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M3™ Compact MRI System

Operator Manual

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www.aspectimaging.com

This product is intended for **pre-clinical research use only**. Not for clinical use.

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Table of Contents

Table of Figures

List of Tables

1 Introduction

Thank you for purchasing the M3™ Compact High-Performance MRI System. The M3 MRI is an innovative, 1 Tesla, high-resolution Magnetic Resonance Imaging (MRI) system. The M3 addresses the needs of laboratories and pre-clinical research centers performing *in vivo* small animal imaging and *in vitro* studies that require the powerful imaging capabilities of MRI but without the cost, complexity, maintenance and expertise involved with traditional MRI systems.

Aspect Imaging's M3 MRI system is designed for specific applications and is optimized according to user requirements; workflow is made simple and streamlined.

This chapter contains the following sections:

- About the Operator Manual
- Operator Manual Conventions
- Navigating the Operator Manual

About the Operator Manual

This operator manual provides the information necessary to operate the M3 in a safe and efficient manner. Please read and thoroughly understand the operator manual before operating the system. If any part of this operator manual is not clear, contact Aspect Imaging Customer Support for clarifications.

The operator manual is intended to be enclosed with the M3 system. It is not intended to replace the user's training course.

This operator manual should always accompany the unit, and all personnel operating the unit must know its location.

Make sure you read the safety instructions carefully before operating the system for the first time.

Audience

This operator manual is written for operators who will be using the M3 MRI system. There are two main types of users:

- **Operator**: a user who can acquire and measure images, and perform most of the system activities.
- **Manager**: a user who can acquire and measure images, and perform most of the system activities. Can manage system users but cannot access proprietary company software.

Operator Manual Conventions

The following conventions are used throughout the operator manual:

- The names of menus, screens, and dialog boxes are capitalized.
- The step-by-step instructions are numbered.
- Controls that have to be acted upon, are marked in bold, as in the following example:

Click ***Next*** to continue. A new screen is displayed.

Fill-in the data and click ***OK***.

- Instructions to press keyboard keys are displayed as follows:

  Press ***<Ctrl>***.

- Cross-references are marked in dark blue italics. Example: ***Acquiring Images***
- Important safety warnings appear in the text as follows:

Warning – indicates precautions and instructions, which, if not followed, may result in serious bodily injury or death.

Caution – indicates instructions, or cautionary notes, which, if not followed, may result in damage to the equipment or to the quality of measurements.

- Notes and tips appear in the text as follows:

Notes – contain helpful information and tips.

Navigating the Operator Manual

The M3 MRI operator manual is comprised of the following chapters:

- **Chapter 1, Introduction**, describes the operator manual structure and conventions. Describes the contents of each of the chapters in the manual.
- **Chapter 2, Safety**, provides an overview of the hazards involved in improper use of the M3 MRI system, and the safety measures that will ensure safe operation. Read this chapter carefully before starting to use the M3 MRI system.
- **Chapter 3, System Overview**, describes the system and its component parts.
- **Chapter 4, Getting started**, describes the system's user interface and main operational modes. Explains the operational concepts of the Preclinical AMF application, the software application that you will use to operate the MRI.
- **Chapter 5, Acquiring Images**, includes prerequisites for image acquisition and describes the image acquisition workflow. This chapter also describes Control Panel tools, the Acquisition queue, and queue functionality.
- **Chapter 6, Histology Subsystem Imaging (Ex Vivo option),** describes the Histology subsystem as an additional option to any of M-series Aspect Imaging magnet. This option allows performing automatic scans for imaging of tissues and organs without the need to manually change the scanned object.
- **Chapter 7, Managing Protocol Sets and Protocol**, explains how to create, edit, and delete protocol sets and protocols.

- **Chapter 8, Managing Archives**, describes how to work with image files stored in the database. Explains how to use the tools available for working with images.
- **Chapter 9, Settings**, describes routine administrative tasks controlled from the Settings tab.
- **Appendix A, Specifications and Labeling**, details the M3 MRI specifications, regulatory requirements and labeling.
- **Appendix B, Protocol Parameters**, details and describes all protocol parameters.
- **Appendix C, System Calibration,** details the M3 MRI system calibration procedures.
- **Appendix D, Physiological Monitoring System,** outlines the basic operation of standard and advanced physiological monitoring systems. These systems allow for continuous, live monitoring of the respiration cycle and body temperature of an animal when placed within the M3 system.
- **Appendix E, Troubleshooting**, describes common problems and how to overcome them.
- **Appendix F, Glossary**, includes a glossary of MRI terms.

2 Safety

The M3 MRI was built to provide the highest safety requirements. Due to its vanishing external fringe-field, it can be safely installed in small spaces. The integrated RF shielding and quiet gradients eliminate the need for a specially shielded room and other limiting operational procedures.

Improper operation of any electrical system, however, may be hazardous. Please read this chapter carefully before attempting to operate the system, to prevent harmful effects to you or your environment.

The information provided in this chapter is not intended to replace professional training on the safety and use of the M3 MRI system.

This system is intended exclusively for pre-clinical research.

This chapter contains the following sections:

- General Safety Guidelines
- General Hazards
- Potential Adverse Effects
- Noise
- Access Control

General Safety Guidelines

This product is designed and manufactured to ensure maximum safety of operation. It should be operated and maintained in strict compliance with the safety precautions, warnings, and operating instructions contained in official Aspect Imaging publications.

- This product should be installed, maintained, and serviced only by Aspect Imaging qualified personnel.
- Do not modify the system in whole or in part in any way without prior written approval by Aspect Imaging.
- Do not connect any third-party equipment to the system without written approval from Aspect Imaging.
- Make sure that only properly trained and fully qualified personnel are authorized to operate this equipment. An authorized operator's list should be maintained.
- This operator manual should always accompany the unit, and all personnel operating the unit must know its location.
- Unauthorized personnel should not be allowed access to the system.
- In case of emergency, immediately shut down the system using the ON/OFF switches of the PLC and compressor and notify Aspect Imaging's Customer Support Department immediately.

- System users should become familiar with product specifications, system accuracy, and stability limitations. These limitations must be considered before making any decision based on quantitative values. In case of doubt, consult the Aspect Imaging Customer Support Department.
- This device complies with Part 18 of the FCC Rules. Operation is subject to the following two conditions:
    - This device may not cause harmful interference, and
    - This device must accept any interference received, including interference that may cause undesired operation.

This is a class A product. Class A equipment is intended for use in an industrial environment. There may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted as well as radiated disturbances.

Changes or modifications to this equipment not expressly approved by Aspect Imaging could void the user's authority to operate the equipment.

Never place a metal or magnetically-susceptible object in or near the M3 magnet's opening or "bore". This could be dangerous and cause irreparable damage to the M3 system.

The Histology Subsystem requires ventilation into a non-hazardous area with a connection to the atmosphere.

In some countries, legislation may exist covering occupational limits for exposure to static magnetic fields. Bear in mind, however, that no evidence exists to support cumulative effects with time for exposure to static magnetic fields.

This equipment (non-consumer magnetic resonance) has been tested and found to comply with the limits pursuant to FCC 47CFR part 18, clause 18.305 of the FCC Rules. This equipment, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, please contact Aspect Imaging Customer Support

General Hazards

Improper use of the system may expose you to various hazards of electrical or magnetic nature. Adhering to the following precautions is critical for your safety.

Electrical Shock

Internal circuits use high voltage that can cause fatal injury. Do not remove the system covers. There are no user serviceable components inside the magnet assembly or electronics cabinet. The electronics cabinet should be kept locked, and should be opened only for start-up, shutdown, and calibration.

Electrical Fire

- Liquids that contact active circuitry may cause an electrical fire. Therefore, never place any liquids near the system cabinet.
- Make sure that fire extinguishers at the site have been approved for use to extinguish electrical fires in an MRI environment.
- Fire precautions should be discussed with the local fire department, and emergency procedures established.

Mechanical Considerations

- The wheels of the magnet sub-system and of the electronics cabinet must be kept locked
- Cable routing of the computer, electronics cabinet, magnet sub system, and all other devices must be done considering the room space in order to prevent tripping over the cables

Explosion

Do not operate the system in the presence of flammable gases or liquids.

Magnetic Field

The magnetic field is 5 Gauss at a distance of approximately 50 centimeters from the center of the magnet.

We suggest you mark a 5 Gauss line at a distance of 50 centimeters from the center of the magnet, surrounding the magnet. This will clearly delineate the safety zone. See Figure 1.

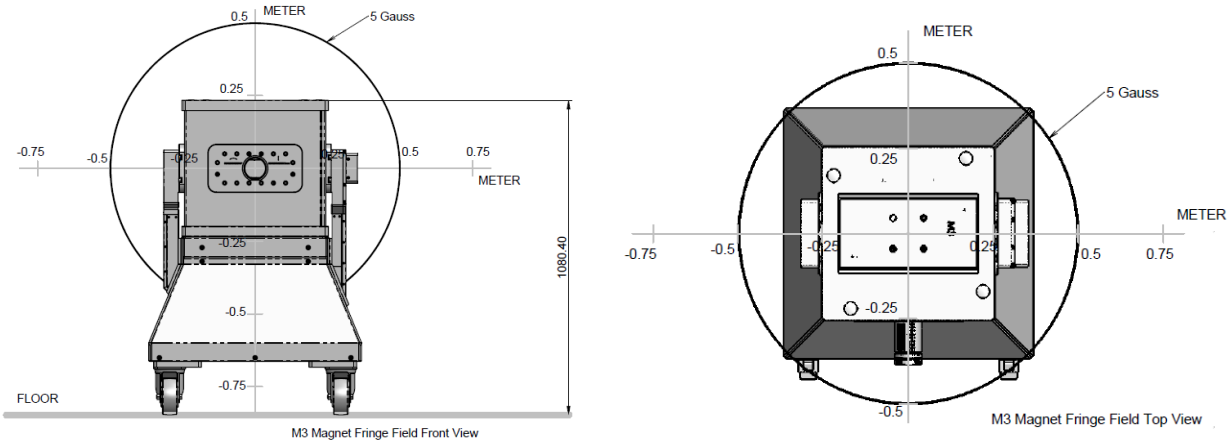


Figure 1: 5 Gauss line fringe field

- No metal objects are to be placed in close vicinity of the magnet.
- No objects are to be placed on top of magnet or attached to the side of the magnet.
- Anyone with surgical metal implants or embedded metal objects in their hands/wrists is not allowed to insert or remove objects from the magnet (the magnetic field inside the magnet is strong enough to potentially torque and twist metal implants.)

Potential Adverse Effects

Danger due to implanted electronic devices:
Persons with pacemakers or other implanted electronic devices should remain at a distance of at least one meter from the system.

Displacement and/or heating of ferromagnetic objects:
The magnetic force exerted by the MRI system on ferromagnetic objects within its field can cause implanted or embedded objects (such as surgical clips, aneurysm clips, or shrapnel) to become dislodged. In some cases, eddy currents induced by magnetic fields may cause heating of metallic implants.

Absorption of Radiofrequency energy:
Radiofrequency energy absorption may cause systemic thermal overload and local thermal injury. The use of auxiliary equipment that has not been specifically tested and approved for use in an MRI environment may result in burns or other injuries to the operator or to the test subject. Even instruments that are MRI compatible may cause injury if not used according to the manufacturer's instructions.

Noise

Acoustic noise may be generated by the pulses of electrical current energizing the gradient coils. The acoustic noise levels associated with the system are below the occupational limits recommended by ACGIH (American Conference of Governmental Industrial Hygienists) and EU Directive 2003/10/EC. The operator is therefore not subjected to potentially dangerous levels of acoustic noise.

Different legislation regarding exposure to noise may exist in other countries.

Access Control

Access to the site where the system is installed is restricted to authorized personnel.

Maintenance

- Wipe the exterior surfaces of the equipment with a damp, soapy cloth or a cloth moistened with alcohol.
- Clean and disinfect subject beds and holders between uses.
- When cleaning the coil, do not pour any cleaning solution directly on the coil and always allow the coil housing to dry before use.
- Preventive maintenance must be performed at least annually by Aspect qualified personal only. The preventive maintenance includes overall system examination for safety, calibration and performance. System parts/components shall be replaced when needed according to the service manual.

Only use accessories that are undamaged and that are intact. If you suspect that an accessory is not in good condition, discontinue its use and contact your Aspect Imaging service engineer. Do not use a coil that is damaged.

The electrical and mechanical assemblies and parts of the coil must be used with care and should be routinely inspected for cracks, exposed wires, or other faulty conditions. Do not use coils with exposed metal conductors or damaged insulation. Skin contact with metal conductors can cause burns.

Under no circumstance should the coil be sterilized or placed into any type of sterilizer.

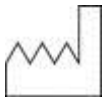
Technical Considerations

The use of accessories other than those specified in the operator's manual may result in the decreased Electro Static Discharge (ESD) immunity of the coil or MR system, increased emission and causing damage to the coil and / or system.

The animal handling system and the Histology loader –where applicable– should be handled with care and caution during setup and usage and stored in their designated protective box when not in use.

- The equipment should not be used with other coils or equipment present in the MR scanner except as specified in this manual.

The interpretation of the harmonized symbols that are used on the system is described below:

Label/Icon	Purpose/Meaning	Location
	Date of manufacture	Electronic cabinet
	Name and address of manufacture	Electronic cabinet
	Caution possible electric shock	Electronic cabinet
	Waste electrical and electronic equipment must not be disposed of as unsorted municipal waste and must be collected separately. Please contact Aspect Imaging for information concerning the decommissioning of your equipment.	Electronic cabinet
	Caution: Follow instructions for use	Electronic cabinet
	Catalogue number	Electronic cabinet
	Manufacturer's serial number.	Electronic cabinet
	Alternating current	Electronic cabinet

3 System Overview

The M3 MRI system comprises hardware and software components. In this chapter, you will become familiar with the system components and the relationship between them.

This chapter contains the following sections:

- What is the M3 MRI System?
- Electronics Cabinet
- Magnet Sub-system
- Computer

What is the M3 MRI System?

The M3 compact MRI system is the smallest of Aspect Imaging's M-series and is intended for dedicated imaging of mice and other similarly sized small animals. The M3 has the same functional capabilities as the rest of the M-series - generation of high-resolution 3D anatomical, functional and molecular images - but its smaller "bore" is optimized for mice. The M3's smaller bore correlates to a smaller total size (footprint), lighter weight, and more affordable cost.

The M3 MRI system is not approved for use in humans.

Aspect Imaging's system is based on revolutionary permanent magnet technology. The magnet is highly efficient with practically no eddy currents from operation of the gradients. The system has quiet gradients, highly sensitive RF coils and user-friendly application software providing high quality MR images.

Unlike most high field MRI systems the M3 MRI system can be placed anywhere in the laboratory, animal facility, etc. It is inherently shielded with virtually no magnetic fringe field. The M3 MRI requires only a small footprint and has no special requirements for operation, enabling every researcher maximum operational flexibility and simplicity. Due to its relatively lightweight and compact design, it is simple to relocate. Installation is simple and fast.

The system includes a PC work station, an electronics cabinet, and a magnet sub-system, as illustrated in *Figure 2*:

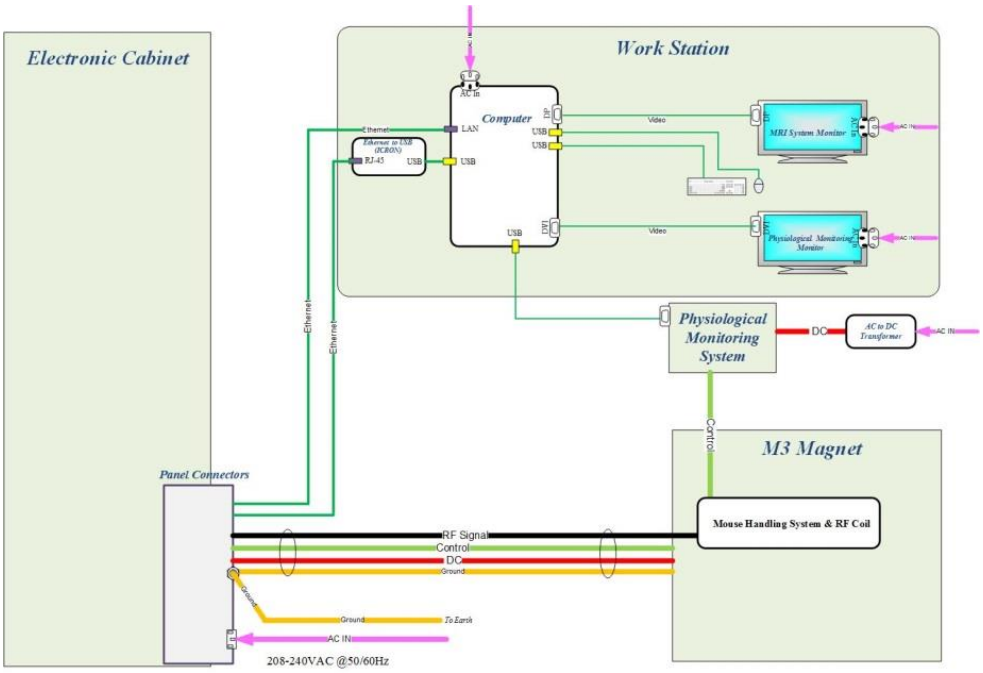


Figure 2: System Diagram

Electronics Cabinet

The electronics cabinet contains all the components required for controlling and operating the magnet sub-system.

Control Unit

Spectrometer

RF Amplifier

Gradient Amplifiers

Power Distribution Unit (PDU)

Figure 3: Electronics Cabinet

The electronics cabinet houses the following rack-mounted components:

- The Control Unit that controls the Radio Frequency signal.
- The Spectrometer that generates the pulse signals and captures the scan data.
- The RF Amplifier that amplifies the Radio Frequency signal delivered by the RF coils.
- The Gradient Amplifiers that amplify the gradient pulses.
- The PDU (Power Distribution Unit) that distributes power to the system.

Magnet Sub-system

The magnet assembly is a closed unit that is controlled by the Electronics Cabinet and the Preclinical AMF application software.

The magnet sub-system includes the magnet assembly and wheeled cart.

