Training course

on Hyperpolarized 13C &129Xe MRI:

moving to clinical use

Venues:

MR Research Centre
Aarhus University
Palle Juul-Jensens Boulevard 99
G205
8200 Aarhus N
Denmark
Contact no: 40465622

Hotel GUESTapart
Tueager 5
8200 Aarhus N

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Training course on Hyperpolarized 13C &129Xe MRI: moving to clinical use

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Program

Monday October 10th

Venue Hotel GUESTapart – registration 8.30-8.55.

09:00-09:45	Welcome, practical details, speaker intro (CL & RFS)
09:45-10:30	Introduction to MR, general overview (SR)
10:30-11:00	coffee break
11:00-11:45	Introductory round (1-2 min from each participant)
11:45-12:30	Running a hyperpolarised MR exam: MRSI, physics, constraints, prescan (JL)
12:30-13:30	lunch
13:30-14:15	Introduction to d-DNP (JHAL)
14:15-15:00	Reconstruction methods: gridding, parallel imaging, SVD (MF)
15:00-15:30	coffee break
15:30-16:15	Postprocessing techniques: fitting, metabolic modelling, denoising (JWG)
16:15-17:00	Imaging strategies: sequences and trajectories (RFS)
17:00-18:00	Meet the Experts session
18:00-20:00	Dinner at hotel GUESTapart Possibility of buying a drink at the hotel after the dinner

Tuesday October 11th

We walk from hotel to hospital 8.50 → the MR Research Centre

09:00-10:30	Hyperpolarisation rotations, Large animal experiments, Matlab, data analysis
10:30-11:00	coffee break
11:00-12:30	Hyperpolarisation rotations, Large animal experiments, Matlab, data analysis
12:30-13:30	lunch
13:30-15:00	Hyperpolarisation rotations, Large animal experiments, Matlab, data analysis
15:00-15:30	coffee break
15:30-16:15	Introduction to SEOP (GN)
16:15-17:00	Imaging considerations for 129Xe MRI (JMW)
17:00-18:00	Free time
18:00-20:00	Dinner at hotel GUESTapart Possibility of buying a drink at the hotel after the dinner

Wednesday October 12th

We walk from hotel to hospital 8.50 → the MR Research Centre

09:00-10:30	Hyperpolarisation rotations, Large animal experiments, Matlab, data analysis
10:30-11:00	coffee break
11:00-12:30	Hyperpolarisation rotations, Large animal experiments, Matlab, data analysis
12:30-13:30	lunch
13:30-15:00	Hyperpolarisation rotations, Large animal experiments, Matlab, data analysis
15:00-15:15	coffee break
15:15-16:00	DNP Data Synthesis and Optimal Inference (MF)
16:00-16:45	Panel discussion: challenges and future of hyperpolarised MR
16:45-18:00	Quick travel to the Museum – by Letbanen (leaves at 17.09)
18:00-20:00	Guided tour and dinner at ARoS Aarhus Art Museum

