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Automatic detection of corrupted volumes in DTI data

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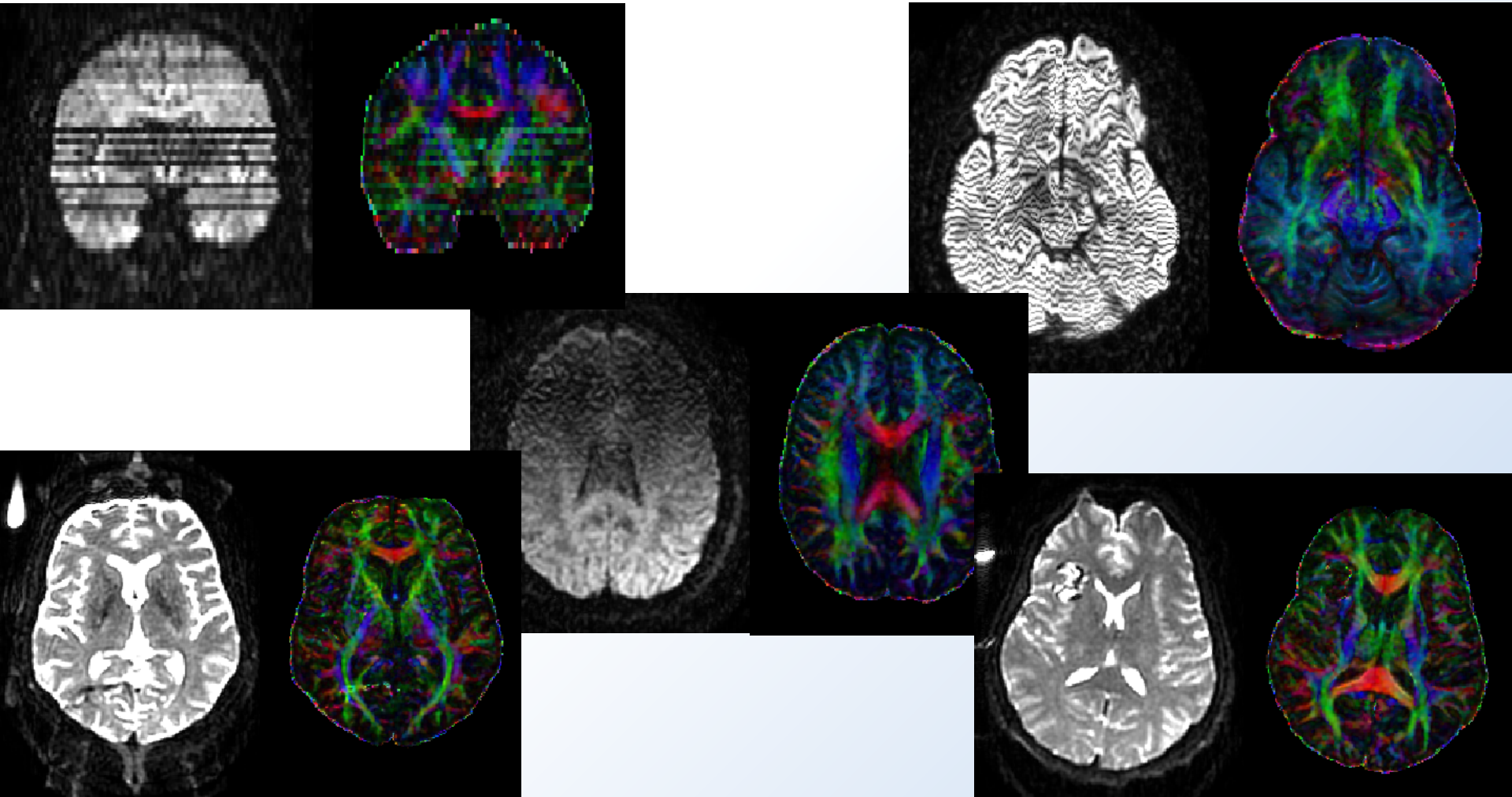
Introduction

- DTI acquisition protocol involves high intensity and high frequency gradients
- They usually involve 16-64 gradient directions and take 5-25 minutes
- DTI is sensitive to noise and motion artifacts which impact estimates of fractional anisotropy (FA)



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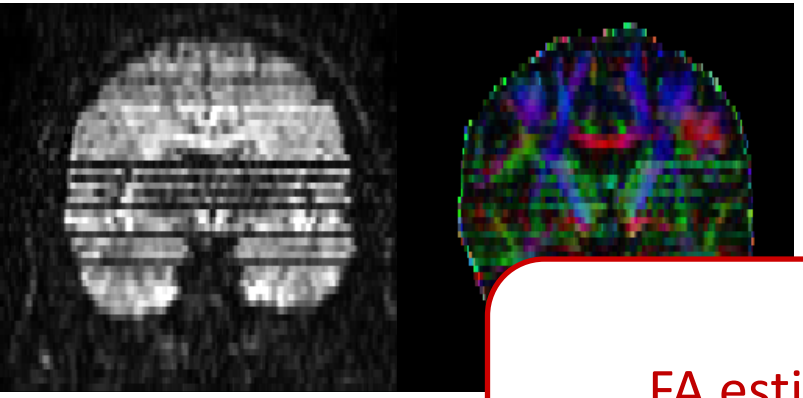
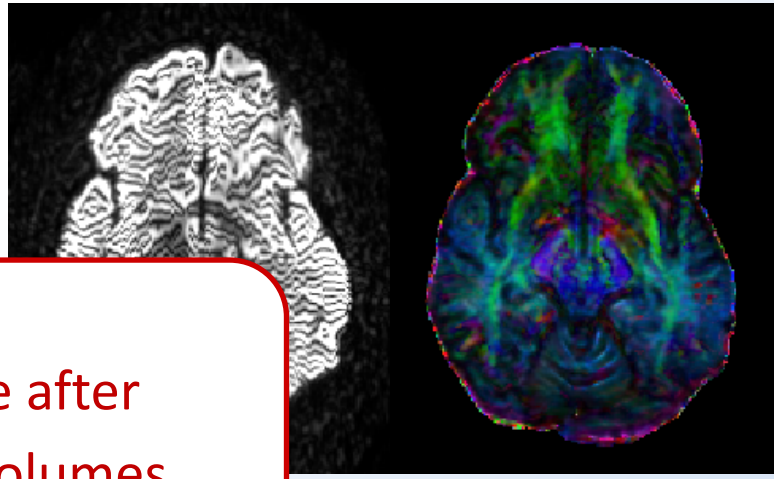
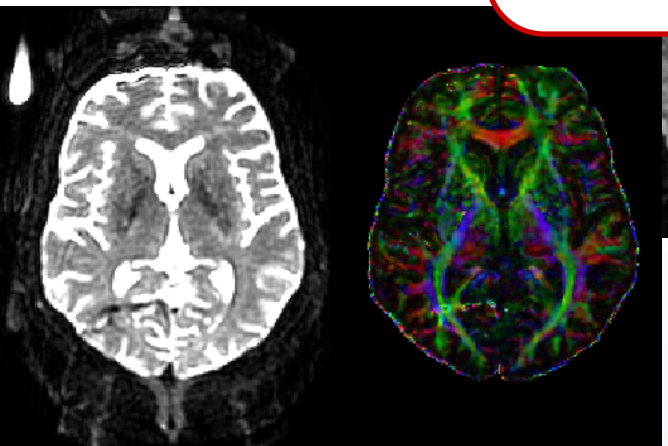
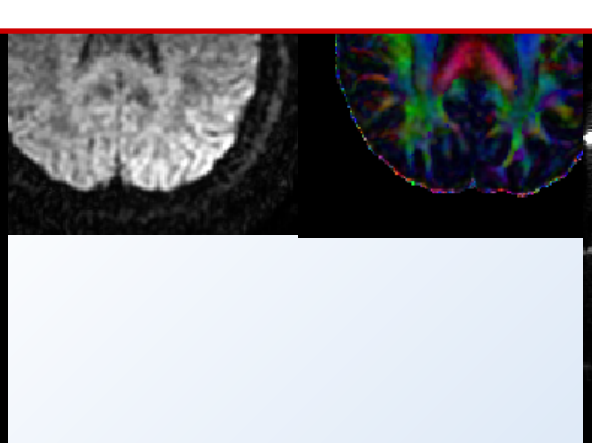
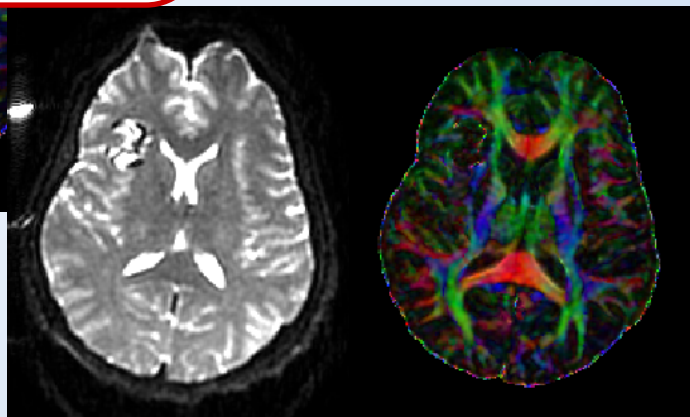