Figure 4: Magnet sub-system

On the front of the magnet assembly, you will find the sample insertion opening or the M3 magnet's bore. When the M3 small animal handling unit is not in place, you can see a flange with centering and orientation marking. *See Figures 5 and 6*.

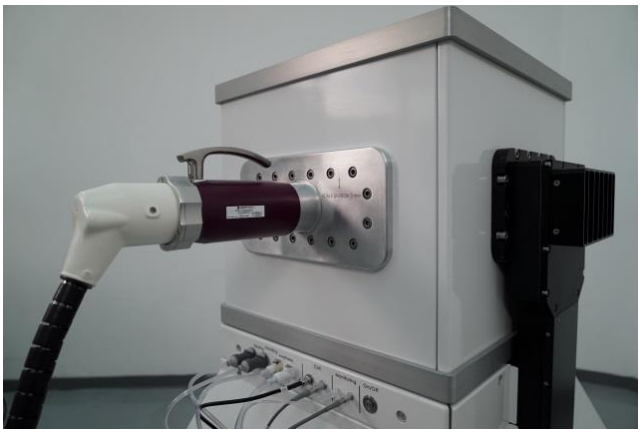


Figure 5: Magnet sub-system with the Animal Handling Unit in place

Figure 6: Magnet sub-system without the Animal Handling Unit in place

Located on the front side of the magnet, the manifold panel includes the Power On/Off switch and connections for elements of the Animal Handling System. See image below.

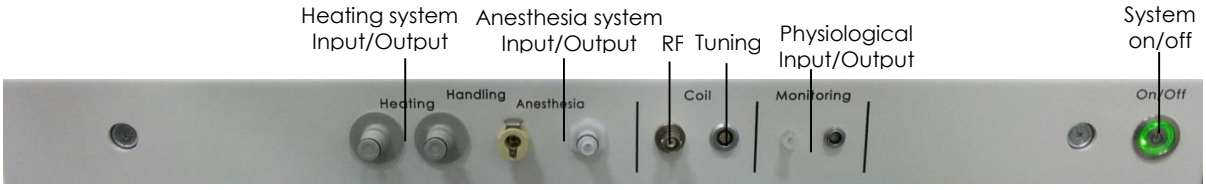


Figure 7: Manifold Panel controls

For information on the Animal Handling System refer to the section ***Setting Up the Animal for Imaging.***

Radio Frequency (RF) Coils

The system can be ordered with multiple application-specific RF coils. *See Table 1*.

Table 1: Available application-specific coils

Name	Inner diameter	length
Mouse Body L50 D38	38mm	50mm
Mouse Body L50 D30	30mm	50mm
Mouse Body L80 D30	30mm	80mm
Mouse Head L25 D23	23mm	25mm

The coils are calibrated to the required radio frequency for proton imaging and are used for RF transmission and reception.

The coils are placed on the holder assembly and inserted from the front side of the magnet.

For best quality of imaging, it is important to use the smallest coil that will provide the tightest fit to your sample.

Figure 8: M3 Coils – Body and Head

Positioning the Subject

Correct positioning of the subject is very important for obtaining high quality imaging results. Position the sample with the area of interest in the center of the RF coil and of the magnet. For further information on subject positioning refer to the section ***Animal Preparation***.

Computer (PC)

The system is supplied with a desktop PC and a 24" LCD monitor. The PC runs the Preclinical AMF application that controls all of the system processes. This is the main operational interface. When purchasing the physiological monitoring system (standard or advanced), an additional screen is supplied to simultaneously display the physiological parameters obtained from the monitoring system.

To prevent application conflict, it is recommended not to install any other applications on the M3 computer.

4 Getting Started

In this chapter, you will become acquainted with the structure of the Preclinical AMF application user interface and its main operational concepts.

This chapter contains the following sections:

- Setting Up the Animal for Imaging
- Turning the System On
- The Preclinical AMF application Main Screen
- Main Functional Concepts
- Functional Tabs

Setting Up the Animal for Imaging

This section describes the selection criteria for the animal bed and coil based on the subject to be imaged as well as on the anatomical target. Additionally, preparing the animal handing system and subject for imaging are described. This section assumes you are new to using the M3 system. You should however be familiar with the handling and anaesthetizing of the animals.

It is important to always follow the guidelines of your animal care committee, and any local or federal laws, when using the M3 system.

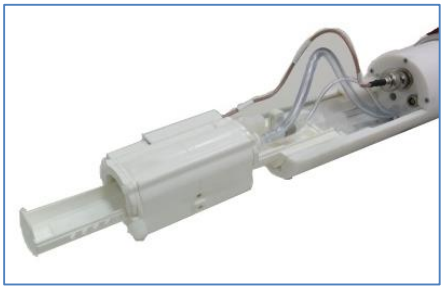
The following procedure assumes the use of an inhaled anesthesia such as Isofluorane. If an alternative means of anesthesia is used, the procedure may vary slightly, however the bed and coil selection steps will remain the same.

Animal Bed/Coil Selection

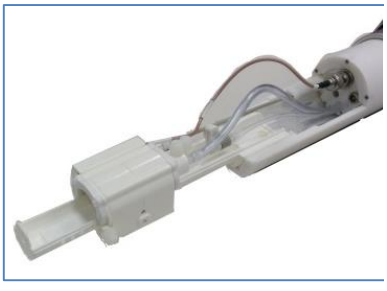
The appropriate animal bed as well as coil must first be selected. The bed is where the animal is positioned during imaging. The coil will both transmit and receive the signal necessary to create the MR image.

The coil should be selected such that it fits as close to the sample to be imaged as possible, this will improve the signal to noise ratio (SNR).

Mouse head



Mouse whole body



Mouse body

Available beds & coils:

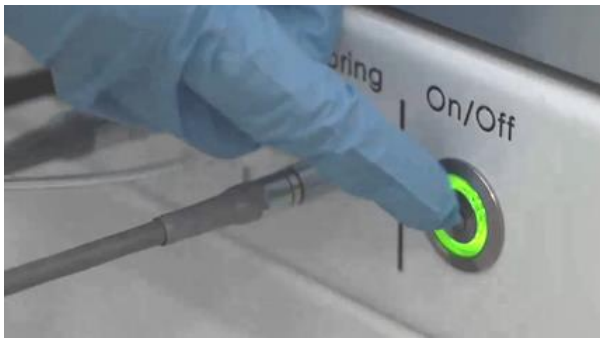
- Mouse head – 23mm diameter, 25mm length
- Mouse whole body – 30mm diameter, 80mm length

- Mouse body – 30mm diameter, 50mm length

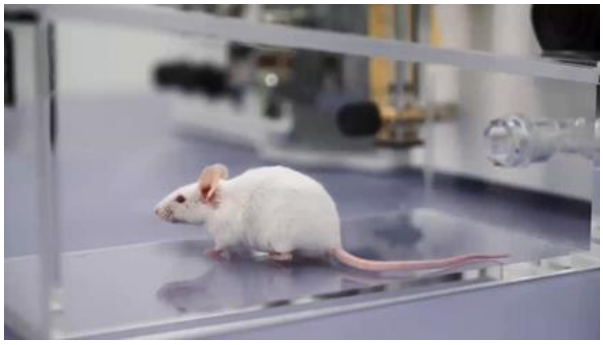
Animal Preparation

Animal Preparation procedure

1 Turn the Manifold Panel On/Off switch to the On position (Green light).



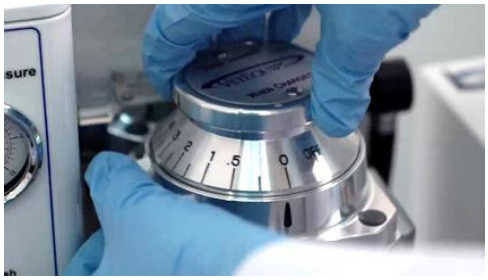
2 While preparing the bed/coil for imaging, anesthetize the animal in the knock down chamber. See image below:



Note/Tip

Animal care committee guidelines should be followed to maintain a safe level of isofluorane or desired anesthesia throughout the entire imaging session.

Use of gloves is recommended for animal handling activities.



Caution

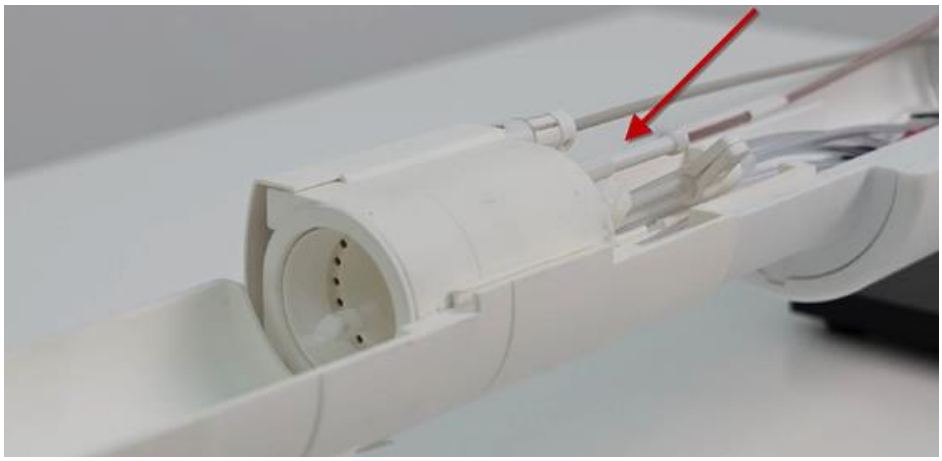
Refer to the operating manual of the anesthesia system.

3 Once anesthetized place the animal in the selected bed.

4 Make sure that anesthesia is flowing to the nose cone of the bed. This will vary between the standard and advanced anesthesia systems.

5 Extend the bite bar such that the teeth of the animal can be hooked onto it, and then retract the bite bar along with the animal into the nose cone. Typically animals are placed in the prone position, however supine is also acceptable if desired.

6 Position the animal's tail through the hole at the back end of the bed and secure the bite bar in place by tightening the screw.

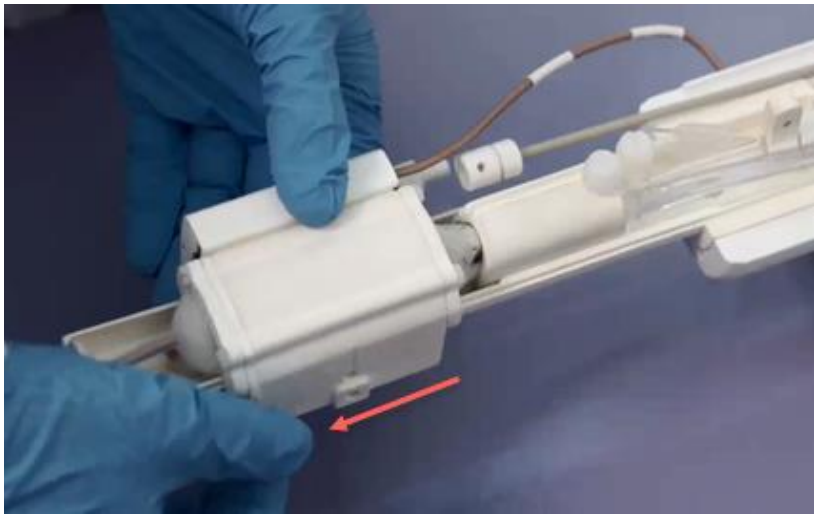


7 If you are using a head coil, adjust the position of the mask using the appropriate screw. This screw will allow the mask to move to place the anatomy of interest in the center of the coil. Rotate the screw to allow positioning of imaging target at the center of the coil.

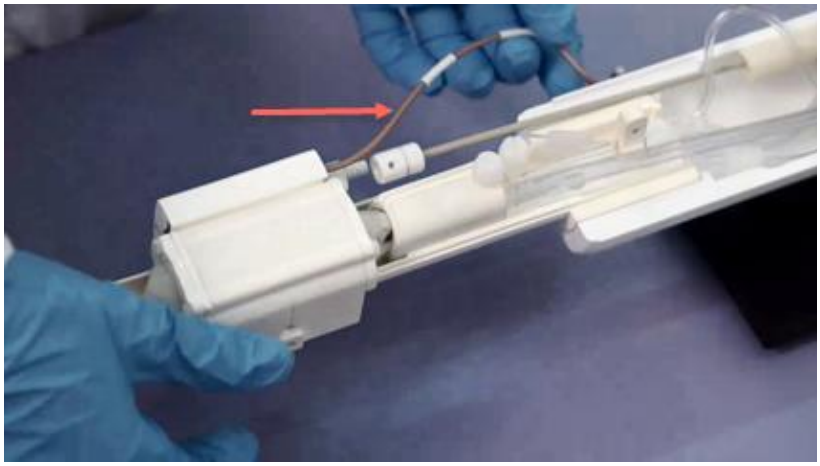
8 Secure the physiological monitoring devices.

9 Make sure all loose cables, extra length of cable, etc., are tidy at the head of the animal bed. Secure cables with tape, taking care to avoid restraining the movement of the coil and tuning wire.

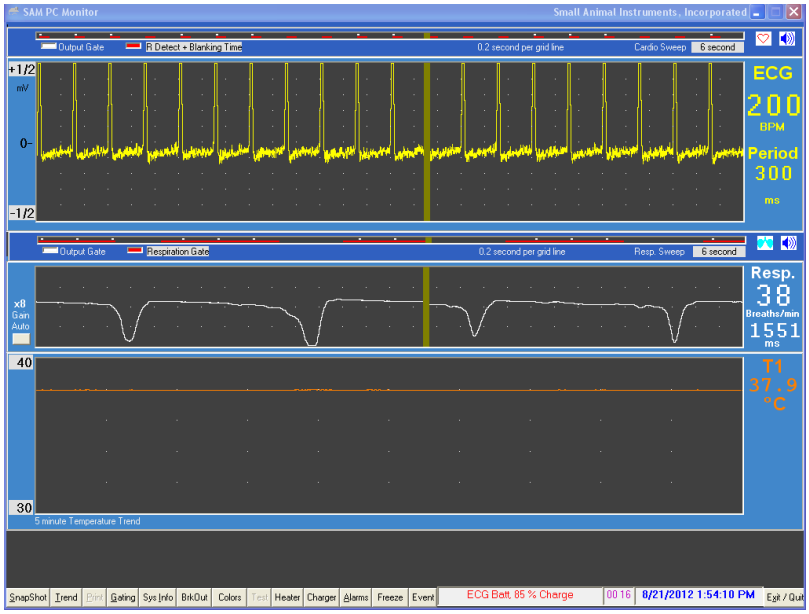
10 For body coils, slide the selected coil over the end of the bed, and over the animal. Slide the coil far enough towards the handle of the bed such that the anatomical target is located at the center of the coil. Make sure that physiological monitoring tubes and wires in use are not pinched in the process.



11 Secure the coil tuning wire, as well as the RF cable connection. If the head coil is being used these connections are not necessary.



12 If respiratory monitoring or other physiological monitoring signals are used make sure a steady strong signal is being detected; if not, ensure the animal is breathing well and is at the appropriate level of anaesthetization.

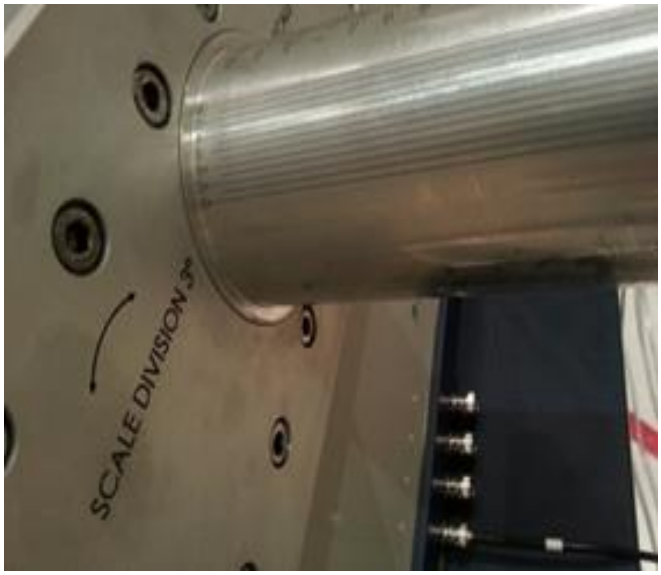


13 Place the anatomical target at the center of the coil. There is an indication on the animal bed around which the target should be placed.

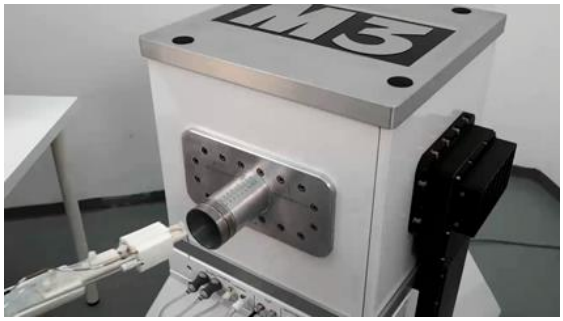
The anesthesia mask location can be adjusted to the required position to accommodate the animal placement. By doing so, with the collar of the purple handle placed at 0.0mm on the flange, the anatomical target will be located at the center of the magnet.

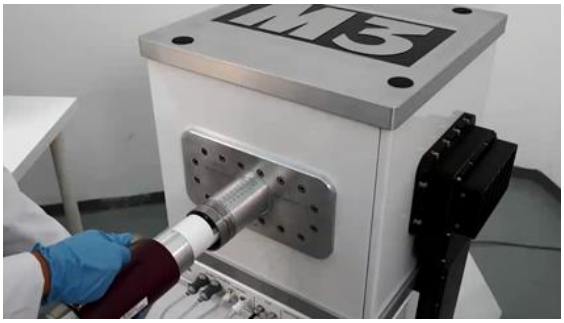
14 If the actual target is not located at the mark on the bed, the location of the purple handle on the flange can be adjusted. If the anatomical target is found to be 0.75cm past the mark on the bed, then the edge of the purple handle should be aligned with the -0.75cm marking on the flange. If however the target's measurement is 2.25cm closer to the anesthesia mask, then the edge of the purple handle should be aligned with the +2.25cm marking on the flange.

If the animal is rotated in the bed, or a specific rotation of the animal is desired, there are degree markings on the side of the flange as well.



