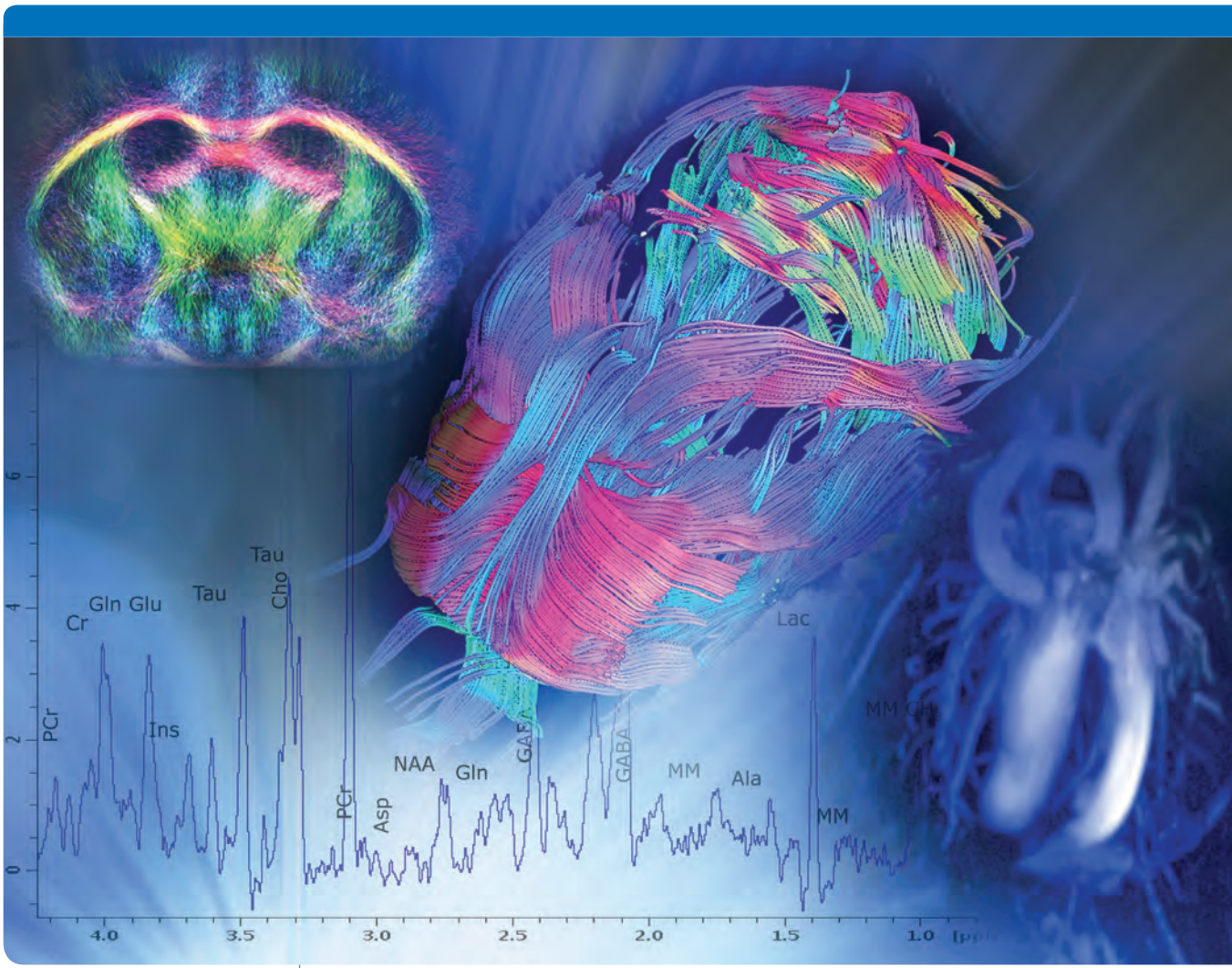
BRUKER



MRI Application Solutions

- Ready to Use Applications for Optimal Results

The Bruker Philosophy for Preclinical Imaging

For preclinical MRI Bruker has embraced a unique philosophy to ensure that we understand our customers' needs and the challenges they face, and that best utilizes our expertise and knowledge. To deliver on this approach Bruker has installed, in-house, eight installed preclinical MRI systems of different bore sizes and field strengths from 1 to 15 Tesla (T) at our main application facility in Ettlingen, Germany.

