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LAPPD 2D Characterization

SL17-ML-MIND-PD3Jb

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Goals and Objectives

- ▶ Characterize the behavior of a Large Area Picosecond Photo-Detector (LAPPD) across the entire sensitive area.
- ▶ Determine the photon detection efficiency, transit time spread, amplification gain, and position resolution of the device.
- ▶ Qualitatively evaluate the behavior of LAPPDs with more than one photon/event.

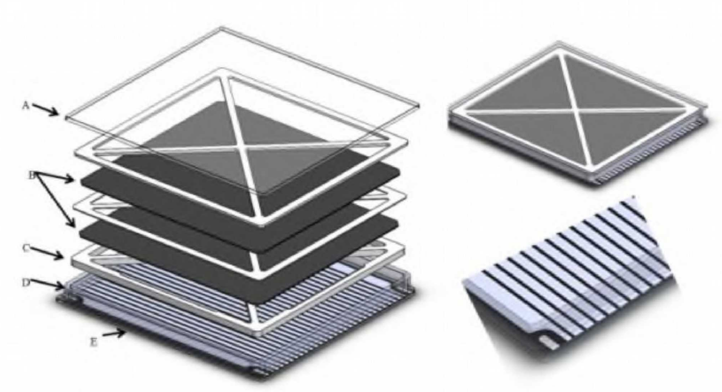


Figure 1 – Schematic design of the LAPPD: Left, exploded view: A) Fused silica window with PC on inside surface, B) Chevron pair of ALD-GCA-MCPs, C) three spacers, D) Anode showing 28 strip lines passing under sidewalls. Top right: consolidated view, Bottom right: expanded view of strip line anodes passing under sidewalls.

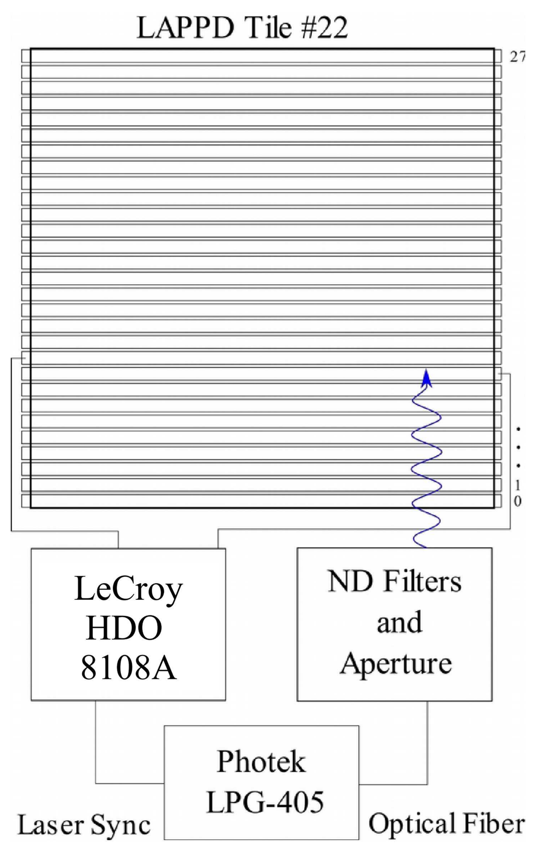
Introduction

LAPPDs use microchannel plates (MCPs) to multiply single photo-electrons liberated from the photocathode (PC) by an incident photon up to a detectable voltage pulse.

This technique results in better time resolution than traditional photomultiplier tubes (PMTs) while also preserving the location of the photon in the final electron cloud.

LAPPDs are being developed commercially by Incom, and this represents the first comprehensive characterization using LAPPD #22.

Methods

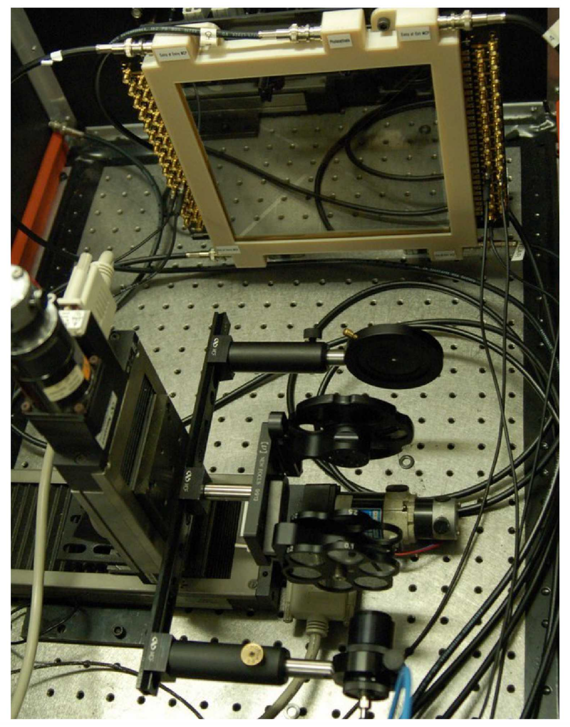


A fast laser (~30ps RMS) along with optical filters and an aperture is used to generate single photons at a well defined time and position.

