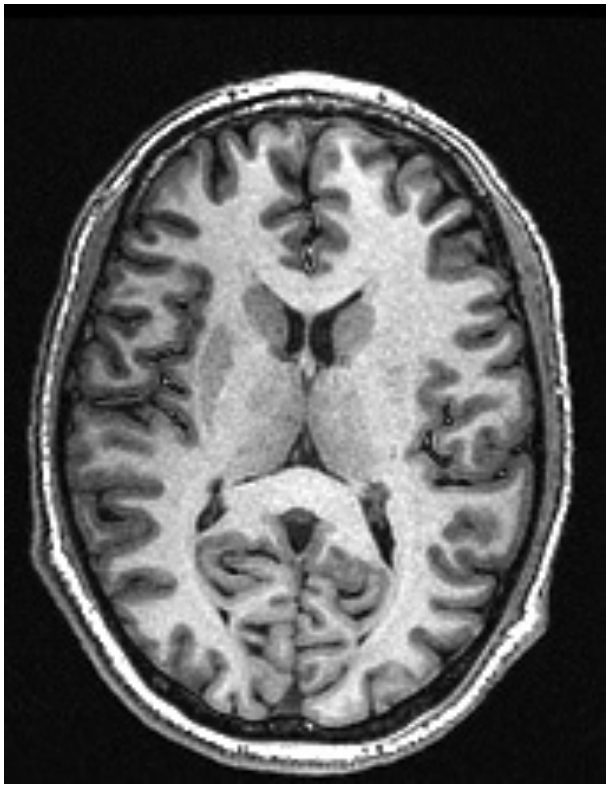
Magnetic Resonance Imaging (MRI)

Part 2: Image Contrast

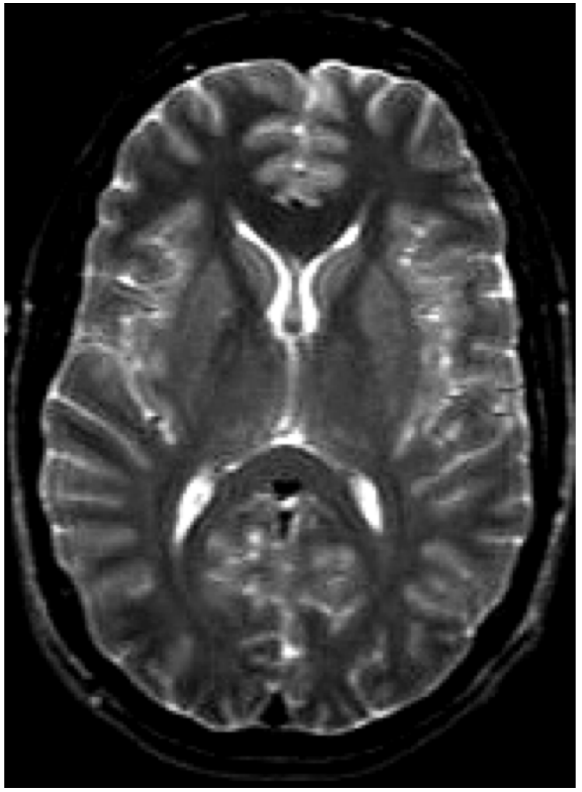
Rasmus M. Birn, Ph.D.

