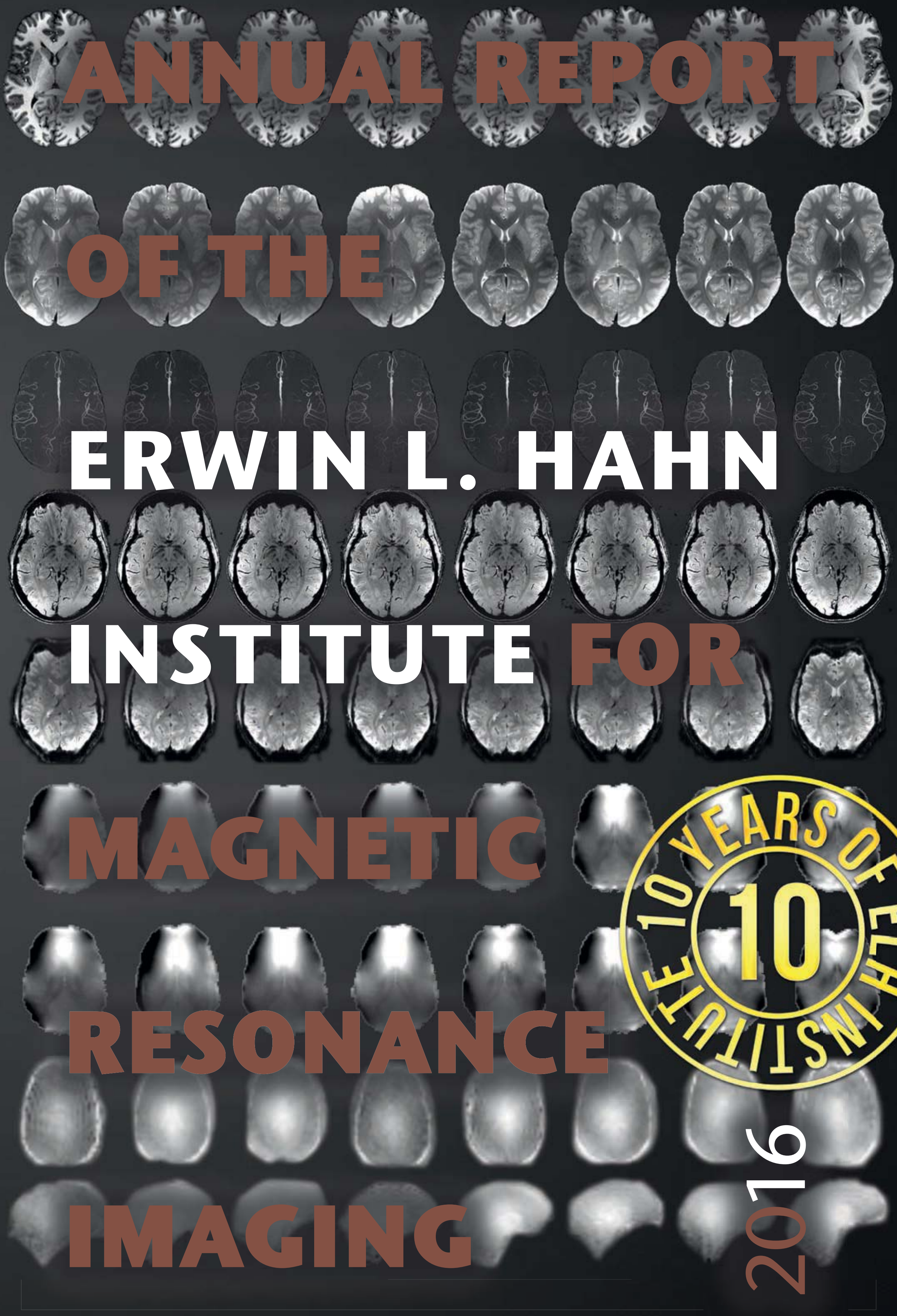
ANNUAL REPORT OF THE ERWIN L. HAHN INSTITUTE FOR MAGNETIC RESONANCE IMAGING



10 YEARS OF ELH INSTITUTE 10

2016

Erwin L. Hahn Institute for Magnetic Resonance Imaging

Kokereiallee 7
D-45141 Essen
Germany

t ++49 (0)201-183-6070
f ++49 (0)201-183-6073
w www.hahn-institute.de

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“10 Years Erwin L. Hahn Institute” – First row, picture on the very left and second row, picture on the very right, courtesy of Martin Christopher Welker (www.martinchristopherwelker.de).

“’An irritating glitch’: In Memoriam Erwin L. Hahn“ - pictures courtesy of Larry Wald and David Feinstein. Many thanks.

Preface

The year 2016 was a very special year for the Erwin L. Hahn Institute in many regards. We celebrated the 10th year of the existence of the Erwin L. Hahn Institute on the unique grounds of the UNESCO World Heritage Zeche Zollverein. When we officially started in the year 2006, our 7Tesla MRI system was only the 6^{th} MRI system in the world operating at this magnetic field strength. By now, almost 70 MRI systems with a magnetic field strength of 7 Tesla or even higher are installed worldwide – and the number is growing.

We invite you to take a look back at our 10^{th} Hahn Lecture which took place on the 5^{th} of October 2016 in the beautiful location of the Ruhr Museum on top of the Zeche Zollverein, Essen. Seven internationally renowned speakers followed our invitation to celebrate with us the 10^{th} year of 7 Tesla at the Erwin L. Hahn Institute. Numerous guests and colleagues from all over Germany and The Netherlands were in attendance. In this annual report, you will find some impressions of this memorable event.

When finalizing the preparations for the 10^{th} Erwin L. Hahn Lecture in September 2016, we learned the sad news that the scientist who generously accepted that we name our institution after him, Professor Erwin Louis Hahn, had passed away peacefully in his sleep. Erwin Hahn was age 95. We highly respected Professor Hahn not only for his enormous scientific contributions to our research field – for example as the father of the spin-echo – but moreover for his very inspiring, motivating and humorous nature. Those of us who had the luck and honor to meet him during his visit to our institute in 2009 were deeply impressed by this outstanding scientist and will treasure this memory. We are proud and honored to perpetuate his memory by continuing ultra-high field MRI research in his name. In this report, you will find a brief remembrance of Erwin L. Hahn.

Scientifically, we also have advanced our endeavors in UHF-MRI. Together with our 11 partner institutions in the German Ultrahigh Field Imaging (GUFI) Network, a DFG-funded initiative, we have successfully initiated and conducted a multi-center study to evaluate the reproducibility of our 7 Tesla MRI equipment at all German UHF institutions. Two “traveling heads” report about their experience performing phantom and volunteer measurements at all different GUFI partner sites. The study is the first of its kind, and the outcome provides a foundation for further multi-center UHF-MRI studies. Thankfully, the DFG decided to continue funding the GUFI network for another funding period of 3 years. We invite you to read more about this great example of true scientific cooperation and active networking in our annual report.

