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Initiative

LIBRE hub
Latam Hub for Bioimaging through Open Hardware

Obtaining your first spin-echo with a low-cost open-source MRI system

Pablo Irarrazaval, Joshua Harper, Belén Bravo

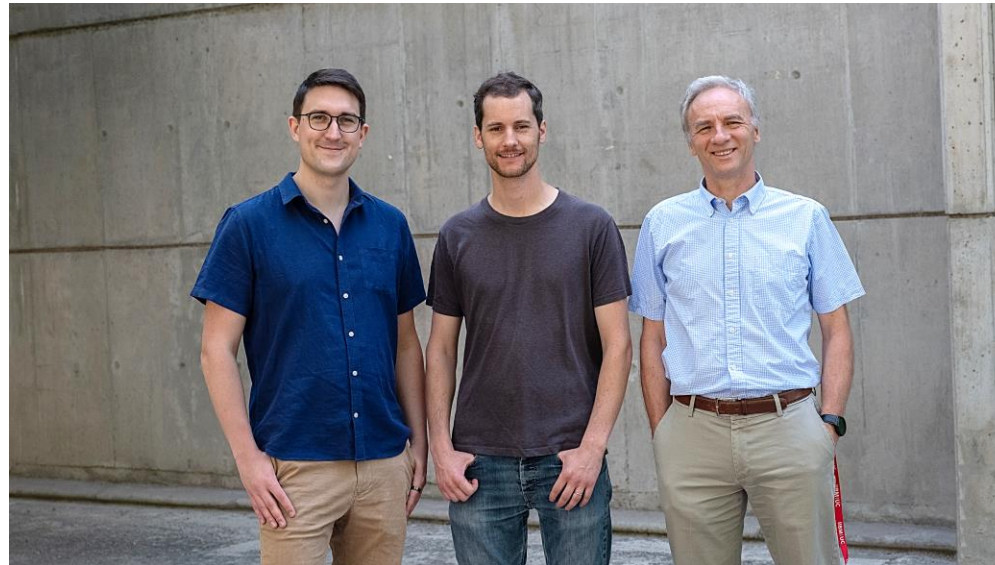
Electrical Engineering Department
Institute for Biological and Medical Engineering
Pontificia Universidad Católica de Chile

August 2025

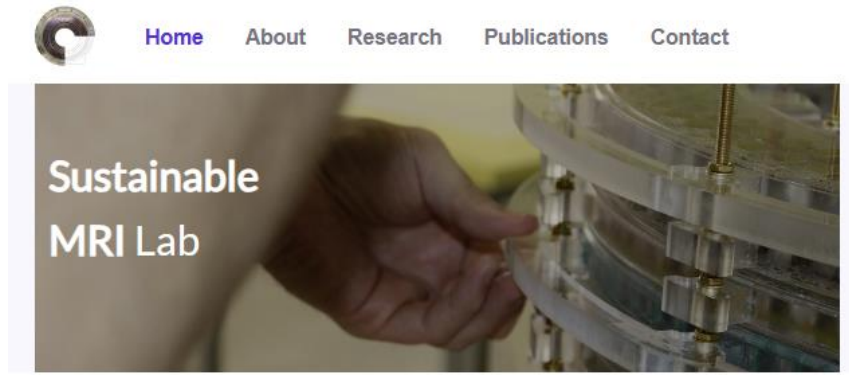
Sponsor and organizer: LIBRE Hub



*The **Latin American Hub for Bioimaging Through Open Hardware (LIBRE Hub)** is a training network for open source bioimaging hardware in Latin America with the goal to empower regional researchers through practical workshops, seminars, networking, and online resources adapted to local needs and re-published in local languages.*



