Neuroimaging advances in Parkinson's Disease; The application of Ultra-High Field MRI

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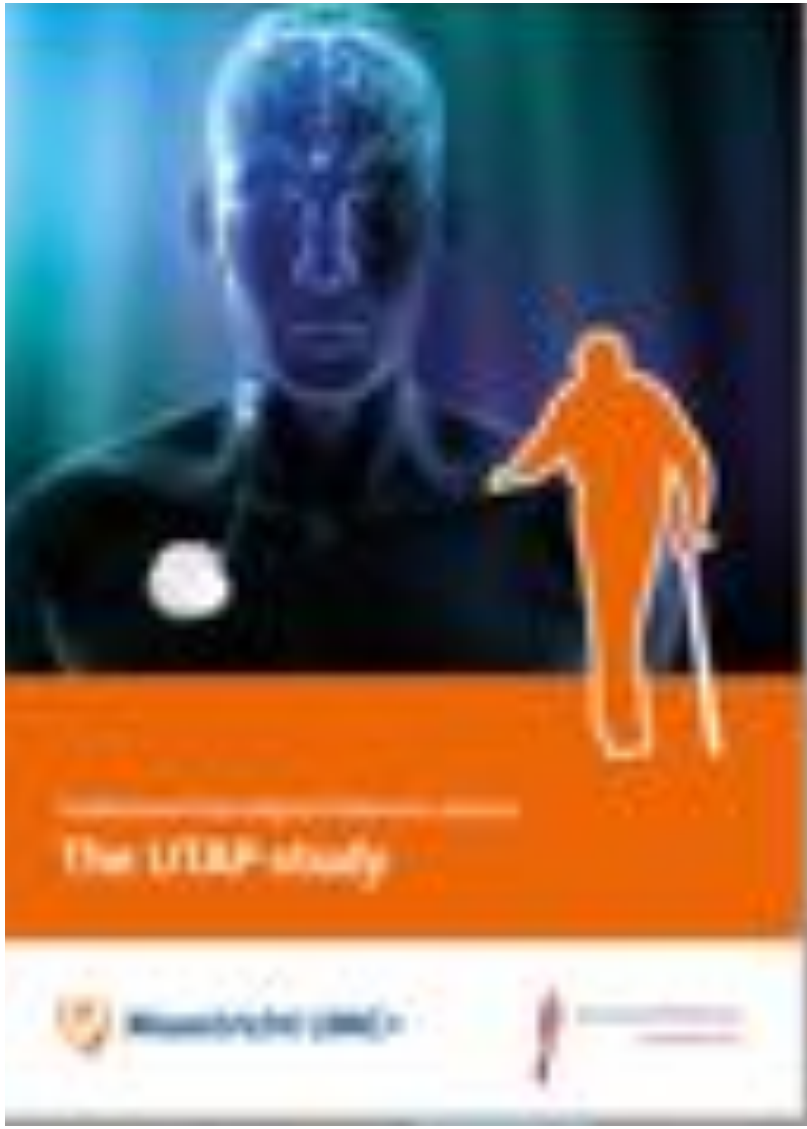
UTAP

- **U**nderstanding
  - 9.4T post-mortem
- **T**racking
  - TRACK-PD, 7T
- **A**djustment
  - sensors and adaptive DBS
- **P**arkinson's Disorder