We hope that you will enjoy this brief review and summary of our research activities in 2016, and will continue to be interested in the activities of the Erwin L. Hahn Institute.

Harald H. Quick
Essen, February 2017

Excellence in Brain and Body UHF-MRI

Scientific Scope

Harald H. Quick, David G. Norris, Matthias Brand

2016 marked the 10th anniversary of the Erwin L. Hahn Institute for Magnetic Resonance Imaging and thus 10 years of UHF-MRI research at the institute. From the beginning, the unique research structure of the ELH has been synergistically combining and mutually fostering the research activities and scientific scope of seven PIs with their respective groups. The motto which best describes this approach is probably *"Excellence in brain and body UHF-MRI"*.

The PIs Prof. David Norris, Prof. Matthias Brand, Prof. Ulrike Bingel, and Prof. Dagmar Timmann are all active in different, yet complementary aspects of *UHF brain MRI* research, reaching from UHF-MR methodology and layer-specific fMRI (Norris) to cognitive brain function (Brand), from fMRI in processing of pain (Bingel), to the structural and functional analysis of the cerebellum with 7T MRI and fMRI (Timmann).

The PI groups of Prof. Mark Ladd, Prof. Harald Quick, and Prof. Tom Scheenen on the other hand focus on development of hardware, methodology, and clinical applications in *UHF body MRI*. The unique RF transmit/receive multichannel hardware developed at the ELH by Prof. Ladd's PI group is now complemented by hardware and methodology developments as well as early clinical applications of Prof. Quick's PI group. With a focus on cancer imaging in the human body, Prof. Scheenen's PI group is at the forefront of clinical application of UHF body MRI in prostate cancer patients.

It should be noted that the 7 PI groups at the ELH are all cross-linked, and actively collaborating in various aspects and projects, including various cooperations between the brain and the body focused PI groups. Furthermore, all PIs at the Erwin L. Hahn Institute share the same hardware, infrastructure, methodology, and on-site expertise as well as research and service staff. Consequently, a broad range of projects and collaborators immediately profit from new hardware and method developments for their own research activities.

ELH Research Topic Brain

Focus on methods and mechanisms

Brain activation studies at 7T open up possibilities of improved spatial resolution and increased sensitivity compared to lower static magnetic field strengths. However, this leads to various new challenges, such as increased technical difficulties, and unresolved questions as to the ideal contrast.

The leitmotif for Prof. Norris' group's work on fMRI methods is the use of multi-channel receiver coils to increase acquisition speed, and to reduce RF power deposition. In this context the group has, for example, invented PINS RF pulses and pioneered their use in SAR reduction at 7T. This made it possible to collect whole brain spin-echo resting state and task data. It was also possible to accelerate turbo spin-echo acquisitions by using PINS pulses.

Furthermore, Prof. Norris' group has also investigated the use of different contrasts for fMRI including gradient-echo, spin-echo and SSFP; reaching the overall conclusion that for almost every application gradient echo contrast is the superior method.

A second major theme has been layer specific fMRI, where 3D EPI was utilised alongside biophysical modelling of the BOLD response, and the development of the spatial general linear model to convincingly demonstrate layer specific top-down signal modulation.

Finally, in recent years the group of Prof. Norris started working on techniques for GABA spectroscopy, as despite the low sensitivity of GABA measurement this signal appears to offer complementary information to that available in BOLD.

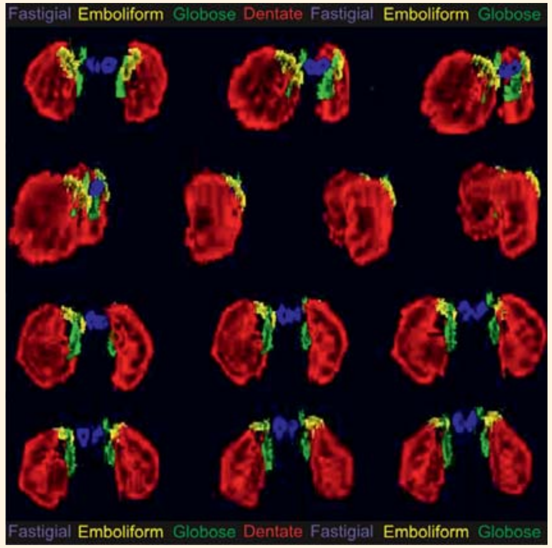
Focus on Subcortical Structures

The ELH PI groups of Prof. Bingel, Prof. Brand and the associated ELH PI group of Prof. Timmann share an interest in investigating subcortical structures of the brain, and their contribution to cognitive-emotive functions as well as their contributions to understanding neurological diseases and psychological disorders. Main structures of interest are the ventral striatum, and its connections to midbrain structures and prefrontal areas, brain stem areas and their interaction with other subcortical structures and the spinal cord, as well as the cerebellum.

The research group of Prof. Bingel focuses on the CNS mechanisms underlying the processing, perception and modulation of pain in healthy volunteers and patients suffering from chronic pain conditions. Prof. Bingel has extensive experience in the neuroimaging of pain processing, and its reciprocal interactions with cognitive and emotional factors. In prior work she investigated how selective nociceptive stimuli are perceived and processed in the healthy human brain, and revealed a somatotopic representation of selective nociceptive stimuli in somatosensory areas such as bilateral SI and contralateral SII cortex, but also in subcortical motor related areas such as the putamen.

The research group of Prof. Brand focusses on neural correlates of cognitive and emotive processes using functional magnetic resonance imaging (fMRI). The interdisciplinary team examines neural mechanisms of decision-making, and their interactions with monitoring and control processes. The main focus lies on the interaction of basal ganglia and prefrontal areas. In particular, a better understanding of how the several parts of the fronto-striatal loops contribute to decision-making processes is the main research goal.

Prof. Timmann's research group is studying the physiology and pathophysiology of the human cerebellum. A long-standing interest is the involvement of the human cerebellum in different forms of motor learning. Questions addressed are whether the cerebellum is involved in particular forms of learning, which cerebellar areas are involved, and what the mechanisms of cerebellar involvement are. The role of the cerebellum in cognition is another concern. The overarching aim is to understand the cerebellar contribution to learning well enough to develop more specific training programs for patients with cerebellar ataxias. Localization of function is performed not only at the level of the cerebellar cortex, but also at the level of the cerebellar nuclei. The excellent signal-to-noise ratio of 7T MRI allows Prof. Timmann's group to perform robust structural and functional imaging of the cerebellar nuclei in humans.



