BRUKER

BioSpec®

MR Imaging and *in vivo* Spectroscopy at High Magnetic Fields

BRUKER BIOSPIN

BioSpec®

Multipurpose Instruments for Applications in MR Imaging and MR Spectroscopy

BioSpec®

Multipurpose Instruments for MR Imaging and MR Spectroscopy Research

Research in neuroscience now relies heavily on animal MRI/MRS where in many instances it has now been established as the gold standard. Other major applications areas include cardiovascular, respiratory and gastro-intestinal studies together with research into arthritis, oncology and metabolic disorders.
Over the past decades magnetic resonance imaging (MRI) and magnetic resonance spectroscopy (MRS) have shown enormous utility for research applications in the life sciences. Functional MRI (fMRI) is probably the most spectacular application and as yet has still to be fully exploited, especially by neuroscientists. The latest developments in molecular biology and genome research have recently led to an expansion in the use of animal MRI/MRS applications. Molecular imaging and rapid phenotyping of transgenic animals are two such applications that have extended the role of MRI/MRS in pharmacology.

BioSpec® instruments form an essential component of any research program in the life sciences that utilises MRI/MRS for the study of disease and metabolism. Due to the modular design the ***BioSpec®*** can be optimally customized for most user applications. The unique, multipurpose capabilities of the ***BioSpec®*** are based on the ***AVANCE™*** digital spectrometer electronics which provide the ultimate in system stability and reliability. The ***BioSpec®*** also benefits from the excellence and expertise of ***BRUKER*** in the design and manufacturing of actively shielded superconducting magnets, high performing gradient systems and suitable RF coils.
Automatic scan adjustments, efficient image reconstruction and flexible post processing features permit easy and routine usage of the ***BioSpec®*** capabilities without compromising full flexibility for the MR expert.

BioSpec® Main Features

- MRI/MRS system
- multi purpose
- high performance
- for animals and material samples
- in research and development
- 4.7 to 11.7 Tesla magnetic field strength
- ultra shielded magnet systems
- 20 cm to 60 cm magnet clear bore size
- actively shielded gradient system
- gradient strength up to 1000 mT/m
- multi channel, multi frequency electronics
- variety of dedicated RF resonators and surface coils
- animal handling and monitoring system

The Outstanding Features of *in vivo* Magnetic Resonance

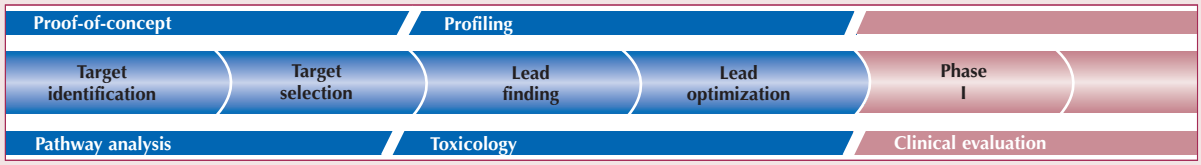
- non-invasive and non-destructive
- quantitative and qualitative, chemical and morphological information accessible
- correlation between morphological, chemical and functional information
- isotropic three-dimensional imaging and analysis
- functional imaging, angiography, perfusion, diffusion
- non-radioactive tracers and molecular markers

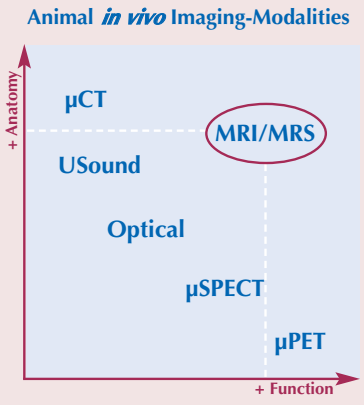
BioSpec®

Animal MR-Imaging & Spectroscopy (MRI/MRS) – the Main Issues

Drug Development & Discovery

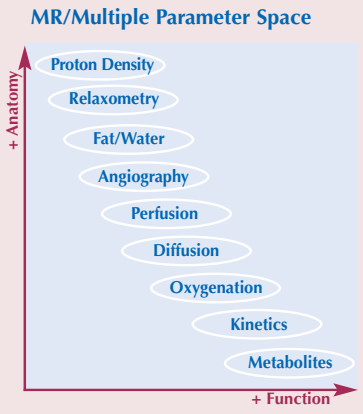
Animal MRI/MRS has its place in pharmaceutical research in preclinical trials on all stages prior to Phase I where it can speed up time-to-market times considerably.





Anatomy & Function

Its unique ability to provide non-invasively a combination of functional/physiological and anatomical information sets MRI/MRS apart from other *in vivo* imaging modalities.



Multiple Parameter Space

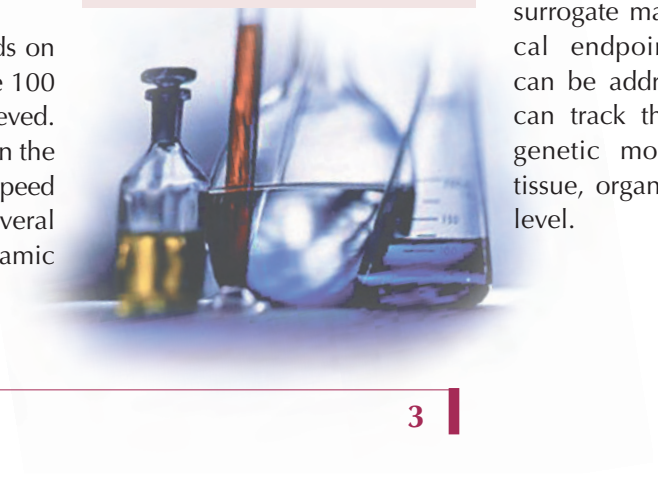
MRI/MRS does not depend on a single physical property but allows the user to play with a multitude of contrast parameters depending on the application. They reflect the physical and chemical state of cell-water and of metabolite molecules and these states are highly sensitive to changes in that environment.

Animals: High Throughput & Reduced Numbers

Throughput of more than 50 animals per day on a single animal MR-scanner is possible. However, animal MRI/MRS can significantly reduce the numbers of test animals in a study due to the high information content and ability to carry out lifetime studies in the same animal.

Resolution & Speed

The pixel resolution depends on the object size, on a mouse 100 microns can readily be achieved. Image scan times are often in the minute range but high speed techniques allow for several frames per second in dynamic studies.

