Structural and Functional Imaging Techniques:
Common and State-of-Art Pulse Sequences at 3T

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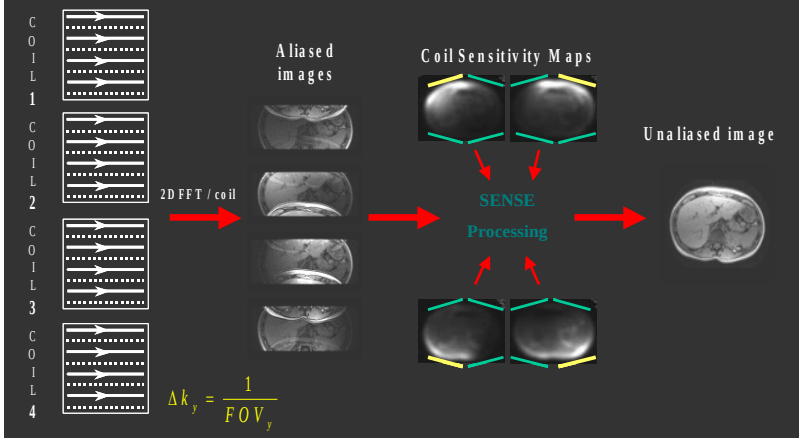
An Overview of the New 3T Scanner

- Short-bore magnet with active shield
- Twin-gradient system
  - 2.2 G/cm for high linearity – body or large FOV scans
  - 4 G/cm gradient for high-slew rate - fast imaging
- Parallel imaging infrastructure
  - 8-channel head coil upgradeable to 16 channels

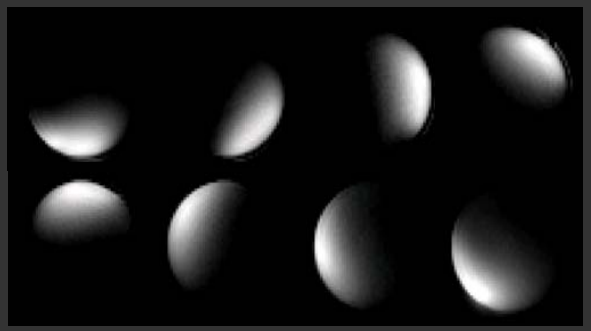
Structural Imaging Techniques

- T1 Imaging
  - 3D Fast SPGR with Intensity Normalization
    - SENSE: shorter acquisition time
    - Non-SENSE: better SNR
- Proton Density and T2 Imaging
  - 2D Fast Spin Echo with Intensity Normalization
- Diffusion Tensor Imaging
  - Low distortion, high SNR with SENSE acquisition

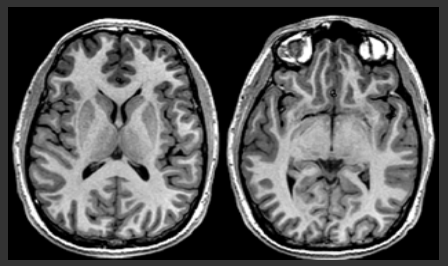
What is SENSE?



