Capacitively coupled pulse readout in MCP-based photo-detectors

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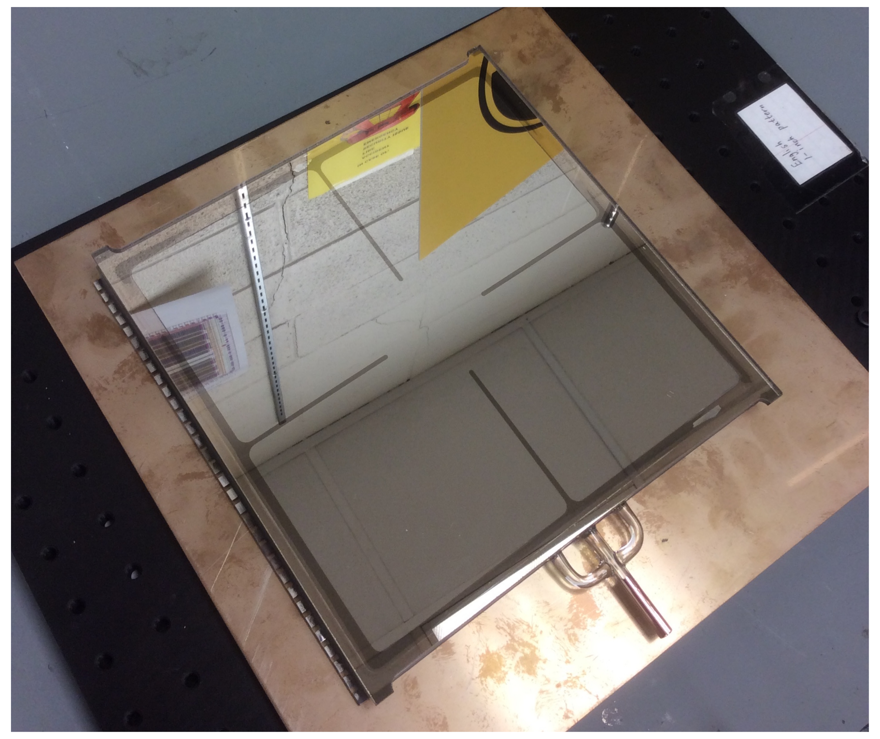

Figure 1: Top-down view of a sealed, LAPPD photo-detector "tile" made by the team at University of Chicago

Introduction

Photo-detectors with large active-area sacrifice timing resolution. An LAPPD is a micro-channel plate (MCP) based photo-detector with 20cm×20cm active area that intends to move from hundreds of pico-seconds (current technology) to a few pico-seconds timing resolution. The signal readout is built into the detector. A removable readout transforms LAPPDs into a customizable detector.

Applications of LAPPDs

- The ANNIE experiment at Fermilab intends to use water-Cherenkov and LAPPDs to reduce backgrounds in neutrino experiments
- Eric Oberla built an 'Optical Time Projection Chamber' that used MCPs to reconstruct 3D particle tracks in *water* by drifting light
- LAPPDs may be able to separate Cherenkov light from scintillation light in neutrino experiments

Capacitively coupled pulse readout

The following two components form a mutual capacitance:

- **Anode:** Thin metal film which receives charge showers, inside the vacuum packaging
- **Pickup:** Conducting pattern which captures an induced signal

This study has shown that the coupling between the pickup and anode allows for measuring pico-second pulses with a removable readout outside of the detector. The readout scheme *preserves rise-time and a large fraction of the signal amplitude.*

