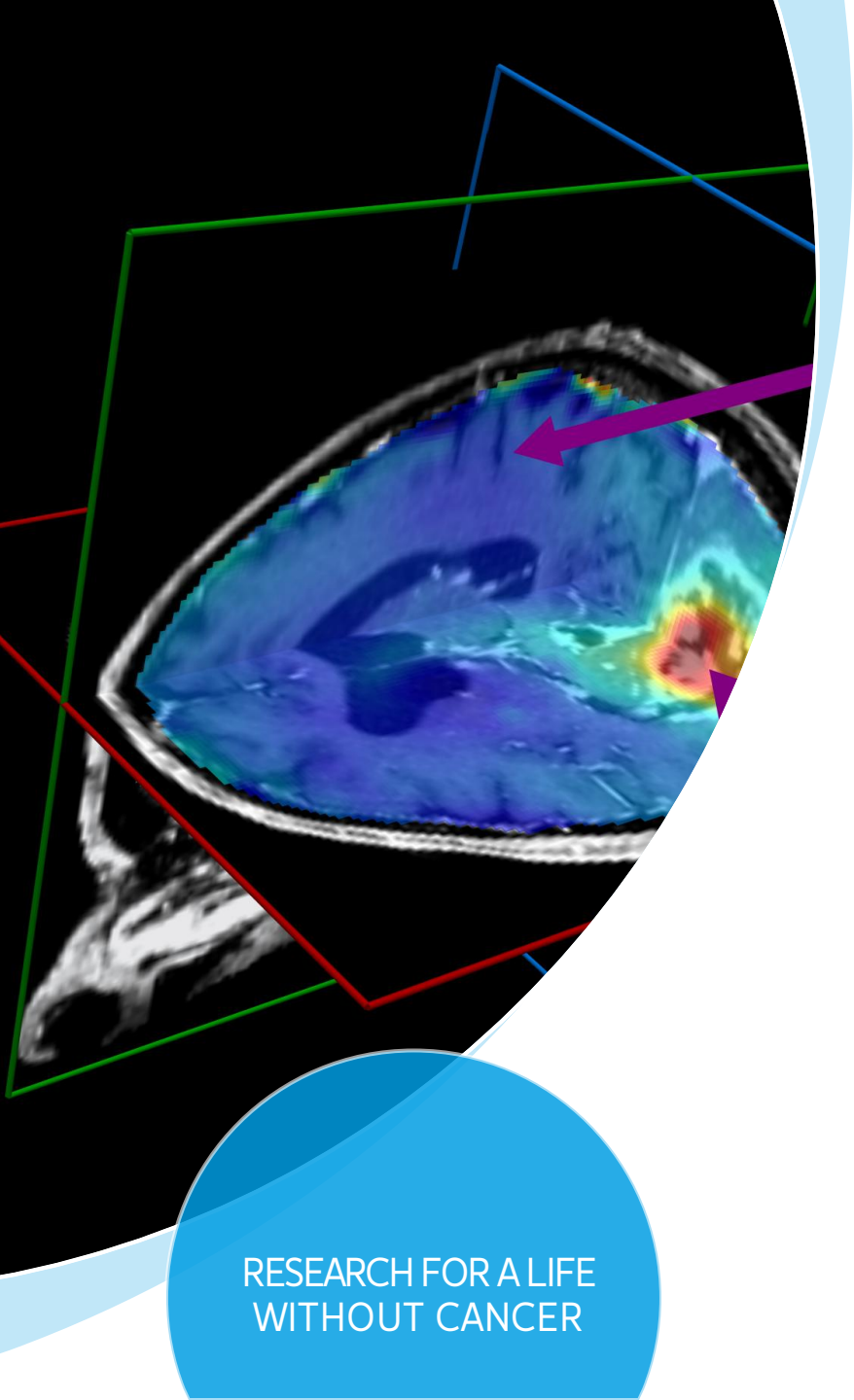




Medical Physics in Radiology

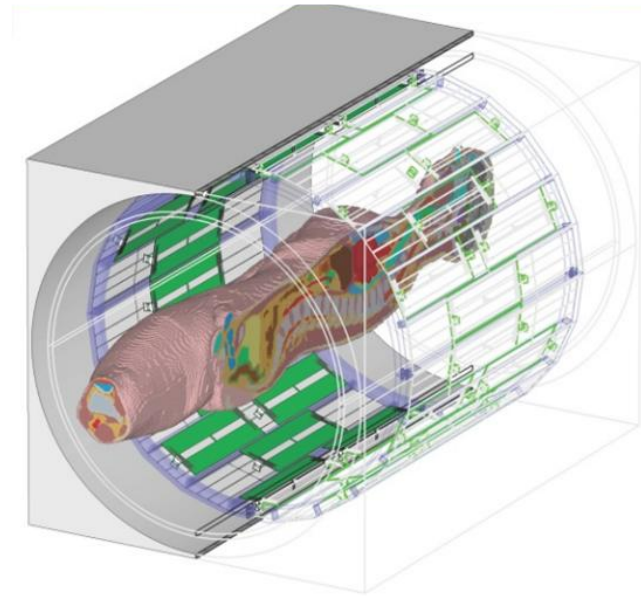
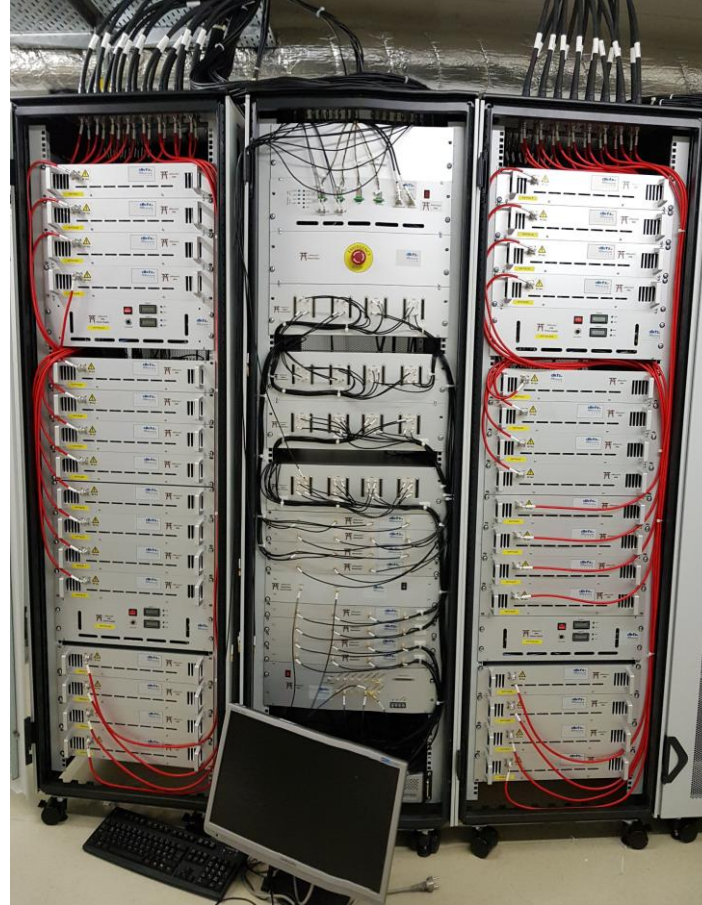
Head: Prof. Dr. Mark E. Ladd | 2026

German Cancer Research Center
Heidelberg

