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ALICE ITS3: a vertex detector based on truly cylindrical, wafer-scale Monolithic Active Pixel Sensors

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ALICE is one of the four major experiments at CERN Large Hadron Collider (LHC), studying the physics of strongly interacting matter at the highest energy densities reached so far in the laboratory. For this purpose, the ALICE detector is optimised to study the collisions of nuclei at the ultra-relativistic energies provided by the LHC. The optimisation involves efficient and precise tracking at high multiplicities of the particles resulting from the collisions, down to very low transverse momentum (p_T > 0.1 GeV/c).

The Inner Tracking System (ITS2) is the detector closest to the interaction point with the main goal to improve the precision of the reconstruction of the primary vertex as well as of decay vertices originating from heavy-flavour hadrons, and the performance in the detection of low-p_T particles. It is based on state- of-the-art silicon monolithic active pixel sensor ALPIDE featuring chip size of 3 cm × 1.5 cm. The ALPIDE chips are arranged in seven, quasi-cylindrical, concentrical layers of which the innermost three feature a material budget of 0.36% X0.

The ALICE Collaboration is planning to upgrade the ITS2 by replacing its three innermost layers during the LHC Long Shutdown 3 (2026-2028) with a completely new detector, based on wafer-scale monolithic active pixel sensors. To produce wafer-scale sensors, small reticles are combined into large sensors during the CMOS manufacturing processes called stitching. These large sensors, fabricated on 300 mm wafers, will subsequently be thinned down to values below 50 µm, where they are flexible to be bent into truly cylindrical half-barrels. By exploiting the self-supporting property of this arched structure, the support mechanics can be almost completely removed, and by reducing the beampipe size, the first layer can be installed even closer to the interaction point. Therefore, the three innermost layers of the ITS3 will be at distances of 18, 24 and 30 mm from the interaction point with a target thickness of below 0.05% X0 per layer. The tracking resolution is projected to improve by a factor of about two at p_T = 1 GeV/c with respect to the ITS2.

This contribution will review the ALICE ITS3 detector concept and the R&D path, focusing on the main results and milestones achieved in the first three years of the project. In particular, the following topics will be discussed: bending of the silicon layers, challenges relative to mechanics and air-cooling, assembly of detector mock-ups, technology qualification, design and testing of wafer scale monolithic active pixel sensors, and the detector integration.

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