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In-depth study of Inverse-Low Gain Avalanche Detectors (ILGAD) for 4-dimensional tracking and radiation tolerance assessment of thin LGAD

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For the high-luminosity LHC upgrade, the ATLAS and CMS experiments are planning to include dedicated detector systems to measure the arrival time of Minimum Ionising Particles (MIPs). Such systems should provide a timing resolution of 30 ps per MIP. State-of-the-art timing technologies integrating Silicon photo-multipliers and plastic scintillators do not tolerate the hadron fluences expected at the end-cap detector regions (up to 3×10ˆ15 neq/cm2). To cope with these requirements, a Silicon sensor with integrated signal amplification, the Low Gain Avalanche Detector (LGAD) is the baseline sensing technology of the end-cap timing detector systems at HL-LHC. A comprehensive radiation tolerance study of LGAD pad-like sensors manufactured at IMB-CNM and irradiated at CERN's PS-IRRAD proton facility up to a fluence of 3×10ˆ15 neq/cm2 is presented here. Two different active thicknesses were studied: 35-microns and 50-microns; the effect of carbon co-implantation on the radiation tolerance was also investigated. The building block LGAD sensor of the above mentioned timing detector systems is designed as a pad diode matrix. The timing resolution of this LGAD sensor is severely degraded when the MIP particle hits the inter-pad region since there is no amplification in this region. This limitation is named as the LGAD fill-factor problem. To overcome the fill factor problem, a p-in-p LGAD (Inverse LGAD) was introduced. Contrary to the conventional LGAD, the ILGAD has a non-segmented deep p-well (the multiplication layer). Timing and tracking performance of the first ILGAD prototype is presented. ILGADs should ideally present a constant timing performance over all the sensitive region of the device without timing degradation between the signal collecting electrodes.These studies were performed within the context of the RD50 collaboration and partially funded by the H2020 EU project AIDA-2020.

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