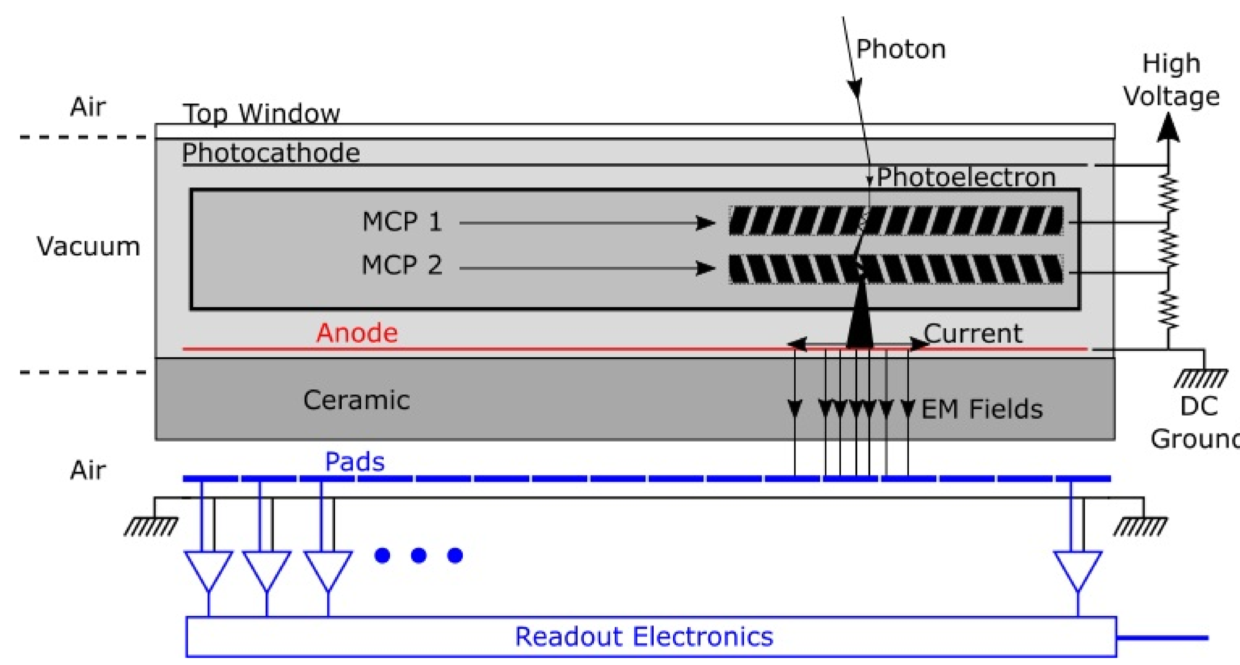

Figure 2: Micro-channel plates (MCPs) produce a shower of electrons, inducing fast signals on the anode. The signal is measured capacitively by a pickup outside.

