Preliminary timing measurements on a data acquisition chain for a SiPM-based detector for prostate imaging

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Prostate cancer (PC) is one of the most common diseases in western countries and a leading cause of cancer death. A variety of treatment options are available but a precise disease characterization is needed: evaluation of cancer location, size, and extent and an indication of tumor aggressiveness. The current standard for diagnosing PC is transrectal ultrasound (TRUS) guided sextant biopsy. A novel multidisciplinary approach is required. Imaging may play a key role provided that dedicated prostate imagers and procedures are available: considerable improvements have been implemented in diagnosis with the Magnetic Resonance Imaging (MRI) and nuclear medicine (PET and SPECT) techniques. Nevertheless, due to sub-optimal prostate imaging geometries with these generic large instruments preventing separation of the signal from surrounding organs, the sensitivity, spatial resolution and lesion contrast detected are lower compared to what can be potentially achievable with optimized dedicated prostate imagers and procedures. Fully exploiting the Time Of Flight (TOF) capability would allow not only to increase the SNR/NECR but also to get rid of the huge background coming from neighboring organs i.e. the bladder. Recently a new research project was initiated by a large INFN collaboration, and a “TOF-PET and MRI for prostate cancer diagnosis and follow up experiment” (TOPEM) was financed as a 3-year experiment by the Italian “INFN Commissione Scientifica Nazionale V” with the goal of designing, building and testing in phantom tests an endorectal PET-TOF probe compatible with MRI. This project covers several scientific and technological aspects to build a probe prototype in 3 years, i.e., Silicon Photo Multiplier (SiPM) characterization, readout approach via Application Specific Integrated Circuit (ASIC), PET-TOF and MRI imaging. A big advantage of using SiPMs in fast timing is a low jitter, typically below 100 ps, despite low photon detection efficiency, not exceeding 10 ÷ 20%, depending on the number of pixels. One of the aims of the experiment is to improve the timing resolution of the detector - today in the order of 600 ps - down to 100 ps and below, as reported in recent works. This presentation reports a feasibility study to use an electronic data acquisition chain that is currently implemented within one of the Large Hadron Collider (LHC) experiments to obtain TOF measurements. This electronic chain is the starting point to design an ASIC component to read out SiPM signals and to match the size and time requirements for applications in prostate TOF-PET imaging. Preliminary timing measurements have been performed in laboratory using the equipment shown in Fig.1. Fig.2 shows that the overall timing resolutions can reasonably stay on the order of tens of ps, i.e. below 100 ps. These results originated providing stimuli from a pulse generator that emulates commercial SiPM signals. Timing performance of commercial SiPMs, photon detection efficiency, pixel capacitance and device size are some of the questions to be addressed by the TOPEM collaboration in the first phase of the R&D.