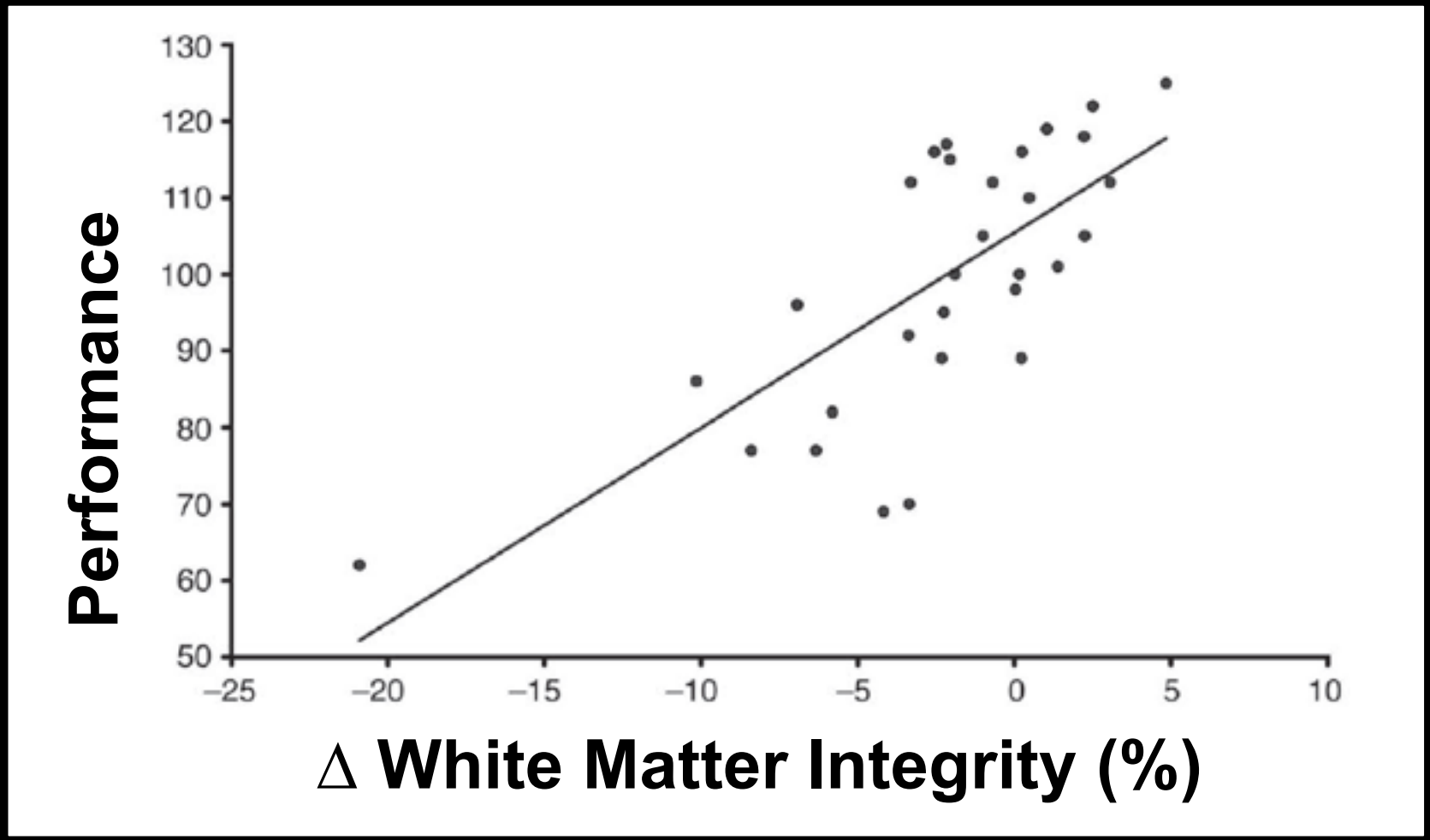
	Monday	Tuesday	Wednesday	Thursday	Friday
8-9		Intro to R	Installing our software	Mouse genetics	Perfusion tricks and issues
9-10	Welcome and Intro	MRI to understand radiation	Multimodal and qMRI	Longitudinal MRI	MMMRI/analysis/ neonatal MRI
10-10:30	Coffee	Coffee	Coffee	Coffee	Coffee
10:30:12:00	Applications	Image registration	Multimodal analysis	Longitudinal registration	MMMRI/analysis/ neonatal MRI
12-1	Lunch	Lunch	Lunch	Lunch	Lunch
1-2	Tour	Statistics	Multimodal analysis	Longitudinal data analysis and In-vivo MRI	Study design and power analysis
2-3	Intro to mouse MRI	Single time point data analysis	Talk and analysis		Breakout sessions
3-4:30			In-vivo MRI and continued analysis		
4:30:6	Intro to bash/Linux				Artefacts jeopardy
Evening		Harbour cruise			

Multimodal and Quantitative MRI (and we are talking about irradiation again)

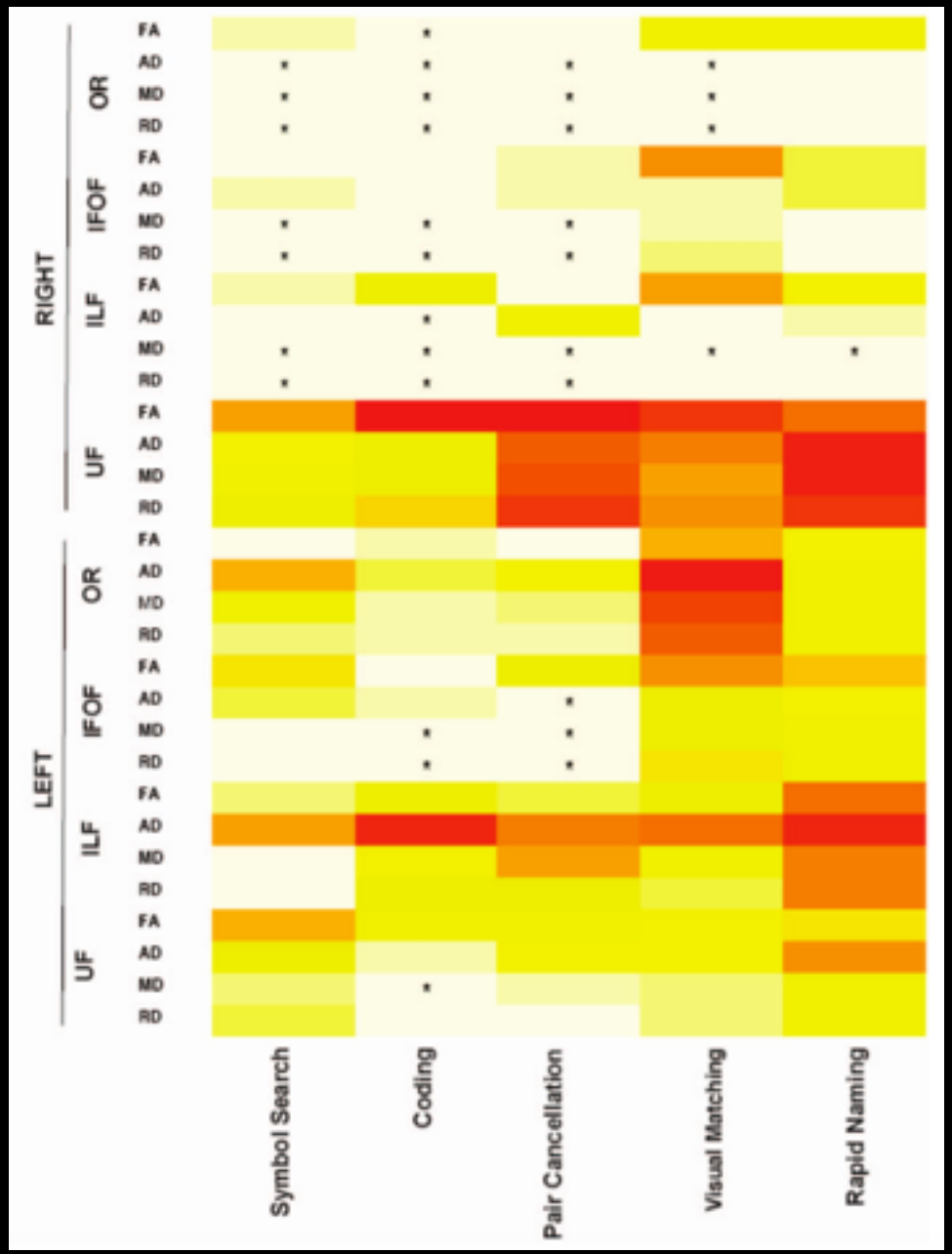
Elizabeth de Guzman
MISS Canada
August 23, 2017