Individual Coil Sensitivity of Our 3T



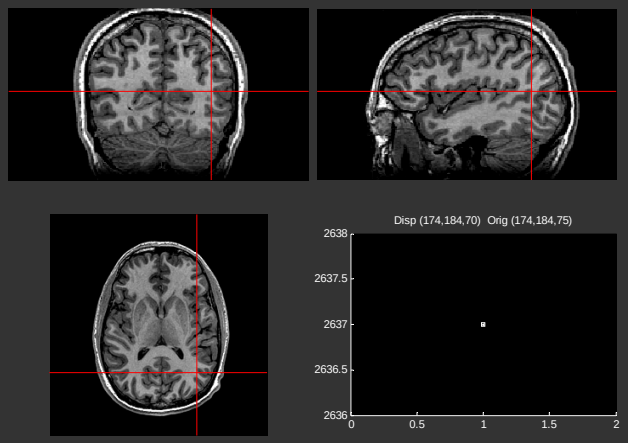
T1 Imaging



- Typical Imaging Parameters

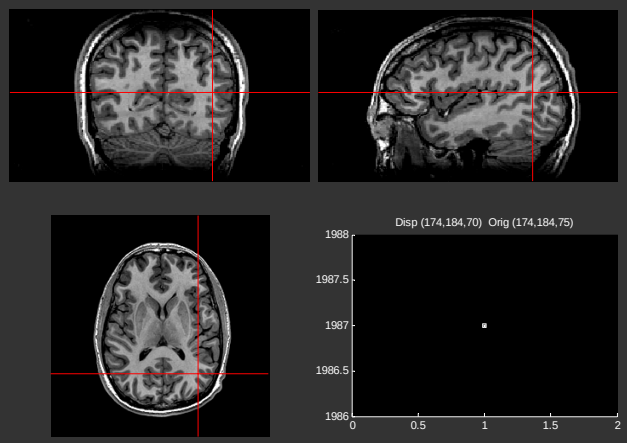
  3D Fast Spoiled Gradient Recalled acquisition
  Inversion-prepared (TI = 450 ms)
  TR 22 ms, TE 5.4 ms, flip angle 20°
  imaging matrix 2562, FOV 25.6 cm,
  slice thickness 1 mm
  Imaging time: 4 min

3D FSPGR with SENSE



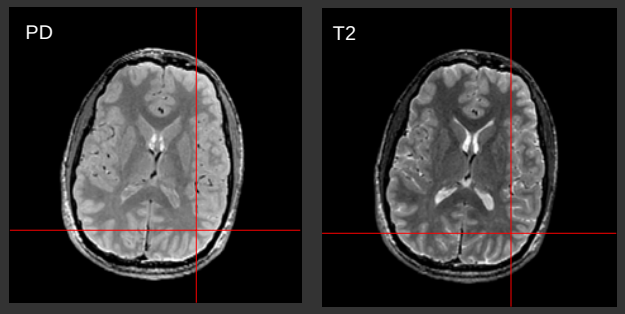
2x imaging speed, better spatial coverage, but lower SNR

3D FSPGR without SENSE



Better SNR, with some signal loss at the edge

PD and T2 Imaging



- Typical Imaging Parameters
  - 2D Fast Spin Echo (FSE),
  - Dual echo times at 30 ms (PD) and 75 ms (T2)
  - 1x1x1 mm isotropic resolution
  - Imaging time: dual contrast – 9 min, T2 only – 5 min

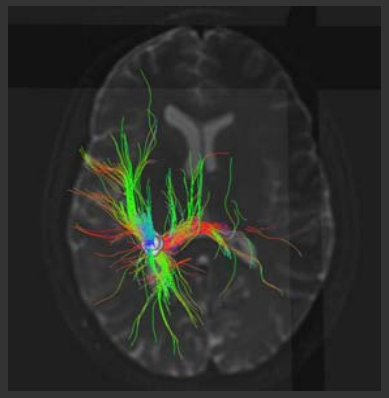
Diffusion Tensor Imaging

With SENSE acquisition, DTI now sees low distortion, high SNR and large spatial coverage.

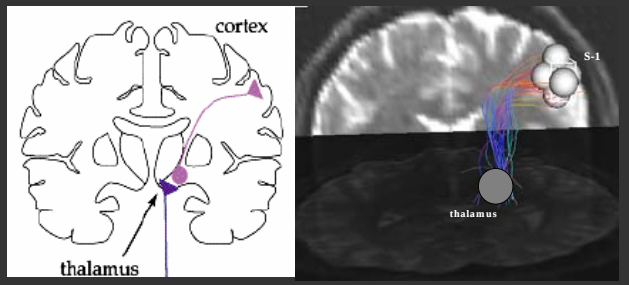
Typical Imaging Parameters:

- 128 x 128 single-shot EPI
- 15 non-collinear encoding directions
- b factor of 1000 s/mm^2
- 8-channel SENSE acquisition
- 2 x 2 x 2 mm isotropic resolution
- under 5 min total imaging time

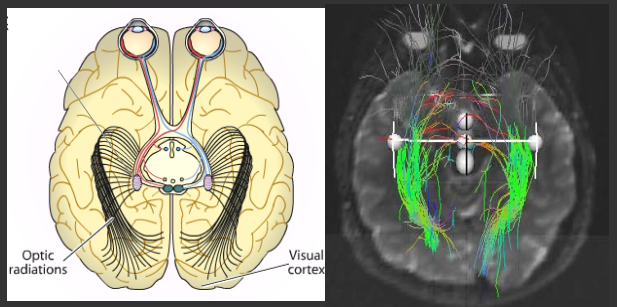
Region Based Fiber Tracking



Thalamocortical Projection (Tracking Between Regions)



