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LGAD radiation hardness studies for the High-Granularity Timing Detector (Phase-II upgrade of the ATLAS detector)

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A High Granularity Timing Detector (HGTD) is proposed for the ATLAS detector upgrade for the high luminosity LHC phase where the pile-up is expected to increase on average to 200 interactions per bunch crossing. The detector will be in front of the liquid Argon end-cap calorimeters for pile-up mitigation and for bunch per bunch luminosity measurements. 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 1.3 mm × 1.3 mm leading to a highly granular detector with about 3 million readout electronics channels on each side of the detector. Low Gain Avalanche Detector (LGAD) technology has been chosen as it provides an internal gain good enough to reach a large signal to noise ratio needed for excellent time resolution.

The main challenge faced by the HGTD collaboration is the development of an LGAD with sufficient radiation hardness for the entire lifetime of HL-LHC running, corresponding to a fluence of 5E15 n/cm2 equivalent neutrons and a total ionizing dose of 4 MGy. An interchange of the inner disc of detector with higher irradiation is planned mid-run. The chosen sensor must maintain throughout the entire run time the time resolution of 50 pico-seconds and a sufficient collected charge to allow the read out electronics to operate properly.
During the presentation the latest studies on radiation hardness of LGAD silicon detectors will be shown including the progress on deep gain layer implantation and carbon addition.

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