# Research at the Imaging Centre of Excellence (ICE)

## University of Glasgow and NHS Greater Glasgow & Clyde

David Porter Ph.D.

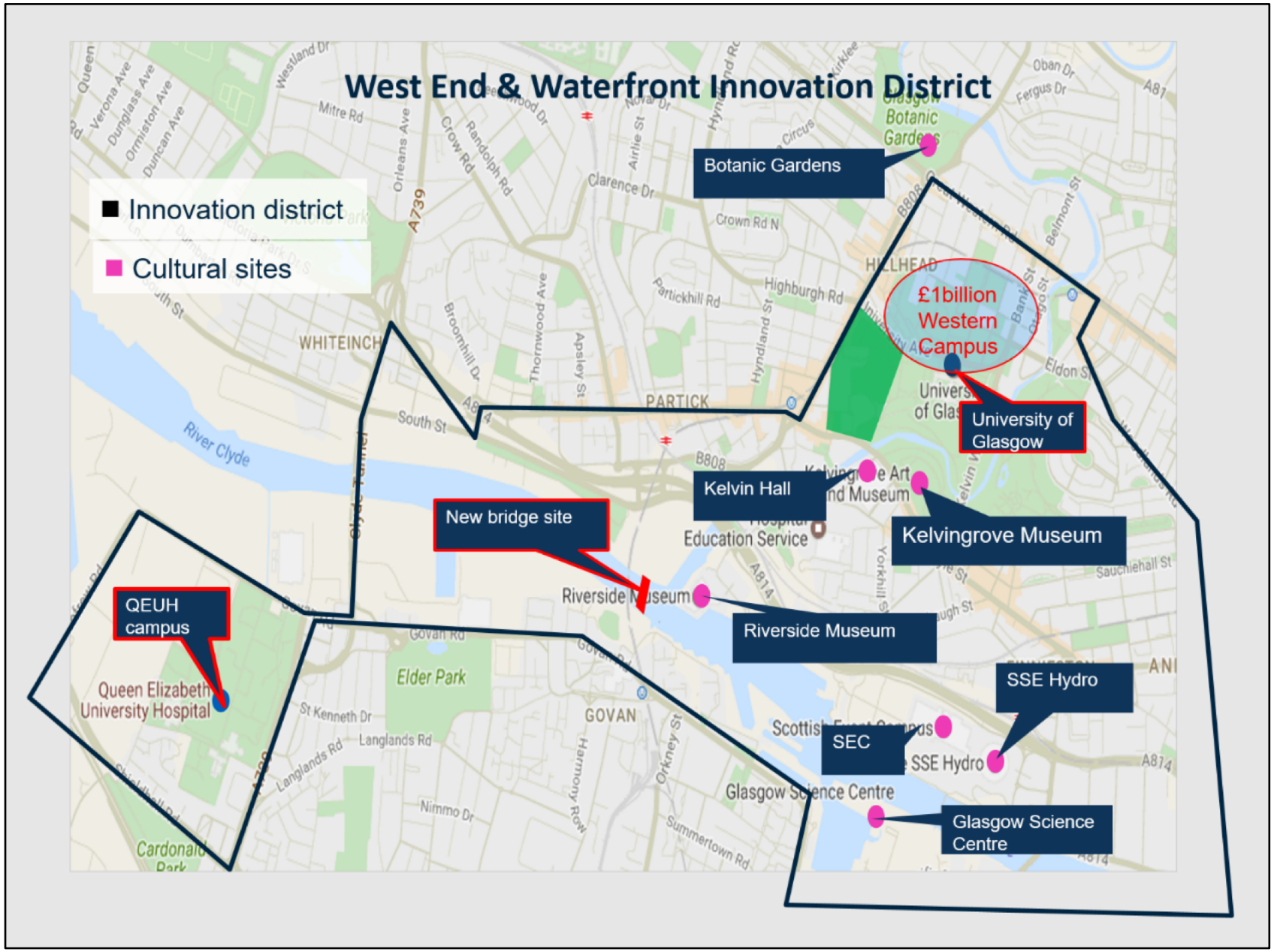

Imaging Centre of Excellence (ICE)

Queen Elizabeth University Hospital

Main University Campus



University of Glasgow


West End & Waterfront Innovation District
Innovation district
Cultural sites
Botanic Gardens
£1billion Western Campus
University of Glasgow
Kelvin Hall
Kelvingrove Museum
New bridge site
Riverside Museum
QEUH campus
SSE Hydro
SEC
Glasgow Science Centre
River Clyde
Elder Park
GOVAN
PARTICK
WHITEINCH
HILLHEAD
Queen Elizabeth University Hospital
Education Service

# Southern General Hospital 2010

# Queen Elizabeth University Hospital 2015

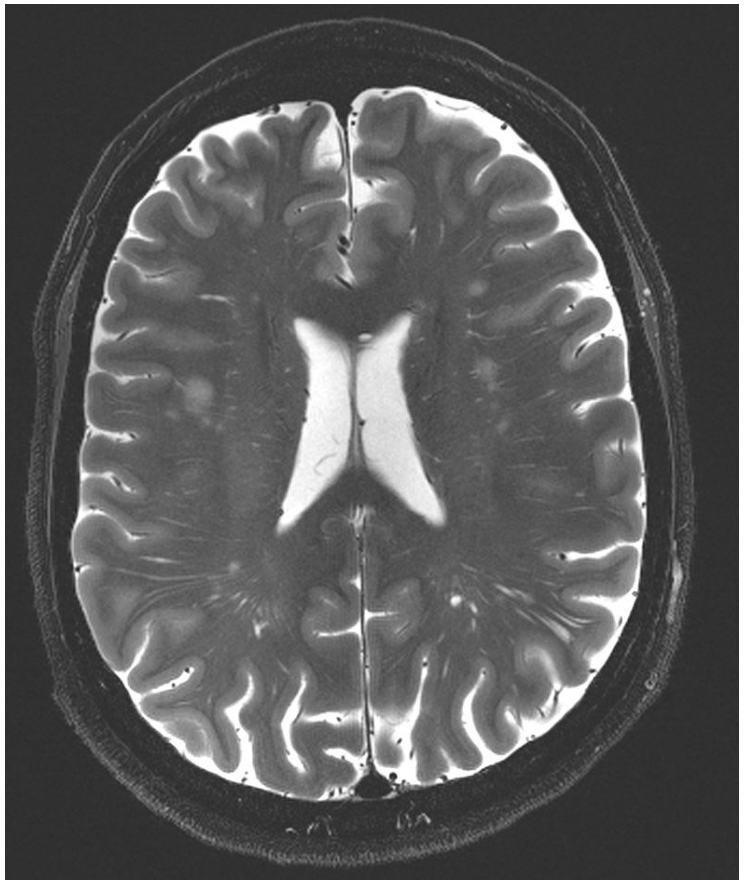
# Imaging Centre of Excellence (ICE)

