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PERFORMANCE COMPARISON OF HIGH SPEED MICROCHANNEL PLATE PHOTOMULTIPLIER TUBES

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The transit time spread characteristics of high speed microchannel photomultipliers has improved since the upgrade of the NASA CDSLR network to MCP-PMT's in the mid 1980's. The improvement comes from the incorporation of 6μm (pore size) microchannels and offers significant improvement to the satellite ranging precision. To examine the impact on ranging precision, two microchannel plate photomultiplier tubes (MCP-PMT) were evaluated for output pulse characteristics and temporal jitter. These were a Hamamatsu R 2566 U-7 MCP-PMT (6μm) and an ITT 4129f MCP-PMT (12μm).

An Opto-Electronics diode laser and a Hewlett Packard 50 GHz digital sampling scope were used to sample a large number of pulses from each tube. The jitter of the sampling scope trigger was independently measured by splitting the diode laser pretrigger signal; one portion of the signal was used to trigger the scope, while the remaining signal was measured by the sampling scope. The scope trigger jitter was found to be about 2.6 ps. The laser pulses were ≃ 40 ps in duration with a wavelength of 764 nm; the pretrigger-to-fire jitter of the diode laser is ≃ 5 ps. During the experiment the pre-fire output of the diode laser control unit was used to trigger the sampling scope while the output responses of each MCP-PMT was captured by the sampling scope.

The optical input from the laser diode was adjusted to produce ~ 7 - 10 photoelectrons on the average. To measure the detector response, several thousand MCP-PMT output pulses were digitized to construct a pulse-distribution for each detector. Measurements were taken around the single (1 - 3 pe) photoelectron level as well as the multi-photoelectron (≃ 5 - 10 pe) level for each PMT. An average waveform was used to determine pulse rise-time and duration, while the standard deviation of the pulse distributions at the half-maximum point were used to determine the RMS of the temporal distribution within each sample set. Statistical information is printed below each graph. Each MCP-PMT was tested separately but under identical conditions. For the above experimental conditions, the ITT MCP-PMT produced about 36 ps jitter while the Hamamatsu MCP-PMT produced 9.1 ps jitter.

The sampling scope jitter and diode laser jitter has no significant effect on the 12μm PMT measurement while deconvolution improves the jitter of the 6μm tube to ~ 7 ps. The single photoelectron jitter can be estimated from these measurements to be ~ 110 ps and ~ 25 ps respectively for each tube.

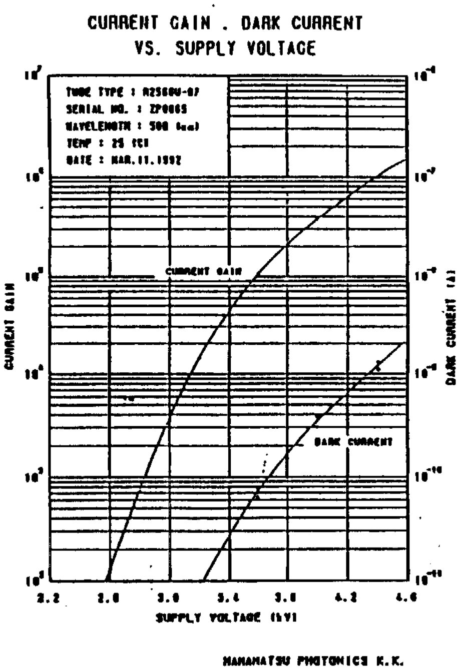
The results of these tests suggest that the MCP-PMTs with 6 micron pore size has the potential to offer improved (x 2) satellite laser ranging data quality, especially at low photoelectron levels. Further testing of a gated Hamamatsu MCP tube in MOBLAS-7 in a parallel configuration using the NASA Portable Standard is planned for later this year. These tests will focus on relative performance at various signal levels as well as the response of the constant fraction discriminator to the higher bandwidth detector output.

DEVICE CHARACTERISTICS

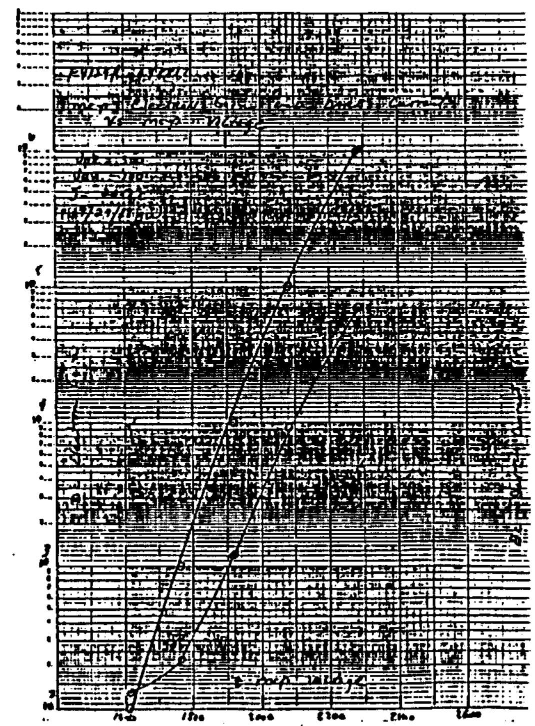
FEATURE	HAMAMATSU R 2566 U-7	ITT MCP-PMT 4129f
Microchannel Plate	2-Stage (V-Type)	3-Stage (Z-Type)
Microchannel Dia	6um	12um
Max. Operating Voltage	-4600V	-3700V
Max. MCP Gain	$3x10^6$	$1x10^6$
Rise Time	≈108ps	~350ps
Fall Time	≈100ps	≳500ps
Full Width	≈160ps	≳550ps
Single Photoelectron Jitter	≈25ps	≤100ps

