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A High-Granularity Timing Detector for the Phase-II upgrade of the ATLAS Calorimeter system

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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 $\times 10^{34} cm^{-2} s^{-1}$ will have a severe impact on pile-up. 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 compared to the central region. A High Granularity Timing Detector (HGTD) is proposed in front of the liquid Argon end-cap calorimeters for pile-up mitigation at Level-0 (L0) trigger level and in the offline reconstruction. This device should cover the pseudo-rapidity range of 2.4 to about 4.2. Four layers of Silicon sensors, possibly interleaved with Tungsten, are foreseen to provide precision timing information for charged and neutral particles with a time resolution of the order of 30 pico-seconds per readout cell in order to assign the energy deposits in the calorimeter to different proton-proton collision vertices. Each readout cell has a transverse size of only a few mm, leading to a highly granular detector with several hundred thousand readout cells. Using the information provided by the detector, the contribution from pile-up jets can be reduced significantly while preserving high efficiency for hard-scatter jets. The expected improvements in performance are in particular relevant for physics processes with forward jets, like vector-boson fusion and vector-boson scattering processes, and for physics signatures with large missing transverse energy. Silicon sensor technologies under investigation are Low Gain Avalanche Detectors (LGAD), pin diodes, and HV-CMOS sensors. In this presentation, starting from the physics motivations and expected performance of the High Granular Timing Detector at the HL-LHC, then the proposed detector layout and Front End readout, laboratory and beam test characterization of sensors and the results of radiation tests will be discussed.

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