

## All-Digital PET: Mechanism and Innovative Systems

Positron emission tomography (PET) is an imaging modality which has found wide applications in pharmacology and pathology investigations. The All-Digital PET solved the challenge of digitizing ultrahigh speed analog signals, with the Multi-Voltage Threshold (MVT) sampling method. In MVT, the signals from photomultipliers are connected to several comparators with programmable thresholds. Time-stamps are generated when analog signals pass the thresholds. Based on an a-priori model of scintillation pulses, digital signals can be reconstructed by applying pulse shape fitting to the time-threshold samples.

Different from conventional analog-digital mixed PET systems, the MVT-based All-Digital PETs can acquire accurate digital samplings of gamma scintillation pulses without having the hassle of analog electronics. We have developed the world's first pre-clinical small animal All-Digital PET, the first clinical whole-body All-Digital PET/CT system and the first brain All-Digital PET. All of them have achieved marvel improvements in performances (double the sensitivity, half the scan time/dose, 8 times higher the resolution) with more concise hardware architectures.

And more importantly, the digital PET technology provides the potential for new system designs for novel applications. Besides better performances, more functions will be achieved with innovative digital PET systems, which we called as the Digital PET 2.0. Among them, there are proton therapy monitoring PET for intra-operative navigation, helmet PET for function neural imaging, bi-dynamic PET for dynamic imaging of free behaving animals, and plant PET for imaging of crop and fruits.