DTI Acquisition Tips and Tricks

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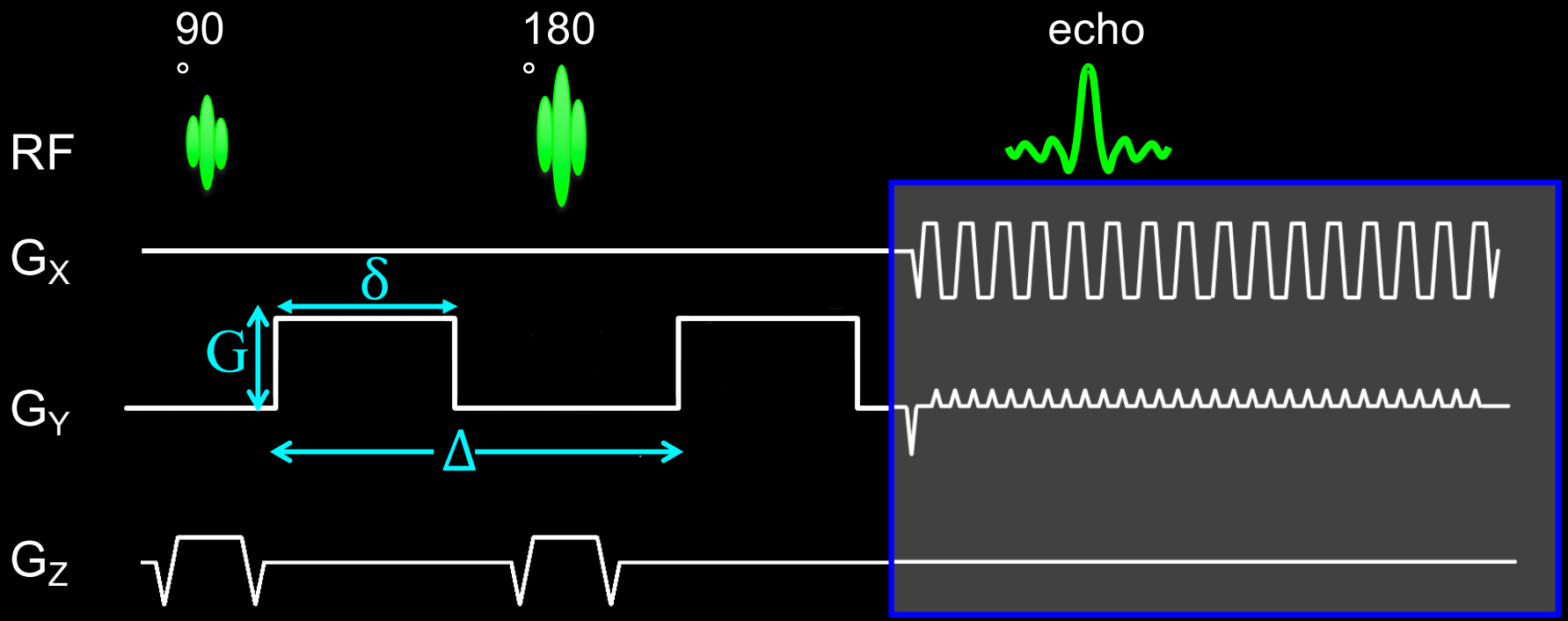
Motivation

- Many artifacts can be alleviated or reduced through choice of acquisition options
- “It’s always better to acquire good data then try to fix bad data!”
- Every vendor and software level has pros and cons, different tips and tricks needed

