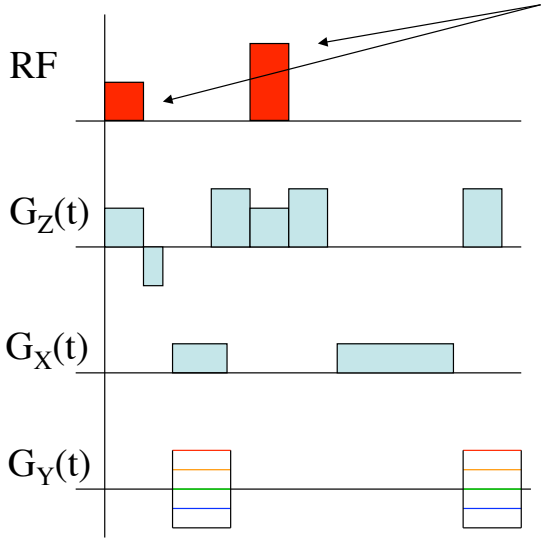
Bioengineering 278
Magnetic Resonance Imaging

Winter 2009
Lecture 2

- The basic spinwarp pulse sequence
  - Slice Selection
  - Frequency Encoding
  - Phase Encoding
  - Other pulses
- Basic image contrast
  - Proton Density
  - T_1
  - T_2

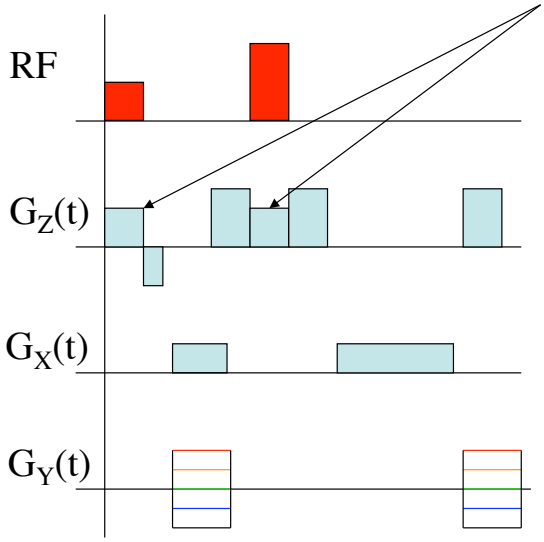
Spin-Warp Pulse Sequence



RF pulses

- What for?
  - 90°: Tip M_Z -> M_{XY}
  - 180°: Refocus resonance offsets
- How Big?
  - $\alpha = \gamma \int B_1 dt$
- What Shape?
  - ~FT(γ G_z slice profile)

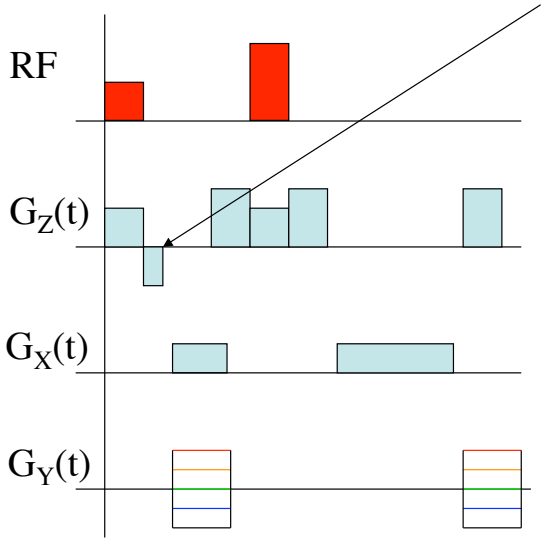
Spin-Warp Pulse Sequence



Slice Select Gradients

- What for?
  - Map space into frequency during RF pulses
- How Big?
  - $G_Z = \frac{RF\_bandwidth}{\gamma(slice\_thickness)}$
- What Shape?
  - Typically flat during RF pulse

