

ICON

- System Manual
(Doc. No. T02985)

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1 Introduction

The System Manual is part of the multi-volume operating instructions for the ICON™ MRI system. It provides information for the system operator.

The operating instructions include the following manuals:

Manual	Document Numbers
System Manual	T02985 (this manual)
ParaVision Software Documentation	Integral part of ParaVision software. Updated versions are available on Bruker homepage (http://www.bruker.com)
Accessories operating instructions	T02346 (Animal Monitoring Unit) T01903 (Animal Temp. Stab. Unit)

A correct and safe operation of the MRI system requires detailed knowledge on the part of the operating personnel and a high degree of familiarity with the operating instructions. Read these operating instructions carefully prior to the start-up of the MRI system. It is mandatory for all users to be familiar with the chapter “Safety” in chapter 3 on pages 23 ff., for French safety directions see chapter 4 on pages 41 ff.



Figure 1.1: ICON™ MRI system

2 MRI System Overview

All components relevant for the usage of the ICON MRI system are described in the following sections.



Figure 2.1: ICON MRI system overview

2.1 Magnet

The ICON MRI system is equipped with a shielded permanent “always on” 1 Tesla (1 T) magnet:



Figure 2.2: ICON permanent 1 T magnet. The main system switch for electronics (1) is located on the right side of the magnet. Animals or placed in the magnet through the front flange (2). The magnet has air-cooling fans on both sides (3, left fan not visible). RF Coils are attached at the connector panel (4).

The ICON magnet has integrated magnetic shielding. Laterally, the 0.5 mT line is protruding the magnet surface < 40 cm (14 inches). On top of the magnet the 0.5 mT line is completely inside the magnet housing.

CAUTION



Risk of temporary impairment for persons with cardiac pacemakers.

Cardiac pacemakers could temporarily switch into test mode in the vicinity of the magnet.

- Persons with cardiac pacemakers must not approach the magnet closer than 35 cm / 14 inches.

2.2 Gradient and shim coils

The ICON MRI magnet has a built-in set of three magnetic field gradient coils (x, y, z).

The gradient coils are cooled by air-flow through the magnet. The air-cooling fans may be seen in Figure 2.2 (3). Never cover these to allow enough air flow through the gradient coils.

For temperature monitoring of the gradient coil two temperature sensors are built in. The temperature supervision uses these sensors to automatically shut down the gradient amplifier whenever a threshold temperature of approximately 45° Celsius inside the gradient coils is exceeded.

To protect the gradient from damage by duty cycle violations, the actual power applied to the gradient coil is monitored and the gradients are automatically turned off as soon as the power is over the allowed limit.

The gradient coils are also used as “shim” coils, i.e. for transiently optimizing the magnetic field homogeneity when inserting a sample or an animal. The ICON system does not feature second or higher order shim coils.

The gradient coils are virtually eddy-current free meaning that gradient shapes are near perfect without using electronic or digital pre-emphasis.

2.3 Electronic Cabinets

The center and right (closed) cabinets under the magnet contain the MRI spectrometer electronics. They contain all components necessary for signal generation and detection, gradient and RF control. No user interaction is needed within these cabinets.



Figure 2.3: The red marked cabinets contain all electronic components. No user interference is needed within these cabinets.

2.4 Anesthesia Cabinet

The left-most cabinet is prepared for the use of an Isoflurane evaporator and an active carbon filter for scavenging (both options).



Figure 2.4: The left-most cabinet is prepared for the usage of an anesthetic gas evaporator and an anesthetic scavenging system.

2.5 Animal Preparation Table

A table for animal preparation is mounted on the anesthesia cabinet. It may accommodate the animal holder while not mounted in the magnet.



Figure 2.5: The animal preparation table provides working space and accommodates the animal holder while not in use.

2.6 Animal Positioning System

The animal support for the ICON is modular and consists of the basic animal holder (see section 2.6.1) and exchangeable front pieces; the actual animal beds (see section 2.6.2). Every animal bed has a RF Coil included, supporting various applications:

- mouse body (length: 65 mm)
- mouse whole body (length: 95 mm)
- mouse head
- rat body
- 60 mm rat body (magnet mounted)
- rat head

The magnet and gradient coil iso-center position is reached when the ICON animal holder is positioned at the zero position on the magnet front flange.

2.6.1 Animal Holder

The animal holder has permanently installed animal anesthesia, care and supervision lines and tubes.

Features of the animal holder:

- Reproducible animal positioning in the magnet (adjustable position and rotation)
- Ergonomic handle at the center of gravity
- Fixation in the magnet with a knurled screw
- Connection plate for the animal anesthesia, care and supervision lines and tubes
- Connection of the RF Coil
- Tuning connection for the RF Coil
- shifting rod for moving the body coils once mounted in the magnet
- RF shielding functionality with filter plate in the rear connection panel (not visible, under the black hood)

- i** Always put the holder on its provided stand on the animal preparation table while not mounted in the magnet.



Figure 2.6: Animal holder on its stand

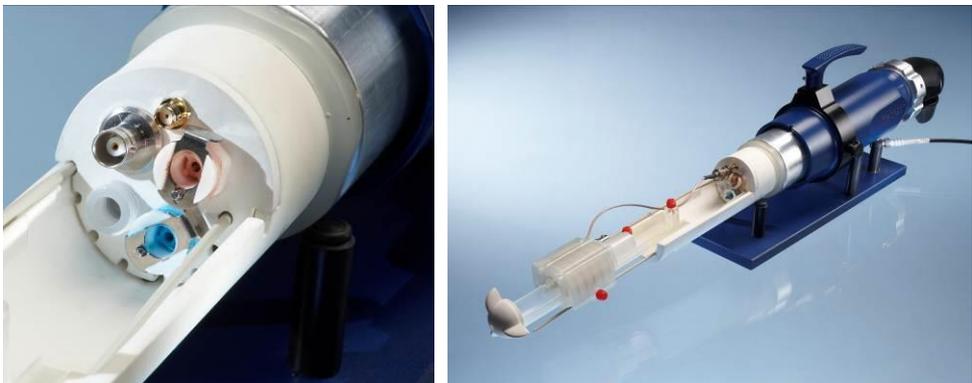


Figure 2.7: Left: Connection plate for the attachment of anesthesia gas, scavenging, warm water heating RF Coil. Right: Animal holder with mounted mouse body bed and mouse body RF Coil.

The animal holder can be locked in place with the knurled screw on the left side, see Figure 2.8 below.



Figure 2.8: The animal holder was inserted into the magnet and locked in place with knurled screw (1)

The center of the magnet is reached when the position mark of the animal holder is at the position marked as “0” position on the magnet front flange.



Figure 2.9: The position and rotation of the animal holder with respect to the magnet center may be read from the magnet front flange.

2.6.2 Animal Beds

A variety of dedicated animal beds is offered. Please note that not all of the beds are included in the standard delivery of an ICON MRI scanner. Dedicated RF Coils (see section 7.1) are part of the animal bed delivery.

A detailed list of available RF Coils and animal beds is available in section 7.1 on page 87 and in the ICON Technical Documentation. Please contact your Bruker representative for availability.

The animal beds for mouse and rat head examinations are optimized for head and brain investigations; the animal beds for mouse and rat body examinations are optimized for body and abdomen investigations. The animal beds are suitable for small rodents with a body weight of up to 300 g for rats, and up to 40 g for mice.

All beds are equipped with a built-in warm water bed to prevent hypothermia of the animal during anesthesia. The warm water tubes may be connected via quick-locking connections to the animal warming unit (option, see section 7.3 on page 90).

A thermostat in the warming unit regulates the temperature of the water flowing through tubes directly under the animal body. This allows maintaining a constant body temperature of the animal. Yet, it is suggested to supervise the animal core temperature separately, for example with the temperature monitoring of the basic animal life monitoring system (option, see section 7.2 on page 89).

For mounting the animal beds to the animal holder see section 5.2.3 on pages 65 ff.

WARNING

Risk of personal injury.

When using narcotic gases (medical gases),

- Pay attention to the local regulations. In particular you must not exceed the maximum allowed concentration for medical gases in a laboratory environment. Carry out appropriate compliance with the regulations.
- Allow for sufficient fresh air and use extraction system for anesthetic gases.
- Make sure, that the scavenging system is turned on (if present).



2.7 RF Coils

All RF Coils are pre-matched to a typical rat and mouse loading. The tune range of these coils is limited to typical in-vivo applications of rats and mice.

The center of the bed mounted head coils is always attached to the magnetic center when inserting the animal holder to the “0” position.

2.7.1 Animal Bed mounted RF Coils

The ICON is equipped with tunable 1H single resonate transmit/receive RF Coils.

The ICON MRI scanner is equipped with one 1H transmit/receive coil for mouse body applications per default. Apart from the standard RF Coil, a variety of different RF Coils can be obtained as options, i.e.:

- Additional 1H transmit/receive mouse body coil (MT1011)
- 1H transmit/receive mouse whole body coil, length: 80 mm (MT1012)
- 1H transmit/receive mouse head coil (MT1021)
- 1H transmit/receive rat body coil (MT1031)
- 1H transmit/receive rat head coil (MT1041)

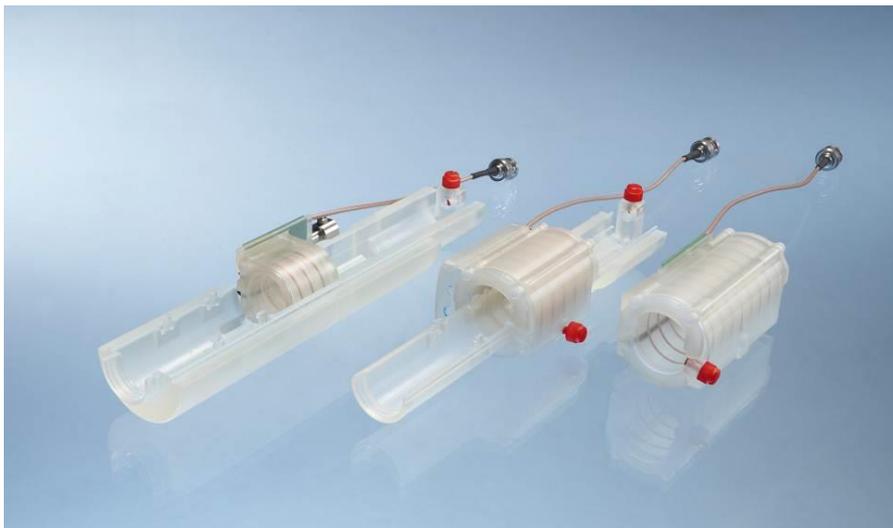


Figure 2.10: From left to right: Mouse head bed with head coil, mouse body bed with mounted body coil, mouse whole body coil.

2.7.2 Magnet mounted RF Coil

As an alternative to the animal bed mounted RF Coils, the ICON can be equipped with an RF Coil mounted from the rear side of the instrument. For further information refer to section 5.2.3.2 and Technical Documentation/Components/ RF Coils/Rat Body 60 mm RF Coil.

- 1H transmit/receive rat body coil, inner diameter: 60 mm



Figure 2.11: Rat body RF Coil, inner diameter 60 mm

2.8 Operating Console

The host computer is the operating console to control the MR system. It works with the LINUX operating system. The ParaVision software is used to set up, acquire, process and visualize MRI imaging data. Please refer to the operating instructions of ParaVision for a detailed software description.



