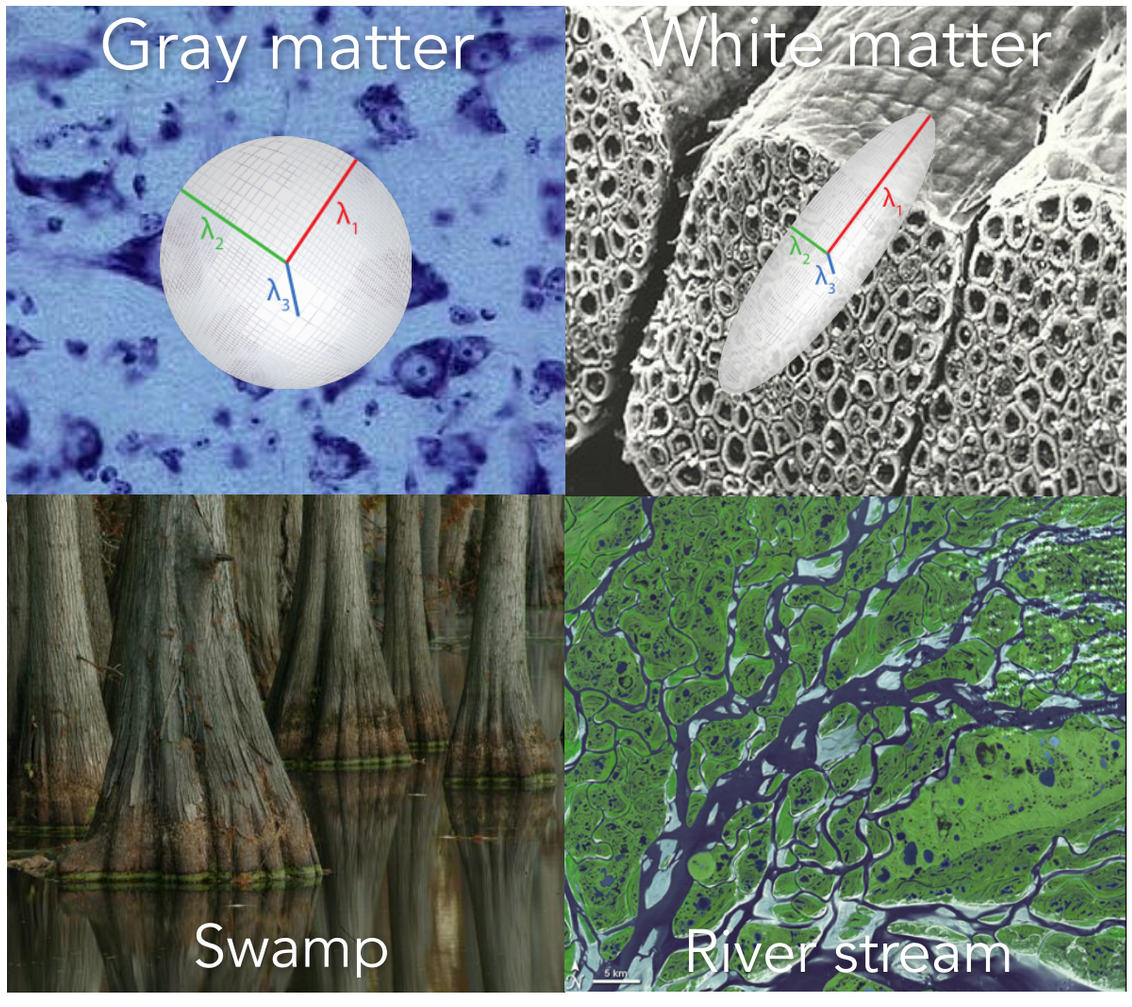
ANALYSIS OF DTI DATA

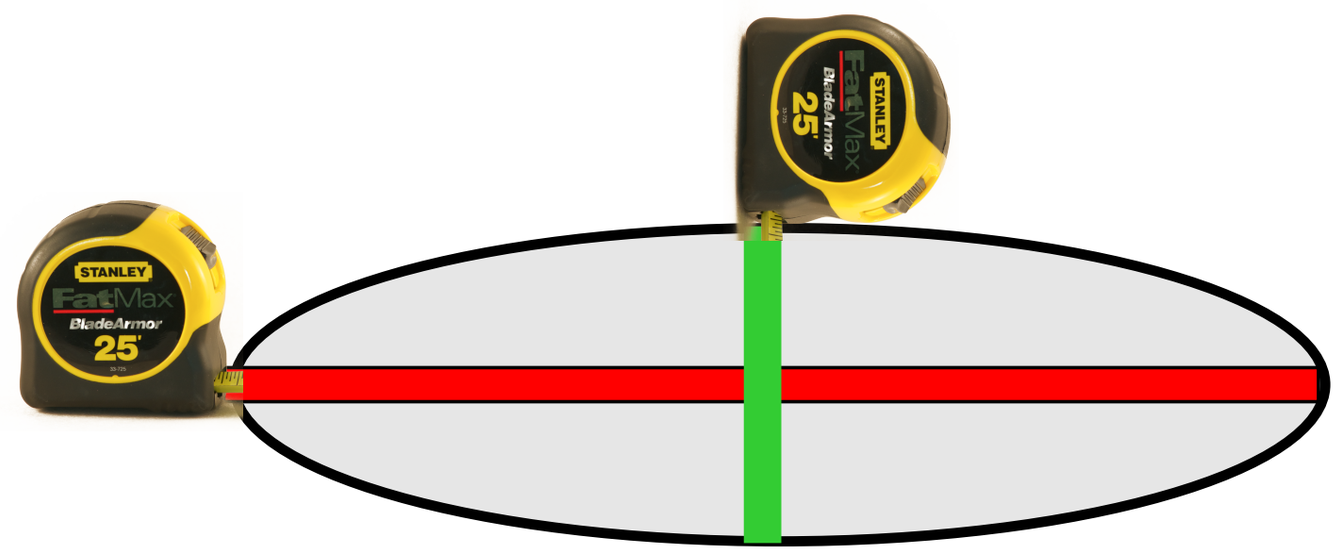
Part 1

DO TROMP - 2015

How diffusion MRI measures brain microstructure



How diffusion MRI measures brain microstructure



λ3

λ2

λ1

Parallel Diffusivity – “Axons”

