# MRI PRACTICALS ON CIBM PRECLINICAL IMAGING SYSTEMS
# PHYS-473

Cristina Cudalbu
*CIBM PCI EPFL*

*9th of September 2025*

CIBM.CH

# WHO ARE WE? WHO ARE YOU? ☺

**Enseignement**: Cudalbu Moldovan Cristina Ramona, Lanz Bernard, Lê Thanh Phong Kevin
**Assistanat**: Alves Brayan, Siviglia Alessio

| 12/12 | Nom Prénom | Section | Courriel | Semestre de l'inscription |
|---|---|---|---|---|
| 1 | **Boissier Charles Louis Pierre Bogdan** | NX | ✉ | Master semestre 3 |
| 2 | **Bordet Johan Igor Achille** | NX | ✉ | Master semestre 1 |
| 3 | **Elkhayat Ameer** | NX | ✉ | Master semestre 3 |
| 4 | **Kockisch Sophia Ursula Hélène Aimée** | ING_PHYS | ✉ | Master semestre 1 |
| 5 | **Lu Hanqi** | NX | ✉ | Master semestre 3 |
| 6 | **Matthey-Junod Angelina** | NX | ✉ | Master semestre 1 |
| 7 | **Mikami Sarah** | NX | ✉ | Master semestre 3 |
| 8 | **Mosegaard Sophie Céline** | NX | ✉ | Master semestre 1 |
| 9 | **Riepenhausen Isabel Clara** | PHYS | ✉ | Master semestre 1 |
| 10 | **Salomon Naomi Andréa Solika** | NX | ✉ | Master semestre 1 |
| 11 | **Strauss Julien** | PHYS | ✉ | Master semestre 3 |
| 12 | **Vorwald Romane Michèle Paula** | NX | ✉ | Master semestre 3 |

# ORGANIZATION

**Withdrawal:** It is not allowed to withdraw from this subject after the registration deadline.

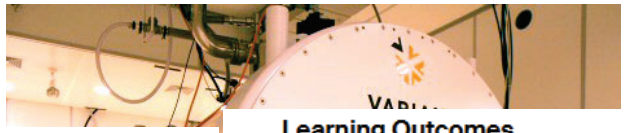
## Summary

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 : 1H 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

## Coursebook



### 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

# ORGANIZATION, EVALUATION

**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 project

**Assessment methods**

Report/mini project

- 6 groups in total – *2 by 2*
- Assessment:
  - Project: review of a theoretical topic
    - Subjects and groups allocated on 28th of October
    - Report submission by 2nd of December
    - Oral presentations on 16th of December
  - Evaluation during semester:
    - Presence is mandatory (min 80%)
    - Actively participate