Do not install other than Bruker released programs on the host computer. The functionality and performance of ParaVision might be disturbed.

The LCD monitor is attached to the host computer and must be switched on or off separately.

The MR system is equipped with a standard keyboard and a two-button wheel mouse.

2.8.1 Keyboard

The MR system is equipped with a standard keyboard.

You can use modifier keys in combination with mouse button actions to execute frequently used functions more easily. These short cuts are context dependent. Please refer to the ParaVision software manuals to learn more about the modifier keys.

2.8.2 Mouse

The MR system is equipped with a two-button mouse and a wheeler. The mouse is connected directly to the computer.



Figure 2.12: 3-button wheel mouse (design might vary)

(1) Mouse buttons

The mouse provides the following functions:

- Left mouse button:
 - Selecting or moving objects
 - Starting applications
 - Executing commands
- Wheeler:
 - Context dependent scroll functionality
 - Replaces the middle mouse button
 - Drag & drop of data sets
- Right mouse button:
 - Opening context dependent function menus



3 Safety (English)

3.1 Introduction

This chapter covers all relevant safety issues for the operation of the system. It is required that every user is familiar with these safety aspects.

Please note, that additional information are described in the following manuals:

- Safety aspects for a secure system installation and operation which must be fulfilled by the system owner are described in the System Owner Manual.
- Safety aspects for service activities are described in the Technical Documentation.

3.2 Key Words and Symbols

The safety alert symbols indicate a potential personal injury or property damage hazard. The key word at the beginning of a safety advice informs about the extent and nature of the threat.

Safety advice must be adhered in order to avoid dangerous situations for persons and property.

There are also notices used in this manual. These notices highlight important information or warn the user of a potentially dangerous situation.



! DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



! WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.



! CAUTION

Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.

NOTICE

Hazard, which could result in property damage.



Information and tips for efficient and trouble-free operation

3.3 Shut-Down

Prior to working with the MR system, familiarize personnel with the function and location of the installed ON/OFF switch.

The ON/OFF switch has the function to switch on/off the electrical power of all electronic devices of the scanner, except the internal line power distributor and the computer console. The switch does never affect the magnet, which is always on.

The ON/OFF switch is installed near the magnet. It is recommended to check in regular intervals the free access to the unit.

If a risk of electrical hazard occurs, the main power supply of the system must be switched off immediately using the ON/OFF switch.



Figure 3.1: ON/OFF switch

3.4 General Safety Information

The ICON product is subject to the safety demands given by the low voltage directive (LVD 2014/35/EEC). General electric safety is proven by the application of the safety requirements for electrical equipment for measurement, control and laboratory use of the EN 61010-1 and EN 61010-2-081.

According to these regulations, no part accessible under the condition of a single electrical fault is hazardous to human life. In terms of electromagnetic conformity, the requirements are cited in the regulations of EN 61326-1.

WARNING

Risk of death by electrocution.

All electronics cabinet doors are safely screwed in place. Removal of cladding or exchanging any component should only be performed by authorized and appropriately trained personnel. The relevant unit or the entire system must be switched off. Some components are charged with very high voltages. Inappropriate action, or non-observance of warning signs, may result in fatal accidents. Special care has to be taken when room climate is out of specification and condense water appears.



WARNING

Risk of injury or death.

Visually inspect the system power mains cable for damage on a regular basis.

- In case of damage immediately replace it.



3.5 Mechanical Injury

The hazard of falling down is related particular to the unfavorable routing of cables/ tubes

of accessory devices.



CAUTION

Risk of personal injury to operating personnel.

- Route cables/tubes such as anesthesia gas tube or water tubes of the animal warming unit such that it is not possible to trip over them.

3.6 Static and Electromagnetic Fields

An MRI system consists of several components that produce various electromagnetic fields. Electromagnetic radiation may cause harm to the operator as well as affect the surrounding environment. The following topics will be addressed:

1. Static magnetic field: The magnet provides a strong time-invariant magnetic field called static magnetic field.
2. Gradient fields: Time-dependent magnetic fields.
3. Radio frequency fields: RF Coils driven by RF power amplifiers produce pulsed high frequency electromagnetic fields.

A controlled access area (sometimes referred to as exclusion zone) is defined by the 0.5 mT contour line of the static magnetic field.



Occupational standards

Ensure that occupational standards are taken into account while preparing experimental setups or while scanning.

3.6.1 Static Magnetic Field

The static magnetic field is generated by a shielded 1 Tesla permanent magnet to minimize the surrounding fringe field. The static magnetic field is highly homogeneous

within the magnet and drops considerably outside the tunnel as a function of the distance to the magnet.

Especially when approaching the entrance of the magnet bore the magnetic field increases within a very short distance to its full strength with a high magnetic field gradient. Thus, ferromagnetic parts will be suddenly strongly attracted by the field gradient. Consequently, such objects in the vicinity of the magnetic field may become hazardous projectiles.

At normal working distance (> 35 cm) away from the magnet housing the magnetic stray field is below 0.5 mT, where no substantial forces exist.

CAUTION

Risk of temporary impairment for persons with cardiac pacemakers.

Cardiac pacemakers could temporarily switch into test mode in the vicinity of the magnet.

- Persons with cardiac pacemakers must not approach the magnet closer than 35 cm (14 inches).

CAUTION

Risk of injury or serious material damage.

Always be aware of the strong and sudden attractive force on ferromagnetic materials inside the shielded magnet system. Do not bring ferromagnetic material into the MRI magnet. Ferromagnetic materials that have been attracted by the magnet might eventually not be removed again, resulting in serious magnet damage.

The magnet may not be switched off. Do not try to remove accidentally attracted magnetic items from inside the magnet. Contact your local Bruker service instead.

CAUTION

Risk of injury, death or destruction of the animal/sample under investigation carrying implants.

Ferromagnetic or electrically-conductive materials inside the sample or object under investigation (i.e. aneurysm-clips, prostheses, shrapnel, metal splinters, needles etc.) may dislocate due to the extreme forces exerted by the magnetic field. This may result in severe internal injuries or destruction of the sample.

Animals bearing ferromagnetic implants might be attracted so strongly by the magnetic field that they eventually cannot be removed from the magnet again.

- No animal/sample carrying ferromagnetic implants may be brought into the MRI magnet.

NOTICE

Risk of damage to magnetic data media, watches etc.

The magnetic field may

- erase magnetic data media (e.g. magnetic disks, magnetic tapes, diskettes, credit cards)
 - destroy mechanically sensitive components (e.g. watches, cameras)
- Do not bring any of these items into the MRI magnet.

3.6.2 Gradient Fields

Faraday's law (law of induction) establishes a relationship between the changes of a magnetic field over time and an electrical rotational field. The frequency change of the magnetic flux (switching on and off the gradient fields) induces an electrical field in the tissue that shifts the charge in the nerve fibers of the tissue. This shift in charge dissipates the resting membrane potential of the nerve fibers and may lead to peripheral nerve stimulation. Currents induced inside conductors can also increase the local temperature considerably (hot-spots).

CAUTION



Risk of peripheral nerve stimulation.

- Never enter with your extremities inside the gradient coil while the system is scanning.

CAUTION



Risk of burn injuries.

- Do not touch the inner surface of a gradient coil during or shortly after running a gradient sequence. Surface temperatures might cause burn injuries.
- Do not enter the gradient field wearing conductive materials.

Risk of overheating of animals.



High duty cycle gradient schemes applied for a long duration lead to high temperatures at the inner surface of the gradient coil. Depending on the animal setup and the remaining air circulation, a lethal heating of the animal can occur.

- Monitor and control the body temperature of the animal under investigation.

**Risk of potential nerve stimulations.**

- In case of scanning non-anesthetized animals with high slew rate gradient schemes be also aware of potential nerve stimulations.

3.6.3 Radio Frequency Fields

Exposure of tissue to radio-frequency electromagnetic fields can cause significant tissue heating.

CAUTION**Risk of burn injuries.**

While the system is scanning the specific absorption rate might be high enough to cause local burn injuries.

- Do not approach or touch the RF Coil, or enter the RF Coil with your extremities while the system is scanning.

Risk of burn injuries to animals.

Forming body loops with e.g. the extremities may induce strong currents in the body tissue and lead to local burn injuries.

- Avoid forming loops with body parts, e.g. do not put the front paws together.
- Twist ECG cables closely to minimize inductions in the ECG.

NOTICE

Risk of damage to electronic devices.

The application of strong RF pulses might lead to unwanted interference with electronic devices of the surrounding environment.

- To avoid such situations, the system must be used under the normal operating conditions as defined in the System Owner Manual.

In general, the RF Coils must be entered in the magnet before using them.

3.7 RF Coils and Accessories

Under normal operation conditions no risk to the operator arises from the usage of Bruker tested RF Coils and accessories. Nevertheless, the following safety aspects need to be considered.

WARNING



Risk of injury or death.

- Do not use RF Coils with damaged cables or housing.
- Do not use RF Coils outside the magnet when scanning.

CAUTION



Risk of personal injury or injury to the animal.

Leaking water may lead to arcing or electric shocks in the RF Coil or animal bed. Before preparing the animal or sample always make sure that the warm water tubes are not leaking. In particular, visually inspect if water entered the animal bed or RF Coil housing. If water was entering the animal bed or RF Coil,

- swab the water completely with a dry and soft cloth;
- any liquids in RF Coils must be completely evaporated at temperatures $\leq 40^{\circ}\text{C}$ before using it.

RF Coils and accessories that are not tested and released by Bruker for compatibility with the MR system bear a potential risk.

CAUTION



Risk of injury.

- ➤Do not use RF Coils or accessories that are not released by Bruker.

NOTICE

Damage to RF Coils.

- Handle RF Coils with great care.
- Do not use RF Coils in different positions/mountings or with different loads than intended.
- Wet-cleaning of RF Coils should be avoided if possible. Any liquids in RF Coils must be completely evaporated before using the RF Coil.

Do not use excessive temperature ($\leq 40^{\circ}\text{C}$) or air ventilation for drying RF Coils after cleaning.

3.8 Medical Gases

⚠ WARNING

Risk of personal injury.

When using narcotic gases (medical gases),

- Pay attention to the local regulations. In particular you must not exceed the maximum allowed concentration for medical gases in a laboratory environment. Carry out appropriate compliance with the regulations;
- Allow for sufficient fresh air and use extraction system for anesthetic gases;
- Make sure, that the scavenging system is turned on (if present).



⚠ WARNING**Risk of personal injury.**

Check daily, if the maximum capacity of the scavenging filter (if present) is exceeded according to the instructions of the manufacturer of the filter.

- Replace the filter early enough to prevent unwanted narcotic gase leakages (medical gases).

⚠ WARNING**Risk of personal injury.**

Visually inspect all tubes and connections of the anesthesia system for leaks. In particular, pay attention to wheezing noises in the pressurized system arising from possible leaks.

- Immediately replace all defective or leaking parts.

3.9 Phantom Fluids

3.9.1 Handling of Measurement Phantoms

Always handle measurement phantoms with great care. Under normal operating conditions, no risk to the operator arises from the usage of Bruker phantoms. Although all phantoms were designed under the aspect of harmless chemical composition, a small residual risk to the operator cannot be avoided especially with leaking or broken phantoms.

