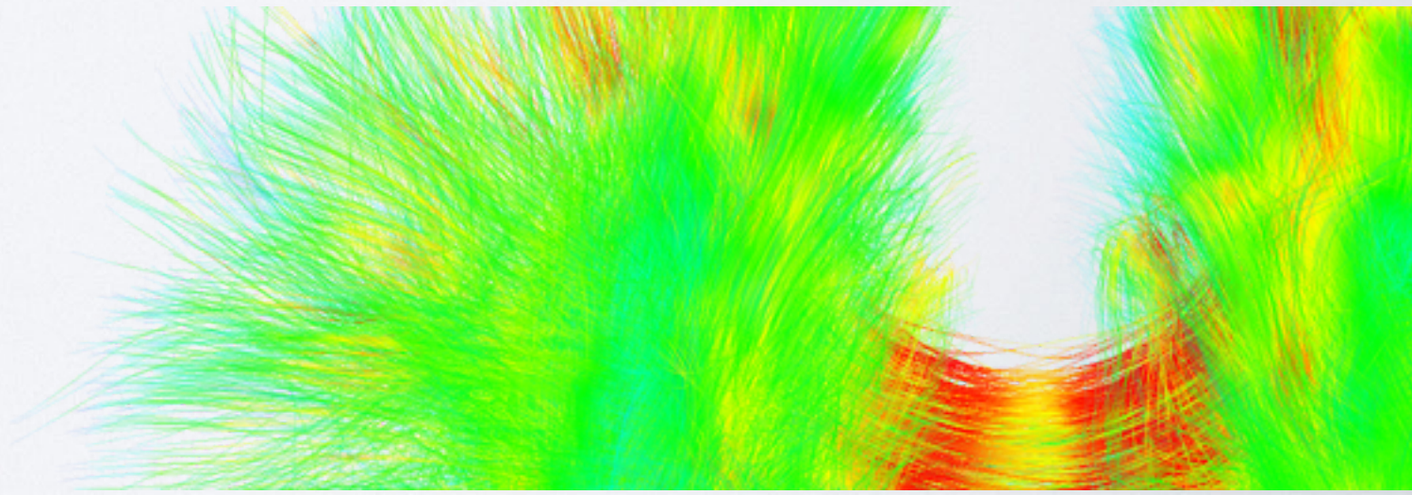
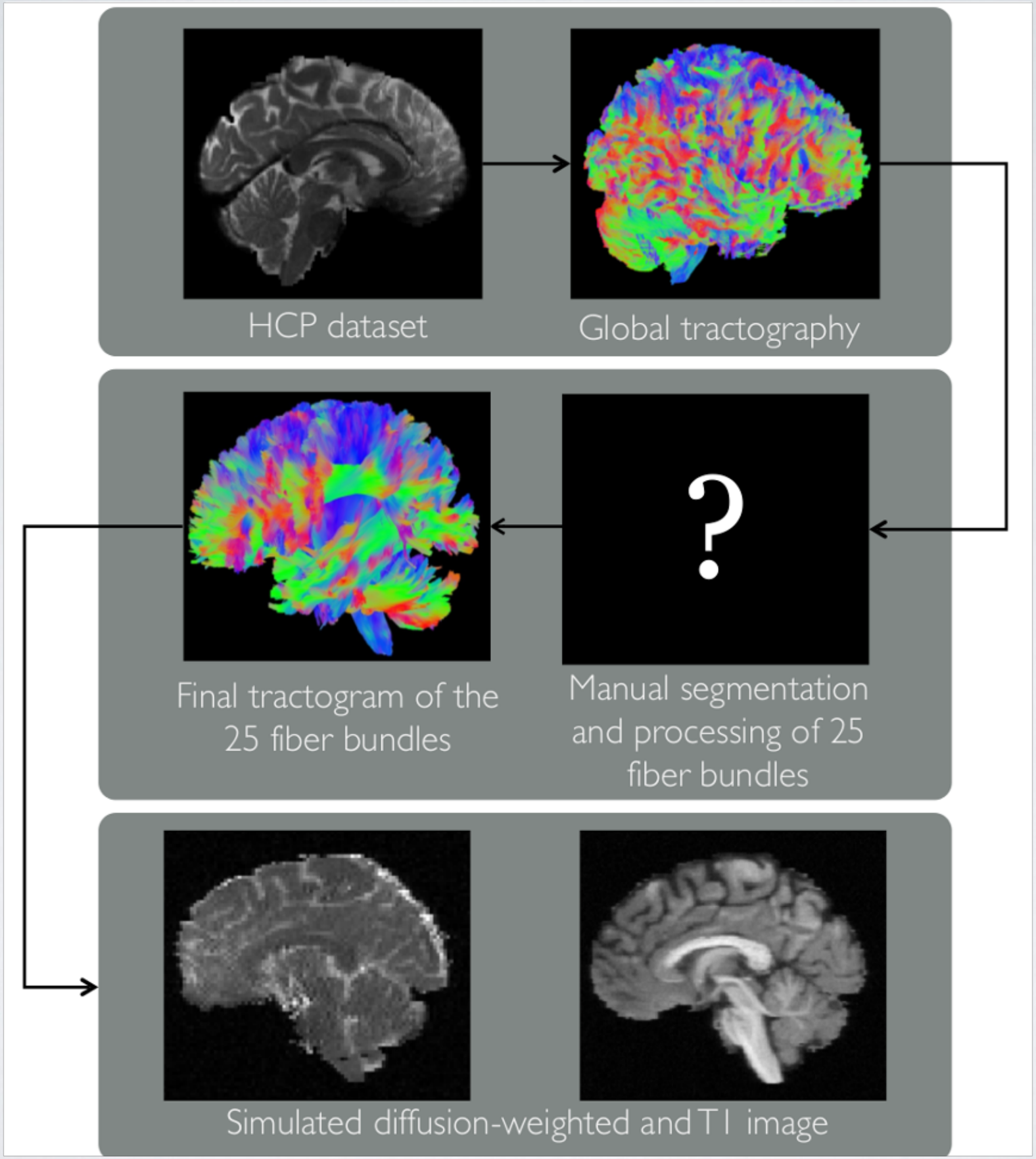
TRACTOGRAPHY CHALLENGE 2015

ISMRM Diffusion Study Group



EXAMPLE OF THE DATA GENERATION PROCESS



IN A NUTSHELL

1. Manually segmented white matter bundles.
   - These serve as ground truth streamline fibers.

2. Clinical-like diffusion MRI dataset generated using *Fiberfox*[1]*:*
   - 2mm isotropic, artefacts (motion, distortions, noise, etc.), 32 directions, b-value 1000 s/mm^2, 2 b=0 images

3. *Tractometer*[2] for the evaluation of fiber tracking results
   - Sensitivity & specificity with ground truth

[1] Neher, P. F., Laun, F. B., Stieltjes, B., & Maier-Hein, K. H. ***Fiberfox: Facilitating the creation of realistic white matter software phantoms.*** *MRM 72(5),1460-1470, 2014.*
[2] Côté, M.-A., Girard, G., Boré, A., Garyfallidis, E., Houde, J.-C., & Descoteaux, M. (2013). ***Tractometer: Towards validation of tractography pipelines***. *Medical Image Analysis, 17*(7), 857–844, 2013.

MANUAL TRACT SEGMENTATION

- Fiber tracking algorithm ran on high-resolution 1.25mm isotropic HCP data

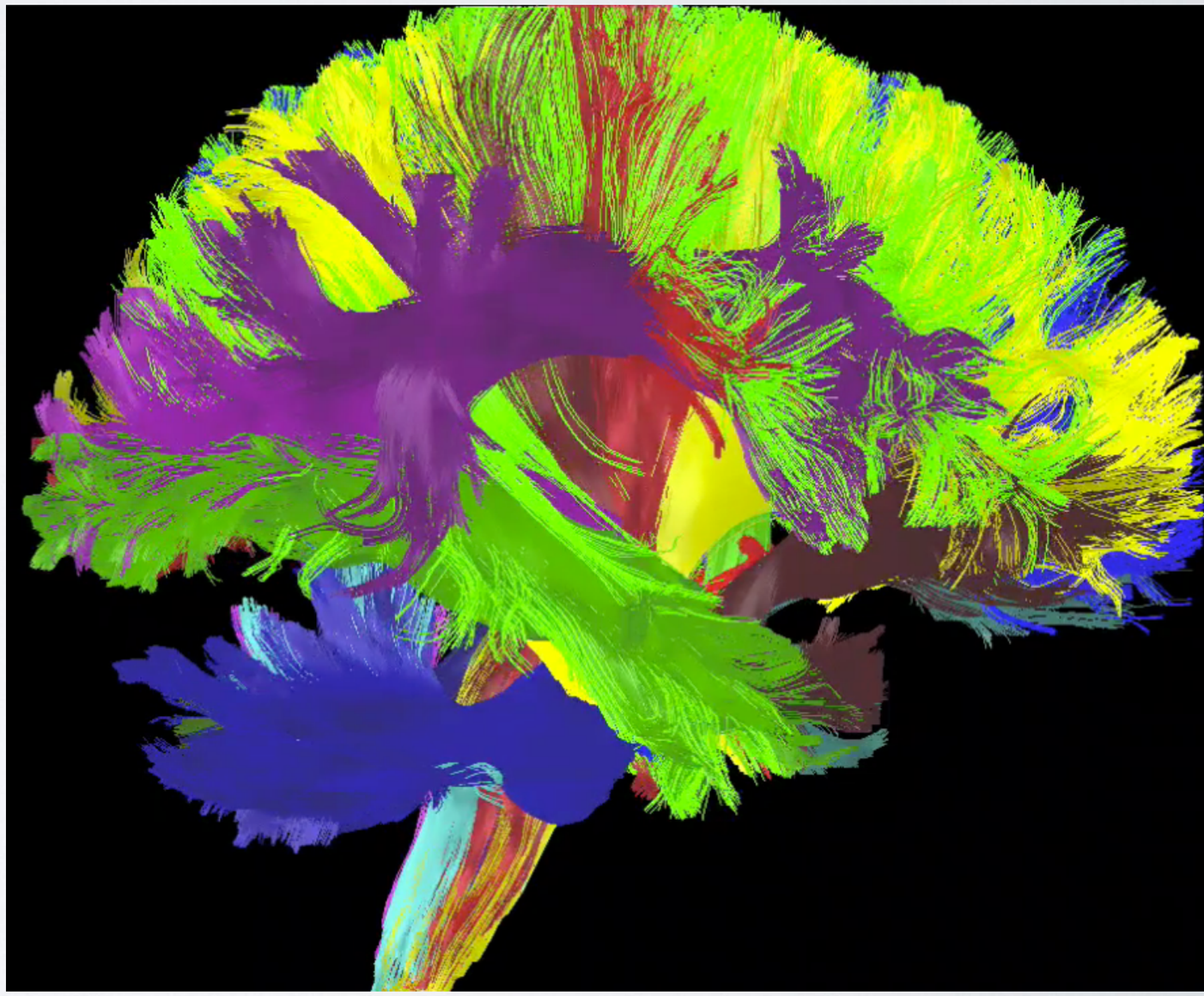
- Bundle segmentation manually done by expert radiologist using anatomically placed regions of interest