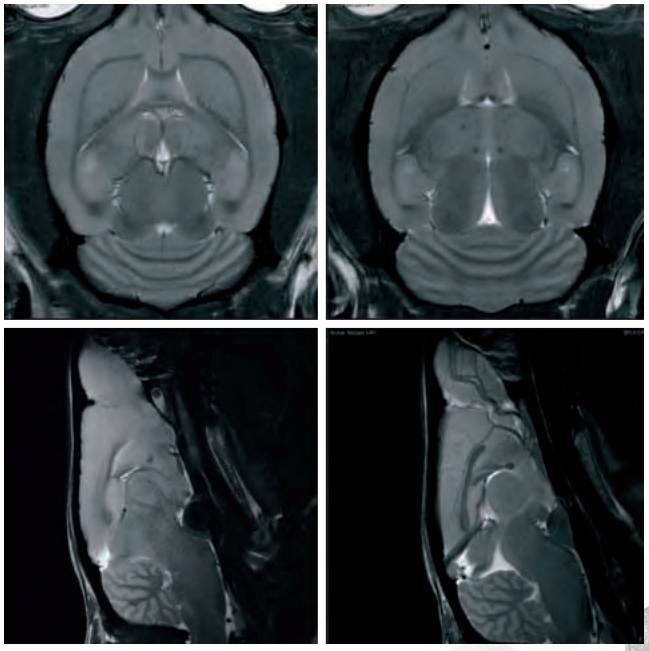


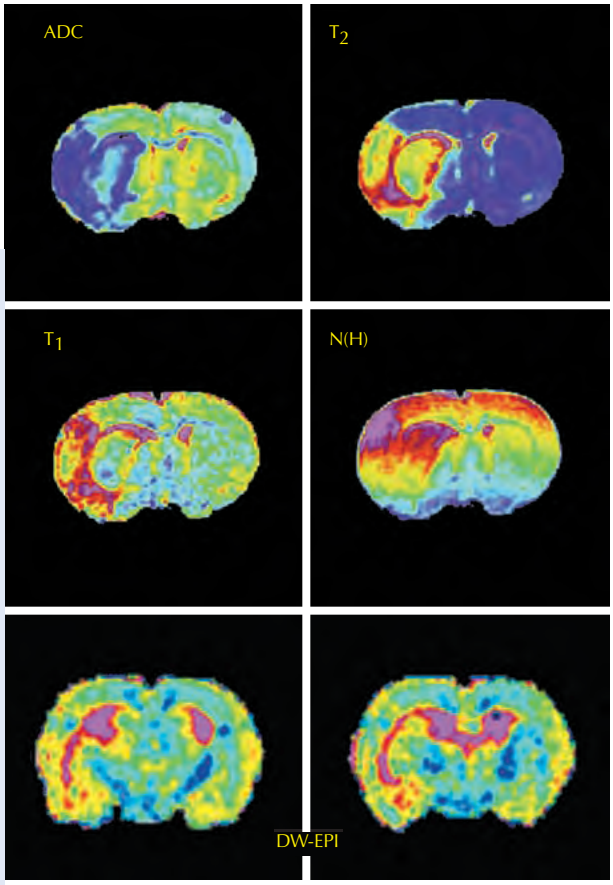
Driving Forces

A rapidly growing number of transgenic animals and drug targets increases the demand for rapid phenotyping. This fact and the new concepts of molecular imaging, highly specific MR contrast agents, surrogate markers, and biological endpoints combine and can be addressed as MRI/MRS can track the changes due to genetic modifications at the tissue, organ and entire animal level.

Rat Brain Imaging

High resolution RARE at 9.4 Tesla *in vivo* with a spatial resolution of 70 µm.

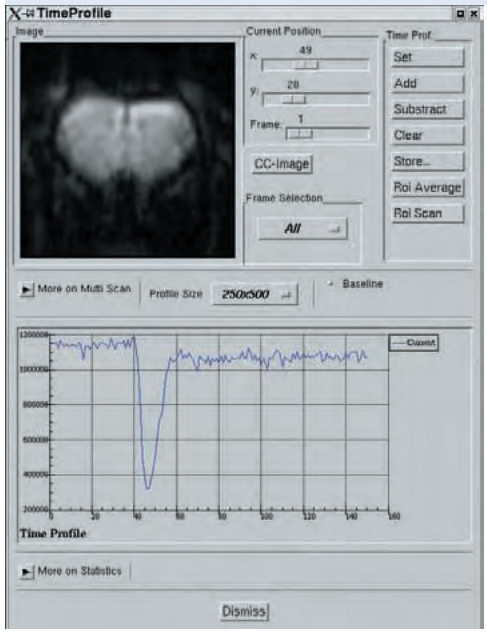




BioSpec®, 47/40
Copyright & Courtesy
M. Eis, M. Neumeier, U. Pschorrn
Böhringer Ingelheim Pharma KG, Ingelheim, Germany

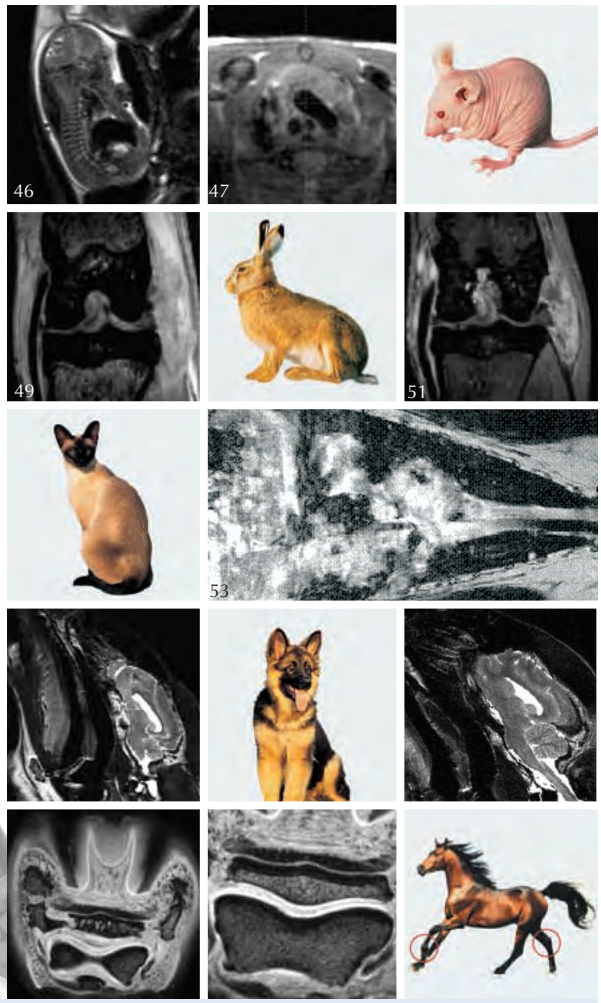
Perfusion Imaging on Rat Brain

Bolus track perfusion imaging of a healthy rat on a *BioSpec*® 47/40. Application of 0.02 mMol/kg Magnevist® during EPI measurement with repetition time of 250 ms: first pass transit of the contrast agent through the brain.



Neuro Drug Trials Combined Imaging Approach

MRI exploits a multitude of biophysical parameters that can be used to examine soft tissue changes down to the cellular level. In this fast EPI study the extent of stroke after a MCAO insult was monitored using calculated maps for ADC, T2, T1, N(H) (proton density), and DW (diffusion weighting).



A Wide Range of Species

Besides the ubiquitous rat, the ***BioSpec®*** can be used to cater a wide range of research animals. Here are four examples, each with applications in the field of chronic diseases.

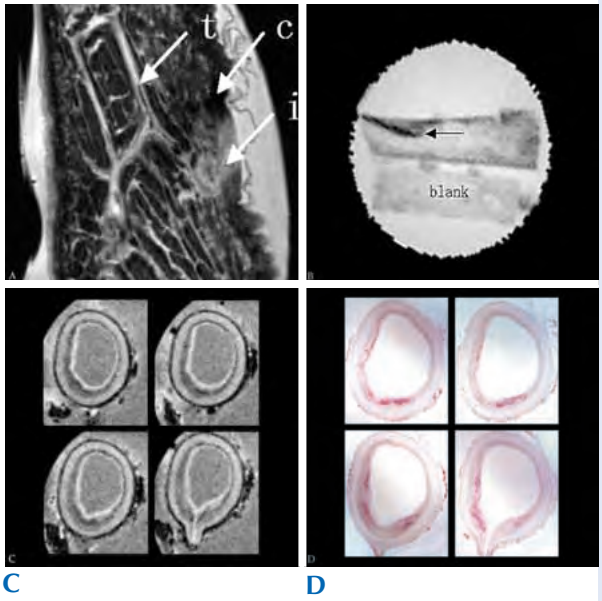
- transgenic mouse (knockout mutant embryo 46, atherosclerosis model 47)
- rabbit (rheumatoid arthritis in the knee)
- cat (abdominal tumor)
- dog (brain tumor)
- horse (cartilage degeneration in the hock)

Other species used by ***BioSpec®*** customers include gerbils, guinea pigs, monkeys, mini pigs, goats, sheep and more.