RESEARCH FOR A LIFE
WITHOUT CANCER

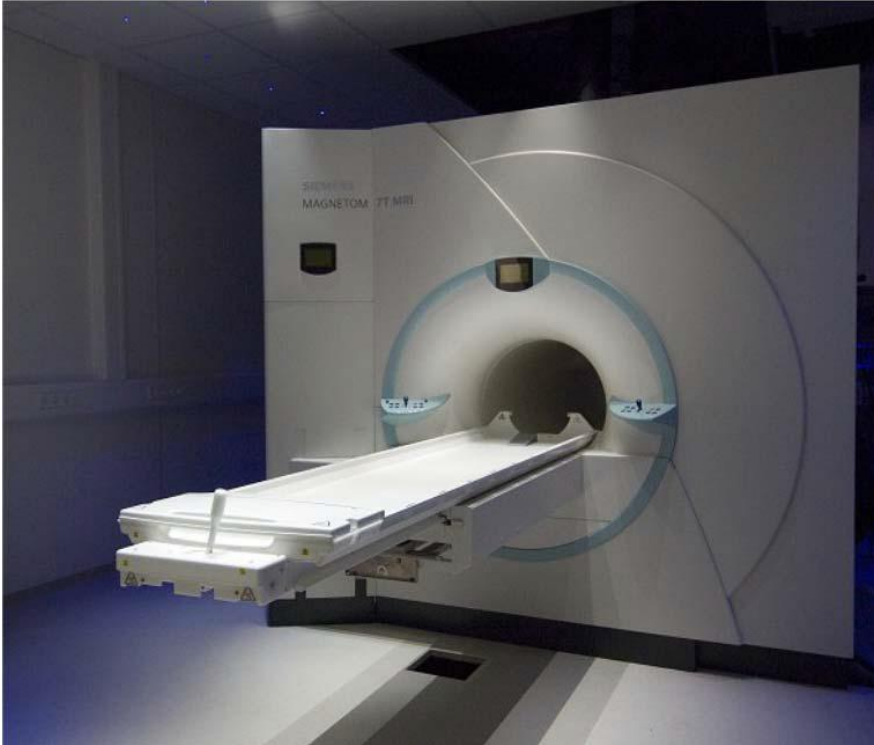
Main subject: Magnetic Resonance Imaging (MRI)

- Hardware development for whole-body 7T MRI: MRExcite



Main subject: Magnetic Resonance Imaging (MRI)