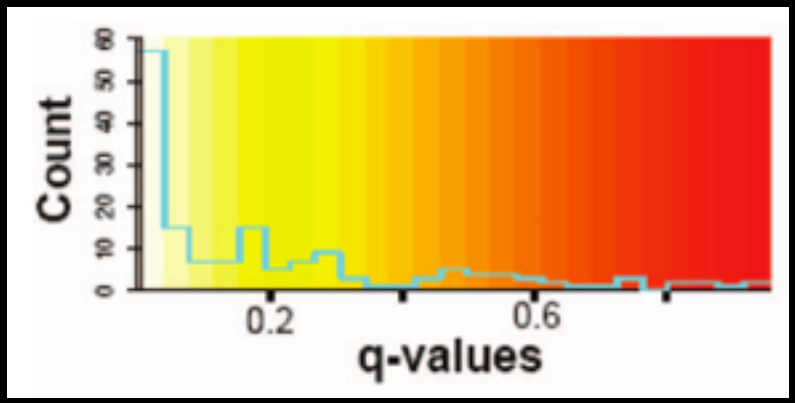
Irradiation affects WM integrity



Khong, P.-L. et al. (2006) *Journal of clinical oncology*

Irradiation affects WM integrity



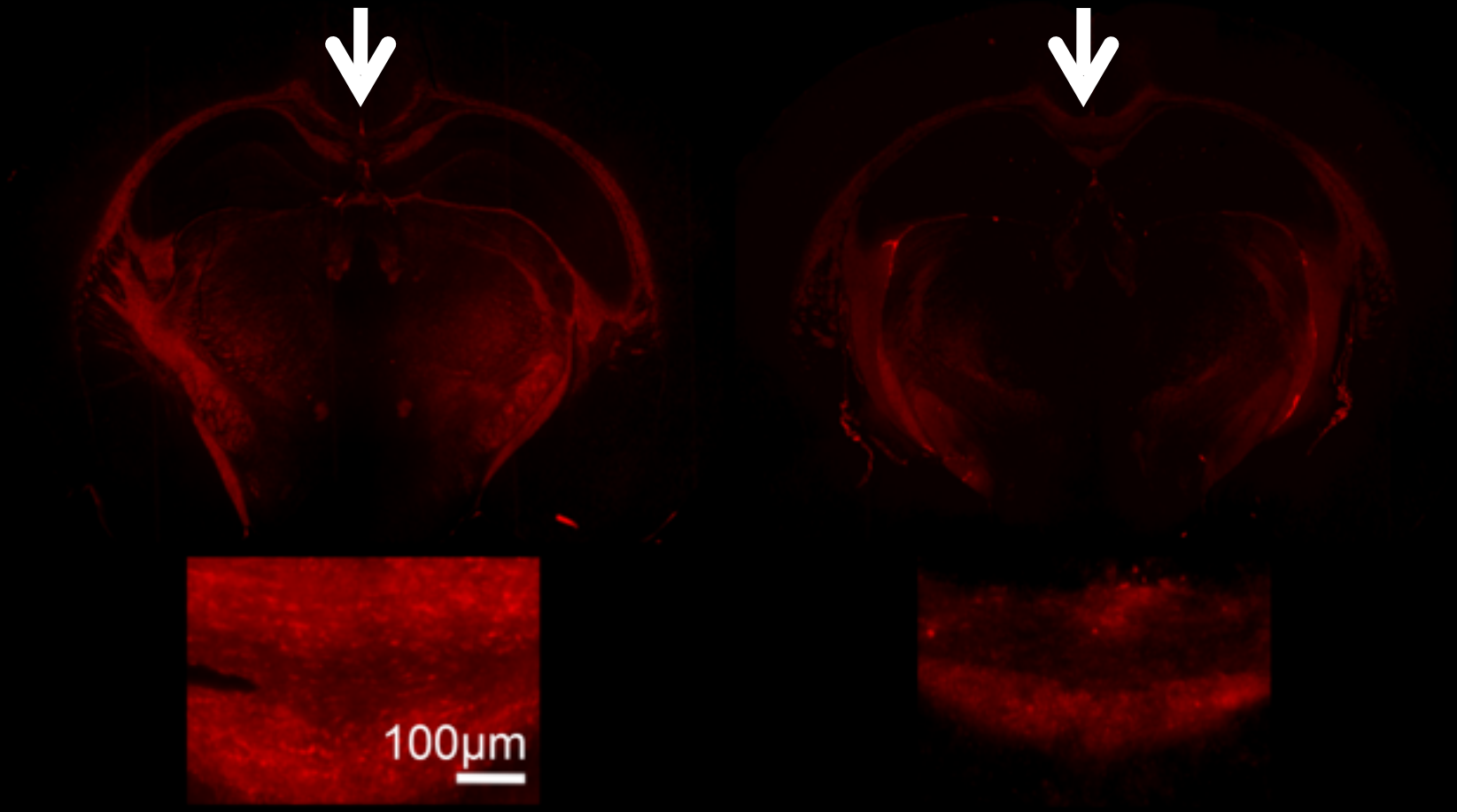


Scantlebury et al. (2016)
Neuropsychology

Irradiation affects WM integrity

Control

Irradiated

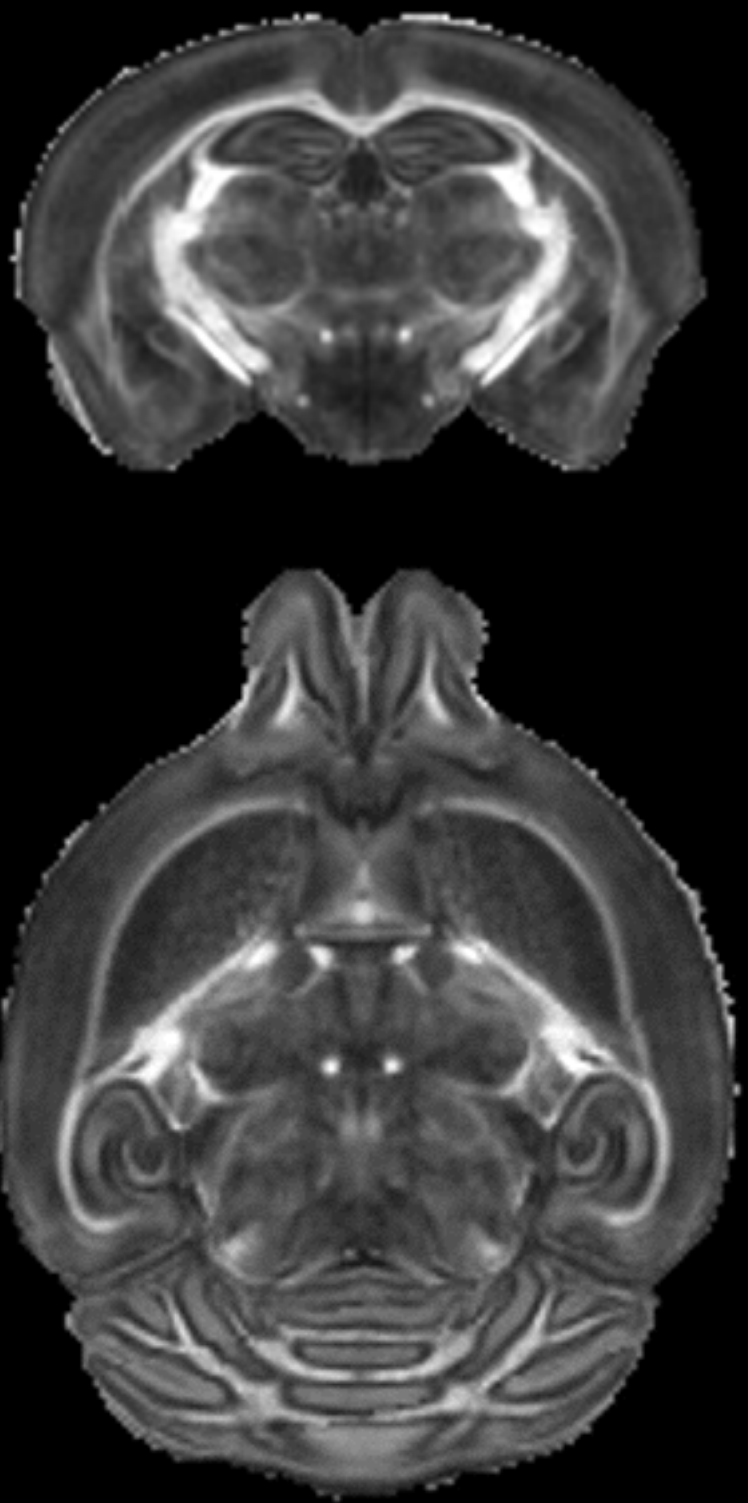


Methods to measure myelin integrity

1. Diffusion tensor imaging
2. Magnetization transfer imaging
3. Susceptibility mapping

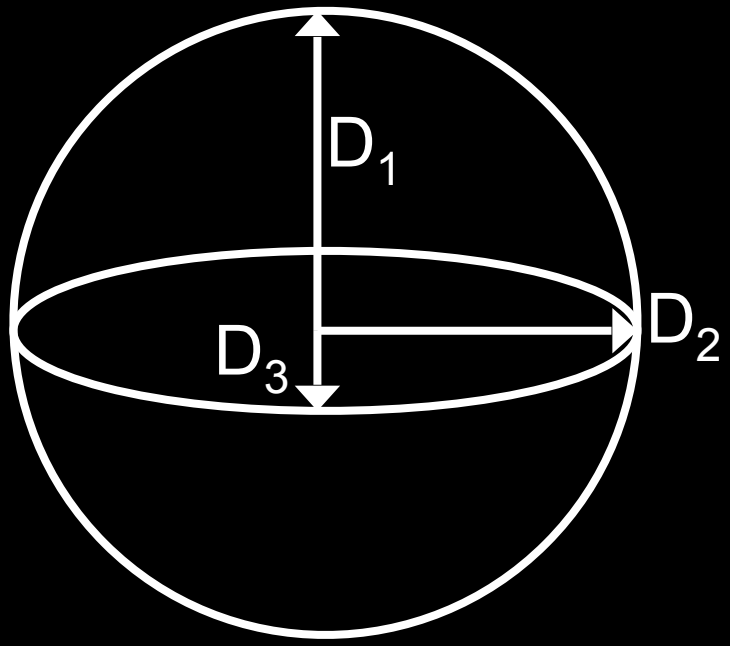
Diffusion Tensor Imaging

- 3D FSE sequence
- 78μm isotropic resolution
- 1 averages
- 6 echoes at 6ms echo spacing with an initial TE of 30ms
- 5 low (b=0 s/mm^2) and 30 high (b=1917s/mm^2, 30 directions) b-value images



