



## RF Coils and Animal Cradles

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## This Document

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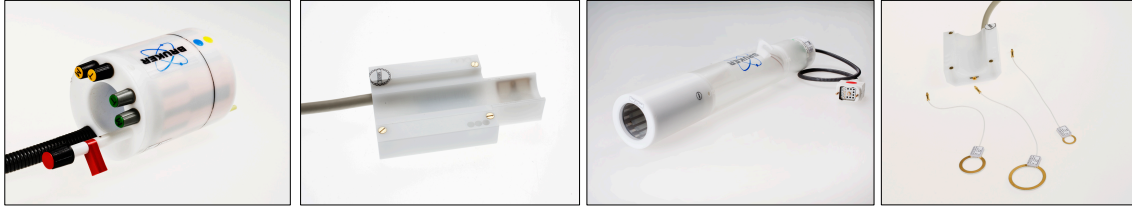
This document describes the use of and the properties of the various RF coils and animal cradles/beds available for imaging in the preclinical MRI facility at the Dep. of Biomedicine

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## RF Coils

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There are several types of for the Pharmascan 7T system and the choice of the coil/coil combination requires some understanding of how the coils differ from each other and the strengths/limitations of each.

The coils, also called resonators, can be divided into main categories:

### 1. Volume coils:

These coils are cylindrical and are used to both excite the net magnetization and to receive signal from it. The active region extends radially to the inner surface of the coil, while the axial active region is roughly the length of the coil's inner diameter. Since the efficiency of these coils is rather homogeneous throughout the active volume, the coils are used to image deep lying anatomical features of the subject.

Volume coils can be either linear or quadrature. The quad coils are more efficient in receiving the signal, but require a more elaborate tuning procedure (in our case, only the rat head/mouse body coil can be tuned).

### 2. Surface coils:

These coils are more or less planar and are designed only to receive MRI signal. Therefore, a secondary volume coil has to be used for the excitation of the magnetization. The efficiency of the of these coils decreases rapidly with the distance from the coil surface, so these coils are used for imaging regions close to the surface of the subject, e.g., brain, spine, joints.

The surface coils can either consist of a single element (linear coils) or from several individual coil elements for higher sensitivity. A coil with two elements is called a quadrature coil, while a coil with more than 2 elements is called a phased-array coil.

Presently, we have the following coils available in the preclinical MRI facility:

### 1. Volume coils:

- 72 mm quadrature transmit coil
- 60 mm quadrature transmit/ receive coil for rat body imaging
- 40 mm quadrature transmit/receive coil for rat head and mouse body imaging, tunable
- 23 mm quadrature transmit/receive coil for mouse head imaging

### 2. Surface coils

- Phased-array coil for rat brain imaging
- Phased-array coil for mouse brain imaging
- 10 mm/20mm/30mm diameter surface loop coils for imaging of small anatomical features on the surface of the body (e.g., subcutaneous tumors)

## Which Coil Should I Use

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There are no absolute rules as to the coil selection, but realize that the appropriate choice of the RF coil is probably the most important factor in obtaining high quality images.

Here are some guidelines:

1. The smaller the coil, the better the performance, as long as the imaged feature properly fits inside the active region of the coil.
2. Quadrature coils have a better signal-to-noise ratio than linear coils.
3. Phased-array coils have a better signal-to-noise ratio than quadrature and linear coils.
4. Quadrature coils have a more elaborate tuning procedure so it will take longer time to set up an experiment with a quadrature coil (in our case, this only applies to the 40 mm rat head coil).
5. Surface coils give in general better SNR than volume coils if the volume of interest is close to the surface of the coil and the drop of the signal intensity across the slice is of no concern.

## Where to Find the Coils

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The smaller volume and surface coils are stored in plastic transparent boxes on the bookshelves to the left of the magnet. Each box is labeled with the name of the coil. In addition, each coil has a color code, an explanation of which is hanging on the wall next to the coils. To minimize confusion, it is extremely important that users place the coil in the corresponding box after each use.

The bigger coils (such as the rat body volume coils and old linear volume coils) are placed on the special supports next to the bookshelves.

## Coil Handling

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The coils are delicate devices that will break if you don't handle them with care. The connectors can break if you drop them on the floor, so you have to be careful when handling coils.

Always connect the coils as soon as you have placed them into the magnet. This prevents accidentally pulsing on the transmit coil with a second (surface) coil lying unconnected in the magnet as this will destroy the surface coil!