- Design study: 14 Tesla human MRI



7T human MRI

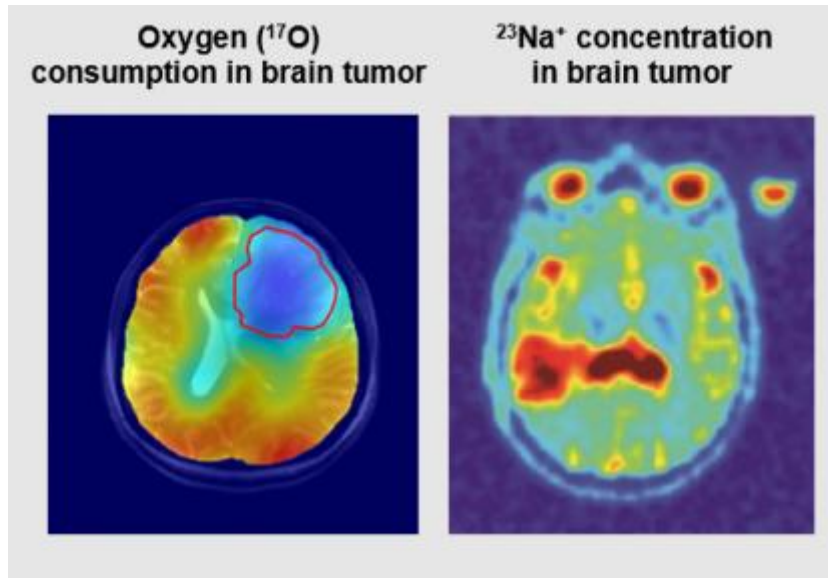


courtesy Tesla Engineering

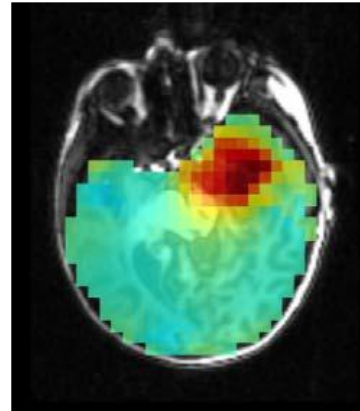
Design study: 14 Tesla

Main subject: Magnetic Resonance Imaging (MRI)

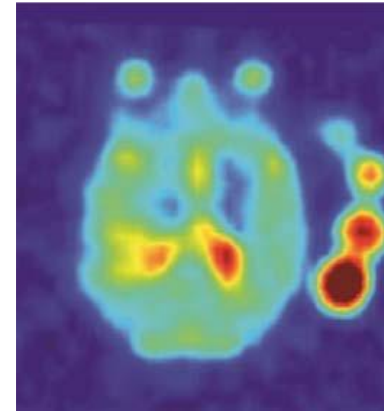
- X-nuclei imaging: Na, Cl, K, P, O-17



pH mapping (^{31}P)



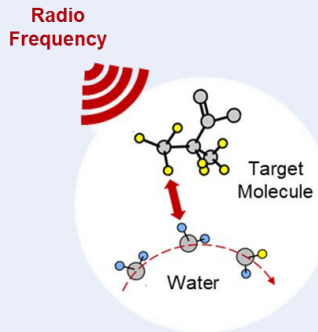
Concentration of ions (^{35}Cl)



What is CEST Imaging?

Chemical Exchange Saturation Transfer

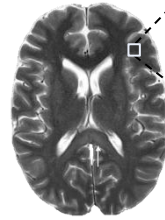
Water signal preparation sensitive to low-concentrated endogenous molecules



