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The ATLAS High-Granularity Timing Detector: test beam campaigns and results

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The expected increase of the particle flux at the high luminosity phase of the LHC (HL-LHC) with instantaneous luminosities up to L ⊠ 7.5×1034 cm−2 s-1 will have a severe impact on the ATLAS detector performance. The pile-up is expected to increase on average to 200 interactions per bunch crossing. The reconstruction and trigger performance for electrons, photons as well as jets and transverse missing energy will be severely degraded in the end-cap and forward region, where the liquid Argon based electromagnetic calorimeter has coarser granularity and the inner tracker has poorer momentum resolution compared to the central region.
The High Granularity Timing Detector (HGTD), a new timing detector for ATLAS, will be installed in front of the liquid Argon end-cap calorimeters for pile-up mitigation and for bunch per bunch luminosity measurements. This detector will cover the pseudo-rapidity range from 2.4 to about 4.0. Two silicon sensors double sided layers will provide a precision timing information for minimum ionizing particles with a time resolution better than 50-70 ps per hit (i.e 30-50 ps per track) in order to assign the particle to the correct vertex. Each readout cell has a transverse size of 1.3×1.3 mm2 leading to a highly granular detector with about 3 millions of readout electronics channels. Low Gain Avalanche Detectors (LGAD) technology was chosen as it provides an internal gain good enough to reach large signal over noise ratio needed for excellent time resolution. A dedicated ASIC for the HGTD detector, ALTIROC, is being developed in several phases producing prototype versions of 2×2, 5×5 and 15×15 channels. HGTD modules are hybrids of the LGAD and ALTIROC connected through flip-chip bump bonding process.
Several test beam campaigns have been conducted at DESY and CERN SPS H6 beamline in 2022 and 2023. The performance of irradiated Carbon-enriched LGAD sensors has been studied. Module prototypes of 15×15 arrays with a pad size of 1.3×1.3 mm2 for the HGTD project have been tested. Their performance with charged-particle beams before irradiation is evaluated. A summary of the results from LGAD-only and hybrids will be presented.

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