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Performance studies towards a TOF-PET sensor using Compton scattering at plastic scintillators

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Positron emission tomography is a powerful tool in nuclear medicine for diagnosing cancers and Alzheimer's disease in early stages. We develop a sensor head for a Time-of-flight PET scanner using plastic scintillators which have a very fast timing property. Since the cross section of the photoelectric absorption in plastic scintillators is extremely small at 511 keV, we use Compton scattering in order to compensate the detection efficiency. The detector consists of two layers of scatterers and absorbers which are made of plastic and inorganic scintillators such as GAGG:Ce, respectively. Signals are read by monolithic Multi Pixel Photon Counters (MPPCs), a.k.a. SiPMs, and recorded by sampling Analog-to-digital converters and Time-to-digital converters with a timing resolution of 27 ps/bit. The scintillators are built to be capable of resolving interaction position in 3-dimentions, so that our system has also a function as Depth-of-Interaction PET scanners. We roughly estimated and confirmed using Geant4 that the total detection efficiency should be comparable to conventional PET sensors, and then proceeded to experimental demonstrations.
We report the capability of our system which is under active development. We successfully demonstrated the better timing performance of the plastic scintillators than that of LYSO:Ce and GAGG:Ce. We will present the timing resolution of the plastic scintillators for coincidence events, position-resolved spectra, and reconstruction of Compton scattering events.

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