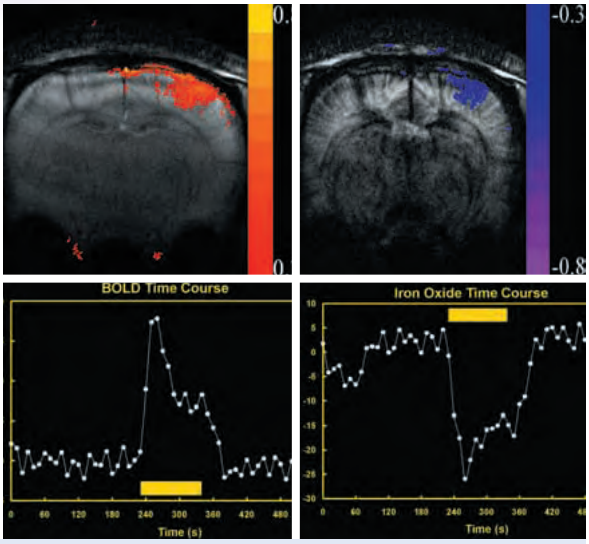
BioSpec®, 70/20
Courtesy of M. Thali, K. Potter, B. Pessanha et al.
Armed Forces Inst. of Pathology
Rockville MD, USA

High Resolution MRI in Human Pathology

MRI has a high potential for *ex vivo*, post-mortem investigations in pathology. A few application examples are electrical injuries in formalin fixed skin specimens (A), surrogate measurements of tissue engineered bone constructs (B) and the characterization of intimal changes in early coronary lesions (C). MRI data correlate well with conventional histology (D) and provide additional information unavailable through traditional modalities.



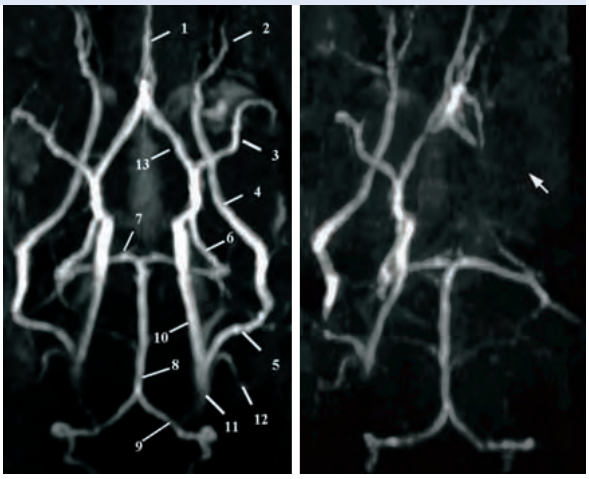
Multiple Dimensions: Spatial, Temporal, Spectral...



fMRI of Rat Somatosensory Cortex at 11.7 Tesla

Time course of rat somatosensory cortex stimulation observed using BOLD contrast (left) and using iron oxide contrast agent (right). In plane resolution: 50 µm.

BioSpec®, 11.7/30
Copyright & Courtesy
A.C. Silva et al.,
National Institutes of Health,
Bethesda, USA



A B

Mouse Brain Micro-Magnetic Resonance Angiography (Micro-MRA)

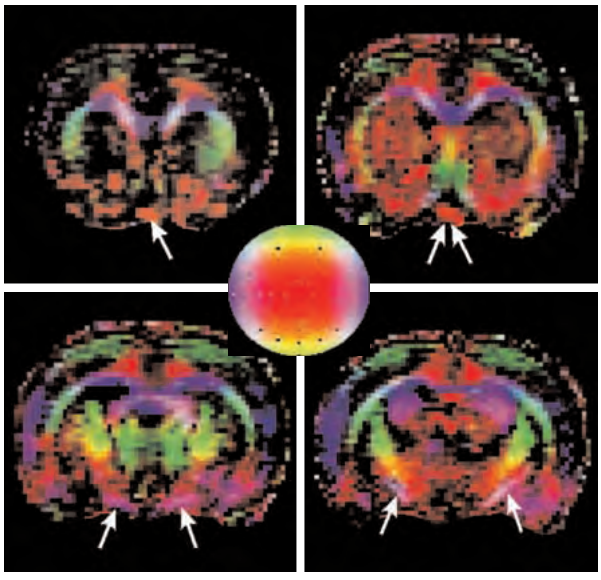
Micro-MRA was performed without contrast agent and resolution of 100 µm. A: the numbers refer to arteries, No. 13 is the circle of Willis. B: a transient MC occlusion experiment. The arrow points to the occluded artery, 15 min after insult.

BioSpec®, 47/40, volume resonator, 20 mm ID
Copyright & Courtesy, N. Beckmann, M. Rudin et al.,
Novartis Pharma, Basel, CH

Fiber Tracking in Rat Brain with DTI

DW-Spin echo, TR/TE=2000 ms/32 ms, Δ/δ=15.4 ms/6 ms, resolution=0.23x0.23x1.0 mm^3. 10 diffusion directions with b=1200 s/mm^2 plus one at b=6.7 s/mm^2, total imaging time 66 min. The insert indicates the color coding of the directional vectors: left-right: blue, up-down: green, dorsal-rostral: red.
Arrows highlight the directional variation in the optical pathways from its rostro-caudal (n. opticus, chiasm in red) to orthogonal (optical tract in violet) course.

BioSpec®, 70/30
Courtesy of M. Czisch, D. Auer et al.
MPI für Psychiatrie, München, Germany



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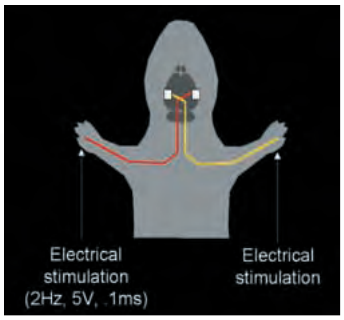
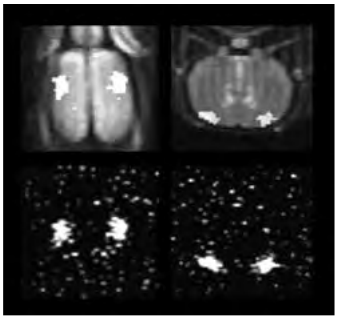
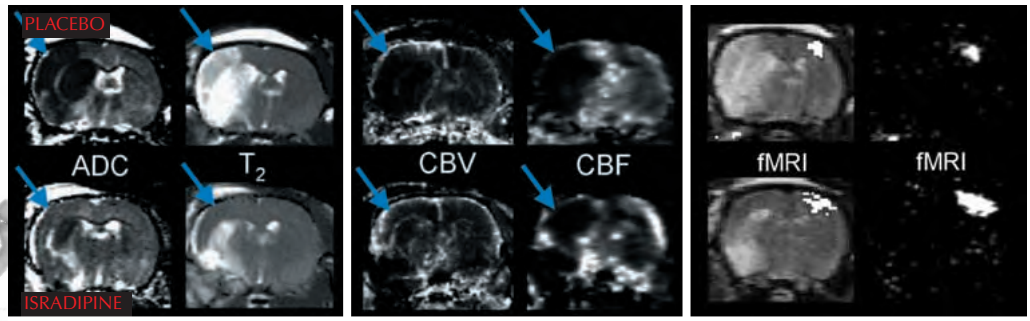


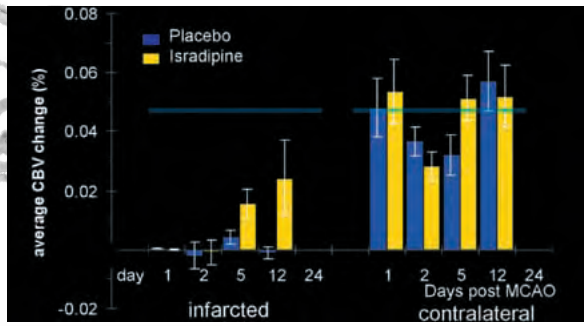


BioSpec®, 47/40
Courtesy of T. Reese, A. Sauter, N. Beckmann, M. Rudin et al.
Novartis Pharmaceutical
Basel, CH