Thursday October 13th

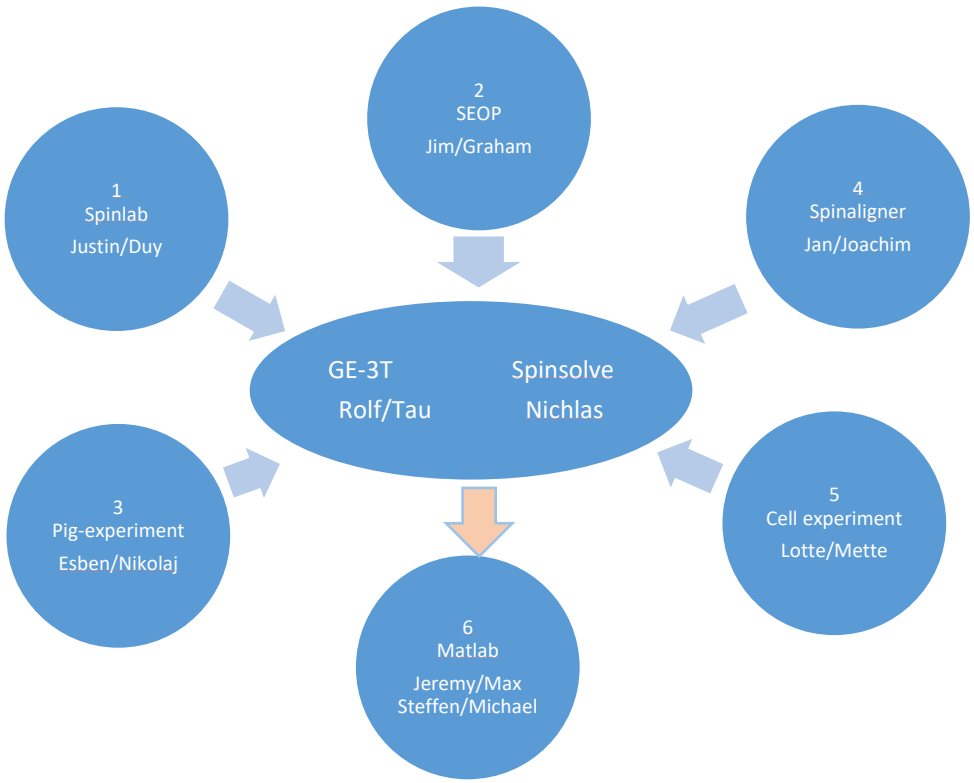
Venue Hotel GUESTapart

09:00-09:45	Advanced acquisition strategies (JWG)
09:45-10:30	Artefacts (RFS)
10:30-11:00	coffee break
11:00-11:45	MNS Hardware and Coils (JMW)
11:45-12:30	Considerations for Human experiments (CL)
12:30-13:15	lunch
13:15-13:45	Alternatives to imaging in vivo (LBB)
13:45-14:15	Course evaluation and farewell – coffee and cake

CL = Christoffer Laustsen
GN = Graham Norquay
JHAL = Jan Henrik Ardenkjær-Larsen
JL = Justin Lau
JMW = Jim Wild
JWG = Jeremy W. Gordon
LBB = Lotte Bonde Bertelsen
MF = Maximilian Fuetterer
RFS = Rolf Schulte
SR = Steffen Ringgaard

Training session schedule

Time schedule/stations	1	2	3	Scan session 3T	4	5	6
Tuesday							
09:00-09:30							
09:30-10:00							
10:00-10:30				Coil setup and walk through			
11:00-11:30				Coil setup and walk through			
11:30-12:00							
12:00-12:30				SEOP "injection"			
13:30-14:00				Change coil			
14:00-14:30							
14:30-15:00				Spinlab "injection"			
Wednesday							
09:00-09:30							
09:30-10:00							
10:00-10:30				Coil setup and walk through			
11:00-11:30							
11:30-12:00				SEOP "injection"			
12:00-12:30				Spinlab "injection"			
13:30-14:00							
14:00-14:30				SEOP "injection"			
14:30-15:00				Spinlab "injection"			



Matlab exercises during the training sessions

The exercises consist of hyperpolarized 13C and 129Xe MRI analyses and data processing. You will not be able to complete all the exercises during the appointed time on the training course. Recommendation is to choose the topic most relevant to you and later complete the remaining. The five topics are as listed below:

1. Carbon 13: Polarization test and CSI data reconstruction (RFS)
2. Carbon 13: Kinetic modelling and quantification of metabolism (JG)
3. Carbon 13 + Xenon 129: Reconstruction methods and synthetic data generation (MF)
4. Xenon 129: Time-domain Voigt fitting of dissolved-phase in the lungs (GN)
5. Xenon 129: Flip angle calibration and k-space correction (JW)

Prerequisite

The exercises are written in or with solutions in Matlab (link).

Data and exercises material

Please download the exercises material prior to attending the course.

This can be done via the following FileSender link (expires 20/10/2022):

https://filesender.deic.dk/?s=download&token=4b2dc373-7505-be76-72ef-14100e6985dc

Faculty/Speakers

Christoffer Laustsen, DMSc, PhD

Graduated in physics and Nano Science from Aarhus University and received his PhD in medical research from the same university. Professor and head of MR Research at the MR-Research Center, Department of Clinical Medicine, Aarhus University, Denmark.

