

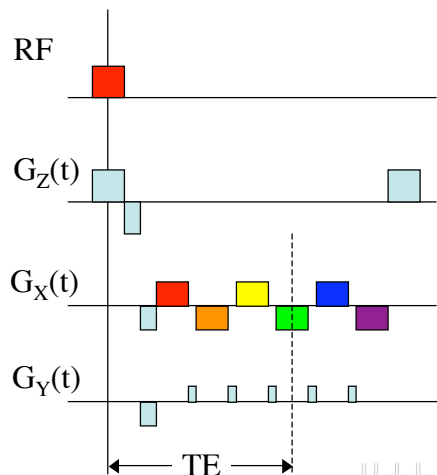
# Bioengineering 208 Magnetic Resonance Imaging

Winter 2008  
Lecture 4

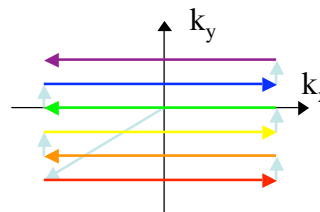
- Echoplanar Imaging
  - Pulse Sequence
  - Nyquist Ghosts
  - Off-Resonance Effects
  - $T_2^*$  Blurring

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## Echoplanar imaging sequence



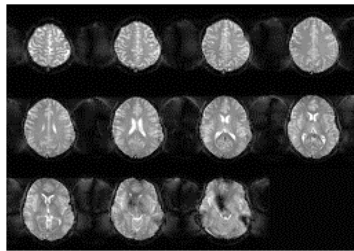
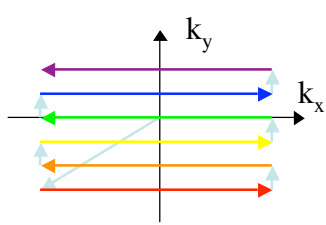
- Multiple lines of K-space with one excitation
- Allows for “snapshot” imaging
- K-space coverage limited by gradient hardware and  $T_2^*$
- Main Applications:
  - BOLD fMRI
  - Diffusion
  - Freezing motion



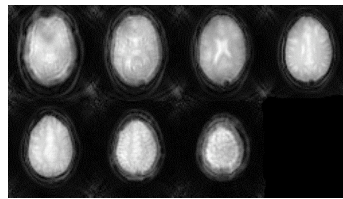
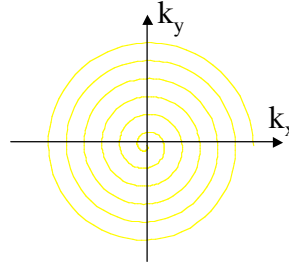
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# The EPI Family

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Cartesian EPI

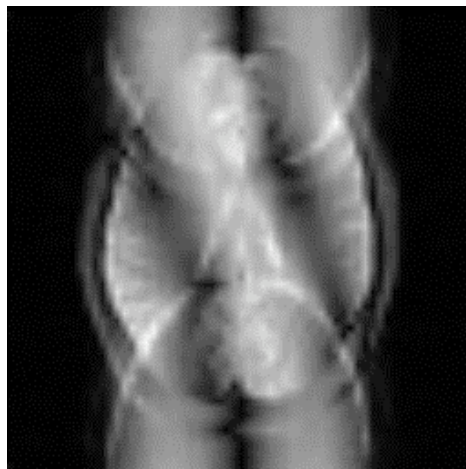


Spiral EPI

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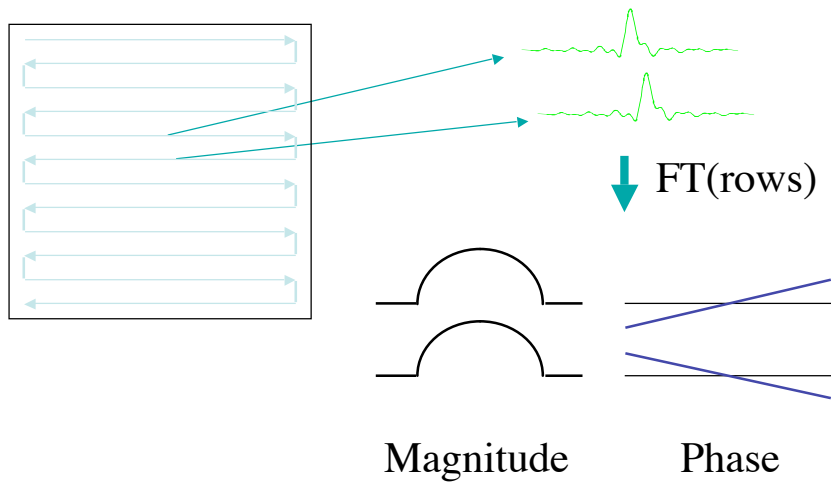
# NYQUIST GHOST

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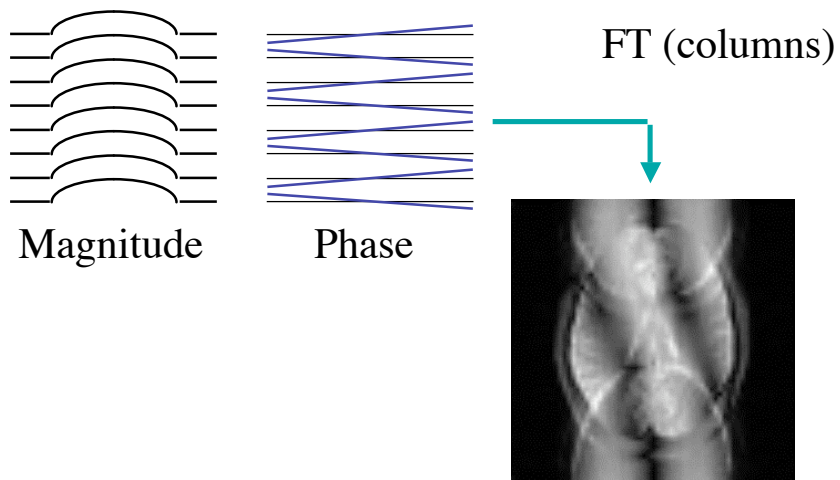
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# NYQUIST GHOST



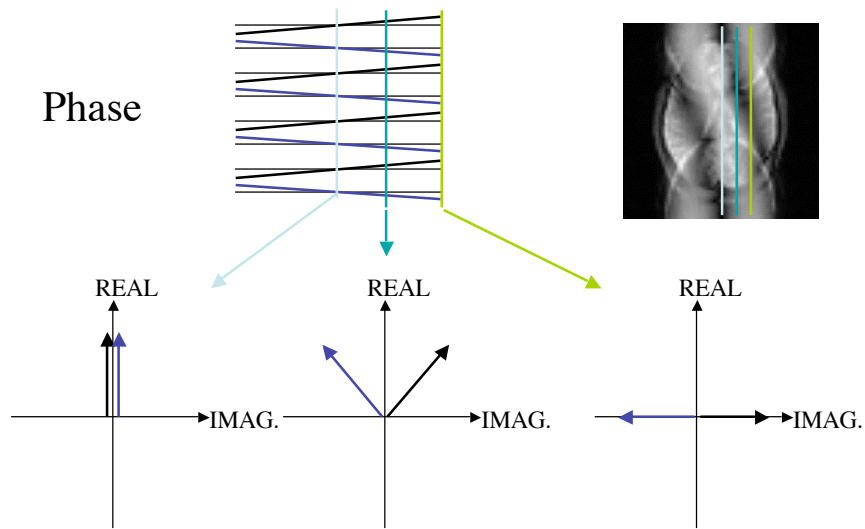
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# NYQUIST GHOST



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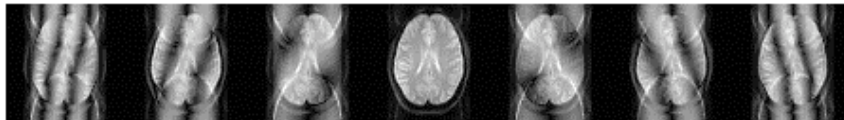
# NYQUIST GHOST



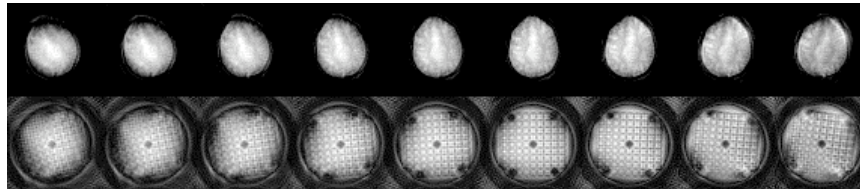
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# TIMING ERRORS

## EPI



## SPIRAL



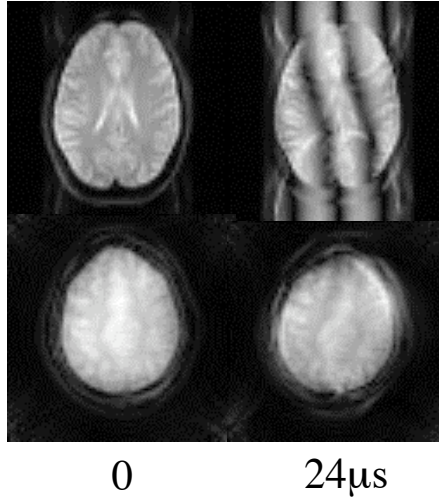
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# TIMING ERRORS

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EPI

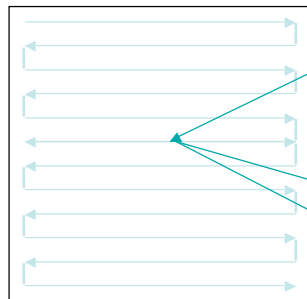
SPIRAL



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# SKIP a BLIP (or two)

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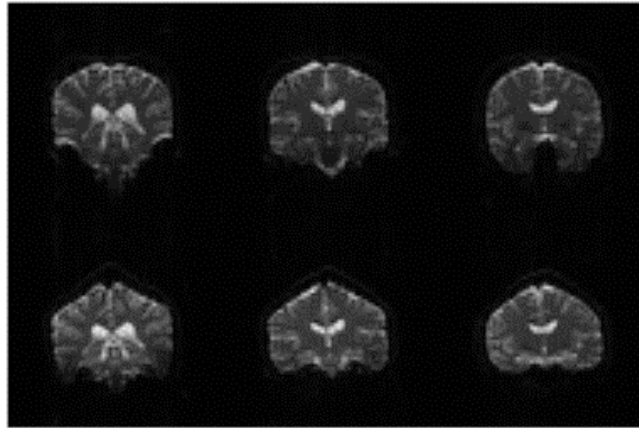
Redundant line  
collected twice:  
once in each  
direction

Use measured time  
shifts to correct data

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# SPATIAL DISTORTION

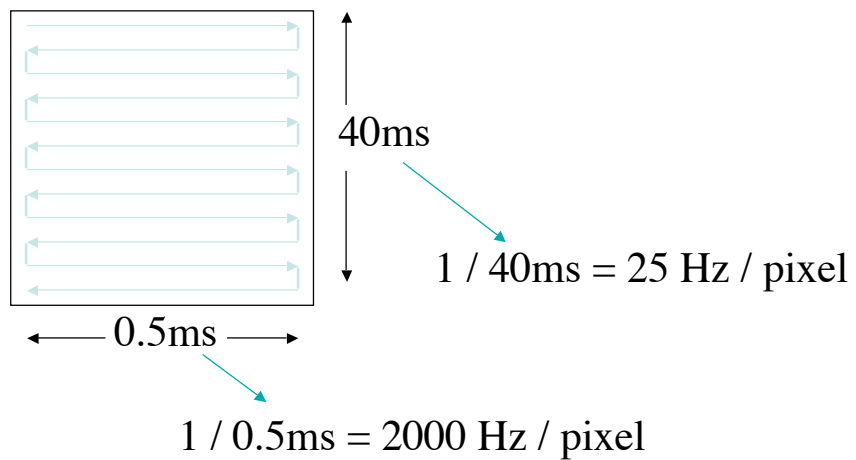
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## Off Resonance Behavior : EPI

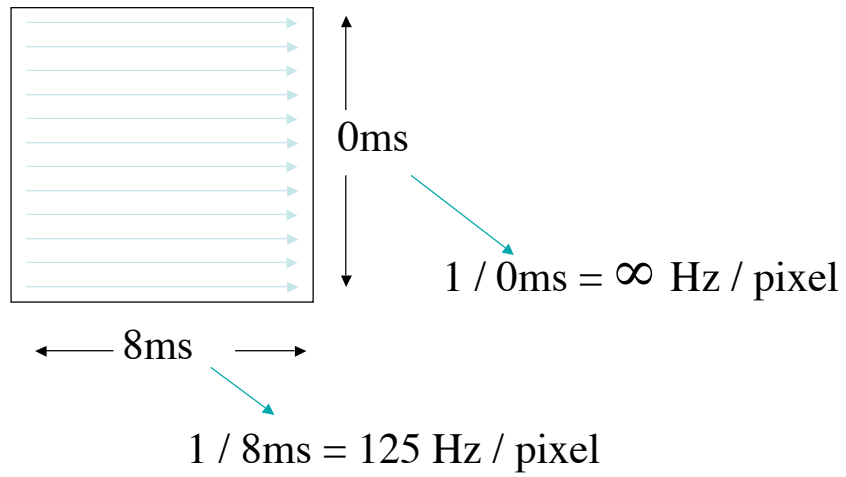
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## CONVENTIONAL IMAGING

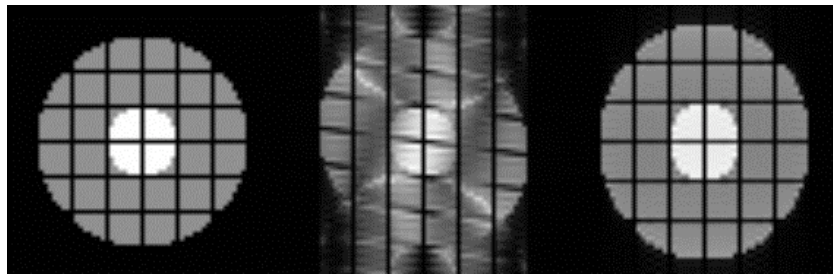
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## SHIM PATTERNS

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PERFECT SHIM

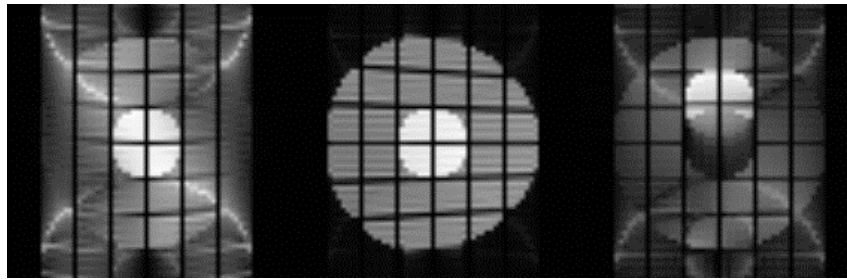
X

Y

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# SHIM PATTERNS

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X<sup>2</sup>

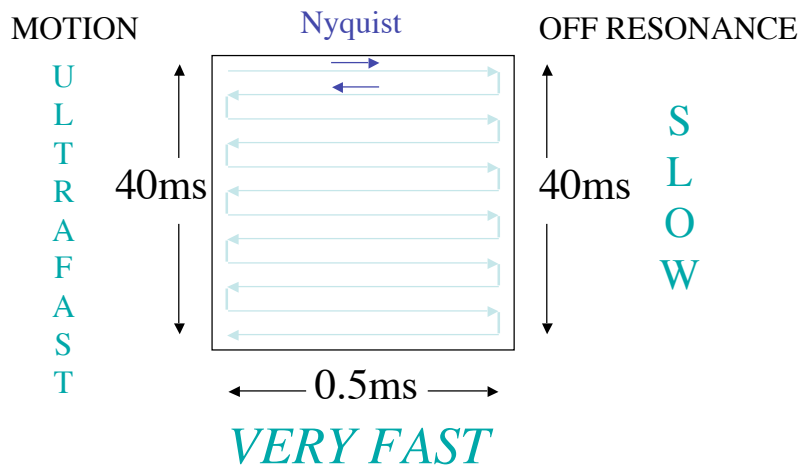
X Y

FAT

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# EPI

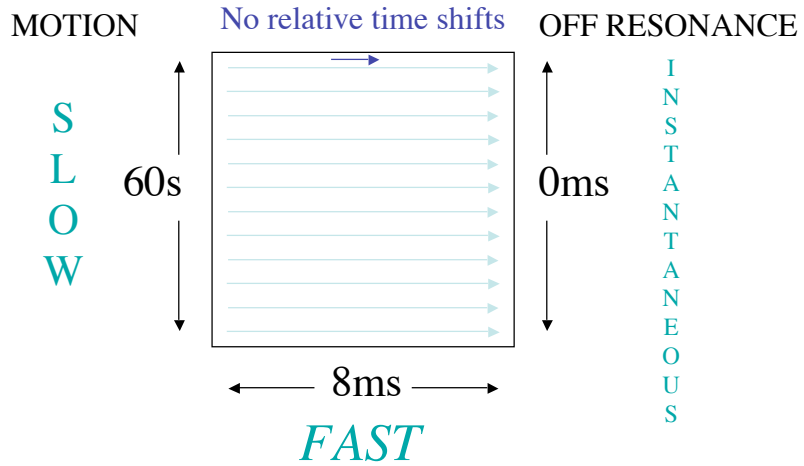
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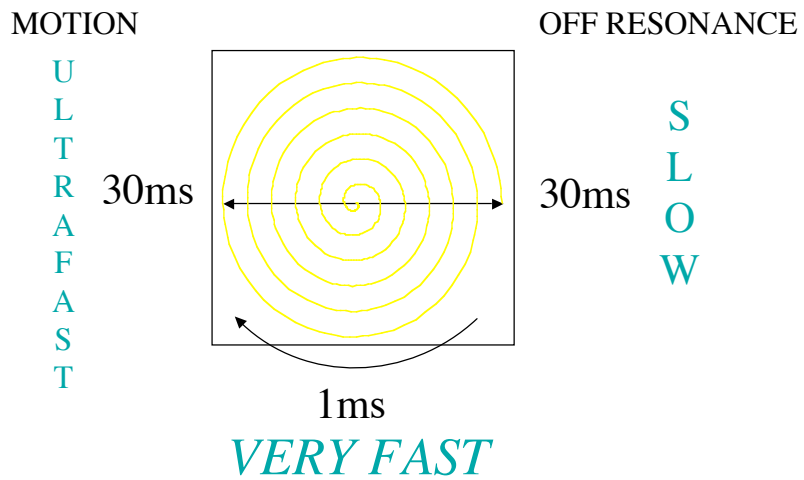


# CONVENTIONAL IMAGING



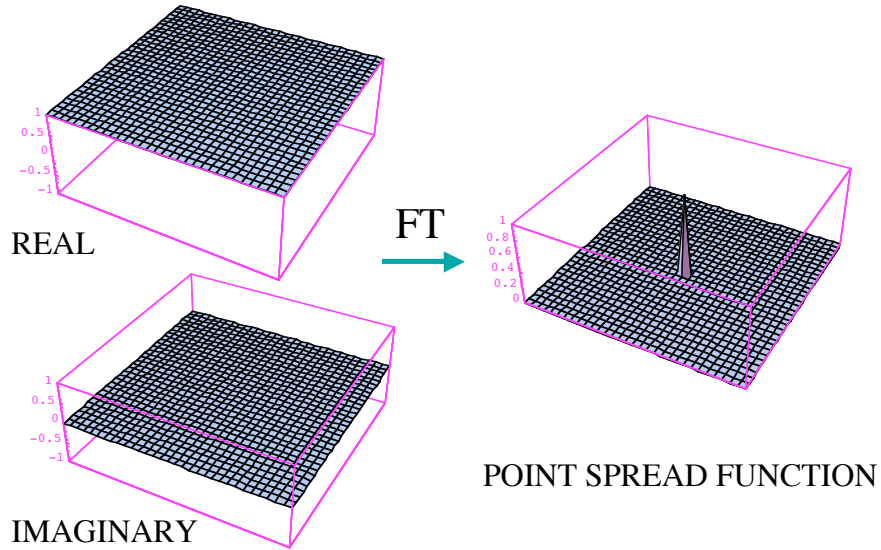
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# SPIRAL



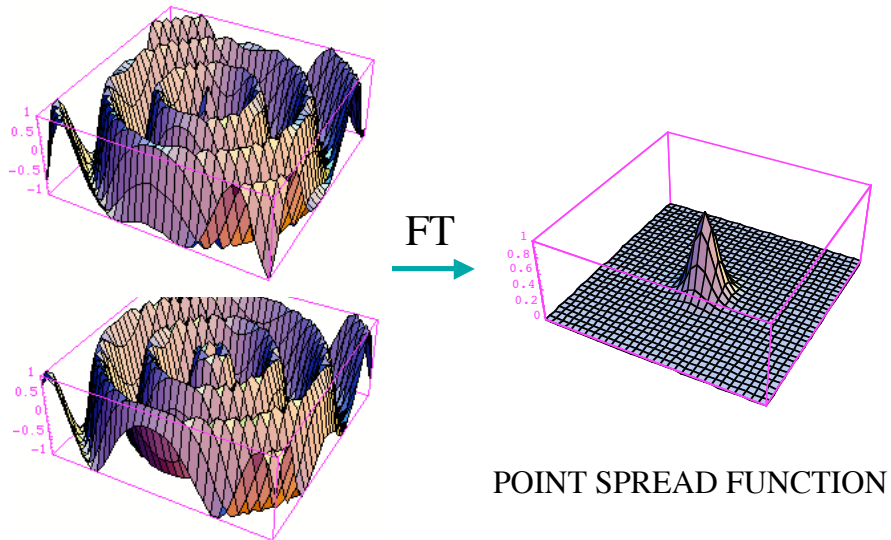
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## SPIRAL PSF (on resonance)



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## SPIRAL PSF (off resonance)



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## SUMMARY

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- Nyquist ghosts
  - Unique to EPI
  - Primarily caused by timing errors
  - Secondarily by off resonance effects
  - Pretty fixable
- Equivalent timing errors in Spiral cause rotation/blurring
  - Also fixable

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## SUMMARY

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- Image distortion
  - Primarily caused by off resonance effects
  - Same as regular chemical shift artifact, but exaggerated
  - Pretty fixable
- Equivalent effects in Spiral cause blurring, and is harder to fix

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## SUMMARY

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- Signal dropout is due to TE, slice thickness, SE vs GE as in conventional imaging
- EPI is unusually sensitive to scanner instability because of:
  - High sensitivity to off resonance effects
  - High SNR from low resolution