

# Bioengineering 208

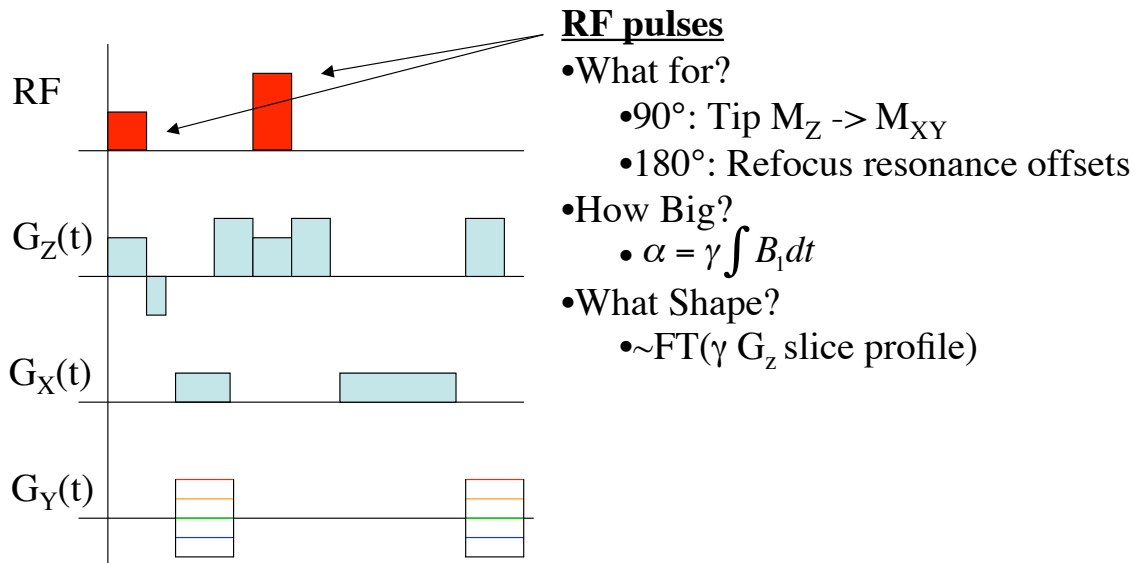
## Magnetic Resonance Imaging

Winter 2008  
Lecture 2

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

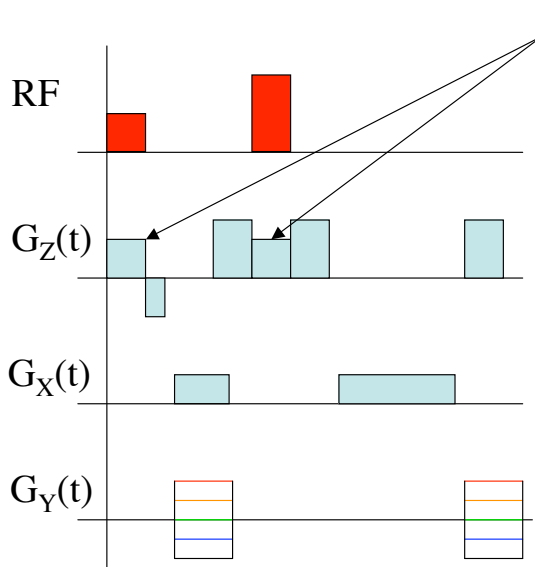
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## Spin-Warp Pulse Sequence



