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Systematic study of heavily irradiated LGAD stability using the Fermilab Test Beam Facility

LGAD sensors will be employed in the ATLAS High-Granularity Timing Detector and the CMS MIP Timing Detector upgrades to mitigate the high levels of pileup expected in the High-Luminosity phase of the LHC. Over the last several years, much attention has focused on designing radiation-tolerant gain implants to ensure these sensors survive the fluences expected, in excess of 1–2E15 n_{eq}/cm^2. As verified with beta source measurements, the latest sensor prototypes are able to provide adequate gain for precision timing even at the end of life. However, in beam tests, highly irradiated LGADs operated at high voltage have been seen to exhibit violent burn-out events that render the sensors non-operational. We present the results of the first systematic study of heavily irradiated LGAD mortality using data collected at the Fermilab Test Beam Facility. In the present campaign, 30 sensors have been exposed to the 120 GeV proton beam in a highly controlled environment. We demonstrate that rare, highly-ionizing proton interactions can lead to single-event burn-out. Sensors with diverse characteristics and treatments are included to study which properties affect the mortality risk and understand potential mitigation strategies. With proper operational mitigation, we expect sensor mortality can be avoided with minimal impact on the performance of the final detectors.

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