In-Vivo RF Power-Controlled B1 Shimming with Tx/Rx array and with Tx array Combined Rx Only Coil without B1 measurements

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Introduction: Multi-transmission approaches (transmit SENSE and B_1 shimming) have generally aimed at reducing RF power deposition in tissue and homogenizing the RF field across the anatomy of interest. Several major obstacles have dampened wide implementation of multi-transmission methods including requirements to have the knowledge of how the RF fields produced by current MRI coils/arrays behave in every imaged subject using B_1 field measurement/mapping prior to performing the multi-transmission experiment. This process not only can take unrealistic scanning and preparation time while the subject in the scanner, it is at many instances unfeasible and inaccurate when signal voids exist in images (due to the lack of the receive field). This work aims at continuing our efforts in overcoming this subject-dependence issue while maintaining a high-SNR intact with receive-only coil inserts.

Methods: The multi-transmit Tic-Tac-Toe array (preliminary design proposed in last year's meeting (2)) which is based on cross-pole antennas (3) is shown in Fig. 1. The plane that encapsulates these elements is in *xy* (perpendicular to the magnet, *z*, axis). The array is excited from the four alternate ends of the Tic-Tac-Toe. The Tic-Tac-Toe array does not posses lumped capacitors and can be easily tuned to 50 Ohms with any human head. Extensive Simulations were performed to evaluate the first prototype 2X2 Tic-Tac-Toe array. Some of the results are shown in Fig. 1. The results show that the B_1^+ field intensity equals to or exceeds that associated with the 16-element TEM coil for the top 3.5in of the head. This is expected as the array elements only exist in the top of the head for this first prototype 2X2 Tic-Tac-Toe array. The coil is highly coupled which tremendously aids in the manipulation of the RF field and diminish the effects due to the changes in the characteristics of each subject. The array was successfully tested on 5 subjects in a Tx/Rx mode and with a receive only coil to enhance SNR.

Results and Discussion: Fig. 2 demonstrates the in-vivo results and predicted simulations for B_1 shimming that aims at localizing the RF excitation in a region of interest, maximizing the flip angle in this region while minimizing the SAR (in here it was chosen to be average SAR.) The B_1 fields were obtained using our simulations with the visible human project, and the experiments were done with two different human heads (see description in Fig. 2.) For demonstration purposes, we B_1-shimmed both the transmit and the receive fields without B_1 mapping and exclusively based on the simulations. The values for localization (signal in region of interest over that outside) and total RF power were within 10% of the simulations for both heads.

The strong coupling on the subject-insensitive, multi-transmit RF array necessitates the development of decoupled receive-only array to reduce the noise and thus increase SNR. Therefore for demonstration purposes, we have built a loop coil that operates as receive-only coil (shown in Fig. 3) with the first prototype (2X2) multi-transmit Tic Tac Toe. The receive-only coil did not cause any detuning/mismatching on the Tic Tac Toe when loaded in it. Fig. 3 compares the results when receiving by the receive-only coil or by sum-of-square from the 4 ports of the 2X2 Tic-Tac-Toe. The noise was reduced by a factor of 2.8 when using receive-only coil on its own. The subject-insensitivity remained intact.

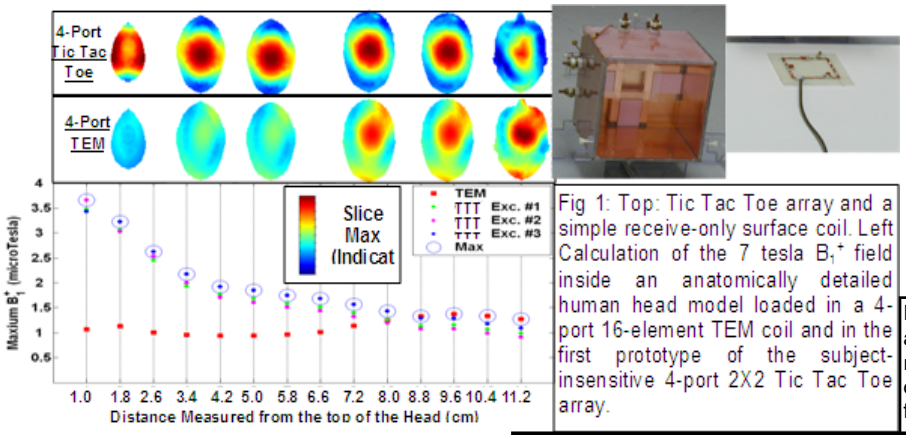

Fig 1: Top: Tic Tac Toe array and a simple receive-only surface coil. Left Calculation of the 7 tesla B_1^+ field inside an anatomically detailed human head model loaded in a 4-port 16-element TEM coil and in the first prototype of the subject-insensitive 4-port 2X2 Tic Tac Toe array.

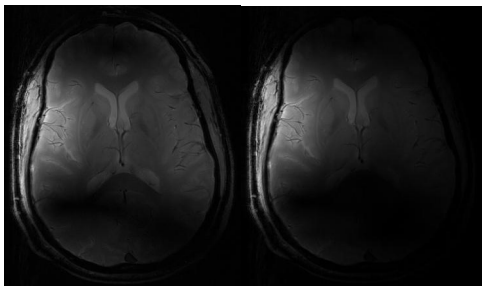

Fig. 3: **Localized B_1 Shimming WO B_1 Meas.** achieved with the same Tx settings as in Fig. 2. Left represents Tx form the Tic Tac Toe & Rx with sum-of-square on all array ports. Right represents Tx form Tic Tac Toe and Rx from the local-receive coil.

References

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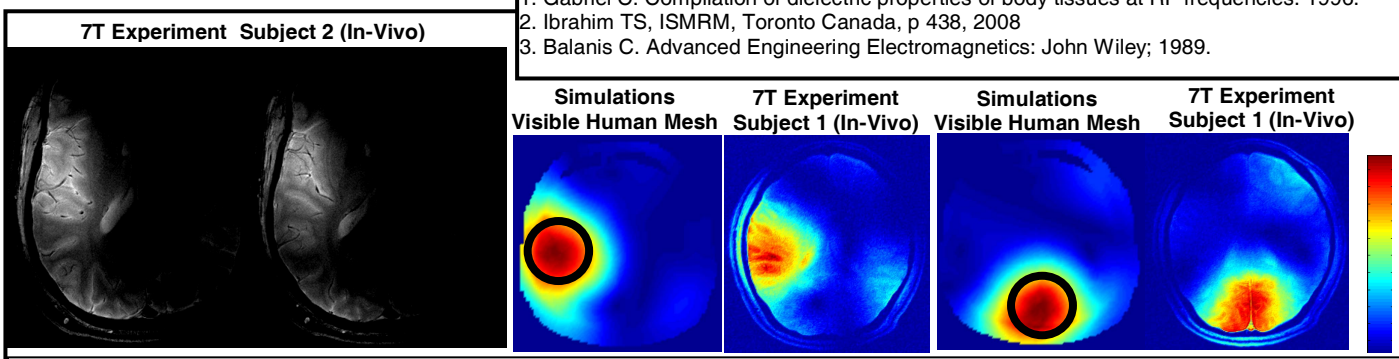

Fig. 2: **In-vivo Localized 7 tesla *B_1 Shimming without B_1 Measurements With* Subject-Insensitive, 2X2 Tic-Tac-Toe, 4-Port Tx/Rx Array.** The simulation data was calculated using the visible human project model (1) (a relatively large White Caucasian head.) The images of Subject 1 (relatively small Asian human head (in-vivo)) was done at 256x256 resolution and of Subject 2 (an average white Caucasian head (in-vivo)) was done at 512x512 resolution (both with whole-slice selective gradient.) The same array tune was used for both heads. The B_1 shimming (denoted by the black circle) was successfully done without B_1 measurements on the two different heads with the same amplitudes and voltages obtained from the numerical simulations (a third head.) The B_1 shimming is done with ½ of the RF power used in a typical quadrature excitation configuration. The signal intensity ($B_1^+ X B_1^-$) inside the black circle = 8.2 times that outside of it and within a 1in axial slab.