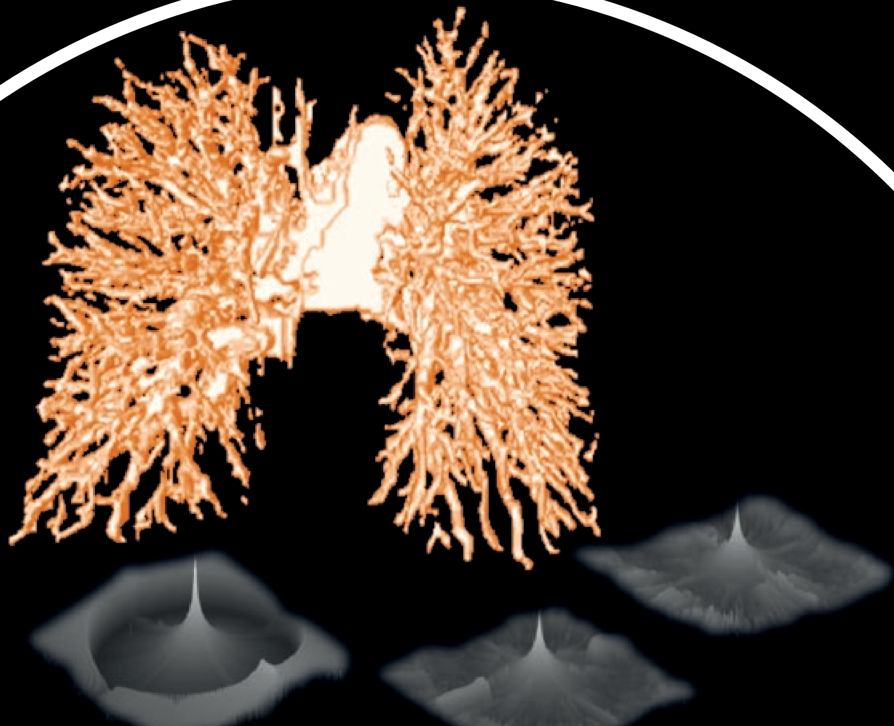
ESMRMB
European Society for Magnetic Resonance in Medicine and Biology



Lectures on MR 2016

Educational courses, exercises, and practical demonstrations on MR physics and engineering

Simultaneous multi-slice/ multiband imaging
January 18–20, Nijmegen/NL

Acquisition strategies for hyperpolarised spin systems: Spectral, spatial and temporal
February 24–26, Munich/DE

Quantitative MRI for characterising brain tissue microstructure NEW!
June 6–8, Leipzig/DE

Create your own echo: How to generate, calculate and manipulate echoes
June 20–22, Tübingen/DE

RF coils: Design, build and characterise your own
June 21–23, L'Aquila/IT

Non-Cartesian MRI: Implementation and application NEW!
August 25–27, Würzburg/DE

RF pulses: Design and applications
September 8–10, Krakow/PL

In vivo MR spectroscopy: From basics to advanced methods NEW!
September 26–28, Vienna/AT

www.esmrmb.org

Content

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General Information

Course Information

- All courses are held in English language.
- The duration of the course is 2 to 3 days.
- The detailed programme of each course and the exact time schedule are available at the ESMRMB website.
- About 40% of the total teaching time is used for repetitions, exercises, and practical demonstrations to practice and intensify the learning experience.
- A maximum of 50 places per course is available (except for the RF coil design course in L´Aquila/IT which is limited to 20). Early registration is recommended.
- If less than 20 participants register, the ESMRMB reserves the right to cancel a course at the latest 4 weeks prior to its beginning.
- The ESMRMB ensures the evaluation and certification of all courses, and guarantees didactically and scientifically experienced teachers.

Accreditation

The **Lectures on Magnetic Resonance** programme is accredited by the **European Federation of Organisations for Medical Physics (EFOMP).** A certificate of attendance of the entire course will be available for the participants online.

Sponsoring

The Lectures on MR programme 2016 is kindly supported by

SIEMENS

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Cover Image:
Research Center Magnetic Resonance Bavaria (MRB)

Scientific images kindly provided by the organisation committee 2016.

Goals of the Courses

With the **Lectures on Magnetic Resonance** the ESMRMB continues to offer new teaching courses that are especially designed to provide the physical fundamentals of MR imaging, diffusion, perfusion, spectroscopy and RF engineering, as well as aspects of applications of these techniques in clinical and biochemical research and development. The ESMRMB and its Education and Workshop Committee is convinced that there is a strong need and request to provide these kind of courses that are dedicated towards the needs of MR physicists and other basic scientists working in a clinical or research environment.

The course on **Simultaneous multi-slice/multiband imaging** will provide participants with a solid grounding in one of the most exciting developments of recent years: The ability to vastly accelerate data acquisition by the simultaneous acquisition of multiple slices. The course will cover the basic concepts of simultaneous excitation, refocusing and inversion for conventional and adiabatic radio frequency pulses. It will show how the application of these pulses can be limited by both peak RF-voltage and power deposition, and describe strategies for circumventing both of these limitations.
The limitations of combined simultaneous multi-slice imaging and in-plane acceleration will be presented. The value of incorporating (blipped) CAIPIRINHA will be explored. Different methods of data reconstruction will be described, and the implications for the acquisition of reference data shown. Finally examples of current and potential future applications will be examined.

The course will focus on
- Basic radiofrequency pulse design
- Strategies for reducing peak voltage
- Strategies for reducing pulse power
- Extensions to adiabatic pulse forms
- Basis of reconstruction methods
- Advanced reconstruction methods
- CAIPIRINHA and blipped CAIPIRINHA technique
- Slice cross-talk
- Practical implementations: Pulse sequence modifications, acquiring reference data, adjusting B0/B1 and additional sensitivity to motion
- Where is the concrete benefit and why?
  Examples from neuroimaging and clinical application

Acquisition strategies for hyperpolarised spin systems: Spectral, spatial and temporal
Imaging of hyperpolarised substances is an emerging field with widespread applications, such as detecting metabolism via 13C labelled compounds or lung function via 129Xe gas. It differs from traditional thermally polarised MRI mainly by time and sensitivity considerations, as the hyperpolarised state is non-recoverably disappearing with T1 relaxation and excitation of magnetisation. Goal of the course is to familiarise the participants with these special constraints for imaging and teach MRI methods for imaging, reconstruction and quantification of hyperpolarised spins. Furthermore, introductions are given into the basic X-nuclei MRI hardware, hyperpolarisation methods, underlying biology and other relevant aspects in this context.

The course on **Quantitative MRI for characterising brain tissue microstructure** provides the basic foundation of the most frequently used quantitative MRI methods for imaging brain structure. The emphasis will be on well-established approaches but also recent developments will be introduced. The course covers the data acquisition and processing methods, such as MR pulse sequences, fitting procedures and biophysical modelling. It will discuss the biophysics and interpretation of the quantitative measures in conjunction with neuroanatomy and brain microstructure. Lectures will be complemented by MATLAB tutorials implementing different data-processing and fitting methods.

At the end of the course attendees will understand the basic principles and implementation of relaxometry, magnetisation transfer mapping and quantitative diffusion imaging. Attendees will appreciate the relationship between the different quantitative measures and brain microstructure based on basic biophysical models. The information will help them to understand current and future developments in the field of quantitative imaging.

The course will focus on:
- Quantification of the longitudinal relaxation time T1
- Quantification of proton density
- Quantification of the transverse relaxation time T2
- Quantification of the effective transverse relaxation time T2* and magnetic susceptibility
- Quantifying magnetisation transfer (MT)
- Quantitative Diffusion-weighted Imaging including tensor and advanced diffusion models
- Biophysical models and interpretation of quantitative MRI data
- Group analysis using quantitative MRI data
- Basic neuroanatomy to place the MRI measures into context

The course on **Create your own echo: How to generate, calculate and manipulate echoes** offers a physically and mathematically oriented description of basic and non-basic physical properties of spins exposed to penetrating radio frequency and gradient fields. Is it possible to generate a spin echo with two 10-degree RF pulses? What is the difference between a spoiled gradient echo sequence and a balanced steady state free precession technique? How can we calculate amplitude and phase of spin echoes, stimulated echoes and steady state signals?

