A 1H-31P Array Coil for Human Brain Spectroscopy at 3T

W. Driesel[1], A. Pampel[1], C. Labadie[1], T. Mildner[1], H. E. Moeller[1], and H. E. Moeller[1]
[1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Previously, a modular approach has been suggested for designing large arrays [1]. It is based on a stacked combination of loop coils and microstrip transmission-line (MTL) elements, which are intrinsically orthogonal. In this work, this concept was adopted to build a helmet-shaped, dual-tuned array coil for human brain ^{31}P spectroscopy and ^{1}H decoupling and imaging at 3 T. The ^{1}H channel is based on a pure MTL design with four spokes [2]. On each spoke, a loop coil was added to permit ^{31}P transmission/reception (Tx/Rx) (Fig.1). Initial results from investigations of the performance for ^{31}P magnetic resonance spectroscopic imaging (MRSI) including phantom studies are presented.

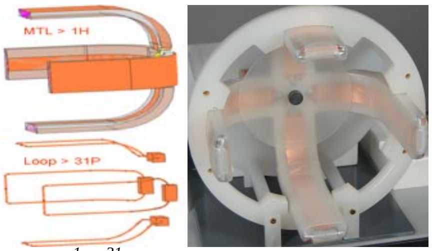

Fig. 1. *^{1}H-^{31}P helmet coil prototype.*

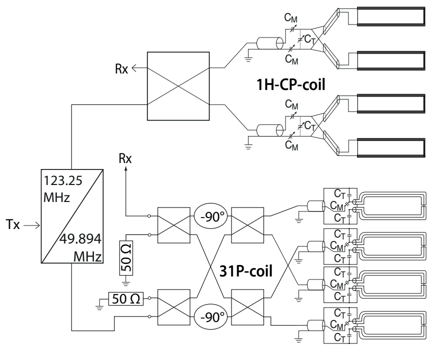

Fig. 2. *Wiring scheme of the coil.*

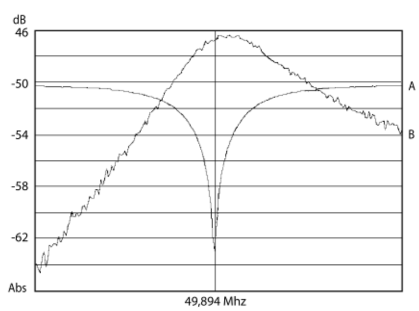

Fig. 3. *Decoupling measurements: Reflection curve from the ^{31}P channel **(A)** and transmission to the ^{1}H channel **(B)**.*

METHODS

The ^{1}H coil element consists of thin strip conductors (Cu; 10µm thick, width ground/strip 50/30mm) on curved low-loss polypropylene (15mm thick) generating an overall helmet-like structure (Ø 23cm; h. 18cm) [2]. The MTLs were terminated by a short to obtain a current maximum at the end pointing to the neck. Opposite coil elements were connected with a 180° phase shift by a short piece of semi-rigid cable. Each pair of coil elements was tuned by a parallel capacitor and matched to 50 Ω by two series capacitors. Four shielded loops [3] (7cm×20cm) arranged in a stacked fashion with respect to the MTLs [1] were used for the ^{31}P coil . The two feed points for the loops were opposite to the gap. The wiring scheme is given in Fig. 2. Each loop was tuned to 49.894 MHz (^{31}P) by a shunt to the shield at the two feed points and matched by a capacitor on one feed point to 50 Ω. The transmit signals were provided via a modified Butler matrix [4]. The same matrix was used to combine the receive signals. The two Tx signals (^{1}H/^{31}P) were separated using a frequency splitter. In the signal path to the ^{31}P preamplifier, a simple stub was integrated to suppress the remaining ^{1}H Tx power by a factor of 36 dB.

Simulations of the rotating transmission field, using a cylinder phantom with average values for brain tissue (ε_r = 93.69 and σ = 0.36 S/m at 49,894 MHz; ε_r = 63.4 and σ = 0.46 S/m at 123,25MHz) were obtained with HFSS 11 (Ansoft Corp., Pittsburgh, PA, USA). Initial MRSI experiments were performed at 3 T on a MAGNETOM TIM Trio (Siemens, Erlangen, Germany) using a spherical phantom (Ø 17cm) filled with standard phosphate buffer solution. Three-dimensional chemical-shift imaging data were acquired using the following parameters: FOV 200×200×200 mm^3, matrix size 16×16×8 (voxel size 12.5×12.5×25mm^3), TR 700ms, excitation angle 25°, NA=1.

RESULTS

Loops and MTLs had nearly similar areas of sensitivity and no significant electromagnetic interaction or degenerated field pattern were found. Due to the balanced coil design, electric fields inside the coil were weak. Measurements of the coupling between MTL and loop element on the same stack yielded −46.78 dB at 49.894 MHz (Fig.3). The drop of the quality factor, Q, as well as the frequency shift, δf, were small under different loading conditions.

The performance of the ^{1}H coil elements was comparable to a single-frequency ^{1}H helmet coil described in Ref. [2] and verified the numerical simulation of the radiofrequency (RF) field, $\mathbf{B}_1$. A representative slice from this data is shown in Fig.4. The signal intensity decreased somewhat with increasing distance from the center, which however results from a suboptimal off-center homogeneity of the main magnetic field. An estimation of the coil sensitivity at the ^{31}P frequency (Fig.5) was based on the signal integral obtained by fitting a Lorentzian to the real part of the spectra. In agreement with the simulations, the coils sensitivity increased in proximity to the coil elements.

CONCLUSION

The stacked element helmet coil design can be used to produce a ^{1}H /^{31}P coil system with low crosstalk. Due to the weak interactions between loops and MTLs no RF field profile distortions were observed.

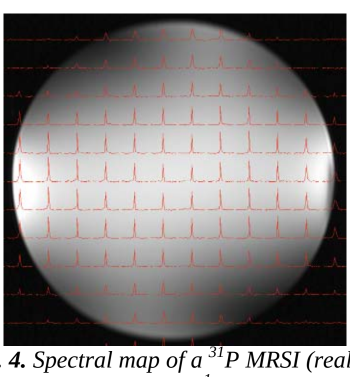

Fig. 4. *Spectral map of a ^{31}P MRSI (real part) superimposed on a ^{1}H GRE image.*

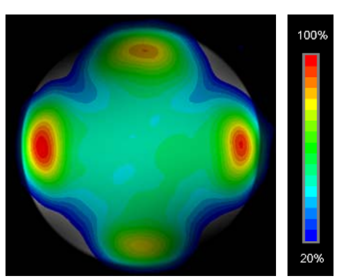

Fig. 5. *Color map (smoothed) of the relative signal integral obtained by fitting a Lorentzian to the spectrum in the respective voxel.*

ACKNOWLEDGEMENTS

We thank Helmut Stark and Manfred Weder for helpful discussions and technical assistance.

REFERENCES

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