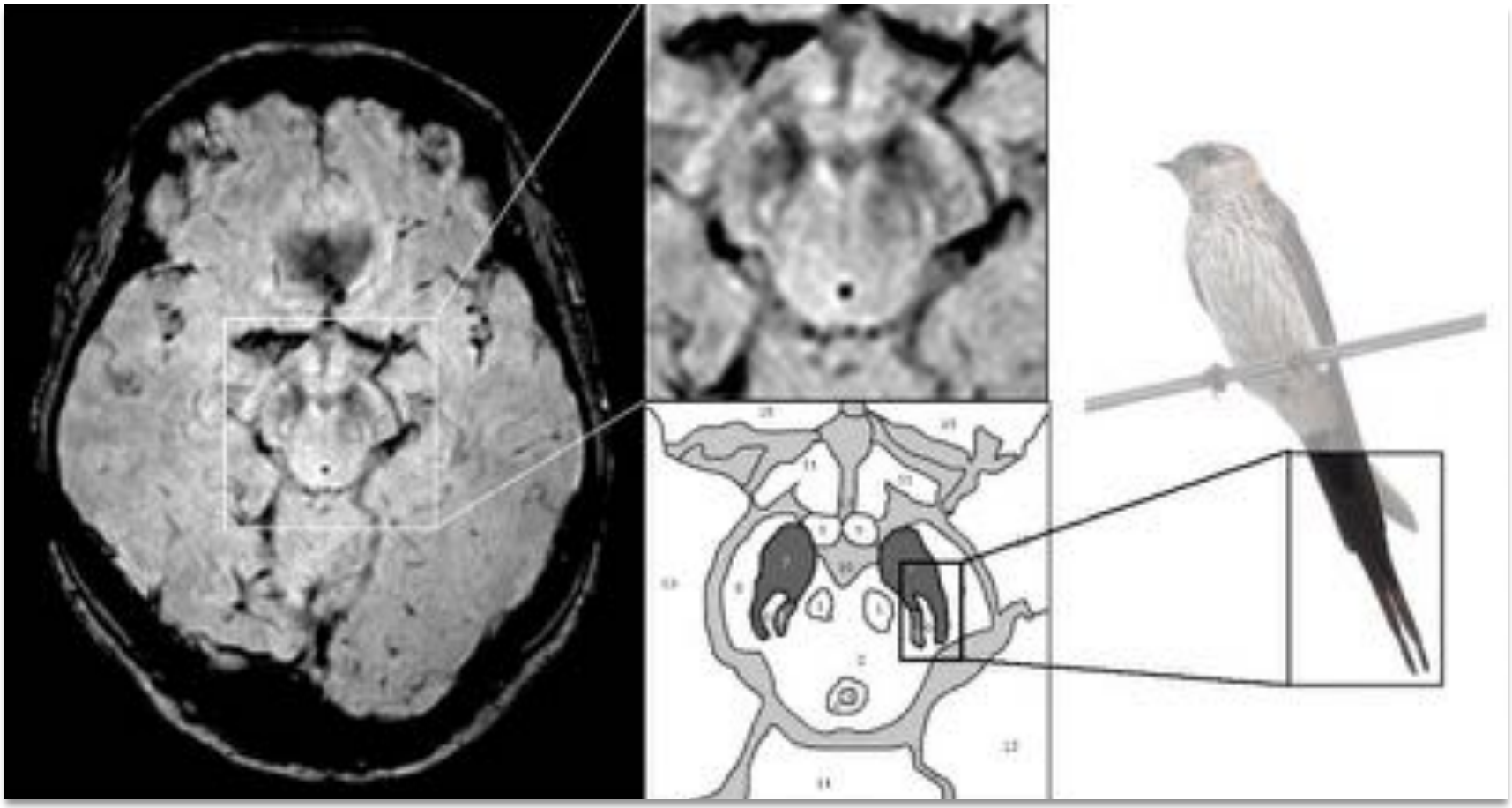


Background UTAP

- Early diagnosis of Parkinson's Disease (PD)
  - Challenging / often not immediately recognised (1)
  - Heterogeneous disorder (2, 3)
  - The underlying aetiology is poorly understood (4)

1. Hughes et al. (2002); 2. Berg et al. (2014); 3. Lewis et al. (2005); 4. Thenganatt et al. (2014)

Early biomarker; swallow-tail disappears



Dorsolateral Substantia Nigra pars compacta

Work Package 1 – Understand PD

- Focus on changes in the microcircuit of the basal ganglia and brainstem
- Diffusion Weighted Imaging
- White matter visualisation and quantification
- Quantitative T2 mapping

Brain container - development

Brain container

Brain samples

- Post-mortem PD
- Fluorinert
- Brains from UK biobank
  - 2-3 years old, fixed in formaldehyde PBS solution

MRI protocol

- T2
  - 0.25mm isotropic GRadient Echo; entire hemisphere
  - Six echo's
    - 6.98ms, 11ms, 16.21ms, 20.23ms 24.46ms and 30ms

- Diffusion Weighted Imaging
  - 1mm isotropic; entire hemisphere
  - 48 random directions b-value 5009s/mm^2
  - 5 low b-value volumes at 279s/mm^2
  - Field of view; 144x132x180mm, TR=450ms

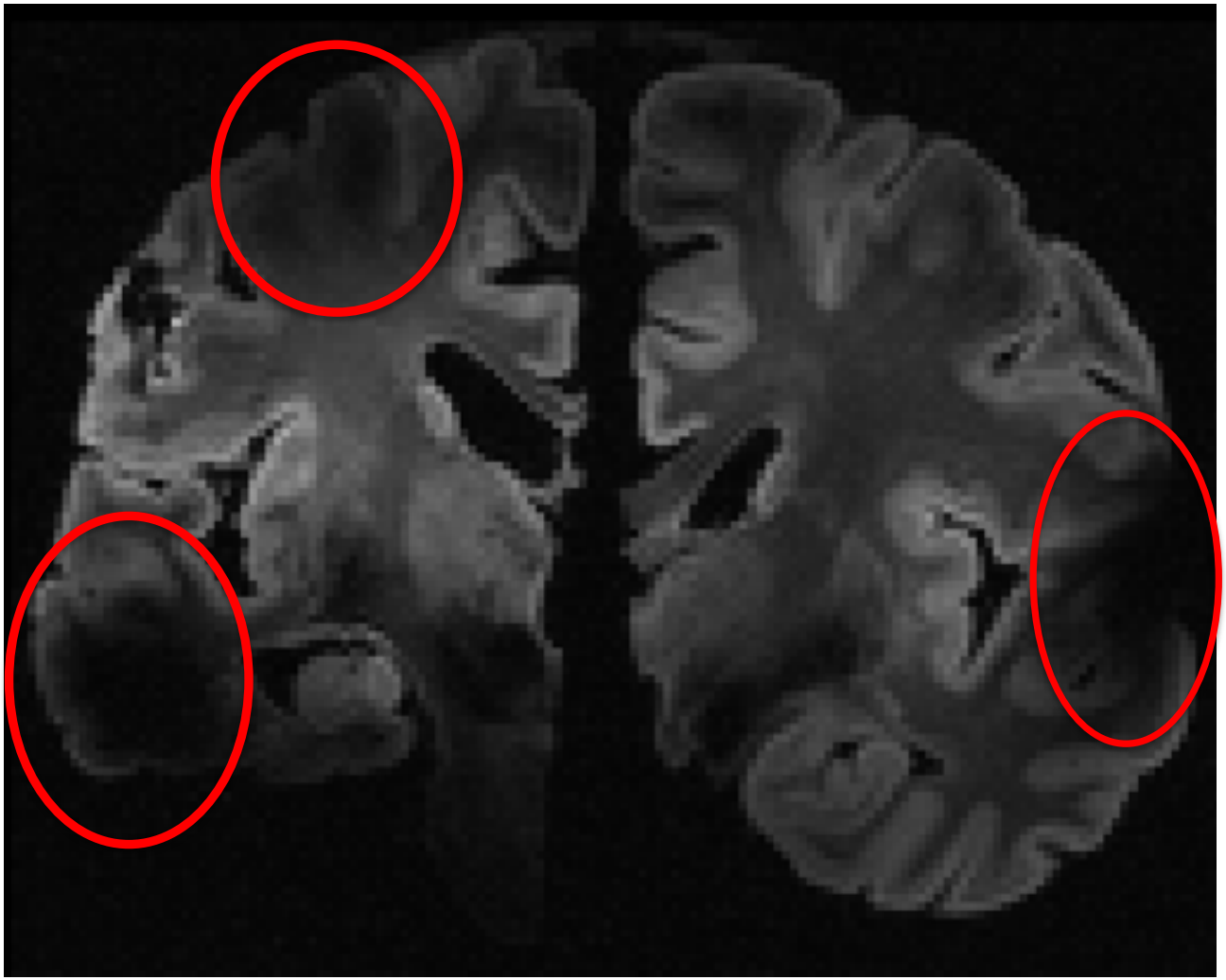
Shimming

- Field inhomogeneities (B0)
- Material introduced → disturbances
- Higher field strength=more inhomogeneities