- 26 bundles extracted covering association, projection and commissural fibers across the whole brain

26 MANUALLY SEGMENTED WHITE MATTER BUNDLES

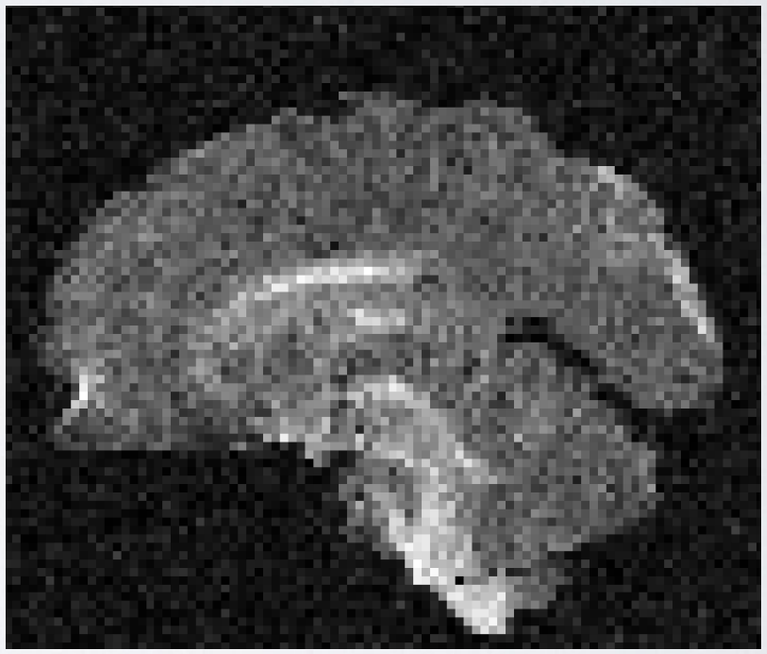
- These 26 bundles serve as ground truth models. They are used as **artificial fibers** to generate the raw diffusion MRI dataset

- This is just another way to generate a phantom dataset based on realistic looking streamline fibers



DIFFUSION MRI SIMULATION

- MOTIVATION: **Clinical-like dataset**
  - 2 mm isotropic, 2 b=0 images
  - 32 directions, b-value 1000 s/mm^2
  - Noise added
  - Many types of artefacts



Example of simulated b=1000 s/mm^2 of typical clinical imaging protocol

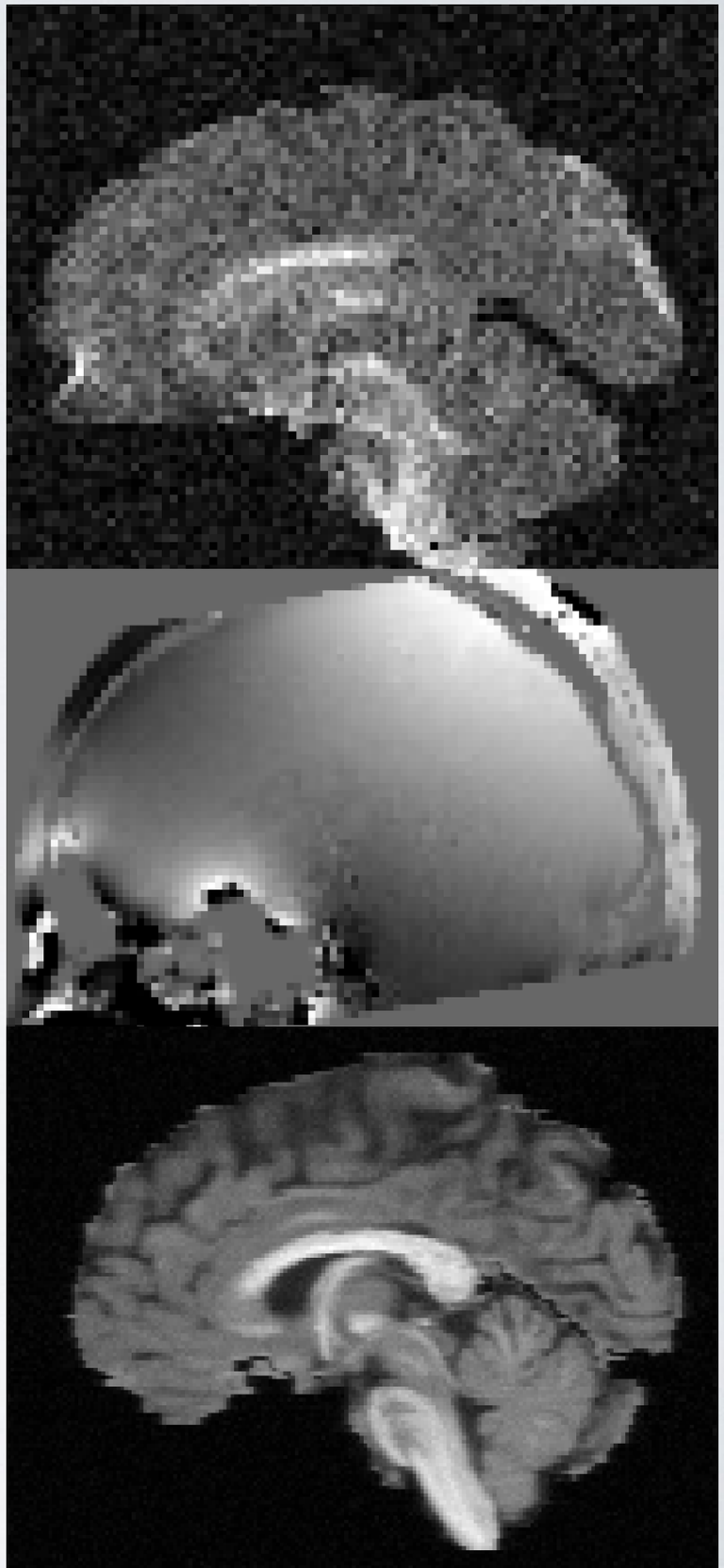
DATA FOR PARTICIPANTS

1. Diffusion MRI dataset:
   Diffusion.nii.gz, Diffusion.bvals, Diffusion.bvecs
   (1st image b=0 and then 32 dwi)

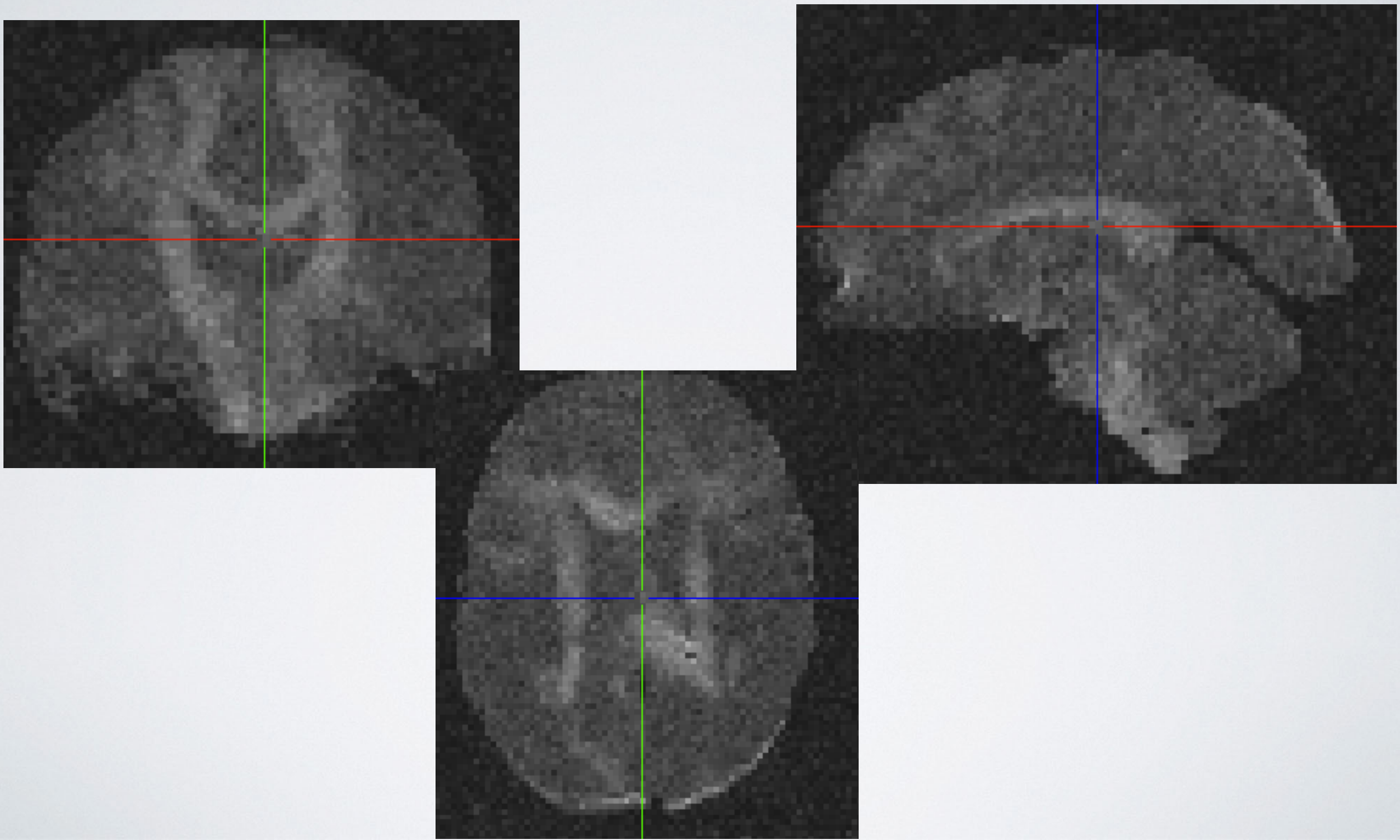
2. Diffusion with reverse-phase encoded b=0 image
   Diffusion_WITH_REVERSEPHASE.nii.gz