Pulse Sequence



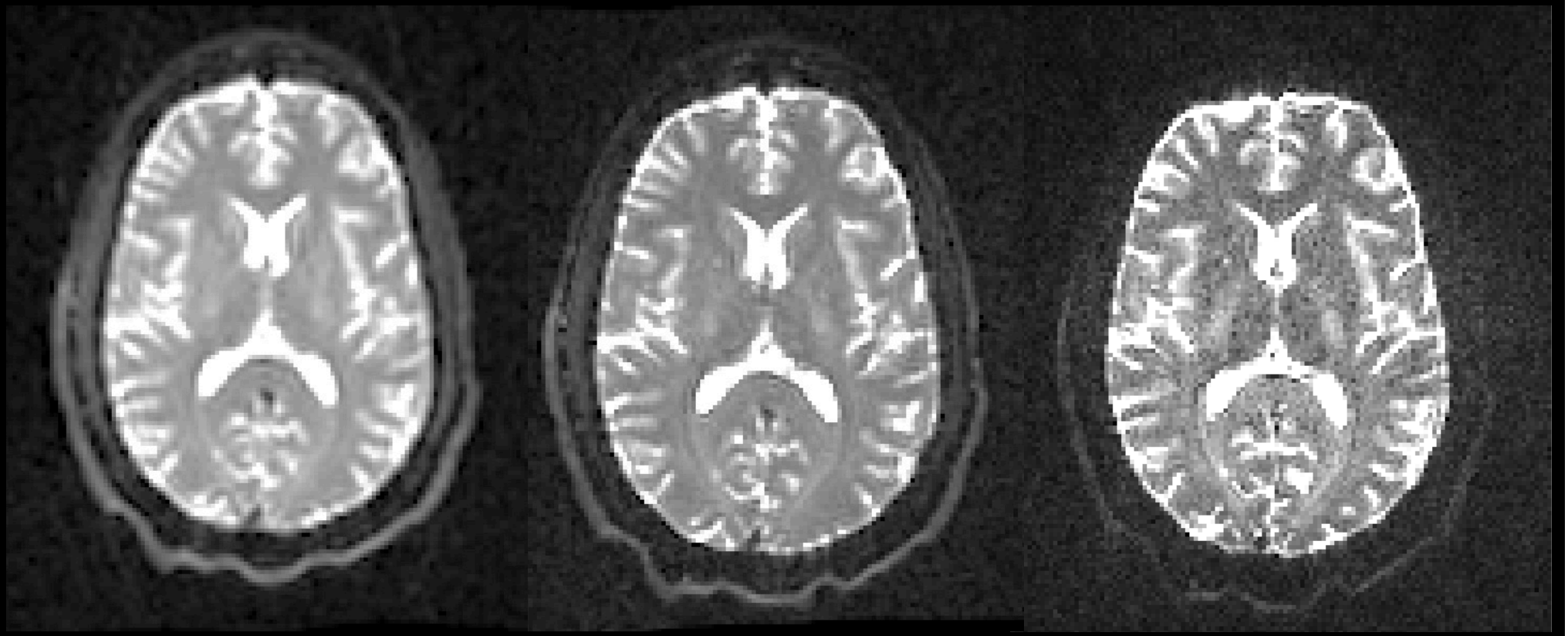
$$b = (\gamma G \delta)^2 \left(\Delta - \frac{\delta}{3} \right)$$

Stejskal, EO and Tanner, JE. J Chem Phys (1965) 42 : 288-292

Common Problems in DTI

- Low SNR
- Incomplete Fat Suppression
- Eddy-current distortions
- EPI related distortions
- Bulk movement
- Ca[illegible]ation

