Computational Brain Connectivity Mapping

Winter School Workshop 2017 – November 20-24 2017, Juan-les-Pins, France

Quality assessment and correction methods for diffusion MRI data

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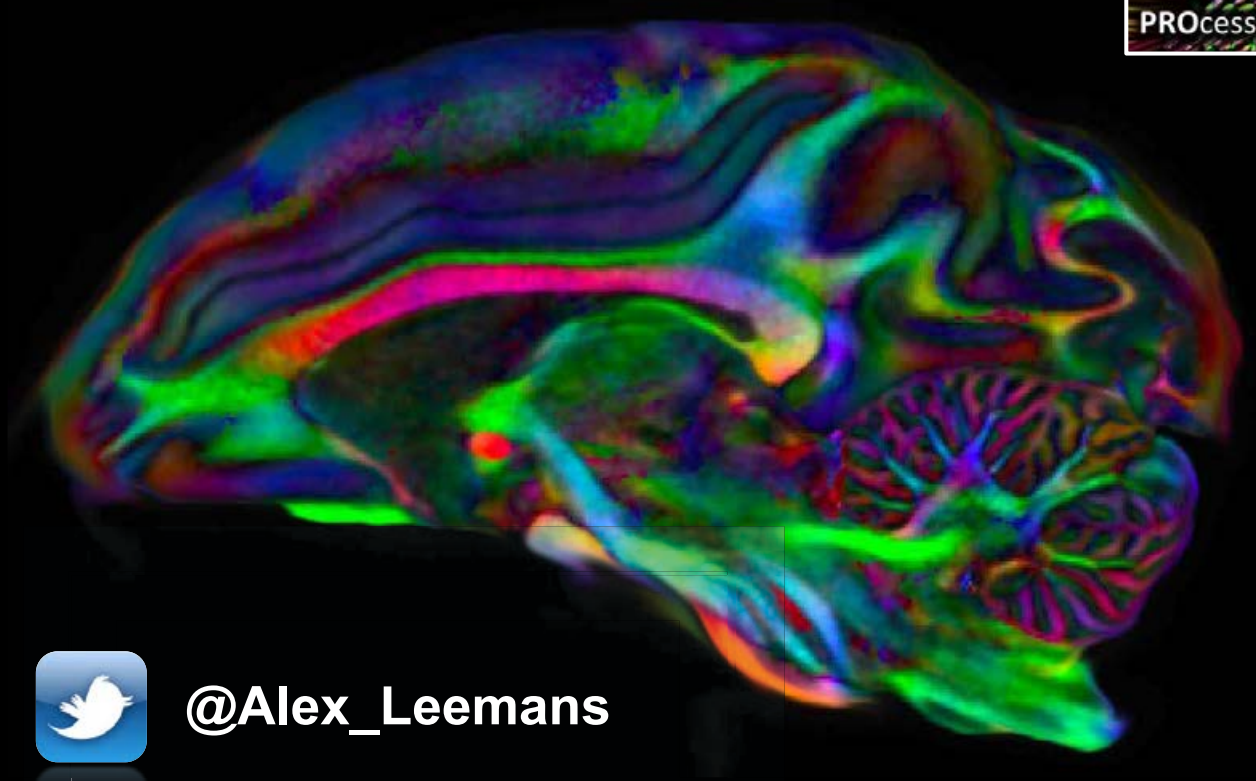
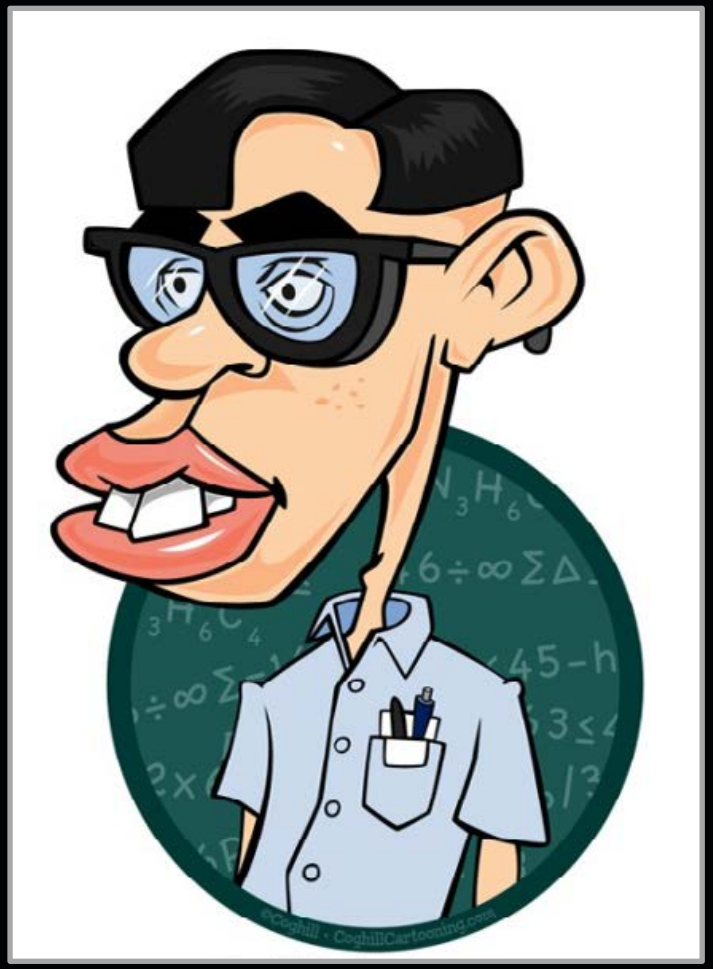
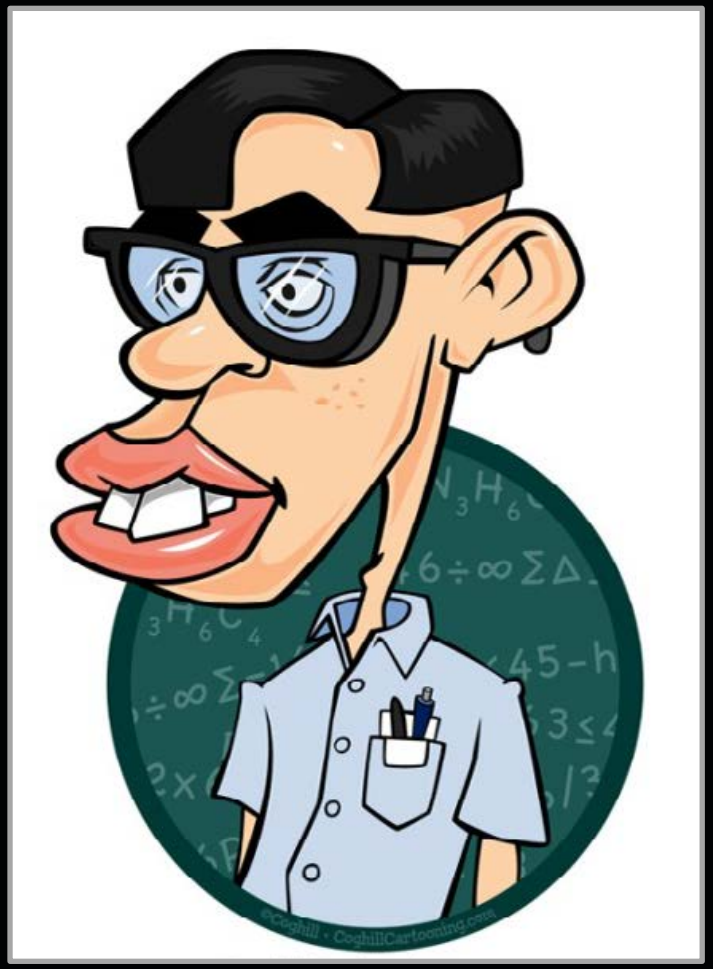


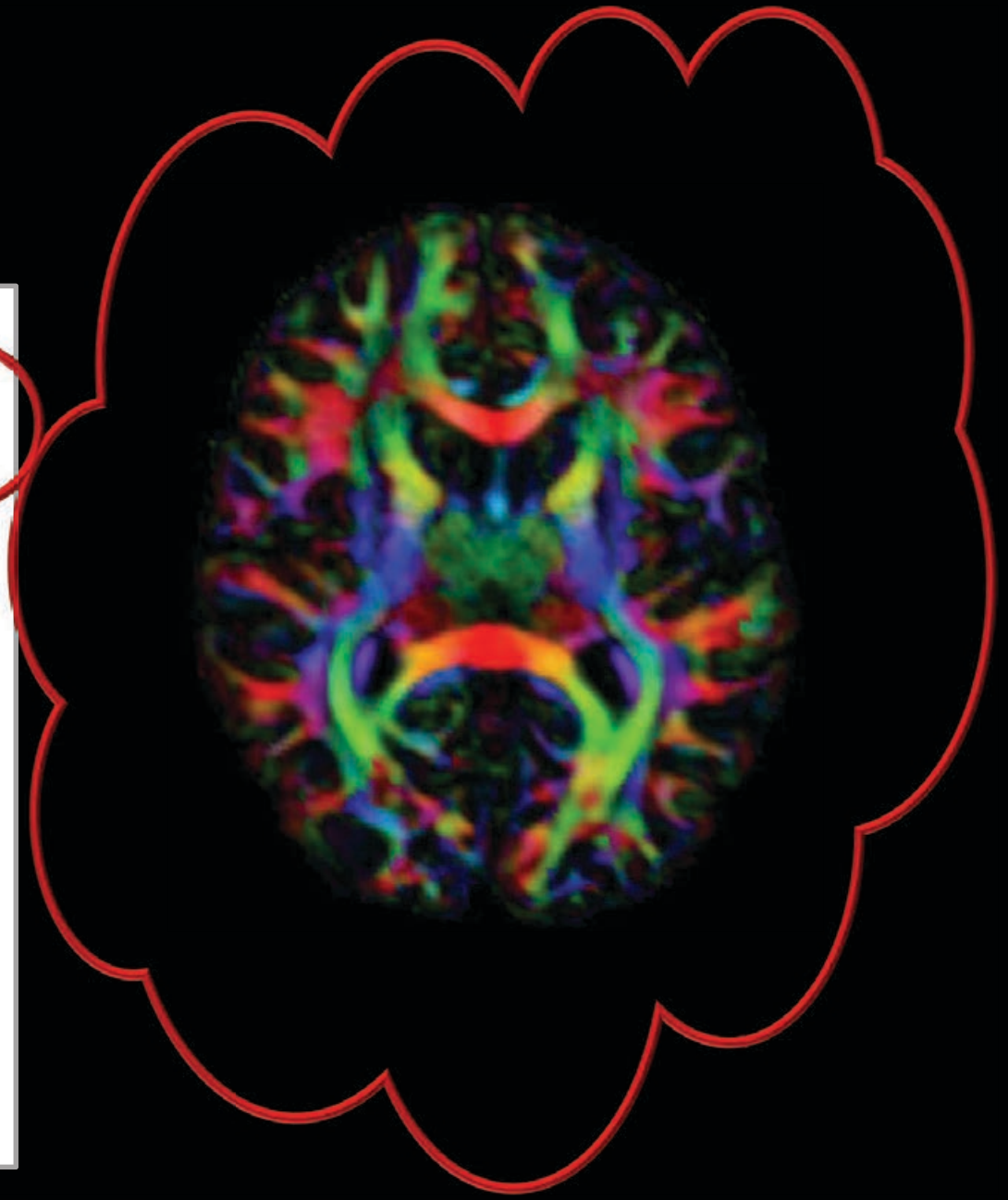
A typical day at the office…

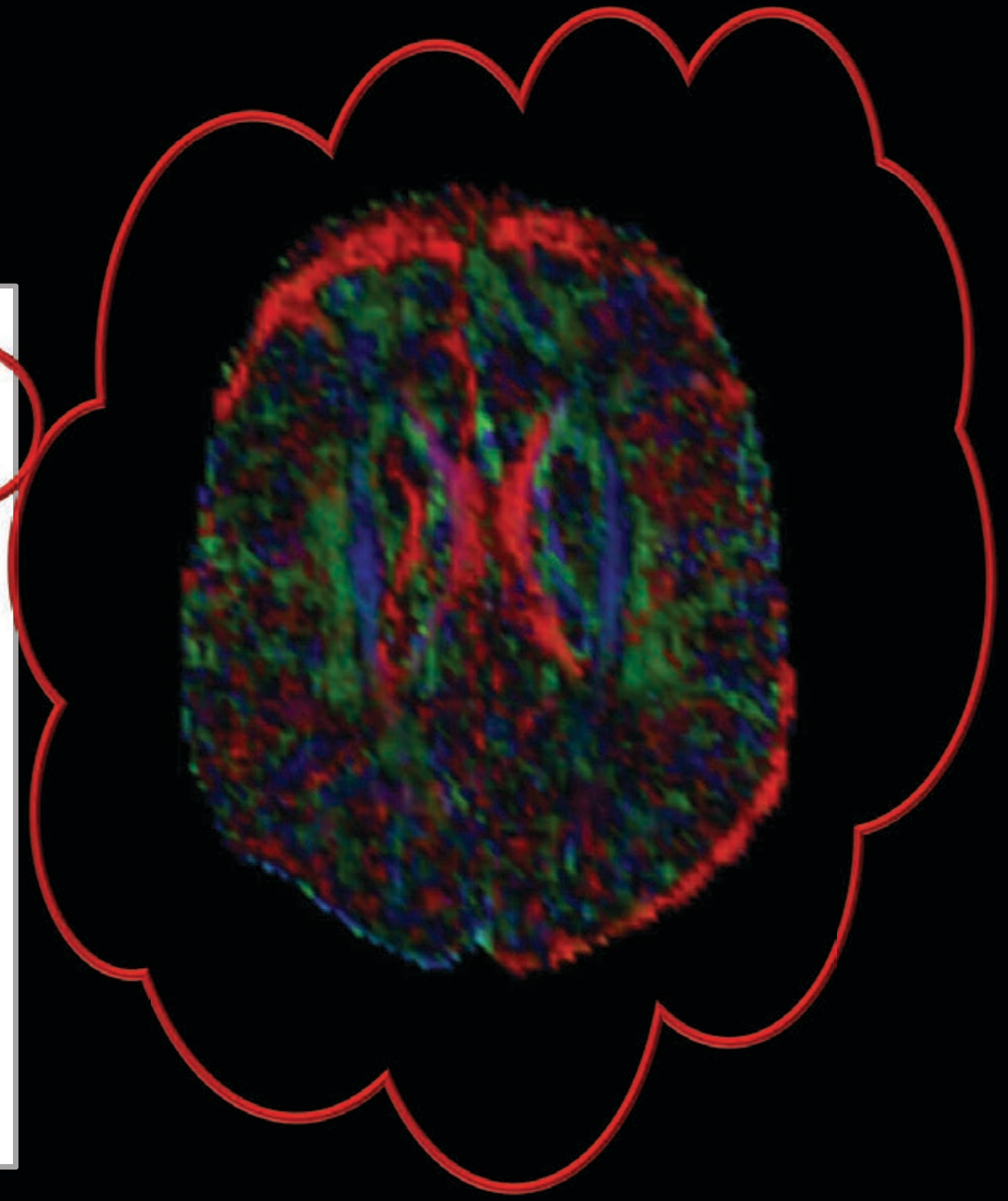


Hi Alex, I have been collecting “advanced DTI data”. Can you help me with the analysis?*

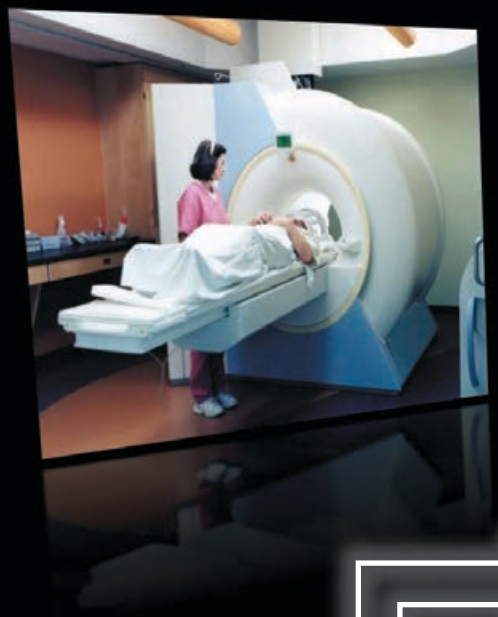


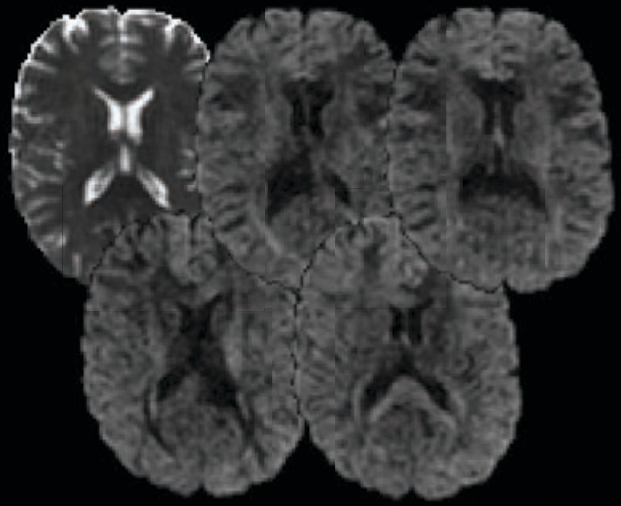
* *Read: “Can you do the analysis for me?”*

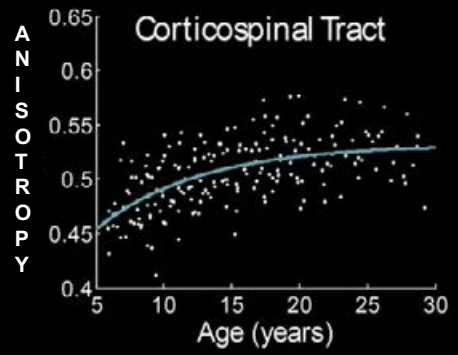


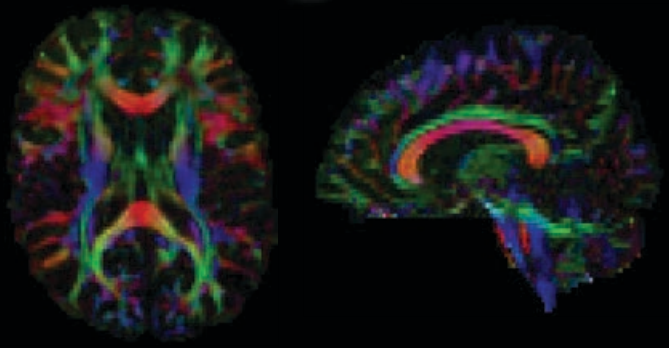


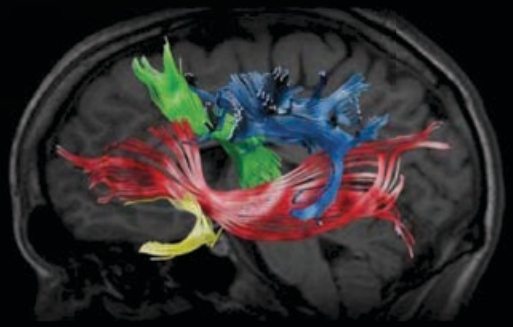
The pipeline ...



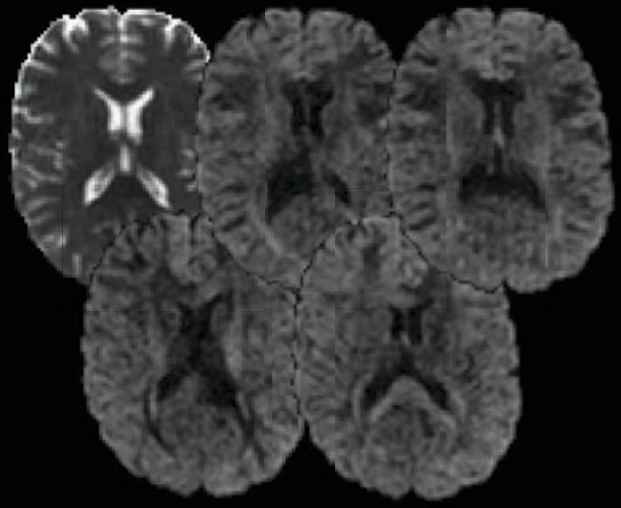


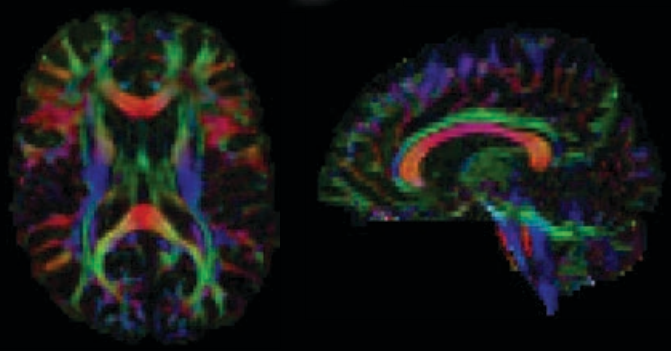




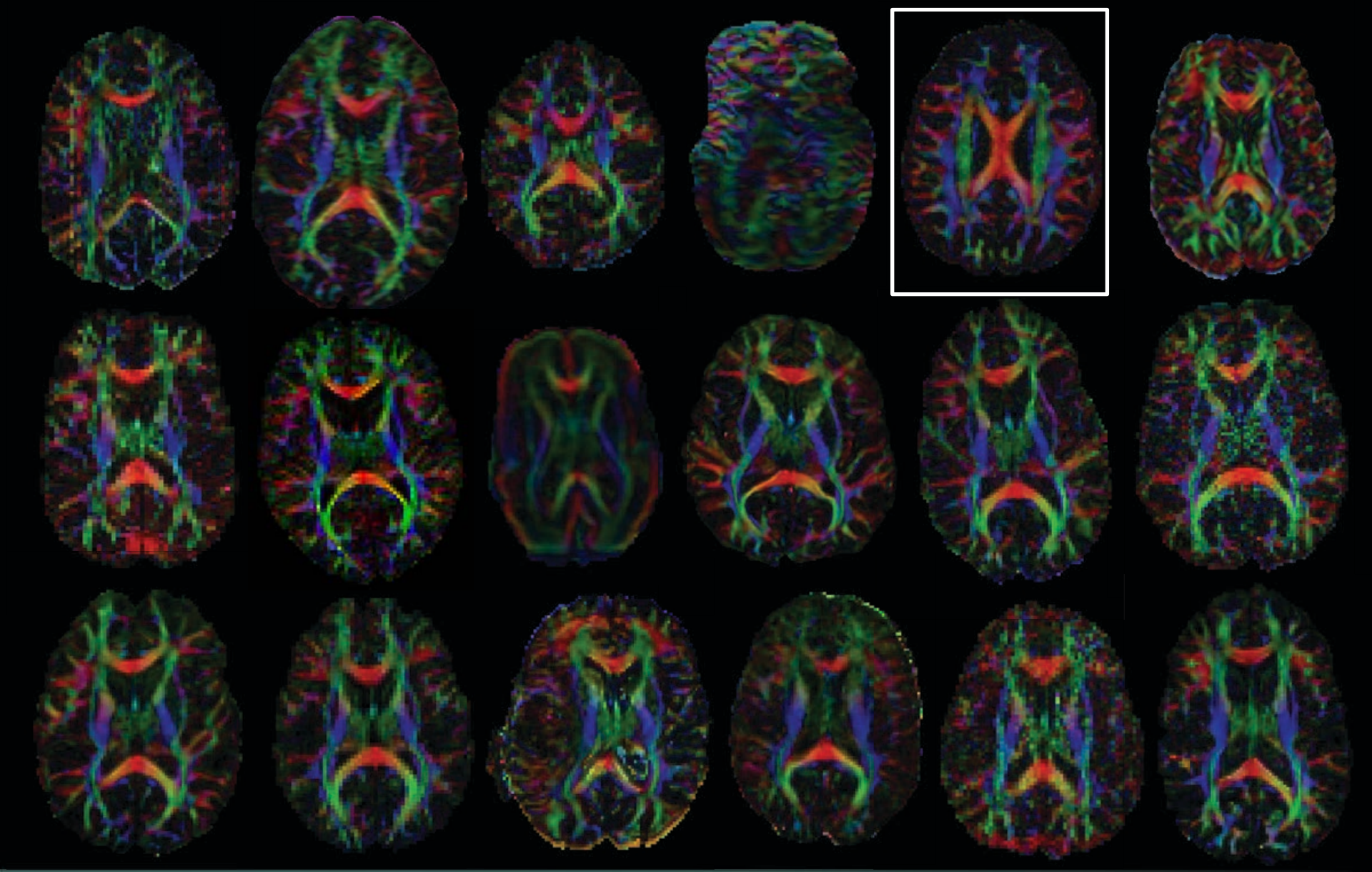


Data quality assessment ...





Data quality assessment ...



Tournier J.-D. et al, Magn Reson Med (2011)

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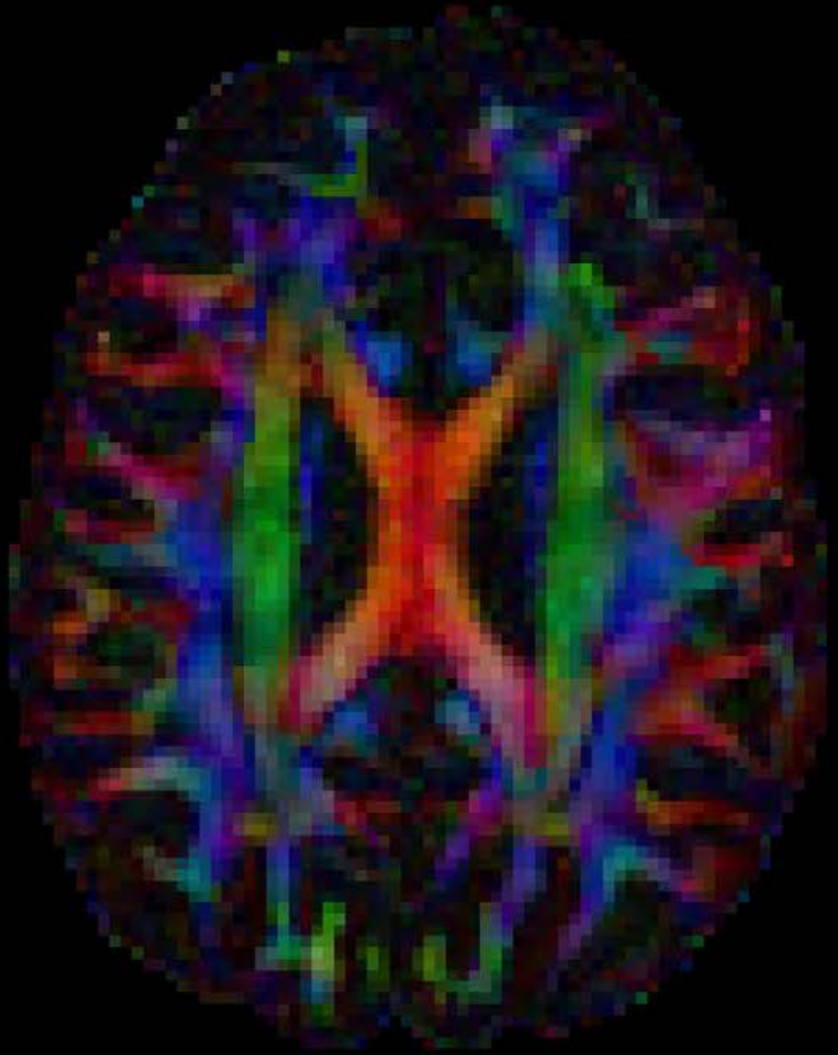
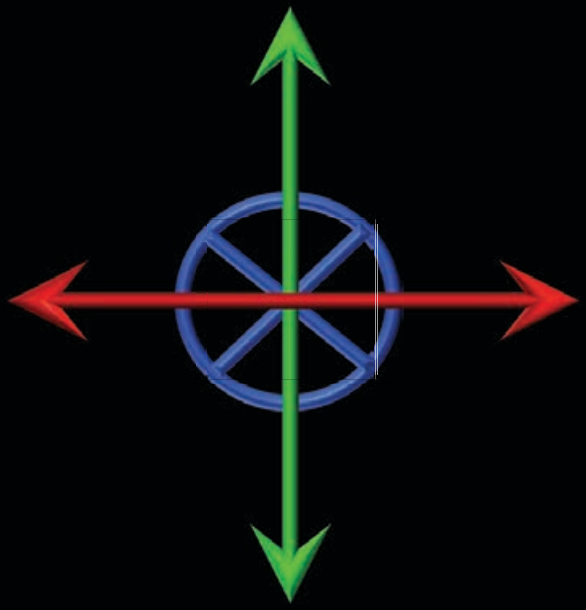
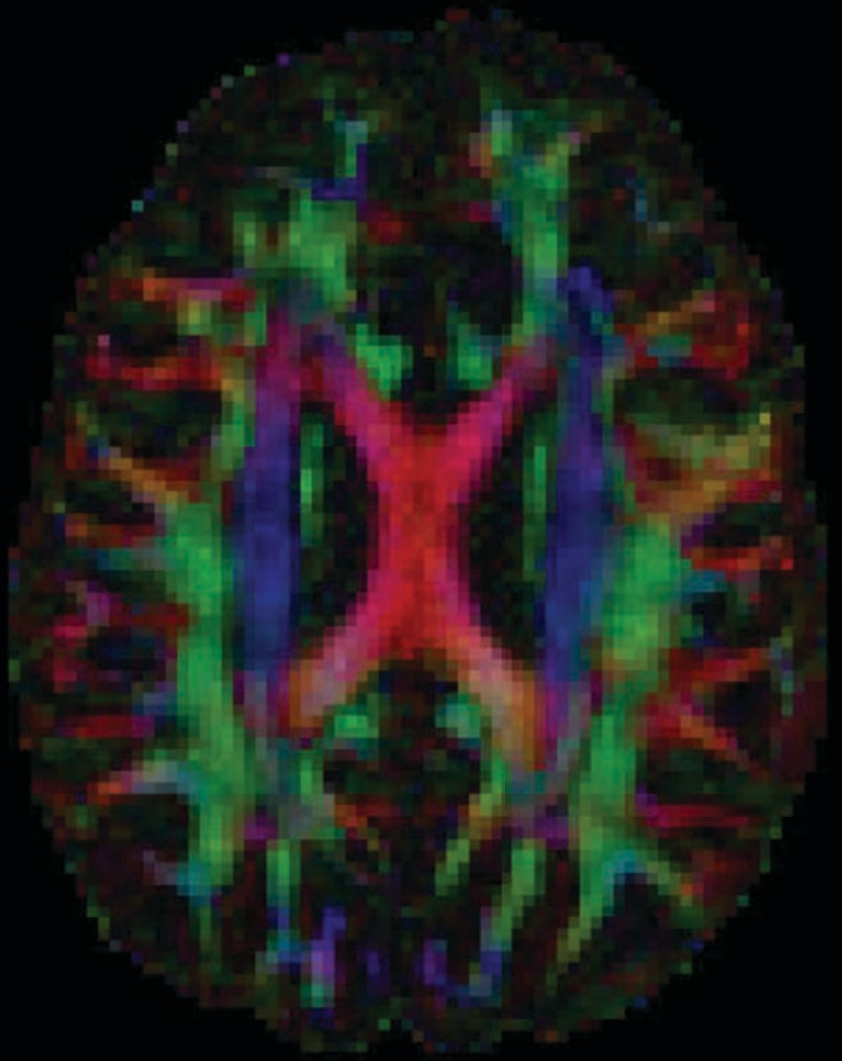
Data quality assessment ...