GAIN CHARACTERISTICS

HAMAMATSU R 2566 U-7

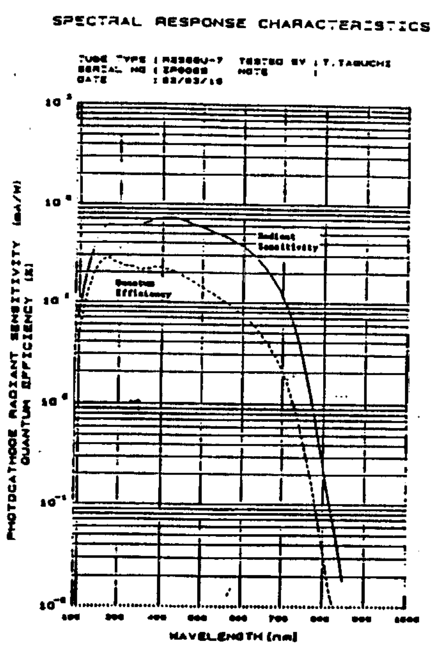


ITT MCP-PMT 4129f

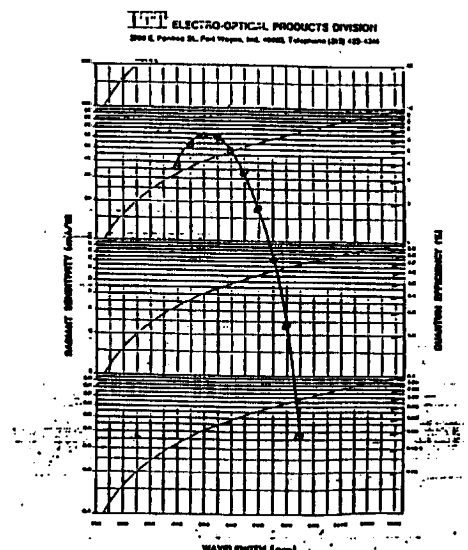


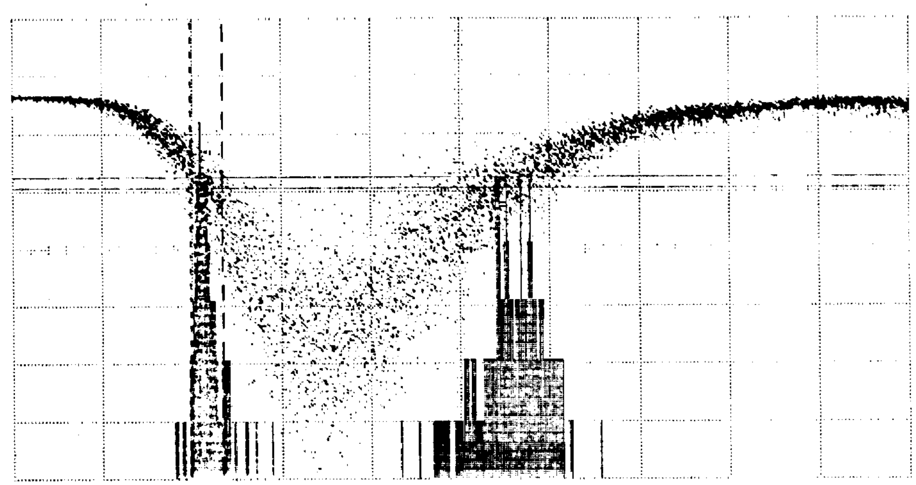
SPECTRAL RESPONSE

HAMAMATSU R 2566 U-7



ITT MCP-PMT 4129f

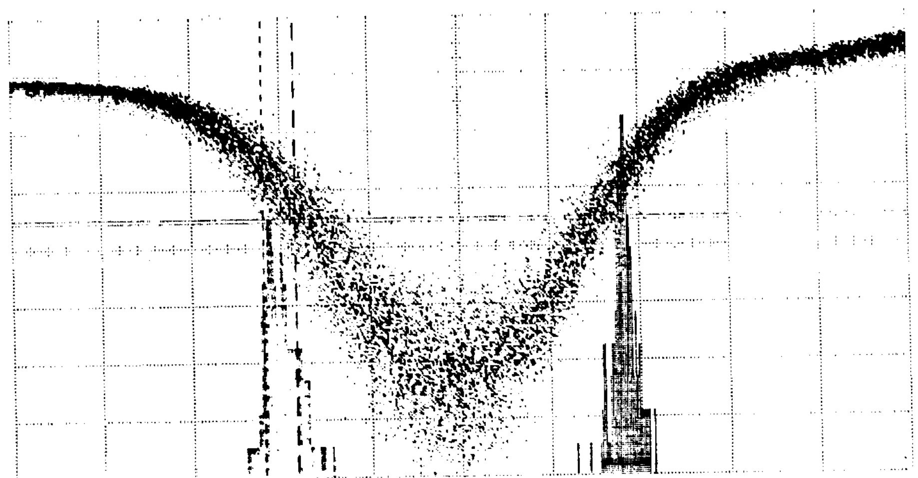




Ch. 1 = 80.00 mVolts/div		Offset	= -204.7 mVolts
Timebase = 200 ps/div		Delay	= 16.1440 ns
Delta Windo= 15.000 mVolts			
Window 1 = -105.00 mVolts		Window 2	= -120.00 mVolts
Delta % = 77.10 %			
Upper = 86.74 %		Lower	= 9.638 %
Delta T = 71.9 ps			
Start = 16.6126 ns		Stop	= 16.5407 ns
# Samples = 255			
Mean = 16.5767 ns		Sigma	= 35.9 ps

Trigger on External at Pos. Edge at 409.5 mVolts

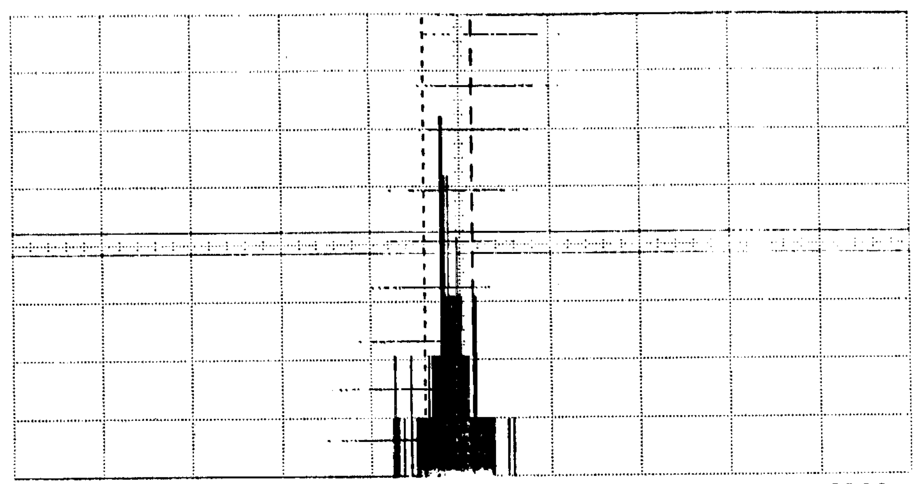
MULTIPHOTOELECTON (8–10) RESPONSE OF SAMPLIING SCOPE MEASUREMENTS OF THE ITT MCP–PMT (F4129F).



Ch. 1 = 50.00 mVolts/div		Offset = -140.0 mVolts	
Timebase = 50.0 ps/div		Delay = 19.4380 ns	
Delta Windo= 3.1250 mVolts			
Window 1 = -115.62 mVolts		Window 2 = -118.75 mVolts	
Delta % = 66.02 %			
Upper = 83.33 %		Lower = 17.30 %	
Delta T = 18.2 ps			
Start = 19.5960 ns		Stop = 19.5778 ns	
# Samples = 295			
Mean = 19.5869 ns		Sigma = 9.1 ps	

Trigger on External at Pos. Edge at 409.5 mVolts

