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Experimental SiPM Parameter Characterization from Avalanche Triggering Probabilities

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Efficient and low noise detection of vacuum ulta-violet (VUV) scintillation photons is critical for the nEXO experiment to achieve its projected sensitivity to zero-neutrino double beta decays. VUV SiPMs are being developed by Fondazione Bruno Kessler and Hamamatsu Photonics to fulfill nEXO's requirements. It is desirable to operate the SiPMs at high over-voltage in order to achieve maximum efficiency and single photon sensitivity while minimizing electronics power dissipation. However, the over-voltage is limited by cross-talk and after-pulse that eventually drive the detector performances. In order to understand the over-voltage dependence in detail, we have built a new model by extracting the electron and hole avalanche triggering probabilities using VUV and Infra-red light sources. Then we show that we can describe the over-voltage dependence of the dark noise, after-pulsing and cross-talk rates using a minimum set of parameters and extract the relative contribution of electrons vs holes for each process. We also show that this model predicts the behavior of the IV (current-voltage) curve. The data that are used in this analysis are for Hamamatsu VUV4 at temperatures ranging from -40 to -110C. In this talk, we will also review a method for extracting after-pulsing rates and discuss a new concept for probing the behavior of charge carrier produced deep in the silicon using two-photon ionization.

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