The position is scanned across the LAPPD while signals from the left and right side of each strip is digitized with an oscilloscope.

The PC was biased to 50V, MCPs biased to 1kV, and other gaps biased to 200V for these results.

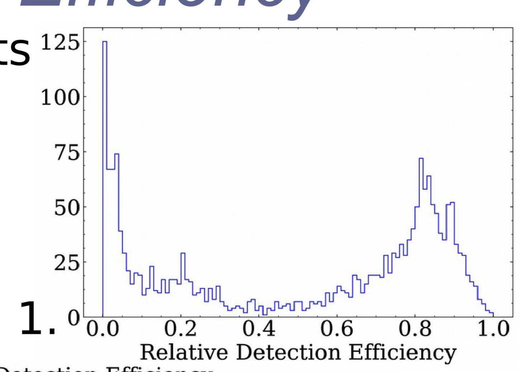
Missing points in the 2D plots to the right represent fit failures, most often due to low statistics.

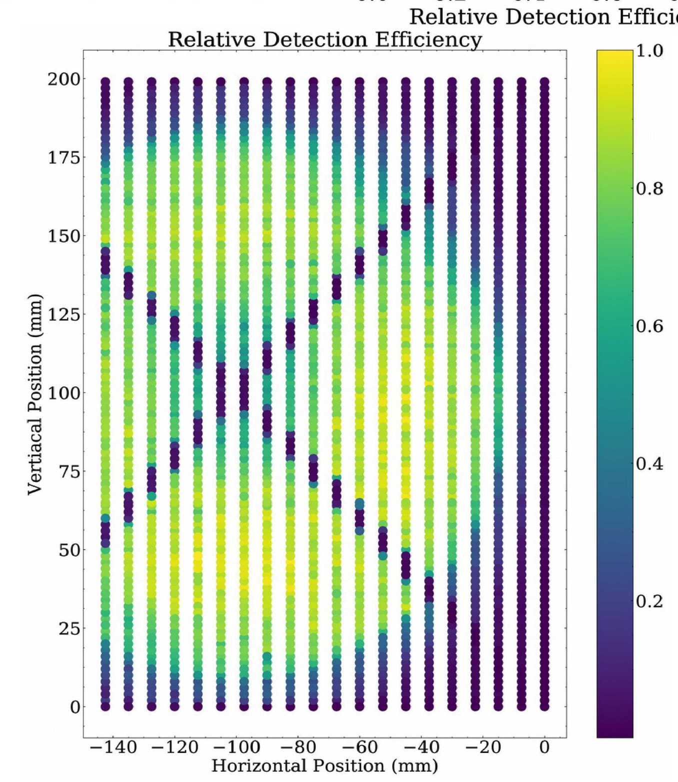


Results

Relative Single-Photon Detection Efficiency

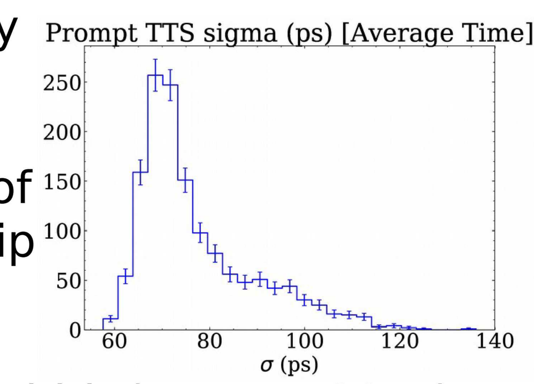
Ratio of events with pulses crossing 2mV to all events, maximum normalized to 1.

