# Ventricular B1 Enhancement - Truth or Fiction?

Wyger Brink[1], Peter Börnert[1,2], Kay Nehrke[2], and Andrew Webb[1]

[1]Radiology, Leiden University Medical Center, Leiden, Netherlands, Zuid-Holland, Netherlands, [2]Philips Research Laboratories, Hamburg, Hamburg, Germany

## Target audience

Users and developers of $B_1^+$ mapping sequences or electrical property mapping techniques.

## Purpose

High resolution $B_1^+$ mapping techniques in the brain at high field often show "residual" structure from, in particular, the ventricles. The purpose of this work is to investigate the degree to which this is a real electromagnetic effect, unrelated to long relaxation time-related effects.

## Methods

In vivo $B_1^+$ maps were acquired in the brain using the DREAM [1] and dual-TR methods [2]. Imaging parameters for the DREAM sequence were: $TR/TE_{TSE}/TE_{FID}$= 3.2/1.09/1.78 ms; STEAM flip angle $\alpha = 35°$; imaging flip angle $\beta = 10°$; field-of-view 240 x 190 x 140 $mm^3$; matrix size 96 x 76; 28 slices; image acquisition time 7 sec. Imaging parameters for the dual-TR method were: $TR_1/TR_2/TE$= 20/100/1.37 ms, flip angle 40°; field-of-view 240 x 190 x 140 $mm^3$; matrix size 96 x 76; 28 slices; image acquisition time 6 min. and 26 sec. All experiments were performed on a Philips Achieva 7T MRI system (Philips Healthcare, Best, The Netherlands) equipped with a 16-rung high pass quadrature birdcage head coil (NM-008A-7P, Nova Medical, Wilmington, MA) for RF transmission and a 32-channel coil array (NMSC025-32-7P, Nova Medical, Wilmington, MA) for signal reception.

Electromagnetic simulations of the $B_1^+$ field were performed using xFDTD (Remcom inc., State College, PA, USA) in which the birdcage head coil was modeled using 32 unit voltage sources with an internal impedance of 50 Ω. The coil was loaded with Virtual Family member 'Duke' and the total configuration was simulated on a 2.5 mm uniform grid. To assess the influence of the strong intrinsic contrast in electrical conductivity between cerebrospinal fluid (CSF) and the surrounding white matter, which is denoted in table 1, the electrical conductivity of CSF ($\sigma_{CSF}$) was varied from 1 S/m to 3 S/m, its actual value being 2.22 S/m.

Table 1. Dielectric properties of brain tissue and CSF indicating the strong contrast in electrical conductivity (σ).

| | $\varepsilon_r$ | σ (S/m) |
|---|---|---|
| White matter | 43.8 | 0.413 |
| Grey Matter | 60.1 | 0.691 |
| CSF | 72.8 | 2.22 |

## Results

Figure 1 shows the experimentally obtained $B_1^+$ maps together with simulations of the $B_1^+$ in the transverse plane at the level of the ventricles. The line plots show the $B_1^+$ along a central line (indicated in white, dashed), indicating a slight dependence of the profiles on the imaging sequence. However, both projections show distinct high spatial frequency features within the central area of high $B_1^+$. The simulations show that the higher the contrast in electrical conductivity between CSF and brain tissue, the more pronounced are these features.

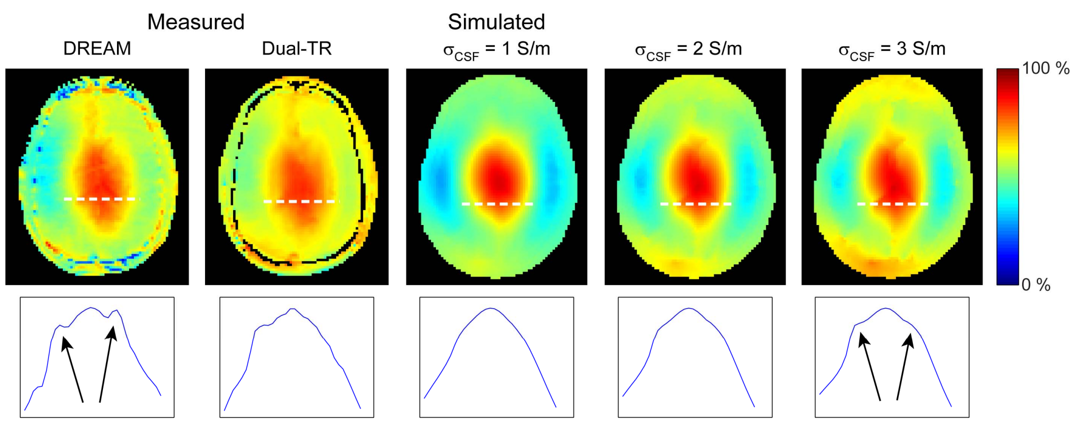


Figure 1. Transverse $B_1^+$ maps at the level of the ventricles (top) acquired in vivo (left) and in simulations (right) with three values of the electrical conductivity of CSF ($\sigma_{CSF}$). The line plots (indicated in white) show a small but noticeable $B_1^+$ contrast near the ventricle boundaries (arrows) in both measured and simulated data.

## Discussion

The long $T_1$ and $T_2$ values of CSF have been suggested as contributing to errors in various $B_1^+$ mapping sequences [1,2] and attempts have been made to correct for these effects [3]. Our results, however, show that ventricular enhancement of the $B_1^+$ is a real effect, and is to a certain extent related to the strong conductivity contrast between CSF and the surrounding tissue. The simulations indicate that this can explain part of the effects, in addition to relaxation effects ($T_1$, $T_2$), in which high resolution $B_1^+$ maps show structural aspects of the ventricles in particular in vivo. This factor should be considered when assessing the accuracy of various $B_1^+$ mapping sequences. Additionally, for correct electrical property mapping these effects should not be interpreted as being a relaxation related artifact but rather a crucial input to the reconstruction method.

## Conclusion

Local $B_1^+$ enhancement at the ventricles can be partially explained by the high contrast in electrical conductivity of CSF with respect to white and grey matter, in addition to long relaxation time-related effects.

## References

[1] Nehrke et al., *MRM 2012*, 68:1517–1526; [2] Yarnyck, *MRM 2007*, 57:192–200; [3] Volz et al., *Proc ISMRM 2009*, 2829.