3. B0 FieldMap for this dataset:
   fmap_RadPerSec.nii.gz,
   fmap_Hz.nii.gz

4. T1-like image:
   T1.nii.gz

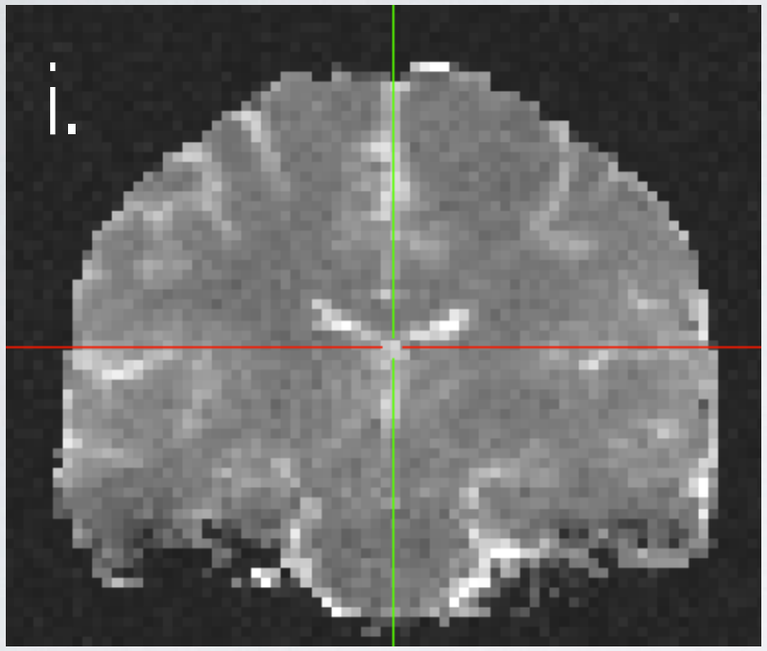


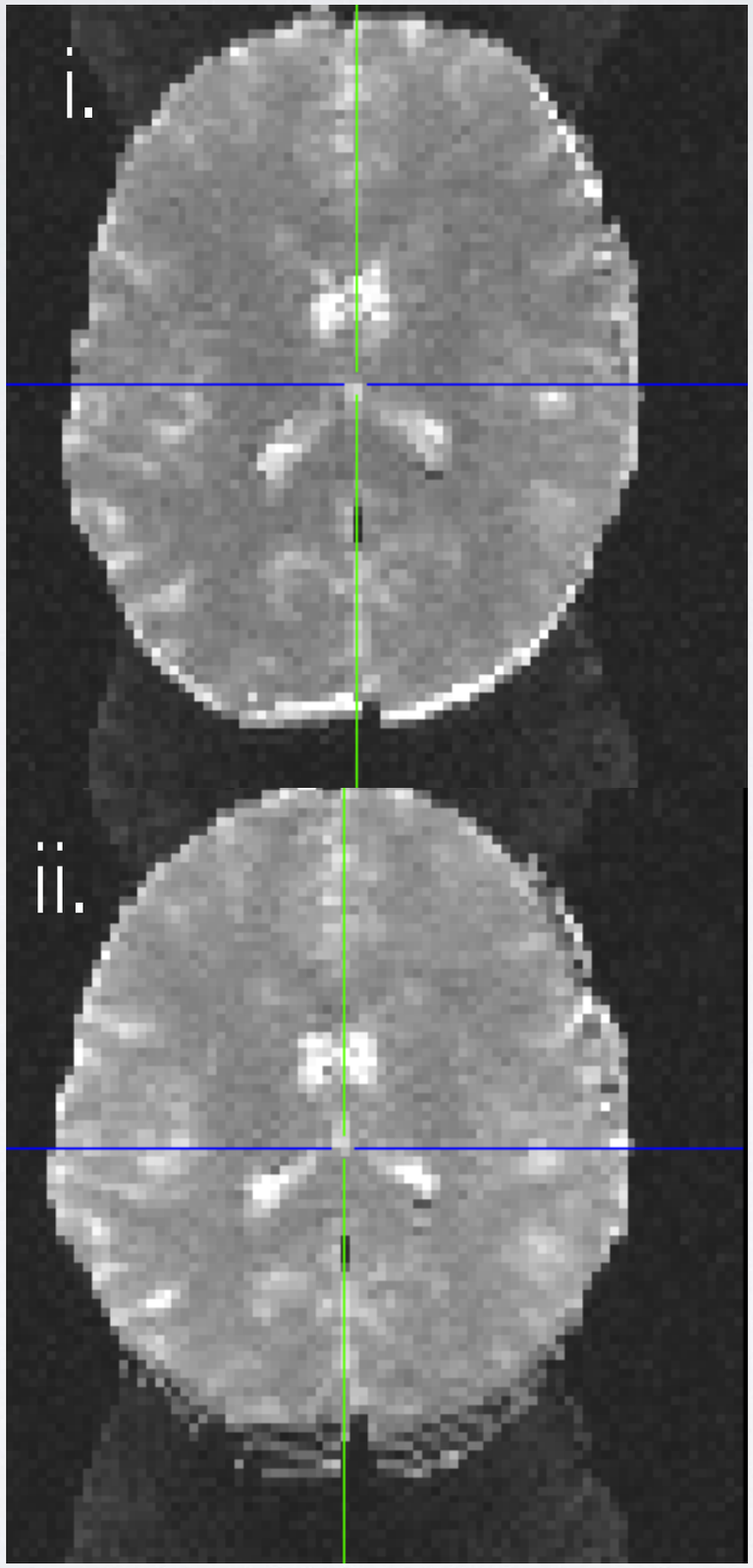
DIFFUSION - DWI #3

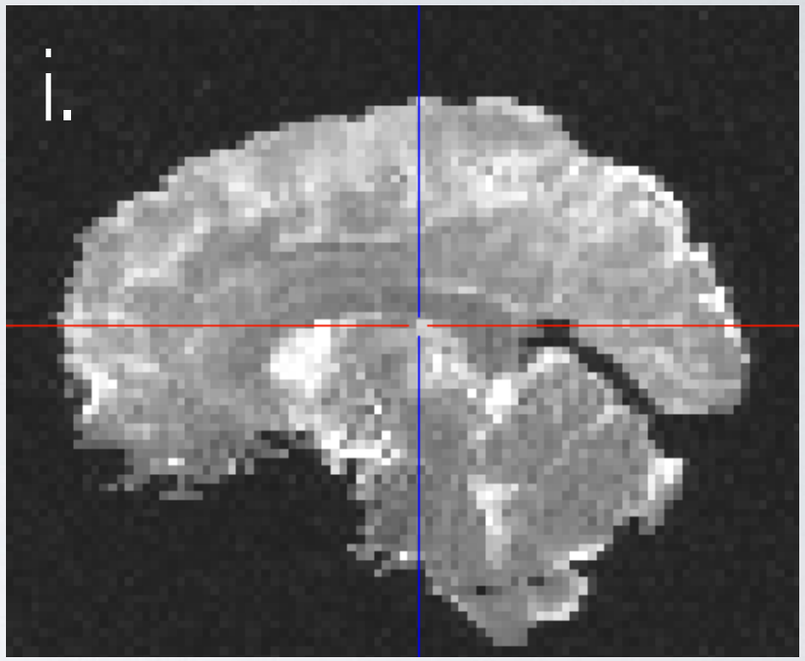


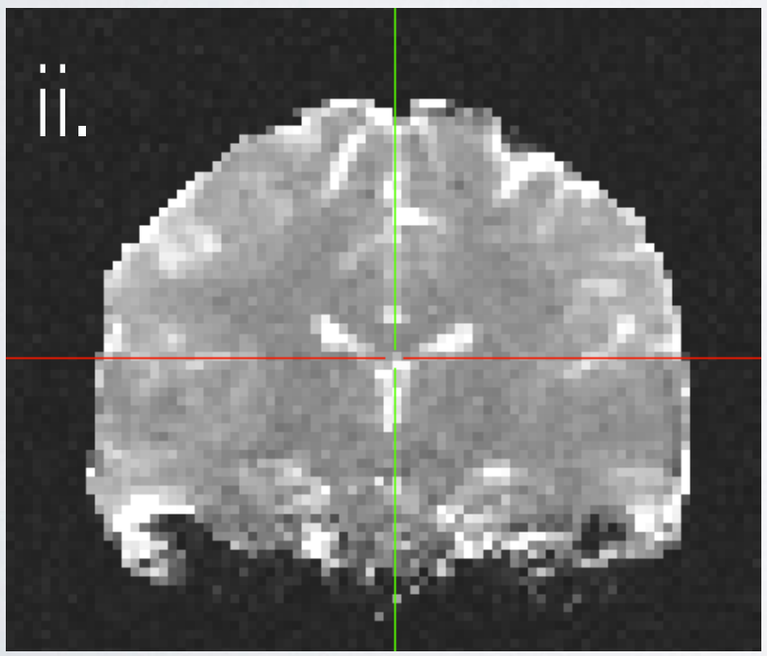
REVERSE PHASE

i. b=0 blipup