University of Wisconsin – Madison
Madison, WI, USA

MRI Contrast

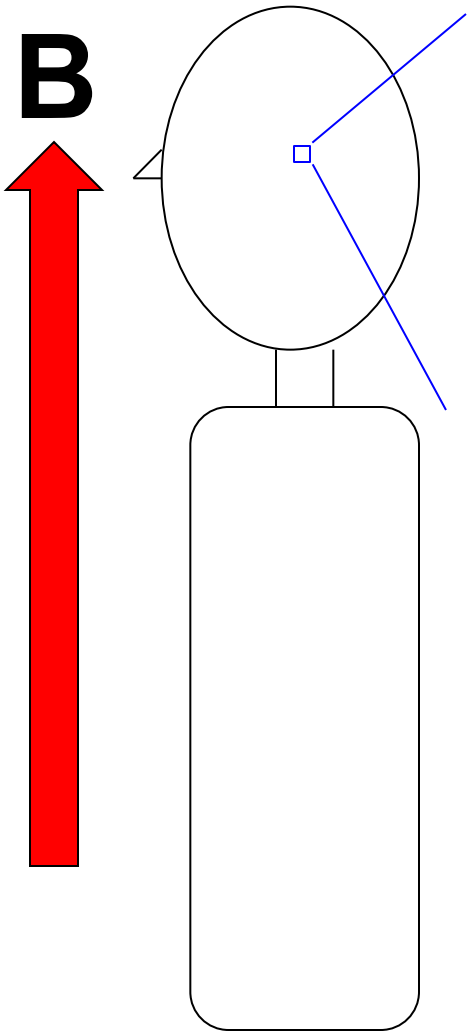


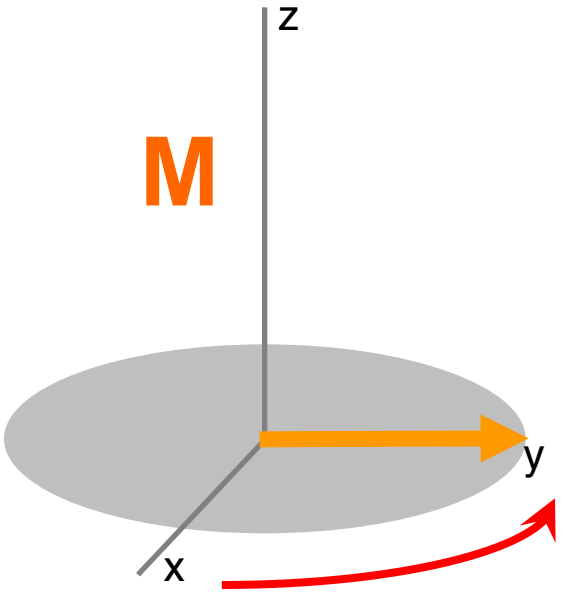
T1-weighted

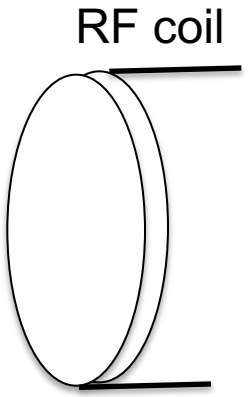


T2-weighted

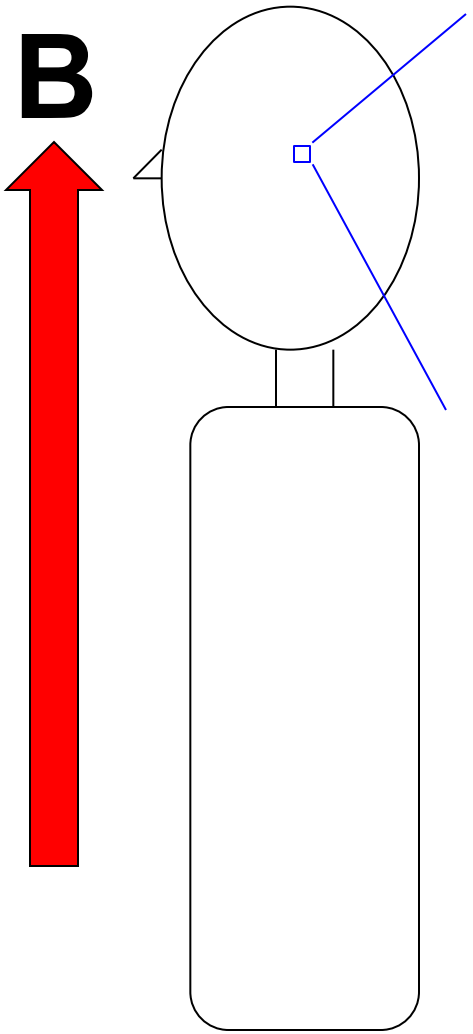
MRI Contrast

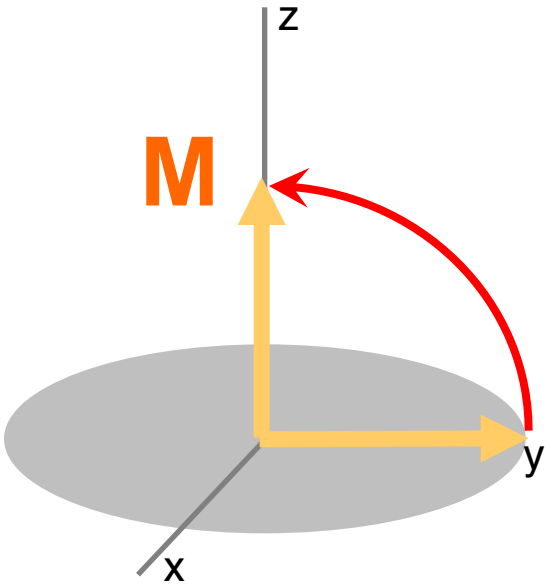


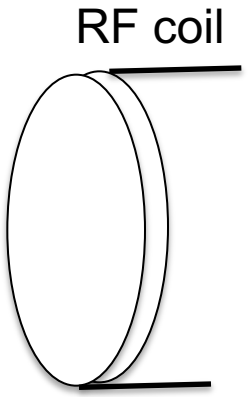




MRI Contrast – T1

