

### 3DREAM – A Three-Dimensional Variant of the DREAM Sequence

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**Target Audience** Physicists /Engineers working at high field systems with interest in B<sub>1</sub> mapping.

**Purpose** Investigation of the performance of a 3D DREAM sequence for B<sub>1</sub> mapping in the human brain at 7T. In contrast to slice based 2D DREAM this circumvents slice profile effects, comes with very low SAR and peak B1 requirements and allows more efficient acceleration, e.g. by 2D parallel imaging.

**Methods** Starting from the T2- and T2\*-compensated (STE\* first; TS = TE<sub>STE</sub> - TE<sub>FID</sub>) variant of DREAM [1] a 3D variant was implemented by replacing all slice-selective RF pulses with non-selective hard pulses (imaging pulse duration 100 us, preparation pulse duration 400 us) and introducing a second phase-encoding direction. A center-out spiral view reordering in the k<sub>y</sub>-k<sub>z</sub> plane is chosen to capture the k-space center as early as possible after the STEAM preparation module. The acquired k-space is restricted to an elliptical subset to reduce imaging time. To limit image distortions short readout durations and low tip angles are chosen. The low tip angles result in extremely low SAR values (around 1% of the maximum allowed SAR as measured by the system's SAR monitor). 3DREAM images were obtained with a 30-year-

old male volunteer (written consent was obtained) with a MAGNETOM 7T scanner (Siemens AG Healthcare Sector, Erlangen, Germany) scanner equipped with a receive array (32 channel) / birdcage transmit head coil (Nova Medical, Wilmington, USA). The acquisition parameters were: 5mm isotropic resolution; matrix size 50x44x30; readout bandwidth 1560 Hz/pixel, TE<sub>STE</sub>/TE<sub>FID</sub>=0.88/1.63 ms; nominal preparation flip angle 60 deg. To study the influence of T1 saturation on the 3DREAM sequence, the TR was set to 3000 ms (acq. time 14s), 5000 ms (acq. time 22s) and 7000 ms (acq. time 30s) with 1 deg imaging flip angle and 246 acquired lines per TR ("turbo factor"). In addition, two more scans (TR=3000 ms) with turbo factors of 64 and 136 were acquired. To investigate the highest possible acquisition speed, a highly accelerated 3DREAM protocol was implemented by utilizing 2-fold GRAPPA acceleration (16 lines fully sampled reference region) and additional 6/8 partial Fourier acquisition in the larger phase-encoding axis – acquiring all 568 views in a single shot of 3s. For reference, an AFI [3] dataset (flip angle 60 deg, TR1+TR2=100 ms; n=5; TE=0.90 ms; acq. time 1:50 min) with optimized spoiling properties was acquired [4].

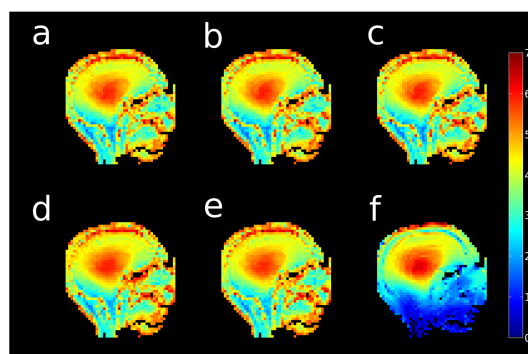
**Results** Figure 1 (a-c) displays the effect of varying TR on the 3DREAM flip angle maps. No systematic deviations can be observed between 3000 ms (a), 5000 ms (b) and 7000 ms (c). In addition no variation can be seen in dependence on the turbo factor (a: 256, d: 64, e: 136). In comparison with the AFI dataset (f) one observes a severe degradation of the 3DREAM flip angle maps (overestimation) in regions where the preparation tip angle is low (< 20deg) – especially in the inferior part of the head. Figure 2 compares the accelerated "single shot" 3DREAM variant with the corresponding AFI sequence, showing again good agreement within the brain.

**Discussion and Conclusion** 3DREAM offers the opportunity for rapid "true" 3D B<sub>1</sub> mapping. A noticeable PSF-induced blurring due to center-out k-space acquisition is not observed due to the smoothness and slow spatial variation of B<sub>1</sub>. Thus, very good agreement between AFI and 3DREAM is achieved. Deviations within the brain are in the range of a few degrees. Even the single-shot acquisitions (which take a few seconds) show good agreement – while just taking a fraction of the AFI scan duration.

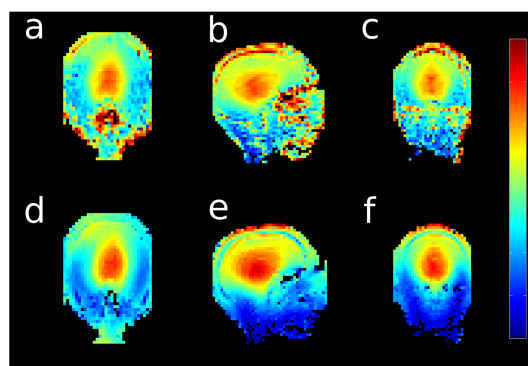
#### References

- [1] Nehrke et al. MRM 2013 *ahead of print* [2] Nehrke et al. MRM 2012; 68:1517–26 [3] Yarnykh MRM 2007; 57:192-200 [4] Nehrke MRM 2009; 61:84-92

\*: The product is still under development and not commercially available yet. Its future availability cannot be ensured.



**Figure 1:** Sagittal cross sections of the 3DREAM flip angle maps (a-e) and the reference AFI (f). The flip angle is depicted in degrees.



**Figure 2:** Axial (a,d), sagittal (b,e) and coronal (c,f) cross sections of the 3DREAM (a-c) and AFI maps (d-f). The flip angle is depicted in degrees.