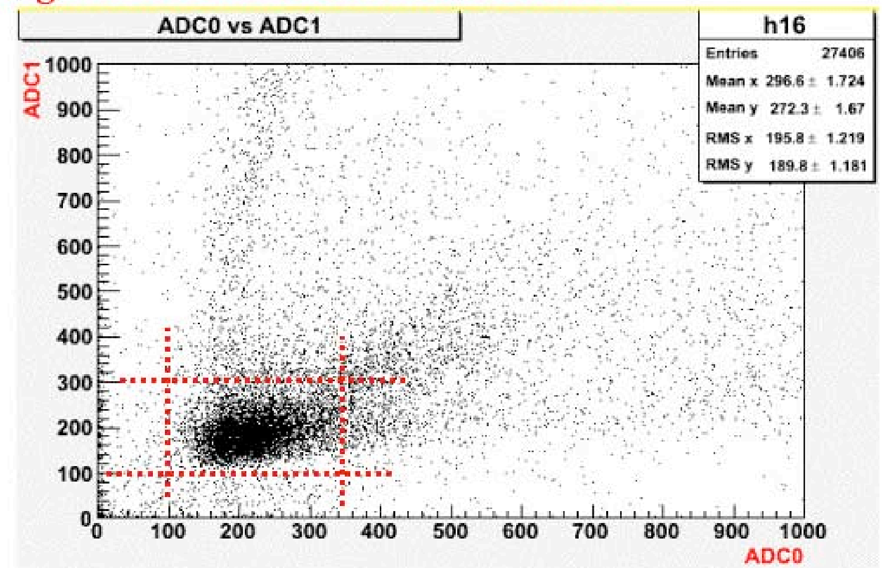
Beam test at Fermilab

120 GeV p:

Tight ADC cuts and pulse height correction:

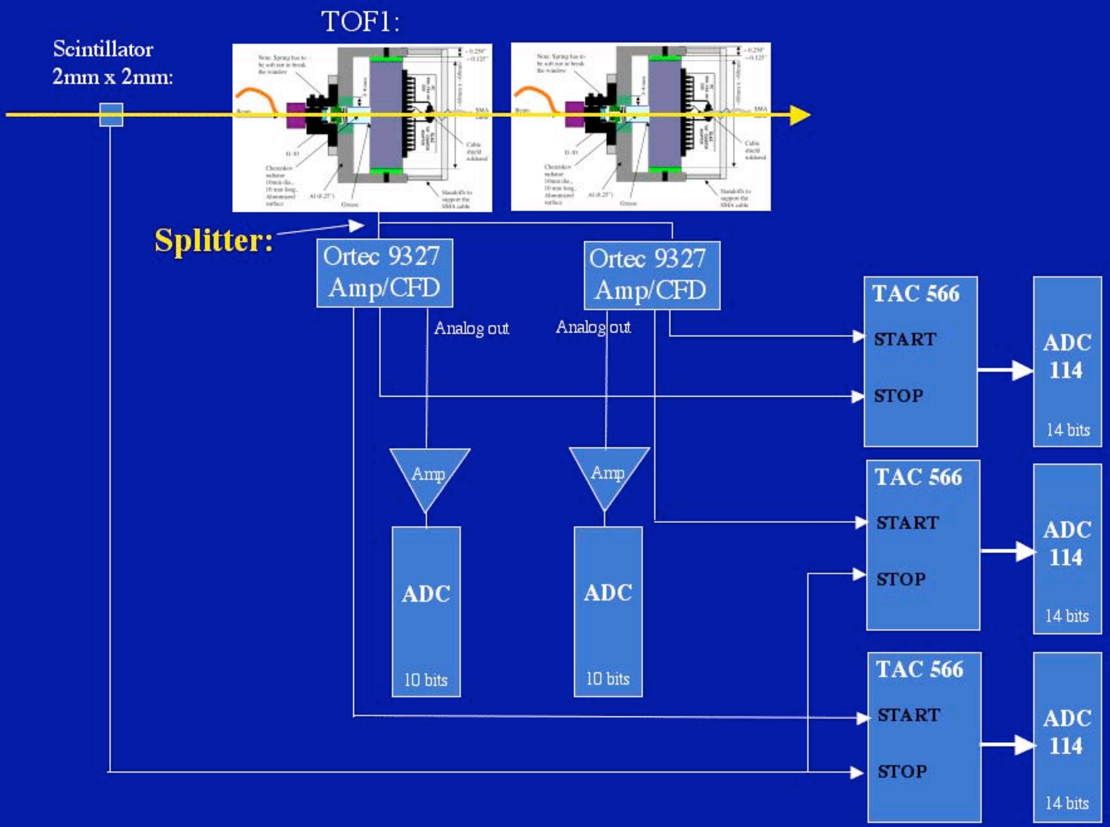


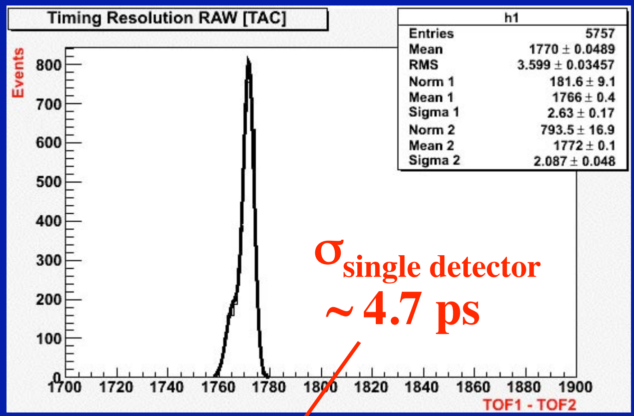
Tight ADC cuts to eliminate doubles:

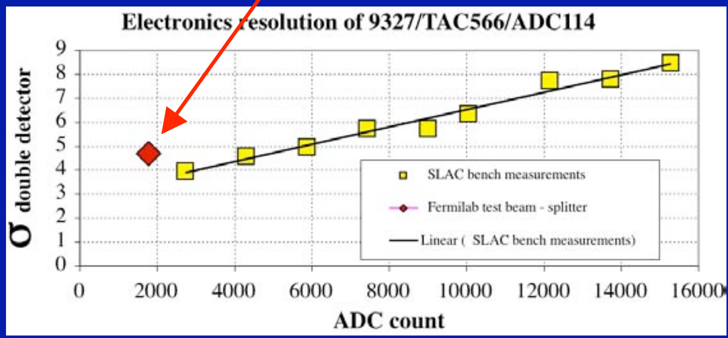


- **ADC correcion to CFD timing & <u>tighter</u> ADC cuts**

Fermilab: Check the electronics resolution





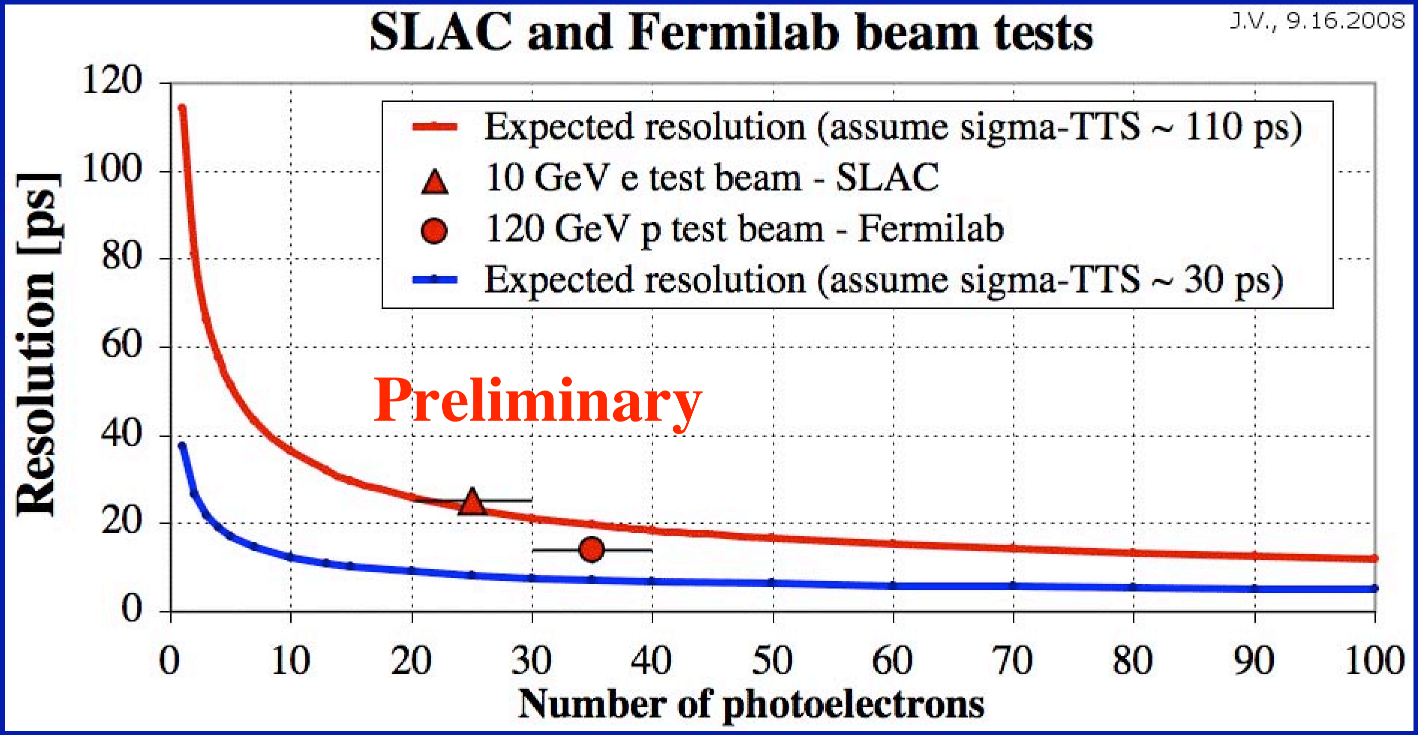


- **The Fermilab beam test electronics resolution is only slightly worse than my bench measurements at SLAC.**

Are the results consistent with expectations ?

$\sigma \sim \sqrt{[\sigma^2_{MCP\text{-}PMT} + \sigma^2_{Radiator} + \sigma^2_{Pad\ broadenibng} + \sigma^2_{Electronics} + \ldots]} =$

$= \sqrt{[(\sigma_{TTS}/\sqrt{N_{pe}})^2 + (((12000\mu m/\cos\Theta_C)/(300\mu m/ps)/n_{group})/\sqrt{(12Npe)})^2 +}$
$\quad + ((6000\mu m/300\mu m/ps)/\sqrt{(12Npe)})^2 + (4.7\ ps)^2\ ]$



- **Laser-based test: $\sigma_{TTS} \sim 106$ ps for Npe ~ 1 & identical SLAC test beam electronics**
- **Calculation: Npe ~ 30**