- Affects image quality
- B1 shim for optimal tissue flip angle

- Complex procedure at 9.4T
- Offline kT-points 3th order shim

Field inhomogeneities T2 (short echo)

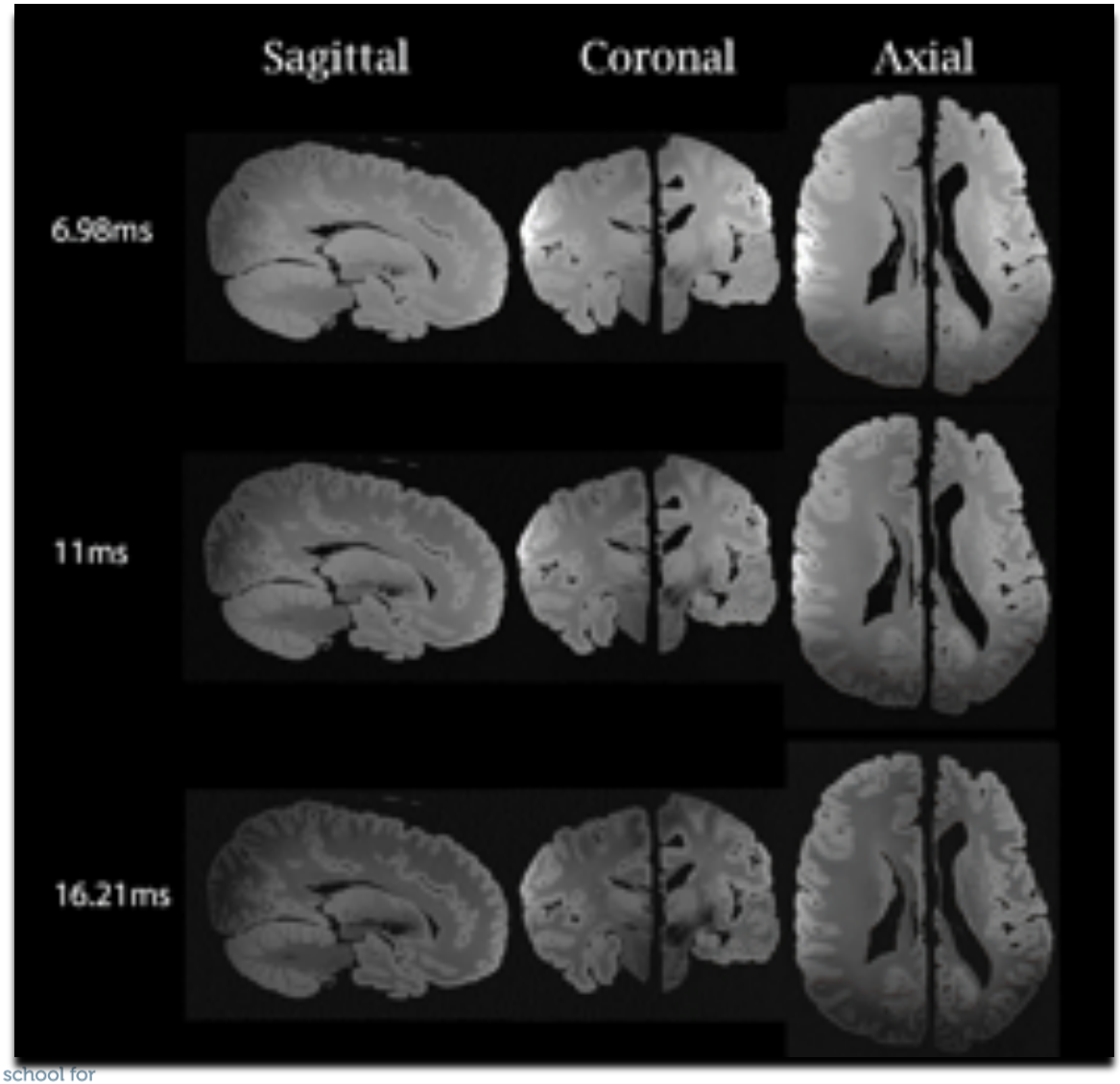


Scanning

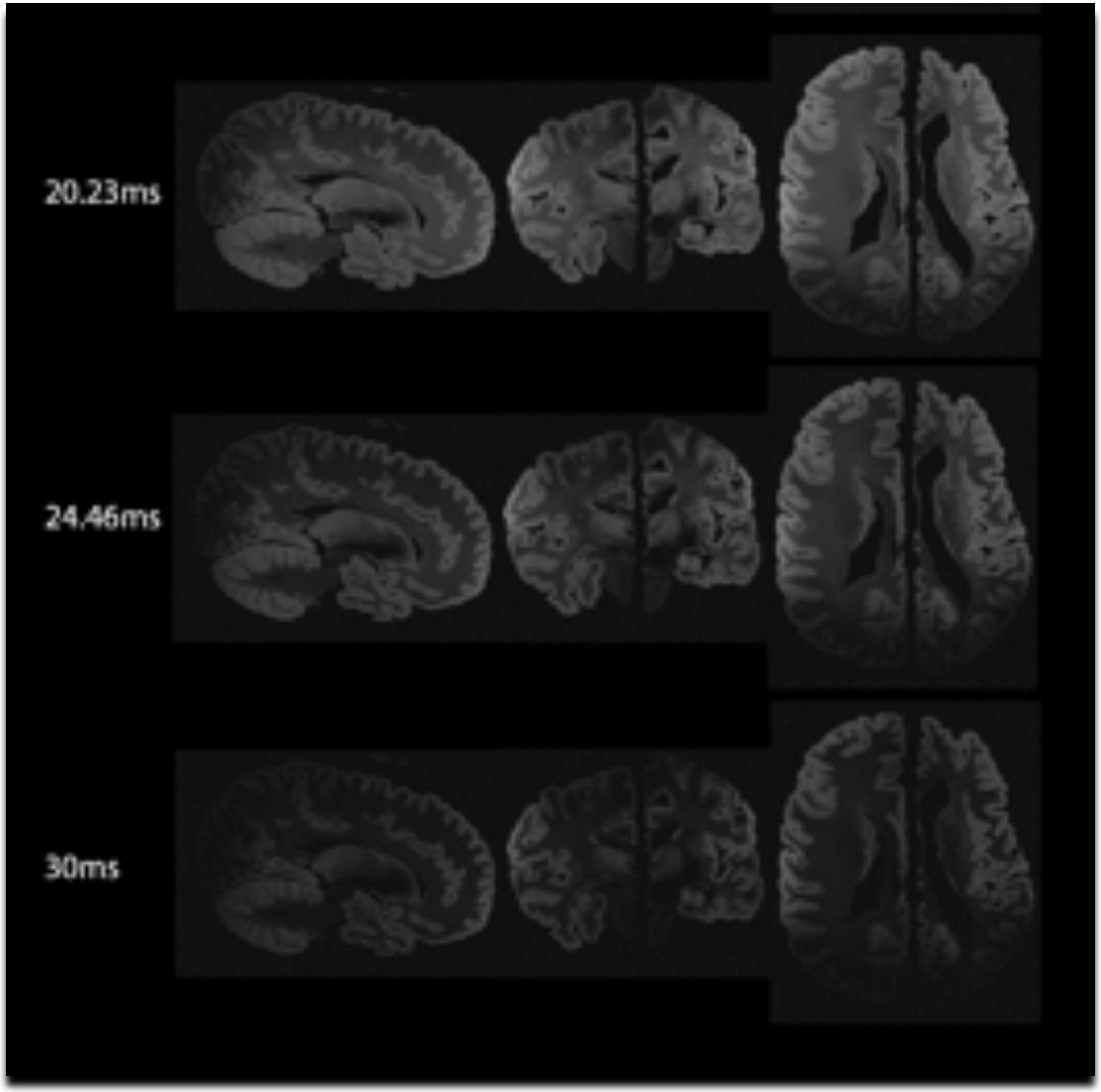
- T2 weighted; 3h (2x)
- Low b-value diffusion; 20min (5x)
- 2h per set of four directions (12x)
- Total 32h (including scan cooldowns)