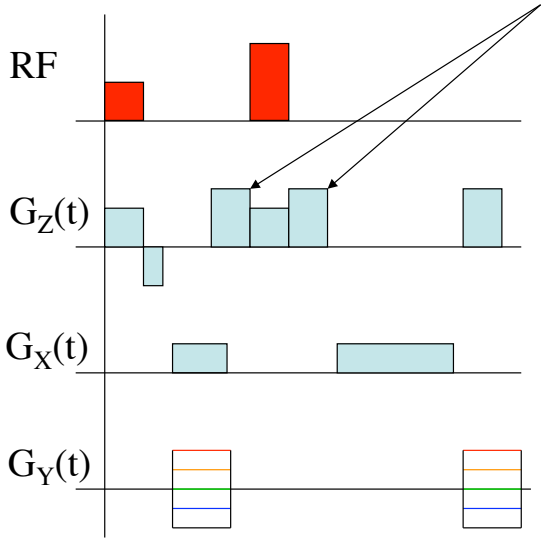
Spin-Warp Pulse Sequence



Slice Refocussing Gradient

- What for?
  - Rewind magnetization that was dephased by the second half of the slice select gradient
- How Big?
  - Half the area of the slice select gradient
- What Shape?
  - Only the area matters

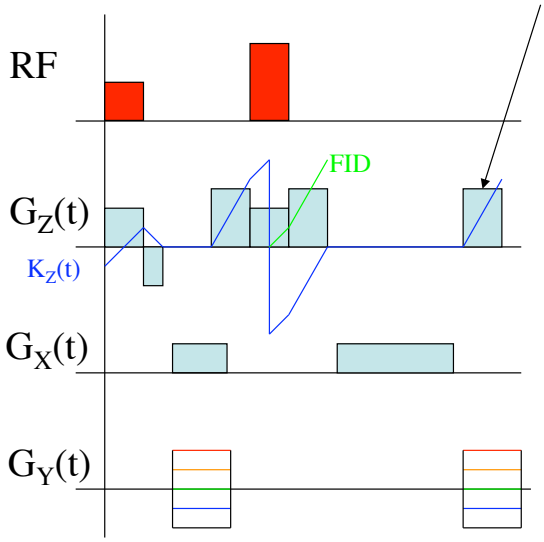
Spin-Warp Pulse Sequence



Crusher Gradients

- What for?
  - Right one destroys FID from imperfect 180°
  - Left one required to balance right one
- How Big?
  - $FID \propto \int M_Z(z) e^{i\gamma z \int G_z dt} dz$
  - Want several phase wraps across slice
- What Shape?
  - Only the area matters

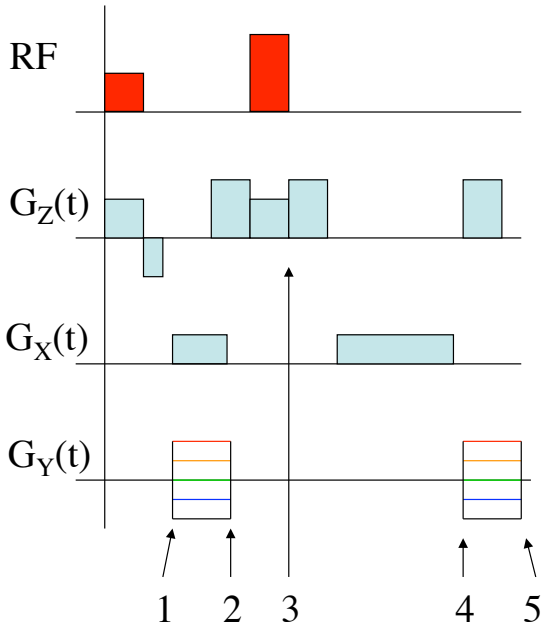
Spin-Warp Pulse Sequence



Killer Gradient

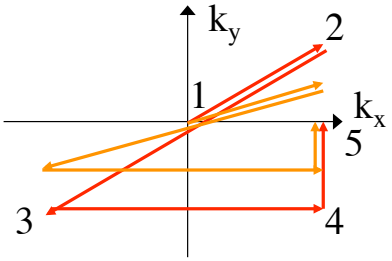
- What for?
  - Destroy residual transverse magnetization prior to next TR
- How Big?
  - Same criteria as Crushers:
  - Want several phase wraps across voxel
- What Shape?
  - Only the area matters