FA estimates improve after discarding corrupted volumes





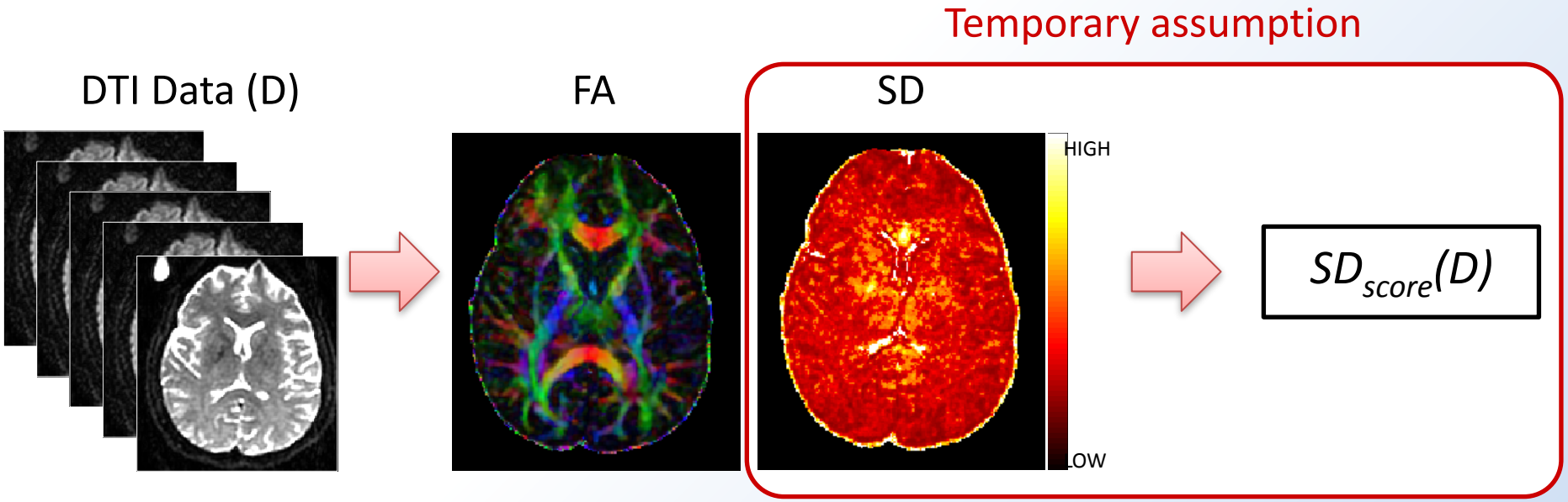


AIM

Present a method to automatically detect and discard corrupted volumes in DTI data

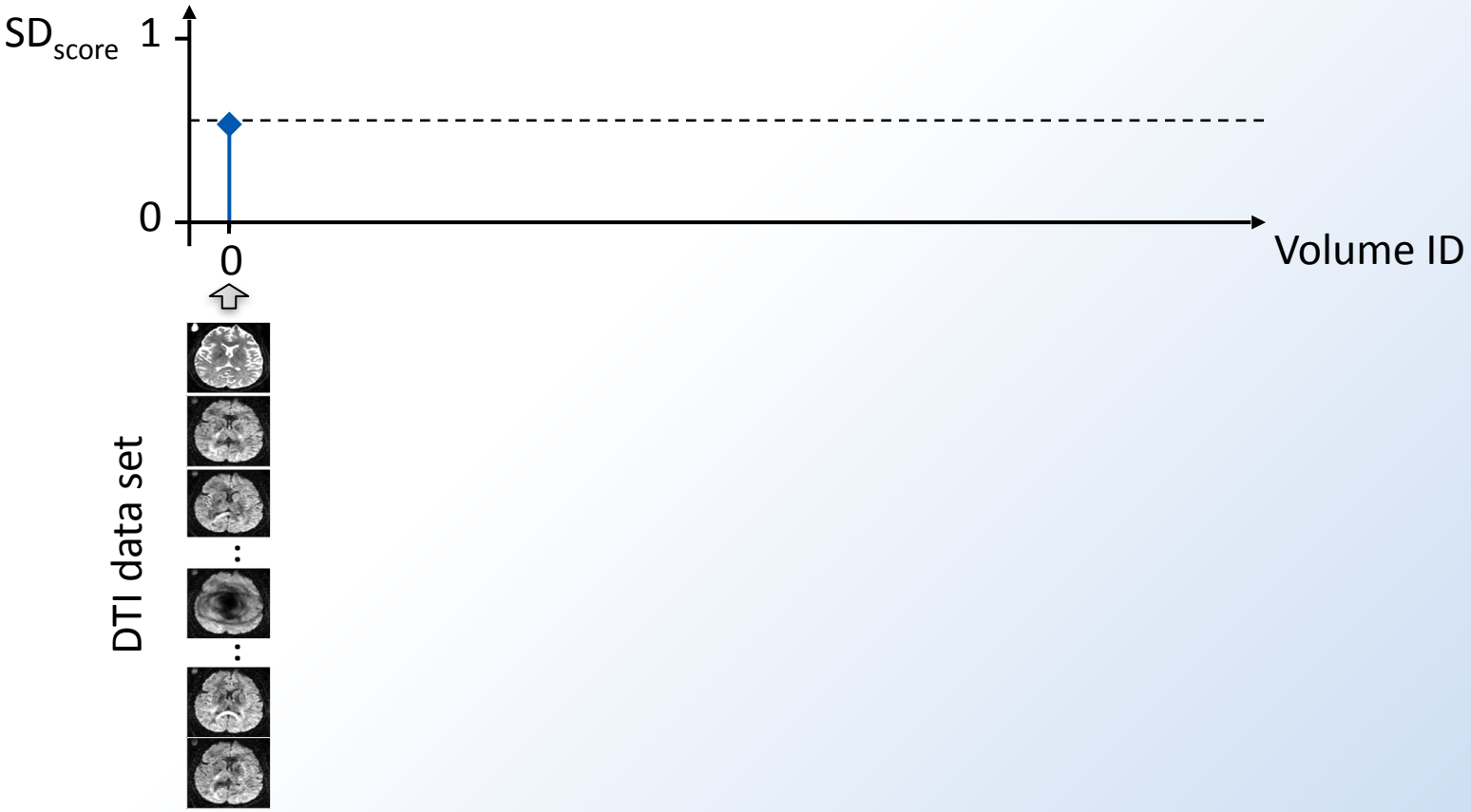
Methods: Temporary Assumption

There is a method to quantify the precision of the FA estimates (SD map) and the quality of the DTI data (SD_{score}).



