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Modelling the behaviour of microchannel plates using CST particle tracking software

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Photon counting detectors are essential for many applications, including astronomy, medical imaging, nuclear and particle physics. An extremely important characteristic of photon counting detectors is the method of electron multiplication.

In vacuum tubes such as photomultiplier tubes (PMTs) and microchannel plates (MCPs), secondary electron emission (SEE) provides electron multiplication through an accelerating field across the dynode. A significant electron cascade, with time resolution in the 10s of picoseconds, can be observed in these structures and are routinely used in industry and research. Both devices have been thoroughly tested experimentally.

Developing new MCP designs can be expensive and time consuming so the ability to simulate new structures will provide many advantages to instrument designers and manufacturers. There are, however, significant challenges in accurately simulating MCPs with many geometrical variables to consider as well as material SEE properties. The SEE process is probabilistic, and with MCPs having a very high gain, significant computational resource is required to simulate the resulting electron output for a model.

In our research we illustrate how this can be achieved by developing a MCP model using Computer Simulation Technology (CST) software. The model consists of a charged particle source, a small seven-pore MCP structure (including electrodes, resistive and emissive surfaces), as well as the readout anode, with appropriate potentials applied to the components of the model.

We present simulation results from the modelled MCPs, demonstrate electron multiplication performance, and compare these results with those predicted by theory and observed experimentally. Our goal is to expand this model and identify optimum MCP parameters for various science applications using novel materials to optimise detector performance.

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