

Toward B₁ estimation using coil locators

Parnian Zarghamravanbakhsh¹, Christopher Ellenor¹, John M Pauly¹, and Greig Scott¹
¹Electrical engineering, Stanford university, Stanford, CA, United States

Introduction: In transmit arrays, prior estimation of the RF field profile is desirable for rapid calibration, shimming and improved RF pulse performance. Experimental B₁ mapping assumes nothing about the coil structure, and computational solvers need real-world inputs for body loading and proximity. In practice, surface coil impedance varies with sample loading, causing a first order perturbation on coil current amplitude and phase. While on-coil current sensors could measure this, the coil location is unknown. In this work, we assess the use of proton and fluorine fiducial markers to identify coil orientation in imaging space, as an aid toward B₁ estimation without mapping.

Method: To localize coils in the imaging coordinate system, three fiducial markers are placed on known locations of conductor edges of a transmit/receive coil while loaded (3 points are needed for specifying each coil plane). The coils are tuned only to the proton Larmor frequency at 1.5 T. The experiments are performed with fiducial markers filled with Hexafluorobenzene (C₆F₆), or with vitamin E capsules as markers to show the feasibility of the proposed method for the systems that have hardware limitations for imaging fluorine. To excite the markers, half passage adiabatic pulses are designed due to their robustness to B₁ inhomogeneity near conductive edges of the coils. Three sets of 1D projection were acquired in the x, y, and z directions to detect the marker locations (shown in figure 2). When using vitamin E capsules, spoiler gradients were applied to separate the markers from phantom signal. Having known the coil geometry, coil orientation in the imaging space can be found either by fluorine marker or vitamin E capsule location extracted from the 1D projection. To validate the proposed method, a double-angle B₁ map¹ was acquired within a thin slice phantom filled with doped water (Medusa console, 1.5T, TR/TE = 500/6ms, 128x128, 32cm FOV). Having known the coil location in imaging coordinates, the approximate transverse B field simulation profile is calculated to within a scale factor using the Biot-Savart law and compared with experimental results.

Result: A surface coil with markers on the conductors (shown in figure 1) was used to image a thin slice phantom placed in a coronal plane, (figure 3). Both fluorine markers and Vitamin E capsules are placed on the coil; either of them can be used to find the coil orientation. Fluorine projections maintain excellent SNR despite proton tuning of the coil (figure 2). Figure 4, shows the double-angle B₁ map compared to the transverse magnetic field distribution generated by calculation in a selected rectangular ROI of figure 3, and also shows a cross-sectional plot of measured B₁ field by double-angle method along with simulated field profile. The plot depicts field variations with respect to the distance from the coil plane for both simulated and measured fields.

Discussion & conclusion: Fiducial markers on transmit coils of known geometry provide the coil location in imaging coordinates. This enables field estimation that can be used for auto-calibration of the system. This technique could be further improved by adding current sensors² to the coil to measure field distribution using FDTD or analytic full-wave computational analysis.



Figure 1: Surface coil (23cmx15cm) with Vitamin E markers (yellow) and fluorine markers (blue)

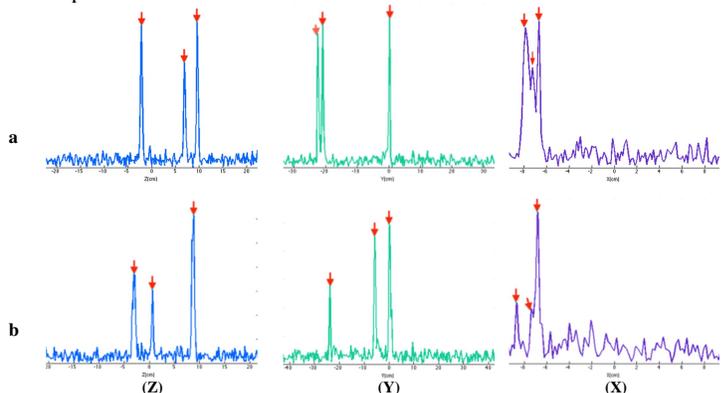


Figure 2: 3 sets of 1D projection along z, y, and x axes .a) Fluorine markers. b) Vitamin E

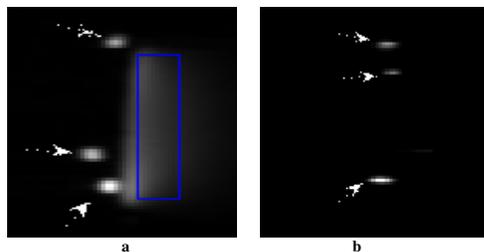


Figure 3. Phantom orientation compared to markers. a) phantom with vitamin E image acquired hydrogen frequency, selected ROI in blue ,b) Fluorine marker image acquired at fluorine frequency

References: [1] E. K. Insko, L. Bolinger, B₁ mapping. Proc. SMRM, 11th, 1992, p.4302. [2] P. Stang et al., Proc 17th ISMRM, 2009, p.3024
 Grant support: R01EB008108, P01CA159992. GE research support.

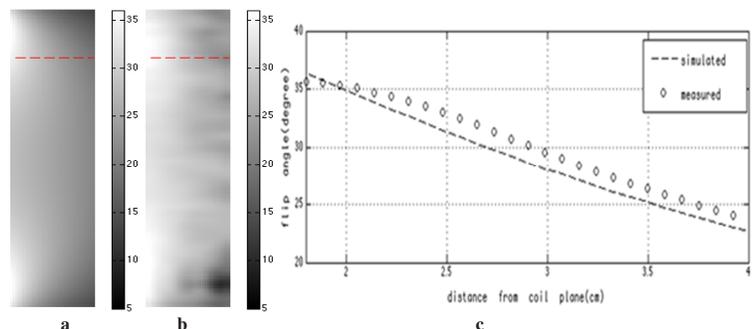


Figure 4: Field distribution. a) Simulated B₁, b) Measured B₁, c) cross-sectional plot through red line shown in a&b shows B₁ field variation with respect to distance from coil plane for measured and simulated fields