3D-volume imaging of a healthy test subject's cerebellar nuclei. (Blue: Nuclei Fastigii, Green: Nuclei Globusi, Yellow: Nuclei Emboliformes, Red: Nuclei Dentati).

ELH Research Topic Body

Research strategy and vision for UHF body MRI

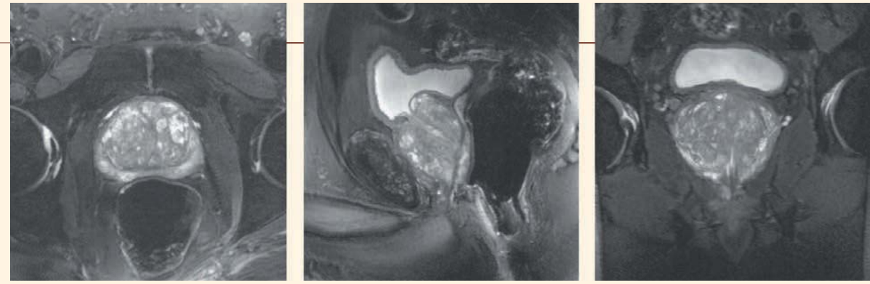
The aim of the UHF body MRI research activities at the ELH is to access and apply the known benefits of UHF-MRI to high-resolution, high contrast structural and functional imaging of all body organs, and in human whole-body MR imaging. The vision is to ultimately use UHF body MRI for early detection of disease as well as for accurate staging and monitoring of therapy (e.g. in cancers) with higher sensitivity and higher contrast than possible with MRI at lower field strength (e.g. 3.0 Tesla), or with other diagnostic imaging modalities. The research activities and successful funding in the years 2011-2015 have brought the UHF body MRI activities at the ELH a major step closer to this aim. In this context, two large grants–"MRexcite" and "Exacta"–from the European Research Council (ERC) should be mentioned.The three PI groups of Prof. Ladd, Prof. Scheenen and Prof. Quick have joined forces to build upon these activities to stay at the international forefront of UHF body MRI.

MRexcite

The significant EU-funding of Prof. Ladd's ERC project "MRexcite" (development of a 32-channel transmit/receive RF body coil) has helped to successfully plan and build a 32-channel transmit/receive RF body coil, and associated RF architecture that puts the ELH and its 7T whole-body MRI system in a unique position among the worldwide UHF-MRI community. This project has laid the groundwork for all current and future hardware and methodological developments at the ELH with regard to UHF body MRI, including the development and application of new multichannel receiver array RF coils, B1 RF signal mapping, B1 shimming and homogenization, as well as parallel RF transmit (pTx) strategies.

From the very beginning after Prof. Quick joined the ELH in 2014, his PI group has worked in very close collaboration with the PI group of Prof. Ladd, and has defined mutual research projects in UHF body MRI hardware and methods development to maximize the output of this major research effort. Prof. Quick's PI group actively works on development of RF receiver arrays, B1 mapping and shimming strategies, and on RF safety and quality control-related research topics. These joint efforts have guaranteed stability of the major activities in UHF body MRI at the ELH, and shall guarantee further and lasting success of the MRexcite project, and its achievements. In 2015, the MRexcite project culminated in the acquisition of the world's first 7T whole-body UHF-MRI image of a volunteer at the ELH.
For the future MRexcite activities, Prof. Ladd and Prof. Quick defined a collaboration between the ELH and the DKFZ (German Cancer Research Center) to further develop the MRexcite hardware at the ELH, and install a replica of the RF coil and RF architecture at the DKFZ 7T MRI system.

The ELH's 32-channel transmit/receive RF body coil.



Anatomical imaging of the prostate in vivo at 7 Tesla in three orientations (axial, sagittal and coronal).

Exacta

A step closer to clinical application of UHF body MRI, the EU-funded grant of Prof. Scheenen "Exacta" (exploring the aggressiveness of prostate cancer to enable an individual treatment approach) has enabled and supported clinically driven 7T research at the ELH for its potential in prostate cancer management. Prof. Scheenen and his PI group explored different RF coil combinations and pulse sequence adaptations for prostate multi-parametric imaging, and investigated new biomarkers with phosphorous spectroscopic imaging for added clinical value of 7T UHF-MRI. An exciting new development in cancer imaging is the use of a contrast agent based on ultra-small particles of iron oxide (USPIO), which enables the visualization of small metastatic lymph nodes. The high spatial resolution attainable at 7T combined with the high sensitivity for the presence of iron represents a unique combination for 7T MRI in providing detailed information on the presence of metastases down to 1 mm in size.

Research Vision

With 10 years under its belt, the ELH can in good conscience be called a success story. The location of the ELH on the historic grounds of the UNESCO World Heritage Site Zollverein is time-tested, the necessary infrastructure to successfully run an UHF-MRI system and research program is installed, and the collaboration between the two universities and also between the ELH and the two medical centers, the University Hospital Essen and the Radboud University Medical Center, is very fruitful and productive. Not to be underestimated, the setting allows for synergistic UHF-MRI research and assembles the unique UHF-MRI expertise of 7 PI groups all within one institution, the ELH.

According to its motto "Excellence in brain and body UHF-MRI", the entire ELH team has strengthened its position within the worldwide UHF-community. Various aspects have contributed to the ELH's uniqueness, such as the international institutional setup equally supported by the two founding universities, or the setup of 7 well-connected PI groups covering a broad and in-depth range of UHF brain and body MRI expertise. This has led to a truly interdisciplinary and international research setting. In early 2017, an eighth PI will join the ELH. With the support of the "Emmy Noether Programme" for Independent Research Groups, Peter Koopmans will continue his studies at the ELH. His PI group will focus on cortical layer fMRI in order to measure the directionality of information flow in the human brain in relation to pain processing.
Furthermore, the ELH houses a 7T MRI system now equipped with an unrivalled hardware setup based on a 32-ch Tx/Rx body RF coil and associated RF architecture for brain and body UHF-MRI, and has access to an USPIO contrast agent for use in cancer UHF-MRI.
On top of all this, the ELH participates in excellent established collaborations with clinical partners from the University Hospital Essen and the Radboud University Medical Center for continued volunteer and patient recruitment, and for active transfer of results into clinically relevant applications.
The directorship of the ELH is eager to maintain and further expand these unique characteristics to further strengthen the position of the ELH institute within the worldwide UHF community in the coming years, and foster national and international collaborations with other 7T sites.

The Traveling Heads: Feasibility of multicenter brain imaging at 7T

Maximilian Völker

The “traveling heads” experiment was started in 2014 to assess the comparability and reproducibility of multicenter human brain imaging at 7T [1]. This study was organized by the German Ultrahigh Field Imaging (GUFI) network, which is financed by the German Research Foundation (DFG) [2], and whose members include all UHF-MR sites within Germany, and a few international partners as well.