15 Insert the animal handling system inside the magnet bore to the appropriate location. The gasket at the end of the flange will expand and hold the handle in position securely.





16 Connect all animal handling system connectors to the Manifold Panel on the magnet's front side. That includes two heated water connectors, two coil connectors, two anesthesia connectors and, if used, two physiological monitoring connectors. Refer to ***Figure 7: Manifold Panel controls***. Imaging can now proceed according to the application protocol.

Only anesthesia system, monitoring system or water heating systems that are approved by Aspect Imaging shall be used with the M3 system

17 Once imaging is complete the animal handling system can be removed from the magnet. To remove the animal from the bed, simply remove the coil (if body coils were used), loosen the bite bar and slide the animal out.

Connection to a Monitoring System

A physiological monitoring system may be used to either monitor the animals physiology while under anesthesia, or to provide the triggering (respiratory and/or ECG) signal depending on the application being performed. For further information refer to ***Appendix D***.

Turning the System On

Turning the system On includes switching On the hardware and the software. Follow the start-up sequence described here.

1 Press the On/Off button on the right side of the magnet assembly's Manifold Panel.

2 Turn On the PC. Enter your User password. Your computer Desktop is displayed.

Note/Tip

Wait approximately one minute before starting the AMF software.

3 On the Desktop, click the  Preclinical AMF program icon. The Login screen is displayed.

4 Enter your ***Name*** and ***Password*** and click the ***LOG IN*** icon. The application's main screen is displayed. See following section.

Note/Tip

- We recommend turning Off the system at the end of the workday and closing the Preclinical AMF application software. You may leave the PC powered On, if you prefer.
- Contact your site manager to obtain a unique operator name and password.

The Preclinical AMF Application Main Screen

The application's main user interface has four functional tabs:

- Imaging
- Protocol
- Archive
- Settings

While moving between tabs the basic user interface presentation remains the same, but content and functionality change according to the selected tab. See ***Figure 9: The Preclinical AMF Application Main Screen.***

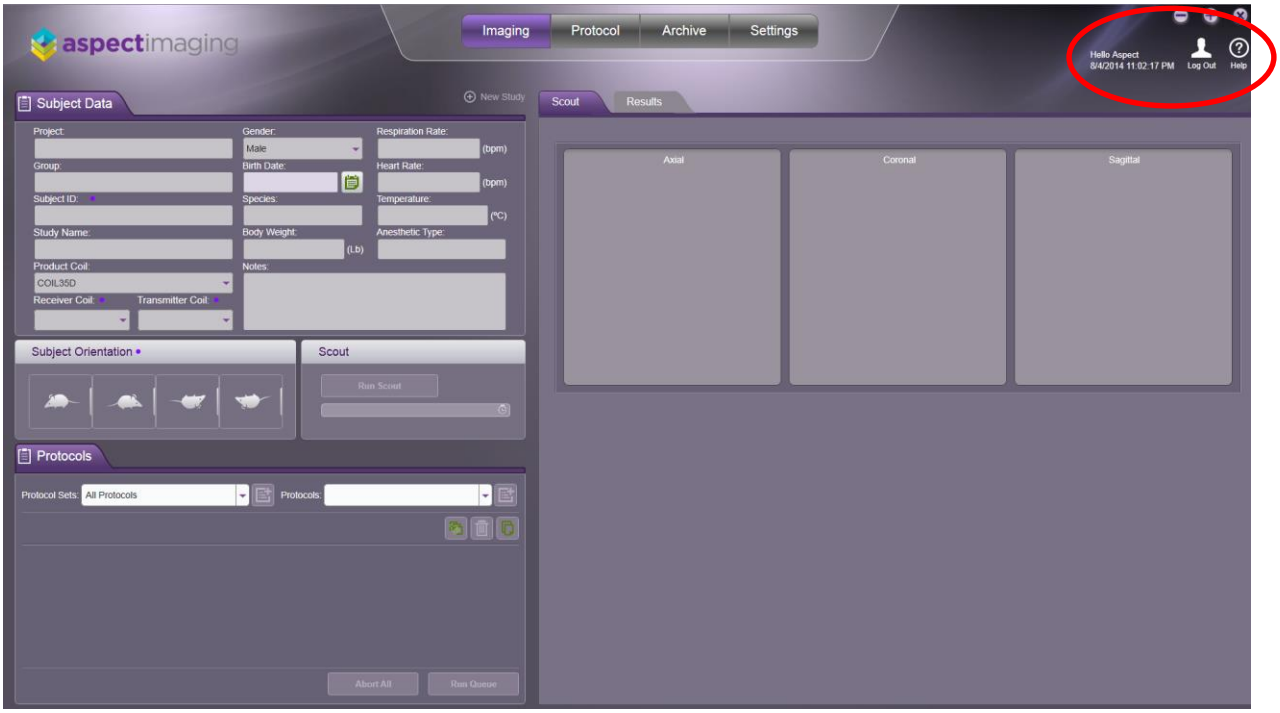
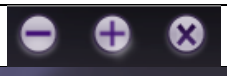
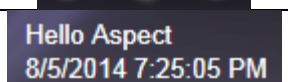


Figure 9: The Preclinical AMF Application Main Screen

The upper right-hand side of the screen displays the following controls which remain displayed regardless of which tab is active. See Table 2.

Table 2: General controls

	Click to Minimize, Maximize or Close the current window
	Displays the current User Name, Date and Time
	Click to Log Out from the application
	Click to display the Operator Manual

Main Functional Concepts

The Preclinical AMF application is used for acquiring, viewing, managing, and measuring MRI images on the M3 MRI system.

The following section describes the functional design of each of the main tabs of the application. For further information on each tab, please click the corresponding link on the table.

Functional Tabs

The system design is based on four distinct functional tabs: The Imaging tab, Protocol tab, Archive tab and Settings tab. The display change according to the selected tab. Table 3 describes the functionality of each of these tabs.

Table 3: Description of functional tabs

Tab	Description
Imaging	When you open the application this is the default tab. It is on this tab that you enter new study information (e.g., subject data and subject orientation). This is the tab where image acquisition is performed as well as running a scout, choosing Protocol Sets, changing specific protocol parameters, etc. For complete information refer to the ***Acquiring Images*** chapter.
Protocol	Used for managing all Protocol Sets, Protocols and their respective parameters. For complete information refer to the ***Managing Protocols Sets and Protocols*** chapter.
Archive	Used for searching, viewing, annotating and exporting previously acquired studies. For complete information refer to the ***Managing Archives*** chapter.
Settings	Used for viewing software version. For complete information refer to the ***Settings*** chapter.

5 Acquiring Images

Imaging Tab

The Imaging tab is used for acquiring new images. It is displayed by default when you first login to the application.

When the Imaging tab is selected, the system displays the following screen before entering any new study parameters. For a description of each of the fields, *see Table 4*.

Figure 10: Imaging tab

Table 4: Description of Imaging tab fields

Subject Data tab	For entering new study information. Only the fields marked with a purple dot (Subject ID, Product Coil, and Subject Orientation) are required fields. The others provide important information about the subject but are not compulsory.
Protocols tab and acquisition Queue	Displays the Protocol Sets and Protocols to be executed. The Acquisition queue displays the protocols to be executed and their execution status.
Control Panel	Includes three display areas for the center scout image slices in each of the three planes, and a scan parameters area, which is filled with content after a pulse sequence is selected.
Scout tab	Displays the control panel with an image for each of the 3 planes: Axial, Coronal and Sagittal.
Results tab	Displays images after scanning. Used to review completed protocols for desirability.

Now that you are acquainted with the components of the system and its user interface, you are ready to acquire images. This chapter guides you through the workflow of image acquisition. Cross-references are provided to other sections of the operator manual that contain more detailed information, wherever appropriate.

This chapter contains the following sections:

- Prerequisites
- Image Acquisition Workflow

Prerequisites

Before you proceed to acquire an image, make sure you have properly placed your sample in the Animal Handling System. For additional information, refer to the ***Setting Up the Animal for Imaging*** section.

If relevant also refer to ***Appendix D*** for a description of the Physiological Monitoring system. This system may be used to either monitor the animal while under anesthesia, or to provide the gating (respiratory and/or ECG) signal, depending on the application being performed.

Image Acquisition Workflow

This section describes a typical workflow for image acquisition on the M3 high-performance MRI system. The section has been prepared for users who are new to using the M3 system. Operation of the system and acquisition software is described.

Always follow your animal care committee recommendations when imaging animals under anesthesia.

This section assumes you have already turned on the M3 system and computer and have logged in to the M3 MRI software application.

Workflow Steps

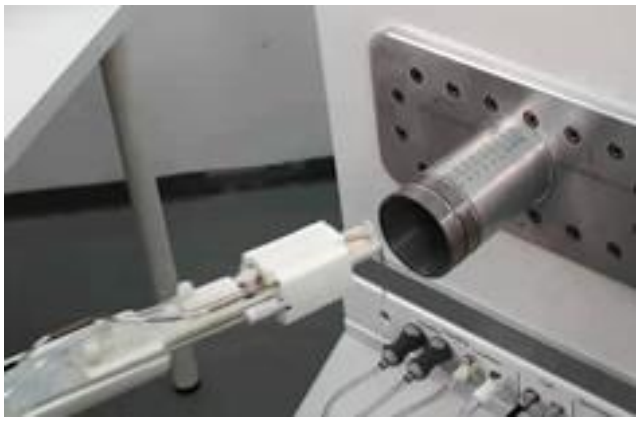
The following table summarizes and describes each of the steps in the Image acquisition process.

Table 5: Description of steps involved in Image Acquisition workflow

Step	Description
Prepare animal	Bed/Coil selection; setup animal in Animal Handling System and insert into magnet (Prerequisite). Refer to the section ***Setting Up the Animal for Imaging***
Enter subject/study details	Open a record for the subject/study and enter at least the required information (marked with a purple dot).
Select subject orientation	Select the subject orientation within the animal handling system and magnet.
Run scout	Perform a preliminary scan.
Select Protocol Set	Select the desired Protocol Set that contains the desired protocols for the imaging.
Select Protocol	Select the Protocol containing the scan sequences you require.
Define slices	Make sure the slice prescription on the imaging sample is appropriate for the selected Protocol.
Run or Run Queue	Select Run Queue only if you have finalized slice prescription and acquisition parameters for all scans contained within the queue. Select Run to initiate only the selected Protocol.
End study	To close the session for the existing subject or to start a new session with a new subject, click the New Study button.

To acquire images

1 Prepare the animal for imaging, and insert the animal handling system into the magnet bore.



2 The software application automatically opens up the New Study information page within the Imaging tab of the software.

Complete any field with a **purple dot** next to it, including:

- Subject ID – e.g. Mouse 1
- Product Coil - Type of coil used
- Subject Orientation – select the appropriate icon for animal positioning. Typically this will be feet first, prone (far left)

Fill in any additional information you need (Project, Group, Study Name, Gender, Species, etc.).

Note/Tip

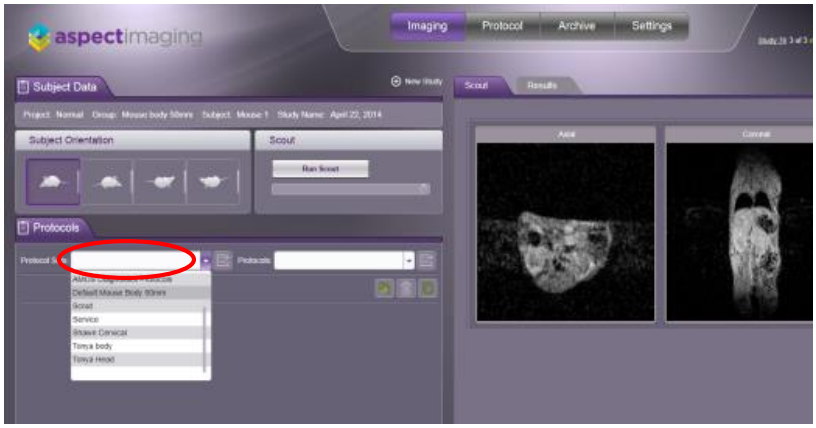
Project/Group/Subject/Study Name is the organizational structure for the acquired data; thus each Subject can have multiple Studies (i.e. time points) within it, while each Study contains numerous image folders as they are acquired.

3 Click the ***Run Scout*** button.
The system will automatically perform all required calibration steps for the study, as well as acquire a multi-slice, multi-plane image to allow for accurate slice prescription for upcoming imaging protocols. The Subject Data tab, with all the relevant information will collapse, with the pertinent information being displayed.

4 Once completed the Scout image will be displayed in the Axial, Coronal, and Sagittal orientations. Hover the mouse pointer over any image and use the scroll wheel on the mouse to move through the acquired slices in each plane.

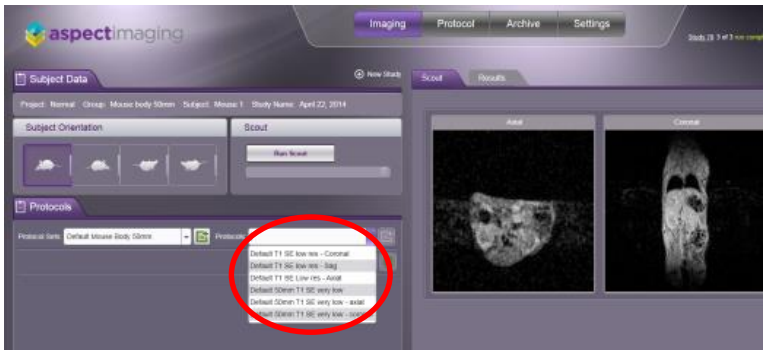
Imaging Protocols, the set of acquisition instructions that control how the image is displayed, are stored in Protocol Sets.

5 Select the appropriate ***Protocol Set*** for the imaging application.



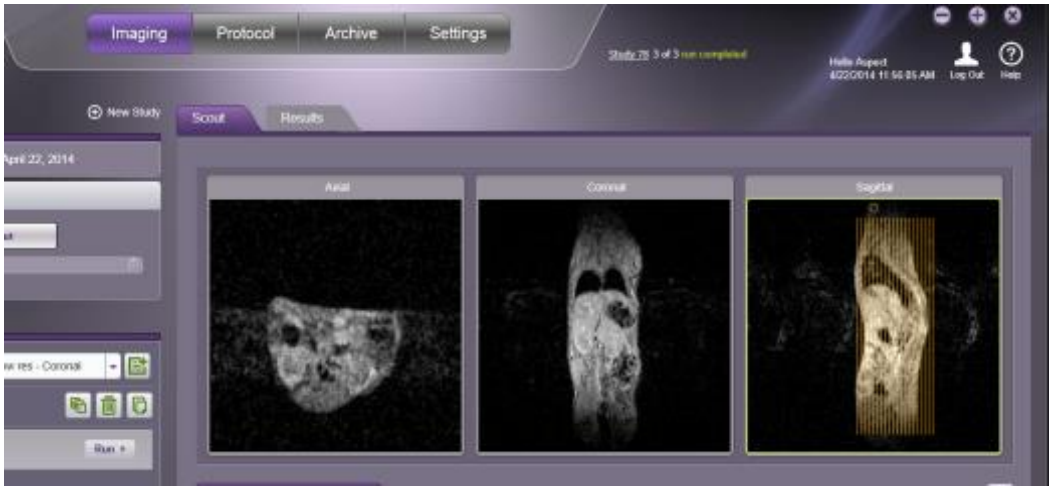
For more information on how to save custom Protocols and collecting those into a Protocol Set refer to the ***Managing Protocols Sets and Protocols*** chapter.

6 Within the Protocol Set, select the Protocol you want to execute. Select the **Protocol** from the drop-down list.



7 Click the icon to add to the queue. Alternatively, you can add every Protocol contained within the Protocol set. To do this, click the icon next to the Protocol Set name.

8 Make sure the Slice Prescription is appropriate for the selected Protocol.



Place the mouse cursor over the **center of the orange lines** which represent the slices to be acquired. Do this in either of the imaging planes in which the acquisition will not take place (i.e. for a coronal acquisition, slices can be adjusted in either the axial or sagittal scout images).

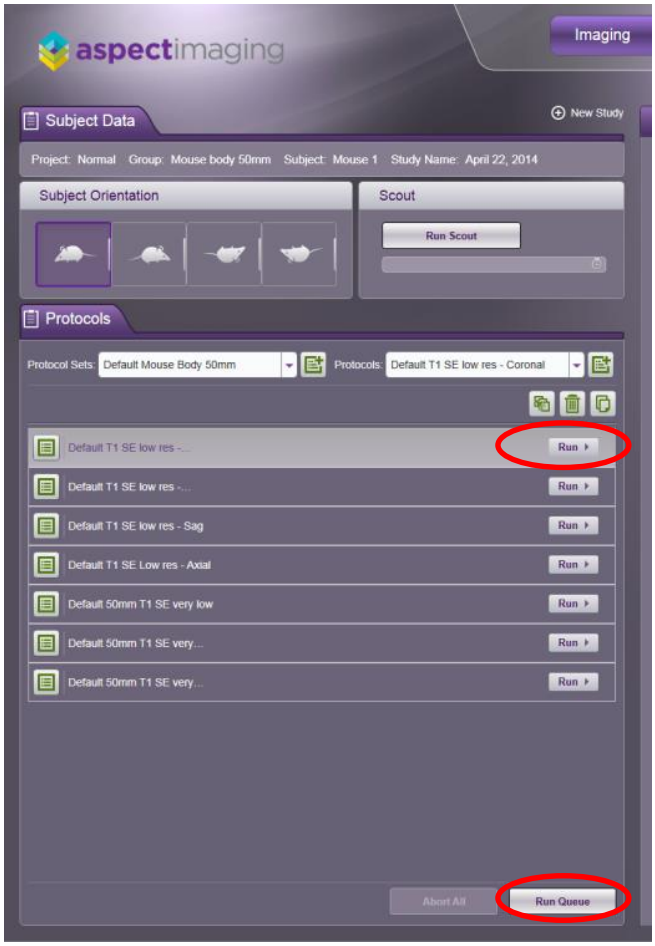
Left-Click and drag the slices to the appropriate location for image acquisition.

9 If necessary, review or modify the Acquisition Parameters within the protocol by clicking the icon next to the selected Protocol. Perform the review and/or changes in the Editor Window. If changes are made, the OK button becomes active.