His main research focus has been on introducing the novel imaging methodology Dynamic Nuclear Polarization for early identification and monitoring of the disease diabetic nephropathy.

Jan Henrik Ardenkjær-Larsen, PhD

Graduated as an engineer from the Technical University of Denmark, and received his PhD from the same university before being employed for many years as a principal scientist at GE Healthcare.

Currently professor and head of the section for Magnetic Resonance as well as center leader for Hyperpolarization in Magnetic Resonance at DTU, Denmark. His research has evolved around means to improve the sensitivity of Magnetic Resonance (MR) Imaging and Spectroscopy, to obtain new, and otherwise inaccessible, information about function and disease at the cellular and molecular levels.

He is the main developer of the methods employed for modern dissolution dynamic nuclear polarization, and has received a number of scientific rewards for his research.

Maximilian Fuetterer PhD

Received his PhD in Biomedical Engineering from ETH Zurich. Completed a postdoctoral fellowship at the University of Oxford. Currently employed as Technical Director for Hyperpolarization and Moderate-Field Imaging at the University and ETH Zurich .

His work focuses on the development of methods (pulse sequences, reconstruction, analysis) for hyperpolarized 13C MR, with a focus for cardiac applications. He is responsible for maintaining and optimizing the platforms (polarizer, scanners, coils, phantom) and coordination of clinical and pre-clinical trials.

Jeremy W. Gordon, PhD

Received his PhD from the University of Wisconsin-Madison in Medical Physics. Currently employed as Assistant Professor at UCSF, USA.

He uses advanced imaging techniques to provide physiologic and metabolic information with MRI, with a focus on the development of novel and rapid acquisition strategies and reconstruction methods for spectroscopic imaging on preclinical and clinical systems.

He leads the technical aspects of the DNP polarization and EPI sequence developments for HP C-13 MR human studies.

Jim Wild, PhD

Received his PhD in MR spectroscopy from the University of Edinburgh. Professor at the University of Sheffield and head of POLARIS (Pulmonary, Lung and Respiratory Imaging Sheffield).

His research focuses on the physics and engineering and clinical applications of hyperpolarized gas (3He and 129Xe) and proton MRI in the lungs and pulmonary vasculature.

Justin Lau PhD

Received his PhD in Medical Biophysics from the University of Toronto. Completed a postdoctoral fellowship at the University of Oxford. Currently Operations Manager of the SPINlab division at GE Healthcare.

His research interests include developing tools such as coils, phantoms, pulse sequences, and acquisition strategies for hyperpolarized 13C imaging. His current work focuses on the production of the next generation of SPINlab technology as a platform for dynamic nuclear polarization research.

Graham Norquay, PhD

Graduated in physics from the University of Glasgow and received his PhD in MR physics from the University of Sheffield. Currently Lecturer in Magnetic Resonance Physics at the University of Sheffield. Leads a lab within the POLARIS (Pulmonary, Lung and Respiratory Imaging Sheffield) group dedicated to the hyperpolarisation of xenon gas for ongoing research and clinical applications with 129Xe MRI.

His research interests span fundamental developments in nuclear spin polarisation physics to exploring new biomedical applications of hyperpolarised 129Xe NMR.

Lotte B. Bertelsen, PhD

Graduated from Aarhus University in Molecular biology and received her PhD degree in medical research from the same university. She is currently an assistant professor at the MR Research centre, Aarhus University.

Her main focus and interests are the development of methods for the study of metabolism in cells and tissue specimens using hyperpolarized MR and biochemical methods.

Rolf Schulte, PhD

Received his PhD in the development of methods for MR spectroscopy from ETH, Zürich. He is currently employed with GE as one of the lead developers of multinuclear MR methods.

His work focuses on the development of sequences and reconstruction methods for multi nuclear MR and, in particular, for hyperpolarized MR.

He is the developer of the Fidall package for doing multi-nuclear spectroscopy and imaging and reconstruction on GE systems.

