SLICE-SELECTIVE RF PULSES FOR IN VIVO B1+ INHOMOGENEITY MITIGATION AT 7 TESLA USING PARALLELL RF EXCITATION WITH A 16-ELEMENT COIL

K. Setsompop[1], V. Alagappan[2], B. Gagoski[1], T. Witzel[2,3], J. Polimeni[2], A. Potthast[4], U. Fontius[5], F. Schmitt[5], L. Wald[3,6], and E. Adalsteinsson[1,3]

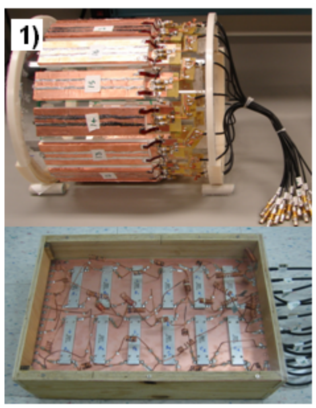
[1]EECS, Massachusetts Institute of Technology, Cambridge, ma, United States, [2]A. A. Martinos Center for Biomedical Imaging, MGH, Charlestown, ma, United States, [3]Harvard-MIT Division of Health Sciences and Technology, Cambridge, ma, United States, [4]Siemens Medical Solutions, Charlestown, ma, United States, [5]Siemens Medical Solutions, Erlangen, Germany, [6]A. A. Martinos Center for Biomedical Imaging, Department of Radiology, MGH, Charlestown, MA, United States

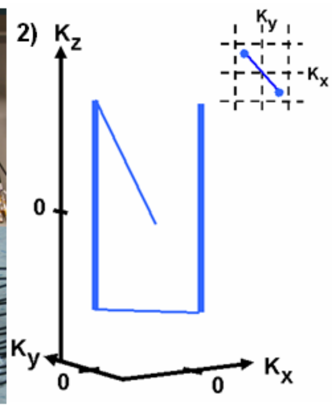
INTRODUCTION: At 7T, B1+ inhomogeneity for human brain imaging causes spatially inhomogeneous flip-angle with detrimental non-uniformity for both signal-to-noise ratio (SNR) and image contrast. Several RF design approaches have been suggested to compensate for this inhomogeneity, including adiabatic pulses (1), RF-shimming (2), and spatially tailored excitation designs (3-5). In this work we applied 8-channel parallel excitation waveforms in the low-flip-angle regime with echo-volumnar k-space trajectories (4,5) that deposit slice-selective sinc "spokes" in k_z, whose complex amplitudes are modulated in (k_x,k_y) to mitigate in-plane B1+ inhomogeneity. We designed parallel RF spoke pulses with magnitude least squares criteria, spoke location optimization, and B0 field map incorporation (6,7) that demonstrated excellent B1+ mitigation for brain imaging on three human subjects at 7T.

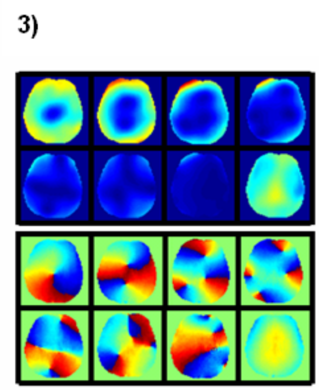
METHODS: A 7T scanner equipped with a 16-channel degenerate birdcage coil coupled with a butler matrix (Fig 1) to excite 8 optimal birdcage modes was used for all experiments. Quantitative B1+ mapping was performed by first estimating the proton-density weighted birdcage receive profile by transmitting (sequentially, at 4 voltage levels, TR=10s) and receiving with the birdcage circularly-polarized (CP) mode. The four images were fitted to extract the proton-density weighted receive profile. Low-flip images for each B1+ mode were then acquired and divided by the proton-density receive to obtain the quantitative B1+ maps. Parallel RF waveforms were designed to mitigate the measured B1+ field by a 1.67-ms long two-spoke trajectory (Fig 2) and magnitude least squares criteria with an optimized, symmetric k-space sampling that significantly improved magnitude profile uniformity and decreased RF power compared to conventional least squares. A B0 field map was incorporated to minimize the impact of local field variations. The parallel mitigation excitation was compared to both a conventional 1-ms long sinc pulse in a birdcage mode, and to 1-ms long RF shimming equivalent to a single-spoke excitation at the center of excitation k-space. The excitation performance was quantified by calculating the standard deviation within the field of excitation (FOX), as well as by the fraction of pixels in the FOX within a 10% and a 20% bracket around the mean excitation.