WARNING

Risk of personal injury.

- Handle phantoms with great care. Do not drop the phantom and store it safely after use. Do not use leaking phantoms.
- Avoid contact of skin or eyes with phantom fluids.
- Do not swallow phantom fluids.
- When handling the phantom, do not eat, drink or smoke.
- In case of fire inform the fire department about the contents of the phantoms.
- Do not use extreme high RF pulse amplitudes too long or with an extreme short repetition time, otherwise the phantom might get hot.



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The filling solution is odorless and not combustible, however, always handle and store the phantom with great care.

- In case of a large air bubble refill the phantom with the original solution.
-

3.9.2 Phantom Fluid Spills

Broken or leaking phantoms bear different potential risks to the operator and must therefore be removed. Phantom fluids must be disposed according to the local regulations and safety aspects.

WARNING

Risk of personal injury.

- Turn off all high power components before cleaning up spilled phantom fluids inside the MRI system.
- Wear protective clothing (gloves, work coat, goggles).
- Wear a mask with a filter for inorganic vapors if aerosols (inhalable droplets) are formed. In case aerosols were inhaled, leave the building immediately to get fresh air. Consult a physician immediately.
- Avoid eye contact with phantom fluids. In case of contamination, consult an ophthalmologist immediately.
- Avoid skin contact with phantom fluids. In case of contamination, immediately remove the clothing covering the contaminated area and wash the skin using soap and water. Consult a physician immediately.
- Do not swallow phantom fluids. In case phantom fluids were swallowed, rinse mouth with water and drink plenty of water. Consult a physician immediately.
- Absorb the fluid immediately using absorbent material such as sand, saw- dust, etc. and prevent phantom fluid from entering the waste water system.
- Collect the fluid in a plastic container or equivalent and label it accordingly.
- Remove any pollution from spilled phantoms inside the MRI system before using it again.
- Clean your hands thoroughly using soap and water and change contaminated clothing.



⚠ CAUTION



Phantom disposal as special waste.

- Label the container accordingly.
- Hire an authorized special waste company for disposal.
- If you have additional questions, contact Bruker Service.

3.9.3 Storage of Measurement Phantoms

⚠ CAUTION



Risk of fire.

- Do not store phantoms in a sunny location. Risk of fire due to the lens effect.

NOTICE

Possible damage to phantoms.

- Phantoms should be stored at ambient room temperature (22 ± 3 °C.) inside the phantom packing at a protected place against unintentional fall off.
- Do not refrigerate or freeze.

3.9.4 First Aid in Case of Contact with Phantom Fluid

The reaction to unwanted phantom fluid contact depends on the chemical composition of the phantom. Therefore, read carefully the label on the phantom.

In addition, the chemical data sheets of all used chemical ingredients are given as appendices in the Technical Documentation.

In general it is recommended to consult a physician immediately!

Skin contamination:

- Immediately remove the clothing covering the contaminated area.
- Immediately wash the skin using soap and water.

Eye contamination:

- It is recommended to consult an ophthalmologist.

Swallowing:

- Rinse mouth with water and drink plenty of water.

Inhalation:

- Leave the building immediately to get fresh air.

3.10 Animal Safety

NOTICE

Risk of overheating animals.

Laboratory animals are precious creatures. Always handle them with great care. The following factors might lead to a temporary rise in body temperature during measurements due to Specific Absorption Rate (SAR):

- excessive RF power
- excessive gradient usage

or due to too high ambient temperature:

- too high water temperature of the animal body conditioning unit
 - malfunction of the gradient air cooling
- Permanently supervise the animal's health status during MRI measurements, especially body temperature and respiration rate. Stop the measurement immediately if physiological parameters leave their normal physiological range.
- To reduce SAR, increase repetition time (TR), or reduce matrix or resolution of the method if applicable.
- To reduce ambient temperature, reduce the water temperature of the body conditioning unit or use air conditioning. Check that the air flow through the gradient fans is not restricted.

NOTICE

Risk of peripheral nerve stimulation of animals.

Excessive gradient usage may lead to peripheral nerve stimulation during measurements.

- Permanently supervise the animal's health status during MRI measurements. Should the situation arise stop the measurement immediately.

4 Sécurité (Français)

4.1 Introduction

Ce chapitre couvre tous les sujets relevant de la sécurité lors de l'utilisation du système. Il est demandé à chaque utilisateur de se familiariser avec ces aspects de sécurité.

Notez que des informations complémentaires sont décrites dans les manuels suivants:

- Aspects de sécurité concernant l'installation du système et son utilisation à remplir par le propriétaire du système sont décrits dans le System Owner Manual.
- Aspects de sécurité concernant les activités de service sont décrites dans le document Technical Documentation.

4.2 Mots clefs et symboles

Les symboles d'alerte de sécurité indiquent un danger potentiel de blessures aux personnes et de dommages matériel.

Les mots clefs en préalable aux conseils de sécurité informent de la nature de la menace.

Les conseils de sécurité doivent être collés en évidence de manière à éviter des situations dangereuses pour les personnes ou les biens.

Des remarques sont aussi présentes dans ce manuel. Ces remarques mettent en évidence des informations importantes ou des mises en garde pour les utilisateurs.



⚠ DANGER

Indique une situation de danger qui, si elle n'est pas évitée, comporte un risque mortel ou de blessure importante



⚠ AVERTISSEMENT

Indique une situation de danger qui, si elle n'est pas évité, peut comporter un risque mortel ou de blessure importante



⚠ ATTENTION

Indique une situation de danger qui, si elle n'est pas évité, peut comporter un risque de blessure mineur ou modérée

REMARQUE

Danger, qui peut résulter dans un dommage matériel



Information et conseils pour une utilisation efficace et sans problèmes

4.3 Arrêt

En préalable à l'utilisation du système, il est impératif de familiariser le personnel avec la fonction et la localisation du bouton d'arrêt.

Le bouton principal de coupure électrique du système fait aussi office de bouton d'arrêt. Le bouton d'arrêt sert à couper l'alimentation des armoires électroniques à l'exception de la station de travail et des alimentations de l'aimant.

L'interrupteur d'arrêt est installé près de l'aimant. Il est recommandé de vérifier régulièrement que l'accès à cet interrupteur n'est pas obstrué.

En cas de risque électrique, l'alimentation électrique principale du système doit être coupée immédiatement en utilisant l'interrupteur d'arrêt.



Figure 3.1: Interrupteur d'arrêt

4.4 Information de sécurité générale

Le produit ICON est soumis aux exigences de sécurité mentionnées dans la directive concernant les basses tensions (LVD 2014/35/EEC). La sécurité électrique générale est garantie par l'application des exigences de sécurité pour les équipements électriques à vocation de mesures, de contrôle et d'utilisation en laboratoires en conformité avec la norme EN 61010-1 et EN 61010-2-081.

Selon ces règles, aucune partie accessible ne peut représenter un danger vital. En termes de conformité électromagnétique, les obligations sont mentionnées dans les textes EN 61326-1.

AVERTISSEMENT

Risque mortel par électrocution.

Ouvrir les armoires électroniques, enlever les façades d'armoire ou échanger des composants ne doit être réalisé que par du personnel autorisé et formé de manière approprié. L'unité appropriée voire le système dans son intégralité doit être éteint. Certains composants sont alimentés par de la très haute tension. Des actions inappropriées ou la non-observation des symboles de mise en garde peuvent conduire à des accidents mortels. Un soin précis doit être pris si la climatisation du local technique est non conforme aux spécifications et que de la condensation se produit.



AVERTISSEMENT

Risque d'incendie

S'assurer de l'interdiction complète de fumer ou de faire du feu dans les locaux d'installation.



4.5 Blessure mécanique

Le danger de chute concerne en particulier l'acheminement incorrect des câbles/tubes des accessoires.

ATTENTION



Risque de blessures corporelles des opérateurs.

- Acheminez les câbles/tubes tels que le tube de gaz anesthésiant ou les tubes d'eau de réchauffement de l'animal de sorte qu'il soit impossible de trébucher.

4.6 Champs électromagnétiques et statiques

Une IRM comprend plusieurs composants qui produisent différents champs électromagnétiques. Le rayonnement électromagnétique peut blesser l'opérateur et affecter l'environnement. Les sujets suivants seront traités:

1. Le champ magnétique statique: l'aimant produit un fort champ magnétique constant appelé champ magnétique statique.
2. Champs à gradient: champs magnétiques temporels.
3. Les champs à radiofréquence: les bobines RF entraînées par des amplificateurs électriques RF produisent des champs électromagnétiques pulsés à haute fréquence.

Normes professionnelles



Assurez-vous que les normes professionnelles sont prises en compte pendant la préparation de l'expérimentation ou du scanner.

4.6.1 Champ magnétique statique

Le champ magnétique statique est généré par un aimant permanent protégé 1 Tesla pour réduire le champ alentour. Le champ magnétique statique est hautement homogène dans l'aimant et chute considérablement en dehors du tunnel en fonction de la distance de l'aimant.

En particulier, en approchant de l'entrée de l'aimant, le champ magnétique augmente à une très courte distance jusqu'à sa puissance maximale avec un gradient élevé de champ magnétique. Ainsi, les parties ferromagnétiques seront soudainement fortement attirées par le gradient du champ. Par conséquent, les objets à proximité du champ magnétique peuvent devenir des projectiles dangereux.

A une distance de travail normale (> 35 cm) de l'habillage de l'aimant, les lignes de champ sont inférieures à 0.5 mT, ce qui n'entraîne pas de forces d'attraction conséquentes.

ATTENTION



Risque de perturbation temporaire pour les personnes munies de stimulateur cardiaque.

Les stimulateurs cardiaques peuvent être amenés à fonctionner en mode asynchrone à proximité de l'aimant.

- Les personnes munies de stimulateur cardiaque ne doivent pas s'approcher à moins de 35 cm de l'aimant.

ATTENTION



Risque de dommages corporels ou matériels.

Soyez toujours conscient de la force d'attraction soudaine et forte sur les matériaux ferromagnétiques dans le système magnétique protégé. N'apportez pas de matériaux ferromagnétiques dans l'aimant de l'IRM. Des matériaux ferromagnétiques qui auraient été attirés par l'aimant pourraient ne plus pouvoir être retirés, créant des dommages importants à l'aimant.

L'aimant peut ne pas être éteint. N'essayez pas de retirer les objets magnétiques accidentellement attirés dans l'aimant. Contactez votre service d'entretien local Bruker.

ATTENTION

Risque de blessure, de décès d'animaux ou de destruction d'échantillons pendant une étude en présence d'implants.



Les matériaux ferromagnétiques ou électro-conducteurs dans l'échantillon ou un objet en cours d'étude (c'est-à-dire, des clips d'anévrisme, prothèses, shrapnels, éclats métalliques, aiguilles, etc.) peuvent se disloquer à cause des forces extrêmes exercées par le champ magnétique. Cela peut provoquer des blessures internes graves ou la destruction de l'échantillon.

Des animaux portants des implants ferromagnétiques pourraient être attirés fortement par le champ magnétique, ne pouvant éventuellement plus être retirés de l'aimant.

- Aucun animal/échantillon portant des implants ferromagnétiques ne doit être apporté dans une IRM.

REMARQUE

Risque de dommage au support de données magnétiques, montres, etc.