Steffen Ringgaard, PhD

Graduated in physics from Aarhus University and received his PhD in medical research from the same university. He is currently employed as an associate professor at the MR Research Centre, Aarhus University.

His main interests focus on the development of magnetic resonance methods and analysis tools.

Travel

Getting to Aarhus by air

Travelling to/from Aarhus Airport

The Aarhus airport Tirstrup is located 40 km north of the city and offers direct international flights to a number of European destinations, for instance Oslo, Stockholm, Gothenburg, Manchester, London (Stansted and Gatwick), Berlin, Munich, Nice, Rome and Cyprus. Please visit their website for information on flight arrival/departure times.

There is an airport shuttle bus from Aarhus airport with frequent departures (every 20 minutes after each flight arrival with departures from just outside the main entrance). The fare is about DKK 100 and it takes about 50 minutes to reach downtown Aarhus. The bus stops at the Aarhus University campus (at Nobelparken). Click on link below for more information on airport bus information or call (+45) 8612 8622.

Bus fare can be paid cash (DKK, NOK, SEK, USD, GBP, EUR). The following credit cards are also accepted on the Airport bus: Dankort, VISA, MasterCard or JCB.

There are direct flights between Aarhus Airport/Tirstrup and Copenhagen International Airport with many daily departures on weekdays and some departures on Saturdays and Sundays. The flight takes 35 minutes. In Copenhagen a free transit bus links the International and Domestic airport terminals.

Aarhus airport Tirstrup

Airport bus information

Copenhagen International Airport

Travelling to/from Billund airport

Billund airport is located 100 km south of Arhus and has direct international flight connections to many European destinations, including Barcelona (Girona), Berlin, Birmingham, Brussels, Edinburgh, Faro, Frankfurt, London, Manchester, Milan, Munich, Oslo, Paris, Riga, Rome, and Stavanger. Please visit the airport website for more information on arrivals and departures.

There is an airport shuttle bus between Aarhus and Billund airport with several daily departures – please click airport link down below to find more information. The travel time from Billund Airport to downtown Aarhus is approximately 1 hour and 30 minutes. Tickets are sold on the bus for about 140 DKK. The following credit cards are also accepted on the Airport bus: Dankort, VISA, MasterCard, Visa Electron, V Pay, China Union Pay, American Express or JCB.

Billund airport

Travelling to/from Copenhagen airport

Please visit the website for more information on arrivals and departures by plane. For connecting trains to Aarhus, please click DSB-link down below. Copenhagen airport is connected to Aarhus Airport/Tirstrup with many daily departures on weekdays and some departures on Saturdays and Sundays. The flight takes 35

minutes. In Copenhagen a free transit bus links the International and Domestic airport terminals. Copenhagen airport has direct flight connections to a large number of international destinations.

Copenhagen Airport
DSB
Aarhus Airport Tirstrup

Getting to Aarhus by train

Aarhus lies at one of the most important railway junctions in Denmark. There are hourly departures to the north, south and west. From Southern and Central Europe, the connections are via Hamburg/Flensburg. Travel time from Hamburg to Aarhus is approximately five hours. From Eastern European countries train connections to Aarhus go via Poland and Copenhagen. Aarhus has hourly services to and from Copenhagen. The opening of the Tunnel under the Great Belt has shortened the journey by one hour, so now the trip takes three and a half hours. There are several daily connections to Sweden, Germany and the rest of Europe.

Please visit *DSB* or *DSB Journey planner* to find all your connection route options.

Trains bound for Aarhus railway station leave Copenhagen Airport hourly. The price is about DKK 410 for a one-way ticket (including seat reservation). To buy a ticket at the Copenhagen airport, you should go to the DSB Ticket Sales booth in Terminal 3 just above a rolling sidewalk which takes you down to the train.

Getting to Aarhus by ferry

Check the *Molslinjen website* for current timetables for ferries to Zealand (Aarhus-Odden).

Getting to Aarhus by car

Aarhus has direct connections to the great European network of motorways, making it easy to get to most European cities. Hamburg can be reached within roughly four hours. There are also excellent roads to most places in Denmark. For more information, please check location on the map *MR research Centre*, *Hotel GUESTapart*

Getting to Aarhus by taxi

Individual taxi services are available - approx. DKK 600 from Aarhus Airport to Aarhus and DKK 1500 from Billund Airport to Aarhus.