Attendance of the course will provide you with a fundamental knowledge of
- Handling and calculations with the Bloch equations
- Understanding of sampling trajectories in k-space
- Fourier description of magnetisation, the phase-graph
- Counting of echo paths in a multi-pulse experiment
- Behaviour of multiple spin echo techniques at low flip angles
- Mathematical description of steady states and their resulting contrasts
- Application of Hyper Echoes to gradient echo methods
- Exotic sequences, Hyper Echoes, TRAPS

The course on **RF coils: Design, build and characterise your own** provides an overview of the basic principles of designing, constructing and testing of RF coils for both animal and human scanners. Introduction into software tools for simulations of electromagnetic fields and for safety evaluation will be included. Practical sessions will cover approximately 50% of the course, in which participants will learn to build surface and volume RF coils relevant to their particular interests. Characterisation of RF coils including S-parameters, Q-measurements and optimisation, B1 calibration and mapping, measurement of E field, and assessment of parallel imaging performance will be also part of the course. The course is designed for basic scientists and engineers but also has been attended in the past by clinicians, radiographers, applications specialists and other MR users interested in gaining a better insight into RF coil technology.

The course will enable you to
- Understand the behaviour of circuit elements used to construct RF coils
- Understand the concepts of resonant circuits, quality factor, and the effects of sample loading
- Design impedance matching networks
- Construct baluns and cable traps
- Get first-hand experience with test equipment used in RF coil design
- Design and build a single-tuned surface RF coil
- Understand the theory of volume resonators
- Design a single-tuned birdcage RF coil
- Understand the effect of RF shields
- Understand the different designs for multiple-tuned RF probes
- See the principles of software packages for RF simulations

The course on **Non-Cartesian MRI: Implementation and application** is designed to provide a firm conceptual and practical foundation. Attendees will be brought up to date with established techniques and will develop an appreciation of emerging technologies and methods in non-Cartesian MRI. The three-day course will rely heavily on interactive tutorials using the MATLAB programming environment. Computers and licenses will be provided for the length of the course. At the end of the course attendees will understand the basic principles of non-Cartesian image reconstruction, practical implementation of various non-Cartesian MRI sequences and necessary correction strategies. In addition, parallel MRI and compressed sensing will be discussed in the context of non-Cartesian data acquisitions. Attendees will also appreciate the role of these methods in established and research practice and how such methods may develop and influence MRI research and clinical routine in the future.

The course will cover
- Basic principles of non-Cartesian imaging
- Gridding and density compensation
- Generation of gradient waveforms for non-Cartesian k-space trajectories in 2D/3D
- Measurement and correction of non-Cartesian k-space trajectories
- Properties of different non-Cartesian trajectories
- Acceleration strategies: Non-Cartesian parallel MRI, compressed sensing
- Dynamic non-Cartesian imaging: 1D/2D golden angle KWIC, self-gating
- Applications: Cardiac imaging/lung/X-nuclei
- Quantitative assessment of image quality: PSF/SNR

Goals of the Courses

RF pulses: Design and applications

Radio frequency (RF) pulses are the tool by which nuclear spins are forced to do their ´gymnastics´ which reveals to us the internal structure of bodies and molecules in MRI and NMR experiments. On their properties depend many essential quality and safety aspects of MR techniques, such as the precision of slice selection, homogeneity of image contrast, efficiency of spectral suppression or the Specific Absorption Rate (SAR). A good understanding of how RF pulses act on the spins, how they should be chosen and how they can be designed is a great asset for all MR scientists seeking a full control of the instruments they use.

The aim of the course is to provide an in-depth insight into the design and usage of RF pulses in magnetic resonance imaging. Starting from a basic introduction to the physics of RF interaction with the spin system, the course will cover the major pulse design and calculation techniques as well as examples of suitable pulses choice for common MRI sequences. A special emphasis will also be put on the design and applications of so-called multidimensional RF pulses, particularly in combination with the recently introduced concept of parallel RF transmission.

The course will cover

- Introduction to the physics and technical aspects of RF pulses
- Calculation of RF pulses in the Small-Tip-Angle approximation
- Calculation methods for Large-Tip-Angle pulses: The Shinnar-Le-Roux and the Optimal-Control approach
- Which RF pulse to choose for which function in common MRI sequences
- Special purpose RF pulses
- Overview of RF field (B1-) mapping methods
- Multidimensional RF pulses: Localisation and modulation of the transverse magnetisation in more than one dimension
- Parallel Excitation/Transmit SENSE: How the world of multidimensional pulses changes with the introduction of new degrees of freedom by multiple transmission channels

In vivo MR spectroscopy: From basics to advanced methods

The aim of this course is to provide a comprehensive overview on MR spectroscopy techniques that are available nowadays. We will start from basic acquisition and post-processing methods that are currently used on clinical routine MR scanners and compare them with more advanced methods that are typically applied in research settings. The main focus will be to provide an understanding of the limitations and advantages of each method compared to other alternatives. After the course, participants will be able to choose the ideal MRS technique to support clinical studies, understand methodical weaknesses and know possible approaches to compensate/correct for them, and gain the basic understanding that is mandatory to further develop/modify MRS sequences.

Educational Levels

The **Lectures on Magnetic Resonance** are dedicated to MR physicists and other basic or clinical scientists. The Lectures on MR courses are certified by the **European Federation of Organisations for Medical Physics (EFOMP).**

Simultaneous multi-slice/multiband imaging

This course is intended for MR physicists, other scientists and PhD students who already have experience in basic MR methods and knowledge of MR acquisition principles, and who wish to extend their knowledge on simultaneous multi-slice/multiband imaging with a view to implementing or applying it.

Acquisition strategies for hyperpolarised spin systems

The course is aimed at post-graduate and post-doctoral MR scientists interested in learning about acquisition strategies for NMR and MRI of hyperpolarised spin systems. A solid background in MR physics and imaging is assumed. It is not a requirement to have experience with hyperpolarisation or imaging of hyperpolarised spin systems. The course moves quickly from introductory to advanced methods over the three-day course. Pre-reading material will be provided to allow students to familiarise themselves with the course curriculum. Amble time will be provided to ask questions and discuss with the faculty. Some previous exposure to MATLAB is preferable, but not mandatory.

Quantitative MRI for characterising brain tissue microstructure

This course is intended for MR physicists, other scientists and PhD students who already have initial experience in basic MR methods, image processing and data analysis, and who wish to extend their knowledge on quantitative MRI principles and techniques. Some knowledge of MATLAB will be advantageous. All tutorials will be based around pre-existing code prepared for this course. Attendees without any MATLAB experience should have other programming experience and be willing to work with MATLAB.

This course runs from introductory to advanced methods over the three days. At the end of these three days, attendees will take with them the MATLAB code that has been provided and developed by them. This code, in combination with notes taken at the course, will form a package, which will enable attendees to understand different and implement some basic methods discussed during the course.

Important note on MATLAB tutorials: For best experience, attendees are asked to bring their own laptop computer with a MATLAB installation (Version 8.3/R2014 or later), since only a small number of computers will be available locally. If you cannot bring your own computer and/or MATLAB, please contact the ESMRMB before registering for the course.

Create your own echo: How to generate, calculate and manipulate echoes

This course is suited for established MR physicists, engineers, and other scientists with several years of direct experience in performing MRI applications and/or MRI technological research and development. The advanced course intends to provide a deeper understanding and mathematical description of state-of-the-art, rapid imaging principles.

RF coils: Design, build and characterise your own

This course is intended for scientists and engineers who have a basic knowledge of mathematics and simple electrical circuits. Attendees should have a working knowledge of magnetic resonance basics.

Non-Cartesian MRI: Implementation and application

This course is intended for MR physicists, engineers, other scientists and PhD students who already have some experience in MR methodology and MR acquisition principles, and who wish to extend their knowledge to non-Cartesian MRI. This course covers introductory to advanced methods in two and a half days. MATLAB tutorials will be provided companying the lectures of the individual topics. At the end of the course, attendees will take with them the code that has been provided together with their modifications and enhancements. This code, in combination with notes taken at the course, will form a package which will enable attendees to implement all the methods discussed during the course.

RF pulses: Design and applications

This course is intended for MR physicists, other scientists and PhD students who already have experience in basic MR methods, and who wish to expand their knowledge in the field of RF pulse design and applications. The three-day course will consist of different thematic modules, ranging from a basic introduction into RF pulse physics up to current developments in the field. Each module will be divided into a lecture presenting the subject matter of the module and exercises with audience participation aiming at a deeper understanding of the key aspects of the lecture.

In vivo MR spectroscopy: From basics to advanced methods

The course is intended for MR physicists (PhD students and early PostDoc with 1-3 years in MRI) who already have basic to intermediate experience in MR spectroscopy or MR method development.

