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Assembly and characterization of 3D pixel modules for the ATLAS ITk detector

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The Large Hadron Collider (LHC) next upgrade is the High-Luminosity LHC (HL-LHC) planned to start operation in 2029. One of the most critical and demanding sub-detector systems of the ATLAS HL-LHC upgrade is the Pixel Detector of the Inner Tracker (ITk), which is a key component to achieve excellent track impact parameter resolution.

The basic unit of the ITk Pixel Detector is the pixel module, an assembly of one or more pixel sensors with their respective readout chips (the so-called bare modules or hybrids), mounted on a single flexible PCB (the flex) which allows for biasing and communication. The linear triplet modules, which will be used in the innermost layer (L0) of the barrel, are composed by a set of three pixel sensors, flip-chipped to their respective readout chips, and glued and wire-bonded to the flex.

Given the space constraint inside the Pixel Detector, each pixel module must meet demanding geometrical and alignment specifications. Consequently, a thorough study of the assembly and electrical validation methods was conducted, in order to develop appropriate strategies and well-structured procedures to ensure fine accuracy and high repeatability.

The sensors used for the linear triplet modules are 3D pixel silicon sensors which have been chosen because of their high-radiation tolerance. Novel 3D pixel sensors were manufactured using a single-side technology on Silicon on Insulator (SOI) wafers with an active thickness of 150 µm. Two kinds of pixel sensor cells will be used in the forward rings and in the barrel part of innermost layer, respectively: 50 x 50 μm^2 and 25 × 100 μm^2 both with one collecting electrode.

In this presentation I am going to briefly describe the assembly methodology to finally focus on the electrical tests and performance of first prototypes of linear triplets assembled at IFAE. Moreover, I am going to show the electrical characterization of the 3D pre-production sensors irradiated in a proton beam up to the final neutron equivalent particle fluence required for the innermost layer of ITk (1.7E16 neq/cm^2). These measurements are part of the Quality Assurance (QA) procedures for the ITk pixel sensor production.

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