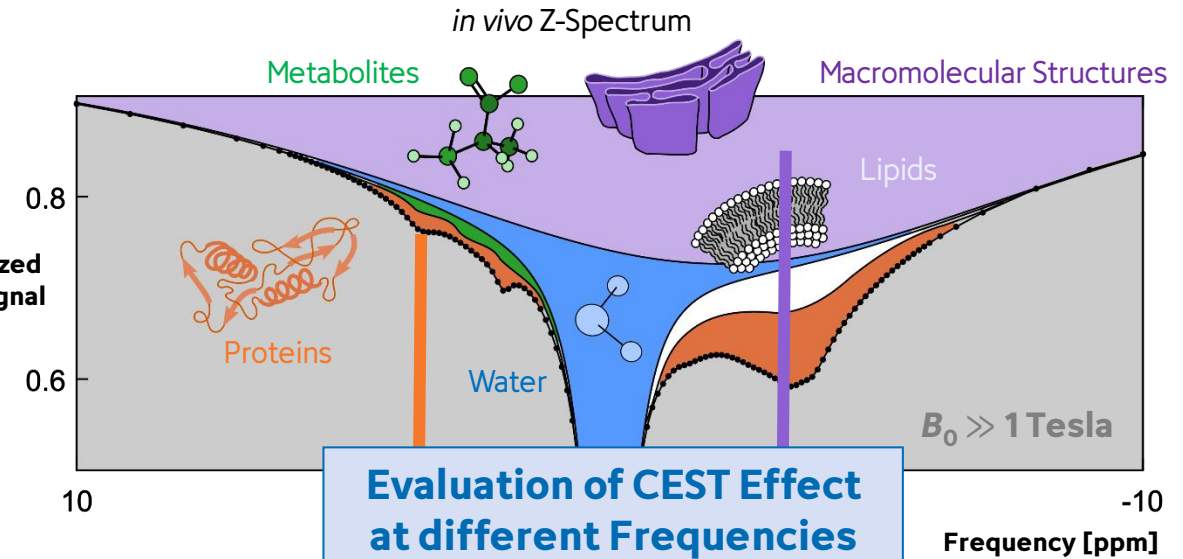
Magnetic Labeling of Water

- ✓ Contrast-agent-free
- ✓ Non-ionizing
- ✓ Non-invasive

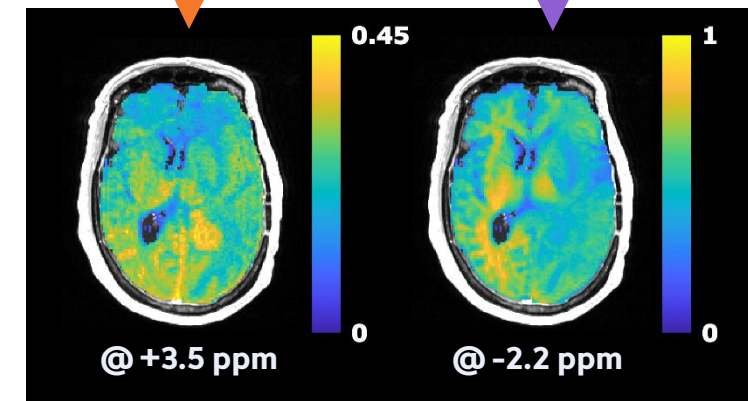
→ **Tumor-relevant Molecular Information with High Spatial Resolution**



Normalized water signal



Evaluation of CEST Effect at different Frequencies



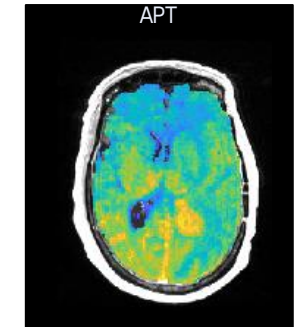
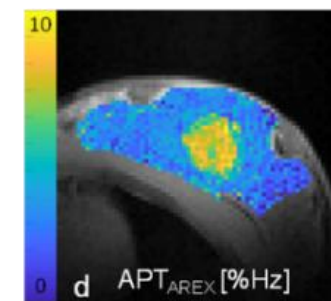
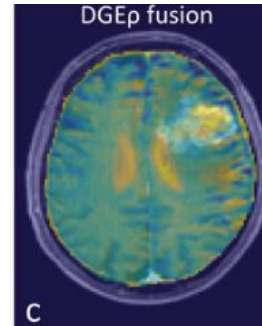
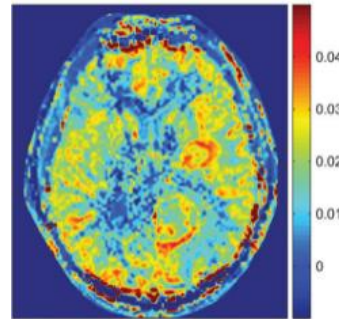
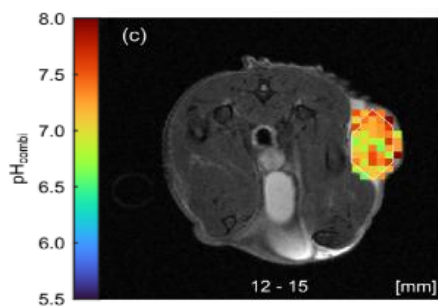
Assessment of Pathologies

**Cancer,
Neurodegenerative Diseases**
(e.g. Alzheimer's), ...

Indicator

What is CEST Imaging?

- CEST contrasts show **specificity to particular pathological changes** (pH, proteome, ...)

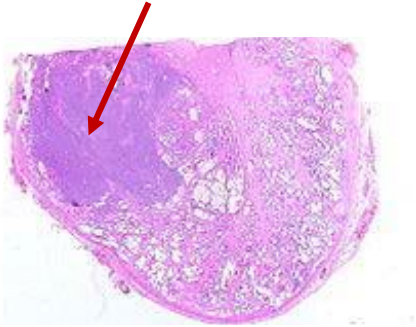


→ Valuable Imaging Biomarker for Diagnosis and Treatment Monitoring of Different Diseases

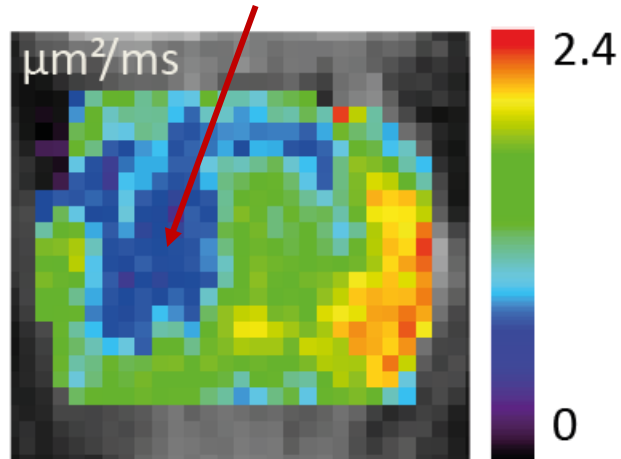
Main subject: Magnetic Resonance Imaging (MRI)

