

Power efficient high-frequency readout of timing optimized SiPMs for Cherenkov radiation

Friday, June 3, 2022 5:30 PM (15 minutes)

Recent SiPM developments and improved front-end electronics have opened new doors in TOF-PET with a focus on prompt photon detection. For instance, the relatively high Cherenkov yield of Bismuth-Germanate (BGO) upon 511keV gamma interaction has triggered a lot of interest, especially for its use in total-body PET scanners due to the crystal's relatively low production costs. However, the electronic readout and timing optimization of the SiPMs still poses many questions. Lab experiments have shown the prospect of Cherenkov detection, with coincidence time resolutions (CTRs) <200ps FWHM achieved with small pixels, but lack system integration due to an unacceptable high power consumption of the used amplifiers.

In this contribution, we will discuss different readout concepts of analog SiPMs for which we studied several high-bandwidth amplifiers with a power consumption ranging from 288mW to 17mW. We found that all tested amplifiers showed similar CTR performance of ~100ps FWHM coupling 3x3x3mm³ LYSO:Ce from Epic-crystals to an S14160-3050HS Hamamatsu SiPM. In addition, we identified the noise contribution to the timing as negligible for all designs.

In a further step, we selected the most practical circuit, having 70mW power consumption per channel, and tested with BGO the CTR performance of newly developed SiPMs from Fondazione Bruno Kessler, optimized for highest single photon time resolution (SPTR). We achieved a best CTR FWHM of 127ps for 2x2x3mm³ and 245ps for 3x3x20mm³ BGO crystals.

To give an insight in the timing properties of these SiPMs, we measured the SPTR with black coated PbF₂ crystals of 2x2x3mm³ size. We confirmed an SPTR of 68ps FWHM published in literature for standard devices and show that the optimized samples can improve this value to 55ps. Pushing the SiPM bias to its limits, we even measured an SPTR as high as 40ps FWHM. In an extended discussion we will give a roadmap to best timing with prompt photons and an outlook on system integration.

Primary authors: GUNDACKER, Stefan (Department of Physics of Molecular Imaging Systems (PMI)); NADIG, Vanessa (PMI); HERWEG, Katrin (PMI); BORGHI, Giacomo (FBK); MERZI, Stefano (FBK); MORETTI, Elena (FBK); PENNA, Michele (FBK); GOLLA, Alberto (FBK); SCHULZ, Volkmar (PMI)

Presenter: GUNDACKER, Stefan (Department of Physics of Molecular Imaging Systems (PMI))

Session Classification: System considerations for TOFPET CTR resolution ≤100ps

Track Classification: System considerations for pushing TOFPET CTR ≤ 100ps