Note/Tip

Choosing OK stores the changes made, allowing for the Protocol to be acquired with the relevant acquisition parameter. However, choosing OK does not over-write the existing Protocol.

10 To begin an acquisition, you can choose to ***Run*** an individual Protocol, or to ***Run Queue***. Select Run Queue only if you have finalized slice prescription and acquisition parameters for all scans contained within the queue.

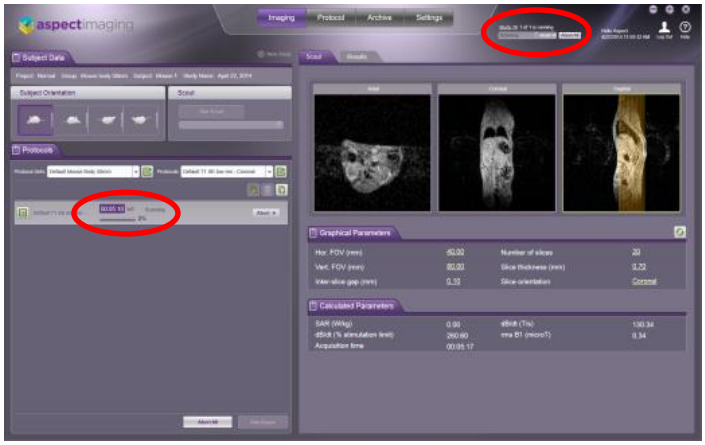


Each Protocol is executed with the selected calibration steps, as outlined in the Editor Window.

Note/Tip

If set to "Retain", the calibration step will only be executed automatically, when the defined amount of time within the system has passed since this calibration was last performed.

Acquisition Progress is displayed next to the Protocol, as well as at the top of the software window (*see following image*).



Completed Protocols are automatically displayed in the **Results** tab. Completed Protocols are also automatically saved.

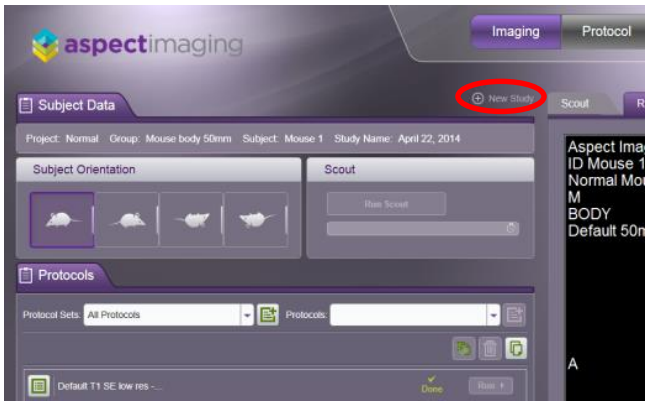
If multiple Protocols are performed, each will have a thumbnail to the right of the main image.

You may left-click on the desired thumbnail to **review the results**.

Continue to **add Protocols** and make adjustments as needed. Additionally, you may change the Protocol Set from which to add Protocols to the Queue if desired.

Navigate back to the **Scout** tab for future **Protocol Slice Prescription** as required to complete the imaging session.

11 To begin a new imaging session, click ***New Study*** and repeat steps 1-10.



6 Histology Subsystem (Ex Vivo option)

This chapter contains the following sections:

- Subsystem Description
- Subsystem Functionality
- Subsystem Setup
- Automatic Operation of the Subsystem
- Manual Operation of the Subsystem
- Capsule Preparation
- Loading the Capsules

Subsystem Description

The Histology subsystem is an add-on to any of M-series Aspect Imaging magnet. It allows scientists and technologists to perform automatic scans for imaging of tissues and organs without the need to manually change the scanned object.

The MR-based Histology application is intended to add functionality to the existing M-series platforms, including hardware and software components, to enable a user or lab to perform high resolution automated scans in fixed (ex-vivo) samples.

The M-Series Histology subsystem incorporates a pneumatic sample loader, tissue and organ handling accessories and a software application running on a system computer.

The main components of the Histology subsystem are:

- Pneumatic sample loader
    - Pneumatic Loader
    - Programmable Logic Controller (PLC)
    - Compressor
- Barcode reader and printer

Subsystem Functionality

Before scanning, the user prepares the sample tissues and organs to be scanned and inserts them into capsules. The capsules are marked using custom barcode stickers, which are printed using the barcode printer provided as a part of the system. The user organizes the capsules in the order in which they should be scanned, and use the barcode reader to import the capsule codes into the application. Next, the user loads the capsules into the pneumatic loader in the right order, and the system is ready to start scanning.

The automatic insertion of the objects to be scanned is performed by means of the pneumatic sample loader. The loaded sample capsules are transported along the pneumatic loader by the application of air pressure at different points. A mechanical blocking pin connected to an air-operated piston, blocks the motion of the capsules, so that the first in line will be in the center of the imaging volume. The system performs the MR scan and stores the results under the relevant

capsule identification. Upon command, the pin is drawn and another sequence of applied pressure ejects the capsule, which presses a switch during its exit from the loader. The pin is restored to the blocking position, and a new load –scan sequence may start.

A schematic description of the Histology subsystem is shown in ***Figure 11: Histology subsystem Block Diagram***. The barcode reader and the printer, enabling an automatic tracking of the scanned capsules, are connected to the PC (as peripherals). A Programmable Logic Controller (PLC) inside the cabinet controls and monitors the set of operations required for the automatic loading.

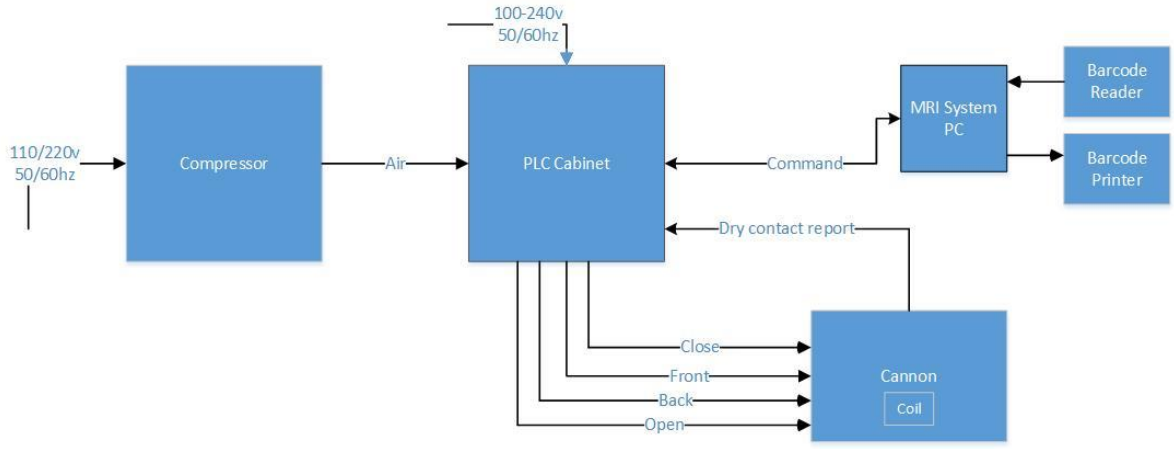


Figure 11: Histology subsystem Block Diagram

The PLC cabinet is connected to the pneumatic loader, the system's Electronics Cabinet and the compressor. The compressor provides air pressure to the PLC cabinet. The PLC controls the operation of pressure valves that stream the pressure along four lines (open, close, front and back) at certain sequences according to commands obtained from the system computer. The PLC also monitors the exit of the capsules from the pneumatic loader's end.

Caution

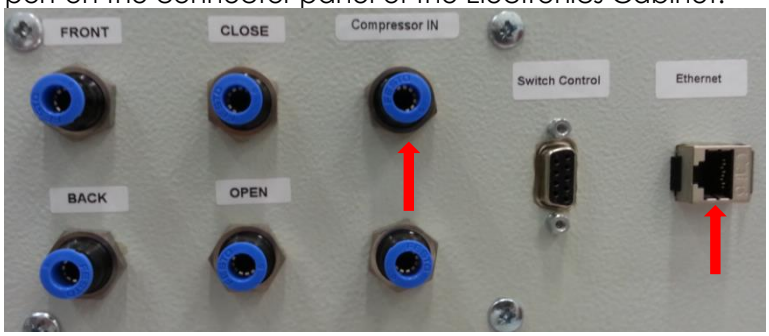
Verify the working pressure of the compressor is set correctly before operating the system. Refer to step 4 in the following procedure.

Subsystem Setup

To setup the Histology subsystem, follow these steps

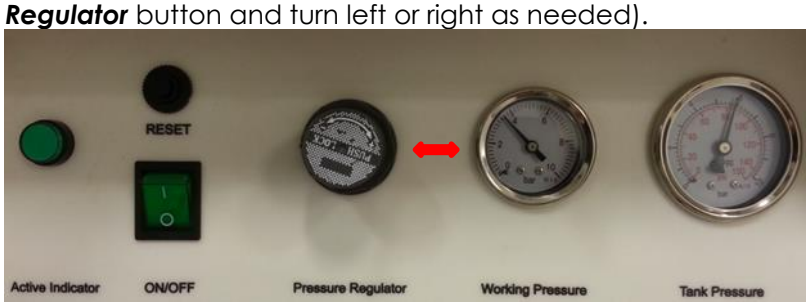
1 Plug both the compressor and PLC to the designated A.C. outlet.

2 Verify connection of the ***Ethernet cable*** (10 mts) from the PLC to the dedicated Ethernet port on the connector panel of the Electronics Cabinet.



3 Verify connection of the PLC Compressor ***In*** tube to the compressor's ***Air Outlet*** valve.

4 Set ***Working Pressure*** between 3.0 and 3.2 Bar (to change working pressure, pull the ***Pressure Regulator*** button and turn left or right as needed).



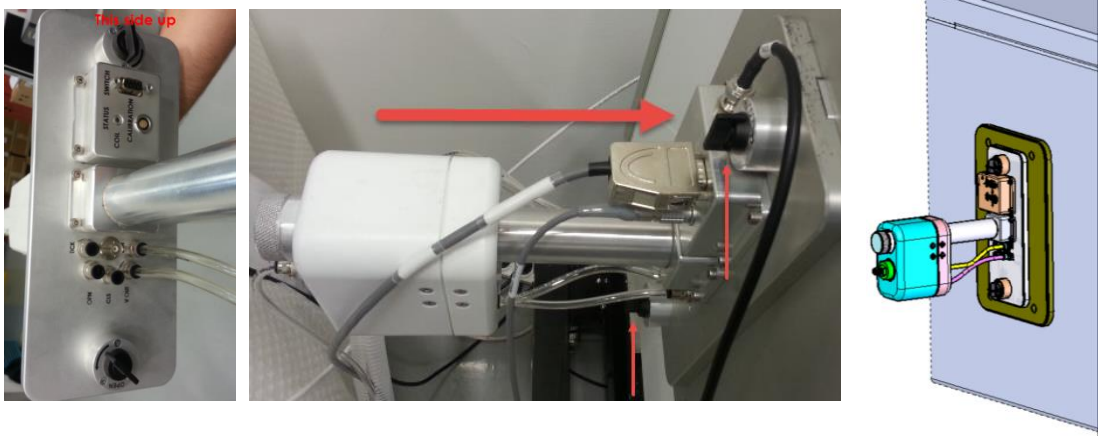
Caution

Working pressures above 3.5 Bar may cause damage to the capsules.

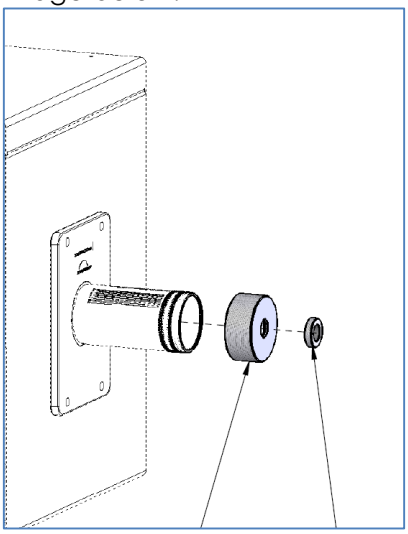
Note/Tip

For further information on operating the compressor refer to the compressor manufacturer's Operator Manual.

5 Remove the cover from magnet's rear flange and insert the Pneumatic Loader. Secure it in place by turning the two black knobs in a clockwise direction until tight.



6 On front side of magnet, slide on the ***Centering Cap*** and secure it with the ***Securing Nut***. See image below.

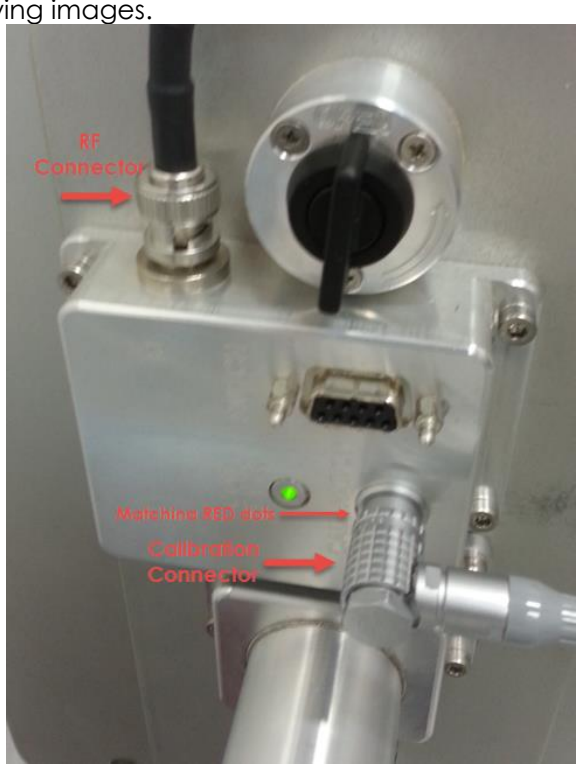


7 Slide on the transparent Collection Basket. See image below.

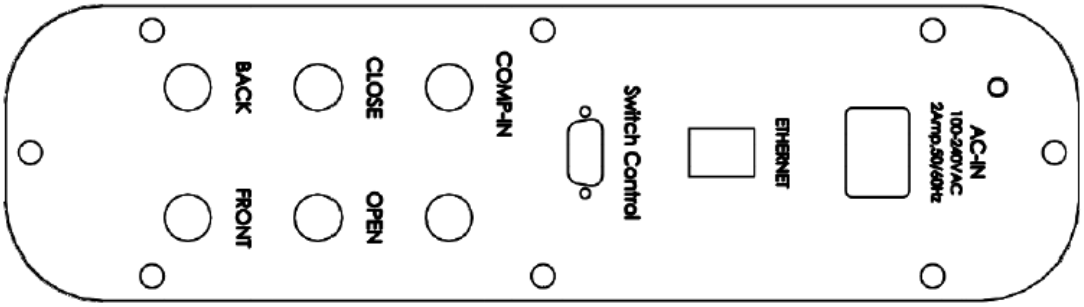
Caution

Install the Collection Basket before operating the system.

8 Connect the ***Coil*** connectors from the Manifold (see two cables) to the ***RF*** and ***Calibration*** connector points on the Loader. Make sure on the Calibration Connector that the red dots are one in front of the other. See following images.



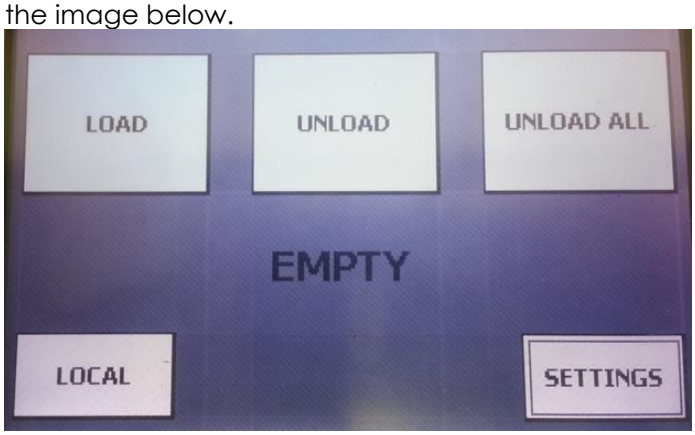
9 Connect the bundled tubes (5 tubes and one switch control) to the ***PLC panel*** as indicated on the labels.



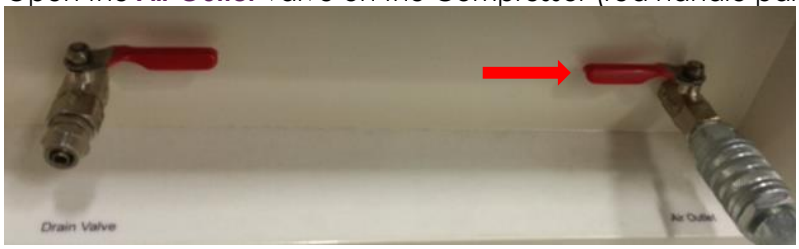
10 Connect the other end of the bundled tubes to the Loader as indicated on the labels. See the following image.

11 Turn ***On*** the Compressor.

12 Turn ***On*** the PLC. Wait for the software to load. The PLC screen will display as indicated on the image below.



13 Open the ***Air Outlet*** valve on the Compressor (red handle parallel to air output).

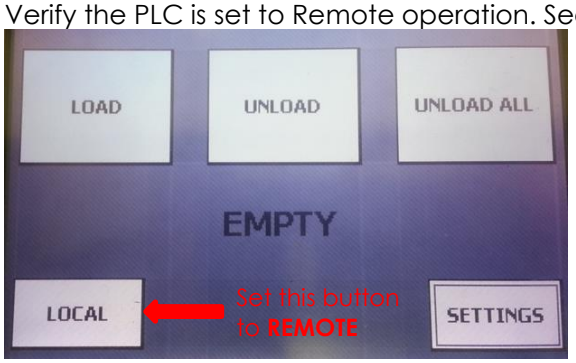


The PLC has two working modes: ***Manual*** and ***Automatic***.