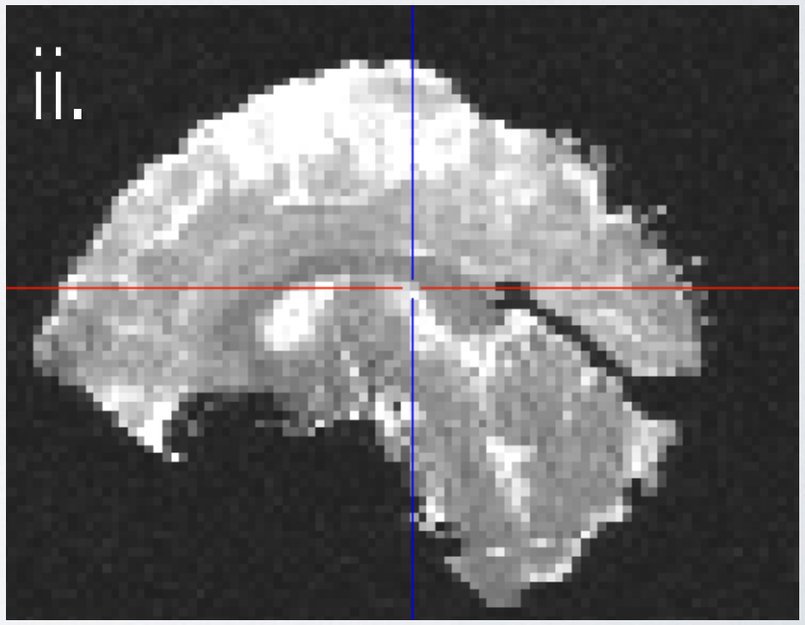




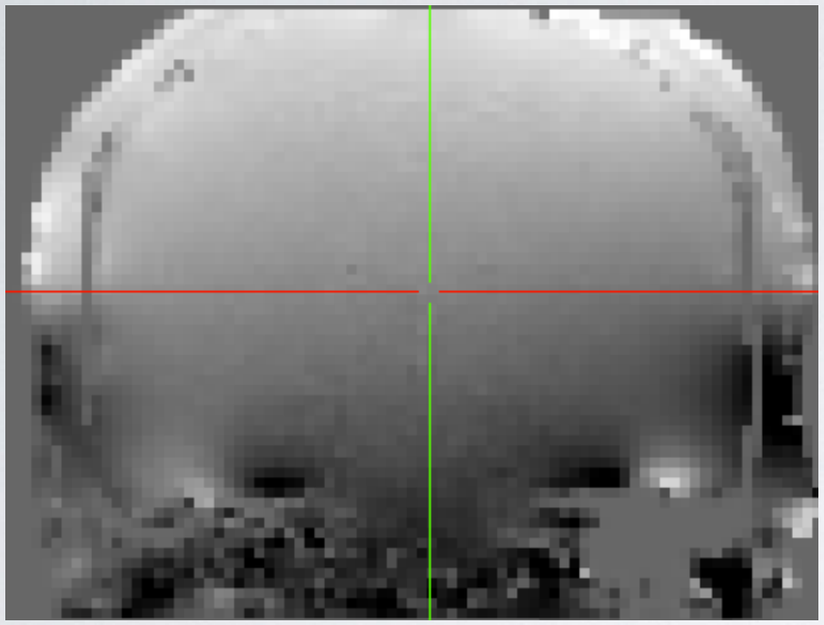


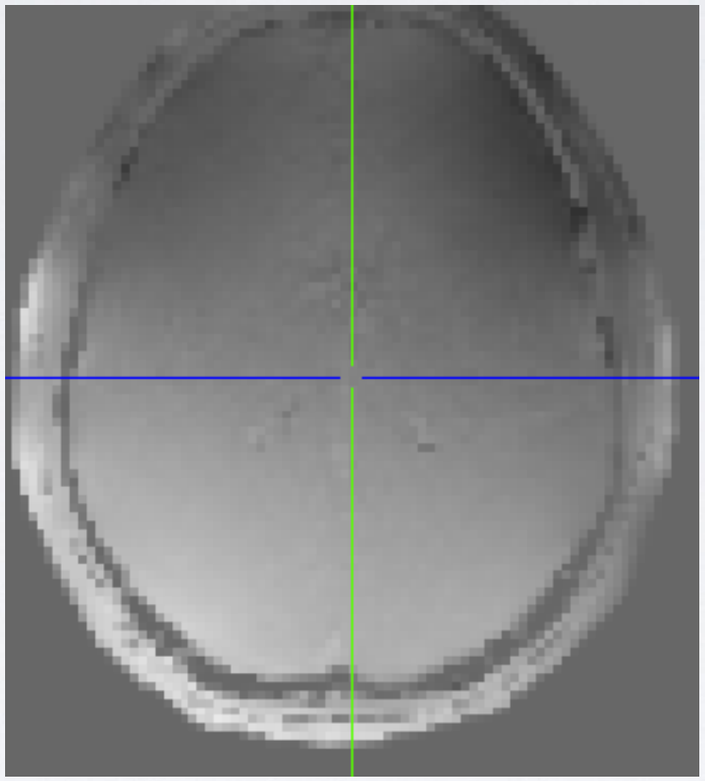


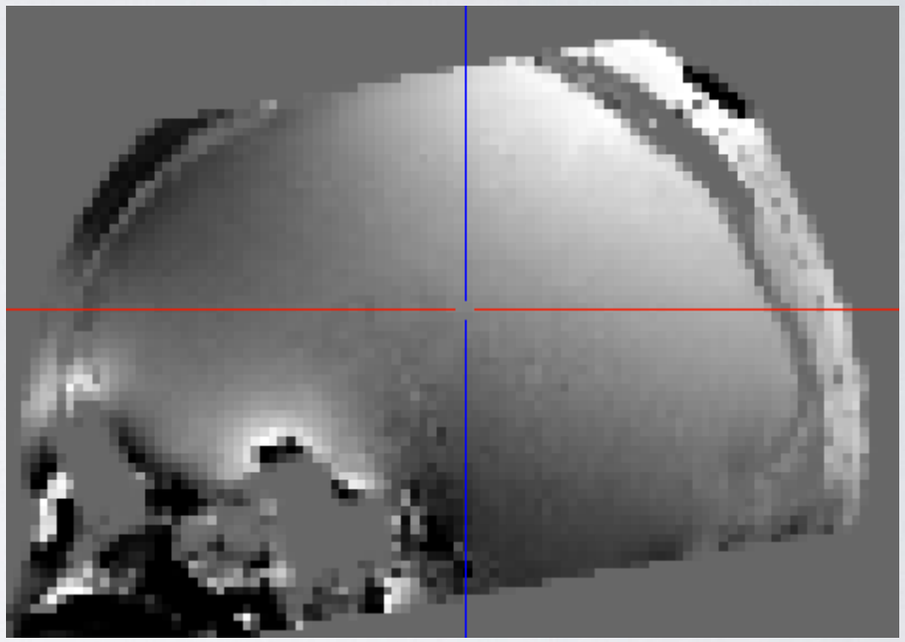
ii. b=0 blipdown



B0 FIELD MAP



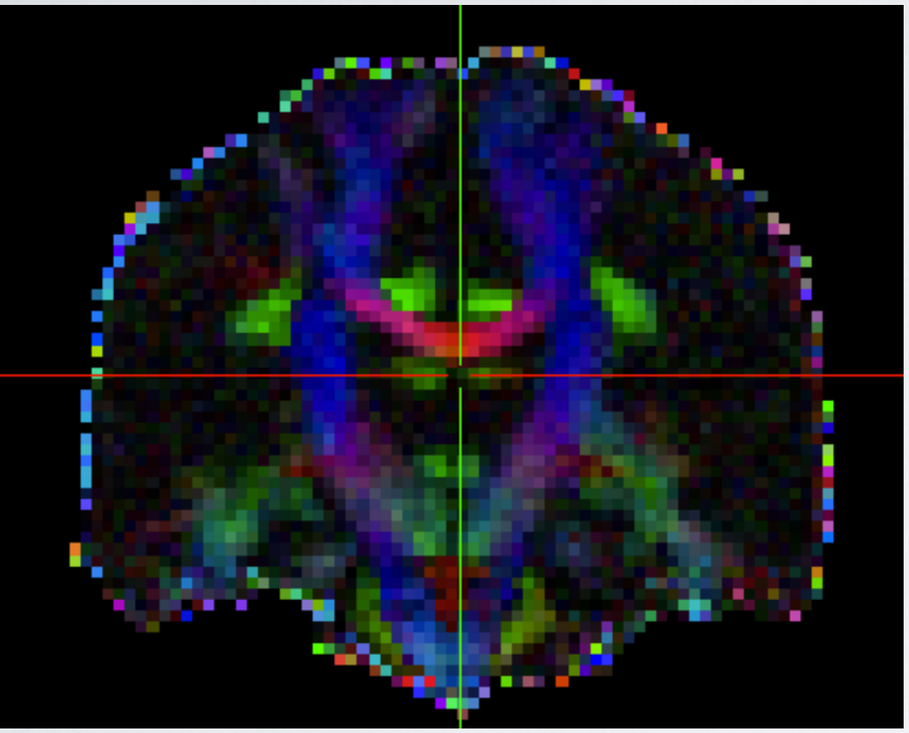


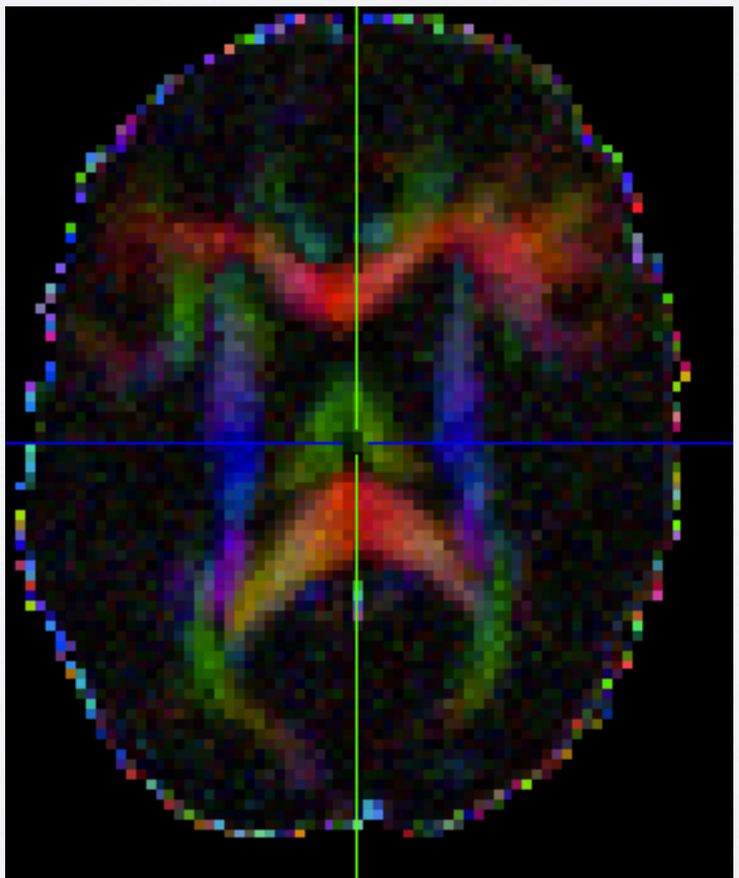


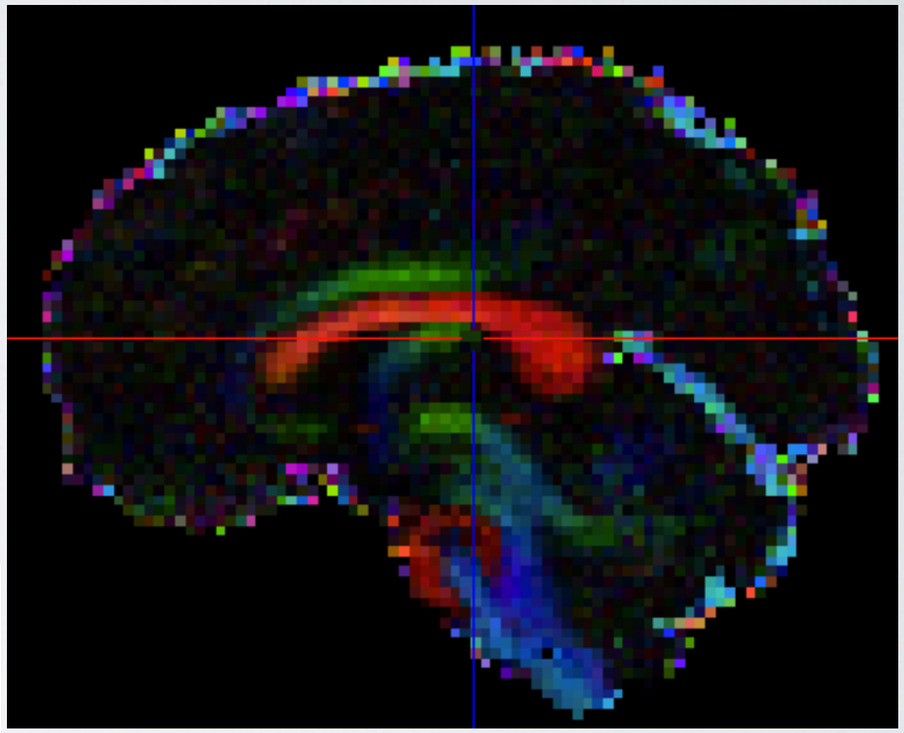