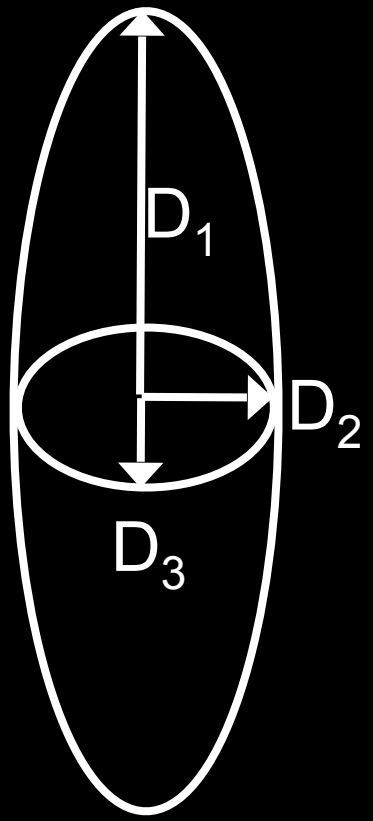
Diffusion Tensor Imaging

Isotropic Diffusion



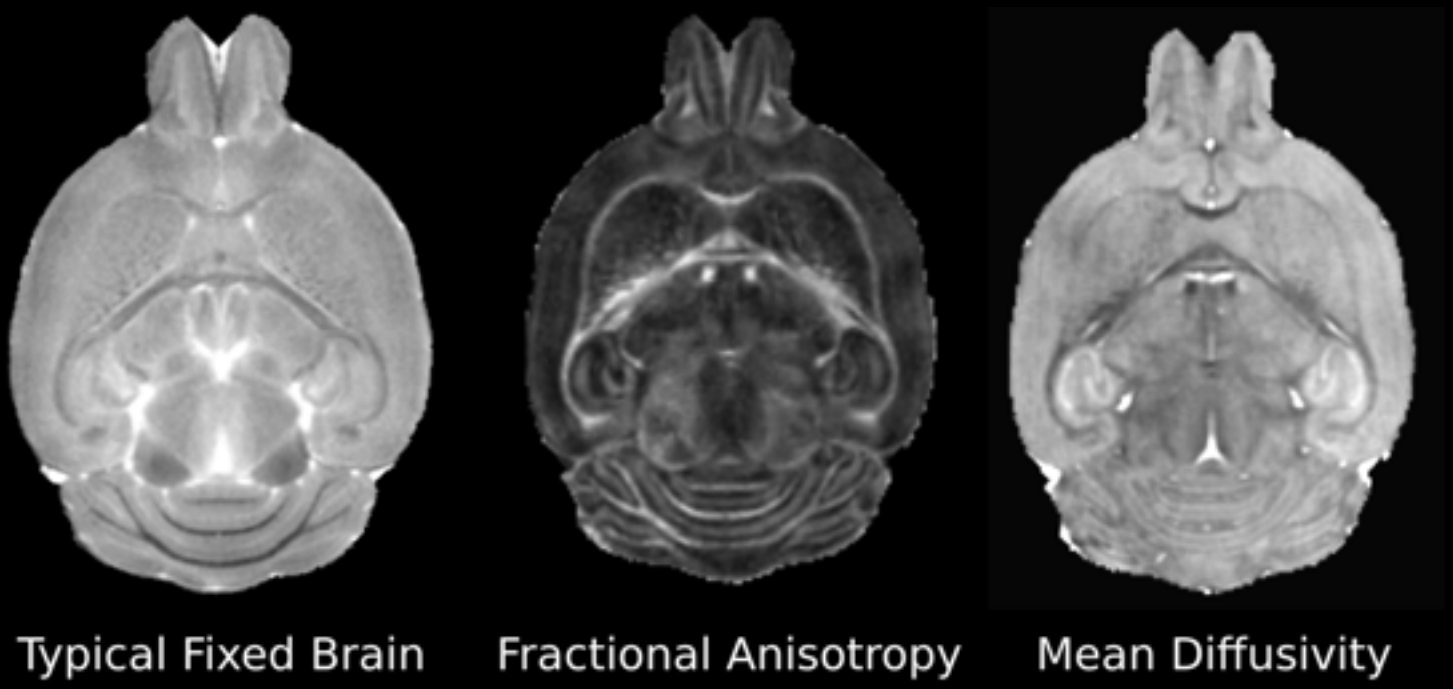
$D_1 = D_2 = D_3$

Anisotropic Diffusion



$D_1 > D_2, D_3$

Diffusion Tensor Imaging



Typical Fixed Brain Fractional Anisotropy Mean Diffusivity

1) Encode movement of water

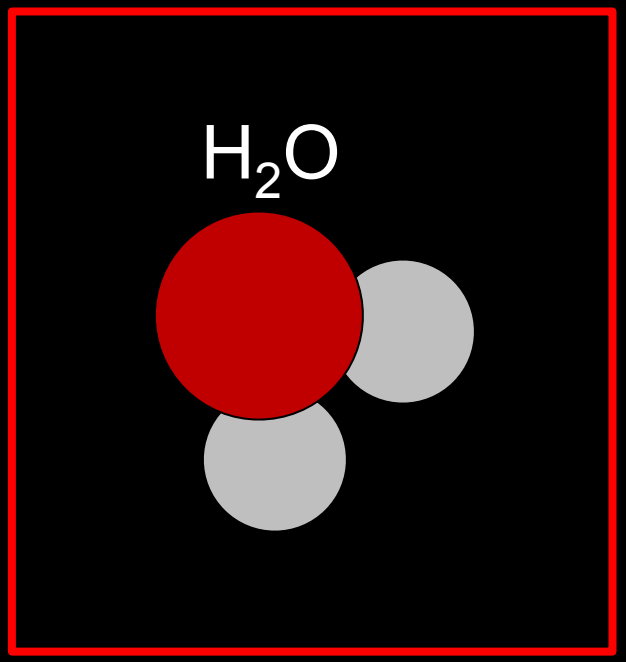
2) Record movement for a particular direction

Magnetization Transfer Imaging

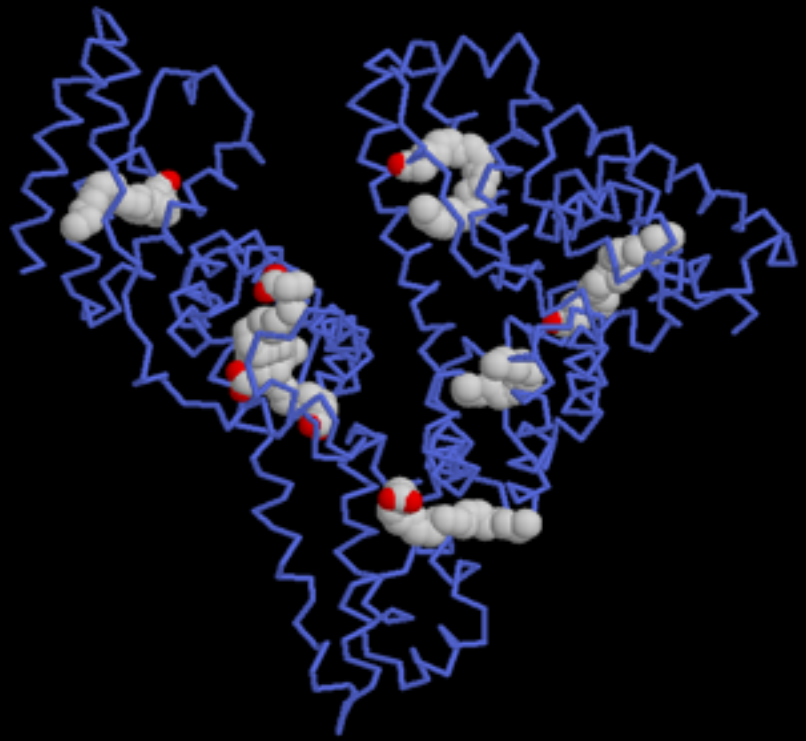
- 3D spin echo sequence
- 98μm isotropic resolution
- 4 averages
- TR/TE=300/8ms

- MT Saturation Pulse
  - Gaussian
  - +3500Hz off resonance
  - 20ms long
  - 5x per TR

