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## Development of thin n-in-p pixel modules for the ATLAS upgrade at HL-LHC

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We present the results of the characterization performed on n-in-p pixel modules produced with thin sensors, ranging in thickness from 100 to 200  $\mu\text{m}$ , assembled to the ATLAS FE-I3 and FE-I4 read-out chips.

Among these samples, the sensors produced at VTT (Finland), 100  $\mu\text{m}$  thick, have been processed to obtain active edges, which considerably reduce the dead area at the periphery of the device down to 50  $\mu\text{m}$  per side. This feature, together with the very reduced material budget, makes them attractive candidates to instrument the inner layers of the upgraded pixel system at HL-LHC.

n-in-p sensors, 200  $\mu\text{m}$  thick, with a standard guard-ring, produced by CIS (Germany) are manufactured without an handle-wafer and they represent reliable and cost-effective detectors to cover the large surface of the outer layers of the new pixel system.

The different flavors of n-in-p pixel sensors are characterized by means of scans with radioactive sources and beam tests at the CERN-SPS and DESY. The results of these measurements will be discussed for devices before and after irradiation up to a fluence of  $1.5 \times 10^{16}$  neq  $\text{cm}^{-2}$ . The charge collection and tracking efficiency will be compared for the different sensor thicknesses.

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