

# Biomedical Engineer Research In Neuro-Science

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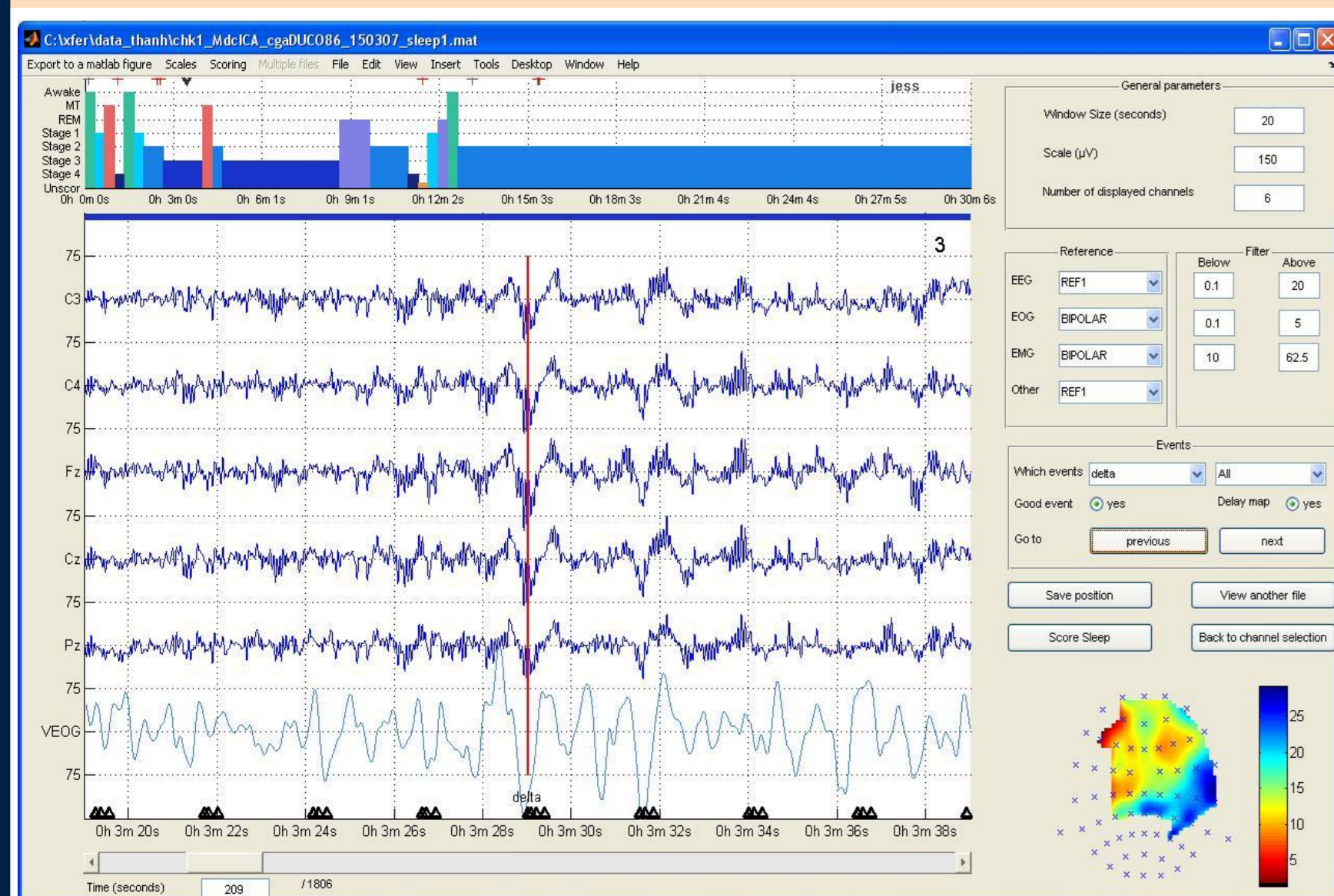
## Background & Environment

The “GIGA - CRC *in vivo* imaging” & “GIGA - *in silico* medicine” (formerly Cyclotron Research Centre) units :