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# Spin-Warp Pulse Sequence

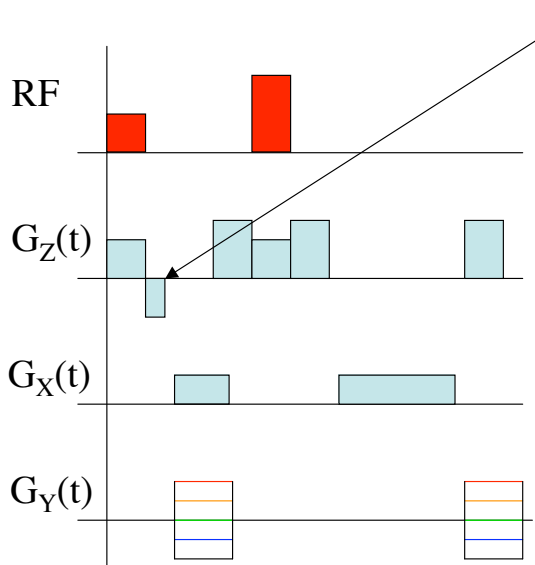


## Slice Select Gradients

- 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

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# Spin-Warp Pulse Sequence

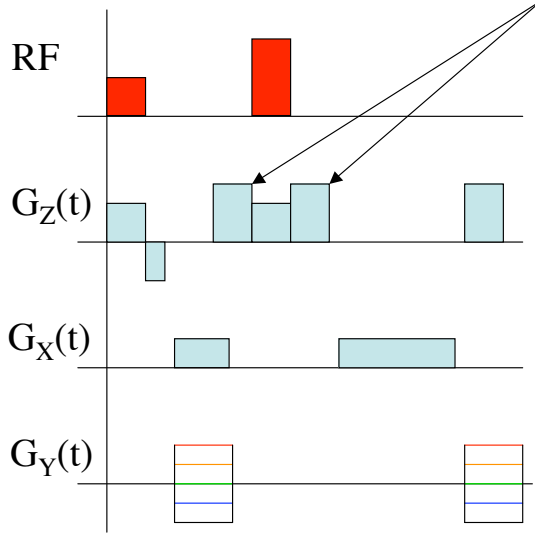


## Slice Refocussing Gradient

- 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

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# Spin-Warp Pulse Sequence

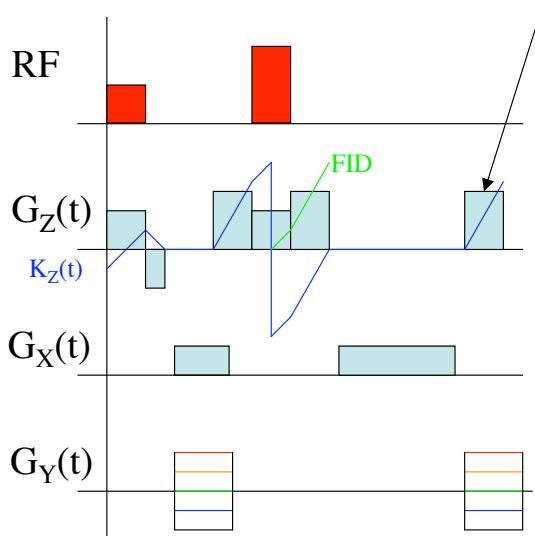


## Crusher Gradients

- 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

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# Spin-Warp Pulse Sequence

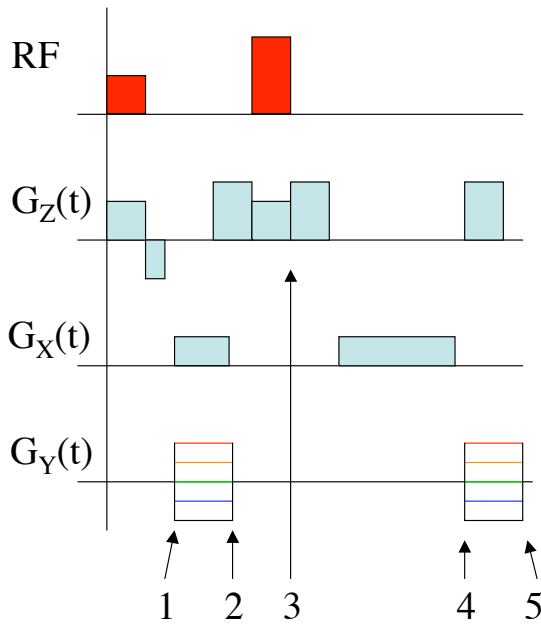


## Killer Gradient

- 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

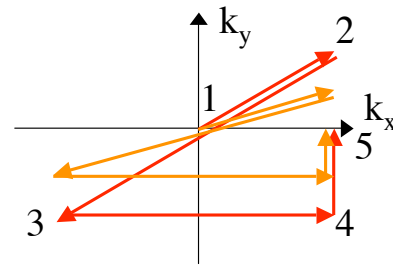
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# Spin-Warp Pulse Sequence