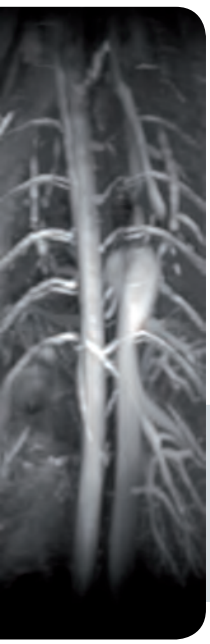
Supported by many application specialists that cover every application, their trusted expertise and knowledge is what drives the development of innovative *in vivo* imaging applications. The resulting solutions benefit a wide range of demanding needs in preclinical imaging, molecular medicine, biomedical and pharmaceutical research. It is this same knowledge and expertise that is made available to individual projects and collaborative developmental efforts.

By developing MRI instrumentation in-house on *in vivo* subjects, the number of unnecessary animal experiments at customer sites is significantly reduced, as is the time required before customers can produce their own data.

The Applications Center has fully optimized protocols for fMRI, DTI, Perfusion, Cardiology, Angiography, Abdomen, Anatomy, IntraGate (Self-Gating), Relaxometry, and Spectroscopy – all of which have been developed *in vivo* in-house, for use with mice and rats across our entire MRI product range, namely BioSpec®, PharmaScan®, ClinScan® and Icon. These protocols have been developed for all field strengths from 1 T to 15.2 T with the appropriate gradient and RF coils. There are more than 600 protocols available that can be used 'out of the box'.

Traditionally such powerful technology required years of expertise, intensive training or specialist operators, but today an MRI system from Bruker does all the complex work for you. You focus on your biological, pharmaceutical and preclinical investigations - we'll take care of the rest.

Angiography



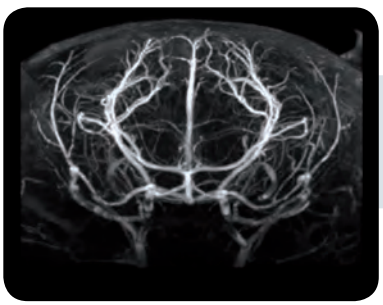
Examine the finest vessels with Bruker's Time of Flight (TOF) and Phase Contrast Angiography (PCA)

- No need for contrast agents
- For all of your pathological questions, all throughout the body
- Qualitative and quantitative analysis

Angiography of mouse spine without contrast agent at (86 × 86) µm² resolution showing visualization of posterior intercostal arteries and veins.

Countless Angiography Applications

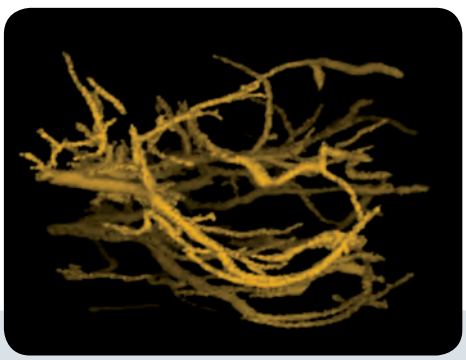
With Bruker's angiography protocols you can do visualization of vessels in the brain, heart, liver, kidneys, spine, extremities, and more, proving valuable information about pathologies such as glioblastoma, inflammation, aneurysms, and congenital vascular abnormalities.



Angiography of mouse brain acquired at 15.2 Tesla with an isotropic resolution of 49 µm.