Simultaneous multi–slice/ multiband imaging

January 18–20, 2016
Donders Centre for Cognitive Neuroimaging
Nijmegen, Netherlands

Course and local organiser:

David Norris
Erwin L. Hahn Institute Essen/DE
Donders Institute Nijmegen/NL

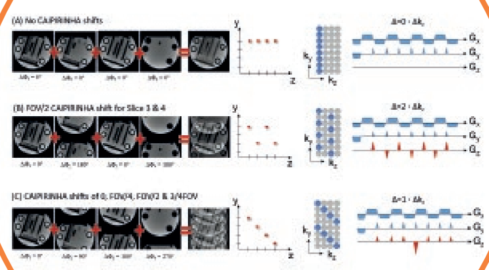
Preliminary faculty:

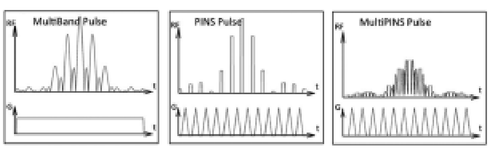
F. Breuer, P. Koopmans, J. Marques, D. Norris

Course description

The primary teaching method will be lectures with problem solving classes and discussions. All participants will be expected to know essential MR physics. A working knowledge of image acquisition methods and k-space is essential.

The course will cover RF pulse design approaches; reconstruction techniques, practical implementation and areas of application.





Learning objectives

RF pulse design

- Understand the methods of generating multiband RF pulses
- Know the limitations of peak voltage and power, and methods for avoiding these

Reconstruction methods

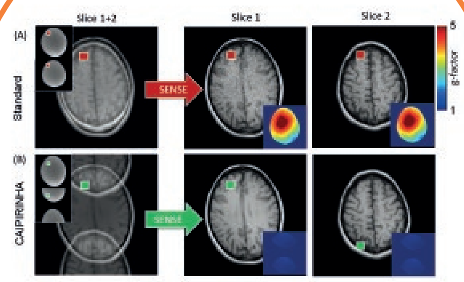
- Understand basic parallel imaging reconstruction methods and how they can be extended to simultaneous multi-slice reconstruction
- Be familiar with the main methods available and their limitations

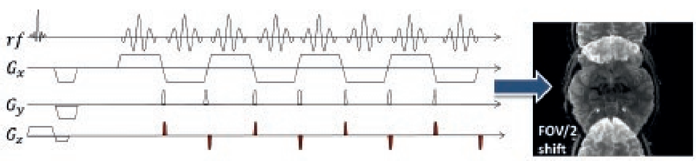
Acquisition techniques

- Modify pulse sequences for multi-slice acquisition
- Apply CAIPIRINHA techniques and understand their advantages and limitations
- Implement appropriate QA for multiband imaging

Areas of application

- Understand the advantages of the multiband approach for fMRI
- Advantages of multiband for Diffusion-weighted Imaging
- Potential advantages for clinical sequences





Acquisition strategies for hyperpolarised spin systems: Spectral, spatial and temporal

February 24–26, 2016
GE Global Research (research/TUM campus)
Munich, Germany

Course and local organisers:

Jan Henrik Ardenkjær-Larsen
GE Healthcare and Technical University of Denmark (DTU)
Lyngby/DK

Rolf Schulte
GE Global Research
Garching/DE

Preliminary faculty:

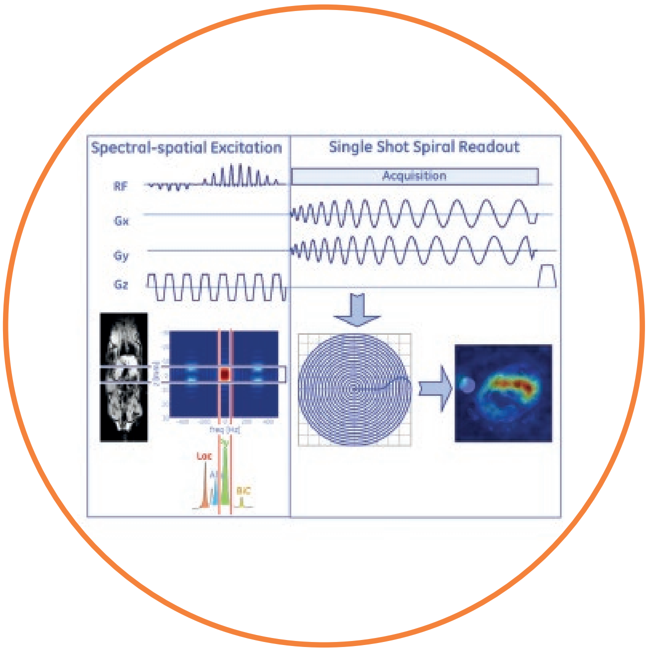
J. Ardenkjær-Larsen, A. Heerschap, S. Kozerke, J. Leupold, R. Schulte, J. Wild

Course description

Hyperpolarisation has opened up new applications of NMR and MRI. Acquisition strategies for hyperpolarised substances differ substantially from those suitable for thermally polarised samples due to the non-recoverable magnetisation.

The aim of this three-day course is to provide the participants knowledge of experimental and theoretical aspects of polarisation, magnetisation use, pulse sequence design and RF hardware for in vivo hyperpolarised MR. Different imaging strategies will be presented with emphasis on the special requirements and adaptations needed for hyperpolarisation studies. The use of specialised RF pulses will be covered as well as possibilities for accelerated acquisitions by means of parallel imaging and compressed sensing. Quantification and modelling of data are important aspects of hyperpolarisation studies and specialised methods will be described as the last part of the course.

An integrated part of the course will be theoretical exercises where the participant will work in more depth and gain hands-on experience on the topics covered in the lectures. Practical MATLAB tutorial exercises will be provided. For those who do not have MATLAB we will provide computers and software licenses for the duration of the course. The students will be able to work through example code provided for them. These examples will demonstrate and enhance their understanding of the concepts discussed throughout the course. At the end of the course they will be free to take this code away with them.



Learning objectives

At the end of the course the student will be able to

- Explain the basic advantages and limitations of the different hyperpolarisation methods
- Explain the relevance of different relaxation mechanisms and their time scale
- Explain hardware (scanner) requirements for hyperpolarisation imaging
- Explain basic imaging sequences for chemical shift imaging (CSI and EPSI)
- Explain advantages and limitations of non-Cartesian (radial/spiral) sequences and exploit the sparsity of the spectral dimension
- Explain the advantages and limitations of spin echo and steady-state sequences
- Design specialised RF pulses for spectral-spatial excitation
- Select parallel imaging methods for hyperpolarised molecules
- Use compressed sensing and sparse sampling strategies efficiently
- Use methods for quantification of spectral data such as intensity, integration, frequency and time domain fitting (jMRUI, LCmodel)
- Model kinetic (temporal) data, explain exchange reactions and methods of solving the rate equations, and correct for relaxation and RF excitation
- Provide a biological interpretation of rate constants and other parameters extracted from in vivo hyperpolarisation data

Quantitative MRI for characterising brain tissue microstructure

NEW!

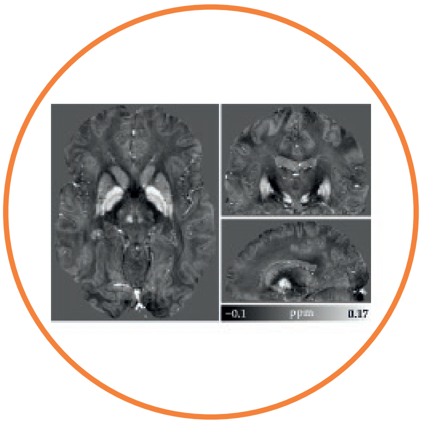
June 6–8, 2016
Max-Planck-Institute for Human Cognitive and Brain Sciences Leipzig, Germany

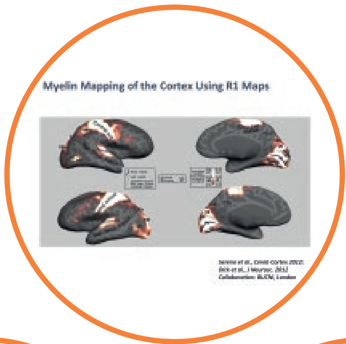
Course and local organisers:

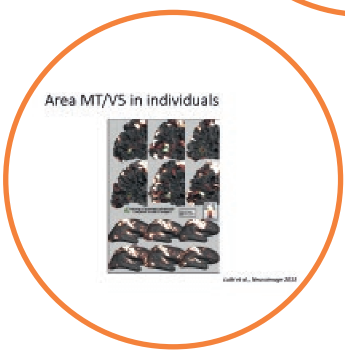
Harald Möller
Nikolaus Weiskopf
Max-Planck-Institute for Human Cognitive and Brain Sciences
Leipzig/DE

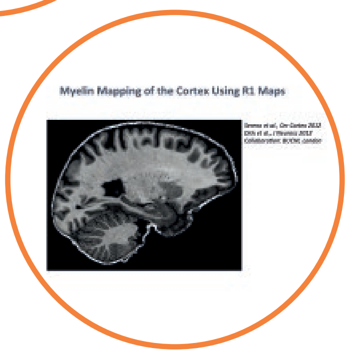
Preliminary faculty:

