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Timepix3 as solid-state time-projection chamber in particle and nuclear physics

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Timepix3 detectors are the latest member of the Medipix/Timepix family of hybrid pixel detectors developed at CERN. These detectors feature a segmented detector (256 x 256 pixels, pixel-pitch of 55 μm) flip-chip bump-bonded to the readout ASIC. In each pixel, Time-over-Threshold and Time-of-Arrival are measured simultaneously, while keeping a counting mode capability. The per-pixel dead time amounts to 475 ns.
In this contribution, we show that the time resolution of approximately 2 ns is sufficient to measure drift times of charge carriers, which in turn are used to reconstruct particle trajectories in 3D (creating a solid-state time-projection chamber). Using 40 GeV/c pion test beam data, we show that a z-resolution of 30 μm and 60 μm can be achieved in 500 μm thick silicon and 2 mm thick CdTe sensor layers, respectively. We show how the 3D information increases the particle type sensitivity and angular resolving power.
We apply the presented techniques to the evaluation of data taken in the ATLAS and MoEDAL experiments at CERN, where Timepix3 detectors (with 500 μm thick silicon sensors) are used as active radiation detectors. We describe how such methodology improves vertex reconstruction and angular correlation function measurement of internally created electron positron pairs in an experiment carried out at the Van-de-Graaff accelerator of the Institute of Experimental and Applied Physics.

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