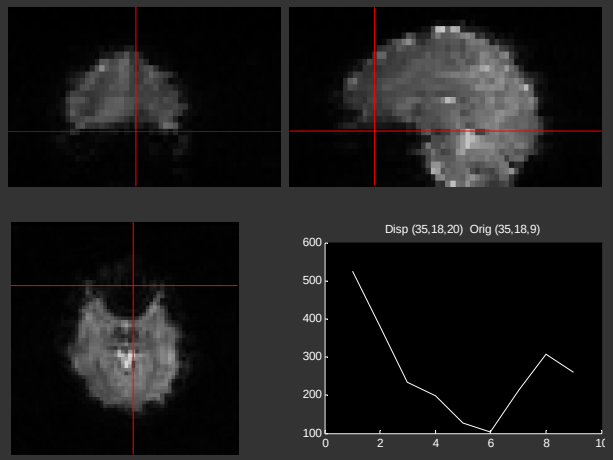
Optic Radiations
(Tracking Between Regions)



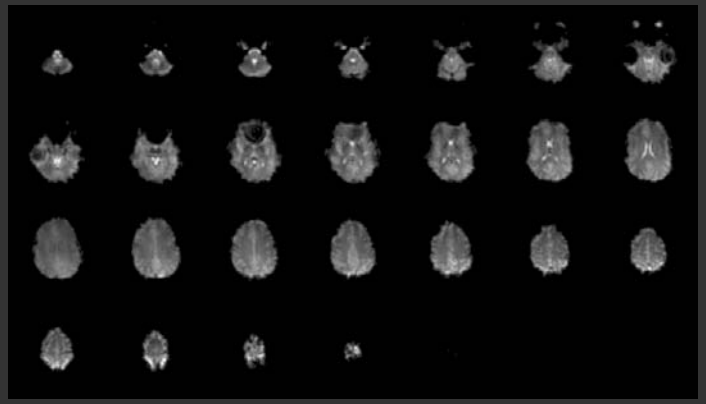
Functional Sequences on the 3T

- Developed in-house at BIAC, built upon the original spiral waveform from Stanford and EPI waveform from MCW
- Capable of high throughput, spiral in: 24 f/s (use < 20 f/s to reduce gradient heating); spiral out: 17 f/s; EPI: 17 f/s
- EPI has been modified to accommodate navigator echoes to remove ghosting artifacts from gradient imperfection and center frequency drift (mostly due to gradient heating at high throughput)