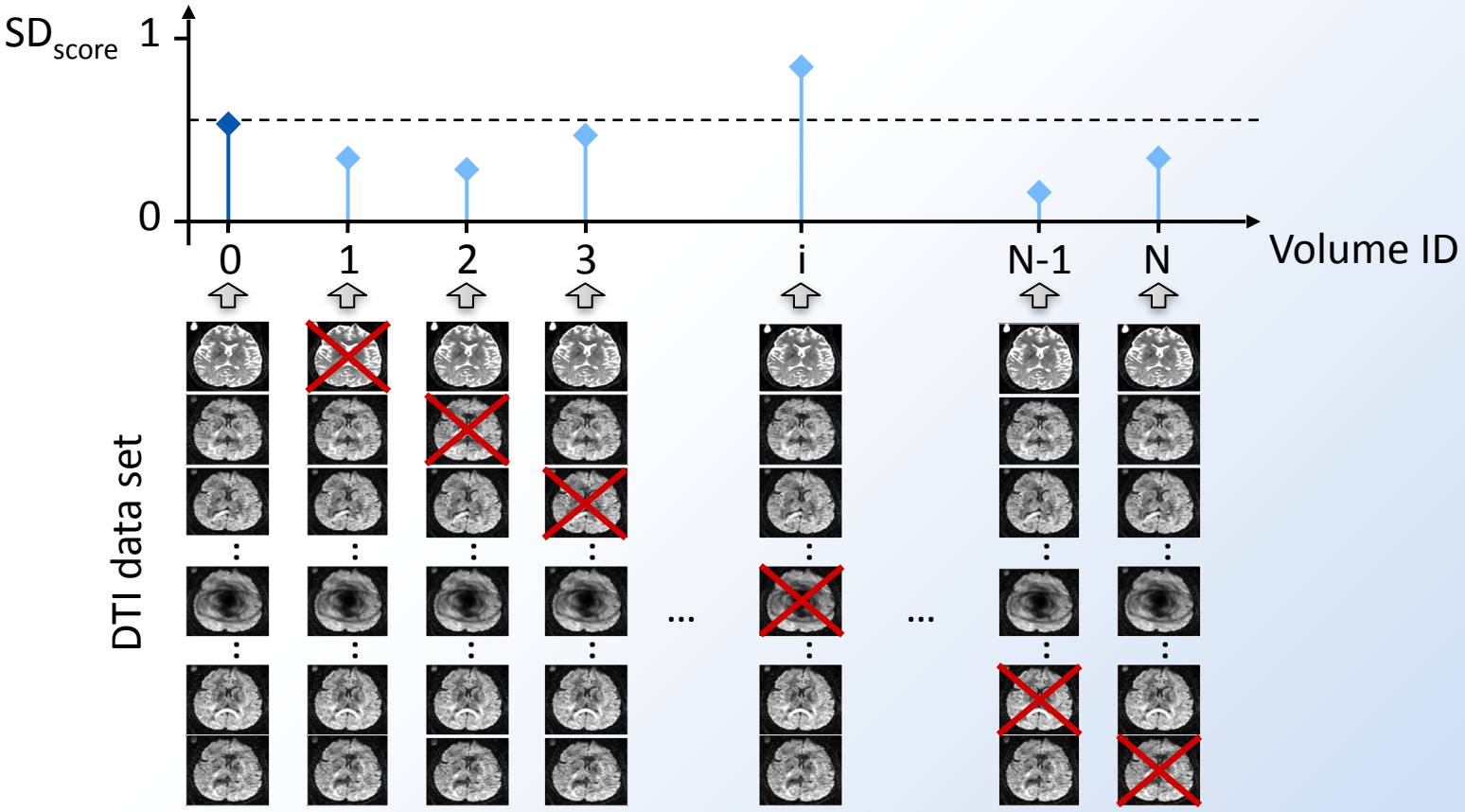
Methods: Corrupted Volume Detection

1. Compute the SD_{score} using all volumes



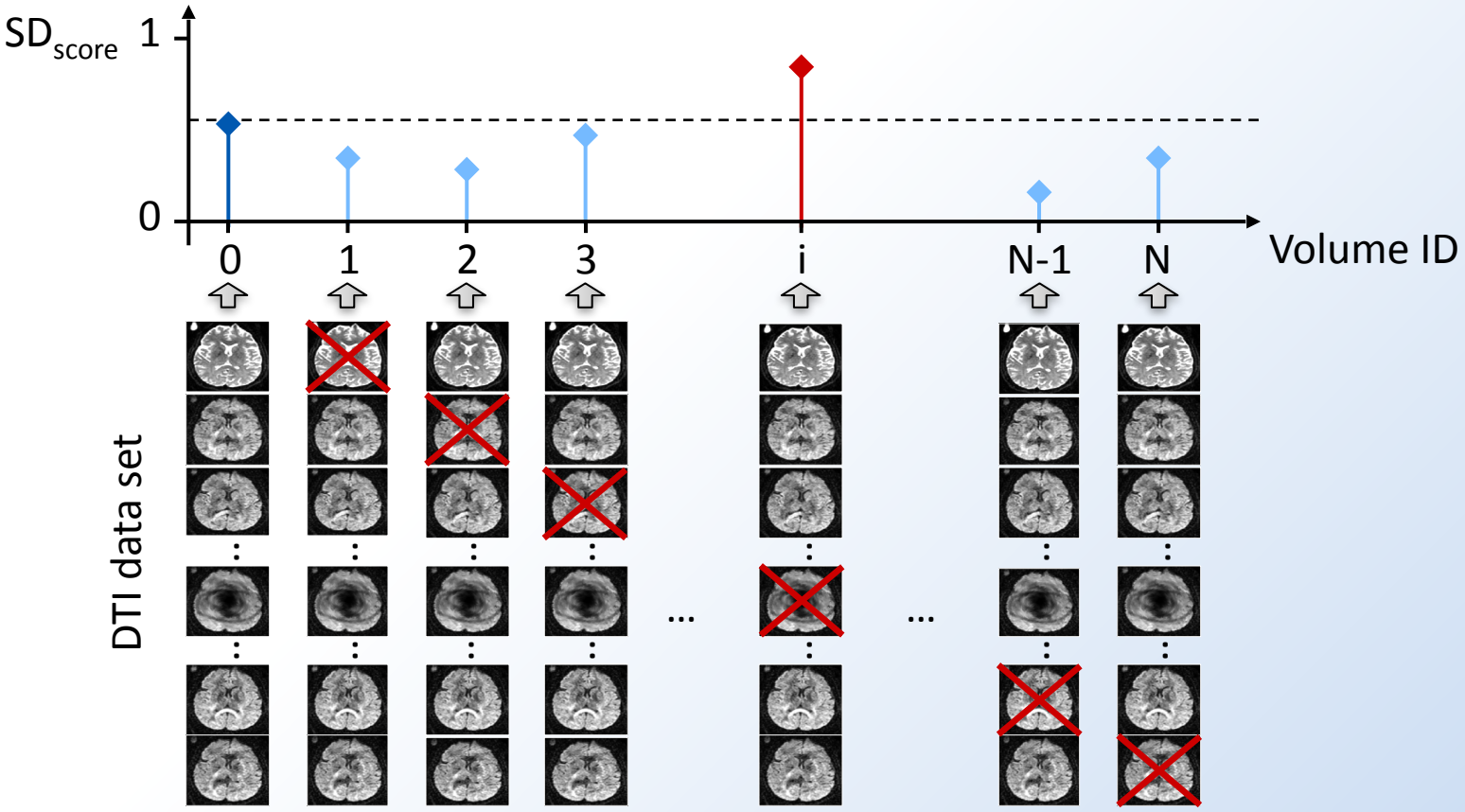
Methods: Corrupted Volume Detection

1. Compute the SD_{score} using all volumes
2. Compute the SD_{score} discarding one volume at time



Methods: Corrupted Volume Detection

1. Compute the SD_{score} using all volumes
2. Compute the SD_{score} discarding one volume at time
3. Find the largest SD_{score}



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1. Compute the SD_{score} using all volumes
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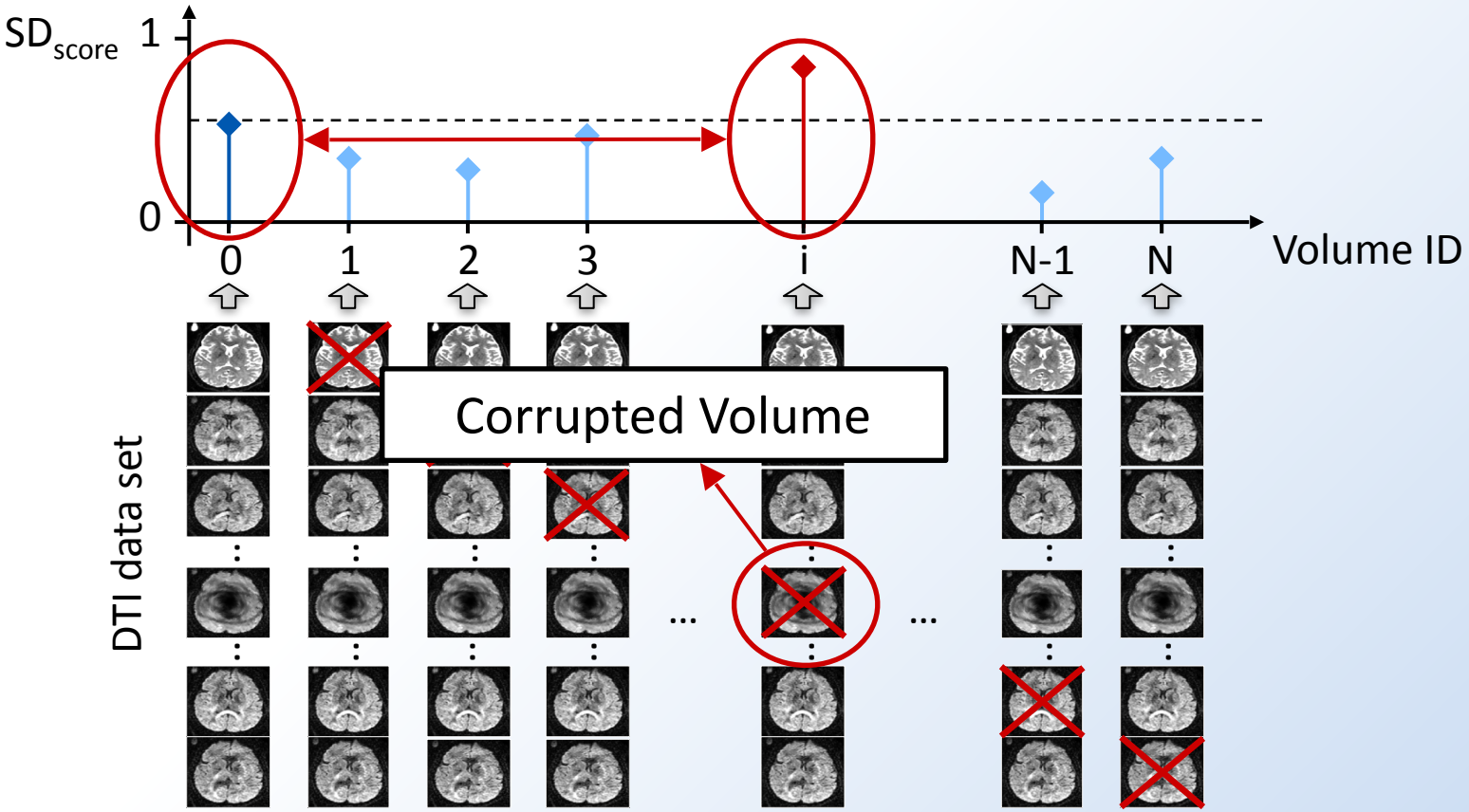
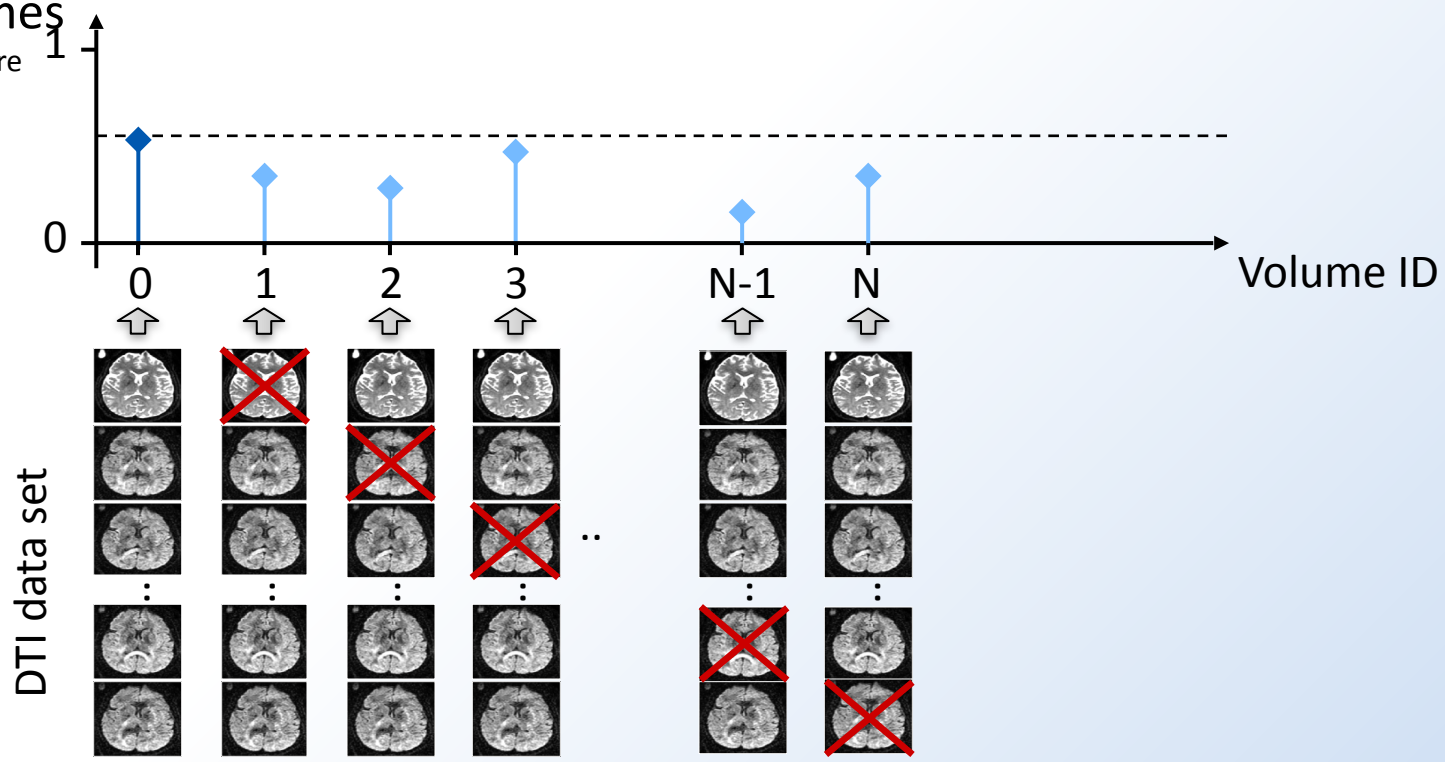
4. If the largest SD_{score} it is not the one obtained using all volumes then it is a corrupted volume



