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Optimization of thin n-in-p planar pixel modules for the ATLAS upgrade at HL-LHC

The ATLAS experiment will undergo around the year 2025 a replacement of the tracker system in view of the high luminosity phase of the LHC (HL-LHC) with a new 5-layer pixel system.
Thin planar pixel modules are promising candidates to instrument the innermost region of the new pixel system, thanks to the reduced contribution to the material budget and their high charge collection efficiency after irradiation. 100-150 μm thick sensors, interconnected to FE-I4 read-out chips, have been characterized with radioactive source scans and beam tests. Their performance up to a fluence of 10^16 1 MeV neq will be compared in terms of charge collection and hit efficiency.
New designs of the pixel cells, with an optimized bias structure, have been implemented in n-in-p planar pixel productions, and the possible gain in the hit efficiency investigated as a function of the received irradiation fluence. The outlook for future planar pixel sensor productions will be discussed, with a focus on sensor design at the pixel pitches (50x50 and 25x100 μm2) foreseen for the ATLAS read-out chip in 65 nm CMOS technology. First results of the characterization on planar sensors produced with these pixel cell sizes will be shown. Highly segmented sensors will represent a challenge for the tracking in the forward region of the pixel system at HL-LHC. In order to reproduce the performance of 50x50 μm² pixels at high eta, FE-I4 compatible planar pixel sensors have been studied before and after irradiation in beam tests at high incidence angle with respect to the short pixel direction. Results on cluster shapes, charge collection and hit efficiency will be shown.

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