Contribution ID: **45** Type: **Talk**

Performance characterization of MPPC modules for ToF-PET applications

Monday, 21 May 2018 16:30 (20 minutes)

Current generations of PET detector designs feature arrays with large numbers of multi-pixel photon counters (MPPCs), also known as silicon photomultipliers (SiPMs), necessitating the use of data acquisition systems with either a high degree of signal multiplexing or using application specific integrated circuits (ASICs) to readout each pixel independently. In this work we evaluate the performance of two Hamamatsu C13500-4075LC-12 PET detector modules designed for time-of-flight (ToF) PET applications. These modules each have a 12 × 12 array of lutetium fine silicate (LFS) scintillator crystals (20 mm deep, 4.2 mm pitch) one-to-one coupled to a 12 × 12 array of 4 mm MPPC elements. Each detector has a total of 8 18 channel ASICs that utilize a time-over-threshold (ToT) readout method. Data were acquired to characterize the detector stability vs. temperature and event rate. At low event rates, the detectors have a FWHM energy resolution of 10.0%, measured in a linearized energy spectrum, and a coincidence timing resolution (CTR) of 275 ps FWHM with an energy window of ±1 FWHM of the 511 keV photopeak. The average change in the 511 keV photopeak amplitude in the ToT spectrum is 0.24%/°C. There was <10% event loss up to 1.45 Mcps/detector, beyond which bandwidth limits were encountered. From a count rate of 35 kcps to 1.45 Mcps the 511 keV photopeak position varied by 1.2%, while the FWHM of the photopeak increased by 53.9%. Over this count rate range the CTR varied from 285 ps to 435 ps FWHM. The performance of the ToF-PET modules suggests they will be well suited to use in whole-body PET and PET/MR imaging applications.

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Session Classification: Session 3 - Instrumentation: systems and detectors