Conventional and Inexpensive Whole-Body PET Detector Based on Suppressing Backgrounds by Compton Scattering

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Existing PET (Positron Emission Tomography) systems make clear images in demonstration (measuring small PET reagent in pure water), however images in real diagnosis become unclear. The authors suspected that this problem was caused by Compton scattering in a detector. When PET systems observe plural photomultiplier tube outputs, an original emission point is regarded as centroid of the outputs. However, even if plural emission in Compton scattering occur, these systems calculate original point in the same way as single emission. Therefore, the authors considered that rejecting Compton scattering events makes PET systems much better, and made prototype counter. Main components of the prototype counter are plate-like high-growth-rate (HGR) La-GPS scintillators and wavelength shifting fibers (WLSF). HGR crystals grow 10 times as fast as a mono-crystal (a normal mono-crystal grows at 2 – 3 mm an hour). Thus, it includes microbubble and its transparency get worth. Consequently HGR crystals usually are not used in radiation measuring instruments. However, this time they are used on the purpose. Because of their low transparency, scintillation lights come out right above and right under of emission position. Therefore, Compton scattering events is rejected easily. The prototype detector has an effective area of 300 by 300 square mm. The detector consists of 24 layers. One layer consists of HGR La-GPS scintillator of 1 mm thickness. Top and bottom surface of scintillator were covered by dual sheets of WLSF with a diameter of 0.2 mm. Sheets of WLSF on top and bottom of the scintillator make a right angle with each other, and measure X- and Y-components. Zcomponent is measured by difference of WLSF outputs between top and bottom. If plural layers output signals, this counter regards the event as Compton scattering event, and reject the event. Even if only a layer output signals, the event is rejected when number output signals from WLSF is more than 1.5 times of single emission. Material cost of this system is, 0.2M$ for HGR La-GPS, 0.03M$ for WLSF, 0.03M$ for 600 units of 6 by 6 mm SiPM's, 0.12M$ for 12000 units of 1 by 1 mm SiPM's, and 0.09M$ for 1800 channel of signal readout circuits. Considering total cost, price of this PET will be set 1M$ or less. This idea was confirmed with numerical simulation and experimentation. In experimentation, position resolution in photoelectric absorption was 0.2 mm, and minimum distance that this detector could recognize plural emission in Compton scattering was 1 mm. In parallel, three kinds of model was made: a prototype detector, all the signals readout method, and resistance delay method. Simulation setting was 2 MBq/L in normal tissue and 10 MBq/L in cancer. As a result of simulation, a prototype detector identified 3 mm cancer, however the others made unclear image and was not able to identified cancer. That is to say, the prototype detector is able to reject Compton scattering events and inexpensive. Therefore whole-body PET system with this detectors must diagnose cancer with a diameter of 3 mm or more and be priced 1M$ or less.