Test Setup

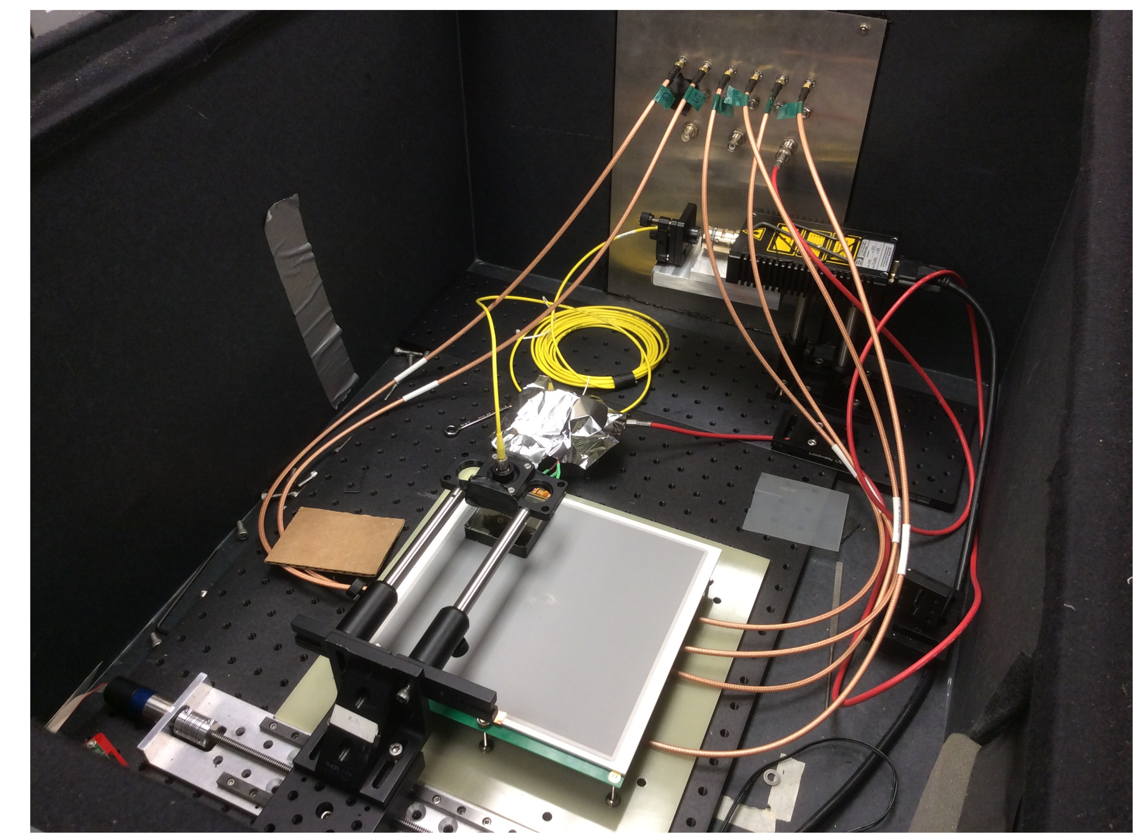

Figure 3: Laser arm setup at University of Chicago, HEP lab 321

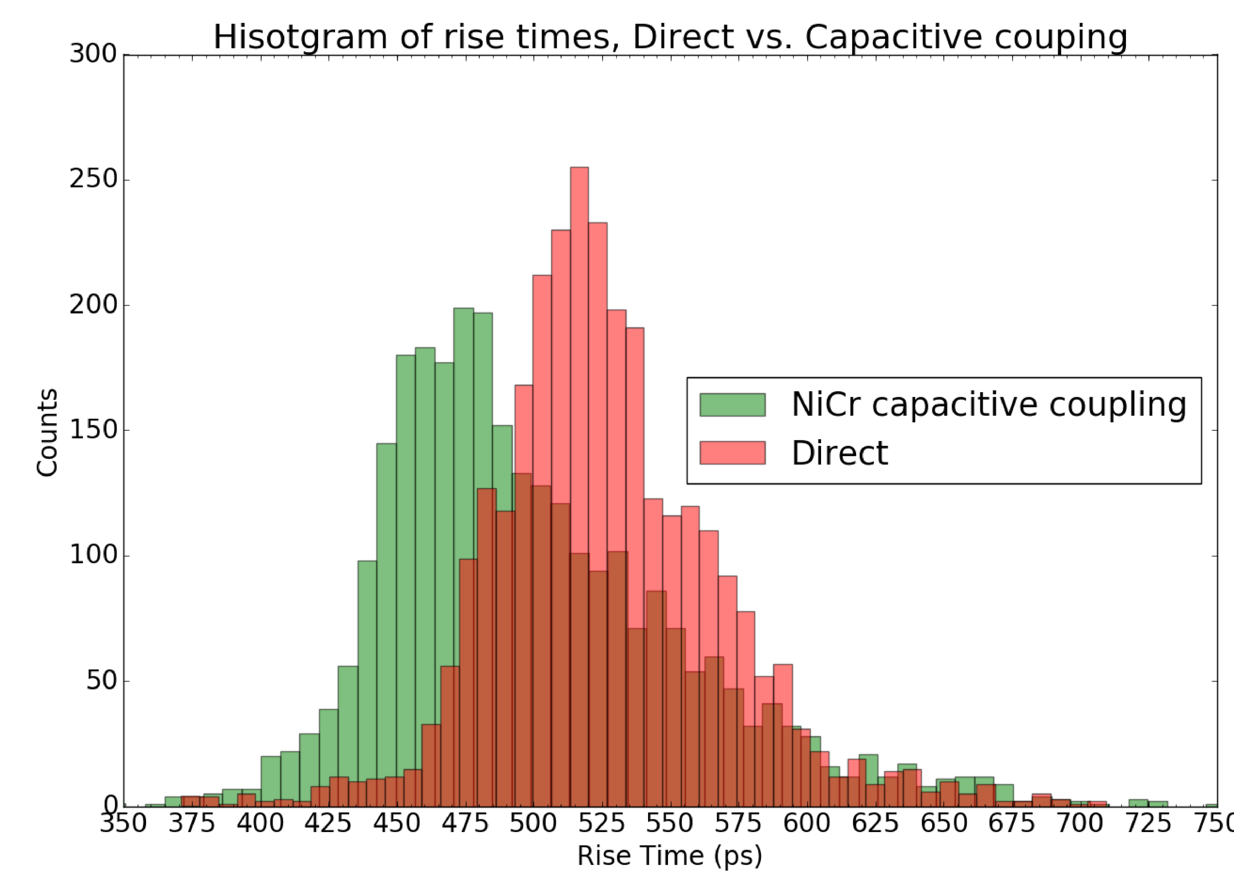

Figure 4: The capacitive readout scheme preserves rise-time of pulses (rise time is a key factor in timing resolution)

Why capacitively coupled readout?

Transmission readout schemes are built into the photo-detector