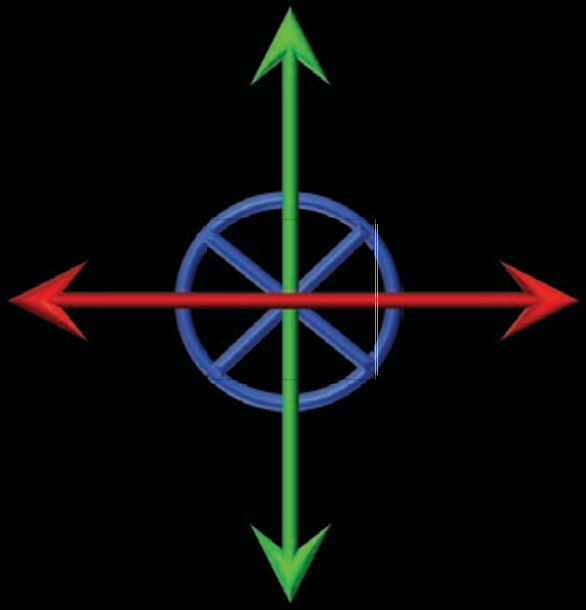




Color-encoding is not conventional

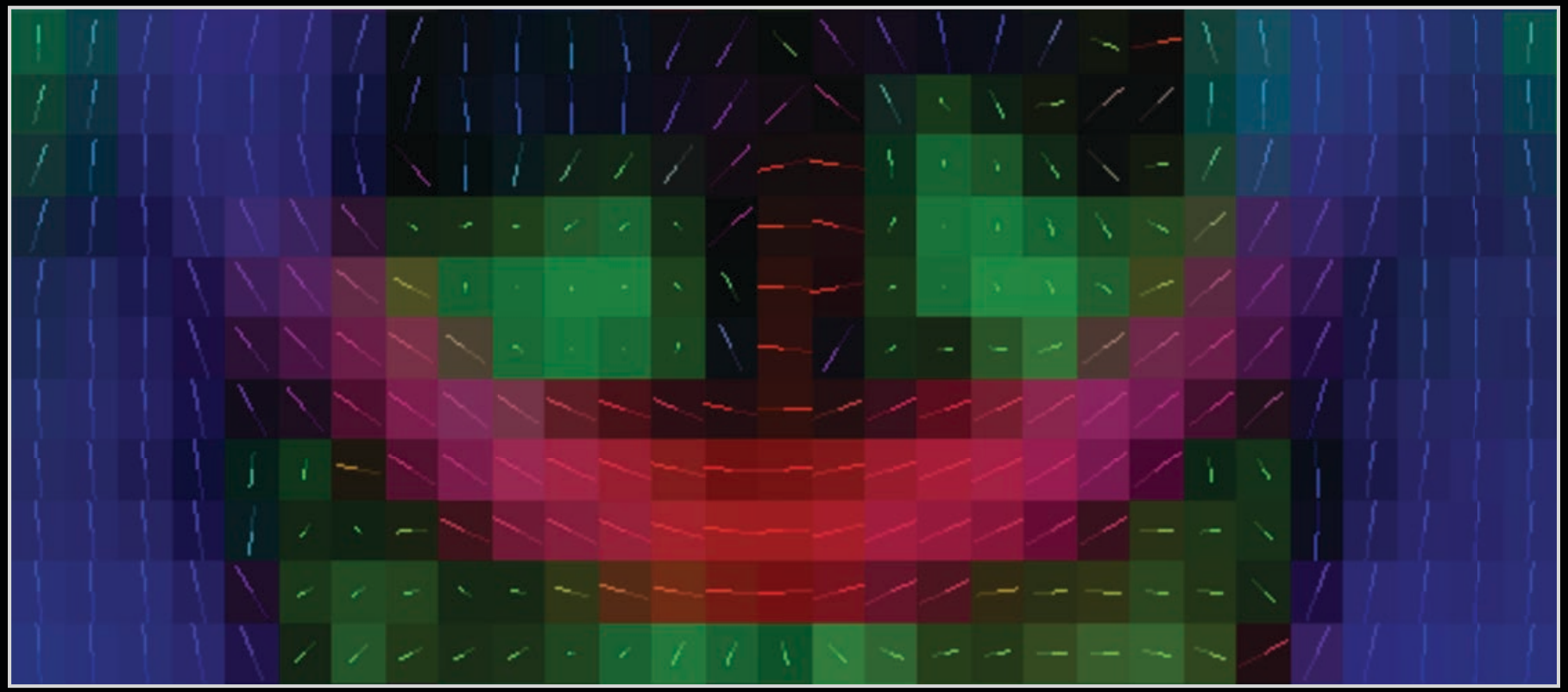
Data quality assessment ...





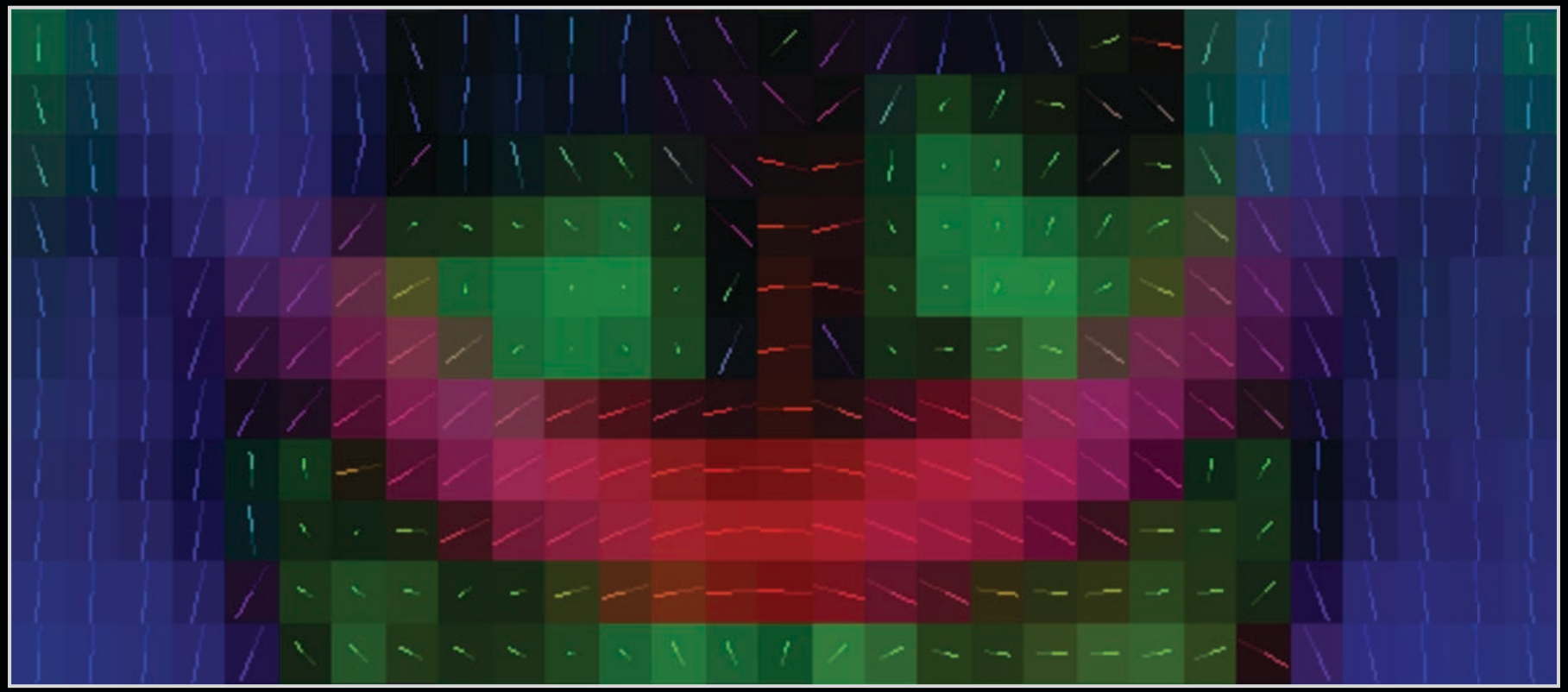
Conventional Color-encoding

Data quality assessment ...



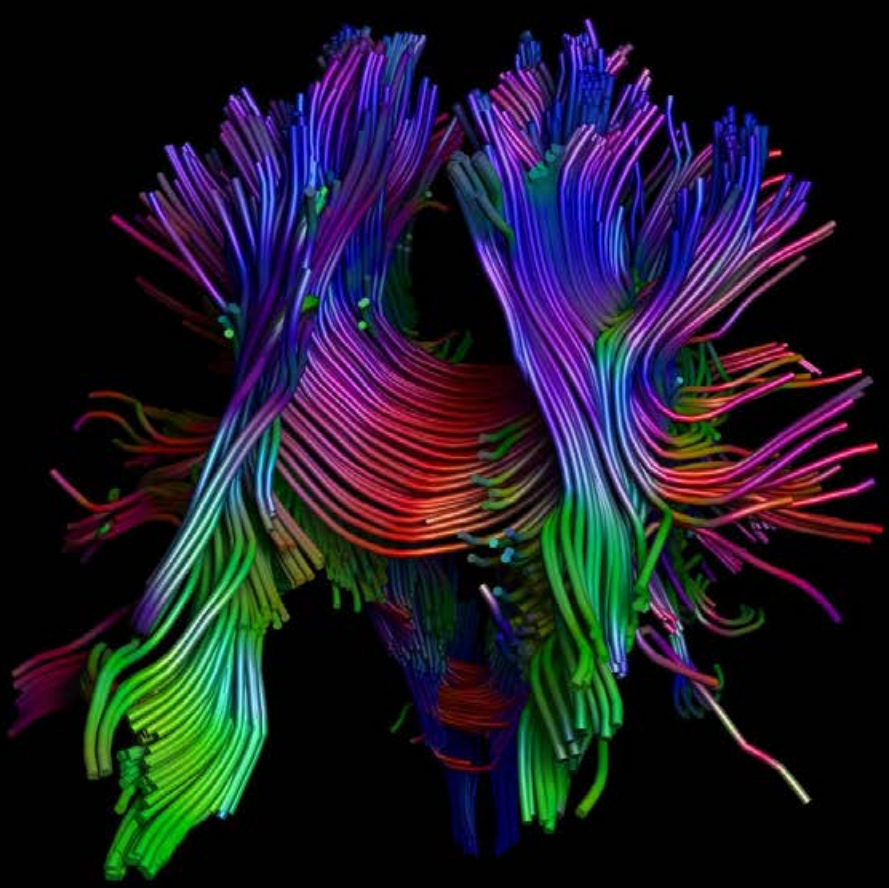
No axis mismatch

Data quality assessment ...



Axis “sign flip”

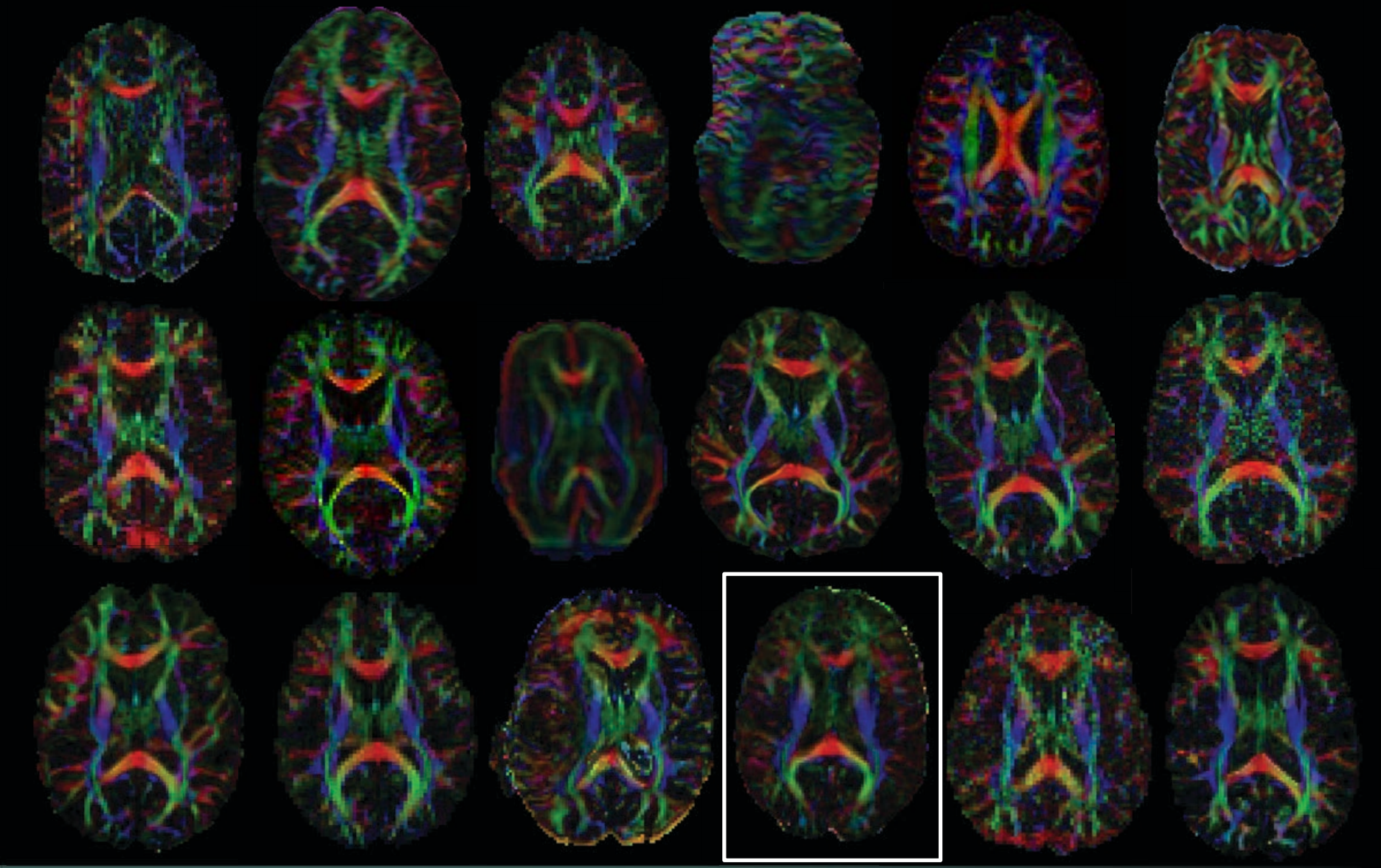
Data quality assessment ...



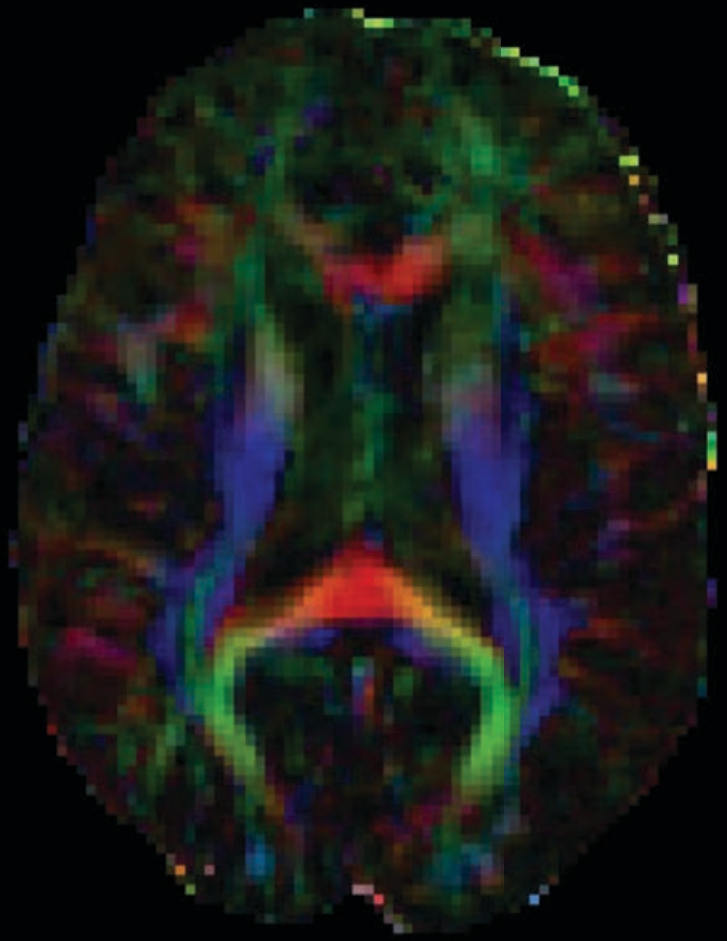
Axis “sign flip”

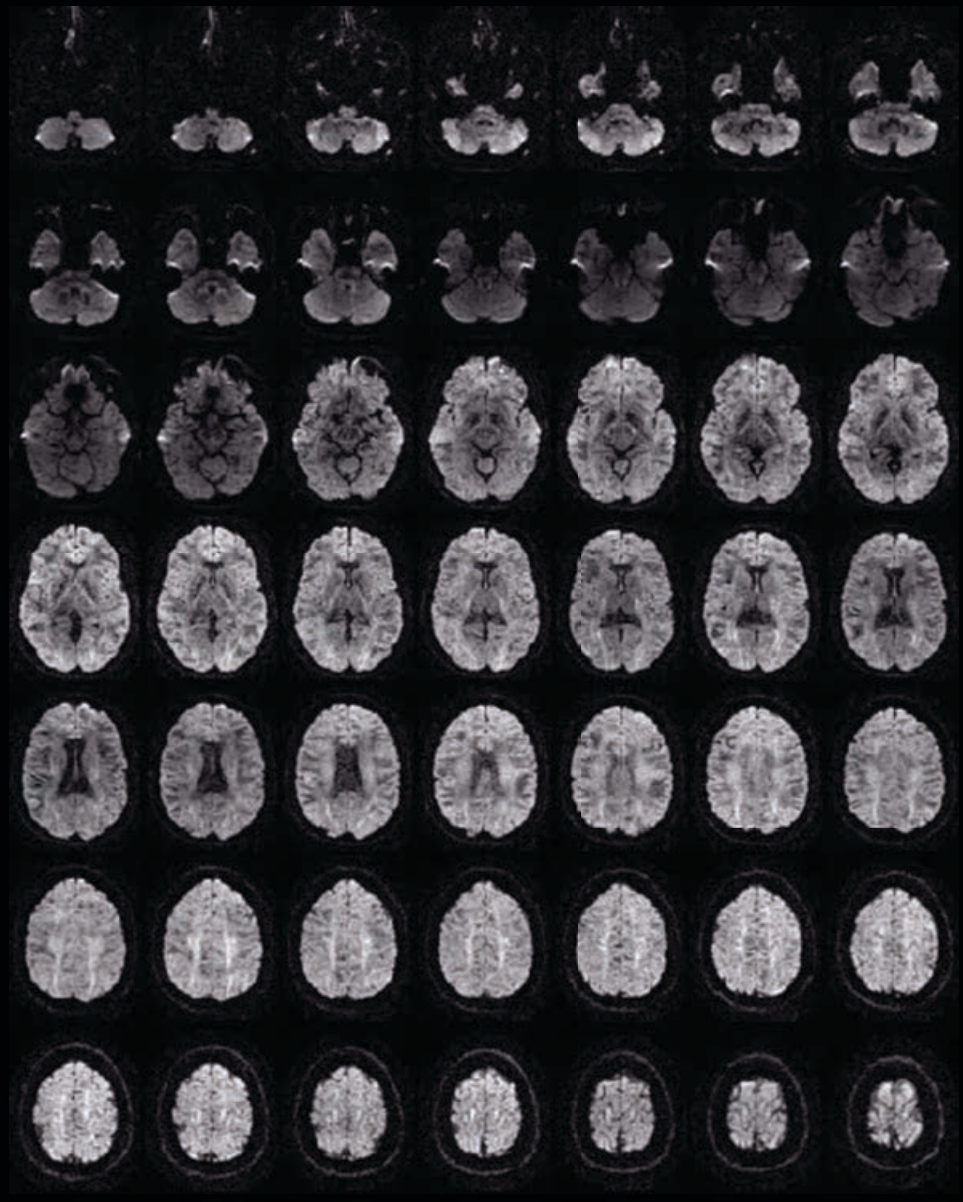
Correct

Data quality assessment ...



Data quality assessment ...



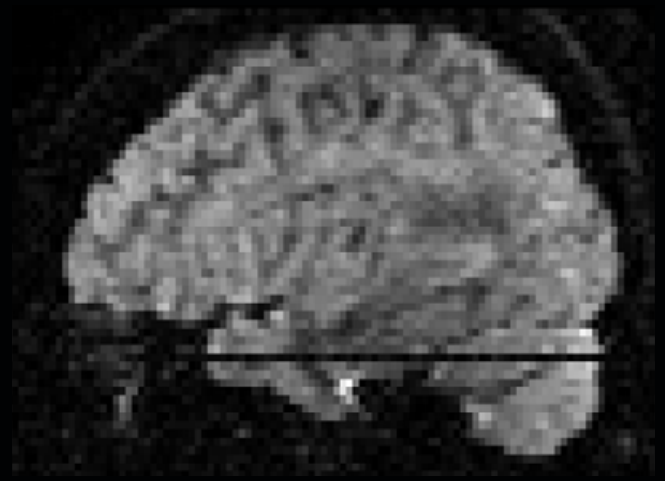


Look at your raw data!
Make a movie loop…

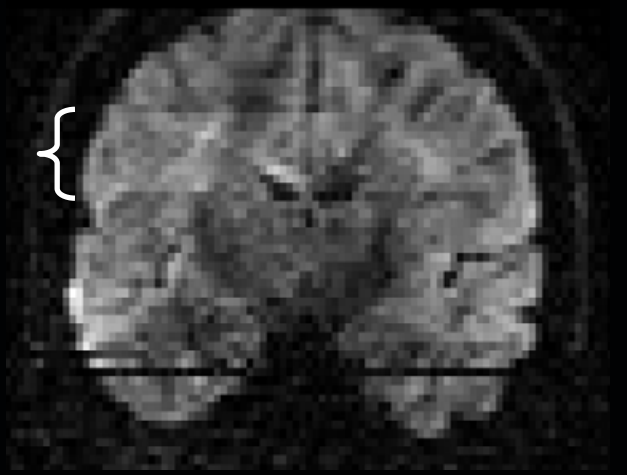
Data quality assessment ...

Different views!

Axial

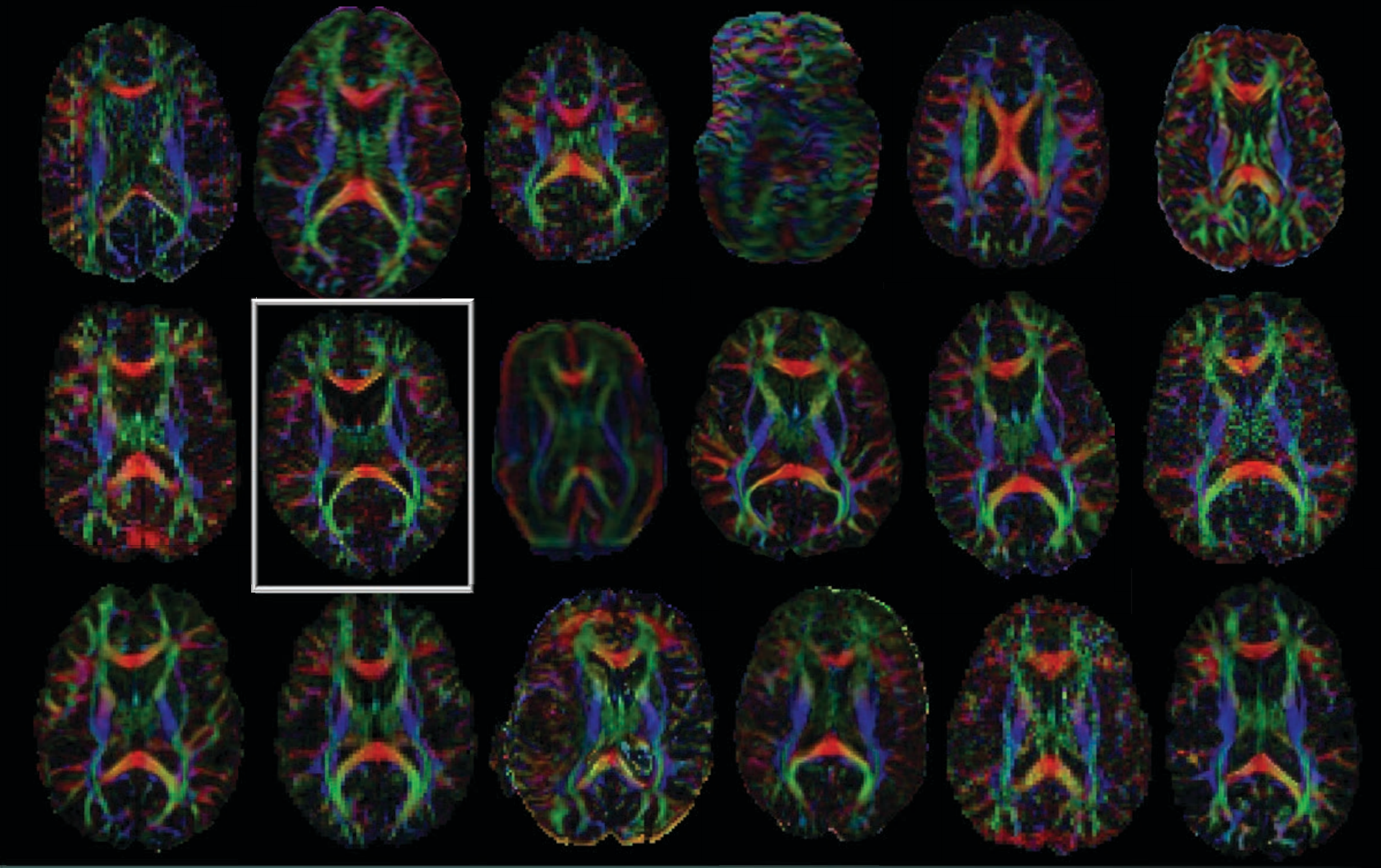


Sagittal

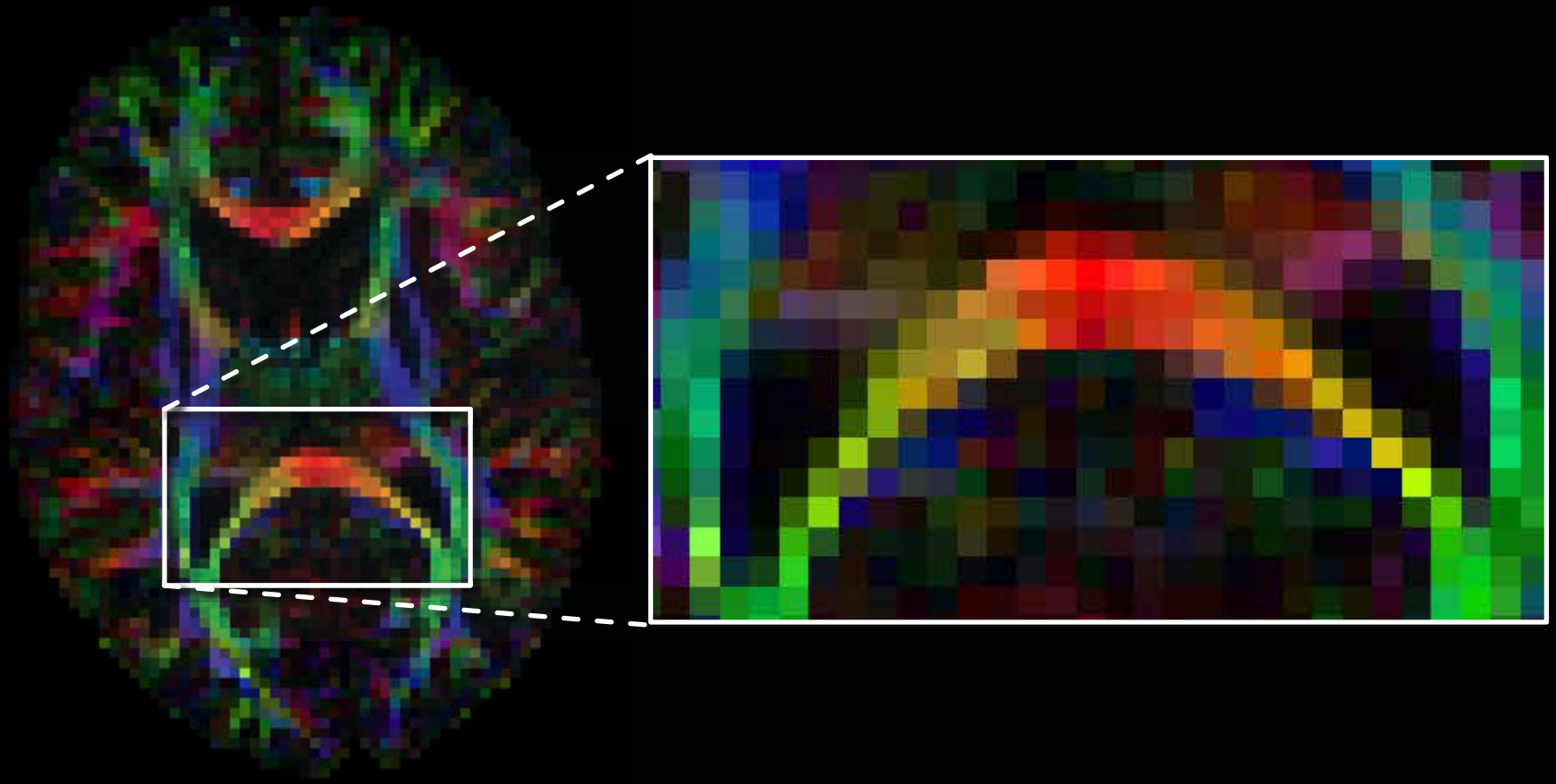


Coronal

Data quality assessment ...



Data quality assessment ...



Data quality assessment ...

"Physically Implausible Signals" (PIS)

$$S = S_0 e^{-b \cdot D}$$

S = diffusion weighted signal

S_0 = non-diffusion weighted signal

b = diffusion weighting

D = diffusion coefficient

Perrone D. et al, NeuroImage (2015)

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Data quality assessment ...

