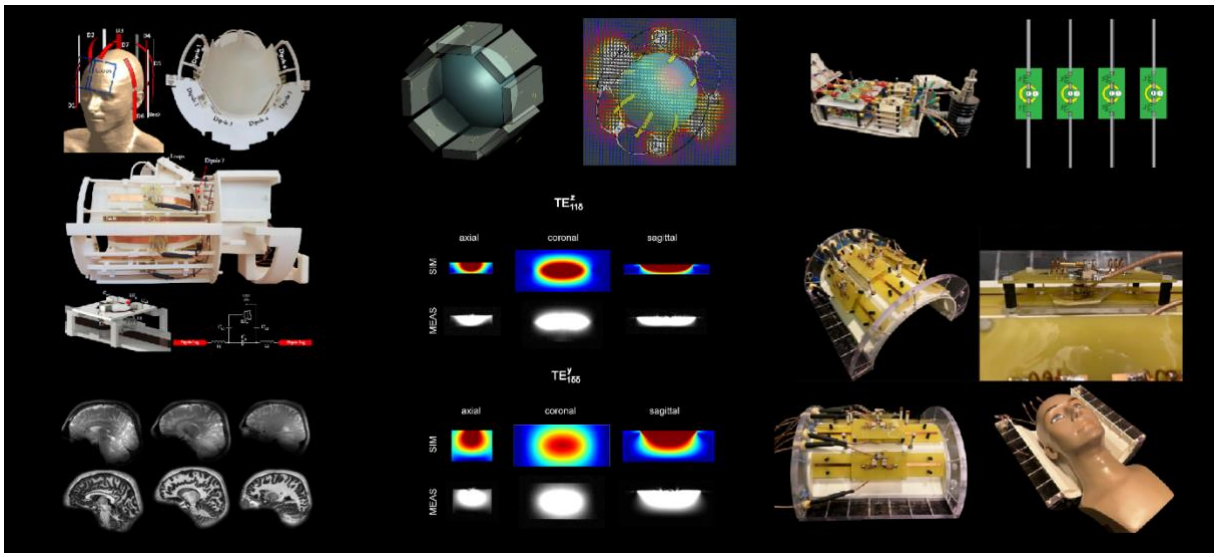
Master or semester project

Location: EPFL AVP CP CIBM-AIT,Bât.CH F.
Dates: Winter semester 2022/2023 or summer semester 2023
Duration: 4 – 6 months.

Development of multi-channel radio frequency technology for human MRI at 7T

Ultrahigh field (UHF) MRI (magnetic field strength $B_0 \geqq 7T$) provides substantial signal-to-noise (SNR) gains. However, since the resonance frequency f increases linearly with B_0, UHF-MRI is by far more challenging than standard clinical MRI at 1.5T or 3T, mainly due to shortened radio frequency (RF) wavelength (~12 cm in human brain) and increased specific absorption rate (SAR ~ f^2). To tackle these challenges, multi-channel transmit/receive RF coil arrays are used. RF coils are critical components of any MR system, and have a direct impact on spatial and temporal resolution, sensitivity and uniformity. They are used for two main purposes: RF transmission (to tip the net magnetization from its alignment with B_0 field) and to receive the nuclear magnetic resonance signal. Our goal is to develop a new generation of multi-channel RF coils for UHF-MRI which would provide substantial gains in transmit field efficiency, SAR efficiency and SNR. We explore new approaches which are not only limited to 7T, but which could be also translated to higher magnetic field strengths of the future (10.5 and 11.7T are already available).

SNR gain provided by 7-T MRI is not limited to anatomical imaging. There are also other nuclei (so called X-nuclei) which can be imaged using MR. They are present in human bodies in very small quantities, yet playing critical roles in physiology and metabolism (e.g. phosphorus ^{31}P or sodium ^{23}Na). Changes in concentration and distribution of such molecules might reflect ongoing pathophysiological processes in different tissues. In vivo X-nuclei MRI can detect such changes, thereby providing a unique type of diagnostic information. However, the signal from X-nuclei is usually several orders of magnitude smaller than the one from water (^{1}H). To capture such weak signals and enable high-performance X-nuclei imaging, we develop custom-tailored RF coils which work at two different frequencies: one for the X-nucleus, and the other one for ^{1}H to support anatomical imaging.



Projects of interest are:

- Dipolectric antenna arrays for human brain and body MRI at 7T
- Loop-dipole fed dielectric resonator antenna arrays for human brain MRI at 7T
- Multi-channel loop-dipole arrays for phosphorus (31P) and proton MR spectroscopy of human brain at 7T
- Local transmit/receive arrays for carbon (^{13}C) MR spectroscopy of human brain at 7T

Each project (either semester or master) is designed such that it can be concluded either with a conference paper or a peer-reviewed publication.

Requirements

- Background in physics / medical physics / electrical engineering / biomedical engineering or related field

Responsibilities

- Performing electromagnetic field simulations in human voxel models
- Development of RF shimming algorithms (transmit field optimization)
- 3D design of RF enclosures
- Construction of RF coils and their evaluation using network analyzer
- Phantom and in vivo experiments at 7T

Supervisor

- Prof. Dimitri Van De Ville, CIBM MRI EPFL AIT Section
- Dr. Daniel Wenz, CIBM MRI EPFL AIT Section

How to apply: if you are interested to learn more about the projects, please contact: daniel.wenz@epfl.ch

About CIBM

The CIBM Center for Biomedical Imaging was founded in 2004 and is the result of a major research and teaching initiative of the partners in the Science-Vie-Société (SVS) project between the Ecole Polytechnique Fédérale de Lausanne (EPFL), the Université de Lausanne (UNIL), Université de Genève (UNIGE), the Hôpitaux Universitaires de Genève (HUG) and the Centre Hospitalier Universitaire Vaudois (CHUV), with the generous support from the Fondation Leenaards and Fondation Louis-Jeantet.
CIBM brings together highly qualified, diverse, complementary and multidisciplinary groups of people with common interest in biomedical imaging.

We welcome you in joining the CIBM Community