Low SNR

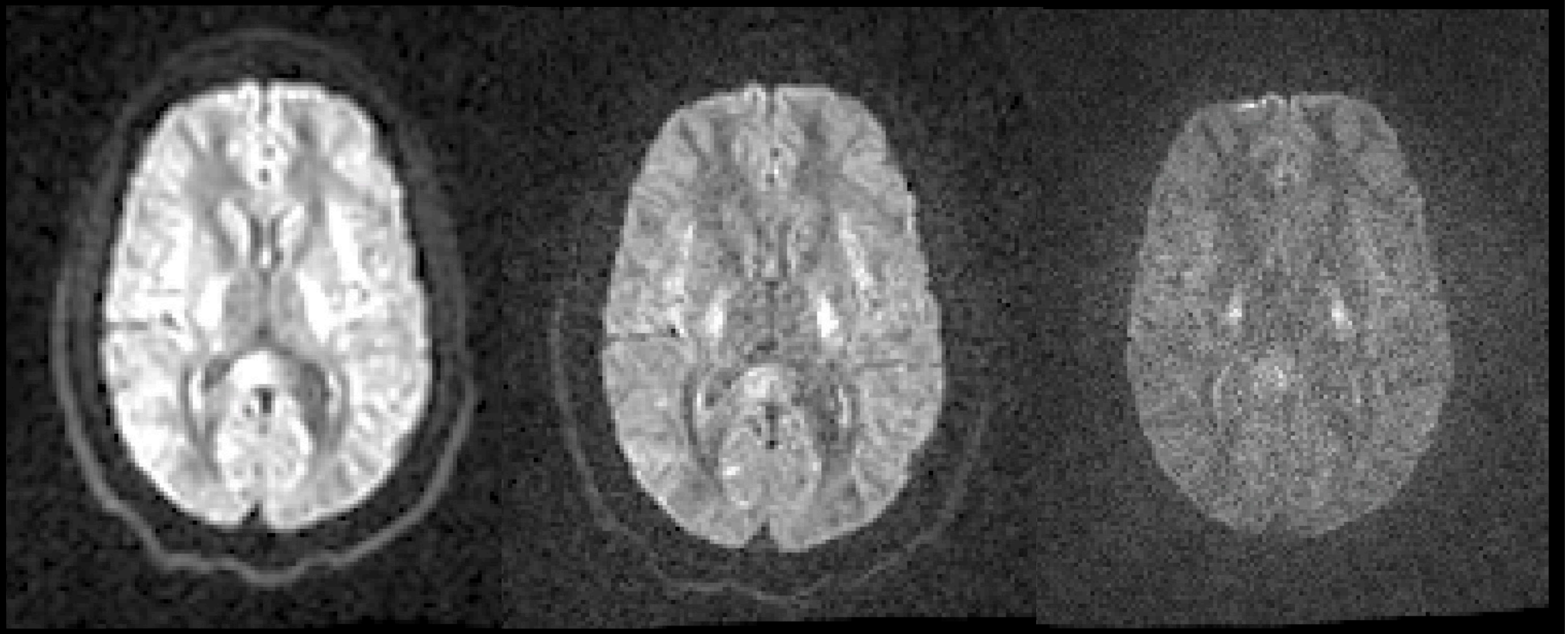


2.5 mm iso

1.7mm iso

1.3mm iso

Low SNR

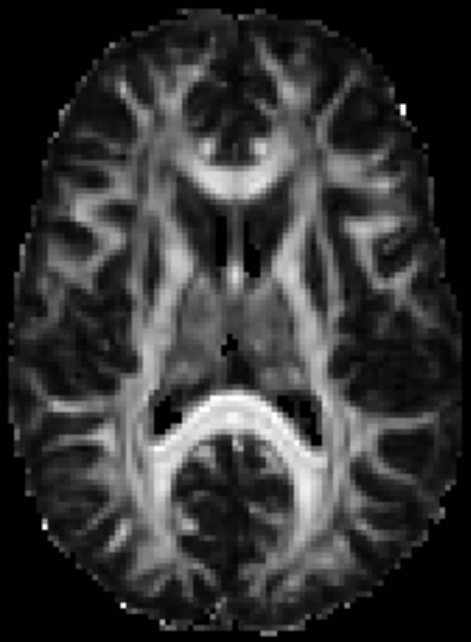


2.5 mm iso
15.625 mm^3

1.7mm iso