- Diffusion Weighted MRI (DWI)

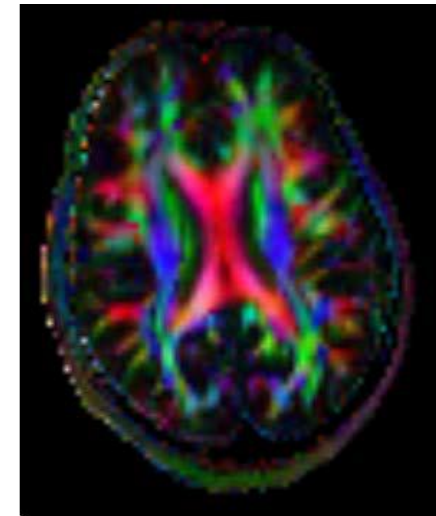
Tumor: Denser cell packaging



Diffusion coefficient
Reduced diffusion distance

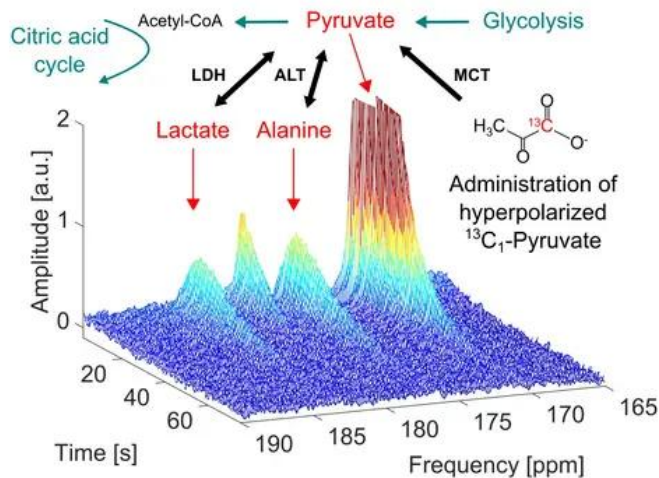


White matter fiber orientation



Hyperpolarized ^{13}C MRS(I): a non-invasive imaging technique for real-time observation of metabolism

- Hyperpolarization of a **Carbon-13 (^{13}C) enriched substrate** leads to a significantly enhanced Magnetic Resonance (MR) signal
- Enables **real-time visualization of metabolic processes**
- Detects **disease-specific metabolic alterations**
- Example: Increased **LDH activity** associated with the **Warburg effect** in cancer metabolism

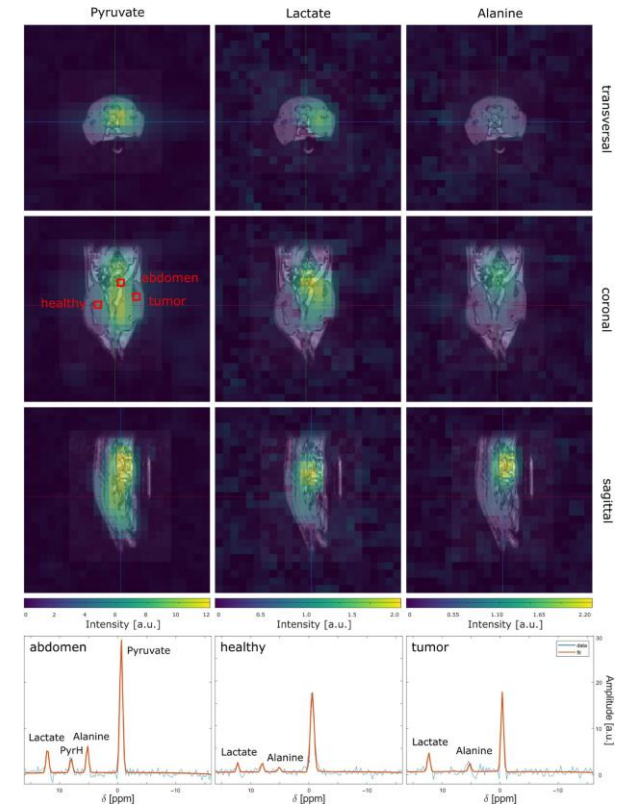


....focus topics of the group:

- ^{13}C MR Probe Development
- In Vitro Studies Using Cellular Models & Bioreactors
- MR Sequence Development & Reconstruction Pipelines
- Clinical Translation



