23Na/1H abdominal MRI at 3T using a 16 channel Rx Array and an asymmetric Birdcage Resonator

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Target audience: RF engineers, researchers interested in abdominal 23Na MRI

Purpose: 23Na MRI has demonstrated increased diagnostic value in a multitude of studies and clinical applications due to its capability to provide information on tissue viability [1]. Yet, sodium MRI suffers from weak SNR and low abundance of sodium in the human body. Going to higher field strengths is one possible way to compete with this challenge. Since high-field scanners are not commonly available, optimized hardware can improve 23Na MRI performance. Additionally, 1H MR images are needed for morphological information. In order to co-register 23Na and 1H MR images, a double resonant 23Na/1H RF system is the optimal solution. In this work we combine an asymmetric 23Na Birdcage (BC) resonator [2] with a 16 channel 23Na Rx array. To enable 1H imaging a local 1H TxRx coil is added to the configuration since the use of the 1H Bodycoil is not possible due to the shield of the 23Na BC resonator. The optimized performance of the 23Na coil configuration might enable 23Na MRI for clinical use.

Methods: 23Na 16 channel Rx array: The 23Na Rx array was comprised of a top and a bottom half (Figure 1) containing 8 coil elements respectively. Each element was tuned to the resonance frequency of 32.586 MHz using two shortening capacitors. A 1H trap was added to each element at a cold joint of the coil. The array elements were each equipped with an active detuning network, a cable trap and a low noise preamplifier. The elements were arranged in an "olympic"-like configuration to ensure overlap decoupling for all nearest neighbors. The total size of the array was 380x300 mm².

1H TxRx coil: The 1H coil was added to the top support of the 23Na array (dimensions: 400x320 mm²). The coil was split using 16 shortening capacitors. The 1H switch was connected to the coil via a lattice balun.

Measurement: For 23Na MRI an isotropic density adapted 3D radial sequence [3] was used with the parameters: TE/TR/FA = 0.42ms/24ms/45°, FoV = (400mm)³, projections = 17000, resolution = (5mm)³. 23Na SNR maps were calculated using a noise scan with the same parameters but fewer projections (1700) and no Tx power applied. In order to protect the detuning PIN diodes of the 23Na BC coil it stayed resonant during the 1H measurement but the 23Na Rx array was detuned. For 1H MRI a standard abdominal localizer was used. The examination subject was a healthy 25 year old male volunteer.

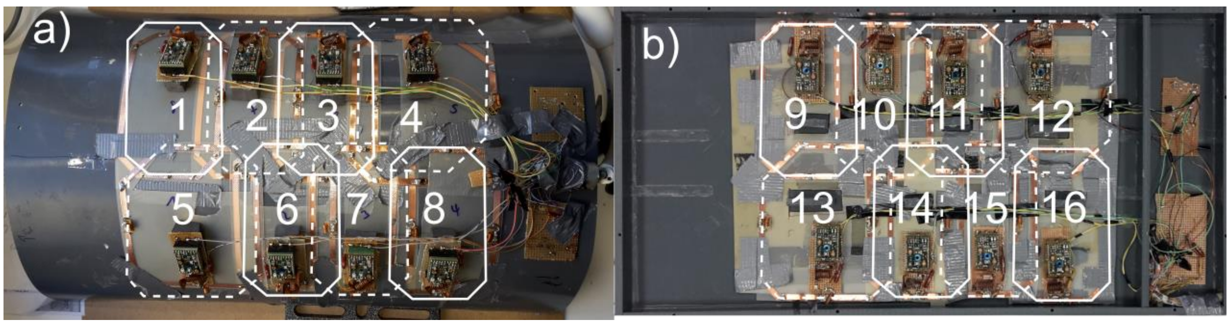
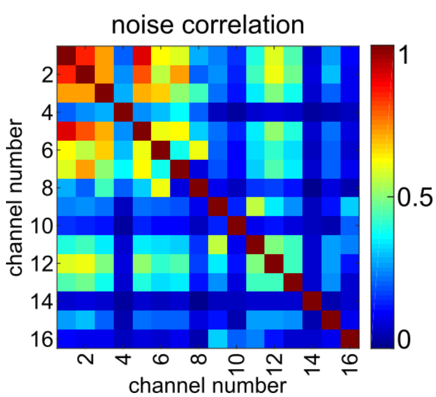


