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Technical Note: AuraTek™ Multi-Anode MCP-PMT

The Photek AuraTek™ family of Multi-Anode PhotoMultiplier Tubes include the MAPMT228 and MAPMT253, both using dual microchannel plates (MCP) for electron gain and providing the best available time resolution for photon counting. Each has a square grid array of anode pads with a native pitch 0.828 mm; the MAPMT228 has 32 x 32 anodes in an area of 26.5 x 26.5 mm and the MAPMT253 has 64 x 64 anodes in an area of 53 x 53 mm. The MAPMT228 uses a 40 mm round vacuum envelop while the MAPMT253 uses a square envelop to enable tiling into larger areas. Relevant mechanical properties of each tube are given in Table 1. Here test results are presented using a global 8 x 8 pattern for both detectors; ganging **4 x 4 pads on the MAPMT228 (3.31 mm anode pitch)** and **8 x 8 pads on the MAPMT253 (6.62 mm anode pitch).**

TABLE 1

Mechanical Properties	MAPMT228	MAPMT253
Photocathode – MCP Gap (mm)	0.3	1.6
MCP – Anode Gap (mm)	2.3	3.0
MCP Pore Diameter* (µm)	10	15
Bare Tube Dimensions (mm)	62.5 (⌀) x 14.6	59 x 59 x 13

***6 µm available on request for both formats**

Timing Resolution

Timing resolution of the MAPMT253 and MAPMT228 were measured using a Photek LPG-650 pulsed laser focussed on to a single pixel in the centre of the detector. The LPG-650 produces a 40 ps FWHM laser pulse plus a small after-pulse ~ 200 ps later. A reflective ND filter was used as a beam splitter, with 95% of the laser power being directed to the input window of a Photek PD010 vacuum photodiode and used as an absolute time reference. The remaining 5% of the laser pulse power was attenuated with absorptive ND filters to single photon levels as determined by using Poisson statistics of photons detected by the PMT under test i.e. the detected photon rate being < 10% of the pulsed laser repetition rate.

The outputs from the PD010 and MAPMT were read out using a Lecroy Wavemaster 808Zi-A (8 GHz, 40 GS/s), measuring each pulse's timestamp at 50% of peak amplitude on the leading edge to correct for amplitude walk. The time difference between the PD010 and MAPMT signals was then recorded (50,000 events) and binned into histograms, as shown below in Figure 1. Both detectors were operated at approximately 2×10^6 gain for single photon sensitivity.

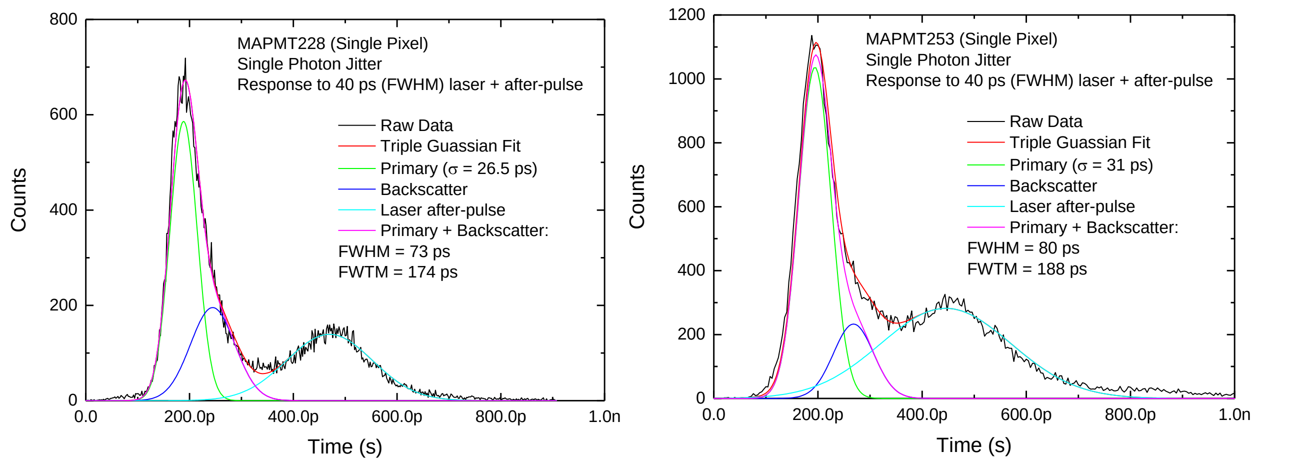

Figure 1: TTS for MAPMT228 and MAPMT253. FWHM of a multi-Gaussian fit to the data provides most realistic measure of performance.

The data are fit with three gaussians to accurately determine the FWHM of the tube response. Correcting for the width of the laser pulse we find that a 3.312 mm anode of the MAPMT228 has FWHM = 61 ps (σ_{rms} = 26 ps) and a 6.624 mm anode of the MAPMT253 has FWHM = 69 ps (σ_{rms} = 29 ps).

Cross Talk

There are many contributors to cross-talk in an MCP-PMT including charge spreading at the anode, induced charge on the anode, capacitive coupling, scattered photoelectrons, etc. When photon counting, the discriminator settings also have a significant impact on digital cross-talk. To measure cross-talk in photon counting mode the LPG-650 was focussed to a ~ 0.2 mm diameter spot and scanned across two neighbouring channels to measure the contrast in single photon count rates in each channel. For both PMTs the width of each anode measured from the cross-over between the anodes agrees with the physical anode size, as seen in Figure 2. The MAPMT228 shows excellent contrast for its 3.312 mm anodes, with sharp transitions and a flat response over the entire anode pad. The MAPMT253 shows good but less defined transitions than the MAPMT228, probably due to physical differences in tube construction, and will be further investigated.

