Optimizing Time Resolution for Large Area Silicon Photomultipliers

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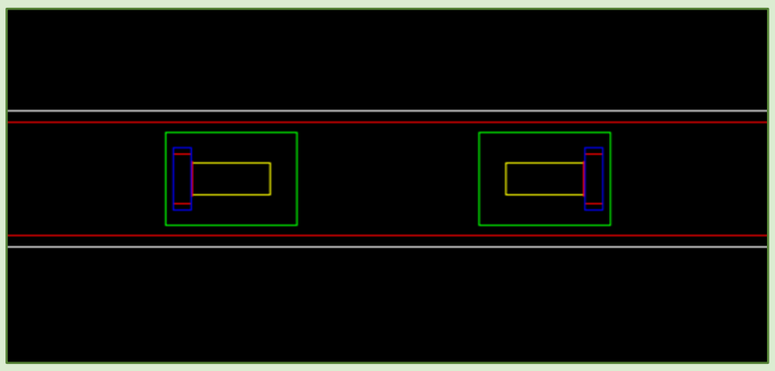
Simulation Overview

Framework that enables a global optimization of the PET system that consider **scintillator** (rise and decay time, surface treatment), **sensor** (sensor size, pixel pitch, dead area, capacitance) and readout **electronics** (bandwidth, input impedance, noise, summation).

- **GATE**; simulation of the gamma ray interaction and light transport inside the crystal towards the sensor.
- **Cadence**; simulation of the sensor electrical output and fast front-end electronics response.

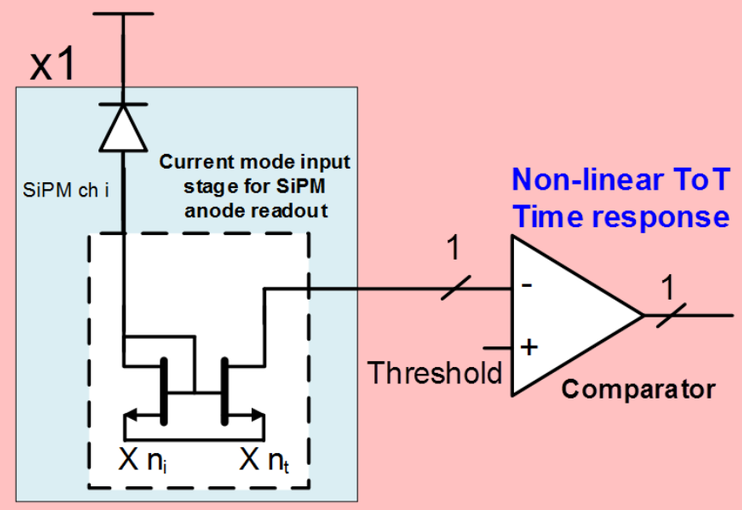
Coincidence Time Resolution (CTR) setup in GATE



- LFS scintillator crystal of 3x3x20mm^2 (yellow).
- SiPM sensor of 3x3 mm^2 and 75μm of pixel pitch (red).

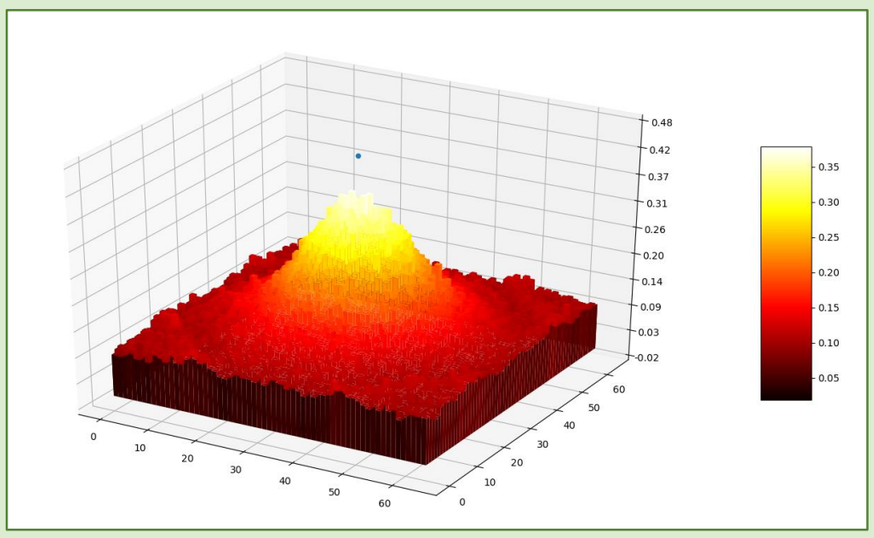
Output file that includes arrival time of photons is used as input for Cadence.