B



C



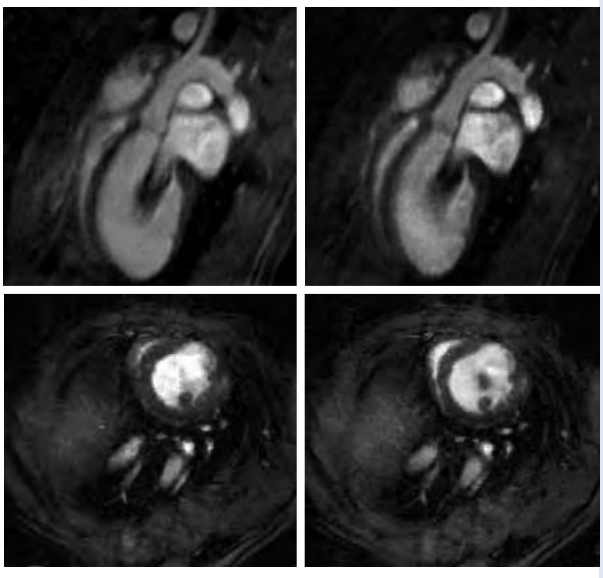
Functional vs. Anatomical MRI in Stroke

CBV-fMRI of rat brain (A) induced by electrical stimulation of both forepaws. This technique is used to track the effect of the calcium-antagonist Isradipine in a MCAO model.
Different MRI-methods are applied (B) to a control group (top) and a cytoprotected group of animals (bottom, situation 24 h after infarct).
Functional recovery under cytoprotective treatment (C). Recovering CBV-fMRI signal over a period of two weeks in the two animal groups clearly shows the effectiveness of the compound.
Data indicate that functional images are much more sensitive indicators of tissue state than anatomical ones and that structural integrity is a necessary but not sufficient condition for brain function.

MRI in Myocardial Infarction

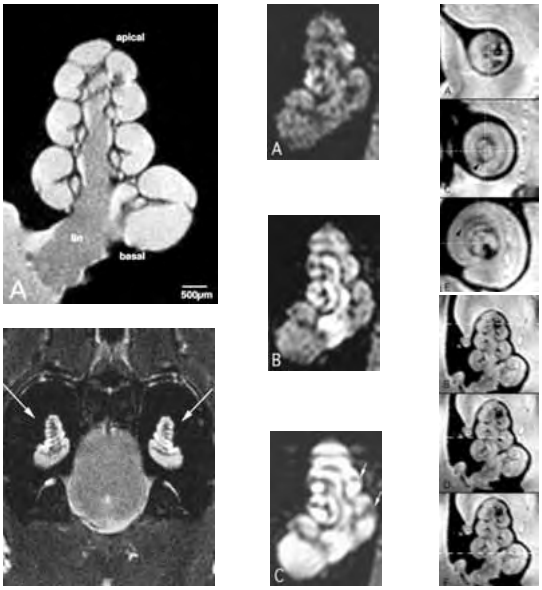
Myocardial wall motion abnormalities in rat heart after infarction can be easily observed using Cine-MRI which provides movies of the beating heart in sagittal (top) and axial (bottom) direction. Shown are enddiastolic images of normal control (left) and infarcted heart (right).

BioSpec®, 70/20
Courtesy of M. Nahrendorf, K.-H. Hiller, University of Würzburg, Würzburg, Germany

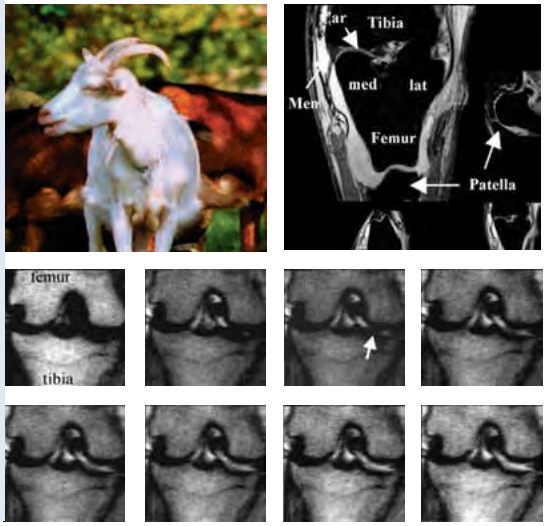


The Inner Ear of the Guinea Pig

High-resolution MRI (50 µm) of the cochlea and an *in vivo* perfusion study with a Gd-contrast-agent (center column). Fine anatomical structures like the scales vestibule and tympani, the cochlear duct and the auditory nerve are visible. Patho-physiological changes in the cochlea of animals after trauma exposure improves the treatment of the inner ear disease and hearing loss in humans.



BioSpec® 47/40
Courtesy and Copyright:
S.A. Counter, B. Bjelke, T. Klason
Z. Chen, E. Borg
Stockholm, Sweden



The Goat Knee: A Model for Cartilage Degeneration

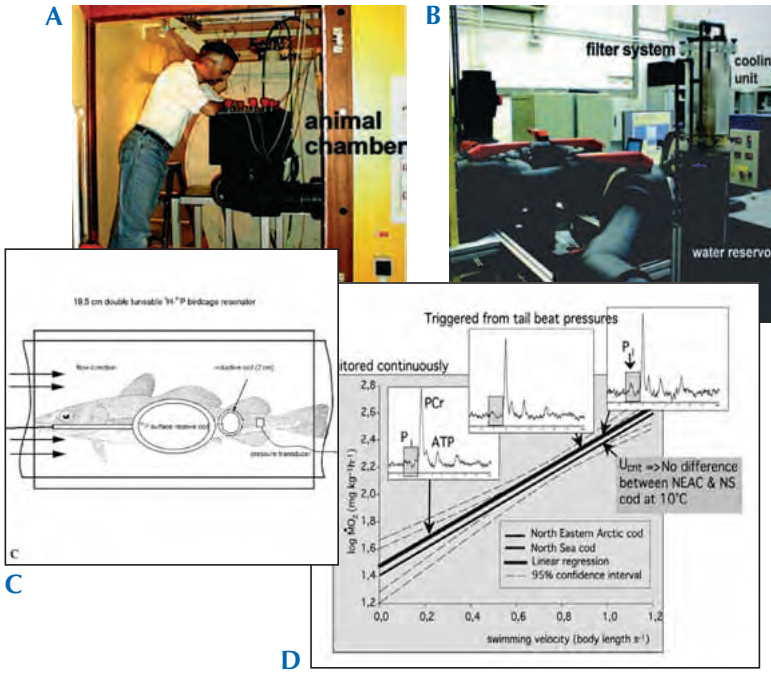
Isotropic (270 µm) 3D high-resolution images of a goat knee (total examination time 20 min) and *in vivo* assessment of glycosaminoglycan loss in articular cartilage after papain injection trauma: bottom rows depict Gd-contrast-agent uptake over a period of 140 min.