4.913 mm^3

1.3mm iso
2.197 mm^3

Low SNR



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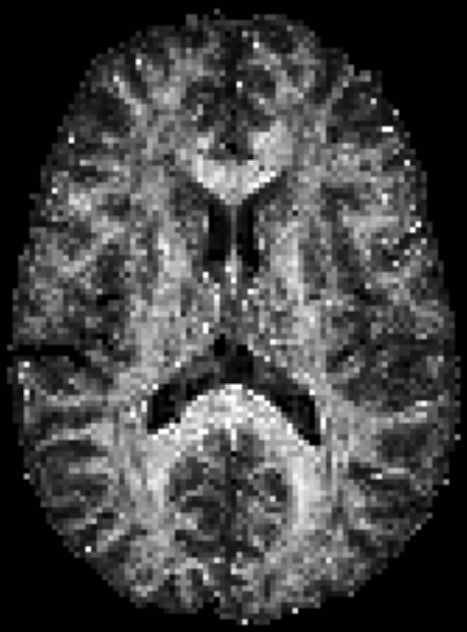
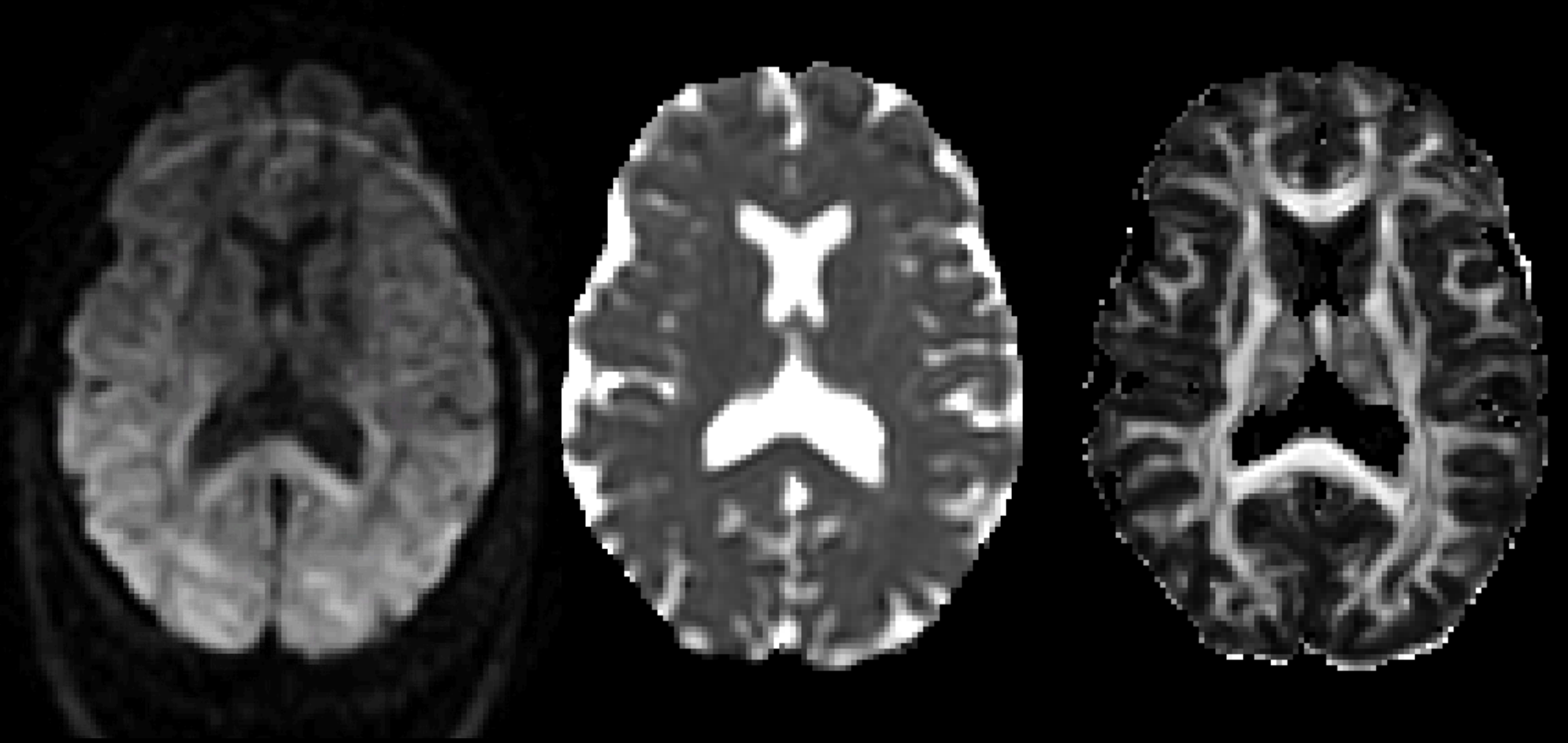