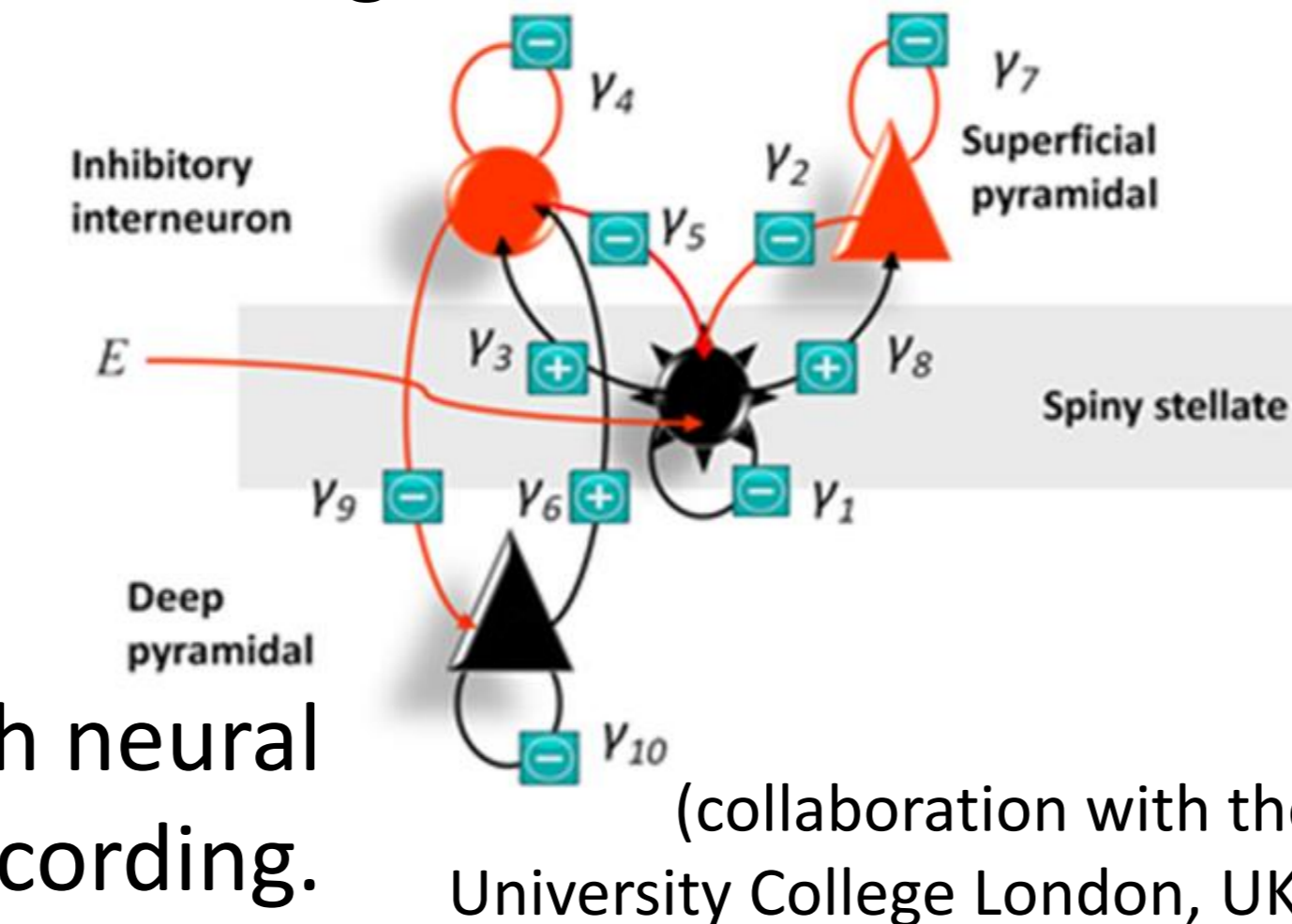
- *pluridisciplinary research centre* including researchers (students, PhD's, postdocs, professors, i.e. ~100 people) with engineering, informatics, physics, neurology, psychiatry, psychology, biology, chemistry, veterinary,... background.
- *research in neuroscience & neuroimaging*, i.e. healthy brain functioning (sleep, memory, circadian rhythm,...), ageing, degenerative diseases (Alzheimer's and Parkinson's disease, multiple sclerosis), etc.
- *unique equipments dedicated to research* for human and animal imaging:
  - MR imagers at 3 Tesla (and 7 Tesla from 2018) for humans and 9.7 Tesla for small animals (mice and rats),
  - PET scanners (human and animal) with on site radiotracer production facility,
  - EEG recorders (sleep polysomnographic, high density, MR-compatible,...),
  - brain stimulators with “transcranial magnetic stimulation” (TMS) and “transcranial direct current stimulation” (tDCS).