Methods: Corrupted Volume Detection

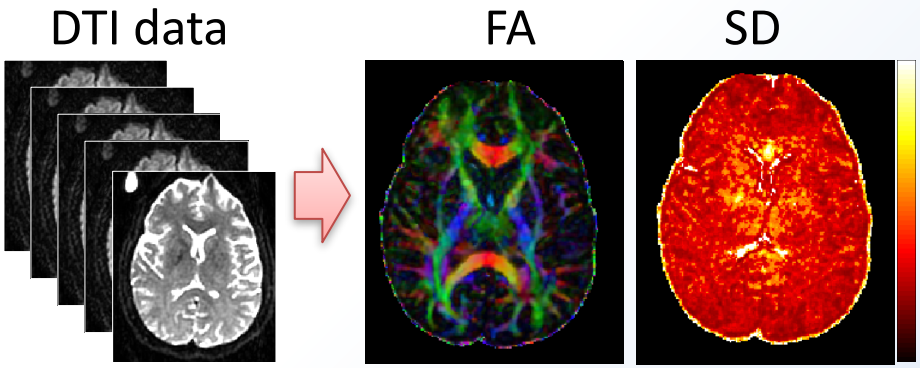
1. Compute the SD_{score} using all volumes
2. Compute the SD_{score} discarding one volume at time
3. Find the largest SD_{score}
4. If the largest SD_{score} it is not the one obtained using all volumes then it is a corrupted volume
5. Discard the corrupted volume and iterate until there are no more corrupted volumes



Methods: SD_{score}

SD_{score}:

1. Compute the FA and SD maps

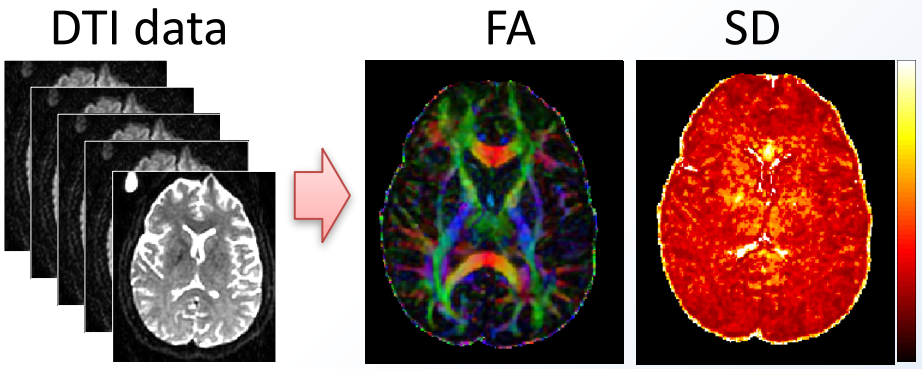


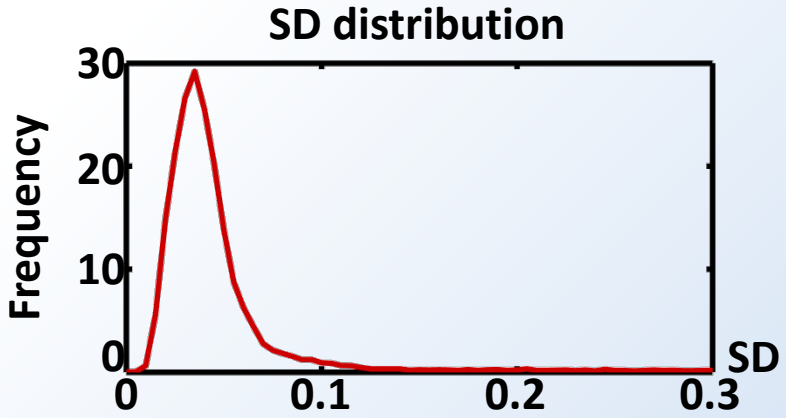
Methods: SD_{score}

SD_{score}:

1. Compute the FA and SD maps

2. Compute the SD distribution

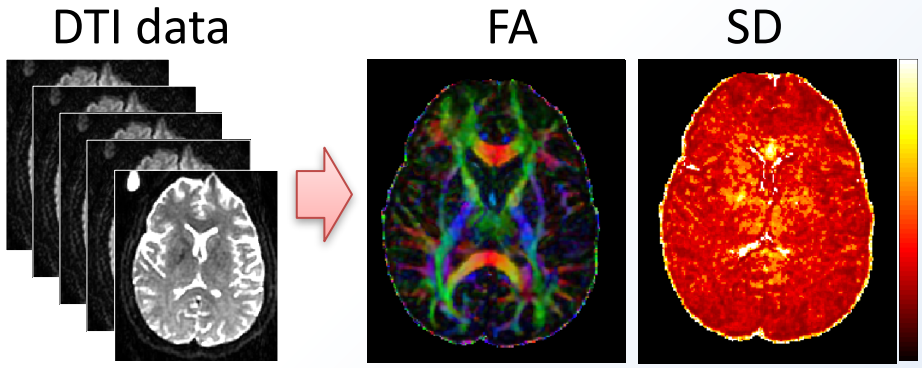


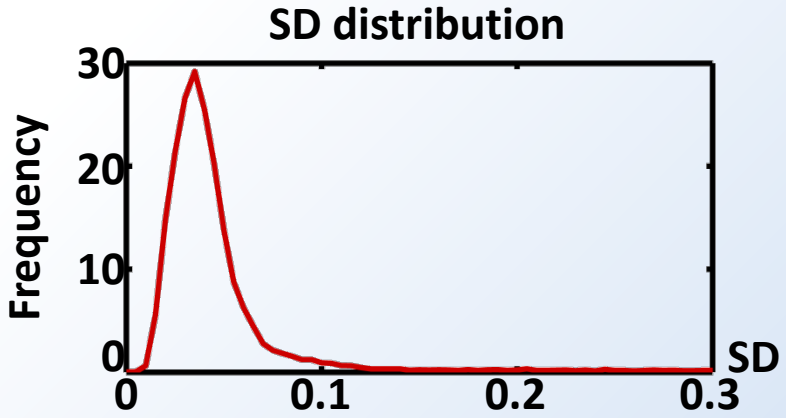


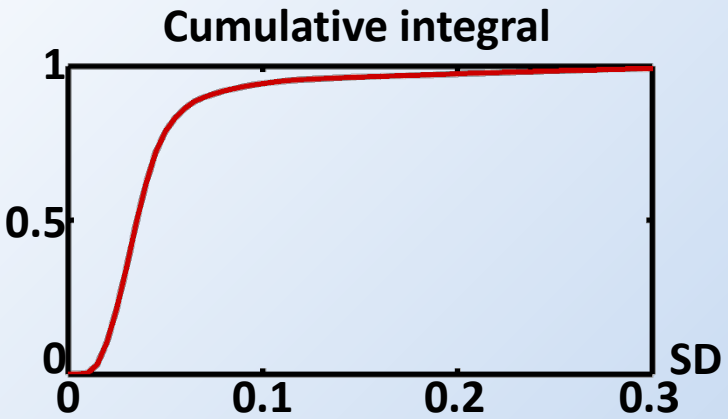
Methods: SD_{score}

SD_{score}:

1. Compute the FA and SD maps
2. Compute the SD distribution
3. Compute the cumulative integral of the SD distribution



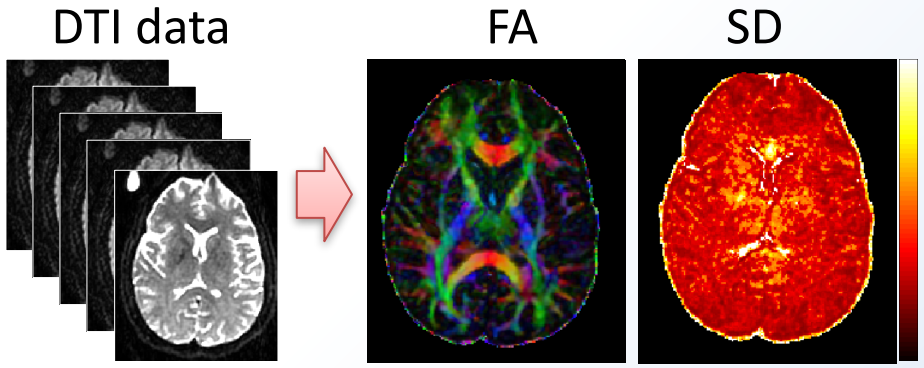


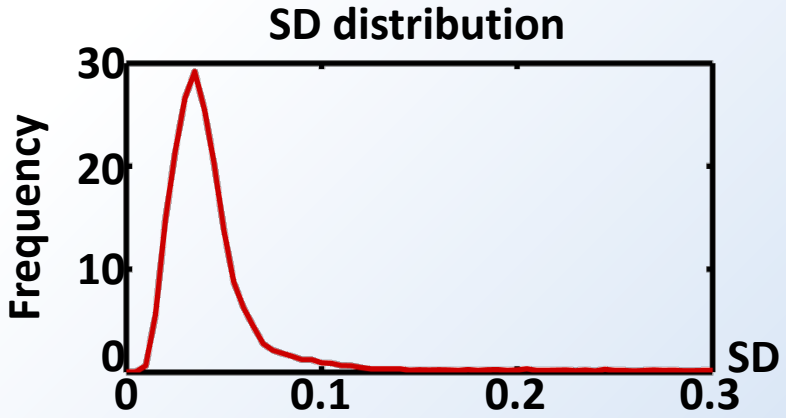


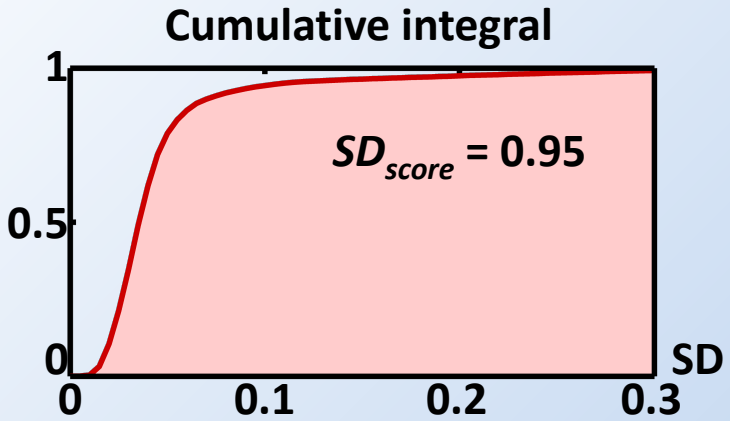
Methods: SD_{score}

SD_{score}:

1. Compute the FA and SD maps
2. Compute the SD distribution
3. Compute the cumulative integral of the SD distribution
4. Compute the SD_{score} ad the area of the cumulative integral







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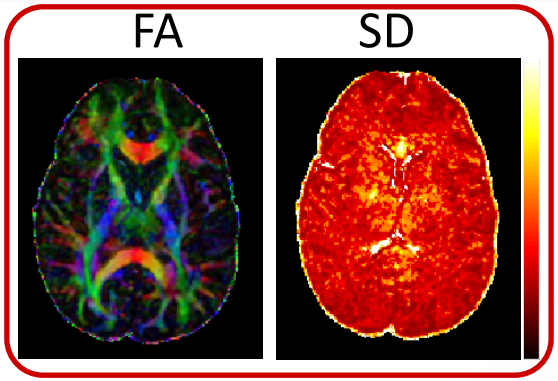
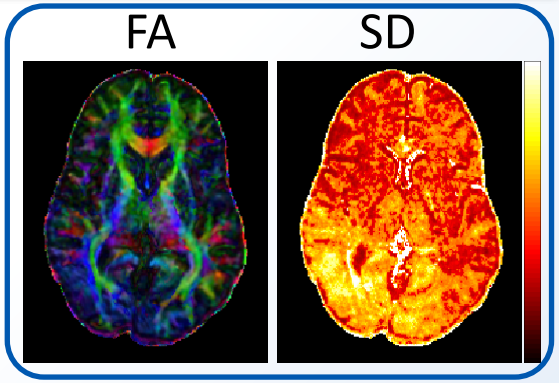
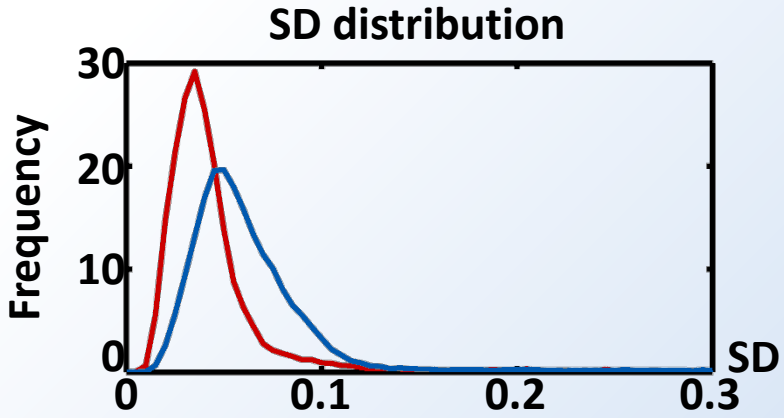


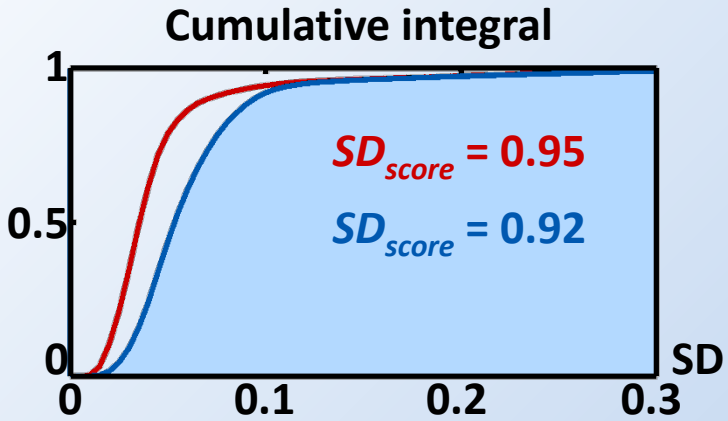


SD_{score}:

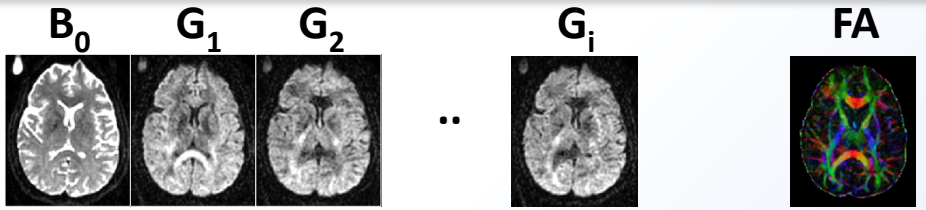
1. Compute the FA and SD maps
2. Compute the SD distribution
3. Compute the progressive integral of the SD distribution
4. Compute the SD_{score} ad the area of the cumulative integral

The SDscore can be used to compare different sets of data:
— good data set
— bad data set





Methods: bootstrap



SD map FA is computed using a bootstrap approach:

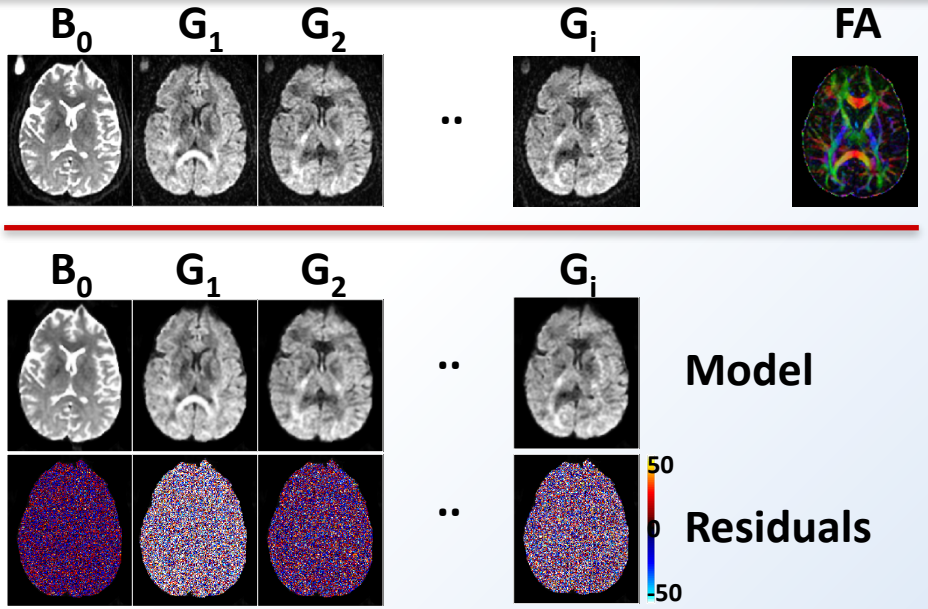
1. Estimate the diffusion tensor model parameters

Methods: bootstrap

SD map FA is computed using a bootstrap approach:

1. Estimate the diffusion tensor model parameters

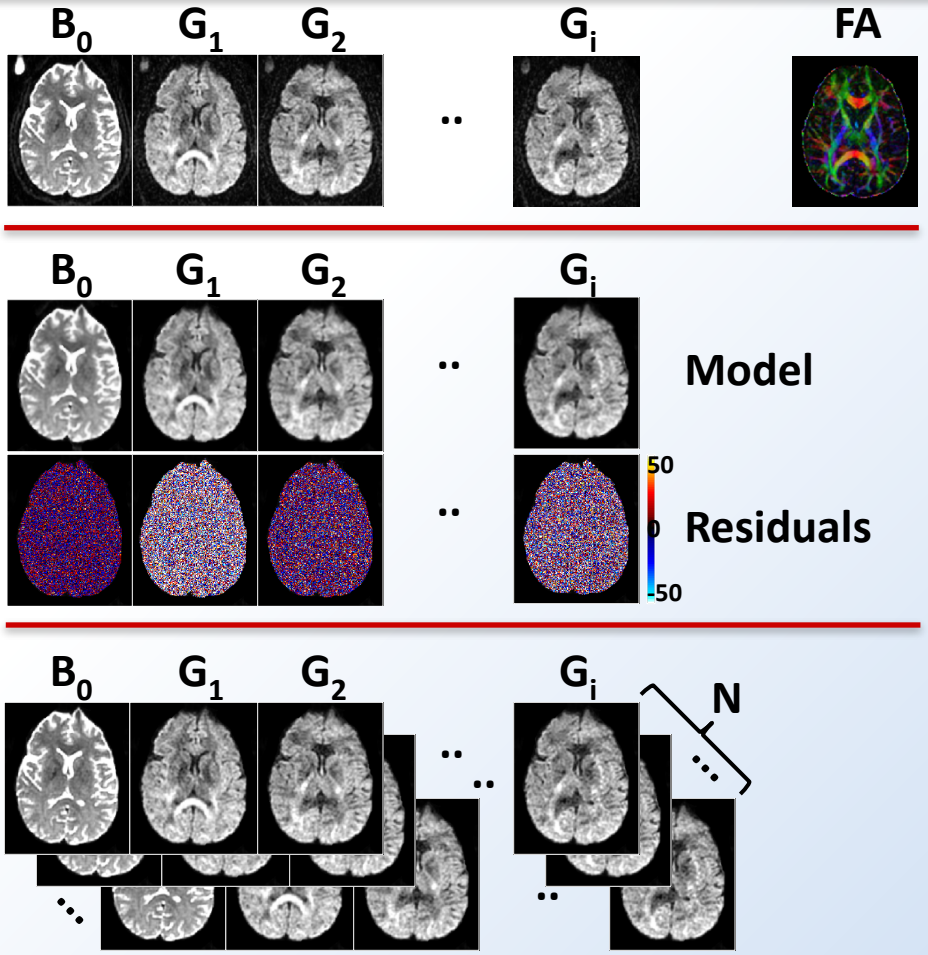
2. Compute the model prediction of the data and the residuals



