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Rate capability and transient gain drop of an single photon timing detector

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Multi-anode Microchannel Plate (MCP) detectors offer distinct advantages, including timing resolutions below 30 ps, single-photon sensitivity, and a modular architecture. Advancements in High-Energy Physics experiments—such as the TORCH project—are driving the need for increased photon rate capability and higher spatial resolution granularity of detector designs. This study presents measurements of the rate capability of multi-anode photomultiplier tubes (MAPMT), including an MAPMT with higher granularity custom readout for the TORCH project of 16 x 96 pixels (0.55 mm pitch), building on this, aims to quantify the lateral spread of the transient gain drop.

When a photoelectron strikes a microchannel plate (MCP), it can trigger an electron avalanche that rapidly drains charge from the microchannel walls. This sudden discharge causes a noticeable drop in gain, which does not recover instantaneously. Instead, the affected regions experience a temporary "dead" period during which their ability to amplify subsequent signals in this channel is significantly reduced. Studies demonstrate that this gain suppression isn't limited to the directly impacted channels—neighbouring channels also exhibit reduced sensitivity, suggesting a lateral spread of the effect. This phenomenon plays a key role in determining the MCP's local rate capability, as the local charge depletion extends the effective dead time across multiple channels.

Quantitatively characterizing the lateral extent of the gain drop is essential for applications like particle physics, where higher photon rates are required. This measurement can guide the optimization of MCP detector designs, including pixel pitch in multi-anode configurations.

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