## Research themes for engineers

### EEG signal processing & modelling



Automatic extraction of features and artefacts from whole-night multichannel polysomnographic EEG recordings.

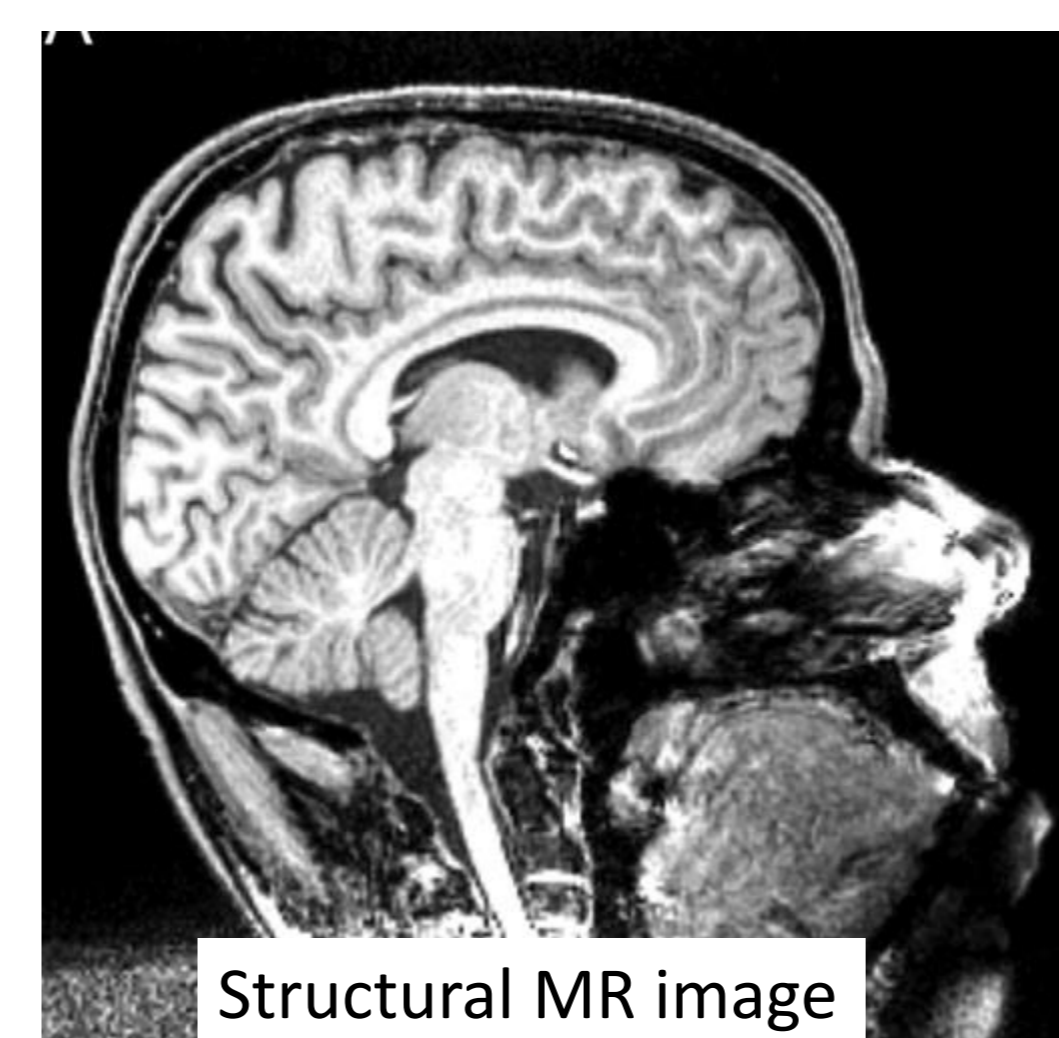


EEG based “dynamic causal modelling” with neural mass model  $\approx$  non-invasive neuronal recording.