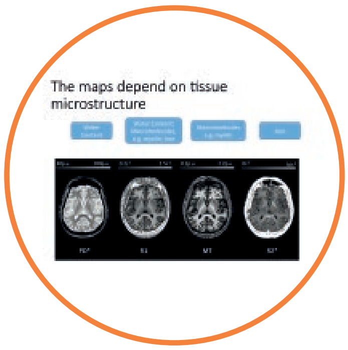
R. Bowtell, R. Deichmann, S. Geyer, G. Helms, A. MacKay, K. Miller, S. Mohammadi, H. Möller, N. Weiskopf











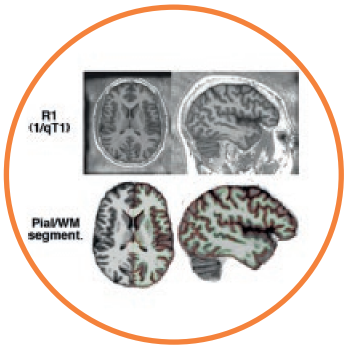
Course description

This course is designed to provide a broad foundation of quantitative MRI of brain structure. Quantitative MRI is of increasing importance, since it is comparable across time points and imaging sites. It also offers a higher specificity for the underlying physical and biophysical contrast mechanisms, facilitating its interpretation with respect to brain microstructure. Recently, these methods have been used to determine local myelin concentrations and different axonal properties. The access to information about structure much smaller than the nominal voxel size opens new possibilities for in vivo biomarkers and may make in vivo ´histology´ possible. This course is aimed at PhD students and scientists new to quantitative MRI who wish to acquire theoretical knowledge and practical skills in this domain. The course will be split in two parts, with approximately half the time spent attending lectures and the other half doing practical MATLAB tutorial exercises.

The course will cover the broad spectrum of quantification methods ranging from relaxometry of T1, T2, T2*, and proton density mapping to magnetisation transfer, diffusion and susceptibility mapping. The definition and basic models underlying the contrast parameters will be discussed. Biophysical models will be introduced for better interpretation and understanding of the relationship between contrast parameters and the underlying tissue microstructure. In order to place the physical models into the context of neuroscience studies, the appropriate treatment of quantitative data in group analyses will be discussed. Furthermore, an introduction into neuroanatomy will complement this.

An integral part of the course will be the MATLAB tutorials where attendees will be able to work through example code provided for them. These examples will demonstrate and enhance their understanding of the concepts discussed throughout the course.

Some previous exposure to MATLAB is preferable but not mandatory. Those participants who have not used MATLAB should have some programming experience. All participants will be expected to know basic MR physics, image processing and data analysis. A working knowledge of image acquisition methods is essential.



Learning objectives

T1 mapping

- Define the longitudinal relaxation time T1
- Understand inversion recovery, variable flip angle methods for T1 mapping
- Identify confounds and pitfalls in T1 mapping, including B1 field inhomogeneities, slice profile effects, inversion efficiency
- List typical T1 values for brain tissue and appreciate their variability across the brain and volunteers
- Understand the dependency of T1 on myelination and iron concentration

PD mapping

- Define proton density
- Understand variable flip angle method for PD mapping
- Identify confounds and pitfalls in PD mapping, including B1 field inhomogeneities, acquisition at finite echo times
- List typical PD values for brain tissue and appreciate their variability across the brain and volunteers
- Understand the dependency of PD on myelination and free water, and its use for macromolecular tissue volume mapping (MTV)

T2 mapping

- Define the transverse relaxation time T2
- Understand multi echo methods for T2 mapping
- Identify confounds and pitfalls in T2 mapping
- List typical T2 values for brain tissue and appreciate their variability across the brain and volunteers
- Understand the dependency of T2 on myelination and iron concentration

MT mapping

- Define the magnetisation transfer ratio (MTR), two-pool model and its parameters
- Understand gradient echo experiment with additional off-resonance saturation pulse for MT weighting
- Identify confounds and pitfalls in MT mapping, including B1 inhomogeneities, off-resonance effects
- List typical two-pool model parameters for brain tissue and appreciate their variability across the brain and volunteers
- Understand the dependency of MT parameters on myelination

DWI

- Appreciate Diffusion-weighted Imaging (DWI) as a probe for microstructure
- Define the diffusion tensor and higher-order models including kurtosis tensor and NODDI
- Understand the single and twice-refocused spin echo experiment with diffusion-weighting gradients
- Identify confounds and pitfalls in DWI, including eddy currents, Maxwell fields, susceptibility-related distortion
- List typical DWI parameter values for brain tissue and appreciate their variability across the brain and volunteers
- Understand the dependency of DWI parameters on white and grey matter microstructure

Gradient echo for T2* and susceptibility mapping

- Define the effective longitudinal relaxation time T2* and susceptibility Chi
- Understand the multi gradient echo methods for T2* and susceptibility mapping
- Identify confounds and pitfalls in T2* mapping, including voxel size, shim
- Identify confounds and pitfalls in susceptibility mapping, including the inversion problem and external sources
- List typical T2* and susceptibility values for brain tissue and appreciate their variability across the brain and volunteers
- Understand anisotropic susceptibility in white matter via the hollow cylinder model
- Understand the dependency of T2* and susceptibility on myelination and iron concentration

Biophysical models and interpretation of quantitative MRI data

- Summarise the main contrast mechanisms in quantitative MRI (T1, T2, T2*, PD, MT)
- Identify the specific sensitivity of quantitative parameters to certain brain microstructure differences and changes
- Combination of different quantitative parameters to elucidate brain microstructure from different angles
- Review examples of recent multi-modal biophysical models, such as axonal g-ratio maps

Quantitative MRI in group analyses

- Describe spatial normalisation and shape analysis for multi-subject analyses
- Challenges of spatial normalisation and registration of different individual brains
- Correct treatment and transformation of quantitative MRI data in group registration approaches; Voxel-Based Quantification (VBQ)
- List possibilities how population studies can be used for understanding brain plasticity, development and validation of quantitative markers

Neuroanatomy

- Fundamental characteristics of grey matter and cortex
- Fundamental characteristics of white matter and major fibre tracts
- Identify major grey, white matter structures and nuclei
- Basic functional neuroanatomy and structure-function relationship
- Basic histology and its relationship to MRI and use for validation

Create your own echo: How to generate, calculate and manipulate echoes

June 20–22, 2016
Max-Planck-Institute for Biological Cybernetics
Tübingen, Germany

Course organiser:

Klaus Scheffler
Max-Planck-Institute for Biological Cybernetics
Tübingen/DE
Department of Biomedical Magnetic Resonance
University of Tübingen/DE

Local organiser:

Tina Schröder
Max-Planck-Institute for Biological Cybernetics
Tübingen/DE

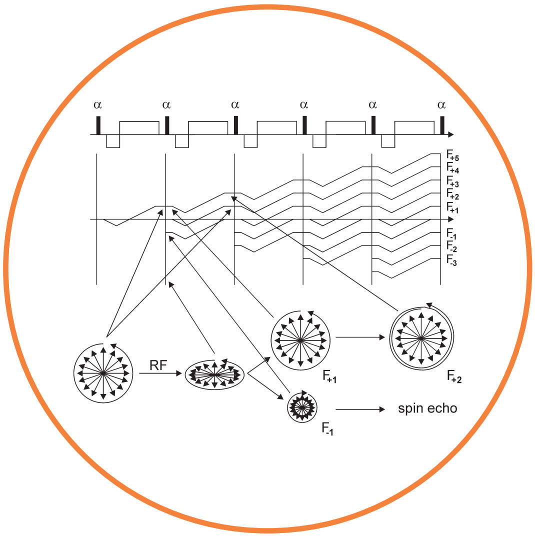
Preliminary faculty:

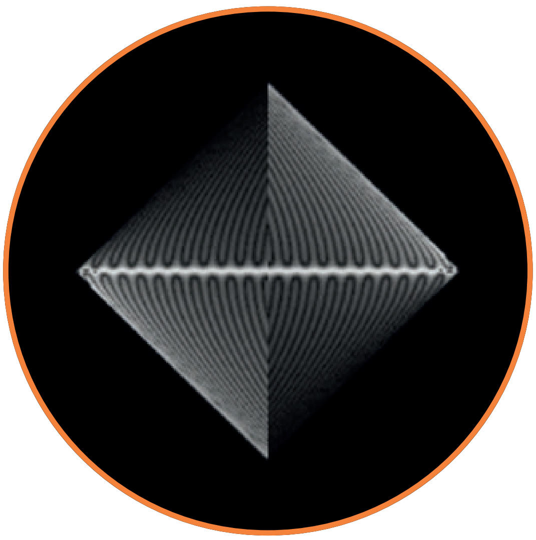
O. Bieri, C. Ganter, K. Scheffler, M. Weigel

Course description

The design and understanding of rapid imaging sequences seems to be a carefully sealed and treasured secret. A train of RF pulses and gradient pulses produce an unmanageable amount of echoes, and these echoes have to be combined and selected very meticulously to produce a useful signal for rapid imaging. How big should we choose the spoiler gradient within a gradient echo sequence, and what do we spoil? Can we use a Hyper Echo to reverse a gradient echo sequence? What is the steady state and its resulting contrast?