BioSpec® 30/60
Courtesy and Copyright:
D. Laurent, M. Rudin, Novartis Pharma,
East Hannover, New Jersey, USA

The Fisherman's Friend: The MRI Swim Tunnel

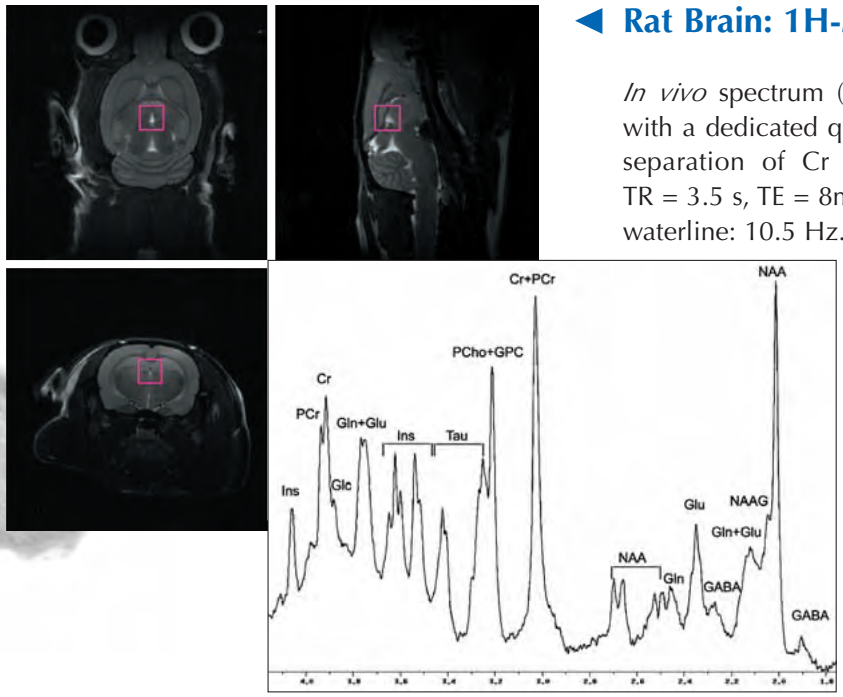
A swim tunnel (A, B) through the ***BioSpec***®, allows different species of cod to swim freely in an adjustable counter current. The MR-setup (C) is comprised of a ^{1}H-^{31}P-excitation birdcage resonator with a ^{31}P-receive-surface-coil (with a small extra coil for improved inductive coupling). Oxygen consumption and metabolism is monitored via ^{31}P-MRS as a function of swimming velocity (D).

BioSpec®, 47/40
Courtesy of Ch. Bock, H. Poertner et al.
Inst. for Polar & Marine Research,
Bremerhaven, Germany



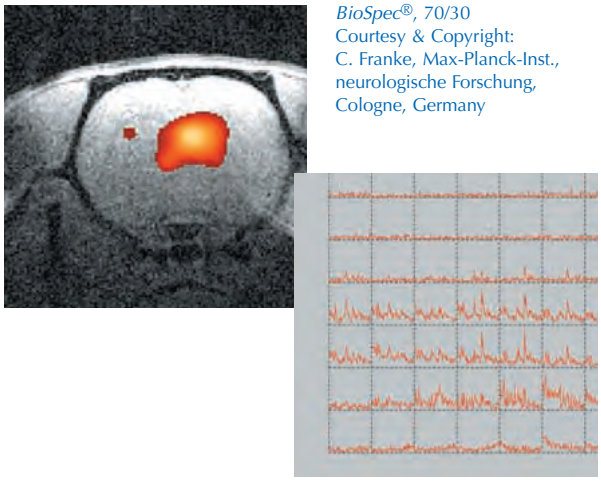
◀ Rat Brain: 1H-MRS at 9.4 Tesla

In vivo spectrum (PRESS) of a rat brain recorded with a dedicated quadrature surface coil. Note the separation of Cr and PCr. Data: 43 µl voxel, TR = 3.5 s, TE = 8ms, FASTMAP shim: linewidth of waterline: 10.5 Hz.

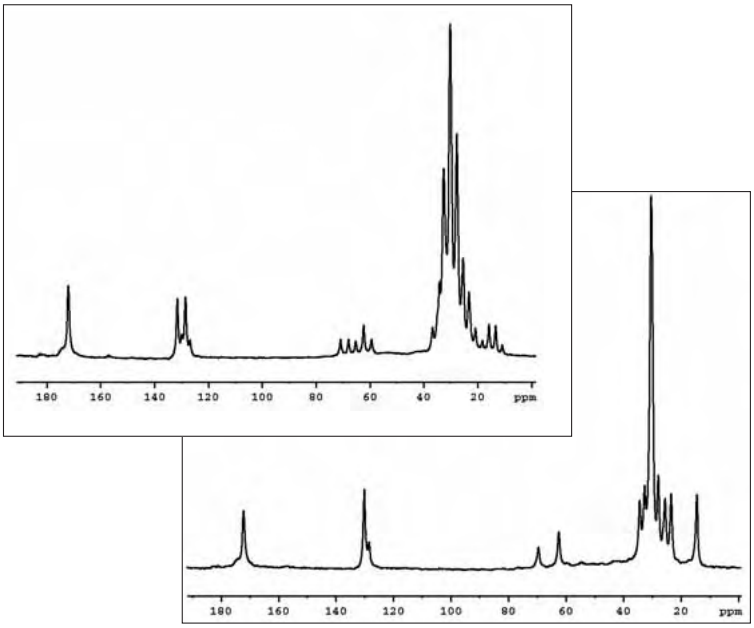


Chemical Shift Imaging (CSI) ▶

CSI combines spatial and spectral information in a way which is unique to MR: metabolite maps and spectral matrices can be generated. The example depicts a lactate map and ^{1}H Spectra in an occluded area in the rat brain.



BioSpec®, 70/30
Courtesy & Copyright:
C. Franke, Max-Planck-Inst., neurologische Forschung, Cologne, Germany



◀ Dual Channels, Broadband Capability

^{13}C-spectra of biological tissue with and without ^{1}H-Decoupling demonstrate that all ***BioSpec®*** systems can cover by default the full spectral range of relevant NMR-nuclei and are equipped with two full channels.

BioSpec® Magnet Characteristics

BioSpec® USR Design Features

- minimum magnetic stray field
- minimum magnetic field distortions by external fields
- maximum magnetic field uniformity
- maximum magnetic field stability
- helium refrigeration, no nitrogen cooling
- extremely long helium refill intervals
- simple cryogenic maintenance
- short installation times
- less stringent siting and safety requirements

The engineering expertise of BRUKER has been employed to create a comprehensive line of horizontally oriented high field small bore MR systems. All of the superconducting BioSpec® magnets exhibit excellent magnetic field homogeneity and stability. Most of the magnets are ultra shielded to provide substantial reduction of the external stray field resulting in less stringent siting requirements. With the latest BioSpec® USR (Ultra Shielded Refrigerated) magnets active helium refrigeration is included in the design. USR technology renders nitrogen cooling unnecessary and dramatically prolongs helium maintenance intervals.

The optimum combination of magnet bore diameter and magnetic field strength is determined by the subject to be studied and the corresponding planned applications. The magnet bore size is the initial dimension that determines the geometrical requirements for the gradient system and the radio frequency (RF) probe and these finally determine the available free access volume.