The biggest advantage of higher field strength – the higher signal-to-noise ratio (SNR) – comes with the drawback of an increased artifact load. The image quality can thereby be severely influenced, and the associated effects may be different at individual UHF sites, where system hardware differences could diminish reproducibility.

To measure inter-site reproducibility, two male subjects (37 and 33 yrs.) were imaged at eight UHF sites, all operating a 7T whole-body MRI system from the same vendor (Siemens). The systems have differences in basic imaging components. Two sites (2, 6) have an actively shielded magnet, whereas the rest of the sites use an older, passively-shielded magnet. There are also two different gradient coil versions installed at the different sites (Site 2, 5-8: 70 mT/m; Site 1, 3, 4: 38 mT/m). At 6 of 8 sites a commercial RF head coil (Nova Medical) with 1 TX and 32 RX channels was used, while at two sites (1, 4) a 24 RX channel version from the same manufacturer was available.

The imaging protocol consisted of a spin-echo-based B1-mapping sequence for transmitter calibration verified by a DREAM B1-mapping sequence. Subsequently, the following imaging sequences were performed: MP2RAGE, TSE, modified TOF and SWI. An EPI sequence was used to acquire functional data during 4 minutes with no task.

Data were analyzed qualitatively and quantitatively after co-registration between the sites. For anatomic sequences (MP2RAGE and TSE), the contrast, T1, and volume of segmented VOIs were compared. For the angiographic sequences (TOF and SWI), vessel contrast against surrounding background was used for quantification. Temporal SNR (tSNR) maps calculated from EPI as well as B1 and B0 field maps were analyzed for each brain. Additionally, both subjects were rescanned at Sites 2, 3 and 4 to assess intra-system variability.

MP2RAGE images showed very high agreement in contrast (Fig. 1) and measured T1 values. Rescans at 3 sites showed higher precision (e.g. 0.6% difference in brain volume vs. 5%) for intra-system data compared to inter-system reproducibility, indicating systematic differences between the sites. The TSE images (Fig. 1) revealed contrast differences between the two different RF coils used. The TOF angiography (Fig. 1) analysis showed high agreement between all sites and subjects, but statistically significant differences were found between the vessel contrasts of sites with different RF coil types. For SWI image data (Fig. 1), higher inter-subject variation than inter-site variation of the segmented vessel contrasts was found, but no influence of the different RF coil types was measured. For EPI time series, the mean tSNR was 15-25% lower for the sites with 24ch coils compared to those with 32ch coils, but high agreement was found between sites with the same RF coil. B1 maps reveal the differences in efficiency between the two RF coil types (Fig. 1). The 24ch coils reached a lower mean flip angle than the 32ch coils (27° vs. 33°) with the same transmit power.

UHF-MR systems are very sensitive measurement devices. Effects of hardware differences between individual devices and sites were revealed in this study, where it could be shown that the RF coils had the greatest effect on inter-site reproducibility.

Nevertheless, our results show that the 7T systems used can deliver high multi-center reproducibility for the supratentorial brain with variability that is similar to that reported in the literature for 3T. This is a promising finding for quantitative imaging and a first step toward future large-scale multi-site studies at 7T.

References

[1] Voelker MN, Kraff O, Brenner D, Wollrab A, Weinberger O, Berger MC, Robinson S, Bogner W, Wiggins C, Trampel R, Stöcker T, Niendorf T, Quick HH, Norris DG, Ladd ME, Speck O. The traveling heads: multicenter brain imaging at 7 Tesla. MAGMA 2016: doi: 10.1007/s10334-016-0541-8.

[2] German Research Foundation (DFG); project German Ultrahigh Field Imaging; PIs: Mark Ladd, Oliver Speck, David Norris; funding: 450.000 €; duration 36 months (start: 10/2013); prolongation of additional 36 months, PIs: Mark Ladd, Oliver Speck, Harald Quick; funding: 355.000 €.

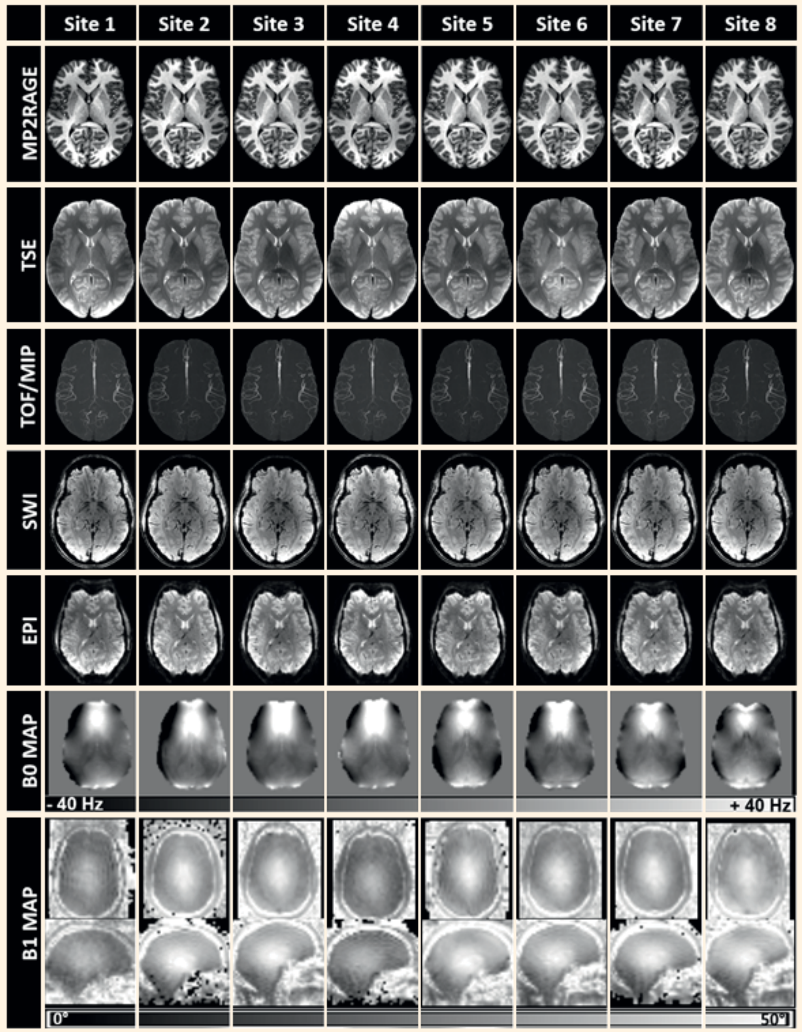


Fig. 1: Excerpt of image data gained from the same subject at different 7T sites. Images are co-registered between sites. High agreement between sites was found. At Sites 1 and 4, a different head coil (24ch) was available than at the other sites (32ch), leading to small differences being found in most imaging sequences. Most notable inter-site contrast differences were found between subcortical regions in the TSE images of Sites 1, 4 and 5, where the sequence parameters (TR) had to be slightly changed to account for the SAR limits of the less efficient 24ch coil, and for RF power problems at Site 5.