When you connect the coil into the coil color-labeled connectors at the back of the magnet, you should hear a beep, confirming that the Hardware Detection Unit (HDU) has recognized the coil. It will also beep when you disconnect the coil from the system. If you do not hear a beep, try to repeat the procedure. If the beep still does not happen, contact the facility manager so that she/he can reset the HDU in the electronics room.

Unlike all other coils, the 40 mm rat head/mouse body volume coil requires tuning and matching before operation, a procedure which tunes the coil (think antenna!) to the correct resonant frequency and adjusts the impedance of the coil under a certain load for maximum power transfer to the load. In other words, if the coil is not properly tuned/matched, it can result in poorer signal-to-noise ratio and a bigger power required to achieve 90- and 180-degree RF pulses.

We advise users to perform tuning/matching when switching from rat head to mouse body imaging and vice-versa. Experience indicates that for routine users, the procedure is not necessary when switching from one rat to another (or one mouse to another).

## 72 mm Quadrature Transmit Coil

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The 72 mm ID quadrature coil is used for excitation of magnetization in combination with one of the surface coils which detects/receives the MR signal from the subject.

### Procedure for mounting the coil:

The coil is normally stored on the bottom shelf of the bookcase. It is mounted into the magnet bore from the back of the magnet. While inserting, make sure that the white box on top of the coil slides in between the two thick cables on the back of the magnet. Then, slightly rotate the coil clockwise and push it completely in (until you feel you hit the back of the gradient coil). Finally, rotate the coil counter-clockwise to position the white plastic hook in place and screw in completely the long thin rod. Check that the coil is in place by trying to pull it gently out and rotating it left/right. If the coil does not move, it is mounted correctly.

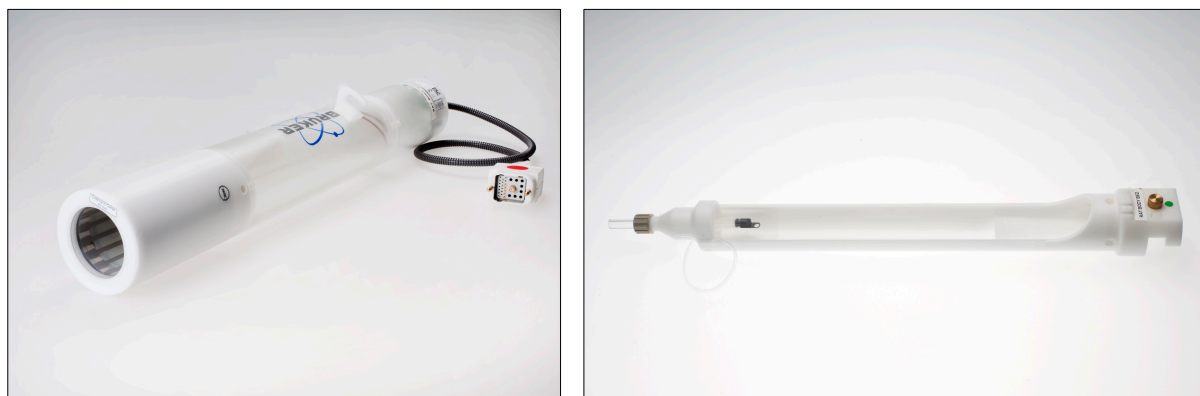
### Procedure for connecting the coil to the system:

To connect the coil to the preamplifier, insert the connector with a red dot into the corresponding red-labeled slot on the back plate. You should hear a click. After you properly mount the desired surface coil (see pages 12 and 13 for details), connect the orange-labeled connector of the surface coil into the orange-labeled slot on the back plate. You should again hear a click.



## 60 mm Quadrature Coil with Bed

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The 60 mm ID quadrature coil is used for exciting and receiving the MR signal from the rat body, providing the rat fits easily into the coil (in general, the rat should not weigh much more than 300 g as then the signal-to-noise ratio achieved by the coil is reduced).

