Scintillation Pulse Analysis by Context-Aware Time-Domain Filtering for Time-of-Flight PET Systems in Moderate Pile-up

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Introduction

Time-of-Flight Positron Emission Tomography is an upcoming trend aiming at improving the relationship between the tomographic image quality, radiative dose administered to patient, and throughput of patients per PET scanner.

Due to relatively stringent requirements on read-out electronics, imposed by the targeted coincidence resolving time resolution of better than 200ps FWHM, a rather attractive read-out architecture option is a spatially multiplexed one, saving significantly on the number of acquisition channels.

First results

Serving more scintillator surface per channel of read-out translates into proportionally higher probability for pulse pile-up. This is commonly considered a showstopper in TOF PET designs. First experimental evidence however indicates that groups of two or more pulses offer significantly more PET information than commonly thought.

We find that the energy resolution is typically almost unaffected, when using sufficiently robust pile-up reconstruction techniques [1]. Temporal resolution, crucial for the TOF regime, is mainly unharmed for the first pulse in a tight group, but lost significantly for all non-first pulses the group.

This however can most likely be overcome to a significant degree by carefully designed interleaving of the multiplexed read-out. We are currently building a scheme to recover most of the events where a Compton scatter as well as the subsequent photo-absorption of the same gamma photon are registered, and exactly one of both pulses affected by pile-up. The speculation is at this point that almost all Time-of-Flight information can be recovered in such cases.

Summary

Algebraic treatment of digitized pulses, combined with adaptive event reconstruction schemes allows for surprisingly tight pile-up conditions while still supporting time-of-flight fidelity of read-out.

Acknowledgment

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Reference

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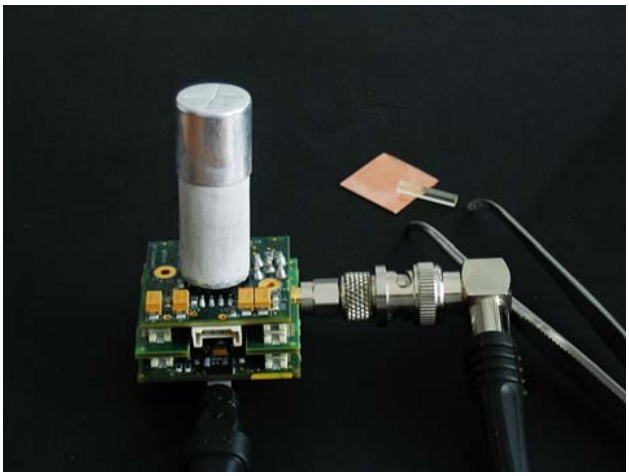

Fig. 1: LYSO based scintillator coupled to a SiPM in the capsule and mounted on a fast low-noise trans-impedance amplifier board.