Distinct Vessel Visualization

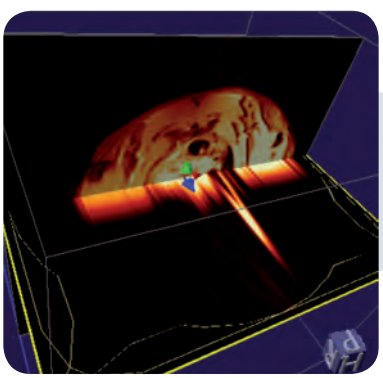
Time of Flight (TOF) protocols yield clear images of vessels where blood is flowing. With the easy placement of saturation slices, you can also choose to image either the veins, the arteries, or both. Maximum Intensity Projection (MIP) and surface rendering reconstructions lead to even greater discernability.



Surface rendering of rat head angiography.

Quantitative Flow Analysis

Quantitative analysis can be done using the Phase Contrast Angiography (PCA) protocol. Run as a Velocity Mapping, the average velocity of each voxel is given in cm/s. For even greater accuracy, the PCA can be run as a Fourier Flow, which resolves the full velocity distribution within every voxel. This is of advantage when complex flow patterns such as turbulence are expected.



Velocity profile of rat aorta reconstructed in Bruker's JIVE: the laminar flow of blood in the aorta is demonstrated well here.

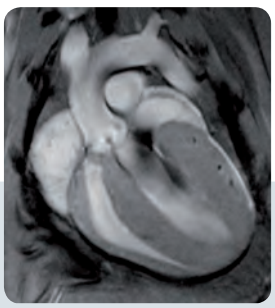
Cardiology

Bruker meets the ultimate challenge in MR Imaging with its unsurpassed cardiac imaging

- Four chamber black blood to locate defects of the septum
- Two chamber bright blood for investigation of ejection fraction
- Short axis tagging for assesment of wall motion

The Ultimate in MR imaging

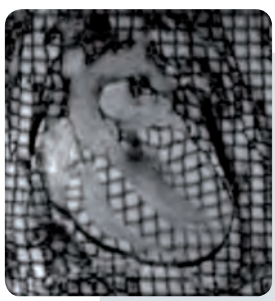
Beating 5 - 10 times per second under anaesthesia, and only half the size of a penny, the mouse heart poses the ulitmate challenge in MR imaging. Bruker meets this challenge with its phased array surface coils designed especially for mouse and rat hearts that allow acceleration for even faster cardiac scanning, and provide optimal signal due to their surface curvature that lets them be placed as near as possible to the heart.



Four chamber bright blood view of mouse heart acquired at 11.7 Tesla with a resolution of (78 × 59) µm², FOV in 8 min.

Four Chamber, Two Chamber, and Short Axis Views

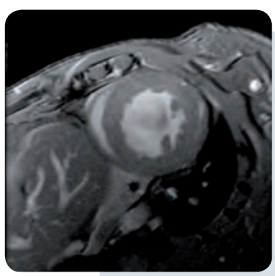
All of these choices can be run in either four chamber, two chamber, or short axis views, unless, of course, like some of Bruker's customers you are looking at the only three-chambered heart of a salamander. Whether it is salamanders, mice, or even crabs that you are using, Bruker lets investigation of septum defects, wall motion, ejection fraction and more be done in a heartbeat (or at least in the case of our cardiac EPIs in twelve seconds).



FLASH imaging with tagging preparation deliveres cine movies of the mouse heart.

Bright Blood, Black Blood, and Tagging

This specialized hardware is supported by Bruker's wide range of cardiac protocols. You can choose between bright blood images where the blood in the heart chambers is brighter than the myocardium, black blood protocols where the blood signal is suppressed, and you can combine these with tagging of the myocarduim, which provides a quantitative analysis of heart motion.



Two chamber bright blood view of mouse heart with ultra high resolution providing detail of coronary arteries.