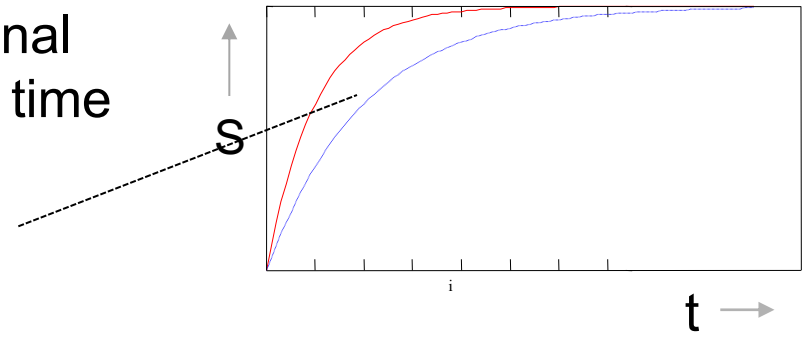




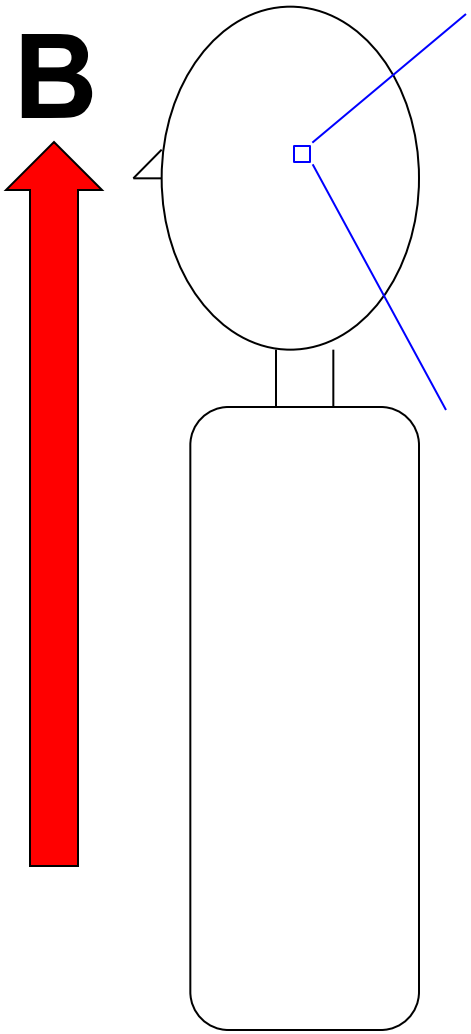


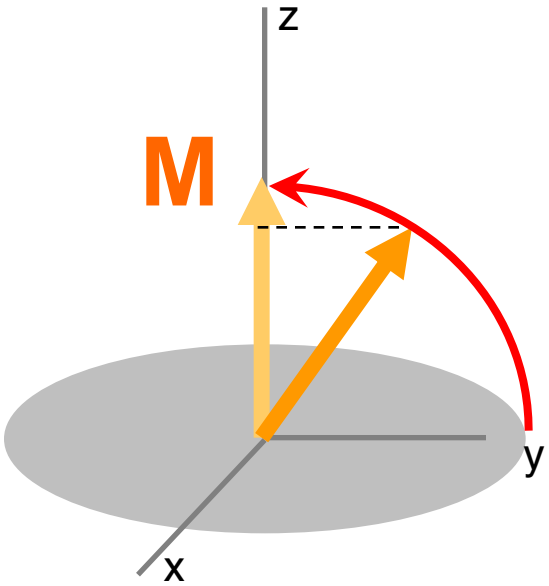
Longitudinal
Relaxation time

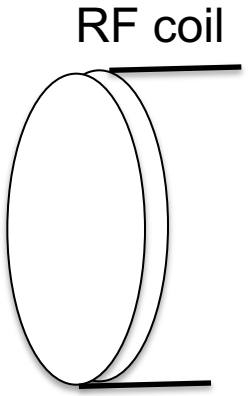
T1

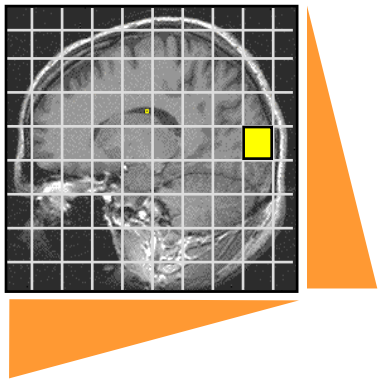


MRI Contrast – T1

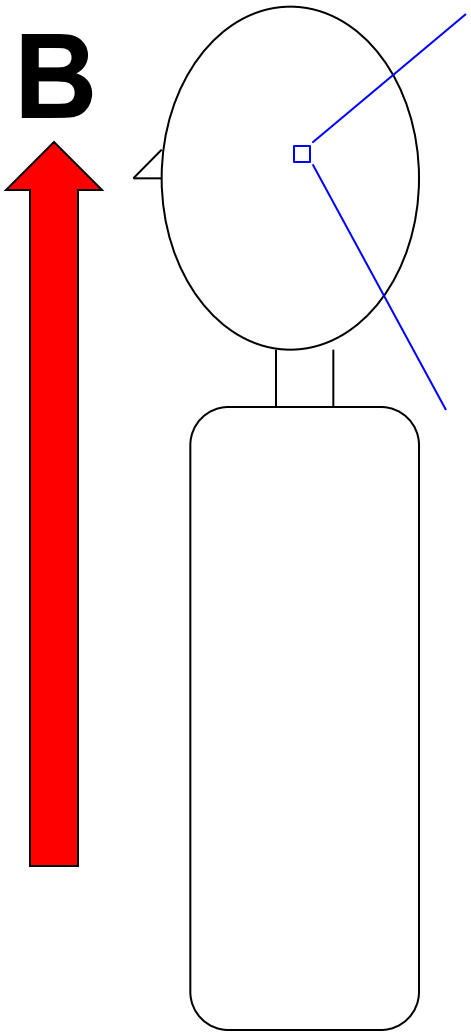


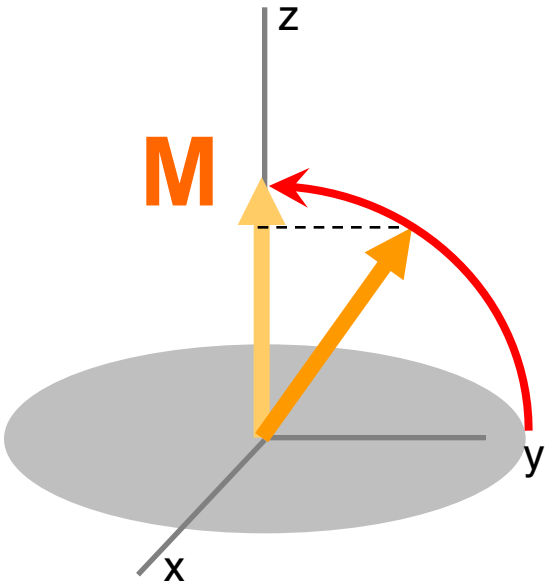


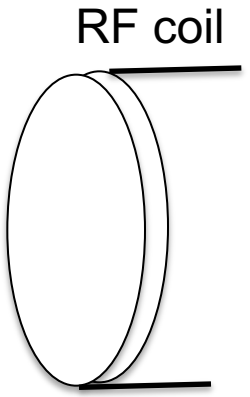