"Physically Implausible Signals" (PIS)

$$S = S_0 \underbrace{e^{-b \cdot D}}_{< 1}$$

$$\rightarrow S < S_0$$

S = diffusion weighted signal

S_0 = non-diffusion weighted signal

b = diffusion weighting

D = diffusion coefficient

Data quality assessment …

"Physically Implausible Signals" (PIS)

The painful reality …

$$S > S_0$$

S = diffusion weighted signal

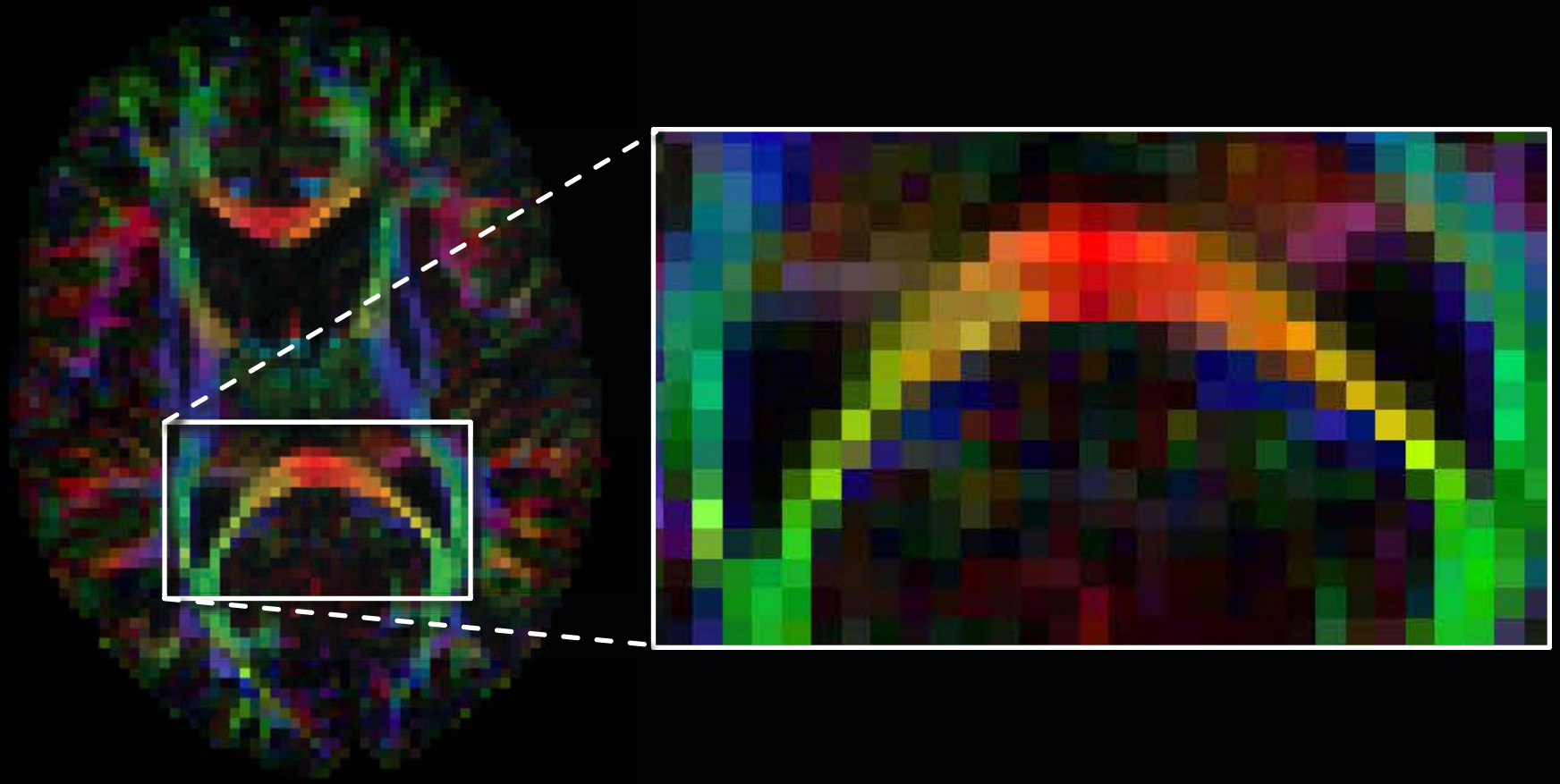
S_0 = non-diffusion weighted signal

b = diffusion weighting

D = diffusion coefficient

Data quality assessment ...

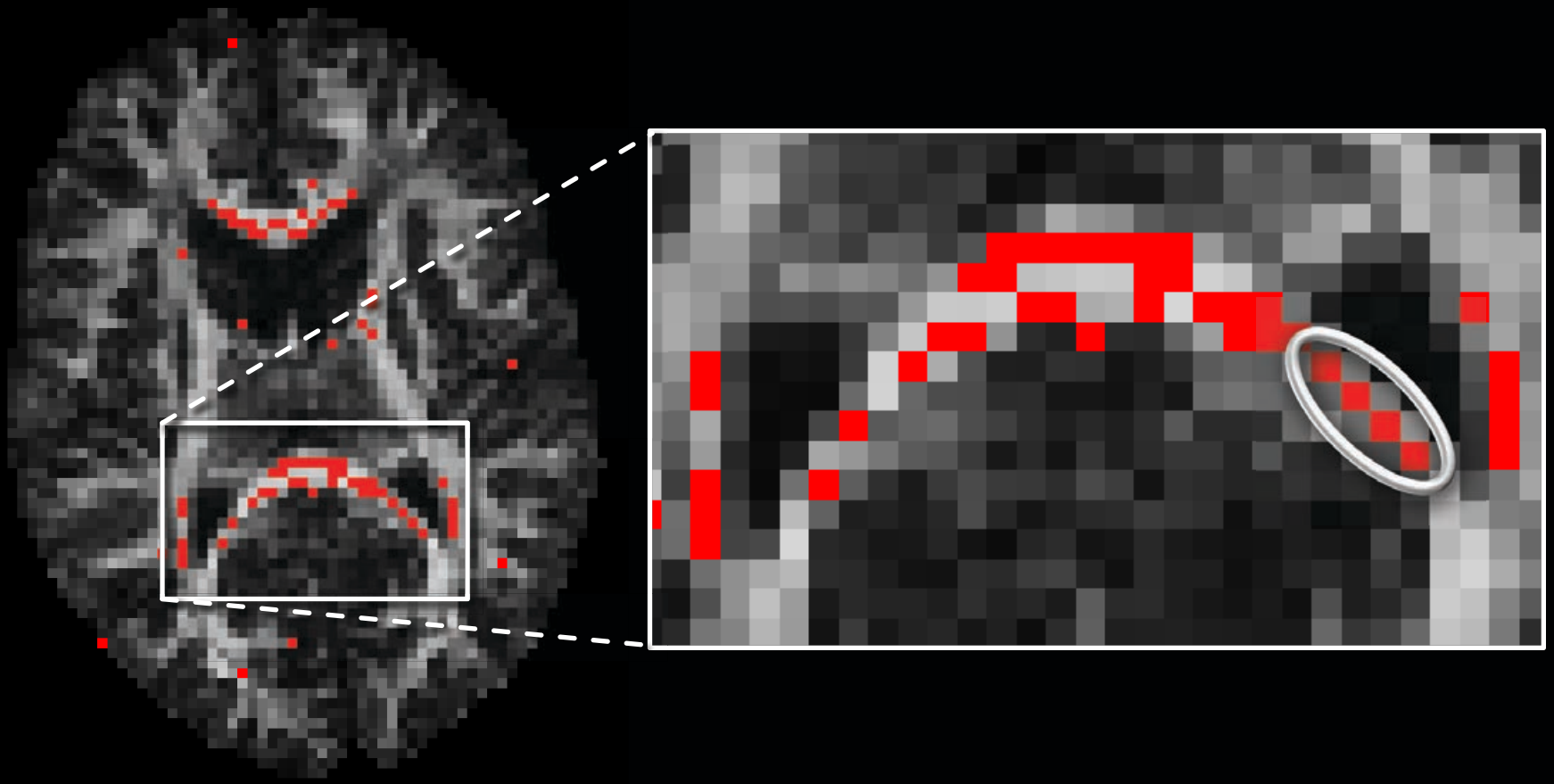
"Physically Implausible Signals" (PIS)



Color-coded fractional anisotropy (FA)

Data quality assessment ...

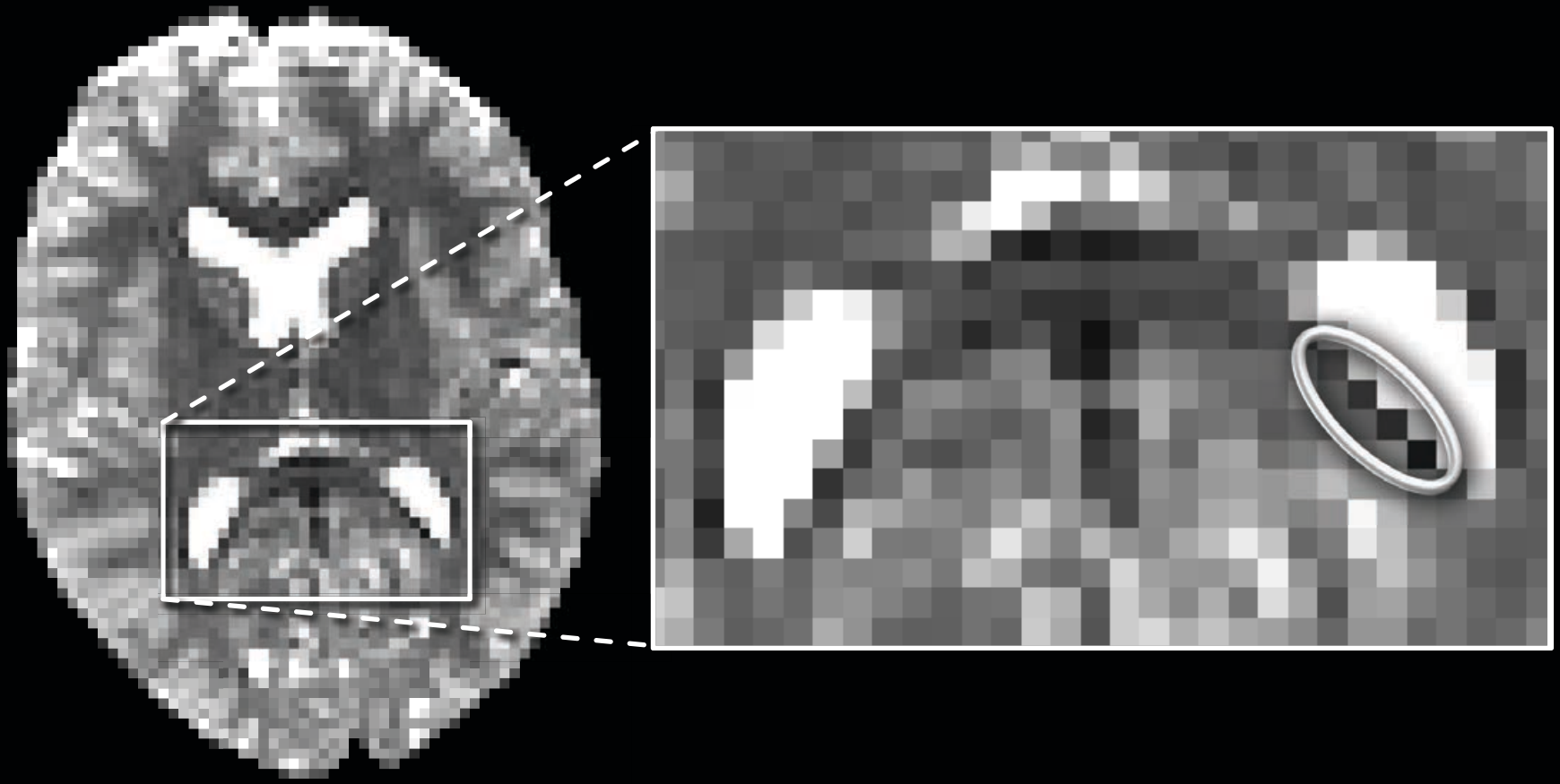
"Physically Implausible Signals" (PIS)



Regions with "PIS" ($S > S_0$) overlaid on FA!!!

Data quality assessment ...

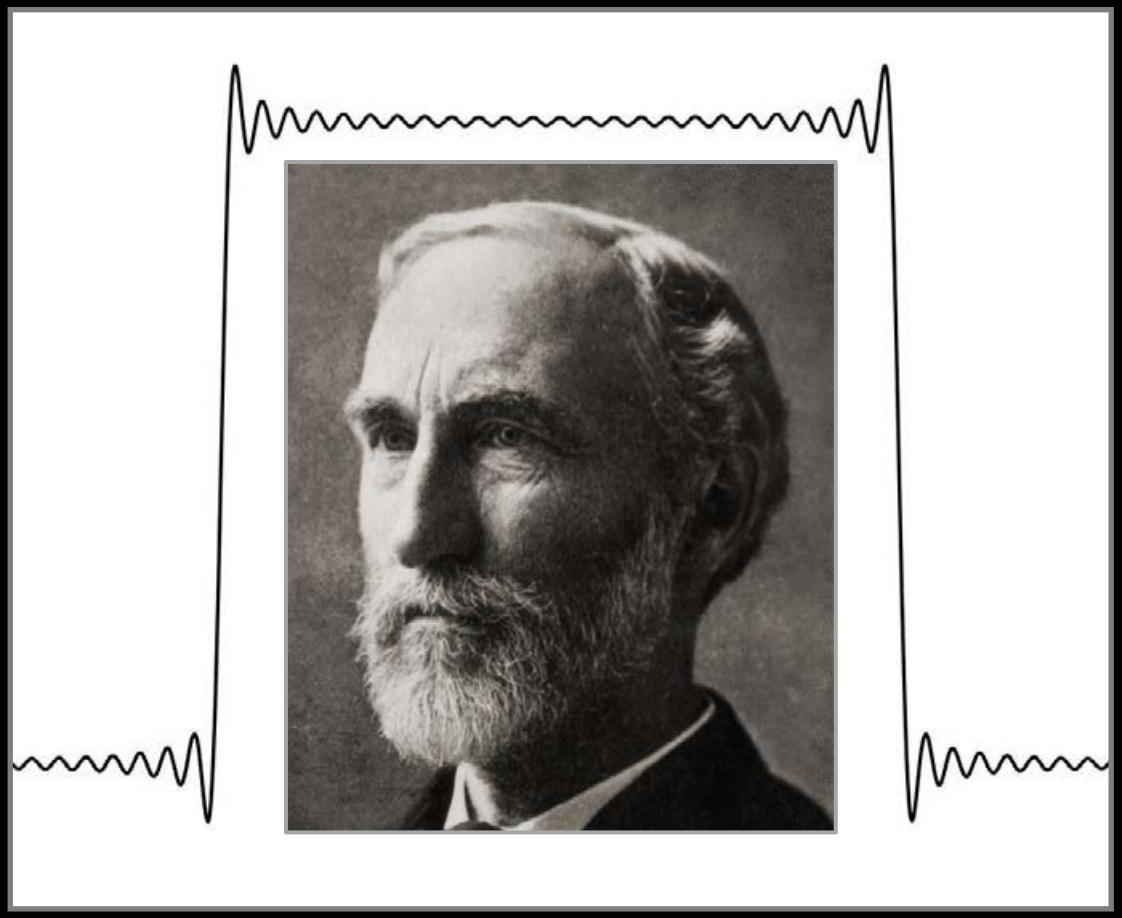
"Physically Implausible Signals" (PIS)



"PIS" → in regions with low S_0 values

Data quality assessment ...

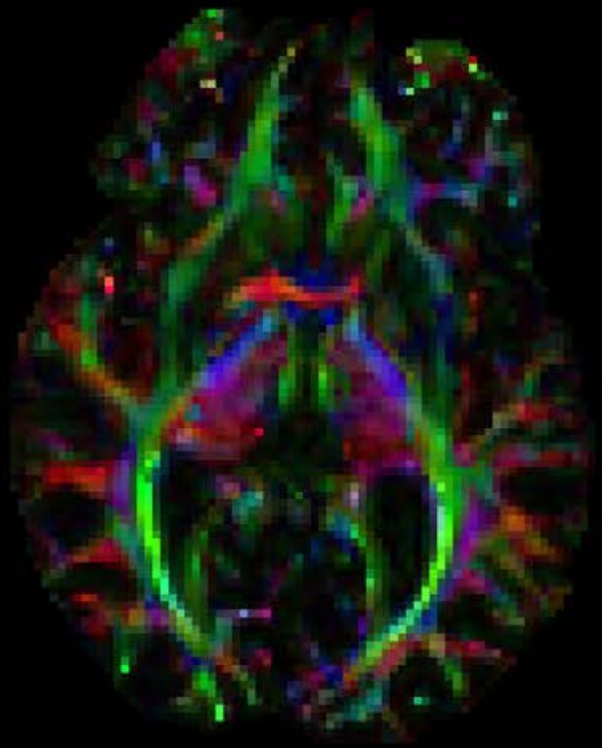
"Physically Implausible Signals" (PIS)



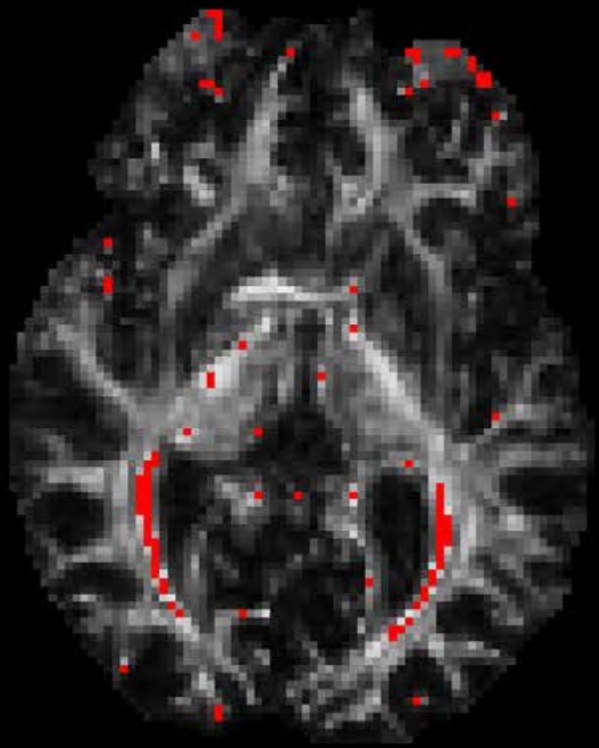
Josiah W. Gibbs

Data quality assessment ...

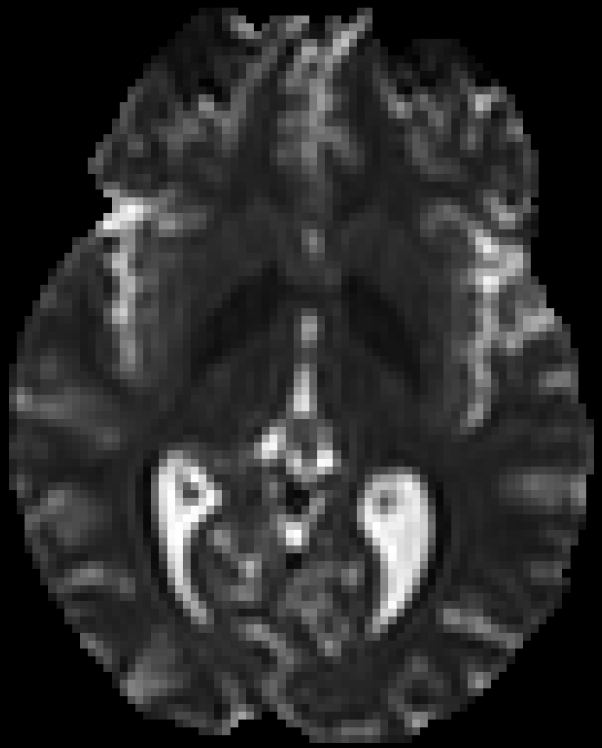
"Physically Implausible Signals" (PIS)



Color-coded FA



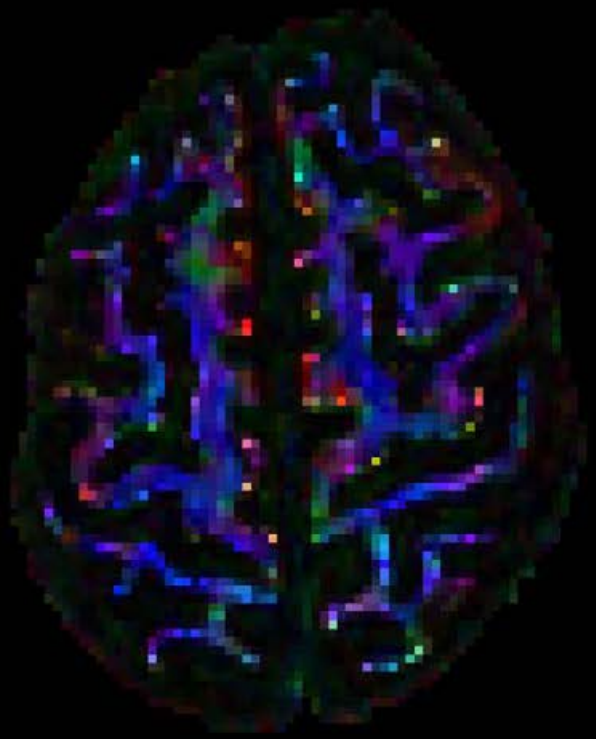
"PIS" on FA



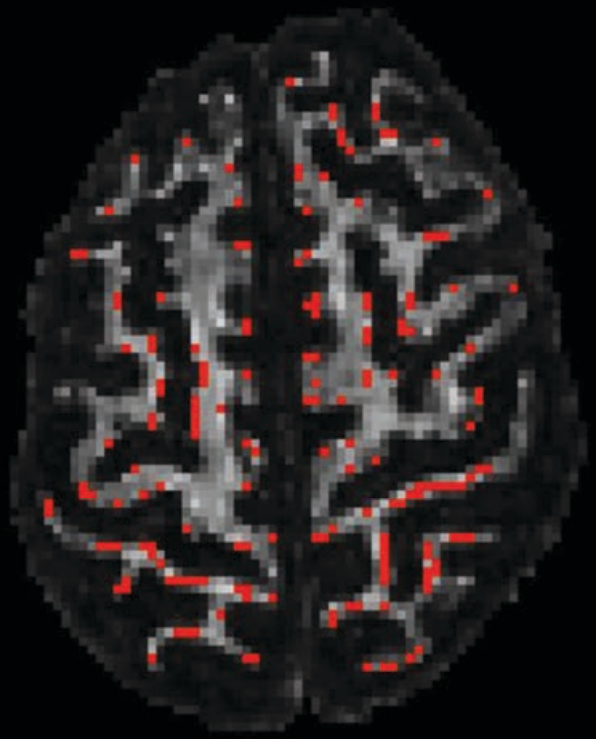
S_0

Data quality assessment ...

"Physically Implausible Signals" (PIS)



Color-coded FA

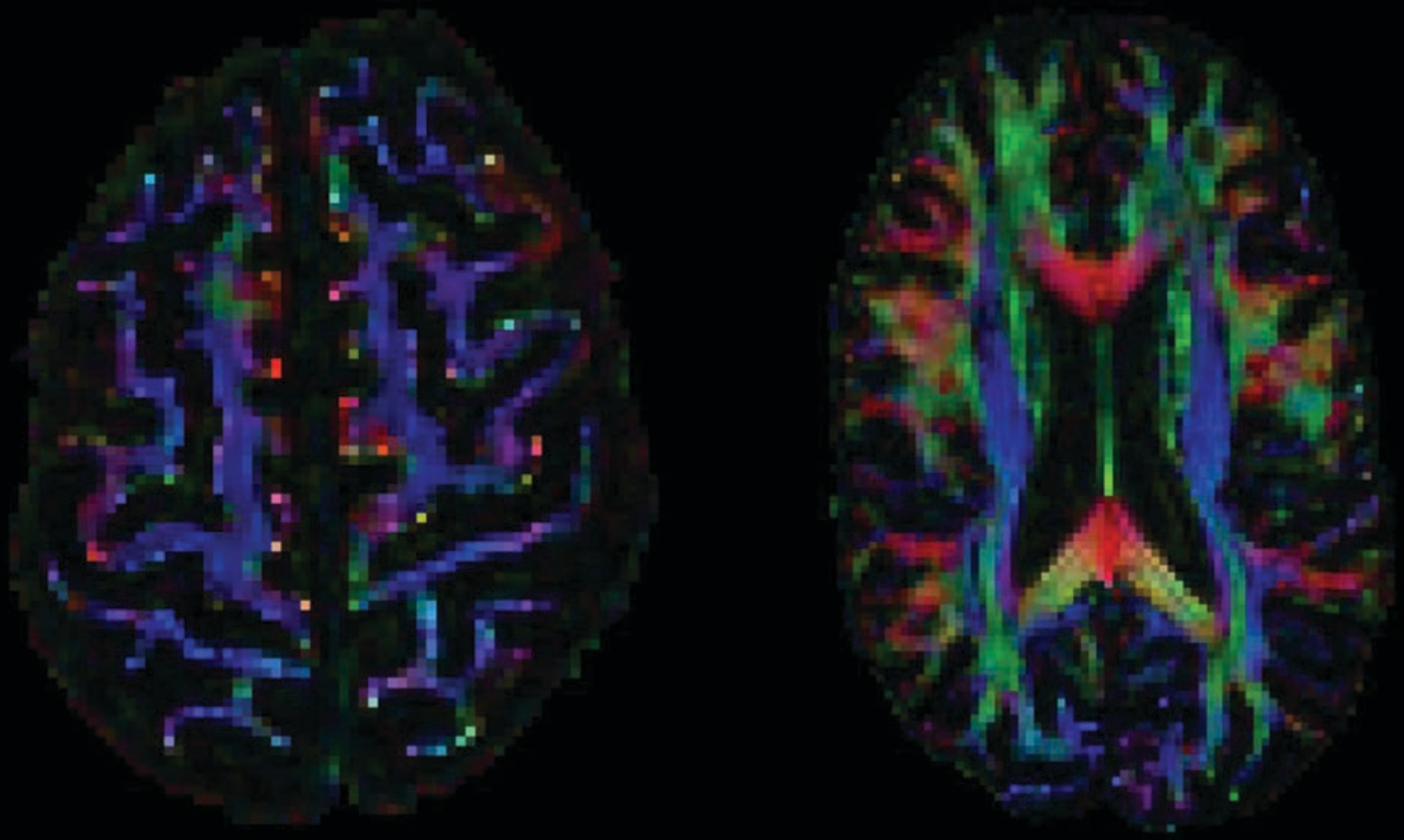


"PIS" on FA

S_0

Data quality assessment ...

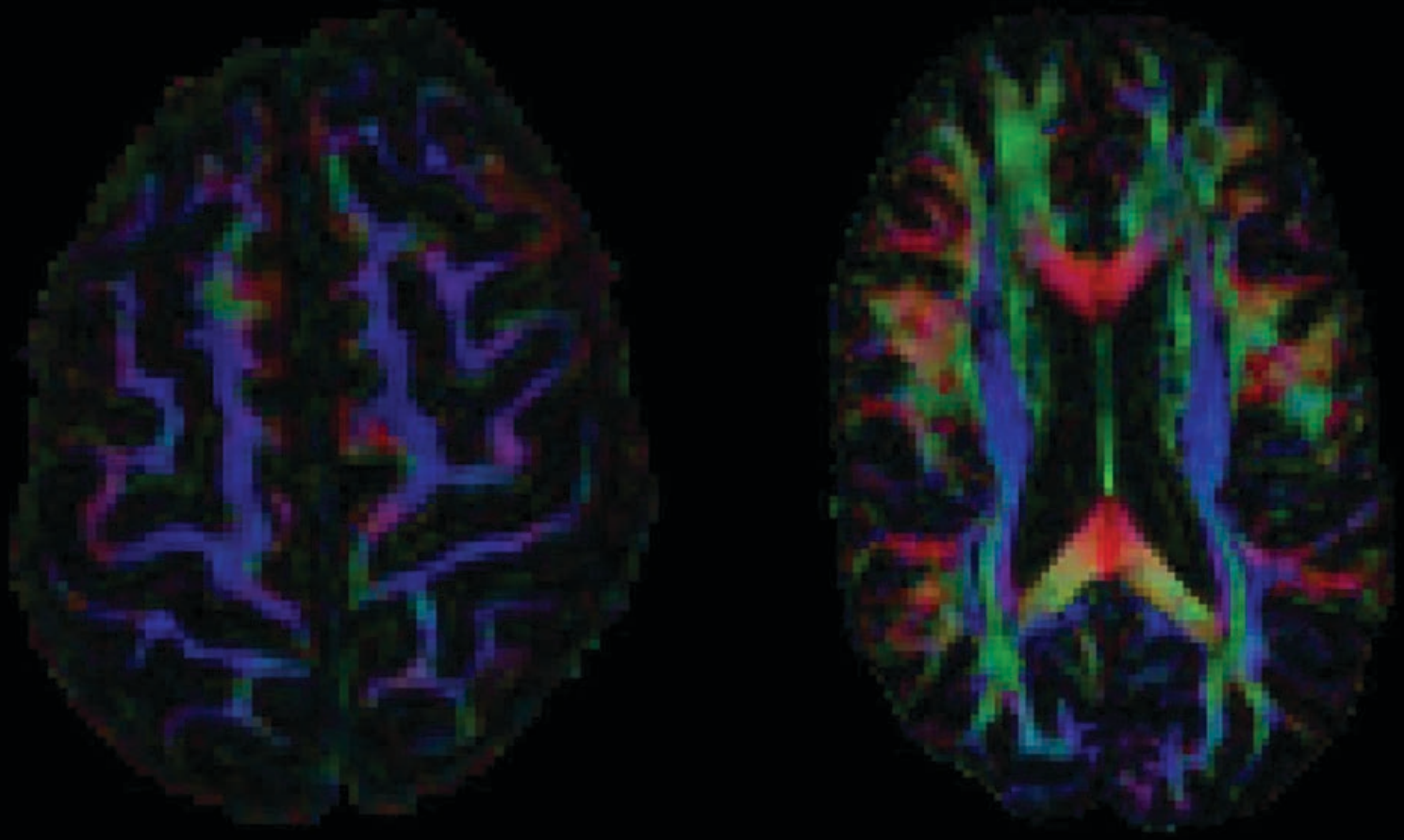
"Physically Implausible Signals" (PIS)



Before correcting for Gibbs ringing artifacts

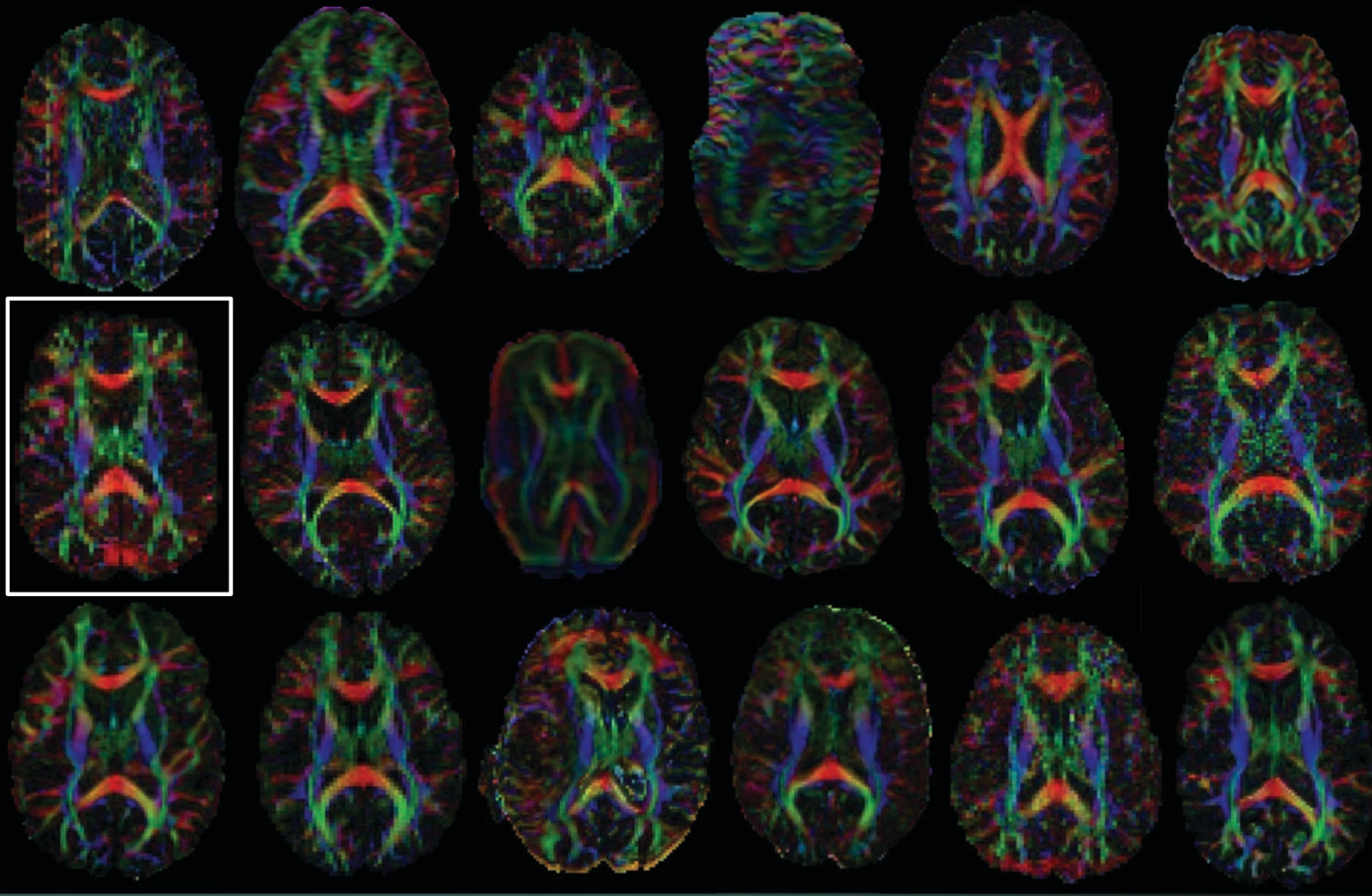
Data quality assessment ...