Spin-Warp Pulse Sequence

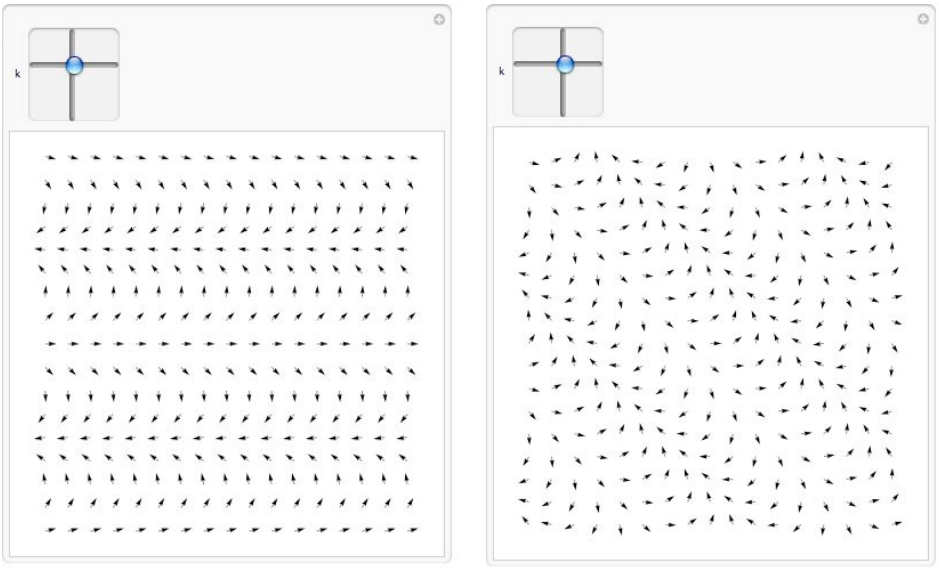


XY Imaging Gradients

- What for?
  - Sample $K(\equiv \gamma \int Gdt)$ space
- Frequency encode:
  - $G_X = \frac{Acquisition\_Bandwidth}{\gamma(FOV)}$
- Phase encode:
  - Only the area matters
  - Phase rewinder leaves phase consistent across phase encodes