MRI Contrast – T1

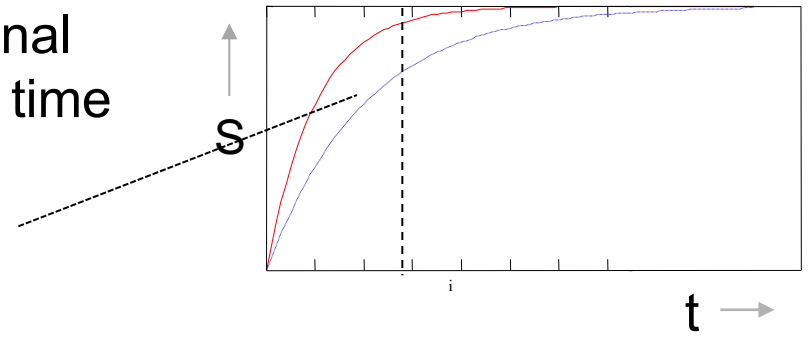






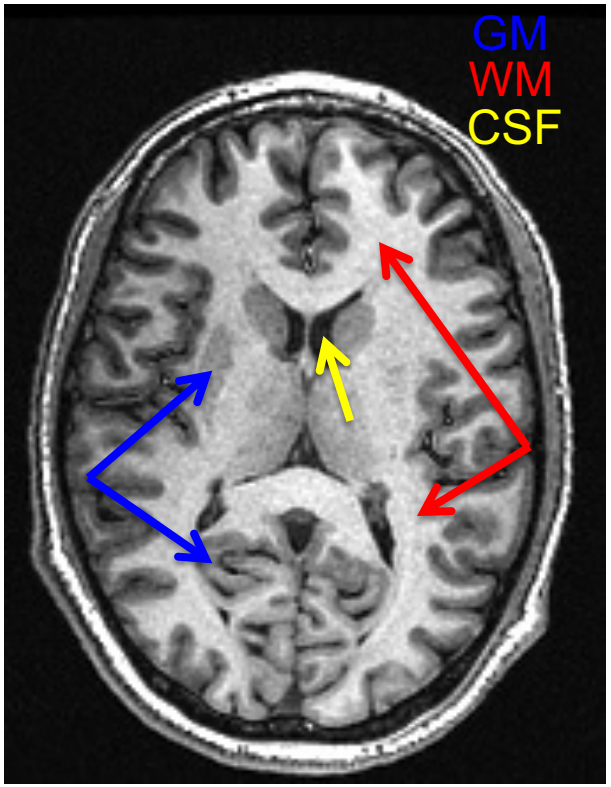
Longitudinal
Relaxation time

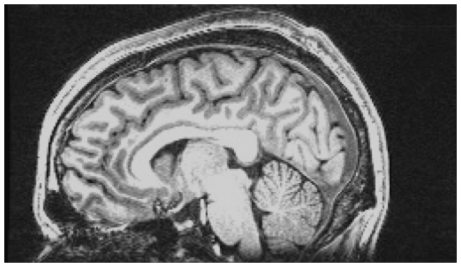
T1

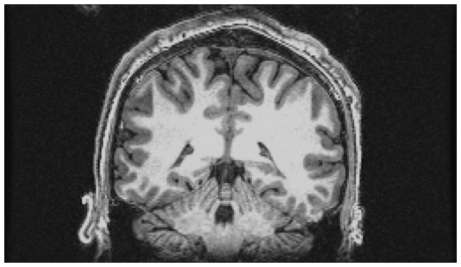


T1-weighted Imaging

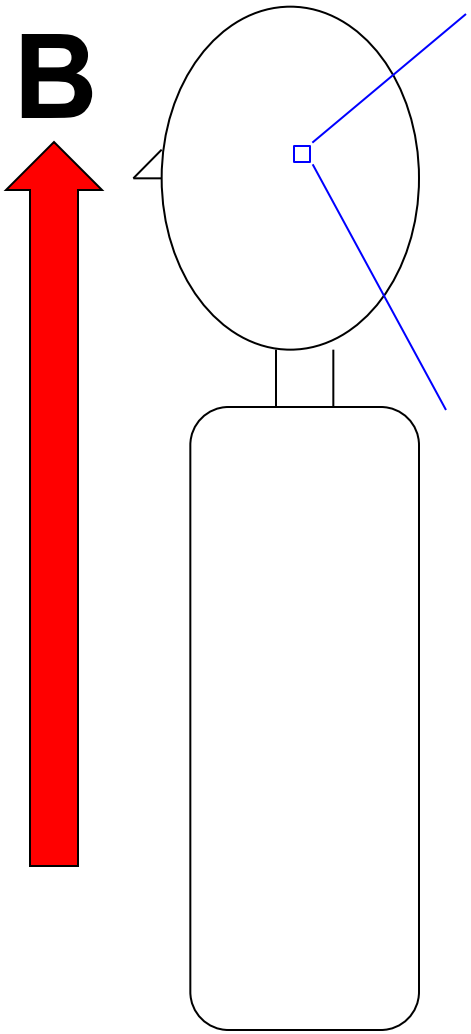
- T1 of Brain Tissues – Shortest to Longest:
  - White Matter
  - Gray Matter
  - CSF