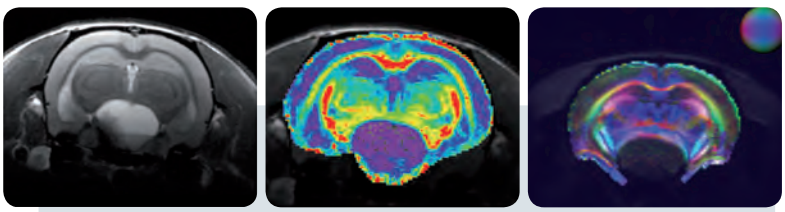
Diffusion

Achieve highest resolution and best possible sensitivity with Bruker's diffusion options

- Measure diffusion weighted images, diffusion tensor images, trace images, fractional anisotropy images, and apparent diffusion coefficient maps
- Acquire highest possible sensitivity in diffusion weighted images with Bruker's world-wide strongest gradients
- Obtain critical information about tumor infiltration, cardiac infarction, connectivity, stroke, and more

View Diffusion in More than Just One Way

Bruker's diffusion imaging is more than Diffusion Weighted Images (DWI) and Diffusion Tensor Images (DTI). When you use Bruker's pre-prepared DWI and DTI protocols, no separate scanning is necessary to receive a non-diffused A0 image and to calculate trace images, Fractional Anisotropy (FA) images, and Apparent Diffusion Coefficient (ADC) maps. This additional information complements DWI and DTI, since for example, ADC, which measures the magnitude of diffusion, is reduce by approximately 50% minutes after the onset of ischemia.



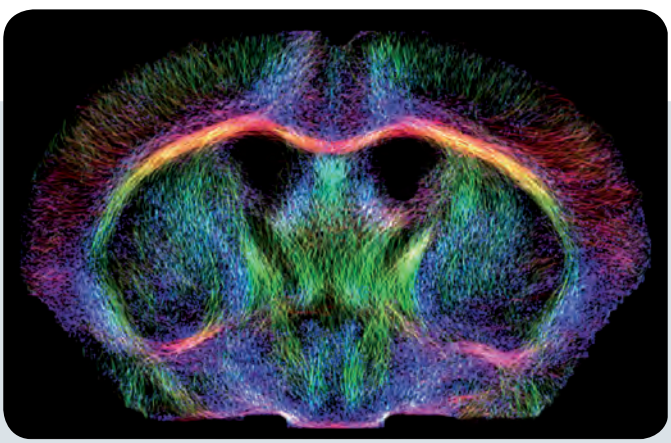
Magnitude (A0), ADC map, and color coded diffusion tensor of a rat brain.

The Best Gradients for the Best Diffusion Weighted Images

The contrast in Diffusion Weighted Imaging (DWI) originates from the difference in amount of diffusion. Regions that have pathologically disturbed diffusion, such as found when multiple sclerosis, epilepsy, and schizophrenia, stroke, or tumors are present, are easily visible. Greatest sensitivity is achieved with higher b values, which can only be realized with extremely strong gradients. This is just one more reason why Bruker invests so strongly in its world-wide leading gradient technology.

Diffusion Tensor Imaging for Unsurpassed Accuracy

Diffusion Tensor Imaging (DTI) surpasses other imaging methods in addressing many biological questions. Since DTI visualizes the diffusion orientation, it is used to assess fiber connectivity in the embryonic development of transgenic models. It is also the only method that can accurately visualize the level of tumor infiltration into healthy tissue.



High resolution fiber tracking of the living mouse brain reconstructed with 16 µm in-plane resolution. Courtesy: L.-A. Harsan, D. von Elverfeldt et al., University Medical Center Freiburg, Freiburg, Germany.

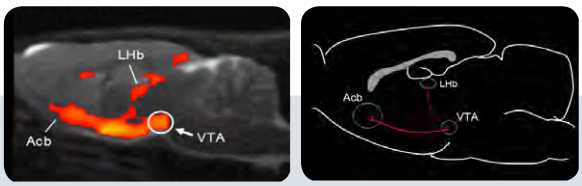
fMRI

Where are they thinking? Find out with Bruker's fMRI

- From visual stimulation to conditioned taste aversion
- The speed you need for fMRI
- Integrated evaluation tool

Exciting Possibilities Become Reality

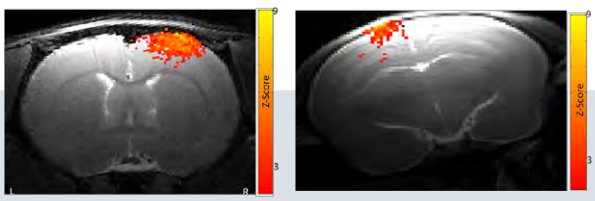
The exciting possibilities of fMRI become reality with the research that Bruker's customers carry out on a daily basis. Their studies extend beyond forepaw stimulation to discoveries in areas such as face recognition and functional connectivity.