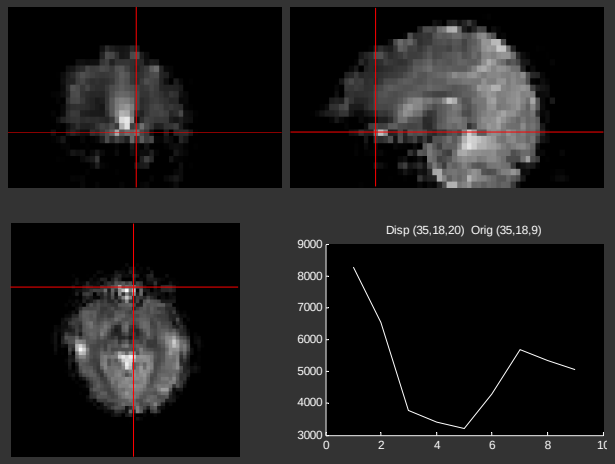
Eight-Channel Spiral-Out Imaging



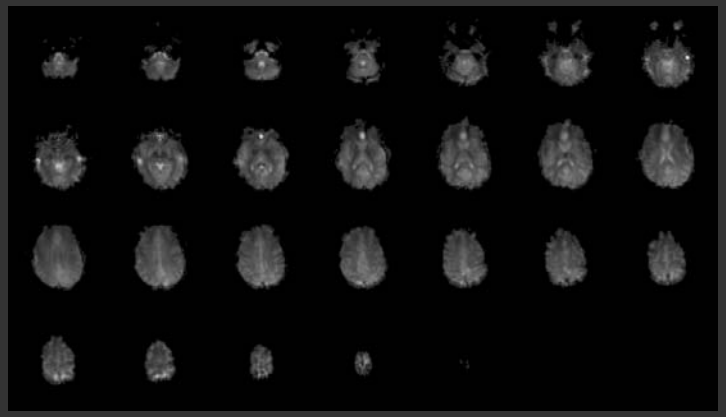
Eight-Channel Spiral-Out Imaging



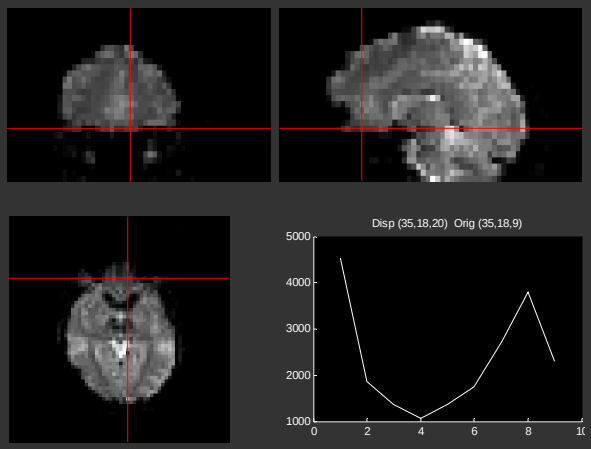
Eight-Channel Spiral-In Imaging



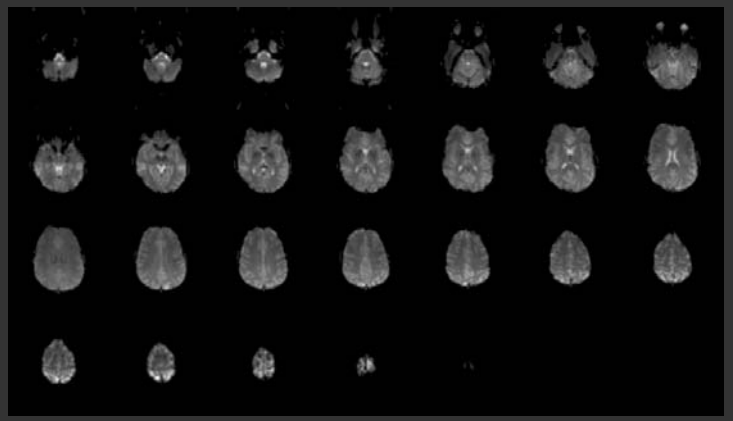
Eight-Channel Spiral-In Imaging



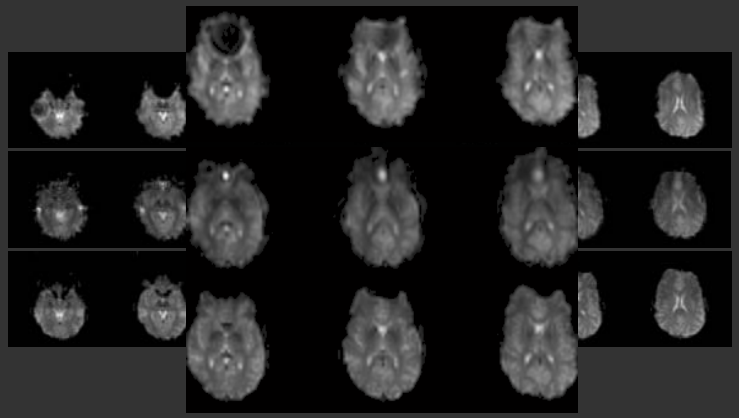
Eight-Channel EPI Imaging



Eight-Channel EPI Imaging



Spiral-Out vs. Spiral-In vs. EPI



Functional Sequence Summary

- Spiral-Out:
  Pros: Capable of very short TE, used in arterial spin labeling technique for perfusion imaging. In addition, it has more room to accommodate diffusion gradients used in diffusion imaging
  Cons: Large signal dropout at the ventral brain regions, low internal contrast
- Spiral-In:
  Pros: Better signal recovery at the ventral brain region, high throughput
  Cons: Blurry edges, low internal contrast
- EPI:
  Pros: High internal contrast, clear edges.
  Cons: Spatial distortions at the ventral and frontal brain regions, along with some signal losses.