Developments in GABA spectroscopy

Donghyun Hong, Seyedmorteza Rohani Rankouhi, Jan-Willem Thielen, David G. Norris

There is a small group of researchers working at the Erwin L Hahn Institute to improve techniques for measuring gamma-amino-butyric acid (GABA), one of the most important inhibitory neurotransmitters. In 2016 they developed some improved measurement techniques, and also investigated a previously unconsidered confound.

In imaging experiments it was previously [1] shown that there is a potential 5-10Hz frequency shift between grey and white matter. This is of the order of 0.05 ppm at 7T, and only somewhat narrower than typical line widths obtained at this field strength. The fact that GABA is 9 times (circa 90% in grey matter (GM), and 10% in white matter (WM)) more concentrated in grey matter [2] means that this effect will most likely cause a line shift rather than a line broadening. We tested whether the frequency shifts reported by Duyn et al. are relevant for the larger voxels used in spectroscopy, and whether the grey matter lineshape differs from that of white matter. Which should then be ideally taken into account when using analytical techniques such as the LC model approach that is based on an assumption of a single lineshape per voxel. We used multi echo images which were acquired at the identical position of the spectroscopic voxel to reconstruct the spectroscopy signal. We reconstructed a lineshape of the spectroscopy signal by combining individual sub voxels' signals (Fig. 2a, b). Then, grey matter and white matter lineshapes were computed by recombining frequency components at the equivalent voxel position. The reconstructed signals were 98.82 ± 0.68 (%) identical to the real spectroscopy signal (Fig. 2b, c). We found a frequency shift, a linewidth change and a lineshape change in GM and WM signals for all subjects we examined. (Fig. 3). Frequency differences were 4.64 ± 2.39 (Hz), and linewidth changes were 4.67 ± 2.76 (Hz) between GM and WM. This confound should hence be considered in the analysis of spectra at 7T.

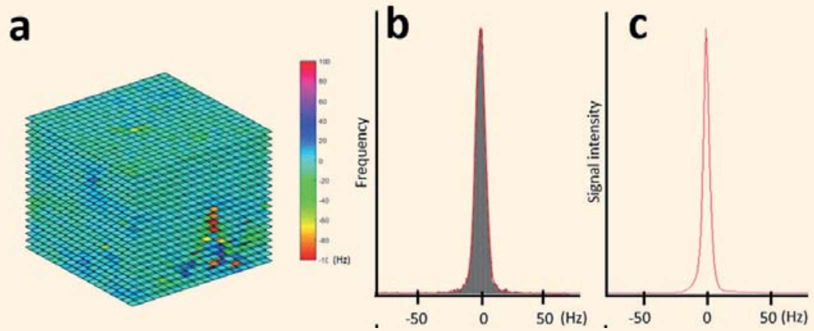


Fig. 2a: Frequency offset distribution inside voxel Fig. 2b: Histograms of the frequency offset distribution, and the outfit line Fig. 2c: Actual spectroscopy water signal.

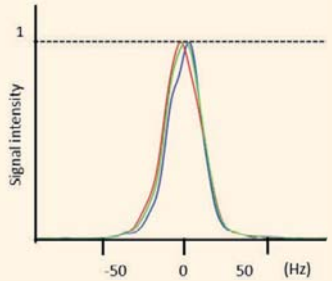


Fig. 3a: A frequency shift and Fig. 3b: a lineshape change grey (blue) and white (red) matter from water lineshape (green).

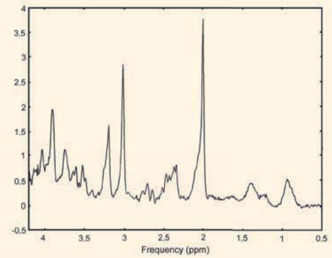


Fig. 4: Short TE = 28 ms spectrum acquired of using MASE-sLASER sequence at 7T.

Recently, Matched-phase Adiabatic Spin Echo (MASE) has been introduced and its application has been shown in diffusion weighted imaging [3]. MASE includes a non-adiabatic matched phase SLR 90 pulse, and an adiabatic SLR 180 pulse creating a spin echo without the need of using a pair of adiabatic refocusing pulses. This characteristic of MASE can be beneficial at ultra-high field by reducing the echo time (TE) in comparison to a full Localization by Adiabatic Selective Refocusing (LASER) sequence [4]. Hence, our aim in this study was to implement sequences for short TE Single Voxel Spectroscopy (SVS) in general, and editing GABA SVS in particular with matched and low Chemical Shift Displacement Error (CSDE) in all three directions while keeping low sensitivity to B1 variations at 7T.

Short TE = 28 ms matched CSDE sLASER sequence (MASE-sLASER) has been implemented using MASE for slice selection in one direction, and two pairs of adiabatic SLR MASE refocusing pulses in the two other directions. The slice selection gradient strength of the excitation pulse of MASE is matched with that of the refocusing pulse of MASE. Together with the matched slice selection gradients for the two pairs of adiabatic SLR refocusing pulses, it gives us matched slice selection gradient strengths in all three directions which consequently provides us with a matched CSDE in all three directions. A high quality single voxel spectrum acquired using MASE-sLASER sequence at TE = 28 ms is shown in Fig. 4.

References

[1] *Duyn JH, van Gelderen P, Li TQ, de Zwart JA, Koretsky AP, Fukunaga M. High-field MRI of brain cortical substructure based on signal phase. Proc Natl Acad Sci U S A 2007;104(28):11796-11801.*

[2] *Bhattacharyya PK, Phillips MD, Stone LA, Lowe MJ. In vivo magnetic resonance spectroscopy measurement of gray-matter and white-matter gamma-aminobutyric acid concentration in sensorimotor cortex using a motion-controlled MEGA point-resolved spectroscopy sequence. Magn Reson Imaging 2011;29(3):374-379.*

[3] *Dyvorne H, O'Halloran R, Balchandani P. Ultrahigh field single-refocused diffusion weighted imaging using a matched-phase adiabatic spin echo (MASE). Magn Reson Med 2016;75(5):1949-1957.*

[4] *Garwood M, and Lance D. The return of the frequency sweep: designing adiabatic pulses for contemporary NMR. Journal of magnetic resonance 2001; 153(2): 155-177.*

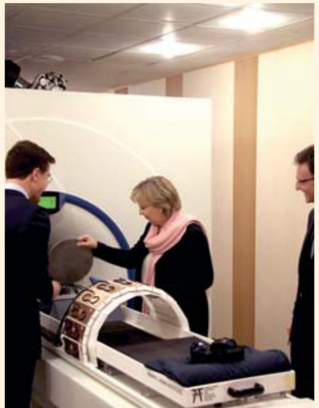
10 Years of Erwin L. Hahn Institute

Installing the 7 Tesla magnet in 2006.

