SiPM Performance Characterization for Total-Body J-PET: Hamamatsu vs. Onsemi

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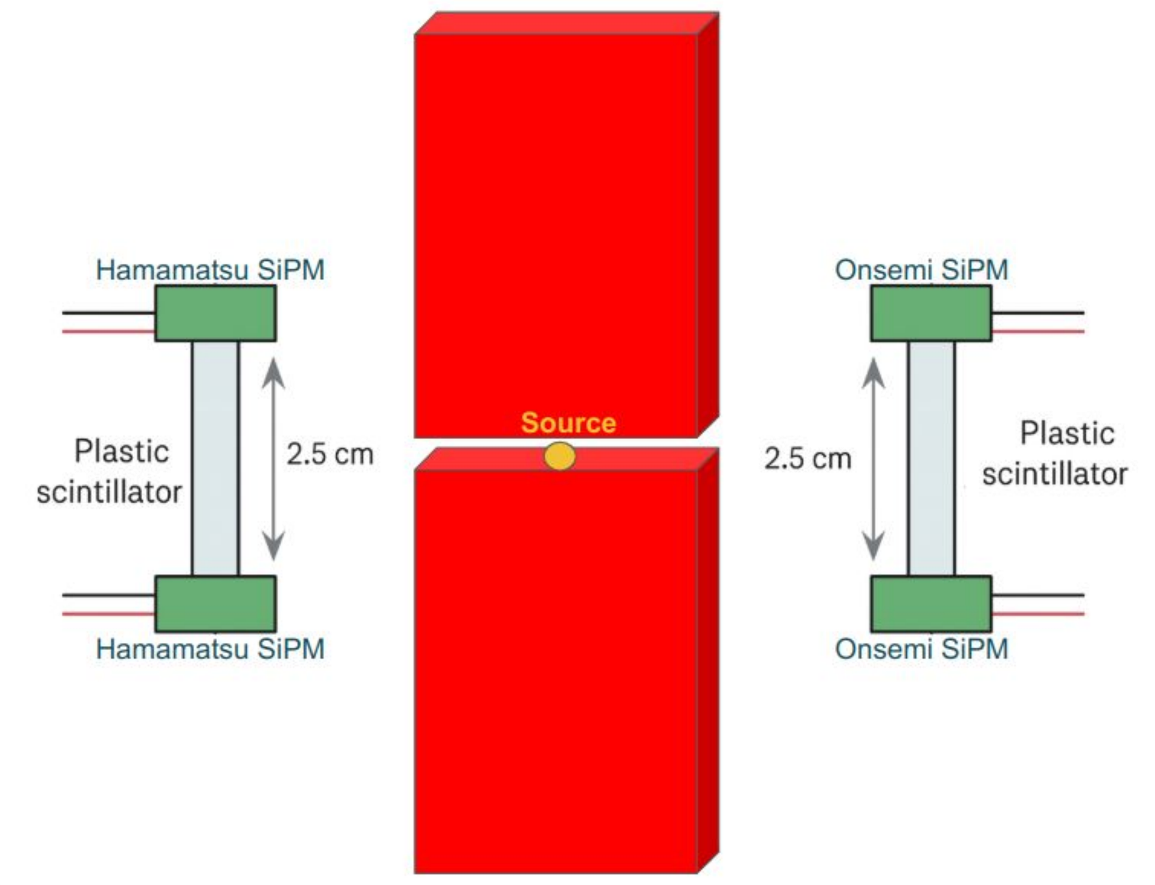
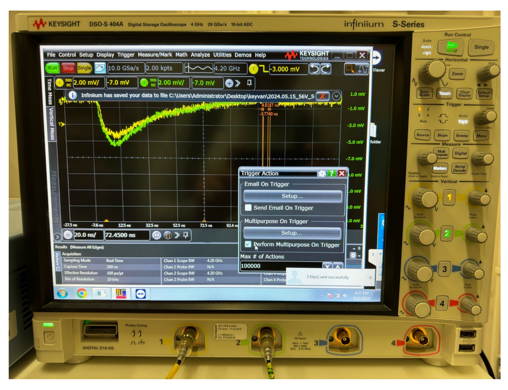
Abstract:

Total-body Positron Emission Tomography (PET) has begun to see clinical use; however, widespread adoption in hospitals requires a significant reduction in construction costs [1]. We are developing a cost-effective total-body J-PET system based on plastic scintillator strips coupled with Silicon Photomultipliers (SiPMs) at their axial ends [2]. A critical aspect of optimizing this involves the comparison of different SiPM types. SiPMs, representing the latest generation of photomultipliers, offer significant advantages over traditional Photomultiplier Tubes (PMTs) [3], including low operating voltage and insensitivity to magnetic fields, making them ideal for various applications, including nuclear medicine. This study focuses on characterizing and comparing the performance of different SiPM types from leading manufacturers, Hamamatsu and Onsemi, to identify the optimal SiPM for the total-body J-PET system.

In the experimental phase, individual detector units comprising plastic scintillator strips (6 × 6 × 25 mm³) coupled with Hamamatsu (S14160-6050HS) and Onsemi (MICROFJ-60035-TSV) SiPMs of identical active surface area were thoroughly characterized. A collimated beam of 511 keV photons from a Na-22 isotope source was employed to evaluate key detector performance parameters, including signal amplitude, rise time, fall time, charge, and Time of Flight (TOF) resolution [4]. Following this thorough characterization and comparative analysis, the optimal SiPM was identified for integration into the total-body J-PET system, contributing to its cost-effective and high-performance design.

Experimental setup:





Scintillator Lengths: 2.5 cm.
Scintillator: EJ-200
SiPM:
1. Hamamatsu S13361-6674
2. Onsemi MICROFJ-60035-T

Scintillator: EJ-200
Source: Na

SiPM	Breakdown Voltage (V)	Over voltage (V) according to the data sheet	Applied Over voltage (V)
Onsemi 1	25.2 – 24.7~ 25	+6	+6 (26, 27, 28, 29, 30, 31)
Onsemi 2	25.2 – 24.7~ 25	+6	+6 (26, 27, 28, 29, 30, 31)
Hamamatsu 1	38	+2.7	+6 (39, 40, 41, 42, 43, 44)
Hamamatsu 2	39	+2.7	+6 (40, 41, 42, 43, 44, 45)

Analysis:

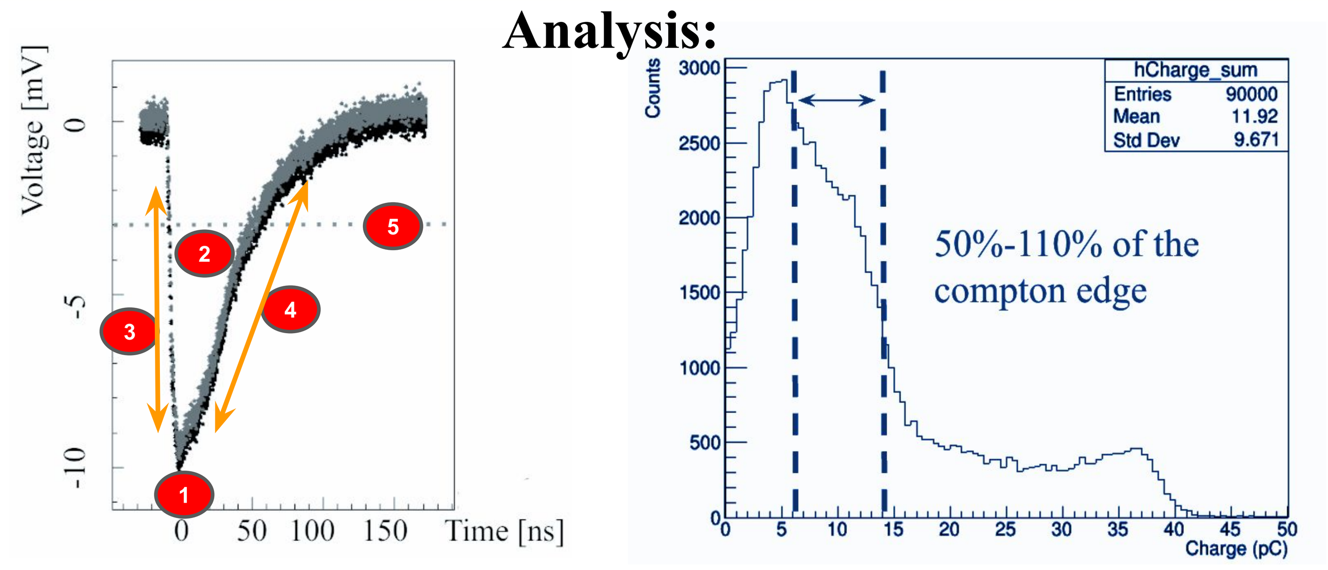


Figure 1. (Left) Sample of the one signal. (Right) raw charge sum spectra.
1- Amplitude (Minimum pick) 2- charge (area under the red signal) 3- Rise Time (based on 10-90% of amplitude) 4- Fall Time (based on 90-10% of amplitude) 5- Time difference (is the difference between the rising edge in constant threshold from both SiPMs)

Results and conclusion:

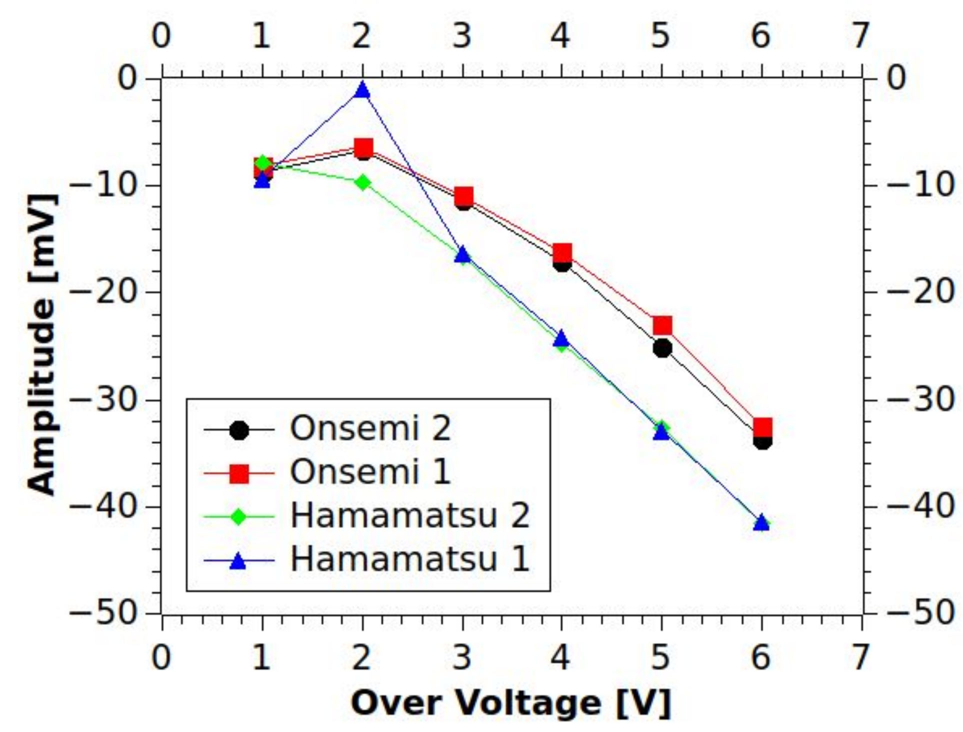


Figure 2. Amplitude based on different over voltage

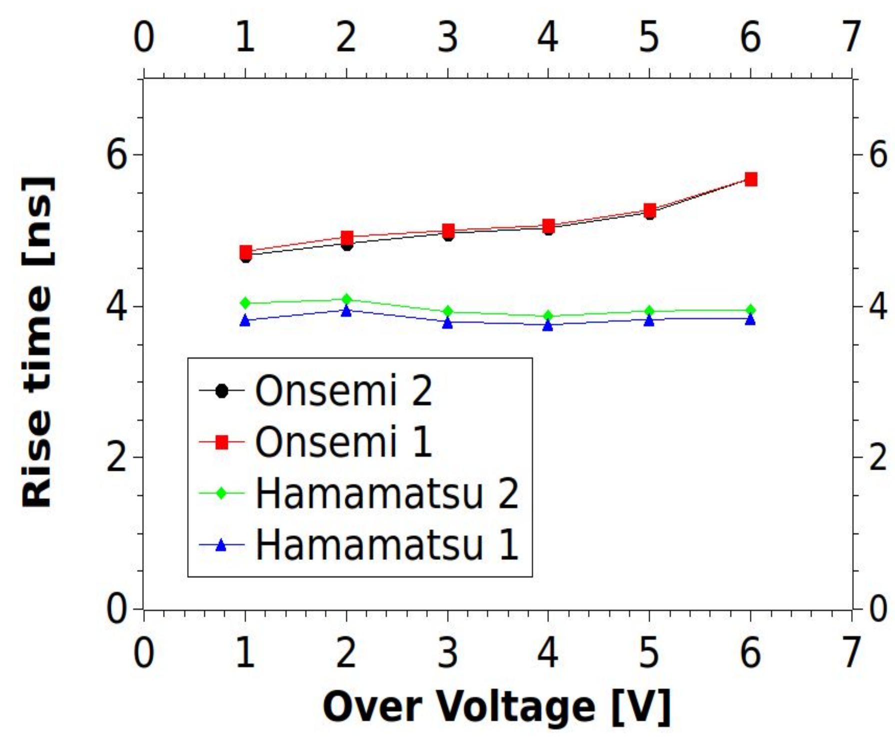


Figure 3. Rise time based on different over voltage

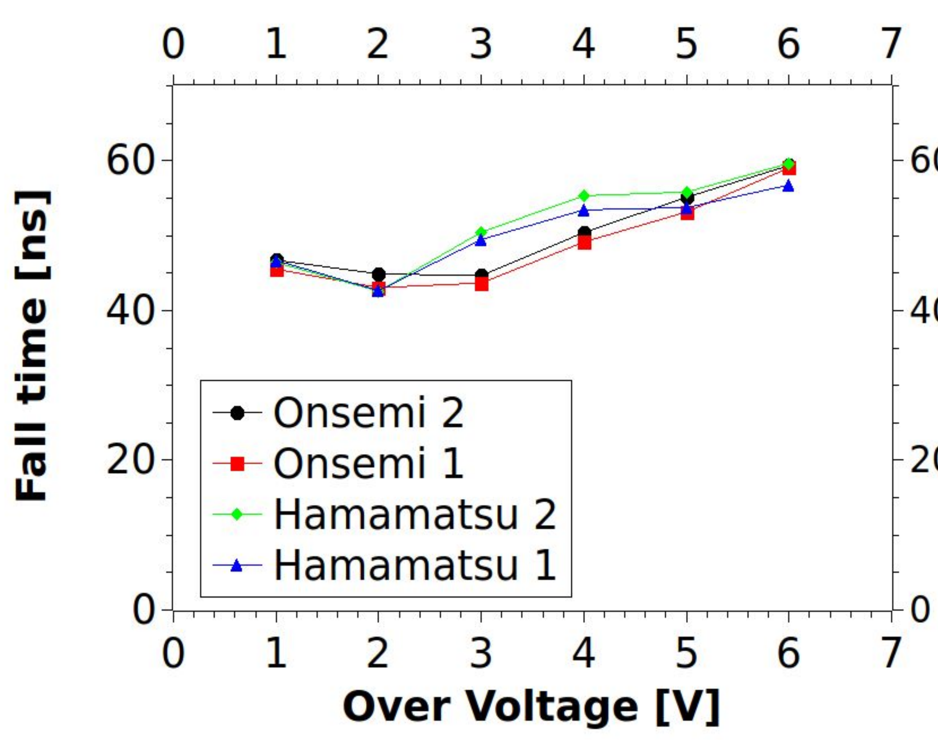


Figure 4. Fall time based on different over voltage

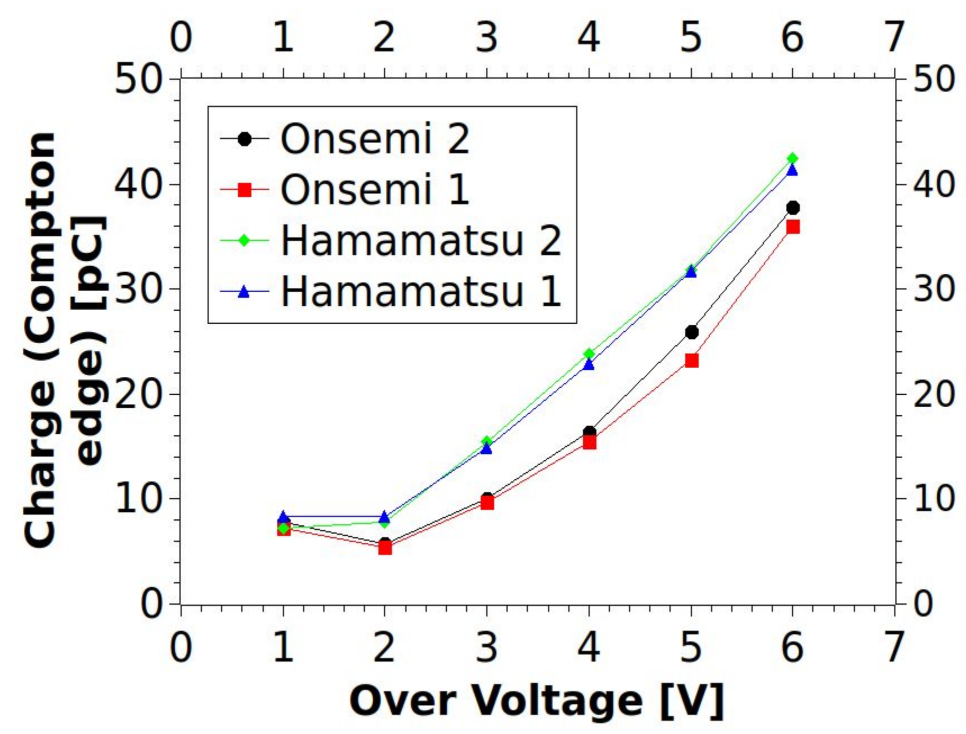


Figure 5. Charge based on different over voltage

