Medical Physics in Radiology

Gaining insights into the body non-invasively

Head of Division: Prof. Dr. Mark E. Ladd

dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

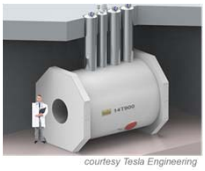
Research for a Life without Cancer

Exploring new and improving existing magnetic resonance (MR) contrasts through

Hardware

- Radiofrequency coils
- Gradient coils
- Tissue-simulating test media
- Ultrahigh magnetic field ($B_0 \geq 7$ T)

7T scanner



Proposed 14T scanner

Acquisition schemes

- Specific acquisition schemes e.g. for
  - Imaging of ion concentrations (sodium ^{23}Na, chlorine ^{35}Cl, potassium ^{39}K)
  - Mapping of oxygen metabolism via ^{17}O MRI
  - Imaging of proteins via CEST (chemical exchange saturation transfer) MRI
  - Investigation of energy metabolism and pH via phosphorous (^{31}P) MR spectroscopy
  - Investigation of veins, hemorrhage and iron distribution via susceptibility mapping

Post-processing

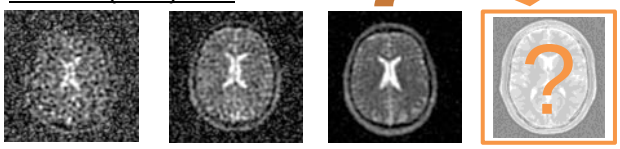
- Iterative or model-based reconstructions to increase the signal-to-noise ratio
- Quantitative analysis (e.g. pH, relaxation times (T_1, T_2), cerebral metabolic rate of oxygen, concentrations)
- Deep-learning-based reconstruction and quantification

Benefit of an ultrahigh magnetic field strength

- Signal-to-noise ratio strongly increases with the magnetic field B_0
- This is particularly beneficial for less sensitive nuclei compared to hydrogen (^{1}H) such as sodium (^{23}Na), chlorine (^{35}Cl), phosphorous (^{31}P), oxygen (^{17}O), potassium (^{39}K) and magnesium (^{25}Mg)

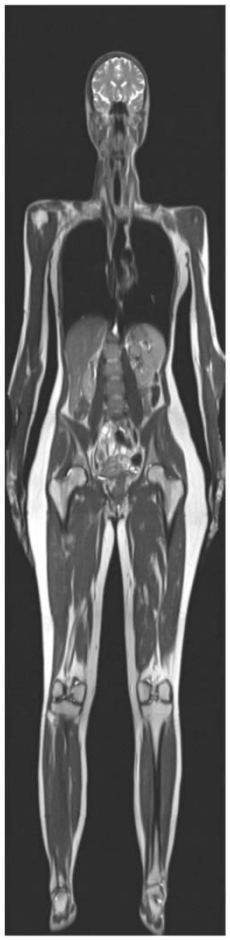
The next step

Sodium (^{23}Na) MRI



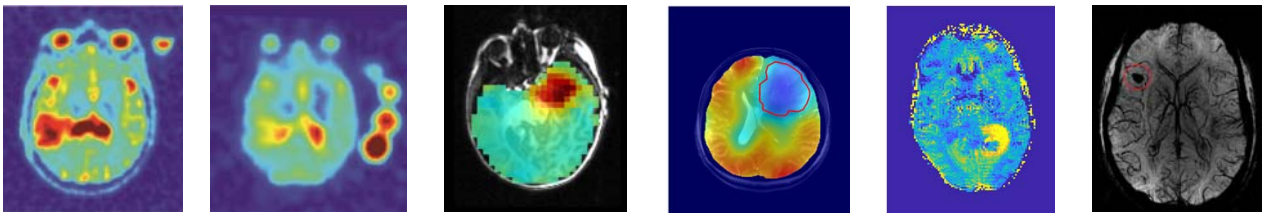
1.5 Tesla | 3 Tesla | 7 Tesla | 14 Tesla