Automatic Operation of the Subsystem

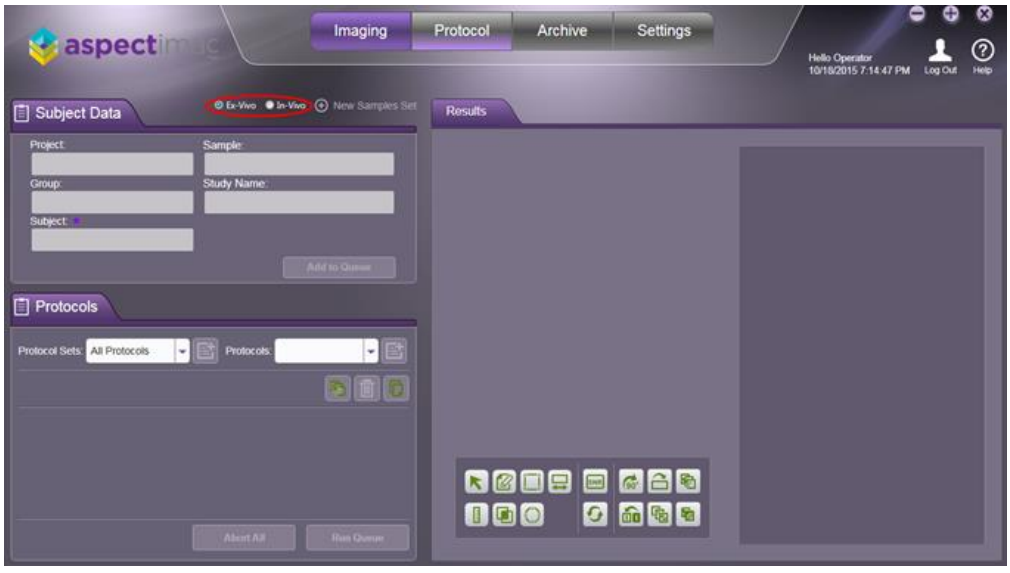
To operate the PLC in Automatic mode and prepare for imaging

1 Verify the PLC is set to Remote operation. See image below.



2 Prepare batch of capsules (refer to the ***Capsule Preparation*** section).

3 Load capsule information into software application (Histology subsystem's Main screen).



4 Follow the steps as indicated on the image below:

1 Select the ***Ex Vivo*** button.

2 Enter Subject Data. Note that information marked by a purple dot is required.

3 Click the ***Add to Queue*** button.

4 Select the Protocol Set you want to use.

5 Select the Protocol.

6 Add the Protocol to the Playlist.

7 Repeat steps 2 to 5 for each capsule in the order they need to be imaged.

5 Your screen should display like the following sample image.

6 Remove cap from the Loader insertion tube and insert capsules.

7 Place cap back on the insertion tube making sure it is securely tightened.

Note/Tip

Insert the capsules in the same order they were entered into the software.

8 Click the ***Run Queue*** button.

Note/Tip

Depending on the number of capsules and protocols selected, imaging acquisition may take several hours to process.

Note/Tip

Capsule Storage
After scanning, samples can be transferred back to the fixative or PBS solution ready to be sent to histopathology (if desired) or to be stored.

Note/Tip

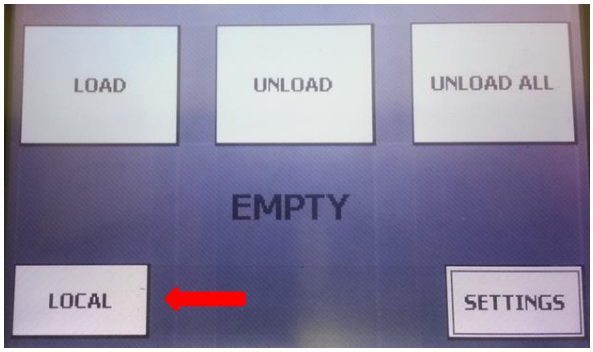
Loader Storage
Store the loader in its respective protective box upon completion of working with the histology subsystem.

Manual Operation of the Subsystem

In Manual mode the PLC processes one capsule at a time.

To operate the PLC in Manual mode

1 Make sure the software is set to ***Local***.

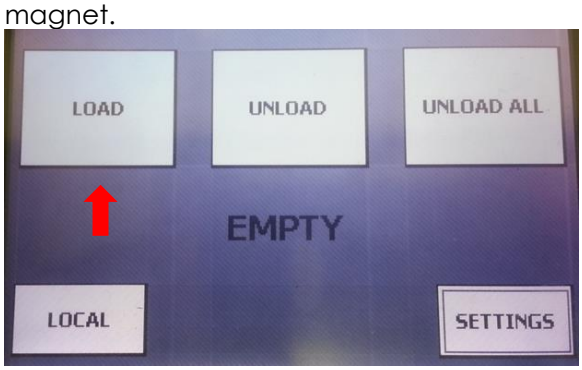


2 Prepare capsule. Refer to the ***Capsule Preparation*** section.

3 Remove cap from the Loader insertion tube and insert capsule.

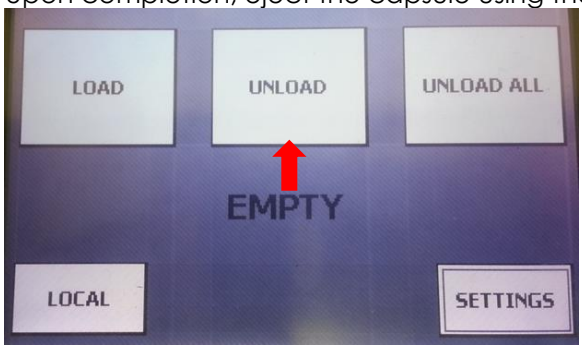
4 Place cap back on the insertion tube making sure it is securely tightened.

5 On the PLC screen, press the ***Load*** button (this action loads the capsule to center of magnet.



6 At the software workstation, start the image acquisition process by following the steps in the ***Acquiring Images*** chapter.

7 Upon completion, eject the capsule using the ***Unload*** button on the PLC screen.



Capsule Preparation

Capsules need to be prepared in advance. Each sample is placed in the center of the capsule and a Fluor inert solution is added to avoid drying of the specimen.

Caution

Use only capsules and stickers supplied by Aspect Imaging.

To accommodate and immobilize the sample in the center of the cartridge, cotton can be used to fill the empty space.

Capsules need to be entered into the queue in their corresponding order. You can run imaging for up to 8 capsules per batch.

Capsule batches are automatically moved through the imaging process by means of compressed air provided by the PLC.

Capsules should only be filled with bio safe materials.

Capsules are for single use only.

Loading the Capsules

To load the capsules

1. Unscrew the pneumatic loader cap.
2. Insert capsules into loader in same order as entered in the software application (up to 8 capsules per batch).
3. Screw loader cap back on.
4. Run the queue in the software application.

7 Managing Protocols Sets and Protocols

Protocol Tab

The Protocol tab is used for managing Protocol Sets and Protocols. Here you can edit, delete or create new Protocol Sets. You can also edit protocols, add protocols to Protocol Sets, edit protocol parameters, view advanced parameters or delete unwanted Protocols.

When the Protocol tab is selected, the system displays the Protocol Sets panel shown below on the left side of the screen. Select a Protocol and the selected protocol's parameters are displayed.

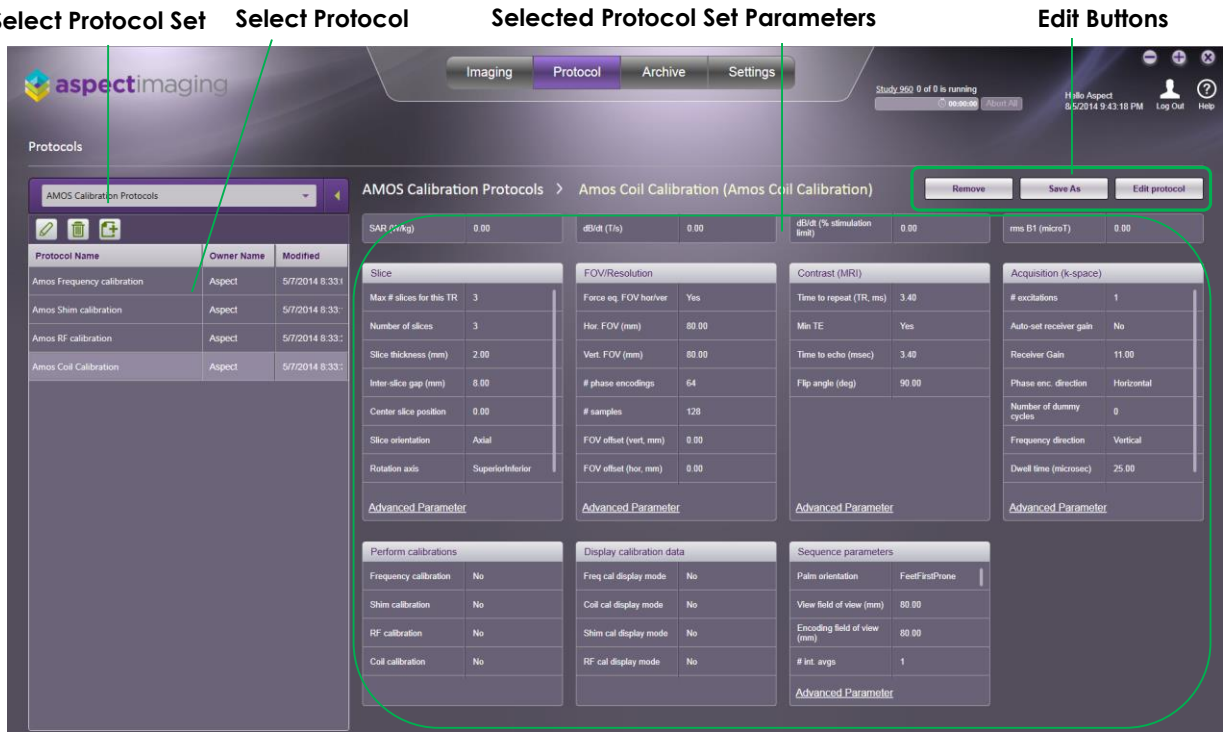


Figure 12: Protocol tab

Tool or Button	Description
	Edit, Delete or Create a Protocol Set
Remove	Click to remove a selected Protocol from the selected Protocol Set
Save As	Click to save edited protocol with new name
Edit protocol	Click to enable editing protocol parameters

Tool or Button	Description
Reload	Click to reload prev. protocol parameters (Enabled after editing a protocol parameter)
Save	Click to Save protocol changes (Enabled after editing a protocol parameter)

The main purpose of protocols is to enable routine, reproducible imaging using a minimal amount of parameter entries and mouse clicks. A protocol contains a single or a group of sequences in which the acquisition parameters are tailored and optimized for a specific application.

This chapter contains the following sections:

- Managing Protocols
- Image Acquisition Sequences

Managing Protocols

Protocols are imaging sequences. You create protocols to store sequences for different applications or to suit the preferences of different users. To choose a sequence for imaging you select the protocol containing the sequence.

This section describes the steps necessary to create a custom Protocol and Protocol Set within the acquisition software on the M3 system. The M3 system has numerous factory default Protocols and Protocol Sets which provide quality images for most basic applications, however with some knowledge of the M3 system and acquisition software it is possible for you to optimize the Protocols for a specific application or study. A factory default protocol can be selected as a starting point for Protocol optimization. Once the various geometry and acquisition parameters have been optimized and the resulting image is confirmed, the Protocol can then be saved to a custom Protocol Set for repeated use in future studies.

You can create new protocols, duplicate existing ones, delete protocols, and manage the sequences contained within protocols.

The user (operator) cannot delete any of the default, factory defined protocols but can copy and modify them.

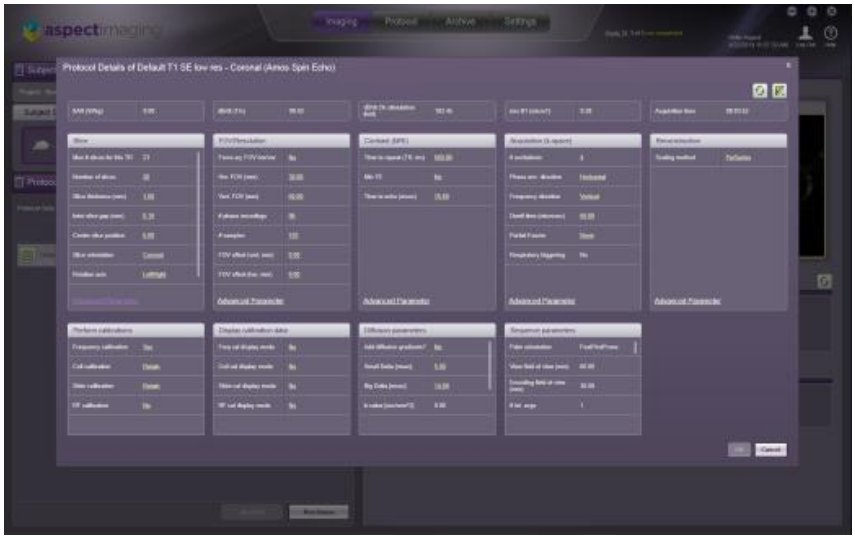
This section assumes you have a basic understanding of how to operate the M3 system and its acquisition software. If you are unfamiliar with any of the standard operating steps please consult the appropriate section of this manual.

Creating a New Protocol

Creating a new protocol is useful when you want to create a set of sequence parameter for a specific need.

To create a new Protocol

1 Select a factory default Protocol Set, and the desired Protocol.



2 Adjust the acquisition parameters within the Editor Window.

This window is accessed by clicking the  icon next to the selected protocol. Changes to the acquisition parameters can be made. The Advanced Parameter option can be used to access additional, more advanced, parameters.

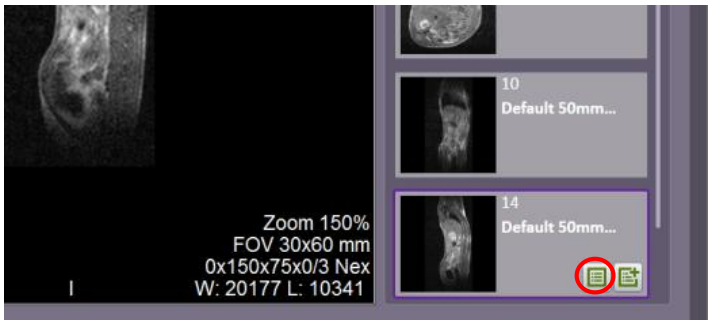
3 Once you have made the desired changes, click ***OK***. Your changes are saved.

Choosing OK will store any changes made, so the Protocol can be acquired. However choosing OK will not over-write the original Protocol selected.

4 Run the Protocol with the desired changes to the acquisition parameters. This will confirm that the changes made result in the desired image.

5 Once completed, Review the image on the Results tab. If the results are desirable, proceed to saving the Protocol. If results require improvement, repeat Steps 2 to 4 until desirable results are obtained.

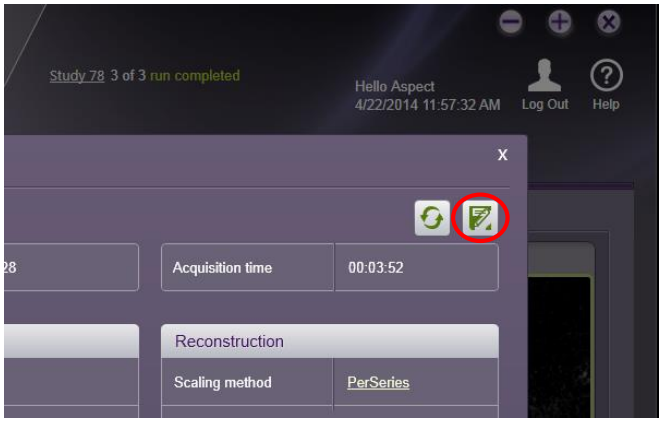
6 To Save the custom Protocol, locate the desirable image within the Results tab. Click the ***Editor Window***  ***icon*** within the thumbnail.



7 Select the ***Save As*** option from the top of the window.

8 Provide an appropriate name for the Protocol.

9 Click ***Ok***. The new protocol is saved.



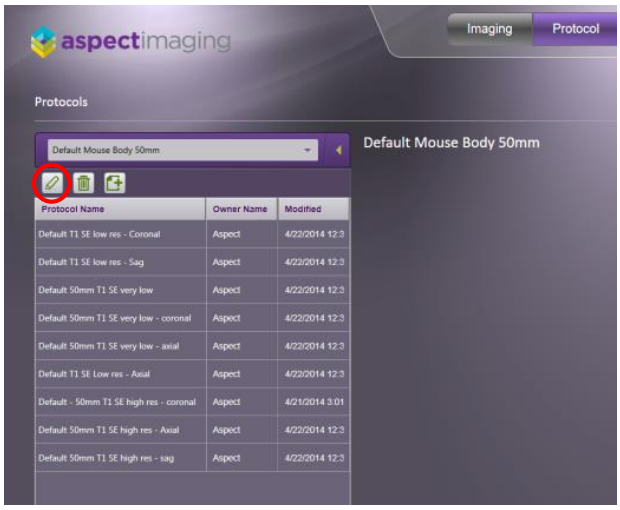
To create a new Protocol Set

1 To create a custom Protocol Set, navigate to the Protocol area within the software.

2 Create a custom Protocols Set by clicking the  ***icon***.

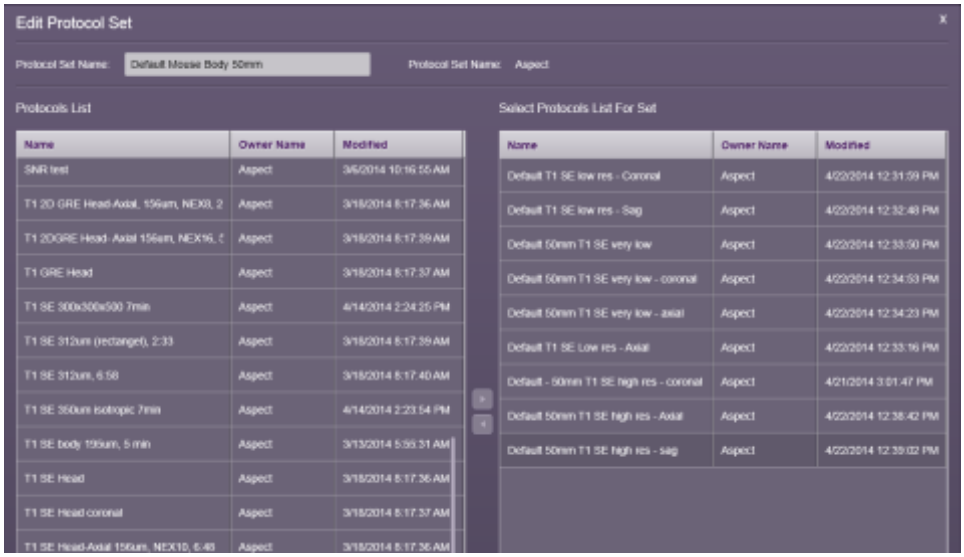
Alternatively, if a custom Protocol Set already exists, and you simply want to add the new custom Protocol to it, then navigate to that Protocol Set within the dropdown list.