After very successful courses held in Basel, London, Essen, Magdeburg and Tübingen, this course will be repeated in Tübingen in 2016. The lectures are designed to provide a general and formal framework for the description and understanding of rapid multi-pulse experiments based on the Bloch equations and its Fourier analogy, the extended phase graph in k-space. This advanced course is aimed at established MR physicists, engineers, and other communities with several years of direct and practical experience in MRI applications and/or MRI technological research and development, who seek a deeper understanding of rapid imaging principles.





Learning objectives

Description of magnetisation in spatial and Fourier domain

- Bloch equations, applied to simple gradient and spin echo techniques
- Description of magnetisation as Fourier series, interpretation of Fourier coefficients as population of states
- Theory of partitions/states
- Description of spin echo, stimulated echo, higher order echoes with extended phase graph
- Calculation of echo amplitudes

Signal formation in rapid gradient echo sequences

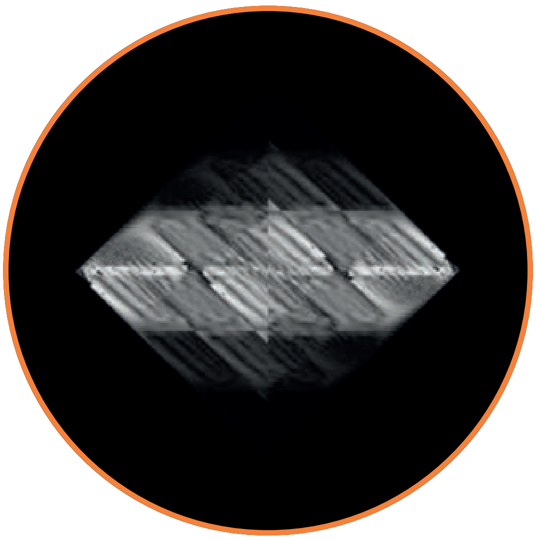
- The stopped pulse experiment
- Conditions and properties of the steady state
- Description of the steady state in spatial and Fourier domain
- Types of steady state sequences
- Double echo techniques
- Echo shifted techniques
- Contrast of rapid gradient echo techniques
- RF spoiling

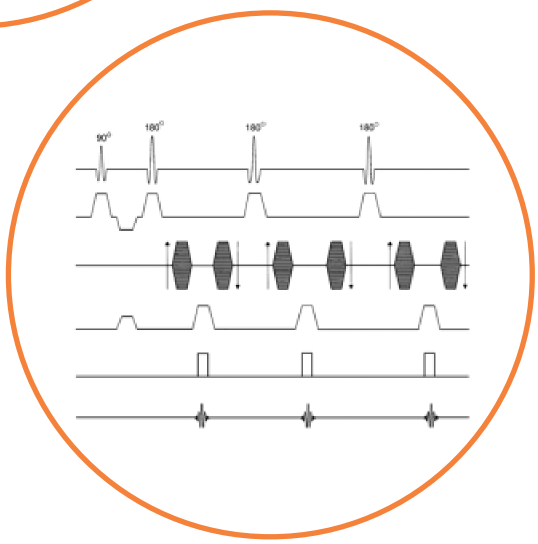
Signal formation in rapid spin echo sequences

- CPMG and non-CPMG condition
- CPMG with reduced refocusing flip angles
- Pseudo steady state
- Preparation of defined echo amplitudes
- Static pseudo steady state
- Hyper Echo
- Implementation of rapid CPMG sequences

Special rapid imaging techniques

- Gradient and spin echoes: GRASE
- Missing pulse techniques
- Motion, diffusion, and flow sensitivity of spin- and gradient echoes
- Single shot techniques
- Major clinical applications of rapid imaging techniques
- A summary of possible contrasts





RF coils:
Design, build and characterise your own

June 21–23, 2016
University of L'Aquila
L'Aquila, Italy

Course organisers:

Marcello Alecci
Molecular Imaging Laboratory
University of L'Aquila
L'Aquila/IT

Andrew Webb
C.J. Gorter Center High Field MRI
Leiden University Medical Center (LUMC)
Leiden/NL

Local organisers:

Marcello Alecci
Angelo Galante
Assunta Vitacolonna
University of L'Aquila
L'Aquila/IT

Preliminary faculty:

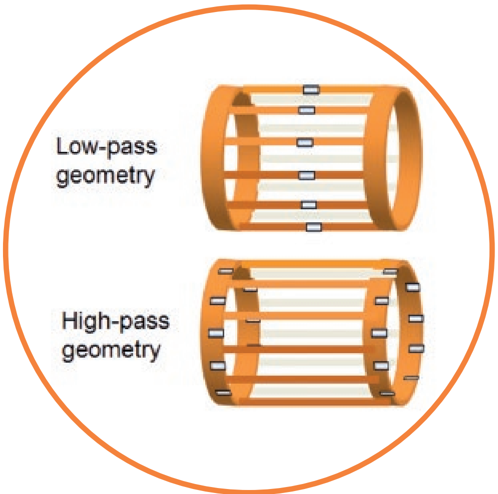
M. Alecci, N. Avdievitch, L. Darrasse, J. Mispelter, A. Monorchio, A. Webb

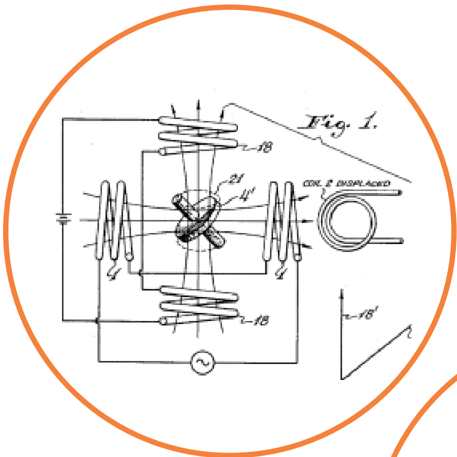
Course description

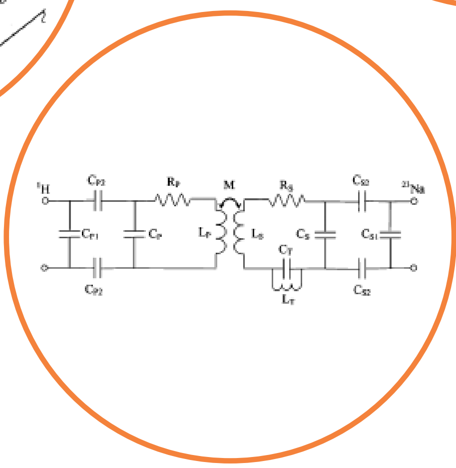
This course is designed to provide a theoretical and practical guide to RF coil design for both animal and human systems. Simple tools for electrical circuit analysis will be introduced, followed by practical design of simple geometries such as surface RF coils. The participants will then design and construct a RF coil with their chosen dimensions and frequency of operation. In the second stage, the design of volume RF coils will be introduced from a theoretical basis, software for modelling these coils discussed, and again the participants can choose which type of RF volume coil to design and construct during the practical session.

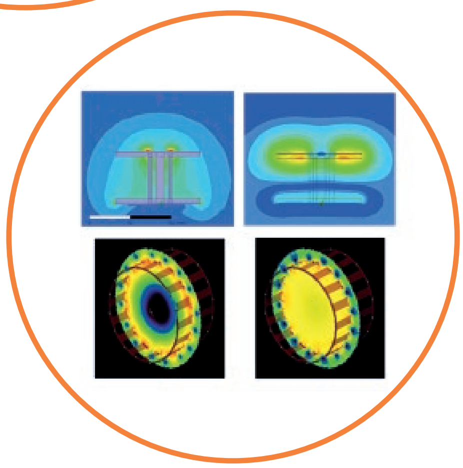
Finally, advanced topics such as multi-tuned coils and phased arrays will be introduced, designed and tested on the workbench. In addition to the large degree of practical work, the course will also include a substantial amount of time that will be spent on exercises, which are intended to enhance the understanding of basic and advanced topics and will be performed in small participant groups under guidance of the lecturers.

Since participants will construct their own RF coil this course is limited to a maximum 20 participants.









