MRI-Basics

Parts of material:
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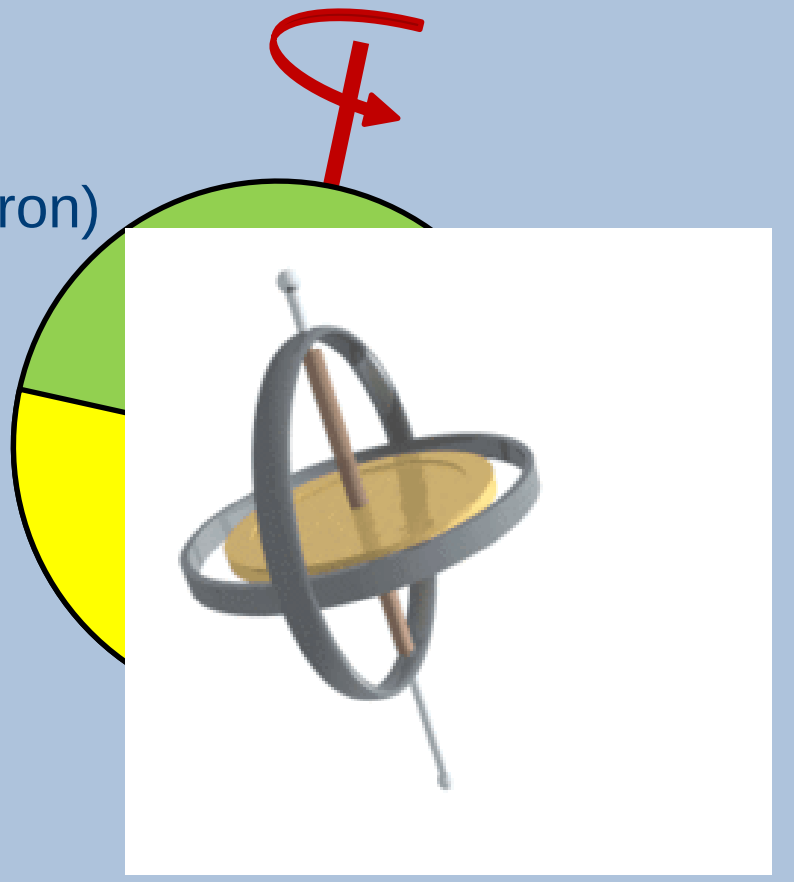
Content

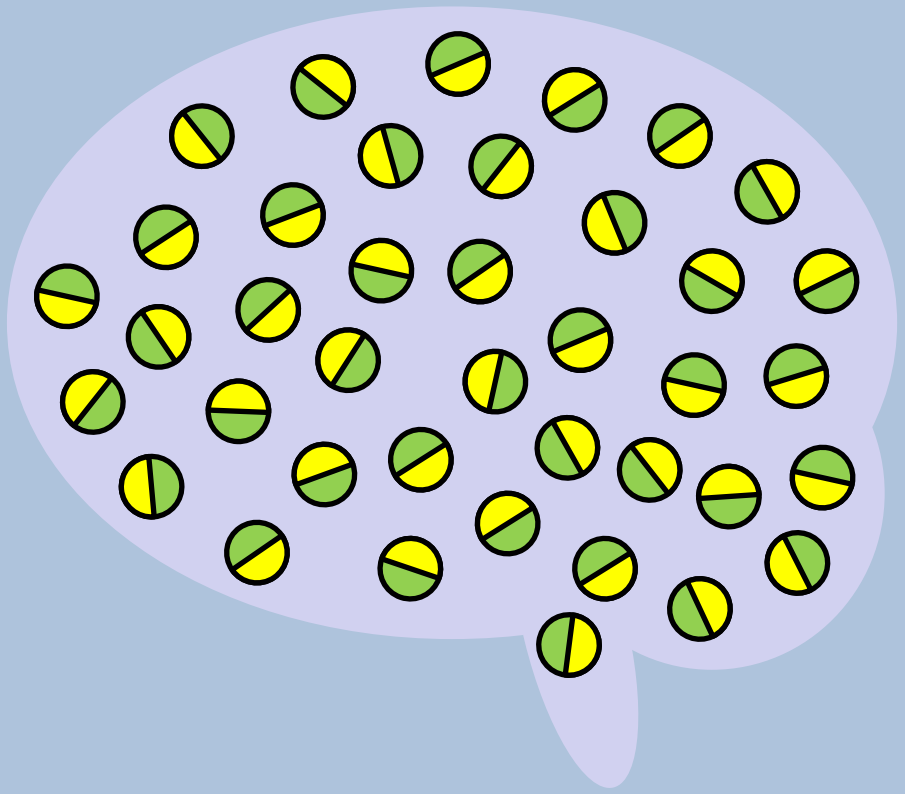
- Spins, Magnetization and HF
- Signal Acquisition
- Contrasts
- BOLD-Effect
- Improving BOLD-Signal
- (Avoiding) Artifacts

Spin

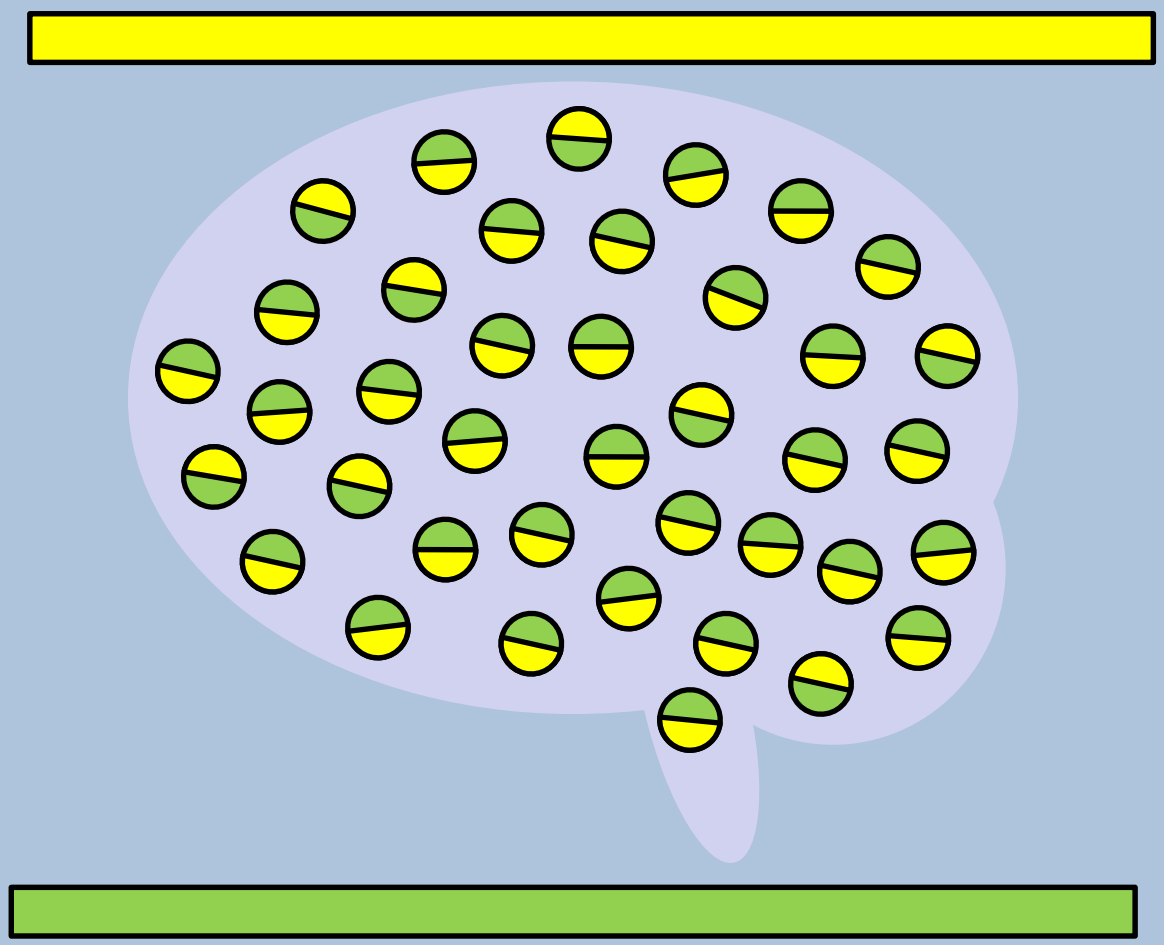
- Protons, Neutrons and Electrons
- North- and South-Pole
- Rotates around his axis
- Hydrogen: 1 Proton (and 1 Electron)
- Precesses like a spinner



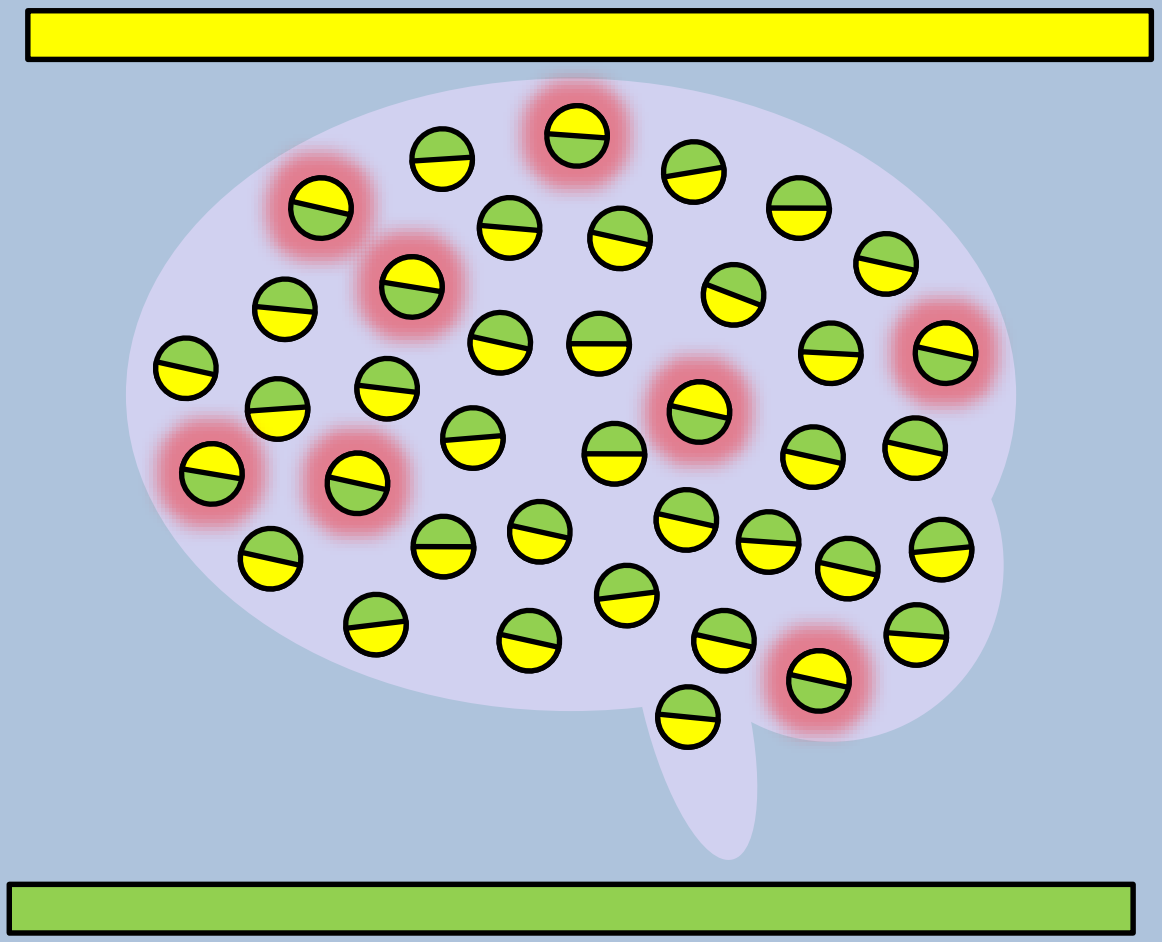
Spin



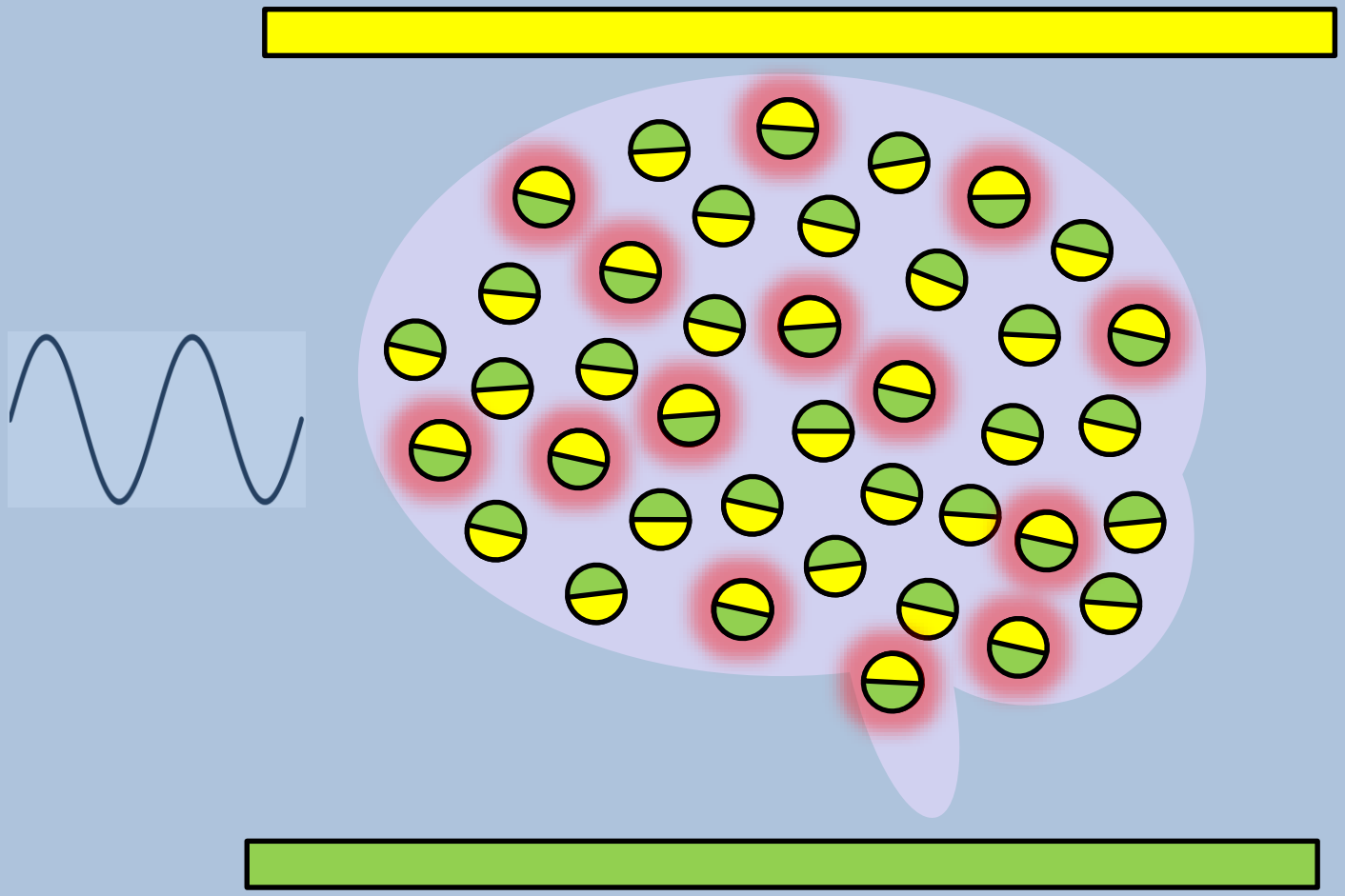
Spin + Magnetic Field



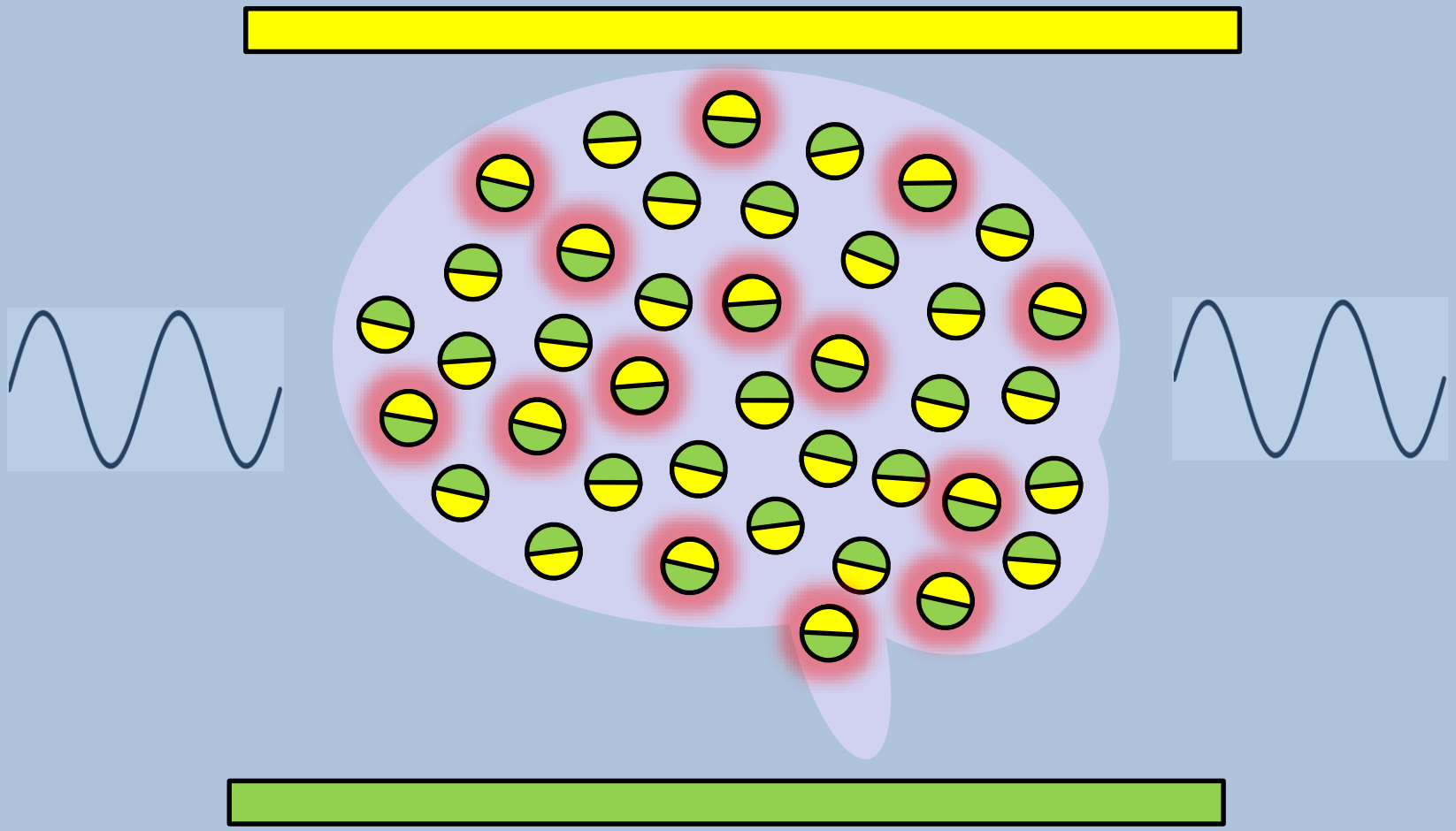
Spin + Magnetic Field



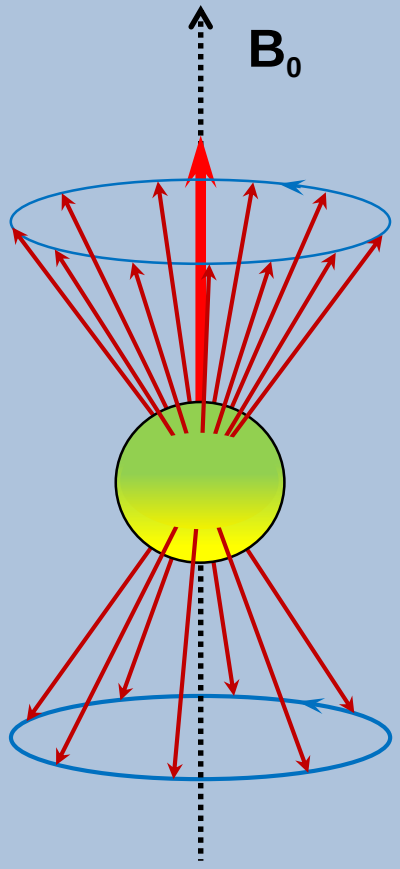
Spin + Magnetic Field + HF



Spin + Magnetic Field + HF

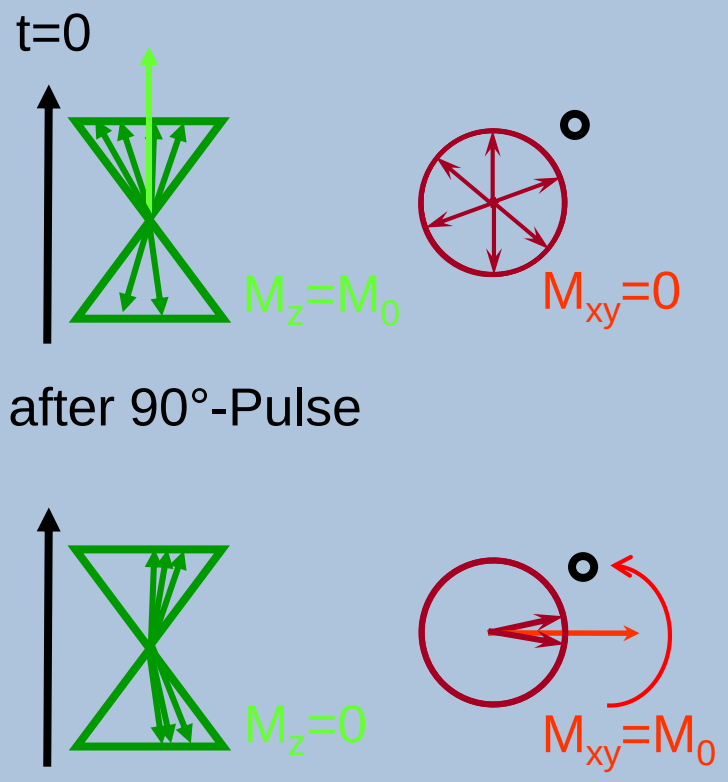


Magnetization



- Sum of all spins in a voxel
- More spins parallel
- Equally distributed on each cone
- Net magnetization
- M_0 in equilibrium

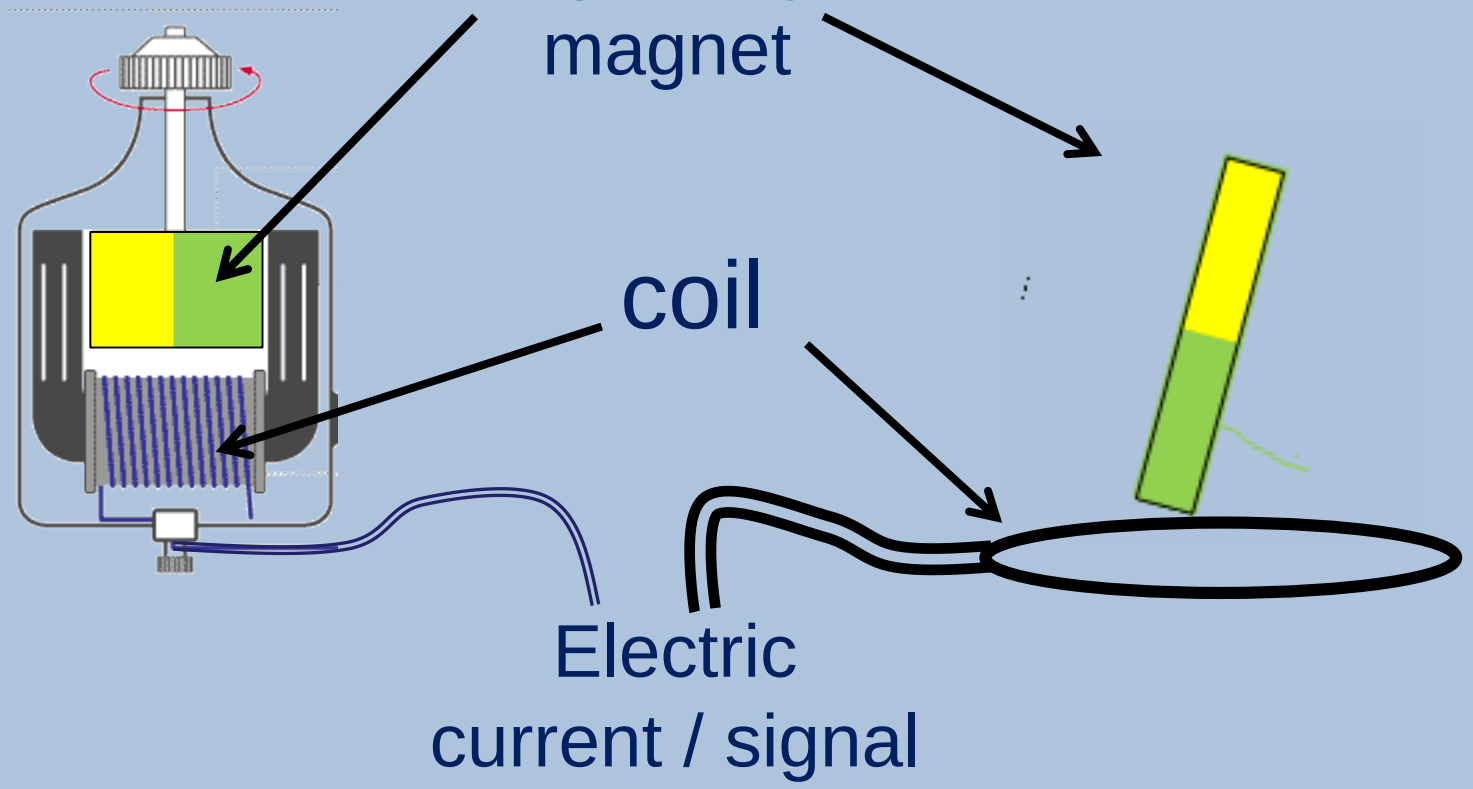
Magnetization + HF



- 2 mechanisms
- totally different
- fully independent

- Magnetization is rotating
- Coordinates are rotating, too ☺

Signal Acquisition

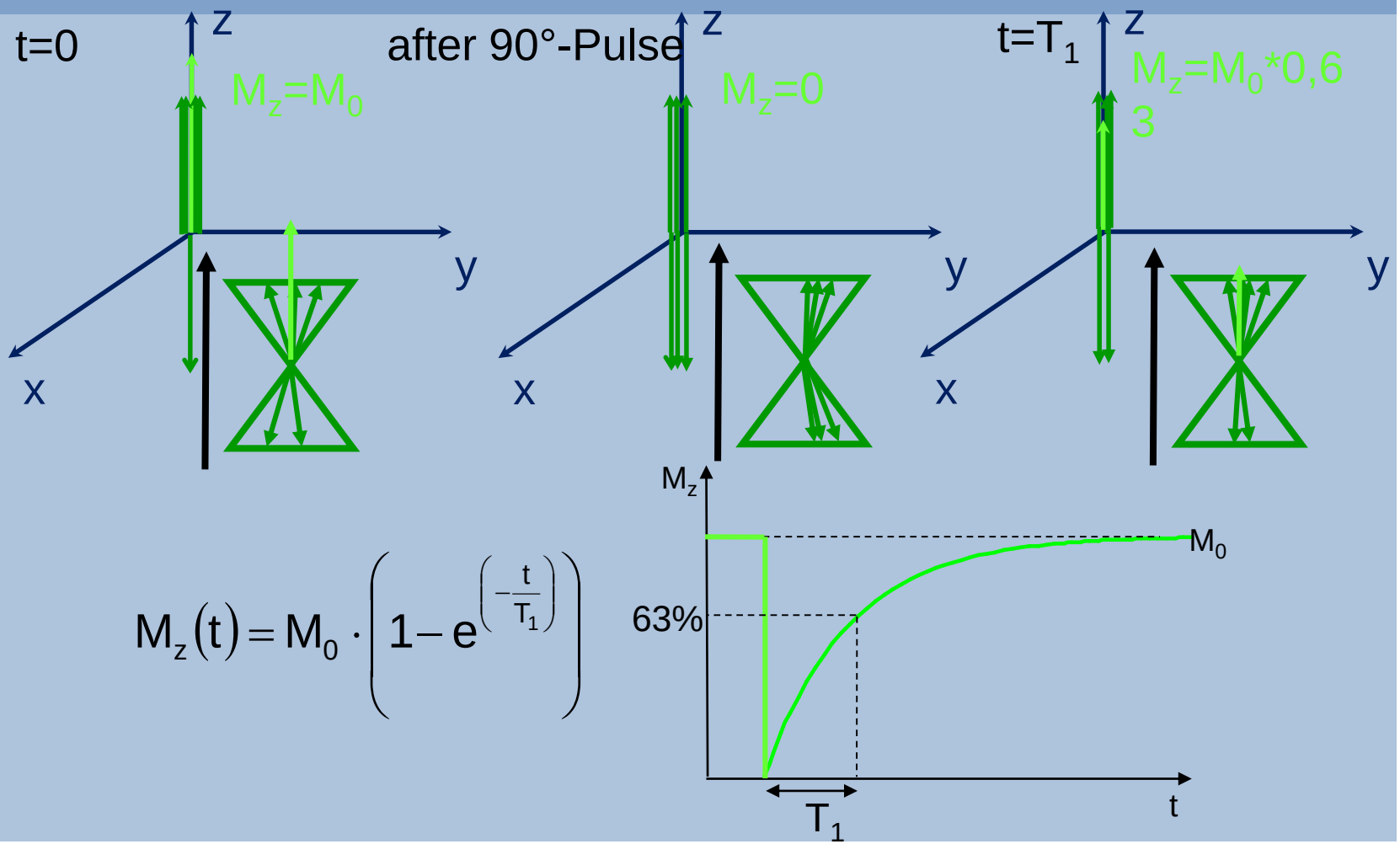


Signal Acquisition

Prototype (MGH)

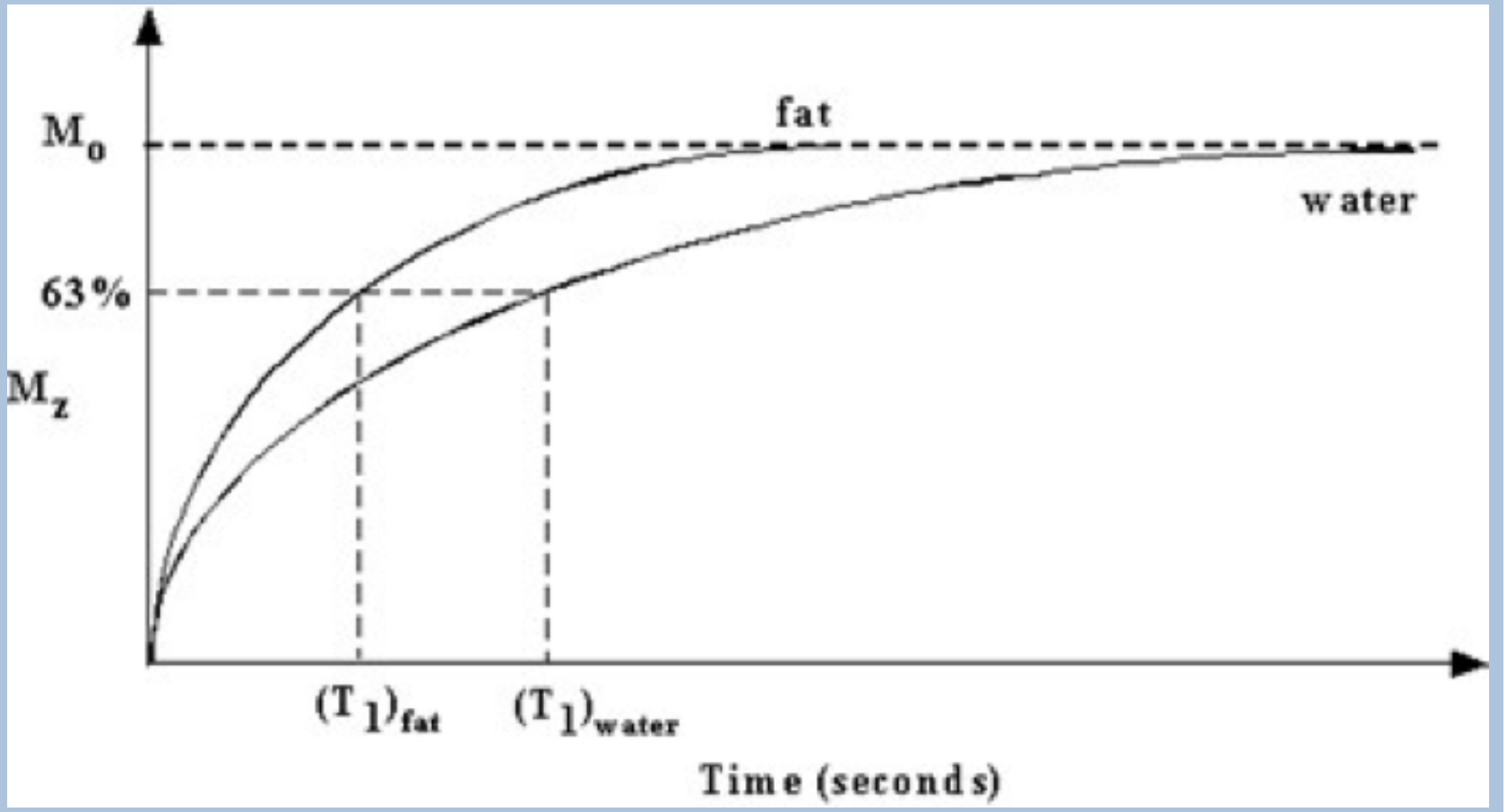
Product (Siemens)

Relaxation (Longitudinal, T_1)

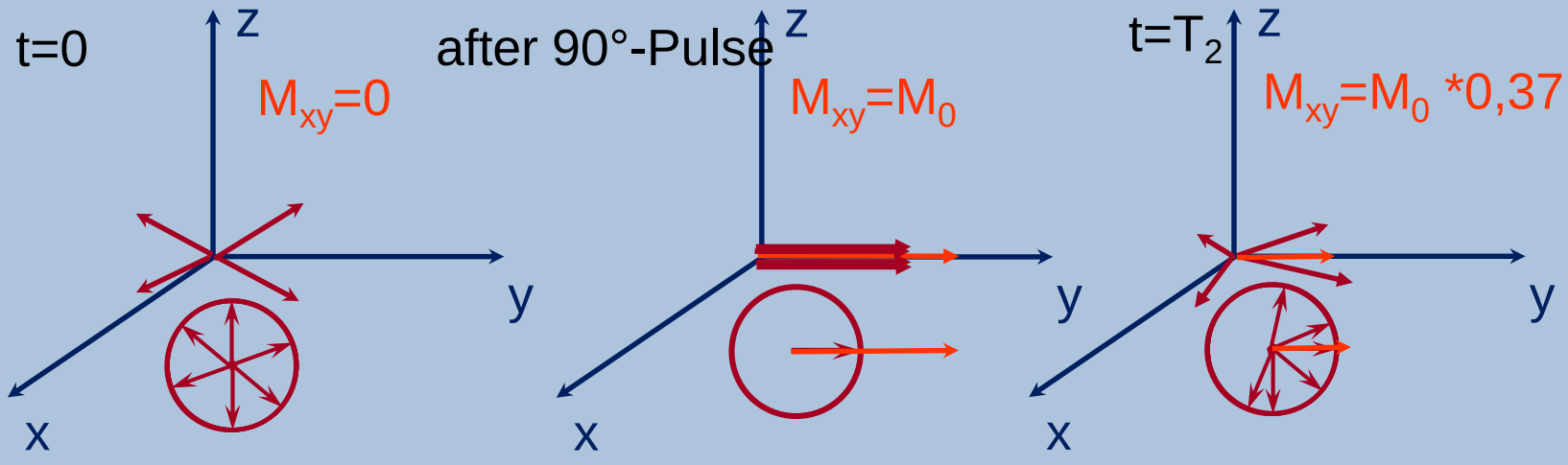


$$M_z(t) = M_0 \cdot \left(1 - e^{\left(-\frac{t}{T_1}\right)}\right)$$

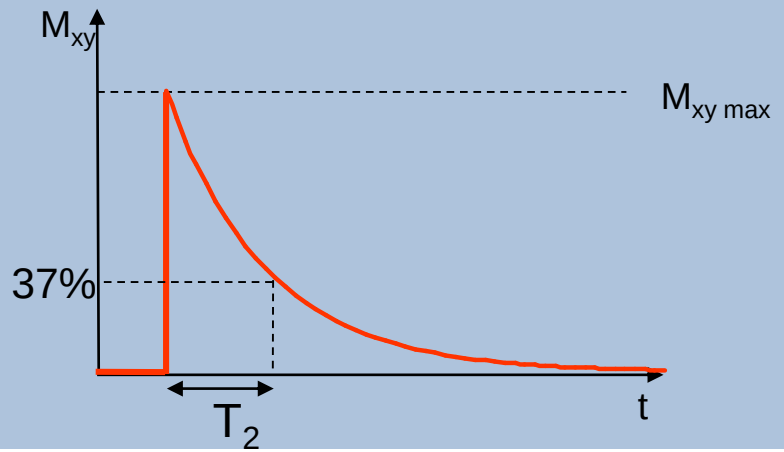
Relaxation (Longitudinal, T_1)



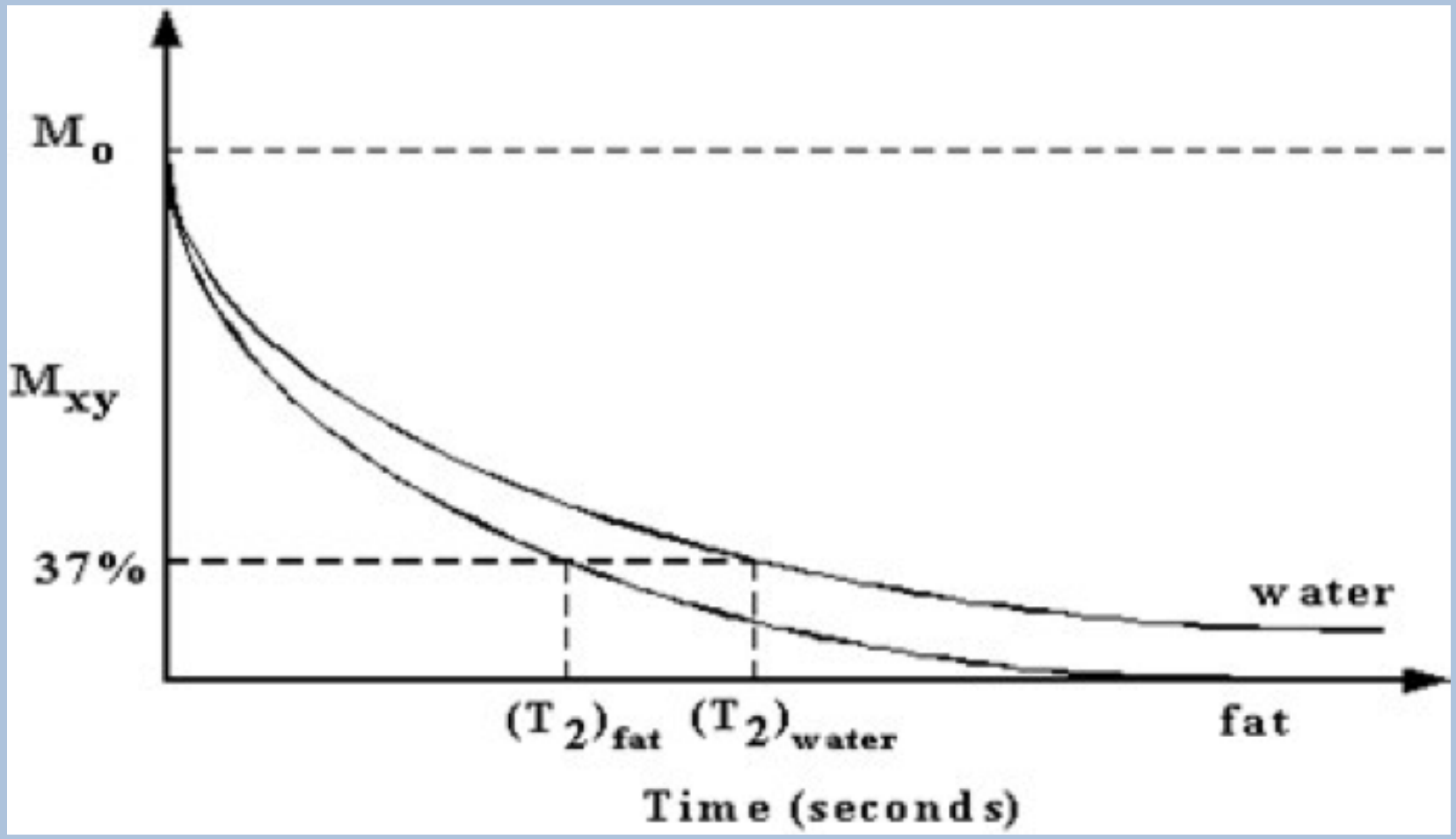
Relaxation (Transversal, T_2)



$$\left|M_{xy}(t)\right| = M_0 \cdot e^{\left(-\frac{t}{T_2}\right)}$$



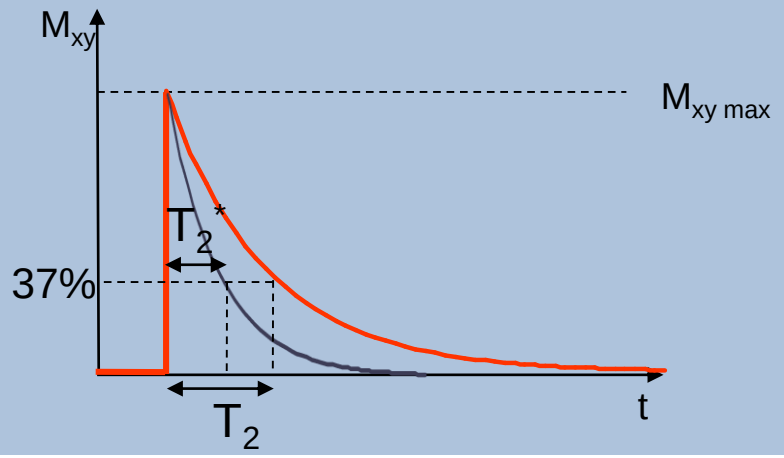
Relaxation (Transversal, T_2)



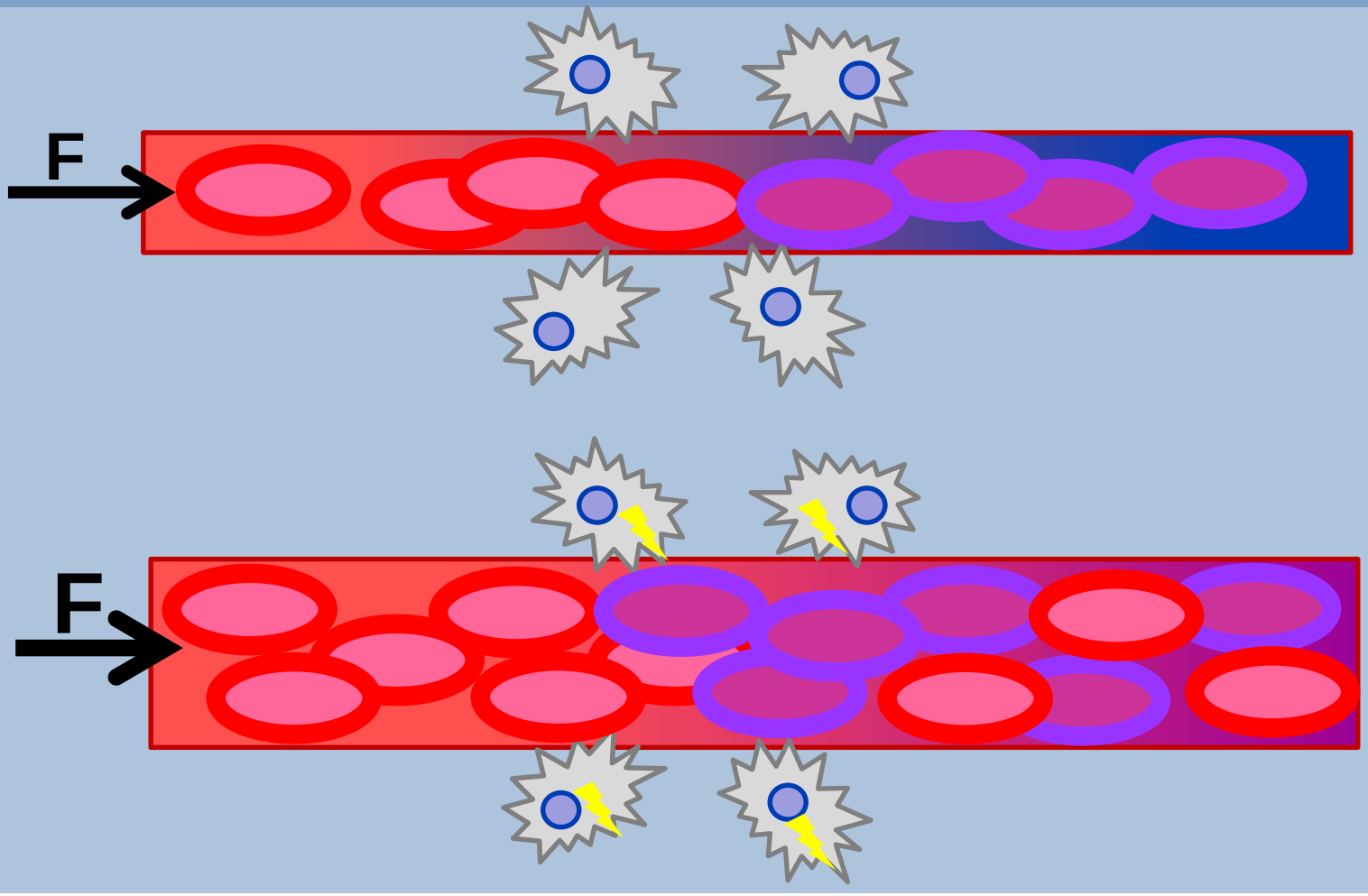
Relaxation (Transversal, T_2^*)

- Accelerated by local magnetic inhomogeneities
  - Susceptibility steps
  - Paramagnetic material (i.e. deoxygenated Hb)
  - …
- Combination of T_2 and T_2 caused by inhomogeneities

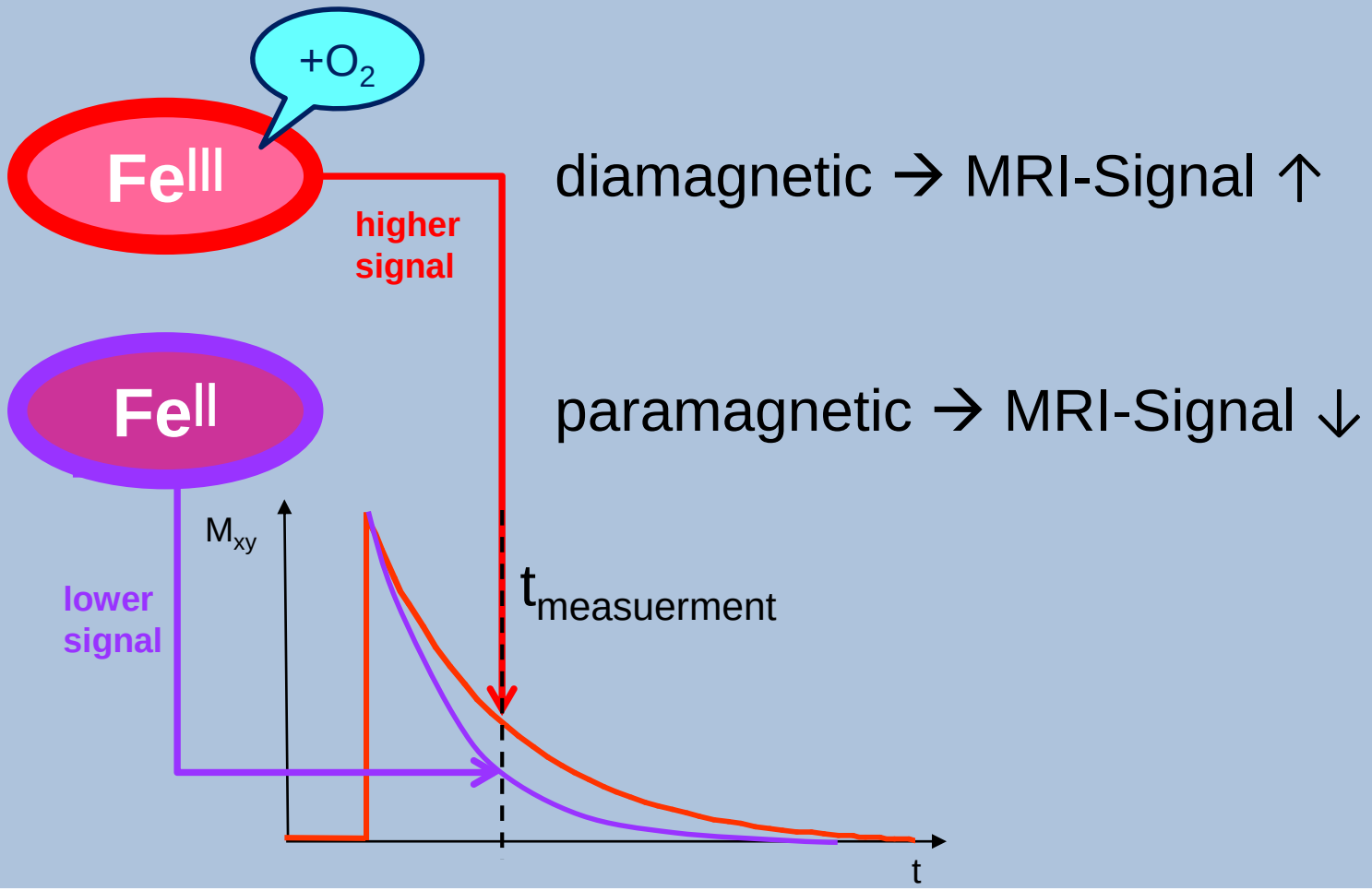
$$\frac{1}{T_2^*} = \frac{1}{T_2} + \frac{1}{T_{2\,\text{inhomogen}}}$$



Blood oxygen level depend (BOLD)



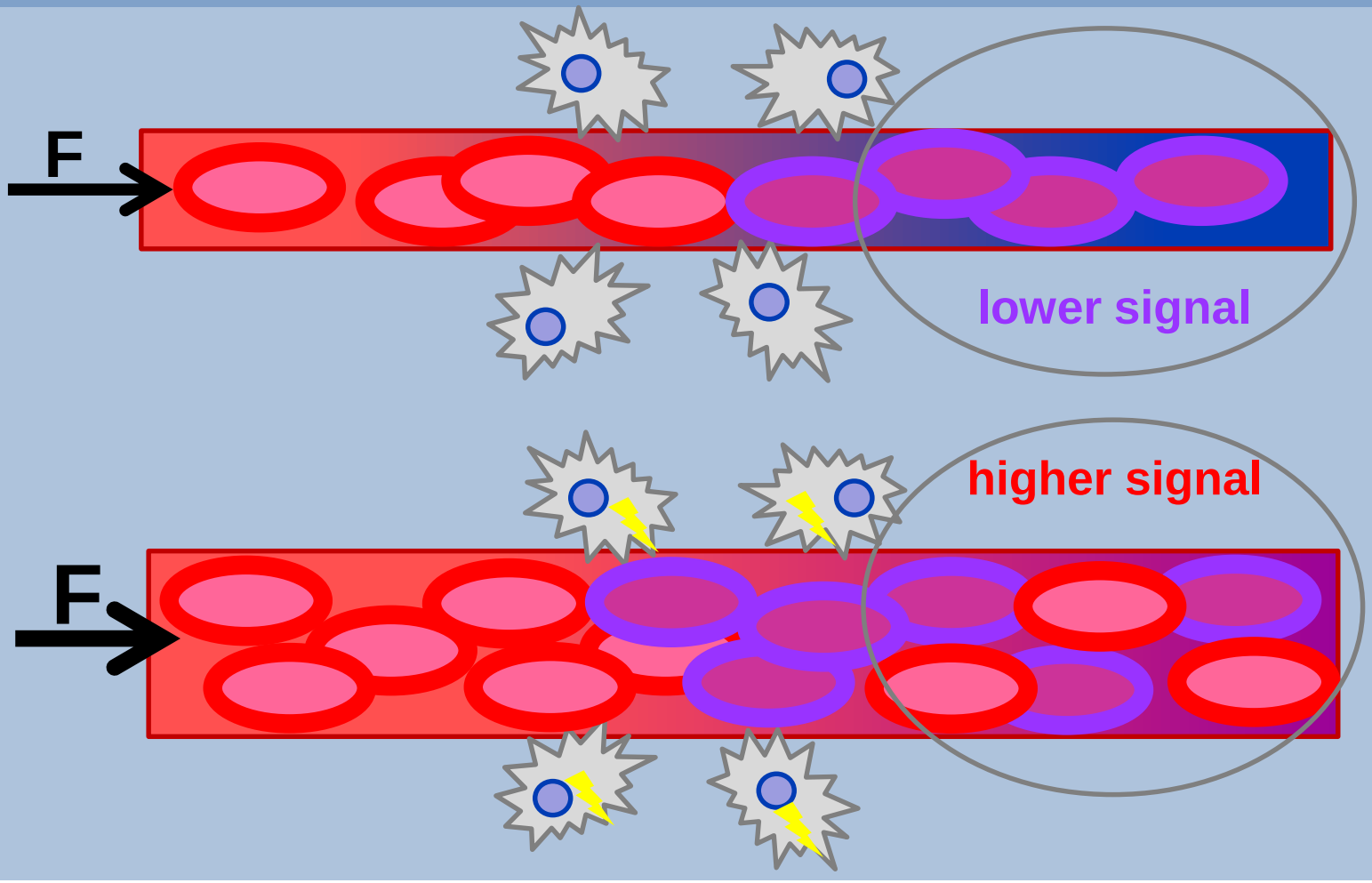
Blood oxygen level depend (BOLD)



diamagnetic → MRI-Signal ↑

paramagnetic → MRI-Signal ↓

Blood oxygen level depend (BOLD)



Blood oxygen level depend (BOLD)

Measurement

- Very fast
- T2*-weighted

→ EPI-pulse-sequence

- **E**cho-**P**lanar-**I**maging
- 1 HF-pulse → 1 image (single shot)
- Bold-sensitive and artifact-sensitive
- Gradient-echo-techique

Improving the BOLD-Signal

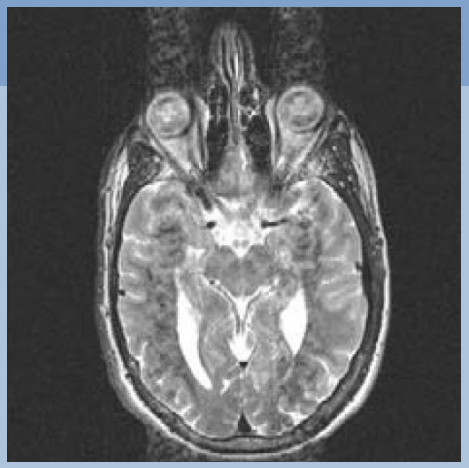
- Optimize paradigm and sequence settings
- Avoid disturbing signals
- Instruct volunteers/patients
- Use appropriate coil (i.e. 32-channel)
- Use higher fields
  - Cave: Distortions ↑

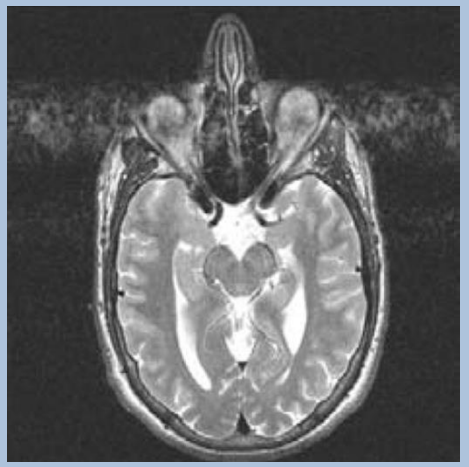
(Avoiding) Artifacts

Motion

- i.e. eye-movement

- Explain to volunteer/patient
- Change phase-encoding-direction



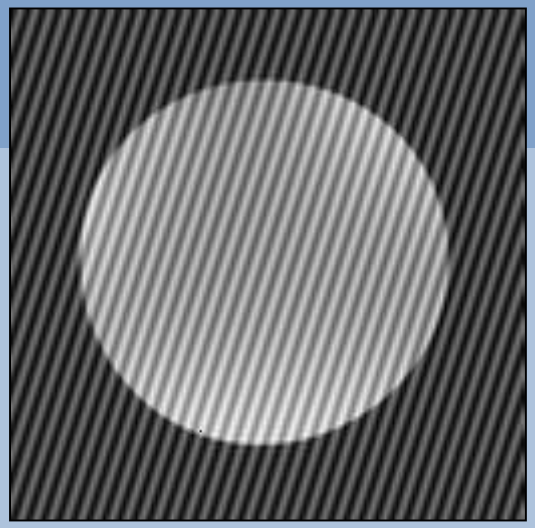


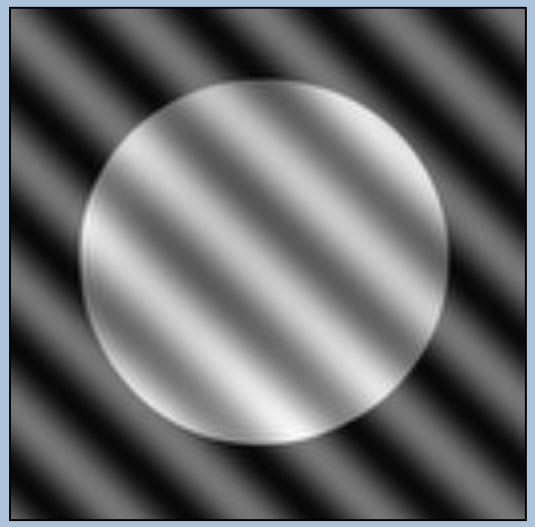
(Avoiding) Artifacts

„Spikes“

- Caused by external HF-signals

- Close the door carefully
- Remove / shield electric devices



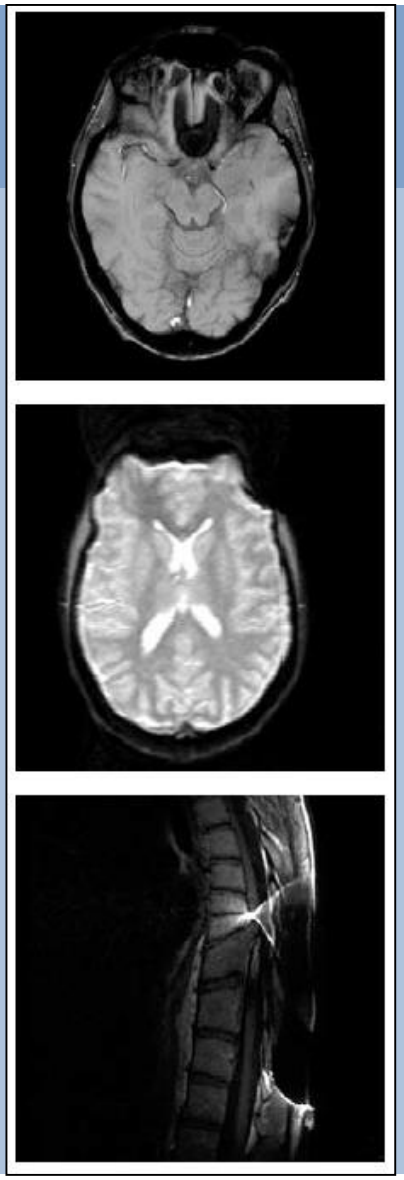


(Avoiding) Artifacts

Distorsions and signal loss

- Caused by B0-inhomogeneities
  - Adjacency of bone or air
  - Metal
- More intense in higher fields

- Remove metal
- Use smaller voxels
- TE ↓, Bandwidth ↑
- Correct using a field map
- Use parallel imaging techniques
  (cave: loss of BOLD-signal possible)



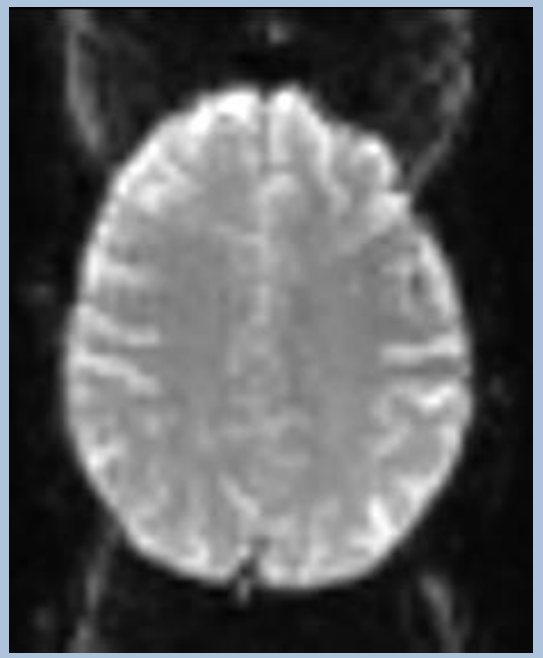
(Avoiding) Artifacts

N/2-Ghosts

- Caused by eddy-currents
- Mainly a technical problem

Try:

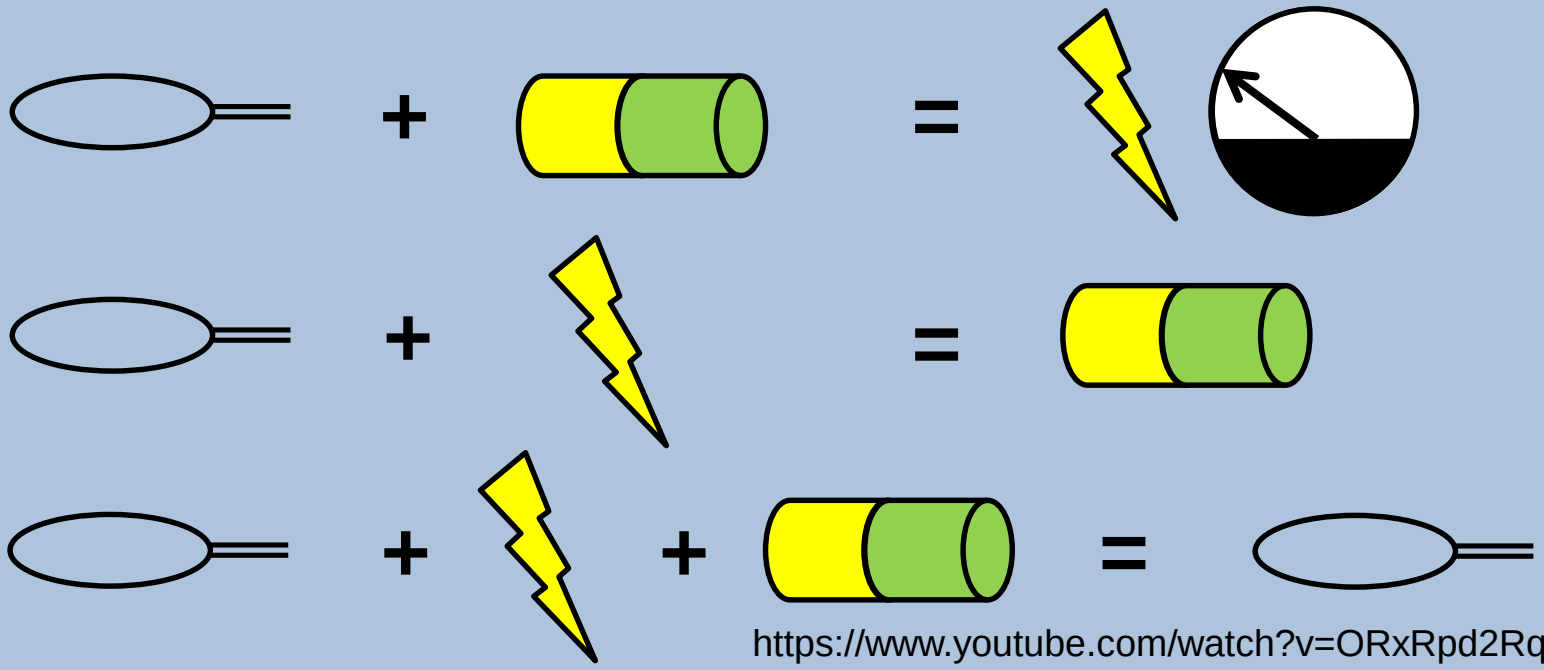
- Change voxel-size
- Change TE and Bandwidth
- Call service



Questions?!

Why is MRI so loud?

- Gradients are coils



https://www.youtube.com/watch?v=ORxRpd2RqqU