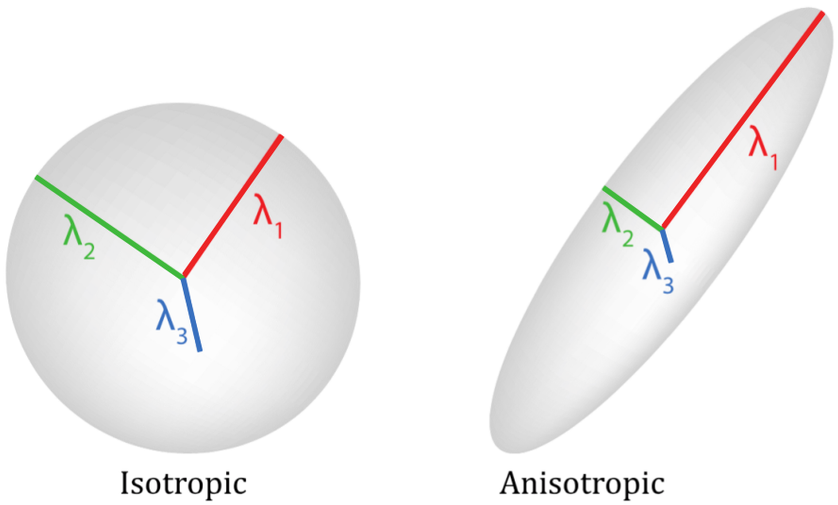
Average:
Perpendicular
Diffusivity
- “Myelin”

Average:
Mean
Diffusivity
- “Density”

Normalized Variance:
Anisotropy
- “White Matter Integrity”

Source: Andrew L. Alexander

How diffusion MRI measures brain microstructure



Isotropic Anisotropic

λ_1 = longitudinal (axial) diffusivity(AD)

$(\lambda_2 + \lambda_3)/2$ = radial diffusivity (RD)

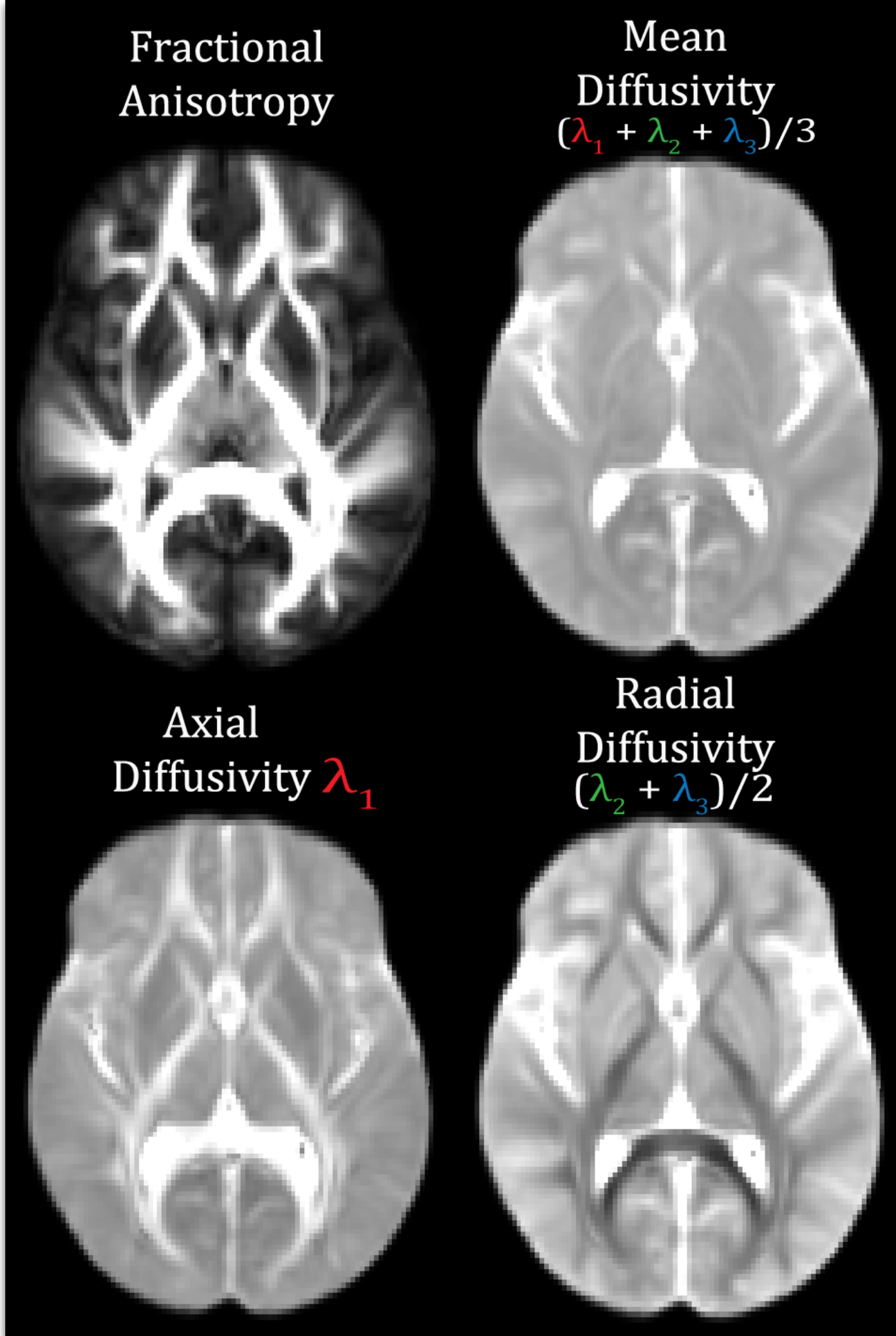
$(\lambda_1 + \lambda_2 + \lambda_3)/3$ = mean diffusivity (MD)

$$\sqrt{\frac{1}{2}}\frac{\sqrt{(\lambda_1-\lambda_2)^2+(\lambda_1-\lambda_3)^2+(\lambda_2-\lambda_3)^2}}{\sqrt{(\lambda_1^2+\lambda_2^2+\lambda_3^2)}}$$ = fractional anisotropy (FA)

