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ALICE ITS3: a truly cylindrical vertex detector based on bent, wafer-scale stitched CMOS sensors

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The new Inner Tracking System (ITS2) of the ALICE experiment at the LHC, upgraded during the LHC Long Shutdown 2 (2019-2021) with CMOS monolithic active pixel sensors (ALPIDE), is currently taking data and demonstrating excellent performance in the LHC Run 3. A replacement of the three innermost layers of the ITS2, called ITS3, is foreseen during the LHC Long Shutdown 3 (2026-2028) in order to further improve tracking precision and efficiency, particularly at very low transverse momentum (pT > 0.1 GeV/c).

The ALICE ITS3 is a cylindrically bent silicon vertex detector based on stitched wafer-scale monolithic active pixel sensors with a 65 nm CMOS technology. The large stitched sensors are 28 cm in length and can be thinned down to below 50 μm, where the sensors are flexible to be bent to form truly cylindrical half-barrels. Air-cooling is feasible thanks to the reduced sensor power consumption of < 20 mW/cm2. An extremely low material budget of 0.05% X/X0 can be achieved in combination with lightweight carbon foam spacers as support structures.

This new technology for ITS3 was qualified with a set of test structures from the first submission (called MLR1: Multi-Layer Reticle 1). A successor prototype with dimensions of 14 x 259 mm, called MOnolithic Stitched Sensor (MOSS), has been designed to demonstrate the feasibility of the stitching process. Comprehensive laboratory characterizations and beam tests are underway to study the performance of MOSS.

In this contribution, the ALICE ITS3 detector concept, sensor bending mechanics and technology qualification achieved through MLR1 prototypes will be concisely reviewed. The MOSS design and its test system will be introduced, and the first results of the MOSS characterization in terms of manufacturing yield, power distribution and efficiency, data rates, noise, charge threshold, detection efficiency and spatial resolution will be discussed in detail.

Submission declaration

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