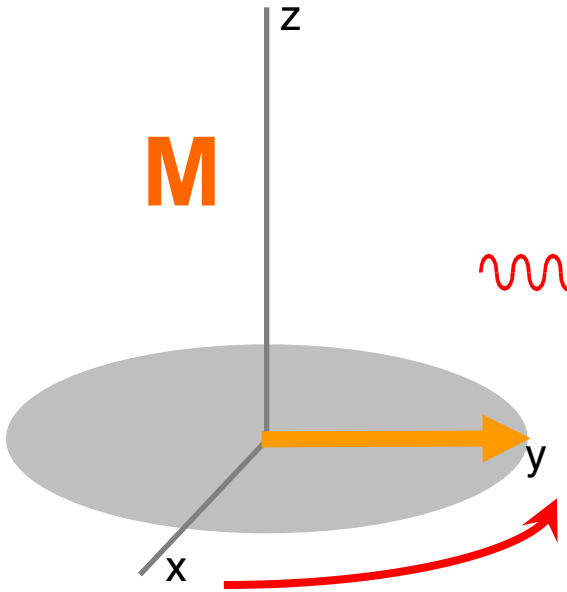


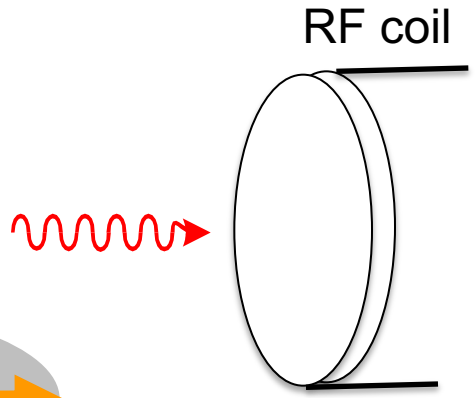


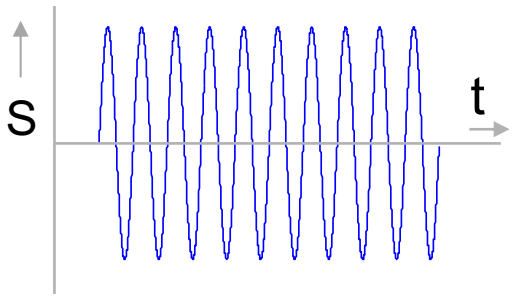


MRI Contrast – T2

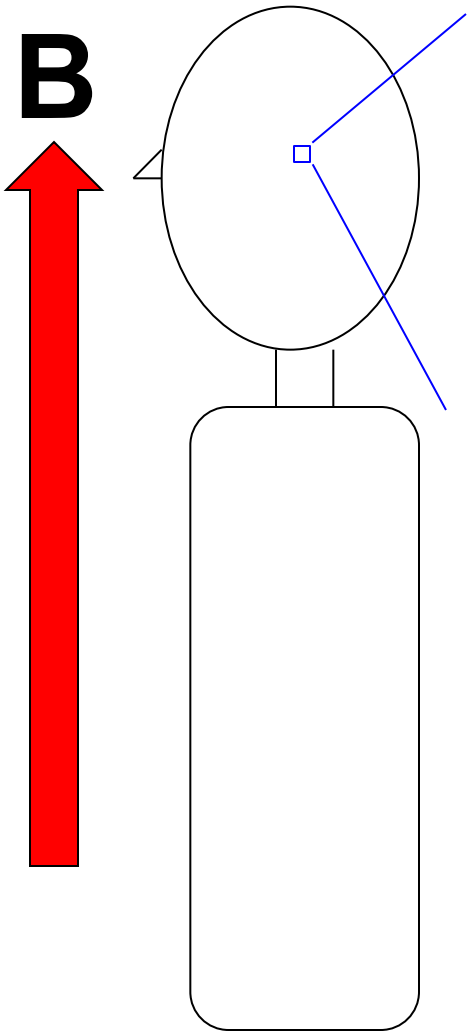


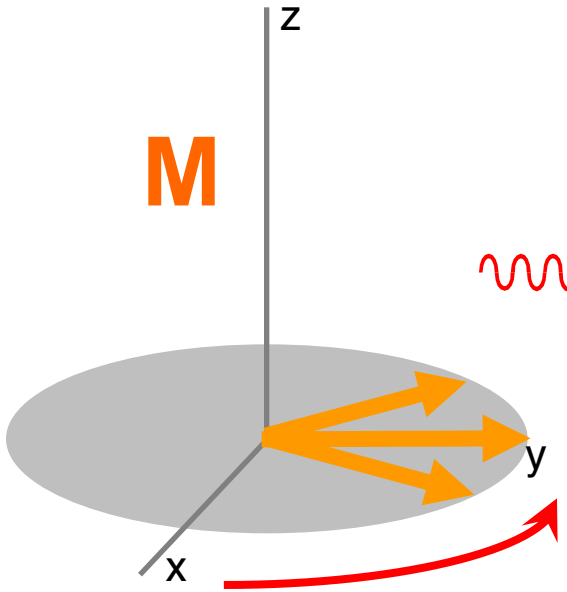


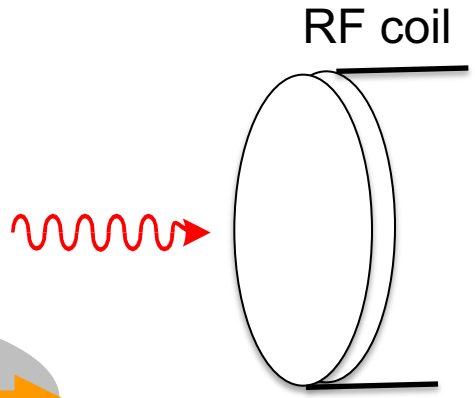


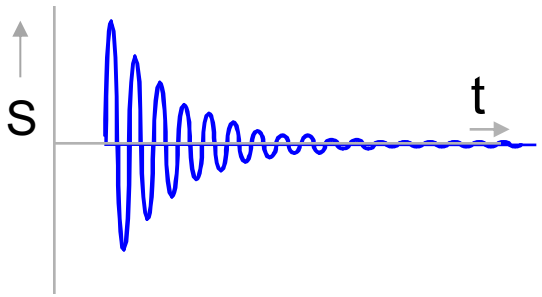


MRI Contrast – T2

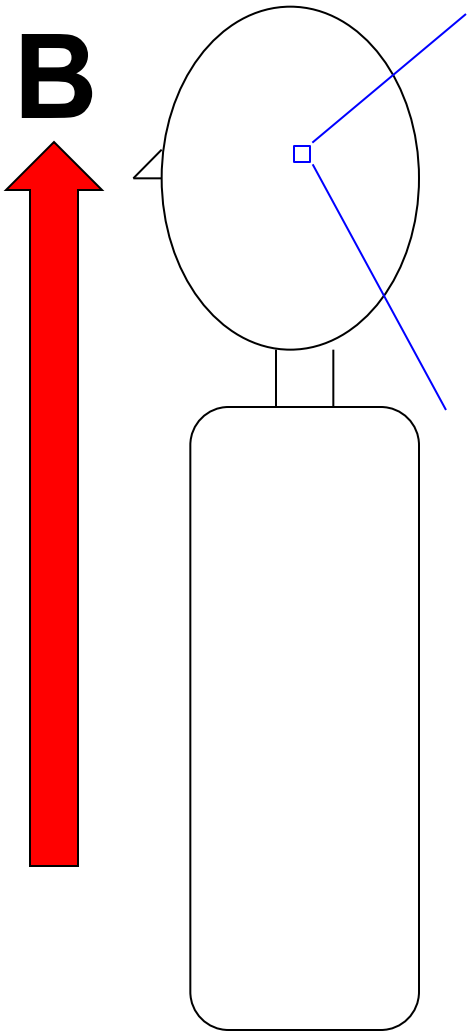


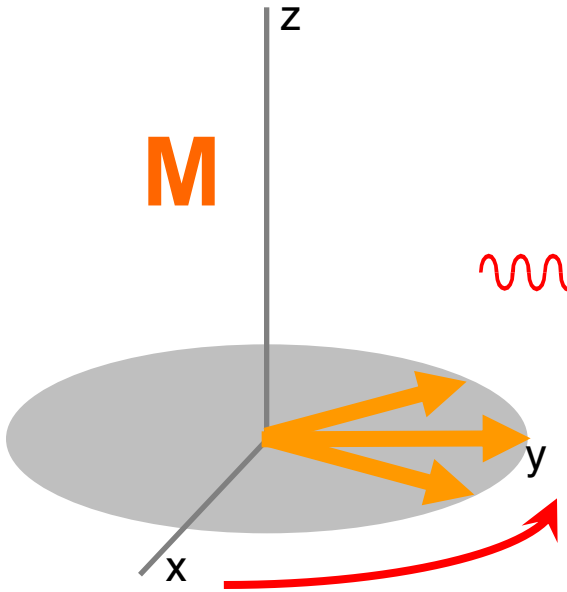


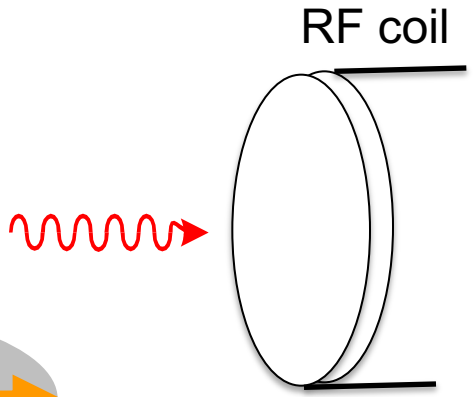




MRI Contrast – T2

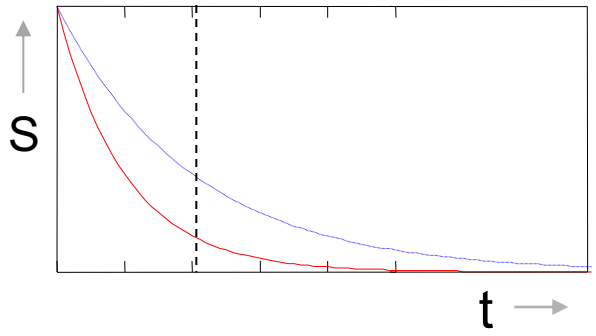






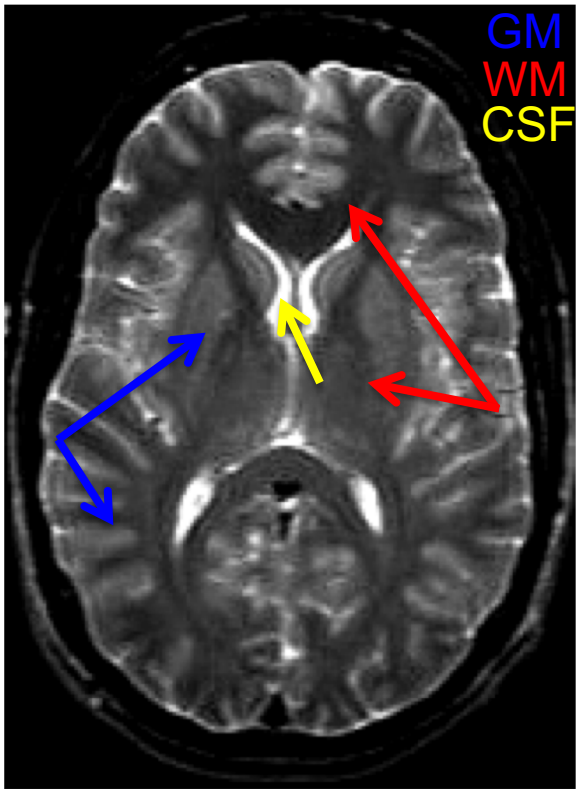
Transverse
Relaxation time

T2

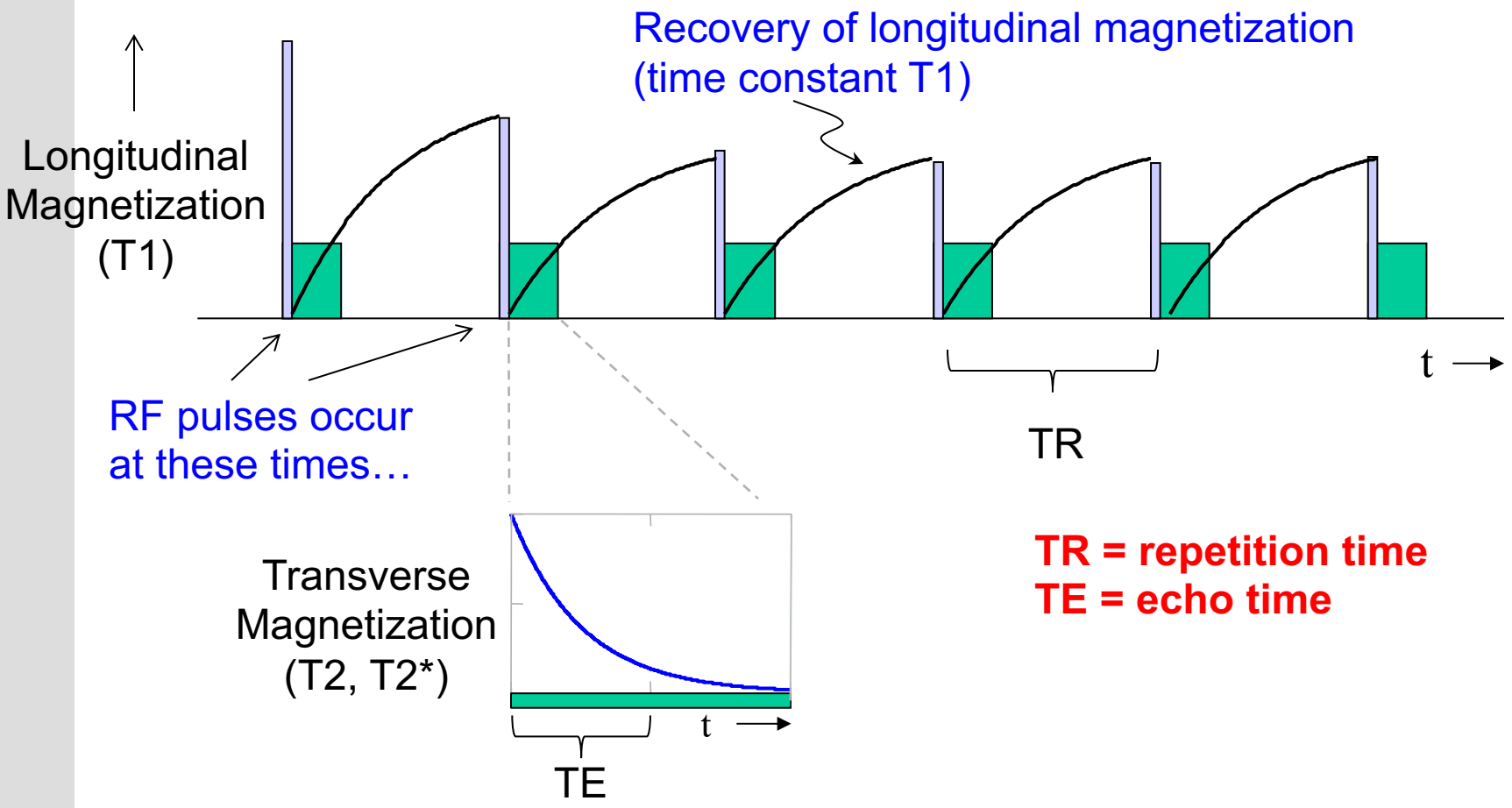


T2-weighted Imaging

- T2 of Brain Tissues – Shortest to Longest:
  - White Matter
  - Gray Matter
  - CSF