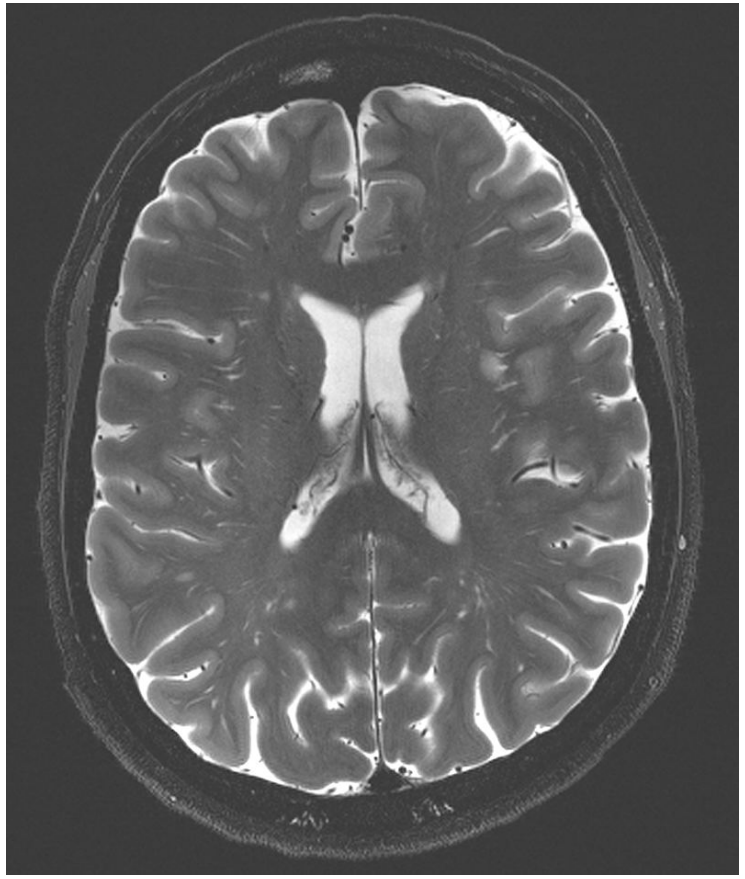
- High-field (7T) MRI research in a clinical environment
- Integrated with existing research in 3T MRI and CT
- ***'Collaboration Zone'*** provides joint space for multi-disciplinary academic resarch teams
- ***'Clinical Innovation Zone'*** provides office and laboratory space for industry

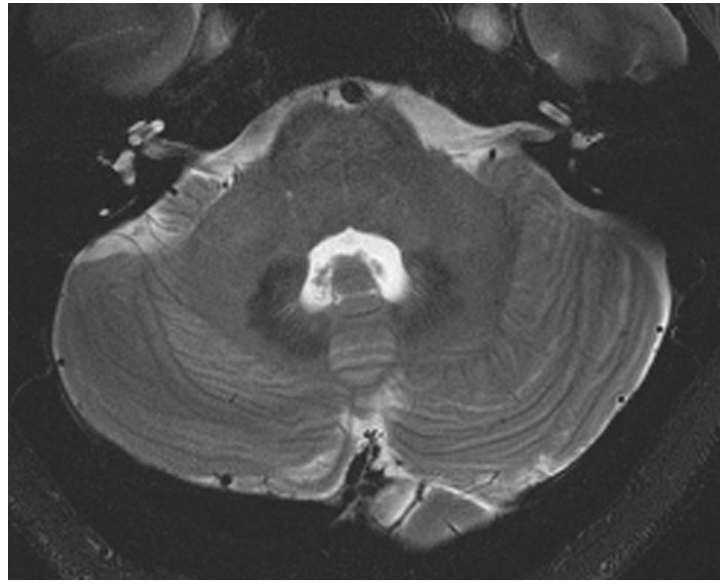
# Imaging Research at 7 Tesla

- Clinical imaging and spectroscopy
  - ➔ High spatial resolution, initially in brain
  - ➔ Stroke, multiple sclerosis, oncology, spinal-cord injury
- Neuroscience
  - ➔ fMRI of cortical layers
- MRI Physics
  - ➔ Motion correction, diffusion-weighted imaging, scan acceleration
- Radiofrequency coil development
  - ➔ Parallel transmit for improved image quality