- Raw data reconstruction (500Gb of data)
- Berkeley Advanced Reconstruction Toolbox (BART) in MatLab

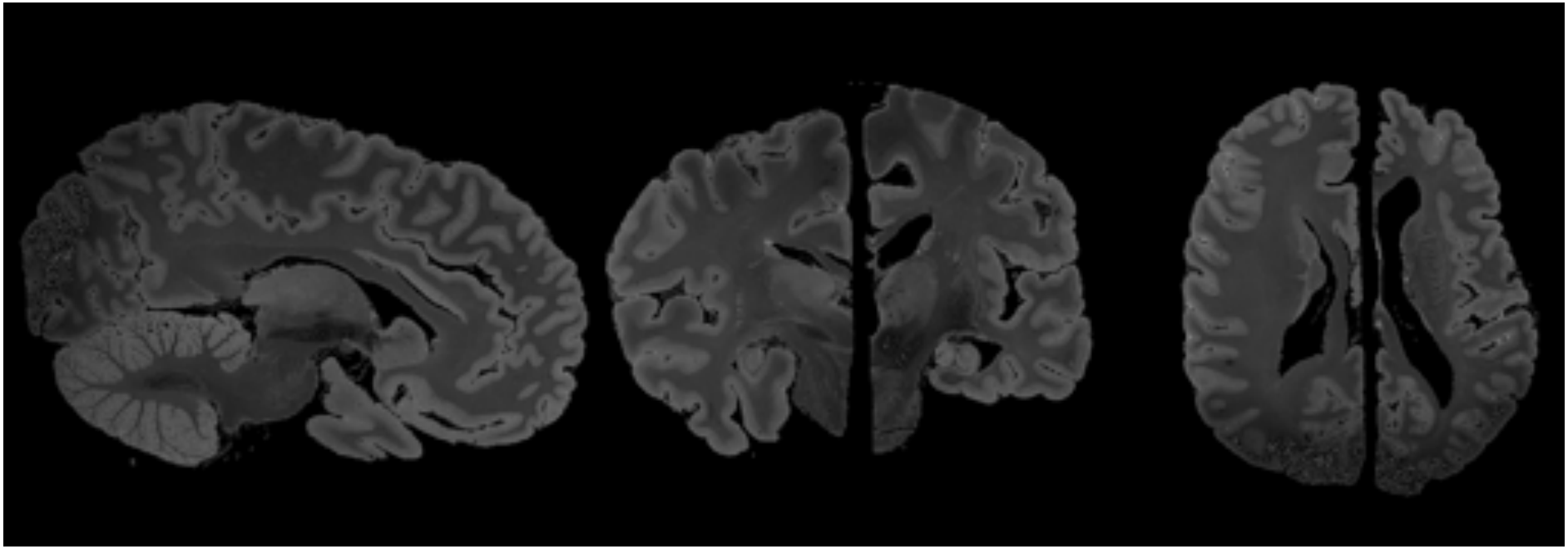
T2 weighted – 250µm resolution



T2 weighted – 250µm resolution



Quantitative T2* map



Diffusion Weighted Imaging

- Create contrast, based on b-values (gradient strength)
- Goal; white matter quantification
- White matter tracking → tractography
- Focus on limbic system and basal ganglia

