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OP503

First measurements and Monte Carlo simulations of a BGO-PMTs blocks array intended for continuous energy spectrum tomography in bremsstrahlung imaging

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Rationale: A conventional Anger camera is not adapted to bremsstrahlung imaging: high energy x-rays may fall into the acquisition energy window after scattering in the collimator septa and also in the PMTs after going through the NaI crystal. This increases noise, limits the contrast, and reduces the quantification accuracy. The aim of this study is to experimentally validate previous Monte Carlo (MC) simulations (Gate-Geant4) showing that using BGO-PMT blocks with a high energy pinhole collimator greatly reduces the scattering contamination and enables the use of an extended energy window ranging from 50 to 400 keV. This would allow the development of a continuous energy spectrum tomography (CET) system. Method: A simple readout board was developed to handle an array of 2x3 BGO-4PMTs blocks coming from a retired PET Exact HR+ (CTI, Knoxville, TN). The energy spectrum of a 137Cs (662 keV) point source was acquired with this simple setup (without collimator or lead shielding). The spectrum was compared to the one simulated by MC (Gate-Geant4), and to the one acquired using a Triad XLT20 (Trionix, Twinsburg, OH) without collimator, equipped with a ½”-thick NaI crystal. BGO blocks pixelization (4.3x4.0mm pixels, 0.4mm-thick reflecting TiO2 separators) was modelled in the MC simulation while the energy resolution of the BGO-4PMTs block was approximated by a convolution with the sum of 2 Gaussians with energy-dependent FWHM . Results: The readout board was able to clearly identify all the BGO pixels. The energy spectrum acquired with the BGO setup was well reproduced by the MC simulations and displayed a scatter contamination in the [50-400] keV energy window 5 times as low as that obtained with the NaI based conventional camera Triad XLT20. The energy resolution of the BGO setup was measured as 17% at 662 keV.Conclusion: First measurements of the energy spectrum of a 137Cs point source on a simple setup consisting of a 2x3 BGO-4PMTs blocks array, confirm the advantage of BGO crystals over conventional NaI based camera in bremsstrahlung imaging by strongly reducing the scatter contamination in the energy window of interest ([50-400] keV). A dual head mobile CET prototype using a front-plate pinhole collimator is under development. This dedicated bremsstrahlung CET system will enable the dose optimization directly inside the catheterization room during 90Y liver radio-embolization which should result in an improvement of patient outcome.

OP504

Gamma-cube and X-cube: A New Scanner Generation for Benchtop Small Animal SPECT/CT

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The first generation small animal imaging systems offer molecular 3D imaging at sub millimetre spatial resolution with SPECT and sensitivities in the order of several percents using PET. These systems often have a large footprint because they are based on large to medium-size detector technology, adopted from clinical scanners. The next generation of systems aims at (i) improved image quality, (ii) flexibility regarding installation and (iii) ease of operation. Our group has been working on detector hardware and collimator designs to perform SPECT and CT imaging at a footprint of 1/4th of a square meter. Using additive manufacturing of tungsten, lofthole collimators and high-resolution detectors, we have designed and constructed a benchtop microSPECT system. On the other hand, using state-of-the-art CMOS X-ray detector technology, a micro-focal X-ray tube and iterative image reconstruction, we have designed and constructed a benchtop microCT system. SPECT benchmarking has been performed for the general-purpose mouse collimator using performance measurements previously used to objectively determine spatial resolution, sensitivity, uniformity and contrast-to-noise. CT quality control has determined spatial resolution, low-contrast detectability and whole-body mouse imaging time. Results show that SPECT spatial resolution is below 700um measured using a line source. Image reconstruction from a hot-rod resolution phantom separates all rods from 700 micron diameter and larger. Point source sensitivity is above 1200cps/MBq in a simultaneous cylindrical FOV of 3 cm diameter and 1 cm height. Differential uniformity is 23% while contrast to noise curves are in line with current commercial systems’ performance. CT imaging at 80um is possible with a soft tissue contrast that outperforms current systems. Whole body imaging of a mouse is possible within 30 seconds, using compressive sensing for dose reduction. All electronics and reconstruction servers are within a cube of 54x54x54cm3 system and the systems can be easily controlled using a tablet or a laptop. The small animal bed supports anesthesia, ECG, respiratory monitoring and heating. It can easily be transferred between both systems to obtain multi-modal SPECT-CT