A stationary SPECT system for simultaneous MRI/SPECT dual-modality pre-clinical imaging

D. J. Wagenaar[1], D. Meier[1], O. Nalciolgu[2], L. T. Muftuler[2], Y. Wang[3], B. M-W. Tsui[3], and B. E. Patt[1]

[1]Research, Gamma Medica-Ideas, Inc., Northridge, California, United States, [2]Tu & Yuen Center for Functional Onco-Imaging, University of California, Irvine, Irvine, California, United States, [3]Radiology, Johns Hopkins Medical Center, Baltimore, Maryland, United States

Purpose: Multi-modality medical imaging was pioneered with PET/CT and, more recently, SPECT/CT. In this work we report on the development of a dual-modality, SPECT/MRI pre-clinical research tool and present in vivo dual-modality SPECT/MRI images of a laboratory animal. Previous reports have shown the ability of semiconductor cadmium-zinc-telluride (CdZnTe, or CZT) to serve as a high-performance, pixellated nuclear imaging device under strong magnetic fields [1]. A stationary tomographic SPECT system capable of obtaining 24 views simultaneously has been designed [2], fabricated, and tested [3]. Reconstruction algorithms for the 24-view SPECT data are under development [4]. In this work we describe the full system design, engineering aspects of materials and EMI shielding techniques, calibration and correction methods, and test results of signal cross-talk and simultaneous phantom and animal imaging.

Methods: A portable insert has been developed for use within the ~12.0 cm inner diameter of high-field gradient coils used in horizontal pre-clinical MRI imaging systems (Fig. 1). SPECT imaging requires multiple views from different projections in order to avoid data truncation artifacts. A SPECT barrel (Fig. 2) consists of up to four rings of eight CZT modules, each with an imaging array of 16 x 16, 1.6 mm pixels. Fig. 3 shows the octagonal configuration of a single ring of the system. This figure also shows the SPECT collimation method, namely a cylindrical arrangement of pinholes with a magnification of approximately 1.0. This collimator is configured in close proximity but at a greater radius than the RF coil. Advanced research is being done on a combined RF coil/pinhole cylinder and this is reported in a separate abstract. When 24-view, high-resolution tomography is desired, a converging arrangement of pinholes is used such that the two outer rings of Fig. 2, combined with the center ring, all focus on the same volume of the animal under study (regional spot-view tomography). For whole body tomography, another collimator with a spiral arrangement of pinholes is used to give ~8 views per region of the animal for dynamic, limited-angle SPECT. Due to the limited volume within the magnet bore, magnification of 1.0 limits spatial resolution to be about 1.5 mm FWHM with the 1.6 mm pixels and a pinhole collimator of 1.0-1.5 mm diameter. As many as 24 to 32 pinholes simultaneously acquiring data give high count-sensitivity compared with conventional dual-head, multi-pinhole systems.

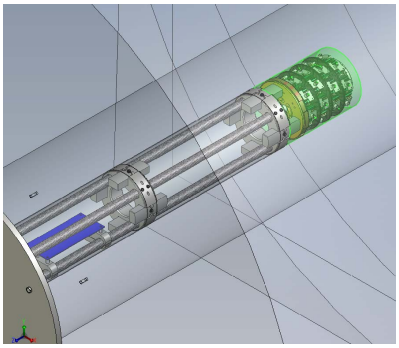

Figure 1. Engineering sketch of the SPECT imaging system (right), and data acquisition electronics (left) within a high-field magnet bore.

Results: Cross-modality EMI testing has been done and an optimum grounding/shielding configuration has been achieved. An external docking station has been fabricated for the SPECT system to be used on the benchtop and a patient bed in larger-bore magnet systems.

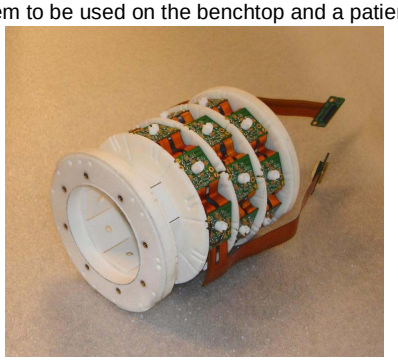

Figure 2. High-resolution (3-ring) configuration of the SPECT system shown. Whole-body, dynamic SPECT is achieved with 4 rings..

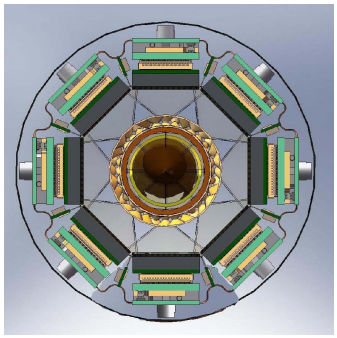

Figure 3. Axial view of the center ring, depicting the cylindrical collimator and the field-of-view of each detector module. Magnification is ~ 1.0.

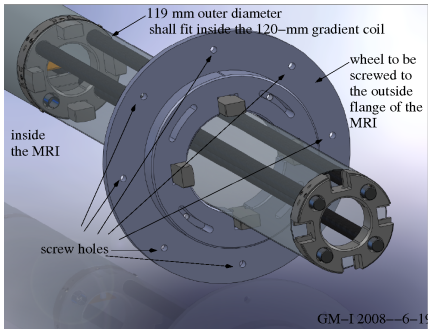

Figure 4. Drawing of the insertion scaffolding used to insert/align/withdraw the imaging barrel in the center of the magnet bore.

Discussion: Multi-modality has become the standard for pre-clinical medical research imaging in PET/SPECT/CT systems. We have built and tested a full functional SPECT system for use in state-of-the art, high-field, 12.0 cm bore MRI systems. Initial phantom ,and animal imaging results will be shown.

References:

[1] Nalcioglu O; Muftuler LT; Wagenaar DJ; Szawlowski M; Kapusta M; Pawlov N; Maehlum G; Patt BE. Development of MR-compatible SPECT system: a feasibility study. ISMRM Annual Meeting 2007 (May 19-26, 2007, Berlin, Germany), oral presentation.

[2] Wagenaar DJ; Nalcioglu O; Muftuler T; Meier D; Parnham K; Szawlowski M; Kapusta M; Azman S; Gjaerum J; Maehlum G; Wang Y; Tsui BMW; Patt BE. A multi-ring small animal CZT system for simultaneous SPECT/MRI imaging. J Nucl Med abstract 302, pages 89P-90P. (Oral presentation, SNM annual meeting, Washington, DC June 4, 2007).

[3] S. Azman, J. Gjaerum, D. Meier, L. T. Muftuler, G. Maehlum, O. Nalcioglu, B. E. Patt, B. Sundal, M. Szawlowski, B. M. W. Tsui, D. J. Wagenaar, and Y. Wang, "A nuclear radiation detector system with integrated readout for SPECT/MR small animal imaging," in IEEE Nuclear Science Symposium and Medical Imaging Conference, 2007, pp. 2311-17.

[4] Wang Y; Wagenaar DJ; Meier D; Patt BE; Tsui BMW. SPECT image reconstruction aspects for a pre-clinical SPECT-MRI system. IEEE Nuclear Science Symposium/Medical Imaging Conference, 2007, abstract M11-5.

Acknowledgment: Support from the NIH NIBIB, grant R44EB006712-02 is gratefully acknowledged.