Test bench in Cadence



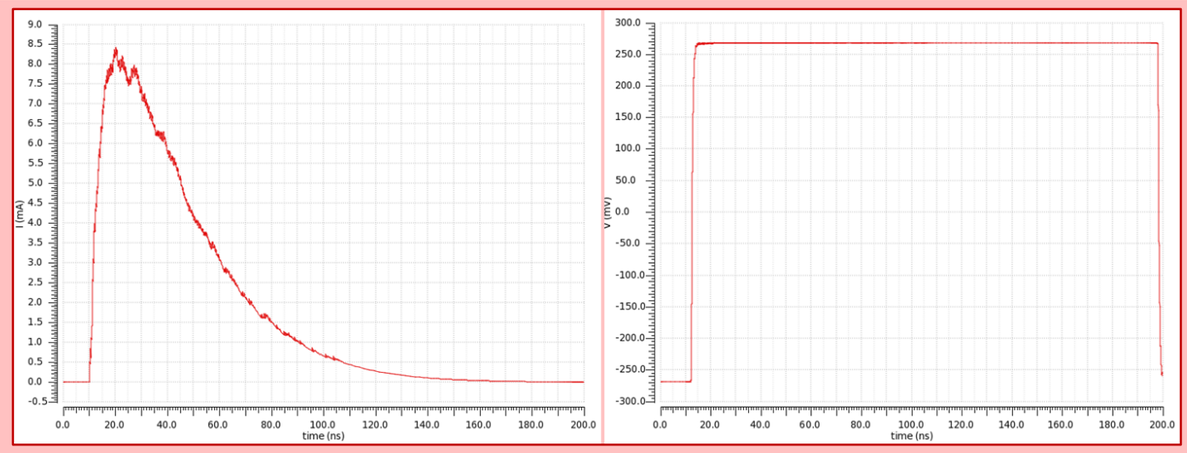
- Time response based on the FlexToT ASIC.
- Optimal threshold is expected to be between 1st and 2nd photoel.

Photon distribution at the sensor face in GATE



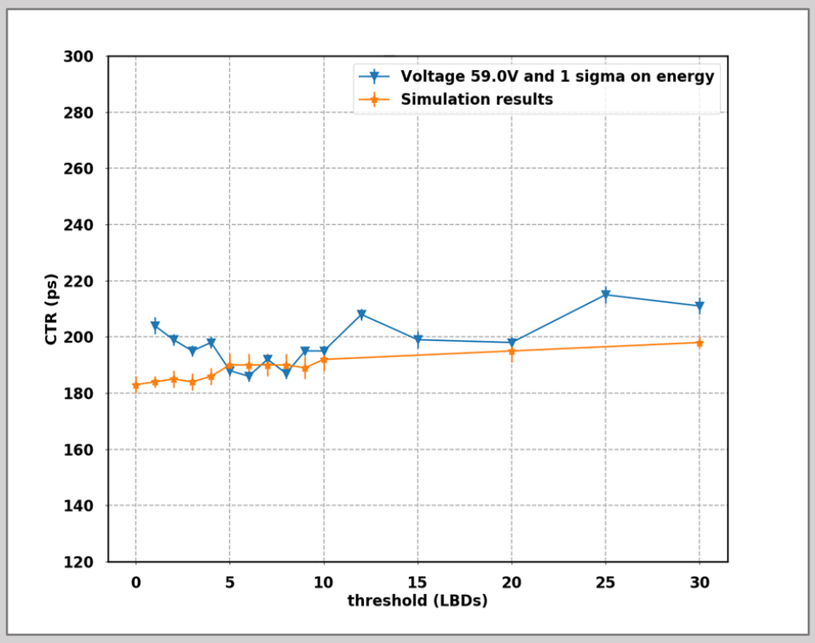
- Typical photon distribution in the detector face when the gamma ray interaction occurs in the central axis of the crystal.

