Magnetic Resonance Imaging (MRI)

Part 1: Image Formation

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Magnetic Resonance Imaging (MRI)

Knee

Neck

Brain

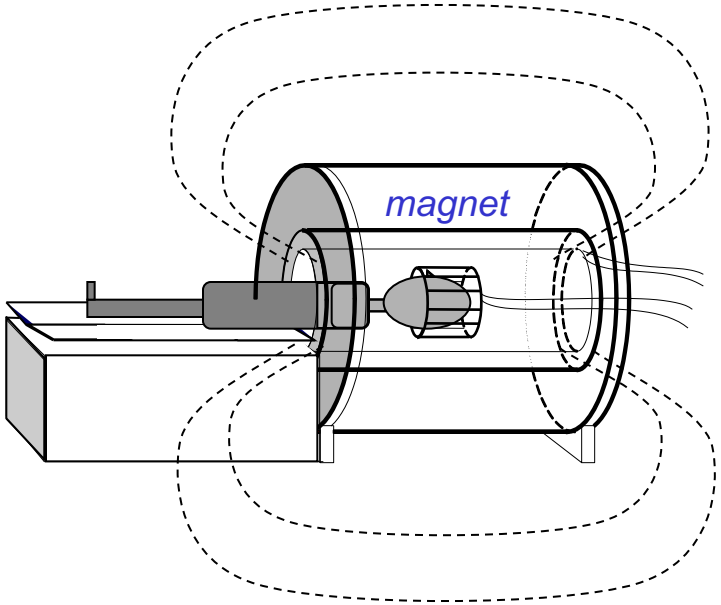
Magnetic Resonance Imaging (MRI)

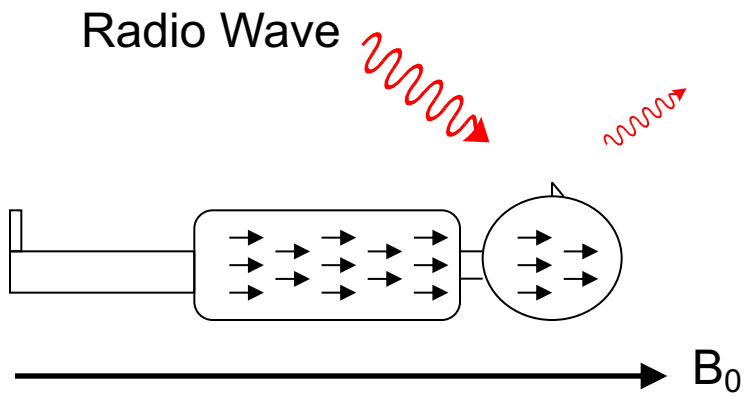
How an MRI works:

Large **magnet**

Send
radio waves
into body
(no X-rays)

Magnetic Resonance Imaging (MRI)

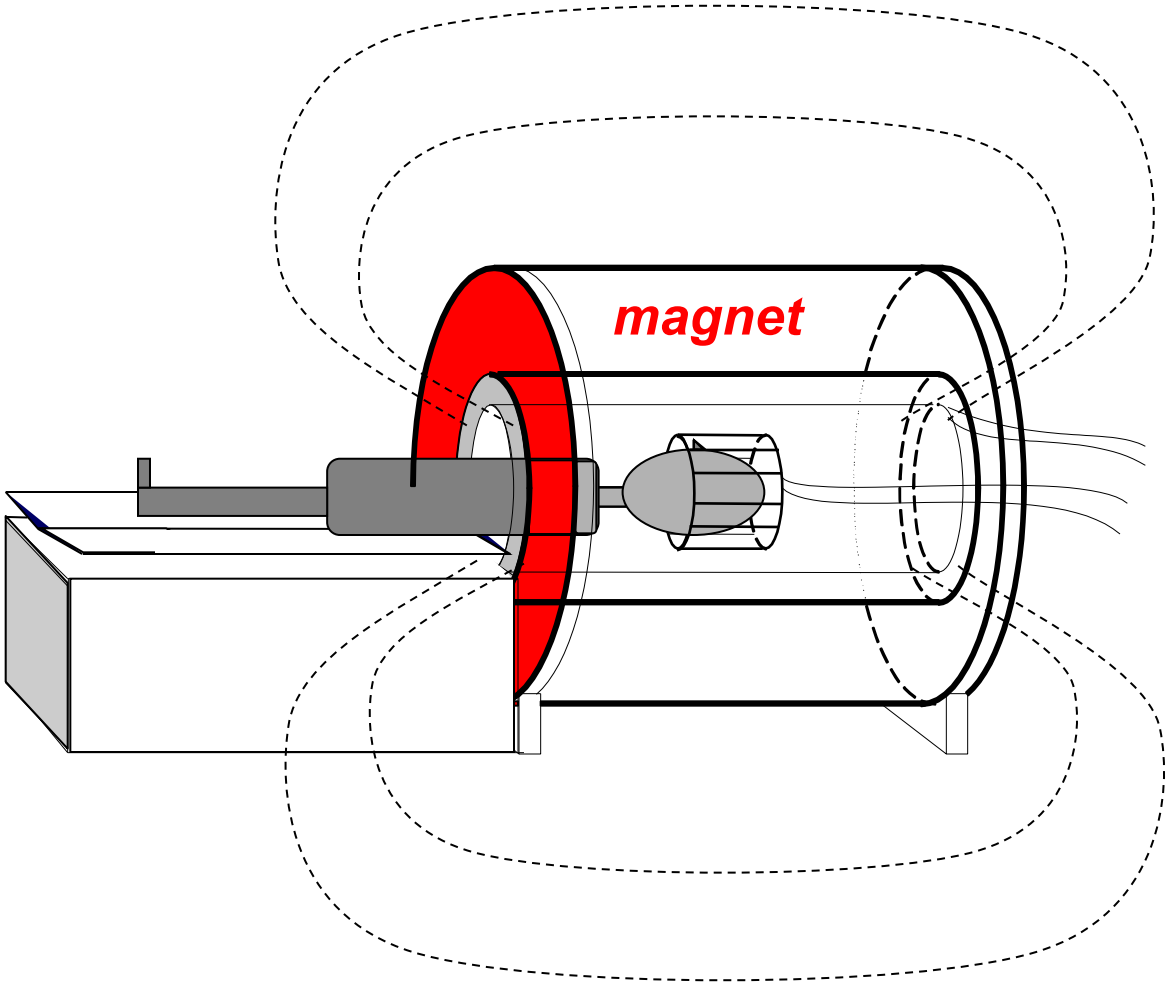


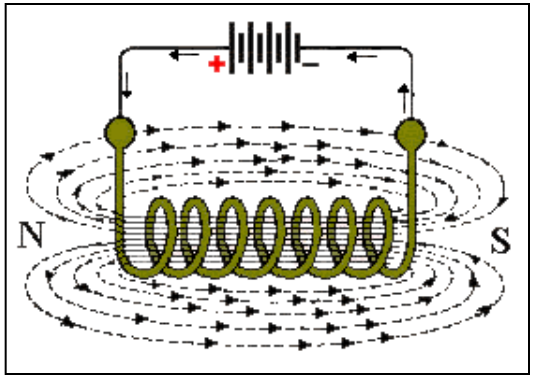


Sensitive to:

- # of protons (H_2O)
- Magnetic environment
  - Tissue structure

1. Apply Magnetic Field





electromagnet

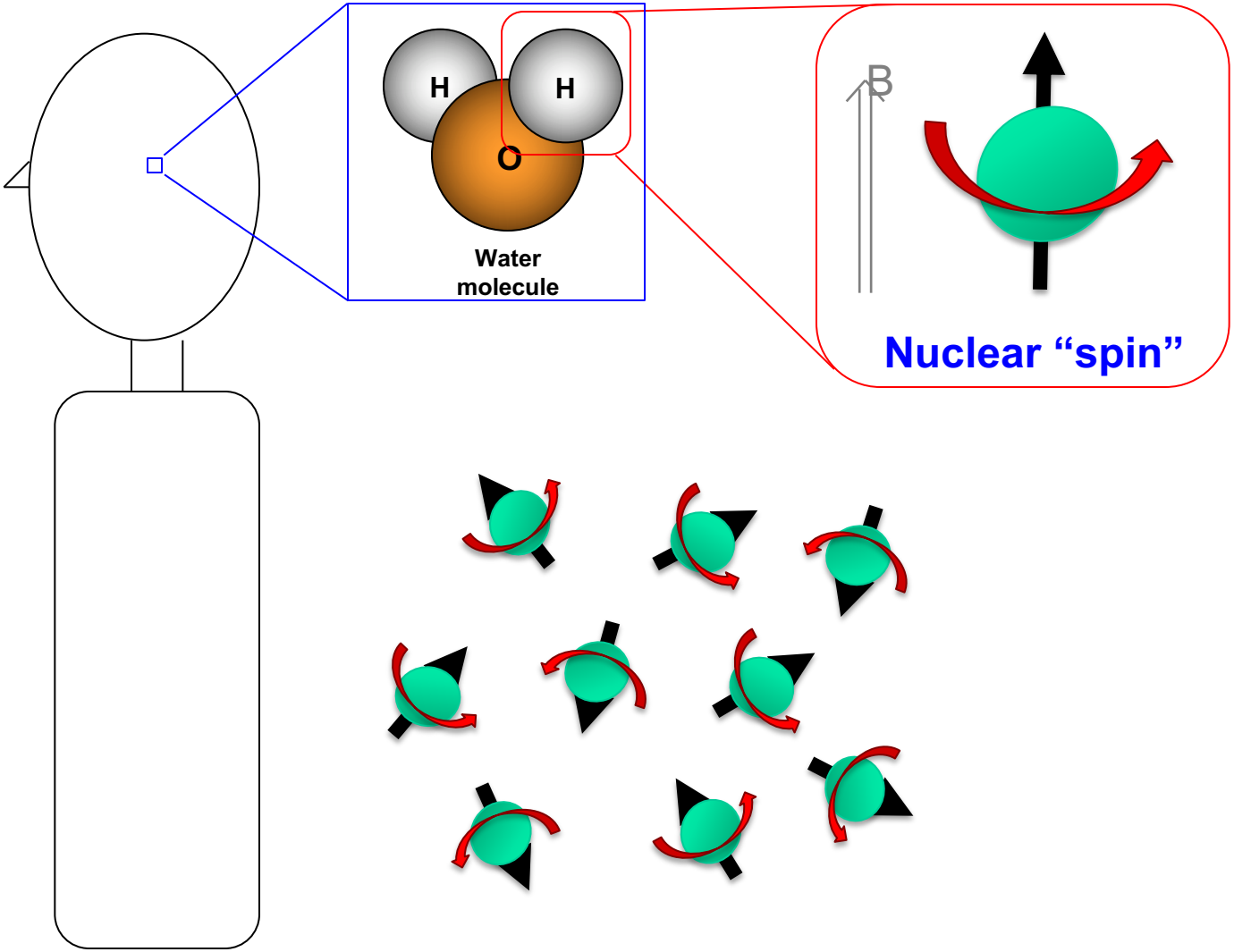
Magnetic Resonance Imaging (MRI)

Large **magnet**

- 3 Tesla!
- 300 times as strong as a typical bar magnet
- Superconducting (magnet is always on)
- Cooled with liquid helium (-265 ° C)
- 11,000 kg.
- ~200km of wire

Send **radio waves** into body
(no X-rays)

1. Apply Magnetic Field



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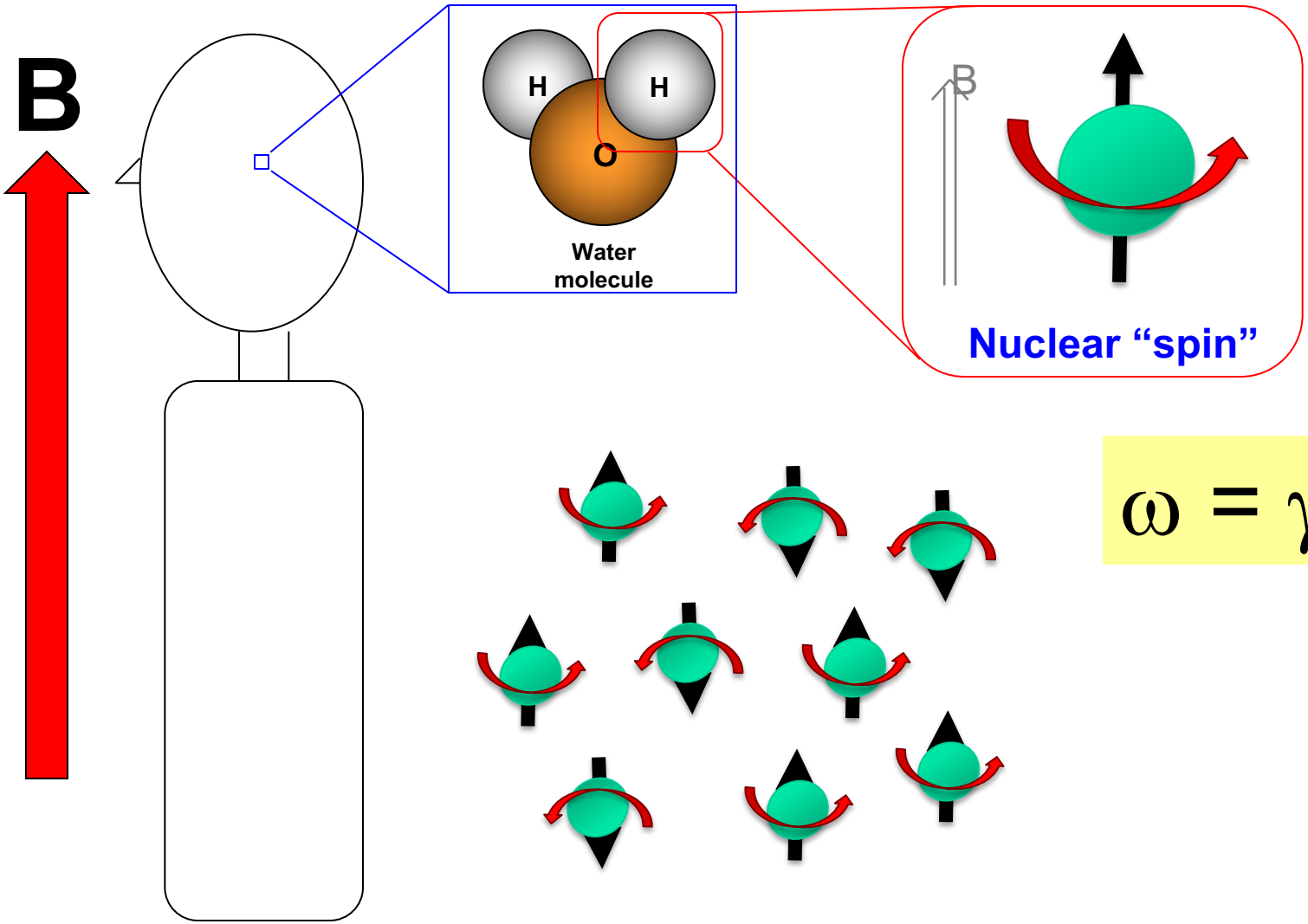
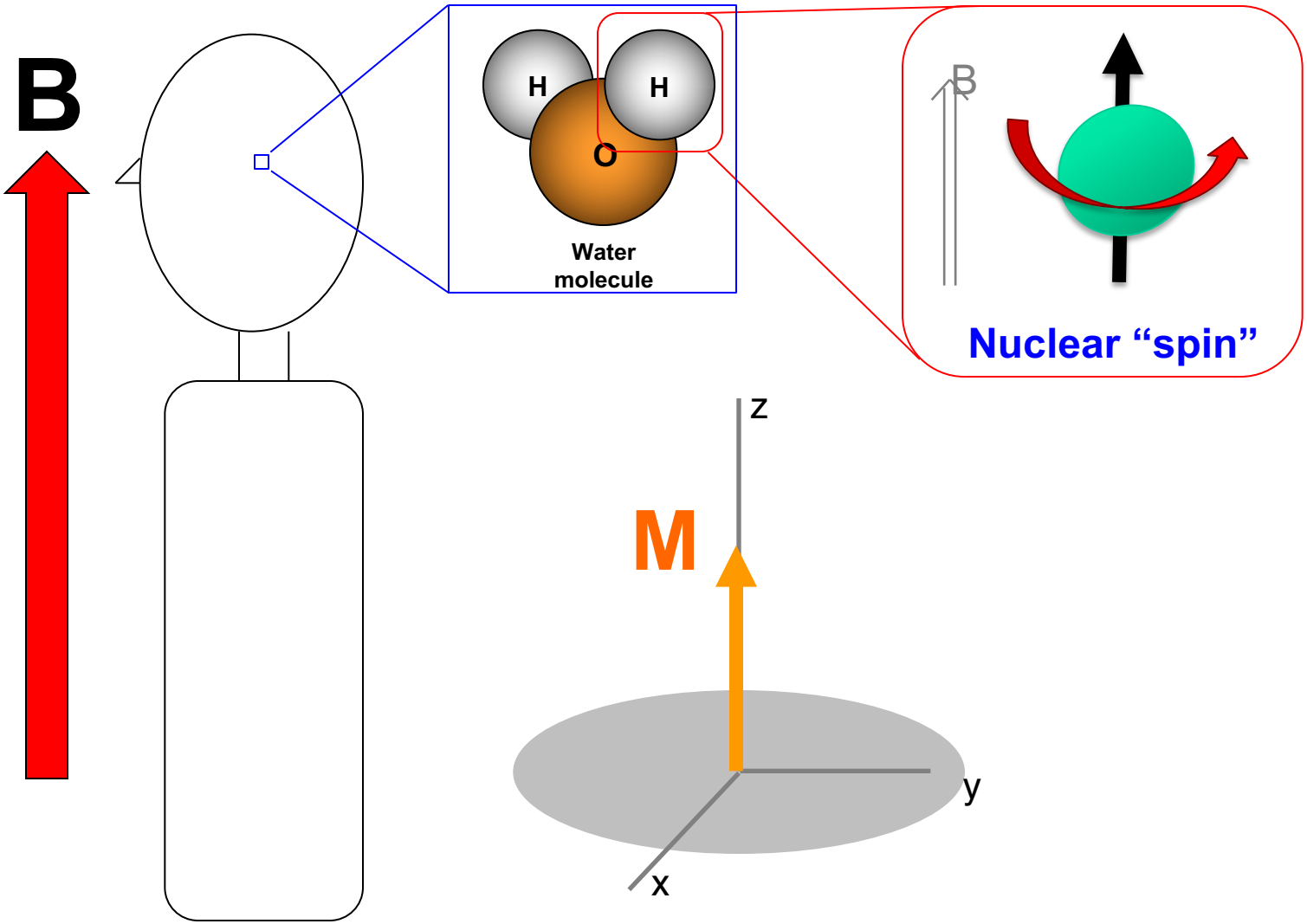
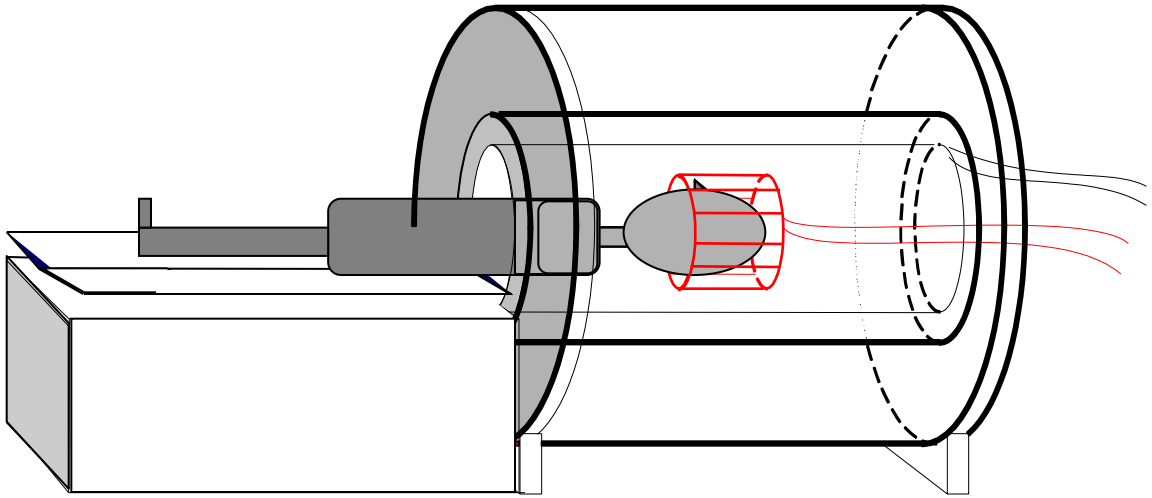


$$\omega = \gamma B$$

1. Apply Magnetic Field



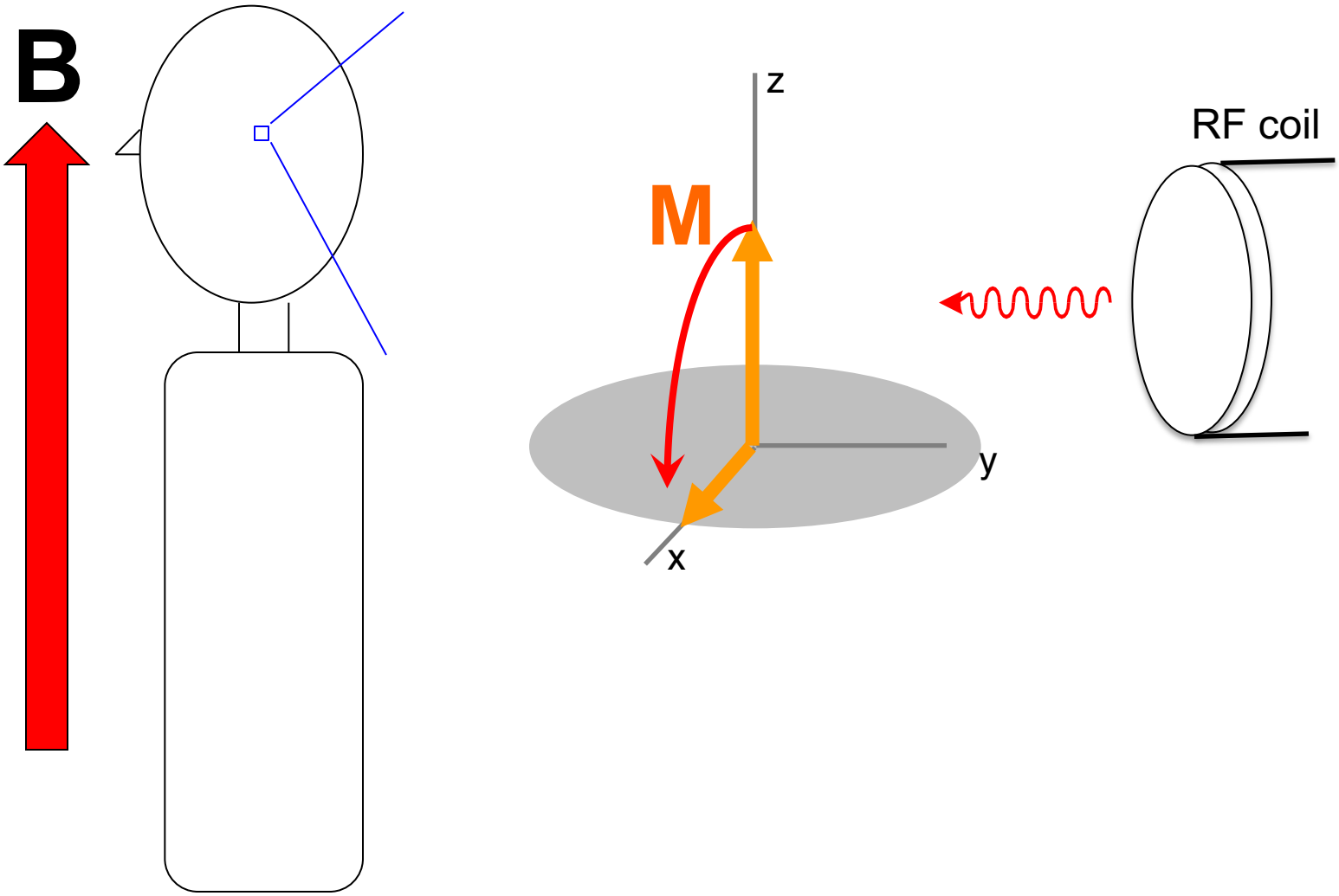
2. Send in a radio-frequency (RF) wave



Radio-frequency coil (antenna)

imexbb.com

2. Send in a radio-frequency (RF) wave



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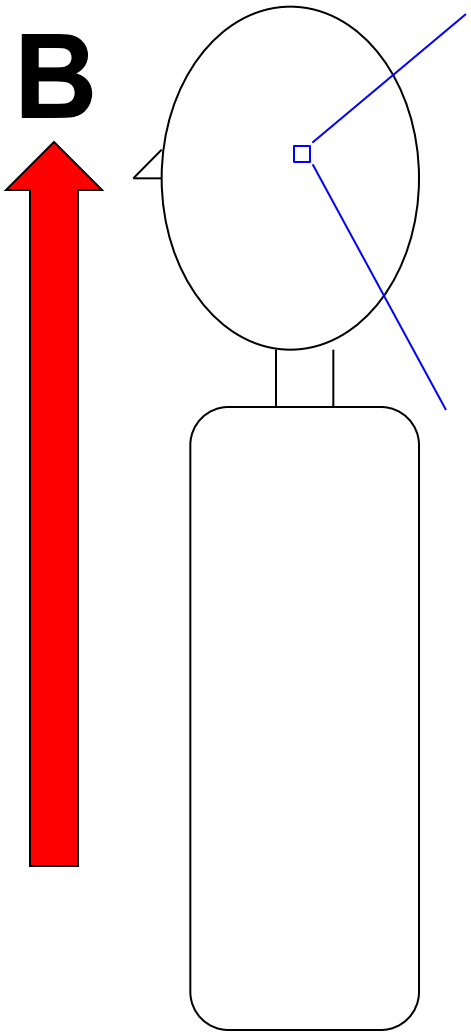
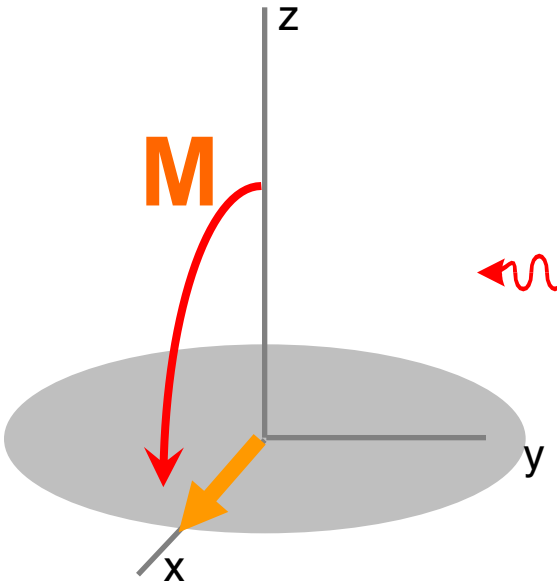
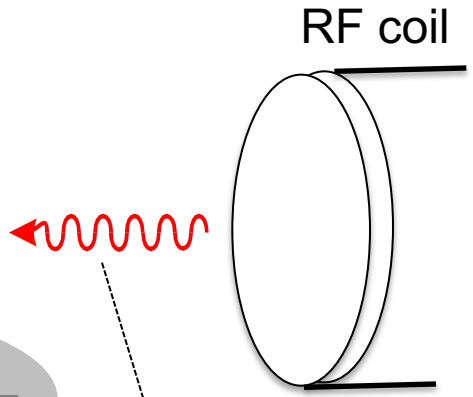


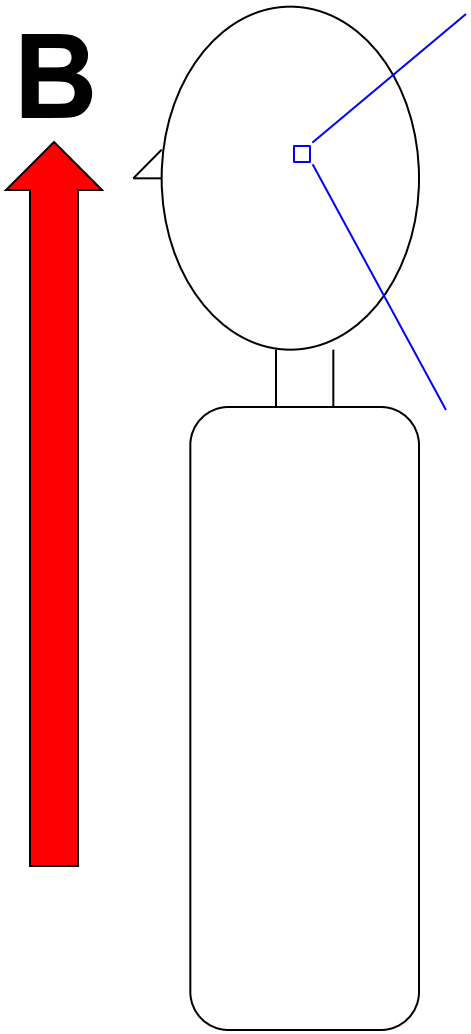


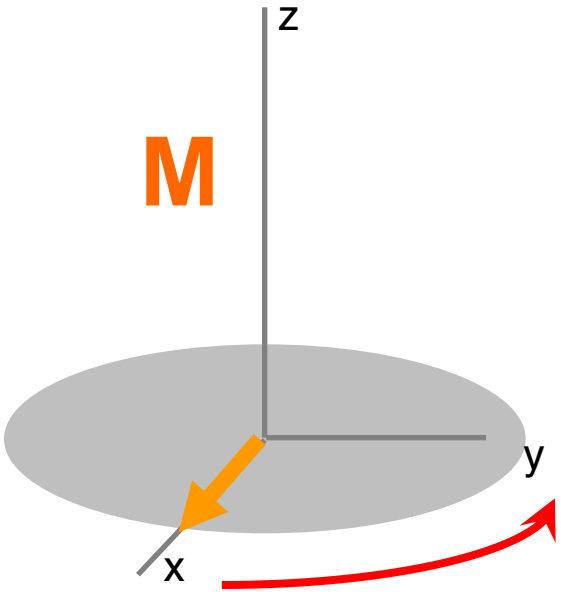


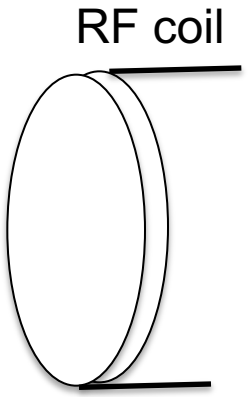
$\omega = \gamma B$

“Resonance”

2. Send in a radio-frequency (RF) wave







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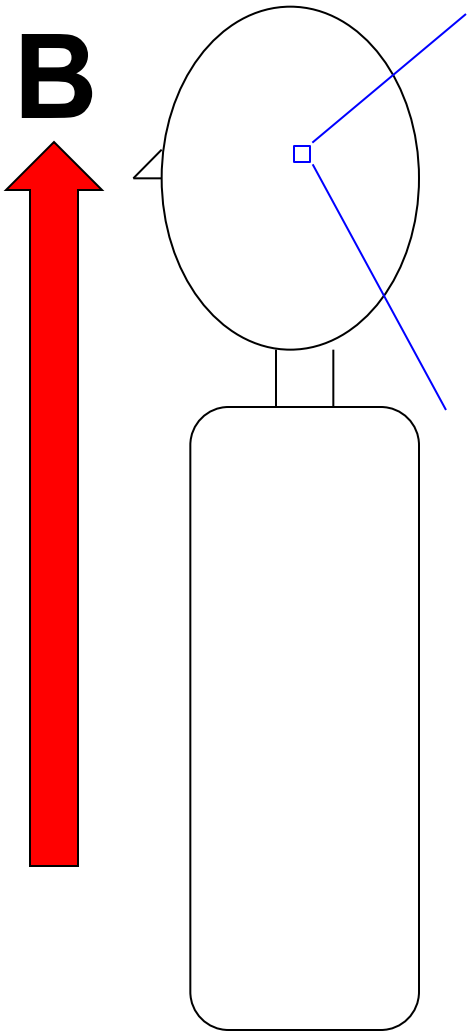
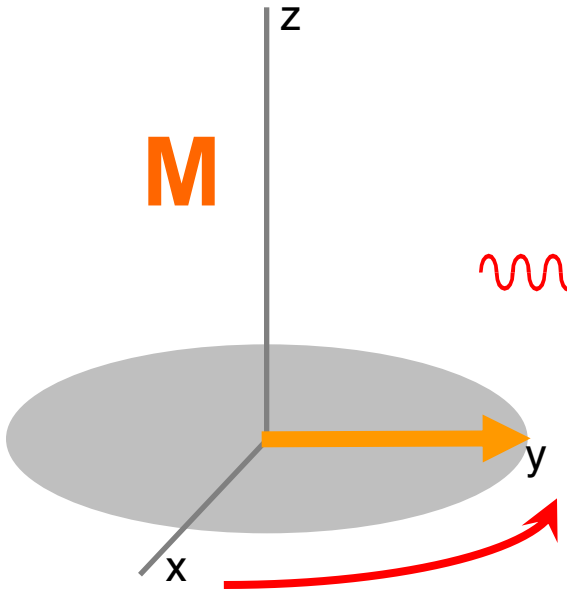
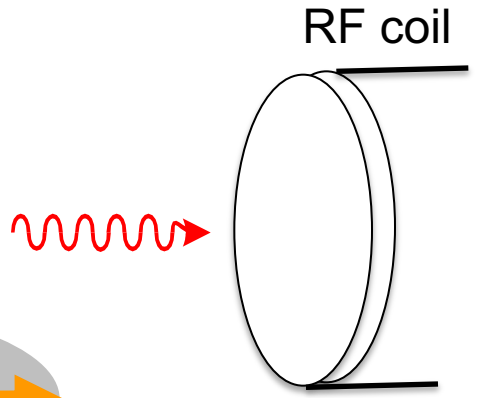
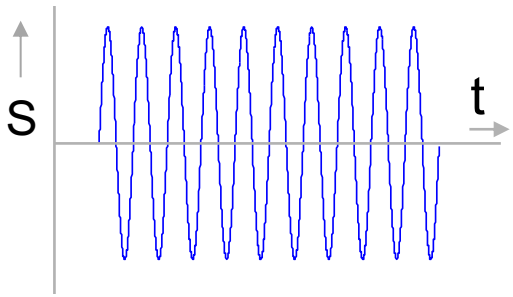
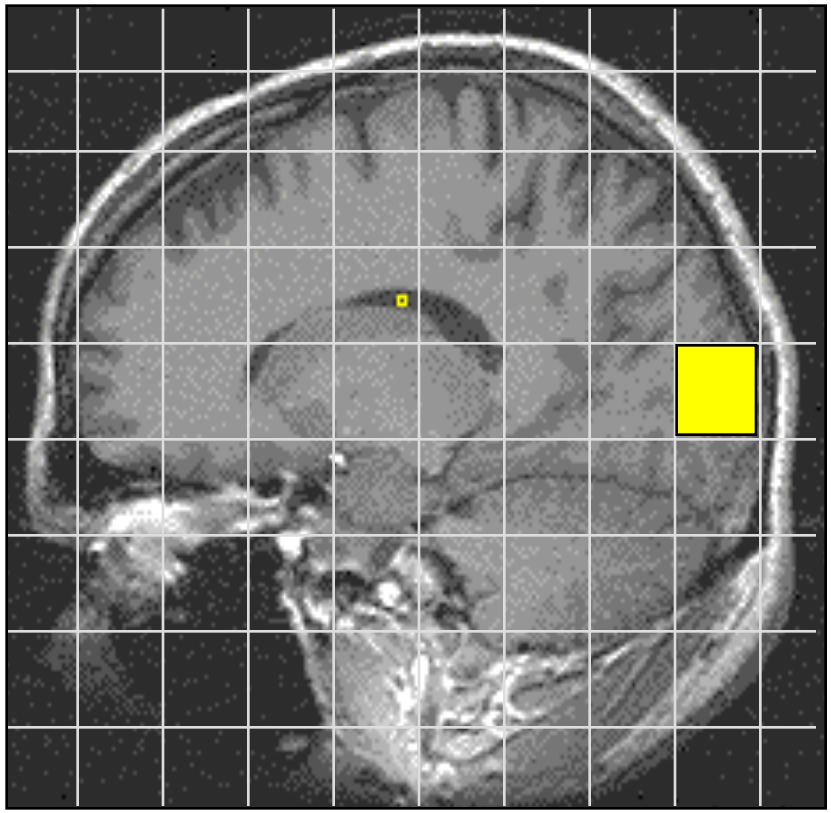


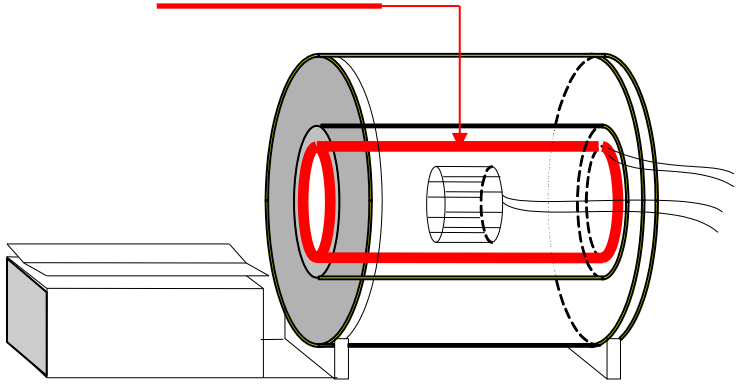






3. Apply Magnetic Field Gradients



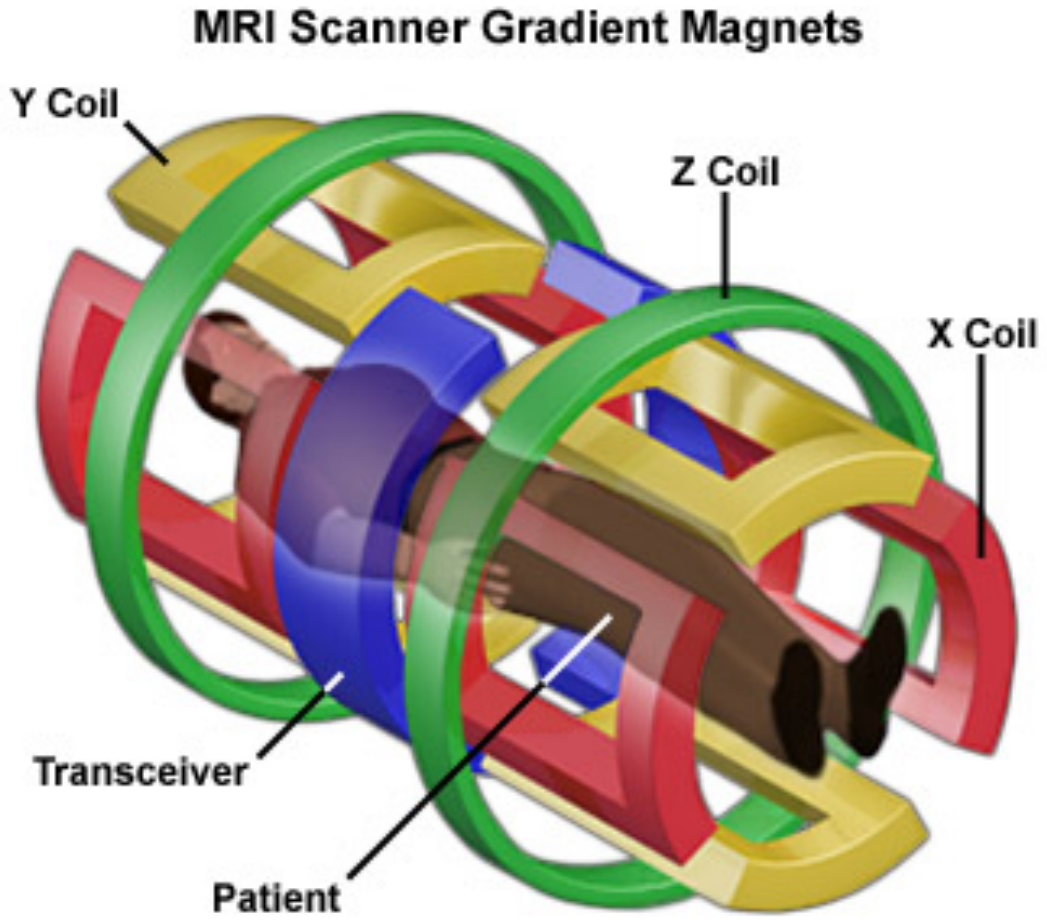


$$\omega = \gamma B$$

Nobel Prize in Medicine 2003
Paul Lauterbur
Peter Mansfield

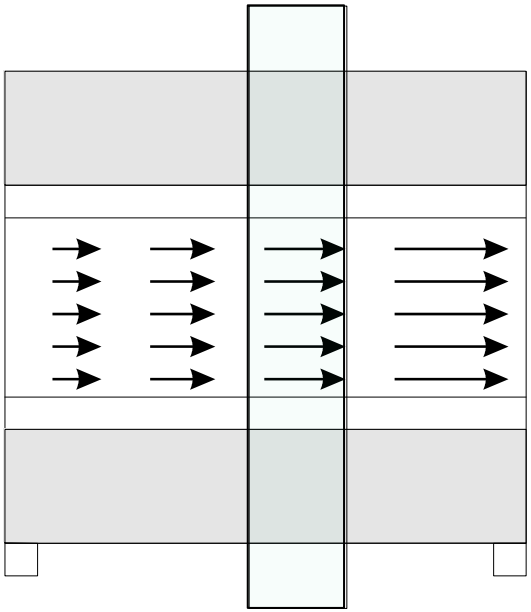
Figure by K. Schmainda

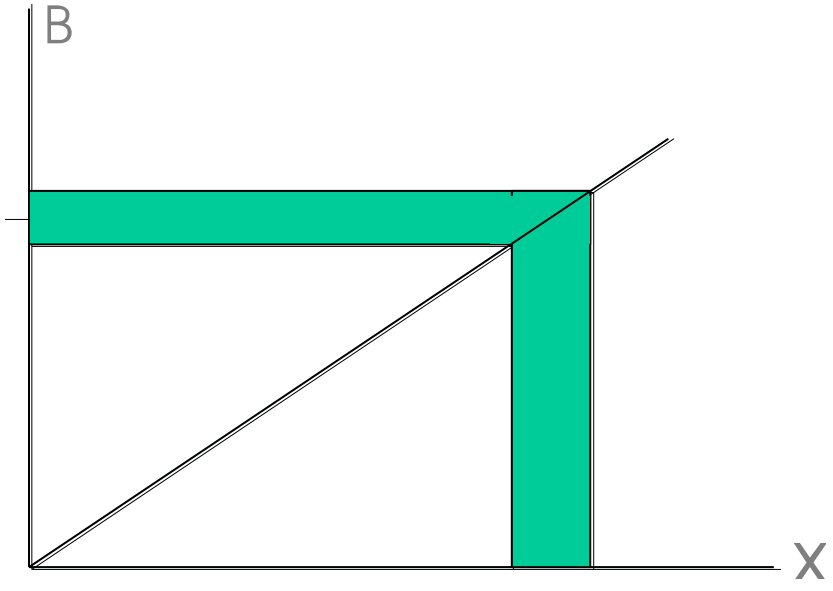
Gradient coil

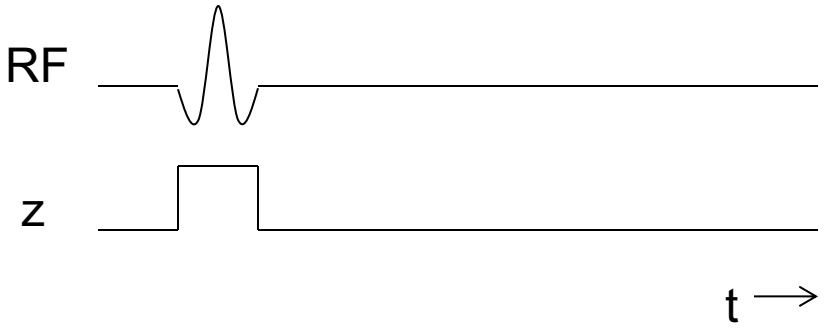


http://www.magnet.fsu.edu/education/tutorials/magnetacademy/mri/fullarticle.html

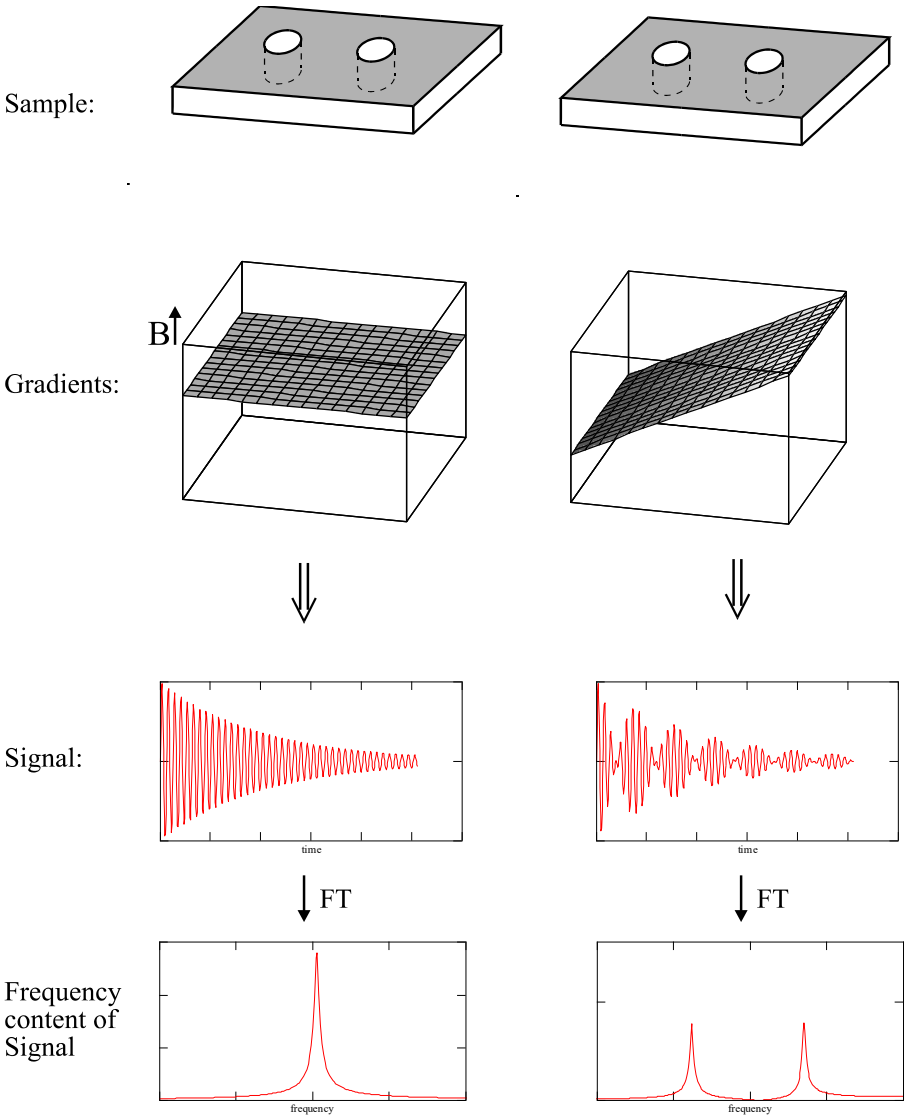
Slice selection

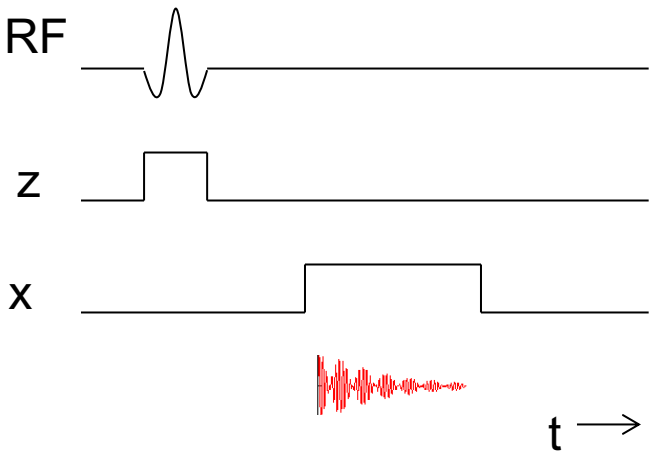






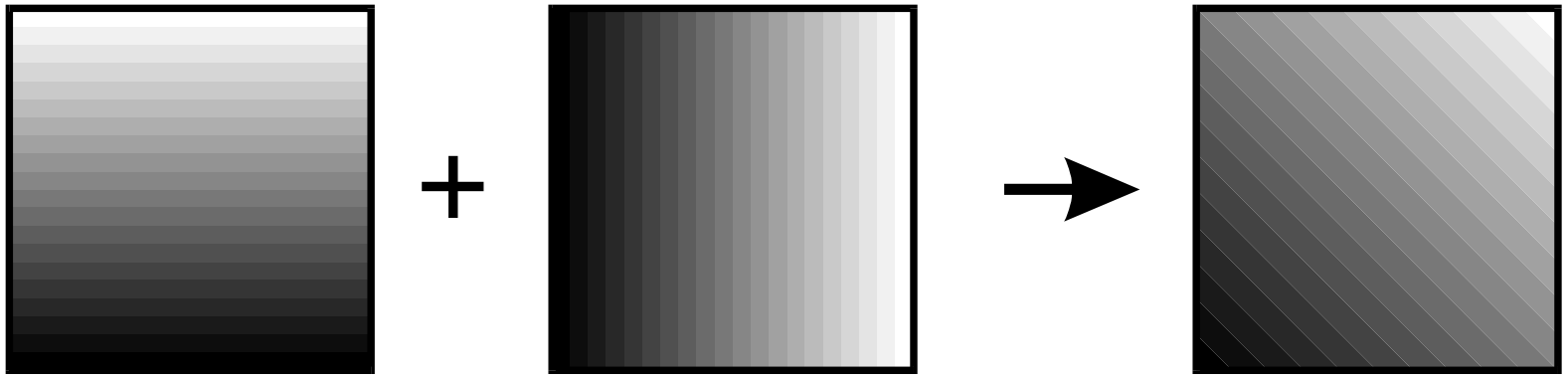
Frequency Encoding

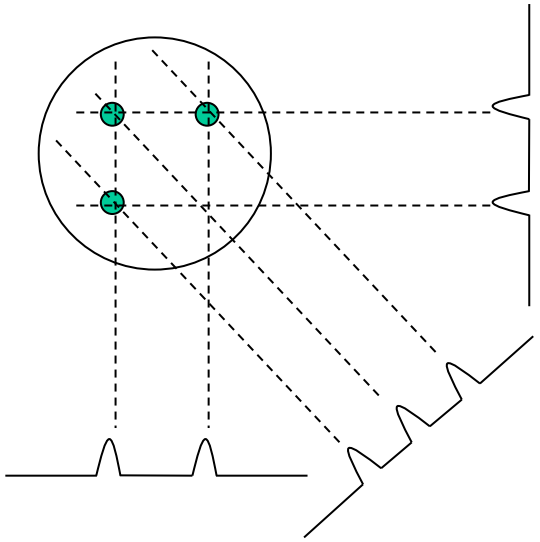




How do we encode the 3rd dimension?

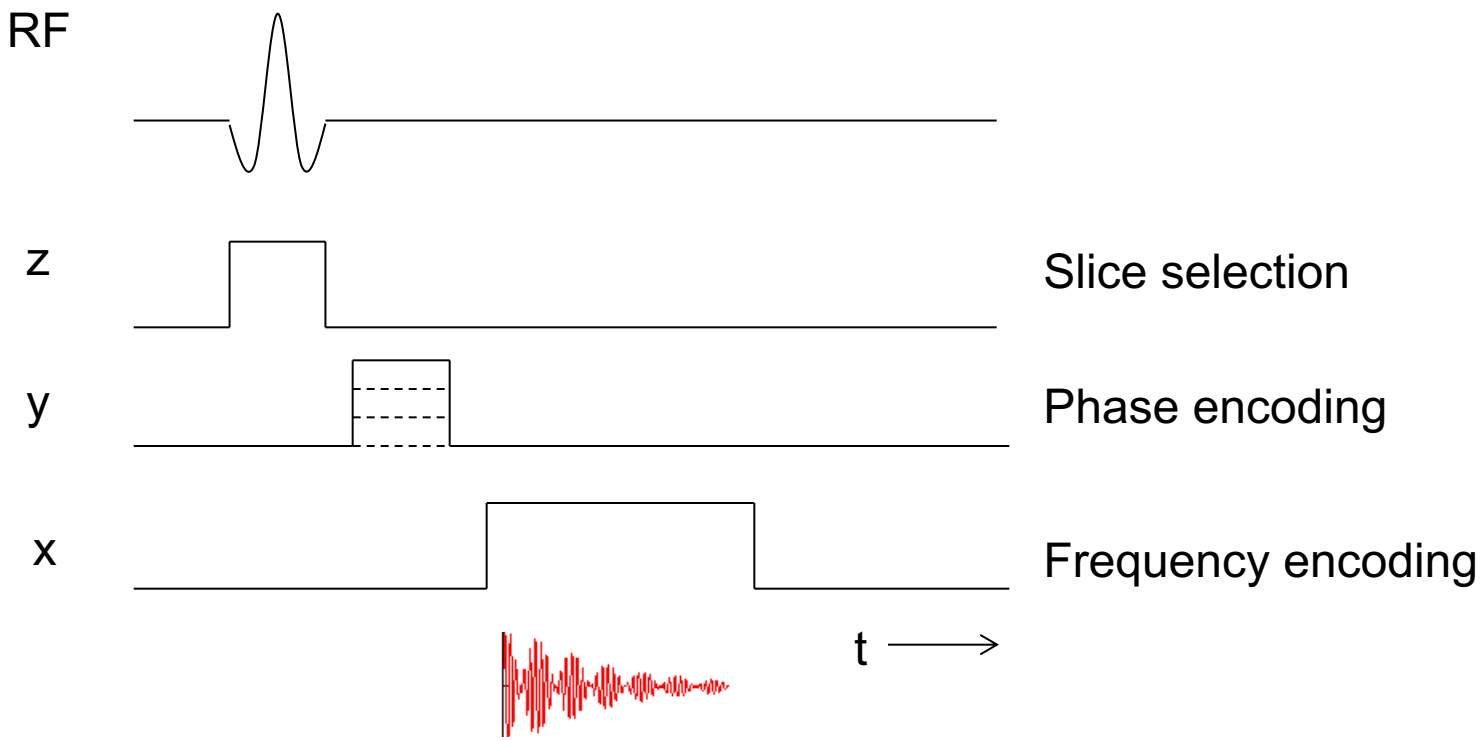
Add a gradient in the y-direction?

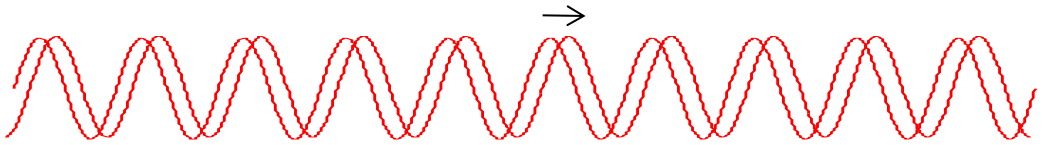




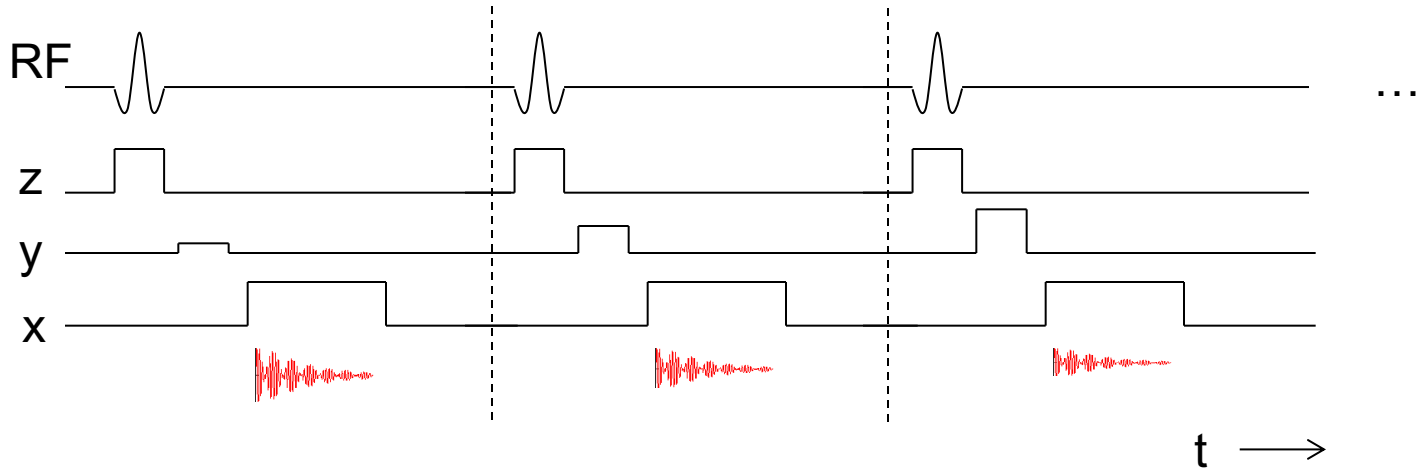
"Projection Reconstruction"

Phase encoding



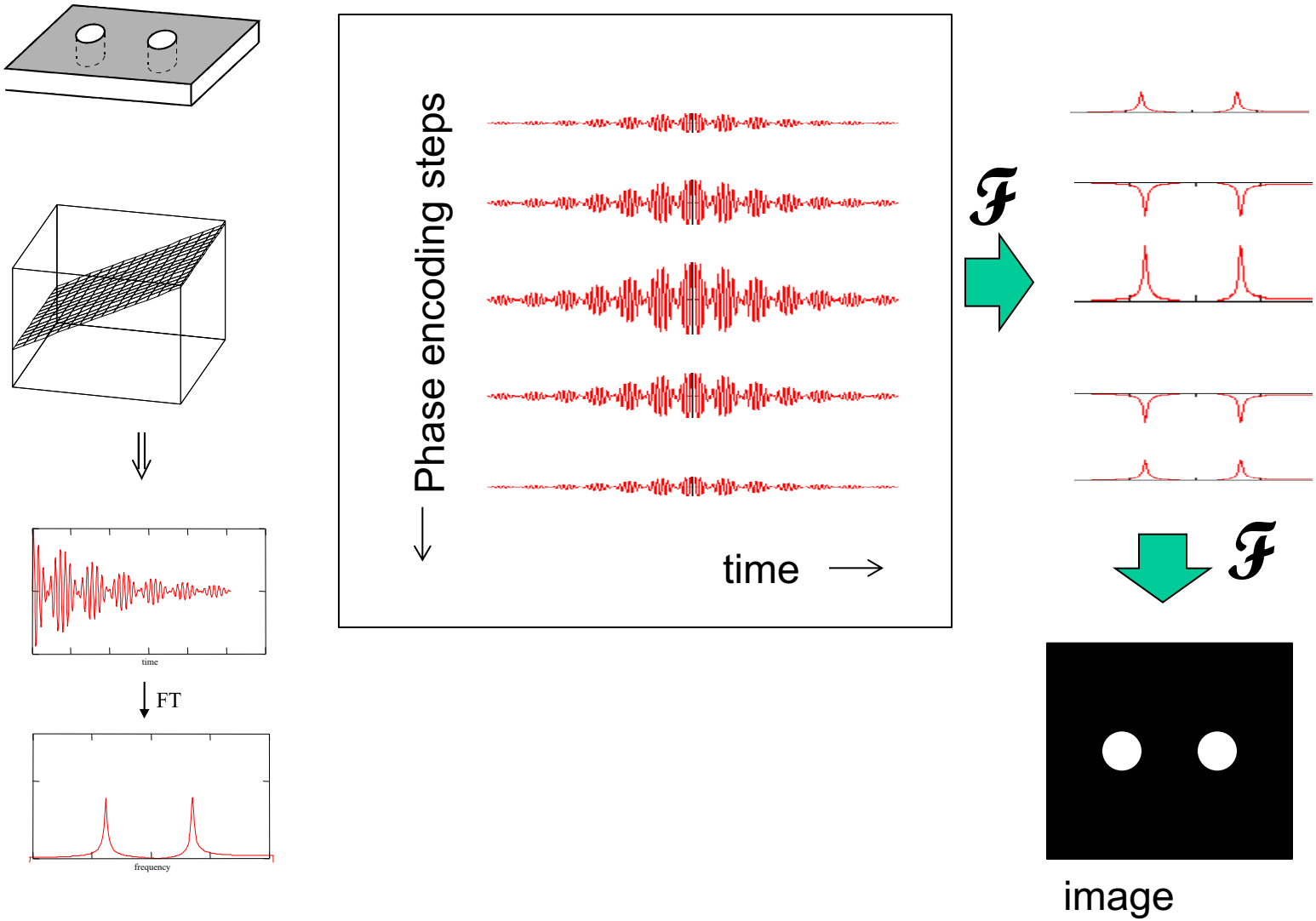


Phase encoding

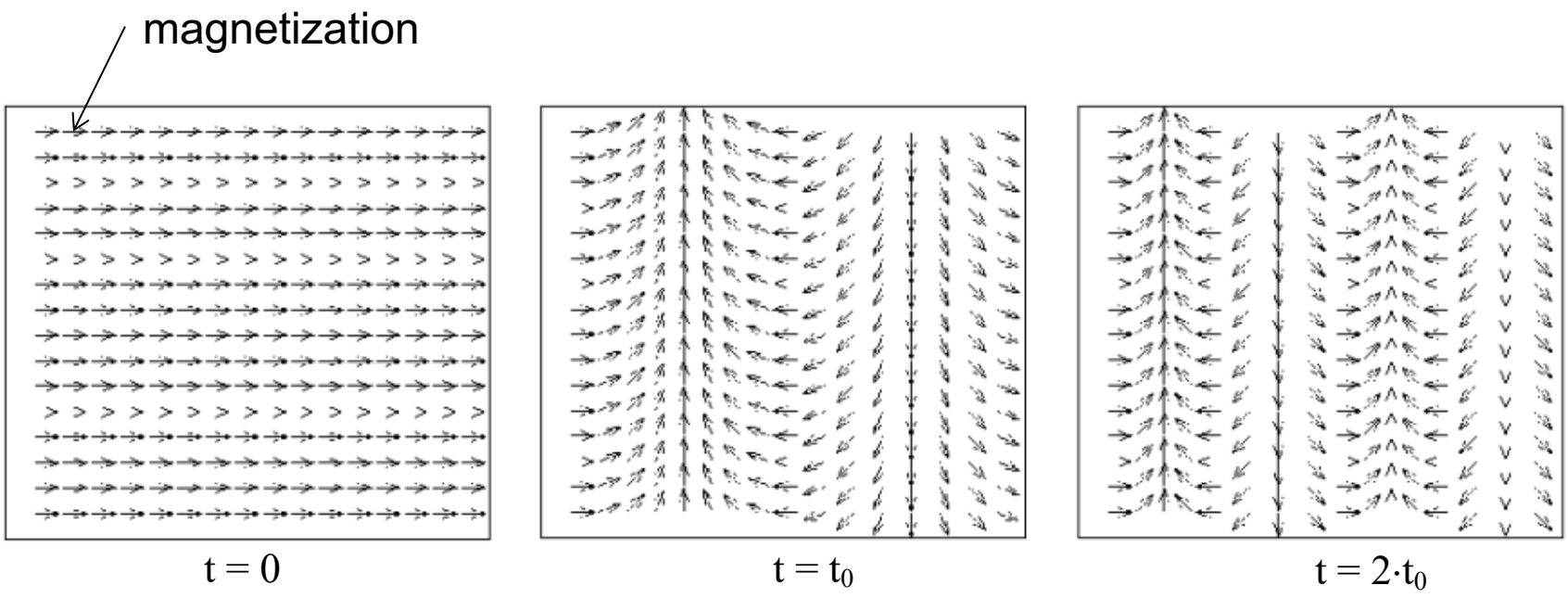


Acquire one phase encoding step for each excitation

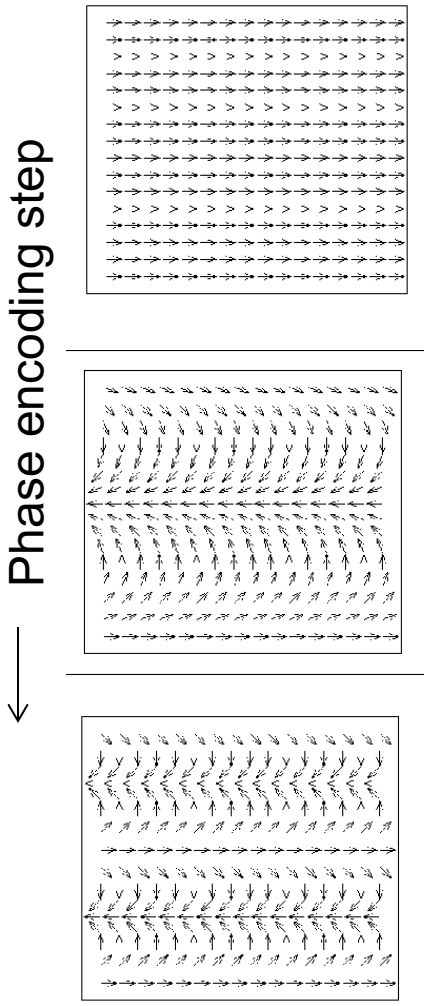
We acquire spatial frequency information

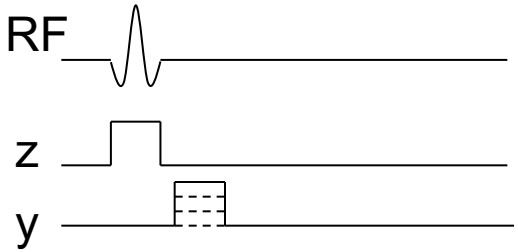


Frequency encoding (a different view)



Phase encoding





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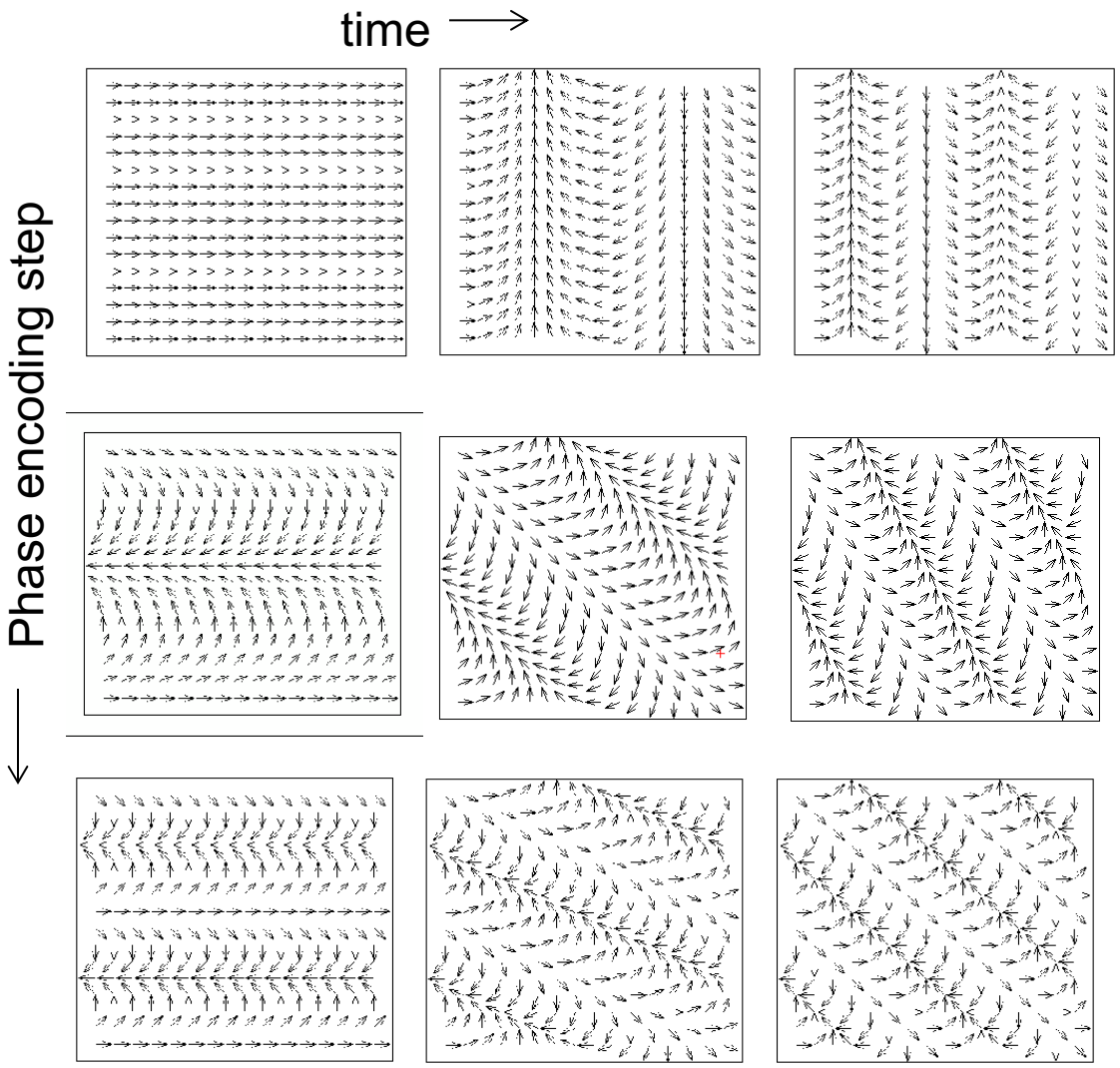
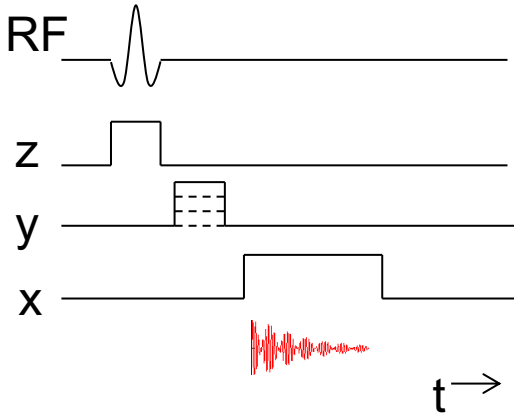
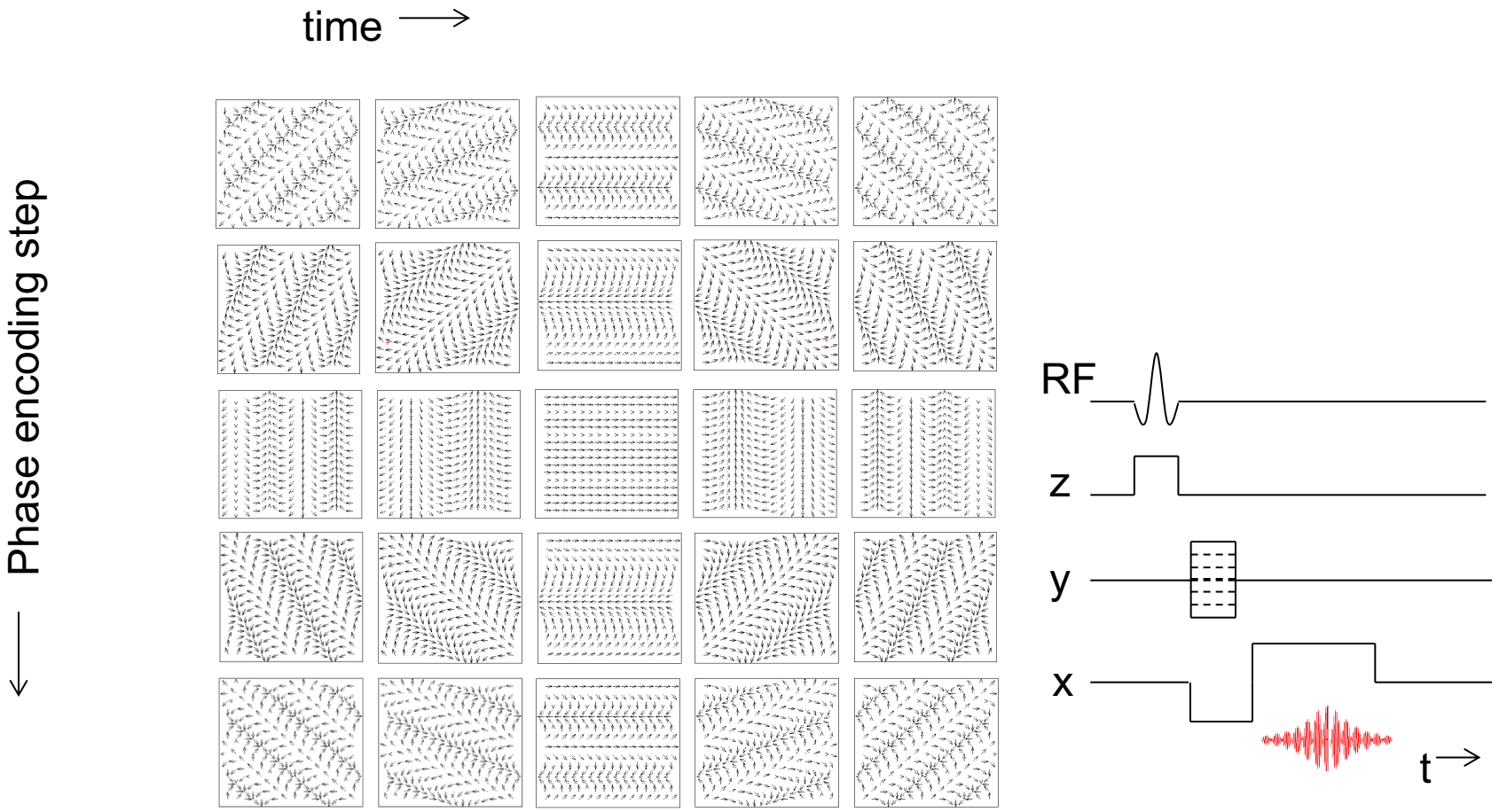




We acquire spatial frequency information

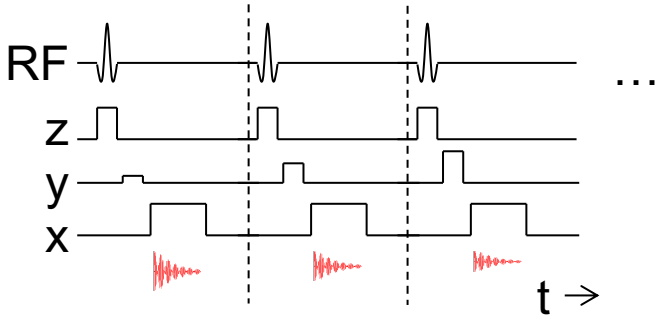


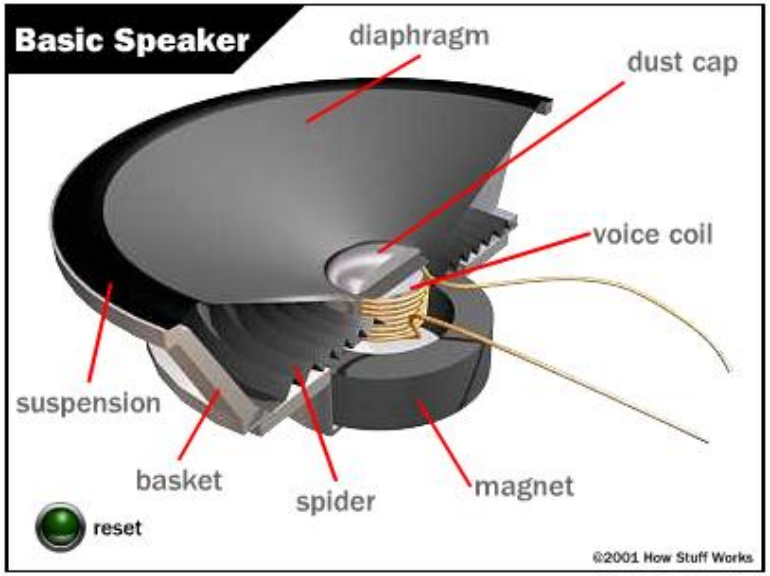
Why are MRIs so loud?

What an MRI sounds like

Typical MRI sound

Rapid Imaging for fMRI (EPI)





http://www.howstuffworks.com