"Physically Implausible Signals" (PIS)



After correcting for Gibbs ringing artifacts

Data quality assessment ...



Tournier J.-D. et al, Magn Reson Med (2011)

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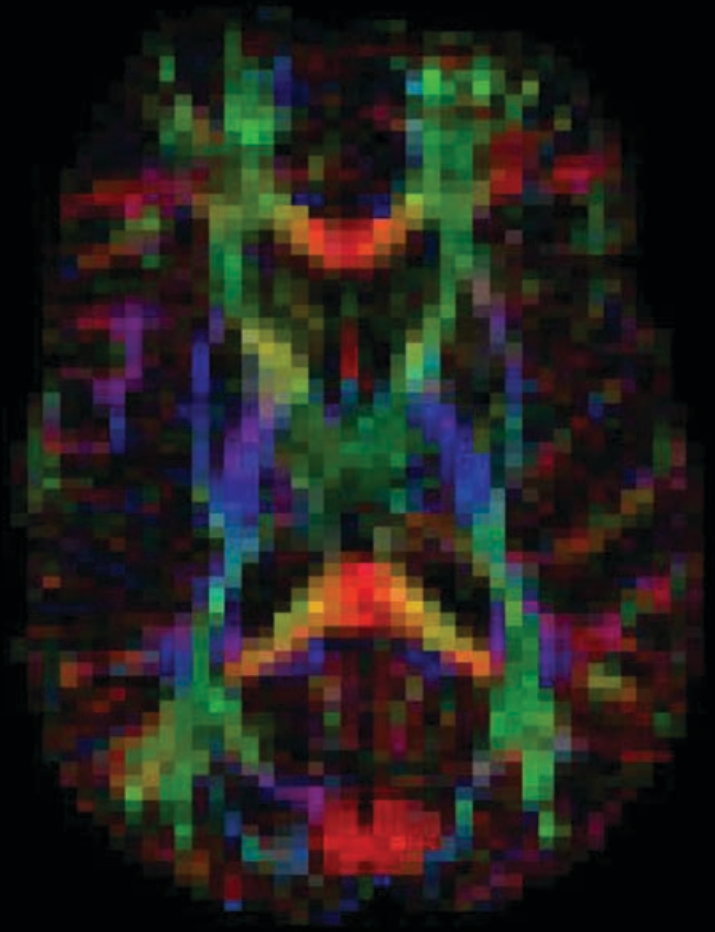
Data quality assessment ...

Residuals from the model estimation

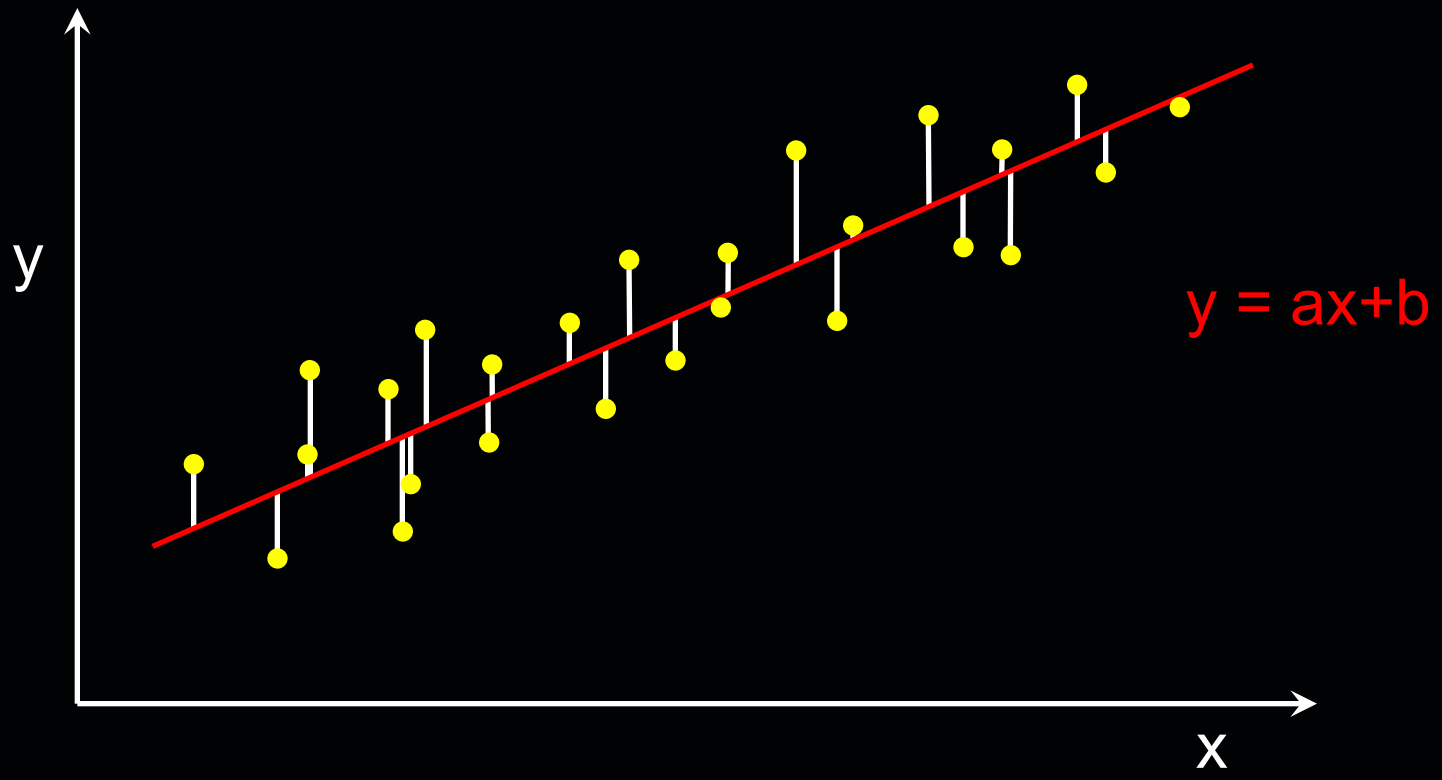


Data quality assessment ...

Residuals from the model estimation

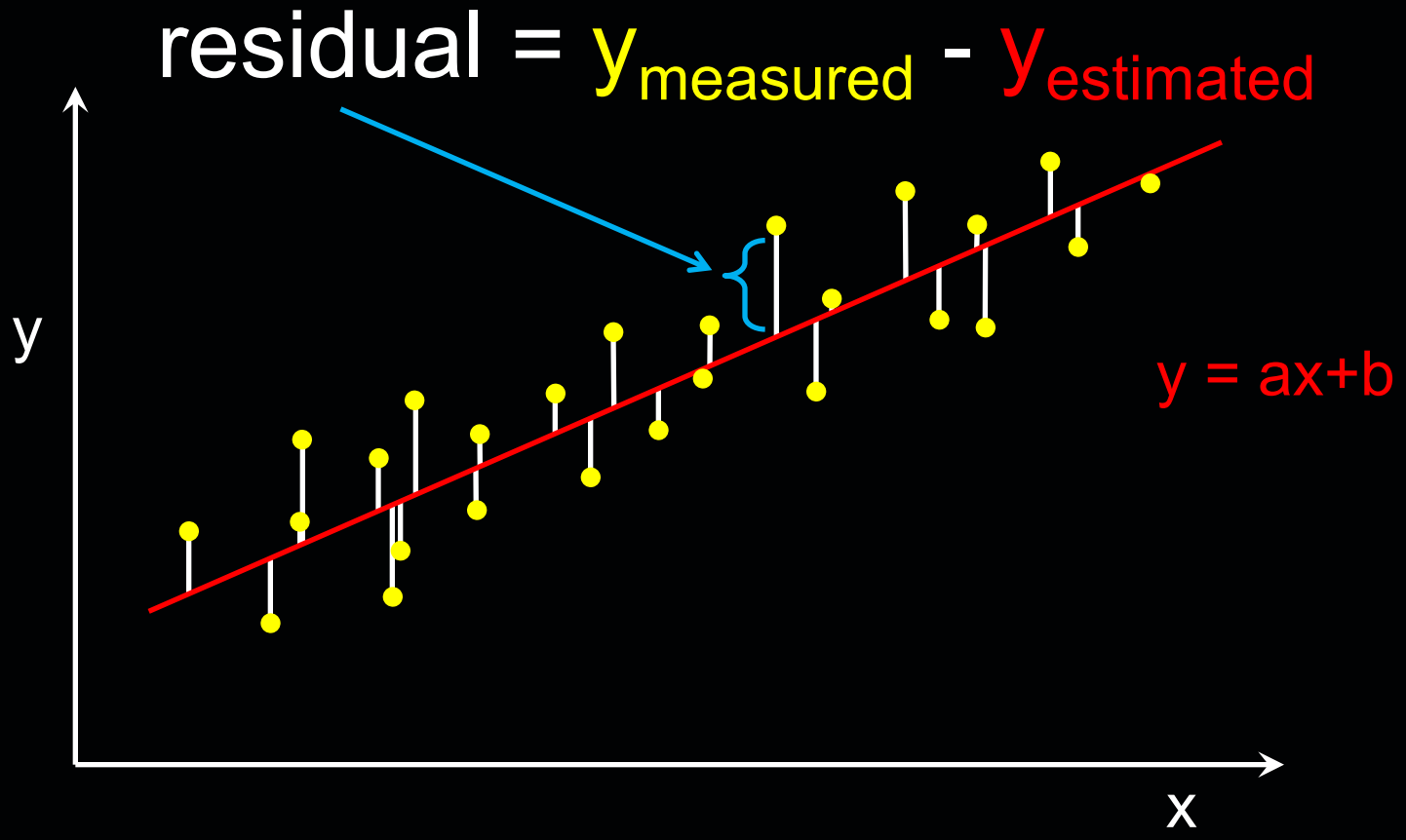
Data quality assessment ...

Residuals from the model estimation



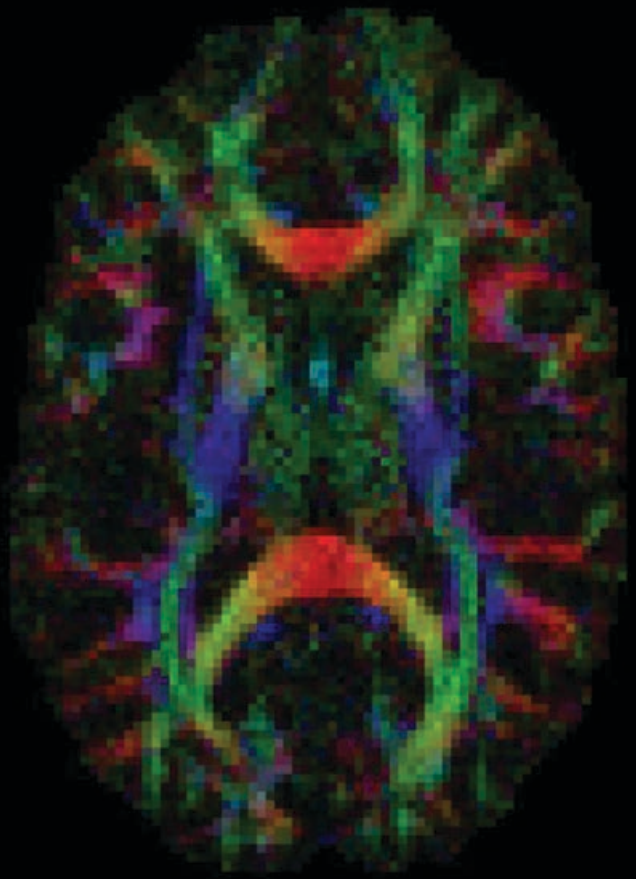
Data quality assessment ...

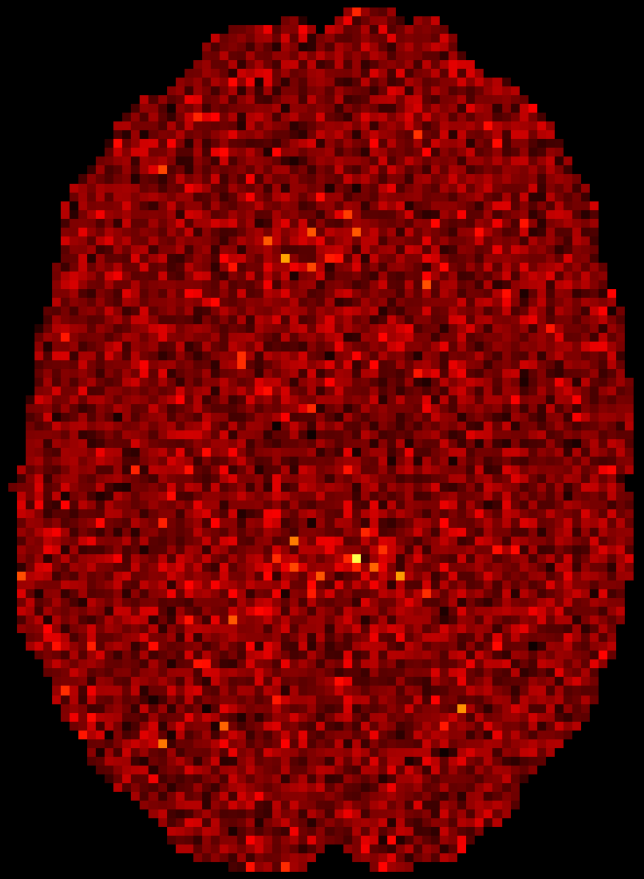
Residuals from the model estimation



Data quality assessment ...

Residuals from the model estimation

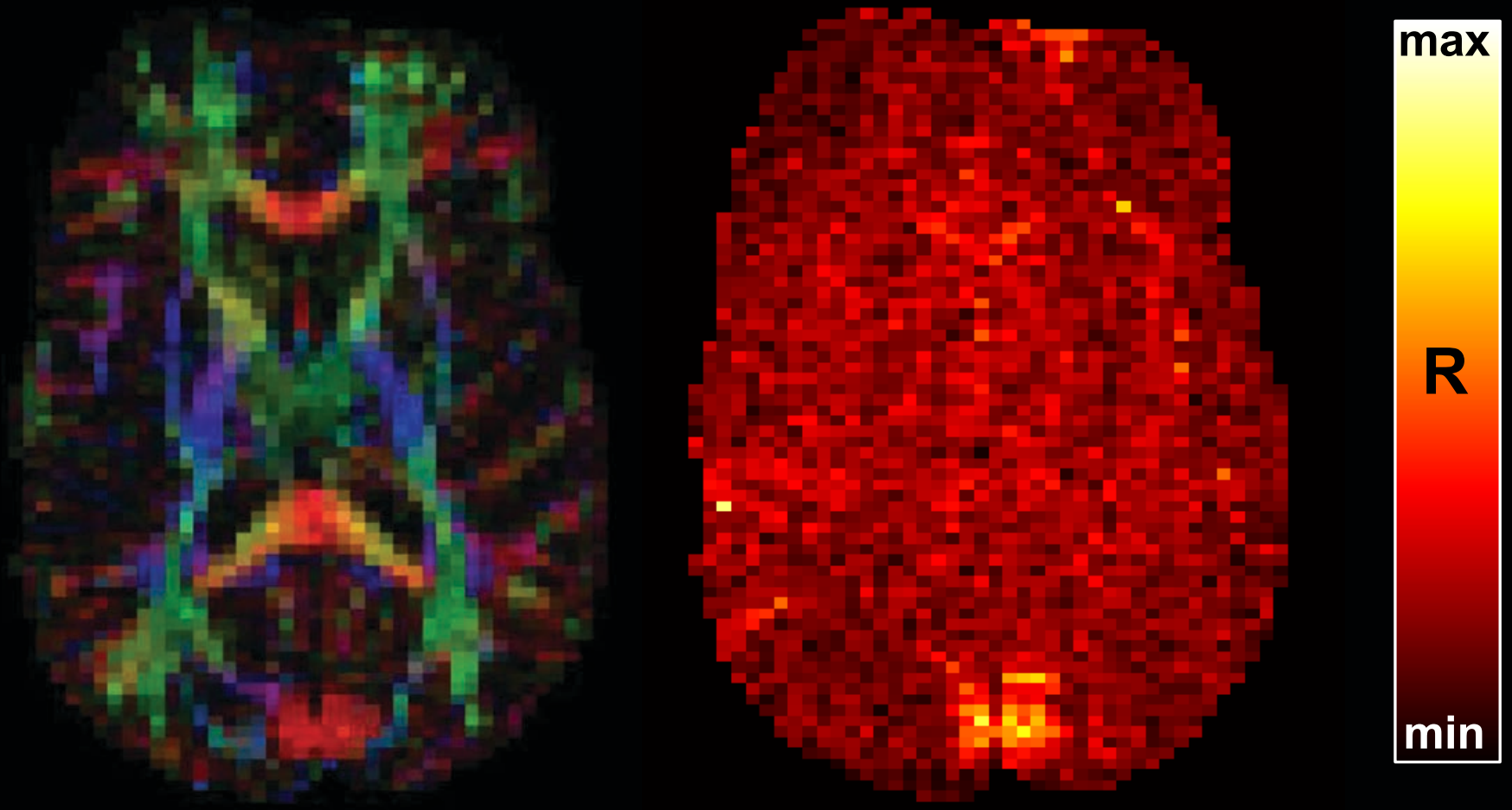




Good quality ⟺ Low values / uniformity

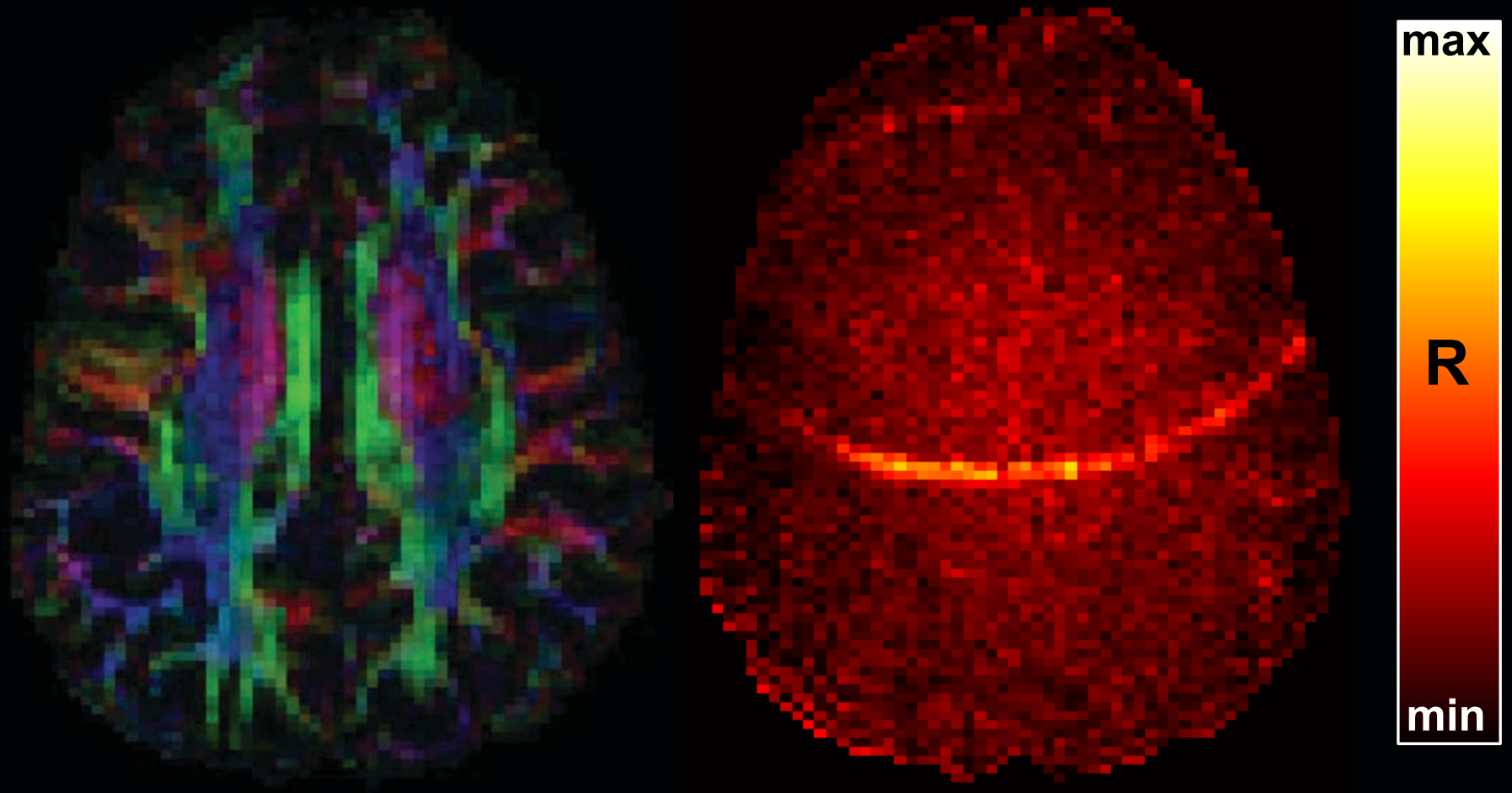
Data quality assessment ...

Residuals from the model estimation



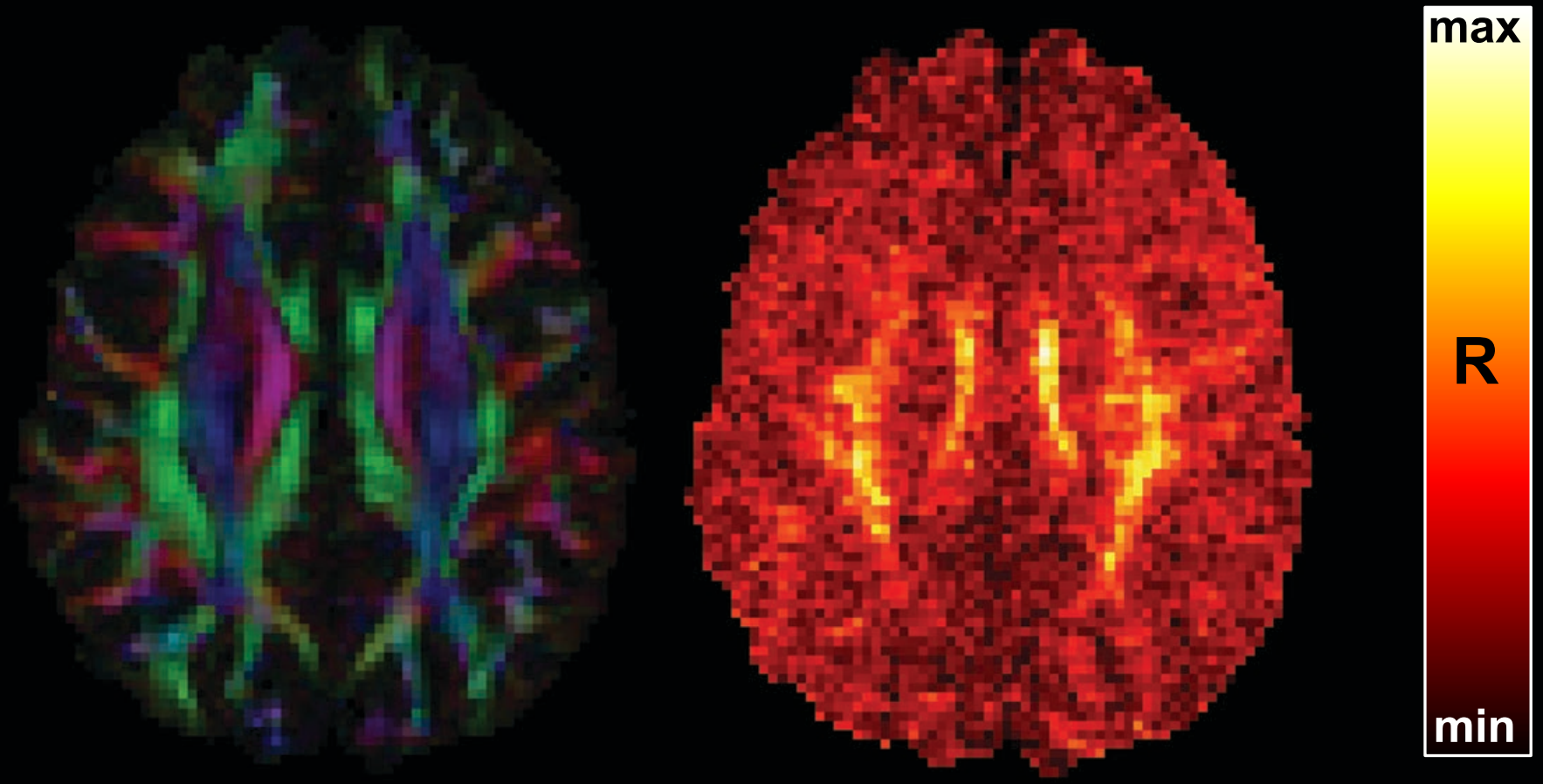
Data quality assessment ...

Residuals from the model estimation



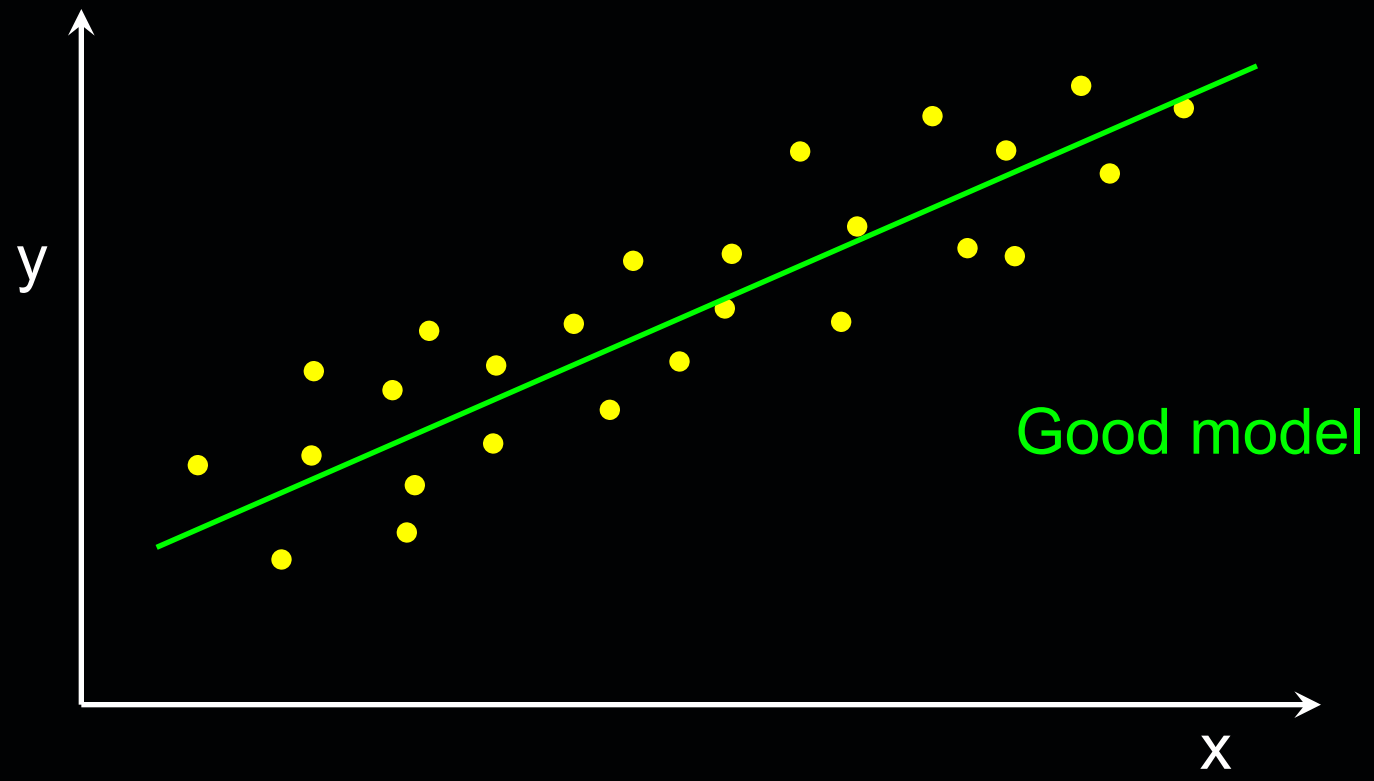
Data quality assessment ...