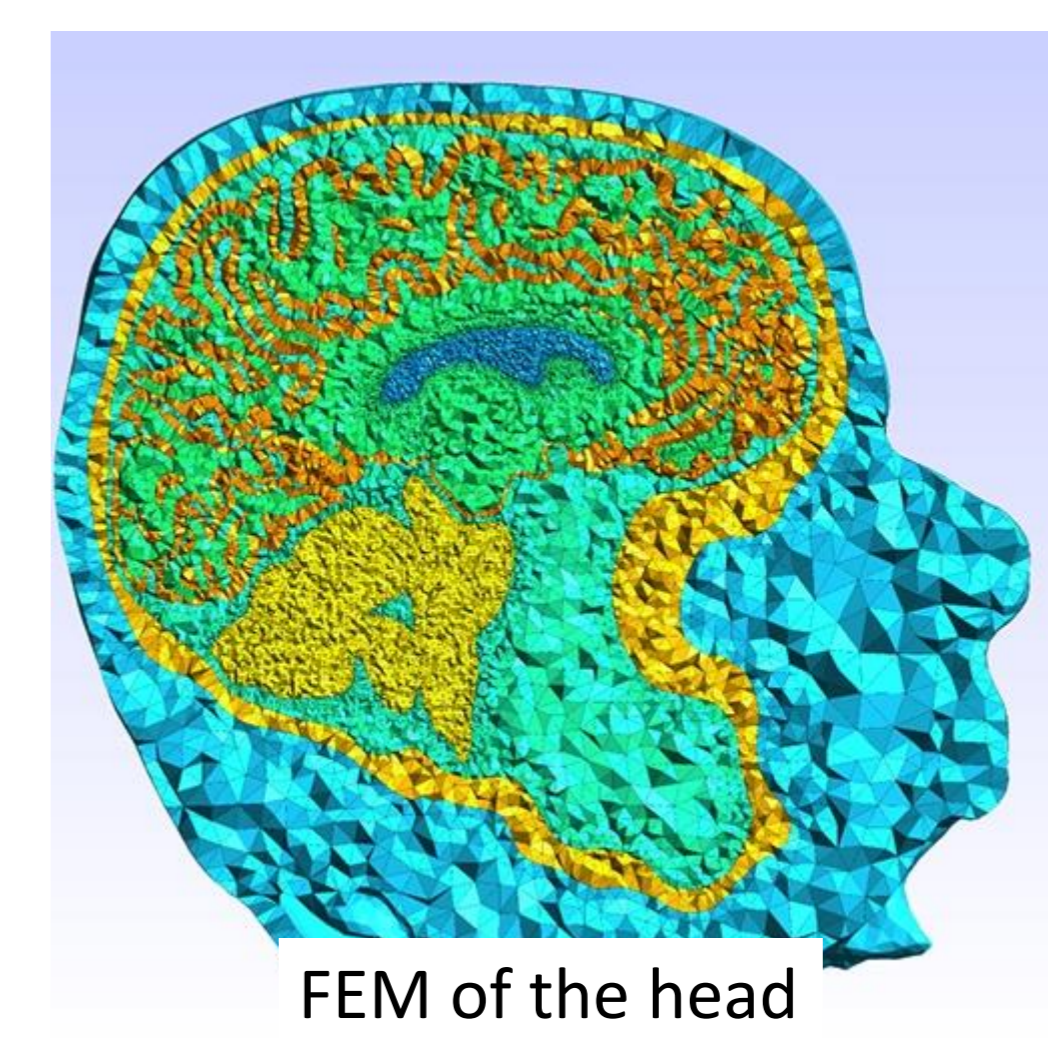
(collaboration with the University College London, UK)