Examples of own MR studies



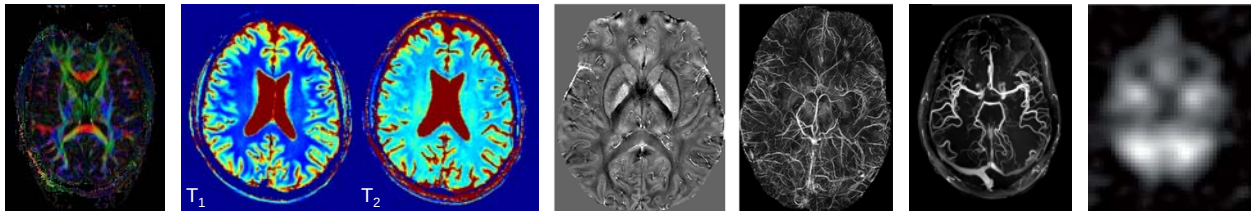
Brain MRI of tumor patients at 7 T

Concentration of ions (^{23}Na, ^{35}Cl) | pH mapping (^{31}P) | Oxygen (^{17}O) consumption | Protein CEST MRI | Veins and hemorrhage



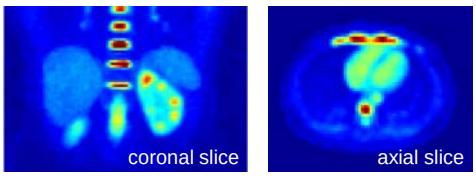
Brain MRI of healthy volunteers at 7 T

White matter tracts (diffusion) | Quantitative mapping of relaxation times | Susceptibility mapping | Venogram | Angiogram | Concentration of ions (^{39}K)



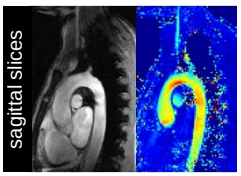
Torso MRI of healthy volunteers at 7 T

Concentration of ions (^{23}Na)



Abdomen | Heart

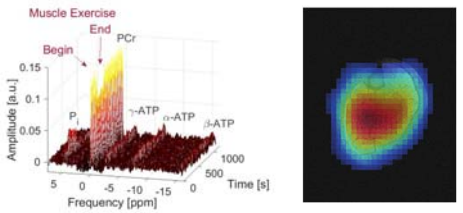
Cardiac MRI



Anatomy | Flow

MR of healthy muscle at 7 T

Dynamic ^{31}P calf MRSI | ^{25}Mg calf MRI



Improved structural imaging and mapping of metabolic processes for earlier diagnosis, selection of personalized treatment, and monitoring of therapy response

Website: https://www.dkfz.de/de/medphysrad/

MedPhysRadiology.theses@dkfz.de

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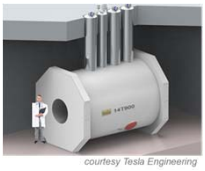

courtesy Tesla Engineering

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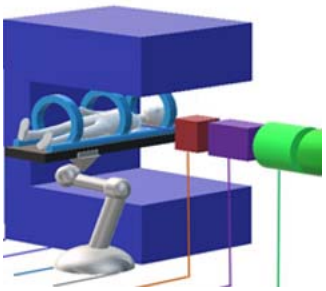
New hardware and up-coming projects

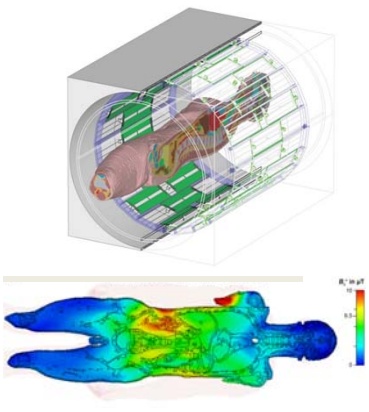
Preclinical 9.4 T PET/MR scanner

SpinLab polarizer system

MR-guidance in radiotherapy

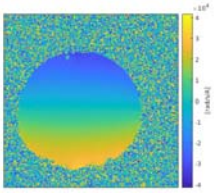


MRexcite: Body MRI @ 7 Tesla with 32 custom-built transmit channels



3 Tesla MRI with strong gradients e.g. for diffusion MRI

with an extra strong breast gradient coil



(in cooperation with University Freiburg & University Erlangen)

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