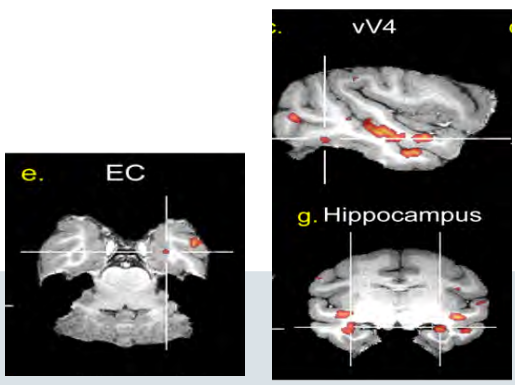
Functional connectivity along dopamine pathway in rat: Courtesy: Bifone A, Gozzi A, Schwarz A, et al., Glaxo Smith Kline S.p.A, Verona, Italy.

Exceedingly Fast Sequences

Mice and rats, macaques and rabbits are all used and Bruker's fastest EPI sequences deliver the needed speed by recording images every second. To make this possible Bruker has pushed physics to its extremes by including all of the mathematical tricks into the software and using its world class coil knowledge when building phased array coils.



Forepaw stimulation in rat is colateral (left), in rabbit contralateral (right) acquired with EPI with a resolution of (150 × 150) µm² at 11.7 Tesla. Courtesy: G. Pelled, Kennedy Krieger Institute and Johns Hopkins University, Baltimore, USA.



Face-processing network of awake macaques: acquisition details: 500 MHz, SE- EPI Courtesy: S.-P. Ku, et al., Neuron 70 (2): 352 (2011). Data provided by J. Goense, Max-Planck Institute for Biological Cybernetics, Tuebingen, Germany.

Integrated Evaluation Tool

The excitement peaks when the data is put into ParaVision's integrated FUN evaluation tool and a perfect time course is seen. FUN tool even allows the evaluation of more than one type of stimulation within a routine.

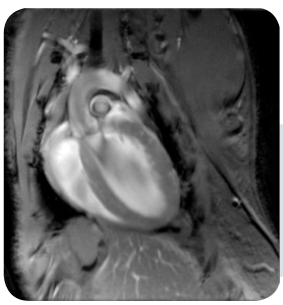
Self-Gating with IntraGate

Bruker's IntraGate is the electrode-and trigger-free method of scanning the heart and abdomen to assess morphology and disease

- Scans quality as crisp as traditional triggered scans
- Retrospective gating of rapid heart beating and strong respiratory motion in small animals
- Choose between abdominal and bright or black blood multislice cardiac cines
- Choose between cardiac, respiratory, or cardiac in combination with respiratory cines

Electrode-free Cardiac Imaging Eases Setup and Saves Time

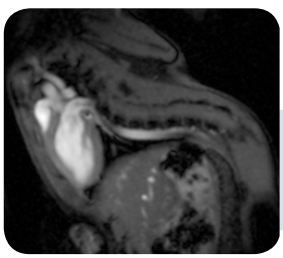
Bruker's patented IntraGate provides artifact-free cardiac imaging without the need for tedious electrode setups. When time is not on your side, you can shorten your animal setup by skipping the electrodes. This is of special interest to users who run their scanners in a "conveyor belt" style, since this critical bottleneck setup time is decreased, allowing a higher throughput. IntraGate is especially useful for animals with particular pathologies that hinder clear and strong electrode signal reception, where triggering is difficult.



