Impact of probe on image quality.

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As in the case of image resolution, it is expected that the image quality of the probe-and-ring system will also vary with position relative to the probe. As the amount of probe-ring LORs passing through a single image pixel reduces with distance from the Si detector, it is expected that their effect on image quality will also reduce. In this study we investigate the probe's contribution to two figures of merit, contrast and spill-over ratio (SOR), using a phantom with cold and hot regions at varying distances from the Si detector. The phantom consists of an $80 \times 144 \times 80$ mm^3 box at the center for the FOV, containing 1 mCi of activity, which serves as a warm background for the contrast and SOR studies. Four empty (cold) spheres, with diameter of 16 mm, are placed at distances of 27, 59, 91 and 123 mm away from the probe surface, and offset by 16 mm relative to its centre. Equally offset but in the opposite direction, at the same distances from the probe, are hot spheres of 16 mm diameter, who's activity concentration is five times that of the background. Each hot sphere is separated from it's corresponding cold one by a distance of 32 mm (centre to centre), which is also the distance that separates successive hot-cold pairs. Figure 1 shows the phantom positioned relative to the probe.

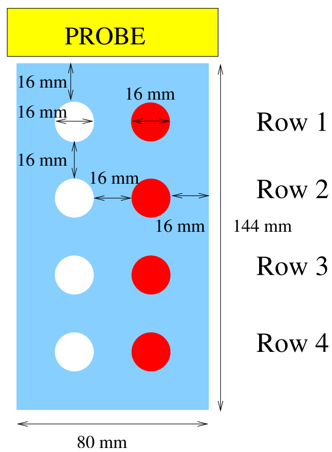

Figure 1. The phantom used for the image quality study and it's relative position to the probe. The phantom is at the center of the FOV.

Spherical ROIs with diameter of 14 mm were chosen centered on each hot and cold spot as well as exactly between each of these belonging to one pair, for the warm ROIs. The SOR, hot-warm contrast ($C_{hot/warm}$) and warm-cold contrast ($C_{warm/cold}$) were calculated using the following definitions:

$$SOR = \frac{\mu_{cold}}{\mu_{warm}},$$

$$C_{hot/warm} = \frac{\mu_{hot} - \mu_{warm}}{\mu_{warm}},$$

$$C_{warm/cold} = \frac{\mu_{warm} - \mu_{cold}}{\mu_{warm}},$$

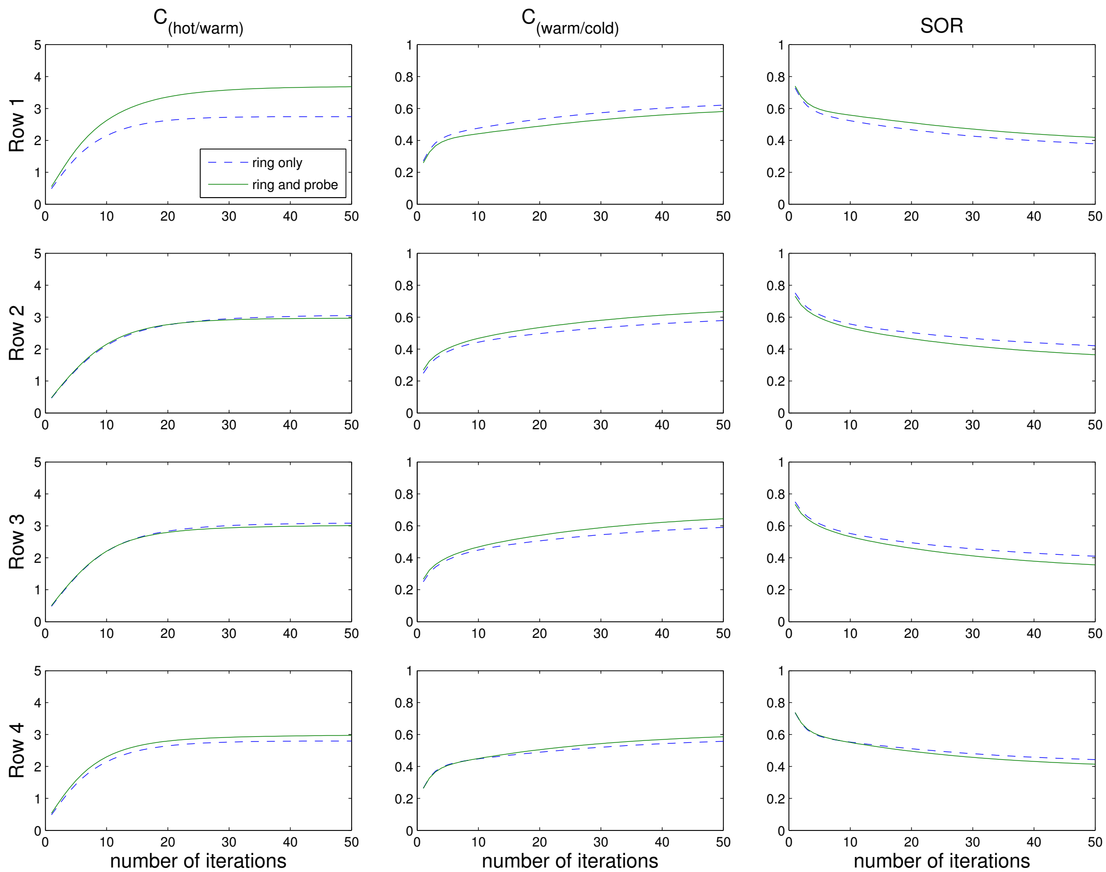

Figure 2. Plots showing $C_{hot/warm}$, $C_{warm/cold}$ and SOR, at different distances from the probe, vs. iteration number. Rows 1, 2, 3, 4 correspond to distances of 27, 59, 91 and 123 mm respectively. The solid line represents values from the probe-and-ring system and the dashed line is for the ring-only system. True values for $C_{hot/warm}$, $C_{warm/cold}$ and SOR are 4, 1 and 0 respectively.

where μ is the mean value of the corresponding ROI in the reconstructed images. The ideal values for SOR, $C_{hot/warm}$ and $C_{warm/cold}$ are 0, 4 and 1 respectively. Results were calculated at each iteration of the reconstruction and plotted as a function of iteration number. Figure 2 shows the results.

Figure 1 shows plots of $C_{hot/warm}$, $C_{warm/cold}$ and SOR, as a function of iteration number, for the four feature pairs. It can be seen that close to the probe there is considerable improvement in $C_{hot/warm}$. In row 1, 27 mm away from the probe, the reconstructed value for the probe system simulation is 3.5, close to the ideal value of 4. The ring-only system value converges bellow 3. In the next three rows the contrast improvement provided by the probe is reduced as the values obtained from both systems converge to similar values, bellow that expected.

The plots of $C_{warm/cold}$ show that the probe provides negligible improvement in rows 2, 3 and 4. Close to the Si detector, in row 1, it appears that the presence of the probe degrades the image quality measure, although by a very small amount. Plots of the SOR demonstrate the same tendency: slight improvement, except close to the probe where slight deradation is observed.