Precision Timing Via Čerenkov Radiation, II

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http://puhep1.princeton.edu/mumu/timingtrans3.ps
Hamamatsu R3809U microchannel-plate photomultipliers (MCP-PMT) claimed to have transit-time jitter of only $\sigma_t = 11$ ps for single photoelectrons.

3 recent papers studying sonoluminescence claim to have verified that $\sigma_t = 13$-14 ps. [Not clear that studies were really made for single photoelectrons.]

If so, our simulation claims we could obtain timing of $\sigma_t = 10$ ps for 200-MeV/c muons incident at $45^\circ$ on $1 \times 1$ cm$^2$ quartz bars up to 30 cm long.

Simulation in good agreement with Kichimi et al., NIM A371, 91 (1996), who studied fine-mesh PMT’s coupled to $2 \times 4$ cm$^2$ quartz bars.

But, do the MCP-PMT’s really perform as claimed?
Test MCP-PMT Transit Time with a Femtosecond Laser

Ti:Sapphire Laser (Pulsed)

Spectraphysics “Tsunami”

Hamamatsu R3809 U

Microchannel-plate Photo Multiplier (MCP-PMT)

EG&G Ortec 9306

1 GHz Preamplifier

EG&G Ortec 9307

“Pico Timing” Discriminators

10 ns delay

EG&G Ortec 9306

1 GHz Preamplifier

EG&G Ortec 9307

“Pico Timing” Discriminators

Stop

Start

Spectrum ACE

Multi Channel Analyzer (MCA)

Canberra Model 2145

Time to Amplitude Converter (TAC)

Computer
Calibrate with a 4-GHz Photodiode

Spectrophysics “Tsunami”

Ti:Sapphire Laser (Pulsed)

beam expander

Semiconductor Photo Diode

EG&G Ortec 9306

1 GHz Preamplifier

“Pico Timing” Discriminators

EG&G Ortec 9307

EG&G Ortec 9307

10 ns delay

Start

Stop

Canberra Model 2145

Time to Amplitude Converter (TAC)

Multi Channel Analyzer (MCA)

Computer
\[ \sigma_t \leq 8.5 \text{ ps with Reference Photodiode} \]

Timing between adjacent laser pulses (14 ns apart).

\[ \sigma_t = \frac{28.5}{2.35\sqrt{2}} = 8.5 \text{ ps.} \]

[Timing on same laser pulse \( \Rightarrow \sigma_{t,\text{electronics}} \approx 4 \text{ ps.} \)]
Study Discriminator Time Walk

EG&G 9307 1-GHz discriminator.

EG&G Ortec 9307

“Pico Timing” Discriminator

Spectrum ACE
Multi Channel Analyzer (MCA)

Canberra Model 2145
Time to Amplitude Converter (TAC)

Lecroy 9212
Pulser

Computer

Attenuator

Stop
Start

1.5 m

trig
out

1.5 m

30 cm

1.0 m
Measured Time Walk for Various “Slewing Compensation”
To insure we are studying only single photons, attenuate the laser beam until the MCP-PMT counts only 1 in 1000 laser pulses.
MCP-PMT Pulse-Height Spectra

PMT Highvoltage = -3400 Volts

PMT Highvoltage = -3200 Volts
MCP-PMT Single Photon Timing: $\sigma_t \leq 16$ ps

$\sigma_t = \sqrt{\left(\frac{42}{2.35}\right)^2 - (8.5)^2} = 16$ ps, after removing 8.5 ps due to jitter of the reference diode.
Conclusion

MCP-PMT single photon timing certainly very good.

But haven’t fully confirmed Hamamatsu’s claim yet.

Timing would improve significantly if made a time vs. amplitude correction event by event (as was done by Kichimi et al.).

We plan to do this – but must spend real money for a new DAQ system.

Then: Beam test with 30-cm quartz bar;

Investigate Galileo MCP-PMT timing “kit”.