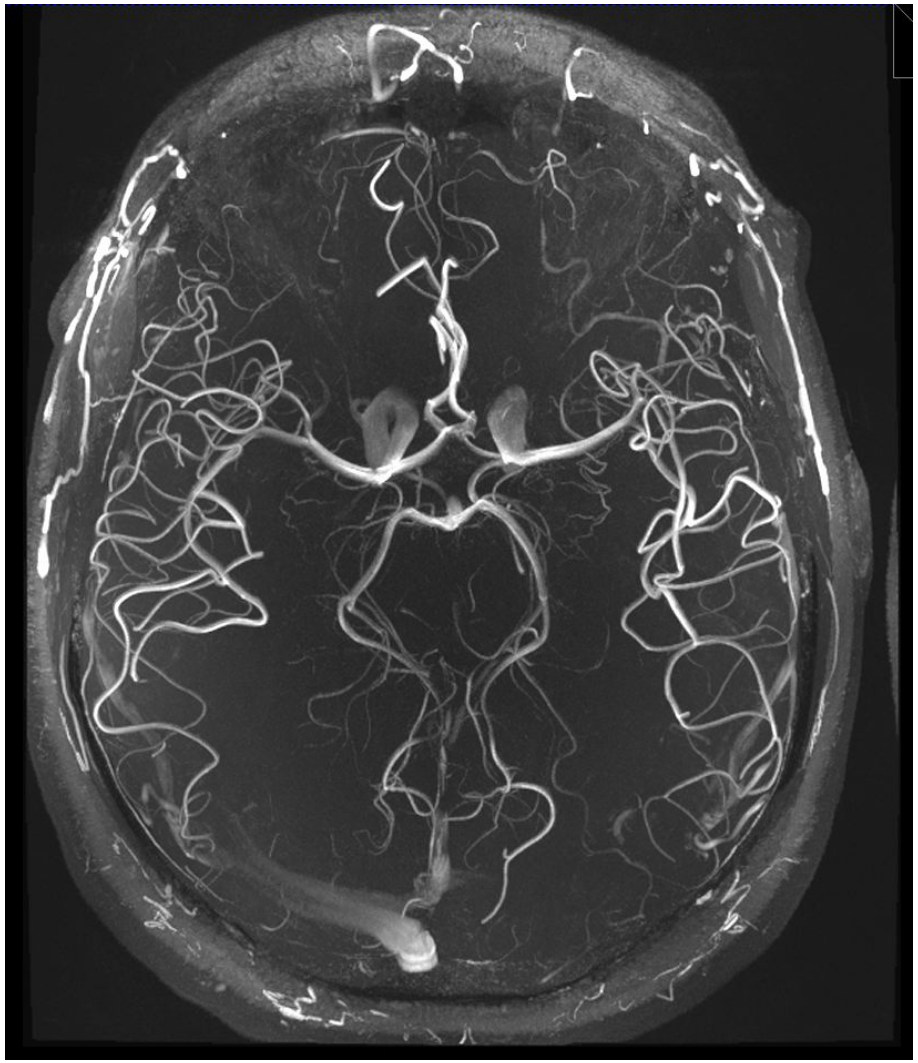
# High-Resolution T2-Weighted Imaging

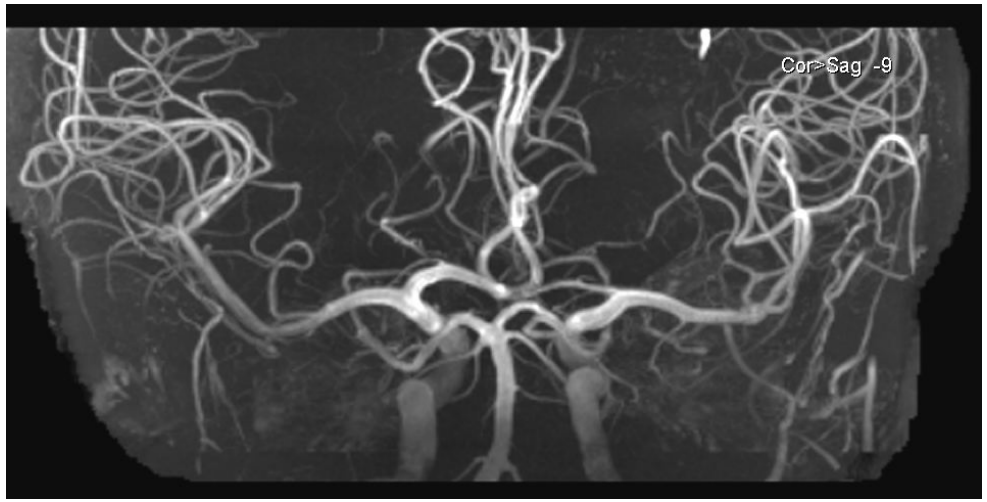


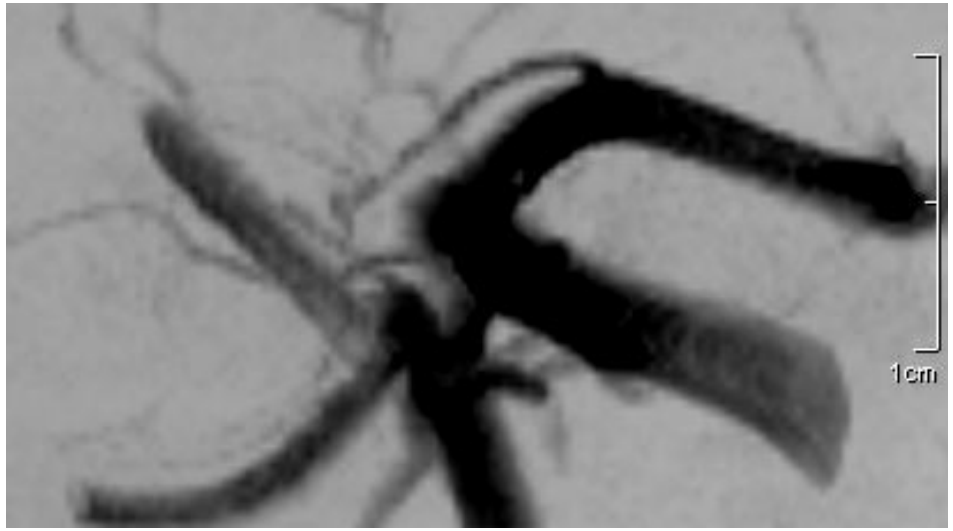




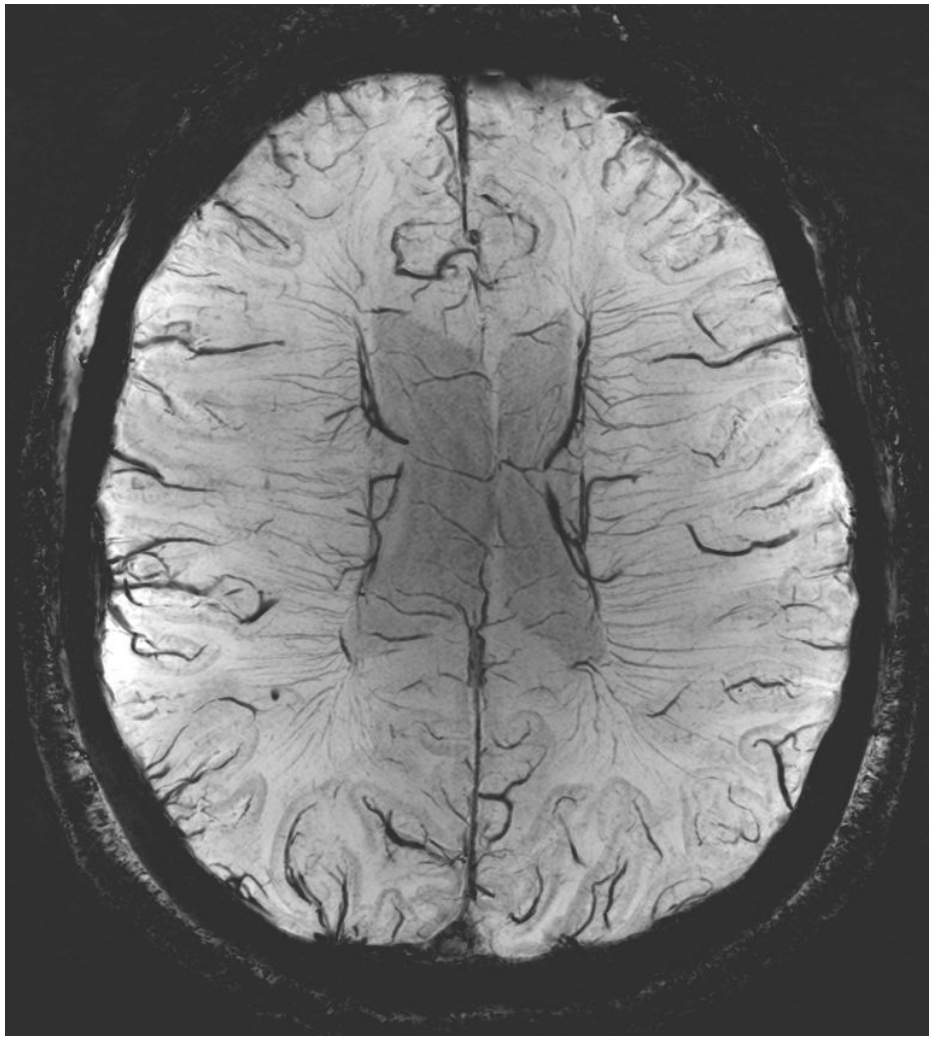
# Magnetic Resonance Angiography (MRA)

