# Whole Body Imaging at 7T with a 16 Channel Body Coil and $B_1$ Shimming

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**Objective:** To investigate the feasibility of whole body imaging at 7T with a 16 channel TEM body coil system with B1 shimming.

**Introduction:** Whole body imaging and its clinical applications have been commercially developed for 3T. Body imaging has been demonstrated in research applications to 4T.(1) Major MRI system manufacturers are now supporting 7T whole body MRI systems for human head imaging. While whole body imaging at 7T has been demonstrated with homogeneous, circularly polarized body coils, the images thereby acquired show severe RF artifacts due to B1 field non-uniformities in the anatomy.(2) B1 shimming has proven to compensate these RF artifacts in head imaging at 4T and 7T, and in bodies to 4T with volume coils and 7T with surface arrays(1,3-5) The aim of this study is to employ B1 shimming with a multi-channel TEM body coil to image the human body at 7T.

**Methods:** The methods consisted of hardware development, modeling, and data measurement.

*Hardware Development:* 7T equipment specific to human body imaging is not commercially available. Therefore, a 16-channel body coil together with the 16 channel RF transmitter (1 kW/channel), 16-channel receiver, and 16-channel power monitoring system were designed in-house. (6) The power amplifiers and phase/gain controller were manutactured by CPC, Hauppauge, NY. The MRI system used for the study included a Magnex 7T, 90 cm bore magnet interfaced to a Siemens console, whole body gradients and shims. The body coil (Fig. 1, 2) was of TEM design measuring overall 66.0 cm od x 60.4 cm id x 125.5 cm long. The 16 TEM elements measured 25.7 cm, were placed 39.1 cm from the patient enty end, and were capacitively decoupled and independently tuned, matched, and driven in transmit and receive mode for this investigation. Independent preamps, power amps, TR switches, console driven phase and gain control, and tune and match circuits were dedicated to each of the coil's 16 channels.

*Modeling:* Initial predictions of B1 field contours and SAR for 300 MHz body imaging were numerically calculated using the Remcom XFDT package, College Station, PA. Figure 3 shows B1+ contours expected for a "conventional" homogeneous, circularly polarized (CP), 24 element TEM body coil at 7T.

*Measurement:* The acquisition parameters for the gradient echo images of Figures 4,5 were: TR/TE=100/3.06 ms, pw=4 ms, 2 acq, thk=5 mm, res=2.6x2.6 mm, scan time = 17 seconds. SAR was monitored per channel, and totaled 3.3 W/kg for the 25 kg FOV. Figures 4a and 5a were acquired with elements phased to circular polarization. To mitigate the RF artifacts of 4a,5a, images in 4b,5b, benefited from B1+ shimming performed by first measuring phase maps and then calculating and setting compensatory B1 for the target ROI.(5)

**Results and Discussion:** Models predict servere (>25 dB) RF contour gradients for CP body coils loaded with human bodies at 300 MHz. Observed in both models (Figure 3) and images (Figures 4a, 5a) are sharp lines running longitudinally through the body, primarilly due to destructive interference of the short (12 cm) wavelengths in the tissue dielectrics at 300 MHz. B1 shimming was used to compensate these artifacts in ROIs. Coil efficiency likely suffered (Qu/Ql < 3), from too little space for efficient TEM conductor pairs, due to limited coil space between the bore tube and gradients. Even so, SAR was successfully monitored and maintained within the FDA guidelines. The observed artifacts and RF power requirements do not appear to preclude the possibility of useful whole body imaging for biomedical applications at 7T.

**Conclusions:** **S**afe and successful whole body imaging with multi-channel transmit technology and methods including B1 shimming may prove useful at 7T.

**References**: 1.) MRM 2004;52:851-9; 2.) Proc. ISMRM Seattle 2006, p 213; 3.) MRM 1994;32:206-218; 4.)MRM 2005;53(2):434-445; 5.) Metzger et. al. "Local B1+ Shimming for Prostate Imaging with Transciever Arrays at 7T Based on Subject-Dependent Transmit Phase Measurements", MRM (in press).
6.) US Pat. 6,969,992. 2005; **Acknowledgments:** NIH- R01 EB000895-04, EB006835, NIH-P41 RR08079

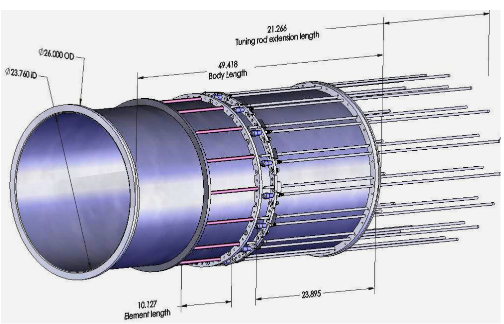


**Figure 1.** Sixteen channel TEM body coil schematic (inches)

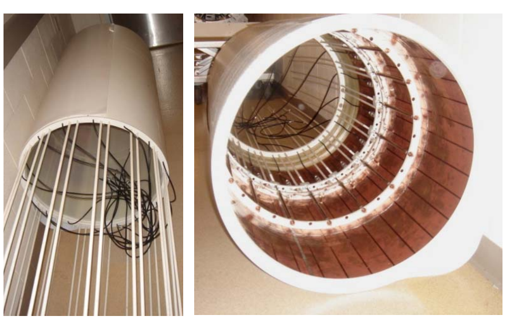

**Figure 2.** Sixteen channel TEM body coil for 7T

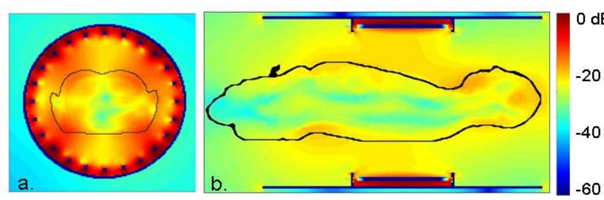


**Figure 3.** Modeled B1+, CP field in body at 300 MHz (7T)

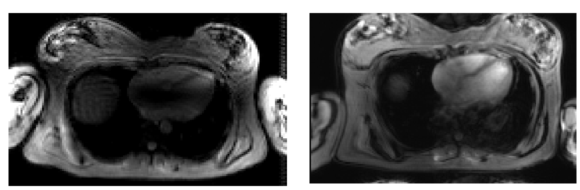

**Figure 4.** Transverse image through heart at 7T.
Left (a) image acquired with homogeneous, CP, 16 channel TEM coil.
Right (b) image acquired with B1 shimmed 16 channel TEM body coil.

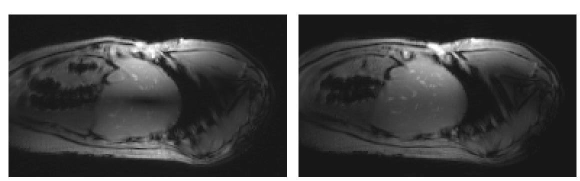

**Figure 5.** Sagittal image through liver at 7T.
Left (a) image acquired with homogeneous, CP, 16 channel TEM coil.
Right (b) image acquired with B1 shimmed 16 channel TEM body coil.