### Electromagnetic (EM) head modelling

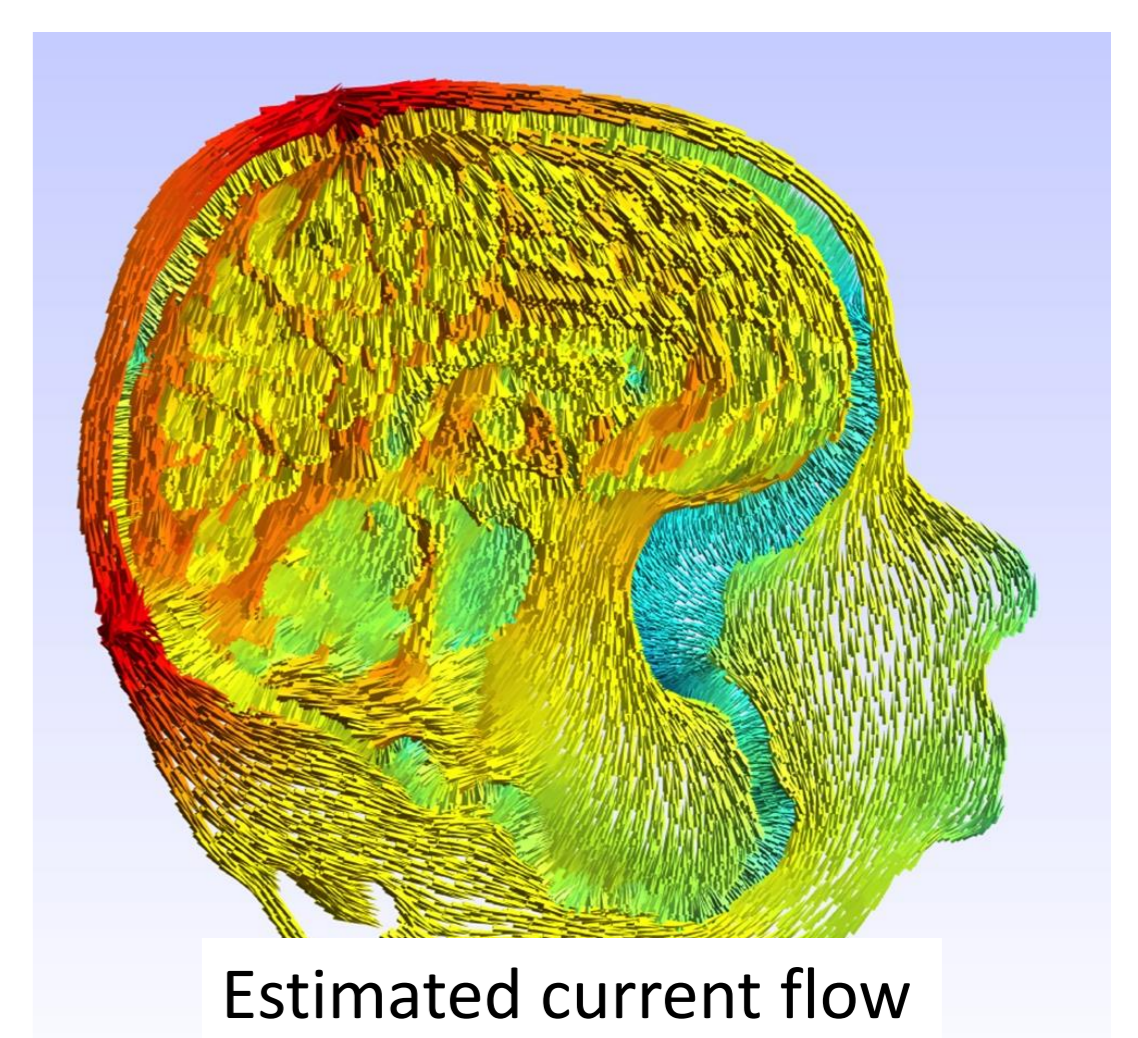
- Build an EM head model from a subject's structural and diffusion-weighted MR images (in collaboration with Prof. C. Geuzaine)
- Estimate the current flow for a tDCS experiment with the subject
- Optimize electrodes location to stimulate specific brain region