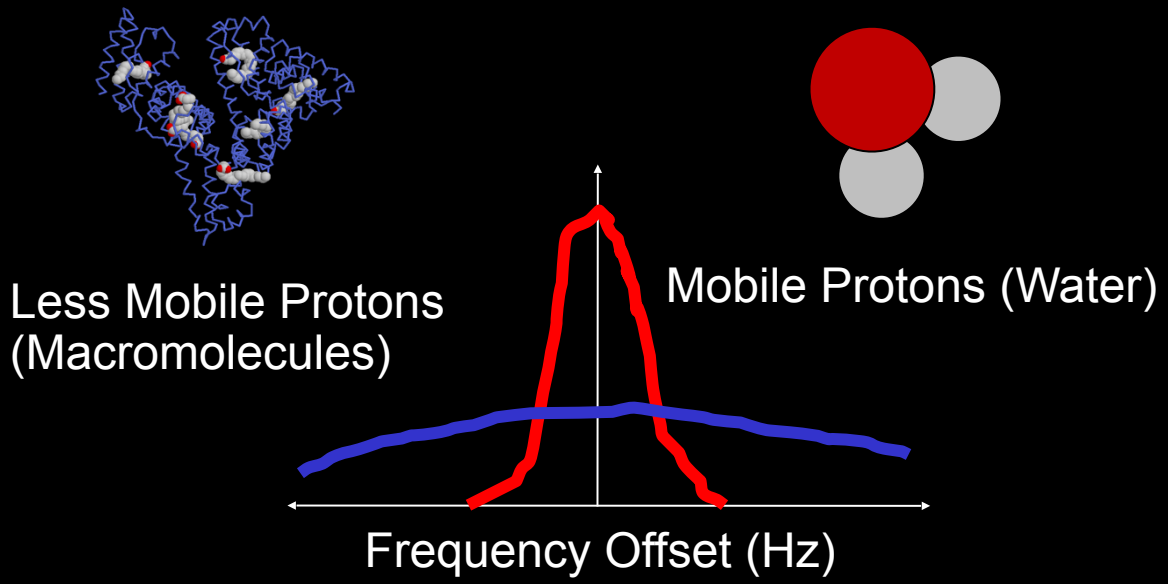
How MT Imaging Works



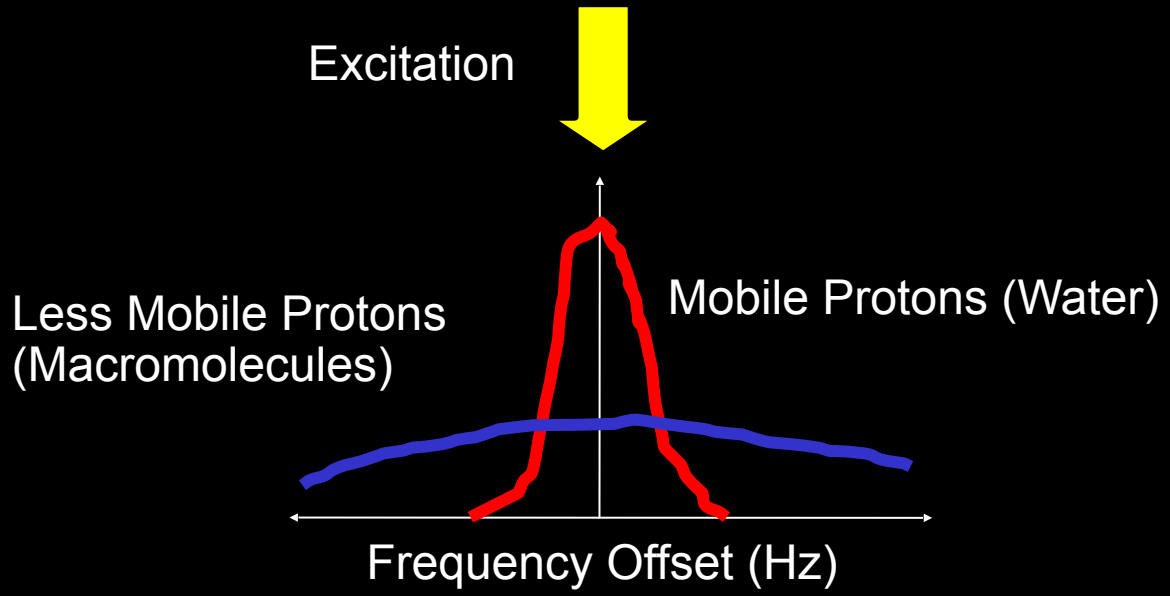
Macromolecules



How MT Imaging Works

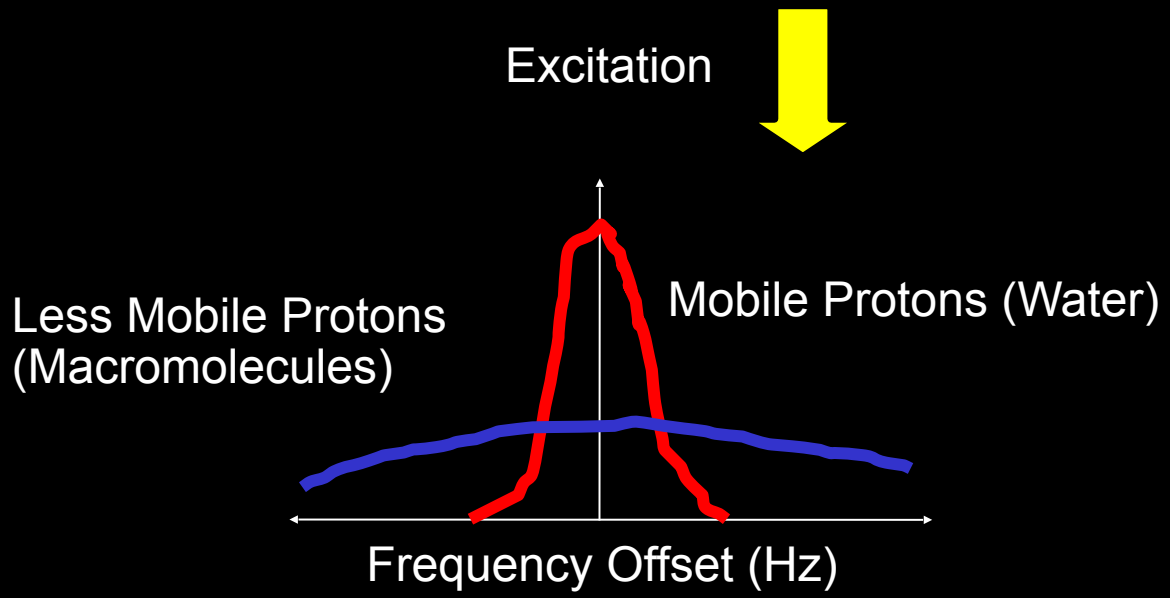


How MT Imaging Works



- Can't image the less mobile protons directly because the signal decays too quickly

How MT Imaging Works



- Can't image the less mobile protons directly because the signal decays too quickly

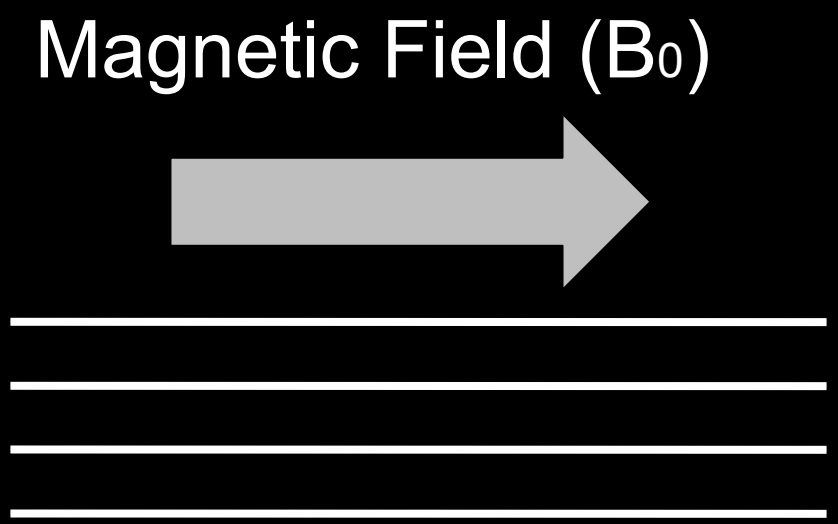
- Count on coupling between mobile protons and macromolecules to transfer signal

Quantitative Susceptibility Mapping

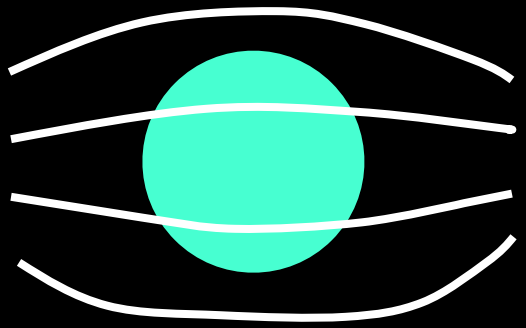
- 3D gradient echo sequence
- 61μm isotropic resolution
- 2 averages
- TR/TE=400/18ms

- Post-processing based on work by Liu et al (2011, Neuroimage)