body. The capacitive readout transforms the detector into a customizable object by separating the pickup plane from the detector body.

Results

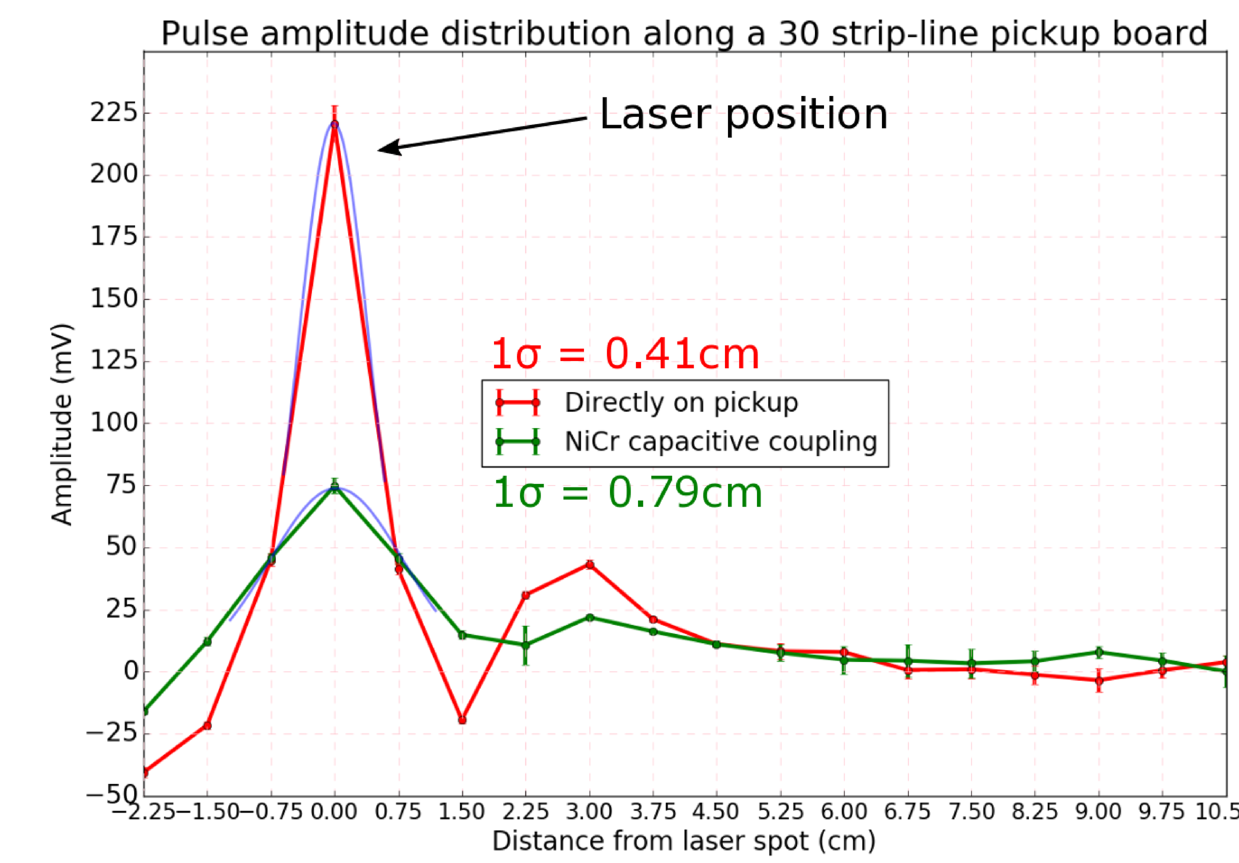

Figure 5: Each strip-line pickup has an associated amplitude. Strips far away from the laser spot have lower amplitude. The capacitive anode spreads the amplitude distribution in space.

