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A High-Granularity Timing Detector for the Phase-II upgrade of the ATLAS Calorimeter system: sensor performance.

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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. A High Granularity Timing Detector (HGTD) is proposed in front of the liquid Argon end-cap calorimeters for pile-up mitigation and for bunch per bunch luminosity measurements.

This device should cover the pseudo-rapidity range of 2.4 to about 4.0. Two Silicon sensors double sided layers are foreseen to provide a precision timing information for minimum ionizing particle with a time resolution better than 50 pico-seconds per hit (i.e 30 pico-seconds per track) in order to assign the particle to the correct vertex. Each readout cell has a transverse size of 1.3mm × 1.3 mm leading to a highly granular detector with about 3 millions of readout electronics channels. Low Gain Avalanche Detectors (LGAD) technology has been chosen as it provides an internal gain good enough to reach large signal over noise ratio needed for excellent time resolution.

Through a 4 period test-beam campaign at the CERN SPS H6A & B beamlines, proton and neutron irradiated LGAD prototypes for the HGTD upgrade were tested from several different technologies and manufactures. Gallium, boron and carbon implanted 1.3x1.3 mm2 diodes and 2 x 2 arrays are compared for achieved timing performance, post-irradiation efficiency and uniformity at fluences up to 6e15neq/cm2. Laboratory characterisation of large sensors arrays recently delivered (5x5 and 15x15 pads) will be also discussed. In addition the beam test measurement of a first HGTD module prototype made of 2x2 array sensor bump bonded to an ASIC called ALTIROC0, will be presented.

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