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Experimental advances of photon detection time resolution limits in SiPMs and scintillator based detectors

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Scintillator based radiation detectors readout by SiPMs successively break records in their reached time resolution. Nevertheless, new challenges in time of flight positron emission tomography (TOF-PET) and high energy physics are setting unmatched goals in the 10ps range. Recently we have shown that high frequency (HF) readout of SiPMs significantly improves the measured single photon time resolution (SPTR), allowing to evaluate the intrinsic performance of large area devices; e.g. we measured 90ps FWHM with FBK NUV-HD SiPMs of 4x4mm^2 area and 40μm SPAD size. In this contribution we will summarize the intrinsic SPTR for different producers, e.g. FBK, HPK, Ketek, SensL etc. In TOF-PET such readout allows to lower the leading edge detection threshold, so that the fastest photons produced in the crystal can be utilized. This is of utmost importance if a high SPTR and prompt Cherenkov light generated by the hot-recoil electron upon 511keV photoabsorption should improve timing. In this context we measured a CTR of 150$\pm$3ps FWHM with 2x2x3mm^3 BGO crystals coupled to FBK SiPMs. This faint Cherenkov signal is as well present in standard LSO scintillators, improving the CTR of 2x2x3mm^3 LSO:Ce:Ca coupled to FBK NUV-HD 4x4mm^2 with 25μm SPAD size to 61$\pm$2ps FWHM using HF-electronics, as compared to 73$\pm$2ps when readout by the NINO front-end ASIC. This new experimental data will allow us to evaluate further the timing limits in scintillator-based detectors.

Authors: GUNDACKER, Stefan (CERN); MARTINEZ TURTOS, Rosana (CERN); AUFFRAY HILLEMANNS, Etiennette (CERN); PAGANONI, Marco (Universita & INFN, Milano-Bicocca (IT)); LECOQ, Paul Rene Michel

Presenter: GUNDACKER, Stefan (CERN)

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