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Transmission Dynodes: Enhancing Vacuum Photodetectors

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MCP-PMT devices represent the state-of-the-art in terms of picosecond timing resolution combined with low noise, high gain, and radiation hardness. However, with experiment upgrades producing higher luminosities, there are concerns over the ability of the existing technologies to achieve sufficiently high rates and longer tube lifetime in terms of extracted charge. To overcome these limitations, we are developing a hybrid diamond/MCP photomultiplier consisting of a transmission dynode followed by an MCP.
The transmission dynode, a diamond-based composite material comprising a single crystal diamond membrane on a high open area support structure, operates at a gain of 10-20, followed by further gain in the MCP. This high first gain stage produces a low gain variance which allows operation at a lower overall gain while maintaining the tight pulse height distribution necessary for single photon counting. Since the maximum MCP signal is current-limited due to the MCP resistance, a lower overall gain allows higher maximum photon count rate to be achieved. In addition, the diamond membrane acts as an impermeable barrier to ion feedback from the MCP, a major cause of photocathode degradation which limits the effective lifetime of conventional tubes.
In the longer term, a complete replacement of MCPs with transmission dynodes is an attractive prospect. These devices would have an excellent single-photon spectrum, higher collection efficiency than MCP-PMTs and their linear geometry will give much improved timing precision over the ˜30 ps of conventional MCP-PMTs.

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