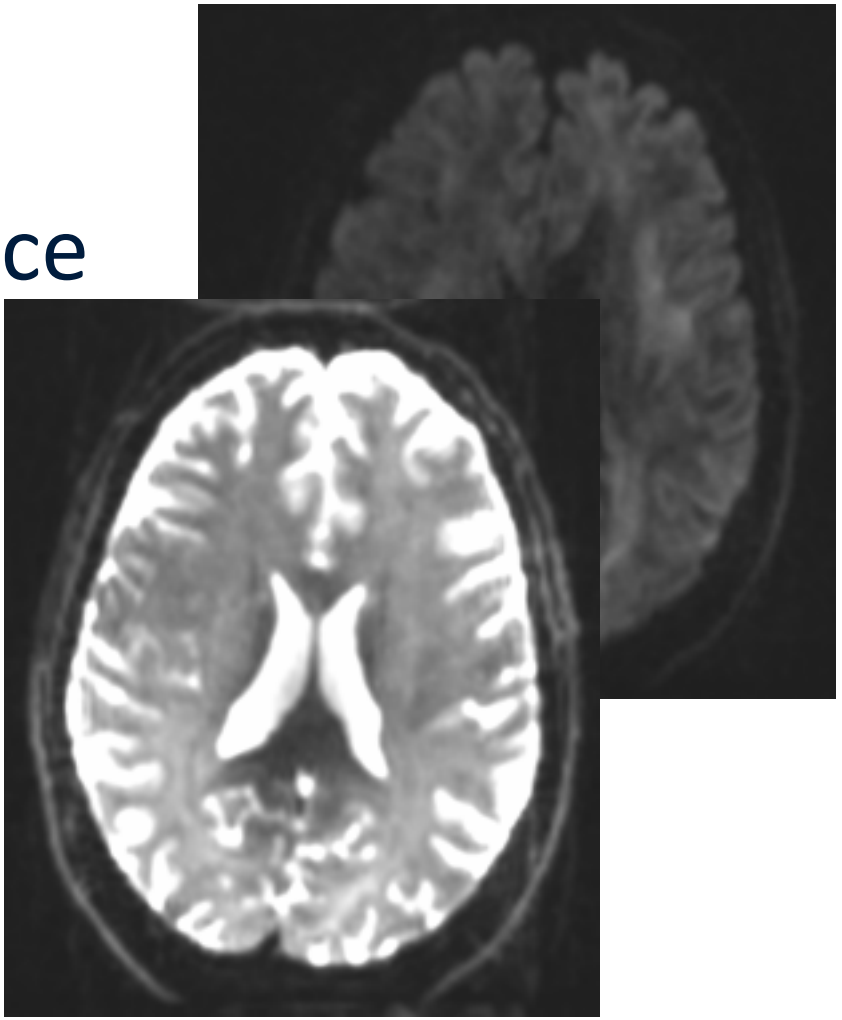
White matter bundles

Terms used

- Diffusion weighted imaging
  - DWI → the MRI acquisition
- Diffusion tensor imaging
  - DTI → tensors, the smallest element
- Tractography
  - Connecting the tensors; create fibers
- Anisotropic diffusion
  - Diffusion equal to all sides

Diffusion Weighted Imaging

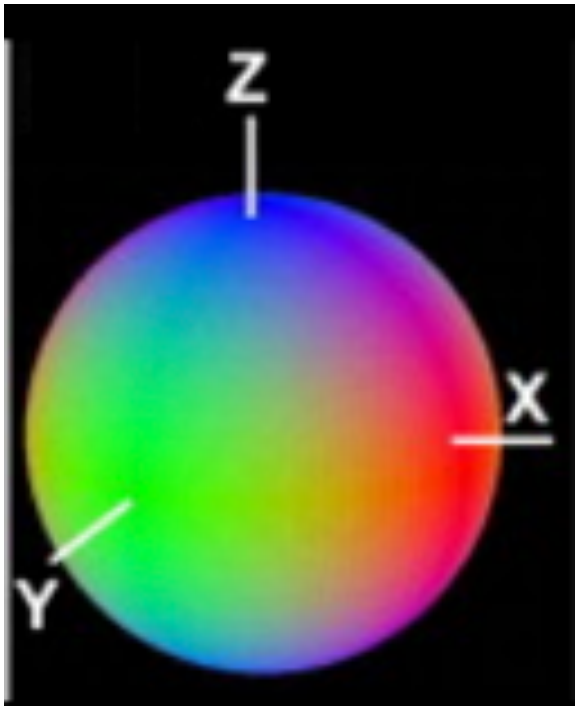
- Noisy data
- Directional dependence
- Strong gradients
- Multiple directions
- B0 image → bright