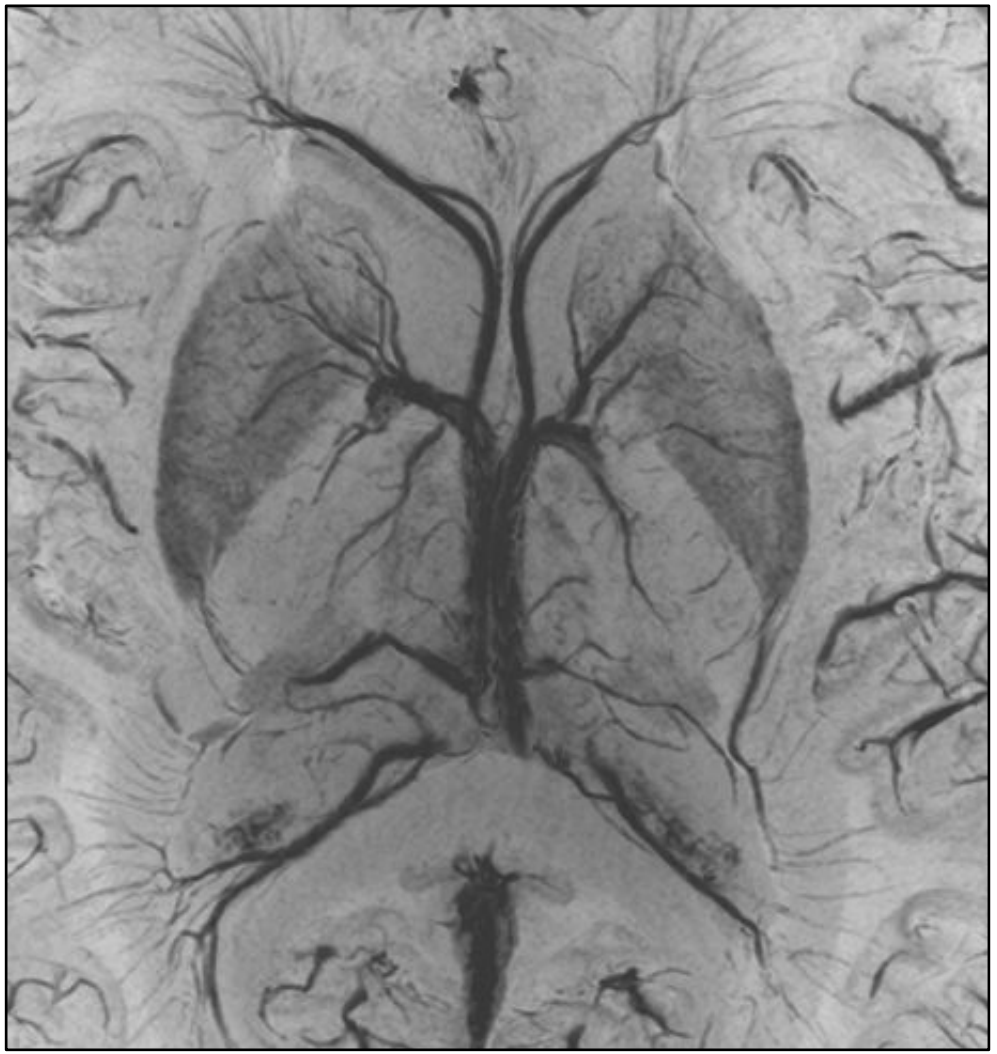


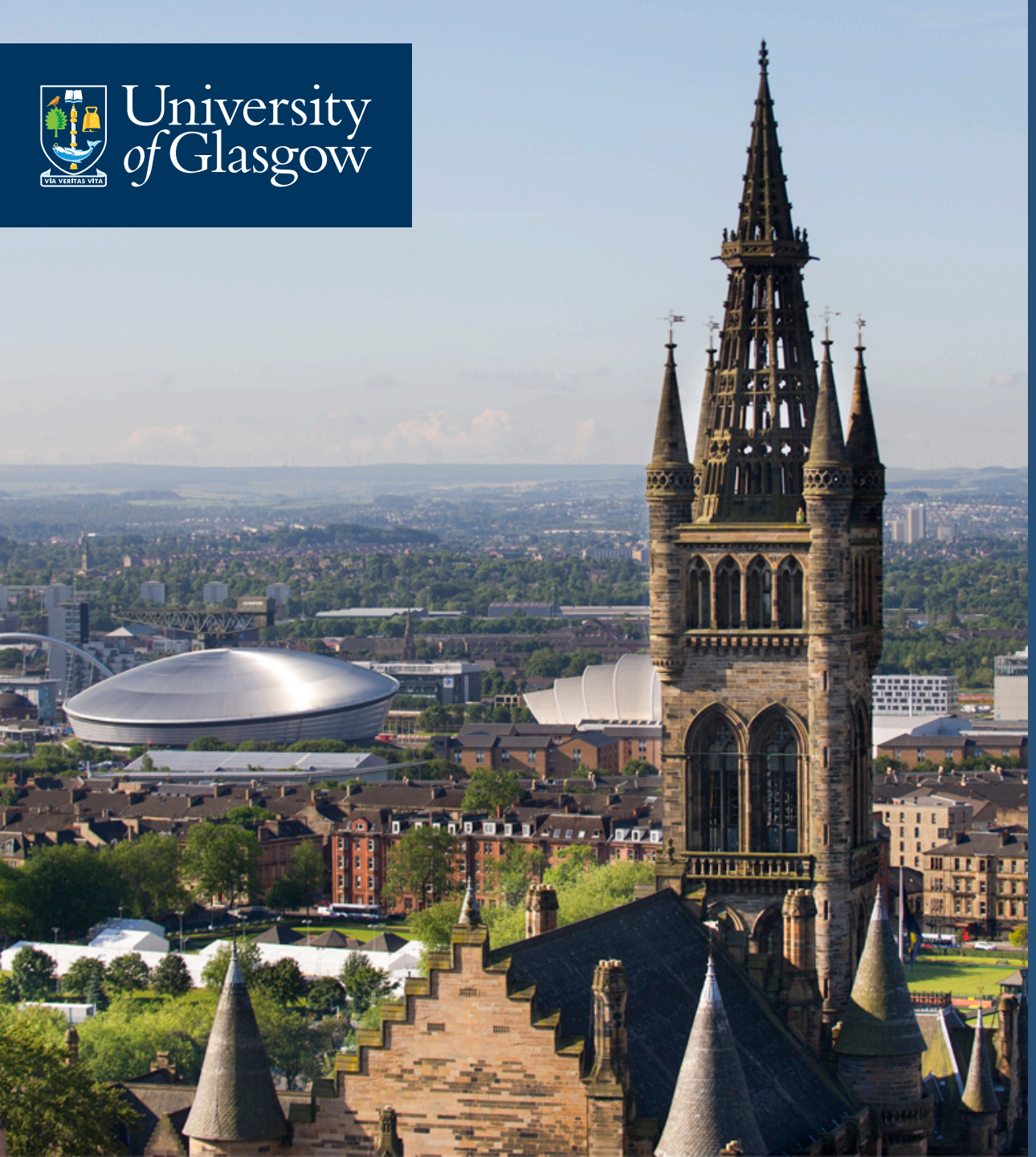


# Susceptibility-Weighted Imaging (SWI)







University of Glasgow

# The brain as a prediction machine

## *Psychology and Psychiatry*

Glasgow, June 16th, 2017


*Lars Muckli*

*Professor of Visual and Cognitive Neurosciences*
*Director of fMRI, CCNi*

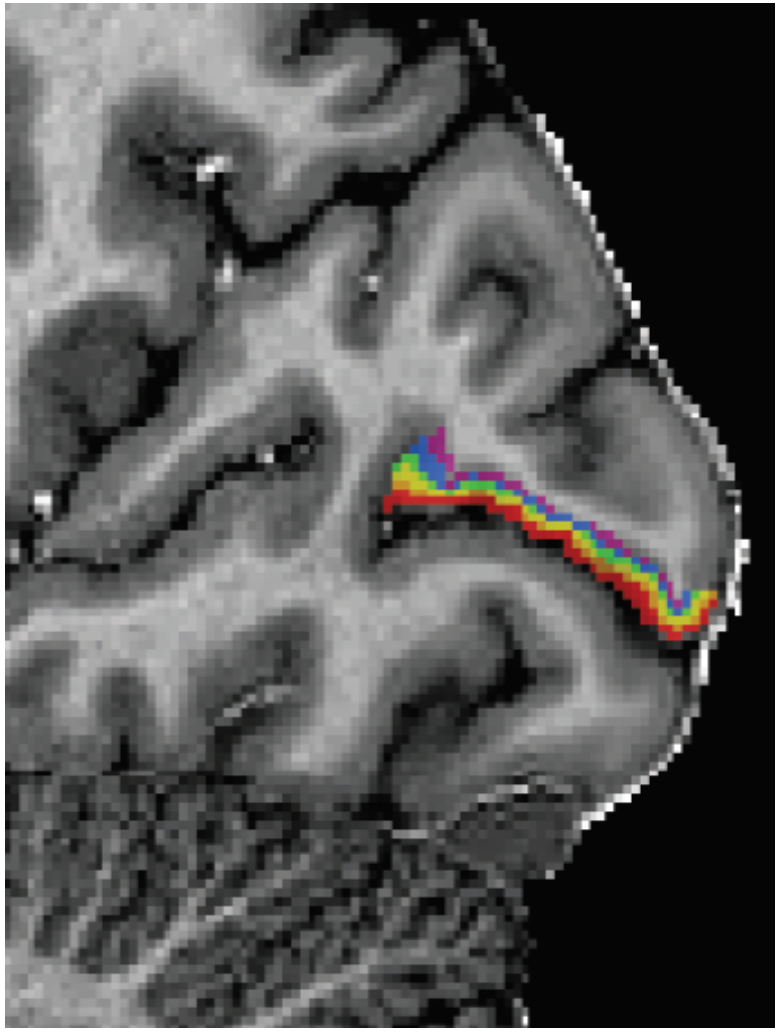
*Research Institute of Neuroscience and Psychology*