1.3mm iso
2.197 mm^3

Low SNR

- Don’t get greedy with resolution. Avoid the noise floor!
  - Remember, you always want isotropic voxels
- DWI is inherently signal-starved due to the long time needed for diffusion weighting preparation
  - The last step of setting up an acquisition should be to set TE to the minimum value
  - For well behaved subjects, partial Fourier acquisition can be used to reduce TE
  - Parallel imaging reduces TE

Incomplete Fat Suppression



b=1100 s/mm^2 MD FA

Incomplete Fat Suppression

- On GE scanners the spectral-spatial excitation pulse works best. This option is on by default. If you click “Chem Sat” or “Fat Sat” then a less robust method is used.
  - SPSP can limit slice thickness on MR750, see Sarlls JE *et.al*. MRM 66:1658-1665, 2011, for alternative method.
- On Siemens scanners, software level VB17 use “Extra Fat Suppression”. VD11 and up Fat Sat with “Fat Sat Mode = Strong”
- On Philips scanners, use SPIR and “Grad. rev. offres. supp.” options when available.

Eddy-current Distortions

- Using a diffusion prep with two 180° refocusing pulses reduces eddy-currents.
- On Siemens, bipolar vs. monopolar
- On Philips latest software release only – “gradient duration” as “twice refocused”
- On GE, dual-spin-echo vs. spin-echo
  - GE software > DV25 spin-echo and RT Field Adjust option

