# ST 9: Magnetic Resonance and PET Imaging

Chair: Franz Pfeiffer

Zeit: Donnerstag 9:00–10:15 Raum: A021

ST 9.1 Do 9:00 A021

**Enhanced MRI Contrast Agents with Resonant Ultrasound** — •Nouri Elmiladi, Christian Höhl, and Karl Maier — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, 53115 Bonn

We have developed a method involving the application of ultrasound (US) in magnetic resonance imaging (MRI) in the presence of antibody coated magnetic nanoparticles to generate contrast. Similar magnetic nanoparticles are already used as contrast agents. It is interesting to control their effect by additional parameters, which can be switched on and off externally, and depend on the properties of the surrounding tissue. In performing proton nuclear magnetic resonance spectroscopy, US is applied to an aqueous sample containing magnetic nanoparticles coated with antibodies from one side only. Therefore, while the asymmetric magnetic nanoparticles in the sample are subjected to an US wave, a torque is initiated along the vibrational motion and will cause the particles to tilt periodically. The asymmetric magnetic nanoparticles will act as an US driven radio frequency antenna, leading to an increase in the spectral density function at the US frequency. If the US frequency matches the Larmor frequency, protons in the near field region of the particle are stimulated to lose energy, and the $T_1$ of the aqueous solution decreases. A significant increase of the longitudinal proton relaxation rate is experimentally observed when using a colloidal aqueous solution of asymmetric magnetic nanoparticles.

ST 9.2 Do 9:15 A021

**„Tumorsuche“ an Phantomen im MRT-Bild mittels Ultraschall** — •Jessica Mende, Marcus Radicke, Ole Oehms und Karl Maier — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, Nussallee 14-16, 53115 Bonn, Germany

Wir untersuchen die Kontrasterzeugung im MRT-Bild mittels des Schallstrahlungsdrucks von Ultraschall. Dieser Kontrast kann die viskoelastischen Eigenschaften wie Elastizitäts- und Schubmodul in einem Phantom graukodiert sichtbar machen. Während einer Standard-Spin-Echo Sequenz mit zwei bewegungssensitiven Gradienten wird ein Ultraschallpuls mit ca. 20 ms Länge bei einer Frequenz von 2,5 MHz eingestrahlt. Zur Untersuchung wurden Phantome aus Agar-Agar mit Kieselerde in verschiedenen Konzentrationen hergestellt. Agar-Agar ist eine gelartige Substanz, Kieselerde dient als Absorber der Ultraschallwelle. Dies soll viskoelastische Eigenschaften von menschliches Gewebe nachahmen. In die Phantome wurden Tumore aus Öl-in-Gelatine-Mischungen eingebaut, die im Protonendichtekontrast abgebildet werden. In MRT-Differenzbildern mit und ohne Ultraschall können diese Tumore mit dem Ultraschall aufgrund von unterschiedlichen mechanischen Eigenschaften „ertastet“ werden.

ST 9.3 Do 9:30 A021

**Schallabsorption und viskoelastische Parameter als Kontrast in der MRT** — •Marcus Radicke, Ole Oehms, Jessica Mende, Bernd Habenstein und Karl Maier — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn

Mittels eines Ultraschallpulses wird in einer Probe eine statische Auslenkung während dieser Pulsdauer erzeugt. Das Prinzip dahinter beruht auf dem Schallstrahlungsdruck. Die lokale Auslenkung der Probe wird mit einer speziellen MRT-Sequenz gemessen und farbkodiert dargestellt. Sie ist abhängig von der Schallamplitude, der Schallfrequenz, der viskoelastischen Eigenschaften der Probe und der Schallabsorption innerhalb der Probe. Da die Schallamplitude sowie die Schallfrequenz frei wählbar sind und die Schallamplitude nicht linear mit dem zurückgelegten Schallweg abfällt, können somit Rückschlüsse auf die viskoelastischen Eigenschaften und die Schallabsorption separat erhalten werden. Wir benutzen eine Spin-Echo-Sequenz mit zwei zusätzlichen, äquivalenten, 20ms langen und 20mT/m starken Gradienten, sowie eine Ultraschallleistung von unter 5W/cm$^2$ bei einer Pulslänge von 20ms. Als Proben werden Phantome aus Gel und Agar-Agar benutzt, die menschlichem Gewebe bzw. menschlichen Organen mit künstlichen Tumoren nachempfunden sind.

ST 9.4 Do 9:45 A021

**4D in-beam PET data reconstruction for moving phantoms irradiated with a tracked carbon ion beam** — •Kristin Laube[1], Christoph Bert[2], Naved Chaudhri[2], Fine Fiedler[1], Katia Parodi[3], Eike Rietzel[4], Nami Saito[2], and Wolfgang Enghardt[1,5] — [1]FZD, Dresden, Germany — [2]GSI, Darmstadt, Germany — [3]HIT, Heidelberg, Germany — [4]Siemens Medical Solutions, Erlangen, Germany — [5]OncoRay, Dresden, Germany

In-beam PET has become a quality assurance tool providing valuable clinical feedback for static tumor entities and shall be extended to monitor the treatment of intra-fractional moving tumors like in the lung or liver which are subjected to respiratory motion. The potential of 4D in-beam PET for the detection of possible malfunction of the motion compensated beam delivery has been investigated by means of systematic phantom experiments at the clinical in-beam PET installation at GSI Darmstadt. The new system for tracking moving targets with the scanned ion beam at GSI Darmstadt was used to adapt the Bragg peak positions laterally and in depth. The pencil beam has been rescanned on a horizontal line in a phantom placed at the central plane of the double head PET scanner with an energy corresponding to 60 mm penetration depth while the target was performing a one dimensional periodic motion perpendicular to the beam direction. 4D PET data were compared with an appropriate 3D PET measurement which followed immediately after the dynamic acquisition. It is shown for different irradiation scenarios that in-beam PET is capable for detecting treatment errors for moving target irradiation.

ST 9.5 Do 10:00 A021

**PET imaging for in-vivo verification of ion beam therapy** — •Katia Parodi — Heidelberg Ion Beam Therapy Center, Heidelberg — Previously at Massachusetts General Hospital, Boston, USA, and Forschungszentrum Dresden-Rossendorf, Dresden

The usage of ion beams in external radiotherapy is rapidly increasing worldwide. The main rationale is their favorable depth-dose distribution with a sharp maximum at the end of range, the "Bragg-peak". Full clinical exploitation of this advantage demands millimeter accuracy in the localization of the beam stopping point and lateral field position in human tissue. Positron-emission-tomography (PET) currently offers the only feasible technique for in-vivo verification of the actual beam delivery and, in particular, of the beam range in the patient. The method exploits the detection of the transient $\beta$+-activation induced by ion irradiation, which is correlated but not proportional to the dose delivery. Treatment verification can be achieved by comparing the measured activity distribution with a calculated one, as originally proposed and implemented for carbon ion therapy at GSI Darmstadt.

After a review of the main principles and experiences, this talk will address the first quantitative study on PET/CT (Computed-Tomography) imaging for in-vivo verification of proton therapy, describing all steps from the calculation modeling to the pre-clinical phantom experiments followed by the first clinical trial at the Francis H. Burr Proton Therapy Center at Massachusetts General Hospital, Boston. Merits and issues of the method will be discussed, including an overview of ongoing research aimed at improved clinical performances.