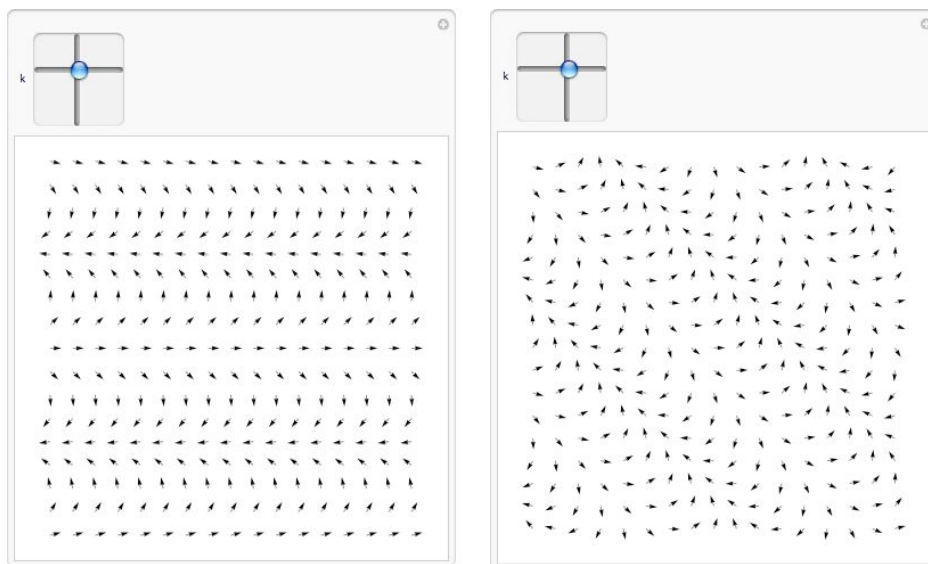
## XY Imaging Gradients

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



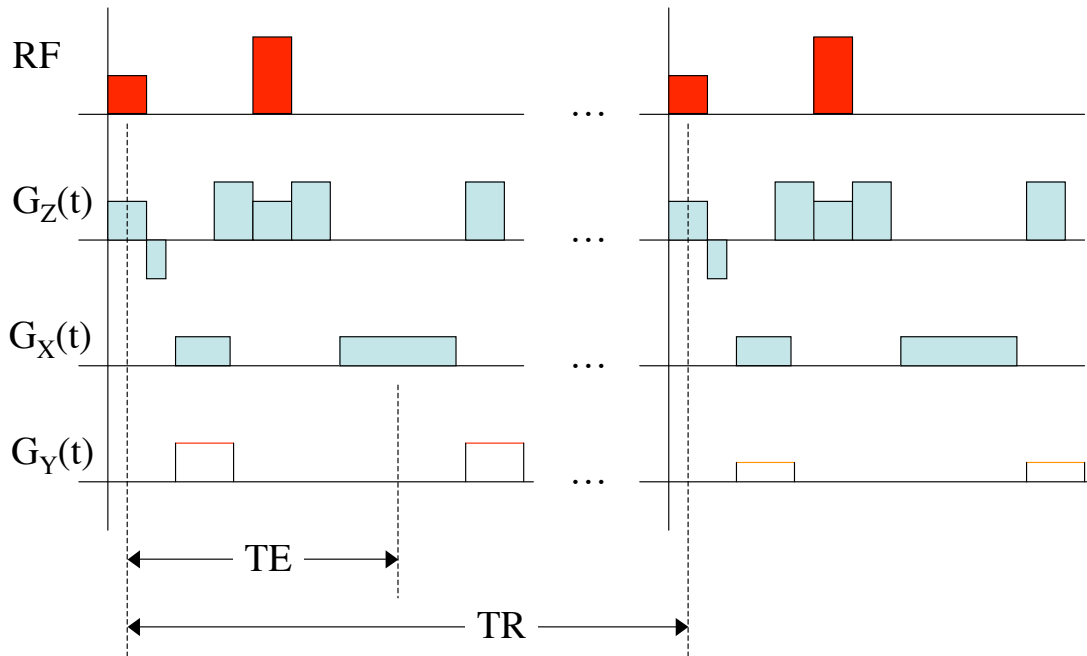
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# Spin-Warp Pulse Sequence



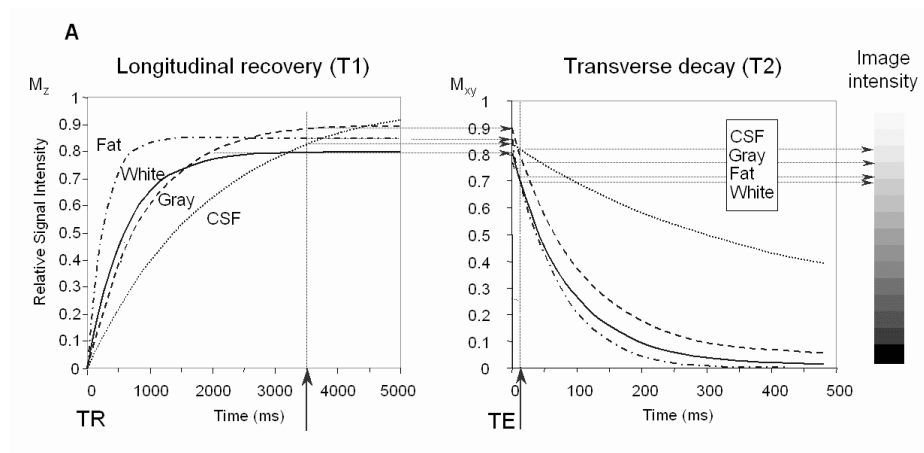
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# Spin-Warp Pulse Sequence

