Integrated RF Birdcage Head Coil* for 7T MRI

R. Lazar[1], F. Schmitt[1], W. Renz[1], B. Stoeckel[1], G. Wiggins[2], and L. Wald[2]
[1]Siemens AG Medical Solutions, Erlangen, Germany, [2]MGH/ A. A. Martinos Center for Biomedical Imaging, Charlestown, MA, United States

Introduction
Circular polarized RF-coils with a bandpass birdcage design for head MRI imaging are well documented in the literature [1],[2]. In our case the task was to build a transmit coil for 7T head imaging which should be integrated into a gradient insert coil. One target was to make the RF-Coil large enough to give space for independent receive coils. A side task of the design was to integrate as much acoustic noise damping as possible.

Motivation
The idea of integrating a Tx-Rx RF-coil in a high field MRI system within a gradient insert coil for head imaging is straight forward. The supporting tube of the RF-Coil has to tightly fit into the bore of the gradient insert coil. A maximum space has to remain available at the inside of the RF-Coil to accommodate eventual RX-only coils. In our case this leads to an O.D. of the RF-Coil of 390mm. and an I.D. of 360mm (position of conductors). *Last but not least*, the supporting tube carrying the RF shield on the outside and the RF structure on the inside has to serve as an acoustic insulator. Finding the right material combination to meeting both acoustic and RF requirements is the main goal of this study.

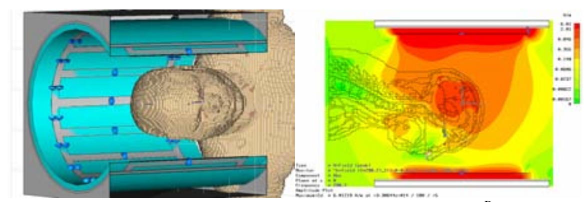

Fig.1: Simulation data obtained with Microwave Studio[P], and the Human Body Model (HUGO[P]) was used to fine tune the geometry and material consistency of the RF-Coil.

Method
The coil is to be built on a supporting tube of 15mm thickness. This thickness defines the spacing between the birdcage elements and the RF screen (field reflux volume). Simulations with the FDTD program Microwave Studio were done to optimize the coil properties. The result was a 16 rod birdcage, 20cm long, with a two port feed.. For the purpose of acoustical noise damping, a tube made of full GRP material would be the optimal choice. From the RF point of view the high dielectric constant has a negative effect on the field length and thereby undesired excitation of the patient shoulders. This was verified by simulation and tested by experiments. In order to improve the electrical behavior of the RF-coil without losing the good acoustical insulation of the readily available GRP material, a supporting tube of only 7.5mm thickness was used to build another coil (390mm O.D., 375 I.D.). The remaining 7.5mm the inside of the GRP tube were filled with a low dielectric constant foam material (Rohacell®).

Fig.2: Two shielded coils were built, on the far left within a GRP suporting tube, on the right hand side within a sandwiched cylinder of 7,5 mm GRP and 7,5 mm foam

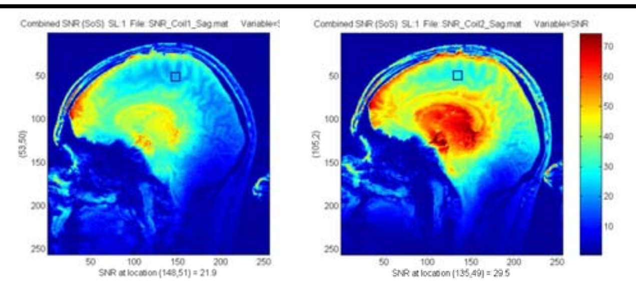

Fig.3: Inivo SNR distributions within the head of a human volunteer obtained with the constructed coils: left with the supporting tube of full GRP, on the right hand side the sandwiched GRP-foam structure

Results
The simulations showed promising results for the described sandwich structure of GRP and Rohacell®. For experiments in a 7T system at NYU two coils were built: one with 15mm GRP and one with the GRP/Rohacell® sandwich structure. Coil quality factor, field structure, homogeneity and image quality were significantly better for the sandwich structure (Fig. 3). Issues like residual RF-illumination of the shoulders which can cause artifacts were also checked for both structures. Additional RF screening of the endrings decreased the signal in the shoulders by about 50%, but caused considerably more signal in central regions of the torso.

Conclusion
The feasibility of a RF-Coil with a rather large diameter compared to traditional head coils, attached to the inner face of a supporting tube made from a material with high acoustic impedance was investigated by both simulation (*Fig. 1*) and by experimental setups (*Fig. 2* and *3*). The coil is aimed towards integration within a gradient insert coil for head MRI imaging. The efficiency of the RF-Coil is tightly correlated to the material properties of the layer in the immediate vicinity of the electrical structure (ε and $\tan(\delta)$). It has been found, that a coil constructed on a sandwiched material of half GRP and half foam is best suited for imaging purposes, when the noise damping function of the supporting tube is of a great importance for the acoustical insulation of the patient bore.

References
[1] Vaughan JT, Adriany G, Snyder CJ, Bollinger L, Liu H, Tian J, DelaBarre L, Ugurbil K. *An efficient high frequency body coil for high field MRI.* Magn Reson Med 2004;52:851-859.
[2] Hayes CE, Edelstein WA, Schenck JF, Mueller OM, Eash M. *An efficient, highly homogeneous radiofrequency coil for hole-body NMR imaging at 1.5 T* J. magn. reson. 1985, vol. 63, no3, pp. 622-628

* The information about this product is preliminary. The product is under development and not commercially available in the U.S. Its future availability cannot be ensured.