Contribution ID: **53** Type: **contributed talk**

Performance variation of FBK Silicon Photomultipliers with proton radiation up to 10^13 neq/cm2

Wednesday 19 February 2020 13:20 (20 minutes)

Silicon Photomultipliers (SiPMs) are very sensitive light detectors made by arrays of many Single-photon avalanche diodes (SPADs) connected in parallel. They are becoming more and more important in an increasing number of applications, such as high-energy physics experiments (e.g. photodetectors in the future upgrade of the CMS calorimeter) or more recently for reading out liquid noble-gasses scintillators, operating at cryogenic temperatures. When used in high-energy physics experiments, they are often exposed to high radiation doses during their operating lifetime, due to the interaction of hadrons, electrons, gamma- and X-rays.
For this reason in the last few years there has been a growing interest in studying the degradation of SiPMs performance after irradiation. Unfortunately, this kind of analysis is not straightforward since in SiPMs many aspects contribute to the overall performance, e.g. primary noise, correlated noise, quenching resistor value, recharge time-constant, etc. These should be studied separately in order to get insight into the damages and the physical modifications introduced by the radiation. Moreover, another drawback is that SiPMs generally lose their single-photon-resolution capabilities for radiation doses higher than ~ 10^9 -10^{10} neq/cm^2, thus preventing the possibility to use the most common measurements techniques for characterizing the photo-detection efficiency and the noise of SiPMs.
In this contribution we present the results of a systematic study of the effects induced in FBK SiPMs by proton irradiation, for different doses. In particular, we compare the effects induced in 1x1mm^2 SiPMs made with different cell pitch and with different technologies: RGB-HD, NUV-HD (HD stands for high-density) and RGB-UHD ("ultra-high-density"of cells). The bare SiPM dies have been irradiated at the LNS-INFN laboratories in Catania (Italy) with doses between 10^8 and 10^{13} neq/cm^2, and tested after about 1 month of room-temperature annealing. Results show that SiPMs are working up to an irradiation dose of 10^{13} neq/cm^2, but that there are saturation effects (due to the very high dark count rate) already at doses of 10^{12} neq/cm^2. The saturation effect is visibly dependent on the SiPM cell density. Noise of the SiPMs (i.e. dark count rate) shows an increment of about 1.5 orders of magnitude at irradiation doses of 10^8 neq/cm^2, of 2.5 orders of magnitude at irradiation doses of 10^{10} neq/cm^2 and of about 4 to 6 orders of magnitude at irradiation doses of 10^{13} neq/cm^2, reaching a DCR of ~10^{10} cps/mm^2. We verified that at irradiation doses higher than 10^{10} neq/cm^2 the SiPMs lose the single-photon resolution capabilities even when cooled down to -20℃. Further studies foresee to irradiate SiPMS with higher doses (e.g. 10^{14} neq/cm^2) and to measure irradiated samples at cryogenic temperatures.

Primary authors: Mrs ALTAMURA, Anna Rita (Fondazione Bruno Kessler, Trento, Italy; University of Udine (UniUd)); Dr REGAZZONI, Veronica (Fondazione Bruno Kessler, Trento, Italy); Dr ACERBI, Fabio (Fondazione Bruno Kessler, Trento, Italy); Dr MAZZI, Alberto (Fondazione Bruno Kessler, Trento, Italy); ZORZI, Nicola (Fondazione Bruno Kessler, Trento, Italy); Dr GOLA, Alberto (Fondazione Bruno Kessler, Trento, Italy)

Presenter: Mrs ALTAMURA, Anna Rita (Fondazione Bruno Kessler, Trento, Italy; University of Udine (UniUd))

Session Classification: Silicon Photomultiplier

Track Classification: Characterization (TCT and others)