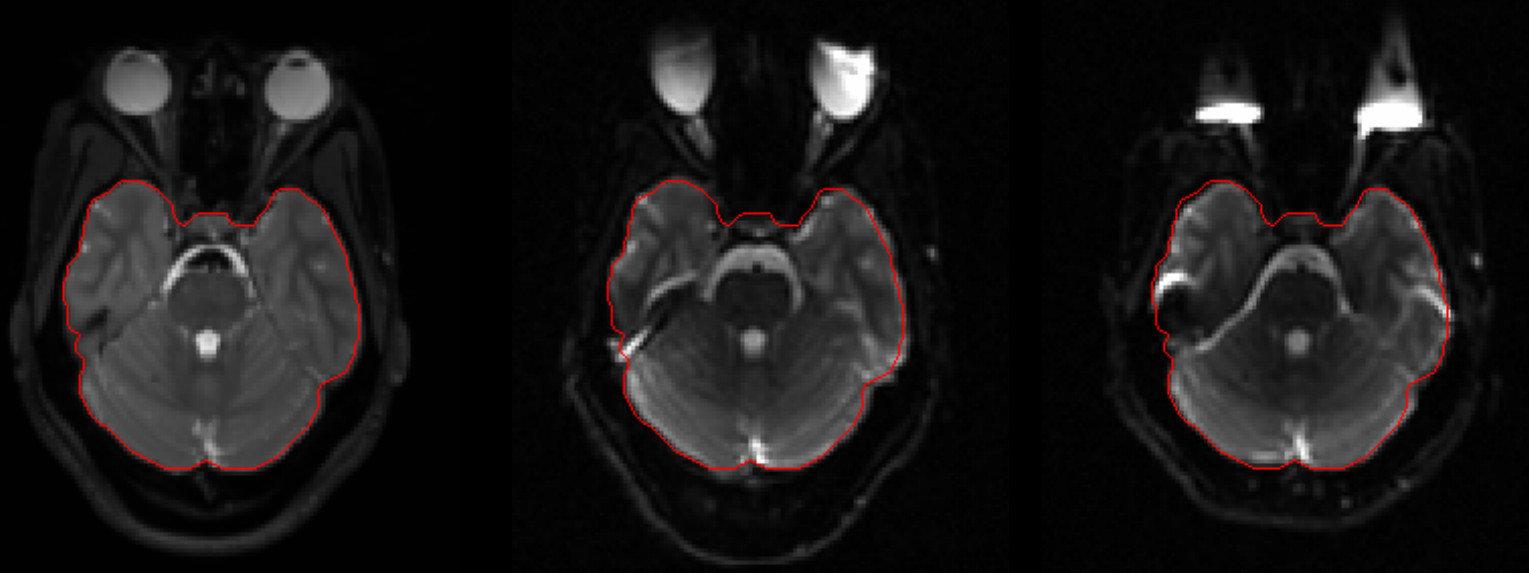
EPI-related Distortions

The distortions reduce as echo spacing reduces

- Implement Parallel imaging to reduce echo spacing
  - On Siemens: PAT mode = GRAPPA, Accel. Factor PE=2
  - On GE: Acceleration tab > Phase = 2.0 (uses ASSET)
  - On Philips: Geometry tab > SENSE = Yes, P reduction factor = 2.0
  - Watch out for loss in SNR
- Optimize the receiver bandwidth to reduce echo spacing
  - On Siemens: optimize to the lowest bandwidth that gives the lowest “esp”
  - On GE: default bandwidth is maximum
  - On Philips: minimize Fat-Water shift

EPI-related Distortions

- Two sets of data with reversed phase-encoding blips can be collect for advanced processing methods
  - On Siemens: Click the gray button next to the “Phase enc. dir.” field and change the “Rotation” angle by 180° .
  - On Philips: Change “Fat Shift Dir” from R to L or A to P.
  - On GE: You must have a research mode enabled. Under “Research Options” and “UserCVs” change “pepolar” to 1.



T2 structural P.E. = AP P.E. = PA

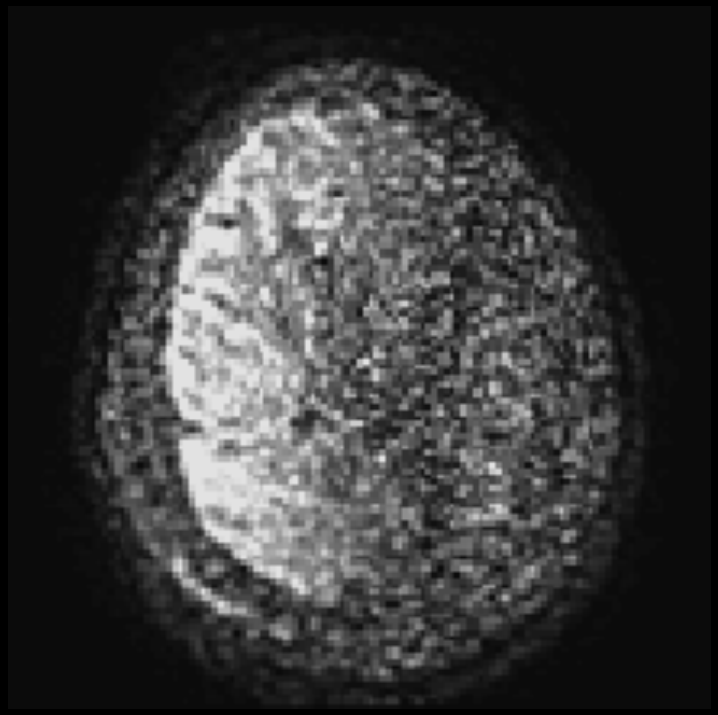
Blip up & down acquisition tips

- On Siemens: Verify the “Phase enc. dir.” field is what you want. There is a known bug when one copies slice prescription that the field will change to R/L
- On GE: Keep the shims and receiver gains constant between series.
  - Use “Shim=AutoShim” for the first series and “Shim=Off” for the second series.
  - Verify values for R1 and R2, Shim X, Y, and Z for the second subsequent series on ”Manual Prescan” page.
- On Philips: One must enter the gradient table manually or load from file, and save the exam card, for the diffusion directions to be consistent between “Fat Shift Dir”