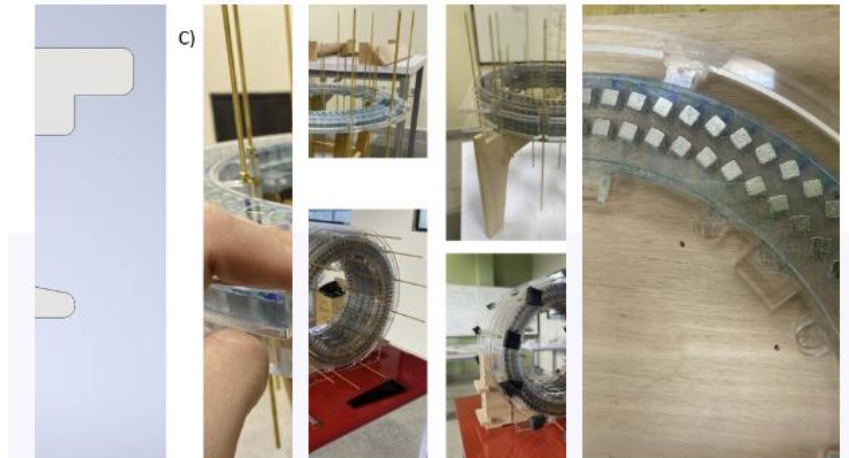
Lecturers



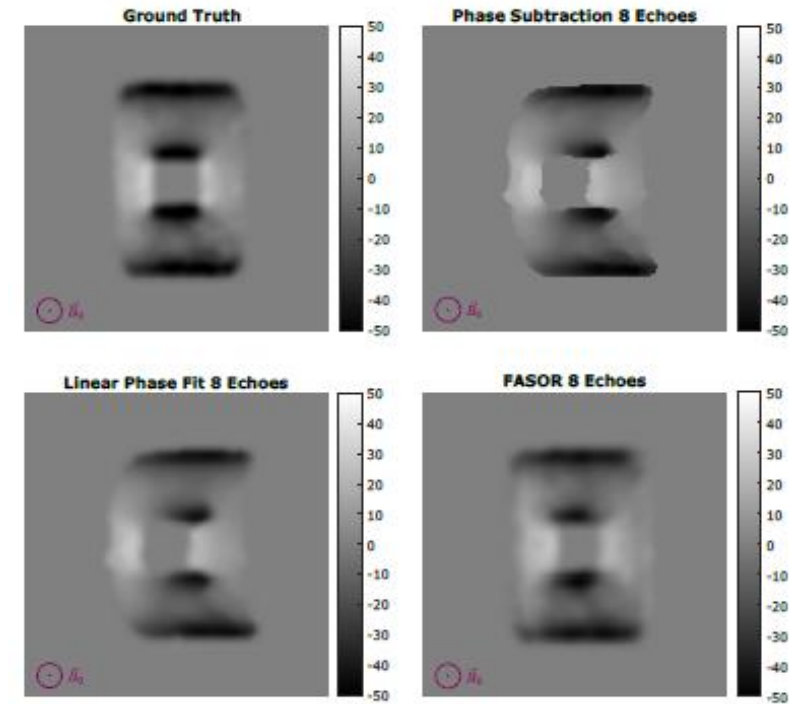
Bringing MRI technology to Paraguay

In the Sustainable MRI lab, our focus is on developing affordable, accessible, and sustainable magnetic resonance imaging technology.

We are currently building the first open-source, low field MRI system in South America in close collaboration with Leiden University Medical Center, the United Consortium, Yale University, and Mbarara University of Science and Technology.



Joshua Harper, PhD (Penn State University)



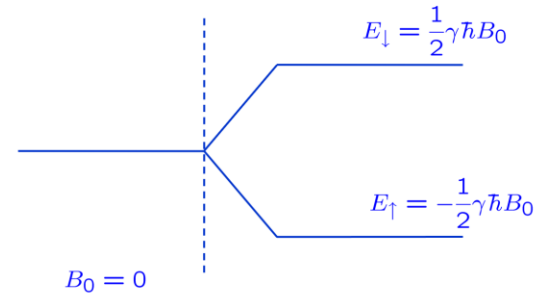
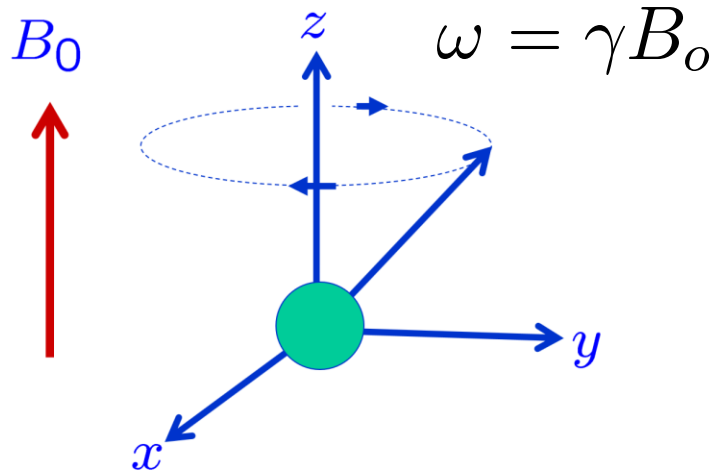
Belén Bravo, MSc (UC)