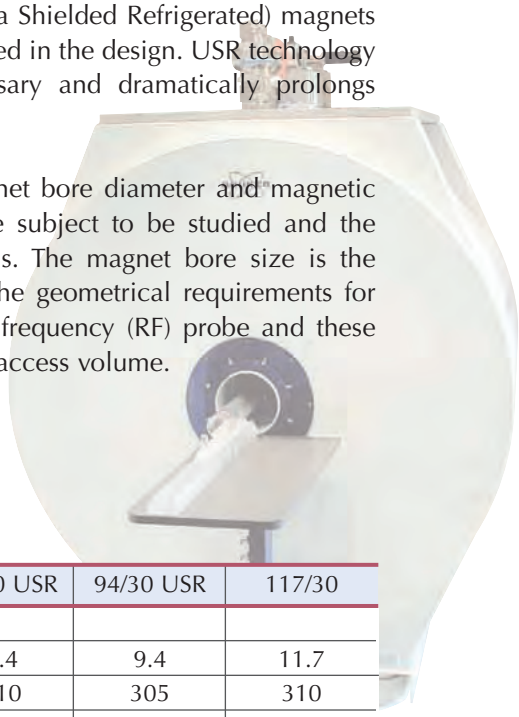


Table 1.: BioSpec® Magnet Designation

Magnet Designation*	47/40 USR	70/30 USR	94/20 USR	94/30 USR	117/30
B_0 field (T)	4.7	7.05	9.4	9.4	11.7
Bore diameter (mm)	400	310	210	305	310
Free access for imaging (mm)	197	154	72	72	154
Magnet front side to field center (mm)	720	720	720	950	1120
Maximum drift rate (ppm/h)	0.05	0.05	0.05	0.05	0.05
5 Gauss fringe field					
from magnet center: radial: (m)	2.0	2.0	2.0	2.0	12.5[1]
axial: (m)	3.0	3.0	3.0	3.0	15.5[1]
Homogenous volume					
Peak-to-peak (ppm)/dsv (mm)	±2.5/180[2]	±2.5/150[2]	±1.5/100[2]	±1/100[3]	±2.5/150[2]
Minimum helium refill interval (days)	>360	>360	>360	>360	50
Maximum helium boil off rate (ml/h)	50	50	50	50	300
Minimum nitrogen refill interval (days)	–	–	–	–	8
Maximum nitrogen boil off rate (ml/h)	–	–	–	–	1250
Minimum ceiling height (cm)	278	278	275	290	320
Approx. weight of cryostat (kg)	4500	5200	5500	4500	12000

* more BioSpec® systems available on request
1) non-shielded magnet; passive iron shielding available
2) 12 plane plot peak-to-peak over a diameter of a spherical volume (dsv)
3) 7 plane plot peak-to-peak over dsv

BioSpec® Gradient Technology

BRUKER offers a variety of water cooled actively shielded gradient systems that are optimised for high gradient strength, shortest rise time, and high gradient linearity over a typical region of interest. ***BRUKER*** gradients have been constructed using 'streamline design' technology which strongly reduces the amplitudes and decay times of any induced eddy currents.

For optimum performance, the characteristics of the magnet's internal structure, shim and gradient coil design, as well as gradient power supply must be carefully matched. Dedicated shim coils are optimized for different gradient systems depending on the magnet's bore size. Gradient systems with smaller diameters can also be used as gradient inserts to provide very strong gradient strengths and extremely fast switching times for echo planar imaging (EPI). The gradient systems can be easily and reproducibly exchanged to allow convenient adaption of the experimental setup to the research problem under investigation.

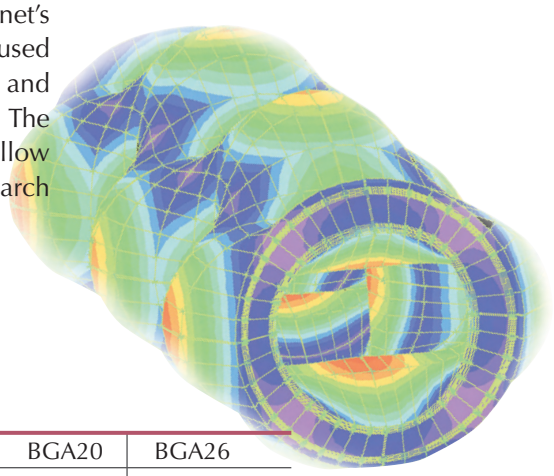


Table 2.: *BioSpec*® Actively Shielded Gradient Systems

Gradient system	BG06	BGA12	BGA20	BGA26
Outer diameter (mm)	112	187	280	344
Inner diameter (mm)	60	121	202	257
Standard shim system	insert only	BS20	BS30	BS40
Maximum standard current (A)	100	100	100	100
Optional maximum current (A)	–	200	200	200
Maximum standard voltage (V)	150	150	150	150
Optional maximum voltage (V)	300	300	300	300
Gradient strength at 100 A (mT/m)	1000	200	100	50
Gradient strength at 200 A (mT/m)	–	400	200	100
Inductive rise time (5% - 95% at 100 A/150 V or at 200 A/300 V, respectively) (µs)	50	80	200	220
Peak-to-peak linearity deviation (%)	± 4.5	± 4.5	± 7.0	± 4.0
over diameter spherical volume (dsv) (mm)	40	80	130	180
Shielding (%)	none*	> 99	> 99	> 99

* shielding not necessary due to small diameter; higher gradient strength can therefore be achieved

Standard Volume Radio Frequency Probes

The free access volume available for the subject under investigation determines the required radio frequency (RF) probe diameter. For this reason a comprehensive line of standard RF resonators and surface coils is provided in order to optimize as many of the applications as possible. The main characteristics of the ***BRUKER*** volume probes is high S/N as well as high RF homogeneity over large volumes. In addition most of the probes are prepared for active RF decoupling.
The design of the ***BRUKER*** probes is continuously being improved. The mini imaging RF resonators are linearly or circularly polarized to provide significantly improved S/N properties. Multiple rung birdcage resonators for the mini imaging line have proved to provide excellent RF homogeneity.

Array of imaging probes of different sizes

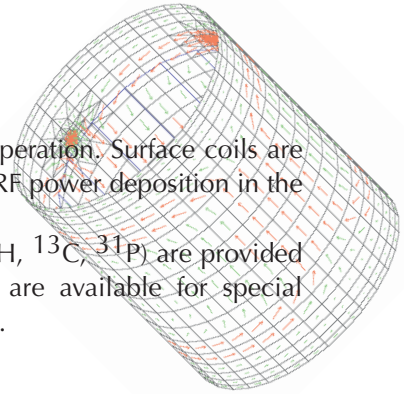
Standard Volume Resonators

Outer diameter (mm)	Inner diameter (mm)	Suited for
255	198	Proton EPI capable RF decoupling
197	154	Proton or double tuned EPI capable RF decoupling
112	72	*Mini imaging* Proton or double tuned EPI capable RF decoupling
59	35, 25, 15	*Micro imaging* Proton or double tuned EPI capable

Standard Volume Radio Frequency Probes

The ***BioSpec®*** is configured to perform the widest possible range of NMR experiments on virtually any nucleus. Hence, double tuned RF volume coils are offered for the most requested nuclei (^{1}H, ^{3}He, ^{13}C, ^{19}F, ^{31}P). The coils are prepared for active RF decoupling experiments when used together with the cross coil unit or active RF decoupling kit, which is available separately. For optimum results cross coil applications RF coils may be actively detuned via the active decoupling unit which is under user control.

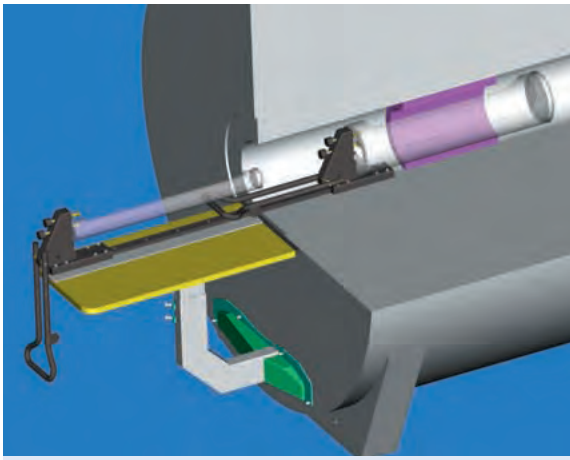
Surface Coils



A set of surface coils is available both for transmit/receive and receive only operation. Surface coils are used in order to increase the sensitivity of the detection signal or to minimize RF power deposition in the volume of interest.
Proton receive only coils, double tuned and even triple tuned surface coils (^{1}H, ^{13}C, ^{31}P) are provided with a variety of diameters. Circular polarized receive only surface coils are available for special applications in rat and mouse brain optimally fitting to respective animal beds.

Animal Accessories

For high animal throughput, animal welfare and monitoring an integrated animal accessory system is essential for every *BioSpec*®.