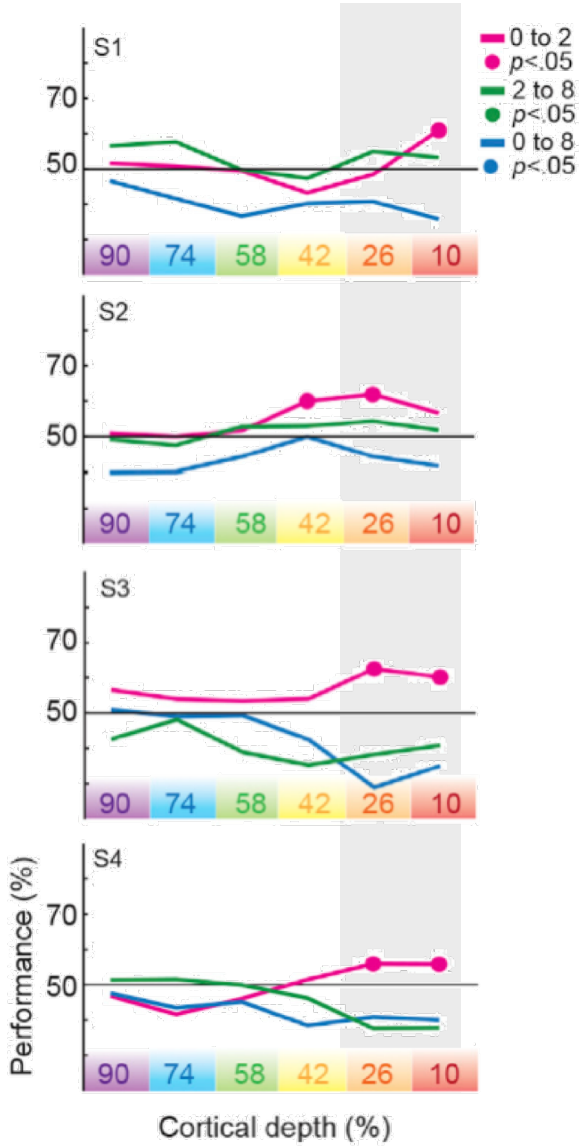

CCNi CENTRE FOR COGNITIVE NEUROIMAGING

BP Human Brain Project

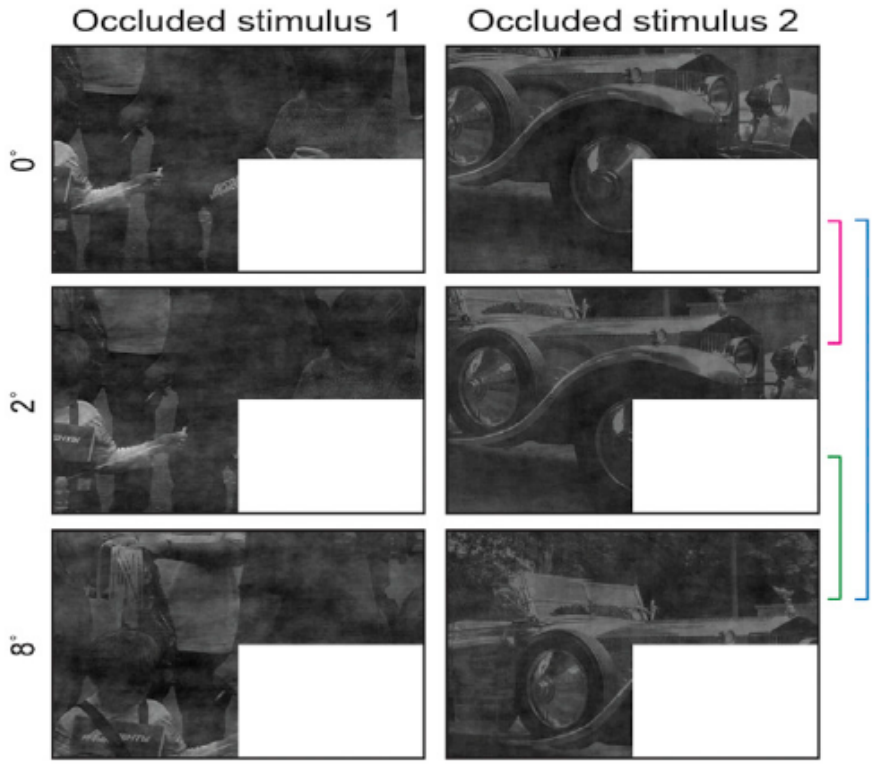
European Research Council erc

# ‘Predictive fields’ only in the outer layers



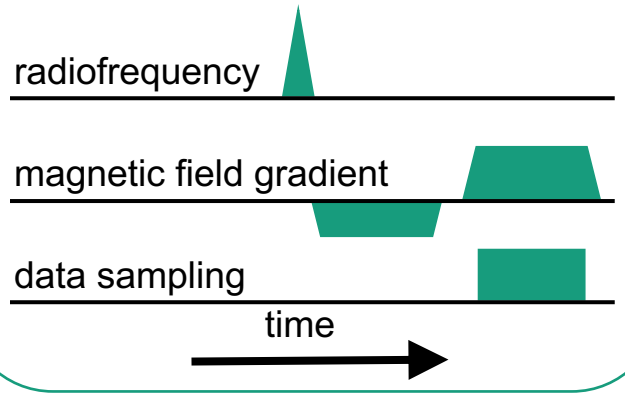



Muckli et al. (2015) Cur Biol



# Physics in Magnetic Resonance Imaging

**Hardware events from computer program**




**Parameters from operator**

**Data acquisition**

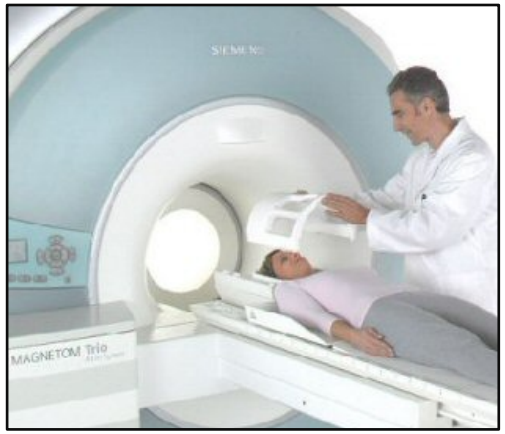
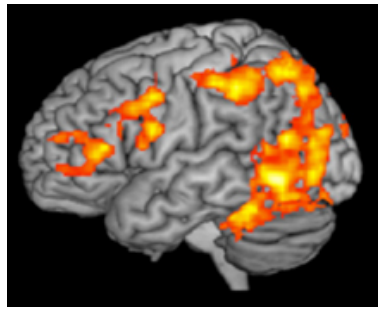
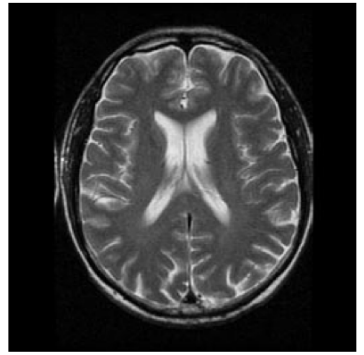