Residuals from the model estimation



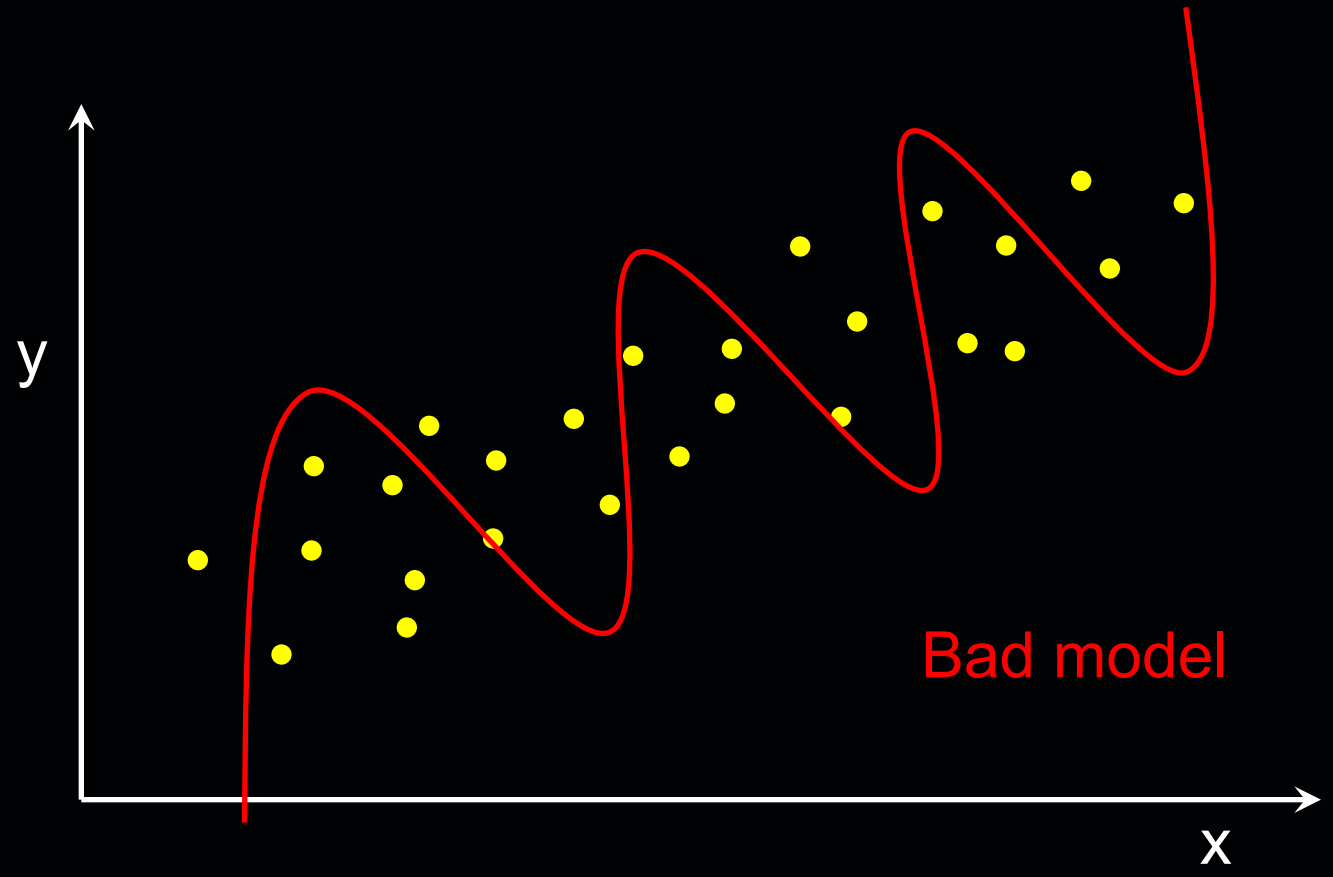
Data quality assessment ...

Residuals from the model estimation

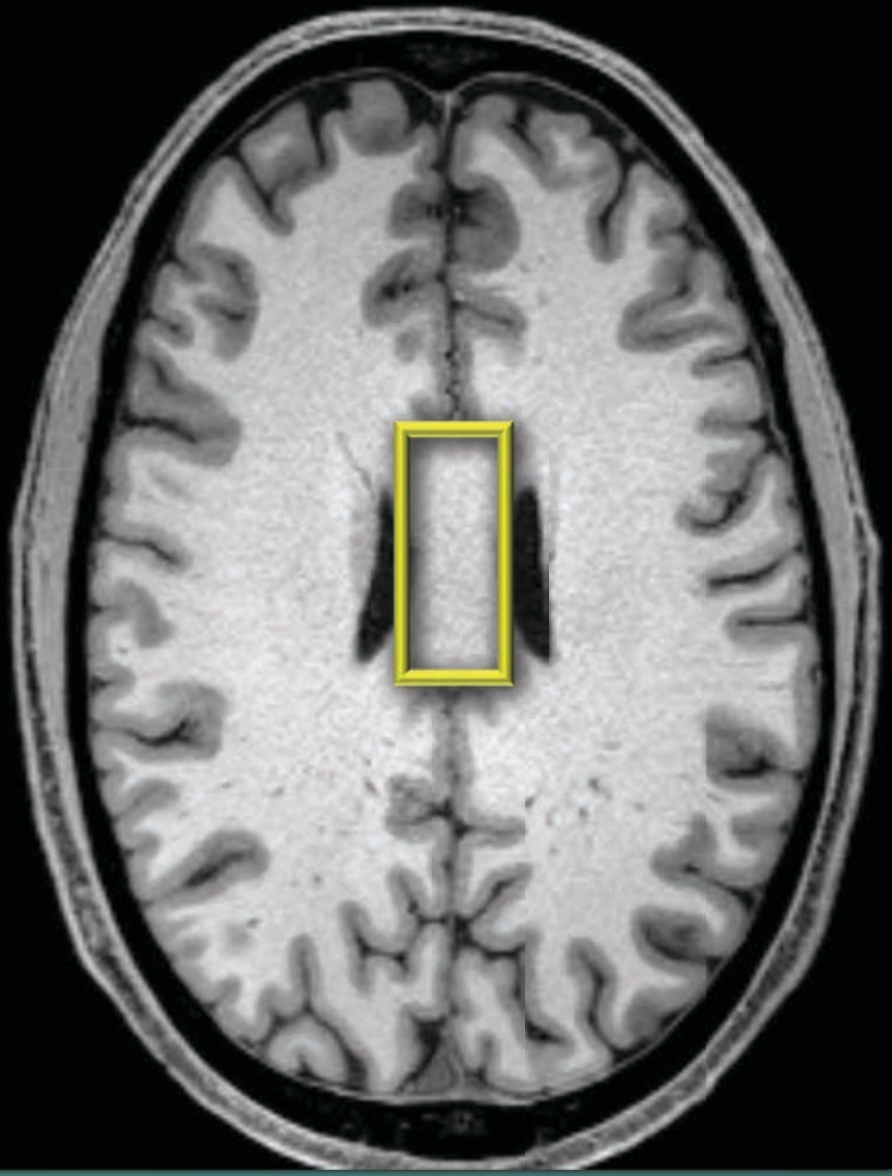


Data quality assessment ...

Residuals from the model estimation

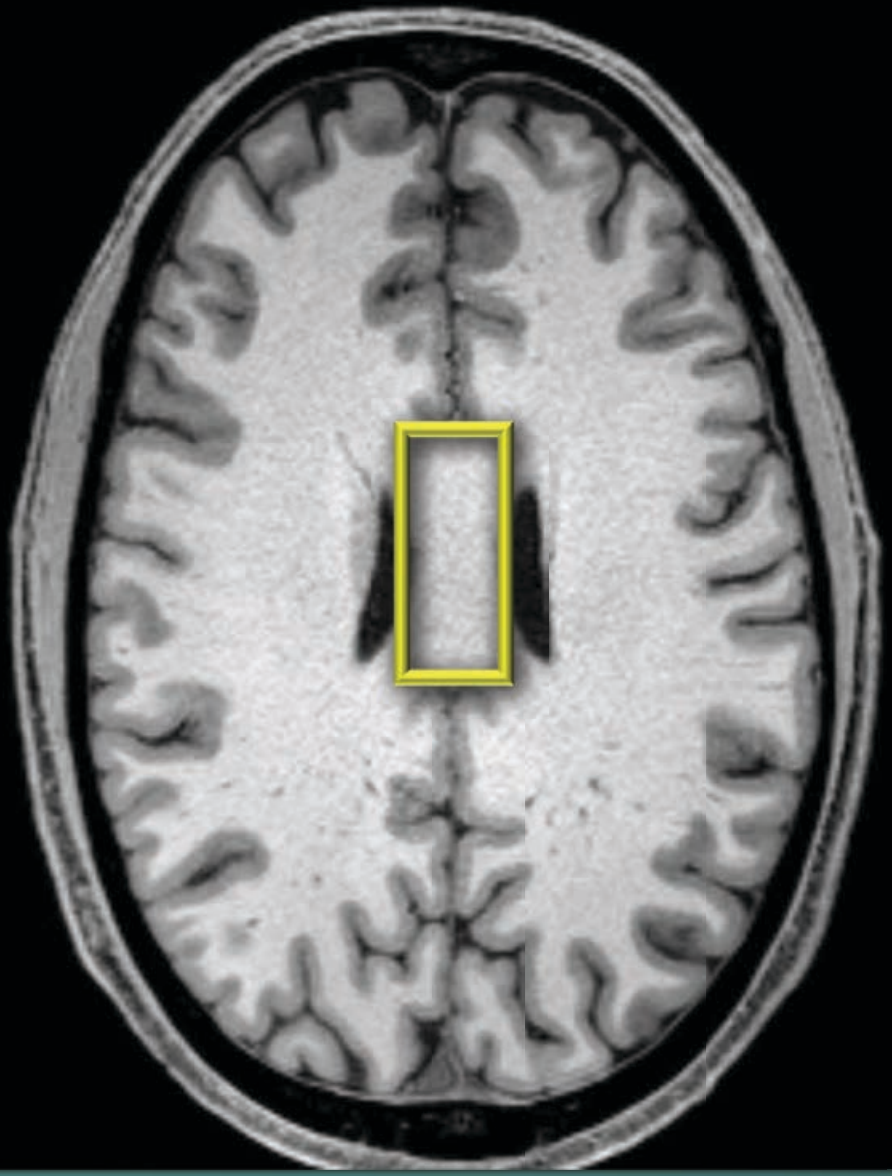


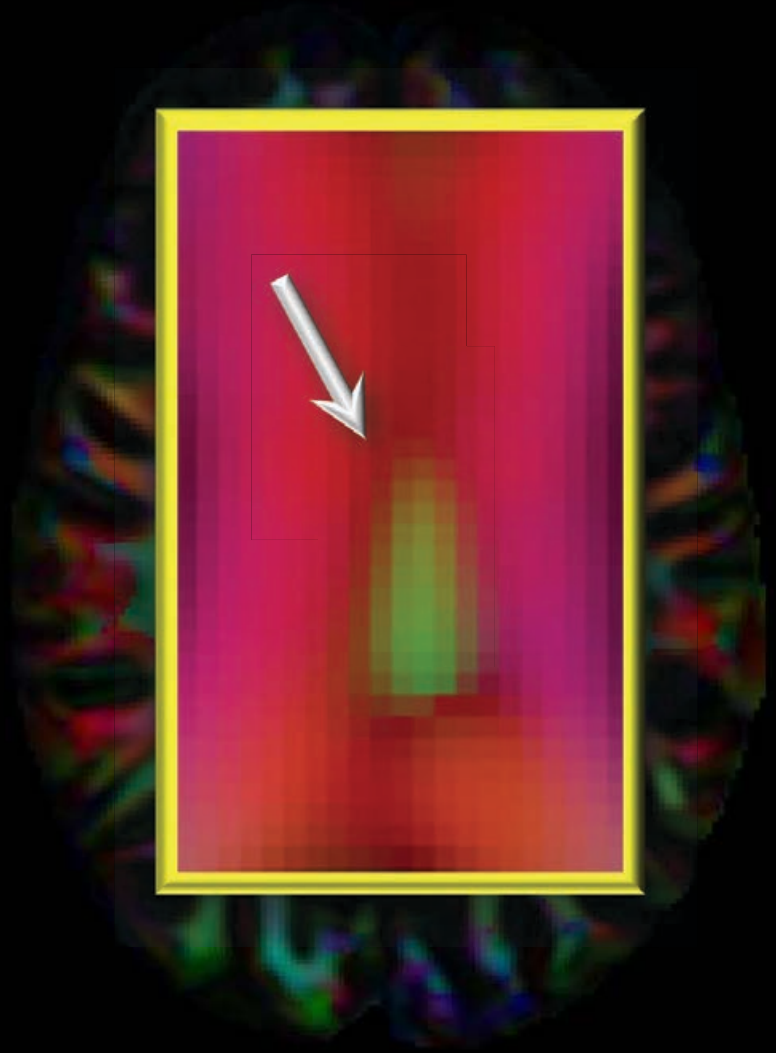
Data quality assessment ...



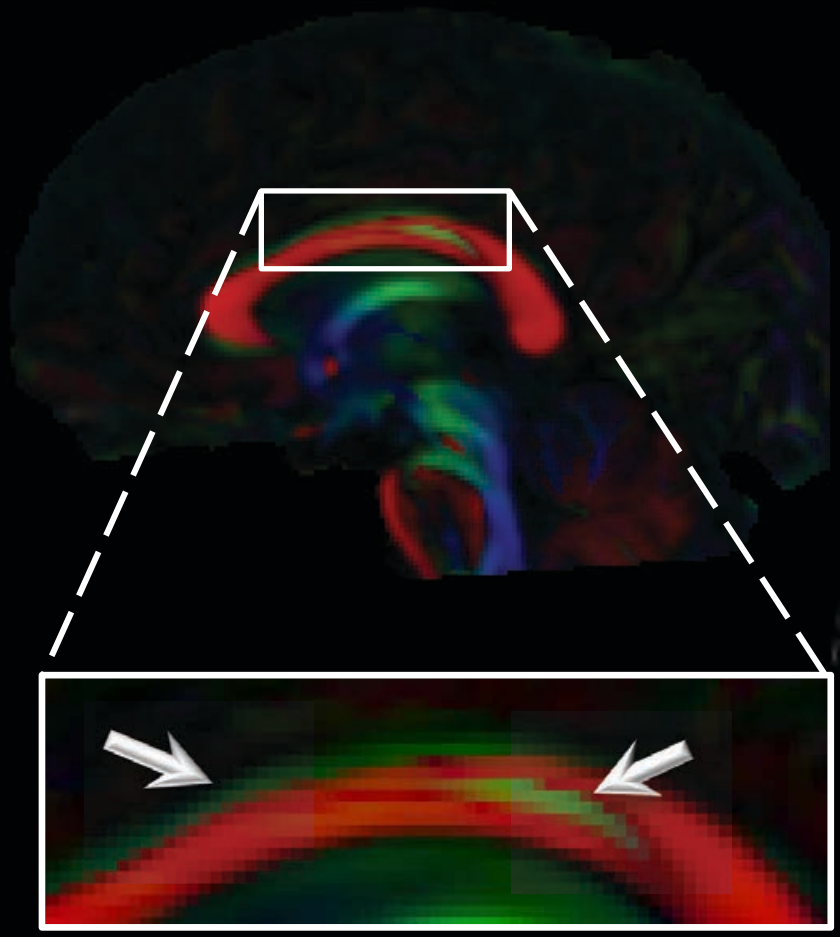
Anything "abnormal"?

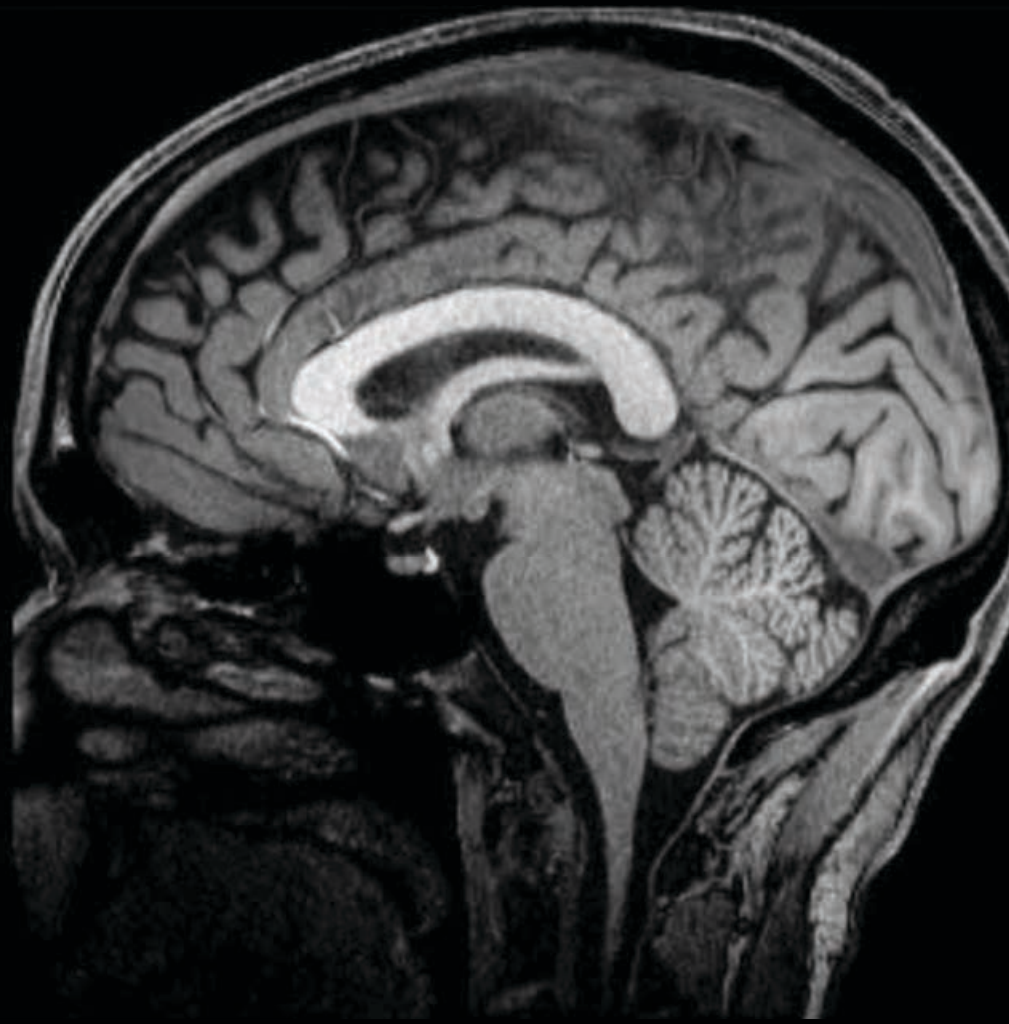
Data quality assessment ...





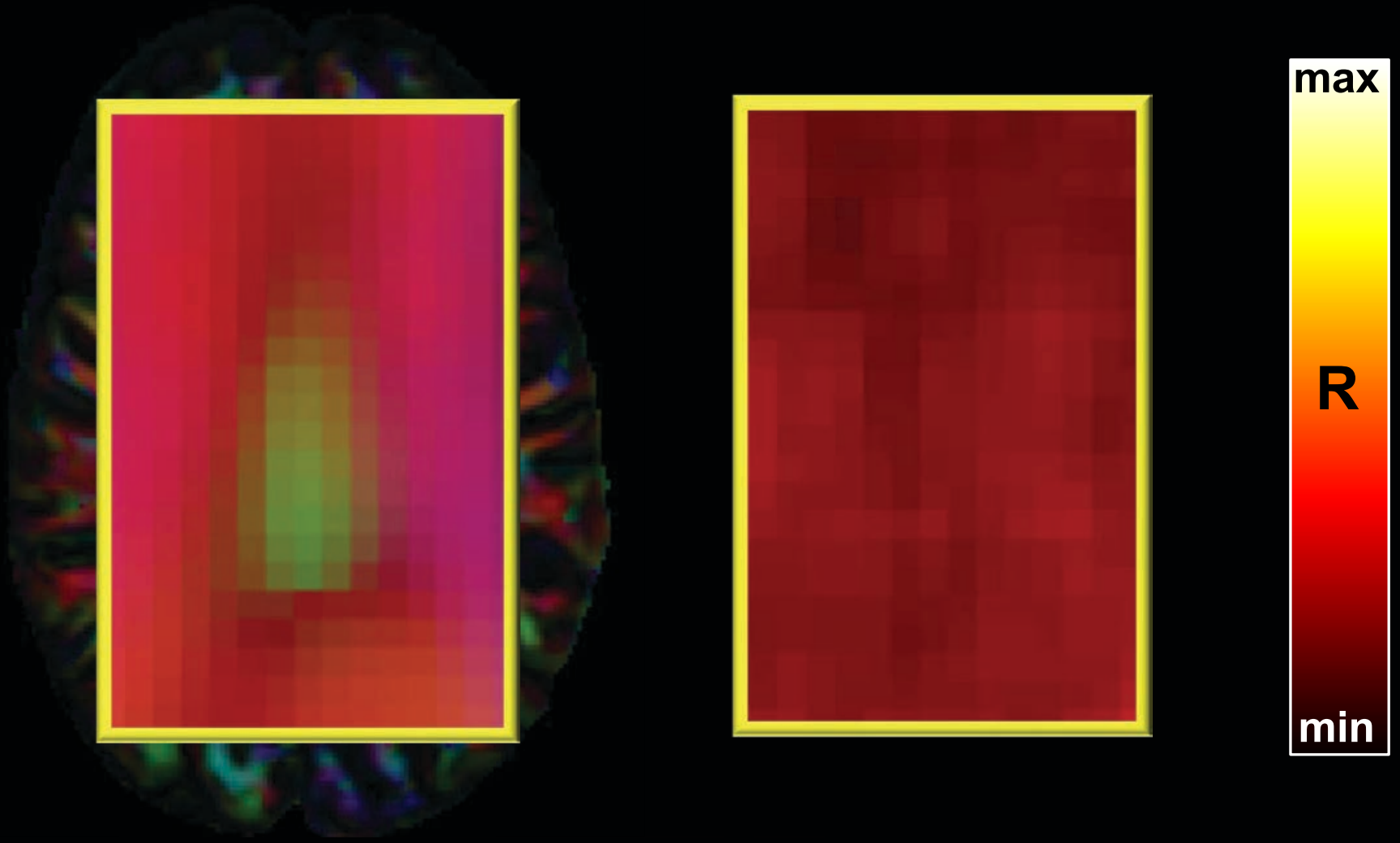
Data quality assessment ...





Data quality assessment ...

Residuals from the model estimation




QA DIFFUSION

Data processing steps

1. Correction for signal intensity drift
2. Correction for subject motion and eddy current induced distortions
3. Correction for EPI deformations
4. Diffusion model *estimation* approaches

S. Deprez et al, Brain Imaging and Behavior (2013)

@Alex_Leemans

Another confession by a dMRI scientist...

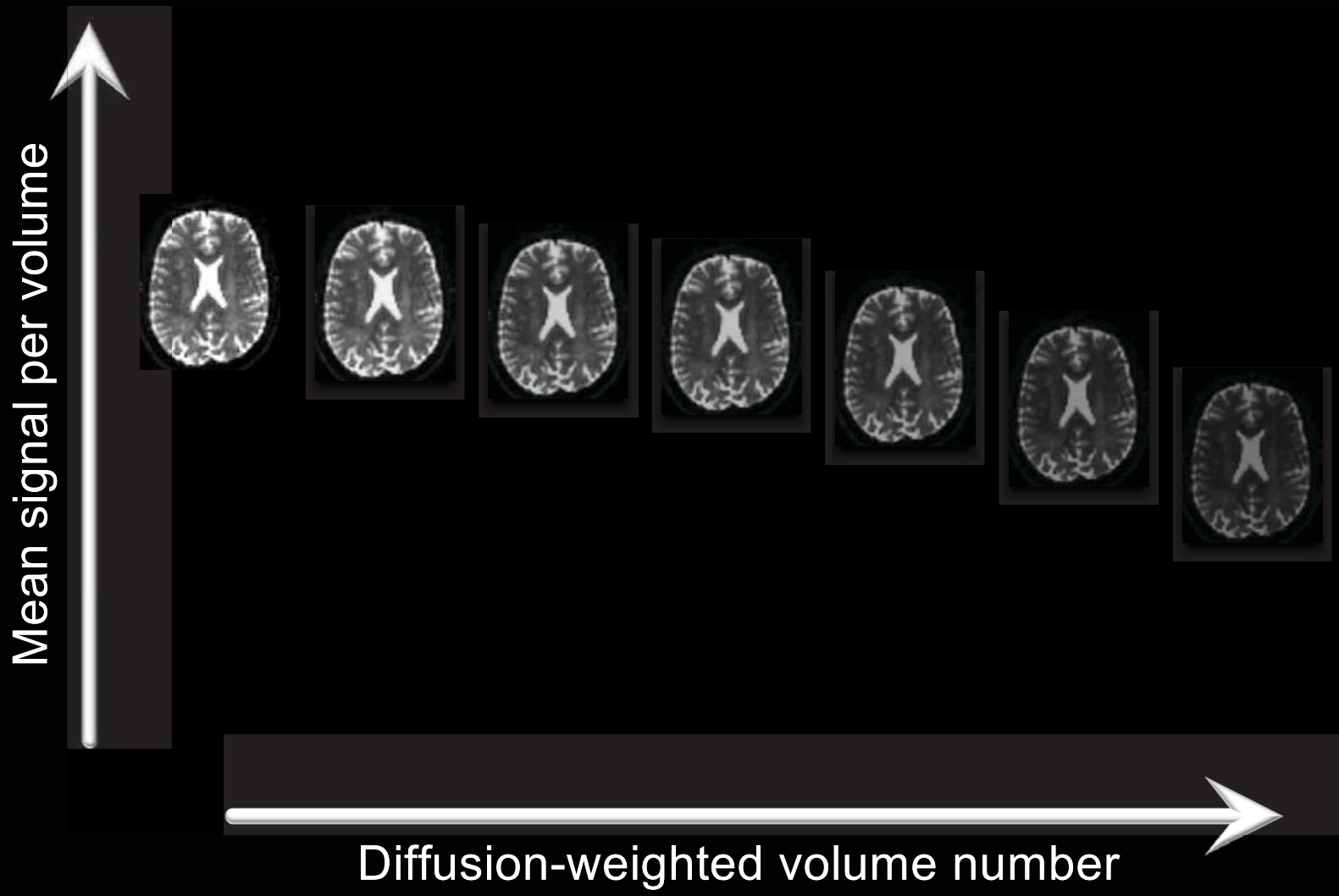
Data processing steps

1. Correction for signal intensity drift
2. Correction for subject motion and eddy current induced distortions
3. Correction for EPI deformations
4. Diffusion model *estimation* approaches

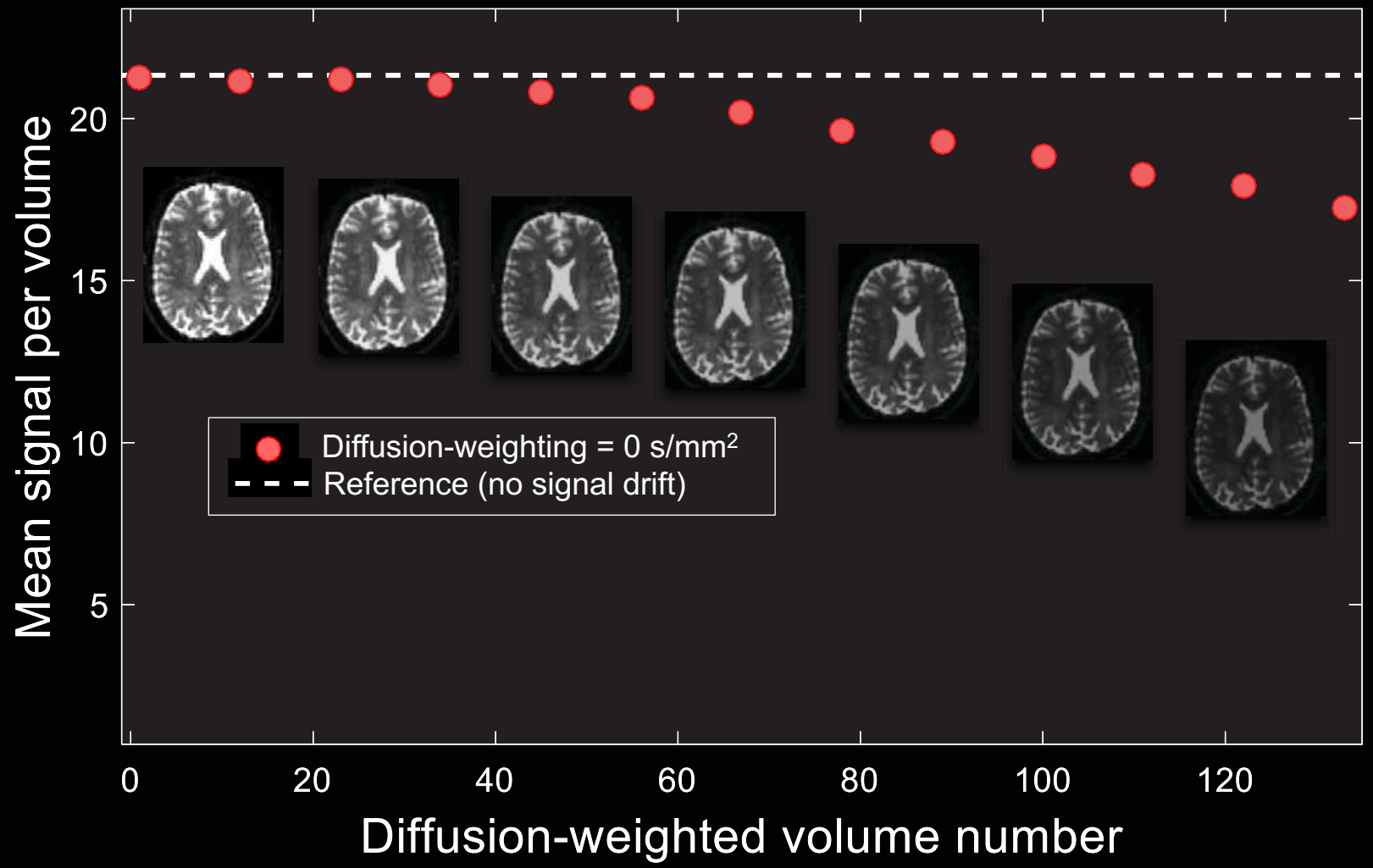
S. Deprez et al, Brain Imaging and Behavior (2013)

