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 four 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.

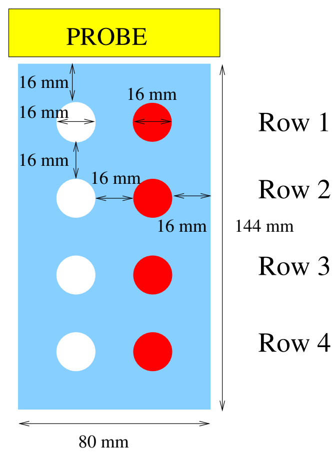

Figure 1. The phantom used for the image quality study and it's relative position to the probe. The phantom is at the center of the FOV.

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:

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

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

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

where μ is the mean value of the corresponding ROI in the reconstructed images. The results were plotted as a function of iteration number. Figure 2 shows the results.

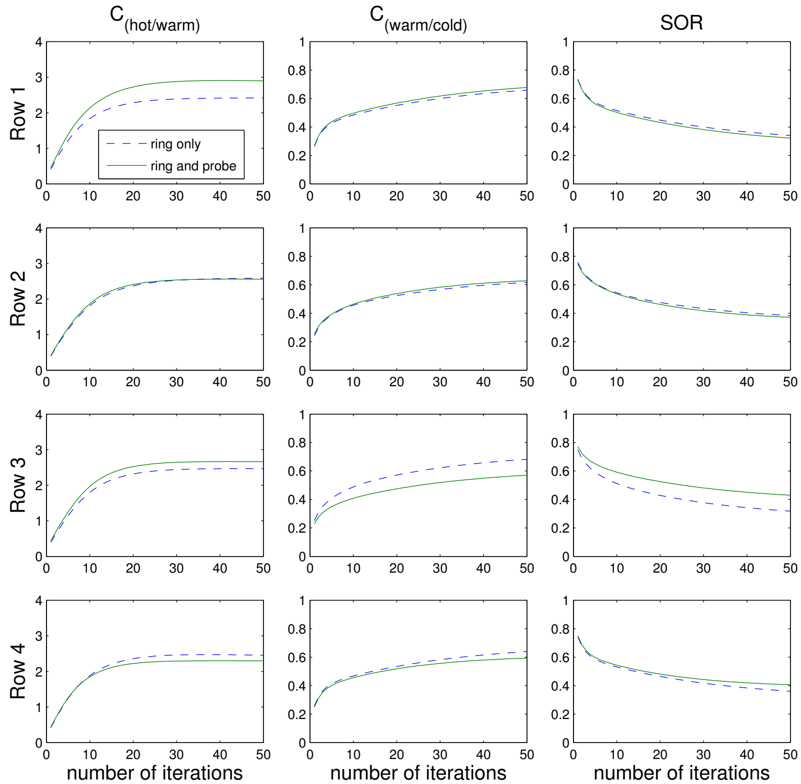

Figure 2. Plots showing $C_{hot/warm}$, $C_{warm/cold}$ and SOR at different distances from the probe. Rows 1, 2, 3, 4 correspond to distances of 27, 59, 91 and 123 mm respectively.

There appears to be a large improvement in $C_{hot/warm}$ close to the probe. This is evident in row 1, 27 mm away from the probe and in the region of improved resolution. Here the reconstructed value of the probe system is very close to the simulated value of 3, while the ring-only system value converges to a value of about 2.5. In the next three rows the ring-only and combined system values converge to similar values, fluctuating slightly. In the $C_{warm/cold}$ and SOR measurements, the addition of the probe has little effect. An exception to this seems to be in row 3, where the addition of the probe degrades the measures. This was previously thought to be due to statistical error but now we have trippled the statistics and the problem persists, although it appears to be reducing.

Figure 2 shows the results for $C_{hot/warm}$ and SOR from the problematic row 3. In the case of contrast, the error seems to acount for the observed discrepancy. In the case of SOR, it does not.

The study is still inconclusive, but it looks like the addition of the probe improves $C_{hot/warm}$ in the region close to the probe, where resolution enhancement is observed, but has little effect elsewhere nor on the $C_{warm/cold}$ and SOR measurements.

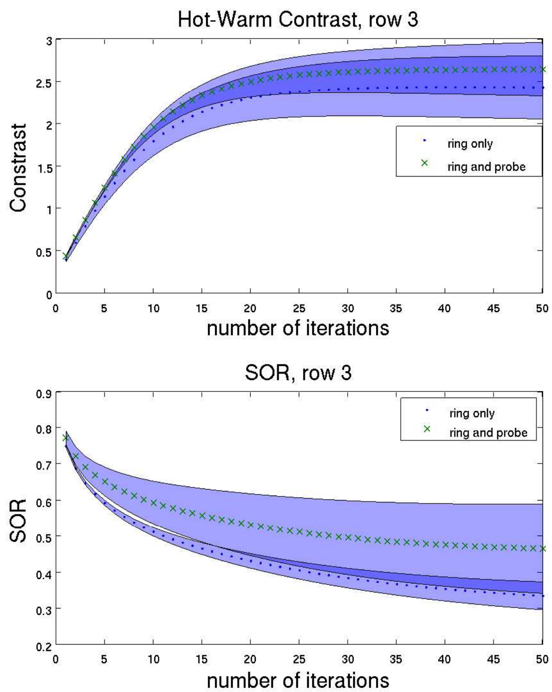

Figure 3. Plots showing $C_{hot/warm}$ and SOR for row 3 corresponding to a distance of 91 mm away from the probe. The shaded regions have a width of two standard deviations and represent error.