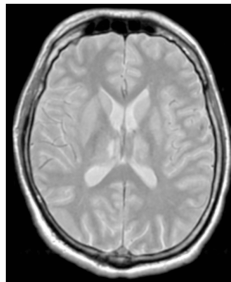


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## Image Contrast - Proton Density

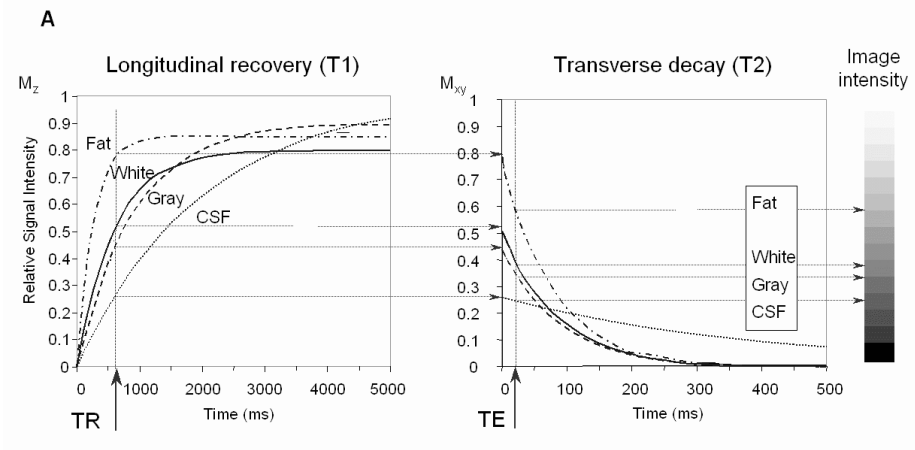


Bushberg - The Essential  
Physics of Medical Imaging

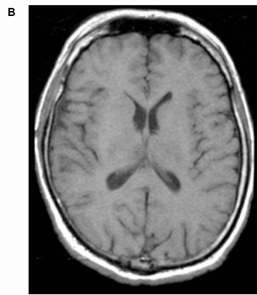


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# Image Contrast - $T_1$

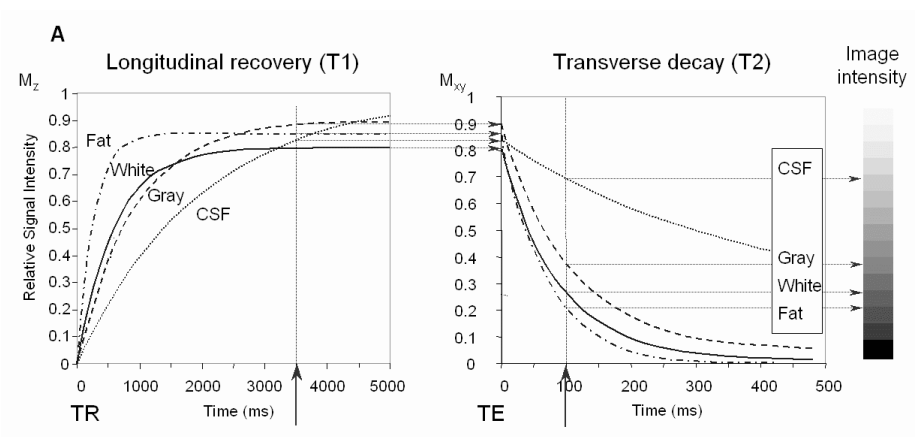


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Physics of Medical Imaging

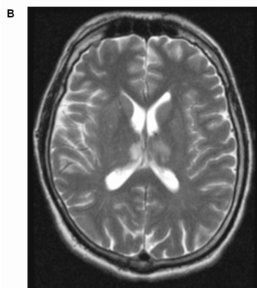


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# Image Contrast - $T_2$



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T<sub>1</sub>-weighted

Density-weighted

T<sub>2</sub>-weighted