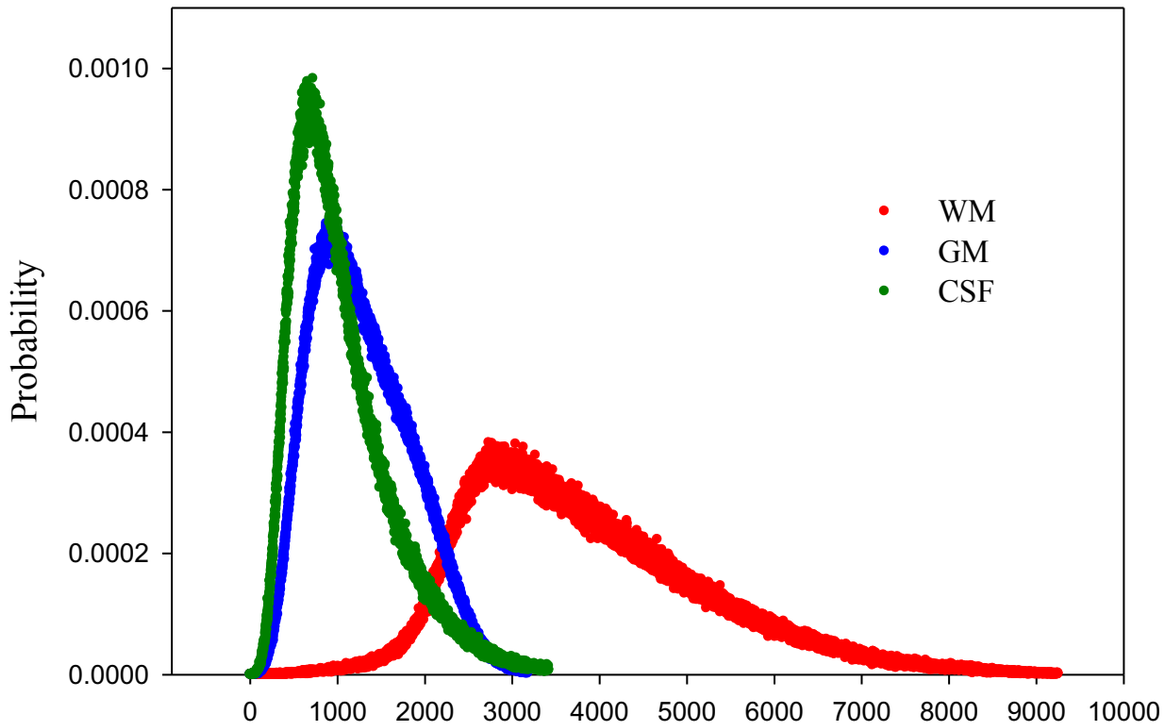
Quantification of diffusion MRI

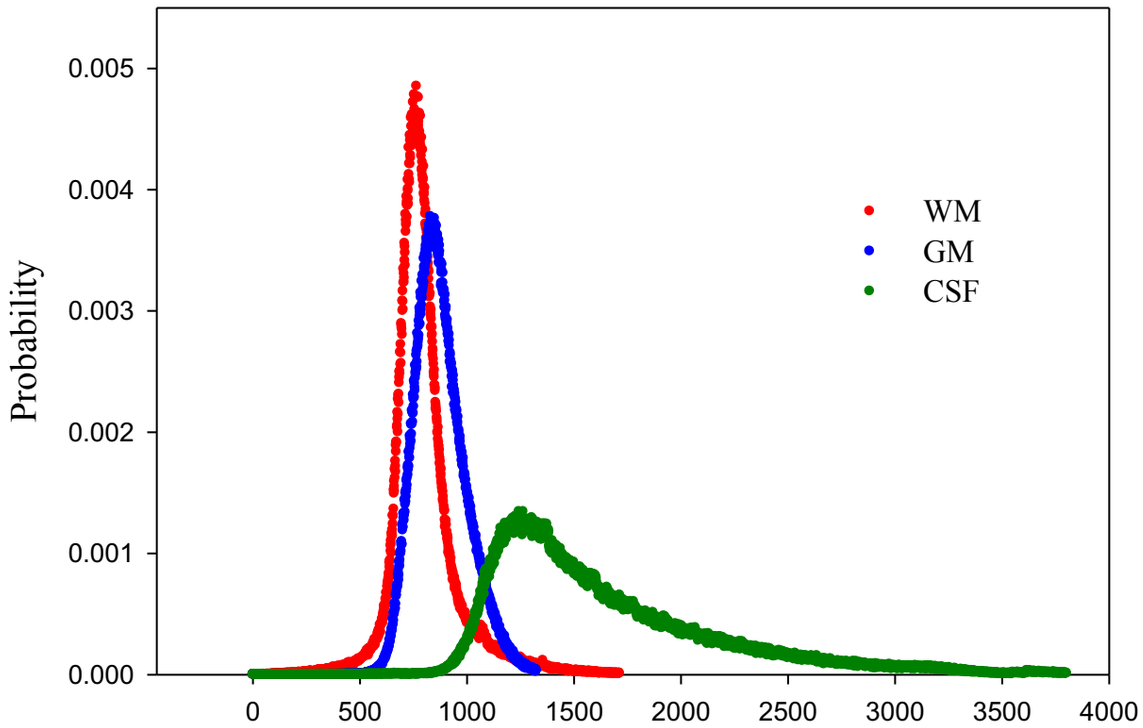
λ_1 = longitudinal (axial) diffusivity(AD)
$(\lambda_2 + \lambda_3)/2$ = radial diffusivity (RD)
$(\lambda_1 + \lambda_2 + \lambda_3)/3$ = mean diffusivity (MD)

