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A pixel matrix prototype chip with high-precision time measurement for CMOS pixel detectors

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CMOS pixel detectors, characterized by high spatial resolution, high sensitivity, and low material budget, are ideal for tracking charged particles. As a result, they have been widely used in particle physics experiments, and are considered the preferred technology for future vertex detectors. Particle physics experiments are constantly moving toward higher luminosities, placing greater demands on future detector performance. The integration of high-precision time measurement functions in CMOS pixel detectors allows the simultaneous measurement of particle hit positions and time of arrival (TOA). This so-called 4-D (four-dimensional) tracking capability allows for event discrimination on the time scale, reducing event pile-up and improving particle track reconstruction. To investigate the feasibility of integrating high-precision time measurement capabilities into CMOS pixel detectors, a pixel matrix prototype chip has been designed, based on a CIS 180 nm process. Each pixel in the pixel matrix is composed of a charge collection diode, a front-end charge signal processing circuit optimized for high timing accuracy, and a common time quantization circuit shared by 8 pixels. In response to the demand for low power consumption and high reliability in the pixel circuits, a time quantization method has been employed that combines fine time stamp measurements within the pixel and coarse time stamp measurements at the periphery of the pixel matrix. This method, along with a fully synchronous zero-suppression readout approach, achieves a time digitization of TOA with a bin size of 2 ns.

Minioral

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