@Alex_Leemans

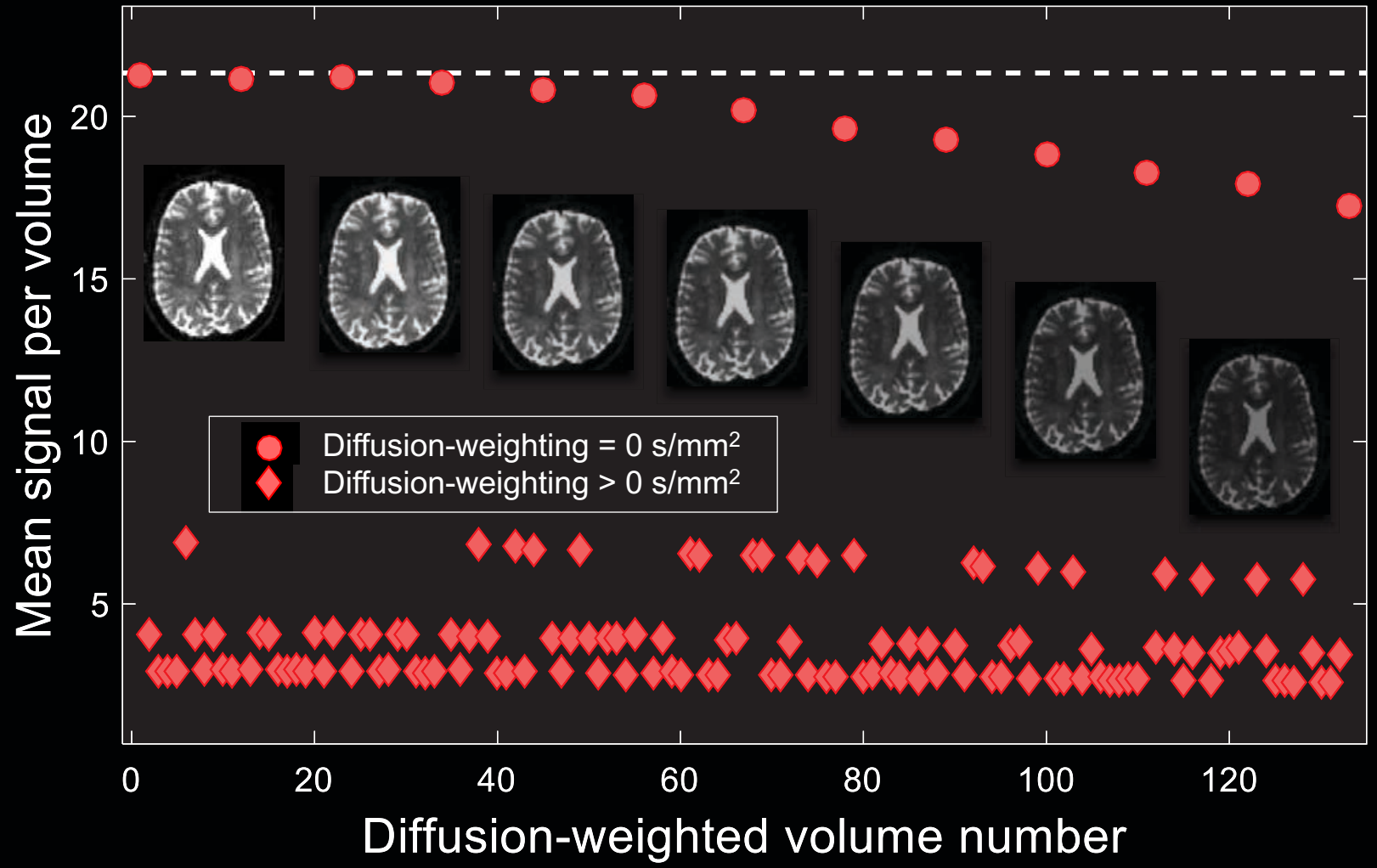
1. Correction for signal intensity drift



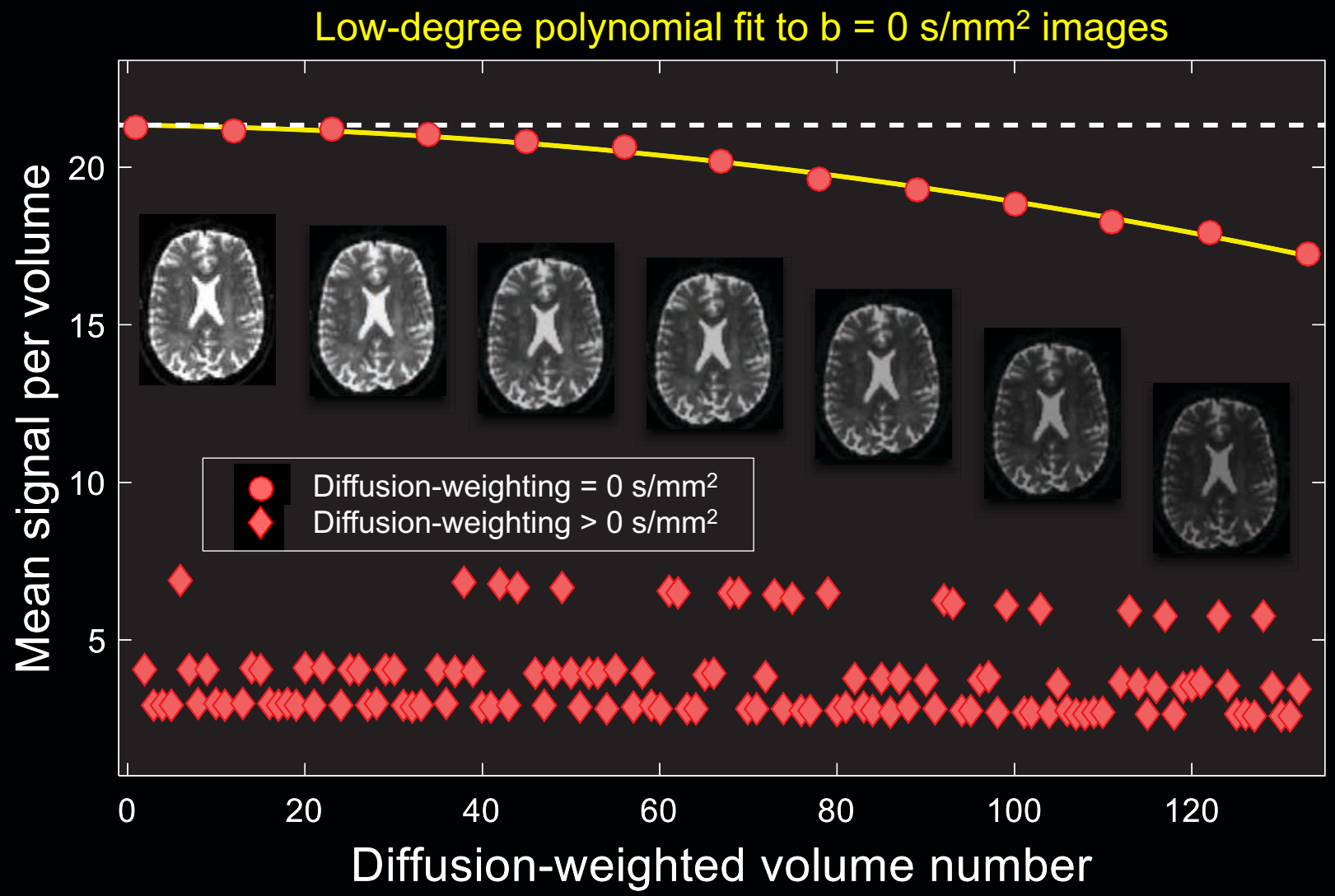
1. Correction for signal intensity drift



1. Correction for signal intensity drift



1. Correction for signal intensity drift



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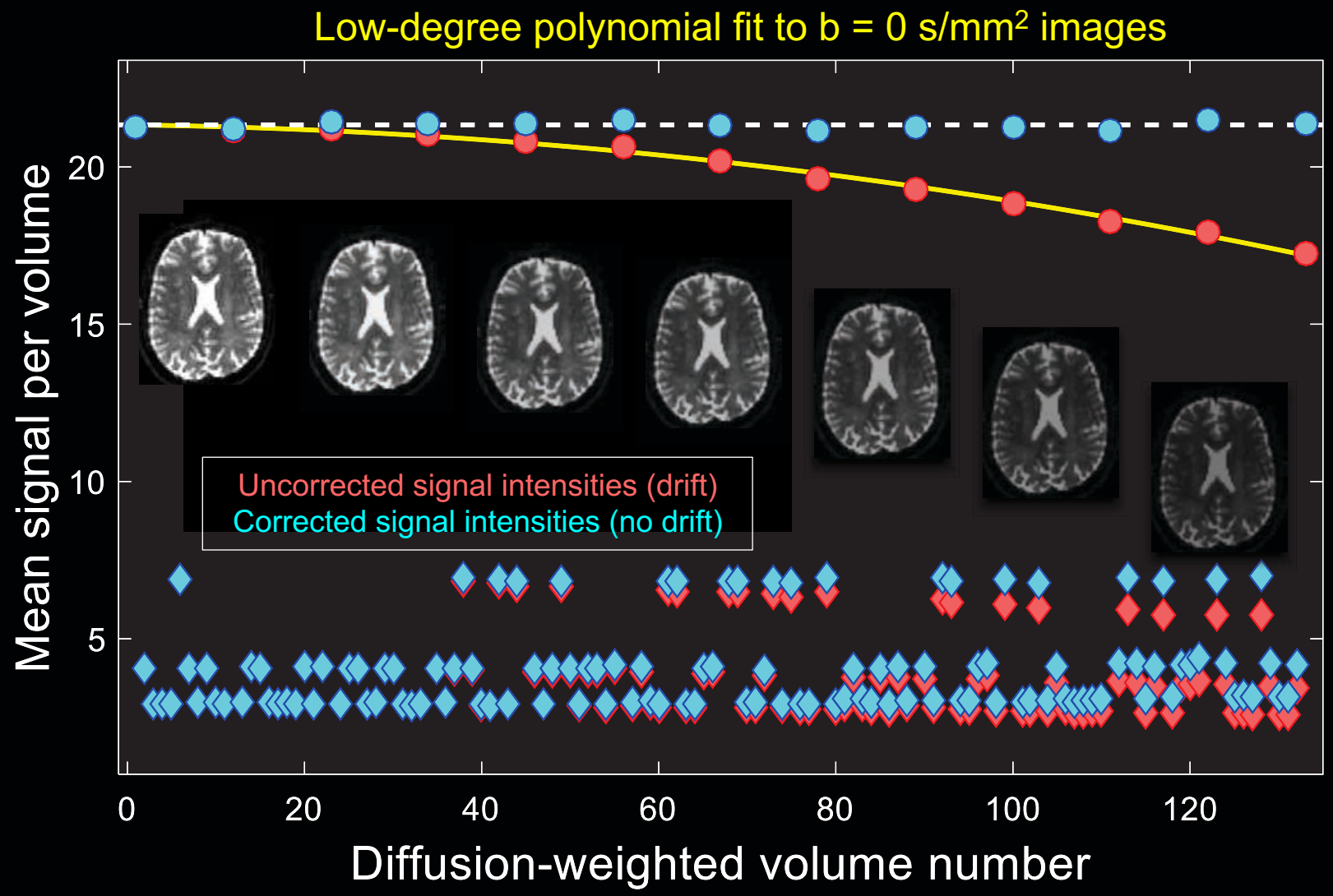
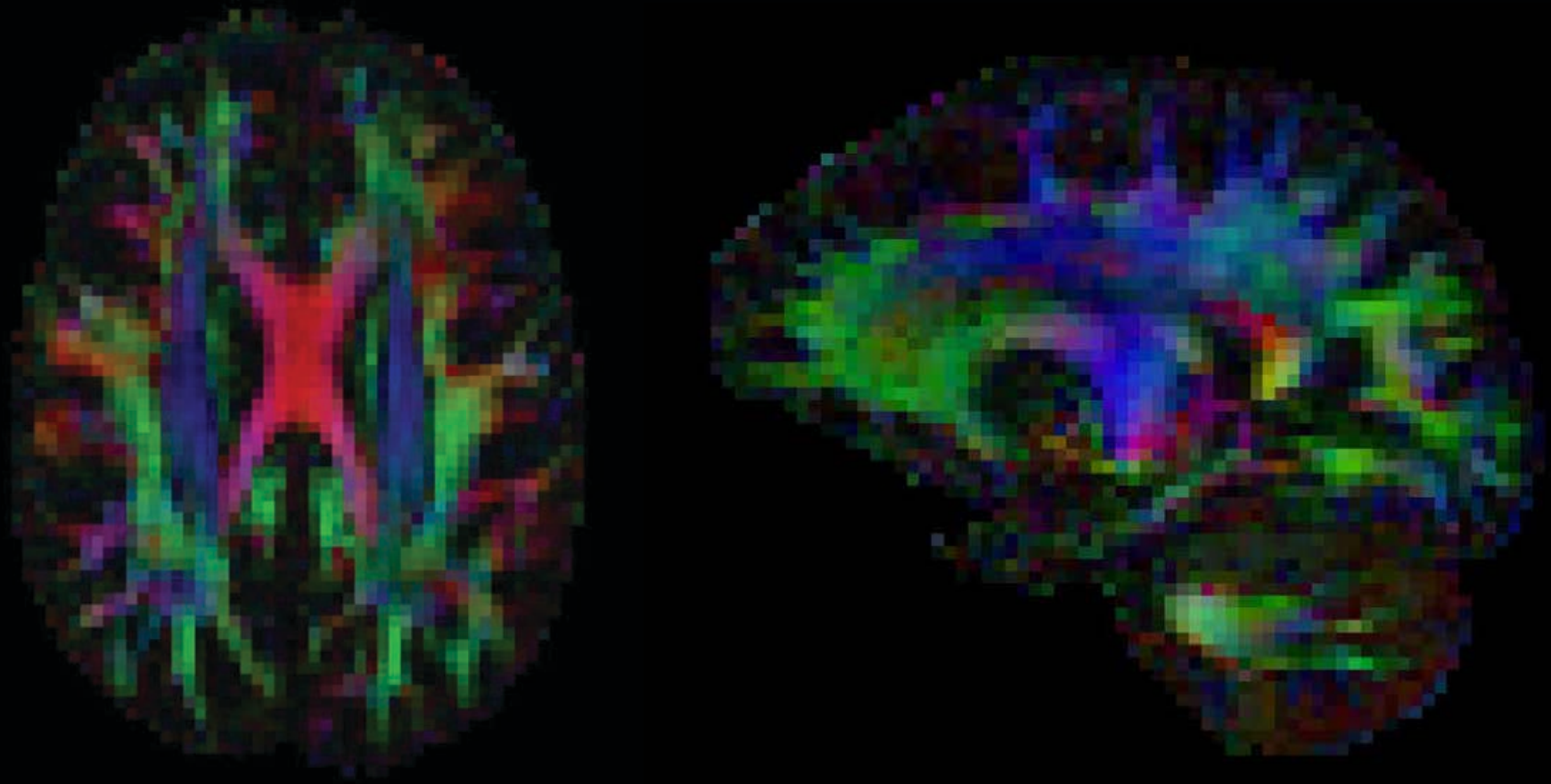
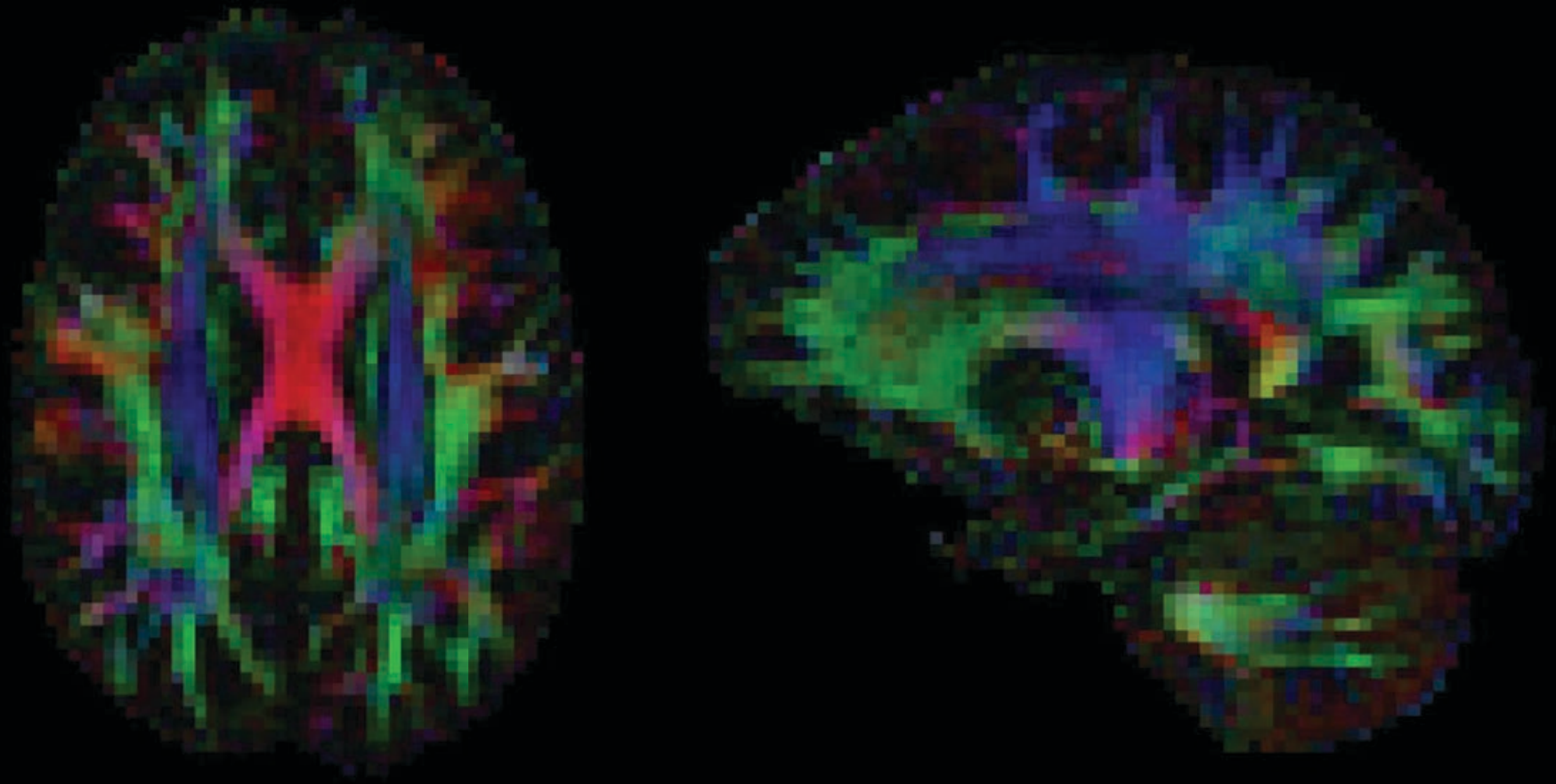


1. Correction for signal intensity drift



Before correcting for signal intensity drift

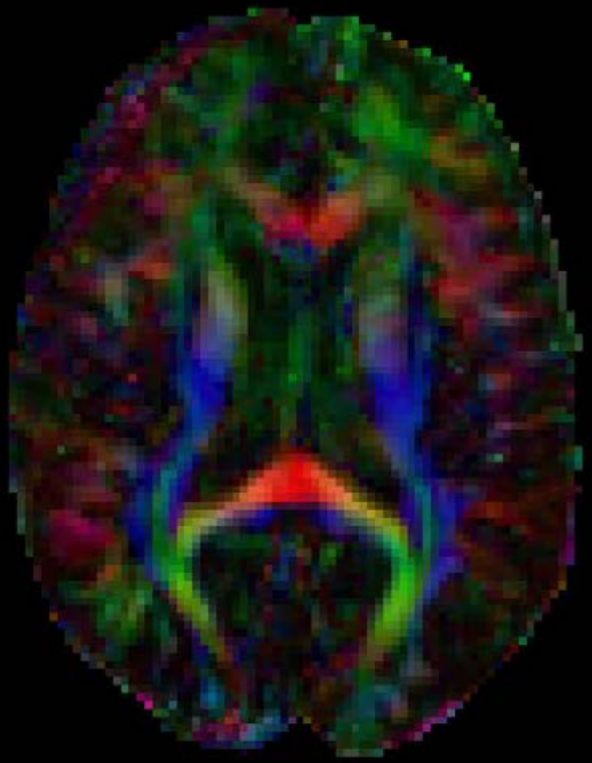
1. Correction for signal intensity drift

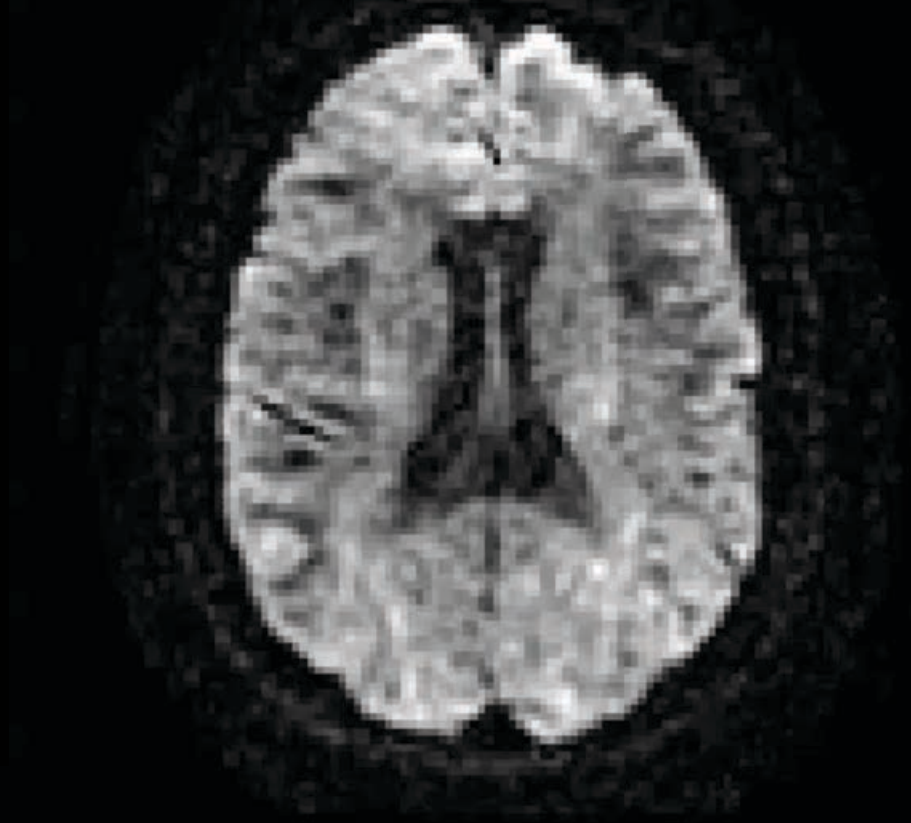


After correcting for signal intensity drift

2. Correction for subject motion and eddy current induced distortions

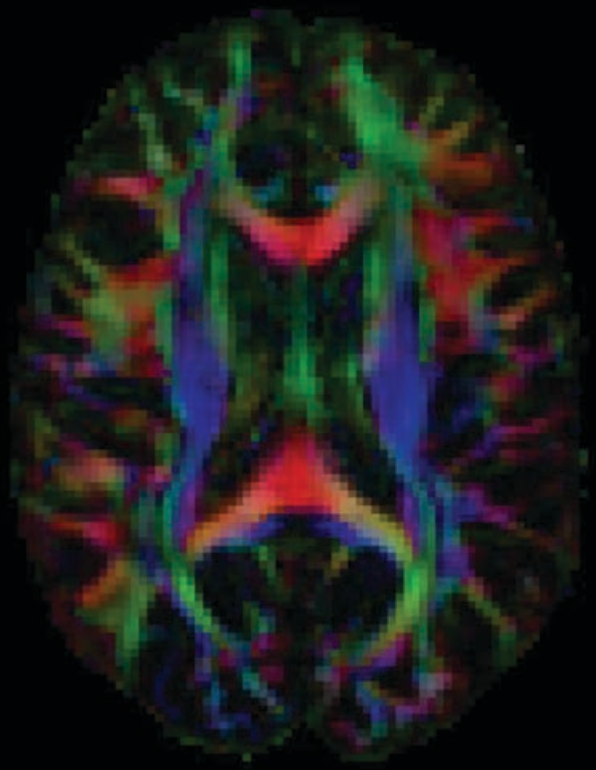
Not corrected for subject motion

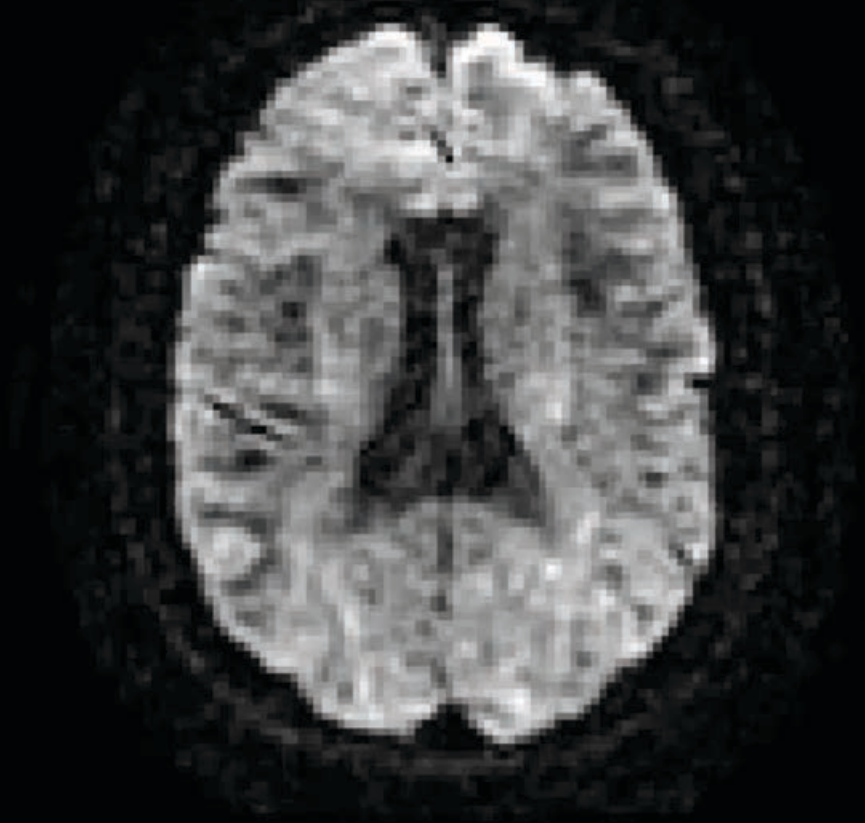




2. Correction for subject motion and eddy current induced distortions

Corrected for subject motion





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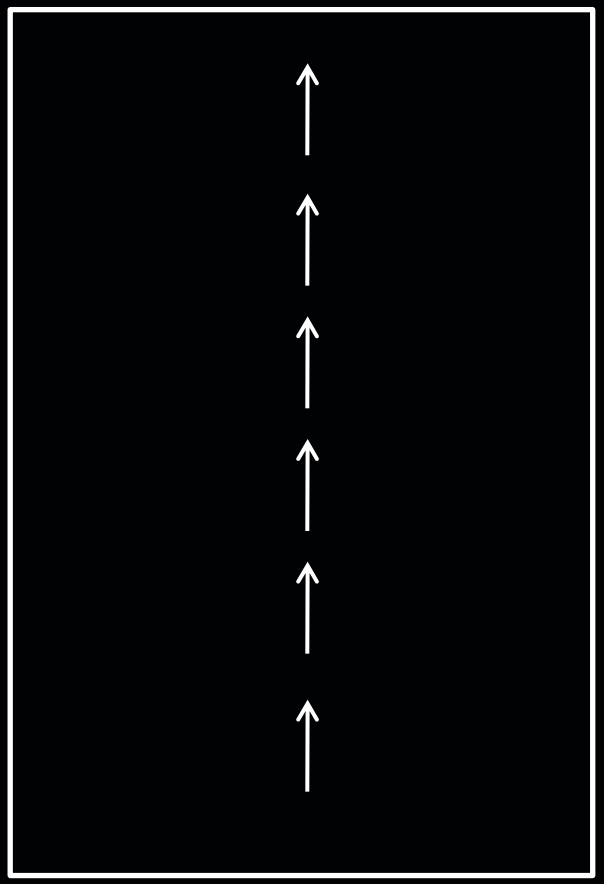
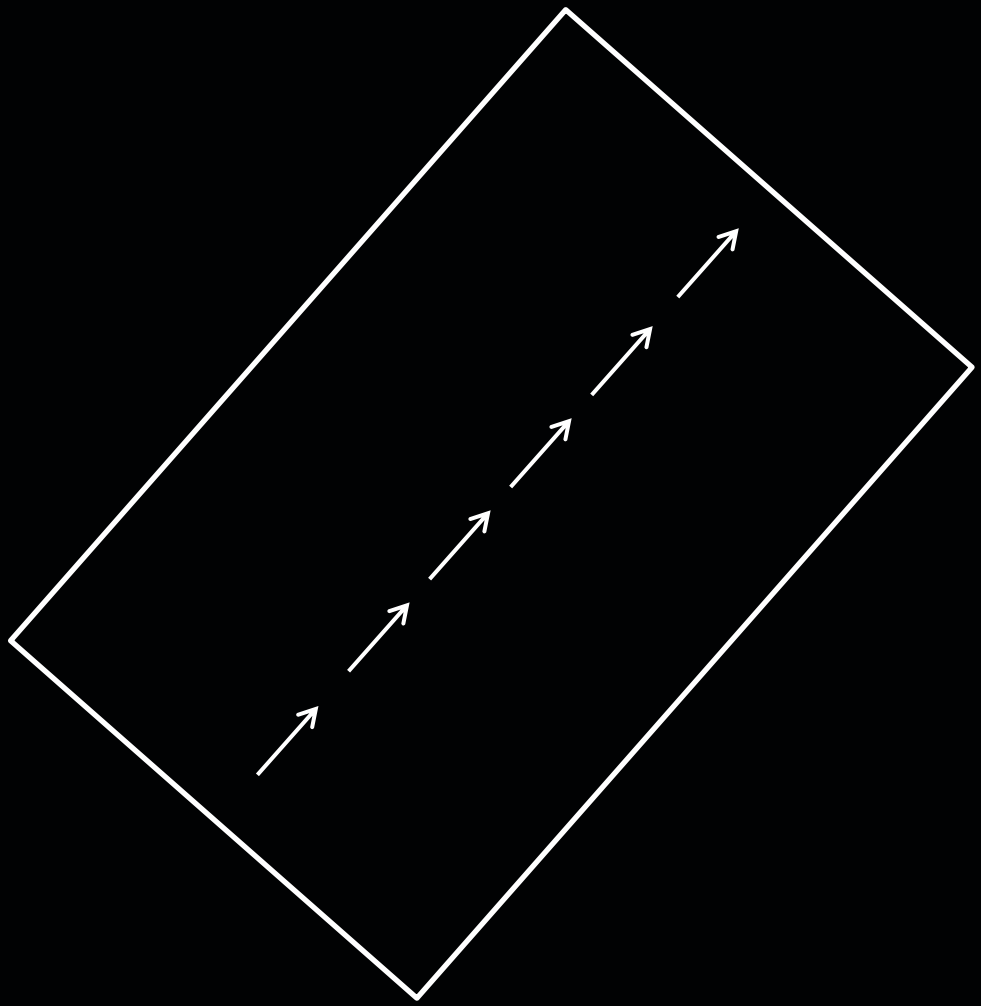
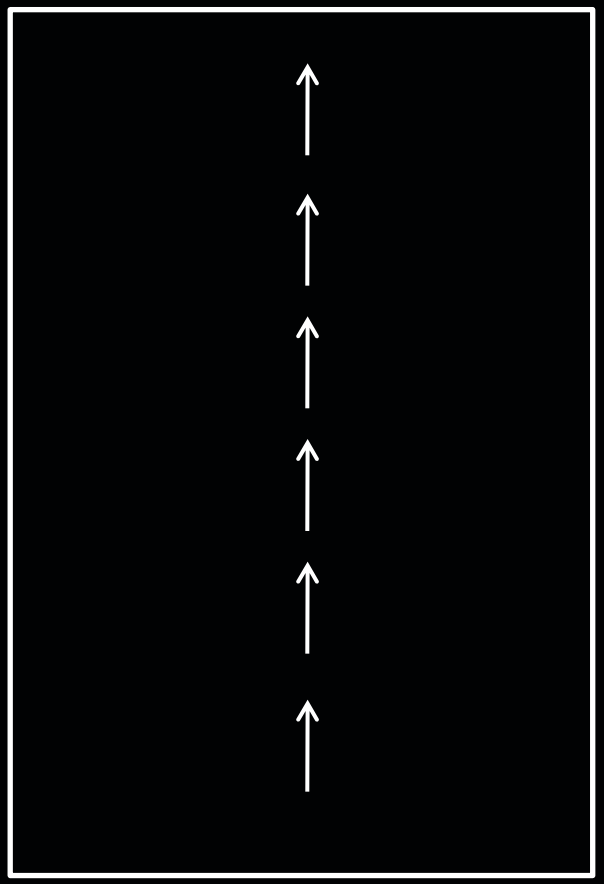




