# Fast Field-Cycled Fast Spin-Echo MRI

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Fast Field-Cycled MRI (FFC-MRI) [1] is a new form of MRI that can provide access to sources of endogenous contrast which may offer new insights into interactions and processes within the body.

By rapidly varying the magnetic field during an imaging sequence it is possible to obtain information on how biological tissues' NMR properties vary with magnetic field, information which is hidden on a standard, non field-cycling, scanner. This in turn could be used to detect disease earlier than currently possible.

Existing FFC-MRI imaging sequences are limited by lengthy scan times. This work aims to change that by combining FFC-MRI methods with existing rapid imaging techniques. A modified version of the multi-shot Fast Spin-Echo sequence [2] has been developed that can acquire images up to 8 times faster than existing sequences while still providing field-cycling capabilities from 0 T up to 0.1 T.

Experiments were carried out on a home-built whole-body fast field-cycled imager [3] comprising a permanent magnet providing a detection field strength of 59 mT and a coaxial resistive offset magnet which provides field-cycling capabilities. The system uses a commercial console (SMIS Ltd., U.K.). Image reconstruction and analysis was performed using Matlab.

Images acquired using the new pulse sequence are comparable in quality to those obtained using existing imaging techniques but are acquired in significantly less time (e.g. 27 seconds, compared to 69 seconds for the conventional sequence). Artefacts due to transverse relaxation during the echo train are minimised by using centric ordered k-space acquisition, where the weakest echoes are used to sample the outer lines of k-space. At longer echo train lengths this can result in blurring due to the attenuation of higher spatial frequencies.

By using interleaved inversion recovery/saturation recovery, relaxometry ($T_1$ vs field strength) can also be performed using the sequence, and $T_1$ dispersion plots were found to be in good agreement with results obtained using a commercial relaxometer (Stelar s.r.l, Italy).

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**References**

[1] Lurie, D.J. *et al.* Fast field-cycling magnetic resonance imaging. *C.R. Physique* **11**, 136-148 (2010).
[2] Hennig, J., Nauerth, A. & Friedburg, H. RARE imaging: a fast imaging method for clinical MR. *Magn.Reson.Med.* **3**, 823-33 (1986).
[3] Lurie, D.J. *et al.* Design, construction and use of a large-sample field-cycled PEDRI imager. *Phys.Med.Biol.* **43**, 1877-86 (1998).