How Susceptibility Works

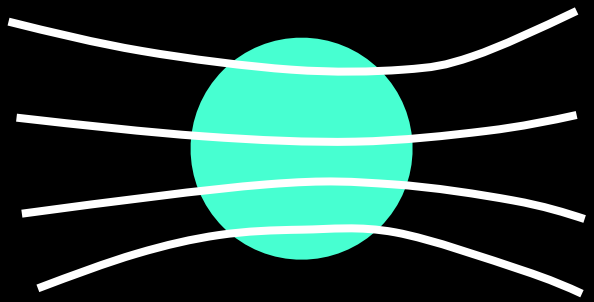


Diamagnetic



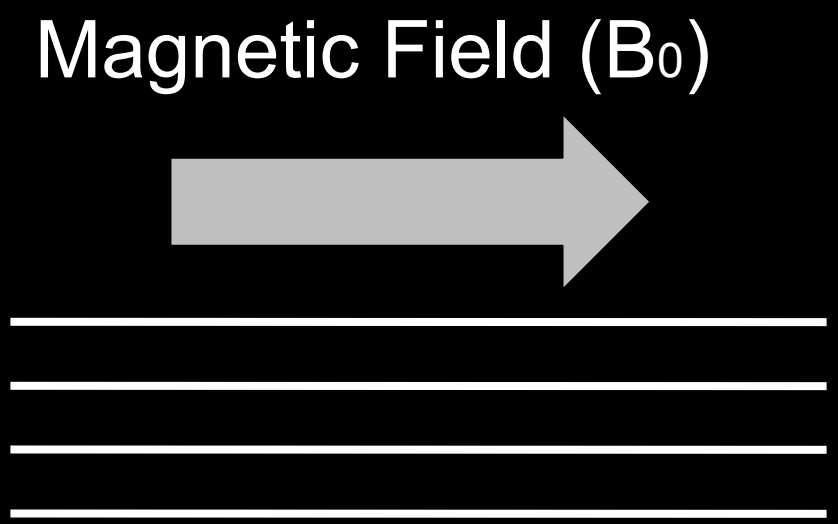
$X < 0$

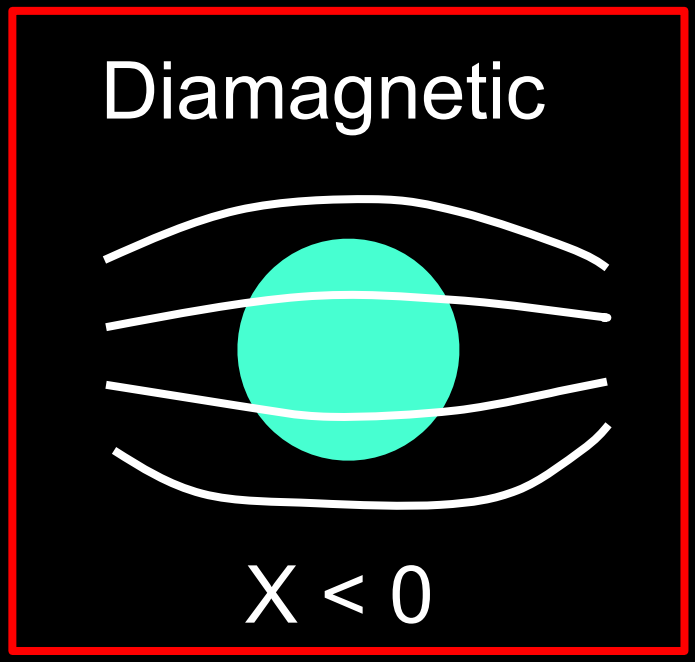
Paramagnetic

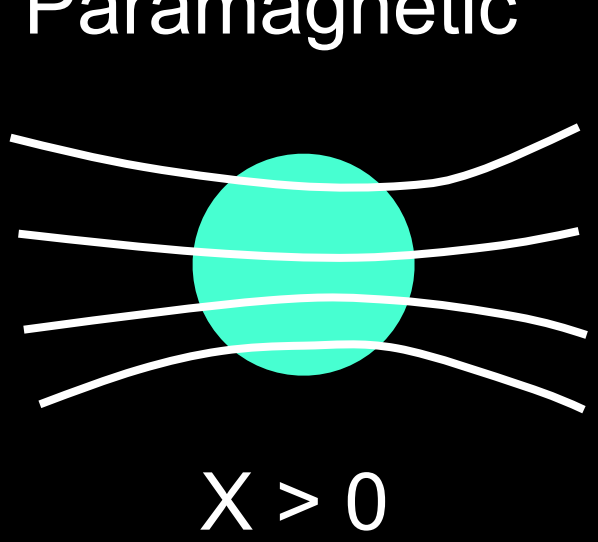


$X > 0$

How Susceptibility Works

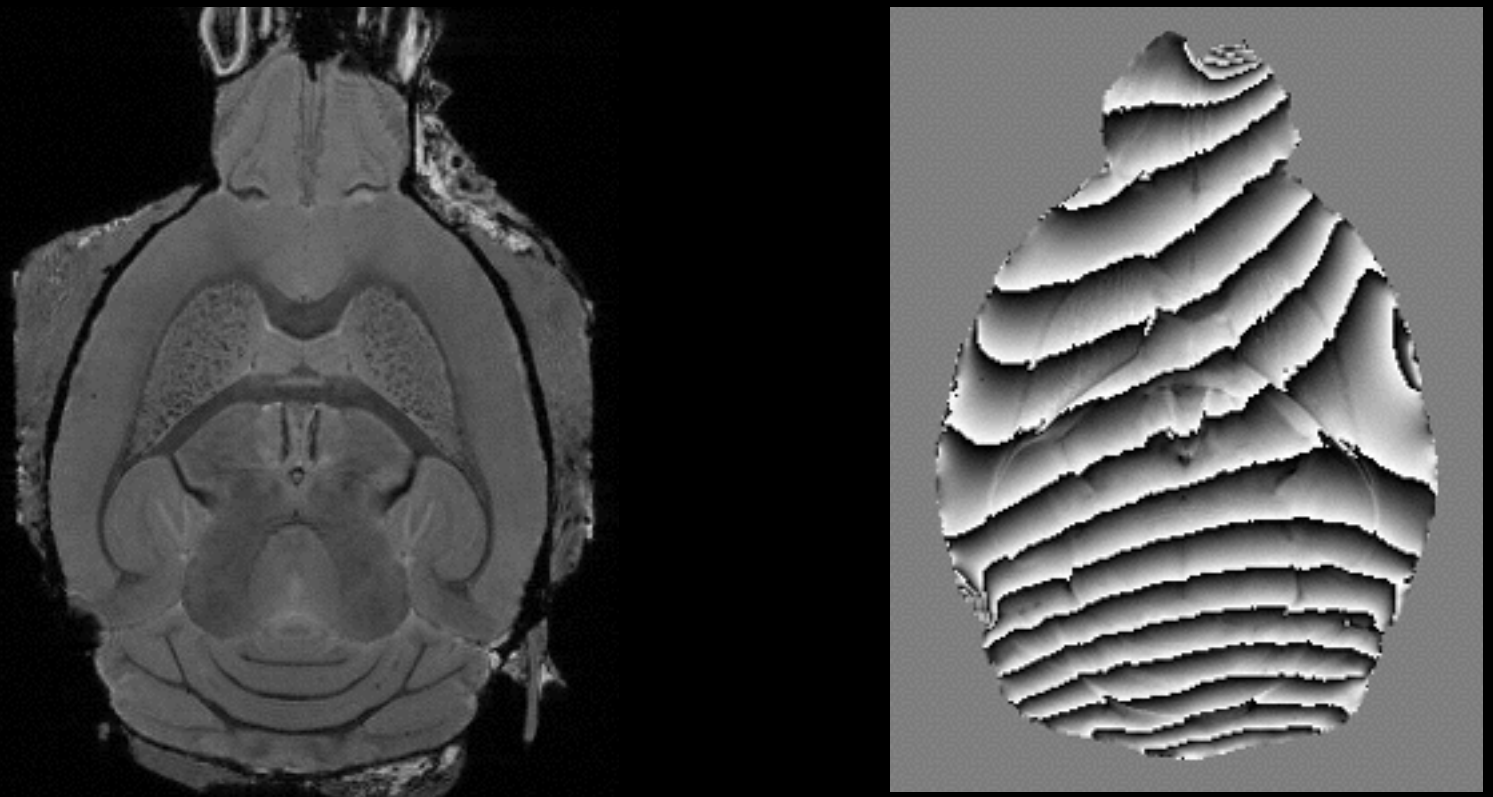






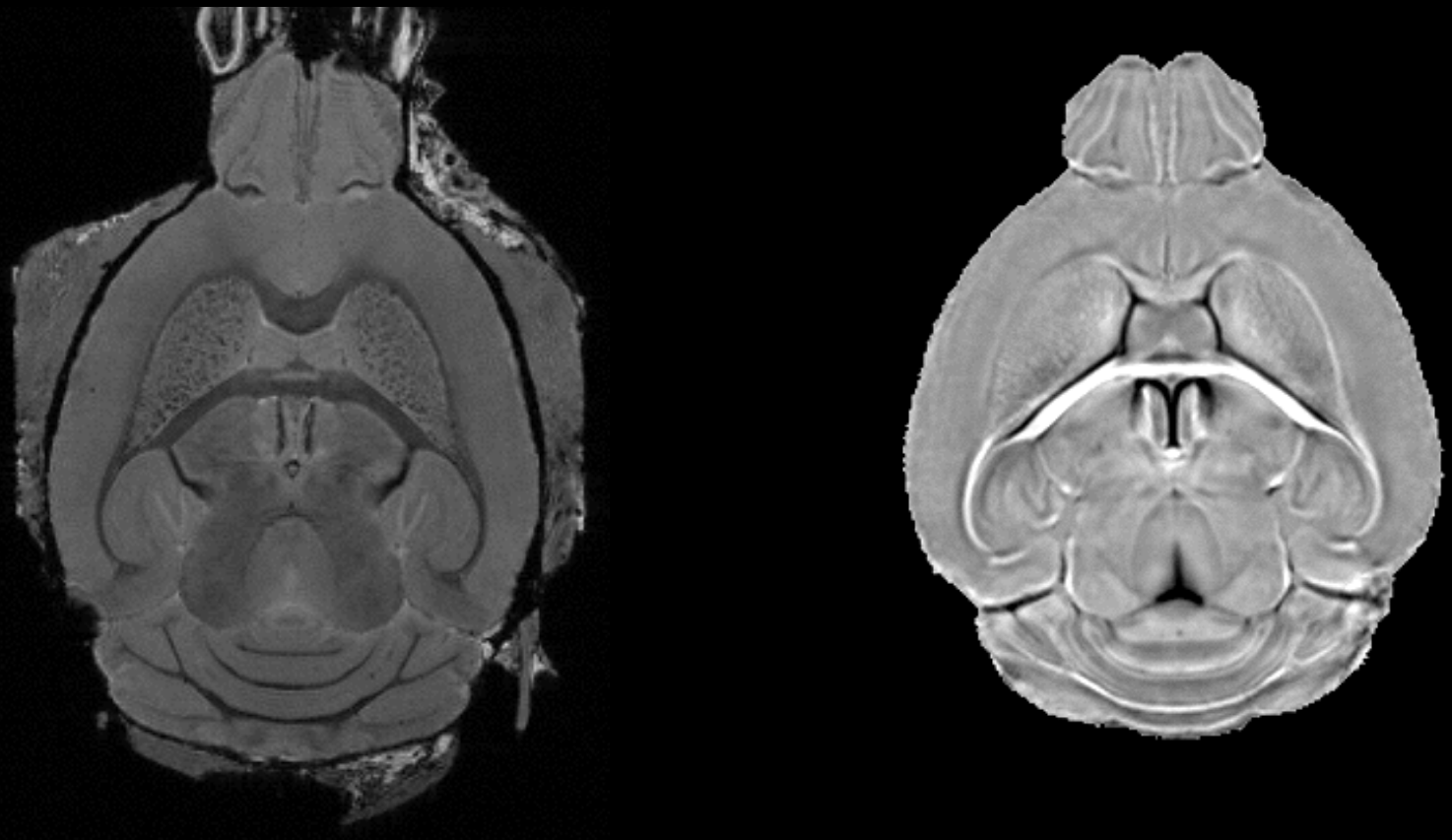
Data off the scanner is complex

