

Timing limits of the TOFPET2 ASIC

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Novel front-end designs have shown to push the timing performance of scintillators and silicon-photomultipliers (SiPMs) used in PET applications, such that their physical limits regarding timing performance can be established. Using an electronic high-frequency (HF) readout concept, we determine the contribution of a commercial application-specific integrated circuit (TOFPET2 ASIC by PETSys Electronics S.A., version 2c) on the time-of-flight (TOF) resolution after establishing the SiPM and scintillator performance as a benchmark. We furthermore adapt the SiPM readout prior to the ASIC front end, filtering and amplifying the signals to boost the timing performance. Small LYSO:Ce crystals (EPIC-crystals, 2x2x3mm³) and Broadcom AFBR-S4N33CO613 achieved a coincidence time resolution (CTR) of 82 ps (FWHM) if connected to an HF readout circuit, while measurements with the same SiPM-crystal configuration and the TOFPET2 ASIC result in a CTR of 142 ps (FWHM). This performance was boosted to 128 ps (FWHM) by an adapted version of the HF readout in combination with the TOFPET2 ASIC. The same method used with a 3x3x20mm³ LYSO:Ce crystal, led to a CTR improvement from 202 ps (FWHM) to 187 ps (FWHM). The intrinsic performance of the TOFPET2 ASIC was determined to 58 ps (FWHM). Evaluating all measurements, we could show that the TOFPET2 ASIC should be capable of achieving 100-ps CTR. The reason for this discrepancy is suspected to lay in the front-end design, but is currently still under investigation. Our attempts to boost the CTR revealed additional side peaks close to the main peak in coincidence time difference spectra. The appearance of these peaks is shown to be linked to the signal height routed into the ASIC front end.

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