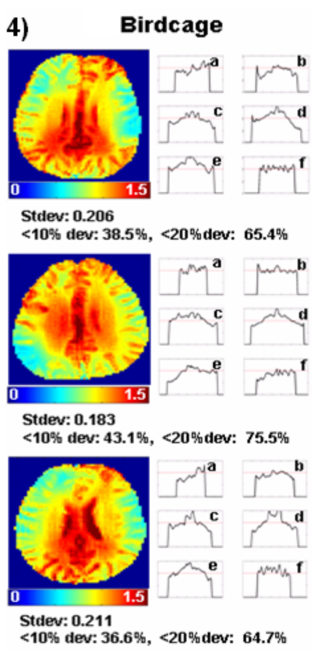
RESULTS: The magnitude and phase of the quantitative B1+ mapping of the 8 applied excitation modes of the array are shown for one subject in Fig 3. Figures 4 through 6 show excitations due to the sinc pulse, RF shim, and two-spoke parallel excitations, along with line plots at six equi-spaced horizontal sections. A general trend is seen in mitigation performance with RF shim improving on the sinc excitation, and the fully parallel two-spoke excitation yielding superior performance.

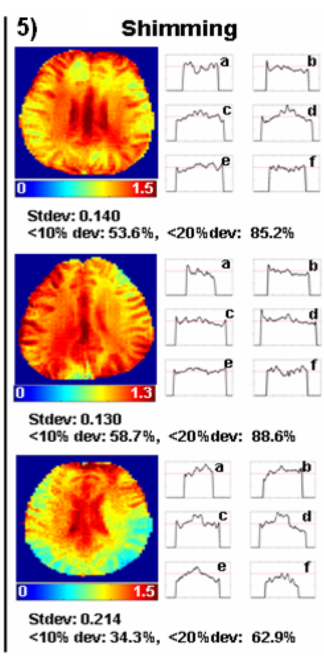
CONCLUSIONS: Slice-selective RF waveforms that mitigate severe B1+ inhomogeneity at 7 Tesla were designed and demonstrated for parallel excitation in three human subjects. This work demonstrates that slice-selective excitations with parallel RF systems offer the means to implement slice selection at high field strengths with spatially uniform flip angle with only a small pulse-duration penalty.

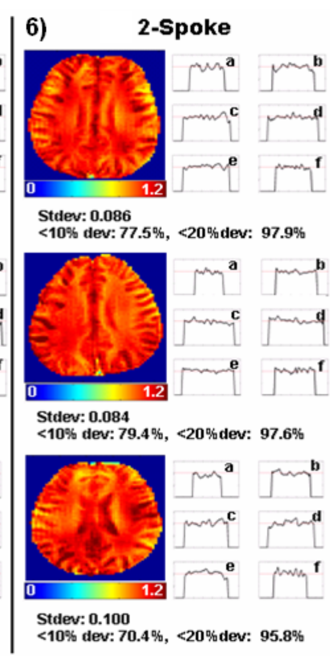












SUPPORT AND REFERENCES: NIH R01EB006847, R01EB007942, R01EB000790, and NCRR grant P41RR14075, Siemens Medical Solutions, R.J. Shillman Career Development Award, and the MIND Institute. **[1]** Silver et al, . JMR 59:347, 1984; **[2]** Ibrahim et al, MRI, 19:1339, 2001; **[3]** Saekho et al MRM 53:479, 2005; **[4]** Saekho et al MRM 55:719, 2006; **[5]** Ulloa et al ISMRM p 21, 2005; **[6]** Grissom et al MRM 56:620, 2006; **[7]** Setsompop et al ISMRM, Berlin, Germany, 2007, p 671.