Learning objectives

RF circuit design

- Characteristics and use of lumped elements
- Concepts of resonant circuits
- Impedance matching for maximum power transfer
- Baluns and cable traps
- Maximising experimental SNR by optimising the coil quality factor
- Concepts in RF coil decoupling
- Multiple-tuned circuits

Hardware for RF testing

- Network analyser operation
- Quality factor measurements
- Frequency generators
- Resistance bridges, inductance and capacitance meters
- Workbench characterisation of RF coil performance

Simulation software

- Principles of EM simulation software packages
- B1-homogeneity versus B1-efficiency
- SAR considerations
- High frequency RF effects

Advanced RF coils

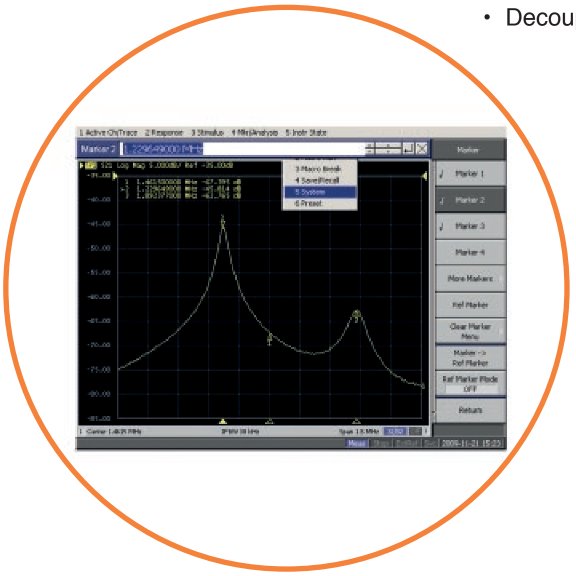
- Birdcage and TEM coils
- Phased arrays
- RF shields and eddy currents
- RF decoupling
- High-TC superconductive RF coils

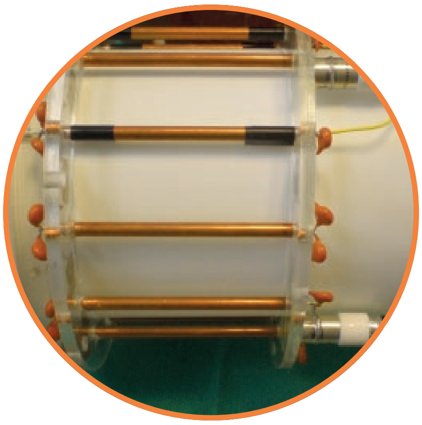
Practical design and/or construction

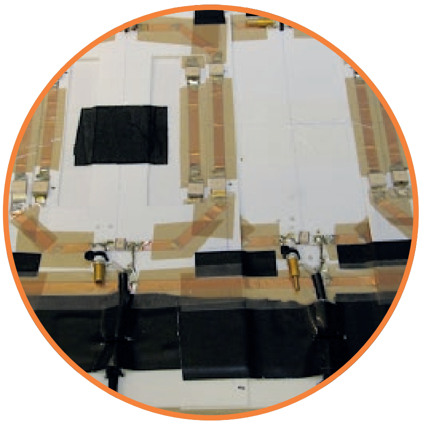
- Surface RF coil
- Solenoid RF coil
- Birdcage volume RF coil
- TEM volume RF coil
- Double-tuned RF surface coil
- Double-tuned RF birdcage and/or TEM coil
- Phased arrays

RF coil characterisation

- Scattering parameters
- RF coil sensitivity profile
- Signal-noise ratio performance
- B1-mapping and shimming
- Parallel imaging performance
- Decoupling and noise correlation







Non-Cartesian MRI: Implementation and application

NEW!

18

August 25–27, 2016
University of Würzburg
Germany

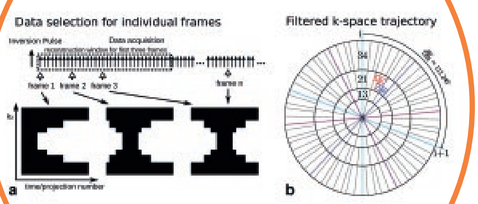
Course and local organisers:

Felix Breuer
Research Center Magnetic Resonance Bavaria (MRB)
Würzburg/DE

Philipp Ehses
Department of Biomedical Magnetic Resonance
University of Tübingen/DE

Preliminary faculty:

F. Breuer, P. Ehses, C. Mirkes, K. Prüssmann, M. Weiger, B. Wilm, B. Zahneisen



Course description

The course is designed to give an in-depth introduction to the basic concepts of the implementation of non-Cartesian imaging sequences and reconstruction. Various algorithms and methods will be presented and different approaches will be discussed.

Gradient waveform design giving time-optimal sampling and incorporating gradient slew rate and amplitude constraints will be covered and the implementation and reconstruction of various non-Cartesian MRI data including radial, spiral, PROPELLER, stack-of-spirals, stack-of-stars, 3D radial, and many more will be topics of this course.

The course will review conventional reconstruction of non-Cartesian k-space data using gridding, including practical algorithms such as INNG and Convolution Gridding. In addition, more advanced reconstruction ideas that are renewing the interest in non-Cartesian imaging will be discussed such as undersampling and sparse reconstruction and the ability to resolve motion as a different dimension.

The effect of unwanted phase errors, primarily from resonance offsets, eddy currents, concomitant fields and gradient waveform distortions are discussed and possible approaches to compensate/correct for these phase errors are presented, such as k-space trajectory measurements with special calibration pulse sequences or field camera hardware.

Finally, several applications where non-Cartesian sampling has proven advantageous over standard Cartesian sampling will be presented.

An integral part of the course will be the MATLAB tutorials where attendees will be able to work through example code provided for them. These examples will demonstrate and enhance their understanding of the concepts discussed throughout the course. Exercises will be set where attendees will modify this code to develop new examples and functionality.

Some previous exposure to MATLAB is preferable but not mandatory. Those participants who have not used MATLAB should have some programming experience. All participants will be expected to have basic understanding of MR physics. Furthermore, a working knowledge of image acquisition methods and k-space is essential.

Learning objectives

The overall goal is to educate participants about the underlying concepts of non-Cartesian MRI as well as all relevant considerations for practical implementations (sequences as well as reconstruction algorithms).

Basic principles of non-Cartesian MRI

- Introduction to the signal equation
- Radial: Radon transform, filtered back projection
- Gridding and density compensation
- Alternative gridding methods: GROG/INNG

Applications

- Lung imaging
- X-nuclei
- Cardiac imaging
- Relaxometry

Sequences/trajectories

- 2D radial/spiral/twirl
- 2D/3D UTE
- ZeroTE

Trajectory corrections

- Gradient delay correction
- Trajectory measurements
- Off-resonance compensation
- Field cameras

Parallel imaging/compressed sensing

- Define the reconstruction problem
- Review mathematical methods used in reconstruction
- Reconstruct non-uniformly sampled data with iterative methods (CG SENSE, SPIRiT)

Dynamic non-Cartesian MRI

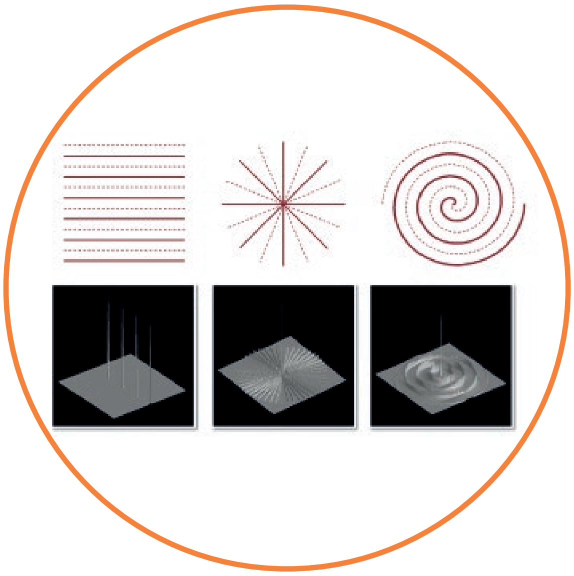
- Radial with view-sharing/pseudo random/golden angle
- DC self-gating
- Motion correction/gating

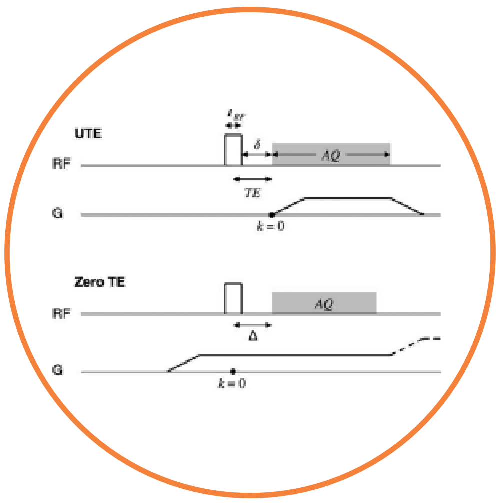
Accessing reconstruction quality

- Signal To Noise Ratio (SNR)
- Point Spread Function (PSF)

