# Field-based spatial self-registration of multi-coil hardware for $B_0$ field control

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## Introduction

- Multi-coil (MC) inserts use an array of individually driven direct current coils for shimming and spatial encoding fields [1]
- MC shimming has been shown to outperform conventional shimming methods [2-4]
- **MC field control relies on reproducible hardware placement** for generated fields to match calibration maps [2,3]
- Precise localization of the shimming hardware remains a significant challenge for the clinical integration of MC shimming inserts

## Purpose

To develop an algorithm that can **reliably detect and correct shifts in hardware placement of $B_0$ field-generating inserts**

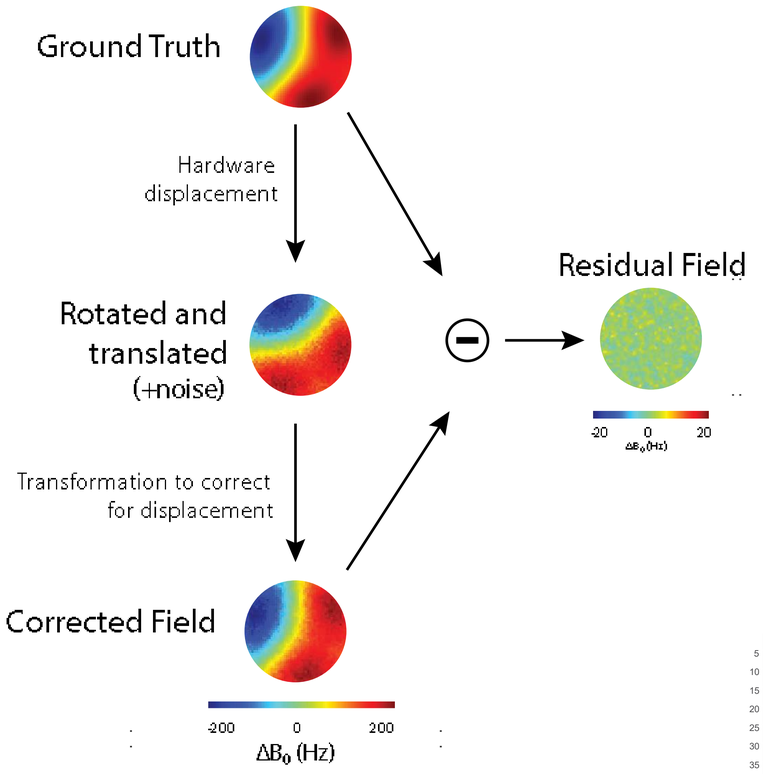



**Figure 1** (above): Schematic of algorithm structure and testing with simulated data. A pre-determined reference field (ground truth) underwent controlled rotation and translation at various noise seeds. Corrected fields generated by applying inverse transform with recovered parameters, and residual was calculated by subtracting the ground truth from the corrected field

**Figure 4** (right): Comparison of residual fields for preliminary scanner data with and without algorithm correction. The imposed hardware shift was 0.40 mm in X, 1.85 mm in Y, and 1.10 mm in Z. A field section in which this small transformation can be seen is circled.

## Methods and Materials

*SIMULATED BASIS DATA*

- **Rotationally and translationally unique ground truth field** generated by a row of coils
- 500 controlled transformations of ground truth at ten different noise seeds generated
- Least squares approach was used to **determine and rectify translations and rotations** and retrieve the original field (Fig.1)
- Performance of algorithm evaluated by norm error of X, Y, Z translation and Z rotation error

*PRELIMINARY SCANNER VALIDATION*

- 6x8 multi-coil prototype constructed and integrated with Siemens scanner (Fig.2)
- Input field maps from before and after a known hardware shift to recover transformation parameters