Getting around in Aarhus

City busses

Midt Trafik, the municipal bus company, runs the yellow buses in the city. The bus route number is indicated at the front and the back of the bus and the destination is displayed at the front and above the rear door. Every bus is equipped with a ticket machine in the middle of the bus (coins and self service only).

Bus tickets for travel within the city limits (Municipality of Aarhus limits) cost 22 DKK. Please check the *Midttrafik website* for more information on busses and city links.

City light rail (Letbanen)

Getting around in Aarhus is also easy with Denmark's first light rail, Letbanen, operated by the company Midttrafik. Stops are located throughout Aarhus, making it easy to experience the city. The area around the Central Station and Dokk1 is the main junction point. Tickets for travel within the city limits (Municipality of Aarhus limits) cost 22 DKK. Remember to buy your ticket before entering Letbanen because you cannot buy tickets in the train.

The light rail has a direct connection between Aarhus railway station and Aarhus University Hospital, just next to Hotel GUESTapart.

List of Participants

First name	Last name	Organisation	Group
Helen	Abeln	DKFZ (German Cancer Research Center)	Red
Emma	Wiström	École polytechnique fédérale de Lausanne (EPFL)	Red
Lionel	Mignion	UCLouvain	Red
Yupeng	Zhao	Technical University of Denmark	Red
Axel	Morgenstjerne	Polarize ApS	Red
Mathias	Loft	KU	Red
Mattias	Kristensen	MR Research Centre, AU	Red
Mariia	Anikeeva	MOIN CC, Section Biomedical imaging, University of Kiel	Green
Marie	Garnæs	Technical University of Denmark	Green
Ingeborg	Skree	DTU	Green
Seyma	Alcicek	University Hospital Frankfurt, Goethe University	Green
Peter	Bodin	Polarize APS	Green
Uffe	Kjærgaard	MR Research Centre, AU	Green
Malene	Aastrup	MR Research Centre, AU	Green
Rie	Bech Olin	Technical University of Denmark	Blue
Nicolas	Joudiou	UCLouvain	Blue
Daniel	Gebrezgiabhier	University of California - San Francisco	Blue
Josh	Peters	Section Biomedical Imaging, MOIN CC Dept. Rad. and Neu.	Blue
Andreas	Clemmensen	KU	Blue
Mohsen	Redda	MR Research Centre, AU	Blue

Speakers, sponsors and others

First name	Last name	Organisation
Jeremy	Gordon	UCSF
Jim	Wild	University of Sheffield
Graham	Norquay	University of Sheffield
Max	Fuetterer	University and ETH Zurich
Jan Henrik	Ardenkjaer-Larsen	Technical University of Denmark
Magnus	Karlsson	Hypermag, DTU Health
Pernille Rose	Jensen	Hypermag, DTU Health
Andrea	Capozzi	Technical University of Denmark
Mathilde	Lerche	DTU
Joachim	Vinther	Polarize
Rolf	Schulte	GE Healthcare
Justin	Lau	GE Healthcare
Poul Erik	Holm	GE Healthcare
Kasper	Larsen	GE Healthcare
Christoffer	Laustsen	MR Research Centre, AU
Lotte	Bonde Bertelsen	MR Research Centre, AU
Esben	Søvsø Szocska Hansen	MR Research Centre, AU
Steffen	Ringgaard	MR Research Centre, AU
Michael	Væggemose	MR Research Centre, AU
Nikolaj	Bøgh	MR Research Centre, AU
Nichlas	Vous Christensen	MR Research Centre, AU
Duy	Anh Dang	MR Research Centre, AU
Tau	Vendelboe	MR Research Centre, AU
Lone	Hanberg	MR Research Centre, AU
Maria	Ditlev	MR Research Centre, AU
Mette	Dalgaard	MR Research Centre, AU
Ida	Mieritz	MR Research Centre, AU
Rikke	Holm	MR Research Centre, AU