3 To add Protocols to the Protocol Set click the  ***icon***.

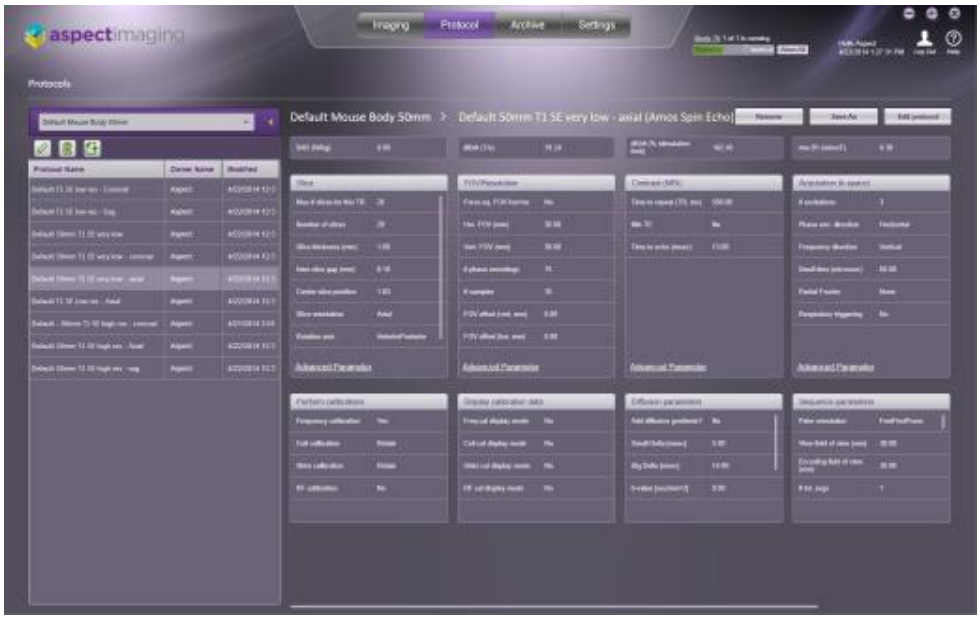


4 Locate the desired custom Protocols to add to the Protocol Set.

5 Click the  ***icon*** to add the selected Protocol to the Protocol Set.



6 Review acquisition parameters for any Protocol within a Protocol Set by simply selecting the desired Protocol.



7 To Edit the acquisition parameters click the ***Edit*** button.

8 Once you complete the desired changes click ***Save***, or ***Save As***. If Save As is selected, the saved Protocol must be added to the Protocol Set by following Steps 11 thru 14.

Copying a Protocol

Copying a protocol is useful when an existing protocol is close in characteristics to a protocol that you require for a specific need, and you do not want to modify the original. After copying the protocol, you will be able to modify the parameters for your purpose, without affecting the original settings.

1 Select the protocol that you want to copy.

2 Click ***Save as***. The Copy Protocol dialog box opens.

3 Type a ***Protocol Name***.

4 Click ***Save***. The dialog box closes and a protocol with a new name is added to the all protocols list. The protocol composition is identical to the original protocol.

5 Modify the protocol composition as described later in this chapter.

Modifying the Protocol Set Composition

You can always modify the list of protocols in a protocol set by removing or adding protocols.

1 Select the protocol set to be modified and click "EDIT".

2 Remove unnecessary protocols:

   a. Select a protocol to be removed from the set and click ***Remove from Protocol set***.

   b. The protocol is removed.

3 Add protocols:

a. Scroll to navigate through all protocols and locate the required protocol.

b. Click ***Add to Protocol set***. The selected protocol is added to the end of the protocol set composition list on the right.

4 Change Protocol data:

a. Select a Protocol to be modified and click  . The Edit Protocol Set dialog box is displayed.

b. Modify ***protocol parameters*** as desired.

c. Click ***Confirm***. The dialog box is closed and the protocol composition updated.

Image Acquisition Parameters

A protocol defines the instructions to the hardware channels (gradients, transmitter, receiver), and the associated parameters.

For a complete list of available imaging parameters refer to ***Appendix B Protocol Parameters***.

8 Managing Archives

Archive Tab

The Archive tab is used for displaying, viewing, manipulating, annotating, measuring and exporting image files stored in the database.

This is the only tab where the drag and drop functionality is used. Use drag and drop to move a selected image from the Series display panel on the right side of the screen to the Layout Grid at the center of the screen.

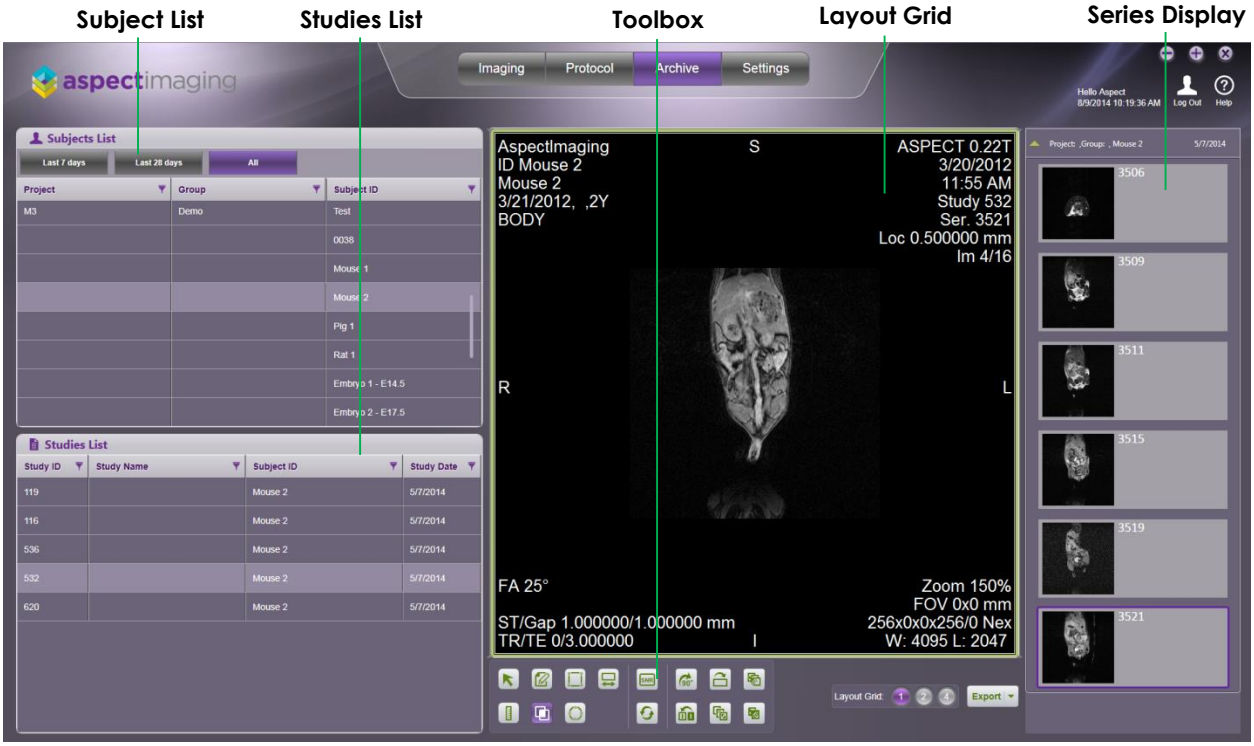


Figure 13: Archive tab

Tool or Button	Description
Layout Grid	Image text displayed: **Upper Left** – Subject Information **Upper Right** – Image Information **Lower Left** – Protocol Information **Lower Right** – Display Information **W and L** – Brightness and Contrast Mouse functionality: **To scroll through images** – Click the Scroll wheel and move up or down to scroll through the images in the current Series

Tool or Button	Description
	Change brightness – Left click and hold mouse button while moving the mouse up for more brightness or down for less brightness **Change Contrast** – Left click and hold mouse button while moving the mouse left for less contrast or right for more contrast **Zoom** – Right click and hold mouse button while moving the mouse up to zoom out or down to zoom in on the image
Series Display	Displays all the Series taken for the selected Subject ID and selected Study ID
	Arrow. Adds an arrow annotation, for pointing to something
	Add Text
	Set Rectangle Region
	Pan the Image
	Arrow Set Ruler. For measuring
	Window Leveling. Brightness and Contrast. Default selection
	Set Ellipse Region
	Start SNR (Signal to Noise Ratio) Calculation
	Reset. Clears image and reloads original settings.
	Rotate Image Right 90°
	Flip Image Horizontally
	Clear Annotation for All Images
	Reverse Image (L-R; R-L)

Tool or Button	Description
	Apply Annotation to All Images
	Clear All Annotations from the Current Image
	Select how many Series to display at the same time on the Layout Grid.
	Choose whether to export Subjects or Studies. A dialog box is displayed for you to select the export path and file format(s) you want to export to.
	Choose whether to export Subjects or Studies. A dialog box is displayed for you to select the export path and file format(s) you want to export to.

9 Settings

This chapter describes the routine administrative tasks controlled from the Settings tab.

This chapter contains the following sections:

- User Management
- Software Version

Function	Description
User Management	Not applicable for the Operator role. **Note:** The Site Administrator role can define new Operators or remove existing ones.
Software Version	Displays software version information

User Management

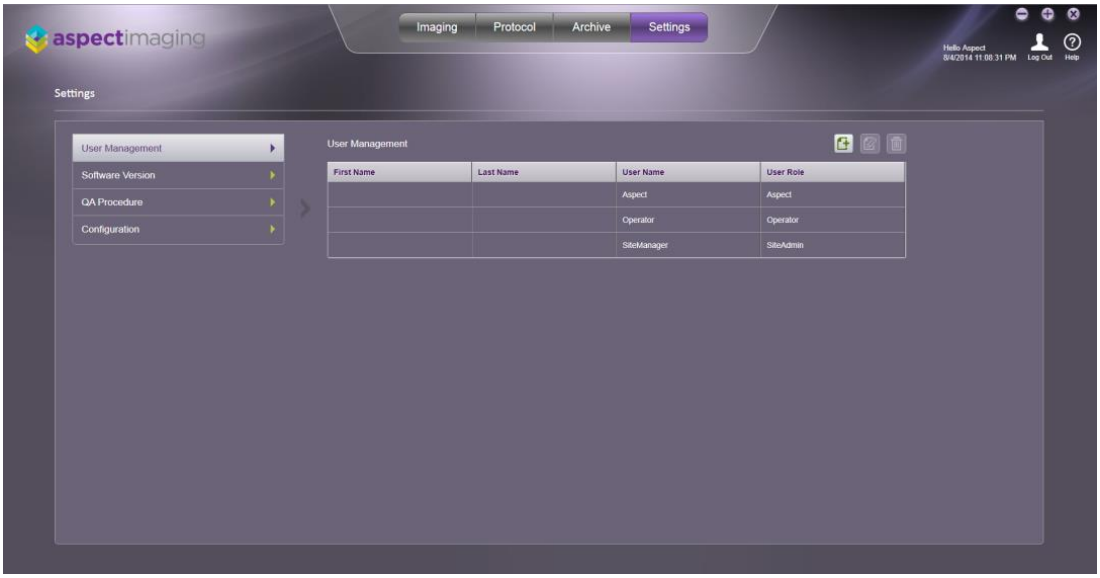


Figure 14: Settings tab

Appendix A Specifications and Labeling

Dimensions, Physical Characteristics

Magnet (including cart)

Dimension	Measurement
Height	1080 mm
Width	734 mm
Length	752 mm
Weight	640 kg

Electronics Cabinet

Dimension	Measurement
Height	176.5 cm
Width	59.8 cm
Depth	115 cm
Weight	300 kg

Histology Subsystem

Dimension	Measurement
PLC dimensions (HxWxD)	39.5x38x24.5 cms
PLC weight	12.3 kg

WorkStation Computer System

System computer	Operating system: Windows 7 64-bit Display: 24" screen, 1920x1080 resolution

Power Requirements

Line voltage:

- 208 VAC, 15 A, single phase in countries using 120V, or
- 220-250 VAC, 15 A, single phase in countries using 220-250V
- 50-60 Hz.

Grounding Requirements:

- A flexible copper cable of type #6 AWG must be used to connect System Electronics cabinet to the site's main ground connection.

Histology Subsystem (Optional)

- 100-240 VAC, 2A, 50-60 Hz

Environmental Conditions

Ambient conditions:

Operating temperature	18°C - 25°C (Magnet) ; 20°C - 30°C (Electronics Cabinet)
Storage Temperature	0°C – 70°C
Operating Humidity	30-70% relative humidity, non-condensing
Storage and transport Humidity	10-80% relative humidity, non-condensing
Atmospheric Pressure	Operating Range: 70 - 106 kPa
Operating altitude	Less than 2000 m above sea level

Transportation Conditions

The magnet center of gravity is very high and special precautions and tools are needed for transportation.

Do not transport the system without first consulting with Aspect Imaging.

Regulatory Compliance

System complies with:

- IEC 61010-1 (Safety requirements for electrical equipment for measurement, control, and laboratory use)
- CAN/CSA-C22.2 NO. 61010-1-12 - Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements
- UL 61010-1 Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements
- EN/IEC 61326-1 (Electrical equipment for measurement, control and laboratory use - EMC requirements)
- FCC - 47 CFR part 18 (Scientific equipment)

Labeling

System labels consist of the following:

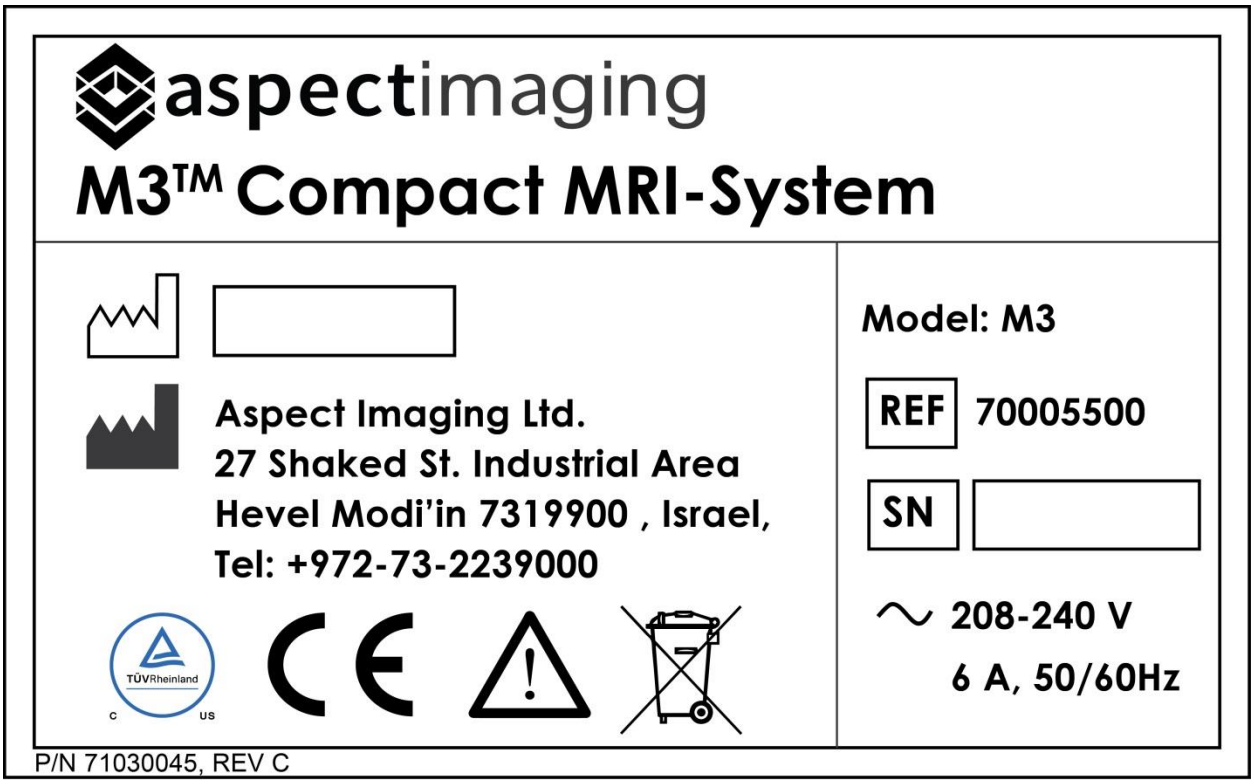


Figure 15: System label

- Manufacturing date
- Manufacturer address
- Manufacturer model name
- Manufacturer reference number
- Power requirements