**Image reconstruction & data processing**

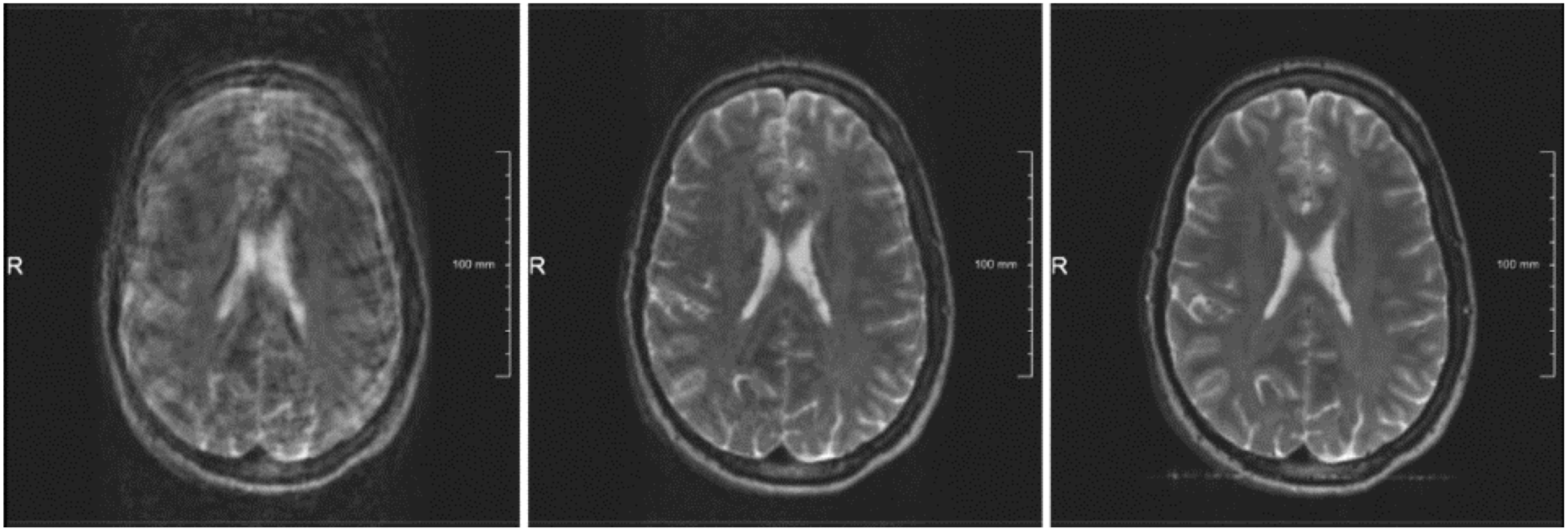




# Image-Based Motion Correction for 2D Imaging Sequences

- Promises reliable clinical diagnosis in the presence of motion
- No external markers or additional hardware

**without motion correction** **with motion correction** **no motion**

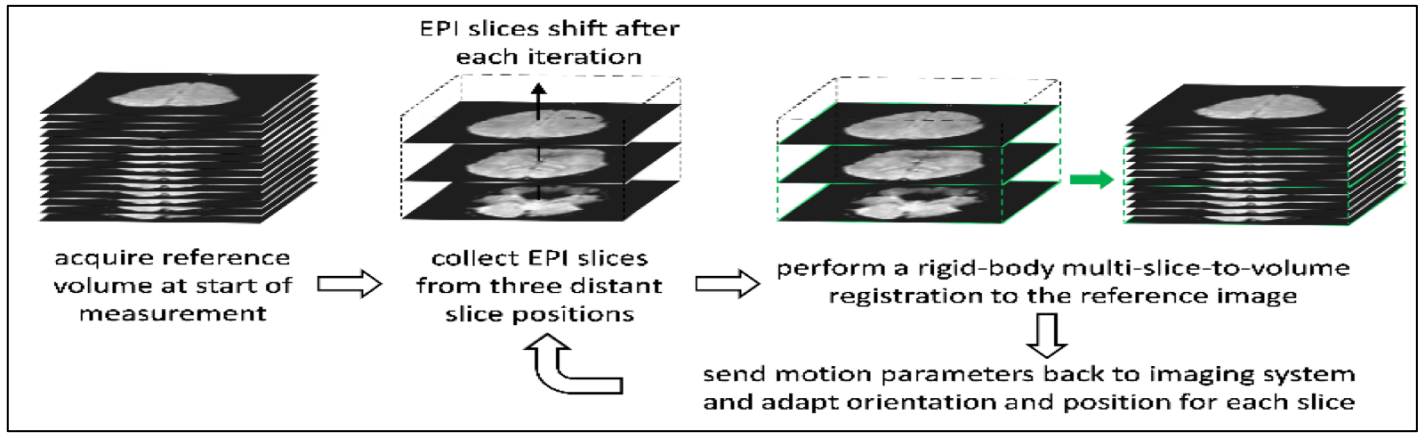




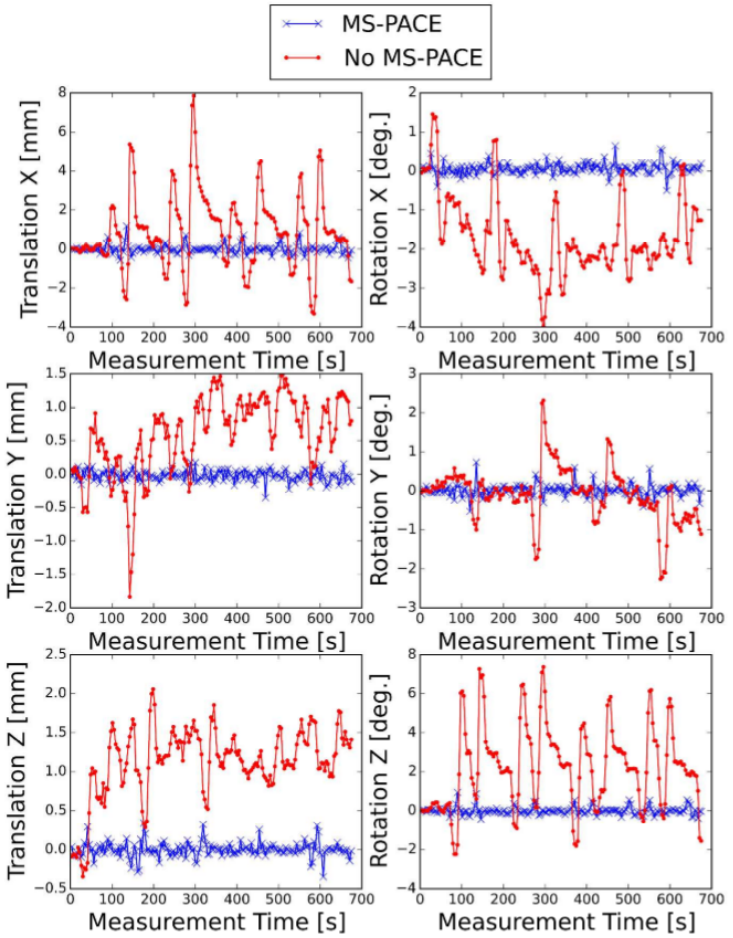

Hoinkiss & Porter, Magnetic Resonance in Medicine 2017

# Image-Based Motion Correction for 2D Imaging Sequences

- Reference volume acquired at start of measurement
- Subset of slices registered to reference volume in real time during scan
- Real-time adjustment of slice positions within 300ms to compensate for subject motion