DTI – color coding

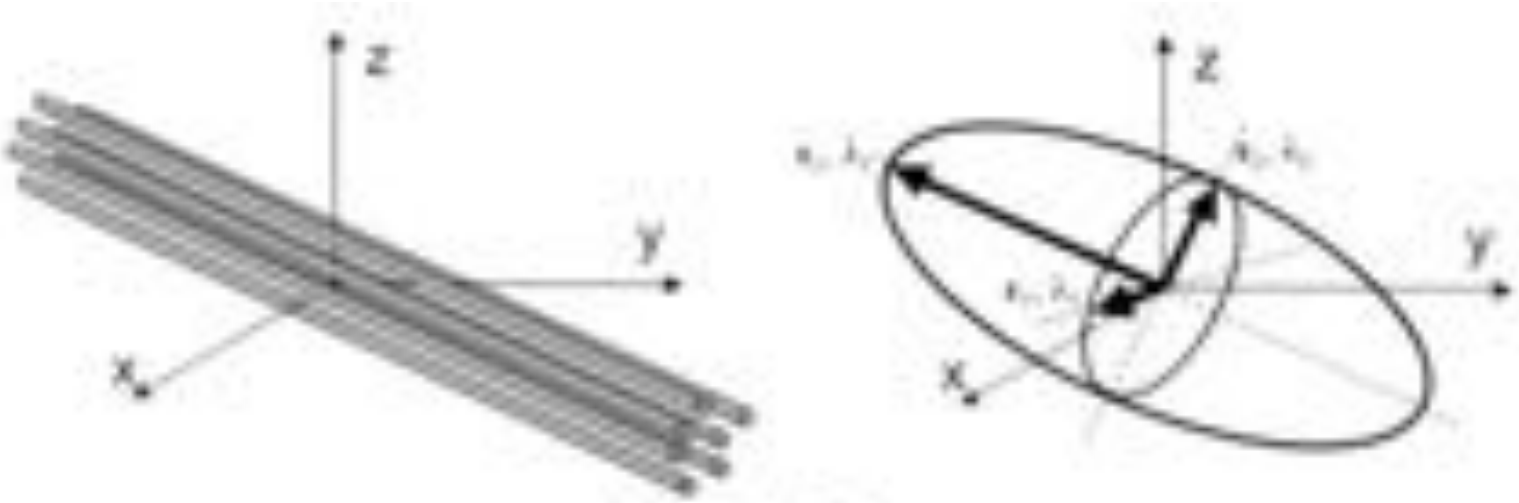
Standard DTI color coding

X = red; medio-lateral
Y = green; anterior-posterior
Z = blue; inferior-superior

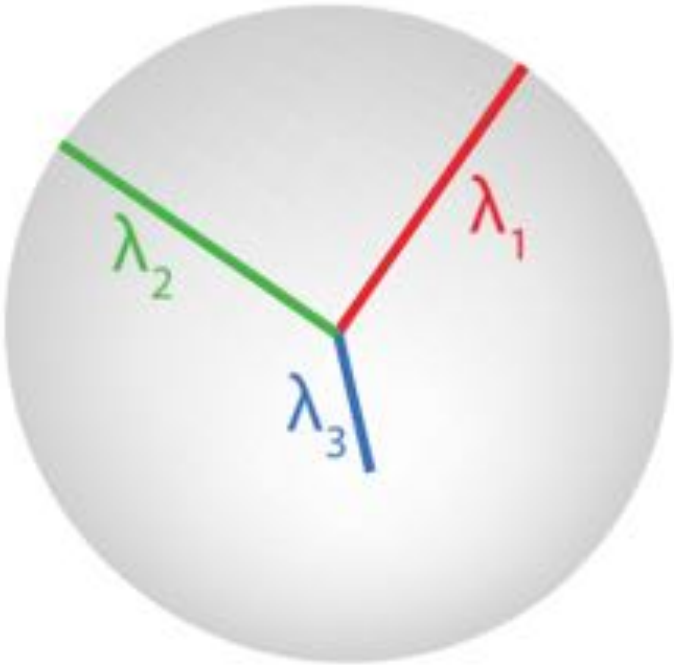


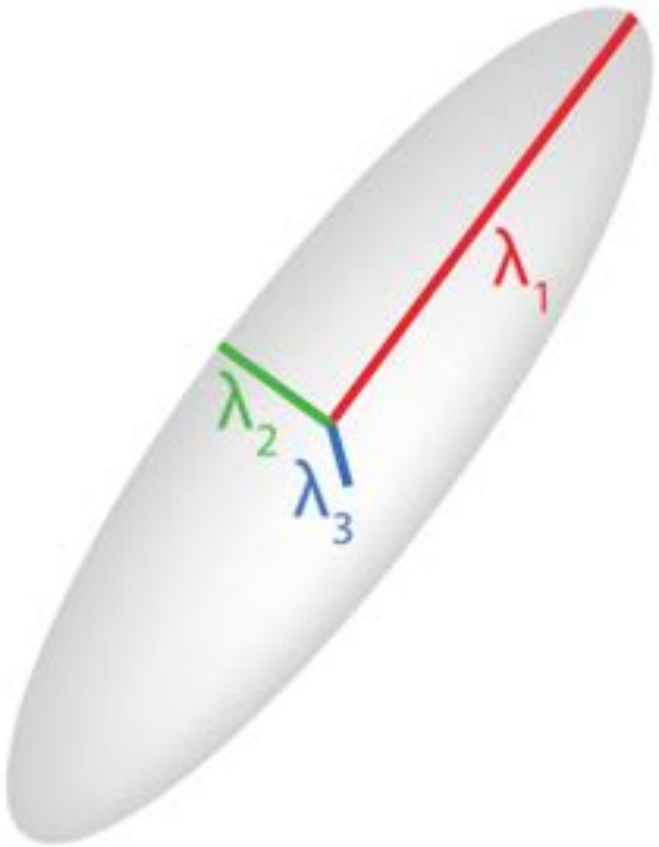
Reconstruct tensor

