

PHYS-473

**MRI Practicals on CIBM preclinical imaging systems**

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Cursus	Sem.	Type
Biomedical technologies minor	H	Opt.
Ing.-phys	MA1, MA3	Opt.
Minor in Imaging	H	Opt.
Neuro-X	MA1, MA3	Opt.
Physicien	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Withdrawal Session	Unauthorized Winter
Semester Exam	Fall During the semester
Workload	120h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Courses	2 weekly
Project	2 weekly
<b>Number of positions</b>	<b>12</b>

**Il n'est pas autorisé de se retirer de cette matière après le délai d'inscription.**

**Summary**

The goal of this course is to teach students how to perform basic MRI and MRS experiments in-vivo and ex-vivo directly on preclinical horizontal ultra-high field MRI systems.

**Content**

Main topics addressed in the course:

1. Introduction to MRI: Nuclear spin and magnetic moment, nmr-active nuclei/isotopes, macroscopic magnetization, classical description of magnetic resonance, FID, spin echo, gradient echo signal acquisition.
2. Basic anatomical imaging and contrast: T1, T2 and T2\* weighted images, impact of acquisition parameters on image contrast
3. Introduction to advanced MRI and contrast : fast MRI, 3D imaging, volumetry, diffusion MRI, *in vivo* vs *ex vivo* imaging, volume vs surface RF coils properties
4. Introduction to Magnetic Resonance Spectroscopy (MRS), data acquisition and processing using MRS4Brain toolbox : <sup>1</sup>H metabolites resonance patterns, chemical shift, J-coupling, shimming, MRS localization approaches, water signal suppression, outer volume signal suppression, metabolites quantification.
5. Introduction to Magnetic Resonance Spectroscopic Imaging (MRSI), reconstruction, data acquisition and processing using MRS4Brain toolbox : Basics of spectroscopic imaging, signal encoding for localization, 2D and 3D MRSI, FID vs echo-based MRSI
6. Basic artifacts in MRS and MRI and how to avoid them
7. Data processing: volumetry, DTI, metabolic imaging

**Keywords**

Magnetic Resonance Imaging (MRI), Magnetic Resonance Spectroscopy (MRS), Brain, ultra high magnetic field, metabolic imaging, brain metabolites, spin physics, processing/quantification,

**Learning Prerequisites****Required courses**

General Physics  
Electromagnetism  
Basic signal processing

**Important concepts:** Fourier transformation

**Recommended courses**

Fundamentals of biomedical imaging - PHYS-438  
 Neural signals and signal processing - Fiche de cours - NX-421  
 Quantum physics  
 Signaux et systèmes

**Important concepts to start the course**

NMR, MRI basics

**Learning Outcomes**

By the end of the course, the student must be able to:

- Understand the physical principles of MRI and MRS during hands on exercises on MRI scanners
- Perform basic MRI and MRS experiments
- Establish MRI and MRS acquisition protocols and understand the impact of the acquisition parameters on image contrast or spectral pattern
- Analyze the results for the acquired data
- Explain the basics of organizing a successful MRS experiment, processing/quantification, image processing, using MRS4Brain toolbox
- Read, analyze and discuss representative scientific papers
- Discover the power of interdisciplinary interaction by working on questions and hands on exercises in groups

**Transversal skills**

- Use both general and domain specific IT resources and tools
- Communicate effectively with professionals from other disciplines.
- Write a literature review which assesses the state of the art.
- Write a scientific or technical report.

**Teaching methods**

In general the course will be organized as follows:

- 2h theoretical
- 2h practical at the scanner

**Expected student activities**

Active participation in the theoretical courses with questions  
 Discussions/questions during the live demos  
 Supervised experimental manipulation of the MRI scanner  
 Processing of the acquired data  
 Work in teams for a joint report/project

**Assessment methods**

Report/mini project

**Supervision**

Office hours	Yes
Assistant.e.s	Yes

**Resources**

**Bibliography**

In Vivo NMR Spectroscopy: Principles and Techniques (Robin de Graaf); Principles of Magnetic Resonance Imaging: A Signal Processing Perspective (Zhi-Pei Liang & Paul C. Lauterbur)  
1. Nuclear Magnetization (youtube.com)  
magritek - YouTube

**Ressources en bibliothèque**

- [Find the references at the Library](#)

**Références suggérées par la bibliothèque**

- [Basics of In Vivo NMR \(Youtube\) / Robin de Graaf](#)
- [Magitrek \(Youtube\) /Magitrek](#)

**Websites**

- <https://cibm.ch/>
- <https://www.epfl.ch/labs/mrs4brain/>

**Moodle Link**

- <https://go.epfl.ch/PHYS-473>

**Videos**

- <https://www.epfl.ch/labs/mrs4brain/links/live-demos/>