MULTIPHOTOELECTON (8–10) RESPONSE OF SAMPLIING SCOPE MEASUREMENTS OF THE HAMAMATSU MCP–PMT (R 2566U–7).



■Ch. 1 = 1.000 mVolts/div		Offset = 237.2 mVolts	
Timebase = 10.0 ps/div		Delay = 18.5280 ns	
■Delta Windo=-375.00 uVolts			
■Window 1 = 237.09 mVolts		Window 2 = 237.46 mVolts	
■Delta % = 71.84 %			
■Upper = 85.43 %		Lower = 13.59 %	
■Delta T = 5.3 ps			
■Start = 18.5794 ns		Stop = 18.5741 ns	
# Samples = 100			
■Mean = 18.5767 ns		Sigma = 2.6 ps	

Trigger on External at Pos. Edge at 409.5 mVolts

SAMPLING SCOPE JITTER CALIBRATION USING PULSES WITH FIXED SEPARATION.

SUMMARY

- 6 um core diameter microchannel plate photomultiplier tubes demonstrate significantly improved (4x) transit time spread than the 12 um core diameter tubes (25 pscosecond vs 110 picosecond)
- The state of the art Hamamatsu MCP-PMT 2566U has a bandwidth of ~3GHz which is approximately 3x better than the 12 um core diameter tubes; this will improve the bandwidth for post detection signal processing and the laser ranging precision.
- Sub-cm single photoelectron ranging to Lageos can be obtained using current SLR instrumentation.
- Advantageous especially for low aperture telescope systems.