Four chamber cine of mouse heart acquired with the self-gating technique IntraGate with a resolution of (78 × 78 × 800) µm³ at 11.7 Tesla.

No Triggering Equals Worry-free Scanning

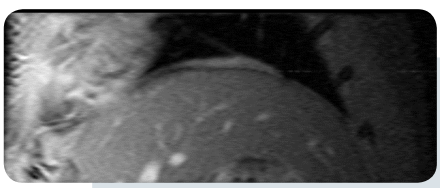
IntraGate can be used for cardiac, respiratory, and abdominal imaging, all of which normally require triggering. With Bruker's IntraGate, there is no need to consider triggering: just select either a time frame cine for abdominal imaging, or a black or bright blood cine for cardiac imaging, set your number of slices, press the traffic light button and sit back and relax while IntraGate takes care of the rest.



Mouse heart with ascending aorta acquired with IntraGate at 9.4 Tesla.

Scan Once, Get up to Three Cines

Since Bruker's IntraGate uses retrospective triggering, you can decide after the scan, what type of cine and even how many frames you would like to have. Cardiac, respiratory, as well as cardiac in combination with respiratory cines are possible, and the number of cine frames can be increased as much as desired, as long as the SNR suffices.

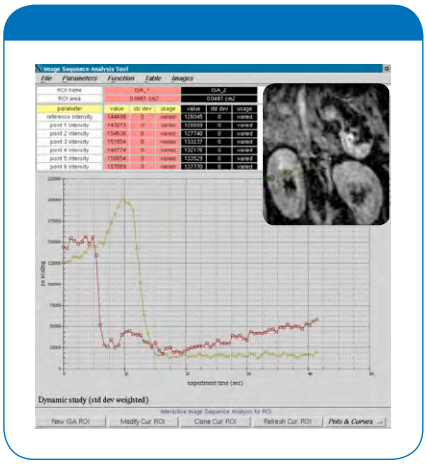


Mouse diaphragm movement cine acquired with IntraGate FLASH.

Perfusion

With Bruker you have the full range of perfusion options: dynamic contrast enhanced and dynamic susceptibility contrast studies using contrast agents and contrast agent-free arterial spin labeling

- Cover all of the pathologies that are of interest to you – stroke, tumor diseases, vessel stenosis …
- Blood flow and mean transit time are easily calculated
- Extremely short scan times give you excellent temporal resolution for your contrast agent studies

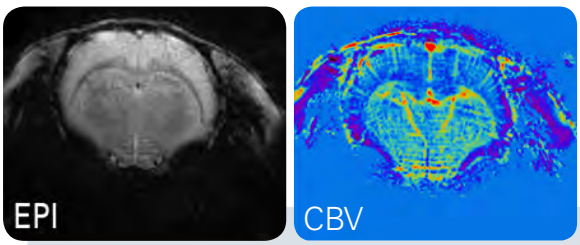


All Perfusion Options at Your Hand

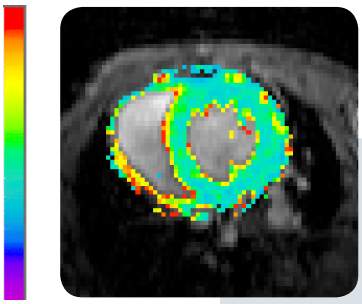
Bruker offers the full range of perfusion study options: whether with or without contrast agent, in the brain or the kidneys, you have the choice. Tumor detection in brain, thorax, and abdomen, tumor neoangiogenesis, tumor vascularisation, cerebral ischemia, disruption of the blood brain barrier, vessel stenosis, flow rates, hypervascularisation, and infectious or inflammatory disease analyses are all possible.

Dynamic Contrast Enhanced (DCE) and Dynamic Susceptibility Contrast (DSC) Studies

A wealth of information can be obtained using contrast agents. Depending on the application, the contrast agent can increase the MR signal, as in tumor neoangiogenesis, or it can decrease the signal, as in stroke, where the amount of perfusion indicates which areas are in the penumbra and which are in the ischemia. For the highest time resolution when using contrast agents, choose Bruker's fastest sequences, which record an image every two seconds.