Structural MR image

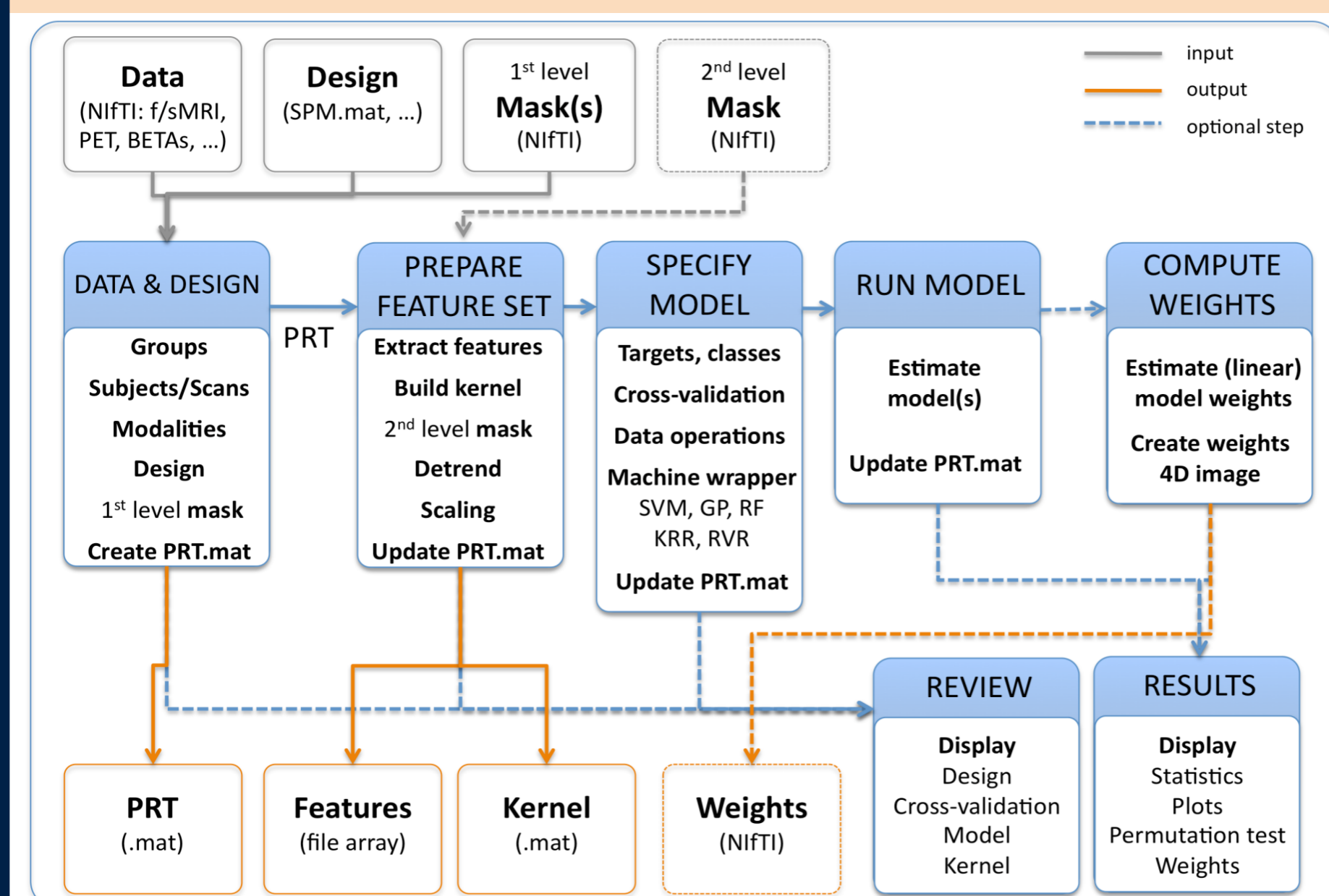


FEM of the head



Estimated current flow

### Multivariate pattern analysis

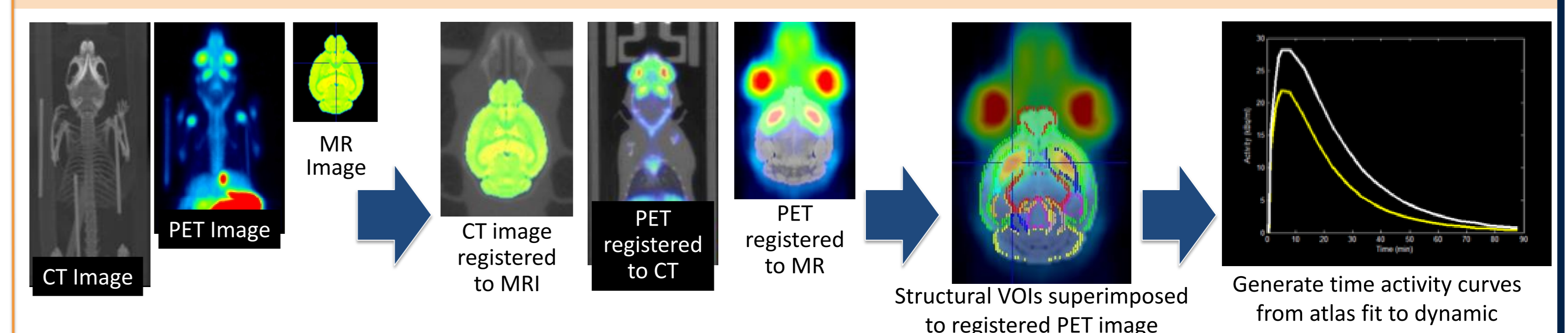


(collaborations with Prof. P. Geurts and the University College London, UK)

“Pattern Recognition for Neuroimaging Toolbox” (PRoNTTo):

- ‘Mind reading’ what a subject is thinking from functional MRI
- Diagnosing patients (e.g. Alzheimer or Parkinson) from healthy controls with their PET and/or MR images