### Procedure for mounting the coil:

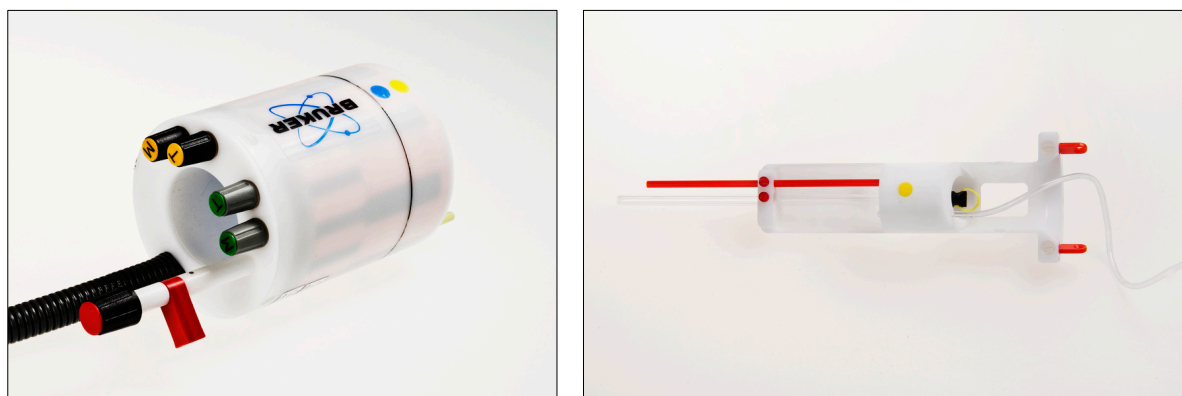
The coil is normally stored on the special shelves next to the bookshelves. It is mounted into the magnet bore from the back of the magnet. While inserting, make sure that the white hook on top of the coil slides in between the two thick cables on the back of the magnet. Then, slightly rotate the coil clockwise and push it completely in (until you feel you hit the back of the gradient coil). Finally, rotate the coil counter-clockwise to position the white plastic hook in place and screw in completely the long thin rod. Check that the coil is in place by trying to pull it gently out and rotating it left/right. If the coil does not move, it is mounted correctly.

### Procedure for connecting the coil to the system:

To connect the coil to the preamplifier, insert the connector with a red dot into the corresponding red-labeled slot on the back plate. You should hear a click. This is the only coil you need to connect as it is used for both, excitation and detection of MR signal.



## 40 mm Quadrature Coil with Bed Tip



The 40 mm ID quadrature coil is used for exciting and receiving the MR signal from the rat head and mouse body.

### Procedure for mounting the bed for rat head or mouse body imaging:

The beds for rat head and mouse body consist of the rat/mouse base and a corresponding rat-head/mouse-body bed tip. You will find the bed bases on the bottom shelves, while the bed tips are stored in the colored-labeled plastic boxes, next to the corresponding coils. To assemble the bed, connect the rat bed tip to the base using the white plastic screws and the non-magnetic black screwdriver, all of which you find on the magnet table. Connect the mouse bed tip to the base by tightening the red screws on the bed base. Then, connect the anesthesia cable to the main anesthesia line and prepare the animal-monitoring equipment. Finally, cover the bottom of the bed base with a paper towel to minimize contamination of the bed.

### Procedure for mounting the coil:

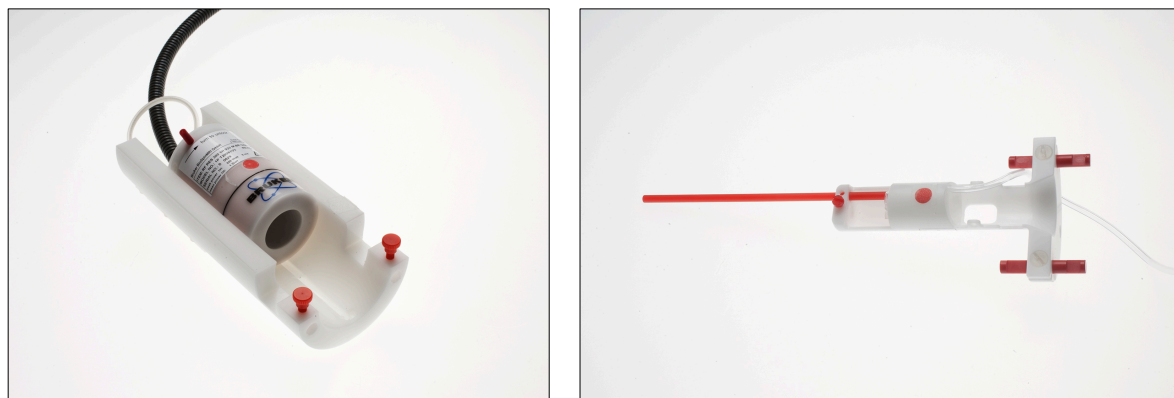
The coil is normally stored in a yellow- and blue-labeled plastic box on the bookshelves. It is mounted into the magnet bore from the back of the magnet. Carefully slide the coil and the coil cable into the magnet just past the gradient coil (you will feel/see the coil dropping slightly down). Then, go to the front of the magnet and pull the coil completely out, so that it is resting on the magnet table. When the animal is correctly positioned on the animal bed and breathing uniformly through the anesthesia mask, gently slide the coil over the animal into the horizontal groove on the bed base. The black line on the outside of the coil marks the most sensitive region of the coil, so it should align with the midsection of the brain or, in the case of mouse body imaging, onto the middle of the imaging region. Make sure you fix the coil by rotating the red bar clockwise into position. DO NOT forget to unhook this bar before removing the coil.