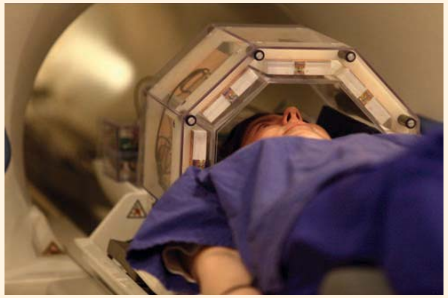
Grand Opening of the ELH.

Erwin L. Hahn visits the ELH in 2009.

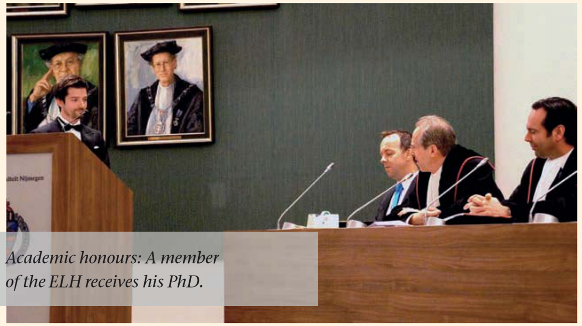
ExtraSchicht – Night of Industrial Culture.



VIP visit: Minister President Hannelore Kraft and the Prime Minister of the Netherlands Mark Rutte examine the ELH's 7 Tesla MRI.



Welterbelauf 2015.



Academic honours: A member of the ELH receives his PhD.

“An irritating glitch”: In Memoriam Erwin L. Hahn

Stefanie Zurek

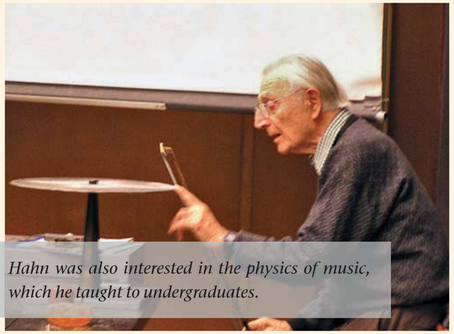
It’s hard to imagine what our world would look like today if Erwin L. Hahn had never discovered the spin echo. What was initially described by Hahn as an “irritating glitch” on his oscilloscope turned out to be one of the major breakthroughs in physics of the 20th century. While the spin echo may have been Erwin Hahn’s most famous discovery, it was by no means the only significant one. Among other discoveries, he was first to see the relevance of gradient echoes and to apply pulse sequences, for example. Without Erwin L. Hahn, magnetic resonance imaging would be unthinkable.

Today, MRI is used in hospitals and labs around the world as one of the safest and most important diagnostics tools. Maybe because of this, we tend to forget how relatively young it is. We are still learning about the human brain and body, and MRI’s full potential as we develop stronger and better scanners.

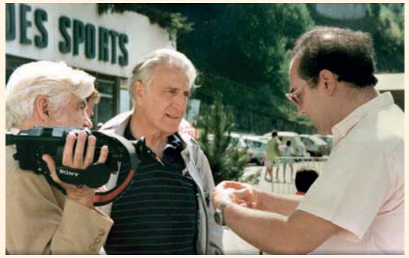
Erwin L. Hahn will be remembered by the physics community as an extraordinary scientist and passionate teacher, who fostered countless young scientists, but also as a gregarious, funny and humble man who never thrust himself into the academic spotlight.

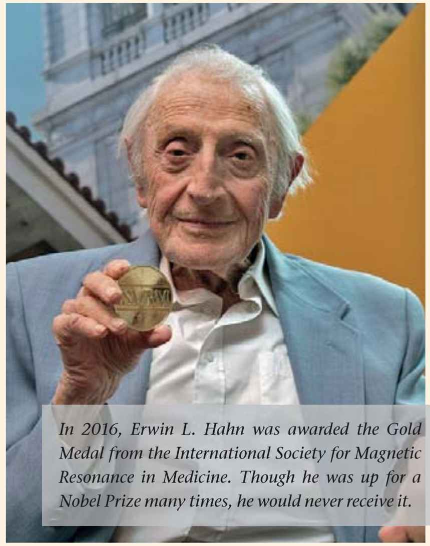
His work will continue to inspire and challenge us at the Erwin L. Hahn Institute. We are proud and honored to preserve his memory by continuing ultra-high field MRI research in his name.

Erwin Hahn was interested in many things, and had a broad list of hobbies to prove it. This included playing the violin in a chamber music ensemble (second on the left).



Hahn was also interested in the physics of music, which he taught to undergraduates.





In 2016, Erwin L. Hahn was awarded the Gold Medal from the International Society for Magnetic Resonance in Medicine. Though he was up for a Nobel Prize many times, he would never receive it.

Hahn visiting the Erwin L. Hahn Institute for Magnetic Resonance Imaging in 2009, where he deeply impressed the ELH-members with his very inspiring, motivating and humorous nature.

Current Grants

P. Koopmans: DFG Emmy Noether Programme – Independent Junior Research Group: Functional Magnetic Resonance Imaging of cortical layers to measure directionality of information flow in brain networks for pain (2016-2021)

Dr. Koopmans proposal focuses on the development of a high-resolution fMRI technique to improve understanding of how the brain processes pain.

T. W. Scheenen, H. H. Quick, J. O. Barentsz: Radboudumc: Nanotechnology at ultra-high magnetic field: towards in vivo detection of small lymph node metastases with MRI (2016 – 2020)

In this project the highest sensitivity of 7T to detect in vivo small lymph node metastases will be validated with histopathology of resected tissues in patients with rectal cancer.

M. E. Ladd, H.H. Quick, O. Speck: DFG: German ultra-high field imaging (GUFI), Core Facility (2016-2019)

Aim of this project is to maintain and expand a nationwide network of UHF-MRI sites.

D. Timmann (PI), M. E. Ladd, A. Deistung (PI), J. Reichenbach: DFG: In vivo assessment of the cerebellum by novel MRI techniques and application to hereditary ataxias: morphological, pathoanatomical and clinical aspects (2015-2018)

The aim of this collaboration project is to obtain deeper insight into the pathoanatomy of cerebellar nuclei in common forms of degenerative ataxias by using novel MRI techniques.