- The same field map is applied to all image volumes, regardless of head motion

- Field map available in rad/sec or Hz

DIFFUSION MRI

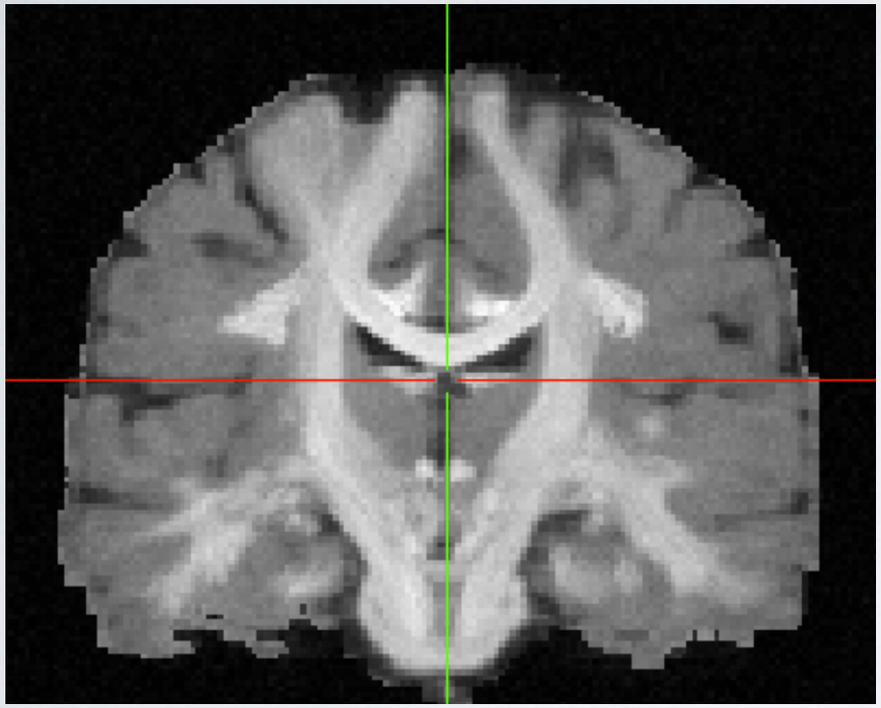


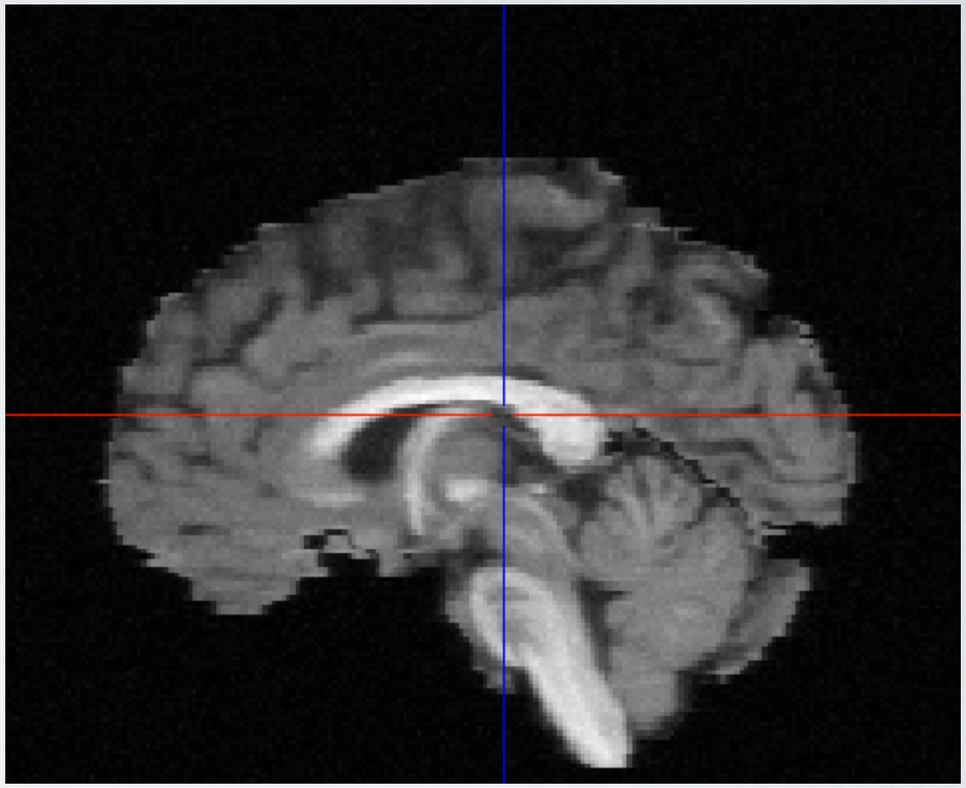


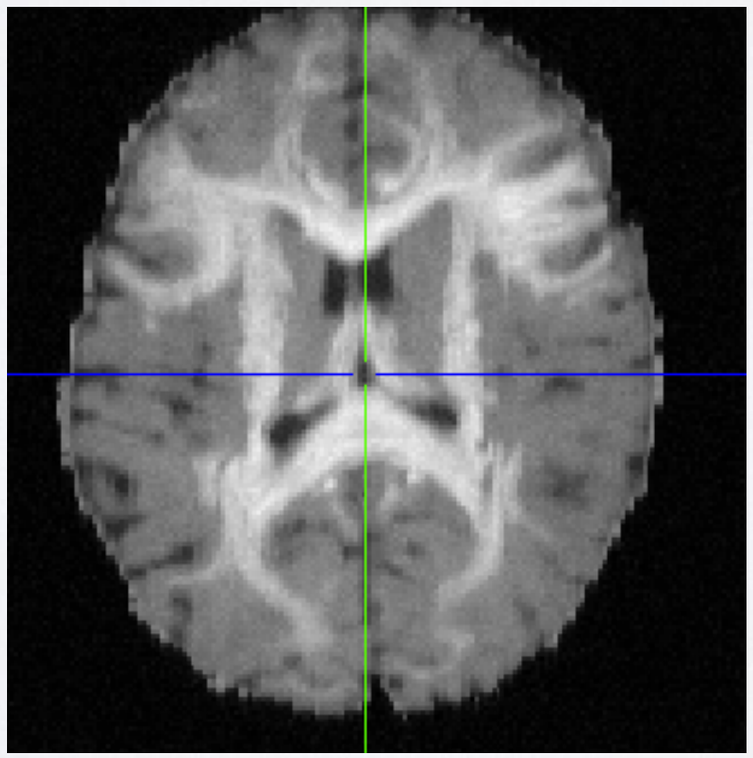


Basic
DTI reconstruction
(no correction)