- Smallest unit that can be measured
- Directional dependence



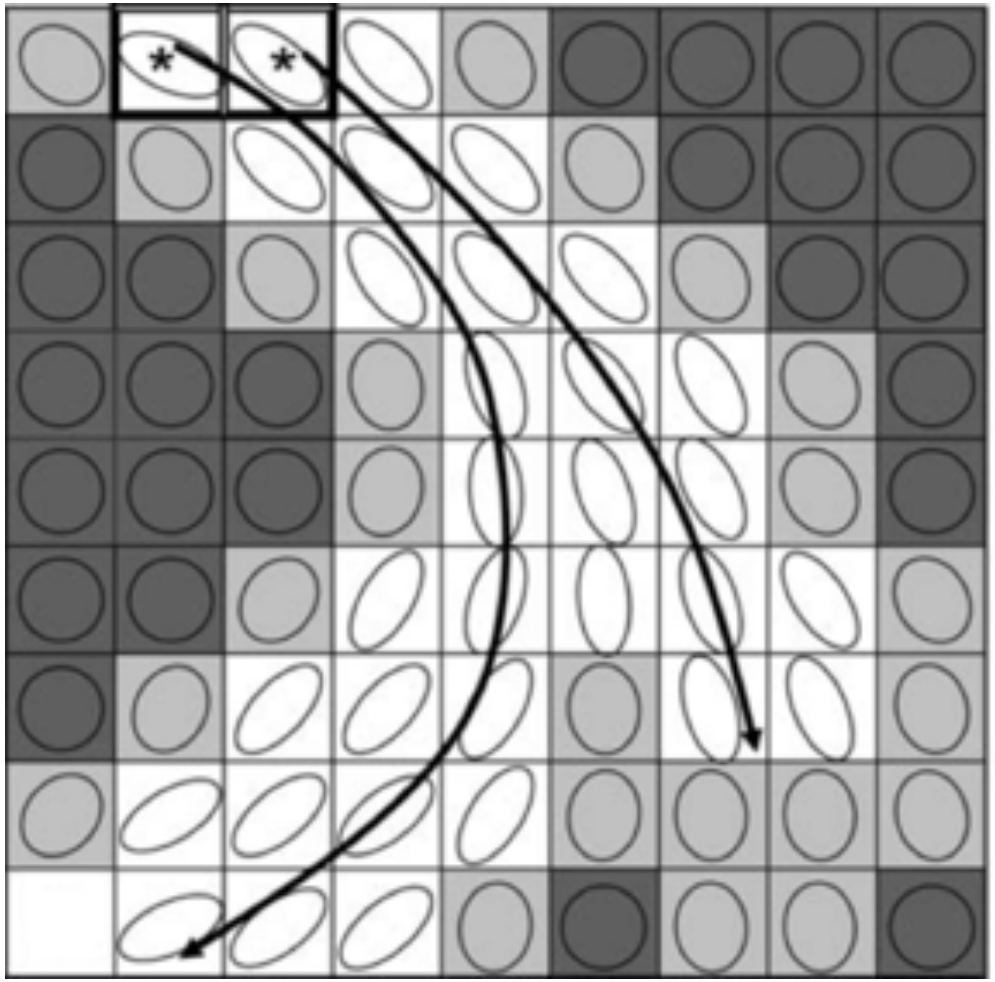
Isotropic movement



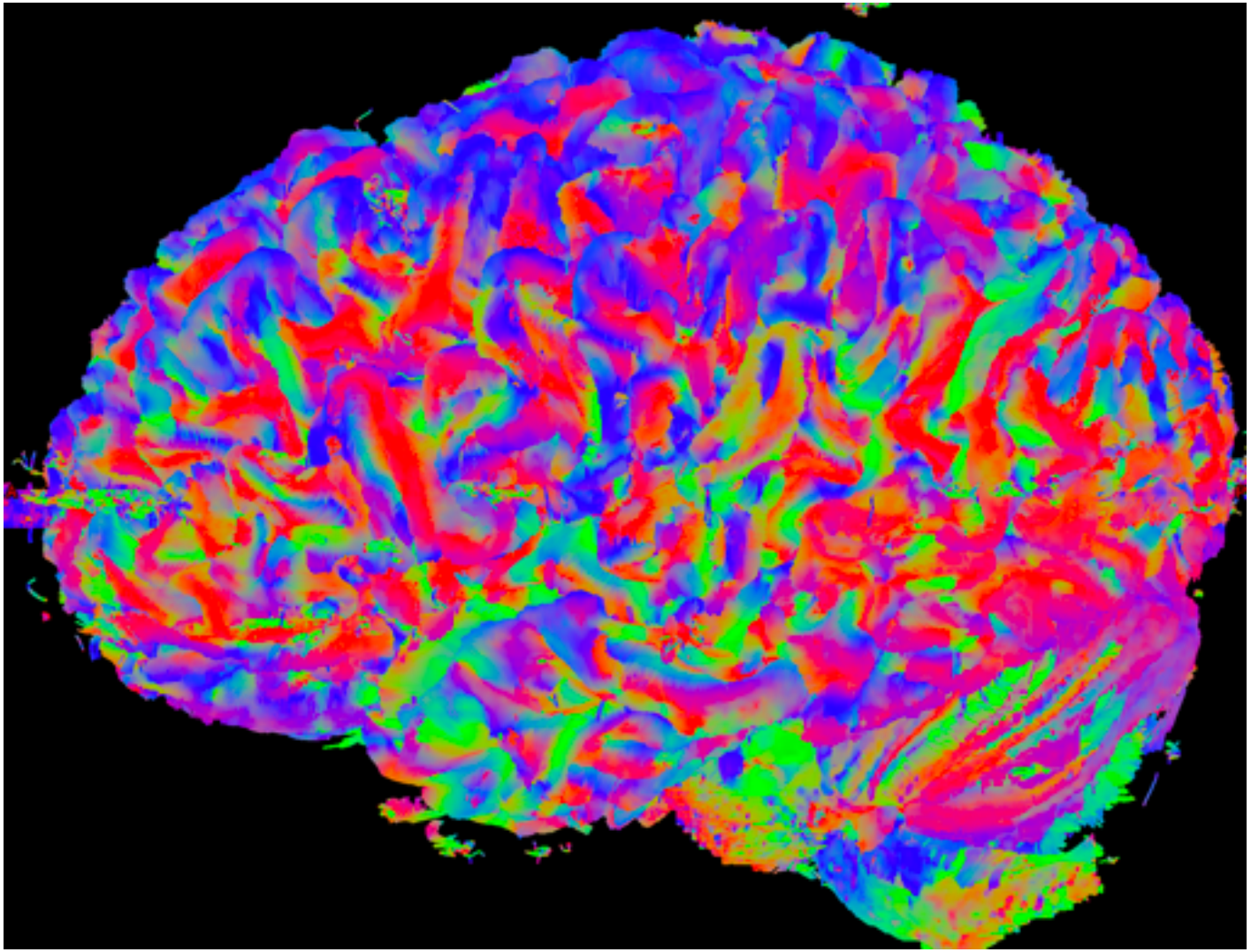


Isotropic vs Anisotropic

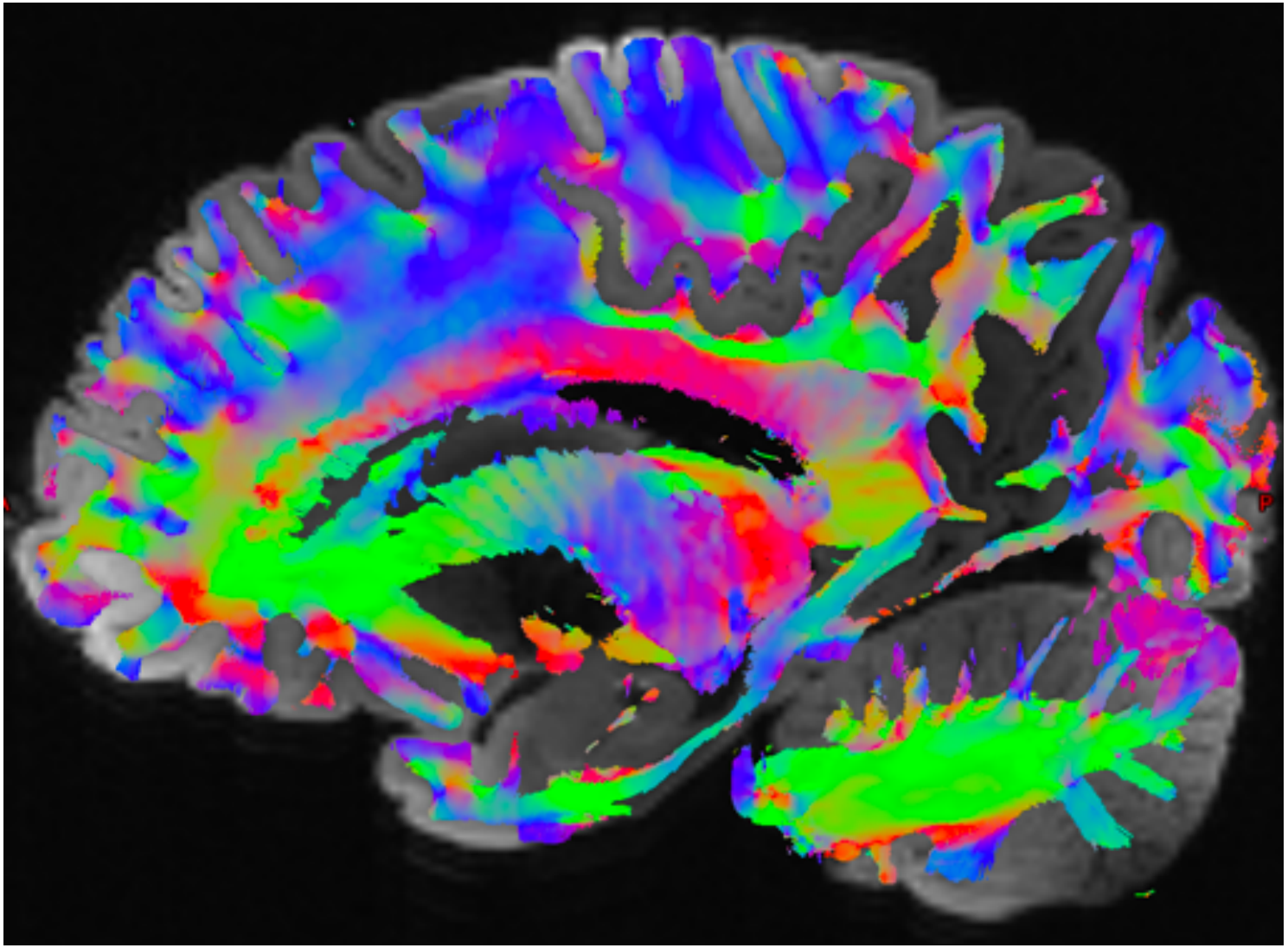
2D image of tractography



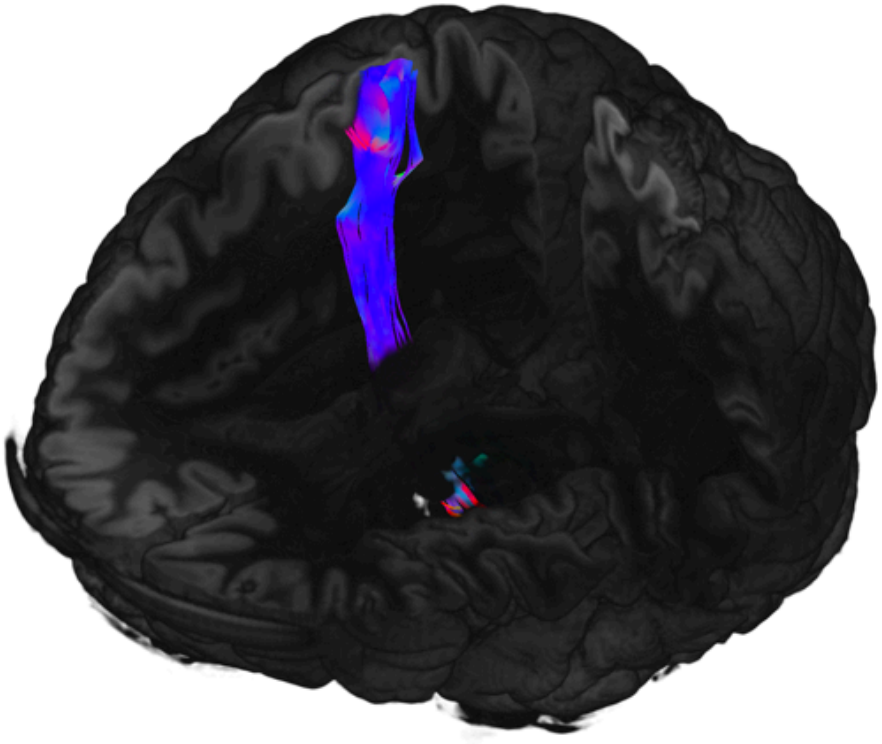
