SP070 - Molecular Imaging PET/SPECT: Part 2

TRACK 01: IMAGING

SP070.1 - Optimal Pixelated Crystal for a Molecular SPECT Scanner: A GATE Monte Carlo Study

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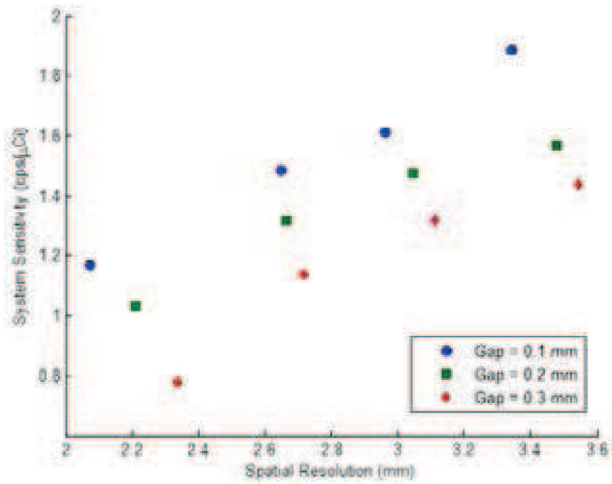
Objective: It is well-known that resolution-sensitivity tradeoff is the most challenging design consideration in small-animal SPECT. In the present work, we addressed such a compromise from pixelated crystal point-of-view for HiReSPECT system, a high-resolution SPECT camera, developed at Research Center for Molecular and Cellular Imaging.

Materials and Methods: For this purpose, we performed GATE Monte Carlo package to simulate the HiReSPECT scanner and to assess the impact of various crystal configurations on tomographic resolution and system sensitivity, using a ^{99m}Tc point-like source and a flood-filed phantom, respectively. The crystals differed in material, pixel-size, and Epoxy pixel-gap. Point-spread-functions (PSFs) were iteratively reconstructed using a dedicated 3D OSEM algorithm. Equal importance factors were assigned to the two conflicting objectives, and pixelated crystal was then optimized using the weighted-sum method. In addition, the Monte Carlo simulations were validated by means of comparisons with the experimental data.

Results: A good agreement (4.3% difference) between simulated and measured tomographic spatial resolutions at 30 mm radius-of-rotation is observed. Likewise, there is a maximum 9.1% difference, at 120 mm source-to-collimator distance, between our Monte Carlo calculations and the experiments for system sensitivity, all for a 1 × 1 mm^2 pixel-size and 0.2 mm Epoxy gap CsI(Na) configuration. The results show that CsI(Na) exhibits the highest sensitivity compared to NaI(Tl) and YAP(Ce) as well as a slightly higher spatial resolution, and therefore is the crystal of choice. A sensitivity of 1.61 cps/μCi is achieved for a 1.5 × 1.5 mm^2 pixel-size and 0.1 mm Epoxy gap CsI(Na)-based camera. Changing pixel-size from 0.5 × 0.5 mm^2 to 2 × 2 mm^2 leads to a 35.7% loss in tomographic resolution while sensitivity improves by a factor of 1.52. Based on our Monte Carlo optimization, the 1.5 × 1.5 mm^2 pixel-size and 0.1 mm Epoxy gap CsI(Na) is the optimal configuration by providing the best tradeoff between spatial resolution and system sensitivity. The crystal-optimized HiReSPECT system also offers a tomographic resolution of 2.98 mm, in terms of FWHM.

Conclusion: Our findings highlighted that performance of a preclinical SPECT imager can be highly affected by the pixelated scintillator configuration, and thereby searching for an optimum configuration is mandatory in order to obtain a more qualified SPECT image.



SP070.2 - Spinning Knife-Edge Slit-Hole: a Novel Collimation for High-Sensitivity Molecular SPECT

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Objective: While conventional collimation systems are widely used in molecular SPECT, such collimators usually limit performance of the camera due to owing a low geometric efficiency. In the present study, we addressed this challenge by proposing a novel collimator offering a high-sensitivity HiReSPECT system, a high-resolution SPECT camera, developed at Research Center for Molecular and Cellular Imaging.

Materials and Methods: For this purpose, we performed GATE Monte Carlo toolkit to design and simulate the collimator for the HiReSPECT scanner. The prototype consists a centered single knife-edge silt-hole of 1.2 mm width extended across long-axis of camera's head, with 30 mm collimator's depth. Planar spatial resolution and in-air sensitivity were assessed at various distances using a ^{99m}Tc point-like source and a flood-field phantom, respectively. At each regular SPECT angle, 16 spin-projections over 180° were then acquired each with 3.75 s time-per-spin. The planar images were iteratively reconstructed using a dedicated MLEM-based algorithm. To speed up our Monte Carlo simulations, a variance reduction technique by ignoring transport of the secondary electrons was also implemented.

Results: Slit-hole geometry give rise to an increased background-subtracted sensitivity of 12.4 times that observed with parallel-hole collimator at 30 mm source-to-collimator distance. System sensitivity with slit-hole collimator falls off as filed-of-view of the camera increases and reaches to a value of 4.6 cps/μCi at 120 mm distance while sensitivity of the system with parallel-hole collimation remains approximately constant over all distances from the collimator and has a value of 1.32 cps/μCi. Slit-hole collimated HiReSPECT scanner provides a magnification factor of 3 and offers a planar spatial resolution, in terms of FWHM, of 3.32 mm compared to 2.91 mm obtained by a parallel-hole collimation, at 10 mm source-to-collimator distance. Implementation of the variance reduction technique in our Monte Carlo simulations results in a 1.51 acceleration factor while imposes no significant effect on spin-projection data.

Conclusion: Our preliminary findings highlighted that the spinning