Le champ magnétique peut

- Effacer les supports de données magnétiques (ex. disques magnétiques, cassettes magnétiques, disquettes, cartes de crédit).
 - Détruire les composants mécaniquement sensibles (ex. les montres, appareils photo).
- N'apportez aucun de ces articles dans l'IRM.

4.6.2 Champs à gradient

La loi de Faraday (loi sur l'induction) établit une relation entre les changements d'un champ magnétique dans le temps et un champ électrique rotatif. Le changement de fréquence du flux magnétique (activant et désactivant les champs à gradient) induit un champ électrique dans le tissu qui transfère la charge dans les fibres nerveuses du tissu. Ce transfert de charge dissipe le potentiel de repos de la membrane des fibres nerveuses et peut conduire à une stimulation nerveuse périphérique. Les courants induits dans les conducteurs peuvent aussi augmenter considérablement la température locale (points chauds).

ATTENTION



Risque de stimulation nerveuse périphérique.

N'entrez jamais vos extrémités dans la bobine de gradient lorsque le système est en train de scanner.

ATTENTION



Risque de brûlures.

Ne touchez pas la surface intérieure d'une bobine de gradient pendant ou peu après avoir opéré une séquence à gradient. Les températures de surface peuvent causer des brûlures.

- N'entre pas dans le champ à gradient en portant des matières conductrices.

Risque de surchauffe des animaux.



Les programmes cycliques à fort gradient appliqués pendant une longue durée provoquent des températures élevées sur la surface intérieure de la bobine de gradient. Selon l'installation de l'animal et la circulation d'air restante, un réchauffement fatal de l'animal peut se produire.

- Contrôlez la température corporelle de l'animal étudié.

**Risque de stimulations nerveuses périphériques.**

En cas de réalisation d'un scanner d'animaux non anesthésiés avec des programmes de gradient à fort balayage, soyez conscient des stimulations nerveuses potentielles.

4.6.3 Les champs à radiofréquence

L'exposition des tissus aux champs électromagnétiques à radiofréquence peut aussi provoquer un réchauffement important des tissus.

 AVERTISSEMENT**Risque de brûlures.**

Lorsque le système scanne, le taux d'absorption spécifique peut être assez élevé pour causer des brûlures locales.

- N'approchez et ne touchez pas la bobine RF, et n'entrez pas vos extrémités dans la bobine RF pendant que le système scanne.

Risque de brûlures sur les animaux.

Formation de boucles corporelles, ex. les extrémités peuvent conduire des courants élevés dans les tissus corporels et provoquer des brûlures locales.



- Evitez de former des boucles avec les parties du corps, ex. ne placez pas les pattes avant, ensemble.
- Enroulez les câbles ECG pour réduire l'induction dans l'ECG.

REMARQUE

Risque de dommage pour les appareils électroniques.

L'application de fortes pulsations RF peut conduire à une interférence involontaire avec les appareils électroniques voisins.

- Pour éviter ces situations, le système peut être utilisé dans le cadre normal d'utilisation comme défini dans le Manuel du Propriétaire.
- En général, les bobines RF doivent être placées dans l'aimant avant leur utilisation.

4.7 Bobines RF et accessoires

Dans des conditions normales d'utilisation, aucun risque pour l'utilisateur n'est provoqué par l'utilisation des bobines RF Bruker testées et des accessoires. Néanmoins, les aspects sécuritaires suivants doivent être pris en compte.

⚠ AVERTISSEMENT



Risque de blessure ou de décès.

- N'utilisez pas les bobines RF avec des câbles ou des caissons endommagés.
- N'utilisez pas de bobines RF en dehors de l'aimant pendant le scan.

ATTENTION

Risque de blessure corporelle ou de l'animal.

Une fuite d'eau peut provoquer un arc ou un choc électrique dans la bobine RF ou le lit de l'animal. Avant de préparer l'animal ou l'échantillon, assurez-vous toujours que les tubes d'eau chaude ne fuient pas. Inspectez visuellement, en particulier si de l'eau est entrée dans le lit de l'animal ou le caisson de la bobine RF. Si de l'eau est entrée dans le lit de l'animal ou la bobine RF,

- essuyez complètement l'eau avec un chiffon sec et doux ;
- tout liquide dans les bobines RF doit être totalement évaporé à des températures ≤ 40 °C avant de l'utiliser.

Toute utilisation des bobines RF et accessoires qui ne sont pas testés et validés par Bruker pour la compatibilité avec le système MR enfreint la déclaration de conformité et comprend un risque potentiel.

ATTENTION

Risque de blessure.

- Bruker ne peut pas être tenue responsable des blessures corporelles causées par l'utilisation des bobines ou accessoires non validés par Bruker. L'utilisation de ces bobines ou accessoires est de la responsabilité du propriétaire du système.

REMARQUE

Dommages aux bobines RF.

- Manipulez les bobines RF avec précaution.
- N'utilisez pas les bobines RF dans des positions/montages différents ou avec des charges autres que celles prévues.
- Le nettoyage humide des bobines RF doit être évité autant que possible. Tout liquide dans les bobines RF doit être totalement évaporé avant d'utiliser la bobine RF.
- N'utilisez pas une température (≤ 40 °C) ou une ventilation excessive pour sécher les bobines RF après le nettoyage.

4.8 Gaz médicaux

AVERTISSEMENT

Risque de blessures corporelles.

Lors de l'utilisation de gaz narcotiques (gaz médicaux) ,

veuillez respecter les réglementations locales. Plus précisément, vous ne devez pas dépasser la concentration maximale autorisée de gaz médicaux dans un environnement de laboratoire. Veuillez-vous conformer aux réglementations ;

- laissez suffisamment d'air frais et utilisez un système d'extraction pour les gaz d'anesthésie ;
- assurez-vous que le système d'évacuation est allumé (s'il existe).

AVERTISSEMENT

Risque de blessures corporelles.

Contrôlez quotidiennement si la capacité maximale du filtre d'évacuation (s'il existe) est dépassée, selon les instructions du fabricant du filtre.

- Remplacez le filtre assez tôt pour éviter la concentration des gaz narcotiques (gaz médicaux).

AVERTISSEMENT

Risque de blessures corporelles.

Inspectez visuellement tous les tubes et connexions du système d'anesthésie pour identifier toute fuite. Faites particulièrement attention aux sifflements dans le système de pressurisation qui pourraient provenir de fuites.

- Remplacez immédiatement toute pièce défectueuse ou fuyante.

4.9 Liquides de fantôme

4.9.1 Gestion des fantômes de mesure

Manipulez toujours les fantômes de mesure avec précaution. Dans des conditions d'utilisation normales, il n'existe aucun risque pour l'opérateur issu de l'utilisation des fantômes Bruker. Même si tous les fantômes sont conçus selon une composition chimique sans danger, un petit risque résiduel pour l'opérateur ne peut pas être évité, en particulier en ce qui concerne les fantômes cassés et fuyants.

AVERTISSEMENT

Risque de blessures corporelles.

- Manipulez les fantômes avec précaution. Ne faites pas tomber le fantôme et rangez-le en sécurité après usage. N'utilisez pas de fantômes fuyants.
- Evitez le contact de la peau ou des yeux avec les liquides de fantôme.
- N'avalez pas les liquides de fantôme.
- Pendant la manipulation du fantôme, ne mangez, buvez ou fumez pas.
- En cas d'incendie, informez les pompiers du contenu des fantômes.
- N'utilisez pas d'amplitudes de pulsation RF extrêmement élevées trop longues ou avec un temps de répétition extrêmement court, sinon le fantôme peut chauffer.



La solution de remplissage est sans odeur et non combustible, toutefois, manipulez et stockez toujours le fantôme avec précaution.

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- En cas de grande bulle d'air, remplissez de nouveau le fantôme avec la solution d'origine.
-

4.9.2 Renversement du liquide de fantôme

Les fantômes fuyants ou cassés comportent différents risques potentiels pour l'opérateur et doivent ainsi être retirés. Les liquides de fantôme doivent être jetés selon les réglementations locales et sécuritaires.

AVERTISSEMENT

Risque de blessures corporelles.

- Eteignez tout composant haute tension avant de nettoyer les liquides de fantôme renversés dans l'IRM.
- Portez une combinaison de protection (des gants, une blouse de travail et des lunettes).
- Portez un masque avec un filtre pour vapeurs inorganiques si des aérosols (gouttes inhalables) sont formés. Dans le cas où des aérosols sont inhalés, quittez immédiatement le bâtiment pour respirer à l'air libre. Consultez un médecin immédiatement.
- Evitez le contact des liquides de fantôme avec les yeux. En cas de contamination, consultez immédiatement un ophtalmologue.
- Evitez le contact des liquides de fantôme avec la peau. En cas de contamination, retirez immédiatement le vêtement couvrant la zone contaminée et lavez la peau en utilisant du savon et de l'eau. Consultez un médecin immédiatement.
- N'avalez pas les liquides de fantôme. Dans le cas où des liquides de fantôme seraient avalés, rincez-vous la bouche avec de l'eau et buvez abondamment. Consultez un médecin immédiatement.
- Absorbent le liquide immédiatement en utilisant une matière absorbante comme du sable, de la sciure, etc. et empêchez le liquide de fantôme d'entrer dans le système d'évacuation des eaux usées.
- Collectez le liquide dans un container en plastique ou un équivalent et étiquetez-le.
- Supprimez toute pollution provenant des fantômes renversés dans l'IRM avant de l'utiliser de nouveau.
- Nettoyez vos mains minutieusement avec de l'eau et du savon et changez vos vêtements contaminés.



ATTENTION



Éliminez le fantôme en tant que déchet spécial.

- Étiquetez le container.
- Faites appel à une entreprise officielle de traitement des déchets spéciaux pour effectuer le rejet.
- Si vous avez de plus amples questions, contactez Bruker Service.

4.9.3 Stockage des fantômes de mesure

ATTENTION



Risque d'incendie.

- Ne stockez pas les fantômes dans un endroit ensoleillé. Il existe un risque d'incendie dû à l'effet de loupe.

REMARQUE

Dompage possible des fantômes.

Les fantômes doivent être stockés à température ambiante (22 ± 3 °C.) dans l'emballage du fantôme dans un endroit protégé de toute chute accidentelle.

- Ne pas réfrigérer ou congeler.

4.9.4 Premiers secours en cas de contact avec un liquide de fantôme

La réaction à un contact involontaire avec un liquide de fantôme dépend de la composition chimique du fantôme. Ainsi, veuillez lire avec attention l'étiquette sur le fantôme.

De plus, les fiches de données chimiques de tous les ingrédients chimiques utilisés sont fournies en annexe dans la documentation technique.

En général, il est recommandé de consulter un médecin immédiatement.

Contamination de la peau :

- Retirez immédiatement le vêtement couvrant la zone contaminée.
- Lavez immédiatement la peau avec de l'eau et du savon.

Contamination des yeux :

- Il est recommandé de consulter un ophtalmologue.

Absorption :

- Rincez la bouche à l'eau et buvez abondamment.

Inhalation :

- Quittez immédiatement le bâtiment et respirez à l'air libre.

4.10 Sécurité de l'animal

REMARQUE

Risque d'échauffement de l'animal.

