DETERMINATION OF THE RESOLUTION LIMIT OF A WHOLE BODY PET SCANNER USING MONTE CARLO SIMULATIONS

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Abstract

We studied the resolution limit that can be obtained for a whole body PET scanner. The results were obtained using a Monte Carlo based simulation program. The influence of two parameters was investigated: the crystal pixel size and the number of layers used for Depth-Of-Interaction (DOI) correction.

Keyword(s): medical imaging

1 Introduction

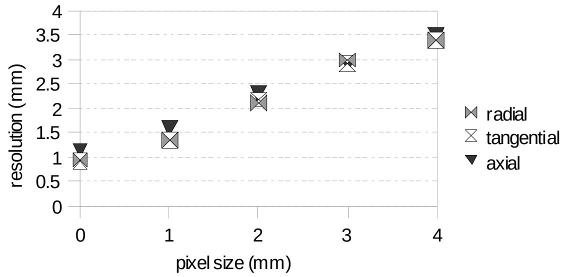
In PET systems the resolution is degraded by several effects. Two important effects are the finite dimensions of the crystal and the parallax effect. Both can be influenced by changing the scanner hardware design. The first effect degrades the overall scanner resolution and can be reduced by decreasing the crystal pixel size of the scanner. The parallax effect has no influence on the resolution in the center of the FOV, but degrades the resolution uniformity mainly in the radial direction. It can be reduced by using several crystal layers, making it possible to do DOI-correction. We investigated the resolution limit that can be obtained by using infinitesimal small crystals and compared this with realistic pixel sizes of finite dimensions. Furthermore we determined the optimal radial resolution uniformity which is obtained by knowing the exact DOI of the gamma photons and compared this with the results obtained by using a discrete number of layers in DOI-correction.

2 Methods

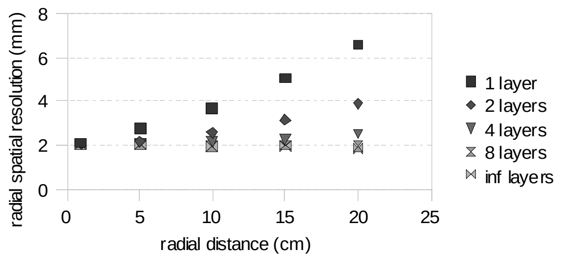
Our simulations were done with GATE, a Monte Carlo based simulation program. All physics processes were modeled from positron emission to gamma photon absorption in the crystal. No optical photons were simulated. The scanner was modeled as a cylindrical PET system with an internal radius of 351.7 mm, containing 22 sectors of 40 mm x 94 mm x 183 mm. We used LYSO crystals with length of 22 mm. Different simulations were done for different crystal pixel sizes (1, 2, 3 and 4 mm). Each simulation contained five point sources filled with fluorine-18, placed at different radial distances (1, 5, 10, 15 and 20 cm) in the axial center of the field of view (FOV). For each simulated data set several reconstructions were done, using a different number of layers for DOI-correction. All reconstruction were done with ML-EM. The resolution in the three orthogonal directions - radial, tangential and axial - was than determined as the FWHM of the reconstructed point source profiles.

3 Results

The radial, tangential and axial resolutions versus the pixel size for the point source placed at 1 cm radial distance are shown in figure 1:



The radial spatial resolution versus radial distance for a crystal pixel size of 2 mm is depicted in figure 2:



4 Discussion

Very comparable results are obtained for the 3 directions when decreasing the pixel size, so we use the average value for quantization. As resolution limit we obtained an average value of 1.00 mm. For a finite pixel size we obtained the best results for 1 mm crystals, with an average resolution of 1.43 mm. Considering the radial resolution uniformity, we approach the uniformity limit when using 4 or more layers for DOI-correction.

5 Conclusion

An average resolution limit was obtained of 1.00 mm. For crystals with 1 mm pixel size we approach this limit, with a difference smaller than 0.5 mm. No more than 4 layers for DOI-correction are needed to have a radial non-uniformity smaller than 0.5 mm.

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