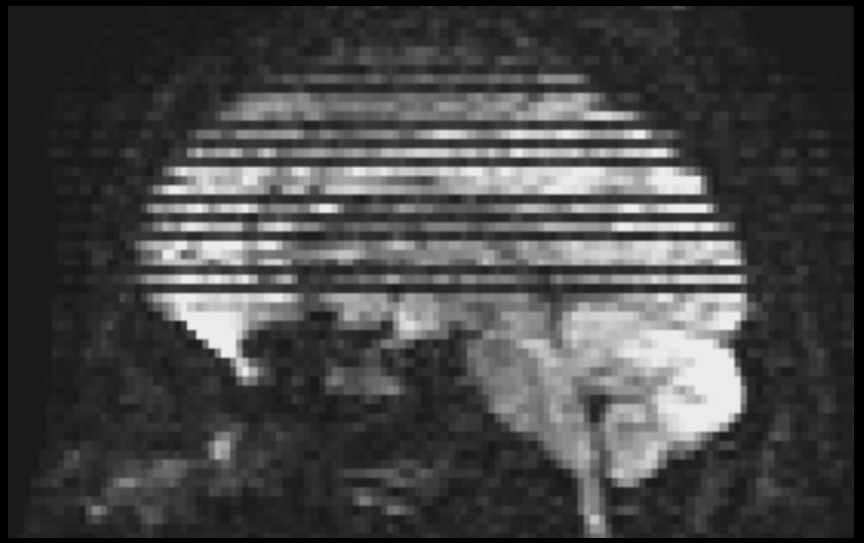
Multi-Channel Coils

- Normalization methods are available for the diffusion series.
  - Preliminary results show DT calculations are consistent
  - Note it is not needed for diffusion tensor fitting
  - On Siemens: no Normalization,Prescan Normalize is OK
  - On GE: no SCIC, Pure is OK
  - On Philips: Clear is OK

Bulk Movement



Axial Slice



Sagittal Reformat

Bulk Movement

- Make sure they've used the restroom
- Make sure they're comfortable!
- Extra padding between head and coil
- Tell them not to move and remind them frequently
- Acquire full Fourier space data.
  - On Siemens: partial fourier off
  - On GE: min full TE (not always an option)
  - On Philips: partial echo off

Gradient Table

- On GE: Any number of directions possible up to 256.
  - Vectors are located in usr/g/bin/tensor.dat
- On Siemens: A few number of directions provided.
  - Vectors are available in user manual
  - Custom directions possible with “Free” Diffusion Mode. Different on some software levels. Check in IDEA code documentation
- On Philips: Low (6), medium (15), and high (32) number of directions.
  - Vector information present in PAR/REC data
  - Custom directions are possible through manual entry in Exam Card.
  - Custom direction possible in E://Export/dti_vectors_input.txt
- Getting a balanced dataset with b=0 images often takes creativity!

Gradient Table

- Axial slices and not oblique to ensure the coordinate system of the images and diffusion gradient table are consistent

T2 Structural

- 2D fast spin-echo sequence with fat suppression
  - Called FSE or TSE (Fast or Turbo spin-echo)
- Acquisition parameters:
  - Resolution slightly higher than diffusion data (1.7x1.7x1.7mm)
  - Cover more than the whole brain (95+ slices)
  - TE~70ms, TR~8000ms
  - Echo train length~18
  - Fat Suppression
  - May use parallel imaging

Observe

- Look at the raw images while they're being acquired
  - On GE: automatically shown to you. De-select autoview to look more closely
  - On Siemens: Turn on "Inline Display", on the right hand side, 2nd icon from top
  - On Philips: Turn on "Autoview", bottom left

Class DTI dataset

Parameter	Value	Comment
TE	89 ms	Limited by b-value
TR	9.3 s	Fully relaxed
Matrix	96 x 96	
FOV	240 mm	2 x 2 mm
Slice Thickness	2.5 mm	Equal dimensions
Slices	64	Whole brain coverage
Plane	Axial	Oblique extra bookkeeping
Phase Encoding	AP and PA	Symmetric distortions
Diffusion directions	30 w/ 3 b=0	Balanced
b-value	1100 s/mm^2	For brain

For optimizing the experimental design, see Jones DK, “Diffusion MRI: Theory, Methods, and Applications”, Oxford Press, 2011, Chapter 15

Summary

- Isotropic Voxel dimensions
- Keep SNR above the noise floor
- Suppress fat
- Minimize TE
- Have a plan for distortion corrections and acquire accordingly
- Look at your images during acquisition!

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THANK YOU