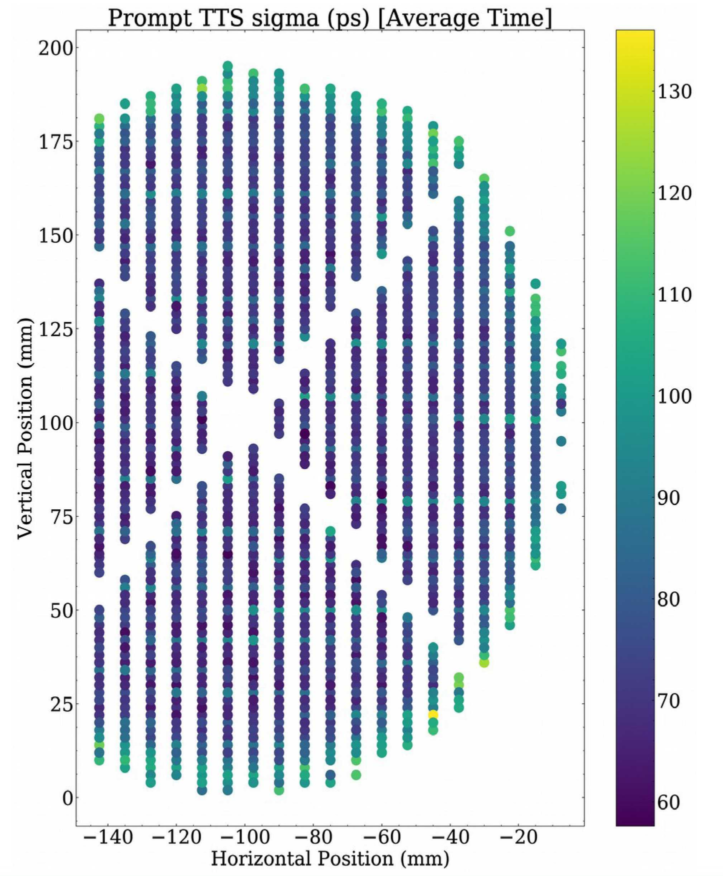




Transit Time Spread

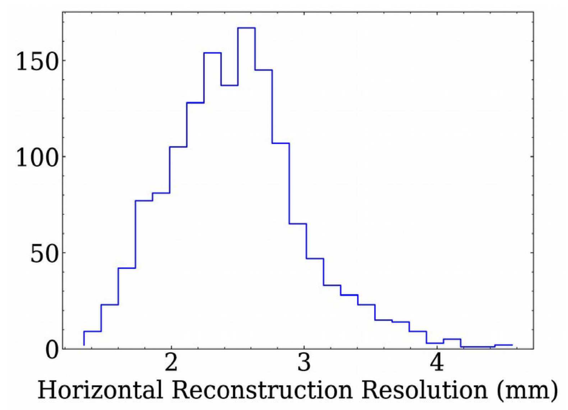
The uncertainty in average hit time of the left and right side of the nearest strip relative to the laser pulse. Includes laser width (approx. 30ps).