Program

Time		Activity
16:00	16:25	1. Introduction to MRI, motivation, RF chain and spin-echo sequence
		Field mapping
		Center frequency (demonstration)
		Ppm in DSV
		Selecting an appropriate phantom
16:25	16:40	2. First RF coil (start small)
		Noise (measurements)
		50 ohm noise for baseline
		Noise level with coil attached
16:40	17:40	3. Tune and match
		Theoretical calculations to start
		Why only add capacitance and not inductance or resistance?
		VNA process flow
17:40	17:55	Break
17:55	19:00	4. Finding the echo
		Setting the initial 90 and 180 degree pulse (6 dB apart)
		Iterating through frequencies
		Identifying the echo
		Optimizing power
		Echo height characteristics

Overview of MRI

Polarization – Excitation – Readout – Reconstruction

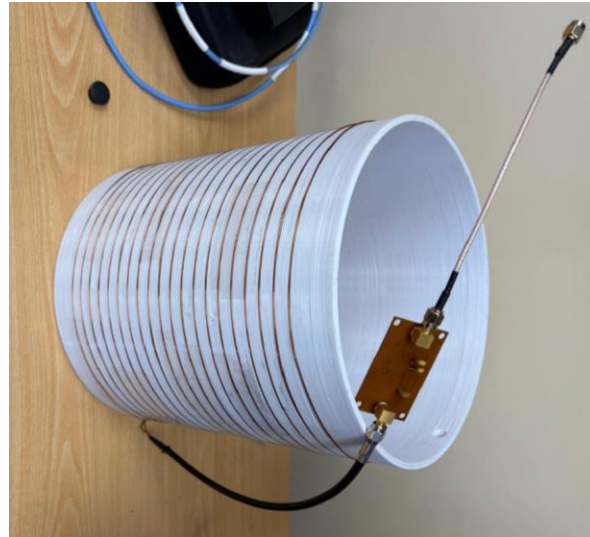
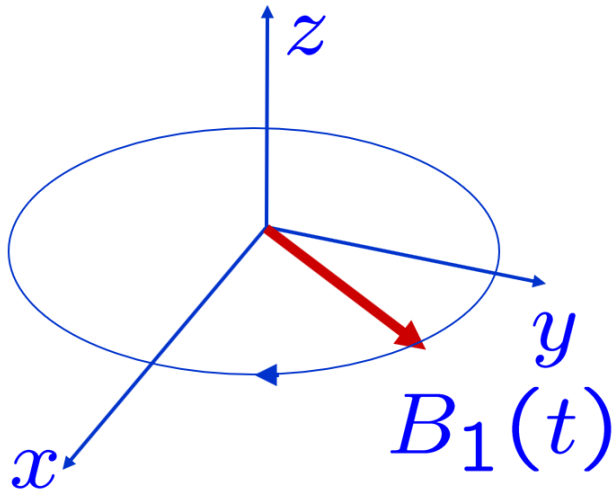


$$M_z^0 = |\vec{M}| = \frac{\gamma^2 \hbar^2 B_0 N_s}{4KT_s}$$

Overview of MRI

Polarization – **Excitation** – Readout – Reconstruction

$$\vec{B}_1(t) = B_1^e(t) [\cos(\omega_{\text{rf}} t + \varphi) \hat{i} - \sin(\omega_{\text{rf}} t + \varphi) \hat{j}]$$

