APPLICATION SHEET: **Improving MR Methods Development**

Dynamic Field Camera™

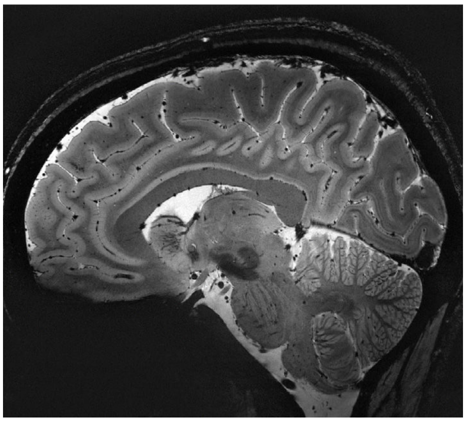
DIRECT, INFORMATIVE MEASUREMENT OF PULSE SEQUENCE PERFORMANCE: RAPIDLY DEVELOP NOVEL PULSE SEQUENCES

Novel sequence development: encoding challenges

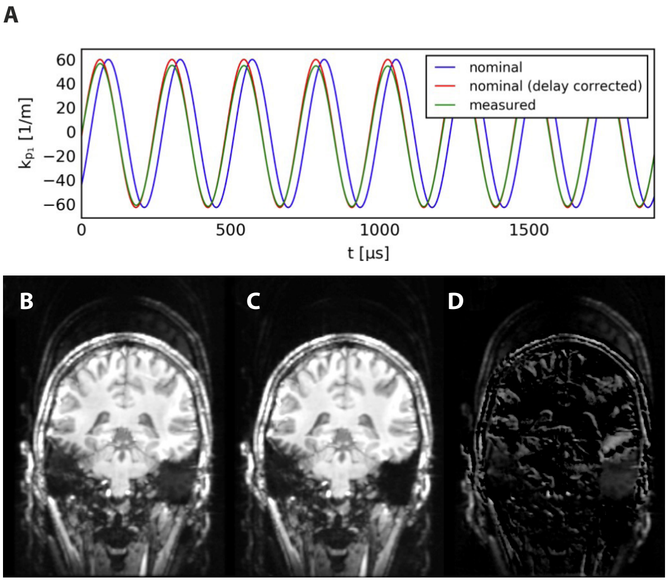
More efficiently encoding your MR signal requires that you explore alternative (non-Cartesian) encoding fields. The design and optimization of these encoding fields, most often accomplished with the scanner gradient subsystem, can be a highly iterative and time-consuming process.

Measure your encoding fields

Gradient-based methods of image encoding rely on the scanner gradient system being accurately timed and accurately executing the prescribed waveform. Fully characterizing the dynamic field in the scanner using Skope solutions can improve image quality[1]. This method provides rapid and direct visualization of scanner performance, allowing you to rapidly iterate pulse sequence design or to generate images with improved geometry or reduced ghosting, as shown below.



Courtesy: IBT ETH Zurich and University of Zurich



Images for this section are courtesy: DOI: 10.1002/mrm.27215 [2].

The importance of directly measuring gradient waveforms can be seen in this example (left) of a wave-CAIPI MPRAGE sequence at 7T by DZNE. The wave-CAIPI sequence uses two sinusoidal gradients in addition to the frequency encode gradient in the readout block. The exact timing and waveform of these gradients directly impacts image quality. Delays inherent in the sequence result in the actual trajectory having a slightly different form and timing than expected (A). Reconstructing the image with the nominal trajectory with a delay calibration results in an image with some residual artifact (B). Using the measured trajectory results in an image with signifcantly reduced artifact (C). The difference image shows that correction with the measured trajectory improves the geometric accuracy and reduces image shading (D).

Dynamic Field Camera™

Programming and validating new gradient waveforms for pulse sequence development can be cumbersome without the right tools. Vendor-provided pulse sequence programming environments often include simulation tools; however, these tools often reflect an idealized model of the scanner's physical environment and therefore may not provide a comprehensive analysis of the sequence's performance. The Dynamic Field Camera provides a complete solution for measuring gradient waveforms for MR methods development. It can also become part of the solution for pre- or post- monitoring in vivo MR acquisitions.