H. H. Quick, D. G. Norris: SIEMENS Healthcare GmbH: Cooperation agreement 7T High Field MR imaging, Erwin L. Hahn Institute (2015-2018)

This cooperation agreement encompasses sequence and 7T MRI application development as well as ELH-provided feedback of clinical experience using the pTX Array step 2.

A. Rennings, K. Solbach, H. H. Quick: DFG: Investigation of Electronic Band Gap (EBG) RF coils for 7T UHF-MRI (2015-2017)

In this DFG-funded project, new transmit/receiver RF coils for UHF brain and body MRI using electronic band gap structures (EBG) are developed and evaluated.

M. Brand, K. Starcke: DFG: Neural correlates of craving in patients with pathological buying – an fMRI study with a cue-reactivity paradigm (2015-2017)

In the current project neural correlates of craving will be assessed in individuals with pathological buying with functional magnetic resonance imaging (fMRI).

D. Bodemer, M. Brand, N. Fuhr, M. Heisel, H. Hoppe, B. König, N. Krämer, S. Stieglitz, T. Zesch, J. Ziegler: DFG Research Training Group: User-Centred Social Media (2015-2017)

The Research Training Group addresses the need of analyzing, and understanding the characteristics and determinants of the behavior of Social Media users.

D. G. Norris, P. Hagoort: NWO: Language regions in Interaction: An investigation of directional connectivity in the human language system using laminar fMRI (2014-2018)

This ambitious project will examine the interaction bet ween temporal cortex, and Broca's area during language comprehension using event-related fMRI at 7T.

B. Philips, T. W. Scheenen: Dutch Cancer Society: Multi-parametric MRI of the prostate cancer: the next level (2014-2017)

Multi-parametric MRI (mpMRI) of the prostate offers new possibilities for detection, localization and characterization of prostate cancer.

D. Timmann, M. E. Ladd: DFG: Contribution of the human cerebellum to extinction learning and renewal (2014-2016)

Comparatively little is known about the role of the cerebellum in extinction learning and related processes. Experiments are performed which make use of recent methodological advances in lesion-symptom mapping in cerebellar patients, and in ultra-high field (7 Tesla) magnetic resonance imaging (MRI) for performing functional MRI of both the cerebellar cortex and nuclei.

D. Suter: DFG: Optimized noise filters for improved contrast in MRI (2014-2016)

We propose to develop and implement optimized experimental schemes for MRI experiments that modulate the interaction between the nuclear spins and their environment.

M. E. Ladd, D. Norris, O. Speck: DFG: German ultra-high field imaging (GUFI), Core Facility (2013-2016)

Aim of this project is to create and promote a nationwide network of UHF-MRI sites.

D. Norris, I. Tendolkar, M. Brand, J. Wiltfang, J. Schulz: Helmholtz-Gesellschaft: Imaging and Curing Environmental Metabolic Diseases (ICEMED), Research Topic 4: Next generation CNS Imaging for metabolic disease (2012-2018)

The primary goal of this project is to examine ways of improving cognitive deficits, particularly in episodic memory performance, in patients suffering from type 2 diabetes (T2DM).

M. E. Ladd, K. Solbach: European Research Council Advanced Grant: MRexcite: Unlocking the potential of ultra-high field MRI through manipulation of radiofrequency excitation fields in human tissue (2012-2017)

The goal of the project is to develop a highly optimized 32-channel transmit/receive RF coil for body MRI at 7T.

M. E. Ladd, D. Norris: Marie Curie Actions - Initial Training Networks, EC: HiMR: Ultra-High Field Magnetic Resonance Imaging (2012-2016)

The primary aim of the Ultra High field Magnetic Resonance (HiMR) Initial Training Network is to train the future leaders of academic and industrial research in the fundamental science and novel applications of ultra-high field in vivo magnetic resonance.

M. E. Ladd, D. G. Norris, M. Brand: Siemens Healthcare: User Workshop (2012-2016)

Usage of the 7T-MRI, technical equipment and the conference room for trainings of physicians and technical operating personnel from other Siemens customers.

M. E. Ladd, H. H. Quick: Medical Faculty, University of Duisburg-Essen: IFORES: Internal stipends for clinical researchers from University Hospital Essen (2011-2017)

Various clinical researchers receive 12-months of intramural funding to conduct defined clinical research projects using 7T-MRI at the Erwin L. Hahn Institute.

Personell and Organisational Structure at ELH

Directorate / Principal Investigators

Managing Director / PI
Prof. Dr. Harald H. Quick

Director / PI
Prof. Dr. David Norris
Prof. Dr. Matthias Brand

PI
Prof. Dr. Ulrike Bingel
Prof. Dr. Timmann-Braun
Dr. Tom Scheenen
Prof. Dr. Mark E. Ladd

Management

Administrative Director
Dr. Corinna Heldt

ELH-Physicist
Dr. Oliver Kraff
Lab Manager
Dr. Stefan Maderwald
Plug and Play-Scientist
Dr. Sören Johst
Radiographer
Lena Schäfer
Assistance
Sigrid Radermacher
Dirk Bremann

Students

Luisa Bräuer
Hamed Digaleh
Sarah Handtke
Viktor Pfaffenrot

Scientists

MSc. Jacob Bellmund
MSc. Sascha Brunheim
Dr. Andreas Deistung
Dr. med. Cornelius Deuschl
Dipl.-Phys. Thomas Ernst
Dr. rer. nat. Marcel Gratz
MSc. Donghyun Hong
Dr. Sören Johst
Dipl.-Phys. Fabian Kording
Dr. Christian Laier
MSc. Vahid Malekian
MSc. Irati Markuerkiaga
Dr. Ivan Maximov
Dipl.-Ing. Yacine Noureddine
MSc. Mark Oehmigen
Dr. Stephan Orzada
MSc. Bart Philips
MSc. Stefan Rietsch
Dipl.-Psych. Christoph Ritter
Dr. Astrid Rosenthal-von der Pütten
MSc. Katrin Scharmach
MSc. Jennifer Schulz
MSc. Daniel Sharoh
Dr. Katrin Starcke
Dr. med. Rutger Stijns
Prof. Dr. med. Indira Tendolkar
MSc. Jan-Willem Thielen
Dipl.-Psych. Patrick Trotzke
Dipl.-Ing. Maximilian Völker

New in 2016

Jacob Bellmund
Florian Bontke
Dirk Bremann
Dana Deeva
Andreas Deistung
Vahid Malekian
Bart Philips
Astrid Rosenthal-von der Pütten
Katrin Scharmach
Jenni Schulz
Rutger Stijns