Les animaux de laboratoires sont des animaux qui ont de la valeur. Pour cela il est nécessaire de les manipuler avec soins. Les facteurs suivants pourraient conduire à une augmentation de leur température corporelle en raison du niveau d'énergie déposée (Specific Absorption Rate : SAR) :

- Puissance RF excessive
- Usage excessif des gradients

ou en raison d'une température ambiante trop élevée :

- Température trop élevée de l'eau de l'unité de refroidissement de l'animal
 - Dysfonctionnement de l'unité de refroidissement par air des gradients
- Contrôler de manière permanente les paramètres physiologiques de l'animal pendant l'expérience IRM, principalement la température corporelle ainsi que la fréquence de respiration. Stopper immédiatement la mesure en cours si les paramètres physiologiques changent brutalement.
- Afin de réduire le SAR, augmenter le temps de répétition (TR), ou réduire la matrice ou la résolution de la méthode si nécessaire.
- Afin de réduire la température ambiante, réduire la température de l'eau de l'unité de refroidissement de l'animal ou agir sur l'air conditionné dans la pièce. Vérifier que le flux d'air généré par les ventilateurs des gradients n'est pas obstrué.

REMARQUE

Risque de stimulation des nerfs périphériques de l'animal.

L'usage excessif des gradients lors d'une expérience IRM peut induire une stimulation des nerfs périphériques de l'animal.

- Contrôler de manière continue les paramètres physiologiques de l'animal lors de l'expérience. Dans le cas où la situation décrite ci-dessus se produit, stopper immédiatement la mesure en cours.



5 MRI System Operation

5.1 Switching ON and OFF

5.1.1 Definition of Scanner Operation States

Four operation states of the scanner can be distinguished:

Unpowered

The spectrometer is completely powered off. The scanner is set in the “UNPOWERED” state for service activity of electrical devices only.



OFF

Line power is present but spectrometer is off. No acquisition is possible. The scanner is typically set into the “OFF” when not in use for longer time. The host is still powered but all built-in electronic and high power components are powered down (except the power line distributor serving the power switches)



Start-Up

The green LED is flashing for approximately 40 seconds during spectrometer start-up.



ON

The spectrometer is ready for use.



5.1.2 Switching ON

The scanner must be in the “OFF” state is indicated by the lit red LED.



To start the scanner, press the power on button.
The system will automatically start.



During the green LED is flashing for about 40 seconds.



After startup the system is ready use, as indicated by the lit green LED.



5.1.3 Switching OFF

The scanner must be in the “ON” state, indicated by the lit green LED.



To power down, press the power off button. This will immediately set the scanner into “OFF” state.



The “OFF” state is indicated by the lit red LED.



5.2 Prepare and Run Scans

5.2.1 Introduction

The animal support for the ICON is modular and consists of the basic animal holder (see section 2.6.1) and exchangeable front pieces; the actual animal beds including dedicated RF Coils (see section 2.6.2). Every animal bed supports a dedicated application (i.e. measurement of a dedicated animal, body part) according to Table 7.1 in section 7.1 on page 88. Each animal bed is designed to work only with the dedicated RF Coil.

The animal is prepared and positioned on the animal bed outside the magnet on the provided animal preparation table. Make sure to connect all required animal life support and monitoring equipment (optional). Then, the setup is inserted into the magnet.

All animal beds provide an adequate fixation mechanism to position and reposition the animal during the scans. Tubes for warm water heating are integrated in all animal beds to prevent hypothermia during anesthesia.

Anesthesia gas is provided by a gas cone incorporated into the front of the animal bed. Anesthesia scavenging connections for safe removal of anesthetic gases is provided for every animal bed, too.

WARNING

Risk of personal injury.

When using narcotic gases (medical gases),

- pay attention to the local regulations. In particular you must not exceed the maximum allowed concentration for medical gases in a laboratory environment. Carry out appropriate compliance with the regulations;
- allow for sufficient fresh air and use extraction system for anesthetic gases.



5.2.2 Basic Workflow

Switch on the console and afterwards switch the scanner on and start ParaVision.

Before you start scanning, complete the following preparation steps:

1. Choose the appropriate animal bed and RF Coil according to your desired application and mount it to the basic holder.
2. Place the animal or sample on the animal bed.
3. Position the setup in the magnet.

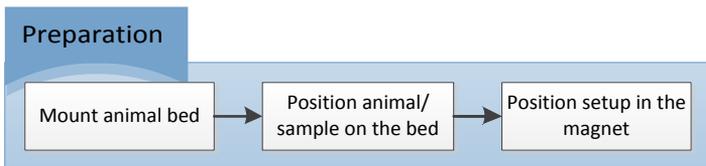
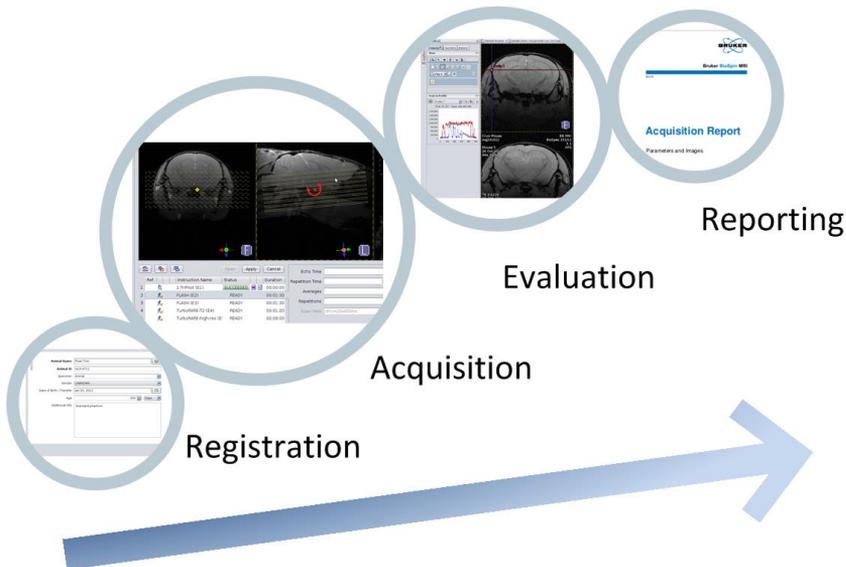


Figure 5.1: Prepare and run scans: Preparation

The generalized ParaVision workflow includes the four steps shown below:



- During the registration a subject is assigned to the planned study, possibly within a project.
- Data acquisition (and reconstruction) is done on the basis of predefined protocols and scan programs
- The reconstruction and evaluation can be performed manually or automated
- Parameter, images and results of an experiment are summarized in acquisition reports

5.2.3 Mounting the Animal Beds to the Basic Holder

Before using the animal beds get familiar with all features and connections, described in the following sections.

5.2.3.1 Overview – Animal Bed

As an example, Figure 5.2 shows the schematic layout of the **mouse body animal bed for fix RF Coils**. This animal bed have following connections:

- Isoflurane anesthesia supply (4) via the tooth bar (3) into the anesthesia mask (2)
- Scavenging (5)
- Two warm water tubes (6) (in-/outlet) for animal warming

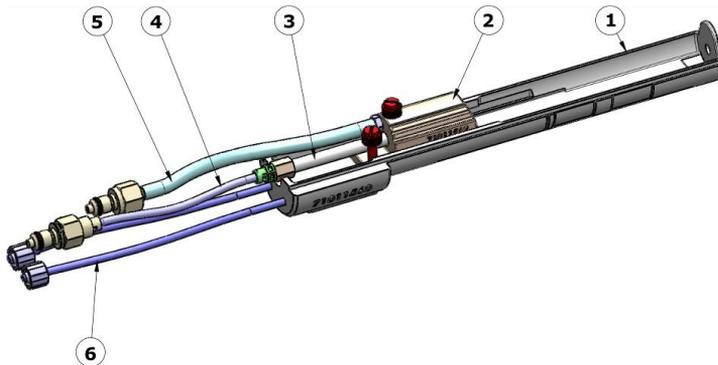


Figure 5.2: Mouse body animal bed

(1) Mouse animal bed; (2) Anesthesia mask; (3) Tooth bar; (4) Anesthesia connection to tooth bar; (5) Scavenging; (6) Warm water tubes (in- and outlet) for animal warming

5.2.3.2 Overview – RF Coils

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For all body examination beds the RF Coils may be taken off for easy animal preparation. The head examination beds are an integral part of a RF Coil and must not be removed. Therefore, the basic holder's fixation rod is not required. This does not apply to the 60 mm rat body RF Coil which is magnet mounted from the rear. The corresponding multimodal animal cassettes (MMAC) are mounted on an adapter and inserted from the front side of the instrument, see Technical Documentation/Components/RF Coils/ Rat Body 60 mm RF Coil.

As an example, Figure 5.3 shows the schematic layout of the **mouse body RF Coil**. This fixed RF Coils have following connections:

- Tuning rod connector (2)
- RF connection cable (3)

In addition, the body RF Coils have a hole (4) and knurled screw (5) for fixation of the RF Coil on the coil fixation rod of the basic holder.

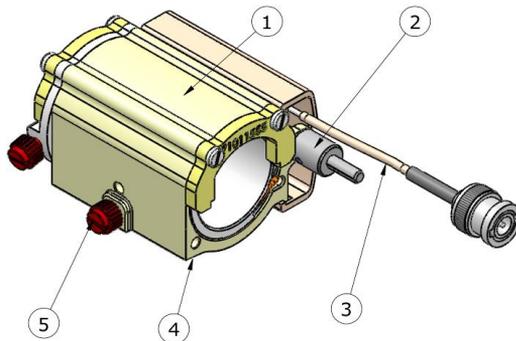


Figure 5.3: Mouse body RF Coil.

(1) Coil housing; (2) Tuning rod connector; (3) RF connection; (4) Hole for inserting the coil shifting rod; (5) Coil fixation on the fixation rod

5.2.3.3 Mounting the Animal Bed

Animal beds have a notch (1) located at the bottom side, which will hold the bed in the basic holder, see Figure 5.4:

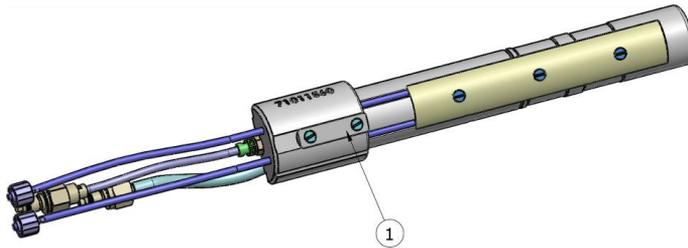


Figure 5.4: Bottom side of the mouse body animal bed.
(1) Notch for animal bed mounting on the basic animal holder

For mounting, slide the animal bed with its notch (1) into the rail (2) of the basic holder as shown in Figure 5.5. Fix it with the fixation lever (3) from below.