Dynamic contrast enhanced imaging of rat brain acquired with EPI and Grappa reconstruction at 11.7 Tesla. A bolus of 0.02 mMol/kg magnevist was administered. Data processing with biomap, Novartis, Basel, Switzerland.



Arterial spin labeling in mouse myocardium: acquired with FAIR-FISP (wip). Courtesy of W. Weglarz, Institute of Nuclear Physics, PAN, Krakow Poland.

Blood Flow Quantification with Arterial Spin Labeling

For calculation of blood flow, no contrast agent is necessary. Bruker's Arterial Spin Labeling (ASL) imaging sequences come with easy to use quantification software that provides blood flow maps of either the entire scanned area or your desired region with just a few simple clicks. Blood flow values can be read out for each individual pixel.

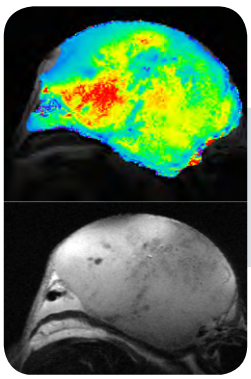
Relaxometry

Gain valuable knowledge about pathologies, contrast agents, and more with Bruker's Relaxometry protocols

- T_1, T_2, and T_2* maps in stand-alone, combined, or fast variations
- For mapping of all pathologies in all tissues
- Complete analysis directly in ParaVision

All Relaxometry Maps in All Tissues

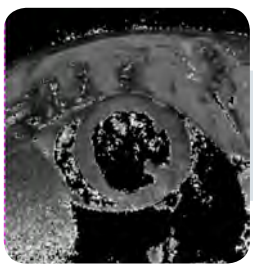
Bruker's relaxometry maps can be run in all areas of the body to address all of your biological questions. Mapping can be used to differentiate healthy from cancerous tissue or to diagnose brain injury. Bruker offers three methods to measure T_1 maps: a spin echo, a gradient echo, and a look locker EPI. The spin and gradient echo methods even measure T_2 values in the same scan.



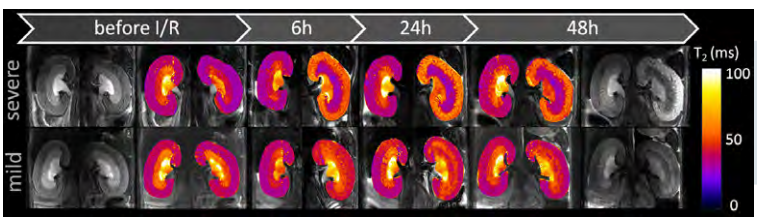
T_2* Map of mouse flank tumor acquired by a multiple gradient echo (MGE) with a resolution of (52 × 52) µm².

Use Relaxometry Knowledge to Optimize Protocols

In addition to the dual T_1 and T_2 measurement methods, Bruker offers two additional methods for calculating T_2, a spin echo and a very fast EPI, which can be used to gain a first impression of T_2. Knowing T_1 and T_2 values is of great value when running experiments such as perfusion or spectroscopy and during development of new contrast agents.



T_2* Map of rat Heart delivered by a triggered MGE.



Acquired with an MSME at 9.4 Tesla. Courtesy: T. Niendorf, Max- Delbrueck Center for Molecular Medicine, Berlin, Germany.

Integrated Pixel per Pixel Evaluation

Bruker's T_2* gradient echo and EPI protocols, as well as with all other relaxometry protocols, can be evaluated directly in ParaVision. Curve fitting and generation of relaxometry maps which can be read out pixelwise, is done with a few simple clicks.