T1







EXPECTED SUBMISSION

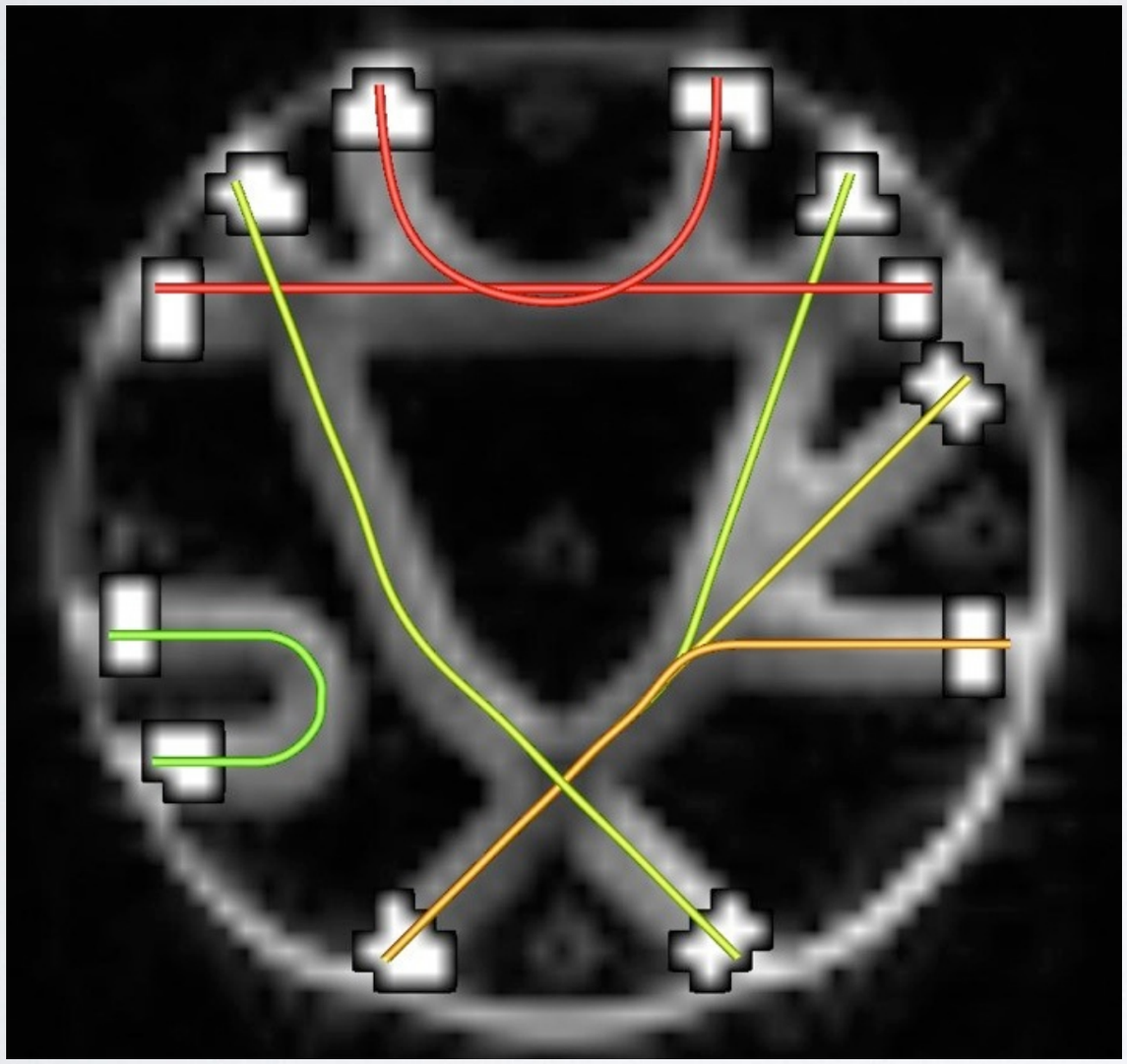
- A single whole brain tractogram (max 2Gb). Accepted format:
  - .trk (TractVis)
  - .tck (MRtrix)
  - .vtk
- Challenge website will gives further indications for fileFormat conversion

EVALUATION WITH THE *TRACTOMETER*

- Valid connections
- Invalid connections
- No connections
  (stopping in white matter or ventricles)
- Overlap with ground truth streamline fibers
- ***Tractometer.*** [Coté et al Descoteaux. MEDIA 2013]

VALID CONNECTION

Connects 2 connected regions



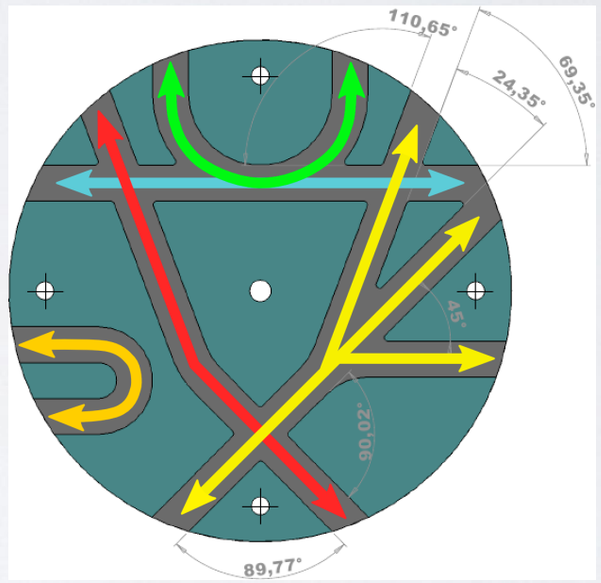
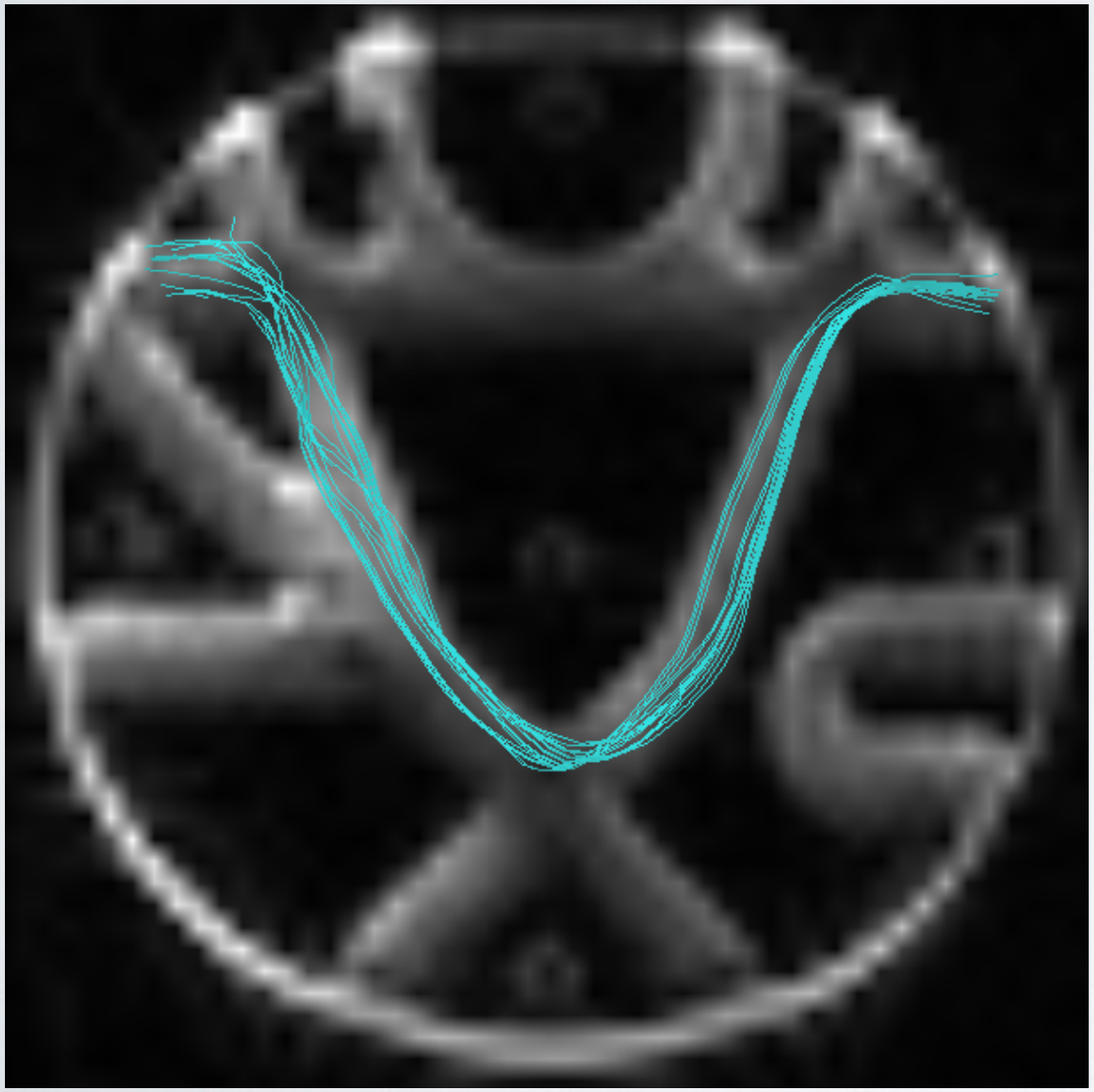
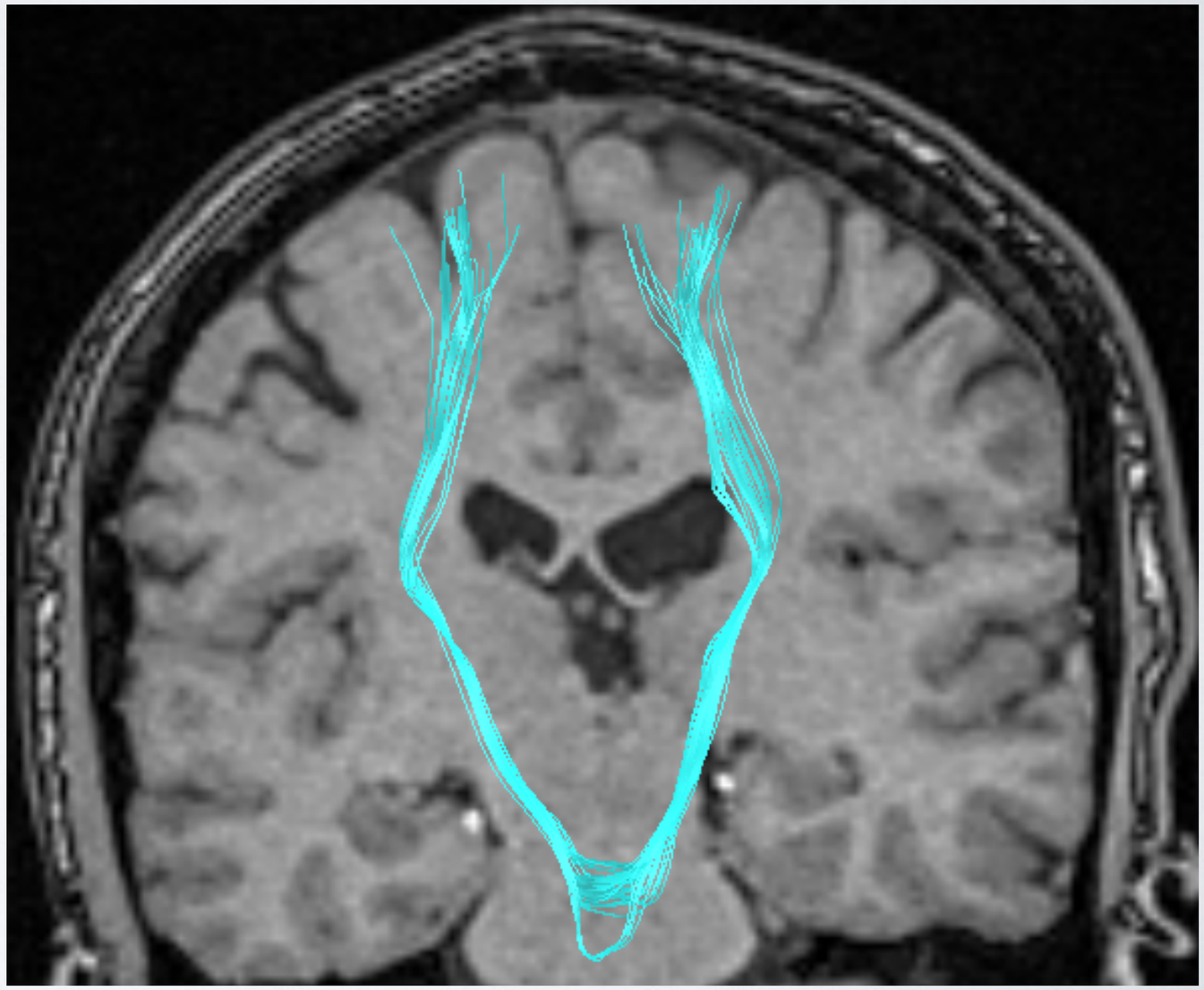