motion parameters with and without correction

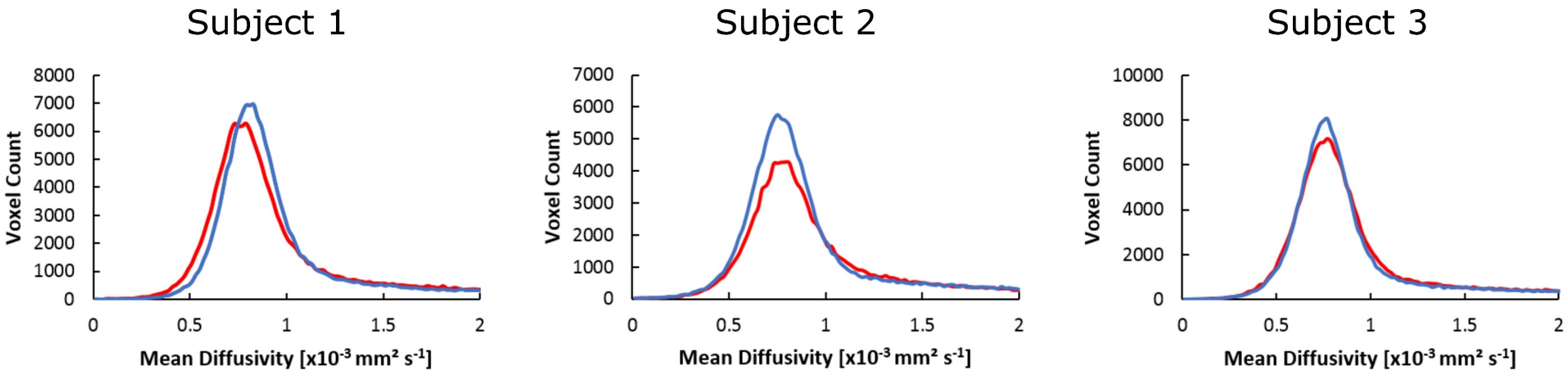





Hoinkiss & Porter, Magnetic Resonance in Medicine 2017

# Motion correction in quantitative diffusion-weighted imaging (DWI)

- Histograms of mean diffusivity (MD) show reduced distribution widths with prospective motion correction

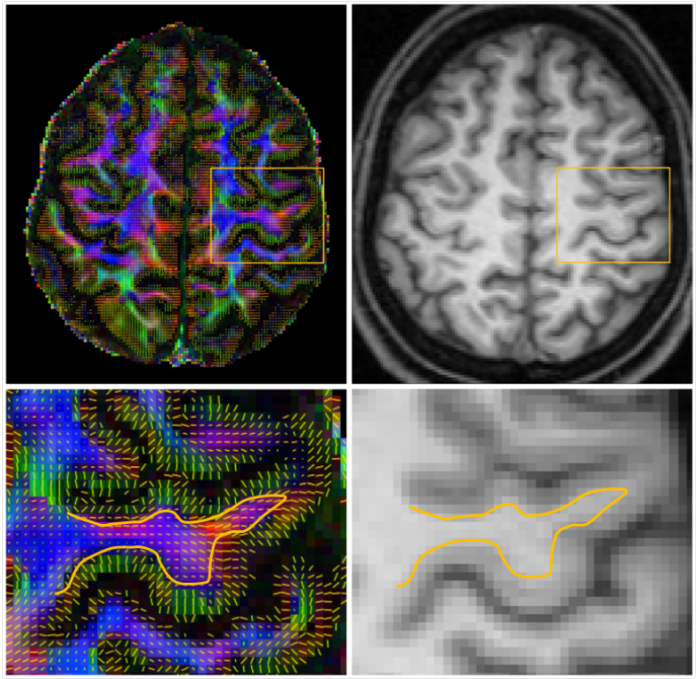



Hoinkiss & Porter, Neuroimage 2016

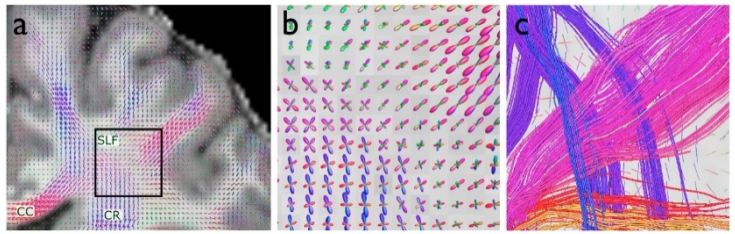
# High-Resolution Diffusion-Weighted Imaging at 7T

- Application at 7T (Max Planck, Leipzig)
- Multi-shot imaging more attractive due to increased artefacts with single-shot EPI

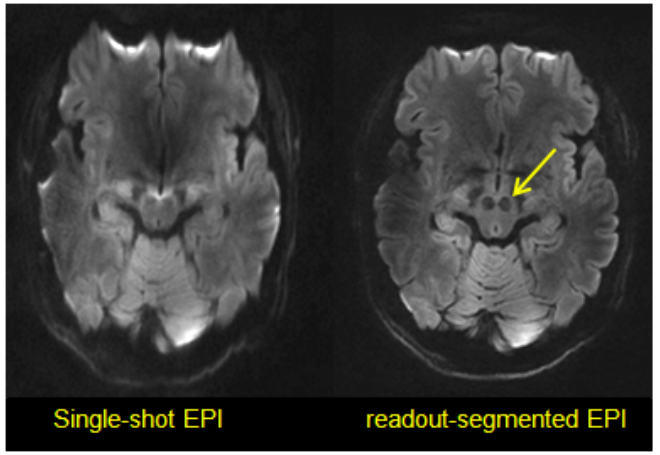
High resolution DTI showing radial anisotropy in cortex



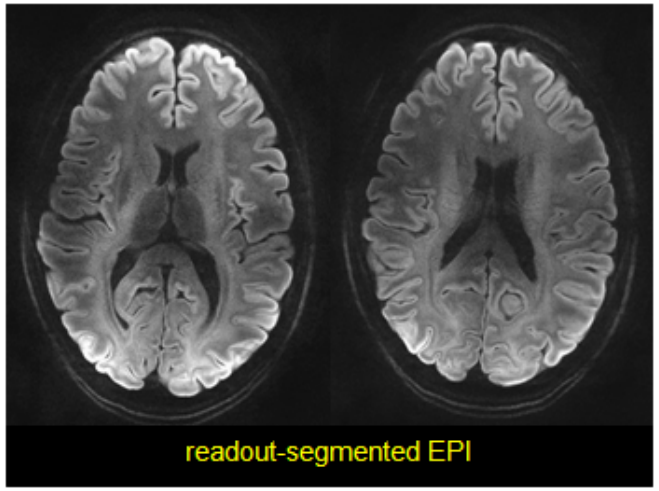
High angular resolution with 1mm isotropic spatial resolution




