

# T2\* Susceptibility Weighted and Echo-Planar Imaging at 7T using RF Shimming

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## Introduction

Addressing RF inhomogeneity that arise at high operational frequencies is pivotal in development of RF coils for high ( $\geq 3$  Tesla) and ultra high fields ( $> 7$  Tesla). At high field strengths the human head/body size becomes comparable to the RF wavelength and the interaction between the RF coil and tissue becomes increasingly sensitive to variations in the size/shape of the human head. In this work, reliability in acquiring high signal to noise images and/or improved acquisition times with the 20Ch Tx and 32Ch Rx were tested. The coils were tested with different contrast parameters, and be it BOLD, T2\*, or structural T1 weighted imaging. We have been able to obtain whole brain  $B_1^+$  homogeneity (max to min  $B_1^+ < 2.6$ ) via. RF shimming. Current work incorporates the effect of receive array on transmit coil RF fields [1].

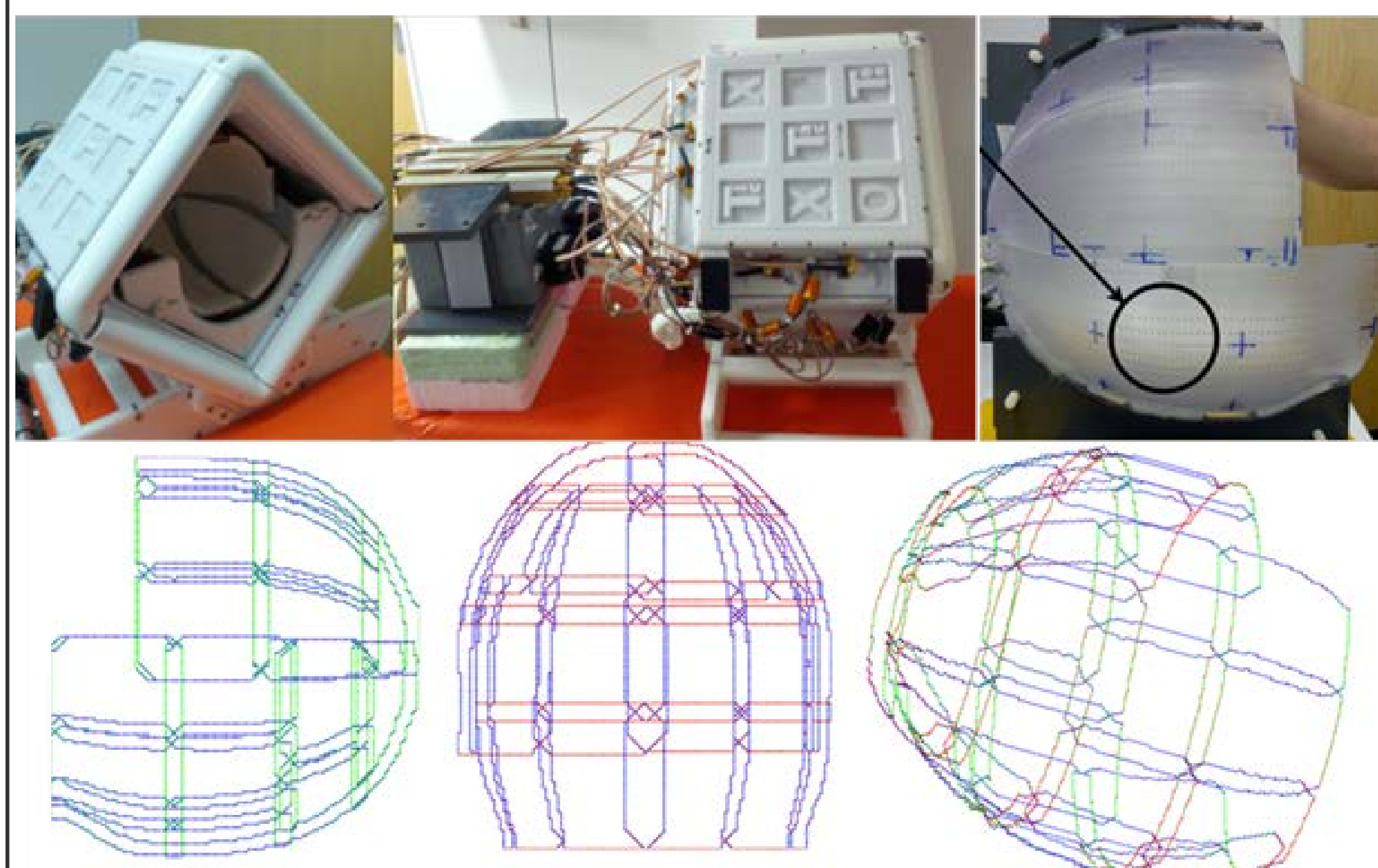
## Materials and Methods

### 1. Tx Coil Tuning:

The TTT 20Ch transmit array was tuned on a volunteer and tested across multiple subjects. Figure 2 shows the robust tuning of the Tx coil  $\sim 50$  Ohm. The array is subject-insensitive does not require tuning and matching.

### 2. Numerical Full wave Simulation of TTT coil with Phantom/Anatomical Head Models

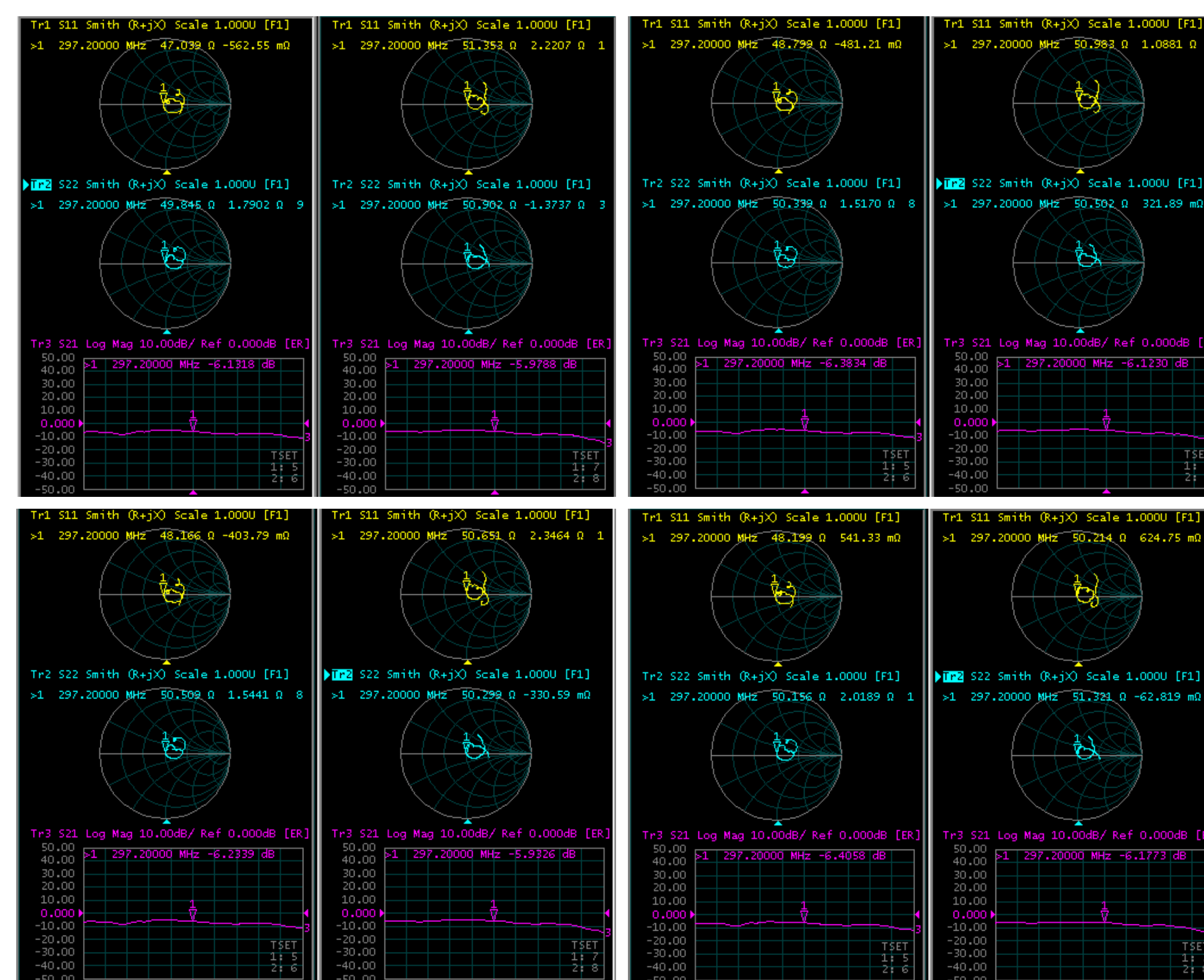
Validation of full wave simulation of the coil with experimental results in terms of matching transmit fields of 20 ports on phantom are shown in figure 3.



**Fig1:** Dedicated 20 Ch Tx and 32 Ch Rx coils. Prototyped Rx helmet inlaid with grid to localize and extract Rx Loop geometry. Extracted FDTD model of 32 Rx Loop Array was used to obtain RF shimming parameters, as we have shown the Rx array causes subtle changes in  $B_1^+$  and SAR [1].

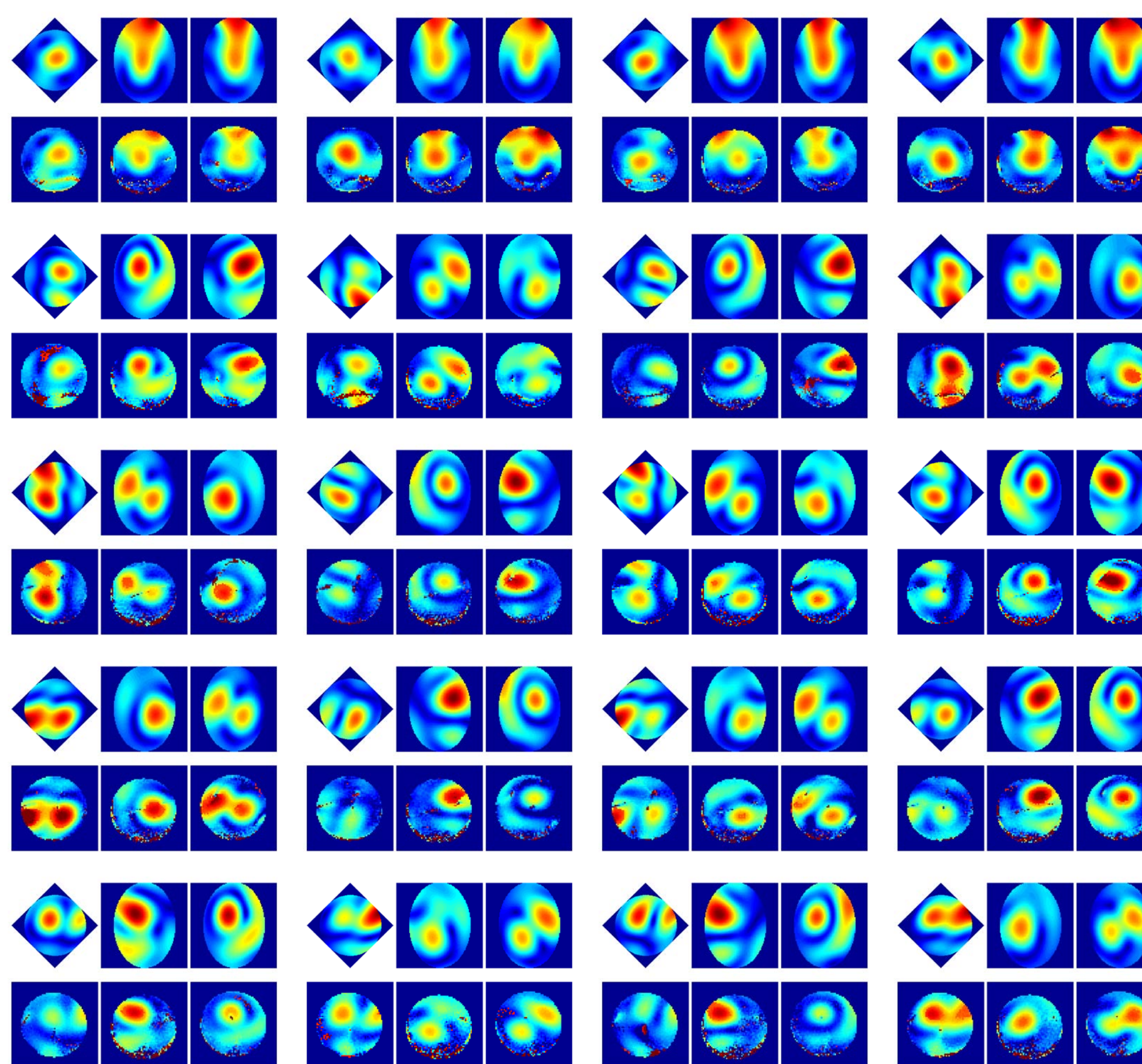
## Results and Conclusions

**3. Invariant Tx Coil Tuning :** The Tx Coil tuning (Smith Chart) on 4 volunteers (different head shapes and sizes) are shown below: The coil tuning was robust around 50 Ohm .



**Fig. 2** Smith chart of 4 ports of 20Ch coil across subjects is invariant around 50 Ohms.

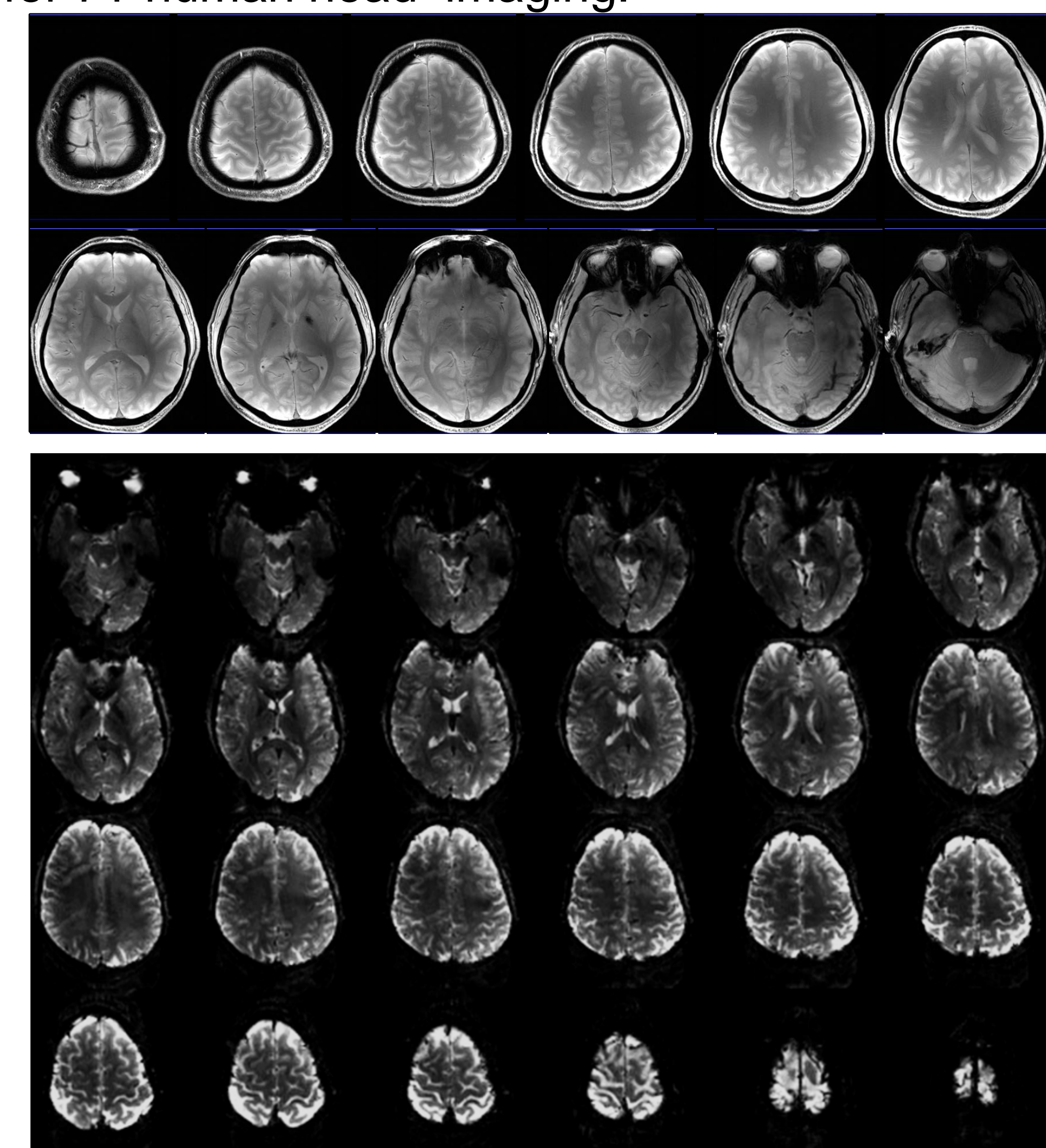
### 4. Validation of Match of $B_1^+$ Field of 20 ports of Tx Coil With Numerical Simulations



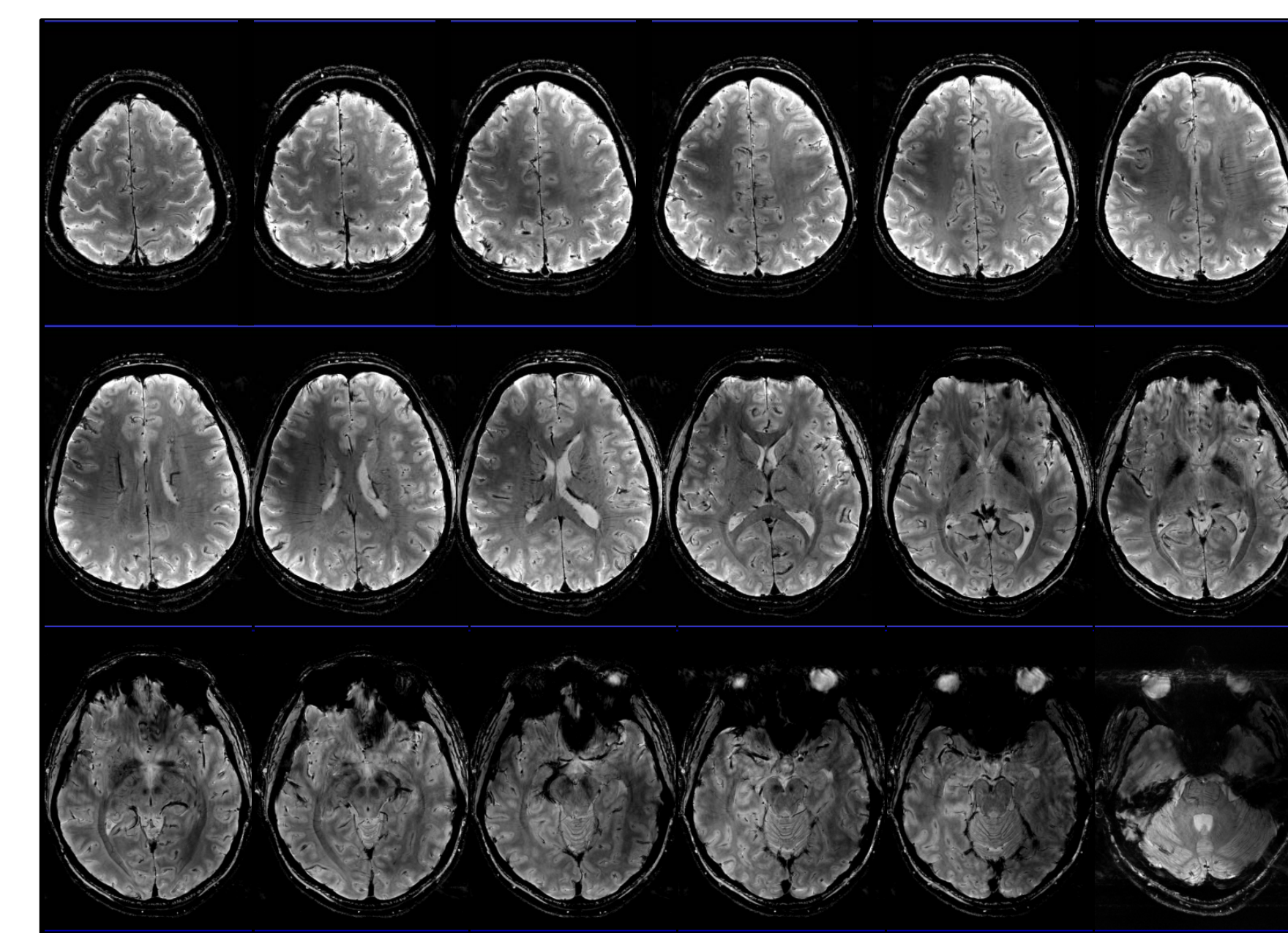
**Fig. 3** Shown are  $B_1^+$  maps from numerical simulations (top sub-figure) and experimentally acquired  $B_1^+$  maps (bottom sub-figure).  $B_1^+$  Maps were acquired in the PTX system with a Ref amplitude 1H 111V, measurements=6. The acquisition parameters : TR =2.2 sec, TE = 1.4 msec, FOV =220 mm, Matrix = 64x64, Thickness 3 mm, receiver bandwidth 510 Hz.

## Results and Conclusions

**5. RF Shimming :** GRE and EPI images are shown in figure 4: RF amplitude and phases were used to obtain a whole Brain + cerebellum  $B_1^+$  (max/min  $< 2.6$ ), with a mean SAR 2.25 W for a continuous mean  $B_1^+$  value of 2uT in the brain + cerebellum and peak/mean SAR ratio  $< 3.5$ . Due to the array's robust insensitivity to different subjects, the images were obtained without  $B_1^+$  mapping using excitation obtained from numerical simulations. This RF Tx/Rx acquisition system can also be used in normal mode without the Parallel Transmit Array System (PTX) on the 7T human scanner. The 3D transmit field homogeneity represents current state of the art for 7T human head imaging.



**Fig. 4** Gradient Echo (GRE) TR=15msec, TE=30msec, Matrix=384x384 and Echo Planar Images (EPI), 20x20x3mm, bandwidth per pixel 2442Hz/Px, TE=20msec, TR=1.4sec



**Fig. 5** T2\* Images obtained at 7T iso-0.25mm<sup>3</sup> obtained with TR=2sec, Flip Angle=75, TE=15msec, Using the 20 Ch Tx and 32 Ch Rx coils, scan time 16min

[Reference] [1] N. Krishnamurthy et al. JMIR 2013. \*This work was supported by NIH.