Polarizing Systems

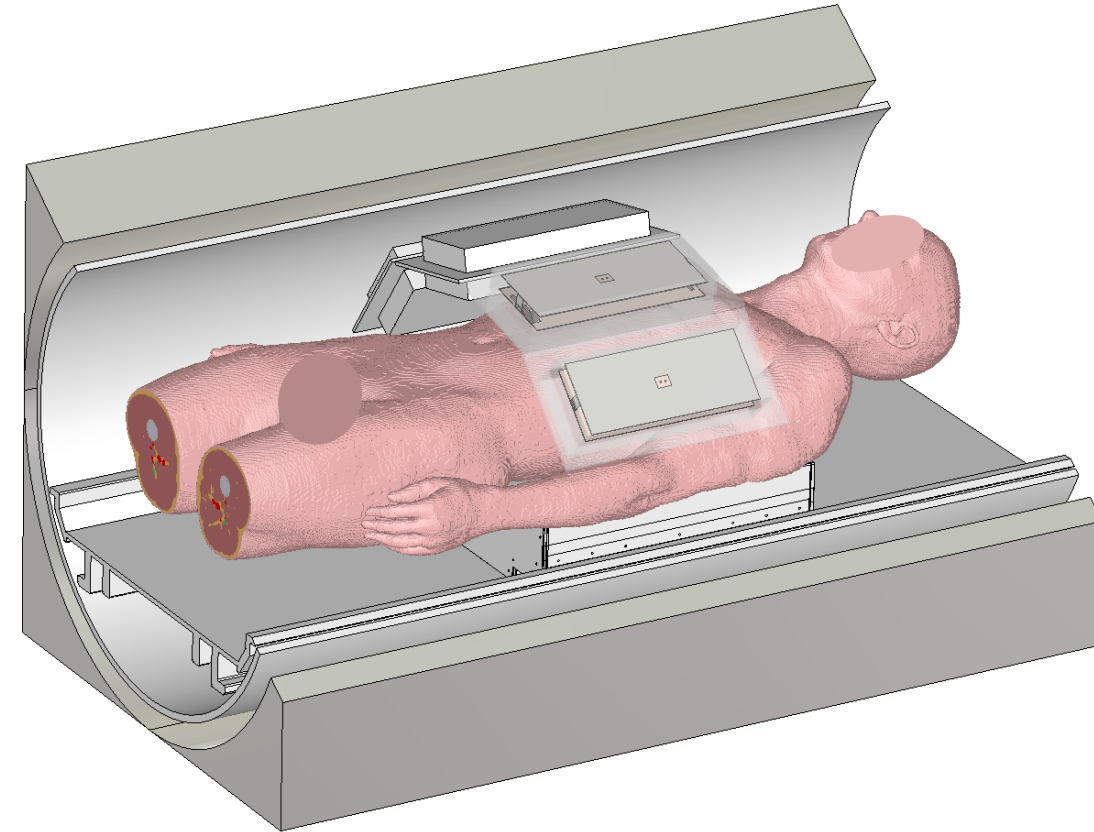


Awenius et al, 3D radial EPSI, doi:10.1002/mrm.30258.

Medical Physics in Radiology

Electromagnetic Simulations and RF Safety

- Pioneering the Next Generation of MRI Technology
 - Our research is shaping the future of medical imaging through advanced electromagnetic simulations and innovative software and hardware designs.
 - We focus on driving transformative research initiatives, including the development of next-generation magnet designs for MR guided particle therapy, the engineering of high-performance radio frequency (RF) antennas for multi-channel MRI, and the advancement of comprehensive MR safety assessments.
- Join us for your Bachelor's/Master's thesis or a PhD.
- Contact: Dr. Thomas Fiedler

