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Design of the NAPA Prototypes Towards Large Area Sensors for Future e+e- Colliders

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The detectors at future e+e- linear colliders will need unprecedented precision on Higgs physics measurements. These ambitious physics goals translate into very challenging detector requirements on tracking and calorimetry. Monolithic Active Pixel Sensor (MAPS) technology offers small dead area, thin sensors, and small pixels over large areas,

Future e+e- Colliders require fast detectors with O(ns) timing tagging. This is feasible at the cost of a relatively high-power consumption that would not be compatible with cooling large areas with gas. Today some commercial imaging technologies offer the possibility of producing large, stitched sensors (with a rectangle area ~30 cm × 10 cm). Such large sensors are very interesting from a physics point of view, but they are very challenging from an engineering point of view.

A first MAPS prototype 'NAPA-p1'was designed by SLAC in CMOS Imaging 65 nm technology. The prototype has dimensions of 1.5 mm × 1.5 mm with a pixel pitch of 25 µm. This work benefits from our collaboration with CERN, capitalizing on the improved sensor's performance after a decade of optimizations. This prototype will set the baseline for the sensor and the electronics performance which will serve future developments.

The pixel is designed with auto-calibration schemes, thus avoiding the per-pixel threshold trimming. The power consumption is kept to a minimum of 720 nW/pixel, which will be scaled down by a factor or 100 or more for low duty cycle e+e- machines.

The simulations results of NAPA-p1 show a time resolution is 350 ps-rms and an equivalent noise charge (ENC) of 12 e-rms which are compatible with the target specifications.

NAPA-p1 is fabricated and the chip characterization has begun. Characterization results will be available soon.

In a parallel effort, a second prototype 'NAPA-p2'is being currently designed to tackle large area challenges. The key features of 'NAPA-2'are reduced power density, power pulsing, and good tolerance to ohmic voltage drops across a large column of 500 pixels. A discussion will be presented about the design strategies to allow the scalability of this design into a large-area stitched sensor of 20 cm × 5 cm, with specifications compatible with future e+e- colliders.

Early Career

Yes

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