# PLANNING (1/2)

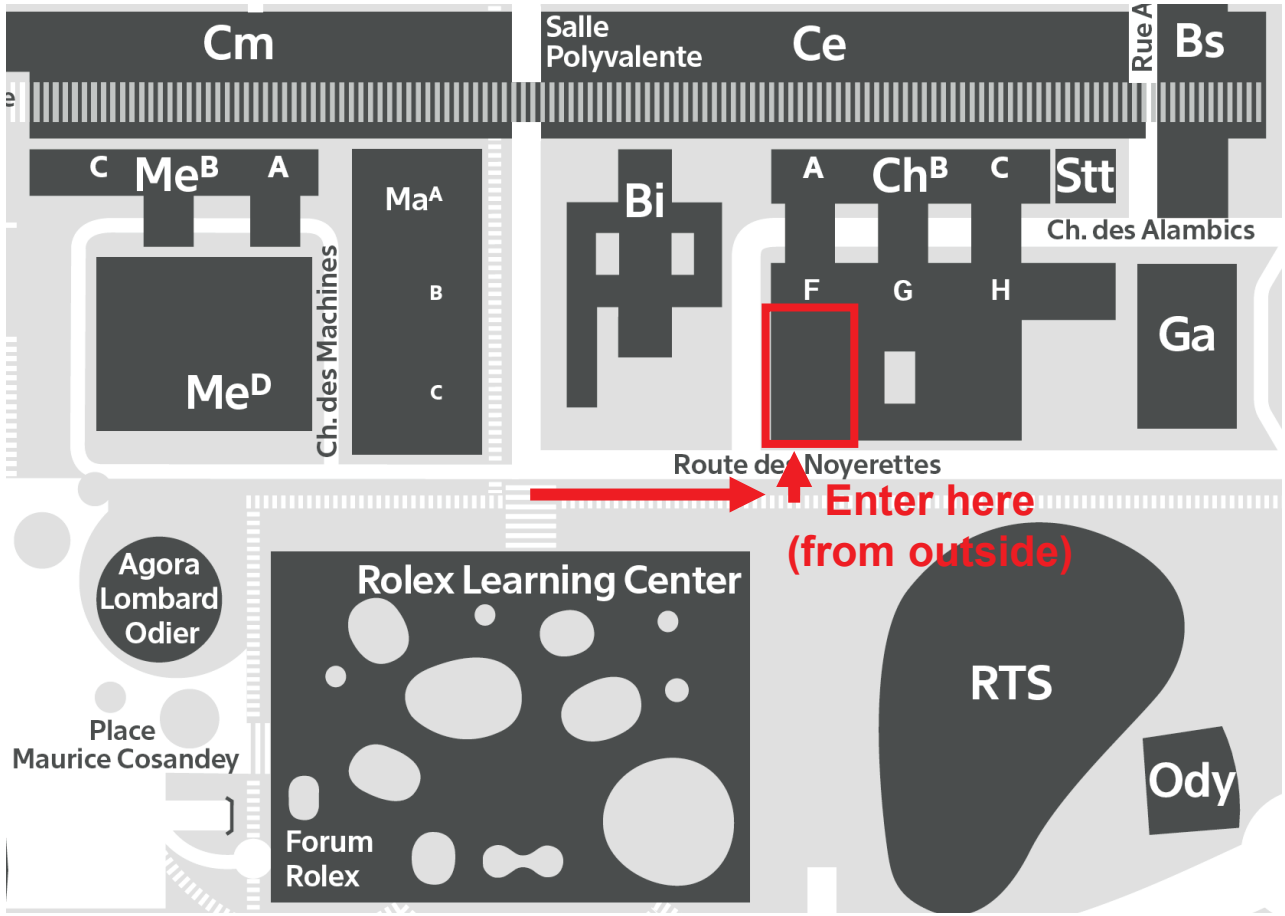
- **Week 1: 9/09: introduction and lecture**
- **Week 2: 16/09: lecture and introduction to the MR scanner**
- **Week 3: 23/09: session on the scanner. Install the MRS4BRAIN toolbox (by yourself)**
- **Week 4: 30/09: lecture**
- **Week 5: 7/10: lecture + test of the MRS4BRAIN toolbox**
- **Week 6: 14/10: session on the scanner**
- **Reading week – no class on 21/10 ☺**

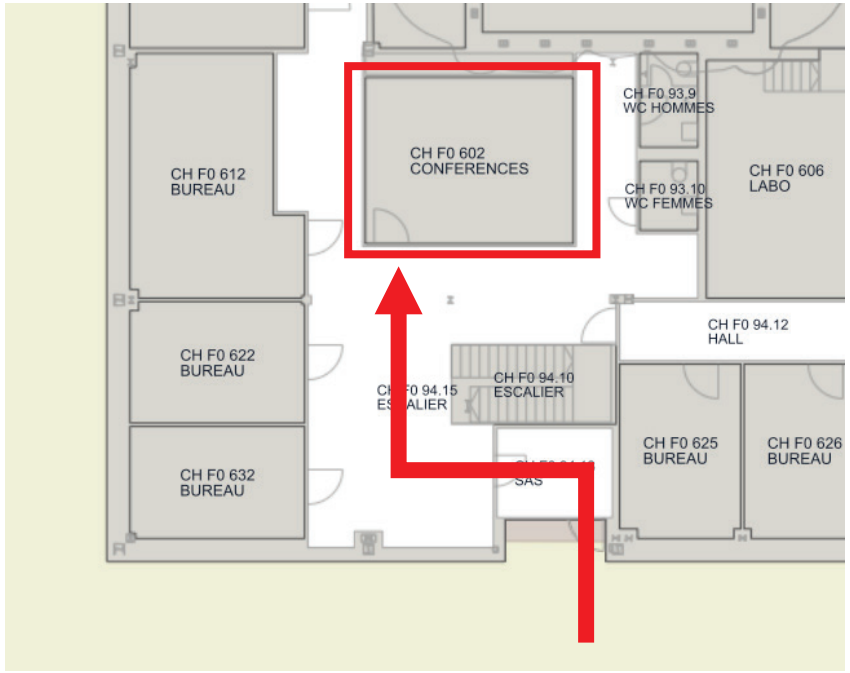
# PLANNING (2/2)

