Performance comparison of parallel transmit arrays for body imaging at 3 T under local SAR constraint

Bastien Guerin[1], Matthias Gebhardt[2], Peter Serano[1], Elfar Adalsteinsson[3], Michael Hamm[2], Josef Pfeuffer[2], Juergen Nistler[2], and Lawrence L Wald[1]
[1]Radiology, Massachusetts General Hospital, Charlestown, MA, United States, [2]Siemens Healthcare, Erlangen, Germany, [3]Electrical Engineering, Massachusetts Institute of Technology, Cambridge, MA, United States

Target audience: RF engineers and MR physicists. **Purpose**: Despite the large amount of research in pTx hardware development, there has been little theoretical evaluation of pTx coil geometries [1]-[3]. We study the performance of pTx arrays for body imaging at 3 T as a function of the number of Tx channels and the configuration of these channels around the body. In particular, we evaluate coils with multiple channels in the z-direction for both transverse and coronal imaging. **Methods**: We simulated 8 pTx arrays with up to 32 Tx channels arranged in up to 4 rows (Fig. 1). All arrays were based on the same basic cylindrical geometry and were simulated using a co-simulation based on the field simulator HFSS (Ansys, Canonsburg PA) and the circuit simulator ADS (Agilent, Santa Clara CA) [1], [4]. Coils were loaded with the 1mm isotropic, 33 tissue types Ansys body model. Tuning (123.2MHz), matching (-30dB) and decoupling (-15dB) were performed by optimizing the value of capacitors using the gradient routine of ADS. It was not always possible to decouple distant coils (decoupling capacitors were placed only between nearest neighbors), especially for arrays with multiple rows and/or more than 16 channels. For these arrays, ideal decoupling was performed in simulation. The E and H fields of the Tx channels were used to compute B1+ maps and SAR matrices, which were clustered using the VOP algorithm [5]. RF-shimming and 2-spoke pulses were designed using an algorithm constraining simultaneously local SAR (via VOPs), global SAR, maximum power and average power on each Tx channel. L-curves were computed for each pTx array by varying the local SAR limit. We also simulated a 32-rung high-pass birdcage coil based on the same cylindrical geometry for comparison.

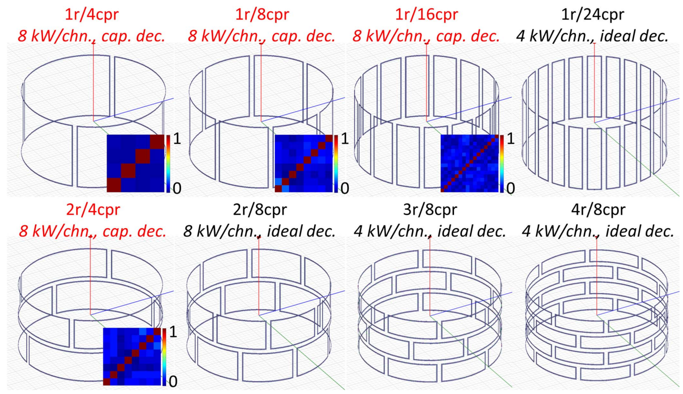

Fig. 1. Snapshots of the 8 pTx arrays simulated. Red arrays were decoupled using capacitors placed between nearest neighbors (the coupling matrix is shown for these arrays). Black arrays could not be decoupled using only nearest-neighbor capacitors and were therefore ideally decoupled in simulation. An array named Xr/Ycpr denotes that it is made of X rows containing Y channels per row (the total number of channels is therefore X×Y).

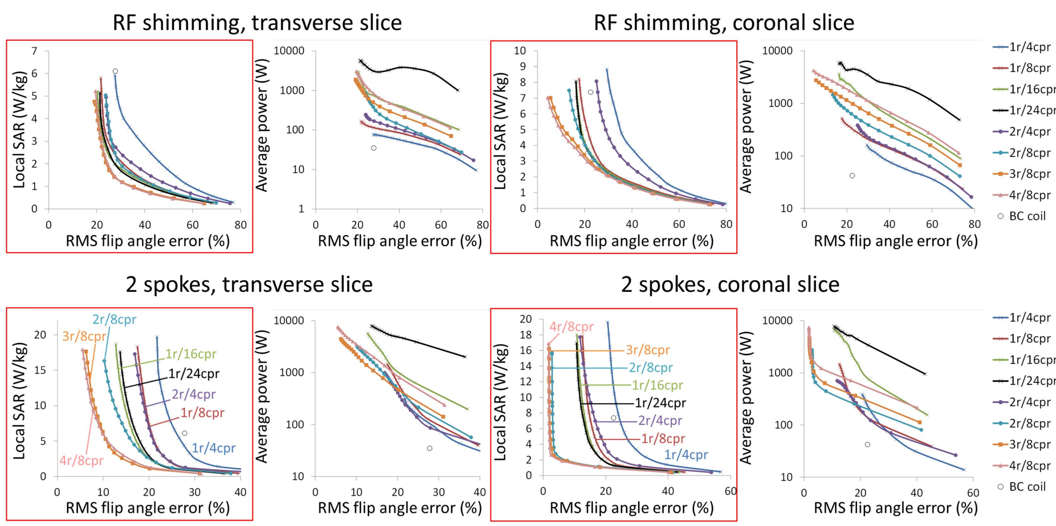

Fig. 2. L-curves quantifying the tradeoff between local and excitation error for all pTx arrays simulated. Red boxes around the local SAR L-curves indicate that this is the constraint being varied in the generation of these L-curves.

Results/Discussion: Fig. 2 shows L-curves obtained by varying the local SAR limit. Adding Tx channels improves the local SAR vs. excitation fidelity tradeoff, when local SAR is being controlled explicitly, however at the cost of increased power. This is true both for RF shimming and 2-spoke pulses. Also, for arrays with at least 8 Tx channels per row, distributing additional Tx channels in rows along z proves beneficial for reduction of local SAR at constant excitation error (e.g., 2r/8cpr>1r/16cpr and 3r/8cpr>1r/24cpr). This is especially true for imaging in the coronal orientation where pTx arrays with Tx channels distributed in the z direction largely outperformed single row arrays. Although most pTx arrays are able to create more homogeneous excitation patterns than the BC coil at constant local SAR, this is at a cost of a large increase in power. In other words, the BC coil has an imperfect B1+ transmit profile that can be "beaten" by pTx but is by far the most efficient transmit coil. **Conclusion**: Increasing the number of Tx channels of pTx coils is beneficial for reduction of local SAR at constant excitation error. For pTx arrays with more than 8 Tx channels, it is beneficial to distribute the Tx channels not only azimuthally but also in rows in the z direction. Doing so improves the local SAR vs. fidelity tradeoff, especially when imaging in the coronal orientation. **References**: [1] Kozlov M (2009). JMR **200**(1): 147-152. [2] Harvey PR (2010). Proc. ISMRM **18**: 1486. [3] Lattanzi R (2009). MRM **61**(2): 315-334. [4] Guérin B (2012). Proc. ISMRM, **20**: 2612. [5] Eichfelder, G. (2011). MRM **66**(5): 1468-1476.