LAPPD Internal Note

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Subject: Initial Comparison of 25um and 10um pore Burle MCP
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An initial comparison of Micro Channel Plate (MCP) photo-multipliers tubes (PMT) from Burle with different pore sizes has been made using the ANL HEP Laser Lab[1].

The devices selected were the 10um MCP (XP85022-800) and 25um MCP (XP85022-600) to which were mounted the Transmission Line (TL) anode prototype readout boards.[2] Figure 1 shows a TL readout board and Figure 2 shows one of the TL boards mounted on an MCP device.

The laser (405nm) was focused to a 1mm diameter on the surface of the MCP and was positioned at the center of trace #5 on the TL readout.

For each device, two different HV set points were selected to yield gains approximately equal to $2x10^5$(High) and $0.4x10^5$ (Low). The gain curves for the two devices are shown in Figure 3. These curves were constructed from data taken at Npe=50 and 80, by applying the previously determine Npe, ADC and electronic calibrations.[3] We note that the 25uMCP rapidly goes into saturation at a gain in excess of $2x10^5$.

To study the time resolution of these two MCPs at the selected High/Low Gain settings we obtain the time difference distribution between the transmission line output (start) relative to a standard 10um MCP PMT(Burle 85011) output (stop) using Ortec 9327 zero-crossing discriminators and Ortec 566 Time to Amplitude converter. The time resolution is defined as the standard deviation of the time difference distribution . The time resolution as a function of number of photoelectrons (Npe) from the calibrated laser beam is shown in Figures 4a and 4b. The naive expectation is that the time resolution should be a power-law function of Npe, scaling as 1/sqrt(Npe), ie straight line on a log-log plot.[4] The data acquired and plotted cover a range of Npe = 15 to 158. Fig 4a shows the results the two MCPs at Low Gain, while Figure 4b shows the results for High Gain. The blue line is a naive power law (100/sqrt(Npe)), where the TTS/sqrt(Npe) is typical for photo-statistics dominated behavior. The TTS represents the Transit Time Spread at Npe=1.

The High Gain data is well described by the TTS/sqrt(Npe) power law with a fit giving TTS=92+/-5 (ps). In addition, for the higher Npe values , the 10 um MCP shows a small but consistently better time resolution than the 25um MCP. At Low Gain the data is not well described by the expected power law, but closer to a A/Npe power law. Extrapolating to low Npe shows very large TTS (300 & 500 ps) while at the highest Npe values the time resolutions are very close to the High Gain results and likely dominated by electronic noise in the measurement process.

The probable region (in Npe) of interest for realistic detectors is Npe = 20 to 50. Table 1 presents a comparison between the Low and High Gain results for the two MCP devices. Note: these results were obtained from the time difference between the MCP device under test and a reference MCP, so to the extent that the reference device is similar to the MCP device under test and statistically uncorrelated, the intrinsic time resolution per device can be obtained (ignoring any electronic noise contribution) by dividing by the sqrt(2).

Device	At estimated 1 pe	At 20 pe	At 50 pe	A 158 pe
25 um at Low Gain ($0.4x10^5$)	500	33.5	13	7.4
10 um at Low Gain	300	26	12	6.7
Difference	200	7.5	1	0.7
25 um at High Gain ($2.x10^5$)	92	22	13.3	8.3
10 um at High Gain	92	20.5	12.2	7.4
Difference	0	1.5	1.1	0.9

Table 1: Time resolution (rms) in picosecond (ps) at various light levels in photoelectrons (pe)

In summary, the 10um MCP device has better time resolution relative to the 25u MCP at the Low Gain mode, especially at low levels of Npe. At the High gain mode the 10um MCP device is only slightly better than 25um MCP device at high Npe values , while it shows little to no difference at low Npe values. Clearly, there is a large dependence of the time resolution on the Gain, especially in the at Npe < 40 region.

[1] "Development of Picosecond_Resolution Large-Area Time-of-Flight Systems", Camden Ertley, et al (SORMA08 June 2008 Berkeley CA).
[2] "Transmission-Line Readout with Good Time and Space Resolution s for a Planicon MCP-PMT",
Fukun Tang et al. Topical Workshop on Electronics for Particle Physics, Prague Czech Republic Sep, 2007.
[3] "Npe Calibration at ANL HEP Laser Lab", in preparation.
[4] “Photomultiplier Tubes - Basics and Applications – Hamamatsu”
http://sales.hamamatsu.com/assets/applications/ETD/pmt_handbook/pmt_handbook_applications.pdf

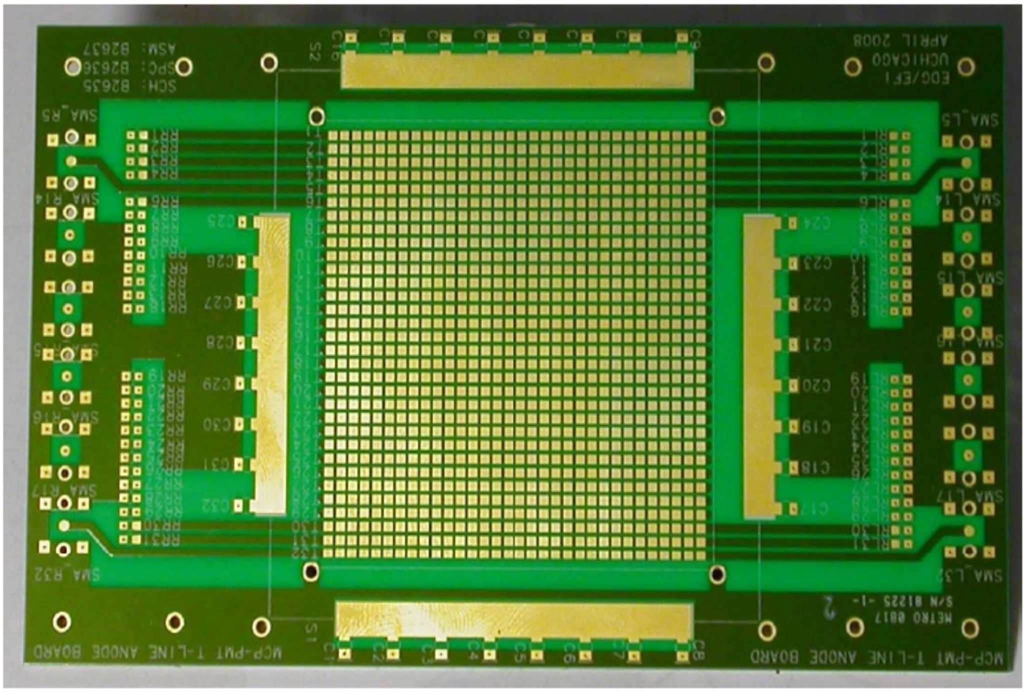

Figure 1: Proto-type Transmission Line readout printed circuit board to 6 of the 32 anode rows on a 1024 anode MCP.

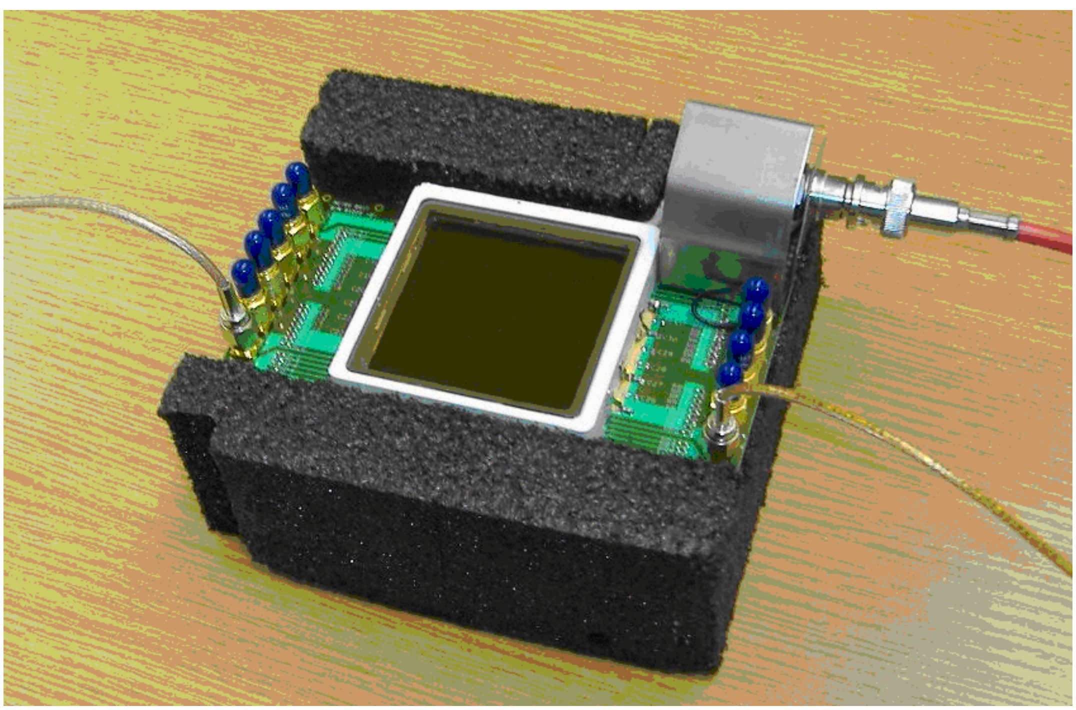

Figure 2. A MCP device mounted on the proto-type TL readout and placed in black foam holder.

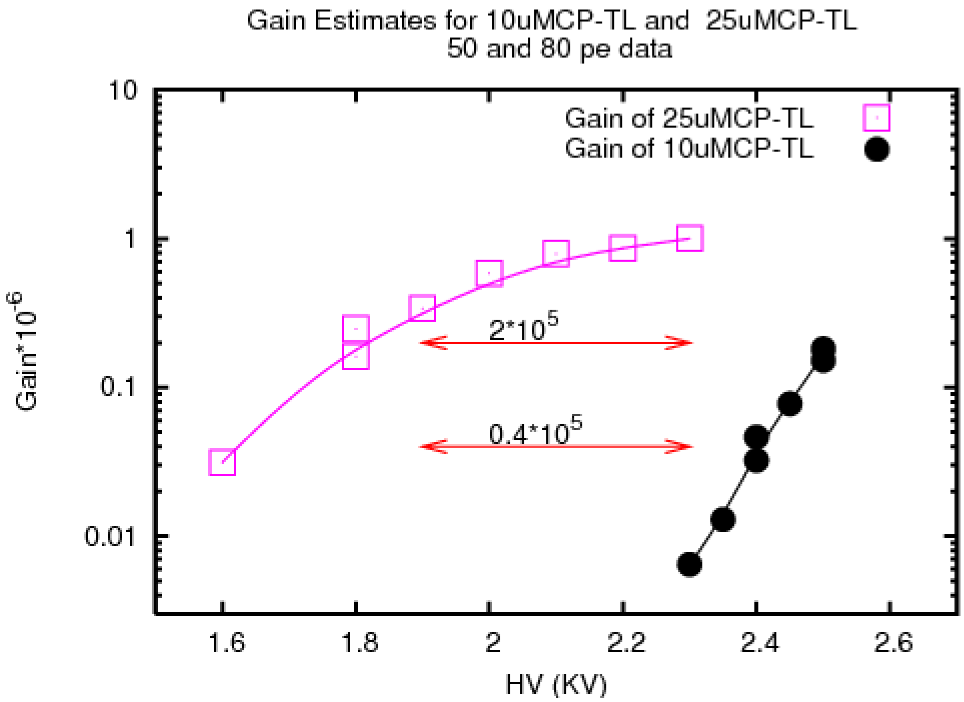

Figure 3: Gain curves for 25um and 10um MCP based on observed pulse height.

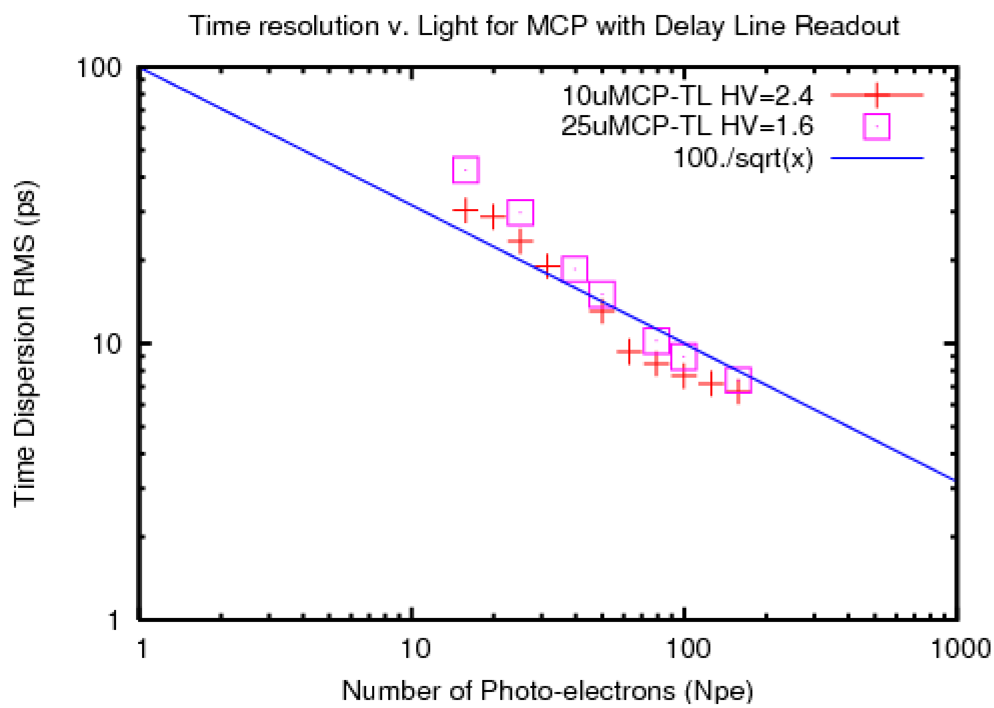

Figure 4a: Time resolution as a function of number of photoelectrons (Npe) at Low Gain.

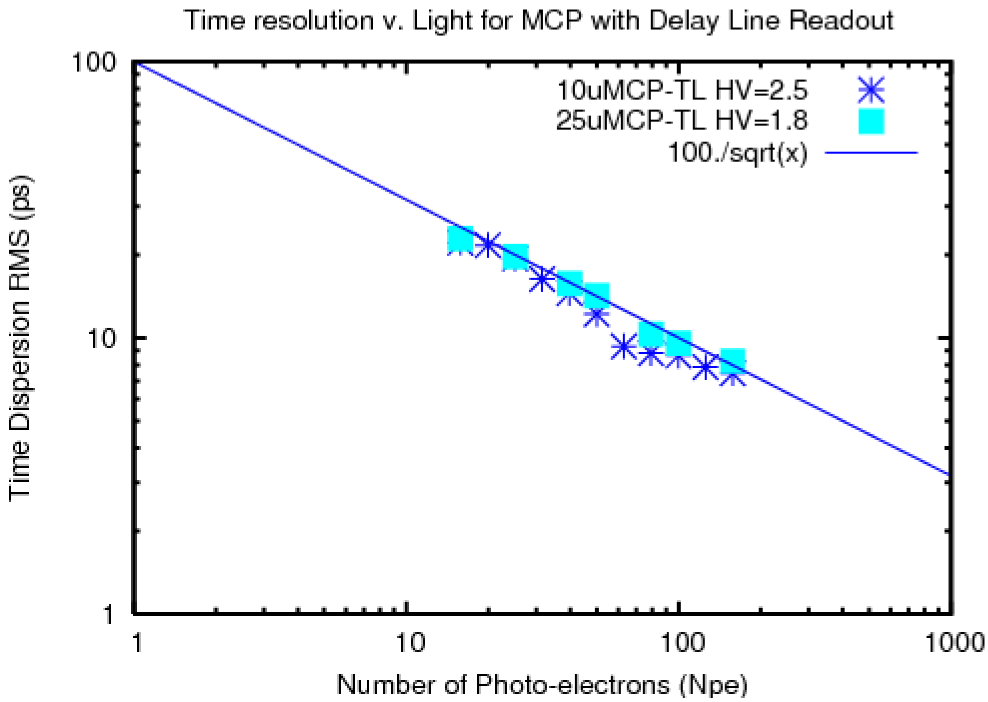

Figure 4b: Time resolution at High Gain.