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3D simulation and measurements of novel bias grid and edgeless ATLAS planar pixel sensor designs for the High-Luminosity LHC upgrade

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Substantial upgrades to the ATLAS Inner Detector (ID) must occur in order to be capable of withstanding the increase in occupancy and radiation damage expected from an upgrade to the High-Luminosity Large Hadron Collider (HL-LHC) in 2022. Minimisation of inactive regions for pixel detectors in ATLAS can be achieved through active edge design, where as implementation of alternative bias rail geometries can decrease efficiency loss. These improvements are desired to allow devices to be placed adjacently (instead of shingled), reducing cooling requirements, power consumption and material budget. Thinning of sensors increases radiation hardness, a vital parameter in the selection of pixel technologies for the inner layers which will be exposed to high particle fluence.

In this presentation three-dimensional simulations with Technology Computer Aided Design (TCAD), required to develop and optimise processing techniques for novel designs such as thin and edgeless structures, will be shown. Characterisation in a laboratory environment has been performed to study sensors coupled to ATLAS FE-I4 readout chips. Measurements include IV curves, laser scans, and source scans with radioactive sources and cosmic muons. Charge collection measurements for non-perpendicular particle tracks, resulting in charge clusters, have also been performed. Selected devices will be irradiated to analyse the performance of sensor designs at fluences expected in the ATLAS ID for the HL-LHC. Furthermore, comparison of simulation with Secondary Ion Mass Spectrometry (SIMS) measurements to study the doping profile of structures will be included.

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