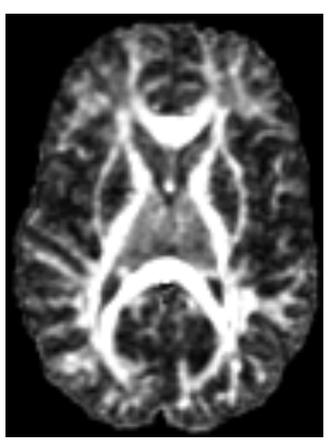
$$\sqrt{\frac{1}{2}}\frac{\sqrt{(\lambda_1-\lambda_2)^2+(\lambda_1-\lambda_3)^2+(\lambda_2-\lambda_3)^2}}{\sqrt{(\lambda_1^2+\lambda_2^2+\lambda_3^2)}}$$ = fractional anisotropy (FA)

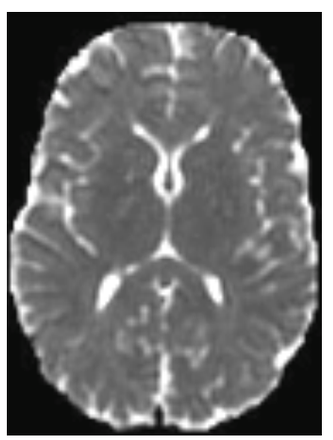


How diffusion MRI measures brain microstructure









Source: Andrew L. Alexander

Underlying mechanisms of diffusion MRI change

	FA	MD $(\lambda_1+\lambda_2+\lambda_3)/3$	XD λ_1	RD $(\lambda_2+\lambda_3)/2$
Gray Matter	↓	–	↓	↑
White Matter	↑	–	↑	↓
CSF	↓	↑	↑	↑
High myelination	↑	↓	–	↓
Dense axonal packing	↑	↓	–	↓
WM Maturation	↑	↓	↑	↓
Axonal degeneration	↓	↑	↓	↑
Demyelination	↓	↑	–	↑
Low SNR	↓	↑	↓	–

DTI ANALYSIS STEPS (Tutorial 1):

1. From scanner format to a usable format

2. Correct distortions common to diffusion images (EPI and eddy currents)

3. Remove any non-brain tissues

4. Make the gradient direction file

5. Fit the tensors

6. Check the fit of the tensors

DTI ANALYSIS STEPS (Tutorial 2):

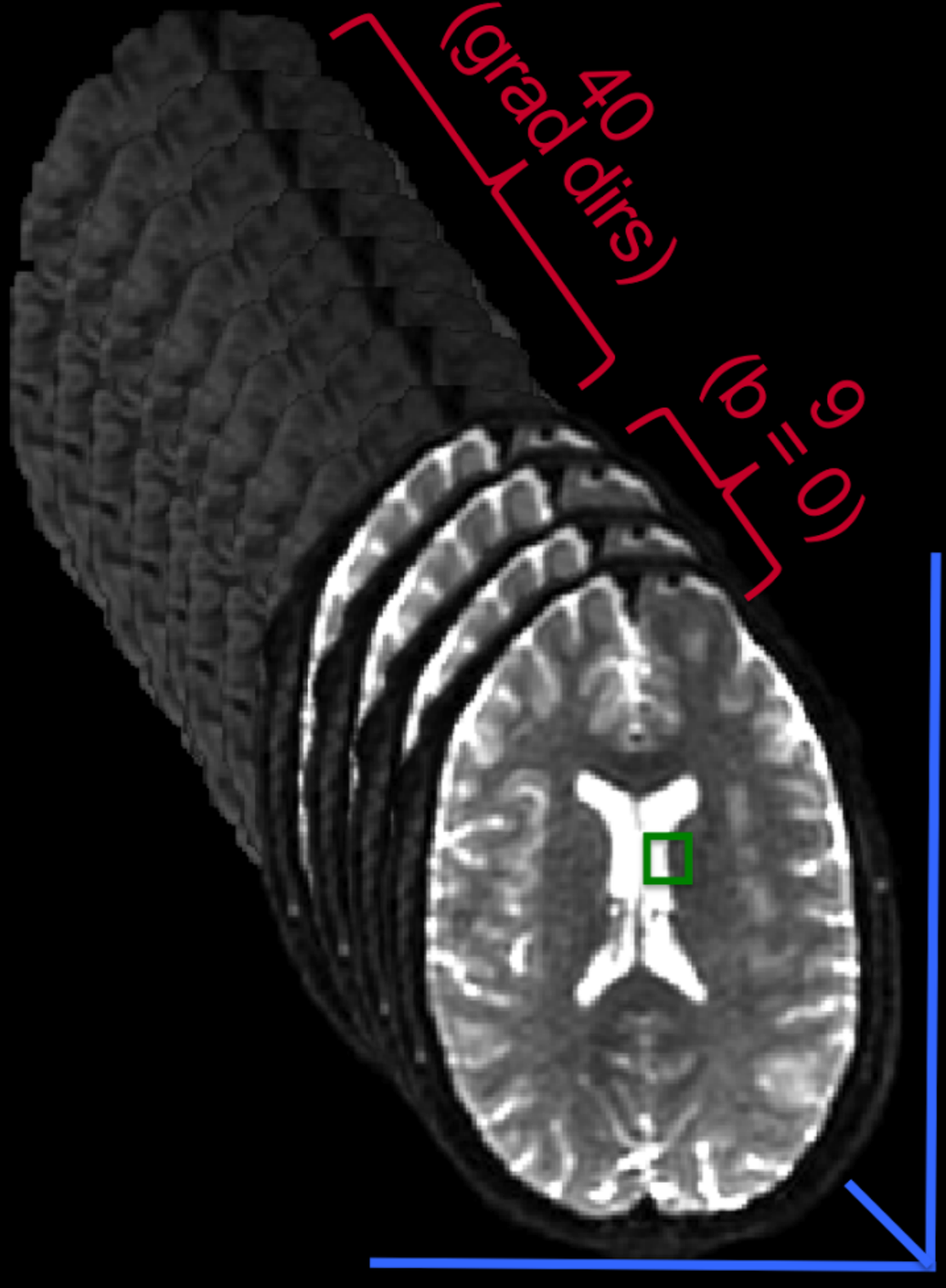
1. Adjust tensor units
2. Make population template by normalizing images
3. Register population template to MNI space
4. Produce scalar images (FA, MD, AD, RD) and check quality
5. Run whole brain voxel-wise statistics

