STUDY OF TIMING RESOLUTION OF PROTON IRRADIATED SILICON LOW GAIN AVALANCHE DETECTORS

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Silicon is the most widely used semiconductor in micro- and nano-electronics applications. Silicon-based particle sensors are widely employed in high-energy and nuclear physics experiments for radiation registering. One of the most prominent examples is the Large Hadron Collider (LHC) based at the European Organization for Nuclear Research (CERN) where silicon-based sensors are employed for particle tracking applications. Silicon-based Low Gain Avalanche Detectors (LGAD) with additional p^+ gain layer are characterised by their high time resolution and radiation hardness. Due to these properties LGADs are a promising alternative for p-i-n structure particle sensors in the future LHC upgrades [1]. The improvement of timing resolution on tracking sensors allows collecting only the data of time-compatible events and rejecting those events that cannot be associated to a track due to an excessive time difference [2].

However, high-energy radiation creates electrically active defects within the bandgap of the material, which determine the deterioration of sensors functional characteristics, e.g., increase of leakage current, decrease of charge collection efficiency, etc. [3], which also influence sensors temporal response. Therefore, it is important to characterise the devices before and after irradiation in order to evaluate the influence of radiation on the timing resolution of the sensor and predict its variations.

In this work, two sets of LGADs produced by Hamamatsu Photonics (HPK) [4] and Centro Nacional de Microelectronica (CNM) [5] with an active area of 1.3×1.3 mm^2 were investigated in a collaboration with CERN. The samples were irradiated with high energy protons (24 GeV) with fluences in the range of 10^{13} - 10^{15} p/cm^2. The timing resolution of the samples were examined and the correlations between its variations and proton fluences will be presented.

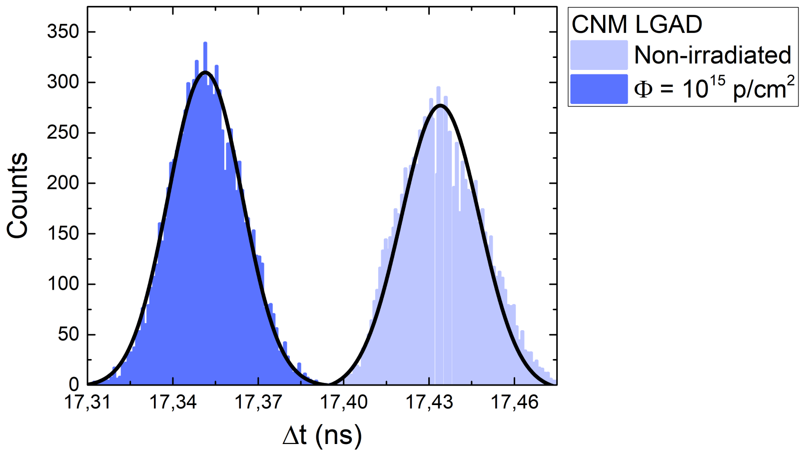

Fig. 1. Comparison of the distributions of time delay between laser pulse and detector signal between non-irradiated and irradiated with protons of fluence 10^{15} p/cm^2 samples.

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[2] M. Carulla et al., Nucl. Instrum. Methods Phys. Res., Vol. 924, 2019, p. 373-379.
[3] H. Spieler, Semiconductor Detector Systems, Oxford University Press, New York, 2005.
[4] www.hamamatsu.com (last checked 25 January 2024).
[5] www.imb-cnm.csic.es (last checked 25 January 2024).