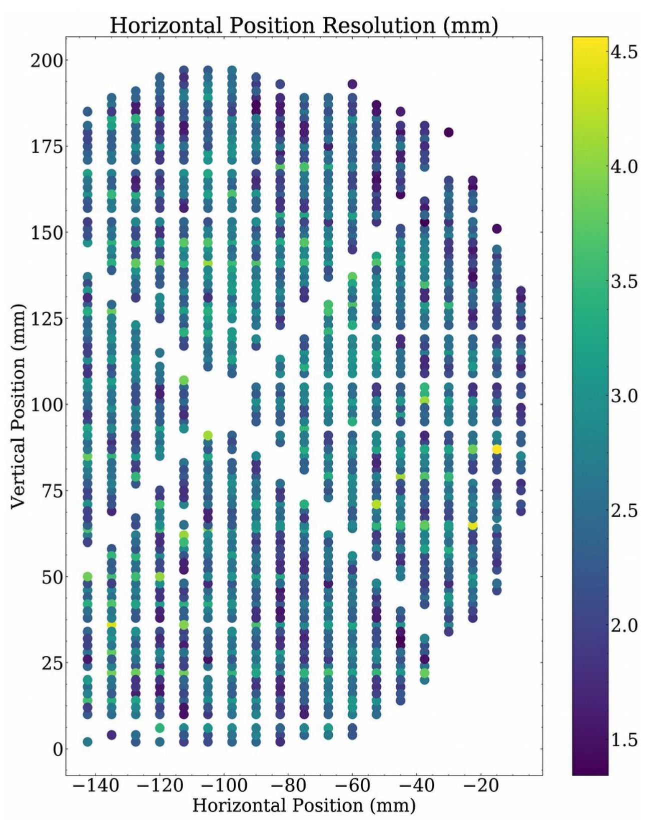




Horizontal Resolution

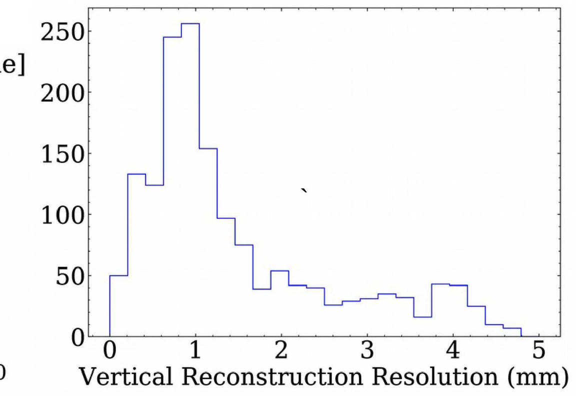
Uses difference in hit time on the left and right side and strip propagation speed (~11.5 ps/mm) to reconstruct position.

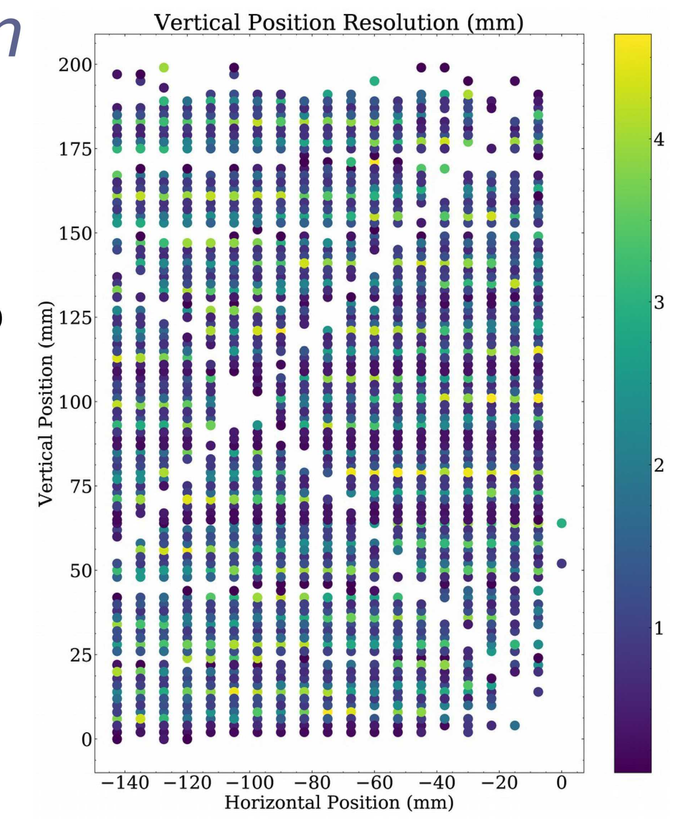




Vertical Resolution

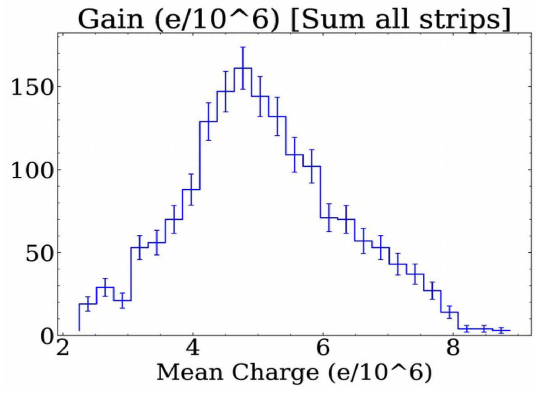
Uses charge sharing between strips to reconstruct vertical position with a charge weighted average of strip positions.