1. DICOM to NIfTI

```
#List scan directories:
ls /study/$your_study/raw_data/$subject_nr/dicoms/
```

```
redwood:dicoms tromp$ ls
cardiac/        s04_3dtof/     s1000_ADC/     s1100_ADC/     s1200_ADC/     s13_fse_xl/     s15_3dtof/     s802_CMB/
s01_assetcal/   s07_2dfast/    s1001_FA/      s1101_FA/      s1201_FA/      s1400_COLLAPSE/ s400_COLLAPSE/ s900_ADC/
s02_bravo/      s08_dti/       s1002_CMB/     s1102_CMB/     s1202_CMB/     s14_3dtof/      s800_ADC/      s901_FA/
s03_fse_xl/     s09_dti/       s10_dti/       s11_dti/       s12_dti/       s1500_COLLAPSE/ s801_FA/       s902_CMB/
```

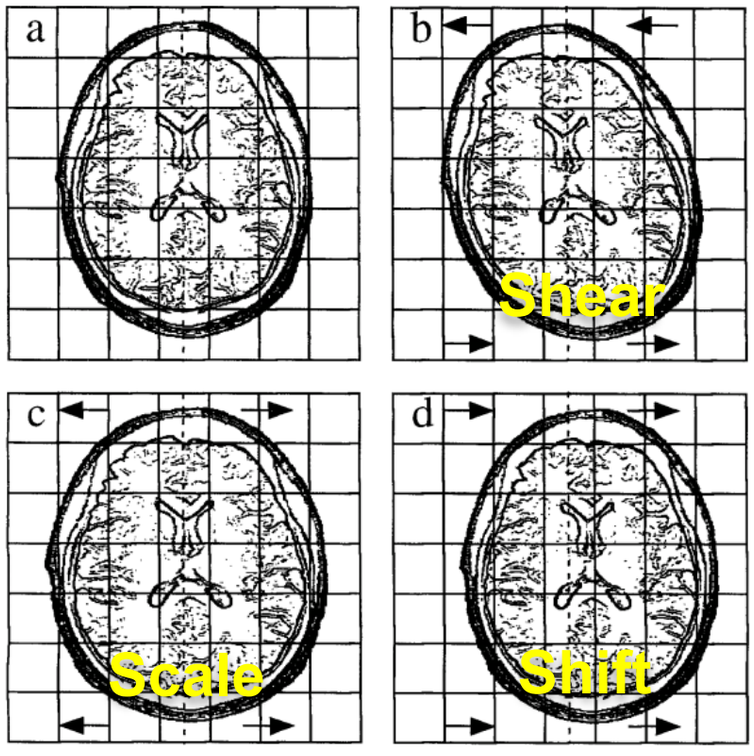
```
#Convert from DICOM to NIfTI:
convert_file s08_dti /$output_dir/$subject_nr_s08_dti nii
```



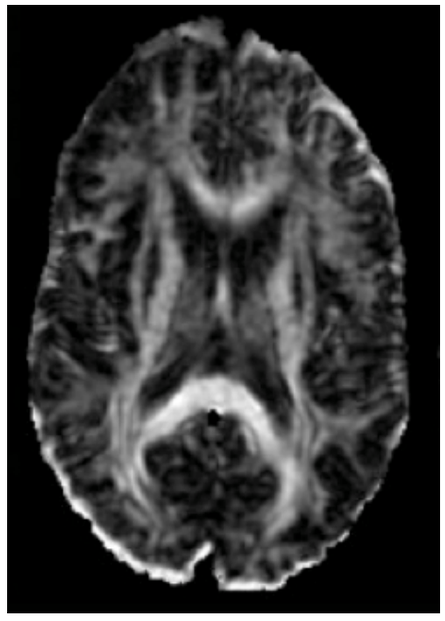

```
> fslinfo subj_s09_dti.nii

data_type      INT16
dim1           256
dim2           256
dim3           67
dim4           49
datatype       4
pixdim1        1.00
pixdim2        1.00
pixdim3        2.00
pixdim4        1000.00
cal_max        0.0000
cal_min        0.0000
file_type      NIFTI-1+
```