Appendix B Protocol Parameters

Parameters in all protocols

Tab	Name	Explanation
Slice	Max # slices for this TR	(2D only) the maximum number of slices that can be acquired in the current Time to Repeat (TR).
	Number of slices	The requested number of slices. If the number of slices is more than "fit" into a single Time to Repeat (TR), the TR is automatically increased and the field is painted yellow to indicate that it was changed.
	Slice thickness (mm)	The requested slice thickness. Decreasing slice thickness may increase the minimum Time to Echo (TE).
	Inter-slice gap (mm)	The empty space between slices. For contiguous slices, set the gap to 0.
	Center slice position	The center of the group of slices. Note: if the number of slices is even, there will be no slice at this position e.g. for 4 slices, slice width = 1 mm gap = 1 mm and center slice position =0, the slice positions will be -3, -1, +1, +3.
	Slice orientation	The primary slice orientation i.e. axial, coronal or sagittal
	Rotation axis	Axis about which an additional rotation is performed (S/I, L/R or A/P) – usually specified by the graphic prescription
	Rotation angle (deg)	Additional rotation angle, degrees (usually specified using a graphic prescription)
	Slice positions	(Advanced, output only) – the slice positions (mm)
	Slice interleaving mode	(Advanced) – The order the slices are excited; interleaved (1,3,5,7,9,2,4,6,8) or not (1,2,3,4,5,6,7,8,9)
FOV/Resolution	Force eq. FOV hor/ver	Force equal field of view (FOV) in the vertical and horizontal direction, so that if one is changed, the other changes as well.
	Hor. FOV (mm)	Horizontal field of view (referring to the final image), units: mm
	Vert. FOV (mm)	Vertical field of view (referring to the final image), units: mm
	# phase encodings	Number of 2d phase encodings
	# samples	Number of sampling points

Tab	Name	Explanation
	FOV offset (vert, mm)	Offset of the center of the field of view in the vertical direction (referring to the final image)
	'FOV offset (hor, mm)':	Offset of the center of the field of view in the horizontal direction (referring to the final image)
	Hor. pixel size (mm)	(Advanced) – Pixel size in the horizontal direction i.e. FOV/n where n is either the number of phase encodings or the number of samples, depending on whether horizontal or vertical encoding is selected. Note: if this field is modified, n (i.e. either the number of samples or the number of phase encodings) is changed accordingly.
	Vert. pixel size (mm)	(Advanced) – See previous
Contrast (MRI)	Time to repeat (TR, ms)	Time to repeat. Units: msec
	Min TE	(Yes/No) – Indicates to the system to select the minimum TE available with all the other scan parameters
	Time to echo (TE, ms)	Time to Echo, units: msec
	Apply inversion pulse	(Yes/No) – Apply a slice selective inversion pulse before the excitation pulse. We use a so-called Hoult-Silver adiabatic inversion pulse. Generally, the inversion pulse is repeated for every line of k_space; however, GRE2D offers an option to apply the pulse only once (IR-Snap).
	Inversion time (TI, ms)	The time between the inversion pulse and the excitation pulse (only applicable if previous field is set to Yes)
	Flip angle (deg)	Rf excitation angle (gradient echo only)
Acquisition (k-space)	# excitations	Number of excitations (NEX)
	Phase enc. direction	Phase encoding direction (horizontal or vertical). The software ensures that the phase encoding direction and the frequency direction are opposite i.e. if one if changed, the other is changed as well.
	Frequency direction	Frequency encoding direction (horizontal or vertical) – see previous item
	Dwell time (microsec)	Time between sampling points, units: microsec. Only integer values are supported

Tab	Name	Explanation
	Partial Fourier	Perform half Fourier acquisition and recon This field can take on the values: • "None "(default) • "Frequency" - used to reduce the minimum TE • "Phase Encoding" - used to perform the scan in a little more than 50% of the "standard" scan time, with a penalty of 30% in signal-to-noise.
	'Averaging mode':	(Advanced) – Only external averaging is currently supported. The full scan is repeated the requested number of times (including recon) and the magnitude images are averaged. Note: If any of the calibrations is set to "yes" it will be repeated at the start of each average.
	Auto-set receiver gain	(Advanced) – Calculate the optimal receiver gain.
	Receiver gain	(Advanced) – The receiver gain value. This can only be changed if 'Auto-set receiver gain' is set to No
	Echo asymmetry (%)	(Advanced) – the offset of the sampling window from the center, expressed as a percent of the full window i.e. 0% means the echo is centered, 50% means the echo occurs after 25% of the window.
	# dummy cycles	(Advanced) – Number of dummy cycles run without sampling data. This is run to ensure the magnetization and the gradients are in steady-state.
	Partial Fourier fraction	(Advanced) – Fraction of k-space sampled if the partial Fourier option is enabled. Increasing the fraction will (potentially) reduce artifacts but increase the scan time.
	Enable navigator	(Advanced) – allow the system to add navigator cycles to measure the field drift. Enabling navigators increases scan time (by up to 10%, depending on the drift rate) but reduces artifacts.
	Encoding Order	(Advanced) – linear encoding or centric encoding
Reconstruction	Scaling method	The user can specify one of three options: "PerSeries" all the images in the series will use a common scale factor "PerSlice" each image in the series is scaled independently "Fixed" Use a preset scale factor (specified by the field "Recon scale factor" (one value for the entire series)).
	Recon scale factor	(Advanced) – Scale factor used if 'Scaling method'= Fixed. Typical values are 0.001 or less. Decreasing the scale factor will increase the pixel values

Tab	Name	Explanation
	Navigator # samples	(Advanced) – number of samples in navigator
	Navigator dwell time (microsec)	(advanced) dwell time for navigator
	Link navigator acquisition parameters	(Advanced) – Forces navigator to use the same number of samples and dwell time as the protocol.
	Recon window bottom percentile	(Advanced) – Fraction of image max used to set the center and width. Increasing this value will increase the number of pure black pixels in the image. Note: the window can be changed interactively to overcome this.
	Recon window top percentile	(Advanced) – Fraction of image max used to set the center and width. Decreasing this value will increase the number of pure white pixels in the image. Note: the window can be changed interactively to overcome this.
	Recon high bit:	(Advanced) – The highest bit in the image (usually 15). This image is scaled so that the highest pixel equals 2 to this power.
	Recon # bits	(Advanced) – The number of bits used to store the image (usually 16)
	Low Pass Filter	(Advanced) – apply a low pass Fermi filter to the k-space data in reconstruction (before the FT). This reduces Gibbs artifacts, increases the signal-to-noise ratio but reduces resolution.
	LPF Width	(Advanced) – width of the low pass filter (if activated – see previous item)
	LPF transition rate	(Advanced) – transition range of the low pass filter (if activated – see previous item)
	Save mag. image files	(Advanced) – store magnitude images (one per slice) in the working directory at the end of recon. The files have no header and simply contain the pixel data in binary format.
	Save complex image files	(Advanced) – store complex images (one per slice) in the working directory at the end of recon. The files have no header and simply contain the pixel data in binary format.
	Save raw data files	(Advanced) – store raw data (fids and navigators) in the working directory at the end of recon. The files have no header and simply contain the pixel data in binary format.

Tab	Name	Explanation
Perform calibrations	Frequency calibration	Perform frequency calibration. 3 possible options: “Yes” i.e. perform the calibration no matter what “No” i.e. do not perform the calibration. “Retain” i.e. calibration is performed if a new study is opened OR 5 minutes have passed since the last calibration.
	Coil calibration	Perform coil calibration. 3 possible options: “Yes” i.e. perform the calibration no matter what “No” i.e. do not perform the calibration. “Retain” i.e. calibration is performed if a new study is opened OR the NMR frequency has changed more than a specified amount as compared with the frequency at the time of the previous coil calibration
	Shim calibration	Perform coil calibration. 3 possible options: “Yes” i.e. perform the calibration no matter what “No” i.e. do not perform the calibration. “Retain” i.e. calibration is performed if a new study is opened OR 1 hour have passed since the last calibration.
	'RF calibration'	Perform coil calibration. 3 possible options: “Yes” i.e. perform the calibration no matter what “No” i.e. do not perform the calibration. “Retain” i.e. calibration is performed if a new study is opened OR 1 hour have passed since the last calibration.
Display calibration data	Freq cal display mode	Control whether the calibration is performed in any of three ways: Without any display (default) Showing calibration plots, which automatically disappear Showing calibration plots and requiring user-confirmation (“OK”) before proceeding
	Coil cal display mode	See above
	Shim cal display mode	See above
	RF cal display mode	See above

Specific Protocol Parameters

Spin echo 2D (SE)

1. Classic single echo SE
2. A navigator is (optionally) added every few phase encodings to help track the frequency of the magnet. For SE, each navigator is an extra FID (with the phase and view

gradients turned off), sampled at the same dwell time and the same number of points as the scan data. The system automatically decides how many extra navigator cycles are required.

3. The option of diffusion-weighting is offered. User can set the 2 "delta" parameter and the direction; the b-value is calculated and displayed.
4. The option of demagnetization (following every gradient pulse) is offered. This will increase the min TE. It should be set to "Yes" for long TE values (TE > 25 msec)
5. The option of crusher gradients around 180 pulse (will increase min TE)

SE protocol parameters

Tab	Name	Explanation
Contrast parameters	Add demagnetization gradients	Add demagnetization (to erase the residual magnetization); necessary for long TE; will increase the minimum echo time.
	Add crusher gradients?	Add crushers to dephase the transverse magnetization the end of the protocol (each TR)
Acquisition (k-space)	gCrush2GsRatio	(advanced) Ratio of amplitude of crusher gradients (horns on 180 gradient) to slice select gradient.
Diffusion parameters	Add diffusion gradients?	Add diffusion-sensitizing gradients (will increase TE)
	Small delta msec)	δ
	Big delta (msec)	Δ
	b-value (sec/mm^2)	B value of diffusion gradients
	diffusion direction	Logical direction (view/encode/slice) of diffusion gradients
	Amp of diffusion grad (%)	Amplitude of flat top of diffusion gradient(s)

Gradient echo (2D and 3D)

1. This is a spoiled gradient echo protocol. For 2D, the navigator is determined in the same fashion as in the Spin Echo protocol. For 3D, a navigator is added to the end of the slice-encoding loop.
2. GRE2D supports both standard inversion and IR-snap options (see the explanation for the field "Inversion mode" below). GRE3D only supports a single volume, at an arbitrary (center) slice position.
3. For 3D scanning, the "interslice gap" is zero, unchangeable. For 2D scans, the interslice gap is user-selectable.

GRE protocol parameters

Tab	Name	Explanation
Contrast parameters	Inversion mode	Standard/fast. In "standard" mode, the inversion pulse is applied before every excitation pulse i.e. per slice and per phase encoding. In the "fast" mode, the inversion pulse is only applied once (so-called IR-snap mode). To obtain T1 contrast with this option, the phase encoding should be set to "centric", the number of duty cycles should be zero (or a small number) and the TR should be as short as possible.
	Time To Repeat Fast Inversion	Used for the IR-snap mode (see above). Sets the TR of the phase encoding loop. Generally set to as small a value as possible.

Fast spin echo (2D and 3D)

1. In FSE, "TE" means the duration from the excitation to the time at which the k = 0 line in k-space is measured, rather than the time from excitation to acquisition. The TE requested by the user is rounded to the nearest value which can actually be achieved. The correct time is displayed in the "TE" field.
2. The number of phase encodings must be an integer multiple of the Echo Train Length (ETL). The value requested by the user is set to the nearest multiple of the ETL **smaller** than the requested value. The actual value is displayed in the "Number of phase encodings" field.
3. Both 2D and 3D scans are supported. As in GRE3D, only a single (contiguous) volume is available in the FSE3D i.e. the interslice gap is zero/unchangeable while the center slice position is arbitrary.

FSE protocol parameters

Tab	Name	Explanation
Slice	Dimension	2D or 3D (single volume)
FSE parameters	Echo train length (ETL)	Echo train length
	Refocusing flip angle	Tip angle of refocusing pulse (normally 180)
	FSE calibration	Perform FSE calibration. 3 possible options: "Yes" i.e. perform the calibration no matter what "No" i.e. do not perform the calibration. "Retain" i.e. calibration is performed if a new study is opened OR FSE calibration parameters has changed more than a specified amount as compared with previous FSE calibration

Tab	Name	Explanation
	FSE cal display mode	Control whether the calibration is performed in any of three ways: Without any display (default) Showing calibration plots, which automatically disappear Showing calibration plots and requiring user-confirmation ("OK") before proceeding
	Calibration: # iterations	(Advanced) – Number of iterations of FSE calibration. Default=1.
	Calibration: use stimulated echoes	(Advanced) – Use both the primary and stimulated echoes in the FSE calibration.
	2 pass phase encoding	(Advanced) – Perform the calibration in 2 passes (needed if stimulated echoes are present, to untangle the right and wrong parity echoes).
	Apply unipolar slice gradient	(Advanced) – Tells the protocol to ensure that all the gradients in the slice channel have the same polarity.

IR-snap

1. This is a method of obtaining a set of images (optionally multi-slice), each with a different T1-weighting. This may be useful for calculating a T1-map.
2. The procedure consists of a loop performed an arbitrary no. of times over a set of (fast) GRE2D protocols, each with the following parameters:
   - Encoding order set to Centric encoding
   - InversionMode set to Fast (a single inversion pulse per the full set of phase encodings), with specified TI
   - The Internal TR is set to minimum and is read only.

IR snap protocol parameters

Tab	Name	Explanation
Procedure Parameters	Inversion time vector msec	List of inversion times to be applied in each scan
	Inter scans overhead sec	Additional overhead between scans (sec)
	Inter-scan repetition time (msec)	Time between successive scans along the list of inversion delays, including the inversion pulse and inversion time

DCE (dynamic contrast enhancement)

1. A procedure used to map time-changes in a user-specified ROI, for example as a contrast agent washes in and out of different regions.
2. The procedure consists of a loop over an arbitrary no. of GRE 2D protocols, with the reconstruction delayed until after all the acquisitions are completed to improve temporal resolution.

DCE protocol parameters

Tab	Name	Explanation
Procedure Parameters	Number of scans	Number of DCE scans to be performed
	Additional wait time between scans (sec)	Additional delay between scans in seconds, not including the scan time itself, calibration time (if applied), and extra delays depending on computer resources)
	Inter scans overhead (sec)	Additional overhead between scans (sec)

Appendix C System Calibration

The M3 MRI system is configured to include several calibration sequences that are identified as 'service' type sequences.

This appendix covers the following topics:

- Frequency Calibration
- Linear Shim Calibration
- RF Calibration
- Coil Calibration

Frequency Calibration

System frequency is affected by several factors, among them temperature fluctuations. Therefore, to ensure good quality images, frequency calibration has to be performed periodically. It is performed automatically before every scout sequence.

Most scanning sequences that you add to the acquisition queue are automatically complemented with a frequency calibration sequence preceding them. You can select or review if this calibration runs within the protocol parameters.

Linear Shim Calibration

The Linear Shim calibration deals with the magnet field homogeneity. It is performed automatically before every scout sequence so you do not need to initiate it manually. You can select or review if this calibration runs within the protocol parameters.

RF Calibration

The RF calibration procedure calibrates the RF pulses.

RF calibration has to be performed every time you replace the coil or the sample. It is performed automatically before every scout sequence so you do not need to initiate it manually. You can select or review if this calibration runs within the protocol parameters.

Coil Calibration

The coil calibration procedure calibrates the RF coil frequency to match the magnet frequency.

Coil calibration has to be performed every time you replace the sample. It is performed automatically before every scout sequence so you do not need to initiate it manually. You can select or review if this calibration runs within the protocol parameters.

Only authorized service personnel are allowed to work on RF circuits and coils.

Appendix D Physiological Monitoring System

Respiratory, Temperature and ECG Monitoring and Triggering on the M3 System

This appendix outlines the basic operation of standard and advanced physiological monitoring systems associated with the M3 system. These systems allow for continuous, live monitoring of the respiration cycle and body temperature of an animal when placed within the M3 system. The advanced physiological monitoring system also allows for continuous monitoring of the ECG signal. Depending on the application both respiratory and/or ECG triggering are possible with the integration of the monitoring system with the M3 electronics.

This appendix assumes you are new to using physiological monitoring systems; however you should be comfortable handling and anesthetizing the animals.

It is important to always follow the guidelines of your animal care committee when using both the physiological monitoring system as well as the M3 instrument.

Please refer to Chapter 4, Section ***Setting Up the Animal for Imaging*** prior to connecting the physiological monitoring system.

Requirements:

- M3 compact high-performance MRI system
- Standard or Advanced physiological monitoring system
- Appropriate animal handling system

To use a Physiological Monitoring System

1 Follow animal handling system instructions until the animal to be imaged is placed in the appropriate animal bed.

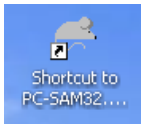
2 Make sure the desired physiological monitoring leads are available. Connect the **respiratory pad** and **temperature probe** to the appropriate connection on the animal handling system. It is best to leave the **ECG leads disconnected**. They will be connected once attached to the limbs of the animal.

We recommend monitoring at least the respiration rate of all animals to be imaged. Additional monitoring of body temperature and ECG can also be achieved. Certain applications require an ECG signal. In these situations the ECG leads must be attached.

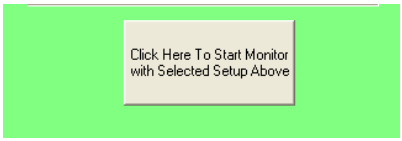
Note/Tip

ECG monitoring and triggering is only available with the Advanced Physiological Monitoring system.

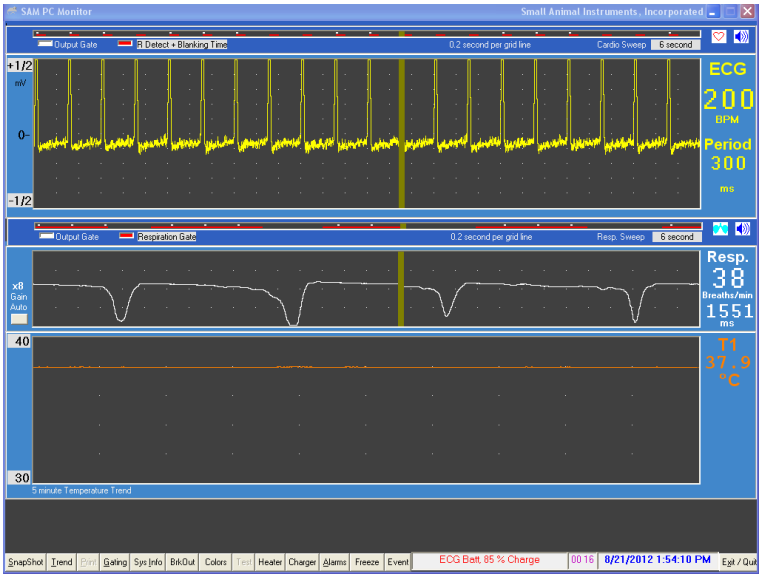
3 Click the ***SAM PC Monitor software*** application icon (PC-SAM32).



