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Influence of the ionization density on LGAD gain as measured with TCT, TPA-TCT and a beta source

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Low Gain Avalanche Diodes (LGADs) is one of the most promising sensing technologies for future 4D-tracking applications and has recently been qualified to be used in the ATLAS and CMS timing detectors for the HL-LHC upgrade. LGADs achieve an excellent timing performance due to the presence of an internal gain that improves the signal-to-noise ratio.
These detectors are designed to exhibit a moderate gain with an increase of the reverse voltage. However, the value of the gain strongly depends on the temperature. Thus, operation voltage and temperature must be kept under control in the experiments to maintain the gain within the required values. A reduction in the reverse bias or an increase in the temperature will reduce the gain significantly.
A further mechanism impacting on the gain was recently observed in LGADs. The gain measured in these devices highly depends on the charge density generated by a laser or particle in the bulk. Measurements performed with different detectors under different conditions showed that ionizing processes that induce less charge density in the detector bulk lead to an increase in the detector's measured gain.
Measurements were already conducted with IR-laser and Sr-90 in the lab confirming this mechanism. In this talk, we will present new measurements performed with a table-top Two Photon Absorption TCT system in a 300 um thick LGAD. Using this technique, very high charge carrier densities can be created inside the detector bulk at different depths that lead to different signal gain values. We present a model describing the observed data.

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