

Proceedings Article

# Spherical harmonic-based receive coil array for a head MPI system

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## Abstract

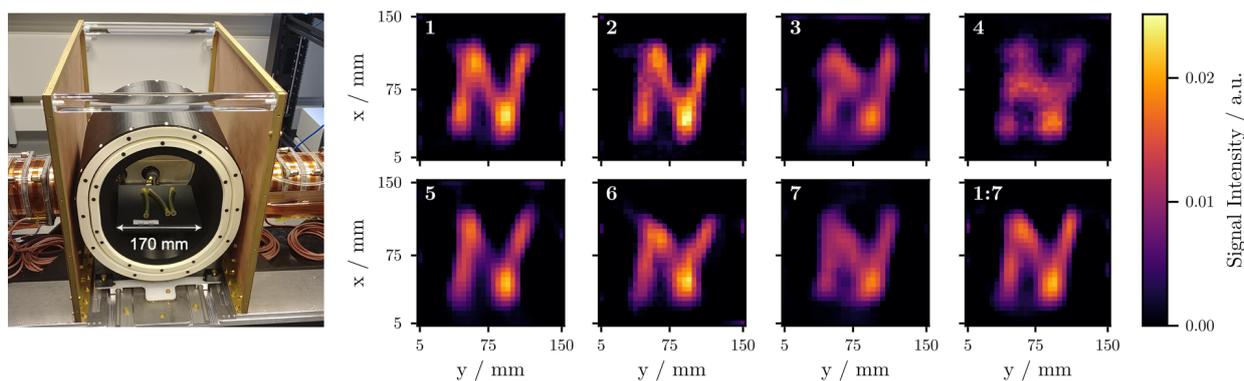
A gradiometric receive coil is practically the modern standard in MPI. Although such a structure is one of the reliable and most effective ways of isolating the receive circuits from the influence of drive fields, it is challenging to implement it for the spatial sensitivity directions orthogonal to the cylinder axis of an MPI scanner. In this work, we demonstrate a concept of matrix coils based on spherical harmonic spatial sensitivity profiles. Our approach permits us to expand the number of independent receive channels in our head-sized MPI system to seven (and potentially more), while preserving important gradiometric characteristics of each channel.

## I. Introduction

The cylindrical shape of a typical MPI system naturally leads to the implementation of solenoidal gradiometric coils with pronounced sensitivity to the magnetic fields, directed along the bore of the scanner [1]. At the same time, this geometry severely limits the possibilities for constructing coils with gradiometric features for fields orthogonal to the cylinder axis. Additionally, Knopp *et al.* [2] reported that employing more than three receive coils does not provide significant benefits for image quality, which can potentially be circumvented by introducing additional orthogonal channels. In this work we propose a receive coil concept based on matrix coils [3]. It enables us to design a large number of independent receive channels with unique spatial sensitivity profiles determined by spherical harmonic (SH) functions.

## II. Methods

The base matrix structure was designed on a surface with the dimensions of the head-sized MPI system bore [4]. It consists of 16 coils (85 x 103 mm, 2 mm thick each) [5]. We performed numerical simulations with 1 A current to simulate the sensitivity profiles of each coil using the law of reciprocity. The obtained data were used in an optimization problem with the objective of finding the number of turns for each coil corresponding to a field profile within a 150 mm diameter sphere. The target field distributions were obtained from SH functions up to and including the third order, describing the magnetic scalar potential. Based on the feasibility of implementation, we selected six coil sets and built them as layered wire structures embedded in a 3D printed base. For the seventh channel, we made a first-order gradiometer.



**Figure 1:** Reconstruction results for SH-based receive array. Left: Photo of the head-sized MPI system, installed at Fraunhofer IMTE with a test phantom inside. Right: Separate reconstructions for each receive channel individually and one combined. Each reconstruction used SNR-based frequency selection.

### III. Results and Discussion

Reconstructed images of a test phantom using a 3D excitation sequence for all seven channels individually and their combination are shown in Figure 1. As a phantom we used three tubes with total volume of 9.1 ml, filled with water and Resotran ( $1.84 \text{ mg}_{\text{Fe}} \text{ ml}^{-1}$ ). The figure depicts a coronal slice, covering the area of 150 x 150 mm, shifted down by 40 mm from the center of the scanner. Each reconstructed image is obtained by approximately solving the inverse problem of MPI by the Kaczmarz algorithm, using respective parts of the large 30 x 30 points system matrix, which comprises information on all seven channels individually.

The results show that each receive coil in the array can be used independently for imaging, despite the considerable differences in the spatial sensitivity profiles of the coils. As a next step, we plan to evaluate the amount of independent information that can be obtained from each channel and explore new methods of multi-channel image reconstruction in MPI.

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### Author's statement

Conflict of interest: Authors state no conflict of interest.

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