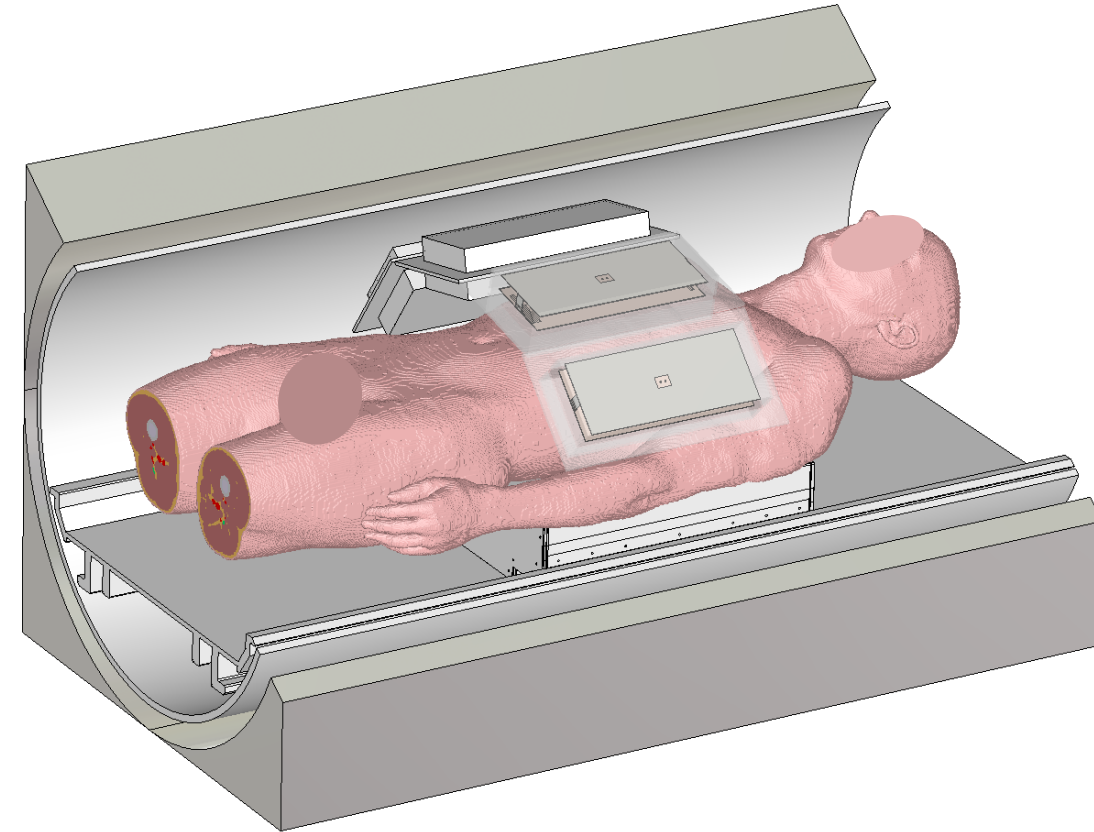


Engineering of RF antennas for MRI

Medical Physics in Radiology

Electromagnetic Simulations and RF Safety

- 14 Tesla: the Next Generation
 - At the absolute frontier of imaging science, 14 T is the next and most powerful MRI generation ever built for human imaging.
 - In close collaboration with the DYNAMIC consortium in the Netherlands, we are tackling the unique electromagnetic challenges of these ultra-high fields to unlock unprecedented image resolution and redefine the future of medical imaging (Project funded by DFG).

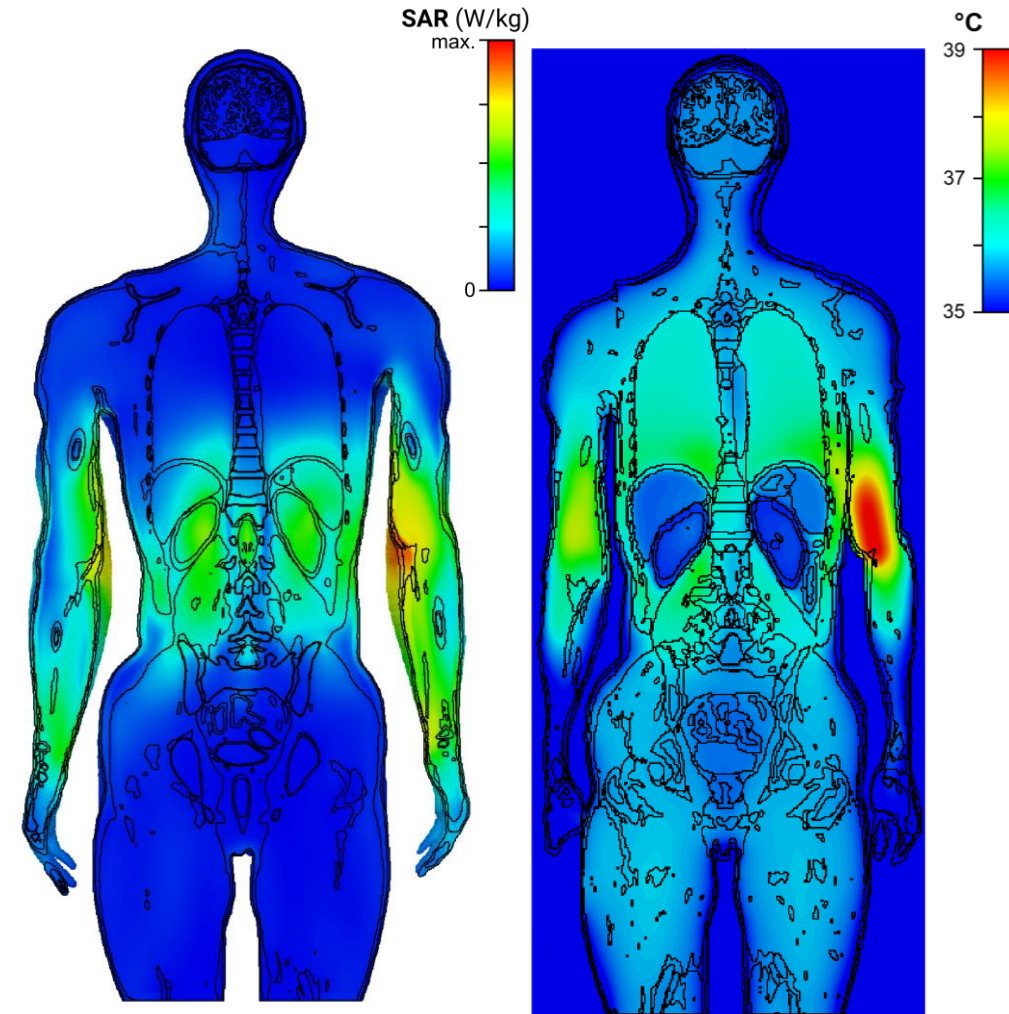


Engineering of RF antennas for MRI

Medical Physics in Radiology

Electromagnetic Simulations and RF Safety

- RF Antenna Engineering and Safety Assessment
 - Simulation-based design and optimization of advanced multi-channel RF transmitter arrays for diverse field strengths (e.g., low-field at 0.55 T and ultra-high-field ≥ 7 T)
 - Enhancing traditional safety assessments by evaluating localized tissue temperature and thermal dose alongside SAR, providing a more comprehensive understanding of patient safety during complex MR examinations.



