

# Bioengineering 208

## Magnetic Resonance Imaging

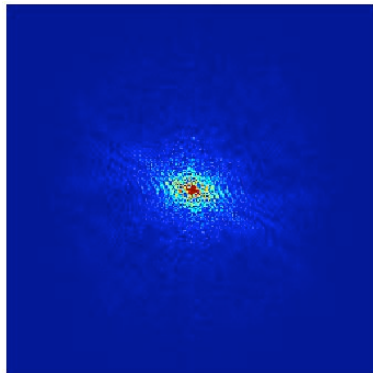
### Winter 2007

#### Lecture 5

- MRI Artifacts
  - Noise spikes
  - Clipping
  - Gibbs Ringing
  - Quadrature ghost
  - Wraparound
  - Motion
  - Chemical Shift
- SNR in MRI
  - RF Coil
  - Magnetization
  - Sampling time

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## Normal Image



K-space

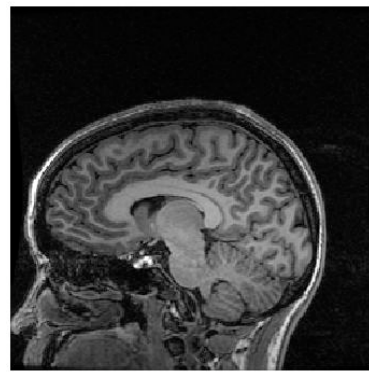
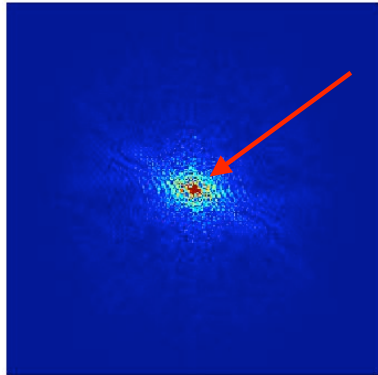


Image space

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# Noise Spike



K-space

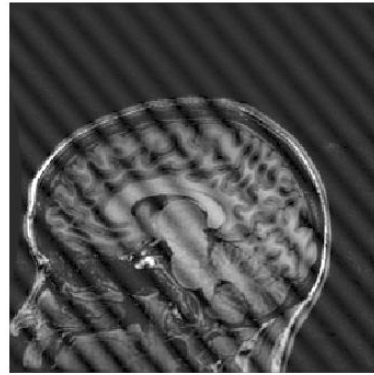
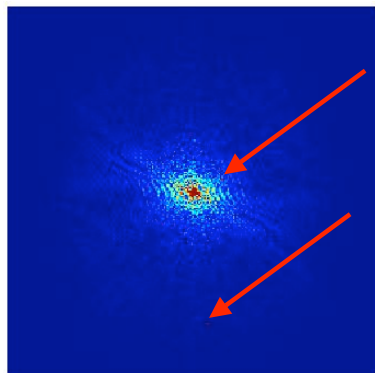


Image space

- Localized in K-space
- Extends outside object in image space
- Come from arcing, loose connections, ground spikes

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# More Noise Spikes



K-space

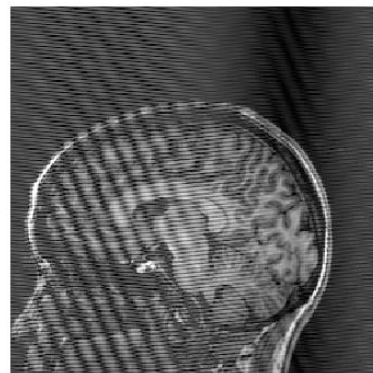
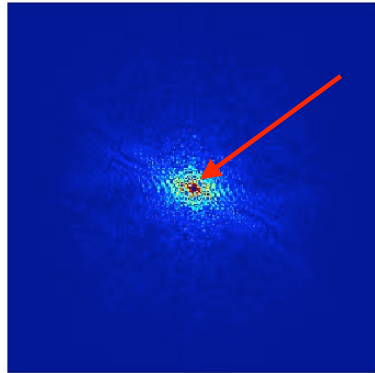


Image space

- Multiple spikes create multiple sinusoids and generate 'herringbone' patterns

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# Data clipping



K-space

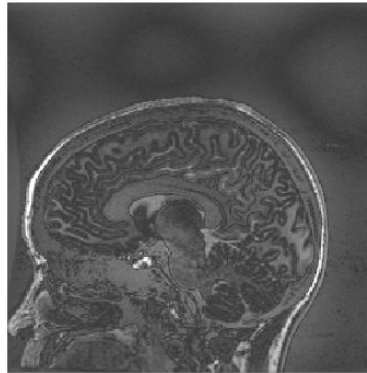
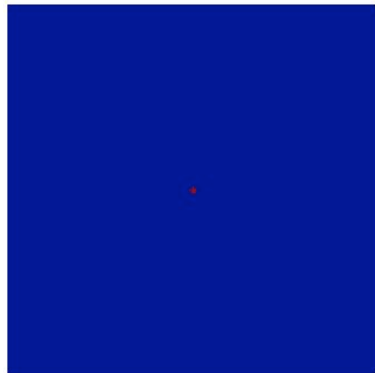


Image space

- Center of K-space over-ranges ADC and clips
- Image is (correct image) - (low frequency image)

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# Data clipping



K-space

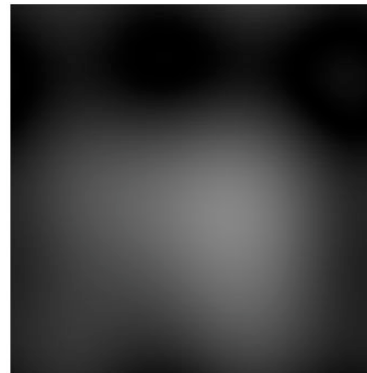
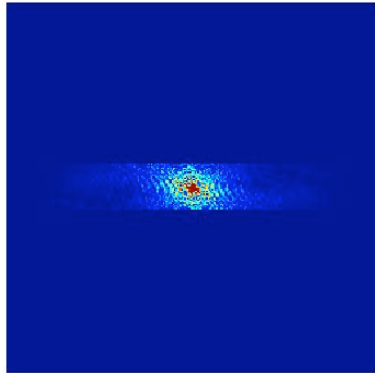


Image space

- Here is the data that was clipped

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# Gibbs Ringing



K-space

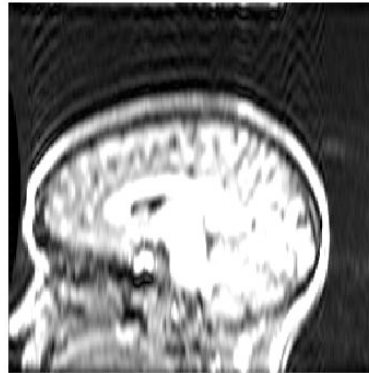
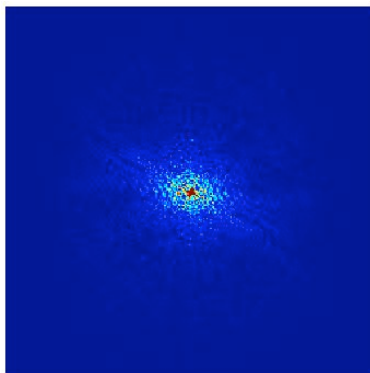


Image space

- Data is truncated before it decays into the noise
- Result is an image convolved with FT of the window in k-space

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# Quadrature Ghost



K-space

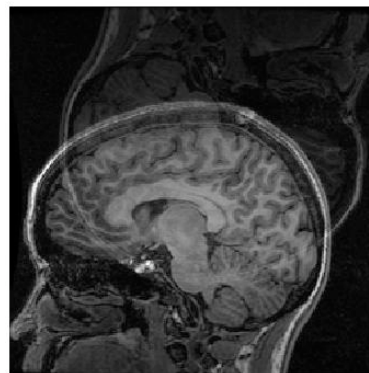
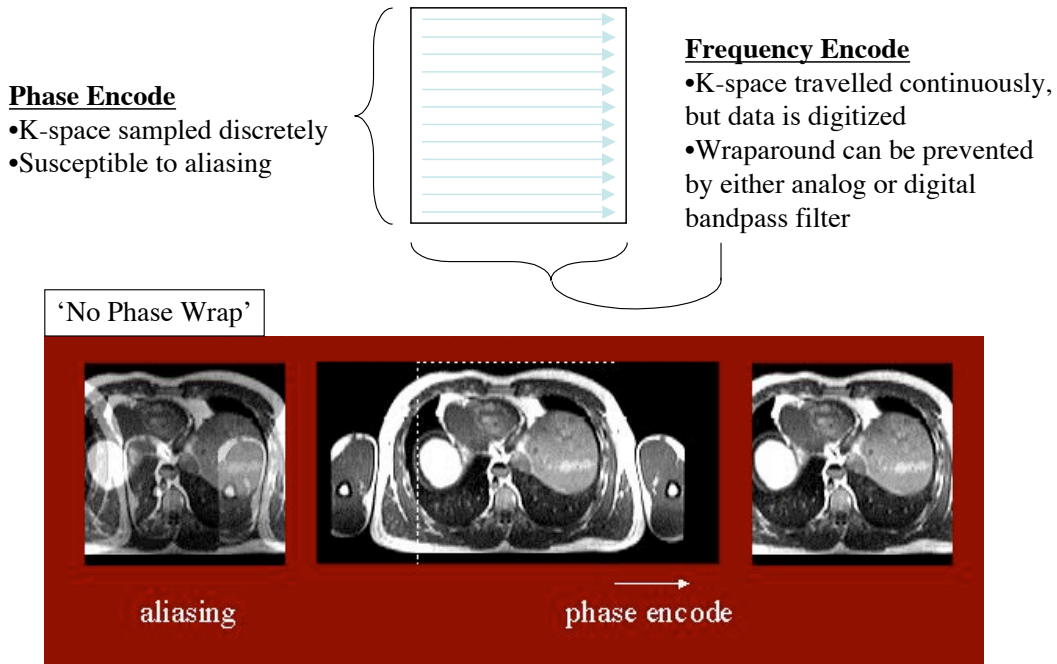


Image space

- K-space data is a superposition of good\_data and good\_data\*
- =>Image space is a superposition of good\_image(x,y) and good\_image(-x,-y)

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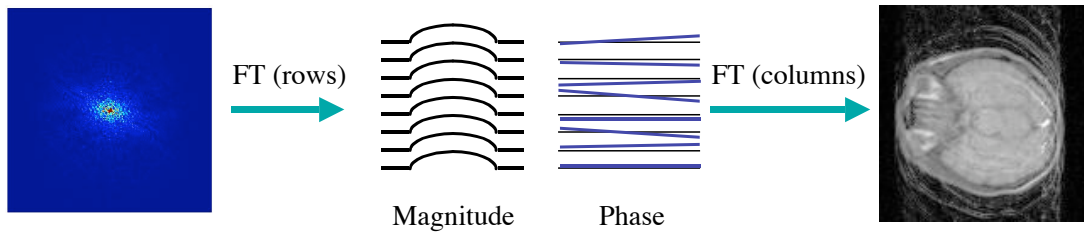
# Wraparound



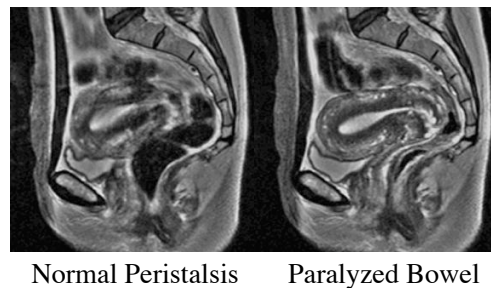
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<http://www.fmrib.ox.ac.uk/~peterj/lectures/kpace/img034.GIF>

# Motion Artifact



- Motion between TR periods generates inconsistency between lines of K-space
- Ghosts propagate in the phase encode direction
- Period motion generates structured ghosts (analogous to EPI Nyquist Ghosts)

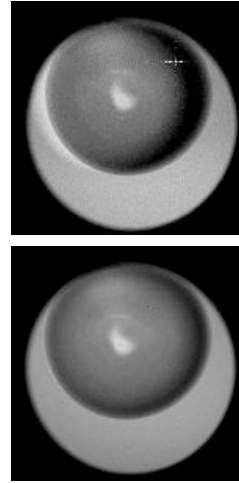


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<http://www.rad.pulmonary.ubc.ca>

# Chemical Shift

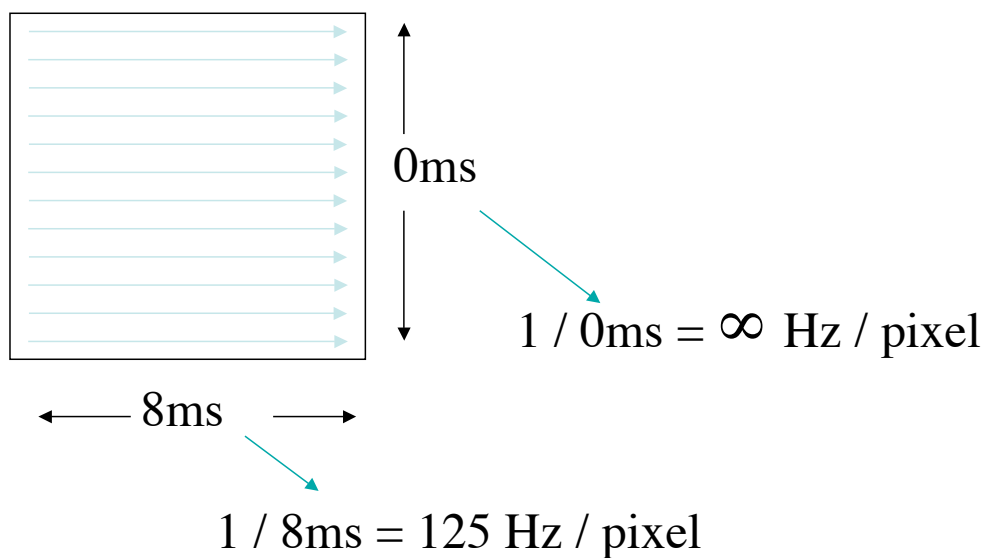
- Magnetic field of electron clouds shields nucleus from external magnetic field
- =>Actual magnetic field experienced by nucleus is smaller than applied field
- Differences in local field are called chemical shift, and are measured in PPM
- Water and fat differ in chemical shift by 3.5 PPM = 440Hz at 3T
- Chemical shift causes phase twist across readout
- Fourier shift theorem tells you how far things are shifted