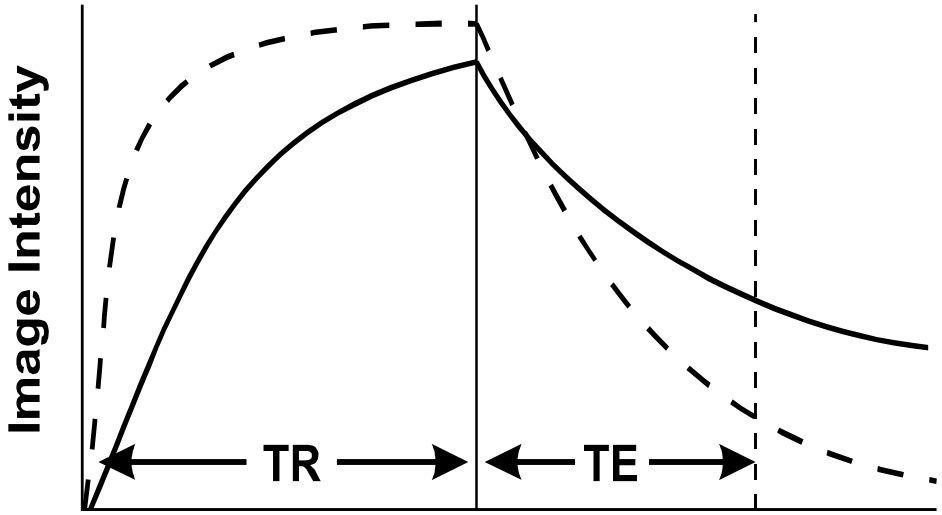
T1 & T2

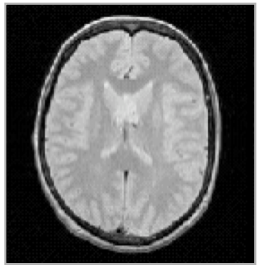


TR = repetition time
TE = echo time

Signal for steady-state images is reduced since the longitudinal magnetization has not fully recovered between excitations.

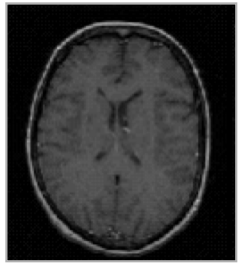
Contrast is determined by TR and TE





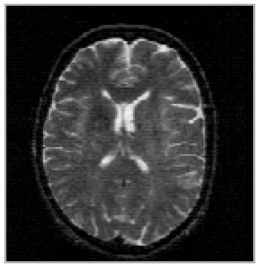
TR = long
TE = short

Proton-Density



TR = short
(TE = short)