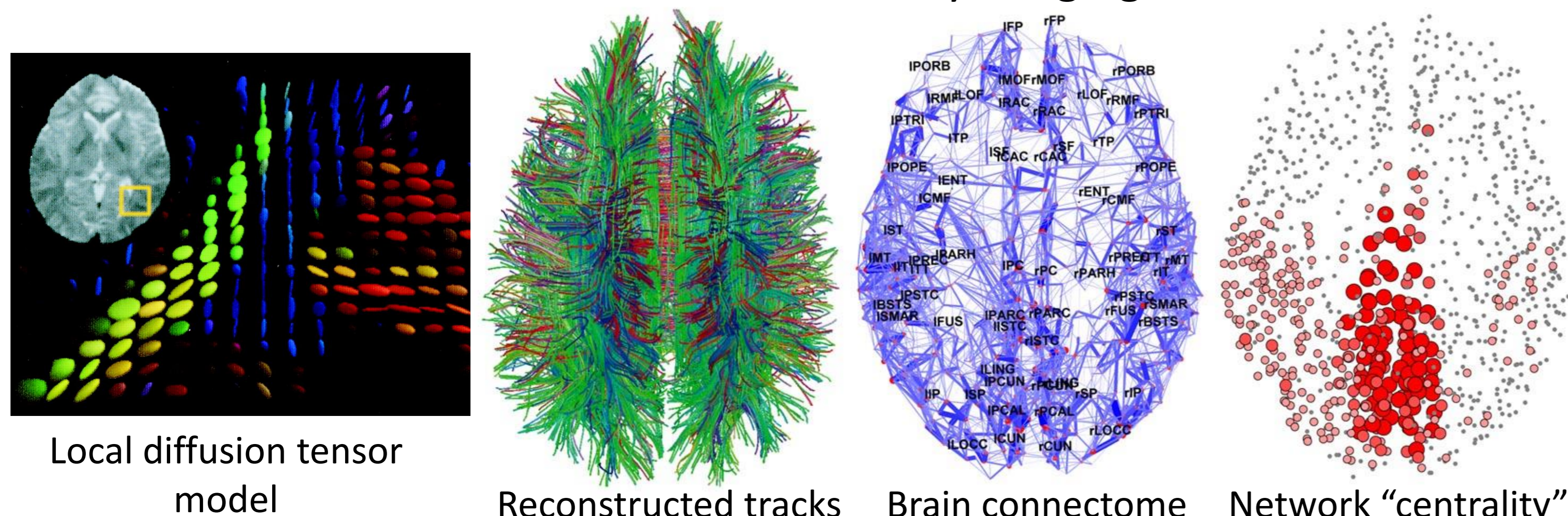
### Preclinical image processing & radiotracers characterization



- Reconstruction of the time activity curve of a “new” radiotracer from CT, MR and PET images, whole-body dosimetry estimation.
- Partial volume effect correction & in vivo dosimetry

### Diffusion-weighted MRI processing

Methods to study the fibrous nature of brain white matter: diffusion tensor model, “Connectomics” & track density imaging.