Illustration with the *FiberCup* dataset MICCAI Challenge 2009. [Fillard, Descoteaux et al NeuroImage 2010]

INVALID CONNECTION

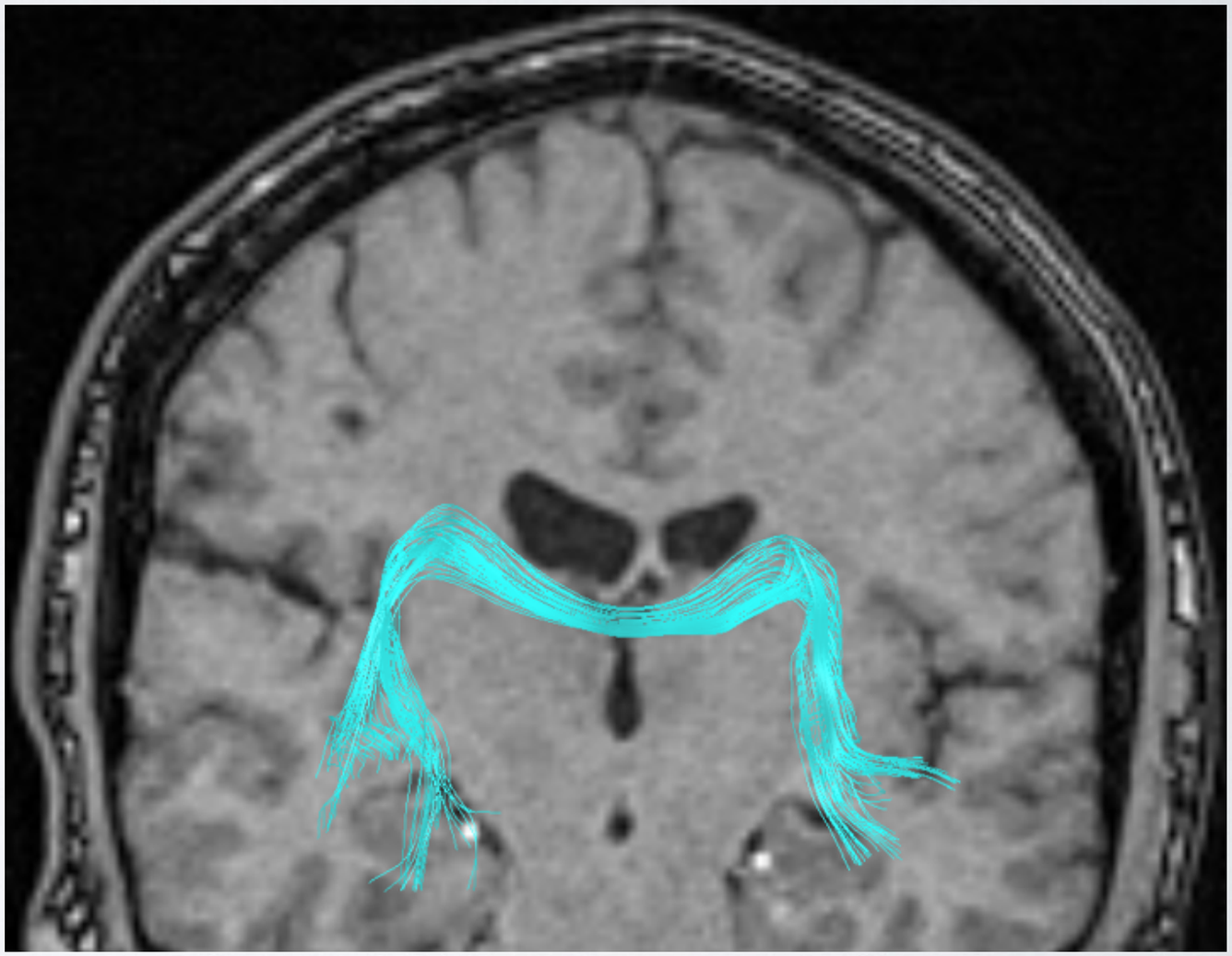
Connects 2 valid regions through a wrong path