2. Eddy Current Correction

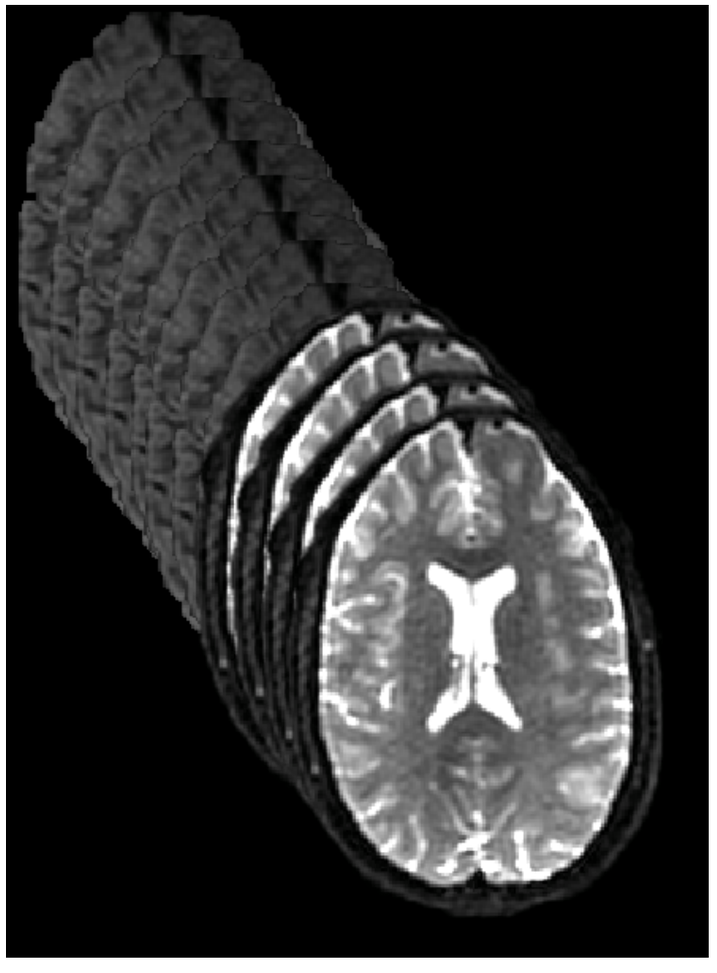
Distortions



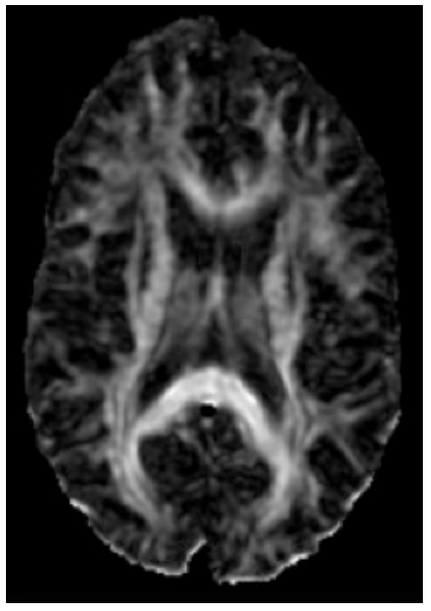
Uncorrected



Registration



Corrected

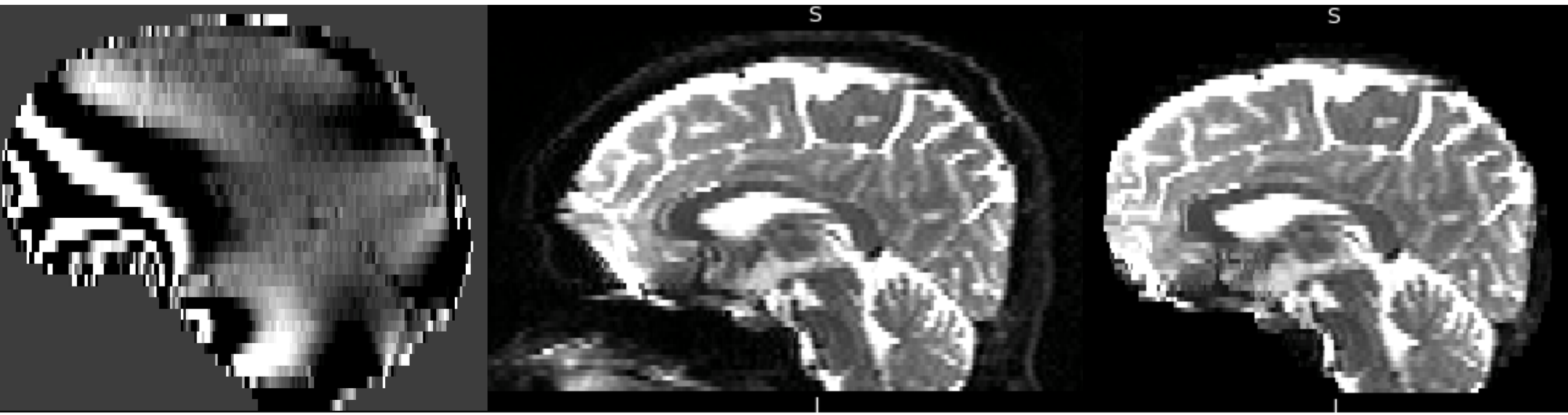


3. Field map (EPI) Distortion Correction

Field map

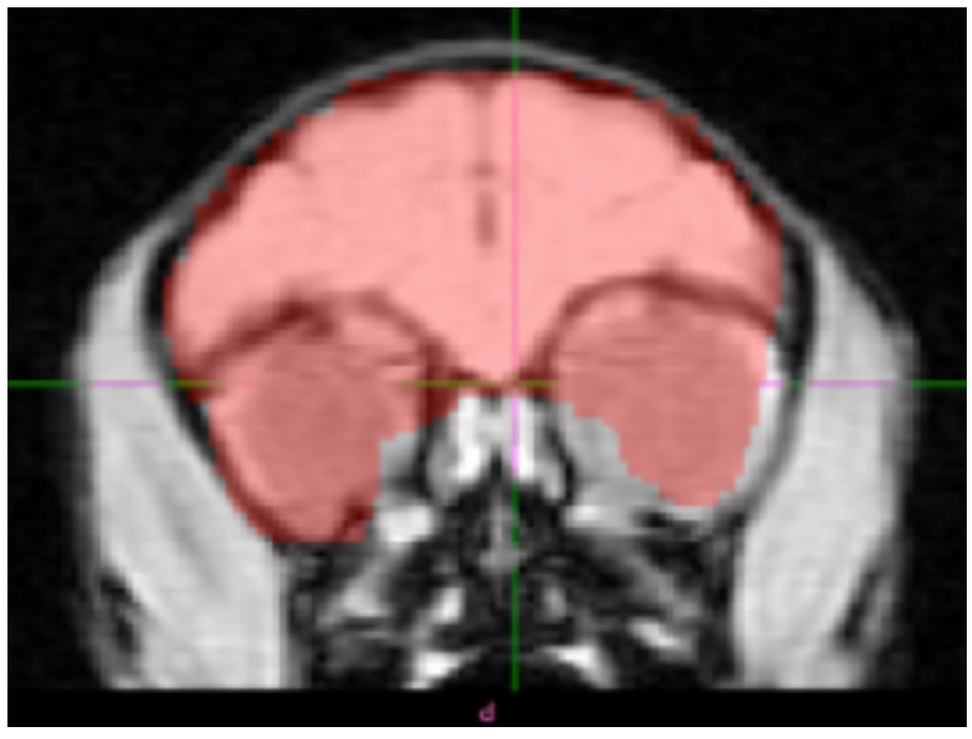
pre-correction

post-correction

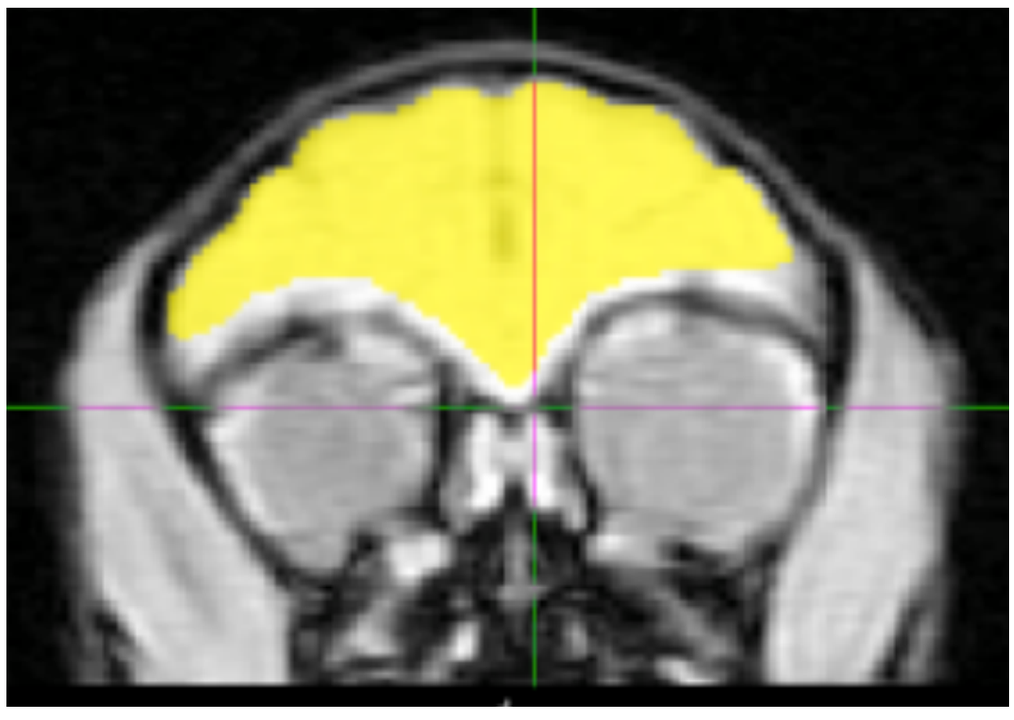


4. Brain Extraction

- FSL tool – brain extraction tool (bet)
- AFNI tool – 3dSkullStrip
- Manual stripping – fslview



Unfixed mask



Manual fixed mask

5. Make gradient direction files

b-vectors:

```
1.000000 0.000000 0.000000
0.480000 0.877000 0.000000
