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20 Mrad-TID Effects on Time over Threshold performance of GEMINI chip

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GEMINI is an integrated readout system designed for Triple-GEM detectors. To fully exploit the potential of this technology, GEMINI produces outputs for both arrival time and energy thanks to Time-over-Threshold (ToT) technique. This work presents an analysis of the effect of up-to-20 Mrad-TID absorbed by GEMINI chip in lab environment with X-rays. ToT data analysis before and after irradiation allows estimating overall performance variation while reproducing typical use cases with emulated input signals. Experimental GEMINI rad-hard performance will open new applications for this device.

Summary

GEMINI is a 16 channels integrated readout interface for Triple-GEM detectors. Each channel detects events comparing input signal with a 9-bit threshold and provides digital output with an LVDS driver for 6.7 mW-per-channel power consumption. The digital output allows to acquire information on both arrival time and input charge thanks to ToT technique. A complete GEMINI characterization, developed for imaging applications, has been presented in [1].

This work presents the experimental radiation hardness study for GEMINI. The methodology observes the same channel on two GEMINI chips irradiated with X-rays up to 20 Mrad-TID. Overall performance variations are evaluated comparing ToT data acquired from the channel with the same input signals before and after irradiation. In this way also TID-induces mismatch is studied, so important in imaging applications. Input signal provided to the GEMINI chips was generated emulating Triple-GEM detector output with charge between 250 fC and 1800 fC, to make generated ToT data to reproduce possible events read from the detector. ToT data histograms before irradiating the samples shows distinguishable peaks with positions consistent with input signals. ToT data acquired after irradiation shows that chip response variation due to radiation damage still allows correct operation of GEMINI. Comparison of average ToT obtained from each input signal before and after irradiation gives an average relative variation lower than 10 % and average variation of standard deviation lower than 6 %. These results suggest that corrections in data analysis could effectively address the problem of device ageing due to ionizing radiation.
Results obtained give positive indications about the adoption of GEMINI for ToT measurements with Triple-GEM detectors in new applications where rad-hard performance are mandatory like fusion experiments and monitoring of neutron sources.

[1] Mangiagalli, L. et al. "Characterization of GEMINI, a 16-channels programmable readout interface for Triple-GEM detectors in 180 nm CMOS.", TWEPP 2018

Author: MANGIAGALLI, Luca (University of Milano-Bicocca)

Co-authors: MATTIAZZO, Serena (Universita e INFN, Padova (IT)); PANTANO, Devis (Universita e INFN (IT)); MURARO, Andrea (CNR); CROCI, Gabriele (Universita & INFN, Milano-Bicocca (IT)); ABBA, Andrea (Università degli Studi e INFN Milano (IT)); GORINI, Giuseppe (Universita & INFN, Milano-Bicocca (IT)); BASCHIROTTO, Andrea (Univ. Milan Bicocca)

Presenter: MANGIAGALLI, Luca (University of Milano-Bicocca)

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