A High Throughput 8 Channel Mouse Probehead for 9.4 T

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Introduction

Rodent MRI is well established but still puts substantial demands on combining highly sophisticated experimental setups with careful animal handling. Rodents, in particular disease models, may be very sensitive to the anaesthetic burden, and, therefore, minimal scan time is essential. In this work we present an 8 channel 9.4 T mouse probehead optimized for high throughput.

Methods

For achieving the highest possible image quality a birdcage resonator (diameter 67 mm, length 82 mm) for homogeneous excitation and an 8 channel volume array (inner diameter 33 mm, element size 14 x 33 mm^2) for sensitive and accelerated detection were chosen. Both coils are integrated into one single probehead in order to fix their relative position (Figure 1). Furthermore, the probehead is locked in the magnet at a well-defined position. Both, the Tx and the Rx coil are fixed tuned. The Tx resonator is large compared to the mouse and experiences only small variations of impedance change. Reflections on the Tx channel can be compensated by higher Tx power. The Rx array comprises high input impedance reflection preamplifiers (S11 = 0.8, integrated into the probehead) and, therefore, provides robust SNR over a wide range of differing loadings. To ensure a simple interface all channels can only be switched simultaneously. Furthermore, two hybrid connectors for receive RF and DC are used. Including the transmit RF coax, a total of only four connectors have to be plugged to the console for 9 RF and 3 DC lines (i.e. active decoupling and preamplifier power supply, Figure 2). Animal handling is provided on a mouse cradle, which is placed immediately after preparation into scanning position. The probehead itself and the main animal chamber for the mouse can be temperature controlled by airflow for saving space and optimizing the filling factor of the array. The probehead is used on a horizontal 9.4 T VNMRS DirectDrive MR-system (Varian Inc, USA) with a gradient bore of 120 mm.

Results

Due to its large size the HP birdcage yields a Q drop of 300/130 when loaded with mouse equivalent saline solution. A rectangular 90° Tx pulses is typically in the order of 100 µs at max power. A z-profile (Figure 3) shows that the array is shielding the sample against Tx power, which is due to the high density of copper and RF components. Nevertheless, homogeneity in z-direction is satisfactory in the region of the array. The Rx array yields a Q drop of 130/100 indicating limited sample noise contribution. SNR comparisons to an equivalent quadrature birdcage (birdcage: 150, array: 140) show that the SNR in the coil centre is lower, but that the array outperforms the birdcage towards the outer regions (data not shown). Noise correlation between all channels is below 12%, during imaging the channels show no coupling (Figure 4a). Active decoupling of Tx and Rx coil proved to be better than 30 dB. The total setup time for the probehead including positioning and wiring is < 1 min. Probehead and animal can be handled completely independently.

Discussion & Conclusion

Due to the large size of the birdcage the probehead shows a reduced, but still sufficient Tx efficiency. The B_1 profile satisfies the need for homogeneous excitation. The Rx array yields high SNR as shown in comparison with a birdcage. In the coil centre SNRs are comparable, whilst in outer regions the array exceeds the birdcage due to the surface coil characteristics. The simple and fast setup ensures time saving to focus on the main object of the investigation, i.e. the mouse.

Acknowledgements

Thanks to Dr Michael Gyngell for fruitful discussions!

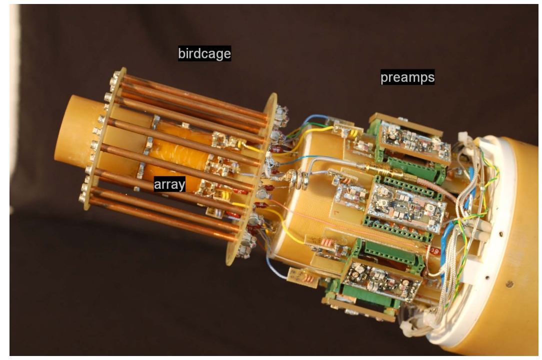

Figure 1: Electronics.

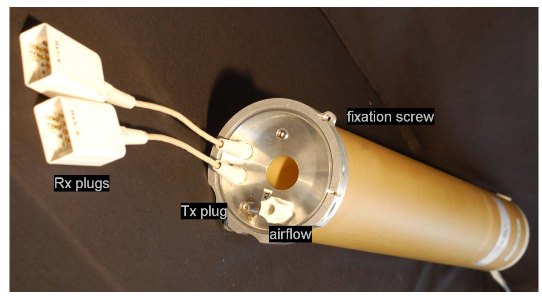

Figure 2: Probehead.

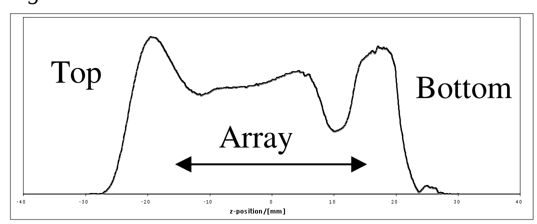

Figure 3: z-profile of homogeneous phantom. The array, especially the coupling network, shields the Tx field due to copper and components.

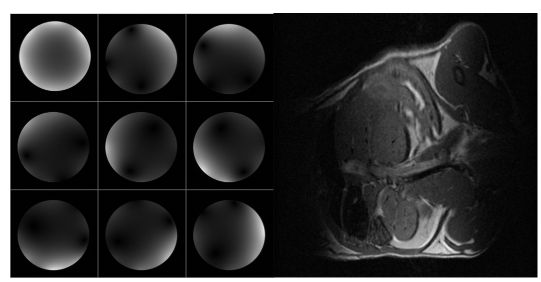

Figure 4: (a) Axial sum-of-squares and single coil images of a saline phantom, (b) coronal view of abdominal area of mouse (SE, TE/TR=6.7/1000ms, 256^2, 60x25.6 mm, double-gated).