Future directions in non-Cartesian MRI

- Where is non-Cartesian MRI taking us?
- 'Killer' applications





RF pulses: Design and applications

September 8–10, 2016
H. Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences Krakow, Poland

Course organisers:

Martin Haas
Bruker BioSpin MRI
Ettlingen/DE

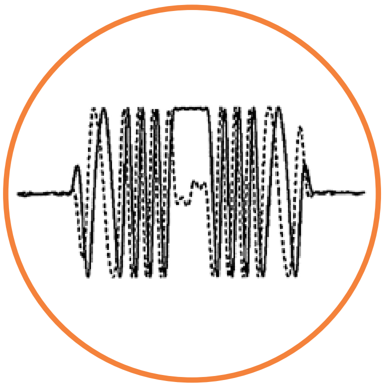
Franciszek Hennel
Institute for Biomedical Engineering (IBT)
University and ETH Zurich
Zurich/CH

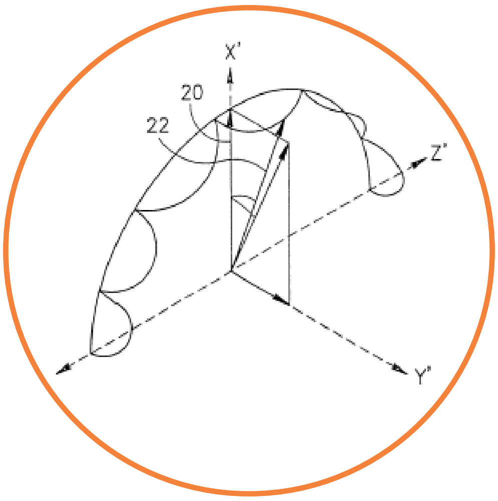
Local organiser:

Władysław Węglarz
H. Niewodniczański Institute of Nuclear Physics,
Polish Academy of Sciences Krakow, Poland
Krakow/PL

Faculty:

M. Haas, F. Hennel, J. Hennig, U. Katscher, R. Pohmann, R. Schulte, J. Warnking



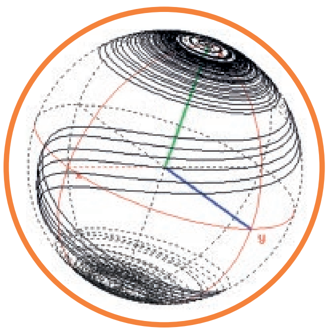


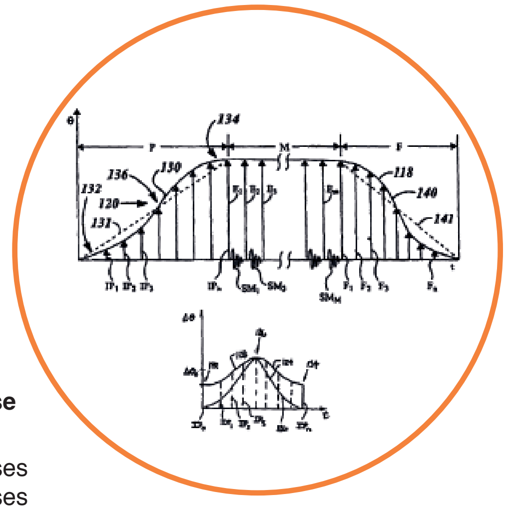
Course description

This course provides an in-depth introduction to basic and advanced RF pulse design methods and applications. It is intended for MR physicists, other scientists and PhD students who already have experience in basic MR methods and who wish to expand their knowledge in the field of RF pulse design and applications.

The course will start with an introduction to the physics and technical aspects of RF pulses and explain the basic design methods for RF pulses in the Small-Tip-Angle approximation as well as their limitations. Addressing these limitations the next module will present principles and properties of calculation techniques for Large-Tip-Angle pulses. Based on these foundations, a module will follow focusing on the different functions RF pulses can play in MRI sequences and examples regarding the proper choice of RF pulses for common MRI sequences will be discussed. A further module will give some insight into selected applications using special purpose RF pulses. The final part of the course will lead into the area of multidimensional selective pulses including an introduction to B1-mapping techniques as well as a module focusing on the rapidly evolving field of parallel transmission pulses.

Each module of the three-day course will consist of a lecture presenting the subject matter of the module and of accompanying exercises with audience participation, in order to deepen the understanding of the key aspects of the lecture.





Learning objectives

Basic RF pulse physics

- Interaction of RF with the spins: From quantum mechanics to classical view
- Frequency-selective pulses in Small-Tip-Angle (STA) approximation
- Combination of RF pulses and 1D gradients: Slice selection
- Excitation k-space (in 1D)
- Focus and effective phase of selective pulses
- Safety aspects: Specific Absorption Rate (SAR)
- SAR reduction with the VERSE principle

Large-Tip-Angle pulses

- Introduction into calculation methods for Large-Tip-Angle (LTA) pulses
  - Shinnar-Le-Roux approach
  - Optimal-Control approach

Which RF pulse should I choose for which function in my sequence?

- RF pulse functions:
  - Excitation pulses
  - Refocusing pulses
  - Inversion pulses
- What are the requirements for the different functions?
- Which pulse shapes are suitable for the different functions and why?
- Examples regarding major MRI sequences

Special purpose RF pulses

- Adiabatic pulses
- Multislice pulses
- Half pulses
- Composite pulses

B1-mapping

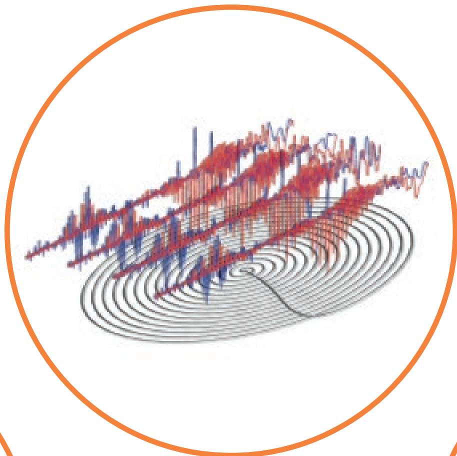
- Introduction into the problem of determining the transmit B1 field distribution
- Examples of common B1-mapping methods

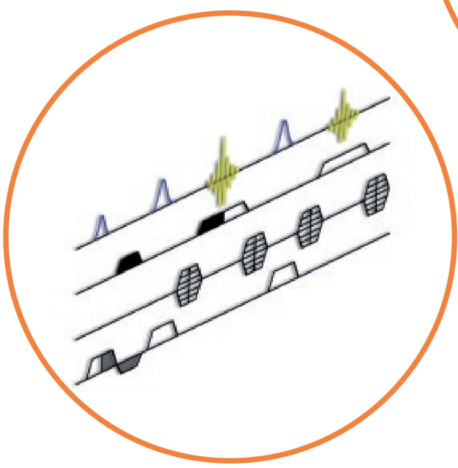
Multidimensional RF pulses

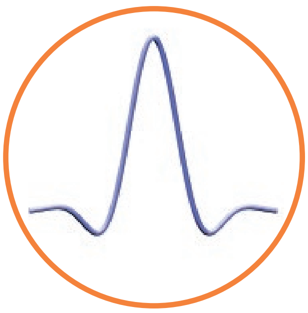
- Multidimensional spatially selective excitation (SSE): Localisation of the excitation in more than one dimension
- Multidimensional excitation k-space
- RF pulse calculation for multidimensional SSE in the STA and LTA
- Spectral-spatial RF pulses
- Applications of multidimensional RF pulses

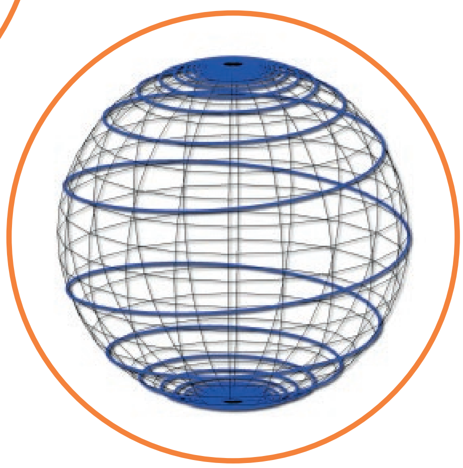
Parallel RF transmission

- From multidimensional excitation to parallel excitation/ transmit SENSE: Introducing new degrees of freedom
- Pulse calculation for parallel excitation in contrast to pulse calculation for SSE: New opportunities – new challenges
- Application perspectives of parallel transmission
- SAR and parallel transmission









In vivo MR spectroscopy: From basics to advanced methods

NEW!