Comparison with single-shot EPI




DWI with pixel size 0.7mm by 0.7mm by 3mm



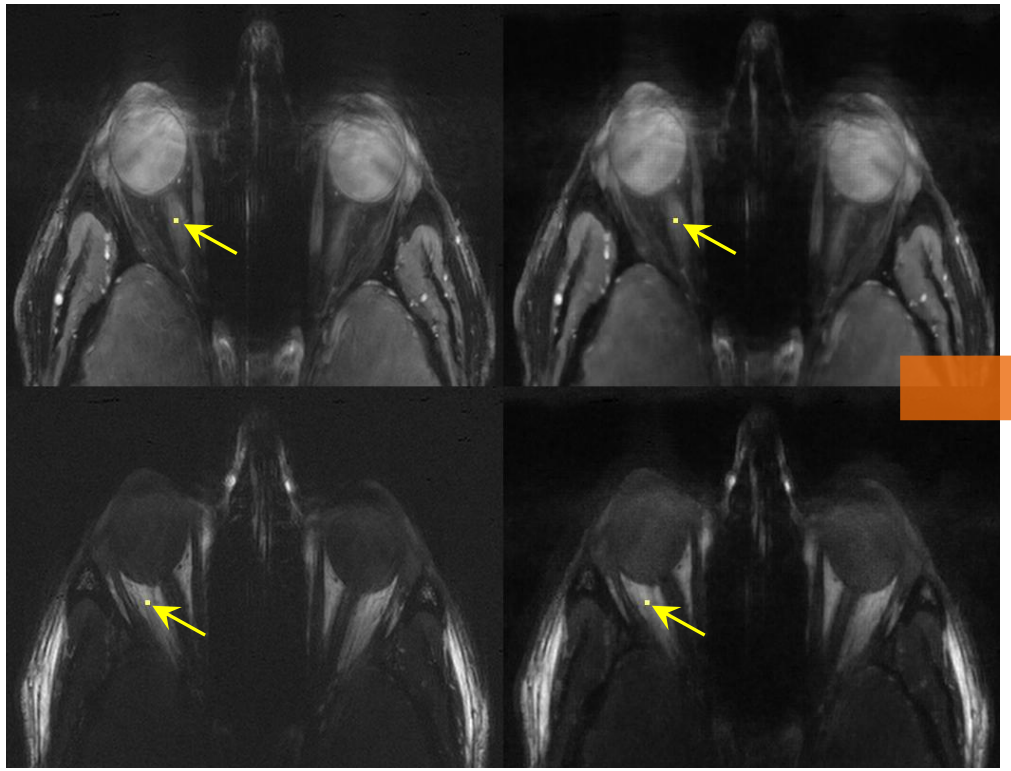



Heidemann, Porter et al. Magnetic Resonance in Medicine 2010; Heidemann, Porter et al. ISMRM 2011

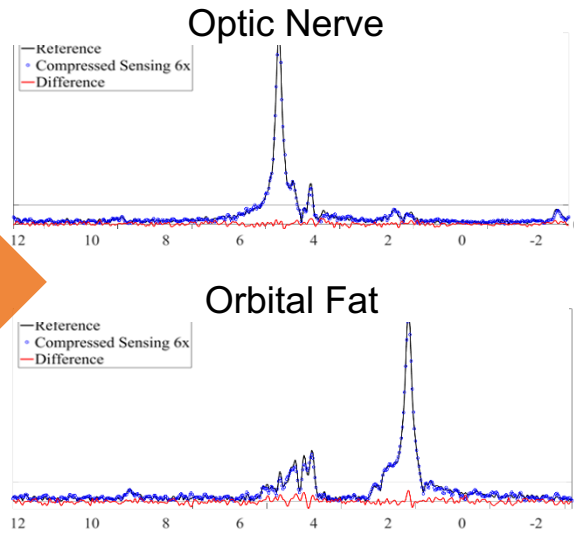
# Accelerated Spectroscopic Imaging

- Reduced scan time using compressed sensing
- Undersampled acquisition and iterative image reconstruction

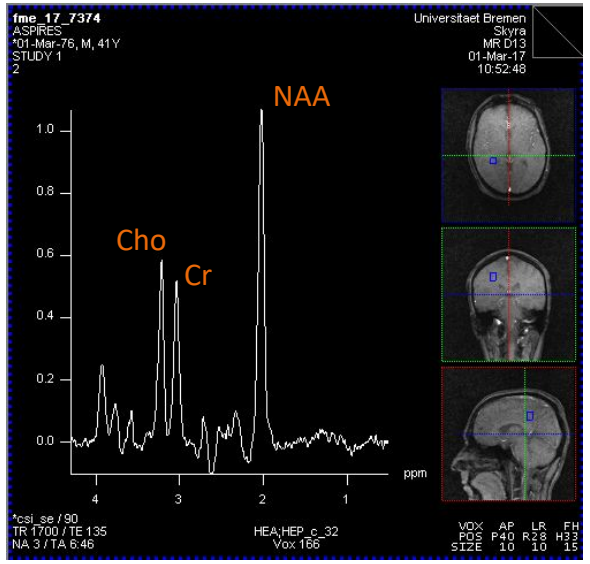
scan time: 5:04 scan time: 0:50



water and fat spectra ($^1$H)

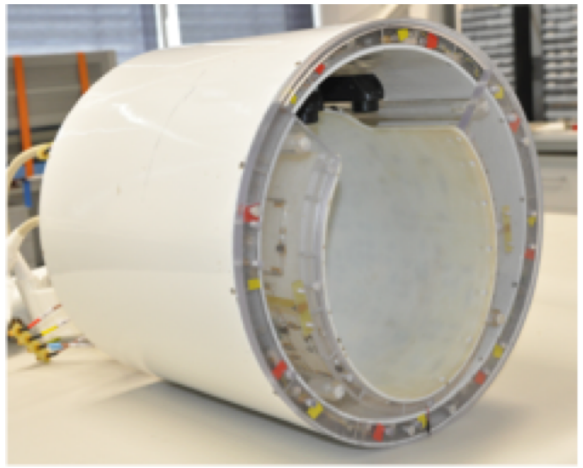



future work: metabolite spectrum ($^1$H)

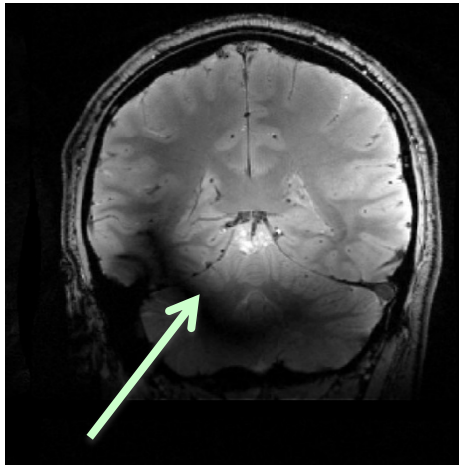



Vicari & Porter. ISMRM 2017

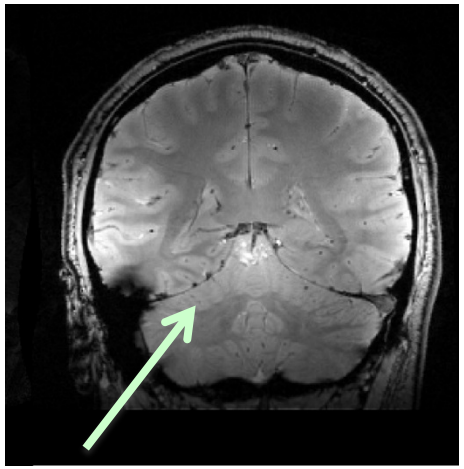
# Radiofrequency Hardware and Scottish Physics



**standard scan**

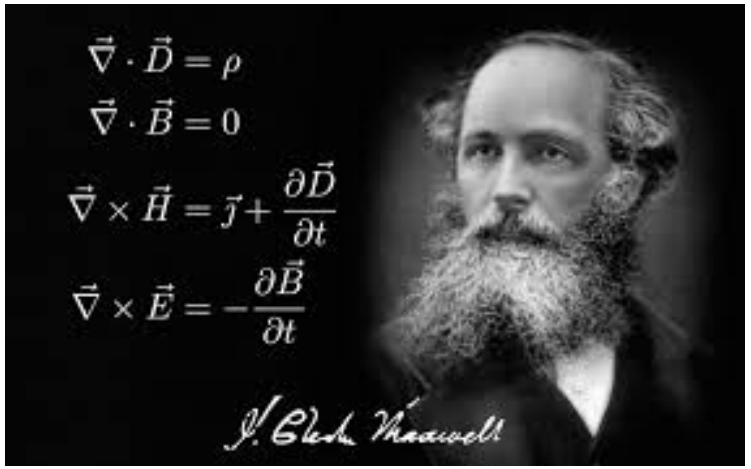


**optimised scan**



- Reduced wavelength at 7T causes $B_1$ field inhomogeneity
- Solved by using multiple transmit channels with optimised waveforms ($B_1$ shimming)
- Requires dedicated RF coil development

**Maxwell's equations**




**Courtesy of Dr. Shajan Gunamony**

# Thank you for your attention!