Title

Hybrid single-photon detector based on microchannel plate
and the Timepix4 ASIC as pixelated anode

Authors list

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Abstract

We present the development of a single-photon detector based on a vacuum tube equipped with transmission photocathode, microchannel plate and a CMOS pixelated active read-out anode. The Timepix4 ASIC, developed by the Medipix4 Collaboration, is used as anode, and consists in an array of 512x448 pixels, 55 μm x 55 μm each, that can timestamp individual hits with a resolution better than 100 ps. In data-driven mode the chip can handle a maximum rate of 2.5 Ghits/s corresponding to a data rate up to 160 Gb/s, that will be handled by a high-throughput FPGA-based external electronics with flexible design. The very low noise of the electronics will allow to operate the MCP at low gain, leading to a longer detector lifetime. The ASIC encapsulated inside the vacuum tube allows for on-detector signal processing and digitization with a very-high channel density (about 230 thousand channels) reducing the number of external interconnections (about 200).
Recent timing resolution measurements of the Timepix4 ASIC, bump bonded to a silicon sensor, using a pulsed picosecond laser will also be presented. A measurement of the time resolution of 60 ps for the Time-to-Digital Converter itself has been obtained, which required frequency mapping and calibration over the whole matrix. Considering the contributions from signal generation in the silicon sensor and the electronics front-end we obtained a resolution of about 100 ps for a single pixel, reaching 50 ps for a cluster of pixels thanks to multiple sampling.
These performances will enable significant advances in particle physics, life sciences, quantum optics or other emerging fields where the detection of single photons with excellent timing and position resolutions are simultaneously required.