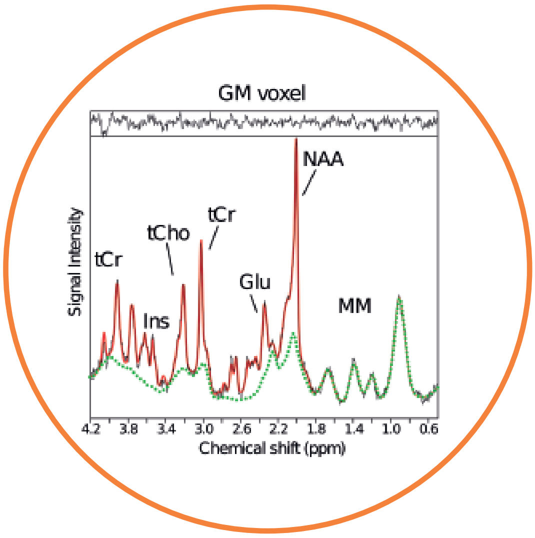
September 26–28, 2016
Vienna, Austria

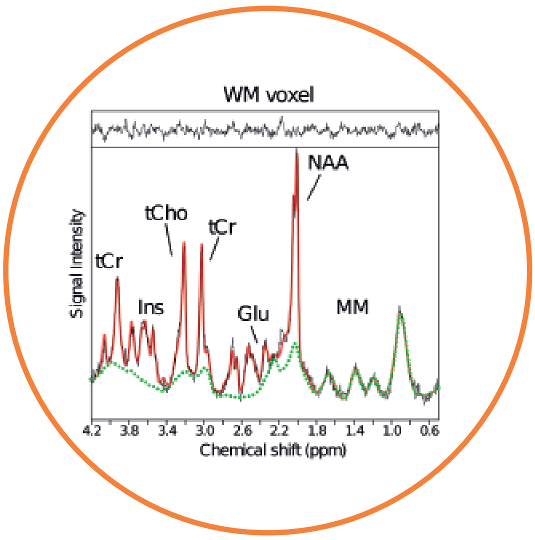
Course and local organisers:

Wolfgang Bogner
Gilbert Hangel
Bernhard Strasser
Michal Povazan
Medical University of Vienna/AT

Preliminary faculty:

V. Boer, W. Bogner, A. Henning, F. Jiru, T. Lange, L. Valkovic, M. Wilson





Course description

The aim of this course is to provide a comprehensive overview on MR spectroscopy techniques that are available nowadays. We will start from basic acquisition and post-processing methods that are currently used on clinical routine MR scanners and compare them with more advanced methods that are typically applied in research settings. The main focus will be to provide an understanding of the limitations and advantages of each method compared to other alternatives. After the course, participants will be able to choose the ideal MRS technique to support clinical studies, understand methodical weaknesses and know possible approaches to compensate/correct for them, and gain the basic understanding that is mandatory to further develop/modify MRS sequences.

The course programme includes modules with theoretical lectures, hands-on exercises (pre- and post-processing of MR spectroscopy data), as well as practical sessions in small groups (~10 participants) on a variety of different MR scanners (3T TIM Trio, 3T PRISMA, 7T MAGNETOM, Siemens, Erlangen).

The lectures will prepare the fundamentals for successful completion of the practical modules. They will start with an introduction on basic hardware requirements for MR spectroscopy, followed by a discussion of different acquisition/correction techniques, pre- and post-processing strategies for metabolite quantification, and an overview on specialised MR spectroscopy techniques (i.e. spectral editing, 2D spectroscopy, X-nuclei spectroscopy, functional MR spectroscopy, diffusion-weighted MR spectroscopy, ultra-high field MR spectroscopy).

During the practical exercises, the participants will deepen the subject matter of the lectures individually or in small groups by solving fundamental problems. Under the guidance of the faculty, different data processing steps will be examined and the adjustment of important simulation parameters with respect to the chosen method will be explained. During the course different research software will be presented. For the practical exercises and hands-on training, desktop PCs will be provided for the participants.

Learning objectives

Physics and acquisition techniques

Hardware & prescan requirements

- B0 Shims
- RF coils
- B1 inhomogeneites
- Coil combination
- Parallel transmit

MRS selection

- Conventional/adiabatic RF pulses
- Volume selection (from STEAM to LASER)
- Ultra-short TE (ISIS, SPECIAL)
- Short TE (STEAM)
- Long TE (PRESS, sLASER, LASER)

MRSI encoding

- Phase encoding
- Hadamard encoding
- Parallel imaging (SENSE, GRAPPA, etc.)
- Spectral-spatial sampling ((P)EPSI, spirals, etc.)

Suppression methods

- Water suppression (selective excitation/refocusing, non-suppressed)
- Lipid suppression (relaxation-based, post-processing)
- Outer volume saturation

Artifacts & correction

- Spectral quality assessment
- Motion correction
- Scanner instability
- Eddy currents

Data processing & analysis

NMR simulations

- J-coupling
- Relaxation
- Prior knowledge & basis sets

Spectral processing & quantification

- Pre-processing steps
- Time-domain vs. frequency-domain fitting
- Absolute quantification
- Partial volume correction

Advanced MR spectroscopy techniques

Spectral editing & 2D MRS methods

- J-difference editing
- Multiple quantum coherence
- Heteronuclear editing
- COSY
- J-resolved NMR

X-nuclei MR spectroscopy

- 31P-MRS
- 13C-MRS
- Dynamic MRS
- Magnetisation transfer

Ultra-high field MR spectroscopy

- Possibilities
- Challenges
- New approaches

Functional MR spectroscopy

- (Hardware) setup
- Acquisition strategies
- Analysis

Diffusion-weighted MR spectroscopy

- Implementation
- Post-processing
- Analysis

Practical exercise of MR spectroscopy

- Human MRS examinations at three different Siemens MR scanners (3T TIM Trio, 3T PRISMA, 7T MAGNETOM)
- Spectral preprocessing and evaluation with different software: MATLAB-based, LCModel, jMRUI, TARQUIN at separate computers will be performed

Registration

In order to register for your desired course(s), please visit our website at **www.esmrmb.org**.

Please note that your registration becomes valid only upon reception of payment and confirmation by the ESMRMB Office, the latter will be available for download in the online 'MyUser Area'.

Registration

Rates refer to one course. If more than one course is booked at once, a 10% reduction will be granted.

Apply to all ESMRMB Lectures on MR courses in 2016.

The registration fee includes
- Attendance of the course
- Teaching material for the course (digital syllabus)
- Coffee & Lunch
- Welcome Reception

Participants are responsible for their own travel and hotel arrangements. When making your flight bookings, please make sure that you will be able to stay for the entire course.

Terms of cancellation

In the case of cancellation of registration by the participant:

> 4 weeks before the course date: the registration fee will be refunded less 20% for administrative costs.
< 4 weeks before the course date: No refund will be granted.

If less than 20 participants register, ESMRMB reserves the right to cancel a course at the latest 4 weeks prior to its beginning. Please keep this in mind for your travel arrangements.
Please be aware that the ESMRMB does not cover or refund for travel and hotel expenses in any case.

Registration is possible online at **www.esmrmb.org**

Registration fees
(except RF coil design course)

Early registration fees
(until 8 weeks prior to the course)

	Members*	**Non-Members**
Basic scientists, physicians, MR technologists/radiographers and others with a professional degree	**€ 490**	**€ 660**
PhD students and physicians in training**	**€ 340**	**€ 435**

Late registration fees
(after 8 weeks prior to the course)

	Members*	**Non-Members**
Basic scientists, physicians, MR technologists/radiographers and others with a professional degree	**€ 610**	**€ 805**
PhD students and physicians in training**	**€ 410**	**€ 530**

Industry fee
This rate applies for employees/representatives of commercial companies.

€ 990

RF coils: Design, build and characterise your own
Please note that due to special requirements for this course different registration fees apply.

Early registration fees
(until 8 weeks prior to the course)

	Members*	**Non-Members**
Basic scientists, physicians, MR technologists/radiographers and others with a professional degree	**€ 640**	**€ 810**
PhD students and physicians in training**	**€ 490**	**€ 585**

Late registration fees
(after 8 weeks prior to the course)

	Members*	**Non-Members**
Basic scientists, physicians, MR technologists/radiographers and others with a professional degree	**€ 740**	**€ 935**
PhD students and physicians in training**	**€ 540**	**€ 660**

Industry fee
This rate applies for employees/representatives of commercial companies.

€ 1,150

* Reduced course fees are available for members in good standing who have paid their 2016 ESMRMB membership fee.
** PhD students and physicians in training are requested to provide a signed attestation from the head of the institution/department confirming their student/training status no longer than 10 days after the registration.