

## Cardiac Imaging at 7T

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**Introduction:** Cardiac imaging has benefited from increased signal to noise at 3T compared to 1.5T.[1] The increased SNR has improved exams and increased the viability of some signal starved techniques. But higher field also accentuates artifacts and imaging constraints and several changes were required to adapt cardiac imaging to 3T. Advancing cardiac imaging to 7T holds the potential of increased SNR, but will likely require new methodologies before that can be realized. This work is to examine the feasibility of cardiac imaging at 7T.

**Materials & Methods:** Previous studies of the human body high field RF landscape have confirmed what simulations predicted: transmitting with a homogeneous coil will produce sharp regions of destructive interference when it is loaded with a body.[2-4] This is due to the 7T Larmor wavelength in tissue (~12 cm) being shorter than the dimensions of the body. To address this, a set of two four-coil microstrip TEM transceive arrays were positioned on the chest and back. Each coil had the dimensions 15 cm long x 5 cm wide x 2 cm thick.[5,6] The output of an 8 kW CPC broadband RF amplifier was split 8 ways to drive 8 coils independently, thus allowing the adjustment of the relative phase of each coil. By collecting images of each individual transmit field, the percentage of destructive interference between the eight  $B_1^+$  fields was calculated, computationally minimized for an ROI, and corrected by changing the relative transmit phase for each coil.[7] ECG gating during breathhold exams minimized motion artifacts. This imaging was performed on a 7T Magnex whole body magnet controlled by a Siemens console based on TIM technology.

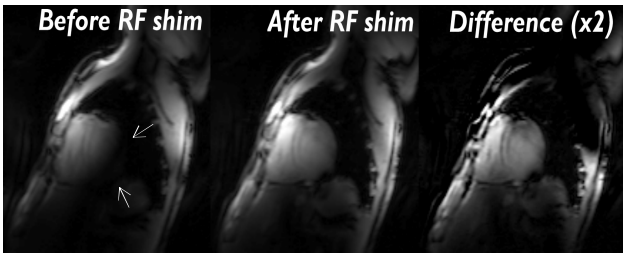


Figure 1 FLASH images demonstrating 7T cardiac RF shimming

**Results & Discussion:** Adjustment of the transmit field with RF shimming proved necessary for cardiac imaging at 7T, as demonstrated in Figure 1. The first image is acquired with the transmit phase of all coils equal, which was found to be a reasonable starting point. A central dark band of destructive interference passes through the posterior of the heart as indicated by the arrows. By adjusting the phase of the transmitters to the prescribed, though non-intuitive calculated phases, this artifact was removed. The difference image (scaled by a factor of 2) demonstrates the gain in transmit efficiency across the heart. Even at 3T, the magnitude of  $B_1^+$  over the heart can vary by up to 50% [8], and at 4T sharp RF artifacts are evident [9]. At 7T destructive interference is inevitable, but it can be locally alleviated. Frames from retrogated FLASH cardiac cines shown in Figures 2 and 3 demonstrate the potential for 7T cardiac imaging. These were acquired with TR/TE = 45/3 ms and 30/3 ms respectively, BW=745 Hz/pixel, 40 frames per cardiac cycle, ~2mm x 2mm x 5.5 mm resolution, and collected in 12 heart beats. Because of the potential for motion, in some cases modest GRAPPA reduction factors produced higher quality images than full resolution images. Figure 3 was acquired with 75% of the phase encoding lines; reductions to 45% are reasonable for some orientations. TrueFISP sequences will require fundamental improvements to address the larger susceptibility artifacts at 7T.

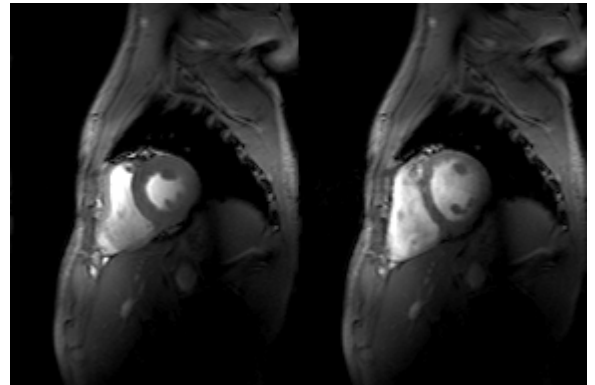


Figure 2 7T Short-axis cardiac cine frames

**Conclusion:** Cardiac imaging was demonstrated to be feasible at 7T. New methods and technologies, such as  $B_1^+$  shimming and controllable transmit array coils are a required first step on the path to high field cardiac imaging.

### References:

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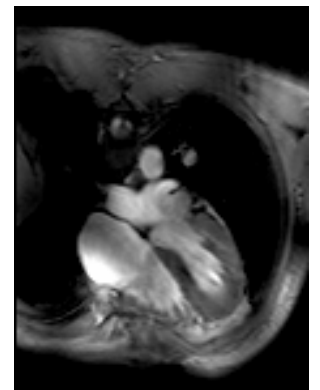


Figure 3 A four-chamber cine image

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