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Digital Signal Processing Applied to Crystal Identification in Positron Emission Tomography Dedicated to Small Animals

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The recent introduction of all-digital electronic architecture in Positron Emission Tomography (PET) scanners enables new paradigms to be explored for extracting relevant information from the detector signals, such as energy, time and crystal identification. The LabTEP(tm) small animal scanner, which implements free-running 45-MHz sampling directly at the output of the charge sensitive preamplifiers, provides an excellent platform to test such advanced digital algorithms. A real-time identification method, based on an Auto-Regressive Moving-Average (ARMA) scheme, was tested for discriminating between LYSO ($\text{tr} \sim 40 \text{ ns}$) and LGSO ($\text{tr} \sim 65 \text{ ns}$) scintillators in phoswich detectors coupled to a single Avalanche Photodiode (APD). The algorithm, that was implemented in a 16-bit fixed point DSP from Texas Instruments running at 500 MHz, can process a sustained rate up to 640 000 events/second. Even with a low energy threshold of 250 keV applied individually, error rates $< 0,4\%$ for LYSO and $< 0,6\%$ for LGSO can be achieved with this algorithm, as compared to $> 10\%$ with conventional analog pulse shape discrimination techniques. Such digital crystal identification techniques can be readily implemented with phoswich detectors for improving spatial resolution in PET, either by increasing crystal pixellisation or by mitigating parallax errors through depth-of-interaction determination.

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