***Figure 1**: Images of a) the top half and b) the bottom half of the 23Na Rx array. The bottom half of the array was enclosed in a fixed housing. The top half of the array was placed on a semi-rigid PVC former.*

***Figure 2**: Noise correlation matrix of the 23Na 16 channel Rx array. The matrix was normalized and averaged over all slices. The semi-rigid top part of the array reveals higher noise correlation values than the fixed bottom part.*



Results/Discussion: The noise correlation matrix of the 23Na 16 channel Rx array is plotted in Figure 2. The top part of the array reveals higher noise correlation values than the lower part. This might be due to the semi-rigid configuration of this part of the array. Nevertheless a more careful adjustment of the decoupling properties might decrease the high noise correlation values. The results of the MRI measurements are displayed in Figure 3. Selected slices of the 23Na MRI measurement are shown in the upper row of Figure 3. In the coronal slice the kidneys and the intervertebral discs can be clearly detected. The same holds for the lower transversal slice. The upper transversal slice is a cut through the heart but SNR is decreased since the heart was at the edge of the sensitivity of the coil. In the sagittal slice almost the whole spine can be seen due to the large FoV of the coil. The results of the 1H localizer are depicted in the bottom row of Figure 3. The 1H images suffer from low SNR and an inhomogeneous coil profile. The performance of the 1H coil might be improved by extending the coil to a Helmholtz coil and adding additional 1H Rx elements. Yet, this might decrease the 23Na performance.

Conclusion: In this work a double resonant 23Na/1H setup was presented comprising of a 23Na 16 channel Rx array, an asymmetric 23Na Birdcage resonator and a local 1H TxRx coil. The 23Na coil covered a large part of the abdomen and the spine, the heart and the kidneys can be clearly seen. The performance of the 1H coil has to be increased in terms of SNR and homogeneity to be able to supply useful morphologic information. Nevertheless, such coil configurations might enable 23Na MRI for the clinical routine.

References:

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[2] Wetterling et al., Phys Med Biol, 2012;57(14), p.4555.

[3] Nagel et al., Magn Reson Med.2009;62(6):1565-1573.

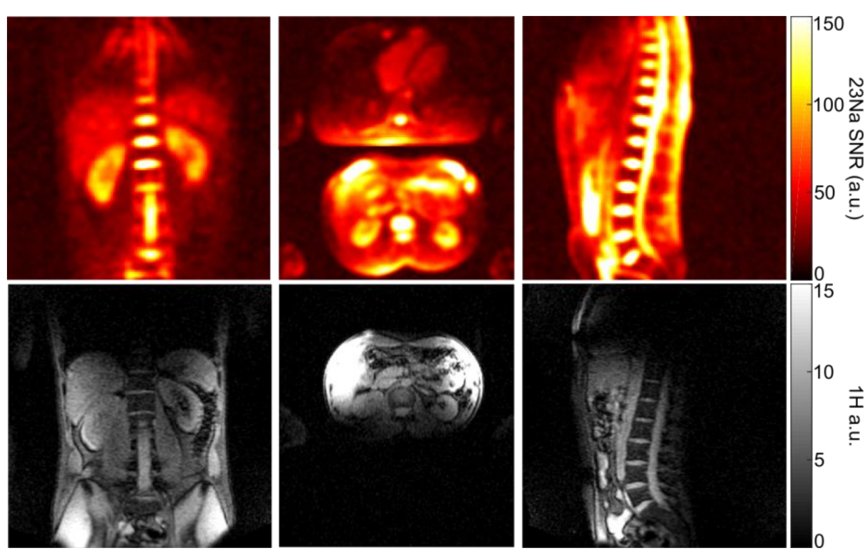

***Figure 3**: 23Na MR images in the top row. One selected slice in coronal and sagittal direction and two slices in transversal direction. The corresponding 1H MR images can be seen in the bottom row. Note that only one transversal slice was available.*