Numerical Model of a Dielectric Resonator for High Field MRI

B. S. Park[1], A. G. Webb[2], M. B. Smith[3], and C. M. Collins[3]

[1]Bioengineering, Penn State University, College of Medicine, Hershey, PA, United States, [2]Bioengineering, Penn State University, University Park, PA, United States, [3]Radiology, Pennsylvania State University, Hershey, PA, United States

INTRODUCTION: Dielectric resonators have been used for integrated microwave filters and oscillators because of their very high Q values of up to several thousand, lower conductor losses, and smaller size than metallic resonant cavities. Capitalizing on these properties, some researchers have used high dielectric materials in MRI and EPR (1, 2). Based on previous research (3), we have designed a dielectric resonator for high field microimaging in MRI and performed full Maxwell numerical calculations of the electromagnetic fields to evaluate the resonator. Here the calculated electrical and magnetic field distributions are shown.

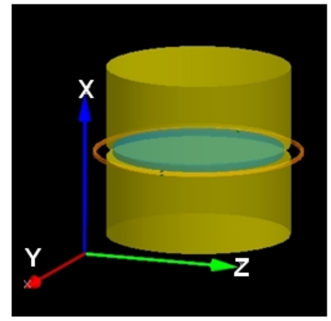

Figure 1 Geometry of the resonator, sample and copper loop for the simulation.

METHOD: A dielectric resonator composed of two discs of barium strontium titanate (having a dielectric constant of 323) each of diameter 28 mm and thickness 12 mm, placed coaxially and 2 mm apart, was modeled for microimaging at 600 MHz/14.1 T (Figure 1). A copper loop was placed between the discs to drive the system and a saline sample having dielectric constant of 78, conductivity of 0.2 and a diameter of 13 mm was placed between the two discs. All simulation work was performed using commercially available software (xFDTD; Remcom, Inc; State College, PA). The conductivity of the resonator was set to 0.1S/m to allow for convergence. Analysis of the results was performed in Matlab (The MathWorks, Inc., Natick, MA). All simulation results of electromagnetic fields were normalized so that the magnitude of magnetic flux density (||B||) was 4μT at the coil center.

RESULTS AND DISCUSSION: In this study the model was based on an existing resonator that has been used to image small samples between the two discs at 600 MHz (3). Limitations in manufacturing capability for such a large resonator have led to this very simple design, rather than the more conventional geometry in which a hole for sample placement is introduced through the center of each disc. As shown in Fig. 2, the electric field is smallest near the central axis of the resonator where the magnetic field is strongest (Figure 2). Thus, the cylindrical dielectric resonator has a region of low loss and high sensitivity along its central axis, and should provide superior SNR to (for example) a solenoid design, which is found to produce a significant electric field in the sample due to the electrical potential on the wires (4), resulting in a significant contribution of the sample to noise in high field microimaging (5). Of course, the dielectric resonator also has significantly lower coil loss than a conductive coil, which should also significantly improve SNR for small samples. Results of ongoing calculations for dielectric resonators with space along the axis containing a cylindrical sample will guide construction of a new resonator in the near future.

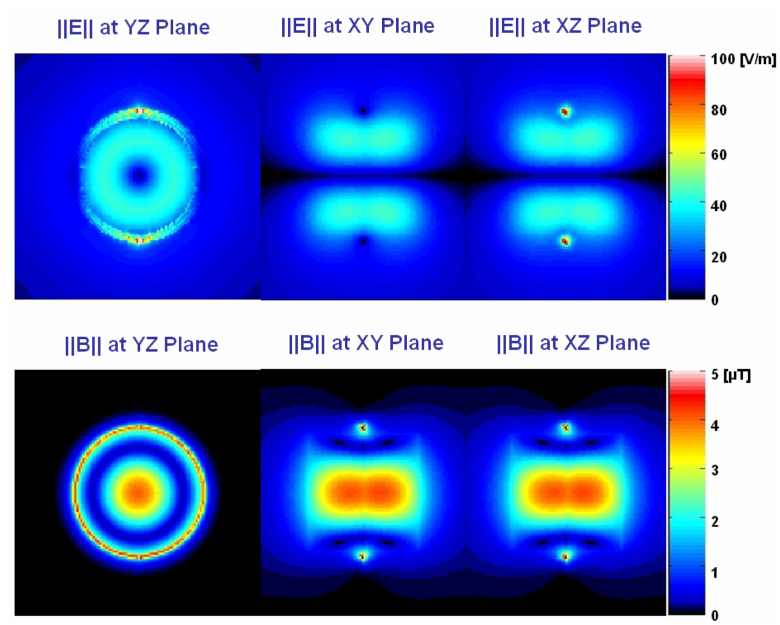

Figure 2 Total magnitude of electric field (top) and magnetic field (bottom) for the central axial (first column), sagittal (second column) and coronal (third column) slices through the resonator.

REFERENCES

1. H Wen *et al.*, JMR Series B 110, 117-123 ,1996.
2. G Lassmann. JMR 172, 312-323, 2005.
3. AG Webb *et al*., 48th ENC, 2007.
4. BS Park *et al.* 15th ISMRM, p. 3245, 2007.
5. KR Minard and RA Wind. Concepts in MR 12:190-210, 2001.

ACKNOWLEDGMENT: Funding through NIH R01 EB000454.