Animal Table & Slider System

A sample table is attached to the magnet and holds a slider system onto which the different animal beds are placed for fast and reproducible positioning of the animals.
The idea is that several animal beds can be used in parallel, e.g. one on the slider in the magnet for data acquisition, one for animal preparation and one is undergoing cleaning.

Animal Beds & Cradles

A variety of animal beds tailored for different animal species, applications and RF coils are available. Most of them are equipped with a nose-cone for gas anaesthesia, three point-fixation system (tooth-bar and ear-plugs) and openings for throat access. The image shows a dedicated brain coil mounted on the bed.

Monitoring & Triggering

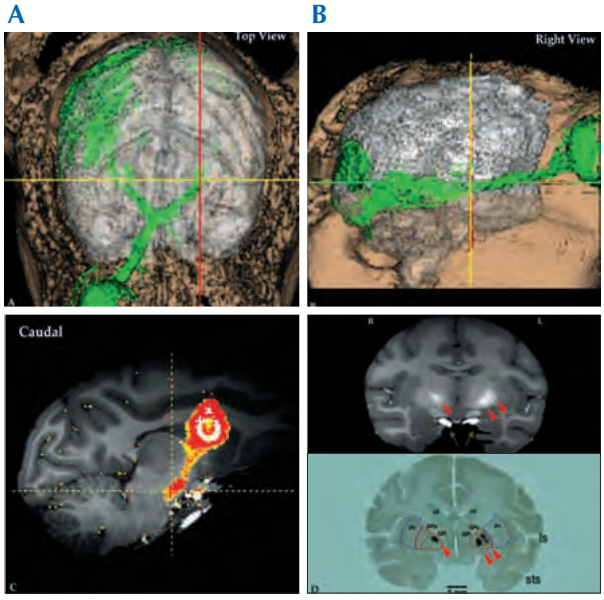
Many MRI/MRS applications require triggered acquisition to avoid motion artefacts. In addition animal care regulations require continuous monitoring of the status of the animal in the magnet.
For that purpose, *BRUKER* offers a stand-alone unit that can trigger and gate on a variety of biological signals (ECG, respiration, temperature) and can record all those tracks for later correlation to an image time series. The ECG-sensors are equipped with special filters to suppress gradient/RF-interference and additional user-defined sensors can be incorporated.

Assistance in site planning to integrate the MR-system and accessories with the local facilities will be provided in compliance with safety requirements.

Tracking Neural Pathways with Mn^{2+}

Intravitreal and cortical $MnCl_2$-injection allows the determination of projections and connectivities in the monkey brain. Mn^{2+} acts as a MRI-contrast agent and is actively transported along fibres and axons.
A, B is the tracer (green) in the visual system (retina, nerve, tract, LGN, radiation in the visual cortex), projections to substantia nigra after caudate injection (C) and to the Globus Pallidus (D, with HRP-histology).

BioSpec®, 47/40V
Courtesy of Nikos K. Logothetis et al.
Max-Planck-Inst. for Biol. Cybernetics
Tübingen, Germany



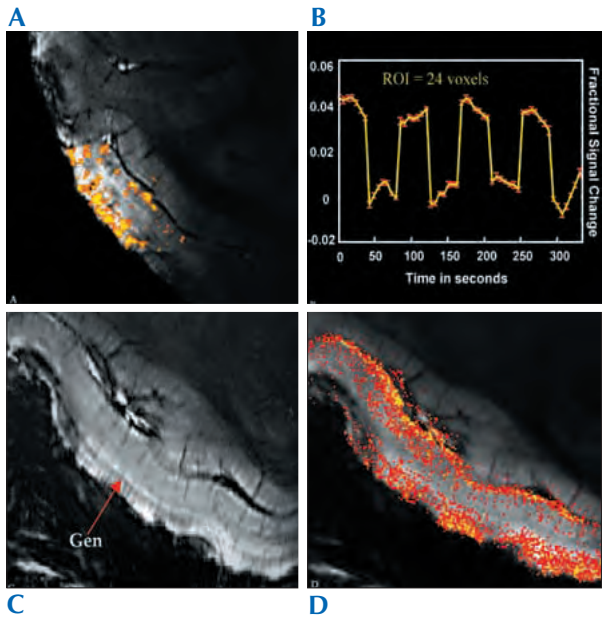
The Monkey's Response to Face Presentations

Complex stimuli in the form of faces of the same and alien species where presented (together with scrambled versions of the same images) to rhesus monkeys. Activation in the temporal lobe, a structure which responds selectively to complex objects was reliably elicited (superior temporal sulcus, amygdala, putamen). The MR-images are coloured BOLD-EPI overlays on 3D-MDEFT anatomical data.

BioSpec®, 47/40V
Courtesy of Nikos K. Logothetis et al.
Max-Planck-Inst. for Biol. Cybernetics
Tübingen, Germany

Ultra-High Anatomical and Functional Resolution

Using implanted RF coils in the monkey cortex, new levels of spatial and temporal resolution have been reached. A: fMRI-EPI-Image with a resolution of 125x125x660 µm in the monkey visual cortex during a rotating checkerboard stimulation. B: the respective signal change over time. C: fine details of the visual cortex (Gen=Gennari Line) including small cortical vessels.
D: a lamina specific activation in the same region obtained by comparing moving vs. flickering stimuli. Each BOLD-pixel represents as few as 600 neurons (!).



BioSpec®, 47/40V
Courtesy of Nikos K. Logothetis et al.
Max-Planck-Inst. for Biol. Cybernetics
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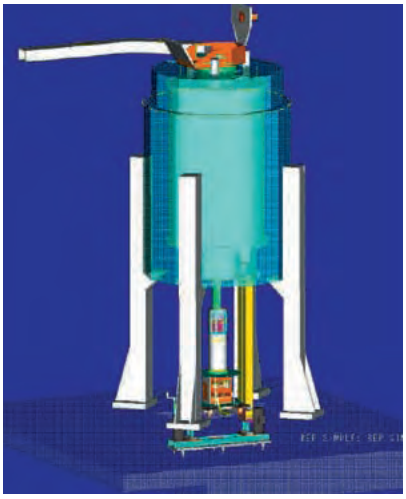
BioSpec® Vertical

New Horizons

Functional magnetic resonance imaging (fMRI) has become an essential tool for studying brain function. The vertical ***BioSpec***® has been engineered for MR research investigations of non-human primates. It enables specifically fMRI studies on monkeys as they are particularly receptive to behavioural conditioning while sitting in upright position. In addition, a vertical body position frees hands for use in behavioural responses. Extremely high spatial resolution were already achieved in fMRI studies with voxels sizes as small as 0.5 µl.

The ***BioSpec***® **Vertical** uses the same ***AVANCE***™ digital spectrometer, workstation, and operating environment as the regular ***BioSpec***®. The ***BioSpec***® is offered with two different magnets operating at 4.7 Tesla and 7 Tesla which both have a high magnetic field stability and excellent homogeneity. The actively shielded gradient coils with integrated shim coils are especially designed for a vertical oriented magnet.



