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Towards a New Generation of Monolithic Active Pixel Sensors

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A new generation of Monolithic Active Pixel Sensors (MAPS), produced in a 65 nm CMOS imaging process, promises higher densities of on-chip circuits and, for a given pixel size, more sophisticated in-pixel logic compared to larger feature size processes. MAPS are a cost-effective alternative to hybrid pixel sensors since flip-chip bonding is not required. In addition, they allow for significant reductions of the material budget of detector systems, due to the smaller physical thicknesses of the sensor and the absence of a readout chip.

The TANGERINE project aims for a sensor with a spatial resolution below 3 µm, temporal resolution below 10 ns, and a total physical thickness below 50 µm, suitable for future Higgs factories or as beam telescope in beam-test facilities. The sensors will have small collection electrodes (order of µm), to maximize the signal-to-noise ratio and hence minimize power dissipation in the circuitry. An extensive program of electric field and Monte Carlo simulations is pursued, to optimize the sensor layout and to reach full depletion of the epitaxial layer, hence high hit detection efficiencies, despite the small collection electrodes. This includes different types of process modifications to enlarge the depletion region and enhance the lateral electric field strength.

The first batch of test chips, featuring the full front-end amplifiers with Krummenacher feedback, was produced and tested at the Mainzer Mikrotron (MAMI) end of 2021. MAMI provides an electron beam with currents up to 100 µA and an energy of 855 MeV. The analog output signal of the test chips is recorded with a high bandwidth oscilloscope and used to study the charge-sensitive amplifier of the chips in terms of waveform analysis. A beam telescope was used as a reference system, to allow for also track-based analysis of the recorded data.

Collaboration

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