Spatially selective excitation (SSE) for brain imaging at 7 T

Tomasz Dawid Lindel[1,2], Andre Kuehne[1,2], Patrick Waxmann[1,2], Frank Seifert[1,2], Thoralf Niendorf[2], and Bernd Ittermann[1,2]
[1]Medical Metrology, Physikalisch-Technische Bundesanstalt (PTB), Abbestr. 2-12, 10587 Berlin, Germany, [2]Max Delbrück Center for Molecular Medicine (MDC), Berlin Ultra-High Field Facility (BUFF), Berlin, Berlin, Germany

Introduction
Ultrahigh fields provide an enhanced signal to noise ratio which can be used for imaging with better spatial resolution. However, high spatial resolution scanning of large objects contains a high degree of redundancy and inefficiency and may not always be feasible due to geometric or scan time constraints. Spatially selective excitation (SSE) might overcome this issue by exciting magnetization only within a given region of interest while suppressing all signal from outside. This allows for reduced field of view (FOV) imaging without aliasing artifacts.

Methods
All measurements were performed on a healthy volunteer using a 7 T whole-body scanner (Siemens Healthcare, Erlangen) equipped with an eight channel parallel-transmit (pTx) array. For signal excitation and detection a commercial eight channel Tx/Rx head coil was used (RAPID Biomedical, Rimpar, Germany). pTx pulses were calculated based on [1-4]. A 32-turn *k*-space spiral was used as the gradient trajectory during excitation. To keep the excitation as short as possible a slew rate and *k*-space center density optimized spiral was used. Using an acceleration factor of four, this approach results in pulse lengths of 2.5 ms, approaching the duration of conventional excitation pulses. Nominal flip angle was 10°. For acquisition we used a 2D inversion-recovery spin echo sequence (TI/TE/TR: 900/7/10 ms, in plane resolution 1.7 mm). Signal inhomogeneities due to the (conventional) refocusing pulse were compensated by an adapted excitation pulse. A phase-modulation approach [5] was used for SSE. The field of excitation (FOX) was arbitrarily chosen inspirited by anatomy. Zoomed images were acquired under identical measurement conditions except for a reduced field of view (FOV) and higher resolution.

Results
In Figs. 1a) and b) the chosen excitation pattern is depicted over spin echo images of the full brain. Figs. 1c) and d) show images obtained with the SSE approach. Signals from outside the FOX are well suppressed and the desired region is accurately extracted. Figs. 1e) and f): zoomed imaging of the same anatomic region acquired in the same measuring time but with enhanced spatial resolution of 0.7 mm isotropic. The images exhibit excellent gray matter/white matter contrast. The background suppression is sufficient to prevent any noticeable aliasing artifacts.

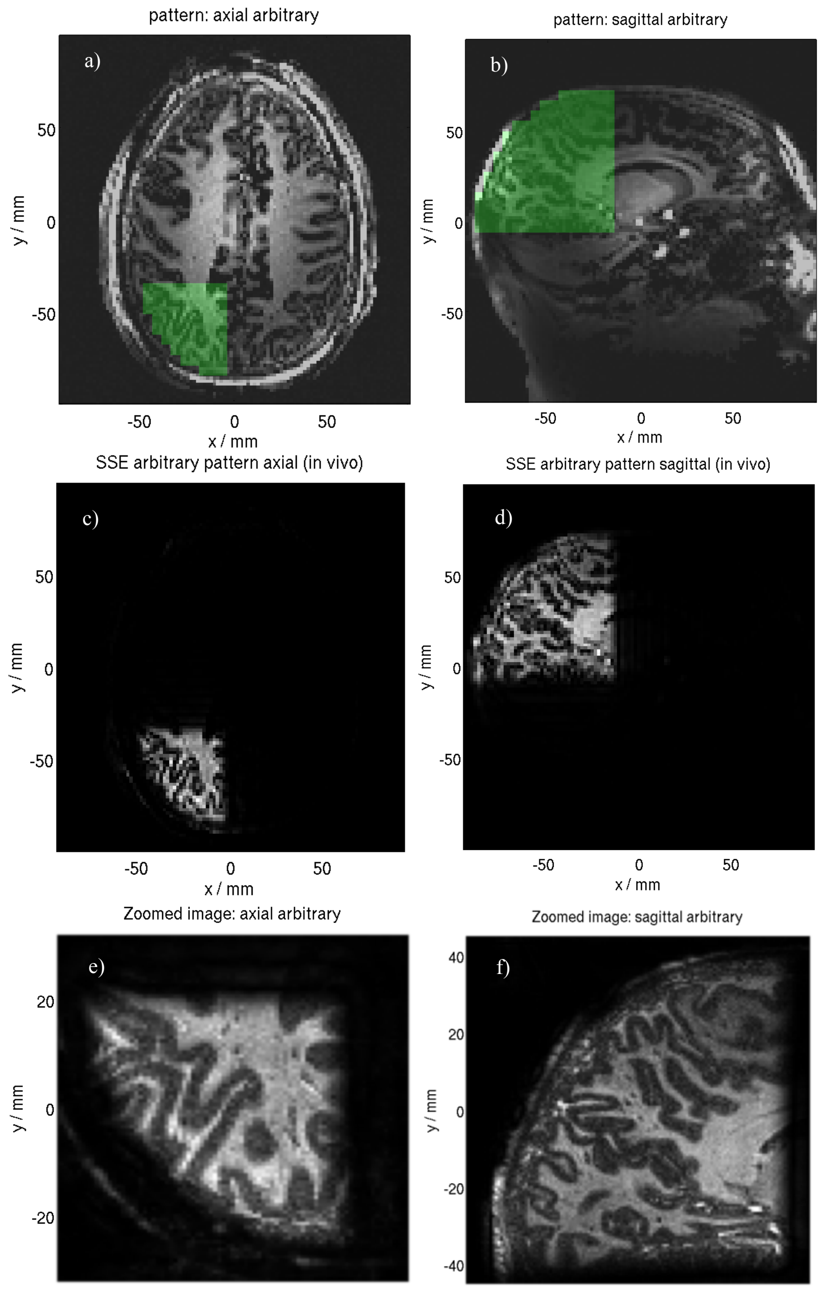

Fig.1: a-b) Spin echo brain images and desired excitation pattern in green. c-d) Full FOV results after SSE. e-f) SSE results with enhanced spatial resolution and reduced FOV

Conclusion
pTx shows great promise for imaging selected spatial patterns in the human head at 7T. While the principle feasibility of SSE for high-contrast in vivo imaging has been demonstrated, meeting clinical image quality requires further research. The benefit of higher spatial resolution without acquisition-time penalty could make this technique very attractive for a variety of neurological applications.

Reference
[1] Katscher et al. (2003) MRM 49:144, [2] Yip et al. (2005) MRM 54:908, [3] Grissom et al. (2006) MRM 56:620, [4] Ullmann et al. (2005) MRM 54:994, [5] Schneider et al. (2011) Proc. ISMRM 19:20