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Radiation Hardness Assessment and Annealing Strategies for Silicon Photomultiplier Sensors on the Terzina Telescope on board the NUSES space mission

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NUSES is a pathfinder for new satellite platforms developed by THALES and cutting-edge photo sensing technologies, such as SiPM and their associated low-power-consuming electronics. NUSES is financed by the Italian Ministry and conducted by GSSI, with INFN sections and the University of Geneva. NUSES hosts two payloads: Ziré is devoted to low-energy cosmic rays and gamma-rays from gamma-ray bursts and space weather, and the Terzina telescope to the first observation from space of the Cherenkov light emitted by atmospheric particle showers induced by ultra-high energy cosmic rays along its optical axis and Earth skimming neutrinos above about 100 PeV. This faint light may only be detected viewing the dark side of the earth and atmosphere, hence the satellite maintains a sun-synchronous orbit at 535 km altitude. Such a space-based telescope would not be constrained by the day-night cycle, allowing for continuous exposure while using a small telescope compared to ground-based ones, viewing a large atmospheric region. Terzina is a Schmidt-Cassegrain telescope with dual mirror optics with a 935 mm effective focal length and a primary mirror with a diameter of 454 mm and a camera composed of 2 rows of 5 tiles of 8 × 8 SiPM pixels of 3x3 mm2 . The University of Geneva collaborated to define the SiPM for Terzina with the FBK Research Foundation and research into how this technology might degrade when exposed to the cosmic radiation background. Understanding the light noise in situ are vital for future larger missions or constellations of such satellites in the plans in the US and Europe. For this purpose we utilized a 50 MeV proton beam and a beta-radioactive source, Strontium-90, to carefully estimate the effect of radiation damage on the SiPMs. Then, we developed an annealing approach suitable for a space-based middle-size satellite to limit the effect of radiation damage while efficiently lowering the SiPM's energy detection threshold.

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