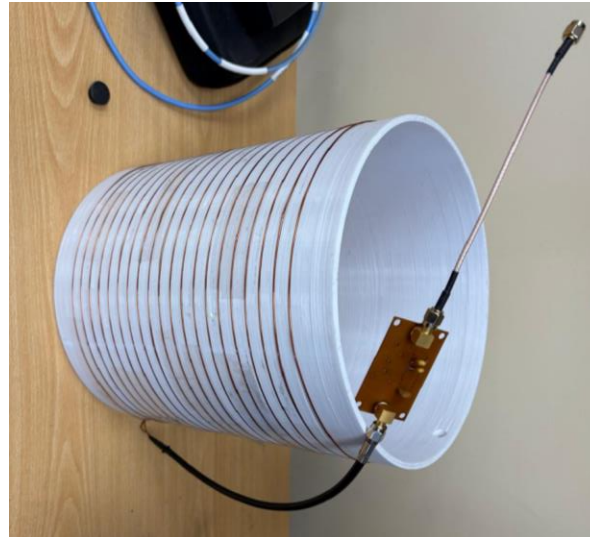
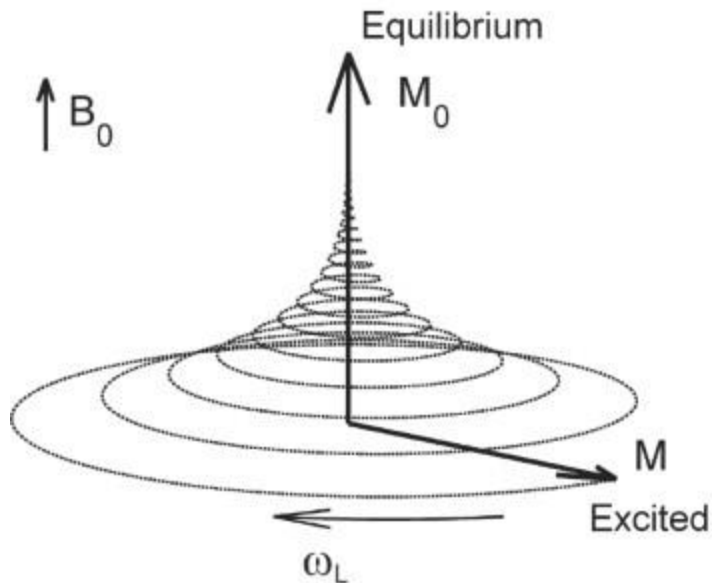


Overview of MRI

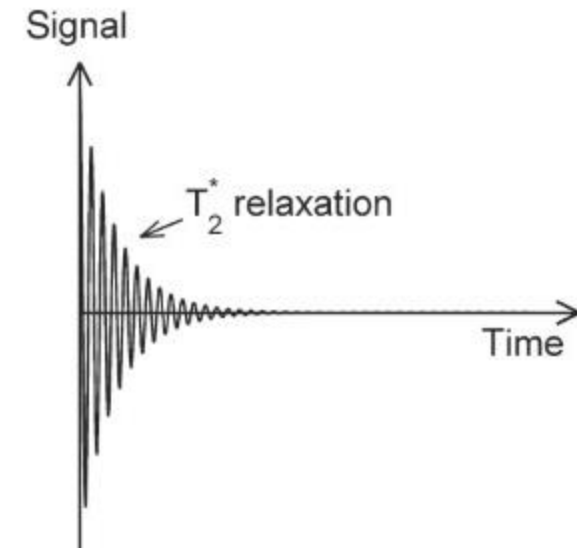
Polarization – Excitation – **Readout** – Reconstruction

$$S(t) = \int M_{xy}(\vec{r}, 0) e^{-i\gamma \int_0^t \Delta B(\vec{r}, \xi) d\xi} d\vec{r}$$

Relaxation



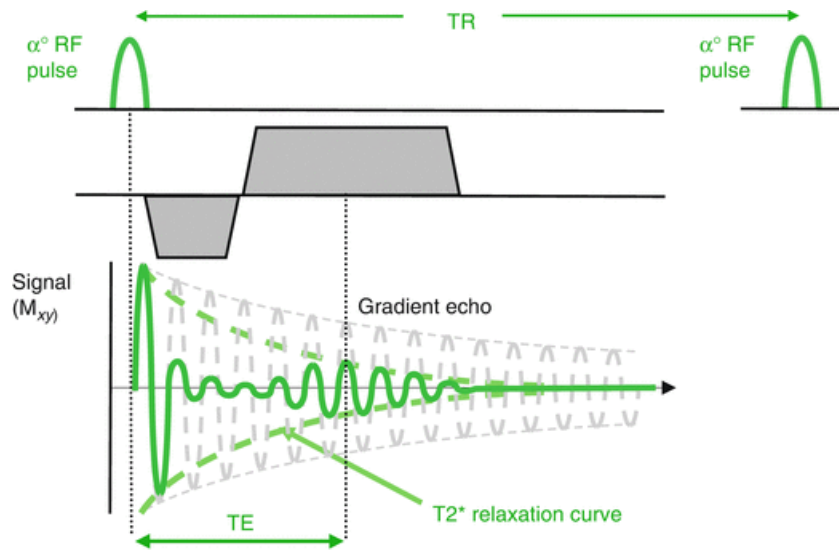
Free induction decay



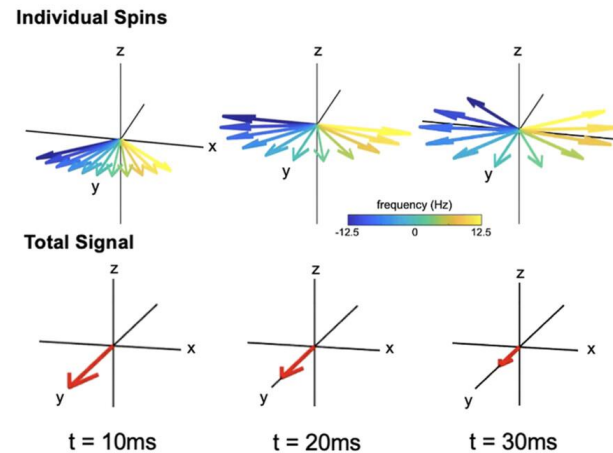
Overview of MRI: off-resonance in Gradient Echo

Polarization – Excitation – **Readout** – Reconstruction

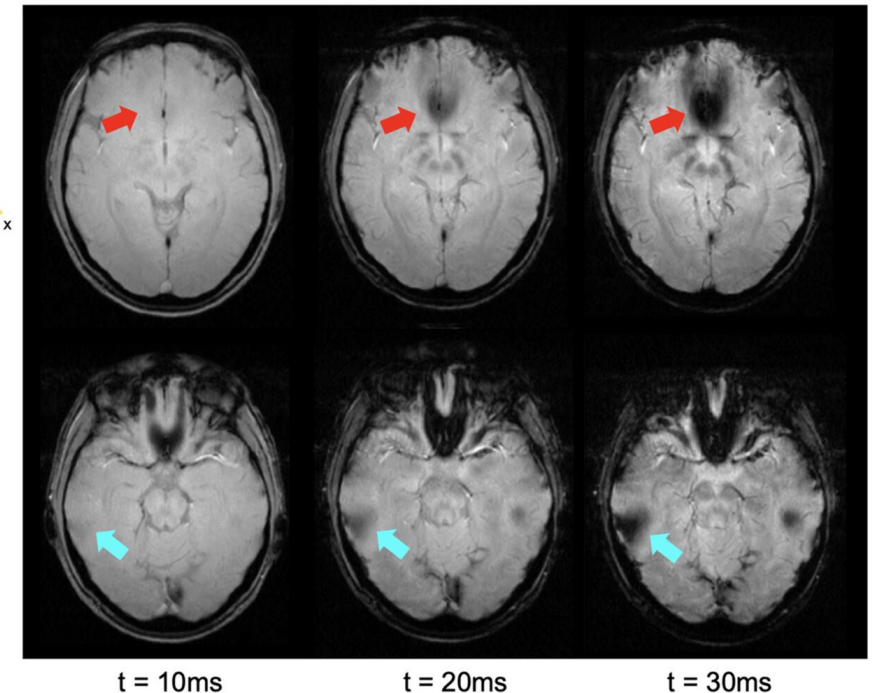
$$S(t) = \int M_{xy}(\vec{r}, 0) e^{-i\gamma \int_0^t \vec{G}(\xi) \cdot \vec{r} d\xi - i\gamma t \Delta B(\vec{r})} d\vec{r}$$