- **Week 7: 28/10: lecture and projects/groups allocation**
- **Week 8: 4/11: lecture**
- **Week 9: 11/11: session on the scanner**
- **Week 10: 18/11: lecture**
- **Week 11: 25/11 : lecture and practice on the computer**
- **Week 12: 2/12: session on the scanner and Submission of the reports**
- **Week 13: 9/12: session on the scanner**
- **Week 14: 16/12: Oral presentations**

# WHERE WILL IT HAPPEN?

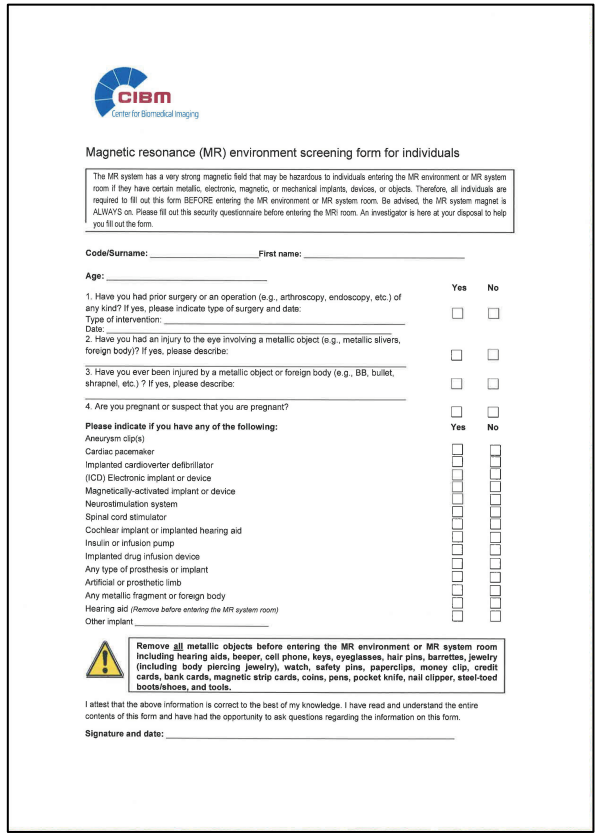
- The next lectures will take place at the CIBM (CH F0 602)



# SAFETY AND QUARANTINE

- For your own safety and the safety of our facility: **2 forms to be read and signed**



CIBM
Center for Biomedical Imaging

Magnetic resonance (MR) environment screening form for individuals

The MR system has a very strong magnetic field that may be hazardous to individuals entering the MR environment or MR system room if they have certain metallic, electronic, magnetic, or mechanical implants, devices, or objects. Therefore, all individuals are required to fill out this form BEFORE entering the MR environment or MR system room. Be advised, the MR system magnet is ALWAYS on. Please fill out this security questionnaire before entering the MRI room. An investigator is here at your disposal to help you fill out the form.

**Code/Surname:** _____ **First name:** _____

**Age:** _____

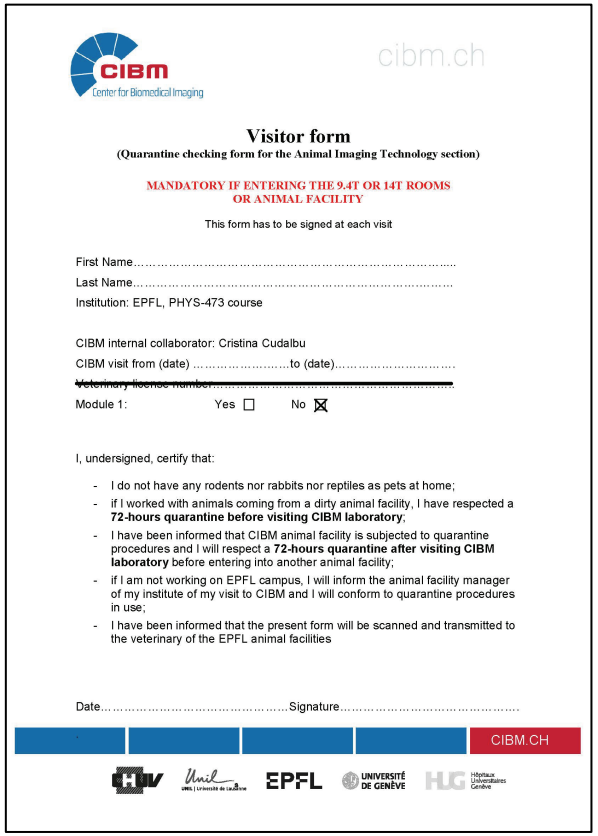
| | Yes | No |
|---|---|---|
| 1. Have you had prior surgery or an operation (e.g., arthroscopy, endoscopy, etc.) of any kind? If yes, please indicate type of surgery and date: Type of intervention: _____ Date: _____ | ☐ | ☐ |
| 2. Have you had an injury to the eye involving a metallic object (e.g., metallic slivers, foreign body)? If yes, please describe: _____ | ☐ | ☐ |
| 3. Have you ever been injured by a metallic object or foreign body (e.g., BB, bullet, shrapnel, etc.) ? If yes, please describe: _____ | ☐ | ☐ |
| 4. Are you pregnant or suspect that you are pregnant? | ☐ | ☐ |

| **Please indicate if you have any of the following:** | Yes | No |
|---|---|---|
| Aneurysm clip(s) | ☐ | ☐ |
| Cardiac pacemaker | ☐ | ☐ |
| Implanted cardioverter defibrillator | ☐ | ☐ |
| (ICD) Electronic implant or device | ☐ | ☐ |
| Magnetically-activated implant or device | ☐ | ☐ |
| Neurostimulation system | ☐ | ☐ |
| Spinal cord stimulator | ☐ | ☐ |
| Cochlear implant or implanted hearing aid | ☐ | ☐ |
| Insulin or infusion pump | ☐ | ☐ |
| Implanted drug infusion device | ☐ | ☐ |
| Any type of prosthesis or implant | ☐ | ☐ |
| Artificial or prosthetic limb | ☐ | ☐ |
| Any metallic fragment or foreign body | ☐ | ☐ |
| Hearing aid *(Remove before entering the MR system room)* | ☐ | ☐ |
| Other implant _____ | ☐ | ☐ |

**Remove all metallic objects before entering the MR environment or MR system room including hearing aids, beeper, cell phone, keys, eyeglasses, hair pins, barrettes, jewelry (including body piercing jewelry), watch, safety pins, paperclips, money clip, credit cards, bank cards, magnetic strip cards, coins, pens, pocket knife, nail clipper, steel-toed boots/shoes, and tools.**

I attest that the above information is correct to the best of my knowledge. I have read and understand the entire contents of this form and have had the opportunity to ask questions regarding the information on this form.

**Signature and date:** _____



CIBM
Center for Biomedical Imaging

cibm.ch

**Visitor form**

**(Quarantine checking form for the Animal Imaging Technology section)**

**MANDATORY IF ENTERING THE 9.4T OR 14T ROOMS OR ANIMAL FACILITY**

This form has to be signed at each visit

First Name……

Last Name……

Institution: EPFL, PHYS-473 course

CIBM internal collaborator: Cristina Cudalbu

CIBM visit from (date) ……to (date)……

~~Veterinary license number:~~ _____

Module 1: Yes ☐ No ☒

I, undersigned, certify that:

- I do not have any rodents nor rabbits nor reptiles as pets at home;
- if I worked with animals coming from a dirty animal facility, I have respected a **72-hours quarantine before visiting CIBM laboratory**;
- I have been informed that CIBM animal facility is subjected to quarantine procedures and I will respect a **72-hours quarantine after visiting CIBM laboratory** before entering into another animal facility;
- if I am not working on EPFL campus, I will inform the animal facility manager of my institute of my visit to CIBM and I will conform to quarantine procedures in use;
- I have been informed that the present form will be scanned and transmitted to the veterinary of the EPFL animal facilities

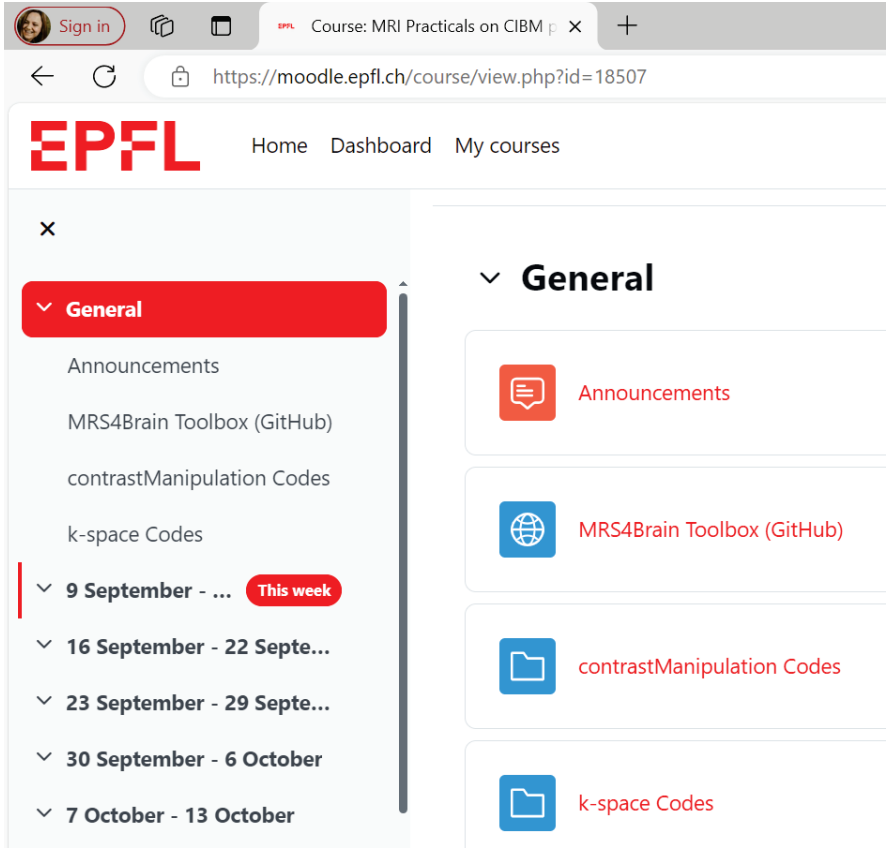
Date……Signature……

CIBM.CH

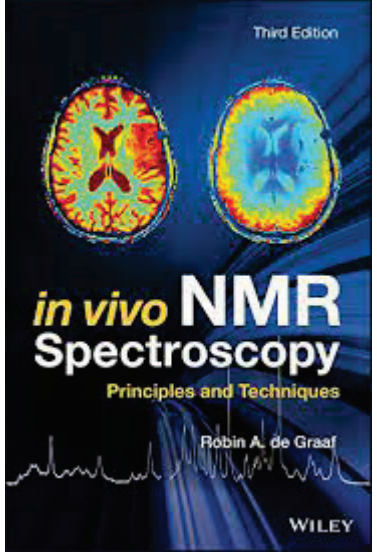
HUG Hôpitaux Universitaires Genève

# TO DOWNLOAD

- MRS4Brain toolbox – MRS4BRAIN - EPFL
  - https://github.com/AlvBrayan/MRS4Brain-toolbox/
  - **Please it by yourself and TEST by the 3rd week!**
- contrastManipulation tool - Moodle
- *k*-space tool - Moodle