SiPM and timing signals in Cadence



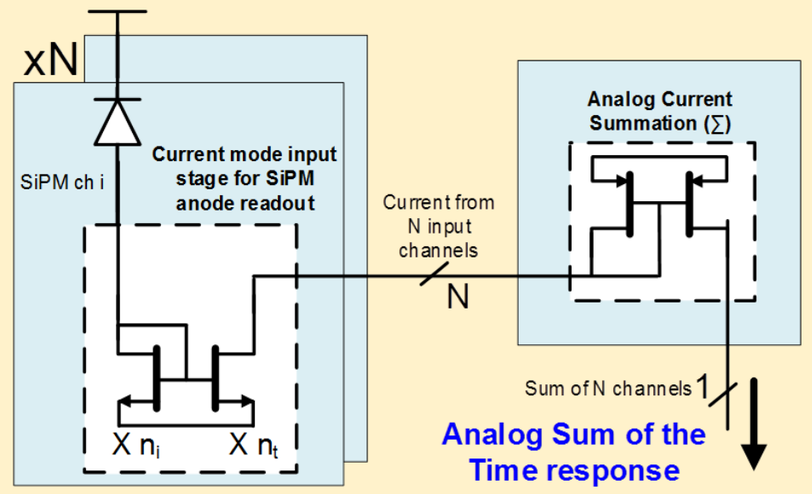
- **Left:** Signal generated after firing hundreds of pixels of the SiPM from a gamma ray interaction with the crystal.
- **Right:** Non-linear ToT time response. The rising edge gives the arrival time of the gamma interaction. CTR is obtained as the std. dev. of the cumulative delay distribution.

CTR comparison between simulation and real measurement

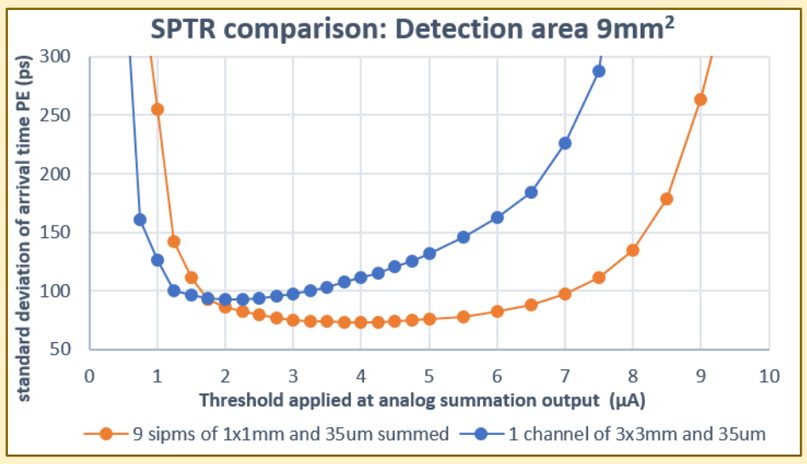


- CTR results comparison between the simulation and the real data taken with the FlexToT ASIC.
- Sensor: LCT4 3x3mm^2 and 75μm of pixel pitch. Crystal: LFS of 3x3x20mm^2.

Simulation of analog summation of individual and small SiPMs



- Block diagram employed to evaluate **summation** of small and individual SiPMs and compare it with a single big SiPM, both system with the same detection area.
- It uses the same readout input stage above mentioned.



- Comparison between a single channel SiPM of 3x3 mm^2 and the analog summation of 9 small SiPMs of 1x1 mm^2.
- The Single Photon Time Resolution (SPTR) is computed as a first parameter to compare the performance of the analog summation.

Better time response summing small SiPMs!

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