Methods: bootstrap

SD map FA is computed using a bootstrap approach:

1. Estimate the diffusion tensor model parameters
2. Compute the model prediction of the data and the residuals
3. Build N realizations of the data randomly resampling the residuals



Methods: bootstrap

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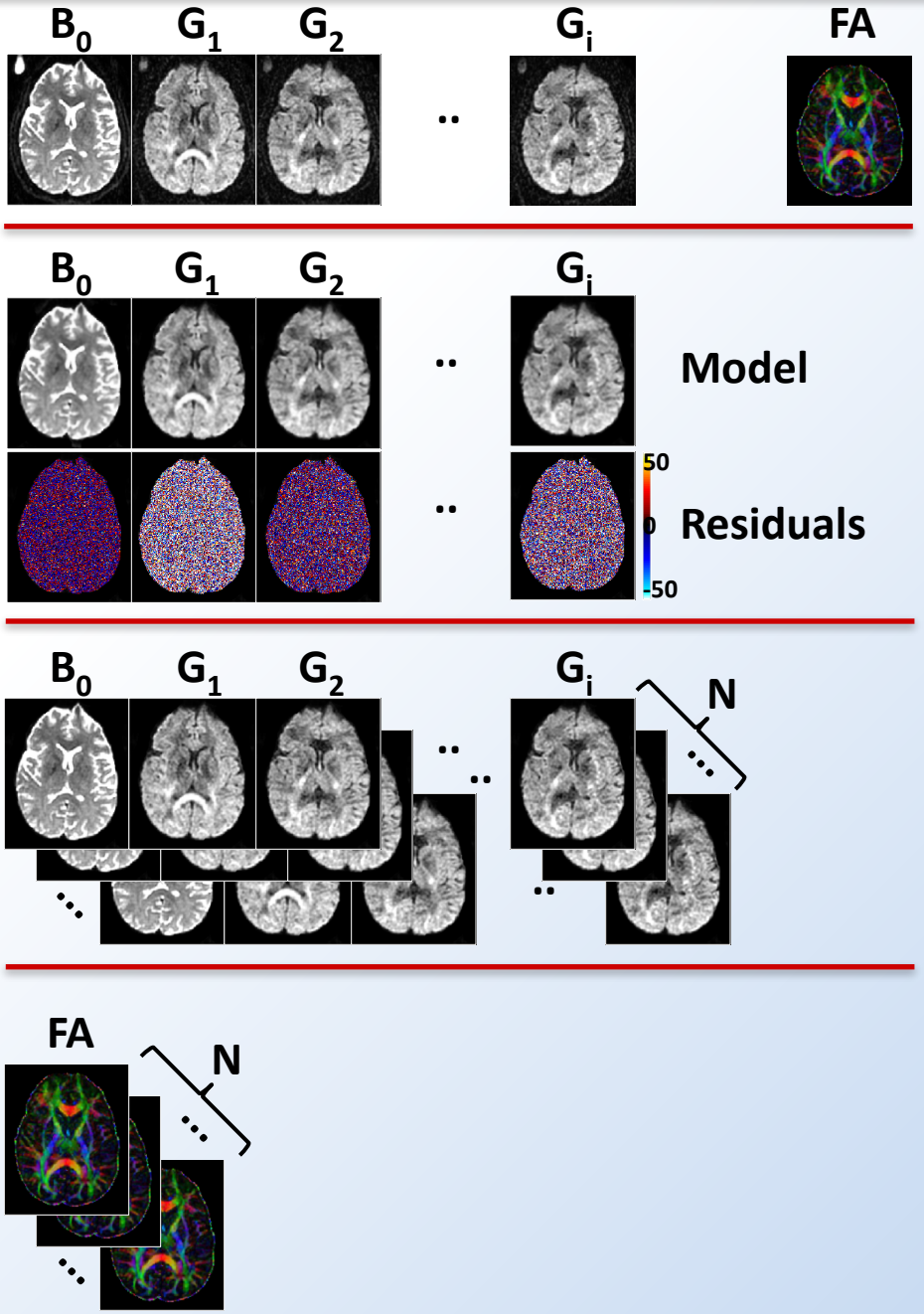
3. Build N realizations of the data randomly resampling the residuals
4. Compute the FA for each realization



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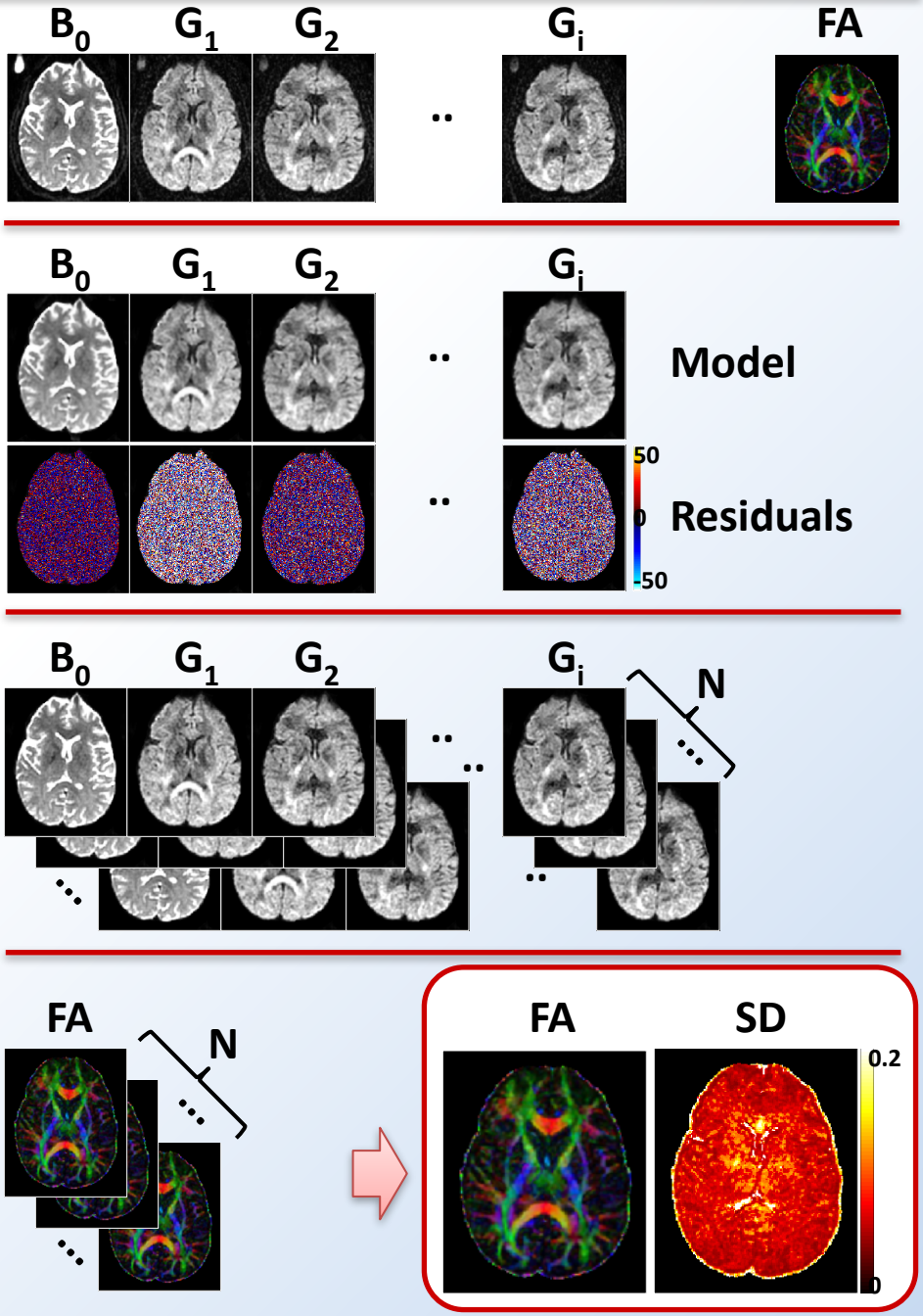
SD map FA is computed using a bootstrap approach:

1. Estimate the diffusion tensor model parameters
2. Compute the model prediction of the data and the residuals
3. Build N realizations of the data randomly resampling the residuals
4. Compute the FA for each realization
5. Compute the average and the SD among the N FA estimates



