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4D Trackers Based on AC-LGAD with Long Strip Readout Electrodes

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Silicon-based sensors that can deliver a timing resolution of a few tens of ps along with a significantly better spatial resolution (O(few μm)) have been studied extensively in recent years. In an AC-coupled Low-Gain Avalanche Diode (LGAD), a highly-doped p+ gain layer is implanted between a continuous n+ layer and p-type bulk to form a high-field multiplication region. Electrical signals in the n+ layer are AC-coupled to metal electrodes that are separated from the n+ layer by a thin insulator layer. Signal sharing among the adjacent electrodes in AC-LGAD sensors enables a significantly better spatial resolution while maintaining the excellent fast-timing resolution offered by the conventional LGAD sensors. The AC-LGAD technology has been suggested to use for particle identification (PID), tracking, and far-forward detectors at Electron-Ion Collider (EIC). Precision timing detectors in EIC will provide PID capabilities below the threshold of Cherenkov PID detectors. We demonstrated for the first time the performance of large-area AC-LGAD sensors produced by Brookhaven National Laboratory (BNL) [1]. The data was collected at the Fermilab 120 GeV proton test beam facility using the LGAD characterization setup comprised of a silicon tracking telescope to measure the impact position of each proton, and a fast micro-channel plate detector (MCP-PMT). The waveforms from AC-LGAD and MCP-PMT were recorded using an eight-channel Lecroy Waverunner 8208HD oscilloscope. Sensors were aligned by considering the variations in the sensor position along the beamline and the rotation around the beam axis. These large-area AC-LGAD sensors achieved an excellent spatial resolution of around 10 – 80 μm, and a timing resolution of around 30 – 50 ps depending on the length of the strip. Despite the excellent performance of AC-LGADs in this prototyping run, we observed a significant non-uniformity of the gain layer [1]. A follow-up production was performed at BNL in order to improve the gain layer uniformity. In this presentation, we will present the signal characteristics and charge sharing of AC-LGADs from the latest production batch with Fermilab test beam measurement.

References:

[1] Madrid, Christopher, et al. “First survey of centimeter-scale AC-LGAD strip sensors with a 120 GeV proton beam.”arXiv preprint arXiv:2211.09698 (2022).

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