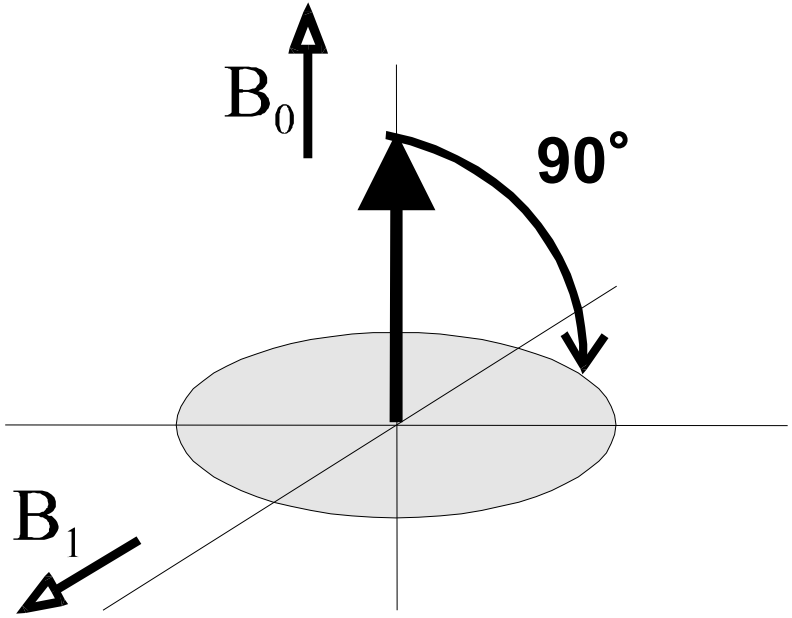
T1-weighted

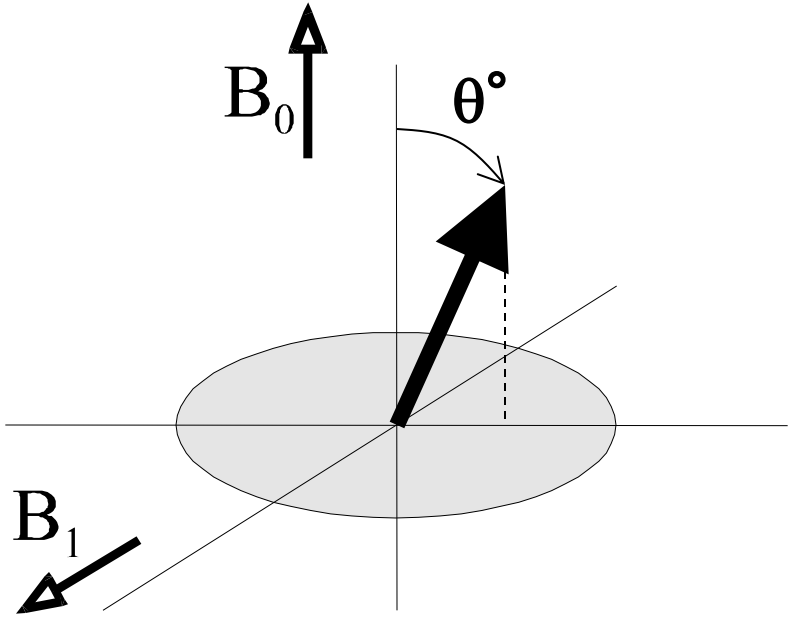


(TR = long)
TE = long

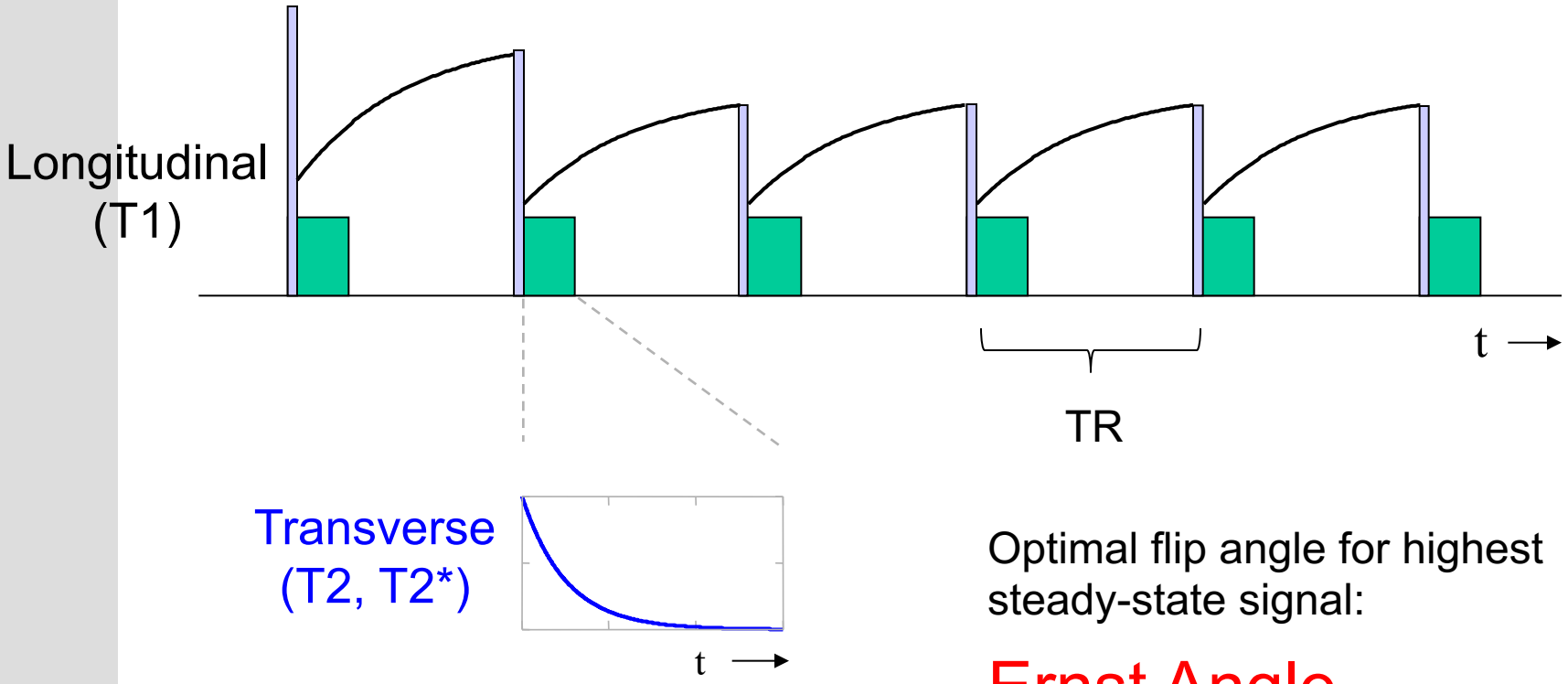
T2-weighted

Flip Angle





T1 & T2

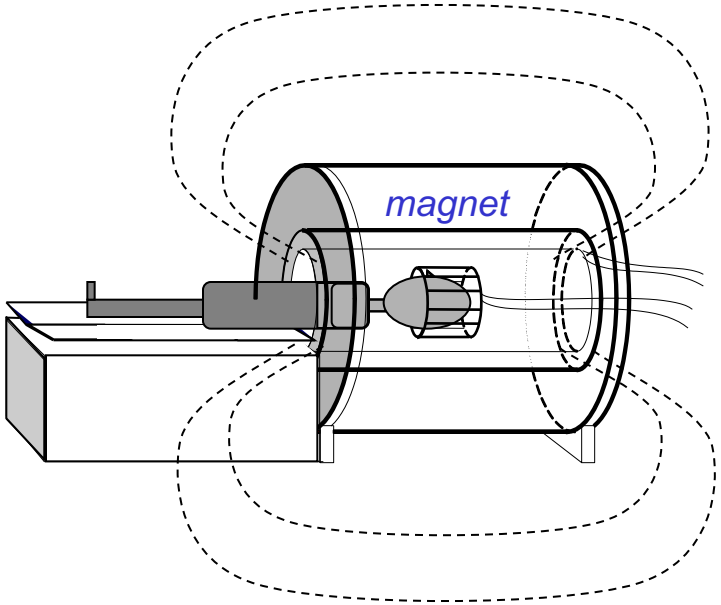


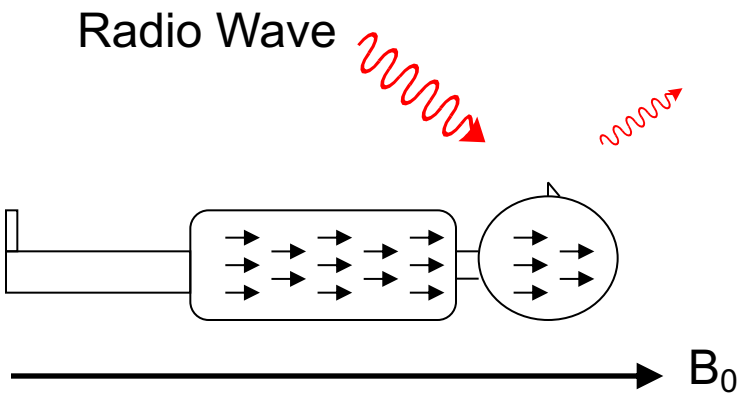
Optimal flip angle for highest steady-state signal:

Ernst Angle

$$\cos(\theta) = e^{-TR/T1}$$

Magnetic Resonance Imaging (MRI)





Sensitive to:

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