Local diffusion tensor model

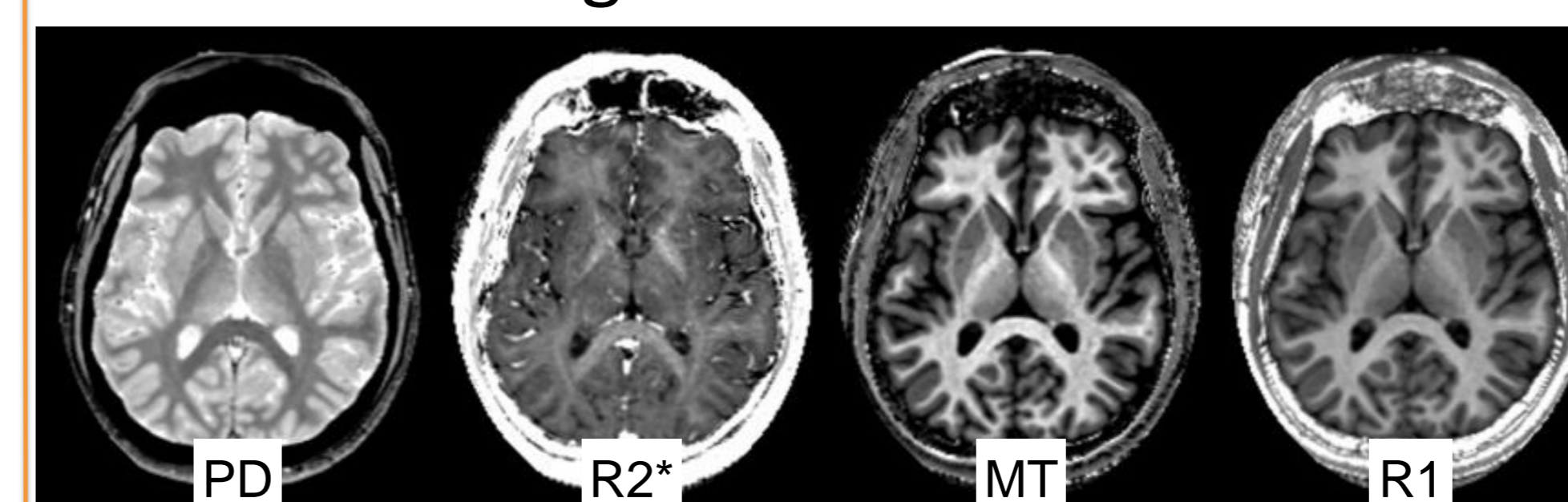
Reconstructed tracks

Brain connectome

Network “centrality”

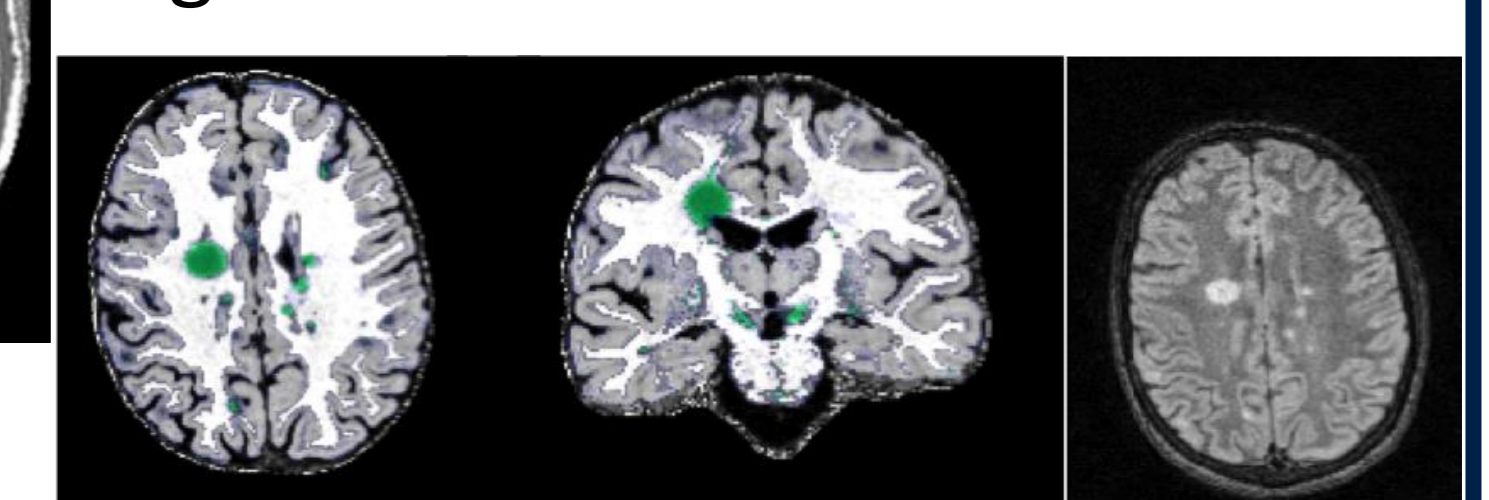
### MR imaging optimization

- Improved sensitivity and denoising of functional MRI (BOLD signal) and diffusion-weighted MRI (e.g. diffusion kurtosis imaging).
- Quantitative multi-contrast MR imaging approach at ultra-high resolution for robust segmentation and characterization of the human brain



(collaboration with the University College London, UK, & Max Planck Institute, Leipzig, Germany)

→ MS patient: white matter lesion segmentation and characterization



## Conclusions & Perspectives

Engineers/computer scientists are needed to collaborate on neuroscientific research projects:

- Contribute in term of *methodological and software developments*

➔ data processing, modelling, management & visualization ◀

- Gain *practical “hands on” experience* in a pluridisciplinary environment
- Have a *significant impact* in neuroscience and medicine!