Evaluation of B_1^+ and E field of RF Resonator with High Dielectric Insert

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Introduction:

For better RF coil performance, strong $\mathbf{B_1^+}$ field and low **E**-field (or high $|\mathbf{B}_1^+|/|\mathbf{E}|$) are expected when unit power was applied. Dielectric shield inside a small solenoid can decrease electric field but magnetic field is not significantly affected [1]. In this work, $\mathbf{B_1^+}$ and **E** field inside a birdcage coil with and without a high-dielectric (relative permittivity is 130) tube insert were investigated by finite difference time domain (FDTD) method [2].

Methods:

Finite difference time domain method can solve electromagnetic field with non-regular boundary condition with high accuracy [3]. Here FDTD method was used to calculate all electrical and magnetic fields through time-dependent Maxwell's curl equations. A 16-rung birdcage (26cm i.d. and 25cm length) was modeled with 2mm resolution in all directions. The conductivity of copper ($5.8\text{x}10^7$S/m) was assigned to coil cells. A high-dielectric tube (22cm i.d., 25cm length, and 2mm thickness, ε = 130) was inserted into birdcage coil. Current sources were used to model capacitors and were placed at the center of each rung. All the current sources have unit amplitude, and have phases of cylindrical coordinate azimuthal angles, which can mimic quadrature driving of birdcage coil.

Results and Discussion:

The magnitudes of $\mathbf{B_1^+}$ and **E** fields with and without high-dielectric insert were shown in Fig. 1. All the results were normalized to input power of 1W, and shown with the same color scale. According to Fig.1, when the high-dielectric tube was applied, the magnitude of $\mathbf{B_1^+}$ increased dramatically, as well as the magnitude of **E** decrease. For details, a ROI (21cm diameter) on the central axial plane within the high-dielectric tube was selected for investigation. The magnitudes of $\mathbf{B_1^+}$ and **E** fields within the ROI with and without high-dielectric insert were shown in Fig. 2. The 1D profile of $\mathbf{B_1^+}$ and **E** field crossing the center of ROI were shown in Fig.3. Without the high-dielectric insert, the average magnitude of $\mathbf{B_1^+}$ and **E** field within the ROI are $1.99\text{x}10^{-7}$T and 101.55V/m respectively. After insert the high-dielectric tube, the average magnitude of $\mathbf{B_1^+}$ and **E** field within the ROI are $4.3\text{x}10^{-7}$T and 50.79V/m respectively. So the $|\mathbf{B}_1^+|/|\mathbf{E}|$ ratio increases by a factor of 4.32.

In conclusion, the high-dielectric insert within RF coil can help to increase $\mathbf{B_1^+}$ field and decrease **E** field, or gain higher $|\mathbf{B}_1^+|/|\mathbf{E}|$ ratio, which means higher SNR can be expected with a high-dielectric insert applied.

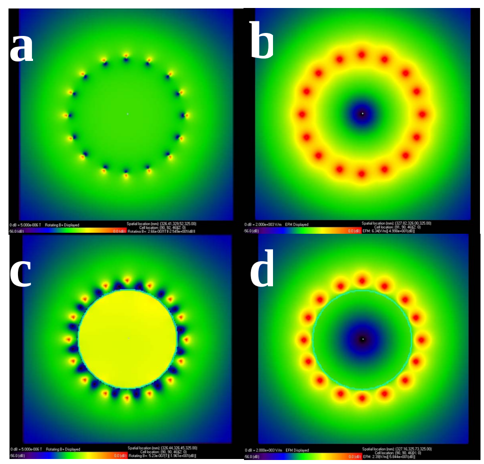

Fig 1. $\mathbf{B_1^+}$ magnitude distribution without(a) and with(c) high dielectric insert. **E** magnitude distribution without (b) and with(d) high dielectric insert

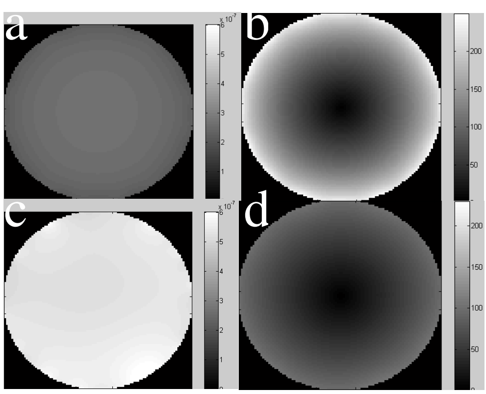

Fig 2. $\mathbf{B_1^+}$ magnitude distribution within ROI without(a) and with(c) high dielectric insert. **E** magnitude distribution within ROI without (b) and with(d) high dielectric insert

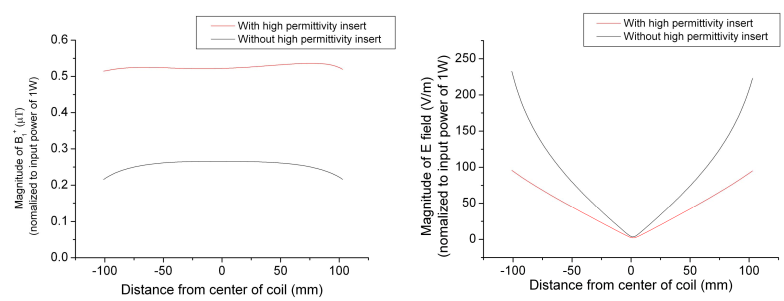

Fig 3. 1D profile of $\mathbf{B_1^+}$ and **E** field crossing the center of ROI with and without high dielectric insert

Acknowledgement:

This work was supported by NIH grant EB004453, QB3 Opportunity Award

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