BioSpec® ***Vertical:*** Main Features

- research MRI/MRS system
- particularly for investigations in non-human primates
- 4.7 Tesla actively shielded magnet
- 7.0 Tesla passively shielded magnet
- actively shielded gradients
- multiple channel (optional), multiple frequency electronics
- RF coil for optimised ^{1}H fMRI brain studies
- animal support including animal mounting and positioning device

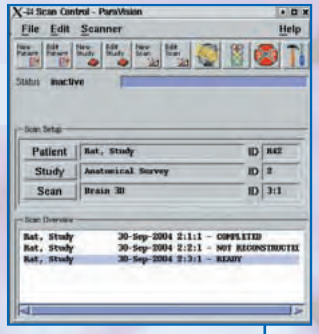
BioSpec® Vertical-Bore Cryomagnet Systems

Magnet	B_0 (T)	Bore free diameter (cm)	Access for imaging (cm)	Peripheral magnetic field contour at 0.5 mT	Field homogeneity ΔB_0	Boil off rate (ml/h)	Min. ceiling height (cm)
47/60 VAS	4.7	60	28	radial: 2.1 m axial: 3.8 m	less than ± 0.5 ppm over 200 mm dsv	He:<210 N_2:<1100	570
70/60 V	7.0	60	28	radial: 5.3 m axial: 8.5 m	less than ± 2 ppm over 300 mm dsv	He:<240 N_2:<1100	710

B-GA 38 S Actively Shielded Gradient System with Integrated Shims

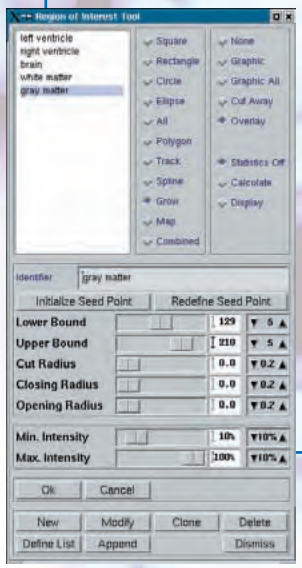
Diameters (inner/outer) (mm)	Gradient strength at maximum current	Inductive rise time	Peak-to-peak linearity deviation
380/570	75 mT/m at 500 A	150 µs at 700 V	± 1% over 160 mm dsv ± 4% over 250 mm dsv

ParaVision®



ParaVision® software for multidimensional MR data acquisition, reconstruction, analysis and visualization.

The powerful Linux based workstation used in the **BioSpec®** systems will be interfaced to the most modern computer technology available. It is configured to meet the requirements for optimum MR data handling.



ParaVision®
Data Acquisition/Processing Workstation

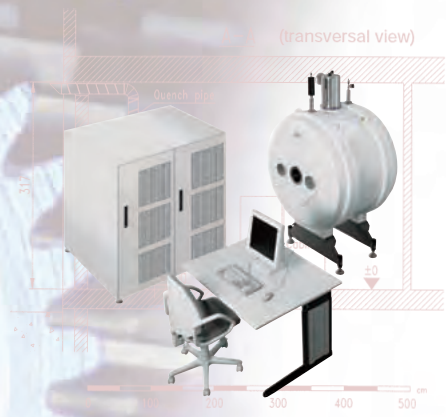
- Linux based workstation
- open system concept
- comfortable graphics environment
- multidimensional MRI acquisition, reconstruction, data analysis, and visualization
- push button operation for routine examinations
- direct access to spectrometer control
- improved integration, e.g. DICOM data export
- integrated data management and archiving

- all common 2D and 3D MRI techniques
- ultra-fast imaging techniques, e.g. EPI
- volume selective spectroscopy
- predefined protocols, queued acquisitions
- powerful sequence development environment and automation capabilities

ParaVision® sets no limits with respect to dimensions and size of the image data set. A rich palette of image analysis and visualization tools allows the user to extract complex information from 2D or 3D images.

AVANCE™

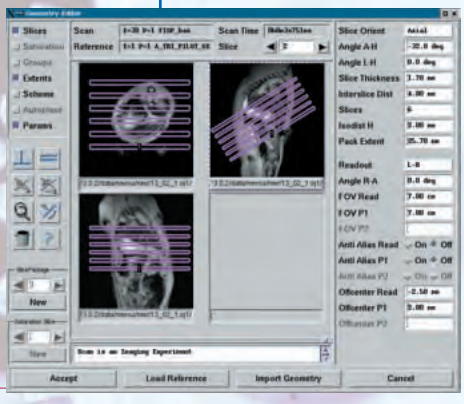
The **AVANCE™** digital electronics which forms the backbone of the **BioSpec®** systems is also employed in the extensive product line of **BRUKER** NMR spectrometers, as well as in the **PharmaScan®** and the **MedSpec®** MRI/MRS systems.



AVANCE™ Hardware of BioSpec® MRI Systems

- **AVANCE™** digital spectrometer electronics
- modular, high-level design
- digital frequency and phase generation
- fast phase coherent frequency switching
- digital receiver concept with A/D oversampling
- high stability, reliability, and immunity against external disturbances
- integrated fast Ethernet network
- high S/N ratio
- high dynamic range (> 90 dB)
- effective digitizer resolution of up to 19 bits
- ideal filter characteristics
- improved baselines due to online digital filtering
- high flexibility of spectrometer control
- standardized networking capabilities
- upgradable components for state-of-the-art performance now and in the future

The **AVANCE™** digital electronics driven by the powerful workstation of the **BioSpec®** systems offers new degrees of freedom in both, research and routine operation.



NMR Suite is the software written for the thousands of **BRUKER** high-resolution NMR spectrometers operating worldwide and can be used on the **BioSpec®** systems. It offers a vast array of routines for acquisition and processing of spectroscopic data.

Customer Support and Site Planning

Installation Planning

The installation of a high-field magnet system is a complex task since all of the possible electromagnetic interactions between the MR instrument (external magnetic field and RF fields) and local laboratory environment within a radius of 10-15 m must be taken into account. ***BRUKER*** engineers and physicists have considerable experience in siting large and small high-field systems, both in existing and in new buildings. The site planning department uses CAD equipment to handle the complete site planning and to incorporate the customer's preferences and requirements as far as technically possible. Thus, expert advice is available for solving virtually any complex siting problem.
The typical floor space requirement for the entire ***BioSpec®*** system is about 50 m^2.

RF Screening

The operation of ***BioSpec®*** systems requires proper RF shielding to avoid RF related interferences. All ***BioSpec®*** systems are delivered with integrated RF shielding of the electronics units. For high quality RF shielding of the magnet a Faraday cage is recommended.
In cases where the local circumstances and site planning requirements allow, a filter box attached to the rear of the magnet instead of the Faraday cage is also offered. This box contains an electronic RF filter plate.

Upgrading

The ***BioSpec®*** series is the most up-to-date spectrometer line for research in biomedicine, pharmacology and biology. Progress in many laboratories throughout the world means that new techniques and methods are being developed continuously. The ***BRUKER*** policy together with the unique design concept maintains these systems at a state-of-the-art level over a long period of time since both hardware and software upgrades can be incorporated at minimum cost.

Magnet Screening

Active Shielding

Most modern magnets are available with ultra or active shielding of the magnetic field. This is achieved by use of a second super conducting coil which compensates the magnetic field outside the magnet. Ultra shielding drastically reduces the stray field close to the magnet and by this the field strength to which the operator is exposed. Two actively shielded magnet types are available.

Ultra Shielded Refrigerated (USR) Magnets:

- **ultra shielding of the magnetic field**
- **very low stray field**

Actively Shielded (AS) Magnets:

- **active shielding of the magnetic field**
- **low stray field**

Actively shielded magnet system (left) and magnet coil (right) of the *BioSpec®* 47/40 USR

Passive Iron Shielding

Some magnet types especially those with ultra high field strength are not available with active shielding. Unshielded magnets can be installed in combination with passive shielding either with iron room shielding or integral yoke iron shielding.

Iron Room Shielding

This is a very flexible method that strongly reduces the stray field outside the room. The iron cage can be easily adapted to the given room architecture but leads to a significant floor load due to the weight of an iron cage. No additional Faraday cage is necessary for RF shielding.

Integral Iron Yoke Shielding

A very efficient but technically very demanding shielding technique for low to medium field strength magnets. The technique involves the precise positioning of a set of iron plates directly around the magnet. The installation leads to a significant floor load due to the weight of the iron plates.

Service / Application / Support

Maintenance and technical service for the first year is provided under the system warranty. Contracts for maintenance service in subsequent years are also available and include a number of interesting features such as software upgrades at no extra cost. Service engineers (from any one of our numerous locations) are available in almost any country in the world. Worldwide professional application support by telephone, email and also on-site.

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