

# Parallel Imaging for Continuously Moving Table MRI Using Moving RF Coils and In-place Sensitivity Calibration

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## INTRODUCTION:

Initial works to combine parallel acquisition techniques (PAT) with continuously moving table acquisition (or move during scan, MDS) have shown that this poses challenges when the receiver coils do not move along with the patient table [1], and when extra coil sensitivity calibration is used [1,2].

We demonstrate here the straightforward use of a coil setup which is moving along with the patient table in combination with in-place sensitivity calibration.

Moving coils, which are stationary with respect to the patient, do not cause inconsistencies between anatomical information and sensitivity encoding in the data. In-place calibration prevents inconsistencies between imaging and sensitivity data. Our PAT method of choice in this context is GRAPPA [3], which permits efficient use of the calibration data by including them in the final result.

## METHODS:

A 1.5T clinical scanner with 32 rf receiver channels (MAGNETOM Avanto) was used. The coil setup consisted of the standard head and body matrix, as well as parts of the standard spine matrix (4 banks of 3 elements arranged left-right on the upper side, and the same on the lower side; a total of 24 elements), used simultaneously for acquisition and reconstruction.

Separate phantom measurements were performed while the patient table was moving continuously, both with full acquisition, and with undersampled parallel acquisition. A standard 2-dimensional gradient echo sequence with added table control was used for both axial and coronal scans. Table 1 summarizes the imaging parameters.

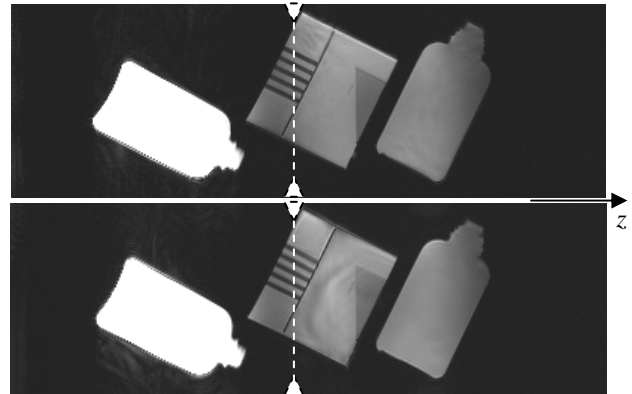
parameter \ slice orientation	coronal	axial
base field-of-view [mm]	300	300
base resolution	128	128
phase encoding (PE) direction	left-right	up-down
number of PE lines (full)	128	128
PAT acceleration factor (AF)	2	2
number of calibration lines	24	24
table speed (full / AF 2) [mm/s]	70 / 100	5 / 9
number of slices	4	1
TE / TR [ms]	3.6 / 30.0	3.6 / 7.3

**Table 1:** Imaging parameters for the coronal and axial MDS experiments.

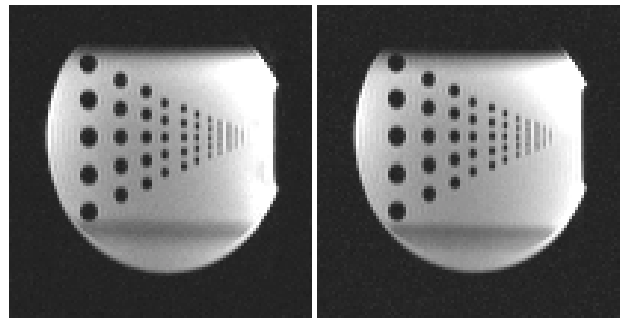
The data were first pre-processed off-line to account for the MDS acquisition: the PE lines of the axial scans were linearly interpolated after readout (RO) Fourier transform (FT) to a common value of the table direction coordinate ( $z$ ). The PE lines of the coronal acquisitions were first shifted in RO according to their  $z$ -position (see [4]); the overlapping parts of adjacent lines were linearly blended over in the hybrid  $k_{PE}-z$  domain. Offline GRAPPA reconstruction was applied to the intermediate data sets in a straightforward manner.

## RESULTS:

Figure 1 shows one slice of each coronal experiment, figure 2 one slice of each axial experiment. There are no visible reconstruction artifacts, neither from the MDS processing, nor from the GRAPPA reconstruction.



**Figure 1:** coronal images, GRAPPA reconstruction (top), full acquisition (bottom). The images are cropped; the dashed line indicates the approximate position of the axial examples below.



**Figure 2:** axial images, GRAPPA reconstruction (left), and full acquisition (right). The images are cropped.

## DISCUSSION AND CONCLUSION:

The intensity inhomogeneity in the coronal images is due to the missing normalization filter in the offline processing. The cloudy structures are attributed to fluid currents in the phantoms.

An advantage of stationary coils is that the sensitivity of the coils may be measured only once and for a small number of channels. This is offset by the use of in-place calibration, which removes the need to perform extra sensitivity calibration altogether.

Moving coils and in-place calibration make the application of parallel acquisition techniques to MDS imaging straightforward. We expect the use of SENSE-type techniques and the extension to 3D acquisitions to be similarly easy with this concept.

## REFERENCES:

- [1] Keupp J. *et al.*, *Proc. ISMRM* **11**, p. 324 (2004)
- [2] Hu H., *et al.*, *Proc. ISMRM* **11**, p. 325 (2004)
- [3] Griswold MA., *et al.*, *MRM* **47**, pp. 1202-1210 (2002)
- [4] Kruger DG., *et al.*, *MRM* **47**, pp. 224-231 (2002)