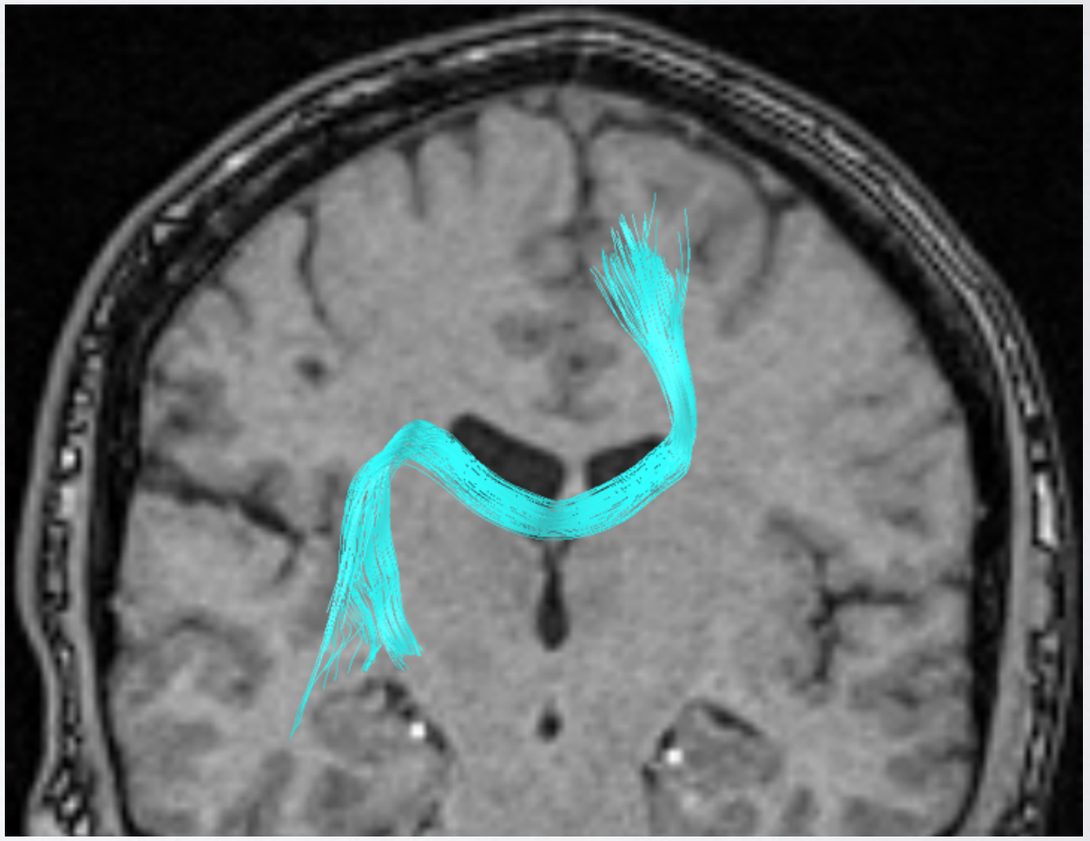
INVALID CONNECTION

Connects 2 regions that should not be connected



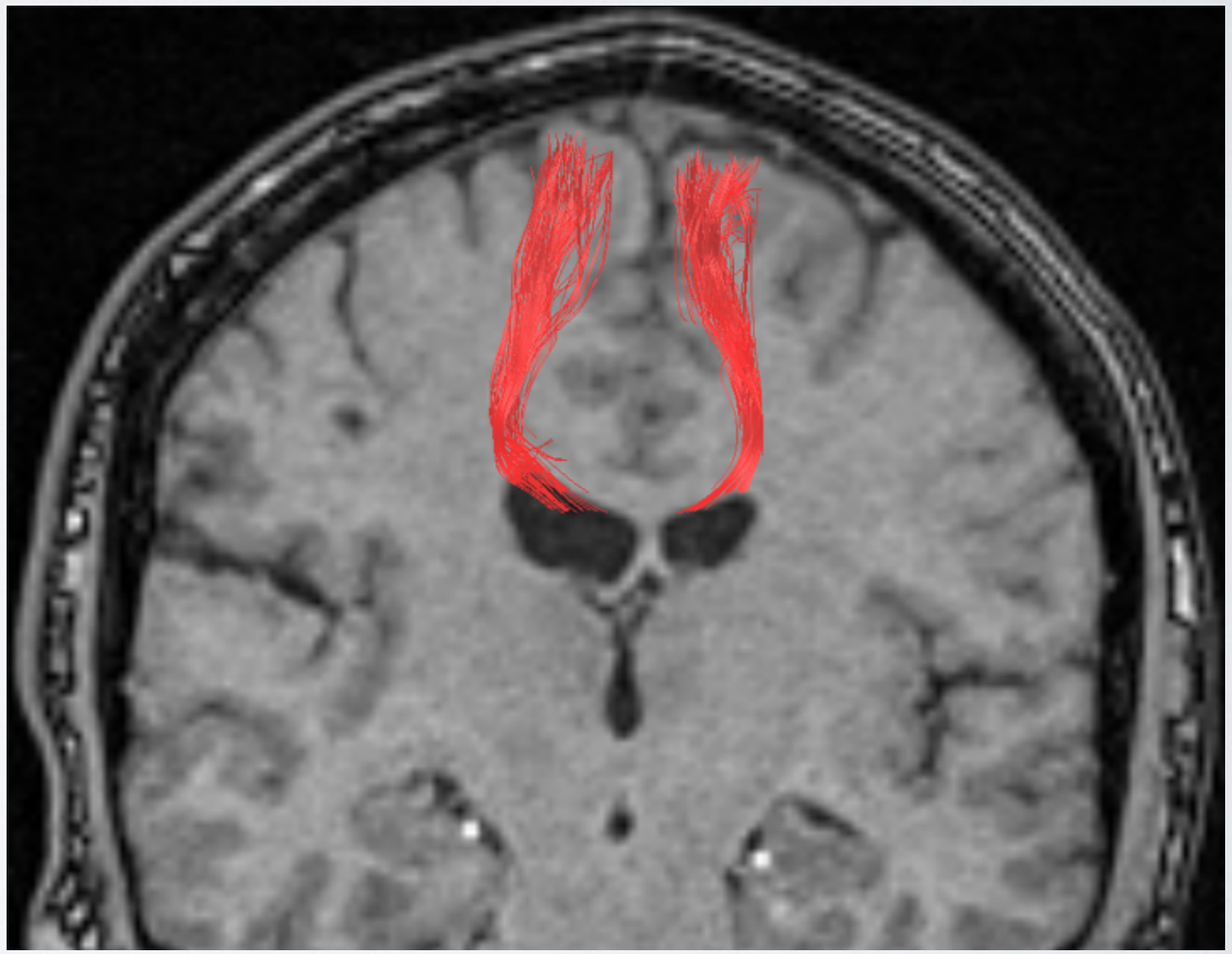
INVALID CONNECTIONS

Connects 2 regions that should not be connected



NO CONNECTION

Does not connect 2 regions
(stops prematurely in white matter or ventricles)



OVERLAP

Ground truth streamlines

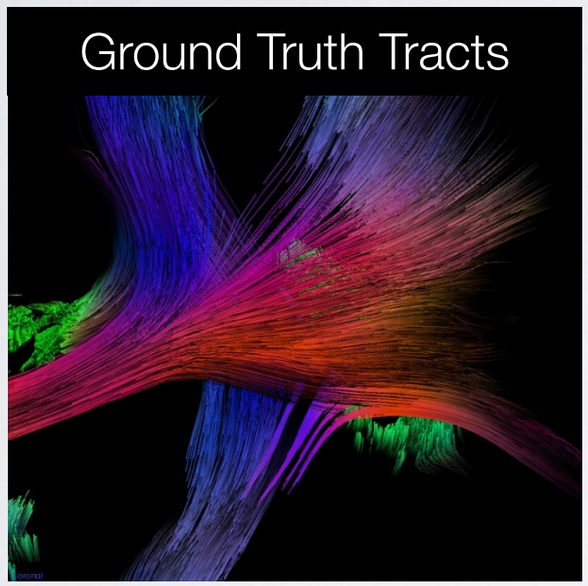
Estimated streamlines

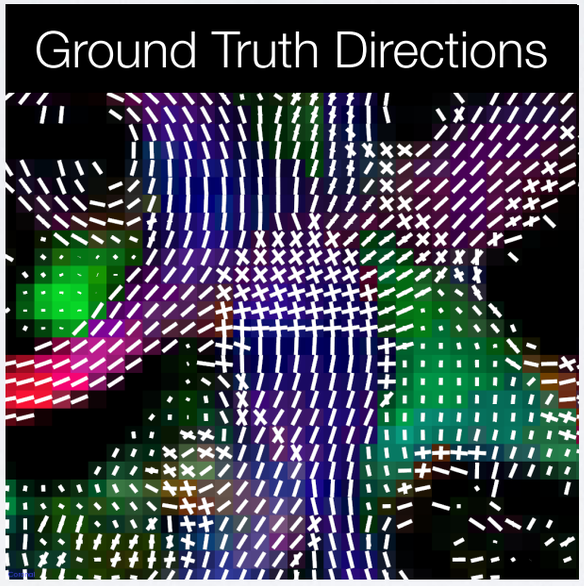
Non-overlapping voxels

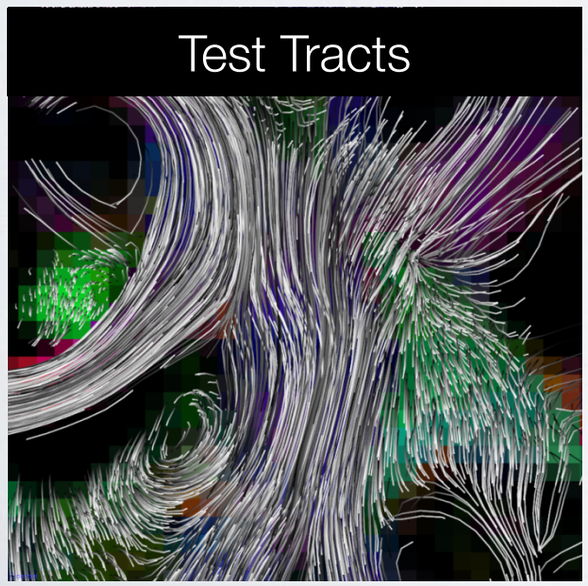
(Example on the CST)

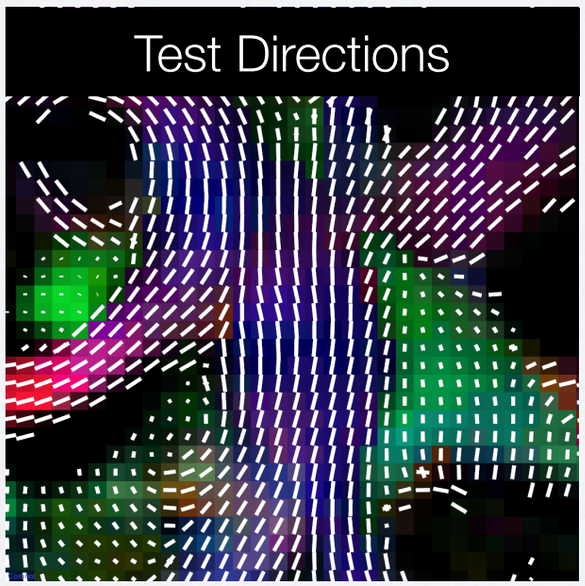
LOCAL ANGULAR ERROR

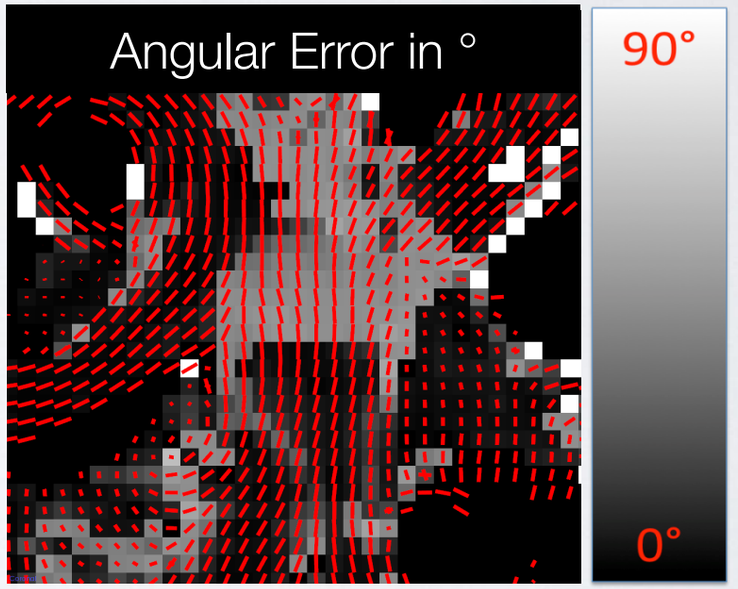
Voxel-wise tractogram directions compared to gorund truth directions.











QUESTIONS?