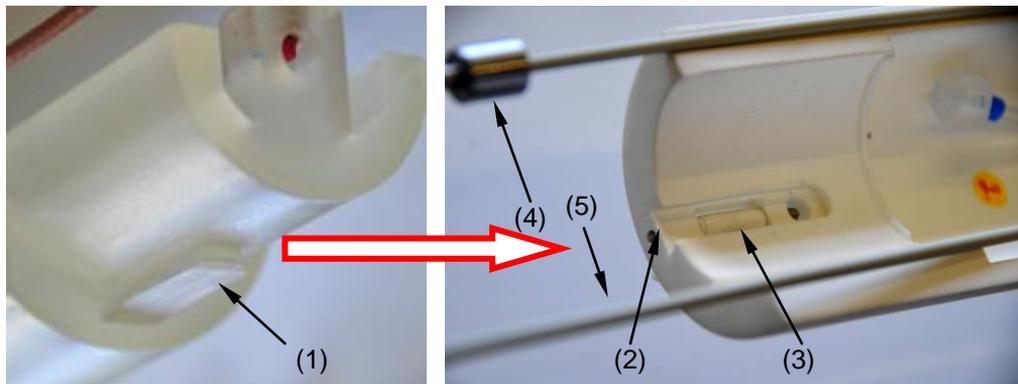


Figure 5.5: Left: Notch (1) on the bottom side of the animal bed. Right: Front part of the basic animal holder. (2) Rail for holding the animal bed notch (1); (3) Fixation for animal bed (lever from below is not visible); (4) Tuning rod; (5) Coil fixation rod

Figure 5.6 shows the attachment of the tuning rod (1) to the tune adapter (2) of the RF Coil. The spring in the screw (3) will lock into the hole (4) when sliding the rod over the tune adapter.

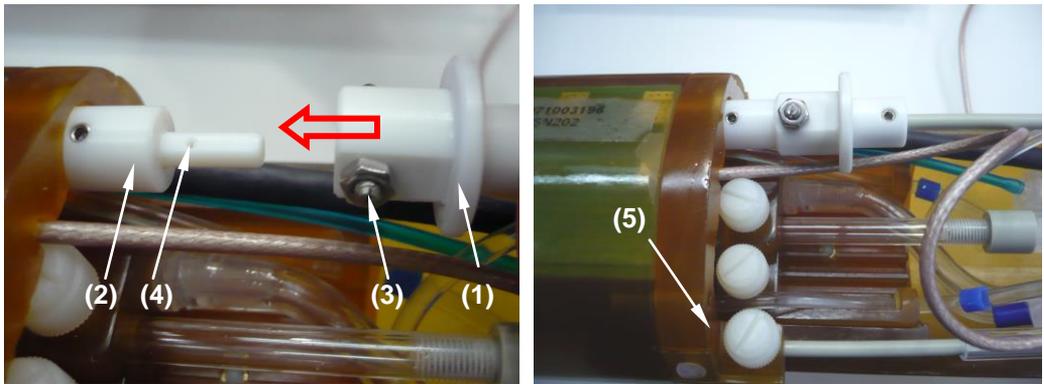


Figure 5.6: Attaching the coil tuning rod.

Left: Push the coupling (1) into the tune adapter (2) at the coil. The spring in the screw (3) will lock into the hole (4). Right: Final setup

Connect all cables and tubes of the animal bed and the RF Coil with the corresponding counterparts of the Basic Animal Holder as shown in Figure 5.7:

- Water connections of the warm water bed (1)
- Isoflurane supply (2)
- Scavenging (3)
- RF cable (4) (for head RF Coils only)
For body RF Coils this should be done after placing the animal on the animal bed since the coil is not integral part of the animal bed. Please refer to section 5.2.4 on page 69.
- Respiratory sensor (option, not shown)
- ECG electrodes (option, not shown)

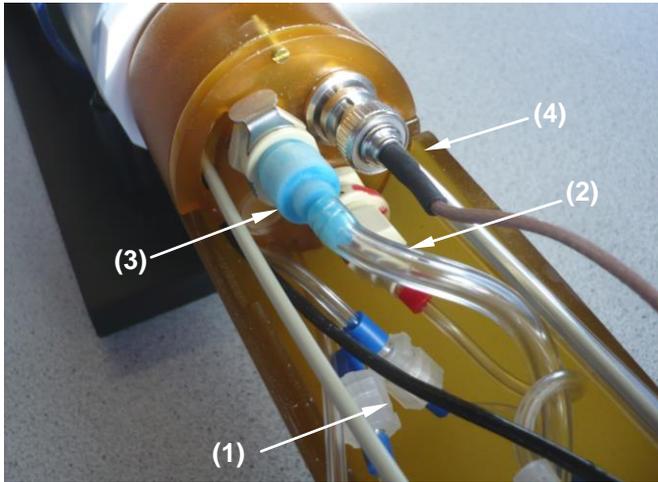


Figure 5.7: All connections to the Basic Animal Holder are established.
(1) Warm water tubes; (2) Isoflurane supply; (3) Scavenging; (4) Cable of RF Coil

5.2.4 Connecting RF Coils

5.2.4.1 Animal Bed mounted RF Coils

The black RF connection cable leading out of the basic holder (labeled “RF Coil”) is connected to the left-most connection (1) located on the bottom side of the magnet, as shown in Figure 5.8. The other connections are not in use (not connected).

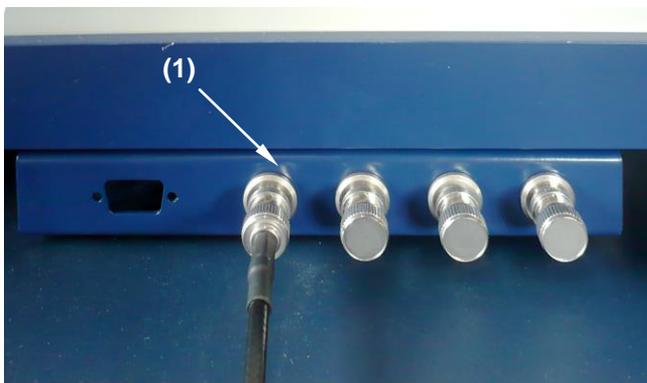


Figure 5.8: RF Coil connection located on the magnet’s bottom side

5.2.4.2 Magnet mounted RF Coil

When using magnet mounted RF Coils connect the BNC cable (2) as described in section 5.2.4.1 with the BNC connector as shown in Figure 5.9.



Figure 5.9: RF Coil connection located on the rear side
(1) Fixation screws; (2) BNC cable

5.2.5 Positioning

Turn on the animal warming unit (option). Regarding the usage of this option please refer to the technical documentation.

CAUTION

Risk of personal injury or injury of the animal.

Leaking water may lead to arcing or electric shocks in the RF Coil or animal bed. Before preparing the animal or sample always make sure that the warm water tubes are not leaking. In particular, visually inspect if water entered the animal bed or RF Coil housing. If water was entering the animal bed or RF Coil,

- swab the water completely with a dry and soft cloth;
- let all parts dry at temperatures $\leq 40^{\circ}\text{C}$ before starting any measurement.

Turn on the Isoflurane gas supply and make sure, that the scavenging system is on (option).

WARNING

Risk of personal injury.

When using narcotic gases (medical gases),

- pay attention to the local regulations. In particular you must not exceed the maximum allowed concentration for medical gases in a laboratory environment. Carry out appropriate compliance with the regulations;
- allow for sufficient fresh air and use extraction system for anesthetic gases;
- make sure that the scavenging system is turned on (if present).

5.2.5.1 Placing the Animal on the Animal Bed

- i** The animals are always placed tail first on the animal beds. When registering a new study in ParaVision do not forget to set the correct orientation information.

Hang the incisors into the bite ring of the tooth bar and pull the head into the anesthesia mask by pulling the tooth bar. Lock the tooth bar with the knurled screw in the anesthesia mask.

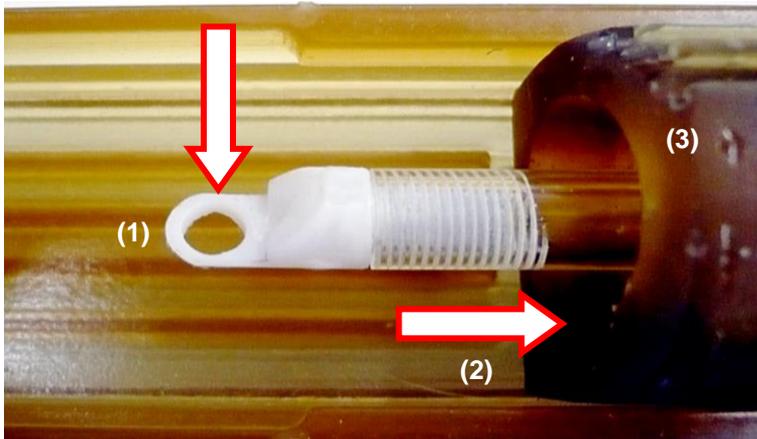


Figure 5.10: Placing the animal in the anesthesia mask. The incisors are placed in the bite ring (1) of the tooth bar (2). Then the animal is pulled into the respiration mask (3). The tooth bar is fixed with a knurled screw (not shown).

Place all necessary life and health monitoring sensors on the animal and connect them.

5.2.5.2 Placing the RF Coil on the Animal Bed (for Body RF Coils only)

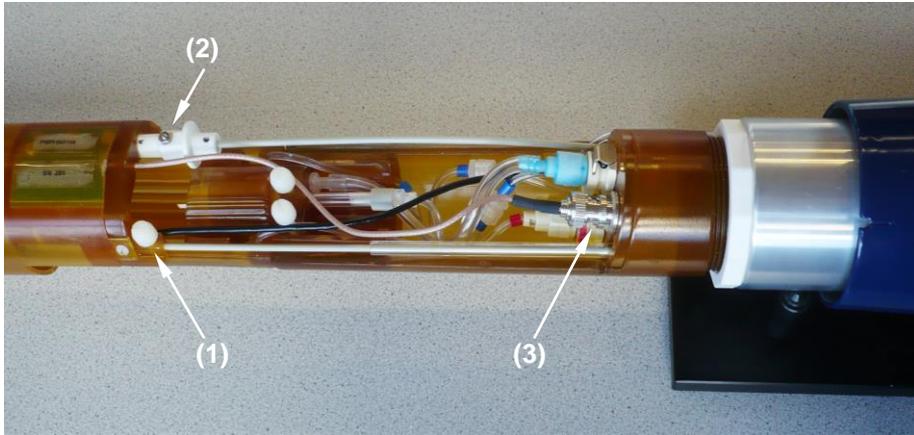


Figure 5.11: The rat body RF Coil has been shifted onto the rat bed. The coil was tightened with the screw (1) to the fixation rod. The tune coupling (2) was attached to the tune adapter (for details also see Figure 5.6 on page 68); (3) The RF Coil has been connected the BNC connector of the basic holder.

- i** The rat body RF Coil will be centered with respect to the magnet center if the marking (1) is aligned with the hole (2) on the body RF Coil, see below.

For rat body RF Coil: The RF Coil will be centered with respect to the magnet center if the marking (1) is aligned with the hole (2) on the body RF Coil, as shown in Figure 5.12.



Figure 5.12: (1) Magnet Center marking on the animal bed. (2) The hole in the body RF Coil was aligned with the Magnet Center marking.