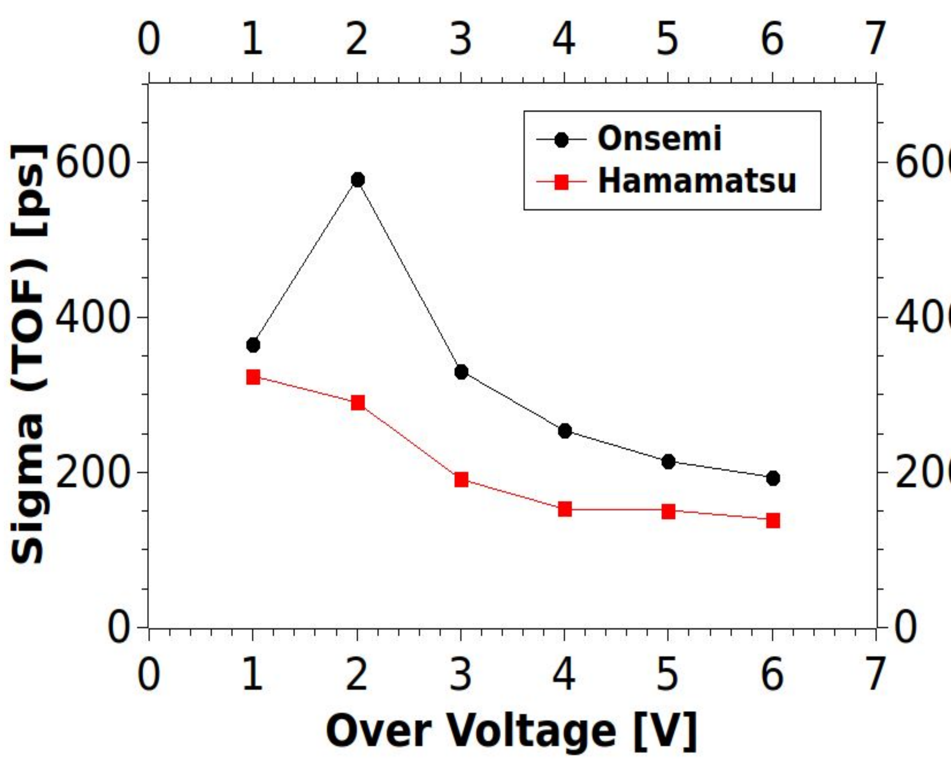


Figure 6. Sigma (TOF) based on different over volta

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References:

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[4]. P. Moskal et al., "Test of a single module of the J-PET scanner based on plastic scintillators", Nuclear Instruments and Methods in Physics Research A, 764 (2014) 317-321.