7T Multi-slab Whole-Head Homogenous and Low SAR T2 Acquisitions with Limited RF Power Amplifiers Capabilities

Narayanan Krishnamurthy[1], Yujuan Zhao[2], Shailesh Raval[2], Junghwan Kim[2], Sossena Wood[2], Tales Santini[2], Tiejun Zhao[3], and Tamer Ibrahim[2]
[1]*University of Pittsburgh, Pittsburgh, PA, United States,* [2]*University of Pittsburgh, Pittsburgh, PA, United States,* [3]*Siemens Medical Solutions, PA, United States*

Target Audience: Users interested in high resolution and homogenous T2 weighted 7T Neuroimaging.

Purpose: UHF imaging is an invaluable non-invasive translational research tool, as one can obtain high resolution high signal to noise images that are more sensitive to contrast mechanisms such as BOLD and susceptibility. The main challenges of UHF imaging are RF absorption and B_1^+ inhomogeneity, and increased patient coil interactions. These issues can impact the feasibility as well as the quality of power hungry T2 weighted sequences. In addition, the limitation of 8KW RF power amplifiers on most UHF human MRI scanner presents serious challenges for achieving high quality T2 weighted imaging. Here we present a multi-slab imaging approach optimized for SAR as well as input power that achieves homogenous whole head 7T turbo spin echo (TSE) and fluid attenuated inversion recovery (FLAIR.) The Tic Tac Toe transmit array combined with a 32 channel receiver helmet were used to obtain generic (non-patient specific) RF excitation shim. We present results that achieve uniform whole brain excitation through multiple 2D slabs.

Methods: *RF Simulation and Experimental Measurements of SAR/B_1^+ Distributions*. The brain was divided into three 2D slabs/regions (top, middle, and cerebellum). RF excitation based on phase-only shimming for the transmit array was optimized for 1) uniformity, 2) high mean B_1^+ field and lower input RF power and 3) SAR measured by average values over the whole head as well as local over any 10 gm of tissues. In each region and for each subject (4 total) MR images were obtained without B_1^+ measurements or retuning/matching across subjects. Figure 1 shows the combined transmit B_1^+ field maps of optimized for three 2D slabs from simulations as well as B_1^+ field maps obtained using 7T human scanner. The 2D slabs were used to obtain TSE and FLAIR images (shown in Figure 2.) The maximum variation (see table below) in B_1^+ in the brain and full cerebellum volume was ~22% (while less than 18% variation could still be achieved across the whole head with the same number of channels -8- with 3D volume excitation and similar SAR values, the required RF power exceeds what's available on the scanner.) Based on transmission loss (from RF amplifier to the array ports) and calculated absorption percentage, the measured 10 Sec SAR average is 0.6~7 W/Kg for 2D TSE & FLAIR with parameters shown below. The FDTD calculation indicates a 0.5~0.6 W/Kg average SAR (the difference could be attributed to losses in circuitry both on the Tx and Rx arrays which are not included in the calculations.) The chosen RF shim excitation peak SARs ranged between 3.4~4.9 times the average SAR.

Results and Discussion: Different 2D slabs with whole brain/cerebellum coverage were used to obtain (TSE & FLAIR) images, these images are often used to detect lesions in the brain and could be overlaid with high resolution susceptibility weighted images as shown in [1,2] for improved analysis of lesions, microvasculature and iron deposits.

2D SLABs with overlap	B1p Std/ Mean	SAR_ave (W/Kg)*	SAR_peak/ SAR_ave
Top (6.6cm)	0.14	1.51	3.45
Middle (3.8 cm)	0.22	2.12	3.95
Cerebellum (3.4cm)	0.17	1.73	4.89
*10 gm SAR average per 2uT B1p in slab			

References: [1] Grabner et.al. MRM 2011, [2] Zwanenburg et.al Eu. Radiology 2010. This work was partially supported by Siemens Medical Solutions and NIH