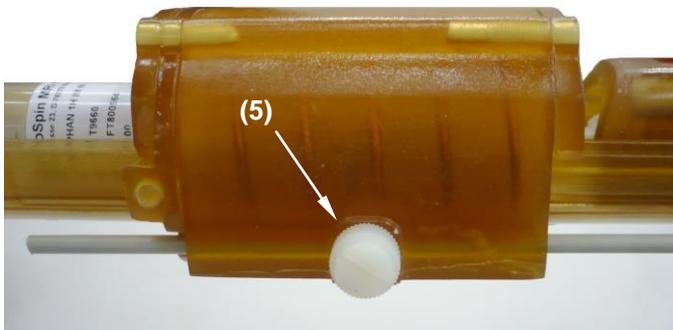


Figure 5.13: Fixating the position of the mouse body RF Coil with screw (5)

5.2.5.3 Inserting the Setup in the Magnet

Move the setup smoothly into the center of the magnet. Shift it to the zero position and fix it with the fixation screw (1) shown in Figure 5.14. Two scales, one for horizontal shifts (2) and one for rotation (3) help exactly positioning the animal.



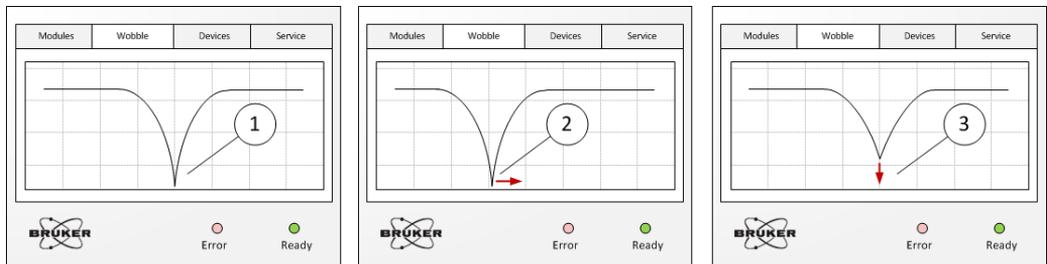
Figure 5.14: Fixate the Basic Animal Holder in the magnet with the knurled screw (1). Two scales, one for horizontal shifts (2, with 2-mm division), and one for rotation (3, with 3-degree division) facilitate positioning. The Magnet Center Position is reached when both scales show zero.

5.2.6 Tuning of RF Coils

Depending on the type of the RF Coil, tuning and matching of the coil ¹⁾ is required when the load of the sample has changed between consecutive imaging or spectroscopy studies.

Correct tuning and matching reduces the reflection of RF power during transmission and increases the sensitivity (SNR) during signal reception. It is therefore most important for the coil receiving the signal and less for the transmission coil in a cross coil configuration²⁾.

Tuning and matching of a RF Coil needs to be performed exactly with the sample and setup that is used when scanning. The so called “wobble curve” is displayed on the RF interface display as soon as the wobble process has been started in ParaVision. The example below shows different situations:



- 1 The RF Coil is correctly tuned and well matched
- 2 The RF Coil is detuned (off-resonant), but well matched => change the tuning of the coil
- 3 The RF Coil is tuned (on-resonant), but miss-matched => change the matching of the coil

Please check the coil-specific user manual for dedicated procedures that are not described in this manual.

5.2.6.1 Workflow

The coil can be tuned and matched inside or outside the magnet bore. If possible, tune/match the coil while it is in its final position inside the magnet.

1. Connect the RF Coil at the corresponding socket of the RF interface
2. Start the tune/match from ParaVision (see corresponding chapter in ParaVision software manual).
3. Adjust and optimize the tune and match condition by turning the tune and match knobs of the RF Coil (labeled T or M).
4. Stop the tune/match on the RF interface display.

5.2.7 Scanning

5.2.7.1 General Scanning Workflow

The detailed procedure for routine system operation, i.e. selecting, positioning and acquiring scans is described in the workflow diagram. For details please also refer to the ParaVision Application Manual

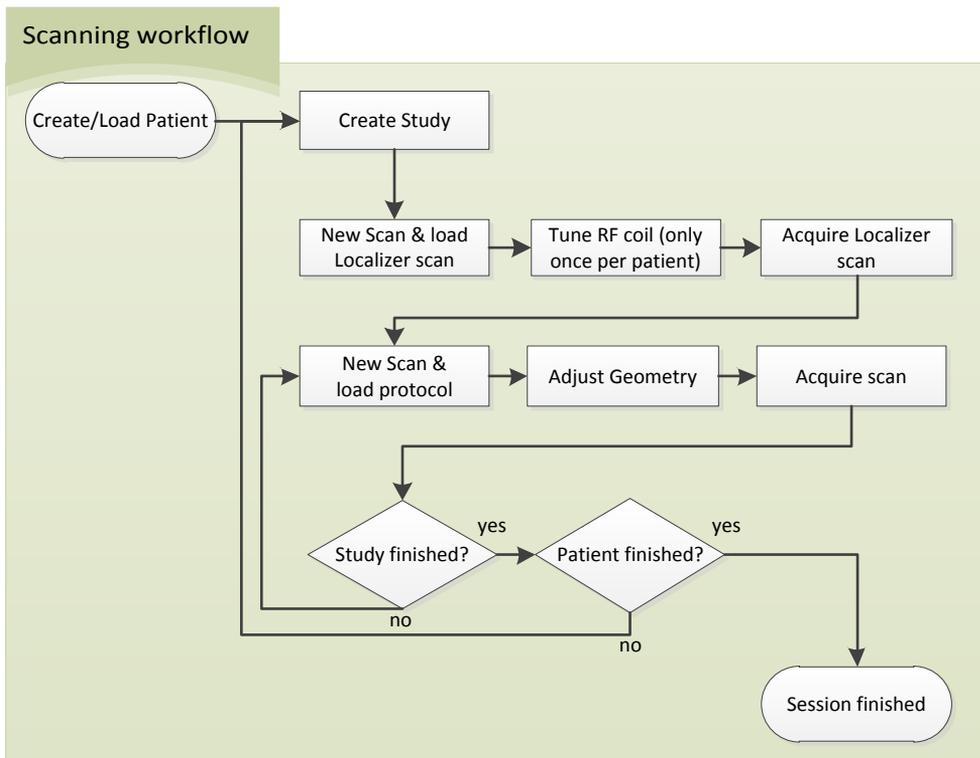


Figure 5.15: Detailed standard workflow for routine system operation

5.2.7.2 Protocol Adaption

ICON offers more than one hundred *in vivo* optimized protocols for mice and rats for various applications. For routine work, only the slice position and orientation should be adapted on a per-scan basis. Other parameters should be kept untouched for the less experienced user.

A detailed description of important scan parameters and their influence on image quality, contrast and scan time, as well as the available contrast modules is given in the ParaVision Application Manual.

The experienced user may create user defined Locations and Protocols, optimized for a certain project. These protocols may later be reused by the less experienced users for routine work. For more details please see the ParaVision Application Manual.

5.2.7.3 Maximum Scan Times

Recommended maximum scan times:

- ca. 1 hour for navigator methods (IntraGateFLASH and all EPI based methods)
- ca. 6 minutes for non-navigator methods (all other methods)

Longer measurement times are possible but might lead to image artifacts.

5.2.7.4 Spatial Resolution

The reachable resolution depends on the application and the type of RF Coil used. As a rule of thumb, the in-plane resolution of a “highres”-protocol is enhanced by a factor of 1.3 ~ 1.5 at about twice the scan time.

For pure anatomical 2D imaging using FLASH, the following resolutions may be expected (slice thickness 1.0 ~ 1.25 mm):

Mouse head:	ca. $(150 \mu\text{m})^2$ within ca. 4 minutes
Rat head:	ca. $(180 \mu\text{m})^2$ within ca. 4 minutes
Mouse head “highres”:	ca. $(100 \mu\text{m})^2$ within ca.10 minutes
Rat head “highres”:	ca. $(135 \mu\text{m})^2$ within ca.10 minutes

For other methods, as well as special techniques such as multiple contrast imaging, parametric mapping, ultra-fast imaging techniques etc., the reachable resolution within the same scan times may be inferior.

The slice thickness may be reduced at the expense of reduced spatial resolution in the image plane or increased measurement time.

i

To keep the same image quality when reducing the slice thickness to 50%, the in-plane resolution has to be compromised by a factor of $\sqrt{2}$ (e.g. by increasing the FOV by a factor of $\sqrt{2}$ while keeping the same encoding matrix); or the number of averages (and hence the total measurement time) has to be increased by a factor of 4.

For very thin slices (< 0.3 mm) 3D spatial encoding is recommended.

For pure anatomical imaging, the following 3D FLASH isotropic resolutions may be reached:

Mouse head:	ca. $(175 \mu\text{m})^3$ within ca. 15 minutes
	ca. $(140 \mu\text{m})^3$ within ca. 60 minutes
Rat head:	ca. $(240 \mu\text{m})^3$ within ca. 15 minutes
	ca. $(190 \mu\text{m})^3$ within ca. 60 minutes

5.3 In- and Output Trigger

The ICON AVANCE III MRI electronics provides one programmable input trigger and one programmable TTL output signal. The trigger connector has a quick latch QLA type connector, including a QLA/BNC adapter.

5.3.1 Input trigger

Input trigger signals are used for synchronizing the scanner with external signals or events, e.g. ECG or respiration threshold detection. If a trigger-in module is activated inside ParaVision, the scanner interrupts the image acquisition until the next trigger event occurs.

Such trigger events are generated by an external triggering device, i.e. the SA Instruments animal supervision device. The ECG external triggering is activated from within the method in the **PVM TRIGGER_IN** parameter class.

For usage of the input trigger please refer to the ParaVision Application Manual.

5.3.2 Output trigger

The output trigger signal is used to control or synchronize external devices (i.e. fMRI stimulation devices) from within the pulse program of the scanner. The output trigger is activated from the **PVM TRIGGER_OUT** parameter class. The **TRIGGER_OUT** class is included in all EPI based method derivatives.

For usage of the output trigger please refer to the ParaVision Application Manual.

5.3.3 Trigger Connection Points

The trigger connectors including QLA/BNC adapters can be found inside the anesthesia cabinet near the system power mains connection, see Figure 5.16. The connection points are labeled “ECG TRIG IN” (input trigger) and “ECG STAMP” (output trigger). The other QLA connectors are not connected.

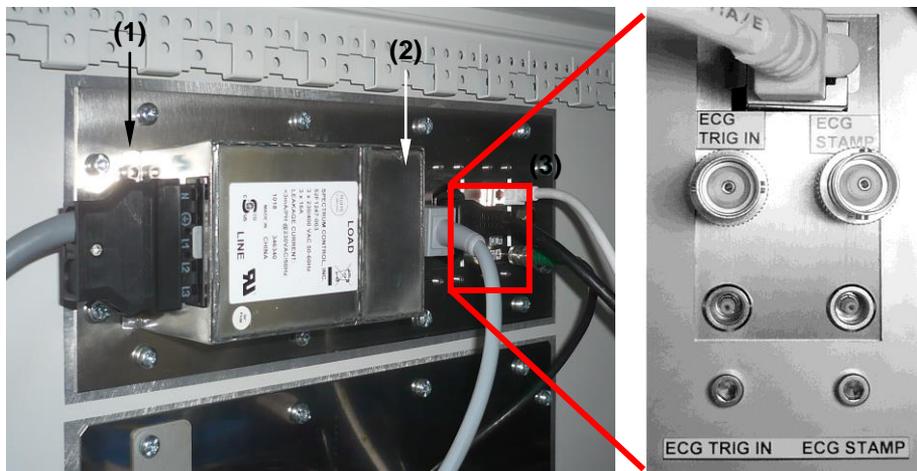


Figure 5.16: Left: Power mains connection point (1), console power connection (2) and trigger connection points (3) inside the anesthesia cabinet. Right: Enlargement of the trigger connection points. The input trigger connection is labeled “ECG TRIG IN”; the output trigger connection is labeled “ECG STAMP”.