### Procedure for connecting the coil to the system:

To connect the coil to the preamplifier, insert the coil connector with a gray dot into the slot on the back plate that has no label. Then connect the red connector from this slot into the red-labeled slot on the preamplifier. You should hear a click. This is the only coil you need to connect as it is used for both, excitation and detection of MR signal.

## 23 mm Quadrature Coil with Bed Tip

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The 23 mm ID quadrature coil is used for exciting and receiving the MR signal from the mouse head.

### Procedure for mounting the bed for mouse head imaging:

The bed for mouse head consists of the mouse base and the corresponding mouse-head bed tip. You will find the mouse bed base on the bottom shelves, while the bed tip is stored in the red-labeled plastic box next to the coil. To assemble the bed, connect the bed tip to the base and screw down the big red screws on the bed base. Then, mount the half-cylindrical base of the coil by sliding it onto the bed tip and tightening the red screws on the half-cylindrical base. Move the coil backwards by unlocking the coil using the small red bar on top of the coil. Then, connect the anesthesia cable to the main anesthesia line and prepare the animal-monitoring equipment. Finally, cover the bottom of the bed base with a paper towel to minimize contamination of the bed.

### Procedure for mounting the coil:

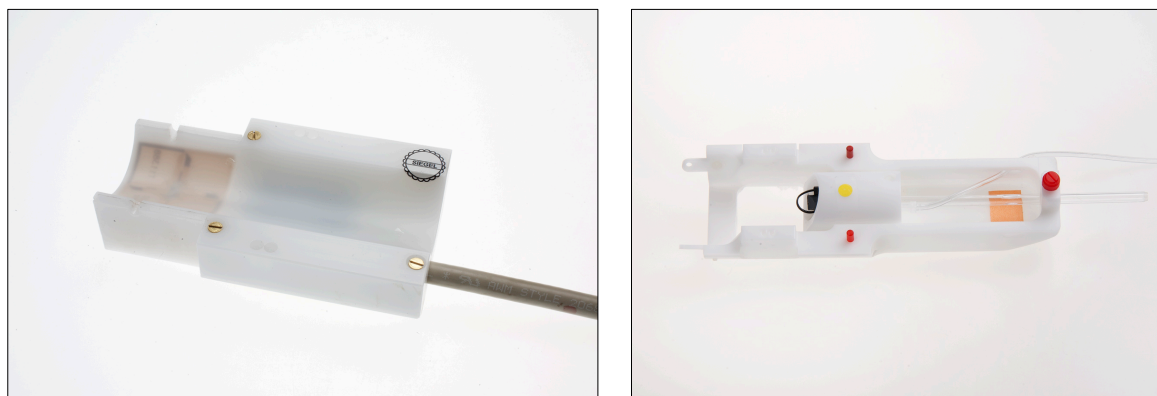
The coil is normally stored in a red-labeled plastic box on the bookshelves. It is mounted into the magnet bore from the back of the magnet. Carefully slide the coil and the coil cable into the magnet just past the gradient coil (you will feel/see the coil dropping slightly down). Then, go to the front of the magnet and pull the coil completely out, so that it is resting on the magnet table. Unlike for the 40 mm ID coil, you will need to mount the half-cylindrical base of the coil BEFORE you place the animal onto the bed (see "Procedure for mounting the bed for mouse head imaging" below). When the animal is correctly positioned on the animal bed and breathing uniformly through the anesthesia mask, gently slide the coil over the head of the mouse. Stop when you hear a click.

### Procedure for connecting the coil to the system:

To connect the coil to the preamplifier insert the coil connector with a gray dot into the slot on the back plate that has no label. Then connect the red connector from this slot into the red-labeled slot on the preamplifier. You should hear a click. This is the only coil you need to connect as it is used for both, excitation and detection of MR signal.