[http://chickscope.beckman.uiuc.edu/roosts/carl/artifact/cs\\_a001.gif](http://chickscope.beckman.uiuc.edu/roosts/carl/artifact/cs_a001.gif)

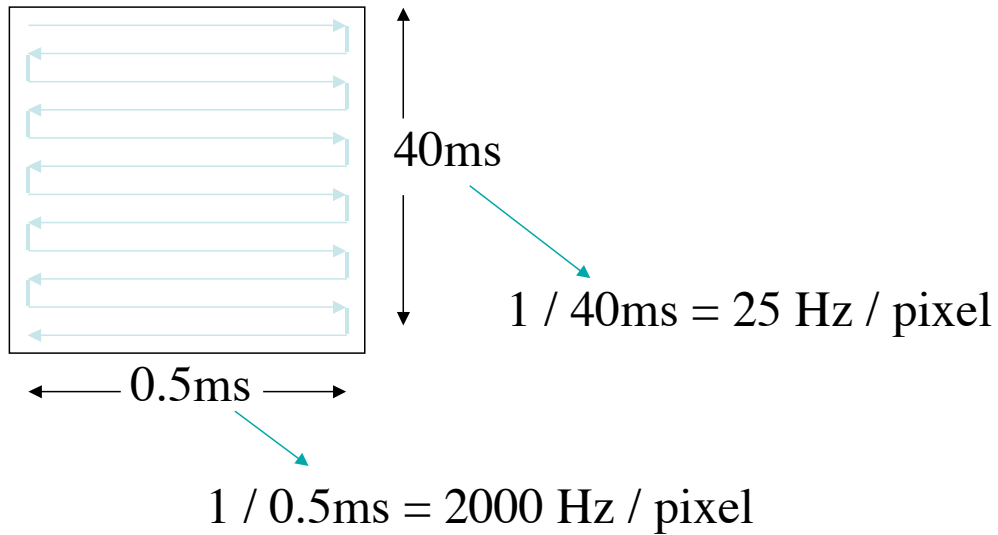
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## CONVENTIONAL IMAGING



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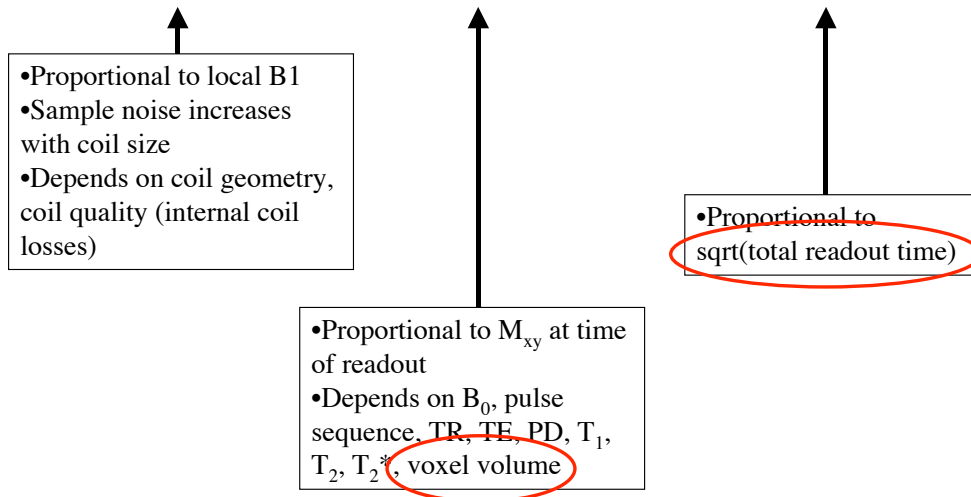
# Off Resonance Behavior : EPI



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# Signal to Noise Ratio in MRI

$$SNR \propto (\text{coil\_factor}) \times (\text{magnetization\_factor}) \times (\text{sampling\_factor})$$



$$SNR \propto (\text{voxel\_volume}) \sqrt{\text{total\_readout\_time}}$$

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