-0.155000 0.466000 0.871000
0.942000 -0.303000 0.146000
0.029000 -0.482000 0.876000
-0.635000 -0.149000 0.758000
0.504000 0.337000 0.795000
0.135000 0.990000 0.042000
0.759000 0.261000 0.596000
-0.031000 -0.959000 0.283000
0.110000 -0.944000 -0.312000
0.377000 -0.692000 -0.616000
-0.310000 -0.713000 0.629000
-0.570000 0.752000 0.331000
-0.643000 0.035000 -0.765000
-0.768000 -0.640000 0.032000
0.749000 -0.151000 -0.645000
0.421000 -0.249000 -0.872000
-0.257000 -0.899000 -0.356000
-0.778000 0.572000 -0.258000
```

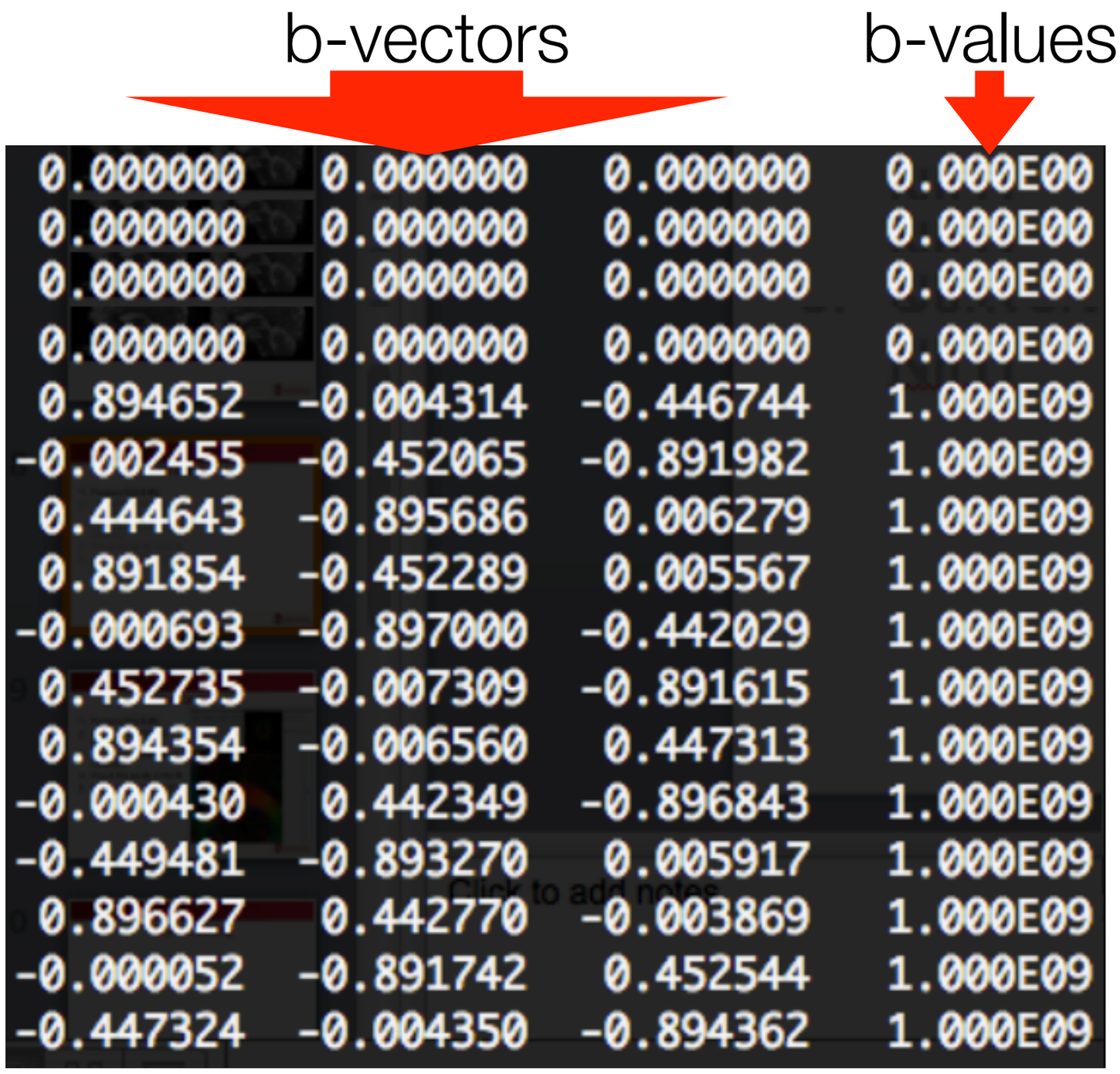
b-values:

```
0
0
0
0
0
0
1000
1000
1000
1000
1000
1000
1000
1000
1000
1000
1000
1000
```