## Rat Brain Array Coil with Bed Tip

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The rat brain phased array is used for receiving the MR signal from the rat brain. It should be used in combination with the 72 mm transmit coil (see page 7).

### Procedure for mounting the bed for rat brain imaging:

The bed for rat brain consists of the rat base and the corresponding rat-brain bed tip. You will find the rat bed base on the bottom shelves, while the bed tip is stored in the yellow-labeled plastic box next to the coil. To assemble the bed, connect the bed tip to the base using the white plastic screws and the non-magnetic black screwdriver, all of which you find on the magnet table. The anesthesia mask can be moved by unscrewing the white screw on the mask and then sliding the mask back/forth to desired position. Then, connect the anesthesia cable to the main anesthesia line and prepare the animal-monitoring equipment. Finally, cover the bottom of the bed base with a paper towel to minimize contamination of the bed.

### Procedure for mounting the coil:

The coil is normally stored in a yellow-labeled plastic box on the bookshelves. It is mounted into the magnet bore from the back of the magnet. Carefully slide the coil and the coil cable into the magnet just past the gradient coil (you will feel/see the coil dropping slightly down). Then, go to the front of the magnet and pull the coil completely out, so that it is resting on the magnet table. When the animal is correctly\* positioned on the animal bed and breathing uniformly through the anesthesia mask, attach the coil, rounded side down, onto the red bars of the bed tip. The middle of the coil elements (appr middle of the Bruker logo) should fall onto the midsection of the brain. To guarantee that the coil is fixed, you can tape it down using the paper tape provided by the facility.

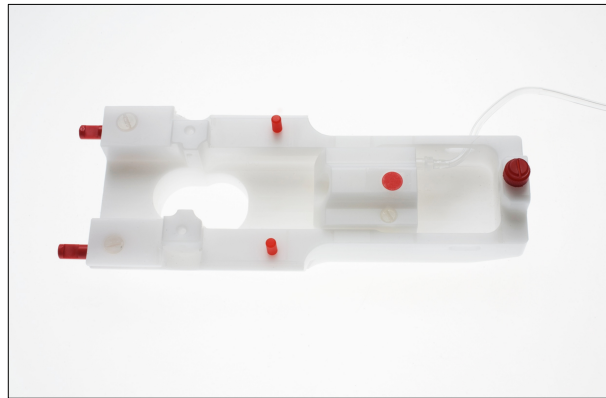
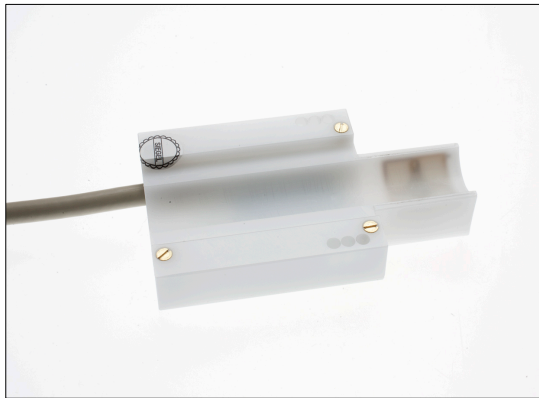
\* A good guideline for positioning the animal is to place the ears of the rat in line with the small holes on the top and the side of the bed tip (these are meant for head-fixation bars).

### Procedure for connecting the coil to the system:

To connect the coil to the preamplifier, insert the connector with an orange dot into the corresponding orange-labeled slot on the back plate. You should hear a click. Note, at this point, the red-labeled connector of the 72 mm transmitter coil should already be connected to the red-labeled slot on the back plate!

## Mouse Brain Array Coil with Bed Tip

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The mouse brain phased array is used for receiving the MR signal from the mouse brain. It should be used in combination with the 72 mm transmit coil (see page 7).

### Procedure for mounting the bed for mouse brain imaging:

The bed for mouse brain consists of the mouse base and the corresponding mouse-brain bed tip. You will find the mouse bed base on the bottom shelves, while the bed tip is stored in the red-labeled plastic box next to the coil. To assemble the bed, connect the bed tip to the base using the red screws on top of the base. The anesthesia mask can be moved by unscrewing the white screw on the mask and then sliding the mask back/forth to desired position. Then, connect the anesthesia cable to the main anesthesia line and prepare the animal-monitoring equipment. Finally, cover the bottom of the bed base with a paper towel to minimize contamination of the bed.