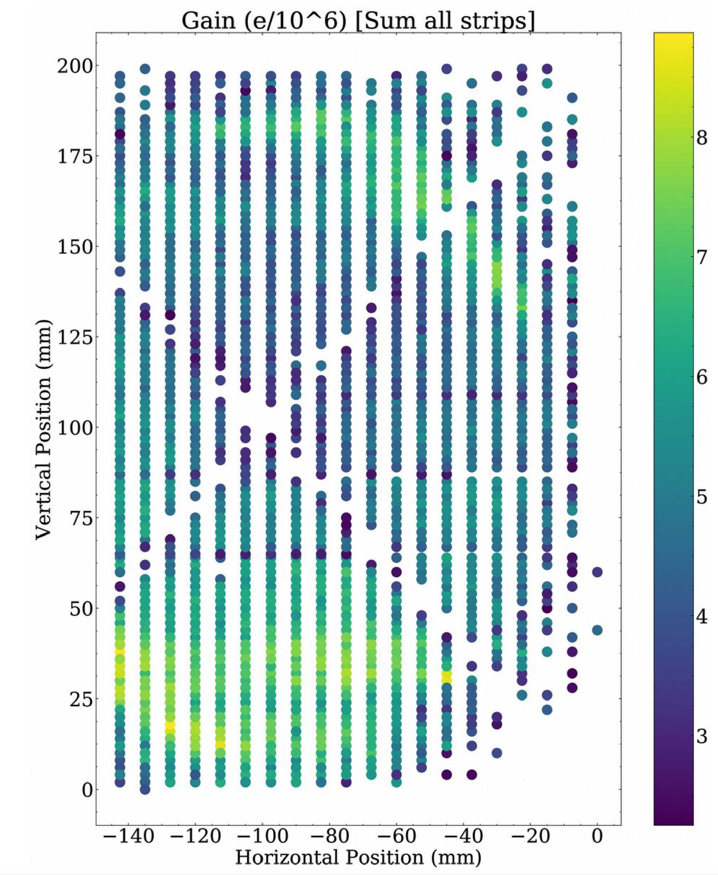




MCP Gain

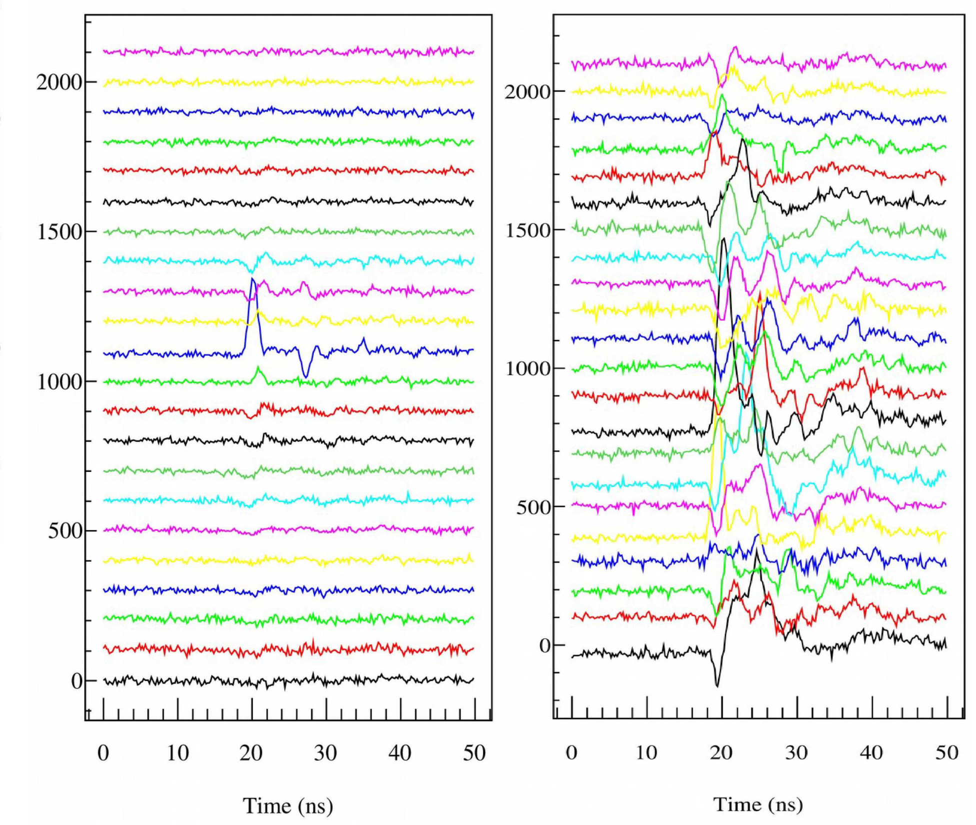
The mean charge resulting from a single photo-electron after amplification by the MCPs.





Many Photon Behavior

This shows raw digitizer data in a single photons (left) and tens of photons (right) for the right side of a majority of strips.



Conclusion

This LAPPD was purchased to evaluate its performance and applicability for the single volume scatter camera (SVSC). The LAPPD meets its advertised specifications for single-photon detection with about 60ps TTS and position resolution of a few mm. This specific LAPPD shows considerable variability in performance metrics across its sensitive area, which would make individual characterization of LAPPDs a requirement for use.

This work did not optimize the bias voltages for the LAPPD, and it is possible that some results may improve with different biases. Further, readout is a key part of the system, and changes to the electronics could impact the results.

For use in a monolithic type SVSC system, pixelated anodes would be required, which could change the observed performance. Finally, the qualitatively observed performance under multi-photon illumination is a show-stopper for the monolithic approach.

Sandia National Laboratories

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