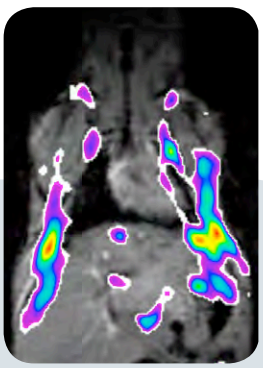
Spectroscopy

From single voxel spectroscopy to X-nuclei imaging, Bruker makes it all possible

- Observe metabolic disorders involving chemicals with only millimol concentrations
- Integrate, filter, and phase your spectra directly within TopSpin
- Perform carbon, fluorine, or phosphorous studies

More than Water

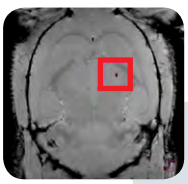
The brain, liver, and muscles of your animals contain more than just water, and MR spectroscopy makes non-invasive studies of metabolic processes in these tissues possible. You can identify metabolic disorders and observe long term changes in metabolic processes even though the chemicals that are detected here are only found *in vivo* in millimolar concentrations.

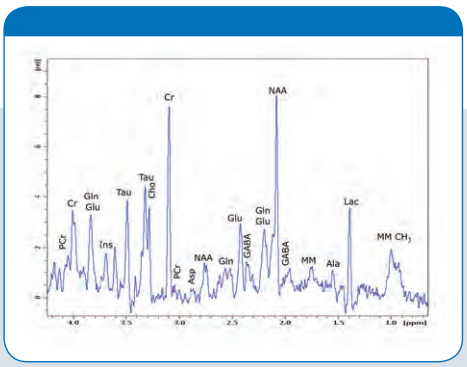


Isoflurane collection in adipose tissue of mouse abdomen gradient echo image with overlayed Flourine image taken after 2 hours of isoflurane anesthesia.

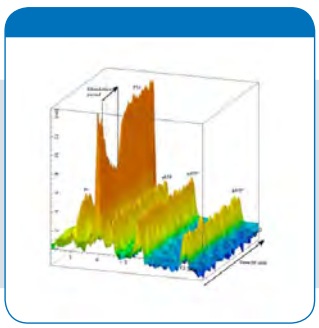
More than Single Voxels

You can choose to look at single voxels or perform chemical shift imaging, knowing that Bruker has powerful integrated software for the analysis of both. This allows you to display multiple single voxel spectra simultaneously, calculate line widths and integrals of your peaks, or overlay a spectral map from your chemical shift image onto a reference image.





^{1}H Spectrum of mouse brain by using STEAM at 15.2 Tesla.



Phosphorous spectra of rat calf muscle with and without stimulation Courtesy: C. Gerard, P. R. Allegrini, et al., Novartis, Basel, Switzerland

More than Protons

With Bruker's standard carbon, fluorine, and phosphorous coils, glucose uptake, changes in ATP, or effects of isoflurane, can be monitored with little to no background signal, and sensitivity can be increased even further by using Bruker's decoupling options.

Service and Support

Bruker commitment to providing the highest quality service results in more productivity from your system. From the initial site evaluation, through system installation, and throughout the life-time of your instrument, Bruker BioSpin's service program is dedicated to providing personalized support. By investing heavily in the training of our engineers and support staff, we ensure their up-to-date expertise in the latest MRI technologies. Whether through Bruker BioSpin's support centers, the application, service and software hotlines, or an on-site visit, you can be confident that your Bruker service representative is trained, experienced, and prepared to work diligently to quickly complete your support request.

Application Support

Bruker provides a worldwide network of senior application scientists to support your research programs. In addition to the training immediately after installation customers can join the Bruker BioSpin Application Continuity Program.

Responsive Technical Support

Should you ever have questions or require assistance with your MRI system, our service & support hotlines are your gateway to a solution. The support center engineers and scientists will quickly and efficiently gather key information and suggest relevant diagnostics. Worldwide support centers arrange for parts to be delivered to your laboratory for troubleshooting and repair.

Training Courses

Bruker BioSpin offers training courses from introductory classes to advanced operator and programming courses. The courses cover a wide range of applications and include hands-on lab sessions in our dedicated application support centers. For the training schedule and registration, please visit www.bruker-biospin.com/mri-training.

Contact

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