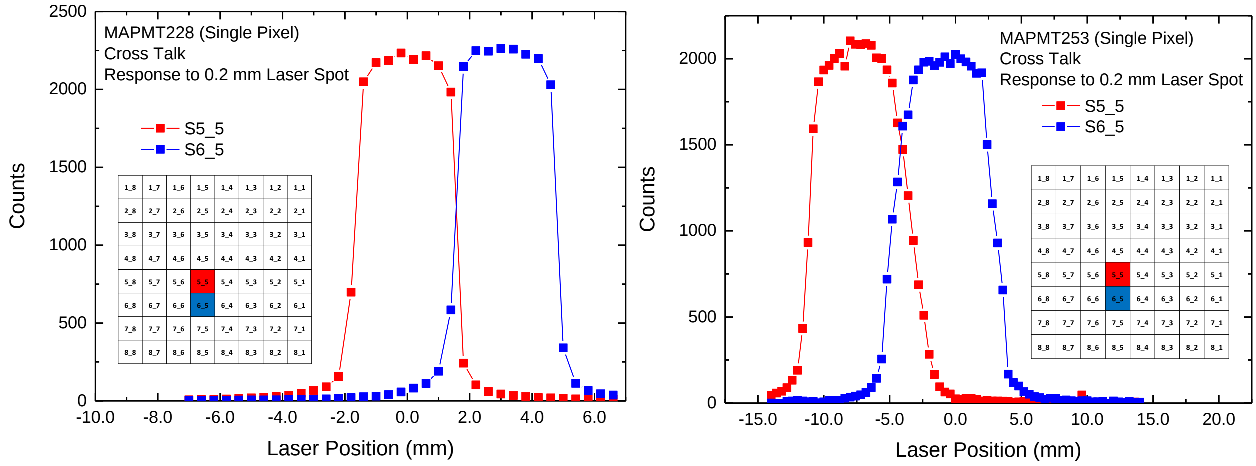

Figure 2: Photon counting anode-to-anode cross-talk in both MAPMTs, with performance impacted by physical characteristics.

Edge Effect

Analogue cross-talk between anodes is illustrated in Figure 3 where a 35 pe pulse illuminates anode 5-5, producing a 375 mV pulse. The adjacent anode 6-5 has a signal of about 60 mV and 7-5 < 10mV, representing the expected analogue cross-talk due to charge spreading and capacitive coupling. Anode 8-5 however shows a small inverted signal at the level of < 10 mV. Further investigation reveals that all perimeter anodes, those near the edge of the MAPMT, exhibit this inverted signal at a level of 2.5 – 3.0% of the peak pulse amplitude as seen in Figure 4. The amplitude of this edge effect remains 2.5 – 3.0% of the peak signal independent of pulse amplitude. It is interesting to note another interior anode diagonally removed by two anodes from anode 5-5 shows no measurable signal, only some small noise oscillations. Since the amplitude of the edge effect is inverted it should not create false triggers. For reference, the average signal for a single photon in these measurements had amplitude of 12 mV.

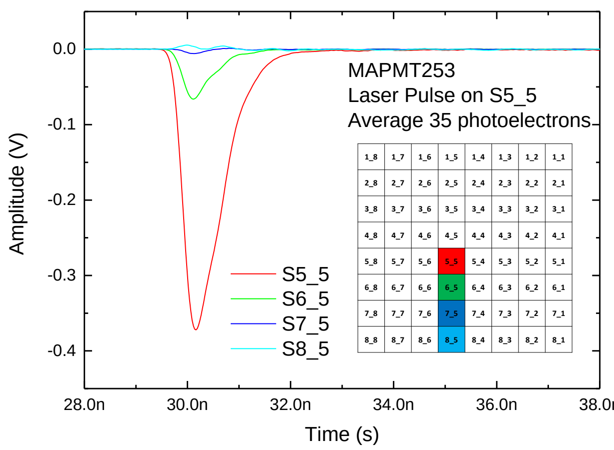

Figure 3: Estimate of analogue cross-talk.

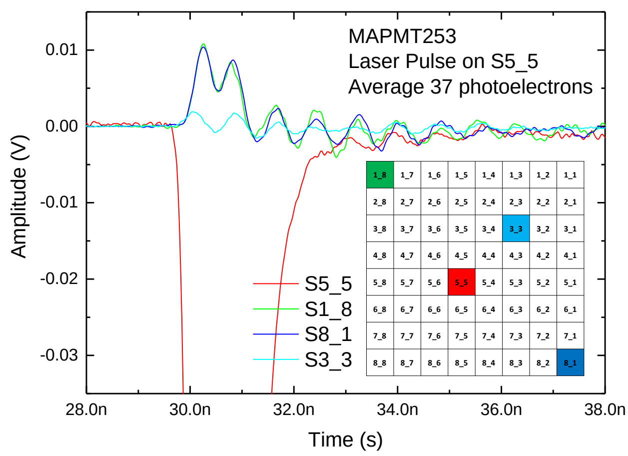

Figure 4: Edge Effect producing inverted signals on perimeter anodes in response to a large signal on an interior anode.