Left in 2016

Lauren Bains
Florian Bontke
Anna Brol
Verena Broszeit
Dana Deeva
Eileen Frerk
Juliane Göbel
Sarah Handtke
Britta Hüning

Participation at ISMRM 2016 in Singapore

Sascha Brunheim: Evaluation of through-time radial GRAPPA for real-time cardiac MR imaging at 7 Tesla; Session: UHF Applications& Modeling; e-poster
Sascha Brunheim: Combining B1 mapping with TIAMO for fast and accurate multi-channel RF shimming in 7 Tesla body MRI; Session: Characterizing Field Environment in the MR Scanner: B0, B1 & Gradients; talk
Bixia Chen: Magnetic resonance imaging of low-grade and high-grade gliomas at 7 Tesla; Session: UHF Applications; talk
Marcel Gratz: Evaluation of highly undersampled contrast-enhanced MR angiography (SPARSE CE-MRA) in intracranial applications; Session: Sparse & Low-Rank MRI: Theory & Applications; e-poster
Sören Johst: Towards Plaque and Thrombus Imaging with Hybrid of Opposite-Contrast (HOP) MR Angiography at 7T; Session: MR Angiography; poster
Fabian Kording: Doppler Ultrasound Triggering for Cardiac Magnetic Resonance Imaging at 7 Tesla; Session: Novel Concepts in MR Technology; talk
Oliver Kraff: 7 Tesla quantitative hip MRI: A comparison between TESS and CPMG for T2 mapping; Session: Cartilage & Joints; e-poster
Oliver Kraff: Evaluation of potential improvements from high permittivity pads for imaging upper extremities at 7 Tesla; Session: UHF Applications& Modeling; e-poster
Mark Ladd: MRI: a systems overview; Session: Physics for Physicists; talk
Mark Ladd: Towards control of temperature; Joint Study Group Session: High Field Systems & MR Safety; chair
Irati Markuerkiaga: Deconvolving the laminar gradient echo activation profiles with the spatial PSF: an approach to revealing underlying activation patterns; Session: Controversies in fMRI s; power pitch session
Stephan Orzada: A 32-channel integrated body coil for 7 Tesla whole-body imaging; Session: RF Coils & Arrays; talk
Stephan Orzada: A method to approximate maximum local SAR in multi-channel transmit MR systems without transmit phase information; Session MR Safety; talk
Bart W.J. Philips: High resolution imaging of pelvic lymph nodes at 7 Tesla; Session: Whole Body & Male Pelvis; e-poster
Harald Quick: Vascular MR at 7T; Session: Sunrise Educational Session: Ultra-High Field Cardiovascular MRI; talk
Stefan Rietsch: An 8Tx/32Rx RF Coil for 7T UHF Body MRI; Session: Engineering;poster
Stefan Rietsch: Cost-Efficient 7ch Rx Shoulder Array for 7T UHF MRI Featuring External Switchbox Detuning; Session: RF Coils & Arrays; poster
Stefan Rietsch: Parallel Transmit (pTx) Capability of Various RF Transmit Elements and Arrays at 7T UHF MRI; Session: RF Coils & Arrays; talk
Nicolai Spicher: High-speed, contact-free measurement of the photoplethysmography waveform for MRI triggering; Session: Motion Correction; poster
Mark J. van Uden: 7 Tesla dual element 31P TxRx/1H Rx endorectal coil combined with an 8-channel 1H-TxRx body coil; Session: Motion Correction; RF Coils & Arrays
Maximilian Völker: On the robustness and reproducibility of spatially selective excitation using parallel transmission at 7T - a multicenter study; Session: UHF Applications& Modeling; e-poster
Maximilian Völker: The traveling heads: Qualitative and quantitative evaluation of multicenter brain imaging at 7 Tesla; Session: UHF Applications& Modeling; e-poster

Awards

Dr. Oliver Kraff, appointed Trainee Representative for the ISMRM MR Safety Study Group

Prof. Dr. Mark E. Ladd, elected Vice President of the German Society of Medical Physics (DGMP) starting 2017

Dr. Stephan Orzada, ISMRM Magna Cum Laude Merit Award for his contribution „A method to approximate maximum local SAR in multi-channel transmit MR systems without transmit phase information“

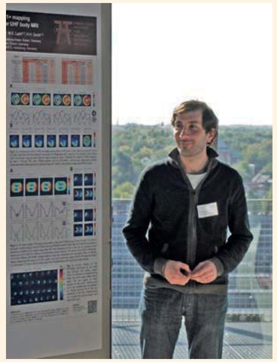
MSc. Stefan Rietsch, ISMRM Magna Cum Laude Merit Award for his contribution ”Parallel Transmit (pTx) Capability of Various RF Transmit Elements and Arrays at 7T UHF MRI”

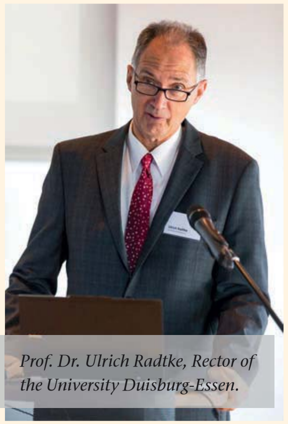
Dr. Miriam Wilhelmina Lagemaat, Erwin L. Hahn Institute Award for Young Scientists for her PhD thesis “1H and 31P MR Spectroscopic Imaging of the prostate at 7 Tesla”

Miriam Lagemaat receives the Award for Young Scientists from director Harald Quick at the 2016 Hahn Lecture.

Erwin L. Hahn Lecture 2016

For its 10th anniversary, the Hahn Lecture moved to the Erich-Brost-Pavillon with its spectacular view at the UNESCO World Heritage Site Zollverein.





Prof. Dr. Ulrich Radtke, Rector of the University Duisburg-Essen.

The directors and PIs of the ELH with the Hahn Lecture’s key speakers.

Publications

Chen, B. X.; Schoemberg, T.; Kraff, O.; Dammann, P.; Bitz, A. K.; Schlamann, M.; Quick, H. H.; Ladd, M. E.; Sure, U.; Wrede, K. H. (2016). Cranial fixation plates in cerebral magnetic resonance imaging: a 3 and 7 Tesla in vivo image quality study. Magnetic Resonance Materials in Physics Biology and Medicine 29(3): 389-398

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PARTICIPATING INSTITUTIONS

Erwin L. Hahn Institute for Magnetic Resonance Imaging

Universität Duisburg Essen
Open-Minded
Fakultät für Ingenieurwissenschaften

Universitätsklinikum Essen

Radboud University Nijmegen

Radboudumc

Donders Institute for Brain, Cognition and Behaviour