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Development of CMOS Pixel Sensor prototypes for the CEPC vertex detector

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The proposed Circular Electron Positron Collider (CEPC) imposes new challenges for the vertex detector in terms of material budget, spatial resolution, readout speed, and power consumption. The TaichuPix chip is a dedicated CMOS Pixel Sensor that is being developed for the first 6-layer silicon vertex detector prototype of the CEPC vertex detector R&D. The TaichuPix chip need to provide a spatial resolution better than 5 μm, and a radiation tolerance higher than 1 MRad. The TaichuPix development is based on a fast in-pixel readout combined with a hit-driven architecture, which would be beneficial for the high hit rate. Over the last years of R&D, several prototypes have been designed to optimize in-pixel circuit and readout architecture, and to verify radiation hardness. Two small-scale demonstrator chips (25 mm^2) capable of achieving a hit rate up to 36 MHz/cm^2, were developed in a 180 nm CMOS process. Two different in-pixel digital readout designs, benefiting from the FE-I3 and ALPIDE approaches, have been implemented to achieve a fast readout. The readout of the pixel array is based on a proposed "column-drain" architecture. The positive results of the small-scale prototypes led to a submission of the first full-scale (2.6 cm × 1.6 cm) TaichuPix prototype in 2022. These prototypes were firstly characterized with electrical and radioactive sources in laboratory. The full-scale sensor chip was further characterized at the DESY test beam facility. The design details of TaichuPix prototypes and a summary of the results obtained are given.

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