# Correction of background phase offsets in phase-contrast MRI using concurrent magnetic field monitoring.

Daniel Giese[1,2], Bertram Wilm[2,3], Julia Busch[2], David Maintz[1], Christoph Barmet[2,3], Klaas Pruessmann[2], and Sebastian Kozerke[2]
[1]*Radiology, University Hospital Cologne, Cologne, Germany,* [2]*Institute for Biomedical Engineering, University and ETH Zurich, Zurich, Switzerland,* [3]*Skope Magnetic Resonance Technologies, Zurich, Switzerland*

## Introduction

Phase-contrast (PC-) MRI is a valuable tool for the assessment of hemodynamics in larger vessels. Concerns about the accuracy of the method due to eddy-current related phase offsets [1] have prompted for in-depth analysis and triggered developments of correction strategies. Image-based approaches [2] are commonly applied. However, inaccuracies can result when SNR is limited and/or when imaging areas with large air cavities are present. Magnetic field monitoring (MFM) has been used to analyze and correct for background phase offsets [3], demonstrating that oscillatory phase offsets play an important role in PC-MRI. Recent studies further demonstrated a temperature dependency of oscillatory phase offsets [4]. The objective of the present work is to demonstrate the use of concurrent imaging and MFM for the analysis and correction of background phase offsets in PC-MRI.

## Methods

A 3rd-order dynamic field camera (Skope Magnetic Resonance Technologies, Zurich, Switzerland), mounted on an 8-channel head-coil, was used for concurrent MFM and PC-MRI on a 3T Achieva system (Philips Healthcare, Best, The Netherlands) (Figure 1a). Temperature sensors (LumaSense Inc., Santa Clara, USA) mounted on the epoxy-layer of the gradient coils were used to monitor the temperature of the gradient mount. A spherical gel-filled phantom was used for the imaging experiments. Dummy sequences were played out to heat up the system. In the actual experiments a gradient-echo PC-MRI acquisition with following parameters was used: 2D slices (axial, sagittal and coronal), 3 directional, symmetric flow encoding, venc=50cm/s, TE/TR=4.3/8ms, spatial resolution=1.5x1.5x5mm$^3$, scan time=0:57s. Figure 1b) shows the temperature evolution of the gradient mount during the heat-up phase, followed by a pause of 2 min, a second heat-up phase, several PC-MRI acquisitions (Acq. "warm"), a long pause and several acquisitions in the "cold" state. Dynamic phase coefficients, fitted to the 3rd spatial order were calculated from the MFM probe data and offset maps, corresponding to the echo-time of each TR. For background phase correction, PC-MRI data was reconstructed using MRecon (Gyrotools LLC, Zurich, Switzerland) and offset maps were subtracted [3].

## Results

Figure 2 compares background phase offsets of uncorrected PC-MRI data (sagittal slice, flow encoding along vertical direction) with MFM corrected using 0th, 1st, 2nd and 3rd spatial orders. The mean sum of squared error over the phantom is displayed. Figure 3 shows axial PC-MRI data with flow encoding along three directions (M: frequency encoding, P: phase encoding, S: slice selection) for a 'cold' and a 'warm' system. Profile plots through the uncorrected (solid) and corrected (dotted), cold (blue) and warm (red) phase maps are shown in Figure 3.

## Discussion

The present work demonstrates the use of a concurrent MFM system to correct phase offsets in PC-MRI. 3rd order correction was found to decrease the error to approximately 1% of the venc value. The residual error is attributed to concomitant field offsets not fully representable by the chosen basis functions.

The data presented here also confirm previous findings of temperature-induced changes in background phase offsets of up to 5% between a 'cold' and 'warm' system. Accordingly, caution has to be exercised when using phantom-based correction methods [5].

## Conclusion

The use of concurrent MFM allows for simultaneous acquisition of background phase offsets and image data in PC-MRI thereby providing background phase correction with high accuracy and independent of temperature effects in the gradient system.

## References

[1] Gatehouse et.al. JCMR(2010):12 [2] Walker et.al. JMRI(1993):3 [3] Giese et.al. MRM(2012):67 [4] Gatehouse et.al. JCMR(2012):72 [5] Chernobelsky et.al. JCMR(2007):9

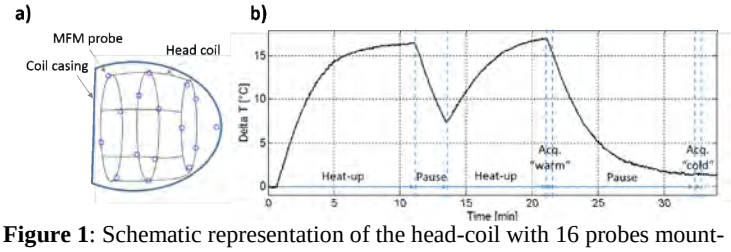


**Figure 1**: Schematic representation of the head-coil with 16 probes mounted a). Temperature recording of the gradient mount. Data acquisition periods are indicated b).

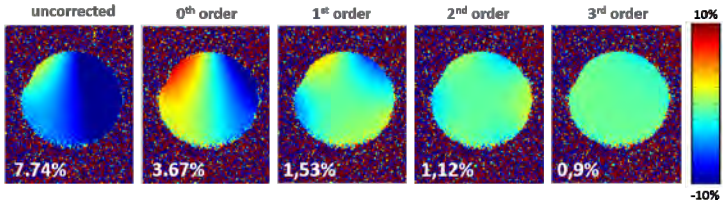


**Figure 2**: Background phase offsets without and with 0th,1st, 2nd and 3rd order correction.

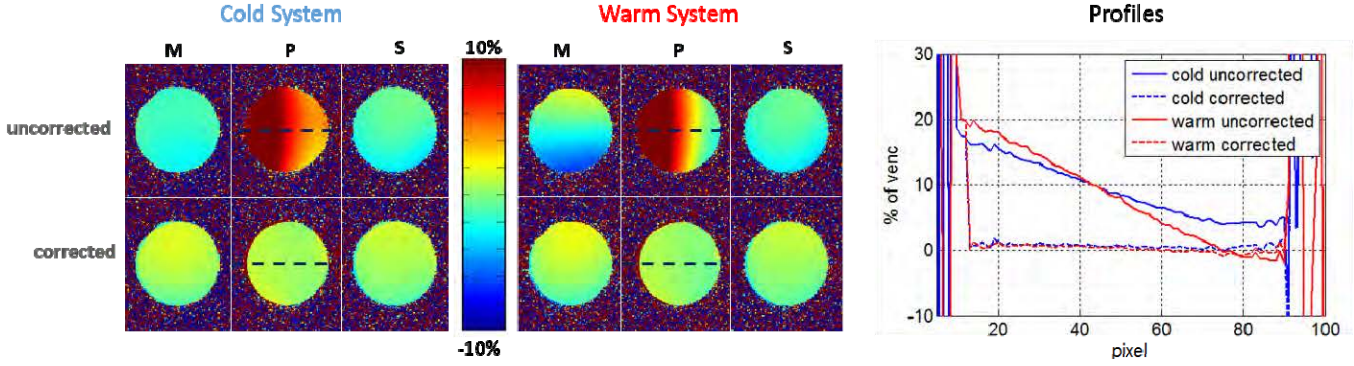


**Figure 3**: Uncorrected and corrected PC-MRI data obtained with velocity encoding along three spatial direction (M,P,S) in the "cold" and the "warm" system (left) along with corresponding profiles.