Spin-Warp Pulse Sequence



Spin-Warp Pulse Sequence

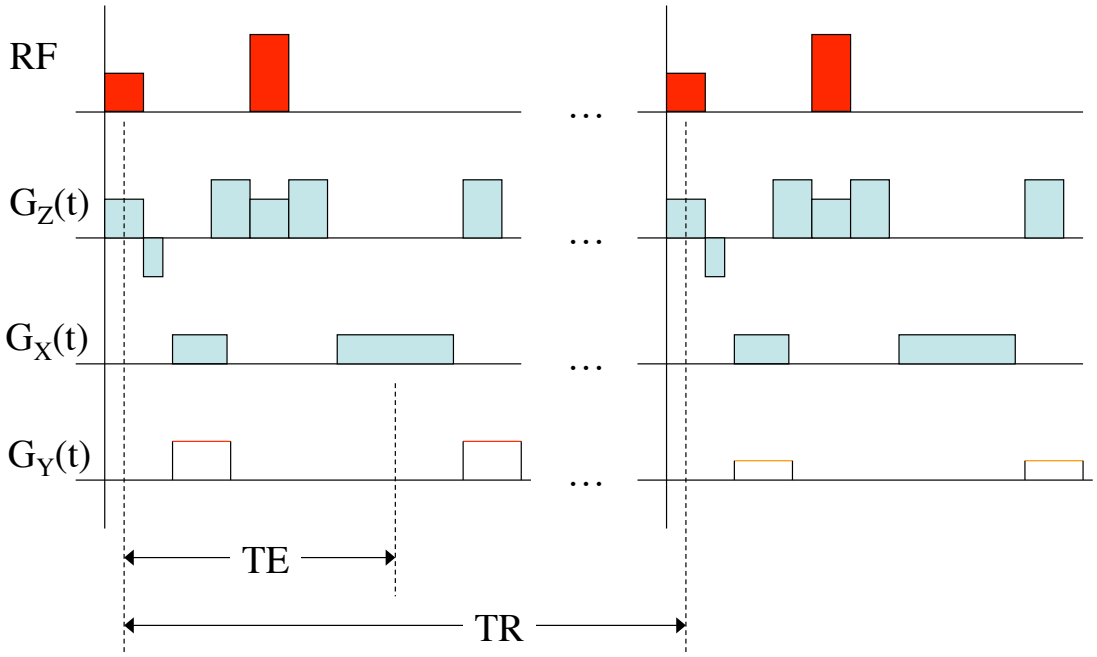


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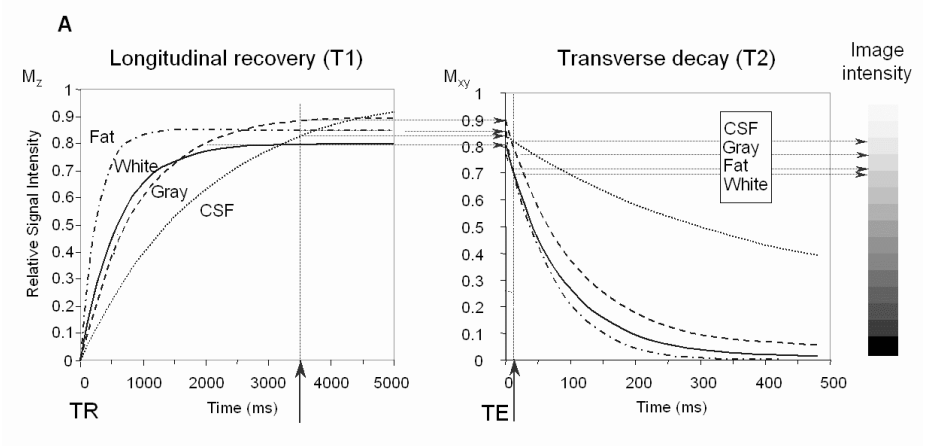
Image Contrast - Proton Density



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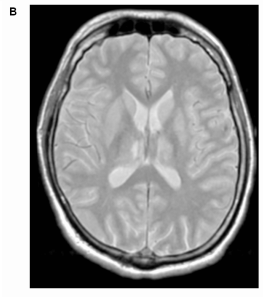