Fiber tracking



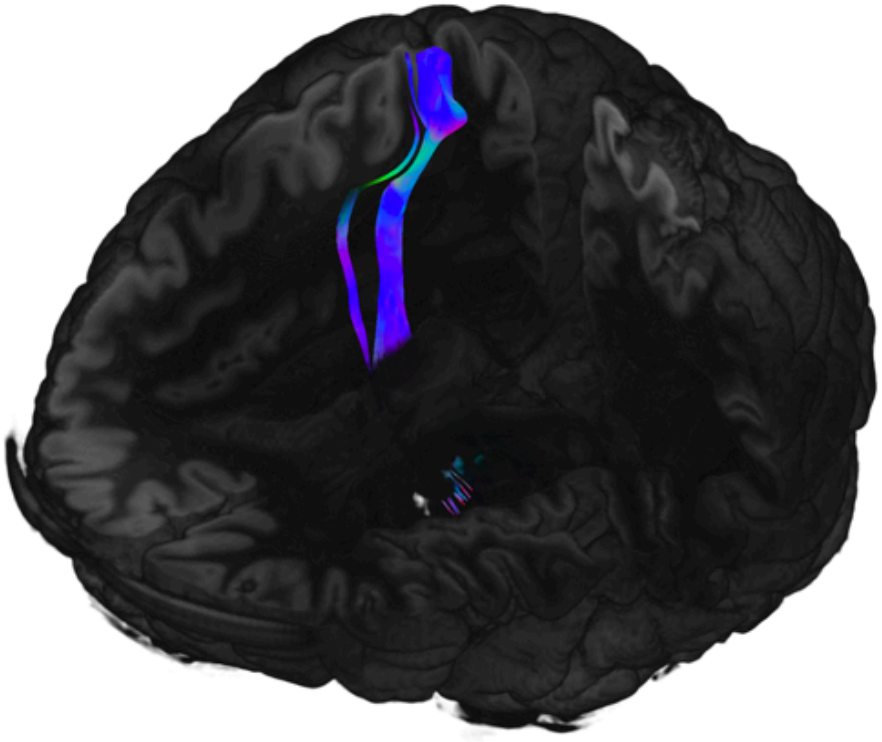
Fiber tracking (2)



Pre and post central gyrus



Motor cortex



Sensory cortex

Use of the brain shell – dedicated coil

Thanks for your attention

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