RF Exposure with anatomical body models
for MRI

Medical Physics in Radiology

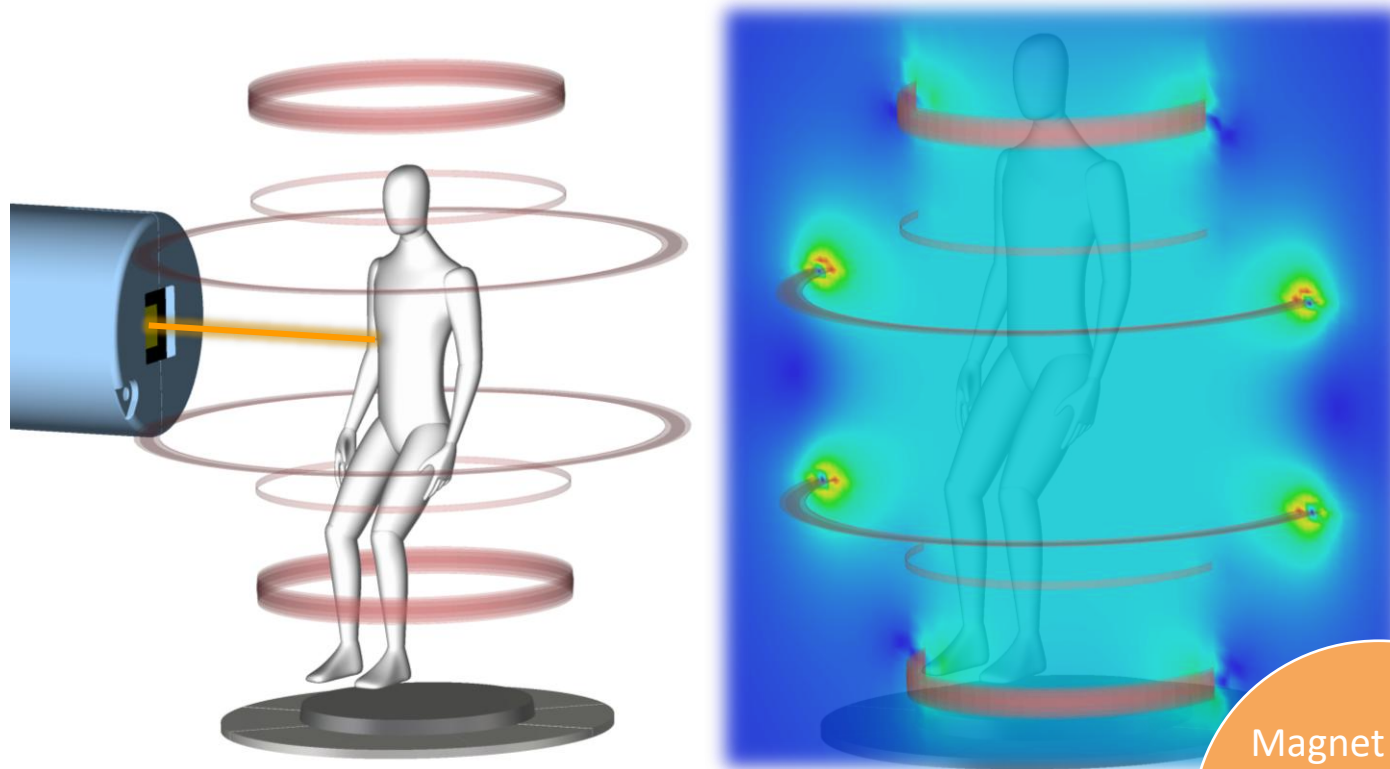
Electromagnetic Simulations and RF Safety



Federal Ministry
of Research, Technology
and Space



HEIDELBERG
UNIVERSITY
HOSPITAL



- MR magnet design for MR-guided particle therapy
 - We are researching and developing novel magnet structures utilizing High-Temperature Superconductors (HTS).
 - We are integrating MRI with Particle Therapy that enable real-time, high-precision image guidance during cancer treatments (Project ARTEMIS - Adaptive radiotherapy with MR-guided ion beams)

Magnet design
with
High-Temperature
Superconductor



See you again!

Contact for Theses



<https://www.dkfz.de/en/medical-physics-in-radiology>



MedPhysRadiology.theses@dkfz.de

RESEARCH FOR A LIFE
WITHOUT CANCER



GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION