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**Presentation Type:**  
Oral - General Abstract

**Category:**  
Instrumentation

**Instrumentation Sub-category:**  
Innovation in Instrumentation

**Title:**  
Imaging molecular dynamics using Fast Field-Cycling MRI

**Abstract Body :**

## Introduction

Fast Field-Cycling (FFC) MRI is a new technology that allows measuring quantitative information on molecular dynamics time scales, from tens of nanoseconds to a few milliseconds, non-invasively<sup>1</sup>. This technique consists in varying the magnetic field during a pulse sequence, which allows generating  $T_1$ -based contrast. In biological tissues,  $T_1$  is closely linked to the autocorrelation function of water and fatty molecules so its field-dependant spectrum, also called the  $T_1$  dispersion curve, provides a direct view of the motion of water and fatty molecules over a range of time scales that is determined by the strength of the magnetic field, via the Larmor frequency of the spin system observed. The  $T_1$  dispersion curve has been used for decades to study materials and various models exist that predict the dispersion profiles in particular microscopic environments<sup>2-6</sup>. It follows that the shape of the dispersion profiles provides a unique insights of tissue architectures and our efforts over the last years have focused on developing a system able to measure  $T_1$  dispersion curves in vivo to exploit this source of information in medicine.

## Methods

The FFC-MRI scanner we have developed has a bore size of 50 mm and a length of 2 m (see

Figure). it can image at 0.2 T and can reach any field down to 20  $\mu$ T by switching at 16 T/s, so full field can be obtained in 12.5 ms (with 15 ms more to allow for ringing damping). It can therefore produce  $T_1$ -weighted images at different magnetic fields to measure  $T_1$  dispersion and we typically measure  $T_1$  at five field strengths within 30 min to complete a complete scan within 45 min, which is comparable to usual MRI scans. We have used this FFC-MRI scanner to measure  $T_1$  dispersion curve in vivo and non-invasively in volunteers, including patients (studies approved by the North of Scotland Research Ethics Committee). Images from standard modalities including CT and 3T MRI were compared to FFC-MRI images obtained from the same patients. FFC-MRI images were acquired using a spin-echo sequence with Cartesian encoding and  $T_1$  weighted contrast, using different evolution fields.

## Results

Despite the narrow bore of the magnet we imaged 60 % of the volunteers recruited into the study, the remaining 40 % could not be imaged because of their size or because of claustrophobia. Image contrast derived on  $T_1$  was found to be larger at lower field in general, with good correlation with clinical images and in particular with diffusion weighted imaging. Interestingly,  $T_1$  contrast at 0.2 T was usually found to be less informative than at fields below 20 mT, at least in the pathologies investigated to date. Early results from  $T_1$  dispersion curve measured in vivo show good agreement with ex-vivo data, opening the way to in vivo molecular dynamics biomarkers and characterisation of molecular motions.

## Conclusions

The device we constructed is an exceptional research tool to investigate pathological modifications that are difficult to detect and analyse using conventional imaging methods. Our prototype scanner provides low-resolution but usable images and can be largely optimised. Large changes in the dispersion curve were often observed at low magnetic fields, typically below 20 mT, and other studies using cell models of breast cancer lines have already showed links between such variations and cellular activity<sup>7, 8</sup>. Several studies are under way to exploit this new source of information in acute stroke, brain glioma, breast cancer, deep vein thrombosis and osteoarthritis.

### Keywords:

Dynamic Molecular Imaging, Low-field Mri, Mri

### References:

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**Presenter Biography:**

Dr Lionel Broche is a research assistant at the University of Aberdeen working in the group led by Prof. David Lurie for the development of FFC-MRI. His work encompasses technology and clinical research and he has been responsible for the organisation and conduct of trials at the site as well as for the commissioning of the scanner.

Dr Broche graduated from the PHELMA school of physics engineering in 2005 with a specialisation in biomedical technologies. He obtained a PhD in Biophysics in 2010 on the topic of dielectrophoresis and automated measurements of electric properties of living cells, following which he started a position at the University of Aberdeen as a research fellow for the clinical investigations of FFC-MRI.

Since then he has been actively developing and promoting this technology, taking an active role in the development of research networks and education around Fast Field-Cycling technologies, in particular amongst the EURELAX research network (COST action CA15209).

**Image/Figure:****Persuasive Data:**

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MRI uses very strong magnetic fields to make high-resolution images that are now part of standard care in many hospitals. A new technology, named Fast Field-Cycling MRI, has been developed by our team that extends the capabilities of MRI to add a new dimension to the images. This additional dimension allows probing molecular motions below the scale of living cells, providing new insights in pathological modifications. This new technology is being developed and explored at the University of Aberdeen, UK, and early results show promising applications in brain pathologies and cancer.

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**Disclosure of Financial Interest**

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**Disclosure:**

I have no conflicts to disclose

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