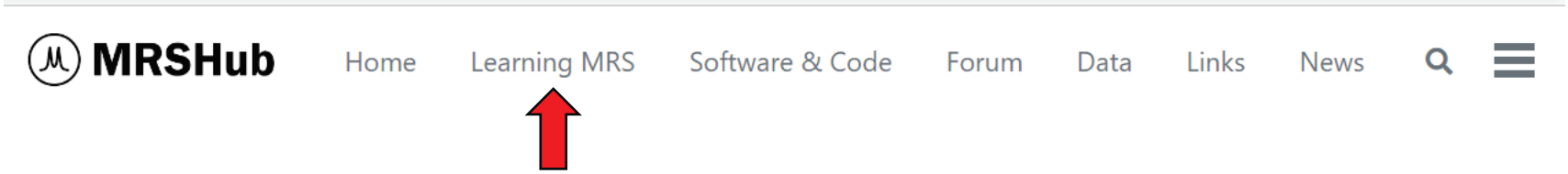
# READING, RESSOURCES AND VIDEOS

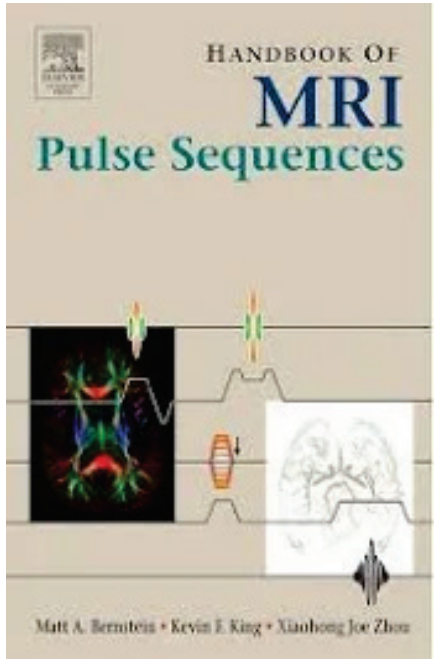



- In Vivo NMR Spectroscopy: Principles and Techniques (Robin de Graaf)
- Principles of Magnetic Resonance Imaging: A Signal Processing Perspective (Zhi-Pei Liang & Paul C. Lauterbur)
- 1. Nuclear Magnetization (youtube.com)
- Magritek NMR - YouTube
- **Moodle Link:** https://go.epfl.ch/PHYS-473
- **Videos:** https://www.epfl.ch/labs/mrs4brain/links/live-demos/

# FURTHER READING

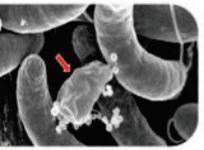
- Fundamentals of Biomedical Imaging (Part 1 and Part 2) - OpenLearnity
- Basics of In Vivo NMR - YouTube

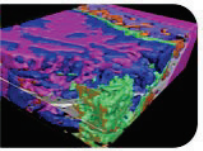


# The Minor in Imaging

**Broaden your career horizon**





**Open to all EPFL students**

- **Transversal & interdisciplinary** program
- Covers **theoretical and practical aspects** in imaging
- Useful in **industry and academic world**

## Requirements

- **Mathematics**
  *Linear algebra & analysis*
- **Basis of programmation**
  *One language*
- **Basis of physics**
  *Optics*

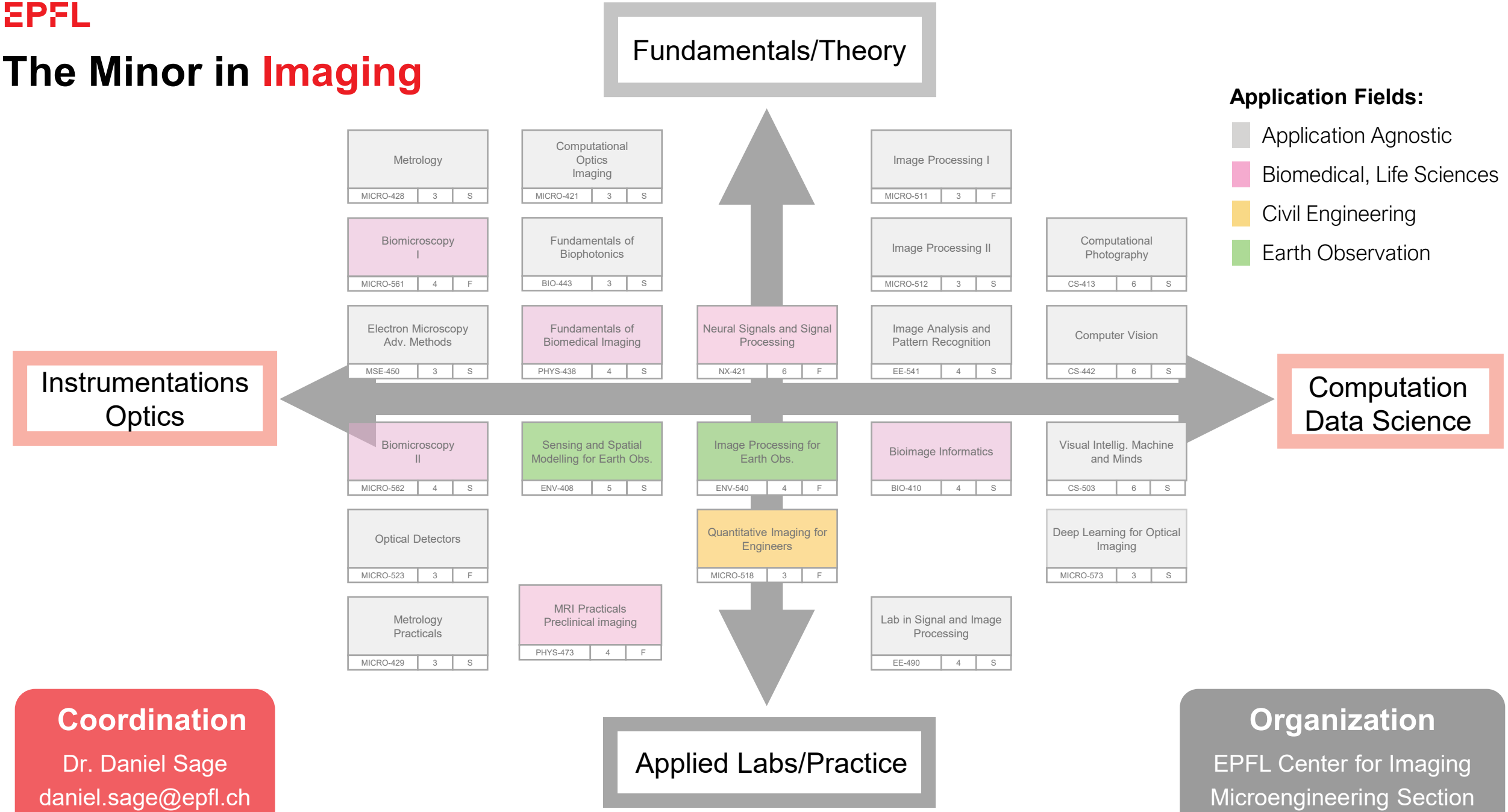

## Minor (30 ECTS):

- 22 ECTS of courses
- 8 ECTS for a project

Info: imaging.epfl.ch/education

EPFL

# The Minor in Imaging




**Application Fields:**

- Application Agnostic
- Biomedical, Life Sciences
- Civil Engineering
- Earth Observation


**Coordination**

Dr. Daniel Sage

daniel.sage@epfl.ch


**Organization**

EPFL Center for Imaging

Microengineering Section

**Info**: imaging.epfl.ch/education

CIBM
Center for Biomedical Imaging

# THANK YOU FOR YOUR ATTENTION

CHUV
UNIL | Université de Lausanne
EPFL
UNIVERSITÉ DE GENÈVE
HUG Hôpitaux Universitaires Genève

CIBM.CH