Magnitude + Phase



Data off the scanner is complex

Magnitude + Phase



Methods to measure myelin integrity

1. Diffusion tensor imaging

   Structure

2. Magnetization transfer imaging

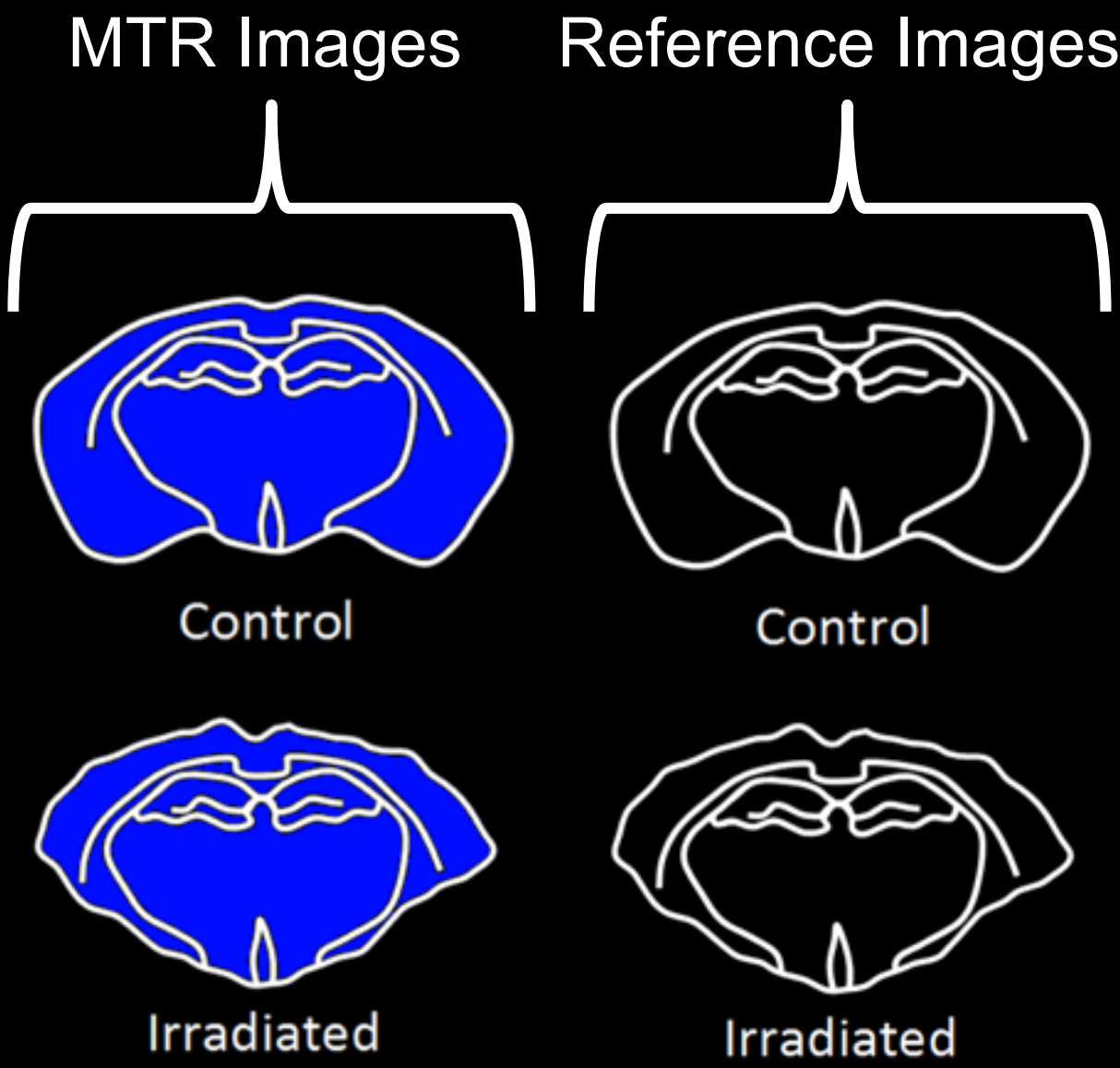
   Composition

3. Susceptibility mapping

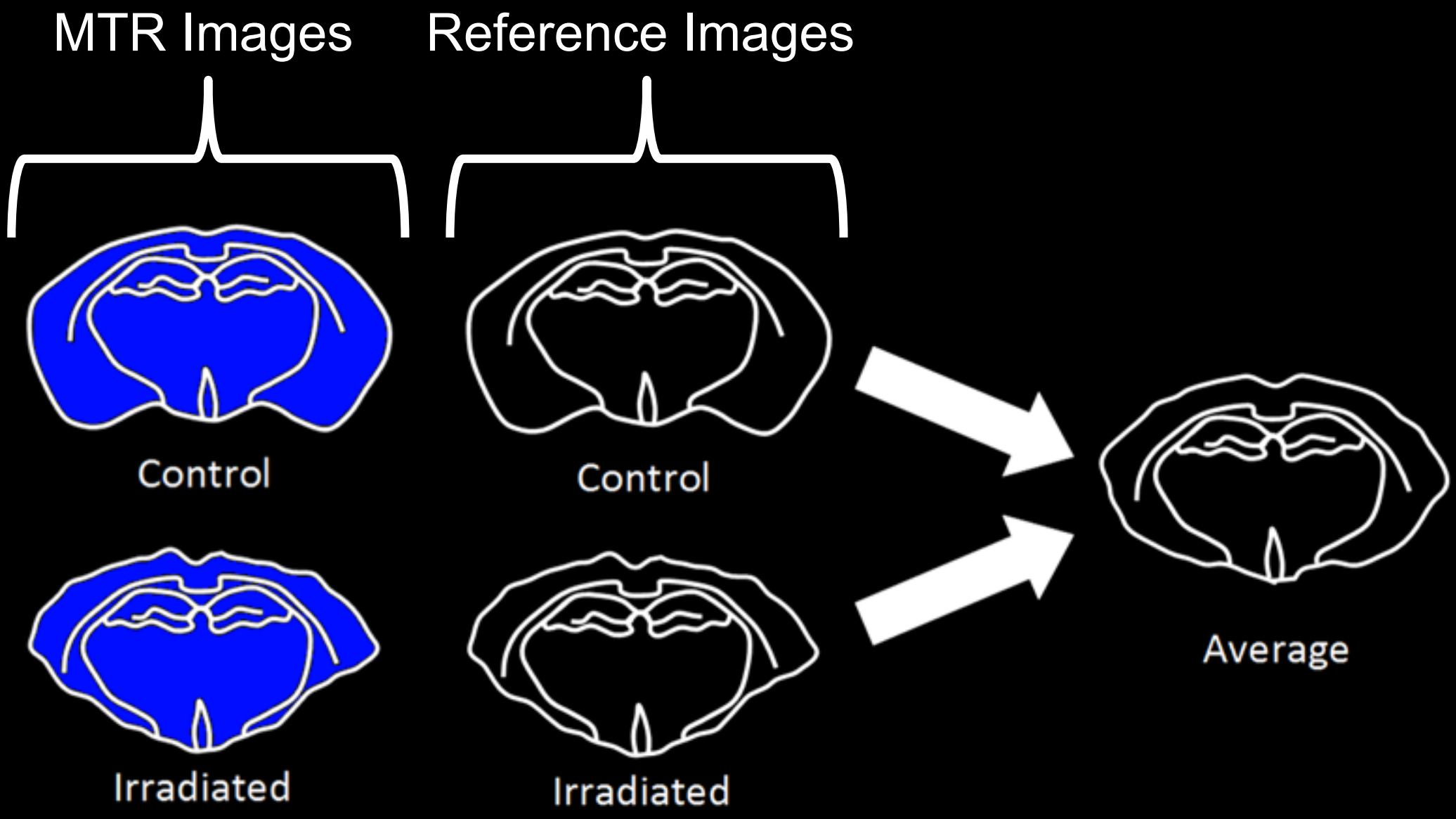
   Composition

Scan with all the things!

