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Multiplication onset and electric field properties of proton irradiated LGADs

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In view of the LHC luminosity upgrade (HL-LHC), new radiation tolerant silicon sensors are being developed. Such sensors will have to cope with radiation levels of up to about 10^{16} fast hadrons/cm^2. Under these conditions, the degradation of the charge collection efficiency remains the main obstacle in detector operation. Furthermore, as new functionalities are given to silicon sensors, such as fast timing, new developments in sensor technologies and particularly in radiation tolerance are required. One of the options in order to tackle these challenges is the use of radiation tolerant silicon sensors with intrinsic charge gain, aiming to improve signal amplitudes after high radiation levels and improve the timing capabilities of silicon sensors. One of the proposed technologies for intrinsic gain sensors is Low Gain Avalanche Detectors (LGADs).

This work focuses on the study of a set of LGADs produced by CNM, Barcelona (Run 7859). Several samples were irradiated with 24-GeV protons up to different fluences, ranging between 10^{12} and 10^{15} 1 MeV n_{eq}/cm^2. The measurements performed to characterise the devices include TCT, edge-TCT, TPA-TCT, and CV/IV measurements. The main goal of these studies was to analyse the voltage required to fully deplete the multiplication layer of LGADs, and measure the gain degradation as well as the distribution of the electric field inside the devices as a function of radiation fluence. In order to do so, the measurements were performed under different temperature, read-out and biasing conditions.

The obtained data confirm that for the investigated highly irradiated LGADs the depletion starts from the back electrode, thus shifting the onset of the charge multiplication towards high voltages.

Author: OTERO UGOBONO, Sofia (CERN/Universidade de Santiago de Compostela (ES))

Co-authors: CENTIS VIGNALI, Matteo (CERN); FERNANDEZ GARCIA, Marcos (Universidad de Cantabria (ES)); GALLRAPP, Christian (CERN); Dr HIDALGO VILLENA, Salvador (Instituto de Microelectronica de Barcelona (IMB-CNM-CSIC)); MATEU, Isidre (Centro de Investigaciones Energéti cas Medioambientales y Tecno); MOLL, Michael (CERN); Dr PELLEGRINI, Giulio (Centro Nacional de Microelectrónica (IMB-CNM-CSIC) (ES)); VILA ALVAREZ, Ivan (Universidad de Cantabria (ES))

Presenter: OTERO UGOBONO, Sofia (CERN/Universidade de Santiago de Compostela (ES))

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