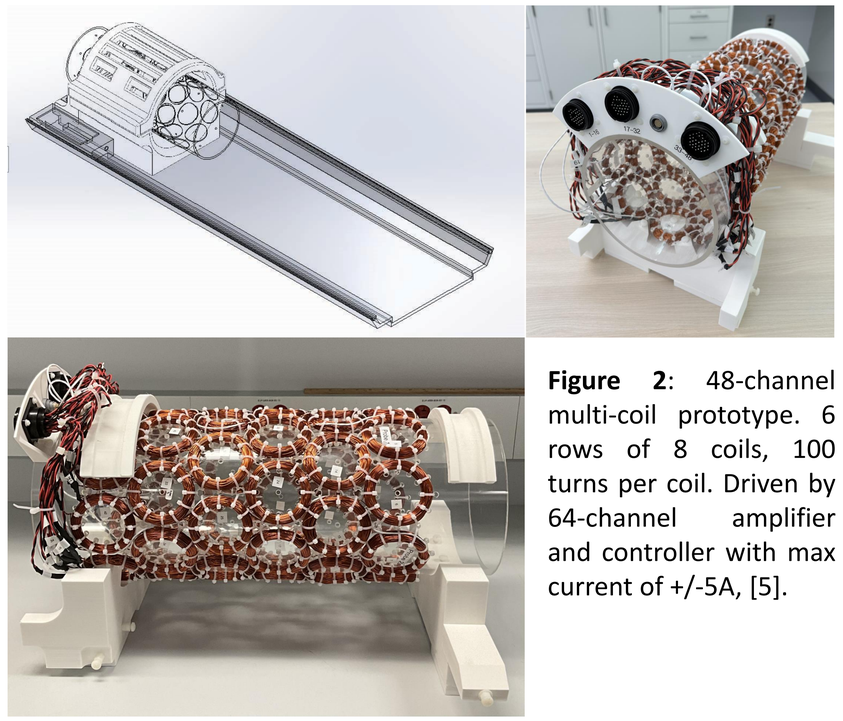


**Figure 2**: 48-channel multi-coil prototype. 6 rows of 8 coils, 100 turns per coil. Driven by 64-channel amplifier and controller with max current of +/-5A, [5].

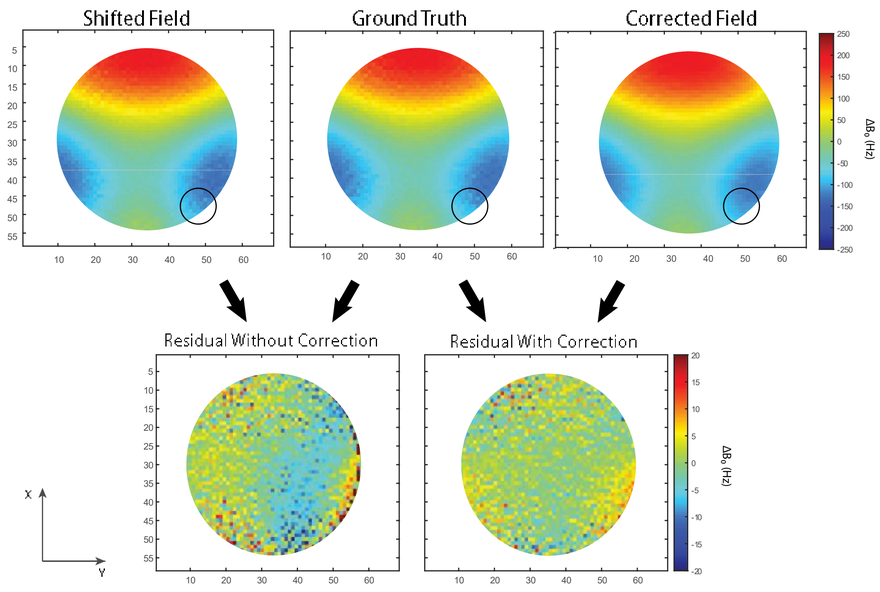
## Results and Discussion

*SIMULATED DATA*

- For SNR levels above 30, all translations and rotations were recovered with an error less than 0.100 degrees and 0.105 mm (Fig.3)

*SCANNER VALIDATION*

- Algorithm successfully recovered a set of known translation parameters with submillimeter norm error
- The mean of the residual decreased 40% with correction across the volume (Fig.4)



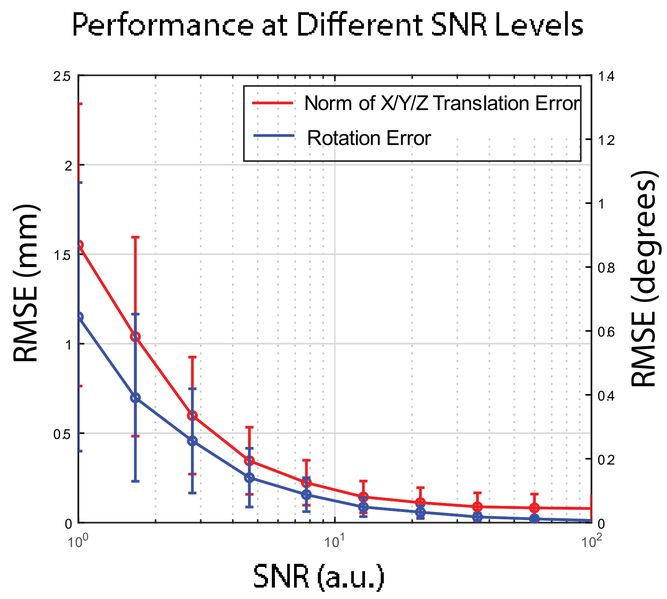




**Figure 3**: Norm of Translation and Rotation Error at SNR levels from 1-100. Only Z-rotation considered. SNR was calculated as the maximum field value divided by the standard deviation of the noise

## Conclusions

- This algorithm offers a promising solution for detecting and correcting hardware placement shifts in multi-coil shimming arrays
- Further validation needed
- Future work needed to incorporate X and Y rotation

## References

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