5.4 Data Storage and Retrieval

Data storage and retrieval is supported by the ParaVision **Data Manager** software. Please refer to the ParaVision Operation Manual for a detailed description of the **Data Manager** and supported storage devices.

6 Quality Assurance

Quality Assurance of RF Coils is typically based on a Signal-to-Noise Ratio (SNR) measurement using a standardized measurement setup, phantom (sample), and measurement protocol. Setup, phantom and protocol may be different for every type of coil and therefore they are defined in the corresponding Coil Specific Information (see accordingly).

Therein, also the QA SNR specification of the RF Coil is given.

The QA SNR specification serves as a reference value for quality assurance. In addition, other parameters may be defined. Normal operation of a RF Coil with regard to SNR is defined as when the actual measurement is better than or equal to the QA SNR specification. Repeating measurements and recording them over time will enable the operator to establish a site specific value for reproducibility and performance.

Quality Assurance of most Bruker RF Coils is based on the protocol QA SNR located in the Scan Programs & Protocols tree “AnyObjects”, “AnyRegions”, “QualityAssurance”.

This protocol measures and determines automatically the SNR value based on a contour finding algorithm for signal and noise regions. Finally, it normalizes the SNR to a volume of one mm³ (SNR / mm³) which is compared with the QA SNR specification. The results are provided on the Routine Card.

In addition, a QA Test Report (filename QaSnrReport.pdf) is automatically created and saved in the corresponding Dataset in the Procno directory.

Please note that the automatically determined QA SNR value is used to check the normal operation of a coil.

The specification is based on the reproducibility of measurements for a specific coil and setup. It cannot be used to compare SNR values of different types of coils.



For QA SNR measurements, use the phantom and setup as described in the Coil Specific Information and tune/match the coils accordingly.

6.1 Quality Phantoms

Appropriate load phantoms are delivered with the RF Coils:

- Mouse load phantom (part number: Q8091204)
- Rat load phantom (option, part number: Q8091238)

The mouse load phantom should be used for all mouse RF Coils, and the rat load phantom for all rat RF Coils.

Ensure that the air bubble is trapped on the top of the phantom between the air bubble stop and the cap of the phantom. Hold the phantom almost horizontal and rotate it such that the air bubble can travel through a little gap between the wall of the phantom and the air bubble stop. When the air bubble has completely entered the space between the air bubble stop and the cap rotate the phantom by 180° such that the little gap between the air bubble stop and the wall of the phantom is now pointing to the downside.



Figure 6.1: Mouse load phantom. Trap the air bubble at the top position of the phantom.

6.2 Placing the Phantoms

The phantoms are placed on the animal beds in a well-defined position in order to deliver reproducible results. To achieve this, all animal beds except the mouse body bed have dedicated phantom holders. An example for the rat load phantom holder on the rat body animal bed is shown in Figure 6.2.



Figure 6.2: Phantom holder for the rat load phantom on the rat body animal bed.

Examples for the phantom placement are given for the mouse body animal bed (Figure 6.3) and for the rat body animal bed (Figure 6.4) below.



Figure 6.3: Placement of the mouse load phantom on the mouse body animal bed. The cap (1) of the phantom rests in the deepening (2) at the end of the animal bed. No phantom holder is needed.

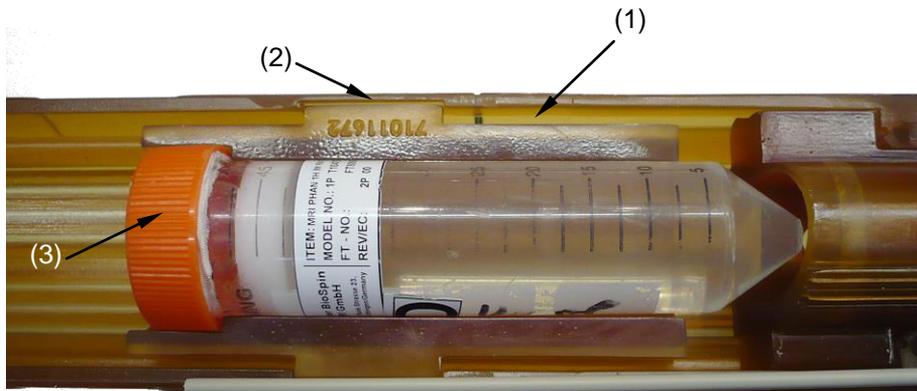


Figure 6.4: Placement of the rat load phantom in the rat body animal bed. First, the phantom holder (1) is placed in the rat body animal bed. The fins (2) of the phantom holder engage in the deepening of the animal bed. The phantom cap (3) rests in the deepening of the phantom holder.

Body RF Coils only: After placement of the phantom on the animal bed place the RF Coil over the phantom and connect the RF cable and tune adapter of the coil and fixate it on the fixation rod of the basic animal holder. For details please refer to section 5.2.5.2 on page 73. A final setup for the mouse body animal bed is shown in Figure 6.5.

When finished, insert the setup into the magnet.



Figure 6.5: Final phantom setup for the mouse body animal bed.

7 Accessories

The following chapter gives an overview of the typical accessories optionally available for your MRI system. In addition to these typical accessories, Bruker BioSpin MRI provides for many applications special accessories. Please contact your local Bruker representative for details.

The option or part numbers of spare parts for the accessories are given in the corresponding accessories operating instructions.

7.1 RF Coils and Animal Beds

RF Coils are dedicated to a given application and are therefore always sold as a set together with the appropriate animal bed. The head RF Coils are even integral part of the animal bed and may not be taken off.

The size and shape of the RF Coils was optimized for in vivo applications. They are pre-matched to a typical loading of a mouse or rat, respectively.

All animal beds have a tooth bar for animal fixation, anesthesia mask, anesthetic scavenging connection, and warm water bed.

Application	Description	Option Number
Mouse body	MRI RF volume coil, designed for mouse body investigations of animals up to 40g body weight. Solenoid coil design, transmit/receive capabilities, liner diameter: 30 mm, length: 50 mm, including animal bed.	MT1011
Mouse whole body (option)	MRI RF volume coil, designed for mouse whole body investigations of animals up to 40 g body weight. Solenoid coil design, transmit/receive capabilities, inner diameter: 30 mm, length: 80 mm, including animal bed.	MT1012

Mouse head (option)	MRI RF volume coil, designed for investigations of the mouse head with animals up to 40 g body weight. Solenoid coil design, transmit/receive capabilities, inner diameter: 23 mm, length: 25 mm, integrated animal bed.	MT1021
Rat body (option)	MRI RF volume coil. designed for mouse body investigations of animals up to 300 g body weight, solenoid coil design, transmit / receive capabilities, dimension: 59 x 50 mm (width x height), length: 90 mm, including animal bed.	MT1031
Rat body (60 mm option)	MRI RF volume coil with 60 mm inner diameter, solenoid coil design, transmit/receive capabilities, inner diameter: 60 mm, designed for use with the multimodal animal cassette (MMAC),	n. a.
Rat head (option)	MRI RF volume coil, designed for investigations of the mouse head with animals up to 300 g body weight, solenoid coil design, transmit/receive capabilities, inner diameter: 35 mm, length: 40 mm, integrated animal bed.	MT1041

Table 7.1: Available animal beds and coils

For details on the RF Coils and animal beds please refer to the Technical Documentation.

7.2 Animal Life Monitoring Unit (MTLIMO01)

A MR compatible small animal life monitoring and gating system is available (option). For triggering or gating the scanner with respiratory or cardiac signals the trigger connectors at the hardware cabinets may be used, see section 5.3 on pages 80 ff.

For details on the animal monitoring and gating system, see accessories operating instructions.



Figure 7.1: MR compatible small animal monitoring and gating system (option)

7.3 Animal Body Conditioning Unit (MT0125)

An animal body warming unit is available (option). All ICON animal beds have an integrated warm water beds and may be connected to this warming unit.

For details, see accessories operating instructions.

8 Maintenance

8.1 Regular Checks

Please read the following instructions carefully and carry out the following regular checks.

8.1.1 Checks before Every Measurement

Check before every measurement:

- The gradient cooling fans must not be covered
- Check for leaks in the anesthesia system
- Visually inspect the RF Coil and its input lead for damage.

WARNING



Risk of fire or serious injury.

The gradient coils may overheat and result in fire or personal injury if the cooling air flow is constrained. Visually inspect both (left and right) gradient cooling fans at the magnet before starting the measurement.

- Make sure that nothing covers the fan openings.

WARNING



Risk of personal injury.

Visually inspect all tubes and connections of the anesthesia system for leaks. In particular, pay attention to wheezing noises arising from possible leaks.

- Immediately replace all defective or leaking parts.

WARNING



Risk of injury or death.

- Do not use RF Coils with damaged cables or housing.
- Do not use RF Coils outside the magnet when scanning.

8.1.2 Daily Checks

Check daily:

- Capacity of the scavenging filter (if present)

WARNING



Risk of personal injury.

Check daily if the maximum capacity of the scavenging filter (if present) is exceeded, according to the instructions of the manufacturer of the filter.

- Replace the filter early enough to prevent the egression of narcotic gases (medical gases).

8.2 Cleaning

The following table provides cleaning aspects for different components.

Cleaning the monitor	<p>Clean the monitor using a microfiber cloth. In case the monitor is contaminated, use a window cleaner.</p> <ul style="list-style-type: none"> ➤ Immediately remove water drops on the monitor ➤ Avoid impacts and scratches to the monitor
Cleaning the system covers	<p>Read the safety chapter first.</p> <ul style="list-style-type: none"> ➤ Clean the covers using liquid household agent
Cleaning the animal beds	<p>Do not use cleaners or disinfectants containing alcohol, ether or acetone.</p> <ul style="list-style-type: none"> ➤ Use a dampened cloth for cleaning ➤ Disinfect the animal bed with a commercially available disinfecting agent and follow the manufacturer's instructions
Cleaning the RF Coils and connectors	<p>Read the safety chapter first.</p> <ul style="list-style-type: none"> ➤ Do not use organic solvents, such as alcohol or acetone ➤ Do not submerge the coil or plug in cleaning liquid ➤ Dampen a soft cloth with water or a diluted household cleaner solution ➤ Carefully wipe the plugs and connectors with the cloth. Do not touch the contacts ➤ Do not use hard or sharp objects (e.g. knives or tweezers)



9 Contact

Manufacturer:

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Rudolf-Plank-Strasse 23

D-76275 Ettlingen

Germany

Phone: +49 721-5161-6531

[http://www.bruker-biospin.com/preclinical imaging](http://www.bruker-biospin.com/preclinical_imaging)

WEEE DE92533205

MRI Hotlines**Service Hotline**

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E-mail: mri-hardware-support@bruker.com

Application Hotline

Phone: +49 721-5161-6621

E-mail: mri-application-support@bruker.com

Software Hotline

Phone: +49 721-5161-6588

E-mail: mri-software-support@bruker.com

Please refer to the Model No., Serial No. and Internal Order No. (see System Owner Manual) in all correspondence regarding the MR system or components thereof.



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