(A) Voxel picture of spin dephasing



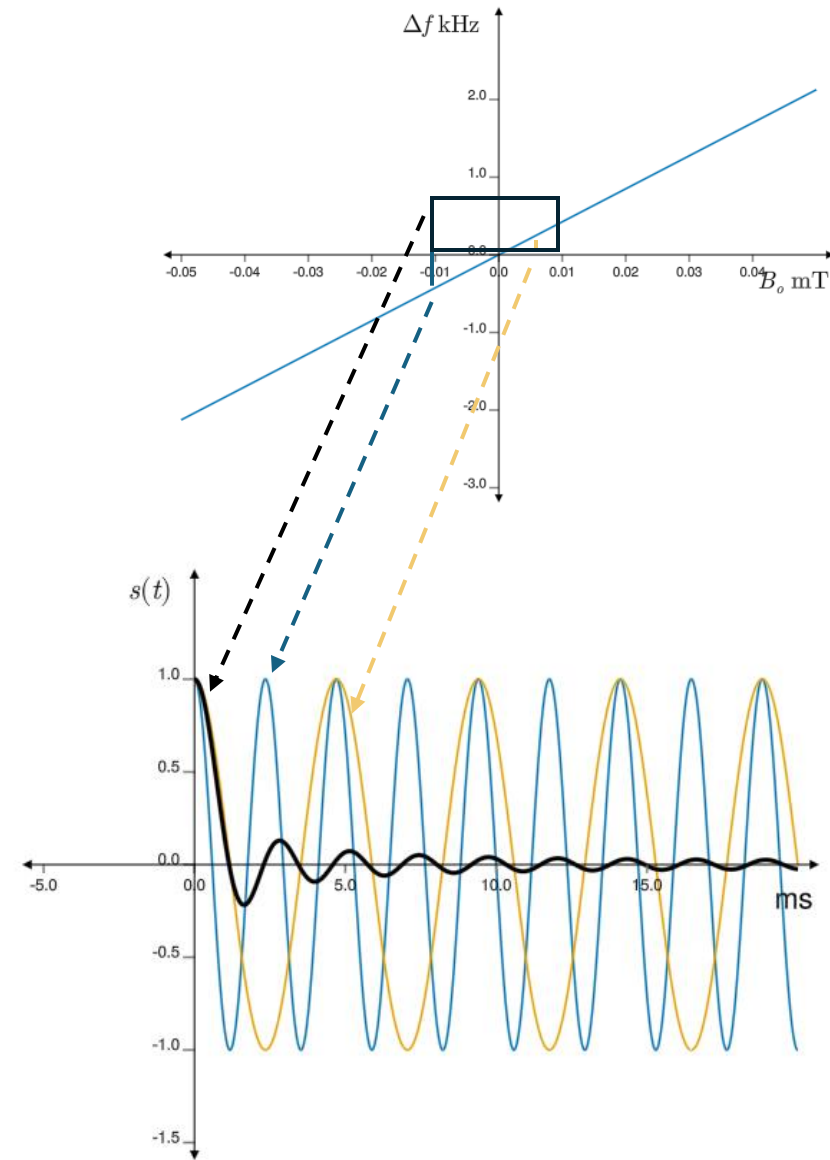
(B) Image signal loss due to dephasing



Overview of MRI: measuring the field

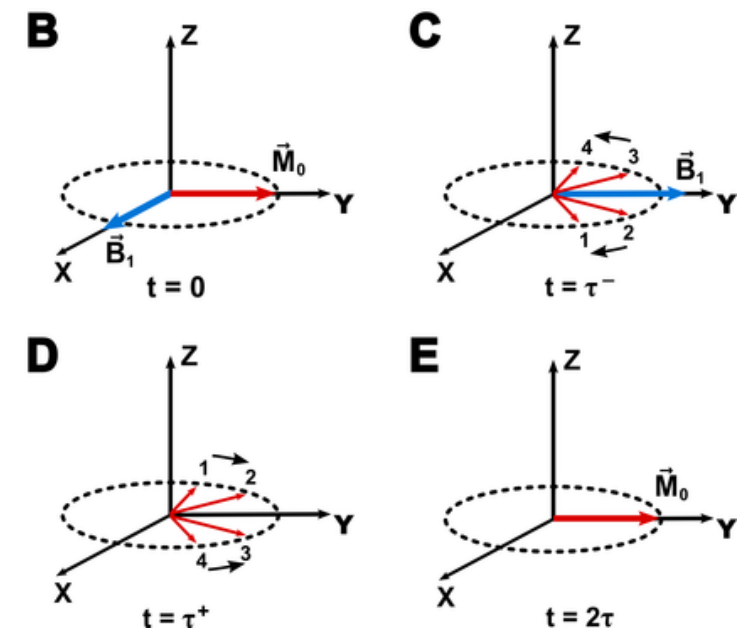
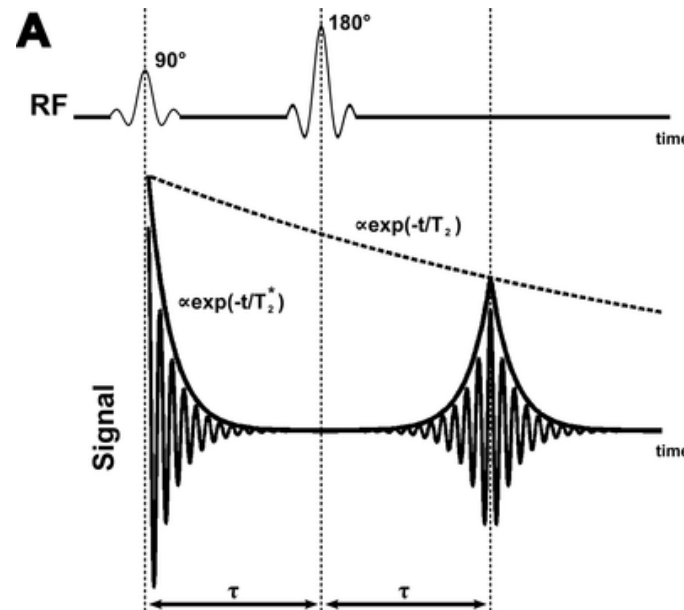
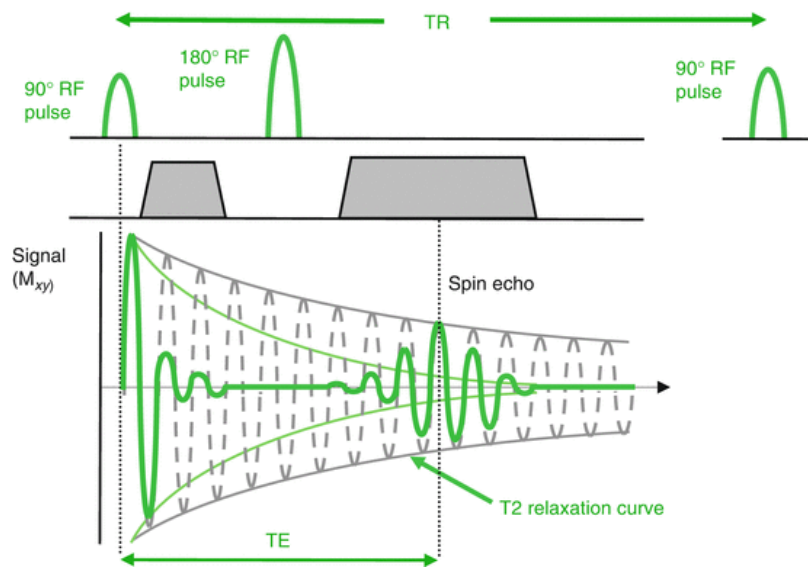