### Procedure for mounting the coil:

The coil is normally stored in a red-labeled plastic box on the bookshelves. It is mounted into the magnet bore from the back of the magnet. Carefully slide the coil and the coil cable into the magnet just past the gradient coil (you will feel/see the coil dropping slightly down). Then, go to the front of the magnet and pull the coil completely out, so that it is resting on the magnet table. When the animal is correctly\* positioned on the animal bed and breathing uniformly through the anesthesia mask, attach the coil, rounded side down, onto the red bars of the bed tip. The middle of the coil elements (appr middle of the Bruker logo) should fall onto the midsection of the brain. To guarantee that the coil is fixed, you can tape it down using the paper tape provided by the facility.

\* A good guideline for positioning the animal is to place the ears of the rat in line with the small holes on the top and the side of the bed tip (these are meant for head-fixation bars).

### Procedure for connecting the coil to the system:

To connect the coil to the preamplifier, insert the connector with an orange dot into the corresponding orange-labeled slot on the back plate. You should hear a click. Note, at this point, the red-labeled connector of the 72 mm transmitter coil should already be connected to the red-labeled slot on the back plate!

## 10/20/30 mm Circular Surface Coils with Preamplifier



These coils are designed for receiving the MR signal from a small anatomical area close to the skin of the animal. They should be used in combination with the 72 mm transmit coil (see page 7).

One of the nice features of these coils is that they come with a special preamplifier, which plugs into the coils in the close proximity of the actual coil element. Because the received signal does not have to propagate a long distance before getting amplified, the SNR of these coils is substantially higher within the active coil region than for other coil types. Note, however, that the active coil region only includes the area within the loop and expands one coil diameter out in axial direction. This rule-of-thumb should also guide you when deciding which coil diameter is the most appropriate to use for your study.

### Procedure for mounting the bed for circular coils:

The amplifier of these coils is designed to have the shape of the phased-array surface coils. It therefore mounts on top of the bed tip for phased-array coils. To assemble the animal bed for imaging with the circular coils, you will need to use the appropriate mouse/rat base and then connect the mouse/rat bed tip to the base in the manner described on pages 11 and 12.

### Procedure for mounting the coil:

The coils are normally stored in a separate plastic box on the bookshelves. The amplifier (which looks like the phased-array coil) is mounted into the magnet bore from the back of the magnet.

Carefully slide the amplifier and the amplifier cable into the magnet just past the gradient coil (you will feel/see the amplifier dropping slightly down). Then, go to the front of the magnet and pull the amplifier completely out, so that it is resting on the magnet table. When the animal is correctly positioned on the animal bed and breathing uniformly through the anesthesia mask, accurately position the coil onto the area of interest. The coil element (the copper part) should be as close to the animal surface as possible and the anatomy of interest should be approximately in the center of the coil. The coil has the largest sensitivity with its axis perpendicular to the main magnetic field, but this is not a requirement. Fix the coil into place using paper tape and connect the coil to the small gold connector on the preamplifier (see inset). Make sure NOT TO make any complete loops with the coil wire when taping the coil in place!

Procedure for connecting the coil to the system:

To connect the coil to the preamplifier, insert the connector with an orange dot into the corresponding orange-labeled slot on the back plate. You should hear a click. Note, at this point, the red-labeled connector of the 72 mm transmitter coil should already be connected to the red-labeled slot on the back plate!



## Rat and Mouse Bed Base

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The rat and mouse bed bases are used in combination with bed tips to hold the animal in place during imaging, as well as to deliver gas anesthesia and heat the animal during scanning.

The rat bed base is deeper than the mouse bed base to accommodate a bigger animal.

Both beds have tubing for warm water built into the base. Note, that this way of heating the animal works well for rats, but in the case of mouse imaging, especially for mouse-body imaging, it is necessary to switch to the heating blanket as the animal lies outside the heating region of the base.

The connectors for bed tips are also slightly different between the rat and mouse bed. The rat base (because of its bigger inner diameter) has side grooves on one end of the base that match the red connectors/rods on the rat bed tips. You have to use white plastic screws and the non-magnetic black screwdriver to mount the bed tip securely onto the bed base. This can be a slightly tedious process as the screws are very small, but with time, you will get used to it.

The mouse bed has a smaller inner diameter and therefore the design is more user-friendly than for the rat base. The mouse base has side holes on one end of the base that match the red connectors/rods of the mouse bed tips. All you have to do is push the rods of the tip into the holes and then screw the top red screws down to secure the bed tip.