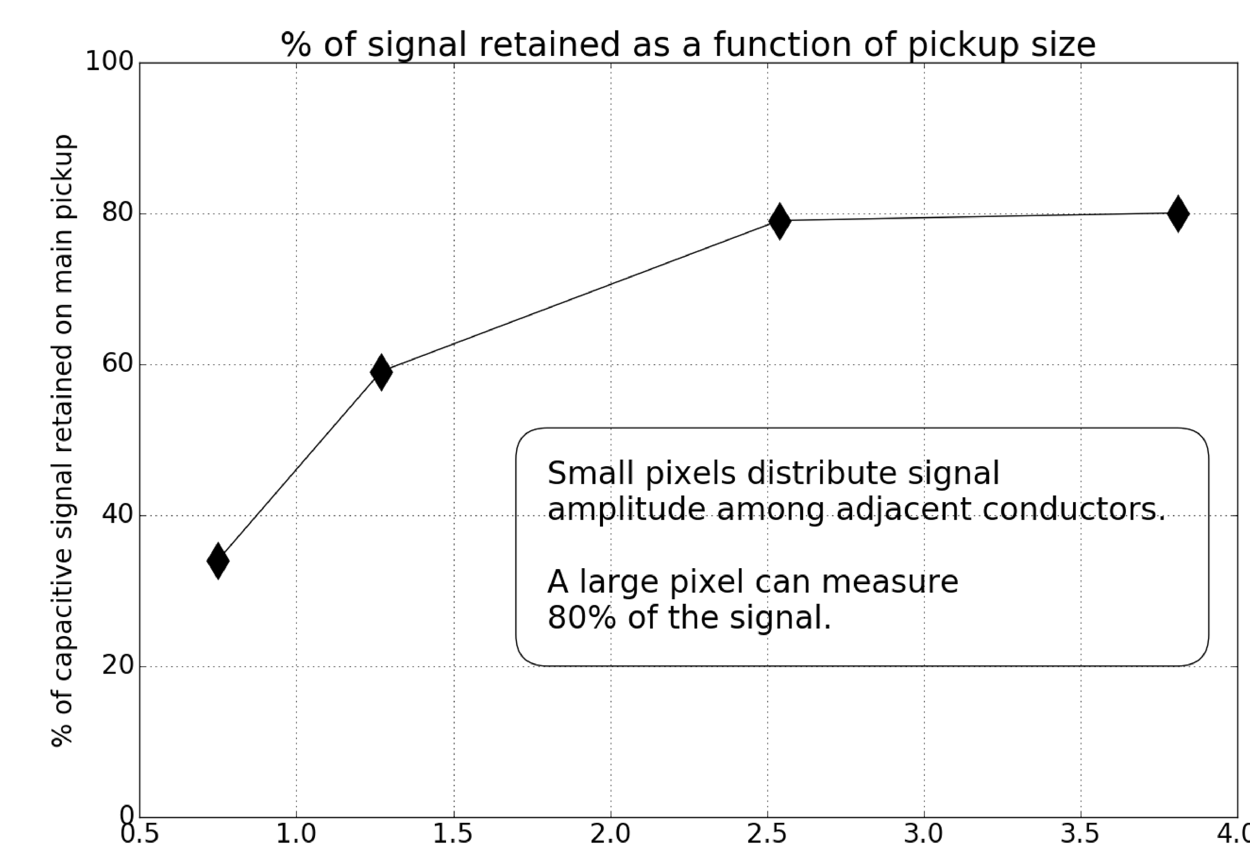

Figure 6: Small pixels will distribute pulse amplitude among neighboring channels. Pads larger than the signal spot size measures a maximum of 80% of the signal amplitude.