A High-pass Birdcage Coil for Small Animal Imaging at 600MHz/14.1T

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Introduction: Birdcage coils become difficult to build at high field strength, as smaller capacitor values are required and coil sections become large relative to the RF wavelength. This abstract demonstrates a birdcage coil operating at 600MHz ($\lambda_{free\ space}$=0.5m) for small animal imaging.

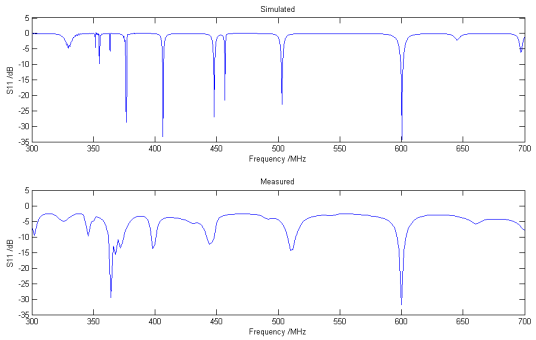

Figure 1: Simulated (top) and measured (bottom) S_{11}.

Methods: A 12-rung high-pass design was chosen (50mm diameter × 32mm long, 2mm track width; 120mm diameter × 200mm long shield). Probe dimensions were chosen to allow construction from off-the-shelf plastic tubes (Angst & Pfister). Birdcage Builder was used to calculate initial capacitor values [1]. The probe was then simulated using Microwave Studio (CST) to fine-tune the capacitor values and investigate B_1 field homogeneity. The probe length was adjusted slightly to move the frequency of the end-ring mode away from that of the desired birdcage mode. The conducting structure was manufactured from flexible PCB (0.1mm FR4, 35µm Cu). Five variable capacitors were used (2×tuning, 2×matching, balance, 1-9pF, type NMKJ10HVE, Voltronics); fixed capacitors are 8.2pF, type 100B (ATC). Bazooka baluns were fitted to the coaxial cables approximately 40mm from the probe, (9mm diameter × 50mm long PTFE tubes coated with 35µm copper tape (3M), tuned using three 1.2pF capacitors (100B, ATC)).

Channel	Q_U	Q_L	Q_U/Q_L
1	195	82.4	2.37
2	199	85.7	2.32

Table 1: Measured unloaded and loaded Q-factors.

The coil was characterised using a network analyser (E5071C, Agilent). MR data was acquired using a 14.1T/26cm horizontal bore scanner (Agilent). B_1 maps were generated using the double-angle method (60°/120° FA, 0.2mm slice thickness, T_R/T_E =20,000/2.5ms, axial FOV: 40×40mm^2, 128×128 matrix, coronal FOV: 40×80mm^2, 128×256 matrix) [2]. Images of an ex-vivo mouse head were acquired using a fast spin-echo sequence (T_R/T_E=6000/10ms, 256×256 matrix, 20×20mm^2 FOV, 15 × 0.1mm slices).

Results: Good correspondence was found between simulated and measured probe reflection (fig. 1). The loaded birdcage was matched to -42.6dB and -39.7dB; coupling between channels was -19.5dB. Unloaded and loaded Q-factors (table 1) demonstrate good sample loading. Figs. 2 and 3 show simulated and measured B_1 maps, demonstrating good axial homogeneity, reasonable coverage along the z-axis, and a slight central brightening effect.

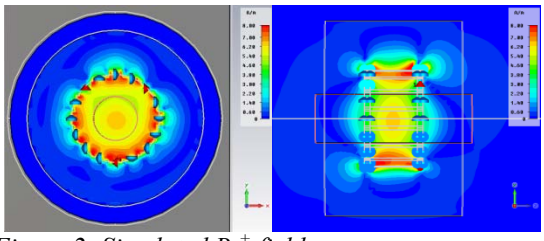

Figure 2: Simulated B_1^+ field.

Discussion: A high-pass birdcage coil has been shown to produce a homogeneous B_1 field over a field-of-view large enough for mouse and small rat imaging at 600MHz, despite the short RF wavelength. The coil was designed as a transmit probe; image SNR is sub-optimal, as preamplifier is located outside the magnet bore, introducing ca. 2dB cable losses before the preamplifier. Future work will focus on developing preamplifiers for use inside the magnet bore, and adding active detuning to the coil to allow use of surface and array receive coils.

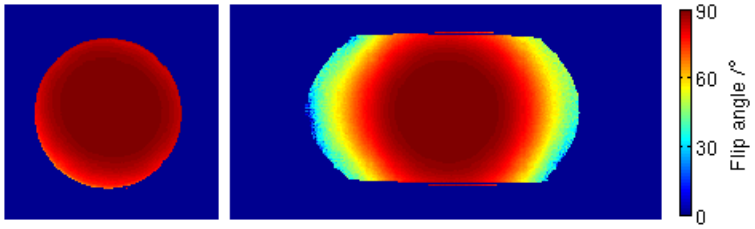

Figure 3: Flip angle map measured in a 60ml water-filled syringe using the double-angle method.

References: [1] C. L. Chin et al, Birdcage Builder, CNR, Penn State 1998; [2] Insko et al, JMR A 103: 82–85 (1993);

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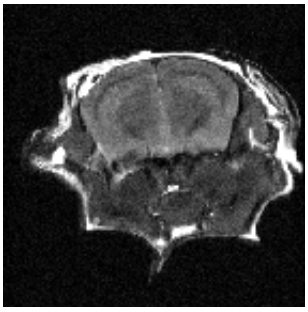

Figure 4 : Image of a mouse head, ex-vivo.