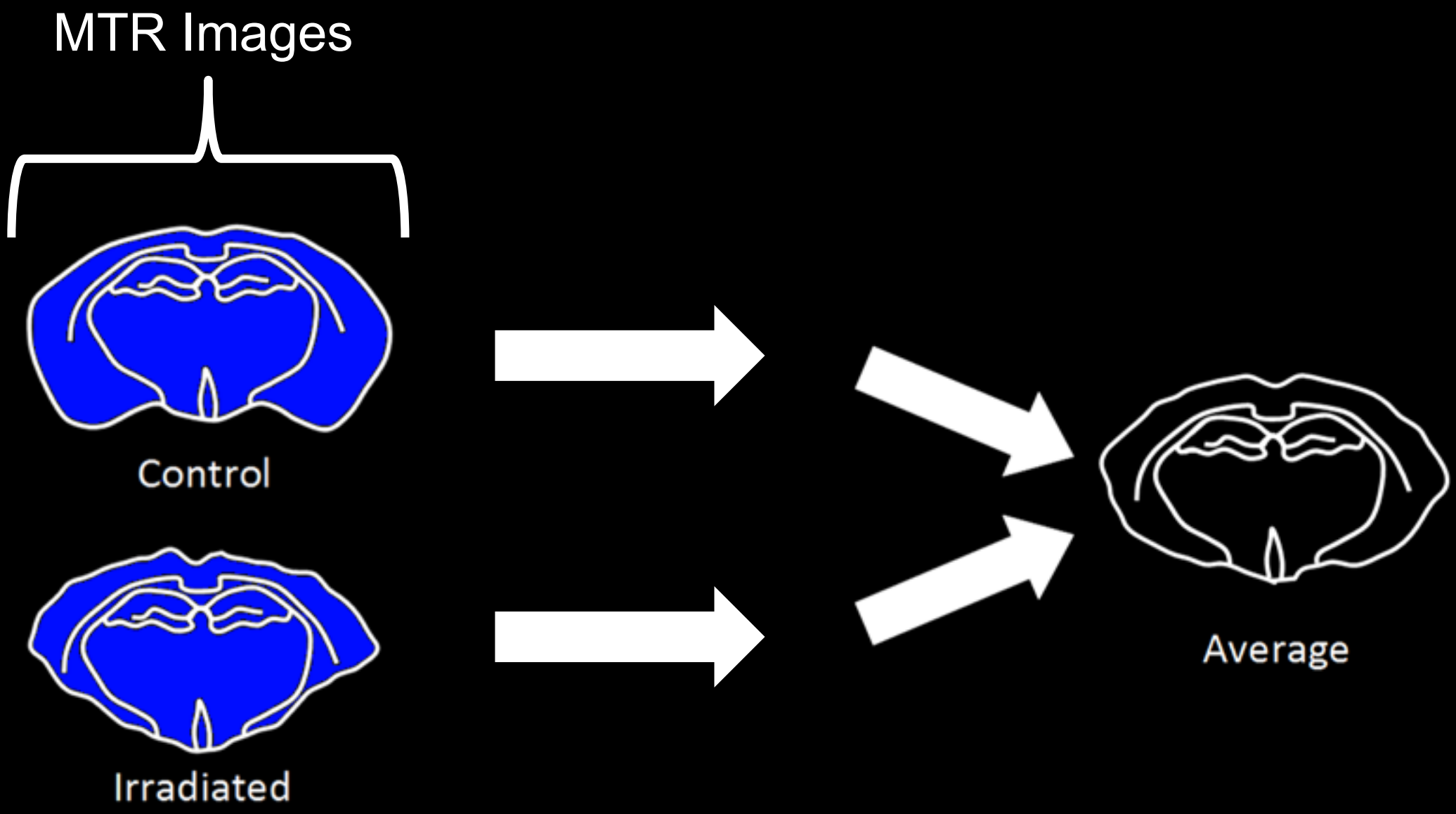
Differences in image registration



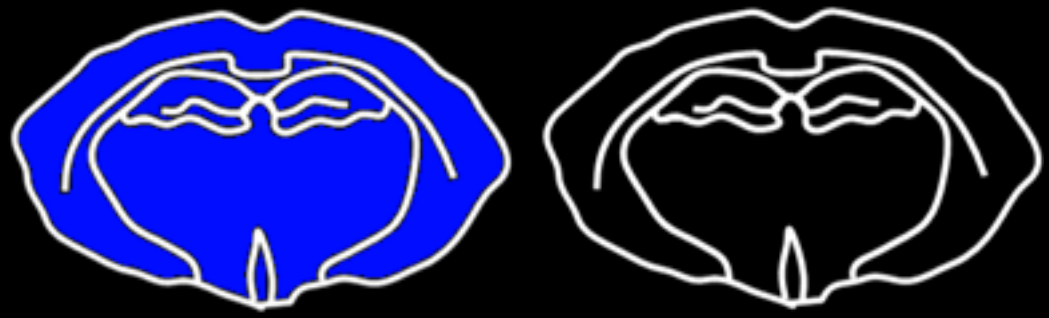
Differences in image registration



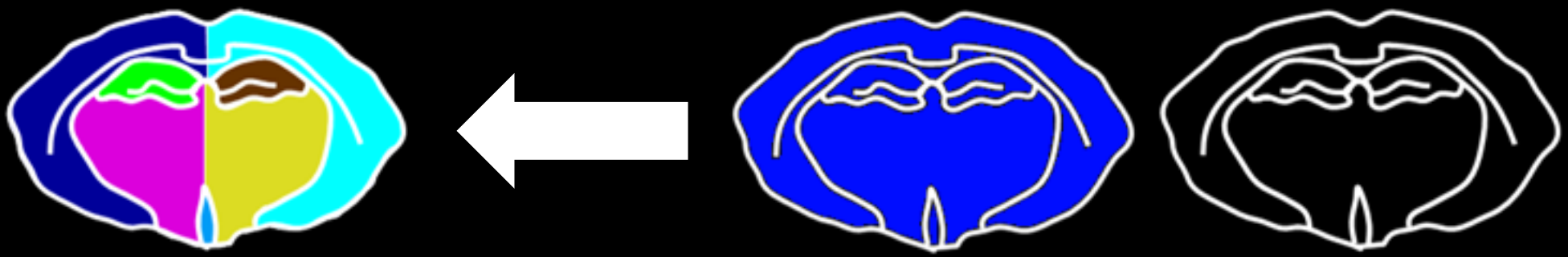
Differences in image registration

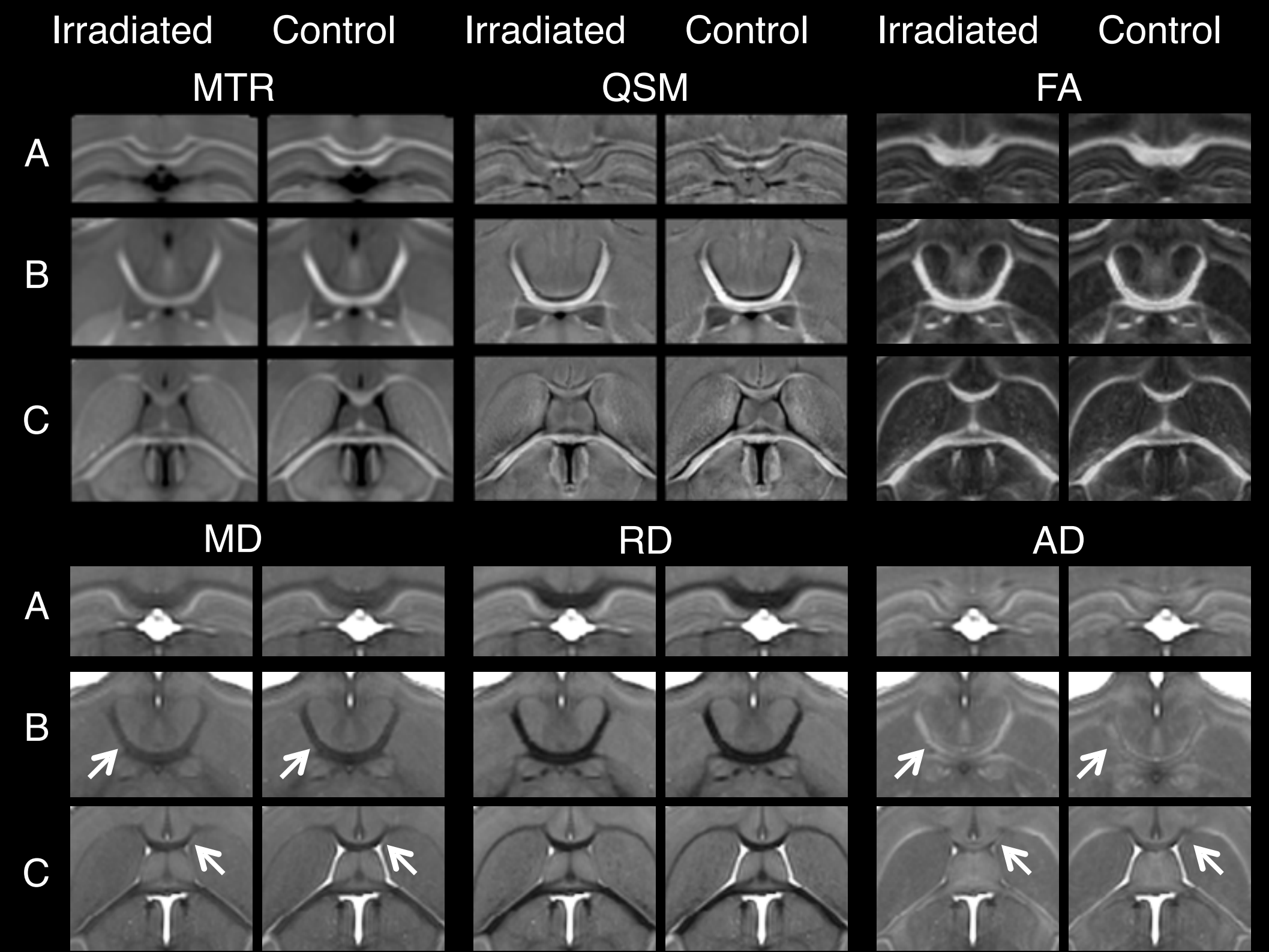


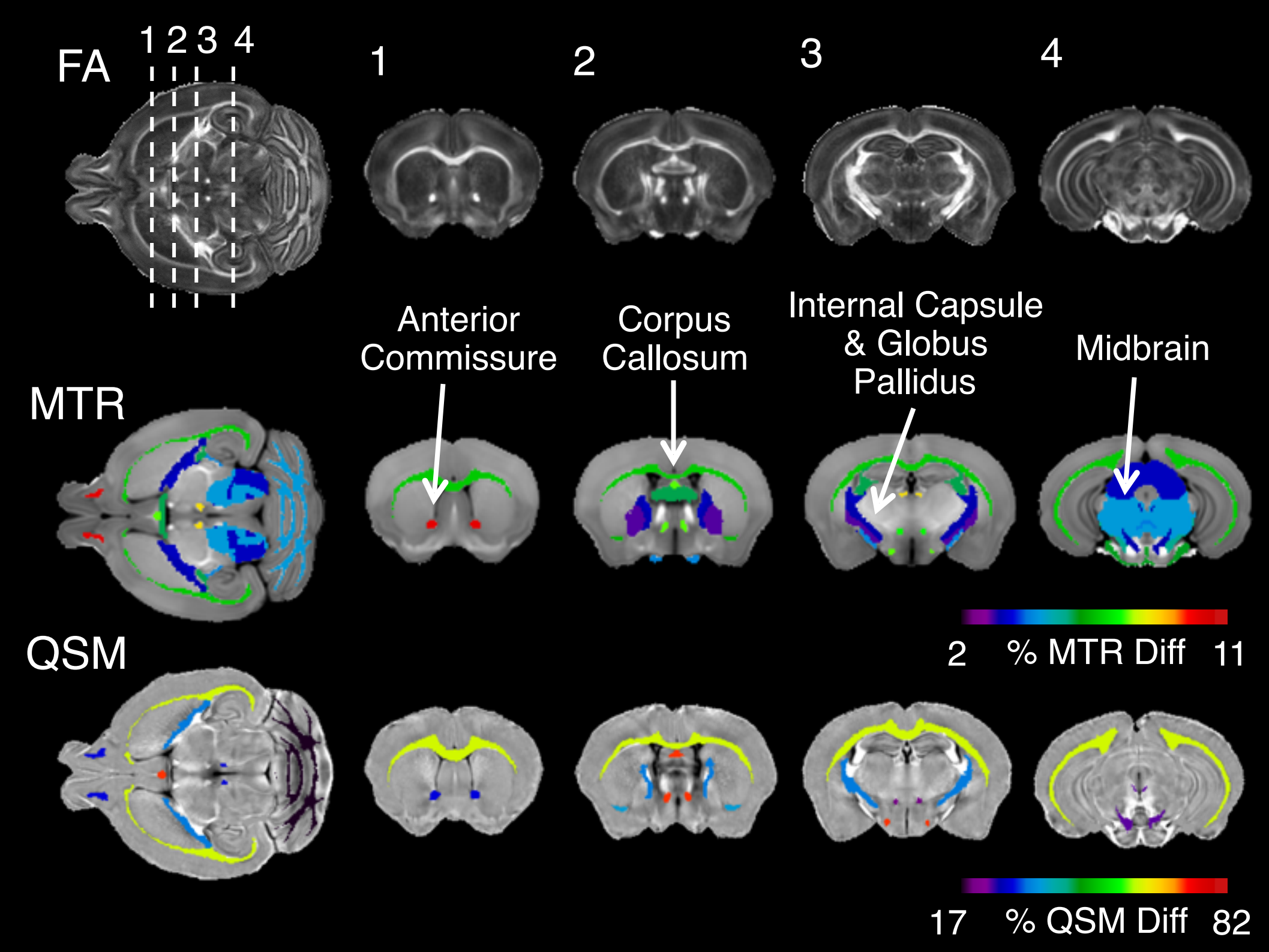
Differences in image registration



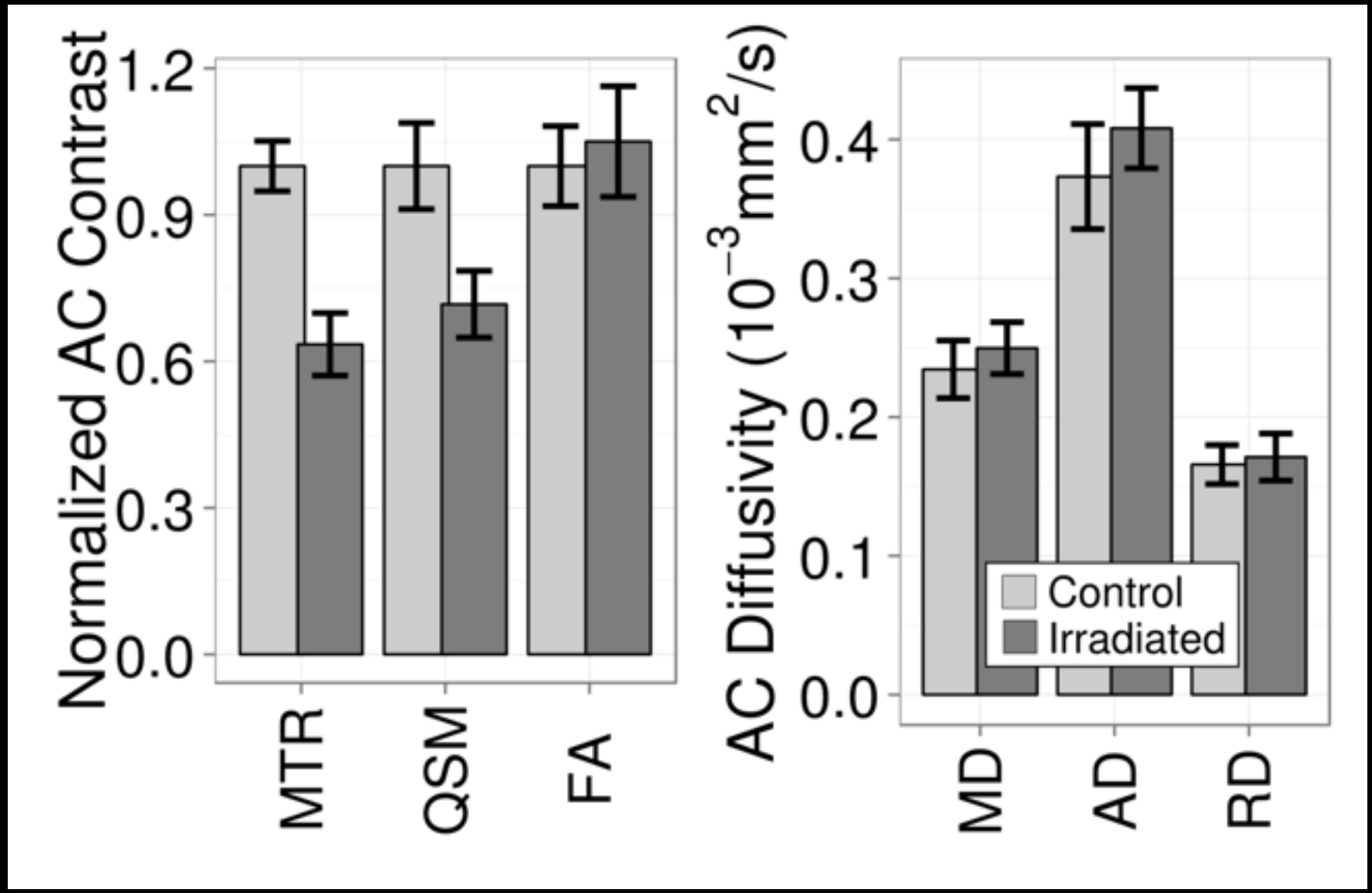
Differences in image registration




Irradiated
Control
Irradiated
Control
Irradiated
Control
MTR
QSM
FA
A
B
C
MD
RD
AD
A
B
C


FA
1 2 3 4
1
2
3
4
MTR
Anterior Commissure
Corpus Callosum
Internal Capsule & Globus Pallidus
Midbrain
2 % MTR Diff 11
QSM
17 % QSM Diff 82

Anterior Commissure Contrast



MT and QSM versus DTI

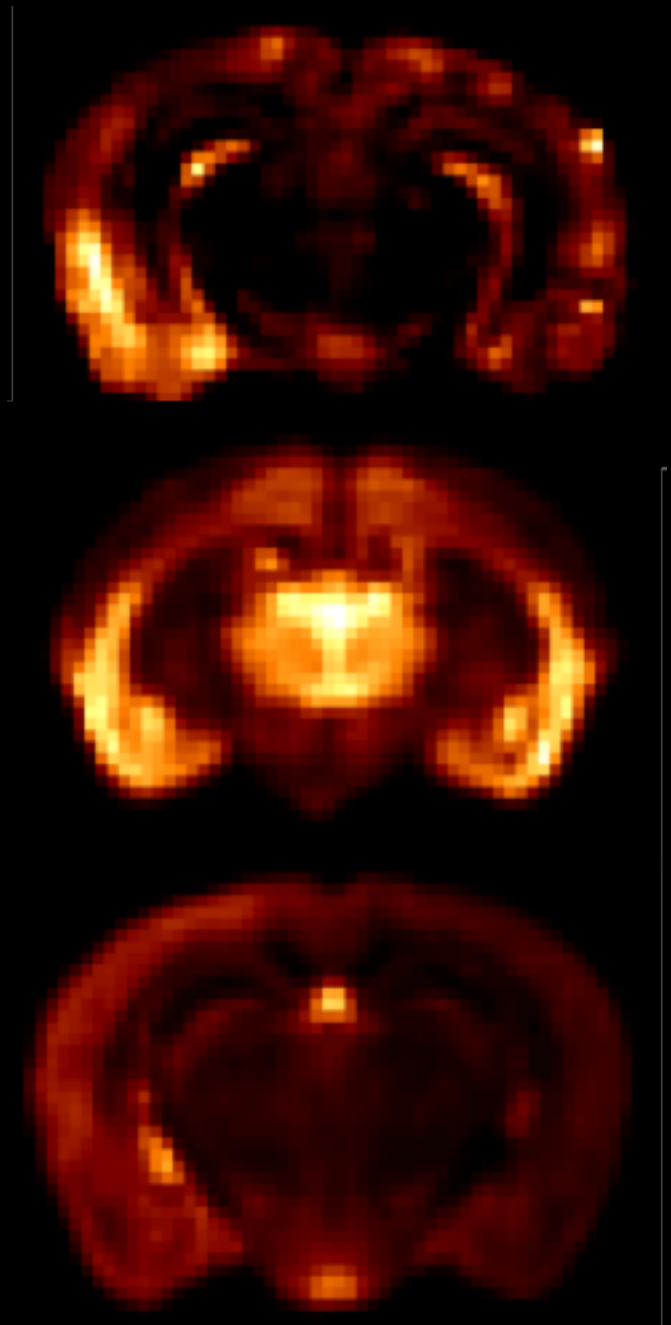
- MTI and QSM have been shown to be predominantly sensitive to demyelination, while many DTI measurements are more sensitive to axonal damage or remodelling

- DTI measurements may be affected by formaldehyde fixation

Data from the
Allen Institute for Brain Science

Connectivity data:

- 488 neuronal tracer injections into various regions in right hemisphere of wildtype mouse brain (more in Cre lines)
- Mice used were male, wildtype C57Bl/6J, adult (P56)
- Tracer expressed EGFP, labeled neurons only, travels anterograde from injection site, does not cross synapse
- Imaging via serial two-photon microscopy
- Post processed and aligned



Data from the
Allen Institute for Brain Science

Gene expression data:

- 4345 whole-brain spatial expression (coronal dataset)
- 21716 single hemisphere, spatial expression (sagittal dataset)
- Mice used were male, wildtype C57Bl/6J, adult (P56)
- Expression data via in situ hybridization
- Post processed and aligned to reference image

Up Next

- Multimodal analysis