Click the ***Start Monitor*** button to begin monitoring with the default setup.



A window showing the **ECG** trace at the top, **respiratory** signal in the middle, and **temperature** at the bottom is displayed.

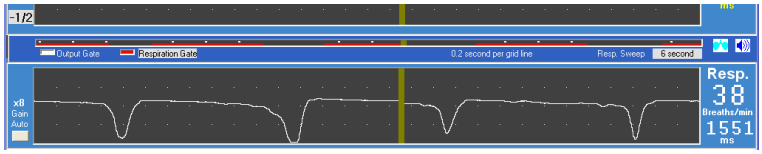


The screen will not display any signal until the animal is connected to the appropriate leads.

4 Place the **respiratory pad** under the abdomen of the mouse. It should be located away from the anatomical target of interest if possible and away from the heart or additional

noise will be introduced into the signal.

Ensure a strong signal is observed on the physiological monitoring software. It may take up to 30 seconds for the software to adjust the scale of the trace to show the respiratory signal appropriately.



5 If either **ECG** or **temperature** monitoring is desired these leads should be connected.

For **ECG** leads, select the appropriate **3 lead system** (needle electrodes, gold disk electrodes, etc.) and connect to the limbs of the animal; ensure that adequate ECG cream/gel is used to conduct the signal.

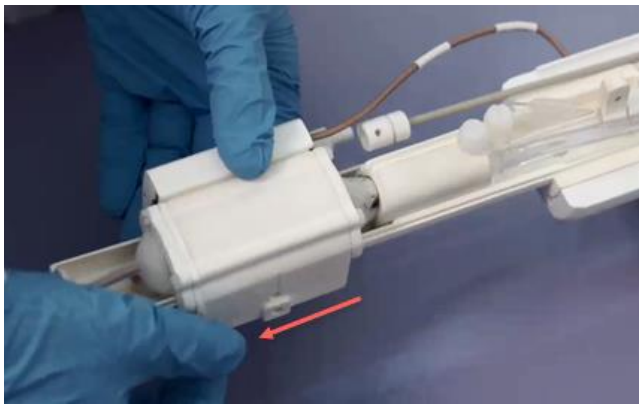
Note/Tip

ECG monitoring and triggering are only available with the Advanced Physiological Monitoring system.

The wires from the 3 lead electrode system should be twisted around one another and then connected to the animal handling system. This will minimize any interference the wires may cause within the magnetic field.

Make sure a strong signal from any connected lead is observed on the physiological monitoring software. Again, it may take up to 30 seconds for the software to adjust the scale of the trace to show the signals adequately.
For **temperature** monitoring insert the **rectal probe** and secure with tape to ensure the probe does not move once in place.

6 Once all of the desired physiological monitoring leads are in place the coil should be placed over the bed and animal if a **whole body** coil is being employed.



If a **head** coil is being employed the coil is already in place.
Make sure none of the connections from the leads to the animal handling system are disrupted.
Consult the chapter describing the ***Animal Handling System*** for details about connecting and securing the body coils to the animal handling system.

7 If physiological monitoring is all that is necessary for the imaging application, the animal and software setup are complete. Proceed to **Step 9**.

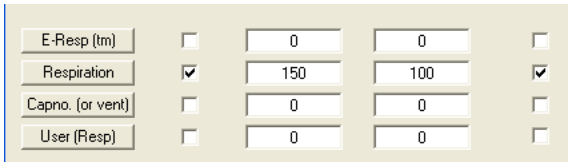
8 If **respiratory** and/or **ECG triggering** are required, an additional set-up is required in the physiological monitoring software.

Note/Tip

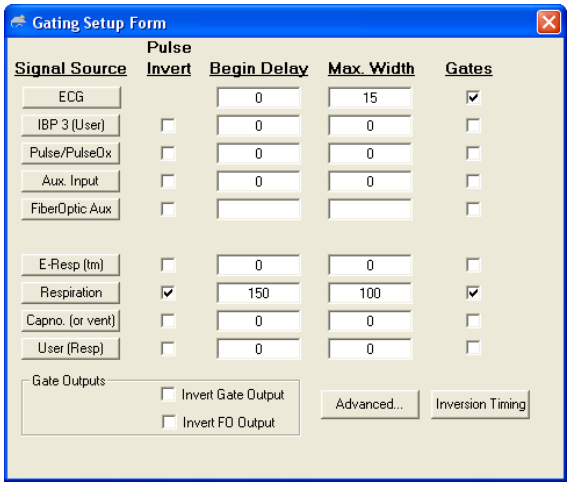
ECG monitoring and triggering are only available with the Advanced Physiological Monitoring system.

Open the Gating dialog box. It can be accessed at the bottom of the PC_SAM screen.

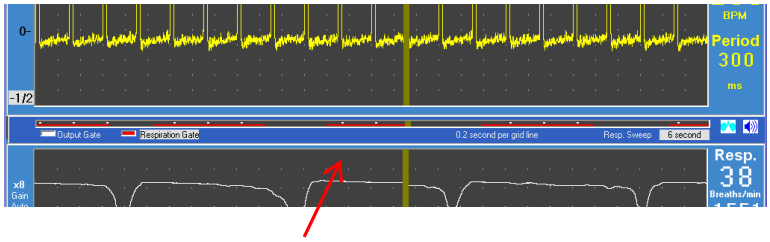
For **Respiratory Gating**, mark the Respiration Gates checkbox. Make sure the **Begin Delay** and **Max Width** values are set so the triggering occurs in the **plateau** of the respiratory cycle, and that it is short enough not to extend into subsequent inspiration phases.



This signal indicates to the electronics of the M3 system when to begin an acquisition of a single repetition cycle.



For **ECG Gating**, mark the ECG Gates checkbox. The system will automatically detect the trigger position.
If **respiration triggering** is also employed then the **signal** will only be sent to the electronics cabinet when **both the ECG and Respiratory triggering are fulfilled**. This is indicated by the **white** mark above the red respiratory gate.



For both respiratory and ECG triggering, the electronics will only use the signal generated by the physiological monitoring software if the acquisition protocol has been set to require this signal.

Note/Tip

If the acquisition protocol has been set to require either respiratory or ECG triggering and this signal is not activated in the physiological monitoring software, or there is no physiological signal being monitored, the sequence will not advance to acquisition. If necessary, turn off the requirement within the acquisition protocol for these triggering signals.

9 Continue with the imaging protocol, monitor the animal's physiology frequently and adjust level of anesthesia or heating accordingly.

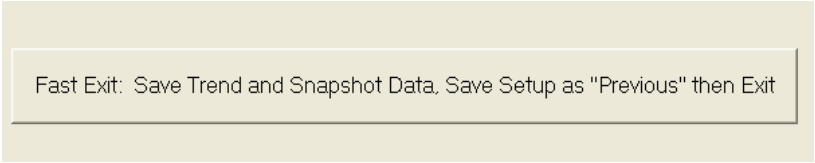
Between animals and within the same imaging session, no changes are required in the software. Simply remove the leads from the initial animal, clean them thoroughly, and place them on the subsequent animal to be imaged.

Caution

Always follow your animal care committee's recommendations when using the M3 system. The physiological monitoring system allows constant monitoring of the animal while inside the magnet.

10 When imaging is completed for the session, close the software by clicking the red X.

A window is displayed with several choices. Select the ***Fast Exit*** option to completely exit the software.



Appendix E Troubleshooting

Introduction

The M3 MRI system is designed to require little adjustment or calibration.

Corrective and preventive maintenance must only be performed by a service engineer who has completed service training on the M3 system.

This equipment generates high voltages which can cause serious personal injury if handled improperly.
Before performing any maintenance, adjustment or repair procedures recommended in this chapter, turn off the system and disconnect the power cable, unless the procedure to be followed necessitates otherwise.

The troubleshooting guide in this chapter should be consulted in the event of a malfunction in the system. The **Causes** should be checked, and the **Corrective Actions** performed in the order in which they appear.

The troubleshooting guide consists of a table with three columns:

- **Fault Message**: the message that appears on the monitor display when a system fault is manifested
- **Cause**: what has caused the symptom or malfunction
- **Corrective Action**: steps that must be taken to correct the matter

The order in which the corrective actions appear is indicative of the relative probability of solving the problem. Therefore, the causes should be checked, and **the actions should be performed, in the order in which they appear**.

Any problem that cannot be corrected by following this troubleshooting guide must be reported to the service department at Aspect Imaging.

Troubleshooting Guide: Fault Messages

Problem	Cause	Corrective Action
White noise appears instead of an image	1. Frequency is not calibrated 2. The NMR Frequency shifted 3. The NMR frequency not inserted correctly to AMF SW. 4. The RF amplifier stopped to work 5. The RF amplifier switch is Off 6. The RF Cables are not connected 7. Sample is not inserted or sample is not centered	1. Run Frequency Calibration 2. Check in system parameters that the NMR frequency is written correctly 3. On the RF amplifier unit, make sure the RF power switch on 4. Make sure the coil is plugged in. Make sure that the coil's Green LED is turned On 5. Make sure you are using a suitable coil 6. Make sure there is a sample in the magnet 7. Make sure sample is within the FOV. Perform calibration and scan again
The image contains a single high-intensity line.	1. The gradients stopped working due to overheating	1. Cool the room. Check the gradient's temperature is below 35° C and try again.

Problem	Cause	Corrective Action
A frequency is not calibrated	1. The software frequency, main coil frequency, and magnet resonance do not match	1. Perform Coil Calibration. Verify that the RF Pulse Amplifier is turned On
Gradients amplifier is not responding	1. The Gradient amp. is switched Off 2. The Inhibit button was pressed 3. There is no phantom or sample in the magnet 4. The scanned object does not generate a strong enough signal	1. Verify that the Power Grad Amp breaker is switched On 2. Check whether the Inhibit light on the Gradient Amp. is On. If yes, press the Inhibit button to reset it 3. Place a standard Aspect phantom in the magnet and check again
The image is very grainy	1. The mounted RF coil does not match the coil indicated in the software 2. The 60 mm coil was used for a small object 3. The SNR (signal to noise ratio) is very low	1. Change the coil setting in the software 2. Replace the coil with the 35 mm coil 3. Change scanning parameters to increase SNR. For example, thicker slice, larger FOV, smaller matrix
There is a fold-over of the image edges	1. The sample is longer than the field of view	1. Change the frequency encoding direction to Vertical. 2. Increase the FOV (Field of View)
Scout Failed Error during the scan process	1.The RF amplifier stopped to function 2. The NMR frequency value is not written correctly	1. Verify that the RF Amplifier RF Power LED is On 2. Set correct value and run the frequency calibration again 3. Make sure the coil is plugged in 4. Verify that on the automatic coil a Green LED is turned On 5. Make sure you are using a suitable coil 6. Make sure there is a sample in the magnet
The image with white horizontal and vertical lines	The Gradient amplifier stopped to work The gradient amplifier is overheated The room temperature is above 35° C	1. Check that all PCI gradient amplifier Green LEDs are On. If not, press the Reset button 2. On the control unit, check that the gradient temperature is below 35° c 3. Cool the room if the room temperature is above 35° c
The scout takes more than a few minute(2-3 min)	The communication with Amos is lost The Ethernet cable is disconnected from the PC work station	1. Check that the LEDs on the Amos are blinking. Restart Amos Verify that the Ethernet cable is connected to the PC Work station

Problem	Cause	Corrective Action
Error in initializing: Error While creating the Amos service	The communication with the Amos Spectrometer is lost	1. Verify that the Ethernet cable is connected 2. Verify that the Ethernet cable is connected to the PC Work station
Coil Calibration Failed	USB Cable between the PC workstation and the electronic cabinet Ethernet port is disconnected There is no sample inside The cables are not connected properly	1. Make sure the coil calibration LEMO CABLE is connected to the manifold. 2. Make sure the USB cable between PC work station and the electronic cabinet Ethernet port on PANEL CONECTOR is connected 3. Disconnect the USB cable between the PC work station and the electronic cabinet Ethernet port on PANEL CONNECTOR. Close all applications 4. Connect the cable again ,run the Test again 5. Make sure the Green light works during the coil calibration.
Image distorted. The received image looks distorted.	1. Gradient Amplifier stopped to function 2. The gradient amplifier is in inhibit state	1. On the Electronics cabinet's PDU, make sure the POWER GRAD amp Main switch is On 2. Check that on the Control Unit the gradient temperature is below 35° C 3. If the temperature is higher than 35° C, cool the room and scan again 4. Run frequency calibration 5. If the problem still exists, one or more gradients are malfunctioning. Please contact support.

Appendix F Glossary

AMF	Aspect MRI Framework – the core software that runs the scanner – creates and stores images and interacts with the data base for all Aspect's products.
Averaging	Repeating the MRI acquisition more than once to improve SNR or to reduce artifacts. See "external averages" or "internal averages"
Axial	An imaging plane bisecting the body into top and bottom parts
Calibration	Some calibrations change either (1) with time (2) with ambient temperature (3) with load (i.e. patient). For some more details see the entries "cf calibration", "rf calibration", "shim calibration" or "coil calibration".
cf calibration	cf = central frequency = NMR frequency. This calibration finds the current NMR frequency, which is directly proportional to the magnetic field strength (for protons, 1 Gauss = 4257 Hz).
Coil calibration	Adjust the resonance frequency of the rf coil to be near the NMR frequency (central frequency).
Coronal	An imaging plane bisecting the body into ventral (front) and dorsal (back) parts.
DAC	Digital-to-analog converter. A device that converts a digital signal (i.e. pattern of numbers) into an analog signal (i.e. current or voltage). DACS are found in the transmitter and the gradient channels of the spectrometer (to convert the RF and gradient patterns into electrical signals for use by the rf and gradient amplifiers).
dB	Decibels. A logarithmic scale widely used in engineering to measure the ratio of two signals or two power levels. It is defined as $dB = 20 \cdot \log_{10}(V_1/V_2) = 10 \cdot \log_{10}(P_1/P_2)$. If two signals differ by 6 dB, their amplitudes differ by a factor of 2. The Tx attenuator in the Spectrometer uses a dB scale i.e. if the rf calibration value changed from 14 to 11 (3 dB), the rf power increased by 50%.
dB/dt	The rate of change of the magnetic field i.e. $\Delta B/\Delta t$. The regulatory agencies like FDA and IEC limit the dB/dt in MRI scans to avoid causing nerve stimulation in the patient. The level that can be run without special instructions to the operator or authorization by the physician is known as the "normal" mode.

DICOM	Digital Imaging and Communications in Medicine, an industry standard for handling, storing, printing, and transmitting information in medical imaging (including headers that characterize the images and the scan used to acquire them).
External averages	Perform averaging (to improve SNR or to reduce artifacts) by repeating the entire scan N times, averaging the (magnitude) images. If any of the calibrations is set to "yes" it will be repeated at the start of each average.
FID	**F**ree **i**nduction **d**ecay – the name of an NMR signal
FOV	Field of View – the extent of space included in the image
FT (Fourier transform)	A mathematical technique that extracts the frequency components from a signal. In MRI, a 2D or 2D FT is the centerpiece of the reconstruction. An algorithm for performing this calculation very efficiently is known as FFT = Fast Fourier transform.
Gauss	Units used to measure magnetic fields. 1T = 10,000 Gauss. The earth's magnetic field (that causes a compass needle to point North) is about 0.25-0.5 Gauss, depending on location.
Ghosting	A unique kind of MRI artifact that produces smeared or coherent signal both inside the true image and far away from the true image. The artifacts stem either from instability of some part of the spectrometer or motion of the object being imaged (e.g. breathing, cardiac, flow, etc.).
Gradient coils	The gradients are used to vary the magnetic field linearly across the imaging volume.
HW	Hardware
Internal averages	Perform averaging (to improve SNR or to reduce artifacts) by repeating each line of k-space N times, averaging the (complex) results inside the spectrometer. If any of the calibrations is set to "yes" it will be only be performed once. Note: The Spectrometer does not currently (3/2014) support this mode.
Preclinical AMF application	The main software operating the M3
Partial k-space (a.k.a. Partial Fourier)	It can be shown that a full image can be reconstructed using only half the data acquired in a "normal" scan. Using Hermitian conjugation symmetry to reconstruct an image with ½ the data (at a penalty of $1/\sqrt{2}$ (30%) in SNR) is known as Half Fourier imaging. In the phase-encoding direction, this is used to save scan time. In the readout direction, Half Fourier imaging is used to decrease TE.

Queue	Several sequences stored in a predefined order, with repetitions and time delays that can be added as a single entity to the acquisition queue.
Prone	Face down
Protocol	The set of parameters needed for a sequence to run e.g. number of slices, slice positions, TR, TE, ETL, etc.
RF	Radio frequency (electromagnetic fields in the band of 3 KHz-300 GHz). At 1.05 Tesla, the NMR frequency is 45 MHz
RF calibration	Find the amplitude for a reference pulse to attain a reference tip angle e.q. voltage required for a 1 msec sync pulse to produce a tip angle of 90. Once this is known, the voltage required for any pulse and any tip angle can be calculated by a simple formula.
RF coils	Radio frequency coils, are used to transmit the pulses to the sample and to receive the MR signal.
ROI	Region of Interest
Sagittal	An imaging plane bisecting the body into left and right parts
SAR	Specific Absorption Rate – the average power absorbed in the body, per kg of tissue. The regulatory agencies like FDA and IEC limit the SAR in MRI scans to avoid heat deposition in the patient. The level that can be run without special instructions to the operator or authorization by the physician is known as the "normal" mode.
Scout	A preliminary scan that generates a localization image of the sample and assists in identifying areas of interest for the scan sequence
Sequence	A sequence defines the instructions to the hardware channels (gradients, transmitter, and receiver), and the associated parameters.
Series	Several images acquired during a single scan sequence.
Shims	Coils that are used to correct the MRI field homogeneity
Shim calibration	Find the values of the X, Y and Z shim currents (DC gradients) that make the magnetic field as homogeneous as possible.
SNR	Signal to Noise Ratio
Study	One or more sequences performed in a single session.
Supine	Face up
Tesla	Units used to measure magnetic fields. 1T = 10,000 Gauss.

Support and Contact Information

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