"Reference image"

"Image with subject motion"

2. Correction for subject motion and eddy current induced distortions



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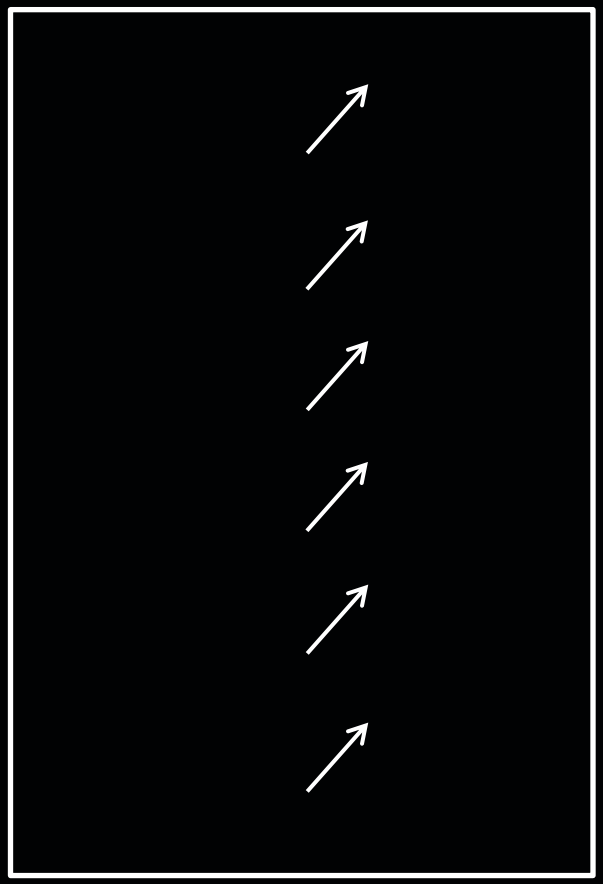
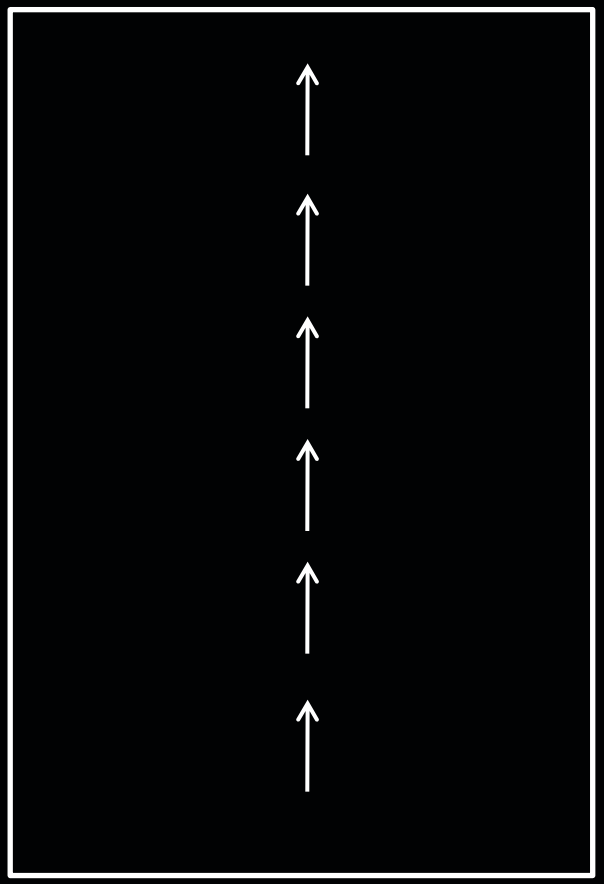
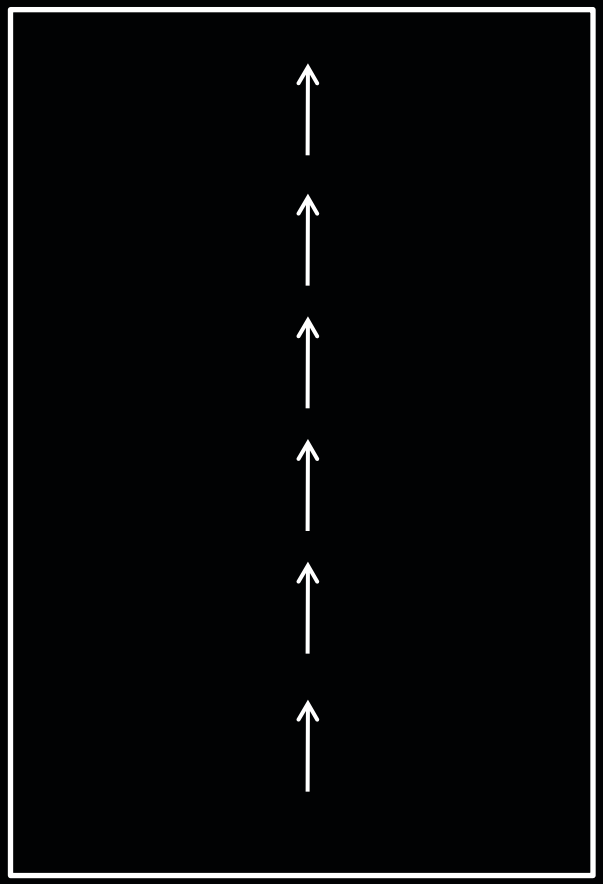


"Corrected image"
(**no** B-matrix rotation)

2. Correction for subject motion and eddy current induced distortions



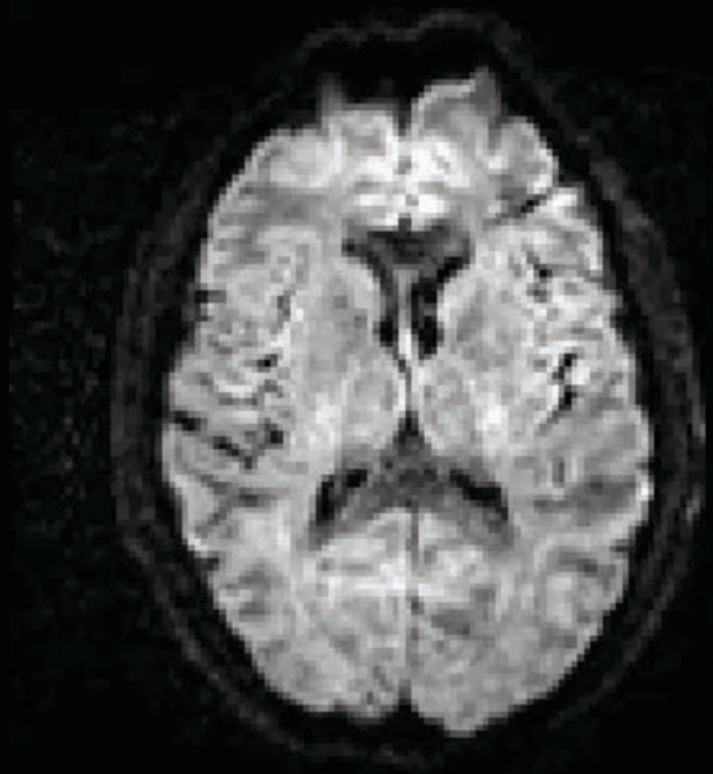
"Reference image"

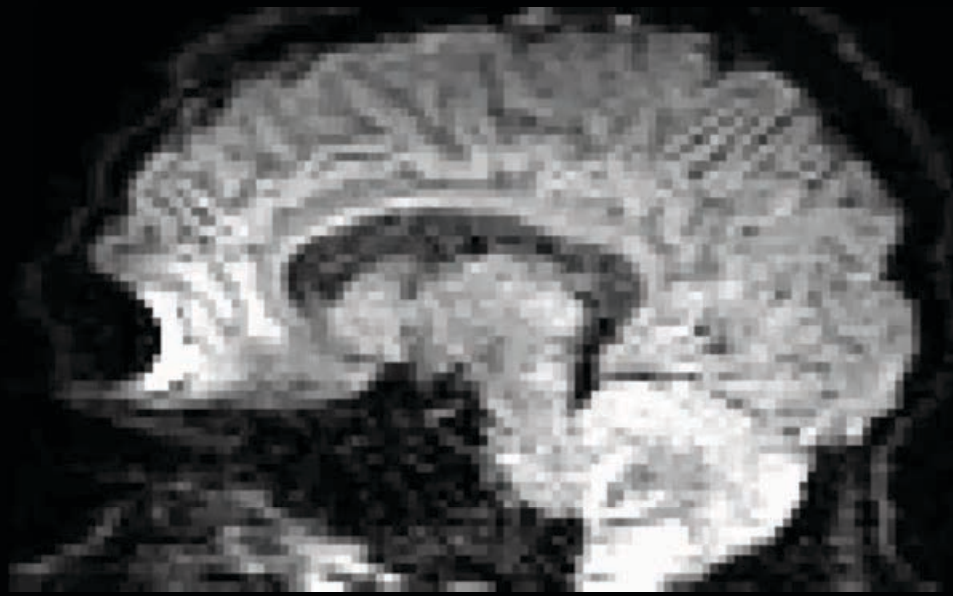


"Corrected image"
(**with** B-matrix rotation)

2. Correction for subject motion and eddy current induced distortions

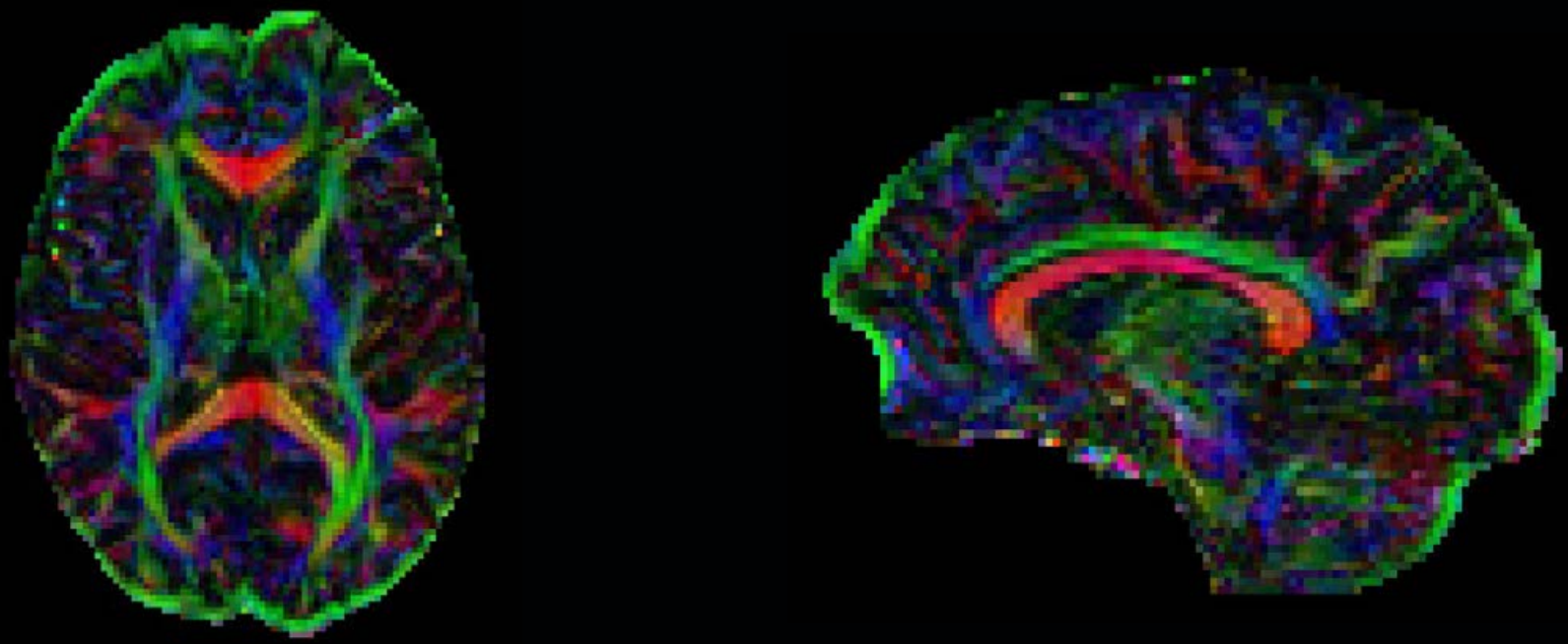
"Eddy currents"





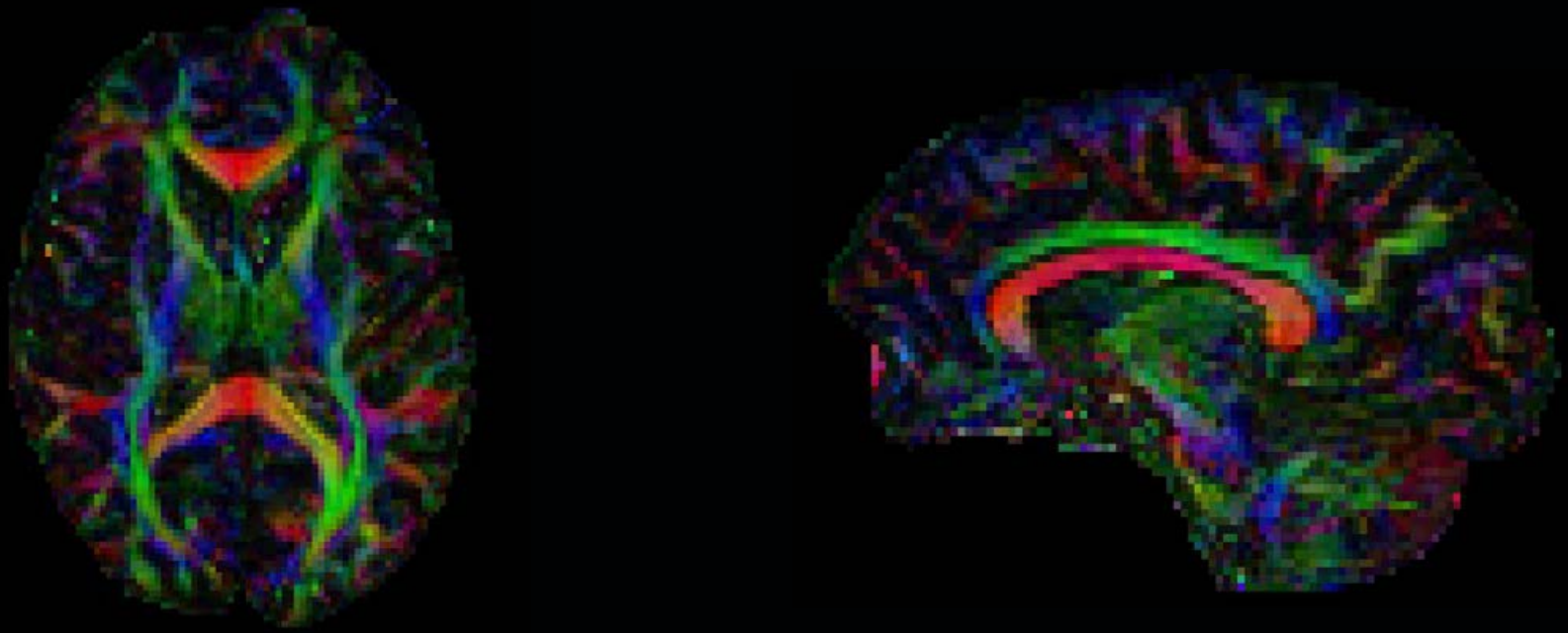
2. Correction for subject motion and eddy current induced distortions

Without eddy currents correction

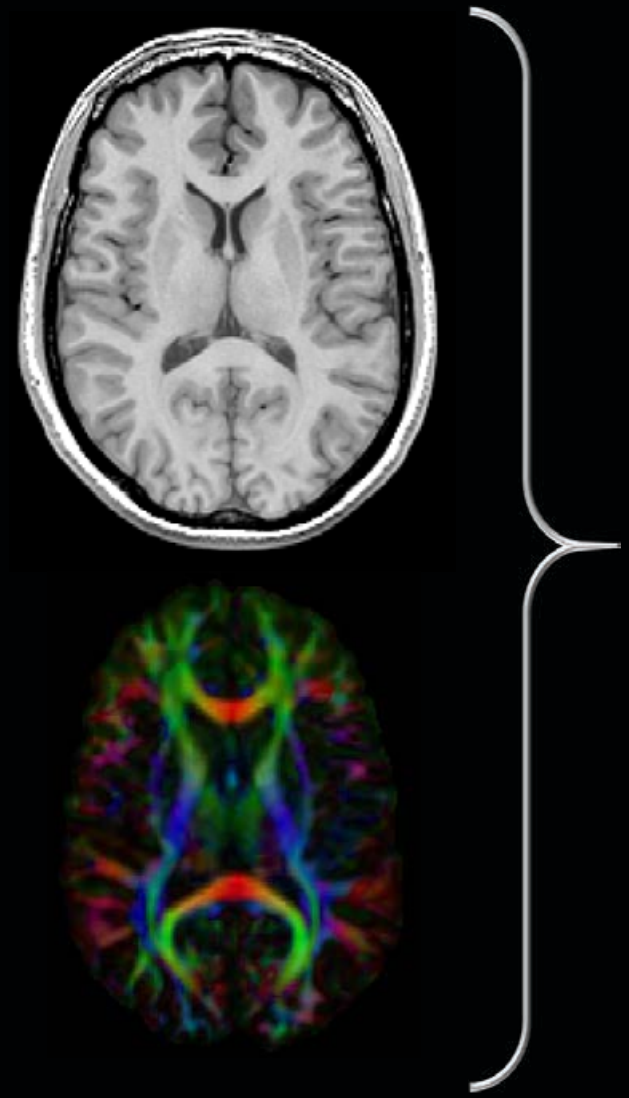


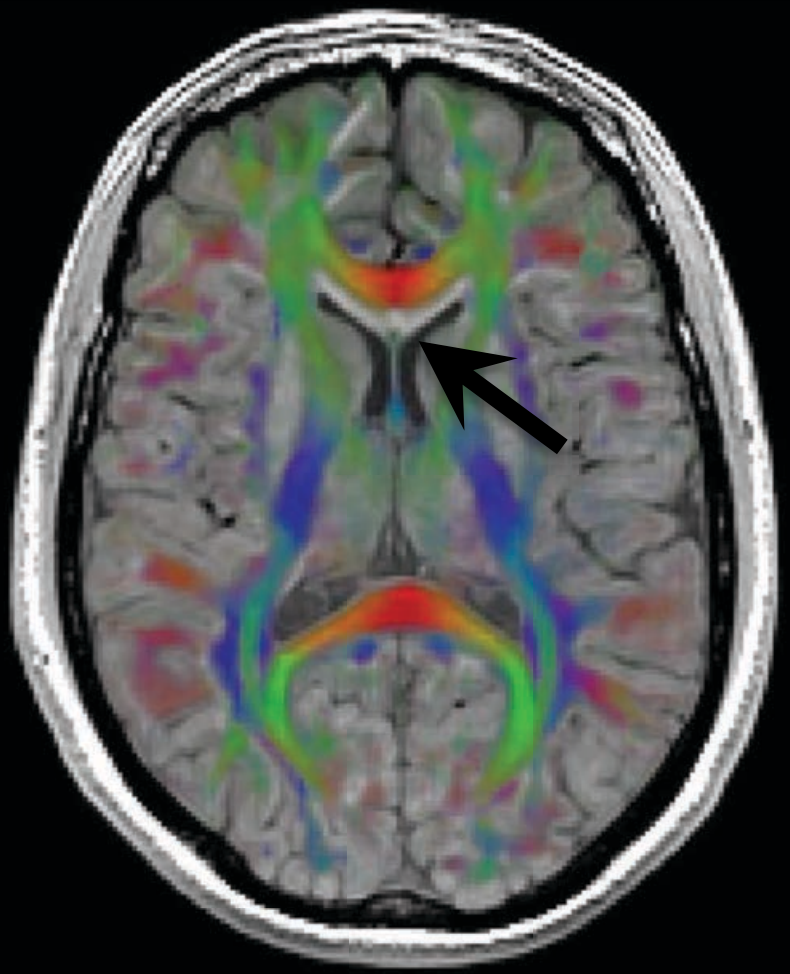
2. Correction for subject motion and eddy current induced distortions

With eddy currents correction



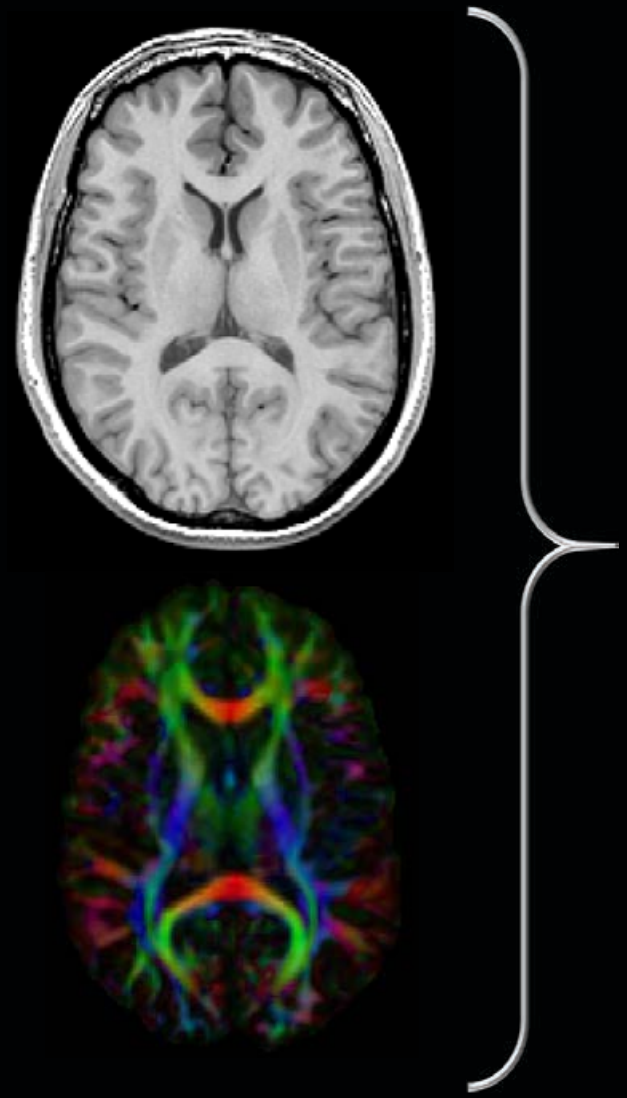
3. Correction for EPI deformations





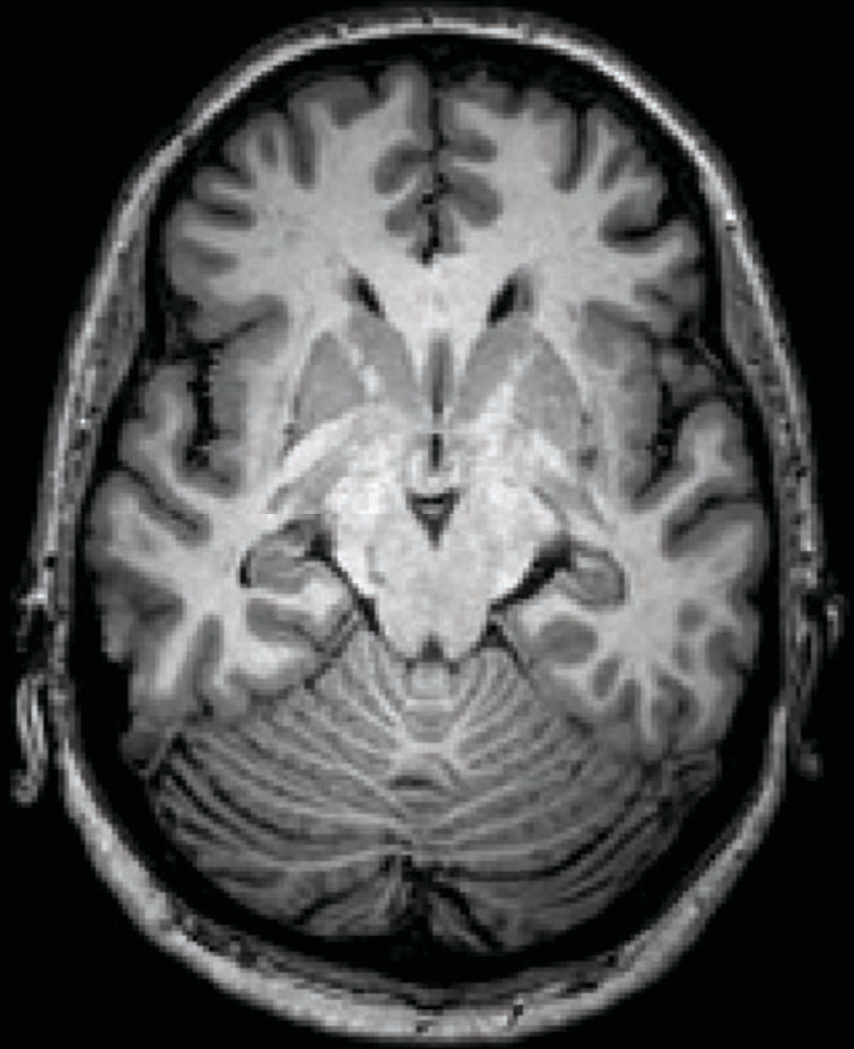
EPI distortions

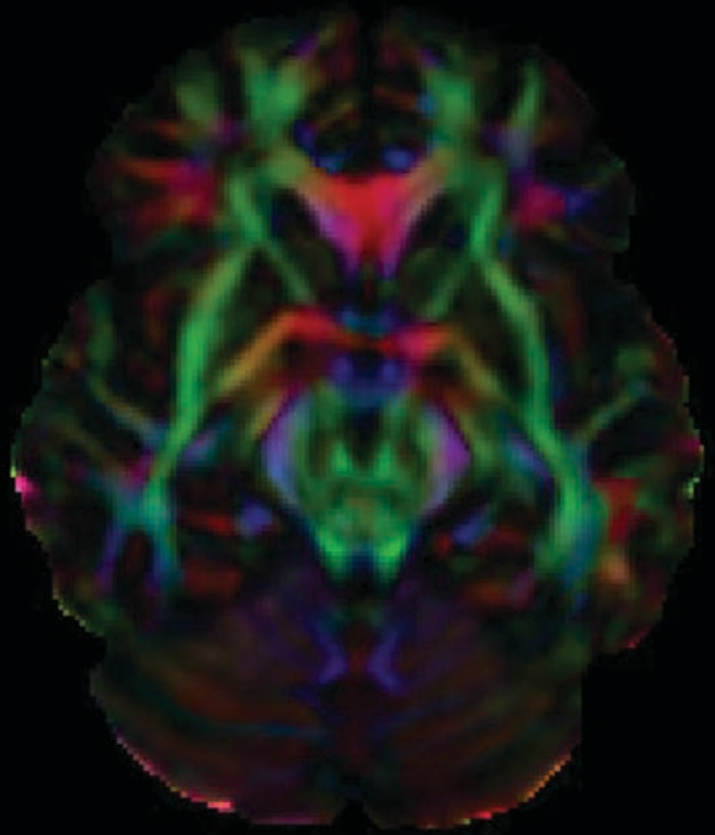
3. Correction for EPI deformations



EPI distortions

3. Correction for EPI deformations





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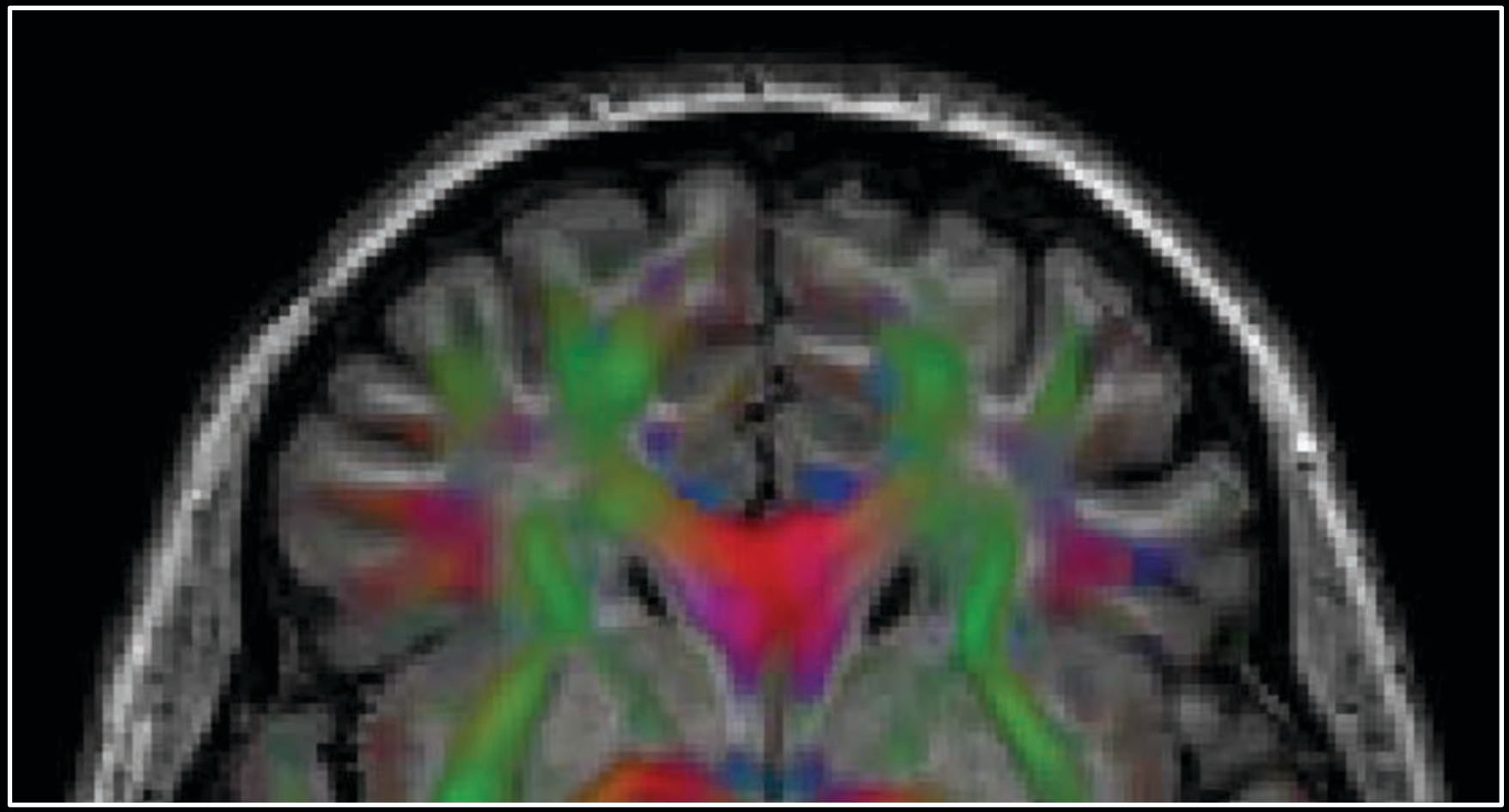
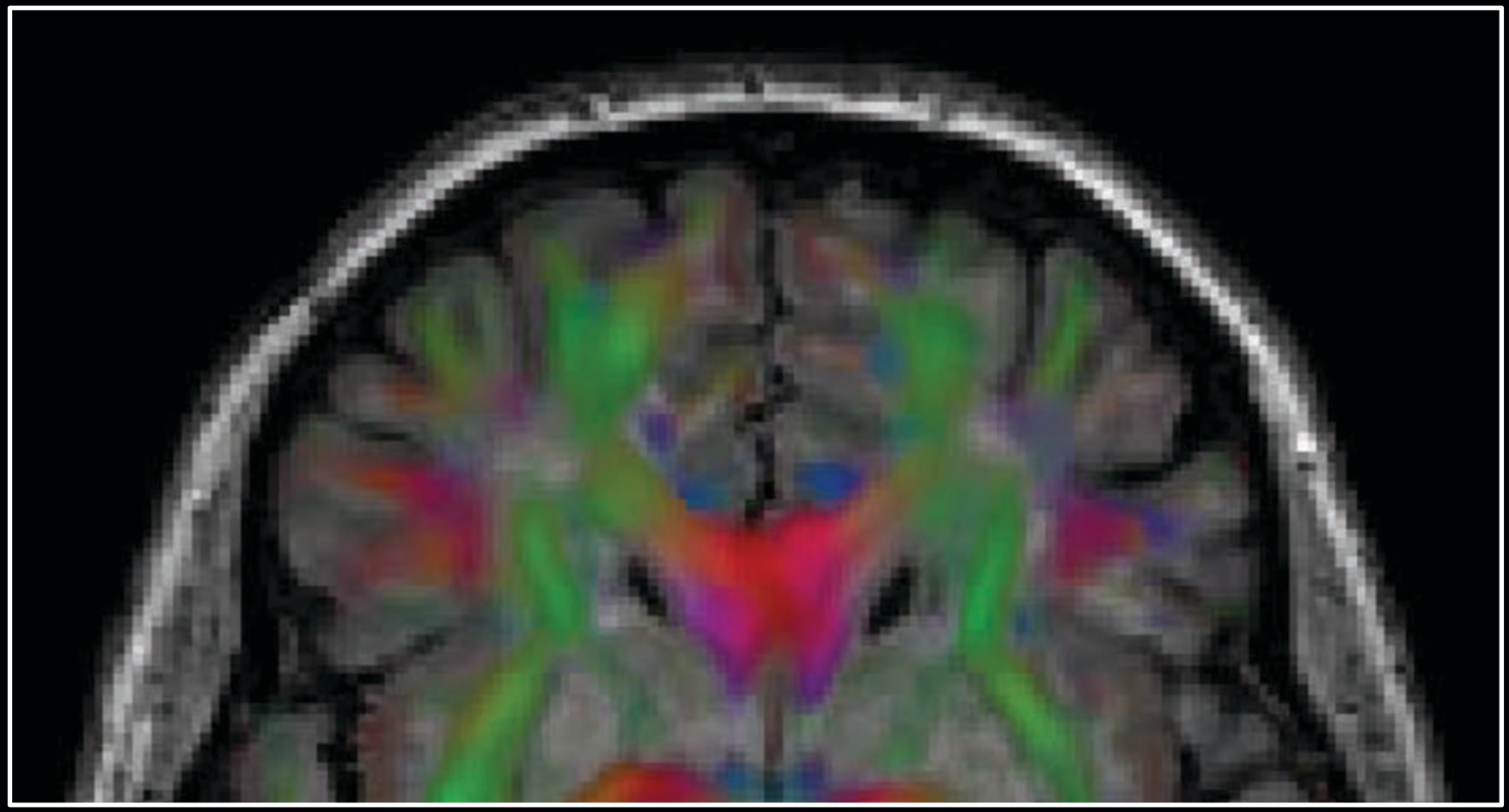