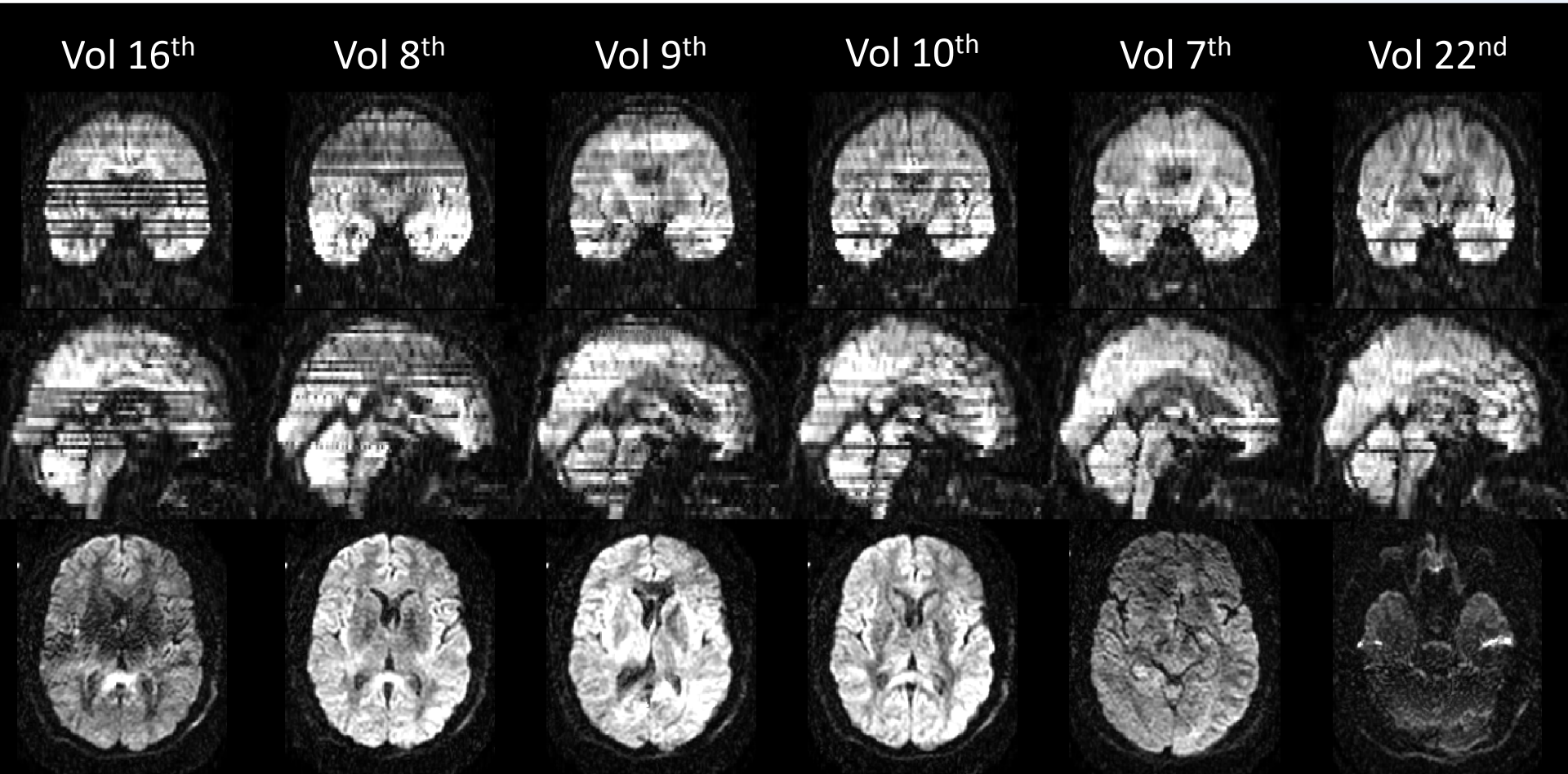
Results: Subject #1

Scanner: GE Signa 3.0T
TR/TE = 14s/84.4 ms

25 gradient directions
B-value = 1000 s/mm^2
5 B0 images

Voxel size = 0.93x0.93x3 mm^3
FOV = 240x240 mm^2

6 volumes have been discarded



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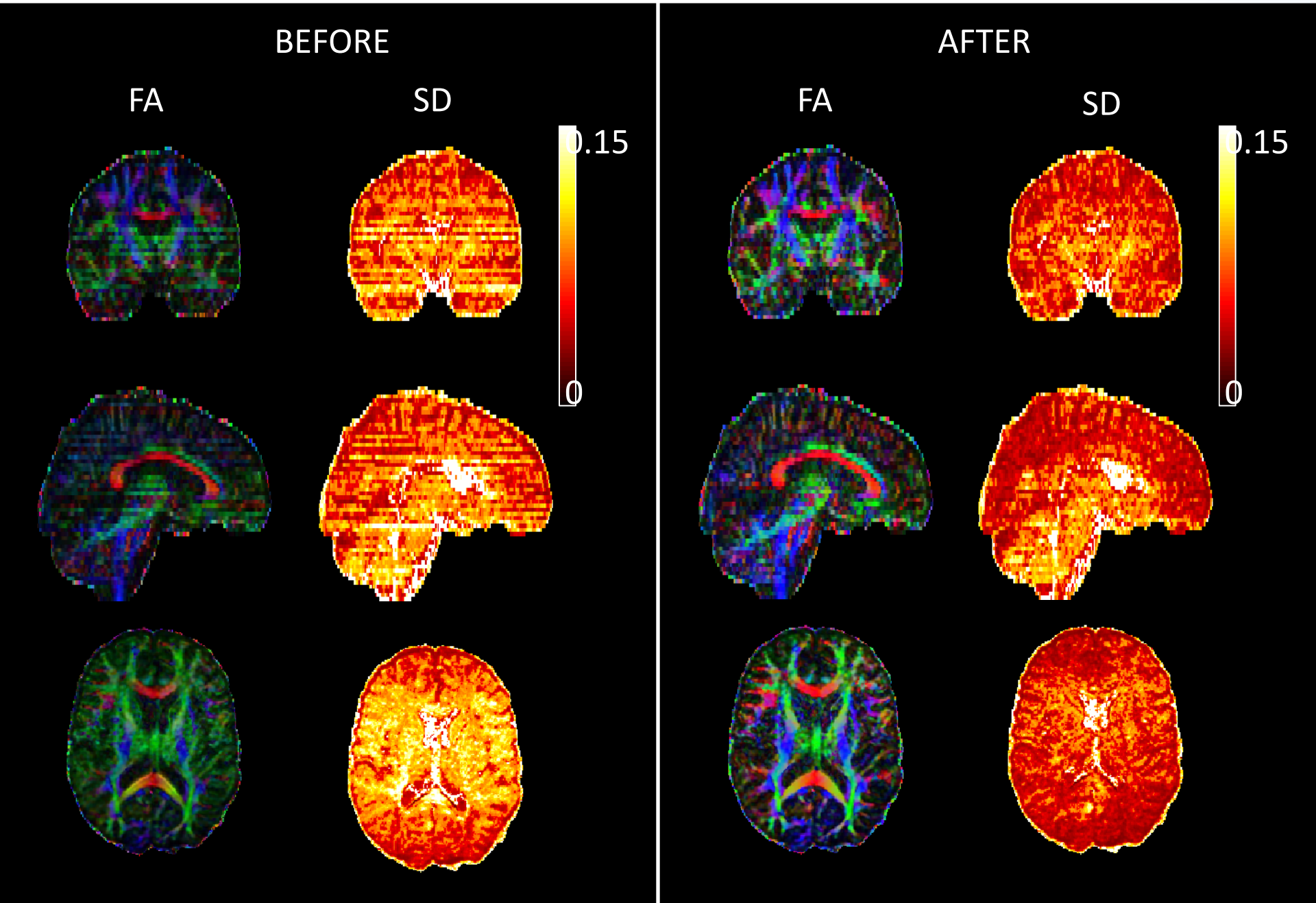