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Physical dimensions

Housing (w x d x h)	75 cm x 28 cm x 31 cm
Cable diameter	3 cm
Coaxial cables	custom fit, < 20 m

NMR field probes

Coherence lifetime	> 100 ms
Minimum repetition time	110 ms
SNR·√BW	> 80'000
Achievable k_{max}	±7'800 rad/m

Field measurement

Data types	Unit	Temporal resolution
Gradients	[mT/m]	1 µs
B0	[mT]	1 µs
k-space values	[rad/m] and k0 [rad]	1 µs
k-higher order	up to 3rd spatial order	1 µs

Bfit, Gfit fitted field value for each interleave/dynamic

Camera Acquisition System

The field sensor signals of the Dynamic Field Camera are acquired by the 16-channel Skope Camera Acquisition System and automatically processed to provide the actual magnetic field dynamics.

skope-fx, field explorer software

The skope-fx software controls the acquisition and processing of the field data, and allows for a fast and easy visualization.

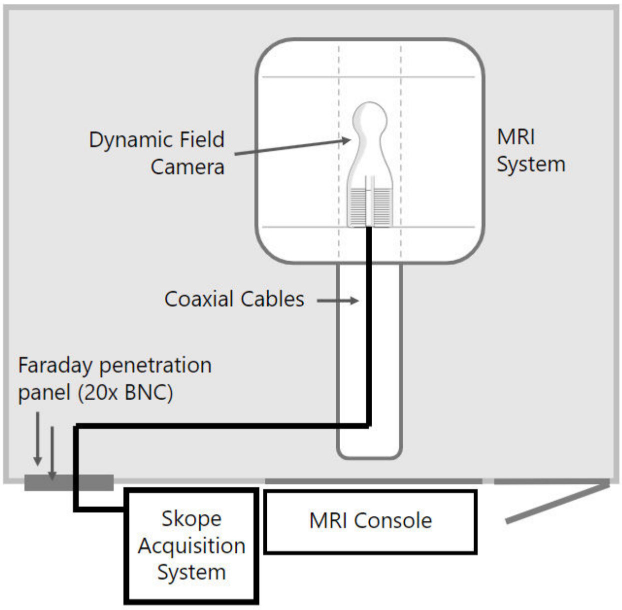
- Compare changes of k-space trajectory
- Analyze time series
- Parametric view (kx vs. ky , kx vs. kz or ky vs. kz)
- Spectral view
- Logarithmic plot
- Detrend data
- Filter data

Table Positioning Unit for the Dynamic Field Camera

The Table Positioning Unit allows for a rigid mounting of the Dynamic Field Camera on the patient bed and enables the height- and orientation-adjusting of the Dynamic Field Camera.

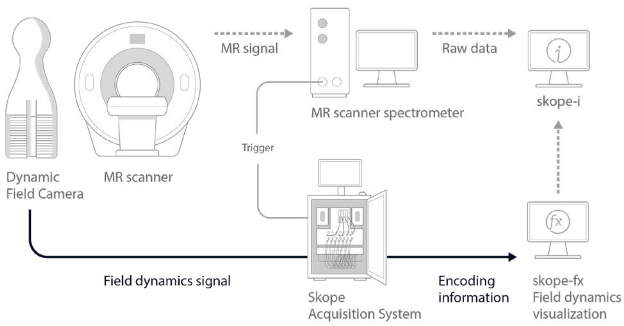
1) Field Camera Unit
2) Field Camera Electronics
3) Table Positioning Unit

Site Overview



Example configuration of Skope Acquisition System in MRI operator room. The Skope Acquisition System can be placed in either the MRI operator room or the scanner equipment room.

Integration into MRI set-up



[1] S. J. Vannesjo et al., "Image reconstruction using a gradient impulse response model for trajectory prediction: GIRF-Based Image Reconstruction," Magn. Reson. Med., vol. 76, no. 1, pp. 45–58, Jul. 2016, doi: 10.1002/mrm.25841

[2] J. M. Schwarz, E. D. Pracht, D. Brenner, M. Reuter, and T. Stöcker, (2018) "GRAPPA reconstructed wave-CAIPI MP-RAGE at 7 Tesla", Magn. Reson. Med., vol. 80, no. 6, pp. 2427–2438, Apr. 2018, doi: 10.1002/mrm.27215