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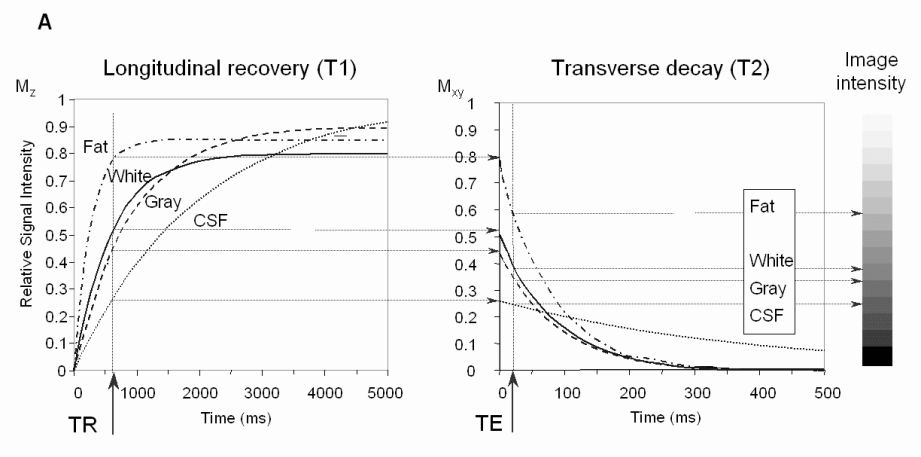
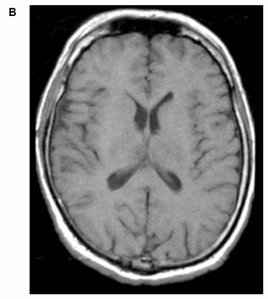
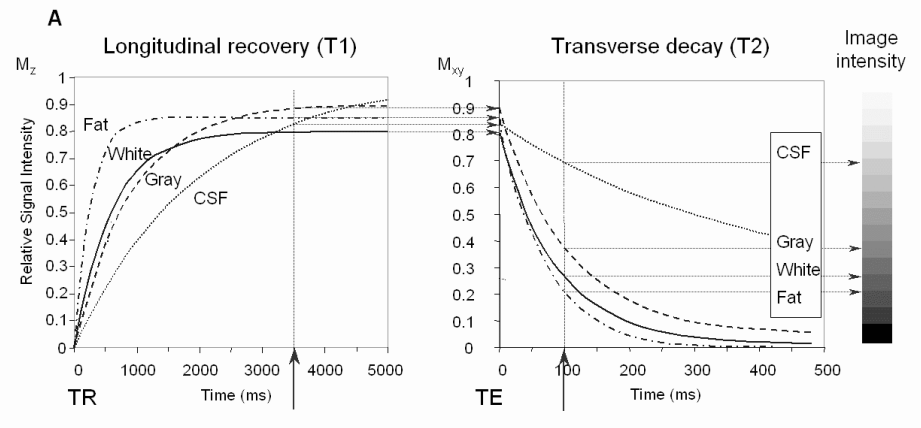
Image Contrast - T_1

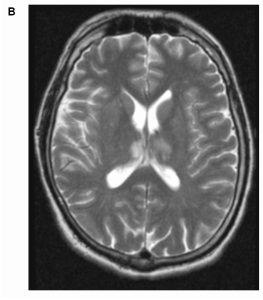




Bushberg - The Essential Physics of Medical Imaging

Image Contrast - T_2





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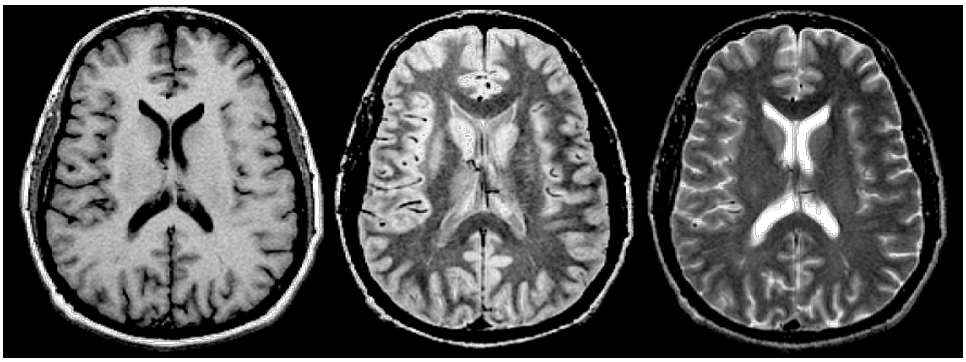

T_1-weighted Density-weighted T_2-weighted

Slide Credit: T.T. Liu