Results: Subject #2

Scanner: GE Signa 3.0T
TR/TE = 14s/84.4 ms

25 gradient directions
B-value = 1000 s/mm^2
5 B0 images

Voxel size = 0.93x0.93x3 mm^3
FOV = 240x240 mm^2

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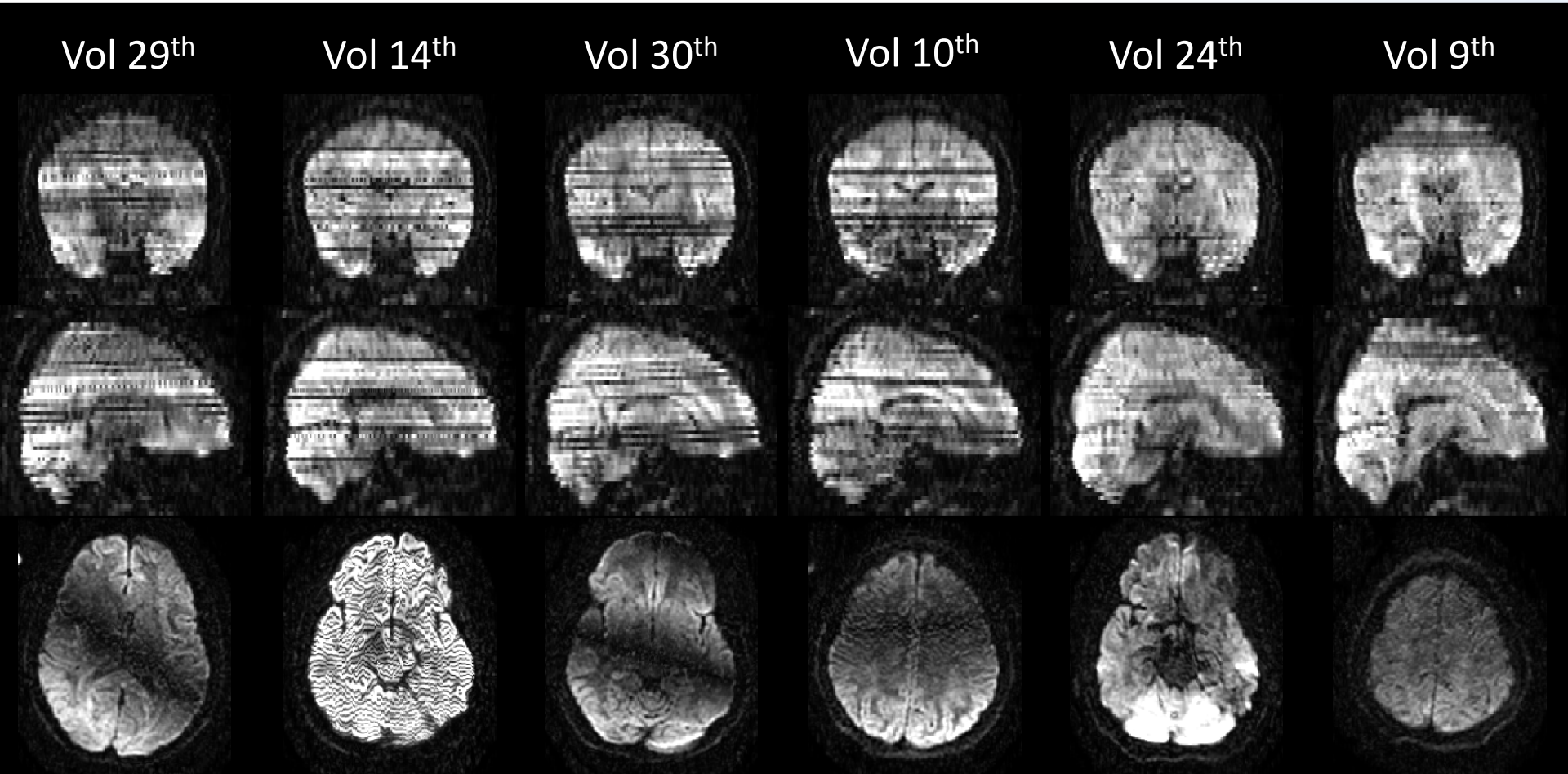
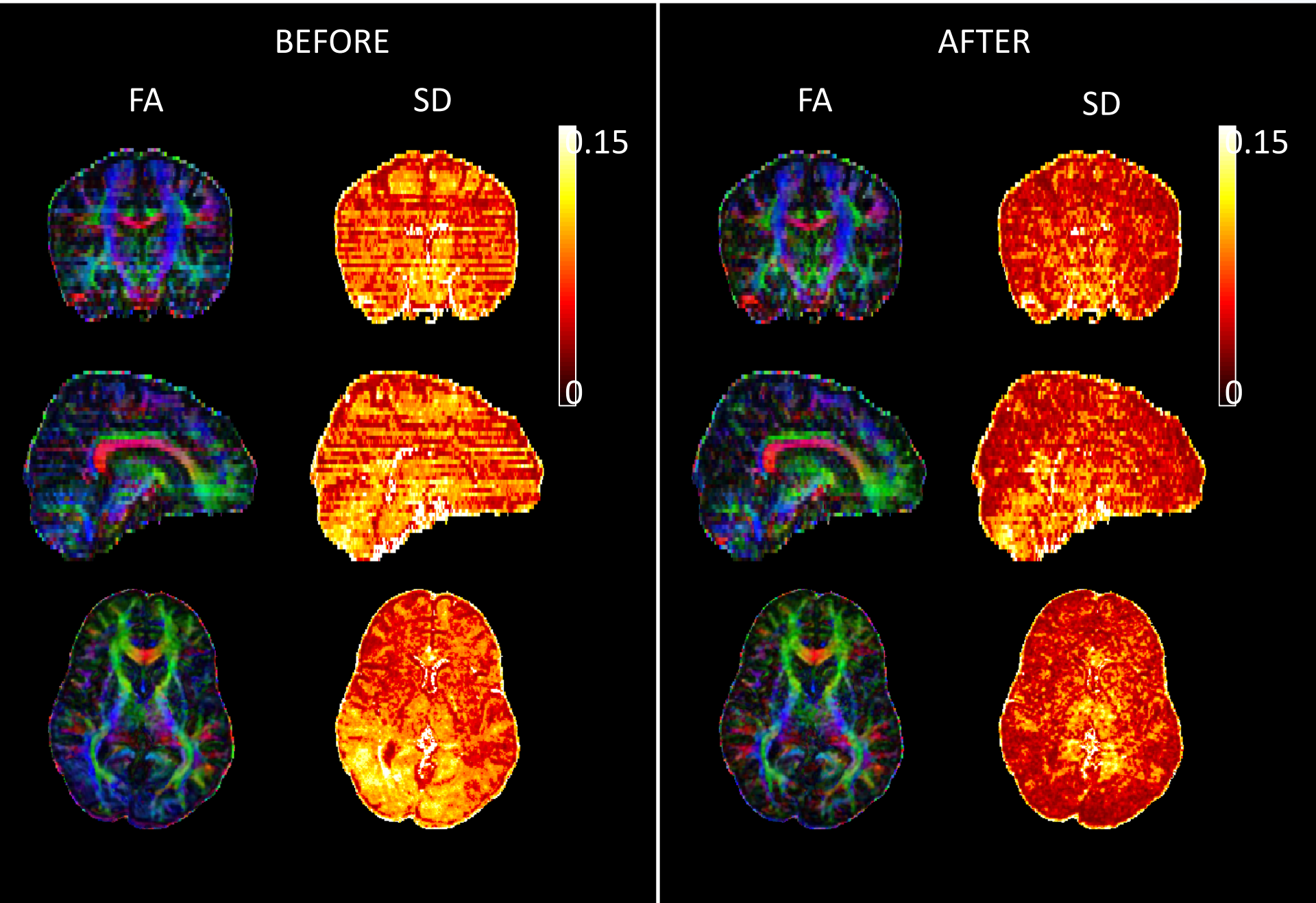


Results: Subject #2



Conclusions

- Using high intensity and high frequency gradients, the DTI acquisition protocol is sensitive to noise and movement artifacts
- Movement artifacts corrupt only some volumes in a subject's data set
- Deletion of the corrupted volumes improve the FA estimates
- A method to automatically detect corrupted volumes on DTI data have been proposed and successfully applied on real data

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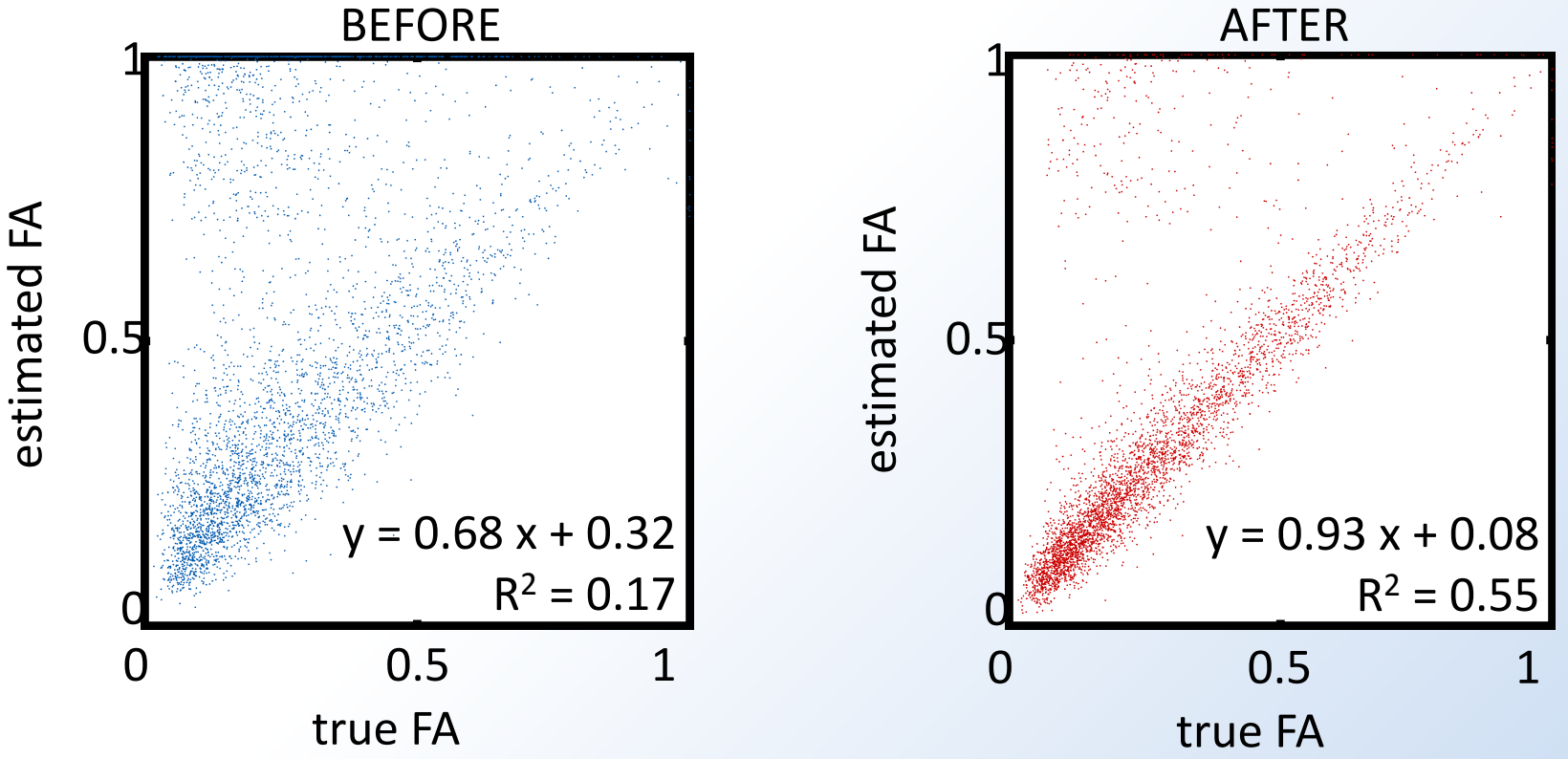
Thank you for your attention

Simulations

32 gradient directions (1 B0 image)
B-value = 1000 s/mm^2

Number of Voxel = 3000
SNR = 12 (standard data)

5 corrupted volumes with SNR 6, 4, 3, 2 ,1

The method correctly select and discard the 5 volumes with worse SNR.