Contribution ID: **88** Type: **Talk**

Multi-Photon Time Resolution and Applications

Wednesday, 13 June 2018 09:50 (20 minutes)

There are many applications demanding for a photon-number-resolving detection of light pulses, some of them also require an extreme timing resolution at the multi-photon level (TOF PET, LIDAR, 4D calorimetry). Silicon photomultipliers (SiPMs) operate in both detection modalities with outstanding performance and appear to be a well-recognized detector of choice in such applications.
Therefore, it is necessary to understand all factors and limitations affecting the time resolution of SiPM-based detectors. Indeed, the time resolution of SiPMs is extensively studied in experiments and Monte-Carlo simulations mostly with respect to scintillation detection. These approaches clarify some basic features, however, there is still a lack of analytical models and results describing multi-photon time resolution (MPTR), especially for an arbitrary pulse shape.
This study is focused on how the single photon time resolution (SPTR) influences the MPTR, because it is still a less clarified point with respect tofactors as, for example, photon detection efficiency (PDE) of a photodetector.
Our goal is to represent and analyze the MPTR analytically as a function of the most important SiPM parameters (SPTR, PDE, single electron response pulse shape) and the light pulse (number of photons, rise and decay times or FWHM).
This analytical model of the MPTR and its correspondence with some experimental results (exponential and Gaussian shapes of the light) will be presented and discussed.

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Session Classification: Timing Properties (FAST Action WG3 Meeting)

Track Classification: Timing Properties