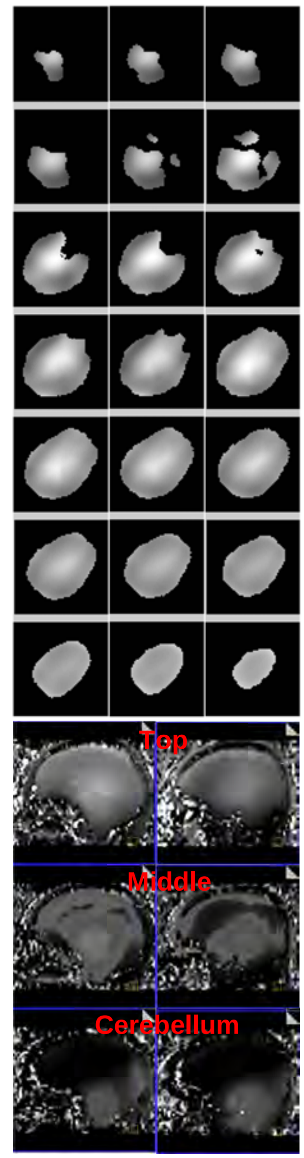

Fig 1 Top: FDTD simulations: transmit B_1^+ of the fused three 2D slabs covering the whole brain and cerebellum. Bottom: Corresponding experimental B_1^+ field maps (Sagittal view) at center (left) and 2 cm off-center (right) showing the three 2D slabs displayed in

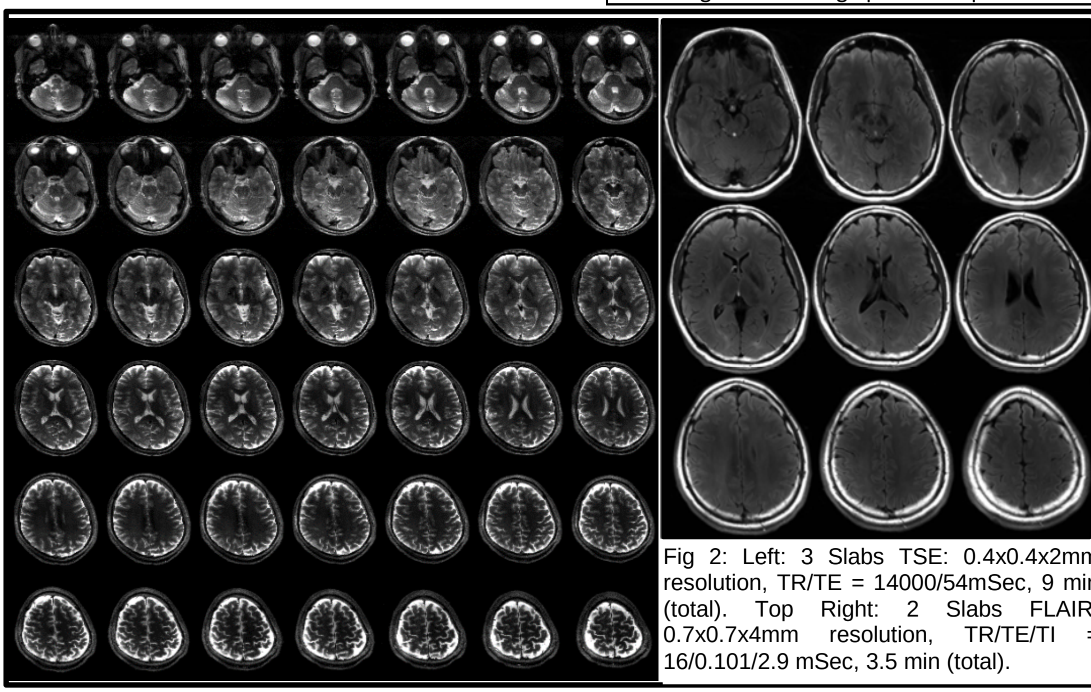

Fig 2: Left: 3 Slabs TSE: 0.4x0.4x2mm resolution, TR/TE = 14000/54mSec, 9 min (total). Top Right: 2 Slabs FLAIR: 0.7x0.7x4mm resolution, TR/TE/TI = 16/0.101/2.9 mSec, 3.5 min (total).