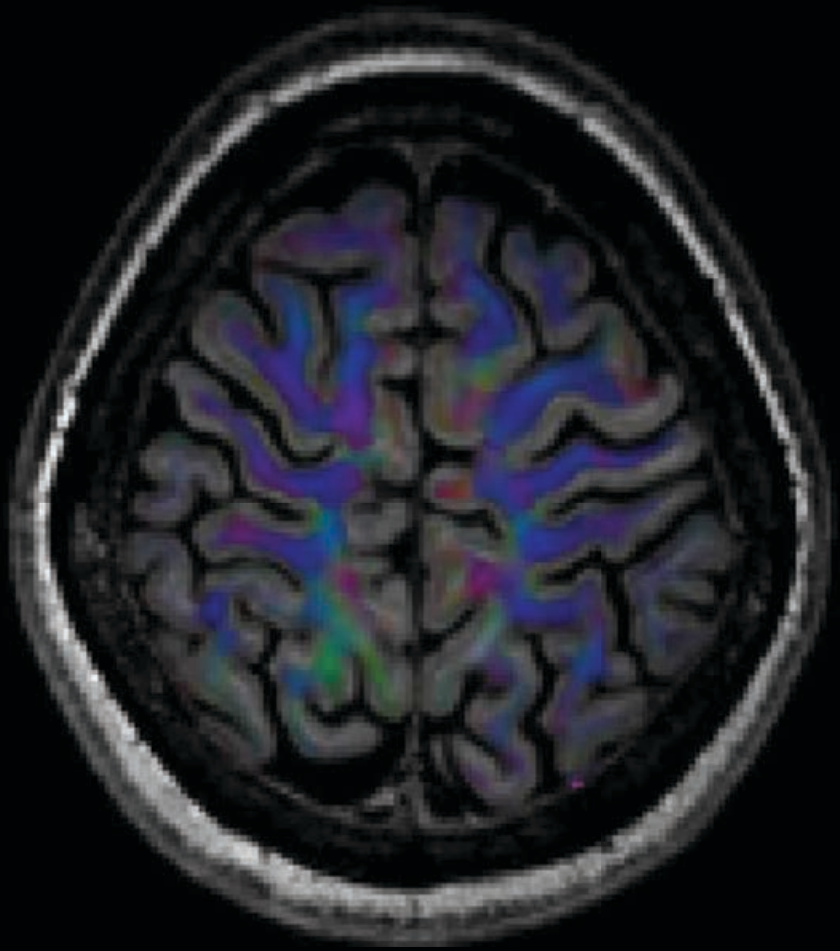
Without EPI distortion correction

3. Correction for EPI deformations



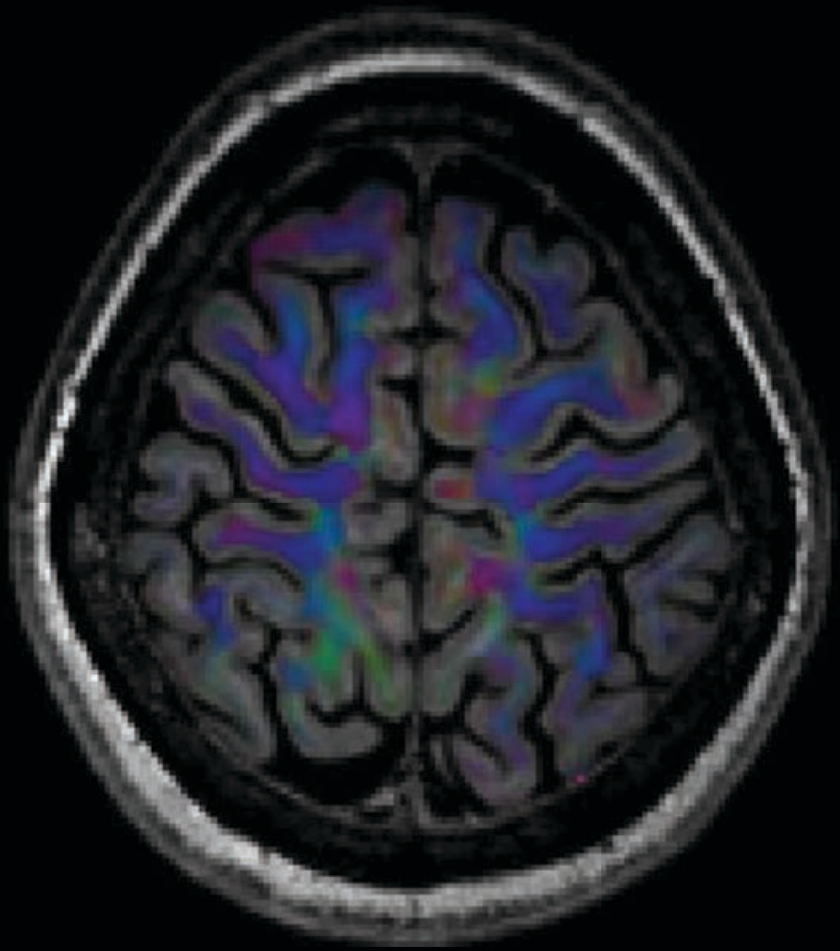
With EPI distortion correction

3. Correction for EPI deformations

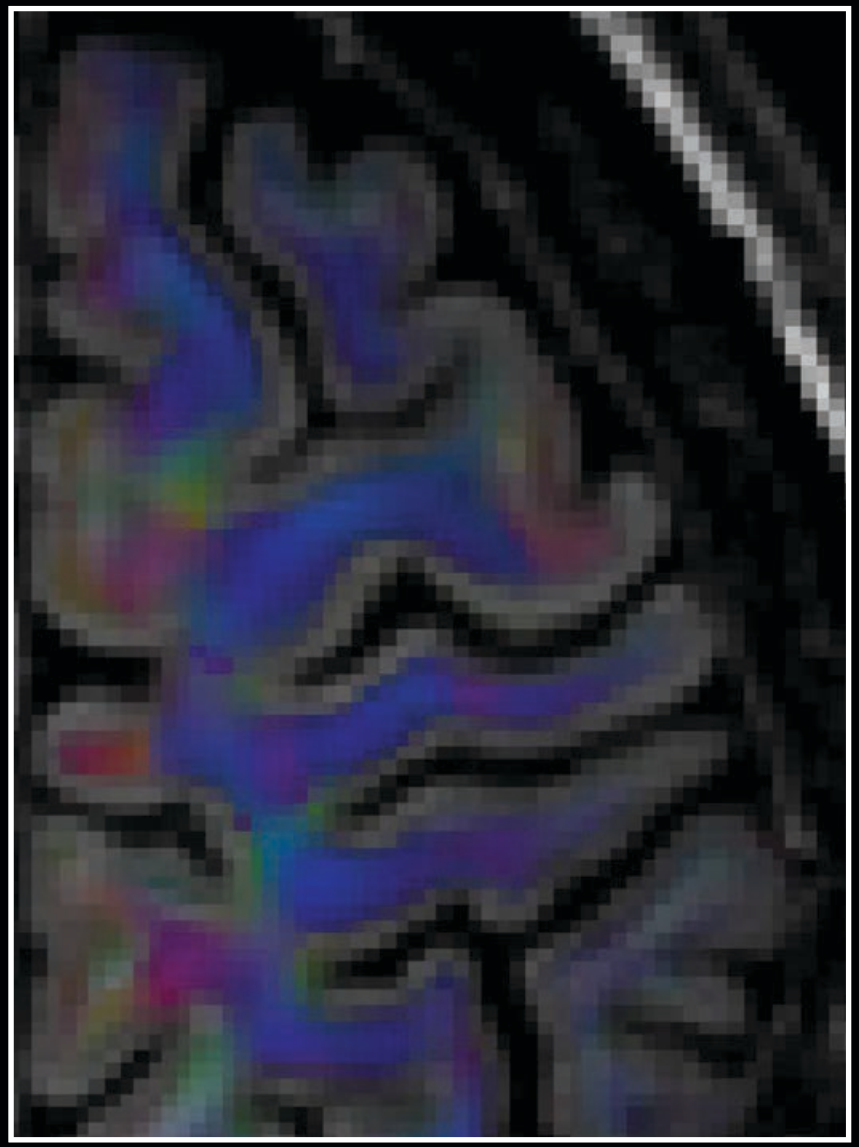


Without EPI distortion correction

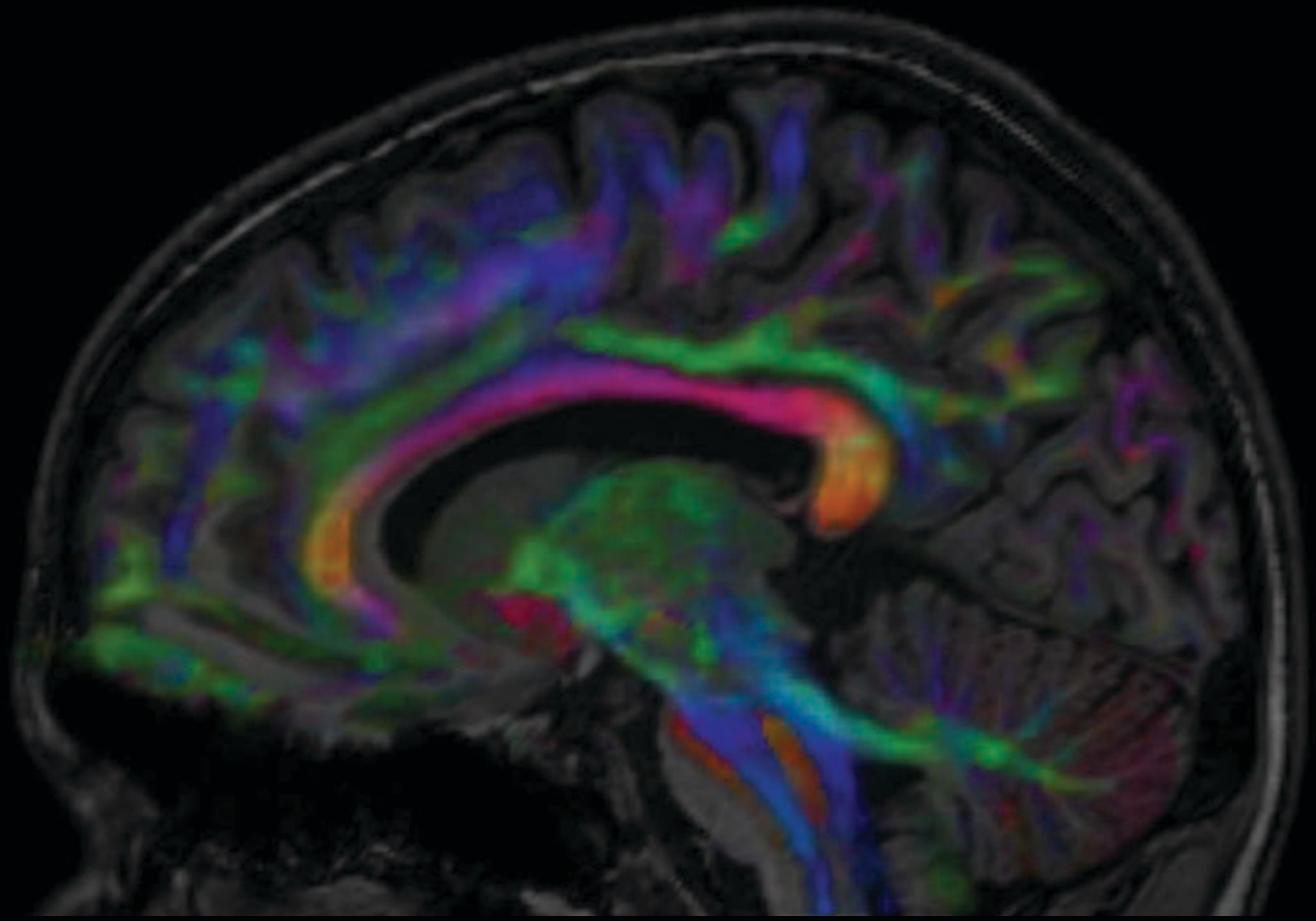
3. Correction for EPI deformations



With EPI distortion correction

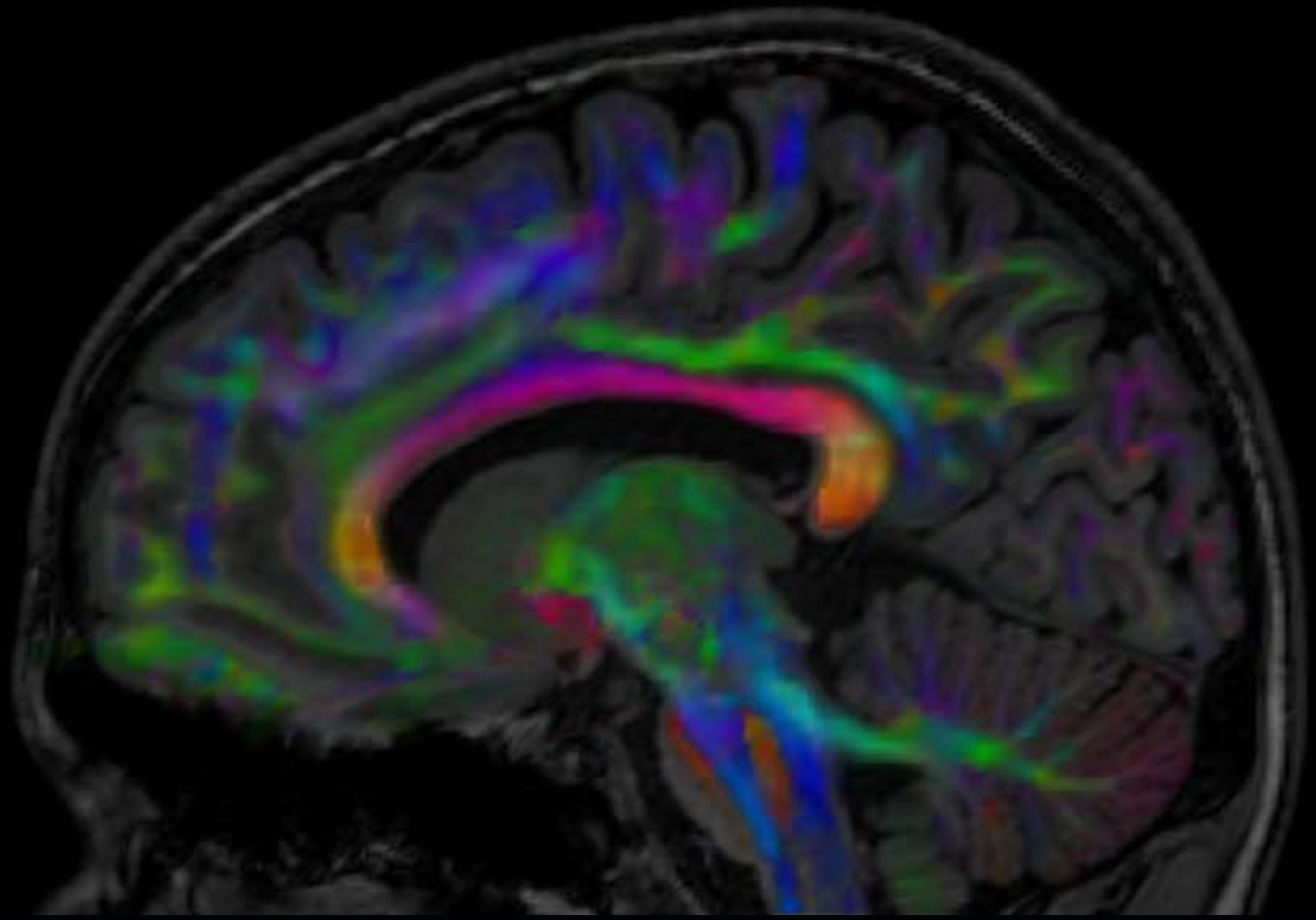


3. Correction for EPI deformations



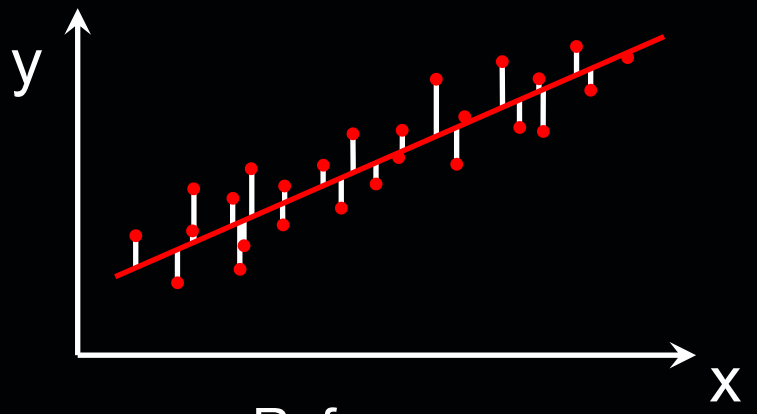
Without EPI distortion correction

3. Correction for EPI deformations



With EPI distortion correction

4. Diffusion model estimation approaches



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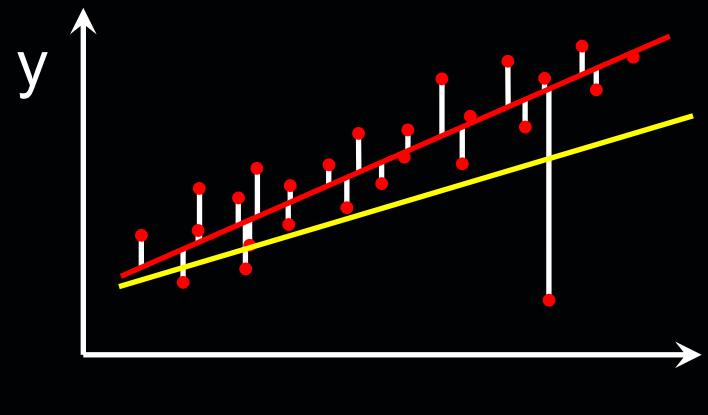
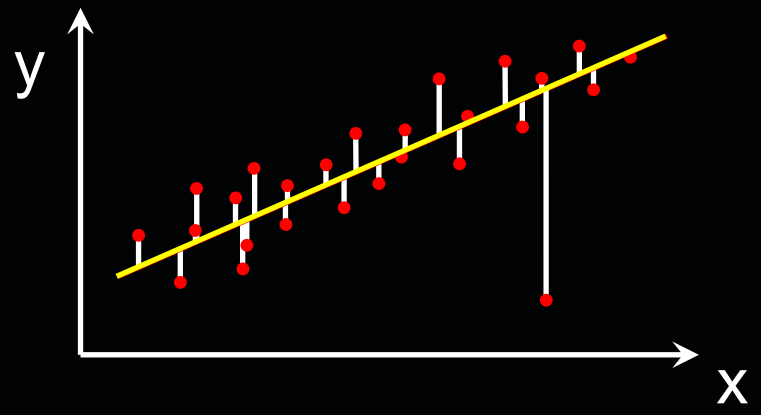
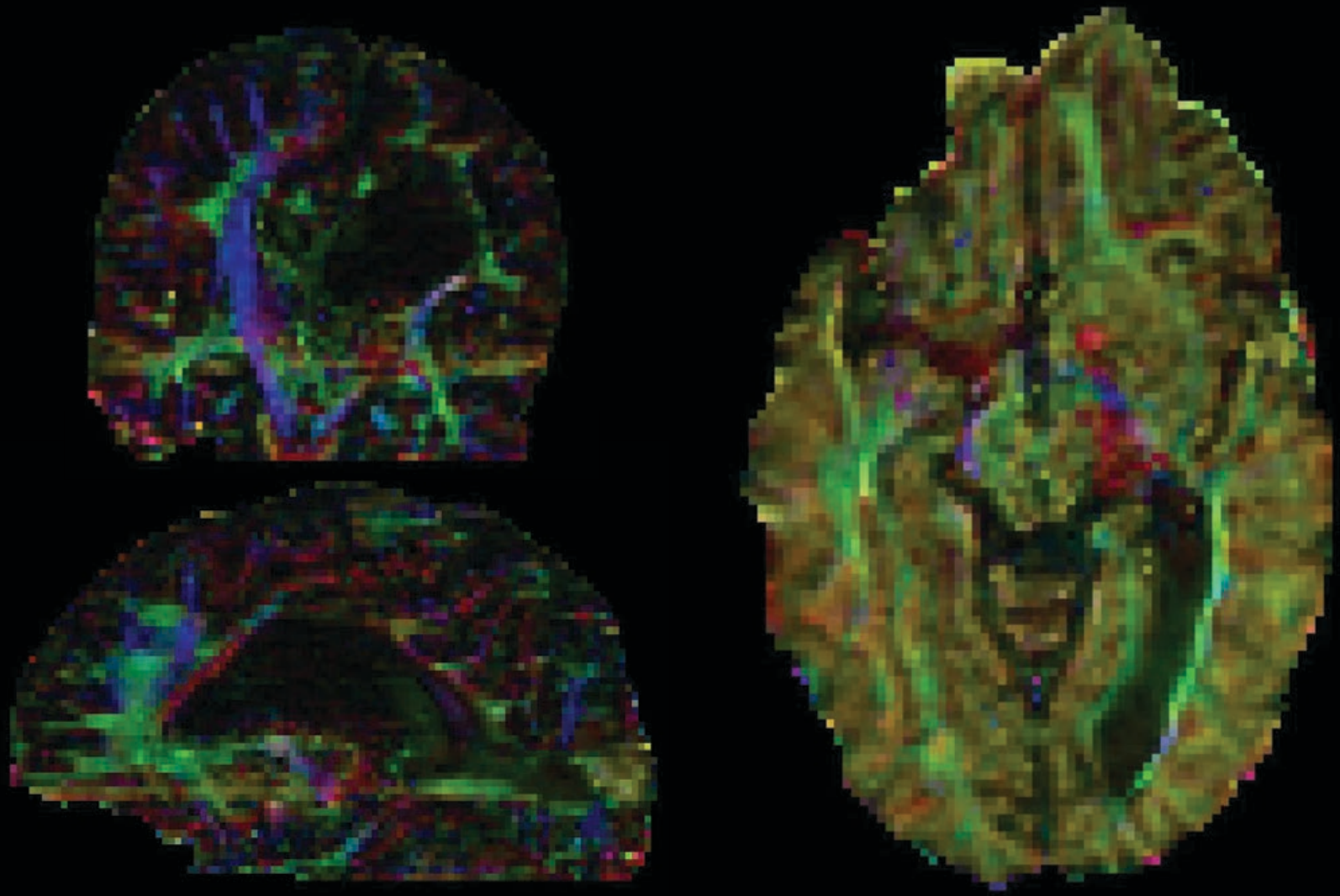


Ordinary least squares estimation



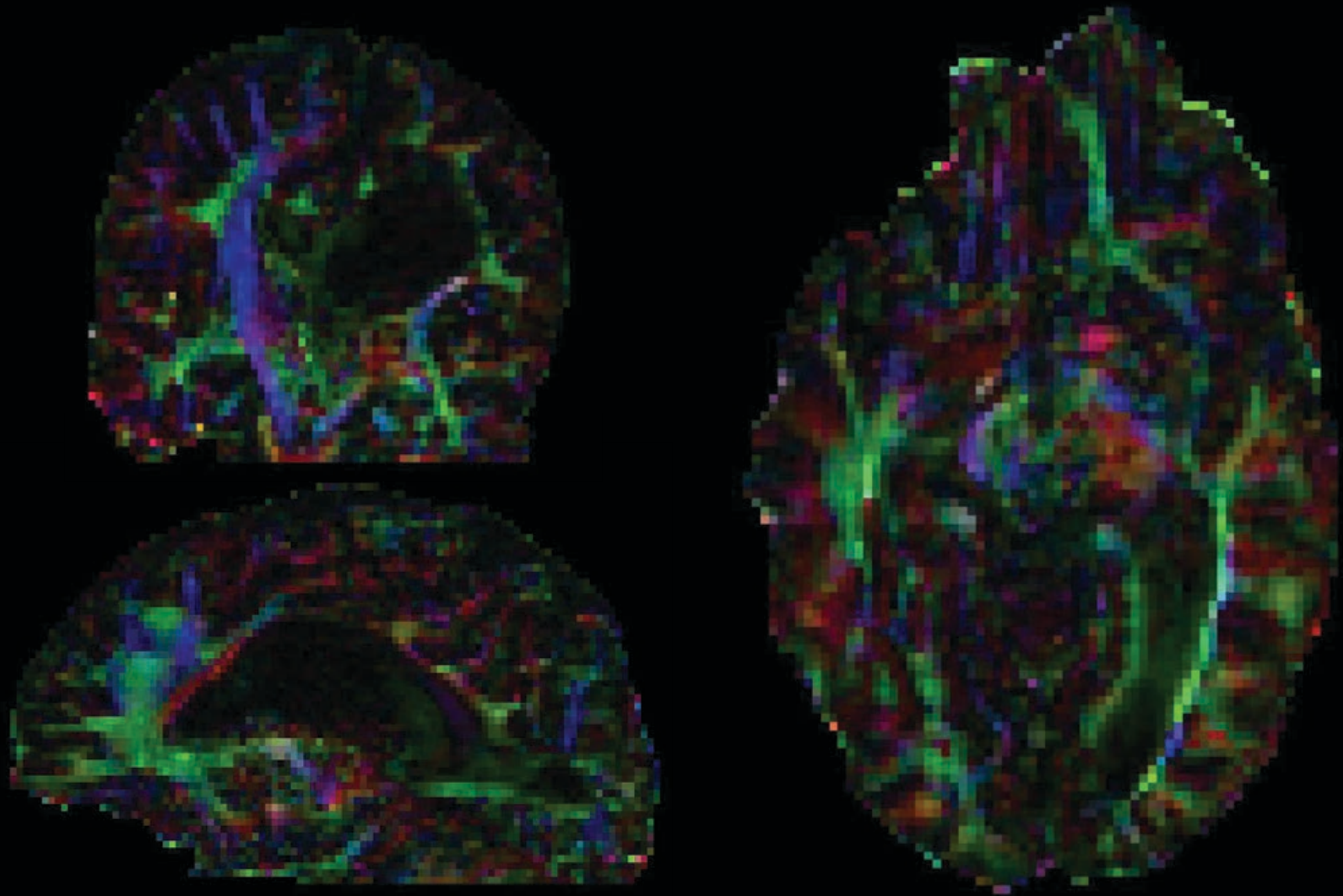
Robust estimation

4. Diffusion model estimation approaches



Ordinary least squares estimation

4. Diffusion model estimation approaches



Robust estimation

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www.ExploreDTI.com

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Merci de votre attention!

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Part 2 ...

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PROcessing & VIsualization in Diffusion Imaging

ExploreDTI Workshop

12-14 March, 2018

Utrecht, the Netherlands

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