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Understanding the Nonlinear Response of SiPM

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Abstract

A systematic study of the nonlinear response of Silicon Photomultipliers (SiPMs) has been conducted through Monte Carlo simulations. SiPMs have been proven to show a universal nonlinear response when it is expressed in terms of relative parameters independent of both the gain and the photon detection efficiency (PDE). Nonlinearity has been shown to mainly depend on the balance between the photon rate and the pixel recovery time. However, exponential-like and finite light pulses have been found to lead to different nonlinear behaviors, which also depend on the correlated noise, the overvoltage dependence of the PDE, and the impedance of the readout circuit. Correlated noise has been shown to have a minor impact on nonlinearity, but it can significantly affect the shape of the SiPM output current.

Considering these dependencies and previous statistical analysis of the nonlinear response of SiPMs, two simple fitting models have been proposed for exponential-like and finite light pulses, explaining the role of their various terms and parameters. Even though these models have only three fitting parameters, they provide an accurate description of the nonlinear response of SiPMs for a wide range of situations.

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