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Smartpixels: radiation-hard ASICs with on-chip neural networks in 28 nm CMOS

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The *smartpixels* project is developing radiation-hard ASICs with embedded neural networks, fabricated using a 28 nm CMOS process, to enable data reduction at source using single-layer hit information in highly granular tracking detectors. This technology addresses the strict bandwidth and power constraints of fine-pitch trackers essential for future particle collider experiments, while simultaneously enhancing high-priority physics, especially signatures with heavy quark decays. For instance, smartpixels can improve low transverse-momentum (pT) b-tagging to increase acceptance of Higgs pair production with low invariant mass. The first implementation of the *smartpixels* ASIC integrates a filtering neural network that classifies the pT of incident particles based on charge cluster patterns in the sensors. This talk will describe the prototyped 1.6 mmˆ2 ASIC design (featuring two 16x16 pixel matrices of 25x25 umˆ2 pixels, with total power consumption of <6uW/pixel or <1W/cmˆ2), along with characterization and performance results evaluated at bunch crossing clock frequency. In parallel, filtering and regression networks to infer incident particle properties are being developed and evaluated for future on-chip implementations. Algorithmic studies assessing the impact of sensor geometry, radiation damage, electronic noise, and Lorentz drift on neural network performance will also be discussed.

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