related volumes:

5. Make gradient direction files

Produce SCHEME file by combining b-vectors and b-values



6. Tensor fitting

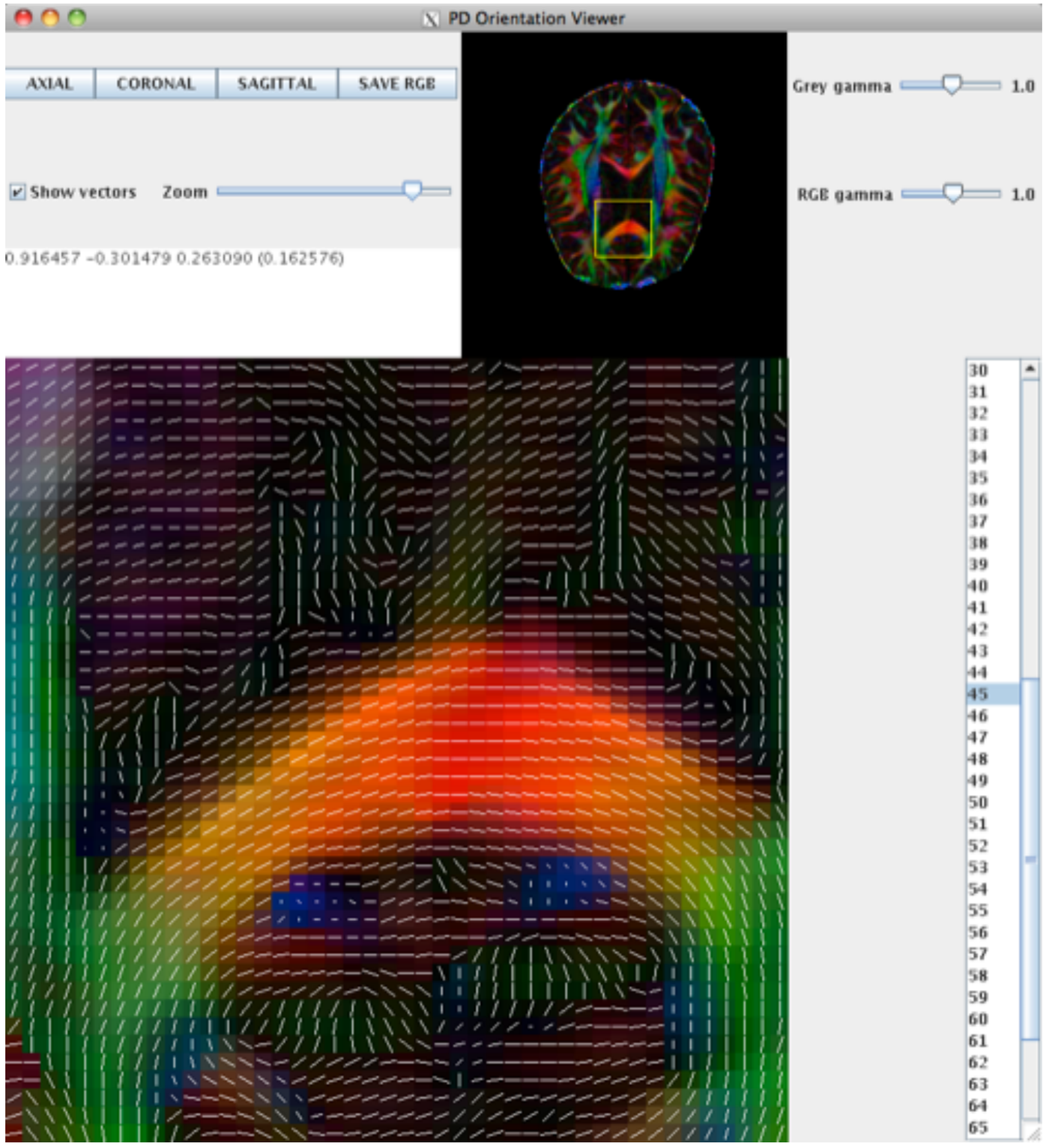
- Convert from NIfTI (.nii) to CAMINO (.Bfloat)

- Run tensor model fit with CAMINO

- Convert from CAMINO to NIfTI

http://www.diffusion-imaging.com/2015/10/what-is-diffusion-tensor.html

7. Check the fit of the tensors



http://www.diffusion-imaging.com/2014/03/dti-quality-control-part-2-tensor.html

DTI Tutorial 1 - From Scanner to Tensor

7:55 PM Do Tromp 0 Comments

Starting out with data analysis often seems like a daunting task, as there are innumerable software packages with often poor documentation. To make this process easier and help you get started with diffusion imaging analyses I put together this tutorial that will introduce you to the most important processing steps and tools. Always keep in mind that there are

ABOUT THIS WEBSITE

"Diffusion Tensor Imaging is a cutting edge imaging technique that provides quantitative information with which to visualize and study connectivity and continuity of neural pathways in the central and peripheral nervous systems *in vivo.*"(Basser et al. 2000).

This website intends to show what DTI entails and give a comprehensive overview of available software, analyzing methods and research possibilities.

Diffusion imaging related questions?
Check the discussion forum

POPULAR POSTS

DTI Scalars (FA, MD, AD, RD) - How do they

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