$$\gamma = 42.51 \text{ MHz/T}$$

$$f_o = \gamma B_o \text{ Hz}$$

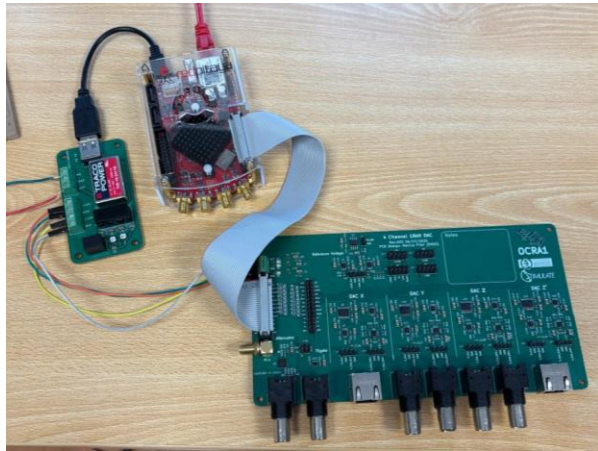


Overview of MRI: off-resonance in Spin Echo

Polarization – Excitation – **Readout** – Reconstruction



RF excitation + readout



Power Amplifier

RFTX

RFRX

Preamplifier

T/R Switch

RF
Coil

